STRIDE | Southeastern Transportation Research, Innovation, Development and Education Center

Technology Transfer Final Report

STRIDE Project C

Performance Measurement and Management Using Connected and Automated Vehicle Data

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1. Project Description

Transportation system performance measurement is a key component in congestion management as well as in setting agency priorities and making policy decisions. Effective estimation of system performance requires detailed data from multiple sources combined with advanced data management and analytics. The availability of connected vehicle (CV) data, even at lower market penetrations, can be sufficient to support critical transportation performance measurement and management functions. This study developed a framework, methods, and algorithms for using CV data to estimate measures to support agency processes.

The study investigated the use of CV data to estimate metrics that can be currently estimated using existing data sources including those related to mobility, reliability, and environmental impacts. In addition, the study investigated the estimation and utilization of additional mobility and safety metrics that cannot be estimated based on existing sources of data.

The developed framework and methods to estimate performance measures can be used by a system operator, a planner, or an automated system to support decisions associated with the agency business processes. The methods can also be used in the real-time operations of traffic management centers (TMCs) to determine the traffic states. In addition, machine learning models were developed for use by the TMCs for short-term prediction of traffic conditions to support proactive activation of operational plans to mitigate potential deterioration in mobility and safety performance.

The project also developed a method to determine the pollutant emission levels under different traffic conditions using CV data. This method can be used for implementing strategies and plans to reduce pollution.

2. Research Goals

The objective of this study was to identify how data collected from connected vehicles can be used alone or in combination with data from other sources, to support transportation system performance measurement for transportation planning and operation purposes. More detailed performance measures are identified that allow agencies to better examine and predict the mobility and safety of the transportation system, considering the availability of emerging vehicle technologies.

3. Findings

The study developed a detailed methodological framework to describe the process of determining performance measures from CV data. The proposed methodological framework contains four parts: (i) physical data flow diagram, (ii) processes and process group's hierarchical diagram, (iii) individual process designs, and (iv) logical data flow diagram. In order to validate the proposed framework, the study examined the estimation of various travel time and reliability measures and compared the results with estimates based on other sources of data. Then, the study showed that including the utilized disturbance metrics allows better recognition and prediction of the traffic breakdown and crash risk. The study confirmed the benefit of utilizing the metrics in traffic state classification and prediction in combination with macroscopic traffic parameters. The study also demonstrated the application of limited connected vehicle data to estimate real time CO_2 emission and fuel consumption of the transportation network.

4. Performance Metrics

Metric	# Completed
OUTPUTS	
Product(s): Number of new or improved tools, technologies, products, methods, practices, and processes created or improved	3
Technical Report: Number of client-based technical reports published	1 STRIDE Final Report
OUTCOMES	
Body of Knowledge: Number of trainings for transportation professionals	2
Professionals Trained: Number of professionals participating in trainings	97
IMPACTS	
Stakeholders: Number of stakeholders you met with to encourage adoption or implementation of product(s)	0
Adoption/Implementation: Number of incidences outputs of research have been implemented or adopted	0

5. Products

1) Framework to estimate mobility, reliability, and environmental metrics using connected vehicle data

Developed a framework for using connected vehicle data to estimate mobility, reliability, and environmental metrics that are currently being estimated using traditional (existing) sources. The estimated performance measures can be used by a system operator, planner, or an automated system to support decisions associated with these processes. The measurements can be also used to derive information for dissemination to travelers, third-party data aggregators, traveler information service providers, and other agencies.

2) Methods to estimate new mobility and safety metrics

Developed methods to estimate new mobility and safety metrics that cannot be estimated based on existing sources of data. The methods can be used in real-time operations by traffic management centers (TMCs) to determine the traffic conditions on the freeway segments. In addition, machine learning models were developed that can be used by TMCs for short-term prediction of traffic conditions that can be used to proactively activate operational plans to mitigate potential deterioration in performance.

3) Method to estimate pollutant emission

Developed a method to estimate pollutant emission based on a limited number of connected vehicles. This method can be used in off-line and real-time analysis of traffic conditions to determine the pollutant emission levels under different traffic conditions. This can be used in making decisions regarding strategies and plans to reduce pollution.

6. Who benefits/will benefit from your products?

The availability of connected vehicle (CV) data, even at lower market penetrations, can be sufficient to support critical transportation performance measurement and management functions. Connected vehicle (CV) technologies promise to allow the estimation of measures currently provided by other technologies, as well as measures that cannot be collected by existing sensor technologies. Examples of the additional measures include stops, accelerations, and decelerations, shockwave speed, detailed signalized intersection movement-level measures, potential for crashes, weather impacts, and emissions. A relatively low market penetration of CV may be required for estimating some of the measures, while other measures will require high market penetrations to produce accurate results. The estimation of these measures based on CV data will allow enhanced traffic management strategies that improve safety, mobility, and environmental impacts as well as reduce the costs associated with collecting data based on traditional data collection methods.

7. Body of Knowledge & Professionals Trained

1) STRIDE webinar – April 22, 2020: Dr. Mohammed Hadi, Florida International University, presented "Performance Measurement and Management using Connected and Automated Vehicle Data" (67 participants; 34 YouTube views)
2) Workshop “Managing Performance from Active Transportation Management to Connected Vehicles” hosted by STRIDE at the ITS-5C Summit in Jacksonville, FL on Sunday October 7, 2018 from 1:00 pm to 5:00 pm. Attended by 30 professionals.

   Agenda
   Introduction
   - Lily Elefteriadou (UF)

   Part 1: Active Transportation Management (ATM)
   - Mike Hunter (Georgia Tech) and Troy Galloway (City of Atlanta), “Creating a Smart Corridor, Data Integration from a Public Agency and a Research Perspective
   - Lily Elefteriadou (UF), Pruthvi Manjunatha (UF), and Raj Ponnaluri (FDOT), “Before-After Evaluation of Adaptive Signal Control in the State of Florida”
   - Thomas Chase (NCSU), “Traffic Signal Performance Measurement based on ATSPM and other Data Sources for Performance-based Prioritization of NCDOT's Statewide Signal Retiming Program”
   - Mohammed Hadi (FIU), Decision Support Systems for Transportation System Management and Operations”

   Part 2: Connected and Automated Vehicle Support of ATM
   - Raj Ponnaluri (FDOT), “Introduction and FDOT CV program”
   - Lily Elefteriadou (UF) and Clark Letter (UF), “Testing the Utilization of Connected Vehicles and Automated Vehicles to Enhance Traffic Signal Control System Performance”
   - Virginia Sisiopiku (UAB), MD Ahsanul Islam (UF), Ossama Ramadan (UAB), and Mohammed Hadi (FIU). “Using Connected Vehicle Data for Transportation Performance Measurement”
   - Mohammed Hadi (FIU), “Support ITS Investment Decisions with Consideration of CV Technology”

10. Adoption/Implementation

The team is building on the findings from this project in on-going FDOT and STRIDE project allowing further enhancement and utilization of the developed methodology.

11. Broader Impacts

This project provides an important framework and methods to enable transportation agencies to use connected vehicle data in their performance-based planning, design, planning for operations, and operations processes. In addition, the products from this project will allow the estimation of existing and new mobility, reliability, safety, and environmental measures that can be used to assess highway performance. These measurements will support congestion-reducing goals and objectives at the national, state, regional, and local levels, and will help operationalize performance management strategies.