List of New Research Projects:

High Spatiotemporal Passenger-Centric Transit Performance Measures using Archived GTFS-Real Time Data

Recipient/Grant (Contract) Number: Celeste Chavis, Morgan State

Center Name: High Spatiotemporal Passenger-Centric Transit Performance Measures using Archived GTFS-Real Time Data

Research Priority: Improving Mobility of People and Goods

Principal Investigator(s): Celeste Chavis

Project Partners:

Research Project Funding: $64,001

Project Start and End Date: 11/01/2023 to 10/31/2024

Project Description: Unreliable public transportation is a barrier to reaching employment, education, and other community lifeline services. Most transit agencies provide a measure of on-time performance as the percentage of time that a bus arrives within a predefined on-time window to a stop. However, automatic vehicle location (AVL) and automatic passenger count (APC) technologies enable higher resolutions performance metrics to be developed. Using archived GTFS-real-time data, this project proposes high spatiotemporal resolution, passenger-centric on-time performance measures for MTA Maryland serving the Baltimore metropolitan area. Metrics include disaggregate on-time performance, reoccurring vs non-reoccurring delay, schedule and headway adherence, and the degree of schedule adherence. These metrics will be weighted by ridership and displayed on a publicly available web-based dashboard. The approach outlined in the project may be generalized to any transit agency that utilizes APC and AVL technology.

US DOT Priorities: This project will develop passenger-centric on-time performance and equity measures to better measure, plan, and advocation for public transit systems. It will directly contribute to the "Multimodal and Equitable Transportation Systems" theme by quantifying the demand (ridership) and supply (trips) at the stop/station level and measuring the status of social equity using socio- demographic and socio-economic data of the service area of the stops/stations. Reliable transit service provides those without vehicles with access to jobs and other community lifeline services. Moreover, reliable high-frequency transit service may shift trips from single occupancy vehicles to transit, thus contributing to sustainability goals.

Outputs: The proposed research project anticipates creating a public data sharing platform with comprehensive insight of the public transit service performance provided in the Baltimore Metropolitan Region. Using high-resolution spatiotemporal data the metrics will provide passenger-centric performance measures and equity assessment by utilizing socio-demographic and economic data.

Outcomes/Impacts: In Baltimore, MD, one-third of residents do not have access to a car. Unreliable public transit provides a barrier to employment and education. The dashboard will provide valuable insights are to where transit is unreliable and who is most impacted by unreliable service. The public dashboard can be used by riders and other stakeholders to advocate for service improvements. Planning agencies can use the dashboard as a means of prioritizing improvements. Though MTA Maryland is used as case study, the methods developed in this study are generalizable to any agency with a GTFS-RT feed.

Promoting Commute Equity in Maryland: A Machine Learning-Based Model Development Proposal

Recipient/Grant (Contract) Number: Mehdi Shokouhian, Morgan State University

Center Name: Promoting Commute Equity in Maryland: A Machine Learning-Based Model Development Proposal

Research Priority: Improving Mobility of People and Goods

Principal Investigator(s): Mehdi Shokouhian, Seinab Bandpey

Project Partners:

Research Project Funding: $80,000

Project Start and End Date: 09/01/2023 to 09/01/2024

Project Description: Unequal mobility and accessibility have been a key constraint in accessing jobs, education and healthcare and other opportunities across the nation. This is aggravated by differences in income, transport infrastructure, transit and indeed all modes, vehicle availability, class of workers and other variables which individually or collectively contribute to the commute inequity. Evaluating these can be challenging because there are types of equity and impacts to consider including horizontal and vertical commute equities and various ways to measure them. Horizontal equity assumes that people with similar needs and abilities should be treated equally; vertical equity assumes that disadvantaged groups should receive a greater share of resources. Through the utilization of cutting-edge machine learning techniques and conducting a comprehensive analysis of the factors influencing commute equity, this project aims to empower Maryland policymakers with an effective decision-making framework.

US DOT Priorities: The research on transportation equity strongly aligns with the strategic goals outlined by the USDOT, specifically focusing on transportation equity. Researchers will delve into the examination of key contributing factors to transportation-related inequity, shedding light on the root causes and disparities in access to transportation services. By understanding these factors, policymakers can develop targeted interventions and policies to address and mitigate transportation inequities. Additionally, the research will develop models that measures transportation equity for several areas in Maryland, that helps policy makers to identify the areas which need more attention.

Outputs: Based on the derived results, the research project will formulate informed recommendations aimed at guiding policymakers in improving inclusivity and accessibility within transportation systems. These recommendations will take into account the identified influential variables and their impacts on transportation equity, providing practical strategies to address disparities and enhance equity within the studied neighborhoods and beyond. The findings, methodology, results, and recommendations of the research will be compiled into final and quarterly reports. These comprehensive summaries will contribute to the body of knowledge on transportation equity, providing valuable insights for researchers, policymakers, and practitioners interested in understanding and addressing transportation inequities. The research outcomes have the potential to inform evidence-based policies and interventions that strive towards more equitable and accessible transportation systems.

Outcomes/Impacts: The implementation plan of this project involves several crucial components to address and advance commute equity. Data collection and analysis of factors influencing commute equity, such as income, transportation infrastructure, mode availability, etc. will form the foundation for a data-driven model. Community engagement with diverse stakeholders, including marginalized groups, transportation experts, and community members, will ensure diverse perspectives are considered in decision-making. Evaluating existing policies within Maryland will identify areas for improvement. Continuous evaluation of project outcomes, measuring success in addressing commuting inequities, and identifying areas for improvement will ensure project effectiveness and sustainability. Communicating project updates, findings, and progress to the public and relevant organizations will foster transparency and inclusivity. Outreach efforts will raise awareness and gather support for transportation equity initiatives system in terms of safety, reliability, durability, costs, etc.)

Competitiveness, User Preference, and Willingness-to-Pay for Peer-to-Peer Ridesharing Service

Recipient/Grant (Contract) Number: Young-Jae Lee, Morgan State University

Center Name: Competitiveness, User Preference, and Willingness-to-Pay for Peer-to-Peer Ridesharing Service

Research Priority: Improving Mobility of People and Goods

Principal Investigator(s): Young-Jae Lee, Hyeon-Shic Shin, Abdulmalik Musa Maleka, Hassan Rezapour

Project Partners:

Research Project Funding: $79,995

Project Start and End Date: 09/01/2023 to 08/31/2024

Project Description: The Peer-to-Peer (P2P) ridesharing model is a cost-effective system where transit service is not available. This research explores the competitiveness, user preference, and willingness-to-pay (WTP) for P2P ridesharing services as a sustainable mode of transportation. The study aims to understand the factors influencing users' choices and WTP for P2P ridesharing platforms. The research methodology includes a suggested stable price structure for P2P ridesharing for drivers and users using a game theory and a comprehensive analysis of the competitiveness of P2P ridesharing compared to traditional transportation modes and other alternatives. Moreover, a survey will be conducted to identify user preferences and the key attributes influencing their decision to opt for P2P ridesharing. To estimate users' WTP, the adaptive choice-based conjoint (ACBC) analysis will be employed using Sawtooth Software's SSI Web. The findings of this study will contribute to a deeper understanding of the viability and user acceptance of P2P ridesharing, enabling policymakers and ridesharing platforms to optimize their offerings and pricing strategies for improving P2P ridesharing system.

US DOT Priorities: Basically, ridesharing stands for a mode of transit in which a group of passengers share their trip with a vehicle to decrease their travel costs (Shaheen, 2012). Ridesharing itself is a broad concept that depends on many real-world factors such as coordination between participants and also the development level of communication and optimization systems. The contribution of these factors reveals the dynamic nature of a successful ridesharing system; hence, in recent years related studies mainly focused on developing optimal ridesharing systems that can coordinate travelers with services based on the real-time data (Wang et al., 2018).

Outputs: The findings of this research are expected to provide valuable insights into the competitiveness and user acceptance of Peer-to-Peer ridesharing services. By identifying the key factors driving user preference and estimating their WTP, we can assist ridesharing platforms in optimizing their service offerings and pricing strategies. Furthermore, this study will contribute to the broader field of transportation research and sustainable mobility solutions.

Outcomes/Impacts: The proposed research will advance our understanding of Peer-to-Peer ridesharing as an alternative and sustainable transportation option. By analyzing competitiveness, user preference, and WTP, we aim to promote the widespread adoption of P2P ridesharing services and contribute to more efficient and eco- friendly transportation systems. Using Sawtooth Software's SSI Web for WTP estimation, we anticipate robust and reliable results that can inform policy recommendations and business strategies in the ridesharing industry. Many state transit agencies are promoting P2P ridesharing to complement their transit services. This research can be used to improve their P2P ridesharing program as well as any private P2P ridesharing platforms.

Mobility and Safety Analysis of Mixed Traffic with Connected and Autonomous Vehicles in Rural and Small Urban Area under Severe Weather Conditions

Recipient/Grant (Contract) Number: Pan Lu, North Dakota State University

Center Name: Mobility and Safety Analysis of Mixed Traffic with Connected and Autonomous Vehicles in Rural and Small Urban Area under Severe Weather Conditions

Research Priority: Promoting Safety

Principal Investigator(s): Pan Lu, Ying Huang

Project Partners:

Research Project Funding: $100,000

Project Start and End Date: 06/01/2023 to 05/30/2024

Project Description: Autonomous vehicles (AVs) utilize a variety of sensor technologies to perceive their surroundings and make logical decisions based on the acquired information. However, real-world conditions such as coexist of CAVs and human driving vehicles (HDVs) situation and adverse weather conditions including rain, snow, fog, and hail will present challenges that can hinder the functionality of AV sensors and subsequently diminish their performance. This research aims to analyze the mobility and safety implications of mixed traffic with connected and autonomous vehicles (CAVs) in rural and small urban areas under severe weather conditions. The methodology includes simulation studies and data analysis to assess mobility and safety performance. The expected results provide insights into the effectiveness of CAVs in mitigating severe weather challenges and improving multi-modal mobility. This research is expected to enhance the understanding of CAV behavior in adverse weather conditions in rural and small urban area, paving the way for safer and more efficient traffic management in the future.

US DOT Priorities: The findings will contribute to a better understanding of CAV performance in severe weather scenarios and the development of strategies to enhance road safety and improve multi-modal mobility. This research will also identify challenges, limitations, and opportunities for implementing CAVs in adverse weather conditions, thereby advancing the field of intelligent transportation systems.

Outputs: The proposed research expects to perform a comprehensive analysis of the mobility and safety implications of mixed traffic with CAVs in rural and small urban areas under severe weather conditions. The research will provide insights into the adaptation strategies employed by CAVs to navigate adverse weather events, their interaction with conventional vehicles, and their impact on overall transportation performance.

Outcomes/Impacts: The impacts of this research are multifaceted including impacts on integration and policy development, safety enhancement, and mobility optimization. For integration and policy development, the findings of this research will inform policymakers and infrastructure planners about the effective integration of connected and autonomous vehicles (CAVs) in rural and small urban areas under severe weather conditions. For safety enhancement, this research aims to contribute to improving road safety by identifying strategies to mitigate risks associated with severe weather. For mobility optimization, the insights gained from this research will enhance multi-modal mobility by optimizing traffic flow, reducing congestion, and minimizing delays caused by adverse weather conditions including all modes of road users such as passenger cars, trucks, buses, and motorcycle users.

Analysis on Traffic Safety and Mobility for Tribal Communities under Severe Weather Conditions

Recipient/Grant (Contract) Number: Pan Lu, North Dakota State University

Center Name: Analysis on Traffic Safety and Mobility for Tribal Communities under Severe Weather Conditions

Research Priority: Promoting Safety

Principal Investigator(s): Pan Lu, Ying Huang

Project Partners:

Research Project Funding: $100,000

Project Start and End Date: 06/01/2023 to 05/31/2024

Project Description: Under the conditions extreme weather, potential power outage, loss of wireless signal coverage, and difficulty in accessibility may cause malfunction to the traffic signals and remain unaccounted for. The safety and mobility management for tribal communities under severe weather conditions is an under-resourced area. This research will provide scenario comparison based on scenario simulation on different alternatives for the case study region with selection and development of car following models. Accordingly, suggestions will be to tribal area traffic management authorities that can provide a safer and more mobile tribal community during the extreme weather conditions. This research can also serve as pioneering research for further traffic analysis in tribal areas.

US DOT Priorities: This resilience-oriented approach will contribute to ensuring continuous traffic operations and enhancing public safety, even during power disruptions. In addition, by comparing the performance of different traffic control methods, this study will provide decision-makers with valuable information to make informed choices regarding the most effective and resilient traffic control measures for tribal areas. This will support the development of evidence-based policies and guidelines. The cost-benefit analysis will also provide insights into the economic feasibility of alternative traffic control methods in tribal areas.

Outputs: Several expected results can be anticipated as summarized below:

1) A comprehensive understanding and summary of literature review on the topic;

2) Development of appropriate car-following models for tribal communities under extreme weather conditions;

3) Better knowledge on the safety, mobility, and resilience performance under power-outage for the case study areas from the simulation-based scenario analysis;

4) Traffic management and safety planning recommendations for the tribal area based on the extreme weather conditions.

Outcomes/Impacts: If properly and effectively conducted, this research could have significant implications for multi- modal mobility in tribal areas in terms of 1) improved decision-making process by allocating resources and determining the most efficient and effective traffic control solutions for promoting multi-modal mobility in tribal area, 2) improved public safety by promoting multi-modal mobility options and improving overall safety and accessibility for tribal communities through the resilient traffic management approach that this study is proposed.

Research and Development: A Bike Equity iMap for the San Francisco Bay Area

Recipient/Grant (Contract) Number: Ahoura Zandiatashbar, San Jose University

Center Name: Research and Development: A Bike Equity iMap for the San Francisco Bay Area

Research Priority: Improving Mobility of People and Goods

Principal Investigator(s): Ahoura Zandiatashbar

Project Partners:

Research Project Funding: $72,058

Project Start and End Date: 10/01/2023 to 09/30/2024

Project Description: Cites are growing their investment in urban bike systems to substitute driving for daily origin to destination commutes and multimodal access. These investments require accurate methods and dataset for equity assessments. This project directly addresses this need in the 9 counties of the San Francisco Bay Area region. In partnership with the community using an integrated Delphi-AHP (Analytical Hierarchy Process) method, we will define the indicators of bike-ability and a weighting matrix for the defined indicators to quantify bike-ability and bike equity assessments. Ultimately, we will design and develop an interactive online user-interface to showcase the findings along with data for other non-auto transportation infrastructure (e.g., transit) to support local policy and planning for enhancing multi-modal mobility in the San Francisco Bay Area.

US DOT Priorities: (see Outputs section)

Outputs: We expect the results of this work to have multiple contributions. The most important contribution is convening and involving the local bike advocacy organizations in the research process through Delphi-AHP method. While this is unique in the bike ability literature, will build a community consensus for a weighting system to measure a weighted bike index for equity assessment of the bike system. The proposed community-driven research strongly supports the generalizability of the results and weighting matrix which make them replicable and reliable to use in other cities. We also expect a significant difference between our weighted measures and the conventional measures (mostly unweighted) for bike infrastructure availability index. In previous work led by the PI of this proposal completed for San Jose CA, it was shown the that the conventional measure (i.e., unweighted bike lanes length per capita) overestimates the bike infrastructure availability which is significantly different than the weighted measure that accounts for infrastructure quality in that work. In comparison, this proposal is extensively expanded by working with the community to design the weighting system and a bigger study area with diverse cities which will supports the generalizability of findings and methodology. Furthermore, more than computing an accurate measure, the availability of the data for this measure in tandem with data for other non-auto transportation infrastructure (e.g., transit) through a publicly available web-map (the proposed outcome is an online User-Interface that maps the results) is crucial to support the local policy and planning for boosting multi-modal mobility in the Bay Area.

Outcomes/Impacts: While adopting cycling for the daily origin-to-destination commutes has numerous benefits for the community, biking also has a key role in supporting multimodal access through supporting the first and last mile connection to transit which empowers the use of chained non-auto mobility means. Multimodal access should support the needs of all users, more connections, and more choices where environmental justice plays an important role. The findings from earlier work unleashed equity challenges in San Jose CA, where lower-income neighborhoods with a higher percentage of

Hispanic and Asian resident were underserved in terms of the provision of bike infrastructure despite the existing demand. The assessment in underserved areas showed that in absence of an adequate bike network, cyclists use sidewalks which can increase bike-pedestrian collisions. Thus, the most important impact of our work is its policy application and implementation in identifying underserved communities in the Bay Area and prioritizing investments and allocation of resources to ensure that all communities have equitable access to bike infrastructure for promoting multi-modal mobility options. By collaborating with local advocacy organizations and creating an easy-to-use user interface, we expect a robust and smooth transfer of our results to policy, practice, and future research. Our results will have research impact and implementation for numerous unexplored outcomes of bike-ability (economic, health, safety, and GHG emission reduction outcomes).

Project Title: Early Understanding of Advanced Air Mobility (AAM): Public Perceptions of Opportunities and Obstacles

Recipient/Grant (Contract) Number: Susan Shaheen, San Jose State University

Center Name: Project Title: Early Understanding of Advanced Air Mobility (AAM): Public Perceptions of Opportunities and Obstacles

Research Priority: Improving Mobility of People and Goods

Principal Investigator(s): Susan Shaheen, Adam Cohen

Project Partners:

Research Project Funding: $70,925

Project Start and End Date: 10/01/2023 to 09/30/2024

Project Description: Advanced air mobility (AAM) is a broad concept enabling consumers access to on-demand air mobility, cargo and package delivery, healthcare applications, and emergency services through an integrated and connected multimodal transportation network. However, a number of challenges could impact the adoption of AAM, such as concerns about safety and trust in novel aviation technologies (e.g., vertical lift, electrification, and pilotless operations). Early exploratory research on AAM identified a number of potential concerns from the user and non-user perspectives, such as concerns about noise, visual pollution, and safety of electric and automated flight. However, this early exploratory research is limited because of respondents' lack of direct experience with AAM. To build upon this early work and help overcome these limitations, the Mineta Transportation Institute (MTI) research team propose conducting immersive pre- and post- small group discussions with (n=40+) employing a real aircraft mock-up. This research will advance early understanding of potential opportunities and obstacles associated (e.g., community impacts such as noise pollution and safety, social equity, and multimodal integration) with AAM.

US DOT Priorities: It is often said that the private sector can make almost any aircraft fly. However, developing and certifying an aircraft for a new mode of transportation does not ensure public trust and readiness to use an aircraft with novel features (e.g., relatively small size, electric, and potentially pilotless). This multidisciplinary, transformative research incorporates social, behavioral, and human factors methods and understanding to a discipline which has been primarily aerospace engineering driven. The results will provide critical early insight into how the public perceives AAM, potential concerns, and preferred use cases for the technology.

Outputs: While there have been a number of exploratory surveys and focus groups asking the public about their perceptions and willingness to use AAM, it is challenging for individuals to respond to an innovation without having direct experience with it. This impacts a respondent's ability to answer questions based upon limited to no experiential understanding. Virtually all of the existing exploratory research reflects this limitation. To date, the researchers are not aware of research using an experiential design with an aircraft mockup. This study helps overcome prior study limitations and advances understanding by allowing research subjects to see and interact with an aircraft prototype. In doing so, the research will yield a more accurate understanding of respondent perceptions and concerns associated with AAM.

Outcomes/Impacts: While there have been substantial investments in AAM from both the private and public sectors, the vast majority of research and development has focused on aircraft and airspace management. To date, there has been very limited research to understand potential social issues such as equity and public perception from the user and non-user perspectives. There is also limited research and understanding on the preferred AAM use cases, how potential travelers might use the service (and for what types of trips), and how travelers might access take-off and landing infrastructure (e.g., vertiports). The lack of research on these important topics leaves critical gaps in understanding for how local, state, and federal agencies should prepare for AAM and what types of steps that might be needed to ensure public confidence in its safety; prevent and mitigate potential adverse impacts; and guide sustainable and multimodal outcomes. As such, the research will provide critical insight to the public and private sectors on issues related to public perception, potential for social adoption of AAM, and community integration. The researchers plan to disseminate key findings through webinars, conferences, and other presentations.

A data-driven framework for traffic incident duration prediction

Recipient/Grant (Contract) Number: Ali Haghani, University of Maryland

Center Name: A data-driven framework for traffic incident duration prediction

Research Priority: Reducing Congestion

Principal Investigator(s):

Project Partners:

Research Project Funding: $100,000

Project Start and End Date: 09/01/2023 to 08/31/2024

Project Description: Traffic incidents pose significant challenges to the efficient flow of transportation systems, causing congestion, delays, and potential safety hazards. This research aims to utilize several data sources, including probe vehicle data, to predict traffic recovery time and analyze the impact of each traffic duration component on traffic recovery time in the State of Maryland. The results derived from the traffic recovery time prediction models can be a valuable tool for decision-makers in planning alternative routes, adjusting signal timings, or providing real-time traffic information to drivers.

US DOT Priorities: The research findings can help decision-makers understand the key contributors to longer or shorter incident durations and consider them in response strategies such as planning alternative routes, adjusting signal timings, or providing real-time traffic information to drivers. Implementing the response strategies will, in turn, reduce the traffic recovery time and improve traffic conditions for all modes of travel that use highway networks.

Outputs: The research results in developing and evaluating prediction models for traffic incident duration. Using statistical methods and machine learning algorithms, the study can propose models that effectively estimate traffic incidents' duration based on factors such as incident type, location, time of day, weather conditions, and historical data. The expected results would include the performance evaluation of these models, including accuracy, precision, recall, and other relevant metrics. The study can identify the factors that significantly influence incident duration by conducting feature importance analysis or correlation studies. These findings can help decision-makers understand the key contributors to longer or shorter incident durations and consider them in response strategies.

The research also compares the performance of different statistical methods and machine learning algorithms in predicting traffic incident durations. By evaluating and comparing the effectiveness of various techniques such as regression models, decision trees, support vector machines, or neural networks, the study can provide insights into which methods are most suitable for this specific prediction task. As the study area of this research is chosen to be the entire state of Maryland, it can demonstrate the practical applicability of the proposed framework. By applying the developed models to real-world traffic incident data and comparing the predicted durations with actual incident durations, the study can validate the framework's effectiveness and demonstrate its potential value in supporting decision-making processes.

Outcomes/Impacts: The research can enhance incident management practices by providing accurate and timely predictions of incident durations. This enables decision-makers to allocate resources effectively, plan appropriate response strategies, and minimize the impact on traffic flow. Improved incident management can reduce congestion, clear incidents faster, and enhance overall traffic safety and efficiency. One of the most critical impacts of this analysis could be the insight it can give the decision-makers regarding the impacts of reducing one minute in incident detection, response, or clearance time on the traffic recovery time.

The research can contribute to the development of more effective traffic management strategies. By understanding the expected incident durations, decision-makers can proactively implement measures such as alternative route planning, adjusting signal timings, or providing real-time traffic information to drivers. These strategies can help mitigate congestion, reduce travel delays, and improve overall traffic flow.

Collaboration between researchers, transportation agencies, and relevant stakeholders is crucial to implement the research findings. This collaboration can involve sharing data, validating the models with real-world incident data, and integrating the framework into existing systems.

Agent based simulation suite for public transit planning and design.

Recipient/Grant (Contract) Number: Cinzia Cirillo, Univerity of Maryland

Center Name: Agent based simulation suite for public transit planning and design.

Research Priority: Improving Mobility of People and Goods

Principal Investigator(s): Cinzia Cirillo

Project Partners:

Research Project Funding: $100,000

Project Start and End Date: 08/15/2023 to 08/14/2024

Project Description: Accurate ridership estimation is a pivotal component of developing a sustainable transit system, applicable to both proposed and existing transit networks. Different methods, including travel demand models, direct ridership models, and regression models, have been used by the practitioners and researchers to estimate ridership at station and network levels. However, travel demand models, the widely used approach for new transit lines, have inherent limitations of aggregate nature and complexity based on their types. Researchers also identified other drawbacks, such as their inability to capture small spatial resolutions and specific characteristics of stations, as often these models are designed for large-scale analysis. This leads to the scope of this study. In this study, authors presented a novel approach utilizing three microscopic agent-based models to develop a travel demand modeling suite, serving as a policy-sensitive forecasting tool reducing these limitations of traditional demand model. The modeling suite incorporates three agent-based models: SILO-MITO-MATSim. The model was validated against the previous year's data and applied for the future year. It was applied to estimate network level ridership for the proposed 'Purple Line', a light rail transit line proposed by MDOT, MTA, Maryland. This line will connect with Washington D.C. Metro which is USA's fourth largest transit system, with an average daily ridership of half a million. The findings indicate a projected ridership of approximately 18,320 passengers during the opening year of 2027. The proposed model offers a robust and policy-sensitive solution empowering decision-makers to make informed choices to support sustainable transportation system.

US DOT Priorities: This proposal contributes to the following themes:

1. Developing more refined models of travel behavior and the factors that influence travel demand,

2. Investigating a wide array of congestion-reduction strategies, including incentivization of public

transit. With reference to the first objective the project offers a state-of-the-art modeling platform for a wide variety of statewide policy analysis. This is a significant improvement over the existing Statewide Transportation Model currently used by the State of Maryland and local authorities for policy evaluation and decision making. Furthermore, the agent-based simulation tool could be further developed to study transit related policies (e.g., Fare-Free Public Transportation), multi-modality, and improvement of accessibility (e.g., Complete Streets).

Outputs: The research will produce a large-scale, integrated land-use and transportation simulation model suite and a test bed for the purple line that can be used to evaluate local and regional transportation projects that are planned to alleviate congestion and offer more sustainable transportation choices to residents of Maryland. We anticipate that the tool will spur further research development and collaboration among CMMM affiliates. In addition to CMMM researchers, this tool will be available upon request with special arrangements for Maryland government agencies including Maryland Departments of Transportation, Environment, Baltimore Metropolitan Council, City of Baltimore and others. It will also set an example for other states and MPOs as the suite can be developed for different geographies given data and resource availability.

We also foresee many other potential opportunities stemming from this proposed work that can be classified in three categories: (1) application-based, (2) methodological, and (3) policy research. Under (1) application-based, we see collaboration potential for all the parties that can benefit from the use of an agent-based microsimulation model for more realistic representation of travel behavior and traffic patterns. For example, better representation of non-motorized travel modes (walking and biking) will allow this model to be used for health impact analysis. Under (2) methodological results, we anticipate that new methods and techniques will be developed especially in the area of population synthesis, data fusion and travel behavior modeling. We expect that new capabilities can be added, existing ones improved, in addition to the refinement of computational efficiencies. Similarly, operations research techniques would likely be used to improve simulating shared mobility modes. Finally, in terms of (3) policy research, we expect that the methods developed here in the area of transit planning can be transferred to studies related to new transportation technologies and that policies on the environment can be better evaluated.

Outcomes/Impacts: Our results and our recommendations will be transferred to State planning agencies, to transit authorities, and to the Transit Caucus of the State of Maryland for an evidence based purple line plan evaluation, to inform next stages of the plan, and for a better integration with other modes (especially walking and biking). Other State, transit agencies and major cities across the nation might use our study to design and implement their own transit related plans. The detailed information about individuals and household characteristics will support the evaluation of infrastructure projects across different communities and population groups, including low income, elderly, and disadvantaged population. Outcomes from this project are expected to address systematic inequities in the accessibility to opportunities and services by disadvantaged segments of the population. Finally, we aim to provide training to students and professionals in the area of transportation modeling and planning and to those interested in public transportation system design and planning.

Integrating progression band and delay optimization for arterials with unbalanced directional traffic

Recipient/Grant (Contract) Number: Gang-Len Chang, University of Maryland

Center Name: Integrating progression band and delay optimization for arterials with unbalanced directional traffic

Research Priority: Reducing Congestion

Principal Investigator(s): Gang-Len Chang, Yao Cheng

Project Partners:

Research Project Funding: $100,000

Project Start and End Date: 10/01/2023 to 09/30/2024

Project Description: Unbalanced directional traffic is commonly observed in commuting corridors, where the high- volume direction may experience queue spillbacks and turning bay blockages that significantly downgrade the traffic efficiency. The traditional wisdom that naturally favors the high-volume direction often neglect the needs of the low-volume direction, incurring unnecessary delays. Such a dilemma raises a challenging need for a signal plan that concurrently ensures the traffic efficiency of both directions with distinct traffic features.

Fully recognizing the achievement of two major families of signal optimization models, delay minimization and progression maximization, this project intend to integrate their merits, and present a novel traffic signal model to minimize the through delay in the high-volume direction while preserving the progression in the low-volume direction. To achieve such an objective, this project will develop a mathematical programming framework with essential formulations. Especially, to estimate the queueing delay accurately with signal related parameters, unlike most existing studies assuming the uniformly distributed incoming traffic flow, the project will explicitly formulate the queue evolution process by accounting for the time-varying vehicle arrival rates resulting from the distinct upstream traffic streams. Such a detailed formulation shall enable the model to flexibly select the optimal phase sequences that allow low-volume traffic streams to join the queue prior to those high-volume ones, thus minimizing queuing delays despite the maximum queue length being inevitably long. Moreover, the negative impacts of left-turn vehicles merging into through queues due to the left-turn bay blockage by the expanding through queue should be also taken into consideration in the through delay computation. The proposed model with carefully designed formulations is expected to yield improved network-wide delay, fewer vehicle stops, and a shorter duration of left-turn bay blockage.

US DOT Priorities: The research product from this project can be applied to rural and urban areas, and more importantly, the commuting corridor connecting residential districts and highly developed business areas which incurred high commuting volumes. The expected benefit of minimizing arterial delays aligns with the center theme of improving the mobility of people and goods. Moreover, the develop framework concurrently optimizing the traffic efficiency of both the high- volume direction and the often-neglected low-volume direction, which promote transportation equity in the traffic network.

Outputs: The developed formulations are expected to indeed reflect critical queue interactions and allow the proposed model to function effectively as expected under the target arterial's traffic conditions. More specifically, the developed formulations should 1) reliably capture complex interrelations between various queue streams; 2) improve the signal plan produced by traditional band maximization models, and 3) yield consistency between the traffic volumes, delays, and queue length distribution among intersections. Moreover, proposed model shall produce the signal plans that enable traffic in the high-volume direction to minimize the total through delay by sequencing the traffic streams of high flow rate to join the intersection queue formation after those of low volume. Such signal designs should also lead to improved network-wide delay, fewer vehicle stops, and a shorter duration of left-turn bay blockage.

Outcomes/Impacts: The developed model and the resulting signal plan can be adopted by transportation agencies to address significant delays on the commuting arterials, and are expected to result in improved traffic efficiency, lower emission and reduced travel cost. The developed formulation can be conveniently expanded to a multi-modal environment, where the signal progression and operation delay of transit vehicles and bicycles can be integrated into the proposed framework.

Optimized Development of Multi-modal Transportation Networks

Recipient/Grant (Contract) Number: Paul Shonfeld, University of Maryland

Center Name: Optimized Development of Multi-modal Transportation Networks

Research Priority: Improving Mobility of People and Goods

Principal Investigator(s): Paul Shonfeld

Project Partners:

Research Project Funding: $100,000

Project Start and End Date: 09/01/2023 to 08/31/2024

Project Description: The proposed project will develop methods for optimizing the selection and scheduling of interrelated alternatives in multi-modal transportation networks, thus optimizing the evolution of those transportation systems through successive stages. The methods will extend previous ones developed at the University of Maryland and adapt them to the analysis of multi-modal transportation systems such as rail transit networks with feeder buses, connected urban street networks with bus lanes, and rural road networks partly usable by heavy trucks. These methods will enable their users to explore the effects on system development, performance, demand, costs and benefits of various objectives, policies, and constraints (e.g., on funding, other resources, equip, service quality, energy use, and environmental impacts).

US DOT Priorities: The proposed research is closely aligned with the CMMM objectives of improving the mobility of people and goods, reducing congestion, and enhancing equity. It also advances specific CMMM objectives, including (1) exploring the feasibility and impact of infrastructure- based solutions such as “complete streets” in reducing congestion and addressing inequity and (2) exploring innovative approaches to project finance and delivery.

Outputs: The main product of this research will be some highly needed methods for optimizing the development over time of multi-modal transportation systems. These methods will enable their users to explore the effects on system development, performance, demand, costs and benefits of various objectives, policies, and constraints (e.g., on funding, other resources, equity, service quality, energy use, and environmental impacts). These methods will be applicable with user- specified inputs appropriate to various jurisdictions and agencies. Their results will also be used to develop some guidelines on the relative effectiveness of various investment and system management policies.

Outcomes/Impacts: The proposed research will provide methods for evaluating, selecting and scheduling interrelated alternatives, which is a pervasive problem not only in transportation systems, but also in other kinds of infrastructure and services, public utilities, manufacturing, operations research, and finance. In particular, the optimization method developed in this project may be connected to existing network analysis and simulation models, thereby transforming them into methods for optimizing the system evolution over time. For example, the multi-modal public transportation model will be able to determine when rail transit lines in a network should be extended and how fixed bus routes and flexible-route bus operations should adapt to the rail transit extensions at every stage. A “complete streets” model for urban networks would determine when existing, widened, or new road links should get exclusive bus lanes, with appropriate continuity. A rural road network model would be used to determine when road sections or bridges should be widened or added, and for what truck weights they should be designed.

Ecological Driving System for Connected Automated Vehicles: A New Model Predictive Control Framework

Recipient/Grant (Contract) Number: Xianfeng (Terry) Yang, University of Maryland

Center Name: Ecological Driving System for Connected Automated Vehicles: A New Model Predictive Control Framework

Research Priority: Improving Mobility of People and Goods

Principal Investigator(s): Xianfeng (Terry) Yang

Project Partners:

Research Project Funding: $100,000

Project Start and End Date: 09/01/2023 to 08/31/2024

Project Description: The growing importance of sustainable and eco-friendly transportation has spurred the need for effective solutions to optimize the operational efficiency of connected automated vehicles (CAVs) in such complex environments. The trajectory planning problem (TTP) for CAVs is complicated by non-linear constraints, especially when dealing with the Eco-trajectory Planning Problem (EPP), characterized by its nonlinear, high-order, and non-convex objective function. To tackle this challenge, we propose a novel heuristic explicit predictive model control (heMPC) framework and aim to develop an innovative multi-objective ecological driving system that optimizes CAVs' trajectories along signalized arterial roads. Three key objectives are targeted: minimizing travel time, reducing fuel consumption, and improving traffic safety. The proposed framework comprises two interlinked modules: an offline module and an online module. In the offline module, we will construct an optimal eco-trajectory batch by optimizing a series of simplified EPPs, considering diverse system initial states and terminal states. This process can be likened to a lookup table in the general eMPC framework, with the intention of precomputing all necessary optimizations and calculations to eliminate online optimization in the subsequent stage. In the online module, we will employ both static and dynamic trajectory planning algorithms to efficiently handle trajectory planning for CAVs. After proving the effectiveness of the proposed algorithms in the simulation environment, we will test the entire system with field studies, leveraging the in-house CAV in our lab.

US DOT Priorities: This research aligns seamlessly with the center's theme of improving multi-modal mobility services in both urban and rural areas. By developing a heMPC framework for trajectory planning of CAVs, this research aims to address key mobility challenges faced in urban regions while prioritizing safety concerns in rural settings. The proposed heMPC framework will optimize CAV trajectories, enhancing traffic flow efficiency and reducing travel times in congested urban areas, thereby improving overall mobility service. In rural areas, the framework's focus on safety considerations will help mitigate accident risks and promote secure transportation. The research's potential to integrate multi-modal transportation and prioritize environmental sustainability further underscores its relevance to the center's theme.

Outputs: The proposed research is expected to yield several impactful results that align with the center's theme of improving multi-modal mobility services in urban and rural areas. The primary outcome will be the development of the heMPC framework for trajectory planning of CAVs along the signalized arterial roads. This framework aims to enhance computational efficiency and optimize CAV trajectories, leading to improved traffic flow efficiency, reduced travel times, and enhanced fuel consumption in urban regions. In rural areas, the heMPC framework will prioritize safety by ensuring safe following distances, mitigating accident risks, and enhancing overall traffic safety. Additionally, the implementation of the heMPC framework can enable seamless integration of multi-modal transportation systems, promoting efficient coordination between various transportation modes and enhancing connectivity. The research's potential to contribute to environmental sustainability through reduced emissions further reinforces its significance. Ultimately, the expected results can drive transformative advancements in multi-modal mobility services, fostering safer, more efficient, and environmentally conscious transportation systems for urban and rural communities.

Outcomes/Impacts: The proposed research is poised to deliver significant impacts and foster practical implementation across multi-modal mobility services in urban and rural areas. The development of the heMPC framework offers a groundbreaking solution, ensuring more efficient computational capabilities that can be seamlessly adopted by CAVs in real-time operations. This advancement will revolutionize trajectory planning for CAVs, leading to improved traffic flow efficiency, reduced travel times, and enhanced fuel consumption optimization in urban regions. Moreover, the simulation models developed during this research will provide valuable resources for the broader research community to address similar trajectory planning challenges in diverse transportation contexts. These models can serve as a benchmark for future studies, fostering collaborative efforts to tackle complex mobility problems. Additionally, the integration of the proposed heMPC algorithm with the FHWA CARMA platform holds the potential to facilitate cooperative driving system development. By harnessing CARMA's capabilities and coupling them with the heMPC framework, a robust and adaptable cooperative driving system can be realized, ushering in a new era of safer, more efficient, and connected mobility solutions.