



CENTRAL TEXAS REGIONAL  
**MOBILITY AUTHORITY**

**INNOVATION TEAM**  
**WHITE PAPER**

# MOBILE APP OPPORTUNITIES FOR TOLL AGENCIES

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The Mobility Authority established the Innovation Team in Fall 2018 to stay informed on emerging mobility and transportation technology and introduce opportunities for these emergent technologies and ideas through projects, programs, partnerships and policies. The purpose of these white papers is to provide a high-level of examination into emerging technologies and their case studies to support decision-making for solutions to the problems we face today and tomorrow.

As part of its Innovation and Technology Roadmap, the Central Texas Regional Mobility Authority (Mobility Authority) is investigating the use of smart phone technology to improve communication with customers, enhance customer service and improve roadway and agency operations. To date, the Mobility Authority has partnered with private sector app developers to pilot ridesharing and active traffic management and route mapping products. The Mobility Authority has also hired third party programmers to produce smart phone apps to help the public navigate construction projects and enhance their experience using agency pedestrian trails.

Prior to embarking on the deployment of further roadway oriented smart phone applications, the Mobility Authority decided to conduct an industry scan that consisted of three elements: (1) an Internet or desktop review of apps currently in use within the tolling industry; (2) case study interviews to glean insights on the development and management of mobile apps, and (3) a literature review to inform and support recommendations.

The research highlights 10 smart phone applications that serve a wide range of needs from traveler information, route selection, toll rates, and roadway conditions to ridesharing and toll payment features. The research team selected two apps – the Florida Turnpike Enterprise Toll Calculator app and the North Texas Tollway Authority Tollmate app – to conduct deeper case studies. Through interviews with representatives from these two agencies, the research team identified important lessons learned, such as:

- With numerous existing app providers and other competing transportation system operators, it is important to understand the actual need for your proposed app and whether you are the right entity to fill that need.
- Detailed planning must occur prior to app development to help support the following goals:
  - The app will appeal to customers by filling a service gap or desired need, both at the time of launch and for some time into the future;
  - App developers clearly understand their scope of work and are equipped to meet the Mobility Authority's needs; and
  - A vision and milestones are clearly defined so the app is flexible to evolve to meet future needs of the agency.
- The Mobility Authority should put mechanisms in place so that an app can be easily updated, and bugs can be quickly resolved. This will help prevent the agency's brand from being negatively impacted by outdated information or technical glitches.

Over the past decade, innovations in transportation technology have signaled transformational improvements within the tolling industry. Mobile apps are a technology that is generating increasing interest among tolling agencies around the globe. This interest is largely driven by the growing utility of tablets, smartphones and related devices; the gradual shrinking of the broadband/digital divide; and rapidly growing Internet of Things (IoT) sector.

In the early days, transportation-oriented mobile app solutions mostly supported navigation and location-based services. Current and converging technologies such as Artificial Intelligence, IoT, and Augmented Reality can enhance mobile app functionality to streamline operations and enhance customer experience. Introducing mobile apps within an agency's business operations connects ongoing public and customer engagement, traffic data collection, toll account management, and mobile tolling." In recent years, the functionality of mobile app solutions has significantly grown and now encompasses a wide range of services including traffic data collection and management, travel and traveler-related information and communications, route and travel mode planning and selection, customer service and account management, and transactional and payment services.

However, in today's rapidly changing technological climate, it is important for agencies to weigh the utility, efficiency, longevity, and scalability of technologies before investing in them. To this end, the Mobility Authority has performed an industry scan of current best practices related to usage of mobile apps within the tolling industry.

The following key questions were used as a framework to guide this study:

1. How can the use of mobile apps best provide utility to users and operators of managed and tolled lanes?
2. What are advantages and disadvantages of agencies partnering and sharing data with private third party apps instead of developing original mobile apps?

Toll authorities across the country have deployed numerous mobile apps to meet various needs. Many of these existing mobile apps are geared towards customer account management including tolling invoice payment and facilitating transactions with the toll facility via a replacement or alternative approach to owning a toll transponder. For the purposes of this report, the research team focused on the key questions above with a priority for apps geared towards communicating traveler information rather than transaction based apps.

## Mobility Authority App History

Over the past decade, the Mobility Authority has implemented several pilot projects with privately developed third party apps such as CARMA and Metropia, and has also contracted with software developers to build proprietary apps such as the 45SW Trail Explorer App and the MoPac Improvement Project Construction App. This section briefly describes these projects to illustrate the Mobility Authority's prior experience with mobile apps.

### Vehicle Occupancy Pilot Project with CARMA Carpooling<sup>1</sup>

In February 2014, the Mobility Authority launched a partnership with CARMA Carpooling, an app that matched drivers and riders in real-time to incentivize carpooling on toll facilities operated by the Mobility Authority. The goal was to increase carpool participation and demonstrate the efficacy of using an app to verify occupancy and eliminate the need for roadside enforcement of carpooling requirements. The federally funded pilot program provided financial incentives (Free Tolls) to drivers who used the CARMA App to carpool on local toll roads. The pilot was funded by a Value Pricing Grant from the Federal Transit Administration administered through the Texas Department of Transportation.

A 2015 Texas A&M Transportation Institute (TTI) study<sup>2</sup> summarized the project by saying, "The occupancy of a carpool can be digitally verified with a smartphone app, and suggests that various

carpooling incentives and recruitment activities may work together to cause changes in travel behavior.”

### [Incentive-based Active Traffic Management Mobility Ecosystem Pilot with Metropia](#)

Metropia, an incentive-based congestion management platform with a front-facing consumer mobile app, and backend processes including: (1) predictive and load-balancing proprietary algorithms to allow travelers to plan and reserve their trip ahead of time while enabling a better distribution of the demand on the transportation system; (2) a set of behavior influencing algorithms that make use of gamification and behavioral economic strategies to help travelers make informed personal mobility decisions that include shifting their travel to off-peak times, taking under-utilized corridors, and opting for alternative modes of transportation; and (3) real-time information communication systems to allow the Mobility Authority to directly deliver messages to travelers about construction related delays and traffic incidents. Metropia also incentivized social carpooling among app users.

Metropia measured and reported on performance analytics of the MoPac Expressway (speed and travel time improvements) and documented changes in traveler behaviors including shifts in travel times out of peak traffic and increase in carpool rates.

### [MoPac Improvement Project Construction App<sup>3</sup>](#)

In 2013 the Mobility Authority contracted with web development firm Monkee-Boy to develop a unique mobile app to keep Austin residents informed about construction of the MoPac Improvement Project. The app integrated APIs from Google Maps, Twilio, and Urban Airship to combine real-time traffic information with interactive, map-based lane, ramp and road closure information. The app also provided convenient access to project photos, webcams, blogs, newsletters, and other pertinent project information. There was also a form for sending questions, comments, or complaints to the project team. Upon completion of the MoPac Improvement Project and opening of the Express Lanes, the app was decommissioned.

### [45SW Trail Explorer App<sup>4</sup>](#)

In 2019, the Mobility Authority implemented a virtual-reality educational app intended to enhance the experience of using the bicycle and pedestrian trail along the 45SW toll road. As users stop at stations along the trail, they use the app to scan barcodes on signs to access narrated educational lessons about the history and natural features of the area. The narration is provided in both English and Spanish, and there are augmented reality animations that accompany each lesson. The animations allow users to watch a prehistoric sea creature swimming right before their eyes, witness a towering live oak tree grow from the ground up, or take a visual deep dive into the caves that are just below their feet.

Additional features of the app include GPS guidance to help users navigate the trail and to alert users to upcoming experiences. Users can also take photos with the augmented reality animations to capture and share the journey with their friends and family.

## Desktop Review

To begin to answer the key questions of this study, the research team investigated existing mobile apps used by tolling and transportation agencies. These mobile apps are summarized in Table 1.

**Table 1: Desktop Review of Mobile Apps**

	Agency	Key Features
<b>CalTrans Quick Map<sup>5</sup></b>	<ul style="list-style-type: none"> <li>CalTrans</li> </ul>	<ul style="list-style-type: none"> <li>Provides real-time highway information to travelers across California, including: freeway speed, traffic camera snapshots, lane closures, changeable message signs, border wait times, snowplows, and Waze traffic data.</li> </ul>
<b>FL511<sup>6</sup></b>	<ul style="list-style-type: none"> <li>Florida DOT</li> </ul>	<ul style="list-style-type: none"> <li>Advanced Traveler Information System (ATIS) app that includes camera images, message signs, and incidents.</li> <li>There is now voice interaction functionality and an option for users to toggle between higher and lower accuracy location data to reduce power consumption.</li> </ul>
<b>GoCarma<sup>7</sup></b>	<ul style="list-style-type: none"> <li>North Central Texas Council of Governments</li> </ul>	<ul style="list-style-type: none"> <li>Automatically verifies the number of people in a carpool (associated with the eligibility and application of carpool discounts), eliminating the need for manual, in-lane enforcement.</li> </ul>
<b>Houston TranStar<sup>8</sup></b>	<ul style="list-style-type: none"> <li>City of Houston, Harris County, Houston METRO, and TxDOT</li> </ul>	<ul style="list-style-type: none"> <li>Provides travel information including traffic and weather conditions, road closures, reported incidents, and traffic camera images.</li> </ul>
<b>MiDrive Mobile App<sup>9</sup></b>	<ul style="list-style-type: none"> <li>Michigan DOT</li> </ul>	<ul style="list-style-type: none"> <li>Traveler information, including travel speeds, work zones, camera snapshots, and incidents.</li> <li>In 2018, the Michigan Department of Transportation (MDOT) discontinued support of their traveler information mobile app MiDrive due to low usage and high maintenance costs. MiDrive is still available as a desktop and mobile website.</li> </ul>
<b>NYSTA Mobile App<sup>10</sup></b>	<ul style="list-style-type: none"> <li>New York State Thruway Authority</li> </ul>	<ul style="list-style-type: none"> <li>Includes an interactive map with real time construction and traffic event information, trip planning and toll calculator capabilities, the ability to report safety or road condition issues or to request roadside assistance, and to get E-ZPass and pay-by-mail information.</li> </ul>
<b>Tollmate App<sup>11</sup></b>	<ul style="list-style-type: none"> <li>North Texas Tollway Authority (NTTA)</li> </ul>	<ul style="list-style-type: none"> <li>Allows users to access account information, calculate the cost of a trip, view the location and toll rate of specific toll gantries, contact TollTag customer service, and call for roadside assistance from any NTTA toll road.</li> </ul>
<b>Toll Calculator App<sup>12</sup></b>	<ul style="list-style-type: none"> <li>Florida's Turnpike Enterprise (FTE)</li> </ul>	<ul style="list-style-type: none"> <li>Allows users to calculate anticipated trip costs on FTE toll facilities.</li> <li><b>Note:</b> TxDOT offers a similar service via their TxTag website: <a href="https://www.txtag.org/en/tollCalc/site.html">https://www.txtag.org/en/tollCalc/site.html</a></li> </ul>
<b>Try Parking It<sup>13</sup></b>	<ul style="list-style-type: none"> <li>North Central Texas Council of Governments</li> </ul>	<ul style="list-style-type: none"> <li>Matches commuters with carpools and vanpools.</li> </ul>
<b>Waze</b>	<ul style="list-style-type: none"> <li>Many (including the Mobility Authority)</li> </ul>	<ul style="list-style-type: none"> <li>Many agencies (including the Mobility Authority) provide high-quality real-time information to the traveling public by participating in the Waze Connected Citizens Program (CCP).</li> <li>Waze data can also assist CCP partner agencies with processes like dynamic pricing or management of construction closures.</li> <li>Waze does not disseminate variable toll prices to users. Where tolls are variable travelers simply receive a notification that the toll amount varies.</li> </ul>

Following the desktop review of existing apps, the research team selected two toll agencies for case study interviews based on the relevance of their use of mobile apps in providing toll rate information to the two key questions identified in the “Purpose & Background” section of this report:

- FTE Toll Calculator App
- NTTA Tollmate App

While the purpose and objectives for these apps vary, the agencies interviewed provided valuable lessons learned and takeaways for the Mobility Authority to consider when determining the need for a mobile app.

### FTE Toll Calculator App

Florida’s Turnpike Enterprise (FTE) Toll Calculator app allows users to calculate anticipated trip costs on Florida Department of Transportation (FDOT) toll roads by entering basic trip information, such as payment method (transponder, cash, or pay by mail), vehicle axle count, and selecting the locations where they plan to enter and exit the toll facility on their trip. The app was developed internally in 2012 by FTE’s General Engineering Consultant (GEC) with an initial goal of providing customers with a new option for accessing current system toll rates.

The agency has received user feedback identifying two concerns with the app that make it challenging to use:

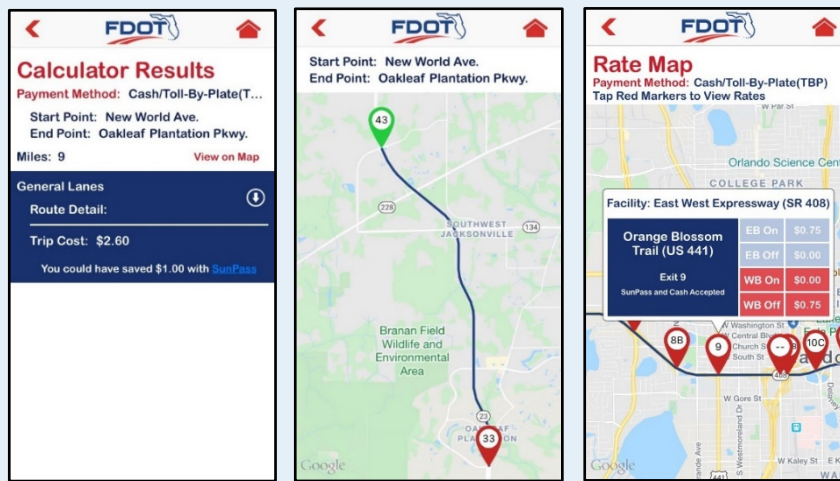
- Only FDOT toll facilities were originally integrated into the app, so predicted costs did not include the costs of tolls on toll roads managed by local agencies.
  - FTE has addressed this issue by incorporating other agencies’ toll facilities and their corresponding rates into the app.
- Users are required to select the specific entry and exit points within the toll network to calculate a trip cost, rather than having the app determine the best route within a toll facility based on the overall trip origin and destination inputs.
  - FTE is currently considering an app enhancement to provide this start/stop point user input flexibility, which would require updating the routing and assignment logic within the mobile app. Providing this new functionality will make the mobile app more user friendly to those out of state visitors and customers who are not familiar with the network of Florida toll roads.

The majority of current app users are visitors rather than residents. This leads to a common trend for visitors to download the app for a short duration and then delete it from their phones once their trip is completed. The existing Toll Calculator App user base makes it difficult for FTE to gather feedback, and thus they have not solicited specific customer surveys to gain additional feedback on current app features.

FTE recommended that other toll agencies consider integrating their toll rates with more commonly used privately developed apps such as Waze or Google Maps, which would be much less costly than developing and maintaining a separate app in-house.

The case study containing more detail from the interview with FTE is included as **Appendix 1**.

Figure 1: FTE Toll Calculator App Screenshots



### NTTA Tollmate App

The North Texas Tollway Authority (NTTA) hired a consultant to develop their Tollmate app, which allows users to:

- Access account information
- Calculate the cost of a trip
- View locations and rates of specific toll gantries
- Contact TollTag customer service
- Call for roadside assistance from any NTTA toll road

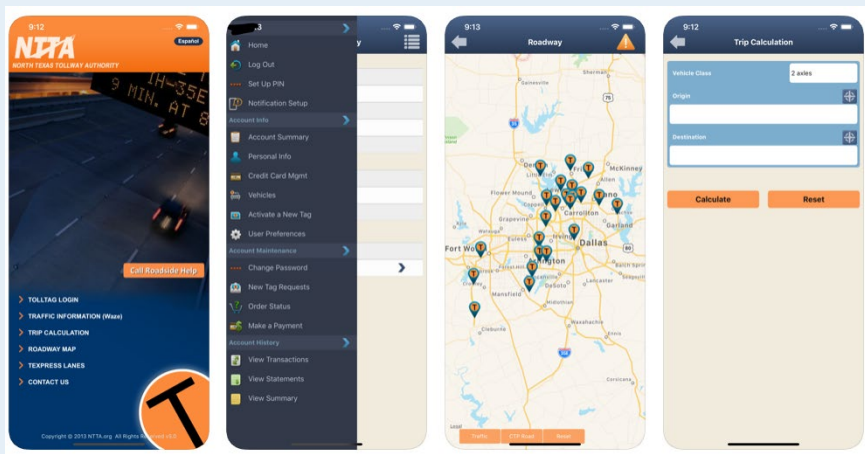
This app was originally developed based on the findings of an NTTA focus group study, which determined a need for an app endorsed by NTTA to provide toll trip costs and improve access to account management for customers.

NTTA is currently planning to implement an improved internal back-office system in summer 2020, at which point the Tollmate app will begin to be managed internally by NTTA rather than by the current third party vendor. NTTA does not anticipate a need to hire additional IT staff to manage the app once the currently planned updates are made public. NTTA has not pursued interoperability for the Tollmate app with other toll transponders besides NTTA’s TollTag, such as TxTag or EZTag.

NTTA staff shared lessons learned with the Innovation Team, including the immense value of any agency determining its vision for app capabilities at launch, as well as two, three, and four years afterwards. Outlining these expectations helps developers to provide more accurate proposals and benefits the agency’s internal team to be on the same page about future app capability priorities at the onset rather than disagreeing about them later.

The Case Study summarizing the survey interview with NTTA is included as **Appendix 2**.

Figure 2: NTTA Tollmate App





## Case Study Findings

A summary of findings from the FTE and NTTA case studies is provided in Table 2.

**Table 2: Summary of Mobile App Case Studies**

	FTE Toll Calculator App	NTTA Tollmate App
Location	<ul style="list-style-type: none"> <li>500 miles of toll facilities throughout Florida.</li> </ul>	<ul style="list-style-type: none"> <li>980 lane-miles of toll facilities in North Texas.</li> </ul>
Objective	<ul style="list-style-type: none"> <li>Provide customers with a mobile option to access toll rates and determine cost of a trip.</li> </ul>	<ul style="list-style-type: none"> <li>Provide customers with a NTTA branded mobile friendly option for determining costs of a trip.</li> <li>Transition frequent ZipCash (Pay-by-mail) users to the TollTag and reduce unexpected automatic re-bill charges by allowing users to add funds to account via mobile app.</li> </ul>
Strategy	<ul style="list-style-type: none"> <li>Users select region, facility, and entry &amp; exit points on app to determine trip cost.</li> <li>App uses a Google Maps overlay.</li> <li>App also includes Rate Map feature, which shows current rates at specific gantries.</li> <li>Target goal for user rating on app store is &gt; 4.0/5.0.</li> </ul>	<ul style="list-style-type: none"> <li>Provide app that allows for easy account maintenance and trip cost calculation.</li> <li>Provide app with links to contact free roadside assistance on NTTA toll roads and TollTag Customer Service.</li> </ul>
App Management & Maintenance	<ul style="list-style-type: none"> <li>App is managed by in-house GEC staff</li> </ul>	<ul style="list-style-type: none"> <li>App is currently managed by third party vendor</li> <li>NTTA will update back-office system Summer 2020, and NTTA IT staff will maintain app in-house.</li> </ul>
Cost	<ul style="list-style-type: none"> <li>Funding for app development, operations, and marketing comes from GEC's annual budget (varies year to year).</li> </ul>	<ul style="list-style-type: none"> <li>Funding for the app comes from the NTTA IT budget (varies year to year).</li> <li>Recurring costs related to annual updates to system toll rates are typically &lt;\$10,000. Initial development and major enhancements could be much more expensive.</li> </ul>
App Usage	<ul style="list-style-type: none"> <li>Google Analytics data used to track app usage</li> <li>Primary app users are non-local travelers rather than frequent commuters</li> </ul>	<ul style="list-style-type: none"> <li>NTTA IT staff monitors usage with user dashboard</li> <li>2018: 14,000 downloads/month</li> <li>2019: 18,000 downloads/month</li> <li>1.1 million total downloads</li> </ul>
Lessons Learned	<ul style="list-style-type: none"> <li>Integrate all key toll facilities in the area into a single app from the start, verifying that partner agency rates are accurate. There is an additional cost incurred by the application's owner to keep another agency's toll rates up to date for customer service.</li> <li>Develop app with easy user inputs for users unfamiliar with the area (origin and destination, not entry and exit toll gantries).</li> <li>Dedicate staff to app so they can quickly make changes when needed (like toll rate updates).</li> <li>Use app branding to connect to related programs (FTE is rebranding the Toll Calculator app to resemble the look and feel of the SunPass app).</li> <li>FTE advises toll agencies to consider integrating toll rates with a widely used third party app such as Waze or Google Maps, which would entail significantly lower costs than developing a customized app in-house.</li> </ul>	<ul style="list-style-type: none"> <li>Prior to competitive procurement process, develop a clear internal vision for app capabilities at launch, and 2, 3, and 4+ years out. Clearly outline expectations to receive more accurate proposals.</li> <li>Consult internal back-office operations provider prior to scope development with a third party developer to determine expected level of effort to integrate the app into existing systems.</li> </ul>

To further augment the findings of the desktop review and case studies, the research team conducted a literature review. The studies explored in this section help illustrate more broadly how agencies can derive benefits from mobile apps, beyond the scope of the existing apps described in this report.

### TTI Study – Advancing Traveler Information Technologies for Priced Managed Lane Networks<sup>14</sup>

**Summary:** The Texas A&M Transportation Institute (TTI) published a study in 2018 titled *Advancing Traveler Information Technologies for Priced Managed Lane Networks*. The study used focus group research conducted in June 2016 to discover how drivers in Austin, Houston, Dallas/Fort Worth, and Bryan/College Station prefer to receive traveler information pertaining to tolls. Of the 31 focus group participants, 16 preferred to receive information through a smartphone application, as opposed to radio, television, roadway signs, electronic messages signs, websites, text messages, or in-car navigation. The next most preferred method of communication was in-car navigation with only 8 votes.

The study also organized types of toll information based on when during the trip the information is desired by the user, as shown in Figure 3. Focus group participants identified the following as information they would want a smartphone application to provide:

- What route (free or managed lane) has the lowest cost and lowest travel time?
- Are there any crashes or construction on my route?
- How much will my total trip home cost?
- What is the expected delay?
- Do I need a tag?
- What exits can I get to from the managed lane?

**Applicability to this Industry Scan:** The study shows the customer demand for mobile apps capable of providing travel and toll rate information to users of toll facilities. The focus group’s preference for information to be provided by mobile apps reinforces the Mobility Authority’s intention to learn more about existing mobile apps geared towards traveler information.

Figure 3: Types of Toll Traveler Information in Trip Sequence (TTI)



### IBTTA – Tolling and Customer Service Workgroup – A Roadmap for Engagement with Third Party Account Issuers<sup>15</sup>

**Summary:** This whitepaper explores when to engage, why to engage, and suggestions for how to engage third party providers for toll payment, account management, and customer service with a focus on considerations for Legal, Technical, and Customer Service requirements. Due to the growing use of Mobile Phones and Smart Phones and penetration in the US across all socio-demographic groups, third party providers are increasingly introducing mobile apps and platforms to facilitate payment and account management for toll payment.

**Applicability to this Industry Scan:** The IBTTA white paper explores the topic of payment and account management in depth and as such, Mobile Apps that are used for payment and account management were not included in this Mobility Authority paper.

#### [IBTTA – Primer on MaaS<sup>16</sup>](#)

**Summary:** This IBTTA white paper explores the potential future impacts to the tolling industry as a result of Mobility as a Service (MaaS). While there is a potential for reductions in toll revenue as revenues are shared with other competing service modes, the white paper explores business use cases that could benefit the tolling industry such as attracting new customers and capturing toll payments from customers with prepaid accounts. The paper closes with a need for collaboration and shared integration between modes and other entities that provide complimentary transportation services, such as tolling agencies, to better serve customers and their community.

**Applicability to this Industry Scan:** This white paper explores the potential impacts to the tolling industry posed by MaaS, which will very likely operate via a mobile app. It emphasizes the need for integration between agencies and operators to ensure the success of all transportation providers in the future. This document may be a useful resource in setting goals for interagency coordination, which supports the argument against a specific toll operator investing significant resources in developing a unique mobile app.

#### [USDOT – Smartphone Applications to Influence Travel Choices: Practices and Policies<sup>17</sup>](#)

**Summary:** This United States Department of Transportation (USDOT) primer demonstrates the growing importance of smartphones (and mobile apps) in the transportation network (primarily to promote transportation efficiency and congestion reduction) and explores the role of smartphones in identifying services and choices for individuals and influencing travel behavior. Specifically, this document focused on four types of apps currently in use: (1) Mobility Apps: Apps that are mobility focused and include business-to-consumer (B2C) sharing apps; mobility trackers; peer-to-peer (P2P) sharing apps; public transit apps; real-time information apps; ridesourcing or transportation network company (TNC) apps; taxi e-Hail apps; and trip aggregator apps. (2) Vehicle Connectivity Apps: Apps that help users to connect to their vehicles remotely; these apps can be very beneficial in case of lockouts or an accident. (3) Smart Parking Apps: Apps that make the parking process more efficient by highlighting the real-time availability and parking cost. Additionally, smart parking apps enable ease of payment. Valet parking apps allow the user to hire an experienced valet to park their vehicle after dropping it off at a convenient location. (4) Courier Network Services (CNS) Apps: Apps that are focused on efficiently delivering goods to individuals.

The USDOT report also addresses challenges related to the use of mobile applications by public agencies and others. These include issues associated with accessibility such as low smartphone ownership levels in some populations, access to broadband service and data limitations in rural and less urbanized areas, and for apps with payment integration present limitations to the unbanked users. There are also interoperability challenges across a growing number and types of devices; developing and maintaining an app that can seamlessly run and scale across a spectrum of devices, ranging from phones to desktops is both complex and costly.

**Applicability to this Industry Scan:** This report thoroughly explores the many purposes of mobile applications in transportation and the issues associated with the development of mobile applications including the many challenges and considerations of their use including privacy concerns, open-data and data sharing, and accessibility and equity issues. This document may be a useful resource in setting goals and assessing the need for a mobile app by Mobility Authority.

## Recommendations

The recommendations from this study are categorized by which key question they answer from the purpose of this study:

1

***How can the use of mobile apps best provide utility to users and operators of managed and tolled lanes?***

**Provide a familiar and seamless user experience.**

Mobile apps are a valuable resource for providing information to the users of toll networks. For the best user experience, it is critical for apps to include the following components:

- Provide real-time trip cost estimates based on current toll rates for dynamic systems.
- Use a common and recognizable user interface and background map (such as Google Maps or Waze) to provide familiarity and avoid confusion for new app users.
- Ensure a simple user experience with minimal user inputs required.
- Include toll facilities for all regional toll authority providers in a single app to avoid confusion for users.

**Develop clear goals for app development efforts.**

Mobile apps are also a valuable resource for operators, and can provide unique insight to customer data and trends. It is important for toll operators to consider the following items when considering whether to develop a unique app for their system:

- Develop a long-term app strategy for the Mobility Authority
- Create a clear internal vision of the current and future capabilities of the app during the initial planning stages of development.
- Consult internal IT and back-office operations teams for input on app development and management strategies to ensure compliance with existing systems and protocols.

2

***What are advantages and disadvantages of agencies partnering and sharing data with private third party apps instead of developing original mobile apps?***

**Consider data integration with private apps.**

Advantages of partnering with third party app developers include:

- Partnering and sharing data with developers of existing commonly used apps will provide familiarity for app users which translates to confidence in the reliability of the app.
- Private app developers have a knowledge base and business model that allows them to develop apps more efficiently than a public agency.
- The Mobility Authority may be able to convey information collected from travelers to existing third party apps to enhance roadway operations and increase overall customer service.

Disadvantages of partnering with third party app developers include:

- Development of a new unique mobile app for a specific agency can present high upfront costs.
  - There is the potential for scope-creep or costly change orders if app features and future updates are not clearly scoped at the beginning of development.
- Technical glitches whose resolution is outside of the agency's control can reflect negatively on the agency's brand if they are not fixed promptly.

## Conclusion

In conclusion, this industry scan found that developing, deploying, marketing and maintaining a mobile app is complicated, time consuming, and potentially expensive. Furthermore, the ability to deliver exceptional user experience is a significant factor in determining the success of a mobile app. The industry scan confirms there are many existing apps that already provide many of the services a toll authority might wish to utilize and many agencies are already using them with varying levels of success. However, there tends to be a lack of existing third party apps that provide mobile tolling or mobility integration-centric solutions specific to the Mobility Authority and their pricing tools.

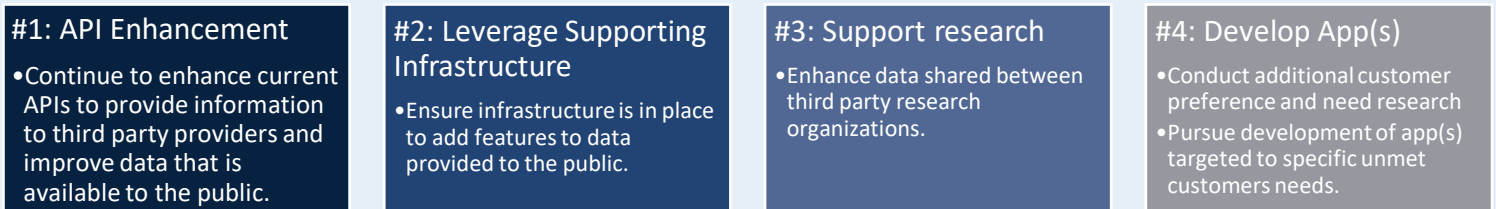
Before deciding to develop an app internally the Mobility Authority should:

- fully consider the need and purpose for a mobile app (what service will it provide?);
- confirm the mobile app will fulfill an unmet need that has been identified by customers (do customers feel they need the service offered by the app and will they use it?); and
- determine if the product already exists through a third party developer or another agency (does an existing mobile app already provide this service?).

These three questions will help the Mobility Authority form a mobile app strategy and provide guidance as they carry it out. It may be that third party developers are better positioned to meet certain customer needs using data provided by the Mobility Authority or another source.

There are several viable courses of action for the Mobility Authority to take for the future use and development of mobile apps, as shown in Figure 4 (the courses of action are numbered only for clarity, not to indicate ranking or priority). The best course of action will depend on the need that the Mobility Authority intends to meet, as well as the resources available for the project. It is likely that the Mobility Authority will pursue several of these courses of action at the same time; they are not mutually exclusive.

**Figure 4: Recommended Courses of Action**



### Option #1: API Enhancement

It is evident from the industry scan that mobile apps specific to local agencies can be expensive to develop and maintain. In addition, they often have lower usage than privately developed apps, although rewards programs for frequent drivers or carpooling may increase usage.

One recurring idea throughout the industry scan was that a potential alternative to developing and maintaining a mobile app in-house is to partner with private app providers, as the Mobility Authority has done through the WAZE Connected Citizens Program. This approach has three key benefits:

1. Partnering with private app providers allows agencies to disseminate real-time traffic and incident information to a wider audience.
2. This approach gives agencies access to smartphone-based customer data (which could enhance traffic management and help better inform decision making on pricing, for example).
3. Furthermore, these partnerships can reduce the need for an agency to invest in staff with this capability and expertise, resulting in greater cost-effectiveness than developing and maintaining an original app in-house.

Whether procured competitively or developed in-house, apps require significant investments in outside contracts or staff time for initial development and then for maintenance, customer service, marketing, and updates. Furthermore, costly marketing efforts are required to spread awareness of agency apps and gain a significant user base. Road users want trip planning resources that will provide costs, travel times and other information from door-to-door, regardless of which agency or company owns or operates a particular travel facility or mode. It can be difficult, if not impossible, for a single agency to provide all of the features desired. Apps with limited appeal or utility will be less likely to be used in an environment where smartphone users are overwhelmed by apps.

As a result, the Mobility Authority's resources may be better spent developing an API to provide real-time pricing, travel speed, travel time, traffic camera and other useful data to third party apps that are already widely used by customers. The Mobility Authority may require branding to accompany the data or promote their role as an active provider of its traveler-related information as a way to maintain some degree of involvement and public recognition in the process.

### Option #2: Leverage Supporting Infrastructure

The Mobility Authority is already investing in enhancing roadside infrastructure to provide accurate real-time traffic and incident management data to the Traffic Management Center (TMC). By continuing to invest in innovative research programs, the Mobility Authority will be able to collect data from its roadway network and disseminate additional travel information to drivers on the network. As the industry continues to develop more advanced ITS and roadside technology, it is critical for the Mobility Authority to understand the capabilities and usefulness of any such piece of infrastructure and determine its applicability and lifespan as it relates to current and future capabilities of in-vehicle hardware and technology.

### Option #3: Support Research

The Mobility Authority should continue to partner with outside research organizations such as Texas A&M Transportation Institute (TTI), The University of Texas Center for Transportation Research (CTR), and others to enhance the amount and quality of data that is shared between academia and private and public sector initiatives.

### Option #4: Develop In-House App

If the Mobility Authority elects to develop a mobile app internally (by contracting with a third party developer), it will benefit from the lessons learned from its prior mobile app projects (see "Purpose and Background" section of this report) as well as the lessons gained from this industry scan (see "Recommendations" section of this report):

- Develop a long-term app strategy for the agency and determine whether one or more apps may ultimately be needed and what their purposes will be.
- Conduct customer research to confirm there is a need for the app and features that are proposed.
- Conduct user interface and user experience (UI/UX) research during all phases of development and refinement to create a user-friendly design and functionality.
- Define clear quantifiable benefits to the agency (or its customers) that the app will provide, and establish a plan to measure and report on those benefits.
- Prior to development of an app, identify how user data could improve roadway operations or provide other benefits to the agency's operations or support future app enhancement. Plan for collection and usage of that data during app development as it may require system integration.
- Develop clear goals for app development efforts.
- Use cost/benefit analysis and other factors to determine whether the app should be developed and managed by third party consultants/contractors or by in-house staff.

## APPENDIX 1: Case Study | FTE Toll Calculator App

Prepared by Dan Cryan, P.E. and Caroline LaFollette, P.E. (K Friese + Associates) based on call held on March 17, 2020 with Shannon Estep (FTE).

### Overview

The Florida's Turnpike Enterprise (FTE) is a part of the Florida Department of Transportation (FDOT). FTE operates nearly 500 miles of toll facilities statewide and manages operations for the state transponder, SunPass. FTE toll rates are adjusted periodically but are not dynamic for congestion pricing.

FTE developed the Toll Calculator mobile app in 2012. The goal is to provide customers with another option for accessing toll rates, in addition to the website and roadside toll rate signs. The app is available for both the iPhone and Android operating systems. It is built on a Google map overlay (as shown in Figure 3) for a user interface that is generally familiar. The Toll Calculator is also available as a mobile-friendly website.

### Inputs

As illustrated by Figure 1, the app allows users to calculate the toll rate for their trip based on:

- Payment option (transponder, cash, or toll by plate),
- Axle count, and
- Entry and exit points from toll facilities.

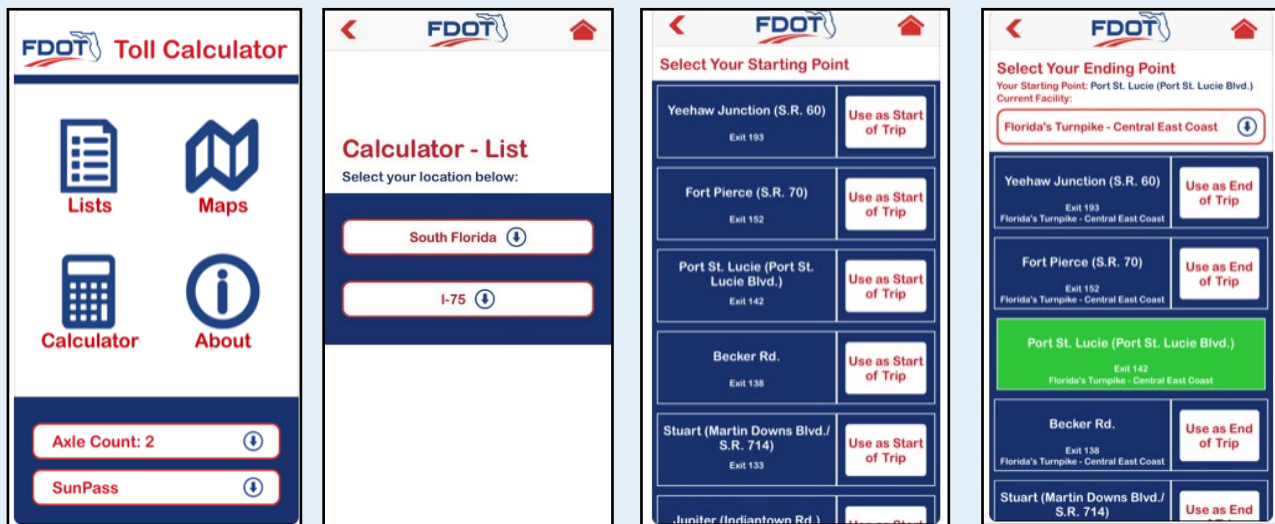


Figure 5. Toll Calculator app input screens

## Results

After entering inputs, the user can view the expected cost of the trip, as well as a map view of the trip, as shown in Figure 2.

## Rate Map

The app also includes a feature called the “Rate Map,” which can be used to view current rates at specific gantries, without entering trip information. This feature is shown in Figure 3.

## Staff Requirements

The Toll Calculator app was first developed by in-house General Engineering Consultant (GEC) staff in 2012. Development was (and continues to be) managed by a planner with a background in app development. The GEC has a subconsultant who handles backend integration efforts. Two internal FTE staff members handle the web application and front-end operations.

Having in-house GEC staff who are dedicated to the Toll Calculator app enables FTE to implement changes quickly when needed. For example, when a bridge had a toll rate increase coming up and kept pushing the date back, GEC staff were available to push the toll rate change out when it occurred. The GEC’s ability to bring on a specialized subconsultant allowed them to provide the necessary skill set for the project.

Customer affairs are handled by the SunPass Customer Service Center and the Public Information Hotline.

## Customer Feedback

FTE has received feedback from app users through the app store and through the 1-800 hotline for FTE customers. Users have had two main complaints about the app:

- Not all toll facilities were originally included in the app. Users were frustrated by seeing only a subset of Florida toll facilities (which were managed by FTE), rather than a comprehensive set of tolls they would need to factor into their trip. This issue has been rectified by incorporating other Florida agencies’ toll facilities and their corresponding toll rates.
- The inputs required by the app to calculate the cost of a Figure 1) can be confusing to users. They must select the region and facility, then enter the entry and exit points on the toll facility. Users would rather enter a starting point and final destination for their trips, and have the app populate the rest of the fields automatically.

FTE has not conducted any surveys to gain additional feedback from app users. There have not been any legal issues regarding misrepresentation rates. However, due to this possibility, FTE’s legal department did require a disclaimer to be posted under the “Using the Calculator” section.

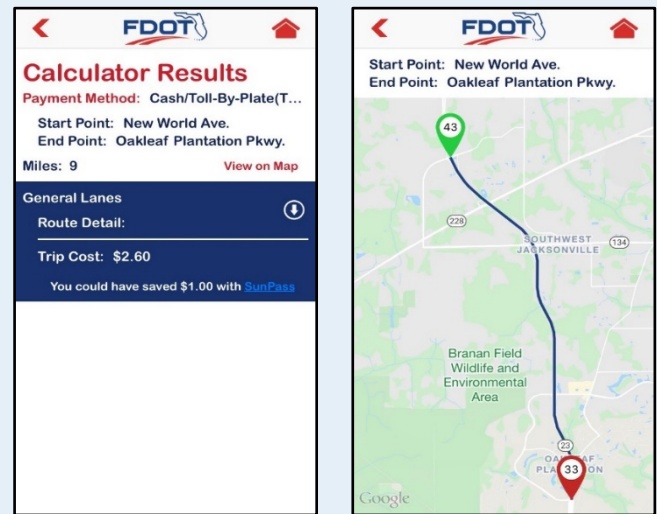


Figure 2. Toll Calculator results screens

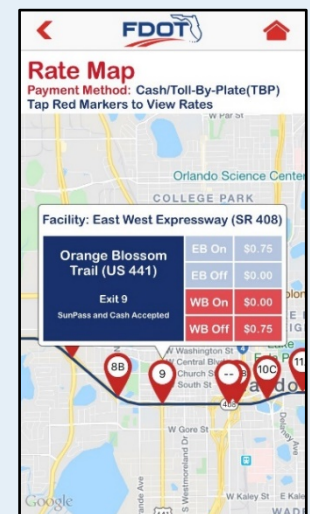


Figure 3. Rate Map feature in Toll Calculator app



## Expected Updates

A major enhancement to the FTE Toll Calculator is being considered to provide the start/stop point user input flexibility that the customers have requested in their comments. This functionality requires updating the routing and assignment logic within the mobile app. Providing this new functionality will make the mobile app more user friendly to those out of state visitors and customers who are not familiar with the network of Florida toll roads.

There is a separate SunPass app (icon shown in Figure 4).

that allows users to manage their accounts. FTE is in the process of branding the Toll Calculator app to resemble the look and feel of SunPass so that it doesn't feel like two distinct products. The Toll Calculator web page already reflects the updated branding, as shown in Figure 5.

## App Usage

FTE uses Google Analytics to track app usage. Currently, the usage statistics are as follows:

- Lifetime downloads: 18,000
- Active users: 1,100 (have hovered around that number for a while for active users)
- Past 30 days: 31 new users; lost 87 users
- Past year: Gained 421 new users; lost 1,000 users

The Google Analytics data and customer feedback indicate that the majority of app users are travelers rather than commuters. It is common for travelers to download the app for a two-week trip, then delete it from their phones. Sometimes there are spikes in downloads during heavy travels seasons. This user base of people who are unfamiliar with their routes and destinations is another reason for FTE to prioritize updating the app to allow the user to enter any start and stop locations, rather than specific toll entry and exit points.

As a public agency, FTE does not have specific usage goals or a required return on investment. However, FTE would like the overall rating to exceed 4.0 out of 5.0. If overall usage decreases in the future, they will reconsider other options to provide the best service to customers.

## Marketing

The FTE Toll Calculator app is listed on the FTE website and available for download in the app store and the Google Play store. For the time being, FTE has not made a significant effort to advertise the app. Once the planned updates are made and ratings increase, FTE will dedicate more efforts to advertising the app.

## Program Costs

Funding for development, operations, and marketing for the Toll Calculator app comes from the GEC's annual budget for app development, which varies year to year. Recurring costs related to annual updates to system toll rates are typically less than \$10,000. Initial development and major enhancements that are undertaken every few years could be much more expensive depending on the type of functionality being added.

## Partnerships

FTE has partnerships with other toll agencies across the state, including THEA in Tampa, MDX in Miami, CFX in Orlando, and additional agencies that operate tolled bridges. These existing partnerships have made it relatively seamless to integrate the toll rates for these agencies' facilities into the Toll Calculator app.



Figure 6. SunPass app icon

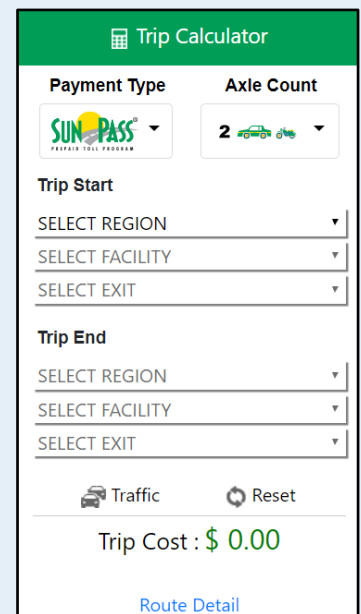


Figure 7. SunPass branding from Toll Calculator web page

FTE communicates with TollGuru and TollSmart, who were already showing FTE's toll rates in their apps, to verify the accuracy of their rate information. FTE is currently looking into using an API to assist with integration. Costs and volume limits vary by company.

### Lessons Learned

FTE offers the following lessons learned from developing the Toll Calculator app:

- Integrate all key toll facilities in the area (even from other agencies) from the start. Integrate so that other agencies' rates are accurately reflected. However, there is an additional cost incurred by the application's owner agency to maintaining another agency's toll rates to keep them up to date for the benefit of customer service.
- Build the app so that users can enter any start and stop point, to make it easier for the user (especially for those who are unfamiliar with the region).

It could also be advisable for toll agencies to consider integrating toll rates with a widely used private app such as Waze or Google Maps, which could entail lower costs than developing a separate app.

## APPENDIX 2: Case Study | NTTA Tollmate Mobile App and TollPerks Rewards Program

Prepared by Dan Cryan, P.E. and Caroline LaFollette, P.E. (K Friese + Associates) based on call held on February 5, 2020 with Randy Evans and Sarah McDaniel (NTTA) and members of the CTRMA Innovation Team.

### Tollmate Mobile App

#### Overview

The North Texas Tollway Authority (NTTA) operates over 980 toll miles in North Texas. The NTTA system covers four counties, with a higher concentration of lanes in Dallas and Collin Counties than in Denton and Tarrant Counties. TollTag is NTTA's transponder system that bills customers

automatically instead of sending a monthly bill at the pay-by-mail

rate. Eighty-two percent (82%) of all systemwide transactions occur through TollTag rather than pay-by-mail. ZipCash is the pay-by-mail option for NTTA customers. Most NTTA toll lane rates are adjusted every two years but are otherwise static. The only congestion-based pricing in the region is on TEXpress lanes.

The Tollmate mobile app allows TollTag customers to:

- View their account balance and make payments
- Edit their account information
- Add vehicles to their account
- Calculate the cost of tolls for trips, and view locations and rates of individual toll gantries
- Call for free roadside assistance on all NTTA toll roads
- Contact TollTag Customer Service

The Tollmate app has been a successful tool for transitioning ZipCash customers to the TollTag. ZipCash customers can generally be categorized into two types: infrequent customers, and frequent users who consistently use the toll roads but have various reasons for not owning a TollTag. Some frequent users, who previously avoided using a TollTag because of the automatic re-bill feature (the lowest increment for automatic re-bill is \$20, which can be a burden to some TollTag users), have migrated to using TollTags due to the ease of managing their TollTag accounts through the Tollmate app. Tollmate app users can easily use their smartphones to check their TollTag balance and calculate the cost of their trip as they walk to their cars, leading to a lower risk of an unexpected automatic re-bill that might overdraw their account. Users are also able to add smaller increments to their TollTag balance with Tollmate than with automatic re-bill.

Because the Tollmate app is available to TollTag and ZipCash customers, a few Tollmate links are located on the app home screen outside of the login page. The app is also available in Spanish.

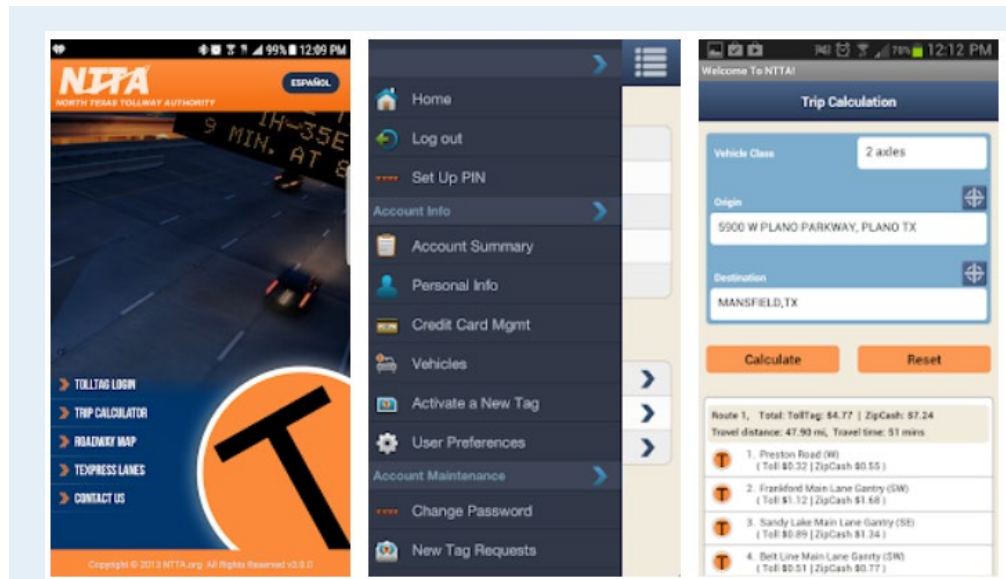


Figure 8. NTTA Tollmate App Screenshots – Set 1<sup>18</sup>

The Tollmate app does not provide travel times, but it does contain a link to Waze, with which a user can leave the Tollmate app and use Waze for route and travel time information. NTTA did pursue integration with Waze at one point, but Waze was in the middle of a merger at the time that precluded full integration. Dynamic message signs along the roadway provide travel time estimates, which are calculated from real-time transponder data.

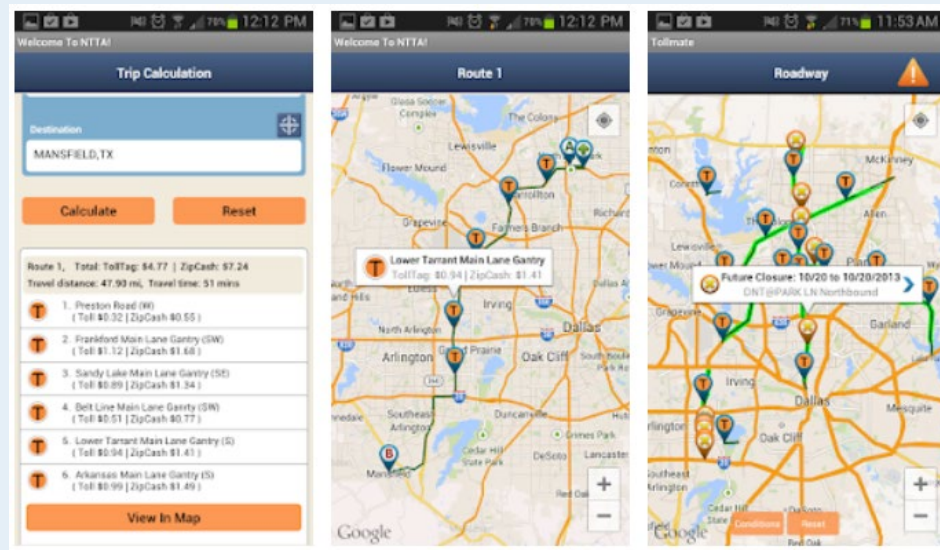


Figure 9. NTTA Tollmate App Screenshots – Set 2<sup>18</sup>

## Background

Development of the Tollmate mobile app originated with a focus group study conducted by the NTTA. Through the study, NTTA staff became aware of a need for easier account maintenance for customers who wanted a TollTag but were hesitant due to the automatic re-bill feature. The existing NTTA TollTag website is not mobile-friendly, and these customers were looking for an easier way to monitor and manage their TollTag accounts.

Prior to development of the Tollmate app, a privately developed mobile app existed that calculated tolls for trips around the region. This app had limitations because it was not integrated with the system or endorsed by NTTA, but did replicate NTTA branding. To prevent confusion and other issues, NTTA's legal team asked the app developers to discontinue the app. Later on, NTTA hired these same developers through a competitive procurement to develop the Tollmate mobile app.

## Expected Updates

Tollmate is currently managed by a third-party vendor, but after NTTA rolls out its new back office system in June or July 2020, it will be managed in-house. The IT staff person who is currently the point of contact for the app will manage ongoing maintenance, which will likely only involve 2-3 projects per year. NTTA does not anticipate needing additional staff to maintain the app in the near future.

NTTA has not pursued interoperability for Tollmate with other transponders besides TollTag, like TxTag or EZTag. This would require data sharing between agencies, and furthermore may not align with the general understanding between toll agencies in different parts of the state not to interfere with one another's operations.

## App Usage

NTTA tracks downloads per month for Android and iPhone. In 2018 there were approximately 14,000 downloads per month, and in 2019 this number increased to 18,000 downloads per month. There have been 1.1 million total downloads. NTTA staff can monitor usage with a dashboard showing customer information, the most popular pages, the number of logins, etc.

## Marketing

NTTA has a sophisticated marketing strategy that is in effect year-round. NTTA uses the following methods to promote the TollTag and the Tollmate app:

- Promotions on NTTA’s website
- Google search ads
- Billboards
- Radio
- Gas toppers in select neighborhoods
- Streaming ads
- Promotions through the TollPerks rewards program

While it’s difficult to quantify the effectiveness of these different strategies, NTTA would guess that the Google ads or other digital methods are most successful for promotion of the Tollmate app specifically. NTTA considers the income level of different geographic areas to determine the best messaging for billboards or for geotargeted digital ads. People in lower income areas are generally more concerned with account management and see more ads for Tollmate emphasizing ease of adding funds to account, while people in more affluent areas may see higher auto re-bill options recommended and typically already use the toll lanes.

### **Lessons Learned**

From the competitive procurement process, NTTA learned that it is valuable to figure out the vision for app capabilities at launch, as well as for years 2, 3, and 4. Outlining these expectations helps developers to provide more accurate proposals, and it also benefits the internal agency team to be on the same page about priorities from the outset rather than disagreeing about them later on.

For successful integration with back office operations, NTTA recommends consulting the back office provider prior to scope development to get feedback about the expected level of effort to integrate the app. This way, it is clear to the developer that wins the bid what it will cost on their side. Otherwise, the proposal is based on assumptions about integration efforts. It is also good to keep in mind that the integration effort for app upgrades can be significant.

### **TollPerks Rewards Program**

TollPerks is NTTA’s rewards program in which customers earn rewards for using the toll facilities. For every dollar spent on NTTA tolls, customers accrue 100 TollPerks points. A third-party vendor, Online Rewards, uses backend data from the TollTag transponders to calculate and distribute the rewards earned by each TollPerks participant.

Due to privacy concerns expressed by customers, the app does not track users’ personal locations to promote location-specific rewards (e.g., a gift card to a nearby Starbucks). NTTA does not share or sell data externally, nor is the data ever stored long-term. The Tollmate app uses push notifications to promote TollPerks rewards and encourage enrollment into the program.

### **Program Costs**

Funding for the TollPerks program comes from the budget for public affairs and marketing. Funding for the Tollmate app comes from the IT budget.

### **Customer Feedback**

To solicit customer feedback, NTTA conducts focus groups at least once per year, and distributes an extensive survey every two years. Feedback from new users is a priority for these outreach efforts, since the toll system is always expanding into new areas.

General user feedback on Tollmate and TollPerks has been positive. The TollPerks rewards program has about 430,000 members. There has been a desire for more rewards to be offered in Tarrant and Denton Counties. NTTA also received numerous emails asking if the rewards program was a scam, because people did not expect a toll agency to distribute prizes.

Findings from the surveys and focus groups include:

- Customers notice and appreciate the link to call roadside assistance. Many do not notice the #999 number advertised on the back of their TollTag, and clicking the link on their app is quicker than dialing the number anyway.
- Outreach has also revealed that more ZipCash customers use the app than expected. The customers tend to be more frugal, so before they get on the road they look at the app and use the trip calculator to figure out where they should exit the tolled lanes and ride the service roads to minimize the cost of their trip.
- NTTA used the survey to test customer receptivity to push notifications from the Tollmate app. Customers were open to receiving these, so NTTA rolled them out.

- <sup>1</sup> *Carma Carpooling Launches in Austin*. Mobility Authority Press Release, February 24, 2014. ([https://www.mobilityauthority.com/upload/files/press\\_releases/Carma\\_Austin\\_Press\\_Release\\_Feb\\_27\\_2014.pdf](https://www.mobilityauthority.com/upload/files/press_releases/Carma_Austin_Press_Release_Feb_27_2014.pdf))
- <sup>2</sup> *Recruiting Carpoolers: Dynamic Ridesharing with Incentives in Central Texas*. Texas A&M Transportation Institute. 95<sup>th</sup> Annual Meeting of the Transportation Research Board, Paper #16-0569. November 13, 2015. (<https://pdfs.semanticscholar.org/19d1/60098f88a38275402c8cfa6d75e0b0e103f6.pdf>)
- <sup>3</sup> *CTRMA The MoPAC App*. <https://www.monkee-boy.com/portfolio/ctrma-the-mopac-app>
- <sup>4</sup> *The 45SW Trail Experience*. <https://www.mobilityauthority.com/traveler-info/open-roads/45SW-Toll/45SW-Trail>
- <sup>5</sup> *CalTrans QuickMap*. <https://apps.apple.com/us/app/caltrans-quickmap/id1193696577>
- <sup>6</sup> *FL 511 Mobile App*. <https://fl511.com/app>
- <sup>7</sup> *GoCarma Mobile App*. <https://www.gocarma.com/dfw>
- <sup>8</sup> *Houston TranStar Mobile App*. [https://play.google.com/store/apps/details?id=org.houstontranstar.traffic&hl=en\\_US](https://play.google.com/store/apps/details?id=org.houstontranstar.traffic&hl=en_US)
- <sup>9</sup> *MiDrive Mobile App*. [https://www.michigan.gov/mdot/0,4616,7-151-9615\\_47588-460962--,00.html](https://www.michigan.gov/mdot/0,4616,7-151-9615_47588-460962--,00.html)
- <sup>10</sup> *NYSTA Mobile App*, Press Release. <https://www.governor.ny.gov/news/governor-cuomo-announces-launch-new-york-state-thruway-mobile-app>
- <sup>11</sup> *NTTA Tollmate App*. <https://www.ntta.org/custinfo/Pages/Tollmate.aspx>
- <sup>12</sup> *FTE Toll Calculator*. <http://floridasturnpike.com/TollCalc/>
- <sup>13</sup> *Try Parking It Mobile App*. <https://tryparkingit.com/>
- <sup>14</sup> *Advancing Traveler Information Technologies for Priced Managed Lane Networks*. TTI Study, 2018. (<https://static.tti.tamu.edu/tti.tamu.edu/documents/0-6907-R1.pdf>)
- <sup>15</sup> *A Roadmap for Engagement with Third Party Account*. IBTTA Tolling and Customer Service Workgroup. October, 2019. (<https://www.ibtta.org/committees-working-groups-and-councils>)
- <sup>16</sup> *A Primer to Position the Toll Industry in this Emerging Market*. IBTTA Council of Platinum Sponsors – Mobility as a Service Sub Committee. August, 2019. (<https://www.ibtta.org/council-platinum-sponsors>)
- <sup>17</sup> *Smartphone Applications to Influence Travel Choices: Practices and Policies*. U.S. Department of Transportation, Federal Highway Administration. April, 2016. (<https://ops.fhwa.dot.gov/publications/fhwahop16023/index.htm#toc>)
- <sup>18</sup> *NTTA TollMate App*. <https://play.google.com/store/apps/details?id=itoll.com.ntta>.