

# Opportunities and Challenges of Probe and Crowdsourced Data Initiatives for Multi-Model Planning and Operations: Insights from the Experience of the Port Authority of New York and New Jersey

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## Abstract

The Port Authority of New York and New Jersey (Port Authority) echoes the conference theme of Transportation 2.0 recognizing that fundamental changes are occurring in how people interact with transportation. There are also fundamental changes possible in how operating agencies carry out their missions, particularly through developing collaborations with probe and crowdsourced data platforms. Traffic is an ideal space to crowdsource – those stuck in traffic don't want to be there, yet being there is what's causing the congestion. Crowdsourcing is a way for agencies to listen to customers, use that data and wisdom to share back with other customers to manage expectations and provide information, and at the same time gain valuable insights from the analysis of the data. Through this paper, the Port Authority presents experience in establishing a program of collaboration with third parties and use of probe and crowdsourced data. It is grounded in strategic planning for matching opportunities with agency goals and needs supporting vital bridges, tunnels, airports, seaports, bus facilities, and the Port Authority Trans-Hudson (PATH) Rail Transit. Despite challenges, there are potential benefits such as cost savings while having access to robust data and effective ways to reach customers. The Port Authority's early successes on several initiatives help to make the business case for continued support of innovation and investment in these data-driven collaborative endeavours. Initiatives presented include providing information to navigation apps, analysing the reliability of Waze travel time data for operations, and evaluating beacons in tunnels to improve the effectiveness of navigation.

## KEYWORDS:

Crowdsourced data, Waze Connected Citizens Program, public-private partnerships

## Introduction

The conference theme of Transportation 2.0 recognizes that fundamental changes are occurring in how people interact with transportation. There are also fundamental changes possible in how operating agencies carry out their missions, particularly through developing collaborations with probe and crowdsourced data platforms. Through this paper, The Port Authority of New York and New Jersey (Port Authority) shares highlights of its approach and experience with these changes – both opportunities and challenges.

The paper is organized as follows:

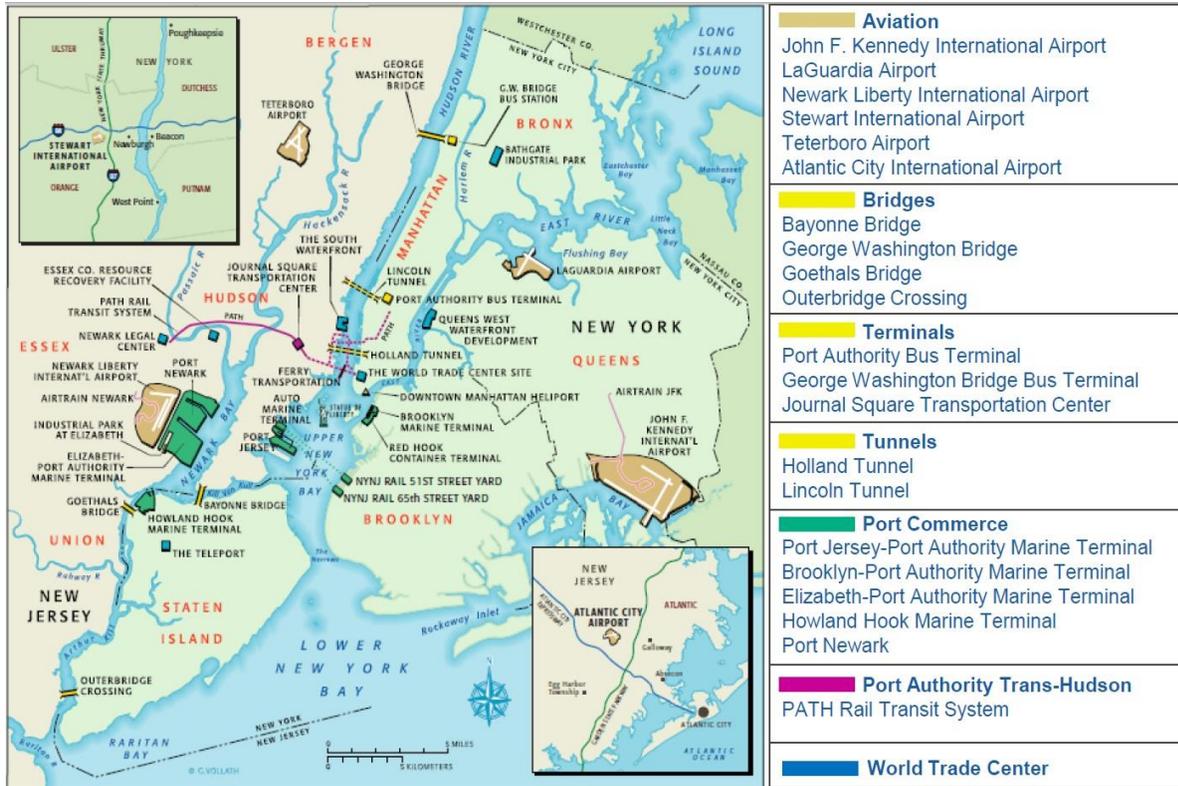
- **Introduction:** Overview of the Port Authority of New York and New Jersey; Strategic Approach to Expanding Opportunities; Beneficial Cycle of Engaging Navigation Platforms Turning Drivers into Probes and Well-Informed Users of Network Capacity; Challenges and Mitigations
- **Port Authority Initiatives Leveraging Probe and Crowdsourced Data:** Reaching Travelers Where They are Looking - Providing Information to Navigation Apps; Analysing the Reliability of Waze Travel Time Data for Operations; Evaluating Waze Beacons; Programmatically Coordinating the Evaluation of New Big Data Sources
- **Conclusion**

## *Overview of The Port Authority of New York and New Jersey*

The Port Authority is a unique multi-modal agency that includes some of the busiest transportation facilities in the world. See Figure 1. The facilities - bridges, tunnels, airports, seaports, bus facilities, and the Port Authority Trans Hudson (PATH) Rail Transit - are strategically important transportation assets. The approved 2018 budget for the agency is \$8.1 billion, of which \$3.4 billion was capital investment and \$3.2 billion was operating costs. The

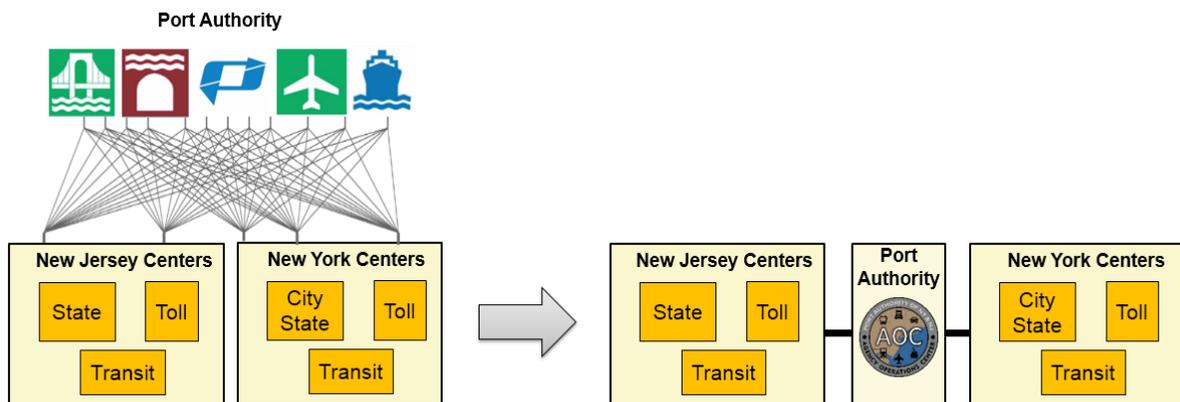
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continued prosperity of the region is largely dependent on the ability of these facilities to handle a steady increase in demand for vehicular, passenger, and freight transportation.



**Figure 1: Port Authority Facilities**

Regional transportation partners need to collaborate in order to transform the complex, fragmented, and congested network of today into a streamlined, functioning system for tomorrow. Prior to the launch of 24/7 Agency Operations Center (AOC) in November 2015, each of the 22 individual Port Authority facilities communicated individually with the transportation management centers in New York and New Jersey. With the launch of the AOC, the Port Authority created a single point of contact for its transportation partners. As shown in Figure 2, this significantly streamlined communications for real-time transportation systems operations and management.



**Figure 2: Regional Communications Before (left) and After (right) the AOC Launched**

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The AOC builds on this communications structure with roles to mitigate the impacts of the many significant construction projects necessary to maintain and modernize its extensive and aging infrastructure. These roles in the development of transportation management strategies, executing the strategies during construction and reporting on the effectiveness of the strategies, and adjusting them, if necessary. This paper explores how the Port Authority is further advancing regional traffic operations through probe and crowdsourced data initiatives, both for construction and other responsibilities. These initiatives are the result of cross-functional teams, including Traffic Engineering and the Technology Department as well as departments representing various modes and facilities. There is also coordination with regional partners including TRANSCOM, a coalition of 16 transportation operating agencies and public safety partners. The AOC, part of Traffic Engineering, spearheads many of the initiatives. The AOC has a full-time Manager of Technologies and Data Partnerships,

### *Strategic Approach to Expanding Opportunities*

The Port Authority realizes that while it keeps its existing facilities in a state of good repair and simultaneously builds the New York City regions' next generation of infrastructure, it must also continue to move people and goods. This places an onus on departments throughout the agency to seek new and improved methods and technologies. Traffic Engineering staff have identified probe and crowdsourced data, along with the companies providing the related navigation platforms, as potentially part of the solution. The combination of these collaborations and the underlying data have the potential to support efficient transportation network management, mitigate construction impacts necessary to facilitate the Port Authority's 10-year \$32 billion capital plan, and enhance customer service including managing expectations by providing accurate and relevant information.

However, embarking on new business models including working with new data types and new companies can introduce risk and challenges. A vision and agency support are necessary for proposed changes. Therefore, the Port Authority probe and crowdsourced initiatives in this area are based in a strategic planning and development effort. It includes:

- Mapping agency goals and needs to opportunities
- Performing a gap analysis
- Staying current on trends and emerging technologies such as through professional societies
- Identifying potential benefits for real-time operations, planning, construction management, and customer service
- Collaborating with related agency staff, including the Technology Department
- Coordinating with regional partners, including through ITS Architecture efforts
- Committing to a programmatic, rather than ad-hoc, approach, including a willingness to work with multiple companies and devoting staff time to strategic planning as well as to supporting implementation
- Approaching from a systems perspective
- Establishing a Traffic Engineering "Big Data Analytics Working Group" to coordinate projects and programs
- Collaborating in the development of data standards for universal adoption of Application Program Interfaces (APIs)
- Using pilot projects, with free data if possible, to evaluate new services and, if successful, use initial results to make the business case for additional investment

In 2016, the Port Authority made third party partnerships a strategic priority recognizing that a significant and growing portion of the Port Authority and regional customers rely on third party companies for both real-time traveler information and navigation. This statement of a strategic priority supports the initiatives described in this paper as well as dedicating specialized staff time to building relationships with the third parties and supporting technical development.

The partnership with Waze through the Connected Citizens Program has successfully been yielding benefits that align with goals identified within the strategic planning process. Waze provides relevant information in real-time about agency customers' end-to-end trips, without regard to the many agency jurisdictions along the way, even for visitors from outside the region. It allows the Port Authority to reach its customers with the information they want, how they want to consume it, on an established platform that they already use.

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### *Beneficial Cycle of Engaging Navigation Platforms Turning Drivers into Probes and Well-Informed Users of Network Capacity*

Smartphone navigation apps can be a platform that combines both collecting probe data and providing traveler information, including routing. While this was originally the sole domain of private companies appealing to travelers to reduce their own travel time, some agencies and companies see the mutual benefit of collaborating as well. For agencies such as the Port Authority, working with the companies is a strategic effort to serve customers and manage the overall network. For companies such as Waze, working with agencies provides an opportunity to improve the quality of the service they provide by including information provided by the agencies. Figure 3 shows the resulting beneficial cycle of information flow.



**Figure 3: Navigation Platforms such as Waze Enabling a Cycle of Probe and Crowdsourced Information Fused with Agency Input to Improve Transportation Network Management**

This cycle reveals a powerful opportunity for traffic management. As discussed in the next section, there are challenges to this and other uses of crowdsourced and probe data.

### *Challenges and Mitigations*

Through the experience of the Port Authority and regional neighbors, the following list of challenges, with some strategies to address them, are provided:

- **Challenge: Inducing Changes in Agency Mindsets**  
Many agencies and their staff are more comfortable owning and controlling data sources and traveler information systems. Part of this may be due to the typical responsibility that they have for the quality of data and the vetting of traveler information messages. While these are still valid concerns, the strategic planning described above helps agencies and staff to understand the opportunities that different models offer and when trading off some of the cost and control can lead to more effectively meeting agency goals.
- **Challenge: Procurement and Related Legal Agreements**  
Similar to the changing mindset challenge, agency procurement methods have mostly been developed around purchasing goods or services in which interested companies actively seek to enter into contracts. While some probe data providers are well equipped for this type of procurement, a company such as Waze may not be looking for any payment, yet want to enter into a legal agreement. Not only is this very atypical for agency procurement

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processes, such companies may have little incentive to engage in extensive legal negotiations. In fact, the Waze Connected Citizen program changed from a negotiated legal agreement to a one click system, establishing a take-it-or-leave-it option for agencies. One possible mitigation is bringing knowledge of the strategic underpinnings, and their champions within the agency, into discussions with procurement staff. This helps to make the case for such the procurement staff to seriously consider requests that may be well outside the normal processes they work with.

- **Challenge: Bridging the Gap between Agency Staff and Third Party Company Staff**  
Intelligent transportation systems have long found strength from bringing together people with varied expertise including traffic engineers, those in operations, electrical engineers, and networking professionals. There has been collaboration between the public and private sectors. However, now relationships grow beyond purchasing goods or services to no-cost collaborations directly with software engineers. The Port Authority has found it valuable to add staff who are experienced working in the tech sector to be embedded in the agency to develop an understanding of agency needs and goals while also being able to speak with the tech companies in their own language. This language goes beyond technical terms into understanding the motivations and work flow processes that can be very different from most agencies. Agencies may also be able to seek to strengthen collaboration between their information technology (IT) staff and staff in other departments with relevant expertise. Another tangible step for close collaboration is using an online collaboration platform where both agency staff and company staff can manage workflow and share documents rather than using e-mail. The online platform is especially beneficial when teams include multiple organizations and individuals, such as Waze collaborations that involve agency staff, Waze staff, and members of the Waze community.

It is also important to be aware of differing motivations among parties. One concrete example is in how rerouting around planned road closures is handled. Waze has a vested interest in providing customers what they want – the most efficient route. This is a user-optimal approach. Public agencies, however, have a long history of developing signed detour routes that take into account many more factors, such as the appropriateness of routing through residential areas or by schools. The Port Authority has made a policy decision to work with companies such as Waze despite this difference, recognizing that travellers will use such platforms regardless of agency involvement and having a seat at the table with the companies may open the door to some adjustments.

The Port Authority also recognizes that Waze is more than a platform and a company, it is a community of knowledgeable, dedicated volunteers working hard to keep the maps up-to date. While many of us who work in the transportation field believe in improving our communities, it is still surprising that others donate significant amounts of time separate from their own careers to improving the quality of information that is available. Port Authority staff have great respect for the dedication, skills, and knowledge of these Waze community members. Part of building collaboration with Waze community members has been through on-site working sessions with facility tours.

- **Challenge: Fusing Probe/Crowdsourced Data with Traditional Sources and Integrating into Planning and Operations**  
Probe data provides valuable input for agencies, but it is still one of many tools that they have available. Before getting to the sometimes substantial challenges of data fusion, it is prudent to understand the advantages and limitations of various types to select the appropriate type or types depending on the need. For example, several years ago the Port Authority teamed with an academic partner to compare travel time data from toll tag readers (considered ground truth) with several commercially available probe data sets. The Port Authority learned that the probe data was least reliable in heavily congested conditions, which unfortunately are the predominant conditions during peak periods at many Port Authority bridges, tunnels, and other facilities. However, neighboring agencies see great value in procuring data to cover an extensive road network with quality that is sufficient for its needs. As described in the initiative section of this paper, the Port Authority is currently extending comparisons among data types to include Waze data. It also integrated flight data into roadway data at an airport during an ambitious construction project to predict roadway peaking, develop mitigation measures, and implement the measures accordingly.

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- **Challenge: Roles and Responsibilities of agency information technology (IT) and traffic staff**  
The influx of data into agency functions, including traffic engineering and operations, has induced a need to revisit the roles and responsibilities of agency IT staff (in the Technology Department (TD) at the Port Authority) and traffic engineering/operations. Data has been transitioning from relatively smaller data sets used by specialized software within various departments to enterprise level, with new data sources needing sophisticated procurement, storage, analysis, and fusion. The Port Authority's TD recognizes that it is both difficult and vital to collect data about network conditions across multi-modal business lines and deliver insights to facility operators, partner agencies, traffic management, and first responders at just the right time, and without creating information overload and overriding other priorities. Involving TD staff and leadership in traffic-related professional society events has been valuable for strengthening collaborations and sharing knowledge. Still, there are many areas that benefit from clarifying roles and responsibilities. Besides the big data issues, there are more tangible concerns, such as maintenance of intelligent transportation systems (ITS) equipment from field sensors to the AOC video wall. Another area with potentially overlapping roles and responsibilities is the procurement and management of enterprise software systems such as geographic information systems (GIS) and advanced traffic management software (ATMS.) Discussing and documenting roles and responsibilities can be beneficial.
- **Challenge: Visualizing Data so that it is Actionable for Planning and Operations**  
The power of data comes from analyzing, interpreting, and applying it. For many audiences, an easy to understand visual representation is most effective. For construction project impact monitoring, a one-page daily summary suitable for management and operations staff can be appropriate. It is important to link travel times to other types of data that assist with understanding, such as if there was a crash that caused delays during the construction closure. Different audiences and different purposes can require different types of presentations. Understanding the intended applications and seeking user feedback can improve the quality of materials presented. For operations, color-coded dashboards that highlight deviations from expected delays are useful.
- **Challenge: Setting Open and Robust Data Standards**  
While National Transportation Communications for Intelligent Transportation System Protocol (NTCIP) has some valuable uses in the ITS sphere, the nature of data and information transfer for these emerging applications, and the involvement of private companies, makes it clear that different standards are necessary. Without data standards, data can't be shared efficiently. A parallel can be found in Google Maps incorporating transit agency information. It was not practical for Google to intake each agency's varied data formats. It was not until the General Transit Feed Specification (GTFS) was developed that the floodgates could open, both out of transit agencies and into many different platforms. The Port Authority is pursuing the SharedStreets vision for an open API as a, "shared language for the world's streets" and looking to incorporate the interface in its advanced traffic management system (ATMS.) SharedStreets is a project of the National Associate of City Transportation Officials (NACTO) and the Open Transport Partnership.

### **Port Authority Initiatives Leveraging Probe and Crowdsourced Data**

The Port Authority's strategic emphasis on partnerships has opened the door to several initiatives that are in various stages of development. All are opening opportunities for more effective application of probe and crowdsourced data in various aspects of planning and operations.

#### *Initiative: Reaching Travelers Where They are Looking – Providing Information to Navigation Apps*

Central to how travellers are interacting differently with the transportation system is that many are using smartphone based navigation apps for real-time optimized routing. As shown in Figure 4, the use of such apps dwarf the use of agency-provided apps. For many years, agency-provided traveller information and radio/TV media were the only main sources for real-time information, but private apps have stepped in providing intuitive user interfaces backed by significant useable data offered by trusted and well-advertised brands.

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User expectations for the apps continue to grow so companies are constantly looking to add functionality. Agencies have insight into some needs of their customers that companies may not be aware of, creating a mutually beneficial opportunity to collaborate. Agencies may also have more accurate information, both advance and real-time, for closures. Highlights of the Port Authority providing information through its participation in the Connected Citizens Program are as follows:

- **Points of Interest (POI's):** The Port Authority has received feedback from customers that it has been confusing to use navigation apps for designations at Port Facilities and airport cargo areas because destinations are typically identified by facility building number rather than by street address. By working with Apple Maps, the Waze Map Editor, and Waze Community Members, the Port Authority has led many updates.
- **Construction Closures and Special Event:** Navigation app partners, such as Google, Apple, and Waze, have various ways to detect and provide road closures and other messaging to their users, but in many cases agency input can improve the timeliness, accuracy, and breadth of information provided. For example, by having agency staff working in the Waze Map Editor, they can select precise links, including ramps and turn restrictions, which improves routing accuracy. Major Traffic Events (MTEs) are targeted push notifications in Waze and Apple Maps that give advance warning based on user history as well as real-time information based on location. Hazard notifications in Waze are triggered by a user's location.
- **Navigation Prompt Clarification:** Another activity of the Port Authority within this initiative has been working with Waze Map Editors to match the audible directions given in Waze to the wording on guide signs, especially in complicated areas or where signs have recently changed. This can reduce driver confusion which not only improves the user experience, but could also potentially reduce last-minute lane changes stemming from confusion that may contribute to crashes. These changes are also eventually reflected in Google Maps.

A specific example of providing impactful information to travellers potentially reducing congestion for all relates to the high-profile need for managing traffic to enable the LaGuardia Airport (LGA) Redevelopment. The LGA Redevelopment is essentially rebuilding the airport within very tight confines while keeping it fully operational. Combining usage data from Waze with Port Authority traffic counts, it has been estimated that 40% of LGA users are also Waze users – proving the reach of Waze to improve operations both as a probe and as a venue for virtually free communication to customers. As part of the LGA Redevelopment, the physical roadway system sometimes changes by the day; therefore, it is critical to communicate these changes to travellers who rely on the routing in their apps. As an example of the reach that the Port Authority can achieve through partnering with Waze, when a new exit to the airport from the adjacent freeway opened, push notifications were sent to over 140,000 targeted Waze users. For another roadway change, a Waze “hazard” was added that drivers would become aware of when they neared the site. Users signalled their appreciation for this information including more than 1,000 thumbs up.

### *Initiative: Analysing the Reliability of Waze Travel Time Data for Operations*

The proliferation of tolled crossings and other toll roads in the New York area makes toll tag-based travel time data an abundant and reliable source of the data. The Port Authority and neighboring agencies have invested in a network of toll tag readers specifically to use for traffic management and traveler information purposes, including travel time estimates on variable message signs. Agencies in the region have also invested through TRANSCOM in a Data Fusion Engine (DFE) that intakes data from toll tags as well as purchased probe data and other sources such as agency Bluetooth readers to current and historical travel time estimates. However, the Port Authority has also identified gaps in these sources of data and is open to evaluating additional options as they become available.

One use case need has been analyzing the impacts of detours outside Port Authority facilities, including the impacts along both the signed detour route and other possible alternative routes. Thus, a motivation and potential benefit of

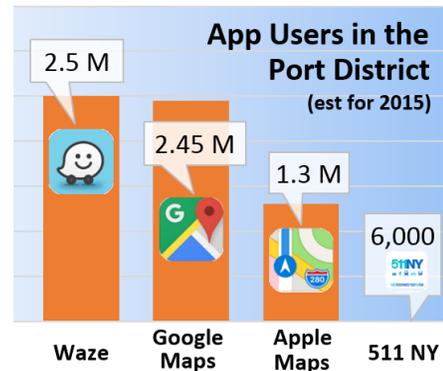


Figure 4: App Users in the Port District

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using Waze-based probe data is providing low cost monitoring of construction impacts. Another potential benefit of Waze or other probe data, should it prove reliable enough, would be to reduce the reliance on costly toll tag readers. The Port Authority is currently evaluating the reliability of the Waze data for operations. In an earlier phase, the Port Authority collected Waze data along a detour route that did not have toll-tag coverage and compared it to travel time runs. Results were positive. The current effort is a more robust data analysis. While the effort is not complete, it has already yielded some insights that may be of interest.

The current effort started by identifying two major cases:

- **Complex geometries** – roadway segments that include closely-spaced parallel roadways (such as express and local), partially covered roadways, urban canyon effects, multi-level bridges, and multi-level airport frontages.
- **Simple geometries** – roadway segments without the complex factors and that are generally uninterrupted.

The analysis began with the simple geometries in order to have a clearer view of how the toll tag and Waze data compare without the complicating effects of the complex geometries. Comparisons on two roadway segments with simple geometries over seven days yielded the unsurprising results that differences between the toll-tag data (ground truth) and the Waze data were magnified under congested conditions. In the speed range of 0-15 MPH, the standard deviation was +/- 4.84 MPH which is a 32.2% deviation in speed. In the speed range of over 45 MPH, the standard deviation was +/- 7.01 MPH which is a 4.8% deviation in speed. This is a similar finding to a previous peer-reviewed study comparing toll tag data to various probe sources.

For complex geometries, results are much less clear. The George Washington Bridge has two stacked levels, each of which has both eastbound and westbound traffic. Since cell phones do not include elevation when estimating location, it is not entirely surprising that Waze data sometimes includes the showed signs of delays on one level indicating a delay on the other level as shown in Figures 5 and 6 below.

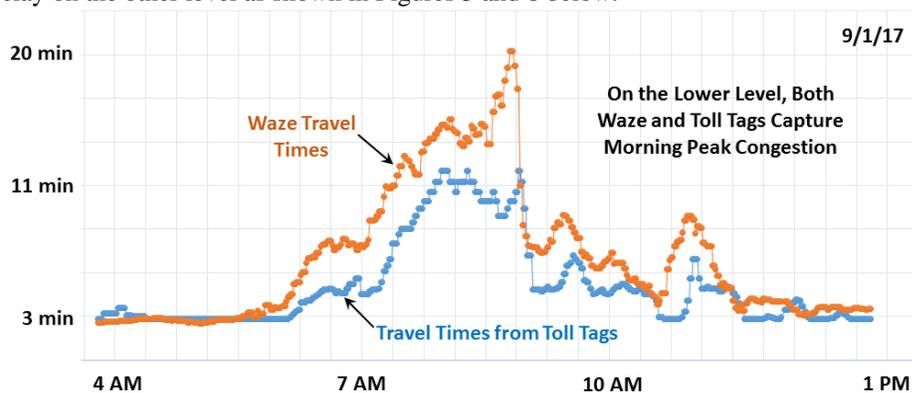


Figure 5: Calculated Eastbound Travel Times on the Lower Level of the George Washington Bridge 9/1/17

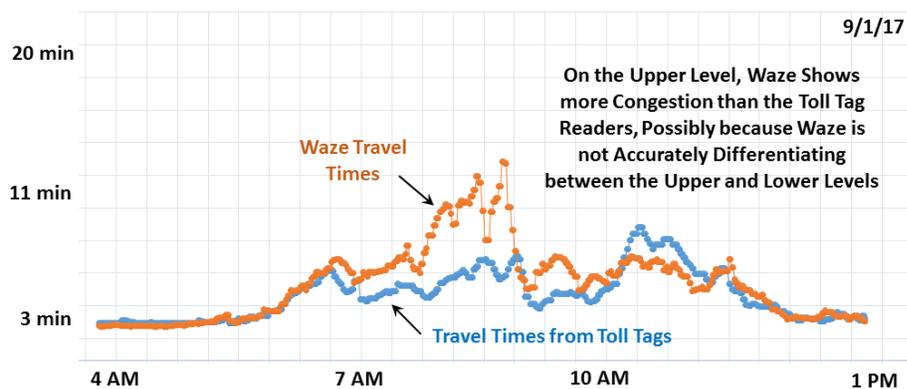


Figure 6: Calculated Eastbound Travel Times on the Upper Level of the George Washington Bridge 9/1/17

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However, further investigations are necessary because in other data samples there is high correlation between toll tag and Waze data within each level even when the delay patterns vary between the levels. See Figures 7 and 8.

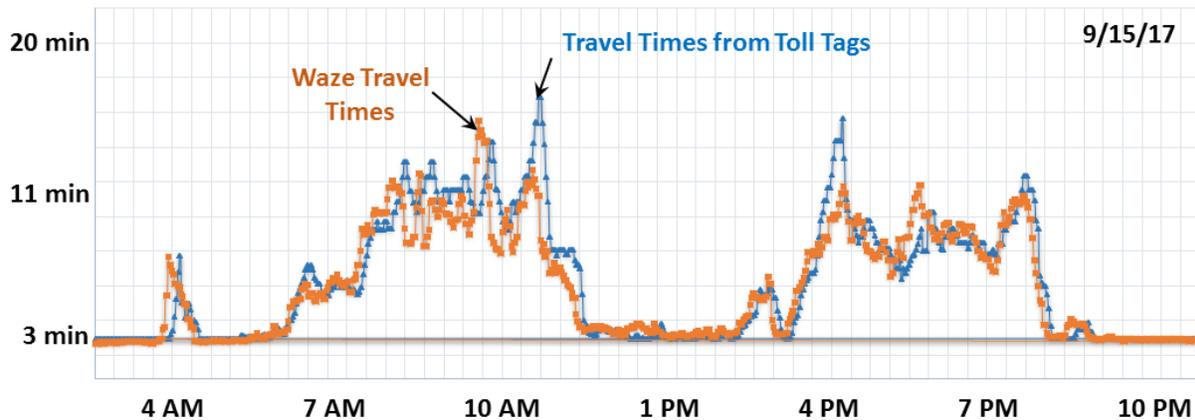


Figure 7: Calculated Eastbound Travel Times on the Upper Level of the George Washington Bridge 9/15/17

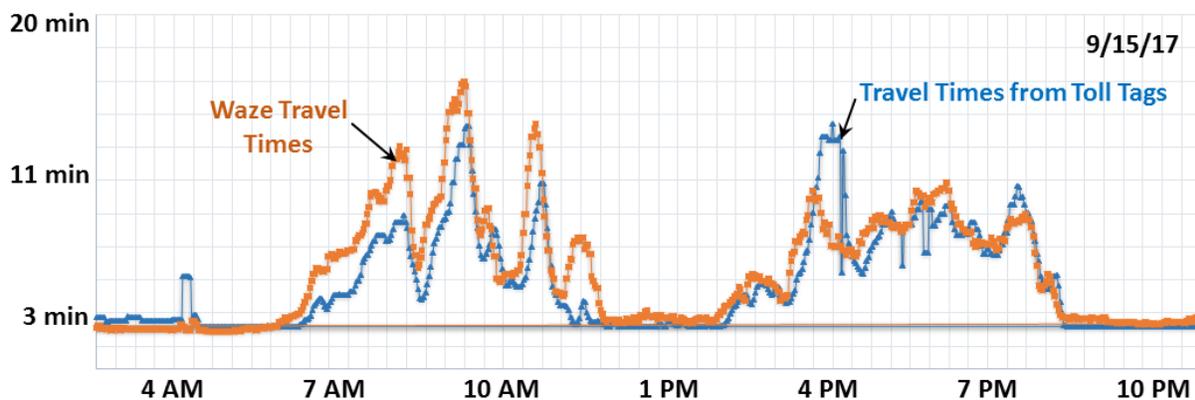


Figure 8: Calculated Eastbound Travel Times on the Lower Level of the George Washington Bridge 9/15/17

Another important finding illustrated in Figures 7 and 8 is that Waze data tends to show building congestion sooner than toll tag data. That is likely due to how the probe data is collected. For the toll tag readers, a delay is not registered until enough vehicles reach a downstream reader. Data is also aggregated every two minutes. However, for Waze, data is returned directly from the phone so more frequent updates are possible during congested conditions. Detecting congestion sooner can be a benefit for traffic operations, but due to the inconsistencies in the Waze data for complex geometries, it would be necessary to check cameras and other sources to verify detection before acting on information.

As the Port Authority continues the analyses, it will gain more insights into the benefits and limitations of the Waze data – useful insights for determining under which situations it is appropriate for use. Also, understanding where complex geometry influences the accuracy of data can help pinpoint where other mitigations such as possibly installing beacons to improve location accuracy.

### *Initiative: Evaluating Waze Beacons*

Waze Beacons are small battery powered Bluetooth devices that have been installed in tunnels to provide cell phone applications with an indication of their location where GPS signals are not available. This enables accurate navigational routing within tunnels and, importantly for the Port Authority, at the far end of tunnels as drivers need prompting for turns that follow quickly outside of the tunnel. This can improve the customer experience and

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potentially improve safety by reducing last-minute lane changes. While Waze Beacons have been installed successfully in many cities, the Port Authority is conducting its own evaluation including for compatibility with tunnel washing systems and absence of interference with Port Authority communication systems. The beacons are sold through Waze (at less than \$30 each with a recommended spacing of 43 per mile), but are open to use by various apps. The Port Authority may also consider them in the future for improving accuracy of location in other complex geometries, such as adjacent local and express lanes or stacked lanes on bridges or airport frontages.

### *Initiative: Programmatically Coordinating the Evaluation of New Big Data Sources*

The Port Authority, like many agencies, is aware that there are many possibilities for emerging big data sources to add new planning and TSM&O capabilities and increasing efficiencies. In addition to data aggregators who have been selling processed travel speeds for several years, new products are being developed and new players are courting transportation agencies, even cell phone providers directly. The types of information are also expanding, such as origin-destination, modal split, travel time reliability, and multi-modal trip patterns. Rather than analysing the selling points of multiple data providers, the Port Authority Traffic Engineering has convened a Big Data Analytics Working Group (DAWG) focus on procuring data to meet use cases.

### **Conclusion**

Strategic planning has been a prudent foundation for the Port Authority as it embarks on a program of using probe and crowdsourced data as well as collaborating with third party navigation platforms. Just as travelers are interacting with the transportation system in fundamentally different ways, agencies also have opportunities to change how they interact with customers and third parties. App-based navigation platforms turn millions of drivers into both a rich source of data and a receptive audience for real-time routings that help to optimize transportation network use while setting accurate driver expectation for travel times. Despite challenges, there are potential benefits such as cost savings from deploying and maintaining less field equipment while also having access to robust data and methods target customers with relevant information. The Port Authority's early successes on several initiatives provide a basis for seeking continued support of innovation, investment, and collaboration that enables these new capabilities to help the Port Authority meeting growing transportation needs.

### **Reference**

1. SharedStreets, <http://sharedstreets.io>, last accessed 2/26/18.