CM² Cooperative Mobility for Competitive Megaregions

Summer Forum 2018

UNIVERSITY OF TEXAS AT AUSTIN

PI(s): Kara Kockelman

GRA(s): Yantao Huang, Neil Quarles, Haonan Yan

The Rise of Trips in a World of Self-Driving Cars: Anticipating Trip Counts & Evolving Travel Patterns Across the Texas Triangle Megaregion

RESEARCH AGENDA

1. BACKGROUND

Vehicle automation technology has experienced rapid development in recent years. More automated vehicles means easier travel & thus more driving of longer distances. Vehicle-miles traveled (VMT) may rise on all roadway types, throughout megaregions, like the Texas Triangle, in the coming decades – well beyond what trends in population & economic activity would predict.

Long-distance travel is usually defined as one-way trips over 50 miles from origin to destination. In 2001, Americans took a total of 2.3 billion long-distance trips in personal vehicles, resulting in just over 760 billion miles of travel on the nation's roads. By 2040, long-haul freight truck traffic in the United States is expected to reach 460 million miles per day.

The Texas Triangle holds 6% of the US population & 7% of US GDP. Autonomous cars & trucks can dramatically change how Americans (& their goods) travel, in & between all megaregions.

2. RESEARCH MOTIVATION

Preliminary results indicate that availability of automated vehicles (AVs) will shift travel towards the AV mode (& away from conventional ground vehicles & air travel), while also delivering more long trips, & more frequent trips. This is due to lower perceived in-vehicle travel time burdens for those formerly driving. Drivers can now pursue other activities during travel, reducing value of time in almost half. This work simulates how these new modes will impact travel patterns & behaviors across the Texas Triangle megaregion.

3.RESEARCH FRAMEWORK

The researchers have reviewed work relating to travel pattern in Texas Triangle Megaregion, before testing different destinations & mode & route change choice parameters within the Texas Triangle megaregion. Specific conclusions & recommendations will be developed to help provide insight to Texas public transportation agencies & other Texas stakeholders. This project builds on existing work under TxDOT Research Project 0-6838, modified for application within the Texas Triangle Megaregion.

4. CONTRIBUTION TO PRACTICE

No research yet exists about AVs' impacts on megaregions. This work will be the first of its kind to assess what types of policies, strategies & models may be most helpful for optimal introduction of AVs and shared AVs (SAVs) in US regions, without compromising mobility, accessibility, and the environment through excessive VMT & congestion. Benefits of this research will include recommendations for public agencies, so they are better equipped to craft transportation policies & investments in advance of negative effects caused by AV implementation.

5.DELIVERABLES

Reports regarding model specifications, predictions, & researcher recommendations for optimal AV implementation within the Texas Triangle region will be delivered.

At least one article for publication in a relevant journal will also be produced.

THE UNIVERSITY OF TEXAS AT AUSTIN
CENTER FOR TRANSPORTATION RESEARCH

WORK TO DATE

1. Related Work

The project team first reviewed all studies & research findings relating travel pattern in Texas Triangle Megaregion, changing values of travel time from vehicle automation, travel demand elasticities, & other relevant topics. This will culminate a general understanding of modeling travel across Texas Triangle Megaregion as well as the current research gap.

2. Data Acquisition + Model Construction

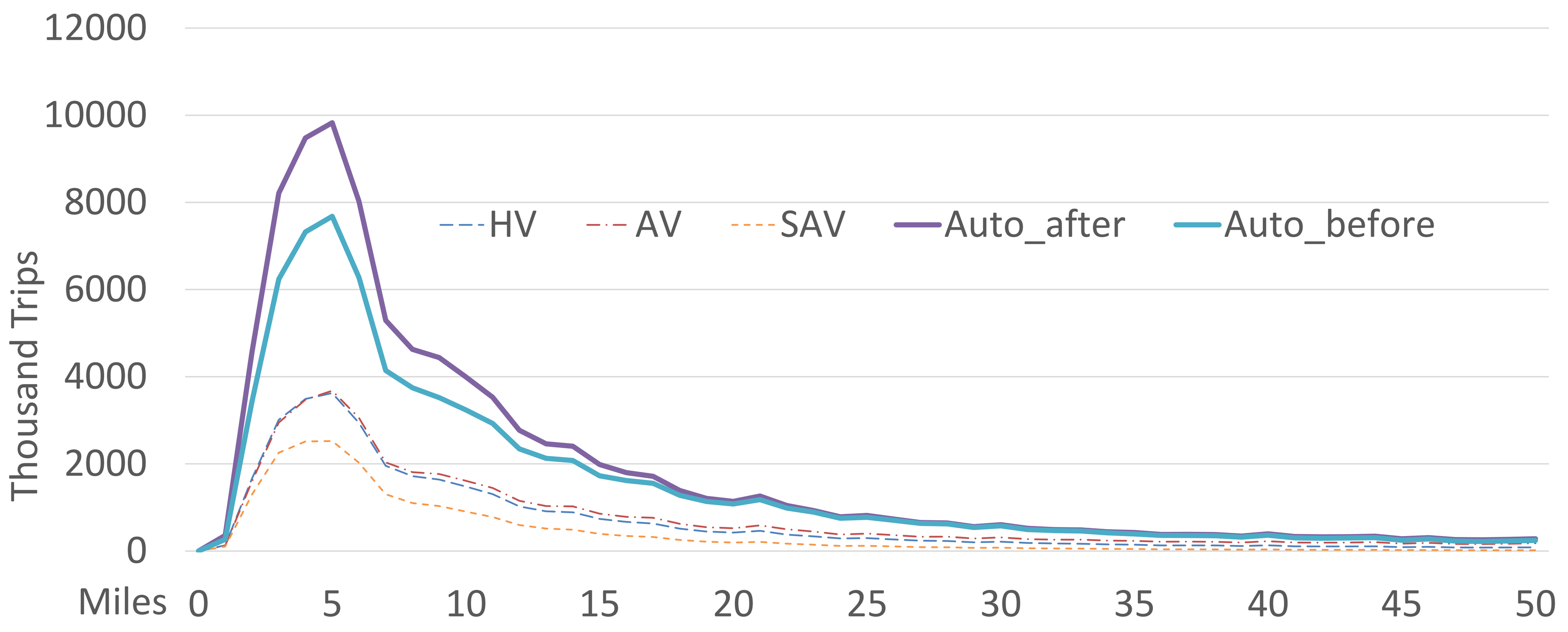
The team assembled data for the Texas Triangle megaregion (including network data & zone systems, land use information & demographics by zone, plus trip-level & link-level flow data). The project team also assembled destination, mode & route change choice parameters for a four-step TransCAD model application of both passengers & freight using outputs from Texas' Statewide Analysis Model (SAM).

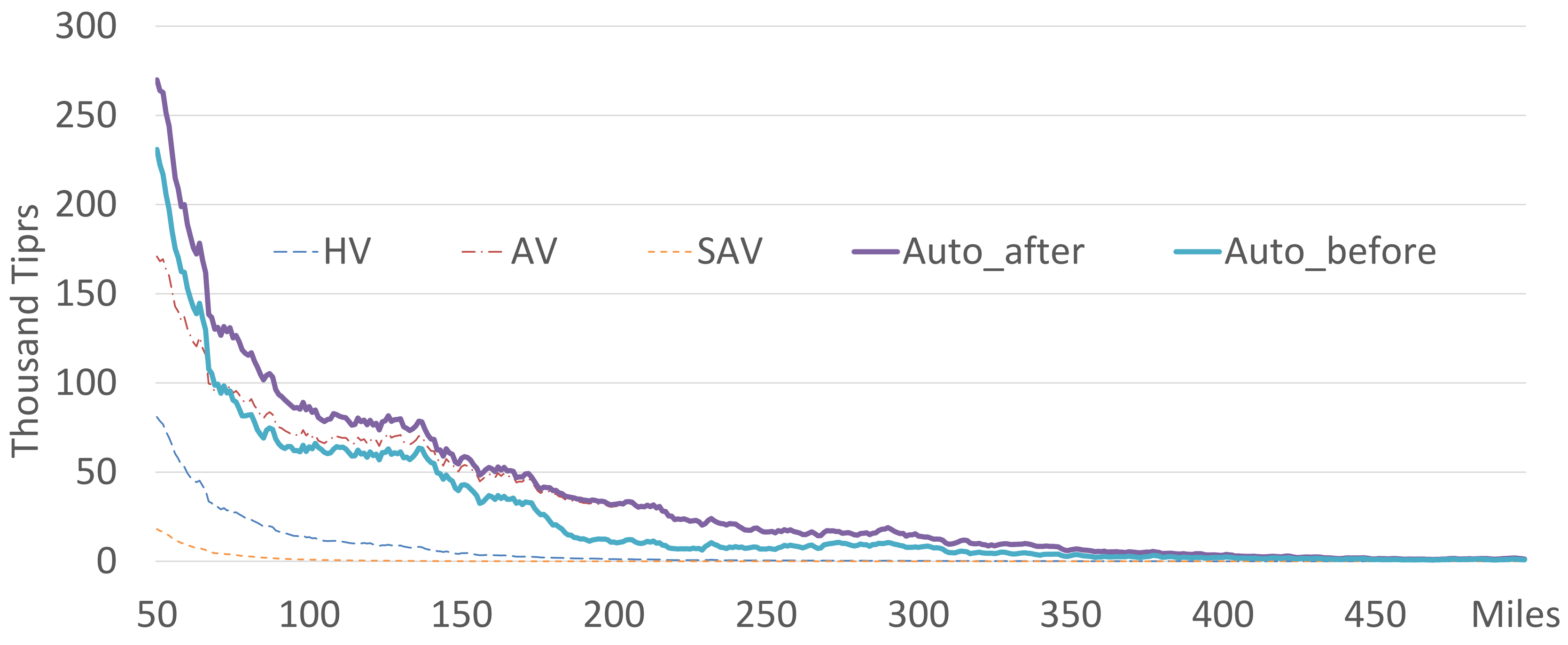
3. Applications & Simulations

We applied the passenger & freight model under different scenarios, with & without AV access, across the Texas Triangle. A suite of statistical specifications was utilized here, for count data, choice data, & other behaviors to calibrate models of vehicle ownership & shared-vehicle membership (SAV) decisions, destination & tour decisions, & mode & departure time choices at the individual & household levels. Once the set of model input parameters was established, a base-case scenario was run, with no AV/SAVs in operation. Outputs of this scenario were used as a baseline in future testing & verification. By examining & revising one component at a time, the project team tested model input. This activity provides in-depth analysis of SAVs as a potential form of transit.

The team will summarize the base model framework that was used to conduct the research for this task, as well as all of the various scenarios that were developed & methods for implementation. Scenario outcomes & implications will be described in detail & from these findings a set of conclusions & recommendations will be drawn.

Mode Use Before & After AVs- at Distances < 100 mi. & > 100 mi.





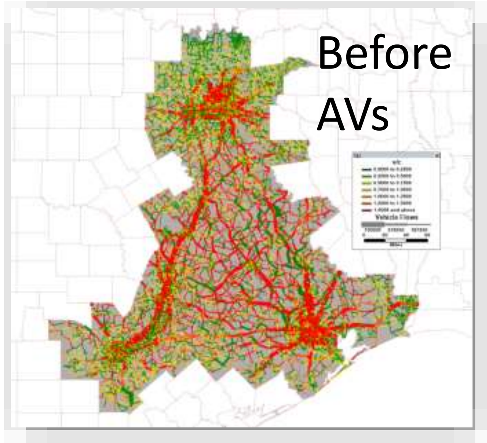
Mode Shifts vs Base Case (No AVs)

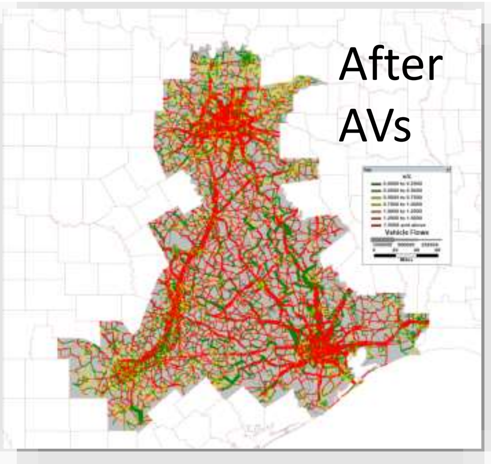
Trips (Million/Day)		Auto	Bus	Rail	Air
Before	< 50 miles	78M/day	2.7M	1.4M	N/A
After		94M/day	0.9M	0.3M	N/A
Change		+21.1%	-66.2%	-75.2%	N/A
Before	> 50 miles	11M/day	0.3M	2.5M	2.9M
After		16M/day	0.01M	1.0M	0.9M
Change		+45.5%	-99.5%	-62.0%	-70.4%

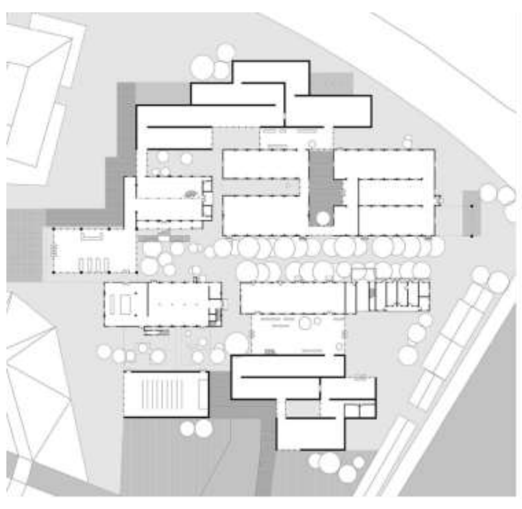
VMT Changes vs Base Case (No AVs)

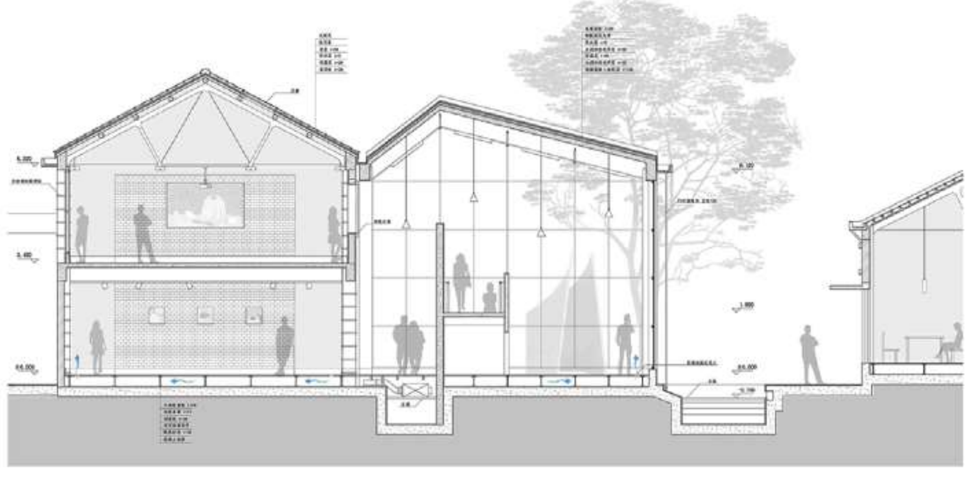
Area	Before (per day)	After (per day)	Change
Dallas-Fort Worth	527M VMT/day	693M/day	+31.6%
San Antonio	142M	175M	+23.2%
Houston	506M	633M	+25.0%
Austin	133M	178M	+33.7%
ENTIRE REGION	**1708M**	**2,314M**	+35.5%

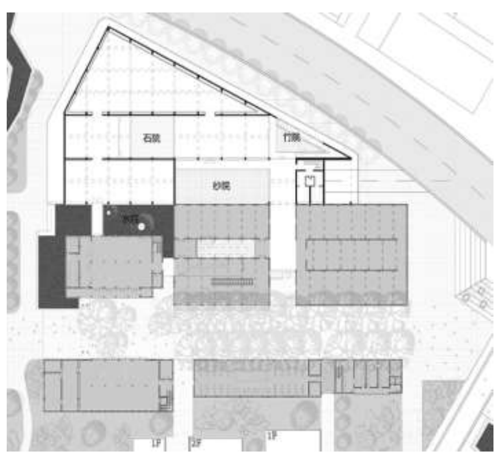
Congestion Change











TEXAS The University of Texas at Austin
Penn University of Pennsylvania
LSU Louisiana State University
TSU Texas Southern University

University of Texas At Austin
Lisa Loftus-Otway
Research Supervisor
Alexander Hunn and Roxanne Lin
Graduate Researcher and Undergraduate Researcher

The Right Structure for the Right Incentives: Multimodal Passenger Transportation in American's Growing Megaregions

Research Agenda

1. BACKGROUND

Most models suggest that American megaregions occupy less than a quarter of its land area, but account for over two thirds of the population and seventy-five percent of the national gross domestic product. In addition, projections show that future population increases and economic growth will be focused within these regions. Current transportation policy remains focused on road building, which harkens back to a decentralized rural America, which no longer reflects developing transportation realities. To account for increasingly dense population within urbanized areas, more frequent intercity travel along megaregion corridors, and disparities in transportation access, state and federal transportation policy and funding criteria should be adapted to encourage innovative, multimodal solutions.

2.RESEARCH QUESTIONS

- Comprehensively analyze current government spending and taxation on transportation in the United States. Review statutes and regulations, budget documents produced by government agencies, and other related publications.
- Analyze the transportation policies of China and Germany and how they facilitate multimodal transportation.. Focus will be on megaregional areas qualitatively comparable to American megaregions. Use a multidisciplinary analysis to compare foreign to domestic policy through an economic, legal, and historical lens.

3. RESEARCH CONTENTS

As we enter a new era of transportation with the entry of autonomous vehicles, the growth of telecommuting, and demographic shifts that are seeing millennials turning away from car ownership and driving, federal and state transportation policy will need to adapt to serve America's growing megaregions without reducing access to rural communities. Megaregions currently present unique access, equity, and congestion issues which are better accommodated by providing an environment in which multiple modes of transportation combine to respond flexibly varying needs for passenger transportation.

4.RESEARCH FRAMEWORK

This project conducted a multidisciplinary analysis of transportation policies in the United States and in China and Germany. The project combines economic, historical, and legal analysis to generate a model of transportation policy which allows different modes of transportation to compete for passengers on an even playing field. In doing so, the project seeks to reduce inefficiencies created by policies which favor one mode of transportation over another through an imbalance of subsidies, taxation, or regulation and instead promote flexibility in addressing megaregion transportation issues.

5. ROADMAP

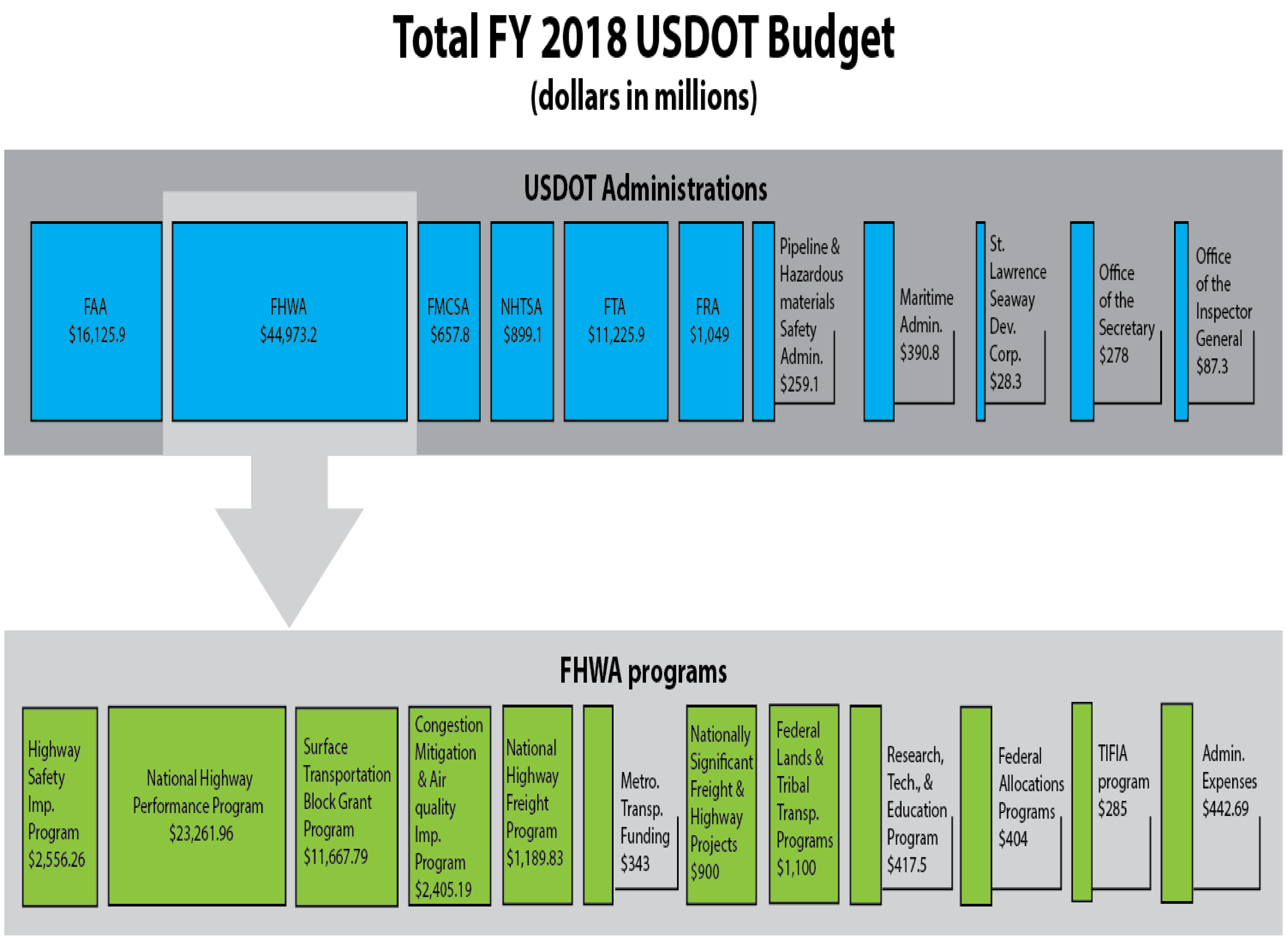
This project has analyzed current federal and state transportation funding policy and will provide recommendations for how to amend these funding streams and transportation policy criteria to more effectively allocate limited resources between different modes of transportation for maximum efficiency. It will apply research to generate a set of example amendments to state and federal transportation and taxation codes. These amendments will be constructed to increase competitiveness between modes of transportation and improve the efficiency, accessibility, and equity of American transportation policy.

6.TIMETABLE

August 2018: Produce a report containing draft amendments to federal and state transportation and tax codes as well as general legal recommendations to modernize transportation policy at the federal, state, and local level.

Findings

- More US government dollars are spent on highways than all other modes combined
- Constitutional provisions require gas tax to be spent exclusively on highways in 26 states
- Mapped the field of secondary research in economics, law, and history as it relates to American transportation finance
- Chinese and German authorities allow more flexible distribution of revenue to pursue transportation alternatives



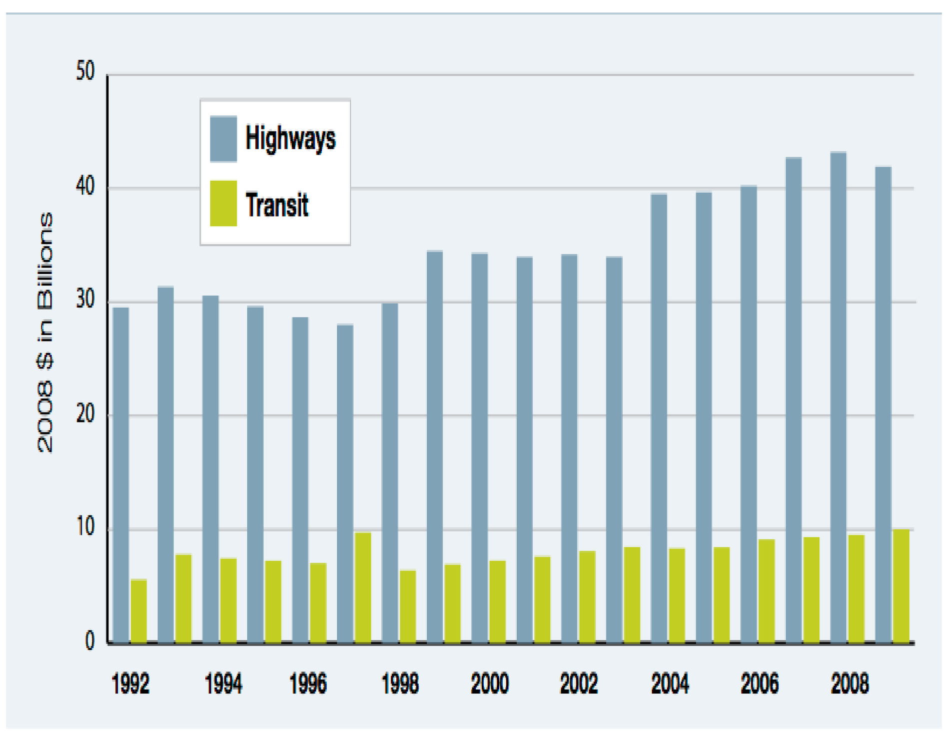


Table 2 Road System Development Responsibility Arrangement in the PRC

Road Classification	Administration Activities	Assignment of Responsibilities
National roads	Planning	Performed by the Ministry of Transport (MOT) in conjunction with relevant central government departments and in consultation with provincial governments; plans are submitted to the State Council for approval.
	Construction, maintenance, and management	Performed by provincial communications departments (PCDs).
Provincial roads	Planning	Performed by PCDs jointly with provincial government departments in consultation with lower-level local government entities; plans are submitted to provincial governments for approval and filed with MOT.
	Construction, maintenance, and management	Performed by PCDs.
County roads	Planning	Performed by the prefecture-level government; plans are submitted to provincial governments for approval.
	Construction, maintenance, and management	Performed by county-level governments.
Township roads	Planning	Performed by county-level road authorities; plans are submitted to county governments for approval.
	Construction, maintenance, and management	Performed by township governments.

TEXAS The University of Texas at Austin · Penn University of Pennsylvania · LSU Louisiana State University · TSU Texas Southern University

CM² Cooperative Mobility for Competitive Megaregions Summer Forum 2018

UNIVERSITY OF TEXAS AT AUSTIN
PI: C Michael Walton, PhD
GRA: Rydell Walthall

The effects of transportation infrastructure investments on freight mobility: A megaregion perspective

RESEARCH AGENDA

1. BACKGROUND

Megaregions demonstrate strong economic linkages and support extensive internal freight movements amongst their constituent metropolitan areas. As megaregions continue to grow, the number of freight movements is likely to increase, and new infrastructure or policies will become necessary to accommodate that growth. Texas was the origin of nearly $1.9 trillion in freight shipments in 2012, more than any other state. Those shipments accounted for 244 billion ton-miles, and the vast majority of this freight originated in the Texas Triangle.

2.RESEARCH QUESTIONS

How can innovative freight strategies be incorporated at the megaregion level technically, economically, and politically? This research examines the applications of both underutilized and emerging freight technologies for the Texas Triangle.

3. RESEARCH CONTENTS

Freight movements at the megaregion level broadly have a choice between two modes: highways or trucking. Because freight mode choice has large external costs, this research looks at the network effects of different strategies, and potential policy levers available at the megaregion level to effect socially desirable outcomes.

4.RESEARCH FRAMEWORK

Strategies tested include truck-only lanes, freight rail electrification, and truck platooning, including autonomous truck platooning. Each of these strategies has the potential to bring about large changes in freight mode utilization, and efficiency. Consistent policies throughout a megaregion will be necessary for smooth policy implementation and maximum social benefits, but this will require coordination amongst the megaregion's municipal, regional, and state authorities.

5. ROADMAP

- Construct a freight network based on the primary freight network and major rail corridors in the Triangle
- Choose an appropriate model of freight mode choice
- Analyze the effects of various technologies, investments, policies for freight movements in the Triangle
  - Truck-only lanes
  - Freight rail electrification
  - Truck platooning
  - Others, time permitting
- Research relevant policies available within a megaregion, and the likely effects of those policies.

6.TIMETABLE

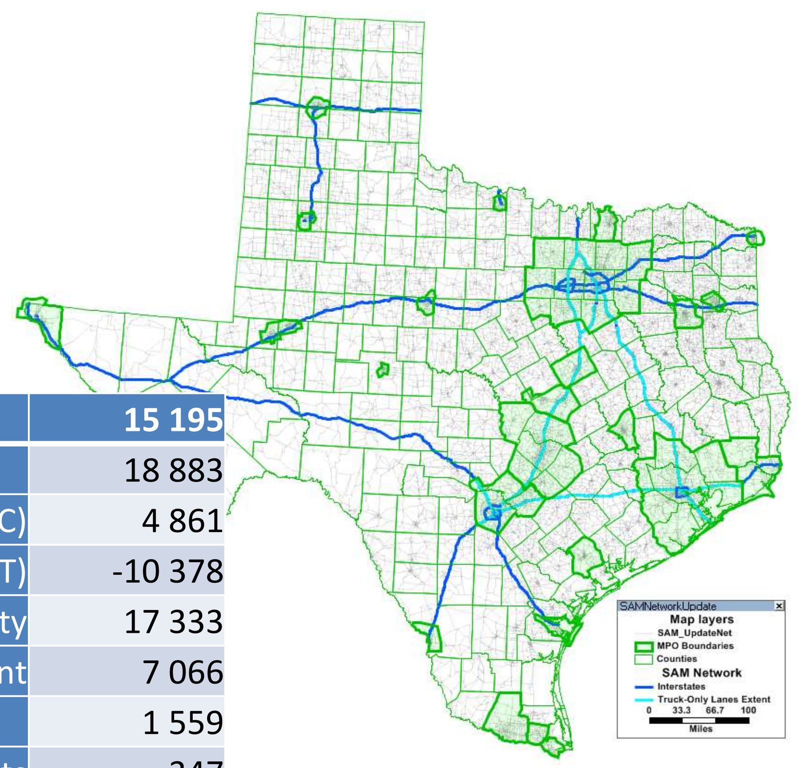
This Summer: synthesize research into a final report.

ACHIEVEMENTS

1. Truck-only lanes have the potential to reduce conflicts between slow-moving trucks and higher speed passenger vehicles on highways. This could improve safety, operational efficiency, passenger comfort, and freight reliability. As part of this research, truck-only lanes were simulated throughout Interstates 10, 35, and 45 in the Texas Triangle, showing large public and private benefits in excess of $15 billion in NPV.

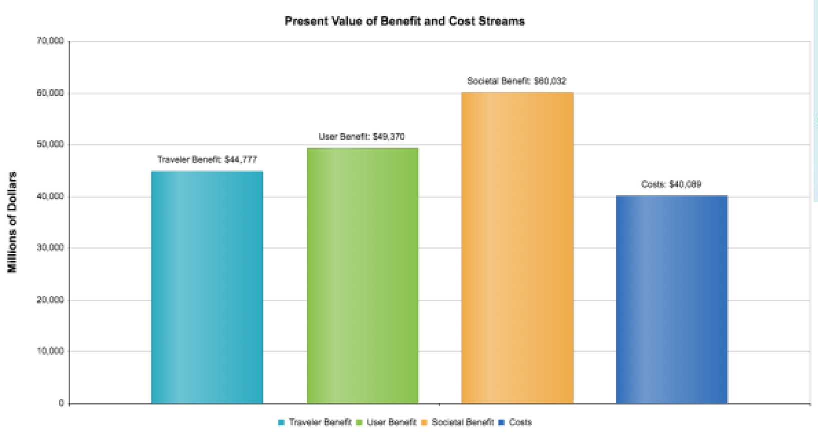

Rendering of proposed truck-only lanes along I-70 Source: FHWA

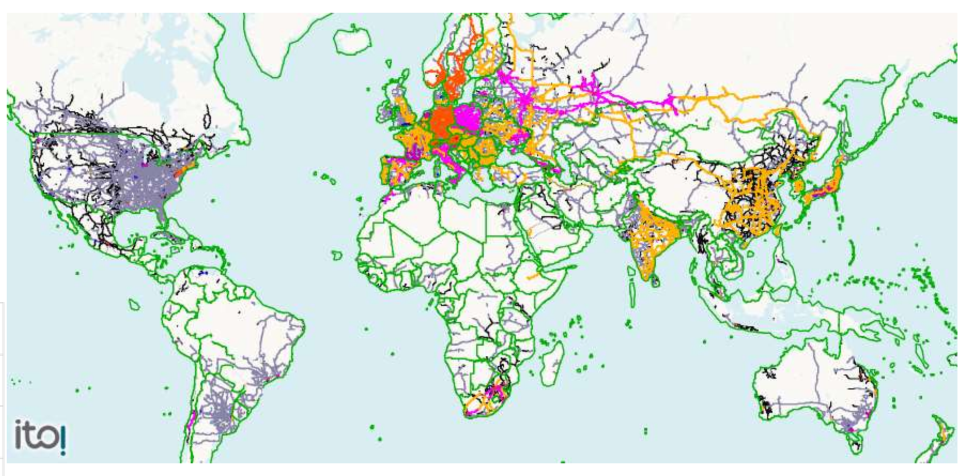
Present Value of Benefit Stream	15 195
Travel Benefits	18 883
Value of Vehicle Operating Cost (VOC)	4 861
Value of In-Vehicle Travel Time (IVTT)	-10 378
Value of Improved Travel Time Reliability	17 333
Value of Safety Improvement	7 066
Environmental and Social Benefits	1 559
Value of Emission Reduction For Mobile Source Pollutants	347
Value of Emission Reduction For Carbon Dioxide	1 243
Wider Economic (Productivity) Benefits	-5 248


Extent of truck-only lanes in the simulations

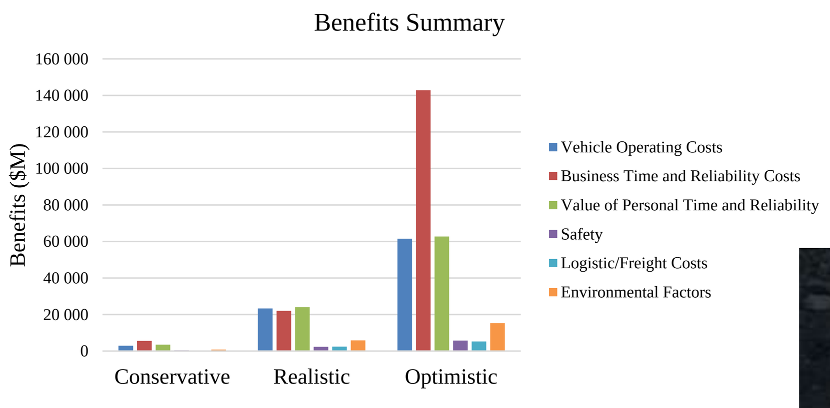
2. Freight rail electrification is a technology used broadly outside the US. As the power grid converts to cleaner energy sources, freight rail electrification offers the potential to provide substantial environmental benefits while reducing operating costs for freight rail companies. This research has led to preliminary estimates of these effects for the Texas Triangle, but needs to evaluate the financial framework that would be necessary for implementation.

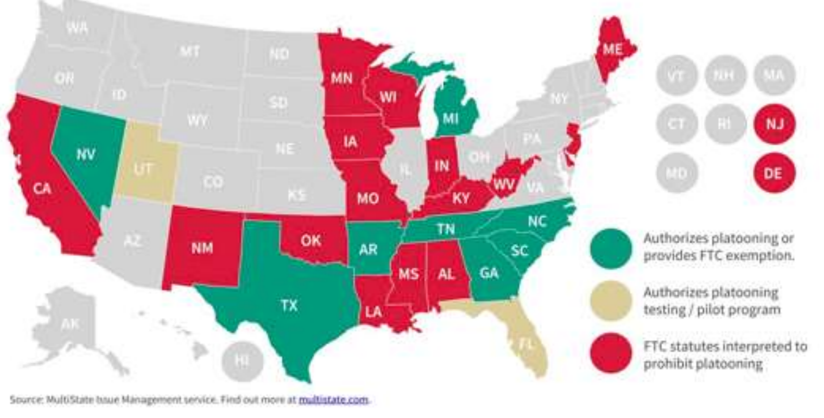

UP Average Trains per day, 2003




Rail electrification across the world. Different colors correspond to different voltages. Grey and black are non-electrified. Source ITO World

3.Truck platooning will reduce trucking emissions in the short term, and can substantially reduce operating costs in the long-run as autonomous truck platoons become available. The total benefits vary wildly based on adoption rates, whether average platoon size, and time-frames for adoption.





Peloton Technology

The University of Texas at Austin · Penn University of Pennsylvania · LSU Louisiana State University · TSU Texas Southern University

CM² Cooperative Mobility for Competitive Megaregions

Summer Forum 2018

UNIVERSITY OF TEXAS AT AUSTIN

Robert Harrison, Senior Research Scientist and Dr. Ron Matthews

Research Supervisors

Sean Mason and Colton Voorhis

Undergraduate Researchers

Improving Megaregion (MR) Freight Mobility: Impact of Truck Technologies

RESEARCH AGENDA

1. BACKGROUND

Megaregion (MR) demand will raise freight mileage (FM) over the next thirty years. Modal engines moving freight are dominated by diesel engines which impacts truck design. Untreated diesel exhaust is unhealthy and some EU cities like London and Paris are considering banning all diesel vehicles. U.S Environmental Protection Agency (EPA) rules in 2002, 2007 and 2010 have reduced the levels of pollution on a truck ton-mile basis. However, further reductions are required to meet the higher levels of future truck vehicle miles of travel (VMT) predicted on MR highway systems. Electric power is now being offered as a solution to urban where daily VMT is modest.

2.RESEARCH QUESTIONS

The project categorized the various groups of Class 8 truck engineering components that are likely to be offered as original equipment to truckers over the model year period 2018-2025. These include:

1. Impacts of the 2012 Department of Environmental Fuel Efficiency Program.
2. CM2 study findings – Class 8 and Urban delivery vehicles.
3. Model year Class 8 specifications for 2018, 2020 and 2025.

3. RESEARCH CONTENTS

This research will evaluate both the operator and societal costs and benefits from a range of truck design and equipment specifications. A case study of a current Texas truck logistical system will be used to identify potential changes in freight patterns mitigating higher VMT levels predicted over the 2018 – 2025 period. The failure of current revenue models for equitable highway use will be summarized,

4.RESEARCH FRAMEWORK

The work will address intercity trucking and metropolitan delivery systems. Trucking companies are already focusing on a wide variety of methods to raise miles per gallon (MPG) and these will be identified. At model year 2021, original equipment manufacturers (OEMs) are expected to offer autonomous features (AF) – probably focused on safety – while 2025 trucks will reflect any higher levels of AF permitted by state and federal agencies.

5.TIMETABLE

First semester: data collection using DOE reports, ASME papers and OEM literature.
Completed

Second semester: group data into model years and estimate fuel efficiencies
Completed

Third semester: trucker interviews and case study of the San Antonio-Austin-Waco megaregion.
Underway

Achievements

1. Literature Review conducted.
2. Truck technologies identified, grouped by model year and aggregated into truck mpg impacts.
3. These are now being translated into the impacts on state and federal highway revenues.
4. Urban freight is impacted both by cleaner diesel engines and the rate of adoption of electric and gas delivery trucks.
5. Traditional methods of fuel taxes is both inefficient and inequitable and alternatives will be recommended.

Truck Example: Freightliner EPA Supertruck

12

Tesla Class 8 Electric Tractor-Trailer

- Near zero emissions in US Metro area delivery systems by 2025?

TEXAS The University of Texas at Austin

Penn University of Pennsylvania

LSU Louisiana State University

TSU Texas Southern University

CM² Cooperative Mobility for Competitive Megaregions Summer Forum 2018

UNIVERSITY OF TEXAS AT AUSTIN
PI: Stephen Boyles
GRA(s): Priyadarshan Patil, Venktesh Pandey, Cesar Yahia

Beyond Political Boundaries: Constructing Network Models for Megaregion Planning

RESEARCH AGENDA

1. BACKGROUND

Megaregions transcend state and political boundaries today, and are characterized by trade and infrastructural connections. They involve multiple cities and economic zones, often spanning many states. In current practice, Megaregion network models are not developed on this scale, due to current models being developed by Metropolitan Planning Organizations (MPOs) or Departments of Transportation (DOTs), which focus on county/city scale and state scale, respectively. This mismatch of network model scale impacts long-range network planning process, specifically traffic assignment on the network. Traffic assignment allows us to predict roadway volumes, travel times, vehicle-miles and vehicle-hours travelled, and other such metrics. To achieve more accurate planning goals for megaregions, the mismatch between traditional models and megaregion models has to be addressed and new methods developed. These new models and methods should not only focus on the interactions between multiple cities and states, but also be computationally solvable and tractable, given current resources. This project aims to address this gap and develop such methods to balance realism and accuracy of megaregion network models.

2.RESEARCH QUESTIONS

The two key questions we are addressing are (1) How to **partition a large network into smaller subnetworks**, in a way which allows parallel computation; and (2) How to **quantify the interactions between these subnetworks**, allowing changes in a subnetwork to impact other subnetworks. These two questions impact the computation time required and the accuracy of the model, respectively. To provide a concrete example, we can consider the Texas Triangle, which includes Austin, San Antonio, and Dallas. A change in the Austin freeway network impacts the freight demand and routing from and to San Antonio and Dallas. Such interactions need to be captured by the model, while being computationally efficient.

3. RESEARCH CONTENTS

Partitioning algorithms have been used in the realm of communication networks previously. We studied various partitioning algorithms, and selected two for implementation on the Texas statewide analysis model (SAM). The first algorithm is the shortest distance domain decomposition algorithm (SDDA) as proposed by Johnson et al. [1] and elaborated upon by Yahia et al. [2]. This was contrasted with spectral partitioning (SP), proposed by Bell et al. [3].

SDDA works by constructing network partitions based on the farthest-distance metric, whereas SP takes into account flow on the network and opts for minimum flow cuts. SDDA is widely accepted as the partitioning algorithm of choice in many fields. The visualizations for the partitions can be observed below.

The SDDA partitions divide major cities like Austin into different subnetworks, resulting in the different areas being processed separately during the traffic assignment algorithm, while SP does not face this shortcoming. At a higher number of partitions (5+ partitions), SDDA generates subnetworks which are negligible in size (a few blocks), making it hard to use SDDA for higher number of sub-networks. SP does not face this issue either, providing more "intuitive" decompositions. The drawback for SP is the requirement for approximate network flow data, which requires more pre-processing than other partitioning algorithms.

4. KEY CONCLUSIONS

The team recommends the usage of Spectral Partitioning for applications pertaining to transportation networks and traffic assignment applications. The main advantages SP has over SDDA are (1) **It takes into account geographical distribution of traffic flows**; and (2) **It does not start with static seeds for partitioning**. These features avoid partitioning urban areas into multiple partitions, avoid partitions with negligible size, and create flow balanced partitions. The lone drawback is the initial need for flow data, albeit approximate.

5. RESEARCH FRAMEWORK

A traffic assignment algorithm, the DSTAP method, was developed by Jafari and Boyles [4]. It partitions a regional network into smaller subnetworks, solves for equilibrium on the subnetworks, updates a simplified and abstracted master network with the results, equilibrates the master network, and iterates until convergence. It has been shown that the algorithm converges regardless of the partition chosen and provides computational savings of roughly 50% on the Austin network. While convergence is independent of partitions chosen, application of the algorithm as a heuristic has its performance depend on efficient decomposition. The next step in this project is application of DSTAP as a heuristic to the results from the partitioning algorithms, as well as comparison of computational performance and accuracy to traditional methods and DSTAP as a standalone algorithm. This would allow the researchers to draw insights and make recommendations for megaregional modelling.

6. ROADMAP AND TIMETABLE

The team has completed Tasks 1 and 2, the literature review and the comparative study for partitioning algorithms, respectively. The next task to be completed is the application of DSTAP as a heuristic to the generated network decompositions. This involves sensitivity analysis and capturing interactions between the network partitions. Following completion of task 3, the findings will be summarized and the team will develop guidelines regarding preferred partitioning methods, interaction effects, modeling behaviors, and megaregional modeling recommendations.

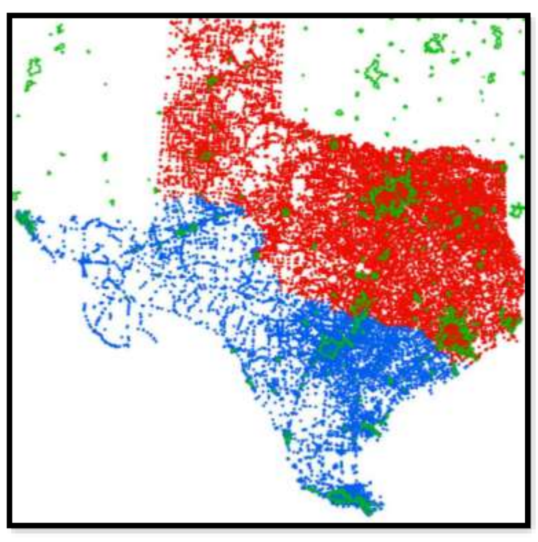
As a part of technology transfer, the team will deliver the results in the form of conference presentations and journal articles, in addition to semi-annual and annual progress reports to CM2 and a presentation at a CM2 conference.

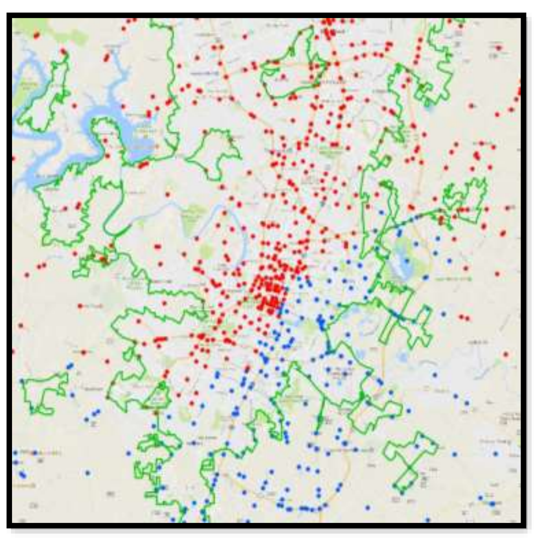
RESULTS

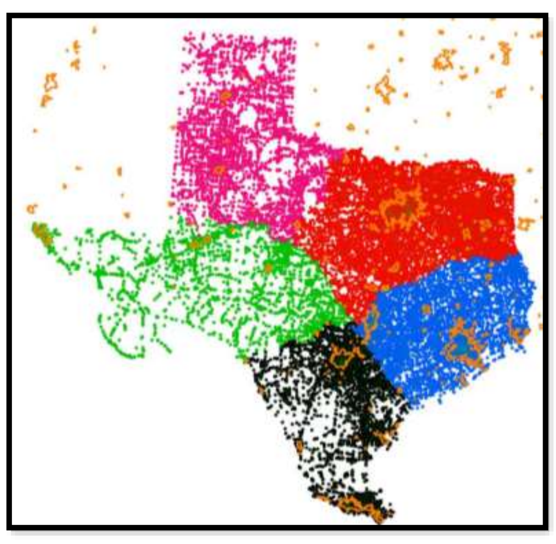
SDDA PARTITIONING

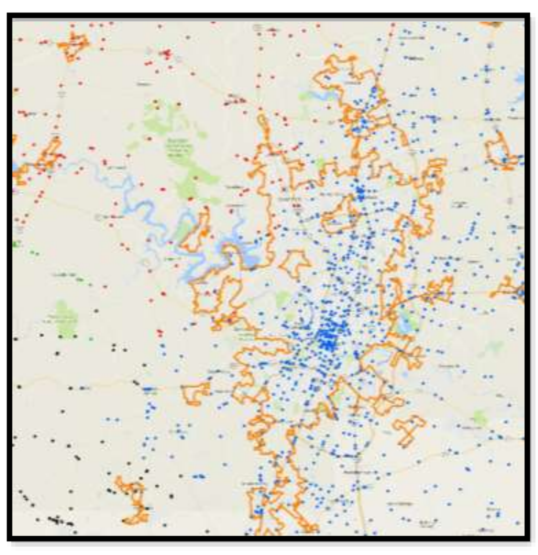
The SDDA algorithm was implemented on the Texas SAM network, provided by TxDOT. The number of partitions was varied and a few cases have been examined here in depth. We see the two-partition and five-partition cases illustrated here, with select urban areas highlighted and overlaid on Google Maps.

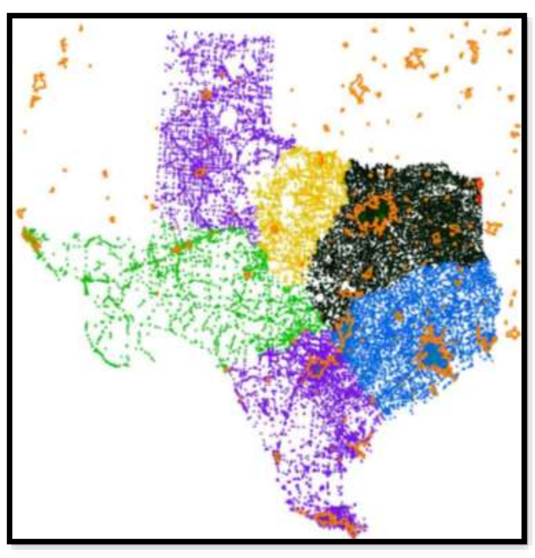
Some of the key observations are as follows: in all the scenarios, multiple urban areas are separated into different partitions (e.g. Austin, San Angelo). In the eight-partition case, we have one partition which is only a few blocks in size, effectively making the decomposition add no additional value and, thus, not providing computational advantages.





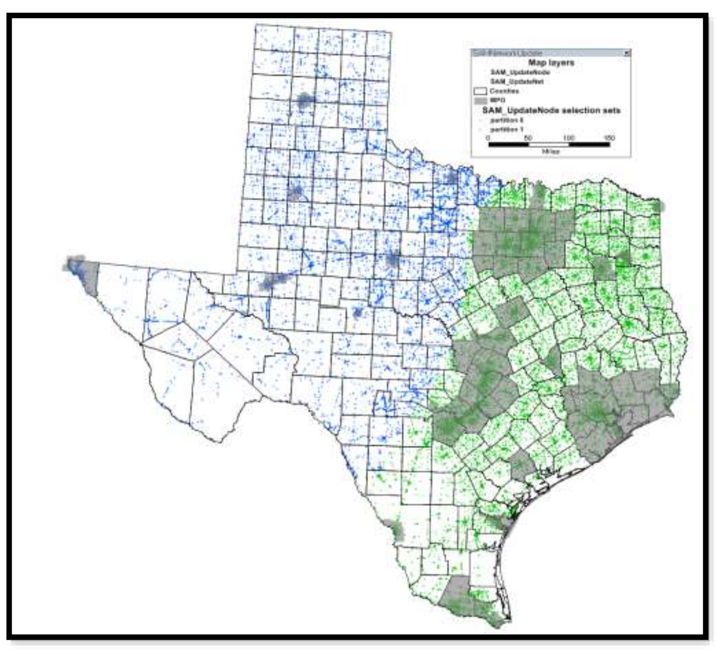


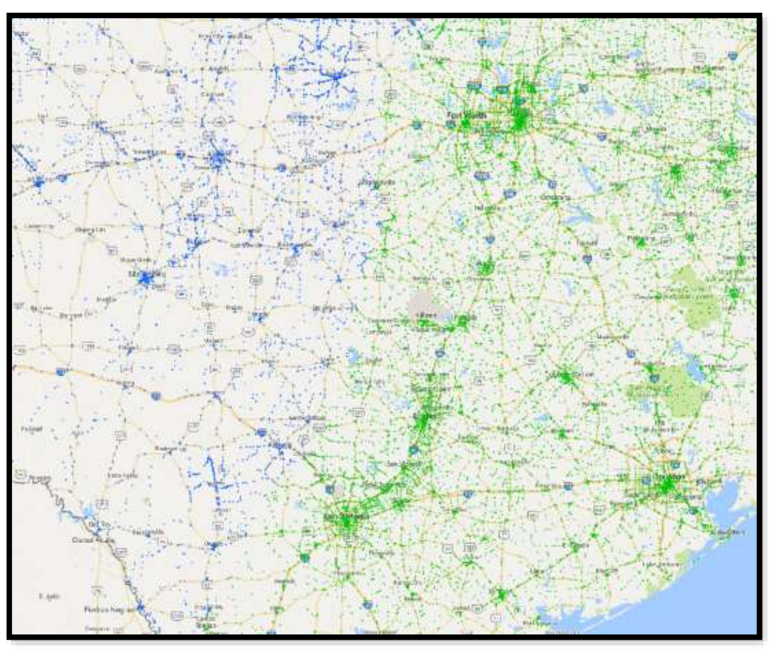




SPECTRAL PARTITIONING

SP was implemented on the same Texas SAM network. The two-partition case is shown here, with higher number of partition cases providing similar trends. We can observe how these partitions are more "intuitive," as they do not cut across any major urban center.





The University of Texas at Austin | University of Pennsylvania | Louisiana State University | Texas Southern University

[1]P. Johnson, D. Nguyen, and M. Ng. Large-scale network partitioning for decentralized traffic management and other transportation applications. Journal of Intelligent Transportation Systems, 20(5), 2016.
[2] Yahia, C. N., Pandey, V., & Boyles, S. D. (2018). Network Partitioning Algorithms for Solving the Traffic Assignment Problem Using a Decomposition Approach (No. 18-06570).
[3] M. G.H. Bell, F. Kurauchi, S. Perera, and W. Wong. Investigating transport network vulnerability by capacity weighted spectral analysis. Transportation Research Part B: Methodological, 99, 2017.