Data Sources and Measures for Transportation Performance Management

M. A. Islam[1], Dr. V. P. Sisiopiku[1], Dr. O. E. Ramadan[1], and Dr. M. Hadi[2]

[1]UAB Transportation Engineering and Development Laboratory, [2]Florida International University

THE UNIVERSITY OF ALABAMA AT BIRMINGHAM

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Introduction

Transportation performance management is an indispensable part of the congestion management process. Transportation system performance measures are used to evaluate the operating performance of local and regional transportation systems and determine if they meet national performance goals. Currently, performance measures are developed from data typically collected via point detectors and vehicle probes. Emerging connected vehicle technologies are expected to increase data availability, quantity and quality, and create opportunities for collecting new types of transportation data. This, in turn, will improve the accuracy of existing transportation performance measures and enable development of novel performance measures.

This study investigates and summarizes performance measures in support of MAP-21 transportation performance management requirements. Attention is given to the availability and potential use of data collected from connected vehicles for measuring transportation performance. The goal is to identify novel data sources from emerging connected vehicle technologies which, along with data from existing sources, can be used to improve the transportation performance management process.

Methodology

This study was conducted through a comprehensive literature review of existing refereed publications, established standards, and formal guidelines. Literature was sought through the Transport Research International Documentation (TRID) database, the FHWA Research Data Exchange, the USDOT Connected Vehicle Pilot Deployment Program, and the Society of Automotive Engineers (SAE) standards database.

Results

Moving Ahead for Progress in the 21st Century (MAP-21) Performance Measurement and Management Overview

Measures for the NHPP System Performance

Data Requirements

- Travel Time, 15 min interval
- Emissions factors of CO_2 per gallon of motor fuel
- Annual motor fuel sales volumes
- Vehicle miles of travel on the NHS and on all roads
- Segment length
- Total annual traffic volume
- Occupancy factor for vehicles

Performance Metrics

Level of Travel Time Reliability (LOTTR)=

$$= \frac{\text{80th percentile travel time}}{\text{50th percentile "normal travel time"}}$$

$$(\textbf{Tailpipe } CO_2 \textbf{ Emission on NHS})_{CY} = = \left(\sum_{t=1}^{T} (Fuel\ Consumed)_t \times (CO_2\ Factor)_t\right) \times \left(\frac{NHS\ VMT}{Total\ VMT}\right)$$

Performance Measures

Interstate or Non-Interstate Travel Time Reliability=

$$100 \times \frac{\sum_{i=1}^{R} SL_i \times AV_i \times OF_j}{\sum_{i=1}^{T} SL_i \times AV_i \times OF_j}$$

Greenhouse Gas (GHG)=

$$\frac{(Tailpipe\ CO_2\ Emission\ on\ NHS)_{CY} - (Tailpipe\ CO_2\ Emission\ on\ NHS)_{2017}}{(Tailpipe\ CO_2\ Emission\ on\ NHS)_{2017}} \times 100$$

Measures for Freight Movement on the Interstate

Data Requirements

- Travel Time, 15 min interval
- Segment length

Performance Metrics

Truck Travel Time Reliability (TTTR)

$$= \frac{\text{95th percentile travel time}}{\text{50th percentile "normal travel time"}}$$

Performance Measures

Freight Reliability:

$$\frac{\sum_{i}^{T}(SL_i \times maxTTTR_i)}{\sum_{i=1}^{T}(SL_i)}$$

Measures for CMAQ Program-Traffic Congestion

Data Requirements

- Travel time, 15 min interval
- Annual Average Daily Traffic (AADT)
- Average Vehicle Occupancy
- Segment length
- U.S. Census Data for population

Performance Metrics

Excessive delay threshold travel $\boldsymbol{time_s}$

$$= \left(\frac{\text{Travel time segment } length_s}{\text{Threshold } speed_s}\right) \times 3600$$

Excessive Delay $_{s,b} = \begin{cases} \frac{RSD_{s,b} \text{ when } RSD_{s,b} \geq 0}{3600} \\ \text{or}_{0 \text{ when } RSD_{s,b} < 0} \end{cases}$

Total Excessive $\boldsymbol{Delay_s}$ = AVO

$$\times \sum_{d=1}^{TD}\left\{\sum_{h=1}^{TH}\left[\sum_{b=1}^{TB}\left(\left[Excessive\ Delay_{s,b,h,d} \times \left(\frac{hourly\ volume}{4}\right)_{s,h.d}\right)_b\right]_h\right\}_d$$

Measure for the CMAQ Program-On Road Mobile Source Emissions

Data Requirements

- Applicable nonattainment or maintenance area
- Applicable MPO
- The emissions reduction estimated for each CMAQ funded project for each of the applicable criteria pollutants and their precursors for which the area is nonattainment or maintenance

Performance Measures

Total Emission Reduction$_p$

$$= \sum_{i=1}^{T} Daily\ kilograms\ of\ Emission\ Reductions_{p,i}$$

Existing Data Sources

1. National Performance Management Research Data Set (NPMRDS)
2. Highway Performance Monitoring System (HPMS) Data Set
3. National Household Travel Survey (NHTS)
4. Congestion Mitigation and Air Quality Improvement Program (CMAQ) Public Access System

Connected Vehicle Data Sources

1. Basic Safety Message (BSM): Location, heading, speed
2. MAP / SPaT: Signal timing and performance
3. On-Board Diagnostic (OBD): Fuel consumption, emissions
4. Vehicle Data Translator (VDT): Precipitation, visibility, pavement condition

Performance Measures

Peak Hour Excessive Delay (PHED) =

$$Annual\ Hours\ of\ Peak\ Hour\ Excessive\ Delay\ per\ Capita = \frac{\sum_{s=1}^{T} Total\ Excessive\ Delay_s}{Total\ Population}$$

Percent of Non-SOV Travel:

Method A - American Community Survey

$$\text{Percent of Non} - \text{SOV Travel} = 100\% - \%\text{SOV}$$

Method B - local survey

Method C - system use measurement

$$Percent\ of\ Non - SOV\ Travel = 100 \times \left(\frac{Volume_{non-SOV}}{(Volume_{non-SOV}) + (Volume_{SOV})}\right)$$

Discussion

Current requirements for transportation performance monitoring include measures such as travel time, travel time reliability, total peak-hour excessive delay person-hours, percent of non-single occupancy vehicle travel, and total emission reductions. Connected vehicles allow for the estimation of measures currently based on existing data sources, as well as measures that cannot be derived from existing sensor databases. The literature review confirms that the availability of connected vehicle data, even at smaller percentages, may suffice to support critical transportation management functions in the future.

Conclusion

Transportation performance measures are used by system operators, planners, or an automated system to improve transportation policy decision making, optimize planning and operations, or improve transportation system outcomes in the future. Performance measures can be also used to derive information for dissemination to travelers and stakeholders. The recently published MAP-21 transportation performance management requirements introduce new transportation performance measures for performance monitoring purposes.

Connected vehicles research and development efforts are growing and have the potential to provide new sources of data in support of transportation performance management. This study can serve as a reference for researchers interested in using connected vehicles data to satisfy transportation performance tracking requirements as well as those interested in developing performance measures using connected vehicle data.