KENTUCKY TRANSPORTATION CENTER
176 Raymond Building, University of Kentucky
859. 257. 4513 www.ktc.uky.edu

Kentucky Vehicle License Plate Study

Kentucky Transportation Center Research Report — KTC-16-11/SPR16-518-1F
DOI: http://dx.doi.org/10.13023/KTC.RR.2016.11

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Kentucky Transportation Center
176 Oliver H. Raymond Building
Lexington, KY 40506-0281
(859) 257-4513

www.ktc.uky.edu

Research Report
KTC-16-11/SPR16-518-1F

Kentucky Vehicle License Plate Study

By

Valerie Keathley, PhD
Research Associate

Andrew Martin, PhD
Senior Research Scientist

Jerry Kissick, PE
Research Engineer

Gray Forlines
Research Associate

and

Jennifer Walton, PE
Program Manager

Kentucky Transportation Center
College of Engineering
University of Kentucky
Lexington, Kentucky

In Cooperation With
Kentucky Transportation Cabinet
Commonwealth of Kentucky

January 2017

1. Report No. KTC-16-11/SPR16-518-1F	**2. Government Accession No.**	**3. Recipient's Catalog No**
4. Title and Subtitle Kentucky Vehicle License Plate Study		**5. Report Date** February 2017
		6. Performing Organization Code
7. Author(s): Valerie Keathley, Andrew Martin, Jerry Kissick, Gray Forlines, Jennifer Walton		**8. Performing Organization Report No.**
9. Performing Organization Name and Address Kentucky Transportation Center College of Engineering University of Kentucky Lexington, KY 40506-0281		**10. Work Unit No. (TRAIS)**
		11. Contract or Grant No. SPR 16-518
12. Sponsoring Agency Name and Address **Kentucky Transportation Cabinet** **State Office Building** **Frankfort, KY 40622**		**13. Type of Report and Period Covered** Final Report
		14. Sponsoring Agency Code

15. Supplementary Notes
Prepared in cooperation with the Kentucky Transportation Cabinet

16. Abstract

This study assesses Kentucky's options for potentially re-plating all motor vehicles registered in the Commonwealth. The report begins with a background and discussion of Kentucky's plate production processes, the difference between flat and embossed plates, and the structure of license plate labor at the Kentucky State Reformatory in La Grange. It details current plate production costs and processes, along with fees and production numbers. It evaluates three scenarios for future plate production: flat plate production, a hybrid system with embossed general issue plates and flat specialty plates, and an embossed plate system with in-house printed sheeting. Also included is an analysis of the effects of license plate characteristics on automated license plate reader accuracy, which has implications for automated screening and tolling. From there, the policies and approaches of other states are discussed. The report ends with a discussion of implementation costs, challenges, and strategies for state officials.

17. Key Words tax, fee, vehicle regulation, license plate production		**18. Distribution Statement** Unlimited with KYTC permission	
19. Security Classification (report) Unclassified	**20. Security Classification (this page)** Unclassified	**21. No. of Pages**	**19. Security Classification (report)** Unclassified

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Executive Summary

The Kentucky Transportation Cabinet (KYTC) has not re-plated the vehicles it licenses in more than a decade. Re-plating entails equipping all currently registered vehicles with a newly designed license plate when the vehicle next comes up for renewal. Newly purchased vehicles and vehicles transferred from other states would also require the new plates. State officials are gradually running out of the six-digit alphanumeric combinations used on current standard issue license plates. At the same time, a trend has emerged since the early 2000s, with several states adopting digitally printed flat plates to replace traditional, embossed plates. Consequently, Kentucky is about to reach a crossroads. The purpose of this study is to evaluate the options available to Kentucky for re-plating. Specifically, the report evaluates the costs of the current system as well as three systems that could be used to replace it. This study also considers the impact of license plate characteristics on license plate readers (LPRs). LPRs play a critical role in automating commercial vehicle enforcement and coordinating electronic tolling. Finally, the research appraises implementation costs, challenges and strategies, which officials can use to guide their decision making.

Inmate labor is used to produce license plates, decals, and stickers at the Kentucky State Reformatory in La Grange, Kentucky, where operations are managed by Kentucky Correctional Industries. Currently, 41 states use inmate labor to produce license plates. This approach gives inmates the opportunity to receive job training while states benefits from inexpensive labor, the price of which cannot be matched by public- or private-sector organizations. Private vendors provide supplies, equipment, and logistical support. Plate warehousing and shipping is handled by the Department of Vehicle Regulation's Motor Vehicle Licensing Division, while over-the-counter customer transactions are processed by county clerks. In 2015, the cost of producing and distributing plates to county clerks was $1.37 million in 2015 — an average of $1.83 per plate if new equipment costs are included ($1.79 if excluded).

If there is a decision made to re-plate vehicles, there are three alternatives to the current production system that Kentucky could consider — a flat-plate production system, a hybrid system which produces embossed standard issue plates and flat specialty plates; and an enhanced embossed plate production system with in-house printed sheeting. Each system would require capital investments in new production materials, including printers, sheeting, ink, and other components. The cost of purchasing this equipment ranges from $175,000 to $500,000 depending on the production system adopted. Making these capital investments will drive up the cost per plate during the first year of re-plating. However, in the following years, the average cost per plate is forecast to be $1.96 per plate under flat-plate production system, $1.72 per plate under a hybrid system, and $1.74 per plate with the enhanced embossed plating production system. These figures are well below the average cost per plate in other states.

Before implementing a new system, lawmakers and officials need to examine several issues. First, embossed plates are very unlikely to be counterfeited, allow for the use of less expensive sheeting, do not require additional materials, allow for cheaper long-run plates, can be read more easily by law enforcement, require less capital investment, and provide more jobs for inmates than flat-plate production. However, producing flat plates does not require additional tasks after blanking, is more energy efficient and eco-friendly, requires less space for inventory, decreases mailing costs, reduces labor costs, supports on-demand printing and elimination of excess inventory, and LPR

systems read them accurately a higher percentage of the time compared to embossed plates. Flat plates could also mitigate workflow issues for commercial vehicle enforcement and enhance potential collections from electronic tolling on the Louisville-Southern Indiana Ohio River Bridges Project. However, transitioning from embossed plates to flat plates is not always a smooth process. At least two states — Nevada and North Carolina — have returned to embossed plates after being dissatisfied with flat plates.

Another potential avenue to improve efficiency and achieve cost savings is to adopt a centralized distribution model. Under this model, license plates would be mailed directly from the Kentucky State Reformatory (or another chosen production facility) to customers instead of having people pick them up at county clerk offices. Theoretically, there are several options available under this production scenario — all plates or specialty plates could be issued from a central production facility while standard issue plates are shipped to county clerks. However, current statutory requirements hold that county clerks must distribute license plates. If officials want to introduce a centralized production system, state laws and regulations will require modification to proceed.

Chapter 1 Introduction

This report examines vehicle registration plating options available to the Kentucky Transportation Cabinet (KYTC). Currently, KYTC produces traditional embossed license plates using prison labor at the Kentucky State Reformatory (KSR). The Motor Vehicle Licensing (MVL) division wants to identify cost savings associated with moving to one of two types of production systems: 1) flat, digitally printed license plates or 2) a hybrid production system in which embossed plates are used for general issue plates and digitally-printed flat plates are reserved for specialty and personalized plates.

Registration plates are produced by inmate labor and distributed at the 155 county clerk offices. Currently, KYTC maintains a contract with Kentucky Correctional Industries (KCI) to produce license plates. After production, they are shipped to the MVL plate warehouse in Frankfort, where county stickers are applied and orders filled. From there, they are mailed (or transported if nearby) to clerks' offices around the state.

The state has not reissued plates in over 10 years. Reissuance would require all vehicles to be equipped with a new, redesigned plate at the next renewal date. Most of Kentucky's current license plates are the general issue vehicle registration plates with Unbridled Spirit or In God We Trust (IGWT) themes. Kentucky also offers 17 miscellaneous plates for exempt vehicles, official and commercial vehicles; 28 plates for Kentucky universities and independent colleges; 25 military-themed plates; and 35 plates for various organizations and causes. Handicapped and motorcycle plates are also available.

Several states transitioned to flat plates during the 2000s because they can be less expensive to produce than embossed plates, cheaper to ship, and reduce unsold inventory. However, this is not the case for all states. In fact, industry experts have noted that state administrators often switch to flat-plate production without studying whether flat-plate production would benefit their state. This report will assist KYTC in its assessment of whether shifting to flat plates is appropriate for Kentucky's budget. Specifically, this paper compares the costs of embossed and flat plates. Information was solicited and best practices summarized from states that have transitioned to flat plates or that implemented a hybrid production process. In addition, the study discusses the legal statures that govern vehicle registration plates.

This report contains an appendix which includes the following: results from the AAMVA survey; a table that includes the plate image, KRS, and cost for customers; a table with fee allocation for each plate; the original estimate, and the details for the JR Wald estimate.

1.1 Background on License Plate Production in the United States

The American Association of Motor Vehicle Administrators (AAMVA) is a highly influential advocacy group for vehicle licensing and driver licensing agencies, and it is important to consider the best practices they recommend for state agencies. AAMVA recommends standardizing the production and appearance of motor vehicle license plates.1 License plates should be reflective and easy to see by other drivers and law enforcement. The association supports a national standard

[1] AAMVA. (2012). *Best Practices Guide for Improving Automated License Plate Reader Effectivenss through Uniform License Plate Design and Manufacture* .

for license plates to improve license plate reader accuracy, which is critical for revenue collection and highway safety. However, AAMVA does not recommend a particular material or plate production process, probably due to the controversial nature of the debate surrounding plate types.

States do not always implement AAMVA recommendations. AAMVA supports the use of front and back registration plates in all 50 states. Proponents of this practice claim it is easier for law enforcement to identify cars, improves surveillance at border crossings, and enhances toll collections. In total, 31 states require front-and-rear display for license plate, while 19 only require rear-plate display.2 Kentucky requires rear-plate display only. Motorists object to the cost of buying two plates because it is more expensive and some contend front plates detract from the aesthetics of the car. Figure 1 shows states that require front and rear registration plates (green) and states where they are not required (yellow).

[2] Matthew Izzi. *License Plate Laws*, Legal Match. http://www.legalmatch.com/law-library/article/license-plate-laws.html.
Melissa Walden et al. (2012). *Front License Plate Market Research: Comparison of Single Versus Dual License Plates*. Texas A&M Transportation Institute.

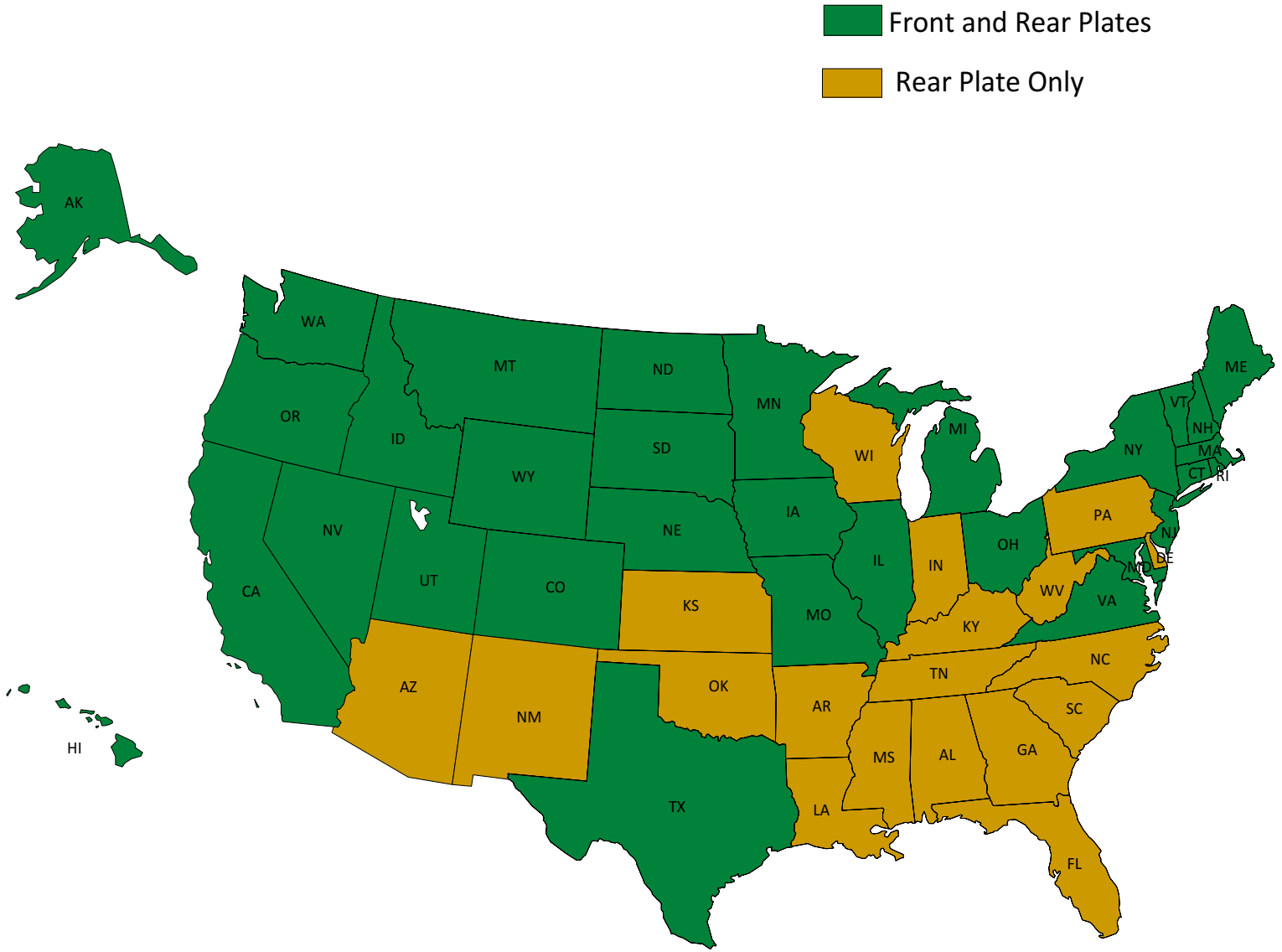

Figure 1 States that Require Front and Rear Plate Display

1.2 The History of License Plate Requirements and Production Technologies

License plates became necessary in the 1900s as the use of automobiles increased. Plates helped states ensure vehicles were properly registered and improved their nighttime visibility.[3] New York was the first state to require motor vehicle registration; by 1915, most states required that drivers pay a registration fee and display a license plate.[4] Since then, license plate materials, usage, production, and distribution have evolved. Plates are still used to indicate that a vehicle is properly registered and to facilitate vehicle and owner identification. They can also be personalized to reflect individual preferences; their production even provides a source of labor for prison inmates.[5]

The introduction of the retro-reflective license plate in the 1920s decreased the number of nighttime crashes and made it easier for law enforcement officials to identify vehicle owners and the state in which the car is registered.[6] Retro-reflectivity refers to the amount of light from a car's headlights that hits a license plate and reflects to the source of the light. Retroreflective sheeting is now a standard feature on license plates in all 50 states. By the late 1970s it was possible to use preprinted graphics on license plate sheeting, which let states to distinguish their plates from one another.[7] By the 1990s it became possible to produce digitally printed flat plates.

Currently, 3M is the primary supplier of the equipment and software needed to produce flat plates. 3M and Avery Dennison are the main suppliers of reflective sheeting. JR Wald is the oldest and most widely used vendor for embossed plates but offers a competitive system to produce digitally printed flat plates. Many states have adopted flat plates because enables on-demand printing is used, which can decrease inventory and labor costs because less labor is needed for production. Material costs also typically decrease following a transition to flat plates because the thin-gauge aluminum used in their production is lighter than what is employed on standard embossed plates. Other states, like Ohio, use a hybrid system where standard issue plates are embossed, while the specialty plates are flat plates.

Most of the states which now distribute flat plates (e.g., Indiana, Montana, South Dakota, Texas) transitioned during the 2000s.[8] The most recent states to adopt flat plating are Georgia, New Jersey, and North Dakota. However, the flat plate trend may be slowing, and some states have reverted to embossed plates. Nevada and North Carolina returned to embossed plates after an unsatisfactory experience with flat plates.[9]

Figure 2 identifies states that only produce flat plates (dark green), embossed plates (yellow), or which use a hybrid system (light green with hash marks). In addition, the map shows states that

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[3] International Association of Chiefs of Police. (2009). *Privacy Impact Assessment Report for the Utliization of License Plate Readers*.

[4] Robert C. George and Gerald R. Webster. (1997). "Heart of Dixie" on the Alabama License Tag: Where Did It Come from and Does It Represent the Past, the Future, or Both? *International Social Science Review.* 72, 1/2.

[5] Amy Riley Lucas. (2008). Specialty License Plates: The First Amendment and the Intersection of Government Speech and Public Forum Doctrines , *UCLA Law Review.* 55,1971.

[6] Walden et al. *Front License Plate Market Research: Comparison of Single Versus Dual License Plates*.

[7] AAMVA. *Best Practices Guide for Improving Automated License Plate Reader Effectivenss through Uniform License Plate Design and Manufacture*.

[8] Andrew Turnbull. *March of the Flats*. http://www.andrewturnbull.net/plates/flat.html.

[9] Cullen Browder. *Dmv Scraps Flat Plates.* http://www.wral.com/news/local/story/4623731/.
Geoff Dornan. (2015, June 28). Nevada Dmv Opening New License Plate Plant in Carson City. *Nevada Appeal.*

transitioned to flat plate production but which returned to embossed plates (grey, striped). Twenty states distribute flat plates, 19 states distribute embossed plates, and eight states use a combination of embossed and flat plates.

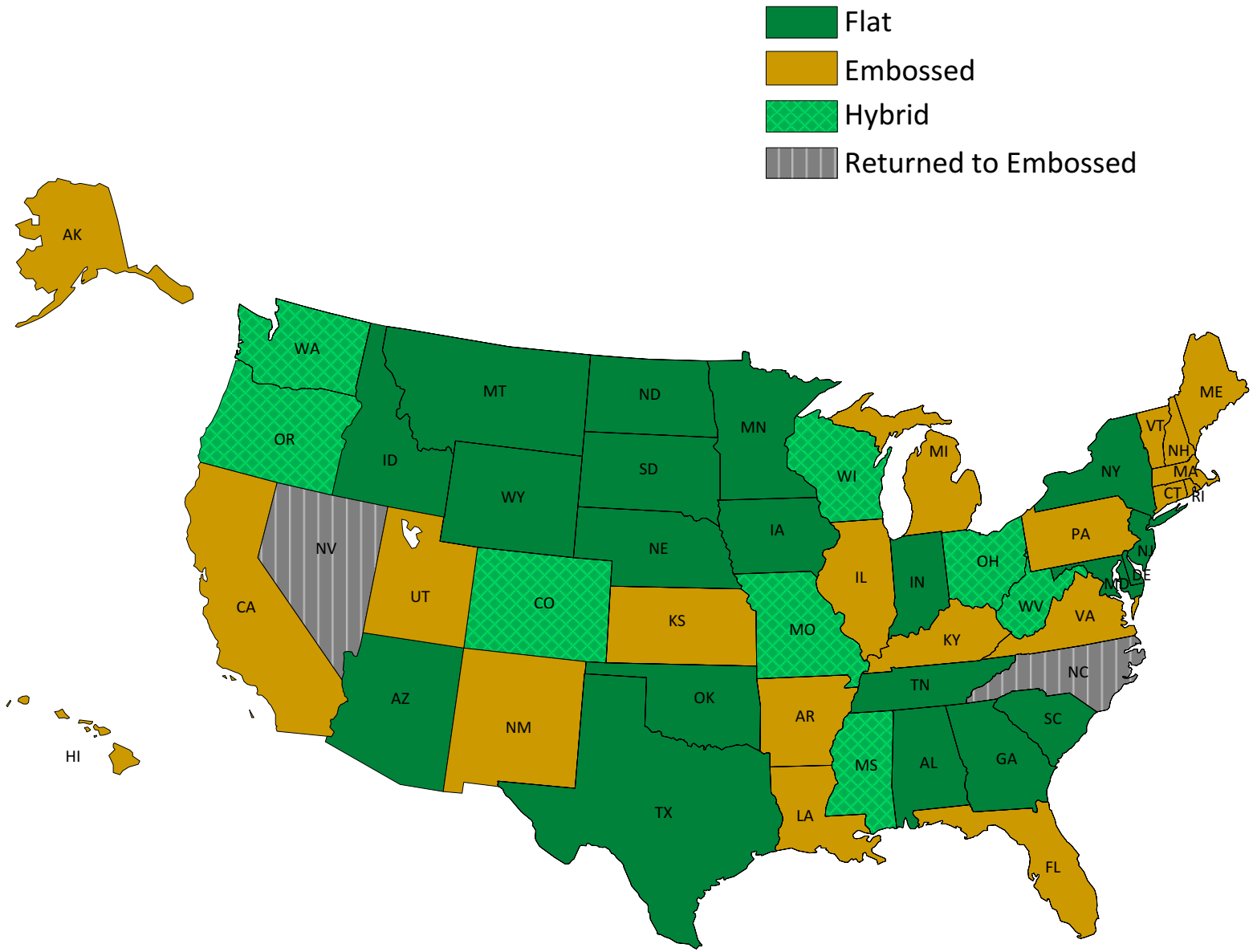

Figure 2 State License Plate Production Types

Specialty Plates

Advances in printing technology allow states to offer more design options for license plates, and many states permit specialty plates to raise revenue for the state and for charitable causes.[10] Specialty plates can be created by motor vehicle administrative agencies or legislatures, and often contain the logo or slogan associated with specific organizations, such as the military, universities, and non-profit associations. States have expressed concerned about the rapid proliferation of specialty license plates, particularly those which maintain an embossed plate inventory.[11] As a result, many states have an application process to introduce new specialty plates and require a specific number of paid pre-orders before a new one enters production. States that use hybrid production and distribution operations can limit unused inventory through on-demand printing operations.

Specialty plates can express state pride, nationalism, charity support, and personal identity.[12] For example in Canada, French-speaking provinces issue plates in French, highlighting their unique identity among English-speaking citizens.[13] Several court cases have arisen out of controversy over logos. These cases have focused on issues such as license plates supporting the Confederate Sons of America (CSA) organization[14], the display of pro-life messages, and the use of profanity on personalized plates. In general, courts have found that states must maintain neutrality if the plate expresses a particular viewpoint. However, these rulings have also affirmed a state's right to maintain decency standards as long as those standards do not counteract free speech protections.

License Plate Readers

License plate technologies have also evolved over decades, giving rise to license plate readers (LPR). An LPR uses cameras to acquire images of a license plate and decodes its alphanumeric characters using optical character recognition (OCR). Once decoded, the registration number is screened against state and nationwide databases, which house information about registrants and the jurisdiction in which vehicles are licensed. LPRs can be installed in mobile or static locations including police cruisers, fixed stations, mobile platforms, and handheld devices.15 LPRs help states collect toll bills, improve security at point of entries, identify stolen cars, send Amber alerts, and aid in criminal investigations.

Efforts to improve LPR accuracy rates are ongoing. Accuracy rates are affected by the design and condition of plates, lighting, weather conditions, and where the plate is located on a vehicle. The growing number of specialty plates, background designs, and the use of multiple colors or stacked

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[10] AAMVA. (2010). *Vanity Plate Law Matrix*.
Lucas. *Specialty License Plates: The First Amendment and the Intersection of Government Speech and Public Forum Doctrines* .
[11] Florida House of Representatives. (2004). *Summary Analysis of Changes to Specialty License Plates*. Florida House of Representatives Staff (Ed.). Florida.
[12] AAMVA. *Vanity Plate Law Matrix.*
Jonathan Leib. (2011). Identity, Banal Nationalism, Contestation, and North American License Plates. *Geographical Review,* 101, 1.
[13] *Identity, Banal Nationalism, Contestation, and North American License Plates.*
[14]Robert C. George & Gerald R. Webster. (2001). "Heart of Dixie" on the Alabama License Tag: Where Did It Come from and Does It Represent the Past, the Future, or Both? *International Social Science Review,* 72, 1/2.
[15] Walden et al. *Front License Plate Market Research: Comparison of Single Versus Dual License Plates*.
Police. (2012). Privacy Impact Assessment Report for the Utliization of License Plate Readers. *Automated License Plate Recognition Systems: Policy and Operational Guidance for Law Enforcement.*

letters pose challenges for maintaining high LPR accuracy. There is also a concern that flat plates negatively affect LPR accuracy. Even with these problems, LPRs help law enforcement improve efficiency because it lets them screen more plates than would be possible without the technology. Chapter 4 provides an analysis of LPR accuracy for flat plates and embossed plates.

1.3 Embossed and Flat Plate Production

The production process for embossed plates and flat plates are significantly different. The general processes are described below as well as the positive and negative aspects of each production system. While the descriptions for plate production are generalized, specific references to Kentucky's process are noted when appropriate.

Embossed Plates

The process begins when a customer registers their vehicle and pays for their license plate. Customers can choose from the standard issue plates or specialty plates. In the case of Kentucky and other states using embossed plates, the clerk (or authorized official) will then provide them with a license plate from the plate inventory. Under this system, all plates are ordered in bulk by the motor vehicle agencies and stamped at the production center, which is often operated by inmates in correctional institutions. At KSR, license plate production begins with a roll of raw stock aluminum, which is obtained from a vendor on a procurement basis every four years. These rolls are the width of a license plate. The aluminum is loaded onto a de-coiler, which unwinds the aluminum stock. Then it is fed into a straightener to remove dents and rolled out into an applicator, which applies graphic sheeting to the aluminum. Graphic sheeting is a long sheet of stickers with the license plate backgrounds printed on them. Once the sheeting is applied to the aluminum, it is fed into a blanking press which cuts the aluminum sheeting into plates (or blanks) and two holes are also punched out. At the LaGrange production facility in Kentucky, 5,400 plates are blanked out per hour. The blank is sent to the embossing section where the plate is inserted into a press. Then, clapper dyes stamp alphanumeric serial numbers onto plate. The plates are immersed in a clearcoat solution which protects them from the elements. Embossed plates are then sent to a thermal inking machine that colors the raised letters. Next, the plate is cured (baked) in the oven for approximately 45 minutes. After curing, each plate undergoes a quality assurance check. In some states, standard plates are typically produced in bulk and then stored as inventory until they are ordered by the motor vehicle agency. In Kentucky, plates are picked up by KYTC employees and stored at a warehouse in Frankfort. Plates are then distributed to county clerk offices.

Flat Plates

Iowa, in 2001, was the first state to adopt digitally printed flat plates for vehicle registration. Flat plate production is faster because more than one plate design can be printed without having to change sheeting.[16] The process also requires fewer workers than does embossed plate production. In Kentucky, between 55 and 60 laborers are needed for embossed plate production, whereas flat printing can decrease necessary labor force to 10 workers. Flat plates can also save on sheeting and shipping costs since they can be printed on thin-gauge aluminum sheeting.

With flat plates, customers register their vehicle, choose a standard issue plate or a specialty plate, and pay their registration fees. The registration and plate information is validated by the motor vehicle agency and sent to the production center. Orders and distribution are managed and tracked

[16] Mike Baker and Michael J. Berens. (2014, December 15). License Plates Have Cost Us So Much. *Seattle Times*.

using a database and barcodes located on the plates. Plates are designed on computers and sent to the print station where they are affixed to reflective sheeting. A protective clear overlaminate is affixed to plates, after which they are sent to the blanking section. The reflective sheeting is then cut into individual plates. Following this, plates are sent to motor vehicle agencies or directly to customers, depending on the system being used. With hybrid systems, customers usually pick up standard plates at the motor vehicle agencies and receive specialty plates in the mail. Also, states like Alabama have invested in mailing systems, which let their production team address and ship plates directly to their customers.

Positive and Negative Aspects of Embossed Plates and Flat Plates

Flat-plate production has many benefits compared to embossed-plate production. Digitally printed flat plates are more versatile and offer more design possibilities because the plates can use multiple colors in the background design; more than one design can be printed in the same run.17 Once the flat plates are blanked, production is complete.[18] In addition, specialty and personalized plates can be manufactured just as quickly as standard issue plates. In contrast, embossed plating runs can only produce one design at a time because sheeting with the background design has to be changed. With flat-plate production, there is no need to keep an inventory of sheeting, plates do not need drying time, and the process is more eco-friendly because solvents are not applied.[19]

According to JR Wald, embossed plates are more secure because the equipment and dyes are not available to the general public. On flat plates, counterfeiters can print a license plate image on a high quality laser printer, attach it to aluminum, and put it on an automobile. Because of this, states must identify security features for integration into flat plates. The visibility of flat plates is also a concern. Law enforcement officials have complained flat plates are more difficult to read than embossed plates because embossed plates have 3-D characters.[20] Also, there is little evidence to suggest that flat plates decrease LPR accuracy (see Chapter 4).

1.4 Inmate Labor and License Plate Production

Since the 1930s, most license plates have been manufactured by incarcerated persons, but prison industries also produce many other products. There is a long history of inmate labor in the United States. Inmate labor has been used in agriculture, manufacturing processes, customer service, and license plate production. Today, inmates craft furniture, provide braille transcription, run recycling programs, and make clothing. Incarcerated workers in the United States are paid anywhere from 21 cents to just over $1.00 an hour. However, it is legal to force inmates to work without pay.[21] Arkansas, Georgia, and Texas do not remunerate prison workers.[22] There are two advantages of using prison labor. Inmate labor is cheaper and saves money on production costs.[23] Additionally, proponents argue that license plate production gives inmates a productive task and provides job

[17] *Leeward Productions. Flat Digital License Plates in the United States: End of the Embossed Era*? http://www.leewardpro.com/articles/licplatefonts/licplate-fonts-nam-flat.html.
[18] Ibid.
[19] Ibid.
[20] Ibid.
[21] Whitney Benns (2015). American Slavery, Reinvented. *The Atlantic*.
[22] Cindy Upton & Sarah Harp (2009). *Cost of Incarcertating Adult Felons*. Kentucky: Legislative Research Commission.
[23] Diane Cardwell. (2012). Private Businesses Fight Federal Prisons for Contracts. *New York Times*.

training in a skilled trade that can assist them in finding employment upon release.[24] Many states have statutes requiring that license plates be produced by inmates in the correctional system. As Figure 3 shows, the vast majority of states use prison labor to produce license plates (green). A much smaller number of states use a third-party vendor or organizations that employ people with disabilities (yellow).

[24] Michael J. Berens & Mike Baker. (2014, December 13). Broken Prison Labor Program Fails to Keep Promises, Costs Millions. *Seattle Times*.
Rebecca Rosen. (2014, June 18). How Dairy Milked by Prisoners Ends up on Whole Foods Shelves. *The Atlantic*.

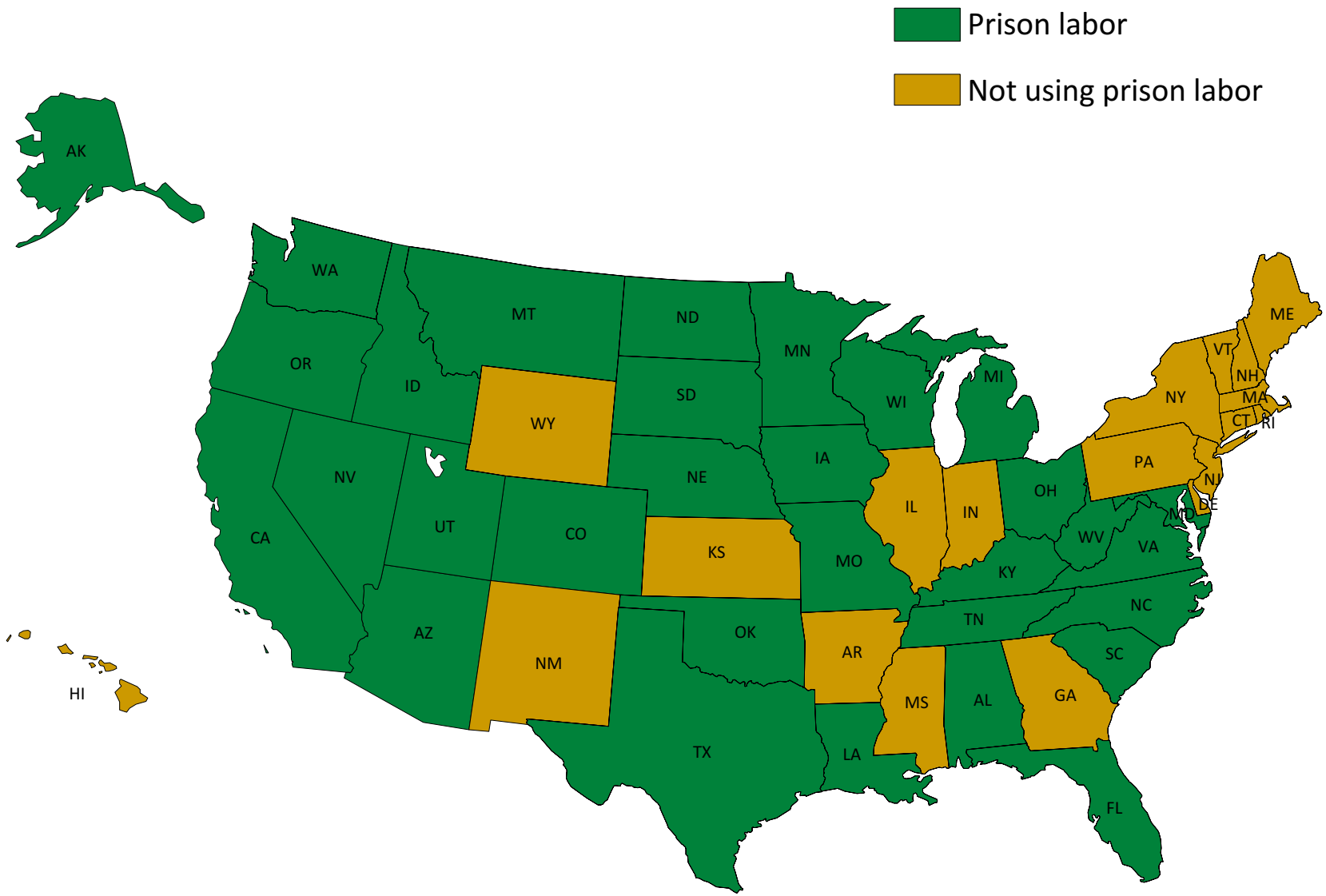

Figure 3 States Using Prison Labor for License Plate Production

License plates produced in correctional facilities are typically of the embossed style, although some states (e.g., Alabama) have inmates at maximum security prisons using digital flat printing to produce plates. Kentucky currently employs 57 inmates for license plate production, a number comparable to other operations that produce embossed plates. In comparison, a typical digital-printing flat plate operation has fewer tasks and can operate with 10 to 12 laborers. Labor needs for embossed and flat plate production are discussed further in Chapter 5.

Proponents of inmate labor contend that work gives inmates the opportunity to learn a new skill that they can use after being released, instills a work ethic, teaches interpersonal workplace skills, and gives inmates productive tasks to accomplish. Many proponents of inmate labor say this helps limit recidivism — work programs reduce recidivism by 24 percent.[25] A study conducted by Eastern Kentucky University also found less recidivism among inmate workers.[26] In addition, some inmates express pride in being productive and learning new labor and interpersonal skills.[27] Prison labor is controversial because incarcerated workers receive few protections. In addition, the low-to-no cost of labor makes it difficult for private businesses — who are legally bound to pay at least a minimum wage — to compete for contracts.

[25] Cardwell. *Private Businesses Fight Federal Prisons for Contracts.*
[26] Irina Soderstrom et al. (2000). A Descriptive Study of the Kentucky Correctional Industries Program. *Kentucky Justice and Safety Research Bulletin* 2, no. 2.
[27] Lauren Pack. (2011, June 6). Inmates Take Pride in License Plate Production. *Journal News*.

Chapter 2 Production and Distribution of License Plates in Kentucky

We interviewed representatives from the Department of Corrections (DOC), Kentucky Correctional Industries (KCI), and MVL to assess the current workflow for production and distribution of vehicle registration plates in the Commonwealth. Overall, these agencies work together quite well and appreciate the efforts of their agency counterparts. In addition, the three agencies must coordinate contracts with outside vendors for plate materials, equipment, and shipping. We collected data from MVL and KCI on plate sales, revenue, and plate production to analyze efficiency and identify available cost savings in production or distribution.

2.1 Contract Details for KCI and KYTC Agreement

MVL maintains a contract with KCI to produce embossed license plates. License plates are produced by KCI at KSR in La Grange, Kentucky. As seen in the map below, the tag plant in La Grange is one of KCI's eight manufacturing facilities, which includes a central office and product showcase in Frankfort. KCI has used inmate labor since 1954 and also manufactures home and office furniture, shelving, signage, cleaning products, clothing, Braille transcriptions, and printing services. KCI employs over 900 inmates in Kentucky correctional facilities.

The contract describes KCI's responsibilities related to the production of license plates, registration decals, and stickers for Gold Star Strips and Armed Forces Military stickers. The contract also requires a status meeting every three months. The current contract expires June 30, 2016.

The contract states that 6 million plates will be ordered over the two years it is in effect. The contract is based on the production of 70 types of standard and specialized plates, 10 decals, and 2 stickers. The contract also includes the price MVL pays for each plate type produced. The price per plate is based on KCI's labor costs, overhead, and material costs.

Under the terms of the contract, KCI is responsible for obtaining the supplies, materials for production, and maintaining and repairing the machines. KCI is also required to keep enough supplies in reserve to fill regular orders from MVL. Each month, KCI is expected to send a report to MVL that indicates their supply of the following items: sheeting, aluminum, stickers, decals, disabled placards, and county designator strips. KCI is also required to store finished plates for up to 30 days at their facility.

KYTC decides whether a plate is of acceptable quality. According to the contract, an acceptable plate has the following characteristics:

- Correct sheeting is applied
- Characters are embossed

Further, the contract holds that MVL will not be charged for unusable plates and that KCI will replace them at no additional cost. The following characteristics are symptomatic of an unusable plate:

- Ink is missing or chipped from the embossed characters,

- Ink is on the side of the embossed characters,
- Bubbles or wrinkles appear in the applied sheeting, and
- Numbers and characters are incorrectly embossed on the plate.

The contract includes a payment schedule for transactions between KYTC and KCI. For an order of less than $10,000, the entire amount is due at the time of order (Table 1). If the invoice amount is $10,000 or more, 50 percent must be paid at the time of the order, and the balance is due within 30 days after receiving the invoice.

Table 1 Payment Timeframes for KCI Contract

Amount of Order	Payment
Less than $10,000	• 100 % is due at the time of order
$10,000 or more	• 50 % is due at the time of the order. • 50 % is due within 30 days of receiving itemized invoice with details

MVL also has obligations under this agreement. It provides graphics for new and redesigned plates and obtains approval for production plates. MVL also applies county stickers to all plates.

Table 2 summarizes the costs for standard and specialty plates. The cost per plate includes the cost of sheeting, aluminum, prison overhead, and labor (for both KCI and the inmates). These costs have not been renegotiated since 2009.[28] On average, KCI charges KYTC $3.00 per plate. Exact costs are based on the number of colors in the background graphics. The two standard-issue plates — Unbridled Spirit and In God We Trust — cost $1.98 and $2.25, respectively. The Historic Motor Vehicle plate is the most expensive, costing $4.48, while the least expensive plates are for Apportioned Weight Trucks, Limousines, Airport, Bus, and Taxis, costing $1.97 each. Military and specialty plates all cost over $3.00 each (Table 2).

[28] Upton and Harp. *Cost of Incarcertating Adult Felons.*

Table 2 Contractual Cost for License Plates

Plate Name	Cost	Plate Name	Cost
Air Force	$3.27	**Kosair Children's Hospital**	$3.59
Airport	$1.97	**Law Enforcement**	$3.36
All Motorcycles	$1.76	**Legislative**	$2.87
All Truck Weights	$1.86	**Limousine**	$1.97
Amateur Radio	$2.24	**Lineman**	$3.59
Apportioned Weight Truck	$1.97	**Louisville Zoo**	$3.59
Army	$3.75	**Marines**	$3.27
Autism Awareness	$3.36	**Masonic**	$3.53
Breast Cancer	$3.29	**Medal of Honor**	$3.02
Bus	$1.97	**Military Reserve**	$2.96
Child Victim	$3.22	**National Guard**	$3.22
Choose Life	$3.11	**Navy**	$3.31
City/County Official with Seal	$2.75	**Unbridled Spirit**	$1.98
Civil Air Patrol	$2.70	**Pearl Harbor Survivor**	$3.74
Coast Guard	$3.31	**Purple Heart**	$3.74
Commercial Vehicle Tag	$1.97	**Quail Unlimited**	$3.36
Gold Star Spouse	$2.84	**Recreational Vehicle**	$2.07
Historic Motor Vehicle	$4.48	**Ryder Cup**	$3.36
Horse Council	$2.80	**Share the Road**	$3.36
House, Camping & Truck Trailer	$1.97	**Spay & Neuter**	$3.70
Hummingbird	$3.36	**State Official**	$2.75
I Support Veterans	$3.51	**State Police**	$2.77
In God We Trust	$2.25	**Street Rod**	$3.02
Judicial-Issued in sets of two	$5.86	**Taxi**	$1.97
Keeneland Association	$3.59	**University Plates**	$2.96
Kentucky Colonel	$3.36	**Utility Trailer**	$1.97
Kentucky Sportsman	$3.54	**Average Cost Per Plate**	$3.00

2.2 Kentucky Correctional Industries

KCI specializes in producing products using inmate labor at Kentucky correctional institutions. Almost half of KCI's revenue comes from KYTC and DOC. Currently KCI's annual revenue is around $10 million. However, revenue has been as much as $14 million (FY 2006 — the last time Kentucky reissued plates).[29] KCI markets their products to state agencies, although anyone in the Commonwealth can purchase consumer goods manufactured by KCI workers. State agencies are required by law to request a bid from KCI and must have a legitimate reason for not awarding them a contract. According to KCI, many state agencies have gotten into the habit of not soliciting bids from KCI. Currently KCI is working to re-establish a vendor relationship with state agencies and is overhauling its website, which contains the organization's mission and products.

[29] Ibid.

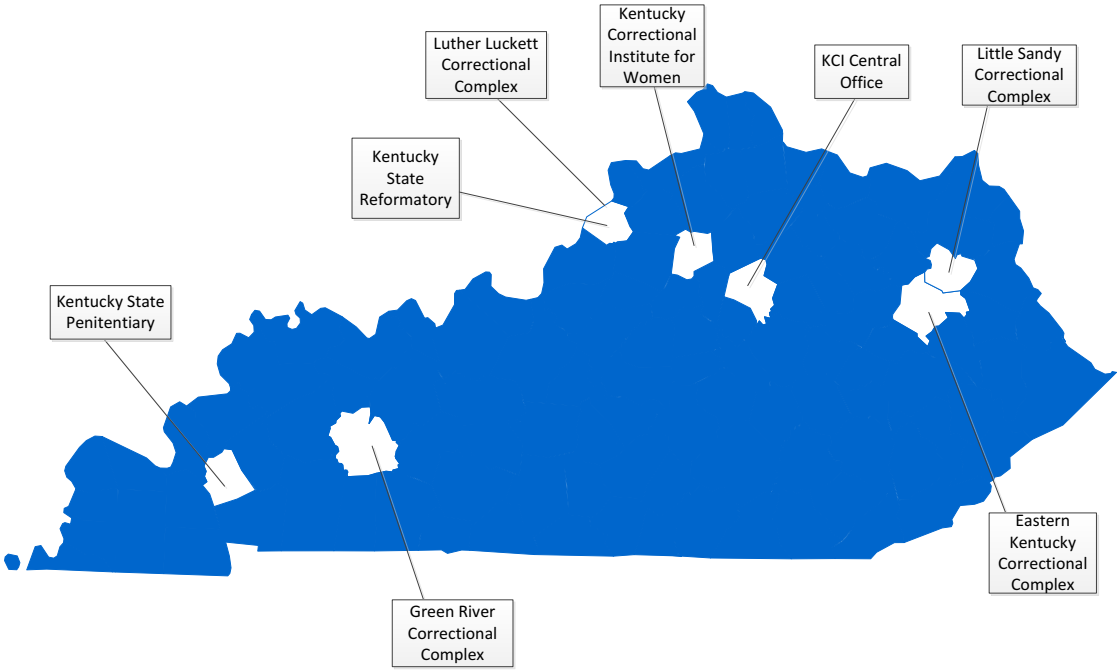

Figure 4 Location of KCI Manufacturing Facilities and Central Office

2.3 The Tag Plant at KSR

Prison inmates have produced vehicle registration plates in Kentucky since at least the 1930s, most recently at KSR, a medium security facility with the largest correctional institute population in the state. The tag plant produces embossed license plates and, as of December 2015, employs 57 inmates. Inmates receive 45 cents per hour for their labor. Currently, they produce standard plates, specialty plates, personalized plates, decals, and stickers. Plate inventory is kept in a warehouse in Frankfort owned by KYTC.

There are a variety of jobs for inmates at the tag plant including janitors, number coders, press operator, and machine maintenance. Inmates are paid through KCI, not through DOC or KYTC. The plant operates on a five-day workweek. Since the workers must undergo a pat-down before and after their shift, the work day is 6.5 hours rather than the traditional eight-hour shift. Transitioning to flat plates will significantly impact the number of available jobs for KSR inmates. KCI estimates that a flat plate system would decrease labor needs from 57 workers to 10, which amounts to an 82.5 percent drop.

The KCI facility at La Grange is financially self-sufficient. Revenues cover supervisors' salaries, inmate pay, supplies, equipment, and maintenance. Since they operate on DOC property, KCI does not have to budget funds for rent, utilities, or security. KCI has contracts with Avery Dennison and JR Wald for sheeting and equipment services. KCI uses historical projections to order sheeting, and they keep enough materials on hand to fulfill a rush order for MVL.

Under the current system, MVL receives orders from the 120 county clerk offices and places orders with KCI. MVL's order specifies the number of plates needed, types of plates, the specific alphanumeric serial number, and when they should be delivered. MVL employees are responsible for picking the plates up from KCI and shipping them to the county clerk offices for distribution. KYTC pays KCI through purchasing orders once they approve the quality and receive the order.

2.4 Challenges in the Plate Manufacturing and Distribution

Both MVL and KCI have stated they have a good working relationship with each other. However, there are always challenges in any manufacturing setting, particularly in the supply chain. KCI has adjusted suppliers and work practices to ensure they are able to meet their contractual obligations with KYTC. KCI recently switched from 3M to Avery Dennison for its sheeting needs due to an ongoing issue with not receiving orders on time. Occasionally the sheeting supply through Avery Dennison has been delayed but KCI has been able to get emergency orders of sheeting in to meet deadlines for KYTC. KCI stocks up on sheeting and supplies during peak demand times.

The contract between KCI and KYTC sets standards for acceptable plate quality. In 2014, a supply mix-up occurred when ink did not adhere to the sheeting. Once the problem was identified, KCI implemented a quality assurance procedure called the lead test where a series of plates are selected and a lead pencil is scraped on the paint to determine whether it flakes off. They do this before boxing the license plates for pick-up by MVL. Flawed plates are cut in half, discarded into a large cardboard box, and sold as scrap metal at market cost.

During this research, KYTC voiced a concern that KCI's embossing machines were antiquated and that finding parts for repairs was challenging. JR Wald Company rebuilds equipment and trains inmates to repair and maintain the machines. Although representatives agree that the machinery is quite old, they believe it is still repairable, efficient, and in good working order.

2.5 KCI and DOC Perspectives on Flat Plating

KCI and DOC have had ongoing discussions with and presentations by JR Wald about acquiring a digital printer for flat-plate production and signage. They are confident they can implement a new system in a short period but are concerned about equipment costs. The cost of the digital printer is $175,000. KCI and DOC are very concerned about the effect flat-plate production will have on inmate labor. Flat-plate production will only need 10 to 12 workers since it does not have the large number of tasks associated with embossing. KCI has reiterated that its core mission is to train inmates and reduce recidivism. KCI contends that transitioning to flat plates could damage its efforts.

2.6 Motor Vehicle Licensing

We also interviewed MVL staff members at KYTC to understand the context of their vehicle registration plate production and distribution workflow. Further, we discussed with staff strategies MVL could implement to decrease the amount of inventory space and costs associated with mailing the plates. Kentucky has not reissued license plates in over 10 years, but KYTC wants to be prepared if the governor orders a plate reissue.

One option would be transitioning from embossed plates to a flat plate, the latter having a print-on-demand process. Another option is to implement a hybrid system where KCI would continue producing embossed standard plates but print specialty plates digitally.

MVL and County Clerk Responsibilities

Almost all staff members in the MVL play a role in some aspect of vehicle plating, even though they may never go to the tag plant or plate warehouse. Some staff members primarily communicate

with county clerk offices while another four to five staff members spend all their time dedicated to license plate production. Those workers receive and process the orders, submit orders to KCI, pick up the plates from KSR, affix county identifiers and ship plates to county clerks. The employees are cross-trained in every area in case someone is sick or on vacation.

Standard, specialty, and personalized issue plates are distributed by Kentucky's 120 county clerks, who are elected by residents of each county. County clerks accept and process vehicle registration applications, order license plates from KYTC to replenish inventory, distribute plates and renewal decals, and mail license plates to individuals who recently purchased a car. In addition to registration plate tasks, county clerks oversee elections, issue marriage licenses, and collect taxes. Because county clerks are elected officials, fulfilling tasks can be hectic during election season.

License Plate Warehouse and Distribution

Researchers toured the Frankfort warehouse where MVL receives and distributes plates. The building is state-owned and maintained by KYTC and houses all license plates until they are distributed to county clerks. The warehouse is approximately 1,500 square feet and divided into an office and a warehouse section. Plates are stored in cardboard boxes labeled with the type of plate; staff members maintain places on shelves marked for each type of plate. In Frankfort, plates are packed and shipped via UPS. A significant amount of space in the warehouse is filled with unused inventory.

County clerks send plate requests through a COBOL-based mainframe system that tracks orders and inventory. A request includes the type and number of plates needed. When a county clerk receives the plates from Frankfort they are marked as accepted in the mainframe systems. If they do not accept the order, the system will not allow them to process and distribute plates until the record is correct. Since production is determined by the amount of plates distributed to the clerks during the previous year, it is crucial to carefully maintain inventory.

Each plate number is in the COBOL system and includes the requested number of plates. MVL warehouse staff check the requested number to make sure that inventory is similar to the number of plates ordered in that location during the previous year. If the requested amount appears to be too high or too low, or if there is not enough existing inventory to fill a complete order, it will be adjusted by warehouse staff. Then, the order is printed out on a dot matrix printer and given to KCI.

Once KCI finishes an order, an MVL warehouse employee picks up the plates from the prison in La Grange and delivers them to the warehouse. KCI does not get paid until the product is delivered and passes the quality approval process. If the plates are satisfactory, they are recorded as accepted and moved to another part of the warehouse. For standard plates, two to three employees affix the county identifier to them. Specialty plates, conversely, lack county identifiers. Since the county identifier stickers are kept in inventory for a long period, they may fade or fall off over time.

MVL maintains an account with UPS to ship plates to county clerk offices. If the order is small, it is shipped in a UPS envelope. Large orders are shipped in bulk, also using the UPS account. In 2015, the warehouse paid $132,674 to UPS for shipping costs. Occasionally, KYTC staff will personally drive plates to nearby clerks' offices instead of mailing them.

Supply Issues with Production and Distribution

Due to the nature of the production facility, there are occasional supply issues. Sometimes KYTC only gets partial orders or does not receive the correct number of plates and decals from KCI. Supply issues stem from the fact that KRS occasionally has lockdowns, which means inmates cannot work that day. Additionally, machines break and bottlenecks hit supply chains, limiting work as well. KYTC anticipates these kinds of issues will arise, but typically KCI does not inform the Cabinet of problems until their orders go unfulfilled.

2.7 Operating Costs for Tag Plant and MVL

Material Costs for Plate Production

Avery Dennison supplies sheeting under a contract with JR Wald, which provides the aluminum. Table 3 shows the cost of sheeting per roll for current plate production at the tag plant. One roll contains 900 feet of sheeting, and a long run of standard issue plates typically requires 40 rolls of sheeting. A roll yields 1,725 plates and a long run generates 69,000 plates. License plates for passenger cars, passenger trucks, commercial vehicles, and specialty plates are made from 12-inch aluminum; motorcycle plates are made from 7-inch aluminum. The cost of aluminum fluctuates, so the cost must be checked every time KCI places an order.

The cost of sheeting is based on the number of colors used in the plate design. As shown in Table 3, for plates with between one and four colors, the sheeting cost is $864. For a plate with five colors the cost rises to $900. Avery Dennison supplies the digitally printed background sheeting used on the military, organization, and collegiate plates, which is then embossed at the tag plant. That sheeting costs $1,917 regardless of the number of colors in the design. A roll of sheeting for standard issue motorcycle plates is $280. There are also three specialty plates for motorcycles: Friends of Coal, I Support Veterans, and Military plates. Sheeting for specialty motorcycle plates costs $840 per roll.

Table 3 Cost of Avery Dennison Sheeting Rolls

Plate Examples	Number of Colors	Cost per Roll
Unbridled Spirit	1 to 4	$864
In God We Trust	5	$900
Nature, Organization Plates, Military, University and Private Colleges	Digitally Printed	$1,917
Motorcycle	Digitally Printed	$840
Motorcycle- Standard Issue	One color (white)	$280

Production Costs for KCI

KCI provided the annual costs for operating the tag plant in La Grange. Annual operating costs are approximately $1 million (Table 4). The building is owned by DOC so KCI does not have to pay for rent, utilities, or building maintenance. Their largest expenses come from sheeting, dyes, and other materials, which cost $703,346.47 in 2015. The second highest expenditure was labor, which totaled $240,112.91, including inmate labor ($49,669.04), DOC supervisors for the tag plant ($110,443.87), and KCI administrative support ($80,000). Grounds maintenance and janitorial services, which are provided by inmates, cost $31,207.54 in 2015.

Table 4 Cost of Tag Plant Operations

Expense	Cost
Sheeting, dyes, and other materials	$703,346.47
Machinery, repairs, and spare parts	$31,993.68
Garbage collection, janitorial supplies, grounds maintenance, and propane for forklift	$31,207.54
Inmate Labor	$49,669.04
Supervisory Labor	$110,443.87
Administrative Support from KCI	$80,000.00
Total	$1,006,660.60

2.8 Costs for MVL

The state owns the plate inventory warehouse and MVL offices. As such, rent and utilities are not included in the costs for MVL. MVL costs consist of finished license plates, mailing costs to ship plates to the county clerks, and salaries for staff members that work on tasks associated with license plate production and distribution. Most license plate tasks occur at the plate warehouse where staff members process and ship orders. Table 5 summarizes labor costs for the MVL workers responsible for various aspects of the registration plate process. The total labor cost for the license plate responsibilities is $221,748.95, which includes benefits as well as the percentage of time devoted to license plate-related tasks.

Nine full-time KYTC employees and one temporary employee work on license plate production and distribution (Table 5). Four employees have 100 percent of their time allocated to license plate responsibilities, which has an annual cost of $133,594. Four other employees spend between 25 and 75 percent of their time on license plate production and distribution, and their labor costs are $65,533. Finally, two employees spend 15 percent of their time on tasks related to license plates, costing a combined total of $22,621.95 annually.

Table 5 MVL Annual Labor Costs for License Plate

Number of Employees	Status	Percent of Time Working on Plates	Loaded Labor Costs	Labor Costs Related to License Plates
3	Full-time	100%	$114,094	$114,094.00
1	Full-time	75%	$38,426	$28,819.50
3	Full-time	25%	$146,854	$36,713.50
2	Full-time	15 %	$150,813	$22,621.95
1	Temporary	100%	$19,500	$19,500.00
Total				$221,748.95

Given that MVL ships plates to county clerks' offices, another consideration is mailing costs. MVL has two accounts with UPS. One account is dedicated to shipments from the Frankfort warehouse to the clerks' offices ($132,674), while the other is for shipments from MVL ($4,536). Table 6 lists the combined shipping costs for calendar year 2015 totaled $137,210.

Table 6 Shipping Costs for License Plate in 2015

Account	Cost
Warehouse	$132,674
Motor Vehicle Licensing	$4,536
Total	$137,210

2.9 Vehicle Registration Plates Currently Issued by the Commonwealth of Kentucky

Kentucky currently offers 117 license plate types. A vehicle's operational purpose determines the type of plate that is issued. Based on the categories used by KYTC and county clerks in annual reports from 2012 through 2015, plate types were divided into the five categories: Regular Issue, Specialty and Personalized, Commercial and Miscellaneous, Exempt, and Dealer. Table 7 shows vehicle registration types and their corresponding plate categories.

Table 7 License Plate Categories

Regular Issue	Commercial and Miscellaneous	Exempt	Dealer	Specialty and Personalized
Passenger Cars	Commercial	Church Bus	Retail	Organizations
Passenger Trucks	Truck Trailer	Concrete Truck	Motorcycle	Collegiate
Motorcycle	House Car	Farm Truck	Duplicate Motorcycle	Military
	House Trailer	Log Truck	Wholesale	
	Low Speed Vehicle	School Bus	Duplicate	
	Camping Trailer	Urban Limited		
		Wrecker		

Regular Issue

Regular issue plates are the standard issue plates for passenger vehicles, passenger trucks, and motorcycles. The fees for these plates are found in KRS 186.050. Farm truck registration is based on weight limits addressed in KRS 186.50. However, annual fee revenue data provided by MVL includes farm trucks under the exempt category and will be treated thusly in the fee analysis below.

Commercial Vehicles and Miscellaneous

KRS 186.050 establishes registration status and fees for commercial vehicles, which are defined as vehicles that carry weight greater than or equal to 10,001 pounds, or that engage in commerce but do not carry passengers. This statute contains the incremental fees, which are based on a vehicle's declared gross weight or its towed unit. Details on low-speed vehicle registration are also found in KRS 186.010 and 189.282. A low-speed vehicle is a four-wheeled vehicle that can operate on public roads but generally cannot operate any faster than 25 miles per hour. The miscellaneous category refers to recreational vehicles such as camping trailers, house cars, and house trailers. The registration fees for these vehicles are found in KRS 186.675.

Exempt

Exempt vehicles are not subject to federal safety regulations for commercial vehicles under the Federal Motor Carrier Act. The specific exemptions are found in KRS 281.605, and the registration fees for these vehicles are in KRS 186.050.

Dealer

Car dealers and car manufactures to pay an annual registration fee for dealer license plates, which enable customers to use vehicles for test drives and let a dealership or manufacturer provide cars for employees and sales staff. Those fees are listed in KRS 186.070.

Specialty Plates

Specialty plates are of significant concern for MVL with respect to production methods, cost, and inventory space. Because specialty plates have individualized designs that are graphic-intensive, and because individuals must specially request them, it is difficult to determine how many of these plates county clerk offices require. Consequently, specialty plates are produced in bulk based on issuance numbers from the previous year and stored as inventory.

KRS 186.162 and 186.164 establish the initial fees and renewal fees for specialty plates. Both statutes describe the manner in which these fees are allocated among KYTC, county clerks, and the organization which benefits from the specialty plate. Organizations must deposit the proceeds from specialty plates into a separate account, which must be audited once per year. They may also collect additional donations.

Kentucky offers specialty plates for a variety of organizations: military, historic motor vehicles, colleges and universities, non-profit organizations, wildlife protection agencies, police, firemen and members of congress. Many of these plates can only be distributed to vehicle owners after they have provided credentials to the clerk. KRS 186.166 mandates these plates be in perpetual production. An organization can periodically request design changes to the plate, but it must wait until the current version has been production for three years. KRS 186.162 defines a specialty plate as: "…a unique license plate issued under this chapter to a group or organization that readily identifies the operator of the motor vehicle or motorcycle bearing the plate as a member of a group or organization, or a supporter of the work, goals, or mission of a group or organization."

An organization which establishes a license plate creates its own design. The designs must comply with the requirements set forth in this statute. As per 601 KAR 9:130, specialty plate applications and designs must be approved by the Special License Plate Committee. Once an organization's application for a specialty plate is approved, KYTC must approve the design. The plates will only go into production once the organization collects 900 applications, each with a $25 fee.

For example, Nature's Finest specialty plates support the Kentucky Heritage Land Conservation Fund, which protects 77,000 acres of wildlife habitats from commercial development. Figure 5 shows a placard posted at Raven Run Nature Sanctuary in Fayette County, informing visitors that funds from the specialty plate have been used to protect the 734 acres in the sanctuary. There have been six Nature's Finest plates in total, although only three are currently issued.

Figure 5 Nature's Finest Plate Sign at Raven Run Nature Sanctuary

County clerks accept the initial and renewal fees for registration, and KYTC distributes the money for the groups identified in 186.162 on a quarterly basis. Groups can also request that supporters have the ability to add an additional donation at the time of initial registration or renewal. Those funds are distributed to the organization on an annual basis.

KRS 186.041 and 186.166 concern military-related plates, such as those identifying active, retired, or widows of the armed forces. In addition, the statutes identify plates that honor prisoners of war (POW), recipients of the Purple Heart, Gold Star widows, a distinguished service cross, and survivors of the Pearl Harbor attack. Once the relevant agency approves an application and verifies the credentials, the plates are sent to the county clerk and distributed to the veteran or their spouse.

Specialty Plate Proceeds

This study analyzed total collections for specialty plates from 2012 to 2015. During that period, specialty plate fees generated over $10 million. As Figure 6 shows, annual plate sales were typically between $2.2 million and $2.9 million. The highest collections were in 2012, with $2.9 million. After proceeds fell in 2013 to $2.2 million, they grew steadily during 2014 ($2.5 million), and 2015 ($2.7 million).

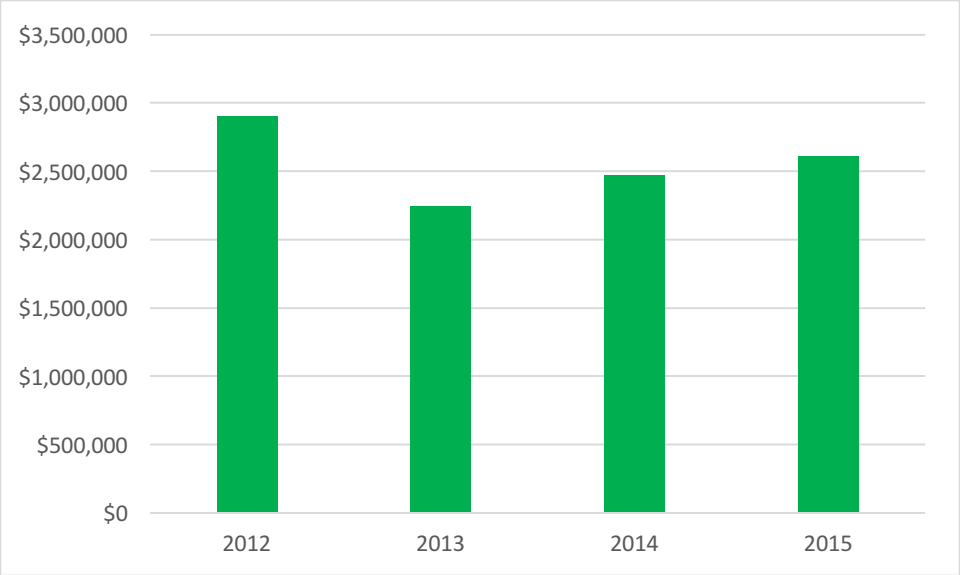

Figure 6 Specialty Plates Proceeds 2012 through 2015

From 2012 to 2015, ten organizations were consistently in the top ten for first-time issuance fees, renewal fees, and donations. As Figure 7 illustrates, average collections for specialty plates totaled almost $2 million. Plates for the Nature Reserve ($471,040) resulted in the most fees collected, followed by those for University of Kentucky ($253,025), Friends of Coal ($244,864), University of Louisville ($212,050), and Breast Cancer Awareness ($204,444). Other plates that garnered significant revenue were the Horse Council ($165,804), Share the Road (150,313), Law Enforcement Memorial ($107,360), Spay-Neuter ($94,728), and Kentucky Sportsman ($89,432).

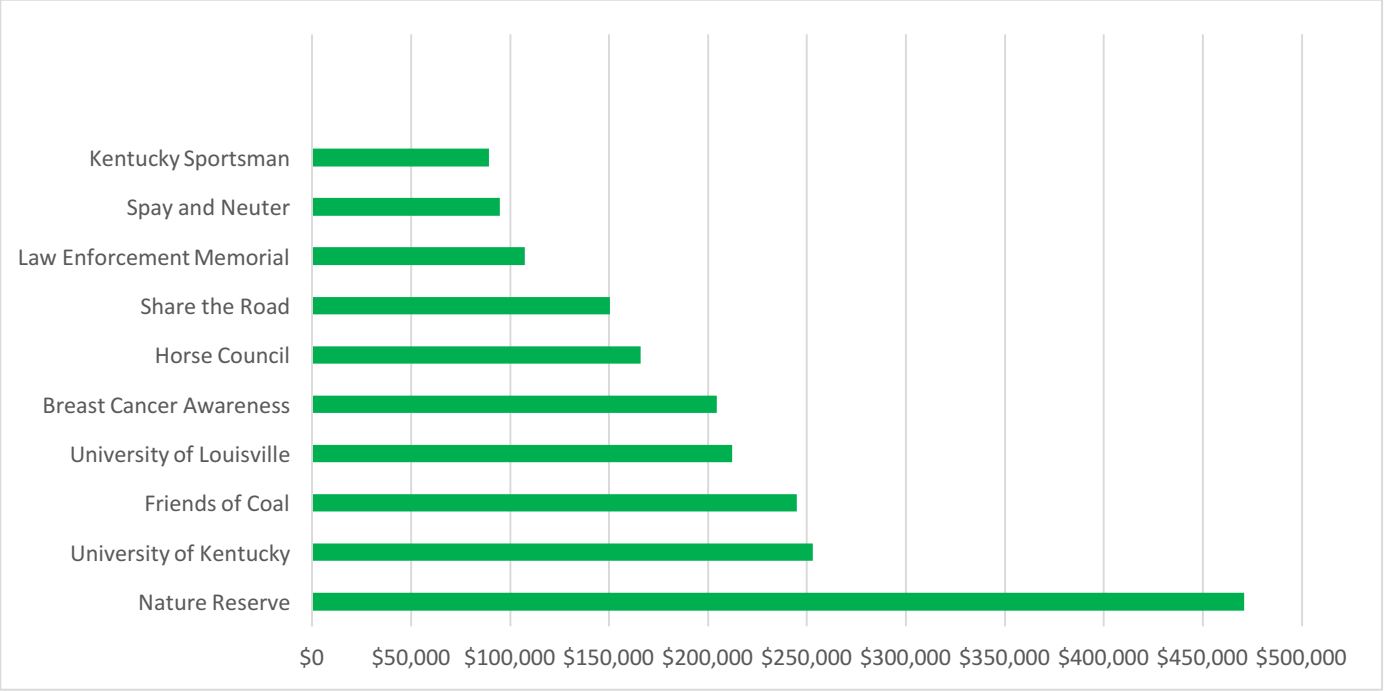

Figure 7 Average Collections for Top 10 Organizations 2012 through 2015

2.10 Fees and Revenue from Motor Vehicle Licensing Activities

We collected data on fee collections and the number of plates that were distributed from 2012 through 2015. KYTC provided the data in text files, and we exported them to Excel spreadsheets. Fee categories included registration renewals, first-time issuance, out-of-state first time issuance, and the year of expiration for each plate and decal. Analysis focused on first-time plate issuance and out-of-state issuance. Table 8 shows the plate categories and names.

Fee Revenue Allocations

Vehicle registration and renewals are required annually and subject to many fees that are retained by the clerks and by various funds established by KYTC. Those fees include the following:

- County Clerk Registration — Allocated to county clerks for collecting fees and processing registrations
- KAVIS Bucket — Placed in an agency fund to pay for technological improvements or the replacement of the Automated Vehicle Information System (AVIS) legacy system
- Technology Equipment Bucket — Placed in a trust fund for technological improvements of the hardware and software used at county clerk offices for collecting and administering road fund taxes
- Population less than 20,000 bucket — Used as an unrestricted revenue supplement for counties with a population less than 20,000. Funds are distributed to the county clerk offices in those counties for duties involving the collection and administration of road fund taxes.
- Re-Plate Fee — Allocated to a program fund in the state road fund and used to issue reflectorized plates
- State Registration Fee — Assessed by the state for annual vehicle registration
- Issuance State Road Fund — Deposited in the state road fund (source of funds for Kentucky's roadways)
- Motorcycle Safety Fund — Fee collected for the motorcycle safety education program

30 percent of state registration fees collected from commercial vehicles is evenly distributed to 120 county road funds

Table 8 Fee Allocations for Standard Motorcycle and Vehicle Plates

	Initial Fees with Fund	County Clerk Reg. Fee	Total State Initial	KAVIS Bucket	Tech Equip Bucket	Pop < 20,000 Bucket	Re-Plate Fee	State Reg. Fee	MC Safety Fund
Standard Motorcycle	$18.50	$6.00	$12.50	$1.00	$1.00	$1.00	$0.50	$5.00	$4.00
Standard Vehicle	$21.00	$6.00	$15.00	$1.00	$1.00	$1.00	$0.50	$11.50	$0.00

License Plate Revenue from 2012 to 2015

On average, MVL collected $10,496,367 from 2012 to 2015. The total amount collected from first time issuance over this period was $41,985,479. As Figure 8 indicates, the highest amount of

collections occurred in 2013 ($11,170,338), and the lowest collections were collected in 2015 with $10,134, 555.

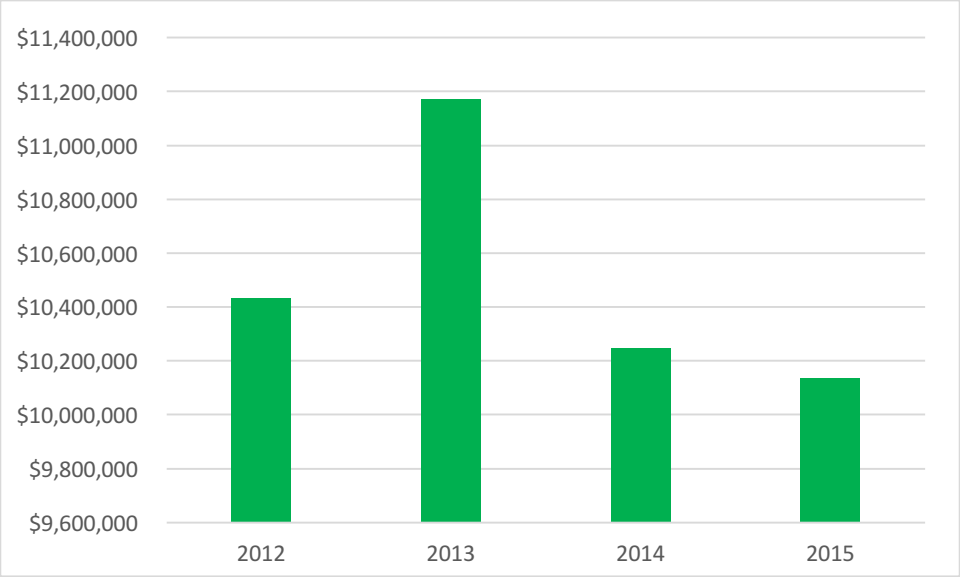

Figure 8 MVL Fee Collections for 2012 through 2015

Fees for each plate type were compared to identify trends in collections. The yearly revenue from each type of license plate remained consistent over the study period. Table 9 shows the average percentage of fees for each category. Most plate types issued at the county clerk offices were the Unbridled Spirit and In God We Trust general issue plates ($4,903,135). The next highest source of revenue was specialty plates ($2,115,378), followed by commercial plates ($1,872,500). The smallest amount of revenue came from the exempted ($1,177,104) and dealer ($243,060) categories.

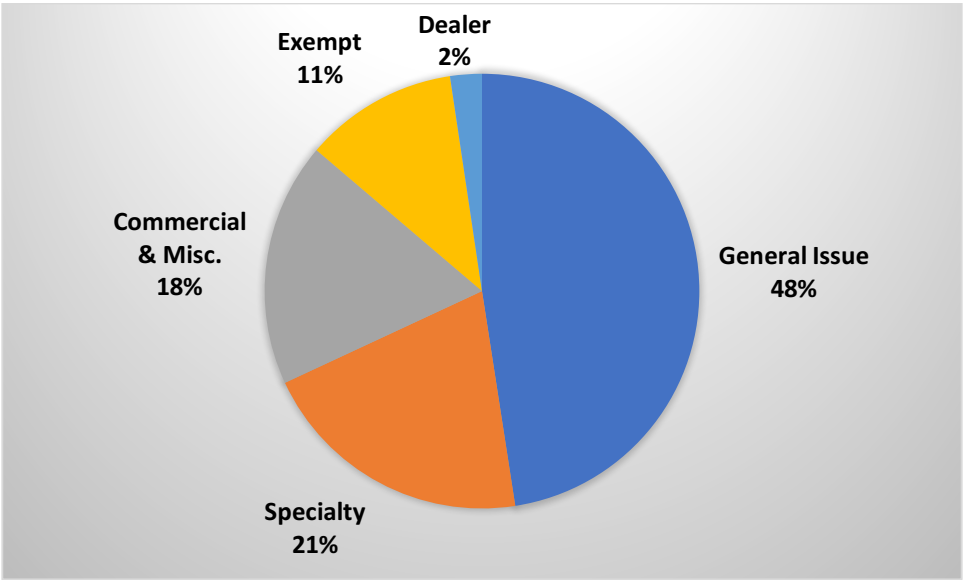

Figure 9 Average Percentage of Revenue Collected 2012 through 2014

Plate Issuance Totals

From 2012 through 2015, KYTC issued 2,558,387 plates through the circuit court clerk offices — or, 639,597 plates per year. The most plates were distributed in 2013 (683,598) and the fewest were issued in 2015 (605,422) (Table 10).

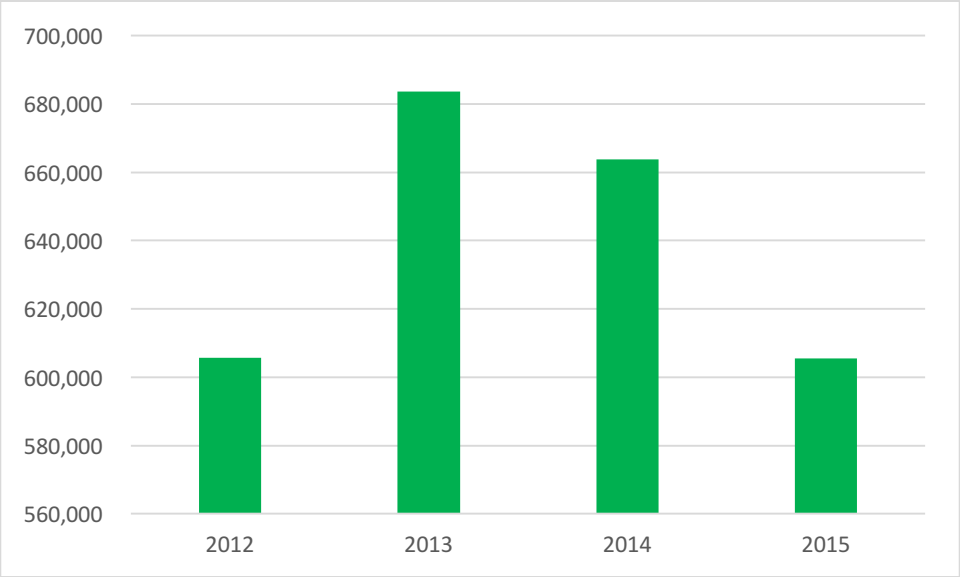

Figure 10 Total Number of Plates Issued 2012 through 2015

Table 11 illustrates the percentage of issued plates classified as general issue, exempt, dealer, commercial, and specialty. Over half the plates were general issue (66 percent), followed by specialty plates (23 percent), and commercial/miscellaneous plates (6 percent). The fewest number of plates were issued to car dealers and exempt entities (5 percent).

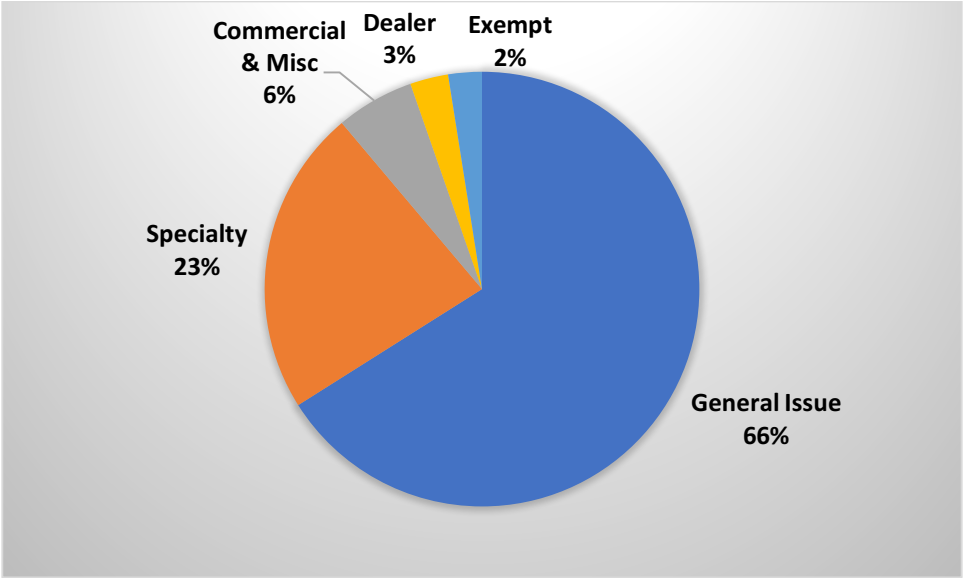

Figure 11 Average Number of Plates Distributed 2012 through 2015

2.11 KCI Production Numbers for 2015

In 2015, KCI produced 95 different plate types. In total, 745,357 plates were manufactured at KSR and 73 percent of those were the standard issue Unbridled Spirit (424,859) and In God We Trust (122,634) plates. The remaining regular plates — the 10,000-pound truck, motorcycle, and farm truck — had the next-highest production numbers at 82,928. The most popular specialty plate is the Friends of Coal (14,823) plate. In terms of collegiate plates, the University of Kentucky (6,190) and University of Louisville (4,471) were the most popular. The least-produced specialty plates were for the Fallen Officers Trust, the Kentucky Chiropractic Association, and Mid-Continent University; one plate of each style was produced in 2015. Table 9 lists the numbers for each plate that was produced at KCI in 2015.

Table 9 Number of Plates Produced by KCI 2015

Plate	Number	%	Plate	Number	%
UNBRIDLED SPIRIT	424,859	57.00%	**STATE POLICE**	152	0.02%
IN GOD WE TRUST	122,634	16.45%	**BELLARMINE**	119	0.02%
TRUCK 10000	24,001	3.22%	**BUTTERFLY NATURE**	101	0.01%
FARM TRUCK	20,000	2.68%	**TRANSYLVANIA UNIVERSITY**	91	0.01%
TRUCK TRAILER	20,000	2.68%	**CENTRE COLLEGE**	88	0.01%
MOTORCYCLE	18,927	2.54%	**PIKEVILLE UNIVERSITY**	82	0.01%
COAL MINER	14,823	1.99%	**AMATEUR RADIO**	81	0.01%
HISTORIC PASSENGER	12,000	1.61%	**ASM**	80	0.01%
TRAILER PLATE	6,500	0.87%	**LSV**	80	0.01%
ARMY VETERAN	6,299	0.85%	**PETS - SPAY AND NEUTER**	65	0.01%
UNIVERSITY OF KENTUCKY	6,190	0.83%	**FREEMASON**	63	0.01%
HANDICAP PARKING	6,000	0.80%	**CAMPBELLSVILLE**	61	0.01%
OFFICIAL	5,233	0.70%	**MOTORCYCLE DEALER DEMO**	57	0.01%
PURPLE HEART	4,929	0.66%	**THOMAS MOORE COLLEGE**	57	0.01%
LOUISVILLE UNIVERSITY	4,471	0.60%	**UNION COLLEGE**	56	0.01%
BREAST CANCER	3,944	0.53%	**BEREA COLLEGE**	55	0.01%
FOP	3,254	0.44%	**WESLEYAN COLLEGE**	55	0.01%
I SUPPORT VETS	3,205	0.43%	**CARDINAL NATURE**	54	0.01%
SMALL MOUTH BASS	3,064	0.41%	**ST CATHERINE**	52	0.01%
DEALER	2,465	0.33%	**AIKCU**	50	0.01%
DONATE LIFE	2,433	0.33%	**MIDWAY COLLEGE**	50	0.01%
MOOREHEAD COLLEGE	2,194	0.29%	**SPALDING UNIVERSITY**	50	0.01%
HANDICAP VET	2,073	0.28%	**BOBCAT NATURE**	44	0.01%
EASTERN KENTUCKY UNIVERSITY	1,898	0.25%	**ALICE LLOYD COLLEGE**	30	0.00%
NAVY VETERAN	1,810	0.24%	**JUDICAL PLATE**	30	0.00%

Plate	Number	%	Plate	Number	%
MARINE VETERAN	1,626	0.22%	**KY CHRISTIAN**	29	0.00%
KY SPORTSMAN	1,595	0.21%	**LINDSEY WILSON COLLEGE**	29	0.00%
AIR FORCE	1,592	0.21%	**CUMBERLAND COLLEGE**	28	0.00%
CAMP TRAILER	1,500	0.20%	**DUCKS UNLIMITED**	28	0.00%
KY COLONEL	1,495	0.20%	**ASHBURY COLLEGE**	26	0.00%
BIKES/RUNNER	1,358	0.18%	**BRESCIA**	25	0.00%
COAL MINER MOTORCYCLE	1,213	0.16%	**RYDER CUP**	25	0.00%
AUTISM	1,065	0.14%	**KY LIBRARIES**	23	0.00%
QUAIL UNLIMITED	1,055	0.14%	**CHILD VICTIM**	19	0.00%
FIREFIGHTERS	913	0.12%	**NORTHERN KENTUCKY UNIVERSITY**	15	0.00%
WESTERN KENTUCKY UNIVERSITY	866	0.12%	**STATE SENATOR LEGISLATIVE**	15	0.00%
MILITARY MOTORCYCLE	780	0.10%	**JUVENILE DIABETES**	12	0.00%
HORSE COUNCIL	692	0.09%	**GEORGETOWN COLLEGE**	11	0.00%
KEENELAND ASSOCIATION	653	0.09%	**ROCK**	10	0.00%
KY LINEMAN	527	0.07%	**KY STATE**	5	0.00%
KOSAIR	522	0.07%	**ORAL HEALTH**	5	0.00%
NATIONAL GUARD	522	0.07%	**COAST GUARD**	4	0.00%
LOUISVILLE ZOO	508	0.07%	**CIVIL AIR PATROL**	3	0.00%
I SUPPORT VETS MOTORCYCLE	457	0.06%	**WHITE TRUCK**	2	0.00%
CHOOSE LIFE	336	0.05%	**FALLEN OFFICIER**	1	0.00%
MURRAY STATE UNIVERSITY	326	0.04%	**KY CHIROPRACTIC**	1	0.00%
STREETROD	312	0.04%	**MID CONTINENT**	1	0.00%
EMS	218	0.03%	TOTAL NUMBER OF PLATES PRODUCED		745,357

License Plate Overage

Because inventory is a concern for MVL, this study analyzed the difference between issuance and production numbers for each plate. Since MVL does not track leftover inventory at the clerk offices, these data are based on KCI's 2015 production numbers, which are derived from MVL's order numbers and the 2015 records for license plate revenue and issuance. In 2015, KCI produced over 745,000 license plates, which cost KYTC $1,403,611.49. Table 10 lists each plate type, the number issued, the number produced, and analyzes the cost of excess license plate production. Table 10 also includes the amount of overage, the per plate cost (as stipulated in KCI's contact), and the true cost. The true cost accounts for the overage. In 2015 the overage costs totaled more than $180,000. The largest total number of un-issued plates is the Unbridled Spirit design (43,402), and the largest total cost of overage is the In God We Trust plates ($58,682.75). MVL absorbs the cost of the plates they purchase but do not issue, and the data shown in Table 10 is overproduction.

Table 10 Overproduction for 2015

PLATE TYPE	ISSUED	PRODUCED	OVERAGE	KCI CHARGES	COST OF OVERAGE	KCI COST	TRUE COST	INCREASE
UNBRIDLED SPIRIT	381,457	424,859	43,402	$841,220.82	$43,402.00	$1.98	$2.21	11%
IN GOD WE TRUST	96,553	122,634	26,081	$275,926.50	$58,682.25	$2.25	$2.86	27%
MOTORCYCLE	11,132	18,927	7,795	$33,311.52	$13,719.20	$1.76	$2.99	70%
FARM TRUCK	14,408	20,000	5,592	$48,000.00	$13,420.80	$2.40	$3.33	39%
FRIENDS OF COAL	11,445	14,823	3,378	$53,214.57	$12,127.02	$3.59	$4.65	30%
TRUCK 10,000	18,007	24,001	5,994	$44,641.86	$11,148.84	$1.86	$2.48	33%
PURPLE HEART	2,452	4,929	2,477	$18,434.46	$9,263.98	$3.74	$7.52	101%
FR. ORDER OF POLICE	819	3,254	2,435	$9,827.08	$7,353.70	$3.02	$12.00	297%
SMALL BASS	1,756	3,064	1,308	$12,102.80	$5,166.60	$3.95	$6.89	74%
DISABLED PARKING	4,787	6,000	1,213	$17,760.00	$3,590.48	$2.96	$3.71	25%
KENTUCKY COLONEL	688	1,495	807	$5,023.20	$2,711.52	$3.36	$7.30	117%
BREAST CANCER	3,444	3,944	500	$12,975.76	$1,645.00	$3.29	$3.77	15%
QUAIL UNLIMITED	576	1,055	479	$3,544.80	$1,609.44	$3.36	$6.15	83%
STREET ROD	9	312	303	$942.24	$915.06	$3.02	$104.69	33367%
LOUISVILLE ZOO	289	508	219	$1,823.72	$786.21	$3.59	$6.31	76%
DISABLED VET 70	1,785	2,073	288	$5,597.10	$777.60	$2.70	$3.14	16%
KOSAIR CHILDRENS	312	522	210	$1,873.98	$753.90	$3.59	$6.01	67%
NATIONAL GUARD	380	522	142	$1,680.84	$477.12	$3.22	$4.42	37%
I SUPPORT VETERNS	3,076	3,205	129	$11,249.55	$452.79	$3.51	$3.66	4%
KEENLAND ASSOC.	573	653	80	$2,344.27	$287.20	$3.59	$4.09	14%
KY LINEMEN	483	527	44	$1,891.93	$157.96	$3.59	$3.92	9%
AMATURE RADIO	42	81	39	$181.44	$87.36	$2.24	$4.32	93%
LEGISLATIVE	10	15	5	$43.05	$14.35	$2.87	$4.31	50%
TOTALS	554,483	657,403	102,920	$1,403,611.49	$188,550.38			

However, plates are not discarded if they are not sold. Remaining stock is held at county clerk offices until they are issued. Consider Table 11 which summarizes data on the plates that were not overproduced in 2015. For these, a negative value between production and issuance exists. KCI made fewer plates than were issued at the county clerk offices, indicating there was adequate inventory for the demand. KYTC made back close to $40,000, presumably from plates remaining from the 2014 inventory.

Table 11 2014 License Plates Sold in 2015

PLATE TYPE	COLLECTED	ISSUED	PRODUCED	REMAINING PLATES	KCI COST	REMAINDER
SPAY AND NEUTER	$19,774.00	1,504	65	1,439	$3.70	$5,324.30
CHOOSE LIFE	$14,759.00	550	336	214	$3.11	$665.54
MILITARY MOTORCYCLE	$10,572.00	892		892	$1.76	$1,569.92
CHILD VICTIM	$8,550.00	324	19	305	$3.22	$982.10
DUCKS UNLIMITED	$8,311.00	322	28	294	$3.36	$987.84
LIBRARY ASSOCIATION	$7,833.00	307	23	284	$3.36	$954.24
ROCK CARES	$5,309.00	201	10	191	$3.36	$641.76
JUVENILE DIABETES	$5,249.00	217	12	205	$3.36	$688.80
RYDER CUP	$3,107.00	121	25	96	$3.36	$322.56
DENTAL ASSOCIATION	$1,395.00	54	5	49	$3.36	$164.64
DISABLED MOTORCYCLE	$1,366.00	169		169	$3.36	$567.84
CIVIL AIR PATROL	$66.00	8	3	5	$2.70	$13.50
DISABLED VETERAN	$63.00	908		908	$2.77	$2,515.16
HORSE COUNCI	$77,703.00	2,936	692	2,244	$2.80	$6,283.20
NATURE	$54,803.00	4,024	199	3,825	$3.36	$12,852.00
KENTUCKY SPORTSMAN	$53,385.00	2,052	1,595	457	$3.54	$1,617.78
COAL MINERS MOTORCYCLE	$31,645.00	1,254	1,213	41	$1.79	$73.39
AUTISM AWARENESS	$31,547.00	1,244	1,065	179	$3.36	$601.44
FIREFIGHTER	$13,850.00	1,154	913	241	$2.96	$713.36
SUPPORT VETERANS MOTORCYCLE	$12,769.00	932	457	475	$1.76	$836.00
MASONIC	$12,439.00	482	63	419	$3.53	$1,479.07
TOTALS	$374,495.00	19,655	6,723	12,932		$39,854.44

We identified 23 plates that were overproduced in 2015. Of those plates, 657,403 were produced by KSR, but only 84 percent were issued. Overage costs for general issues plates were $140,373.09; specialty plate overage costs amounted to $48,177.29 (approximately $188,000 total). Almost 75 percent of the overproduction was attributable to the general issue plates, the farm plate, and 10,000 pounds commercial plates.

MVL and KCI have two options to address overproduction. The first is to identify which plates were overproduced and adjust production numbers based on those data. Another option is to transition to a flat-plate system with its print-on-demand production model. This would correct overproduction for general issue and specialty plates. In contrast, a hybrid system with a print-on-demand production model would only eliminate the overproduction of specialty plates. The cost of implementing a new production system is discussed in Chapter 6.

2.12 Conclusion

The numbers and type of plates issued each year is fairly consistent. However, there are some challenges with overproduction — MVL issues fewer plates than are produced by KCI. Data analysis suggests that MVL could adopt a strategy of annually comparing present production and issuance numbers with the historical record of issuance for each plate to avoid overages. The largest contributors to overproduction were the general issue, motorcycle, farm, and Friends of Coal plates.

However, it is difficult to predict production needs in advance. The most concrete data available allow comparison of production numbers and plate issuance statistics, but documentation is lacking on the number of plates which remain at the clerk offices. KTC recommends that MVL develop a data retention policy for clerks, mandating that they document the number of plates issued at their offices and the number of plates leftover at the end of the year. This would help MVL accurately determine the production needs for the upcoming year and avoid costly overages.

Chapter 3 Future Scenarios for License Plate Production in Kentucky

KTC investigated the cost of transitioning from Kentucky's current system of license plate production to one of two alternative systems: 1) flat, digital plate production for general issue and specialty plates; and (2) a hybrid system, where general issue plates retain the standard embossed production and specialty plates are a flat, digitally printed plate. KTC requested an estimate for the cost of implementing these systems from JR Wald. They also participated in conference calls about the necessary components for flat plating and hybrid plating.

JR Wald currently maintains the embossing system at KCI but also offers equipment for digitally printed flat plate production, servers, and their Veridata software. JR Wald provides a turnkey solution: they supply and install the necessary equipment, software, and they train workers on using the equipment. JR Wald's estimate for flat-plate production and hybrid production systems assumes that MVL will continue to use KCI labor for plate production. The estimated cost per plate for each system is based on yearly production of 745,357 plates — the total number KCI produced in 2015.

3.1 Scenario 1: Flat Plate Production for General and Specialty Issuance

Flat-plate production requires a sizeable investment in printing equipment and software. And while producing flat plates demands more materials than embossed plates, it involves fewer production steps. Flat plates must include a thermal transfer ribbon, and all sheeting must have the protective clear overlaminate as part of the component stream. If KYTC went to a flat plate manufacturing process, the added materials would increase the cost of the long-run general issue sheeting as well as the cost of specialty plate sheeting. In addition, flat plates must include added security features since they are easier to counterfeit with the use of a high-quality laser printer.

The estimate for a complete flat-plate system includes a server and printer. All production could be done with one printer but this is not the ideal scenario. JR Wald recommends a second printer to maximize efficiency. Specialty plates usually have more graphics-intensive designs. This slows the printing process compared to general issue long-run plates, which typically consist of printing alphanumeric characters on a basic plate. Two printers allow for the simultaneous printing of general issue and specialty plates. Another advantage is that two printers allow for a backup printer if the main printer requires servicing. A second printer would give KYTC more flexibility in the event MVL plans to re-plate in the near future. If Kentucky re-plates, JR Wald also recommends a two-year reissuance, which would save on the cost of implementing a new production system.

A flat-plate system would also require a server that stores plate designs and receives and tracks the plate orders from MVL, including the plate types and plate number series. The order information from the server would be used to create a series run that would match the license plate number to the appropriate background. Orders would go into a queue for production, after which the plates would be printed and blanked.

In addition, MVL has the option to invest in a barcoding system that would enable it to incorporate direct mailing at a later date. If MVL moved to a direct mailing system for specialty plates, this barcode would allow for a tracking system that hides personal addresses from inmate workers. On-demand printing and direct distribution would make flat-plate production a good choice for

reducing inventory and increasing efficiency. However, JR Wald does not recommend flat plating under the current inventory system and distribution process through the county clerk offices.

Installing the flat-plate system would take approximately six months. This includes installation of the equipment, training, and programming the server to interface between KYTC's mainframe system and JR Wald's system. JR Wald and KCI are aware that the governor may order re-plating in the near future and have advised MVL to begin the procurement process as soon as possible.

3.2 Estimates for New Plate Production Systems

Every license plate consists of two main materials regardless of the type of plate being produced — aluminum and sheeting. Background graphics are printed on the sheeting; this is affixed to aluminum. Sheeting costs are based on square footage and the number of colors printed on the sheeting. Aluminum cost fluctuates based on current market prices. In addition, flat plates need to have an overlaminate added to protect the plate from the elements.

Current Costs for Embossed Plate Production

KCI charges KYTC a fixed unit cost for each plate. The charges include the cost of materials and overhead. To establish a cost-per-plate baseline, it is necessary to calculate the true cost that KYTC is paying per plate. It is also necessary to factor in all costs that go into the production of license plates including KCI and KYTC's costs for 2015. In 2015, more than $1.3 million was spent on license plate production and distribution. An additional $31,000 was spent on janitorial supplies, garbage disposal, grounds upkeep, and propane fuel for the forklift. KYTC purchased 745,357 plates from KCI in 2015: 114,936 specialty plates and 630,421 general issue plates (Table 12).

Table 12 Costs for License Production in 2015

Cost Item	Cost
Production Materials	$703,346.47
Equipment Maintenance	$31,993.68
Sanitation, Grounds Maintenance, and Fuel	$31,207.54
Inmate Labor	$49,669.04
KSR Supervisors	$110,443.87
KCI Admin	$80,000
Mailing Costs	$137,210
KYTC Labor	$221,748.95
Total Cost	$1,365,619.55
Average Cost Per Plate	$1.83

Flat Plate Production

JR Wald provided estimates for implementing a flat-plate production system. The total cost would be $500,000. Table 13 provides a cost breakdown of the flat plate production. The system would include two printers, a graphics workstation, and a server-based system that would provide an electronic order entry. The estimate assumes that KCI would need two printers: one for long-run (general issue) plates and another for specialty plates. The second printer, although not mandatory, was strongly suggested.

Table 13 Estimate for Flat General Issue and Specialty Issue Plates

Components for System	Cost
Two Printers	$325,000
Equipment and Server	$175,000
Total	$500,000

Table 14 provides detailed cost estimates for introducing a flat-plate production system; 2015 production levels are the baseline. Under this scenario, both general issue plates and specialty plates would be digitally printed. KCI estimates they would need approximately 10 laborers, which would cost just over $9,000. Material cost estimates range from $1.13 for general issue plates to $1.35 for specialty plates. This includes the cost of aluminum, sheeting, overlaminate, and four ribbons for printing, which amounts to $867,539.30. The total cost for flat-plate production is $1.9 million dollars or $2.63 per plate. Cost per plate is based on production of 745,357 plates, the total number of plates KCI produced in 2015. Of these, 630,421 were standard issue plates and 114,934 were specialty plates.

Table 14 Price Per Plate for Flat-Plate Production

Cost Item	Cost
Production Materials	$867,539.33
New Equipment	$500,000.00
Sanitation, Grounds Maintenance, and Fuel	$31,207.54
Inmate Labor	$9,156.00
KSR Supervisors	$110,443.87
KCI Admin	$80,000.00
Mailing Costs	$137,210.00
KYTC Labor	$221,748.95
Total Cost	$1,957,305.69
Average Cost Per Plate	$1.83

3.3 Scenario 2: Embossed Plate General Issue and Flat Plate Specialty Plates

Another option KYTC could pursue is a hybrid production system. Under this scenario, KCI would continue embossed production for general issue plates, however, specialty and personalized plates would be transitioned to digitally-printed flat plates. It would be possible to print specialty license plates on demand. The estimate for the system includes a printer with a server for electronic orders from KYTC and order fulfillment. As Table 15 shows, total equipment costs are $325,000.

Table 15 Cost of Equipment for Hybrid System

Components for System	Cost
Printer and server	$325,000
Total	$325,000

The material costs are $665,804.60, which includes $0.81 per plate for long-run embossed plates and $1.35 per plate for specialty flat plates. If KYTC were to choose this production system, KCI representatives said they would shift more experienced and skilled plate makers to the digital plate production. Fewer inmates will be needed for the hybrid system given that specialty plates would be digitally printed. However, the production of embossed plates would still require numerous

workers. As Table 16 reveals, the total cost for this system is estimated at over $1.4 million, or $1.98 for each plate produced. As with the previous scenario, the cost per plate assumes production of 745,357 plates, the number KCI produced in 2015. Of those, 630,421 were standard issue plates and 114,934 were specialty plates).

Table 16 Cost Per Plate for Hybrid System

Cost Item	Cost
Production Materials	665,804.60
New Equipment	$325,000.00
Sanitation, Grounds Maintenance, and Fuel	$31,207.54
Inmate Labor	$38,025.00
KSR Supervisors	$110,443.87
KCI Administrative	$80,000.00
KYTC Labor	$221,748.95
Mailing Costs	$137,210.00
Total Cost	$1,472,229.96
Average Cost Per Plate	$1.98

3.4 Scenario 3: Embossed Plate System with In-House Printed Sheeting

We held conference calls with KCI and JR Wald to determine prices of equipment and systems that would improve efficiency and reduce cost. A JR Wald representative said KYTC should consider in-house production for specialty plate sheeting and printing, so that inmate labor at KSR handled production. The background graphics for specialty sheeting are currently printed at the JR Wald facility. This is the typical process: a 900-foot roll of reflective material is purchased from Avery Dennison through a contract with JR Wald; Avery Dennison sends white sheeting to JR Wald, which then prints the background for specialty plates; the sheeting is sent back to Avery Dennison for quality control; and the sheeting is sent to the prison to be blanked and embossed.

KCI pays $1,917 for a roll of digitally printed sheeting regardless of the number of colors used in the design. Currently, KCI pays Avery Dennison for digitally printed sheeting even though it could invest in a digital printer and place it at the prison. KCI could take advantage of cost savings by printing their own plate backgrounds using a digital printer and then embossing the plates. Pre-printed sheeting costs $1,917 a roll, while white sheeting using four color ribbons costs $720 per roll. KCI would not need to modify its inmate labor force, since plates would still be embossed, nor would its distribution system require adjustments.

The estimate includes the price of items KCI already has as well as the cost for a new numeral coating and curing system due, which is necessary because the curing oven is at least 40 years old. The new system would be more ecologically friendly, use UV ink, and eliminate volatile inorganic compounds, which the current system emits. The cost for the printer for digitally-printed sheeting is estimated to be $175,000 (Table 17).

Table 17 Cost of Equipment for Embossed Plate

Components for System	Cost
Printer with graphic workstation	$175,000
Total	$175,000

Error! Reference source not found. Table 18 lists the costs if KCI started to print specialty plate sheeting for embossed plates. Its labor needs would remain unchanged (approximate cost of $49,000). The material costs are estimated at $0.81 per general issue plate and $1.38 per embossed

specialty plate, totaling $669,252.70. The cost per plate is based on 745,357 units, the total number of plates KCI produced in 2015. Of those, 630,421 were standard issue plates and 114,934 were specialty plates.

Table 18 Cost Per Plate

Cost Item	Cost
Production Materials	$669,252.70
New Equipment	$175,000.00
Sanitation, Grounds Maintenance, and Fuel	$31,207.54
Inmate Labor	$49,669.04
KSR Supervisors	$110,443.87
KCI Admin	$80,000.00
Mailing Costs	$137,210.00
KYTC Labor	$221,748.95
Total Cost	$1,474,532.10
Cost Per Plate	$1.98

3.5 Distribution Options

These estimates assume that county clerk offices will continue to distribute plates. JR Wald did not provide an estimate for shipping direct to customers — more information would be required of KYTC to provide an accurate assessment. However, representatives discussed strategies for how direct mail and inmate labor could be used alongside one another. Some states are less stringent about inmate access to customer addresses. However, JR Wald offers bar codes that would allow inmates to address and ship plates without seeing customers' personal information. JR Wald also recommended that digital printing equipment be housed in a climate-controlled and dust-free environment. One possible location the printer could be installed at is the Luther Lucket facility in La Grange.

3.6 Conclusions

Many states are adding some type of flat-plate production into the license plate production and distribution system. Consider Table 19, which shows the advantages of distributing both embossed and flat plates. This information was identified from a literature review, survey responses, interviews with stakeholders, and from the vendor. Flat plates can add more efficiency to the production process, can be directly mailed to customers, require less inventory space, and reduce labor costs. In addition, flat plate production emits fewer chemicals into the environment than embossed plate production. However, embossed plates also have positive features. They are less likely to be counterfeited, are more labor-intensive to produce (and therefore provide more jobs to inmates), are less expensive to produce for standard-issue plates, and do not require large capital investments if a state already owns the requisite production equipment.

Table 19 Comparison Between Embossed and Flat Plate Production

Embossed	Flat Plate
Highly unlikely to be counterfeited	No additional tasks after blanking
Reflective sheeting is less expensive	More energy efficient and ecofriendly
Does not require additional materials	Less space needed for inventory
Long-run plates are not as expensive	Decreased mailing costs
Easier to read according to law enforcement	Lower labor costs
No expensive investment on equipment	Easier to provide plate on demand
Provides employment skills to inmates	Higher LPR accuracy

Chapter 4 Plate Characteristics Analysis

Kentucky officials expressed interested in determining not only the direct impacts of license plate production and distribution choices, but also the potential indirect impacts on critical KYTC operations — particularly commercial vehicle enforcement and electronic tolling. Commercial vehicle enforcement is crucial for meeting federal and state safety goals; complying with tax, permitting, and credentialing requirements for motor carriers; and collecting electronic tolls. If specific license plate characteristics significantly impact the accuracy of license plate readers, safety enforcement operations, motor carrier compliance, and electronic tolling revenues, plate characteristics might be of significant importance beyond the mere cost of production. The purpose of the following analysis is to advise KYTC of the anticipated impact that license plate characteristics have on safety enforcement, motor carrier compliance, and tolling revenue.

4.1 License Plate Accuracy Comparison

License plate data were collected from 11 Kentucky weigh stations using data from Kentucky's Automated Truck Screening (KATS) system. One day's worth of data from each weigh station, collected during typical operating hours, was used in these analyses. The number of commercial vehicles observed during this period was used to determine the sample size required to analyze each site and generate a sample with a 95 percent confidence level and a margin of error of ±3.00 percent. After determining sample size, a random number generator was used to select which inspections were analyzed for this study so that they were sampled independently during the entire period during which the station was open. Each observation was coded using several variables. The plate string is the combination of numbers and/or letters which identify a specific vehicle. The jurisdiction is the state or Canadian province the truck is plated in. Date is the date a truck was observed going through a station. Time is the time of day a truck passed through the station. The research team also coded whether the vehicle plate was embossed or flat, whether it contained stacked lettering, whether the plate contained alphanumeric or just numeric characters, and the number of characters on the license plate. Stata statistical software was used to analyze the data. During initial analysis, data were analyzed on a site-by-site basis, a vendor-by-vendor basis, and a combined basis for both vendors at all locations. Additional analysis was conducted using a probit regression model to statistically control other potential causes of LPR performance and to generate predicted probabilities that LPR will be accurate, given certain variables.

4.2 Embossed vs. Flat Plates

The first analysis was on whether plate type (i.e., embossed or flat) affected LPR accuracy. Looking at each weigh station shows mixed results. At most locations, the flat license plates were read more accurately, although at a couple of locations the embossed license plates were read more accurately. The variability of the results among sites indicated that the equipment's ability to read license plates is highly contingent on factors such as weather, time of day, font type, condition of the plate, physical qualities of license plate production, location on the vehicle, and other factors. Figure 12 summarizes these results. The number in parentheses beside each station name indicates the total number of observations from that site.

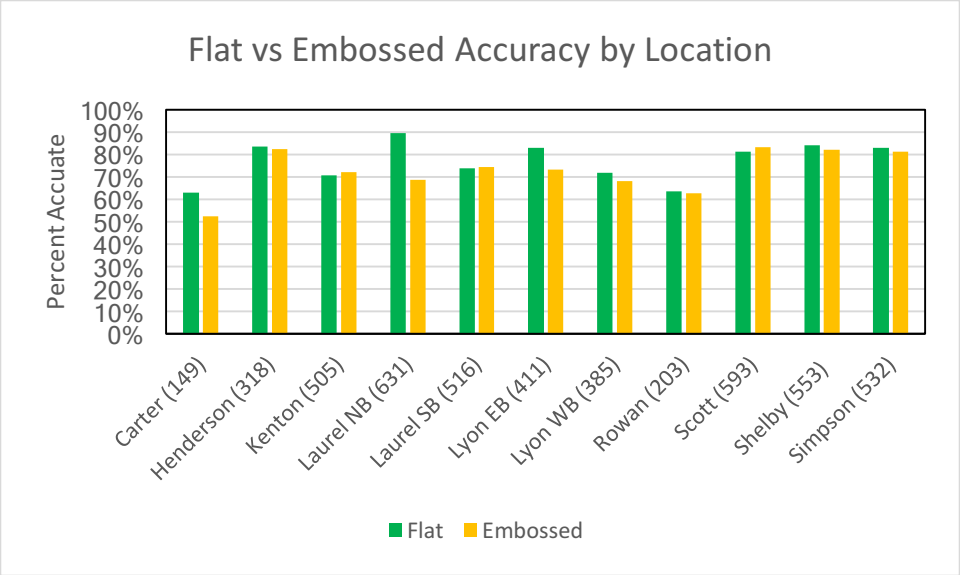

Figure 12 Flat and Embossed Accuracy Rates at Each Location

Combining all data yielded 4,796 records — 2,346 flat plates (49 percent) and 2,450 embossed plates (51 percent). Across all sites, flat plates were read approximately 5 percent more accurately than embossed plates (Figure 13).

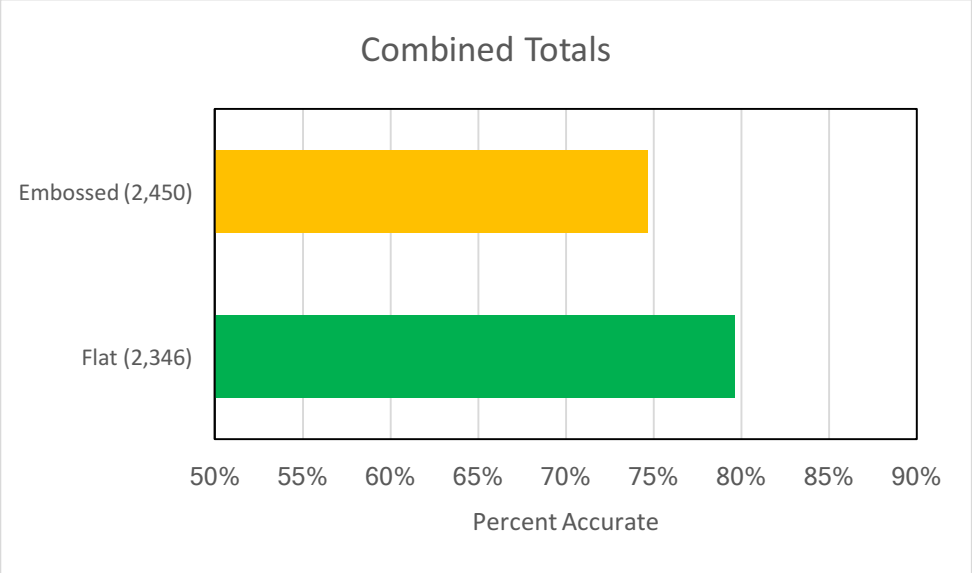

Figure 13 Embossed and Flat Combined Accuracy Rates for All Sites

Kentucky currently uses two equipment vendors to supply LPRs for weigh stations. Figure 14 shows the accuracy results from both vendors for flat and embossed license plates. 631 license plates were read with Vendor A's equipment (302 flat and 329 embossed) and 4,165 license plates were read with Vendor B's equipment (2,044 flat and 2,121 embossed). Equipment from both vendors read flat license plates more accurately, however, the accuracy rate of Vendor A's equipment was approximately 20 percent higher for flat license plates than for embossed license plates.

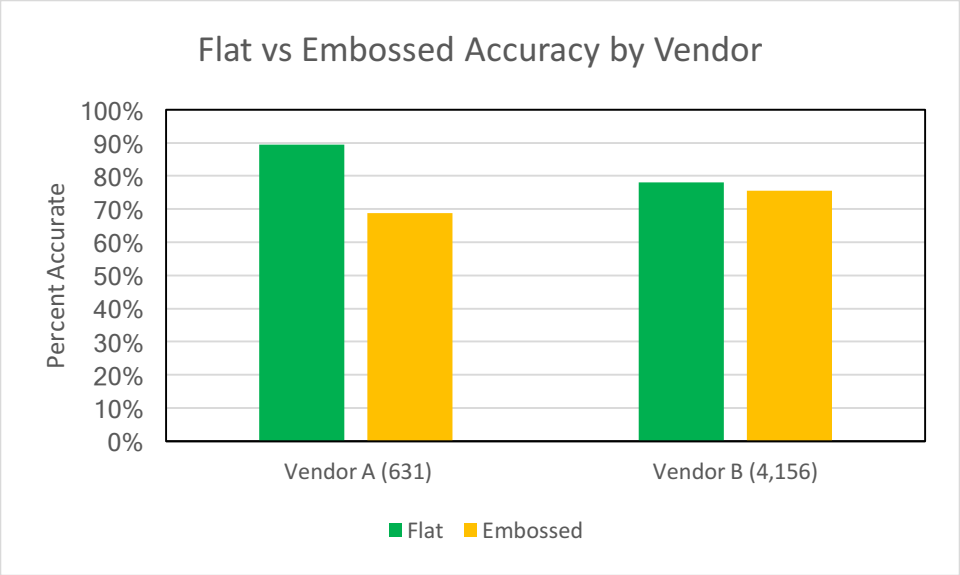

Figure 14 Vendor Comparison for Flat and Embossed Plates

After analyzing all of the data collected for flat and embossed plates, significant differences were only found at the Laurel NB inspection station (which uses Vendor A's equipment) . Even though the Lyon EB inspection station (83 percent flat, 73 percent embossed) and Carter virtual inspection station (63 percent flat, 52 percent embossed) — which used Vendor B's equipment — appeared to have noticeable differences in accuracy for flat and embossed license plates, those results were not replicated at other sites that relied on Vendor B's equipment, suggesting those outcomes may have been anomalous. The Carter site does not provide much support for the results because many of the embossed plates passing through the station are affixed to Kentucky-plated trucks that are coming from a rock quarry, which means they have plates that are typically very dirty and difficult to read. Analysis of combined data showed that LPRs were more accurate reading flat plates (80 percent) than at reading embossed plates (75 percent), however, the magnitude of the difference was small. Given the possible influence of confounding factors, the evidence here is insufficient to conclude there is a significant difference between LPR cameras' ability to read different license plate types. This runs counter to the expectations going into the regression analysis, which was that LPRs would read flat plates more accurately than embossed plates.

4.3 Stacked Lettering

The next license plate characteristic analyzed the plate string; more specifically, whether plates contained vertically stacked letters. A limited number of jurisdictions use stacked lettering as part of their string. Figure 15 details the accuracy rates at locations where data were collected. Even though some sites such as Lyon EB and Carter appeared more accurate at reading stacked lettering, this was based on a very small number of stacked letter observations (<10). Small sample sizes (less than 30) are denoted with a "*" in the figure. Scott (70) and Simpson (38) counties were the exception and had the most observations with stacked lettering, but the results were mixed. At Scott County the accuracy rates for stacked lettering were about the same as for unstacked lettering, but at Simpson County license plates with unstacked lettering were read approximately 30 percent more accurately. The limited number of observations and mixed results makes it difficult to draw conclusions about the readability of those license plates.

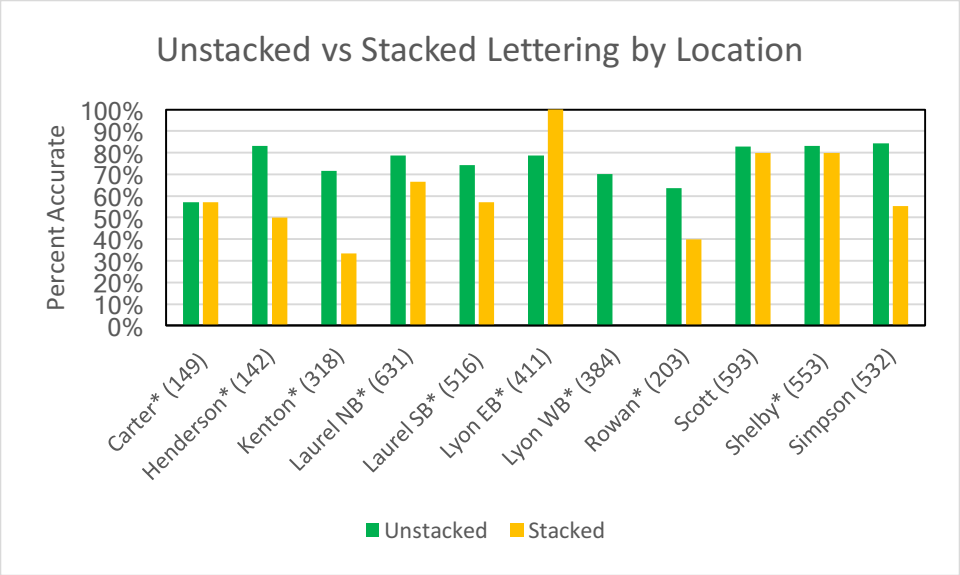

Figure 15 Unstacked and Stacked Accuracy at Each Location

Combining the totals for each location makes it clear that license plates without stacked lettering are read at a much higher accuracy rate than those with stacked lettering. Figure 16 shows that license plates with unstacked lettering were read accurately approximately 9 percent more often that plates with stacked lettering. Problems typically arise when LPRs are unable to determine whether the stacked letters are part of the license plate string. Accurate readings are needed to identify the jurisdiction. Some jurisdictions use the stacked letters PWR to denote the power unit. In such cases, those letters are not needed to identify the jurisdiction and they are not part of the string. However, the system attempts to include them as if they are part of the plate string, which creates an accuracy problem. Other jurisdictions, such as Virginia, use stacked lettering that is part of their license plate string, and it is needed to correctly identify the jurisdiction. Because various jurisdictions have different approaches, it poses significant problems for administrators who want to use LPR technology to identify vehicles by their license plate numbers.

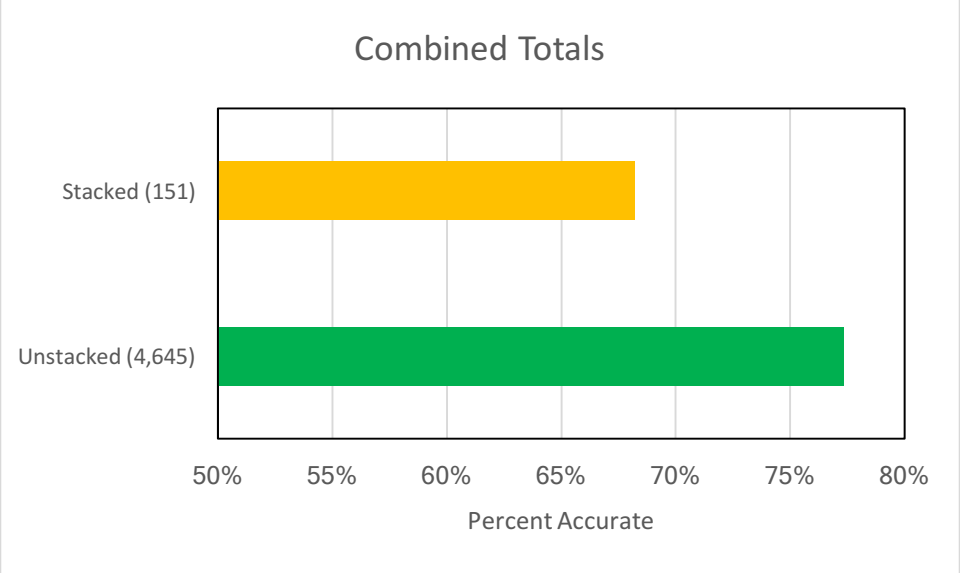

Figure 16 Unstacked and Stacked Combined Accuracy Rates for All Sites

The final comparison looked at the equipment Kentucky uses to read license plates. Figure 17 indicates that Vendors A and B handle stacked lettering almost identically. Because Kentucky has more license plate readers from Vendor B, its equipment has been used to read a larger number of plates with stacked lettering. For unstacked license plates, Vendor A's equipment achieved 79 percent accuracy, while Vendor B's products was accurate 77 percent of the time. During the observation period, equipment from Vendor A only processed 9 license plates with stacked lettering. As such, there are not enough observations to confidently evaluate whether Vendor A's equipment accurately reads stacked lettering. Given the statistics for Vendor B's equipment, these data show that if Kentucky adopted a license plate with stacked lettering it could significantly hamper the ability of the license plate cameras to properly decode license plates.

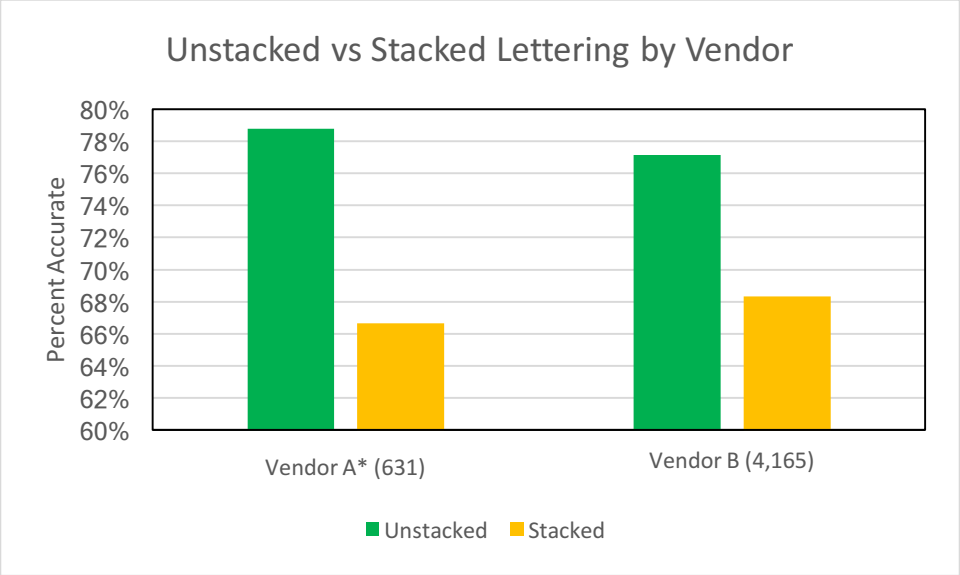

Figure 17 Vendor Comparison — Unstacked and Stacked Lettering

When the data are combined it appears that lettering significantly influences the accuracy of LPRs. Because 151 license plates had vertically stacked lettering while 4,645 had unstacked lettering, there is not sufficient information to say what effect stacked lettering would have on license plate recognition. The only inspection station from which an adequately large sample size was obtained showed that LPRs did not perform as poorly at reading vertically stacked lettering as the combined totals would suggest. The statistics from the combined totals would likely hold up to a much larger sample of license plates with stacked lettering from each inspection station. Given the lack of data, a statistically significant result was not expected in the probit analysis, although researchers predicted a slightly negative association between LPR accuracy and stacked lettering.

4.4 Plate Length

License plate length (i.e., the number of characters on the license plate) was examined to determine its effect on the accuracy of the LPRs. Figure 18 shows the accuracy of LPRs at each location based on the number of characters in the license plate string. The results were somewhat misleading. A few of the locations showed 100 or 0 percent accuracy for a particular plate length. Five-, eight-, and nine-digit license plates were underrepresented in the sample. There were fewer than six of each per site; therefore the accuracy rates are not statistically meaningful. The majority

of the license plates were six or seven characters in length — 1,798 license plates had six characters and 2,938 had seven characters.

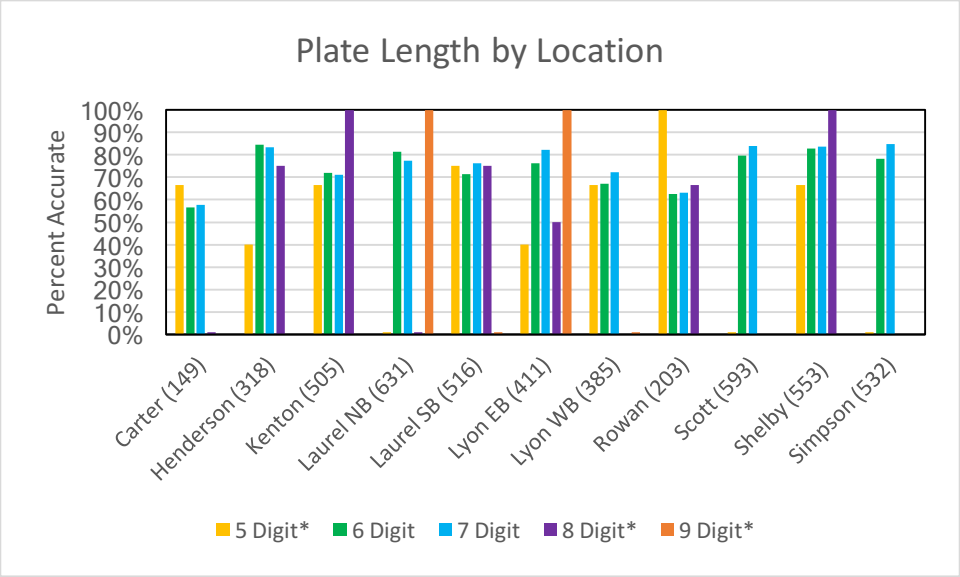

Figure 18 Accuracy for Plate Lengths Based on Location

Figure 19 illustrates the combined accuracy results for all sites based on the length of the license plate string. Again, there were not enough five-, eight-, or nine-digit observations to meaningfully assess LPRs accuracy in reading these license plates; however, the data are presented to show how accuracy varies based on length of the license plate string. Contrary to what was expected, LPRs' accuracy rate was slightly higher for seven-digit license plates than for six-digit license plates — 78 percent vs. 76 percent. The prediction was that a longer string would produce more errors due to the LPR reading extra digits. Further research is needed to explain why the longer license plates tend to be read more accurately.

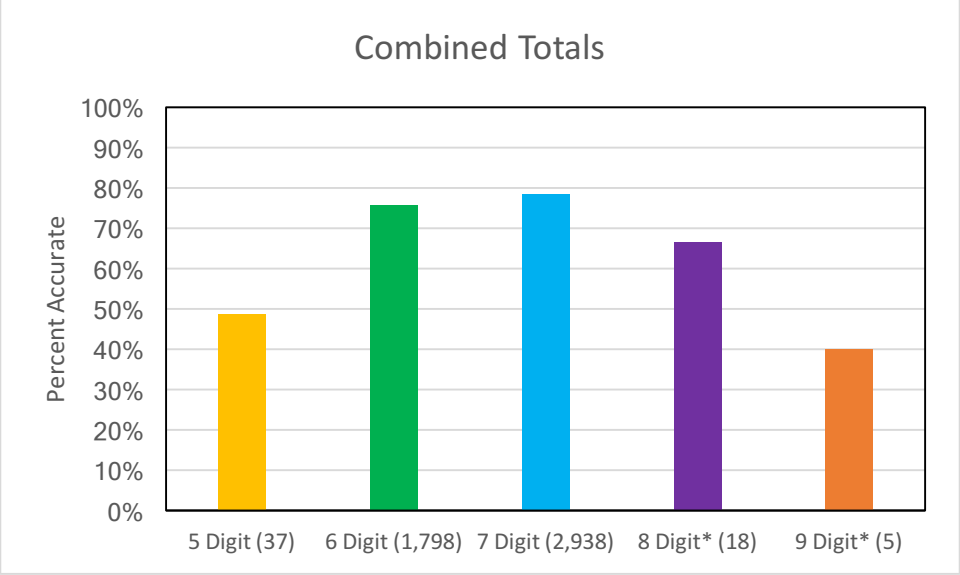

Figure 19 Accuracy by Plate Length and Weigh Station

Figure 20 shows how accurately equipment from Vendors A and B read license plates of varying string lengths. Vendor A does not appear for five- or eight-digit plates because there was only 1 observation for each license plate length, and they both were read incorrectly. Similarly, Vendor A's equipment was 100 percent accurate reading plates with nine characters; however, there was only a single observation. The most notable difference is that Vendor A's equipment was slightly more accurate on six-digit license plates while Vendor B's equipment performed slightly better on seven-digit license plates. Vendor A's equipment read approximately 150 fewer plates with six digits than seven-digit plates. This could account for why the equipment proved more accurate at reading plates with six characters. Even though there was a four percent difference between the accuracies for Vendor A's equipment, it is presumed that the accuracies may have been equalized if the number of observations of six- and seven-character long license plates were even. Vendor B's equipment was four percent more accurate at reading plates with seven characters than those with six characters. The reason for this difference is unclear, but for the probit analysis an inverse relationship between accuracy and the number of characters on a plate was expected.

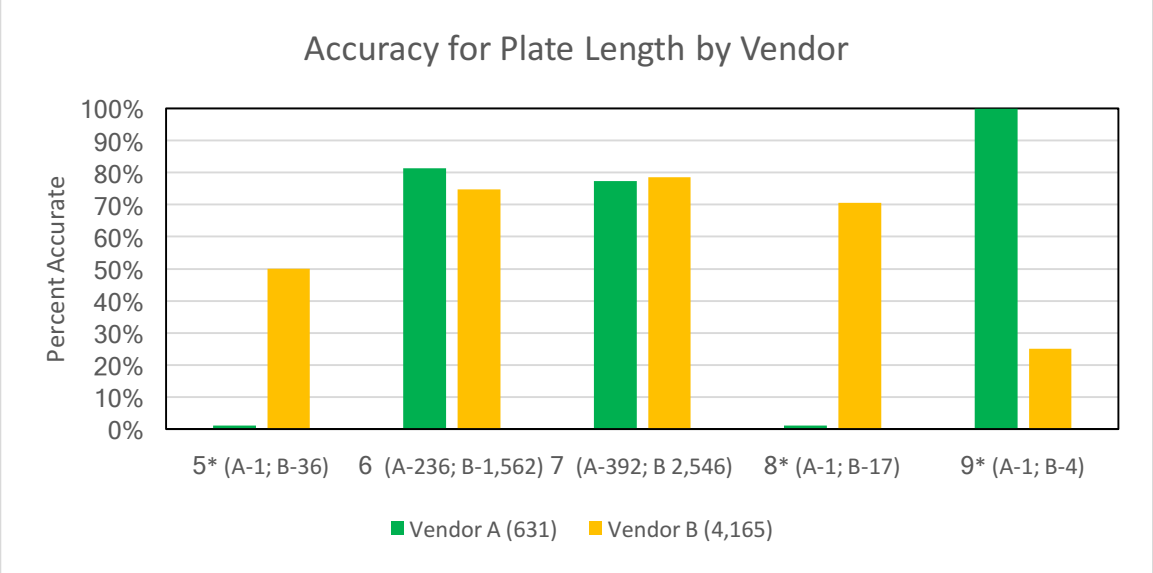

Figure 20 Plate Length Accuracy Based on Vendor

4.5 Alphanumeric vs Numeric

The next test was to determine accuracy rates for reading alphanumeric and numeric license plates. Data were collected from each location and are summarized in Figure 21. At all but one location, numeric license plates were read less accurately by the LPRs. The one location where the accuracy rates for numeric plates was higher is the only site where Vendor A's equipment is used. Even though it was clear that alphanumeric license plates are read with a higher degree of accuracy at most locations, only two sites showed a significant difference in license plate accuracy. Four locations read alphanumeric license plates significantly better than numeric license plates:

- At the Simpson location, the difference was 17 percent.
- At the Laurel SB location, the difference was 15 percent.
- At the Rowan location, the difference was 14 percent.
- At the Carter location, the difference was 13 percent.

These results indicated that some sites support more accurate readings of alphanumeric plates than numeric plates. Across these sites, alphanumeric plates outnumbered the numeric plates by a 4-to-1 margin.

At the Laurel NB inspection station LPRs' interpreted numeric plates with greater accuracy than alphanumeric plates — a trend opposite of what was observed at the other sites. This location uses Vendor A's equipment, while all of the other sites use Vendor B's equipment. As with the other locations, the ratio of alphanumeric plates to numeric plates was 4-to-1, however, the results were the exactly opposite. Further analysis is necessary to determine if these findings would hold for all locations with Vendor A's equipment.

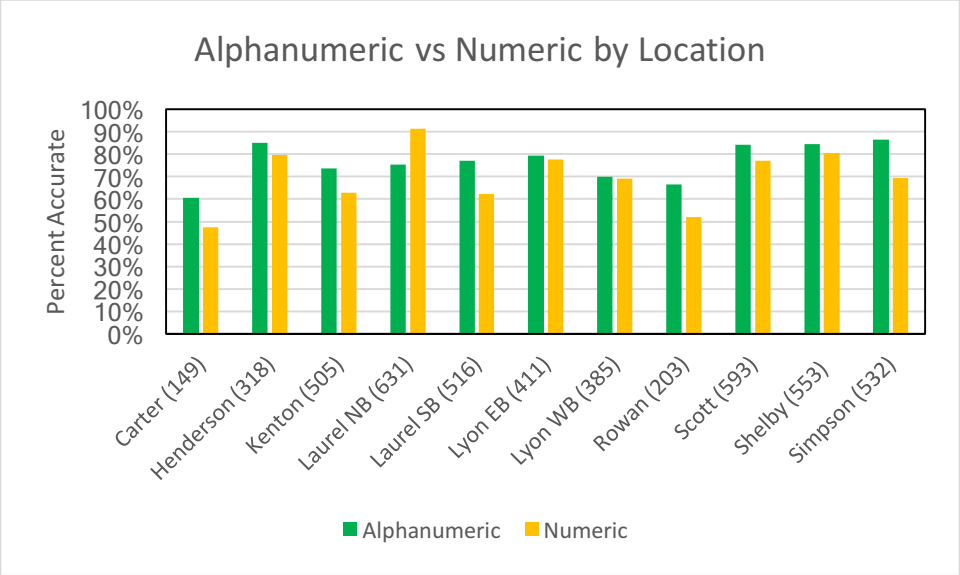

Figure 21 Alphanumeric and Numeric Accuracy for Each Station

The combined totals for all of the sites show that alphanumeric plates are read more accurately (Figure 22). When the data are combined, the difference in accuracy is approximately 5 percent in favor of alphanumeric plates. However, the combined analysis masks variation in accuracy across locations. The vendor comparison sheds further light on these findings.

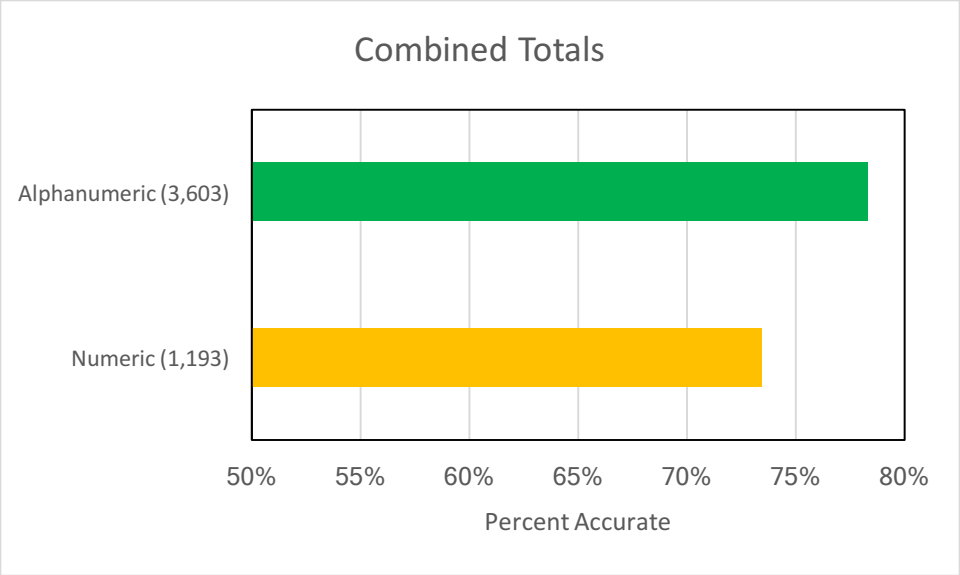

Figure 22 Numeric and Alphanumeric Combined Accuracies for All Sites

Figure 23 shows the license plate accuracy for each vendor's equipment according to the type of license plate. The accuracy rate for Vendor A's LPR technology on numeric plates was 16 percent higher than for alphanumeric plates. Conversely, the accuracy rate for Vendor B's LPR technology on alphanumeric plates was 8 percent higher than for numeric plates. Consequently, before running the probit model, the research team expected the analysis would statistically confirm this discrepancy. However, the results of later analysis turned out differently than expected.

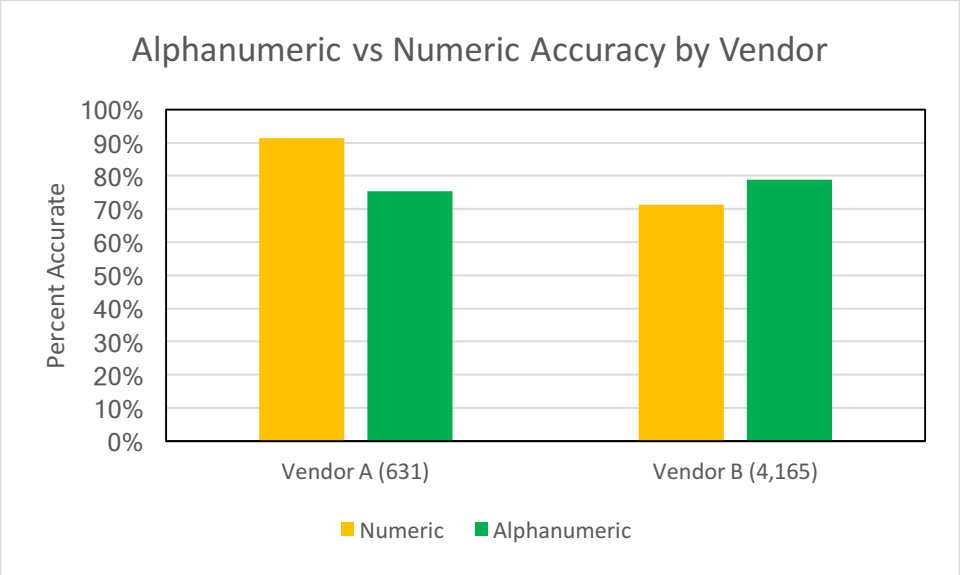

Figure 23 Alphanumeric and Numeric Accuracy by Vendo

4.6 Daytime vs Nighttime Accuracy

License plate data were analyzed to determine the effect of lighting conditions on the accuracy of LPRs. To determine whether a plate was read during daytime or nighttime hours, a website was used where users input weigh station or virtual weigh station GPS coordinates, along with a date and time zone, to generate official sunrise and sunset times. Records for trucks passing a station

between sunrise and sunset were coded as daytime, and those between sunset and sunrise were coded as nighttime records.

Figure 24 summarizes these results. Sites without a column for a nighttime accuracy rate did not have any nighttime observations to analyze. The exception is the Rowan County station, where the KATS system incorrectly read two license plates during the nighttime hours. Data were collected for the typical operating hours of each inspection station, so some stations had more observations at night than others. Two of the inspection stations (Kenton and Lyon EB) appeared to have a distinct difference between their daytime and nighttime accuracy rates. Upon closer examination, Kenton only had seven license plates at night and Lyon EB only had six. The small number of observations could explain the higher accuracy rates. It is possible these inspection stations would have results similar to the other stations if there were a larger number of nighttime observations. One interesting observation is that the Laurel NB station produced almost identical results for both day and night — a less than 1 percent difference in accuracy. At the Laurel NB stations, there were 300 daytime observations and 331 nighttime observations. Given the large sample sizes, it lends more weight to the fact that the daytime and nighttime accuracy rates at Laurel NB were basically identical.

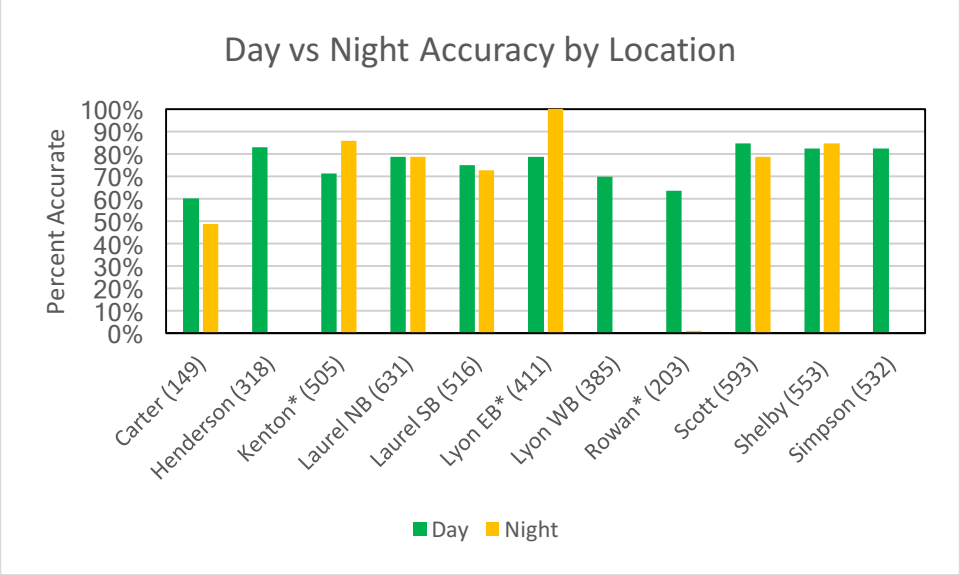

Figure 24 Day and Night Accuracy by Location

Figure 25 shows combined totals for all inspection stations. Accuracy rates for night observations were approximately 0.5 percent higher compared to the daytime accuracy. There was a roughly 4-to-1 ratio of daytime to nighttime observations. However, because of the large sample size and the nearly identical accuracy rates, the belief was that there would be no significant difference in the probit model.

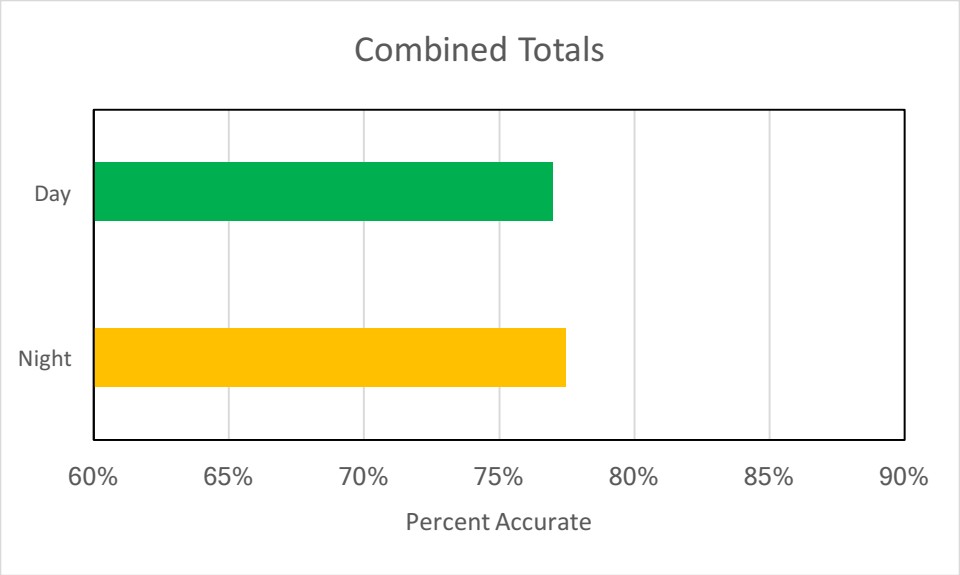

Figure 25 Day and Night Accuracy for Combined Totals

Figure 26 summarizes the daytime and nighttime results for each vendor's equipment. Vendor A's equipment was slightly more accurate than Vendor B's for both day and night observations. But this difference is less than 2 percent. Both vendors' equipment performed nearly identical during the day and night. There is only about 0.1 percent difference in accuracy between them, suggesting that the time of day does not impact LPR capabilities. Vendor A's equipment has a slight advantage in reading license plates. However, the sample size for Vendor B's LPRs is much larger, with 6.6 times as many observations as for Vendor A's equipment, which only has LPRs installed at the Laurel NB station. Station-specific factors could influence the accuracy of Vendor A's equipment.

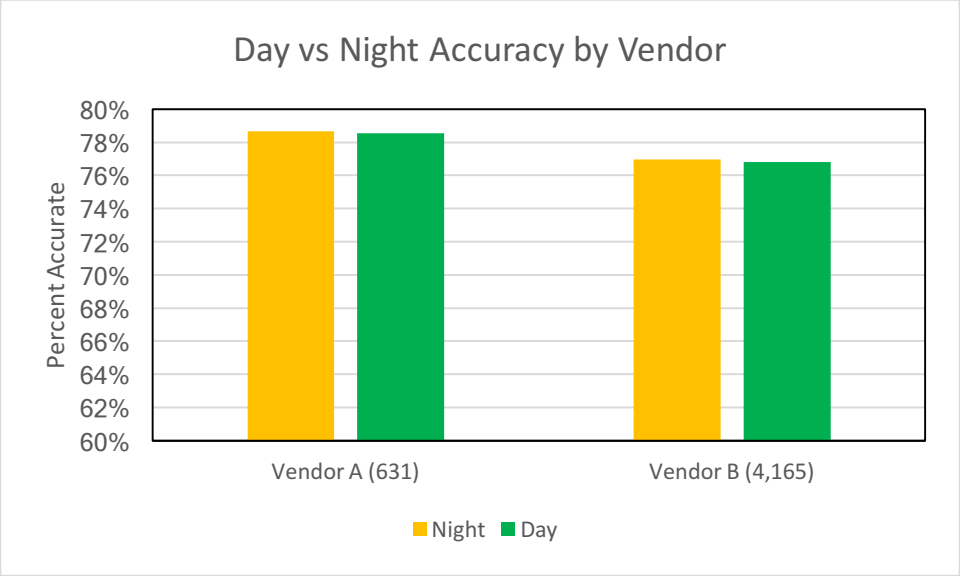

Figure 26 Day and Night Accuracy by Vendor

4.7 Proximity to Kentucky Comparison

The data were further analyzed to determine if the proximity of the state to Kentucky impacted the LPRs' ability to read the out-of-state license plate. The data were split into the following three

groups: Kentucky plates, Border State Plates, and Non-Border State Plates.[30] Figure 27 shows the accuracy rate at each inspection station based on the proximity to Kentucky. Generally, the license plates from Kentucky and Kentucky's border states were accurately read a higher percentage of the time than plates from non-border states. Accuracy rates varied based on the weigh station location. Kentucky plates were read accurately a greater percentage of the time than plates from non-border states at every location except for Lyon County WB and Carter County. The number of Kentucky-plated vehicles at the Lyon WB station was relatively small (28 observations), and the sample size at the Carter County station was only slightly larger. However, plates from border states were read accurately a higher percentage of the time than Kentucky plates at five sites. And the KATS systems do nearly as well (87.2 percent) reading border-state plates as Kentucky plates (87.7 percent) at the Scott County station.

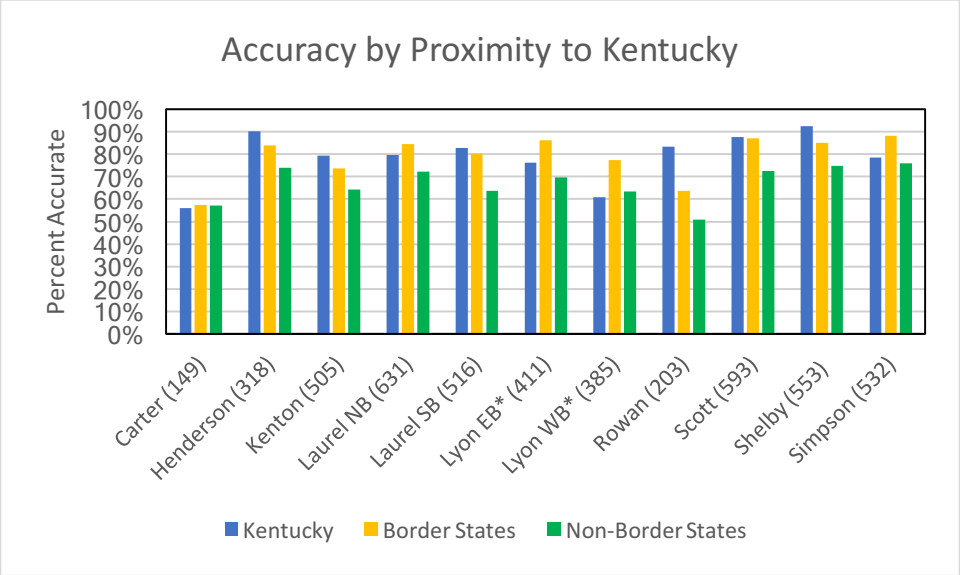

Figure 27 Accuracy by Proximity to Kentucky

Figure 28 shows the accuracy results for the combined totals based on the proximity to Kentucky. The accuracy rate for plates from non-border states was 12 percent less than for all other license plates across all inspection stations. South Carolina and Illinois both use a similar plate string which can be problematic for the LPR-based KATS systems. Also, license plates from North Carolina and Wisconsin are more difficult to read based on the way they are manufactured. Consequently, they are less visible in the 850nm light camera component used at the majority of the inspection stations. Alabama license plates are sometimes problematic because they use a string similar to the Indiana license plates. Most LPR systems use four basic techniques: image acquisition, license plate recognition, character segmentation, and optical character recognition. Because there is a greater variety of alphabetical characters, the character segmentation and recognition process can be more complicated than with numeric characters. In addition, if plate design elements are similar (characters, spacing, font, background, color, etc.), as is the case with Indiana and Alabama, there can be additional challenges with getting accurate jurisdiction recognition. While there may be other explanations for these discrepancies, a full analysis is beyond the scope of this report. There are little comparative data on the impacts of retroreflectivity, color contrast, font, curing process, inks, and plate designs on LPR system accuracy. State and

[30] The Non-Border States include data from the Canadian provinces with truck plate data in the sample.

federal stakeholders should consider funding more research in this area if they plan for LPR and USDOTR systems to be the standard mechanism for electronic tolling and for screening commercial vehicle operations.

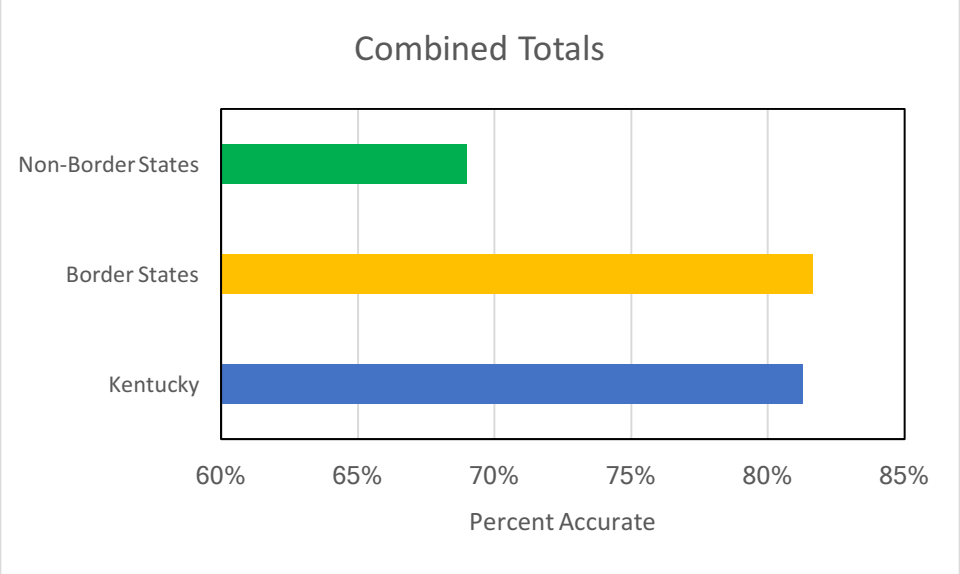

Figure 28 Accuracy for Proximity to Kentucky and Combined Totals

When the accuracy rates are broken down by vendor, there is not a clear difference between them. Figure 29 shows that Vendor A's equipment appears to be slightly more accurate at reading license plates from non-border states. However, this may be due to sampling error. Vendor A's LPRs examined 208 license plates from non-border states while Vendor B's looked at 980. Vendor A's equipment performed better at reading plates from border states, but this sample consisted of 253 license plates, whereas Vendor B's LPRs looked at 1,830 plates. With only a 3 percent difference in accuracy Vendor A's equipment cannot claim to be better at reading license plates from Kentucky's border states. Not only is the sample size smaller, but it was taken from a single location, while the sample of Vendor B's equipment came from 10 separate locations. There may be geographical differences that account for the variation in accuracy. Vendor B's equipment read Kentucky license plates at a higher accuracy rate than Vendor A by (approximately 2 percent), but the sample size was 390 license plates compared to 35 for Vendor A's LPRs. A larger sample size for Vendor A may reduce sampling error for the Laurel NB station, but that would still omit any regional differences that cannot be accounted for at this time due to Vendor A's equipment only being installed at one location.

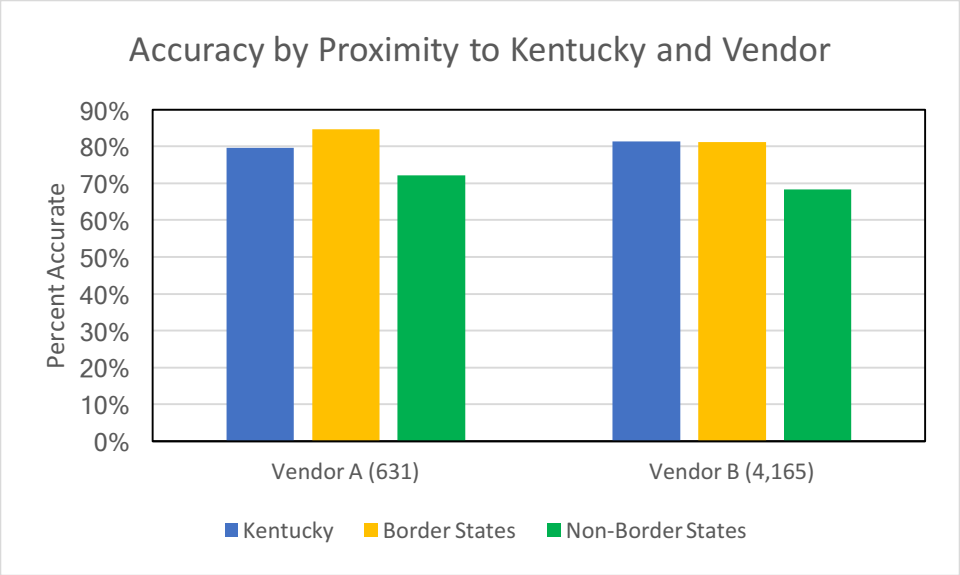

Figure 29 Accuracy by Proximity to Kentucky and Vendor

4.8 Jurisdictional Accuracies

License plate data from each sampling location originated from many jurisdictions. Each jurisdiction uses its own standard for plate type and for their manufacturing process. Each state or province uses either a flat license plate or an embossed license plate, but there are differences even among the same type of plate. Font styles vary among jurisdictions. Multiple font styles decrease the likelihood that LPRs will correctly identify the jurisdiction. The font and background colors also influence plate readability. Depending on the wavelength of infrared illumination used, some colors are more difficult for the cameras to pick up and interpret. The manufacturing process can also play a major role in plate readability. Certain jurisdictions use coatings on their plate that make it more aesthetically pleasing but also lessen its visibility under some lighting conditions. Finally, the string of the license plate (i.e., the letters and numbers on the plate) can make reading the license plate correctly a difficult task. Some jurisdictions use the same combination of letters and numbers as other jurisdictions, and this makes it more difficult for LPRs to correctly identify the jurisdiction. These characteristics — in addition to the other license plate attributes discussed in this chapter — account for the differences in how accurate LPRs are at interpreting the plates from each jurisdiction. Figure 30 shows the combined accuracies of all stations and how well the KATS' LPR systems performed for each jurisdiction.

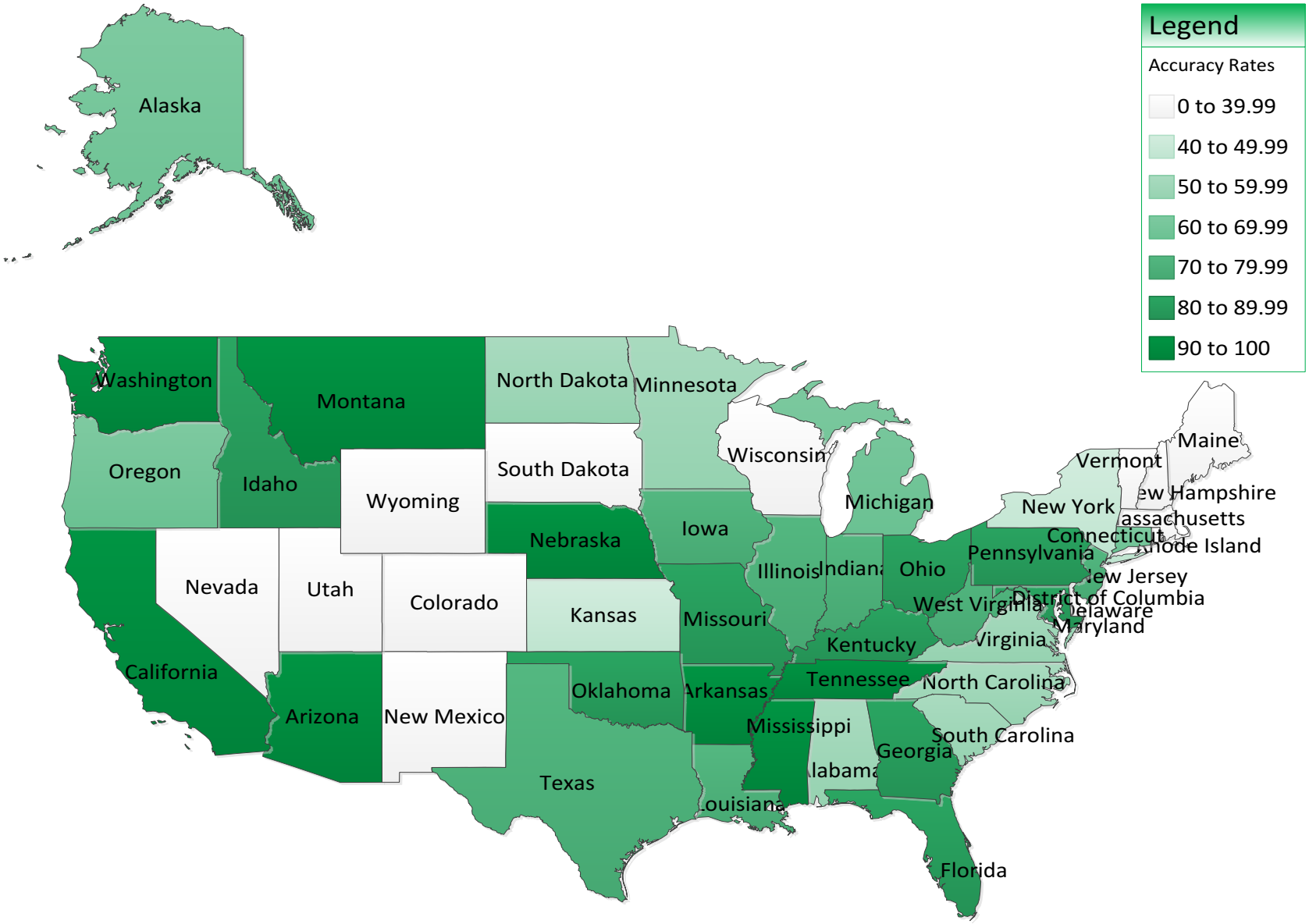

Figure 30 Accuracy Map for United States

Figure 30 indicates that most of the license plates issued in states bordering Kentucky were read correctly by the LPRs. The only exception is Virginia. Virginia uses stacked lettering, and as previously noted, the accuracy rates for stacked lettering are very inconsistent. LPRs do not always handle this license plate effectively, and it is not surprising that accuracy rates were lower for plates from Virginia. Moving beyond the border states, South Carolina is another state that is somewhat problematic, but for different reasons. The license plate string and format for South Carolina mirrors what is used by Illinois. The only difference is where the word Apportioned is situated on the license plate. North Carolina plates cause problems for an entirely different reason than Virginia or South Carolina's. The state uses a different coating process for its plates, which decreases their visibility under the infrared lighting used by the LPRs. Currently Vendor B is testing alternative infrared lighting wavelengths to determine if it will boost the accuracy when reading South Carolina plates. Currently, Virginia and North Carolina use embossed license plates for commercial vehicles, while South Carolina uses both embossed and flat license plates. Overall, preliminary analysis suggests that Kentucky plates (81.3 percent) and border-state plates (81.7 percent) are more likely to be read correctly than plates from non-border states. The difference between Kentucky and border-state plates is suspected to be statistically insignificant. In-state plates and border-state plates are more frequently observed by KATS systems than non-border-state plates, and in most cases, vendor technicians modify the screening algorithms to focus on states with high commercial vehicle traffic volumes passing through Kentucky.

4.9 License Plate Readers and Commercial Vehicle Plate Characteristics Model

The samples of commercial vehicle license plates from 11 KATS systems across the state established the expectations of which plate characteristics have the greatest positive or negative impact on the performance of LPR components. If only the descriptive statistics are analyzed, it is impossible to isolate alternative explanations for why the accuracy rate fluctuates. To understand which variables drive the performance of the LPR systems, multiple regression analysis was used so that the particular effect of each independent variable (i.e., plate characteristics) could be assessed by finding linear combinations of variables that best predicted the dependent variable (i.e., whether or not the KATS system properly decoded the plate string). Given that the independent variable is dichotomous (i.e., correct or incorrect reading), a probit regression model was used.

Before running the model, each characteristic was coded in a way that was compatible with regression analysis. All plate characteristics were converted to a numeric value. Table 20 shows each variable used in the model and its coding rule. The LPR read was the dependent variable, and was coded "0" if incorrect, and "1" if correct. Several independent variables – embossed, stacked, alphanumeric, and daytime – were also dichotomous, which means they were coded "1" if the attribute was present and "0" if not. Region and station were categorical variables, which means they were treated as factor variables because their values cannot be ranked or ordered. The only continuous variable was length, but was treated as a factor variable due to the preponderance of six- and seven-digit plates in the sample.

Table 20 Coding Rules for License Plate Characteristic Model Variables

Variable	Type	Coding
LPR	Dependent	"0" if incorrect, "1" if correct
Embossed	Independent	"0" if flat, "1" if embossed
Stacked	Independent	"0" if single line of characters, "1" if stacked characters
Length	Independent	Number of characters in the plate string
Alphanumeric	Independent	"0" if numbers only, "1" if alphanumeric
Daytime	Independent	"0" if nighttime, "1" if daytime
Region	Independent	"0" if KY, "1" if border state, "2" if non-border state
Station	Independent	Unique value between 1-11 assigned to each station

All observations for which insufficient or incomplete data were discarded. Stata automatically dropped incomplete records from the probit model because statistical model's algorithm deletes any records missing outcome or predictor variables. As such, the model sample size was 4,796. Researchers ran an alternate specification with all of the raw data, which included observations with blurry (because of weather or camera issues), incomplete, or invalid photos that coders were unable to completely code. In some instances, they were able to code all of the data relevant to the model but were unable to determine the USDOT number or some other piece of information. The entire sample size for those data was 6,435, but only 5,346 of those observations were usable. It is crucial to point out that in these instances (or 16.9 percent of the sample), reviewers were unable to determine whether an LPR read the plate correctly. Additional missing data for the independent variables, due to validation issues or other problems, accounted for the remaining reduction of the sample size, from 5,346 to 4,796. Adding these observations could have significantly influenced the coefficients and predicted probabilities. In most cases, the independent variable characteristics could not be identified, so we cannot know how those observations might impact the predicted probabilities. The coefficients and predicted probabilities presented here are based on an analysis of instances where humans could validate LPR imagery. In reality, there are instances where no determination can be made. Therefore, the probabilities are likely upwardly biased. This issue cannot be fixed without interpolating or extrapolating values for missing data, and even doing that would require numerous assumptions that would be problematic from a modeling standpoint.

Table 21 shows the probit regression coefficients for three license plate characteristics and LPR system accuracy models. The first model includes the entire sample (N=4,796), the second model includes only data from Vendor B's equipment (N=4,165), and the third model includes only the data from Vendor A's LPRs (N=628). Models 2 and 3 both use a subset of the full Model 1 dataset. The variable/factor column identifies the independent variable or variable factor. The coefficient denotes the direction of the relationship between the independent variable and dependent variable. The coefficients for categorical regression models are difficult to interpret, unlike their continuous dependent variable counterparts. However, the standard error and the statistical significance based on the p-values can be used in along with the coefficient to assess the direction of the relationship and whether a relationship is merely a byproduct of sampling error. Baseline categories for the factors (length=5, jurisdiction=Kentucky, and the Carter County weigh station, which just happened to be the first listed alphabetically) are compared to other variable categories. There is no coefficient for Laurel NB in Model 2 because that weigh station uses Vendor A's equipment, which was excluded from the sample. There are several missing coefficients in Model 3 because there are no data for plates with five, eight or nine characters; consequently, seven-digit plates are

omitted. There is only a single weigh station in the model, so every station other than Laurel NB is excluded.

Table 21 License Plate Characteristics and LPR Accuracy Models

	(1) Full sample		(2) Vendor B		(3) Vendor A	
Variable/Factor	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.
Embossed	-0.385	(0.052)***	-0.311	(0.056)***	-0.883	(0.151)***
Stacked	-0.202	(0.116)	-0.189	(0.121)	-0.402	(0.483)
Length=6	0.428	(0.217)*	0.298	(0.222)	0.631	(0.159)***
Length=7	0.408	(0.217)	0.367	(0.221)	0.000	(.)
Length=8	0.024	(0.378)	0.037	(0.395)	0.000	(.)
Length=9	-0.597	(0.648)	-0.975	(0.741)	0.000	(.)
Alphanumeric	0.572	(0.061)***	0.638	(0.064)***	-0.024	(0.211)
Daytime	0.075	(0.059)	0.097	(0.069)	0.034	(0.120)
Border states	-0.024	(0.088)	-0.043	(0.094)	0.347	(0.283)
Non-border states	-0.564	(0.080)***	-0.575	(0.085)***	-0.396	(0.254)
Henderson	0.735	(0.136)***	0.742	(0.137)***		
Kenton	0.368	(0.122)**	0.354	(0.123)**		
Laurel NB	0.691	(0.121)***			0.000	(.)
Laurel SB	0.495	(0.122)***	0.497	(0.122)***		
Lyon EB	0.673	(0.129)***	0.675	(0.129)***		
Lyon WB	0.375	(0.127)**	0.374	(0.127)**		
Rowan	0.147	(0.140)	0.134	(0.140)		
Scott	0.845	(0.123)***	0.834	(0.123)***		
Shelby	0.816	(0.123)***	0.831	(0.124)***		
Simpson	0.784	(0.126)***	0.778	(0.126)***		
Constant	-0.302	(0.247)	-0.315	(0.254)	1.162	(0.312)***
N	4,796		4,165		628	
Pseudo R2	0.065		0.071		0.116	
Prob. > chi2	336.268		319.927		75.218	
Standard errors in parentheses						
*** p<.05, ** p<.01, ***p<.001**						

For Models 1 and 2, the most critical findings are for embossed plates, alphanumeric plates, and plates from non-border states. Across all three models, the negative, significant coefficient means that flat plates with a greater degree of accuracy than embossed plates. The most surprising finding is that alphanumeric characters are read significantly better than numeric characters in Models 1 and 2 — a finding that holds even when running the Model 2 specification, which only includes the observations from Vendor B's equipment. This is significant because the raw numbers showed that Vendor B's equipment read numeric plates better. Once model controls are implemented, the prediction flips for the impact of alphanumeric characters. Oddly enough, in Model 3, the opposite happens on the alphanumeric variable with Vendor A's equipment, except the negative coefficient is not statistically significant. Given the greater variety of possible characters, the finding for

alphanumeric characters is somewhat counterintuitive. Models 1 and 2 predict that the accuracy rate for non-border-state plates will be significantly lower than for Kentucky plates or border-state plates. The only discordant finding between Models 1 and 2 is the accuracy rate for six-character plates. In Model 1, this is significant at the .05 level, however, this disappears in Model 2 once we discard the records from Vendor A's equipment. The significance reappears in Model 3, but the sample may be too small to tell us much. Vendor was not used as an independent variable of Model 1 because of the perfect correlation with values corresponding to Vendor A, and the Laurel NB weigh station required that the vendor category be omitted. Overall, there are no significant findings for stacked lettering, time of day, or border-state effects on accuracy rate when compared to accuracy rates for Kentucky plates in any of the models.

While these results provide useful insights about the nature of the system, neither translating them into quantitative terms nor applying them in context is straightforward. To better understand the practical implication of these results, the research team calculated the marginal probability that each specific plate attribute would yield a correctly decoded license plate string based on the Model 1 estimates. These calculations included the predicted probabilities, standard error, significance, the low end of a 95 percent confidence interval, and the high end of a 95 percent confidence interval.

Flat plates (embossed=0) have a marginal probability of .822, or an 82.2 percent chance they will be read correctly by the LPR system, all else equal. When sampling error is taken into account, the 95 percent confidence interval is between .806 and .838. Embossed plates, on the other hand, have a marginal probability of .714. Given the differences in accuracy, we can say definitively that the accuracy rates for flat plates are higher once we have controlled for the effects of other known plate attributes. The predicted probability for plates with unstacked lettering is higher than for stacked lettering, although the confidence interval for the latter is quite large due to the low number of observations, which produces a higher standard error. The six- and seven-character plates have substantially higher predicted probabilities, but the large confidence intervals for the less-sampled (five, eight, and nine-digit plates) make it difficult to ascertain whether there is a significant difference among the groups.

The difference in predicted probabilities for alphanumeric plates and numeric plates is quite stark. The probability that KATS' LPR technology will correctly decode an alphanumeric plate is .806, while the predicted probability for numeric plates (alphanumeric=0) is only .632. Even if one takes the low end of the alphanumeric confidence interval and the high end of the numeric confidence interval, the difference in predicted probability is .139. Setting aside differences in the performance of systems at different weigh stations, this is among the strongest differences in the performance of any characteristic, although the embossed vs. flat plate characteristic also has a strong effect. If one examines the confluence of these characteristics, an interesting trend sets up.

Table 22 Predicted Probabilities by Plate Characteristic and Value

Variable/Value	Margin	Std. Err.	Low Int.	High Int.
Embossed=0	0.822	(0.008)***	0.806	0.838
Embossed=1	0.714	(0.010)***	0.693	0.734
Stacked=0	0.773	(0.006)***	0.761	0.785
Stacked=1	0.712	(0.036)***	0.641	0.783
Length=5	0.640	(0.075)***	0.493	0.787
Length=6	0.776	(0.011)***	0.755	0.797
Length=7	0.771	(0.008)***	0.754	0.787
Length=8	0.648	(0.108)***	0.437	0.860
Length=9	0.420	(-0.224)	-0.019	0.860
Alphanumeric=0	0.632	(0.017)***	0.598	0.665
Alphanumeric=1	0.806	(0.006)***	0.794	0.818
Daytime=0	0.753	(0.015)***	0.724	0.783
Daytime=1	0.775	(0.007)***	0.762	0.788
Region=0	0.831	(0.018)***	0.796	0.866
Region=1	0.825	(0.008)***	0.809	0.841
Region=2	0.664	(0.012)***	0.640	0.688
Carter	0.569	(0.039)***	0.492	0.646
Henderson	0.809	(0.022)***	0.765	0.853
Kenton	0.700	(0.020)***	0.660	0.740
Laurel NB	0.797	(0.016)***	0.766	0.829
Laurel SB	0.741	(0.019)***	0.703	0.778
Lyon EB	0.793	(0.020)***	0.754	0.831
Lyon WB	0.702	(0.023)***	0.657	0.748
Rowan	0.623	(0.033)***	0.558	0.689
Scott	0.836	(0.015)***	0.807	0.866
Shelby	0.829	(0.016)***	0.798	0.860
Simpson	0.822	(0.017)***	0.789	0.855

Table 22 shows the predicted probabilities of a correct LPR reading for a pairwise combination of plate production process and character type, for both the entire sample and Kentucky plates in particular. The categories of interest are set to the specified value listed in Table 20 and the table shows the predicted probability based on the model in Table 23. For both full samples and Kentucky samples — numeric, embossed plates have the lowest predicted LPR accuracy. Projected LPR accuracy rates improve to .701 and .769 for the general sample and Kentucky sample, respectively, in the hypothetical event that all plates are numeric and flat. When the model looks at alphanumeric characters, the numbers jump even higher, whether the plate itself is embossed or flat. The model predicts that alphanumeric, flat plates will produce the highest LPR accuracy rates. Predicted probabilities for LPR accuracy rates when reading alphanumeric, flat plates are .857 and .901 for the general sample and Kentucky sample, respectively. The separation among the categories for all jurisdictions makes it easy to rank the categories from most to least desirable with respect to LPR accuracy rates: 1) alphanumeric, flat; 2) alphanumeric, embossed; 3) numeric, flat; 4) numeric, embossed. Because there are only 89 plates in the lowest-ranked category, there is greater sampling error due to the somewhat anomalous status of that particular

set of plate characteristics. Each combination of character and production types includes over 1,000 in their respective samples.

Table 23 Predicted Probabilities by Character Type and Production Type

Plate Characteristics		All Plates		Kentucky Plates	
Characters	**Production**	**Probability**	**95% CI**	**Probability**	**95% CI**
Numeric	Flat	0.701	0.673 to 0.729	0.769	0.721 to 0.818
Numeric	Embossed	0.566	0.520 to 0.612	0.642	0.582 to 0.703
Alphanumeric	Flat	0.857	0.839 to 0.875	0.901	0.873 to 0.929
Alphanumeric	Embossed	0.759	0.742 to 0.776	0.820	0.788 to 0.852

What are the implications for Kentucky? In this sample, embossed, alphanumeric plates were the most common (2,361), and they performed better than any other character and production category except for flat, alphanumeric plates. The model predicts the LPR accuracy rate in Kentucky is 82 percent for those plates (the raw numbers peg the accuracy at 81.3 percent). If Kentucky agencies were to implement flat plates instead of embossed plates while retaining alphanumeric characters, the probit model predicts the marginal effect would translate into an approximately 8 percent increase in LPR accuracy.

Adopting flat license plates could increase the LPR accuracy of KATS systems at weigh stations around the state, and may enhance the efficiency of toll collection efforts by Kapsch, the vendor selected by the Joint Board and Tolling Body of the Louisville-Southern Indiana Ohio River Bridges Project. Both CVE and Kapsch have employees verify large volumes of LPR vehicle logs. Switching to flat plates would not eliminate record validation, but it would enhance overall labor efficiency. In the case of KATS, reviewers validate the LPR and USDOTR strings to ensure the appropriate truck has been screened. Officers at the station can do this, but employees at KYTC and KTC also use remote desktop applications to login and help validate records so that officers can focus on safety inspections. Incorrect reads must be corrected and rescreened; correct reads merely require that users click a radio button to confirm the record has been verified. More accurate reads of Kentucky plates will reduce the log of records to be verified.

The Transportation Enterprise Database (TED) is the central repository for records from each weigh station and virtual weigh station with a KATS system, PrePass system, ALTS data, or other automated screening prototypes. According to raw observation counts where the system could determine a jurisdiction, KATS systems observed 395,852 Kentucky plates between April 1, 2014 and September 30, 2015. Kentucky commercial vehicle plates constituted approximately 8.4 percent of the 4.6 million vehicles screened (with a known state) by KATS during that period. Because ALTS records are keyed manually, and PrePass uses transponder technology purported to have 99.9 percent accuracy, records from those two systems do not require manual validation to satisfactory accuracy.

Error! Reference source not found. reports the number of Kentucky plates observed at each station, the predicted probability of correct LPR reads of Kentucky plates with current embossed plates, the predicted probability of correct plate reads with flat plates, the marginal effect of the switch, and the number of records that would not have to be rescreened as a result. Over the 18-month period, there were 395,852 trucks with Kentucky plates screened. In the future, this number should increase — at most stations during this period, KATS systems were not active the entire

time. The marginal impact of switching from embossed plates to flat plates ranges from .059 at the Scott County weigh station to .132 at the Carter County virtual weigh station. Overall, the reduction of rescreened records is 32,064 for the data. There are limitations to keep in mind, however. These records would still need to be verified, but for better accuracy, those are records that CVE, KYTC, or KTC personnel can verify more quickly because the license plate does not have to be rekeyed. This does account for the joint probability of the USDOT read, which in some cases would affect rescreening as well. And the impact is obviously limited to Kentucky plates, which make up a small percentage of plates that are screened at weight stations. Perhaps most problematic is the fact that none of the organizations that verify records have enough personnel to validate all the records.

Table 24 Plate Accuracy by Station, Marginal Effects of Kentucky Flat Plates

Plate State Name	Kentucky Plates	Embossed	Flat	Marginal FX	Rescreen Reduction
Carter VWS	9,080	0.636	0.768	0.132	1,197
Henderson	6,193	0.860	0.929	0.068	423
Kenton	24,187	0.763	0.864	0.101	2,451
Laurel NB	70,255	0.850	0.922	0.072	5,071
Laurel SB	46,941	0.800	0.890	0.090	4,213
Lyon EB	5,903	0.846	0.920	0.074	435
Lyon WB	5,346	0.765	0.866	0.101	538
Rowan	2,008	0.690	0.810	0.121	242
Scott	70,253	0.883	0.942	0.059	4,159
Shelby	95,098	0.877	0.939	0.062	5,853
Simpson	39,140	0.871	0.935	0.064	2,511
Total	395,852	0.820	0.901	0.081	32,064

Turning to the implications for electronic tolling, a study by Steer Davies Gleave used a custom toll forecasting model to generate projections for the Louisville-Southern Indiana Ohio River Bridges Project.[31] The model provided estimates of traffic and toll revenues generated at the three tolling sites — the Abraham Lincoln Bridge, Lincoln Bridge, and as-yet-named East End Bridge — between Louisville, Kentucky, and Southern Indiana, where both states have entered into a bilateral tolling agreement. The projections look at a variety of factors, including toll revenue leakage. The study identified three sources of potential toll revenue leakage: 1) license plate of a non-transpondered vehicle cannot be identified; 2) the license plate is identified, but Kentucky and Indiana have no agreement to obtain the vehicle information; and 3) the license plate of the non-transpondered vehicle is identified but the owner does not pay the bill. Atkins — consultants hired by Steer Davies Gleave to provide toll leakage projections — determined the toll leakage rates would be 7 percent (starting in 2017) before gradually falling to 2.4 percent in 2030, after which they are projected to hold constant. During the first several years they will also identify ramp-up efforts (i.e., effects related to the implementation of the technology, familiarizing customers to the tolling payment process, and eliminating administrative obstacles). Despite these effects being phased out after the first few years, toll leakage will likely remain. Given the difficulty LPRs have

[31] Steer Davies Gleave. (2013). *Louisville-Southern Indiana Ohio River Bridges Traffic & Revenue Study*. Prepared for the Kentucky Public Transportation Infrastructure Authority.

with identifying vehicles at weigh stations, there could be spillover effects at the electronic tolling sites. These could have incredibly significant effects on projected tolling revenues.

Table 25 shows the tolling projections prepared by Steer Davies Gleave for 2017-2030.[32] The columns include annual traffic after taking ramp-up efforts into account, annual revenue, annual revenues less tolling leakage, the tolling leakage rate, the ramp-up collections discounted rate, the overall collection rate (discounting ramp-up efforts and toll leakage), and average collection per toll. The projections show a steady increase in tolling revenue, which starts at $33.8 million in 2017 before climbing to more than $110 million by 2020. The projections assume a monotonic increase in both traffic and tolling revenue. Initially, ramp-up efforts and toll leakage hamper collection efforts, which are only slated to be 64.3 percent in 2017, and 70 percent in 2018. Thereafter, collection efficiency jumps to 82.7 percent in 2018 and crosses the 90 percent threshold in 2020. Meeting the revenue targets in the annual-less-leakage category is imperative if the bonds held by investors are to be paid off during the specified period of tolling, which runs through 2054. However, the assumptions about the actual efficiency for tolling collection hinge on the study's assumptions — which include a 2.5 percent annual increase in tolling rates, meeting traffic projections, traffic composition projections, transponder adoption, and several other assumptions detailed in the memo.

Neither the tolling leakage memo nor broader study addresses LPR accuracy rates, which could be a real impediment to meeting revenue projections. Kapsch — the contractor selected by the Tolling Body of the Joint Board for the Ohio River Bridges Project — is using video LPR technology for tolling, which is different than the cameras used at the weigh station. The company employs individuals to verify license plate reads to ensure they are correct, but as with the KATS system, verification is a labor-intensive task, particularly given that the volume of tolls is expected to exceed 100,000 per day. To streamline the process, the LPR equipment assigns a confidence level to each vehicle photo, which lets quality assurance specialists focus on those most likely to be read incorrectly.

[32] The projections go through 2054, but the basic dynamics for toll leakage assumptions are static, meaning the authors project 97.6 percent collection rates in perpetuity from 2030 to 2054.

Table 25 Steer Davies Gleave Revenue Projections, 2017-2030

Fiscal Year	Annual Traffic	Annual Revenue ($)	Annual Less Leakage ($)	Leakage	Ramp-up	Collection%	Per Toll ($)
2017	10,860,000	52,619,000	33,841,000	7.0	28.7	64.3	4.85
2018	24,803,000	113,236,000	79,252,000	5.0	25.0	70.0	4.57
2019	30,356,000	118,741,000	98,158,000	4.6	12.7	82.7	3.91
2020	33,575,000	121,317,000	110,248,000	4.3	4.8	90.9	3.61
2021	35,122,000	124,158,000	117,222,000	4.0	1.6	94.4	3.54
2022	36,162,000	127,285,000	122,529,000	3.7	0.0	96.3	3.52
2023	36,683,000	130,720,000	126,165,000	3.5	0.0	96.5	3.56
2024	37,238,000	134,488,000	130,096,000	3.3	0.0	96.7	3.61
2025	37,811,000	138,544,000	134,281,000	3.1	0.0	96.9	3.66
2026	38,418,000	142,834,000	138,703,000	2.9	0.0	97.1	3.72
2027	39,058,000	147,371,000	143,377,000	2.7	0.0	97.3	3.77
2028	39,734,000	152,172,000	148,198,000	2.6	0.0	97.4	3.83
2029	40,445,000	157,252,000	153,297,000	2.5	0.0	97.5	3.89
2030	41,193,000	162,629,000	158,691,000	2.4	0.0	97.6	3.95

Table 26 shows the year, annual traffic, estimated LPR percentage, total LPR-based tolls, estimated LPR errors, the number of estimated LPR errors for Kentucky plates, the number of estimated LPR errors if Kentucky adopted flat plates, and the total error reduction of a potential switch. The number of LPR errors was generated by multiplying the number of LPR tolls by the weighted average of in-state and out-of-state LPR accuracy. The rate of errors for Kentucky is 40 percent, as we assume an even split of Kentucky and Indiana plates in the absence of any projections that distinguish between the plate share of the two states. As noted, the marginal effect of switching to flat plates is an 8 percent increase in LPR accuracy, which if applied to the tolling model means 50,000 to 60,000 more correct reads of Kentucky plates per year, many of which would probably not require human verification by Kapsch system algorithms. This is not to say that switching to flat plates would have the same impact on Kapsch's LPR technology as with the LPR systems at weigh stations installed by different vendors. Nor does it account for the number of unverifiable records, because we do not have enough information to determine whether plate type would significantly impact the 16.9 percent unverifiable record rates. We restrict our focus to screenings where humans can verify if a license plate was read correctly by LPR equipment. Nevertheless, these calculations show the importance of evaluating license plate characteristics and their indirect impacts when making decisions about re-plating.

Table 26 Estimated Tolling LPR Error Rates Based on KATS LPR Accuracy Rates

Year	Annual Traffic	LPR	LPR	LPR Errors	Ky. Current LPR Errors	Flat Plate LPR Errors	LPR Error Reduction
2018	24,803,000	35.0%	8,681,050	1,562,589	625,036	575,033	50,003
2019	30,356,000	33.4%	10,138,905	1,825,003	730,001	671,601	58,400
2020	33,575,000	31.8%	10,676,850	1,921,833	768,733	707,235	61,499
2021	35,122,000	30.2%	10,606,844	1,909,232	763,693	702,597	61,095
2022	36,162,000	28.6%	10,342,332	1,861,620	744,648	685,076	59,572

2023	36,683,000	27.0%	9,904,410	1,782,794	713,118	656,068	57,049
2024	37,238,000	26.0%	9,681,880	1,742,738	697,095	641,328	55,768
2025	37,811,000	25.0%	9,452,750	1,701,495	680,598	626,150	54,448
2026	38,418,000	24.0%	9,220,320	1,659,658	663,863	610,754	53,109
2027	39,058,000	23.0%	8,983,340	1,617,001	646,800	595,056	51,744
2028	39,734,000	22.0%	8,741,480	1,573,466	629,387	579,036	50,351
2029	40,445,000	21.0%	8,493,450	1,528,821	611,528	562,606	48,922
2030	41,193,000	20.0%	8,238,600	1,482,948	593,179	545,725	47,454

It is more challenging to estimate what level of impact indeterminate LPR reads will have on revenue. As stated previously, KTC reviewers could not validate 16.9 percent of the images. There are several possible explanations. Some of the missed vehicles could be police cruisers or non-commercial vehicles entering the weigh station for state business. However, there are other issues that also plague LPR readers on the bridges: 1) dirty license plates; damaged or bent license plates; 2) license plates obstructed by tow bars, hitches, or license plate covers; 3) poor lighting; 4) periodic equipment malfunctions; 5) fog, rain, snow, sleet or other weather phenomena; 6) LPR reads missed in the event of an accident or unusually high levels of traffic near or over camera loops and triggers; 7) missing license plates; 8) dealer plates or temporary plates for newly purchased vehicles; and 9) blurry images or video feeds. Parsing the effects of these problems is difficult, but the issues could very easily cause Kapsch to miss its goal of correctly identifying and billing 99.9 percent of vehicles, and the leakage could be even the somewhat more conservative toll leakage estimates made by Steer Davies Gleave.[33]

[33] The 99.9 percent accuracy rate for vehicle identification and mailing is specified in the contract between Kapsch and the state partners.

Table 27 LPR Unverifiable Rate and Revenue Impacts

Fiscal Year	Impact/Leakage Rate	16.4% Unverifiable	15% Unverifiable	10% Unverifiable	5% Unverifiable	1% Unverifiable
2018	Impact	$ 6,499,746	$ 5,944,890	$ 3,963,260	$ 1,981,630	$ 396,326
	Leakage Rate	(5.7)	(5.3)	(3.5)	(1.8)	(0.4)
2019	Impact	$ 6,504,157	$ 5,948,924	$ 3,965,950	$ 1,982,975	$ 396,595
	Leakage Rate	(5.5)	(5)	(3.3)	(1.7)	(0.3)
2020	Impact	$ 6,326,924	$ 5,786,821	$ 3,857,880	$ 1,928,940	$ 385,788
	Leakage Rate	(5.2)	(4.8)	(3.2)	(1.6)	(0.3)
2021	Impact	$ 6,149,298	$ 5,624,358	$ 3,749,572	$ 1,874,786	$ 374,957
	Leakage Rate	(5)	(4.5)	(3)	(1.5)	(0.3)
2022	Impact	$ 5,970,176	$ 5,460,527	$ 3,640,351	$ 1,820,176	$ 364,035
	Leakage Rate	(4.7)	(4.3)	(2.9)	(1.4)	(0.3)
2023	Impact	$ 5,788,282	$ 5,294,160	$ 3,529,440	$ 1,764,720	$ 352,944
	Leakage Rate	(4.4)	(4.1)	(2.7)	(1.4)	(0.3)
2024	Impact	$ 5,734,568	$ 5,245,032	$ 3,496,688	$ 1,748,344	$ 349,669
	Leakage Rate	(4.3)	(3.9)	(2.6)	(1.3)	(0.3)
2025	Impact	$ 5,680,304	$ 5,195,400	$ 3,463,600	$ 1,731,800	$ 346,360
	Leakage Rate	(4.1)	(3.8)	(2.5)	(1.3)	(0.3)
2026	Impact	$ 5,621,946	$ 5,142,024	$ 3,428,016	$ 1,714,008	$ 342,802
	Leakage Rate	(3.9)	(3.6)	(2.4)	(1.2)	(0.2)
2027	Impact	$ 5,558,834	$ 5,084,300	$ 3,389,533	$ 1,694,767	$ 338,953
	Leakage Rate	(3.8)	(3.5)	(2.3)	(1.2)	(0.2)
2028	Impact	$ 5,490,366	$ 5,021,676	$ 3,347,784	$ 1,673,892	$ 334,778
	Leakage Rate	(3.6)	(3.3)	(2.2)	(1.1)	(0.2)
2029	Impact	$ 5,415,759	$ 4,953,438	$ 3,302,292	$ 1,651,146	$ 330,229
	Leakage Rate	(3.4)	(3.2)	(2.1)	(1.1)	(0.2)
2030	Impact	$ 5,334,231	$ 4,878,870	$ 3,252,580	$ 1,626,290	$ 325,258
	Leakage Rate	(3.3)	(3)	(2)	(1)	(0.2)
Total	Impact	$ 69,574,845	$ 63,635,529	$ 42,423,686	$ 21,211,843	$ 4,242,369
	Average (by year)	(4.4)	(4)	(2.7)	(1.4)	(0.3)

Table 27 shows the projected toll leakage rate for misidentified vehicles if the LPR systems prevent validation of a certain percentage of records. Because we have no sample of their particular vendor equipment, we calculated the toll leakage rate using the 16.9 percent unverifiable records statistic from the weigh station samples and the overall projected revenue for 2018-2030 from Steer Davies Gleave. In addition, we looked at unverifiable validation rates of 15, 10, 5 and 1 percent; we therefore assume, at worst, that the technology will continue to perform at current levels and will likely improve with the passage of time. The projected revenue is the total without taking the Steer Davies Gleave collection losses from the ramp-up effort or their own toll leakage accounts. Traffic projections are the same. Whether the vehicle is in a state with a tolling agreement or the customer pays the bill are not taken into account. The numbers assume the same transponder adoption rates in the Steer Davies Gleave study, starting at 65 percent of tolling trips in 2018 and moving to 80

percent by 2030. They also assume that 100 percent of verifiable LPR misreads are corrected and correctly identified by administrative support at Kapsch. There is also no billing threshold, as none of these tolls will be billable if they cannot be validated.

Table 27 shows that such impacts, if the verifiable rate is the same as the equipment at the weigh stations, would be $6.7 million in FY 2018 and 2019, before declining to $5.5 million in 2030 due to the increased adoption rates for transponders, which are assumed to have a negligible unverifiable rate. Nevertheless, the impact is more than $78 million over the 13-year period if no technological improvements are assumed and no policy changes are made. The 13-year impacts are about $69.6 million with a 15-percent unverifiable rate, nearly $46.4 million with a 10 percent unverifiable rate, just shy of $23.2 million with a 5 percent unverifiable rate, and $4.6 million with a 1 percent unverifiable rate. Averaged by year, the toll leakage rates vary based on the unverifiable record percentages. The averages for the 13-year period are 4.5, 4.0, 2.7, 1.3 and 0.3 percent for their respective columns. These estimates assume no technological improvements are made, which is unlikely. Nevertheless, stakeholders involved in the Louisville-Southern Indiana Ohio River Bridges Project should be aware of the technology's limitations and develop strategic plans accordingly.

4.10 Conclusion

This chapter's analysis identified several important license plate characteristics that officials should be mindful of when deciding on a course of action for re-plating vehicles in Kentucky. Based on the samples of records acquired from LPR readers in KATS systems at Kentucky weigh stations in early 2016, descriptive statistics and the probit model confirmed that LPRs have higher accuracy rates for flat plates than for embossed plates. There are several potential reasons for this result. The beveled edges of stamped or embossed letters and numbers hamper OCR technology and increase the number of inaccurate codings relative to flat plates. Flat plates offer better contrast against the plate background. Embossed letters and numbers may also retain more debris and moisture, which can also introduce problems for LPR systems. Another potential explanation is that unmeasured factors — such as plate contrast, color schemes, and retroreflectivity — may be correlated with flat plates and the newer printing technology used to produce them. More research is needed to draw more definitive conclusions.

Another general finding is that alphanumeric plates are read correctly more often than numeric plates. This was not true for Vendor A's equipment at the Laurel NB station, but for the sample of stations at which Vendor B's LPRs were installed. In the probit model, there is evidence to suggest that KATS systems post higher accuracy rates with alphanumeric plates. This finding is somewhat counterintuitive given the additional variability and complexity of alphanumeric characters, but anecdotal evidence points toward the distinctiveness of a character being a better predictor of accuracy rate than character type. The similar loops and curves in "0s", "5s", "6s", "8s" and "9s" — not to mention the similarity in "1s" and "7s" for many font styles — can create difficulties for the computer algorithms that decode these characters. There is also an interactive effect with production type and character type. Based on the technologies currently in use at Kentucky's weigh stations, flat, alphanumeric plates are preferable. The probit model predicts that switching to flat plates would boost the accuracy of LPR readers in KATS systems by approximately 8 percent.

The analysis demonstrates the presence of station-specific effects. This finding should be of some concern to officials, because the performance of these systems appears to be influenced by local conditions, including infrastructure conditions, local weather patterns, system configuration, and the camera models used. Station performance can, generally speaking, be improved if engineers and technicians devote sufficient time and resources to tweaking various system components, but some stations continue to perform better than others for reasons that are not yet fully known. The jurisdiction from which a plate originates also has some impact. Technicians and engineers have spent significant time and effort working on enhancing the ability of LPR systems to recognize the design and characters specific to particular plate styles based on templates they create. The data show that commercial truck plates from Kentucky and its border states are read correctly a higher percentage of the time than plates from non-border states. Because these plates are more abundant, they have received more attention from technicians and engineers in the field.

Other characteristics were not significantly related to accuracy rates — at least not at high confidence levels. Plates with stacked lettering fared worse in terms of accurate rates than plates without stacked lettering. Character length did not significantly influence the accuracy of LPRs. The most common plate lengths — 6 and 7 characters — had very similar predicted probabilities, and the plates with other character lengths occurred too infrequently in the sample to draw robust conclusions. An alternative probit specification revealed there was not a significant difference between the accuracy rates of the two vendors Kentucky utilizes for the KATS systems. Nor does any statistically significant difference exist for LPR accuracy rates between daytime hours and nighttime hours.

Our findings have significant implications for automated commercial vehicle enforcement and electronic tolling. Plate characteristics, especially production style and character style, impacted LPR accuracy rates, and therefore the amount of labor required to rescreen and verify readings in order to maximize the benefits of both systems. Estimates showed that switching to flat plates may increase accuracy such that rescreening and reverification is reduced by approximately 32,000 records per year in commercial vehicle enforcement activities, and by 50,000 records per year in the electronic tolling sphere. In the latter instance, flat-plate technology appears to have the same impact on the video LPRs used for tolling, which has not been tested.

Perhaps most importantly, a high percentage (16.9) of images could not be verified due to poor photo quality, obstructions, inclement weather, or other factors. If we keep assumptions from the Steer Davies Gleave study and apply this rate to collections, the potential impact is between $5 and $6 million per year between 2018 and 2030. Ultimately, the technology used to collect bridge tolls may prove more accurate than the weigh station equipment, and improvements over the next several years could mitigate this issue. But officials should be aware of the logistical challenges of verifying such a high volume of plate reads and the implications that has for electronic tolling revenue.

Chapter 5 Multi-State Survey and Case Studies

Making recommendations to change state government procedures benefit from identifying best practices based on the experiences of other states. For this study, it was imperative to solicit the insight of administrators at other state transportation agencies. As discussed earlier in the report, many states have either transitioned to flat-plate production or incorporated flat-plate production into some aspect of their license plate programs. KTC conducted a nationwide survey to better understand the positive and negative aspects of this transition as well as to identify lessons learned based on those experiences.

Survey questions were developed by KTC and approved by MVL officials. It included questions about plate types, details on production and distribution, cost savings, and state replating policies. The 14-question survey was distributed on AAMVA's membership webpage. Thirty-three states and one Canadian province submitted a response (Table 28). When additional information was needed, researchers contacted the individual who submitted the survey if they provided contact information.

Table 28 States that Submitted a Survey Response

Alabama	Montana
California	North Carolina
Colorado	North Dakota
Florida	Nebraska
Georgia	New Hampshire
Idaho	New York
Illinois	Ohio
Indiana	Oregon
Kansas	Pennsylvania
Kentucky	Rhode Island
Louisiana	South Carolina
Manitoba (CA)	Texas
Maryland	Utah
Maine	Vermont
Michigan	Virginia
Minnesota	Washington
Missouri	Wyoming

5.1 Plate Types

Survey respondents were asked to indicate whether their state distributed flat, embossed, or both types of plates. Table 29 lists what type of plates each state distributes. Fifteen of the responding states distribute embossed plates. Eleven states distribute flat plates, and seven states provide both embossed and flat plates.

Respondents from some states that have switched to flat plates noted there are cars that still display embossed plates. While Alabama only distributes flat plates, embossed plates are still on the road and in inventory. Idaho uses its remaining inventory of embossed plates for special programs such as the Old Timer plates. North Dakota recently moved to flat plates, and re-plating should be finished by June 2017. Until then, embossed plates will remain on the road. Rhode Island currently uses embossed plates, but flat plates will be added by June 2016, when the state reissues.

Table 29 Plate Types from Survey Respondents

Embossed	Flat	Both
California	Alabama	Colorado
Florida	Georgia	Missouri
Illinois	Idaho	New York
Kansas	Indiana	Ohio
Kentucky	Minnesota	Oregon
Louisiana	Montana	Pennsylvania
Maine	Nebraska	Washington
Manitoba	North Dakota	
Maryland	Texas	
Michigan	South Carolina	
New Hampshire	Wyoming	
North Carolina		
Rhode Island		
Utah		
Virginia		

The Benefits and Drawbacks for Selecting a License Plate Material and Production

States have many reasons for choosing a particular type of plate material, including the cost of materials and labor, production efficiency, production flexibility, and visibility based on reflectivity. Kansas and California continue to use embossed plates because they are the only plate types they have ever produced, although Kansas is considering a move toward flat plates. Other states use embossed plates because they are what their vendors provide. Vendors for Louisiana, Florida, and Kentucky only produce embossed plates. Respondents in Michigan said moving away from embossed to flat plates has no advantages for their state, and will only increase the cost of plates.

Michigan's response to this question demonstrates that the choice of plating materials is not always about cost. Like many states, Michigan's embossed plates are produced by prison labor. Michigan administrators said plate production gives inmates meaningful work, and that switching to flat plates would leave prisoners jobless. Additionally, implementing flat-plate technology is too expensive given the equipment and implementation costs. In short, the costs outweigh any benefits their states would accrue.

Law enforcement needs have influenced Oregon, Illinois, Michigan, and Manitoba's decisions to issue embossed plates because, in their experience, they are more reflective and easier to read. North Carolina switched to flat plates but returned to embossed plates after law enforcement expressed dissatisfaction with their visibility and reflectivity. The respondent from Maryland (which uses embossed plates) said that LPR accuracy rates are higher with embossed plates. Maine and Utah say embossed plates are more secure because they are unlikely to be counterfeited.

Idaho and Georgia opted for flat plats because at the time of procurement they were cheaper than embossed plates. The metals used in flat plates fluctuate in price and increase the cost of production significantly. Switching to flat plates can reduce the amount of space needed for storing license plate inventories. Since adopting flat plates, Ohio no longer requires inventory for specialty plates. Similarly, Texas, Nebraska, Indiana, and Montana said flat plate production reduced inventory warehouse space requirements because of on-demand printing. Pennsylvania, Vermont, and Ohio

appreciate the flexibility of flat plate production because it offers more design and color options for customers.

Texas provided an exhaustive list of reasons explaining why digitally printed flat plates are the best option for vehicle registration. According to the survey respondent, aluminum flat plates are lighter than the embossed steel plates, and the switch to flat plates also decreased waiting time for specialty plates from 3–4 weeks to 1–2 weeks. Flat plates eliminated the need for space in which to story the inventory of embossed plates and made it easier to adjust quantities.

Nine respondents reported that hybrid systems have many benefits. Hybrid production gives states the ability to capture the benefits of both plate types. Embossed plates are usually cheaper for mass-produced, standard license plates. Flat plates have more versatility in terms of color and design, and therefore are better suited to low-volume specialty plates. Oregon, Ohio, New York, Colorado, Missouri, and Washington all cited flexibility as a benefit of offering two types of plating options.

Production Costs

The survey asked respondents to provide the average cost of producing standard license plates in their state. Table 30 summarizes the findings. On average, an embossed plate costs $1.98, flat plates cost $3.89, and plated produced under hybrid systems cost $3.08. Most states have a cost per plate less than $5.00. North Carolina has the lowest production cost — $1.61 per plate — while in North Dakota the average plate cost is $10.00. Manitoba, New York, and Virginia did not provide a response. Several states require that vehicles have two plates for vehicle identification. Eight states require the display of registration plates on the front and rear of the vehicle.

Table 30 Average Cost to Produce a Standard Plate

State	Cost Per Plate	State	Cost Per Plate
Alabama	$1.77	**New Hampshire**	$1.88
California (set)	$4.29	**New York**	NA
Colorado (set)	$3.78	**North Carolina**	$1.61
Florida	$1.71	**North Dakota**	$10.00
Georgia	$2.65	**Ohio**	$2.75
Idaho	$2.63	**Oregon (set)**	$3.33
Illinois (set)	$2.00 to $3.00	**Pennsylvania**	$1.80
Kansas	$2.94	**Rhode Island (set)**	$3.50
Kentucky	$1.98	**South Carolina**	$6.05
Louisiana	$1.81	**Montana**	$6.00
Manitoba CA	NA	**Texas (set)**	$3.06
Maryland	$2.25	**Utah**	$2.00
Maine (set)	$5.00	**Vermont**	$4.79
Michigan	$1.70	**Virginia**	NA
Minnesota	$6.39	**Washington (set)**	$2.47
Missouri	$1.63	**Wyoming**	$3.00
Nebraska	$3.14		

Prison Labor and License Plate Production

Only 7 of the 34 states we surveyed do not use prison labor for license plate production. Georgia (3M), Manitoba (Waldale), Indiana (Intellectual Technology) and Oregon (Irwin-Hodson) source vehicle plates from third-party vendors. Kansas's plates are produced by Center Industries, a non-

profit which employs workers with disabilities. Illinois plates are manufactured by MRI, a non-profit which employs individuals with developmental, cognitive, and intellectual disabilities. In Wyoming and South Carolina, embossed plates are manufactured by prison inmates while flat plates are produced by another vendor.

The types of plates needed by a state impacts the number of inmate workers needed to meet production requirements. In general, it takes many more steps (and therefore more workers) to produce embossed plates than flat plates. As Table 31 shows, the number of workers needed for each production type is partially contingent on the number of plates produced each year. Embossed-plate production typically requires between 55 and 65 workers. Flat-plate production requires 10 to 12 workers. In 2015, Kentucky produced almost 750,000 plates, which translates to 13,000 plates per worker. Missouri and Michigan produced between 1.3 million and 1.5 million plates with each worker producing between 21,000 and 23,000. Although Ohio has a hybrid plate system, 140 workers are assigned to embossed production and 10 to specialty plates. Texas uses flat plates exclusively, which in 2015 required 165 workers for printing, blanking, boxing, maintenance, and shipping. Of those 165, 49 engaged in printing and blanking license plates.

Table 31 License Plate Production Systems and Labor

State	Year	Type	Total Plates	Workers	Plates per Worker
Kentucky	2015	Embossed	745,357	57	13,076
Michigan	2015	Embossed	1,500,000	65	23,077
Missouri	2012	Embossed	1,300,000	60	21,667
Alabama	2015	Flat	868,926	12	72,411
Texas	2015	Flat	12,806,150	165	77,613
Ohio	2015	Embossed Flat	3,952,218 302,801	140 10	28,230 30,280

Distribution and Inventory

South Carolina, Maine, Montana, North Carolina, North Dakota, Nebraska, Utah, Vermont, and Washington distribute license plates from branches or field offices. All Ohio and Alabama plates are centrally produced and distributed by the incarcerated laborers who produce them. California, Virginia, and Oregon drivers may obtain a vehicle registration plate over the counter or through centralized distribution. In Georgia, Illinois, Maryland, Pennsylvania, and Florida license plates are distributed over the counter. Michigan, Colorado, Manitoba, Idaho, New Hampshire, New York, and Minnesota issue standard plates over the counter while specialty plates are mailed to customers. Initial registration plates in Texas and Rhode Island are distributed over the counter, but reissuance plates are mailed. Most states (16) maintain an inventory of plates for distribution.

Savings

Survey respondents were asked to comment on whether switching from one type of plate to another yielded cost savings. However, most respondents did not provide specific cost savings. The following areas were mentioned as sources of cost savings if either a hybrid or all flat-plate system were adopted:

- Decreased labor needs

- Lower cost for sheeting and metal
- Lower shipping costs due to the lighter weight of flat plates
- Lower shipping costs due to the use of direct mail or centralized distribution

Indiana saved money primarily through decreased labor costs. South Carolina officials did not report any savings with flat plates, but anticipate significant savings when they move to a rolling reissue cycle instead of a single reissue. Some states reported that flat plates were cheaper to mail because they are lighter than embossed plates. Idaho saved money on mailing plates by passing costs onto customers. The Idaho state government no longer pays for bulk mailing plates to county service locations. Administrators also realized savings by replacing expensive sheeting from their vendor with lighter weight aluminum.

5.2 Interviews with Alabama and Ohio

Following up on the survey, we contacted states with experience using the two systems that most interested MVL. Questions were selected to investigate particular aspects of the processes that MVL had expressed concerns with, such as workflow and transitioning to a new production and distribution system. The following case studies summarize the findings.

Alabama — Flat Plates

We contacted Alabama agencies about their flat-plate production and distribution. The Department of Revenue and DOC transitioned to flat plates to save on production costs. The agencies negotiated a contract with 3M for equipment, including the printer, software, and maintenance. Legal statutes in Alabama mandate that DOC inmates manufacture license plates. They saved the funds necessary to purchase the equipment by strategically delaying the issuance of new plates and adopting a new plate issuance cycle of five years.

Alabama's tag plant has a 100 inmate workforce for embossed plate production. With the new production system, four paid employees from DOC and approximately 12 inmates are needed at peak production times to fill orders. During non-peak times, they process plates with only one or two people. The DOC has a graphic designer, a clerical worker, and two production supervisors. They run shifts from 8:00 AM through 5:00 PM, Monday through Friday. Sometimes scheduling is challenging due to issues unique to prison settings, such as lockdowns.

Flat plates have a shorter production time, which helps Alabama meet the demand for the new specialty license plate orders. The state's motor vehicle agency sends a file to the tag plant very week with the orders, and production takes two to three weeks. The plates are sent directly to the customer, but inmates do not have access to registration information. County licensing agents issue the registration and provide temporary tags, which are good for 60 days.

The embossed plate manufacturing process involves boxing plates and shipping them to the motor vehicle branches around the state, but this process is too difficult with the new specialty plates. The standard issue pre-numbered plates are printed 500,000 at a time. The plates are sorted by county and delivered to the clerk offices by truck.

We asked the Alabama official about visibility issues with flat plates. He reported the reflectivity of flat plate sheeting is excellent. Law enforcement conducts visibility tests on any new plate

designs and they sign off on each new plate. They are also working to ensure that LPRs can easily read the new plates. Alabama has requirements for license plate designs. Ink can only be black or blue, with alphanumeric characters on a clean background in order to not interfere with reading the license plates. Alabama provides plate specifications to groups applying for specialty plates, and they must follow those specifications or their design will not be approved.

Ohio — Hybrid

Ohio uses a hybrid production system. Embossed plates are used for standard registration, while flat, digital plates are issued for specialty and personalized plates. Since 1964, inmates have been required by state law to produce license plates. While up to 140 inmates are assigned to embossed-plate production, including quality control and packaging, 10 inmates are assigned to flat-plate production. Ohio reports no significant change in the labor force, although it did shift job duties to adjust to the new workflow processes and equipment. Inmates work 6.5-hour shifts five days per week.

Flat plates are printed on demand and sent directly to the customer from the prison. Since tag plant inmates have access to customer addresses for the distribution process, the prison limits access to the flat-plate production to inmates with good behavior records. Embossed plates are produced by inmates and sent to a Deputy Register for distribution.

The primary reason that Ohio transitioned to a hybrid system was to cut back on inventory for specialty plates while preserving the lower production costs of the embossed single color plates.

5.3 Conclusions

Several conclusions follow from our survey and follow-up interviews. First, it appears that a hybrid system is a viable choice for Kentucky's license plate system because it enables agencies to take advantage of cost efficiencies realized by relying on embossed plates for standard issue plates. At the same time, the amount of inventory space needed to house specialty plates is decreased because they are printed on demand. A hybrid system might also alleviate DOC and KCI's concerns about losing inmate jobs at the KSR tag plant since embossed plate production would still be used for standard plates.

Although at least one vendor contends there are significant cost savings associated with flat-plate production, the survey and interviews do not support this claim. The most significant savings appear to result from reduced postage and labor costs.

Critics of flat-plate licensing claim that law enforcement prefers embossed plates because LPRs and officers can read them more easily. Some states reverted to embossed plates after law enforcement voiced concerns over visibility. Alabama law enforcement officials have attempted to avoid these issues by reviewing all plate designs prior to production, limiting the number of ink colors, and prohibiting cluttered backgrounds on license plate sheeting. Kentucky should consult members of the law enforcement community and tolling agencies to ensure that any flat plates it introduces could easily be read by the human eye (see Chapter 4 for a discussion of LPR accuracy).

Chapter 6 Implementation Costs, Challenges, and Strategies

In Kentucky, county clerks are solely authorized to process vehicle registrations and distribute vehicle registration plates, regardless of type. Below is a summary of the statutes and how they relate to the current project.

6.1 Basic Requirements of Vehicle Registration and Plating

Kentucky has close to 20 statutes which govern vehicle registration and vehicle registration plates. KRS 186.005 is perhaps the most critical statute with respect to vehicle registration. Cars must be registered and have a metal, license plate affixed to the car. Their registration, which is indicated by a decal attached to the plate, must be renewed each year in the owner's birth month. The plate serials must consist of three letters and three numbers.

6.2 The Role of County Clerks

The locus of vehicle registration and plating is at the 120 county clerks throughout Kentucky. KRS 186.20 mandates that cars be registered in the owner's county of residence at the county clerk's office and pay a registration fee. Owners must renew their registration every year prior to its expiration date. The county clerks are responsible for the following:

- Collecting ad valorem taxes on vehicles (KRS 134.805)
- Registering motor vehicles for the Cabinet and collecting applicable fees (KRS 186.040, 186.050)
- Distributing registration plates, maintaining records of plates distributed and revenue collected from vehicle registration along with submitting collections to KYTC (KRS 186.230, 186.005, and 186.040)
- Processing the applications for dealer plates submitted by car dealers or manufacturers, distributing the plates to the applicable party, and keeping track of the quarterly-reported records (KRS 186.070)

Discussion with KYTC Legal Staff

We also interviewed Todd Shipp, KYTC's Special Assistant for the Office of Legal Services about legal statutes and vehicle registration plates. Mr. Shipp also serves on the Specialty Plate Board, which governs specialty plate applications and administration. He advised that plate distribution through the county clerk system is well-established and that it would be challenging to convince state lawmakers to statutorily change that requirement.

Table 32 Kentucky Revised Statutes Relevant to Vehicle Registration and Plates

Statute Number	Statute Topics
186.005	• Policy on regulation and registration of vehicles — License plates
186.020	• Registration requirement • Application for registration • Application and other documents to be sent to Transportation Cabinet • Renewal by mail • Extension of renewal period for military personnel stationed outside United States

186.040*	• Issuance of certificate of registration • Plates • Clerk's fee • Donations to child care assistance account Additional fees and distribution
186.041	• Special military-related license plates
186.042*	• Accessible parking registration plates and parking privileges for persons with certain disabilities • Application procedure • Issuance
186.043	• Special license plates for historic motor vehicles • Permanent registration
186.050	• Registration fees • Voluntary donation for wildlife management and conservation activities and the agricultural program trust fund
186.053	• License for dealer-demonstrator trucks or tractors • Fee • Tags
186.070*	• Registration of manufacturers and dealers • Dealer plates and stickers • Names of drivers authorized to use dealer plates to be made available to law enforcement agencies • Revocation of licenses • Appeal
186.162	• Special license plates for members or supporters of certain groups and organizations Initial and renewal fees • Combination of special license plate with personalized license plate • Special license plates for motorcycles
186.164	• Collection and distribution of special license plate fees • Design, printing, and replacement • Application process • Voluntary contribution for designated group • Administrative regulations • Audit of special license plate funds
186.166	• Perpetual production of certain special license plates • Design of Purple Heart license plates
186.167	• Masonic Homes of Kentucky, Inc. • Petition for voluntary contributions under KRS 186.164
186.172	• Special license plates for firefighters
186.174	• Personalized license plates
186.230*	• County Clerk's duties • Lien on vehicle, effect • Issuance of plate without collecting taxes and fees prohibited

186.240*	• Cabinet to furnish forms and plates • Records • Receipts • Reflectorized license plate program fund — Use of receipts • Accounting by clerk • Audit
186.1722	• I Support Veterans special license plate

*Specifies the plate is to be distributed by county clerk offices.

6.3 Cost Comparisons

Kentucky has four options to improve the cost efficiency of its vehicle registration plating program: maintain the current system, implement flat-plate production, develop a hybrid system, or add a digital printer to print background designs for specialty plates at KSR. Table 33 compares the cost of the scenarios. Cost per plate is based on 745,357, the total number of plates produced in 2015. Currently, KYTC pays $1.83 for each embossed plate for a total of $1.3 million per year. The flat-plate production scenario is the most expensive option at $2.63 per plate. The per plate cost for either a hybrid system or for adding a digital printer to the current embossed system is $1.98.

Table 33 Cost Comparison of Each Production System

Cost Item	2015	Flat	Hybrid	Embossed
Production Materials	$703,346.47	$867,539.33	$ 665,804.60	$669,252.70
New Equipment	$31,993.68	$500,000.00	$325,000.00	$175,000.00
Daily Costs	$31,207.54	$31,207.54	$31,207.54	$31,207.54
Inmate Labor	$49,669.04	$9,156.00	$38,025.00	$49,669.04
Supervisors	$110,443.87	$110,443.87	$110,443.87	$110,443.87
KCI Admin	$80,000.00	$80,000.00	$80,000.00	$80,000.00
Mailing	$137,210.00	$137,210.00	$137,210.00	$137,210.00
KYTC Labor	$221,748.95	$221,748.95	$221,748.95	$221,748.95
Total Cost	$1,365,619.55	$1,957,305.69	$1,472,229.96	$1,474,532.10
Cost Per Plate	$1.83	$2.63	$1.98	$1.98

Although the cost of the hybrid system and adding a printer to the current embossed system are very similar, the hybrid system will be more efficient if the plates can be printed on demand and shipped from a central location. Kentucky statutes mandate that plate distribution occur through county clerk offices and that DOC inmates produce the plates. The simplest change would be to purchase a digital printer for the embossed plate production system. KCI would be able to take advantage of the cost savings by printing their own specialty plate sheeting, there would be no need to adjust inmate labor levels, and the distribution could stay with the county clerk offices. Production costs can also be controlled by improving inventory practices and analyzing historical statistics on plate issuance versus plate production.

Since equipment is a one-time cost, it is useful to consider the cost of the new system in the years following its implementation. Consider Table 34 under the current system, where the total cost of

plates is $1.3 million ($1.79 per plate) while a flat plate system would cost $1.4 million a year ($1.96 per plate). The hybrid and embossed plate system would each cost just under $1.3 million or $1.72 and $1.74 respectively. The cost per plate assumes the production of 745,357 plates, the number of plates produced in 2015.

Table 34 Cost of New System in Year Two

Cost Item	Current	Flat	Hybrid	Embossed
Production Materials	$703,346.47	$867,539.33	665,804.60	$669,252.70
Daily Costs	$31,207.54	$31,207.54	$31,207.54	$31,207.54
Inmate Labor	$49,669.04	$9,156.00	$38,025.00	$49,669.04
Supervisors	$110,443.87	$110,443.87	$110,443.87	$110,443.87
KCI Admin	$80,000.00	$80,000.00	$80,000.00	$80,000.00
Mailing	$137,210.00	$137,210.00	$137,210.00	$137,210.00
KYTC Labor	$221,748.95	$221,748.95	$221,748.95	$221,748.95
Total Cost	$1,333,625.87	1,457,305.69	$1,284,439.96	$1,299,532.10
Cost Per Plate	$1.79	$1.96	$1.72	$1.74

Based on these figures, it is also possible to identify what savings the new systems could provide when overproduction is eliminated and the process transitions to a print-on-demand option. As indicated earlier in the report, KYTC lost $188,550.38 in overage costs due to overproduction in 2015. Table 35 compares the cost savings of a print-on-demand system versus the current embossed system. The equipment and materials costs for a flat plate system are over $1.3 million. If KCI implemented a flat-plate production system, KYTC could save $188,550. However, outside of those savings, the system would require a $1.2 million capital investment for equipment and production materials. The hybrid system doesn't generate as much savings. A hybrid system would continue to produce embossed general issue plates and digitally print specialty plates. As a result, the only savings from the print-on-demand option would come from specialty plates, which had over $48,000 in overage costs due to overproduction. A hybrid system would require almost $950,000 in capital investment to be implemented. Despite the savings associated with print-on-demand, the proposed systems have capital requirements which far exceed those savings.

Table 35 Overproduction Savings for Flat and Hybrid Production Systems

	Current	Flat	Hybrid	Embossed
Production Materials	$703,346.47	$867,539.33	$665,804.60	$669,252.70
New Equipment	$0.00	$500,000.00	$325,000.00	$175,000.00
Total Cost	$703,346.47	$1,367,539.33	$990,804.60	$844,252.70
Overage Cost	$188,550.38	$0.00	$140,373.09	$140,373.09
Remaining Cost	$0.00	$1,178,988.95	$942,627.31	$703,879.61

6.4 Conclusion

The Kentucky General Assembly will need to repeal or amend statutes if MVL decides to proceed with moving any aspect of license plate distribution away from the county clerks' authority. As previously noted, license plate production by inmates is standard practice in most states, although some states use third-party vendors instead. There are many reasons given to justify that tradition. First, it gives an opportunity for prisoners to engage in productive work. Plate production helps

limit recidivism by instilling good work habits and building skills. It also allows inmates to give something back to society as penance for their crimes. Any change in current workflow and activities related to license plate production will require the consideration of policies which may limit these benefits.

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Appendix A Accuracy Rates for Canada

Appendix B Fee Allocations

Standard	Initial Fees with Fund	Fund Fee	County Clerk	Total State Initial	KAVIS Bucket	Tech Equip Bucket	Pop < 20,000 Bucket	Re - Plate Fee	State Reg. Fee	Issuance-State Road Fund	MC Safety Fund	Personalized Fee (Optional)
Motorcycle	$18.50	$0.00	$6.00	$12.50	$1.00	$1.00	$1.00	$0.50	$5.00	$0.00	$4.00	$25.00
Vehicle	$21.00	$0.00	$6.00	$15.00	$1.00	$1.00	$1.00	$0.50	$11.50	$0.00	$0.00	$25.00

Farm	Initial Fees with Fund	Fund Fee	County Clerk Reg Fee	Total State Initial	KAVIS Bucket	Tech Equip Bucket	Pop < 20,000 Bucket	Re - Plate Fee	State Regis. Fee	KRS 47.020 30% Split	KRS 47.020 70 % Split
Farm	$31.00	$10.00	$6.00	$15.00	$1.00	$1.00	$1.00	$0.50	$11.50	$3.45	$8.05
38,001-44,000	$209.10	$10.00	$6.00	$193.10	$1.00	$1.00	$1.00	$0.50	$189.60	$56.88	$132.72
44,001-55,000	$311.10	$10.00	$30.00	$271.10	$1.00	$1.00	$1.00	$0.50	$267.60	$80.28	$187.32
55,001-62,000	$446.30	$10.00	$30.00	$406.30	$1.00	$1.00	$1.00	$0.50	$402.80	$120.84	$281.96
62,001-73,280	$543.50	$10.00	$30.00	$503.50	$1.00	$1.00	$1.00	$0.50	$500.00	$150.00	$350.00
73,281-80,000	$607.50	$10.00	$30.00	$567.50	$1.00	$1.00	$1.00	$0.50	$564.00	$169.20	$394.80

Specialty	Initial Fees with Fund	Fund Fee	County Clerk Reg Fee	Total State Initial	KAVIS Bucket	Tech Equip Bucket	Pop < 20,000 Bucket	Re - Plate Fee	State Reg Fee	Issuance-State Road Fund	Personal (Optional)
Amateur Radio	$46.00	$0.00	$6.00	$40.00	$1.00	$1.00	$1.00	$0.50	$11.50	$25.00	$0.00
Autism Awareness	$44.00	$10.00	$6.00	$28.00	$1.00	$1.00	$1.00	$0.50	$11.50	$13.00	$20.00
Breast Cancer Awareness	$44.00	$10.00	$6.00	$28.00	$1.00	$1.00	$1.00	$0.50	$11.50	$13.00	$20.00
Cardinal	$31.00	$10.00	$6.00	$15.00	$1.00	$1.00	$1.00	$0.50	$11.50	$0.00	$20.00
Child Victim	$44.00	$10.00	$6.00	$28.00	$1.00	$1.00	$1.00	$0.50	$11.50	$13.00	$20.00
Chiropractor Association	$34.00	$0.00	$6.00	$28.00	$1.00	$1.00	$1.00	$0.50	$11.50	$13.00	$20.00
Choose Life	$44.00	$10.00	$6.00	$28.00	$1.00	$1.00	$1.00	$0.50	$11.50	$13.00	$20.00
Congressional	$46.00	$0.00	$6.00	$40.00	$1.00	$1.00	$1.00	$0.50	$11.50	$25.00	$20.00
Ducks Unlimited	$44.00	$10.00	$6.00	$28.00	$1.00	$1.00	$1.00	$0.50	$11.50	$13.00	$0.00
Emergency Management	$34.00	$0.00	$6.00	$28.00	$1.00	$1.00	$1.00	$0.50	$11.50	$13.00	$20.00
Firefighter	$31.00	$10.00	$6.00	$15.00	$1.00	$1.00	$1.00	$0.50	$11.50	$0.00	$20.00
Fraternal Order of Police	$44.00	$10.00	$6.00	$28.00	$1.00	$1.00	$1.00	$0.50	$11.50	$13.00	$20.00
Friends of Coal	$44.00	$10.00	$6.00	$28.00	$1.00	$1.00	$1.00	$0.50	$11.50	$13.00	$20.00
Friends of Coal MC	$44.00	$10.00	$6.00	$28.00	$1.00	$1.00	$1.00	$0.50	$7.50	$13.00	$20.00
Historic Motorcycle	$59.00	$0.00	$6.00	$53.00	$1.00	$1.00	$1.00	$0.50	$7.50	$38.00	$0.00
Historic Vehicle	$59.00	$0.00	$6.00	$53.00	$1.00	$1.00	$1.00	$0.50	$11.50	$38.00	$0.00
Horse Council	$44.00	$10.00	$6.00	$28.00	$1.00	$1.00	$1.00	$0.50	$11.50	$13.00	$20.00
I Support Veterans	$31.00	$10.00	$6.00	$15.00	$1.00	$1.00	$1.00	$0.50	$11.50	$0.00	$20.00
I Support Veterans MC	$31.00	$10.00	$6.00	$15.00	$1.00	$1.00	$1.00	$0.50	$7.50	$0.00	$20.00
Judiciary	$46.00	$0.00	$6.00	$40.00	$1.00	$1.00	$1.00	$0.50	$11.50	$25.00	$0.00
Juvenile Diabetes	$44.00	$10.00	$6.00	$28.00	$1.00	$1.00	$1.00	$0.50	$11.50	$13.00	$20.00
Keeneland Association	$39.00	$5.00	$6.00	$28.00	$1.00	$1.00	$1.00	$0.50	$11.50	$13.00	$20.00

Independent Colleges	Initial Fees with Fund	Fund Fee	County Clerk Reg Fee	Total State Initial	KAVIS Bucket	Tech Equip Bucket	Pop < 20,000 Bucket	Re - Plate Fee	State Reg Fee	Issuance-State Road Fund	Personal App	Personal
Asbury College	$44.00	$10.00	$6.00	$28.00	$1.00	$1.00	$1.00	$0.50	$11.50	$13.00	$5.00	$20.00
Bellarmine University	$44.00	$10.00	$6.00	$28.00	$1.00	$1.00	$1.00	$0.50	$11.50	$13.00	$5.00	$20.00
Berea College	$44.00	$10.00	$6.00	$28.00	$1.00	$1.00	$1.00	$0.50	$11.50	$13.00	$5.00	$20.00
Brescia University	$44.00	$10.00	$6.00	$28.00	$1.00	$1.00	$1.00	$0.50	$11.50	$13.00	$5.00	$20.00
Campbellsville University	$44.00	$10.00	$6.00	$28.00	$1.00	$1.00	$1.00	$0.50	$11.50	$13.00	$5.00	$20.00
Centre College	$44.00	$10.00	$6.00	$28.00	$1.00	$1.00	$1.00	$0.50	$11.50	$13.00	$5.00	$20.00
University of the Cumberlands	$44.00	$10.00	$6.00	$28.00	$1.00	$1.00	$1.00	$0.50	$11.50	$13.00	$5.00	$20.00
Georgetown College	$44.00	$10.00	$6.00	$28.00	$1.00	$1.00	$1.00	$0.50	$11.50	$13.00	$5.00	$20.00
KY Christian University	$44.00	$10.00	$6.00	$28.00	$1.00	$1.00	$1.00	$0.50	$11.50	$13.00	$5.00	$20.00
KY Wesleyan College	$44.00	$10.00	$6.00	$28.00	$1.00	$1.00	$1.00	$0.50	$11.50	$13.00	$5.00	$20.00
Lindsey Wilson College	$44.00	$10.00	$6.00	$28.00	$1.00	$1.00	$1.00	$0.50	$11.50	$13.00	$5.00	$20.00
Midway College	$44.00	$10.00	$6.00	$28.00	$1.00	$1.00	$1.00	$0.50	$11.50	$13.00	$5.00	$20.00
University of Pikeville	$44.00	$10.00	$6.00	$28.00	$1.00	$1.00	$1.00	$0.50	$11.50	$13.00	$5.00	$20.00
St. Catharine College	$44.00	$10.00	$6.00	$28.00	$1.00	$1.00	$1.00	$0.50	$11.50	$13.00	$5.00	$20.00
Spaulding University	$44.00	$10.00	$6.00	$28.00	$1.00	$1.00	$1.00	$0.50	$11.50	$13.00	$5.00	$20.00
Thomas More College	$44.00	$10.00	$6.00	$28.00	$1.00	$1.00	$1.00	$0.50	$11.50	$13.00	$5.00	$20.00
Transylvania University	$44.00	$10.00	$6.00	$28.00	$1.00	$1.00	$1.00	$0.50	$11.50	$13.00	$5.00	$20.00
Union College	$44.00	$10.00	$6.00	$28.00	$1.00	$1.00	$1.00	$0.50	$11.50	$13.00	$5.00	$20.00
Independent College Association	$44.00	$10.00	$6.00	$28.00	$1.00	$1.00	$1.00	$0.50	$11.50	$13.00	$5.00	$20.00

Military	Initial Fees with Fund	Fund Fee	County Clerk Reg Fee	Total State Initial	KAVIS Bucket	Tech Equip Bucket	Pop < 20,000 Bucket	Re - Plate Fee	State Reg Fee
Gold Star Father	$26.00	$5.00	$6.00	$15.00	$1.00	$1.00	$1.00	$0.50	$11.50
Gold Star Spouse	$26.00	$5.00	$6.00	$15.00	$1.00	$1.00	$1.00	$0.50	$11.50
Silver Star	$26.00	$5.00	$6.00	$15.00	$1.00	$1.00	$1.00	$0.50	$11.50
Gold Star Sibling	$31.00	$10.00	$6.00	$15.00	$1.00	$1.00	$1.00	$0.50	$11.50
Congressional Medal of Honor	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Air Force Cross	$9.50	$0.00	$6.00	$3.50	$1.00	$1.00	$1.00	$0.50	$0.00
Army Cross	$9.50	$0.00	$6.00	$3.50	$1.00	$1.00	$1.00	$0.50	$0.00
Navy Cross	$9.50	$0.00	$6.00	$3.50	$1.00	$1.00	$1.00	$0.50	$0.00
U.S. Air Force Academy	$26.00	$5.00	$6.00	$15.00	$1.00	$1.00	$1.00	$0.50	$11.50
U.S. Military Academy	$26.00	$5.00	$6.00	$15.00	$1.00	$1.00	$1.00	$0.50	$11.50
U.S. Naval Academy	$26.00	$5.00	$6.00	$15.00	$1.00	$1.00	$1.00	$0.50	$11.50
U.S. Coast Guard Academy	$26.00	$5.00	$6.00	$15.00	$1.00	$1.00	$1.00	$0.50	$11.50
U.S. Merchant Marine Academy	$26.00	$5.00	$6.00	$15.00	$1.00	$1.00	$1.00	$0.50	$11.50
Air Force Veteran	$26.00	$5.00	$6.00	$15.00	$1.00	$1.00	$1.00	$0.50	$11.50
Army Veteran	$26.00	$5.00	$6.00	$15.00	$1.00	$1.00	$1.00	$0.50	$11.50
Civil Air Patrol	$26.00	$5.00	$6.00	$15.00	$1.00	$1.00	$1.00	$0.50	$11.50
Coast Guard Veteran	$26.00	$5.00	$6.00	$15.00	$1.00	$1.00	$1.00	$0.50	$11.50
Marine Veteran	$26.00	$5.00	$6.00	$15.00	$1.00	$1.00	$1.00	$0.50	$11.50
Navy Veteran	$26.00	$5.00	$6.00	$15.00	$1.00	$1.00	$1.00	$0.50	$11.50
Pearl Harbor	$26.00	$5.00	$6.00	$15.00	$1.00	$1.00	$1.00	$0.50	$11.50
Prisoner of War	$26.00	$5.00	$6.00	$15.00	$1.00	$1.00	$1.00	$0.50	$11.50
Gold Star Mother	$26.00	$5.00	$6.00	$15.00	$1.00	$1.00	$1.00	$0.50	$11.50

State Universities	Initial Fees with Fund	Fund Fee	County Clerk	Total State Initial	KAVIS Bucket	Tech Equip	Pop < 20,000 Bucket	Re - Plate Fee	State Reg. Fee	Issuance State Road Fund	Personal App Optional	Personal Optional
Eastern Kentucky University	$56.00	$10.00	$6.00	$40.00	$1.00	$1.00	$1.00	$0.50	$11.50	$25.00	$5.00	$20.00
Kentucky State University	$56.00	$10.00	$6.00	$40.00	$1.00	$1.00	$1.00	$0.50	$11.50	$25.00	$5.00	$20.00
Murray State University	$56.00	$10.00	$6.00	$40.00	$1.00	$1.00	$1.00	$0.50	$11.50	$25.00	$5.00	$20.00
Morehead State University	$56.00	$10.00	$6.00	$40.00	$1.00	$1.00	$1.00	$0.50	$11.50	$25.00	$5.00	$20.00
Northern Kentucky University	$56.00	$10.00	$6.00	$40.00	$1.00	$1.00	$1.00	$0.50	$11.50	$25.00	$5.00	$20.00
University of Kentucky	$56.00	$10.00	$6.00	$40.00	$1.00	$1.00	$1.00	$0.50	$11.50	$25.00	$5.00	$20.00
University of Louisville	$56.00	$10.00	$6.00	$40.00	$1.00	$1.00	$1.00	$0.50	$11.50	$25.00	$5.00	$20.00
Western Kentucky University	$56.00	$10.00	$6.00	$40.00	$1.00	$1.00	$1.00	$0.50	$11.50	$25.00	$5.00	$20.00

COMMERCIAL	Initial Fees	County Clerk Reg Fee	Total State Initial	KAVIS Bucket	Tech Equip Bucket	Pop < 20,000 Bucket	Re - Plate Fee	State Reg. Fee
14,000	$39.50	$6.00	$33.50	$1.00	$1.00	$1.00	$0.50	$30.00
18,000	$59.50	$6.00	$53.50	$1.00	$1.00	$1.00	$0.50	$50.00
22,000	$141.50	$6.00	$135.50	$1.00	$1.00	$1.00	$0.50	$132.00
26,000	$169.50	$6.00	$163.50	$1.00	$1.00	$1.00	$0.50	$160.00
32,000	$225.50	$6.00	$219.50	$1.00	$1.00	$1.00	$0.50	$216.00
38,000	$309.50	$6.00	$303.50	$1.00	$1.00	$1.00	$0.50	$300.00
44,000	$483.50	$6.00	$477.50	$1.00	$1.00	$1.00	$0.50	$474.00
55,000	$702.50	$30.00	$672.50	$1.00	$1.00	$1.00	$0.50	$669.00
62,000	$1,040.50	$30.00	$1,010.50	$1.00	$1.00	$1.00	$0.50	$1,007.00
73,280	$1,283.50	$30.00	$1,253.50	$1.00	$1.00	$1.00	$0.50	$1,250.00
80,000	$1,443.50	$30.00	$1,413.50	$1.00	$1.00	$1.00	$0.50	$1,410.00