BY FRED PHILIPSON[1]

PAVING THE WAY TO VEHICLE MILES TRAVELED

With his cruise control engaged and a conference call droning through his car stereo, the executive's mind drifts to the day's planned events: more calls, a shareholder meeting, and lunch with a prospective client. He glances at the time- 7:50 a.m. He will be in his parking spot in ten minutes, just in time for his meeting. He barely noticed the metallic structure of cameras above him that dangled like ever-present watchmen. He does, however, notice the mile-long line of cars *parked* on the highway several lanes over, each "driver" waiting to pay a toll. "Why don't those people get a tag?" he thinks to himself as he sips the last of his first Starbucks of the day, ratcheting up the cruise control as he manipulates the multi-colored, high definition screen on his mobile.

AS THE TOLL INDUSTRY CONTINUES ITS NATURAL EVOLUTION FROM GATED COLLECTION, TO ORT, TO AET, AND BEYOND TO NATIONAL INTEROPERABILITY AND POSSIBLY VMT, THE PROCESSES AND TECHNOLOGIES USED MUST KEEP PACE.

Today, depending on which road the executive was using, his electronic payment might have transpired in any number of ways; he might have a prepaid account- or not. His car might have a transponder, or an

on-board unit, or he might be a toll violator. Alternately, he may have chosen to be billed later, leaving it to the entity billing him to determine his identity and billing address via his license plate. Under each scenario, something essential must happen. His vehicle needs to be identified uniquely apart from those passing through the toll gantry by his side, before him, and after him. This identification initiates a sequence of events that ultimately lead to toll payment or nonpayment.

Because the viability of user-pay transportation funding rests on the successful collection of tolls, the toll industry must invoke an electronic toll collection 'ecosystem' that takes full advantage of every opportunity to collect. As the toll industry continues its natural evolution from gated collection, to open-road tolling (ORT), to all-electronic tolling (AET), and beyond to national interoperability and possibly vehicle miles travelled (VMT), the processes and technologies used must keep pace. To succeed, the industry must actively shape the technology, information sharing, and legislation supporting this ecosystem.

To better understand the transportation environment and its needed changes, this article surveys the state of electronic toll collection, noting trends in the political, technical, and market forces shaping our collective future. Throughout the world, technology improves at an ever-increasing pace, influencing technical standards and being influenced by those standards. It is a world in which technology vendors influence politics, which in turn influences legislation and, ultimately, buying decisions. As the need for tolling explodes, this world is up for grabs.

MEETING ELECTRONIC TOLL COLLECTION ECOSYSTEM DEFICITS IN EMERGING MARKETS

India has made astounding plans for wide-ranging infrastructure upgrades and expects to spend $1.5 trillion over the next ten years. With public-private partnerships (P3s) as a focal point of the government's funding strategy, an increasing percentage of the tab for surface transportation will be funded by investors. While the previous decade in the Indian subcontinent has been called "the IT decade," the next ten years can perhaps be coined "the infrastructure decade." Therefore, the Indian government will do well to aid investors in resolving the revenue collection challenges that are inherent

with electronic-toll collection. These challenges are many.

With an estimated per-capita GDP of $3,700, in 2011 (roughly 8% of that in the United States) approximately 25% of India's 1.2 billion residents live in poverty. With enough highway kilo-meters to rank it as one of the major networks of the world, India's largely tolled National Highways account for less than 2% of these kilometers, but claims *40% of the country's traffic.* The facility owner's ability to reduce the resulting congestion is limited. Tolling at highway speeds would greatly improve throughput, but at the

time of this publication it does not exist-because the electronic toll collection ecosystem of vehicle identification, owner identification, and payment assurance is incomplete.

The National Highways Authority of India's (NHAI) Model Concession Agreement is silent on the matter of open-road tolling, providing limited assistance in solving the ecosystem issue. Given the 8% growth rate in vehicles on the roads over the past five years, gated electronic-toll collection lanes are not likely to sustain the flow of traffic at collection points. Rather, ETC lanes would cause long lines of

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queued vehicles waiting at gates to pay their toll electronically.

Shifting from a robust European transponder solution to a more affordable International Standards Organization (ISO) Radio Frequency Identification (RFID) standard has reduced customer cost for transponders from $25.00 to about $3.50. This was a significant step toward increasing ETC use. However, meeting ORT objectives will likely require a more systemic act, such as marrying the planned rollout of National Identification Cards with a unique identification scheme with tolling applicability. Even if this were to be accomplished, further impediments must be addressed, such as the lack of a reliable motor vehicle database and the enforcement of toll violations.

NATIONAL IDENTIFICATION PROGRAMS AND AET

Governments that are attempting to increase tax revenue to offset budgetary shortfalls are increasingly looking to a type of national identification card known as electronic vehicle registration (EVR). Under an EVR system, vehicle registrants receive a sticker for their windshield that contains a chip similar to what is used in electronic tolling devices. Inspection points are placed throughout the road system — and similar to electronic tolling — images of the vehicle's license plate are captured when the vehicle is out of compliance with registration policies. The benefits of such a system increase as compliance decreases, such as during economic downturns.

With low cost stickers providing unique identification that can be monitored remotely for every vehicle in a country, billions in previously lost vehicle registration revenue can be recouped. Furthermore, criminals can be more readily apprehended, motor vehicle databases can become more reliable, and, because the chips can be read at highway speeds, every vehicle in the country has a de facto toll tag. This relieves toll authorities from the burden of supplying tags to their

users, and greatly increases the viability of ubiquitous road tolling systems such as with VMT.

Government officials in Thailand, the Philippines, Indonesia, and Malaysia are reportedly in discussions with prospective vendors regarding national EVR programs. Bermuda, Mexico, and Brazil have undergone recent implementations using the aforementioned open-standard RFID, which appears to be a prevailing trend. Initiating national programs of this magnitude requires a large amount of political will due to the enormity of the effort, perceived privacy implications, costs, and subsequent enforcement of compliance. At the time of this writing, the Chinese government — owner of more than 70% of the world's total toll roads — is rolling out the largest national identification program in history. Considering China's proven ability to commoditize and mass-produce technologies of all varieties, it is perhaps the Chinese solution that will greatly influence the world's solution.

AN EMERGING TREND IN TRANSPONDER PROCUREMENT

When procuring transponders or on-board units (OBUs), a variety of factors drive buying decisions including price, interoperability, "open" or "closed" proprietary technology, accuracy, and reliability. Other considerations are security and functions such as read/write and form factor. All things being equal, between two transponders exhibiting similar performance and serving the same purpose, the likely procurement decision is based on price- increasingly so in emerging economies such as Mexico and Brazil.

However, much discussion about how transponder technology standards may or may not be appropriate for tolling use is taking place in a very developed economy- the United States. Traditionally, transponder technology has been composed of a mix of technical standards and protocols, which define the rules and manner by which digital messages are exchanged between systems. The most recent procurements in the U.S. have been for transponders manufactured to an open specification. These procurement decisions made by public tolling authorities have been based largely on price differential, much of which is driven by costs that are no longer there — no case, no battery, no read/write high production volume — and competition.

There continues to be some question and even controversy regarding what defines an open standard in the tolling environment. In a very general sense, a software, hardware, or firmware product can be defined as "open" if there are no rights or opportunity for royalties to be earned by an intellectual property holder from the manufacture or sale of the product. Also, an open standard is freely available in the public domain for general use. In a very practical sense, "open" simply means there are multiple producers of the product, thus leading to a more competitive price.

An open standard by this definition does exist, and transponders produced to this specification are used by governments and companies the world over to track the movement of goods through the supply chain. Because of the sheer scale required to produce enough transponders, manufacturing costs are significantly reduced and tolling is an unintended benefactor.

In contrast to operators in emerging markets, American tolling entities have existing electronic tolling infrastructure which introduces added challenges for those hoping to lower costs by changing transponder technologies or protocols. Any decision to procure new technology must be defensible in the face of previous decisions. Economically and practically, the total cost of making a changeover is the decision point; and most tolling authorities have a low tolerance for public-facing political risk, which is always factored into the cost. To reduce costs, a new

technology must be extensively tested for backward compatibility; meaning the installed base of transponders must coexist with the new ones. This compatibility can be achieved via a multi-protocol RFID reader and/or multi-protocol transponder or lane controller firmware.

As a toll environment matures beyond gated ETC into open road tolling, loftier needs such as interoperability come into focus and become pressing objectives — or opportunities. The benefits that result from increased interoperability shine through when a customer of one tolling entity can pass through the free-flowing lanes of another entity without billing concerns. Interoperability cost can also be significantly reduced if the vehicle owner has a prepaid account that operates within all regions in which transactions occur.

In America, interoperability is currently regionalized with the northeast, west, and south central, interoperating within their respective regions, but not with each other. The current trend toward open tolling standards supported by the International Bridge, Tunnel and Turnpike Association and the Alliance for Toll Interoperability (ATI) may benefit efforts to patch the country's toll networks together, and provide impetus to develop the missing connections. The opportunity to reinvent the way interoperable toll transactions are captured and subsequently parsed to their various agencies, may also serve to put increased focus on providing the industry with a common extensible interface for capturing transactions from a variety of automatic vehicle identification (AVI) technologies.

AVI VIA VIDEO

The performance of automatic license plate recognition (ALPR) systems is arguably lower than RFID/DSRC (Designated Short Range Communication) technology. However, technological improvements are quickly increasing the effectiveness of ALPR-based solutions. For example, those manufacturing plates and advances in optical character recognition software have increased performance and reliability, thanks in part to research and development performed in the security and military sectors. Many ALPR installations are now capable of producing color images at high confidence levels in near real time, thus reducing image review costs and increasing capabilities for roadside toll-violation enforcement.

IF THE INDUSTRY EMBRACES A COMPRE-HENSIVE, STANDARDIZED SOLUTION, COMPETITION AND INNOVATION AMONG SERVICE PROVIDERS WILL DRIVE DOWN COSTS AND TOLLING CUSTOMERS WILL BE ABLE TO CHOOSE ANY NUMBER OF WAYS TO SELF-IDENTIFY FROM A RANGE OF CREATIVE OPTIONS.

Unfortunately, until motor vehicle databases become as reliable as camera images, ALPR will probably remain a backup, rather than primary means of detecting vehicles. This is due to the impaired link in the electronic toll collection ecosystem. To compensate for the risk of non-collection, tolling entities planning AET implementations first attempt to increase their transponder penetration rate to the highest extent possible, often granting price concessions for both the tag and the toll to influence consumer adoption. All AET conversions experience a subset of travelers that refuse to use a

transponder. Reasons offered for this exclusion are frequently price, privacy, lack of bank account or credit card and the infrequency of expected toll road use.

BRIDGING THE GAPS

Many toll authorities attempt to coax these remaining customers into opening a pre-paid, plate-based account, which they can use in the same way as a transponder-based account. These attempts are normally met with limited success. Additional efforts are being made worldwide to make cash replenishment of toll accounts easy for those without traditional credit or debit cards. Some entities are also offering a range of non-traditional account-replenishment methods such as PayPal, prepaid credit/debit cards, and smart cards. Reloading account balances using payment mechanisms that are not contingent on credit rating or citizenship enables consumers to retain privacy and increases the number of customers. Although these methods work well in regions with solid toll ecosystems — like Singapore, where smart cards are inserted into government-mandated OBUs — they are most needed in developing regions. When no other form of automatic vehicle identification method is present,

video detection is the primary default means of vehicle identification. Adding to the electronic toll collection ecosystem is the necessity for laws supporting post-transaction toll collection. Laws enabling the enforcement of toll violations vary widely, yet none are so stringent that they entirely reduce the risk of non-collection entirely. Operators therefore price in this risk in the form of fees that are paid in addition to the toll. Unfortunately, because the fees are normally based on "reasonable costs," they incorporate the funds lost when toll violators do not pay their toll. Paying customers are therefore paying not only for the costs of getting drivers to pay, but also for the costs associated with violators who never pay.

FORECASTING THE FUTURE

National AET is likely the future of tolling. However, if gas taxes do not increase, VMT may be implemented due to the necessity of covering the significant shortage of transportation funding- thus making every road a toll road. If all vehicles are to be charged for their road use, an all-encompassing, "holistic" electronic toll collection solution must be developed.

Which vehicle identification method or technology — if any — will become ubiquitous? Who will pay for it? Why might one technology be chosen over another? Several scenarios may play out; but in the end, the particular solution is really of minimal

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significance. If the industry embraces a comprehensive, standardized solution, competition and innovation among service providers will drive down costs and tolling customers will be able to choose any number of ways to self-identify from a range of creative options.

Conceivably, tolls of the future will be billed along with other subscription service charges. The answer might be in transportation-based software applications built into the driver's vehicle, integrated afterward or in one's pocket, allowing firms that provide these services to disconnect them due to nonpayment of tolls, resulting in a new form of "denial of service" as a toll violation collection strategy. In addition to laws supporting the tolling entity's

ability to collect tolls (perhaps at the federal level), uniformity will enable customers to freely travel across the country while paying for road use in a transparent manner.

CONCLUSION

Budget shortfalls for transportation funding are endemic the world over. User-pay scenarios are on the increase as a supplement to other infrastructure financing methods. Enough tolls must be collected to provide expected risk-adjusted returns or investors will seek alternatives. In less developed nations, cash remains highly revered; but collecting it, counting it, and transporting it is an expensive proposition having undesirable effects on traffic throughput and safety, as is the case with cash-based lanes in the United

States. Moreover, industry cost studies prove that at many tolling points, the cost to collect the cash toll is greater than the toll amount itself. Logically, as electronic tolling increases, the average number of cash transactions will further decrease- yet the fixed costs remain. As a result, manual toll collection is becoming less cost-effective, which puts increased pressure on tolling entities to move to AET.

Governments have sovereign interests at stake in their transportation infrastructure. They must therefore work *with* public and private toll-facility owners to create and support solutions that incorporate technology standards, privacy legislation, reliable vehicle owner database, and reasonable toll-violation enforcement laws, including intra-state and Interstate reciprocity. By supporting the development of a new, holistic tolling ecosystem, governments position themselves to gain notable benefits, such as increased toll collections, higher rates of vehicle registration, and streamlined road usability for every traveler.

— FRED PHILIPSON is a Senior Management Consultant at Atkins. He may be reached at Alfred.Philipson@atkinsglobal.com.

1   The views in this article are the author's alone and are not necessarily shared by Atkins.