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Total Recall:
A Data-Driven Analysis of the
Takata Airbag Recall

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¹ Frost, Robert. "The Road Not Taken." *Poetry Foundation*.

Introduction

According to Toyota, their vehicles are made of an average of 30,000 parts, and the automotive industry has grown exponentially since cars were first manufactured. Building at such a large scale from a wide array of components contributes to an extremely complex manufacturing process.

Protocols and rigorous safety measures may be intentionally or unintentionally bypassed for the sake of meeting deadlines and getting products on the market. Due to an added level of complexity from products using components from across global supply chains, manufacturers must often rely on vendors' assurances of safety and reliability. As a result of global supply chain complexity and potentially harmful lapses in safety assurance (whether intentional or unintentional), products in a wide array of industries must be recalled for remediation when defects are found.

Notable recent recalls include the Samsung Galaxy Note 7 mobile device and Cuisinart Food Processors. However, in addition to these high profile recalls, numerous different products including beef, chicken, candy bars, spinach, peanut butter, medicines, power tools, and baby cribs have also been recalled in recent years.² Six federal agencies³ within the U.S. Government have collaborated to create a website⁴ that serves as a hub for all U.S. recalls for consumer products, motor vehicles, boats, food, medicine, cosmetics, and environmental products.

² Benjamin, Scott. "How Automotive Recalls Work." February 10, 2010.
www.auto.howstuffworks.com/automotive-recalls.htm.

³ Consumer Product Safety Commission, National Highway Traffic Safety Administration, U.S. Coast Guard, Food and Drug Administration, U.S. Department of Agriculture, Environmental Protection Agency.

⁴ www.recalls.gov

In the automotive industry, several hundred recalls are released every year, impacting tens of millions of vehicles and end consumers. In 2015, for example, United States vehicle recalls surpassed an all-time high for two years in a row, with 51.2 million vehicles affected over 868 separate recalls.⁵ Data analysis by iSeeCars indicates that the industry cumulative average from January 1985 to September 2016 is 1,115 vehicles recalled per 1,000 vehicles sold, with some vehicles recalled for multiple reasons. However, recalls by manufacturer vary, with eleven out of eighteen automakers having recall rates below that average.⁶

This paper focuses specifically on informing readers about automotive recalls in the United States using the National Highway Traffic Safety Administration (NHTSA) automotive recall datasets. The recall process is illustrated by highlighting a particularly egregious recall, the Takata airbag inflator defect.

⁵ Bomey, Nathan. "U.S. auto recalls hit all-time record in 2015." January 21, 2016. www.usatoday.com/story/money/cars/2016/01/21/nhtsa-recall-completion-washington-auto-show-mark-rosekind/79111364/

⁶ Salomon, Sanjay. "The automakers with the best and worst recall rates." Boston.com. November 1, 2016. www.boston.com/cars/cars/2016/11/01/the-automakers-that-have-the-best-and-worst-recall-rates

Chapter 1: The Automotive Recall Process Explained

Background

The National Traffic and Motor Vehicle Safety Act, which was originally enacted in 1966, gives the Department of Transportation's NHTSA the authority to issue vehicle safety standards and require manufacturers to recall vehicles that have safety-related defects or do not meet Federal Motor Vehicle Safety Standards. These standards apply to all vehicles and vehicle related equipment manufactured or imported for sale in the United States. They also set minimum performance requirements for the parts of the vehicle that most directly affect its safe operation or that protect drivers and passengers in the event of a crash. Since 1966, more than 390 million cars, trucks, buses, recreational vehicles, motorcycles, and mopeds, as well as 46 million tires, 66 million pieces of motor vehicle equipment, and 42 million child safety seats were recalled to correct safety defects.⁷

Initiating a Recall

Recalls can be voluntarily initiated by manufacturers (who produce the vehicle or particular part), influenced by NHTSA investigations, or ordered by NHTSA via the courts. If a safety defect is discovered, the manufacturer is required to notify NHTSA, as well as vehicle or equipment owners, dealers, and distributors. The manufacturer is also required to fix the problem at no charge to the owner. NHTSA is responsible for monitoring the manufacturer's corrective action to ensure successful completion of the recall campaign. If a complaint is filed, the party

⁷"Motor Vehicle Defects and Safety Recalls: What Every Vehicle Owner Should Know." SaferCar. May 2011. www-odi.nhtsa.dot.gov/recalls/recallprocess.cfm.

that filed the complaint may be contacted by an investigator from the Office of Defects Investigation (ODI), which conducts defect investigations to support NHTSA's efforts.

If the manufacturers become aware of a recall and do not notify the appropriate parties, they can be brought to court and charged large fines for knowingly putting customers in danger.

NHTSA Recall Investigation Process

If enough consumers contact the NHTSA and file a report about the same problem with the same type of vehicle, the NHTSA may decide to open an investigation.⁸ The ODI is the agency in charge of performing the automotive recall investigation which consists of the following steps:

1. Screening

This is the first step in the process to determine whether to open an investigation regarding an alleged safety defect. During the screening process available information received from the manufacturer or consumers is reviewed by the Defects Assessment Division (DAD).⁹ If this division determines that the available information indicates a drastic failure is developing, the same information is "presented to a panel of ODI staff for a recommendation on whether to open a safety defect investigation."¹⁰

⁸ Benjamin, Scott. "How Automotive Recalls Work." February 10, 2010.

⁹ "What Every Vehicle Owner Should Know." SaferCar. May 2011.

¹⁰ Ibid.

2. Petition Analyses

During this stage, petitions, which can be submitted by anyone asking NHTSA to open a safety related defect investigation, are analyzed by ODI. After analysis, ODI either opens a defect investigation or publishes the reasons for denial in the Federal Register, the daily newspaper of the United States federal government.¹¹ A person may also submit a petition for NHTSA to hold a hearing on “whether a manufacturer has met its obligation to notify and/or remedy a safety defect or disregard for a Safety Standard.”¹² If approved, a hearing is held, otherwise the reasons for denial are published in the Federal Register.

3. Investigations

During the Preliminary Evaluation (PE) phase, ODI gathers information from the manufacturer and determines whether further analysis is warranted.¹³ The manufacturer also has the opportunity to present its views regarding the alleged defect at this point.¹⁴ PEs are either closed because further investigation is not needed or because the manufacturer decided to conduct a recall.¹⁵ If ODI believes further analysis is warranted, the PE is upgraded to Engineering Analysis (EA).¹⁶

During an EA, ODI conducts a more detailed analysis of the alleged defect by supplementing the information collected during the PE with inspections, tests, and surveys from

¹¹ “About the Federal Register.” National Archives. September 15, 2016.
www.archives.gov/federal-register/the-federal-register/about.html.

¹² “What Every Vehicle Owner Should Know.” SaferCar. May 2011.

¹³ Ibid.

¹⁴ Ibid.

¹⁵ Ibid.

¹⁶ Ibid.

manufacturers and suppliers.¹⁷ The EA investigation can be closed if the manufacturer notified NHTSA that it will conduct a safety recall or if NHTSA did not identify a safety-related defect. However, if ODI believes that a safety-related defect exists, the ODI investigator prepares a briefing to be presented to a panel of experts.¹⁸ If the agency panel agrees with ODI's recall recommendation, ODI notifies the manufacturer and then sends a Recall Request Letter¹⁹ to the manufacturer.

4. Recall Management

The Recall Management Division maintains the records for all recalls, and “monitors these recalls to ensure that the recall completion rate and remedy are adequate.”²⁰ If the facts indicate a problem with the number of recalls or the recall execution, it may lead in a recall investigation which can expand a previously announced recall or adjust the method of recall remedies.²¹

¹⁷ Ibid.

¹⁸ “What Every Vehicle Owner Should Know.” SaferCar. May 2011.

¹⁹ See Appendix A, www-odi.nhtsa.dot.gov/acms/cs/jaxrs/download/doc/UCM467335/INRM-PE14016-60978.pdf

²⁰ “What Every Vehicle Owner Should Know.” SaferCar. May 2011.

²¹ Ibid.

Chapter 2: Automotive Recall Case Study: The Infamous Takata Airbag Inflator Recall

Background

The automotive recall incident explained in this chapter guides the data analysis throughout this paper. This incident is what Department of Transportation Secretary Anthony Foxx called “the most complex consumer safety recall in U.S. History” on May 19, 2015, during the press conference when the expansion of the recall was announced.²² Vehicles made by nineteen different automakers were recalled to replace potentially hazardous frontal airbags on the driver’s side or passenger’s side. As of 2017, the recall in the United States has affected nearly 70 million airbags in 42 million vehicles.²³

The airbags are made by Takata Corporation, an automotive safety parts company based in Japan that has production facilities on four continents and supplies airbags for major automotive manufacturers around the world. Since production began around June 2000, a family of Takata-manufactured airbag inflators has contained a propellant that degrades due to a combination of time, high temperature fluctuations, and/or humidity.²⁴ The end date of production of the faulty inflators is still unclear and one of the reasons that the recall is continuously expanded.

²² Rosekind, Mark R. “Remarks: Takata Press Conference.” May 19, 2015. NHTSA. www.nhtsa.gov/speeches-presentations/remarks-takata-press-conference

²³ Atiyeh, Clifford and Blackwell, Rusty. “Massive Takata Airbag Recall”. March 2, 2017. www.blog.caranddriver.com/massive-takata-airbag-recall-everything-you-need-to-know-including-full-list-of-affected-vehicles.

²⁴ “Takata Recall Expansion: What Consumers Need to Know”. www.nhtsa.gov/takata-air-bags/takata-recall-expansion-what-consumers-need-know.

Takata representatives have admitted to being unsure how many airbag inflators are in question²⁵ and which cars use its defective inflators. At one point, Takata was replacing the faulty part with another faulty part.²⁶

The degradation in the faulty inflators can cause the propellant to burn too quickly, creating more pressure than the inflator can withstand during airbag deployment, and potentially causing the steel inflator housing to rupture, propelling steel fragments outward. In extreme cases, these metal fragments present vehicle occupants with the potential for injury or death.²⁷ As of January 2017, eleven deaths²⁸ and approximately 180 injuries occurred due to the Takata airbag inflator defect.

Recall Repair Process

As a result of the size and impact of the recall, it can take weeks or months for the replacement airbags to arrive to dealers for installation. The involved automakers are prioritizing resources by focusing on high-humidity areas such as Florida and Georgia where the airbag inflators have higher risk of resulting in the fatal explosion.²⁹ In an attempt to replace the large number of airbag inflators, Takata ramped up production but with all the projected replacements, other suppliers have supported their initiatives. Takata said that it is using competitors', including AutoLiv, TRW, and Daicel, products in half the inflator-replacement kits and expects

²⁵ Atiyeh, Clifford. "Toyota Recalling 844,000 U.S. Cars for Shrapnel-Shooting Airbags." June 16, 2014. www.blog.caranddriver.com/toyota-recalling-844000-u-s-cars-for-shrapnel-shooting-airbags/

²⁶ Atiyeh, Clifford and Blackwell, Rusty. "Massive Takata Airbag Recall". March 2, 2017.

²⁷ Blomquist, Harold R. "Expert Report." NHTSA. May 4, 2015. www.nhtsa.gov/sites/nhtsa.dot.gov/files/documents/expert_report-hrbloomquist.pdf.

²⁸ See Appendix E, "Injuries & Deaths." Honda. March 31, 2017. www.hondaairbaginfo.com/takata-airbag-inflator-recall-fact-sheet/

²⁹ See Appendix D, "Takata Recall Expansion." NHTSA. www.nhtsa.gov/recall-spotlight/takata-air-bags, "Identify Your Zone". Mopar. www.mopar.com/ramtrucks/en-us/my-vehicle/recalls/takata-recalls.html.

that number to reach more than 70 percent.³⁰ In some cases, vehicle owners need to have their airbag inflators replaced a second time because a temporary fix is needed due to parts shortages.

Despite the severity of this issue, recall completion rates are still considered too low by government standards. According to NHTSA completion rate data³¹ in the United States a total of sixty-five percent (13,035,556) of affected airbags were repaired with nearly seventy percent of driver-side airbags (6,950,164) and about sixty percent (6,085,392) of passenger-side airbags repaired.³²

Effect on Takata

In November of 2015, US federal regulators fined Takata Corporation \$200 million³³ in response to Takata's admittance of a defect in its airbag inflators for which it did not initiate a timely recall.³⁴ Additionally, several manufacturers, including Toyota, Mazda, Honda, Nissan, and Ford, announced that they will no longer equip new vehicles with Takata's front or passenger airbag inflators.

In January 2017, United States prosecutors charged three executives at Takata with fabricating test data to mask the airbag defect. According to the indictment, the executives were at the center of manipulating the airbag safety data for as long as fifteen years and knew as early as the year 2000 that the airbags' metal inflators could explode. The prosecutors also fined

³⁰ "Takata Airbag Recall - Everything You Need to Know". Consumer Reports. March 2, 2017. www.consumerreports.org/cro/news/2016/05/everything-you-need-to-know-about-the-takata-air-bag-recall

³¹ As of January 6, 2017.

³² "Completion Rates." NHTSA. January 6, 2017. www.safercar.gov/rs/takata/takata-completion-rates.html

³³ \$70 million of this fine was paid upfront.

³⁴ Puzanghera, Jim. "Takata fined \$70 million for faulty airbags in at least 19 million U.S. vehicles." Los Angeles Times. November 3, 2015. www.latimes.com/business/la-fi-takata-airbags-20151103-story.html.

Takata \$1 billion and announced that Takata agreed to plead guilty to charges of wire fraud for providing the false data.

The United States Justice Department said that Takata would be required to pay a \$25 million fine, \$125 million in a victim compensation fund, including for future incidents, and \$850 million to compensate automakers for massive recall parts. Although the guilty plea and fine were expected, the charges against the executives intensified the scandal and brought the company to the brink of bankruptcy.³⁵ At the time of this report, Takata also faces a class-action lawsuit filed by owners of cars fitted with Takata airbags, among other litigation.

Consumer Inquiries

An effect of being one of the largest recalls in history is that not all recalled vehicles can be repaired immediately and as a result concerned vehicle owners ask several questions.

One frequently asked question is whether it is safer to drive with a defective airbag or to disable the defective airbag. In summary, it is illegal and unsafe to disable an airbag in a vehicle and therefore the consumer should never disable his or her airbags. NHTSA estimates that frontal airbags saved 2,400 lives in 2014 alone. Therefore, if involved in a crash, it is more likely that the airbag will perform properly and protect the passenger than rupture and cause harm.

On the contrary, an airbag that is purposely disabled has a 100 percent chance of failing to provide any protection in a crash. Additionally, NHTSA says that “the vast majority of Takata airbags will perform as expected.” If the consumer feels uncomfortable driving the vehicle before the recall repair has been performed, he or she can contact the dealer to ask for a loaner

³⁵ Tabuchi, Hiroko and Boudette, Neal E. “3 Takata Executive Face Criminal Charges Over Exploding Airbags.” The New York Times. January 13, 2017.
www.nytimes.com/2017/01/13/business/takata-airbag-criminal-charges.html

until an interim or final repair is completed. However, dealers and manufacturers are not required by law to provide the owner with a loaner vehicle.³⁶

Another commonly asked question is regarding the priority of vehicles that are registered in northern states but spend winters in warm climates such as southern Florida. Consistent with the research, the data collected and examined by NHTSA demonstrates that long-term exposure to combined high heat and humidity creates the risk that a Takata inflator is likely to rupture. A vehicle that spends winters in a hot and humid location is not subjected to the same sustained periods of heat and humidity as a vehicle that has been driven in these conditions year-round for a prolonged period.³⁷

Case Reflections

An important factor regarding the Takata Airbag Recall is the impact of utilizing a global supply system. Takata sells automotive parts to various manufacturers around the world. Many of the articles as well as the NHTSA data focus on injuries and fatalities this defect has caused in incidents in the United States. However, because Takata is a global supplier there have been injuries reported in other countries. This emphasizes the importance of regulated safety precautions when developing products at a global scale. The effect and cost of failure is widespread and high. Regulations and procedures can vary by country.

Although manufacturers have a legal obligation to report a defect as soon as they become aware of it, Takata did not adhere to this obligation. Earlier tests several years back indicated there was a problem with the airbags but senior executives ignored the warnings and reports and

³⁶ “Takata Air Bags: FAQs.” NHTSA. January 19, 2017. www.nhtsa.gov/recall-spotlight/takata-air-bags.

³⁷ Ibid.

continued along their initial trajectory. In addition to the large financial cost of supplying a defective product globally, Takata now faces litigation and fines because of the fact that the executives did not address the defect and inform the appropriate parties as soon as it came to their attention.

Chapter 3: Data and Methods

Motivation

The motivation for focusing on vehicles is due a personal interest in the field. Exploration of vehicle dataset APIs such as Edmunds and iSeeCars, prompted questions pertaining to the reliability of specific cars and how they compare to manufacturers' reputations. This eventually led to information regarding automotive recalls and ultimately the NHTSA data website.³⁸

Data

The NHTSA ODI provides databases for complaints, defect investigations, recalls, and manufacturer communication to the public through the safercar.gov site. This project focuses on the Automotive Recall databases looking at both the Flat Recall and Quarterly Recall databases. The data was loaded into a PostgreSQL database for ease of query and analysis. Only recalls for the Takata airbag inflator were considered during analysis.

³⁸ "Download Data From NHTSA/ODI Databases." SaferCar. www-odi.nhtsa.dot.gov/downloads/

Flat “All” Recall Database

The Recall dataset contains all NHTSA safety-related defect and compliance campaigns since 1967. This dataset contains a range of information regarding particular recall records including all products within a campaign. The database contains the following fields:

Name	Description	Example Data	Notes
RECORD_ID	Uniquely identifies the record.	104180	
CAMPNO	NHTSA campaign number used to uniquely identify a defect.	14V362000	From researching the campaign numbers, there is no additional meaning or significance to the particular characters and digits in a campaign number. Different vehicles, vehicle years, etc. can share a campaign number
MAKETXT	Vehicle or equipment make	Mazda	Different than manufacturer, for example General Motors (manufacturer) makes Chevrolet, Cadillac, etc. If not a vehicle, make is related to the part (i.e. Takata for air bags).
MODELTXT	Vehicle or equipment model	Mazda6	
YEARTXT	Model year	2004	If year unknown, designated as 9999 or N/A

MFGCAMPN O	Manufacturer campaign number used to uniquely identify a defect for a manufacturer.	7714F	Different campaign number than NHTSA, likely used for manufacturer record purposes. Can be blank, often equipment manufacturers do not have a separate campaign number.
COMPNAME	Defect component	Air Bags	
MFGNAME	Manufacturer that filed the defect or noncompliance report	Mazda North American Operations	Not necessarily the same as the manufacturer that produces the product
BGMAN	Begin date of manufacturing	5/29/02	Date that the defected product began manufacturing
ENDMAN	End date of manufacturing	3/4/04	Date that the defected product finished manufacturing
RCLTYPECD	Vehicle (V), equipment (E), or tire report (T)	V	
POTAFF	Potential number of units affected by recall	19544	Often refers to the number of cars owned that are affected. The number of potential units is tied to a specific campaign and will appear in all of that campaign's records. Therefore, it is only informative to sum the potential units by manufacturer.
ODATE	Date when owner was notified by manufacturer	8/21/14	

INFLUENCED _BY	Recall initiator	MFR	MFR (manufacturer), OVSC (Office of Vehicle Safety Compliance), or ODI (Office of Defect Investigation)
MFGTXT	Manufacturer of recalled vehicles/products	Mazda Motor Corp.	
RCDATE	Report received date	6/23/14	
DATEA	Record creation date	6/24/14	
RPNO	Regulation part number		
FMVSS	Federal Motor Vehicle Safety Standard Number		
DESC_DEFEC T	Defect summary	Mazda North America Operations (Mazda) is recalling certain model year 2003-2004 Mazda6 vehicles and 2004 RX-8 vehicles to address a safety defect in the passenger side frontal airbag which may produce excessive internal pressure causing the inflator to rupture upon deployment of the air bag.	
CONSEQUEN CE_DEFECT	Consequence summary	In the event of a crash necessitating deployment of the passenger's frontal airbag, the inflator could rupture with metal fragments striking and potentially seriously	

		injuring the passenger seat occupant or other occupants.	
CORRECTIVE _ACTION	Corrective summary	Owners of all vehicles on which a defective air bag may have been installed as original equipment will be notified. Dealers will replace the defective air bag inflator, free of charge. The safety recall is scheduled to begin in August 2014. Owners may contact Mazda Customer Assistance Center at 1-800-222-5500. Mazda's recall campaign number is 7714F. Note: This is an expansion of NHTSA Recall No. 13V-130.	
NOTES	Recall notes	Owners may also contact the National Highway Traffic Safety Administration Vehicle Safety Hotline at 1-888-327-4236 (TTY 1-800-424-9153), or go to www.safercar.gov .	
RCL_CMPT_I D	Uniquely identifies a recalled component	00005435500011055 3000000256	

Quarterly Recall Database

The Recall Quarterly database contains data from Year 2015 Quarter 1 through the Year 2016 Quarter 2. It differs from the overall recall database in that it provides completion data (number of defective units remedied) for specific quarters of the year in relation to specific recall campaigns.

Name	Description	Example Data
MFGTXT	Manufacturer name	Ford Motor Company
CAMPNO	NHTSA campaign number	11V445000
MFGCAMPNO	Manufacturer campaign number	12212
RCLSUBJ	Recall subject	Front Turn Signal Bulbs
ODATE	Owner notification begin date	20140908
ODATEEND	Owner notification end date	Sometimes blank if still ongoing
RPTNO	Report number	3
RPTQTR	Report quarter	2015-1
INVOLVED	Involved population	120426
TTLREMEDIED	Total number of defects remedied	80958
TTLUNREACH	Total number of defects unreachable	1611
TTLREMOVED	Total number of defects removed	0
SUBMDATE	Date that quarterly report data was submitted	20150409

Considerations

Most of the analyses in this paper focus on looking at trends specifically related to automotive manufacturers. Therefore, the charts exclude information related to parts manufacturers that distribute to automotive manufacturers. When listing the manufacturers most affected by the Takata airbag inflator recall, the numbers attributed specifically for Takata (the supplier) in the dataset are excluded from visualizations.

In addition to having a consistent campaign number, the number of potential units affected is also consistent across the same campaign. By doing some additional research regarding number of particular vehicle models sold^{[39][40]} and summing up the numbers, it appears to be generally true that the number of potential units is the sum of the total number of vehicles sold pertaining to the specific campaign which could have that defect. Therefore, the number of potential units affected (POTAFF in the Flat Recall Database) is consistent for an entire campaign because it represents all the vehicle make and models.

For example, if a recall campaign contains different Mazda vehicles including the 2004 RX-8, the 2005 Mazda6, and the 2006 Mazda6, the potential units is the sum of the number of all those vehicles sold. In a recall expansion campaign that includes the 2007 Mazda6 in addition to the 2006 Mazda6, the potential affected units contain the number of 2006 Mazda6 units that were part of the earlier campaign. As a result, summing potential affected units for multiple campaigns does not provide reliable information as it may contain overlapping data.

³⁹ “Mazda 6 US Car Sales Figures.” www.carsalesbase.com/us-car-sales-data/mazda/mazda6/.

⁴⁰ Cain, Timothy. “Mazda 6 Sales Figures.” Good Car Bad Car. January 1, 2011. www.goodcarbadcar.net/2011/01/mazda-6-sales-figures.html

After attaining a better understanding of this dataset and researching data available through other APIs such as Edmunds, it appears there is no concrete way to measure the severity, meaning the potential of harm, of a particular defect entry using NHTSA recall data. As indicated in the fields above, the recall data includes the specific recall text and estimated number of vehicles impacted, however it is difficult to gauge the potential for harm and how extreme the harm would be solely from the data provided.

The idea of using consumer sentiment analysis on the defect summary was considered. However, because there is no data field for the severity of the recall, it would not be possible to measure the accuracy of a sentiment analysis. If the recall severity data is available, a future research project could conduct a sentiment analysis of the recall descriptions to determine the severity of the recall.

Chapter 4: Data Analysis

Completion Rates

Although the actual size of the recall is important in terms of the effect it has, another important aspect to consider is to what extent consumers actually fulfill the recall notices. Completion rates indicate whether the manufacturers are effectively communicating the need for repair to vehicle owners and whether the owners are taking their vehicles to their dealers for recall repairs.

In recent years, car companies have stopped selling new cars with recently discovered defects. Federal law prohibits dealerships from selling a new car if a recall repair has not yet been performed. Additionally, new rules prevent rental car companies from renting cars with open recalls. However, used-car buyers are not protected the same way and there are ongoing efforts to prevent used car dealers from selling used cars with open recalls. These efforts help encourage new car and used car dealers to investigate and repair affected vehicles.⁴¹

Existing Work on Completion Rates

Stout Risius Ross (SRR), a leading independent advisory firm specializing in investment banking, valuation advisory, dispute consulting, and management consulting services, conducted a study in 2015 regarding automotive safety and recalls. SRR found that from the years 2004-2013, the average completion for recalls increased.⁴²

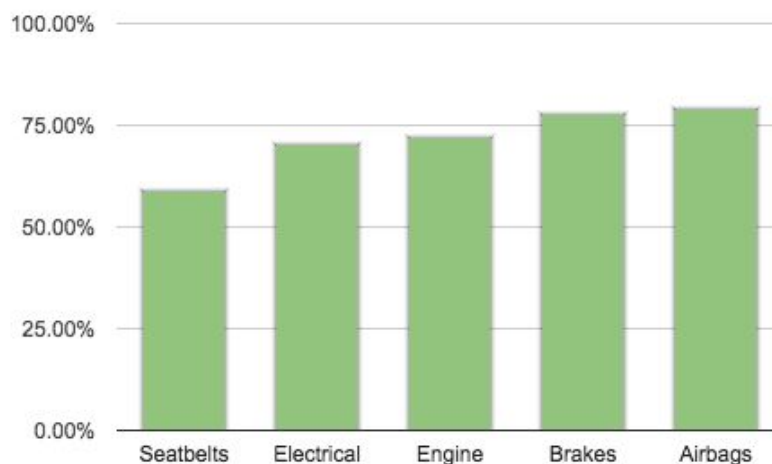
⁴¹ Linkov, Jon. "How Recalls Impact Used-Car Buyers." August 31, 2015.
www.consumerreports.org/cro/cars/how-recalls-impact-used-car-buyers

⁴² See Appendix C. Steinkamp, Neil and Reed, Jake. "A Study Of Recall Completion Rates." July 6, 2015.
www.autoindustrylawblog.com/2015/07/06/a-study-of-recall-completion-rates/.

SRR also found that completion rates vary significantly depending on the type of the component that failed (Figure A), vehicle age, and size of the recall. Through the past ten years, completion rates for air bags and seat belt related defects were much lower than those for powertrain and steering-related defects. Completion rates for recalls involving older vehicles are generally lower, with the greatest difference between vehicles older than three years and newer than three years. Also, completion rates for larger recalls are often 5 to 10 percent lower than for smaller-sized recalls.

Various research organizations performed consumer surveys and spoke to industry experts to discover other factors that negatively influence completion rates. Consumer fatigue, perception of severity, and burden of repair have an impact on recall completion. Consumers are also increasingly technologically inclined and thus less likely to respond to paper mailings.

Figure A: Vehicle Subsystem Recall Completion Rates⁴³



⁴³Timian, Jennifer. "Safety Recalls Completion." SAE International, NHTSA. www.sae.org/events/gim/presentations/2012/timian.pdf

Results and Insights

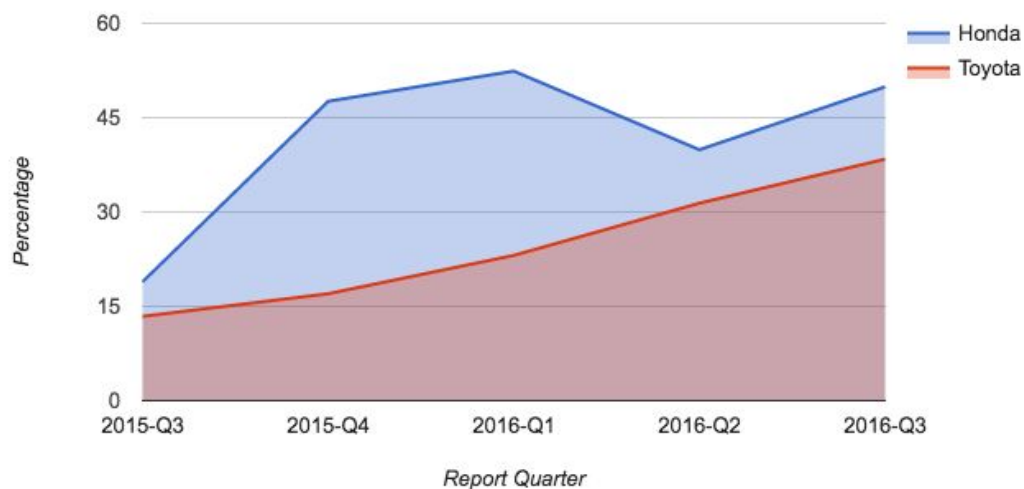
This research raises the question of whether certain manufacturers performed better than others in regards to the number of customers that fulfilled the Takata airbag recall. Analysis of the quarterly data highlighted differences in completion rates across manufacturers. This analysis was performed by querying the dataset for entries related to the Takata airbag recall (i.e. containing “metal fragments” or “air bag inflators”).

As the quarterly data contains completion information pertaining to a particular campaign, it was only possible to see how various manufacturers compare. For example, by the end of the third quarter of 2015, Honda had a total of 4,322,559 vehicles involved in the campaign with 815,943 remedied, whereas Toyota had 3,042,525 involved and 408,746 remedied. By drawing out the particular recall campaigns for each manufacturer and looking at the various numbers, it is possible to calculate overall completion rates by each quarter.

General Motors was not included in this analysis because it only had data for one quarter, compared to the other manufacturers that had data for at least five quarters. This suggests, that for unknown reasons, that numbers were not entered in the quarterly dataset for General Motors. Regarding the data in general, especially related to quarterly data, it is unclear who enters the data and what date the quarterly data is collected until. Even further researching and digging did not fill in the gaps regarding the data.

When looking at Figure B, it is perplexing how Honda could have taken a dip in percentage of remedied recalls. After all, how can a remedied vehicle become unremedied? Looking at the numbers provided in the dataset as well as additional research, the dip may be due to additional vehicles added to the list of affected vehicles. Honda remains the most affected manufacturer by the Takata Airbag recall. However, it is unclear whether Toyota did not have as large of an increase in vehicles added or is better at getting owners to bring their vehicles in for repair.

Figure B: Percentage of Faulty Airbag Inflators Remedied by Quarter



Figures C and D show completion rates for various manufacturers. These figures suggest that there is no relation between number of airbags remedied and reachability of vehicle owners. In Figures C and D, manufacturers who have higher completion rates do not have a smaller percentage of unreachable vehicle owners. However, the completion rates still have a lot of room for improvement as there are a large number of vehicles on the road that still have the faulty Takata airbag inflator either due to a lack of parts or owners not getting their vehicles repaired.

Figure C: Percent of Faulty Airbags Remedied

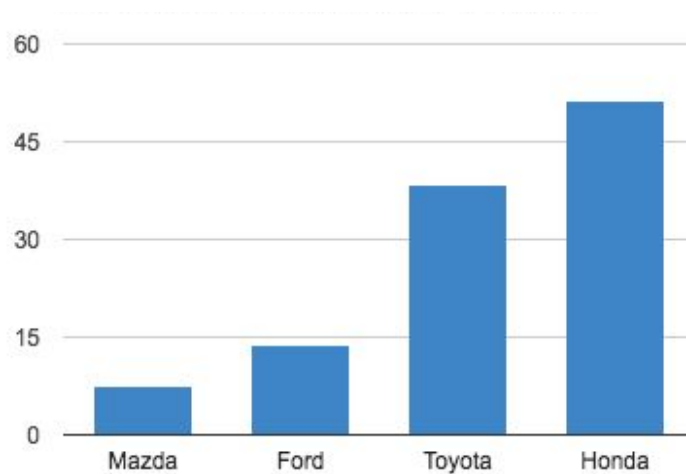
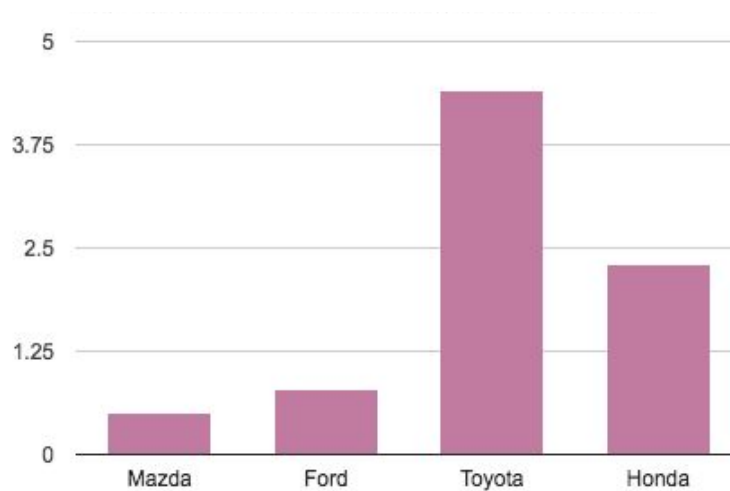


Figure D: Percent of Faulty Airbags Unreachable



Make and Model

Although it was not possible to track trends for particular vehicle makes and models within the quarterly data as the data was not given to that level of granularity, it was available in the overall NHTSA recall dataset. While it is possible to view the number of recalls associated with a particular vehicle make and model using the NHTSA recall information service, it is not possible to see how different vehicles compare to one another. Perhaps when consumers are looking to purchase a used vehicle, they would be curious to know which recalls have been published for that vehicle and whether the owner had them repaired.

Figure E represents the ten vehicles that had the most number of recalls related to the Takata airbag inflator. In this figure, each recall counted for a vehicle represents a unique recall campaign. The potential units column provides a sense of the scale of recall campaigns, but does not accurately represent the number of units for the particular vehicle model that was recalled. Notably, there are some rows that contain the same number of potential units. This is because the potential units are estimated for an entire recall campaign, which represents many models for a particular make. The NHTSA dataset does not provide units associated with particular vehicle makes and models. Although all of the top ten vehicles affected by the Takata airbag inflator recall shown are Honda vehicles, making conclusions about particular vehicle makes and models is limited when using the NHTSA dataset.

Figure E: Make and Models with Most Number of Takata Airbag Inflator Recalls

Make	Model	Number of Recalls	Total Potential Units
Honda	CR-V	8	16,655,713
Honda	Pilot	6	14,423,011
Honda	Accord	5	12,632,117
Honda	Civic	5	12,632,117
Honda	Civic GX	3	12,498,910
Honda	Civic Hybrid	4	12,498,910
Acura	MDX	5	11,703,625
Honda	Element	5	11,703,625
Honda	Odyssey	5	11,703,625
Honda	Ridgeline	5	10,437,331

Consumer Reviews

The results from Figure E helped inform the researcher that the NHTSA dataset could not predict reliability of a particular vehicle. The main initiatives of NHTSA are to inform vehicle owners of recalls and encourage them to repair the defects for their own safety. However, the Edmunds vehicle API provides the NHTSA recall information and other automobile data such as ratings and reviews. To determine whether recalls can affect a vehicle's reliability or ratings, reviews from the Edmunds API were sampled before and after vehicle recalls.

Although this analysis looks at the Edmunds API, the NHTSA data was utilized to select which vehicles makes to research and provide the date owners were notified of the recall. Additionally, the vehicle make and year needed to have reviews by consumers both before and

after the recall was initiated. Initially, one of the vehicles considered for the analyses was the Honda Element. However, some additional research indicated that this vehicle was discontinued after the year 2011 and it was only popular with a niche group of consumers.

The next vehicle that was selected for further analysis was the 2005 Honda Pilot. This vehicle has been produced since 2002, with model years beginning in 2003 and continuing today⁴⁴. The vehicle has been consistently rated well by NHTSA safety reports and popular among consumers over the years. The 2005 Honda Pilot was recalled on July 1, 2015. However, because this is an older car, most of the reviews came prior to the recall date. Out of 386 consumer reviews, nine of them were written after the recall date and did not differ substantially from those written prior to the recall.⁴⁵

The Honda Civic, which was first introduced in 1972 and has a reputation for being fuel-efficient and reliable, has sixty-three entries in the NHTSA database related to the Takata airbag inflator recall for various combinations of models and years. Less than a month after the 2004 Honda Civic, an Edmunds user rated the vehicle highly, but did mention the need to bring it in for servicing because of the recall. In an excerpt from the review⁴⁶, the customer says “Since then she has put only 12,000 miles on it and the only time it was in the shop was for the airbag recall. It runs and drives like new after 11 years.”

Reading an excerpt that referenced a recall to quantify the amount of service needed, provided the motivation to explore whether other owners mention recalls to make a point. The 2004 Honda Pilot has several owners that mention recalls in positive reviews. Martin Cooke

⁴⁴ As of 2017

⁴⁵ Recall date from NHTSA database and results from Edmunds API queries

⁴⁶ Boy, Davie. “Grandma demanded the Civic VIP.” July 30, 2015.
www.edmunds.com/honda/civic/2004/consumer-reviews

praised his vehicle and then concluded his review by praising the manufacturer⁴⁷, “Honda has been very good at doing all the recalls and their service is excellent.” Another 2004 Pilot owner is so committed to Honda that he/she mentions all the Honda vehicles he/she has purchased and the minimal work that has been needed⁴⁸, “This car has been subject to at least 3 Honda recalls, one being the transmission issue. I will continue to drive it until the wheels fall off.”

Conclusion

Throughout the course of this paper, we were able to conduct analyses on the data to answer questions regarding automotive recalls. Although the results from the data analysis were insightful, the NHTSA data is limited and leaves a lot of questions unanswered. In order to benefit from the results as best as possible, it required a great deal of background research into the various data fields and what information they provide. This research provides a basis for better informing vehicle consumers about what can be learned from automotive recalls.

However, this research paper focused specifically on informing customers regarding decisions surrounding a particular recall in history, the Takata Airbag Inflator recall. Further research can dive deeper into other recalls in automotive history or holistically evaluate different recalls over the course of history.

Since starting this research project towards the end of 2016, NHTSA has greatly improved their consumer facing website. This is the site users are directed to in order to learn more about a recall notice they received or to research a particular vehicle or recall. The NHTSA

⁴⁷ Cooke, Martin. My 2004 Honda Pilot EX”. April 6, 2016.

www.edmunds.com/honda/pilot/2004/consumer-reviews

⁴⁸ “240K+ miles and still going strong!” April 26, 2015. www.edmunds.com/honda/pilot/2004/consumer-reviews

SaferCar site now allows users to view summary data pertaining to particular manufacturer completion rates.

Previously existing features, such as searching for a particular recall, are easier to locate and not buried deep in the site. However, the average consumer will not visit the website and there is still further research to be performed regarding how to make users comply with recall notices and be generally informed about manufacturer reputation.

Completion rates are still not as high as the government would like them to be. However, improving the usability of the site and requiring digital notices in addition to the existing snail mail notices⁴⁹ are some of the tactics employed to increase completions rates. Future research can dive deeper into ways to inform customers of the grave nature of the facts exposed in this paper.

⁴⁹ Beene, Ryan. "NHTSA proposes digital recall notices to increase repair rates." August 31, 2016. www.autonews.com/article/20160831/OEM/160839970

Appendices

Appendix A: Excerpt from Takata Airbag Recall Request Letter



U.S. Department
of Transportation
**National Highway
Traffic Safety
Administration**

NOV 26 2014

1200 New Jersey Avenue SE.
Washington, DC 20590

BY EMAIL AND U.S. MAIL

Kazuo Higuchi
Senior Vice President
TK Holdings Inc.
888 16th Street, N.W.
Suite 800
Washington, D.C. 20006
Kazuo.higuchi@takata.com

NVS-210fsb
PE14-016

**RE: PE14-016 - Air bag Inflators
Recall Request Letter**

Dear Mr. Higuchi:

As you are well aware, on June 11, 2014, the Office of Defects Investigation (“ODI”) of the National Highway Traffic Safety Administration (“NHTSA” or the “Agency”) opened a Preliminary Evaluation, No. PE14-016, to investigate vehicle crash incidents resulting in the rupture of frontal driver and passenger side air bag inflators manufactured by TK Holdings, Inc. and/or Takata Corporation (collectively, “Takata”).

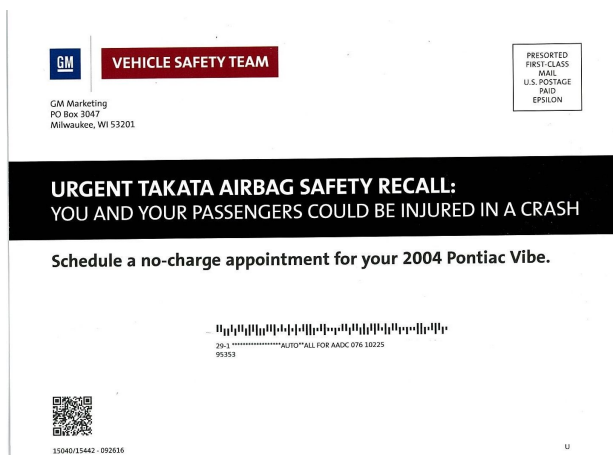
Takata has supplied millions of frontal driver’s side air bag inflators to at least five motor vehicle manufacturers over the last fifteen years. A growing number of these inflators have ruptured, projecting metal fragments into vehicle occupants; thereby creating an unreasonable risk of death and injury.

In June 2014, at NHTSA’s insistence, five auto manufacturers - BMW of North America, LLC (“BMW”), Chrysler Group, LLC (“Chrysler”), Ford Motor Company (“Ford”), American Honda Motor Company (“Honda”), and Mazda Motor Corporation (“Mazda”) - commenced regional recall campaigns for certain driver’s side air bag inflators manufactured by Takata and installed in vehicles operating in areas of high absolute humidity. The subject driver’s side inflators have been designated by Takata as types PSDI, PSDI-4, and PSDI-4K.

On November 17, 2014, ODI contacted Takata, demanding that the manufacturer submit a Part 573 Safety Recall Report that unequivocally states that a defect exists in the subject driver’s side air bag inflators. The following day, NHTSA publicly demanded that the five auto manufacturers expand their regional recall campaigns and conduct a nationwide recall of all vehicles equipped with the subject driver’s side air bag inflators. The decision to take these two



Appendix B: Takata Recall Reminder Notice Received by my household for 2004 Pontiac Vibe [Note: Personal Information has been removed]



Page 1: Front of Postcard



Page 2: Back of Postcard



Page 3: Inside of Postcard

Appendix C: Schedule for filing of Takata Airbag Recalls

Schedule for Recalls

Takata Defect Filing Date	Zone A Vehicles	Zone B Vehicles	Zone C Vehicles
May 16, 2016	MY 2011 & Older	MY 2008 & Older	MY 2004 & Older
December 31, 2016	MY 2012 & Older	MY 2009 & Older	MY 2008 & Older
December 31, 2017	MY 2013 & Older	MY 2010 & Older	MY 2009 & Older
December 31, 2018	All remaining vehicles	All remaining vehicles	All remaining vehicles
December 31, 2019	All like-for-like replacement parts	All like-for-like replacement parts	All like-for-like replacement parts

Recall Zones Based on Temperature & Humidity

Zone A: Hot & Humid

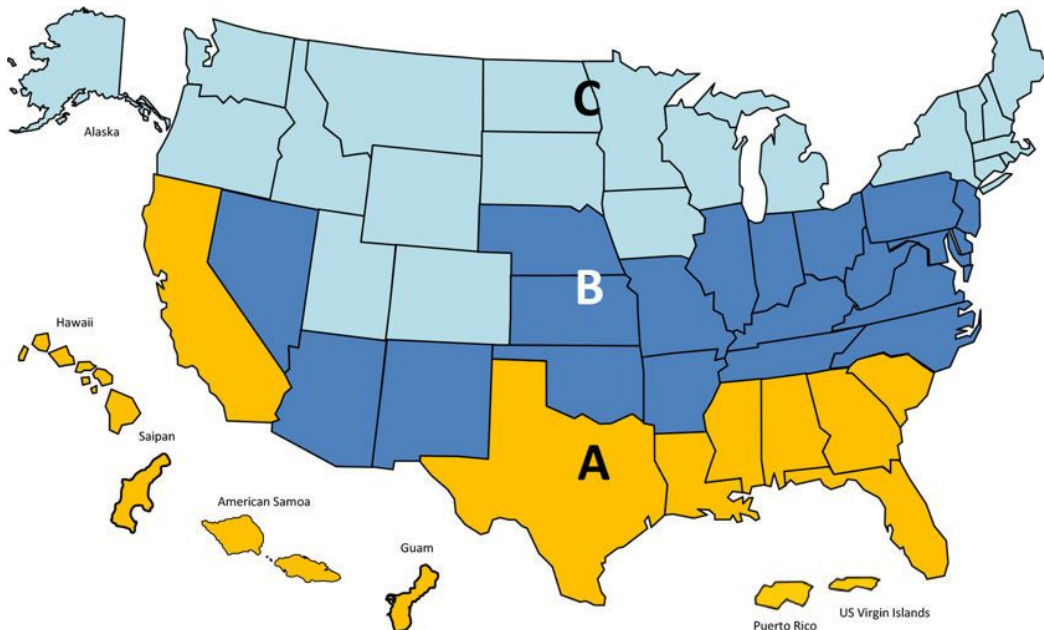
Alabama, California, Florida, Georgia, Hawaii, Louisiana, Mississippi, South Carolina, Texas, Puerto Rico, American Samoa, Guam, the Northern Mariana Islands (Saipan), and the U.S. Virgin Islands

Zone B: Less Hot & Humid

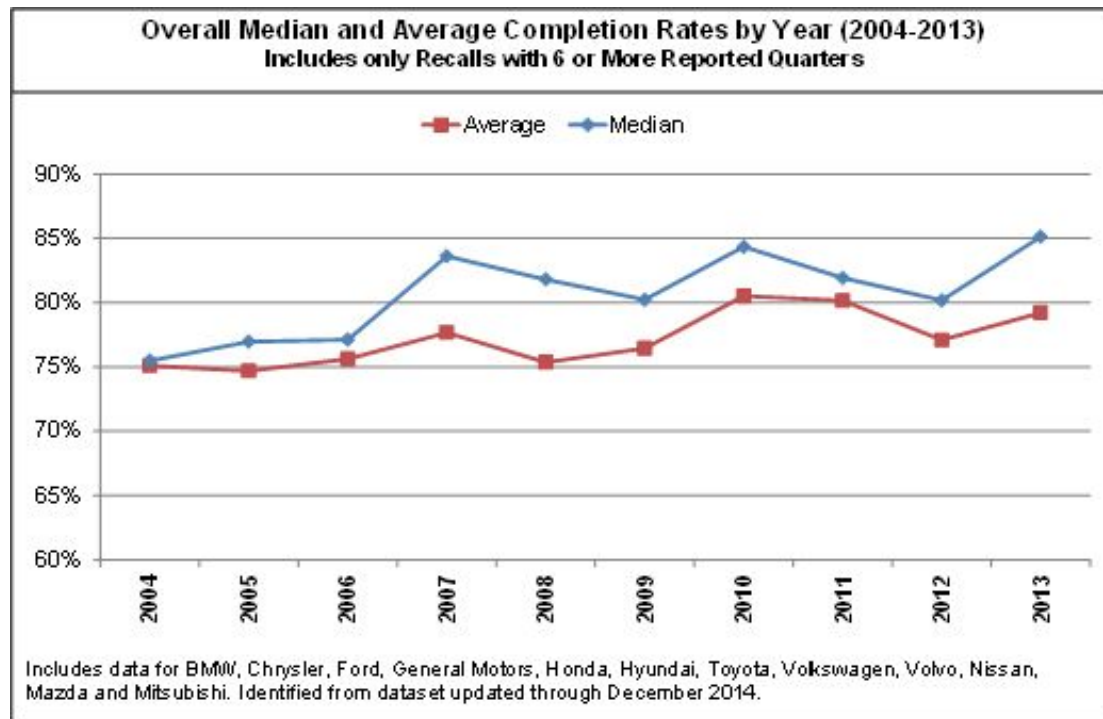
Arizona, Arkansas, Delaware, District of Columbia, Illinois, Indiana, Kansas, Kentucky, Maryland, Missouri, Nebraska, Nevada, New Jersey, New Mexico, North Carolina, Ohio, Oklahoma, Pennsylvania, Tennessee, Virginia, and West Virginia

Zone C: Least Hot & Humid

Alaska, Colorado, Connecticut, Idaho, Iowa, Maine, Massachusetts, Michigan, Minnesota, Montana, New Hampshire, New York, North Dakota, Oregon, Rhode Island, South Dakota, Utah, Vermont, Washington, Wisconsin, and Wyoming



Appendix D: Completion Rates by Year



Appendix E: Table of Deaths in U.S. Due to Defective Takata Airbag Inflator in Honda Vehicles

Date of Crash	Location of Crash
5/27/09	Oklahoma
12/24/09	Virginia
9/3/13	California
9/7/14	California
9/29/14	Florida
1/18/15	Texas
4/5/15	Louisiana
7/22/15	Pennsylvania
3/31/16	Texas
9/30/16	California