2017

Automotive Warranty & Recall Report

Fault Lines

The Changing Relationship Between OEMs and Suppliers

STOUT

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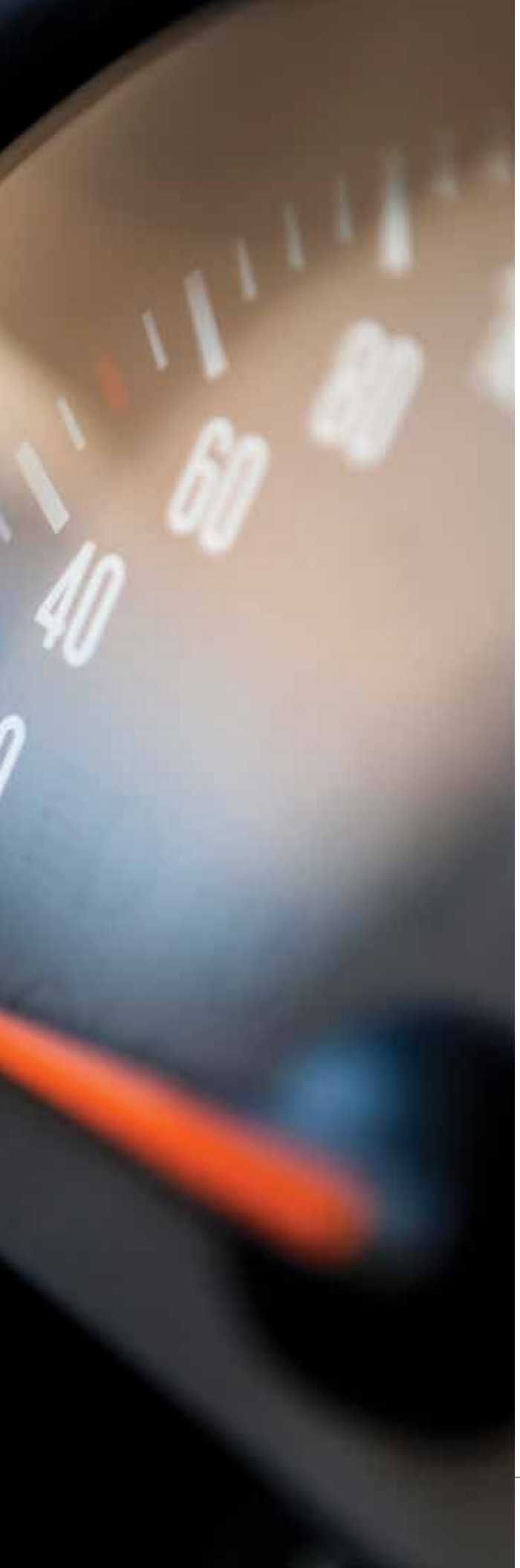
Introduction



Stout's third annual *Automotive Warranty & Recall Report* is the industry's most comprehensive analysis of automotive recall trends. This report greatly expands on previous reports, with the inclusion of an unprecedented examination of defect-related domestic and international data that can influence the way original equipment manufacturers (OEMs) and suppliers prepare for recalls.

Our previous reports pointed to a new era of heightened recall activity, which continued in 2016. While the massive Takata airbag recall had a major influence on 2016 numbers and generated the most news, several other factors aside from the large, headline-grabbing campaigns contributed to this sustained high level of recalls.

This year we took a deeper dive into what might be causing the increase in recalls, as well as the changing dynamics between OEMs and suppliers following the detection of a defect.

For suppliers, risks are rising with the volume and scope of recalls around the world, particularly given greater supplier-OEM collaboration on design and manufacturing and the increased use of global platforms to build efficiency.

In addition to a comprehensive review of recall trends in 2016, this report focuses on the following topics:

Defect descriptions

Our analysis of thousands of defect descriptions over the last 10 years can help suppliers learn how to make more informed business decisions about the components they manufacture.

Global exposure

By examining National Highway Traffic Safety Administration (NHTSA) records and providing exclusive analysis of recall-related databases in several countries, we help suppliers anticipate the possible consequences of the rapidly increasing use of global platforms and why planning for the possibility of an international recall is critical.

Petition predictions

A rare look at Motor Vehicle Defect Petitions (MVDPs) and Petitions for Inconsequential Noncompliance (PINs) provides insight as to how NHTSA reviews certain issues of noncompliance. Such information offers valuable additional input into a risk assessment framework for OEMs and suppliers.

Technological defects

The rise in technologically advanced vehicles is causing a raft of new types of recalls, and it indicates that suppliers need to understand the extent of how their components integrate with highly advanced systems in order to protect against possible liability.

Financial preparation

We analyze why suppliers must carefully plan their risk mitigation strategies to prevent recalls, and we offer a new process to help accomplish that task.

REPORT BACKGROUND

Stout's Automotive Warranty & Recall Report is the industry's most thorough and integrated assessment of recall trends, risks, and costs. It is a proprietary analysis of important metrics that drive those areas, incorporating data from recalls, technical service bulletins, investigations, financial reporting, international campaigns, and multiple other sources.

This report leverages Stout's qualitative and quantitative approaches to understanding automotive industry recall risks and costs. It stems from original research that Stout Managing Director Neil Steinkamp and his team began in 2013. This is the third year for this comprehensive report, which compiles and analyzes prior-year data to predict likely trends for the coming year and beyond.

SECTION 1:

2016 in Review: A Record Year

"The sheer volume (of recalls) has created a 'new normal' for car shoppers who have almost come to expect that their vehicles will be recalled at some point."

- **Jessica Caldwell**, executive director of industry analysis, Edmunds.com[1]

As shown in Figures 1 and 2, in 2016, total light vehicle automobile recall units topped 50 million. This is the third consecutive year of elevated volumes as we settle in to the new normal of automotive recall activity.

50M Light vehicle recalls in 2016

As described in previous annual reports, increased vehicle complexity, regulatory scrutiny, technology and integration, and the aging of the automobile fleet have all set the stage for significant numbers of recalls. Furthermore, U.S. light vehicle sales reached a record

[1] MediaPost.com, September 13, 2016

FIGURE 1:

2016 Timeline of Notable Events

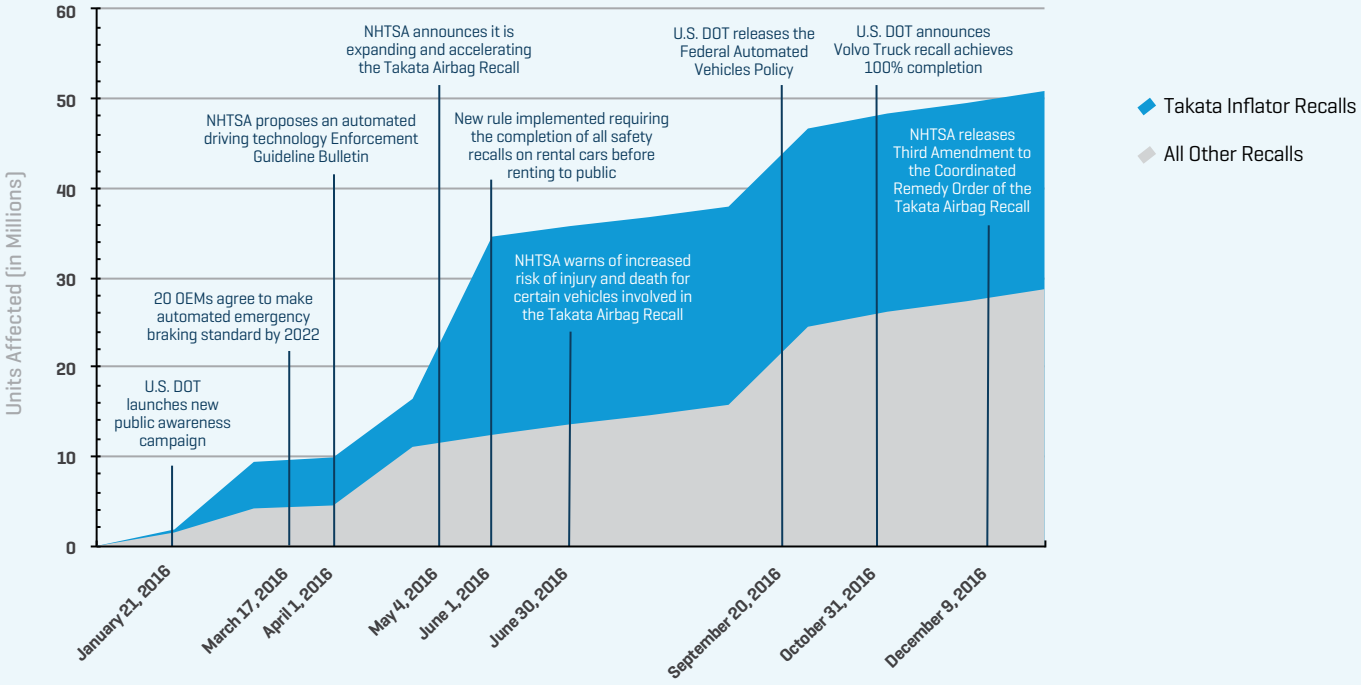
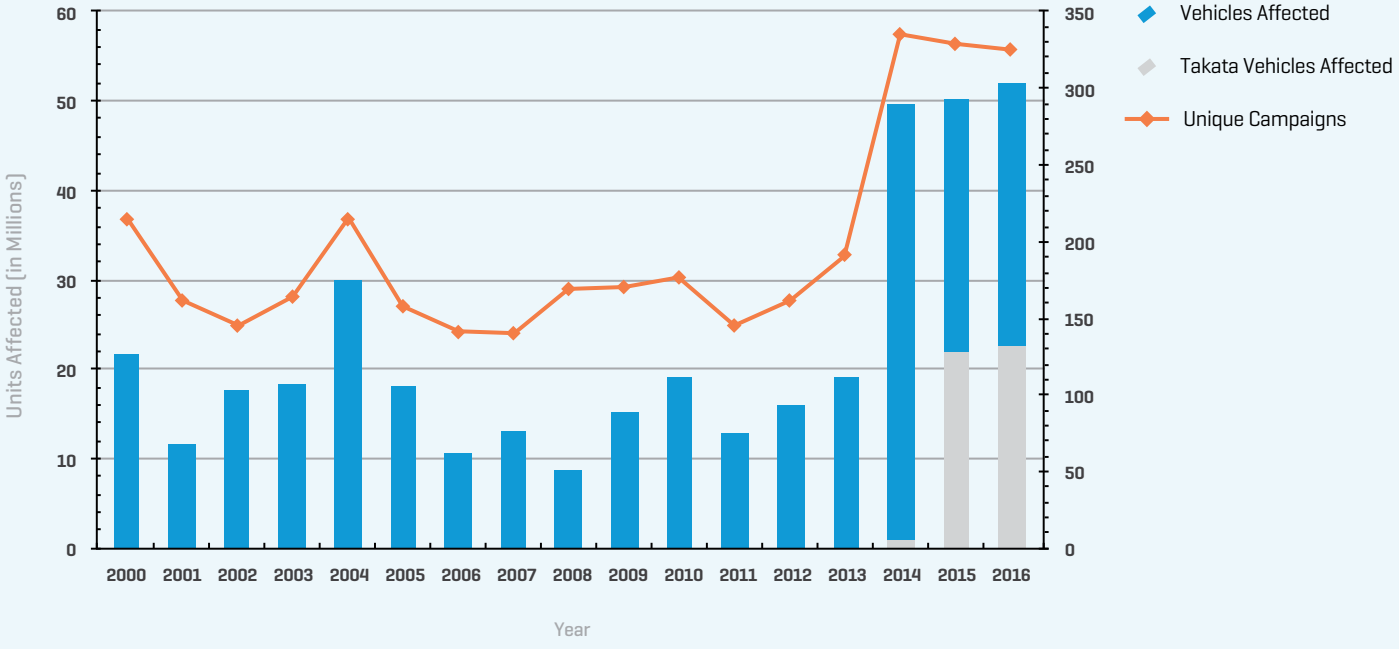


FIGURE 2:

Unique U.S. Recall Campaigns and Vehicles Affected by Year



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high for a second consecutive year, putting more new automobiles on the roads. Three years into this new era there is still much to learn about the nature of the defects, the cost of the recalls, and how the industry is responding to these new challenges.

Auto recalls continued to generate national headlines in 2016, including the prolonged and expanded recall of defective Takata airbags, which have been blamed for 12 fatalities and more than 180 injuries in the U.S. In addition, the ongoing recall of Volkswagen vehicles related to defective emissions components has been closely watched in the U.S. and around the globe.

SMALL AND MIDSIZED RECALLS CONTINUE TO PROLIFERATE

For 2016, the total number of vehicles affected by recalls was up,[2] though the number of unique campaigns was down slightly, according to Stout's analysis of data made available from NHTSA.

The Takata-related airbag recalls significantly contributed to the high mark in recalls in 2015 and again in 2016. It is unlikely that 50 million vehicles is the new normal, even though the annual numbers have been at or near that level since 2014, due in part to the Takata airbag and General Motors ignition switch campaigns.

30M Stout estimate of expected annual light vehicle units recalled in coming years

Based on experience from the last several years and the continued influence of industry and regulatory factors, 30 million new units recalled per year for the next several years appears to be a reasonable expectation with respect to the OEMs included in the Stout analysis. This number excludes what remains from the Takata campaign. The year 2017 will prove to be important for assessing the extent to which this recall level has taken root.

It is important to note, as demonstrated in Figures 3 and 4, that 75% of all light vehicle recall campaigns had fewer than 100,000 units, and approximately 50% involved fewer than 10,000 vehicles. From a compliance perspective, OEMs and suppliers are still required to devote substantial time and money on smaller campaigns.

However, the threat of medium and large recalls will likely remain a significant concern for OEMs and suppliers. These campaigns often have considerable financial obligations and can involve additional complexity in recall administration. Approximately 15% of recall campaigns in 2016 comprised between 50,000 and 250,000 vehicles. Recalls on that scale can trigger multi-million-dollar liability, often on components with limited profit margin on original sale.

4% Recalls that were 1 million units or more

It is easy to see the outsized effect of large campaigns. While only 4% involve 1 million units or more, they account for 55% of the total light vehicles recalled in 2016. Consider further that in 2016, there were approximately 30 million vehicles affected by non-Takata recalls, with the three largest being:

General Motors sensing and diagnostic module software defect (3.6 million)

On September 8, 2016, GM announced campaign 16V651, affecting the following 2014-2017 model year (MY) vehicles: Buick Encore and Lacrosse; Cadillac Escalade; Chevrolet Caprice Police Pursuit; Corvette; Silverado 1500, 2500, and 3500; Spark; Suburban; SS; Tahoe and Trax; and GMC Yukon; Sierra 1500, 2500, and 3500 vehicles. The defect may cause the airbag sensing and diagnostic module software to activate a diagnostic test, which could block the deployment of airbags in a crash.

[2] Total number of vehicles affected, considered in Stout's analysis, represents vehicles recalled by manufacturers of cars and light trucks, and excludes recalls of equipment, heavy trucks, and motorcycles. Therefore, the total number of vehicles affected may differ from amounts reported by other sources.

FIGURE 3:

Industrywide U.S. Recall Severity in 2016 (Distribution of Unique Recalls by Size)

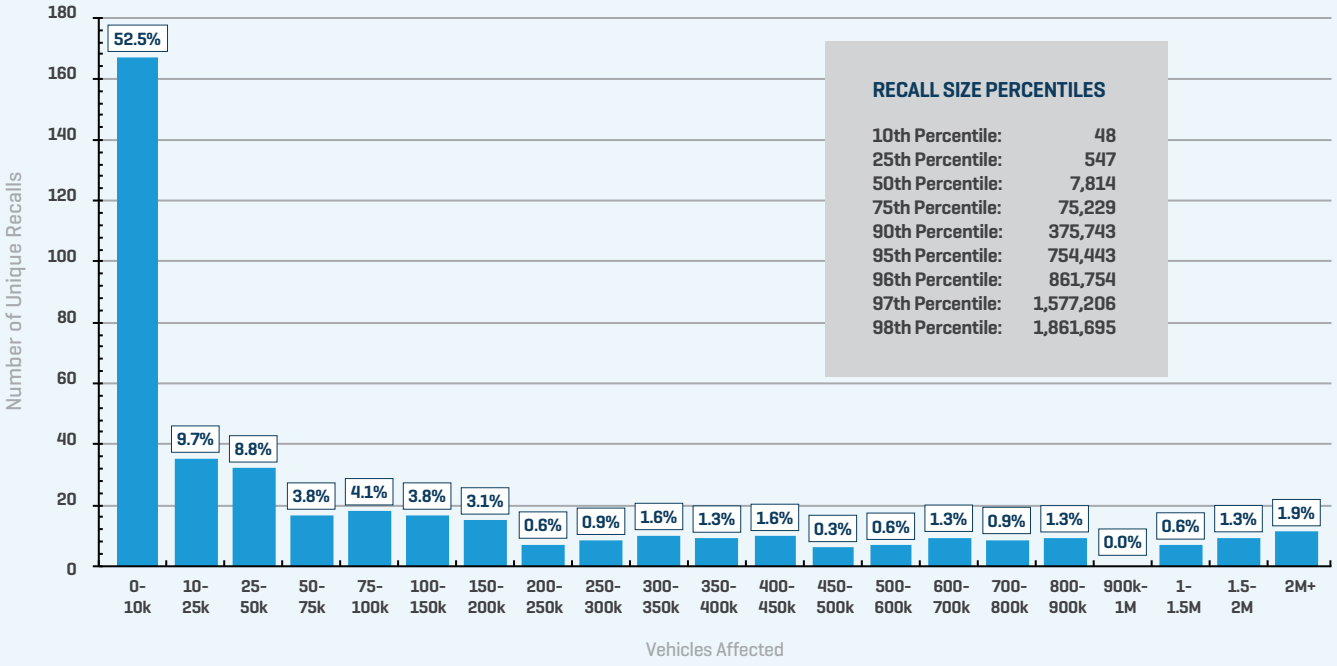

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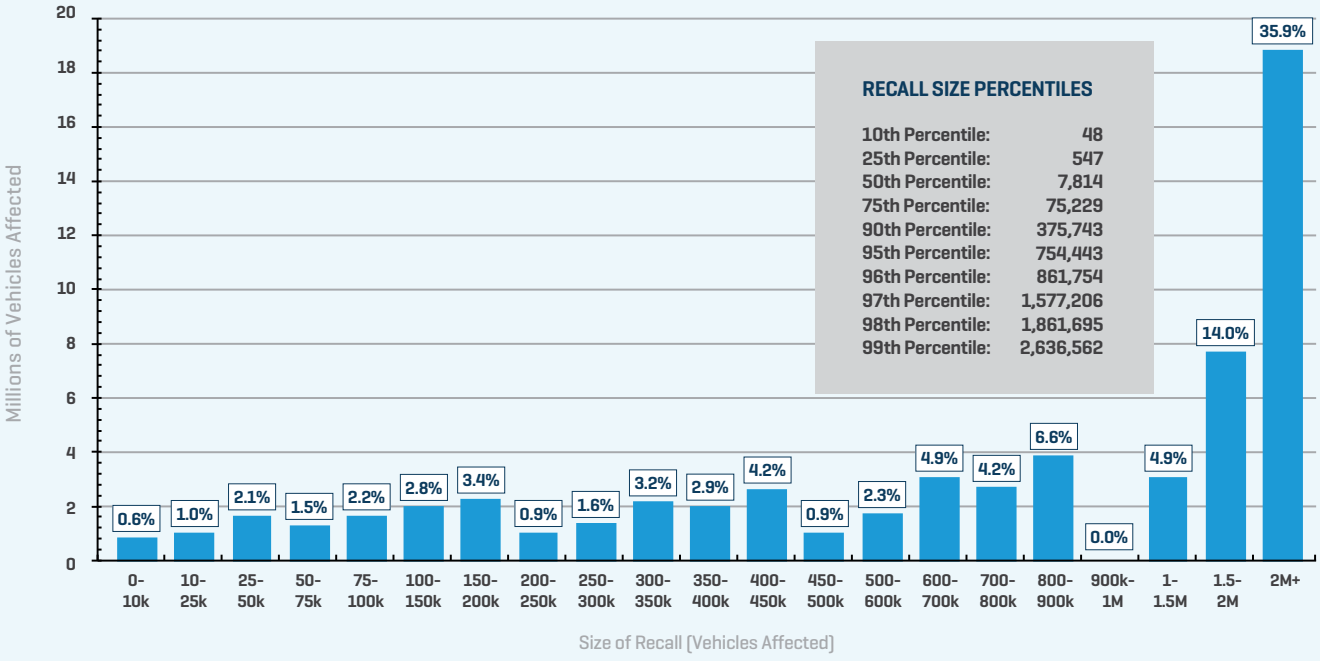
FIGURE 4:

Industrywide U.S. Recall Severity in 2016 (Distribution of Vehicles Affected by Recall Size)



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Nissan occupant classification system (3.3 million)

On April 26, 2016, Nissan announced campaign 16V244, affecting 2013-2017 model year vehicles, including: Nissan Altima, Leaf, Maxima, Murano, NV200, Pathfinder, Rogue, and Sentra; and Infiniti JX35, Q50, and QX60 vehicles. In the affected vehicles, the defect may cause the front passenger-seat occupant classification system to incorrectly classify an adult passenger as a child or classify the seat as empty despite being occupied, which may turn off the airbag and cause it not to deploy in an accident.

Ford door latches (2 million)

On September 9, 2016, Ford announced that it was expanding an existing door latch recall to include an additional 1.5 million vehicles. Campaign 16V643 affects 2013-2016 model year vehicles, including: Ford C-Max, Escape, Focus, Mustang and Transit Connect, and Lincoln MKC vehicles. The defect relates to a component within the door latch that may break, preventing affected doors from latching, and causing drivers or passengers to believe that a door is secure when it is not.

These three campaigns accounted for nearly 9 million vehicles recalled in 2016 and for more than 40% of the non-Takata vehicles recalled during the year.

INTEGRATED ELECTRONIC COMPONENT RECALLS INTENSIFY

One reason for the likelihood of sustained elevated recalls in the coming years is an increased number of defects related to software and integrated electronic components.

The continued development of new technologies to assist drivers, differentiate vehicles, and improve vehicle safety also poses recall risk. The widespread use of such innovations as adaptive cruise control, rear backup cameras, forward-collision detection, emergency braking, and brake assist improve vehicle safety, yet add complexity to safety-critical systems.

As is discussed in Section 5, recalls involving integrated electronic components and software have escalated in the last several years, including 2016. We expect this to persist. As vehicle technology continues to improve, such defects are likely to be detected early in a vehicle's life. Furthermore, new notification and remedy methods (such as "Over-the-Air," or OTA, software flashes) may significantly increase recall completion rates while also reducing costs.

AIRBAG RECALLS LEAD THE WAY

As noted in Figure 5, recalls of airbag components contributed significantly to the total units recalled in 2016.

While the Takata airbag campaign was the primary recall-related news story in 2016, there were other lesser-known airbag recalls during the year. A wide variety of airbag components were recalled by various OEMs with parts sourced across multiple manufacturers. Figure 6 demonstrates the trend of airbag component recalls for the last three years.

Airbags represent a complex series of components, relying on an inflator with chemical compounds, wiring, control units, and multiple sensors, in addition to a highly engineered bag that is intended to protect occupants in the event of a crash.

As noted in *Bloomberg Businessweek*[3]

Airbags aren't filled with air. They're filled with gas created by a burning propellant. Propellants are used in jet aircraft to produce thrust, in the interiors of gun chambers, and in mining and demolition. In airbags, the propellant is compressed into aspirin-size tablets and placed in a metal tube called an inflator. After a crash, the tablets are ignited and convert from solid to gas, which erupts out of the inflator and into the bag in milliseconds.

[3] June 2, 2016

FIGURE 5:

Unique U.S. Recall Campaigns by Component and Year

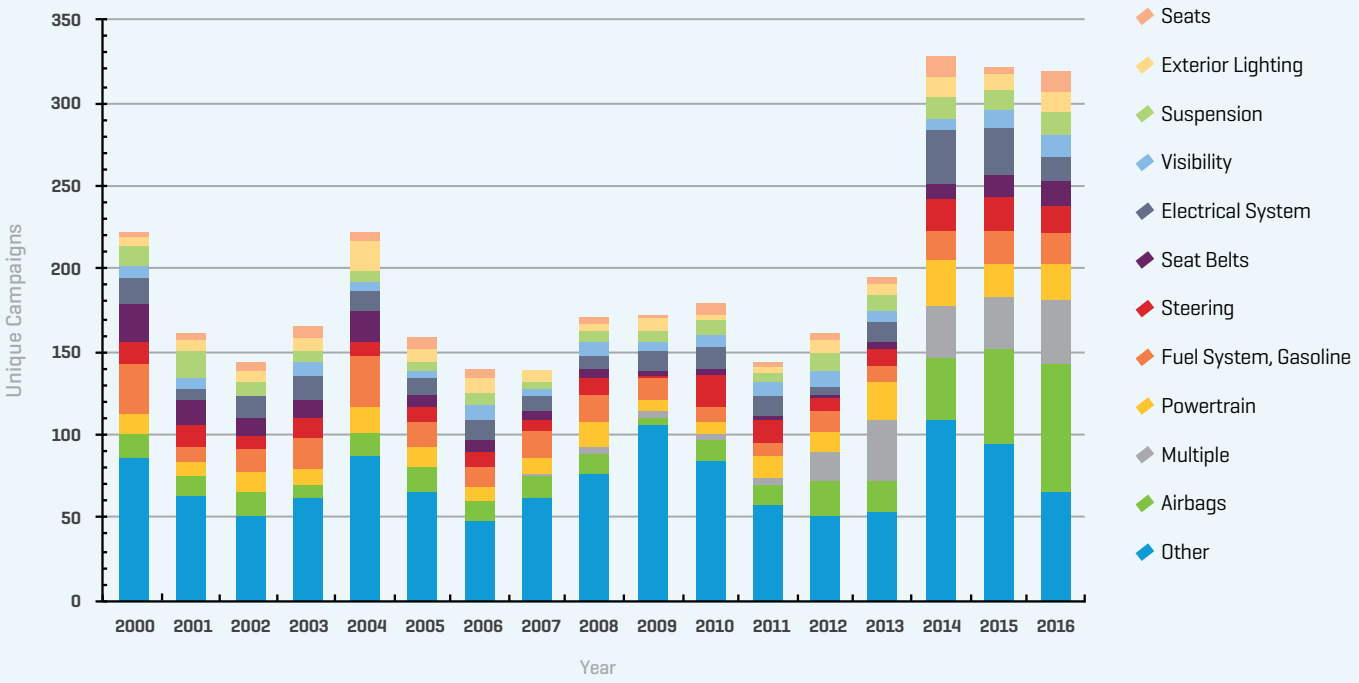

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FIGURE 6:

Unique U.S. Recall Campaigns of Airbag Components and Year

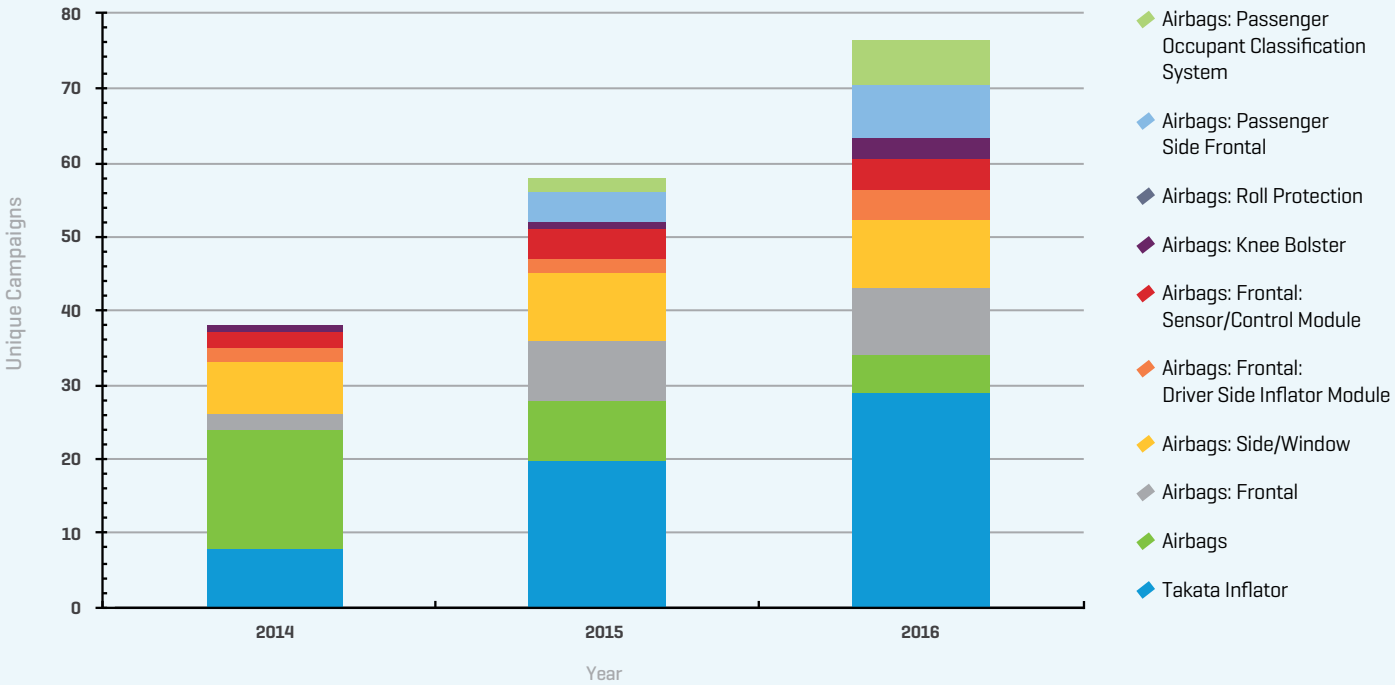

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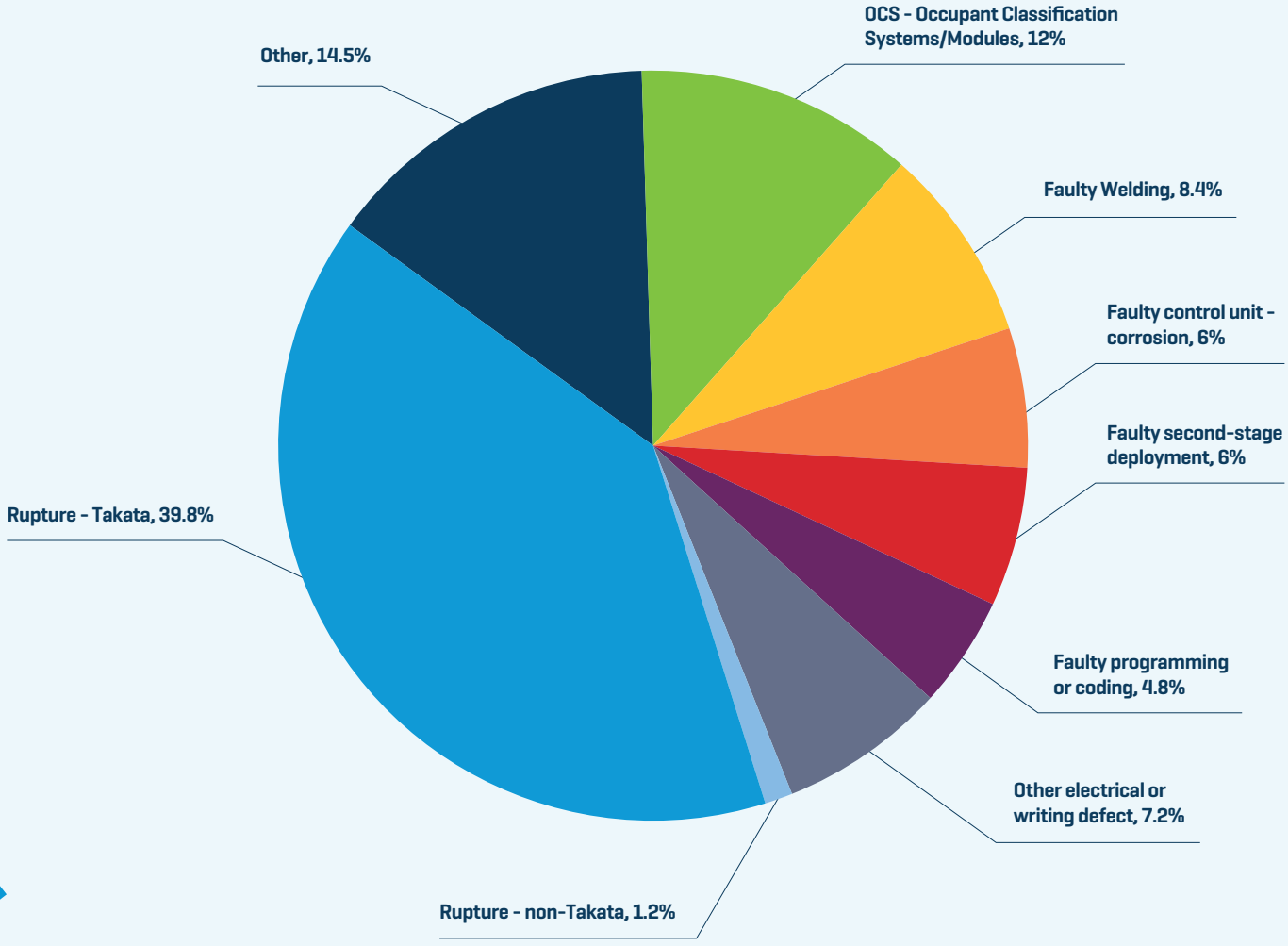
FIGURE 7:

Percentage of Unique 2016 U.S. Recall Campaigns With Airbags Listed as Component



This combination of carefully engineered components is integrated into a complex system intended to ensure split-second, life-saving deployment of airbags throughout the vehicle. While essential to occupant safety in modern vehicles, the intricacy of the system and the number of components that must function with great precision in very challenging circumstances also present the potential for defects in function and integration.

Figure 7 indicates that approximately 40% of the airbag-related recalls in 2016 involved the Takata defects that could result in inflator rupture. Other airbag flaws composed nearly half of the airbag-related recalls in 2016, including software malfunction and manufacturing defects, such as faulty welding and corrosion.

For example:

- Nissan recalled more than 3.3 million U.S. vehicles to repair sensors that might disable its airbags in a crash.
- GM announced a recall of approximately 3.6 million vehicles because their computers can, in rare cases, go into test mode and cause the airbags and seat belts to malfunction.

This increased attention on airbag safety and related component defects may have far-reaching effects. Vehicle owners may, for many years, be predisposed to an awareness of such defects, affecting vehicle owner confidence in airbag safety.

Additionally, it could positively impact completion rates for future airbag campaigns and work to elevate consumer perception that OEMs are dedicated to the safety of the passengers in their vehicles. In addition, OEMs and suppliers will certainly take note of the cost and difficulties of these recalls – likely resulting in renewed efforts for the improvement of airbag system reliability and functionality.

IDENTIFYING CHALLENGES

In the sections that follow, we will illuminate additional trends and observations from 2016. A consistent theme throughout this report is that the elevated levels of recalled vehicles over the last several years present significant challenges to both OEMs and suppliers. For OEMs, the development and integration of new technologies may prove to be powerful forces in vehicle sales, but also drive the potential for more defects and recalls. In addition, OEMs will face additional challenges as the industry looks to maximize completion rates for all vehicles – both new and old.

For suppliers, this new era of elevated recall volumes presents significant challenges, as well. Suppliers will be asked to bear the financial burden of many of these recalls – both large and small. However, not all suppliers and all components are equally disposed to the risks of recall.

Risk management related to recall is also entering a new era, and suppliers will need to react and adapt accordingly – developing new tools, using better data, instituting smarter systems, creating updated processes, and preparing for the years ahead, both financially and operationally.

SECTION 2:

Defects: A Deeper Look

"The costs of an automobile recall can be immense for an OEM automobile or light truck manufacturer – and potentially ruinous for a member of the industry's supply chain."

- **Alan Zeichick**, *D-Zone/ioT Zone* - August 14, 2016

This year, Stout expanded its review and analysis of defect descriptions of U.S. recalls in an effort to determine whether they appear to be more closely associated with supply, assembly, or manufacturing defects. By better understanding where they originate, we can assess the intersection of recall trends and industry trends.

For example, if we observe increases in defects that appear to be occurring at assembly facilities and for particularly complex integrated systems, we may look to see how supplier and OEM collaboration can improve to ensure adequate assembly.

Alternatively, we may see trends related to particular components that seem to have design-related defects.

We then explore ways for OEMs and suppliers to work together to improve the design process. Such assessments enable us to better appreciate trends in evaluating defects as well as how industry participants are resolving them and improving reliability.

This analysis also assists in understanding the degree of potential exposure suppliers have, and provides an opportunity for benchmarking. That is, if an OEM has a significant number of recalls involving defects that appear to be happening at their assembly facility, the likelihood for cost recovery from suppliers might be very different than that for an OEM affected by recalls that appear to be more closely related to manufacturing defects by the supplier. By understanding the mix of recalls and how they compare across OEMs, the industry can improve benchmarking as it relates to cost recovery solutions.

Stout reviewed thousands of defect descriptions for recalls from the last seven years and classified each as being potentially related to labels/manuals, assembly, manufacturing, or design – or as being unclear (Figure 8). Because our data sets are interconnected, we are then able to assess trends for various components, OEMs, model years, etc.

One finding is that the proportion of recalls that appear to involve supplier manufacturing-related defects has increased in the last few years. However, based on the number of vehicles affected (which has a significant impact on the cost of most recalls), both design and manufacturing defects increased in 2016 (Figure 9).

FIGURE 8:

Unique U.S. Campaigns by Defect Classification and Year

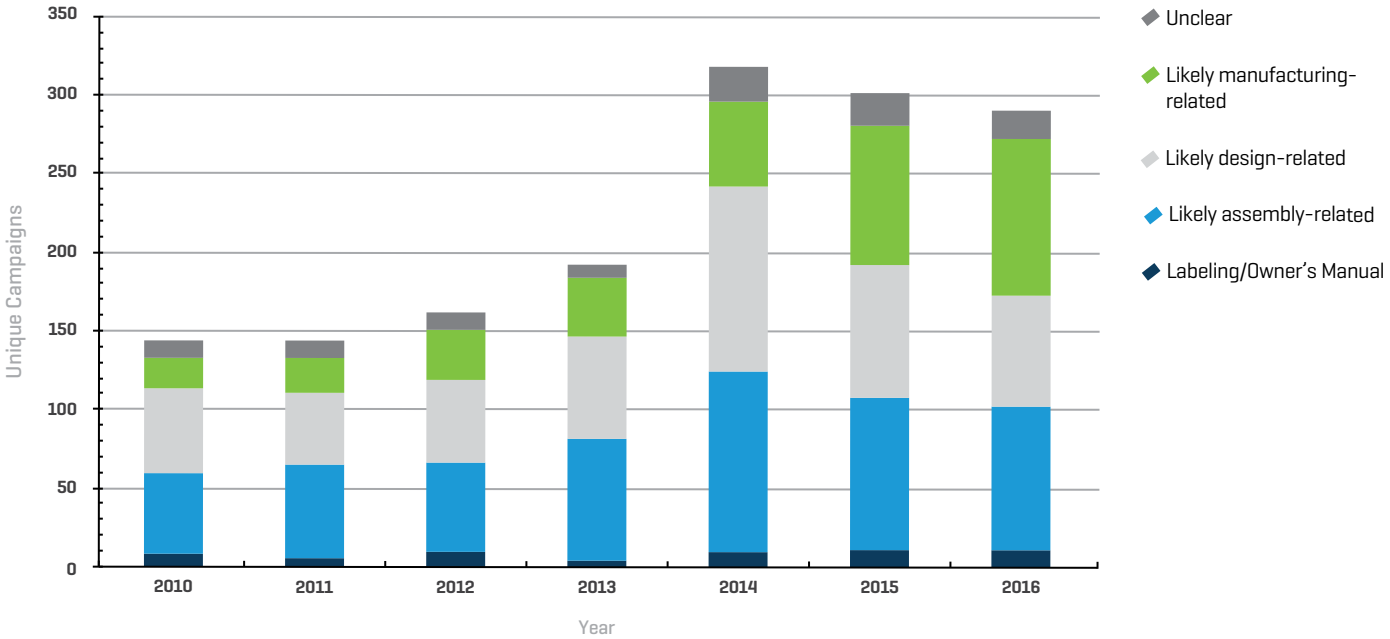


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FIGURE 9:

U.S. Vehicles Affected by Recall Defect Classification and Year

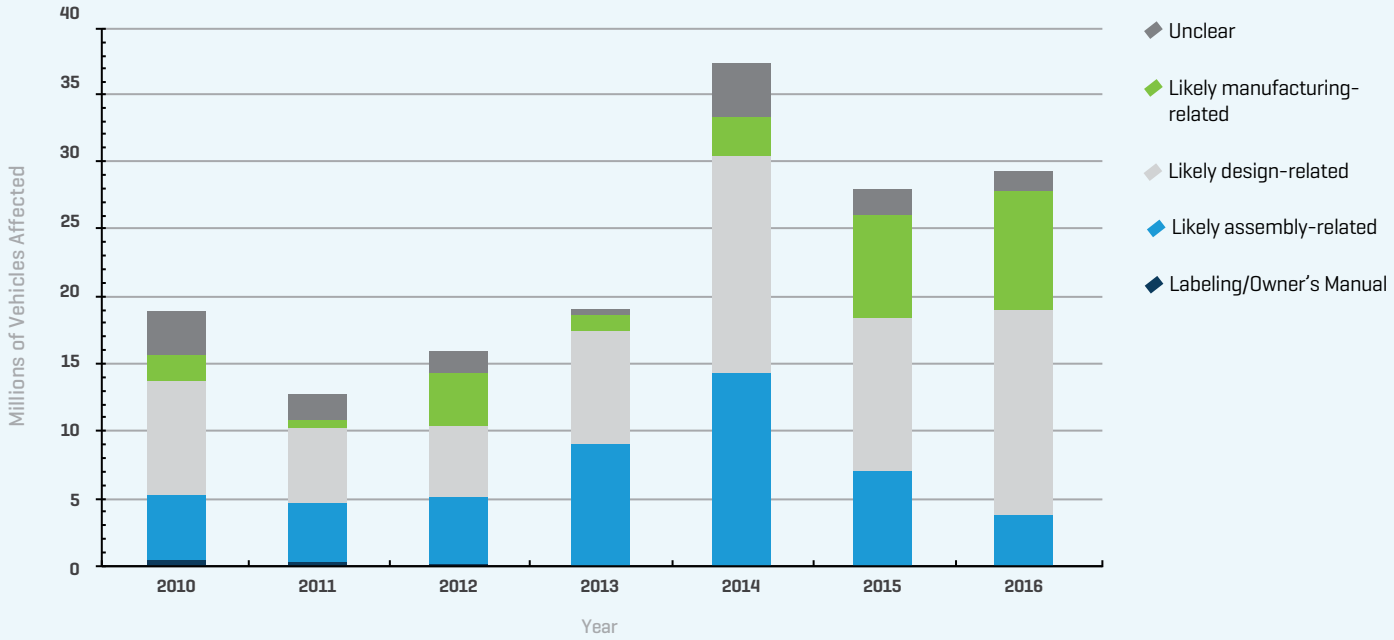

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FIGURE 10:

U.S. Vehicles Affected by Recall Defect Classification and Component (Since 2010)

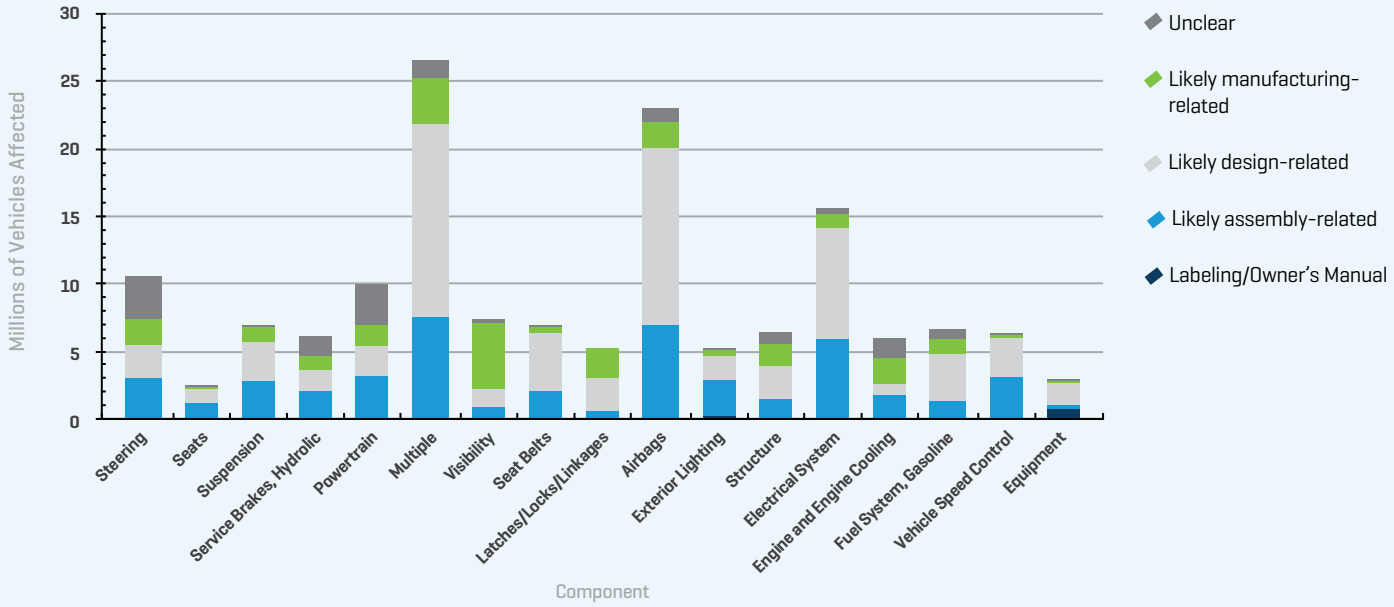

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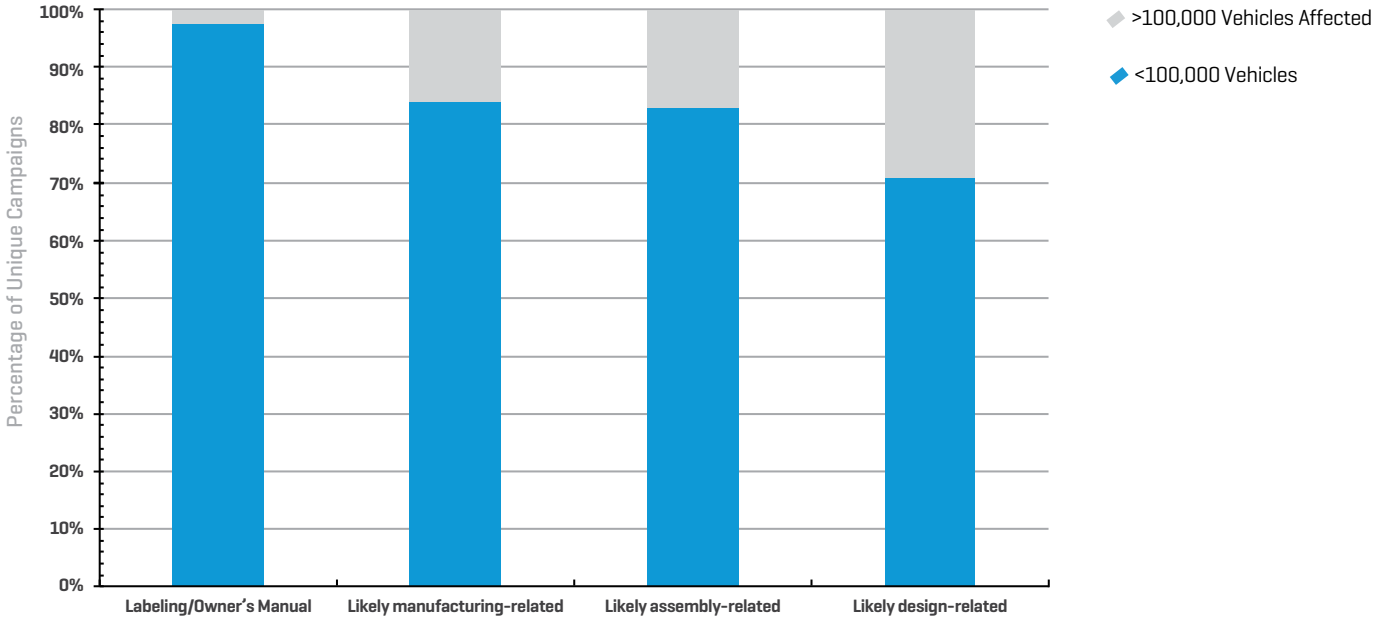
FIGURE 11:

Percent of Unique U.S. Recall Campaigns by Recall Defect Classification (Since 2012)



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In analyzing the distribution of issues across components, we observe significant differences in the proportions of recall for each type of defect. That is, the component matters. Certain components are more established, have been through years of manufacturing refinement, and are likely less susceptible to manufacturing defects (Figure 10).

For components that may be using new materials or newer processes and technology, the potential for manufacturing defects may be elevated. This is also an important consideration when conducting both risk analysis and benchmarking.

As illustrated in Figure 11, recalls that appear to have design-related defects tend to result in larger campaigns. This is consistent with the expectation that design defects can often affect larger vehicle populations, as they do not affect a particular range of manufacturing or assembly dates.

In contrast, a manufacturing recall would likely be limited to a particular time period when a machine was malfunctioning or not properly calibrated, thus affecting smaller vehicle populations.

THE RISKS OF DESIGN-RELATED COLLABORATION

In recent years, many OEMs have sought increased supplier collaboration on the design and engineering of components. This presents a unique challenge to suppliers. While collaboration with the OEM often enhances the quality and reliability of the component, as well as its integration with other systems, the supplier may be exposed to risks associated with a potentially large recall (Figure 11). This is frequently the case involving new technologies with which OEMs have less familiarity.

Even suppliers with internal controls related to collaborative design know that engineers from each entity – who spend their entire day thinking and talking about these parts – often communicate, resulting in ad hoc design changes. Emails and calls between engineers are a common way that suppliers find themselves inadvertently involved in design changes.

Think of it like the construction of a building. An architect has a plan, but the contractor on site might decide to move a wall, and gets permission directly from the building owner to make the change. Soon the building is dramatically different from the initial design, which can be a recipe for disaster if proper internal controls are not followed.

A new scenario is emerging, in which OEMs may insist that suppliers collaborate because of the need to integrate technologically dependent components, such as those in advanced safety systems. Suppliers need to enter into those arrangements with caution, and work to understand the potential risk exposure.

Design defects can also be challenging with respect to formal root cause investigations. Because of collaboration relative to sophisticated design, engineering, and integration, it is not always clear which party is responsible for a particular defect.

This ambiguity can lead to challenging legal battles and strained relationships.

It is possible the OEM and supplier can amicably sort out the issue and quickly come to an agreement. However, litigation is another possibility that could cost hundreds of millions of dollars, putting the supplier's profits – or the company itself – at risk.

PREPARING FOR COLLABORATION

Recalled units associated with potential design defects have escalated, in part, because of the incorporation of components that have to function within increasingly complex and integrated systems. As systems change and the demands on their components evolve, the components' designs may need to be modified.

Based on our review of defect descriptions and recall data sets, our analysis demonstrates that suppliers do have the ability to use these findings to make more informed business decisions regarding the components they supply.

Specific analyses can be completed for individual components, similar components, or component groups that enable suppliers to fully understand the defects and circumstances for the components they supply. A combination of internal and external data, combined with a collaborative, iterative feedback process, can empower a supplier to better understand its risks and how to mitigate them.

When a supplier has significant history in manufacturing specific components, being involved in design-change discussions with an OEM may be reasonable.

For a new component using a new material, it may be important to understand whether other suppliers have been involved in recalls, the nature of the defect, whether the defects were design- or manufacturing-related, and what risk mitigation strategies could be deployed. All of these considerations can influence pricing, contracting, engineering, operations, and the related strategies to be informed about risks and how to mitigate them or account for them.

Suppliers cannot afford to put their heads in the sand. They need to invest in internal risk assessments to know what they are facing and to develop risk strategies across sales, engineering, insurance, risk management, legal, etc. – all of which have the opportunity to assist in measuring, understanding, and mitigating recall risk.

Certain suppliers have anticipated this change and are retooling their sales and risk processes. They are conducting overhauls of virtually every part of their organizations: adding new data centers, external validation, improved collaboration, and continuous cross-functional recall and defect-related feedback systems. But many suppliers are slow to react and still unsure what they can or should do.

Before the recent increase in vehicle recalls, suppliers could pin their recall reactions on hope – hoping the recall will not happen, and, if it does, hoping that it will not be large and that the OEM will be understanding and not seek cost recovery.

Hope was never a great strategy, and it is a terrible one now because recalls are much more likely. For many suppliers, the exposure can be significant, and the ultimate costs painfully substantial. Strategy starts with understanding the information that is available – internal and external – and then developing plans and solutions based on a more refined understanding of potential problems.

SECTION 3:

Risks of Global Exposure

In addition to analysis of U.S. recall and defect information, we expanded our review of international data this year. International recall data and trends have become particularly relevant in recent years, as the use of global vehicle platforms has intensified.

When considering global vehicle volumes, the size and cost of recalls can expand significantly, as evidenced by the Volkswagen and Takata campaigns. As OEMs embrace global platforms – using the same or a similar platform for automobile production across multiple countries – they become more vulnerable to a large-scale recall.

Stout examined publicly available databases in several countries and compiled a comprehensive and exclusive analysis of the records. We also reviewed NHTSA records of international recalls involving vehicles substantially similar to those sold in the U.S.

4 Years of increased U.S.-type recalls

OEMs inform NHTSA about campaigns that are being conducted in a foreign jurisdiction in which the vehicles involved are substantially similar to those sold in the U.S. Figures 12 and 13 show that the number of these campaigns and vehicles affected has spiked in the last four years, likely influenced by forces similar to those in the U.S., as well as the increasingly global automotive supply chain.

FIGURE 12:

Count of Unique NHTSA Substantially Similar Foreign Campaigns by Year

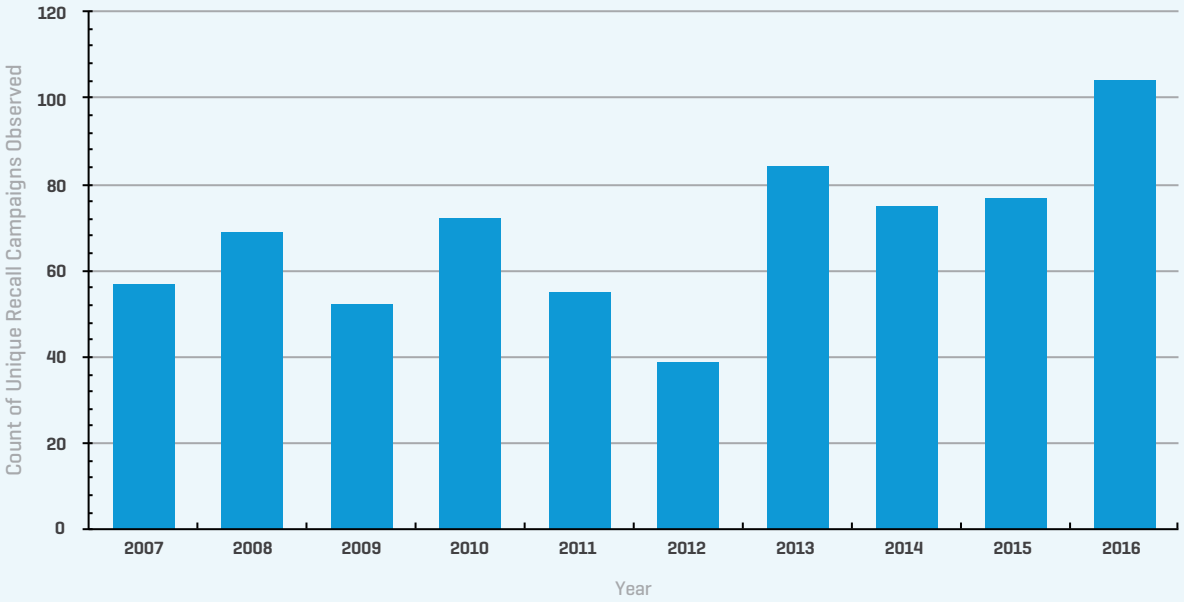

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FIGURE 13:

Vehicles Affected by NHTSA Substantially Similar Foreign Campaigns by Year

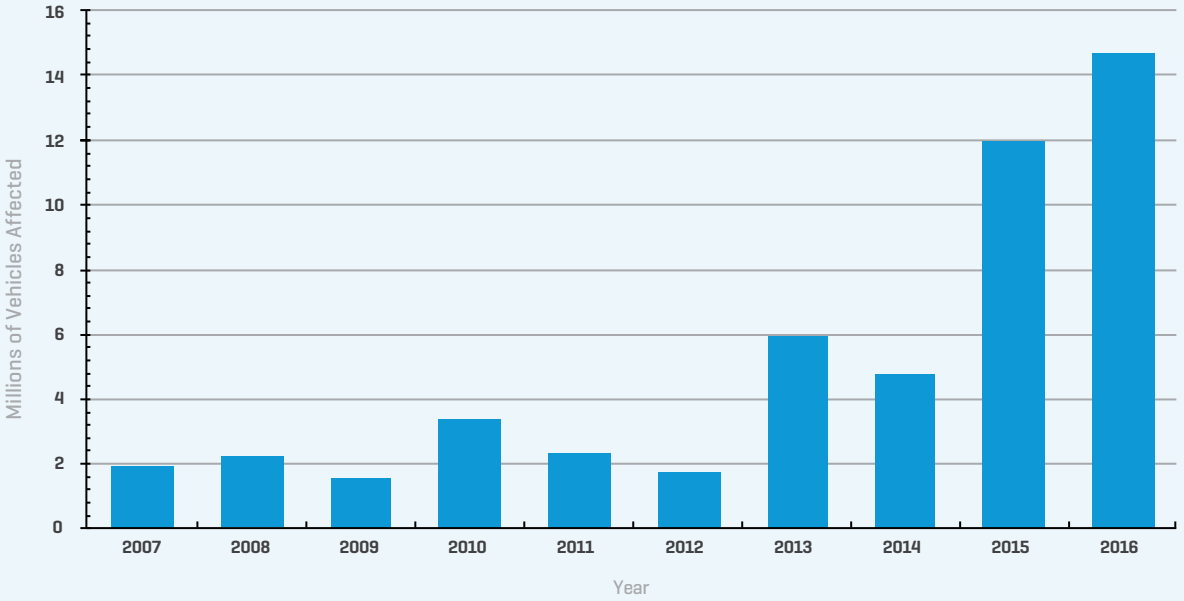

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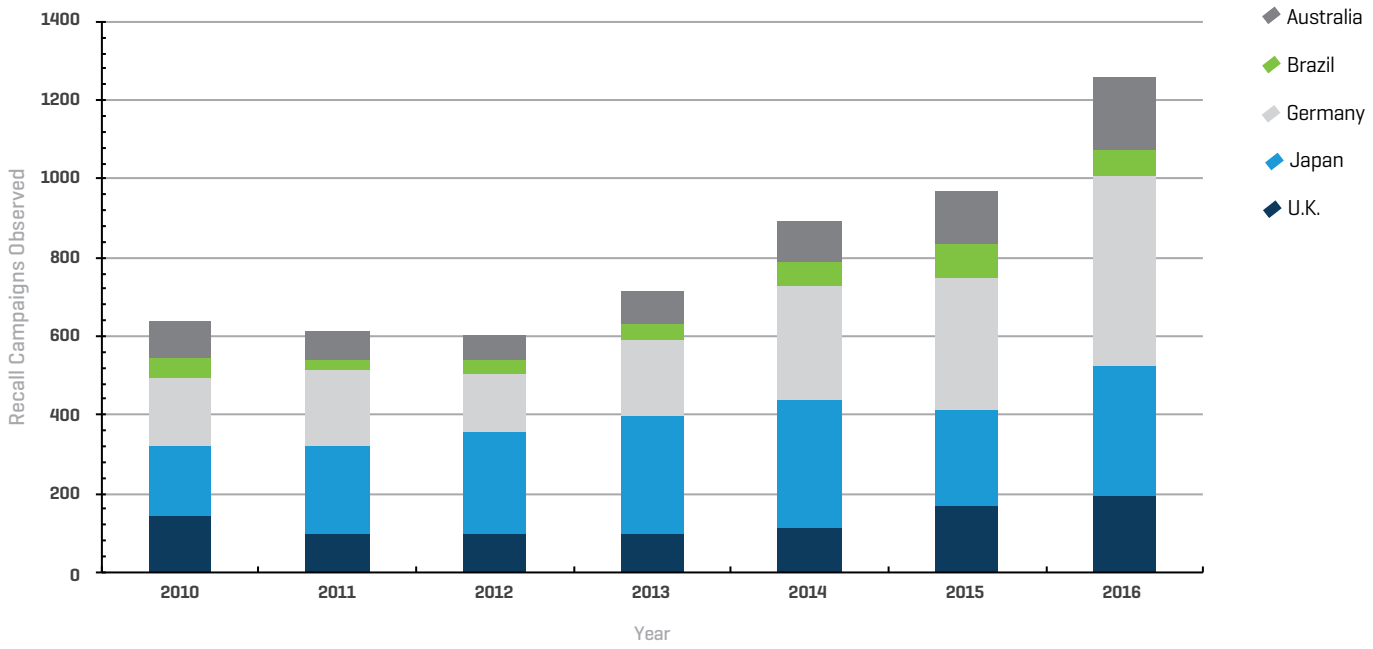
FIGURE 14:

International Recall Campaigns by Country and Year



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The trend toward globalization and common platforms is likely to continue, as there are significant efficiencies and cost savings associated with this strategy. However, it may also present additional exposure for the suppliers of components for these vehicles – another important consideration for suppliers as they re-evaluate their recall and defect risk.

In addition to assessing the risks related to a potential recall in the U.S., suppliers must also consider their global exposure and related costs for certain components.

Stout also took a deep dive into the recall numbers of five other countries – U.K., Japan, Germany, Brazil, and Australia. Figure 14 shows the number of unique recall campaigns observed in each country for which we were able to collect data.

It should be noted that gathering and analyzing such data takes tremendous effort, because the information made available and the format in which it is presented can differ significantly from one country to another.

As each locale has its own requirements for reporting, the information contained in the data collected by Stout varies by country.

Generally, each country provides information indicating the number of vehicles potentially affected: their makes, models, model years, and the defect descriptions. Because of the variation in the availability and accessibility of this data, Stout's analysis relies upon manual review of the information provided by each country.

As seen in Figure 14, nearly all of the countries we analyzed demonstrated increases in the number of recall campaigns. This is similar to the trend observed in the U.S., though the increase has been more gradual in the international markets.

"If something goes wrong with the base of a platform that was used for hundreds of thousands of vehicles, the recall is going to be horrendously expensive."

– **Sebastian Toma,** *Autoevolution* - January 17, 2017

Figures 15 and 16 are reflective of the component analyses Stout developed for each country analyzed. This data provides a number of interesting insights, and opportunities for further analysis. Of particular note is the increased proportion of airbag component recalls, which is similar to that observed in the U.S. This means the issues associated with airbag components appear to be a global problem.

In our first analysis of data gathered from international data sets, we have observed consistency with trends in the U.S. and across these foreign jurisdictions. While there are certainly nuances within the data, the overall trends appear to be similar – increasing volumes of recalled vehicles, particularly related to airbag components. Platform globalization is likely a contributing factor to this trend. This influence provides certain economic efficiencies for OEMs, but it may place them and their suppliers at more risk associated with global recalls.

FIGURE 15:

Percent of Unique German Recall Campaigns by Component and Year

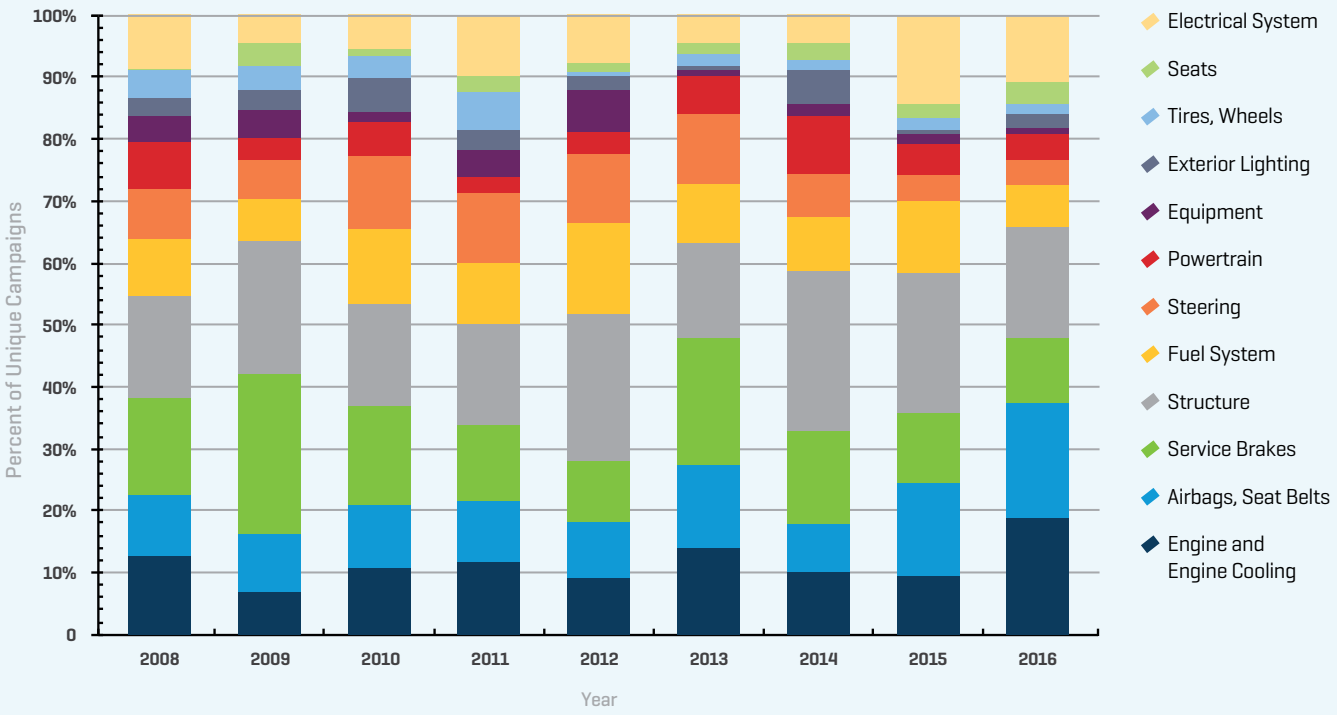
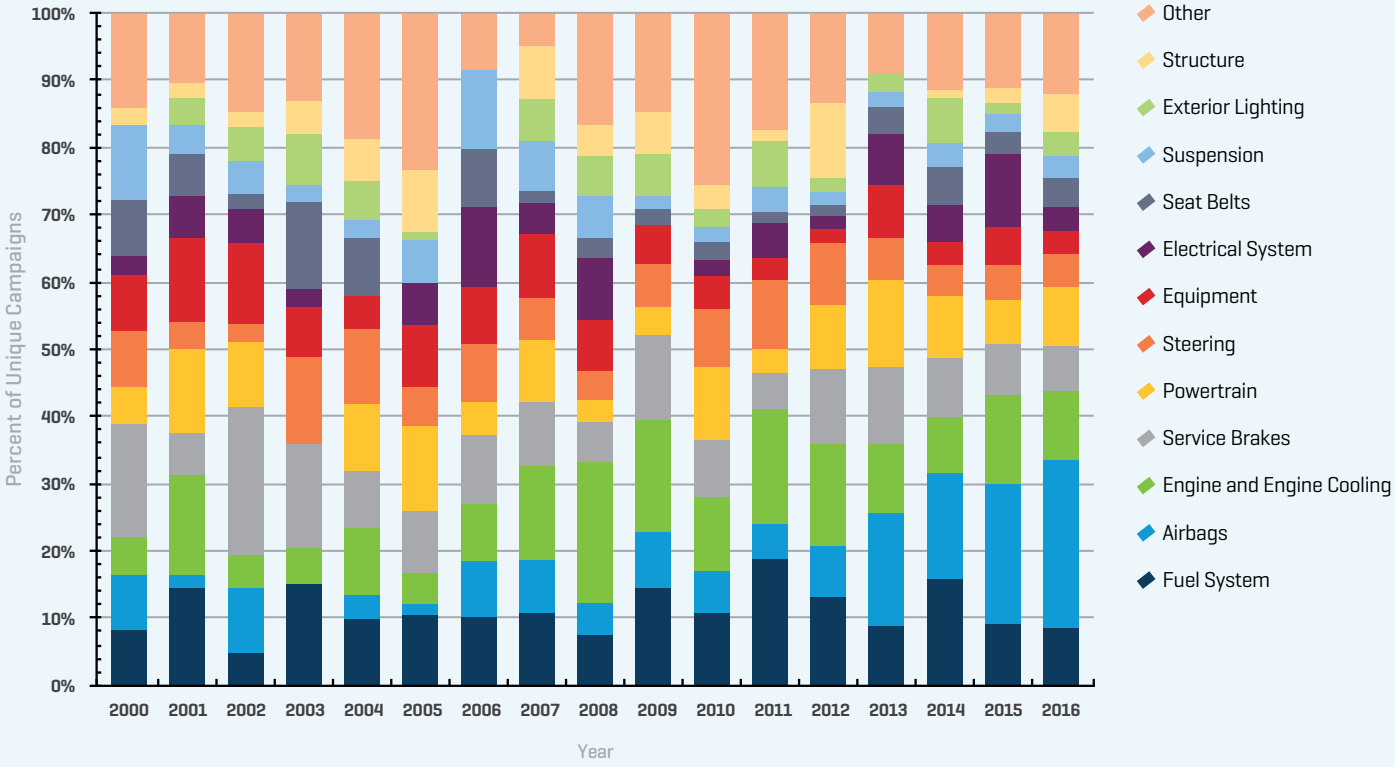


FIGURE 16:

Percent of Unique Australian Recall Campaigns by Component and Year



SECTION 4:

MVDPs and PINs

Beyond data related to recalls and investigations, there are additional sources of information associated with motor vehicle noncompliance that can help us identify nascent trends and provide insight into how NHTSA considers which issues may pose an unreasonable risk to vehicle safety and which do not.

Specifically, Motor Vehicle Defect Petitions (MVDPs) and Petitions for Inconsequential Noncompliance (PINs) provide information related to potential issues of noncompliance identified by consumers, safety advocates, and manufacturers. NHTSA's responses to both sets of petitions can help us more fully understand the agency's perception of safety risks.

MVDPs and PINs can, in certain instances, be particularly instructive for suppliers. When supplemented with internal data and expertise, and external data regarding recalls, investigations, and technical service bulletins, these petitions can provide further clarity for the supplier regarding when a defect may necessitate a recall or have an elevated perception of risk.

MOTOR VEHICLE DEFECT PETITIONS (MVDP)

MVDPs provide unique insight into the manner in which NHTSA evaluates safety concerns, and whether a defect affects driver safety. The filing, granting, and denial of MVDPs may also be an early indicator of defects, field service actions, and recalls.

Under 49 U.S.C. 30162(d), the public has the ability to petition NHTSA to open an investigation into a suspected defect or whether a manufacturer has appropriately conducted the recall notification and remedy process.

According to NHTSA.gov:

Any person may submit a petition requesting NHTSA to open an investigation into an *alleged safety defect.* After conducting a technical analysis of such a petition, [the Office of Defects Investigation] informs the petitioner whether it has been granted or denied. If the petition is granted, a defect investigation is opened. If the petition is denied, the reasons for the denial are published in the Federal Register. Similarly, a person may submit a petition requesting NHTSA to hold a hearing on whether a manufacturer has *reasonably met its obligation to notify and/or remedy a safety defect or noncompliance with a federal motor vehicle safety standard.* If the petition is granted, a hearing is held to assess the matter and decide what corrective action should be taken. If the petition is denied, the reasons for the denial are published in the Federal Register. [Emphasis added through italicizing]

Here are examples of defect petition denials from 2016. The information was excerpted directly from the petitions themselves. [Emphasis added through italicizing]

Toyota Electronic Throttle Control

This MVDP alleged a defect in the electronic throttle control software in Toyota vehicles, causing unexpected vehicle acceleration while traveling at slow speeds and attempting to park.

> "Reports of braking ineffectiveness in controlling a vehicle experiencing the onset of unintended acceleration from a stopped position or when moving slowly requires an explanation for the ineffectiveness, such as physical evidence of damage to the brake system. *Under these circumstances, investigating for phenomena other than pedal misapplication absent an explanation for the ineffectiveness of the brakes, which are independent of the throttle control system and are designed to dominate engine torque, is not likely to be useful.*"

Volvo Truck Cab Sway

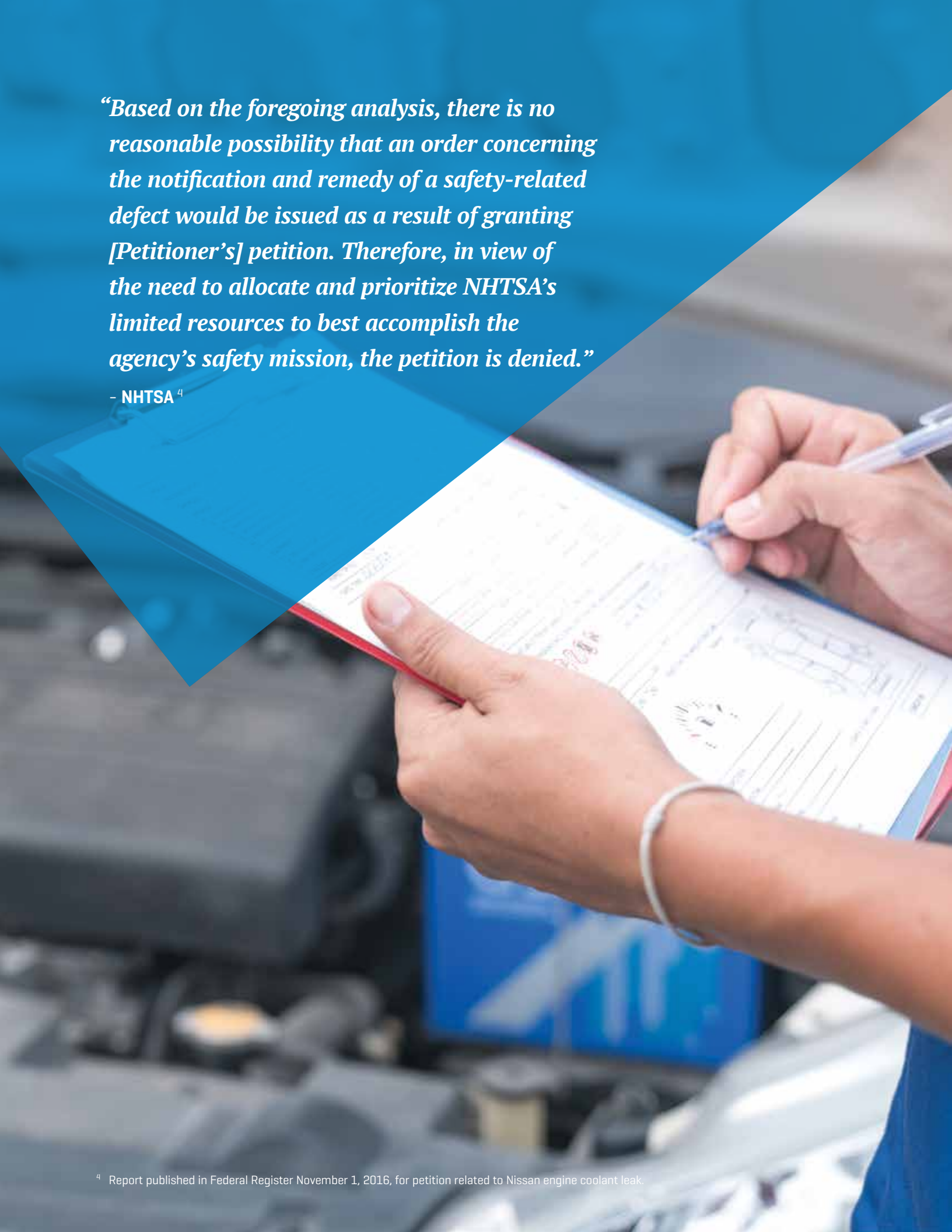
This petition alleged that there was a defect on Volvo trucks involving cab sway, cab misalignment, bottoming out, and loss of control issues related to crash-avoidance systems.

> *"This alleged defect does not adversely affect vehicle control.* Furthermore, the advanced safety systems are controlled by inputs on the chassis and not the cab; therefore, the systems are not affected."

Nissan Engine Coolant Leak

Petitioner alleged a defect related to automatic transmission failures due to engine coolant leakage in 2005-2010 Nissan vehicles. Complaints included "sudden jerking" and "loss of control" in vehicles. Nissan extended the warranties on these vehicles in 2010 and 2012.

> "The Office of Defects Investigations (ODI) has opened many defect investigations into engine stalling and/or loss of motive power. The majority of investigations resulting in safety recalls involved a complete loss of motive power, frequently



"Based on the foregoing analysis, there is no reasonable possibility that an order concerning the notification and remedy of a safety-related defect would be issued as a result of granting [Petitioner's] petition. Therefore, in view of the need to allocate and prioritize NHTSA's limited resources to best accomplish the agency's safety mission, the petition is denied."

– **NHTSA** [4]

[4] Report published in Federal Register November 1, 2016, for petition related to Nissan engine coolant leak.

accompanied by loss of power-assist to steering and brake systems (the latter conditions not present here). *Factors that support recalls to remedy these conditions include a lack of warning or precursor symptoms to the driver; stalling during power-demand situations such as accelerating or to maintain highway speeds / uphill grades; and an inability to immediately 'restart' or restore mobility to a stranded vehicle. Absent very high failure rates in new vehicles, NHTSA has not successfully pursued hesitation, reduced engine power modes, or stalling outside the conditions listed above, primarily because these conditions have not been found to demonstrate an unreasonable risk to motor vehicle safety.* Experience of harsh shifting and transmission degradation over time would typically fall into this category, even if it leads to an eventual loss of motive power condition."

NHTSA's analysis of the alleged defects and discussion of conclusions reached is instructive. In all three of the recent examples provided, NHTSA provides insight into what could render a defect to be considered an unreasonable risk to vehicle safety. Specifically, NHTSA takes into account whether the driver can control a vehicle when the defect is manifested.

In the third example, NHTSA also explains that a warning to the driver from the vehicle – either through notification or precursor symptom – might also mitigate the potential safety risk.

For suppliers of components that might affect vehicle control, these recent MVDPs may be particularly instructive, as they provide additional input to the risk assessment framework.

When using internal and external data sets to evaluate risks the supplier may face, MVDPs such as these may help the supplier prioritize risk mitigation opportunities. For example, suppliers might aim to achieve certain defect outcomes that minimize the risk to vehicle safety in a manner similar to that expressed in the MVDP decisions.

MVDP trends must be carefully evaluated. The review and decision-making relating to each is based on the information provided to NHTSA and the research and analysis it conducts. Regardless, the filing, granting, and denial of MVDPs are important data points to monitor.

The granting of MVDPs may be an early indicator of necessary recalls or technical service bulletins, in addition to demonstrating the tone, focus, interests and perspectives coming from the NHTSA regarding certain components and the threshold for safety concerns. They may also indicate the dedication of NHTSA resources to review, analyze, and respond to concerns raised by consumers and other interested parties.

PETITIONS FOR INCONSEQUENTIAL NONCOMPLIANCE (PIN)

Manufacturers can petition NHTSA to alert the agency of a potential violation that the manufacturer believes is an inconsequential issue that does not pose a safety risk. Whereas MVDPs are petitions to further investigate potential defects, PINs are petitions to allow noncompliance with no further action.

By NHTSA's grant of a PIN, the manufacturer is relieved of any further responsibility to provide notice and/or remedy the defect or noncompliance. A denial will continue to enforce all duties of the manufacturer relating to notice and remedy of the defect or noncompliance. Examples of issues that are commonly the subject of such petitions include misspelling on a safety label that would not likely lead to confusion, failure of a cupholder mechanism, and seat cushions that fail to meet the burn rate requirements set forth by NHTSA.

Given the inconsequential nature of eligible noncompliance issues, many such petitions are granted. However, in certain instances the PIN involves a potential issue that may affect vehicle safety more significantly. In these instances, similar to an MVDP, there can be unique insights into when NHTSA believes noncompliance poses risks to safety. In these instances, OEMs may perceive that there is

not a risk to vehicle safety, and NHTSA might agree or disagree. Regardless, PINs can also provide a unique opportunity for suppliers to better understand the gradations of safety risk and when noncompliance may require a recall.

Indeed, NHTSA has denied only six PINs in the last five years (see below).

A review of the denials below highlights NHTSA's consideration of noncompliance related to lighting, and the agency's reluctance to identify them as inconsequential to vehicle safety. A position sometimes taken by manufacturers related to lighting noncompliance is that the photometric performance of the subject lamp is within a 25% threshold of minimal zonal requirements, otherwise known as a "just noticeable difference," or "JND," argument.

PINs denied in the last five years

2013

A Ford petition related to the formation of air bubbles in the windshield of F-Series trucks when subjected to high temperatures

2014

A Daimler (Mercedes Benz) petition related to a tire pressure monitoring system software glitch that resulted in the indicator light not illuminating properly

2014

A GM petition in which the indicator for a turn signal failure of a multiple-bulb turn signal would not illuminate until all bulbs failed

2015

A GM petition related to the height of letters in labels that were applied to compressed natural gas vehicles

2015

A Daimler (Mercedes-Benz) petition related to the candle power output level of turn signals resulting from a programming issue

2016

A Daimler (Mercedes-Benz) petition related to the sealing caps of a horizontal adjustment screw associated with visually aimed headlamps

Such assertions are based upon a 1994 NHTSA study demonstrating that a change in "luminous intensity" of 25% or less is not noticeable by drivers. However, NHTSA has rejected this position, stating that:

"Drivers do not look at zones when they observe lamps; they look at the lamps from very narrow angles based on the distance between their eyes and the distance to the lamps. Using the JND justification on zones would imply that drivers would be looking at lamps from all the test points in the zone simultaneously and somehow integrating the numerous intensities into some false representation of how intense the lamps should be."[5]

Similar to MVDPs, NHTSA's decisions regarding PINs may be an early indicator of necessary recalls. In addition, such decisions may provide indications of NHTSA's tone, focus, interests, and perspective regarding certain components and the threshold for safety concerns. When combined with internal and external data and analysis, MVDPs and PINs can assist suppliers in more fully understanding and mitigating risks related to potential defects and noncompliance.

[5] Docket No. NHTSA-2012-0165, Notice 2; 2014-16552.

SECTION 5:

Why Technology-Related Recalls Are Increasing

"Autopilot is getting better all the time, but it is not perfect and still requires the driver to remain alert."

- Tesla statement after the death of Joshua Brown in a Tesla Model S [6]

In a similar way that smartphones are small, powerful computers that also allow you to talk, cars are as much about the interaction between the onboard software and electrical systems – and the safety and entertainment features they enable – as they are machines that get you from point to point.

As with any apparatus or device, software bugs and innumerable electrical issues can happen in ways no one could have anticipated during the design and manufacturing stages. This is particularly the case given the physical environment many components in a vehicle are exposed to throughout the four seasons, including extreme cold during the Alaskan winters, heat and humidity in South Florida, dry desert conditions in the Southwest, and a variety of changing climates in mountain areas.

Based on our review of recall and defect data, we identified two significant issues suppliers may need to be concerned with when they provide components for integration with technologically advanced equipment:

[6] Company statement on Tesla.com, June 30, 2016

1. Suppliers do not always know the extent of other components in the system or understand how those components and their own will interact. These myriad parts are all intertwined in a living, breathing, thinking ecosystem that must function seamlessly in ways few would have anticipated even 10 years ago.

2. Even if multiple components in the system communicate well, suppliers need to realize that the physical environment can cause risks that could affect the performance of the software. For example, extreme temperatures, humidity levels, objects hitting a car, skidding, and low-impact collisions are just a few of the seemingly minor situations that could ultimately compromise the safety of an entire vehicle.

SOFTWARE VS. CIRCUIT BOARD RECALLS

This year, we expanded our scope to technology-related recalls, which also includes three types of software defects. We can now track multiyear analysis of defects caused by:

Software integration

Software on one component that does not communicate correctly with another component or piece of software.

Software defect

Software controlling a component needs to be fixed because it was programmed incorrectly, or was programmed correctly but is not working.

Software remedy

Software flash or replacement is identified as the appropriate remedy for a component defect.

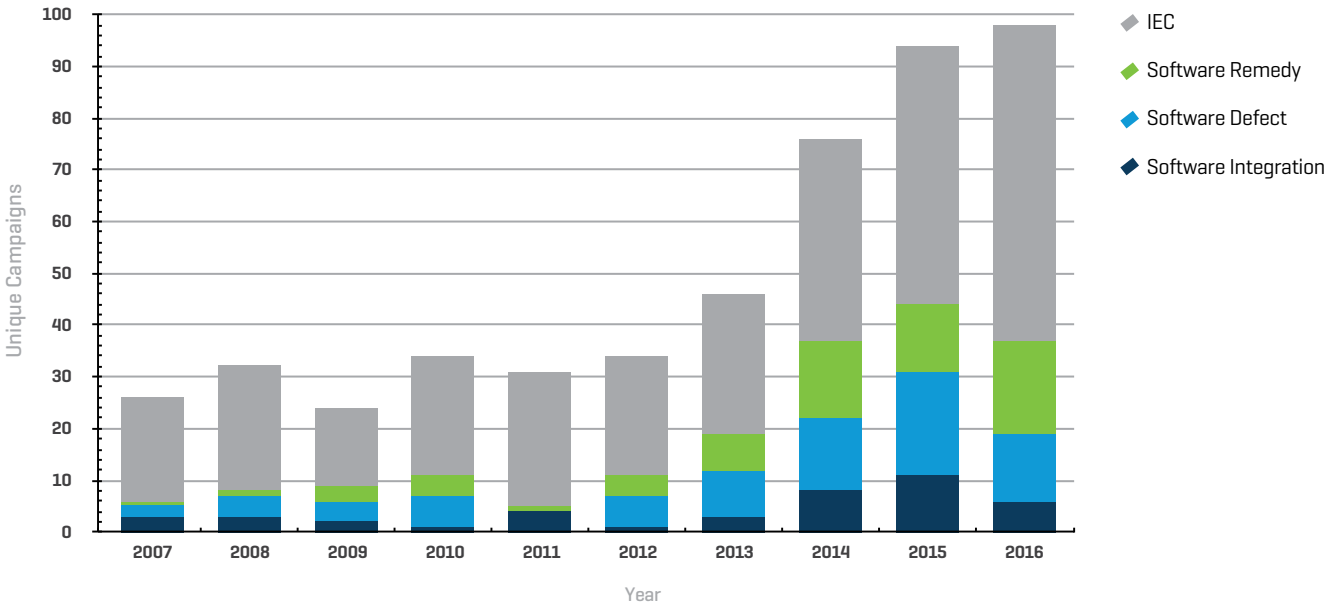
Integrated Electrical Components (IECs)

Malfunction or failure of electrical components due to physical defect. This includes defects related to water intrusion, wiring failure, etc.

As Figure 17 indicates, defects due to failures with IECs, which serve as the backbone for the automobile's electrical system, are much more prevalent.

FIGURE 17:

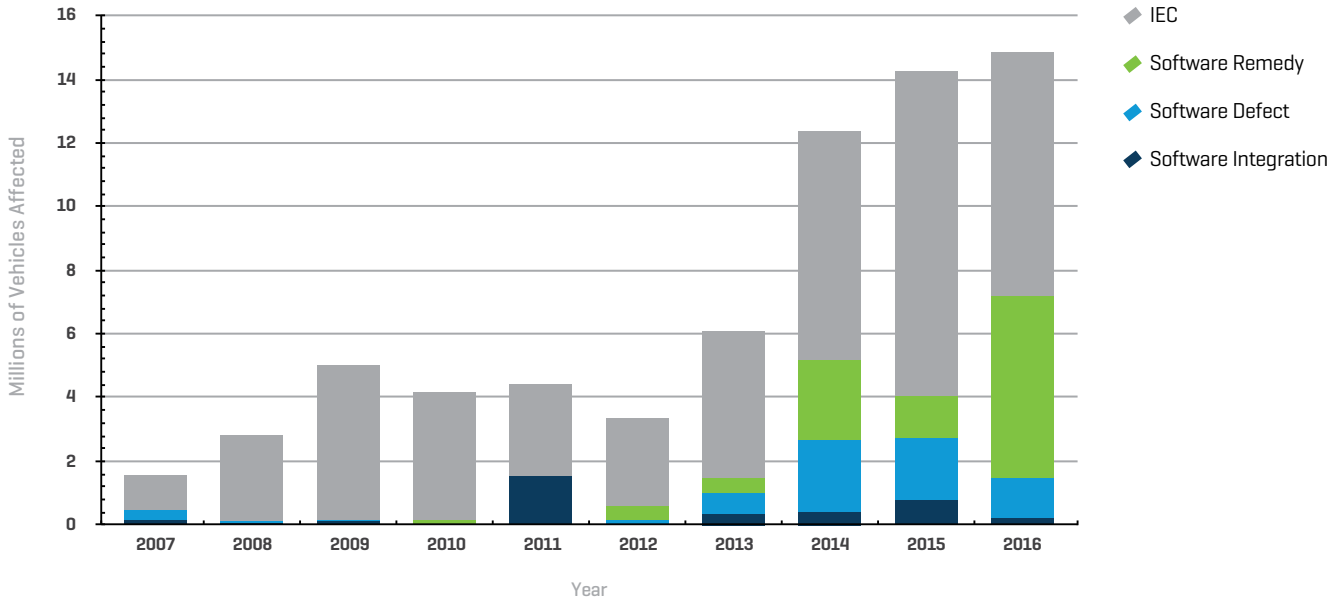
U.S. Recalls of Electronic Components by Year



Contains data for BMW, Daimler AG, FCA, Ford, General Motors, Honda, Hyundai, Kia, Toyota, Volkswagen, and Volvo.
Identified from data set updated through 2016. Excludes Takata Inflator recall campaigns.

FIGURE 18:

U.S. Recalls of Electronic Components Year



Contains data for BMW, Daimler AG, FCA, Ford, General Motors, Honda, Hyundai, Kia, Toyota, Volkswagen, and Volvo. Identified from data set updated through 2016. Excludes Takata Inflator recall campaigns.

Technology-focused recalls, as Figure 18 shows, affected more than 14 million automobiles in 2016.

Software recalls are much more common in newer vehicles, which tend to contain more high-tech content than older ones, and automakers and drivers will often know very quickly if software is not working correctly.

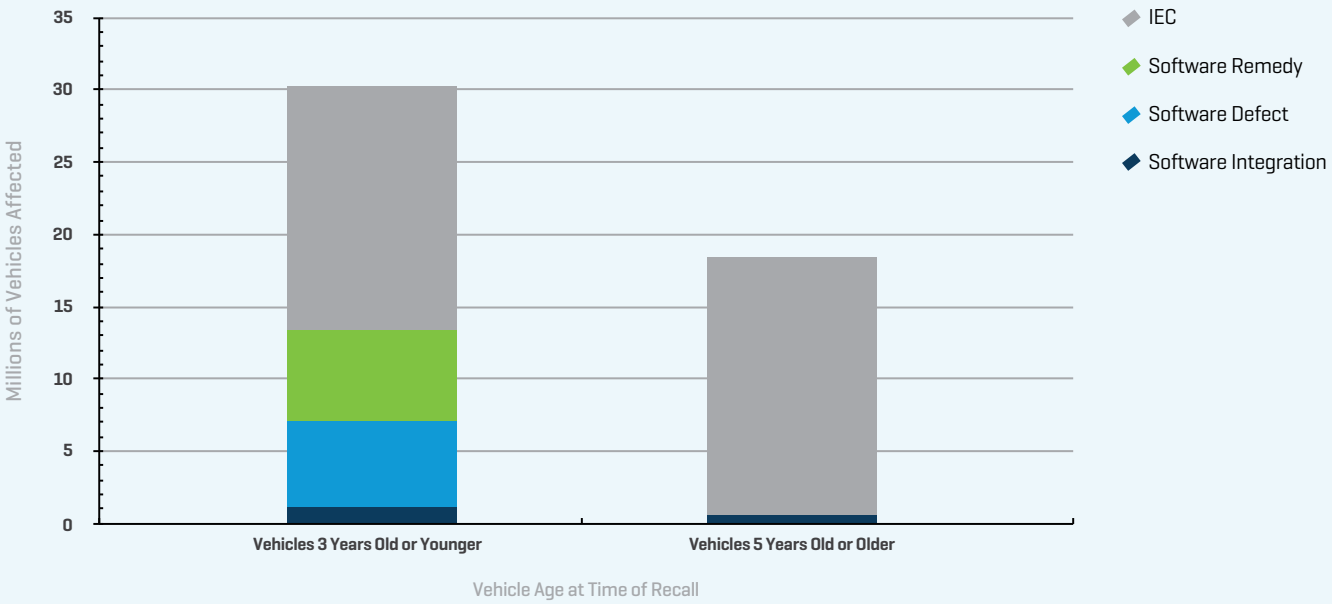
In vehicles 5 years old or older, as Figure 19 indicates, IEC-related defects are much more prevalent than software-related defects.

As defects in circuit boards and control modules continue to occur, OEMs and suppliers will remain pressured to develop components that will be safe for the life of the vehicle – an increasingly long time, as the average age of a vehicle in the U.S. is well over 11 years. There is a tremendous incentive for the industry to ensure that the electrical nerve center and the myriad control modules and sensors throughout the vehicle are reliable over the short term and long term.

Part of the challenge is weather-related stress and water intrusion. While a tech-enabled device such as a smartphone is usually kept in a relatively controlled environment, vehicles can be taxed with exposure to extreme heat or cold. The challenge is to prevent damage to IECs in those environments.

FIGURE 19:

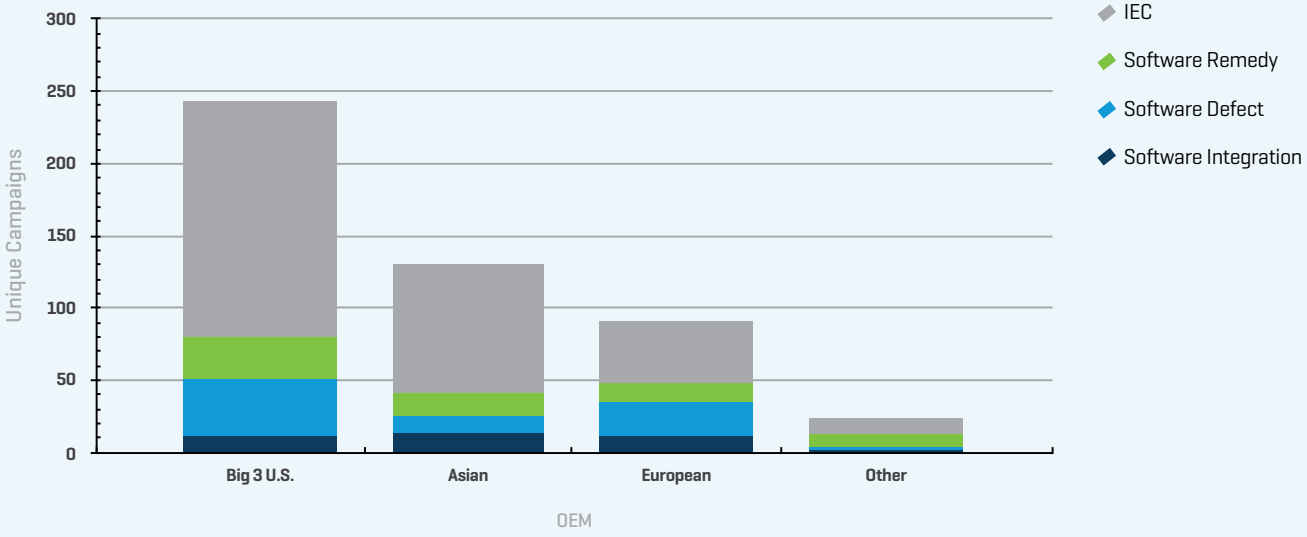
U.S. Recalls of Electronic Components Since 2007 by Age at Time of Recall



Contains data for BMW, Daimler AG, FCA, Ford, General Motors, Honda, Hyundai, Kia, Toyota, Volkswagen, and Volvo. Identified from data set updated through 2016. Excludes Takata Inflator recall campaigns.

FIGURE 20:

U.S. Recalls of Electronic Components Since 2007 by Region



Contains data for BMW, Daimler AG, FCA, Ford, General Motors, Honda, Hyundai, Kia, Toyota, Volkswagen, and Volvo. Identified from data set updated through 2016. Excludes Takata Inflator recall campaigns.

Right now, when reviewing defect descriptions for many of these recalls, we are seeing that many of them do not.

Another finding was that the Big Three automakers have combined for many more technology-based recalls than automakers from other parts of the world (Figure 20).

TECHNOLOGY-RELATED RECALL TRENDS, ISSUES

This year Stout discovered more technology-related issues across the board, from consumer complaints that were investigated by NHTSA to technical service bulletins to recalls.

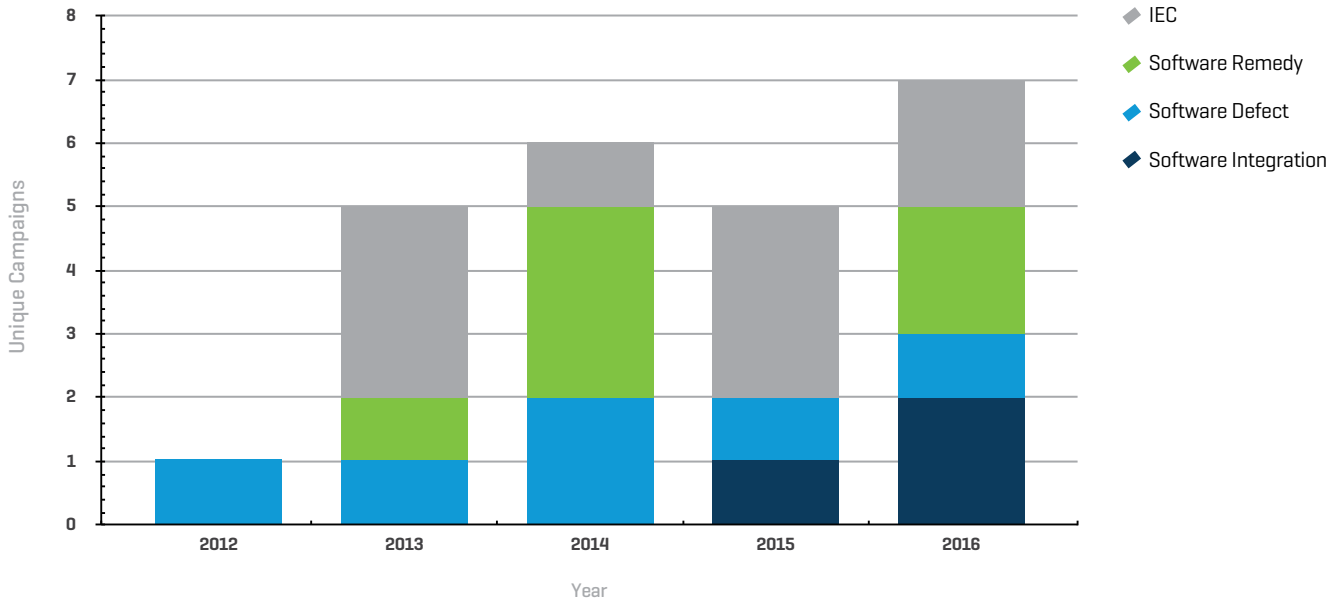
7.6M Vehicles recalled for airbag sensor defects since 2012

Other key trends we are observing:

- There continues to be an increase in software-related defects among mature component types. For example, we identified several powertrain deficiencies related to the timing of gear shifting that required a software refresh to remedy (Figure 21). Powertrain defects were also implicated in the Jeep and Maserati rollaway recall campaigns.
- We continue to see campaigns related to airbag sensors, which are different from the Takata inflator-focused recalls. Since 2012, more than 7.6 million vehicles have been recalled related to airbag sensor defects. As previously discussed, Nissan recalled approximately 3.3 million vehicles in 2016 related to a defect in the occupant classification system, representing nearly half of vehicles recalled due to airbag sensor defects in the past five years.

FIGURE 21:

U.S. Recalls of Electronic Components by Year - Powertrain Systems



Contains data for BMW, Daimler AG, FCA, Ford, General Motors, Honda, Hyundai, Kia, Toyota, Volkswagen, and Volvo. Identified from data set updated through 2016. Excludes Takata Inflator recall campaigns.

14M Vehicles recalled because of technology-related issues in 2016

In the case of the powertrain recalls, the technology was integrated five to 10 years before showing problems, revealing an unanticipated effect of the long-term use of technology. Powertrains experience a great deal of wear and tear through regular use, so it is not entirely surprising to see. This begs a question: Will software installed in automobiles today endure at peak levels over long periods of time, remaining able to handle harsh conditions, such as 10 years of extreme heat or cold? In the airbag recalls (as noted in Section 1), most non-Takata recalls were related to technology, including control boards, sensors, and wiring issues – not the airbag itself.

12 Component groups affected by technology-related recalls in 2016

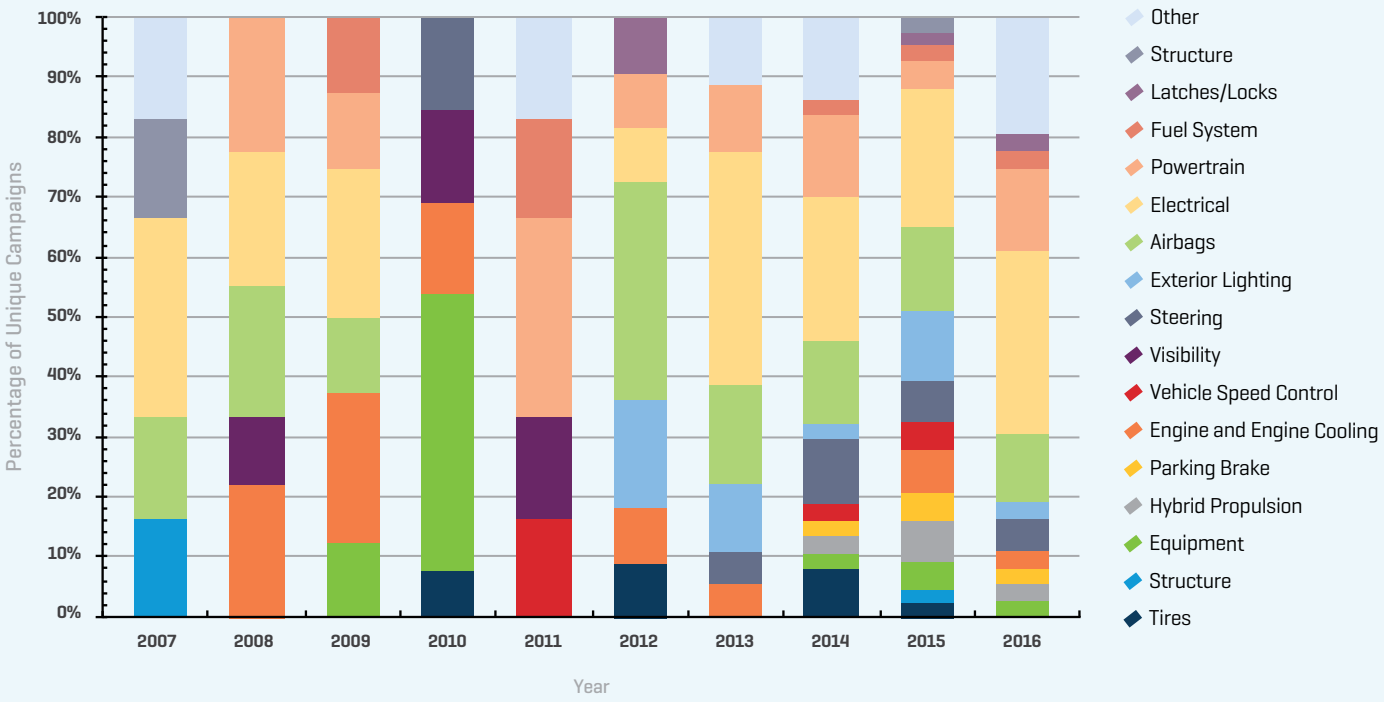
Figure 22 shows that the number of components involving software-related defects has increased significantly over the last 10 years. There were five impacted component groups in 2010 and 12 in 2016. As technology becomes even more pervasive in vehicles, the numbers of components involved in software-focused recalls will continue to rise.

OTHER TECHNOLOGY-RELATED ISSUES

There are multiple other indicators which show substantial increases in technology-related problems that do not reach the level of a recall. For example, we observed a significant number of technical service bulletins related to software (Figure 23). Dealers were notified about the issues, and fixed them when vehicles were brought to the dealership for services.

FIGURE 22:

Summary of U.S. Software Recalls by Year and Component

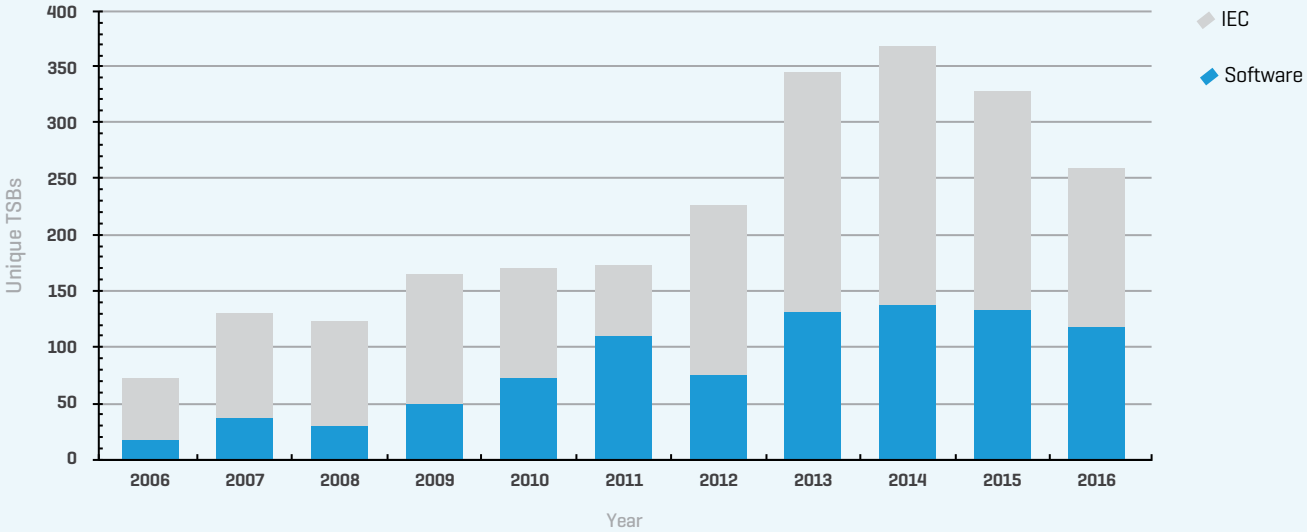


Contains data for BMW, Daimler AG, FCA, Ford, General Motors, Honda, Hyundai, Isuzu, Kia, Mazda, Mitsubishi, Nissan, Subaru, Tata Motors, Tesla, Toyota, Volkswagen, and Volvo. Identified from data set updated through 2016.

FIGURE 23:

Summary of Technical Service Bulletin Trends

By Software or Electrical-Related TSBs (Last 10 Years)



Includes BMW, Daimler, FCA, Ford, GM, Honda, Hyundai, Isuzu, Kia, Mazda, Mitsubishi, Nissan, Subaru, Tata Motors, Tesla, Toyota, Volkswagen, and Volvo. Contains data through December 2015.

Suppliers still need to plan for the ramifications of technical service bulletins because they may be required to bear the financial responsibility for the defect, in full or in part. Because the system failure could be due to one or more components not interacting correctly, it could become another situation where OEMs and suppliers go back and forth on who is responsible.

Another area we explored were MVDPs, as discussed in the previous section. Two of these petitions were related to software (see below).

In addition, NHTSA opened three technology-focused investigations in 2016. Two are still open, and the third – the Tesla forward-collision avoidance probe – was closed in January 2017.

Petitions Related to Software

Petition 1

Alleged Defect:
Electronic Throttle Control (ETC) software causing unexpected vehicle acceleration. Instances of the alleged defect occurred while vehicles were traveling at slow speeds or parking (and applying the brake pedal).

- The investigation could not identify phenomena other than pedal misapplication for explanation of unintended acceleration.
- **Petition Status:** Denied.

Petition 2

Alleged Defect:
Passenger sensing system failures due to circuitry in the sensing mat deteriorating over time.

- The printed conductor used in the OCS flexible sensor mat can crack or tear over time. Installation variability during the manufacture of the seat assembly can also affect the long-term durability of the sensor.
- Repeated flexing of the printed conductor used in the flexible sensor mat – which occurs, among other times, during occupant entry and exit from the vehicle – can cause the conductive traces to crack and tear over time, leading to less continuity.
- **Petition Status:** Open.

3 Technology-related investigations opened by NHTSA in 2016

The first two investigations might be indicative of drivers' interactions with technology beyond simply a failure of the technology itself. NHTSA is paying attention to changes in design that may rely on newer tech, but may not be fully appreciated by, or intuitive to drivers.

In the third example, NHTSA investigated a fatal crash that occurred May 7, 2016, when an Ohio man was killed after his 2015 Tesla Model S crashed into a truck while the car was operating under the autopilot system on a Florida highway.

Technology-Focused Investigations

Example 1

COMPONENT:
VEHICLE ROLLAWAY – *POWERTRAIN*

Alleged Defect:
Vehicle rolling away from parked position.

"These subject vehicles are equipped with an electronically shifted transmission and electronic rotary control for driver gear selections. The reports alleged that the unintended motion occurred after the driver moved the transmission gear selector to Park and exited the vehicle."

- Reports did not indicate that vehicle parking brakes were applied.
- **Investigation Status:** Open.

Example 2

COMPONENT:
POWERED ROLLAWAY – *POWERTRAIN*

Alleged Defect:
Claims that vehicle rolled away from parked position.

"All reports alleged that the unintended motion occurred after the driver switched the transmission gear selector to Park with the engine running and after the operator exited the vehicle."

- Reports did not indicate that vehicle parking brakes were applied.
- **Investigation Status:** Open.

Similar to the investigations detailed earlier, NHTSA investigates driver interaction with technology. In this case, NHTSA concluded that the Tesla ADAS performed as designed, and that driver inattention/error caused the fatal accident.

Technology-related recalls are likely to continue at a high level, especially as more parts are dependent on an extensive and critical level of integration and the vehicles with increased technology content begin to age. In addition, the manufacturing of vehicles with advanced safety technology and self-driving features is increasing dramatically.

Technology-Focused Investigations

Example 3

COMPONENT:
AUTOMATIC VEHICLE CONTROL SYSTEMS – *FORWARD-COLLISION AVOIDANCE*

Alleged Defect:
Vehicle did not automatically brake.

- **Investigation:**
  - Vehicle was traveling with autopilot and automatic emergency braking (AEB) system and had no record of driver braking.
  - NHTSA's examination did not identify any defects in the design or performance of the autopilot or AEB systems of the subject vehicles, nor any incidents in which the systems did not perform as designed.
  - AEB systems used in the automotive industry through model year 2016 are rear-end-collision avoidance technologies that are not designed to reliably perform in all crash modes, including crossing-path collisions.
  - The autopilot system is an Advanced Driver Assistance System (ADAS) that requires the continual and full attention of the driver to monitor the traffic environment and be prepared to take action to avoid crashes. Tesla's design included a hands-on-the-steering-wheel system for monitoring driver engagement. That system has been updated to further reinforce the need for driver engagement through a "strike out" strategy.
  - Drivers who do not respond to visual cues in the driver monitoring system alerts may "strike out" and lose autopilot function for the remainder of the drive cycle.
- **Investigation Status:** Closed.

SECTION 6:

Completion Rates

"The current look and feel of a recall notice is about as friendly as an IRS letter. They tend to be verbiage heavy, quite technical, and not very user-friendly."

- **Rebecca Lindland,** Senior Director, Kelley Blue Book [7]

To motivate a busy consumer to do something that is out of the ordinary and likely to be an inconvenience – such as dropping off a car at a dealership for a recall-related repair that could take most, if not all, of a day – a company needs to provide a compelling reason.

OEMs, through their marketing departments, do a fantastic job encouraging people to visit dealerships to browse new cars. The same strategy and tactics – market research, segmentation, personalized messages, digital-heavy outreach – can improve recall completion rates.

[7] NPR.org, June 21, 2016

For example, our analysis of completion rates has indicated that:

- Vehicles that are likely to be used for work or to transport a family with children have lower completion rates.
- If a component is not perceived to affect the operation of a vehicle, completion rates are lower than if the part is seen as crucial to prevent the vehicle from being stranded.

NHTSA has established a goal of a 100% completion rate for each recall. To reach this level, it would like OEMs to move beyond the very dry and formal letter used historically to inform consumers. Last summer, the agency proposed a new rule that recall notifications be made in an electronic manner in addition to first-class mail. This rule would sync with evidence that many consumers access information online, especially on mobile devices.

45M Unfixed recalled cars

According to a 2016 J.D. Power report, there are 45 million vehicles recalled between 2013 and 2015 still unfixed. Clearly, there is still plenty of work to do.

In this section we will look at two successful recent recalls – one for newer vehicles, another for mostly older automobiles – that offer insights from data analysis and takeaways for OEMs.

100 Percent of recalled Volvo trucks fixed

VOLVO ACHIEVES 100% COMPLETION

NHTSA's 100% completion rate goal seems unattainable to most OEMs, even if the recalled vehicles are only a few years old.

Yet, in less than one year, Volvo Trucks North America reached 100% completion for a recall repair of a serious steering defect on over 16,000 vehicles. Volvo worked in concert with NHTSA and the Federal Motor Carrier Safety Administration (FMCSA) to achieve this feat. Volvo's outreach strategy included:

- Direct contact with truck owners
- Announcements on social media platforms by Volvo, FMCSA, and NHTSA
- Several media notifications to trucking trade publications
- Appearances by federal officials on satellite radio programs that cater to long-haul truck drivers

To be sure, this recall involved relatively new vehicles typically used for a special purpose. But building a partnership with federal officials, taking aggressive steps beyond a form letter, and using varied communication platforms paid off for Volvo.

GENERAL MOTORS IGNITION SWITCH RECALL

GM's recall for an ignition switch defect was a worst-case scenario that other OEMs would like to avoid, as it was connected with more than 124 deaths, criminal legal action and fines, and many civil court cases.

However, the recall did bring about some needed changes at GM and in the industry. Among them were trying new methods to find and fix more than 26.8 million vehicles – all between 3 and 11 years old – to prevent further injury or loss of life.

GM adopted many of the same strategic outreach techniques of its marketing department. It augmented the staff of its safety office, adding people with marketing and dealer relationship skills to the traditional mix of engineers and legal technicians. To better target its customers, GM used these tactics, according to media reports:

- Conducted research on owners
- Contacted owners at least six times by letter and/or phone call
- Used English and, when appropriate, Spanish
- Targeted owners through social media and email
- Opened a call center with 72 workers
- Worked with dealers to conduct special events, extend hours, and provide transportation
- Provided incentives, including gift cards

GM's success is evident in Figure 24, which shows incremental improvement in completion rate for each quarter. Although the overall completion rate of about 74% falls well short of the desired 100%, it is important to note that many of the cars were at least 5 years old at the time of the recall announcement. Completion rates for vehicles in that category are usually 40% to 50%. In addition, GM continues to repair these vehicles as it seeks to move its completion rate ever closer to 100%.

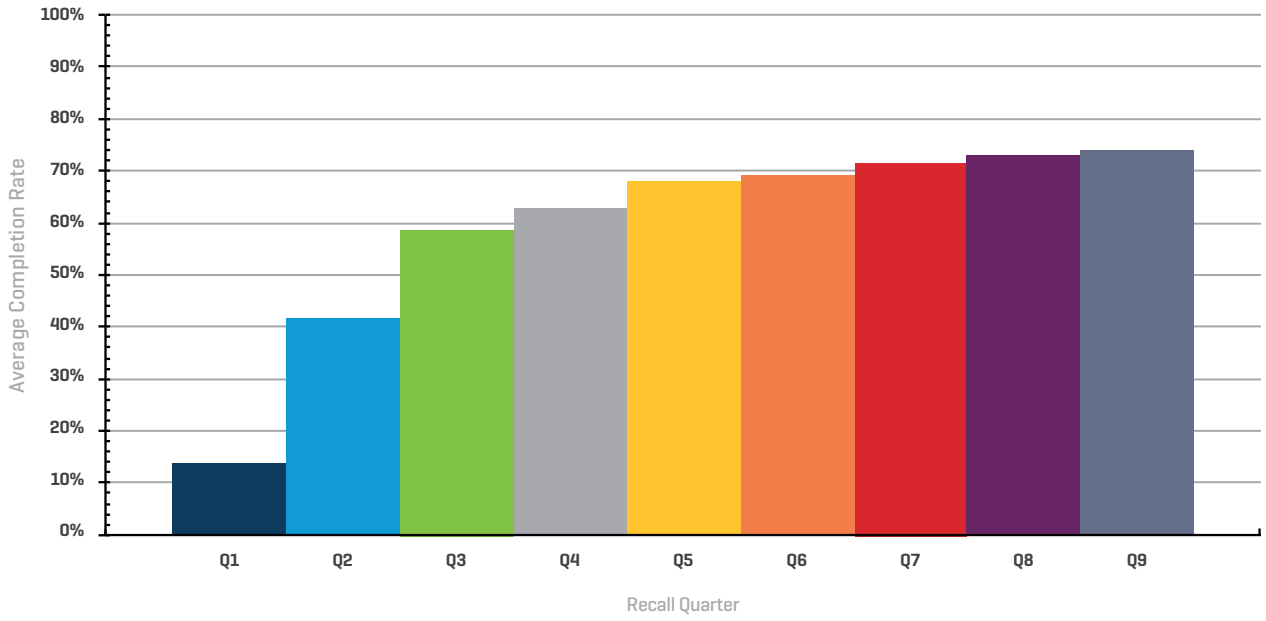
It is likely that many of these very old vehicles are not on the road any longer. As such, GM's reporting is attempting to accurately convey the completion rate based on the vehicles it can likely repair, something other OEMs may not have done in years past.

COMPLETION RATE AGING ANALYSIS

Traditionally, vehicle recall analysis is broken out by quarters, and the completion rate is measured based on how well the OEM fixed vehicles during that time period. For a closer look, we analyzed recalls

FIGURE 24:

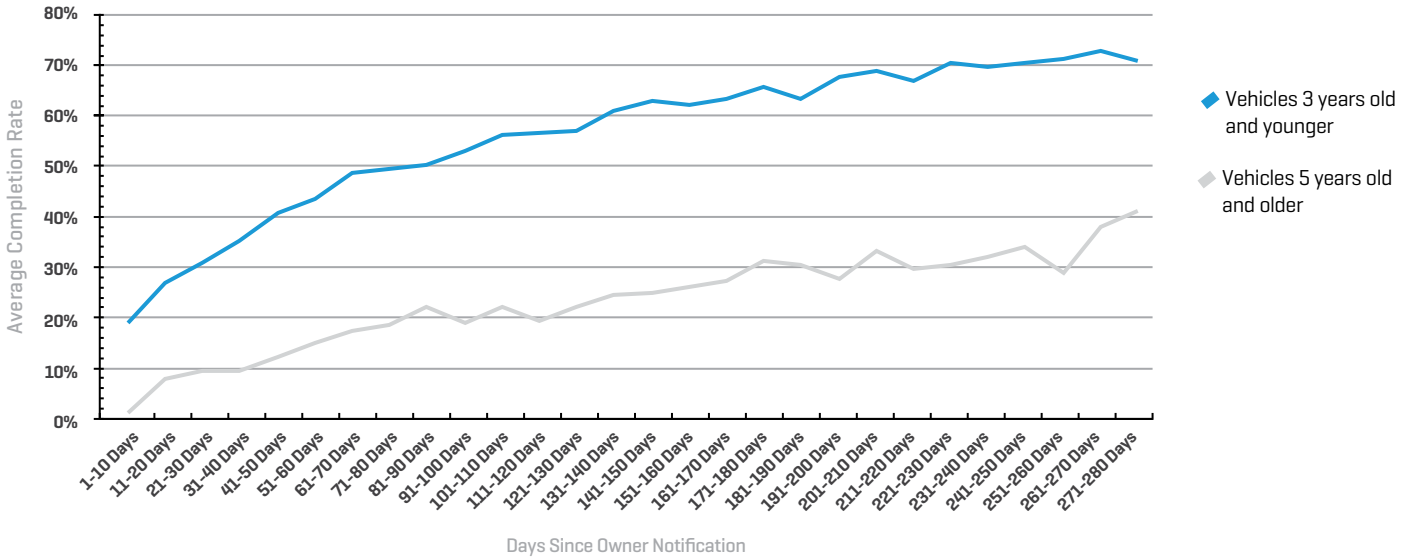
Summary of Quarterly Completion Rate for GM Ignition Switch Recall




ENGINE
START
STOP

FIGURE 25:

Average Completion Rate by Days Since Owner Notification and Vehicle Age at Time of Recall (U.S. Recalls)



Contains data for BMW, Daimler AG, FCA, Ford, General Motors, Honda, Hyundai, Isuzu, Kia, Mazda, Mitsubishi, Nissan, Subaru, Tata Motors, Tesla, Toyota, Volkswagen, and Volvo. Identified from data set updated through 2016.

starting from the date on the filings. This is significant because some recalls begin in the first day or two of the quarter, while others begin near the last day. This analysis gave us a much more refined chronology of completion rates (Figure 25).

150 DAYS Recall response levels off after this period

We found that OEMs have the most success in their recall programs in the first 150 days. After that, repair rates slowed for both older and newer vehicles.

The main takeaway is that OEMs need to be very aggressive during the first five months, using their best outreach tactics so the initial completion rate can climb to the highest level possible. After that point, the pace of recall completion between old and new vehicles is more similar – in both instances, owners have likely received the notice and have not acted, for any number of reasons.

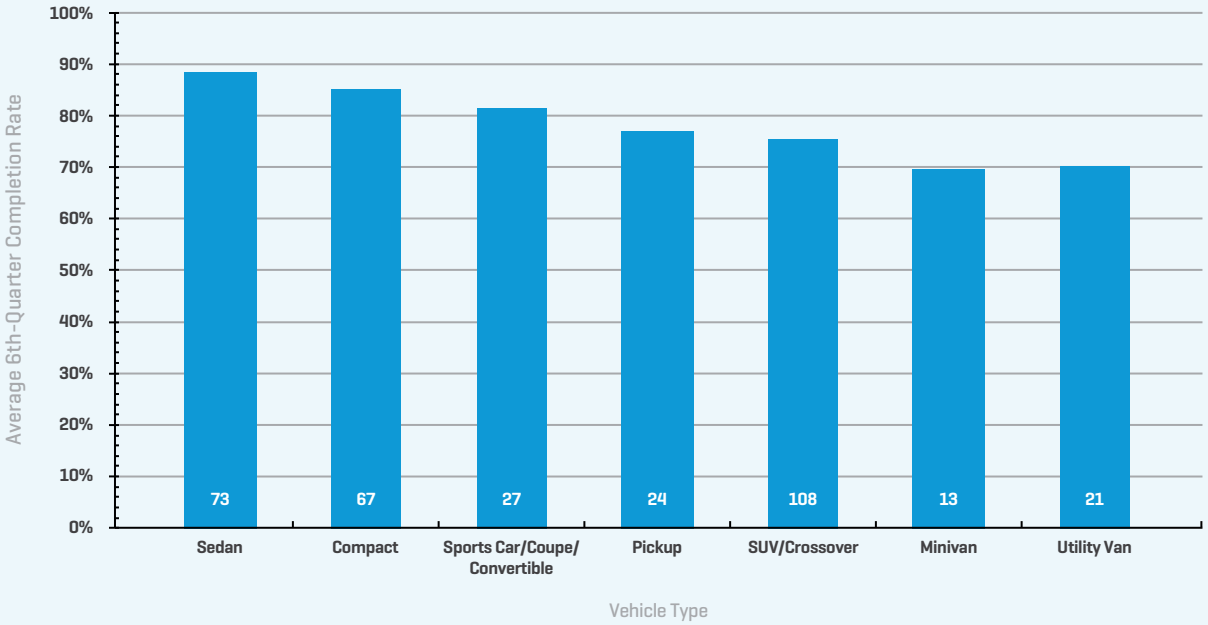
To be sure, there is room for improvement in the early periods and later periods, but there appears to be a particularly compelling opportunity in the first several months to engage vehicle owners. In the latter months, the challenge is overcoming other circumstances that have prevented the owner from having the vehicle repaired.

ADDITIONAL INSIGHTS ON COMPLETION RATES

Owner dependence is often overlooked as a factor in recall completion rates. Research into types of vehicles shows that pickups, utility vans, and minivans have a lower completion rate than sedans (Figure 26). Why? Because pickups and utility vans are often used for work and minivans are a popular family vehicle. In all of those cases, the owners likely believe they cannot afford to go without their vehicle even for a few hours.

FIGURE 26:

Average 6th Quarter Completion Rate by Vehicle Type Since 2012 (U.S. Recalls)

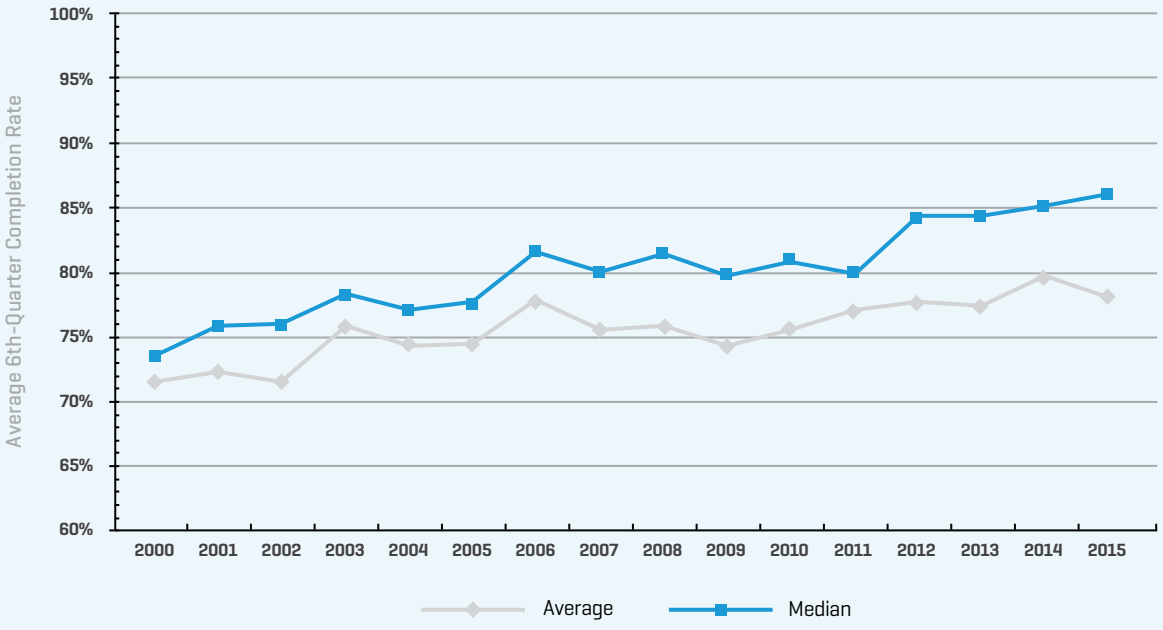


Contains data for BMW, Daimler AG, FCA, Ford, General Motors, Honda, Hyundai, Isuzu, Kia, Mazda, Mitsubishi, Nissan, Subaru, Tata Motors, Tesla, Toyota, Volkswagen, and Volvo. Identified from data set updated through 2016. Includes only data from single-model recalls with at least six quarters of completion rate data.

FIGURE 27:

Overall Median and Average Completion Rates by Year

Includes Only Recalls With 6 or More Reported Quarters



Contains data for BMW, Daimler AG, FCA, Ford, General Motors, Honda, Hyundai, Isuzu, Kia, Mazda, Mitsubishi, Nissan, Subaru, Tata Motors, Tesla, Toyota, Volkswagen, and Volvo. Identified from data set updated through 2016.

Overall, the median rate of recall completion has continued to improve over the last five years, from about 80% to 85% (Figure 27). The recalls that get lower response are typically large (more than 100,000 units) and, in most cases, involve older cars.

85% Median rate of recall completion

The recall completion rates for vehicles 3 years old and younger is stronger than for older vehicles. OEMs have adopted new outreach tactics such as social media, emails, and on-board notifications. But OEMs are still struggling to make progress on completion rates for vehicles 5 years old and older, where percentages hover around 40% to 50% (as shown in Figure 28).

New in this year's report, Stout explored the impact specific defects might have on the operability of a vehicle and whether that factor made a difference in recall completion rates. In other words, how does the perception of whether a defective part could make it impossible for the owner to get around day-to-day in the vehicle affect completion rates?

In Figure 29, it is evident that when an automobile owner is facing a recall for a part that could severely affect the operability of a vehicle – such as losing the ability to steer – the owner is more likely to get it fixed.

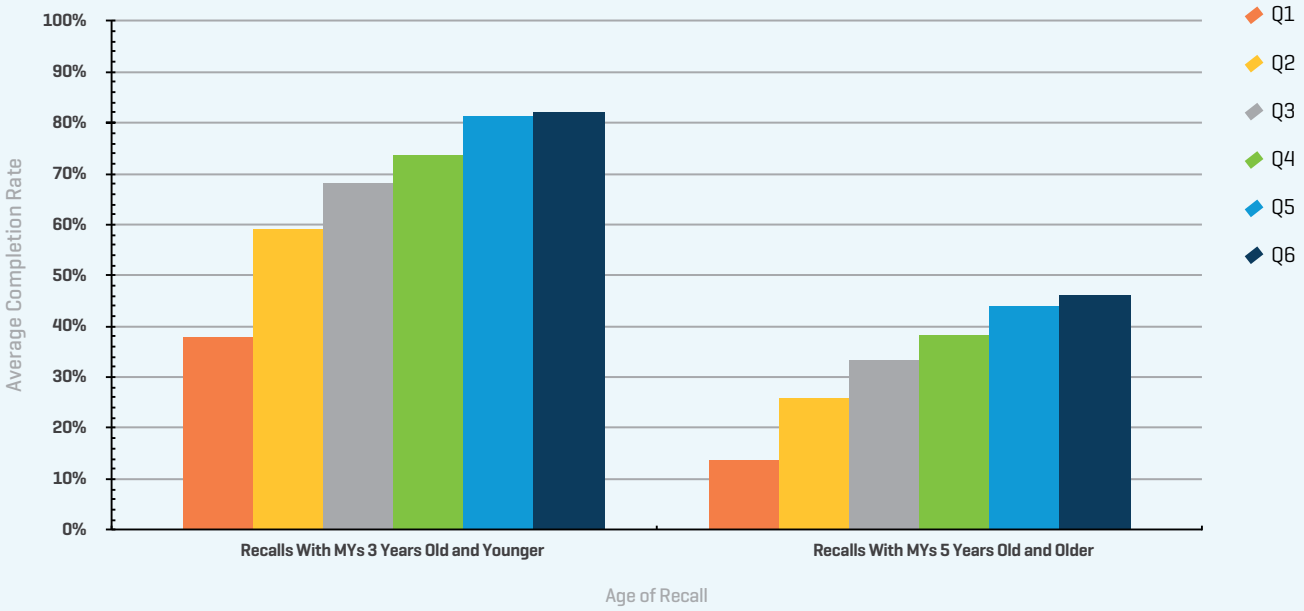
For certain recalls, it may be particularly effective to communicate to vehicle owners that the defect could cause a serious inconvenience in their lives, in addition to being a safety risk, possibly leaving them without a vehicle for a period of time.

For newer cars, repairing a defect may not matter much because the owners are usually bringing the vehicle to the dealership for routine maintenance or warranty repairs. For older cars, it can make a difference, and it takes a pointed conversation for owners to understand that, and why the defect is relevant.

FIGURE 28:

Summary of Average Completion Rate by Age of Recall (Since 2000)

Including Only U.S. Recalls With 6 Quarters Reported

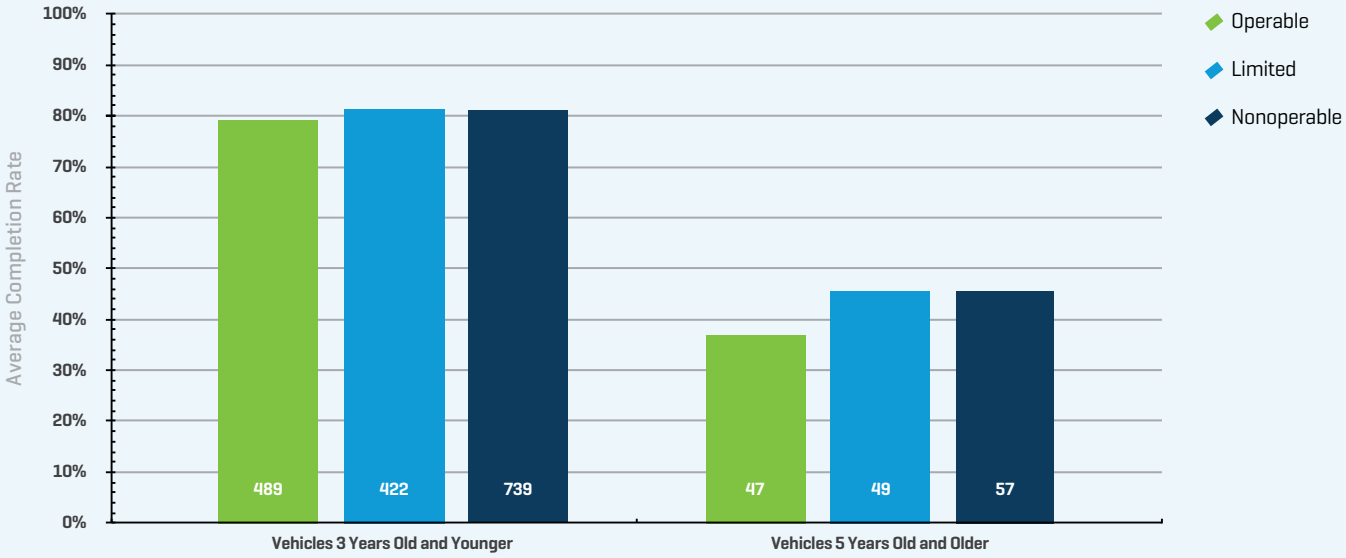


Contains data for BMW, Daimler AG, FCA, Ford, General Motors, Honda, Hyundai, Isuzu, Kia, Mazda, Mitsubishi, Nissan, Subaru, Tata Motors, Tesla, Toyota, Volkswagen, and Volvo. Identified from data set updated through 2016.

FIGURE 29:

Summary of Average Completion Rate by Operability (Since 2000)

Including Only U.S. Recalls With 6 Quarters Reported



Contains data for BMW, Daimler AG, FCA, Ford, General Motors, Honda, Hyundai, Isuzu, Kia, Mazda, Mitsubishi, Nissan, Subaru, Tata Motors, Tesla, Toyota, Volkswagen, and Volvo. Identified from data set updated through 2016. Operability determined by component.

“Too busy.”

Common reason owners do not get recalled vehicles fixed

In fact, when consumers perceive a serious defect that could make the car inoperable for a period of time, recalls for these types of defects on vehicles 5 years old and older perform 10% better than those for other defects.

If automakers would stress the serious nature of the defects that could cause a major inconvenience for drivers of older vehicles in certain recalls, they might improve their completion percentages.

A NEW APPROACH TO IMPROVING COMPLETION RATES

When people are asked why they do not get their defective vehicle fixed, they offer up a variety of answers. Among the most common: too busy, need the car all the time, and/or it does not seem like a major problem.

There are many different reasons for communication disconnect on recalls, and there are no silver bullets to fix that gap. Many in the industry have often thought that informing people of a risk to their safety and health would motivate them to bring their vehicle to the dealership to fix the defect. But that may be a false premise, as people ignore risk all the time on a variety of everyday issues, and consumers have adopted an attitude of "It won't happen to me."

OEMs ought to review and test their messaging when confronting a variety of human experiences and circumstances. For example, they can emphasize the inconvenience of a nonoperational vehicle, encouraging owners to fix the defect now to ensure that the car is running smoothly when they need it most.

Safety and recall offices will benefit from more sophisticated messaging and a call to action that appeals to individual audience segments, much like OEMs do when trying to convince consumers to purchase cars.

Other factors that will play a significant role in improving recall completion rates are on-board notification systems and owner apps. While on-board notification systems and over-the-air software updates may be years away still for many OEMs, owner apps are fast becoming a valuable way to build owner loyalty and ongoing engagement by offering features and information that are of value to consumers.

For example, if an OEM allows drivers to access remote start and lock features through a free app, it is more likely owners will use it. Then it becomes a valuable platform for OEMs to communicate with owners about new brands, offers, and, of course, recalls. Drivers might not allow the OEM to "push" messages about recalls to them, but the OEM will have other contact information – email and phone number – and can also try to change the notification methods through an app update. The email address would be especially important to fulfill any requirements for online notification.

The app might also help OEMs overcome one of their most persistent problems with recall notifications for older vehicles: reaching the second or third owners of a vehicle. If the app has value for subsequent owners and they download it, it opens the door for OEMs to notify them when needed.

Developing or considering on-board notification, and even remote software updates, may be especially successful because of the persistence factor. For example, the notification could stay on the dashboard until the owner completes the recall.

Technology cannot solve all the difficulties OEMs have with increasing their completion rates for older vehicles, especially ones that have changed owners. But the power of technology will play an increasingly vital role as more vehicles are equipped with on-board notification systems and people interact with smartphone apps.

SECTION 7:

Cost Recovery Benchmarking Analysis

"Ford Motor Co. reported a more than 50% drop in third-quarter (2016) net income, saying its North American business suffered from lower sales, higher recall costs, and a complicated introduction of a new pickup truck."

- ***Reuters*** - October 27, 2016

Manufacturers and suppliers subject to financial reporting requirements must record and disclose reserves resulting from expected warranty and recall activity. For the year 2016, U.S.-based OEMs and suppliers reported paying approximately $11.8 billion in claims, and recorded $10.3 billion of warranty and recall accruals.[8] Since 2014, U.S. manufacturers have been recording expected warranty *and* recall accruals at the time of sale, rather than at the point in time when specific campaigns are identified.

[8] Automotive Warranty Expense Report, *Warranty Week*, March 30, 2017.

Financial statement disclosures provide further insight into how OEMs are reacting to the record-setting pace of recall activity and NHTSA's more active regulatory posture. [Emphasis added through italicizing]

FCA:

"Given recent increases in both the cost and frequency of recall campaigns and increased regulatory activity across the industry in the U.S. and Canada, *an additional actuarial analysis that gives greater weight to the more recent calendar year trends in recall campaign experience was added to the adequacy assessment to estimate future recall costs."*

Ford:

"In 2014 and 2015, there was an unprecedented increase in the number of vehicles involved in safety recalls by manufacturers in the United States. The increase reflects NHTSA's continued expansion of its definition of safety defects under the Safety Act. In addition, *NHTSA's enforcement strategy shifted to a significant increase in civil penalties levied and the use of consent orders requiring direct oversight by NHTSA of certain manufacturers' safety processes, a trend that could continue."*

GM:

"Government regulatory requirements could significantly affect our plans for global product development and, given the uncertainty surrounding enforcement and regulatory definitions, may result in substantial costs, including civil or criminal penalties. In addition, an evolving but unharmonized regulatory framework *may limit or dictate the types of vehicles we sell and where we sell them,* which can affect revenue… *We also expect that manufacturers will continue to be subject to increased scrutiny from regulators globally."*

In addition to the cost of warranty and recall campaigns, these reserves may be influenced by OEM cost recovery activity. For manufacturers, successful cost recovery represents a reduction to reserves (to the extent not already realized); for suppliers, cost recovery activity would most often represent an increase to these liabilities. According to *Warranty Week*, manufacturers can expect to shift approximately 10% to 20% of warranty claims to suppliers.[9] Indeed, OEM cost recovery activity, as measured by suppliers' share of overall industry warranty claims, has increased to nearly 15% since reaching a post-recession low point during the massive recalls of 2014.[10] For the year that ended December 31, 2016, suppliers' share represented nearly 13% of warranty and recall costs experienced in the U.S.-based market.[11]

13% Suppliers' share of warranty and recall costs

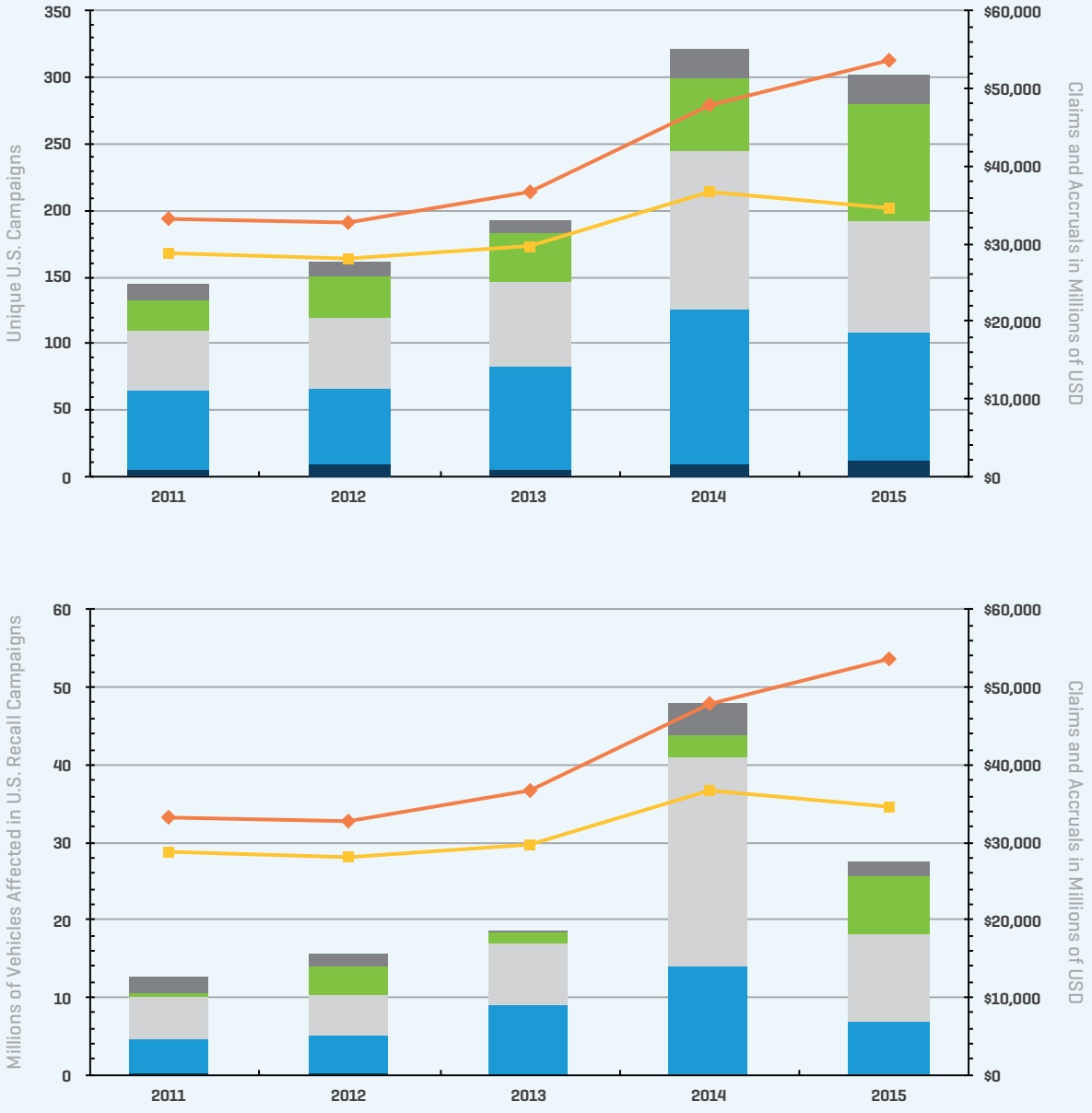
The success of manufacturers' cost recovery activity may be influenced by a variety of factors, such as macroeconomic conditions, supplier viability, and contractual sharing ratios. Stout has benchmarked the relationship between accrual and net claims activity, and recall defect classification; these relationships are depicted in Figures 30–33. Using this framework, we present our analysis of OEM and supplier claims and accruals, and the indicators of industry cost recovery.

The analyses presented throughout this section include data through December 31, 2015, which reflects the limited availability of data from European and Asian OEMs and suppliers as of the date of this writing. Additionally, the claims and accrual data presented include activity related to the Takata inflator recalls, which have been excluded from the presentation of recall campaigns and numbers of vehicles affected.

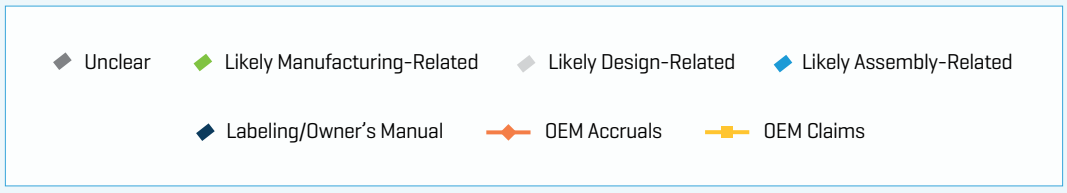
[9] Automotive Supplier Recovery, *Warranty Week*, August 25, 2016.
[10] *ibid.*
[11] Automotive Warranty Expense Report, *Warranty Week*, March 30, 2017.

FIGURES 30-31:

OEM Claims and Accruals by Recall Defect Classification and Year



Contains U.S. recall data for BMW, Daimler AG, FCA, Ford, General Motors, Honda, Hyundai, Kia, Toyota, Volkswagen, and Volvo. Identified from data set updated through 2016. Claims and accrual data reflect limited availability of full year 2016 results. Excludes Takata Inflator recall campaigns.



OEM CLAIMS AND ACCRUALS

Consistent with the narrative of escalated defect and recall activity industrywide, we observe in Figures 30–31 elevated OEM claims activity in 2014 and 2015. The trajectory of claims activity in recent years is consistent with the relative number of recall campaigns and vehicles affected by defects. We also observe that in early years, OEM accruals appear to move in a pattern parallel to claims; however, claims and accruals diverge in 2015.

The divergence between claims and accruals may reflect the change to reserve estimations at the time of vehicle sale as reported by several OEMs, and therefore be indicative of OEMs' expectations of elevated future warranty and recall claims costs despite the reduction in 2015 claims.

Using this approach, OEMs are acknowledging their estimate of claims and recognizing their estimate of those costs immediately, instead of reporting costs as they are incurred over time. Such a change in methodology will result in an upward shift in reserves, as unrecorded estimates for vehicles previously sold are recognized – which we observed in 2014. Furthermore, warranty and recall reserves are not typically reported net of cost recovery, while claims activity does reflect a reduction for costs successfully passed on to suppliers. OEMs' ability to realize reduced net claim activity in 2015 may also reflect the increase in defects associated with supplier manufacturing issues in relation to the mix of defects identified.

SUPPLIER CLAIMS AND ACCRUALS

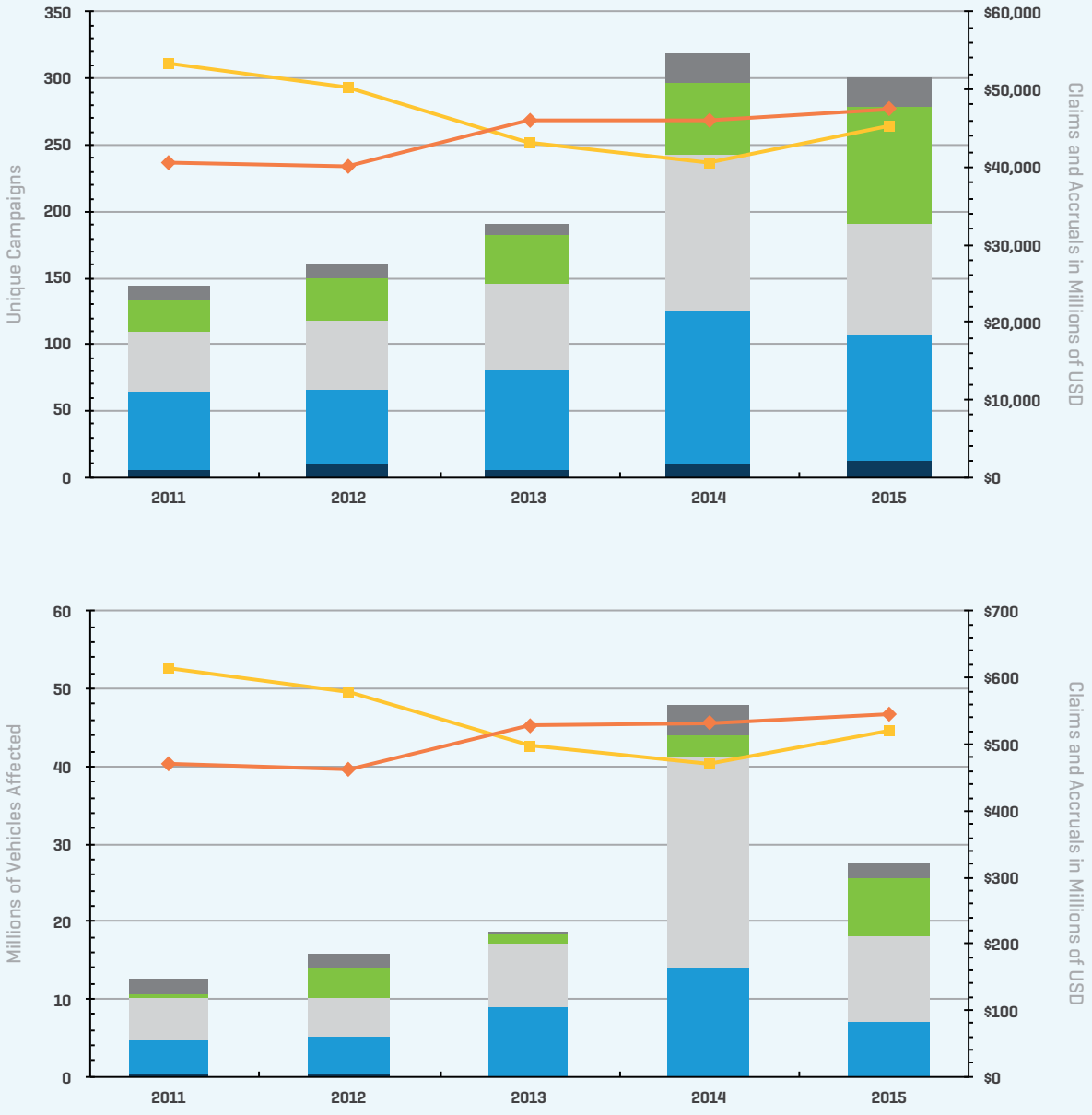
The supplier analysis presents a different pattern of claims and accruals (Figures 32–33). Supplier accruals remain relatively steady over the period presented; this is consistent with supplier accruals that we have observed historically. From our review of supplier financial statements, we know that most suppliers are not recording reserves for recall-related activity at the time of sale as are the OEMs, and are instead often realizing these costs when reaching cost recovery settlements with OEMs. As such, it may be that some of this activity is only reflected in supplier claims and is never recognized in supplier accruals.

Supplier claims, however, demonstrate a behavior that complements the OEM claims. That is, supplier claims were at their lowest when OEM claims peaked during 2014. Manufacturing-related defects in 2014 represented a relatively small proportion of the recall activity in terms of vehicles affected in that year. Supplier claims then rose again as manufacturing-related defects increased in 2015. According to *Warranty Week*, nearly half of the supplier claims since 2013 relate to manufacturers of powertrain components.[12] In fact, *Warranty Week* observes that recent powertrain warranty costs have been rising while claims expenses of other manufacturers fell.[13]

[12] Automotive Warranty Expense Report, *Warranty Week*, March 30, 2017.
[13] *ibid.*

FIGURES 32-33:

Supplier Claims and Accruals by Recall Defect Classification and Year



Contains U.S. recall data for BMW, Daimler AG, FCA, Ford, General Motors, Honda, Hyundai, Kia, Toyota, Volkswagen, and Volvo. Identified from data set updated through 2016. Claims and accrual data reflect limited availability of full year 2016 results. Excludes Takata Inflator recall campaigns.

OEM COST RECOVERY EFFORTS ARE INCREASING INDUSTRYWIDE

The patterns of OEM and supplier claims are instructive – the increase in the supplier claims and decrease in OEM claims suggest meaningful cost recovery efforts in the industry. As OEMs successfully pursue cost recovery, their net claims decrease while those costs are passed to suppliers. With an increase in the number of units affected by design- and manufacturing-related defects in 2016, we may observe an increase in supplier claims and accruals and OEM efforts pertaining to cost recovery. Future settlements of ongoing warranty and recall campaigns may also result in further increases in supplier claims in the years to come.

As overall recall costs remain at elevated levels, benchmarking analyses may be useful for OEMs and suppliers in assessing the effectiveness of cost recovery efforts. In doing so, OEMs should consider the mix of defects and potential supplier responsibility when making comparisons across the industry. That is, an OEM with significant large, complex recalls of powertrain or engine components may have different recall costs than OEMs that do not have such recalls.

Furthermore, OEMs with a large number of defects arising at assembly facilities may have different degrees of cost recovery than OEMs with recalls that are primarily occurring at supplier facilities. Variations in OEM standard terms and conditions and other contracting documents will also affect the degree to which OEMs are successful in supplier cost recovery. By developing and refining these comparative features and data sets, OEMs can more carefully benchmark cost recovery efforts, claims levels, and accruals with other industry participants.

SECTION 8:

Introducing the CDRA

Just as responsible drivers expect to drive home from work without setting off a chain-reaction accident, auto-parts manufacturers design, engineer, and validate components to ensure, to the extent possible, that they will not fail and trigger a million-unit recall.

But hundreds of recalls still occur every year, even though suppliers have instituted layers of quality control processes, from the C-suite to the shop floor. Following three consecutive years of highly elevated recall numbers in the U.S., it is essential for suppliers to fully grasp the potential risks and costs of recalls and other defects.

However, it is increasingly difficult for companies to predict – and plan for – future component failures on their own, because they are relying almost exclusively on internal knowledge. Most notably, there is a risk of an internal bias, such as when engineers and project managers cannot truly project that anything would go wrong with the component because of how it was designed and made.

External factors – like the heightened regulatory environment and an ever-growing reliance on technological integration – are playing a larger role in sparking recalls or investigations, such as:

- Problems stemming from the design of a part, which might have been done in conjunction with the OEM.
- Propensity of failure of other parts that interact with a component. For example, a forward-collision avoidance system relies on sensors such as lasers, screens to protect the laser, and the brake mechanism. If one part of that integrated system fails, there could be a dispute about whether other suppliers are at least partially to blame.

What suppliers need is a blind-spot warning system for their recall risks, to get the kind of unbiased third-party reporting that can give them an edge when they negotiate with insurance companies and OEMs about their future financial and legal exposure to recalls. A more complete understanding of risk presents unique competitive advantages for sales, engineering, finance, insurance, and legal teams.

Stout's Automotive Component Defect Risk Assessment (CDRA) provides the industry's most comprehensive analysis of component risk factors, leveraging more than 20 data sets built by Stout's team of automotive recall experts.

With our expansive capabilities and experience in this area, we are uniquely positioned to provide suppliers to automotive OEMs with information regarding recalls, technical service bulletins, investigations, international activity, cost recovery factors, recall completion rates, repair costs, and more.

We use complex text mining, relational databases, visualization, and independent, individual review of thousands of documents annually in order to ensure that our assessment is comprehensive and tailored to a specific component. Rather than just providing raw data, we provide a comprehensive assessment that details how these findings apply to a company's components of interest, and we will consult with its team on how best to understand and apply our findings.

Every CDRA is prepared on a case-by-case basis with considerable input and collaboration from the company's perspective, based on its internal knowledge, expertise, and experience. This is not a standardized template. Stout's CDRA is customized to the needs of the supplier.

With this information, suppliers can make better decisions across the board. Suppliers are adjusting to the new reality of an increased volume of recalls, as well as a heightened likelihood that they will be deemed partially or primarily responsible for the defect.

On the positive side, suppliers can get access to more data than ever before that can help predict whether a particular component is susceptible to a recall.

With the influx of global platforms and the more stringent regulatory environment, it is crucial for suppliers to analyze their internal systems as well as available industry data. When suppliers develop new ways to analyze their risk exposure, they can implement new systems and processes that will prepare them financially and operationally for many years to come.

Request an initial consultation by visiting
stoutadvisory.com/services/component-defect-risk-assessment

BENEFITS TO THE SUPPLIER ACROSS THE BOARD

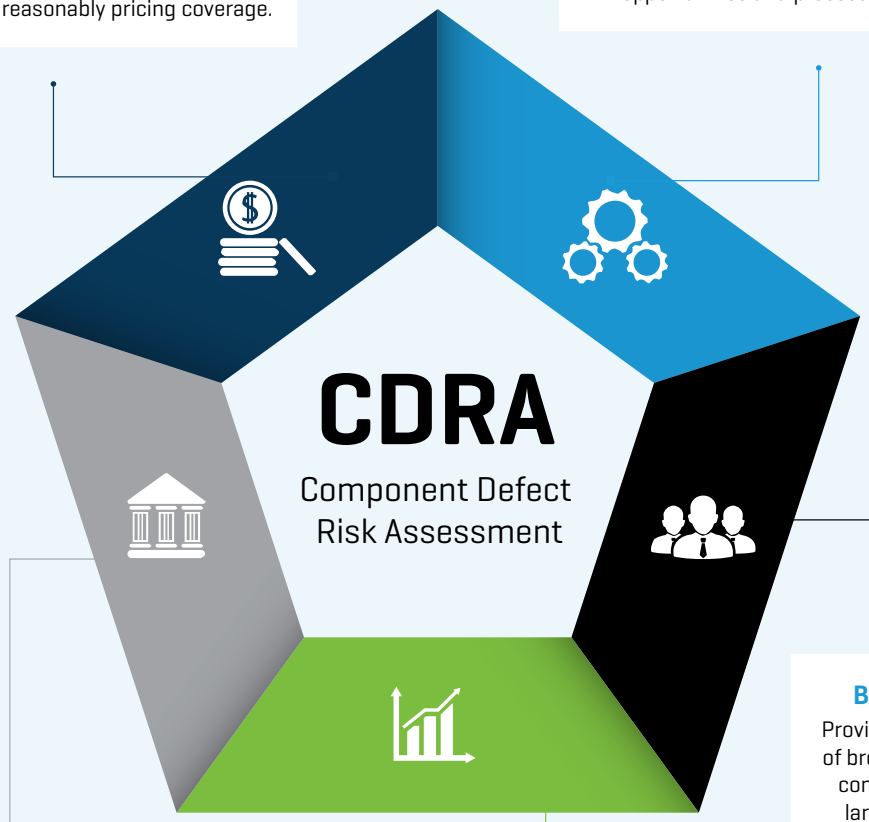
A Stout **Component Defect Risk Assessment** helps suppliers make informed decisions within various functions and levels of an organization.

FINANCIAL

Helps to determine the appropriate level of self-insurance (capital reserves) or assists third-party insurance providers in appropriately and reasonably pricing coverage.

PROCESS, ENGINEERING, AND DESIGN

Can be integrated with internal information and expertise to provide opportunities for enhanced product development, design, production, and quality, as well as continuous feedback loops that assist in identifying risk mitigation opportunities and process improvements.



BOARD OF DIRECTORS

Provides a refined understanding of broad risk and exposure to the company related to recall and large-scale product defects.

LEGAL

Provides critical information identifying opportunities to mitigate risks through contractual clarifications with suppliers and customers, and information valuable in responding to cost recovery actions from customers or pursuing cost recovery from subsuppliers.

SALES

Can be used to identify products and sales opportunities with the greatest margin and lowest risk. May also provide insight into competitive advantages by identifying defects of competitors.

"One can assume that OEM legal teams are now looking for ways to boost their reimbursements for faulty airbags, ignition switches, power steering motors, and other allegedly supplier-caused problems."

- **Eric Arnum, editor,** *Warranty Week*

Conclusion

The new era of elevated vehicle recall activity, along with rapid technological advancements throughout the auto industry, have further complicated the synergistic relationship between suppliers and OEMs.

It is now a time of collaboration and accountability. The dramatic increase of interrelated components in today's technologically advanced vehicles has exposed suppliers to many more recalls in recent years. Our finding that suppliers are being named in more design-related recalls than ever before is a red flag for companies that are used to their liability being focused almost exclusively on manufacturing-related recalls.

Technology has created an urgency for both OEMs and suppliers to increase collaboration as more components are linked – hence the failure of one can trigger a recall for all. The financial exposure for OEMs and suppliers is certain to intensify, especially when they are testing unproven technology in response to competitive pressure and consumer demand, and as the industry moves ever more quickly toward autonomous vehicle systems.

While OEMs have enjoyed record vehicle sales, they have also borne a significant financial burden from the unprecedented level of recalls in the last three years. Because this represents a remarkable hit to their income statements and balance sheets, they are finding ways to recover a portion of those costs from suppliers that they believe are accountable for at least part of the liability stemming from a defect.

Suppliers have a choice. They can be reactionary and hope to cut the best deal possible with OEMs should a defect hit the recall stage and affect the OEMs' bottom lines. Or they can be proactive by aggressively researching and anticipating their potential risks and making adjustments well ahead of any defects, to mitigate the potential for recall altogether.

Our analysis of a variety of recall-related risk factors indicates that suppliers are able to predict and prepare for recalls as never before. It is up to them to dedicate resources for analyzing ways of preventing major economic damage related to a global recall – or even a much smaller domestic recall that still cuts deeply into profits – instead of just absorbing the financial shock as it happens.

By taking into account data points such as defect-related identification data, MVDPs and PINs, international recall trends, and technology-based recall indicators, suppliers can prepare for and protect their companies from future recalls. They can also gain a competitive edge by showing OEMs that they are strong partners on a global scale. A tool such as the CDRA can bring the data analysis together with a company's own insights on its strengths and weaknesses.

Our Automotive Expertise

Stout is recognized internationally as a leading advisory firm in the automotive sector. Our experts have advised companies ranging from multinational, publicly traded OEMs and Tier 1 suppliers to closely held component suppliers around the world. We have also worked with franchised and independent dealerships, raw material suppliers, logistics and data providers, and other stakeholders and participants in the automotive supply chain.

Our professionals understand the complex relationship between OEMs and tiered automotive suppliers, both internationally and domestically. Our expertise is the result of numerous transactional, valuation, consulting, and dispute advisory engagements across the automotive supply chain. Our cross-functional expertise affords the confidence that our technical knowledge reaches far beyond general economic and financial theory to the specialized, industry-specific considerations of the automotive manufacturing and distribution supply chain.

What We Do

Stout professionals have provided consulting services and expert testimony for significant automotive industry warranty and recall programs and disputes.

On behalf of both OEMs and suppliers, Stout has analyzed:

- Warranty and recall data collection systems, warranty repair history, administrative processes and costs, recall risks and costs, component risk factors, recall completion rates, and other information
- Warranty and recall circumstances of many sizes and types – from the largest of recalls affecting millions of vehicles, to small recalls or extended warranty actions affecting several thousand vehicles – and everything in between

Our analyses are used to assist clients in understanding the risk and economic costs of warranty service repair, recall campaigns, and other actions for purposes of risk mitigation, improved business processes, customer and supplier negotiations, claim assessment, or settlement and trial testimony.

We work closely with our clients to understand the risk and potential impacts associated with defects of automotive components, whether it is a customer service action, extended warranty offers, a voluntary recall or one required by NHTSA, or other responses to warranty data, component defects, or customer complaints.

How We Do It

We take a collaborative approach leveraging our clients' knowledge, experience, and expertise – seeking to integrate cross-functional expertise from our clients with Stout's data and experience. To do this, we:

- Develop and use over 20 data sets containing recall and other defect campaign data
- Use our expertise in understanding the wide variety of potential warranty and recall activities, and the costs associated with each
- Employ traditional and creative approaches in assessing risk from multiple perspectives, as appropriate
- Make use (wherever possible) of supplier and program-specific information to further refine and support our analysis
- Apply both quantitative and qualitative risk factors impacting warranty and recall risk, as warranty and recall risk is often nuanced and not easily represented by simple mathematical or actuarial calculations
- Identify likely warranty and recall scenarios and establish cost and risk parameters for each
- Work to develop risk mitigation strategies based on our work with the cross-functional teams of our clients (engineering, legal, insurance, risk management, sales, etc.)

About the Authors

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