White Paper #3 — The Future of Tolling

Video Tolling: 21st Century Technology for Superior Toll Collection

Compiled by: A-to-Be® | Mobility-Beyond

Executive Summary

Video tolling is an electronic tolling technique that uses video cameras and software to identify and charge a vehicle owner using video images. Video tolling is very common in All-Electronic Tolling (AET) systems, where it is used to identify drivers without a valid transponder. Systems which rely primarily on video tolling are still rare.

However, **the time is now right for video tolling to play a leading role in Electronic Toll Collection (ETC).** Thanks to advances in camera technology and computer vision software, **the cameras** which nearly all AET systems have for audit purposes **can now read license plates with accuracy approaching that of transponder-based tolling.** Additionally, video tolling offers a highly convenient service for **tolling customers**, who can **configure their account and use it instantly,** without waiting for a transponder to arrive in the mail. And by prompting occasional toll road users to create accounts, **road operators can reduce revenue leakage and save money** by reducing bills sent by mail. By making a few new choices, road operators can make video tolling a successful, accurate and efficient part of their ETC system.

What is video tolling?

Video tolling is a tolling technique that uses software and images captured by video cameras to identify, and then charge, a vehicle. Video tolling **relies on cameras positioned on gantries and/or poles alongside each toll lane.** Cameras are typically triggered by in-pavement treadles, lasers, or other sensors as cars approach the tolling point. Video tolling can also utilize dual lens cameras or multiple cameras to capture both color and infrared images. Infrared images use a flash that is invisible to the human eye, which does not disturb the driver, and can provide a better image during adverse conditions such as darkness or sun glares. Using some or all of these different tools, the **Video Tolling System captures an image of each passing license plate as it passes each video tolling point** (1).

> “Video tolling is a tolling technique that uses software and images captured by video cameras to identify, and then charge, a vehicle.”

Still, “raw” images need to be processed before they can be used to create tolling transactions. Rather than manually reviewing each image, **operators use image analysis and recognition algorithms to digitally “read” the license plate and communicate that information to the Back Office System (BOS).** Operators can apply multiple algorithms, machine learning, and more to each image or set of images of a vehicle, in order to “read” the image with a particular degree of certainty. Poor weather conditions (such as rain, fog or snow), dirty camera lenses, vehicles pulling trailers, intense sunlight and other issues can cause the read to be statistically less certain. For these cases, operators typically require a manual review to confirm the license plate number (1).

Once the video tolling system identifies the license plate number to the road operator’s desired level of certainty, the BOS then compares the license plate information to the road operator’s database of accounts and/or to nearby DMVs in order to identify the account holder or car owner and issue the toll. **Since this system can easily bill customers without a transponder, it is sometimes called “pay by mail” or “pay by plate”.**

> “[Video Tolling] is present in virtually all Open Road Tolling (ORT) environments, in order to find a way to bill drivers without a transponder and tolling account.”

Since this process relies on such sophisticated technology, video tolling is a relatively new ETC technique, despite the occasional need for manual image reviews. Video tolling is most often used alongside transponder-based toll collection as an enforcement tool. **In fact, it is present in virtually all Open Road Tolling (ORT) environments, in order to find a way to bill drivers without a transponder and tolling account.**

Additionally, while it is not tolling per se, **video tolling technology is often used for automatic vehicle classification (AVC), which allows toll booth operators or payment machines to complete transactions faster.** Video tolling technology can also be used in **HOV lanes**, to ensure that users have the correct number of occupants in the car. Today’s video tolling technology can even count passengers in the rear seats.

How is video tolling used today?

Video tolling is most often used in combination with other tolling technologies, but there are some geographies where it stands alone – **about 4.9 percent of the ETC market uses video tolling alone, with this percentage expected to rise to 33.9% by 2030** (2)**.** Its most frequent use is as an **enforcement, audit or interoperability tool** in the U.S. and Europe, **where ETC systems primarily rely on transponders to register passages through a tolling plaza and to communicate the vehicle’s class and account information to the toll zone host system.** Video systems are used to perform periodic audits of the transponder-based system, to ensure they are performing accurately, capturing all passages and confirming the vehicle classification, and they are also used to charge “violators” who use the toll lanes without a valid transponder. The toll zone host system will compare its reading of the vehicle’s license plate with DMVs and will issue a bill by mail to the vehicle owner.

> “About 4.9 percent of the ETC market uses video tolling alone, with this percentage expected to rise to 33.9% by 2030.”

> Video tolling can be used to identify and charge drivers who belong to another, non-interoperable tolling system.

Video tolling can also be used to facilitate interoperability between different tolling systems. Although many tolling systems use transponders which are compatible with nearby systems, **video tolling can be used to identify and charge drivers who belong to another, non-interoperable tolling system by comparing the license plate read to the other tolling system's database.** Video-only tolling is also present on some roads in Canada, the United States, Austria and Poland, although it is not the dominant system in these areas.

As a stand-alone technology, **video tolling has two major applications in Europe, namely, the London Congestion Charge Zone and the Stockholm Congestion Charge Zone.** Both systems use video tolling, or Automatic Number Plate Recognition (ANPR) as it is also known in Europe, **to charge drivers entering certain areas of the urban centers.** In London, vehicles are charged a flat rate between 7 AM and 10 PM; in Stockholm, the charge is dynamic, with the price varying based on the time of day and location within the charging zone. **Both systems use a third-party to lookup vehicles and to charge them accordingly.** Sweden's system also includes a partner to identify the owners of vehicles with foreign license plates.

Finally, **the largest example of pure video tolling comes from China.** In China, video tolling systems rely on payment apps such as Alipay and WeChat, which **allow users to link their license plate number to their account** (3)**.** When their license plate is read at a toll plaza, the toll amount is automatically debited from the owner's WeChat or Alipay account. The vehicle owner's smartphone is not required to be awake or even present in the car while driving.

Why should operators consider video tolling?

Video tolling has many advantages, and as technology improves, these advantages only get stronger. **Video tolling takes advantage of equipment that virtually every ETC system already has – cameras.** The same cameras which provide an ETC system with the ability to audit transactions or confirm HOV lanes eligibility can be used to conduct video tolling**.** In this way, **video tolling requires no extra hardware investment and installation by the road operator.** Software to read and process these images can be installed without interrupting toll road service, and there is no additional hardware to maintain. In this sense, **video tolling puts little to no burden on the road operator.**

1 Video tolling requires no extra hardware investment and installation by the road operator.

2 Low-revenue leakage method of tolling, thanks to more accurate image-reading algorithms and improving DMV look-up providers.

Video tolling is also a **low-revenue leakage method of tolling**, thanks to more accurate image-reading algorithms and improving DMV look-up providers. In its early days, video tolling was less accurate than transponder-based tolling, with about 90% accuracy**,** as opposed to more than 99% for transponders. However, as technology to "read" video images have improved, **video tolling's accuracy has improved as well, with accuracy rates of up to 98%** for new systems in good weather conditions (1). In addition to improved image-reading algorithms, video tolling benefits from the improved ability of DMV look-up providers to identify drivers. **Through agreements and data sharing with authorities** in the operator's jurisdiction as well as those in nearby jurisdictions, **operators can identify and bill drivers without a tolling account.** As the U.S. continues to work toward regional and even national interoperability, sharing vehicle owner data between DMVs and adapting legislation will remain a critical step for interoperability, and one that will ultimately enable video tolling to become even more accurate and efficient.

3 Easy for road users - vehicle owners can simply receive their toll bills by mail and pay these bills online.

In addition to posing little burden on road operators, **video tolling is exceptionally easy for road users.** Rather than having to order a transponder in the mail or pick it up in a store, **vehicle owners can simply receive their toll bills by mail and pay these bills online.** Other video tolling systems also allow patrons to create accounts which can be charged monthly, like a transponder-based account. One video tolling system implemented by A-to-Be in Poland offers just such a system: **patrons create their account via a custom app, associate one or more cars to the account and supply license plate and classification details, and select a payment method.** Each time their license plate is read, their account is charged.

What cautions should road operators have when using video tolling?

As much as video tolling has advanced, **no technology is perfect.** While image recognition algorithms and cameras have improved substantially in the last 15 years, they still have some deficiencies. In areas with very diverse and varied license plate designs, like the United States, **image recognition systems may struggle to read certain plates.** This will lead to **higher amounts of manual reviews**, taking time and costing road operators. This is part of why, currently, **video tolling's cost to collect is higher than transponder-based tolling, and why it is often used in combination with RFID or DSRC systems.**

Beyond image reviews, **video tolling systems also require camera maintenance.** This maintenance is necessary for DVAS systems regardless of whether or not they are the primary method of building toll transactions, however, in a video tolling system, **the need for maintenance takes on an even greater importance.** Without well-functioning cameras, road operators may lose the ability to collect revenue for a time. **Video tolling systems often rely on multiple cameras per lane** for this reason, **which reduces the chances of revenue loss but also increases the need to maintain a high level of camera performance.**

Considerations for implementing video tolling

Despite its imperfections, **video tolling remains a popular and growing form of electronic toll collection.** As toll road systems in the U.S. continue to transition to electronic toll collection, many of them will also incorporate a video tolling component, **either for directly charging patrons or for audit and enforcement purposes.**

For road operators looking to optimize convenience for their patrons, video tolling can be an important part of their roadside toll collection system. Roads in areas with large tourist populations or with non-interoperable systems nearby can significantly reduce revenue leakage by implementing video tolling and bill by mail. For these systems, a few simple steps can help create a better, more efficient video tolling system:

- **Add intelligence:** Using multiple algorithms to read video images performs better than using only one algorithm. With multiple algorithms, the system has multiple chances to make a high-confidence-level read. If a manual image review is required, the system can suggest multiple possibilities to the reviewer and help them come to a conclusion faster.

- **Optimize data:** In a country with a myriad of different license plate colors and designs like the United States, it is especially important to provide a video tolling system with good data to learn to "read" these different plate configurations. Video tolling operators should "train" their image recognition engines on a diverse variety of license plates.

- **Prioritize customer experience:** For video tolling patrons, the customer experience continues after they've left the toll road. The bill by mail experience should be as simple as possible in order to reduce friction on the customer side, requiring as few clicks and as little information as business rules allow. One A-to-Be customer, located near a popular vacation area, automatically creates temporary accounts for a bill by mail customers. By entering the account number and bill number found on their bill, plus a method of payment, customers can pay in just two clicks. They can also set up autopay, so that future video tolling bills don't require any clicks at all. Another A-to-Be customer, described below, chose to implement an easy-to-use app where drivers can create a license plate-based account and configure a payment method in just a few clicks.

Video tolling in action

> A-to-Be developed one of the first systems of its kind in Europe in collaboration with Gdansk Transport Company (GTC) in Poland.

Systems that rely primarily on video tolling are rare, but **A-to-Be developed one of the first systems of its kind in Europe in collaboration with Gdansk Transport Company (GTC) in Poland.** In 2017, **A-to-Be implemented a video tolling pilot on A1, a 152-kilometer highway connecting Gdansk to Lodz, in the north of Poland,** home of major ports and popular beaches during the summer months. The existing manual tolling, which used only cards and cash, frequently resulted in queues in excess of five kilometers around summer holidays. **GTC turned to video tolling from A-to-Be in order to increase throughput and reduce queues while providing their customers with a simple account management experience.** GTC used the pilot to gather experience with a video tolling system and A-to-Be's solution was used for one year.

> A simple, user-friendly mobile app allowing A1 drivers to create an account, select their vehicle classification, and associate a license plate number to their account.

A-to-Be very quickly developed the video tolling system described below, which integrated with a newly developed local system providing all client-related matters including a **simple, user-friendly mobile app allowing A1 drivers to create an account, select their vehicle classification, and associate a license plate number to their account.** Because of the importance of the port for logistics in central Europe, **A-to-Be's system was prepared for cars from virtually every European Union nation,** but only cars registered in Poland were used during the pilot.

Whenever a vehicle used an entry lane, it was detected by the loop and a front picture taken. The Optical Character Recognition (OCR) engine read the license plate number and the Lane Controller validated if it was a valid client (e.g. if the video tolling client account was registered on the network). **If the license plate was associated with a valid client, the barrier opened.** The Toll Management System recorded the license plate obtained to be used at the exit lane.

If the car was not associated with a valid client — or if the license plate read's level of confidence was below GTC's defined threshold — **the driver was requested to retrieve a ticket at the entry ticket machine.** A similar process recognized the client's license plate or accepted the entry ticket as the driver exited the A1.

"The video tolling solution put our customers' experience first and foremost," said Torbjörn Nohrstedt, CEO of GTC. "Using the latest camera technology and computer vision technology, we were able to meet our accuracy goals while helping move drivers along the A1 and creating a possibility to avoid queues. **After the positive experience of A-to-Be's pilot project we have expanded video tolling to all lanes, and we look forward to helping more customers get to their destination more quickly and safely."**

Conclusion

Video tolling has long been a supporting team member in ETC systems, but **thanks to advances in camera technology and computer vision, it can be much more.** As AET continues to expand its footprint, more and more toll roads will have all the equipment and systems necessary to also adopt video tolling. With accuracy rates approaching transponder-based tolling and unparalleled customer service advantages, **video tolling can and should be a core tolling method for ETC systems,** whether it stands alone to provide "pay by plate" functionality, supports auditing and enforcement functions, or enables new technologies like mobile tolling.

Contact information
Henrique Cordeiro, Vice President Sales US
Henrique.Cordeiro@a-to-be.com
A-to-Be, Powered by Brisa
a-to-be.com

Interested in continuing the story?

Stay tuned for the next White Paper of this series, where **A-to-Be** will explore a different, modern, trendy form of tolling, based on the device none of us can leave without. Can you guess it?

SCAN ME

More industry content can be found at A-to-Be's open library.

Works Cited

1. A-to-Be, Innovation and Sales Teams. *Video Tolling Informational Interview.*
2. Ptolemus Group. *Electronic Toll Collection Global Study.* 2020.
3. Toll Links Plates, Mobile Payment. *GlobalTimes.CN.* [Online] https://www.globaltimes.cn/content/1095116.shtml .