REPORT TO CONGRESS:

Electronic Tire Identification Study

NATIONAL HIGHWAY TRAFFIC SAFETY ADMINISTRATION

Prepared by the

U.S. Department of Transportation

National Highway Traffic Safety Administration

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This report is submitted in response to the request by Congress under the transportation reauthorization bill, Fixing America's Surface Transportation Act (FAST Act). The FAST Act authorizes funds for Federal-aid highways, highway-safety programs, transit programs, and other purposes.

EXECUTIVE SUMMARY

Introduction: On December 4, 2015, the President signed into law the Fixing America's Surface Transportation (FAST) Act.[1] The FAST Act is a five-year legislation that authorizes funding to improve the Nation's surface transportation infrastructure and highway safety. Among the various traffic safety topics addressed by the Act, several sections focus on tires. This report addresses the FAST Act, Section 24334, "Tire Identification Study and Report," which directs the Secretary of Transportation to perform a study to examine the feasibility of requiring all manufacturers of tires subject to section 30117(b) of title 49, United States Code, to—

> (1) include electronic identification on every tire that reflects all of the information currently required in the tire identification number (TIN); and
>
> (2) ensure that the same type and format of electronic information technology is used on all tires."

The first question asks whether it is feasible to require manufacturers of new tires to include TIN-based electronic identification technology on all tires. This study addresses the second question in terms of whether it would be feasible to require manufacturers to ensure that this electronic tire identification be accomplished using a single technology and information format.

The Act requires that the results of this study be documented in a report to Congress. NHTSA has completed the requested study as documented in this report, which will be presented to Congress to satisfy the requirement.

Study Approach: In response to the FAST Act mandate, NHTSA conducted a preliminary study of the feasibility of requiring tire manufacturers to implement electronic identification in all new tires. To do so, NHTSA identified technologies that are currently in use, or being explored for use, for electronic tire identification by industry. Once identified, the technologies were evaluated per criteria such as: technical capabilities, limitations, robustness, availability, and current market use. Some cost information was obtained through stakeholder input, but a full cost-benefit examination was not performed as part of this effort.

NHTSA's approach to the study included a review of relevant literature, meetings with industry stakeholders, and time measurements for the process of manual collection of TINs from vehicles' tires. Literature reviews included past research, journal publications, press releases, applicable standards, and government regulations. Stakeholders included tire manufacturers, tire retailers, automotive safety advocates, and industry service providers. The TIN collection time measurements consisted of measuring the time it took for an experimenter to visually locate and hand-record, on a piece of paper, the full TIN from all four tires mounted on a passenger vehicle.

Tire Identification Numbers (TINs): A Tire Identification Number (TIN) is a string of 6 to 13 letters and numbers marked on the sidewall of a tire that contains information about the tire, including the plant where the tire was manufactured, the tire size, and the week/year of manufacture. The TIN requirement was established as part of the Code of Federal Regulations (CFR) Title 49 – Transportation, Section 574, "Tire Identification and Recordkeeping" in 1971.

[1] U.S. Congress. "Fixing Americas Surface Transportation Act," Public Law 114-94 (Dec. 4, 2015)

The purpose of the TIN is to facilitate notification of purchasers of defective or noncompliant tires. All newly manufactured and retreaded tires must have the complete TIN marked on at least one sidewall and a partial TIN on the other sidewall.

It is important to note that TINs are not unique for each individual tire. All tires of the same make, model, and size produced in a particular factory in the same calendar week have the same TIN.

Electronic Tire Identification: Electronic tire identification would involve applying an electronically-readable marking or tag within or on the sidewall of a tire. With electronic tire identification, the TIN could be captured electronically and transmitted electronically using a hand-held scanning tool.

Electronic Tire Identification Technologies: Currently available electronic tire identification technologies include radio frequency identification (RFID) tags, two-dimensional (2D) barcodes, and one-dimensional (1D) barcodes.

RFID tags are small electronic components that consist of a small chip and an antenna. RFID tags are typically attached to, or implanted within, an item and contain electronic information used to identify that item. RFID chips can carry up to 2000 bytes of information. When scanned with a hand-held RFID reader, the tags transmit their stored information to the reader. For tire applications, the tags are embedded within the tire sidewall during manufacturing. RFID tags currently used in tires do not contain the TIN.

2D barcodes are two-dimensional optical arrays that represent data using many small, contrasting geometric shapes, such as squares and circles. Typically, the barcodes are applied to an item and encoded with information used to identify, track, or provide details about the item. 2D barcodes are read using digital image sensors, such as the camera in a smart phone. For tires, 2D barcodes are etched into the tire sidewall after manufacturing. 2D barcodes currently in use for tires contain the TIN.

1D barcodes are one-dimensional linear optical arrays that represent data using contrasting vertical lines of varying widths. The amount of data that 1D barcodes can hold is limited and the barcodes generally increase rapidly in size as data capacity is increased. 1D barcodes are found on nearly all consumer goods, including tires. The current use of 1D barcodes on tires is mainly for inventory tracking and supply chain management. 1D barcodes are currently printed on labels that are adhered to the exterior of tires along the bead and do not contain the TIN.[2] Some tire installers remove these labels from the tire beads before mounting the tire on a wheel because they believe that their presence may lead to the tire leaking air. If not removed, once a tire is mounted on a wheel the barcode is no longer visible. These factors limit the utility and potential benefits of 1D barcodes for tire identification applications. No information regarding the feasibility of applying 1D barcodes on tires in locations other than the tire bead or using other marking methods was found during the course of this study. Stakeholders did not mention 1D

[2] Tire "bead" is defined in FMVSS No. 109 as "that part of the tire made of steel wires, wrapped or reinforced by ply cords, that is shaped to fit the rim."

barcodes as a technology under consideration for use in implementing TIN-based electronic tire identification.

This study found that both RFID tag and 2D barcode technologies appear technologically feasible for use in implementing electronic tire identification and could achieve a standard data format. Either one of these technologies, or both together, could be used to implement electronic tire identification on all new tires. However, differences between the two technologies present some advantages and disadvantages that should be considered. These differences are noted here and discussed in more detail later in the report. RFID tags only require the reader to be in proximity to the tag to be read, with read ranges for RFID tags embedded in tires found to be less than 2 feet. 2D barcodes require a clear line-of-sight to be read and have nominal read ranges of approximately 1 foot. 2D barcodes as currently used on tires have the memory capacity to store the TIN and, therefore, are more efficient to use than current tire RFID tags which do not have enough memory to store the TIN. Including the TIN in RFID tags would require using higher-priced tags that have additional memory. 2D barcodes have more up-front machine cost, but are cheaper per-tire than RFID tags. However, RFID tags have the advantage that they can are readable regardless of which tire sidewall is facing outward, unlike 2D barcodes which require a clear line of sight to be read.

TIN Collection: TIN collection, or locating and transcribing the TIN from tires, is performed by both tire owners and tire service personnel when preparing to register tires or prior to checking to determine whether a tire has been recalled. Writing the TIN by hand can provide the opportunity for recording errors and data entry errors when typing the TIN into a computer. How quickly TIN collection can be performed depends on whether the full TIN is on the outward face of all four tires.

NHTSA performed a time measurement exercise to gain a better understanding of the process of manually locating and recording TINs from tires installed on a vehicle and to examine whether some time efficiency may be gained through the implementation of electronic identification. The initial intent was to compare how long TIN collection takes for tires having TINs molded into the tire sidewalls versus tires with electronic TINs. However, in carrying out the time measurements, too few tires equipped with electronic identification were found to permit a time estimation for that identification type. As a result, the time measurements focused only on the collection of molded TINs.

TIN collection time consisted of the time it took for an experimenter to visually locate and hand-record on a piece of paper the full TIN from all four tires mounted on a passenger vehicle. The average time to locate and record TINs from all four tires of a vehicle was 2 minutes and 43 seconds. The maximum time for a single vehicle was 5 minutes and 45 seconds. This longer collection time was due to the front tires on this vehicle being mounted with the full TINs on the inner sidewall, making the TINs more difficult to physically access for recording purposes. It is believed that the process of collecting TINs from tires containing electronic identification would likely be faster and more accurate than that for tires equipped with molded TINs. However, this would depend on whether the particular tire identification technology encoded the TIN directly or required acquiring the TIN from a separate database.

Stakeholder Meetings: NHTSA held stakeholder meetings at which input was received from vehicle and tire industry organizations, tire manufacturers, tire sellers, a technology supplier, and a service provider. Through these meetings, NHTSA gathered information and learned about stakeholders' views on electronic tire identification. The meetings included discussion of available technologies, technological feasibility, cost, and industry impact. Most of the stakeholders that NHTSA spoke with indicated that they would be in support of the implementation of electronic tire identification. Stakeholders believe that electronic tire identification would be beneficial for improving the tire registration and recall processes. One group felt that more general study of electronic tire identification is needed, but did not note specific study objectives or research questions. Lastly, one group indicated a neutral position regarding electronic tire identification.

Conclusions: The findings of NHTSA's preliminary study of the feasibility of requiring tire manufacturers to implement electronic identification in all new tires suggest that it would be technologically feasible for manufacturers to include TIN-based electronic tire identification in all new tires. The study identified two technologies currently in use for tire electronic identification and found that either or both of these technologies could be used to implement electronic TIN information on all new tires. However, while the technologies identified have the ability to accomplish electronic tire identification, no data regarding the long-term durability of these technologies was found during the course of this study. The two primary technologies, RFID tags and 2D barcodes, have advantages and disadvantages that would affect process efficiencies and implementation costs. These differences would need to be thoroughly considered in determining whether implementation of electronic tire identification using one or multiple technologies would garner the most benefits. While some cost information and anecdotal comments noting potential benefits were shared in the context of stakeholder meetings, a full analysis of the costs and benefits associated with implementation of electronic identification in all tires was not performed in the context of this study.

The study also concluded that industry action would be needed to develop standard information content and a standard format for the data. NHTSA regulatory action may also be required to ensure that a standard format is followed. The most efficient method of providing electronic tire identification would be to include the TIN locally within the identification tag. Since TINs follow a standard format, encoding the TIN directly in the identification tag would ensure a standard data format. Current electronic tire identification technologies do not follow the same format. However, if the use of multiple identification technologies is desired as opposed to focusing on a single technology, it is believed that a consistent format could be achieved by modifying the content format for one of the technologies to match that of the other.

TABLE OF CONTENTS

EXECUTIVE SUMMARY ii

TABLE OF CONTENTS vi

LIST OF FIGURES vii

LIST OF TABLES viii

ACRONYMS ix

1.0 Introduction 1

2.0 Approach to Study 3
- 2.1 Literature Review 3
- 2.2 Stakeholder Meetings 3
- 2.3 Tire Identification Number Collection Time Measurements 4

3.0 Current Tire Identification Method: Tire Identification Numbers (TIN) 5
- 3.1 TIN Format and Content 5
- 3.2 TIN Location 7
- 3.3 TIN Marking Method 9
- 3.4 TIN Use 9

4.0 Electronic Tire Identification and Associated Technologies 10
- 4.1 Radio Frequency Identification Tags 10
- 4.2 2D Barcodes 14
- 4.3 1D Barcodes 17
- 4.4 RFID Tag and 2D Barcode Technology Comparison 18

5.0 Current TIN Collection Process 21
- 5.1 TIN Collection Time Measurement 21

6.0 Electronic Tire Identification Technology Differences That Impact Utility 22

7.0 Consumer Privacy Concerns 23

8.0 Stakeholder Meetings 24
- 8.1 Summaries of Stakeholder Thoughts – Main FAST Act Questions 24
- 8.2 Other Stakeholder Ideas 25

9.0 Summary 27
- 9.1 Feasibility of Requiring TIN-Based Electronic Tire Identification 27
- 9.2 Feasibility of Ensuring a Standard Type and Format of Technology 28
- 9.3 Conclusions 28

APPENDIX A. Stakeholder Meeting Summaries 30

LIST OF FIGURES

Figure 1. Example of a TIN following the "old requirements" with individual sections indicated 6
Figure 2. New TIN format with individual sections indicated 7
Figure 3. Example RFID tag; bare (top) and encased in rubber (middle) 11
Figure 4. Example 2D barcode; QR code etched in rubber 15
Figure 5. Example 1D barcode on tire bead 18

LIST OF TABLES

Table 1. RFID and 2D Barcode Technology Comparison.. 19

ACRONYMS

1D	One-Dimensional
2D	Two-Dimensional
ACEA	European Automobile Manufacturers Association
Auto Alliance	Alliance of Automobile Manufacturers
CFR	Code of Federal Regulations
CIMS	Computerized Information and Management Services, Inc.
DMC	Data Matrix Codes
DMV	Department of Motor Vehicles
DOT	U.S. Department of Transportation
EPC	Electronic Product Code
FAST	Fixing America’s Surface Transportation
FMVSS	Federal Motor Vehicle Safety Standard
HF	High Frequency
ID	Identification
ISO	International Organization for Standardization
LF	Low Frequency
NHTSA	National Highway Traffic Safety Administration
NTSB	National Transportation Safety Board
OE	Original Equipment
OEM	Original Equipment Manufacturer
QR Codes	Quick Response Codes
RFID	Radio Frequency Identification
RMA	Rubber Manufacturers Association (now USTMA)
SGTIN-96	96-bit, Serialized Global Trade Item Number
SRS	Safety Research and Strategies
TIA	Tire Industry Association
TID	Tag Identification
TIN	Tire Identification Number
UHF	Ultra High Frequency
UII	Unique Item Identifier
USTMA	U.S. Tire Manufacturers’ Association (previously RMA)
VIN	Vehicle Identification Number

1.0 INTRODUCTION

On December 4, 2015, the President signed into law the Fixing America's Surface Transportation (FAST) Act.[3] The FAST Act is a five-year legislation authorizing funding to improve the Nation's surface transportation infrastructure and highway safety. Among the various traffic safety topics addressed by the FAST Act, Part III of the Act, "Tire Efficiency, Safety, and Registration Act of 2015," focuses on tires. The four sections of FAST Act Part III are:

- SEC. 24332. Tire Fuel Efficiency Minimum Performance Standards.
- SEC. 24333. Tire Registration by Independent Sellers.
- SEC. 24334. Tire Identification Study and Report.
- SEC. 24335. Tire Recall Database.

This report responds to the requirements of Section 24334(a) of the FAST Act, "Tire Identification Study and Report," which reads:

> "(a) STUDY.—The Secretary shall conduct a study to examine the feasibility of requiring all manufacturers of tires subject to section 30117(b) of title 49, United States Code, to—
>
> > (1) include electronic identification on every tire that reflects all of the information currently required in the tire identification number; and
> >
> > (2) ensure that the same type and format of electronic information technology is used on all tires."

The National Highway Transportation Safety Administration (NHTSA) believes the first question to be asking whether it is feasible to require manufacturers of new tires to include TIN-based electronic identification technology on all tires. The second question asks whether it would be feasible that this electronic tire identification be accomplished using a single technology and standard information format.

In response to the FAST Act mandate, NHTSA has completed a preliminary study of the feasibility of requiring tire manufacturers to implement TIN-based electronic identification in all new tires as summarized in this report. No comprehensive analysis of the costs and benefits of implementation of electronic identification in all new tires was performed as part of this study. Section 24334(b) of the Act requires that the results of this feasibility study be documented in a report to Congress. When delivered to Congress, this report will satisfy that requirement.

Sections 24333 and 24335 of the FAST Act support improving the tire registration and recall processes by modernizing aspects of information collection and access. Section 24333, "Tire Registration by Independent Sellers," requires independent tire dealers to maintain records of purchasers and to use electronic submission when sending tire registration information to the manufacturer. Section 24335, "Tire Recall Database," requires NHTSA to establish a publicly available, searchable, electronic database of tire recall information. The Act specifies that this recall database be searchable by "Tire Identification Number (TIN) or any other criteria that assists consumers in determining if a tire is subject to a recall." Electronic tire identification,

[3] U.S. Congress. "Fixing Americas Surface Transportation Act," Public Law 114-94 (Dec. 4, 2015)

together with these two Sections of the Act, would help to address some of the issues with the current tire registration and recall processes. In doing so, it has the potential to increase the efficiency and efficacy of the tire registration and recall processes.

2.0 APPROACH TO STUDY

In response to the FAST Act mandate, NHTSA conducted a preliminary study of the feasibility of implementing electronic identification in all new tires. To do so, NHTSA identified technologies that are currently in use, or being explored for use, for electronic tire identification by industry. Once identified, the technologies were evaluated per criteria such as: technical capabilities, limitations, robustness, availability, and current market use. Some cost information was obtained through stakeholder input, but a full cost-benefit examination was not performed as part of this effort.

NHTSA's approach to the mandated study documented in this report included a literature review, stakeholder meetings, and time measurements for the process of manual collection of TINs from a vehicle's tires. Literature reviewed included past research, journal publications, press releases, applicable standards, published reports, and government regulation-related documents. Stakeholders included tire manufacturers, tire retailers, automotive safety advocates, and industry service providers. However, it should be noted that the stakeholder information received was limited to verbal input provided at meetings and was not substantiated by any objective data. The TIN collection time measurements consisted of measuring the time it took for an experimenter to visually locate and hand-record, on a piece of paper, the full TIN from all four tires mounted on a passenger vehicle. This report summarizes the information gathered from these sources.

2.1 Literature Review

NHTSA reviewed relevant literature on topics pertaining to electronic tire identification. The reviewed literature included past research, journal publications, press releases, applicable standards, and government reports and rulemaking documents. Information gathered in this literature review is presented throughout the report.

2.2 Stakeholder Meetings

NHTSA held stakeholder meetings to discuss electronic tire identification at which input was received from vehicle and tire industry organizations, tire manufacturers, tire sellers, a technology supplier, and a service provider. The goal was to gather information and learn about stakeholders' views on electronic tire identification. The meetings included discussion of available technologies, experience with those technologies, technological feasibility of implementation, cost, and industry impact.

NHTSA held meetings with the stakeholders listed below. Further discussion of the stakeholder meetings can be found in Section 9.0 and summaries of individual meetings can be found in Appendix A.

- Tire Industry Association (TIA)[4]
- U.S. Tire Manufacturers Association (USTMA)[5]; companies attending included:
    - Bridgestone Americas Tire Operations, LLC

[4] NHTSA–TIA stakeholder meeting. June 28, 2017

[5] NHTSA–USTMA stakeholder meeting. August 3, 2017

    - Continental Corporation, Rubber Group
    - Cooper Tire & Rubber Company
    - Goodyear Tire and Rubber Company
    - Michelin North America Inc.
    - Toyo Tire Corporation
- Goodyear Tire & Rubber Company[6]
- Alliance of Automobile Manufacturers (Auto Alliance)[7]; companies attending included:
    - BMW North America
    - Daimler
    - Ford Motor Company
    - Jaguar/Land Rover
    - Volkswagen Group of America
- Safety Research and Strategies, Inc. (SRS)[8]
- 4Jet Technologies GmbH[9]
- CARFAX, Inc.[10]

2.3 Tire Identification Number Collection Time Measurements

NHTSA performed TIN collection time measurements to gain a better understanding of the process of manually locating and recording TINs from tires installed on a vehicle and to examine whether some time efficiency may be gained through the implementation of electronic identification. The initial intent was to compare how long TIN collection takes with tires having TINs molded into the tire sidewalls versus the TIN collection time for tires with electronic TINs. However, in carrying out the study, NHTSA found too few tires equipped with electronic identification to permit a time estimation. Therefore, the time measurements focused only on the collection of molded TINs.

The study consisted of measuring the time it took for an experimenter to visually locate and hand-record on a piece of paper the full TIN from all four tires mounted on a passenger vehicle. Time started with the experimenter standing next to the vehicle and ended once the fourth and final TIN was recorded on the piece of paper. This measurement is representative of the process that would be performed by a service technician or a vehicle owner prior to checking a vehicle's tires in a recall database for tires that is searchable by TIN. More information about this study and its results can be found in Section 5.1.1 of this report.

[6] NHTSA–Goodyear stakeholder meeting. July 18, 2017
[7] NHTSA–Auto Alliance stakeholder meeting. July 27, 2017
[8] NHTSA–SRS stakeholder meeting. July 7, 2017
[9] NHTSA–4Jet stakeholder meeting. August 9, 2017
[10] NHTSA–CARFAX stakeholder meeting. August 24, 2017

3.0 CURRENT TIRE IDENTIFICATION METHOD: TIRE IDENTIFICATION NUMBERS (TIN)

A tire identification number (TIN) is a string of letters and numbers marked on the sidewall of a tire that contains information about the tire including the manufacturer, the plant where the tire was manufactured, the week/year of manufacture, and characteristics of the tire such as the size and model. Beyond providing information about the tire, TINs are used to register tires and facilitate tire recalls in the United States.

The requirements for the TIN were established by NHTSA in 1971. Code of Federal Regulations (CFR) Title 49 – Transportation, Section 574.5, "Tire Identification Requirements," sets forth the methods by which new tire manufacturers and new tire brand name owners must identify tires for use on motor vehicles. The section also sets forth the methods by which tire retreaders and retreaded tire brand name owners must identify tires for use on motor vehicles. Section 574.5(a), "Tire identification number (TIN) labeling requirement" states that "each new tire manufacturer must conspicuously label on one sidewall of each tire it manufactures, except non-pneumatic tires or non-pneumatic tire assemblies, by permanently molding into or onto the sidewall… a TIN."

3.1 TIN Format and Content

Tire identification requirements are outlined in 49 CFR part 574.5. Per a final ruling recently published by NHTSA, the format and contents of the TIN are currently in a transitional period. Tires currently in circulation will have a TIN following one of the following two formats.

49 CFR part 574.5(g) outlines what are referred to in the document as the "Old TIN Content requirements."[11] A TIN following the "old requirements" will contain 6 to 12 characters divided into the following four sections:[12]

1. Plant Code – Two-character code that identifies the manufacturer and the specific plant where the tire was manufactured.
2. Tire Size Code – Two-character code that identifies the tire size. Tire size codes are manufacturer-specific. Manufacturers must maintain a record of the size codes and corresponding tire size and must provide it to NHTSA upon request.
3. Manufacturer Construction Code – Up to four characters to be used by the manufacturer to indicate tire type or other significant tire characteristics. This code also indicates the tire brand name if manufactured for another brand.
4. Date Code – Four-character code that identifies the week and year in which the tire was manufactured. The date format is "mmyy."

An example of a TIN following this format can be seen in Figure 1 below.

[11] 49 CFR Part 574.5(g)

[12] This variation in length considers all possible requirements, including those of retreaded tires.

Figure 1. Example of a TIN following the "old requirements" with individual sections indicated

On April 13, 2015, NHTSA published a final rule modifying the TIN requirement by expanding the plant code to 3 characters and standardizing the overall length of the TIN.[13] The longer plant code was needed because NHTSA was running out of two-character plant codes. The new standardized TIN length is 13 characters for new tires and 7 characters for retreaded tires. This change was enacted to reduce confusion caused by the non-standard length of the "old" TIN requirements. As part of the new standardized length, former TIN sections 2 and 3(as labeled above) are now combined into one section containing manufacturer's tire-specific information, such as tire size and model. The new content requirements are summarized in the following list and depicted in Figure 2.[14]

1. Plant Code – Three-character code that identifies the manufacturer and the specific plant where the tire was manufactured.
2. Manufacturer's code – Six-character segment used as a descriptive code for identifying significant characteristics of the tire or to identify the brand name owner.
3. Date code – Four-digit segment identifying the week and year of manufacture.

The new TIN requirements are currently being phased-in and must be fully implemented by April 12, 2025.

[13] 80 FR 19553

[14] 49 CFR Part 574.5(b)

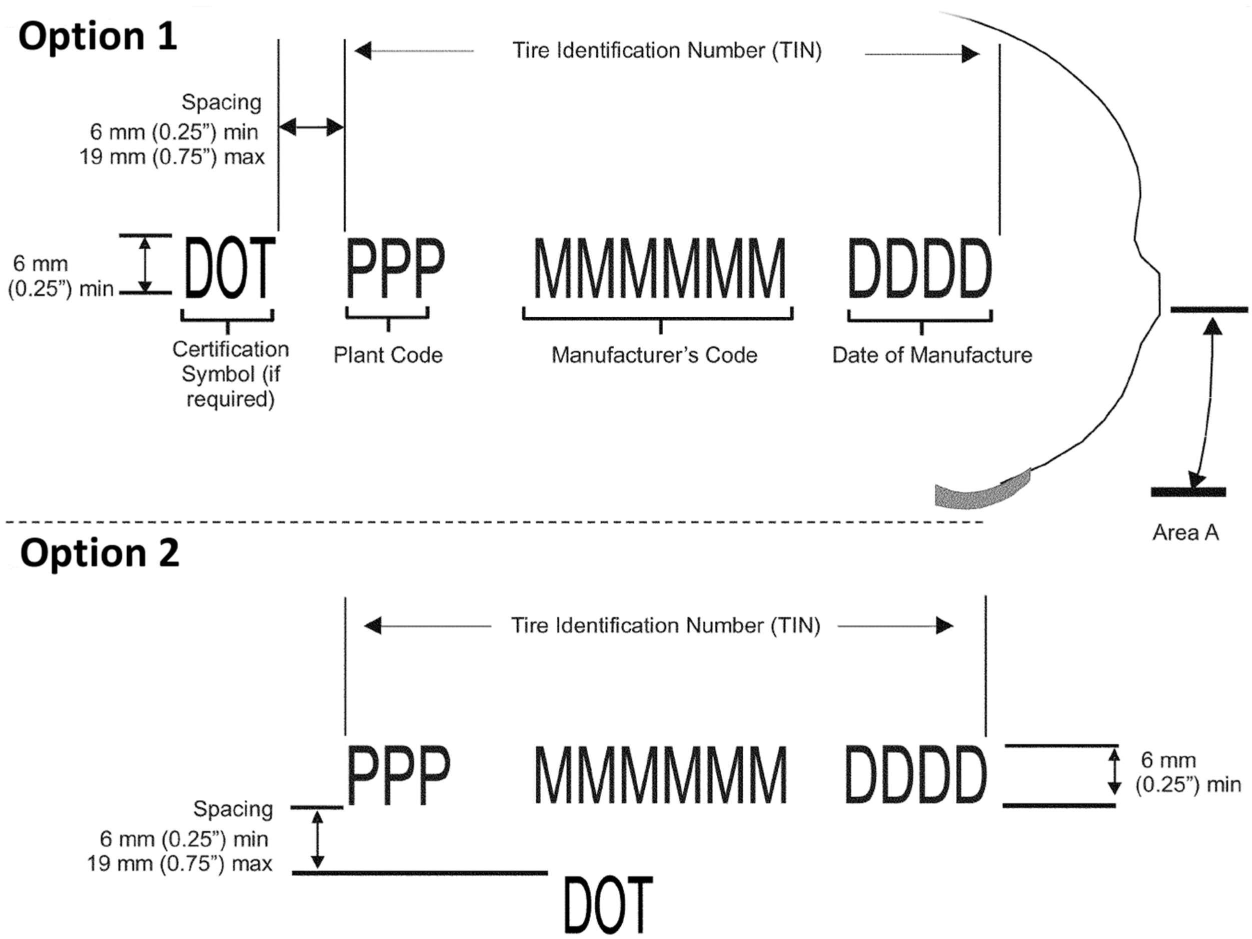

Figure 2. New TIN format with individual sections indicated

The "DOT" markings that can be seen in Figures 1 and 2 certifies that the tire conforms to applicable Federal Motor Vehicle Safety Standards (FMVSS).[15]

It is important to note that TINs are not unique for each individual tire. All tires of the same make, model, and size produced in a particular factory in the same calendar week have the same TIN.

3.2 TIN Location

Per 49 CFR part 574.5, all newly manufactured and retreaded tires, "must conspicuously label on one sidewall of each tire it manufactures" a TIN "by permanently molding into or onto the sidewall, in the manner and location specified" in Figure 2 above. While the requirements specify TIN labeling on one sidewall, labeling of both sidewalls has been considered multiple times over the years. The original 1970 proposal recommended that the full TIN be marked on both sidewalls, but drew objections from manufacturers who stated that such a requirement

[15] 49 CFR Part 574.5(e)

would cause substantial safety and economic hardships, given current tire production methods. [16, 17] As a result, NHTSA concluded that such a requirement would cause substantial safety and economic hardships, given current tire production methods.

The TIN location requirements were later revisited in 2002 in a final rule that created a single standard for light vehicle tires in response to the Transportation Recall Enhancement, Accountability, and Documentation (TREAD) Act. FMVSS No. 139, New Pneumatic Tires for Light Vehicles. The preamble to the 2002 final rule highlighted the issue that when tires are mounted so that the TIN appears on the inward facing sidewalls, motorists have three difficult and inconvenient options for locating and recording the TINs. Consumers must either: (1) Slide under the vehicle with a flashlight, pencil and paper and search the inside sidewalls for the TINs; (2) remove each tire, find and record the TIN, and then replace the tire; or (3) enlist the aid of a garage or service station that can perform option 1 or place the vehicle on a vehicle lift so that the TINs can be found and recorded. Without any TIN information on the outside sidewalls of tires, the difficulty and inconvenience of obtaining the TIN by consumers results in a reduction of the number of people who respond to a tire recall campaign and the number of motorists who unknowingly continue to drive vehicles with potentially unsafe tires. As a result, a requirement was added for new tires to be labeled with "the full TIN on the "intended outboard sidewall" of the tire and either the full TIN or a partial TIN, containing all aspects of the TIN except for the date code, on the opposite sidewall."[18, 19]

The idea of displaying the full TIN on both tire sidewalls was raised again in a 2015 National Transportation Safety Board (NTSB) report focused on passenger vehicle tire safety. NTSB that recommended in H-15-30 that NHTSA should "Require tire manufacturers to include the complete tire identification number on both the inboard and outboard sidewalls of a tire" to "reduce the potential for confusion and misidentification by consumers."[20] A May 2016 response from NHTSA stated:

> "NHTSA proposed requiring the full tire identification number (TIN) on both sides of a tire when developing Federal Motor Vehicle Safety Standard (FMVSS) No. 139 for passenger car tires in a December 2001 notice of proposed rulemaking (66 FR 65536). However, comments received in response to this proposal and a visit to a tire manufacturing plant by NHTSA staff revealed that there are safety and cost issues associated with marking both sides of the tire with the date code portion of the TIN. Tire manufacturers imprint the date code onto the tire during the molding process. In order to include the date code on both sides of the tire, a worker would need to climb inside the hot mold used to make tires every week and change out the date. An alternative is for a manufacturer to etch a date into the side of a tire after the tire has been removed from the

[16] 35 FR 11800

[17] See footnote 16.

[18] Transportation Recall Enhancement, Accountability, and Documentation (TREAD) Act on November 1, 2000. Public Law 106–414. 114 Stat. 1800.

[19] 67 FR 69599

[20] Special Investigation Report – Selected Issues in Passenger Vehicle Tire Safety. NTSB/SIR-15/02. PB2016-100009. Notation 8727. Adopted October 27, 2015. National Transportation Safety Board.

mold, however this would require additional tooling and result in additional costs making any proposed regulation difficult to justify.[21]

3.3 TIN Marking Method

49 CFR part 574.5 requires that all newly manufactured and retreaded tires, "must conspicuously label" a TIN "by permanently molding into or onto the sidewall, in the manner and location specified" in Figure 2 above. A 2004 amendment to the rule gave tire manufacturers the option of laser etching the date code onto the tire sidewall rather than molding it.[22, 23]

3.4 TIN Use

The TIN plays an important role in identifying which tires are subject to recall and remedy campaigns for safety defects and noncompliances. The purpose of the TIN requirements is to facilitate efforts by tire manufacturers to notify purchasers of defective or nonconforming tires so that purchasers can take appropriate action in the interest of motor vehicle safety.[24] More on tire registration and recalls is presented in Section 5 of this report.

[21] https://ntsb.gov/_layouts/ntsb.recsearch/Recommendation.aspx?Rec=H-15-030. Accessed March 2, 2018.
[22] 69 FR 31306
[23] 49 CFR Part 574.5(d)(1)
[24] 67 FR 69599

4.0 ELECTRONIC TIRE IDENTIFICATION AND ASSOCIATED TECHNOLOGIES

Electronic tire identification would involve applying an electronically-readable marker within or on the sidewall of a tire. With electronic tire identification, the TIN could be captured electronically and transmitted electronically, eliminating the need to hand-write the TIN or type it into a computer. A robust and durable method of electronic tire identification would provide a more efficient means of identifying individual tires for registration and recall purposes.

NHTSA's research identified technologies that are currently in use, or being explored for use, for electronic tire identification by the tire industry. Once identified, the technologies were evaluated per criteria such as: technical capabilities, limitations, robustness, availability, cost, and current market use. Currently used electronic tire identification technologies include radio frequency identification (RFID) tags, two-dimensional (2D) barcodes, and one-dimensional (1D) barcodes.

4.1 Radio Frequency Identification Tags

4.1.1 Technology Description

RFID tags are small electronic components that are typically attached to, or implanted within, an item, and contain electronically stored information used to identify that item. The tags are read using an RFID reader. When scanned, the tags transmit their stored information to the reader. The stored information typically consists of an identifying number or code. In most cases, the identifying code itself does not provide any immediate information. An associated database would be used to "look up" the item using the code.

RFID tags consist of an integrated circuit, an antenna, and a means of power. A tag is classified as either "active" or "passive" based on its means of power; "active" tags having a local power source, such as a battery, and "passive" tags are powered using energy collected from the radio waves emitted from an RFID reader. RFID tags operate within one of three frequency bands; Low Frequency (LF) 30 to 300 KHz, High Frequency (HF) 3 to 30 MHz, or Ultra High Frequency (UHF) 300 MHz to 3 GHz.[25] Higher frequency tags can be read faster and over longer ranges but are more prone to interference. The amount of memory available in an RFID tag depends on design of the tag. Tags can be expanded to have increased storage capacity, but doing so increases the cost of the tag.

4.1.2 Tire Application Details

An RFID tag, as shown in Figure 3, can be embedded in a tire by placing the tag in the tire before the molding process, or by permanently affixing a patch containing the RFID tag to the tire after fabrication is completed. The type of RFID tags currently seeing the most use in tires are passive UHF tags following the GS1 Electronic Product Code (EPC) Class-1 Generation-2

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[25] S. Smiley, "What is RFID?," 21 February 2017. [Online]. Available: https://blog.atlasrfidstore.com/what-is-rfid?utm_source=Quick-Start&utm_medium=Link&utm_campaign=Content&utm_content=What-is-RFID

communication protocols, otherwise known as UHF Class 1 Gen 2 RFID tags.[26, 27] In optimal conditions, UHF Class 1 Gen 2 RFID tags can have read ranges of over 50 feet.[28] However, the read range of tags embedded in tires is greatly impeded by the tire material and construction. Nominal read ranges for RFID tags embedded in tires have been found to be less than 2 feet. Since reading an RFID tag does not require a direct line of sight, an RFID tag embedded within an inside-facing sidewall would still be readable by a scanner held near the outward face of the tire.

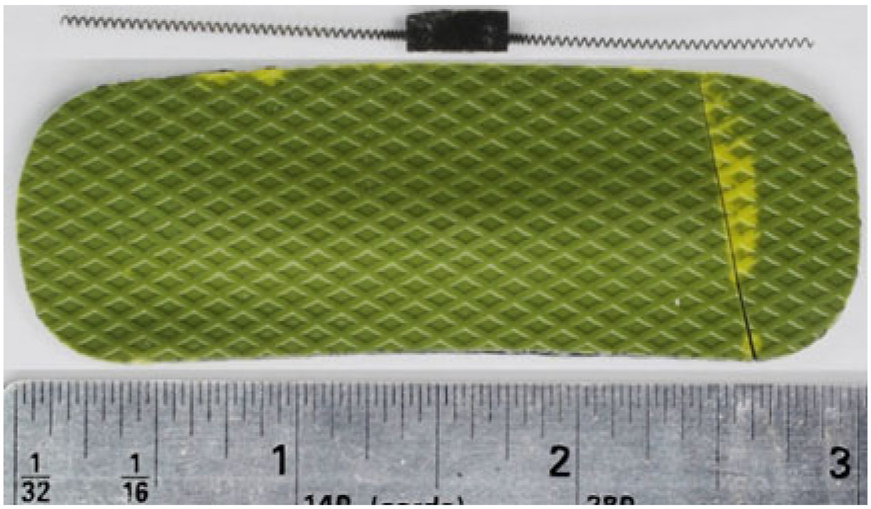

Figure 3. Example RFID tag; bare (top) and encased in rubber (middle)

Internally, the UHF Class 1 Gen 2 tags have up to four memory areas: Reserved memory, EPC memory, Tag Identification (TID) memory, and User memory. Descriptions of these memory areas are as follows:

Reserved Memory: This reserved area of memory contains the tag's access and kill passwords, both 32-bit. The access password is used to unlock a tag's write capability, the kill password can be used to permanently disable the tag.

EPC Memory: This area is where the EPC is stored.[29] EPC memory has a minimum of 96 bits of writeable memory that can be locked after writing to it, making it read only.

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[26] "GS1 is an international not-for-profit association with Member Organisations in over 100 countries. … There are no words associated with the acronym 'GS1'." http://xchange.gs1.org/sites/faq/Pages/who-we-are-and-what-we-do.aspx. Accessed February 26, 2018.
[27] GS1 EPCglobal™, "Radio-Frequency Identity Protocols Generation-2 UHF RFID, Specification for RFID Air Interface Protocol for Communications at 860 MHz - 960 MHz, Version 2.0.1
[28] SkyRFID Inc, "RFID Tag Maximum Read distance," 2007 ~ 2018. [Online]. Available: http://skyrfid.com/RFID_Tag_Read_Ranges.php
[29] An EPC is a universal identifier designed to uniquely identify a specific physical object. https://www.epc-rfid.info/

TID Memory: This area contains the unique tag identification number. The tag ID is programmed by the manufacturer of the tag and cannot be changed. The TID is programmed at the time the tag's electronic circuits are manufactured.

User Memory: User memory is an optional area on the tag that can be encoded with any data the user desires. The storage capacity of the user memory can be selected based on user needs, but including user memory increases cost and can affect the RFID tag's read range and read speed.[30]

The tags used in tires today have an approximate minimum of 320 bits of memory. This assumes 192 bits of TID memory, 96 bits of EPC memory, 64 bits of password memory, and no user memory. One sample RFID tag sent to NHTSA included 512 bits of user memory, for a total of 864 bits of tag memory.

Goodyear indicated that most RFID tags in tires are using EPCs as the identifier.[31] The EPCs are encoded following the Serialized Global Trade Item Number (SGTIN-96) format.[32] An SGTIN-96 EPC contains a company prefix, assigned to the manufacturer by GS1, along with an item reference indicator and a unique serial number.[33] An EPC is unique to a specific item, meaning that a tire with an RFID tag encoded with an EPC would be uniquely identifiable.

One of the questions asked by Section 24334 of the FAST Act is whether it is feasible "to include electronic identification on every tire that reflects all of the information currently required in the tire identification number." Stakeholders indicated that the RFID tags currently being used in tires do not directly contain the TIN or "all of the information currently required in the TIN." This information would need to be retrieved from an associated database using the EPC as the "look up" code.

The user memory area of an RFID tag could be used to store a TIN directly. However, this would require the tag include sufficient user memory to do so. Stakeholders indicated that adding user memory increases the cost of RFID tags. One stakeholder said that they only include user memory when it is requested by their customers.[34]

4.1.3 RFID Use in Tires to Date

Research for in-tire RFID tag applications began during the 1980s. Goodyear began evaluating the use of RFID tags in tires in 1984 and Michelin did the same in 2002/2003.[35, 36] RFID tags are most frequently found in heavy truck tires where they are used for fleet management purposes. Michelin has been installing RFID tags in a portion of their truck tires for some time and have

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[30] S. Armstrong, "Types of Memory in RFID Tags," 1 May 2013. [Online]. Available: https://blog.atlasrfidstore.com/types-of-memory-in-gen-2-uhf-rfid-tags
[31] NHTSA–Goodyear stakeholder meeting. July 18, 2017
[32] https://www.epc-rfid.info/sgtin
[33] GS1 is a not-for-profit organization that develops and maintains global communication standards [https://www.gs1.org/].
[34] NHTSA–Goodyear stakeholder meeting. July 18, 2017
[35] C. Swedberg, "RFID Tracks Tires at NASCAR," 25 November 2005. [Online]. Available: http://www.rfidjournal.com/articles/view?2006
[36] RFID Journal, "Michelin Embeds RFID Tags in Tires," 16 January 2003. [Online]. Available: http://www.rfidjournal.com/articles/view?269

indicated that currently about 88 percent of their new tires are equipped with RFID.[37] The use of RFID tags in light vehicle tires is less common, but has been on the rise in recent years. Kumho Tire implemented the capability to install RFID tags in tires in their three Korean and one U.S. plant in 2016 and in their Vietnam plant in 2017. Kumho Tire is currently installing RFID tags in all of the passenger car, light truck, and truck and bus tires they produce, except those produced in China. Kumho warehouses in the U.S. have capability to read RFID information from individual tires and use this information . for inventory management purposes Korea starting in 2014.[38,39, 40]

4.1.4 Tire-Related Standards or RFID

The International Organization for Standardization (ISO) has the following four standards currently under development regarding the use of RFID tags in tires for identification purposes:

- ISO/DIS 20909 – Radio frequency identification (RFID) tire tags[41]
- ISO/DIS 20910 – Coding for RFID tire tags[42]
- ISO/NP 20911 – Embedding methods for RFID tire tags[43]
- ISO/NP 20912 – Testing methods for RFID tire tags[44]

ISO/DIS 20909 and ISO/DIS 20910 are currently available as draft industry standards. Together, the standards specify general requirements for the type of RFID tags that should be used, the data that the tags should contain, and the format that the data should be encoded in. The standards specify passive UHF RFID tags that comply with either the ISO/IEC 1800-63 or GS1 EPC Class 1 Gen 2 communication protocols.[45] The coding of the EPC, which ISO refers to as the Unique Item Identifier (UII), should follow the SGTIN-96 format. An SGTIN-96 UII contains a company prefix, assigned to the manufacturer by GS1, along with an item reference indicator and a unique serial number.[46] With this format, each tire would be uniquely identified. Tires with RFID tags following the ISO standard would not be required to directly contain the TIN.

[37] Tire Business Staff, "Michelin adding RFID to all truck tires," 2 March 2017. [Online]. Available: http://www.tirebusiness.com/article/20170302/NEWS/170309984/michelin-adding-rfid-to-all-truck-tires
[38] E-mail communication from Brian H. Buckham, Managing Director, Kumho America Technical Center, May 8, 2018.
[39] C. Swedberg, "At Kumho Tire Factory, RFID Drives First-In, First-Out Process," 30 September 2015. [Online]. Available: http://www.rfidjournal.com/articles/view?13548/
[40] C. Swedberg, "Tire Manufacturers Roll Forward With RFID," 01 August 2013. [Online]. Available: http://www.rfidjournal.com/articles/view?10880
[41] ISO/DIS 20909:2017(E) – Radio frequency identification (RFID) tyre tags. https://www.iso.org/standard/69435.html
[42] ISO/DIS 20910:2017(E) – Coding for radio frequency identification (RFID) tyre tags. https://www.iso.org/standard/69436.html
[43] ISO/NP 20911 – Embedding methods for radio frequency identification (RFID) tyre tags. https://www.iso.org/standard/69437.html
[44] ISO/NP 20912 – Testing methods for radio frequency identification (RFID) tyre tags. https://www.iso.org/standard/69439.html
[45] ISO/IEC 1800-63 – Information technology -- Radio frequency identification for item management -- Part 63: Parameters for air interface communications at 860 MHz to 960 MHz Type C
[46] GS1 is a not-for-profit organization that develops and maintains global communication standards [https://www.gs1.org/].

4.1.5 Estimated Cost for Tire Applications

Current cost estimates for adding RFID tags to tires include the cost of RFID tags, ranging from $0.25 to $0.50 per tag[47], plus the cost of integrating RFID tags into the manufacturing process. Tire manufacturer stakeholders estimate the total cost for including RFID tags in every tire will be between $0.50 and $1.00 per tire. It is expected that the per-tire cost would decrease with full implementation in every tire.

A UHF RFID reader would be needed to read the tags. The readers are commercially available at prices ranging from about $200 to upwards of $4,000. It is estimated that the basic functionality needed to scan RFID tags in tires can be had at the lower end of that price range. Additional networking equipment may be needed to interface the scanner to a computer. Computer networking capability would allow for easy transfer of the tire identification EPC code from the reader to a computer, obviating the need for manual data entry of the EPC code and facilitating access to a database that links EPCs to TINs. Networking capability would also be needed to access download or update any database residing on the scanner.

4.1.6 Durability in Tires

No formal research into the longevity of RFID tags in tire applications was found during this study. Stakeholders indicated that RFID tags in commercial tires have been shown to be quite robust, routinely surviving multiple retreading events. Tire manufacturers stated that they are "confident in the survivability" of RFID tags through the retread process. While stakeholders acknowledged that the size of commercial tires provides an environment that is likely easier on the tags than that of passenger car tires, they do believe that RFID tags can survive in all types of passenger car tires, including low profile tires. However, no data documenting any of these assertions was provided to NHTSA.

4.2 2D Barcodes

4.2.1 Technology Description

2D barcodes are a form of barcode that represent data as a two-dimensional optical array consisting of many small, contrasting geometric shapes, such as squares or circles.[48] There are many different types of 2D barcodes, each with their own features and capabilities that make them better suited for particular applications. Typically, the barcodes are applied to an item and encoded with information used to identify, track, or provide details about the item. Barcodes application on a flat surface is necessary, as a barcode applied to a curved or uneven surface will be more difficult to read.[49]

2D barcodes encode data along both the vertical and horizontal axes, allowing them to hold a large amount of data in a relatively small space. The data capacity of a 2D barcode depends on the type and size of the barcode and the encoding scheme used. These barcodes can be encoded

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[47] NHTSA–USTMA stakeholder meeting. August 3, 2017

[48] LowerySolutions, "What is the Difference Between 1D and 2D Barcode Scanning," 29 January 2015. [Online]. Available: https://lowrysolutions.com/blog/what-is-the-difference-between-1d-and-2d-barcode-scanning/

[49] https://www.gtschmidt.com/2d-part-marking. Accessed March 6, 2018.

with any combination of numeric, alphanumeric, or binary data with capacities ranging from a few characters up to many thousands of characters.[50]

2D barcodes are read using digital image sensors, such as the camera in a modern smart phone. Reading the barcodes requires clear line-of-sight, visual features within the barcodes allow them to be read regardless of their orientation relative to the reader.[51] Another 2D barcode feature is error correction. Error correction enables the barcodes to remain readable even when partially damaged or blocked. Error correction can be applied at varying levels and is measured as the percentage of the barcode that can be blocked or damaged while still maintaining readability. Applying error correction comes at the expense of reduced data storage capacity.[52]

4.2.2 Tire Application Details

2D barcodes are applied to tires by laser etching them into the sidewall. 4Jet Technologies designs and manufacturers laser etching machines for applying markings on tires. 4Jet has developed what they call "SCANNECT" technology, which is a process of laser etching 2D barcodes on the tire sidewalls and a supporting smart phone application to read the 2D barcodes.[53] 4Jets's laser etching process creates what they call "super-black," high contrast, 2D barcodes. The barcodes range from 20 to 50 mm square and are etched to a depth of 300 to 500 microns. 4Jet's SCANNECT phone application is specifically designed to read the black-on-black barcodes. Nominal read ranges for 2D barcodes etched into the sidewall of tires have been found to be in the range of about 1 foot. 4Jet supports around 10 major tire manufacturers who are installing production laser etching capability on some manufacturing lines. In the US alone, 4Jet has orders for 5+ systems capable of etching 2D barcodes on tires.[54] An example of a laser etched 2D barcode can be seen in Figure 4 below.

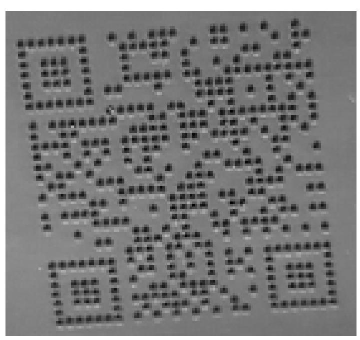

Figure 4. Example 2D barcode; QR code etched in rubber

[50] "How Much Data Can a QR Code Store?," February 2017. [Online]. Available: http://qrcode.meetheed.com/question7.php?s=f
[51] "Can a QR Code be Rotated?," February 2017. [Online]. Available: http://qrcode.meetheed.com/question1.php?s=s
[52] "QR Code Error Correction," February 2017. [Online]. Available: http://qrcode.meetheed.com/question17.php?s=s
[53] http://www.4jet.de/en/solutions/laser-tire-marking/scannect/
[54] NHTSA–4Jet stakeholder meeting. August 9, 2017

Two types of 2D barcodes are seeing the most use in electronic tire identification applications: Quick Response (QR) codes and Data Matrix codes (DMCs).[55] Both QR codes and DMCs excel at encoding large amounts of data in a small physical space, making them ideal for this application. [56] 4Jet stated that some of their customers prefer QR codes because they are more universally recognizable, and users tend to understand the purpose of the code with little to no guidance.[57] In the size range of the barcodes being etched into tires, DMCs are capable of a smaller physical size for a given amount of data. DMCs can also be rectangular in shape (QR codes are always square), which allows for more flexibility when sidewall space is limited, such as on low-profile tires.[58]

4Jet indicated that most manufactures using 2D barcodes are requesting that they be etched into both sidewalls.[59] Etching them into both sidewalls of a tire would avoid having a situation in which a tire with a single barcode is mounted with the barcode on the inner sidewall. Since 2D barcodes require line-of-sight to be read, a barcode on an inner sidewall would be difficult to access and read.

4.2.3 Use in Tires to Date

Some European auto manufacturers have started specifying the use of 2D barcodes on their original equipment (OE) tires. BMW will begin using laser-etched 2D barcodes on OE tires for a limited number of their model year 2018 vehicles.[60] 2D barcodes are also used on heavy truck tires for fleet management purposes. Two major tire manufacturers have run successful pilot projects using 2D barcodes on their truck tires and are planning to begin implementing their use starting in 2018.[61]

4.2.4 Tire-Related Standards for 2D Barcodes

No official standards regarding the use of 2D barcodes on tires for identification purposes were identified. However, through interaction with a stakeholder, NHTSA learned of a document written by BMW and Audi that outlines a proposed method for the use of 2D barcodes on tires for identification purposes.[62] The document was a "proposal for possible standardization that was presented to ACEA (European Automobile Manufacturers Association)."[63] The document specifies physical characteristics of the barcode as well as the format and contents of the encoded data. It specifies a 22 x 22 module DMC created in accordance to ISO/IEC 16022:2006.[64] It specifies the use of numeric encoding which would allow a capacity of 60 digits, 58 of which are reserved for encoding tire information. The tire information includes the full TIN for each tire

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[55] NHTSA–4Jet stakeholder meeting. August 9, 2017

[56] "Overview 2D Barcode Symbologies." [Online]. Available: https://www.tec-it.com/en/support/knowbase/barcode-overview/2d-barcodes/Default.aspx

[57] NHTSA–4Jet stakeholder meeting. August 9, 2017

[58] NHTSA–4Jet stakeholder meeting. August 9, 2017

[59] NHTSA–4Jet stakeholder meeting. August 9, 2017

[60] C. Swedberg, "Tire Industry Works Toward Global RFID-Tagging Standards," 11 November 2016. [Online]. Available: http://www.rfidjournal.com/articles/view?15225

[61] NHTSA–4Jet stakeholder meeting. August 9, 2017

[62] BMW/Audi, "Specification car tire identification," Version 1.1, September 22, 2016

[63] D. Rinehardt, BMW Group (personal communication, February 16, 2018)

[64] ISO/IEC 16022 - Information technology -- Automatic identification and data capture techniques -- Data Matrix bar code symbology specification

and a unique serial number (unique for each tire when coupled with the plant code). Additional encoded information includes the vehicle manufacturer for whom the tire was manufactured, the tire type, tire size, load rating, speed rating, and other information about the tire.

4.2.5 Estimated Cost for Tire Applications

According to information supplied by 4Jet, the cost for engraving a single barcode into a sidewall is about $0.08. [65] However, auto companies using 2D barcodes are requesting that the barcode be etched into both sidewalls making the total cost per tire about $0.16. This same technology could be used to apply other markings to the tires, such as the DOT date code. The cost for a single DOT date code engraving is about $0.07. Since a significant portion of the etching cycle time is spent orienting the tire, co-engraving (i.e., etching two or more features into the same sidewall) reduces the cost per etch. For example, the cost of co-engraving a QR code and the date code portion of the TIN is estimated to be about $0.10 per sidewall. The date code is the only portion of the TIN that is permitted to be laser etched rather than molded.[66]

A digital image sensor would be needed to read the barcodes. The scanners come in many forms, ranging from a free app on a common camera-equipped smart phone to dedicated industrial unit costing upwards of $3000. It is estimated that the basic functionality to scan barcodes on tires could be acquired for less than $100. Additional networking equipment may be needed to interface the scanner to a computer for easy transfer of the tire identification information and to download or update the tire recall database residing on the scanner.

4.2.6 Durability in Tires

No published studies of 2D barcode durability in tires were found. Stakeholder, 4Jet, indicated that initial testing has shown the etched 2D barcodes to be very durable and capable of lasting the full life of tires. According to 4Jet, one of their customers has performed extensive testing on heavy truck use and experienced only one lost code, which was located on an area of the tire prone to heavy wear.[67] With the applied error correction, these codes can still be read even when a portion of the code is damaged (e.g., due to the tire rubbing against a curb) or visually blocked. 4Jet's estimate is that 95 percent of the time, the barcode can be read without any cleaning to remove surface dirt. No supporting data documenting the durability of barcodes etched in tire sidewalls was provided to or found by NHTSA.

4.3 1D Barcodes

One-dimensional, or "1D," barcodes are one-dimensional, linear arrays of contrasting vertical, parallel lines with varying widths, such as that shown in Figure 5.[68] One-dimensional barcodes are found on nearly all consumer goods, including tires. The current use of 1D barcodes on tires is mainly for the support of inventory and supply chain management. Tire 1D barcode are currently printed on labels that are adhered to the exterior of the tire along the bead during the

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[65] NHTSA–4Jet stakeholder meeting. August 9, 2017
[66] 49 CFR Part 574.5(d)(1)
[67] NHTSA–4Jet stakeholder meeting. August 9, 2017
[68] Lowery Solutions, "What is the Difference Between 1D and 2D Barcode Scanning," 29 January 2015. [Online]. Available: https://lowrysolutions.com/blog/what-is-the-difference-between-1d-and-2d-barcode-scanning/

manufacturing process.[69, 70] No information regarding the feasibility of applying 1D barcodes on tires in locations other than the tire bead or using marking methods other than adhesive labels was found during the course of this study. For a barcode applied to the tire bead, the barcode can be easily read before the tire is sold to a consumer, but once installed upon a wheel, the barcode is no longer visible. Thus, after sale, a tire's 1D barcode is no longer useful for determining recall status unless the tire is uninstalled from the wheel. Further, some tire installers remove the 1D barcode labels from the tire beads because they believe that their presence may lead to the tire leaking air.[71] A concealed or removed 1D barcode would not aid vehicle service personnel or the tire owner in determining the recall status of the tire.

Figure 5. Example 1D barcode on tire bead

Another factor that limits the usefulness of 1D barcodes for determining recall status is that, currently, 1D barcodes are not used for encoding the TIN. The amount of data that 1D barcodes can hold is limited and the barcodes generally increase rapidly in size as data capacity is increased.[72] Expanding a 1D barcode to add the TIN top the stored information would lengthen the barcode and may increase the difficulty of applying such a code to a tire.

These factors limit the utility and potential benefits of 1D barcodes for the electronic tire identification application discussed in this study. Further, stakeholders did not mention 1D barcodes as a technology under consideration for use in implementing TIN-based electronic tire identification. For these reasons, 1D barcodes are not discussed in depth in this report.

4.4 RFID Tag and 2D Barcode Technology Comparison

Both RFID tags and 2D barcodes appear to be technologically feasible technologies for use in electronic tire identification. A comparison of the two technologies can be seen in Table 1 below.

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69 Tire "bead" is defined in FMVSS No. 109 as "that part of the tire made of steel wires, wrapped or reinforced by ply cords, that is shaped to fit the rim."

70 The bead is the lowermost region of the tire that contacts a matching profile on the rim via an interference fit. From "Laboratory Tire Bead Unseating – Evaluation of New Equipment, Pressures and "A" Dimension From ASTM F-2663-07as (DOT HS 811 735)," April 2013. National Highway Traffic Safety Administration, Washington DC.

71 "Dealer says, 'Move those barcodes!," Modern Tire Dealer, Posted on February 23, 2010. http://www.moderntiredealer.com/blogpost/lori-s-listening/340186/dealer-says-move-those-barcodes. Accessed March 7, 2018.

72 LowerySolutions, "What is the Difference Between 1D and 2D Barcode Scanning," 29 January 2015. [Online]. Available: https://lowrysolutions.com/blog/what-is-the-difference-between-1d-and-2d-barcode-scanning/

Table 1. RFID and 2D Barcode Technology Comparison

	RFID	2D Barcodes
Read Method	• Industrial hand-held readers • Proximity reading; • 2 ft read range permits reading of tag embedded in either sidewall while the user stands adjacent to the vehicle	• Industrial hand-held readers, smart phones • Line-of-sight reading • Approximately 1 ft read range
Standards for Tire Use	• Draft ISO Standards	• None

Standardized Data Format	• EPC/UII in SGTIN-96 format
	• Does NOT contain TIN in tag
	  o Access to an external database that relates EPC to TIN is necessary to obtain TIN
	  o Possible to encode directly with added memory, increased costs
		• Current tire barcodes contain TIN

Long-term Durability	• No formal studies • Stakeholders indicated no durability concerns	• No formal studies • Stakeholders indicated no durability concerns • Error correction allows for reading even when barcode is partially damaged
Estimated Costs*	• Tags ~$0.25 – $0.50 per tag • Total ~ $0.50 - $1.00 per tire	• Single engraving ~$0.09 per sidewall • Both sidewalls ~ $0.18 per tire
Challenges	• Difficult to identify individual tires when stacked • Limited memory • Tire owners would have to purchase and use an RFID scanner	• Cannot read barcodes on stacked tires • Requires more handling to achieve line-of-sight for reading • Cannot be read easily if barcode is on inside-facing sidewall • Cannot be read while tire is in motion

*Note: Cost information is based on verbal stakeholder input.

4.4.1 Data Compatibility

If both RFID tags and 2D barcodes were permitted for use in implementing electronic tire identification, it would be important that the two technologies contain data following a compatible format. A standard data format would be critical to obtaining maximum ease of use and effectiveness. Data compatibility is also being stressed in the draft RFID ISO standards. The following is an excerpt from ISO/DIS 20910:

> "An extensive effort has been undertaken to make data interchangeable between 2D (e.g., Data Matrix / QR Code) optical symbols and electronic media like RFID to permit the user to select the appropriate technology with a minimum impact on Information Technologies (IT) infrastructures. These technologies complement each other and may be used jointly or separately as the application may require."[73]

Both technologies are capable of directly containing the TIN, although RFID tags would require the addition of user memory. Since TINs follow a standard format, containing the TIN directly satisfies the first question asked in the FAST Act as well as the part of the second question that asks if a standard format is feasible.

If electronic tire identification were also to contain unit-level identification, it is believed that a standard format could be achieved between the two technologies. Since the format of the data on RFID tags is fairly inflexible, achieving compatibility would require that 2D barcodes include an SGTIN-96 format EPC. Although 2D barcodes on tires do not currently follow this format, the capacity of the barcodes would allow them to do so. 4Jet investigated this question and indicated that the European vehicle manufacturers were open to the idea.

It should also be noted that many scanners/readers that are on the market are capable of reading both technologies.

[73] ISO/DIS 20910:2017(E) – Coding for radio frequency identification (RFID) tyre tags.

5.0 CURRENT TIN COLLECTION PROCESS

Equipping new passenger vehicle tires with electronically readable TIN information would impact the TIN collection process. TIN collection, or visually locating and transcribing the TIN from tires, is performed by both tire owners and tire service personnel when preparing to register tires or prior to looking into whether the tires have been recalled. Writing the TIN by hand can provide the opportunity for recording errors and data entry errors when typing the TIN into a computer. How quickly TIN collection can be performed depends on whether the full TIN is on the outward face of all four tires.

5.1 TIN Collection Time Measurement

NHTSA performed measurements to gain a better understanding of the process of manually locating and recording TINs from tires installed on a vehicle and assess whether electronic identification could allow for faster TIN collection. The initial intent was to compare how long TIN collection takes with tires having TINs molded into the tire sidewalls versus tires with electronic TINs. However, NHTSA found too few tires equipped with electronic identification to permit time measurements for RFID-equipped tires. Therefore, measurements focused only on the collection of molded TINs.

TIN collection time consisted of the time it took for an experimenter to visually locate and hand-record on a piece of paper the full TIN from all four tires mounted on a passenger vehicle. Time measurement started with the experimenter standing next to the vehicle and ended once the fourth and final TIN was recorded on the piece of paper. Three different experimenters recorded TINs from a total of 33 vehicles at NHTSA's Vehicle Research and Test Center in September of 2017. The average time to locate and record TINs from all four tires of a vehicle was 2 minutes and 43 seconds. The maximum time for a single vehicle was 5 minutes and 45 seconds. This longer collection time was due to the front tires on this vehicle being mounted with the full TINs on the inner sidewall, making the TINs more difficult to physically access for recording purposes.

The time measurement data presented here are representative of the process that would be performed by, e.g., a service technician or a vehicle owner, prior to checking a vehicle's already-mounted tires in a recall database searchable by TIN. This timing information may not reflect the time required for TIN collection at the time of installation of the tires for registration purposes. Before installation tires are easily movable, so visually locating the TIN should be quicker. Therefore, manual TIN collection time at tire installation could be slightly faster than the times obtained in this study.

6.0 ELECTRONIC TIRE IDENTIFICATION TECHNOLOGY DIFFERENCES THAT IMPACT UTILITY

Characteristics of certain available technologies for electronic tire identification limit their utility and potential benefits for the type of electronic tire identification application discussed in this study. Differences in the ability of the identification to be read at different points in the life of the tire impact the utility of the identification for different users (i.e., vehicle/tire service personnel and tire owners).

One example is that of 1D barcodes applied on the bead of a tire. These barcodes are visible on a tire before it is mounted on a wheel, but then are either removed prior to mounting or, if not removed, are concealed once a tire is mounted on a wheel. This means that 1D barcodes would be helpful to a tire installer in performing TIN collection and tire registration at the point of sale, but renders them useless to service personnel and the tire owners throughout the remaining life of the tire. As a result, checking a mounted tire for tire recalls would require carrying out the traditional manual TIN collection process of visually locating the molded TIN, writing it down, and then typing it into a computer that access a recall database.

Tire electronic identification access by an owner of RFID-equipped tires would present a challenge as well. Reading RFID tags requires a hand-held RFID scanner, which tire sellers/servicers would presumably have, but consumers would likely not have. Therefore, while vehicle service personnel may have the needed scanner to read the RFID tag when the vehicle is brought in for service, tire owners are less likely to be able to read the RFID tags and check for tire recalls on their own. As such, to check for a tire recall, the tire owner would either need to carry out the traditional manual TIN collection process or take the vehicle to a service center that has the ability to scan the tire.

The current study was unable to find any long-term studies examining the durability and longevity of the electronic identification tags examined in this study. All of the identification technologies discussed in this report could be subject to damage in the event that a tire strikes a curb or other object. 2D barcodes are known to be readable even with some degree of damage. RFID tags are small electronic devices that, like any other electronic device, could malfunction resulting in an inability for the tag to be read. A tire containing a malfunctioning RFID tag would still have the molded TIN form of identification, but none of the potential benefits of electronic identification. Objective data documenting the hardiness of identification technologies under consideration would provide critical input to a technology selection decision.

Barcodes can be read using a common smart phone and, therefore, should be easily readable by tire installers, tire owners, and vehicle service personnel throughout the life of the tire. However, if electronic identification barcodes were only implemented on only one sidewall, achieving line of sight for an inside-facing barcode would require either crawling under the vehicle or putting it on a lift.

7.0 CONSUMER PRIVACY CONCERNS

One of the issues NHTSA aimed to explore in this study is the concern that electronic tire identification could pose some risk to consumer privacy. For instance, some consumers harbor concerns that widespread use of RFID tags in tires would pose a risk to consumer privacy. A simple Internet search of the term, "RFID tags in tires," will yield links to numerous discussions claiming that RFID tags in tires pose a privacy risk and that the tags could be used to gather private information or even to track an individual.[74]

In stakeholder meetings, NHTSA raised this point with tire industry members to gather information. Though stakeholders acknowledge privacy concerns should be explored and addressed, their consensus is that the presence of electronic identification in tires would not pose any added risk to consumer privacy.

RFID tags and 2D barcodes can be read by any person having the correct reading equipment. However, NHTSA's research showed that no personal information about the owner of a tire would be directly accessible from scanning an electronic tire identification of either type. Scanning a tire would only provide information about the tire itself, such as the TIN. Gaining any further information, such as the owner's contact information, would require access to a secure external database.

Another concern is that the tires could be easily scanned in a way that enables tracking the location of the tire and, by extension, the vehicle. For example, could roadside equipment scan the tires with the intention of logging every passing vehicle? NHTSA's research shows the key difficulty with this scenario is the relatively short distances over which either technology can be read. On tires, the optimal read range for RFID tags is about 2 feet and for 2D barcodes is less than 1 foot. 2D barcodes also require a clear line of sight and stationary conditions.

It is important to note that electronic identification provides no additional privacy risks when compared to other forms of identification present on vehicles. Vehicle owners are already tied to a vehicle through two forms of readily accessible identification present on the exterior of the vehicle: the VIN, visible on the windshield in front of the driver, and the license plate number. Both options also require access to secure databases to gain any further information. License plates offer a much easier and more plausible roadside scanning scenario. Advances in camera technology, modern license plate scanning technologies, and the proliferation of cameras in public areas offer multiple opportunities for collecting license plate information.

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[74] "Fast Company," 15 October 2013. [Online]. Available: https://www.fastcompany.com/3019847/think-you-can-live-offline-without-being-tracked-heres-what-it-takes

8.0 STAKEHOLDER MEETINGS

NHTSA held meetings with industry stakeholders to discuss electronic tire identification. The goal was to gather information and learn about stakeholders' views on the feasibility of requiring tire manufacturers to implement electronic tire identification in all tires. The meetings included discussion of available technologies, technological feasibility, cost, and industry impact. Input was received from vehicle and tire industry organizations, tire manufacturers, tire sellers, a technology supplier, and a service provider. These included:

- Tire Industry Association (TIA)[75]
- U.S. Tire Manufacturers Association (USTMA)[76]; companies attending included:
    - Bridgestone Americas Tire Operations, LLC
    - Continental Corporation, Rubber Group
    - Cooper Tire & Rubber Company
    - Goodyear Tire and Rubber Company
    - Michelin North America Inc.
    - Toyo Tire Corporation
- Goodyear Tire & Rubber Company[77]
- Alliance of Automobile Manufacturers (Auto Alliance)[78]; companies attending included:
    - BMW North America
    - Daimler
    - Ford Motor Company
    - Jaguar/Land Rover
    - Volkswagen Group of America
- Safety Research and Strategies, Inc. (SRS)[79]
- 4Jet Technologies GmbH[80]
- CARFAX, Inc.[81]

Summaries of individual meetings can be found in Appendix A.

8.1 Summaries of Stakeholder Thoughts – Main FAST Act Questions

Most of the stakeholders indicated that they were in support of electronic tire identification being required. The Auto Alliance was neutral on the issue. The consensus among the stakeholders is that it is feasible to include electronic tire identification on all tires. USTMA believes that the technology is available and feasible, but the topic of electronic tire identification requires more study. However, no specific areas of study were noted. USTMA stated that their first and foremost consideration is always the tire itself. Before including any technology in or on their

[75] NHTSA–TIA stakeholder meeting. June 28, 2017
[76] NHTSA–USTMA stakeholder meeting. August 3, 2017
[77] NHTSA–Goodyear stakeholder meeting. July 18, 2017
[78] NHTSA–Auto Alliance stakeholder meeting. July 27, 2017
[79] NHTSA–SRS stakeholder meeting. July 7, 2017
[80] NHTSA–4Jet stakeholder meeting. August 9, 2017
[81] NHTSA–CARFAX stakeholder meeting. August 24, 2017

tires, they would ensure that there would be no negative effect on the integrity or quality of the tire.

Stakeholders believe that electronic tire identification could be beneficial for improving the tire registration and recall processes. The ability to scan a tire for quick and accurate registration and to rapidly determine if that tire has been recalled, in combination with more focused recalls of uniquely identified tires, would be vast improvements over current methods.

TIA and USTMA were mostly familiar with RFID tags but acknowledged that other technologies, such as 2D barcodes, should be examined. TIA has no preference for a particular technology as long as the technology implemented is effective. European vehicle manufacturers are mostly using 2D barcodes and prefer the barcodes since this technology has the ability to hold all the information they would like to include without relying on access to an external database.

Most of the stakeholders believe that NHTSA regulatory action would be necessary to ensure a standard data format. USTMA believes that most, if not all, major US tire manufacturers using RFID would follow the draft ISO standard. However, it is important to recognize that there is a portion of the market that USTMA does not represent, specifically tire manufacturers that do not produce tires within the U.S. There is no way to guarantee that these manufacturers would also follow the standard.

The question of whether RFID tags and 2D barcodes could have, at least in part, a unified data format was discussed in the stakeholder meetings. Having a consistent data format such that any tag technology could access manufacturers' databases and the NHTSA recall database in the same way would be most efficient and flexible. Since the format of the data on RFID tags is fairly inflexible, achieving compatibility would require that 2D barcodes include an SGTIN-96 format EPC. Although 2D barcodes on tires do not currently follow this format, the capacity of the barcodes would allow them to do so. 4Jet investigated this question and indicated that the European manufacturers were open to the idea.

8.2 Other Stakeholder Ideas

<u>8.2.1 Electronically Identify Aged Tires</u>

NHTSA research has shown that tires degrade with age whether used on the road or not.[82] The research also found that the structural degradation from aging tires can be nearly impossible to detect through visual inspection, which can lead to unused, aged tires unknowingly put into service.

A tire's age can currently be determined from the date code in the TIN. However, the date is often overlooked by consumers and retailers alike. It was suggested that tire identification scanner designs and programming could be modified to check a tires age when scanned and provide an alert to the technician if the tire is beyond a certain age. This could then prompt a

[82] "Research Report to Congress on Tire Aging (DOT HS 810 799)," August 2007. National Highway Traffic Safety Administration, Washington DC.

response to inspect the tire, remove it from service/inventory, or perform another action based on vehicle and/or tire manufacturer recommendations. Some tire retailers have their own policy regarding aged tires. For example, one tire retailer stated that they do not service tires that are 10 or more years old.[83]

8.2.2 Tire Inventory Management

Stakeholders also indicated that there is some possibility they could use electronic tire identification containing the TIN for storage and warehouse logistics instead of current methods, such as 1D barcodes. If so, the increase in the number of times a tire is scanned provides additional opportunities to identify recalled tires.

8.2.3 Accounting for Tires Removed from Service

Stakeholders suggested that an additional benefit of an active database would be the scanning of tires upon their removal from service and updating of the database to reflect that the removed tire is no longer in use. This would allow the manufacturers to keep better track of active tire population.[84] This would allow tire manufacturers to send recall notices only for tires that are still in service.

[83] NHTSA–TIA stakeholder meeting. June 28, 2017
[84] NHTSA–USTMA stakeholder meeting. August 3, 2017

9.0 SUMMARY

This report summarizes NHTSA research conducted to respond to the FAST Act, Section 24334 that asked for an examination of the feasibility of requiring all tire manufacturers to:

> 1) "include electronic identification on every tire that reflects all of the information currently required in the tire identification number; and
>
> 2) ensure that the same type and format of electronic information technology is used on all tires."

NHTSA conducted this preliminary study of the feasibility of requiring electronic identification in all new tires to satisfy these FAST Act requirements and has summarized the effort in this report to Congress. The study involved technology identification, meetings with stakeholders, and measurement of the time it takes to perform manual TIN collection. The study identified technologies that are currently in use, or being explored for use, for electronic tire identification by industry. Once identified, the technologies were evaluated per criteria such as: technical capabilities, limitations, robustness, availability, and current market use. Input from stakeholders was gathered regarding their thoughts on and use of available tire identification technologies and the feasibility of requiring electronic identification. Some technology-related cost information was obtained through stakeholder input, but a full analysis of implementation costs and benefits was not performed as part of this effort. The impacts of tire electronic tire identification on the TIN collection, tire registration, and tire recall processes were also considered.

9.1 Feasibility of Requiring TIN-Based Electronic Tire Identification

Both the findings of this study and input from tire industry stakeholders suggest that it would be feasible to require manufacturers to include TIN-based electronic tire identification in all new tires. However, if a single technology is desired for use in implementing electronic tire identification, effort from industry to develop a consensus standard and from NHTSA to develop a regulation specifying requirements for electronic tire identification may be necessary.

The study identified two technologies currently in use for tire electronic identification, RFID tags and 2D barcodes, and found that either or both of these technologies could be used to implement electronic TIN information on all new tires. Each technology has advantages and disadvantages that affect process efficiencies and implementation cost. While the technologies identified have the ability to accomplish electronic tire identification, no data regarding the long-term durability of these technologies was found during the course of this study.

The most efficient method of providing electronic tire identification would be to include the TIN locally within the identification tag. 2D barcodes have sufficient data capacity to contain the TIN directly, so scanning the tire to get the TIN is a single-step process that can be accomplished with a common, camera-equipped smart phone. RFID tags as currently used in tires do not have sufficient user memory to encode the TIN. The tags contain an electronic product code, which must be read using an RFID scanner tool and then the obtained product code is used to query an external database to retrieve the corresponding TIN: a two-step process. RFID tags can be modified to have the capacity to store TIN information, but would require additional memory capacity which would increase the cost of the tag.

9.2 Feasibility of Ensuring a Standard Type and Format of Technology

The study also concluded that achieving a standard information content and format for the data is feasible. Stakeholders indicated that additional effort, including possible NHTSA regulatory action, may be required to ensure a standard data format was followed by all, particularly tire manufacturers that do not produce tires within the U.S.

The most efficient method of providing electronic tire identification would be to include the TIN locally within the identification tag. Since TINs follow a standard format, encoding the TIN directly in the identification tag would ensure a standard data format. Since the format of the data on RFID tags is fairly inflexible, achieving compatibility would require that 2D barcodes include an SGTIN-96 format EPC. Although 2D barcodes on tires do not currently follow this format, the capacity of the barcodes would allow them to do so.

9.3 Conclusions

The findings of NHTSA's preliminary study of the feasibility of requiring tire manufacturers to implement electronic identification suggest that it would be technologically feasible for manufacturers to include TIN-based electronic identification in all new tires. However, additional industry effort and possible NHTSA regulatory action may be required to ensure use of a single type of technology and standard information format.

The study identified two technologies currently in use for tire electronic identification and found that either or both of these technologies could be used to implement electronic TIN information on all new tires. However, while the technologies identified have the ability to accomplish electronic tire identification, no data regarding the long-term durability of these technologies was found during the course of this study. The two primary technologies, RFID tags and 2D barcodes, have advantages and disadvantages that affect process efficiencies and implementation costs. These differences would need to be thoroughly considered in determining whether implementation of electronic tire identification using one or multiple technologies would garner the most benefits.

The study concluded that achieving a standard information content and format for the data would be possible and feasible. The most efficient method of providing electronic tire identification would be to include the TIN locally within the identification tag. Since TINs follow a standard format, encoding the TIN directly in the identification tag would ensure a standard data format. Current electronic tire identification technologies do not follow the same format. However, if the use of multiple identification technologies is desired as opposed to focusing on a single technology, it is believed that a consistent format could be achieved by modifying the content format for one of the technologies to match that of the other.

While some cost information and anecdotal comments noting potential benefits were shared in the context of stakeholder meetings, a full analysis of the costs and benefits associated with implementation of electronic identification in all tires was not performed in the context of this study.

APPENDIX A. STAKEHOLDER MEETING SUMMARIES

Electronic Tire Identification Discussion with the Tire Industry Association

Date: June 28, 2017
Location: NHTSA Headquarters, Washington D.C.

Attendees:

Roy Littlefield	TIA
Roy Littlefield IV	TIA
Congressman Albert Wynn	TIA Consultant
Kevin Rohlwing	TIA
John Baldwin	Discount Tire
James Parr	Discount Tire
David Martin	American Tire Distributors
John Evankovich	Sam's Club Tire & Battery Centers
Glen Nicholson	TBC Corporation
Riley Garrott	NHTSA VRTC
Elizabeth Mazzae	NHTSA VRTC
Claudia Covell	NHTSA
Lisandra Garay-Vega	NHTSA
Abraham Diaz	NHTSA
Eric Gerdus	TRC, Inc. on behalf of NHTSA VRTC
Ken Woodruff	TRC, Inc. on behalf of NHTSA VRTC

NHTSA met with the Tire Industry Association (TIA) on June 28th, 2017.

> "The Tire Industry Association (TIA) is an international non-profit association representing all segments of the tire industry, including those that manufacture, repair, recycle, sell, service or use new or retreaded tires, and also those suppliers or individuals who furnish equipment, material or services to the industry. The mission of TIA is to promote tire safety through training and education, to act as the principal advocate in government affairs, and to enhance the image and professionalism of the industry so that our member businesses may be more successful. TIA has over 10,000 members from all 50 states and around the globe."

The TIA has been a big proponent for electronic tire identification and played a big role in the addition of Section 24334 to the FAST Act. On March 10, 2016 TIA submitted comments to NHTSA in response to an Advanced Notice of Proposed Rulemaking (ANPRM) and request for public comments on Updating Means of Providing Notification and Improving Efficacy of Recalls (Docket No. NHTSA-2016-0001). Within the submitted comments, TIA states:

> "While TIA recognizes the importance of notifying owners when a tire recall becomes necessary, we believe the focus should be on recovery, so our comments are focused on removing defective tires from the highway."

> "…while improved notification processes are necessary, in the context of defective tires, electronic identification will be the most significant factor in improving recall efficacy and effectiveness."

> "By incorporating technology into the tire registration and recall recovery system, retailers could easily and accurately scan every tire that is sold. The TINs could then be automatically recorded in a database and human error dramatically reduced. Rather than relying on a technician with a pen and clipboard, a quick scan could capture the TIN without the risk of human error."

The following is a summary of TIA's thoughts/comments from the meeting:
TIA hoped to focus the discussion on not only the technology of electronic tire identification, but how the technology could be applied to solve the issue of getting defective tires off the road. They believe electronic tire identification could help facilitate doing so by:

1. Providing increased accuracy of tire registration when compared to manually collecting and entering TINs
2. More easily identifying recalled tires at point of sale and during regular vehicle service
3. More easily identifying aged tires at point of sale and during regular vehicle service

Regarding identifying recalled and aged tires, they envision the technology functioning such that when a tire is scanned, the scanner would in some form alert the user if the tire were indeed recalled or aged.

TIA would not have any issues with performing electronic tire RFID scans every time that a consumer brought their vehicle in for service. They think that doing so would only take a few seconds. However, TIA pointed out that tire shop may not have a proper replacement tire on hand and might not be able to immediately replace a tire.

TIA pointed out that 17 states perform annual vehicle inspections. If these states scanned tires to determine if they had been recalled and forced replacement of recalled tires, it would improve tire safety.

TIA believes that beyond identifying recalled tires at point of sale or during vehicle service, there is still the issue of how to better contact purchasers of recalled tires once a recall is issued. They believe the success rate of tire recalls is low due to factors including:

- Errors when manually collecting and entering TINs
  - TIA estimates a 10-15 percent error rate
- Incorrect or out of date customer contact information
- Low voluntary registration rate when left to the customer to complete and mail the registration forms
- The current methods of recall notification being either not received or ignored by customers

The more the consumer can be taken out of the data gathering process the better. Consumers can often be reluctant to provide personal data, the data that is provided can often be inaccurate/out dated. TIA believes that collecting the VIN of the customer's vehicle could help with accuracy of customer contact information and ensure that the information is up to date.
If a system were implemented that included a database of recalled tires, some questions arise about the database. What customer data should be stored in the database? Who is responsible for the database and who has access? Dealers do not want to hand over their customer data to manufacturers before a recall is initiated. Also, how will the database be kept up to date as tires are replaced?

TIA also noted that manufacturer's strict requirements on what brand/style of tire can be used to replace a recalled tire is very inhibiting. The requirements can often lead to tires that have been identified as recalled being sent back out on the road because the shop that identified the tire does not have the manufacturers specific replacement tire.

Discussion of the Use of RFID Tags for Electronic ID
TIA recognizes that the technology should be left open to the manufacturers and that there are likely multiple options, they are most familiar with RFID tags. They think RFID tags embedded into the tires being a feasible option for electronic tire identification. They point to TPMS as an example of how the technology could work, would love to see a single scanner capable of servicing TPMS and to scan tire RFID tags. When registering tires, the seller could simply scan all the tires and transfer that data into the computer when entering the customer's information. When tires are scanned at point of sale or during

service the reader could alert if the tires are recalled or aged. TIA recognizes that there would be some cost burden on the dealers to purchase scanners but don't see it as a huge issue.

Retailers feel that RFID may enhance in some shape or form their inventories for storage and warehouse logistics thereby saving them money and time constraints

According to TIA, retailers cannot optically scan TINS. Black letters on a black background is very hard to scan. Dirt on tires aggravates this problem.

Use of RFID in commercial tires is the best way to facilitate recall identification and recovery. Tires are purchased in bulk by a fleet manager and are not typically tracked to an individual truck or trailer. After a tire is installed, that particular truck or trailer may not return to the maintenance facility that installed the tire. There are also a large number of leased vehicles where the owner and operator are separate entities, which further complicates the registration process. The most effective method for identifying a recalled tire in a fleet environment would be some form of imbedded electronic identification technology so the technician could quickly scan the tire in the field to determine if it has been subjected to a recall. Without electronic ID, identifying and recovering a defective commercial truck tire in a fleet is totally dependent on human factors since the TINS would need to be visually read and then checked against the recall TIN.

Answers to Congressional Questions

The TIA thinks that electronic identification is feasible on all motor vehicle tires. They support having electronic tire identification. The TIA thinks that it will require NHTSA action to ensure that the same type of electronic information technology is used on all tires.

Other Statements from TIA

"TIA opposes the current fine process and is requesting an addendum to the legislation adjusting the current proposed fine process. That fine process could involve two written warnings. With a third violation the offender would be fined a specified dollar amount. There could be an escalating fine program after the third violation." TIA has met with several manufactures that are in agreement on this.

Electronic Tire Identification Discussion with Safety Research & Strategies, Inc.

Date: July 17, 2017

Attendees:

Sean Kane	SRS
Ellen Lieberman	SRS
Riley Garrott	NHTSA VRTC
Elizabeth Mazzae	NHTSA VRTC
Ken Yates	NHTSA
Lisandra Garay-Vega	NHTSA
Jack Chern	NHTSA
Eric Gerdus	TRC, Inc. on behalf of NHTSA VRTC
Ken Woodruff	TRC, Inc. on behalf of NHTSA VRTC

A meeting was held with Safety Research & Strategies (SRS), Inc. on July 17th, 2017.

> **"Safety Research & Strategies, Inc. provides research, investigation, analysis, strategies, and advocacy on safety matters. With a particular specialty in motor vehicle issues, our background extends to and includes consumer, medical, industrial, farm, and construction product safety. We work with clients to help them understand the history surrounding issues that cause injuries and fatalities, to resolve safety issues, and to promote safety and reduce harm."**

Safety Research and Strategies (SRS) has been an advocate for tire registration reform, including electronic tire identification. As a part of their efforts, they produced a paper in 2007 titled "Tire Recalls and Tire Safety: The RFID Solution". The paper presented SRS's thoughts on issues with current tire registration methods and proposed RFID tags as a solution. In 2016, Sean Kane, founder and president of SRS, gave a presentation at the Global tire Conference titled "Tire Safety Matters". In that presentation, he makes the following statement:

> **"Without the ability to scan a tire, there is no efficient way for service professionals or consumers to determine if a specific tire is recalled or should be replaced, based on service life recommendations."**

The following is a summary of SRS's thoughts/comments from the meeting:

Sean Kane, the founder and president, presented the views of SRS during our conversation. Mr. Kane suggested SRS's 2007 paper as a good source of information

Tire recalls fall short, typically have very low completion rates. Not the fault of dealers or consumers, the main issue is the inability to identification tires that are subject to a recall. Simply stated, "Tires that look good will end up on the road.". SRS still investigates accidents caused by tires recalled years ago that are still on the road, Firestone Wilderness AT tires are a good example of this. In 2013, a TV producer in Georgia purchased a 17-year old "new" Wilderness AT tire included in the Firestone recall. Mr. Kane pointed to vehicle VINs as a very successful identification standard that has been used to support recall efforts for vehicles.

Recalls currently rely heavily on the dealer's customer data. SRS is concerned that dealers already play a large role in the recall process without much incentive, and that manufacturers should be responsible for providing the tools to dealers to improve the process and reduce the burden on retailers, which is already disproportionate. Accuracy of customer data is decent at point of sale, it is often the TINs that are inaccurate or missing because the current manual retrieval and data entry is burdensome. They have seen examples of technicians recording a single TIN for all tires that are sold. There is a large error rate in the process of manually reading and recording TINs. SRS states, "There is no reason in 2017 to have a pen and paper system."

Independent tire dealers don’t like giving their customer data to the manufacturers, forwarding it to manufacturers only after a recall is initiated. This begs the question, “Are the tires truly registered?”. SRS recognizes the sensitivity of retailer’s customer lists and their reluctance to share those lists with retailers. There must be a way for retailers to register tires without giving customer lists directly to tire manufacturers who may have retail stores of their own and directly market to those customers.

SRS believes electronic identification will help get recalled and defective tires off the road. Tire registration is only one aspect of the recall system – and it does not equate to recall remediation. SRS believes that service providers AND consumers should have the tools to easily, quickly, and accurately discern whether a tire is included in a recall. The best way to accomplish that is via a scan that will connect to a recall database. Tire dealers and service providers could scan the tires to check the tires against a recalled tire database, if recalled, the scanner could alert the user. They are technology neutral, the technology needs to be machine readable with an identification number or code unique to each tire, both of which are not the case with the current TIN. The technology should also be required to have a level of durability that could ensure it lasts the life of the tire.

Electronic ID

The two methods for electronic tire identification that are currently seeing the most industry use are RFID tags and QR codes. SRS believes these are both good options for machine-readable tire identification. Bar codes on a tire sidewall could also be an option, but as currently applied on the bead of a tire, barcodes are not visible once a tire is mounted on a wheel and are used only during the vehicle assembly process. RFID tags seem to be the current preference of U.S. tire manufacturers, while QR codes are being adopted by some European vehicle OEs and may offer an alternative or complimentary capability.

RFID

RFID tags would only be encoded with an EPC/UII and would require a database to get the TIN. SRS believes it is important that EPC and TIN be connected in some way, Mr. Kane states that he is aware of software that Kumho is developing to connect EPC to TIN, it is currently in Korean and SRS has not had a chance to try the software. The durability of RFID tags seems good when examining their use in specialty applications such as racing tires. SRS is not aware of durability studies in other applications. Some manufacturers are starting to implement RFID tags. SRS has been finding tags in some Kumho tires, only coming from 2 plants in Korea. An I-Phone dongle RFID scanner was purchased by SRS from Kumho’s vendor for less than $200. However, it is not enabled for U.S.

Mr. Kane states that he is aware of an ISO standard being drafted specifically with regard to the use of RFID tags in tires.

QR Codes

SRS likes that QR codes don’t require any electronics within the tire. The durability of laser etched QR codes looks good from what they have seen. There are some European vehicle manufacturers starting to implement QR codes, starting soon, BMW is requiring laser etched QR codes on the OE tires for some of their models. Other European vehicle OEMs are expected to follow BMW’s lead. SRS predicts a rapid expansion of the use of QR codes on tires once most tire manufacturers have the laser etching machines.

SRS is not aware of any ISO standards for the use of QR codes on tires.

Cost

SRS provided some estimates on the cost of RFID and QR codes:

- Laser Etching QR codes
    - $1 per tire for low volume
    - $0.50 per tire for larger volumes (100K – 200k tires)
    - $0.10 per tire for full production
- RFID tags in tires
    - $2.50 per tire as an add-on

- $0.25 – $0.50 per tire for full production OE tires
- Most recent estimates show $0.20 – $0.40 per tire
  - Unsure what production volume this represents

Privacy
SRS does not see any privacy issues stemming from the use of electronic tire ID. The technologies will tend to have a very limited read range. Furthermore, scanning the tire would not provide any personal information about the owner. They see it as less of a concern than options already out there, e.g. VIN scanners or optical plate readers.

In Closing
The main objective is to get recalled tires off the road. Machine-readable tire identification will help get recalled tires off the road by improving tire registration accuracy and by making it easy for the vehicle service industry to identify and replace recalled tires.

Main FAST Act Sec. 24334 Questions:

1) **Is it feasible to include electronic identification in all tires?**
   Yes, SRS believes the technology is available and that it would be feasible to include electronic identification in all tires.

2) **Would NHTSA action be required to ensure a standard data format?**

Yes, SRS believes NHTSA action would be required. Regulation "from the get-go" would help optimize the usefulness of the technology, otherwise things could go down a road leading to more complications. Points to TPMS as an example, there are many different formats that require multiple types of scanners.

Electronic Tire Identification Discussion with Goodyear Tire & Rubber Company

Date: July 18, 2017

Attendees:

Mark Cherveny	Goodyear
John Fenkanyn	Goodyear
Dale Freygang	Goodyear
Riley Garrott	NHTSA VRTC
Elizabeth Mazzae	NHTSA VRTC
Abraham Diaz	NHTSA
Eric Gerdus	TRC, Inc. on behalf of NHTSA VRTC
Ken Woodruff	TRC, Inc. on behalf of NHTSA VRTC

The following is a summary of the information discussed during the meeting with Goodyear:

A list of questions was sent to Goodyear, and the conversation followed the outline of those questions. John Frenkanyn presented most of Goodyear's responses to the questions.

1. **Is Goodyear in support of electronic identification for tires?**
   Yes, Goodyear supports electronic tire identification. They believe it could increase the accuracy of tire registration information gathered at the point of sale.

2. **What do you consider to be the best way to implement electronic identification in tires?**
   Goodyear's approach is an RFID tag containing the tire's Electronic Product Code (EPC) embedded in the tire. Goodyear is not exploring any other technologies for electronic tire identification.

3. **Can the TIN be encoded in the RFID tags?**
   SGTIN-96 encoding leaves no room for the TIN in the tag's EPC memory. TIN could be encoded in user memory but memory in an RFID tag is expensive. The additional memory also effects the tag's read range and read time. Along with other tire manufacturers, Goodyear believes that when the TIN is needed it can be recovered from a tire database, using the EPC as an index into the database.

   Goodyear currently maintains a database (or collection of databases) containing tire information, to which EPC references could be added as a searchable field. Permission can be given for entities to access all, or only a portion of, the database. For example, the database could be used to get a specific tire's TIN, customers who want a tire's force and moment data could get the data from the same database.

   The issue of latency of access to the database to recover a tire's TIN, either because of a slow or intermittent Internet connection, was raised. Delays associated with accessing an on-line database can be eliminated by downloading the EPC-to-TIN portion of the database locally, resulting in near instant EPC to TIN translation.

4. **Can a standard format be developed by industry for electronic identification?**
   Yes. An ISO working group is developing standards for RFID enabled tires, with a target of 2018 for acceptance of the initial standards. Most manufacturers would adhere to the standard; however, some

manufacturers may not achieve 100 percent compliance without a mandate. Government regulation will likely be required to ensure RFID tag presence.

5. **Is it feasible to include an electronically readable tag in all tires, passenger car tires as well as truck tries?**
   Yes, it is feasible for all types of tires. All tires have areas that are "RFID friendly." These are lower stress and strain areas of the tire where RFID tag placement is optimal. Goodyear's process is applicable to all tires, including retreads. Their RFID tag installations have been demonstrated to survive multiple retreads in commercial vehicle tires. While there may still be some issues with durability, the technology will catch with the demand.

6. **What affect will electronically readable tags in tires have on privacy?**
   Goodyear does not believe the use of electronic tire identification poses any risk to consumer privacy.

7. **Is Goodyear currently including electronically readable tags in tires?**
   Goodyear has a history of working with RFID tags in tires. They have been supplying tires to NASCAR and the European Dunlop Racing Series since 2005. Goodyear also supplies RFID tags in certain commercial tire SKUs sold in European and Latin American markets. Goodyear is not currently including electronically readable tags in passenger vehicle tires destined for the U.S. markets. (Truck tires were not mentioned.) Goodyear currently places RFID tags in tires when customers request them. While they are not currently putting RFID tags in any tires for the U.S. passenger vehicle markets, several OEs who have asked Goodyear to investigate putting RFID tags in tires.

   Goodyear selects RFID tags based on customer requirements. When designing a tag for a tire, the fundamental requirement is that the tag can have no adverse effect on the tire itself. Goodyear designed tags to be durable enough to last for the life of the tire, including through the retreading process.

   Attaching an RFID tag to a tire currently is accomplished using pre-cure insertion or post-cure attachment. As the name implies, pre-cured tags are placed into the tire prior to the curing step in the manufacturing process. Pre-cured tags last for the life of the tire. Post-cured tags are applied as a "patch" after the tire has been manufactured. Post-cure patch tags are the most expensive to apply because of the laborious process required to affix them to the tire. Post-cured tags also last the full life of the tire.

   The electronic chips in tags are commercial off the shelf (COTS) devices used in retail applications worldwide. While the tag components are not proprietary, the way they are assembled into a tire RFID tag is a trade secret. Goodyear's tags are assembled by a 3rd party vendor, who dices wafers into individual chips, mounts the chip on a circuit board, adds antennae, puts it in a package, and encases the resulting assembly in rubber for embedding in a tire.

   Goodyear is confident in the survivability of RFID tags throughout a tire's lifecycle, including through the tire retreading process. Goodyear tags are made specifically to survive the retread environment.

8. **What information SHOULD BE recorded in a tire tag?**
   Goodyear agrees with the ISO working group, in that EPC/UII is the only information that should be required on RFID tags. Other information could be included in the tags but should be at the discretion of the tire manufacture, and should not be required.

9. **How much do electronically readable tags add to the cost of the tires?**

Cost for RFID tags is highly correlated to the volume of tags produced. The cost of an RFID tag today is higher than what tags will cost if they are being embedded in every tire manufactured. The more that are made, the less expensive they will be. Estimates for the cost of an RFID tag (tag only) in production quantities, are estimated to cost a few tens of cents per tag. This estimated cost does not include other related assembly costs.

10. **How will dealer/service provider processes have to change to take advantage of electronically readable tags in tires?**
    Goodyear sees tire installers scanning tires for their customers. Consumers' tires would be scanned when the vehicle is serviced, or in response to a tire recall. Goodyear expects this would be a free service, with service providers scanning a vehicle's tires each time it is serviced.

Electronic Tire Identification Discussion with the Alliance of Automobile Manufacturers

Date: July 27, 2017

Attendees:

Scott Schmidt	Alliance of Automobile Manufacturers
Mike Hernandez	BMW
Thomas Zorn	Volkswagen
Dan Selke, Amy Klinkenburger	Daimler
Jacob Azria	JaguarLandRover
Wendy Hause, Greg Pawlica, Emily Frascaroli, Julie Mercer	Ford
Riley Garrott	NHTSA VRTC
Elizabeth Mazzae	NHTSA VRTC
Lisandra Garay-Vega	NHTSA
Ken Yates	NHTSA
Eric Gerdus	TRC, Inc.
Ken Woodruff	TRC, Inc.

The following is a summary of Auto Alliance's thoughts/comments from the meeting:

1. **Does the Alliance support the idea of implementing electronically readable tags on tires?**
   - Members are generally neutral on the issue of electronic identification for tires
2. **How will electronically readable Tire identifiers benefit Alliance members?**
   - Possible benefits could be:
     - Inventory tracking
     - Providing info to customers to assist recall
3. **Does the Alliance have any thoughts on electronic identification technologies?**
   - 2D bar code may be great for factory, but not sure about how it aids recall
     - Curious about QR code durability
   - If scanners could be incorporated into service tools, that should be good
   - Members were not sure if the benefits from a system that actively monitors tire recall info and communicates this to the driver would outweigh the cost and complexity associated with such a system.
   - A patent searches on prospective technologies would be good to perform
4. **Would automotive manufacturers have to change any of their processes if electronically readable tire tags are implemented?**
   - Any change in recording numbers in a factory setting can be a hurdle for some
   - Change in manufacturing methods requires a fair amount of lead time to implement
5. **What effect will RFID tags in tires have on privacy?**
   - Alliance has no information on this
   - The Alliance recognizes that is a concern to the public, it should be covered in NHTSA's report
6. **Will government intervention be required to guarantee electronically readable tags in all tires have content and format and are readable using a single tool (reader)?**
   - They think that an SAE standard could likely be adequate
   - If a federal regulation is pursued, they feel a part standard is more appropriate than a safety standard

<u>Electronic Tire Identification Discussion with U.S. Tire Manufacturers Association:</u>

<u>Date:</u> August 3, 2017

<u>Location:</u> NHTSA Headquarters, Washington D.C.

<u>Attendees:</u>

Candice Scheifele	Bridgestone
Jay Spears	Continental
Brad Rump	Cooper
Mark Cherveney	Goodyear
John Emerson	Michelin
Steve Wesner	Toyo
Tracey Norberg	USTMA
Riley Garrott	NHTSA VRTC
Elizabeth Mazzae	NHTSA VRTC
Claudia Covell	NHTSA
Lisandra Garay-Vega	NHTSA
Jack Chern	NHTSA
Ken Yates	NHTSA
Eric Gerdus	TRC, Inc. on behalf of NHTSA VRTC
Ken Woodruff	TRC, Inc. on behalf of NHTSA VRTC

USTMA members currently consists of 10 tire manufacturers, all of whom manufacture tires within the United States. The 10 members of USTMA currently represent 80% of replacement tires and 90% of OE tires sold in the United States.

> **"The U.S. Tire Manufacturers Association is the national trade association for tire manufacturers that produce tires in the U.S. USTMA members operate manufacturing facilities in 19 states, employ nearly 100,000 workers and generate annual sales of more than $27 billion."**

USTMA has been a longtime advocate for improved tire registration. USTMA pushed for the addition of Section 24333 to the FAST Act which mandates that all independent tire distributors and dealers would be required to electronically submit all tire registration data to the manufacturers.

<u>The following is a summary of USTMA's thoughts/comments from the meeting:</u>

USTMA noted that they pushed for the addition of Section 24333 to the FAST Act, and they perceive that the biggest problem now is dealers not collecting TIN's and registering tires. USTMA believes that improvements in tire registration would increase recall success, noting that the current system of tire registration does not work well. Tire manufacturers recognize and understand the reluctance of the tire retailers to share their customer lists with the manufacturer but point out, that even now most manufacturers use third party data holders to hold and manage the tire registration data.

USTMA prepared a presentation for the meeting based on question and discussion points provided to them by NHTSA. This presentation will be referenced throughout this summary.

Starting the discussion into electronic tire identification, USTMA presented potential uses of electronically readable tires. USTMA noted that the uses represent potential best practices and benefits of the technology, not recommendations for regulatory action.

- **Inventory screening:** Tire manufacturers and tire distributors/dealers could quickly scan their tire inventory.
- **Installation screening/tire registration**: Tires could be scanned before installation to ensure the tires are not recalled. Scanned data from the tires could be electronically transferred to a computer for tire registration purposes.
- **Post-installation screening:** Tires could be scanned when the vehicle is serviced or inspected to check for recalls.
- **OE vehicle compatibility:** Scanning the tire could return information to ensure correct tire/vehicle fitment.
- **Record tires removed from service:** USTMA stated that the current methods of removing tires from the in-service tire population only allow them to get a rough estimate of the number of a specific tire that has been removed from service. Since they are not precisely recorded, tire recalls assume that all the tires that were manufactured are still in service, while the actual number still in service may be much lower. This makes the reported success rate of tire recalls seem lower than it actually may be. Tires could be scanned when removed from service allowing the manufacturers to focus their recall efforts on tires that are still in service.
- **More focused recalls:** The current method of recalling tires based on the TIN only allows the manufacturers to identify batches of tires down to a week's worth of tire production. Electronic identification would allow for tires to be identified at an individual level. Recalls could be narrowed from a whole week of production down to a day, hour, specific process line, specific batch of material, etc.

  USTMA provided an example where one roll of bad material was identified, affecting 54 tires. The manufacturer had to recall the whole week's production, a total of 15,000 tires. Of the 15,000 tires, only 20 were found to be registered. The vehicle manufacturer provided info for 68,000 vehicles that the tires could have possibly been installed on, another example of low traceability. In the end, the manufacturer sent out 68,000 recall notifications for 15,000 tires, all in an attempt to recover 54 tires.

  Another point made by USTMA was that more focused recalls allow for sending fewer notifications, which results in increasing the impact and meaningfulness of recall notifications. "If you are receiving the notification your tire is recalled".

USTMA pointed out that, depending on NHTSA's goals for electronic tire ID, both temporary and permanent forms of electronic identification should be evaluated. A temporary ID, e.g. a sticker placed on the tire after manufacturing that includes a form of scannable ID, would remain until the point of sale. Permanent identification would be built into the tire during the manufacturing process or permanently affixed to the tire as part of a "patch" after manufacturing. This form of identification would remain functional throughout the life of the tire. USTMA believes that tire registration would benefit greatly from either temporary or permanent identification but recognizes that temporary identification would not assist in detecting recalls throughout the life of a tire.

USTMA recognizes that there are many options for electronic identification technology including: RFID, 1D barcodes, 2D barcodes (e.g. QR codes), and optical scanning of the TIN.

Each technology has advantages and disadvantages. USTMA has some concerns with the line of sight technologies (barcodes and optical TIN scanning) when compared to proximity scannable technologies (RFID). There are concerns about readability on larger tire inventories, and some concern that it would be more difficult to scan the line of sight technologies during installation or service. They identified some criteria that should be considered when evaluating potential technologies. When examining each criterion, it is important to consider the impact on both the tire manufacturer/manufacturing process and the tire dealers.

- **Cost**
  - Initial cost of purchase and manufacturing
  - Future IT, data management, and support costs
  - Costs of tools, hardware, and software to scan the tires and manage the data
- **Complexity**
  - Impact on the design, manufacturing, and quality of the tire
  - Ease of scanning
- **Efficiency**
  - Is it more efficient than the old method of collecting TINs and registering tires?
- **Effectiveness**
  - Will it increase tire registration and tire recall success rates?
- **Robustness**
  - Will the technology hold up from manufacturing through the life of the tire?

Of the possible technologies, there are currently two that have the most market use: embedded or implanted RFID tags and QR codes etched into the tires sidewall.

RFID

USTMA believes that RFID would be the most expensive option to implement. Current market penetration of embedded RFID tags in passenger vehicles is very low, they are aware of at least one company that has implemented the use of RFID tags company wide. There is some concern with durability of RFID tags given the lack of data. USTMA is not aware of any formal studies on RFID longevity in automotive tires, anecdotal evidence suggests that RFID tags are quite robust. RFID use is currently most prevalent in commercial tires, tags used in commercial applications have survived many miles of service and lasted through at least six recapping processes.

An ISO standard is currently in review that applies specifically to the use of RFID tags in tires. USTMA believes that most major U.S. tire manufacturers would follow the standard without any need of NHTSA regulation. However, it is important to recognize that there is a portion of the market that USTMA does not represent, specifically tire manufacturers that do not produce tires within the U.S. These manufacturers are outliers and there is no way to guarantee that they would also follow the standard absent regulation. The tags would contain a UII in the SGTIN-96 data format which allows unique, serialized identification of each tire. Although RFID tags are more expensive than barcodes or optical TIN readers, USTMA believes RFID offers the most benefits and prefers RFID over the other technologies available.

QR Codes

QR codes laser etched into the sidewall of the tire do see some use. USTMA believes QR codes would be good for increasing tire registration but they have concerns with durability. Located on the sidewall, the QR code could be damaged or filled with debris, making them more difficult to read. Most tire manufacturers already have laser etching ability and could etch a QR code into a tire. If done properly, etching a QR code into a tire sidewall does not weaken a tire, however manufacturers would still be reluctant to make it a third-party process. Although not standard, QR codes are capable of being programmed with the same SGTIN-96 UII as RFID tags and in theory could access the same database.

Database

USTMA recognizes that electronic tire identification would require a database which brings up questions:

- Where is the database?
- Who holds and maintains the database?
- Who pays for the database?
- What information about the tires/tire registration data is held in the database?

Besides removing the human error of manually collecting and recording TINs, there is also room to improve the accuracy of customer contact information. USTMA agrees that a TIN to VIN connection could be one way of accomplishing this.

It would be important the once recalled tires are removed from service that they are also removed from the database.

USTMA does maintain a database of tire recalls by TIN for USTMA members. USTMA started this database 20 years ago in response to a request from the NTSB. Currently there are less than 1,000 lines of data in the USTMA's recalled tire database which covers over 20 years of recalls. They estimate the database development cost was less than $50,000.

Answers to Congressional questions:

1) *Is it feasible to include electronic identification on all tires?*

   USTMA supports the technology and does believe it is feasible, but urges that more study of the topic is required. USTMA proposes considering a multi-phase approach. This approach could allow for a more seamless, smooth transition into the technology.

   - **Short term (minimum 2-5 years):** Consider temporary forms of electronic ID. Slowly phase into inventory and registration practices.
   - **Long term (minimum 10 years):** Consider permanently affixed/embedded RFID tags.

2) *Would NHTSA action be required to ensure a standard data format?*

   USTMA believes that most major U.S. tire manufacturers would follow the ISO standard without any need of NHTSA regulation should the presence of RFID be required. However, it is important to recognize that there is a portion of the market that they do not represent, specifically tire manufacturers that do not produce within the U.S. These manufacturers are outliers and there is no way to guarantee that they would also follow the standard without regulation. Should a manufacturer elect to implement electronic tire identification using a QR code rather than an RFID, regulation may be required to ensure use of SGTIN-96 encoded data.

Electronic Tire Identification Discussion with 4Jet Technologies

Date: August 9, 2017

Attendees:

Dr. Armin Kraus	4Jet Technologies
Riley Garrott	NHTSA VRTC
Eric Gerdus	TRC, Inc. on behalf of NHTSA VRTC
Ken Woodruff	TRC, Inc. on behalf of NHTSA VRTC

A meeting was held with the 4Jet Technologies on August 9th, 2017 to discuss their tire laser engraving technology.

> **"We are a fast-growing young technology company. Since our founding in 2006 we have developed in a short time become a leading supplier of laser systems and technologies for surface processing."**
>
> **"4JET has developed a novel laser marking process – SCANNECT^{TM} (short for "scan and connect") that can engrave an individual and permanent QR Code or DataMatrix Code in tire sidewalls. The high contrast engraving is the world's first solution that can be read using public domain apps available for Apple iOS or Android devices."**

4Jet's Dr. Armin Krauss gave a presentation on their technologies as part of the discussion. The focus of the discussion was on laser-etched 2D barcodes and 4Jet's Scannect app.

The following is a summary of the information discussed during the meeting with 4Jet:

Marking tires using laser etching is a mature, well established, and widely used process in the tire industry. Many companies use the process for general tire markings such as serial numbers and TIN date codes.

2D Barcodes

4Jet believes tire safety can be drastically increased using the laser-engraved 2D barcodes, even beyond enhancement of tire recall efficiency. The codes can be used by the tire manufacturers, tire dealers, and end customers. Two main types of 2D barcodes in use are QR codes and DMCs, the codes are very similar in function/form but differ visually. The barcodes are capable of being encoded with any combination of letters and numbers, the total storage capacity depends on the size of the code. The codes can use "error correction" which allows the codes to be read with varying levels of damage. Applying error correction to a barcode comes at the cost of storage capacity.

4Jet's Process

4Jet's etching process for the 2D barcodes creates a high contrast "super-black" barcode that can be read using smart phones (using the camera to view the code) or commercial scanners. The code is applied to the tire as a relief, 300 – 500 microns deep, where the recesses represent the black elements of the code. The "super-black" is achieved by rounding the bottom of the recesses, minimizing back-reflection of light from the bottom of the recesses. The marking process for one code on one sidewall takes about 20 seconds, most of which is the time it takes to correctly orient the tire in the machine and locate the spot of the tire on which to etch the code. 4Jet's machines are capable of etching approximately 1 million sidewalls per year, equating to 500 thousand tires per year if etching both sidewalls.

4Jet supplies a custom smart phone application, called "SCANNECT", that is specially tuned to read the black-on-black barcodes even when dirty, wet, or in poor lighting conditions. Their experience indicates that 95 percent of tires in use can be read with no cleaning required. When a QR code does require cleaning, a quick wipe with a rag is generally all that's needed. 4Jet's app can easily be integrated into other apps as required by users.

Durability
A QR code etched into a tire sidewall is at and below the tire surface, making the code less likely to experience scuffing or other wear. Initial testing has shown them to be very durable and capable of lasting the full life of tires. One of 4Jet's customers has performed extensive testing on heavy truck use and only experienced one lost code, that code was located on a bad area of the tire prone to heavy wear.

Cost
CAPEX depreciation is the cost driver for laser engraving. The cost for engraving a single barcode is about $0.08, and the cost of a single date code is about $0.07. Since a significant portion of the cycle time is spent orienting the tire, co-engraving reduces the cost per etch by as much as 50 percent. The cost of co-engraving a QR code and date code would cost about $0.10 per sidewall. Since the auto companies using DMC are requesting that it be placed on both sidewalls, the total cost per tire would be about $0.16.

Current Use
There are currently some European vehicle manufacturers that are requiring the DMCs on both sidewalls of OE tires for a portion of their vehicle models starting in 2018. Around 10 major tire manufacturers have started to install production laser etching capability. For the U.S. alone, 4Jet has orders for 5+ systems dedicated to etching the barcodes. Two major tire manufacturers have run successful pilot projects and are planning to implement QR codes for use in their truck tires starting in 2018. For the implementation, 2 systems for QR Code marking on truck tires have already been ordered and will be installed in the U.S. in March 2018.

Car manufacturers are developing an industry standard for the use of DMCs for tire identification. The standard dictates the type, or "version", of DMC to use a well as what data should be on the codes and in what format. The DMC being used is a Version 3 (22x22 modules) with ECC 200 error correction encoded with 58 digits. The codes contain all relevant tire information including, but not limited to, the TIN, make/model data, mounting/inflation specs, and a 10-12 digit serial number unique to each tire. The car makers have signaled their willingness to include a comprehensive serial number standard like SGTIN96 in their specification. 4Jet states that the version 3 codes, when etched by their machines, are about 20-50 mm square. Any version larger than version 3 and it becomes difficult to find a space on the tire.

<u>4Jet's Comparison of 2D barcodes to RFID tags</u>

- 2D barcodes are "order of magnitude" cheaper than RFID tags
  - Can be read with existing devices
- QR codes could be encoded using the SGTIN 96 format if it was desired
  - Could utilize same database
  - Vehicle manufacturers don't like the idea of encoding only SGTIN 96
    - Want offline use of barcodes, don't want to depend on database
    - Don't want to give metadata to tire manufacturers
- 2D barcodes have disadvantage of being line-of-sight read**
  - No readability during driving
  - No reading of hidden tires
- ** RFID's proximity reading can create some difficulty when trying to read one tire in a group of tires
  - Multiple tires read at once, wrong tire registered

Is it feasible to include laser etched 2D barcodes on all tires?

Yes, laser etching technology is becoming available at most tire manufacturers and the technology has been proven to work on tires. Using the technology on white tires has presented some difficulty.

<u>Electronic Tire Identification Discussion with CARFAX, Inc.</u>

<u>Date:</u> August 24, 2017

<u>Attendees:</u>

Faisal Hasan	CARFAX, Inc.
Riley Garrott	NHTSA VRTC
Elizabeth Mazzae	NHTSA VRTC
Jack Chern	NHTSA
Alex Ansley	NHTSA
Eric Gerdus	TRC, Inc. on behalf of NHTSA VRTC
Ken Woodruff	TRC, Inc. on behalf of NHTSA VRTC

A meeting was held with CARFAX on August 24th, 2017, representing CARFAX was Faisal Hasan.

> **"CARFAX started with a vision - to be the leading source of vehicle history information for buyers and sellers of used cars. Today, CARFAX has the most comprehensive vehicle history database available in North America. In fact, millions of consumers trust CARFAX to provide them with vehicle history information every year."**

<u>The following is a summary of CARFAX's thoughts/comments from the meeting:</u>

CARFAX has had discussions with many tire manufacturers through the Rubber Manufacturers Association for suggestions on the use of electronic tire identification and how to best set up a database. They believe a TIN (or EPC/UII) to VIN connection is very important.

CARFAX explored the possibility of establishing a recall database searchable by TIN; however, there was limited customer interest due to the time commitment and potential difficulty.

CARFAX stressed the importance of making sure tires actually are scanned by dealers and service providers. They do believe there is incentive to do so but stated that it may take time to become standard practice. It took almost 10 years for CARFAX to initiate consistent VIN capturing during vehicle service. Currently VIN's are captured through methods such as scanning the doorplates or entering the VIN or license plate number, as well as other methods. This is done fairly consistently at all the CARFAX-affiliated service providers.

CARFAX envisions integrating electronic tire identification into their existing vehicle information database. CARFAX vehicle history reports, which already provide vehicle recall information, would also indicate if the tires associated with that vehicle's VIN are subject to a recall.

CARFAX has a mobile app that users can sign up for and register their vehicle by VIN. One of the services provided by the app is to alert the user if their vehicle has an active recall, this service is provided free of charge by CARFAX. With electronic tire identification, the app could also provide this service for tires, the system would continuously check the potential tire recall data stored on CARFAX's database and alert the user if any tires were recalled. This could be based off tires associated with the users VIN, or users could enter the TINs/UIIs of their tires themselves.