by Harold Worrall

RFID'S DAY

TOLLING'S ULTIMATE CONUNDRUM

The route to achieving true state-to-state tolling interoperability has left many transportation experts scratching their heads. Cooperation between states and agencies is crucial, while harmonization of the technology to be adopted is a must

Technology in the transport sector encompasses an enormous array of electronic applications focused on improving the safety and convenience of the transportation system. Vehicle-to-vehicle and vehicle-to-roadside communications are the foundation for the Vehicle Infrastructure Initiative (VII) in the USA. This substantial undertaking is a public-private partnership of the USDOT and the automotive industry. It is a top-down, logical definition of the architecture, electronics and applications that will make up transport electronics in the future. This program is nationally significant and is extremely important to the future of ITS in North America. And yet unless regulation is promulgated to affect this worthwhile outcome, an application must be identified that will create a market large enough to move the initiative forward.

Since the early 1990s, electronic infrastructure has blossomed – and no more so than in the field of electronic toll collection (ETC), growing as it has done from a few lanes of hardware and software to a global phenomenon. Almost every toll operation in the world either has ETC or is considering implementing it. In fact, many are now considering the conversion to all-electronic toll collection (AETC), in which there are no toll collectors and no toll plazas – simply gantries. To do so with RFID technology will require a ubiquitous tag environment – that is, a tag in (or on) every vehicle.

ETC

ETC has introduced such a level of convenience in toll collection that it has affected transportation policy debates concerning the most effective means for funding transportation overall. There are approximately 109 separate ETC operations throughout the world, of varying sizes.[1] ETC toll lanes have recorded processing volumes of more than 1,200 vehicles per hour (vph),[2] dedicated ETC toll lanes accurately process 1,800vph and multi-lane free-flow collection rates are limited only by the capacity of the highway. Obviously, ETC offers significant benefits in time savings for the customer and ultimately reduced operating costs for the operator. It is an accurate and proven application and has been in operation since 1987 in Europe and since 1990 in the USA.[3] Today, such systems collect more than 50% of all toll revenue, with some systems nearing 80%. Furthermore, many toll operators are considering converting to AETC or multi-lane free-flow. By any measure, ETC has been an enormous market success and could be the market that creates the momentum necessary to implement VII.

An issue of great concern in the toll industry is that of interoperability – the ability to use one tag and one account to travel on roadways operated by numerous public and private sector organizations. It is a question that goes beyond 'standard' technology. The contractual and procedural arrangements between toll operators have proved to be a very difficult task, but they cannot be addressed until a 'standard' technology is in place. There have been two distinct approaches to the setting of standards, the first of which was the International Standards Organization (ISO) effort. A standard was adopted in the 5.8GHz range and has been used by many to develop ETC. However, the USA developed ETC in the 902-928MHz range and did so using primarily proprietary products and protocols adapted from other applications.

Today, the USA uses essentially three RFID technologies, those manufactured by two RFID providers and those manufactured to the Title 21 standard established by California – an approach that has been a constraint to achieiving interoperability. The one open-architecture standard, Title 21, has been adopted mostly in the western USA.

SUPPLY-CHAIN RFID APPLICATIONS

Since the late-1980s, a quite different market for RFID has been developing in the private sector, predominantly for the purpose of tracking shipments and controlling inventory. Applications for RFID in this sector also include product authentication, access control and asset tracking/ traceability. The process of manufacturing, shipping and then placing the product in inventory until it is needed for a larger product assembly, or until it has been sold, has changed. That 'push' environment has morphed into a 'pull' process that some have termed 'just-in-time inventory'. This new way of doing business has moved the inventories of old to the highway: a massive amount of end product and components are constantly being tracked through the supply chain using small, inexpensive and simple RFID tags. For this massive and highly complex supply-chain transport system to work, interoperability is essential. For this reason, the technology is built on an open architecture and the readers and tags are manufactured by a number of companies. Furthermore, this market was driven by large retailers specifying the use of this technology to its suppliers based on an economic agenda. The technology is a short-range, low data transfer rate, minimal or no security chipset. The tag market is extremely competitive. Interestingly, this RFID market has been developed through the ISO standards-making process. The original standard for the supply chain market was known as the ISO 18000 6B standard, or the '6B'. This foundation standard was modified and features were added to the chipset to make it more robust with greater range, greater data rate, and security provisions. This new standard is ISO 18000 6C.

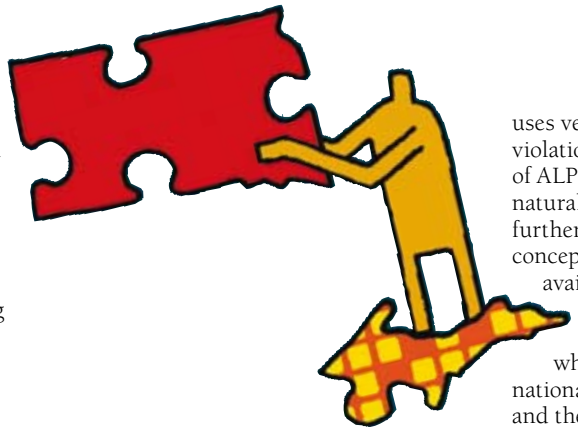
Transcore's RFID eZGO tag is a read-write OBU that supports adding and editing data to the OBU at high speeds in real-time

"AN ISSUE OF GREAT CONCERN IN THE TOLL INDUSTRY IS THAT OF INTEROPERABILITY – THE ABILITY TO USE ONE TAG AND ONE ACCOUNT"

By 2012, traditional toll plazas will be eliminated and gantries equipped to read SunPass signals will be in place on all MDX expressways. There will also be the alternative to join a video tolling program

A MARKET IN THE MAKING

Another market for RFID is the emerging Electronic Vehicle Registration (EVR), which is being driven by factors such as vehicle registration enforcement and safety. The growing concerns for unregistered or uninsured vehicles, emissions compliance, personal and property security, as well as Homeland Security, have convinced several nations that RFID technology should be applied. Vehicular theft, kidnapping and other crimes have convinced many politicians of its need, while a significant amount of revenue is lost each year due to the lack of an enforcement tool that is inexpensive and effective. EVR fills that need. It has been implemented fully in Bermuda and is in various stages of deployment in China, South Africa, the Philippines, Colombia,



Uruguay, Brazil, and Argentina. The advantages of implementing EVR go beyond ensuring vehicle registration revenue collection. It has the potential to positively affect property crime and personal security. Vehicle theft and crimes where a vehicle is involved will be significantly curtailed.

EVR can also affect air quality by tracking the status of vehicle inspections and reducing the need for large freight vehicles to stop for safety inspections. If all vehicles were equipped with EVR, data could be collected on traffic patterns and potentially used to guide vehicles to less congested routes in real-time.

China is considering using EVR for such a program.[4] Real-time data collected by EVR systems will allow it to more efficiently strategize highway construction through the study of traffic patterns and the data used to trigger barriers deployed in ramp metering schemes. China (and many other countries) is planning to use EVR to manage traffic streams and traffic velocity in city centers.

The financial benefits of EVR can be considerable for registration revenue collection. In the case of the Philippines, the government expects collections related to vehicle registrations and omissions compliance to grow approximately US$309 million in 2008.[5] This represents a 20 to 25% increase in expected collections and is a direct result of implementing the EVR project. Estimates are that 5 to 10% of motorists fail to legally register their vehicles in the USA, resulting in lost annual state revenues of between US$720 million and US$1.44 billion. Outside the USA, some governments estimate 30 to 40% of vehicles are not properly registered.[6] Bermuda estimated additional revenue at more than US$2 million per year with the recent implementation of an island-wide EVR system.[7]

The techniques for implementing EVR vary, but most require the RFID device to be installed in such a way that it cannot be removed without negating the registration process. The RFID technology that has been adopted for EVR in Mexico and South Africa is the ISO 18000 6C. One of the earliest EVR systems, Bermuda, was developed on an enhanced 6B technology.

AN INTERIM SOLUTION

ETC technology is well established, but to attain maximum benefit, the lack of an interoperable solution and the inconvenience of account establishment are limiting factors. In contrast, EVR is a regulatory process that covers all vehicles and is interoperable within the jurisdiction of registration. The toll industry presently uses vehicle registration information for violation enforcement and the establishment of ALPR accounts, and it would seem a natural transition to connect the processes further. If EVR and ETC applications are conceptually converging, is the technology available that can service both applications? Further, if the technological issues can be resolved, what about issues such as privacy, a national toll transaction clearing process, and the need to maintain the voluntary aspects of establishing an ETC account?

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Transcore's increasingly popular RFID sticker tag

TECHNOLOGY

The ISO 6C technology may be sufficient to effect the marriage of ETC and EVR, although it has not been developed for either application. It is an open-architecture standard chipset, developed primarily for the retail market, and is currently manufactured by a number of companies. There have been very few applications of this standard to ETC, but it has been adopted by several countries as the standard for EVR. A comparison of the chipset specifications of the ISO 6C, the 915MHz ETC and 5.9GHz established for VII is informative.

A comparison of RFID technologies is relative to the requirements for performance in each application area. The 5.9 specification has been developed to serve a wide platform of vehicle-to-vehicle and vehicle-to-roadside applications. The 915MHz technology has been adapted to ETC, although not originally developed for it, and the ISO 6C standard was originally developed for the retail logistics market.

The application requirements for EVR and ETC are unique. EVR requirements are much less complex than those for ETC. The tag required should be unobtrusive, very low cost, while the requirement for data transfer rate is low. The primary data involved is the vehicle identification number (VIN) and small amounts of data about vehicle registration. Also, the application requires read-only RFID technology.

In contrast, ETC applications transmit more data, sometimes require the ability to move the transponder from vehicle to vehicle, and occasionally require read/write capability for ticket systems. The most common transponder types in use for ETC in the USA are active and provide highly accurate results. The requirements for read-range accuracy and security are similar. The issue of security is a particularly significant one considering the data transmitted and the potential for its misuse. This is an area in which the ISO 6C standard is an improvement over earlier chipset standards.

Several threats exist for any RFID technology. First is tag skimming – a process whereby an unauthorized reader acquires tag data. This has been addressed by the ISO 6C standard, which provides for reader authentication and even supports password protection. Authentication protects the passwords of tags from being read by 'rogue' readers. Tag cloning – which is the ability to duplicate tags – is another concern and threat to security that has been incorporated into the ISO 6C standard chipset. Finally, the ISO 6C standard also provides for a writable memory, which can be used for additional authentication algorithms.[8]

Table 1 (*p12*) provides a glimpse of the relative capabilities of the various technologies, while the following are brief definitions of the criteria used:
Read/write capabilities: Refers to the ability of the reader and the tag to have a two-way communication sufficiently robust to meet application requirements (yes/no);
Data rate: The data transfer capacity between the tag and reader (numeric);
Tag and antenna size: The device size reduces the likelihood that technology will meet the requirements of the application;
Cost: As a result of the large numbers of tags and readers deployed in most applications, cost is a factor (tag cost);
Communication range: The maximum distance at which the tag and reader communication can take place with a high degree of reliability (numeric in meters);
Security provisions: The use of encryption, tamper bits, and other security methods to ensure security of tag data and RFID communications (yes/no);
Interference: The ability of readers and tags to communicate in a dense RFID environment without interfering with neighboring communications (yes/no);

"FIXING AN RFID DEVICE TO A VEHICLE FOR THE PURPOSE OF REGISTRATION DOES NOT CHANGE THE AMOUNT OF INFORMATION THAT IS AVAILABLE, SIMPLY THE MANNER IN WHICH IT IS OBTAINED"

Dedicated licensed bandwidth: The reservation of specific bandwidths for applications and restricting the use of these bandwidths to specific purposes (yes/no);
Portability: The ability to use portable readers to accurately carry out transponder communications (yes/no);
Accuracy: The ability of the reader and tag to communicate accurately (numeric);
Commercialization: The degree to which a particular standard has been commercialized (high, moderate, low);
Implementation: Proprietary nature of the technology;
Intended application: The applications for which the technology was designed.

The data presented in Table 1 has been collected from available specification data, technical reports and industry experts.[9-13] It is intended to reflect a general level of capabilities rather than a rigorous analysis of technology and application requirements fit.

Kapsch's 5.9GHz trials on Denver's E-470 have proved incredibly successful in terms of capture rates

In some regards, the ISO 6C standard would perhaps be superior to existing 915MHz technology. Dense reader environments are of particular concern in ETC applications at toll plazas. Due to the manner in which ISO 6C equipment is designed, ETC communications within a toll lane can be segregated from communications with other readers and neighboring lanes. In contrast, 'tuning' or synchronization of lane equipment in 915MHz ETC environments has been common practice to share available bandwidth. Existing ETC equipment is also commonly based on a fixed communications link, while ISO 6C is adaptive.

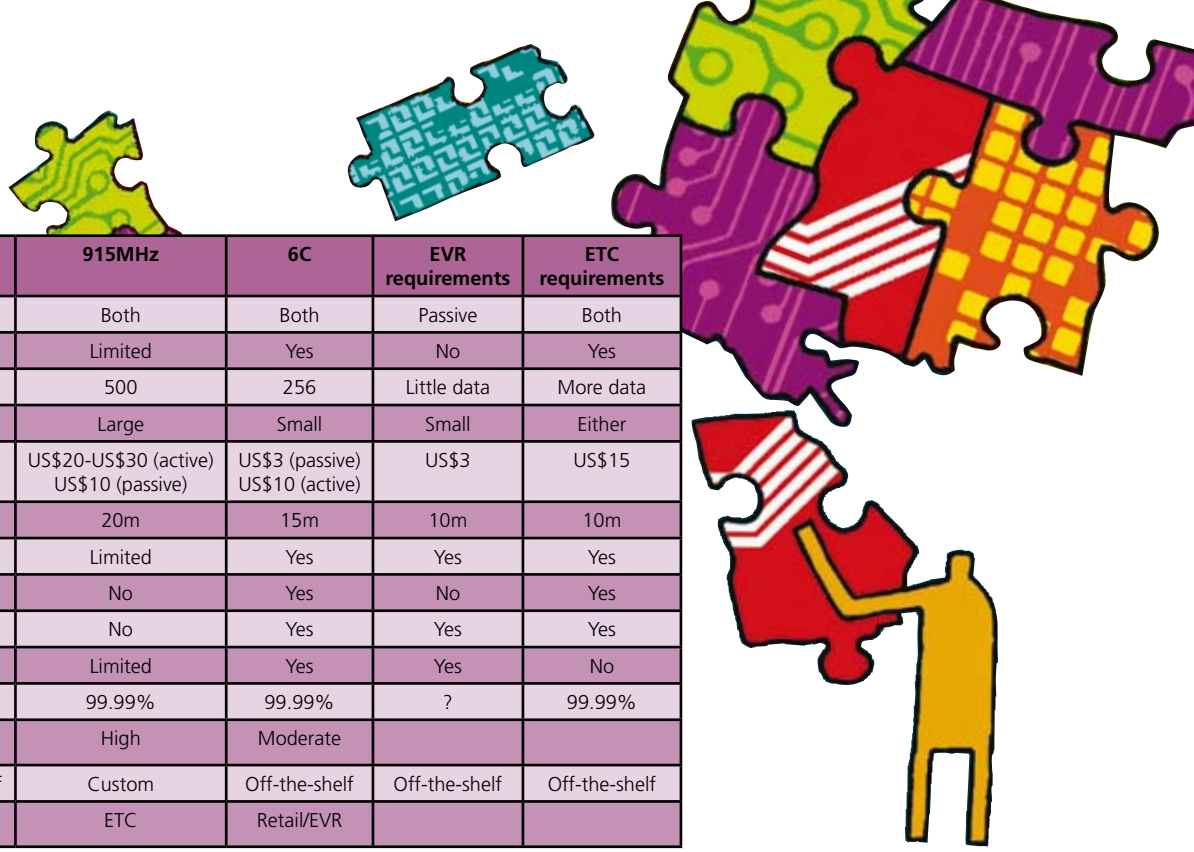
Certainly, RFID products that have been developed specifically for ETC applications are superior for that application environment. Modifications have been made to ensure that read ranges are longer, data transfer rates are higher, read/write capabilities exist and security is available, but these have been developed at the cost of the manufacturer and must be recovered. This generally leads to a proprietary environment in which the client is captive to one technology.

In contrast, EVR is a very new application area for which RFID standards have not been developed specifically. Although the ISO 6C standard may be capable of supporting EVR, it was not developed for that market but for the supply chain market. Several political jurisdictions have adopted the ISO 6C standard for EVR, and in some cases those same jurisdictions have active ETC applications. If the ISO 6C technology can be applied to both EVR and ETC, significant benefits may result. An ETC environment in which every vehicle has a standard tag – a tag that is regulated in conjunction with vehicle registration – would provide enormous benefit. Further, violation enforcement systems could be based on RFID reads, which are significantly more accurate than present practices for determining the address of the registered vehicle owner.

The ISO 6C standard – while not developed specifically for the combination EVR and ETC application environment – does seem to have most of the attributes necessary for both. The determination of such a decision should, however, be based on considerable and thorough testing in an operational environment.

OTHER ISSUES

Perhaps no issue affects the deployment of technology as much as the issue of personal



	5.9GHz	915MHz	6C	EVR requirements	ETC requirements
Passive/active	Active	Both	Both	Passive	Both
Read/write	Yes	Limited	Yes	No	Yes
Data rate (Kbps)	2,700	500	256	Little data	More data
Tag size	Large	Large	Small	Small	Either
Tag cost	US$30	US$20-US$30 (active) US$10 (passive)	US$3 (passive) US$10 (active)	US$3	US$15
Range (m)	1,000m	20m	15m	10m	10m
Security	Yes	Limited	Yes	Yes	Yes
Interference	Yes	No	Yes	No	Yes
Exclusive bandwidth	Yes	No	Yes	Yes	Yes
Portability	No	Limited	Yes	Yes	No
Accuracy	99.99%	99.99%	99.99%	?	99.99%
Commercialization	High	High	Moderate		
Implementation	Off-the-shelf	Custom	Off-the-shelf	Off-the-shelf	Off-the-shelf
Intended application	Numerous	ETC	Retail/EVR		

privacy. When we consider the amount of information that is currently available in the financial community and other personal records held by public and private institutions, one cannot help but be concerned about privacy.

However, fixing an RFID device to a vehicle for the purpose of registration does not change the amount of information that is available, simply the manner in which it is obtained. Certainly, vehicles can and are tracked through the transportation system today. EVR is typically implemented with tag data restricted to the electronic license plate number, while details about the driver are contained in a secure central system. Just reading the tag does not provide access to information about the individual.

There are also significant personal benefits of EVR systems. Car theft, drug trafficking and other criminal activities in which a vehicle is used would be impacted. Homeland Security is also a significant concern for many nations. For these reasons and the benefit of ensuring that vehicle registration revenue is properly collected, EVR systems will continue to be deployed.

To ensure interoperability and the efficient movement of people and goods on the USA's highways, a solution must be found to the checkerboard of technical, contractual and procedural processes of ETC. Today in Europe and the USA, the daily interstate travelers (trucks) carry numerous tags to ensure they can use tollways. Short of a national registration process for vehicles, a central repository of registration information could be one result of implementing nationwide EVR. Although toll rates, discounts, safety regulations and other contractual and procedural issues would continue to be addressed by the proper state organization, national ETC interoperability could become a reality.

SUMMARY

Several courses of action are open to the USA. It could continue to support a proprietary and non-interoperable solution, it could wait until the 5.9GHz VII solution is in place and all vehicles traveling on the nation's highways are equipped with RFID at the time of manufacture, or it could consider encouraging the implementation of a nationwide EVR system. If implemented with technology that could serve both the ETC and EVR environments, a nationwide interoperable payment system could be in place within one vehicle registration cycle. It seems reasonable to conclude that RFID standards are available that can serve both application environments.

The deployment of such a wide-ranging initiative would require considerable testing to ensure that the basic ISO 6C technology would be robust enough to serve both application areas. Requirements for the ETC area are readily available because ETC has been widely deployed. A similar set of application requirements would need to be developed for EVR and the combination of these requirements used to test commercial hardware and software products.

Although it is vital to continue the work of developing an electronic platform in VII that will serve all the safety, traffic management and transport payment processes of the future, recent developments and new applications using RFID in the transport sector may bode a quite different interim solution for vehicle registration and electronic payment systems.

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