2019

CRASHCOURSE

I OWN MY CAR

I DRIVE MY CAR

I FIX MY CAR

PREPARED BY SUSANNA GOTSCH

CONTENTS

EXECUTIVE SUMMARY

How has technology helped our industry evolve to where it is today?

How will technology transform the industry even further and faster in the future?

Our industry has evolved over the last several years with advances in technology such as cloud computing, data analytics, and mobility. Newer technologies such as the Internet of Things (IoT), machine learning, artificial intelligence (AI) and connected cars will transform our industry even further and faster than ever before. Evolution has become revolution.

Long-accepted tenets or established truths like “I own my car,” “I drive my car,” “I insure my car,” “I contact my insurer in the case of an accident,” and others will be challenged as ride-sharing, ride-hailing, vehicle autonomy, telematics, AI, 3D-printing and more bring dramatic change to personal mobility and the industries that have traditionally supported it.

Some of these changes are happening rapidly, others more slowly, but the changes already are dramatic in terms of their impact to customer expectations, traditional business roles, accident frequency and accident loss costs. Companies must adapt, invest, and extend to ensure they can operate successfully now and in the future.

As technology changes the who, the how, the why, and the when of customer engagement, it is even more critical to focus on the customer experience itself, and not lose sight of that in the race to automate and digitize.

This year’s Crash Course will explore how technology has helped our industry evolve to where it is today, and how technology will transform it even further and faster in the future, disrupting personal mobility as we know it.

I OWN MY CAR

Autonomy. Connectivity. Electrification. Shared. The megatrends "ACES" are transforming the traditional auto industry and its players, forcing more competition and new business models.

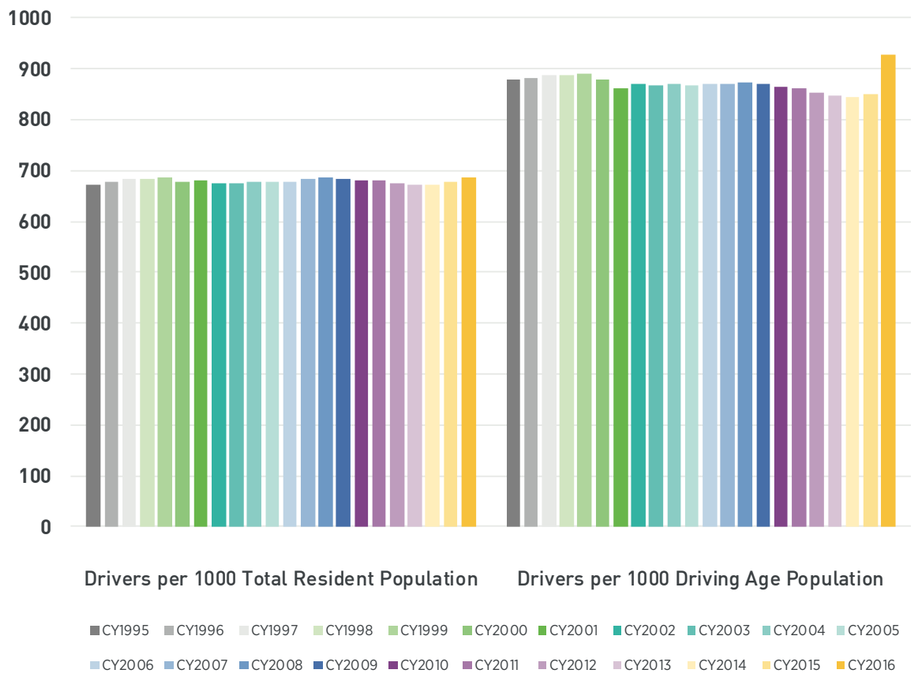
Between CY 2008 and CY 2013, the growth rate for the overall number of licensed drivers and vehicle registrations grew more slowly than the overall U.S. population. Since then, both have outpaced the growth in population with Drivers per 1000 Total Resident Population and Drivers per 1000 Driving Age Population up from CY 2015 (see **Figure 1**).[1] Auto sales slowed significantly during the Great Recession, (dropping to 10.44 million in CY 2009), but then set a new record of 17.55 million in CY 2016.

Auto sales began to slip slightly but continued to exceed 17 million in CY 2017 and CY 2018 (see **Figure 2**). Looking ahead, most analysts expect auto sales to flatten and then decline slowly, eventually stabilizing at about 15-16 million sales annually.[2]

As overall vehicle quality improved, vehicle scrappage rates remained low, leading to a slow turnover of the overall U.S. vehicle fleet and older fleet. IHS Automotive estimates the average age of vehicles on the road in the U.S. is 11.6 years.[3] With auto sales trending about 17 million annually, the overall vehicle fleet continues to grow at about 2 percent annually. Many new vehicles include features — such as advanced driver assistance systems (ADAS), advanced powertrains, and connected and automated vehicle technologies — that are changing the very industry responsible for their manufacture.[4] Automakers are challenged to balance the continued production of vehicles at profit that consumers want to buy, yet make bets and investments in the 'ACES' (Autonomous-Connected-Electric-Shared) technologies poised to change mobility paradigms as we know them today.[5] The Center for Automotive Research has called this 'The Great Divide'.[6]

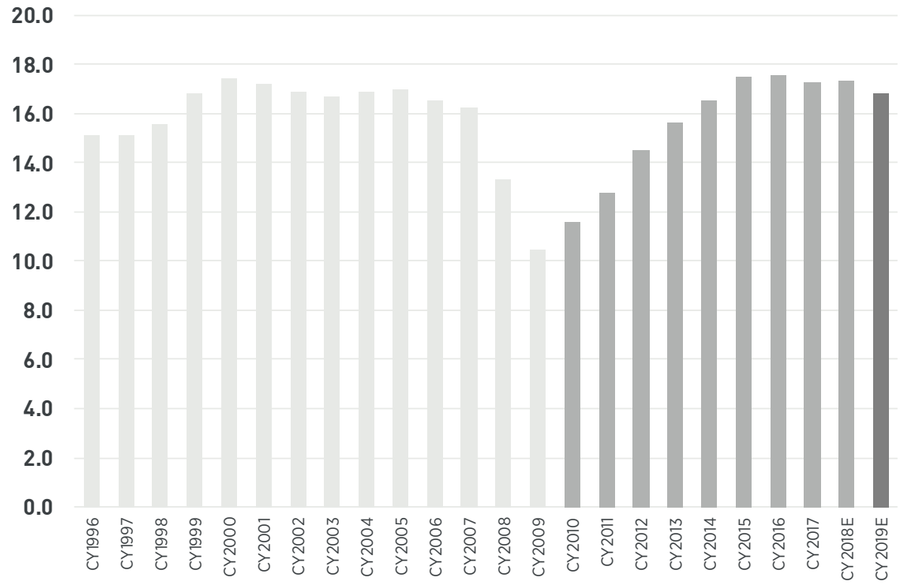
NHTSA Licensed Drivers per 1000 Total Resident Population and Drivers per 1000 Driving Age Population (FIGURE 1)

CY1995-CY2016 | SOURCE: US DOT FHWA POLICY & GOVERNMENT AFFAIRS HIGHWAY POLICY INFORMATION HIGHWAY STATISTICS



U.S. Light New Vehicle Sales (in Millions) (FIGURE 2)

CY1996-CY2019E | SOURCE: AUTOMOTIVE NEWS

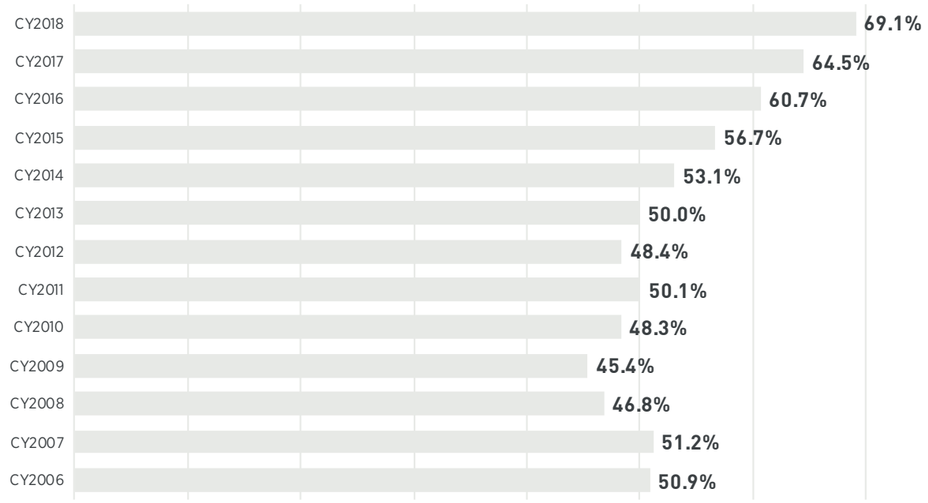


> Automated, Connected, Electric, and Shared (ACES) vehicle technologies are compelling automotive engineers to reevaluate vehicle design, materials, and manufacturing technologies.
>
> Increased duty-cycles, emphasis on interiors, battery and sensor protection, and the changing consumer perception over vehicle performance will change fundamental engineering requirements...

SOURCE: CENTER FOR AUTOMOTIVE RESEARCH. "THE IMPACT OF ACES ON DESIGN, MATERIALS, AND MANUFACTURING" JUN 15, 2018. HTTPS://WWW.CARGROUP.ORG

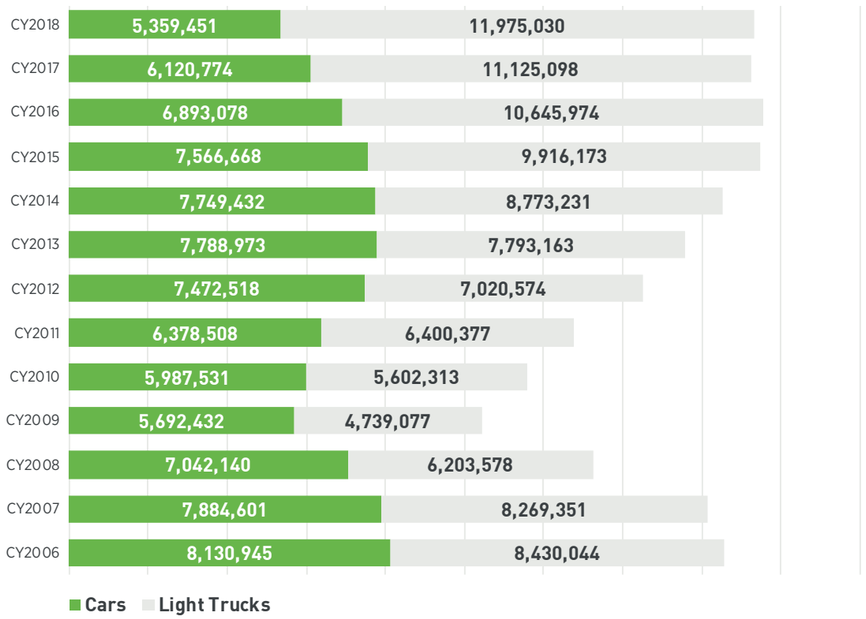
Light-Truck Share of U.S. New Vehicle Sales (FIGURE 3A)

CY2006-CY2017 | SOURCE: AUTOMOTIVE NEWS



Light-Truck vs Car Share of U.S. New Vehicle Sales (FIGURE 3B)

CY2006-CY2017 | SOURCE: AUTOMOTIVE NEWS

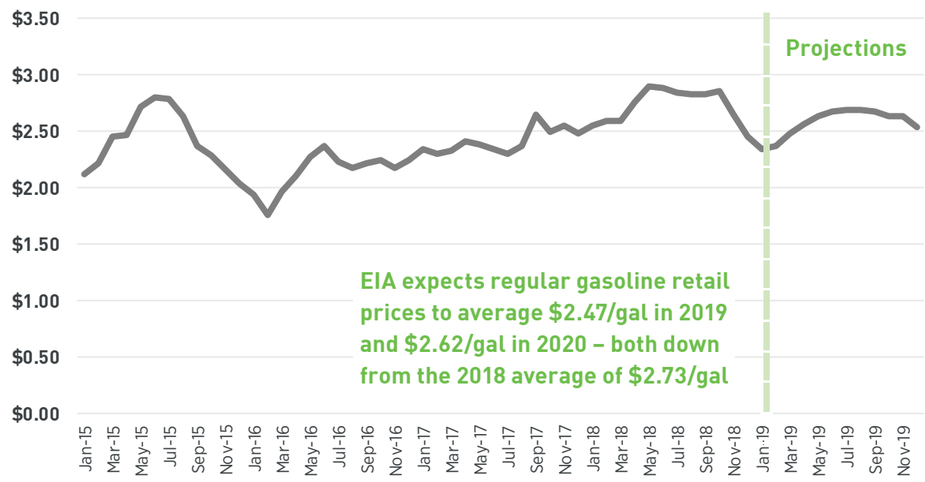


Consider the significant demand for light trucks, which accounted for 69 percent of all new vehicle sales in CY 2018 (see **Figures 3A-B**).[7] Much of the increase in light truck share came from crossover vehicles and large pickups. Higher-priced trucks helped to drive up the average MSRP of new vehicles sold in the U.S., pricing many consumers out of the new vehicle market. In fact, data from J.D. Power shows much of the overall decline in vehicle sales came from lower-cost models that would have been the choice for the more cost-sensitive customer. For the first 10 months of CY 2018, sales of vehicles priced under $20,000 were down by 20 percent, while sales of vehicles priced above $80,000 were up 25 percent.[8] Additionally, more than one-third of all pickups sold during this period had sticker prices of $50,000 or more, and nearly 20 percent of pickups are true luxury vehicles now versus 5 percent 10 years ago.[9] Trucks today offer not only the ability to haul or tow, but also the same amenities offered by luxury vehicles, popular in particular among the 50 percent of people in the U.S. that live in the suburbs. According to Cox Automotive, 60 percent of vehicles sold in the U.S. were priced below $30,000 only five years ago; in 2018 that was closer to 40 percent.[10] As more automakers such as Ford, FCA, and GM phase out their car offerings, consumers have even fewer affordable options. For example, many compact crossovers are $5,000 more than their compact sedan counterparts.[11]

With gas prices expected to remain below $3 per gallon in CY 2019 (per the U.S. Energy Information Administration (see **Figure 4**), automakers are likely to produce more of the popular, profitable light trucks, balancing investments to improve fuel efficiency and emissions in their internal combustion engine technology with investments needed to stay competitive in the electric vehicle space being driven by countries such as China and the EU.

U.S. Energy Information Administration:
Gasoline Regular Grade Retail Price Incl Taxes (U.S. Avg Dollars per Gallon) (FIGURE 4)

SOURCE: U.S. EIA SHORT-TERM ENERGY OUTLOOK DECEMBER 11, 2018. HTTP://WWW.EIA.GOV/FORECASTS/STEO/INDEX.CFM



Vehicle Affordability Driving Change Within the Marketplace

As automakers ramp up the content of vehicles now manufactured with more safety features, telematics, and other technology, the cost of vehicles is rising. New tariffs put in place by the Trump administration in CY 2018 (or under review for CY 2019) are expected to drive prices even higher. Analysts predict the price of a vehicle will increase by another 1 percent due to tariffs on aluminum and steel sourced outside the U.S.[12] And the Center for Automotive Research predicts the expansion of North American capacity for auto assembly, parts and components manufacturing, and steel and aluminum production, and the higher labor costs in Mexico called for under the newly proposed USMCA treaty will add more than 2.5 percent to the cost of U.S. non-truck vehicles, and imports of parts and components.[13] Automakers and consumers already are footing the bill for the 25 percent tariff applied to auto parts made in China, such as catalytic converters, compressors, bearings, and speed sensors. The current 10 percent tariff on other parts — such as vehicle sensors; brake pads, drums, rotors and hoses; automotive tires; bearings; mufflers; drive axles; suspension parts; gaskets; safety glass; and accessories such as floor mats, wipers and mirrors — may increase to 25 percent the early part of 2019.[14] And while the share of overall replacement part spend for vehicles involved in collisions is less than 10 percent, a 25 percent tariff on these parts alone represents an additional $21 per claim, or a 0.7 percent increase in average repair costs.

Finally, additional tariffs of 25 percent on vehicles produced by European Union, Japanese, and Korean automakers still are under consideration for CY 2019, which the Alliance of Automobile Manufacturers estimates could mean an additional cost of $5,800 per vehicle to the 44 percent of vehicles imports sold annually in the U.S.[15] And, the 25 percent tariff on imports also could increase costs for U.S.-built vehicles by as much as $2,000 per vehicle based on foreign-made content of about 35 percent according to the American Automotive Policy Council.[16] As the cost of new vehicles rise, the cost of used vehicles will also likely rise, leading not only to higher repair costs, but higher total loss costs as well. So, while there remains a great deal of uncertainty about the final outcome of the automotive tariffs, it's clear that higher costs across the entire automotive industry are a likely result.

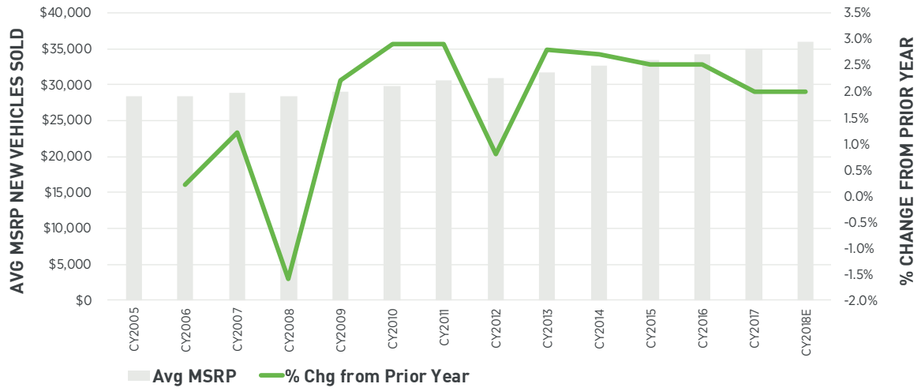
According to the National Automobile Dealers Association (NADA), the average MSRP of a new vehicle sold in CY 2018 increased another 2 percent from CY 2017 (see **Figure 5**). Higher vehicle ownership costs are a concern not only due to the potential drag on new vehicle sales, but also as a key factor driving consumers to explore alternative options to vehicle ownership such as, flexible ownership, ride-sharing, or car-sharing.

The available options related to vehicle ownership continue to grow: new, new lease, new subscription, used, used certified pre-owned (CPO), and used lease. As the average MSRP of new vehicles has grown, a brand-new vehicle has become less affordable for many, driving the popularity of leasing (particularly when interest rates are low). The percentage of vehicles leased annually in the U.S. fell sharply during the recession, but within several years reached 30 percent of all new sales (see **Figure 6**).

As leases reached their termination, many of these vehicles were refurbished and sold as certified-pre-owned (CPO) vehicles, giving many consumers the option to purchase a nearly-new vehicle with warranties similar to those earlier offered only on new vehicles. According to Edmunds.com, a vehicle buyer in CY 2017 who bought a 3-year-old certified-pre-owned (CPO) vehicle versus a brand new vehicle saved nearly 35 percent more than they would have in CY 2010.[17] CPO sales, as well as sales of vehicles up to 3 years of age, helped keep used vehicle sales (and prices) elevated through CY 2018, with the average used vehicle transaction (according to Edmunds.com) exceeding $20,000 in Q3 2018, up over 3 percent from the previous year.

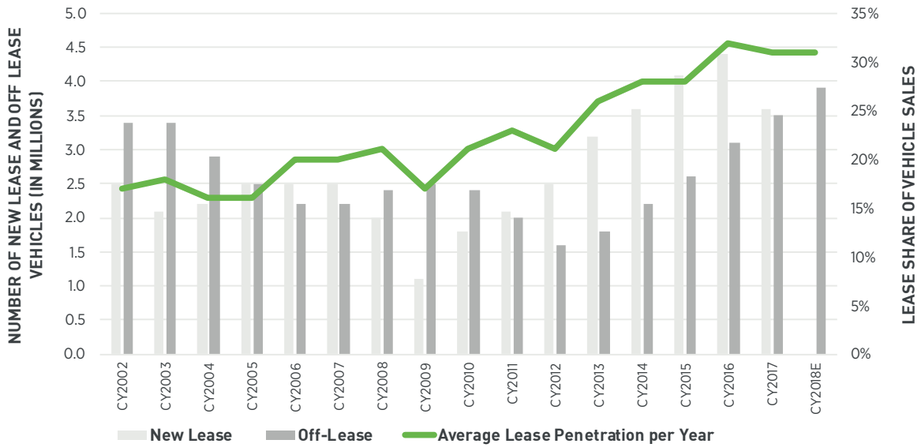
NADA "Average Selling Price of New Vehicles Sold" (FIGURE 5)

CY2005-CY2018E | SOURCE: NADA



U.S. Annual Volume of New Leases and Off Lease Volumes, and Annual Average Lease Penetration (FIGURE 6)

CY2002-CY2018 | SOURCE: MANHEIM CONSULTING - 2017 AND 2018 VOLUME FOR OFF-LEASE VEHICLES ARE MANHEIM'S FORECASTS. THE 2019 FIGURE IS AN ESTIMATE BY REUTERS. EDMUNDS.COM. "2018 AUTOMOTIVE INDUSTRY TRENDS: MIDYEAR UPDATE." JUNE, 2018.



These concerns about affordability, coupled with the growing desire among some consumers to be freed from the hassles of vehicle ownership, are leading OEs and dealers to experiment with various types of subscription programs for both new and used vehicles. There are several key differences between leasing a vehicle versus a subscription plan (also commonly referred to as a flexible ownership program). First, there is no multi-year lease agreement or contract committing the consumer to that vehicle for an extended period of time after which the vehicle can be returned or purchased for its residual value.[18] Most subscription programs are structured to allow a consumer to cancel a subscription at any time via an easy-to-use online app, and to let the consumer easily select a different vehicle in the program with varying levels of frequency. Finally, the subscription typically includes the warranty, maintenance, roadside assistance, repairs, and insurance bundled into a single fee. Subscription programs require that the dealers offering them be prepared to maintain an efficient, full-scale fleet or asset-based management solution.[19] Dealers cannot 'rent,' or include in a subscription program, a vehicle on their floor plan – they actually must own the vehicle.[20] This also means the dealer must know the best time to re-market that vehicle after it has been in the subscription program to assure highest residual value.

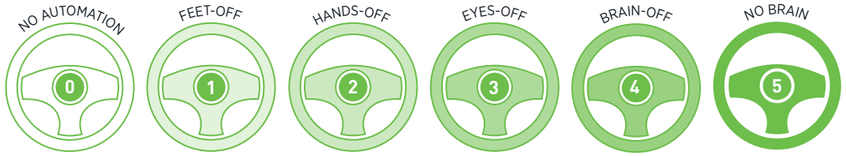
Long term, these types of flexible ownership options point to a blurring of the lines among companies that today operate in much more distinct areas within the mobility sector – i.e. rental car companies, OE vehicle manufacturers, re-marketing companies, fleet operators, auto dealerships, etc. With investments in companies like Lyft and Getaround, and the creation of businesses like Maven (GM), DriveNow (BMW) and Car2Go (Daimler), automakers are looking to ensure they have a place in the changing personal mobility ecosystem. Support and development of car-sharing and ride-hailing programs potentially also ensure a future sales channel where the overall number of sales may be smaller, but the frequency of car replacement may be higher.

SAE International Levels of Automation (FIGURE 7)

SOURCE: HTTPS://WWW.SAE.ORG/STANDARDS/CONTENT/J3016_201806/

SAE LEVEL	0	1	2
	No Automation All roads	**Feet-off** All roads	**Hands-off** Motorway, slow traffic
DRIVER RESPONSIBILITY	Driver performs longitudinal control of vehicle (i.e. maintaining speed, accelerating, and braking) and lateral control (i.e. steering). No automated driving functions; no systems intervene, only issue warnings	System can assume either longitudinal or lateral control of the vehicle, while the driver continuously performs the other task	The driver can now relinquish longitudinal and lateral control to the system in a certain use case. The driver continuously monitors the vehicle and the traffic during the journey
EXAMPLES	Lane departure warning, Blind spot monitoring	Adaptive cruise control, Automatic Emergency Braking, Parking steering assist, Lane keeping assist	Key parking, Highway Driving Assistant, Audi Traffic Jam Assist, Telsa Autopilot, Mercedes-Benz Driver Assistance Systems

Will Vehicle Autonomy Transform Vehicle Ownership? When?



As of CY 2016, global car-sharing members were estimated to be about 6 million, with 2 million in North America, or less than 0.7 percent of the U.S. population.[21] Ride-hailing users globally were estimated at 250 million by the same time.[22] Plenty of questions remain about the ability for ride-hailing companies to be profitable, as their primary fixed cost – the driver – appears to be a necessary fixture for the near future. The technical challenges of creating a fully autonomous vehicle that can operate in all types of road and weather conditions are becoming more apparent. The tragic death of a woman struck by an Uber vehicle in Arizona in CY 2018 underscored the challenges of programming a vehicle that can handle the myriad scenarios necessary to operate autonomously, particularly when many expect these vehicles to be much safer than non-AVs.

Projections for new vehicle sales in the U.S. are expected to decline slowly over the next several years, as headwinds of affordability, higher interest rates, and limited pent-up demand continue. As automakers continue to deliver on commitments to standardize the ADAS features of automatic emergency braking (AEB) and frontal crash avoidance/warning, the vehicle fleet will be transformed, increasing in degrees of automation, ultimately arriving at Levels 4 and 5 of autonomy (see **Figure 7**).

3	4	5
Eyes-off Single stretch of road	**Brain-off** Well-defined urban areas	**No Brain** All road conditions
The driver no longer has to continuously monitor the longitudinal and lateral control of the vehicle - the vehicle requests the driver to resume the task of driving. Driver must be able to resume driving when the system signals him to do so, with some extra time in reserve.	The driver can hand over the entire task of driving to the system in specific use cases. These scenarios refer to the type of road, the speed range, and the environmental conditions.	The vehicle can completely independently perform the task of driving in full on all types of roads, in all speed ranges and under all environmental conditions.
Highway driving assist, Traffic jam assist, Audi Traffic Jam Pilot	Urban driving, Valet parking (driverless parking), Waymo Chrysler Pacifica	TBD

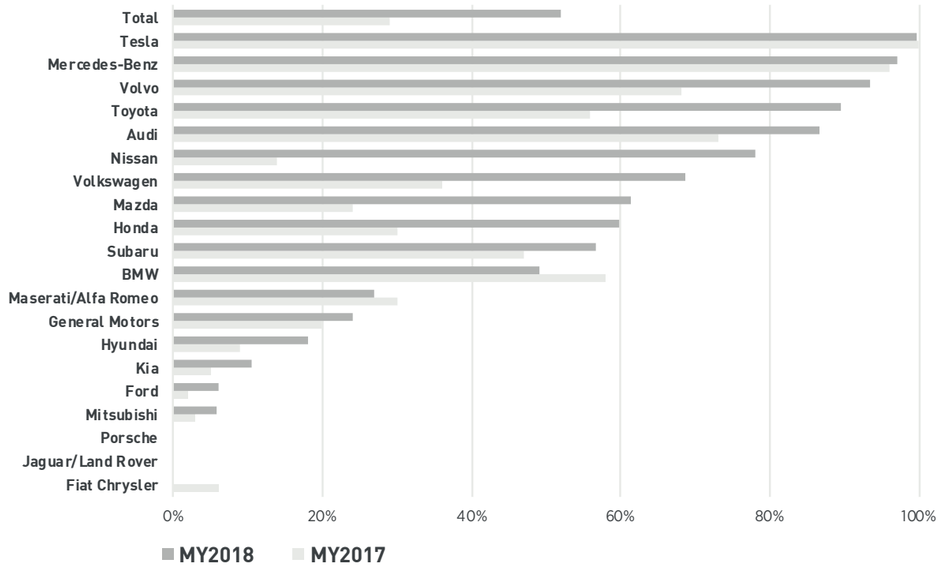
Many vehicles on the road in the U.S. are still at Level 0, with no automated driving functions. But growth among vehicles with Level 1-2 automation is accelerating, as numerous OE's included AEB as a standard feature in MY 2017-18 vehicles. And 20 automakers have committed to the National Highway Traffic Safety Administration to make AEB technology standard in light-duty cars and trucks with curb weight less than 8500 pounds manufactured after September 1, 2022 (see **Figure 8**).[23] The percentage of vehicles with AEB standard across these 20 automakers grew from just under 30 percent for MY 2017 to over 50 percent for MY 2018 based on those that reported actual volumes of AEB-equipped vehicles. Over time, fewer Level 0 and Level 1 vehicles will be manufactured. In fact, the PTOLEMUS Consulting Group, "Autonomous Vehicle Global Study" projects Level 2 vehicles will account for 73 percent of all passenger sales by CY 2025 (see **Figure 9**).[24]

Numerous analysts have published predictions on the delivery of autonomous vehicles (AV), and many vary dramatically in terms of both numbers and delivery dates. For example, Berylls Strategy Advisors projects 13 percent of new vehicle registrations (approximately 2 million) in the U.S. by CY 2030 will be for Level 4 and 5 AVs. Of those, Berylls predicts 30 percent will be robotaxis with the remainder privately owned.[25] IHS Automotive predicts the first AVs will be available in CY 2019 via mobility services' shared fleets such as Waymo's in AZ, and at least 50,000 personally owned AVs will be sold by CY 2021, reaching nearly 1 million sold to individual owners and shared fleets by 2025.[26]

Waymo's promise to deliver a Level 4 autonomous taxi service in the Phoenix area in CY 2018 was met with less than a month to spare. The commercial robotaxi service, called Waymo One, met the timeliness, but the launch is quite conservative. The area of operation is a tightly geo-fenced 60-square mile area covering western half of Chandler, AZ and southern Tempe, AZ.[27] Prior to launch, Waymo added a co-driver to all rides, installed interior 'fatigue' cameras to identify whether the backup driver was alert, and even returned the backup driver to the driver seat in their most advanced AV models.[28] Each autonomous taxi also is connected to a 'remote assist driver' that monitors the AV remotely, and assist with tricky driving scenarios like steering around a double-parked car that doesn't require the backup driver to take over.[29]

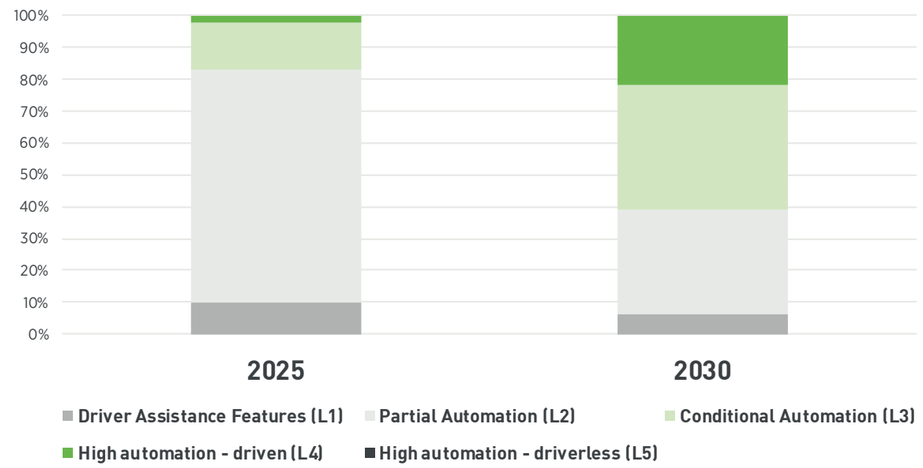
Percent of MY2017 and MY2018 Vehicles Conforming to AEB Voluntary Commitment per OEM (FIGURE 8)

AS REPORTED BY MANUFACTURER FOR LIGHT-DUTY VEHICLES 8,500 LB. OR LESS GROSS VEHICLE WEIGHT | SOURCE: WWW.NHTSA.GOV



PTOLEMUS Consulting Group: Share of North American Passenger Vehicle Sales per Level of Autonomy (FIGURE 9)

SOURCE: PTOLEMUS CONSULTING GROUP. "AUTONOMOUS VEHICLE GLOBAL STUDY." PRESENTATION TO THE CASUALTY ACTUARIAL SOCIETY, RPM SEMINAR, CHICAGO, MARCH 20TH, 2018

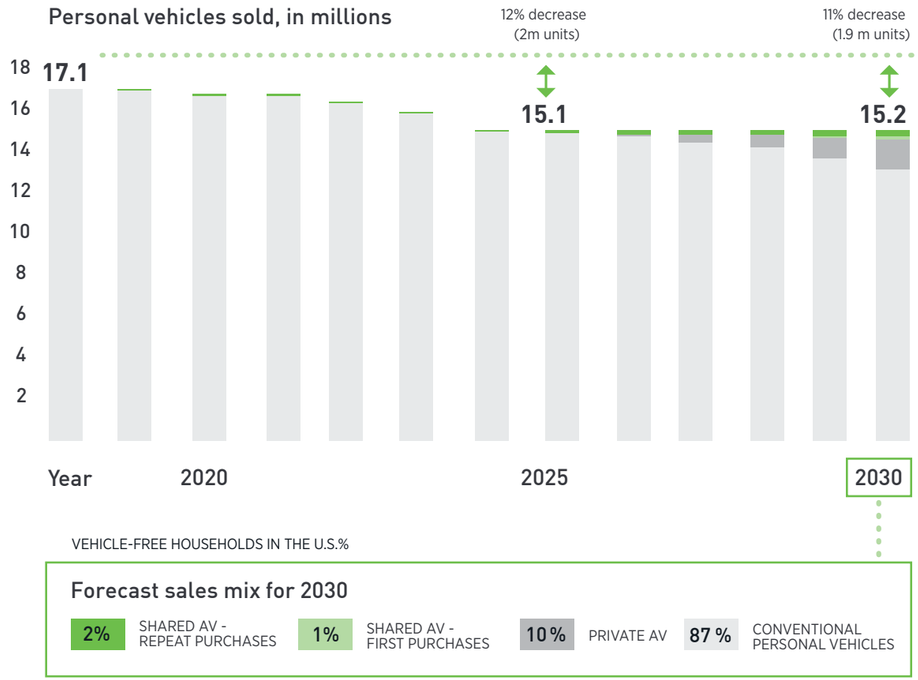


Many analysts predict commercial availability of Level 4 and 5 AV's will lead to fewer overall vehicles sold annually, as options for combination of autonomous features coupled with ride-sharing and car-sharing eliminate the need for individual vehicle ownership. For example, the Berylls report suggests 9 percent of potential vehicle buyers will choose ride-sharing or car-sharing alternatives versus purchasing their own vehicle, reducing overall vehicles sold in the U.S. to about 15 million by CY 2030 (see **Figure 10**).[30] As more technology makes its way into the vehicle, the value will shift further from hardware to software.

Today about 90 percent of a vehicle's value lies in its hardware; with AVs, Morgan Stanley predicts that number will drop to 40 percent, with another 40 percent coming from the software, and 20 percent from the content that streams into the vehicle.[31] As the composition of the vehicle changes, so too will the skill sets of the individuals needed to design, manufacture, and repair them.

Autonomous Vehicles Impact to U.S. Auto Sales - Some Vehicle Sales Will Be Cannibalized (FIGURE 10)

SOURCE: HTTP://WWW.BERYLLS.COM/WP-CONTENT/UPLOADS/2018/11/20181114_STUDY_AUTONOMOUS2030_EN.PDF



As consumers, automakers, auto dealers and others adapt to AVs and mobility-based solutions such as flexible ownership, ride-hailing, and car-sharing, we could see fewer sales overall, but 50 percent of all new vehicles could be sold to fleet-based companies by CY 2040.[32] As a by-product, many analysts forecast significant declines in the overall number of auto dealerships in the U.S., from over 18,000 today to potentially half that number. Already dealerships are expanding their business models, taking on new responsibilities and business partners — such as Autonation working with Waymo to service and maintain its fleet of AVs in Phoenix, and Waymo working with Avis to charge, refuel, and clean its vehicles, — blurring the lines among the traditional roles of dealership, rental car company, and fleet management company.[34]

Finally, the actual product being purchased – a vehicle – is undergoing more change than perhaps at any other time. Vehicles are becoming smartphones on wheels, connected to the internet, with more features designed to ultimately remove the need for the driver to even drive the vehicle. With more connected vehicles each new model year, automakers will increasingly provide over-the-air updates for regular maintenance and even vehicle recalls. As more countries mandate that automakers meet specific targets regarding emissions and fuel economy, automakers are introducing more electric vehicles with fewer moving parts than traditional internal combustion engine vehicles, potentially reducing the need for as many service businesses as well. These megatrends "ACES" (autonomy-connectivity-electrification-shared) are transforming the traditional auto industry and its traditional players, forcing more competition and new business models.

> Where once the auto-sector workforce was anchored by workers responsible for mechanical and machine-maintenance roles, the need for electrical skills is now growing exponentially due to the increasing electrical and electronic content of the car.
>
> Likewise, where mechanical engineers once predominated, the original equipment manufacturers (OEMs) are increasingly looking for software engineers, energy management experts, and data scientists able to build electric and self-driving vehicles.

SOURCE: MARK MURO AND ROBERT MAXIM. "WHAT GM'S LAYOFFS REVEAL ABOUT THE DIGITALIZATION OF THE AUTO INDUSTRY." HTTPS://WWW.BROOKINGS.EDU. DECEMBER 13, 2018

Auto sales in the U.S. have been a major economic force for many years, and the U.S. has the highest rate of vehicle ownership in the world. As new mobility options such as car-sharing, ride-sharing, bike-sharing, and autonomous vehicle technology mature, the one-vehicle to one-person model is expected to change. The "I" and the "car" in the tenet "I own my car" will change – perhaps the "I" becomes a "we" and the "car" becomes a transportation-as-a-service (TAAS) membership. With fewer potential new vehicle sales to individual consumers, and changes to the product itself, the traditional lines between the new/used vehicle dealer, service centers, rental car companies, fleet maintenance companies and more will blur, and it will be those companies that provide consumers with the best overall experience for the best value that will survive and thrive in the new world.

I INSURE MY CAR

I bought a car – now what? I need to buy insurance coverage for that vehicle.

Historically, the driver has been the responsible party in most vehicle accidents, and our insurance and regulatory systems were built based on this assumption. Individual states establish regulations that require vehicle owners to purchase minimum amounts of insurance coverage, and tracks driver ability through point systems tied to driving violations.[35] Insurance carriers then use this information, along with other data such as driver age, education, marital status, etc., to create rating models and price product. When an accident occurs, claims are paid by the insurance carrier for the at-fault vehicle via the premiums they have collected.

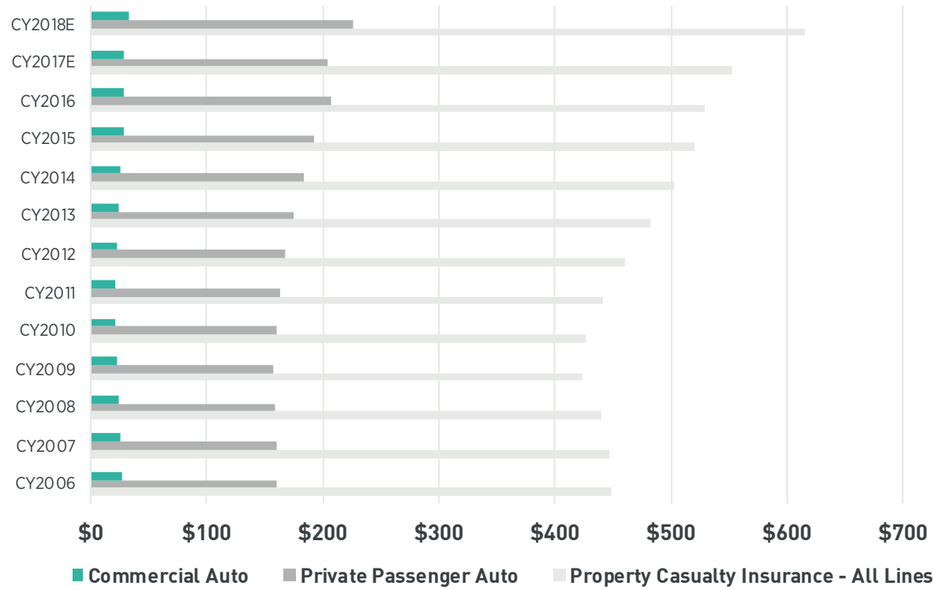
Private passenger and commercial auto insurance in the U.S. accounts for over 40 percent of the total property/casualty insurance industry's net premiums, with private passenger auto accounting for 88 percent of total auto premiums as of CY 2016 and commercial auto the remaining 12 percent (see **Figure 11**).[36]

Auto insurance profitability suffered in CY 2015 and CY 2016 as increases in both frequency and loss costs exceeded premiums collected. Personal auto insurers' rate increases of 7.5 percent in CY 2017 and an estimated 6.5 percent in CY 2018 and some slowdown in frequency have helped combined ratios fall to about 100 again, after several years where it was much higher (see **Figure 12**).[37] Personal auto's net incurred loss ratio also improved in CY 2017, falling to 67.9 percent from CY 2016's 15-year high of 70.3 percent.[38] Estimates from Fitch Ratings, based on the first nine months' results of CY 2018 for nine publicly held U.S. insurers, suggest the industry results improved even further last year. The group's combined ratio for the first nine months of CY 2018 improved to 92.2 percent versus 98.1 for full year CY 2017 and 98.8 for full year CY 2016.[39]

Personal auto results were helped in large part by a slowdown in claim frequency across collision, property damage liability and comprehensive. Auto claim frequency has trended down for many decades, but recently rose with the recovery after the Great Recession. In 2017 and 2018, it began to fall again (see **Figure 13**).[40]

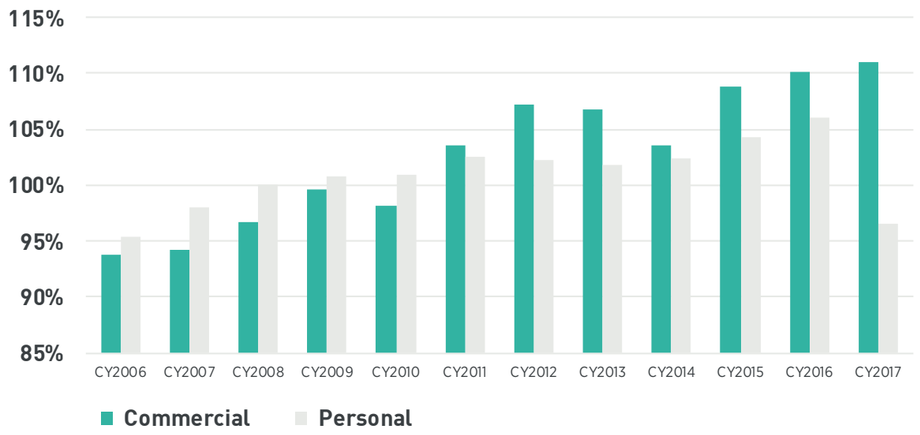
U.S. Net Insurance Premiums (in Millions) (FIGURE 11)

NOTE: THE TAX REFORM ACT AT THE END OF 2017 LED TO THE SPIKE IN NET WRITTEN PREMIUM IN 2018 - $314B AT SECOND QUARTER.
CY2006-CY2018E | SOURCE: INSURANCE INFORMATION INSTITUTE



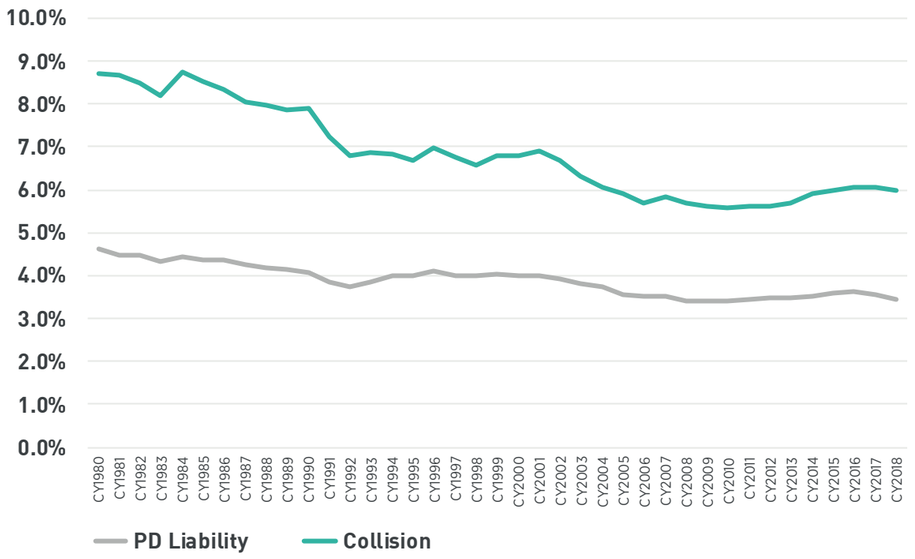
Auto Insurance Combined Ratio (FIGURE 12)

CY2005-CY2017 | SOURCE: NATIONAL ASSOCIATION OF INSURANCE COMMISSIONERS DATA, SOURCED FROM S&P GLOBAL MARKET INTELLIGENCE; INSURANCE INFORMATION INSTITUTE



Fast Track Paid Claim Frequency by Calendar Year Rolling 4 Quarters Ending Q4 Each Year (FIGURE 13)

CY1980-CY2018 | NOTE: CY2018 ROLLING 4 QUARTERS ENDING Q3 2018
SOURCE: ISS FAST TRACK PLUS™ PERSONAL AUTO, AS OF SEPTEMBER 30, 2018



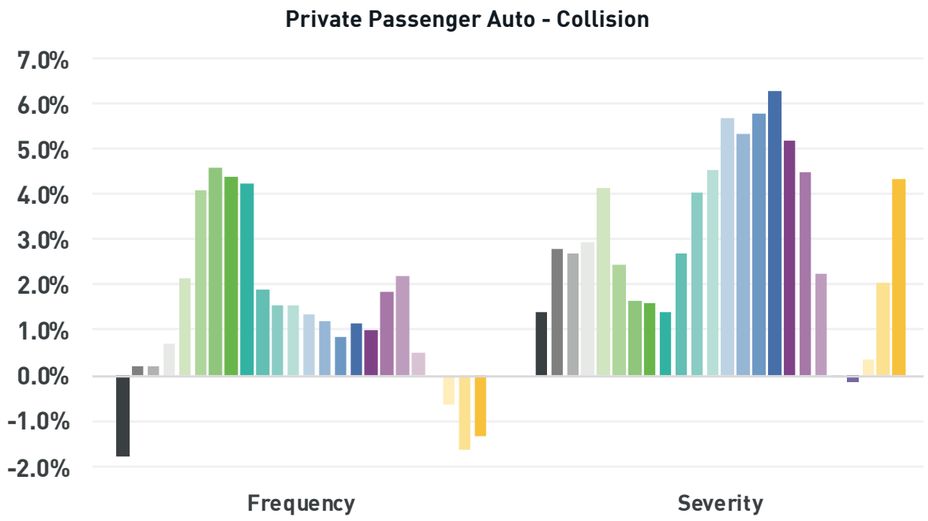
According to the ISS Fast Track Plus™ reports, private passenger auto collision frequency closed out CY 2017 down flat versus CY 2016, and the four quarters ending Q3 2018 show collision frequency down another 1.3 percent (see **Figure 14**).[41]

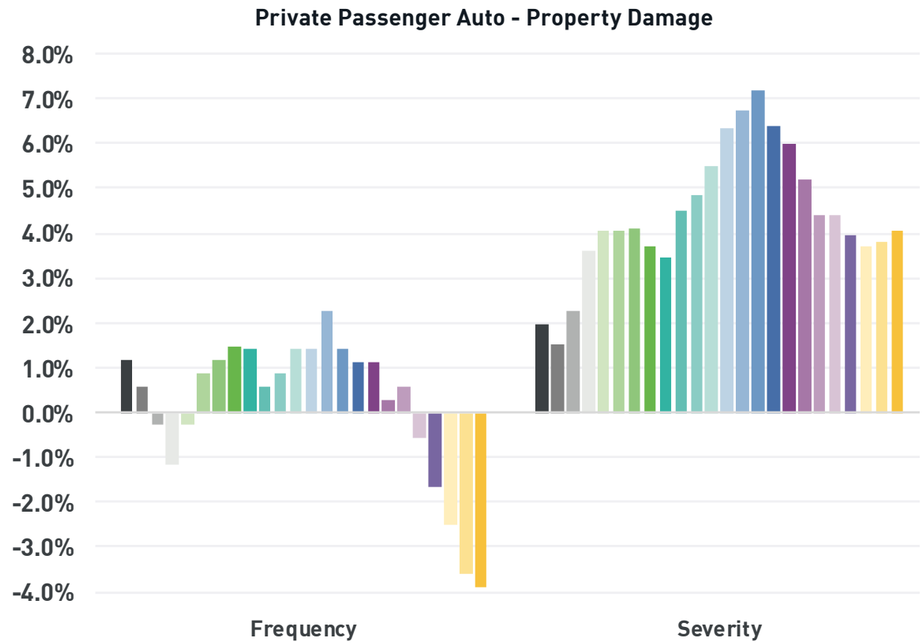
Private passenger auto property damage liability frequency also declined 1.7 percent in CY 2017 from CY 2016, and the four quarters ending Q3 2018 show liability frequency down another 3.9 percent (see **Figure 15**).[42] And despite devastating wildfires, hurricanes, and thunderstorm events (includes tornadoes, hail, and straight-line winds) in numerous parts of the U.S. in CY 2018, comprehensive loss frequency ended down nearly 1 percent in CY 2017 and for the four quarters ending Q3 2018 (see **Figure 16**).[43] Average claim costs across all three lines of coverage continued to climb however, though more slowly than what we saw in CY 2015 and CY 2016.

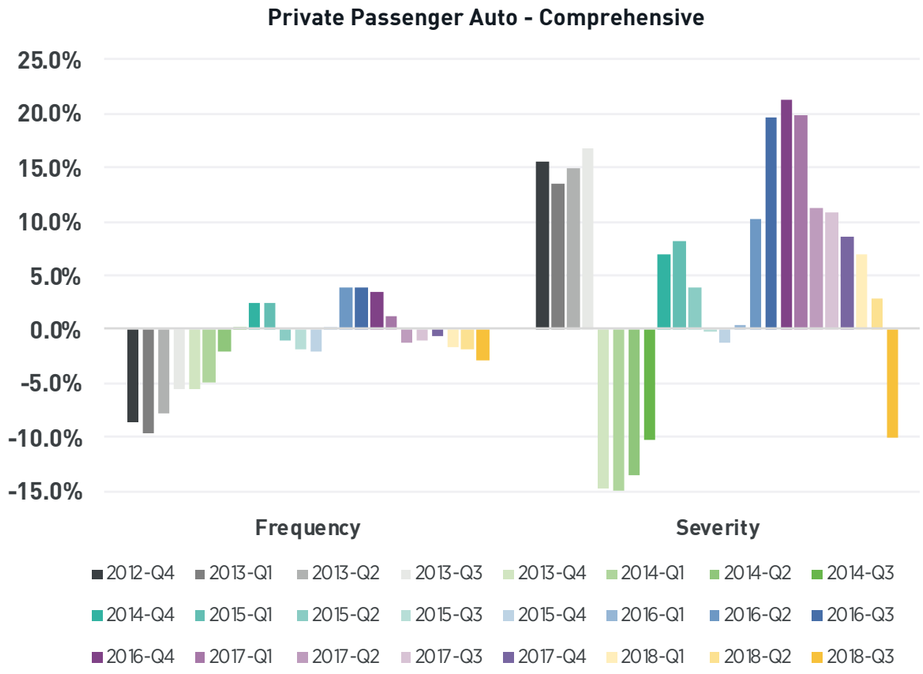
Commercial auto continues to see poor results, despite significant rate increases since 2012, a 7.0 percent increase in CY 2017, and an estimated 9.5 percent increase in CY 2018 per Moody's.[44] Both personal and commercial auto had seen results deteriorate as miles driven and accident/claim frequency rose along with loss costs, but commercial auto results were also impacted by higher attorney involvement, increases in large-scale losses of $10 million plus, and demand for drivers leading to more inexperienced drivers hired by many firms.[45]

Percent Change in Claim Frequency & Severity from Quarter One Year Prior
Each Quarter Represents Rolling 4 Quarters Data Ending That Quarter (FIGURES 14-16)

SOURCE: ISS FAST TRACK PLUS™ PERSONAL AUTO, AS OF SEPTEMBER 30, 2018







> [Research] finds that the consequences of higher temperatures on the U.S. economy may be more widespread than previously thought.
>
> By examining changes in temperature by season and across states, they find evidence that rising temperatures could reduce overall growth of U.S. economic output by as much as one-third by 2100.
>
> RICARARDO COLACITO, BRIDGET HOFFMAN, AND TOAN PHAN, "TEMPERATURE AND GROWTH: A PANEL ANALYSIS OF THE UNITED STATES." FEDERAL RESERVE BANK OF RICHMOND WORKING PAPER NO. 18-09, MARCH 2018.

Mother Nature provided only limited relief in CY 2018 in terms of the scale, scope, and placement of major storms, hail, wind, wildfires, hurricanes, and more. U.S.-insured catastrophe losses were more than $90 billion in CY 2017 (CY 2016 dollars) (see **Figure 17**).[46] From 1997 to 2016, convective storms events, including tornados, hail, wind, and flood losses associated with tornadoes accounted for 40 percent of all U.S. insured catastrophe losses,[47] and hail alone is about 70 percent of the annual amount of damage produced by severe thunderstorms each year.[48] In fact, hailstorm insured losses in the U.S. in CY 2018 were estimated to be over $10 billion for the 11th consecutive year. Wildfires in California in CY 2017 in October and December resulted in losses of $13 billion across northern and southern parts of the state,[49] and CY 2018 provided no relief. Numerous wildfires, like the Camp Fire in Butte County, caused many fatalities and historic levels of damage. Early estimates of the devastation brought by the wildfires in CY 2018 suggest insured paid losses will likely exceed $16.5 billion.[50] Numerous hurricanes also made landfall in CY 2018, with Hurricanes Florence and Michael bringing some of the worst damage, with insured losses estimated at $5 billion and $10 billion respectively.[51]

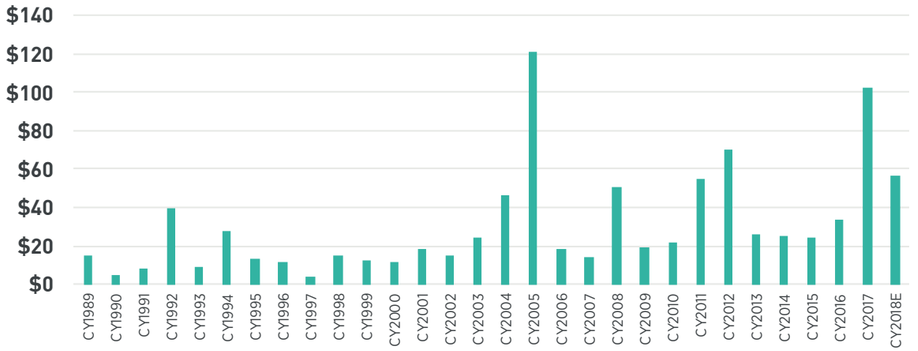
As the temperature of the globe continues to rise, the cost and devastation of natural disasters becomes worse, and more states such as California, Texas, New York, Florida, and other states struggle with resources to assist before, during, and after these major disasters. Many state and local governments are looking for approval from voters for billions of dollars of debt bonds for environmental projects largely aimed at protecting against the impact of rising global temperatures.[52] In fact, scientists and engineers are updating catastrophe models, because many decades of historical data is no longer as useful for predicting risk, as things like rainfall levels are more extreme than ever. Insurers are at the forefront of this challenge, as Torsten Jeworrek, chief executive for reinsurance at Munich Re stated: "We don't discuss the question anymore of, 'Is there climate change.' For us, it's a question now for our own understanding."[53]

Insurance Industry Transforming to Meet Customer Demand

The insurance industry is responding to consumer demand for greater digitization of all interactions with an insurance carrier. Insurance carriers are making investments to build capabilities in house, or working with established or new players in the marketplace to enable new products and services focused on underwriting and risk selection, product design and distribution, customer engagement, and claims management and prevention.[54] Global investment in Insurtech increased 32 percent in CY 2017, and the number of individual Insurtech deals increased 39 percent.[55] North America leads in overall share of value and number of deals, accounting for $1.24 billion, or 46 percent of the deals in CY 2017 (see **Figure 18**).[56]

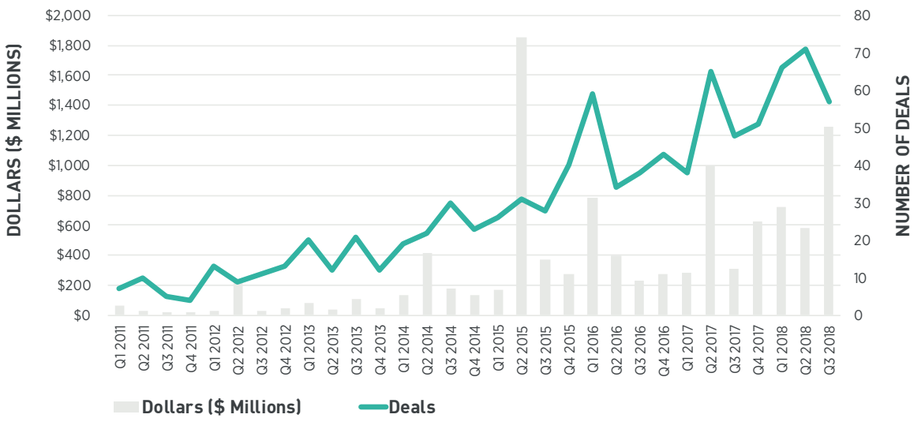
U.S. Insured Catastrophe Losses U.S. Dollars in Billions, CY2016 Dollars (FIGURE 17)

CY1989-CY2018E | SOURCE: AON PLC. IMPACT FORECASTING®. "WEATHER, CLIMATE & CATASTROPHE INSIGHT: 2018 ANNUAL REPORT," P. 39.



CB Insights Quarterly InsurTech Funding Value and Deals - All Stages (FIGURE 18)

SOURCES: WILLISTOWERS WATSON, WILLIS RE, CB INSIGHTS. "QUARTERLY INSURTECH BRIEFING" REPORTS FOR Q1 2018, Q2 2018, Q3 2018



Consumers expect support of a digital experience from their insurance companies in claims, policy updates, insurance shopping, etc. According to the J.D. Power 2018 Auto Insurance Study, better access to online self-service tools through insurer websites and mobile apps has helped drive auto insurance customer satisfaction to its highest level since CY 2000 (see **Figure 19**).[57] And while there are other components that contribute to a customer's overall experience with the insurance industry (such as billing and payment and policy offerings), online and offline service interactions combined account for 67 percent, and were shown to improve with digital interaction.[58] Customer satisfaction is particularly important given the overall slow growth of new customers entering the personal lines auto insurance market (only about 2 percent in CY 2018 – roughly the same as new vehicle registrations). As customer satisfaction increases, there is a corresponding decline in the intent to shop for different insurer.[59]

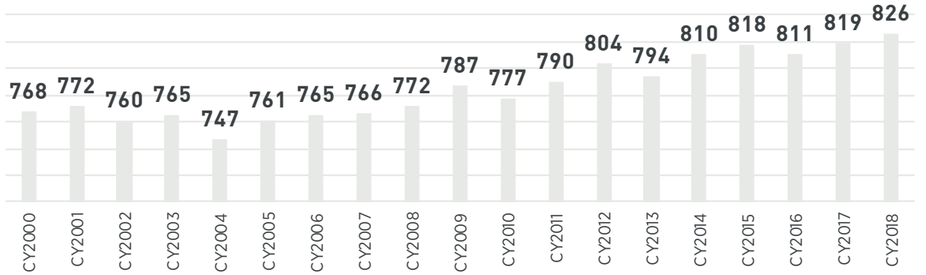
Customer retention is a huge benefit gained from improving digital channel experiences, yet there are additional benefits that help insurance carriers with their loss adjustment expenses. For example, the J.D. Power 2017 Auto Insurance Study found that customers who set up an account online with their insurer are two times as likely to submit incident photos through an app and receive digital updates, and three times more likely to report first notice of loss online.[60] However, the overall percent of customers willing to report their first notice of loss is low, with 9 percent in J.D. Power's 2017 survey growing only to 11 percent in their 2018 survey.[61] But the same survey data also showed 65 percent of customers received digital status updates for an auto claim, and 42 percent submitted their own photos.[62]

According to Capgemini's 2018 World Insurance Report, self-service through the Internet/website is cited by customers as one of the most important channels of communication and for conducting transactions (see **Figure 20**).[63] In general, most people interact with their insurance company on a limited basis – with the two primary interactions occurring at policy sale/renewal and claim.[64] So, it is not surprising that insurance carriers are focused on 'digitizing' those two experiences for their customers. For example, many insurance carriers implemented programs that provide consumers with proactive updates on the status of their claim.

Virtual auto claims handling via integrated smartphone technology has emerged as a key competency that consumers not only want and expect, but the technology also removes significant cost from the claims process, by "…essentially eliminating the first half of the work. [The insurer doesn't] have to get the car to the human or the human to the car."[65] Insurance carriers are increasingly providing their customers with access to mobile photo estimating apps as a means to conduct the preliminary vehicle inspection. Analysis of vehicle appraisals generated annually shows a shift among insurance carriers and their customers to new and different methods of vehicle inspection such as virtual or photo inspections and away from insurance staff appraisers inspecting the vehicle in the field or in a drive-in facility (see **Figure 21**).

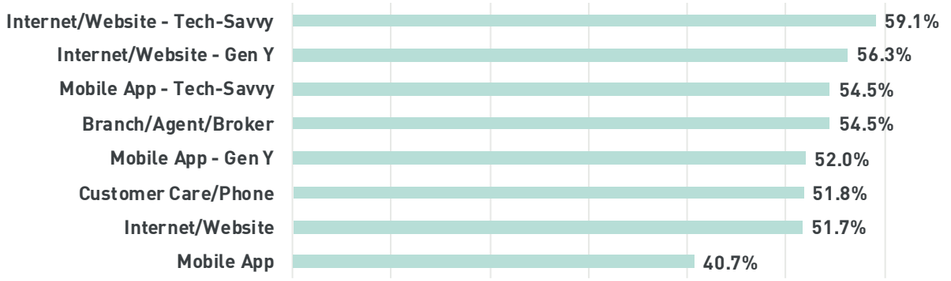
J.D. Power 2018 U.S. Auto Insurance Study℠
Auto Insurance Customer Satisfaction Index (on a 1,000 point scale) (FIGURE 19)

SOURCE: LAJDZIAK, ROBERT M. "HIGH CUSTOMER SATISFACTION LEADS TO NEW CHALLENGES FOR INSURERS." SEPTEMBER 18, 2018. HTTPS://WWW.CARRIERMANAGEMENT.COM/FEATURES/2018/09/18/184296.HTM.



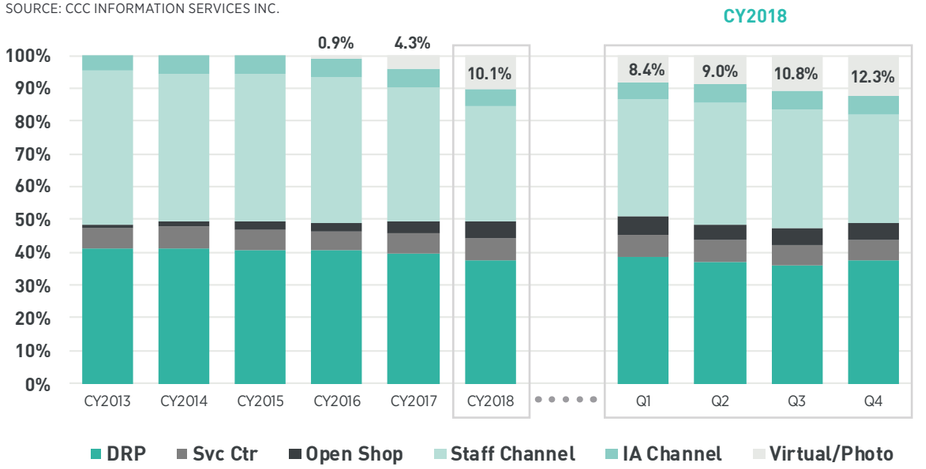
Capgemini 2018 World Insurance Report - Importance of Channels for Customers (%)

(FIGURE 20) | SOURCES: CAPGEMINI 2018 WORLD INSURANCE REPORT; CAPGEMINI FINANCIAL SERVICES ANALYSIS, 2018; CAPGEMINI VOICE OF THE CUSTOMER SURVEY, 2018 | NOTE: GEN Y CUSTOMERS ARE CHARACTERIZED AS CUSTOMERS AGED 18 TO 34.



CCC National Industry Repairable Appraisal Volume Share per Estimate Method of Inspection (FIGURE 21)

SOURCE: CCC INFORMATION SERVICES INC.



With photo inspections, consumers who have no intention of repairing their vehicle save time they otherwise would spend shopping for an estimate. A comparison of repairable appraisal volume by method of inspection reveals few of the photo estimates have damage that exceeds 30 percent of the loss vehicle's ACV (see **Figure 22**), and the age mix is weighted older among those claims where the customer chose photo estimating as the method of inspection (see **Figure 23**). The capture rate (ratio of actual repairs to appraisals generated) for shops participating in DRPs is much lower for repairs less than $1,000 (see **Figure 24**), and lower for older model year vehicles (see **Figure 25**). This suggests many customers with lower repair costs opt to forgo the repair, perhaps because their vehicle is older, or the deductible exceeds the repair cost and the claim is made without payment, or they are willing to simply live with the damage to the vehicle.

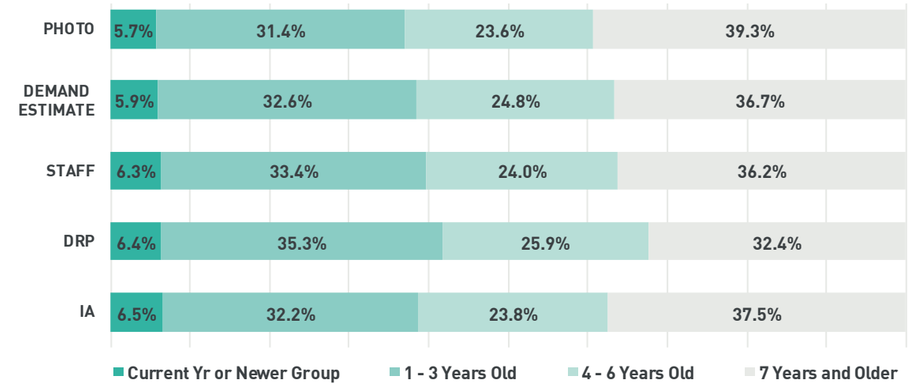
CY2018 Share of CCC Repairable Appraisal Volume by Repair Cost % of Loss Vehicle's ACV Range (FIGURE 22)

SOURCE: CCC INFORMATION SERVICES INC.

	DRP	IA	STAFF	OPEN SHOP	SERVICE CENTER	PHOTO	ALL MOIs
→0% and ←30%	71.5%	70.9%	70.5%	71.1%	78.3%	82.5%	**72.4%**
→=30% and ←50%	17.3%	17.1%	17.8%	16.0%	14.7%	11.3%	**16.8%**
→=50% and ←70%	8.1%	7.7%	8.4%	7.8%	5.5%	4.4%	**7.7%**
→=70% and ←75%	1.0%	1.0%	1.0%	1.1%	0.6%	0.5%	**0.9%**
→=75% and ←80%	0.6%	0.7%	0.8%	0.8%	0.4%	0.3%	**0.7%**
→=80%	1.5%	2.6%	1.5%	3.3%	0.5%	0.9%	**1.5%**

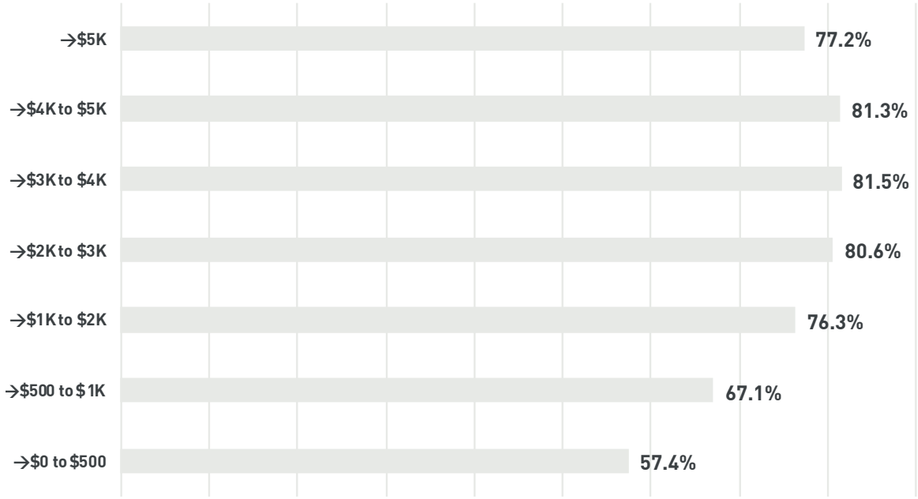
CY2018 Share of CCC Repairable Appraisal Volume by Method of Inspection and Vehicle Age Group (FIGURE 23)

SOURCE: CCC INFORMATION SERVICES INC.



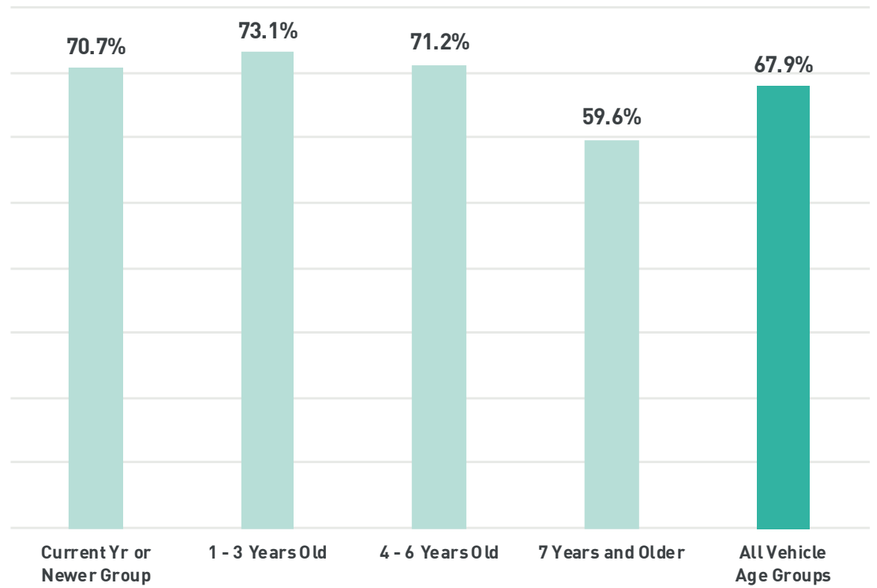
CY2018 CCC DRP Industry Capture Rate per Repair Cost Dollar Ranges (FIGURE 24)

SOURCE: CCC INFORMATION SERVICES INC.



CY2018 DRP National Industry Capture Rate per Vehicle Age Group (FIGURE 25)

SOURCE: CCC INFORMATION SERVICES INC.



With a growing number of insurance carriers offering photo estimating apps like CCC®– Quick Estimate, and consumers appearing to opt-in for that preliminary method of inspection on vehicles with less damage and ultimately lower repair costs, this may help to achieve time savings for the customer and the repairer. A comparison of claim cycle times reveals the number of days from the last estimate assignment to the date the initial estimate of record is completed is lowest for those appraisals with a photo estimate method of inspection, and photo inspections have the highest percent of appraisals where the last estimate assignment to date of estimate complete is less than or equal to 12 hours (see **Figure 26**).

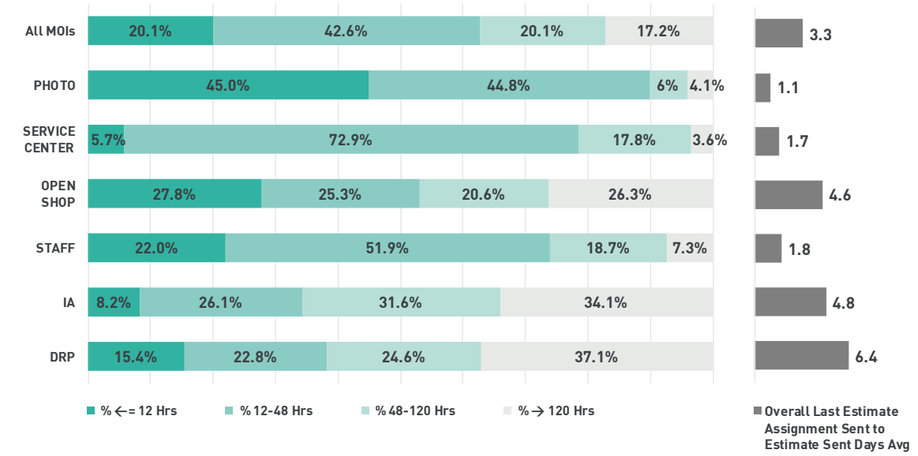
As the industry looks to offer customers greater flexibility and digital self-service capabilities, the key is to do so in a manner that doesn't ultimately lead to more work, more confusion, or longer cycle times for the customer. There are certain types of vehicle damage where photos can provide enough detail to arrive at a preliminary estimate of the damages, or a prediction of whether the vehicle is repairable or total loss. But, when photos are combined with AI and deep learning algorithms, the capabilities of processing a claim with more limited human intervention can be expanded to a broader set of claims. For example, CCC Smart Total Loss™ solution can help insurers more accurately predict if a vehicle is repairable or a total loss with a single photo. And, the CCC® Smart Estimate solution applies CCC's estimating logic and AI to vehicle collision photos to predict repair requirements and suggest estimate lines — including parts likely required to complete the repair — for human estimators to review, edit, and advance. Through the process, Smart Estimate AI and human estimators learn from each other, creating fast and ever-smarter auto physical damage estimates over time. As vehicles become more connected, the data from the vehicle itself will supplement digital technology such as photos, and AI, to enhance decision-making precision and further streamlined claims processes. With more customers looking for self-service claim capability, and more claims eligible for photo inspection via the combination of photos with AI and deep learning algorithms, adjuster productivity could improve at rates never seen before.

The streamlined appraisal process also sets the stage for a streamlined repair process – where within the same app the customer can view the estimate of record produced from the vehicle photos, then choose the repair facility he/she wants to fix their vehicle, and even schedule the appointment with that shop. Photo estimating coupled with online claims communication and scheduling saves the consumer time he/she may traditionally have spent driving around to multiple shops to get estimates or waiting for an insurance adjuster to show up at their home or work, ultimately ending up with a paper copy of the estimate and maybe a check, only to then have to decide where to get the car repaired, and schedule the vehicle repair.

Data from a recent case study of nearly 20,000 DRP assignments reveals customers who schedule their own assignment online with the shop via CCC Shop Scheduling have a higher propensity to show up for the scheduled assignment – leading to higher assignment capture rates for the repairers who list their appointment times online for the consumer to book directly (see **Figure 27**). With online shop scheduling available as a 'next step', the customer has the ability to select the repairer based on proximity, DRP program participation, on-line reviews, customer referrals, or availability of OE certification, essentially enabling the overall experience to occur on a single platform in a personalized manner – not too different from what consumers experience on Amazon today. Insurance companies and repairers who adopt a single platform can enable consumers to efficiently process their claim, schedule the repair, and ultimately deliver an experience more in-line with modern expectations.

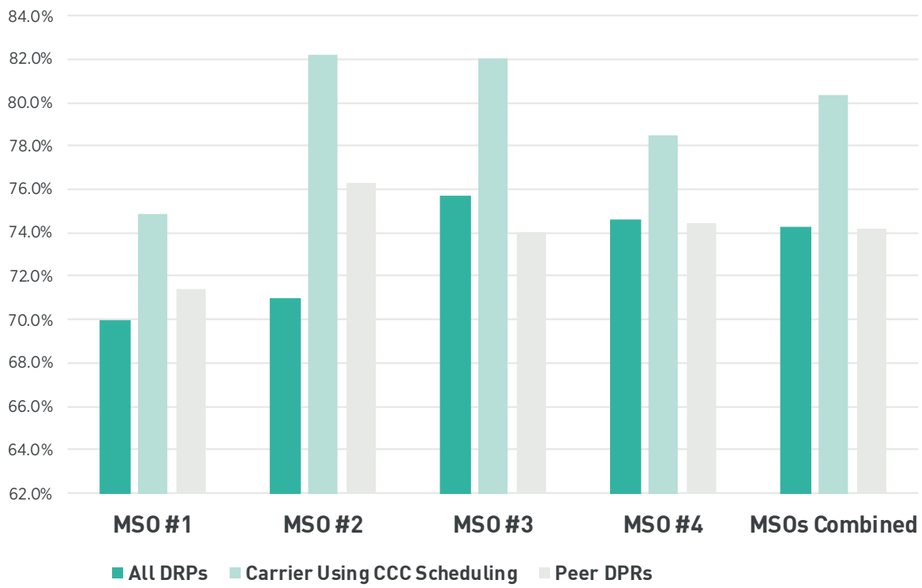
CY2018 Percent of CCC Repairable Appraisals Where Last Estimate Assignment Sent to Estimate Upload Within Specified Hour Range and Overall Average Days (FIGURE 26)

SOURCE: CCC INFORMATION SERVICES INC.



Assignment Capture Rate Comparison - Case Study of CCC Shop Scheduling (FIGURE 27)

SOURCE: CCC INFORMATION SERVICES INC.



ABOUT THE AUTHOR

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> The Shift-Left Effect describes how a process is made more efficient by merely re-ordering its steps. Typically, it requires an investment in technology to power the revised process and the resultant process yields higher customer satisfaction, shorter cycle time, and lower costs.

The "Shift-Left" Effect

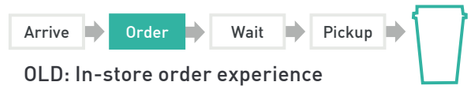
Ron Nelson

Sometimes small changes yield big results. The Shift-Left Effect describes how a process can become more efficient when one of its steps shifts left. Imagine a process with four steps: A-B-C-D. Now imagine, step B shifts left. The result might be that step C is no longer needed as a result: B-A-D. Ignore the acronym BAD, this outcome is good!

A real-world example of the Shift-Left Effect is the Starbucks® Mobile Order and Pay service. Launched in 2015, the service enables consumers to pre-order their beverage before arrival.

Starbucks® Mobile Order and Pay

In the diagram below, the "Order" step is left-shifted to occur before the "Arrive" step. As a result, the consumer can avoid the "Wait" step.



OLD: In-store order experience

NEW: Pre-order experience

Starbucks innovated their business process through a Left Shift resulting in clear benefits:

- **Choice:** Offering multiple service channels increases the likelihood of customer satisfaction.
- **Data and insights:** Analytics on a mobile app provide early insight into consumer behavior.
- **Worker productivity**: Less cashier time is required to take orders and payments.
- **Reduced cycle-time:** All customers benefit when fewer customers are in line to order.
- **Loyalty**: Consumers are more likely to revisit a brand that provides superior experience.

Many examples like Starbucks exist. And the unifying theme is often web and mobile technology. At its core, web and mobile apps reduce the need for human service, through technology. Many service interactions are now available 24x7 through self-service technology.

The Shift-Left in Auto Physical Damage (APD)

A mega-trend in APD continues to be consumer self-service in claims. Within CCC's network alone in 2018, there was a 250 percent increase in the number of self-service claims. For each of these claims, the vehicle owner captured photos of their own damaged vehicle. This Shift-Left is transforming the claims process. Instead of waiting days for an estimator to take photos, the extent of damage is knowable at First Notice of Loss (FNOL), and vehicle damage photos facilitate speedier decisions to be made about the claim.

OLD: Traditional FNOL

NEW: Self-service FNOL

Using advanced technology such as Artificial Intelligence (AI), instant decisions can be made around repairability, inspection channel, and predicted repair costs.

...Continued (by Ron Nelson)

The "Shift-Left" Effect

CCC Amplifies Shift-Left Effect with AI

CCC's investment in AI began in 2012. Today, CCC employs dozens of Data Scientists and PhD's in its Research & Development group. Their mission is to solve the world's most-difficult problems in photo analytics and claims.

Over the past two years, CCC has brought numerous breakthroughs to market including the following photo-AI technologies:

- **CCC Smart Total Loss™:**
  Automatically helps a carrier makes a Total Loss vs. Repairable decision in about one second at 90 percent accuracy using a single photo and loss facts.

- **Damage Detection:**
  Automatically colorizes vehicle photos to highlight vehicle damage with a "heat map." Useful in building confidence with the consumer and estimator in automated decisions.

- **CCC® Smart Estimate:**
  Automatically generates an initial vehicle damage estimate using photos alone.

These products are being used today by the largest insurance companies to process millions of claims annually. As these technologies grow and expand, so do the benefits they provide.

Finding the Perfect Mix of Shift-Left, AI, and HI

The Shift-Left Effect is a powerful business process pattern. To unleash its full potential requires melding process changes with technology investment and the human factor. AI alone is not the answer. Human Intelligence (HI) cannot be underestimated and finding the right balance of AI + HI is key to long-term success.

In summary, the Shift-Left Effect describes how a process is made more efficient by merely re-ordering its steps. Typically, it requires an investment in technology to power the revised process and the resultant process yields higher customer satisfaction, shorter cycle time, and lower costs.

Connected Car Changing the Insurance Industry

Demand for greater digital capability and wireless connectivity in the vehicle itself has led many automakers to introduce connected vehicle technology into their fleets. Vehicle connectivity, or telematics, has the opportunity to transform the traditional automobile. Vehicle performance data can be shared over the air to assess vehicle health; navigation and driving data can be used to assess vehicle acceleration, braking patterns, location and route history; data can be shared for vehicle-to-vehicle and vehicle-to-infrastructure communication; emergency alerts can be generated in the case of an accident or emergency; and numerous services can be streamed directly into the vehicle.[66] Telematics – defined by IHS Automotive as "… solutions and applications built on top of information content flowing via wireless communication to and/or from the auto"[67], can be either a factory/OEM embedded system, a consumer electronics device such as a smartphone, an aftermarket telematics control unit (dongle that plugs into the on-board diagnostics port), or a hybrid device that includes an embedded telematics control unit and a consumer electronics device.[68] Today, connectivity via a smartphone accounts for approximately 50 percent of the market, but embedded systems will gain traction with the incorporation of more autonomous vehicle features which require significantly fresher data on road conditions and maps, and the European eCall mandate that went into effect in 2018 (see **Figure 28**).[69]

Connected Car Volumes – U.S. Market (FIGURE 28)

SOURCE: CCC INFORMATION SERVICES INC., IHS AUTOMOTIVE

	CY2017	CY2018	CY2019	CY2020	CY2021	CY2022
# of OEM Connected Cars	12 M	17 M	28 M	42 M	59 M	74 M
# Vehicles in Car Parc	274.9M	280.1M	284.7M	288.6M	291.9M	294.6M

Numerous insurance carriers identified access to actual driving behavior via a telematics device as a more precise way to assess driving behavior and risk. With OE telematics, dongles, or smartphones, insurance carriers collect data on the actual driver and his/her individual trips. As that data has become richer, insurance carriers have expanded offerings beyond simply 'pay as you drive' to policies that help the driver manage the overall driving experience. Yet despite steady growth in the percent of connected vehicles in the market today, and significant improvements in the ability to capture similar data via dongles or smartphones, the percent of consumers opting in for auto insurance policies written as user-based insurance remains relatively low. According to J.D. Power 2018 Auto Insurance Study, the rate of personal auto insurance customers in the U.S. who had the option to select a user-based insurance policy grew from 32 percent in CY 2015 to 42 percent in CY 2018; but the rate of customers who chose it increased only 2 percentage points from 8 percent in CY 2015 to 10 percent in CY 2018.[70] Given the benefits to both the consumer and the carrier, many insurance carriers have ramped up their focus in this area, and are extending their user-based insurance (UBI) offerings to include numerous services such as coaching, emergency services, automated first notice of loss, and others to entice more customers, and to make the choice of a UBI policy about more than just a discounted policy, but a much more personalized policy with added services.

As automakers plan for a potential drop in auto sales annually due to changes in personal mobility, they are actively pursuing connected car services as a key driver of revenue in the future, where vehicles are transformed into mobile marketplaces and payment centers.[71] The hope is that consumers will be willing to pay for features such as driver and passenger personalization via cloud services; voice, gesture, and motion control; augmented reality; biofeedback; integration with wearables and the home; and the ability to set the car's internal climate controls before drivers get in.[72] Telematics also enables the OE to provide insurers information on consumers for whom they may want to extend offers or advertise discounted insurance policies. With connected cars, OE's can now engage with the customer after the vehicle sale throughout the ownership of the vehicle. Tapping into the opportunities available from a connected car fleet has only just begun. In fact, as vehicles become more high-tech and connected, there is more overlap between the auto industry and the consumer electronics industry – traditional players in the auto industry are challenged to build new offerings and to do so where the competition is already incredibly steep.

Automakers now provide their connected car customers with value-adds such as feedback on driving, alerts for parents on teen driving, discounts and other notification of nearby services, emergency services, and even automated loss notification when an accident occurs. They now offer many of the same capabilities offered by insurers' telematics programs. For example, in the case of an accident, a connected vehicle can share crash data and initiate first notice of loss with the automaker through its connected vehicle program. The OE can be the first to engage with that customer, provide emergency services, information on their certified repair network, and then share crash data with the insurer and repairer, helping their drivers move seamlessly into the entire claims process. Details on the accident and vehicle damage can be sent by the OE on behalf of their customer via telematics to the customer's insurer and repairer of choice, potentially enabling the vehicle damage assessment and parts ordering processes. These capabilities help the OE bring a branded experience to their customers in the event of an accident, enabling the OE to engage with the customer, helping them navigate the events that occur after a collision.

As OE's begin to play a more active role in their customer's vehicle ownership experience and become the first to interact with the customer after an accident, lines of responsibility will blur further between the OE's and the insurers. Whether OE's will eventually try to provide the auto insurance remains to be seen, but the most critical thing will be to ensure the customer is engaged, delighted, and clearly communicated with throughout the overall accident and claim experience. Proper hand-offs and communication of roles will be essential. Advances in telematics and vehicle connectivity will continue to drive change in the future given its ability to help drive customer engagement and the personal mobility experience.

With the adoption of telematics among commercial fleets advancing even faster than among personally owned vehicles, commercial auto is best poised to use data such as driver behavior, driver routes and route densities, weather, and other connected vehicle data to improve the accuracy of risk assessment and product pricing. The U.S. federal government's mandate that commercial truckers install electronic logging devices by December 2017 that track time spent driving, resting, and on-duty but not driving could make insurer access to that information even easier.[73]

With the significant growth in e-commerce, fleet traffic and demand for commercial auto insurance has increased, and the 'last mile' challenge has led to greater diversity among commercial fleets in terms of who is actually driving, when and where they are driving, and what they are driving. Amazon, for example, has followed Uber's model by introducing Amazon Flex, where an individual can sign up to deliver packages in four-hour shifts, drive their own vehicle (regardless of the condition of the vehicle), and get paid $18-$25 per hour. The driver need only be 21 years of age, have a smartphone that can download the Amazon Flex app, have a social security number, have auto insurance, have a valid driver's license, pass a background check, and have a bank account capable of receiving direct deposits.[74]

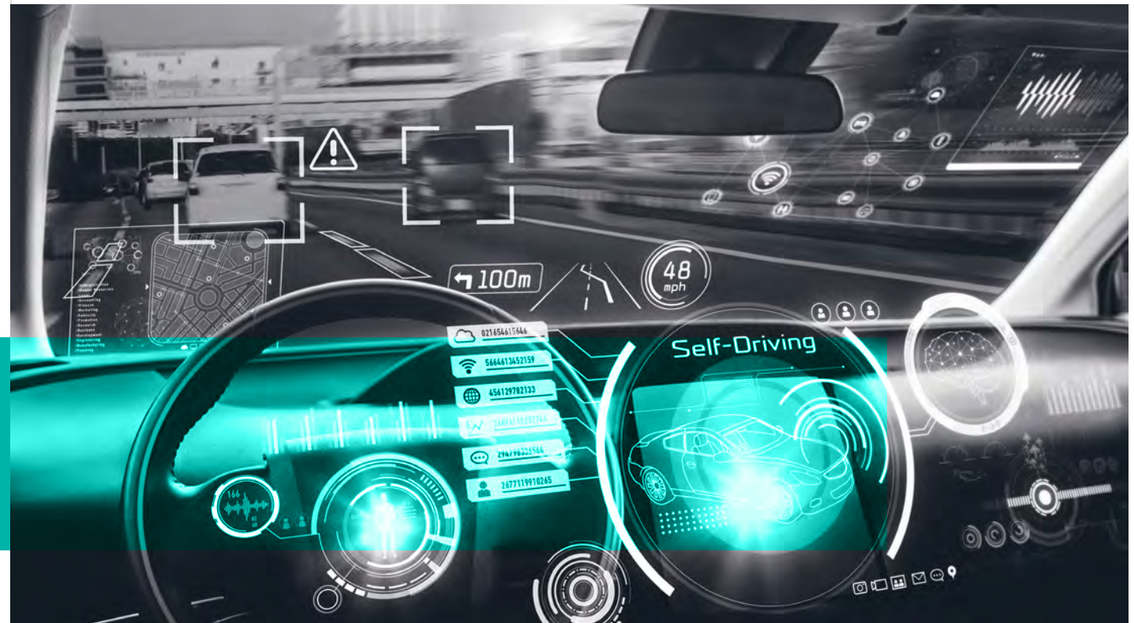
As the on-demand economy expands further, questions on policy, coverage, and liability become more challenging. When car-sharing and ride-sharing programs were first launched, numerous questions about coverage arose, and it took some time to create the current framework specifically for ride-sharing drivers in terms of which type of insurance covers the driver before and during customer trip. Unfortunately, a survey conducted of ride-sharing drivers suggest that over 45 percent of drivers still do not carry the necessary ride-share insurance – particularly alarming given the same survey reveals 1 in 5 ride-share drivers had been in an accident while driving, and 80 percent of the drivers also drive for other on-demand digital services such as Amazon Flex.[75]

Here is an area that could benefit from data collected via a telematics device, and then analyzed with AI to identify use patterns that flag a policy holder that could need additional coverage. AI has immense promise to transform the insurance industry by helping to do things like better identify customer needs, predict risk, process policies, and process claims. In fact, a report by UBS Group AG found that companies within the automotive, aerospace, defense and retail sectors are the most likely to experience a great deal of transformation due to AI.[76]

Of course, the autonomous vehicle is one of the most anticipated AI applications by the auto insurance industry.

The Autonomous Vehicle Drives Change in Insurance

It is hoped that the technology in Level 4 and 5 AVs will eliminate the vast majority of accidents that are result of poor human decision-making. With substantially fewer accidents, the insurance industry would pay out fewer claims, which could lead to reduction in auto insurance premiums by as much as 20 percent by CY 2035 and 40 percent by CY 2050, according to Aon.[77] The remaining accidents likely will be the fault of the autonomous vehicle itself, shifting liability to the vehicle manufacturer, its software, and individual components provided by numerous suppliers. With the vehicle fully in charge of the driving, the liability should, in theory, fall back on the software developer, whether an accident occurred due to failure within the programming itself, or due to the software not properly protected from malicious cyber activity. The hope is that data collected by the vehicle itself would make liability assignment easier. The identification of which part of the technology failed will be increasingly difficult but is very important to help ensure that accident is avoided in the future. A 2018 report published by the Casualty Actuarial Society's Automated Vehicles Task Force discussed the importance of cooperation during the development and rollout of AV technology among the numerous parties impacted – manufacturers, technologists, policymakers, attorneys, risk managers, insurers, and actuaries.[78] The report underscores the need to develop an alternative liability system for AV's, where a negligence-based liability system is used versus a strict products-liability system, and where performance benchmarks and safety standards are developed and optimized.[79] With the driver no longer in charge of the vehicle, how risk and premium are determined will need to change and focus instead on things like the system capabilities of each individual OE or other tech company's product, like crash prevention, crash worthiness, cyber-security vulnerability, and how well it handles the human-machine interaction in case of emergency.[80]



ABOUT THE AUTHOR

Jason Verlen is SVP of Product Management at CCC.

> The real tipping point began when we looked at other use cases for telematics data. Those cases vastly increased the adoption of the technology and made it much more mainstream.

A Vision for 2028, Powered by Telematics

Jason Verlen

It's 2028. The world's population stands at more than 8 billion. In the past decade, we've added a billion people, and we're living in a hyper-connected world. Our smart tools are diagnosing a growing number of conditions — taking your pulse and counting steps was just the beginning; the smart tools of 2028 detect all kinds of vitals to accurately diagnose a number of ailments and diseases. Even our roads have changed. Today's glass-topped highways are beautiful stretches of solar roadways embedded with a multitude of sensors aligned with the self-driving cars traveling on them, preventing accidents.

Insurers have figured out ways to underwrite and insure all that autonomy in all of its different modes. The same is true for transportation-as-a-service. And, we're already discussing how to regulate and insure the next generation of vehicles – custom, 3D-printed, flying cars.

The pace at which all of this has happened is amazing. But the big question is, how did we get here?

In a word, telematics.

Telematics – also known as the Internet of Things – changed everything since it started interacting with all of our lives years ago. For insurance, it started with underwriting and data monetization. And, although there were a lot of interesting early results, there wasn't a lot of uptake or market success.

2018 was a turning point for the auto insurance industry.

Data exchanges started to come out. Telematics data (from OEMs, mobile devices or OBDII devices) started to funnel into one place, normalized and ready for insurance companies to use to make attractive offers to subscribers. Insurers could also use the data to innovate.

At the time, CCC was working with its data exchange, CCC X. Our systems already had processed more than 50 billion driver miles. In retrospect, that time really was the turning point for telematics. As an industry, we saw the checkerboard get filled up — slowly at first — by forward-thinking companies that were making investments in telematics technology.

The real tipping point began when we looked at other use cases for telematics data. Those cases vastly increased the adoption of the technology and made it much more mainstream. Additionally, telematics was combined with other technologies and innovations of that time, and that really sent us on a rocket ride.

Early Use Cases Evolve, Things Get Exciting

In 2006, cell phones were mainly used by people making phone calls. Remember how fast it all changed when the first smartphone came out? What really made cellular technology take off was when the smartphone became your calendar, your music collection, your newspaper. It became how you bought products. It was everything, and everyone had to have one.

And remember the companies that were slow to adopt? They had a tough time. In 2018, it was exactly the same with telematics. New use cases opened up the future and enabled innovation.

In April 2018, in Cypress, Texas, CCC began working with State Auto to ingest telematics that would enable connected claims. With a flip of a switch, a 100-year-old accident triage process was changed. Suddenly, State Auto knew about a crash seconds after it happened. And what did they do? They picked up the phone, called their customer and said, "We see you've been in a crash. How can we help?" One hundred years of process was flipped on its head overnight. Customers were amazed.

...Continued (by Jason Verlen)

A Vision for 2028, Powered by Telematics

The Moment When Change Happens

Up to this point, the three fundamentals of the insurance process were set in stone: I own my car, I drive my car, I call my insurance company when I get into an accident. After telematics, people started to think differently.

I own my car.

Do I? Remember, new modes for transportation as a service and driving subscriptions, among other innovations, started to become a more widespread conversation. People started to consider that maybe they didn't need to own a car.

I drive my car.

Do I? In 2018, self-driving cars and taxis started hitting the streets of Singapore, Tokyo and Las Vegas. Maybe I don't have to drive my car?

I call my insurance company when I get into an accident.

Should I? As mentioned, on April 26, 2018, we found that maybe that was no longer necessary or always true.

Another flashback. In 2018, we also introduced the capability to determine injuries from telematics-powered crash dynamics. We used the data to understand the principles of force and Delta-V and used that to detect what kinds of injuries the occupants may have, the potential severity of those injuries and what the range of medical treatments may be. That came together to allow our customers to treat people with the same efficiency and process as we were able to repair the car.

Going into and throughout 2019, many new applications of telematics began to appear. Around this time, OEMs using CCC's platform could offer customers an easy way to digitally shop for insurance through a new capability called Connected Offers. If the customer was interested he would simply authorize the OEM to send his telematics driving data to insurance companies. The insurers could then analyze the data and provide targeted offers for coverage for the consumer to conveniently select from. Further, around this time it became possible for a consumer to reach out to an insurer directly to authorize that insurer to ask the OEM for his driving data. Once again, the insurance company would be able to do analysis and respond quickly to the customer with an offer for coverage right at point of sale.

And in early 2019, CCC announced CCC® Accident Advisor, the world's first end-to-end connected safety experience, making it possible for OEMs and other connected service providers to offer their customers a digital experience to protect and guide them in the minutes following an accident. That experience includes sending the relevant information to the customer's insurance company if the customer requested it, making this difficult experience a bit easier on everyone.

Finally, around this time telematics was applied to the repair. Cars were getting more complicated with a lot more sensors, more diagnostic trouble codes. Cars were capable of sending data right from their computers straight to the repair shop to make repairs faster and more accurate, helping to ensure those increasingly complex cars were getting fully repaired and safely returned to the road. The change greatly expanded the use of telematics.

But what really lit the match was when those telematics use cases were combined with other innovations of that period.

Photo analytics in estimating? Check. Insurers already were using artificial intelligence (AI) to instantly detect from one photograph the likelihood a car was repairable or a total loss. AI was used to build the estimates themselves, using photographs and the help of telematics data.

From there, mobile and smart technologies enabled the detection of an accident all the way through to the disposition of the vehicle. The experience was self-guided and highly efficient. The person in the car accident was interacting with shops and insurance companies to get the job done in a streamlined way.

All of these new possibilities were suddenly at our fingertips. That crash in Cypress, Texas, if it was serious enough, would have the tow truck quickly dispatched to pick the car up. Or, if the injuries were serious, an ambulance could get there more quickly, saving the customer's life.

Continued Acceleration

After 2018, the acceleration of technology innovation went through the roof. That's how we got to the world we live in today. We were struck with this awareness of exactly how telematics and photo analytics are going to lead to a new world order. The future became clear.

Those that got in early with those data exchanges and started using telematics for usage-based insurance purposes started to gain an understanding of data and chip away at the learning curve. They improved their book of business. They added use cases, detected crashes and delivered better injury disposition for customers and better repairs.

When the autonomous vehicles started coming in all different modes and configurations, they were ready to price the risk. When the transportation as a service option started coming up, they were ready to go.

Innovation is always the same. It doesn't matter if it's 2018 or 2028 or 2058. The timeless advice about innovation is this: You need to adopt as early as possible. You need to give yourself permission to fail, the opportunity to learn and the time to get it right. When that match gets lit, you are ready to take the rocket ride to the future. Stay brave and power forward.

Historically the growth of the auto insurance industry has been closely aligned with periods of strong economic growth and strong new vehicle sales. As the pace of automation increases within the vehicle sector, the automotive insurance industry will also need to change. New vehicles are being sold with varying levels of automation and connectivity, where the human machine interaction, or the trade-off of who is driving between the driver and the vehicle has become increasingly difficult to assign risk and assess fault in the case of an accident. Many of these features may actually distract the driver even more, so risk in the near term may be more versus less. As automakers face a future where potentially fewer new vehicles will be sold directly to consumers, nearly all are looking to expand the services offered via the connected car technology, changing vehicles into mobile marketplaces and payment centers. As they look to expand their touchpoints, they could also ultimately look to provide services that have historically been provided by the insurance industry, further blurring the lines between traditional business models and players. Ultimately it will be the companies that can access the most comprehensive, detailed data, including connected vehicle data, and have the technical knowledge to know what that data is telling them to both to assign risk and price product will be in the best position to succeed in this new environment.

In the near term, as insurance carriers respond to the challenges of underwriting and repairing these technologically advanced vehicles, ensuring they continue to engage the customer throughout the insurance process is critical. Consumers want the same types of tools and experience they get online from companies like Amazon, where personalization, pro-active communication re: deals or products, and ease of use are the norm. With OE's actively looking to extend their reach via the connected car, a new balance will need to be achieved among the companies to ensure the experience is seamless for the customer, whether it is an auto claim, an offer for reduced auto premium, or a notice re: needed maintenance on the vehicle.

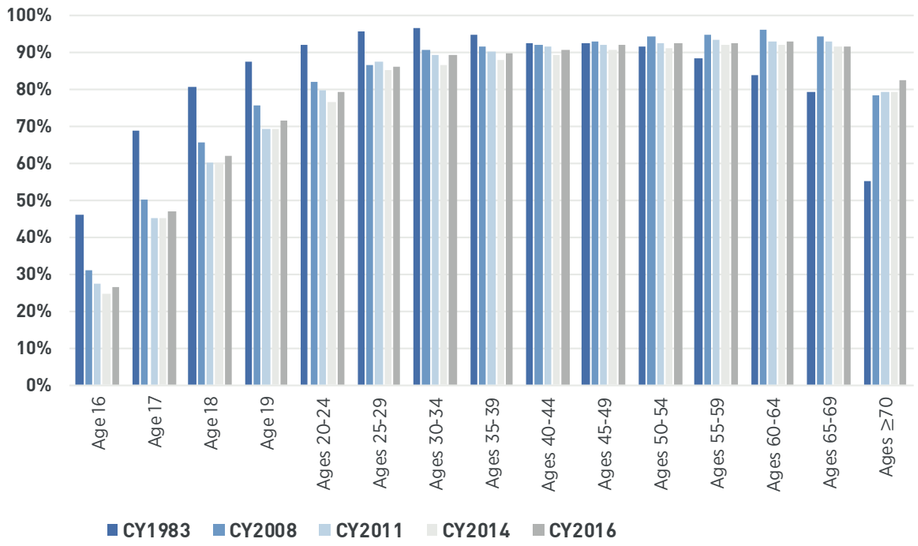
I DRIVE MY CAR

Turning 16 years old, getting your driver's license, and buying your first car are key rites of passage into adulthood.

Millennials were feared to be the first generation where all of that was going to change. Among the metrics supporting this theory was the drop in licensed drivers as a percent of the total population among the youngest age groups between CY 2008 and CY 2014 (see **Figure 29**).[81] However, the most recent data from the U.S. DOT Federal Highway Administrations' 2016 Highway Statistics points to some reversal of this trend, revealing a growing share of individuals among every age group now have driver's licenses, with the largest increases among those aged 30-34 and 70-plus. Additionally, while the "Drivers per 1000 Total Resident Population" and the "Drivers per 1000 Driving Age Population" fell each year between CY 2009 and CY 2013, both increased between CY 2014 and CY 2016.[82] In fact, growth in drivers and vehicles outpaced growth in population in CY 2015 and CY 2016 (see **Figures 30A-C**).

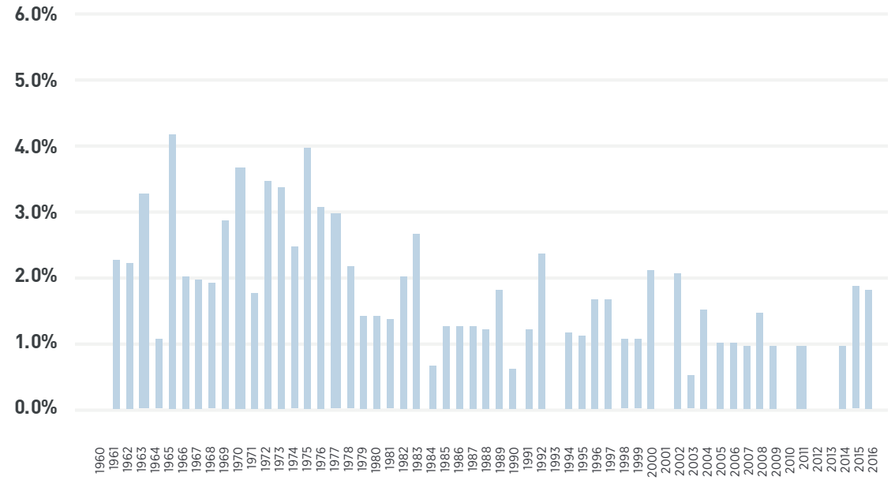
U.S. Licensed Drivers as Percentage of Their Age-Group Population (FIGURE 29)

SOURCES: SIVAK AND SCHOETTLE, UMTRI; USDOT FWHA HIGHWAY STATISTICS 2016



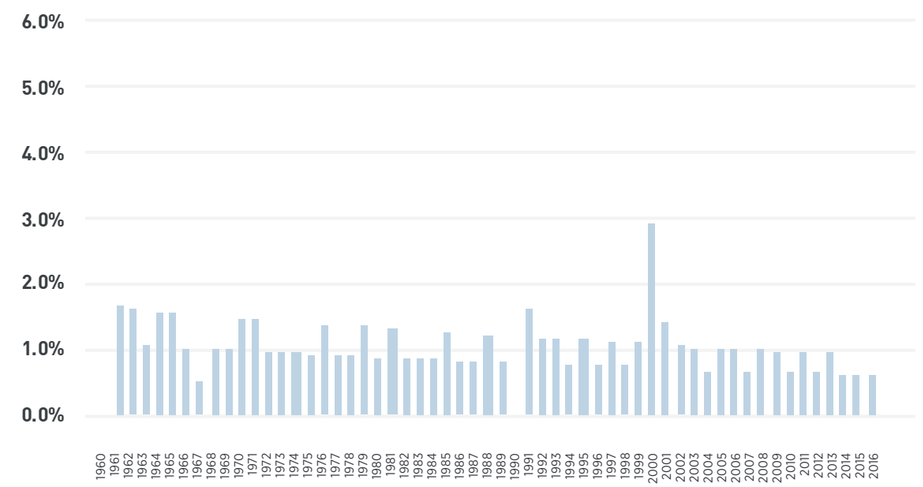
Annual Percent Change in U.S. Drivers (FIGURE 30B)

CY1960-CY2016 | SOURCE: US DOT FHWA POLICY & GOVERNMENT AFFAIRS HIGHWAY POLICY INFORMATION HIGHWAY STATISTICS, 1995 TO 2016.



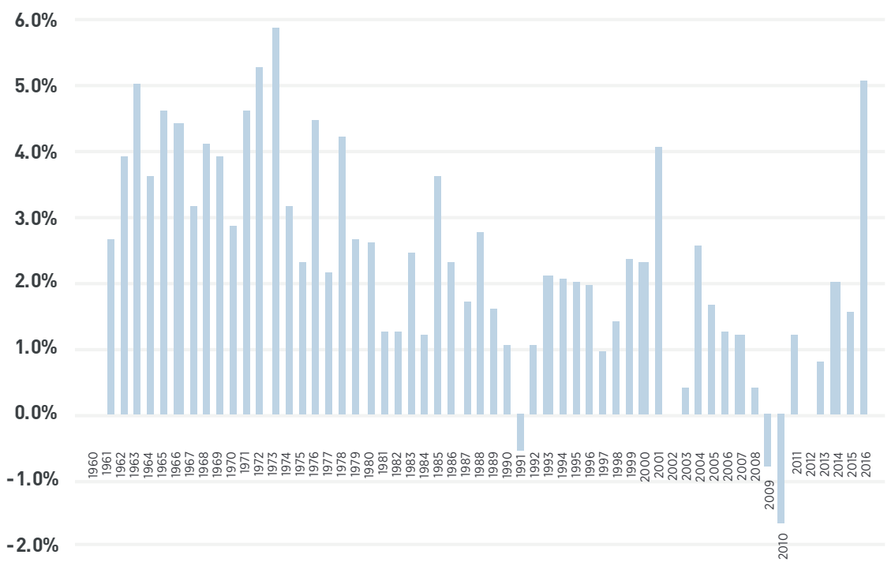
Annual Percent Change in U.S. Population (FIGURE 30A)

CY1960-CY2016 | SOURCE: US DOT FHWA POLICY & GOVERNMENT AFFAIRS HIGHWAY POLICY INFORMATION HIGHWAY STATISTICS, 1995 TO 2016.



Annual Percent Change in U.S. Registered Vehicles (FIGURE 30C)

CY1960-CY2016 | SOURCE: US DOT FHWA POLICY & GOVERNMENT AFFAIRS HIGHWAY POLICY INFORMATION HIGHWAY STATISTICS, 1995 TO 2016.



Strong auto sales have led to an increase in the estimated number of vehicles per household in the U.S. again, as well as growth in the percentage of households with 3 or more vehicles available (see **Figure 31**).[83] Historically, a key proxy for likely vehicle accident exposure was the number of miles driven per vehicle. With overall miles driven per household roughly flat to down per the U.S. Census Bureau's 2017 National Household Travel Survey, despite increases in vehicles and licensed drivers per household, this would suggest a key factor driving vehicle accident frequency in the U.S. has returned to pre-recession levels (see **Figure 32**).[84]

Another key finding of the 2017 National Household Travel Survey was an overall decline in the reported trips taken for 'shopping and errands,' which at least in part appears to be driven by the higher frequency of purchases delivered to the household (see **Figure 33** and **Figure 34**).[85] A higher share of individuals who work at home also is likely a culprit – the number of workers aged 16 years or older whose primary means of transportation to work was 'worked at home' grew from 3.6 percent in 2005 to 5.1 percent in CY 2017, while those that used a 'car, truck, or van (alone or in carpool)' dropped from 87.7 percent in 2005 to 85.8 percent in CY 2017 (see **Figure 35**).[86]

Percent of Households by Availability of Household Vehicles (FIGURE 31) | CY1969-CY2017

SOURCE: 2017 NATIONAL HOUSEHOLD TRAVEL SURVEY, P. 60. HTTPS://NHTS.ORNL.GOV/ASSETS/2017_NHTS_SUMMARY_TRAVEL_TRENDS.PDF.

Survey Year	No Vehicle	One Vehicle	Two Vehicles	Three or More Vehicles	Vehicles per Household
1969	20.6%	48.4%	26.4%	4.6%	1.16
1977	15.3%	34.6%	34.4%	15.7%	1.59
1983	13.5%	33.7%	33.5%	19.2%	1.68
1990	9.2%	32.8%	38.4%	19.6%	1.77
1995	8.1%	32.4%	40.4%	19.1%	1.78
2001	8.1%	31.4%	37.2%	23.2%	1.89
2009	8.7%	32.3%	36.3%	22.7%	1.86
2017	8.9%	33.5%	33.1%	24.4%	1.88

National Household Travel Survey - Major Travel Indicators per Survey Year (FIGURE 32)

CY1969-CY2017 | SOURCE: 2017 NATIONAL HOUSEHOLD TRAVEL SURVEY, P. 9. HTTPS://NHTS.ORNL.GOV/ASSETS/2017_NHTS_SUMMARY_TRAVEL_TRENDS.PDF.

Travel Indicator	CY1969	CY1977	CY1983	CY1990	CY1995	CY2001	CY2009	CY2017
Persons per Household	3.16	2.83	2.69	2.56	2.63	2.58	2.5	2.55
Vehicles per Household	1.16	1.59	1.68	1.77	1.78	1.89	1.86	1.88
Licensed drivers per Household	1.65	1.69	1.72	1.75	1.78	1.77	1.88	1.89
Vehicles per Licensed Driver	0.7	0.94	0.98	1.01	1	1.06	0.99	1
Workers per Household	1.21	1.23	1.21	1.27	1.33	1.35	1.34	1.33
Vehicles per Worker	0.96	1.29	1.39	1.4	1.34	1.39	1.39	1.42
Average Annual Miles per Licensed Driver (Self-Estimate)	8685	10006	10536	13125	13476	13827	12888	11621

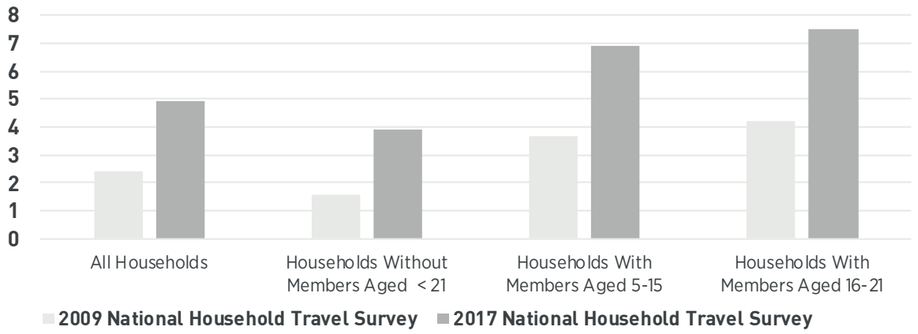
Share of Annual Number of Person Trips per Person by Trip Purpose (FIGURE 33) | SOURCE:

2017 NATIONAL HOUSEHOLD TRAVEL SURVEY, P. 35, TABLE 10A. HTTPS://NHTS.ORNL.GOV/ASSETS/2017_NHTS_SUMMARY_TRAVEL_TRENDS.PDF

	CY1990	CY1995	CY2001	CY2009	CY2017
To or From Work	15.3%	16.4%	14.9%	15.6%	17.4%
Work Related Business	1.1%	2.4%	2.9%	3.0%	1.6%
Shopping and Errands	42.2%	42.6%	41.4%	42.5%	38.4%
School/Church	8.7%	8.2%	9.2%	9.6%	10.9%
Social and Recreational	24.9%	23.1%	25.1%	27.5%	27.5%
Other	0.6%	0.2%	0.8%	1.8%	4.1%

NHTS Average Number of On-Line Purchases and Deliveries to U.S. Households in the Last Month (FIGURE 34) | SOURCE: 2017 NATIONAL HOUSEHOLD TRAVEL SURVEY, P. 35, TABLE 10A. HTTPS://NHTS.

ORNL.GOV/ASSETS/2017_NHTS_SUMMARY_TRAVEL_TRENDS.PDF



U.S. Primary Means of Transportation to Work (FIGURE 35) | SOURCE: U.S. CENSUS BUREAU, 2017 AMERICAN

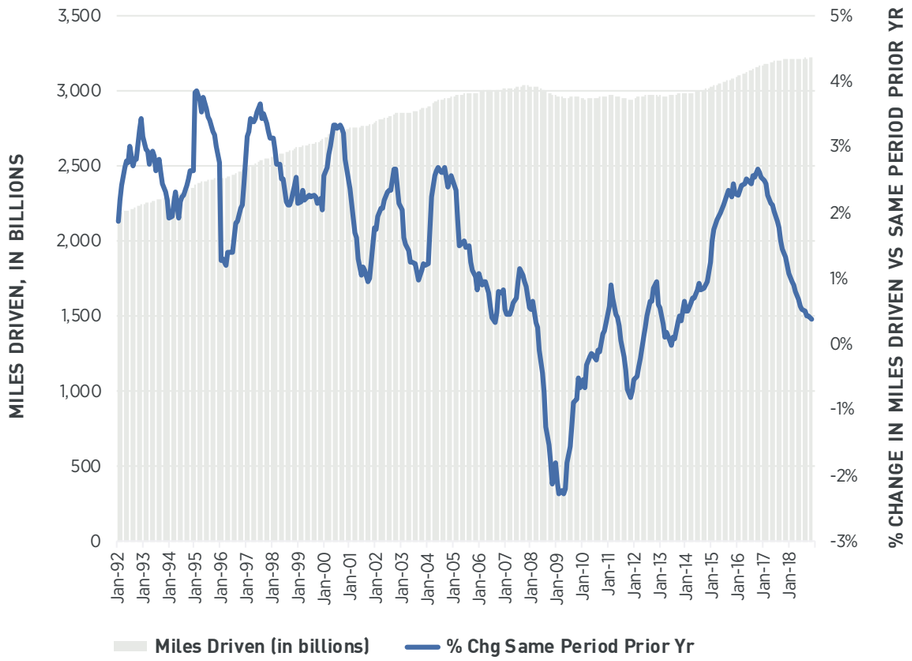
COMMUNITY SURVEY 1-YEAR ESTIMATES

	CY2005	CY2006	CY2007	CY2008	CY2009	CY2010	CY2011	CY2012	CY2013	CY2014	CY2015	CY2016	CY2017
Car, truck, or van total	87.7%	87.2%	87.0%	86.7%	86.7%	86.8%	86.6%	86.5%	86.3%	86.2%	86.1%	85.9%	85.8%
Car, truck, or van - drove alone	**77.0%**	**76.5%**	**76.6%**	**76.1%**	**76.6%**	**77.1%**	**76.9%**	**76.8%**	**77.0%**	**77.0%**	**77.0%**	**76.8%**	**76.9%**
Car, truck, or van - carpooled	**10.7%**	**10.7%**	**10.4%**	**10.7%**	**10.0%**	**9.7%**	**9.7%**	**9.7%**	**9.4%**	**9.3%**	**9.0%**	**9.0%**	**8.9%**
Public transportation (excluding taxicab)	4.7%	4.8%	4.9%	5.0%	5.0%	4.9%	5.0%	5.0%	5.1%	5.2%	5.2%	5.1%	5.0%
Walked	2.5%	2.5%	2.5%	2.5%	2.5%	2.4%	2.4%	2.5%	2.4%	2.4%	2.4%	2.3%	2.3%
Taxicab, motorcycle, bicycle, or other means	1.6%	1.7%	1.7%	1.8%	1.7%	1.7%	1.7%	1.8%	1.9%	1.8%	1.8%	1.8%	1.8%
Worked at home	3.6%	3.8%	3.9%	3.9%	4.1%	4.2%	4.2%	4.2%	4.2%	4.3%	4.5%	5.0%	5.1%

Overall, the increase in the total miles driven annually in the U.S. has slowed, with miles up less than 1 percent for the rolling 12-month period ending November 2018 versus the period one year prior (see **Figure 36**). On a full year basis, a comparison of miles driven by U.S. shows a wide variance, with several states such as Washington, Oregon, Idaho, and Arizona seeing miles driven up between 2 and 4 percent, while states such as Minnesota, Michigan, Kentucky and Arkansas see miles driven down by more than 1 percent (see **Figure 37**). Lastly, a key proxy for vehicle accident exposure has been miles driven on a per vehicle basis. Analysis of claims data shows the average annual miles per loss vehicle (as measured by the odometer of the loss vehicle divided by the vehicle age) has continued to trend downward, after experiencing a big jump between 2013 and 2014 (see **Figure 38**).

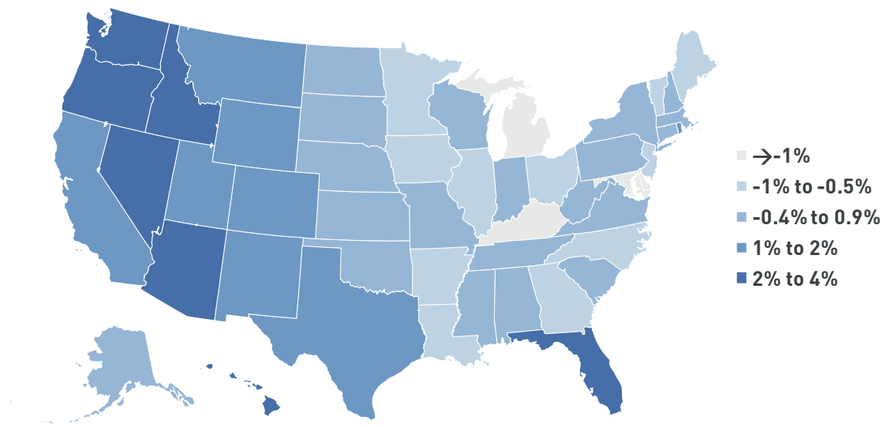
Annual Vehicle-Distance Traveled - Moving 12 Month Total on All Roads (Million Miles) and Percent Change from Prior Year (FIGURE 36)

JAN. 1991 - DEC. 2018 | SOURCE: FRED® MOVING 12-MONTH TOTAL VEHICLE MILES TRAVELED, WWW.RESEARCH.STLOUISFED.ORG



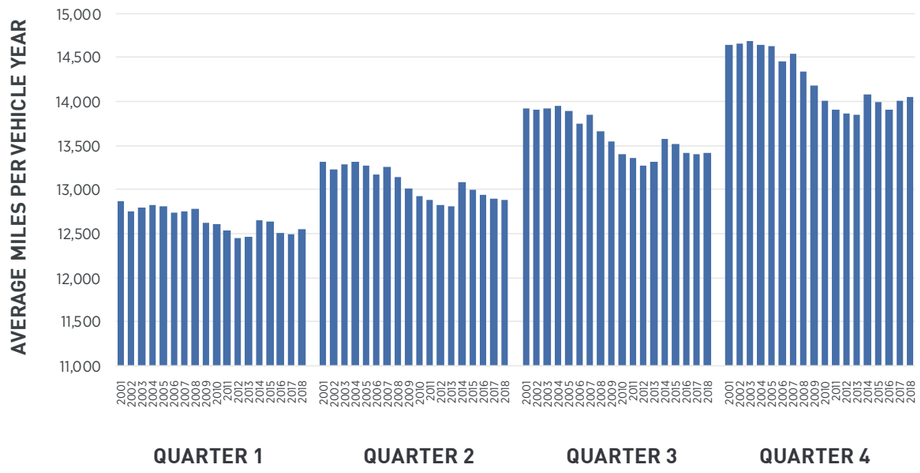
Percent Change in Miles Driven CY2018 through November versus Same Period Prior Year by State (FIGURE 37)

SOURCE: USDOT OHPI FHWA



CCC National Industry Average Annual Mileage Driven Based on Vehicle Age (All Vehicle Conditions – All Loss Categories) (FIGURE 38)

CY2001-CY2018 | SOURCE: CCC INFORMATION SERVICES INC.



Urbanization and Congestion Are a Bad Combination

A key driver of collision accident frequency identified by the Insurance Information Institute is the level of congestion on roads, measured best as "Drivers per Lane Mile (licensed drivers / total lane miles driven), followed by the urban average commute time, rural average commute time, and the urban share of overall miles driven (see **Figure 39** and **Figure 40**).[87] Between CY 2004 and CY 2018 "urban interstate" miles' share of overall miles driven grew from 15.3 percent to 17.6 percent, while all "rural" road systems saw their share fall from 36.1 percent to 30.2 percent.[88] Each of these variables has increased in recent years, as economic recovery led to high levels of employment and more people driving on roads during peak driving times.

Increased traffic density – measured as the number of all road users in a traffic flow at one time on a particular stretch of road - has become a significant challenge as more of the overall population moves to large urban areas. According to the United Nations, World Urbanization Prospects, the proportion of North America's population that will live in urban areas has grown from 75 percent in CY 1990 to 81 percent in CY 2014 and will grow to 86 percent by CY 2050.[89] Add to that the dramatic growth in freight traffic, and congestion levels get even worse. Kleiner Perkins 2018 Internet Trends reported e-commerce share of U.S. retail sales grew to 13 percent in CY 2017 from 5 percent in CY 2007, total sales were up nearly 16 percent in CY 2017 alone to more than $400 billion, and over 10 billion parcels were delivered by USPS, UPS and FedEx combined.[90]

According to American Transportation Research Institute's 2016 "Cost of Congestion to the Trucking Industry" report, the operational cost to the trucking industry from congestion rose 0.5 percent in 2016 to $74.5 billion, with some 86.7 percent of congestion occurring on 17.2 percent of National Highway System miles, and more than 91 percent of the overall cost of congestion occurring in metropolitan areas.[91]

> It is a safety issue, no question. The dilapidation of our infrastructure is dangerous, not just for the commercial motor vehicle industry, but for everyone who shares those roadways.
>
> -RAY MARTINEZ, ADMINISTRATOR OF THE FEDERAL MOTOR CARRIER SAFETY ADMINISTRATION | SOURCE: GILROY, ROGER. "INFRASTRUCTURE FAILING AS FUNDING REMAINS ELUSIVE, EXPERTS SAY." OCT 29, 2018 TRANSPORT TOPICS. TTNEWS.COM.

All of this new traffic is traveling on deteriorating roads, bridges, and other infrastructure that is not getting the needed funds to maintain or improve, despite worsening traffic congestion, expanding international trade along the borders and at ports, and a supply chain quickly adapting to more e-commerce than ever before.[92] The Highway Trust Fund, historically funded through fuel taxes, has seen its annual revenue fall in the face of improved fuel mileage. Ninety cents of every dollar in revenue is going to pay for a system of infrastructure that is about 65 years old, and only 10 cents are going toward new capacity.[93] With much of the U.S. population growth occurring in states like Texas (see **Figure 41**)[94] that already have some of the most congested highways, there appears to be little near-term relief.

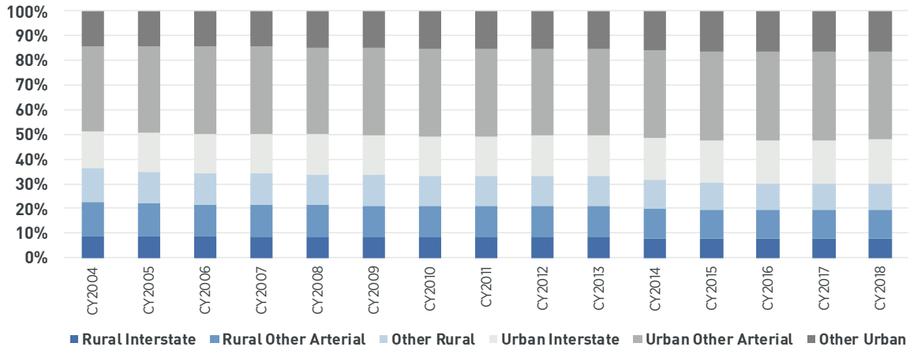
Workers by Commute Time (FIGURE 39)

SOURCES: OAKRIDGE NATIONAL LABORATORY. TRANSPORTATION ENERGY DATA BOOK: EDITION 36.2 - 2018, CH 8. WWW.CTA.ORNL.GOV/DATA. 1990-2000 – U.S. BUREAU OF THE CENSUS, JOURNEY TO WORK: 2000, TABLES 1 AND 2, 1990-2000, MARCH 2004. | 2010-2016 – U.S. BUREAU OF THE CENSUS, 2012-2016 AMERICAN COMMUNITY SURVEY, 5-YEAR ESTIMATES, TABLES S0802 AND B08303. | ADDITIONAL RESOURCES: WWW.CENSUS.GOV

Commute time (one-way)	CY1990	CY2000	CY2010	CY2016
Less than 15 minutes	32.5%	29.4%	28.6%	26.7%
15–29 minutes	37.0%	36.1%	36.2%	36.3%
30–39 minutes	15.2%	15.8%	16.1%	16.6%
40–59 minutes	9.2%	10.7%	11.1%	11.8%
60 minutes or more	6.1%	8.0%	8.0%	8.7%
Average travel time (minutes)	22.4	25.5	25.2	26.1

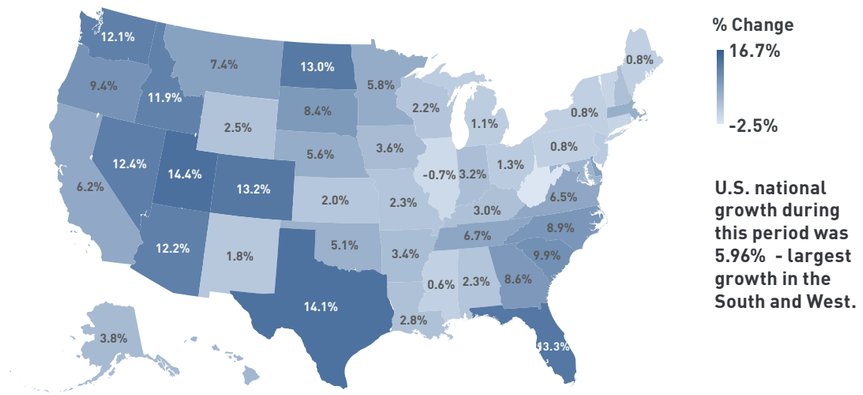
USDOT FHWA Estimated Individual Monthly Motor Vehicle Travel in the U.S. by System

(FIGURE 40) | SOURCE: HTTPS://WWW.FHWA.DOT.GOV/POLICYINFORMATION/TRAVEL_MONITORING/TVT.CFM



U.S. Census Bureau - Percent Change in Population (FIGURE 41)

APR 1, 2010 TO JUL 1, 2018 | SOURCE: VINTAGE 2018 POPULATION ESTIMATES, POPULATION DIVISION, U.S. CENSUS BUREAU. RELEASED DEC 2018



U.S. national growth during this period was 5.96% - largest growth in the South and West.

Ride-hailing, as discussed above, has not led to dramatic drops in personal vehicle ownership, but has instead led to more vehicles on the road in urban areas and created higher levels of congestion. According to research from Schaller Consulting, ride-hailing companies — or transportation network companies (TNCs) — transported 2.61 billion passengers in 2017, a 37 percent increase from 1.90 billion in 2016.[95] And, 70 percent of Uber and Lyft trips were made in nine large, densely-populated metros: New York City, Boston, Chicago, Los Angeles, Miami, Philadelphia, San Francisco, Seattle, and Washington D.C.[96] More concerning – particularly as it relates to congestion levels – is the finding that private ride TNC services put 2.8 new TNC miles on the road for each individual mile of personal driving removed, resulting in a 180 percent increase in driving on city streets.[97] In fact, about 60 percent of TNC users in the large dense metro areas analyzed would have taken public transportation, walked, or biked if the TNC was not available, versus 40 percent that would have instead used a personal vehicle or taxi.[98] Usage of ride-hailing services overall has increased substantially, with a Fall CY 2018 survey conducted by Pew Research showing 36 percent of U.S. adults saying they used a ride-hailing service versus only 15 percent in a similar survey from late CY 2015.[99] Usage continues to vary sharply by passenger age, income, and education level (see **Figure 42**).[100] This Pew Research survey also found that only one in 10 users of ride-hailing services say they use them at least weekly, and just 2 percent use them every day or nearly every day.[101]

The top two ranked reasons why respondents from this same survey used ride-hailing services instead of driving themselves were "To avoid driving while I might have alcohol", and "Parking is too difficult to find".[102] This data, along with data from several other studies, show that most frequency use of TNCs occurs on weekends and at nighttime (see **Figure 43**),[103] and suggests convenience is a factor driving use of ride-hailing services.

Lastly, while it was hoped that congestion was a problem that AVs could help alleviate, a study from the University of California, Berkeley suggests that may not happen, as passengers will be freed from the task of driving to focus on other things, and there could be as much as a 14 percent increase in overall vehicle miles traveled as AV's will provide more users with access to use vehicles independently (i.e. nearly 30M elderly, children, disabled, and non-driving individuals).[104]

Pew Research Survey of Ride-Hailing Users (FIGURE 42) | AUTUMN 2018 | SOURCE: JINGJING JIANG.

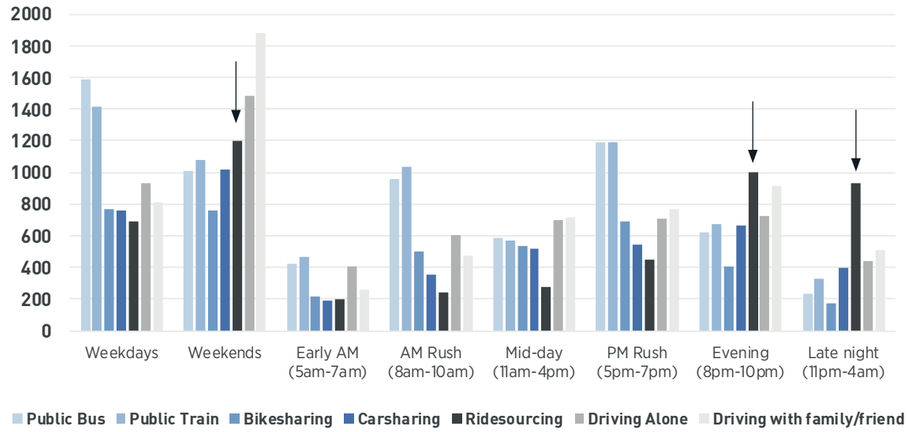
"MORE AMERICANS ARE USING RIDE-HAILING APPS." JANUARY 4, 2018. HTTP://WWW.PEWRESEARCH. ORG/FACT-TANK/2019/01/04/MORE AMERICANS-ARE-USING-RIDE-HAILING-APPS/ | "PERCENT OF ADULTS WHO SAY THEY HAVE EVER USED RIDE-HAILING SERVICES LIKE UBER OR LYFT" (SURVEY CONDUCTED 24SEP18-7OCT18)

	CY2015	CY2018	Difference
U.S. Adults	15%	36%	21%
Ages 18-29	28%	51%	33%
Ages 30-49	19%	43%	24%
Ages 50+	7%	24%	17%
Education High School or less	6%	20%	14%
Some College	15%	36%	21%
College grad+	29%	55%	26%
Annual Income less than $30K	10%	24%	14%
$30K-$74,999	13%	35%	22%
$75K or more	26%	53%	27%
Use on a weekly basis	3%	4%	1%

	CY2018
Urban users	19%
Suburban users	6%
Rural users	5%
Ages 18-49	12%
Ages 50+	7%
Use on a monthly basis	22%
Use less than once per month	67%

Additionally, because AVs will be driving alongside conventional non-autonomous vehicles for some time, we may actually see an increase in congestion and delays, and possibly accidents.[105] For example, analysis of the collision reports for AVs being tested in California reveals the most frequent cause reported is a rear-end crash (see **Figure 44**).[106] Of those rear-end crashes, the vehicle was in charge of the driving 78.5 percent of the time (22 out of 28), and many of the side-swipes appear to be caused by non-autonomous drivers trying to pass the AVs. Detail analysis of the reported crash details suggest the AVs are not behaving as humans might, and subsequently create confusion for other drivers around them.[107]

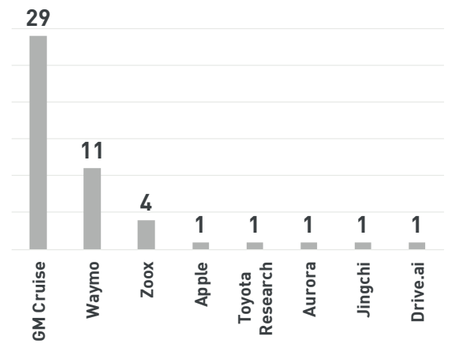
"When You Use Different Forms of Transportation – At What Hours of the Day/Week Do You Generally Use Each Form of Transportation?" (FIGURE 43) | (COLUMN VALUE REPRESENTS THE NUMBER OF SURVEY RESPONDENTS THAT SELECTED EACH OPTION) | SOURCE: TRANSIT COOPERATIVE RESEARCH PROGRAM RESEARCH REPORT 188. "SHARED MOBILITY AND THE TRANSFORMATION OF PUBLIC TRANSIT." FIGURE 9, P. 14. HTTP://NAP.EDU/23578.



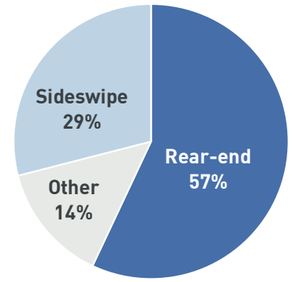
California Autonomous-Vehicle Collision Details (FIGURE 44) | 2018 YTD

CHART: CCC INFORMATION SERVICES INC. | SOURCE: WIRED.COM ANALYSIS OF AUTONOMOUS VEHICLE COLLISION REPORTS FROM CALIFORNIA DEPARTMENT OF MOTOR VEHICLES. HTTPS://WWW.WIRED.COM/STORY/SELF-DRIVING-CAR-CRASHES-REAR-ENDINGS-WHY-CHARTS-STATISTICS/.

Collisions Reported 2018 YTD



Collision Type 2018 YTD



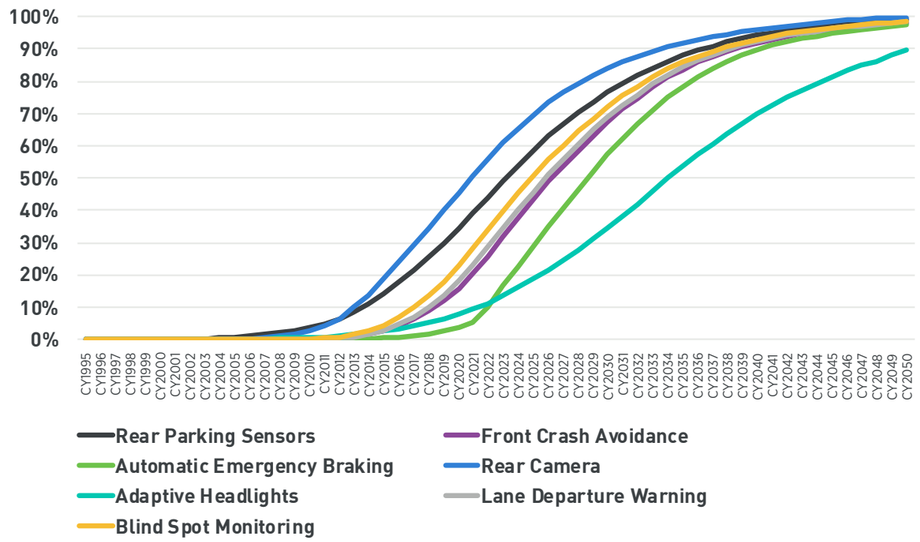
ADAS Challenging Building Blocks to Full Autonomy

The commercial availability of fully autonomous vehicles will be preceded by the release of vehicles with partial autonomy. As discussed previously, the expectation is that many fewer Level 0 and Level 1 vehicles will be manufactured over time, and Level 2 vehicles will account for 73 percent of all passenger sales by CY 2025.[108] Automakers developing Level 2 and Level 3 AVs with the goal to improve motor vehicle safety must decide how aggressively the systems compel driver awareness and reduce human response time to takeover warnings.[109]

Projections from the IIHS and Highway Loss Data Institute (HLDI) show it can take decades before all vehicles on the road are eventually equipped with new technologies – as evidenced by their projections on the various adoption rates of ADAS features among U.S. registered vehicles (see **Figure 45**). While the vast majority of vehicles of curb weight 8500 pounds or less after September 1, 2022 manufactured for the U.S. market will minimally come equipped with rear backup assist, AEB and forward collision warning, the net change in the vehicle fleet annually (new vehicles versus those scrapped) remains small. There will be a significant number of years where we will see a mixed fleet on the roads alongside one another.

IIHS/HLDI Predicted Percent of Vehicles Equipped with ADAS Technologies (Standard or Optionally Equipped) (FIGURE 45)

CY1995-CY2050 | SOURCE: "PREDICTED AVAILABILITY AND FITMENT OF SAFETY FEATURES ON REGISTERED VEHICLES." HLDI BULLETIN VOL. 34, NO. 28, SEPTEMBER 2017.



> Changes are coming at transportation from all directions, including potentially revolutionary technologies such as drones and automated vehicles, rapid innovations in urban transportation services, unreliable funding for infrastructure and operations, and possible changes in national policies affecting trade, climate, environmental protection, and sources of energy.

SOURCE: TRANSPORTATION RESEARCH BOARD. "CRITICAL ISSUES IN TRANSPORTATION. PREPUBLICATION DRAFT: NOVEMBER 2018." NATIONAL ACADEMY OF SCIENCES, 2018. WWW.TRB.ORG.

The November 2017 Forum on the Impact of Vehicle Technologies and Automation on Users sponsored by the AAA Foundation for Traffic Safety and the University of Utah discussed this issue, exploring questions such as: a) What are the anticipated safety outcomes that result from a mixed fleet (e.g., increased rear end collisions?); b) How do enhancements from automated technologies affect behaviors of pedestrians and other drivers on the road? c) How do risk factors change over time with increases in market penetration? d) Given that automated vehicles generally drive very defensively, how will they react to bullying by drivers of non-automated vehicles? What are the safety implications of this? e) How will continuous or intermittent software updates for specific vehicles impact the overall system function and coordination?[110] One of the key goals of the forum was to identify areas that would need to be researched, and to raise awareness of the need for collaboration and coordination among the numerous stakeholders in the research community, government, insurance, and technology.[111]

The situation is compounded by the wide variability in performance of the ADAS systems designed by each automaker. Specifically, real-world data and tests conducted by the Insurance Institute for Highway Safety (IIHS), Thatcham, and other organizations reveal that the ADAS offered on today's vehicles varies quite a bit in terms of how effective it is at mitigating speed and avoiding crashes, and in what type of road conditions it works reliably. Many challenges remain before automakers can address every potential accident scenario, at all traveling speeds, and in a consistent manner. And this is just the technology; how each driver responds to the technology will vary as well, with three key challenges of mode confusion, role confusion, and misplaced trust likely to further complicate the path towards full vehicle autonomy.[112] Research conducted by the Advanced Vehicle Technology Consortium studied real-world response of drivers to both Level 1 and Level 2 ADAS technologies. The research found that different implementations of the technologies result in very different behaviors among drivers by age of the driver, gender, and vehicle make,[113] underscoring the challenge for insurers in pricing any type of discount associated with ADAS.

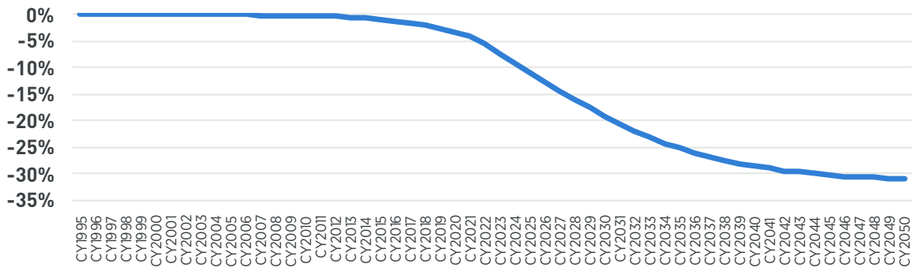
Given the wide array of ADAS technologies in the marketplace today, the variation in how they are packaged, the different designs and goals of each system, and the rate at which each is entering the marketplace, it becomes difficult to project what the real long-term impact on auto claim frequency and auto loss costs may be. In Crash Course 2018, analysis was completed to gauge what percentage of auto claims might benefit from ADAS features such as frontal crash avoidance, AEB, lane departure warning, adaptive headlights, and blind spot monitoring given the mix of auto claims by age and loss coverage. HLDI's predictions on the increase in percent of registered vehicle fleet equipped with each ADAS system to CY 2050 in the U.S. also was used. Finally, pooled data from analyses conducted across automakers on the likely reduction in frequency was also incorporated. Because there was limited data released to suggest that ADAS efficacies had improved dramatically, or that the rate of adoption will ramp up more quickly, our projection remains the same this year (see **Figure 46**). So, while this is only a high-level estimate, it underscores the inevitable decline in frequency that these systems will have as ADAS market penetration grows. This projection also does not account for the potential adoption of aftermarket devices such as those created by Mobileye which have been shown to improve driver safety and could help lead to additional reduction in crash frequency.[114]

What Does Real World Claims Data Tell Us About How Accidents Might Change with ADAS?

In *Crash Course 2018* we looked at early data on differences in crash frequency, crash characteristics, and crash severity among the same vehicle when equipped or not equipped with ADAS. Further analysis conducted this year shows a continuation of the same trend. Vehicle appraisals for four different vehicles from two different automakers – a small sedan, two small crossovers, and a midsize crossover – were analyzed to determine whether there were any distinct differences among those vehicles equipped with ADAS versus those not equipped with ADAS. Similar to prior analyses, the vehicles equipped with ADAS continue to show a lower share of collision losses where the primary impact was front, suggesting features like AEB and frontal crash warning are helping to reduce front impacts for the 'striking' vehicle (see **Figure 47**). Among liability losses, ADAS equipped vehicles also had a lower share where the primary impacts were rear impacts, suggesting rear backup cameras and warning systems are helping to reduce rear impacts where the 'striking' vehicle is ADAS equipped (see **Figure 48**).

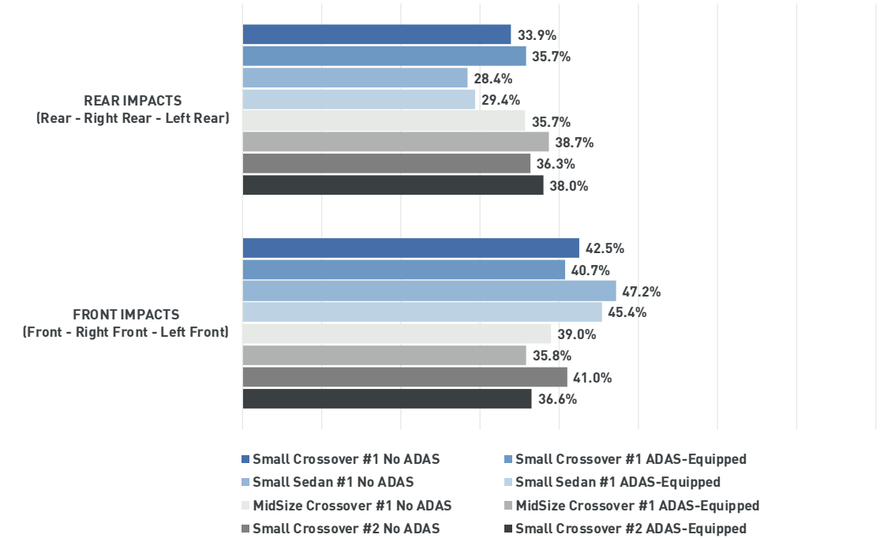
Potential Decline in Number of Vehicles in Accidents as ADAS Feature Adoption Grows

(FIGURE 46) | CY1995-CY2050 | SOURCE: CCC INFORMATION SERVICES INC.



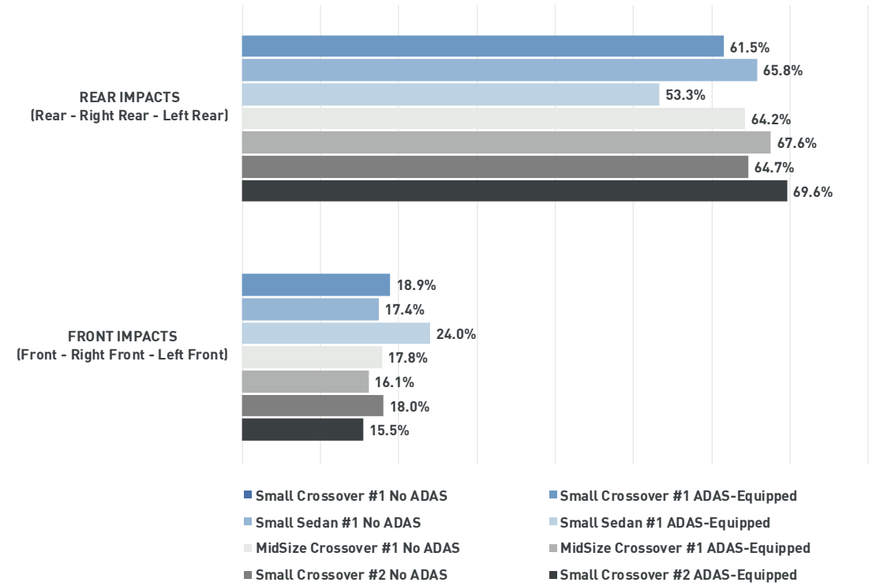
Repairable Appraisals for Collision Losses - Share of Volume by Primary Impact

(FIGURE 47) | CY2018 | SOURCE: CCC INFORMATION SERVICES INC.



Repairable Appraisals for Liability Losses - Share of Volume by Primary Impact

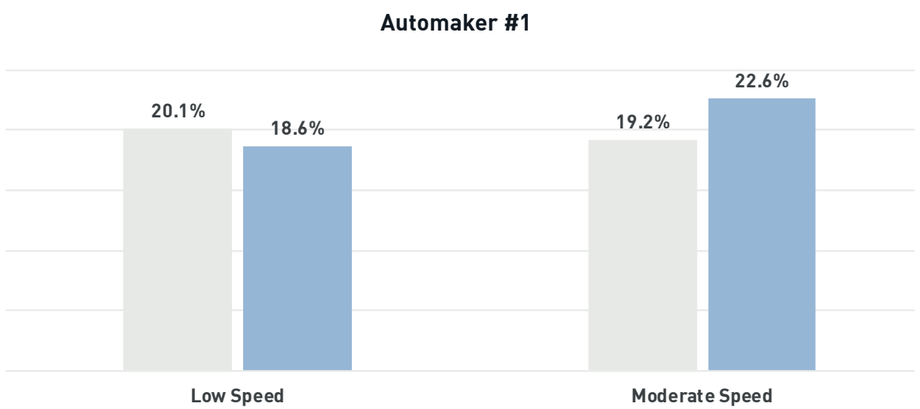
(FIGURE 48) | CY2018 | SOURCE: CCC INFORMATION SERVICES INC.

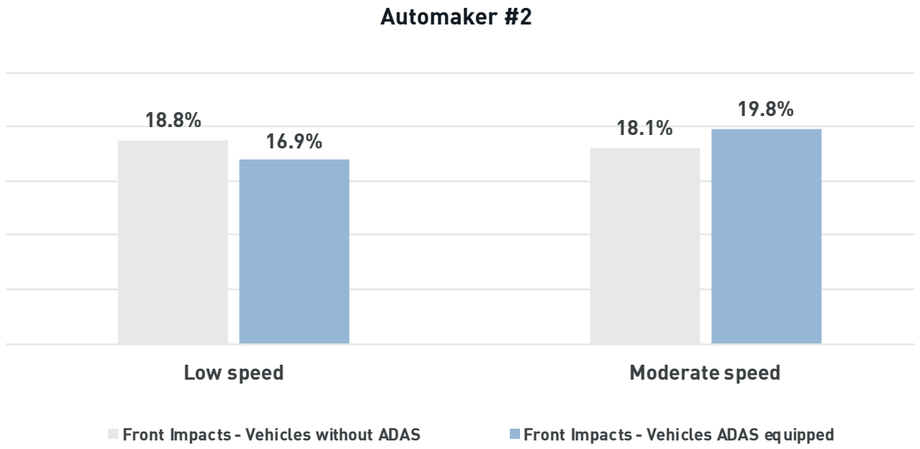


Perhaps one of the most promising outcomes of ADAS is the potential to avoid certain accidents altogether, and to reduce the severity of what would otherwise be much more severe accidents. A comparison of CY 2018 appraisal data for two automakers' model year 2016-2018 vehicles, and the Delta-V of the crash that caused the vehicle damage (determined using a proprietary methodology developed by CCC) suggests the range of accidents by the crash Delta-V may be changing for ADAS-equipped vehicles. The ADAS equipped vehicles with a front impact for both automakers show a smaller share of volume within both the lowest and highest Delta-V ranges, suggesting ADAS may be helping prevent low speed crashes altogether, and slowing the speed of the vehicle prior to impact for those crashes that otherwise might have had higher Delta-V's (see **Figure 49** and **Figure 50**). Similar results were found among rear impacts and side impacts, although the difference within each Delta-V range was smaller. This is consistent with research conducted by IIHS and other organizations that shows ADAS is very effective in helping to reduce one of the most common types of accidents – where one vehicle rear-ends another, although less so among other types of accidents.

Relative Frequency of Low-Speed and Moderate-Speed Front Impact Crashes when Vehicle Equipped with ADAS or No ADAS (FIGURES 49-50)

SOURCE: CCC INFORMATION SERVICES INC.



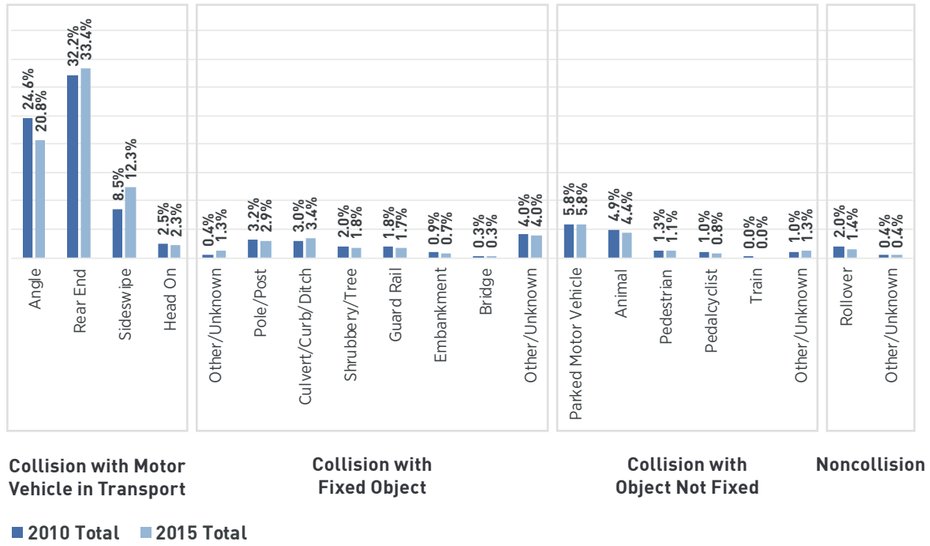


Data from the National Highway Traffic Safety Administration Fatality Analysis Reporting System (FARS) from Traffic Safety Facts 2015 shows rear end crashes were the most common manner of collision among all police-reported accidents (see **Figure 51**). This is consistent with data in the National Safety Council's Annual Injury Facts analysis of motor vehicle crashes (see **Figure 52** and **Figure 53**). Rear-end crashes have seen an increase in frequency over the last several years – potentially a by-product of greater road congestion and more distracted driving. So, it is promising that numerous tests of front crash warning (FCW) and AEB equipped vehicles appear to be helping reduce these types of accidents – specifically for the rear-end striking vehicle – by roughly half.

A report from IIHS's Cicchino "Effectiveness of forward collision warning and autonomous emergency braking systems in reducing front-to-rear crashes" looked at police-reported crash data from 22 states between 2012 and 2014 to compare the ability of vehicles equipped with FCW only, low-speed AEB, and FCW and AEB (see **Figure 54**). The results were significant and are similar to results from other studies underscoring the ability for these technologies to significantly avoid front-to-rear crashes, specifically when the striking vehicle was equipped with this technology. Unfortunately, the results also show that vehicles equipped with this technology may actually see higher rates of being struck, perhaps because these vehicles stop more suddenly. However, because the overall reduction in rear-striking vehicle accident frequency significantly outweighs the increase in rear-struck accident frequency, that increase may disappear as more and more vehicles on the road are themselves equipped with FCW and AEB.[115]

FARS – All Crashes by First Harmful Event, Manner of Collision (FIGURE 51)

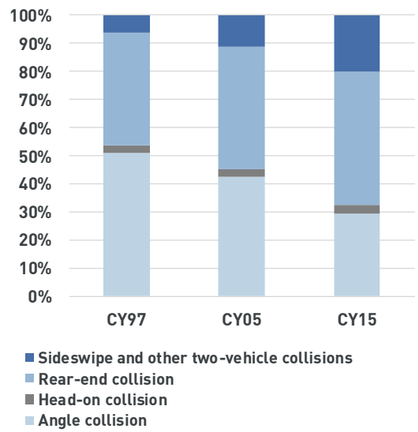
CY2010 & CY2015 | CHART: CCC INFORMATION SERVICES INC. | SOURCE: USDOT NHTSA TRAFFIC SAFETY FACTS 2015. TABLE 29 CRASHES BY FIRST HARMFUL EVENT, MANNER OF COLLISION, AND CRASH SEVERITY, 2015.



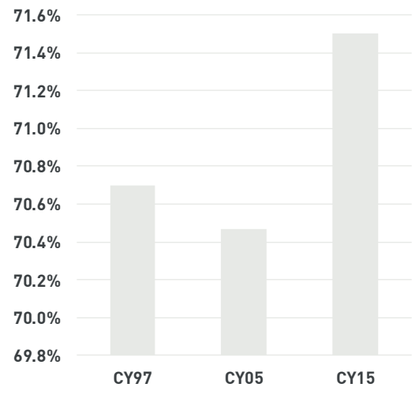
NSC All Accidents - Type of Motor Vehicle Accident - Percent that were Collision with Other Motor Vehicle and Other Motor Vehicle Collisions by Accident Type

(FIGURES 52-53) | SOURCE: NATIONAL SAFETY COUNCIL INJURY FACTS®

Type of Motor Vehicle Accident - Percent that were Collision with Other Motor Vehicle by Accident Type



Collision with Another Motor Vehicle



IIHS Study to Evaluate Effectiveness of These Systems in Police-Reported Crash Involvements per Insured Vehicle in 22 U.S. States During 2012-2014: (FIGURE 54)

- FORWARD COLLISION WARNING (FCW) ALONE
- LOW-SPEED AUTONOMOUS EMERGENCY BRAKING (AEB) SYSTEM OPERATIONAL AT SPEEDS UP TO 19 MPH THAT DOES NOT WARN THE DRIVER PRIOR TO BRAKING
- FCW WITH AEB THAT OPERATES AT HIGHER SPEEDS IN REDUCING FRONT-TO-REAR CRASHES AND INJURIES

	FCW Alone	Low-Speed AEB**	FCW with AEB
Rear-end striking crash involvement	-27%	-43%	-50%
Use on Rear-end striking crash involvement with injuries	-20%	-45%	-56%
Rear-end striking crash involvement with third-party injuries	-18%*	-44%	-59%
Rear-end struck crash involvement	-13%	-12%	20%
Rear-end struck crash involvement with injuries	-8%	-15%	4%
Rear-end struck crash involvement with injuries to occupants of the struck vehicle	-15%	-14%	8%

*MARGINALLY SIGNIFICANT
** RESULTS BASED ON VOLVO S60 AND XC60 MODELS

SOURCE: CICCHINO, JESSICA B. IIHS. "EFFECTIVENESS OF FORWARD COLLISION WARNING AND AUTONOMOUS EMERGENCY BRAKING SYSTEMS IN REDUCING FRONT-TO-REAR CRASH RATES." ACCIDENT ANALYSIS & PREVENTION, 99 (2017) 142-152.

Will Impaired and Distracted Driving Counter Gains from ADAS in the Near-Term?

Despite acknowledgement that distracted driving is a dangerous habit, too many people admit to doing so. Data from the 2018 Travelers Risk Index Distracted Driving reveals 85 percent of individuals surveyed said driving while using personal technology is extremely risky, yet 25 percent of those that engage in distracted driving believe they can do so safely.[116] According to Zendrive's analysis of 4.5 million drivers that drove 7.1 billion miles between December 2017 and February 2018, over 60 percent of drivers are using their phone at least once while behind the wheel during an average trip of 13.5 miles lasting for 20 minutes.[117] This is a substantially higher percentage than the 5.9 percent of drivers using electronic devices reported by National Highway Traffic Safety Administration in CY 2016 (includes "Handheld Cell Phone Use", "Visible Headset Cell Phone Use", and "Visible Manipulation of Handheld Devices").[118]

Unfortunately, urbanized areas were found to have higher risk of distracted driving vehicle crashes based on analysis conducted by researchers Zhenhua Chen and Youngbin Lym, assistant professors in city and regional planning at The Ohio State University's Risk Institute, of 1.4 million police records obtained from the Ohio Department of Transportation. Their analysis of crashes in Ohio found both a 35 percent increase in distracted driver fatalities and a 23 percent increase in serious injuries between CY 2003 and CY 2013.[119] Areas such as work zones were found to be twice as fatal in terms of distracted driving fatalities, and that even the length of a roadway segment or number of lanes drove the frequency of distracted driving crashes.[120] Roundabouts actually had zero distracted driving fatalities during the period studied, and roads with a median or asphalt-paved shoulder had a lower distracted driving fatality frequency. Overall, their study found distracted-driving related crashes were 49 percent more severe when they occurred on a highway system, underscoring the growing challenges as more urban miles are driven on more congested roads, and many more drivers now driving with a smartphone.

Driving while drowsy also remains a problem, with data from a naturalistic driving study conducted by the AAA Foundation for Traffic Safety suggesting drowsiness was involved in approximately 9 percent of all crashes examined, and in more than 10 percent of crashes that resulted in significant property damage, airbag deployment, or injury, versus the 1-2 percent of motor vehicle crashes reported by National Highway Traffic Safety Administration.[121]

As more states have legalized recreational marijuana, and opioid use and abuse has grown in recent years, impaired driving has seen an increase, and claim frequency has also risen. For example, the prevalence of THC metabolites detected in the blood or oral fluids of weekend nighttime drivers participating in the National Roadside Survey rose from 8.6 percent in 2007 to 12.6 percent in CY 2013–CY 2014.[122] And, the percentage of fatally injured drivers who tested positive for prescription opioids rose sevenfold from 1 percent in 1995 to over 7 percent in 2015.[123]

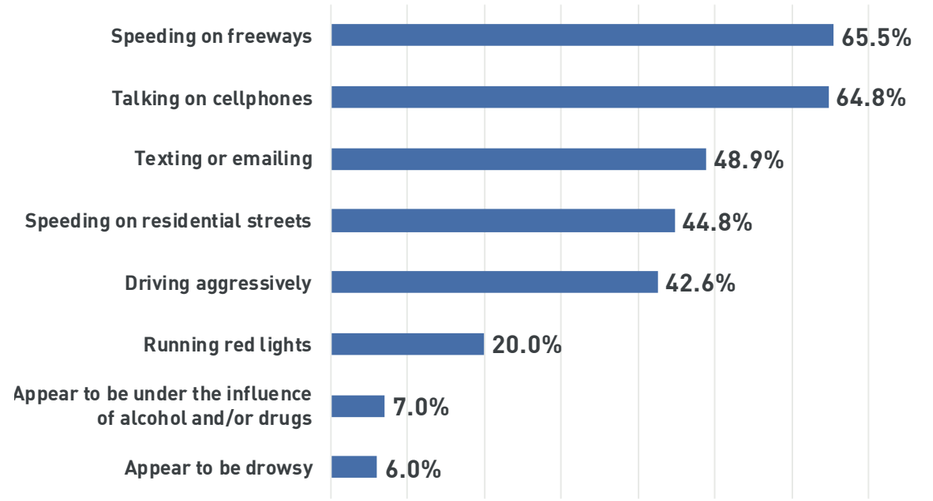
According to data from IIHS - HLDI, the frequency of collision claims per insured vehicle year rose a combined 6 percent following the start of recreational marijuana in Colorado, Nevada, Oregon and Washington, compared with the control states of Idaho, Montana, Utah and Wyoming (the combined-state analysis is based on collision loss data from January 2012 through October 2017, and the analysts controlled for differences in the rated driver population, insured vehicle fleet, the mix of urban versus rural exposure, unemployment, weather and seasonality).[124]

And, drivers in general appear to be engaged in all sorts of risky behavior while driving. Data from the survey conducted for the AAA Foundation for Traffic Safety's 2017 Traffic Safety Culture Index reveals drivers often see other drivers regularly doing things like talking on their phone and speeding (see **Figure 55**).[125]

Combine distracted driving with higher speed limits, more urban driving, more interstate driving, nearly 15 percent of Americans not wearing seat belts,[126] 37 percent of U.S. workforce sleep deprived and three times more likely to be in a car crash,[127] greater road congestion, higher employment, growing vehicle population, and more miles driven, and it becomes more evident why the U.S. has seen higher rates of automotive accident frequency and higher injury and fatality rates. More recently, as auto claim frequency has begun to flatten and motor vehicle fatalities have fallen slightly, there is evidence that perhaps some of this can be attributed to a greater share of vehicles on the road with ADAS. A key challenge will be to develop ADAS systems in a way that counter humans' natural inclination to take on more risk behind the wheel as they feel safer from ADAS. Clearly the future holds plenty of opportunity to reduce accidents and develop ADAS systems that help counter human inclination to distraction.

Survey - "How Often Do You See the Following Behavior by Another Driver on the Road?"

(FIGURE 55) | SOURCE: AAA FOUNDATION FOR TRAFFIC SAFETY'S 2017 TRAFFIC SAFETY CULTURE INDEX



Early data on ride-hailing and AVs being tested on real-world streets today underscore the need to consider how these dramatic changes to personal mobility will change demands on vehicle ownership, driving patterns, insurance, accident frequency, infrastructure, public transportation, and more.

Vehicles equipped with ADAS contain the radar, sensors, cameras and more that are the building blocks for tomorrow's AVs. Nearly all but the highest level of vehicle autonomy includes a driver, so the handoff between the vehicle and the driver is critical to clearly define responsibility. It also underscores the need for technology to help thwart the mode confusion, role confusion, and over-confidence that some early systems are experiencing with their human drivers. Too many drivers today already drive impaired, either from distraction, alcohol, opioids, marijuana, or in-vehicle technology. Humans are too prone to risk-homeostasis, where removal of risk makes them think they can take on more; having full understanding of the true capabilities and limitations of AVs is key, particularly given the wide range across automakers, tech companies, and vehicles today.

Impaired driving, congestion and urbanization have combined to create a potent cocktail that has helped drive up accident frequency and motor vehicle fatalities over the last several years; with AVs expected to add more vehicles to our roads — many which already are in poor condition — infrastructure challenges abound. Consider, for example, these basic metrics: highways today can carry about 2,000 cars per lane per hour; AVs could quadruple that; and yet, the best rail systems can carry more than 50,000 passengers per lane per mile.[128] The best solutions long term will take all of these variables into consideration, adjusting for range in metro size, existing transportation options, growth patterns, etc. A big challenge for sure.

I CRASH & FIX MY CAR

Each year around the world over 1 million people are killed in motor vehicle accidents.

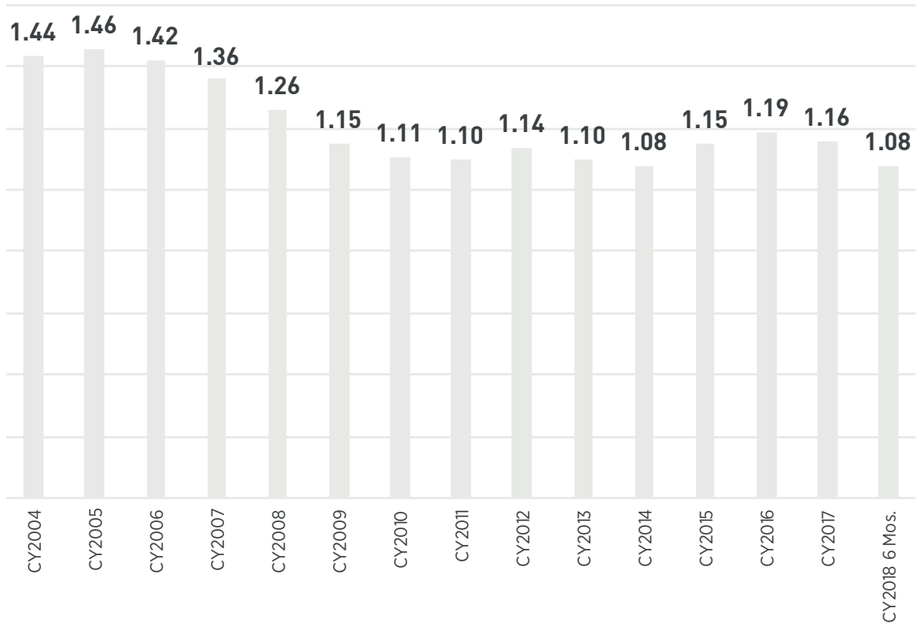
Much has been done by safety organizations, governments, and automakers to improve the safety of roads, vehicles, and raise awareness of risky behaviors, but the problem remains. Much hope has been placed in the ability for AVs to help reduce vehicle accidents and resulting injuries and fatalities, by taking the human driver out of the equation. Over 90 percent of accidents are believed to be the fault of the human driver today. As more vehicles are equipped with ADAS, early data suggests we will start to see a reduction in auto crash rates, and resultant injuries and fatalities, because the vehicle speed and subsequent impact are slowed by ADAS features, even if the accident is not avoided altogether. For example, IIHS/HLDI studies of the efficacy of various ADAS features in reducing claim frequency and costs found FCW without autobrake reduced bodily injury claim frequency by 15 percent; adding AEB pushed the reduction up to 19 percent.[129]

U.S. motor vehicle fatalities in CY 2017 again exceeded 37,000 individuals, but were down 1.8 percent from CY 2016, versus the 8.4 percent increase from CY 2014 to CY 2015 and the 6.5 percent increase from CY 2015 to CY 2016.[130] Data for the first six months of CY 2018 show further decline, with the fatality rate per 100 million miles driven falling each quarter since Q3 2017 (see **Figure 56** and **Figure 57**). A comparison of motor vehicle fatality composition from CY 2008 to CY 2017 reveals non-occupant fatalities increased from 14 percent to 19 percent, while passenger car occupant fatalities fell from 39 percent to 36 percent, light-truck occupant fatalities fell from 29 percent to 27 percent, and motorcycle fatalities were flat (see **Figure 58**).[131] Overall, the share of people killed "inside the vehicle" declined from 80 percent in CY 1996 to 67 percent in CY 2017, while those "outside the vehicle" grew over that same period from 20 percent to 33 percent. Not surprisingly, both motor vehicle fatalities and the fatality rate per 100 million miles driven in urban areas have grown but declined in rural areas (see **Figure 59**).[132]

More people walking while distracted is also believed to be a factor. According to data from the National Electronic Injury Surveillance System, U.S. emergency room visits blamed on phone use spiked 83.5 percent from 17,851 in CY 2007 — the year Apple introduced the iPhone — to 32,755 in CY 2016.[133] Improved vehicle safety and availability of ADAS may be helping reduce fatalities and injuries of vehicle occupants, but until features such as pedestrian airbags are standard, the non-occupants' share of motor vehicle crashes may continue to trend higher.

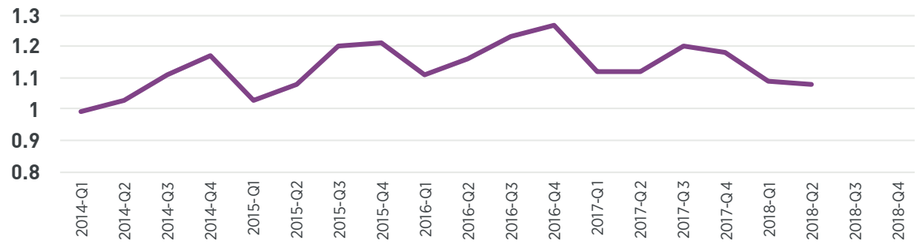
U.S. Motor Vehicle Fatality Rate per 100 Million Vehicle Miles Traveled Annually (FIGURE 56)

CY2014-CY2018 | SOURCES: USDOT NHTSA "2016 FATAL MOTOR CRASHES: OVERVIEW." DOT HS 812 456, OCTOBER 2017. USDOT NHTSA "EARLY ESTIMATE OF MOTOR VEHICLE TRAFFIC FATALITIES FOR THE FIRST HALF (JAN–JUN) OF 2018." OCTOBER 2018. DOT HS 812 629.



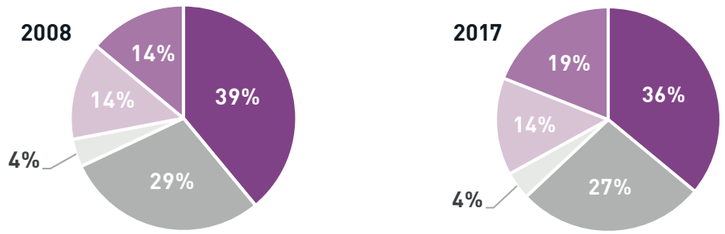
U.S. Motor Vehicle Fatality Rate per 100 Million Vehicle Miles Traveled Quarterly (FIGURE 57)

CY2014-CY2018 | SOURCES: USDOT NHTSA "2016 FATAL MOTOR CRASHES: OVERVIEW." DOT HS 812 456, OCTOBER 2017. USDOT NHTSA "EARLY ESTIMATE OF MOTOR VEHICLE TRAFFIC FATALITIES FOR THE FIRST HALF (JAN–JUN) OF 2018." OCTOBER 2018. DOT HS 812 629.



U.S. Motor Vehicle Fatality Composition (FIGURE 58)

CY2008 VS CY2017 | SOURCE: USDOT NHTSA "2017 FATAL MOTOR VEHICLE CRASHES: OVERVIEW." OCTOBER 2018. DOT HS 812 603.



Comparison of U.S. Motor Vehicle Fatalities and Vehicle Miles Traveled: Urban vs Rural

(FIGURE 59) | CY2008 VS CY2017 | SOURCE: USDOT NHTSA "2017 FATAL MOTOR VEHICLE CRASHES: OVERVIEW." OCTOBER 2018. DOT HS 812 603.

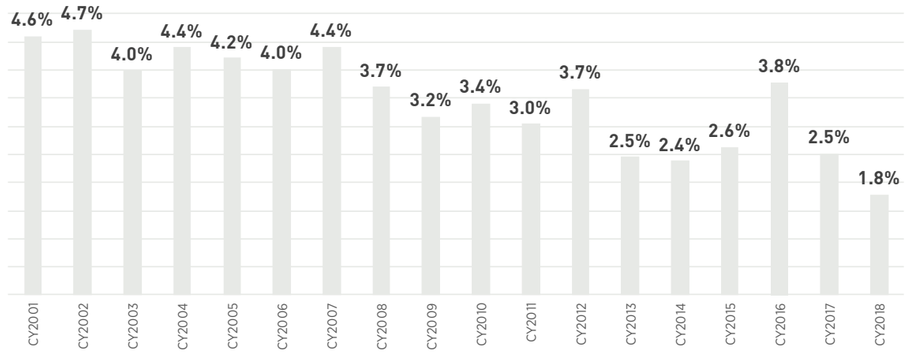
	URBAN CHANGE CY2017 vs CY2008	RURAL CHANGE CY2017 vs CY2008
Fatality Rate per 100 Million Miles	3.7%	-16.0%
Passenger Vehicle Occupant Fatalities	9.0%	-19.0%
Pedestrian Fatalities	46.0%	-6.0%
Pedalcyclist Fatalities	13.0%	-15.0%
Motorcyclist Fatalities	15.0%	-25.0%
Share of U.S. Vehicle Miles Travelled	6.7%	-4.6%

Medical Costs Continue to Rise

A comparison of the Bureau of Labor's CPI data reveals the medical care index since CY 2001 show some of the fastest growth in the last decade occurred in CY 2016, but costs for CY 2018 are finally running slightly below overall CPI (see **Figure 60**). The indices for hospital services, prescription drugs, and services by other medical professionals have seen larger increases over the last several years than overall inflation (see **Figure 61**). Among the primary drivers of overall medical inflation are an increased baby-boomer population increasing enrollment in Medicare, and increases in the cost of medical goods and services.[134] In early CY 2018, the U.S. Centers for Medicare and Medicaid Services (CMS) projected healthcare spending on average would rise 5.5 percent annually between CY 2017 and CY 2026, comprising nearly 20 percent of the U.S. economy in 2026 from 17.9 percent in CY 2016.[135]

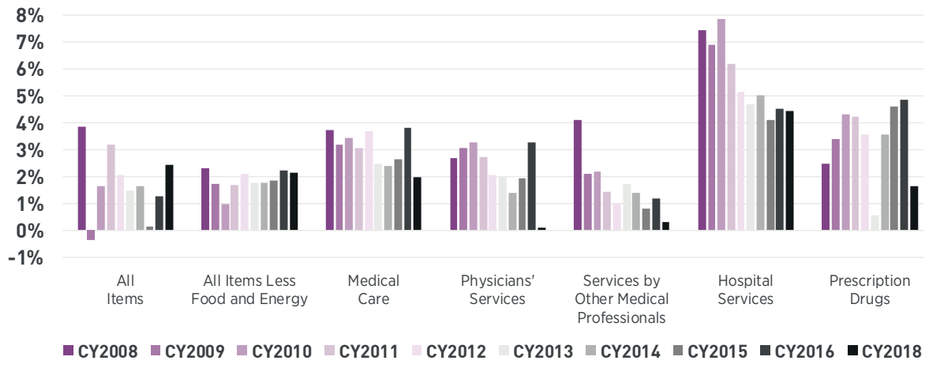
Annual Percent Change, CPI - Medical (FIGURE 60)

SOURCE: INSURANCE INFORMATION INSTITUTE, BLS CPI



Healthcare Costs Continue to Rise Faster Than Inflation - BLS CPI Price Level Change

(FIGURE 61) | ANNUAL CPI PERCENT CHANGE FROM PRIOR YEAR - U.S. CITY AVERAGE, ALL URBAN CUSTOMERS, NOT SEASONALLY ADJUSTED
SOURCE: WWW.BLS.GOV

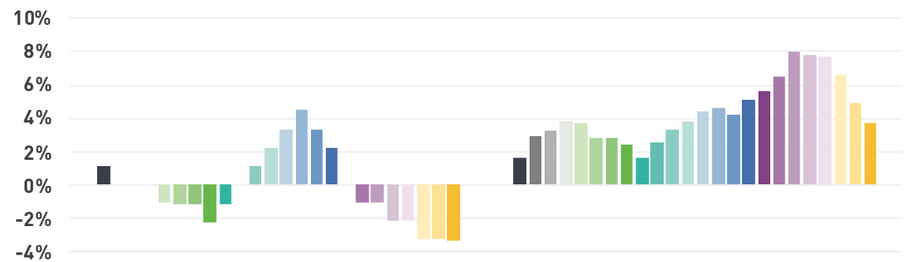


Frequency for bodily injury (BI) and personal injury protection (PIP) coverages is trending lower again (see **Figure 62** and **Figure 63**), as overall accident frequency begins to decline, although PIP frequency ticked up the twelve months ending Q3 2018. BI claim severity rose steadily since CY 2014, peaked in CY 2017, and has since seen smaller rates of increase, although BI claim severity continues to grow faster than overall inflation and inflation in medical care.[136] In fact, data from the Insurance Research Council shows insurer payments for BI claims between CY 2012 and CY 2017 grew 6 percent annualized, nearly double the rate of overall medical inflation.[137] Furthermore, a CY 2018 hospital costs study released by Johns Hopkins found rates paid by the different types of commercial insurers for hospital services between CY 2010 and CY 2016 increased more than the rates paid by public and private insurers.[138] The study looked at the median price paid by HMO/PPO health insurers at 153 private hospitals in Florida, showing it increased from 1.9 to 2.5 times the price paid by the Medicare program, while the median price paid by auto insurers and other non-conventional commercial insurers increased from 2.8 to 3.8 times.[139]

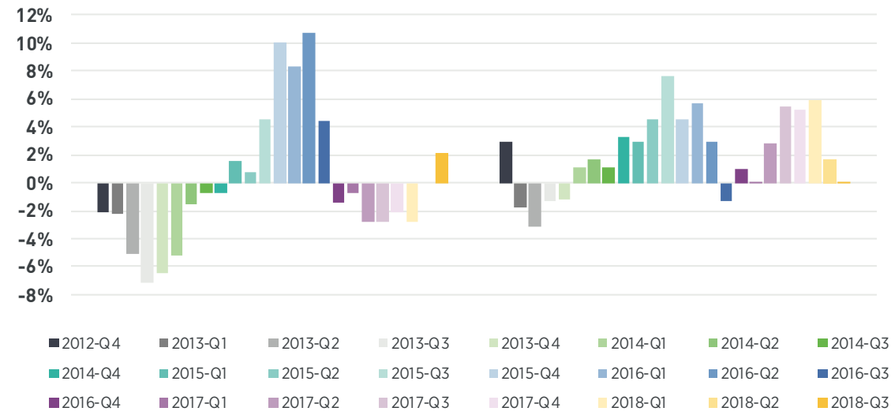
Percent Change in Claim Frequency & Severity from Quarter One Year Prior (Each Quarter Represents Rolling 4 Quarters Data Ending that Quarter)

(FIGURES 62-63) | SOURCE: ISS FAST TRACK PLUS™ PERSONAL AUTO, AS OF SEPTEMBER 30, 3018

Private Passenger Auto - Bodily Injury



Private Passenger Auto - PIP



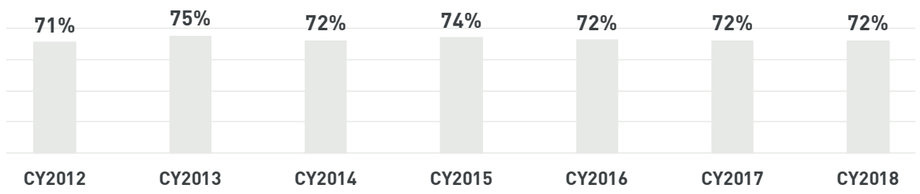
PIP severity has seen more sporadic increases in severity over the last several years, but most recent data also shows some slowdown in the rate of increase. Historically, most of the trends in PIP have been driven by three of the largest states with no-fault approaches to compensating auto injuries – Florida, Michigan, and New York.

Analysis of bodily injury claims data reveals very little change in the highest ranked diagnoses in terms of total dollars billed/claimed per diagnosis (either standalone or in combination with other diagnoses) over the last several years. Data from the FARS/GES continues to show rear-end collisions are the most common type of accident (see **Figure 51**), so it is not surprising that neck injuries and treatment plans including chiropractic care continue to top the list. In fact, among third-party casualty claims referred for causation analysis, low impact crashes (change in velocity of 10 MPH or less) as a percent of all crashes have remained relatively stable over the last several years, coming in at 72 percent again in CY 2018 (see **Figure 64**).

According to the Insurance Research Council's Countrywide Patterns in Auto Injury Insurance Claims: 2018 Edition, attorney involvement in auto injury claims also continues to climb (see **Figure 65**).[140] Insurance Research Council research has shown claims with attorney involvement tend to have higher utilization rates for chiropractic treatment, physical therapy and expensive diagnostic procedures such as MRIs and CTs, even when comparing claimants with similar injuries.[141]

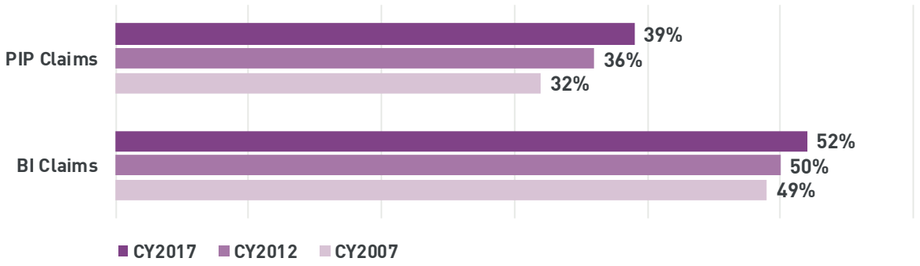
Low Impact (Change in Velocity of 10 MPH or Less) as a Percent of All Crashes for Third Party Casualty Claims Referred for Causation Analysis (FIGURE 64)

CY2012-CY2018 | SOURCE: CCC INFORMATION SERVICES INC., AIS



Attorney Involvement in Auto Injury Claims (FIGURE 65)

SOURCE: INSURANCE RESEARCH COUNCIL, "COUNTRYWIDE PATTERNS IN AUTO INJURY INSURANCE CLAIMS: 2018 EDITION."



Major Trends Contributing to Medical Inflation

Medical inflation is in large part being driven by a number of key variables. To understand some of the key factors driving the above trends in auto BI and PIP claim frequency and loss costs, Auto Injury Solutions, Inc. (AIS), a CCC company, completed an analysis of over 4 million auto BI and PIP /Medpay claims for the period CY 2014-CY 2018. The results of this analysis are outlined below.

1 Speed Shifts

- Road speed limits are higher in many jurisdictions compared to 5 yrs ago
- Electric vehicles with faster acceleration capabilities
- Vehicle safety measures designed to prevent low speed collisions have a diminished effect against collisions at higher speeds

2 Unsafe Behaviors

- Increased distracted driving due to smart phone usage and more technology in cars
- Engineered technology to improve safety does not change innate driver behavior
- Chemical impairment due to marijuana, alcohol, and opioids increasingly related to fatal crashes

3 Aging Population

- Massive demographic shifts as Baby Boomer generation continues to age
- Higher fatality rate in older drivers
- Increased treatment complexity due to chronic or pre-existing conditions, more medications, and longer duration of treatment

4 Increased Surgery Volume

- Increased outpatient surgeries resulting in less initial hospitalizations but use of more expensive technologies
- Increased complications with surgeries in older age groups
- Chronic conditions complicating auto injury, acute, soft tissue claims

5 Shifting Urban vs. Rural Mix

- Continuing population density shift towards urban areas
- Auto repair & medical treatment more expensive in urban areas versus rural areas
- Road sharing initiatives in cities leading to increased volume of collisions and risk to pedestrians and cyclists

Between 2007 and 2016, the number of people aged 65+ years increased by 30% in the US Population. During the same period, there was a 34% increase in licensed drivers aged 65+, to a number of 41.7 million. As this demographic shift continues to mature over time, deeper data analytics will be imperative in identifying trends that will require carriers to review and recalibrate claims reserving strategies and claims handling best practices. Additionally, identification of chronic and pre-existing conditions early in the claim lifecycle will help control duration of treatment and develop additional cost containment methodologies. In summary, a strategic approach to a book of business reflecting the aging population will be critical in consistent claim triage, early assignment to the correct claims professional, and accurate reserving on BI claims.

Bodily-Injury Claims Review

For the period of study (CY 2014 to CY 2018), the top diagnoses for bodily injury claims in terms of overall dollars charged have remained consistent, with neck pain (Cervicalgia) and neck sprain and strain among the top one or two positions in the last four years (see **Figure 66**). Subsequently, there have been only moderate changes in both the procedure utilization by category (see **Figure 67**), and the medical procedures billed for treatment of bodily injury claims (see **Figure 68**), underscoring the consistency in the types of injuries, diagnoses, and treatment over that period. Perhaps the most noteworthy change in ranking of procedures based on dollars-billed is the increase in the ranking for emergency department visits and the appearance of "CT head/brain w/o contrast material" among the top 10 procedures billed in the last two years. There is some debate that greater public awareness of traumatic brain injuries among athletes who have sustained numerous concussive head injuries has led to more individuals injured in vehicle crashes concerned about similar injuries, subsequently leading to more claims with related medical procedures.

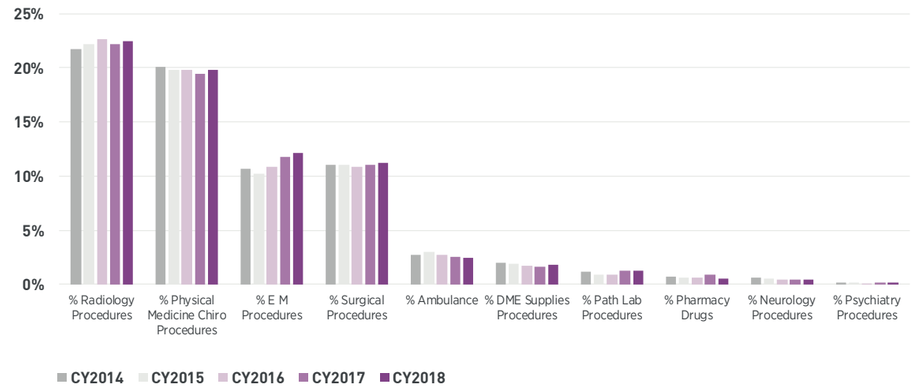
BI Claims: Top Diagnoses based on Total Dollars Billed for Period (FIGURE 66)

CY2014-CY2017 | SOURCE: AUTO INJURY SOLUTIONS (AIS), A CCC COMPANY

	DIAGNOSIS RANKING BASED ON DOLLARS CHARGED				
	CY2014	CY2015	CY2016	CY2017	CY2018
Cervicalgia	4	4	2	1	1
Low back pain			5	2	2
Sprain lig cerv spine initial enc			3	3	3
Sprain ligaments lumbar spn initial			7	4	4
Strn musc fasc tendon neck levl int				6	5
Sprain ligaments t-spine initial			10	5	6
Radiculopathy cervical region				9	7
Essential primary hypertension				7	8
Pain in thoracic spine				10	9
Headache	6	7		8	10
Brachial neuritis/radiculitis nos	9	9			
Displcmt lumbar disc w/o myelopathy	10	10			
Lumbago	5	5	9		
Lumbar sprain and strain	2	2	6		
Neck sprain and strain	1	1	1		
Spasm of muscle	7	6			
Thoracic sprain and strain	3	3	8		
Unspecified essential hypertension	8	8			

Procedures in Third Party Auto Casualty - All Closed Claims (FIGURE 67)

CY2014–CY2018 | SOURCE: AUTO INJURY SOLUTIONS (AIS), A CCC COMPANY
NOTE: RADIOLOGY PROCEDURES INCLUDE CTS, MRIS AND OTHER DIAGNOSTIC XRAY STUDIES.



BI Claims: Top Medical Treatment Procedures based on Total Dollars Billed for Period

(FIGURE 68) | CY2014-CY2018 | SOURCE: AUTO INJURY SOLUTIONS (AIS), A CCC COMPANY

	PROCEDURE RANKING BASED ON DOLLARS CHARGED				
PROCEDURE	CY2014	CY2015	CY2016	CY2017	CY2018
Therapeutic px 1/→ areas each 15 min exercises	1	1	1	1	1
Operating room/other	2	2	2	2	2
Emergency department visit high/urgent severity	5	5	5	3	3
Manual therapy tqs 1/→ regions each 15 minutes	3	3	3	4	4
CT cervical spine w/o contrast material	7	6	7	5	5
Mri spinal canal cervical w/o contrast matrl	6	7	8	7	6
Chiropractic manipulative tx spinal 3-4 regions	4	4	6	6	7
Mri spinal canal lumbar w/o contrast material	10	8	9	8	8
CT head/brain w/o contrast material			10	9	9
Emergency dept visit high severity&threat funcj					10
Medical/Surgical Supplies: Other implants	8	9			
Chiropractic manipulative tx spinal 1-2 regions	9				
Emergency/other		10		10	

Physical Medicine & Rehabilitation Procedures
Radiology Services Procedures
Facilities Procedures
Other

Overall however, when reviewing summary level procedure data, we see just how little change there has been over the last five years in ranking of the most common procedures based total amount paid (see **Figure 69**), with steady growth in average fees per procedure for many of the most common (see **Figure 70**).

What has seen significant change is the average number of days between the first treatment date of service to the last treatment date of service, which grew from 146 days in CY 2014 to 228 days in CY 2018, while the median number of days grew from 86 to 89 days over the same period.

Historically, increases in utilization have been a principal cause for the rising costs in medical dollars for BI claims. However, for the observation period from CY 2014 to CY 2018, the number of unique procedures has fluctuated very little (between 16 and 17 across all five years), as has the average number of procedures: 175 in CY 2014, 172 in CY 2016, 168 in CY 2017, and 172 in CY 2018.

So why are third-party medical costs increasing? The newer drivers of rising cost are twofold: a) the same types of injuries are being treated with more expensive treatment approaches (e.g., emergency room and hospital related treatments); and b) cost-increases in these more expensive care modalities are increasing at a much faster rate than traditional modalities such as chiropractic and physical therapy related procedures.

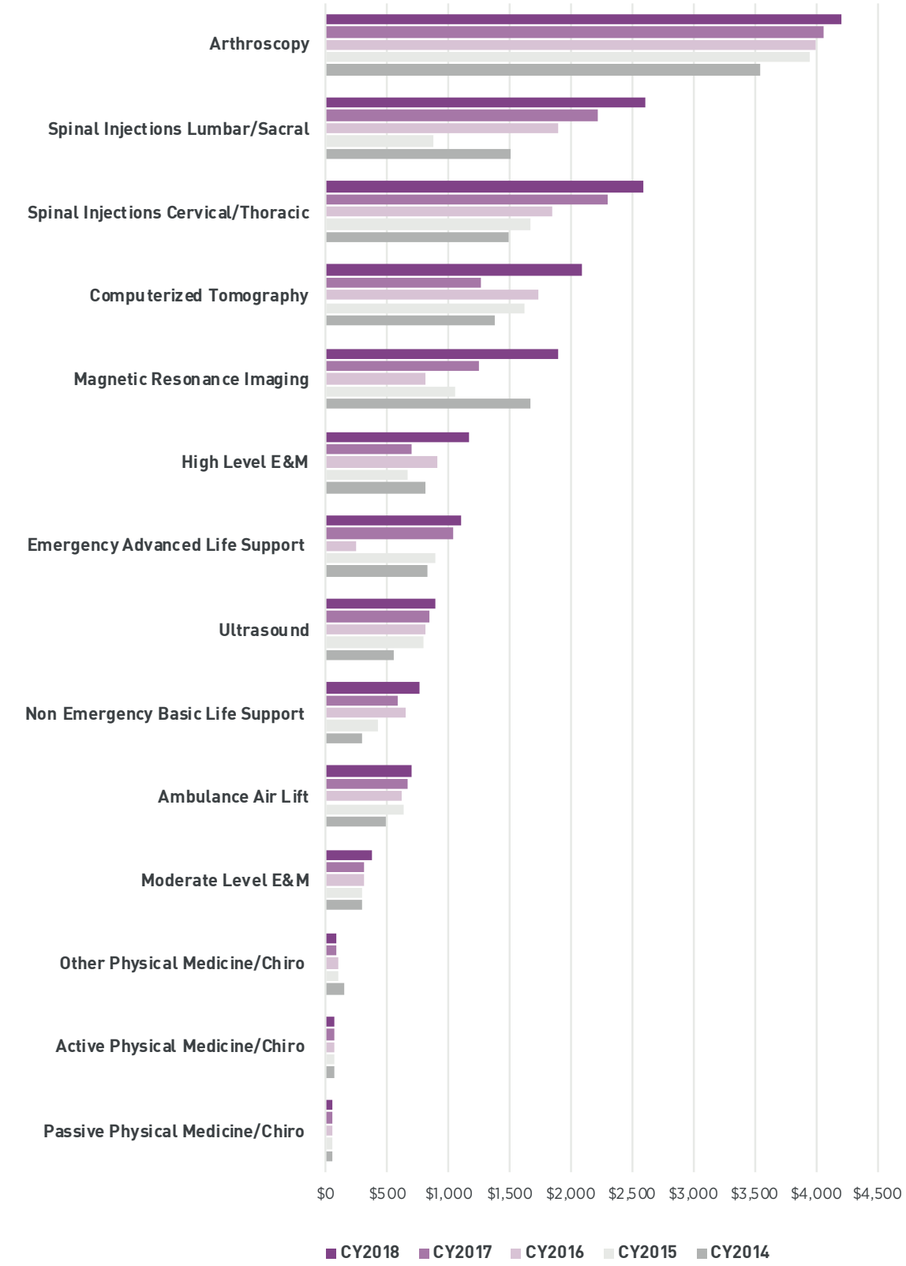
BI Claims Top Medical Summary Procedures Based on Total Dollars Paid (FIGURE 69)

CY2014-CY2018 | SOURCE: AUTO INJURY SOLUTIONS (AIS), A CCC COMPANY

	RANKING BASED ON TOTAL DOLLARS PAID				
PROCEDURE CODE SUMMARY CATEGORY	CY2014	CY2015	CY2016	CY2017	CY2018
Radiology	1	1	1	1	1
Physical Medicine/Chiro	2	2	2	3	3
Surgical	3	3	3	2	2
Evaluation & Management	4	5	4	4	4
Other	5	4	5	5	5
Durable Medical Equipment/Supplies	6	6	6	6	6
Inpatient	7	7	7	7	7
Pharmacy & Drugs	8	9	9	8	9
Pathology/Lab	9	8	8	9	8
Ambulance	10	10	10	10	10
Neurology	11	11	11	11	11
Psychiatry	12	12	12	12	12
Dental	13	13	13	13	13

Average Paid Amount for Common Third Party Procedures (FIGURE 70)

CY2014-CY2018 | SOURCE: AUTO INJURY SOLUTIONS (AIS), A CCC COMPANY



PIP/Medpay Claims Review

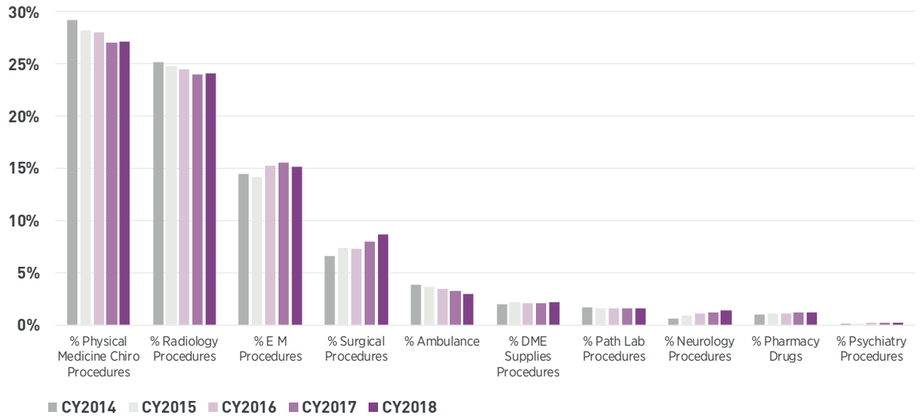
PIP/Medpay claims analyzed from CY 2014 to CY 2018 also reveal very little change in the diagnoses of injuries: neck pain (Cervicalgia) or neck sprain and strain held the top spot all five years, while low back pain or lumbar sprain and strain was typically in second place (see **Figure 71**). Medical procedures for PIP/Medpay claims - both in terms of frequency (see **Figure 72**) and when ranked in terms of dollars billed (see **Figure 73**) - saw greater use of emergency room and neurology procedures.

PIP/Medpay Claims: Highest Ranked Diagnoses in Terms of Dollars Billed/Claimed for Period (FIGURE 71) | CY2014–CY2018 | SOURCE: AUTO INJURY SOLUTIONS (AIS), A CCC COMPANY

	DIAGNOSIS RANKING BASED ON DOLLARS CHARGED				
DIAGNOSIS	CY2014	CY2015	CY2016	CY2017	CY2018
Cervicalgia	3	2	2	1	1
Sprain lig cerv spine initial enc			4	3	2
Diagnosis code not provided					3
Strn musc fasc tendon neck levl int				7	4
Low back pain			6	2	5
Radiculopathy cervical region					6
Car occ injured uns traf acc init					7
Neck sprain and strain	1	1	1		8
Unspecified injury head initial enc					9
Oth iv disc displacement lumbar rgn					10
Acute posthemorrhagic anemia	8	9			
Brachial neuritis/radiculitis nos		10			
Essential primary hypertension			10	5	
Head injury, unspecified	10				
Headache	7	7		9	
Lumbago	6	5	9		
Lumbar sprain and strain	2	3	5		
Nondependent tobacco use disorder	9	8			
Pain in thoracic spine				10	
Sprain ligaments lumbar spn initial			8	4	
Sprain ligaments t-spine initial				6	
Thoracic sprain and strain	4	4	7		
Uns street highway place ext cause				8	
Unspecified essential hypertension	5	6			

Procedures in PIP/Medpay Auto Casualty - All Closed Claims (FIGURE 72)

CY2014–CY2018 | SOURCE: AUTO INJURY SOLUTIONS (AIS), A CCC COMPANY



PIP/Medpay Claims: Top Medical Procedures in Terms of Dollars Billed/Claimed for Period (FIGURE 73) | CY2014–CY2018 | SOURCE: AUTO INJURY SOLUTIONS (AIS), A CCC COMPANY

		PROCEURE RANKING BASED ON DOLLARS CHARGED				
	PROCEDURE	CY2014	CY2015	CY2016	CY2017	CY2018
	Therapeutic px 1/→ areas each 15 min exercises	1	1	1	1	1
	Emergency department visit high/urgent severity	7	6	2	2	2
	Manual therapy tqs 1/→ regions each 15 minutes	3	3	4	3	3
	CT cervical spine w/o contrast material	2	2	3	4	4
	Chiropractic manipulative tx spinal 3-4 regions		5	5	5	5
	CT head/brain w/o contrast material	5	4	6	6	6
	Mri spinal canal cervical w/o contrast matrl	9	9	8	7	7
	Mri spinal canal lumbar w/o contrast material	10	10	9	9	8
	Operating room/other	6	8	7	8	9
	Emergency dept visit high severity&threat funcj				10	10
	Emergency/other	8	7			
	Chiropractic manipulative tx spinal 3-4 regions	4				
	Emergency department visit moderate severity			10		

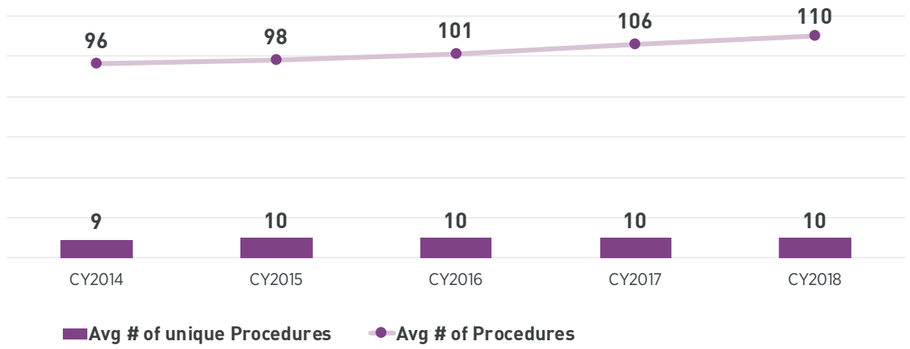
Physical Medicine & Rehabilitation Procedures
Radiology Services Procedures
Facilities Procedures

Additionally, rising costs are coming are coming not just from more costly procedures, but also from higher costs per procedure and the number of visits. **Figure 74** shows how the average number of unique procedures for first-party claims was nine or 10 procedures throughout the period analyzed, but the average number of procedures grew from 96 to 110 between CY 2014 and CY 2018.

Finally, a comparison of the average charge-per-claim and the average charge-per-claim excluding duplicates reveals the increase in medical inflation, where the same types of treatments and procedures are simply being billed at higher rates (see **Figure 75**).

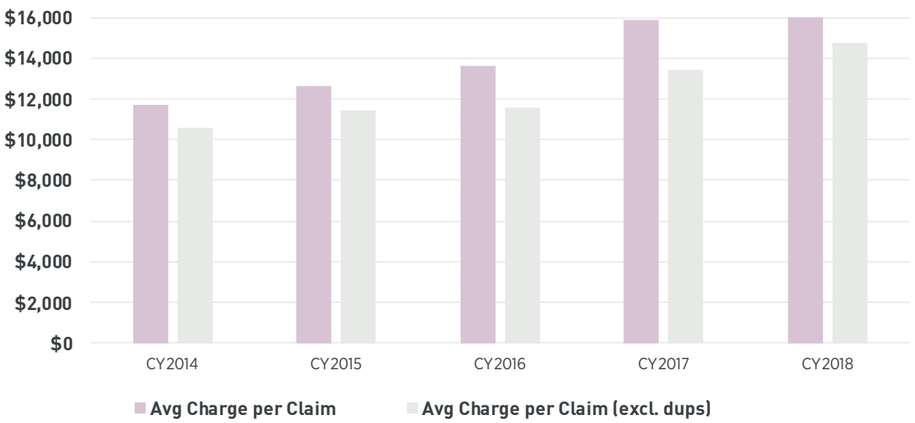
First Party Casualty - Average Total Number of Procedures Increasing While Average Number of Unique Procedures Remains Flat - All Closed Claims (FIGURE 74)

CY2014-CY2018 | SOURCE: AUTO INJURY SOLUTIONS (AIS), A CCC COMPANY



PIP/Medpay Increasing Average Charges per Claim (FIGURE 75)

CY2014-CY2018 | SOURCE: AUTO INJURY SOLUTIONS (AIS), A CCC COMPANY



The types of auto-related BI and PIP/Medpay diagnoses most frequently seen in the last three years have remained relatively unchanged and are predominately by nature soft tissue neck and back injuries. And, despite the prevalence of improved head restraint systems, seat backs and other related occupant safety features, treatment has become more complex and the overall cost of treating these same injuries has increased.

At the same time, the average age of the claimant continues to increase in both BI and PIP claims. Continued increases in this metric over the longer-term point to higher medical costs per patient as the treatment of older patients, all things considered equal, can become more complex and thus more costly relative to their younger counterparts. With advanced age, individuals may appear during crash triage with inter-current health conditions, more use of medications, and physical or psycho-social vulnerabilities in the setting of acute trauma, thereby complicating their initial clinical evaluation and management (E&M) and requiring more initial medical, surgical or diagnostic procedures. Additionally, many of the top BI and PIP/Medpay treatment procedures have ranges to be considered when being billed. These ranges include the level of service selected or the number of units that are employed. The percentage of claims that include these types of medical services has grown; in fact, the Insurance Research Council recently published research that showed medical utilization rates exceeding national norms were a primary contributor to high claim costs in eight of the 12 least affordable auto insurance systems.[142] Other factors included: High injury claim frequency rates, excessive attorney involvement, and high rates of claim abuse.

As more people move to high-deductible insurance plans or plans with co-insurance provisions that mean higher out-of-pocket expenses, the temptation to find a way to have that covered elsewhere grows.[143] And the growing number of people who work within the Gig economy means fewer covered under group health insurance plans.

CY 2017 efforts by the Republican-controlled U.S. government to repeal the ACA failed, but they succeeded in making several changes to weaken the bill: a repeal of the individual mandate penalty was included in the 2017 tax law; the ACA's advertising budget was reduced by 90 percent; the open-enrollment period cut from three months to six weeks; and funds for personal enrollment assistance were reduced by 41 percent.[144] A 2018 report released by The Commonwealth Fund revealed a 3 percent drop between CY 2017 and CY 2018 of people enrolled in the ACA exchange plans, and the uninsured rate among working-age people (ages 19 to 64) jumped to 15.5 percent from 12.7 percent in CY 2016.[145] As a result, there are higher numbers of uninsured Americans, which will add to the pressure to reduce healthcare expense, particularly by Medicaid.[146] Subsequently, with less money available in the system, the P/C insurance industry might become an even bigger target of cost-shifting in the future.

Finally, growth of ADAS-equipped vehicles within the registered vehicle population is expected to reduce auto injury frequency and severity based on analysis from IIHS/HLDI and others. Comparison of the same vehicles equipped with ADAS or not equipped with ADAS reviewed above, suggest the Delta-V, or severity of a crash, may be less for ADAS equipped vehicles involved in a crash. The Delta-V (or speed loss or gained in a crash) as well as the speed of the vehicle prior to the crash and the direction the impact came from, are important in determining the mechanics and severity of the injury. Other variables such as the age of the driver, as well as driver's understanding of ADAS true capabilities (i.e. mode confusion, role confusion, and misplaced trust) may mean ADAS could have very different benefits/outcomes depending on the demographics of the driver. So, despite all of the potential benefits to BI and PIP frequency and severity expected from ADAS, people are still involved, so it becomes ever more critical to focus on the experience that is distinct to each individual, and also understand the implications of those differences to your business.

ABOUT THE AUTHOR

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There are many vehicles in the auto market today with safety technologies that can reduce the risk of collisions. The consumer benefits can be huge, but they rely on driver engagement.

Protecting Consumers

Dr. Mary Capelli-Schellpfeffer

Autos are advancing, and so are we! How do we figure out the best fit between available protection technologies and our driving needs? When it comes to safety, that could be a "life or death" question. Each day, in the US more than 100 people die in collisions, and thousands are injured.

Safety innovations are increasingly available in the market: Sensors signal drivers on collision risk, lane departure, and pedestrian presence. Advanced braking systems engage when a vehicle crash hazard is detected ahead. Computerized cameras "see" and message posted speed limits. These complex technologies deliver safety enhancements for drivers and occupants.

Early data on collision avoidance systems performance shows some crashes are being eliminated, but not all. Part of the explanation for this trend is that collision protection is typically optimized around a vehicle's activity over time. We naturally expect, for example, when a vehicle is not moving, or at "no speed", that braking assistance or lane departure warnings are not needed. In fact, these systems will not activate at "zero miles per hour".

However, backing out of a parking space slowly, or progressing smoothly after an intersection stop, a vehicle tends to be in "slow motion". By design, in these situations of low velocity, automation to avoid collisions is highly effective. Recent studies by IIHS and others have documented this benefit to vehicle owners.[1] Given this information, for drivers who commonly navigate at lower speed limits and cross frequent intersections, the value of collision avoidance safety features is significant and includes reduced collision risk and possible savings on vehicle insurance premiums.

As a vehicle leaves an intersection and travels further, intuitively we might infer that the vehicle's safety systems will show more responsiveness. Isn't this what occurs when we put our foot on the accelerator? The vehicle goes faster. However, thinking about safety systems behaving like vehicle acceleration doesn't fit the situation of how collision avoidance technology acts for consumers. Above speeds of 30 miles per hour, the effectiveness of this automation to minimize collision risk starts dropping. And certain protections don't work very well at all above 40 miles per hour.

After leaving a neighborhood intersection and on-ramping to an interstate highway, if I am commuting at the posted speed 70 miles per hour, I need to know that my vehicle's collision avoidance technologies, including automatic emergency braking, may not be able to react to a near crash scenario.

The same is true for all drivers: travel on roadways with infrequent stops and higher posted speed limits should inform expectations around collision avoidance technologies.

The limits of vehicle speed over time, or velocity, is just one aspect of "fit" between available collision avoidance features and a driver's needs. A consumer who intentionally purchases a vehicle that is fully-loaded with collision avoidance "bells and whistles", but turns these off because the messages, sound alerts or warnings are annoying, is not benefitted at all. Even worse, the purchase may create a false sense of protection when none are operational. To be even minimally protective, these systems must remain "turned on."

Finally, the best available science and engineering deployed in truly exceptional vehicles can't change the choices individuals might make to drive impaired or distracted. Impairment due to fatigue, prescriptions, alcohol or marijuana is not reduced by technology. To the contrary, impairment impacts technology effectiveness by reducing driver situational awareness and reaction ability. Tired, drugged, intoxicated or overly relaxed muscles do not act quickly under emergency conditions. Distraction—whether it be through cell phone use, texting, watching movies, reading a printed newspaper, applying makeup, eating or arguing with another person on the trip—has the potential to disengage the driver's brain from the critical decisions that may be needed to avoid a crash.

There are many vehicles in the auto market today with safety technologies that can reduce the risk of collisions. The consumer benefits can be huge, but they rely on driver engagement. When collisions are prevented, lives are protected, and injuries minimized.

1. HTTPS://WWW.IIHS.ORG/IIHS/TOPICS/T/AUTOMATION-AND-CRASH-AVOIDANCE/TOPICOVERVIEW.

Fixing the Car

The process for filing an auto claim and getting the vehicle fixed has been fairly consistent over the last several decades. The customer gets in an accident and — depending on the severity — may contact his/her insurance company right away or may first get a shop estimate to determine where the damage lies in comparison to the consumer's deductible and then call the insurer. Assuming the vehicle is driveable, the customer would choose his/her desired method of inspection, get the insurer's estimate of damage, and then select the repairer to fix his/her car to schedule the repair. However, the onslaught of connected vehicle technology and other technology being incorporated into today's vehicles is changing the traditional notion of "I call my insurer after an accident".

Already today, vehicle telematics and other crash-detection analytics can automatically identify when an accident occurs, sharing the accident information directly with the OE and/or insurer, triggering vehicle routing and preferred method of inspection. In the future more data from the vehicle itself, such as damage area, triggered diagnostic trouble codes, change in the velocity/speed of the vehicle from the crash (Delta-V), and other information, could be collected and sent to the OE and/or insurer to identify potential repair amount, and which type of repairer is best suited based on the vehicle itself. As the immense amount of technology added to vehicles moves downstream to mainstream vehicles, the industry may see a greater need for specialization in repair, where access to information from the vehicle itself informs much of the repair process.

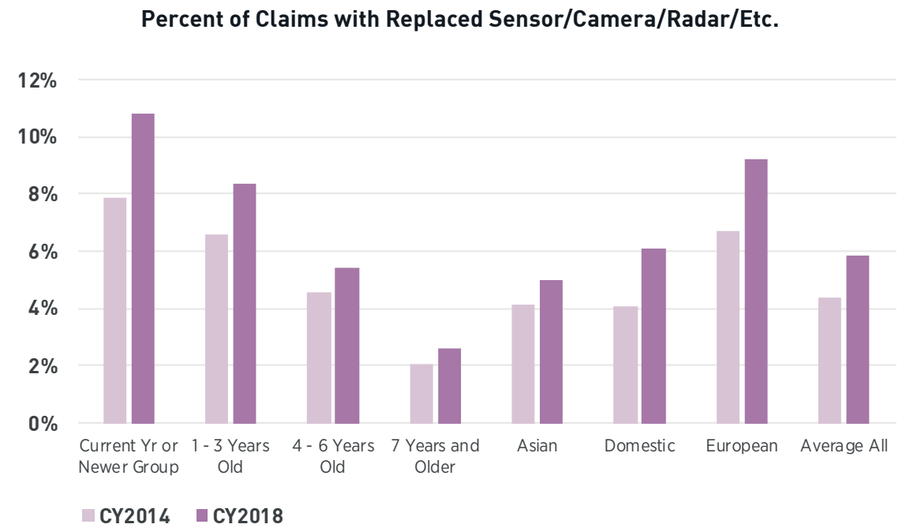
The industry has acknowledged the critical nature of understanding the individual features of each individual vehicle and the OE recommended repair procedures. Driving this is the growing complexity in both electronic content and material composition and the wide variation in both among automakers and among individual vehicles. These developments have resulted in the need for major investment by repairers in tooling, training, and data to ensure they are equipped to properly return the vehicle to pre-accident condition. Let's look at some specific examples at how increased vehicle complexity is driving repairer challenges.

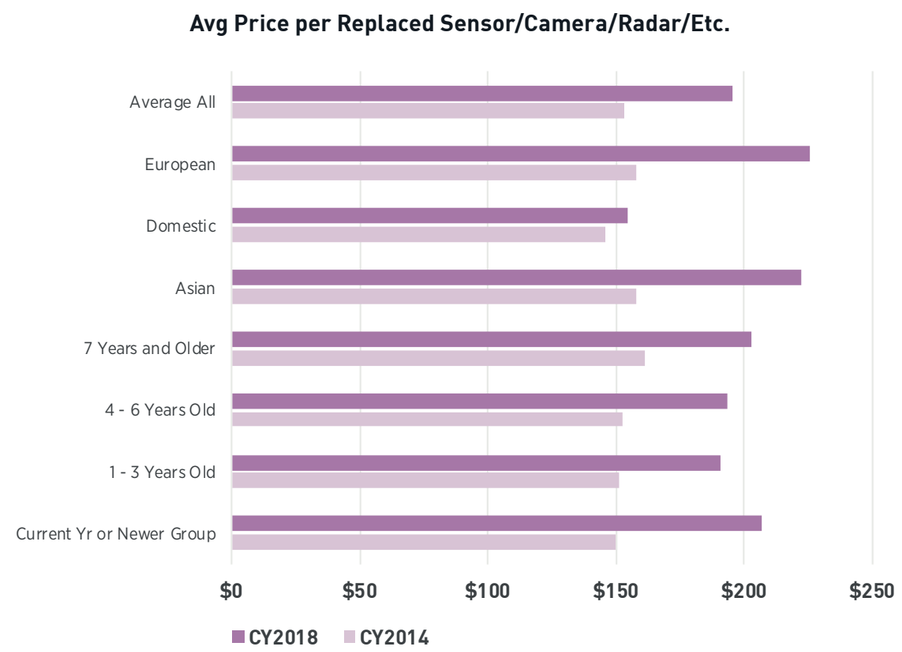
Electronics Further Transform the Vehicle

Consider the new technologies introduced into the vehicle fleet with ADAS. FCW, AEB, and other features such as adaptive cruise control, parking assist, highway driving assist, and traffic jam assist require vehicles be equipped with numerous cameras, sensors, radar and lidar. Radar sensors, often placed at the front and rear of the vehicle, use microwaves to detect and measure distances from other vehicles and obstacles, with long-range radar monitoring traffic in front, and short-range radar monitoring the vehicle's immediate surroundings.[147] Ultrasound sensors are used for systems such as parking assist, to measure distances from objects at close range.[148] Cameras enable the vehicle to identify lane markings, traffic signs, traffic lights, and other road users, and infrared cameras provide night-vision capability to detect humans and animals.[149] Finally, lidar measures distances from objects and relative speeds, using ultraviolet or infrared radiation or visible light.[150] Analysis of repairable vehicle appraisal data from CY 2014 and CY 2018 shows the growth in rate of replacement for these electronic components such as sensors, cameras, radars. In CY 2014 just over 4 percent of all appraisals included the replacement of one of these parts; by CY 2018 this grew to nearly 6 percent (see **Figure 76** and **Figure 77**), and the average cost per component replaced grew from $153 to $195.

Camera/Sensor/Radar/Etc. Replacements Repairable Appraisals (FIGURES 76-77)

CY2014 VS CY2018 | SOURCE: CCC INFORMATION SERVICES INC.





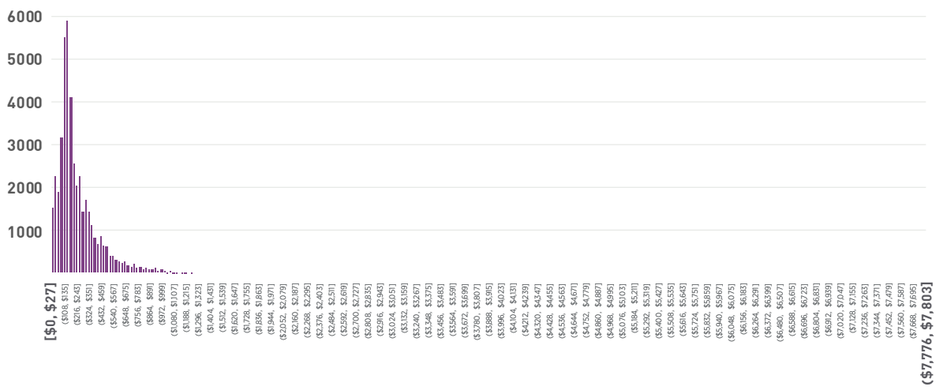
All of these components must be aligned properly to work as designed, and even a minor fender bender can result in the need to re-position, reprogram and/or re-calibrate these systems. As vehicles become embedded with more computers and electronic control modules, error codes no longer light up the dash. A scan tool must be used to get a full read-out of the electronics and whether or not they are operating properly. If they are not, a diagnostic trouble code will be triggered, and the repairer must then repair/replace the broken part, clear the code, and perform a calibration to confirm the part is aligned properly after the repair. Even the remove and replacement of a camera, sensor, radar or lidar may require re-calibration, depending on the OE and how its system is designed. Unfortunately, calibration requirements can vary dramatically by automaker or even by individual vehicle and ADAS technology, reinforcing the importance of understanding the OE repair procedures. In fact, the Automotive Services Association and the Alliance of Automotive Manufacturers (Alliance) held a press conference in the summer of 2018 alerting the industry to their intent to highlight OE repair procedures in a number of states during the 2019 legislative season.[151]

The cost for a repairer to invest in the people with the right skill sets need to perform pre- and post-repair scan and calibration, as well as the tools needed to perform them can be very expensive, and the return on investment will vary based on the number of each vehicle nameplate it repairs. Some repairers will opt to invest and build out a 'hybrid collision-mechanical role to handle calibration in-house,[152] others will sublet to a dealership.

Analysis of repairable vehicle appraisal data uploaded between November 2017 and October 2018 showed slightly less than 1 percent of all vehicles included an entry in the appraisal for a calibration (any estimate line containing the text string of 'calibrate') with an average fee of $167, standard deviation of $250, a maximum fee of over $7000 – a wide range of fees for sure (see **Figure 78**). Not surprisingly, calibration was included on nearly 2 percent of the current model year vehicles, where the average fee was slightly higher at $207. European current model-year vehicles included calibration fees most often and with the highest average fee; lowest average fee was for Asian vehicles aged seven-years plus (see **Figure 79**).

Calibration Fee Distribution - Repairable Appraisals (FIGURE 78)

NOV'17-DEC'18 | SOURCE: CCC INFORMATION SERVICES INC.



Percent of CCC National Industry Repairable Appraisals with Calibration Entry (FIGURE 79)

NOV'17-DEC'18 | SOURCE: CCC INFORMATION SERVICES INC.

Vehicle Age Group	% Claims with Calibration Fee	Avg Fee per Calibration	Calibration Fees % Repair Cost
Current Yr & Newer	1.9%	$207	0.13%
1-3 Yrs	1.0%	$173	0.06%
4-6 Yrs	0.5%	$141	0.03%
7 Yrs Plus	0.2%	$113	0.01%
All Vehicle Age Groups	**0.7%**	**$167**	**0.0%**

Vehicle Source / Vehicle Age Group	% Claims with Calibration Fee	Avg Fee per Calibration	Calibration Fees % Repair Cost
Asian Current Yr	2.3%	$201	0.16%
Asian 1-3 Yrs	1.2%	$168	0.08%
Asian 4-6 Yrs	0.6%	$121	0.03%
Asian 7 Yrs Plus	0.3%	$93	0.01%
Asian - All Age Groups	**0.8%**	**$158**	**0.06%**
Domestic Current Yr	0.8%	$145	0.03%
Domestic 1-3 Yrs	0.5%	$132	0.02%
Domestic 4-6 Yrs	0.3%	$131	0.01%
Domestic 7 Yrs Plus	0.1%	$115	0.01%
Domestic - All Age Groups	**0.3%**	**$132**	**0.02%**
European Current Yr	3.6%	$258	0.25%
European 1-3 Yrs	2.2%	$226	0.15%
European 4-6 Yrs	1.1%	$199	0.08%
European 7 Yrs Plus	0.4%	$167	0.03%
European - All Age Groups	**1.4%**	**$222**	**0.11%**

Example Appraisals with Average Fee for Calibration per Vehicle Source/Age Group

(FIGURE 80) | SOURCE: CCC INFORMATION SERVICES INC.

Vehicle Source / Vehicle Age Group	Loss Category & Vehicle Primary Impact	Calibration Line Detail	Fee per Calibration	Avg Total Cost of Repair
Asian 1-3 Yrs	Liability - Right T-Bone	Sublet - Calibrate and Aim Mirror Camera +25%	$169	$2,533
Domestic Current Yr	Collision - Lt Qtr Post	Subl Recalibrate ADAS	$146	$12,580
European Current Yr	Liability - Lt Qtr Post	Align/Recalibrate Blind Spot Monitoring	$250	$13,464

Example Appraisals with Most Costly Calibration Fee per Vehicle Source/Age Group

(FIGURE 81) | SOURCE: CCC INFORMATION SERVICES INC.

Vehicle Source / Vehicle Age Group	Loss Category & Vehicle Primary Impact	Calibration Line Detail	Fee per Calibration	Avg Total Cost of Repair
Asian 7 Yrs Plus	Collision - Front	Replace/Recalibration Distance sensor	$3,107	$6,383
Domestic Current Yr	Collision - Rt Front	Subl Dealer Calibration per Invoice	$2,745	$49,160
European 4-6 Yrs	Collision Front	Subl Sensor Replacement and Recalibration	$4,422	$7,831

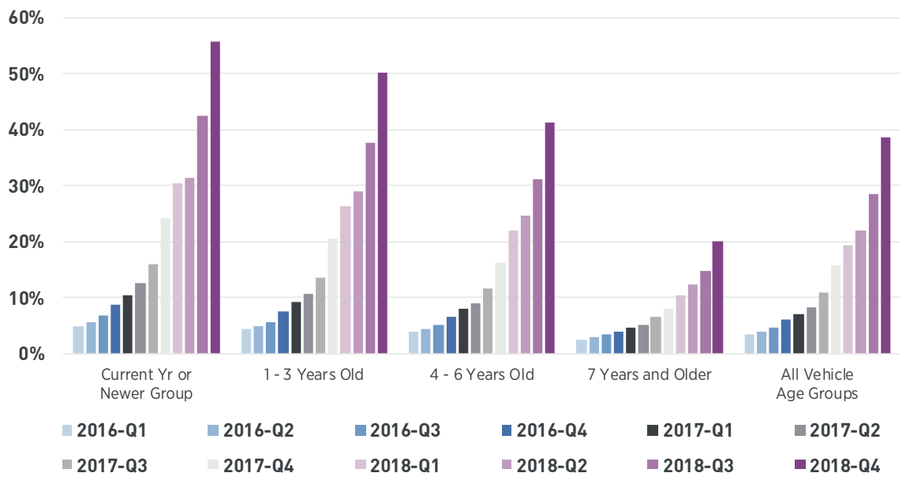
Detail analysis shows a wide variation in the fees and the types of calibration being performed. **Figure 80** and **Figure 81** provide examples by vehicle source and age group of appraisals where the calibration fee was close to the average overall fee charged for that group of vehicles and the maximum fee charged over the twelve-month period analyzed. Among the examples where the maximum fee was found, the calibration fee charged accounted for 6 percent to 57 percent of the overall repair cost, while among those with the average fee, the calibration fee ranged between 1 percent and 10 percent of the overall repair costs.

The majority of the entries are manual entries, so the specific parts requiring calibration are not always identified clearly or at all but, not surprisingly, the majority identify a specific ADAS feature such as blind-spot monitoring sensor, distance sensor, camera, parking sensor, lane departure, adaptive cruise control, as well as mechanical parts such as occupant sensors, steering angle sensors and tire pressure monitoring sensors, and finally parts such as headlamps.

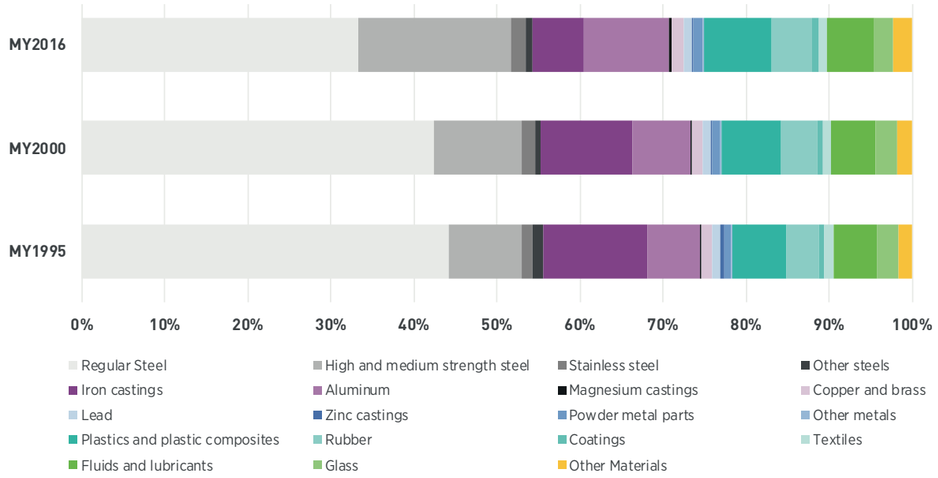
Pre- and post-repair scans on appraisals have grown dramatically over the last several years, particularly on the newest vehicles where scans are a critical part of the repair to ensure all damage is identified and the vehicle has been brought back to pre-accident condition. Nearly 40 percent of all Q4-2018 appraisals (see **Figure 82**) included an entry with average fee of $70 (including flat fee and/or labor time). The average fee has fallen steadily as the percent of claims including scan fees has grown – from a peak of $150 in CY 2016 to $85 in Q1-2018 to $70 in Q4-2018. Note that the absence of estimate line detail including scan fees does not mean a scan was not completed, just not recorded in the appraisal.

Percent of Repairable Appraisals by Vehicle Age Group with Manual Appraisal Line for "Scan/Health/asTech/Diagnose"

(FIGURE 82) | SOURCE: CCC INFORMATION SERVICES INC.



Average Material Consumption for a Light Vehicle (FIGURE 83) | MY1995, MY2000, AND MY2016 | SOURCE: "TABLE 4.17 (UPDATED AUGUST 2018) AVERAGE MATERIAL CONSUMPTION FOR A DOMESTIC LIGHT VEHICLE, MODEL YRS 1995, 2000, AND 2016." P. 4-19. TRANSPORTATION ENERGY DATA BOOK: EDITION 36.2—2018. HTTPS://CTA.ORNL.GOV/DATA/TEDBFILES/EDITION36_CHAPTER04.PDF.



CCC National Industry Top Parts Most Commonly Manufactured of Lightweight Material - Share by Material Type (FIGURE 84) | CY2018 | SOURCE: CCC INFORMATION SERVICES INC.

		Fender	Hood	Front or Rear Impact Bar	Front or Rear Door Shell	Front or Rear Outer Panel	Quarter Panel	Front or Rear Bumper Reinforcement	Rear Body Panel	Radiator Support	Lift Gate
% Total Part Cnt (Including Repaired & Replaced Parts)	ALU	33.0%	32.0%	33.3%	13.9%	4.1%	12.3%	22.8%	4.5%	13.0%	59.0%
	BOR			10.3%				3.8%	0.8%		
	CFC		0.0%								
	HSS	67.0%	18.0%	24.1%	83.7%	94.4%	87.5%	13.0%	94.7%	48.6%	40.5%
	MAG			>0%						38.4%	0.6%
	UHS		50.0%	5.0%	2.4%	1.5%	0.2%	60.3%			
Avg Replaced Part Amt	ALU	$421	$696	$266	$919	$344	$1,509	$270	$455	$196	$913
	BOR			$207				$359	$412		
	CFC		$2,844								
	HSS	$216	$404	$228	$661	$330	$836	$204	$389	$619	$726
	MAG			$535						$334	$1,010
	UHS		$591	$226	$369	$349	$815	$181			
Repaired % Repaired / Replaced Part Cnt	ALU	51.0%	45.0%	1.9%	56.4%	89.3%	83.9%	2.4%	64.1%	5.9%	63.1%
	BOR			5.6%				5.2%	76.0%		
	CFC		58.6%								
	HSS	49.5%	44.6%	5.3%	45.5%	84.2%	88.8%	4.6%	58.1%	27.2%	48.3%
	MAG			0.0%						12.0%	75.9%
	UHS		44.8%	5.0%	40.4%	88.4%	96.4%	3.2%			

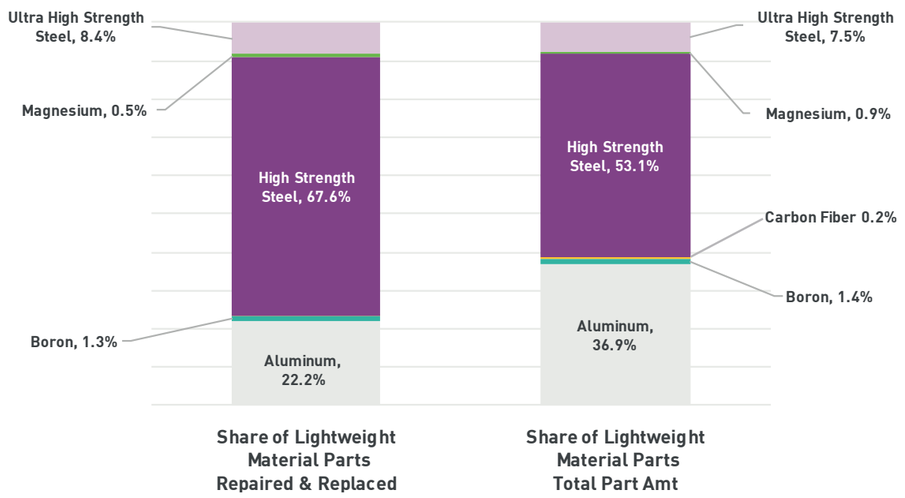
Material Complexity Requires Careful Repair Planning

The importance of blue-printing a repair before it begins has become increasingly important as vehicle construction methods and materials have undergone dramatic changes. Historically, much of the vehicle was comprised of mild steel. Estimates from the Center for Automotive Research, Ducker Worldwide and other analysts suggest automakers are using numerous other materials – with mild steel share dropping from 44 percent per MY 1995 light vehicle to 33 percent by MY 2016 (see **Figure 83**).[153] High- and medium-strength steel and aluminum have seen significant growth, accounting for nearly 30 percent of materials used for MY 2016 light vehicles.[154]

Analysis of CCC national industry repairable vehicle appraisals for vehicles MY 2000+ for a recent rolling 12-month period shows a growing number of major part components are identified as a lightweight material such as aluminum, boron, carbon fiber, high strength steel, magnesium, or ultra-high strength steel. Among the most common are major panels such as hoods, fenders, quarter panels, as well as structural components such as rails, hinge pillars, mount brackets and supports. A comparison of 10 of the most commonly repaired or replaced parts where at least one OE manufactures the part component with a lightweight material reveals high-strength steel and aluminum are the most commonly used, and where aluminum is used, replacement part cost is typically higher (see **Figure 84**). In fact, among all lightweight material parts, the most common in terms of frequency and share of spend was high strength steel (see **Figure 85**). Numerous automakers are beginning to incorporate more of materials like carbon fiber, but they are often being used in lower volume vehicles, so the impact to repairers has not been felt to the same degree.

Material Type Share of Lightweight Material Part Count and Part Amount (FIGURE 85)

CY2018 | SOURCE: CCC INFORMATION SERVICES INC.



Among the major part groups, components within the Frame group have the highest share comprised of one of these materials, followed by the Hood group, and Rear Body & Floor part group (see **Figure 86**). Part components within the Front Bumper part group account for 18.7 percent of all part components repaired or replaced in CY 2018, but only 2.2 percent of them were identified as comprised of aluminum, boron, carbon fiber, high strength steel, magnesium, or ultra-high strength steel.

As automakers move to electrify the vehicle fleet, more lighter-weight materials will be used in combination, resulting in numerous types of welds and adhesives used, often in a single vehicle. For example, the Chevy Bolt's upper and lower rails are assembled using laser welds, resistance spot welds, MIG fillet welds, silicon bronze welds and an adhesive.[155] The growing number of materials being used in vehicle construction and the numerous ways they are being combined, makes repair operations like welding more challenging, as a proper weld involves the correct type of welder, at the correct settings, with the correct wire, and the correct gas mixture. More and more OE's are recommending destructive test welds be performed — an operation considered a non-included operation within the estimating systems — but their importance is key, as a failure to adjust the welder to the correct settings can result in an insufficient weld or weakened metal.[156] Less than 1 percent of all CCC national industry repairable appraisals included a manual entry for a test weld in CY 2018, with an average flat fee of $35 or between 0.5 and 1.0 labor hours. Note this does not mean repairers are not completing the test welds, but they are not including a fee for them on the appraisal. According to Collision Advice and CRASH Networks' "Who Pays for What: 2018 Frame and Mechanical", 64 percent of repairer survey respondents never asked to be paid for test welds, compared to 81 percent from the CY 2015 survey.[157]

With all of these changes occurring to the vehicle itself, it is not surprising to see the industry experiencing some of the largest increases in the cost of both vehicle total loss and vehicle repair costs in many years. Let's start with vehicle repair costs and the downstream impacts to repair cycle time and customer satisfaction.

CCC National Industry Part Group Share of All Parts on Appraisals and Percent That Are Lightweight Material (FIGURE 86) | CY2018 | SOURCE: CCC INFORMATION SERVICES INC.

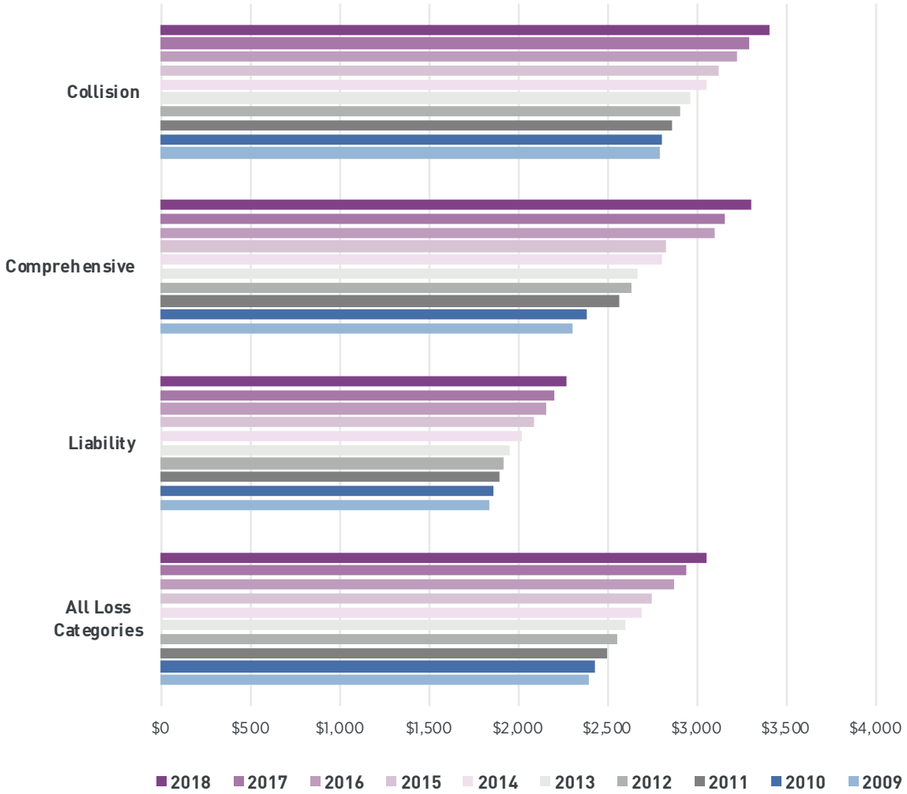
Part Group	Part Group Share of Overall Part Count (Repaired + Replaced)	% of Part Group Part Count of Lightweight Material
FRONT BUMPER	18.7%	2.2%
REAR BUMPER	11.6%	2.9%
FENDER	9.7%	12.7%
FRONT DOOR	7.2%	10.1%
QUARTER PANEL	4.9%	2.7%
FRONT LAMPS	4.8%	0.0%
REAR DOOR	4.7%	11.8%
RADIATOR SUPPORT	3.8%	5.1%
HOOD	3.7%	17.5%
AIR CONDITIONER & HEATER	2.7%	0.0%
PICK UP BOX	2.6%	2.5%
LIFT GATE	2.6%	2.1%
REAR BODY & FLOOR	2.2%	16.2%
GRILLE	2.1%	0.0%
PILLARS, ROCKER & FLOOR	1.9%	12.1%
WHEELS	1.9%	0.6%
TRUNK LID	1.8%	1.6%
REAR LAMPS	1.7%	0.0%
FRONT SUSPENSION	1.5%	0.4%
RESTRAINT SYSTEMS	1.2%	0.0%
WINDSHIELD	1.2%	0.0%
ELECTRICAL	0.9%	0.0%
CAB	0.6%	8.2%
ROOF	0.6%	4.2%
REAR SUSPENSION	0.6%	0.0%
EXHAUST SYSTEM	0.6%	0.0%
ENGINE / TRANSAXLE	0.5%	0.0%
FRAME	0.3%	21.1%
BACK GLASS	0.3%	0.0%
SIDE PANEL	0.3%	1.3%
SIDE LOADING DOOR	0.2%	13.9%
SEATS & TRACKS	0.2%	0.0%
COWL	0.1%	1.4%
TAIL GATE	0.1%	14.6%
ALL OTHERS	2.1%	0.2%

Rising Vehicle Repair Costs

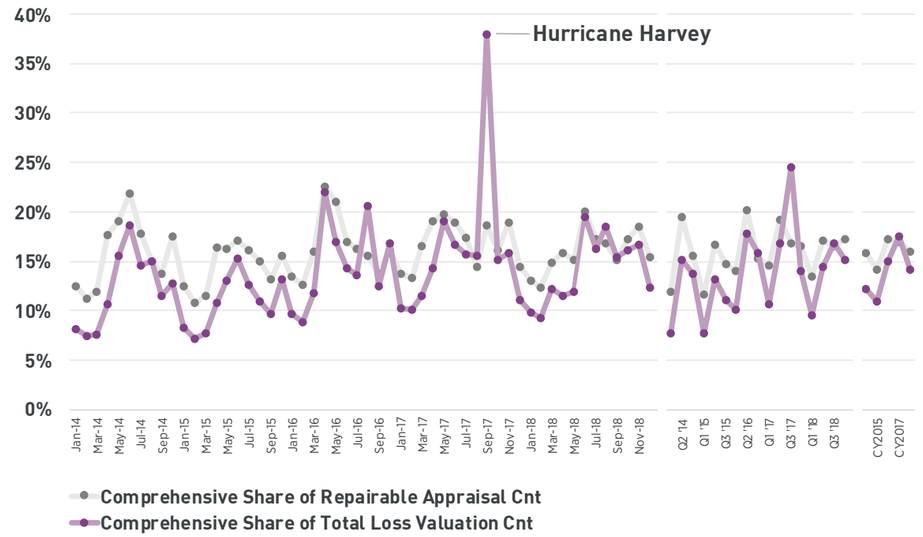
In CY 2018, the average repairable vehicle appraisal amount rose by 4 percent to $3,053, a big jump from the 2.5 percent increase experienced in CY 2017. Repairable comprehensive losses rose by 4.8 percent, while collision and liability losses rose 3.5 percent (see **Figure 87**). Comprehensive total loss vehicles jumped sharply in September 2017 with Hurricane Harvey. Few losses from Harvey were repaired and subsequently were not included in the repair cost numbers (see **Figure 88**). In CY 2018 hail losses — most which are repairable — accounted for a larger share of comprehensive losses, helping to drive up the overall comprehensive repair cost, particularly for newer model year vehicles (see **Figures 89-91**). While ADAS may be helping to temper the increases in average repair costs for the newest model year collision and liability losses, the systems do little to help in a hail storm, especially when a garage is considered the primary ADAS for hail.

Average Total Cost of Repairs by Loss Category, CCC National Industry Repairable Appraisal Statistics (FIGURE 87)

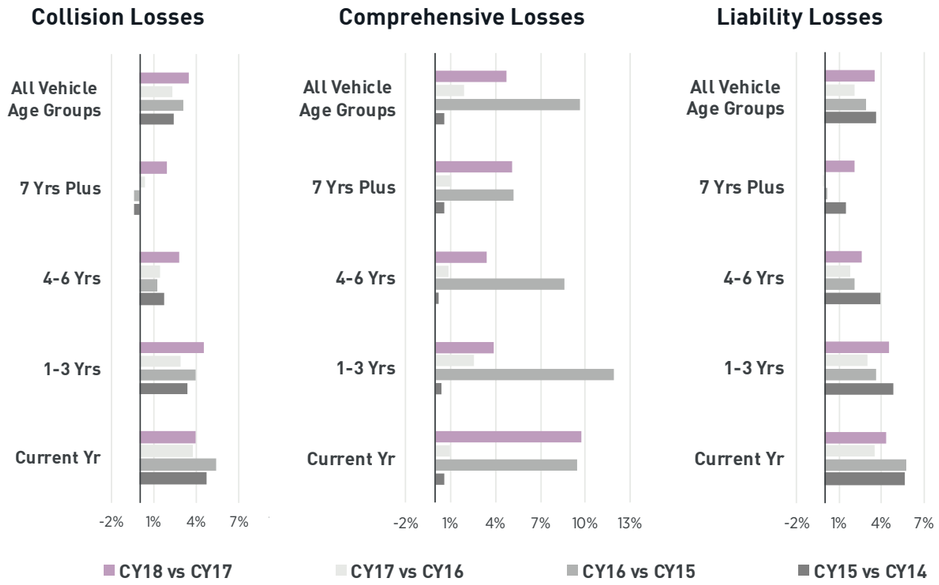
SOURCE: CCC INFORMATION SERVICES INC.



Comprehensive Losses Share of Repairable Appraisal Cnt and Total Loss Valuation Cnt by Month, Quarter, Year (FIGURE 88) | CY2014-CY2018 | SOURCE: CCC INFORMATION SERVICES INC.



Percent Change in Average Repairable Appraisal Amount vs Prior Year by Loss Category and Vehicle Age Group (FIGURES 89-91) | SOURCE: CCC INFORMATION SERVICES INC.



Vehicle complexity has grown with more electronics, safety features and complexity of materials, as the growth in average number of part replacements per claim and parts share of the overall repair cost have grown (see **Figure 92**). Individual cost-per-replacement part has grown on average at least 1 percent annually over the last several years (see **Figure 93**), while OEM share of replacement part cost has continued to decline (see **Figure 94**).

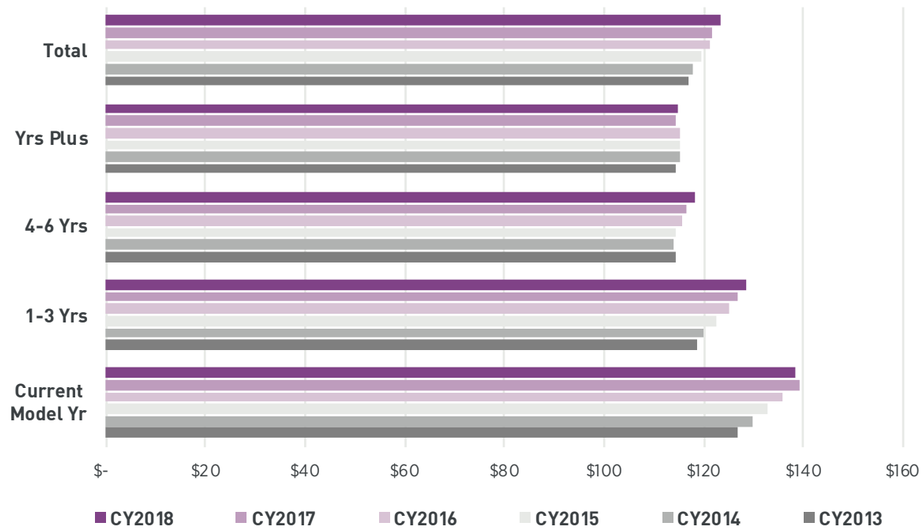
Collision and Liability Repairable Appraisals by Vehicle Age Group (FIGURE 92)

SOURCE: CCC INFORMATION SERVICES INC.

		COLLISION LOSSES			LIABILITY LOSSES		
	Vehicle Age Group	Share of Overall Vol by Age Group	Parts % Total Repair Cost	Avg # Parts Repl per Claim	Share of Overall Vol by Age Group	Parts % Total Repair Cost	Avg # Parts Repl per Claim
CY2001	Current Yr	9.4%	42.3%	10.9	7.8%	39.1%	6.4
	1-3 Yrs	39.0%	41.9%	10.4	31.5%	38.3%	6.3
	4-6 Yrs	27.8%	40.5%	9.3	25.1%	36.7%	5.8
	7 Yrs Plus	23.7%	37.3%	7.0	35.5%	34.1%	4.5
	All Age Groups	100%	40.7%	9.3	100%	36.6%	5.6
CY2009	Current Yr	5.3%	43.0%	11.9	4.3%	37.7%	6.5
	1-3 Yrs	36.3%	42.4%	11.2	28.9%	37.5%	6.3
	4-6 Yrs	29.4%	40.7%	9.9	25.9%	36.1%	5.8
	7 Yrs Plus	29.1%	37.1%	7.3	40.8%	32.1%	4.4
	All Age Groups	100%	40.7%	9.7	100%	35.2%	5.4
CY2018	Current Yr	6.5%	46.9%	15.2	5.3%	41.9%	9.1
	1-3 Yrs	36.3%	45.1%	13.9	29.5%	39.5%	8.4
	4-6 Yrs	25.7%	41.7%	12.0	23.0%	36.2%	7.3
	7 Yrs Plus	31.5%	37.3%	8.7	42.2%	32.1%	5.2
	All Age Groups	100%	42.5%	11.9	100%	36.3%	6.8

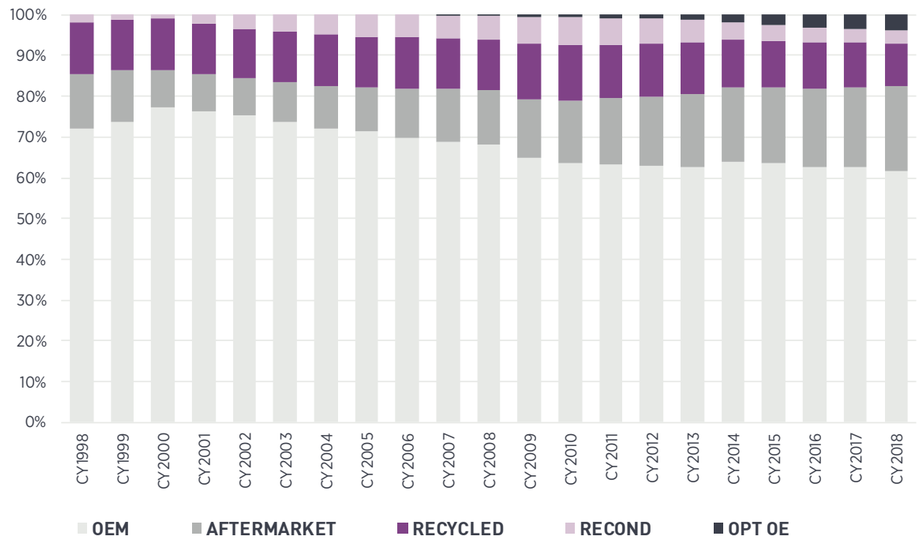
Average Cost per Replaced Part by Vehicle Age Group (FIGURE 93)

CY2013-CY2018 | SOURCE: CCC INFORMATION SERVICES INC.



Percent of Total Part Replacement Dollars by Part Type (FIGURE 94)

CY1998-CY2018 | SOURCE: CCC INFORMATION SERVICES INC.



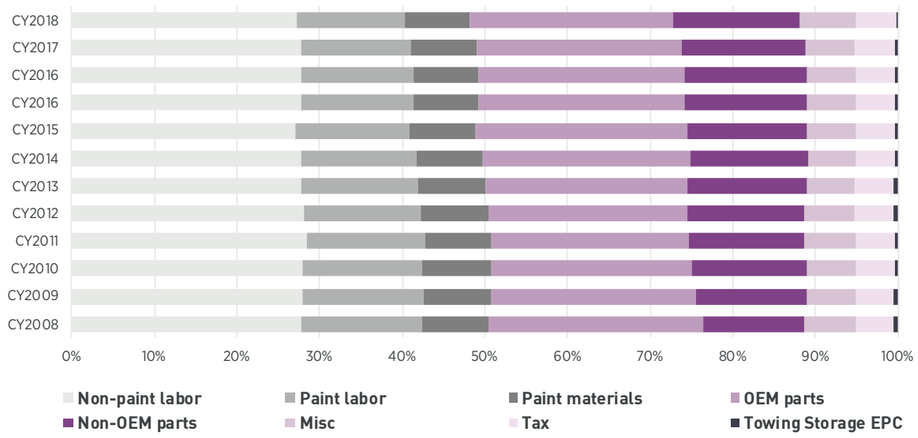
Combined, OEM and non-OEM replacement parts now account for 40 percent of the overall repair cost, up from 38 percent in CY 2008 (see **Figure 95**), while Miscellaneous expenses (includes manual entries for scan fees, calibration fees, and other sublet fees) have grown from 5.7 percent of the overall spend in CY 2013 to 6.7 percent in CY 2018. And don't forget the impact of tariffs. As noted at the start of this update, the additional 25 percent tariff on auto parts made in China such as catalytic converters, compressors, bearings, and speed sensors, and the current 10 percent tariff on other parts such as vehicle sensors; brake pads, drums, rotors and hoses; automotive tires; bearings; mufflers; drive axles; suspension parts; gaskets; safety glass; and accessories such as floor mats, wipers and mirrors that may increase to 25 percent the early part of 2019,[158] and it's estimated this is already adding approximately $21 additional per claim, or a 0.7 percent increase in the overall average repair cost.

Average labor rates per labor category also experienced some of their largest increases in CY 2018 (see **Figure 96**) as many shops struggle to find and keep qualified technicians. TechForce Foundation's "Transportation Technician Supply Report" found post-secondary supply of new-entrant technicians has not kept up with spike in demand based on analysis of National Center for Education Statistics' data from CY 2011 to CY 2016.[159] And, despite the Bureau of Labor Statistics projection that there was demand for over 17,000 new collision techs, there were less than 6,000 postsecondary completions in CY 2016.[160] According to CollisionWeek's quarterly survey of repairer business conditions, the median number of unfilled positions per facility was two technicians as of Q3 2018.[161]

With each vehicle repair requiring more part replacements, at a higher cost, with more labor hours at a higher rate, it's easy to understand why repair costs are increasing. Combine that with a continuation of the shift of the vehicle fleet to newer, more expensive light trucks (see **Figure 97**), and the industry will likely continue to see repair costs rise over the next several years until such time as ADAS-equipped vehicles account for a much larger share of the overall registered vehicle population in the U.S., and some of the anticipated reductions in both frequency and repair cost will have a broader impact.

Repair Dollars Distribution by Category (FIGURE 95)

CY2008-CY2018 | SOURCE: CCC INFORMATION SERVICES INC.



Average Labor Rates per Labor Category (FIGURE 96) | CY2014-CY2018 | SOURCE: CCC INFORMATION SERVICES INC.

	AVERAGE HOURLY RATE (WEIGHTED AVERAGE)					% CHANGE FROM PRIOR YEAR				
	Body (Sheet Metal) Labor	Frame Labor	Mechanical Labor	Paint Labor	Paint Materials	Body (Sheet Metal) Labor	Frame Labor	Mechanical Labor	Paint Labor	Paint Materials
CY2014	$46.67	$53.32	$78.23	$46.61	$27.12	1.2%	1.7%	1.5%	1.3%	1.8%
CY2015	$47.27	$54.15	$80.47	$47.21	$27.78	1.3%	1.6%	2.9%	1.3%	2.5%
CY2016	$47.82	$55.20	$82.07	$47.79	$28.31	1.2%	1.9%	2.0%	1.2%	1.9%
CY2017	$48.87	$56.54	$84.98	$48.68	$29.07	2.2%	2.4%	3.6%	1.9%	2.7%
CY2018	$50.27	$58.25	$87.17	$49.87	$29.93	2.9%	3.0%	2.6%	2.4%	3.0%

CCC National Industry Repairable Vehicle Damage Appraisals - Vehicle Mix Statistics by Calendar Year (FIGURE 97) | SOURCE: CCC INFORMATION SERVICES INC.

	CY2009	CY2010	CY2011	CY2012	CY2013	CY2014	CY2015	CY2016	CY2017	CY2018
Avg Repair Cost	$2,399	$2,425	$2,497	$2,551	$2,597	$2,689	$2,752	$2,870	$2,941	$3,053
% Chg from Prior Calendar Yr	-1.7%	1.1%	2.9%	2.2%	1.8%	3.5%	2.3%	4.3%	2.5%	3.8%
Non-Driveable %	22.4%	22.6%	21.9%	21.8%	21.1%	20.6%	20.6%	20.3%	20.5%	20.8%
% of Claims with Suppl(s)	47.7%	47.1%	46.9%	47.2%	46.1%	46.5%	48.0%	49.2%	51.4%	51.2%
Suppl % of Total Repair Cost	10.4%	10.4%	10.7%	11.2%	12.1%	12.6%	13.3%	14.4%	16.1%	16.5%
Avg Vehicle Age	5.45	5.79	5.99	6.11	6.19	6.10	6.00	5.90	5.90	5.90
Avg CCC Regional Value Amt	$12,444	$12,851	$13,133	$14,280	$14,996	$15,022	$15,324	$15,275	$15,790	$16,071
Avg Odometer	76,696	80,412	82,634	83,875	82,712	83,696	82,206	80,098	79,677	79,507
Avg Mileage per Vehicle Yr	14,077	13,899	13,792	13,726	13,372	13,615	13,620	13,576	13,505	13,476
Parts % Total Repair Cost	38.2%	38.2%	37.7%	38.2%	38.9%	39.3%	40.1%	39.8%	39.7%	39.9%
Avg # Parts Repl per Claim	7.8	7.9	8.0	8.3	8.7	9.0	9.3	9.4	9.6	9.9
OEM % of Total Part Amt	64.8%	63.4%	63.3%	63.1%	62.8%	64.0%	63.7%	62.9%	62.6%	61.7%
Labor % Total Repair Cost	42.8%	42.6%	42.8%	42.3%	41.9%	41.7%	40.9%	41.2%	41.0%	40.4%
Avg Labor Hrs per Claim	22.5	22.3	22.3	22.4	22.5	22.7	22.8	23.1	23.2	23.3
Avg Hourly Body Rate	$43.86	$44.61	$45.01	$45.50	$46.13	$46.67	$47.27	$47.82	$48.87	$50.27
% Chg from Prior Calendar Yr	1.8%	1.7%	0.9%	1.1%	1.4%	1.2%	1.3%	1.2%	2.2%	2.9%
Repair % Total Labor Amt	40.9%	40.8%	42.2%	41.8%	41.3%	41.3%	40.7%	42.2%	41.8%	40.7%
Total Loss % Vol	15.3%	15.0%	14.7%	15.1%	14.0%	14.1%	15.4%	16.7%	17.9%	18.4%
Collision Losses % Vol	53.1%	52.8%	51.8%	52.2%	53.5%	53.9%	54.5%	53.3%	53.3%	53.9%
Comprehensive Losses % Vol	16.5%	16.2%	18.4%	17.5%	15.9%	15.9%	14.8%	16.5%	16.8%	16.0%
Liability Losses % Vol	30.5%	31.0%	29.8%	30.3%	30.6%	30.2%	30.7%	30.2%	29.9%	30.1%
Vehicles 7 Years & Older % Vol	33.7%	36.5%	38.8%	40.7%	42.2%	42.8%	41.8%	38.3%	36.5%	35.5%
Light Truck % Vol	42.3%	42.6%	42.6%	42.9%	43.1%	43.4%	44.2%	45.9%	48.1%	50.1%
Asian Vehicles % Vol	42.6%	43.8%	45.0%	46.3%	47.5%	48.3%	49.0%	49.6%	50.1%	50.5%
Domestic Vehicles % Vol	49.2%	47.7%	46.2%	44.5%	43.1%	42.2%	41.4%	40.8%	40.5%	40.1%
European Vehicles % Vol	8.3%	8.5%	8.8%	9.2%	9.4%	9.5%	9.6%	9.5%	9.5%	9.5%
Luxury % Vol	15.3%	15.7%	15.7%	15.9%	15.8%	15.6%	15.5%	15.5%	15.5%	15.5%

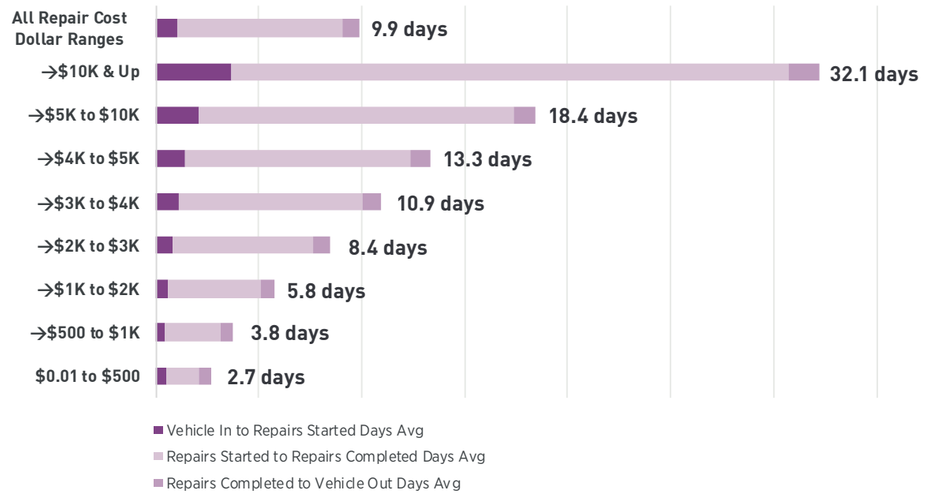
Percent of Repaired Vehicle Count by Driveable Flag and Repair Cost Dollar Ranges

(FIGURE 98) | Q4'15 TO Q3'16 VERSUS Q4'17 TO Q3'18 | SOURCE: CCC INFORMATION SERVICES INC.

	DRIVEABLE			NON-DRIVEABLE			TOTAL		
	Q4'15 to Q3'16	Q4'17 to Q3'18	Change	Q4'15 to Q3'16	Q4'17 to Q3'18	Change	Q4'15 to Q3'16	Q4'17 to Q3'18	Change
$0.01 to $500	2.4%	1.9%	-0.6%	0.8%	0.8%	0.0%	2.1%	1.7%	-0.5%
→$500 to $1K	16.4%	13.3%	-3.1%	2.0%	2.0%	0.0%	13.7%	11.2%	-2.5%
→$1K to $2K	33.3%	32.0%	-1.3%	8.7%	8.4%	-0.2%	28.7%	27.7%	-1.0%
→$2K to $3K	21.1%	22.2%	1.1%	13.5%	13.2%	-0.4%	19.7%	20.6%	0.9%
→$3K to $4K	11.8%	13.0%	1.2%	14.6%	14.3%	-0.3%	12.3%	13.2%	0.9%
→$4K to $5K	6.5%	7.5%	0.9%	13.6%	13.3%	-0.3%	7.9%	8.5%	0.7%
→$5K to $10K	7.7%	9.3%	1.6%	36.3%	36.6%	0.3%	13.1%	14.3%	1.2%
→$10K & Up	0.6%	0.8%	0.2%	10.5%	11.4%	0.9%	2.5%	2.8%	0.3%

Average DRP Vehicle Repair Cycle Time by Repair Cost Dollar Ranges (FIGURE 99)

Q4'17-Q3'18 | SOURCE: CCC INFORMATION SERVICES INC.



Higher Repair Costs Translate to Longer Repair Cycle Times and Lower CSI

Analysis of DRP-repaired vehicle data from the last several years reveals repairers are seeing repair order amounts creep higher also, with largest increase among those with repair amount between $5,000and $10,000 (see **Figure 98),** where the vehicle-in to vehicle-out days average was over 18 days for the period Q4'17-Q3'18 (see **Figure 99**). Repairers continue to do a better job getting the vehicle in for repairs (vehicle-in to repairs-started fell from 1.2 days to 1.1 days) and are holding steady on the time for vehicle check-out (repairs-completed to vehicle-out was 0.8 days for all three years), but overall days from repair-started to repair-completed continues to climb (see **Figure 100**). Driveable repair times have been growing faster than non-driveable, suggesting even vehicles not heavily damaged are becoming more complex to repair.

DRP Repair Cycle Time by Driveable Flag and Period (FIGURE 100)

SOURCE: CCC INFORMATION SERVICES INC.

		Q4'15-Q3'16	Q4'16-Q3'17	Q4'17-Q3'18
Vehicle In to Repairs Started Days Avg	Driveable	0.8	0.7	0.7
	Non-Driveable	3.1	3.0	2.6
	Total	**1.2**	**1.2**	**1.1**
Repairs Started to Repairs Completed Days Avg	Driveable	6.3	6.5	6.7
	Non-Driveable	13.8	13.7	13.8
	Total	**7.8**	**7.9**	**8.0**
Repairs Completed to Vehicle Out Days Avg	Driveable	0.8	0.8	0.8
	Non-Driveable	1.1	1.2	1.1
	Total	**0.8**	**0.8**	**0.8**
Vehicle In to Vehicle Out Days Avg	Driveable	7.9	8.0	8.2
	Non-Driveable	18.0	17.9	17.5
	Total	**9.8**	**9.9**	**9.9**

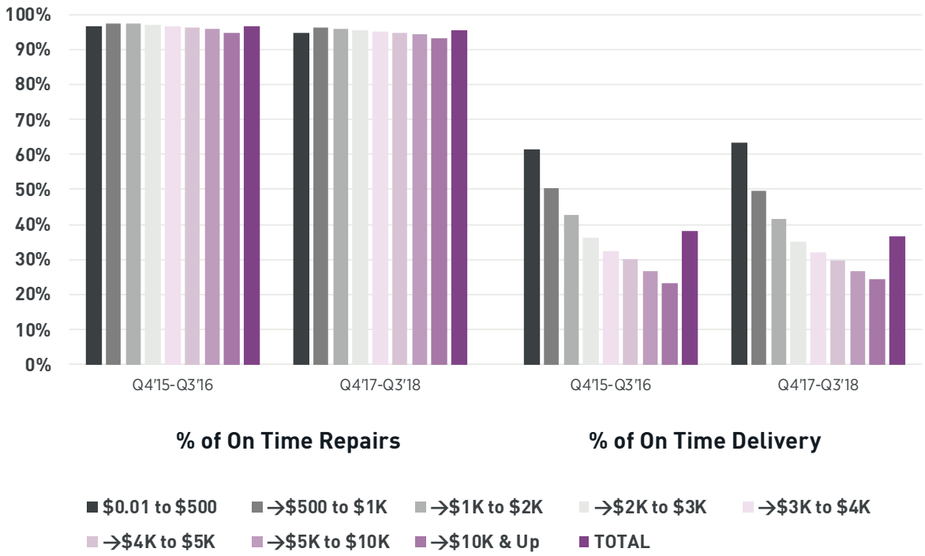
Not surprisingly, a comparison of repairers' ability to meet the targeted repair completion date and to meet the original promise date provided to the consumer has become more difficult and subsequently fallen as the repair costs rise (see **Figure 101**).

Repairer productivity, measured as labor hours per day from repair-start to complete and labor hours per day from vehicle-in to vehicle-out, is highest for repairs in the $1,000 to $4,000 ranges where the majority of the repair volume falls. It is lower where the volume is growing in the higher ranges (see **Figure 102**). This points longer term to continued growth in repair cycle time, as vehicle complexity continues to grow.

Customer satisfaction with a repair also falls as the repair cost rises, as does a customer's corresponding satisfaction with the insurer's handling of the claim and his/her willingness to recommend that shop or insurer (see **Figure 103**). As repair costs rise, consumers may need more frequent updates to feel informed, and potentially increase the average service score. The need to return a vehicle also grows as repair costs rise, with over 25 percent of vehicles with repair cost of $10,000 or more returned at least once to the repairer after initial delivery of the repaired vehicle. With fewer diagnostic trouble codes displaying directly in the dash lights, and growth in the number of electronic components within today's vehicle, repairers may find fewer returns if post-repair scans are completed, and all OE procedures re: calibration of electronics are followed properly.

Percent of Repairs Completed On Time and Percent of Repairs Delivered On Time (Met Promise Date) by Repair Cost Dollars Ranges (FIGURE 101)

Q4'15-Q3'16 VERSUS Q4'17-Q3'18 | SOURCE: CCC INFORMATION SERVICES INC.



DRP Repairs Q4'17-Q3'18 Repair Productivity by Repair Cost Dollar Ranges (FIGURE 102)

SOURCE: CCC INFORMATION SERVICES INC.

DRP Repair Customer Satisfaction Rating by Repair Cost Dollar Ranges (FIGURE 103)

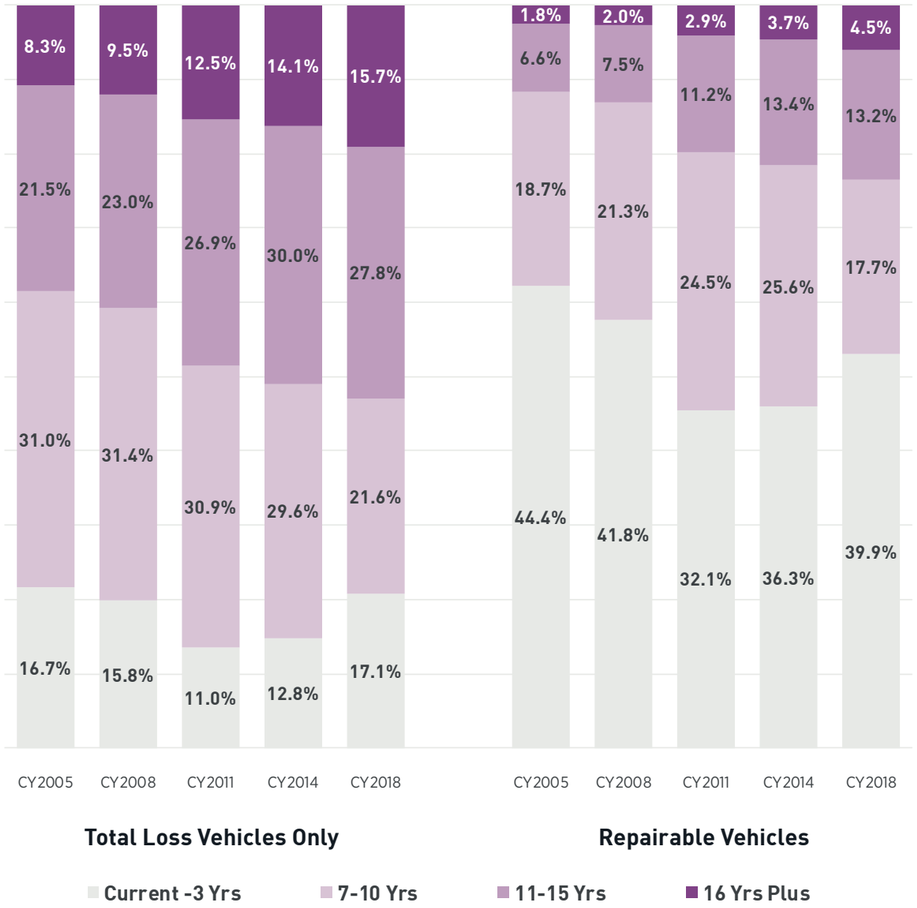
Q4'17-Q3'18 | SOURCE: CCC INFORMATION SERVICES INC.

Repair Cost Range	Repair Satisfaction %	Avg Recommend Shop Score	Avg Recommend Insurer Score	Avg Insurer Handle Claim Score	Kept Informed %	Survey % of On Time Delivery	Survey % of Vehicles Returned	Avg Quality Score	Avg Service Score	Avg Cleanliness Score
$0.01 to $500	97.3%	9.5	8.9	9.3	94.8%	94.5%	5.0%	9.7	9.6	9.2
→$500 to $1K	96.3%	9.6	9.0	9.4	95.4%	93.4%	5.5%	9.7	9.7	9.8
→$1K to $2K	95.6%	9.6	9.1	9.4	95.2%	90.7%	7.6%	9.7	9.7	9.8
→$2K to $3K	95.1%	9.5	9.2	9.4	95.0%	88.3%	9.7%	9.6	9.6	9.7
→$3K to $4K	94.1%	9.5	9.2	9.4	94.5%	86.3%	12.1%	9.6	9.6	9.8
→$4K to $5K	93.9%	9.4	9.2	9.4	94.3%	84.6%	14.5%	9.5	9.5	9.8
→$5K to $10K	92.3%	9.3	9.2	9.3	93.4%	81.3%	17.7%	9.5	9.5	9.7
→$10K & Up	89.1%	9.0	9.0	9.1	91.3%	70.9%	26.6%	9.2	9.2	9.7
All Ranges	94.6%	9.5	9.2	9.4	94.6%	87.5%	10.9%	9.6	9.6	9.8

More Vehicles Deemed Not Repairable

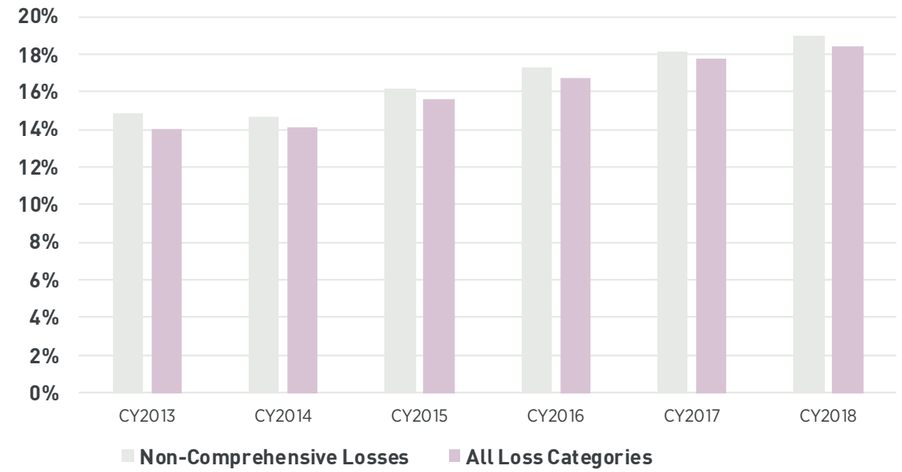
As the industry continues to see growth in the oldest vehicle segments (see **Figure 104**), total loss frequency has increased approximately 1 percent per year over the last several years (see **Figure 105**). Scrappage rates have remained low, and people are holding on to vehicles that are lasting longer than ever before. Rising repair costs that are accelerating as fast or faster than vehicle values also means total loss frequency is up across all vehicle ages (see **Figure 106**).

Total Loss and Repairable Claims - Collision and Liability Losses - Share of Volume per Vehicle Age Group (FIGURE 104) | SOURCE: CCC INFORMATION SERVICES INC.



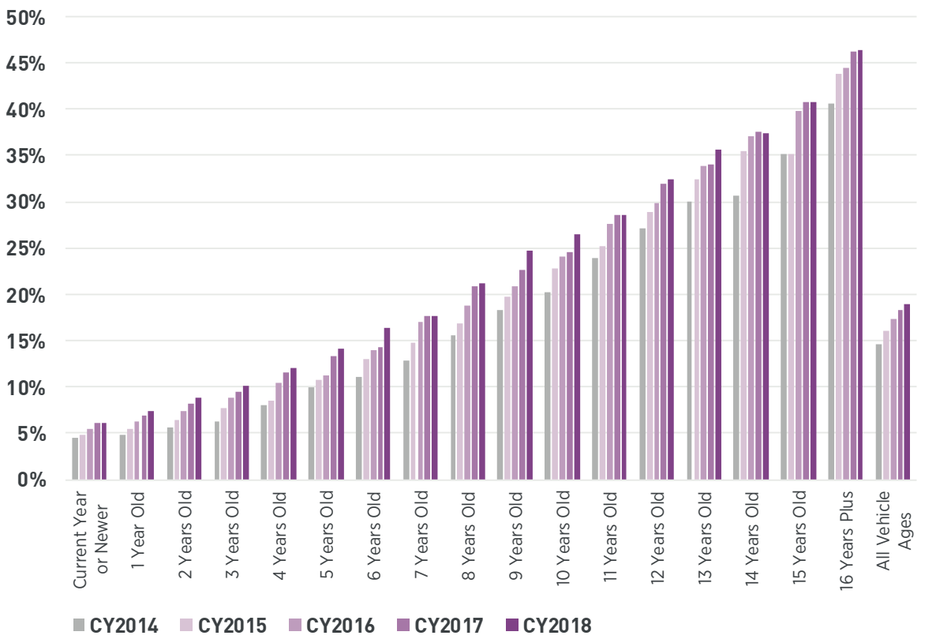
Percent of Vehicle Appraisals Flagged Total Loss (FIGURE 105)

CY2014-CY2018 | SOURCE: CCC INFORMATION SERVICES INC.



Percent of Non-Comprehensive Repairable Appraisals Flagged Total Loss by Vehicle Age

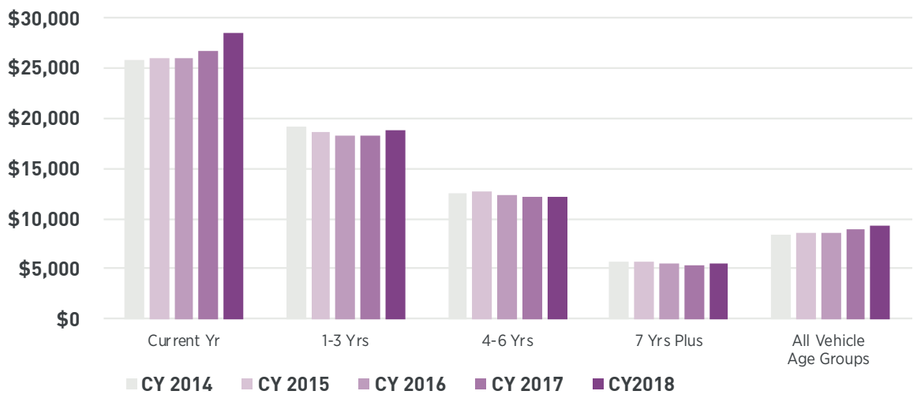
(FIGURE 106) | SOURCE: CCC INFORMATION SERVICES INC.



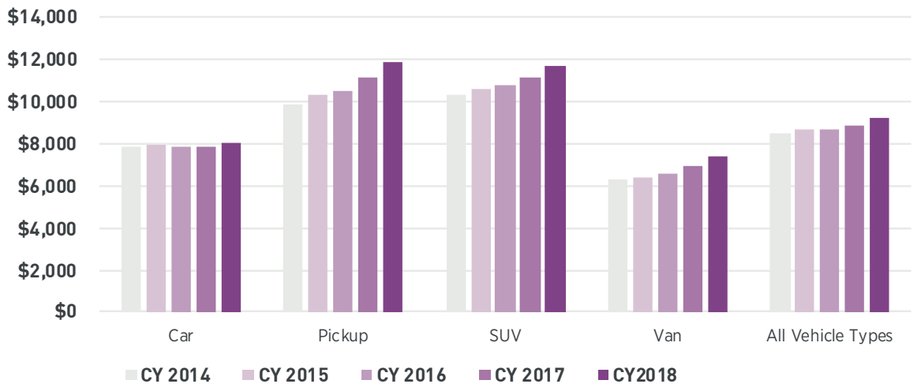
Used-vehicle demand and used-vehicle prices have been lifted by higher new vehicle MSRP's, higher interest rates and, most recently, by the tariffs implemented and proposed by the Trump administration. New vehicles are increasingly unaffordable for the average American, whose median income has risen, but has not risen fast enough to keep up with the cost of a new vehicle. Analysis of total loss costs underscores the nearer term impact of higher used vehicle demand, both in terms of dealer supply and the prices they are paying at auction, but also in terms of the market values of used vehicles. In CY 2018 the average non-comprehensive total loss vehicle adjusted vehicle value was up 4.4 percent, with current model-year vehicles up 6.6 percent and those aged 7-years plus up 3.4 percent (see **Figure 107**). By vehicle type, vans and pickups continue to lead in terms of the year-over-year increase in average value (see **Figure 108**), with cars experiencing the lowest rate of increase.

Total Loss Valuations Adjusted Total Loss Vehicle Value by Vehicle Age Group (FIGURE 107)

CY2014-CY2018 | SOURCE: CCC INFORMATION SERVICES INC.



Non-Comprehensive Total Loss Valuations Adjusted Total Loss Vehicle Value by Vehicle Age Group (FIGURE 108) | CY2013-CY2018 | SOURCE: CCC INFORMATION SERVICES INC.



There continues to be a shift to a newer mix with fewer domestic vehicles (see **Figure 109**). And, with light trucks now accounting for 69 percent of all new vehicle purchases, it is not surprising that light trucks comprise a growing share of total losses as well, growing from 36 percent in CY 2014, to nearly 39 percent in CY 2018. Given the current market conditions, the proposals in the update to NAFTA, and the remaining uncertainty about tariffs with other countries, demand for an alternative to higher cost new vehicles likely will keep used-vehicle demand (and subsequently prices) elevated over the next several months. With more total-loss vehicles shifting younger and to light trucks, and continued elevation in used vehicle prices, the insurance industry can expect total loss-costs to remain elevated through 2019.

Total Loss Valuations - Vehicle Mix Statistics by Calendar Year (FIGURE 109)

SOURCE: CCC INFORMATION SERVICES INC.

VEHICLE MIX STATISTICS	CY 2014	CY 2015	CY 2016	CY 2017	CY 2017 (LESS HARVEY)	CY2018
Final Valuation Amt Avg	$8,722	$8,867	$8,943	$9,272	$9,125	$9,498
% Chg from prior year	2.1%	1.7%	0.9%	3.7%	2.0%	4.1%
Avg Vehicle Age	10.02	10.01	9.87	9.64	9.73	9.66
Avg Odometer	119,309	119,079	116,839	113,965	114,768	114,196
Avg Mileage per Vehicle Year	11,902	11,894	11,834	11,817	11,800	11,822
Light Trucks % Vol	36.4%	36.3%	36.6%	37.7%	37.5%	38.7%
SUV's % Vol	19.4%	19.9%	20.7%	22.2%	22.0%	23.3%
Car Final Val Amt Avg	$8,083	$8,129	$8,042	$8,143	$8,041	$8,228
% Chg from prior year	1.3%	0.6%	-1.1%	1.3%	0.0%	2.3%
Truck Final Val Amt Avg	$9,839	$10,164	$10,506	$11,133	$10,925	$11,508
% Chg from prior year	3.1%	3.3%	3.4%	6.0%	4.0%	5.3%
Collision %	62.2%	62.9%	61.0%	59.9%	61.3%	62.8%
Comprehensive %	25.8%	25.9%	24.5%	16.7%	14.8%	14.1%
Liability %	12.0%	11.2%	14.5%	23.4%	23.9%	23.0%
Collision Adj Vehicle Value Avg	$9,662	$9,817	$9,806	$10,000	$10,000	$10,397
Comprehensive Adj Vehicle Value Avg	$8,744	$8,833	$9,080	$10,116	$9,357	$9,575
Liability Adj Vehicle Value Avg	$5,766	$5,874	$5,906	$6,067	$6,067	$6,315
Asian Vehicles % Vol	43.8%	45.4%	47.2%	48.4%	48.5%	49.5%
Domestic Vehicles % Vol	47.9%	46.2%	44.1%	42.7%	42.6%	41.6%
European Vehicles % Vol	8.3%	8.4%	8.7%	8.9%	8.9%	8.9%
Asian Veh Final Val Amt Avg	$9,047	$9,028	$8,941	$9,051	$8,943	$9,202
% Chg from prior year	0.6%	-0.2%	-1.0%	1.2%	0.0%	2.9%
Domestic Veh Final Val Amt Avg	$7,788	$8,038	$8,270	$8,769	$8,608	$9,116
% Chg from prior year	3.0%	3.2%	2.9%	6.0%	4.1%	5.9%
European Veh Final Val Amt Avg	$11,990	$12,175	$12,162	$12,944	$12,580	$12,872
% Chg from prior year	0.6%	1.5%	-0.1%	6.4%	3.4%	2.3%
Theft % Vol	1.6%	1.4%	1.4%	1.3%	1.4%	1.3%
Vehicles Current Yr & Newer %	2.3%	2.4%	2.5%	2.6%	2.5%	2.2%
Vehicles 1-3 Years %	10.2%	11.8%	13.2%	14.4%	14.1%	14.6%
Vehicles 4-6 Years %	13.3%	12.2%	14.0%	16.2%	16.0%	17.8%
Vehicles 7 Years & Older %	74.2%	73.6%	70.3%	66.8%	67.4%	65.4%
Luxury % Vol	13.6%	13.7%	14.1%	14.5%	14.5%	

There is much hope that advances in vehicle technology such as ADAS will, over time, lead to fewer accidents, and subsequently fewer people and vehicles to fix. In the near term however, vehicles are being sold with many more sensors, cameras, radar, lidar, etc. and complex material construction than ever before. The wide variation in technologies used among the OE's is leading to challenges for repairers, where the importance of understanding exactly what they are dealing with for each and every individual vehicle has become critical. These changes also mean the industry is making major investments in tooling, training, and data to ensure it is equipped to properly return vehicles to pre-accident condition. With greater complexity, the industry has seen the cost of repair rise, as vehicle design has resulted in more parts requiring replacement in a repair on average than ever before, with added labor time to boot. As long as these vehicles continue to crash, they will need to be repaired, and the cost to do so will likely only rise further as complexity continues to grow, and a greater share of vehicles on the road are these newer, more complex vehicles. With repair cycle times growing, other claim costs such as rental costs will also grow, driving up not only the repair itself, but the cost of the claim overall, leading to more vehicles where the economic decision to repair versus total a vehicle result in higher total loss frequency overall. With new vehicle affordability becoming harder for many, used vehicles remain in strong demand, keeping their prices elevated as well. The industry may see some flattening and eventual decline in accident frequency, but strong continued vehicle sales means the registered vehicle population is growing, so the overall number of claims and vehicles needing repair will also see moderate growth in the coming year. With repair and total loss costs expected to remain elevated through 2019, the industry's overall loss costs will remain a pressure point, at a time when investment in technology continues to be an imperative.

THE ROAD AHEAD

Technology is bringing change to nearly every part of our lives. Where we work, how we work, who we work with, who our customer is, what products and services we sell, and what tools we use to do our jobs. Platforms like Amazon have created expectations among consumers that they shouldn't have to send the same information to multiple parties across different methods – digital and mobile technology should make the process seamless and should be personalized based on who I am. For our industry this, personalization, convenience and level of service will apply who I am insured with, what vehicle make I drive, what the characteristics of my accident were, and whether or not I have any injuries.

Data and AI have entered enough aspects of their lives that consumers are less surprised when steps in a process are eliminated based on knowledge of the customer, the vehicle, the accident, and more. Companies that are unable to support their customers in this manner will lose them to companies that can.

The long-standing accepted norms of "I buy my car," "I drive my car", "I insure my car," "I contact my insurer in the case of an accident" and more are changing with the adoption of car-sharing, ride-hailing, vehicle autonomy, telematics, AI, 3D printing, etc. - as are industries that have traditionally supported it.

Automakers are changing and adapting to the changing world of personal mobility, and the building blocks to full vehicle autonomy are introducing more technology that is complex and expensive to repair, but does not yet fully deliver on all its promises in terms of accident prevention. A ripple-effect is being created downstream for insurers and repairers as the industry adapts to different insurance pricing models and data to support them, and the necessity to stay current on new technologies, tooling, and training. Operating costs are increasing, and the industry is looking to things like photo estimating and online scheduling as a way to reduce loss-adjustment expense but still delivery a good experience for the customer.

Repairers have begun to understand that completing a vehicle repair in a manner that follows recommended repair procedures can help head off any potential unplanned returns of the vehicle, and that as repair costs rise it is ever more essential to keep their customer well-informed throughout the process to ensure satisfaction with the repair experience.

Technology plays a key role in a company's ability to quickly assess and respond to consumer feedback and other information on market conditions. It also holds great potential for improving communication and collaboration with customers and business partners. Knowing how to use technology to cater the claims and vehicle repair experience to each distinct customer will lead to higher levels of customer satisfaction, retention and growth.

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