University Transportation Research Center - Region 2

Final Report

Improve Congestion Performance Measures Via Conflating Private and Public Information Sources

Performing Organization: New Jersey Institute of Technology

August 2018

Sponsor:
University Transportation Research Center - Region 2

University Transportation Research Center - Region 2

The Region 2 University Transportation Research Center (UTRC) is one of ten original University Transportation Centers established in 1987 by the U.S. Congress. These Centers were established with the recognition that transportation plays a key role in the nation's economy and the quality of life of its citizens. University faculty members provide a critical link in resolving our national and regional transportation problems while training the professionals who address our transportation systems and their customers on a daily basis.

The UTRC was established in order to support research, education and the transfer of technology in the field of transportation. The theme of the Center is "Planning and Managing Regional Transportation Systems in a Changing World." Presently, under the direction of Dr. Camille Kamga, the UTRC represents USDOT Region II, including New York, New Jersey, Puerto Rico and the U.S. Virgin Islands. Functioning as a consortium of twelve major Universities throughout the region, UTRC is located at the CUNY Institute for Transportation Systems at The City College of New York, the lead institution of the consortium. The Center, through its consortium, an Agency-Industry Council and its Director and Staff, supports research, education, and technology transfer under its theme. UTRC's three main goals are:

Research

The research program objectives are (1) to develop a theme based transportation research program that is responsive to the needs of regional transportation organizations and stakeholders, and (2) to conduct that program in cooperation with the partners. The program includes both studies that are identified with research partners of projects targeted to the theme, and targeted, short-term projects. The program develops competitive proposals, which are evaluated to insure the mostresponsive UTRC team conducts the work. The research program is responsive to the UTRC theme: "Planning and Managing Regional Transportation Systems in a Changing World." The complex transportation system of transit and infrastructure, and the rapidly changing environment impacts the nation's largest city and metropolitan area. The New York/New Jersey Metropolitan has over 19 million people, 600,000 businesses and 9 million workers. The Region's intermodal and multimodal systems must serve all customers and stakeholders within the region and globally.Under the current grant, the new research projects and the ongoing research projects concentrate the program efforts on the categories of Transportation Systems Performance and Information Infrastructure to provide needed services to the New Jersey Department of Transportation, New York City Department of Transportation, New York Metropolitan Transportation Council , New York State Department of Transportation, and the New York State Energy and Research Development Authorityand others, all while enhancing the center's theme.

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The modern professional must combine the technical skills of engineering and planning with knowledge of economics, environmental science, management, finance, and law as well as negotiation skills, psychology and sociology. And, she/he must be computer literate, wired to the web, and knowledgeable about advances in information technology. UTRC's education and training efforts provide a multidisciplinary program of course work and experiential learning to train students and provide advanced training or retraining of practitioners to plan and manage regional transportation systems. UTRC must meet the need to educate the undergraduate and graduate student with a foundation of transportation fundamentals that allows for solving complex problems in a world much more dynamic than even a decade ago. Simultaneously, the demand for continuing education is growing – either because of professional license requirements or because the workplace demands it – and provides the opportunity to combine State of Practice education with tailored ways of delivering content.

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16. Abstract

A series of transportation related legislations, from ISTEA (1991) to FAST (2015), have been consistently mandating the Congestion Management Plan as integral part of long-range transportation planning (LRTP) for metropolitan areas in the US. As the critical elements of CMP, performance measures, such as travel time and speed, traffic volume and roadway characteristics, are not collected by a single entity, public or private, therefore; it is a challenge to develop performance measures using data from various sources.

This report documents an approach to measure the dynamic performances of arterial roadways by combining probe vehicle and transit speed data. With widely spread subscriptions of General Transit Feed System (GTFS) Real Time data and rapidly deployed probing vehicle data collected from private sectors, this particular study proposes a methodology that incorporates the two variables into a Speed Ratio for Auto/Transit (SRAT). Combined with Minimum Estimated Arrival Time (MEAT) and/or Speed, those metrics may be used to measure the transportation service quality for any given two points at any given time where transit service is available.

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1. INTRODUCTION

The latest transportation legislation, Fixing America's Surface Transportation (FAST Act, 2015) has not only retained the requirement for a Congestion Management Process (CMP) but also allows a Metropolitan Planning Organization (MPO) to develop a Congestion Management Plan (CMP) as part of its Transportation Improvement Program (TIP)(Federal Highway Administration, 2017). Distinct from the Congestion Management Process, the Plan must include regional goals for reducing peak hour Vehicle Miles Traveled (VMT) and improving transportation connections.

The requirement for a Congestion Management Process is not a new mandate as the Intermodal Surface Transportation Efficiency Act (ISTEA, 1991) has introduced the concept of Congestion Management System (CMS) more than a quarter centuries ago. Its successor, the Transportation Equity Act for the 21st Century (TEA-21, 1998), extended the CMS program with the intent to augment and support effective decision making as part of the overall metropolitan transportation planning processes. The Moving Ahead for Progress in the 21st Century Act (MAP-21, 2012) mandated that each state establish a Congestion Performance Management System (CPMS) to ensure the most efficient investment of federal transportation funds. It also specified three basic data requirements for congestion performance measures: average travel time and/or speed, traffic volumes, and length of road segments.

In reality, those measures are not usually collected by a single entity, public or private. There is no systematic data collection on all the roadway systems, and the collection of certain data by each agency may be sporadic and/or targeted to certain projects. In our effort to assist transportation agencies meeting the mandates of federal legislations and providing a critical link in solving our national and regional transportation problems, the research team has explored approaches to conflate various transportation data from diversified sources.

A particular highlight of the approach is to measure the dynamic performances of transit services via real time General Transit Feed System (GTFS) data. With the arrival of real time GTFS data for transit routes and real time auto travel time/speed data, this particular study presents a methodology that incorporates the two variables into a Speed Ratio for Auto/Transit Travel (SRAT). Combined with Minimum Estimated Arrival Time (MEAT) and/or Speed, those metrics can be used to measure the transportation service quality for any given two points at any given time where transit service is available.

This report documents the research effort via several tasks. After a focused literature review on the topics of conflation, the research team has conducted an inventory of public and private data sources directly related to the Congestion Performance Management Systems (CPMS). An effective approach was developed to utilize public and private data sources to measure congestion performances along urban streets.

2. RESEARCH BACKGROUND

To initiate the study, the research team has performed a focused literature review on the subject of spatial information conflation, especially the conflation of transportation performance measures. The first impressions obtained during our proposal preparation stage are confirmed via a broad scan of general internet and in-depth search through a number of databases, such as Transportation Research Information Database (TRID) (Transportation Research Board 2017); Environmental Systems Research Institute (ESRI 2017); and other mapping and imagery research entities. There are limited journal papers but a large number of conference presentations on the conflation algorithm and research approaches, which may be a direct reflection of the rapid development process and diversified interests, approaches, and perspectives on the spatial information conflation topic. Highlighting the objectives of this study effort, the research team grouped the existing literature into a few categories and presents them below.

2.1 Congestion Management Plan

As defined in the Federal Regulation (US Congress, 2007), a Congestion Management Process (CMP) is a systematic and regionally-accepted approach for managing congestion that provides accurate, up-to-date information on transportation system performance and assesses alternative strategies for congestion management that meet state and local needs. The CMP serves as a systematic process for safe and effective integrated management and operation of the multimodal transportation system.

The CMP measures remain flexible as the federal regulations are not prescriptive regarding the methods and approaches used to implement a mandatory CMP. The flexibility not only allows MPOs to design their own approaches and processes to fit their individual needs but also enables CMP as a continuously progressing and adjusting process as goals and objectives change, new congestion issues arise, and new information sources become available.

2.2 Performance Measures

The three basic data requirements specified for a statewide CPM by MAP 21 (2012) have created certain challenges. Given the wide variations of travel conditions along diverse roadways serve various environments and during different times, average travel time and/or speed can vary widely for the same facility among different time of the day, day of the week. Besides the classic free flow speed vs. congested speed, there are various terms to measure travel time/speed. For example:

Travel Time Index (TTI) is defined as the ratio between travel time during peak period and the free-flow travel time (Green, et al 2013). For example, a TTI value of 1.2 means travel time during peak period is 20% longer than the free-flow travel time between the same origin and destination. TTI is calculated for each segment, for each 15-minute interval.

Planning Time Index (PTI) is computed as the ratio between the 95th percentile travel time and the free-flow travel time. It is an indicator of travel time needed to ensure an on-time arrival at destination in 19 days out of 20. A PTI value of 2.0 for a given time period indicates that a traveler should budget twice as much time for traveling during a given period as the free-flow travel time to ensure a 95% chance on-time arrival.

Percentage Travel under Congestion (PYUC) is defined as the percentage Vehicle Miles Traveled 19 (VMT) under congested condition. When the average speed is 20% or more below the free-flow speed on a facility, the traffic is considered as congested.

Buffer Index (BI) is closely related to Travel Time Index (TTI) and Planning Time Index PYI). It is the percentage time that traveler needs to plan, relative to his/her own average travel time to ensure a 95% of on time arrival. It is computed as 95% percentile speed/average speed minors 1, PTI/TTI -1, based on its definition.

Transit and Auto Travel Time Differences is a concept mentioned in the latest Transit Capacity and Quality of Service Manual (TCQSM), 3rd Edition (Kittelson and Associates 2013), the transit counterpart to the widely accepted Highway Capacity Manual (HCM) (Transportation Research Board 2010). Adopting the level of service (LOS) concept introduced in HCM, TCQSM continued the tradition to measure the quality of transit service from users' perspective. Recognizing the complexity of multiple elements, such as various stakeholders, diverse temporal and spatial coverages of transit services, the TCQSM proposed six LOS measures to evaluate the quality of service for a fixed route transit system without dictating how those values are derived:

- service frequency;
- service span;
- service coverage;
- passenger loading;
- service reliability; and
- transit and auto travel time difference.

3. DATA INVENTORY FOR CPM

Searching for the appropriate datasets to measure transportation performance, the research team has conducted a thorough inventory of transportation performance measures in the New York/New Jersey Metropolitan Area from both public agencies and private enterprises. A detailed review, analysis, and evaluation of individual databases was carried out to assess the potential to be incorporated into the Congestion Performance Management System. The following section highlights those most relevant to the objective of this study.

3.1 Highway Performance Monitoring System (HPMS) Network

As a national level highway information system, Highway Performance Monitor System (HPMS) includes data on the extent, condition, performance, usage and operating characteristics of the nation's highways (Office of Highway Policy Information 2015). The HPMS contains administrative and extent of system information on all public roads, while information on other characteristics is represented in HPMS as a mix of universe and sample data for arterial and collector functional systems. Limited information on travel and paved miles is included in summary form for the lowest functional systems.

HPMS was developed in 1978 as a continuing database, replacing the special biennial condition studies that had been conducted since 1965. The HPMS has been modified several times since its inception to reflect changes in the highway systems, legislation, and national priorities, to incorporate new technologies, and to consolidate or streamline reporting requirements. As documented in **Appendix 1**, the state transportation agencies are required to collect a number of metrics in five main categories: Inventory, Route, Traffic, Geometric and Pavement data.

Many state and local transportation agencies have been investing heavily on their facility inventory's databases and Geographic Information System (GIS). For example, New York State Department of Transportation (NYSDOT)'s Highway Data Services Bureau has built a roadway inventory database that stores hundreds of roadway features such as:

- Roadway location;
- Functional Classification, such as freeway, arterial, collector and local etc.;
- Physical characteristics, such as number of lanes, shoulder width, and ramp length, etc.;
- Traffic information; and
- Traffic control device inventory.

These RCI databases have been maintained for many years and used for many engineering, planning, and operating projects. However, due to its static data collection approaches, the critical elements of travel time and/or speed are usually missing or out of date. Until recently, the only source for speed data is the agency owned sensors. However, due to the high cost associated with deploying and maintaining the sensors, the number of sensors is very limited or often restricted on freeways and major arterials in core urban areas.

Both New York and New Jersey State Department of Transportation have collected and maintained Roadway Characteristic Inventories (RCI) for its respective highway systems. NYSDOT has created a linear referenced base map, in which each road segment was assigned a unique ID with starting and ending mileposts. The roadway segment ID and starting/ending mileposts were also stored in the database to ensure the proper connection between the base map and the database. Similarly, NJDOT also maintains its roadway inventory in a linear referenced GIS database in which each asset is identified by an ID and starting/ending mileposts.

3.2 Traffic Message Channel:

As a technology for delivering traffic and travel information to motor vehicle drivers, Traffic Message Channel (TMC) was originated about 30 years ago (Castle Rock Consultants, 1988). Its peak development around the millennium was associated with personal navigation devices (PND), such as Garmin, Tomtom and other similar applications. More recent development and application of traffic information delivering via mobile devices employing GPS have rendered the TMC less useful to end users on the road but its achieved databases may still be useful to government agencies, academia and practitioners to develop traffic trends and network performance measures.

3.3 HERE Traffic

As the successor of NAVSTREETS, the HERE Traffic Patterns contained in the HERE Map Contents provides traffic conditions and driving maneuvers layering on the basic street network (NavMart 2018). The network is updated yearly to reflect the latest change in roadways. It also serves as the base map for the navigation applications of the vendor.

HERE Traffic Portfolio use information collected from variety of devices across the globe including vehicle sensor data, smartphones, PNDs, road sensors and connected cars. The HERE Traffic data is monitored 24/7 to reflect incidents such as accidents and constructions. The HERE Traffic Data is updated every 60 seconds and is available across 100% of the roads in the 63 markets served by HERE Technologies (HERE Technologies 2018).

3.4 General Transit Feed Specification (GTFS)

As a common format for transit schedule and vehicle location open data, the General Transit Feed Specification (GTFS) was developed jointly between Google and TriMet, the public transit agency for Portland Oregon. GTFS defines a publishing standard for transit operational data, such as stops, stop times, and routes. With six mandated variables and seven optional variables, GTFS is hosted in a simple CSV spreadsheet with comma-delineated values. The simple structure of the database and commonly used software platform not only allow transit agencies large or small to share their operation data but also provide access for diversified users (McHugh 2013).

As a set of protocols to collect transit information, GTFS has been quickly adopted by a large number of transit agencies around the world due to its simple structure. A typical GTFS database contains only a few key data fields, such as:

- Agency: agency name, ID, URL, time zone, and other contact information;
- Calendar: the applicable dates and times for each schedule;
- Stop: the geographic location of each bus stop/station;
- Route: a list of bus routes ran by each agency;
- Trip: a list of scheduled bus trips for each route;
- Stop time: a trip's scheduled arrival and departure time at each stop along the route.

As an extension to the static GTFS, real-time GTFS is a feed specification that allows transit agencies provide real time updates about their fleet (Google 2015). While the basic GTFS provides the information that are mostly static, or seldom changing, GTFS-realtime provides the following three types of real time data:

- Trip Updates: it provides estimated arrival, departure, and/or delay vs published schedules at each stop along routes for each bus in real time;
- Service Alerts: it recognizes scheduling disruptions and changes that could impact stations, trips, routes, or the network performances;
- Vehicle Positions: it broadcasts positioning data including latitude, longitude, current speed, and odometer readings from the vehicle.

As shown in **Appendix 2**, the number of real time feeds are growing exponentially since the beginning of 2018. When examined the feeding link: (http://transitfeeds.com/search?q=gtfsrt) in February, the research team has recorded almost 60 feeds just in the U.S as shown in Table 1. When checked again in April, the researchers have observed more than 700 feeds while it is acknowledged that more backlog of feeds are accumulating in the pipelines (Transit Feeds 2018). The distribution of GTFS is worldwide as shown in Figure 1.

Table 2. GTFS Real Time Feed Locations
Source: Transit Feed 2018

Anchorage, AK, USA	Halifax, NS, Canada	Pierce County, WA, USA
Arlington, VA, USA	Kingston, ON, Canada	Portland, OR, USA
Atlanta, GA, USA	Lansing, MI, USA	Providence, RI, USA
Auckland, New Zealand	London, UK	Riverside, CA, USA
Austin, TX, USA	Louisville, KY, USA	Saint Louis, MO, USA
Barrie, ON, Canada	Luxembourg	San Antonio, TX, USA
Boston, MA, USA	Madison, WI, USA	San Francisco, CA, USA
Brisbane QLD, Australia	Maryland, USA	Santa Monica, CA, USA
Burlington, ON, Canada	Mississauga, ON, Canada	Saskatoon, SK, Canada
Cairns QLD, Australia	Monterey, CA, USA	Seattle, WA, USA
Calgary, AB, Canada	Montreal, QC, Canada	St Petersburg, Russia
Chicago, IL, USA	Nashville, TN, USA	Tampa, FL, USA
Cincinnati, OH, USA	Nassau, NY, USA	The Netherlands
Columbus, OH, USA	New Jersey, USA	Thunder Bay, ON, Canada
Connecticut, USA	New York, NY, USA	Vancouver, BC, Canada
Daytona Beach, FL, USA	Oakland, CA, USA	Virginia, USA
Denver, CO, USA	Olympia, WA, USA	Waterloo, ON, Canada
Edmonton, AB, Canada	Orange County, CA, USA	York, Toronto, ON, Canada
Eugene, OR, USA	Phoenix, AZ, USA	

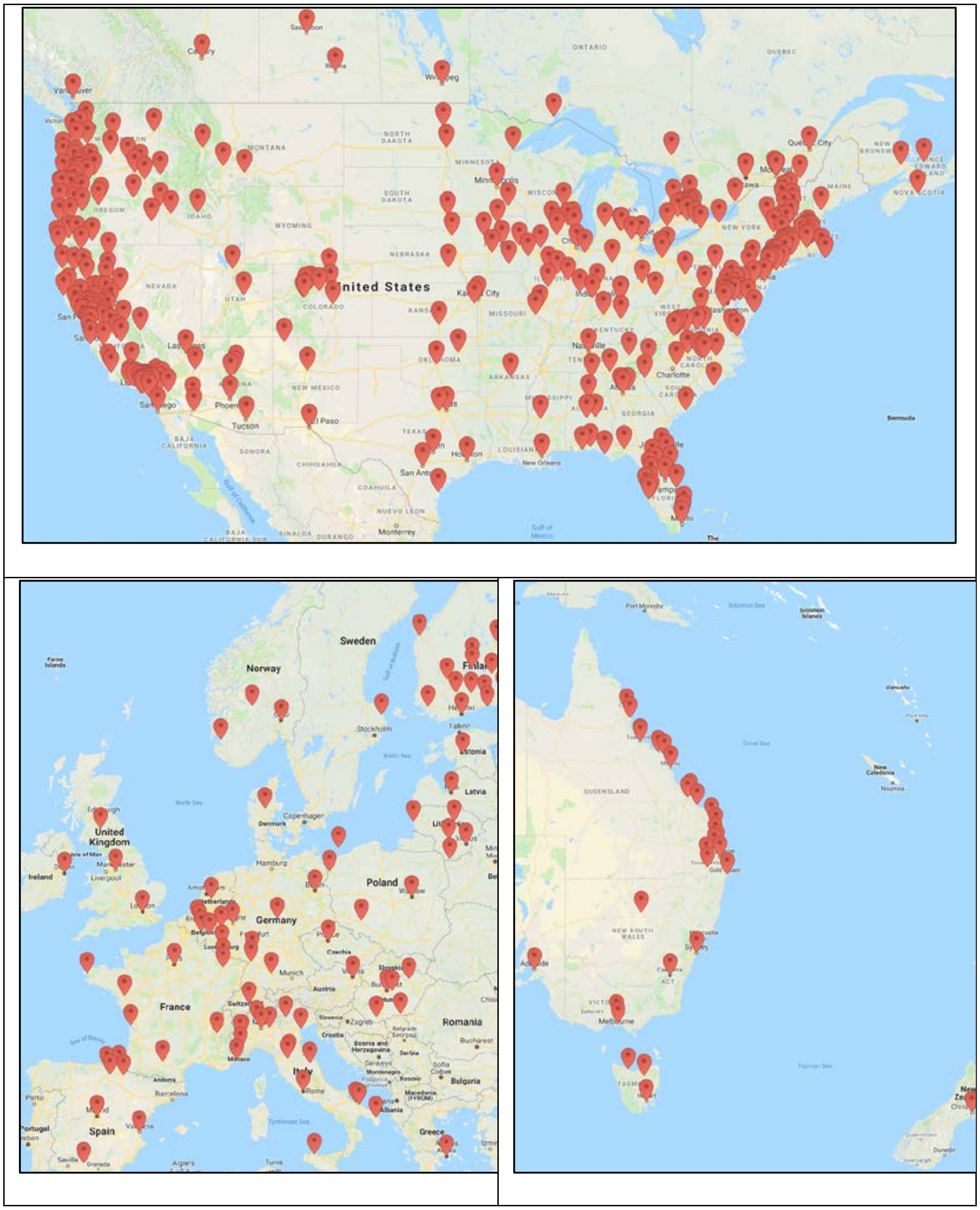


Figure 1. GTFS Subscribers around the World
Source: http://transitfeeds.com/feeds

3.5 Evaluation of Datasets

As the basic platform for transportation systems and travel patterns, GIS based transportation network is the first dataset or source for traffic information gathering, analysis and presentations. While the private industry has largely agreed on a standard location referencing system called Traffic Message Channel (TMC), TMC is not the same as LRS used by public agencies. There are some major differences between TMC and LRS:

- TMCs are directional; each direction of travel will have its own TMC. While DOTs are improving their map details, most of roads are referenced as a single direction, even on freeways.
- TMC is not referenced by mileposts; instead, it is normally segmented between major interchanges/intersections.
- TMCs have better coverages, especially on ramps and local roads. While DOTs are improving their ramp coverage, the interchange ramps are still missing from many maps.
- Some TMCs have different geographic alignments than the public maps.

On the other hand, private vendors have in recent years started providing travel time/speed data based on the location data from GPS navigation devices in fleets as well as personal vehicles. Therefore, instead of relying on sensor data from fixed locations, many agencies have started to use the travel time/speed data from private sector for regional or state-wide coverage on both freeways and arterials. For example, FHWA’s National Performance Management Research Data Set (NPMRDS) project collects archived 5-min link travel times on all National Highway System (NHS) from HERE, a private vender.

Comparing the analytical traffic pattern data on Traffic Message Channel (TMC) network with link based network by public agencies, Green (2013) noted that both data sets included average speeds, probe counts and standard deviation from each time interval for various times. While TMC network provides more reliable descriptive statistics, the link based network uses free-flow speeds in records with no probe data. Free-flow speeds are useful as a secondary estimate for travel times for navigation, but not for performance measures. Conversely, the coverage of the link-based network was significantly more prominent than that of the TMC-network.

Independent from highway performance measures, GTFS data, especially real time GTFS data, has emerged quickly since 2015. Most publications so far have focused on the use of static GTFS data, such as online applications to provide route and schedule information to transit users (Fortin, Morency, and Trepanier 2013), transit network optimization (Porter et al 2014) and transit operation and planning (Catala 2011). This research explores the potential to conflate GTFS and traffic data collected by private venders to measure congestion performance in urban and suburban locations, which is one of the contributions of this particular effort.

4. GTFS DATA USAGE

Existing literature has largely focused on the history, format and uses of static GTFS data, i.e. transit schedules. Since its release in 2006, GTFS has been increasingly used by transit agencies to publish their bus and rail schedules, which, in turn provides solid digital and GIS based transit information for researchers.

4.1 Delineating Transit Services

The early literature introduced the GTFS format, its unofficial industry stand among transit industrial and potential applications in transit analysis (Amey 2010). For example, Catalá, Downing and Hayward (2011) demonstrated that GTFS data provides a clear illustration of an agency's service and can be very helpful in understanding the impact of service change after highlighting the wealth of visualization techniques. The Delaware Valley Regional Planning Commission (DVRPC) modeling group cites the advantages of GTFS feeds to avoid manual coding errors, ease data integration among multiple providers and improve general data quality (Scherr, Burton and Puchalsky 2011). DOT of CA (Dion 2011) issued a final deployment package at 2011, which can be seen as the instruction manual of "Google Transit", the initial name for GTFS. The document includes GTFS resources, GTFS implementation process, transit data hosting/ maintenance models, and training resources, etc.

Aided by its simple format, easy to adopt standard and low cost for adoption and maintenance, GTFS has quickly become the unofficial industry standard by transit agencies and go to source for transit researchers. In Florida (Datz 2010) GTFS provided stop and route data for the travel assistant device (TAD). When GTFS unified TAD importing data from outside as a technical standard, all transit agencies modified their TAD system to be compatible with GTFS format. In Oregon (Porter 2014), State Department of Transportation (DOT) developed a software using open source GTFS to meet the Transit Network Analysis (TNA) need. The software can be used to visualize, analyze and report the Oregon transit network based on GTFS and Census data. A Transit IDEA Program (Williams and Sherrod 2011) developed a tool named “transit data feeder (TDF)” that enables small transit agencies to enter, export and host the transit data needed to put their transit information on Google Transit or GTFS.

Hiilsman (2011) explored the feasibility and challenges of using open transit data in multimodal trip planners. The study team made tremendous strides in developing OpenTripPlanner software and creating a framework and software to synchronize GTFS data and Open Street Map (OSM). The study demonstrated how GTFS format can be adapted to meet the requirements of multimodal trip planners and recommended the GTFS as the preferred input for multimodal trip planning applications.

Lee (2013) used GTFS data to delineate transit service areas and developed Stop Aggregation Model (SAM). The author derived detailed stop location information via GTFS and applied willing-to-walking distance, which made up the main elements of network-based service area delineations. Lee proposed three Stop Aggregation Models: Distance-Based Stop Aggregation Model (DBSAM), Text-Based Stop Aggregation Model (TBSAM) and Catchment Based Stop Aggregation Model (CBSAM) and demonstrated how to integrate all three approaches to enhance the capabilities of SAM.

In addition to its popularity with transit agencies in the U.S, GTFS has also been widely adopted in various international locations. For example, Eros (2014) documented GTFS created by different transit providers in Mexico City and demonstrated various applications and planning tools based on GTFS to improve transit services. Gkiotsalitis (2016) tried to improve the operations of demand-responsive transit system by examining the joint-leisure-trips. Utilizing GTFS data from Sweden, the author proposed transit schedule changes to serve leisure trips better.

4.2 Conflating GTFS and Other Data Sources

As one of the late comers on transportation “block”, GTFS has been quickly amalgamated into various analyses to supplement travel time and speed data from other channels. For example, CALTRAN (Sauer 2012) has explored the use of GTFS in conjunction with National Transit Database (NTD) to plan, operate and improve transit services. Using CALTRAN experience as a case study, Sauer (201) has documented GTFS implementation process, estimated data hosting and maintenance costs and suggested an open data ecosystem via subscription, which is largely the format currently in use for gathering GTFS around the world.

Guthrie (2016) used GTFS data to forecast the accessibility for the future transit network. Combining census tract and GTFS data layers, the author has delineated potential transit access region around a centroid, which has the potential to incorporate population and other factors into transit planning processes.

Many existing studies combined GTFS data with other transit statistics, such as ticket revenue, number of passengers, or map data for market analysis or data comparison. For example, Bertolaccini (2015) developed a python script for calculate Transit Opportunity Index (TOI) based on the GTFS and ArcGIS. Cicha (2016) introduced method to use GTFS and Open Street Map (OSM) to identify candidate network links for transit users. Lawson (2016) used GTFS routes source to define market area and combined GTFS data and Census data to complete the Transit Market Analyst.

Bick (2011) introduced a method to understand transit vehicle lateness by matching archived GPS data provided through NextBus with the corresponding schedule provided in GTFS format. Giraud (2016) developed a method to link smart card, automated passenger counting system and GTFS data. Mai (2011) used GTFS schedule data and Automated Passenger Counter (APC) data to redesign Marey graph for measuring transit performance.

4.3 Evaluating Transit Performances

Early studies have focused the transit network accessibility since the GTFS data contains all the basic information for transit systems. For example, Owen (2015) calculated accessibility to jobs via transit in the 49 of 50 largest metropolitan areas using GTFS data. An accessibility rank was developed for the cities and detailed accessibility information was provided even the report did not provide detailed methodology. Wong (2013) documented effort in using multiple feeds to represent multiple agencies whose metrics could be compared. Kiavash and Fayyaz (2017) used GTFS data to analyze dynamic transit accessibility. Using transit stops, routes and trip information collected via GTFS, the researchers have mapped out the connected routes to station, under the constraints of max transfer numbers and max walking distance allowed. They also calibrated all-pairs travel time and Weighted Average Travel Time (WATT) as performance measures. Similar approaches can be found in other studies (Wessel 2017 and Oh 2017).

As the latest development of GTFS data, GTFS-R (Realtime) supplies the transit data with real time vehicle location, stop, and trip data collected and published by various transit agencies. There were some early attempts to utilize GTFS-R data even the transit industry is still in the early stages of collecting, processing and figuring out how to use the data. For example, the Massachusetts Bay Transportation Authority (MBTA) created a new system, MBTA-performance, which generates subway performance metrics in real-time using GTFS-R data feeds and makes them publicly available (Tribone 2015). Another paper developed a model to estimate crowding conditions using GTFS- R data. The proposed algorithm uses GTFS-RT data as input to predict train arrival times, then assign passengers on the platform to an incoming train (Caspari 2016).

National Center for Intermodal Transportation for Economic Competitiveness (CITEC) (Hu 2015) developed a real-time online decision support system for optimize intermodal travel. In this project, Hu and his team combined data from GTFS and Transit agency with Python and GIS. With an all-in-one database setup, the application was used to be optimize travel routes for passengers and GTFS data, including static and real-time data, were used to estimate travel time and travel time reliability in the existed transit network.

5. DEVELOPING PERFORMANCE MEASURES

In today’s fast growing market and digital government, it is important to transform numerous and often disparate data sources into knowledge that supports critical decision making in a timely manner. The challenge remains in the accurate and efficient conflation of geographic information with various databases from public agencies and private institutions. In the field of mapping/Geographic Information Systems (GIS), conflation is defined as the process of combining geographic information from overlapping sources so as to retain accurate data, minimize redundancy, and reconcile data conflicts accordingly (Longley 2001).

After evaluating a number of datasets as candidates to CPMS, the research team has focused on the real time auto travel data collected by private vendors and Real Time GTFS for the same corridor/network. Studies documented in the existing literature have largely focused on the transit vehicle, route or coverages. There is no comparison between transit and automobile travel along the same corridor. Conflating real time auto and transit travel data from both private and public sources, the research team developed a series of congestion performance measures to be used for travel navigation and congestion management.

5.1 Transit Service Reliability

The very first set of metrics that can be developed using both static and real time GTFS data is service reliability, which measures the difference between published schedule and real time travel trajectories. The comparison between the transit schedule, statics GTFS data, and actual transit travel trajectory via GTFS real time data not only provides bench marking for transit performance but also has the potential to guide transit operations planning. Detailed procedures to clean up both static and real time GTFS data and compute transit service reliability is demonstrated in the following case application.

5.2 Minimum Expected Arrival Time (Meat) for Transit

Many researchers (Fu and Xin 2007, Polzin et al 2002, and Hensher et al. 2004) have attempted to develop transit service quality indicators and performance measures. However, limited by the data availability, there is no commonly accepted indicator or index such far. Even the transit level of service indicators defined via the TSQM are not able to address the major aspects of transit services. For example, the service coverage, frequency, and span measures transit availability/ supply but not the demand distribution and/or comfort and convenience, therefore it is hard to gauge the quality of transit services.

Assisted by the ubiquitous mobile interaction points, travel time/speed along a corridor/route can be easily estimated and have been widely used in applications such as Google Maps, Navistreet, and other hand held navigation devices. In comparison, travel time/speed for transit is much more complex as it not only involves roadway links but also stops/transfers. One potential approach is to use Real Time GTFS to estimate the travel time/arrival, which will be beneficial to real travel time route choices and long term mode choices.

When GTFS Realtime Data is harvested, trips are represented by polylines that are defined by latitudes and longitudes (lat/lon) of multiple points that generally follow roadway alignments. The distance between two points is calculated by the lat/lon of the points under a projected coordinate system that is based on the wgs84 datum (EPSG 3857). Line distances are also verified by the vector length function in the QGIS geometry tool.

As demonstrated in Figure 2, the bus locations are fairly accurate when trip distances are calculated between lat/lon and trip shape file polylines. With very frequent, every 30 seconds, bus location data collected via GTFS Realtime, it is quite possible to estimate and forecast MEAT for Transit. Adopting the Connection Scan Algorithms (CSA) developed by Dibbelt, et al. (2013), the research team has developed an intriguingly simple and fast transit routing process that considers stochastic delays and estimates the Minimum Expected Arrival Time for transit users. Using the GTFS realtime data and applying the CSA approach, the research team has developed MEAT for the study area.

As shown in Figure 3, the average distance between two points along the bus trajectory is around 45 meters, or 150 feet, based on the sample data from New York City Metropolitan Transportation Authority (MTA). Some of extreme values are deemed erroneous and removed from further analysis.

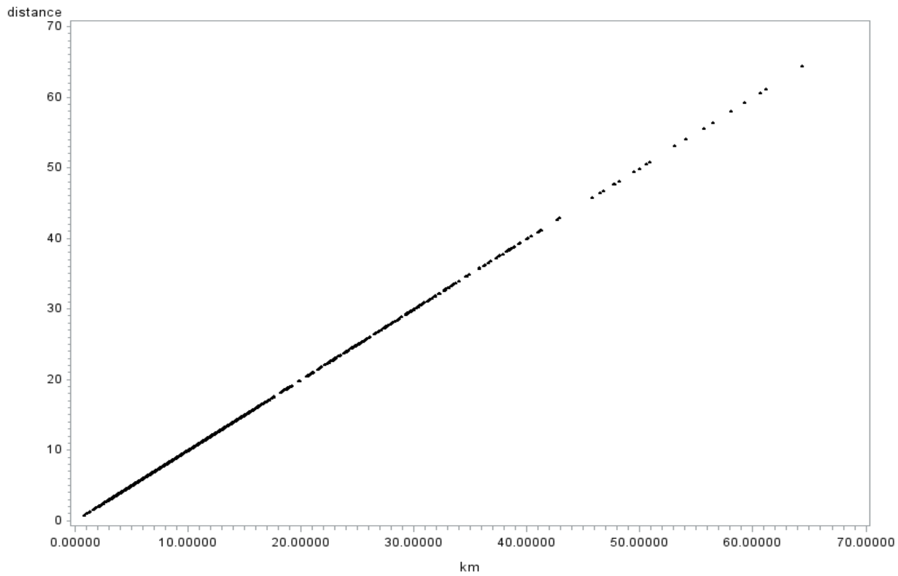


Figure 2. Trip Distances Calculated from Lat/Lon vs Trip Shapefile Polylines

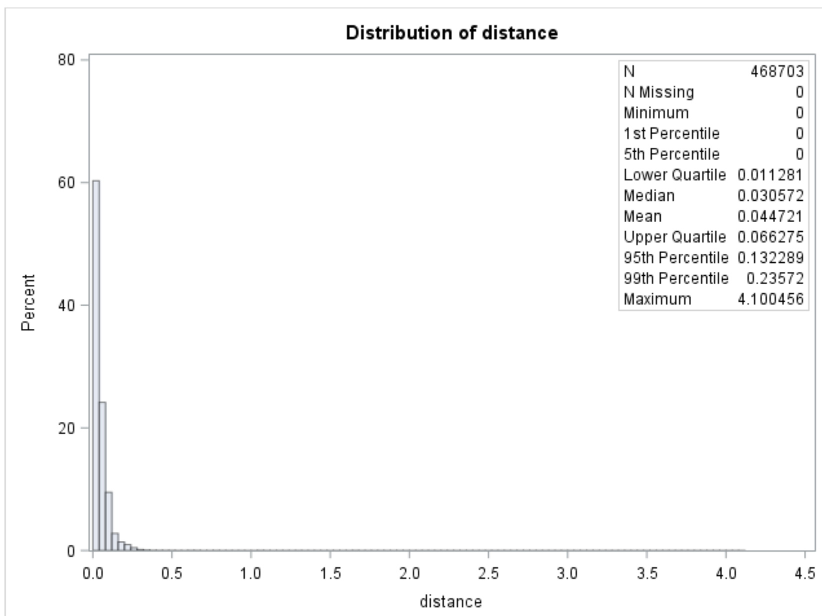


Figure 3. Distribution of Distances between Two Points Source Data: MTA Oct 25, 2017

5.3 Speed Ratio for Auto and Transit Travel

By incorporating both automobile and transit travel time into travel demand forecast network models, Fu and Xin (2007) has derived **transit auto travel time difference**, which could be the first step to evaluate the transit performance by marrying both supply and demand for travel services along a particular corridor or region. The research team has adopted the concept of transit auto travel time differences but derived different algorithm, Speed Ratio of Auto and Transit (SRAT), to measure the travel time differences between auto and transit in the same corridor.

6. A SAMPLE APPLICATION

A case study is included here to demonstrate the data collection, cleaning, processing and network conflation process. Midtown Manhattan is chosen to evaluate transit service reliability, compare the travel metrics between auto and transit, and to show the travel condition distributions spatially and temporally. A series of performance measures are identified and derived to highlight the effectiveness and validity of proposed metrics.

6.1 Transit Routes in Midtown Manhattan NY

Selecting midtown Manhattan as the testing area, the research team has obtained data from New York City Metropolitan Transportation Authority (NYCMTA) on bus routes and HERE for roadway maps and auto traffic information. As shown in Figure 4, there are several bus routes running along the main thoroughfares:

- Bus route M42 on 42nd St, both directions;
- Bus routes M1, M2, M3, and M4 on Madison Av between 23rd St and 72nd St, northbound only along one-way street.

There are some additional bus services, such as express buses run by neighboring borough or state agencies that would also make stops on the test segments but the team focused on the MTA buses only.

The research team has harvested static GTFS files from transitfeeds.com. And MTA provided a sample of the real time GTFS data archived on Oct 25, 2017. The bus position was recorded every 30 seconds with Bus ID, Trip ID, Route ID, Next scheduled bus stop and Lat/Lon.

Figure 4. Selected Bus Routes along 42 St and Madison Ave. NYC

6.2 Static Route Configuration

As shown in Figure 5, the initial mapping of bus positions, grey dots, and bus stop locations, red dots, are well aligned with the main roadways, 42nd street and Madison Ave, which indicates the high quality GPS equipment installed on MTA buses, therefore; high confidence on location data. The static GTFS data is used to identify the bus stops, which are the key points to configure bus routes along the roadways. There are two simple steps involved in the process, first calculate the distance between two adjacent bus stations based on their lat/lon, then identify the bus routes that stop at the stations. With limited bus routes, the process is straightforward.

On the other hand, one potential issues is that some stations have inconsistent latitude and longitude from different borough feeds, the stations that are closest to the downstream intersections are kept. When station shape files are available, the accuracy is improved by snapping the vehicle locations onto the stop locations.

6.3 Real Time Bus Position Identification

In order to estimate the travel speed, the research team need to locate the bus positions in real time. As the time intervals between bus positions contained in real time GTFS file is usually consistent about 30 second with a few exceptions, the researchers have removed those less than 20 seconds and longer than 40 seconds to maintain a fairly consistent time interval between bus position points.

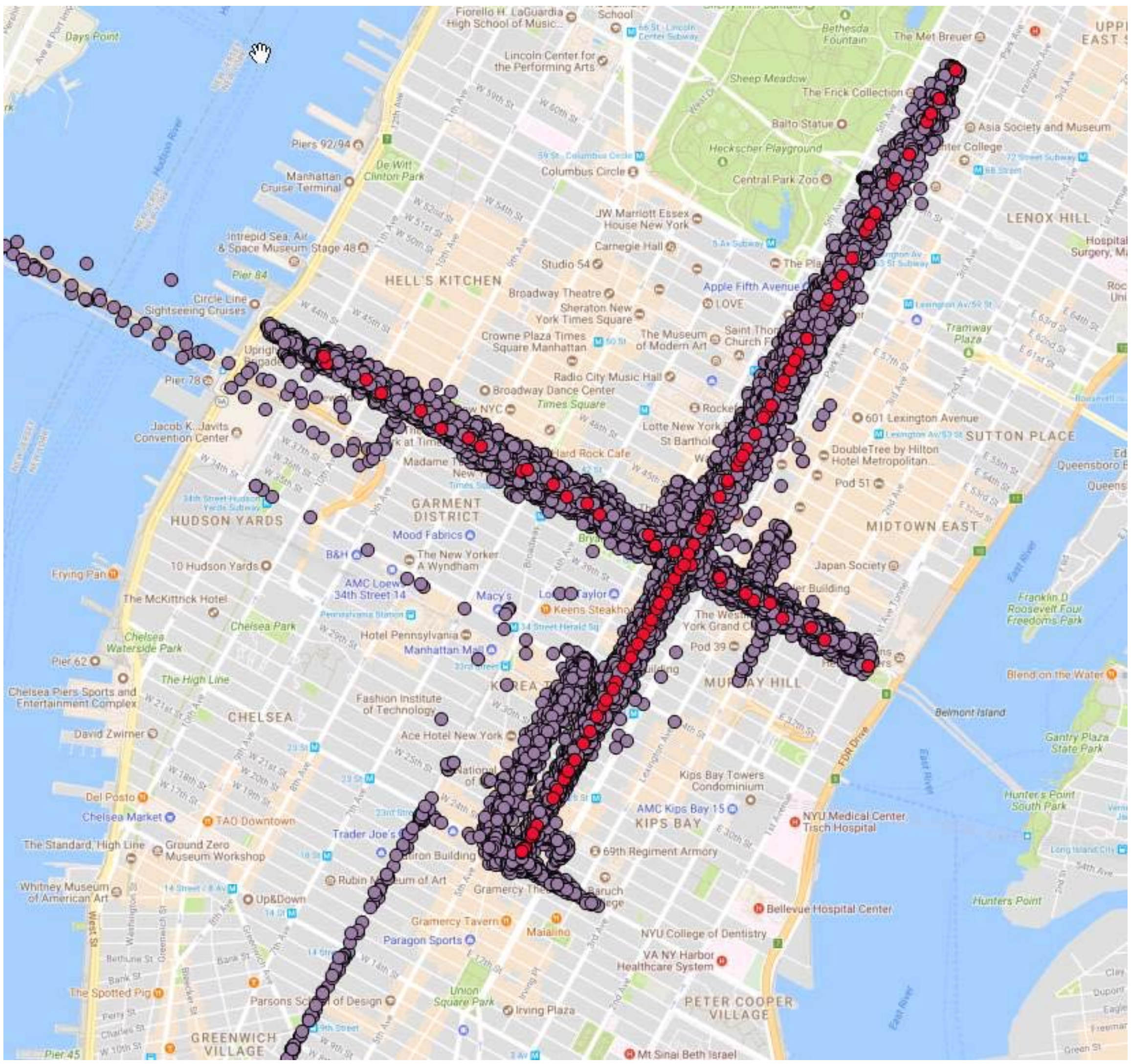


Figure 5. Bus Positions and Stop Locations

The next step is to identify a unique bus: “Trip ID” was first thought to be a unique, but it was found that multiple bus IDs existed within a single “trip ID”, so a new identifier, “Trip_ID_Bus_ID”, was constructed as the unique identifier for a single trip by an individual bus. As shown in Figure 6, the distribution of time intervals are tightly concentrated around 34 seconds.

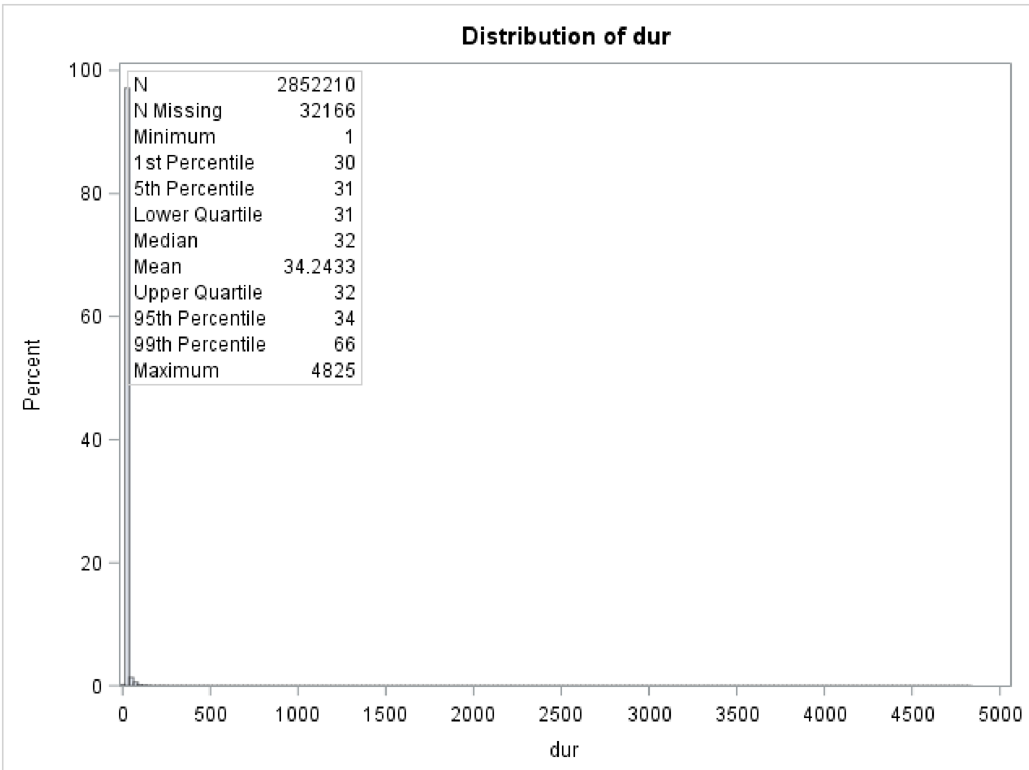


Figure 6. Distribution of Duration between Observations

A large number of records are retained and demonstrated in Figure 7, when applying the following criterion:

- “Next Bus Stop ID” is within the test routes;
- Bus lat/lon is within a tight polygon around the test routes;
- Buses that traveling backwards are also removed.

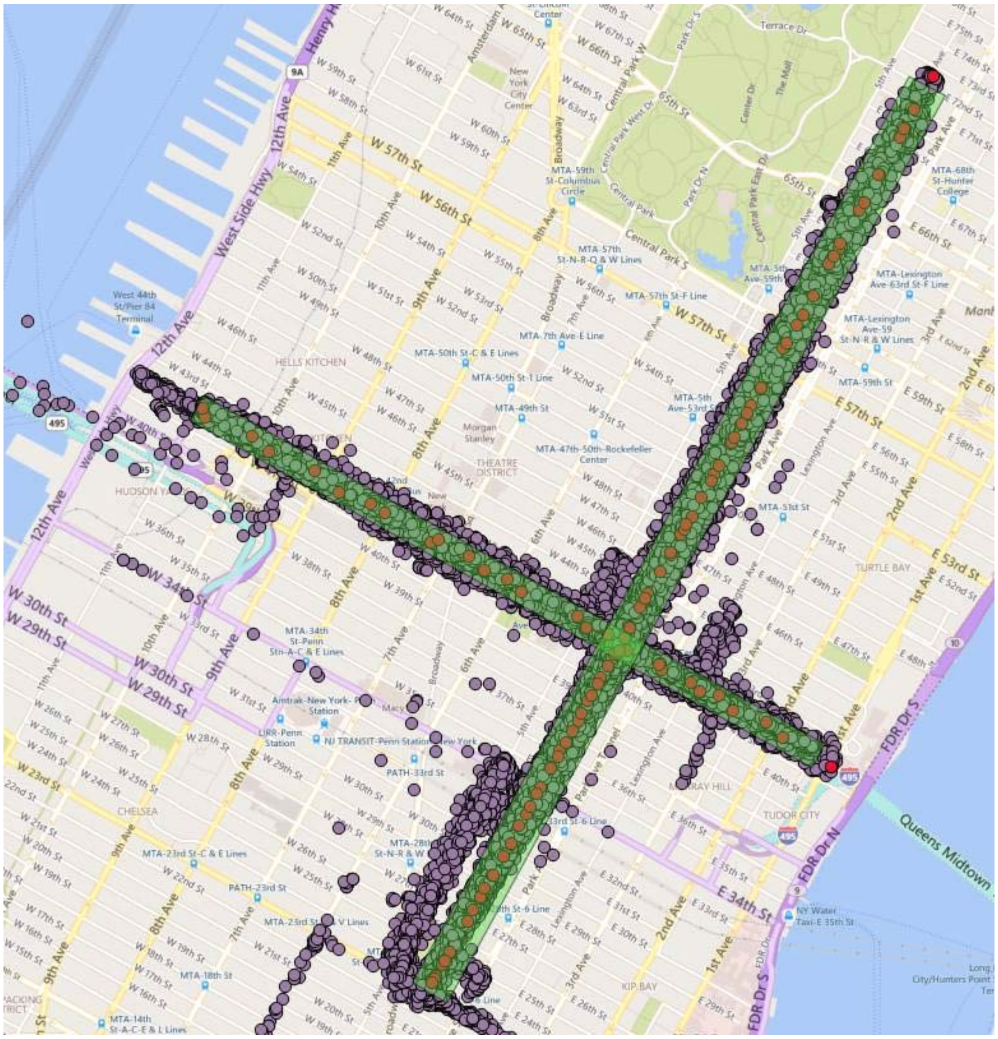


Figure 7. GPS Point Selections along Bus Routes

6.4 Bus Performance

The research team has developed a series of time-space diagrams for various bus routes using GTFS RT data as shown in Figure 8. A quick scan of the time-space diagram for both East and West directions along 42nd st. reveals the travel conditions throughout the day and along the entire route. For example, the top graph in Figure 8 shows that delays occured during the morning peak period, from 7 to 9 am, particularly around location 1 and 2, which roughly correspond to Time Square and United Nations Plaza.

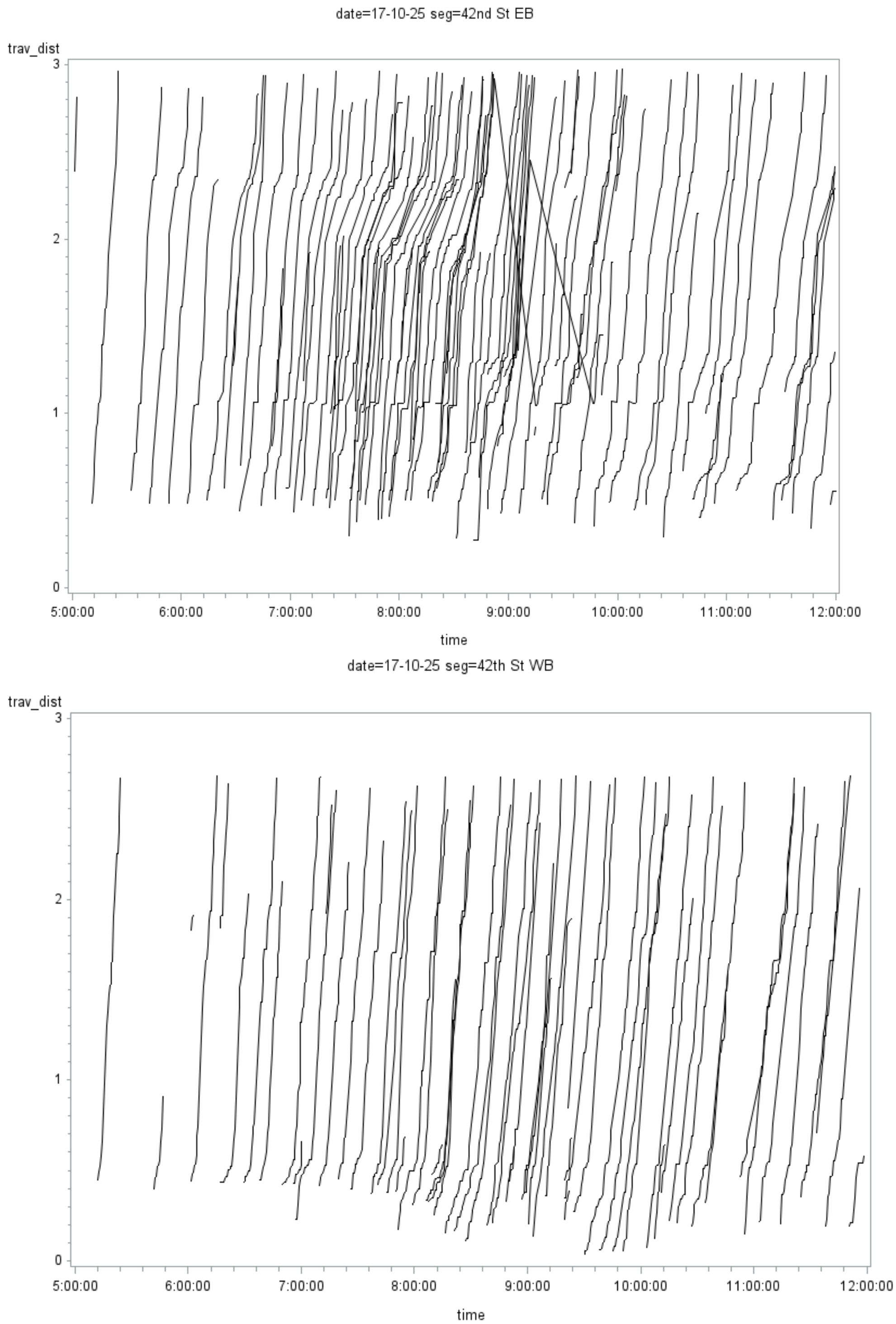


Figure 8. Time - Space Diagram for 42nd St.

Further comparison between schedule and GTFS data shows the congestion conditions and effectiveness of transit operations planning. As shown in Figure 9, the mean speed for schedule transit trips is around 13 KMPH while the real time GTFS data shows the mean speed of the same route around 11 KMPH.

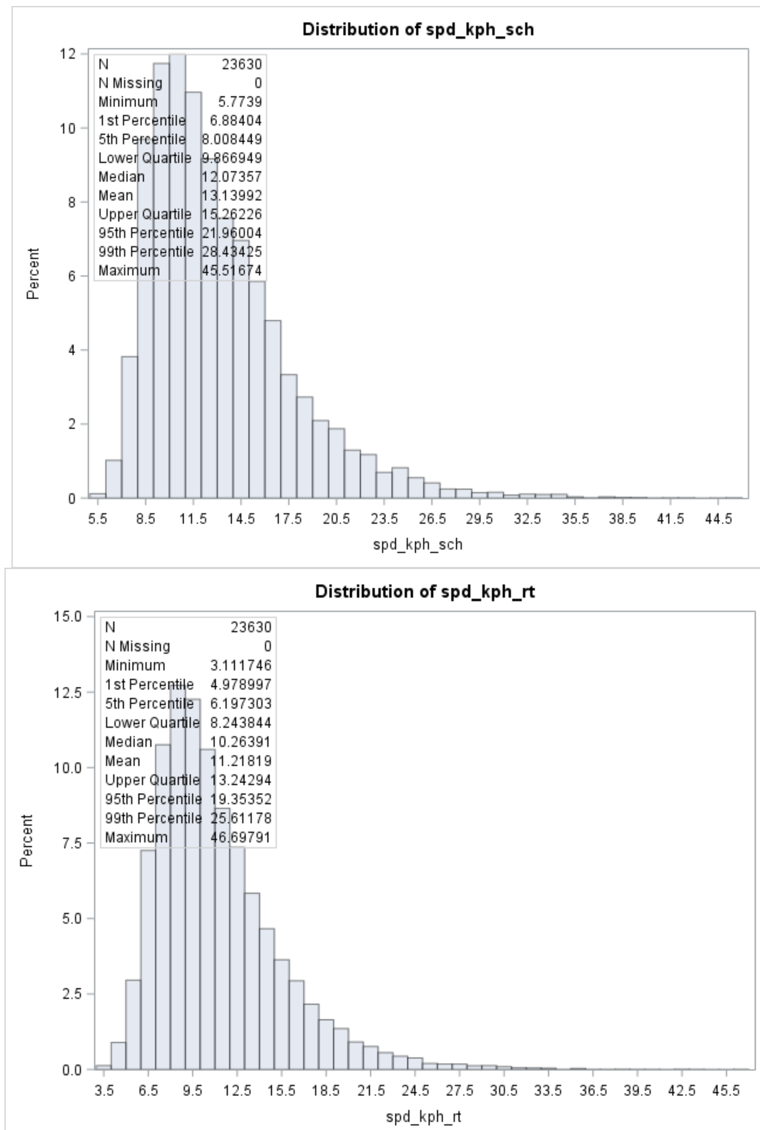


Figure 9. Speed Distribution Comparison between Scheduled and Real Time Travel

6.5 Comparing with Probe Vehicle Data

The research team also examined the raw probe vehicle speed data from a private source, to verify and/or supplement the GTFS data. A quick comparison of both data shows that speed distributions are similar, especially up to 75% percentile as shown in Figure 10.

Anticipating the auto probe data will improve in the future or other sources data becomes available, the research team has developed algorithm to derive the Speed Ratio of Auto and Transit (SRAT) travel, which has the potential to measure the auto and transit travel time differences. Assuming the ratio is stable, the performance along a particular route can be measure via probe vehicle data if it is available or GTFS data even when the probe vehicle is not present or insufficient.

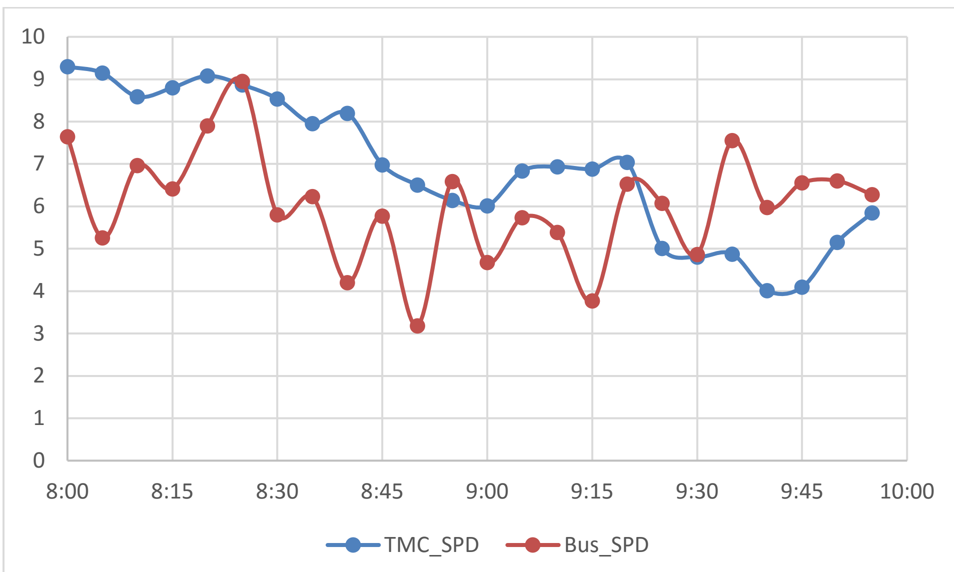


Figure 10. Speed Distribution by Auto and Transit

6.6 Congestion Detection

The research team has tested various space and time speeds along various bus routes in order to select appropriate parameters to measure performance and identify congestion. Given the high density location data obtained from GTFS,   the space speed every 100 meters were calculated and presented in Figure 11.

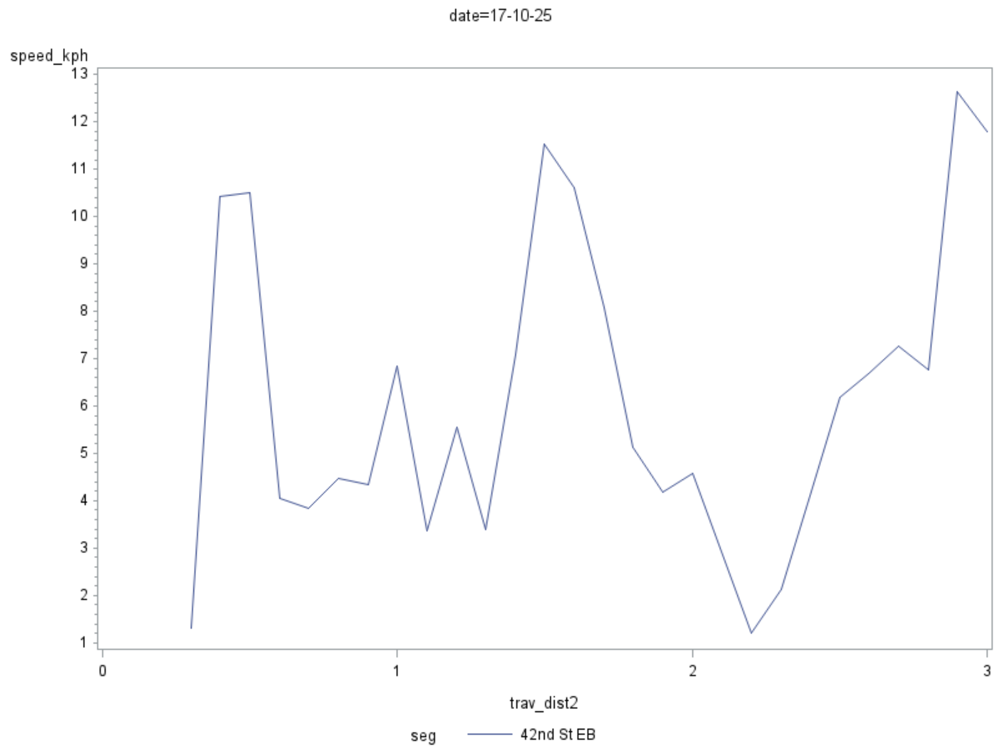


Figure 11. Speed Profile along 42 St. East Bound

A quick calculation of 15 minute travel speed are also derived to measure the travel conditions throughout the day and along various locations of the bus route. As shown in Figure 12, both 42nd street and Madison Ave were congested throughout the day, bus speeds were lower than 5 KMPH during the day and went up to above 10 KMPH before 6 am and after 8 PM. Further examination reviews that 42nd St. is more congested than Madison Ave, which is consistent with our general observations in Manhattan, subway provides much needed transit services along the north-south direction while east-west travel is largely dependent on bus or auto, surface transportation alone, therefore, much more congested. Another characteristic of spatial distribution of bus travel in Manhattan is highlighted by the very low speed around Time Square, both M42 and Madison Ave Routes exhibit a dip in speed, which further proves the congested conditions in the heart of midtown Manhattan.

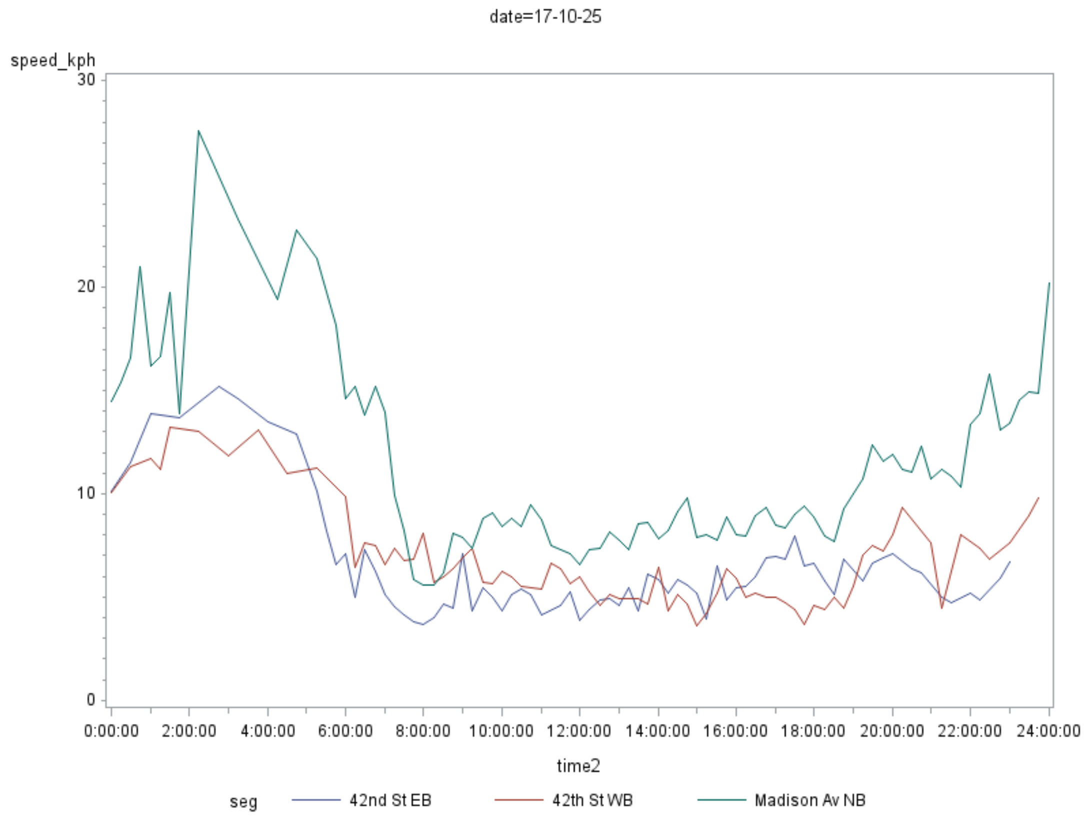


Figure 12. Temporal Distribution of Speeds

Overlaying the bus travel trajectories with associated speed contours, it is possible to detect congestion in the both spatial and temporal dimensions. As shown in Figure 13, the bus travel trajectories are plotted along time and space, horizontal and vertical axis, respectively, using northbound bus on Madison Ave starting at 23rd St as an example. Each black spot represents a data point and the slope of the blue line indicates the speed contour. Congestion bottleneck locations, such as the yellow triangular area, in both time and space can be identified when and where the bus trajectories went flatter. Previously, the probe auto data alone was only able to outline a congestion rectangle. Overlaying GTFS real time data, a congestion triangle starts to form at 2.3 km from the route start point around 6:40 AM and clears around 9:00 AM, which is more realistic and close to the real world situations.

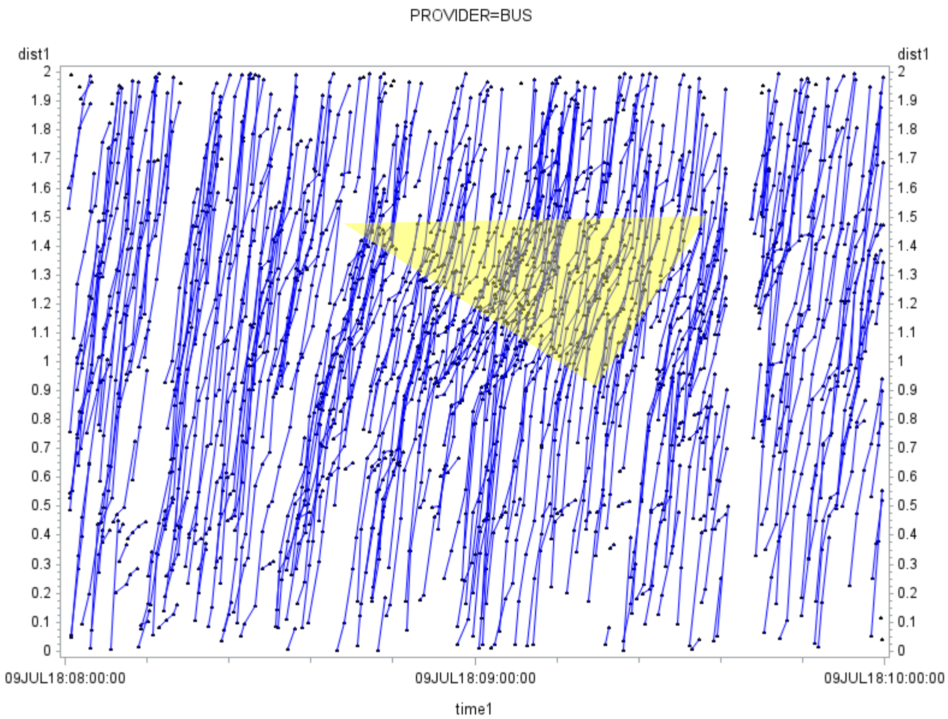


Figure 13. Congestion Detection

7. SUMMARY

Data integration is increasingly being recognized in the transportation sector as a valuable asset-forming activity that has the potential to improve decision making process even map conflation is a relatively young and emerging research field. The critical need for data conflation is becoming more predominant while large quantities of data from diversified sources grow exponentially. The timing is ripe for transportation professionals to develop and utilize adequate conflation techniques to improve our transportation research and asset management systems.

REFERENCES

Amey, Andrew "The Importance of a Common Data Specification for Ridesharing" TDM Review. Winter 2010.

Barbeau, Sean; Georggi, Nevine Labib and Winters, Philip "Travel Assistance Device Deployment to Transit Agencies" State of Florida Department of Transportation. August 2010.

Bertolaccini, Kelly and Lownes, Nicholas E "Using GTFS Data to Measure and Map Transit Accessibility" Transportation Research Board 94th Annual Meeting Washington DC. 2015.

Castle Rock Consultants. *Radio Data System (RDS) Traffic Message Channel (TMC).* Final Report to the Commission of the European Communities, DRIVE Project V1029, Nottingham, UK, October 1988.

Cicha, Glenn, et al. "Data Preparation to Simulate Public Transport in Micro-Simulations using OSM and GTFS" Computer Science 83, Pp 50–57. 2016.

Dibbelt, J. et al. "Intriguingly Simple and Fast Transit Routing" Karlsruhe Institute of Technology (KIT) 76128 Karsruhe Germany.

Dion, François; Grace Lin, Krute Singa, and Manju Kumar "Online Transit Trip Planner for Small Agencies Using Google Transit: Final Deployment Package" California PATH Research Report UCB-ITS-CWP-2011-7. Sep 2011.

Eros, Emily; Mehndiratta, Shomik; Zegras, Chris; Webb, Kevin and Ochoa, Maria "Applying the General Transit Feed Specification to the Global South." Transportation Research Record: Journal of the Transportation Research Board 2442 44–52. December 2014.

Ewing, Reid; Hamidi, Shima "Measuring Sprawl 2014" Smart Growth America. April 2014

Federal Highway Administration, 2017. "Metropolitan Planning" https://www.fhwa.dot.gov/fastact/factsheets/metropolitanplanningfs.cfm. Accessed in March 2017.

Fortin, P., C. Morency, and M. Trepanier, 2016. “Innovative GTFS Data Application for Transit Network Analysis Using a Graph-Oriented Method”. Journal of Public Transportation, Vol. 19, No. 4, Pp 18-37. 2016.

Fu, Liping and Yaping Xin, 2007. “A New Performance Index for Evaluating Transit Quality of Service”, Journal of Public Transportation Vol. 10, No. 3 2007.

Giraud, Antoine “Data Fusion of APC, smart Card and GTFS to Visualize Public Transit Use” CIRRELT-2016-54. Oct 2016.

Gkiotsalitis, Konstantinos; Stathopoulos, Antony “Demand-responsive public transportation re-scheduling for adjusting to the joint leisure activity demand” International Journal of Transportation Science and Technology 5 P68–82. 2016.

Google Developer, 2015. “GTFS Realtime Overview” https://developers.google.com/transit/gtfs-realtime/. Accessed in August 2017.

Green, E. R., et al. 2013. “Conflation Methodologies to Incorporate Consumer Travel Data Into State HPMS Datasets” Proceedings of Transportation Research Board 2013 Annual Meeting. Washington DC. 2013.

Guthrie, Andrew; Fan, Yingling and Das, Kirti Vardhan “Accessibility Scenario Analysis of a Hypothetical Future Transit Network” Transportation Research Record: Journal of the Transportation Research Board Vol. 2671, pp. 1-9. Jan 2017.

HERE Technologies, 2018. “HERE Traffic Overview” https://www.here.com/en/products-services/here-traffic-suite/here-traffic-overview. Accessed in May 2018.

Hillsman, Edward L.; Sran J. Barbeau “Enabling Cost-Effective Multimodal Trip Planners through Open Transit Data” Florida Department of Transportation. May 2011.

Hu, Mengqi; Wu, Yao-Jan; Chen, Yang and Yang, Shu “A Real-Time Online Decision Support System for Intermodal Passenger Travel” NCITEC Project No.2013-13. September 2015.

Intelligent Transportation Systems Joint Program Office, 2017. "Trilateral Probe Data" https://www.its.dot.gov/factsheets/us_japan_probedata.htm. Accessed in July 2017.

Kiavash, S.; Fayyaz, S.; Liu, Xiaoyue Cathy; Zhang, Guohui "An efficient General Transit Feed Specification (GTFS) enabled algorithm for dynamic transit accessibility analysis" PLOS ONE. October 5, 2017.

Lawson, Catherine "Integration of Bus Stop Count Data with Census Data for Improving Bus Service" University Transportation Research Center. 2015.

Lee, Sang; Daoqin Tong, Mark Hickman "Generating Route-Level Mutually Exclusive Service Areas" Transportation Research Record: Journal of the Transportation Research Board Dec Vol. 2350, pp. 37-46. 2013.

McHugh, 2013. "Pioneer Open Data Standards: The GTFS Story". In Beyond Transparency, Edited by B. Goldstein. http://beyondtransparency.org/chapters/preface/. Accessed in August 2017.

Navmart 2018. "Here Map Content Comparison Sheet" https://navmart.com/here-navstreets-comparison/. Accessed in Jan 2018.

Office of Highway Policy Information, 2015. "Highway Performance Monitoring System (HPMS), https://www.fhwa.dot.gov/policyinformation/hpms.cfm. Accessed in August 2017.

Oh, Jun-Seok; C. Scott Smith, Rostam Qatra, Mohammad Al-Akash "Estimating and Enhancing Public Transit Accessibility for People with Mobility Limitations" Transportation Research Center for Livable Communities (TRCLC). June 30, 2017.

Owen, Andrew; Murphy, Brendan and Levinson, David "Access Across America Transit 2015" University of Minnesota CTS16-09. December 2016.

Porter, J. David; David S. Kim, Saeed Ghanbartehrani “Proof of Concept: GTFS Data as a Basis for Optimization of Oregon’s Regional and Statewide Transit Networks” Final Report SPR 752. May 2014.

Roush, Wade “Welcome to Google transit: How (and why) the search giant is remapping public transportation” Community Transportation. 2012.

Sauer, Scott, 2012. “Integrating Transit Data into State Highway Planning” Caltrans Division of Mass Transportation. July 2, 2012

Scherr, W.; G. Burton and C. Puchalsky 2011. “A Paradigm Shift in Travel Forecasting: Let Web 2.0 Feed the Network Model” Proceedings of Transportation Research Board 2013 Annual Meeting. Washington DC. 2011.

Tribone, Dominick; Riegel, Laura; Warade, Ritesh and Barker, David “Measuring Transit Agency Performance Using Open Realtime Data” Proceedings of Transportation Research Board 95th Annual Meeting. Washington DC. 2016.

VReddy, Alla; Hanft, Jeffrey; Levine, Brian and Caspari, Adam “Real-Time Estimation of Platform Crowding for New York City Subway” Proceedings of Transportation Research Board 96th Annual Meeting. Washington DC. 2017.

Vuurstaek, J., Cich, G., Knapen, L., Yasar, A.-U.-H., Bellemans, T., Janssens, D. “GTFS Bus Stop Mapping to the OSM Network” Procedia Computer Science
Volume 109, Pages 50-58. 2017.

Wessel, Nate; Allen, Jeff; Farber, Steven “Constructing a routable retrospective transit timetable from a real-time vehicle location feed and GTFS” Journal of Transport Geography Volume 62, Pages 92-97. June 2017.

Williams, Bruce; Sherrod, Prescott ‘Google Transit Data Tool for Small Transit Agencies” TRANSIT-IDEA Program Project Final Report 58 2017

Wong, J. 2013. Use of the General Transit Feed Specification (GTFS) in Transit Performance Measurement, A thesis Presented to the Academic Faculty, Georgia Institute of Technology. Dec 2013.

APPENDIX 1. HIGHWAY PERFORMANCE MONITORING SYSTEMS

U.S. Department of Transportation
Federal Highway Administration
1200 New Jersey Avenue, SE
Washington, DC 20590
202-366-4000

Policy and Governmental Affairs
Office of Highway Policy Information

Office of Highway Policy Information
March 2014

Field Manual
Chapter 4: DATA REQUIREMENTS AND SPECIFICATIONS

4.3 Data Items to be Collected

Table 4.2 lists the data items that are to be collected by the States, which must be reported in the Sections dataset. The five types of data items that are to be reported are as follows: Inventory, Route, Traffic, Geometric, and Pavement data. In addition to the Data Item Type(s), Table 4.2 lists the Item Numbers for each Data Item, the specific name for each Data Item, and the Extent for which the Data Item is to be reported. Detailed information on coding instructions, extent requirements, and additional guidance for each Data Item is contained in Section 4.4.

The Table of Potential Samples (TOPS) (discussed in Section 6.2) is developed based on the spatial intersection of the following five data items: Functional System, Urban Code, Facility Type, Through Lanes, and AADT. Accordingly, the length of these data items are used as control totals for system extent. Each of these data items must be reported for the entire extent of all Federal-aid highways for a given State.

The HPMS is an inventory system that requires reported data to represent the condition and operation in both directions for all roadways. As a result, directional conflicts in coding may arise for specific data items under certain reporting conditions. The following provides some guidance on how these conflicts can be addressed.

Data items may differ in shape or dimension on either side of a roadway. To resolve this, one side of the facility should be designated for inventory purposes, and the applicable data items should be coded for the designated side of the roadway. The "inventory direction" should be applied on a statewide basis (i.e., always South to North, East to West, or vice versa) and should never change once it has been designated.

Information reported for some data items such as AADT, Through Lanes, Median Width, etc., must reflect the entire facility (i.e., bi-directional information). Caution should be exercised when reporting Through Lane totals and AADT because these data are used for apportionment purposes.

As indicated in Chapter 5 on Pavement Guidance, IRI must be reported for the same inventory direction and lane all of the time. The "inventory direction" of a facility should be used as the side where IRI is measured and reported. IRI should not be reported or averaged for both sides of a roadway.

Table 4.2: Data Items

Data Item Type	Item Number	Database-Specific Data Item Name	Data Item Name	Extent	
Inventory	1	F_System	Functional System	FE + R	

	2	Urban_Code	Urban Code	FE + R	
	3	Facility_Type	Facility Type	FE + R	
	4	Structure_Type	Structure Type	FE**	
	5	Access_Control	Access Control	FE*	SP*
	6	Ownership	Ownership	FE	
	7	Through_Lanes	Through Lanes	FE + R	
	8	HOV_Type	HOV Operations Type	FE**	
	9	HOV_Lanes	HOV Lanes	FE**	
	10	Peak_Lanes	Peak Lanes		SP
	11	Counter_Peak_ Lanes	Counter Peak Lanes		SP
	12	Turn_Lanes_R	Right Turn Lanes		SP
	13	Turn_Lanes_L	Left Turn Lanes		SP
	14	Speed_Limit	Speed Limit		SP
	15	Toll_Charged	Toll Charged	FE**	
	16	Toll_Type	Toll Type	FE**	
Route	17	Route_Number	Route Number	FE*	
	18	Route_Signing	Route Signing	FE*	
	19	Route_Qualifier	Route Qualifier	FE*	
	20	Alternative_Route_Name	Alternative Route Name	FE	
Traffic	21	AADT	Annual Average Daily Traffic	FE + R	
	22	AADT_Single_Unit	Single Unit Truck and Bus AADT	FE*	SP*
	23	Pct_Peak_Single	Percent Peak Single-Unit Trucks and Buses		SP
	24	AADT_Combination	Combination Truck AADT	FE*	SP*
	25	Pct_Peak_Combination	Percent Peak Combination Trucks		SP
	26	K_Factor	K-factor		SP
	27	Dir_Factor	Directional Factor		SP
	28	Future_AADT	Future AADT		SP
	29	Signal_Type	Signal Type		SP
	30	Pct_Green_Time	Percent Green Time		SP
	31	Number_Signals	Number of Signalized Intersections		SP
	32	Stop_Signs	Number of Stop-Sign Controlled Intersections		SP
	33	At_Grade_Other	Number of Intersections, Type - Other		SP
Geometric	34	Lane_Width	Lane Width		SP
	35	Median_Type	Median Type		SP
	36	Median_Width	Median Width		SP
	37	Shoulder_Type	Shoulder Type		SP
	38	Shoulder_Width_R	Right Shoulder Width		SP
	39	Shoulder_Width_L	Left Shoulder Width		SP
	40	Peak_Parking	Peak Parking		SP
	41	Widening_Obstacle	Widening Obstacle		SP
	42	Widening_Potential	Widening Potential		SP
	43	Curves_A through Curves_F	Curve Classification		SP*
	44	Terrain_Type	Terrain Type		SP

	45	Grades_A through Grades_F	Grade Classification		SP*
	46	Pct_Pass_Sight	Percent Passing Sight Distance		SP
Pavement	47	IRI	International Roughness Index	FE*	SP*
	48	PSR	Present Serviceability Rating		SP*
	49	Surface_Type	Surface Type		SP
	50	Rutting	Rutting		SP
	51	Faulting	Faulting		SP
	52	Cracking_Percent	Cracking Percent		SP
	53	Cracking_Length	Cracking Length		SP#
	54	Year_Last_Improv	Year of Last Improvement		SP
	55	Year_Last_Construction	Year of Last Construction		SP
	56	Last_Overlay_Thickness	Last Overlay Thickness		SP
	57	Thickness_Rigid	Thickness Rigid		SP
	58	Thickness_Flexible	Thickness Flexible		SP
	59	Base_Type	Base Type		SP
	60	Base_Thickness	Base Thickness		SP
	61	Climate_Zone**	Climate Zone**		SP
	62	Soil_Type**	Soil Type**		SP
Inventory	63	County_Code	County Code	FE	
Special Networks	64	NHS	National Highway System	FE**	
	65	STRAHNET_Type	Strategic Highway Network	FE**	
	66	Truck	National Truck Network	FE**	
	67	Future_Facility	Future National Highway System	FE**	
Inventory	68	Maintenance_Operations	Maintenance & Operations	FE	
Traffic	69	Capacity	Capacity		SP

FE = Full Extent for all functional systems (including State and non-State roadways)
FE* = Full Extent for some functional systems, see Sec. 4.4 for more details
FE** = Full Extent wherever data item is applicable, (Sec. 4.4 for more details)
SP = All Sample Panel Sections (as defined by HPMS)
SP* = Some Sample Panel Sections, see Sec. 4.4 for more details
FE + R = Full Extent including ramps located within grade-separated interchanges
** = States have the option to override initial codes assigned by FHWA
# = Optional reporting requirement

The States must submit their section-level data for certain data items (Data Items 1-3, 7, and 21) as homogenous sections. For most other data items, this submittal format is optional. By definition, a homogenous section is a section that has the same value for a given data item over its entire extent. A homogenous section has a natural beginning and ending point where the value for a given data item changes beyond the limits of that section. This type of section may be longer or shorter than the sections identified in the Table of Potential Samples or "TOPS" (discussed in Section 6.2). The requirements for the reporting of these sections are identified by data item in Table 4.3.

If preferred, the States may structure and submit their non-homogenous section-level data in accordance with the limits of the TOPS sections (i.e. section limits must be equivalent to TOPS section limits). However, the States **must** submit their section-level data for Data Items 31-33, 43, and 45 in accordance with the limits of TOPS sections. If a State submits section-level data that matches the limits of the TOPS sections, then, they must apply one of the following calculation methods to ensure that the values reported provide the required representation of those sections:

1) No Calculation Required - Reported value must be consistent within the limits of the section.

2) Combination - Reported value must consist of a concatenation of multiple (text) values within the limits of the section.

3) Minimum Value - Reported value must be the lowest value in a range of values within the limits of the section.

4) Predominance - Reported value must be based on the most prevalent value within the limits of the section.

5) Weighted Averaging - Reported value must be based on an averaging of values within the limits of the section, weighted by the length of the sub-section for each value.

The calculation method to be applied depends on the particular data item being reported. Table 4.3 provides a summary of the data items and their applicable calculation method:

Table 4.3: Calculation Method by Data Item

Item Number	Data Item Name	Method
1	Functional System *	No Calculation Required
2	Urban Code *	No Calculation Required
3	Facility Type *	No Calculation Required
4	Structure Type	No Calculation Required
5	Access Control	Predominance
6	Ownership	Predominance
7	Through Lanes *	No Calculation Required
8	HOV Operations Type	Predominance
9	HOV Lanes ***	Predominance
10	Peak Lanes	Predominance
11	Counter-Peak Lanes	Predominance
12	Right Turn Lanes	Predominance
13	Left Turn Lanes	Predominance
14	Speed Limit	Predominance
15	Toll Charged	Predominance
16	Toll Type	Predominance
17	Route Number	Predominance
18	Route Signing	Predominance
19	Route Qualifier	Predominance
20	Alternative Route Name	Predominance
21	AADT *	No Calculation Required#
22	Single-Unit Truck and Bus AADT	Weighted Averaging
23	Percent Peak Single-Unit Trucks and Buses	Weighted Averaging
24	Combination Truck AADT	Weighted Averaging
25	Percent Peak Combination Trucks	Weighted Averaging
26	K-factor	Weighted Averaging
27	Directional Factor	Weighted Averaging

Item Number	Data Item Name	Method
28	Future AADT	Weighted Averaging
29	Signal Type	Predominance
30	Percent Green Time	Weighted Averaging
31	Number of Signalized Intersections **	No Calculation Required
32	Number of Stop Sign-Controlled Intersections **	No Calculation Required
33	Number of Intersections, Type - Other **	No Calculation Required
34	Lane Width	Predominance
35	Median Type	Predominance
36	Median Width	Predominance
37	Shoulder Type	Predominance
38	Right S	Predominance
39	Left Shoulder Width	Predominance
40	Peak Parking	Predominance
41	Widening Obstacle	Combination
42	Widening Potential	MinimumValue
43	Curve Classification **	No Calculation Required
44	Terrain Type	Predominance
45	Grade Classification **	No Calculation Required
46	Percent Passing Sight Distance	Minimum Value
47	International Roughness Index	Weighted Averaging
48	Present Serviceability Rating	Weighted Averaging
49	Surface Type	Predominance
50	Rutting	Weighted Averaging
51	Faulting	Weighted Averaging
52	Cracking Percent	Weighted Averaging
53	Cracking Length	Weighted Averaging
54	Year of Last Improvement	Predominance
55	Year of Last Construction	Predominance
56	Last Overlay Thickness	Weighted Averaging
57	Thickness Rigid	Weighted Averaging
58	Thickness Flexible	Weighted Averaging
59	Base Type	Predominance
60	Base Thickness	Weighted Averaging
61	Climate Zone	Predominance
62	Soil Type	Predominance
63	County Code	Predominance
64	National Highway System	No Calculation Required
65	Strategic Highway Network	No Calculation Required
66	National Truck Network	No Calculation Required
67	Future National Highway System	No Calculation Required
68	Maintenance & Operations	Predominance

Item Number	Data Item Name	Method
69	Capacity	Weighted Averaging

*Data items must be reported as homogenous sections (used to define the TOPS)
**Values for these data items must be reported for the defined limits of the TOPS
***Sections for this data item must be the same as for Data Item 8
#Weighted Averaging may be used if multiple traffic counts are combined to comprise a homogenous section

4.4 Data Item Requirements

NOTE: The following descriptions for each Data Item include an "English" name (in parenthesis) for clarification purposes. However, **the States must use the database-specific data item names shown in bold gray to populate Field 6 in their Sections datasets**.

Item 1: F_System (Functional System)

Description: The FHWA approved Functional Classification System.
Use: For analysis and mapping of information by functional system.
Extent: All Federal-aid highways including ramps located within grade-separated interchanges.

Functional System		1	2	3	4	5	6	7
	NHS	Int	OFE	OPA	MiA	MaC	MiC	Local
Rural	FE+R	FE+R	FE+R	FE+R	FE+R	FE+R		
Urban	FE+R	FE+R	FE+R	FE+R	FE+R	FE+R	FE+R	
FE + R = Full Extent & Ramps SP = Sample Panel Sections								

Coding Requirements for Fields 8, 9, and 10:

Value_Numeric: Code the value that represents the FHWA approved functional system. These following codes are to be used for all rural and urban sections:

Code	Description
1	Interstate
2	Principal Arterial - Other Freeways and Expressways
3	Principal Arterial - Other
4	Minor Arterial
5	Major Collector
6	Minor Collector
7	Local

Value_Text: No entry required. Available for State Use.

Value_Date: No entry required. Available for State Use.

Guidance: This Data Item must also be reported for all ramp sections contained within grade separated interchanges. If a section is defined as a ramp (i.e., Data Item 3 = Code '4'), then it must be coded the same as the highest order Functional System roadway that traverses the interchange.

Codes '6' and '7' must be reported for all National Highway System (NHS) sections.

Additional guidance on functional systems and the coding of this item can be found in Chapter 5.

Item 2: Urban_Code (Urban Code)

Description: The U.S. Census Urban Area Code.

Use: For the querying and analysis of data by the unique identification of a State's urbanized areas, and generically by small urban or rural areas.

Extent: All Federal-aid highways including ramps located within grade-separated interchanges.

Functional System		1	2	3	4	5	6	7
	NHS	**Int**	**OFE**	**OPA**	**MiA**	**MaC**	**MiC**	**Local**
Rural	FE+R	FE+R	FE+R	FE+R	FE+R	FE+R		
Urban	FE+R	FE+R	FE+R	FE+R	FE+R	FE+R	FE+R	
FE + R = Full Extent & Ramps SP = Sample Panel Sections								

Coding Requirements for Fields 8, 9, and 10:

Value_Numeric: Enter up to five digits for the Census urban area code. Leading zeros are not required.

Value_Text: No entry required. Available for State Use.

Value_Date: No entry required. Available for State Use.

Guidance: Code '99998' for small urban sections and '99999' for rural area sections. A small urban area is derived from Census Urban Clusters or Places that are not located within an urbanized area, with a population of at least 5,000.
Appendix I lists the U.S. Census Urban Area Codes that are currently in use. FHWA may issue interim guidance when Urban Codes change.
This Data Item must also be reported for all ramp sections contained within grade separated interchanges.
A Census Urbanized Area can be expanded for transportation purposes. This Adjusted Urbanized Area, once approved by FHWA, must be identified using the Census Urban Area Code for the Urbanized Area that it was based upon. Contiguous Urbanized Areas can be merged into one FHWA approved Urbanized Area. The combined area must be identified by the Urbanized Area code that was assigned to the largest (population) of the original Urbanized Areas that it was derived from.

Item 3: Facility_Type (Facility Type)

Description: The operational characteristic of the roadway.

Use: For determining public road mileage, for investment requirements modeling to calculate capacity and estimate roadway deficiencies and improvement needs, in the cost allocation pavement model, and in the national highway database.

Extent: All Federal-aid highways including ramps located within grade-separated interchanges.

Functional System		1	2	3	4	5	6	7

Functional System	NHS	Int 1	OFE 2	OPA 3	MiA 4	MaC 5	MiC 6	Local 7
	NHS	Int	OFE	OPA	MiA	MaC	MiC	Local
Rural	FE+R	FE+R	FE+R	FE+R	FE+R	FE+R		
Urban	FE+R	FE+R	FE+R	FE+R	FE+R	FE+R	FE+R	
FE + R = Full Extent & Ramps SP = Sample Panel Sections								

Coding Requirements for Fields 8, 9, and 10:

Value_Numeric: Use one of the following codes as applicable regardless of whether or not the section is on a structure. The definition for each code is as follows:

Code	Description	
1	One-Way Roadway	Roadway that operates with traffic moving in a single direction during non-peak period hours.
2	Two-Way Roadway	Roadway that operates with traffic moving in both directions during non-peak period hours.
4	Ramp	Non-mainline junction or connector facility contained within a grade-separated interchange.
5	Non Mainline	All non-mainline facilities excluding ramps.
6	Non Inventory Direction	Individual road/roads of a multi-road facility that is/are not used for determining the primary length for the facility.
7	Planned/Unbuilt	Planned roadway that has yet to be constructed.

Value_Text: No entry required. Available for State Use.

Value_Date: No entry required. Available for State Use.

Guidance: *General*

Use Codes ‘1’or ‘2’ for sections that are located entirely on a structure (i.e., where Data Item 4 = Code ‘1,’ ‘2,’ or ‘3’).
Public road mileage is based only on sections coded ‘1,’ or ‘2,’. This includes only those roads that are open to public travel regardless of the ownership or maintenance responsibilities. Ramps are not included in the public road mileage calculation.
Frontage roads and service roads that are public roads should be coded either as one-way (Code ‘1’) or two-way (Code ‘2’) roadways.
Use Code ‘7’ to identify a new roadway section that has been approved per the State Transportation Improvement Plan (STIP), but has yet to be built.

”One-way Pairs”
Characteristics:

- Divided roadway sections that have the same route designation (e.g., Route 1), but different street names (e.g., West Avenue, and East Avenue);
- Typically located in an urban area or a city/town;
- Usually connects to roadways with two-way traffic;
- Are typically separated by some physical or visual element other than a curb or barrier, such as buildings, landscaping, or terrain;

- Parallel roadway sections which complement each other in providing access at both termini; and
- Not designated as an Interstate

Ramps

Ramps may consist of directional connectors from either an Interstate to another Interstate, or from an Interstate to a different functional system. Moreover, ramps allow ingress and egress to grade separated highways. Ramps may consist of traditional ramps (i.e., gore to gore), acceleration and deceleration lanes, as well as collector-distributor lanes.

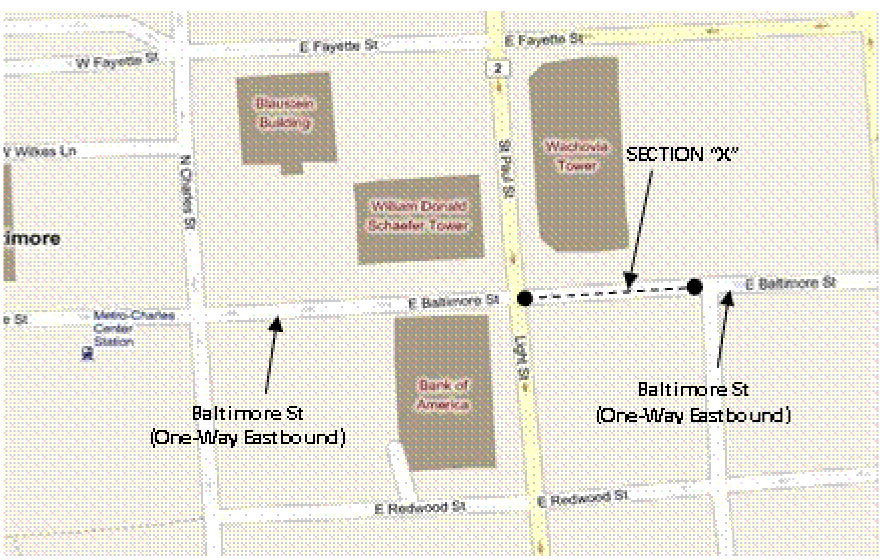
Ramps must be coded with the highest order functional system within the interchange that it functions. A mainline facility that terminates at the junction with another mainline facility is not a ramp and should be coded '1.'

Non-Mainlines

Non-mainline facilities include roads or lanes that provide access to and from sites that are adjacent to a roadway section such as bus terminals, park and ride lots, and rest areas. These may include: special bus lanes, limited access truck roads, ramps to truck weigh stations, or a turn-around.

Figure 4.4a shows an example of a street (E. Baltimore St.), for which traffic is only permitted to move in the eastbound direction. In this particular case, this data item should be assigned a Code '1' for a given section (Section "X") along this stretch of road.

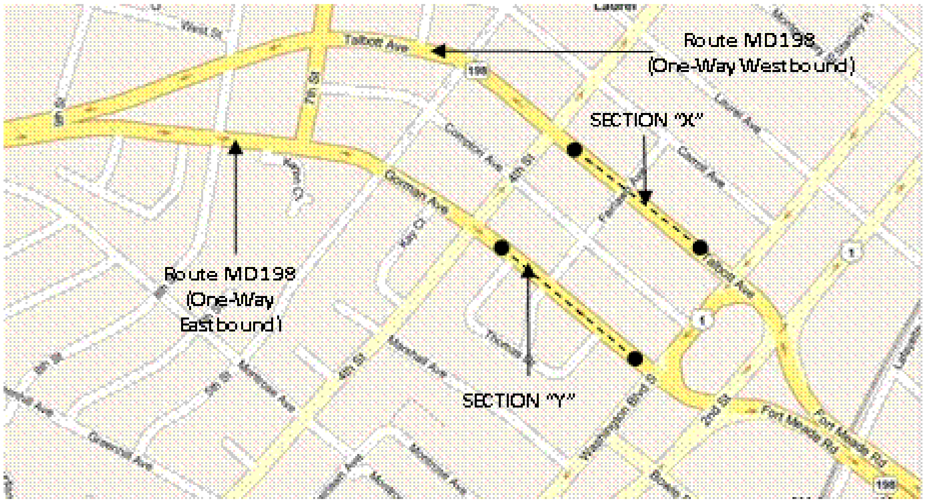
Figure 4.4A: One-Way Roadway (Code '1') Example



Source: Bing Maps

Figure 4.4b shows an example of a street (MD 198), for which traffic moves in the east and westbound directions along a set of one-way pairs (i.e., divided sections located along given route). In this particular case, this data item should be assigned a Code '1' for section "X", and section "Y".

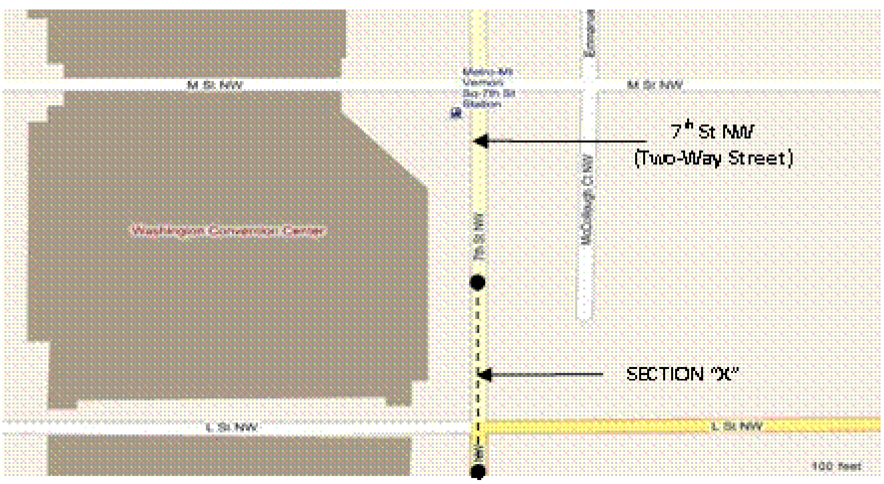
Figure 4.4B: One-Way Pairs (Code '1') Example



Source: Bing Maps

Figure 4.5 shows an example of a street (7th St. NW), for which traffic is permitted to move in both the north and southbound directions. In this particular case, this Data Item should be assigned a Code '2' for a given section (Section "X") along this stretch of road.

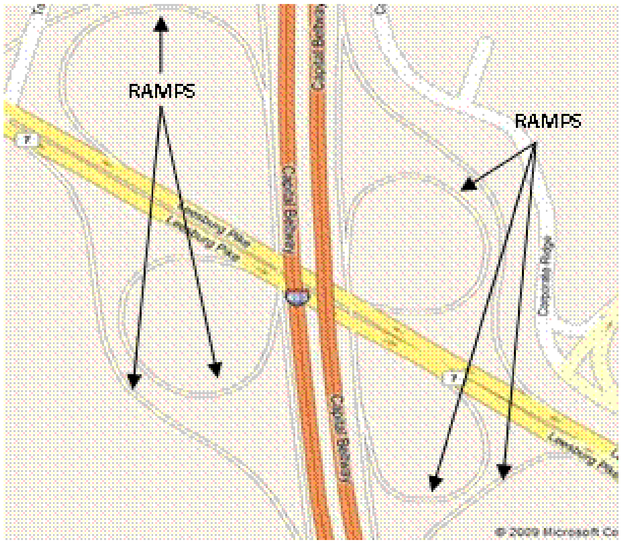
Figure 4.5: Two-Way Roadway (Code '2') Example



Source: Bing Maps

Figure 4.6 shows an example of ramps contained within a grade-separated interchange located on a highway (Interstate 495). In this particular case, this Data Item should be assigned a Code '4' for all applicable ramp sections (denoted as "Ramps" in the figure).

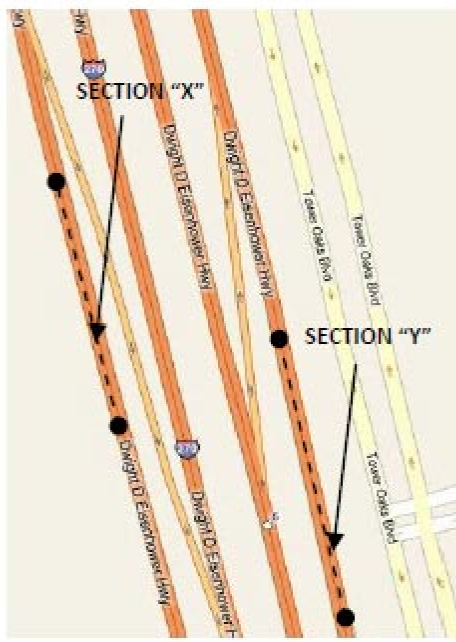
Figure 4.6: Ramp (Code '4') Example



Source: Bing Maps

Figure 4.7 shows an example of a highway (Interstate 270), which consists of express and local lanes in both the north and southbound directions. In this particular case, this Data Item should be assigned a code '5' for Sections "X" and "Y" to indicate that they are non-mainline facilities.

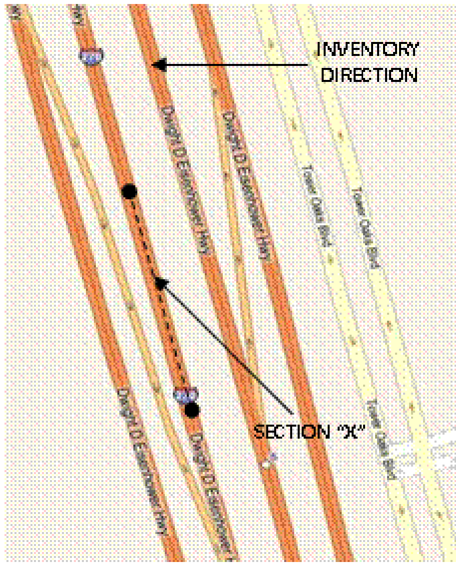
Figure 4.7: Non-Mainline (Code '5') Example



Source: Bing Maps

Figure 4.8 shows an example of a highway (Interstate 270), for which an inventory direction is defined (northbound). In this particular case, this Data Item should be assigned a code '6' for Section "X", as the southbound side of the roadway would be defined as the non-inventory direction.

Figure 4.8: Non-Inventory Direction (Code '6') Example



Source: Bing Maps

Item 4: Structure_Type (Structure Type)

Description: Roadway section that is a bridge, tunnel or causeway.
Use: For analysis in the national highway database.
Extent: All Federal-aid highways

Functional System		1	2	3	4	5	6	7
	NHS	Int	OFE	OPA	MiA	MaC	MiC	Local
Rural	FE**	FE**	FE**	FE**	FE**	FE**		
Urban	FE**	FE**	FE**	FE**	FE**	FE**	FE**	
FE** = Full Extent wherever data item is applicable					SP = Sample Panel Sections			

Coding Requirements for Fields 8, 9, and 10:
Value_Numeric: Use the following codes:

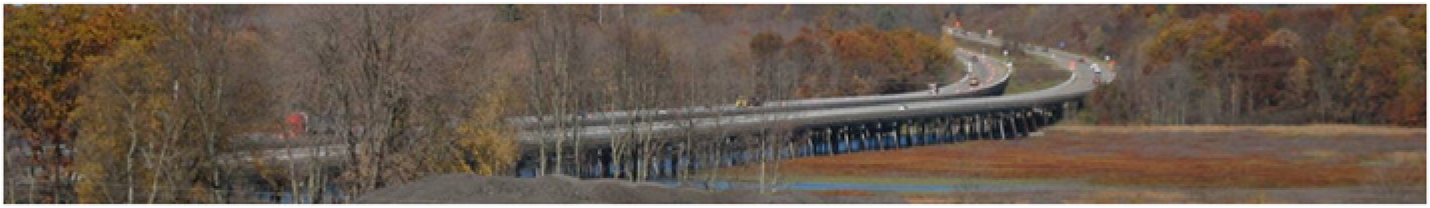
Code	Description
1	Section is a Bridge
2	Section is a Tunnel
3	Section is a Causeway

Value_Text: No entry required. Available for State Use.

Value_Date: No entry required. Available for State Use.

Guidance: Code this data item only when a roadway section is a bridge, tunnel, or causeway is present. Bridges must meet a minimum length requirement of 20 feet (per the National Bridge Inventory (NBI) guidelines) in order to be deemed a "structure." Do not include culverts.
A tunnel is a roadway below the surface connecting to at-grade adjacent sections.
A causeway is a narrow, low-lying raised roadway, usually providing a passageway over some type of vehicular travel impediment (e.g. a river, swamp, earth dam, wetlands, etc.).

Figure 4.9: Bridge (Code '1') Example



Source: PennDOT

Figure 4.10: Tunnel (Code '2') Example

Source: PennDOT

Figure 4.11: Causeway (Code '3') Example

Source: PennDOT Video-log.

Item 5: Access_Control (Access Control)

Description:	The degree of access control for a given section of road
Use:	For investment requirements modeling to calculate capacity and estimate type of design, in truck size and weight studies, and for national highway database purposes.
Extent:	All principal arterials and Sample Panel sections; optional for other non-principal arterial sections beyond the limits of the Sample Panel

Functional System		**1**	**2**	**3**	**4**	**5**	**6**	**7**
	NHS	**Int**	**OFE**	**OPA**	**MiA**	**MaC**	**MiC**	**Local**
Rural	FE	FE	FE	FE	SP	SP		
Urban	FE	FE	FE	FE	SP	SP	SP	

FE = Full Extent SP = Sample Panel Sections

Coding Requirements for Fields 8, 9, and 10:

Value_Numeric: Use the following codes:

Code	Description	
1	Full Access Control	Preference given to through traffic movements by providing interchanges with selected public roads, and by prohibiting crossing at-grade and direct driveway connections (i.e., limited access to the facility).
2	Partial Access Control	Preference given to through traffic movement. In addition to interchanges, there may be some crossings at-grade with public roads, but, direct private driveway connections have been minimized through the use of frontage roads or other local access restrictions. Control of curb cuts is not access control.
3	No Access Control	No degree of access control exists (i.e., full access to the facility is permitted).

Value_Text: No entry required. Available for State Use.

Value_Date: No entry required. Available for State Use.

Figure 4.12: Full Control (Code '1'); all access via grade-separated interchanges

Source: TxDOT, Transportation Planning and Programming Division.

Figure 4.13: Partial Control (Code '2'); access via grade-separated interchanges and direct access roadways

Source: TxDOT, Transportation

Figure 4.14 and 15: No Access Control (Code '3')

Figure 4.14 **Figure 4.15**

Source for Figures 4.15 and 4.16: FDOT RCI Field Handbook, Nov. 2008.

Item 6: Ownership (Ownership)

Description:	The entity that has legal ownership of a roadway.
Use:	For apportionment, administrative, legislative, analytical, and national highway database purposes, and in cost allocation studies.
Extent:	All Federal-aid highways.

Functional System		1	2	3	4	5	6	7
	NHS	Int	OFE	OPA	MiA	MaC	MiC	Local
Rural	FE	FE	FE	FE	FE	FE		
Urban	FE	FE	FE	FE	FE	FE	FE	

FE = Full Extent SP = Sample Panel Sections

Coding Requirements for Fields 8, 9, and 10:

Value_Numeric: Code the level of government that best represents the highway owner irrespective of whether agreements exist for maintenance or other purposes. If more than one code applies, code the lowest numerical value using the following codes:

Code	Description	Code	Description
1	State Highway Agency	60	Other Federal Agency
2	County Highway Agency	62	Bureau of Indian Affairs
3	Town or Township Highway Agency	63	Bureau of Fish and Wildlife
4	City or Municipal Highway Agency	64	U.S. Forest Service
11	State Park, Forest, or Reservation Agency	66	National Park Service
12	Local Park, Forest or Reservation Agency	67	Tennessee Valley Authority
21	Other State Agency	68	Bureau of Land Management
25	Other Local Agency	69	Bureau of Reclamation
26	Private (other than Railroad)	70	Corps of Engineers
27	Railroad	72	Air Force
31	State Toll Road	73	Navy/Marines

Code	Description	Code	Description
32	Local Toll Authority	74	Army
40	Other Public Instrumentality (i.e., Airport)	80	Other
50	Indian Tribe Nation		

Value_Text: Optional. Enter secondary ownership information, if applicable.

Value_Date: No entry required. Available for State Use.

Guidance:

"State" means owned by one of the 50 States, the District of Columbia, or the Commonwealth of Puerto Rico including quasi-official State commissions or organizations;

"County, local, municipal, town, or township" means owned by one of the officially recognized governments established under State authority;

"Federal" means owned by one of the branches of the U.S. Government or independent establishments, government corporations, quasi-official agencies, organizations, or instrumentalities;

"Other" means any other group not already described above or nongovernmental organizations with the authority to build, operate, or maintain toll or free highway facilities.

Only private roads that are open to public travel (e.g., toll bridges) are to be reported in HPMS.

In cases where ownership responsibilities are shared between multiple entities, this item should be coded based on the primary owner (i.e., the entity that has the larger degree of ownership), if applicable. Information on additional owners should be entered in Data Field 9 for this item.

Item 7: Through_Lanes (Through Lanes)

Description The number of lanes designated for through-traffic.

Use: For apportionment, administrative, legislative, analytical, and national highway database purposes.

Extent: All Federal-aid highways including ramps located within grade-separated interchanges.

		1	2	3	4	5	6	7
Functional System	**NHS**	**Int**	**OFE**	**OPA**	**MiA**	**MaC**	**MiC**	**Local**
Rural	FE+R	FE+R	FE+R	FE+R	FE+R	FE+R		
Urban	FE+R	FE+R	FE+R	FE+R	FE+R	FE+R	FE+R	

FE = Full Extent & Ramps SP = Sample Panel Sections

Coding Requirements for Fields 8, 9, and 10:

Value_Numeric: Enter the predominant number of through lanes in both directions carrying through traffic in the off-peak period.

Value_Text: No entry required. Available for State Use.

Value_Date: No entry required. Available for State Use.

Guidance:

This Data Item must also be reported for all ramp sections contained within grade separated interchanges.

Code the number of through lanes according to the striping, if present, on multilane facilities, or according to traffic use or State/local design guidelines if no striping or only centerline striping is present.

For one-way roadways, two-way roadways, and couplets, exclude all ramps and sections defined as auxiliary lanes, such as:

- Collector-distributor lanes
- Weaving lanes
- Frontage road lanes
- Parking and turning lanes
- Acceleration/deceleration lanes
- Toll collection lanes
- Truck climbing lanes
- Shoulders

When coding the number of through lanes for ramps (i.e., where Data Item 3 = Code '4'), include the predominant number of (through) lanes on the ramp. Do not include turn lanes (exclusive or combined) at the termini unless they are continuous (turn) lanes over the entire length of the ramp.

Exclusive HOV (High Occupancy Vehicle) lanes operating during the off-peak period are to be included in the total count of through lanes.

Figure 4.16: A Roadway with Four Through-Lanes

Source: TxDOT, Transportation Planning and Programming Division.

Item 8: HOV_Type (High Occupancy Vehicle Operations Type)

Description: The type of HOV operations.

Use: For administrative, legislative, analytical, and national highway database purposes.

Extent: All sections where HOV operations exist. This should correspond with the information reported for Data Item 9 (HOV lanes).

Functional System		**1**	**2**	**3**	**4**	**5**	**6**	**7**
	NHS	**Int**	**OFE**	**OPA**	**MiA**	**MaC**	**MiC**	**Local**
Rural	FE**	FE**	FE**	FE**	FE**	FE**		
Urban	FE**	FE**	FE**	FE**	FE**	FE**	FE**	

FE** = Full Extent wherever data item is applicable SP = Sample Panel Sections

Coding Requirements for Fields 8, 9, and 10:

Value_Numeric: Use the following codes:

Code	**Description**	
1	Full-time HOV	Section has 24-hour exclusive HOV lanes (HOV use only; no other use permitted).
2	Part-time HOV	Normal through lanes used for exclusive HOV during specified time periods.
3	Part-time HOV	Shoulder/Parking lanes used for exclusive HOV during specified time periods.

Value_Text: No Entry Required. Available for State Use.

Value_Date: No Entry Required. Available for State Use.

Guidance:

Code this data item only when HOV operations exist.

Code this Data Item for both directions to reflect existing HOV operations. If more than one type of HOV lane is present for the section, code the lesser of the two applicable HOV Type codes (e.g., if Codes '2' and '3' are applicable for a section, then the section should be coded as a Code '2').

Alternatively, if more than one type of HOV operation exists, the secondary HOV Type may be indicated in the Value_Text field.

This information may be indicated by either HOV signing or the presence of a large diamond-shaped marking (HOV symbol) on the pavement, or both.

Figure 4.17: HOV Signage

Source: FDOT RCI Field Handbook, Nov. 2008.

Item 9: HOV_Lanes (High Occupancy Vehicle Lanes)

Description: Maximum number of lanes in both directions designated for HOV operations.

Use: For administrative, legislative, analytical, and national highway database purposes.

Extent: All Sections where HOV lanes exist. This should correspond with the information reported for Data Item 8 (HOV Type)

		1	2	3	4	5	6	7
Functional System	**NHS**	**Int**	**OFE**	**OPA**	**MiA**	**MaC**	**MiC**	**Local**
Rural	FE**	FE**	FE**	FE**	FE**	FE**		
Urban	FE**	FE**	FE**	FE**	FE**	FE**	FE**	

FE** = Full Extent wherever data item is applicable SP = Sample Panel Sections

Coding Requirements for Fields 8, 9, and 10:

Value_Numeric: Enter the number of HOV lanes in both directions.

Value_Text: No entry required. Available for State Use.

Value_Date: No entry required. Available for State Use.

Guidance: Code this data item when Data Item 8 (HOV Type) is coded.

If more than one type of HOV operation exists on the section, code this data item with respect to all HOV lanes available, and indicate (in the Value_Text field) how many lanes apply to the HOV Type reported in Data Item 8.

Item 10: Peak_Lanes (Peak Lanes)

Description: The number of lanes in the peak direction of flow during the peak period.

Use: For investment requirements modeling to calculate capacity, and in congestion analyses, including estimates of delay. Also used in the Highway Capacity Manual (HCM)-based capacity calculation procedure.

Extent: All Sample Panel sections, optional for all other sections beyond the limits of the Sample Panel.

		1	2	3	4	5	6	7
Functional System	**NHS**	**Int**	**OFE**	**OPA**	**MiA**	**MaC**	**MiC**	**Local**

Functional System		1	2	3	4	5	6	7
	NHS	Int	OFE	OPA	MiA	MaC	MiC	Local
Rural	SP	SP	SP	SP	SP	SP		
Urban	SP	SP	SP	SP	SP	SP	SP	

FE = Full Extent SP = Sample Panel Sections

Coding Requirements for Fields 8, 9, and 10:

Value_Numeric: Code the number of through lanes used during the peak period in the peak direction.

Value_Text: No entry required. Available for State Use.

Value_Date: No entry required. Available for State Use.

Guidance:

Include reversible lanes, parking lanes, or shoulders that are legally used for through-traffic for both non-HOV and HOV operation.

- For urban roads, code based on the peak direction of travel;
- For rural 2 or 3-lane roads, code both directions; and
- For rural roads with 4 or more lanes, code based on the peak direction of travel.

The peak period is represented by the period of the day when observed traffic volumes are the highest.

Figure 4.18: Peak Lanes Example (Peak Lanes = 3)

Source: Mike Kahn/Green Stock Media

Item 11: Counter_Peak_Lanes (Counter-Peak Lanes)

Description: The number of lanes in the counter-peak direction of flow during the peak period.

Use: For investment requirements modeling to calculate capacity, and in congestion analyses, including estimates of delay. It is used in the Highway Capacity Manual (HCM)-based capacity calculation procedure.

Extent: All Sample Panel sections, optional for all other sections beyond the limits of the Sample Panel

Functional System		1	2	3	4	5	6	7
	NHS	Int	OFE	OPA	MiA	MaC	MiC	Local
Rural	SP	SP	SP	SP	SP	SP		
Urban	SP	SP	SP	SP	SP	SP	SP	

FE = Full Extent SP = Sample Panel Sections

Coding Requirements for Fields 8, 9, and 10:

Value_Numeric: Code the number of through lanes used during the peak period (per Data Item 10) in the counter-peak direction of flow.

Value_Text: No entry required. Available for State Use.

Value_Date: No entry required. Available for State Use.

Guidance:

Include reversible lanes, parking lanes, or shoulders that are legally used for through-traffic for both non-HOV and HOV operation.

- For urban roads, code based on the counter-peak (i.e. opposite-peak) direction of travel;
- For rural 2 or 3-lane roads, do not code this data item

Visual inspection should be used as the principle method used to determine the number of peak lanes and counter-peak lanes.

The number of peak and counter-peak lanes should be greater than or equal to the total number of through lanes (i.e., Peak Lanes + Counter-Peak Lanes >= Through Lanes). The number of peak and counter-peak lanes can be greater than the number of through lanes if shoulders, parking lanes, or other peak-period-only lanes are used during the peak period.

The peak period is represented by the period of the day when observed traffic volumes are the highest.

Item 12: Turn_Lanes_R (Right Turn Lanes)

Description: The presence of right turn lanes at a typical intersection.

Use: For investment requirements modeling to calculate capacity and in congestion analyses, including estimates of delay

Extent: All Sample Panel sections located in urban areas, optional for all other urban sections beyond the limits of the Sample Panel

Functional System		1	2	3	4	5	6	7
	NHS	Int	OFE	OPA	MiA	MaC	MiC	Local
Rural								
Urban	SP	SP	SP	SP	SP	SP	SP	

FE = Full Extent SP = Sample Panel Sections

Coding Requirements for Fields 8, 9, and 10:

Value_Numeric: Enter the code from the following table that best describes the peak-period turning lane operation in the inventory direction.

Code	Description
1	No intersection where a right turning movement is permitted exists on the section.
2	Turns permitted; multiple exclusive right turning lanes exist. Through movements are prohibited in these lanes. Multiple turning lanes allow for simultaneous turns from all turning lanes.
3	Turns permitted; a continuous exclusive right turning lane exists from intersection to intersection. Through movements are prohibited in this lane.
4	Turns permitted; a single exclusive right turning lane exists.
5	Turns permitted; no exclusive right turning lanes exist.
6	No right turns are permitted during the peak period.

Value_Text: No entry required. Available for State Use.

Value_Date: No entry required. Available for State Use.

Guidance:

Include turning lanes that are located at entrances to shopping centers, industrial parks, and other large traffic generating enterprises as well as public cross streets.

Where peak capacity for a section is governed by a particular intersection that is on the section, code the turning lane operation at that location (referred to as most controlling intersection); otherwise code for a typical intersection.

Through movements are prohibited in exclusive turn lanes.

Use codes '2' through '6' for turn lanes at a signalized or stop sign intersection that is critical to the flow of traffic; otherwise enter the code that best describes the peak-hour turning lane situation for typical intersections on the sample.

Code a continuous turning lane with painted turn bays as a continuous turning lane. Code a through lane that becomes an exclusive turning lane at an intersection as a shared (through/right turn) lane; however, if through and turning movements can be made from a lane at an intersection, it is not an exclusive turning lane.

Roundabouts (as shown in Figure 4.19) should be considered as an intersection where turns are permitted with no exclusive lanes. Use a Code '5' for this item since traffic can either turn or go through the roundabout from the same lane. However, if an exclusive turning lane exists (as indicated by pavement markings), use a Code '4'. Code if the roundabout controls the capacity of the entire HPMS section. If there is not a controlling intersection, then code for a typical intersection.

Figure 4.19: Roundabout Configuration Example

Source: SRA Consulting Group, Nov. 2008

This Data Item should be coded based on the same intersection that is used for identifying the percent green time for a given roadway section.

Painted islands (Figure 4.21) located in the center of a roadway should be considered a median, for the purpose of determining whether or not a turn lane exists.

Slip-ramp movements should not be considered for the purpose of determining turn lanes.

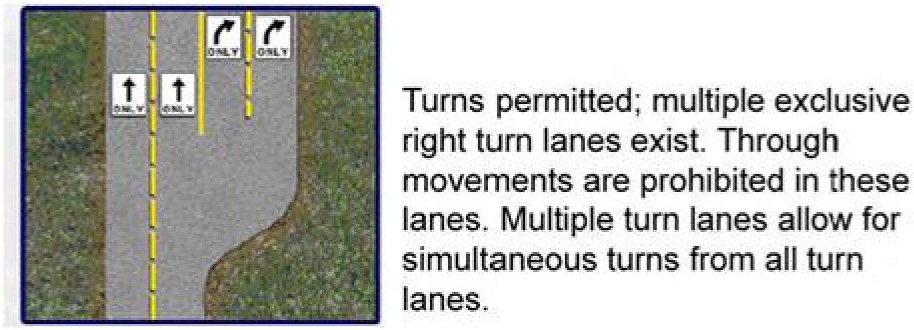
On-ramps and off-ramps which provide access to and from grade-separated, intersecting roadways are to be excluded from turn lane consideration.

Figure 4.20: Painted Island Example

Source: TxDOT, Transportation Planning and Programming Division.

Right Turn Lanes Coding Examples:

Figure 4.21: Multiple Turn Lanes (Code '2') Example



Source: FDOT RCI Field Handbook, Nov. 2008.

Figure 4.22: Continuous Turn Lane (Code '3') Example

Source: Minnesota Dept. of Transportation (MnDOT).

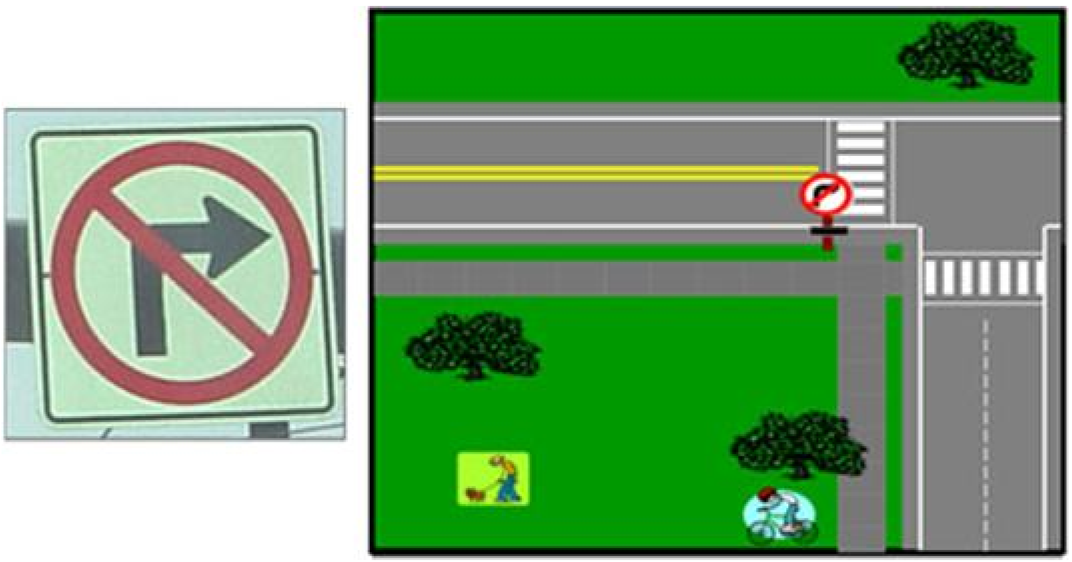
Figure 4.23: Single Turn Lane (Code '4') Example

Source: MoveTransport.com

Figure 4.24: No Exclusive Turn Lane (Code '5') Example

Source: FDOT RCI Field Handbook, Nov. 2008.

Figure 4.25 No Right Turn Permitted (Code '6') Example



Source: TxDOT, Transportation Planning and Programming Division.

Item 13: Turn_Lanes_ L (Left Turn Lanes)

Description:	The presence of left turn lanes at a typical intersection
Use:	For investment requirements modeling to calculate capacity and in congestion analyses, including estimates of delay
Extent:	All Sample Panel sections located in urban areas, optional for all other urban sections beyond the limits of the Sample Panel

Functional System		**1**	**2**	**3**	**4**	**5**	**6**	**7**
	NHS	**Int**	**OFE**	**OPA**	**MiA**	**MaC**	**MiC**	**Local**
Rural								
Urban	SP	SP	SP	SP	SP	SP	SP	

FE = All sections SP = Sample Panel Sections

Coding Requirements for Fields 8, 9, and 10:

Value_Numeric: Enter the code from the following table that best describes the peak-period turning lane operation in the inventory direction.

Code	Description
1	No intersection where a left turning movement is permitted exists on the section.
2	Turns permitted; multiple exclusive left turning lanes exist. Through movements are prohibited in these lanes. Multiple turning lanes allow for simultaneous turns from all turning lanes.
3	Turns permitted; a continuous exclusive left turning lane exists from intersection to intersection. Through movements are prohibited in this lane.
4	Turns permitted; a single exclusive left turning lane exists.
5	Turns permitted; no exclusive left turning lanes exist.
6	No left turns are permitted during the peak period.

Value_Text: No entry required. Available for State Use.

Value_Date: No entry required. Available for State Use.

Guidance:

Where peak capacity for a section is governed by a particular intersection that is on the section, code the turning lane operation at that location (referred to as most controlling intersection); otherwise code for a typical intersection.

Include turning lanes that are located at entrances to shopping centers, industrial parks, and other large traffic generating enterprises as well as public cross streets.

Through movements are prohibited in exclusive turn lanes.

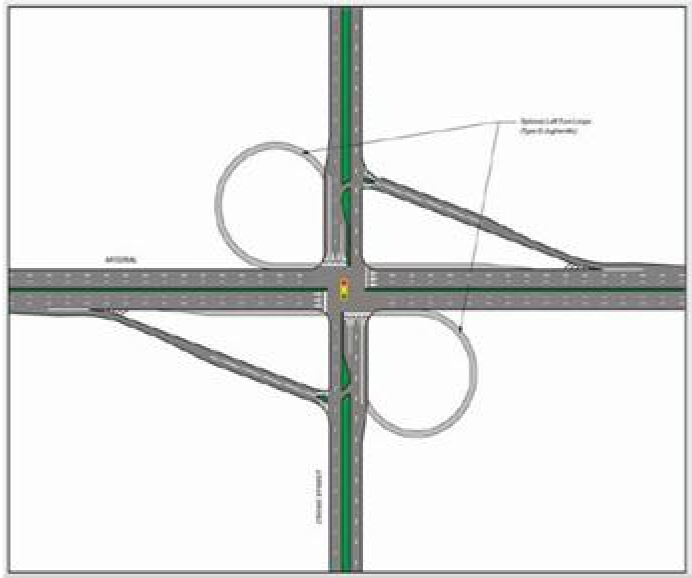
Use codes '2' through '6' for turn lanes at a signalized or stop sign intersection that is critical to the flow of traffic; otherwise enter the code that best describes the peak-hour turning lane situation for typical intersections on the sample.

Code a continuous turning lane with painted turn bays as a continuous turning lane. Code a through lane that becomes an exclusive turning lane at an intersection as a shared (through/left turn) lane; however, if through and turning movements can be made from a lane at an intersection, it is not an exclusive turning lane.

Roundabouts (as shown in Figure 4.20) should be considered as an intersection where turns are permitted with no exclusive lanes. Use a Code '5' for this item since traffic can either turn or go through the roundabout from the same lane. Code if the roundabout controls the capacity of the entire HPMS section. If there is not a controlling intersection, then code for a typical intersection.

On-ramps and off-ramps which provide access to and from grade-separated, intersecting roadways are to be excluded from turn lane consideration.

Figure 4.26: Jug Handle Configuration Example



Source: SRA Consulting Group, Nov. 2008

Jug handle configurations (as shown in Figure 4.26), or lanes on either side of the roadway should be considered as an intersection with protected (exclusive) left turn lanes. Although a jug handle may be viewed as a right turn lane, it is intended for left turn movements, therefore it should not be coded as a right turn lane; vinstead use Code '6.'

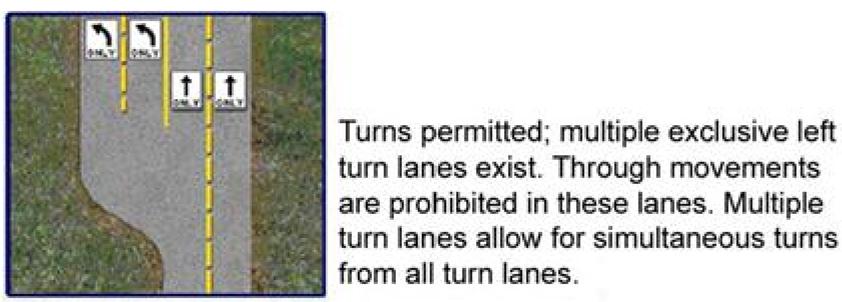
This Data Item should be coded based on the same intersection that is used for identifying the percent green time for a given roadway section.

Painted islands located in the center of a roadway should be considered a median, for the purposes of determining whether or not a turn lane exists.

Permitted U-turn movements are not to be considered for the purpose of determining turn lanes.

Left Turn Lanes Coding Examples:

Figure 4.27: Multiple Turn Lanes (Code '2') Example



Source: FDOT RCI Field Handbook, Nov. 2008.

Figure 4.28: Multiple Turn Lanes (Code '2') Example

Source: Unavailable

Figure 4.29: Continuous Turn Lane (Code '3') Example

Source: Kentucky Transportation Cabinet

Example for Coding Turn Lanes and Through Lanes:

For an intersection that has a single left turn lane and no right turn lane with turns permitted in the peak period (as shown in Figure 4.30), use a code '4' for this Data Item, and a code '5' (turns permitted; no exclusive right turning lane exists) for Data Item 12 (Right Turn Lanes). Additionally, this intersection has four through-lanes (Data Item 7), and two peak-lanes (Data Item 10).

Figure 4.30: Exclusive Turn Lane (Code '4') Example

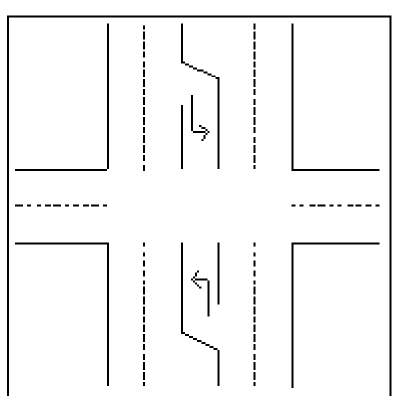


Figure 4.31: No Exclusive Left Turn Lane (Code '5') Example

Figure 4.32: No Left Turn Permitted (Code '6')

Item 14: Speed_Limit (Speed Limit)

Description:	The posted speed limit
Use:	For investment requirements modeling to estimate running speed and for other analysis purposes, including delay estimation
Extent:	All Sample Panel sections, optional for all other sections beyond the limits of the Sample Panel

Functional System		1	2	3	4	5	6	7
	NHS	Int	OFE	OPA	MiA	MaC	MiC	Local
Rural	SP	SP	SP	SP	SP	SP		
Urban	SP	SP	SP	SP	SP	SP	SP	

FE = Full Extent SP = Sample Panel Sections

Coding Requirements for Fields 8, 9, and 10:

Value_Numeric: Enter the daytime speed limit for automobiles posted or legally mandated on the greater part of the section. If there is no legally mandated maximum daytime speed limit for automobiles, code '999.'

Value_Text: No entry required. Available for State Use.

Value_Date: No entry required. Available for State Use.

Guidance: If the speed limit changes within the limits of a section, the State must determine and report the predominant speed limit

Item 15: Toll_Charged (Toll Charged)

Description: Identifies sections that are toll facilities regardless of whether or not a toll is charged
Use: For administrative, legislative, analytical, and national highway database purposes
Extent: All roadways that are toll facilities, whether public or privately-owned / operated

Functional System		1	2	3	4	5	6	7
	NHS	Int	OFE	OPA	MiA	MaC	MiC	Local
Rural	FE**	FE**	FE**	FE**	FE**	FE**	FE**	FE**
Urban	FE**	FE**	FE**	FE**	FE**	FE**	FE**	FE**

FE** = Full Extent wherever data item is applicable SP = Sample Panel Sections

Coding Requirements for Fields 8, 9, and 10:

Value_Numeric: Use the following codes:

Code	Description
1	Toll charged in one direction only.
2	Toll charged in both directions.
3	No toll charged

Value_Text: Assign the appropriate Toll ID. See Appendix D for the list of IDs.

Value_Date: No entry required. Available for State Use.

Guidance:

Code this data item only when a toll facility is present.

Code each toll and non-toll portion of contiguous toll facilities as separate sections.

If tolls are charged in both directions, but only one direction at a given time, then use Code '1'.

Include High Occupancy Toll (HOT) lanes and other special toll lanes. Use Code '3' for subsections of a toll facility that do not have tolls.

Figure 4.33: Toll-Road Signage

Source: FDOT RCI Field Handbook, Nov. 2008.

Item 16: Toll_Type (Toll Type)

Description:	Indicates the presence of special tolls (i.e., High Occupancy Toll (HOT) lane(s) or other managed lanes)
Use:	For administrative, legislative, analytical, and national highway database purposes
Extent:	All roadways where special tolls exist

Functional System		**1**	**2**	**3**	**4**	**5**	**6**	**7**
	NHS	**Int**	**OFE**	**OPA**	**MiA**	**MaC**	**MiC**	**Local**
Rural	FE**	FE**	FE**	FE**	FE**	FE**	FE**	FE**
Urban	FE**	FE**	FE**	FE**	FE**	FE**	FE**	FE**

FE** = Full Extent wherever data item is applicable SP = Sample Panel Sections

Coding Requirements for Fields 8, 9, and 10:

Value_Numeric: Use the following codes:

Code	Description
1	This section has toll lanes but no special tolls (e.g., HOT lanes).
2	This section has HOT lanes.
3	This section has other special tolls.

Value_Text: Assign the appropriate Toll ID. See Appendix D for the list of IDs.

Value_Date: No entry required. Available for State Use.

Guidance:

This may not be an HOV facility, but hasspecial lanes identified where users would be subject to tolls.

High Occupancy Toll (HOT) lanes are HOV lanes where a fee is charged, sometimes based on occupancy of the vehicle or the type of vehicle. Vehicle types may include buses, vans, or other passenger vehicles.

Item 17: Route_Number (Route Number)

Description: The signed route number

Use: Used along with route signing and route qualifier to track information by specific route

Extent: All principal arterials, minor arterials, and the entire NHS

Functional System		1	2	3	4	5	6	7
	NHS	Int	OFE	OPA	MiA	MaC	MiC	Local
Rural	FE	FE	FE	FE	FE			
Urban	FE	FE	FE	FE	FE			

FE = Full Extent SP = Sample Panel Sections

Coding Requirements for Fields 8, 9, and 10:

Value_Numeric: Code the appropriate route number (leading zeros should not be used), e.g., Interstate 81 should be coded as '81'; Interstate 35W should be coded as '35'.

Value_Text: Enter the full route number, e.g., "35W" or "291A."

Value_Date: No entry required. Available for State Use.

Guidance:

This should be the same route number that is identified for the route in Data Items 18 and 19 (Route Signing and Route Qualifier).

If two or more routes of the same functional system are signed along a roadway section (e.g., Interstate 64 and Interstate 81), code the lowest route number (i.e., Interstate 64).

If two or more routes of differing functional systems are signed along a roadway section (e.g., Interstate 83 and U.S. 32), code this Data Item in accordance with the highest functional system on the route (in this example, Interstate).

For the official Interstate route number, enter an alphanumeric value for the route in Data Field 9.

If Data Items 18 or 19 (Route Signing or Route Qualifier) are coded '10,' code a text descriptor (in Field 9) for this Data Item.

If the official route number contains an alphabetic character (e.g. "32A"), then code the numeric portion of this value in Field 8, and the entire value in Field 9.

Item 18: Route_Signing (Route Signing)

Description: The type of route signing

Use: For tracking information by specific route; used in conjunction with Data Item 19 (Route Qualifier)

Extent: All principal arterials, minor arterials, and the entire NHS

Functional System		1	2	3	4	5	6	7
	NHS	Int	OFE	OPA	MiA	MaC	MiC	Local
Rural	FE	FE	FE	FE	FE			
Urban	FE	FE	FE	FE	FE			

FE = Full Extent SP = Sample Panel Sections

Coding Requirements for Fields 8, 9, and 10:

Value_Numeric: Code the value that best represents the manner in which the roadway section is signed with route markers, using the following codes:

Code	Description	Code	Description
1	Not Signed	6	County
2	Interstate	7	Township
3	U.S.	8	Municipal
4	State	9	Parkway Marker or Forest Route Marker
5	Off-Interstate Business Marker	10	None of the Above

Value_Text: No entry required. Available for State Use.

Value_Date: No entry required. Available for State Use.

Guidance: When a section is signed with two or more identifiers (e.g., Interstate 83 and U.S. 32), code the highest order identifier on the route (in this example, Interstate). Follow the hierarchy as ordered above

Item 19: Route_Qualifier (Route Qualifier)

Description: The route signing descriptive qualifier

Use: For tracking information by specific route; used in conjunction with Data Item 18 (Route Signing)

Extent: All principal arterials, minor arterials, and the entire NHS

Functional System		1	2	3	4	5	6	7
	NHS	Int	OFE	OPA	MiA	MaC	MiC	Local
Rural	FE	FE	FE	FE	FE			
Urban	FE	FE	FE	FE	FE			

FE = Full Extent SP = Sample Panel Sections

Coding Requirements for Fields 8, 9, and 10:

Value_Numeric: Code the value which best represents the manner in which the roadway section is signed on the route marker described in Data Item 18 (Route Signing).

Code	Description	Code	Description
1	No qualifier or Not Signed	6	Loop
2	Alternate	7	Proposed
3	Business Route	8	Temporary
4	Bypass Business	9	Truck Route
5	Spur	10	None of the Above

Value_Text: No entry required. Available for State Use.

Value_Date: No entry required. Available for State Use.

Guidance: If more than one code is applicable, use the lowest code

Figure 4.34 Business Route (Code '3') Example

Source: FDOT RCI Field Handbook, Nov. 2008.

Figure 4.35 Proposed Route (Code '7') Example

Source: FDOT RCI Field Handbook, Nov. 2008.

Figure 4.36 Temporary Route (Code '8') Example

Source: FDOT RCI Field Handbook, Nov. 2008.

Item 20: Alternative_Route_Name (Alternative Route Name)

Description: A familiar, non-numeric designation for a route

Use: For tracking information by specific route; used in conjunction with Data Items 18 and

	19 (Route Signing and Route Qualifier)
Extent:	Optional for principal arterial, minor arterial, and NHS sections where this situation exists

Functional System		1	2	3	4	5	6	7
	NHS	Int	OFE	OPA	MiA	MaC	MiC	Local
Rural	FE	FE	FE	FE	FE			
Urban	FE	FE	FE	FE	FE			

FE = Full Extent SP = Sample Panel Sections

Coding Requirements for Fields 8, 9, and 10:

Value_Numeric: No entry required. Available for State Use.

Value_Text: Optional. Enter the alternative route name.

Value_Date: No entry required. Available for State Use.

Guidance:	Examples for this Data item would be the "Pacific Coast Highway" (in California), and the "Garden State Parkway" (in New Jersey)

Item 21: AADT (Annual Average Daily Traffic)

Description:	Annual Average Daily Traffic
Use:	For apportionment, administrative, legislative, analytical, and national highway database purposes
Extent:	All Federal-aid highways including ramps located within grade-separated interchanges

Functional System		1	2	3	4	5	6	7
	NHS	Int	OFE	OPA	MiA	MaC	MiC	Local
Rural	FE+R	FE+R	FE+R	FE+R	FE+R	FE+R		
Urban	FE+R	FE+R	FE+R	FE+R	FE+R	FE+R	FE+R	

FE + R = Full Extent & Ramps SP = Sample Panel Sections

Coding Requirements for Fields 8, 9, and 10:

Value_Numeric: Enter a value that represents the AADT for the current data year.

Value_Text: No entry required. Available for State Use.

Value_Date: No entry required. Available for State Use.

Metadata:	See Chapter 3 for a description of the metadata reporting requirements for this Data Item
Guidance:	For two-way facilities, provide the bidirectional AADT; for one-way couplets, one-way roadways, and ramps, provide the directional AADT.

This Data Item must also be reported for all ramp sections contained within grade separated interchanges

All AADTs must reflect application of day of week, seasonal, and axle correction factors, as necessary; no other adjustment factors shall be used. Growth factors should be applied if the AADT is not derived from current year counts.

AADTs for the NHS, Interstate, Principal Arterials (OFE, OPA), and HPMS Sample Panel sections must be based on traffic counts taken on a minimum three-year cycle. AADTs for the non Principal Arterial System and non Sample Panel sections can be based on a minimum six-year counting cycle.

If average weekday, average weekly, or average monthly traffic is calculated or available, it must be adjusted to represent the annual average daily traffic (AADT). AADT is an average daily value that represents all days of the reporting year.

AADT guidance for ramps:

AADT values representing the current data year are required for ramps contained within grade separated interchanges on all Federal-aid highways. To the extent possible, the same procedures used to develop AADTs on HPMS sections should also be used to develop ramp AADT data. At a minimum, 48-hour ramp traffic counts should be taken on a six-year cycle, so at least one-sixth of the ramps should be counted every year.

Ramp AADT data may be available from freeway monitoring programs that continuously monitor travel on ramps and mainline facilities. Ramp balancing programs implemented by the States for ramp locations and on high volume roadways could be used to gather traffic data on ramps. States are encouraged to use adjustment factors that have been developed based either on entrance or exit travel patterns, or on the functional system of the ramp. The procedure should be applied consistently statewide.

Additional guidance on how this data is to be developed and reported is contained in Chapter 5.

Item 22: AADT_Single_Unit (Single-Unit Truck and Bus AADT)

Description: Annual Average Daily Traffic for single-unit trucks and buses

Use: For investment requirements modeling to estimate pavement deterioration and operating speeds, in the cost allocation pavement model, the truck size and weight analysis process, freight analysis, and other scenario based analysis

Extent: All NHS and Sample Panel sections; optional for all other non-NHS sections beyond the limits of the Sample Panel

Functional System		1	2	3	4	5	6	7
	NHS	Int	OFE	OPA	MiA	MaC	MiC	Local
Rural	FE	FE	SP	SP	SP	SP		
Urban	FE	FE	SP	SP	SP	SP	SP	

FE = Full Extent SP = Sample Panel Sections

Coding Requirements for Fields 8, 9, and 10:

Value_Numeric: Enter the volume for all single-unit truck and bus activity over all days of the week and seasons of the year in terms of the annual average daily traffic.

Value_Text: No entry required. Available for State Use.

Value_Date: No entry required. Available for State Use.

Metadata: See Chapter 3 for a description of the AADT metadata reporting requirements related to this Data Item

Guidance:

This value should be representative of all single-unit truck and bus activity based on vehicle classification count data from both the State's and other agency's traffic monitoring programs over all days of the week and all seasons of the year. Actual vehicle classification counts should be adjusted to represent average conditions as recommended in the *Traffic Monitoring Guide (TMG)*. Single-unit trucks and buses are defined as vehicle classes 4 through 7 (buses through four-or-more axle, single-unit trucks)

AADT values shall be updated annually to represent current year data.

Section specific measured values are requested based on traffic counts taken on a minimum three-year cycle. If these data are not available, values derived from classification station data on the same route, or on a similar route with similar traffic characteristics in the same area can be used.

Specific guidance for the frequency and size of vehicle classification data collection programs, factor development, age of data, and other applications is contained in the *Traffic Monitoring Guide*.

Item 23: Pct_Peak_Single (Percent Peak Single-Unit Trucks and Buses)

Description: Peak hour single-unit truck and bus volume as a percentage of total AADT

Use: For investment requirements modeling to calculate capacity and peak volumes

Extent: All Sample Panel sections; optional for all other sections beyond the limits of the Sample Panel

Functional System		1	2	3	4	5	6	7
	NHS	Int	OFE	OPA	MiA	MaC	MiC	Local
Rural	SP	SP	SP	SP	SP	SP		
Urban	SP	SP	SP	SP	SP	SP	SP	

FE = Full Extent SP = Sample Panel Sections

Coding Requirements for Fields 8, 9, and 10:

Value_Numeric: Enter the peak hour single-unit truck and bus volume as a percentage of the applicable roadway section's AADT rounded to the nearest tenth of a percent (0.001%). This percent should not be rounded to the nearest whole percent or to zero percent if minimal vehicles exist.

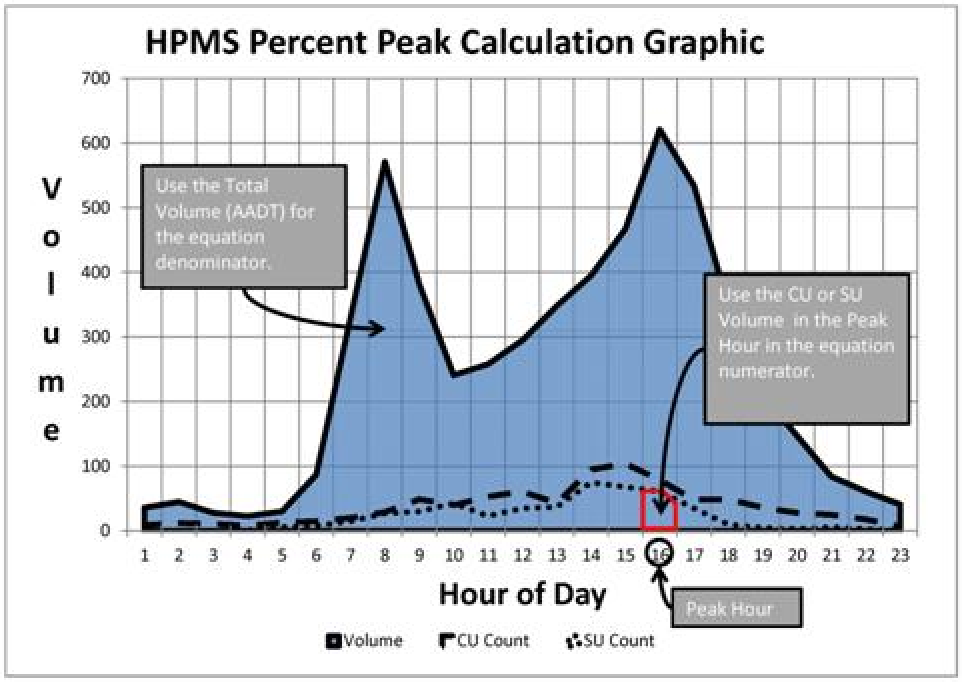
Value_Text: No entry required. Available for State Use.

Value_Date: No entry required. Available for State Use.

	Code this item based on vehicle classification data from traffic monitoring programs for vehicle classes 4 through 7 (as defined in the *Traffic Monitoring Guide*), based on traffic counts taken on a three-year cycle, at a minimum. The Percent Peak Single-Unit Trucks and Buses value is calculated by dividing the number of single-unit trucks and buses during the hour with the highest total volume (i.e. the peak hour) by the AADT (i.e. the total daily traffic). Note that this data item is based on the truck traffic during the peak traffic hour and not the hour with the most truck traffic. If actual measured values are not available, then an estimate shall be made based on the most readily available information. The most credible method would be to use other site specific measured values from sites located on the same route. Other methods may include: assigning site specific measured values to other samples that are located on similar facilities with similar traffic characteristics in the same geographic area and in the same volume group; or assigning measured values from samples in the same functional system and in the same area type (i.e., rural, small urban, urbanized). Statewide or functional system-wide values should not be used. Peak hour values may be different than daily averages which must be taken into consideration. Supplemental methods and sources may be particularly useful in urban areas. These include turning movement studies, origin and destination studies, license plate surveys, design estimates and projections, and MPO data obtained for other purposes. Short term visual observation of truck travel can also be helpful when developing an estimate. Note that this data represents the truck traffic during the peak traffic hour, not the 30th highest hourly volume for a given calendar year or the hour which has the peak truck traffic (see Figure 4.38).

Guidance:

Figure 4.37 Peak Hour Truck Traffic vs. AADT



Code this data item in accordance with the limits for which Data Item #22 is reported.

The following examples illustrate the % Peak Single-Unit (SU) Trucks calculation:

Example #1

AADT = 150,000 vehicles

SU AADT = 12,100 SU trucks (classes 4-7)

Peak hour SU Trucks = 1,550 SU trucks (classes 4-7)

% Peak SU Trucks = (Peak hour SU trucks/AADT)*100 =

(1,550 SU trucks/150,000)*100 = 1.0333%

**When reported in HPMS, this % Peak SU value would be reported as 1.033%.*

Example #2

AADT = 2,050 vehicles

SU AADT = 85 SU trucks (classes 4-7)

Peak hour SU Trucks = 8 SU trucks (classes 4-7)

% Peak SU Trucks = (Peak hour SU trucks/AADT)*100

(8 SU trucks/2,050)*100 = 0.39024%

**When reported in HPMS, this % Peak SU value would be reported as 0.390%.*

Item 24: AADT_Combination (Combination Truck AADT)

Description: Annual Average Daily Traffic for Combination Trucks

Use: For investment requirements modeling to estimate pavement deterioration and operating speeds, in the cost allocation pavement model, the truck size and weight analysis process, and freight analysis

Extent: All NHS and Sample Panel sections; optional for all other non-NHS sections beyond the limits of the Sample Panel

		1	2	3	4	5	6	7
Functional System	**NHS**	**Int**	**OFE**	**OPA**	**MiA**	**MaC**	**MiC**	**Local**
Rural	FE	FE	SP	SP	SP	SP		
Urban	FE	FE	SP	SP	SP	SP	SP	

FE = Full Extent SP = Sample Panel Sections

Coding Requirements for Fields 8, 9, and 10:

Value_Numeric: Enter the volume for combination-unit truck activity over all days of the week and seasons of the year in terms of the annual average daily traffic.

Value_Text: No entry required. Available for State Use.

Value_Date: No entry required. Available for State Use.

Metadata: See Chapter 3 for a description of the AADT metadata reporting requirements related to this Data Item

Guidance:

This value should be representative of all combination truck activity based on vehicle classification data from traffic monitoring programs over all days of the week and all seasons of the year. Actual vehicle classification counts should be adjusted to represent average conditions as recommended in the *Traffic Monitoring Guide (TMG).* Combination trucks are defined as vehicle classes 8 through 13 (four-or-less axle, single-trailer trucks through seven-or-more axle, multi-trailer trucks).

AADT values shall be updated annually to represent current year data.

Section specific measured values are requested based on traffic counts taken on a three-year cycle, at a minimum. If these data are not available, use values derived from classification station data on the same route or on a similar route with similar traffic characteristics in the same area.

Specific guidance for the frequency and size of vehicle classification data collection programs, factor development, age of data, and other applications is contained in the *Traffic Monitoring Guide.*

Item 25: Pct_Peak_Combination (Percent Peak Combination Trucks)

Description: Peak hour combination truck volume as a percentage of total AADT

Use: For investment requirements modeling to calculate capacity and peak volumes

Extent: All Sample Panel sections; optional for all other sections beyond the limits of the Sample Panel

Functional System		1	2	3	4	5	6	7
	NHS	**Int**	**OFE**	**OPA**	**MiA**	**MaC**	**MiC**	**Local**
Rural	SP	SP	SP	SP	SP	SP		
Urban	SP	SP	SP	SP	SP	SP	SP	

FE = Full Extent SP = Sample Panel Sections

Coding Requirements for Fields 8, 9, and 10:

Value_Numeric: Enter the peak hour combination truck volume as a percentage of the applicable roadway section's AADT rounded to the nearest thousandth of a percent (0.001%). This percent should not be rounded to the nearest whole percent or to zero percent if minimal vehicles exist.

Value_Text: No entry required. Available for State Use.

Value_Date: No entry required. Available for State Use.

Guidance:

Code this item based on vehicle classification data from traffic monitoring programs for vehicle classes 8 through 13 (as defined in the TMG) based on traffic counts taken on a three year cycle, as a minimum. Code this data item in accordance with the limits for which Data Item #24 is reported.
The Percent Peak Combination Truck value is calculated by dividing the number of combination trucks during the hour with the highest total volume (i.e. the peak hour) by the AADT (i.e. the total daily traffic). Note that this data item is based on the truck traffic during the peak traffic hour and not the hour with the most truck traffic.

If actual measured values are not available, then an estimate shall be made based on the most readily available information. The most credible method would be to use other site specific measured values from sites located on the same route. Other methods may include: assigning site specific measured values to other samples that are located on similar facilities with similar traffic characteristics in the same geographic area and in the same volume group; or assigning measured values from samples in the same functional system and in the same area type (i.e., rural, small urban, urbanized).

Statewide or functional system-wide values should not be used. Peak hour values may be different than daily averages which must be taken into consideration.
Supplemental methods and sources may be particularly useful in urban areas. These include turning movement studies, origin and destination studies, license plate surveys, design estimates and projections, and MPO data obtained for other purposes. Short term visual observation of truck travel can also be helpful when developing an estimate.
Note that this data represents the truck traffic during the peak traffic hour, not the 30th highest hourly volume for a given calendar year or the hour which has the peak truck traffic (see Figure 4.38).
The following examples illustrate the % Peak Combination-Unit (CU) Trucks calculation:

Example #1

AADT = 15,000 vehicles

CU AADT = 2,800 CU trucks (classes 8-13)

Peak hour CU Trucks = 215 CU trucks (classes 8-13)

% Peak CU Trucks = (Peak hour CU Trucks/AADT)*100 =

(215 CU Trucks/15,000)*100 = 1.433%

**When reported in HPMS, this % Peak CU value would be reported as 1.433%.*

Example #2

AADT = 70,240 vehicles

CU AADT = 22,750 CU Trucks (classes 8-13)

Peak hour CU Trucks = 1,528 CU Trucks (classes 8-13)

% Peak CU Trucks = (Peak hour CU Trucks/AADT)*100

(1,528 CU Trucks/70,240)*100 = 2.175%

**When reported in HPMS, this % Peak CU value would be reported as 2.175%.*

Item 26: K_Factor (K-factor)

Description: The design hour volume (30th largest hourly volume for a given calendar year) as a percentage of AADT

Use: For investment requirements modeling to calculate capacity and estimate needed capacity improvements, in the cost allocation pavement model, and for other analysis purposes, including delay estimation

Extent: All Sample Panel sections; optional for all other sections beyond the limits of the Sample Panel

Functional System		1	2	3	4	5	6	7
	NHS	Int	OFE	OPA	MiA	MaC	MiC	Local
Rural	SP	SP	SP	SP	SP	SP		
Urban	SP	SP	SP	SP	SP	SP	SP	

FE = Full Extent SP = Sample Panel Sections

Coding Requirements for Fields 8, 9, and 10:

Value_Numeric: Enter the K-factor to the nearest percent.

Value_Text: No entry required. Available for State Use.

Value_Date: No entry required. Available for State Use.

Guidance:

The K-factor is the design hour volume commonly known as, the 30th largest hourly volume for a given calendar year as a percentage of the annual average daily traffic Section specific values should be provided. Statewide or functional system-wide values should not be used.

The best source of this data is from continuous traffic monitoring sites. If continuous data is not available, use values derived from continuous count station data on the same route or on a similar route with similar traffic characteristics in the same area.
When utilizing traffic count data gathered from continuous traffic monitoring sites, the 30th highest hourly volume for a given year (typically used) is to be used for the purposes of calculating K-factor.
Other sources of this data may include the use of project level information for the section, turning movement and classification count data, regression analysis of computed K-factors at ATR stations, continuous site data grouped by urbanized areas to estimate urbanized area K-factors, and continuous site data grouped by number of lanes for high volume routes.
The hour used to calculate K-factor should also be used to calculate D-factor.
Code this data item in accordance with the limits for which Data Item #21 is reported.

Item 27: Dir_Factor (Directional Factor)

Description: The percent of design hour volume (30th largest hourly volume for a given calendar year) flowing in the higher volume direction

Use: For investment requirements modeling to calculate capacity and estimate needed capacity improvements, in congestion, delay, and other analyses, and in the cost allocation pavement model

Extent: All Sample Panel sections; optional for all other sections beyond the limits of the Sample Panel

Functional System		1	2	3	4	5	6	7
	NHS	**Int**	**OFE**	**OPA**	**MiA**	**MaC**	**MiC**	**Local**
Rural	SP	SP	SP	SP	SP	SP		
Urban	SP	SP	SP	SP	SP	SP	SP	

FE = Full Extent SP = Sample Panel Sections

Coding Requirements for Fields 8, 9, and 10:

Value_Numeric: Enter the percentage of the peak hour volume flowing in the peak direction. Code '100' for one-way facilities.

Value_Text: No entry required. Available for State Use.

Value_Date: No entry required. Available for State Use.

Guidance:

Section-specific values based on an actual count should be provided. If this information is unavailable, use values derived from continuous count station data on the same route or on a similar route with similar traffic characteristics in the same area. Statewide or functional system-wide values should not be used.
For two-way facilities, the directional factor normally ranges from 50 to 70 percent.
When utilizing traffic count data gathered from continuous traffic monitoring sites, the 30th highest hourly volume for a given year (typically used) is to be used for the purposes of calculating D-factor.
The hour used to calculate D-factor should also be used to calculate K-factor.
Code this data item in accordance with the limits for which Data Item #21 is reported.

Item 28: Future_AADT (Future AADT)

Description: Forecasted AADT

Use: For investment requirements modeling to estimate deficiencies and future improvement needs, in the cost allocation pavement model and in other analytical studies

Extent: All Sample Panel sections; optional for all other sections beyond the limits of the Sample Panel

Functional System		1	2	3	4	5	6	7
	NHS	Int	OFE	OPA	MiA	MaC	MiC	Local
Rural	SP	SP	SP	SP	SP	SP		
Urban	SP	SP	SP	SP	SP	SP	SP	

FE = Full Extent SP = Sample Panel Sections

Coding Requirements for Fields 8, 9, and 10:

Value_Numeric: Code the forecasted two-way AADT (one-way where applicable).

Value_Text: No entry required. Available for State Use.

Value_Date: Four-digit year for which the Future AADT has been forecasted.

Guidance:

This should be a 20-year forecast AADT, which may cover a period of 18 to 25 year periods from the data year of the submittal, and must be updated if less than 18 years.

Future AADT should come from a technically supportable State procedure, Metropolitan Planning Organizations (MPOs) or other local sources. HPMS forecasts for urbanized areas should be consistent with those developed by the MPO at the functional system and urbanized area level.

This data may be available from travel demand models, State and local planning activities, socioeconomic forecasts, trends in motor vehicle and motor fuel data, projections of existing travel trends, and other types of statistical analyses.

Code this data item in accordance with the limits for which Data Item #21 is reported.

Item 29: Signal_Type (Signal Type)

Description: The predominant type of signal system on a sample section

Use: For the investment requirements modeling process to calculate capacity and estimate delay

Extent: All Sample Panel sections located in urban areas; optional for all other urban sections beyond the limits of the Sample Panel and rural Sample Panel sections

Functional System		1	2	3	4	5	6	7
	NHS	Int	OFE	OPA	MiA	MaC	MiC	Local
Rural	SP*	SP*	SP*	SP*	SP*	SP*		
Urban	SP	SP	SP	SP	SP	SP	SP	

FE = Full Extent SP = Sample Panel Sections SP* = Sample Panel Sections (optional)

Coding Requirements for Fields 8, 9, and 10:

Value_Numeric: Enter the code that best describes the predominant type of signal system for the direction of travel (in the inventory direction). Signal information may be coded for rural sections on an optional basis.

Code	Description
1	Uncoordinated Fixed Time (may include pre-programmed changes for peak or other time periods).
2	Uncoordinated Traffic Actuated.
3	Coordinated Progressive (coordinated signals through several intersections).
4	Coordinated Real-time Adaptive
5	No signal systems exist.

Value_Text: No entry required. Available for State Use.

Value_Date: No entry required. Available for State Use.

Guidance:

It is difficult to determine coordinated signals from field observations, therefore the best source of such data may be traffic engineering departments or traffic signal timing plans. However, if such information cannot be obtained, field inspection and/or observation may be necessary.

Code '4' - Coordinated Real-Time Traffic Adaptive is difficult to determine from field reviews and may require discussion with local traffic engineering personnel. It is good practice to always contact the agencies responsible for the signals in question to obtain information on thetype of signal and green time when available.

Examples of Types of Signals:

Figure 4.38: Uncoordinated Fixed Time (Code '1') Example

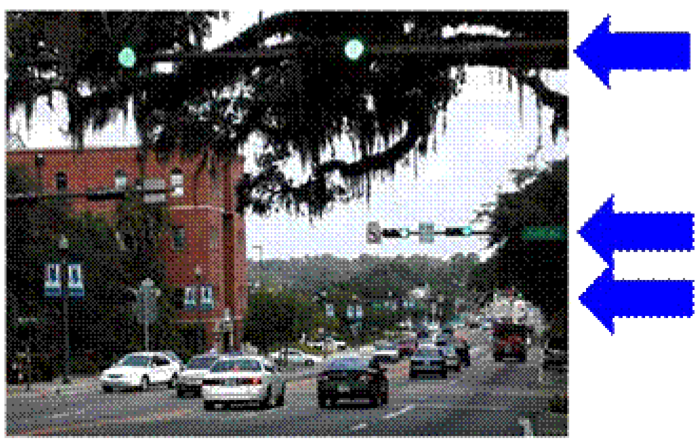
Generally found in rural areas, and in some cases small urban areas; typically not in close proximity to other traffic signals.

Figure 4.39: Uncoordinated Traffic Actuated (Code '2') Example

These signals are typically identified by the presence of in-pavement loops or other detectors (intrusive or non-intrusive) on the approach to the intersection in one or more lanes.

Figure 4.40: Coordinated Progressive (Code '3') Example

These signals usually occur in high-traffic urban or urbanized areas, in close proximity to other signals (as shown in Figure 4.40), and are usually timed or coordinated with adjoining signals. This type of signal allows for a more constant free flow of traffic.



Item 30: Pct_Green_Time (Percent Green Time)

Description:	The percent of green time allocated for through-traffic at intersections
Use:	For investment requirements modeling to calculate capacity and in congestion analyses
Extent:	All Sample Panel sections located in urban areas; optional for all other urban sections beyond the limits of the Sample Panel and rural Sample Panel sections

Functional System		**1**	**2**	**3**	**4**	**5**	**6**	**7**
	NHS	**Int**	**OFE**	**OPA**	**MiA**	**MaC**	**MiC**	**Local**
Rural	SP*	SP*	SP*	SP*	SP*	SP*		
Urban	SP	SP	SP	SP	SP	SP	SP	

FE = Full Extent SP = Sample Panel Sections SP* = Sample Panel Sections (optional

Coding Requirements for Fields 8, 9, and 10:

Value_Numeric: Enter the percent green time in effect during the peak period (max peak period preferred) for through traffic at signalized intersections, for the inventoried direction of travel.

Value_Text: No entry required. Available for State Use.

Value_Date: No entry required. Available for State Use.

Example - Procedure for Calculating Percent Green Time:

The timing of signals should occur during either the AM or PM peak period (i.e., 7-9 AM or 4-6 PM). Using a stopwatch, the entire signal cycle (green, amber, red) should be timed (in seconds), followed by the timing of the green cycle (in seconds). Then, divide the green cycle time by the entire signal time to find the percent green time. If the signal has a green arrow for turning movements, do not include the green arrow time in the timing of the green cycle. Use the average of at least three field-timing checks to determine a "typical" green time for traffic-actuated or demand responsive traffic signals.

Additional Guidance:

Code this Data Item for all sections where right and left turn data (Data Items 12 and 13) are coded.

Guidance: For uncoordinated traffic actuated signals only, data can be collected when monitoring green time. Consider the surrounding environment and determine if the inventory direction of the signal would actually carry the peak flow for the intersection. Based on this approach, the value received may be an estimate depending upon the operation of the traffic signal during the peak hour. Furthermore, if the traffic signal is fully actuated, or the approach of interest is actuated, estimate the percent of green time based on the maximum green time available for that phase of operation versus the maximum cycle length. This would provide the "worst case" scenario since the volume on the actuated approach typically varies cycle by cycle.

Where peak capacity for a section is governed by a particular intersection that is on the section, this Data Item should be coded based on the percent green time at that location; otherwise code this Data Item for the predominate intersection.

For traffic actuated traffic signals, use the results of a field check of several (three complete cycles) peak period light cycles to determine a "typical" green time. Ignore separate green-arrow time for turning movements.

Item 31: Number_Signals (Number of Signalized Intersections)

Description: A count of the signalized at-grade intersections

Use: For investment requirements modeling to calculate capacity and estimate delay

Extent: All Sample Panel sections, optional for all other sections beyond the limits of the Sample Panel

Functional System		**1**	**2**	**3**	**4**	**5**	**6**	**7**
	NHS	**Int**	**OFE**	**OPA**	**MiA**	**MaC**	**MiC**	**Local**
Rural	SP	SP	SP	SP	SP	SP		
Urban	SP	SP	SP	SP	SP	SP	SP	

FE = Full Extent SP = Sample Panel Sections

Coding Requirements for Fields 8, 9, and 10:

Value_Numeric: Code the number of signalized at-grade intersections, controlling traffic in the inventory direction.

Value_Text: No entry required. Available for State Use.

Value_Date: No entry required. Available for State Use.

Guidance:

A signal which cycles through red, yellow (amber), and green for all or a portion of the day should be counted as a signal.

Access points to large traffic generators (e.g., shopping centers, malls, large work sites, office parks, apartment complexes, etc.) should be counted as intersections if the access point is controlled by a traffic signal.

Special treatment is required when a Sample Panel section begins and/or ends with a traffic control device (i.e., Data Items 31, 32, and 33). This is accomplished by doing the following as illustrated in Figure 4.45:

- Choose a statewide direction for inventory purposes (e.g., South to North, West to East, etc.);
- Choose a statewide rule to either always count the beginning at-grade intersection only or the ending at-grade intersection only, but never both.

For divided roadways, continuous cross streets are to be counted as a single intersection. If the cross street is not continuous and is separated by at least 50 feet, then it should be counted as two intersections.

Roundabouts (see Figure 4.20) should be coded under Data Item 33 (At-Grade/Other) intersections.

The sum of Data Items 31, 32, and 33 should be equal to the total number of intersections on the section.

Figure 4.41 Signal Inventory

Count the signals controlling the route being inventoried. Each signal must cycle through red, yellow, and green.

Inventory direction

Source: FDOT RCI Field Handbook, Nov. 2008.

Item 32: Stop_Signs (Number of Stop-Sign Controlled Intersections)

Description:	A count of the at-grade intersections with stop signs
Use:	For investment requirements modeling to calculate capacity and estimate delay
Extent:	All Sample Panel sections, optional for all other sections beyond the limits of the Sample Panel

Functional System		**1**	**2**	**3**	**4**	**5**	**6**	**7**
	NHS	**Int**	**OFE**	**OPA**	**MiA**	**MaC**	**MiC**	**Local**
Rural	SP	SP	SP	SP	SP	SP		
Urban	SP	SP	SP	SP	SP	SP	SP	

FE = Full Extent SP = Sample Panel Sections

Coding Requirements for Fields 8, 9, and 10:

Value_Numeric: Enter the number of at-grade intersections, with a stop sign, controlling traffic in the inventory direction.

Value_Text: No entry required. Available for State Use.

Value_Date: No entry required. Available for State Use.

Guidance:

A continuously operating (i.e. all day), flashing red signal should be counted as a stop sign.

Stop signs on intersecting roads should not be included in the total count.

Access points to large traffic generators (e.g., shopping centers, malls, large work sites, office parks, apartment complexes, etc.) should be counted as intersections if the access point is controlled by a stop sign.

Special treatment is required when a Sample Panel section begins and/or ends with a traffic control device (i.e., Data Items 31, 32, and 33). This is accomplished by doing the following as illustrated in Figure 4.45:

- Choose a statewide direction for inventory purposes (e.g., South to North, West to East, etc).
- Choose a statewide rule to either always count the beginning at-grade intersection only or the ending at-grade intersection only, but never both.

For divided roadways, continuous cross streets are to be counted as a single intersection. If the cross street is not continuous and is separated by at least 50 feet, then it should be counted as two intersections.

Roundabouts (see Figure 4.20) should be coded under Data Item 33 (At-Grade/Other) intersections.

The sum of Data Items 31, 32, and 33 should be equal to the total number of intersections on the section.

Figure 4.42 Stop Sign Controlled Intersection

Source: MnDOT, Dec. 2012.

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APPENDIX 2. GTFS SUBSCRIBERS AROUND THE WORLD

As of April 2018

Africa

University of NairobiNairobi, Kenya

Asia

Bogor Angkots Bogor, Bogor City, West Java, Indonesia
Ministry of Transport and Road Safety Israel
OpenTransit Shizuoka Prefecture, Japan
Yamanashi Yamanashi Prefecture, Japan

Europe

Aachener Verkehrsverbund Aachen, Germany
ACTV Venice, Italy
Agenzia Mobilità Ambiente Territorio, Milan, Italy
Alilaguna Venice, Italy
Amat Palermo SpA Palermo, Italy
Artxanda Funicular Bilbao, Biscay, Spain
Association of Train Operating Companies, United Kingdom
Athens Urban Transport Organisation, Athens, Greece
Autolinee Mugello Valdisieve Mugello, 50032 Borgo San Lorenzo FI, Italy
Autolinee Varesine Varese VA, Italy
Azienda Trasporti dell'Area Fiorentina Florence, Italy
Azienda Varesina Trasporti Varese VA, Italy
Bean Shuttle Prague, Czechia
Bibus Brest, France
Bilbobus Bilbao, Biscay, Spain
BIOKOM Nonprofit Pécs, Hungary
Bizkaibus Bilbao, Biscay, Spain
BKK Budapest, Hungary
Carabus 17200 Royan, France
Citymapper London, UK
City of Hämeenlinna Hämeenlinna, Finland
City of Joensuu Joensuu, Finland
City of Jyväskylä Jyväskylä, Finland
City of Kotka Kotka, Finland

City of Kouvola Kouvola, Finland
City of Kuopio Kuopio, Finland
City of Lahti Lahti, Finland
City of Lappeenranta Lappeenranta, Finland
City of Mikkeli Mikkeli, Finland
City of Oulu Oulu, Finland
City of Turku Turku, Finland
City of VaasaVaasa, Finland
Communauté urbaine du Grand Nancy Nancy, France
Compañía del Tranvía de San Sebastián San Sebastián, Gipuzkoa, Spain
Consorcio Regional de Transportes de Madrid Madrid, Spain
Cuneo12100 Cuneo CN, Italy
DAKK Szeged, Hungary
Deutsche Bahn Germany
Empresa Malagueña de Transportes Andalusia, Spain
EMT Madrid Madrid, Spain
EMT Valencia Valencia, Spain
Euskotren Bilbao, Biscay, Spain
Ferries Finland
Ferrotramviaria Bari, Italy
Ferrotramviaria SpABari, Italy
FlixBus Europe
Gruppo Torinese Trasporti Turin, Italy
Helsinki Regional Transport Helsinki, Finland
iDBUS Paris, France
Karlsruher Verkehrsverbundes Karlsruhe, Germany
Kauno viešasis transportas (KVT)Kaunas, Lithuania
KautraDruskininkai, Lithuania
Klaipėda Transport Klaipėda, Lithuania
Koleje Mazowieckie Warsaw, Poland
Kolumbus Rogaland, Norway
Komunikacja Miejska Łomianki Warsaw, Poland
La Burundesa Bilbao, Biscay, Spain
La Union Bilbao, Biscay, Spain
Lignes d'Azur Nice, France
Liikennevirasto North Karelia, Finland
Maanteeamet Estonia
Metro Bilbao Bilbao, Biscay, Spain
Metro Warszawskie Warsaw, Poland
Metz Métropole Metz, France

Ministry of Transport and Communications	Finland
Mobilità e Trasporti Molfetta	Molfetta BA, Italy
MPK Wrocław	Wrocław, Poland
MVK Zrt	Miskolc, Hungary
Norsk Reiseinformasjon AS	Norway
OpenOV	Luxembourg
Oulun joukkoliikenne	Oulu, Finland
OV	The Netherlands
Panevezio Autobusu Parkas	Panevėžys, Lithuania
Praha	Prague, Czechia
Régie Autonome des Transports Parisiens	Paris, France
Region Marche	Marche, Italy
Rejseplanen	Denmark
Rhein-Neckar-Verkehr	Mannheim, Germany
Rīgas Satiksme	Rīga, Latvia
Roma Servizi per la Mobilità	Rome, Italy
Ruter	Oslo, Norway
Saint Petersburg	St Petersburg, Russia
SBB CFF FFS	Switzerland
Semitan	Nantes, France
Società Gestione Multipla SpA	73100 Lecce, Province of Lecce, Italy
Société des Transports Intercommunaux de Bruxelles	Brussels, Belgium
Société nationale des chemins de fer belges	Belgium
Société Régionale Wallonne du Transport	Walloon Region, Belgium
Stadt Wien	Vienna, Austria
STAR	Paris, France
STIF	Paris, France
SWU Verkehr GmbH	Ulm, Germany
Szybka Kolej Miejska w Warszawie	Warsaw, Poland
TAG	Grenoble, France
Tampereen joukkoliikenne	Tampere, Finland
Tisséo	Toulouse, France
TrafikLab	Sweden
Transbordador Vizcaya	Bilbao, Biscay, Spain
Transilien SNCF	Paris, France
Transporte Urbano Comarcal de Pamplona	Pamplona, Navarre, Spain
Transport for Greater Manchester	Manchester, UK
Transport for Ireland	Dublin, Ireland
Trenitalia DTR Piemonte	Piedmont, Italy
Trenord	Lombardy, Italy
Trentino Trasporti Esercizio	Trento, Italy

Tuvisa-EuskoTran Vitoria-Gasteiz, Álava, Spain
Verkehrsverbund Berlin-Brandenburg Berlin, Germany
Verkehrsverbund Rhein-Sieg Cologne, Germany
Verkéiersverbond Luxembourg
Vilnius Transport Vilnius, Lithuania
Vlaamse Vervoersmaatschappij De Lijn Flanders, Belgium
Warszawska Kolej Dojazdowa Warsaw, Poland
Weekendbus Pest County, Hungary
ZDiTM Szczecin Szczecin, Poland
ZTM Warszawa Warsaw, Poland

1. North America

10-15 Transit Ottumwa, IA 52501, USA
128 Business Council Waltham, MA, USA
9 Town Transit Middlesex County, CT, USA
ABQ Ride Albuquerque, NM, USA
AC Transit Oakland, CA, USA
Addison County Transit Addison County, VT, USA
Advance Transit Hartford, VT, USA
Agence métropolitaine de transport Montreal, QC, Canada
Airport Valet Express Bakersfield, CA, USA
Albany Transit System Albany, OR, USA
Alexandria Transit Company Alexandria, VA, USA
Allegany County Transit Allegany, MD, USA
Altamont Corridor Express Stockton, CA, USA
Amador Transit Amador County, CA, USA
Amazon Seattle, WA, USA
Anaheim Resort Transportation Anaheim, CA, USA
Annapolis Transit Annapolis, MD, USA
Ann Arbor Area Transportation Authority Ann Arbor, MI, USA
Arcata & Mad River Transit System Humboldt County, CA, USA
Arlington Transit Arlington, VA, USA
Asheville Transit Service Asheville, NC, USA
Athens Public Transit Athens, OH 45701, USA
Barrie Transit Barrie, ON, Canada
BART San Francisco, CA, USA
Basin Transit Service Klamath Falls, OR, USA
Bay Town Trolley Panama City, FL, USA
BC Ferries Vancouver, BC, Canada
BC Transit British Columbia, Canada
Beloit Transit Beloit, WI 53511, USA
Ben Franklin Transit Richland, WA, USA

Benton County Transportation Benton County, OR, USA
Birmingham Jefferson County Transit Authority Birmingham, AL, USA
Bi-State Development Agency Saint Louis, MO, USA
Blacksburg Transit Blacksburg, VA, USA
Bloomington Transit Bloomington, IN, USA
Blue & Gold Fleet San Francisco, CA, USA
Blue Star Transportation Portland, OR, USA
Brampton Transit Brampton, ON, Canada
Broward County Transit Fort Lauderdale, FL, USA
Bullhead Area Transit System Bullhead City, AZ, USA
Burlington Transit Burlington, ON, Canada
Bustang Denver, CO, USA
Butte Silver Bow Transit Butte, MT, USA
BWI Airport Shuttle Baltimore, MD, USA
Calaveras Transit San Andreas, CA, USA
Calgary Transit Calgary, AB, Canada
Caltrain San Francisco, CA, USA
Canby Area Transit Canby, OR 97013, USA
Capital Area Transportation Authority Lansing, MI, USA
Capital District Transportation Authority Albany, NY, USA
Capital Metro Austin, TX, USA
Capital Trailways Alabama, USA
Capital Transit Juneau, AK, USA
Capitol Corridor Oakland, CA, USA
Caravan Airport Transportation Portland, OR, USA
Carroll Area Transit System Carroll County, MD, USA
Cascade POINT Eugene, OR, USA
Cascades East Transit Bend, OR, USA
CATABUS State College, PA, USA
Cat Tran Shuttle Tucson, AZ, USA
CCC Xpress Clackamas County, OR, USA
Cecil Transit Cecil County, MD, USA
Cedar Rapids Transit Cedar Rapids, IA, USA
Central Arkansas Transit Authority Little Rock, AR, USA
Central Florida Regional Transportation Authority Orlando, FL, USA
Central Maryland Regional Transit Laurel, MD, USA
Central New York RTA New York, USA
Central Ohio Transit Authority Columbus, OH, USA
Central Oregon Breeze Bend, OR, USA
Champaign-Urbana Mass Transit District Champaign, IL, USA
Chapel Hill Transit Chapel Hill, NC, USA

Charleston Area Regional Transportation Authority Charleston, SC, USA
Chattanooga Area Regional Transportation Authority Chattanooga, TN, USA
Cherriots Salem, OR, USA
Chicago Transit Authority Chicago, IL, USA
Chittenden County Transportation Authority Chittenden County, VT, USA
Cincinnati Metro Cincinnati, OH, USA
Cities Area Transit Grand Forks, ND, USA
Citrus County Transit Citrus County, FL, USA
City 2 City Shuttle Eugene, OR, USA
CityLink Peoria, IL, USA
City of Atlanta Atlanta, GA, USA
City of Escalon Escalon, CA 95320, USA
City of Glendale Glendale, CA, USA
City of Kingston Kingston, ON, Canada
City of Lodi GrapeLine Lodi, CA, USA
City of Milton-Freewater Milton-Freewater, OR 97862, USA
City of Racine Racine, WI, USA
City of San Luis Obispo San Luis Obispo, CA, USA
City of Santa Monica Santa Monica, CA, USA
City of Saskatoon Saskatoon, SK, Canada
City of Torrance Torrance, CA, USA
City of Windsor Windsor, ON, Canada
Clemson Area Transit Clemson, SC, USA
Clinton MTA Clinton, IA, USA
Cobb Community Transit Cobb County, GA, USA
Codiac Transpo Moncton, NB, Canada
Colorado Mountain Express Denver, CO, USA
Columbia Area Transit Hood River County, OR, USA
Columbia County Rider Columbia County, OR, USA
Community Transit Everett, WA, USA
Confederated Tribes of the Umatilla Indian Reservation Pendleton, OR 97801, USA
Connecticut Transit Connecticut, USA
Connect Transit Bloomington, IL, USA
Coos County Area Transit Coos County, OR, USA
Corona Cruiser Corona, CA, USA
Corpus Christi RTA Corpus Christi, TX, USA
Corvallis Transit System Corvallis, OR, USA

Cottonwood Area Transit Cottonwood, AZ, USA
County Connection Concord, CA, USA
County Ride Queen Anne's County, MD, USA
C-TRAN Vancouver, WA, USA
Curry Public Transit Brookings, OR, USA
DART Dallas, TX, USA
DART First State Delaware, USA
Des Moines Area Regional Transit Authority Des Moines, IA, USA
Detroit Department of Transportation Detroit, MI, USA
Diamond Express Oakridge, OR, USA
Dodger Area Rapid Transit Fort Dodge, IA 50501, USA
Duarte Transit Duarte, CA, USA
Duke University Durham, NC, USA
Duluth Transit Duluth, MN, USA
Durham Region Transit Durham Regional Municipality, ON, Canada
Eastern Sierra Transit Bishop, CA 93514, USA
ECO Transit Eagle County, CO, USA
Edmonton Transit System Edmonton, AB, Canada
El Dorado Transit El Dorado County, CA, USA
Elevated Transit Utah, USA
El Monte Transit El Monte, CA, USA
Embark Oklahoma City, OK, USA
Emerald Coast Rider Okaloosa County, FL, USA
Emery Go-Round Emeryville, CA, USA
Escambia County Area Transit Pensacola, FL, USA
Everett Transit Everett, WA, USA
Fairfax Connector Fairfax, VA, USA
Fairfield and Suisun Transit Fairfield, CA, USA
Florida Department of Transportation Orlando, FL, USA
Foothill Transit San Gabriel Valley, Avocado Heights, CA 90601, USA
Fort Wayne Citilink Fort Wayne, IN, USA
Fort Worth Transportation Authority Fort Worth, TX, USA
Fresno Area Express Fresno, CA, USA
Fresno County Rural Transit Agency Fresno, CA, USA
Glendale Beeline Glendale, CA, USA
GoCary Cary, NC, USA
GoDurham Durham, NC, USA
Gold Coast Transit Oxnard, CA, USA
Gold Country Stage Nevada County, CA, USA
Golden Empire Transit District Bakersfield, CA, USA

Golden Gate Bridge Highway & Transportation District San Francisco, CA, USA
GoRaleigh Raleigh, NC, USA
GO Transit Oshkosh, WI, USA
GO Transit Toronto, ON, Canada
GoTriangle Durham, NC, USA
Grand River Transit Waterloo, ON, Canada
Greater Cleveland Regional Transit Authority Cleveland, OH, USA
Greater Lynchburg Transit Co. Lynchburg, VA, USA
Greater Sudbury Transit Sudbury, ON, Canada
Green Mountain Community Network Bennington, VT 05201, USA
Green Mountain Transit Agency Vermont, USA
GRTA Atlanta, GA, USA
Guelph Transit Guelph, ON, Canada
Gulf Coast Center Galveston, TX, USA
Gwinnett County Transit Gwinnett County, GA, USA
Hamilton Street Railway Hamilton, ON, Canada
Hampton Roads Transit Hampton, VA, USA
Harford Transit Harford County, MD, USA
Harrisonburg Transit Harrisonburg, VA, USA
Hernando County Transit Brooksville, FL, USA
Hillsborough Area Regional Transit Tampa, FL, USA
Huntsville Shuttle Huntsville, AL, USA
HUT Airport Shuttle Portland, OR, USA
IndyGo Indianapolis, IN, USA
Intercity Transit Olympia, WA, USA
Inter-Island Ferry Klawock, AK 99925, USA
I-Ride Trolley Orlando, FL, USA
Jacksonville Transportation Authority Jacksonville, FL, USA
Janesville Transit System Janesville, WI, USA
JATRAN Jackson, MS, USA
JeffCo Express Jefferson County, MO, USA
JFK Airtrain Queens, NY, USA
Josephine County Transit Josephine County, OR, USA
Kansas City Area Transportation Authority Kansas City, MO, USA
Kern Transit Bakersfield, CA, USA
Ketchikan Gateway Borough Ketchikan, AK 99901, USA
King County Metro Seattle, WA, USA
Kitsap Transit Bremerton, WA, USA
Klamath Shuttle Klamath Falls, OR, USA
Knoxville Area Transit (KAT) Knoxville, TN, USA

LADOT Transit Services Los Angeles, CA, USA
Laguna Beach Transit Laguna Beach, CA, USA
Lakes Region Explorer Cumberland County, ME, USA
Laketran Painesville Township, OH, USA
Lake Transit Authority Lower Lake, CA, USA
LA Metro Los Angeles, CA, USA
Lane Transit District Eugene, OR, USA
Lassen Rural Bus Susanville, CA, USA
Lehigh and Northampton Transportation Authority Allentown, PA, USA
Lextran Lexington, KY, USA
Lincoln County Transit Lincoln County, OR, USA
Link Transit Wenatchee, WA, USA
Linn-Benton Loop Bus Albany, OR, USA
Linn Shuttle Linn County, OR, USA
Livermore Amador Valley Transit Authority Livermore, CA, USA
London Transit Commission London, ON, Canada
Long Beach Transit Long Beach, CA, USA
MACS Transit Fairbanks, AK, USA
Madera County Transit Madera, CA, USA
Malheur Council on Aging & Community Services Malheur County, OR, USA
Manatee County Area Transit Bradenton, FL, USA
Manatee County Area Transit Manatee County, FL, USA
Marble Valley Regional Transit District Rutland, VT, USA
Marin Transit Marin County, CA, USA
Marshalltown Municipal Transit Marshalltown, IA 50158, USA
MARTA Atlanta, GA, USA
Mason City Public Transit Mason City, IA 50401, USA
Mason Transit Mason County, WA, USA
massDOT Massachusetts, USA
MATBUS Fargo, ND, USA
MBTA Boston, MA, USA
Mendocino Transit Authority Mendocino County, CA, USA
Mendocino Transit Authority Mendocino, CA, USA
Merced Transit Authority Merced, CA, USA
Metra Chicago, IL, USA
METRO Houston, TX, USA
Metrobus Transit St. John's, NL, Canada
Metrolink Los Angeles, CA, USA
MetroTransit Halifax, NS, Canada
Metro Transit Madison, WI, USA

Metro Transit Minneapolis, MN, USA
Mexico City Federal District Government Mexico City, Federal District, Mexico
Miami-Dade County Transit Miami, FL, USA
Michigan Flyer East Lansing, MI, USA
Milton Transit Milton, ON, Canada
Milwaukee County Transit System Milwaukee, WI, USA
Minnesota Valley Transit Authority Minneapolis, MN, USA
MiWay Mississauga, ON, Canada
Modesto Area Express Modesto, CA, USA
Monroe County Transportation Authority Monroe County, PA, USA
Monterey-Salinas Transit Monterey, CA, USA
Montgomery County Department of Transportation Montgomery, MD, USA
Montgomery Transit Montgomery, AL, USA
Mountain Line Flagstaff, AZ, USA
Mountain Line Missoula, MT, USA
Mountain Metropolitan Transit Colorado Springs, CO, USA
Mountain Rides Transportation Authority Ketchum, ID, USA
Mountain Transit Big Bear, CA, USA
MTA Maryland Maryland, USA
Mt Hood Express Sandy, OR, USA
MuscaBus Muscatine, IA 52761, USA
MVgo Mountain View, CA, USA
Nashville MTA Nashville, TN, USA
Nassau Inter-County Express Nassau, NY, USA
National Park Service United States
New Orleans Regional Transit Authority New Orleans, LA, USA
New York City MTA New York, NY, USA
Niagara Frontier Transportation Authority Buffalo, NY, USA
NJ Transit New Jersey, USA
North Carolina State University Raleigh, NC, USA
North County Transit District San Diego, CA, USA
Northeast Oregon Public Transit La Grande, OR 97850, USA
NorthWest POINT Astoria, OR, USA
Norwalk Transit System Norwalk, CA, USA
NYC DOT New York, NY, USA
Oakville Transit Oakville, ON, Canada
Ocean City Transportation Ocean City, MD, USA
OC Transpo Ottawa, ON, Canada
OmniTrans San Bernardino, CA, USA

Orange County Transportation Authority Orange County, CA, USA
Oregon Express Shuttle Albany, OR, USA
Pace Suburban Bus Chicago, IL, USA
Pacific Crest Bus Lines Eugene, OR, USA
Pacific Transit Pacific County, WA, USA
Palm Tran West Palm Beach, FL, USA
Palos Verdes Peninsula Transit Authority Palos Verdes Peninsula, CA, USA
Palo Verde Valley Transit Agency Palo Verde Valley, California 92266, USA
PASS Transit Beaumont, CA, USA
PATCO New Jersey, USA
People Mover Anchorage, AK, USA
People Mover Grant County, OR, USA
Petaluma Transit GTFS Petaluma, CA, USA
Piedmont Authority for Regional Transportation Greensboro, NC, USA
Pierce Transit Pierce County, WA, USA
Plumas Transit Plumas County, CA, USA
Port Authority of Allegheny County Pittsburgh, PA, USA
Port Authority of New York and New Jersey Jersey City, NJ, USA
Potomac and Rappahannock Transportation Commission Woodbridge, VA, USA
PSTA Pinellas, FL, USA
Pulaski Area Transit Pulaski, VA, USA
Quail Trail Public Transit Klamath Falls, OR, USA
Rabbit Transit York, PA, USA
Radford Transit Radford, VA, USA
Red Apple Transit Farmington, NM, USA
Redding Area Bus Authority Redding, CA, USA
Redwood Coast Transit Crescent City, CA, USA
Regional Municipality of Niagara Niagara Regional Municipality, ON, Canada
Regional Transit System Gainesville, FL, USA
Regional Transportation Agency of Central Maryland Maryland, USA
Réseau de transport de la Capitale Quebec City, QC, Canada
Réseau de transport de Longueuil Longueuil, QC, Canada
Rhode Island Public Transit Authority Providence, RI, USA
Rhody Express Florence, OR 97439, USA
Ride Connection Portland, OR, USA
Rider Transit Cabarrus County, NC, USA
RIDE Sitka Sitka, AK, USA

Rio Vista Delta Breeze Rio Vista, CA, USA
RiverCities Transit Longview, WA, USA
Riverside Transit Agency Riverside, CA, USA
Roaring Fork Transportation Authority Aspen, CO 81611, USA
Rochester City Lines Rochester, MN, USA
Rochester Genesee Regional Transportation Authority Rochester, NY, USA
Rogue Valley Transportation District Medford, OR, USA
RTC Southern Nevada Las Vegas, NV, USA
RTC Washoe Reno, NV, USA
RTD Denver Denver, CO, USA
Rural Community Transportation Vermont, USA
Sacramento Regional Transit Sacramento, CA, USA
Sage Stage Modoc County, CA, USA
SamTrans San Francisco, CA, USA
San Benito County Express San Benito County, CA, USA
San Diego MTS San Diego, CA, USA
Sandy Area Metro Sandy, OR, USA
San Joaquin RTD Stockton, CA, USA
San Luis Obispo RTA San Luis Obispo, CA, USA
Santa Cruz Metro Santa Cruz, CA, USA
Santa Maria Area Transit Santa Maria, CA, USA
Sarasota County Area Transit Sarasota, FL, USA
Seattle Children's Hospital Seattle, WA, USA
Sedona RoadRunner Sedona, AZ, USA
SEPTA Philadelphia, PA, USA
SFMTA San Francisco, CA, USA
Simi Valley Transit Simi Valley, CA, USA
Sioux Area Metro Sioux Falls, SD, USA
Sioux City Transit System Sioux City, IA, USA
Siskiyou Transit and General Express Siskiyou County, CA, USA
Skamania County Public Transit Skamania County, WA, USA
Snowmass Village Transportation Snowmass Village, CO, USA
Société de transport de Laval Laval, QC, Canada
Société de transport de l'Outaouais Gatineau, QC, Canada
Société de transport de Montréal Montreal, QC, Canada
Société de Transport de Sherbrooke Sherbrooke, QC, Canada
SolTrans Solano County, CA, USA
Sonoma County Transit Sonoma County, CA, USA
Sound Transit Seattle, WA, USA
South Clackamas Transportation District Clackamas County, OR, USA

South Florida Regional Transportation Authority Pompano Beach, FL, USA
South Lane Wheels Cottage Grove, OR 97424, USA
South Shore Line Chesterton, IN 46304, USA
SouthWest POINT Brookings, OR, USA
Space Coast Area Transit Melbourne, FL, USA
Spirit Bus Monterey Park, CA, USA
Spokane Transit Authority Spokane, WA, USA
Springfield Mass Transit District Springfield, IL, USA
Stagecoach Transportation Services Orange County, VT, USA
St Albert Transit Saint Albert, AB, Canada
Stanford Marguerite Shuttle Stanford, CA, USA
Stanislaus Regional Transit Stanislaus County, CA, USA
StarMetro Tallahassee, FL, USA
StarTran Lincoln, NE, USA
STAR Transit Dallas County, TX, USA
Strathcona County Transit Edmonton, AB, Canada
Streamline Bozeman, MT, USA
SunLine Transit Agency Thousand Palms, CA, USA
Sun Metro El Paso, TX, USA
Sunset Empire Transportation District Astoria, OR, USA
Sunshine Bus Company St Augustine, FL, USA
SunTran Tucson, AZ, USA
SunTran Ocala, FL, USA
Swan Island Evening Shuttle Portland, OR, USA
T3 Transit Charlottetown, PE, Canada
TAC Transportation Eugene, OR, USA
Tahoe Area Regional Transit Placer County, CA, USA
Tar River Transit Rocky Mount, NC, USA
Tehama Rural Area eXpress Tehama County, CA, USA
Terre Haute Transit Terre Haute, IN, USA
TheBus Honolulu Honolulu, HI, USA
The City of Regina Regina, SK, Canada
The Current Town of Rockingham, VT, USA
The JO Johnson County, KS, USA
The MOOver Wilmington, VT, USA
The Rapid Grand Rapids, MI, USA
The Victoria Clipper Seattle, WA, USA
The Wave Tillamook, OR 97141, USA
Thousand Oaks Transit Thousand Oaks, CA, USA
Thunder Bay Transit Thunder Bay, ON, Canada

Tideline Water Taxi San Francisco, CA, USA
Toronto Transit Commission Toronto, ON, Canada
Transfort Fort Collins, CO, USA
Transit Authority of Northern Kentucky Fort Wright, KY, USA
Transit Authority of River City Louisville, KY, USA
TransLink Vancouver Vancouver, BC, Canada
TriMet Portland, OR, USA
Trinity County Transportation Commission Trinity County, CA, USA
Tulsa Transit Tulsa, OK, USA
UDASH Missoula, MT, USA
Union Gap Transit Yakima, WA, USA
Unitrans Davis, CA, USA
University of Michigan Parking & Transportation Services Ann Arbor, MI, USA
Utah Transit Authority Salt Lake City, UT, USA
UTrans Roseburg, OR, USA
Vail Transit Vail, CO 81657, USA
Valley Metro Phoenix, AZ, USA
Valley Metro Roanoke, VA, USA
Valley Retriever Buslines Newport, OR, USA
ValleyRide Boise, ID, USA
Ventura County Transportation Commission Ventura County, CA, USA
Verde Lynx Cottonwood, AZ, USA
Vermont Translines Vermont, USA
VIA Metropolitan Transit San Antonio, TX, USA
Victor Valley Transit Authority Hesperia, CA, USA
Virginia Railway Express Virginia, USA
Votran Daytona Beach, FL, USA
VTA San Jose, CA, USA
Wallowa Community Connection Wallowa County, OR, USA
Washington Park Shuttle Portland, OR, USA
Washington State Ferries Seattle, WA, USA
WATA Williamsburg, VA, USA
Waukesha Metro Transit Waukesha, WI, USA
Wave Transit Wilmington, NC, USA
WestCAT Pinole, CA, USA
Westchester County Department of Transportation Westchester County, NY, USA
Wichita Transit Wichita, KS, USA
Wilsonville Transit Wilsonville, OR, USA
Winnipeg Transit Winnipeg, MB, Canada

WMATA Washington, DC, USA
Woodburn Transit Service Woodburn, OR, USA
Yakima Transit Yakima, WA, USA
Yamhill County Transit Area Yamhill County, OR, USA
York Region Transit York Regional Municipality, ON, Canada
Yosemite Area Regional Transportation System Yosemite Valley, CA, USA
Yuba-Sutter Transit Yuba City, CA, USA
Yuma County Intergovernmental Public Transportation Authority Yuma, AZ, USA

2. Oceania

Action Buses Canberra ACT, Australia
Adelaide Metro Adelaide SA, Australia
Auckland Transport Auckland, New Zealand
Byron Easybus Byron Bay NSW 2481, Australia
Christchurch Metro Christchurch, New Zealand
InterCity Group New Zealand
Metlink Wellington, New Zealand
MetroTas Tasmania, Australia
Mornington Railway Mornington Peninsula, VIC, Australia
NT Department of Transport Darwin NT, Australia
PTV Melbourne VIC, Australia
TransLink Brisbane Queensland, Australia
Transperth Perth WA, Australia
Transport for NSW New South Wales, Australia

3. South America

BHTRANS Belo Horizonte, Belo Horizonte - State of Minas Gerais, Brazil
BogoMap Bogotá, Bogota, Colombia
Empresa Publica de Transportes e Circulação Porto Alegre - RS, Brazil
Mar Chiquita SRL Córdoba, Cordoba, Argentina
Prefeitura de Bage Bagé, RS, Brazil
Subterráneos de Buenos Aires Buenos Aires, Autonomous City of Buenos Aires, Argentina

4. South East Asia

Chiang Mai University Chiang Mai, Mueang Chiang Mai District, Chiang Mai, Thailand
Coopthai NCT Chiang Mai, Mueang Chiang Mai District, Chiang Mai, Thailand
GreenBus Thailand Chiang Mai, Mueang Chiang Mai District, Chiang Mai, Thailand

Kwanwiang Transport Chiang Mai, Mueang Chiang Mai District, Chiang Mai, Thailand
Lampoon Pattana Transport Chiang Mai, Mueang Chiang Mai District, Chiang Mai, Thailand
Northern Chiang Mai Chiang Mai, Mueang Chiang Mai District, Chiang Mai, Thailand
Philippines Dept of Transportation Philippines
WhiteBus Chiang Mai, Mueang Chiang Mai District, Chiang Mai, Thailand

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