


<b>Federal Agency/Organization</b>	U.S. Department of Transportation
<b>Federal Grant Number</b>	Grant No: 69A3551747120
<b>Project Title</b>	Freight Mobility Research Institute (FMRI)
<b>Center Director Name, Title, and Contact Information (email/phone)</b>	Evangelos I. Kaisar Professor & Director Freight Mobility Research Institute (FMRI) Geomatics and Transportation Engineering Program Florida Atlantic University 777 Glades Rd. Bldg. #36, Rm. 214 Boca Raton, FL 33431 Tel: (561) 297- 4084 ekaisar@fau.edu
<b>Name of Submitting Official, Title, Contact Information (email/phone)</b>	Emma Rodriguez Research Coordinator Freight Mobility Research Institute <a href="mailto:rodrigueze@fau.edu">rodrigueze@fau.edu</a> (561) 297 - 3443
<b>Submission Date</b>	10/30/2019
<b>DUNS/EIN Number</b>	004147534/ 65-0385507
<b>Recipient Organization (name/address)</b>	Florida Atlantic University 777 Glades Road Boca Raton, FL 33431
<b>Recipient Identifying/Account Number</b>	
<b>Project/Grant Period (start – end)</b>	11/30/2016 - 9/30/2022
<b>Reporting Period End Date</b>	04/01/2019 – 9/30/2019
<b>Report Term or Frequency (e.g. annual, semi-annual, quarterly)</b>	PPPR for FMRI – UTC. This report covers the period from April 1, 2019 to September 30, 2019, per Exhibit B, Grant Deliverables and Requirements for UTC Grants (November 2016, revised July 2019)
<b>Signature of Submitting Official</b>	

## Accomplishments

### What are the major goals of the program?

The FMRI aims to promote strategic transportation policies, investment, and decisions that bring lasting and equitable economic benefits to the U.S. and its citizens. The Center mission is to address critical issues affecting the planning, design, operation, and safety of the nation's intermodal freight transportation system, in order to strengthen our nation's economic competitiveness. Efficient and safe freight movement is inextricably linked to the economic vitality of a local area, state, region, and beyond. In consultation with stakeholders, as well as USDOT's strategic priorities, as expressed in FAST Act Improving Mobility of People and Goods priority and the known exclusive topic areas established by the Secretary of Transportation, we will focus on research and development that ***improves freight mobility through information technology, freight network modeling and operations, intermodal logistics, as well as freight and supply chain sustainability*** to promote smart cities, improve multimodal connections, system integration, and security, data modeling and analytical tools to optimize freight movements and improve efficiency. Also, to advance regional planning and setting of transportation priorities that deliver higher practice and economic growth and enhance productivity.

### **Major center activities are as following:**

**Advanced & Applied Research Improving Freight Mobility:** Our research activities are multimodal/intermodal and multidisciplinary in scope, with the aims of addressing nationally and regionally significant transportation issues pertinent to economic competitiveness and providing practice-ready solutions. We have assembled top expertise on supply chain and logistics freight transportation, network modeling, sustainability, and Intelligent Transportation Systems (ITS), representing leading universities across the nation with deep connections to local, state, and regional communities. Each of these universities has an established transportation research center/lab with top quality faculty conducting cutting-edge research. We are motivated to embrace innovative research projects, train the current and future transportation leaders and workforce, and engage with the industry to enhance collaboration between agencies by improving transport efficiency and safety, first- and last- mile efficiencies, sustainably, traffic congestion reduction, and develop tools and procedures to ensure interoperability today and in the future.

FMRI is well-poised to address a variety of issues directly applicable to the US DOT strategic goal of economic competitiveness. In consultation with our respective state DOTs and metropolitan planning organizations, as well as US DOT strategic priorities, our first years of operation will focus on improving freight fluidity in four major research areas:

- *Information Technology*
- *Freight Network Modeling and Operations*
- *Intermodal Logistics*
- *Freight and Supply Chain Sustainability*

**Education, Workforce Development, Technology Transfer, & Diversity:** The consortium is committed to providing high-quality transportation education and workforce development programs for a broad and diverse audience. The Center's efforts will support the development of a critical transportation knowledge base and a transportation logistics workforce that is prepared to design, deploy, operate, and maintain the complex transportation systems of the future.

FMRI's effort towards K-12 initiatives include the following:

- Increased minority student participation in transportation education.
- Workforce development and increased minorities participation in transportation field.
- Educated High School teachers as well as students in logistics and supply chain management.

## What was accomplished under these goals?

In the first and second year, the center developed guidelines and procedures for inviting proposals. The submitted proposals conducted external reviews and the final projects selected for funding. FMRI research program aims to generate a body of knowledge that makes a significant contribution to solving freight transportation problems. Year 1 endeavors were a set of pre-selected launch projects from proposals submitted and reviewed during the proposal preparation process, which has allowed us to begin the research during Fall 2017. As the first year research projects completed, results from the data have been recorded and has been tested and/or deployed by the engaged stakeholders. Please find listed below a brief description of the second year project reports' research findings. Also, find listed the third year projects that have been awarded by the FMRI. The first year projects have been completed and are currently located on the FMRI website. Please explore the FMRI website for in-depth project results.

### Second Year Research Projects

#### **FMRI Y2R1-18: Interactive web-based Platform for Analyzing Freight Data – Phase I (PI: Kaiser, Florida Atlantic University, Subcontractors: Edara, University of Missouri)**

The efficient movement of goods and timely provision of services is critical to the economic and sustainable development of a region. Public decision makers require a comprehensive picture of freight movements to understand how freight transportation supports economic development, how land use affects freight transportation, and how transportation infrastructure supply impacts private sector freight and commercial activity. The freight data needed to provide such insights are available from many public and private sources. However, the datasets may vary significantly in terms of collection method, data quality, existence of gaps, availability or timeframe (daily, monthly, and quarterly), format (shape files, documents, tables, etc.) and suitability. The lack of coordination among freight data vendors not only prevents the seamless integration of data sources but also disables data-driven decision making. The need for frameworks that can help integrate and analyze information from existing freight databases is therefore crucial. Under the above context, the proposed research seeks to develop a user-friendly, interactive, web-based prototype platform that takes advantage of recent advances in spatial data analysis, big data and user-centered visualization to integrate freight data across different private and public databases for the purpose of improving freight planning activities and data driven decision making.

#### **FMRI Y2R2-18: Sustainable Urban Freight Mobility through Optimization of Logistics Facility Locations (PI: Kaiser, Florida Atlantic University; Co-Investigator: Lili Du, PhD, University of Florida)**

The growing mitigation rates towards urban zones, global use of e-commerce and advancing technologies implemented in the logistics operations are the main contributors to the constant increase of product delivery volumes, especially in metropolitan areas. Furthermore, the need for sustainable development has been highlighted, due to the great extent that the matter of environmental impacts caused by transportation systems has taken in today's urban centers. These aspects provide a clear indication of the urban freight transport systems' necessity of providing reliable, cost-efficient and environmentally-friendly services. Logistics providers are required to address many strategic operational issues while designing their distribution networks. One of the most essential is the decision of where to position their transshipment and delivery facilities, as well as which of those facilities should serve each of the customers. The main motivation for conducting the study lies on the fact that typically freight operators locate their distribution centers outside the cities and deliver the products using trucks, traveling "door-to-door" to all the downtown destinations. This delivery approach causes many problems in urban areas, ranging from traffic congestion, increasing emissions, to higher delays. This project, considering the need for sustainability and cost-efficiency in city logistics, addresses this matter by developing a multi-objective novel mathematical framework for the capacitated facility location-allocation problem, an NP-Hard optimization problem, with the objectives of minimizing the costs for using the designated locations, the costs associated with the transportation of cargo to the allocated facilities and the distances between the chosen facilities and final destination nodes. The model selects the optimal number and locations of mini-hubs inside urban areas, where trucks will directly head from the main facility and unload the products. The products are further delivered by eco-friendly transportation means (e.g. handcarts, bicycles, self-picked up) to the final destinations, promoting sustainable delivery solutions and improving urban freight mobility.

### **FMRI Y2R3-18: Disaggregation of Freight Flows for Tennessee (PI: Gkolias, University of Memphis)**

As freight transportation draws ever increasing attention in the 21st century, freight related data (e.g., commodity flows, truck flows, freight facility economic and establishment data) are becoming critical to conducting transportation planning at state, regional, and local jurisdictional levels and for corridors. The purpose of using commodity flow data is to understand which industries generate the most demand by mode on the transportation system and how to divert movement of certain commodities between various modes optimize freight flows and the use of the existing transportation network. These data provide a key link between economic trade relationships and freight demand and are used in modal diversion studies. Currently, there are several useful commodity flow data sources (open source and proprietary) at the national level. However, their application is limited to state, regional and local planning because they lack the appropriate geographic detail for flow origins and destinations. Many of the commodity flow data sources and survey techniques do not track cargo movements in a set of linked modal transfers from point of production of a product to point of consumption. This does not directly align with the desire of many state DOTs and Metropolitan Planning Organizations (MPO) who want to use commodity flow data for mode diversion to study their impact on specific highways or rail lines, and as the primary freight demand input to travel demand models. Commodity flow data often do not explicitly account for intermediate handling of cargo in specifying origins and destinations, and further mode specific information is not attached to the commodity flow data. Research is needed to collect, process, prepare, and develop commodity flow data for the state of TN at various aggregation levels. TDOT, and regional agencies can utilize commodity flow data to (1) better understand movement of freight and to plan ahead to provide the adequate infrastructure to meet the growing needs of freight demand, (2) use in the travel demand model for planning and forecasting, (3) maintain a database of intra and inter regional commodity flows to obtain growth and to further enhance policy decision-making such as freight diversion, and (4) develop and analyze links between commodity flows, economic activity and land use.

### **FMRI Y2R4-18: Truck Parking Study: Unveiling the Parking Space Density and Truck Volume Relationship: Phase II (PI: Wang, TAMU)**

The truck parking issues have caught wide attention as a national concern for many years. There are several reasons for the attention. One is that truck driving and on duty hours are regulated by the federal law for the sake of traffic safety. Truckers cannot drive for more than 8 straight hours within any consecutive 24 hours of time. Truckers, especially those for inter-city travel, must find a rest area with an available spot when the driving hours reaches its federally enforced limit. Truck volumes fluctuate with time of year and time of day driven by economic activities. The intuitive observation is that a higher volume demands more parking space statistically. Due to unavailability of truck parking space at locations it is needed, truckers are often found parking illegally on highway ramps or other unsafe spots. Or some truckers are caught driving beyond the limit hours, which significantly contribute to the highway fatal rate. As a result, almost every state has conducted truck parking studies in an effort to address truck parking issues. The objective of this study is to continue on the success of Phase I of this effort by continuing to study the relation between truck volume and parking space density in a simulation environment as phase I. The truck space availability issue is essentially one between volume and density subject to boundary conditions. In phase I, the team developed computer simulation program to numerically show the relationship between volume, driving behavior and parking capacity need, which allows to illustrate the inherent relationship between behavior, truck volume and parking capacity needs. In addition, Phase I has also led to a literature review that surprisingly identifies cases in telecommunication area which model the relationship between cell phone traveler's volume and ground station service capacity and spacing, also along a highway. However, that study is inherently different from this truck parking problem, although it sheds light to the problem. Our goal in Phase II is to build on the literature reviewed and also utilize the simulation tool developed in Phase I to analytically derive the inherent analytical relationship between truck volume, driving behavior and truck parking capacity need in a hope that policy makers may use to examine adequacy of truck parking space within their jurisdiction areas.

### **FMRI Y2R5-18: Optimization of Winter Maintenance Stations for Safe and Efficient Freight Transportation (PI: Khani, University of Minnesota)**

In the northern states, winter maintenance of major transportation corridors is an ongoing issue. Apart from the general cost to the traveling public, freight transport has additional economic considerations as well as operational and safety characteristics. The effect of winter maintenance operations and severe weather conditions on freight

fluidity has not been adequately investigated. Specifically, efficient planning and operations of stations, where trucks, snowplows and other road machinery as well as deicing materials are maintained in and dispatched from, can significantly improve the cost-effectiveness of the operations. In the state of Minnesota, most of the truck stations are reaching their life expectancy and need to be reconstructed or relocated in a multi-period plan. An efficient plan starts with optimization of stations' location, type and size, followed by vehicle routing and scheduling for snow plowing and salt distribution on roads, to facilitate safe and efficient freight transport in winter, with minimum operations cost. This proposal intends to study the freight fluidity challenges in winter, and narrows it down to optimizing winter road maintenance operations for better freight transportation. We will develop an optimization model for finding the optimal location of stations for new construction or capacity expansion, considering desired service quality for major freight corridors, followed by assignment of stations and trucks to service zones. Two key aspects of the study that distinguishes it from regular station location optimization are 1) determining the freight volume on the state road network and determining critical links or zones for prioritized maintenance, and 2) accounting for stochastic model parameters, e.g. snowfall amount and storm duration, and employing robust optimization to design reliable service for extreme conditions. A decision support system will be developed based on mathematical programming and road network topology in GIS. The decision support system could benefit agencies from a financial perspective by reducing the winter maintenance operations cost, and the freight industry by safe and efficient freight transport in winter. Any software tool created in this research will be shared with local agencies and research community in open source format.

### **FMRI Y2R6-18: Modeling the Impacts of Regulations and Safety Constraints on UAVs Costs and Emissions - Phase II (PI: Figliozzi, Portland State University)**

The integration of more sustainable vehicles in goods distribution and service delivery depends on a number of factors related to vehicle costs, technology, infrastructure, energy sources, and financial incentives (Feng and Figliozzi, 2012). Energy cost fluctuations and the rapid evolution of vehicle types and engine technologies creates a highly uncertain environment. Problems and issues faced by policy makers, transportation planners, and private companies are rapidly evolving over time. In addition, new vehicle technologies such as unmanned aerial vehicles (UAVs) or drones have the potential to disrupt last mile deliveries and supply chains. The comparison of conventional diesel vehicles and cleaner vehicles is not straightforward because there are substantial tradeoffs regarding vehicles costs, payload, range, and supporting infrastructure. The comparison is even more complex regarding UAVs since this is a new vehicle type and technology. Furthermore, the regulatory framework may significantly affect UAV adoption rates as well as potential cost and environmental efficiencies. There is scant or no research that models the impact of regulations and safety constraints on UAVs last mile deliveries environmental, logistics and cost tradeoffs. This research proposal builds upon research and models developed in 2017-18 (first phase) that focused on UAVs energy and emissions modeling (Figliozzi, 2017). The main goal of this proposal (phase two) is to develop robust tools and models to analyze the impacts of regulations and/or safety constraints on UAV costs and emissions. More specifically, this research project will: (1) review and analyze UAV regulations in the USA and abroad, (2) review and analyze UAV safety concerns, and (3) model and analyze the impact of regulations on UAVs costs and lifecycle CO<sub>2e</sub> emissions

### **FMRI Y2R7-18: Next Generation of Freight Planning and Operation Models To Incorporate Emerging Innovative Technologies (PI: Figliozzi, PhD, Portland State University, Kaisar, PhD, Florida Atlantic University; Miguel; Mihalios Gkolias, PhD, University of Memphis; Sabyasachee Mishra, PhD, University of Memphis)**

This project leverages expertise from three universities (FAU, PSU, UoM) and attempts to accomplish the project objectives to (1) quantify adoption of connected and autonomous trucks by freight organizations, (2) incorporate truck platooning in transportation planning and operation models, (3) analyze the emissions impacts of last mile deliveries by delivery robots, (4) study how disruptive technologies are affecting intermodal transportation, and (5) outline future research necessary to address the opportunities and challenges created by disruptive technologies. Recent rapid explosion of new technologies has created opportunities to address critical freight transportation challenges across all modes in urban, suburban and rural areas. Some examples of new technologies include expansion of e-commerce, last mile deliveries by unmanned aerial vehicles (UAVs) or delivery robots, and potential applications of automated and connected vehicles in freight transportation (e.g. truck platooning). These new technologies are also influencing consumer behavior and thereby reshaping freight supply chains at the urban, regional, and international level. *First*, the project will develop diffusion of innovation based models to predict how

the adoption of autonomous trucks will be in the future by freight organizations. *Second*, we will address how truck platooning will be incorporated in transportation planning models such as how many trucks will be allowed in a platoon, platoon speed, platooning hours, freeway platooning zones, etc. *Third*, we will model the potential emissions impacts of last mile delivery robots. *Fourth*, assess the role and feasibility of technological innovations in intermodal transportation. Finally, the project will summarize the findings, challenges, and scope for future research.

### **FMRI Y2R8-18: Dynamic Trajectory Control and Signal Coordination for a Signalized Arterial with Significant Freight Traffic (PI: Zhang, TAMU)**

Freight traffic affects the performance of a road network in a more sensitive and significant way compared to other traffic with respect to mobility, environment, and safety. This is due to the complexity of the characteristics of the mixed-class traffic. As a result, a traffic bottleneck may appear on road segment where freight traffic is significant even though the overall volume is not high enough to cause congestion if the traffic composition is not truck heavy. What is more, for a signalized arterial, the coordination often fails when the traffic is composed of a large portion of trucks. This has been shown in the research of FMRI first-year project. In year II this proposed project tries to look into the area of freight signal priority control, which is related to control and information technology. Given the existing infrastructure, the improvement of freight traffic operation can be conducted at the tactical and operational level. This second-year FMRI research focuses on the vehicle dynamics of trucks. In this proposed research, multiple trucks dynamic trajectories and their interactions with the conventional cars will be investigated, and an analytical tool of traffic flow performance will be developed. Based on the analytical models, control strategies are developed to schedule the trajectories of trucks/cars dynamically to improve the mobility of a corridor, assisted by the new coordination strategies of signals. Two levels of the strategies are defined in the scope of this research: At the first level, the strategy takes into account the vehicle dynamics and optimizes the trajectories of trucks/cars given signal timing plans, signal states and traffic conditions. Real-time decisions and behaviors of vehicle motions and their interactions with other vehicles and with the infrastructure are analyzed. At the second level, the strategies will model the interactions among trucks and conventional vehicles while a new coordination strategy of signals is established, in which the timing variables are used as decision variables. While developing these strategies, the factors of robustness, optimality, predictability will be considered if necessary, and realistic factors such as truck market penetration rate, truck characteristics, speed variability, and signal types will be considered.

### **FMRI Y2R9-18: Truck Parking Needs in Tennessee (PI: Gkolias, University of Memphis, Subcontractors/Co-PIs: Dan Murray, American Transportation Research Institute; Airton Kohls, University of Tennessee, Knoxville; Chris Cherry, University of Tennessee, Knoxville)**

The objectives of this research are to provide TDOT with important guidance on truck parking issues and opportunities, by identifying parking needs (i.e., addition of capacity and/or construction of new facilities); developing truck parking violation rates (i.e., truck parking on- and off- ramps) and developing/applying a methodology to identify candidate locations for new truck parking facilities in the State of TN. This study extends the work done by Goliias et al. (2017) and Cherry et al. (2017) who used truck GPS and survey data to evaluate the performance of truck parking in TN. More specifically, by addressing strategic truck parking needs, TDOT can play an integral role in supporting hours-of-service compliance, unauthorized truck parking and the economic gains that come from highly efficient supply chains – particularly those that are becoming increasingly reliant of the e-commerce evolution. Recognizing that truck parking is one of the most influential factor for route selection decisions, and that lack of truck parking has safety and economic ramifications, this research can be a key component of the state's freight planning and investment activities. The proposed project will help TDOT improve safety in the state by identifying the problematic rest areas (either with regards to lacking capacity or experiencing high violations rates or both) and proposing either capacity increase or development of new rest areas. Identification of new rest areas will be supported by the models developed through this research. Outcomes from this research will be immediately implementable and will support budget allocation for truck rest area enhancement and enforcement in Tennessee. Finally, the innovative use of GPS data for truck parking analysis can become a “best practice” for other state DOTs.

### **FMRI Y2R10-18: Two-lane Highway Analysis Methodology Enhancements Considering Commercial Trucks (PI: Washburn, University of Florida)**

The growing mitigation rates towards urban zones, global use of e-commerce and advancing technologies implemented in the logistics operations are the main contributors to the constant increase of product delivery

volumes, especially in metropolitan areas. Furthermore, the need for sustainable development has been highlighted, due to the great extent that the matter of environmental impacts caused by transportation systems has taken in today's urban centers. These aspects provide a clear indication of the urban freight transport systems' necessity of providing reliable, cost-efficient and environmentally-friendly services. Logistics providers are required to address many strategic operational issues while designing their distribution networks. One of the most essential is the decision of where to position their transshipment and delivery facilities, as well as which of those facilities should serve each of the customers. The main motivation for conducting the study lies on the fact that typically freight operators locate their distribution centers outside the cities and deliver the products using trucks, traveling "door-to-door" to all the downtown destinations. This delivery approach causes many problems in urban areas, ranging from traffic congestion, increasing emissions, to higher delays. This project, considering the need for sustainability and cost-efficiency in city logistics, addresses this matter by developing a multi-objective novel mathematical framework for the capacitated facility location-allocation problem, an NP-Hard optimization problem, with the objectives of minimizing the costs for using the designated locations, the costs associated with the transportation of cargo to the allocated facilities and the distances between the chosen facilities and final destination nodes. The model selects the optimal number and locations of mini-hubs inside urban areas, where trucks will directly head from the main facility and unload the products. The products are further delivered by eco-friendly transportation means (e.g. handcarts, bicycles, self-picked up) to the final destinations, promoting sustainable delivery solutions and improving urban freight mobility.

### **Third Year Research Projects:**

During the previous period (April 2019 - September 2019), the center has developed their Year 3 Request for Proposals (RFP) for research projects through discussion with the advisory board and the stakeholders under the center thematic areas. These projects have undergone full external peer reviews, with each project having three to four reviewers. Each project has been revised to reflect the comments from each peer reviewer. Once revised by the PI, these projects have been viewed by the Advisory Board and changed accordingly, as needed. The Year 3 approved research projects have been listed below. These projects have been started September 2019 depending when the project amendment has been signed. You may find the overview of these projects listed on the FMRI website, as well as the previous Program Project Progress Report.

**FMRI Y3R1-19: Analysis of Freight Movement within Regional Evacuations (PI: Kaiser, Florida Atlantic University)**

**FMRI Y3R2-19: Identification and Evaluation of Critical Urban Freight Corridors (PI: Kaiser, Florida Atlantic University)**

**FMRI Y3R3-19: Integrate Autonomous Delivery Vehicle into Sustainable Urban Logistics Planning and Optimization: Economic and Environmental Evaluation (PI: Kaiser, Florida Atlantic University)**

**FMRI Y3R4-19: Managing the Growth of Last-mile Deliveries and Curb Space Demand (PI: Figliozzi, Portland State University)**

**FMRI Y3R5-19: Fathoming the Maximum Potential for freight Sensitive Intersection Control (PI: Wang, Texas A&M University)**

**FMRI Y3R6-19: Optimal and Robust Control of Vehicle Platooning on Signalized Arterial with Significant Freight Traffic (PI: Wang, Texas A&M University)**

**FMRI Y3R7-19: Identifying Critical and Vulnerable Freight Routes in Roadway Networks: A Game Theory Framework and Application in the State of Florida (PI: Gkolias, University of Memphis)**

**FMRI Y3R8-19: Incorporating Freight in regional Land Use Planning Models (PI: Mishra, University of Memphis)**

## **Education and Workforce Development:**

FMRI's education goal is to foster education and training to contribute to the development of the transportation workforce. Our approach is multi-disciplinary, multimodal, under this grant we are developing a series of education activities, from K-12 to graduate level. These programs build on the education and training programs available at the consortium universities.

For our second year educational projects, the center has developed two projects that are ongoing at our consortium locations: Hampton University, University of Florida, and Florida Atlantic University.

## **Curriculum Development for Highway Freight Transportation (PI: Washburn, University of Florida; Co-PIs: Du, University of Florida; Kaiser, Florida Atlantic University)**

Coverage of freight transportation in a university curriculum is rarely comprehensive and instead usually consists of sprinkling a few related topics throughout a range of courses within the broader curriculum. One challenge to offering a focused and comprehensive course on highway freight transportation is the dearth of curriculum material across the full range of relevant topics. The objective of this project is to develop curriculum content that can be used for an entire 1-semester course focused on highway freight transportation. The focus of the curriculum will be on providing a fairly high-level overview of the transportation of goods via commercial trucking. The focus leans more towards breadth than depth. The primary format of the material will be PowerPoint slides, but a number of example problems and active learning exercises will also be developed.

## **Transportation and Workforce Development Project (PI: Maheshwari, Hampton University)**

The expanding transportation industry in the U. S. has a growing need for professionals qualified to manage advanced transportation systems. With up to 50% of the current workforce expected to retire in the next ten years, the industry faces a challenge of finding replacements. The overall goal of the proposed Education and Workforce Development Project is to attract and educate the next generation of transportation professionals through well-designed program of coursework, guest lectures, case studies, and experiential learning that reinforces classroom knowledge. The transportation education project will incorporate related programs offered by various departments within the University integrating research results into courses to produce a well-trained, effective, and efficient workforce. The partnerships with the transportation industry will offer students experiential learning through co-ops and internships. Special focus will be placed on K-12 education. Based on First Year connections, the K-12 programs will be expanded.

Continuing the pursuit of the Transportation and Workforce Development Project, FMRI has accomplished the items listed below:

### Major Activities:

1. Lecture Series from FMRI Consortium Partners.
2. Student Internships
3. High School Teachers Workshop
4. K-12 Student Transportation Essay Competition
5. K-12 Transportation and Logistics field trips
6. K-12 Transportation Science Fair
7. Board of High School curriculum planning
8. Summer Camps

### Specific Objectives:

1. Minority student education—2 and 7 above
2. Increase minority participation—1 through 8 above
3. Increase K-12 participation –1 through 8 above



## Significant results

1. Minority student education—Lectures, Workshops
2. Increase minority participation—Internship, scholarships and field trips
3. Increase K-12 participation –Lectures, Workshops, Field Trips, Essay and Science Fair

The development and implementation of graduate courses continues, as CGN 5935 Advance Transportation and Logistics management has played a key role in education and workforce development for the summer 2019 semester at Florida Atlantic University. Transportation system management and operations strategies provide multimodal solution that relieve congestion, optimize infrastructure investments, promote travel options, and reduce greenhouse gas emissions. Modeling of complex interactions and causal relationships among current issues. Transportation modes and technologies, vehicle dynamics, basic facility design, capacity analysis, transportation planning, evaluation and choice, network analysis, logistics, and ITS. Transportation risk assessment and computation; evacuation modeling; reliability analysis; infrastructure interdependency analysis; network impact assessment. Dr. Dan Liu, FMRI Research Associate, and her students visited the Port of Palm Beach and Tropical Shipping facilities, to discuss port operations and logistics as part of the course curriculum. The port authorities gave a tour to the students on all the different sections of the port. The students were provided with information on inventory control, transportation management and logistics. Dr. Liu also as a guest speaker gave a lecture on Freight and autonomous delivery vehicles.

The established certificate in Transportation, Logistics and Supply Chain Management had the first students. This certificate was established by the Department of Information Technology and Operations Management (ITOM) in the College of Business and the Department of Civil, Environmental and Geomatics Engineering (CEGE) in the College of Engineering and Computer Science at Florida Atlantic University. This 12-credit certificate permits graduate students to expand their knowledge on technical skills of transportation engineering and the analytical business decisions-making skills of supply chain management.

The Florida Atlantic University (FAU) Freight Mobility Research Institute (FMRI), sponsored two Summer Engineering and Technology Camp for students from middle schools across Palm Beach County. The camps took place in June 2019 and were a couple of several in an annual STEM education initiative directed by Jessica Hibberd and George Edmonds of the FAU College of Engineering and Computer Science. With help from Dr. Sharad K Maheshwari, Professor in the Department of Business Administration in Hampton University and Dr. Dan Liu, Postdoctoral Researcher in FMRI, as well as the minority students Ms. Taraneh Ardalan and Ms. Panagiota Goulianou, graduate research assistants at the FMRI FAU, a 5-day Transportation Engineering Camps were facilitated. The transportation camps covered basics of transportation engineering, SPSS based data analysis, freight operations and logistics, intelligent transportation systems (ITS), connected vehicles, origin destination calculation, and traffic count observations.

## **FAU ITE Student Chapter Lecture Series at Florida Atlantic University**

The FMRI aims to contribute to the life-long learning of transportation engineering. Along with classroom experience, educational initiatives sponsored by the FMRI would provide opportunities to students to become familiar with numerous fields of transportation engineering and gain practical experience and knowledge. The center is a proud affiliate of the Institute of Transportation Engineering (ITE). The FAU ITE Student Chapters from participating universities closely collaborate with the FMRI to organize educational lectures. Below are the listed lectures from this reporting period.

April 1, 2019 – Stavroula Manta, M.S. – Florida Atlantic University. “Evaluation of Freight and Transit Signal Priority Strategies for Improving Transportation Operations in Urban Corridors”

April 3, 2019 – John Hourdos, Ph.D. Director, Minnesota Traffic Observatory. “Talking Robots, or Talking Robot Cars”

## How have the results been disseminated?

Project reports are published to the FMRI website and presented at FMRI lecture series, which are open to the public. Preliminary results are often presented at peer review conferences and stakeholders meetings, such as brown bag meeting with the local agencies. All research projects are expected to result in refereed journal publications. In addition, dissemination is via new graduate courses and developed certificate programs, internship assistance, employment opportunities, professional development seminars and distinguish lecture series, and our website.

The FMRI research seminars serves as a forum for faculty, industry, and graduate students to present their research and work. Seminars and lecture series take place fall and spring semesters, open to public, and are well-attended.

The FMRI has recently established a social media effort, which includes Facebook and Twitter. Facebook and Twitter has been used to share our news, events, workshops, and other content. The center is using social media to drive more traffic to the website. Also, the center established webinars that it is going to be placed in Fall 2019. The FMRI has established quarterly newsletters sent through the email distribution platform to update stakeholder’s state and federal agencies, and other interested parties on the progress of the center. In addition, the FMRI plans to establish monthly newsletter with focus on the presentation of research project results.

Through peer review conferences, the center has held workshop sponsorship throughout this period, which includes the following:

**Automated Parking and Mobility: Benefits, Challenges, and Best Practices for rapidly Expanding Technology in Boca Raton, – May 2019.** The presentations covered Discussion about how evolving disruptive technology can assist automated vehicles and truck platooning, better urban design and walkability, sustainability, truck parking, and profitable infill development on difficult urban and suburban areas. Speakers Mr. Marcos Radonic from Automated Parking Corp. and Mr. Ken Stapleton from Ken Stapleton & Associates, were addresses innovative concepts including invisible parking, parking diets, and automated parking. This event was hosted by FMRI and the Women in Transportation, South Florida Chapter.

## What do you plan to do during the next reporting period to accomplish the goals?

FMRI Year 2 projects are all almost complete and research findings will be disseminated as needed. FMRI Year 3 Research RFP projects have been awarded and have been under contract. The center’s Advisory Board oversaw the review process and we were planning to have a quarterly conference call for approving each project progress. Our consortium research selection goal is to develop a comprehensive program that focuses on solving high-priority freight transportation, logistics and supply chain problems. In subsequent years, the center will establish an annual request for proposals focusing on the stated theme as well as high priority needs expressed by our public and private sector partners.

The center will continue their relationship with their stakeholders and State DOTs on cost-share projects and other collaborative efforts in order for the FMRI to successfully deploy their technology transfer to the community. The center will also explore collaborative opportunities with local private and public sector entities in order to develop freight related research needs.

The FMRI will also develop local community educational and technology transfer efforts to advance the knowledge on transportation supply chain, management, logistics, and operations.

For the educational initiative, FMRI plans are to:

1. Implement the approved Year 3 projects, --More K-12 involvement

- a. An additional workshop for K-12 teachers;
  - b. Essay Competitions;
  - c. Transportation & Logistics Science Fair;
  - d. Participating in ITS America's for technology
  - e. Logistics & Summer Camps Summer Camps & Invited practitioners;
  - f. High School Participation;
  - g. Internship for minority student's s with local stakeholders.
  - h. Curriculum planning
2. Begin the Year 3 RFP educational projects, to build on the continuing educational project;
  3. Continue dissemination of research results via our website, professional presentations to stakeholders, technical workshops and our seminar series.

## Participants & Collaborating Organizations

### What organizations have been involved as partners?

The FMRI works with multiple partners on main projects, as well as cost-share projects to help further economic development. The center has developed multiple research collaborations for the Year 2 and Year 3 initiatives. Please find below the collaborative projects for Year 2 and Year 3.

**FMRI Y2R1-18: Interactive web-based Platform for Analyzing Freight Data – Phase I** (PI: Kaisar, Florida Atlantic University, Subcontractors: Edara, University of Missouri)

**FMRI Y2R2-18: Sustainable Urban Freight Mobility through Optimization of Logistics Facility Locations** (PI: Kaisar, Florida Atlantic University; Co-Investigator: Lili Du, PhD, University of Florida)

**FMRI Y2R7-18: Next Generation of Freight Planning and Operation Models To Incorporate Emerging Innovative Technologies** (PI: Figliozzi, PhD, Portland State University, Kaisar, PhD, Florida Atlantic University; Miguel; Mihalis Gkolias, PhD, University of Memphis; Sabyasachee Mishra, PhD, University of Memphis)

**FMRI Y2R9-18: Truck Parking Needs in Tennessee** (PI: Gkolias, University of Memphis, Subcontractors/Co-PIs: Dan Murray, American Transportation Research Institute; Airton Kohls, University of Tennessee, Knoxville; Chris Cherry, University of Tennessee, Knoxville)

**FMRI Y3R1-19: Analysis of Freight Movement within Regional Evacuations** (PI: Kaisar, FAU; Co-PI: Dhanak, FAU; Subcontractor: Parr, (Embry-Riddle Aeronautical University)

**FMRI Y3R4-19: Managing the Growth of Last-Mile Deliveries and Curb Space Demand** (PI: Figliozzi, PSU; Khani, UMN)

**FMRI Y3R7-19: Identifying Critical and Vulnerable Freight Routes in Roadway Networks: A Game Theory Framework and Application in the State of Florida** (PI: Gkolias, UM; Co-PIs: Mishra, UM, Kaisar, FAU, Hourdos, UMN, Pujats, UM)

Education also plays a crucial role in collaborative efforts. Hampton University, the center's educational partner, works with multiple agencies, companies, and academia to develop and implement workshops, lecture series, internships, and field trips. These partners include Newport News School District (K-12 logistics education), Hampton School District (K-12 logistics education, Hampton School District Logistics Academy member), Hampton University (workshops, lecture series, internships, and administration), Canon, Inc. (field trips and internships), Norfolk Southern Corp. (internships), Hampton Roads Transits (internships), Virginia Department of Transportation (field

trips and internships), Virginia Port Authority (field trips and internships), Unilever (internships), and Massimo Zanetti Beverage USA (internships), and US Maritime Administration (MARAD). FAU works with local port authorities for students filed trips and internships

The FMRI works with State DOTs and other entities, including the Florida Department of Transportation, Portland Bureau of Transportation, Center for Urban Transportation Research at University of South Florida, and Tennessee Department of Transportation for their cost-share efforts towards freight mobility.

Portland State University is currently working with the Portland Bureau of Transportation towards research collaboration, collaborative research, discussion of research gaps and contributions to the new Portland Freight Master Plan.

University of Florida is working in conjunction with the University of South Florida on a Florida Department of Transportation project, providing matching funds through the project “Commercial Heavy Vehicle Impacts on Signalized Arterial Corridor Performance.” Project #: BDV25 TWO 977-50.

Florida Atlantic University is working with the Florida Department of Transportation on the following projects:

- Florida Department of Transportation. “Evaluation of Freight and Transit Signal Priority Strategies in Multi-modal Corridor for Improving Transit Service Reliability and Efficiency” Subcontractor Florida International University. Monthly meetings take place for discussion on progress.
- Florida Department of Transportation. “Evaluation of Truck Tonnage Estimation Methodologies.”

University of Memphis currently is working with the Tennessee Department of Transportation on the following projects:

- Tennessee Department of Transportation. “Impact and Adoption of Connected and Autonomous Vehicles.”
- Tennessee Department of Transportation. “Planning Guidebook for Commodity and Freight Movement in Tennessee.”

## Have other collaborators or contacts been involved?

The American Transportation Research Institute is involved in the FMRI Y2R9-18: “Truck Parking Needs in Tennessee”

## Outputs

Outputs	Target	Progress
# of proposals/projects with collaborative efforts	5 collaborative proposals/projects	4 projects in Year 2 3 Projects in Year 3
# of website page views	2,500 page views	2,134 pages views
# of conference presentations	10 conference presentations	12 conference presentations
# of peer-reviewed papers	6 peer-reviewed papers	7 peer-reviewed journal papers 7 under review, 8 in preparation

## Publications, conference papers, and presentations

### Journal publications

Charisis A., Kaisar E., Mitrovic N., and Papadimitriou S., “Containership Routing with Multiple Time Windows and Excessive Demand Consideration”, Journal, Maritime Economics and Logistics (MEL), exp. June 2019.

Simpson, J., Mishra, S., Talebian, A., and Golias, M. (2019). An Estimation of the Future Adoption Rate of Autonomous Trucks by Freight Organizations. *Research in Transportation Economics* (Accepted).

Chauhan, D., Unnikrishnan, A., & Figliozzi, M. (2019). Maximum coverage capacitated facility location problem with range constrained drones. *Transportation Research Part C: Emerging Technologies*, 99, 1-18.

Anastasios Charisis, Stephen Spana, Evangelos Kaisar, Lili Du (2019). Logistics Hub Location and Scheduling Model for Inner City Last-Mile Deliveries. *International Journal of Information Systems and Supply* (under review).

Sun, Wei and Washburn, Scott S. *Freeway Network Travel Time Reliability Analysis Methodology and Software Tool Development*. Submitted to 99th Annual Meeting of the Transportation Research Board, Washington, D.C., 2020 (under Review).

Charisis, A., Kaisar E., Spana, S., and E., Du, L. (2019) A Mathematical Model for Logistics Hub Location for Inner-City Last Mile Deliveries. *Transportation Research Part E: Logistics and Transportation Review* (Under review).

Manta, S., Ardalan, T., Kaisar, E. I., Hadi, M., Iqbal, S., Matthews, G. Evaluation of Freight and Transit Signal Priority Strategies for Improving Transportation Operations in Multi-Modal Corridors. Submitted to 99th Annual Meeting of the Transportation Research Board, Washington, D.C., 2020 (under Review)

Ardalan, T., Liu, D., Kaisar, E. I., Zhong, M., Tabatabaee, F. Truck Tonnage Estimation Using Weigh-In-Motion (WIM) Data in Florida submitted to 99th Annual Meeting of the Transportation Research Board, Washington, D.C., 2020 (accepted).

Goulianou, P., Charisis, A., Liu, D., Kaisar, E. I., and Golias, M. M. Intermodal Freight Network Design Model Considering Emission Levels and Time Constraints. Submitted to 99<sup>th</sup> Annual Meeting of the Transportation Research Board, Washington, D.C., 2020 (accepted).

Jennings, D. and Figliozzi, M. Study of Sidewalk Autonomous Delivery Robots and Their Potential Impacts on Freight Efficiency and Travel. *Transportation Research Board: Journal of the Transportation Research Board*. 2019. DOI: <https://doi.org/10.1177%2F0361198119849398>

Jennings, D. and Figliozzi, Can Autonomous Delivery Robots Can Reduce Last Mile Energy Consumptions and CO2 Commissions. *Transportation Research Board: Journal of the Transportation Research Board*. 2020 (accepted).

Keeling, K. and Figliozzi, E-Commerce Home Delivery Impacts on Food Access and Equity: a Portland Case Study. *Transportation Research Board: Journal of the Transportation Research Board*. 2020 (accepted).

### ***Books or other non-periodical, one-time publications***

Nothing to Report

### ***Identify for each one-time publication***

Nothing to Report

### ***Other publications, conference papers and presentations***

Zhang, Y., Khani, A., and J. Hourdos "Optimization of Winter Maintenance Station Location for Safe and Efficient Freight Transportation" Submitted to 99<sup>th</sup> Annual Meeting of the Transportation Research Board, Washington, D.C., 2020 (under Review).

Charisis A., Manta S., Kaisar E., and Al-Ghandour M., “Estimation of Container Port Efficiency Using Data Envelopment Analysis and Free Disposal Hull Approaches: The Case of the Caribbean”, conference proceedings at 2019 International Conference on Transportation and Development (ICTD 2019), Alexandria, VA June 2019.

Figliozzi M., “A Study of Sidewalk Autonomous Delivery Robots and their Potential Impacts on Freight Efficiency and Travel”, presented at ITE Student Chapter at the University of Memphis, May 2019.

Goulianou, P., Kaisar, E. I., Dhanak, M. R., and Parr, S. Port and Transportation Network Resilience Review in Port Everglades. Presented at WTS International Annual Conference, Boston, May, 2019.

Figliozzi M., “Autonomous Delivery Robots and their Potential Impacts on Urban Freight Travel, Energy, and Emission”, conference proceedings at the 11<sup>th</sup> International Conference on City Logistics, Dubrovnik, Croatia.

Liu, D., Ardalan, T., Kaisar, E. I. Mapping of Truck Tonnage in Florida Using Weigh-in-Motion Data. Presented at FIU-ITE student chapter event, Miami, September 2019.

Pujats K., Golias M., Mishra S. A Mathematical Framework for Container Terminal and Liner Shipping Companies Cooperation and Competition. Proceedings of the MHCL 2019 Conference, XXIII International Conference on Material Handling, Constructions and Logistics.

## Website(s) or other Internet site(s)

The Freight Mobility Research Institute’s official website is [fmri.fau.edu](http://fmri.fau.edu). Please find below other websites pertaining to technology transfer and research:

- FMRI Y1R3-17: Enhancement of Transportation Network Analysis Tools for Truck-Related Planning and Operations - Part B (PI: Washburn, UF). Software and user guide will be published at: <https://github.com/swash17>

## Technologies or techniques

Under Hampton University, the workshop material for K-12 teacher (special High School) teacher was renewed. A 60-minute lecture was created and presented for High School Students for Logistics, called “Transportation Logistics, and Marketing.”

Under Texas A&M University, the creation of optimal control and ACC (adaptive cruise control) technology for vehicles (trucks) approaching and passing multiple signalized intersections under mixed traffic conditions on the multimodal corridors will be shared in a published paper.

The software product developed through the Enhancement of Transportation Network Analysis Tools for Truck-Related Planning and Operations – Part B Year 1 project will help transportation agencies perform travel time reliability at a network level, which is also sensitive to the vehicle performance of commercial trucks. FMRI Y1R3-17: Enhancement of Transportation Network Analysis Tools for Truck-Related Planning and Operations – Part B (PI: Washburn, UF). Software and user guide will be published at: <https://github.com/swash17>

## Inventions, patent applications, and/or licenses

Nothing to Report

**Outcomes**

Outcomes	Target	Progress
# of workshops/seminars/webinars developed	8 workshops/webinars/seminars	3 research workshops 4 educational workshops/seminars 2 ITE lecture series events
# of featured articles of FMRI research	5 featured articles	7 articles accepted 7 under review
# of organizations participating in consortium activities	4 organizations	4 research-related organizations 7 educational organizations
# of attendees to seminar/webinar/outreach activities	120 attendees	110 research-based attendees 33 education-based attendees 87 ITE attendees

**What outcomes has the program produced?**

Under the research component, there is an increased understanding of adoption of new technologies and their implications on Freight transportation to improve the nation’s mobility of people and goods. The center studied new technologies that have created opportunities to address critical freight transportation challenges across all modes in urban, suburban and rural areas. Some examples of new technologies include expansion of e-commerce, last mile deliveries by unmanned aerial vehicles (UAVs) or delivery robots, and potential applications of automated and connected vehicles in freight transportation (e.g. truck platooning). These new technologies are also influencing consumer behavior and thereby reshaping freight supply chains at the urban, regional, and international level. The center is developing diffusion of innovation based models to predict how the adoption of autonomous trucks will be in the future by freight organizations.

Under the educational component, the following outcomes have been achieved:

- Lectures and visit FAU High School the FMRI Facilities, Fall 2019.
- Summer camps with logistics for middle school students
- 10 female and minority students placed in industry as interns. Canon, Inc.; Norfolk Southern Corp., Hampton Roads Transit, VA Port Authority, Unilever, MZB-USA, AECOM, and State Department of Transportations, and VA Port Authority.
- An essay competition among high school student has been organized for two high schools.
- K-12 Transportation Science Fair has been planned for fall of 2019. Participation flyer has been distributed to two high schools.

The FMRI held and sponsored workshops, conferences, and other events during this period. The FMRI, with the Women Transportation Society, held a meeting on May 22<sup>nd</sup> at FAU Boca Raton Campus. This event brought together academia, government, and industry to discuss local research-on automated parking in the South Florida region. The agenda gave attendees a chance to learn about updated local government activities and research information.

The PSU also participated in a City of Portland study, collaborating with the peer review, to support a new freight plan. Discussions and meetings related to the growth of e-commerce and last mile deliveries led to the development of a new research proposal.

**How are the research outputs described in section (3) above being used to create outcomes?**

The center is actively working with stakeholders and academia to create technology transfer throughout the industry and other entities. Examples below show the first initiatives the center is taking with the Year 1 and 2 completed

projects. The application of the proposed approach of autonomous vehicles is to be used in many other innovations such as drones, collaborative and shared logistics, truck platooning, etc. in Texas. The technologies used in the dynamic trajectory control and signal coordination are combined and applied in a coordinated way to complete the algorithm.

## Impacts

Impacts	Target	Progress
# of methodologies, models, and tools developed	5 models developed	11 methodologies, models, and tools developed
# of partnerships from industry, agencies and academic institutions	8 partnerships	10 partnerships
# of adopted methodologies, models, and tools	2 adopted models	3 adopted models

### What is the impact on the effectiveness of the transportation system?

Under the education effort, K-12 students' exposures to various transportation fields through lecture series, field trips, essay competition, Transportation Science Fair, and High School Teacher's workshop will help move students to a career in transportation engineering and logistics.

Under the research effort, the center, for the project Next Generation of Freight Planning and Operation Models To Incorporate Emerging Innovative Technologies; studied freight planning by developing a hybrid based approach in modeling truck platooning. The hybrid model will be based on feedback from a micro-simulation and macro-simulation of heavy vehicle route choice. The microsimulation model will be based on analytical formulation of speed-density relation of mixed traffic flow and development of simulation framework for truck platooning in a small to medium freeway network. Multi-regime speed-density relationships will be used to describe the mixed traffic flow consisting of trucks and passenger cars. The speed-density relation will incorporate percentage of platooned trucks, traffic density and spacing policy of platoons. Various spacing and number of platooned vehicle performance will be used to assess the total system travel time. Adequate spacing and number of vehicles needed in efficient platooning will be further applied in macroscopic traffic assignment to assess overall efficiency in a larger case study area.

### What is the impact on the adoption of new practices, or instances where research outcomes have led to the initiation of a start-up company?

The work produced under project Y2R2- 18 Sustainable Urban Freight Mobility through Optimization of Logistics Facility Locations is providing an alternative operating method for urban freight systems that can potentially solve many of the problems encountered in the logistics sector, varying from operational costs, problems in safety and mobility, to increased risk factors and environmental impacts. The key elements that are bound to experience the largest benefit from this study are labor costs, environmental impacts, and mobility. First, the main objective of the proposed solution will be to minimize the costs associated with the operation of the system, when finding the optimal locations of the city logistics facilities. These costs are comprised of three components: (i) the costs to use the facilities chosen for the unloading and delivering of the products, (ii) the costs associated with the transportation of cargo to the selected facilities and (iii) the costs related to the distances from the mini-hubs chosen and the final destinations, which is referred to as the last-mile problem. A set of candidate locations will be identified (e.g. warehouse facilities, parking lots, etc.) and each of these locations will be linked with a utilization cost. For the project to be cost efficient towards the logistics operators, instead of acquiring the chosen hubs, they will lease the facilities for a predefined daily time-window required to unload and deliver the products. This leasing function also provides long-term flexibility in the system, since it can address potential uncertainty in the demand and cost patterns. The logistics providers will conduct short-term (e.g. 6-month, yearly) leasing contracts and after the



contracted time expires again use the model developed to identify the new optimal locations for the corresponding product demands or fluctuating facility costs. Additionally, the transportation costs from the main hub to the selected facilities are related to the position of each candidate facility, the load that is assigned to each location and must be delivered, the number and type of trucks used for the transportation of cargo, etc.

Moreover, the last-mile is one of the most important areas of operation for the delivery processes, as allows shippers to get more products to consumers faster and cost-effectively and it has become one of the most significant aspects influencing the logistics operations, since it makes up around 28 percent of shipments total cost. So, the minimization of the distances between the chosen locations and the destination nodes comprises a vital component for the success of the operations. The project intends on promoting environmental-friendly solutions for the last-mile deliveries, like the bicycle logistics initiatives that are constantly gaining ground in the global supply chain market and start being implemented by major logistics companies (e.g. DHL, UPS, FedEx, etc.). Furthermore, the study will help improve mobility and sustainability in urban areas, since the trucks used for the product deliveries will not be traveling between all the downtown destination nodes, increasing the vehicle volumes in roads, but will directly head to the hubs and return to their origin from predefined routes, allowing a controllable vehicle distribution in the network and decreasing emission levels. Last, as one of the objectives is to minimize the distance from the chosen facilities to the end destinations, the study also ensures that the hubs are in close proximity and easily accessible to the customers, therefore providing opportunities for deliveries on foot, using handcarts, or self-pickup opportunities and relieving the urban network from unnecessary extra heavy vehicle loads. Overall, the project is offering an alternative, cost-efficient and innovative method of distributing goods in metropolitan areas that will help improve urban freight mobility, alleviate traffic congestion from city centers and assist in the reduction of the environmental impacts caused by the transportation systems.

In the Dynamic Trajectory Control and Signal Coordination for a Signalized Arterial with Significant Freight Traffic project, the developed models and algorithms will have the potential to be implemented in onboard devices for driver assistantship systems, or as a part of the infrastructure (signal) control system prototypes.

The Truck Parking Study: Unveiling the Parking Space Density and Truck Volume Relationship project would allow private sectors to associate truck parking problems along the interstate highways with the supply of parking capacities so that they may proposal projects to add parking capacities for truckers. The signal optimization project will allow consulting firms on signal to improve their control algorithms to improve practices.

### What is the impact on the body of scientific knowledge?

The impacts on the body of scientific knowledge are listed below:

The proposed freight data analytics platform produces a nationwide integrated data warehouse from public and private sector to improve freight transportation system. In this ecosystem, decision makers will be able to leverage innovations in big data analytics to evaluate the performance of the state's freight transportation assets or system and also assess the essential role of freight to the State's economy. In addition, the platform also provides flexible, easy-to-use, interactive web interface which could be used by state agencies to quickly identify causes or trends, perform impact analyses of decisions. This will enable leaders to easily comprehend and act on valuable information much more quickly.

The development of the methods in this program used knowledge from the fields of optimization and control theory under the Dynamic Trajectory Control and Signal Coordination for a Signalized Arterial with Significant Freight Traffic project. The development of the dynamic system and application of theories have shown the effectiveness to solving the problem using that knowledge. The fastest way is applied using the knowledge to solve the problems compared to previous research on similar topics.

The work produced under project Next Generation of Freight Planning and Operation Models to Incorporate Emerging Innovative Technologies will inform how newer technologies will affect freight transportation so that the lessons learned from this project can be utilized by state and local planning agencies in their decision making and

facilitating appropriate infrastructure to accommodate upcoming innovations for improved understanding of freight mobility.

The Enhancement of Transportation Network Analysis Tools for Truck Parking project created a new capability to analyze network-level travel time reliability at a macroscopic level. This methodology and tool now gives the practice an analysis capability, within reasonable time constraints, that was not previously available. This will ultimately allow agencies to make more information highway network investment decisions.

The Two-lane Highway Analysis Methodology Enhancements Considering Commercial Truck aims to improve the state-of-the-art for accounting for the impact of trucks on two-lane highway operations. The work accomplished by building on the work that was done for NCHRP Project 17-65. The issues examined in this project are ones which are very difficult and/or very expensive to study in the field. Thus, the SwashSim simulation tool was utilized exclusively in this project.

### What is the impact on transportation workforce development?

The impact on the transportation workforce development has been greatly influenced by the efforts under the FMRI. Multiple endeavors, including post-doctoral researchers, graduate research assistants, and under student assistants have worked under the various research projects, providing opportunities for research, teaching, and training in transportation and logistics. Currently, there are more than 15 graduate and undergraduate students who are actively involved in these projects. K-12 initiatives have also exposed many non-engineering college majors to the transportation field. Graduate Courses was developed and will be continue developed based on research findings, as well. These programs have provided opportunities for research and teaching in transportation to graduate and undergraduate students, including the development of a generic framework for consolidation and routing principles in the intermodal transportation network. The research conducted will provide new information for classroom learning, such as sustainability issues related to freight new technologies, and new mathematic models and sound scientific research process on the area of network modeling, routing schedule, and logistics.

In order to give students a real-world experience, tours have been given to FAU students to various logistic facilities such as the Port of Palm Beach. Students had a chance to tour the Port of Palm Beach, exploring Tropical Shipping, Florida Sugar & Molasses Exchange, and cruise ship docking area, by Mr. Carl Baker, Director of Planning and Development.

Transportation Camps and Workshops have been held at multiple universities throughout this period. FAU held a two-week long Transportation Camp during June 2019. The Transportation Camps were a highly competitive scholarship program that provides middle school students with a great chance to investigate careers and educational opportunities in today's freight transportation industry and beyond. Students participated in discussions, hands-on design competitions, and trips to study local and regional transportation hotspots. They also spend time with industry role models and a diverse group of students. The graduate research assistants were heavily involved in teaching the students about ArcGIS based spatial analysis, VISSIM based intersection simulations, basics of transportation engineering, freight operations, logistics, connected and automated vehicles, and traffic count observations. The campers also took part in debates, quizzes, and fun freight transportation-related cards games. Hampton University, held a one-day transportation camp for middle School Student on transportation logistics. The students also, had the opportunity to participate in discussions and fun games related top logistics and supply chain management in 2019.

## Changes/Problems

### Changes in approach and reasons for change

Nothing to Report

**Actual or anticipated problems or delays and actions or plans to resolve them**

Nothing to Report

**Changes that have a significant impact on expenditures**

Nothing to Report

**Significant changes in use or care of human subjects, vertebrate animals, and/or biohazards**

Nothing to Report

**Change of primary performance site location from that originally proposed**

Nothing to Report

**Special Reporting Requirements**