Maximizing Data Usage by Transit Agencies

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ACRONYMS AND ABBREVIATIONS

ACS	American Community Survey
AM	Ante Meridiem
APC	Automated Passenger Counter
API	Application Programming Interface
APTA	American Public Transportation Association
AVL	Automatic Vehicle Location
AWS	Amazon Web Services
COA	Comprehensive Operational Analysis
CTPP	Census Transportation Planning Package
DART	Dallas Area Rapid Transit
DFW	Dallas/Fort Worth
DPW	Denver Public Works
FDOT	Florida Department of Transportation
FMLM	First Mile Last Mile
FTA	Federal Transit Administration
GTFS	General Transit Feed Specification
GPS	Global Positioning Systems
HART	Hillsborough Area Regional Transit Authority
ICM	Integrated Corridor Management
ID	Identity Document
IT	Information Technologies
JTW	Journey to Work
LEHD	Longitudinal Employer-Household Dynamics
MaaS	Mobility as a Service
MAX	Metro Arlington Xpress
MDT	Miami-Dade Transit
MDOT MTA	Maryland Department of Transportation's Maryland Transit Administration
MPO	Metropolitan Planning Organization
MTA	Maryland Transit Administration
MUMA	Moovit Urban Mobility Analytics
NTD	National Transit Database
O-D	Origin Destination
PII	Personally Identifiable Information
PM	Post Meridiem
RAC	Resident Area Characteristics
RFP	Request for Proposals
RTS	Gainesville Regional Transit System
SaaS	Software as a Service
SUV	Sport Utility Vehicle
SWOT	Strengths, Weaknesses, Opportunities, and Threats
TaaS	Transportation as a Service
TAM	Transportation Authority of Marin
TAP	Transit Access Pass
TAZ	Traffic Analysis Zone
TCRP	Transit Cooperative Research Program
TDP	Transit Development Plan
TriMet	Tri-County Metropolitan Transportation District of Oregon

TNCs	Transportation Network Companies
UFS	Universal Farebox System
US	United States of America
UTA	University of Texas at Arlington
UTTP	Urban Transportation Planning Package
UZA	Urbanized Area
VTA	Santa Clara Valley Transit Authority
WAC	Workplace Area Characteristics

EXECUTIVE SUMMARY

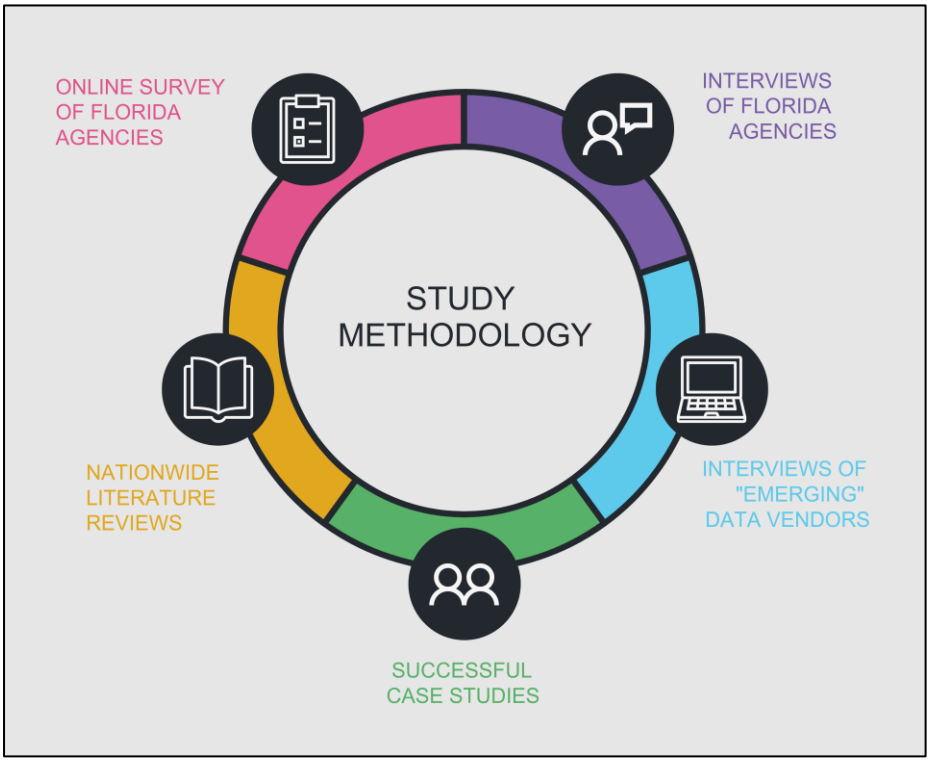
Transit agencies face challenges every day with accessing and utilizing data for improved decision-making in service planning, operational analysis, corridor studies and forecasting. Various collected and publicly available state and national datasets can be accessed by transit agencies, yet many are currently struggling to effectively utilize this data, especially with the virtually exponential rise of emerging data sources. Moreover, the increased penetration of smart phones and high-speed internet over the last decade has led to an explosion in data being collected and made available by private vendors. New startups are also finding innovative ways to collaborate with transit agencies across the country. This adds an additional challenge for transit agencies in understanding the type of data, tools, and solutions being provided by these private vendors as well as dealing with numerous contractual challenges from these emerging data sources.

The purpose of this study is to:

- Summarize the key data and tools currently available to the transit agencies in Florida, as well as some of the datasets being provided by private vendors. Potential applications of these types of data are also provided to further inform and assist transit agencies.
- Document the current state of practice and knowledge about data in Florida's transit agencies based on findings from a survey of these agencies and follow-up interviews with two of the survey respondents.
- Understand the experiences of private vendors with transit agencies. This study conducted interviews with three different private vendors for this purpose.
- Summarize case studies of successful collaboration between private vendors and public transit agencies from around the country. This study provides two case studies from Texas and California.
- Provide recommendations for transit agencies on how to maximize the data usage in their day to day planning, operational and corridor analyses.

This study classifies data into two broad categories:

- "Traditional" data: This refers to data that is typically collected by transit agencies or already available to them from other sources.
- "Emerging" data: This refers to data that is becoming available from private vendors using apps and location-based services on cell phones and other mobile devices.



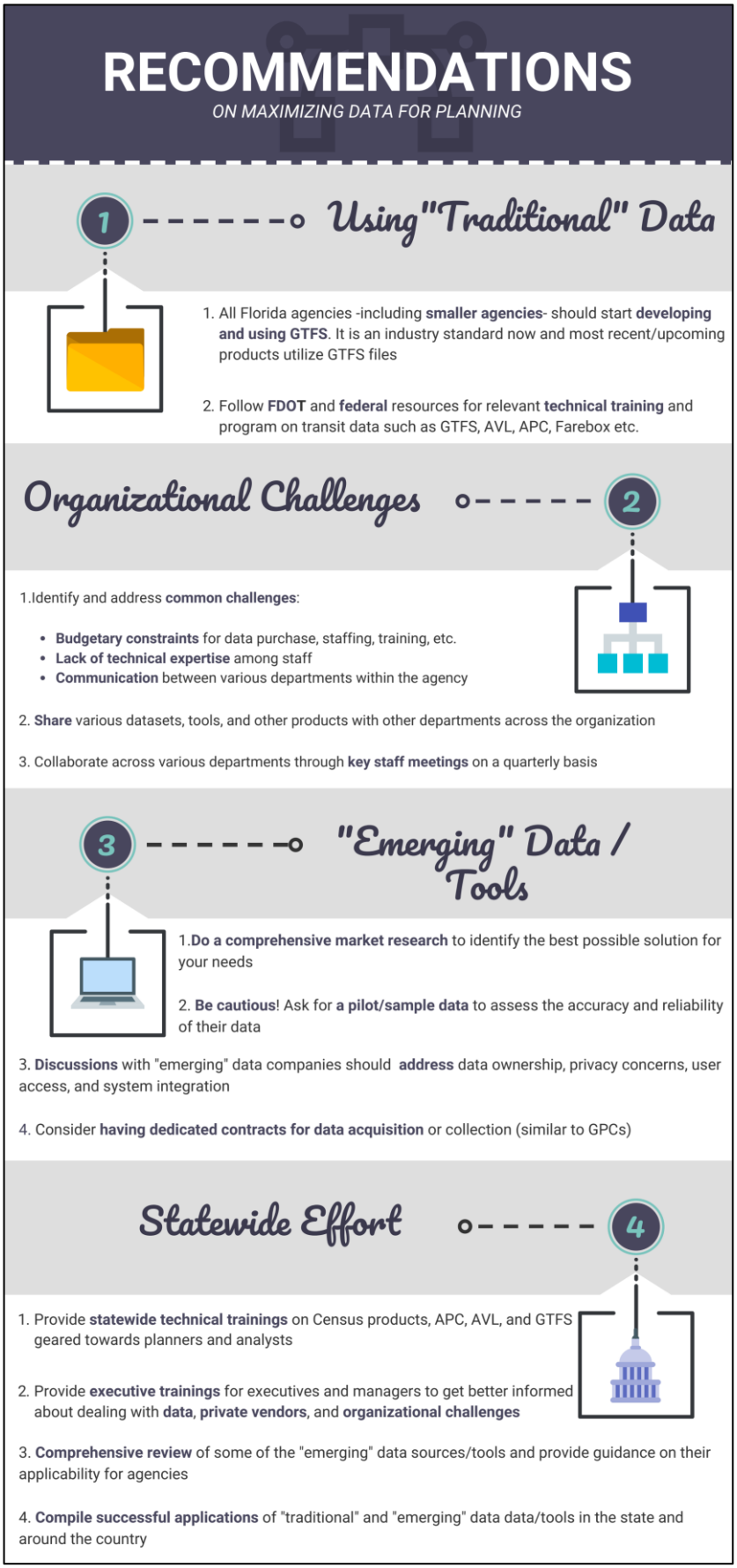
To help transit agencies better utilize “traditional” data, and to introduce several “emerging” datasets, a body of literature that included descriptions with an application of each around the nation is provided in this document. Following that, the study team conducted an online survey that was sent to thirty (30) transit agencies in Florida that have urban fixed route systems. The purpose of this survey was to identify the extent of their knowledge and experience with “traditional” and “emerging” data. Follow-up interviews were also conducted with Gainesville Regional Transit System (RTS) and Bay Town Trolley to delve deep into the practice of data usage at transit agencies. Results showed that agencies were having trouble allocating resources and time to analyze data available or collected. Some agencies reported lack of technical expertise and availability of technical training to assist them in maximizing data usage. Also, standardization of public data and lack of coordination between various intra-agency departments are some of the other issues faced by transit agencies.

To understand the public-private partnership dynamics, interviews were conducted with Moovit, Via, and Swiftly to identify the extent of their experiences with transit agencies. The interviews also gauged the extent and type of data collected, and their business models with agencies. These interviews showed that mid-sized agencies were increasingly interested in acquiring data, whereas smaller agencies often wanted to utilize tools developed by the vendors. Also, vendors are willing to provide a range of flexibility in terms of their platforms and business models to meet the agency’s needs. They are also committed to prevent unauthorized or improper access to data due to privacy concerns. Further, the ownership of data depended on the type of data collected, and the vendor collecting the data.

This study also provides two case studies from City of Arlington, Texas and Santa Clara Valley Transit Authority (VTA) where “emerging” data had been used for planning applications. City of Arlington, Texas was a story of an on-demand public transit solution through partnering with Via for a city with no fixed route service and how data collected through the system helped shape the city council’s

future planning decisions. VTA was a story of how an agency overcame the challenges due to decentralized and siloed data collection and analysis effectively utilizing the large volumes of data collected on their system while partnering with Swiftly.

Finally, based on the literature review of data, surveys and interviews with transit agencies and private vendors, the study provides recommendations for transit agencies on how to maximize the data usage in their day to day planning, operational and corridor analyses. The recommendations are summarized in the figure to the right.



1. INTRODUCTION

Transit agencies rely on a range of datasets and tools to assist them with their service planning, operational analysis, corridor studies, and forecasting efforts. There is a lot of data already being collected by transit agencies, and various datasets are also being made available by state and national agencies. Further, the emergence of passive data from mobile phones and GPS systems being collected and made available by private vendors provides transit agencies with potential new datasets and tools that can be utilized for smarter decision-making and resource allocation. Transit agencies have struggled to effectively utilize the data that is already being collected by them, and the passive data from mobile phones adds further challenges. This report strives to address several key questions:

- What are the various datasets already available to transit agencies and how can they potentially be used?
- What is the current state of practice and knowledge about data in Florida's transit agencies?
- What kind of passive datasets and related tools are being made available by private vendors?
- How are transit agencies in Florida and across the country benefitting by partnering with private vendors?
- What can transit agencies do to maximize the data usage in their decision making?

The rest of the document is divided into five chapters:

- Chapter 2 provides a review of the various data sets under the two broad categories – traditional and emerging data – and provides example applications of each dataset.
- The study team conducted an outreach of the Florida transit agencies through an online survey questionnaire and interviews to investigate the extent of data usage for planning and operations analyses purposes. The methodology of this outreach and the findings are summarized in Chapter 3.
- The study team also conducted an outreach of a few private vendors in the "emerging" data sector to identify the extent of their experiences with transit agencies, and the details are documented in Chapter 4.
- Chapter 5 provides two case studies from around the nation of transit agency partnerships with private vendors and how data helped them make informed decisions.
- Finally, in Chapter 6, the study team provides recommendations to improve and optimize the usage of "traditional" and "emerging" data by transit agencies.
- The appendices contain the survey questionnaire used in Chapter 2 and figures summarizing the survey responses.

Terminology and Formatting

This report focuses on two broad categories of data:

- "Traditional" data: This refers to data that is typically collected by transit agencies or already available to them from other sources.
- "Emerging" data: This refers to data that is becoming available from private vendors using apps and location-based services on cell phones and other mobile devices.

In Chapter 2, text in blue color against a white background provides a key point or definition related to the corresponding section, whereas text in blue color inside a box against a dark background provides example applications of the specific dataset.

2. UNDERSTANDING DATA AND CURRENT PRACTICE

The information in this chapter will help transit agencies better utilize "traditional" data that is readily available by offering specific real-world applications of each dataset. This chapter also introduces transit agencies to several "emerging" datasets and provides specific examples of their usage across the country that might help improve planning processes, day-to-day planning and operational activities, and other forecasting efforts.

The rest of the chapter describes the various datasets under each of the two broad categories and provides example applications of each dataset. "Traditional" datasets are described first, followed by "emerging" datasets.

2.1. "TRADITIONAL" DATA

Several datasets are already available to transit agencies that can improve the decision-making process in planning and operational efforts. These include datasets that are available from existing sources (e.g. Census data), and data that is collected by transit agencies (e.g. farebox). These datasets are referred to as "traditional" data in this document.

"TRADITIONAL" DATA IN THIS DOCUMENT REFERS TO DATA THAT IS TYPICALLY AVAILABLE OR COLLECTED BY TRANSIT AGENCIES. EXAMPLES INCLUDE DATA WHICH IS AUTOMATICALLY COLLECTED ON TRANSIT VEHICLES SUCH AS APC, AVL, AND FAREBOX DATASETS. FURTHER, "TRADITIONAL" DATA ALSO INCLUDES DATA WHICH IS COLLECTED LESS FREQUENTLY SUCH AS RIDECHECK DATA, ORIGIN-DESTINATION SURVEYS AND CENSUS DATA PRODUCTS.

Collectively, these "traditional" datasets include but are not limited to:

- Census data (such as American Community Survey – ACS, Longitudinal Employer-Household Dynamics – LEHD, and Census Transportation Planning Package – CTPP products);
- General Transit Feed Specification (GTFS);
- Automated Passenger Counter (APC);
- Automatic Vehicle Location (AVL);
- Manual ridecheck data;
- Farebox transaction data;
- Origin-Destination surveys.

The following sections describe the above data sets and provide an application of each.

2.1.1. Census Data

US Census data products have been available for transit planning efforts for many years. Some of the most commonly utilized datasets are listed below:

- **American Community Survey (ACS)** is an on-going survey of the population of the United States conducted by the Census Bureau. The ACS collects information related to housing and person characteristics and asks travel-related questions that focus solely on commuting patterns. Census Bureau uses a series of monthly samples to produce annually updated estimates for the same small areas (census tracts and block groups) formerly surveyed via the decennial census long-form sample. Initially, five years of samples were required to produce

these small-area data. Once the Census Bureau released its first 5-year estimates in December 2010; new small-area statistics now are produced annually. The Census Bureau also produces 3-year and 1-year data products for larger geographic areas.[1] Data can be downloaded in a tabular format and joined with Census TIGER line shape files.

- **Census Transportation Planning Products (CTPP)** is a set of special tabulations that includes worker flows between home and work by travel mode. CTPP data includes workplace-based worker, residence-based worker and household characteristics. From 1970 to 2000, the CTPP and its predecessor, Urban Transportation Planning Package (UTPP), used data from the decennial census long form. The decennial census long form has now been replaced with ACS. Therefore, the CTPP now uses the ACS sample for the special tabulation. The 2006-2010 CTPP, using 5 years of ACS, includes small geographic units such as census tracts and Transportation Analysis Zones (TAZs). The 2012-2016 CTPP data was announced to be available in December 2018 and released to public on CTPP website in Spring 2019[2]. However, all CTPP data released after the 2020 Census will be reported by block group as opposed to TAZs. An online CTPP mapping tool helps users visualize CTPP data and perform analysis[3].
- **Longitudinal Employer-Household Dynamics (LEHD)** is a program that combines federal, state and Census Bureau data on employers and employees. It provides statistics on employment, earnings, and job flows at detailed levels of geography, industry and demographic groups. Data files are state-based and organized into three types: Origin-Destination (O-D), Residence Area Characteristics (RAC), and Workplace Area Characteristics (WAC), all at 2010 census block geographic detail. Data is available for most states for the years 2002–2015 based on the 2016 TIGER/Line shapefiles, with a quarterly release frequency.

ACS, CTPP AND LEHD ARE DATA PRODUCTS COLLECTED OR DEVELOPED BY THE CENSUS BUREAU ON A REGULAR BASIS.

Longitudinal Employer-Household Dynamics (LEHD) OnTheMap[4]

The "OnTheMap" tool developed by the US Census is an online mapping and reporting application that shows where workers are employed and live, along with companion reports on worker characteristics and optional filtering by age, earnings, and industry groups. It provides an easy-to-use interface for creating, viewing, printing and downloading workforce related maps, profiles, and underlying data. OnTheMap synthesizes home-to-work flows at the Census Block level[5]. This data can be utilized in journey-to-work (JTW) flow analysis. Such data can assist in travel demand modeling/forecasting activities, identifying current or future demand for transit or ridesharing, and improved bus route planning. The data can be exported in tabular and shapefile format through OnTheMap tool (**Figure 1**).

Accessibility Observatory at the University of Minnesota published a report in 2016 focusing on investigating the effectiveness of transit in facilitating access to jobs over time in a metro area. Accessibility measures the number of jobs that can be reached in a specified time, and data describing the distribution of labor and employment is drawn from the US Census Bureau's LEHD

[1] American Community Survey Design and Methodology, Chapter 1 Introduction, U.S. Census Bureau, https://www2.census.gov/programs-surveys/acs/methodology/design_and_methodology/acs_design_methodology_ch01_2014.pdf#, accessed: 05/20/2019
[2] Census Transportation Planning Products, Federal Highway Administration, https://www.fhwa.dot.gov/planning/census_issues/ctpp/status_report/sr0119/index.cfm, accessed: 05/20/2019
[3] CTTP Mapping and Analysis tool, http://data5.ctpp.transportation.org/ctpp/Browse/browsetables.aspx, accessed: 05/20/2019
[4] Longitudinal Employer-Household Dynamics, U.S. Census, https://lehd.ces.census.gov/applications/, accessed: 04/25/2019
[5] Understanding LEHD and Synthetic Home to Work Flows in "On The Map", FHWA Office of Planning, http://www.edthefed.com/papers/lehd_process_draft.pdf, 2007, accessed: 04/25/2019

program. Results are used by transit agencies to analyze the transit service and the data can also be used to improve job accessibility for transit[6,7].

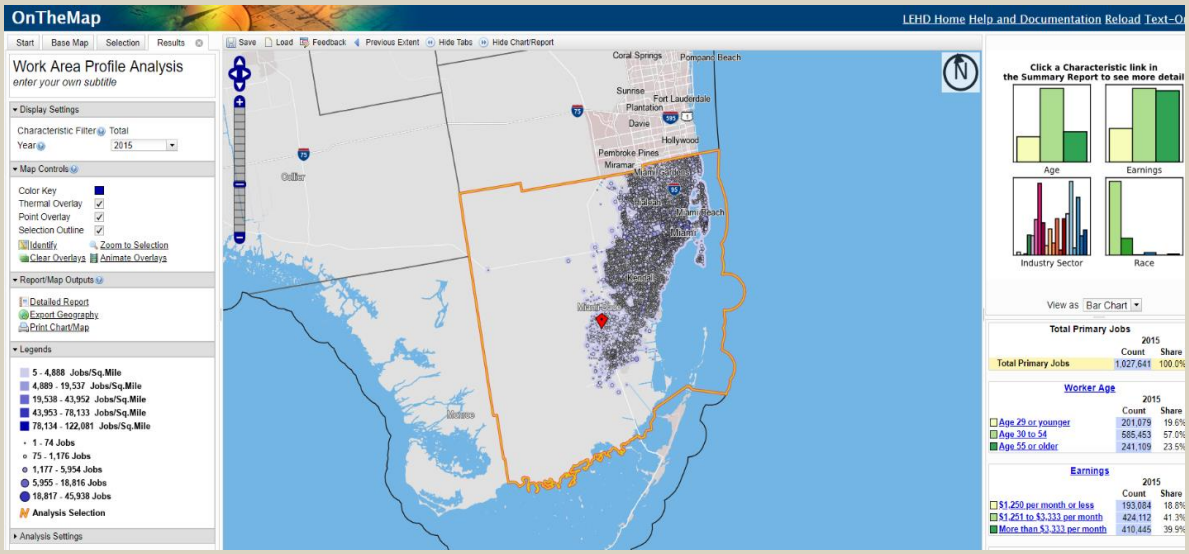


Figure 1 Longitudinal Employer-Household Dynamics (LEHD) OnTheMap Visualization

2.1.2. General Transit Feed Specification (GTFS)

GTFS is a set of files that defines a common format associated with geographic information for public transportation schedules. GTFS, nowadays, is very common and is used as the de facto standard by mid to large-sized agencies. Originally, GTFS was developed by TriMet (formally known as the Tri-County Metropolitan Transportation District of Oregon) and Google as the "Google Transit Feed Specification". It was released in late 2005 and has since been utilized by more than a thousand agencies. In 2009, the GTFS format name was changed to the General Transit Feed Specification to accurately represent its use in many different applications outside of Google products.

GTFS DEFINES A COMMON FORMAT FOR PUBLIC TRANSPORTATION SCHEDULES AND IS A KEY COMPONENT IN A VARIETY OF SOFTWARE FOCUSING ON TRIP PLANNING, DATA VISUALIZATION, ANALYTICS, REAL-TIME INFORMATION SYSTEMS ETC. THAT MILLIONS OF USERS ALREADY ACCESS EVERY DAY.

Today, GTFS feed is universally used by almost all mid to large-sized transit agencies, allowing them to be a part of a common data product that millions of users already access every day. The interoperability of GTFS feed allows it to be utilized universally among local and regional transit agencies and has become an important component in a variety of software focusing on trip planning, data visualization, analytics, real-time information systems, etc. In general, any agency that deals with public transportation can utilize GTFS to develop and provide schedules and geographic information for maps or other applications.

[6] Access Across America: Transit 2017, University of Minnesota Accessibility Observatory, http://ao.umn.edu/research/america/transit/2017/index.html, accessed: 04/25/2019

[7] Twin Cities metro shows significant improvement in access to jobs by transit according to annual U of M study, University of Minnesota, https://twin-cities.umn.edu/news-events/twin-cities-metro-shows-significant-improvement-access-jobs-transit-according-annual-u-m, 2018, accessed: 04/25/2019

A GTFS feed is composed of transit information with a series of text files that relates the schedule information to spatial locations which helps in visualizing the routes. An example of GTFS feed can be found in Google developers page[8]. A typical GTFS feed includes:

- agency.txt: List of transit agencies that have services represented by the GTFS feed.
- stops.txt: List of stops, stations, including exact latitude/longitude locations where vehicles pick up or drop off riders.
- routes.txt: List of transit routes. A route is a group of trips that are displayed to riders as a single service.
- trips.txt: List of trips for each route. A trip is a sequence of two or more stops that occur during a specific time period.
- stop_times.txt: Provides the times when a vehicle arrives at and departs from individual stops for each trip.
- calendar.txt: Defines service dates when service is available for routes.
- calendar_dates.txt: Defines exceptions for the services defined in the calendar.txt file.

GTFS feeds allow vendors like Moovit and TransLoc to utilize the data to develop innovative mobile applications and can help transit agencies and their patrons make better decisions. A variety of open-source and private tools are available for creating and maintaining GTFS data. Some of these are presented below:

- GTFS Builder by the Rural Transit Assistance Program[9]
- OpenPlans started an open-source web-based GTFS Editing Tool that is now maintained by Conveyal[10]
- GO-Sync, an open-source GTFS-OpenStreetMap Synchronization tool[11]
- Educational resources available online from the transit developer community for agencies interested in creating a GTFS feed[12]
- Remix is a product for quickly sketching out transit routes and generating GTFS data
- TransLoc offers their web based GTFS tool TransLoc Architect, which is a free software tool for transit agencies.

2.1.3. Automatic Vehicle Location (AVL)

Automatic Vehicle Location (AVL) describes the use of software and Global Positioning Systems (GPS) in dispatching and tracking transit vehicles. Using AVL, transit agencies can observe transit vehicle locations and arrival/departure times to enhance schedule adherence and monitor transit on-time performance.

AVL systems have two main components, on-board GPS systems that let agencies track the real-time location of the fleet, and software that displays the vehicle location on a map. There are additional costs of operating and maintaining the equipment, but transit agencies benefit from improvements to customer service through real-time information. Today, AVL costs range from $1,000 - $10,000 per bus, with an added maintenance cost of $1,000 per bus[13].

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[8] Example GTFS Feed, Google Transit APIs Static Transit, https://developers.google.com/transit/gtfs/examples/gtfs-feed, accessed: 05/20/2019
[9] GTFS (General Transit Feed Specification) Builder, National Rural Transit Assistance Program, http://nationalrtap.org/supportcenter/GTFS-Builder, accessed: 04/25/2019
[10] A web-based GTFS editing framework., GTFS-Editor, https://github.com/conveyal/gtfs-editor, accessed: 04/25/2019
[11] Tran, K., Hillsman, E., Barbeau, S., Labrador, M.A., GO-Sync- A Framework to Synchronize Crowd-Sourced Mapping Contributions from Online Communities and Transit Agency Bus Stop Inventories, ITS World Congress, Orlando, Florida, USA, October 16, 2011.
[12] Other GTFS Tools, Google Code Archive, https://code.google.com/archive/p/googletransitdatafeed/wikis/OtherGTFSTools.wiki, accessed: 04/25/2019
[13] How Automatic Vehicle Location (AVL) Systems Work, ThoughtCo, https://www.thoughtco.com/automatic-vehicle-location-avl-2798823, 2019, accessed: 04/25/2019

AVL PROVIDES TRANSIT AGENCIES INFORMATION ABOUT EXACT LOCATION OF ALL THEIR VEHICLES AT ANY GIVEN TIME, WHICH CAN BE VITALLY IMPORTANT FOR OPERATIONAL PURPOSES.

While GTFS provides a common format for scheduling, there is no such standard for AVL data provided by vendors. This is a challenge for agencies to get the data in a workable format. Since the data is not in a standard format, it cannot directly be used by agencies. The data must be post-processed prior to applying it for the agencies' needs.

One of the earliest AVL applications was with TriMet in Portland, Oregon[14]. TriMet decided to concentrate on the on-time performance of buses. Archived AVL data was used to construct running time distributions by route and time period. The analysis generated typical running, recovery and layover times that could then be compared to published standards, as well as Tri-Met's own scheduling standards. It was found that 80 percent of the routes had excessive running, recovery, and layover times and estimated that $7 million in operating cost could be saved per year by resolving scheduling inefficiencies. Based on this study, adjustments were made that led to a 9 percent improvement in on-time performance, along with enhancements of running time reliability.

2.1.4. Automated Passenger Counters (APCs)

An automated passenger counter (APC) is an electronic device that records boarding and alighting data on a transit vehicle. Using ridership data from APCs and on-time performance information from AVL, planners can make better decisions in evaluating the efficiency of their services. Ridership data from APCs can also be utilized to contribute to the National Transit Database (NTD) reporting process[15]. The NTD collects financial and service information from public transportation agencies across the country and requires all transit agencies to report these statistics on an annual basis.

APCS PROVIDE MORE ACCURATE INFORMATION THAN MANUAL COUNTING METHODS. APC DATA CAN BE UTILIZED TO INVESTIGATE SCHEDULE ADHERENCE, JUSTIFY CHANGES TO SERVICES AND IMPROVE THE ALLOCATION OF RESOURCES TO MEET ACTUAL AND POTENTIAL DEMANDS.

The use of APCs allows for a more comprehensive counting of passenger trips and is a superior method of collecting ridership compared to manual ridechecks or farebox data. Ridechecks refer to manual counting of boardings and alightings by people onboard a vehicle. While ridechecks have accuracy to a certain degree, they are very limited in scope. Specifically, manual ridechecks are based on small number of randomly selected trips and are prone to outliers that distort calculations. On the other hand, farebox data is often considered to be more accurate but cannot provide information on where passengers alight the bus. This prevents planners from identifying accurate ridership patterns and trip-level line loads on buses. APCs record detailed timestamps that can be utilized to determine schedule adherence and running times between scheduled timepoints. They can help agencies gain insight into rider behavior, identify unproductive stops, and save on operating expenses.

[14] Strathman, J.G., et al, Evaluation of Transit Operations: Data Applications of Tri-Met's Automated Bus Dispatching System, Transportation Research Board, Transportation Research Record. Washington, DC. 2002

[15] FTA Relaxes Rules for APC Data Certification, TripsSpark Website, https://www.tripspark.com/blog/fta-relaxes-rules-for-apc-data-certification, 2019, accessed: 04/25/2019

There are several APC system suppliers that provide both hardware and software. However, current research does not indicate that there are standards for defining APC accuracy in the industry. Therefore, any claims about accuracy solely rely on their own respective algorithms and metrics. American Public Transportation Association (APTA) and other industry stakeholders have made significant efforts to standardize APC data, yet there's no active monitoring to prove that the data from any APC system provider is accurate. Some of the APC vendors are: GMV Syncromatics[16], Infodev EDI[17], Urban Transportation Associates Inc.[18].

One of the ways to decrease crowding on transit lines is to know how, when, and where congestion occurs. For instance, a bus might experience congestion at a specific point or along a segment of a route during peak hours. By analyzing APC information and other data sets, agencies can figure out how to deploy buses to address these congested areas. The Dallas Integrated Corridor Management (ICM) Transit Vehicle Real-time Data Demonstration project investigated the capability of collecting and transmitting passenger load data to a transit management center in real-time[19]. It also created a chance to make informed decisions in real-time. Having APCs funneling real-time data enabled Dallas Area Rapid Transit (DART) to make immediate adjustments to its service in response to light rail passenger demand on their Red Line. Responding quickly to the needs of the system (e.g., increasing or decreasing the capacity) was identified as the most important benefit of this deployment.

2.1.5. Farebox System

A farebox is a device that is used to accept fare payments on a transit system. Additionally, fare can also be paid via magnetic stripe media, smart cards or smartphones. Ridership and revenue numbers play a crucial role in system design, policy, and budgeting decisions, and the use of farebox data can support standard planning, scheduling, and operations management activities. Many agencies rely on electronic fare collection devices as a primary source for ridership and revenue data. It not only helps with financial or operational planning but also can contribute to developing a more efficient and reliable transit system.

FAREBOX SYSTEMS MAKE IT EASIER TO SUPPORT STANDARD PLANNING, SCHEDULING AND OPERATIONS MANAGEMENT ACTIVITIES. MANY AGENCIES RELY ON ELECTRONIC FARE COLLECTION DEVICES AS A PRIMARY SOURCE FOR RIDERSHIP AND REVENUE DATA.

Farebox systems automatically generate payment records when the fare is paid. The most common method of fare payment throughout the transit industry is either cash or cards based on magnetic technology. However, a growing number of options for transit fare collection have emerged in the last five years. Advances in mobile phone technology and banking have increased the methods for paying and/or collecting fare. A few examples of fare payment methods other than cash are described below:

- Magnetic Stripe Media: These are cards with a magnetic stripe and are easy to manufacture and distribute. However, their failure rate is higher compared to more advanced systems and they can be reloaded only at designated locations.
- Smartcards: Contactless transactions have become more common at transit agencies in recent years. From an operational perspective, smart cards are faster than both magnetic stripe and cash payment methods. This is further described in the example below.

[16] Gmvsyncromatics, http://gmvsyncromatics.com/, accessed: 04/25/2019
[17] Automatic Passenger Counting, Infodev Website, http://www.infodev.ca/transit/automatic-passenger-counting/, accessed: 04/25/2019
[18] Urban Transportation Associates Advanced APC, http://www.utatransit.net/, accessed: 04/25/2019
[19] Dallas Integrated Corridor Management (ICM) Transit Vehicle Real-Time Data Demonstration, Final Report, U.S. Department of Transportation, Federal Transit Administration, https://www.transit.dot.gov/sites/fta.dot.gov/files/FTA0082_Research_Report_Summary.pdf, 2015, accessed: 04/25/2019

- Smartphone: The use of smartphones as a fare payment method is also being utilized by some transit agencies. A study shows that 80% of US transit riders would be willing to pay more per ride for a completely paperless journey, while over 75% said they would pay more if they could use their smartphones for ticketing[20]. This option offers an increase in customer convenience over paper or smart card payments. This eliminates the need for customers to buy and carry a separate card, reduces delay in fare payment, and may reduce maintenance cost. It should be noted that demographic and income level of survey respondents for the study above were not disclosed, and hence it is unclear how many of the respondents were transit dependent users.

The use of a farebox system can help decrease dwell times for buses. A transit research team examined the effect of Transit Access Pass (TAP) card (smartcard system) usage in Los Angeles on bus dwell times by analyzing data automatically generated from on-board farebox systems. For the study, Universal Farebox System (UFS)[21] and APC data from March 3 to March 16, 2014 were used. The study focused on two Metro bus lines: a limited-service, low ridership neighborhood route and a high volume, high frequency rapid route. Results show that smartcard payments add around two seconds per person to dwell time, while cash or other payment methods add about four seconds. If 20% of non-TAP paying customers (at that time) were to switch to TAP, buses would spend about 56 fewer hours per day waiting at bus stops. This would not only decrease the total travel time of buses, thereby improving reliability, but also decrease the depreciation costs of buses.

2.1.6. Manual Ridecheck

A manual ridecheck refers to the counting of passengers boarding and alighting the bus at each stop[22]. With manual ridechecks, ride checkers are sent to ride in transit vehicles to observe and record passenger boardings and alightings at each stop for a random sample of one-way vehicle trips. They also keep track of the times the bus arrives and leaves the stop. Ridechecks can be helpful in analyzing heavily used routes in the system by processing the limited amount of data collected by ride checkers. The drawback of this manual method is that it cannot be used to generate detailed systemwide reports, since the focus is usually on specific routes.

MANUAL RIDECHECKS CAN BE HELPFUL IN ANALYZING BOARDING AND ALIGHTING ACTIVITIES ON HEAVILY USED ROUTES.

In early 2012, Santa Cruz Metro of Santa Cruz County, California conducted an extensive ridecheck analysis study[23]. The purpose of this analysis was to provide a comprehensive assessment of the transit services, generating a snapshot of the current level of system activity and delivery performance. It also intended to identify the issues impacting the quality of the customer experience as well as possible scheduling issues. The evaluation process was based on five time-intervals (A.M. other, A.M. peak, midday, P.M. peak and P.M. other) and four on-time performance criteria (on-time, early, late or missed). Based on the ridecheck data, Santa Cruz Metro showed a 70 percent on-time performance. It also consistently had a large percentage of trips leaving early.

[20] Using Technology to Deliver Better Services to Travelers, Accenture, retrieved from http://www.accenture.com/us-en/Pages/insight-technology-public-transport.aspx, accessed: 4/29/2019
[21] Shockley, D.B., Salinas, J., Taylor, B.D., Making Headways: An Analysis of Smart Cards and Bus Dwell Time in Los Angeles, TRB 94th Annual Meeting, Washington, DC. 2015.
[22] Baltes, M.R., The Ins and Outs of APCS: An Overview of Automatic Passenger Counters, Journal of Public Transportation, Volume 2, Issue 2, 1999.
[23] Ride Check Analysis Chapter 4, Sant Cruz Metro – Watsonville Transit Study, Moore & Associates, Inc., https://www.scmtd.com/images/department/planning/wats_plan_metro_final_report_chapters4-5.pdf, 2012, accessed: 04/25/2019

Beginning in March 2012, Santa Cruz Metro started using software to automate the scheduling process, to optimize the service and achieve better on-time performance.

2.1.7. Origin Destination (O-D) Surveys:

An on-board O-D survey is generally conducted to better understand transit users, their travel patterns, and demographics. The survey data can provide insights into the nature of travel markets, help improve regional travel demand models, and investigate the effects of new transit services. The data collected in an on-board O-D survey generally includes trip characteristics: trip purpose, access/egress modes, origin/boarding/alighting/destination locations, and transfer routes; and rider characteristics: auto availability and demographic information. Despite the time and cost associated with such surveying efforts, the results obtained from surveys of public transit customers can be extremely useful to a public transit system's planning and operational functions. These surveys are still one of the best methods to obtain demographics characteristics of the transit users.

ON-BOARD O-D SURVEYS OFTEN PROVIDE HIGHER RESPONSE RATES THAN ALTERNATIVE METHODOLOGIES SUCH AS TELEPHONE, MAIL, AND ONLINE SURVEYS.

Response bias is a potential issue for on-board surveys, especially at small sample sizes; if the survey has a low response rate, it can lead to inaccurate travel patterns. For example, small sample sizes can make specific travel patterns, such as station-to-station flows, less reliable for analysis. It should be noted that on-board surveys typically do not account for low-response riders and travel markets, as traditional practice tends to aggregate data and develop a sample plan based on route level boardings and types of bus service. Additionally, due to cost and time constraints, O-D data cannot be collected regularly.

Metro Transit, the primary public transportation operator in the Minneapolis–Saint Paul, Minnesota, provided more than 80 million rides in 2016, averaging almost 250,000 rides per day. In 2016, an on-board transit survey was conducted in the seven-county metro area.[24] Riders were asked about where they live, where they boarded, where they were going, how they access the trip, purpose of their trip, whether they had access to a vehicle, payment method, and various demographic information. Using the data from the survey, Metro Transit built an interactive data analysis and visualization application for transit planners in the region. One of the early applications of the survey data was in evaluating ridership forecasts for the construction the light rail Green Line and determining the current and future year forecasts. Another application of the survey was to compare routes and identify where service could be improved.

2.2. "EMERGING" DATA

The advancement and penetration of smart phones and mobile applications (apps) has led to large amounts of data being generated every second. In the transportation and transit industry, this has led to an explosion of startup businesses that gather, process and analyze these datasets. These large volumes of data, referred to as "emerging" data in this document, can provide transit agencies with potentially new valuable insights and analysis that can improve their transit systems' quality and performance.

[24] Survey Yields Robust Data to Forecast Travel, Understand Transit Users, Metropolitan Council, https://metrocouncil.org/News-Events/Transportation/Newsletters/Survey-yields-robust-data-to-forecast-travel,-unde.aspx, 2017, accessed: 04/25/2017

"Emerging" data refers to data that is becoming available due to improved location-based and cell phone technology. This data is primarily collected by private companies using apps and location-based services on cell phones of transit riders. These apps track user travel behavior, but also provides them with transit vehicle locations, schedules/arrival times, route mapping, etc. The travel pattern data from these apps can be utilized by transit planners to improve transit performance and design routes/systems tailored to their constituent's needs. Tracking travel patterns at an individual level not only provides a detailed picture of a rider's location from origin to destination, but also identifies the modal choices made by the rider. Some of the vendors involved in collecting this data and providing analytics tools include Airsage, Streetlight, Uber, Lyft, Moovit, Bird, Lime, "Transit App", etc.

"EMERGING" DATA IN THIS DOCUMENT REFERS TO DATA THAT IS PRIMARILY COLLECTED BY PRIVATE COMPANIES USING APPS AND LOCATION-BASED SERVICES ON CELL PHONES OF TRANSIT RIDERS. SOME OF THE VENDORS INVOLVED IN COLLECTING THIS DATA AIRSAGE, STREETLIGHT, UBER, LYFT, MOOVIT, BIRD, LIME, "TRANSIT APP" ETC.

"Emerging" data is already transforming sectors such as retail and logistics, but it is still relatively new to the public transit industry. The industry has only recently begun leveraging this wealth of data to enhance services, understand driver and passenger behavior, and in day-to-day planning and operational activities.

The remaining sections in this chapter describes several "emerging" datasets along with their potential applications with transit planning and operations.

2.2.1. Public Transportation Data from Startups/Mobile Apps

Public transportation apps are mobile services that gather information from transit agencies and provide users transit schedules and current locations of transit vehicles in real-time. Additionally, these apps give information on delays and can assist with trip planning to a user's destination. More recently, public Transportation apps are also being integrated with other popular services such as bike-share, ride-share, and car-share[25].

WITH THE ADVENT OF SMARTPHONES AND MOBILE APPLICATIONS, A LARGE AMOUNT OF INFORMATION BECAME PUBLIC IN REAL-TIME, INCLUDING PUBLIC TRANSPORTATION DATA. MANY PRIVATE STARTUPS ARE PROVIDING COMPREHENSIVE TRANSIT RELATED INFORMATION TO MANY CITIES AROUND THE WORLD.

These apps combine information from authorities, public transit operators, and riders. Startups, such as Moovit and "Transit App" , are already supporting hundreds of cities around the world[26]. A few examples of the data that can be provided to transit planners/agencies include:

a) Transit Line Report: Critical for improving service levels, operational efficiency, or looking to understand the impact of schedule or route changes on ridership. This report usually contains:
   - Average boarding and alighting information, detailed by the hour
   - Typical load-factor and estimation of vehicle crowding
   - Data to identify first/last-mile connectivity problems

[25] Uber adds public transit to app as it expands transportation beyond traditional rides, USA TODAY, https://www.usatoday.com/story/tech/talkingtech/2019/01/31/uber-transit-brings-public-transportation-regular-uber-app/2731486002/, accessed: 04/25/2019

[26] Transit, Transit Website, https://transitapp.com/, accessed: 04/25/2019

- Additional descriptive statistics of line riders and their complete journeys

b) Transit Station Report: Provides data for a wide variety of planning functions to improve and optimize station use. This report usually contains:
   - First/last mile access to stations
   - Average boarding and alighting per line, including the location and time
   - Breakdown of common line transfers and waiting time
   - Origin/destination information

c) Zonal Level Report: Comprehensive understanding of travel patterns to and from a region, whether it is a city neighborhood, or even specific venues like a shopping mall or stadium. The report usually contains:
   - Journey origin and destination zones
   - Modal split
   - Popular transit lines and stations
   - Data to assess impact of network changes to the region

In 2018, "Transit App", was endorsed by the Maryland Department of Transportation's Maryland Transit Administration (MDOT MTA) as the official go-to app for trip planning, schedules, etc. MDOT MTA equipped their buses with GPS trackers, and real-time positions were processed by another startup (Swiftly) that utilized historic and real time vehicle data to accurately predict the vehicle arrival times[27]. Those estimated arrival times reached users through the "Transit App". By partnering with "Transit App", MDOT MTA had access to the app's data and dashboard for planning and operational purposes.

[27] Swiftly, Swiftly Website, https://www.goswift.ly, accessed: 04/25/2019

Moovit is another public transportation app that currently provides the following products for agencies: *Moovit Urban Mobility Analytics (MUMA) and Moovit Mobility as a Service (MaaS)*. MUMA essentially is an analytics tool combining multiple data sources (people movement, user attributes, transit data, etc.), with advanced algorithms to provide detailed insights with exportable and rich visualization, origin-destination matrices, and transit insights. Zone analysis, trip analysis, average trip time and modal splits are some of its capabilities. MaaS, on the other hand, integrated with MUMA provides door-to-door solutions that encompass every aspect of a commuter's daily travel, from payment systems to multimodal route planning (**Figure 2**).

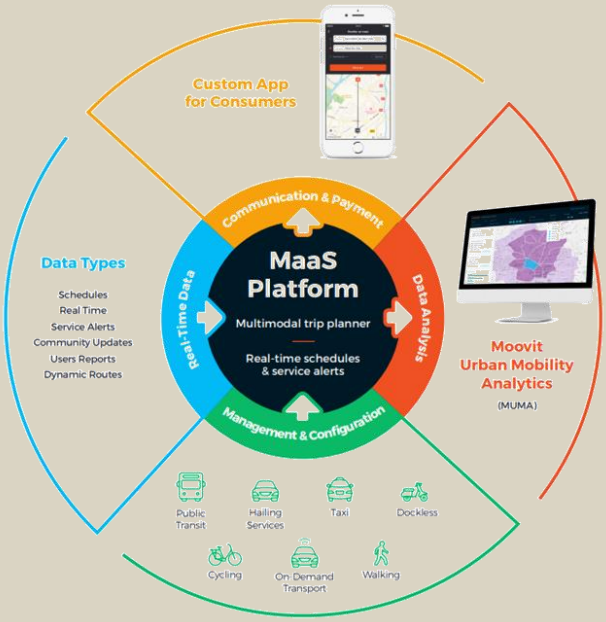


Figure 2: Moovit's Mobility as a Service[28]

2.2.2. First Mile/Last Mile

A major challenge in public transit is first mile/last mile (FMLM) connectivity. FMLM refers to the gap of getting to/from stops at the beginning and/or end of a trip. FMLM is challenging for transit agencies to address in a cost-efficient manner. Buses and trains can serve a large region, but they are not door-to-door services. Recently, private firms have been used to help with the FMLM connectivity issues of transit. Two potential solutions to FMLM connectivity are the use of Transportation Network Companies (TNCs) and Micro-mobility.

Transportation Network Companies (TNCs) as FMLM Connection

The Transit Cooperative Research Program's (TCRP) Research Report on shared mobility defines a TNC as the "*use of online platforms to connect passengers with drivers and automate reservations, payments, and customer feedback. Riders can choose from a variety of service classes, including drivers who use personal, non-commercial, vehicles; traditional taxicabs dispatched via the providers' apps, and premium services with professional livery drivers and vehicles.*" [29] TNCs can also serve end-to-end trips, however, this report focuses on utilizing TNCs to provide FMLM connectivity. Uber and Lyft have been the dominant companies in the TNC market.

[28] Moovit, Moovit Website, https://moovitapp.com/, accessed: 05/20/2019

[29] National Academies of Sciences, Engineering, and Medicine, Shared Mobility and the Transformation of Public Transit, Washington, DC: The National Academies Press, 2016. https://doi.org/10.17226/23578.

IMPROVED FMLM CONNECTIVITY BY TNCS SUCH AS UBER AND LYFT CAN POTENTIALLY CONTRIBUTE TO RIDERSHIP INCREASES. DATA FROM TNCS CAN ALSO HELP AGENCIES IN MODELING TRAVEL BEHAVIOR IN TERMS OF TRIP PURPOSE, DEMOGRAPHICS AND FORECASTING.

While TNCs are arguably pulling riders away from public transit, there is some evidence that it also can improve transit ridership[30,31]. Currently, there is no consensus on whether it increases transit ridership or not. Outcomes may vary depending on the population and employment in the area, average age, median income, education level of its residents, the type of mass transit systems available, and other characteristics of the location. A study in UC Berkeley found that 4 percent of TNC riders used it for FMLM connection, suggesting that they were using it to connect to transit.[32] Another study argued that numerous surveys show that 5 percent of the respondents relied on TNC for FMLM connection. Agencies should note the following points related to using TNCs as an option for FMLM connectivity:

- These are isolated studies and the outcomes might be very different in a different location.
- Additional research needs to be conducted to better understand whether these are offset by diversion of trips away from transit.
- A thorough cost-benefit analysis should be conducted before adopting such an approach.
- There might be reductions in carpools, carsharing, bike, and walk travel due to TNCs.

Overall, additional research is needed to better quantify and measure the effect of TNCs on transit ridership.

Understanding TNCs should still be important to transit agencies since they are significantly changing the transportation landscape. TNCs can offer certain FMLM data that can help transit agencies in providing better connectivity to their riders. This data can be:

- Total trips by time of day (TOD), day of week, month, TAZ or another Census unit
- Travel times
- Boarding and alighting locations, including the time stamps
- Origin and destination location
- Route taken
- Trip length
- Riders per trip
- Trips per hour per vehicle
- Trip purpose
- Rider demographics
- Reasons for taking TNCs
- How the trip would have been completed otherwise

These datasets, including partnerships with limited data access, can help agencies in modeling travel behavior in terms of trip purpose, demographics, and forecasting. TNCs, especially Uber and Lyft, are very conservative about sharing their data due to privacy concerns and to protect their business from competitors. These companies sometimes share data with other private companies who contractually agree that the data and information will not be shared with third parties.

[30] Rodier, C., The Effects of Ride Hailing Services on Travel and Associated Greenhouse Gas Emissions, National Center for Sustainable Transportation, University of California, 2018.
[31] Hall, J.D., Palsson, C., Price, J., Is Uber a Substitute or Complement for Public Transit?, Journal of Urban Economic, 2018, Volume 108, Pages 36-50.
[32] Rayle, L., Shaheen, S., Chan, N., Dai, D., Cervero, R., App-Based, On-Demand Ride Services: Comparing Taxi and Ridesourcing Trips and User Characteristics in San Francisco, university of California Transportation Center, 2014.

TNCs are interested in partnership with local cities[33]. For instance, the City of Cincinnati has partnered with Uber to study and improve public transit. The collaboration is called Cincinnati Mobility Lab and the three-year partnership includes expanded driver resources, a curbside traffic study, access to Uber's data-sharing website, and several other initiatives aimed at improving the commuting experience throughout the city.

Uber is also providing anonymized zone-to-zone travel times for Boston, Cincinnati, Los Angeles, Miami, New York City, Orlando, Pittsburgh, San Francisco, Seattle, Tampa Bay, Toronto, and Washington D.C. through Uber Movement[34].

Over the last two years, transit agencies have also been exploring partnerships different from data sharing. Instead of requesting TNCs to share the data, transit agencies partner with TNCs and provide subsidized trips to/from transit stations. Theoretically, TNCs get more riders and agencies save money and connect more riders to transit hubs, resolving the FMLM problem. However, agencies should note that degrees of success and continuation of the projects vary across the country. Some of the examples are shared below.

In 2016-2017, Pinellas Suncoast Transit Authority (PSTA) subsidized 50% of Uber rides to or from a transit station (up to $3)[35]. In 2017, the Transportation Authority of Marin (TAM) in Marin County, California initiated a pilot program to provide subsidized Lyft experience to and from four commuter rail stations. Riders paid the first $2 of their Lyft ride and TAM paid up to the next $5[36]. Recently in 2019, the Los Angeles County Metropolitan Transportation Authority (Metro) launched a year-long pilot project to offer shared, on-demand rides serving three Metro rail stations[37]. The ride-hailing service is intended to reach out to people who have been excluded from using transit services. A study in early 2018 provided a significant information on numerous partnerships (around 30) between TNCs and Public Agencies in US[38].

Micro-mobility as FMLM Connection

Micro-mobility refers to personal vehicles that can carry one or two passengers, with bicycles being the most common example. Other micro-mobility vehicles include small electric cars, electric bicycles, and scooters – generally small powered micro-mobility vehicles run on charged batteries. These services offer a new personalized accessible mode of transportation for short distances that may help alleviate traffic congestion and FMLM transit gaps.

MICRO-MOBILITY OPTIONS SUCH AS E-SCOOTERS HAVE BEEN SHOWING A HIGH ADOPTION RATE IN RECENT YEARS DUE TO THEIR AFFORDABILITY AND EASE OF USE.

Many cities in the United States have been operating bikeshare systems for the past decade, with the common model of having stations scattered across the city for users to rent and return bikes. However, unlike their docked counterparts, the newest wave of bicycles – and now electric

[33] Uber is Giving Cincinnati a Glimpse at the Data so Many Cities Covet, The Washington Post, https://www.washingtonpost.com/news/dr-gridlock/wp/2018/01/30/uber-is-giving-cincinnati-access-to-the-data-so-many-cities-covet/?utm_term=.31b48e4400e0, 2018, accessed: 04/25/2019
[34] Uber Movement, Uber, https://movement.uber.com/?lang=en-US, accessed: 06/10/2019
[35] Cochran, C., First Mile/last Mile to Transit Innovation, Florida Commuter transportation Summit, http://www.commuterservices.com/wp-content/uploads/2017/05/First-Mile-Last-Mile-PSTA.pdf, 2017, accessed: 04/25/2019
[36] Transit and Ride-Sharing Partnerships on the Rise, Despite Growing Pains, Government Technology, http://www.govtech.com/fs/transportation/Transit-and-Ride-Sharing-Partnerships-on-the-Rise-Despite-Growing-Pains.html, 2018, accessed: 04/25/2019
[37] LA Metro Launches Low-cost Ride Share Pilot, Railway Age, https://www.railwayage.com/news/la-metro-launches-low-cost-ride-share-pilot, 2019, accessed: 04/25/2019
[38] Schwieterman, J.P., Livingston, M., Van Der Slot, S., Partners in Transit A Review of Partnerships between Transportation Network Companies and Public Agencies in the United States, Chaddick Institute for Metropolitan Development at DePaul University Policy Series, 2018.

scooters too – are dockless[39]. Riders can use an app to locate a bike or scooter in the vicinity. After scanning the code on the bike or scooter and completing the transaction, they can ride and eventually park anywhere they want. These services attracted a significant acceptance and demand due to their affordability (Figure 3) and ease of use. E-scooter sharing services operate in a similar way to dockless bike share, allowing users to rent e-scooters for short rides (typically one mile) without searching for docks to park.

Bird was the first company to enter the shared e-scooter market, introducing equipment to the streets of Santa Monica in September 2017[40]. Other companies started to hit the markets eventually. In February 2018, Spin, which had launched as a dock-less bicycle-sharing system rolled out scooter sharing, starting in San Francisco[41]. Following that, Lime[42], formerly known as LimeBike, had officially rebranded as Lime to emphasize its expansion to the newly emerged market of e-scooters. They announced a partnership with Segway to provide new scooters in the San Francisco Bay Area.

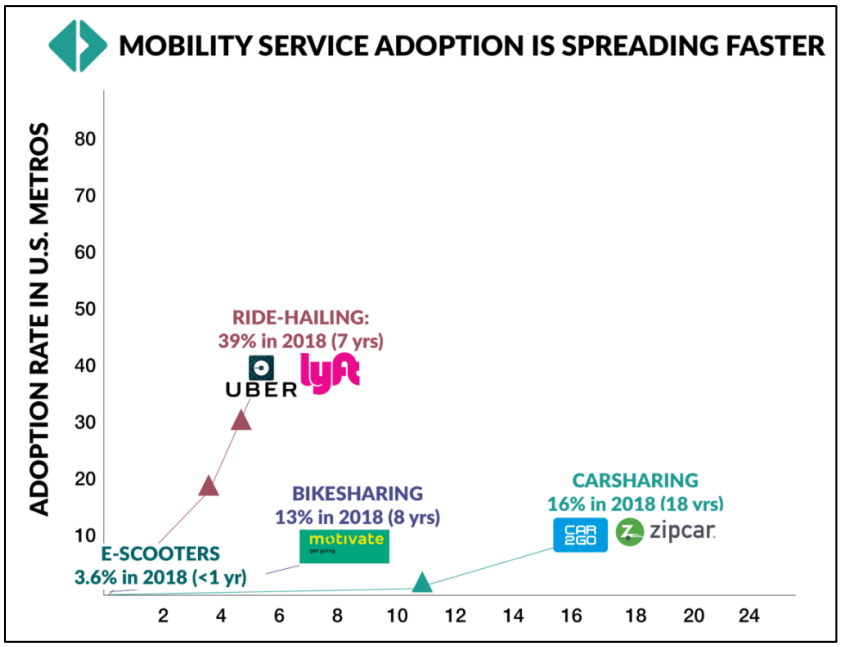


Figure 3: Mobility service adoption rates[43]

In June 2018, Denver Public Works (DPW) initiated a dockless mobility program that allowed the city to explore new ways of providing accessible options for all. It is also going to help with their mobility goals, including a reduction of single-occupant vehicle commuter trips from 73% to 50% by 2030[44]. The City offers permits for e-scooters under certain agreements. From a data perspective, each permit holder is responsible for providing real-time data feed via API (Application

[39] Dockless Bikes and Scooters: The Rise of Micro-Mobility, Bipartisan Policy Center, https://bipartisanpolicy.org/blog/dockless-bikes-and-scooters-the-rise-of-micro-mobility, 2018, accessed: 04/25/2019
[40] Bird Marks One Year Anniversary with 10 Millionth Environmentally friendly Ride, Bird Website, https://www.bird.co/press/bird-marks-one-year-anniversary-with-10-millionth-environmentally-friendly-ride/, 2018, accessed: 04/25/2019
[41] Bike-sharing Startup Spin is Getting into Scooter-sharing, Techcrunch, https://techcrunch.com/2018/02/08/bike-sharing-startup-spin-is-getting-into-scooter-sharing/, 2018, accessed: 04/25/2019
[42] Lime Rebrands and Announces a Partnership with Segway, PR Newswire, https://www.prnewswire.com/news-releases/lime-rebrands-and-announces-a-partnership-with-segway-300650581.html, 2018, accessed: 04/25/2019
[43] The Micro-Mobility Revolution, Populus, https://medium.com/populus-ai/the-micro-mobility-revolution-95e396db3754, 2018, accessed: 04/25/2019
[44] Department of Public Works, Transit Amenity Program - Dockless Mobility Vehicle Pilot Permit Program, Denver Dockless Mobility Program Pilot Interim Report, 2019.

Programming Interface) and monthly reports to the City and County of Denver displaying trip information including but not limited to the following:

- Utilization rates
- Total downloads, active users & repeat users' information
- Total trips by day of week, time of day
- Origins and destination information for all trips
- Trips per bike or scooter by day of week and time of day
- Average trip distance
- Trips originating in or destined for designated opportunity areas
- Numbers of users participating in discount programs disaggregated by program type (low income, students etc.)
- Accident/crash information

As cities continue partnering with companies such as Bird, they also continue to share their data with the public. The City of Austin Transportation has published their data and reporting tools that lay out citywide usage of dockless options. Numbers showed that the average distance traveled by e-scooters is 1 mile. In January 2019, 7,500 e-scooters completed more than 260,000 trips[45].

2.2.3. On-demand Microtransit

The TCRP Research Report on shared mobility defines microtransit as "*IT (Information Technology)-enabled private multi-passenger transportation services that serve passengers using dynamically generated routes and may expect passengers to make their way to and from common pick-up or drop-off points. Vehicles can range from large SUVs to vans to shuttle buses. Because they provide transit-like service but on a smaller, more flexible scale, these new services have been referred to as microtransit*" [46]. Essentially, it refers to services that function like TNCs but with larger vehicles or minibuses, matching riders with similar trips using an app. Via is a startup for on-demand microtransit that allows the service to be flexible to the needs of the riders[47]. After requesting a ride on the app, users are usually asked to walk to a designated pick-up point and wait a few minutes for the shuttle/van to arrive.

ON-DEMAND MICROTRANSIT FUNCTIONS LIKE TNCS BUT WITH A LARGER VEHICLE, MATCHING RIDERS WITH SIMILAR TRIPS USING AN APP. THESE CAN PROVIDE A MORE COST-EFFICIENT SERVICE IN DISADVANTAGED TRAVEL MARKETS SUCH AS ELDERLY OR DISABLED POPULATIONS.

Many agencies around the country operate paratransit services for persons with disabilities. With wide access to smart phones and the increasing availability of mobility data, on-demand microtransit can become a solution for riders and agencies alike. Private microtransit options could potentially provide a more cost-effective service by targeting certain populations which are currently underserved by existing transit services.

[45] Austin Transportation Publishes New Dockless Mobility Open Data Tools, City Of Austin, http://www.austintexas.gov/news/austin-transportation-publishes-new-dockless-mobility-open-data-tools, 2019, accessed: 04/25/2019

[46] National Academies of Sciences, Engineering, and Medicine, Shared Mobility and the Transformation of Public Transit, Washington, DC: The National Academies Press, 2016. https://doi.org/10.17226/23578.

[47] Via, Via Website, https://ridewithvia.com/new-rider-info/, accessed: 04/25/2019

Agencies all around the country have been involved in partnerships with private companies such as Via, TransLoc, Uber or Lyft. Even though the number of partnerships is increasing every day, success of these partnerships varies among agencies and other parties. A few examples are listed below:

- In 2016, officials in San Clemente, California canceled fixed-route buses with the lowest ridership and provided discounts for people to travel with Lyft[48]. Using the Lyft app with a specific code, riders were able to save $9 on an $11 ride. To be eligible, rides were supposed to be taken between 6 AM and 6 PM and be picked up and dropped off along the corridors of specific bus routes. This partnership began as a soft start, before the city formally launched the rideshare program in April 2018 throughout the city. It should be noted that the project is still on-going in city of San Clemente.
- In 2017, The City of Arlington partnered with Via for a new on-demand rideshare service in select areas[49]. Riders were charged a $3 flat fee for each trip. In addition to a fleet of six vans, Via also operated a limited number of wheelchair accessible vehicles during the pilot program. The City of Arlington contributed one-third of the project cost, while the remainder came from a grant from the Federal Transit Administration (FTA). Results were so positive that the City of Arlington announced the expansion of the rideshare service area in late 2018. It should be noted that the project is still on going in City of Arlington.
- In 2017, Innisfil, a rural town of 36,000 in Canada, initiated a pilot program with Uber[50]. The Town had no public transportation system, the only stop belonged to a regional bus line. Uber's first full ridesharing partnership was started this way, by being subsidized completely. The Town set aside $74,000 to pay Uber to subsidize the rides. It was supposed to cover the difference after the flat fee. The main objective was to collect enough data to understand the number of riders and their origin and destination locations. Ultimately, the Town was willing to use that data to develop their own public transit system.

2.3. SUMMARY

This chapter provides an overview of the various datasets already available ("traditional" data), and new datasets being made available using cellphone-based app and location-based services data ("emerging" data) in the transit industry. The example applications provided in this chapter for various datasets can potentially help transit agencies in identifying new ways to leverage their existing datasets and look for opportunities with "emerging" data.

Private vendors have been dominating the "emerging" data market and are looking to collaborate with transit agencies. The collaboration can either be in terms of complementing existing transit services or providing datasets that can be helpful to agencies in their operations, planning, and forecasting activities. Already, many public transportation agencies nationwide have been collaborating with these private vendors, working on business models to improve their operations in terms of customer flexibility and mobility, and providing equal or better service at a lower cost. The datasets from these vendors are also being leveraged by public transportation agencies for various purposes.

[48] Reimagining Public Transit in San Clemente, Lyft Blog, https://blog.lyft.com/posts/reimagining-public-transit-in-san-clemente, 2016, accessed: 04/25/2019
[49] Via Rideshare, City of Arlington Transportation Planning Website, https://www.arlingtontx.gov/news/my_arlington_t_x/news_archive/2018_archived_news/march_2018/arlingtons_via_on__demand_rideshare_service_area, accessed: 04/25/2019
[50] A Canadian Town Wanted a Transit System It Hired Uber, New York Times, https://www.nytimes.com/2017/05/16/world/canada/a-canadian-town-wanted-a-transit-system-it-hired-uber.html, 2017, accessed: 04/25/2017

3. OUTREACH TO TRANSIT AGENCIES

This chapter investigates the extent of data usage for planning and operations analyses purposes by Florida transit agencies. The study team interacted with transit agencies through two different methods: 1) An online survey that was prepared in consultation with the Florida Department of Transportation (FDOT), and 2) Conference call interviews with planning staff from transit agencies to shed light on the extent of data that is being utilized in operations and planning efforts.

In consultation with FDOT, the study team designed survey questionnaire and interviews to address the following topics:

- The extent of transit agencies' experience and understanding of data sources such as existing census products, APCs and AVLs.
- The extent of their knowledge of "emerging" transit data from private sector/startups.
- Experiences in big data/data fusion applications through transit startups/private sector.
- Their expectations/needs for data in the future.

To address these topics, this chapter provides details of the outreach efforts and discusses the methodology of how the online surveys and the interviews were conducted. The results and key findings from the outreach effort are also provided, followed by a brief summary.

3.1. OUTREACH

3.1.1. Online Survey

Background

Currently, there are 30[51] urban fixed-route systems (Figure 4) operating in Florida that report to the NTD. The survey was developed to identify the extent of the knowledge and experience of these transit agencies in terms of "traditional" data. The survey also gauged transit agencies' understanding of "emerging" data and its sources.

[51] FDOT Fast Facts, https://floridatransit.org/wp-content/uploads/2017-Florida-Transit-Fast-Facts.pdf, accessed on 7/16/2019 (Note Clay County is now served by JTA).

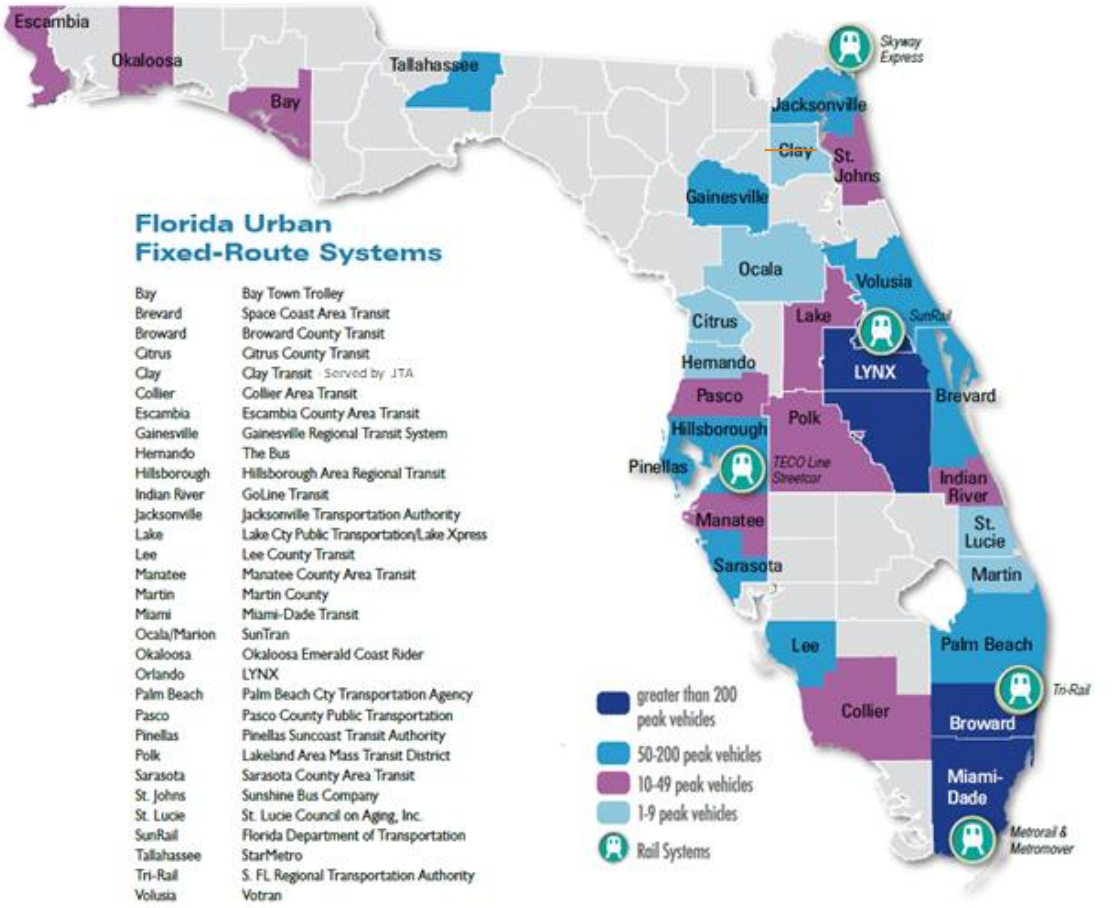


Figure 4: Florida Urban Fixed-Route Systems[52]

Survey Methodology

After consulting with FDOT Central Office, an online survey was selected as the preferred survey methodology. The motivations behind the decision to choose online surveys were:

- Ease of data gathering
- Fast production and delivery
- Flexibility in design

Typically, a faster response, improved quality of responses, and survey completeness are achieved using online surveys when compared to paper and pencil surveys[53,54]. Hence, the internet survey tool, Survey Monkey[55] was utilized to create the final survey. A link to the survey was sent through an email blast to reach out to each of the Florida transit agencies identified in Figure 4.

Survey Details

The survey questions aimed to investigate the prevalence and ubiquity of "traditional" data in agencies' decision-making processes regarding transit modeling, service planning efforts, development of Transit Development Plans (TDPs), Comprehensive Operations Analyses (COAs), and corridor and system planning studies. Additionally, the survey examined agencies' familiarity with "emerging" data which can significantly contribute to transit planning efforts. The responses from this

[52] Ibid.
[53] Truell, D. Allen. Use of Internet Tools for Survey Research, Information Technology, Learning, and Performance Journal, Vol. 21, No. 1, Spring 2003 3
[54] Couper, M. P. (2000). Web surveys: A review of issues and approaches. Public Opinion Quarterly, 64(4),464-494.
[55] Survey Monkey, https://www.surveymonkey.com/, accessed on 7/16/2019

survey were utilized to identify potential opportunities to improve and maximize data usage by transit agencies.

The survey consisted of seventeen (17) questions. The first few questions were related to "traditional" data, followed by questions related to "emerging" data and vendors. The questions included multiple choice and fill-in options. Generally, it included a mix of open-ended questions—in which users completed the answer—and closed questions. The survey requested planning director/managers or staff (e.g. transportation planner, transit planner, service planner, etc.) involved with mid to long-term transit planning to respond to the survey. The full survey questionnaire is shown in Appendix A.

The survey was transmitted to transit agencies via an email blast that was sent out on March 25, 2019. The first wave of responses was obtained by March 27, 2019, and a second email blast was sent out on April 1, 2019. Additional responses to the survey were obtained on April 2, 2019.

3.1.2. Interviews

Background

In addition to the online survey, interviews were conducted to delve deep into the practice of data usage at transit agencies across Florida. The goal was to collect additional information regarding how agencies maximize their data usage. Based on the survey results, a sample of agencies utilizing "traditional" and "emerging" data experience were identified. These agencies are currently using or have used different proprietary tools, in-house approaches, and publicly available datasets for transit planning. The following agencies were selected for interviews:

- Regional Transit System (RTS), Gainesville, FL
- Bay Town Trolley, Bay County, FL

Interview Methodology

The methodology for conducting interviews was selected as a conference call after consultation with FDOT Central Office. The motivation behind the decision to choose a conference call were:

- They are easier and much less costly than a face-to-face interview, especially if travel is involved for any parties.
- There is no need for visual prompts based on the objective of this research.

Individuals who previously responded to the survey were the first to be contacted for interview requests. If those specific individuals were not available, additional requests were made to other available planning staff in the agency. Each interview lasted approximately 30 to 45 minutes but were occasionally extended.

Interview Details

Prior to the interview, initial results of the survey were provided to the interviewees, along with a set of questions and discussion topics. The interview was set to follow an informal question and answer (Q&A) format, in which discussions could evolve and did not necessarily have to follow questions or topics provided. As a reference, the general set of questions and discussion topics that were provided to the interviewees are listed below:

1. How do you handle data collected on a regular basis within the agency (data processing, quality checks, reconciliation between departments, archiving etc.)?
2. What do agencies need to maximize the data usage in their service planning and scheduling activities? (resources, training etc.)?
3. Reasons for partnering with transportation analytics or TNC companies? (lack of resources, lack of expertise, data quality, cost savings)?

4. How do you handle contracts and execute them? Under sunshine law, can you share a copy of the contract?
5. If you were to overcome the various challenges, should the data collection, processing, visualization, etc. be done by the agencies in house or is this something agencies are better off utilizing specialized data vendors?
6. What are the lessons learned from your partnership with transit data analytics companies/ TNCs?
    i. Improvement in efficiency in decision making
    ii. Type and quality of data obtained and usage in service planning and scheduling
    iii. Contract management and data ownership
    iv. Data privacy issues, if any
7. Is there a case study/write-up available that we can use to inform other Florida agencies on efficiency improvement?
8. What other data can help you in your planning and operations activities?
9. Are you considering anything exciting from technology and data perspective (such as collecting new type of data to help planning activities or considering more partnership with private vendors or analytics companies)?
10. Given the recent volume of "emerging" data being made available from start-ups/private vendors, what are your thoughts on the near future of transit agency/industry partnerships?
11. What would you want people to know about data/maximizing data usage and partnerships?

Key discussions and findings from the interviews are summarized in the following sections. An objective assessment of the vendor products or agency partnerships was ensured throughout the entire process and no product was promoted in any way.

3.2. OUTREACH RESULTS

3.2.1. Online Survey Results

Seven transit agencies completed the online survey (Appendix A), which resulted in an overall response rate of 23 percent. Responses were received from various sized urban transit agencies (small, medium and large bus fleets) from across the state. Appendix B provides a list of agencies who responded.

"Traditional" Data

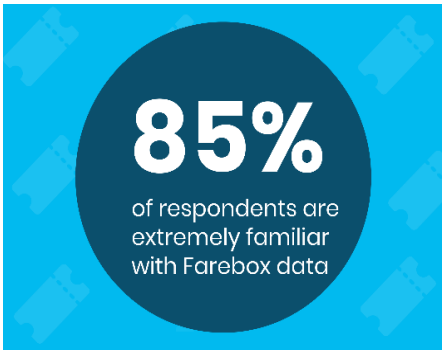
The first set of questions in the survey were related to "traditional" datasets. Agencies were asked about their level of familiarity and how often they applied each of these datasets for service planning, operational analysis, corridor studies, and forecasting. Agencies were also asked to list any challenges they faced when working with these datasets. "Traditional" datasets in the survey were broadly classified into two groups:

- Datasets which are automatically collected on transit vehicles/developed more frequently: APC, AVL, Farebox data, and GTFS.
- Datasets which are collected less frequently: Census Products (e.g. CTPP, ACS, LEHD), Ridecheck data (e.g. on/off counts), and Origin-Destination Surveys

The rest of the section summarizes the findings from the survey for each of the "traditional" datasets identified above. The graphical results of the findings are shown in Appendix C.

Farebox

Farebox data had the highest familiarity rating, with 85% of agencies responding that they were 'extremely familiar' with the data. This familiarity resonates with how often they applied the data as well. One-third of the agencies applied this dataset 'weekly', while another one-third applied it 'quarterly' and one-sixth of the agencies applied farebox data on a 'daily' basis.



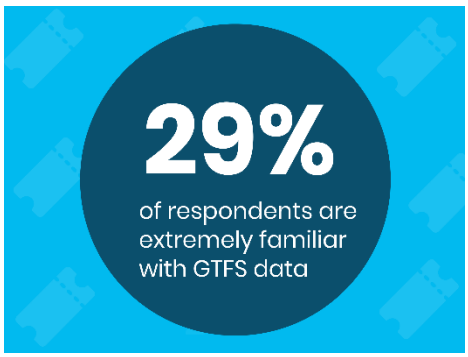
When asked about challenges, agencies identified reliability and consistency of farebox data as their biggest challenge, with most respondents expressing that they were having trouble with the accuracy and completeness of the data collected. Also, maintenance of farebox data was another challenge identified by some agencies.

Automated Passenger Counter (APC)

APC ranked second in familiarity rating with 71% of the agencies being 'extremely familiar' with the data. However, approximately one-third of the respondents almost never used it. Also, another one-third stated that they applied the data 'quarterly', while one-sixth applied 'annually'. Results showed that only one-sixth of the respondents applied APC data 'daily'. In terms of challenges with APC data, agencies preferred the availability of more up-to-date data to accurately conduct analysis. Several agencies expressed issues with having an up-to-date stop locations database, otherwise leading to errors in assigning boarding/ alighting counts to bus stops.

Automatic Vehicle Location (AVL)

AVL ranked third in familiarity rating with 57% of the respondents being 'extremely familiar' with the data. Overall, one-third of the respondents were using the data 'daily', while the remaining respondents were equally split between the 'weekly', 'quarterly', 'annually', and 'almost never' options. In order to explore AVL related challenges that agencies face, each respondent was asked to list their experience. One of the major issues agencies had with AVL data was the connectivity between the bus and AVL system. Additionally, most of the smaller agencies lacked technical expertise on AVL data while trying to understand the advantages and disadvantages of transitioning to AVL.

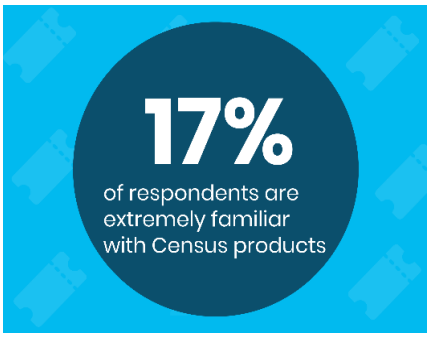


General Transit Feed Specification (GTFS)

Regarding GTFS, familiarity dropped significantly among agencies compared to other datasets in the survey. Only 29% of the respondents were 'extremely familiar' with the data. Results showed that agencies were generally familiar with GTFS data but not to the extent of feeling comfortable enough to understand all its components. In terms of GTFS application, one-third of the respondents 'almost never' used GTFS data. Respondents with GTFS experience stated that they were having trouble maintaining the accuracy of the database. Additionally, most of the respondents had difficulty understanding the input files and needed technical training.

Census Products

In terms of familiarity with Census Products, only one-sixth of the respondents were 'extremely familiar' with the data. Overall, more than 80% of the respondents had some familiarity with the data. One of the reasons for this might be the frequency of the data application. Survey results showed that half of the respondents used Census Products 'annually' and none of the respondent agencies used the data 'daily'.



Agencies that had partnerships with private vendors/companies had fewer problems with Census products because the data was provided through the software of the private vendor. Moreover, it should be noted that, the type of census data they provided could change depending on the private vendor, and agencies may still need to process the raw data source from the Census websites. Some agencies also found it difficult to navigate and access the various Census products, while others reported the lack of technical expertise to understand and apply Census datasets.

Ridecheck

Regarding ridecheck data, one-third of the respondents were 'extremely familiar' with the data, while another 50% of the respondents had 'above average' familiarity with the data. The remaining one-sixth of the respondents had 'below average' familiarity with the data. Further, in terms of application of ridecheck, one-sixth of the respondents almost never used ridecheck data, while half of the respondents applied the data for service planning, operational analysis, corridor studies or forecasting on a 'quarterly' basis.

While working with the data, agencies reported having different challenges. One of the challenges was the accuracy of the data. Agencies were facing challenges in verifying the accuracy of ridecheck data and the reliability of the staff. Additionally, another challenge identified was the reconciliation of ridecheck data originating from various departments within the transit agency.

Origin-Destination (O-D) Surveys

Results showed that all respondents had actively been using Origin-Destination surveys (e.g. detailed on-board travel surveys). While one-third of them were 'extremely familiar' with the data, the remaining respondents had an 'average' to 'above average' familiarity with the data. In terms of how often they applied O-D survey data, results showed that two-thirds of the respondents applied O-D surveys 'annually' for service planning, operational analysis, corridor studies or forecasting. The remaining one-third worked on O-D data 'quarterly'. When asked about the main challenge for the agencies in maximizing their use, they stated that O-D surveys were time-consuming and expensive to conduct on a regular basis.

"Emerging" Data

In the second part of the survey, agencies were asked to respond to questions related to "emerging" data and tools available from private companies. The graphical results of the findings are shown in Appendix C. In order to rate their knowledge about dataset/tools available from private companies which collect data using apps and location-based service on cell-phones, they were given a list of

companies (Airsage[56], Streetlight[57], Swiftly[58], Moovit[59], Lyft, "Transit App"[60], Uber, Bird[61], Lime[62], Uber Jump[63]) and asked to rate them using the following four categories: never heard of their data, unfamiliar with their data, familiar with their data, applied their data. Findings from the survey are presented by grouping the private companies into the following four broad categories:

Public Transportation Data from Startups/Mobile Apps: Swiftly, Moovit, and "Transit App"

With the advent of smartphones and mobile applications, a large amount of information, including public transportation data is gathered in real-time. Many private startups are providing comprehensive transit related information to many cities and agencies around the world. Their services gather information from transit agencies and provide app users transit schedules and current locations of transit vehicles in real-time. They extend their services to provide real-time information to agencies such as bus locations, aggregate O-D data, on-time performance reports, etc.

To understand the extent of agencies' familiarity with these companies, a set of transit-focused companies such as Swiftly, Moovit and "Transit App" were provided to agencies in the survey. Regarding their knowledge about Swiftly and Moovit, 20% of the respondents said they had never heard of them, and 20% were unfamiliar with the data. Additionally, only 20% of the respondents mentioned that they had applied their data or tools. The highest application rate was observed for "Transit App" with 40% of the respondents having applied this data. However, a total of 40% of the respondents either were not familiar with the data from "Transit App" or had never heard of them. Apart from these companies, two others, Urban Transportation Associates and Transloc, were also listed by responding agencies.

Regarding partnering with public transportation data companies such as Swiftly, Moovit, "Transit App", etc., only 40% of the respondents were considering partnering or had partnered with them. A major focus of the agencies in partnering with these companies were for planning purposes and serving internal/external customers. However, contractual issues and costs were major challenges agencies face in partnering with transit data analytics companies.

First Mile/Last Mile: Transportation Network Companies (TNCs)

Uber and Lyft arrived on the urban transportation scene a decade ago, and over the last couple of years there has been a slew of partnerships between agencies and TNCs. While some transit agencies look for sharing data such as travel times, trip length, rider demographics, total trips by time of day etc., another group of agencies are focusing on a different kind of partnership. Instead of requesting TNCs to share the data, transit agencies partner with TNCs and provide subsidized trips to/from transit stations. Theoretically, TNCs get more riders and agencies save money and connect more riders to transit hubs, resolving the FMLM problem[64].

To explore the extent of agencies' familiarity with these companies, Uber and Lyft options were provided to agencies in the survey. All the respondents have heard of them but never applied their data. However, more than 50% of the respondents were familiar with their data.

[56] Airsage, https://www.airsage.com/, accessed on 7/16/2019
[57] Streetlight, https://www.streetlightdata.com/, accessed on 7/16/2019
[58] Swiftly, https://www.goswift.ly/, accessed on 7/16/2019
[59] Moovit, https://company.moovit.com/maas-solutions/, accessed on 7/16/2019
[60] Transit, https://transitapp.com/, accessed on 7/16/2019
[61] Bird, https://www.bird.co/, accessed on 7/16/2019
[62] Lime, https://www.li.me/, accessed on 7/16/2019
[63] Uber Jump, https://www.uber.com/us/en/ride/uber-bike/, accessed on 7/16/2019
[64] Metro Magazine, How Microtransit Can Help Solve Slowing Ridership, https://www.metro-magazine.com/mobility/article/734277/how-microtransit-can-help-solve-slowing-ridership,accessed on 8/19/2019

In terms of partnering with them, 60% of the respondents had not partnered or were not partnering with TNCs and only 40% of them were considering a partnership. Agencies that were considering partnerships stated that they initially wanted to utilize this partnership to serve areas where public transit cannot reach. Additionally, providing first and last mile services and assisting with paratransit service were their major focuses. When asked about common challenges faced by agencies in partnering with TNCs, contractual issues stood out. However, it should be noted that the response rate from agencies to this question was lower compared to the other survey questions.

First Mile/Last Mile: Micro-mobility

New micro mobility services such as e-scooters and e-bikes have emerged since 2017 and are potential first and last mile service options. Less than a year or two after their debut, e-scooters are operating in more than 65 cities. These services offer a new personalized accessible mode of transportation for short distances that may help alleviate traffic congestion and first and last mile transit gaps.

To delve into the extent of agencies familiarity with micro-mobility companies, Bird, Lime and Uber jump options were provided to agencies in the survey. Respondents were asked to rate their exposure and familiarity to Bird and Lime (e-scooter companies). Results showed that 20% of the respondents had never heard of these companies. Respondents were more familiar with Bird's data than with Lime's data, yet none of the responding agencies had applied their data. Also, e-bikes have secured their own fair share of the micro mobility market, however, 50% of the respondent had never heard of Uber Jump provided in the list.

Big data companies: Streetlight and Airsage

Big data companies such as Streetlight and Airsage provide anonymous origin-destination data from certain cell-phone providers and navigation devices. These companies provide population location, movement, and traffic information based on wireless signaling data, and more recently they have stated that they also collect data from numerous other sources, which are not disclosed due to company policies. When agencies were asked about their familiarity with these two big data companies, none of the agencies were familiar with their data or had applied their data. It showed that 40% of the respondents never heard of them while the remaining 60% heard them but were unfamiliar with their data.

3.2.2. Interview Results

This section provides key findings and discussions from conference call interviews with two transit agencies: Gainesville Regional Transit System (RTS) and Bay Town Trolley. It delves into their partnerships with private companies, how they initiated these partnerships, how they resolved contractual issues, and the purposes for the data and tools provided by these private companies.

Interview with Gainesville Regional Transit System (RTS)

Gainesville Regional Transit System (RTS) is the transit agency that serves Gainesville, Alachua County, and the University of Florida and Santa Fe College campuses. Based on the online survey conducted, RTS indicated they used new technologies and were eager to explore additional opportunities. The study team conducted an interview with RTS on July 3, 2019.

RTS is currently partnering with TransLoc, a startup founded in 2004. The partnership has been going on for three years. TransLoc provides real-time vehicle tracking equipment for the existing fleet. TransLoc also provides real-time information to riders, such as predicted arrival times and route and stop level alerts to inform riders. It also provides location-based data using TransLoc mobile app that also works with the existing AVL system. RTS, through TransLoc, is monitoring its fleet performance,

reviewing on-time performance reports, headway reports, and arrival/departure reports through dashboards.

In terms of cost and contract, RTS had chosen to make an upfront payment for real time equipment installations through capital funds. On the contractual side, TransLoc retains ownership of all data, information, content, documents or electronics files created by TransLoc. While TransLoc is responsible for protecting the data and the backup operations, RTS is responsible for providing access to the services to selected users for business purposes. However, TransLoc has a contact person that the agency can reach out regularly and have update meetings every three months based on the contractual terms. RTS has also been partnering with Urban Transportation Associates Inc. as their main APC provider for over a year.

For planning purposes, the use of TransLoc services in combination with Census products allows RTS to efficiently execute transit planning. Based on the success of this TransLoc partnership, RTS is looking for new opportunities to collect additional datasets or provide services, such as on-demand services with a 15-minute reservation window. RTS is also testing the use of a company called Remix[65] for route planning and identifying new stop locations.

Lessons Learned from Gainesville RTS Interview

1- The TransLoc partnership is helping data reconciliation between the operations and planning departments of RTS.
2- RTS can see how riders utilize their service and can communicate directly with riders and ask questions to set benchmarks and prioritize enhancements.
3- TransLoc retains all ownership rights, title, and interest of all data created by TransLoc from the agency or its users during the contract.
4- TransLoc provided different payment options such as one-time and monthly payments for recurring fees.
5- RTS has access to up to three designated TransLoc personnel and by contract they have access to unlimited technical support.

Interview with Bay Town Trolley

Bay Town Trolley is the primary provider of mass transportation in Bay County, Florida. The survey results showed that analyzing the collected data is a common challenge for small-size agencies. When agencies are trying to justify their decisions and budget, they need to have a way to monitor their system performance and be able to produce actionable information and outputs. Manpower and funding are the most common challenges small agencies are facing to produce actionable insights. Furthermore, even if there is enough manpower and funding, allocating time to analyze the data collected is a challenge. Smaller agencies are easily sidetracked due to day-to-day operational issues and challenges.

[65] Remix, https://www.remix.com/, accessed on 7/16/2019

Bay Town Trolley is a small sized agency and faces similar challenges. Based on the online survey conducted, Bay Town Trolley has already been partnering with private companies. The study team approached them for an interview that was eventually conducted on July 1, 2019.

Bay Town Trolley recently commenced a partnership with Swiftly, a startup founded in 2014. Partnership has been going on for a year and a half, although in 2018, Hurricane Michael hampered the agency's operations and plans, and changed their priorities. Bay Town Trolley is utilizing Swiftly to improve the reliability and convenience of transit service by analyzing performance and identifying operational issues. They can analyze travel times and on-time performance. Swiftly provides AVL trackers for their fleet that gives access to real time data and a dashboard tool for their system including information and analysis reports to pinpoint issues.

Bay County Trolley did not release a Request for Proposal (RFP) for this purpose, however they had three quotes from companies specialized in providing real time data platforms and analysis, and eventually decided to move forward with Swiftly. Swiftly provides a contact person that the agency can reach out to regularly based on the contract. In terms of cost, Bay Town Trolley had chosen to make an upfront payment for the services through capital funds, however, any other recurring fees such as real-time services would be covered through operational funds.

For agencies, data ownership is deemed as an additional challenge. Regarding the Bay Town Trolley and Swiftly partnership, Bay Town Trolley has ownership of the data. Florida sunshine law guarantees that the public can and have access to the public records under these circumstances. While companies are trying to avoid disclosing personal information and revealing their data and proprietary tools or algorithms, they are also facing dilemma in states like Florida with sunshine laws. This issue still needs attention by both parties.

In terms of data storage and user access, data collected by Swiftly is stored in Amazon Web Services (AWS) servers that provide on-demand cloud services for computing, backups, and cybersecurity. There are no restrictions for login credentials. Agency provided credentials to other departments, and even consultants, which was helpful during and after Hurricane Michael.

Based on the success with Swiftly partnership, Bay Town Trolley is looking for new opportunities and partnerships to collect additional datasets, such as APC which will help them justify their stops, routes and other programs to local governments.

Lessons Learned from Bay Town Trolley Interview

1- Bay Town Trolley is getting new insights for planning purposes with their partnership with Swiftly and can now monitor and receive a snapshot of their system's performance at any time.
2- Data is available in real time and they can better monitor bus locations and on-time performance.
3- User friendly dashboard and reports helped to create a better communication between different departments. Data reconciliation is smooth and mostly uneventful.
4- Bay Town Trolley can consult Swiftly on how other cities or same sized transit agencies have approached similar problems.
5- Bay Town Trolley can now immediately verify customer complaints by replaying vehicle movements through archived historical GPS data.
6- Partnership increased customer satisfaction significantly.
7- Outsourcing enabled them to have time for other duties and become more efficient.

3.3. SUMMARY

This chapter details the study team's outreach to transit agencies through two different methods: 1) An online survey that was prepared in consultation with FDOT, and 2) Conference call interviews. Seven transit agencies completed the online survey, and two agencies were interviewed to understand data usage and familiarity within Florida agencies. A brief summary of findings from the survey and interviews is shown below:

- Agencies are having trouble allocating resources and time to analyze data collected.
- There should ideally be dedicated people for specific purposes in the agencies, so that they can harness the services better.
- Passenger counters with APCs stand out as the priority for smaller agencies to justify stops, routes, and programs to local governments and stakeholders.

- Agencies that have managed to integrate APC and AVL efficiently, have experienced a significant change in their network efficiency due to introduction of new insights and analysis.
- Some agencies reported lack of technical expertise and technical training to assist them in maximizing data usage.
- Knowledge about "emerging" data is limited within Florida agencies.
- In this data rich environment, standardization is an issue for agencies. All the data collected from different devices, different companies, and different sources comes with their own format. More standard reports – a standardization of data formats would make agencies' life considerably easier.
- Agencies partnering with private vendors or analytics companies develop a better understanding of their own system, as well as get insights from experiences with other systems and agencies who use a similar platform.

4. EXAMINING DATA SOURCES OUTSIDE TRANSIT AGENCIES

This chapter summarizes details of the outreach effort to private vendors/TNCs operating nationwide that deal with urban mobility data analytics. The study team interacted with sales representatives and/or account executives of these companies through conference call interviews to evaluate the following:

a. The extent of their experience with agencies
b. The extent of the data
    a. Temporal, spatial and modal resolution
    b. Sample size and penetration rate (if provided)
        i. Big cities
        ii. Mid-size cities
        iii. Small cities
c. Their expectations, business models and privacy concerns
d. Data acquisition options and cost implications

To address these topics, the next section provides details of the outreach efforts and discusses the interview methodology. The results and key findings from the outreach effort are also provided, followed by a brief summary of results.

4.1. OUTREACH

4.1.1. Background

Recently, the ability to capture, store, and analyze vast quantities of information to create advanced analytical tools has made it possible to optimize planning and operations efforts in public transportation. A few public transportation agencies around the nation are already collaborating with private companies, working on business models to improve their service, operational or planning ability and customer mobility. They are also testing how to make a transition to better on-demand options.

To understand the public-private partnership dynamics, the study team conducted interviews to identify the extent of these "emerging" data companies' experience with transit agencies. The interview also gauged the extent and type of data collected, and their business models. Based on the literature review (Chapter 2: Understanding Data and Current Practices) and responses received from transit agencies during the online survey outreach (Chapter 3: Outreach to Transit Agencies), a sample of vendors/private companies were identified. These companies are currently in partnerships with agencies across the nation providing various datasets, proprietary tools, technical support, equipment, etc. The study team conducted interviews with the following three companies:

- Moovit
- Swiftly
- Via

4.1.2. Interview Methodology

The methodology for conducting interviews was selected as conference call after consultation with FDOT Central Office.

Companies which were discussed in Chapter 2 were the first to be contacted for interview requests. If those specific companies were not available, additional requests were made to other companies across the nation. Each interview lasted approximately 45-60 minutes but were occasionally extended.

4.1.3. Interview Details

The interview was set to follow an informal question and answer (Q&A) format, in which discussions could evolve. Occasionally, companies were not comfortable with providing answers during the interview without an internal review and discussion. In such cases, they provided follow-up responses.

The general set of questions and discussion topics provided to the interviewees are listed below:

1. Data Coverage
   - What is the number of unique users in the US and in Florida?

2. Data Penetration
   - Is it more difficult in the US to penetrate the market or partner with agencies than in Europe or other parts of the globe? (If the company is operating outside US)
   - What are the acceptance rates in the US versus other countries?
   - What is the coverage by agency size?
   - Do you think agencies are ready for this?
   - What is your target audience or department within the agency?

3. Data Accuracy
   - What is the sample size by bus and rail? What are the factors affecting the sample size?
   - How reliable is your data? Have you compared your data to independent source?

4 Data Delivery and Usability
   - What are the hardware requirements for agencies to access the platform?
   - How do you store the data?
   - Is there a scalable delivery time? (From execution of the contract to data delivery)
   - What is your data scalability? (One corridor vs. systemwide)
   - Do you have trainings or certifications?
   - Is there a regular documentation from your side that keep tracks every maintenance, update, correspondence?
   - What happens in your tool when an employee logs in and deletes a bunch of data?

5. Contractual / Business Model
   - What are the major contractual issues you have faced in the US?
   - Who has the ownership of data in a partnership?
   - What is the cost/business model? – Is it project basis or subscription basis (an example from a recent contract)
   - Are you willing to customize the software to meet agency's goals?
   - Can you briefly talk about the technical support and maintenance coverage?
   - Are you willing to do pilot projects?

6. Privacy Issues
   - What are some of the issues raised by the agencies, or you specifically care about?

7. Expectations from Agencies?

Key discussions and findings from the interviews are summarized in the following sections. An objective assessment of the vendor products or agency partnerships is ensured, and no product is promoted in any way by the study team or by FDOT. These summaries are based on notes taken by the study team during the interview. The summaries were not sent to the interviewees prior to documenting in this chapter.

4.2. OUTREACH RESULTS

This section provides key findings and discussions from conference call interviews with three companies: Moovit, Swiftly, and Via. It delves into their partnerships with transit agencies, how they manage these partnerships, how they resolved contractual issues, the purposes for the data and tools they create, and the purposes for which the transit agencies are using them.

4.2.1. Interview with Moovit

Moovit[66] is a public transportation app, founded in 2012, operating all over the world, especially in several European countries. Primarily, the Moovit app gathers information from transit agencies and provides users with transit schedules and real-time transit vehicle locations. Additionally, this app provides information on schedule delays and can assist users with trip planning. More recently, the app has also been integrated with other popular services such as bike-share, ride-share, and car-share[67].

Moovit, as discussed in Chapter 2, currently provides the following products for agencies: *MUMA and MaaS*. MUMA is an analytics tool that combines multiple data sources (people movement, user attributes, transit data, etc.) with advanced algorithms to provide detailed insights through reports and rich visualization. It is also capable of providing origin-destination matrices, conducting zone and trip analyses, and producing average trip times, and modal splits. MaaS (Figure 2), on the other hand, integrated with MUMA provides door-to-door solutions that encompass every aspect of a commuter's daily travel, from payment systems to multimodal route planning. It is a software platform that provides data in real time, urban mobility analytics, on-demand transport management and configuration.

To investigate these tools and Moovit's partnership with agencies, a conference call interview was conducted with Moovit on May 17, 2019. The reminder of this section provides a summary of the discussions and responses during the interview.

Data Coverage

Moovit did not provide the number of users in the U.S but they had 430 million users all around the globe at the time of the interview. They stated that they already mapped 5.6 million bus stops with 7,000 operators on the app.

Currently, they have no direct partnerships in Florida, however, they are heavily involved in talks at various levels with Tampa Hillsborough Area Regional Transit Authority (HART) and LYNX. They also stated that they were interested in responding to Maas-related RFPs across the state. At the time of interview, Moovit did not operate in Florida in terms of their mobility solutions, but their Moovit app, which provides transit schedules and locations of transit vehicles based on available GTFS, is active throughout Florida.

[66] Moovit, https://company.moovit.com/maas-solutions/, accessed on 7/16/2019

[67] Uber adds public transit to app as it expands transportation beyond traditional rides, USA TODAY, https://www.usatoday.com/story/tech/talkingtech/2019/01/31/uber-transit-brings-public-transportation-regular-uber-app/2731486002/, accessed: 04/25/2019

Data Penetration
From their experience, a typical partnership in the US would occur through relationships with organizations and agencies. They stated that penetrating the market becomes easier after building relationships. On the planning side, they stated that they reached out to Metropolitan Planning Organizations (MPOs) more than transit agencies. Also, they noted that they were comfortable with reaching out to staff/executives in the planning/operations departments.

Data Accuracy
Moovit has experience with agencies in different parts of the world. That experience has helped them understand bias in the data, including low sample size issues related to certain regions and/or demographic characteristics. Additionally, any data provided by the agency would help and make corrections around sample sizes and biases. Further, they are not solely dependent on their app data, and they are working with data aggregators in the market to have as much data as possible about the agency and the region, and to minimize the low sample size issues. They also stated that data acquired from other providers would be at no additional cost.

Overall, any data would be better than no data and Moovit was ready to work with any data available from agencies. Also, they were also willing to work with agencies to grow the data over time, if available data is limited.

Data Delivery and Usability
Moovit Urban Mobility Analytics (MUMA) would provide comprehensive and detailed analytics of travel patterns to and from specific regions, on a specific line, or at a specific station. That would include reports and analysis such as origin-destination matrices, zone analysis, trip analysis, modal splits, average trip times, etc. Delivery time of this platform varies from client to client. For an agency with 40 routes, the development of a systemwide platform would take anywhere from several weeks to a month and may take longer if there were issues with the data. An advantage of this tool is that it would not need to be installed or updated on individual computers.

Contractual / Business Model
For companies trying to penetrate this "emerging" data market, building a level of trust with all the agencies, is crucial. In order to build that level of trust, Moovit was willing to do no-cost pilot projects. Once the trust is built, Moovit is in favor of annual contracts as they had seen benefits for both sides from such an arrangement, however, they have various options depending on the needs and budget of the clients. Smaller agencies would have smaller budgets and might struggle to afford MaaS solutions annually. One of the options would be onetime payment by agencies. In that case, the agency would get the analysis report for their system only once with no update. They also emphasized that they provided a range of flexibility in their platforms and business models.

Privacy Issues
In terms of privacy issues, Moovit stated that they were more concerned about it than agencies. All the data collected from users are location-based data and sharing that data could disturb Personally Identifiable Information (PII) compliance. To protect PII records and avoid privacy issues, if the agency is looking for an analysis or a report to see trip origin-destinations, production-attraction, they keep the data at an aggregate level for ridership such as Census Tract/ TAZ level.

However, they stated that it would be different for 'TimePro', which provides agencies a custom dashboard displaying the information for all running vehicles, in real time. It is a platform where driver and vehicle location are constantly transmitted to Moovit's server through AVL trackers and real-time

positioning. This information would be displayed in the agency's dashboard. This data would belong to the agency and would not be shared with other agencies or companies.

Expectations from Agencies

Moovit stated that there is a lot of turbulence in the market, since there are numerous products and solutions especially related to MaaS solutions. It was indicated that with the advent of new technologies, mobility options were rapidly changing and Moovit aims to assist agencies in adopting these changes.

4.2.2. Interview with Swiftly

Swiftly[68], founded in 2014, is a public transportation startup for urban mobility solutions that harness agencies' public transit data to make transportation more efficient. Agencies have been utilizing Swiftly to improve the reliability and convenience of transit service by analyzing performance (Figure 5) and identifying operational issues. They can analyze travel times and view on-time performance in real time. While Swiftly can utilize existing AVL data from agencies, they can also provide AVL trackers for an agency's fleet that give access to real time data and a dashboard tool for their system including information and analysis reports to pinpoint issues.

To investigate these tools and their partnerships with agencies, a conference call interview was conducted with Swiftly on May 17, 2019. The reminder of this section provides a summary of the discussions and responses during the interview.

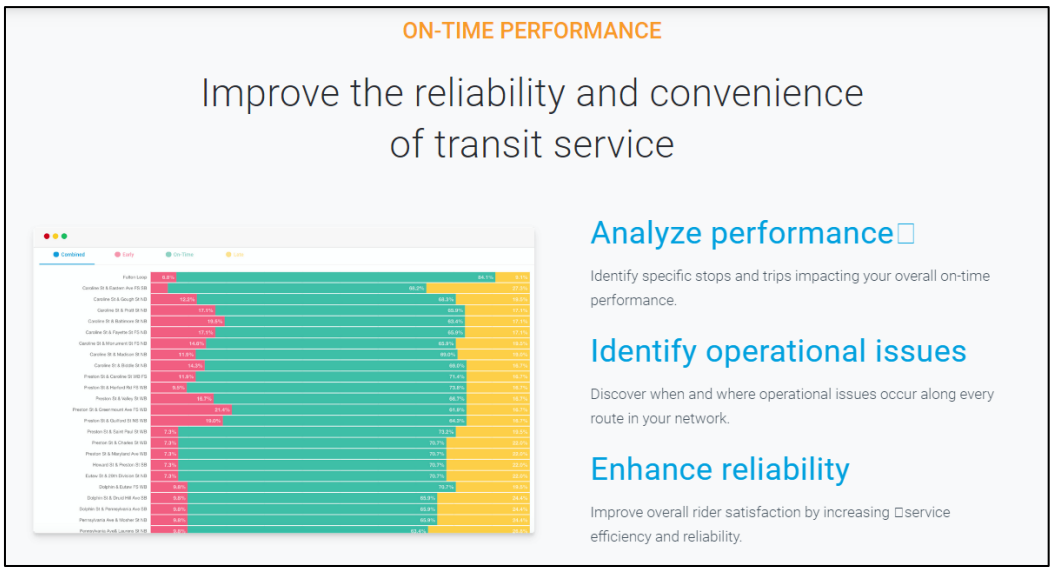


Figure 5: Swiftly On-Time Performance Infographic[69]

Data Coverage

Swiftly, at the time of interview, had over 60 agency clients across US. In Florida they have partnered with Tampa HART, Miami Dade MDT, and Bay Town Trolley. In Tampa, HART has multiple AVL feeds and Swiftly is merging these datasets for more accurate real time analysis and for on-time performance.

[68] Swiftly, https://www.goswift.ly/, accessed on 7/16/2019
[69] Swiftly, https://www.goswift.ly/products, accessed on 8/19/2019

Data Penetration
Swiftly does not have a preference on the agency size. They have been working with smaller agencies with fleet size of 10 buses and larger agencies such as Baltimore MTA. They also noted that they do not have a target audience. Any agency or department willing to make their transit system more efficient are their possible partners. One of the reasons they do not have a target audience or agency is that their sales associates are former planners or consultants. They acknowledged that having staff with agency or consultancy backgrounds has assisted them in understanding how agencies operate, providing them the ability to translate their products to their audience.

Data Accuracy
Swiftly's first goal is to use the agency's available data. They technically do not have sample size issues since it is based on the trackers. They also stated that they do not install GPS trackers to an agency's fleet unless needed.

They stated that accuracy and reliability of the data coming from these trackers was top-notch in the market. Using AVL trackers with instant online access, it would take only couple of seconds to process and visualize the data. However, with outdated systems having hardware issues and limited reporting abilities it could take a few minutes. Bay Town Trolley has been using Swiftly platforms, taking advantage of this speed and reliability even in extreme weather conditions.

Data Delivery and Usability
Delivery time varies for each agency and is dependent on the scope of the contract. If the contract only includes setting up an AVL feed and providing the link along with the GTFS files, it could be accomplished in a few days. However, if the agency wants to assess bus running times, it would take more time depending on the request.

Data coming from these AVL feeds along with GTFS files could be used to asses running times with Swiftly's analytical tools. An advantage of their reporting/analytics is that it would not need to be installed or updated on individual computers. As a company policy, Swiftly emphasized that they conduct demonstrations regularly to brief the agencies and technical staff on how to use these reporting/analytics tools.

Contractual / Business Model
Pricing would change based on the fleet size and transit modes. Generally, they prefer a subscription-based contract. They said that they were willing to partner with an agency for multiple years rather than a set period of months (e.g., for corridor planning). These contracts are typically covered with agency operating funds; however, there are several examples of partnerships that were covered from funds allocated for capital costs.

Swiftly would also conduct pilot studies but evaluates them on a case by case basis. Depending on the region or system, their method of pilot studies also changes. They usually preferred a systemwide pilot but in London, for instance, there was a case where they executed a pilot for one route.

Swiftly stated that they had a person for every agency with whom they have a partnership agreement. If an issue is more technical, they bring in people with additional expertise to resolve the issue. Additionally, customer success teams are deployed to train agencies.

Swiftly can customize the software and adapt its service to the unique needs of each city/agency. They stated that they have 6 modules and they do quite a bit of customization as needed. There were cases

where agencies wanted to see the bus number, driver Identity document etc., which was successfully implemented.

Overall, Swiftly stated that the most common challenges they face have generally been related to budget cycle, timing, and the procurement process.

Expectations from Agencies

They stated that their products were easy to use, and visually enriched, and had assisted agencies in improving communications amongst different departments. For instance, operations as well as other departments could easily review on-time performance analyses, reports or even the real time fleet locations. Finally, Swiftly wanted to emphasize that they would not limit the total number of accounts, and credentials that have authorization to access to Swiftly platforms, even consultants to agencies can access to the Swiftly platforms.

4.2.3. Interview with Via

Via Transportation[70], Inc. is an American transportation network company and real-time ridesharing company headquartered in New York City. Cities of all sizes rely on Via's technology to solve a range of transportation challenges such as:

- Cost-effective Rural & Suburban Transit: Their technology enables small fleets to serve large rural and suburban areas where operators face challenges. By providing a readily available on-demand shared ride service, Via offers an alternative to driving alone and provides mobility for those who cannot drive themselves.
- Paratransit & Dial-a-Ride Upgrades: Via's solution enables agencies to improve the quality of service for those with limited mobility, and at a lower operating cost.
- First- and Last-Mile Connections: In cities of all sizes, connecting to fixed-route transit and major hubs is one of Via's primary use-cases, facilitating streamlined commutes, attracting new customers to existing transit, and enhancing regional connectivity.
- Late Night (Off-Peak Service): Via provides a means for agencies to provide service during off-peak times when fixed-route services are typically less efficient, infrequent, and more expensive to operate.

These challenges are tackled by Via's technology and services to cities and transit agencies primarily through the two collaborative models shown in Figure 6.

To investigate these tools and Via's partnership with agencies a conference call interview was conducted with Via on May 28, 2019.Via also decided to answer the questions on a formal basis after a round of internal review. On July 12, 2019, an extensive report was presented to the study team covering all the topics. Based on this interview and the report provided, the reminder of this section provides a summary of the discussions and responses.

[70] Via, https://ridewithVia.com/, Accessed on 8/19/2019

Software as a Service (SaaS): Via's SaaS solution allows partners to plug our on-demand transit software into existing fleets of vehicles and rely on Via to provide, maintain, and support the software that powers the system. Our SaaS solution offers a full suite of tools and support services for partners who prefer to use their own drivers, vehicles, and dispatchers.

Transportation as a Service (TaaS): Via's TaaS solution is for cities seeking a turnkey solution that includes technology as well as drivers (1099 status independent contractors), vehicles, and operations management. In TaaS deployments, we collaborate closely with our partners to scope the service in a manner that best achieves their goals and makes the most of their resources.

Via Tools & Services	SaaS	TaaS
Pre-launch service planning and detailed modeling	✓	✓
Intuitive, consumer-grade rider and driver apps (iOS and Android)	✓	✓
Best-in-class rider aggregation and dynamic routing algorithms	✓	✓
Support for riders without smartphones and credit cards	✓	✓
Access for riders with limited mobility and wheelchairs	✓	✓
Seamless integration with third-party payment and trip planning systems	✓	✓
Analytics, reporting, and operations and marketing partner success services	✓	✓
Driver training pre-launch	✓	✓
Training on powerful and intuitive dispatch tools	✓	
Fleet acquisition and maintenance		✓
Driver, vehicle, and operations management		✓
Live customer service and driver support		✓
A 360° communications plan and execution		✓

Figure 6: Via Technology and Services Provided to Agencies

Data Coverage

At the time of interview, Via had 2.4 million registered riders in the United States, with no active deployment in Florida.

Data Penetration

Via stated that over the past few years, they have observed a substantial increase in the number of RFPs issued by transit providers that seek to optimize their services through innovative data-driven technologies. In particular, the growing number of transit agencies that served dynamically evolving communities and disadvantaged populations, such as the elderly, low-income, and limited-mobility, could reap substantial benefits from on-demand technologies and robust data reporting. However, the newness of the technology could make it difficult for cities and transit providers to understand its capabilities, limitations, and optimal launch conditions. That problem often resulted in RFPs that occasionally preclude the solutions that would best address the original concern.

Data Delivery and Usability

They stated that launch requirements, such as fleet acquisition, driver training, regulatory compliance, and other tasks could affect the timeline on a case-by-case basis. Their Software as a Service (SaaS) services typically would launch within 10 weeks, and their Transportation as a Service (TaaS) system within 12 weeks.

After receiving the Arlington City Council approval for its 'Arlington-On-Demand' pilot in early November, 2017, Via had built a fleet, localized its technology, established a marketing plan, onboarded local drivers, and launched a fully-functional microtransit service by December 11, while also simultaneously obtaining the licenses necessary to operate in the Arlington market.

The back-end software that powers Via applications does not need to be installed or updated on individual computers. Via updates and maintains the software, and the partners are not required to install updates or pay separately for maintenance. Their system is hosted on AWS servers, allowing them to rapidly scale up or down depending on demand and system performance. Additionally, they

hosted a replica and backup environment, allowing them to quickly recover important data in case of a failure.

Contractual / Business Model

Via noted that while agencies would express interest in benefits of the "emerging" data solutions, generally, the scope of work, detailed specifications, or available budgets turned out to be restrictive to permit a relevant solution.

At the time of the interview, Via did not provide free trials of their service since their capabilities had been proven through their many partnerships around the world. However, they stated that their pricing model did permit considerable flexibility based on several factors including service parameters such as fleet size, risk- and reward-sharing, outside funding sources, and strategic growth opportunities.

If the agency is interested in their TaaS solution, it is generally priced on a per-vehicle-hour basis that varies with fleet size and total vehicle hours purchased, while their SaaS solution entailed a one-time installation and launch fee, as well as monthly per-vehicle technology fees. They stated that they worked with each potential partner to determine the most appropriate service parameters to maximize cost efficiency. In close collaboration with stakeholders, they had adjusted configurable parameters before to best serve the local use case, from service planning, through to launch, optimization, and scaling.

It was also stated that in both TaaS and SaaS deployments, a partner could retain all revenue from passenger fares, which could be used to offset the total cost of its on-demand transportation network. Via also offered a special risk-share pricing model for TaaS partnerships. Under this model, they could provide a lower per-vehicle- hour price but retained some or all the farebox revenue. This model aligned Via's incentives with the agencies.

Once there is an agreement, their support is in two folds: operational and launch support and technical support. Operational and launch support focused on the implementation and success of Via's global on-demand transit partnerships. This team would include a seasoned project manager and support staff, which would serve as the operational and technical points of contact from service planning to post-launch. They would be available to assist the partner city or agency personnel with questions or concerns at any time, including with the generation of reports and use of Via's backend tools. On the other hand, technical support is committed to providing a high-quality service through a 24/7 on-call schedule. Via stated that they regularly provide technical training and support to clients along with on-call technical support.

Privacy Issues

They noted that they are committed to prevent unauthorized or improper access to data by Via employees, contractors, vendors or third parties. Via prohibits all employees, consultants and contractors at every level from accessing member and driver data, except when there is a legitimate business purpose. They had never experienced any incidents of erroneous deletions or employee sabotage to their data or internal systems. They also stated that they used appropriate encryption technologies to protect data stored on their corporate and production servers based on the sensitivity of the data elements in question.

Via stated that they co-owned the data collected through their services with partners, and shared it through their standard reporting package, which includes dashboards, downloadable files, and periodic reports. Typically, in their SaaS deployments, PII was co-owned as well, while in their TaaS

deployments, through which Via managed the service directly, Via owned this data and provided it on a case-by-case basis. They complied with all regulatory requirements around reporting and passenger privacy concerns. The only data they did not share was data that would enable the reverse engineering of their algorithm.

Expectations from Agencies

They believed that Via's solutions are a critical component of the MaaS movement that promised to bring all modes of transportation together into a single service, allowing for point-to-point trip planning based on a customer's preferences of mode, route, and payment method. Via hoped that cities and transit agencies would help them promote a more equitable, accessible, and sustainable future for transportation. They emphasized that all parts of the transit landscape could complement each other to serve communities and empower them to thrive.

4.3. SUMMARY

This chapter provides the details of the outreach to urban mobility data analytics companies or TNCs operating nationwide to investigate their partnerships with agencies and the type of data they collected. The study team interacted with the sales representatives or account executives of Moovit, Swiftly, and Via through conference call interviews. A brief summary of lessons learned from the interviews is shown below.

Lessons Learned from the Interviews

1- Currently, the data and solutions provided by private vendors are still evolving as they learn from experiences around the globe and adapt to the changing technologies.
2- Private vendors provide a range of flexibility is provided in their platforms and business models.
3- Private vendors are willing to see themselves as partners, and not just a solution.
4- Data ownership depends on the data collected, and the vendor collecting the data.
5- While mid-sized agencies are increasingly interested in acquiring data, smaller agencies often want to utilize the tools developed by the vendors.
6- Generally, there is no hardware requirements unless agencies are willing to set up various equipment, such as AVL trackers. Platforms are easy to use and visually enriched in a way that anybody can understand.
7- Tools often helped different departments within the agency to communicate better with each other.

5. NATIONWIDE CASE STUDIES OF TRANSIT DATA PARTNERSHIPS

This chapter introduces case studies from two transit agencies where "emerging" data had been used for planning applications. The study team compared and analyzed the nature, business model, cost, structure, organization, feasibility and success of using the "emerging" data from publicly available information.

5.1. CASE STUDIES

This section includes two case studies of partnerships between agencies and private companies that improved services by effectively utilizing data. The case studies include the City of Arlington, Texas (Via partnership) and the Santa Clara Valley Transportation Authority (VTA) (Swiftly partnership). Both case studies present unique features and helpful outcomes that can address other transit agencies' challenges in a market that is rife with "emerging" data applications.

5.1.1. City of Arlington, Texas

This case study is a story of an on-demand public transit solution for a city with no fixed route service and how data collected through the system helped shape the city council's future planning decisions.

DATA COLLECTED THROUGH THE ON-BOARD SYSTEM HELPED CITY SHAPE THE CITY COUNCIL'S FUTURE PLANNING DECISIONS.

Arlington is a town in Texas, west of Dallas, home to the University of Texas at Arlington (UTA), the Dallas Cowboys football team, and the Texas Rangers baseball team with an estimated population around 400,000 in 2017. Arlington was the largest US city without a public transit option until a few years ago[71]. Initiated by the UTA, DART launched Metro Arlington Xpress (MAX) service in August 2013. This service was funded by the city of Arlington and operated by DART[72] (which lies outside of its service area). The MAX consisted of a single bus route that connected Dallas/Fort Worth (DFW) International Airport station to downtown Arlington and the University of Texas at Arlington campus.

MAX was launched with the expectation of 500 boardings a day in 2013. However, in the first year of service it only managed to pull an average of 240 boardings per day. The total budget for MAX in 2017 was $708,406, with $354,203 coming from an FTA grant and $169,601.50 from both Arlington and UTA. MAX, initially started as a trial, was extended every year till the end of 2017[73]. One of the goals of the trial was to eventually expand DART's service area into Arlington and support the expansion through a sales tax increase. Unfortunately, the City of Arlington rejected joining DART and started looking for other solutions[74].

In December 2017, the Arlington Transportation Advisory opted to replace the MAX with Via's comprehensive micro transit solution. Via Transportation, Inc. is an American transportation network company and real-time ridesharing company headquartered in New York City. Cities of all sizes rely on Via's technology to solve a range of transportation challenges such as cost effective rural and suburban transit, paratransit, first mile- last mile connections, and late-night services.

[71] Citylab, https://www.citylab.com/transportation/2017/11/a-bus-shunning-texas-towns-big-leap-to-microtransit/546134/, accessed on 8/24/2019
[72] Dallas News, https://www.dallasnews.com/news/transportation/2013/05/28/dart-gives-conditional-ok-to-arlington-commuter-bus-line, accessed on 8/24/2019
[73] Star Telegram, https://www.star-telegram.com/news/local/arlington/article119349503.html, accessed on 8/24/2019
[74] Star Telegram, https://www.star-telegram.com/news/local/arlington/article176211446.html, accessed on 8/24/2019

The City of Arlington committed to contributing approximately one-third of the project cost in the amount of $322,500 with the remainder coming from FTA. The contract initially was set for one year with four one-year extension options. Data collected was expected to help shape the city council's future planning decisions[75]. The City was committed to improving mobility in Arlington but had no dedicated vehicles or operators, a limited budget, and required an end-to-end service because they terminated their agreement with DART.

In December 2017, Via launched Arlington On-Demand using a fleet of 10 custom-branded Mercedes Metris vans. The service operated from 6 AM to 9 PM on weekdays and 9 AM to 9 PM on Saturdays. Service zones included Centreport Station, connecting riders to DFW airport and employment centers in the Dallas-Fort Worth area via the Trinity Railway Express.

Customers book rides using a localized app or by phone and can pay with a credit or debit card. Through an integration with the city paratransit system, Handitran, Arlington On-Demand is accessible to riders of all physical abilities. Customers pay a flat $3 fare per person per trip to travel anywhere within the broad service zone, which includes the University of Texas at Arlington, AT&T Stadium, and the downtown and entertainment districts. Customers also have the option to purchase a ViaPass for $15 per week, which covers up to four trips per day.

Arlington has emerged as the first city to run solely on microtransit, covering over 120,000 of its residents with an approval rate of over 97 percent. As the project was found to be successful, the City Council renewed and expanded Via's contract in December 2018, which included a significantly larger zone and eight more vehicles (Figure 7).

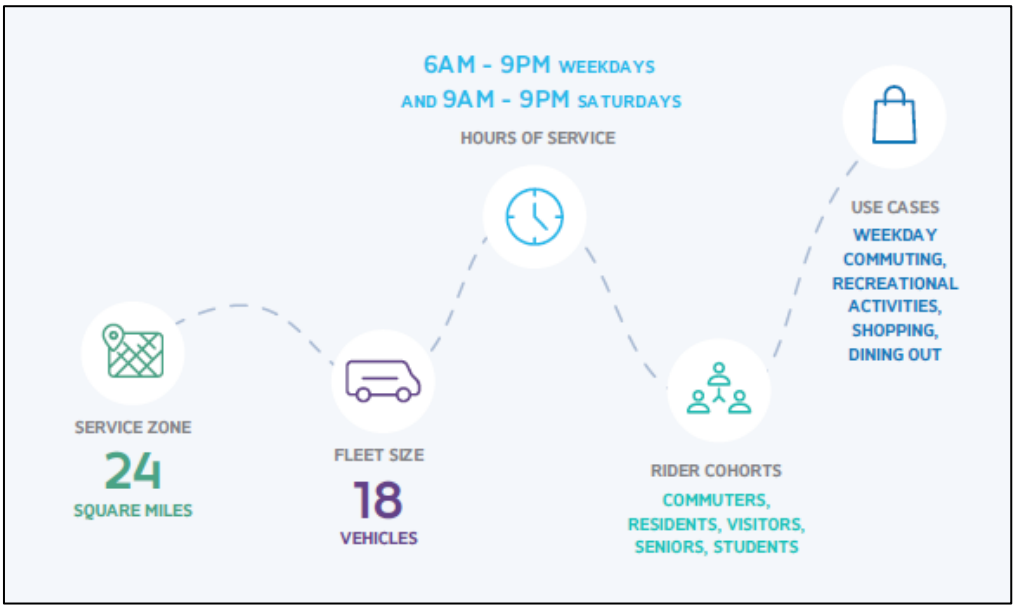


Figure 7: Via and Arlington Partnership Details

According to some reports, there were more than 113,000 rides between December 2017 and February 2019, and a total of 175,000 rides until July 2019[76]. Another article published in March 2019 also stated that Via has been carrying 4,500 passengers per week (600 to 700 passengers per

[75] Arlington Texas Government, https://www.arlingtontx.gov/news/my_arlington_t_x/news_archive/2017_archived_news/december_2017/via__city_of_arlington_launch_innovative, accessed on 8/24/2019

[76] Downtown Arlington Management Corporation, https://downtownarlington.org/transportation-and-mobility/via-arlington-rideshare-expands-service-area/, accessed on 8/29/2019

weekday)[77]. Arlington's experience provides an example of how similar cities can deliver an affordable, flexible alternative to operating their own public transit systems.

5.1.2. Santa Clara Valley Transportation Authority (VTA)

This case study from Santa Clara County, California is a story on how an agency overcame the challenges of decentralized and siloed data collection and analysis and began to effectively utilize the large volumes of data collected on their system.

Officially established in 1995, VTA is an independent special district that provides various innovative and reliable transportation options to California's third-largest metropolitan area, including some of the state's fastest-growing communities. VTA is also responsible for countywide transportation planning, including congestion management, design and construction of highways, pedestrian, and bicycle improvement projects, and the promotion of transit-oriented development[78]. On the transit side, overall population of VTA's service area is close to 2 million people, ranking 29th across all the Urbanized Areas (UZA) in the country. VTA is serving this area with a fleet size of 654 vehicles based on 2017 NTD reports[79]. Close to 40 million passengers boarded these vehicles in 2017.

A LIST OF CHALLENGES:

- **SILOED DEPARTMENTS**
- **DISORGANIZED DATA**
- **OUTDATED TOOLS AND DATA QUALITY**
- **TRACKING DOWN PERFORMANCE ISSUES**
- **SUSCEPTIBLE DATA MASHING**

Located in the center of Silicon Valley, VTA faces different types of challenges compared to the other systems in the nation. VTA's planning and operational efforts need to keep up with the pace of technological innovations created in the Silicon Valley, as it is a region where streets are test beds for autonomous vehicles and other innovative transportation modes such as e-scooters. Citizens often have higher adoption rate of technological innovations, which in turn creates various types of "emerging" data through location-based services such as mobile apps.

Until recently, VTA was experiencing issues dealing with these massive data sources and keeping up with the pace of innovation. The challenges VTA faces can be listed as follows:

- **Siloed Departments**: Every department had its own set of tools for data and analysis, and only a few of their systems could communicate efficiently.
- **Disorganized Data**: VTA's transit planners were poorly equipped to conduct short- and mid-range planning, because it was difficult to get the necessary data.
- **Outdated Tools and Data Quality**: The process for detecting and correcting (or removing) corrupt or inaccurate records from data and identifying irrelevant parts was difficult to accomplish with the agency's and/or department's available capacity.
- **Tracking Down Performance issues**: In case of an issue, customer service had to email IT first. Then, IT would email their real-time vendor. The vendor would then work on the problem who would take several days to respond to the IT. Finally, IT had to relay the information back to the customer service. This inefficient operational flow would take up to weeks for the customer service team to resolve an issue.

[77] Fort Worth Magazine, https://fwtx.com/news/voice/arlington-transit-program-gets-plug-south-southwest/, accessed on 8/29/2019
[78] VTA, https://www.vta.org/about, accessed on 8/24/2019
[79] VTA Annual Agency profile, https://www.transit.dot.gov/sites/fta.dot.gov/files/transit_agency_profile_doc/2017/90013.pdf, accessed on 8/29/2019

- **Susceptible Data Mashing**: Data was disorganized in a way that every department had its own tools and vendors. Data coming from these tools and vendors were also in different formats (e.g., bus data were coming from one vendor, whereas train data was coming from another vendor). This large volume of disorganized data had to be mashed in the servers where eventually something would break.

To tackle these challenges, VTA initiated a partnership with Swiftly in 2018. Swiftly[80], founded in 2014, is a public transportation startup for urban mobility solutions that harness agencies' public transit data to make transportation more efficiently. Agencies have been utilizing Swiftly to improve the reliability and convenience of transit service by analyzing performance and identifying operational issues. They can analyze travel times and see on-time performance. Additionally, their platform includes a suite of APIs that enable public transportation networks to connect and integrate with infrastructure and other forms of transportation effectively.

The nature of this partnership is as follows:

- VTA feeds real time data to Swiftly
- VTA used Swiftly data in the VTA Trip Planner
- VTA began utilizing Swiftly reports and analytics tools

With this partnership, VTA has seen radical advancements in the way they handle their service planning, customer service, and service reliability by seizing control of their own data and delivering the most accurate real-time information available. Some of the advancements are as follows:

A LIST OF ADVANCEMENTS:

- **QUICKER TURNAROUND**
- **CONSISTENT DATA ACROSS DEPARTMENTS**
- **REAL TIME INVESTIGATION OF ISSUES**
- **INCREASED DATA ACCURACY**

- VTA can now track real-time and historical performance of every vehicle in their fleet.
- The planning team is equipped to quickly make informed decisions early in the planning process. The Swiftly dashboard provides capacity to analyze data in just a few minutes.
- Due to the efficiency of data access and quality, the planning team is equipped to work through more scenarios in significantly less time.
- A significant increase in the vehicle location accuracy is observed. The customer service team can now identify the location of each vehicle in their fleet in mere seconds compared to several minutes.
- On-time performance analysis is much easier, as there is no need to communicate with the IT department or other parties. VTA is now able to pull on-time performance metrics in as few as five minutes.

The Swiftly partnership has elevated VTA's communication with third parties as it is cleaner to integrate with other apps. In VTA's case, real-time information flows quickly and reliably to the "Transit App"[81], a user app for real-time vehicle information. With Swiftly, any change in the system can be quickly pushed through to "Transit App" with no additional efforts. The VTA case study demonstrates that by seizing control of the data, it is possible to revolutionize service planning, customer service, and service reliability for the better.

[80] Swiftly, https://www.goswift.ly/, accessed on 8/24/2019
[81] Transit App, https://transitapp.com/, accessed on 8/24/2019

5.2. SUMMARY

This chapter presents two case studies across the nation to showcase how agencies can potentially address some of the challenges they regularly face.

The first case study from Arlington, Texas, focused on a story of an on-demand public transit solution for a city with no fixed route service. In this case study, the Arlington Transportation Advisory replaced an ineffective bus service with Via's comprehensive micro transit solution. Via provided customers to shared rides by dynamically routing vehicles in real time in response to demand. Additionally, Via's technology optimized the balance between maximizing fleet utilization and ensuring that each rider has a high-quality experience. While providing this service, Via also supplied the city with data collected through the ride-share service to shape future transportation planning decisions. Eventually, the city was able to deliver an affordable, flexible alternative to operating their own public transit systems.

The second case study from Santa Clara County, California, is a story of how an agency overcame the challenges of decentralized and siloed data collection and analysis and began to effectively utilize the large volumes of data collected on their system. VTA was dealing with siloed departments, disorganized data, outdated tools and data quality, tracking down performance issues, and susceptible data mashing. To tackle these challenges, VTA initiated a partnership with Swiftly in 2018. With this partnership, VTA has seen significant advancements in the way they handle their service planning, customer service, and service reliability by seizing control of their own data and delivering the most accurate real-time information available. This case study shows how a private vendor partnership helped in bringing different departments together to communicate better and improved customer experience.

While the two case studies presented in this chapter show a successful partnership between private startups and public transit agencies, however it should be noted that each agency is unique, and a thorough study of market opportunities should be conducted through requests for proposals or informal outreach before making any decision to address their challenges.

6. RECOMMENDATIONS

This chapter identifies potential opportunities for transit agencies to improve and maximize the usage of "traditional" data and "emerging" data from private vendors and analytics companies. Based on the review of the survey (seven responses), agency outreach (two interviews), and private vendor outreach (three interviews), this effort proposes a four-step approach as follows:

- Using "traditional" data
- Organizational challenges
- "Emerging" data/tools
- Statewide effort

6.1. USING "TRADITIONAL" DATA

Any planning effort requiring comprehensive information at a local level **must rely on data**. This study demonstrated that many agencies are not fully utilizing the available "traditional" data because of lack of resources and technical expertise. Further, agencies that reviewed and analyzed various "traditional" data sources tended to observe significant improvements to their decision-making abilities and efficiency in planning.

It is recommended that all Florida transit agencies (including small-sized agencies) should **use GTFS format** because it is an industry standard, and many recent/upcoming data products utilize these GTFS files.

Census products such as ACS and LEHD data have been one of the preeminent reliable sources for planners examining trends over long periods of time and should be more widely analyzed by all agencies in Florida. They provide information related to demographics, home/work locations, travel time to work, socio-economic characteristics, etc.

Agencies should closely **follow FDOT and federal resources** for any relevant technical training and programs, which are conducted on a regular basis by both agencies. Data from other sources, such as GTFS, AVL, APC, etc. can potentially be used in combination with Census data to make better informed decisions.

6.2. ORGANIZATIONAL CHALLENGES

While accurate, reliable, and frequent data is crucial for agencies, challenges due to **organization structure** and issues caused by siloed departments cannot be solved by data. Agencies should identify and address common challenges, some of which include:

- Budgetary constraints for data purchase, staffing, training, etc.
- Lack of technical expertise among staff
- Communication between various departments within the agency

Every department in the agency should consider sharing various datasets, tools, and other products being developed or used by them, with other departments across the organization. This can be done by having the key department staff meet on a quarterly basis and sharing their work efforts. This can lead to **collaboration across different departments** and potential innovative applications of the datasets.

6.3. "EMERGING" DATA/ TOOLS

Agencies should evaluate the various "emerging" datasets available in the market before purchasing any data or signing any agreement. There is a lot of turbulence in this market where new products are being developed every year. Prior to committing resources to any particular "emerging" data product, agencies should conduct **comprehensive market research** of the relevant private vendor data products and tools to identify the best possible solution for their needs.

Further, they could also **ask for a pilot**/sample data from the private vendors to assess the accuracy and reliability of the data being promised by the vendor. Any discussion with "emerging" data companies should at the minimum address the following:

- Data ownership related to user information/data collected from the vehicles
- Privacy concerns, user access, and system integration

Finally, agencies should consider having **dedicated contracts for data acquisition or collection** (similar to General Planning Consultant contracts) to save time if and when data is needed to assist in efficient and informed service planning.

6.4. STATEWIDE EFFORT

In a market filled with new technologies, practices, and policies, there can be a coordinated statewide effort at an executive level to address some of the previously mentioned challenges which might be difficult for agencies to accomplish due to budget constraints. This statewide effort should include the following:

- **Statewide Technical and Executive Trainings**: **Statewide technical trainings** on Census products, APC, AVL, and GTFS should be considered because smaller agencies have limited understanding of the usefulness of these data products. Such technical trainings should be geared towards planners and analysts who work with data at the agency. **Executive trainings** should also be considered for executives and managers to help them get better informed about dealing with organization's structural challenges, data sharing, the potential of the "emerging" data products, and to negotiate with these data analytics companies or private vendors.
- **Review of "Emerging" Data:** There has been influx of private vendors who use new technologies and provide solutions to common problems faced by agencies. Hence, a **comprehensive review** of some of the "emerging" data sources/tools and guidance on their applicability to agencies will be helpful for the agencies.
- **Compilation of Success Stories**: A statewide effort to compile successful applications of "traditional" or "emerging" data/tools in the state and around the country will be a good **reference for agencies** who are doing research for their potential use.

The overall recommendations are summarized in Figure 8.

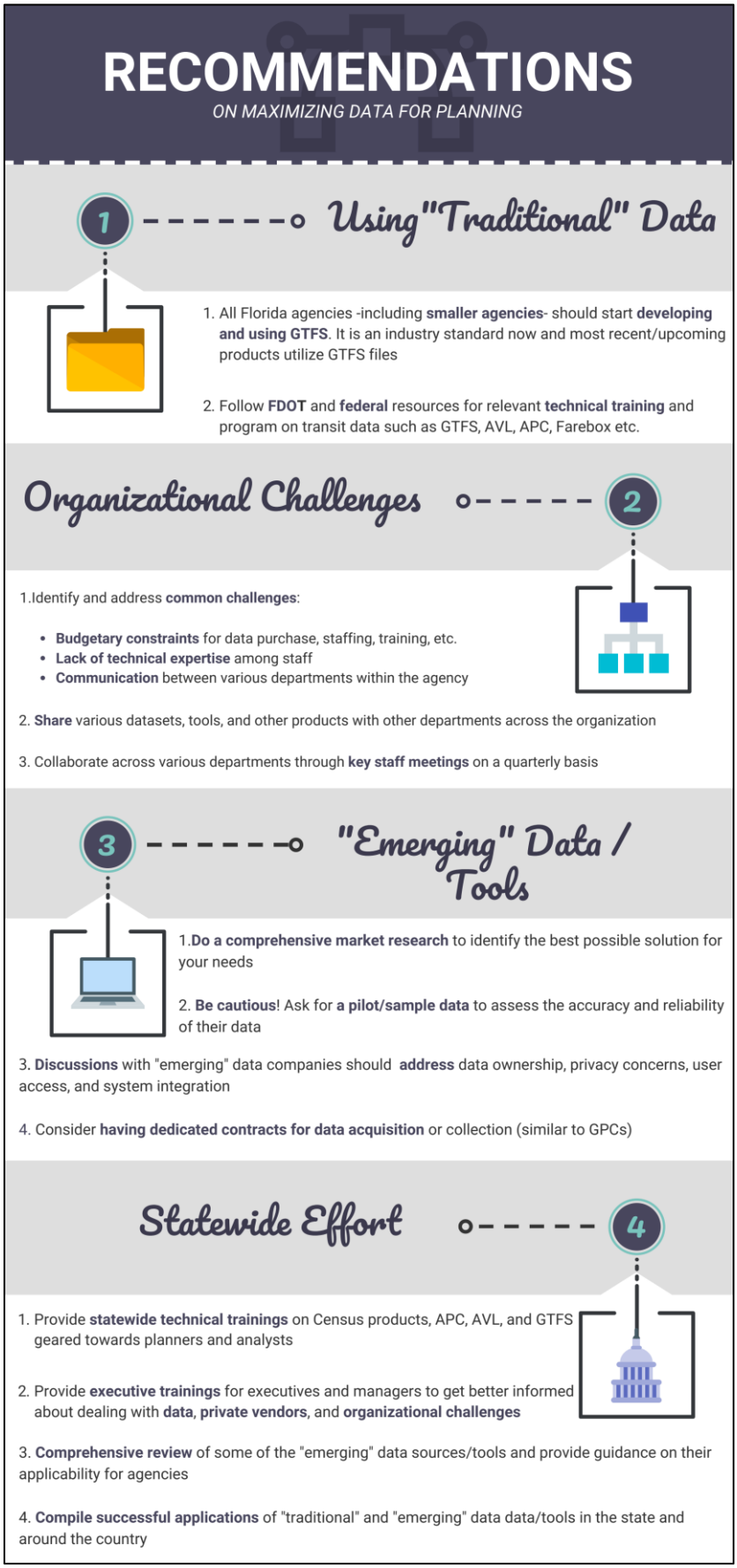


Figure 8: Recommendations on Maximizing Data for Planning

7. APPENDICES

7.1. APPENDIX A: TRANSIT DATA AWARENESS AND APPLICATION SURVEY

Transit Data Awareness and Application Survey

The Florida Department of Transportation (FDOT) Central Office is conducting this survey to understand the level of awareness and application of "traditional" and "emerging" transit data by transit agencies in Florida. The responses from this survey will be used to identify potential opportunities to improve and maximize data usage by transit agencies.

"Traditional" data in this survey refers to data that is typically available or collected by transit agencies. Examples in this category include data which is automatically collected on transit vehicles such as Automatic Passenger Counter (APC), Automatic Vehicle Location (AVL), and farebox datasets. Further, "Traditional" data also includes data which is collected less frequently such as ridecheck data (e.g. on/off counts), on-board origin-destination surveys collected by pen/paper or tablets and Census data products (e.g. Longitudinal Employer-Household Dynamics – LEHD).

"Emerging" data in this survey refers to data that is becoming available due to improved cell-phone technology. This data is primarily collected by private companies using apps and location-based services on the cell-phones of the transit riders and helps in identifying travel patterns. Some of the vendors involved in collecting this data and providing analytics tools include AirSage, Streetlight, Uber, Lyft, Moovit, Bird, Lime, Transit App, etc.

We request that the planning director/managers or staff (e.g. transportation planner, transit planner, service planner, etc.) involved with medium to long-term transit planning respond to this survey. The first few questions of the survey are related to "traditional" datasets, followed by questions related to "emerging" datasets and vendors.

Please provide your responses by April 5, 2019. If you have any questions, feel free to contact Gabrielle Matthews (Gabrielle.Matthews@dot.state.fl.us). Thank you in advance for your responses.

1. Agency Name

2. Name of the Individual and Job Title

3. On a scale from 1 (not very familiar/little to no understanding of the data) to 5 (extremely familiar/understand the components in the data), please rate your level of familiarity with each of these datasets which are automatically collected on transit vehicles/developed more frequently.
By familiarity, we mean how often you have come across the data, as well as how well you know the data.

	1-Not very familiar	2	3	4	5-Extremely familiar
Automated Passenger Counter (APC) (A device that records boarding and alighting data)	○	○	○	○	○
Automatic Vehicle Location (AVL) (A means for automatically determining and transmitting the geographic location of a vehicle)	○	○	○	○	○
Farebox data (A device used to collect fares)	○	○	○	○	○
General Transit Feed Specification (GTFS) (A common format for public transportation schedules and associated geographic information)	○	○	○	○	○

Other (please specify)

4. How often have you applied each of these datasets which are automatically collected on transit vehicles/developed more frequently for service planning, operational analysis, corridor studies or forecasting?

	Daily	Weekly	Quarterly	Annually	Almost Never
Automated Passenger Counter (APC)	○	○	○	○	○
Automatic Vehicle Location (AVL)	○	○	○	○	○
Farebox data	○	○	○	○	○
General Transit Feed Specification (GTFS)	○	○	○	○	○

Other (please specify)

5. Please describe any issues and/or challenges you may have faced (e.g. lack of technical expertise) when working with datasets which are automatically collected on transit vehicles/developed more frequently.
If you do not work with or believe a dataset applies to your job, enter "NA".

Automated Passenger Counter (APC)

Automatic Vehicle Location (AVL)

Farebox data

General Transit Feed Specification (GTFS)

6. On a scale from 1 (not very familiar/little to no understanding of the data) to 5 (extremely familiar/understand the components in the data), please rate your level of familiarity with each of these datasets which are collected less frequently.
By familiarity, we mean how often you have come across the data, as well as how well you know the data.

	1-Not very familiar	2	3	4	5-Extremely familiar
Census Products (e.g. Census Transportation Planning Package – CTPP, American Community Survey – ACS, Longitudinal Employer-Household Dynamics – LEHD)	◯	◯	◯	◯	◯
Ride check data (e.g. on/off counts)	◯	◯	◯	◯	◯
Origin-Destination surveys (e.g. detailed on-board travel surveys)	◯	◯	◯	◯	◯

Other (please specify)

7. How often have you applied each of these datasets which are collected less frequently for service planning, operational analysis, corridor studies or forecasting?

	Daily	Weekly	Quarterly	Annually	Almost Never
Census Products	◯	◯	◯	◯	◯
Ride check data	◯	◯	◯	◯	◯
Origin-Destination surveys	◯	◯	◯	◯	◯

Other (please specify)

8. Please describe any issues and/or challenges you may have faced (e.g. lack of technical expertise) when working with datasets which are collected less frequently.
If you do not work with or believe a dataset applies to your job, enter "NA".

Census Products	
Ride check data	
Origin-Destination surveys	

9. Please rate your knowledge about datasets/tools available from the following private companies which collect data using apps and location-based services on cell-phones.

	Never heard of	Unfamiliar with their data	Familiar with their data	Applied their data
AirSage	○	○	○	○
Streetlight	○	○	○	○
Swiftly	○	○	○	○
Moovit	○	○	○	○
Transit App	○	○	○	○
Uber	○	○	○	○
Lyft	○	○	○	○
Bird	○	○	○	○
Lime	○	○	○	○
Uber Jump	○	○	○	○

Other (please specify)

10. Have you partnered/are considering partnering/are currently partnering with Transportation Network Companies (TNCs) (e.g. Uber, Lyft, Bird, Lime, etc.) to complement/supplement your existing transit service?

○ No

○ Yes

11. If Q10 was answered as yes, please enter the following details.

If multiple TNCs need to be entered, use "/" to separate out the responses. For example:
Name: C1/C2
Purpose: Purpose for C1/Purpose for C2
Partnership in place: Current/Considering

Name of the TNC	
Purpose of the partnership	
Partnership in place (Current/Past/Considering)	

12. Below are a few common challenges agencies face in partnering with Transportation Network Companies (TNCs) (e.g. Uber, Lyft, etc.). If any of these apply to you, please add specific details behind these challenges.

Contractual issues	
Costs	
Data privacy	
Other (please specify)	

13. Have you partnered/are considering partnering/are currently partnering with transit data analytics vendors (e.g. Swiftly, Moovit, Transit App, etc.)?

- ○ No
- ○ Yes

14. If Q13 was answered as yes, enter the following details.

If multiple vendors need to be entered, use "/" to separate out the responses. For example:
Name: C1/C2
Type of data: C1 provided .../C2 provided ...
Purpose: Purpose of C1's data/Purpose of C2's data

Name of the vendor	
Type of data provided	
Purpose of the data	

15. Below are a few common challenges agencies face in partnering with transit data analytics vendors (e.g. Swiftly, Moovit, Transit app, etc.). If any of these apply to you, please add specific details behind these challenges.

Contractual issues	
Costs	
Data privacy	
Other (please specify)	

16. Please use this box to share any general comments on transit data and how it applies to your agency.

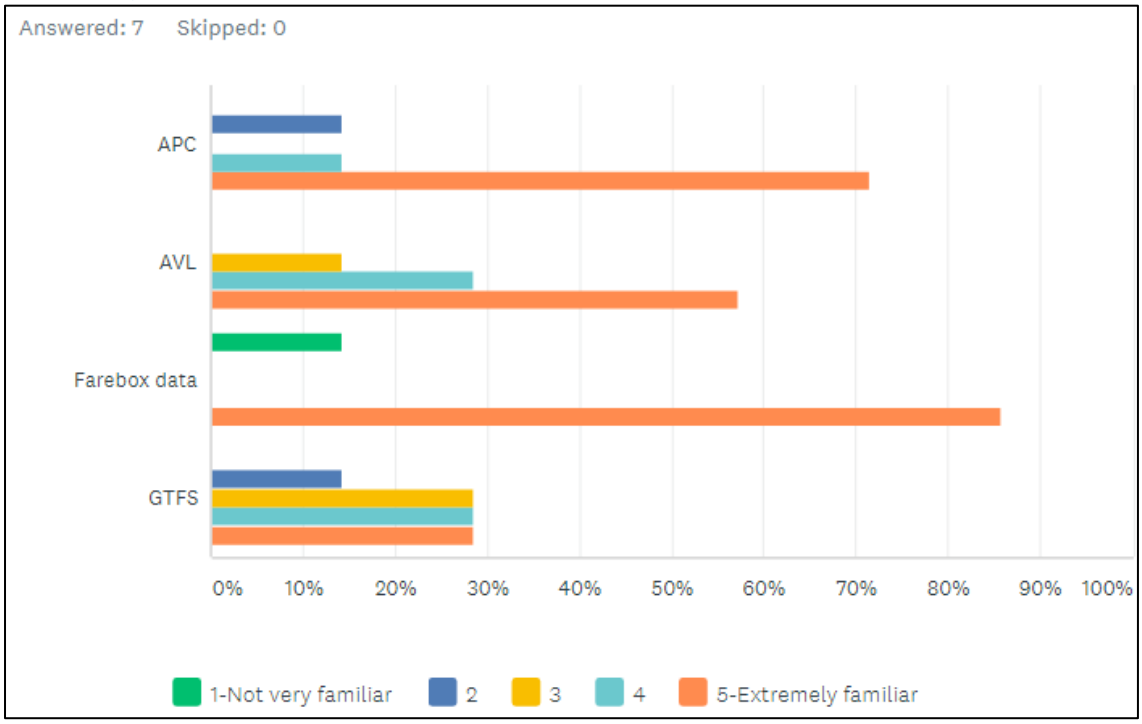
17. What data do you wish you had, and how would you use it?

7.2. APPENDIX B: RESPONDENTS TO THE ONLINE SURVEY

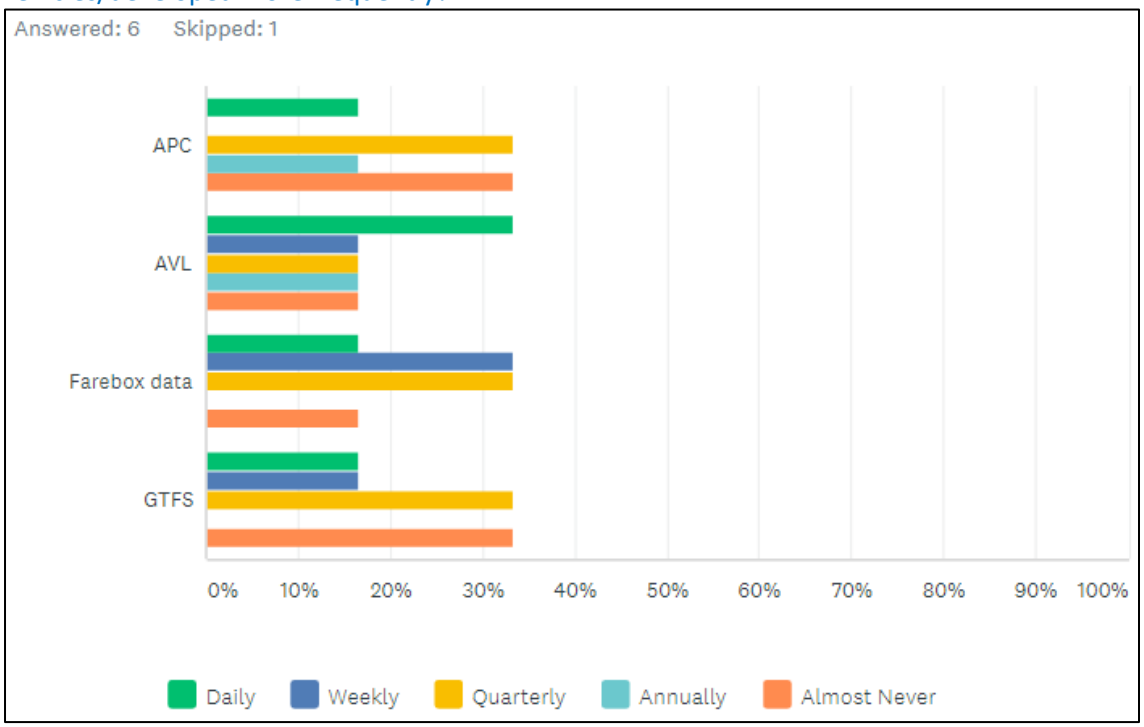
Agency	Service Area Population	Ridership (Annual)	Fleet Size	Size	Type of Outreach
Bay - Bay Town Trolley	105,192	716,364	32	Small	Online Survey + Interview
Brevard - Space Coast Area Transit	579,130	2,554,122	142	Medium	Online Survey
Broward - Broward County Transit	1,909,632	29,764,400	494	Big	Online Survey
Collier - Collier Area Transit	325,785	996,499	46	Small	Online Survey
Gainesville - Gainesville Regional Transit System	163,990	9,513,421	158	Medium	Online Survey + Interview
Indian River - GoLine Transit	143,696	1,255,136	34	Small	Online Survey
Orlando - Lynx	2,134,411	26,031,038	610	Big	Online Survey
Pasco - Pasco County Public Transportation	488,310	869,650	84	Small	Online Survey

7.3. APPENDIX C: RESPONSES TO THE ONLINE SURVEY

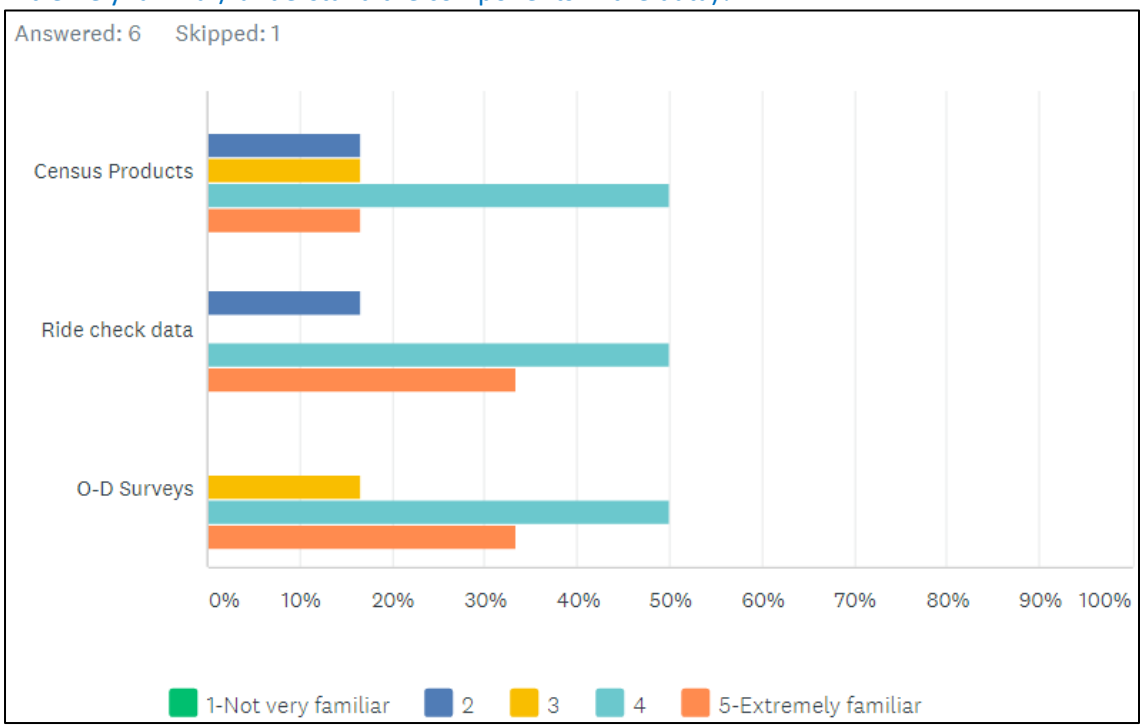
What is your level of familiarity with each of these datasets which are automatically collected on transit vehicles/developed more frequently (1-Not very familiar, 2-Below average familiarity, 3-Average familiarity, 4-Above average familiarity, 5- Extremely familiar/ understand the components in the data)?



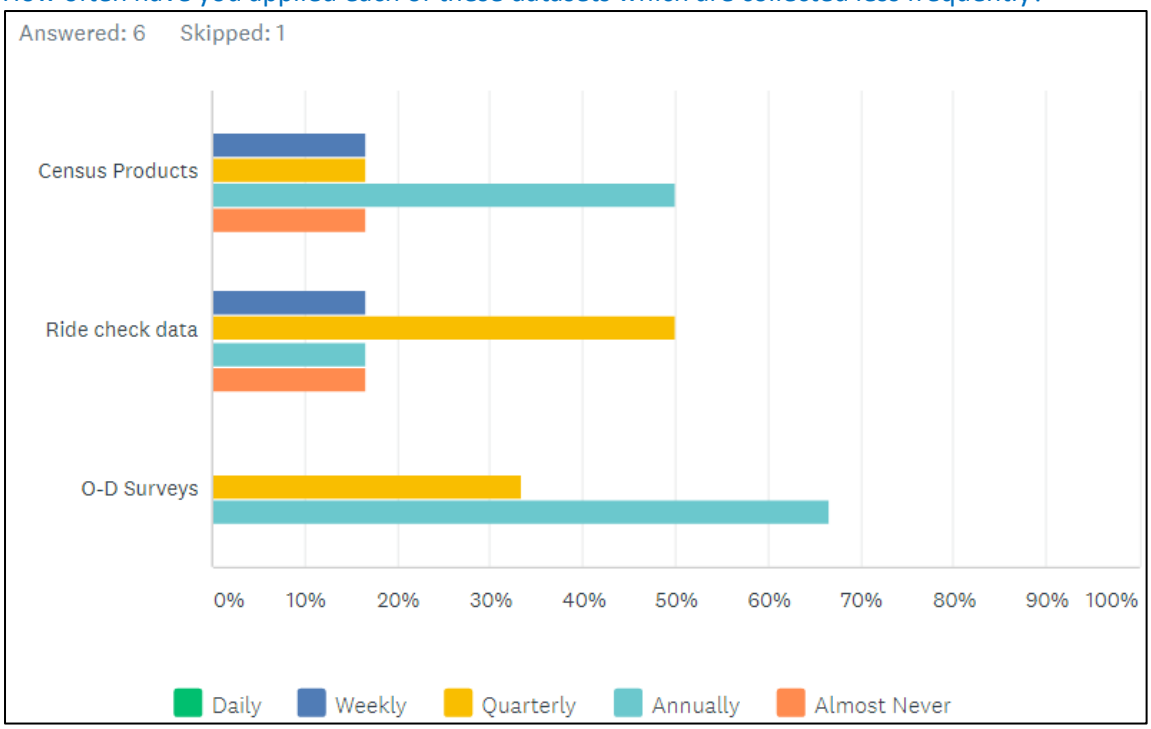
How often have you applied each of these datasets which are automatically collected on transit vehicles/developed more frequently?



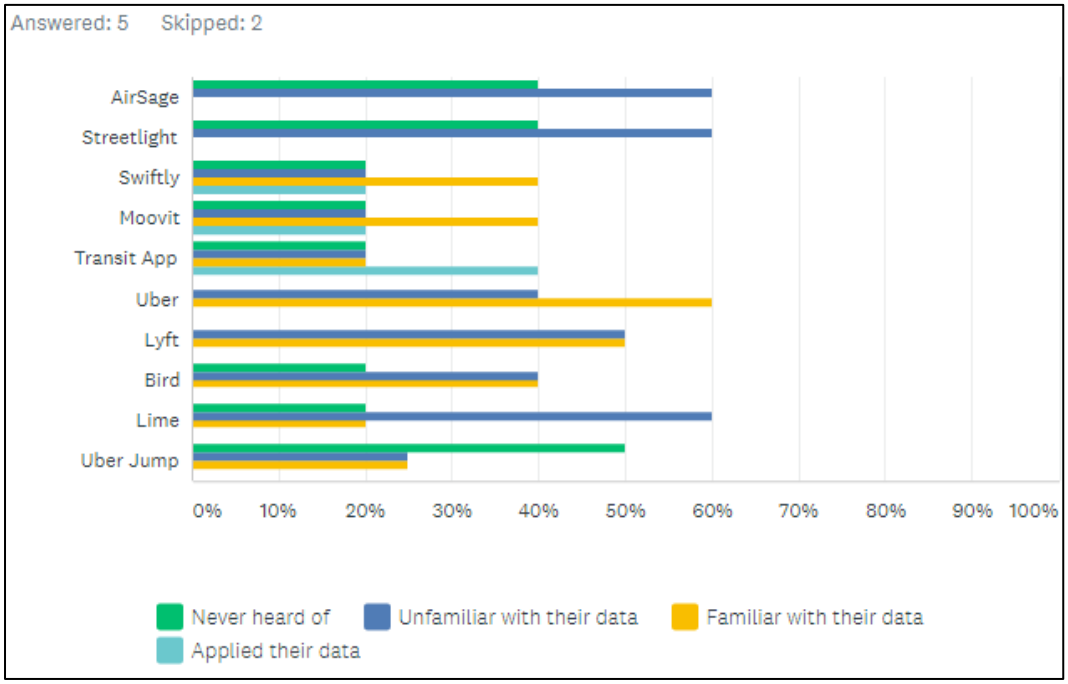
What is your level of familiarity with each of these datasets which are collected less frequently (1-Not very familiar, 2-Below average familiarity, 3-Average familiarity, 4-Above average familiarity, 5-Extremely familiar/ understand the components in the data)?



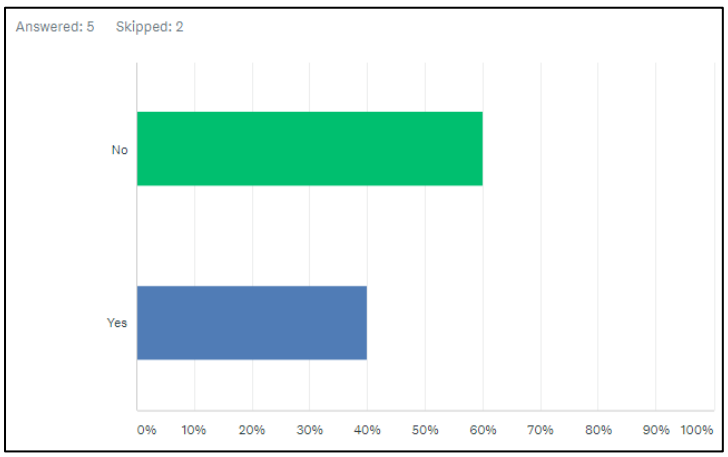
How often have you applied each of these datasets which are collected less frequently?



Please rate your knowledge about datasets/tools available from the following private companies.



Have you partnered/are considering partnering with TNCs to complement/supplement your existing transit service?



Have you partnered/are considering partnering with transit data analytics vendors?