White Paper

IBTTA Emerging Technology Committee

IBTTA CASE Working Group

CASE Vehicle Impacts on Tolling Systems

Abstract

Connected, Automated, Shared and Electric (CASE) vehicle trends and technologies are already impacting the tolling system model and will likely increasingly force a move towards a more dynamic system and operation. Tolling agencies should consider the future in order to appropriately prepare. This white paper outlines what and how emerging trends could change tolling system technology in the future and recommended approach for agencies.

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Introduction

Connected, Automated, Shared, and Electric (CASE) vehicle technologies are becoming more common and are spurring mobility innovations that are starting to impact the tolling industry. The purpose of this white paper is to identify how the growing use and integration of CASE vehicles already is or could further impact tolling systems.

To aggregate the most current and relevant ideas and be diligent in background research, several previous white papers from IBTTA's Emerging Technology Committee and Platinum Sponsors were first reviewed:

- IBTTA Tolling and Customer Service Workgroup White Paper: A Roadmap for Engagement with Third-party Account Issuers,

- IBTTA CAV/CASE Workgroup White Paper: CAV and Toll Agencies: Impacts, Role of Toll Agencies, and Roadmap for Deployment,

- IBTTA Strategies for Innovation and Technology White Paper: A Roadmap to Establishing Innovation Practices, Engaging Technologies, and Preparing for The Future of Mobility,

- IBTTA Big Data Workgroup White Paper: How Toll Agencies Can Make Best Use of Big Data, and

- IBTTA Mobility as a Service Sub Committee: A Primer to position the Toll Industry in this Emerging Market.

In addition, to gather a comprehensive set of insights and perspectives, the preliminary findings for this white paper were discussed with targeted industry experts (see cover page for list) to gather contributions. This paper is thus a collection of ideas from industry contributors and is developed to be used within the tolling industry to plan for near-term and future changes to tolling systems.

Disruptive Market Dynamics That Influenced White Paper Development

As disruptive market dynamics such as Connected and Automated Vehicles (CAVs), Zero Emission Vehicles, Road User Charging (RUC), and Smart Mobility continue to take shape and increase in momentum, Infrastructure Owners and Operators (IOOs) are increasingly faced with associated risks and opportunities. Tolling IOOs or "toll agencies" should consider how their tolling system will interact with these transportation related trends and technologies. More specifically, agencies should consider the potential impacts to Road Side Equipment (RSE), Back Office Systems (BOS), supporting Intelligent Transportation Systems (ITS) as well as procurements, planning and design efforts associated with these core tolling system elements. Throughout the next ten or more years, IOOs should incorporate the necessary technologies into tolling systems to take advantage of the evolving benefits of CASE technologies and to avoid delay in readiness when the above trends further penetrate the market.

In addressing the emerging dynamics, five overarching goals for tolling agencies could be to:

- Understand timing, trends, advances, and policy dynamics in the transportation space to identify potential future roadblocks and solutions,

- Work proactively to prepare for increased use of CASE vehicles on tolling systems and understand their impacts,

- Understand how a tolling system will need to change for CASE vehicles,

- Give CASE vehicle owners and users value-added for using toll roads, and

- Consider methods to "future proof" equipment and system procurements.

Current Tolling System

The current tolling system has five main components (Figure 1) – asset management, road equipment, tolling back office, customers, and enforcement channels – many of which will likely be altered to accommodate the aforementioned trends. The asset management component includes aspects such as the construction and maintenance of toll roads. Roadside toll collection equipment must be installed and maintained and is used for capturing toll data. The tolling back office includes creating a "billable" trip and identifying who should pay. Then, to collect funds from a customer, a contact center must be established as both a fund-collection mechanism and a relationship management service. The fifth component is channels for enforcement which includes pursuing delinquent funds and managing recuperation efforts by collections agencies and/or court processes.

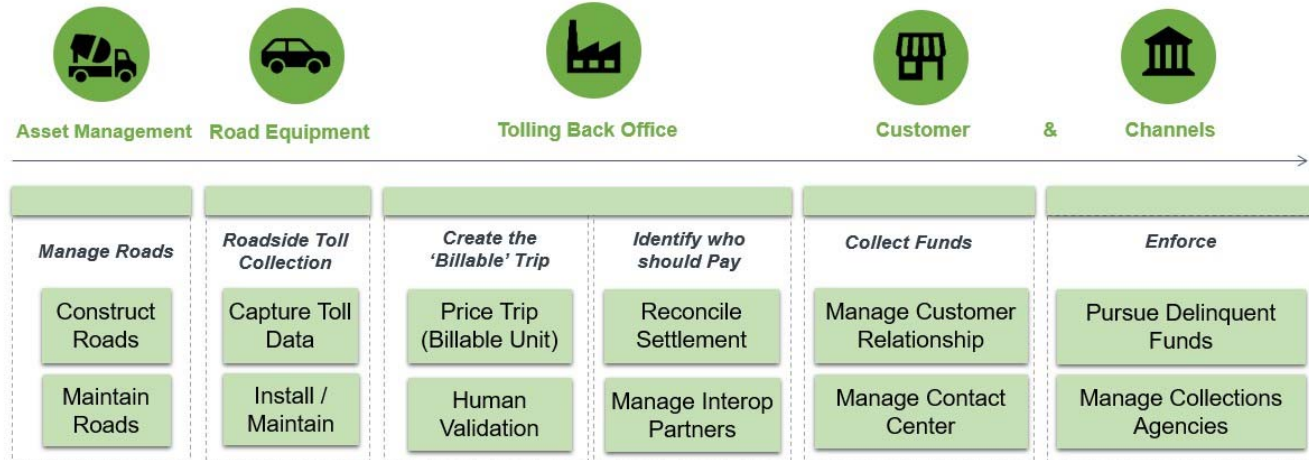| Asset Management	Road Equipment	Tolling Back Office		Customer	&	Channels
Manage Roads	**Roadside Toll Collection**	**Create the 'Billable' Trip**	**Identify who should Pay**	**Collect Funds**		**Enforce**
Construct Roads	Capture Toll Data	Price Trip (Billable Unit)	Reconcile Settlement	Manage Customer Relationship		Pursue Delinquent Funds
Maintain Roads	Install / Maintain	Human Validation	Manage Interop Partners	Manage Contact Center		Manage Collections Agencies

Figure 1: Tolling System Sample Model (example from Transurban)

Emerging Trends That Could Change Tolling System Technology

The following are emerging trends that will likely change the tolling system from its current, more traditional process to an increasingly dynamic system. In a dynamic tolling system, integration, interoperability and co-dependence with and/or reliance on third parties will create both risk and opportunity. The identified emerging trends are organized by order of impact timing, which is when the emerging trend will *begin* to affect the tolling system – between zero and ten plus years. A summary table can be found in Appendix A.

Mobile Payments – Smartphone or In-Vehicle Payments (0-3 Year Impact Timing)

Description

The tolling system should be able to interface and reconcile, in other words be compatible, with different forms of mobile payments. Potential forms of mobile payments include smartphone applications or in-vehicle payments via On-Board Units (OBUs), or Original Equipment Manufacturer (OEM) built-in systems. Especially as Connected Vehicles (CVs) become more common on the roads, mobile toll payments will likely be used more often. Interoperability will be imperative as more third-party payment providers enter the market and Mobility as a Service (MaaS) concepts become more common. Under MaaS scenarios, such as third-party shared-mobility and navigation apps, vehicle occupants may take greater responsibility for paying tolls and other fees that were traditionally paid by the vehicle owner. Such third-party services will likely operate by using GPS or perhaps other location-aware services (e.g. cellular-based vehicle triangulation) to determine when and where a vehicle is on a toll road and then charge the customer based on toll trips tracked through GPS. The toll payment to the toll agency would likely need to be guaranteed in order to be acceptable. Customers may expect third-parties to present equal or improved customer service, compared to toll agencies. In addition, increasingly common over-the-air vehicle or connected device software updates could accelerate mobile or in-vehicle payment ability. Further, the MaaS provider could be other public entities if, for instance, transit agencies pursue becoming regional mobility account providers.

Impact on Tolling System

Mobile payments will affect four components (road equipment, tolling back office, customer, and channels) of the tolling system. Road equipment has the potential to change over time if gantries are removed from toll roads (in the next 10+ years) and replaced with smartphone or in-vehicle tolling. Tolling back offices would have to consider interoperability because they could see a steady decline in tag-based transactions and an increase in third-party collections leveraging alternative technologies. Over time, customer interaction and delinquency enforcement could change for toll agencies, especially if third-party transactions come with payment guarantees.

Recommended Approach and Impact of Doing Nothing

There will be ever-increasing pressure to adopt third party integration to avoid a partial loss of customers and revenue. Toll agencies should make their BOS interoperable with mobile

payments and consider the ongoing role they will likely play in managing customer interfaces.

Further Details

Interoperability with mobile payments or toll payment service providers will be one of the more immediate items to address as the tolling industry moves from a product to more of a service model that provides added customer value for using a toll road. However, currently, there is a divide in the industry between the desires to manage customer interactions versus a willingness to incorporate third parties. More traditional agencies may be reluctant to make significant changes and move to a more open tolling and customer service model due to their desire to ensure quality customer service and prevent issues that could be negatively publicized in legislature and media. In addition, these agencies typically have millions of customers already and may in some cases see less business rationale to become interoperable with third party payment platforms.

Other agencies are demonstrating willingness to embrace third parties as long as payment is guaranteed. Many third-party services create a platform that is easy to use and convenient for the customer, which could bring more customers to the toll road. Additionally, numerous third-party platforms that could provide mobile tolling could have much larger customer bases than any individual tolling facility. As toll agencies become interoperable, some agencies may develop a central processing hub for tolling as a service that could be outsourced to other tolling agencies. In other words, agencies in the future could potentially "plug into" a central processing hub for interoperability rather than developing it themselves.

Numerous third-party platforms that could provide mobile tolling have much larger customer bases than any individual tolling facility. Ease and accessibility of toll payments should be a major customer draw.

Shifting Vehicle Ownership Trends (0-3 Year Impact Timing)

Description

Ride-hailing and ride-sharing has propelled shifting vehicle ownership trends where individuals may not need or desire to own a personal vehicle in the future. There is an emerging trend towards shared-mobility as ride-hailing and ride-sharing becomes more common and easy to access. Changing vehicle ownership could create a need to modify how toll accounts are managed, because while the vehicle registrant owns the toll charge, payment will be handed off to the user, whether the user is an individual, corporate, or shared-mobility user. There could also be a need, likely by third-party ride-sharing companies to split the transaction between several users.

In light of COVID-19, many people do not feel comfortable utilizing ride-hailing or ride-sharing services and prefer to drive in personal vehicles. Even though COVID-19 has changed current preferences, it likely will not change the prevailing trend in the longer term. COVID-19 is likely only creating a temporary setback in shifting vehicle ownership.

Impact on Tolling System

Changing vehicle ownership models will affect tolling back offices, customer, and

enforcement aspects of a tolling system. Customer interactions will need to be managed differently as people may move away from owning a personal vehicle. Toll agencies may need to shift to managing accounts by user rather than by vehicle registrant and/or develop more efficient methods to deal with fleet/commercial accounts.

Additionally, the enforcement aspect of the tolling system could change in two possible ways. First, if accounts are managed by toll agencies, they may have to track individual customers and what vehicles they drive or ride in. Second, if accounts are managed by third parties, the third party would handle the enforcement aspect especially under a guaranteed toll business arrangement.

Recommended Approach and Impact of Doing Nothing

Toll agencies should prepare for a broader and more nuanced adoption of fleet accounts. If the tolling system is not prepared for broader adoption of fleet accounts with possible individual traveler tracking, there could be diminished customer experience and billing issues. Any issues that arise could cause a loss of customers if they choose to open or transfer their account to another agency which does support these types of accounts.

Road User Charging (RUC) (3-10 Year Impact Timing)

Description

Fuel taxes no longer provide enough revenue to fund modern, safe and efficient roadway infrastructure. Therefore, a pay-per-mile solution to replace the gas tax, such as RUC, looks to be a viable option for broad roadway infrastructure revenue collection. The shift to electric vehicles and market penetration of CVs could accelerate the introduction of RUC as the number of vehicles that rely on gasoline or diesel decreases, while connectivity makes it increasingly feasible to implement RUC.

Impact on Tolling System

Similar to mobile payments, RUC could affect four components of a tolling system. Tolling back offices could change because RUC may promote third party payment interoperability in tolling systems. Finally, the customer and delinquency enforcement aspects could change as a result of third-party account and collections management. There could also be a need for tighter integration with the vehicle registration process depending on how RUC is managed. The Department of Motor Vehicles may either own the customer accounts or collect the money owed and forward it to the toll agency. In the longer term, the potential for RUC to aid in the removal of gantries (in 10+ years) could change the road equipment aspect of tolling.

Additionally, RUC could improve enforcement because third parties and the government will collect and ensure payment, thereby lowering the risk and agency cost associated with it. The customer interface could transition directly to RUC third-party vendors or there could be a hybrid model where toll agencies provide fleet and direct customer support to the customers who use a third-party platform.

Recommended Approach and Impact of Doing Nothing

Since RUC could promote third party account management, toll agencies should prepare

their BOS for the potential transition to third-party processors and potentially the complete elimination of payment processing if revenue collection is eventually centralized under one or more private or governmental agencies. If BOS cannot adopt, there is the potential to lose customers and have a diminished customer experience.

Integrate Tolling and Traffic Back Office (3-10 Year Impact Timing)

Description

By the time the aforementioned emerging trends come into play, the tolling system and traffic management system will likely experience enhanced integration. For example, more CV-based data could be incorporated into the traffic management system which may facilitate integration between tolling and traffic back offices.

Further in the future, CV-data could yield changing or real-time traffic patterns to be incorporated into more responsive toll pricing updates and a diminished need for Dynamic Message Signs (DMS) by leveraging virtualized toll pricing signs instead. Pricing updates could be sent directly to a CV or mobile application.

Impact on Tolling System

Back offices will need to integrate in order to move towards a more dynamic tolling system overall. Converging the tolling and traffic back offices could affect not only back offices but the road equipment itself if there is a reduced need for ITS equipment, such as DMS signs.

If CVs have a trip pre-planned and communicate it to a tolling system, real-time origin to destination data could be incorporated to provide more accurate pricing updates directly to the vehicle or customer. The ultimate destination point of a vehicle is a data point that the industry currently lacks, and when this is available through CV or mobile application technology, it can add to routing and optimization of the tolling system. In result, the large amounts of data ("Big Data") received from CVs would need to be properly managed and processed.

Recommended Approach and Impact of Doing Nothing

Back offices should be integrated for real-time tolling capability in order to better prepare for CVs. This will yield the opportunity for a more proactive toll pricing scheme. Further, there is the potential to offer CV customers a tolling discount in exchange for sharing their CV data. This shared data could in turn be leveraged to proactively maintain the roadway. Agencies should consider the potential need to create solutions to allow for Big Data processing.

Embedded Vehicle to Infrastructure (V2I) Communication – Dedicated Short Range Communication (DSRC) / CV2X (3-10 Year Impact Timing)

Description

CASE vehicles may either have an embedded or aftermarket communication ability to process tolls, rather than needing a toll transponder. Toll systems would need the ability to work with embedded vehicle communication modules in order to avoid the loss of customers and revenue. Embedded V2I communication could eventually aid in the elimination of gantries, instead relying on DSRC/Cellular V2X (CV2X)-type RSE. Another possibility is that CVs may

communicate directly to third-party payment processors via wireless technology and may not rely on toll agency owned systems.

Impact on Tolling System

Embedded V2I communication could affect the asset management, road equipment, and tolling back office aspects of the system. Asset management and road equipment could change due to the need for DSRC/CV2X communication ability and because of possible gantry elimination (in the next 10+ years). Back offices will be affected from the need for interoperability with V2I payment channels.

Recommended Approach and Impact of Doing Nothing

Toll agencies should consider making the roadside and BOS interoperable with forms of V2I communication. If the tolling system is interoperable, a partial loss of customers and revenue to third parties could be avoided.

Enforcement (10+ Year Impact Timing)

Description

If CVs or mobile based tolling is deployed throughout systems and across the country, enforcement may also become increasingly managed by third parties. Third party accounts, including a RUC system, could likely guarantee payments and therefore internal agency enforcement likely minimized over time.

Gantries could eventually be removed, if agencies became comfortable that toll passage detection and payment is sufficiently guaranteed by third parties. To support gantry elimination, there would need to be near 100% market penetration of CVs or mobile based tolling technology that could identify a vehicle's location with lane-level accuracy. If gantries are removed, License Plate Recognition (LPR) may be moved to the side of the road or eventually eliminated.

Impact on Tolling System

For similar reasons as mentioned previously in the mobile payment and RUC sections, enforcement would affect the road equipment, tolling back office, customer, and enforcement aspects of the tolling system. If gantries are removed (in the next 10+ years) and replaced by smartphone or in-vehicle and RUC-based tolling, road equipment could change.

Tolling back offices would have to become interoperable with third party payments, which could change customer interaction and enforcement as a result because customers may be managed through third parties instead.

CVs may be equipped with technology and sensors capable of confirming vehicle classification and vehicle occupancy. The potential for CVs to self-identify their vehicle classification as well as self-declare for High Occupancy Vehicle (HOV) purposes could change how toll pricing is determined and how HOV-specific enforcement is managed, respectively, by potentially applying added charges or discounts automatically.

Recommended Approach and Impact of Doing Nothing

For longer term planning, it is anticipated that toll agencies may eventually reconsider the need of in-house enforcement using gantries and LPR, as well as in-house versus outsourced collection, in order to avoid partial loss of revenue and a diminished customer experience.

Dedicated CASE Vehicle Lanes (10+ Year Impact Timing)

Description

Tolled lanes, such as managed lanes, could be purpose-built for CASE vehicles and have features for added customer value. Features such as connectivity, special signs, lane markings for computer vision, and charging ability could incentivize drivers or riders of CASE vehicles to choose such dedicated lanes over general purpose lanes. While there would be new infrastructure and maintenance costs, these added features would likely draw more customers to the toll road.

Impact on Tolling System

Dedicated CASE vehicle lanes could affect the asset management and road equipment aspects of the toll road because lane geometry would need to change to accommodate the necessary road features mentioned above for CASE vehicles.

Recommended Approach and Impact of Doing Nothing

As toll agencies prepare their capital investment strategies of the future, they should build in, as much as possible, the flexibility for possible alternative RSE and lane geometry requirements for future developments.

Conclusion, Recommendations, and Next Steps

Toll agencies should establish a path to prepare for the increased use of CASE vehicles and specifically, to understand how the tolling system will need to adapt to emerging trends. The tolling system's current model will likely change from its traditional, linear format to more of a dynamic process that's interoperable and co-dependent with third parties. There is an opportunity for toll agencies to proactively shape the industry's response to these risks and opportunities, optimizing outcomes and guarding against undesirable shifts.

While there are emerging trends that will develop within a range of timelines (from zero to more than ten years), toll agencies should begin preparing now and consider the impacts to their future toll systems, including: the potential impacts to RSE, BOS, supporting ITS as well as procurements, planning and design efforts associated with these core tolling system elements.

Next Generation Requirements

The key recommendations from this white paper, toll agencies should focus on the following in response to CASE vehicles:

- Prepare for interoperability of Roadside and BOS with third parties for mobile payments, RUC, embedded V2I communication, Traffic Management Systems, and enforcement mechanisms;

- Assess broader adoption of fleet accounts with possible individual traveler tracking, which could necessitate deviation from registered vehicle owner account models;

- Integrate tolling back offices with Traffic Management Systems for real-time tolling capability to better prepare for CAVs;

- Assess the long-term need for gantries to facilitate in-house enforcement with LPR versus fully outsourced toll collection and alternate enforcement mechanisms;

- Consider re-design of tolling roadside equipment around possible, new lane geometry; and

- More generally, adopt a long-term approach to planning and design of new roads and capacity enhancement projects to consider infrastructure that optimally supports the increasing number of CASE vehicles.

Next Steps

Finally, while this white paper was meant to provide a broad view of CASE technology impacts, further industry efforts and collaboration will undoubtedly be necessary. Suggestions for continuing work within IBTTA in preparing for CASE emerging technologies and trends in the tolling system include:

- A centralized aggregation of reference system / business requirements from interested agencies, as relevant to the topics presented herein,

- Development of uniform standards for integrating and facilitating the

aforementioned emerging trends in tolling systems,

- A white paper that further details interoperability in tolling systems, in coordination with related, on-going efforts, for example with the Tolling and Customer Management working group's third-party interface standards initiative,

- Assessment of advances from outside standards groups and associated trade organizations that could impact IBTTA member's preparation and ability to leverage CASE vehicles and associated technologies, and

- Scenario planning and impact assessment for alternative evolutionary paths. This will help to identify policy, management, technical and other issues. This will provide a framework to understand the range of possible outcomes.

	Asset Management *Manage Roads*	Road Equipment *Roadside Toll Collection*	Tolling Back Office *Create the "Billable" Trip, Identify who should pay*	Customer *Collect Funds*	Channels *Enforce*	Recommended Approach	Impact of doing nothing	Impact Timing
Mobile Payments (Smartphone or in-vehicle telematics)	The tolling system needs to be able to interface and reconcile with different forms of mobile payments. Interoperability could be imperative in the future, such as integration with third-party rideshare and navigation apps. Could eventually lead to the elimination of gantries (in 10+ years).					BOS should be interoperable	Partial loss of customers and revenue	0 – 3 years
		✓	✓	✓	✓			
Shifting Vehicle Ownership Trends	Shared-mobility trends have propelled shifting vehicle ownership trends where individuals may not need or desire to own a personal vehicle in the future. Changing vehicle ownership could create a need to modify how toll accounts are managed (possibly by individual instead of vehicle). There could also be empty vehicle trips which raises the question of who (if anyone) should be charged for the trip.					Broader adoption of fleet accounts with possible individual traveler tracking	Diminished customer experience and possible billing issues	0 - 3 years
			✓	✓	✓			
Road User Charging (RUC)	The shift to Electric Vehicles and market penetration of CVs could accelerate the introduction of RUC. RUC may eventually replace the need for gantries (in 10+years) and promote 3rd party account management. RUC could improve enforcement and lower the risk and agency cost associated because 3rd parties and the government will collect and ensure payment.					BOS should be interoperable	Partial loss of customers and diminished customer experience	3 – 10 years
		✓	✓	✓	✓			
Integrate Tolling and Traffic Back Office	More CV-based data could be incorporated into the traffic management system which could facilitate integration between the tolling and traffic back offices. As a result, dynamic scenarios could be incorporated into more responsive pricing updates and diminished need for DMS (e.g. virtualized toll pricing signs). The system could incorporate real-time origin to destination data from CAVs. The large amounts of data ("Big Data") received from CVs may need to be properly managed and processed.					Integrate BOS for real-time tolling capability to better prepare for CVs	Missed opportunity for proactive vs. reactive tolling system	3 – 10 years
	✓		✓					
Embedded V2I Communication - DSRC/CV2X	CASE vehicles may have embedded (or aftermarket) communication ability to process tolls, rather than having a toll transponder. Toll systems could need to have the ability to work with embedded vehicle communication in the future. Could eventually lead to the elimination of gantries.					Roadside system and BOS should be interoperable	Partial loss of customers and revenue	3 – 10 years
	✓	✓	✓					
Enforcement	Enforcement may become increasingly managed by 3rd parties if CVs and/or mobile based tolling is deployed throughout systems. Internal agency enforcement could likely be minimized over time if 3rd party accounts, including RUC, guarantee payments. As CV and/or mobile payment based tolling results in possible removal of toll gantries, License Plate Recognition (LPR) may be moved to the side of the road and/or eliminated.					Reconsider in-house enforcement's need for gantries, LPR, and in-house vs. outsourced collection	Partial loss of revenue and diminished customer experience	10+ years
		✓	✓	✓	✓			
Dedicated CASE Vehicle Lanes	Tolling lanes (e.g. managed lanes) could be purpose built for CASE vehicles and have features for added customer value such as connectivity, special signs, lane markings for computer vision, and charging ability. These added features would likely draw more customers to the toll road.					Re-design tolling roadside equipment around new lane geometry	Missed opportunity to provide additional customer value	10+ years
	✓	✓						