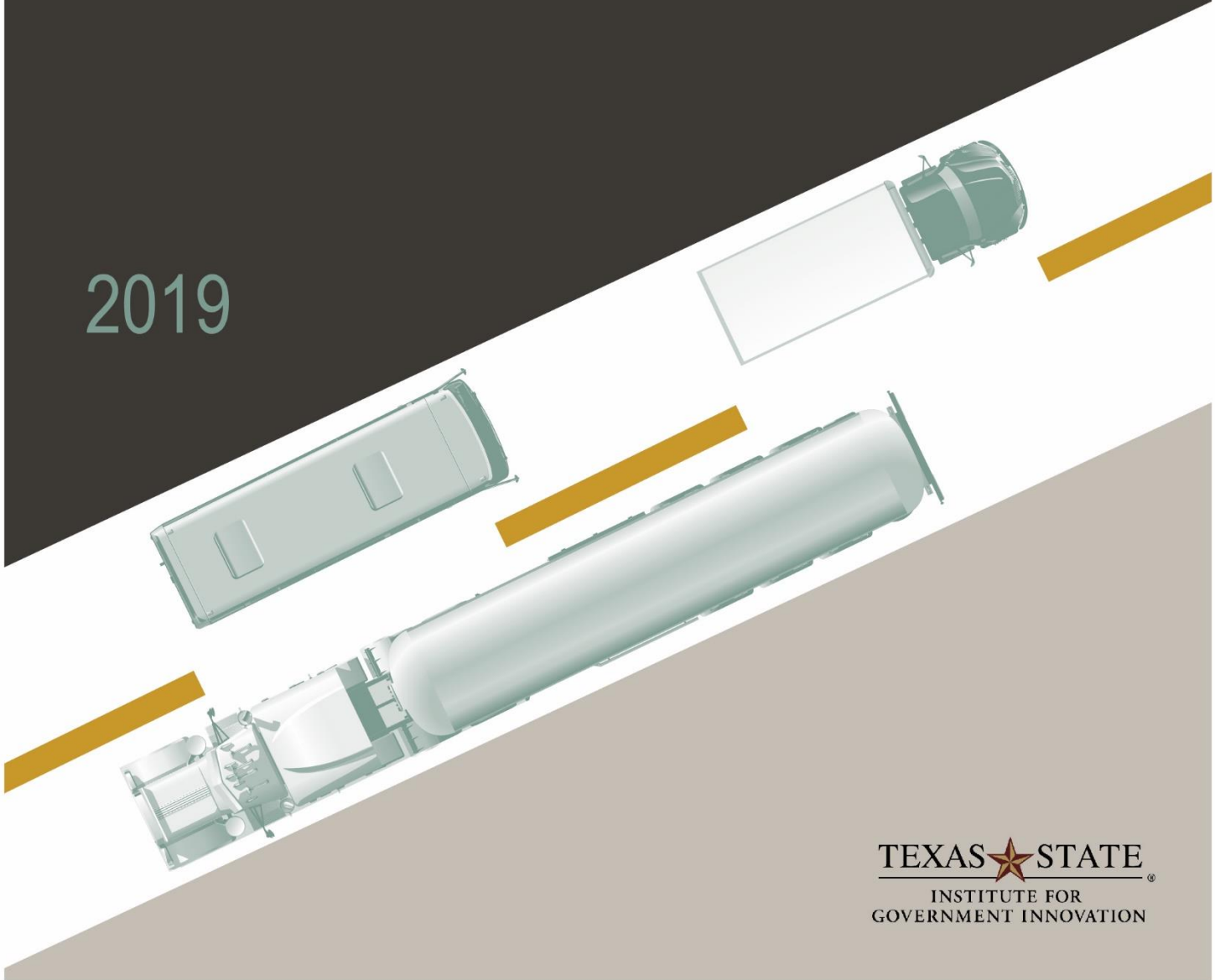


INTERIM STUDY

ALTERNATIVE REGISTRATION TECHNOLOGY

TEXAS DEPARTMENT OF MOTOR VEHICLES

2019



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Executive Summary

The purpose of this study is to satisfy the requirements of House Bill 1959 (85th Regular Session), which required the Texas Department of Motor Vehicles (TxDMV) to “conduct a study that identifies and assesses alternative technologies for registering commercial motor vehicles to replace license plates, permits, and other existing documentation and registration methods currently in use in [Texas]; and evaluate the safety and suitability for use on roadways of the technologies identified.” The TxDMV contracted with Texas State University to complete the study and provide a pilot plan for any technologies identified as feasible to test on Texas roadways.

Four alternative technologies with the potential to replace some of the required commercial motor vehicle documentation were identified including: Automated License Plate Readers (ALPR), Radio Frequency Identification (RFID) transmitters, connected license plates, and electronic registration cards. One of the foundational elements all these technologies share is their ability to connect to a central database or series of databases to validate near real-time information about a commercial motor vehicle.

Connected license plates and electronic registration cards use this connectivity to enable law enforcement to visibly validate documentation on the road on license plates and smart phones, respectively. On the contrary, ALPRs and RFID transmitters would provide a connection to documentation databases, but otherwise be invisible to law enforcement without an ALPR or RFID reader affixed to their vehicles. ALPRs and RFID chips do offer the potential for remote compliance monitoring wherever readers are located.

Both connected license plates and electronic registration cards have the potential to make documentation issuance more efficient, benefitting both documentation-issuing entities and motor carriers. The most fundamental change to issuance is the potential for the TxDMV to change documentation status in near real-time.

Smart phones have become ubiquitous and are becoming well-known for their ability to become digital wallets. ALPR and RFID are familiar technologies that are commonly used by tolling authorities. Of the identified technologies, connected license plates are the least explored.

Six patents for connected license plates were identified, ranging from fully computerized hardware, hybrid designs that add a computerized element to traditional metal plates, and RFID chip-embedded metal plates. Given the computerized nature of these plates, they are more expensive than traditional plates. Other potential considerations with connected plates include: the need to verify they work with existing infrastructure; the potential impact of connected plate sales on the revenue generated for the State through specialty license plate sales; the need to safeguard against technological vulnerabilities; and the absence of standards for connected plate legibility or durability. Additionally, connected license plates raise some privacy concerns, although these concerns are somewhat muted for commercial motor vehicles.

There are a number of stakeholders interested in the use of connected license plates including law enforcement, Tax Assessor-Collectors (who issue some commercial motor vehicle license plates and registration), the Texas Department of Criminal Justice (who, through their Texas Correctional Industries, manufactures license plates), the TxDMV, tolling authorities (interested in ensuring their ability to collect tolls for commercial vehicles is not degraded), motor carriers, MyPlates (the company authorized by the State to market and sell specialty license plates), and 3M (supplier of the reflective sheeting used on traditional license plates). It will also be important to weigh the potential adoption rate against the costs for modifying the TxDMV technology systems to accommodate connected plates.

Arizona and California conducted pilots with connected plates and both allow consumers to purchase electronic paper connected plates—which look something like a Kindle. The State of Michigan passed a law and expects to make connected plates available for use on their roads within the year. It is important to note that none of these other states were or are focused on the unique population of commercial motor vehicles. Connected license plates are handled differently than

traditional license plates. In Arizona, the connected plates are considered *display devices* rather than license plates. In both California and Arizona connected plates are sold directly to consumers through automobile dealers and other vendors.

This study concludes that it is feasible to conduct a Texas pilot study of connected license plates on commercial motor vehicles at no cost to the state by requiring voluntary participants to pay all costs, not the State. Since connected plates are not in widespread use, this pilot plan was developed to reveal more information about their potential use in Texas, including legibility, law enforcement usability, and carrier usability. The pilot will generate qualitative and quantitative data gathered under both ideal and real-life conditions. The proposed pilot plan of connected license plates on commercial motor vehicles includes two phases and should be able to be completed for \$300,000 or less, not including the DPS and the TxDMV employee costs.

Phase I would use off-road testing to determine license plate legibility for both humans and license plate readers in ideal conditions. Additionally, a brief survey would identify the usefulness of connected plates for law enforcement. Finally, a marketability survey would identify how likely motor carriers would be to adopt connected plates.

Phase II would use real life, on-road testing on a regional basis. The pilot plan suggests the use of I-45 between Dallas and Houston. The regional on-road test is designed to further understand law enforcement officers' use of the technology and the ability of weigh station ALPRs to read connected license plates. A test of toll station ALPR and RFID readers ability to read connected license plates would also be conducted. Additionally, a brief survey would document participating motor carriers' responses to connected plate technology. Phase II would require any participating connected plate manufacturers to work with the TxDMV to complete a data update test as well.

Conducting a pilot of connected license plates will provide more information about all stakeholder impacts and help develop standards to evaluate connected license plates to know if connected license plates are in the best interest of the State.

Introduction

The purpose of this study is to satisfy the requirements of House Bill 1959 (the Bill), enacted during the 85th Regular Session of the Texas Legislature. The Bill required the Texas Department of Motor Vehicles (TxDMV) to “conduct a study that identifies and assesses alternative technologies for registering commercial motor vehicles to replace license plates, permits, and other existing documentation and registration methods currently in use in [Texas]; and evaluates the safety and suitability for use on roadways of the technologies identified.” The TxDMV contracted with Texas State University to complete the project and to produce a study on their findings and recommendations. Additionally, through this contract, Texas State University will provide a pilot plan for any technologies identified that may be feasible to test on Texas roadways.

Commercial motor vehicles are subject to higher level of regulation than typical non-commercial passenger cars and trucks. As a result, a multitude of documents issued by various state and federal agencies are required before a commercial motor vehicle may legally operate on Texas roadways. In the typical scenario, formally issued documentation is required for a motor carrier (this is the business that the vehicle operates under), the driver, and the vehicle. In some cases, documentation is required for the vehicle’s load if the vehicle is hauling hazardous materials or an oversize/overweight load. Depending on the document, it may be issued by a federal agency, or one of Texas’ State Agencies, including the TxDMV.

The focus of this study is documentation that is administered and issued by the TxDMV. The study did not evaluate the necessity of this documentation but focused on alternatives that may offer a reduction in administrative burden for both the TxDMV and commercial motor vehicle owners and operators. Additionally, alternatives to existing technology were evaluated based on their ability to assist commercial motor vehicle officers with enforcement.

Commercial motor vehicles are critical to every aspect of modern life. Reducing the administrative burden on commercial motor vehicle owners and operators to receive and maintain a multitude of required documents can make Texas a more competitive marketplace. However, the need to be competitive must be balanced with the need for safety and the integrity of Texas roadways. Alternative technologies were evaluated to determine if they had the potential to: 1) decrease administrative burden for both the State of Texas and commercial motor vehicle owners and operators and 2) improve the safety and integrity of Texas roadways to positively impact business owners and Texans alike.

This study has concluded that connected license plates may offer the desired reductions in administrative burden and improvements to available information for law enforcement and that it is feasible to conduct a pilot study of connected license plates on commercial motor vehicles.

In the remainder of this study, the methods to complete the study will be presented, followed by a discussion of current commercial motor vehicle documentation, and alternative technologies identified to display this documentation and their suitability. After identifying suitable technologies, the study will outline considerations for a pilot study on those suitable technologies. Finally, a conclusion section that summarizes main points and provides a look to the future will be presented. Additionally, in Appendix 1, plans for a pilot test of alternative technologies have been included.

Methods

A mixed-methods approach was used to conduct the study. The methods included: interviewing subject matter experts and stakeholders, benchmarking Texas' practices with other states and other countries, researching on the Internet, and reviewing existing research.

Our interviewees were:

- Vehicle title and registration subject matter experts,
- Stakeholders representing state governments, state, and international trade associations, and
- Private business owners.

Some of the experts interviewed were recommended by the TxDMV; others were identified through benchmarking or internet research. For a complete list of interviews, see Appendix 3: Interviews.

Required Commercial Motor Vehicle Documents in Texas



The required documentation for commercial motor vehicles is multi-layered and highly regulated, involving Federal and State entities. It is important to begin by identifying all the different entities from which documents may be issued. The first is motor carriers. Motor carriers are companies that operate commercial motor vehicles. For example, the motor carriers must receive operating authority in the United States. The proof of this authority is issued by the United States Department of Transportation (USDOT) in the form of a USDOT Number. Once a motor carrier has completed all requirements, they may operate commercial motor vehicles on Texas roadways. However, any vehicles the motor carrier would like to use on the roadways must also have the proper documentation. This vehicle documentation includes things such as a vehicle safety inspection, registration, and license plates, among others.


In addition to the required documentation for the carrier and vehicle, the driver operating the vehicle must have the proper documentation including the appropriate driver license. Finally, the load the driver is hauling in the truck may also require documentation. This documentation is load-specific and includes documentation such as oversize/overweight permits and bills of lading.

Further, the required documentation varies depending on if the commercial motor vehicle travels through Texas and other states (interstate) or within Texas only (intrastate). Most importantly for this study, commercial motor vehicle registration

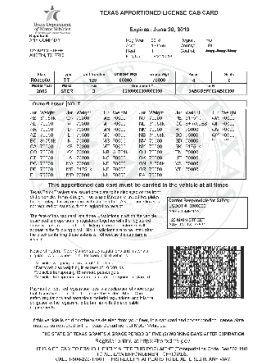
can be interstate or intrastate. The International Registration Program (IRP) is an agreement between American states and Canadian provinces that simplifies the registration process for carriers traveling in multiple states by providing a single portal to pay vehicle registration fees which are then apportioned out to the appropriate states. Apportioned registration through the IRP can be obtained online through the TxDMV or in person at a Regional Service Center. If a commercial motor vehicle only travels intrastate, registration can be obtained at a County Tax Assessor-Collector's office and online through the TxDMV website.


Table 1. Credentials, issuers, recipients, and formats


Documentation Name	Documentation Purpose	Documentation Issuer	Documentation Recipient	Documentation Format	Image
USDOT Number	A unique identifier to track the history of a motor carrier nationally (interstate)	United States Department of Transportation	Motor Carrier	Number (affixed to vehicles by motor carrier)	
TxDMV Number	A unique identifier to track the history of a motor carrier in Texas (intrastate)	Texas Department of Motor Vehicles	Motor Carrier	Number (affixed to vehicles by motor carrier)	


Documentation Name	Documentation Purpose	Documentation Issuer	Documentation Recipient	Documentation Format	Image
International Fuel Tax Agreement (IFTA) License	Provides proof of reporting of fuel use by motor carriers that operate in more than one jurisdiction	Office of the Comptroller of Texas	Motor Carrier	Sticker (affixed to vehicles by motor carrier)	 <p>The image shows a blue square sticker with a white outline of the state of Texas in the center. The letters 'I', 'F', 'T', and 'A' are arranged around the map. 'I' is at the top left, 'F' is on the left side, 'T' is in the middle, and 'A' is at the bottom right. The number '16' is in the top right corner. At the bottom left, 'TX' is written. At the bottom right, the number '1707181993' is written.</p>


<p>Vehicle Registration (includes interstate and intrastate registration)</p>	<p>Interstate registration, or apportioned registration, provides proof of payment for use of roadways by motor carriers that operate in more than one jurisdiction.</p> <p>Intrastate registration provides proof of payment for use of roadways in Texas.</p>	<p>Texas Department of Motor Vehicles</p>	<p>Vehicle</p>	<p>License plate and paper report</p> <p>Note: A registration sticker is included for intrastate registration (affixed to vehicles by motor carrier)</p>
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Documentation Name	Documentation Purpose	Documentation Issuer	Documentation Recipient	Documentation Format	Image
Temporary Permit	<p>Provides proof of payment for the use of Texas roadways for a period more limited than Vehicle Registration—either 72 hours or 144 hours.</p> <p>Note: In effect, a temporary permit is a form of Vehicle Registration.</p>	Texas Department of Motor Vehicles	Vehicle	Paper license plate	

Documentation Name	Documentation Purpose	Documentation Issuer	Documentation Recipient	Documentation Format	Image
Insurance	Provides proof a vehicle is properly insured.	Private Insurance Companies	Vehicle	Paper or electronic document	 <p>COMMERCIAL MOTOR FLEET CERTIFICATE OF CURRENCY</p> <p>This letter is to certify that our client's policy is current as detailed below and cover has been granted in terms of the Insurer's Standard Policy.</p> <p>The policy referred to is current as at the date of issue of this certificate and whilst, a due date has been indicated it should be noted that the policy may be cancelled in the future. Accordingly, reliance should not be placed on the expiry date.</p> <p>This certificate is not a substitute for the Policy of Insurance. The policy, not this certificate, details the rights and obligations of the Insured and the extent of the Insurance cover.</p> <p>The Insured: University Of Wollongong including subsidiary companies for their respective rights and interests.</p> <p>Nature of Policy: Comprehensive</p> <p>Interest Insured: Covering 95 Motor Vehicles and Trailers as declared. Total value declared \$1,138,000</p> <p>Sum Insured: SECTION 1 – Own Damage Current Market Value at the time of the loss or damage or Sum Insured Value whichever is lesser, but limited to \$10,000,000 any one event</p> <p>SECTION 2 – Third Party Property Damage \$30,000,000 but limited to \$1,000,000 for dangerous goods carrying vehicles, for all claims arising from the one accident or series of accidents resulting from the one original cause (as defined in Section 2 of the Policy).</p> <p>Excess: \$500 per vehicle, each & every claim</p> <p>1. Nil excess will apply to windscreen if no other loss or damage has occurred and only if your vehicle is a sedan, station wagon, 4WD, utility or other goods Carrying vehicle up to 3.5 tonnes payload carrying capacity.</p> <p>2. Age Excess and Inexperienced Drivers excess also applies as follows: \$800 Drivers under 21 years of Age \$750 Drivers 21 but under 25 Years of Age \$750 Drivers over 25 years of Age but license less than 2 years</p> <p>3. Excess applies separately to each vehicle and each claim on that Vehicle.</p> <p>Policy Wording: Zurich Motor Fleet Policy (ZURM-001616-1017) except as otherwise modified by the following Endorsement(s): Claims Experience Discount Special Condition to Section 2</p>

Documentation Name	Documentation Purpose	Documentation Issuer	Documentation Recipient	Documentation Format	Image
Vehicle Inspection	Provides proof a vehicle has passed a vehicle safety inspection.	Texas Department of Public Safety	Vehicle	Texas vehicle inspection report	

Documentation Name	Documentation Purpose	Documentation Issuer	Documentation Recipient	Documentation Format	Image
Commercial Driver License	Provides proof the operator of a commercial motor vehicle has met all necessary requirements (can include classes that authorize different vehicle sizes and types, additional credentials—endorsements—may also be added to the license to allow for the driver to carry hazardous materials, for example).	Texas Department of Public Safety	Driver	Physical driver license	

Documentation Name	Documentation Purpose	Documentation Issuer	Documentation Recipient	Documentation Format	Image
Load Permits	Over 50 different load permits exist for specific loads, such as oversize/overweight, temporary permits, and hazardous materials.	United States Department of Agriculture, United States Nuclear Regulatory Commission, Texas Department of Motor Vehicles, or Texas Commission on Environmental Quality	Load	Paper form or electronic document	

In summary, documentation is issued to motor carriers, vehicles, drivers, and loads. This documentation is issued by a variety of authorities and is provided in a variety of formats. There are currently several types of documentation which are issued and may be presented in an electronic format, including proof of insurance, operating authority cab cards, certain load permits, and interstate registration through the International Registration Plan.

It is important for enforcement capabilities to be as effective and efficient as possible to allow law enforcement to focus on safety compliance that arises from the sheer size of many of these vehicles.

For this study, the focus was on those forms of documentation that the TxDMV administers even though all of this documentation is not always required. From Table 1, the documentation that the TxDMV administers are:

- TxDMV Number,
- Vehicle Registration,
- Temporary Permits, and
- Load Permits.

Table 2. TxDMV Administered Documentation with Current Technology

Document Name	Document Recipient	Current Technology	External Indicator
TxDmv Number	Motor Carrier	Number (affixed to vehicles by motor carrier)	Yes

Document Name	Document Recipient	Current Technology	External Indicator
Vehicle Registration	Vehicle	License plate and paper report Note: A registration sticker is included for intrastate registration	Yes, registration expiration is indicated on the license plates of vehicles registered interstate and on a windshield-affixed registration sticker for vehicles registered intrastate
Temporary Permit	Vehicle	Paper document	No
Load Permits	Load	Paper form, sticker, or electronic document	No

The TxDMV number is affixed to the side of commercial motor vehicles. As such, an external indicator of compliance is provided. Vehicle registration provides two external indicators of compliance: 1) a license plate and 2) if the vehicle is intrastate, a registration sticker. If the vehicle is interstate, the plate will include the word “Apportioned” as an indicator of registration as well as an expiration date on the plates. There is an expiration date shown on Temporary Permits and Load Permits.

Alternative Technologies

The purpose of this section of the study is to identify and evaluate alternative technologies to the technologies currently used for the documents of interest.

The documents of interest in this study are the TxDMV Number, vehicle registration documentation, temporary permit documentation, and load permit documentation as these documents are administered by the TxDMV.

There are several stakeholder groups interested in commercial motor vehicles. This study focuses on the administrators of documentation issuance, law enforcement, motor carriers, toll authorities, and the motoring public. It is important that any alternative technology consider the impact to each of these stakeholder groups. The impact of alternative technologies on the motoring public's ability to identify a vehicle involved in a crime or for some other reason will also be considered.

No alternative technologies were identified that address the current method of displaying a USDOT Number or TxDMV Number. Vehicle registration is the documentation that alternative technologies most commonly address. It follows that because temporary permits are a form of vehicle registration, these technologies could also display temporary permits. Furthermore, it is clear each of the identified technologies could be extended to include vehicle inspection and insurance and may be capable of extending to include carrier, driver, and load documentation with the proper technology infrastructure in the future, though there are unique complications that may arise when displaying driver and load documentation externally.

The technologies this study identified as alternatives to current vehicle registration documentation were:

- Automated License Plate Readers (ALPR),

- Radio Frequency Identification (RFID) transmitters,
- Connected license plates, and
- Electronic registration cards (eCards).

In general, connected license plates and eCards are tools to display required documentation for motor carriers, drivers, and vehicles to aid law enforcement. ALPRs and RFID transmitters are documentation verification tools for law enforcement. The difference between a display tool and a verification tool is important for enforcement.

Connected license plates and eCards would provide visible enforcement tools—that is, they would enable law enforcement to visibly validate documentation on the road. On the contrary, ALPRs and RFID transmitters would provide a connection to documentation databases, but otherwise be invisible to law enforcement who do not have an ALPR or RFID reader affixed to their vehicle. However, these technologies offer the potential to cite or remind motor carriers automatically if there is a problem with the vehicle’s documentation when an ALPR or RFID reader is passed on a roadway. This procedure could be similar to how toll entities use RFID-equipped toll tags to detect vehicles using the toll roads and then automatically bill the appropriate account. However, issues have previously arisen from technologies such as red-light cameras as it relates to remote enforcement that should be considered. While tolling entities have already invested in the infrastructure required to make this possible for their purposes, law enforcement would need to make significant investments in similar infrastructure in order to comprehensively use these technologies. These costs would vary depending on the technology adopted. ALPRs are typically more expensive than RFID.

Aside from that difference, one of the foundational elements all these technologies share is their ability to connect to a central database or series of databases to validate information about a commercial motor vehicle. As such, each of these technologies pose security risks, though these risks vary among the four technologies. Aside from these common elements, it is useful to compare the technologies with an external visible indicator and those without one separately.

Automated License Plate Readers (ALPR) and Radio Frequency Identification (RFID) Transmitters

Both ALPRs and RFID transmitters have the potential for improving enforcement of vehicle registration requirements. It is important to note that neither of these technologies currently provide an external *visible* indicator of a commercial motor vehicle's documentation status. However, the usefulness of a visual indicator depends on the availability and priorities of law enforcement. For alerts such as "Silver Alerts" and "Amber Alerts", external visual indicators would be useful to the motoring public for reporting to law enforcement.

An ALPR captures an image of a license plate, then Optical Character Recognition (OCR) converts the pixel-based image into letters and numbers which are used to query a database. ALPRs could be used to check a vehicle's current registration status in the state's motor vehicle database and return that information to a law enforcement officer, though that is not how they are used currently.

An RFID transmitter on a license plate or vehicle sends a signal to a reader outside the vehicle. The reader then transmits a query to the appropriate databases to check compliance.

Texas tolling authorities serve as an excellent example of how these technologies can be used as enforcement tools. When a driver is a registered customer with a tolling entity, they receive an RFID transmitter to affix inside their vehicle. When the driver passes through a toll booth, an RFID reader reads the transponder and bills the customer. When a driver is not a registered customer with a tolling entity,

an ALPR is used in the manner described previously. While the ALPR method is effective, it may require additional human verification if the OCR is not accurate due to a poor-quality image capture.

Looking to Texas toll authorities, their example shows that RFID is a more effective technology for passively enforcing toll payments. The reasons for this are based on the technologies themselves. ALPRs are a directional technology that must be pointed at a specific location to work properly. RFID is omnidirectional and does not require the same calibration. As a result, tolling authorities in Texas report more accuracy with RFID technology than ALPR technology and RFID technology is more efficient. Additionally, ALPRs would be an indiscriminate way of collecting data and would unnecessarily collect data on private citizens travelling on roadways, whereas RFID transmitters can be tuned to a specific frequency and target the population of interest, in this case, commercial motor vehicles. As such, ALPRs present greater privacy concerns than RFID readers. Though, both tools present these concerns.

It is important to note that RFID technology can be integrated into traditional metal plates and function as a type of connected license plate. Issues could arise in this scenario because RFID is a passive technology. That means that once the data is encoded, it does not communicate with an external source to receive updates, it simply emits a signal that contains the data previously stored on it. So, stolen license plates with an RFID transmitter would make it difficult for law enforcement to determine whether the RFID transmitter was affixed to the correct vehicle. Once those plates were reported stolen though, the location of the stolen plates could be identified. The same is true of traditional license plates except they cannot be easily tracked.

Finally, it is important to note the network of infrastructure that would be required to set up readers across the State to adequately enforce vehicle registration requirements. Following the Texas Tolling example, RFID readers would be a less expensive and more accurate option than ALPRs. Some Texas law enforcement entities are already equipped with ALPRs and could leverage this technology without additional purchase. ALPRs are quite expensive, however, and expanding

their distribution to all commercial motor vehicle enforcement officers in the State could be cost-prohibitive.

Connected License Plates and Electronic Registration Cards (eCards)

Both connected license plates and eCards have the potential to make documentation issuance more efficient, benefitting both documentation issuing entities and motor carriers. Connected plates and eCards could also make enforcement more effective and efficient.

All these electronic alternatives present unique issues as well. The American Association of Motor Vehicle Administrators (AAMVA) has established national standards for license plates. One of the license plate standards recommends a level-1 security feature on the plates which allows law enforcement personnel to visually or tactilely determine, without the use of tools, if the plate is a forgery. What this security feature will be is at the discretion of the issuing jurisdiction. Several connected plates do not currently include level-1 security features.

The most fundamental change to issuance is the potential for the TxDMV to change documentation status in near real-time and indicate that status directly on the connected plate. The ability to denote documentation status visibly on the license plate of commercial motor vehicles would be a fundamental change for law enforcement enabling focus on out-of-compliance vehicles.

Connected License Plates

A connected plate essentially combines the design of a traditional license plate with computer elements. These designs vary, and this study identified six patents for different designs of connected plates. The designs range from fully computerized hardware, hybrid designs that add a computerized element to traditional metal plates, and RFID chip-embedded metal plates. Given the computerized nature of these plates, they are more expensive than traditional plates. Exact pricing comparisons are difficult to make because none of these plates are being produced at a scale comparable to metal license plates. Without an incentive to motor carriers—such as reduced administrative burden—adoption may occur slowly or not at all because these technologies may subject them to increased enforcement. Given the availability of these different designs, it is important for any pilot to include as many different technologies as possible.

Two different types of fully-computerized connected plate designs were identified: digital (imagine a digital clock) and electronic paper (imagine an Amazon Kindle). Because of the pixel nature of an electronic paper plate, more possibilities exist for expanding the interface. However, both designs currently have the capability to display an alphanumeric license plate pattern and month and year of registration expiration like traditional metal license plates. The digital clock design would likely not be capable of appearing similar to current license plate designs, but the electronic paper can replicate the current license plate design with significant accuracy.

What is unique about fully connected plates is that they can also dynamically display words such as “Valid”, “Invalid”, “Stolen”, etc. There is also potential to show “Amber Alert” or “Silver Alert” directly on the plate of the target vehicle. It should also be possible to check multiple required documents and display a single indicator on the license plate if there is problem with one or more of the documents as an alert to law enforcement. Even with this potential, without authenticating the driver of the vehicle’s identity and authenticating the load being transported, the plates would be incapable of adequately displaying the status of all required documentation and would likely only serve to display vehicle-related documentation.

Given the completely new design of these plates, their long-term durability and reliability is unknown. Electronic paper connected plates have been tested on roadways in tests of less than 5 years duration and no state-conducted pilot study results were available at the time this study was completed. In Texas, license plates are no longer automatically replaced after 7 years but vehicle owners can replace plates for cosmetic or readability reasons. It is unclear how long connected plates will last. Additionally, any connected plates that use any form of battery power will likely need to have the battery replaced more often than license plates are currently replaced. These two factors could add to the administrative burden and cost for motor carriers.

AAMVA currently does not have standards for connected plates but anticipates establishing them by 2020. Without these new standards, it will be necessary to ensure any connected plate designs meet the current standards where reasonable.

California and Arizona are currently pilot testing electronic paper connected plates. Arizona and California are both allowing consumers to purchase electronic paper connected plates. The State of Michigan expects to make connected plates available for use on their roads within the year. It is important to note that none of these other states were or are focused on the unique population of commercial motor vehicles.

Electronic Registration Cards

As with connected plates, eCards would fundamentally change issuance because they could be issued directly to a user's device and provide additional details not possible to convey on a license plate. The device could be a smart phone or tablet device kept in the commercial motor vehicle. The benefit of this is that most commercial motor vehicle drivers will likely have a smart phone or tablet with them in the vehicle. Additionally, documentation would be accessible from multiple devices and locations so that motor carriers, drivers, and law enforcement could all have access. While the detailed information on eCards would be helpful to law enforcement, it would only be usable after a vehicle has been pulled over and stopped because there would be no external status indicator with eCards.

However, unlike connected plates, full documentation information would be accessible and readable on a portable device, eliminating the need for going through many paper documents.

Texas, as part of the International Registration Program (IRP) adopted eCards for interstate commercial motor vehicles in January 2019. Similarly, Texas has allowed electronic display to verify insurance coverage since 2013. Texas has allowed electronic display to verify operating authority (cab cards) since 2015, and electronic display of certain load permits since 2017.

The important consideration for eCards is that all documentation could be centralized in an electronic wallet that holds all necessary eCard documentation, including everything from motor carrier to insurance to load permits and driver licenses.

Considerations for a Pilot Plan of Alternative Technologies

Before implementing a pilot test in Texas, it is important to understand any ongoing or completed pilot tests of similar technology conducted in other states in order to apply the lessons learned from those tests. Lessons learned from other states' alternative technology studies can be applied to a commercial motor vehicle alternative technology pilot. By understanding these other pilots, Texas can limit its pilot and avoid duplicating costly tests.

Other Pilot Tests of Similar Technology

2016 Motor Carrier Electronic Credential Pilot

In 2016, the Wisconsin Department of Transportation partnered with Federal Motor Carrier Safety Administration (FMCSA) – Wisconsin Division, the IFTA Electronic Credential Working Group, and Aim Transfer and Storage Inc., along with 6 other states including Alabama, Illinois, Iowa, Michigan, Minnesota and Virginia for the 2016 Motor Carrier Electronic credential pilot. The long-term goals of this pilot

were to save time for carriers, drivers and law enforcement while simultaneously providing more up-to date in-cab credentials.

The project participants used this pilot to develop and test procedures, and to promote the acceptance and use of electronic motor carrier credentials that could replace paper credentials. To do this, the pilot tested the ability of Law Enforcement to receive, accept, view and use the electronic documents from drivers while also ensuring that motor carriers are able to get the electronic credentials into the cab so that drivers will be able to not only present documents in the electronic format but also be able to directly forward electronic pdf copies to a law enforcement e-mail address when requested. Other short-term goals for the pilot program included familiarizing Law Enforcement with electronic credentials while reviewing as many possible electronic credentials as possible to determine any potential issues or problems.

During the pilot program, any commercial motor vehicle driver that was stopped by law enforcement in the participating states had to provide their credentials on a portable electronic device or hardcopy paperwork. If the driver chose to use an electronic credential, it had to be accurate, viewable, and readable by law enforcement. The credentials included in this pilot were:

- IRP cab card, or intrastate vehicle certificate of registration,
- Trailer vehicle certificate of registration,
- IFTA license,
- Lease Agreement, if lessee was provided IFTA or IRP,
- Authority (for-hire) documents,
- Certificate of insurance,
- Hazmat registration certificate, and
- Non-hazmat bills of lading.

The pilot lasted from April 1, 2016 to September 30, 2017 at which time a final report was compiled that included an executive summary, the origin of the pilot, future recommendations to the different credentialing agencies for future changes

that would be needed to support full implementation of electronic credentials and lastly, the summary of findings for the pilot.

Beginning in 2019, commercial motor vehicle carriers will be allowed to carry their IRP cab card and IFTA license in the form of an electronic image as a result of the 2016 Motor Carrier Electronic Credential pilot. The electronic images will be optional as drivers may still display the physical copy of the credential. It is strongly suggested that the electronic credential is stored in PDF format so that the credential will be viewable and accessible in areas of no service or WIFI. The corresponding parties involved will review the impact of these electronic credentials for the first quarter of 2019 beginning in April. Due to the completion of this pilot and implementation of the IRP credentials, we do not recommend any additional pilot tests be completed for eCards as part of a Texas pilot.

California Alternatives to Traditional Registration Products Pilot

In 2014, the California Department of Motor Vehicles issued a Request for Proposal (RFP) to identify “Alternatives to Traditional Registration Products” (i.e., license plates, stickers, tabs, or registration cards). The RFP indicates the goal was “to assist vendors in demonstrating alternative registration products”. The technologies currently being tested in California are: electronic paper connected plates, eCards, and a vinyl license plate wrap. Each product evaluated had to be deemed acceptable by the Department of Motor Vehicles and the California Highway Patrol. All technology pilots were required to be conducted at no cost to the Department of Motor Vehicles.

The pilot project began in 2015 and has been ongoing for over four years. The Department of Motor Vehicles required the pilot project vendors to recruit consumers to agree to pilot their products.

The license plates being tested are electronic paper connected plates. There have been approximately 1,500 consumers who have purchased a connected plate and participated in the pilot since its inception. The consumers have been allowed to

enter and exit the pilot voluntarily. The California electronic paper connected plate shows the license plate alphanumeric pattern and the month and year of registration expiration. They also have the ability to frequently change the information displayed at the bottom of the license plate, from the standard 'dmv.ca.gov' to 'Happy Thanksgiving' or 'Support our Troops'. The plates being used in the pilot are not connected to California's motor vehicle database. Instead, California communicates with a third-party vendor and credentials are updated through the third-party vendors database of credentials for participants in the pilot. The pilot is not focused on commercial motor vehicles.

The California eCard is a PDF document with the image of registration credentials stored on a smart device. The intention is to allow drivers to carry registration credentials that can be updated in real-time and can be accessed from multiple smart devices. No additional pilot is recommended based on the IRP eCard implementation.

The vinyl license plate wrap is a vinyl wrap with the image of a license plate and registration credentials that is affixed to the front of a vehicle. The intention is to provide consumers with a front license plate option that does not require bolt holes in the front bumper. Approximately 80 consumers have purchased vinyl license plate wraps. This was not considered relevant for commercial motor vehicles.

No documentation of the results from the California study were available at the time this study was completed.

Arizona Department of Transportation Electronic Paper Connected Plate Pilot

Arizona engaged in a pilot with an electronic paper connected plate vendor. The draft Arizona pilot plan was reviewed and feedback from the Arizona Department of Transportation (ADOT) pilot was also used as background for this study, although no formal report was available.

As stated in the pilot plan, the pilot was intended to test the plate's fleet management capabilities of the plate's web application. The plan tested 10 ADOT vehicles initially with plans to continue monitoring the connected plates.

The success criteria of the electronic paper connected plate ADOT pilot is whether the product can operate successfully in Arizona's various climates and the ability to transmit information in real-time to the plates. There was no piece of legislation requiring the pilot, however, the Arizona DOT wanted to conduct this pilot on their own fleet to understand the technology and determine if it is a viable alternative for Arizona drivers.

Other Considerations

The State of Texas has existing infrastructure on roadways to help with law enforcement and tolling. Connected license plates will need to be tested with this infrastructure to determine the impact of implementation.

Typically, discussions surrounding connected plates consider privacy concerns. In this case, with a focus on commercial motor vehicles, these concerns are less critical. A commercial motor vehicle operator can be pulled over by law enforcement with no probable cause and therefore has a much lower expectation of privacy while on the road. However, it will be important to understand commercial motor carriers' receptiveness to a plate that may cause privacy concerns for their employees or their business. Most commonly, motor carriers are hoping to reduce *any* administrative burden that results from the need for documentation. Connected license plates may offer this reduction and therefore would require motor carriers to balance their drivers' privacy or other concerns with those reductions. As such, it is recommended a motor carrier marketability survey be completed to ensure that if connected license plates are implemented voluntarily, there will be sufficient volumes sold to avoid unnecessary costs and time for the TxDMV to develop a connected plate communication system. MyPlates, the State's vendor for the marketing and sales of specialty license plates, for example, has a minimum revenue amount they must generate to fulfill the requirements of their contract. A similar arrangement would not only help offset

development costs to the TxDMV from the creation of a connected plates communication system, but it could generate revenue for the State. The minimum revenue from connected plate sales would need to be evaluated based on system development and maintenance costs.

With that said, law enforcement will likely benefit most from connected license plates. As a result, any pilot test should include significant research into law enforcement's potential use of the technology.

The State of Texas uses the AAMVA standard for license plates. Currently, there is no connected license plate standard from AAMVA. A new standard is anticipated by 2020. However, absent a specific connected license plate standard, connected license plates should be held to as many of the current metal plate standards as are applicable. Two notable standards have emerged that should be evaluated for any connected license plate design: legibility and anti-forgery. A legibility test should be conducted that follows the AAMVA standard.

Additionally, an understanding of the importance to law enforcement of an anti-forgery mechanism should be evaluated. Anti-forgery should not be confused with security and hacking risk. Anti-forgery refers to what AAMVA describes as a level-1 security for first-line inspection, meaning examination without tools or aids that involves easily identifiable "visual or tactile features" for rapid inspection at the point of usage. Texas uses visual features on current metal plates. That said, security and hacking should also be of serious concern to decision-makers. Regardless of security measures, hacking remains a possibility as most systems are not entirely 'unhackable'. The technologies identified in this study vary in vulnerability to hacking, with RFID likely being the least vulnerable.

Finally, it is important any pilot test acknowledge that the TxDMV systems are not currently prepared to implement connected license plates and any pilot test should serve to provide the TxDMV with the information necessary to build functional systems for implementation.

Stakeholder Considerations

This section contains information about the interests of the many stakeholders with regards to a connected plate pilot project. Widespread implementation would clearly affect other third-party organizations and the impacts would need to be evaluated by decision-makers.

3M

3M is the sole supplier of reflective sheeting and manufacturing equipment for license plates in the State of Texas. If connected plates were implemented in Texas, it would potentially reduce the amount of reflective sheeting rolls the state purchases from 3M. Consequently, based on the reduction in bulk purchasing, the state might have to pay more for each reflective sheeting roll, thereby increasing the cost to produce metal license plates.

Law Enforcement

Law enforcement would be the primary beneficiaries of the new capabilities of connected plates. Law enforcement's primary concern is the capacity of connected plates to perform in a similar manner to metal plates in terms of visibility, legibility, and reflectivity. The ability to display changes in documentation status affords law enforcement the ability to improve compliance enforcement. In order to receive input on connected plates' performances, law enforcement plays a vital role and should actively participate during the pilot.

Motor Carriers

The implementation of connected license plates could lead to a variety of implications for motor carriers, regardless of their fleet size. Connected license plates have the potential to reduce the burden of replacing registration stickers on commercial motor vehicles. Certain connected license plates may offer additional telematics that could be beneficial to a motor carrier by providing them with real time information about their vehicle power units. It is important to note that some connected license plates have varying battery lives (as short as 3 years). Motor carriers would be required to replace these batteries promptly if the connected plate is not operational.

This new technology will make it easier for law enforcement to concentrate their efforts on non-compliant carriers which would level the playing field for the motor carriers that follow all laws and pay all required fees. One potential drawback for motor carriers would depend on law enforcement's interest and use of the connected plate. If the plate has enough significant benefits to law enforcement, and that connected license plate becomes mandatory, then motor carriers would have to absorb the additional costs of purchasing and attaching these connected plates to all of vehicles in their respective fleet.

MyPlates

MyPlates was the successful bidder to be the third-party marketing vendor of specialty license plates in the state of Texas. Specialty plates either display a personalized alpha-numeric pattern, a colored background, or a combination of both. MyPlates sells an average of 45,000 plates per year and generated over \$76 million in revenue for the State between 2009 and 2018.

Some connected license plates offer different display options than the current Texas license plates. In California, for example, consumers have the capability to choose from several DMV-preapproved messages to display on the bottom of the license plate. Additionally, the electronic paper connected plate does not currently have the capability to display color, though it is in development. Since many of the

current specialty plates available for sale in Texas depend on color, specialty plate sales might be affected by the introduction of electronic paper connected plates which cannot currently display color. Specialty plate sales may also be affected by other technological capabilities of digital and electronic paper connected plates. If connected plates were approved for sale, the TxDMV would need to determine how specialty plates displayed on connected plates are sold to consumers and managed.

These connected plate capabilities have the potential to impact sales of specialty plates and the revenue they generate for the State.

Tax Assessor-Collectors

Connected plates would reduce the number of commercial motor carriers visiting County Tax Assessor-Collectors to renew their intrastate registration. Connected plates would change the current process by updating the license plate remotely and avoid tracking the vehicle to apply the registration sticker.

This reduction in walk-in visits would affect the service fees collected by the counties. While the county's service fee would not go away, the fee collected decreases from \$2.30 to \$0.25 when a registration is not obtained in person. Even though the county collects a lower fee this could be offset because less people would be visiting the office. This may help counties who have long lines by decreasing office walk-in traffic and allowing quicker service, but it may also trigger staff reductions necessitated by lower revenue. This lost revenue would be directly related to the adoption rate of connected plates.

Texas Department of Criminal Justice

Currently, the Texas Department of Criminal Justice (TDCJ) through Texas Correctional Industries (TCI) produces regular and specialty license plates for the Texas Department of Motor Vehicles. In Fiscal Year (FY) 2018, TCI generated \$15.8 million in revenue from license plates which represented roughly 20% of

TCI's annual budget. License plates used on commercial motor vehicles represent a small and difficult to quantify portion of the license plate revenue.

Today, Texas Administrative Code prohibits TCI from manufacturing products on behalf of private entities. If connected license plate technology, provided by a private business, were to be adopted for commercial motor vehicles there would likely be a reduction in TCI's revenue.

Texas Department of Motor Vehicles

Connected license plates can offer certain benefits to the TxDMV. One major feature that remains consistent for each of the connected license plate designs identified for this study is the ability to display registration status on the license plate. This could lead to operating cost reductions for the TxDMV as they would no longer be responsible for printing and mailing registration stickers. The TxDMV would also no longer have to reimburse TDCJ for the cost of manufacturing as many license plates. Since some connected plate providers sell plates online (direct-to-consumer), through dealers, or other third-parties, the TxDMV would not have to manage or distribute license plate inventory to counties.

Some of these connected plates boast the ability to offer automatic registration renewal for customers, potentially a cost savings for the Department. If connected plates were to be fully implemented on Texas roads, there could be additional revenue for the State from consumers purchasing the connected plates if the vendor dedicates a portion of sales back to the State in a manner similar to the contract the TxDMV currently has with MyPlates.

Tolling Authorities

For connected plates to work on Texas roads they must be compatible with existing infrastructure used by Texas toll authority stakeholders. Current existing license plate identification technology used on Texas toll roads includes a proprietary license plate reader system and radio frequency identification (RFID). License plates with high contrast between the background and letter colors work

best with the license plate readers. RFID chips help improve the speed and accuracy of vehicle identification on toll roads.

Costs

HB 1959 requires any pilot study to be no cost to the state and paid for by voluntary participants. In order to encourage participation, the cost of the pilot should be as limited as possible while still providing the State with the necessary information for decision-making.

Laws and Rules

The purpose of this section is to identify and discuss potential changes to existing Texas laws and rules which could result from the implementation of connected license plates.

The TxDMV identified sections of statute and administrative rules applicable to license plates and provided their list to the Sunset Commission and Texas State University for this study. The list may not be comprehensive as specific nuances required by particular connected plate characteristics may necessitate additional changes or new laws and rules entirely. Their list was analyzed for this study to determine whether connected plates would require changes to these laws and rules.

Note: Any findings in this study should be further evaluated by legal professionals.

The primary role of license plates is to provide a unique identifying alphanumeric pattern for vehicles so they can be identified by law enforcement and the general public. License plates are issued by the TxDMV and have been a fundamental aspect of Texas roads for decades. As a result, there have been a number of laws and rules to ensure the regulation of license plates used on the road. These laws provide requirements for many aspects of license plates such as who can make them, how they are made, and how they are distributed.

The laws that pertain to license plates are critical because they provide a legal structure to ensure the safety and legality of vehicles on the road and maintain the financial interests of the state. This study found there would need to be changes to Texas laws if connected license plates were implemented.

Through the course of this study, several potential legal issues were identified:

- There are no laws or rules addressing the legality of using RFID,
- There are unclear distinctions between the specification of design, which seem to refer to the visual appearance of traditional license plates, and the design of connected plates which could entail the intellectual property of connected plates, and
- There is no determination of whether connected license plates would be treated as specialty plates under the law.

Two fundamental issues were identified that depend on legislative approach.

First, some connected license plates—specifically full-screen electronic paper plates—have been categorized as license plate *display* devices in other states as opposed to license plates themselves.

Full-screen electronic paper plates have the capability to identically render the design of existing license plates. As an analogy, it would be like showing a law enforcement officer proof of insurance on a smart phone. It is understood the officer is viewing an insurance document, not a phone. If a connected license plate is simply a license plate display device, it would affect the changes necessary to existing laws and rules because they do not currently address such an approach. This approach would likely require the creation of entirely new laws and rules that would be required to establish a set of standards for “license plate display devices.” The identified necessary changes have been summarized in Appendix 1: Necessary Changes to Laws and Rules. Appendix 1 distinguishes between whether a connected plate would be considered a *license plate* or a *license plate display device*.

Second, in other states, connected plates have been sold directly to consumers through car dealerships or through a third-party website. If connected plates were

sold direct-to-consumer, it would affect the changes necessary to existing laws and rules because they do not address such an approach. The identified necessary changes have been summarized in Appendix 1. Appendix 1 distinguishes between whether a connected plate would be sold *direct-to-consumer* or *through the State*.

Conclusions

In conclusion, it is feasible to conduct a pilot study of connected license plates on commercial motor vehicles. Plans for this pilot are available in Appendix 2: Pilot Plan.

Given the commercial trucking industry's impact on almost all facets of Texans' lives, the reductions in administrative burden are worth investigating and the potential improvement to law enforcement's ability to enforce the law could create safer roadways in Texas.

By developing a pilot that encourages participation, the State of Texas can determine what is best for it, law enforcement, tolling entities, motor carriers, other stakeholders, and the motoring public. Because these technologies are so new, it is important that the pilot focus on the development of standards by which any connected license plate can be evaluated. Until the pilot is completed, it will not be possible to know how many, if any, connected license plates are deemed to be in the best interest of the State.

Looking ahead, no technology identified in this study connected all facets of a commercial truck's documentation requirements. No technology could authenticate a driver in a vehicle, with an authenticated load, and a properly documented vehicle. If this were possible, an external visible indicator would tell a law enforcement officer everything they would need to know across all required documentation. Without this, an officer is only seeing a portion of the required documentation externally. This capability would require significant infrastructure and potentially necessitate in-truck weigh systems and other load sensors. It is clear though that the identified technologies could be integrated and extended into this kind of system.

Ultimately, it will become clear that these technologies will improve enforcement, but if motor carriers are not interested in investing in them the State will be left to decide if they should be optional or mandatory. If they are mandatory, the administrative burden will again be a major consideration for whether they will register their commercial motor vehicles in Texas or another jurisdiction.

Appendix 1: Necessary Changes to Laws and Rules

Note: The table includes all laws and rules that were provided by the TxDMV with the exception of Texas Transportation Code §547.30 regarding vehicle equipment and the restriction on use of lights which was included due to its potential implications from connected license plate designs.

Table 3. Laws and Rules with Necessary Changes

Code Section	Code Summary	Law Needs to Change if Connected License Plate is:			
		Considered a License Plate	Considered a Display Device	Purchased Directly by Consumers	Supplied by Government to Consumers
TEXAS TRANSPORTATION CODE §504. License Plates §504.002.(3) GENERAL PROVISIONS. link	Establishes the TxDMV as the exclusive owner of the designs of each license plate	Y	N	N/A	N/A

Code Section	Code Summary	Law Needs to Change if Connected License Plate is:			
		Considered a License Plate	Considered a Display Device	Purchased Directly by Consumers	Supplied by Government to Consumers
TEXAS TRANSPORTATION CODE §504. License Plates §504.002.(5) GENERAL PROVISIONS. link	Establishes the TxDMV as the preparer of designs and specifications of license plates	Y	N	N/A	N/A
TEXAS TRANSPORTATION CODE §504. License Plates §504.005(a). DESIGN AND ALPHANUMERIC PATTERN link	The TxDMV exclusively controls the design, typeface, color, and alphanumeric pattern for all license plates	N	N	N/A	N/A

Code Section	Code Summary	Law Needs to Change if Connected License Plate is:			
		Considered a License Plate	Considered a Display Device	Purchased Directly by Consumers	Supplied by Government to Consumers
TEXAS TRANSPORTATION CODE §504. License Plates §504.005(b). DESIGN AND ALPHANUMERIC PATTERN link	The TxDMV is to prepare designs and specifications of license plates and devices selected by the Board to be unique identifiers	Y	N	N/A	N/A
TEXAS TRANSPORTATION CODE §504. License Plates §504.005(c). DESIGN AND ALPHANUMERIC PATTERN link	Requires the designs of license plates to include a silhouette of the state of Texas, with a few exceptions	N	N	N/A	N/A

Code Section	Code Summary	Law Needs to Change if Connected License Plate is:			
		Considered a License Plate	Considered a Display Device	Purchased Directly by Consumers	Supplied by Government to Consumers
TEXAS TRANSPORTATION CODE §504. License Plates. §504.005(d). DESIGN AND ALPHANUMERIC PATTERN link	Requires the use of reflectorized material in order to promote highway safety	Y	Y	N/A	N/A
TEXAS TRANSPORTATION CODE §504. License Plates §504.006. COST OF MANUFACTURING. link	Instructs the TxDMV to reimburse TDCJ for the cost of license plate manufacturing	N	N	Y	Y

Code Section	Code Summary	Law Needs to Change if Connected License Plate is:			
		Considered a License Plate	Considered a Display Device	Purchased Directly by Consumers	Supplied by Government to Consumers
TEXAS TRANSPORTATION CODE §504. License Plates §504.601. GENERAL PROVISION APPLICABLE TO SPECIALTY LICENSE PLATE FOR GENERAL DISTRIBUTION. link	Establishes fees for specialty license plates	Y	Y	Y	Y

Code Section	Code Summary	Law Needs to Change if Connected License Plate is:			
		Considered a License Plate	Considered a Display Device	Purchased Directly by Consumers	Supplied by Government to Consumers
TEXAS TRANSPORTATION CODE §504. License Plates §504.801. CREATION OF NEW SPECIALTY LICENSE PLATES BY THE DEPARTMENT. link	Establishes the parameters for the creation of new specialty license plates	Y	Y	N/A	N/A
TEXAS TRANSPORTATION CODE §504. License Plates §504.802. MARKETING AND SALE BY PRIVATE VENDOR OF SPECIALTY LICENSE PLATE. link	Establishes parameters for the marketing and sale relationship between the TxDMV and private vendors associated with specialty license plates	N	N	Y	N

Code Section	Code Summary	Law Needs to Change if Connected License Plate is:			
		Considered a License Plate	Considered a Display Device	Purchased Directly by Consumers	Supplied by Government to Consumers
TEXAS TRANSPORTATION CODE §504. License Plates §504.851. CONTRACT WITH PRIVATE VENDOR. link	Establishes parameters for the TxDMV contracting with a private vendor for purposes of specialty license plates	Y	Y	N/A	N/A
TEXAS TRANSPORTATION CODE §504. License Plates §504.945. WRONG, FICTITIOUS, ALTERED OR OBSCURED LICENSE PLATE. link	Describes the instances in which individuals may be found at fault for license plate infractions	N	N	N/A	N/A

Code Section	Code Summary	Law Needs to Change if Connected License Plate is:			
		Considered a License Plate	Considered a Display Device	Purchased Directly by Consumers	Supplied by Government to Consumers
TEXAS TRANSPORTATION CODE §504. License Plates. §504.947. LICENSE PLATE FLIPPER; OFFENSE. link	Defines “License Plate Flipper” as a manual, electric, or mechanical device designed or adapted to be installed on a motor vehicle that may hide or flip between license plates, which may include some connected plate designs	Y	Y	N/A	N/A
TEXAS TRANSPORTATION CODE §547. Vehicle Equipment. §547.305.(b) RESTRICTION ON USE OF LIGHTS link	Except as expressly authorized by law, a person may not operate or move equipment or a vehicle, other than a police vehicle, with a lamp or device that displays a red light visible from directly in front of the center of the equipment or vehicle	Y Note: Changes to this law would be dependent on approved connected plate designs.	Y Note: Changes to this law would be dependent on approved connected plate designs.	N/A	N/A

Code Section	Code Summary	Law Needs to Change if Connected License Plate is:			
		Considered a License Plate	Considered a Display Device	Purchased Directly by Consumers	Supplied by Government to Consumers
TEXAS TRANSPORTATION CODE §547. Vehicle Equipment. §547.305.(d) RESTRICTION ON USE OF LIGHTS link	A vehicle may be equipped with alternately flashing light equipment described by section §547.701 or §547.702	Y Note: Changes to this law would be dependent on approved connected plate designs.	Y Note: Changes to this law would be dependent on approved connected plate designs.	N/A	N/A
TEXAS ADMINISTRATIVE CODE §217 Title 43 §217.27 Vehicle Registration Insignia link	Sets forth specific display requirements for license plates	Y	Y	N/A	N/A

Code Section	Code Summary	Law Needs to Change if Connected License Plate is:			
		Considered a License Plate	Considered a Display Device	Purchased Directly by Consumers	Supplied by Government to Consumers
TEXAS ADMINISTRATIVE CODE §217 Title 43 §217.32 Replacement of License Plates, Symbols, Tabs, and other devices link	When a license plate, symbol, tab or other registration device is lost, stolen, mutilated, or needs to be replaced for cosmetic or readability reasons, a replacement may be obtained from any county tax assessor-collector	Y	Y	Y	Y
TEXAS ADMINISTRATIVE CODE §217 Title 43 §217.45. Specialty License Plates, Symbols, Tabs, and other devices. link	Includes rules of specialty plates applications, refunds, and approval of specialty plates	N/A	N/A	Y	N

Code Section	Code Summary	Law Needs to Change if Connected License Plate is:			
		Considered a License Plate	Considered a Display Device	Purchased Directly by Consumers	Supplied by Government to Consumers
Texas Government Code §497. Texas Prison Made Goods Act. §497.024(a) Agencies and Political Subdivisions: Duties to Purchase link	If Texas Correctional Industries produces an article or product an agency of the state or a political subdivision may purchase the article or product only from TCI	N/A	N/A	N	Y
Texas Government Code §497. Texas Prison Made Goods Act. §497.024(b) Agencies and Political Subdivisions: Duties to Purchase link	Provides that if the comptroller finds that TCI is not able to fill a requisition for an article or product then the agency may purchase the article or product from another source	N/A	N/A	N	N

Code Section	Code Summary	Law Needs to Change if Connected License Plate is:			
		Considered a License Plate	Considered a Display Device	Purchased Directly by Consumers	Supplied by Government to Consumers
Texas Government Code §2155. Purchasing: General Rules and Procedures §2155.065. Contracts with Department of Criminal Justice link	Deals with Comptroller’s office making a contract with TCDJ for the purchase of goods and services by another agency	N/A	N/A	N	N
Texas Government Code §2155. Purchasing: General Rules and Procedures §2155.066. Review of Specifications link	Provides for Comptroller’s office to review specification and purchase conditions of good and services	N/A	N/A	N	N

Code Section	Code Summary	Law Needs to Change if Connected License Plate is:			
		Considered a License Plate	Considered a Display Device	Purchased Directly by Consumers	Supplied by Government to Consumers
Texas Government Code § 2155. Purchasing: General Rules and Procedures §2155.067 Proprietary Purchases link	Provides for procedures approving purchase by an agency of a proprietary product	N/A	N/A	N	N

Appendix 2: Pilot Plan

Summary

This plan to pilot connected license plates on commercial motor vehicles includes two-phases. This pilot has been developed to reveal information about the potential use of connected plates potential use in Texas, including legibility, law enforcement usability, and carrier usability. The pilot will generate qualitative and quantitative data gathered under both ideal and real-life conditions.

Phase I would use off-road testing to determine license plate legibility for both humans and license plate readers in ideal conditions. Additionally, a brief survey would identify the usefulness of connected plates for law enforcement. Finally, a marketability survey would identify how likely motor carriers would be to adopt an alternative technology.

Phase II would use real life, on-road testing on a regional basis using a particular roadway. The regional on-road test is designed to further understand law enforcement officer's use of the technology, and ALPR legibility in real-life conditions. A test of toll station license plate readers would also be conducted. Additionally, a brief survey would document participating motor carriers' response to connected plate technology. Phase II would require any participating connected plate manufacturers to work with the TxDMV to complete a data update test as well.

House Bill 1959 requires voluntary participants in this pilot program to provide the necessary funding to administer the pilot. To ensure the State of Texas learns as much as possible about these new technologies and encourages participation, it is recommended that connected plate providers be able to participate in some tests, but not all if funding is the primary limitation of not being able to participate in all

tests. Of course, this means that those plates not subjected to the full rigor of testing could not be approved for use on Texas roadways. Their inclusion in tests, specifically those in Phase I, could provide invaluable information to decision-makers about what a connected plate needs to be able to do to be as useful as possible to the State of Texas.

Table 4. Pilot Test Phases, Test Name, and Expected Outcome

Phase	Test	Outcome
Off-Road	License Plate Legibility	Quantitatively determine if plate meets AAMVA requirements Note: This test must be passed to participate in the on-road portion of the pilot test.
Off-Road	Registration Legibility	Quantitatively determine if plate meets AAMVA requirements Note: This test must be passed to participate in the on-road portion of the pilot test.
Off-Road	Legibility Qualitative Survey	Qualitatively determine the usefulness of plate design for law enforcement
Off-Road	License Plate Reader Legibility	Quantitatively determine connected plate legibility using a license plate reader affixed to a law enforcement vehicle

Phase	Test	Outcome
Off-Road	Marketability Survey	Qualitatively determine motor carriers' general receptiveness to connected plates to understand the benefits of incorporating connected plates in the State
On-Road	New Waverly License Plate Reader Test	Quantitatively determine stationary license plate reader legibility at a commercial motor vehicle weigh station
On-Road	New Waverly Qualitative Survey	Qualitatively determine the usefulness of plate design for law enforcement
On-Road	Toll Station License Plate Reader Test	Quantitatively determine toll entity license plate reader legibility
On-Road	Data Update Test	Determine the minimum requirements for sharing data with third-party and assess if the shared information has been updated on the desired plate

Phase	Test	Outcome
On-Road	Carrier Participant Qualitative Survey	Qualitatively determine motor carrier receptiveness to connected plates to understand the benefits of incorporating connected plates in the State

Pilot Test Costs

Given the controlled and short duration of the pilot, it is estimated that the pilot should be able to be completed for \$300,000 or less not including the DPS and the TxDMV employee costs.

The Details

Phase I: Off-Road Testing

This phase would test the digital plates for human legibility, ALPR legibility, and law enforcement usability. The phase is divided into three tests and includes two surveys. One survey of law enforcement officers and one of motor carriers. The three tests are:

1. A License Plate Legibility Test based on the AAMVA License Plate Legibility Testing Guidelines for Reflective Sheeting,
2. A Registration Status Legibility Test adapted from the AAMVA License Plate Legibility Testing Guidelines for Reflective Sheeting, and
3. ALPR Legibility Testing based on draft United States Department of Justice's draft Mobile License Plate Reader System Standard for Law Enforcement.

A brief survey would be given to all law enforcement officers before and after these tests to gauge the perceived usefulness of connected license plates for law enforcement purposes.

A brief survey will also be given to motor carriers to gauge the perceived usefulness of connected plates for their purposes. Should motor carriers not find connected plates useful, but law enforcement finds them useful, law enforcement would not be able to obtain the maximum benefits unless plates were made mandatory. However, Texas has an interest in being a business-friendly state.

It is recommended all the tests in this phase be administered at the Texas Department of Public Safety Florence Test Track. This recommendation requires permission from the Executive Director of the Texas Department of Public Safety.

License Plate Legibility Test

Phase: Off-Road

Duration: One (1) day

Time of Day: Day and Night

Participants Required: Minimum of 5, including a mix between different law enforcement entities and the civilian population.

The license plate legibility test will evaluate the legibility of the participating plates according to the AAMVA License Plate Legibility Testing Guidelines for Reflective Sheeting found in Appendix 3. This test will use the current standard, apportioned metal license plates as the control. In order to pass the test, the plates must be read with 100% accuracy by at least 80% of participants.

Note: Any plate that does not meet the AAMVA legibility standard may not be eligible to participate in the on-road portion of the pilot test.

Two license plates per design will be required for this test. The intended outcome of this test is to quantitatively determine if the participating plates meet AAMVA requirements.

Registration Legibility

Phase: Off-Road

Duration: One day

Time of Day: Day and Night

Participants Required: Minimum of five law enforcement officers

The registration legibility test will evaluate the legibility of the participating plates according to modified AAMVA license plate legibility standards. Refer to the original AAMVA License Plate Legibility Testing Guidelines for Reflective Sheeting in Appendix 3.

Note: Currently there are no AAMVA standards on registration legibility, therefore if a plate does not pass it will not be excluded from participating in the on-road test but does provide more information for policy-makers.

This test will use the current windshield registration sticker and apportioned metal plates with expiration dates as the control group.

The AAMVA test should be modified to test three statuses instead of license plate characters: 1) valid registration, 2) invalid registration, and 3) distress. Distress can either be a specific distress signal, such as, 'Stolen' or may be a general distress signal. These three statuses will be displayed to participants in a random series of seven status changes. Seven has been chosen to include the same number of reads as a standard seven-character license plate.

In order to pass the test, the random series of seven registration statuses displayed must be read with 100% accuracy by at least 80% of participants.

Additional modifications to the license plate legibility test are necessary. The first modification is to conduct the test from 35 feet as opposed to 75 feet in the original AAMVA test. This is done because generally the registration credential is smaller than the license plate and therefore the distance for the credential would need to be closer. Conduct the test on commercial motor vehicles as opposed to passenger vehicles on the AAMVA test because the placement of credentials on

commercial motor vehicles may present unique issues. Finally, a law enforcement patrol vehicle should be used by the readers in the test because this test is only related to law enforcement's ability to identify a status change.

There is an additional survey referenced on page 66 that should be administered immediately after this test has been completed.

Legibility Qualitative Survey

Phase: Off-Road

Duration: Less than a day

Participants Required: The same law enforcement participants in both license plate and registration legibility tests

The Legibility Qualitative Survey consists of a survey developed by the research team and administered to participants of both the license plate and registration legibility tests. The purpose of this survey is to qualitatively determine the usefulness of plate designs for law enforcement. This survey should be administered immediately upon completion of the Registration Legibility test to all participants.

Note: Survey questions have not been developed as a part of this plan to ensure the questions are relevant to the participating connected plates.

Automated License Plate Reader Legibility

Phase: Off-Road

Duration: 1 day

Time of Day: Day and Night

Participants Required: None

The Automated License Plate Reader Legibility test will evaluate the legibility of connected plates using ALPRs. Currently, there are no AAMVA standards for license plates and ALPRs. Therefore, the proposed test is adopted from standards on ALPRs drafted by the United States Department of Justice in 2015.

Three parking positions will be tested: 1) parallel parking, 2) angled parking (120 degrees), and 3) right-angled parking (90 degrees). An ALPR will be attached to a law enforcement vehicle where it will test each parking position at two speeds: 1) 15 mph and 2) 40 mph.

Current metal license plates should also be tested as a control group for this test.

To evaluate the ALPR legibility of the plate the number, the total number of accurate reads from each test scenario will be divided by the total number of license plates in the test (20) to determine the percent accuracy. The use of twenty plates is a modification from the current DOJ test because only the specific plate designs included in the study need to be evaluated.

This is not a pass/fail test and a connected plates accuracy will not affect its participation in the on-road test since no standards exist. The goal of the test to gather as much information as possible on these plates for policy makers.

Note: A standard RFID test was not identified, but it would be helpful to conduct a similar test to this test using RFID-enabled connected plates with RFID readers instead of ALPRs.

Marketability Survey

Phase: Off-Road

Duration: Variable depending on motor carrier response

Participants Required: Dependent on the number of motor carrier participants

The research team will develop a marketability survey to be administered to motor carriers to gauge initial receptivity to connected license plates. This survey will have the purpose of determining the general receptiveness of connected plates from motor carriers.

The survey should be designed to qualitatively determine motor carriers' general receptiveness to connected plates to understand the benefits of incorporating connected plates in the state.

Phase II: On Road Testing

The on-road test would be on I-45, between Dallas and Houston, utilizing 25-30 combination commercial motor vehicles for a period of two weeks. I-45 was selected because DPS has a well-equipped weigh station at New Waverly with plate readers, etc. to provide additional test information. Test messages would be pushed to the plates to determine if law enforcement is able to read and respond to the data displayed.

This phase would test the connected plates for:

- What information needs to be exchanged between a connected plate manufacturer and the TxDMV (license plate #, USDOT #, TxDMV #, owner's name, etc.),
- How the connected plates work with stationary license plate readers,
- How the connected plates work with tolling authority license plate readers,
- Is the connected plate usable for law enforcement in real-world conditions, and
- Receptivity of motor carriers to connected plates.

This phase will also include three tests and two surveys. The tests are:

- A DPS stationary license plate reader test,
- Toll station license plate reader test on the Hardy Toll Road near I-45, and
- A data update test.

A survey will be given to law enforcement officers at the New Waverly station to gauge the usefulness of the technology in real-world applications.

Additionally, a survey will be given to motor carrier participants to gauge their interest in the technology.

New Waverly Automated License Plate Reader Test

Phase: On-road

Duration: 2 weeks

Time of Day: 24 hours a day

Participants Required: 25-30 truck tractors

The DPS New Waverly Automated License Plate Reader (ALPR) Test will use weigh station ALPRs to capture license plate images from truck tractors' front license plate on I-45 at the New Waverly weigh station and compare those captures to the total number of times a vehicle passed through the weigh station to determine a percent accuracy.

This test will quantitatively determine stationary license plate reader legibility at a commercial motor vehicle weigh station.

To conduct the test, affix a participating plate design to the front of a truck trailer for the duration of the two-week test.

Each participating plate will need to be flagged in the ALPR database so that Texas Department of Public Safety officials can retrieve the records at the end of the two-week test. At the conclusion of test, DPS officials will send the total number of times a given alphanumeric pattern was captured during the two-week period. DPS officials will need to indicate if the ALPR read the front or back plate. If this is not possible, the images will also need to be provided to researchers for visual verification.

Similarly, at the conclusion of the test, participating motor carriers will provide the GPS coordinates, including trip routes, to researchers so that the total number of times the weigh station was passed through during the test can be verified.

The total number of times a vehicle passed through the New Waverly weigh station will be compared to the total number of times the vehicles plate was captured from the front license plate to determine a percent accuracy. A survey

should also be developed for those officers working at the New Waverly station during this two-week period. More information about the survey is available on page 71.

Note: A standard RFID test was not identified, but it would be helpful to conduct a similar test to this test using RFID-enabled connected plates with RFID readers instead of ALPRs.

New Waverly Qualitative Survey

Phase: On-road

Duration: Dependent on survey response rate

Participants required: Include all DPS officers working at New Waverly during the test period

Plates Required per Design: 1 front plate per truck tractor

The New Waverly Qualitative Survey will be developed by the research team to determine law enforcements' assessment of the connect-plates at the New Waverly weigh station and is dependent on the on-road test participants. This survey should be designed to better understand the real-world use of connected plates for law enforcement and whether they could improve law enforcement activities or processes.

Toll Station Automated License Plate Reader Test

Phase: On-Road

Duration: 2 weeks

Time of Day: Day and Night

Participants Required: 25-30 truck tractors

Plates Required per Design: 1 front plate for each truck tractor

The Toll Station Automated License Plate Reader (ALPR) Test will use toll station ALPRs to capture license plate images from truck tractors' front license plate on the Hardy Toll road and compare those captures to the total number of times a vehicle passed through a toll station to determine a percent accuracy.

This test will quantitatively determine stationary license plate reader legibility at a toll station.

To conduct the test, affix a participating plate design to the front of a truck trailer for the duration of the two-week test.

Each participating plate will need to be flagged in the tolling authority database so that the tolling authority officials can retrieve the records at the end of the two-week test. At the conclusion of test, tolling authority officials will send the total number of times a given alphanumeric pattern was captured during the two-week period. Authorities will need to indicate if the ALPR read the front or back plate. If this is not possible, the images will also need to be provided to researchers for visual verification.

Similarly, at the conclusion of the test, participating motor carriers will provide the GPS coordinates, including trip routes, to researchers so that the total number of times a toll station was passed through during the test can be verified.

Data Update Test

Phase: On-Road

Duration: 2 Weeks

Time of Day: Day and Night

Participants Required: 25-30 truck tractors

Plates Required per Design: 1 front plate for each truck tractor

This test is designed to validate the ability of the connected plate to relay status changes throughout the duration of the on-road pilot. This will allow researchers to determine if the plate can change its status to accurately reflect the TxDMV's records. The TxDMV will also be able to gauge how much change would be necessary to the information databases to allow for a full-scale implementation of the connected plate.

The TxDMV will need to provide any participating third-party plate provider with a table of Vehicle Identification Numbers (VIN), license plate alphanumeric patterns, and registration expiration date for each participating vehicle.

Additionally, each day of the two-week test, the TxDMV will send one of three unique statuses to display on the plate. The statuses will include: "The Lone Star State", "TxDMV.gov" and a blank display. The TxDMV will need to work with third-party plate providers to determine if the data updates can be completed with license plate numbers only, VIN only, or a combination of the two.

To validate the change, the vehicle operator will be responsible for sending a picture of the plate to the test administrators at a designated time each day of the test. Test administrators will need to work with motor carriers to determine an appropriate time.

At the end of the test, the research team will evaluate the pictures sent from motor carriers and the data tables provided to third-party plate providers to determine if the data were being updated accurately. This test will help determine the minimum requirements for sharing data with connected plate manufacturers and assess if

the shared information has been updated on the desired plate. Additionally, a survey should be developed for motor carrier participants to understand the usefulness of the connected plate for their purposes. See page 76 for more information.

Carrier Participant Qualitative Survey

Phase: On-Road

Duration: Dependent on participant response rate

Participants Required: 25-30 truck tractor operators

The Carrier Participant Qualitative Survey will survey of all motor carriers participating in the pilot to determine if the benefits of the connected plate are significant enough for the State of Texas to begin full-scale implementation of connected plates on Texas roads. This survey cannot be developed until the participants in the pilot have been determined. This test should be designed to help qualitatively determine motor carrier receptiveness to connected plates.

Appendix 3: Interviews

Entity	Interviewee	Title
3M Science	Kyle Crangle	Regional Sales Manager
3M Science	David Pointon	Business Manager, State and Local Government Relations
3M Science	Sara Sachde	Chief Operating Officer of Blackridge
American Association of Motor Vehicle Administrators	Catherine Curtis	Director, Vehicle Programs
American Association of Motor Vehicle Administrators	Casey Garber	Manager, Vehicle Programs
Arizona Department of Transportation	Eric Jorgensen	Director, Motor Vehicle Division
California Department of Motor Vehicles	Sandra Ancira	Unit Manager
California Department of Motor Vehicles	David Galucia	Governmental Program Analyst
California Department of Motor Vehicles	Eric Sutter	Registration Operations Division

Entity	Interviewee	Title
California Department of Motor Vehicles	Phaung Wang	Contract Administrator
Compliance Innovations	Dick Butcher	Chief Financial Officer
Federal Motor Carrier Safety Administration	Rodney Baumgartner	Texas Program Manager
Federal Motor Carrier Safety Administration	Tom Kelly	Manager, Innovative Technology Department (ITD)
Federal Motor Carrier Safety Administration	Tom Liberatore	Division Chief, State Programs
International PROOF Systems	Rachel Hankerson	Chief Executive Officer, Founder
International Registration Plan, INC.	Tim Adams	Chief Executive Officer
MyPlates	Steve Farrar	President
MyPlates	Jake Posey	Consultant
Red Flag	Dean Naddeo	Chief Executive Officer, Founder
Reviver Auto	Neville Boston	Chief Executive Officer, Co-Founder
Reviver Auto	Reed Clay	Consultant

Entity	Interviewee	Title
Reviver Auto	Brandi Lites	Director of Legislative Affairs
Ruan Trucking	Williams Burns	Operations Leader
Ruan Trucking	Jonathon Martindale	Austin Trucking Lead
Ruan Trucking	Chris Reiman	Terminal Manager
Ruan Trucking	Dan Van Alsteine	President, Chief Operations Officer
Texas Department of Criminal Justice	Kirk Moss	Deputy Director, Texas Correctional Industries
Texas Department of Criminal Justice	Darin Pacher	Deputy Division Director
Texas Department of Criminal Justice	JoAnn Rawlinson	Deputy Director, Financial Operations
Texas Department of Motor Vehicles	Jimmy Archer	Director of Motor Carrier Division
Texas Department of Motor Vehicles	Renita Bankhead	Assistant Chief Financial Officer
Texas Department of Motor Vehicles	Whitney Brewster	Executive Director

Entity	Interviewee	Title
Texas Department of Motor Vehicles	Jeremiah Kuntz	Director of Vehicle Titles & Registration
Texas Department of Motor Vehicles	Caroline Love	Director of Government & Strategic Communications
Texas Department of Motor Vehicles	Shelly Mellott	Deputy Executive Director
Texas Department of Motor Vehicles	Grady Meyer	CVISN Program Manager, Motor Carrier Operations
Texas Department of Motor Vehicles	Jonathan O'Quinn	Deputy Chief Information Officer
Texas Department of Motor Vehicles	Taurie Randermann	Government Relations Specialist
Texas Department of Motor Vehicles	Tom Shindell	Innovation & Strategic Analyst
Texas Department of Motor Vehicles	Candy Southerland	Chief of Registration
Texas Department of Motor Vehicles	Clint Thompson	Chief of Titles
Texas Department of Motor Vehicles	Tim Thompson	Deputy Director of Vehicle Title & Registration Division

Entity	Interviewee	Title
Texas Department of Public Safety	Chris Nordloh	Major, Texas Highway Patrol, Commercial Vehicle Enforcement Programs.
Texas Trucking Association	John Esparza	President and Chief Executive Officer

Appendix 4: AAMVA License Plate Legibility Testing Guidelines for Reflective Sheeting

Appendix: AAMVA License Plate Legibility Testing Guidelines for Reflective Sheeting

Policy

The American Association of Motor Vehicle Administrators (AAMVA) endorses the concept of a uniform motor vehicle registration license plate system. In addition, AAMVA recommends that member jurisdictions adopt the following standards:

1. Two license plates should be issued for all passenger type vehicles and single unit trucks. One plate can be issued for tractors, motorcycles, and all types of trailers.
2. License plates should prominently display the name of the jurisdiction and the registration number. The date of registration expiration shall be displayed on the vehicle by means of a reflecting validating sticker on the rear license plate, except on vehicles that are required or permitted to have only one license plate, or those plates manufactured with an expiration date and for which a sticker is not required. Secondary decals should be placed on the windshield for jurisdictions that have multiple uses for the stickers. New validating stickers may be issued upon renewal of registration in lieu of issuing new plates for the vehicle.
3. License plates should be manufactured in two sizes, depending on their use. Passenger type vehicles, tractors, trucks, trailers, etc., should be issued standard 6" x 12" plates. Smaller plates measuring 4" x 7" may be used on motorcycles or other small vehicles.
4. License plates can be issued for multi-year periods and should be reissued on a regular basis to insure that the information they display remains legible.
5. Fully reflective license plates should be adopted and used.
6. Motor vehicle agencies should consult with jurisdictional, and if applicable local law enforcement representatives, prior to adopting new license plate standards or designs.
7. Jurisdictions should use a standardized format for all license plates, including specialty plates.
8. License plates must be readable in daylight and night using low beam headlights, under optimal conditions at a distance of no less than 75 feet.
9. Duplication of alpha/numeric combinations is discouraged to allow accurate retrieval of vehicle registration information.
10. Reflective decals should be color-coded and with durable printing. Motor vehicle agencies should consult with jurisdictional, and if applicable local law enforcement representatives, prior to adopting new color schemes for registration stickers.
[Amended 2003]

Design Guidelines

The design guidelines listed here are based on knowledge gained from both laboratory and field testing of legibility of reflective license plates and signs. These guidelines should be considered by motor vehicle administrators to ensure a readable license plate design. Consult with jurisdictional, and if applicable, local law enforcement representatives prior to adopting new license plate standards or design.

Note: For those jurisdictions employing the exposed lens reflectorized license plate process, a dark non-reflective background with contrasting light reflecting (white or yellow preferably) alpha numerics would be acceptable for both standard and graphic design license plates if they meet the 75 foot readability criteria.

Background Color

White (optimum)

Yellow

Pastels / Toned Colors / Other background colors are possible (See Graphics, below)

Alpha Numerics

Colors in recommended order for contrast with *white* background:

1. Black
2. Green (transparent or opaque)
3. Blue (transparent or opaque)
4. Brown (transparent or opaque)
5. Red (transparent or opaque)

Colors in recommended order for contrast with yellow background:

1. Black
2. Opaque Blue, Green, or Brown
3. Red (transparent or opaque)

Transparent colors must be coated dark enough to provide adequate color intensity and contrast ratio.

Minimum **contrast ratio** between the alpha numeric colors and the background is 4-to-1, that is, the background is 4 times brighter than the alpha numeric (Olson & Sivak, 1983).

Size of alpha numerics should be maximized to provide best legibility.

Spacing between characters should be at least equal to the stroke width.

Graphics

Jurisdiction name character color should provide a good color contrast with the background color.

Graphics provided behind the alpha numerics should be avoided. When desired in a design, these graphics should never exceed 30 percent of full color strength to maintain good contrast with the alphanumeric.

Use of a standardized format for specialty plates.

Legibility Testing

This test is designed to eliminate illegible license plates. It is not designed to provide the optimal legibility or identify the maximum legibility distance. The test procedure measures legibility accuracy in stationary vehicles. The rear plate legibility is assessed as if the observer were trying to read the plate of a lead car. The front car test places the observer in the position of identifying the plate of an approaching car. If jurisdictions wish to test legibility for plates of marked cars, the target car position can be changed appropriately and the lights turned off.

Test Preparation Recommendations

License Plates

The license plate(s) to be tested should be fabricated in the same manner as in-use plates if possible. For consistency across different jurisdictions, we recommend the use of mixed numbers and letters for the test plate(s). The number and grouping of alphanumeric should be in accordance with the jurisdiction's policy. If more than one plate design is being tested, different legends should be used on each plate to avoid memorization. Likewise, different plates with different legends should be used for the front and rear tests, and the day and night tests. So, four unique plates will be needed for a complete evaluation.

Substantial differences in the ease of legibility exist across letters and numbers. Legends containing medium difficulty alphanumeric should be used. Combinations that form words, or pronounceable non-words (e.g. CUZ), or familiar acronyms (e.g. FBI) should be avoided as these are recognized and remembered better than random arrangements. Likewise, series of numbers or letters (e.g. 123, DEF) should be avoided. Recommendations for average difficulty combinations are listed below (based on Zwahlen, 1991):

<i>LLL NNN</i>	<i>NNN LLL</i>	<i>LNL NLN</i>
UPJ279	729KET	B3W4Z3
PWF407	299MSA	C6Y4D5
XKU240	924PJN	C9S9Y7
KPJ290	475PCV	C3T3Y6
CFY392	070WRH	D9X3C9

<i>LLL NNN</i>	<i>NNN LLL</i>	<i>LNL NLN</i>
XOW427	803PKV	C7H4Z9
MWF039	469YZU	D4N7T9
KCY304	404UXN	D3G9P4
PYJ739	702PRD	C3X5J6
MKO024	772TGF	C4A8X7

Test Location

The same test location should be used for both the day and night sessions if possible. A location should be selected that has a low background complexity. There should be no moving traffic, commercial signs, or pedestrians in the background to interfere with the test. The location should be dark at night with no overhead lighting or light sources from buildings or commercial signs in the background. The road used should be level, smooth asphalt. The roadway should be dry, as wet roads can reflect a significant amount of light and bias the testing. A minimum distance of 150 feet is necessary with a minimum width of 24 feet or two standard lane widths.

Suggestions for appropriate locations include parking lots (provided there is no overhead lighting), driving test exam roads, private driveways (provided there is enough distance).

Vehicle Selection & Preparation

Two vehicles will be needed for the test. It is recommended that similar passenger cars be used for both the observer's car and the target car on which the test plates will be placed. The target car should have its headlights and taillights off for the rear plate night test. This is recommended to reduce differences across vehicles due to taillight design. For the front plate test, the target car should have its low-beam headlights on.

The headlights on both cars should be cleaned and aimed properly prior to the testing (headlight aiming guidelines can be found in the Society of Automotive Engineers Ground Vehicle Lighting Manual, 1991). The observer's car should use both low-beam headlights and high-beams only for the nighttime test. The windshield of the observer car should be clean and free of cracks or pits that may interfere with viewing.

Patrol cars should not be used for the test vehicles, as they are often marked with reflective materials and the extra lights and words present on most official vehicles could be distracting.

The test license plates should be mounted in the standard center front and rear position. If direct mirror reflection occurs from the observer's car headlights, the plate should be tilted back 5 degrees.

Vehicles should be positioned in the same lane for the rear plate test and in the oncoming lane for the front plate test.

Test Subject Selection & Instruction

Test subjects should be selected according to each jurisdiction's needs. Law enforcement officers are likely candidates and should be included. Be aware that law enforcement officers in general have excellent eyesight and are well-practiced in reading license plates. For this reason, their accuracy on the legibility test may be much higher than average citizens. It also would be appropriate to include average citizens in the testing as their license plate reading abilities should be included in design decisions for plates to be legible in accident and crime witness reports. Only licensed drivers should be used.

Subjects should not be allowed to see the test plates prior to testing. They should be unaware of the letters and numbers being used in the study. For this reason, those people arranging the testing should not participate as subjects in the legibility test.

Subjects should be tested alone, seated in the driver position of the car. It is important to have the subject in the driver position because of the geometry of the headlights illuminating the license plates. Subjects should be tested alone so that the responses are unbiased by others' opinions. They can report their responses either to an experimenter in the car or via radio to an experimenter positioned near the target car. Subjects should be instructed to be as accurate as possible and to guess when not certain. A guess is better than responding "blank" or "I didn't see it." Often in tasks such as these, a guess is found to be accurate even when confidence in the answer is low.

A minimum number of five subjects is recommended. Ideally, a range of ages should be represented in the subject group.

Testing Procedure

The measure of performance in the test will be number (or percent) of letters correctly identified. In addition, it is recommended that a subjective rating of difficulty be obtained from each subject. This rating will be particularly helpful if more than one candidate plate is being evaluated. It is possible that two plates would produce similar legibility accuracy, but all subjects could agree that one was much more difficult to read than another.

The test conditions proposed here are rather ideal. When other factors are introduced (e.g. motion, poor weather, dirt on license plate), the legibility in the field could significantly worsen. Any plate judged to be difficult to read in these ideal test conditions may prove impossible to read when any worsening factors are introduced. Because of these ideal testing conditions, a strict pass/fail criterion for legibility is recommended (see section below).

The distance between the subject and the car should be held constant. The exposure duration, or amount of time the license plate is visible to the subject, should also be held constant.

Testing must be conducted both day and night. It is possible for a candidate plate to appear fine at night and be illegible during the day, and vice versa.

Distance Between Cars

We recommend a distance of seventy-five (75) feet between vehicles. Legibility distances this great should be attainable with law enforcement officers as subjects. This distance will be challenging for many subjects, but the test is meant to be challenging to weed out poor license plate designs.

Subjective Difficulty Rating

In addition to the legibility test, a rating of legibility difficulty is also useful information to obtain in testing. A five-point difficulty as shown below is recommended:

1	2	3	4	5
Very Easy	Easy	Challenging	Difficult	Very Difficult

Subjects should be instructed to circle the appropriate number. Ratings of “2¹/₂” should be avoided, as they make tallying the results difficult. In analyzing this data, the average rating could be calculated (sum of the numbers divided by the number of subjects) or a frequency tabulation of each response could be presented (e.g., three people rated it #2, five people rated it #3).

Pass/Fail Criteria

This test is constructed to provide information for a “go/no go” decision. It is recommended that in order for a license plate to be judged as legible, 80 percent (4 out of 5) of the subjects should be able to *accurately identify each character* in the test as described.

If the test is being used to compare two competitive designs, the rating scale should provide useful information in the case of a tie on the legibility test.

References

- Olson, Paul & Sivak, Michael (1993). *Nighttime legibility of license plates*. University of Michigan Transportation Research Institute, Report # 83-35.
- Fricke, Jon (1986). *Human information processing and license plate design*. Transportation Research Record # 1093.
- Zwahlen, Helmut (1991). *Reflective license plate material: Evaluation of conspicuity and legibility performance for a standard license plate configuration using beads on paint versus reflective sheeting*. Arizona Department of Transportation, Research Project HRP – PL-1 (39)358, Study Log Number 93-2-0005.

Appendix 5: United States Department of Justice Draft Mobile License Plate Reader Test Guidelines Excerpt

Complete document available at: <https://www.justnet.org/video-standards-rfp/DRAFT-Mobile-LPRS-Standard-June-25-2015-Final.pdf>

6.2.7.2.3 Download the System Audit Log, and verify that the diagnostic check is documented as being performed upon system startup, at least every 60 seconds, and for every simulated malfunction listed above.

6.2.7.3 Report

6.2.7.3.1 Each trial result and observations shall be documented and reported.

6.2.8 Power Variation Test Method

6.2.8.1 Shutdown and remove power from the LPRS.

6.2.8.2 Connect the system to a DC power source to the rated supply voltage plus 10% and switch the system on. Perform the *System Operation Test* as specified in Section 6.2.6. Switch the system off. Record observations and results.

6.2.8.3 Decrease the DC power source to the rated supply voltage minus 10% and switch the system on. Perform the *System Operation Test* as specified in Section 6.2.6. Switch the system off and disconnect from the DC power source. Document observations and results.

6.2.8.4 Reporting

6.2.8.4.1 Data, observations, and results shall be documented and reported.

6.3 Mobile LPRS Field Test

6.3.1 Overview

6.3.1.1 Test Scenarios

Each LPRS shall be evaluated for performance in three test scenarios:

- (1) Basic parking: This scenario simulates cars, with rear license plates, parked perpendicular to the direction of the LPRS travel.
- (2) Angled parking: This scenario simulates cars, with rear license plates, parked at an angle to the direction of the LPRS travel.
- (3) Parallel parking along city streets with LPRS moving at lower speeds: This scenario simulates cars, with rear license plates, parked along a city street parallel to the curb in the same direction as the LPRS travel.

6.3.1.2 Systems Under Test

At least one LPRS installed on a vehicle shall be put through the testing. Each system under test (SUT) shall be fully described on the *LPRS SUT Data Sheet*⁵, which shall be provided as part of the test report. *Note: A supplier may opt to test more than one LPRS.*

6.3.1.3 Pre-job Briefing

A safety briefing shall be performed prior to beginning the testing, including at least the following topics:

⁵ Data sheets are included in Appendix C.

- Overview of hazards that may be encountered during setup and testing.
- Radio communications to inform personnel whenever vehicles are in motion.
- Maintaining a safe distance from the testing area unless performing a specific role for testing.

6.3.1.4 Testing Participants

6.3.1.4.1 Test Leader – The Test Leader has authority over all personnel participating during testing and over all activities at the testing site and has responsibility for ensuring safe practices during testing. The Test Leader has “Stop work” authority.

6.3.1.4.2 Vehicle Coordinator – The Vehicle Coordinator is responsible for documenting each SUT on the *LPRS SUT Data Sheet* and ensuring that each system is ready to be tested.

6.3.1.4.3 Scenario Setup Personnel – These individuals are responsible for the positioning of all test targets for each scenario.

6.3.1.4.4 Test Administrator – The test administrator is responsible for verifying that all steps are taken in the correct order and as specified to ensure the validity of the test.

6.3.1.4.5 Observer – This individual is responsible for documenting results and observations from each test run on the appropriate *Test Run Data Sheets*.

6.3.1.4.6 Vehicle Driver – This individual is responsible for verifying that the LPRS is ready and functioning properly prior to each test run, driving the vehicle at the specified speed and distance from the test targets, and verifying that the LPRS performed as expected during each test run.

6.3.1.4.7 Speed Taker – This individual is responsible for monitoring and relaying to the Observer the speed of the vehicle at a specified point during each test run as an external confirmation of the vehicle speed.

6.3.1.5 Test Targets

6.3.1.5.1 A set of 50 license plates shall be used as the test targets. The testing organization, purchaser, and/or supplier shall select the test targets based on the license plate characteristics listed below:

- (1) At least 20 plates with solid light background and dark alphanumerics.
- (2) At least 5 plates with solid dark background and light alphanumerics.
- (3) At least 5 plates with dark background having graphics and light alphanumerics.
- (4) At least 5 plates with solid light background having graphics and dark alphanumerics.
- (5) At least 5 with two stacked characters.
- (6) At least 5 flat (i.e., printed) plates.
- (7) At least 5 embossed (i.e., stamped) plates.
- (8) At least 10 with serif font.

(9) At least 10 with san-serif font.

Note: A single test target may include more than one of the listed characteristics (e.g., dark background with stacked characters).

6.3.1.6 Test Conditions

6.3.1.6.1 Daylight conditions

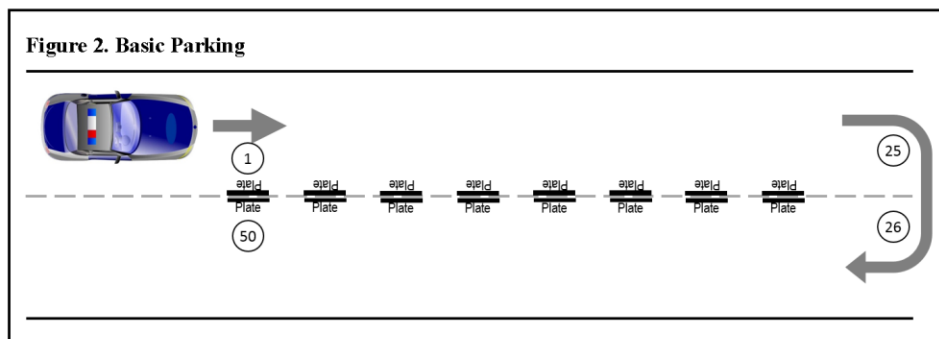
6.3.1.6.2 No precipitation

6.3.1.6.3 Dry roads

6.3.1.7 Basic Parking Scenario Setup

The *Basic Parking Scenario Setup Sheet* with test target numbers identified is provided, and spacing is as described below and illustrated in Figure 2:

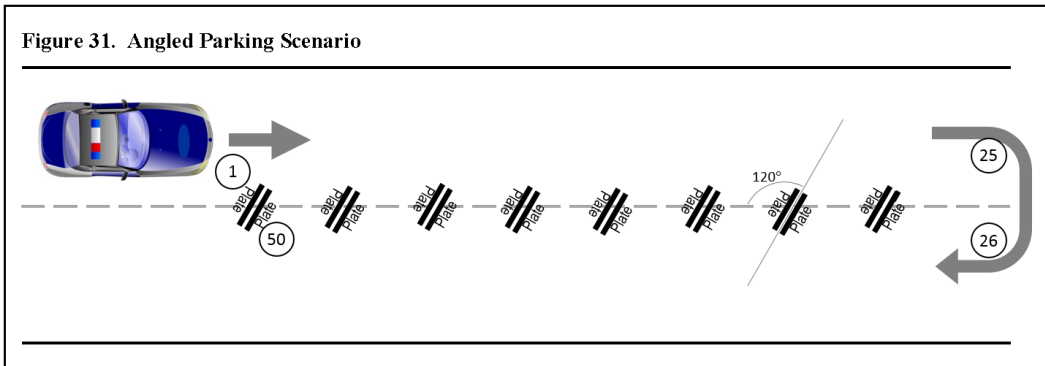
- 50 test target stands with a total of 50 test targets (one per stand). The mounting holes on the top of each test target shall be 30 inches from ground level.
- Double row of test stands placed back-to-back on the centerline of the test track such that the plates are parallel to the centerline. *Note: Figure 2 does not show all of the required test stands.*
- Distance between each pair of test target stands: 10 feet (left edge to left edge).
- Each test target will be given a position designation of 1 through 50 and positioned in sequential order with respect to the direction of LPRS travel.
- The vehicle shall be driven at constant speed, centered in the left side lane (with respect to the vehicle direction) of the two-lane track until the first 25 plates are passed. The vehicle shall be turned around, and this step shall be repeated for the next 25 plates.



6.3.1.8 Angled Parking Scenario Setup

The *Angled Parking Scenario Setup Sheet* with test target numbers identified is provided, and spacing is as described below and illustrated in Figure 3:

- 50 test target stands with a total of 50 test targets (one per stand). The mounting holes on the top of each test target shall be 30 inches from ground level.
- Double row of test stands placed back-to-back on the centerline of the test track such that the plates are at a 120-degree angle to the centerline. *Note: Figure 3 does not show all of the required test stands.*
- Distance between each pair of test target stands: 10 feet (left edge to left edge).
- Each test target will be given a position designation of 1 through 50 and positioned in sequential order with respect to the direction of LPRS travel.
- The vehicle shall be driven at constant speed, centered in the left side lane (with respect to the vehicle direction) of the two-lane track until the first 25 plates are passed. The vehicle shall be turned around, and this step shall be repeated for the next 25 plates.

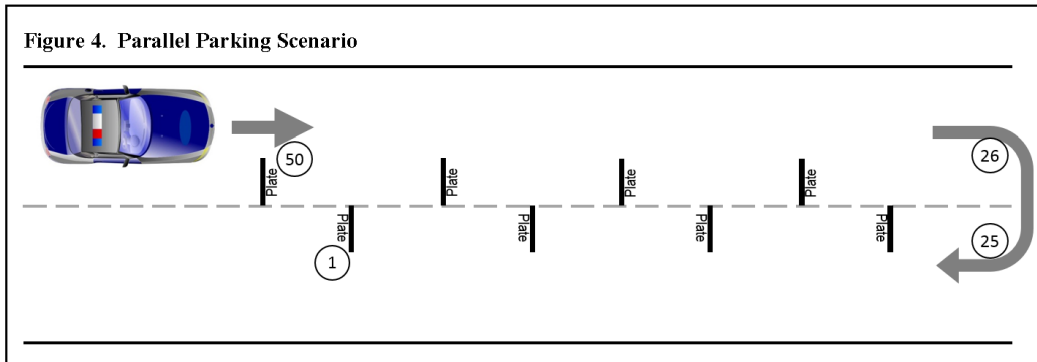


6.3.1.9 Parallel Parking Scenario Setup

The *Parking Scenario Setup Sheet* with test target numbers identified is provided, and spacing is as described below and illustrated in Figure 4:

- 50 test target stands with a total of 50 test targets (one per stand). The mounting holes on the top of each test target shall be 30 inches from ground level.
- Single row of test target stands with a single test target on each and placed on the centerline of the test track. Test target stands shall be staggered with the inside edge on the centerline. *Note: Figure 4 does not show all of the required test stands.*
- Test target stands with plates positioned as shown in Figure 4 with respect to the direction of LPR travel. *Note: The staggering of stands and positioning of the plates is for the purpose of limiting the time which the LPRS camera can view the plate of interest.*
- Distance between each test target stand: 10 feet.

- Each test target will be given a position designation of 1 through 50 and positioned in sequential order with respect to the direction of LPRS travel.
- The vehicle shall be driven at constant speed, centered in the left side lane (with respect to the vehicle direction) of the two-lane track until the first 25 plates are passed. The vehicle shall be turned around, and this step shall be repeated for the next 25 plates.



6.3.1.10 Test Method

- 6.3.1.10.1 The Vehicle Coordinator shall complete the *LPRS SUT Data Sheet* for each SUT prior to beginning test runs.
- 6.3.1.10.2 The SUT shall be put through each scenario in test runs performed according to the details below:
 - Only one LPRS camera unit viewing (i.e., all other LPRS camera units shall be masked or turned off) for each test run.
 - Three passes at 15 mph and three passes at 40 mph.
- 6.3.1.10.3 An independent video camera shall be installed on the vehicle and positioned in alignment with the viewing direction of the LPRS camera unit in use.
- 6.3.1.10.4 The test setup shall be completed as described in the appropriate scenario.
- 6.3.1.10.5 The Observer shall complete page one of the *Test Run Data Sheet* and complete the subsequent pages as the test run occurs.
- 6.3.1.10.6 The Test Administrator shall verify the following and complete the *Test Run Start Checklist*⁶:
 - (1) All personnel ready, including Observer, Vehicle Driver, and Speed Taker.
 - (2) SUT on and operational.
 - (3) START and END slates entered in alert list.
 - (4) LPR camera units masked, if necessary.

⁶ Appendix E includes the *Test Run Start Checklist*.

- (5) Independent video camera in place.
- 6.3.1.10.7 The Test Administrator shall perform the following at the start of each pass of a test run:
- (1) Activate independent video camera recording.
 - (2) Show START slate to SUT until an alert is sounded.
 - (3) Speak the SUT time of the alert and the pass identifier.
- 6.3.1.10.8 The Observer shall record on the *Test Run Data Sheet* the following information for each pass of a test run.
- (1) Test identification.
 - (2) Pass identifier.
 - (3) SUT time of alert spoken by Test Administrator.
 - (4) Vehicle speed noted (out).
 - (5) Vehicle speed noted (back).
 - (6) Time from SUT alert of END slate.
- 6.3.1.11 The Test Administrator shall verify that LPRS reads from the SUT were recorded and shall stop recording on the independent video camera.
- 6.3.1.12 Data Collection
- 6.3.1.12.1 A test report shall be provided for each SUT and shall include lists, data sheets, and electronic files described below:
- 6.3.1.12.2 List of test targets, with state, plate number, and photograph, in the order positioned in the test setup(s).
- 6.3.1.12.3 *Test Run Start Checklist* for each test run.
- 6.3.1.12.4 Data sheets – The *LPRS SUT Data Sheet* and *LPRS Test Run Data Sheet* shall be completed for each SUT.
- 6.3.1.12.5 Independent video camera – video for each pass of each scenario to verify plate order and position.
- 6.3.1.12.6 LPRS SUT data – exported file in format (machine-readable) specified.
- 6.3.1.12.7 LPRS results from exported files.
- 6.3.1.12.8 Contextual photos exported from SUT.
- 6.3.1.12.9 Plate images exported from SUT.
- 6.3.1.12.10 OCR – Number of definitive reads (taken from file exported from SUT).
- 6.3.1.12.11 Required metadata (necessary for performing analysis following the test runs).

6.3.2 Reporting

6.3.2.1 Data, observations, and results shall be documented and reported.

7. Labeling and Information

7.1 General Product Label Requirements for Mobile LPRS Models

7.1.1 For each compliant LPRS model, the requirements of this section shall be met.

7.1.2 The system shall have a product label permanently and visibly attached to, stamped on or printed on the recording unit housing of the system.

7.1.3 All text on the required product label shall be at least in English.

7.1.4 Symbols and other graphical information shall be permitted to be used to supplement text on the product label(s) and shall be explained in the user information.

7.1.5 The housings of the recording unit and of each camera unit of the system shall have at least the following information printed legibly on the label(s) in letters at least 3.2 mm (1/8 inch) high:

- Legal name and legal address of the supplier.
- Manufacturing location address (city, state/province, country).
- Date of manufacture (i.e., month and year).
- Model number.
- Serial number.

7.2 User Information to Be Provided by Supplier of LPRS Model

7.2.1 The supplier shall provide written user information including, but not limited to, warnings, information and instructions with each LPRS (and with each system-level component that may be acquired or provided separately). The supplier shall provide the required user information in such a manner as to make such information clear, prominent, and immediately available to any individual opening the package.

7.2.2 The supplier shall provide at least the following instructions and information with each system:

- Information required in Chapter 4.
- System-level components tested with the system. System-level components shall be identified by model number with allowable substitutions (including model numbers and specifications).
- Instructions for proper installation and use as intended by the supplier, including safety considerations and user-definable settings.
- Warranty information.
- Proper care and maintenance instructions, including cleaning, inspection guidelines and frequency, recommended operating temperature range, recommended storage