THE FUTURE OF AUTONOMY – FACT, FANTASY, OR A LITTLE OF BOTH?

THOUGHTS ON THE PATHWAY TO AUTONOMOUS TRUCKS

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INTRODUCTION

Over the last year, so much has happened in the world of automated and autonomous vehicles, it's mind-boggling. We've gone from conceptual ideas to real-world testing for both automated cars and trucks. Uber has been testing autonomous taxi cabs in Pittsburgh. Peloton continues to promote dual-truck platooning for fleet fuel efficiency. And Embark, Otto, and Alphabet are all working on and demonstrating autonomous truck concepts, while Nikola and Tesla look to electrified powertrains.

And it's not just on the technology development side – the National Highway Traffic Safety Administration (NHTSA) has released its Federal Automated Vehicles Policy, along with a Notice of Proposed Rulemaking (NPRM) for connected cars. An ever-growing list of states – from coast to coast – are proposing legislation to, or have already legalized the testing of automated and autonomous vehicles on their roads. And in July 2017, the U.S. House of Representatives passed legislation regarding autonomous vehicles – the SELF-DRIVE (Safely Ensuring Lives Future Deployment and Research in Vehicle Evolution) Act, which seeks "… to memorialize the Federal role in ensuring the safety of highly automated vehicles as it relates to design, construction, and performance, by encouraging the testing and deployment of such vehicles." The act seems more focused on light vehicle development than large trucks, but we'll see what happens when this moves through the Senate.

To help provide a little clarity on what's happening, along with the where and how, we've assembled a collection of blog posts published on our knowledge-dock.com website over the last year.

Like I said, mind-boggling!

So how do we ferret out the facts from the fiction and the reality from the hype? It's not easy. Bold claims and aggressive promises are being made almost weekly from various start-ups, as well as respected and long-tenured corporations, all trying to push the envelope and get their approach out first. Ford has claimed it will have a fully autonomous car by 2021, and Audi recently announced a Level 3 automated vehicle of its own. And, of course, the Google car continues to impress while Apple looks to join the fray.

Amid all the clamor, there have been issues around getting technologies to the market too soon, without providing consumers a clear-cut understanding of the capabilities and limitations of the technology. Regrettably, some of these consumers have paid the ultimate price for not understanding – or abusing – the limits of particular applications. And we've seen questionable practices, leading to lawsuits and ousters of several of the original pioneers in the field.

Too much hype mixed with too little understanding is a proven recipe for problems.

Bendix, as a leader in the development of commercial braking systems and advanced driver assistance systems (ADAS), is looking at these and other developments and considering their implications for the future of safety technologies on commercial vehicles.

While we believe we should embrace the excitement, we also believe the most prudent approach is to be realistic about the implications and the timing. As a technology provider, we realize that it's not just the technology that makes the difference. Autonomy encompasses a number of factors, including the appropriate use, understanding, and implementation of the technology, along with the wider impact of the ecosystem surrounding the application. All these aspects combine to determine whether the technology delivers the promise, performance, and return on investment expected – or ends up in the "what might have been" pages of history.

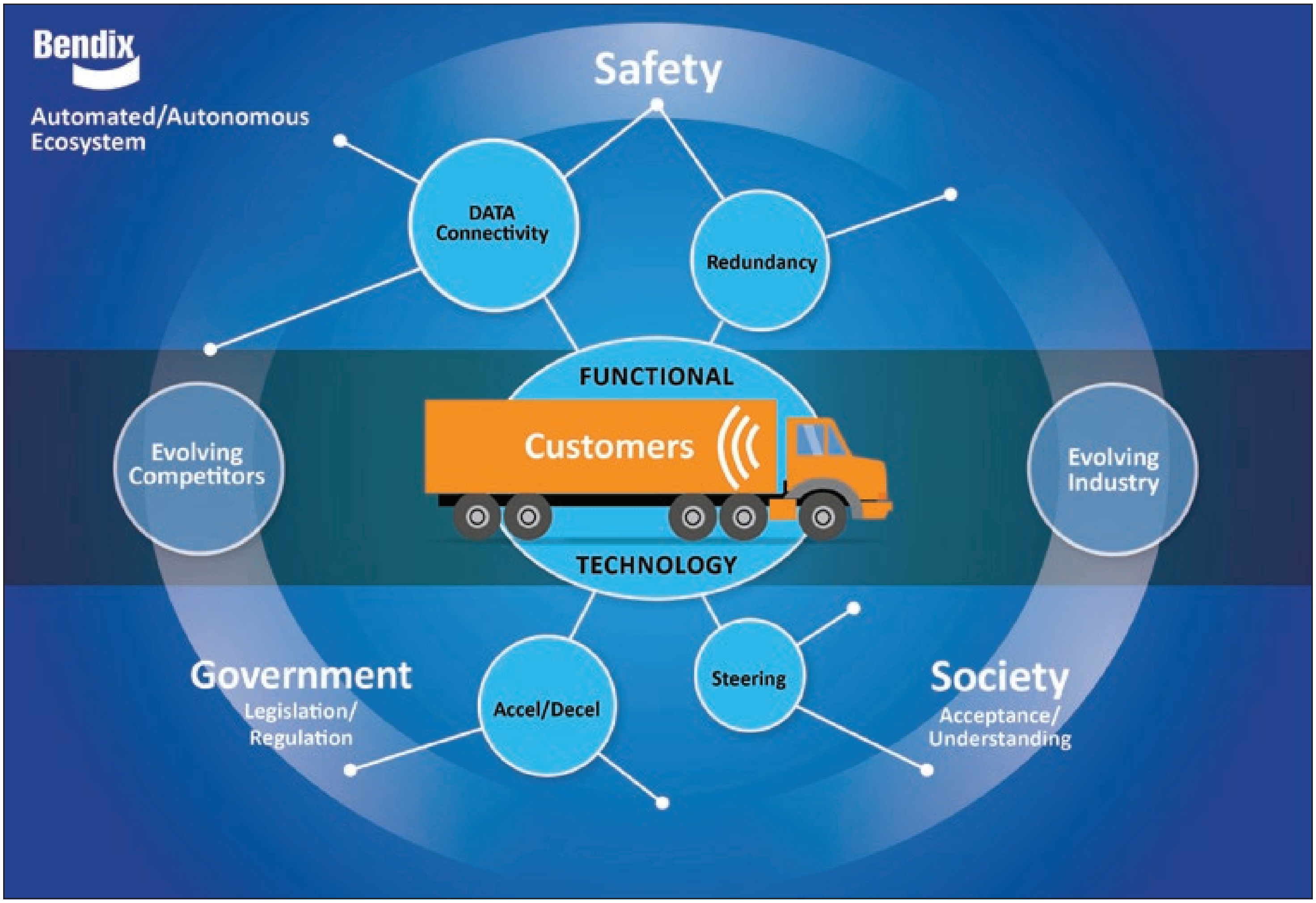
While the approach may differ organization to organization, after examining the technologies in development by our Original Equipment Manufacturer (OEM) partners and start-ups, as well as taking into account the technologies that comprise our own development portfolio, it's easy to see why this is truly an exciting time for the trucking industry. The things we have seen could mean tremendous advancements for safety, fuel economy, productivity, and the fleet's bottom line.

But this excitement needs to be combined with a dose of reality. Getting to truly automated and autonomous vehicles is not a revolution, but an evolution. It will involve building upon proven technologies and expanding the capabilities of those technologies with a strong understanding of their impact on all who use the roads and are involved in the transportation industry. From our perspective, continuing to grow and evolve advanced driver assistance systems is the logical pathway to the future. Change will come, but probably not as fast as the venture capitalists would like.

To help provide a little clarity on what's happening, along with the where and how, we've assembled a collection of blog posts published on our multimedia center, knowledge-dock.com, over the last year. These blogs provide insights to help you make the call on the pathway to the future. As is often the case, prognostications, like the weather, are always subject to change depending on events – both positive and negative – that can alter the best laid forecasts. We reserve the right, as should you, to keep an open mind and evolve our opinions as events unfold.

In the meantime, enjoy these thoughts from our "future of autonomy" blog post series.

We welcome your thoughts on "The Future of Autonomy – Fact, Fantasy, or a Little of Both."
Please share them at autonomous@bendix.com.



Why the future doesn't happen overnight: The Automated and Autonomous Ecosystem means that more than just technology has to be considered before autonomous vehicles become a reality on our roads.

Like what you're reading? Want to learn more?
We welcome your thoughts: autonomous@bendix.com

BY THE NUMBERS (PART 1) UPDATED WITH 2015 NUMBERS

July 6, 2017

Last year we reviewed some of the key data from the 2014 "Large Truck and Bus Crash Facts." In April, 2017, the Federal Motor Carrier Safety Administration (FMCSA) released the latest version of the "2015 Large Truck and Bus Crash Facts." Since FMCSA updated the numbers, we want to keep this blog up to date as well, so, without further ado, let's take a look at the new numbers and compare them with past stats.

Each year, FMCSA releases its "Large Truck and Bus Crash Facts," which summarizes data from a range of sources to provide statistics on a number of levels surrounding commercial vehicle accidents. The stats are sliced and diced in a variety of ways to offer information from the crash, vehicle, and people perspective, along with overall trends. Although always a two-year lag, if you want to know about trucks, combination vehicles and buses, plus what's behind the basic numbers, it's the perfect compendium. From my perspective, that's okay, as the past is often a prologue – especially around crash trends.

> The fatality crash rate (crash rate per 100 million vehicle miles traveled) for heavy trucks increased from 1.23 to 1.29 between 2014 and 2015 – an increase of about 5 percent.

FMCSA often hosts a webinar to review the top-level information; so in this blog post I'll dive a little deeper into some of the details you may not be aware of, but which I often use in discussions with fleets regarding what's happening on the roadways. Before we get into the details, let's start with a few definitions:

- First, a large truck has a gross vehicle weight rating (GVWR) greater than 10,000 lbs. – what we typically think of as Class 3-Class 8 vehicles. (While I could go into the definition of a bus, let's keep this post focused only on the large truck segment.) Now, before you get concerned that this is a pretty big spread, keep in mind that 78.5% of the trucks involved in crashes had a GVWR of 26,001 lbs. or more. That means a majority of the large trucks involved in heavy truck crashes were Class 7 and 8 vehicles. Roughly, the large trucks involved in crashes split 60/40 tractors to single unit trucks. (This estimation based on the numbers still holds for 2015 data.)
- Second, the data sources used for this information include:
  - ***Fatality Analysis Reporting System (FARS)*** – the National Highway Traffic Safety Administration (NHTSA) maintains this database as a "census of fatal crashes involving motor vehicles traveling on public trafficways."

- ***General Estimates System (GES)*** – Another NHTSA database, GES is "a probability-based nationally representative sample of police-reported fatal, injury, and property damage (PDO) crashes."
- ***The Motor Carrier Management Information System (MCMIS) Crash File*** – This comes from FMCSA and focuses on state-reported data involving fatality, injury, or tow-away crashes.
- ***Highway Statistics*** – Add another DOT administration into the mix – the Federal Highway Administration (FHWA). "State agencies report the data, ranging from driver licensing to highway financing, and FHWA aggregates them to get national totals." This is the source for vehicle miles traveled and vehicle registration information.

Now that we know how we get the numbers, let's delve into a few of the key numbers that might be impactful to your fleet. We'll start with a few top-level facts, just to get the basics down:

- **In 2015, fatality crashes involving heavy trucks went up compared to 2014 (3,598 fatality crashes in 2015 compared with 3,429 in 2014 – an increase of about 5%)**. You'll recall from our last blog that 2014 fatality crashes actually declined over 2013, so this is a change in the wrong direction! Of course, the total number of fatality crashes needs to be compared with the vehicle miles traveled – after all, we may see a bulk change in the numbers, but the crash rate may actually decrease based on a major increase in the miles traveled. (More miles traveled could mean a lower "rate" vs. actual number of crashes – which could be an improvement since the more trucks that are traveling, the more chance for a crash to occur.)

With this in mind, the news is still not good. The fatality crash rate (crash rate per 100 million vehicle miles traveled) for heavy trucks increased from 1.23 to 1.29 between 2014 and 2015 – also an increase of about 5%.

- **In 2014, total crashes involving heavy trucks rose significantly – from 326,541 in 2013 to 411,429 in 2014 – an increase of 26%**. I'm afraid the bad news continued in 2015, as crashes involving heavy trucks rose about 1%, to 414,598. (All right, not a huge increase, but regrettably, an increase just the same.)
- **The average large truck crashes per 100 million miles traveled also increased slightly**. In 2014, 147.4 fatality, injury, and property damage crashes involving large trucks occurred per 100 million miles traveled. In 2015, this rate was 148.2, an increase of about 0.5%. It is significant to note, however, that both the 2014 and 2015 rates were above the 2013 rate of 118.7 – by 24% and 25%, respectively.

- Since we touched on crash rates in the previous paragraphs, let's talk a little about how far trucks traveled. **In 2014, large trucks covered 279,132 million miles vs. 275,018 million miles in 2013**. The majority of these miles, about 61%, were covered by combination trucks, with the remaining 39% covered by single-unit trucks. For 2015, much the same: Total miles traveled were 279,844 million miles, an increase of only 0.2% ... yes, that's point 2%. Not much of an increase compared to the increases in crashes. As in 2014, most of these miles (61%) were covered by combination trucks.
- Lastly, how many large trucks are registered? **In 2015, there were 11,203,184 large trucks registered in the U.S., an increase of 2.7% over the 10,905,956 registered large trucks total in 2014**. As in 2014, however, about a quarter of the large trucks registered in 2015 were combination vehicles.

For 2015, more trucks on the road, more miles being driven, more goods being moved and – regrettably – more crashes. Not the best of times, but truly not the worst of times: Note that things have improved from about 10 years ago, when the overall number of crashes involving large trucks per 100 million vehicle miles traveled was 190.3. Continued vigilance is required, however, as this rate is creeping back up, driving the need for fleets and owner-operators, along with their drivers, to consider what can be done to improve the fleet safety equation for their operation.

But, before you can choose what to do, knowing where to focus is helpful. In part 2 of this blog post, we'll delve into a few more details regarding types of crashes. Stay tuned!

BY THE NUMBERS (PART 2)

August 21, 2017

In our last blog post, we talked about the "2015 Large Truck and Bus Crash Facts," covering how the data is collected and looking at some of the information provided. In a nutshell, fatality crashes went up about 5%, while overall crashes – driven by property-damage only (PDO) crashes and injury crashes – were up by only about 1% in 2015 after a 26% increase from 2013 to 2014. Still, the increases don't bode well for the industry, especially in light of the fact that during the same period (2015), miles driven were up only a miniscule 0.2%. It all adds up to the fact that heavy truck crashes continue to occur and rates increased.

Of course, the data only shows the numbers, not the reasons why. Much as I'd like to delve into this aspect, there's really a need for more methodical research in this area. That said, let's take a look at some of the crash types that driver assistance systems (DAS), such as stability and collision mitigation, can help fleets address – specifically, rollovers, rear-end collisions with passenger vehicles, and other types of collisions between cars and trucks:

- ***Rollovers and loss-of-control (jackknife) crashes:***
  - Let's begin with the numbers. In 2014, 14,260 large trucks were involved in rollover and/or jackknife crashes, an increase of 8% over the 2013 figures. In 2015, the numbers dropped about 5% to 13,498 rollovers and/or jackknifes. So our figure of 1.6 large trucks rolling over and/or jackknifing every hour in 2014 dropped a little in 2015 to about 1.5 – still a significant data point. The continuing number of rollovers and loss-of-control/jackknife crashes reinforce why the National Highway Traffic Safety Administration (NHTSA) has mandated full-stability (ESC) technology to help drivers mitigate and reduce these instances. The mandate, which took effect beginning Aug. 1 of this year for Class 7 & 8 6x4 vehicles, may still be eliminated by the current administration under their "two for one" cleanup initiative. We contend that while there may be regulations that likely could be eliminated, this isn't one of them. Why? The problem still exists and, while the mandate won't eliminate all rollover and jackknife crashes immediately, it's a strong step in helping reduce their incidence.
  - Not surprisingly, the most harmful event – when comparing rollover vs. jackknife crashes – is the rollover crash. A total of 9,272 trucks were involved in rollover crashes (where the rollover was the most harmful event for the large truck) vs. 4,226 large trucks in jackknife crashes. It's a foregone conclusion that rollovers are devastating and resulted in most of the fatalities in this category.

> What's the "so what" of the statistics? First, we still have a problem with crashes involving large trucks in this country. Too many accidents are still happening, accidents that can probably be reduced significantly through a variety of measures – from driver training to technology application.

- ***Rear-end collisions:***
  - This one is of particular interest due to the focus on a specific incident type within the "Crash Facts." There is a category of "Large Truck Rear-Ending Passenger Vehicles." (In addition, there's also a category of "Passenger Vehicles Rear-Ending Large Trucks.") For the large-truck category, there was a 60% increase in the number of these collisions vs. the 2013 information. In 2014, 37,088 large trucks rear-ended a passenger vehicle. That's 4.2 trucks/hour of every day in a year involved in a rear-end collision somewhere in the U.S. This is cause for concern – due to both

the increase and the number. For 2015, the trend unfortunately continued. The numbers actually increased – a little over 40,000 large trucks rear-ended a passenger vehicle, an increase of about 8%. Another way to view the data is that, in 2015, a large truck rear-ended a passenger vehicle every 15 minutes.

- Going one step further, the data shows that 93,751 large trucks had a collision with a passenger vehicle other than a rear-end collision. This could be a sideswipe, T-bone, or other crash involving the large truck and a passenger vehicle. Again, the unfortunate trend line continues, this time reflecting a 13% increase in this type of crash over the 2014 numbers.
- Combine the two and you have 133,837 trucks involved in collisions of some kind with a passenger vehicle, an increase of about 12% YOY.
- Passenger cars, however, are not innocent bystanders. In 2015, 34,335 passenger cars rear-ended a large truck – a 17% increase over 2014, while 75,687 passenger cars struck the large truck at another point, a 4% increase. Adding it all up, 110,022 passenger cars hit a large truck in 2015, a statistic that is headed in the wrong direction as well.

What's the "so what" of all the facts and figures? First, we still have a critical challenge with crashes involving large trucks in this country. Too many accidents are still happening. Accidents that can probably be reduced significantly through a variety of measures – from driver training to technology application. If you have a fleet that has experienced some of these crashes, you know how devastating they can be – especially when fatalities or injuries are involved. In addition, there's a financial cost – including productivity reductions due to loss of equipment and driver availability, plus profit impacts to cover costs (such as repairs, medical expenses, and liability costs). These are costs that come right from the bottom line.

The solution? As we discussed in our white paper "The Fleet Safety Equation, Part 1" – online at bendix.com and knowledge-dock.com – it's not a single approach that helps resolve the issues with crashes. Dealing with crashes requires a multilevel effort – ranging from technology adoption and implementation, along with driver training and selection, through maintenance and monitoring – just to name a few. The fleet that embraces a multifaceted approach is likely to see significant reductions in the number of crashes involving their trucks and drivers. Reducing crashes, while reducing fatalities and injuries, also reduces costs.

Safety does deliver an ROI, but like your investment portfolio, it takes diversity to optimize.

And it starts with the numbers.

HOW WE GOT TO WHERE WE ARE ...

September 29, 2016

The development of Antilock Braking Systems, or ABS as it's more commonly referred to, really marks the beginning of the driver assistance system revolution. Why? Because for the previous hundred years or so of heavy truck brakes, braking was a mechanical, not electronic, function. To engage the brakes, the driver stepped on a pedal and some lever, wire, fluid or air moved to engage the brakes. Mechanical, not electronic. With ABS two things happened to the braking system – it could think and it could see.

The thinking part of ABS comes from its brain – the ECU – electronic control unit. The ECU contains the algorithms that, based on input from the eyes (in this case the wheel speed sensors) determines if a course of action is needed to mitigate a skid situation. If the ECU determines that an intervention is necessary, the system engages the modulators to release the brakes and "cycle" them, to help the driver control a skid. Brains and eyes – thinking and vision via the ECU and sensors – revolutionized braking on heavy vehicles. More importantly, ABS provided the foundation for advancing technologies to help drivers in more situations to control their trucks and avoid crashes or have the opportunity to reduce the intensity of crash situations. NHTSA (National Highway Traffic Safety Administration) saw the value of the technology to help keep control of their vehicles and mandated ABS for tractors in '97 and for single unit trucks and trailer in '98. This not only made the technology widely available, it also made it cheaper as economies of scale of a mandated product, as opposed to optional, kicked in and reduced the costs for the technology.

Add a few more sensors to the braking system, beef up the ECU with some additional algorithms and now you have electronic stability control (ESC). Electronic stability control (ESC), or what we introduced to the market in 2004 as Bendix® ESP® helps drivers mitigate not only rollovers, but loss-of-control situations on dry, wet, snow- and ice-covered roadways. The three sensors that are added? First, a steer-angle sensor which provides information about the driver's intent on where they want the vehicle to go. Second, a yaw-rate sensor which provides information to the ECU about which direction the vehicle is going. Finally, a lateral acceleration sensor which delivers input about side forces acting on the vehicle. These three sensors provide input into the ECU which then compares these readings with algorithms to determine if a stability event – rollover and/or loss-of-control is going to occur. If the system determines this is happening, the system intervenes by reducing speed either through throttle reduction or, if necessary, applying the brakes on the steer, drive, and trailer axles to help the driver mitigate the situation. Now, drivers have an aid to help them avoid one of the most dangerous and deadly crashes in the trucking industry. This is another technology that NHTSA has mandated for Class 7 & 8 tractors and motorcoaches beginning in 2017.

Moving forward to 2009, an additional sensor – a radar – is added to the front of the vehicle. The radar provides information about what's happening in front of the vehicle, sending out a signal to detect metallic objects in the vehicle's path. This additional sensor, along with the stability system built on ABS, provides adaptive cruise control (ACC) for commercial vehicles. With ACC, when the driver engages the cruise control and sets speed, the system helps him or her maintain a set following distance behind a forward vehicle. As the gap between the truck and forward vehicle starts to close, the system provides the driver following distance alerts. If necessary, the system will dethrottle, engage the engine retarder, and apply the brakes to help the truck maintain the following distance. While the intervention for adaptive cruise control with braking only occurs when the vehicle is in cruise control, the driver still receives following distance alerts whether in cruise control or not, to keep him or her aware of the distance between the truck and the forward vehicle.

From ABS with an ECU and wheel speed sensors, to full-stability control with additional algorithms and sensors, to adaptive cruise control and collision mitigation by adding more logic and sensors – all in the last 20 years. Imagine what the next 20 years will bring!

Adaptive cruise control, or what we call, Bendix® Wingman® ACB – Active Cruise with Braking, starts the integration of technologies for advanced driver assistance systems. Wingman ACB brought together both a collision warning and mitigation technology with full stability to help drivers in a variety of situations, from rollovers and jackknifes to rear-end collisions. All in one package. All designed to complement, not replace, safe drivers and safe driving practices.

In 2011, the next step in advanced driver assistance was delivered: Wingman® Advanced™ – a Collision Mitigation Technology. Upgrading the software in the radar, and eventually upgrading the radar hardware, added to the adaptive cruise control of Wingman ACB automatic emergency braking (AEB). Whether the driver is in cruise control or not, when the system determines a collision is imminent, it alerts the driver and applies the brakes to help the driver mitigate the collision situation. Also built on stability, Bendix Wingman Advanced does more to help drivers improve safety performance on the road through alerts and mitigation regarding rear-end collisions, rollover and jackknife situations. Bendix was also first to include stationary object alerts, which provide the driver an up to 3-seconds heads-up of a sizable metallic object in his or her lane of travel. This alert provides the opportunity for the driver to slow, or, if necessary, swerve to avoid the object.

The value of the technology can be summed up by a major fleet customer that had a reduction of up to 70% in the number of the rear-end crashes and up to a 70% reduction in the severity of the remaining 30%.

From ABS with an ECU and wheel speed sensors, to full-stability control with additional algorithms and sensors, to adaptive cruise control and collision mitigation by adding more logic and sensors – all in the last 20 years. Imagine what the next 20 years will bring! Now that we know where we are … where do we go from here?

Autonomy – in a nutshell is what the future holds. The path leads towards increasing autonomous applications to further assist drivers in a variety of situations on the roadway. First step for Bendix along this path has been to add a camera to the radar and create the recently introduced Bendix® Wingman® Fusion™ system – a system that takes input from both the camera* and the radar to deliver a higher level of collision mitigation. Think about it, when you make a decision, isn't it better to have more than one source of information? That's what's happens with Fusion – the camera and the radar work together, enabling the system to cross-check information for an earlier read of the situation and deliver an appropriate intervention sooner, than the previous radar-only based system. Also, as important is being able to reduce false alerts and, probably more critical, false interventions. While false alerts can be a driver dissatisfier, false interventions can be dangerous – as when the truck brakes for a nonthreatening obstacle or overhead signing that results in a crash from a car following too closely.

Considering the pathway to driverless vehicles, additional sensors (more information into the system) along with advanced algorithms (the intelligence of the system) will help drive more and more autonomous applications that, over the next 10 years will continue to help drivers do their jobs more effectively and efficiently. Driver assistance systems today are controlling acceleration and braking. As we look to the future, adding steering control will likely be the next step. Steering control will assist in autonomous applications such as lane keeping (helping the driver stay in the center of the lane), self-parking, loading-dock assist, and even providing automated driving on long stretches of roadway. Again, applications designed to help drivers, but not replace them.

Beyond this, expectations for driverless vehicles are high, as already driverless truck retrofits are being touted and innovative approaches are being demonstrated. However, getting to truly driverless vehicles will take some time. While technology has advanced greatly and will continue at a fast pace, societal acceptance and government regulations will not move at the same speed.

* Fusion's camera is powered by the Mobileye System-on-Chip EyeQ Processor with state-of-the-art vision algorithms.

Incidents involving driverless functions and concerns about cybersecurity around driverless vehicles will ensure that time is taken to develop robust and secure systems. The need for virtually flawless driverless system performance to cope with the myriad of situations that human drivers face today, in all weather conditions and along all types of roadways will require time, testing, and tweaking. Also critical will be the security infrastructure both on and around the vehicle. It's critical that a driverless vehicle's control systems cannot be hacked by outsiders for kicks or nefarious activities. Performance expectations and specifications will be required to ensure systems perform properly and simply, so drivers (or are they now passengers?) can enjoy the benefits of the system without worrying about the need to take over immediately because the system can't handle a particular situation. Driverless will come, but not for a good while yet!

Increasing safety and performance on the road, now and into the future. To think it all started with brakes, brains, and vision.

FOUNDATIONS FOR THE FUTURE – AVAILABLE TODAY

April 18, 2017

We've frequently used this blog space to discuss the importance of driver assistance systems (DAS) and, from a Bendix perspective, the pathway to automated and autonomous vehicles through advancing driver assistance technologies. Just as ABS is the foundation for a lot of great braking system improvements, such as stability control, DAS technologies are the building blocks for the next generation – the future. All the current hype in the market around driverless vehicles doesn't change this fact.

But there are other technologies available today – elements that will also play a key role in the growth and advancement of automated and autonomous commercial vehicles. These technologies help ensure that future automated approaches are able to deliver on the promises intended. And just as with DAS, they are also critical and must be kept in mind, because failure in one of these technologies will impact the performance of the higher-level technologies.

Six Foundations for the Future

In a way, this blog post ties to the importance of maintenance and the "hierarchy of maintenance" we've discussed in the past. You might recall the basic premise from an earlier blog post ("Maintaining

Driver Assistance Systems: Why Covering the Basics Takes Care of the Advanced Technologies," December, 2016) is that taking care of the lower-level systems – such as tires and brakes – helps to ensure the performance of the higher-level systems, such as stability and collision mitigation technology. Some of these foundations do just that – they are needed to help ensure that the higher-level systems are able to perform optimally. Without them, there are going to be problems.

Along with advanced driver assistance systems, other technologies important in delivering the future include: full-stability (ESP/ESC) technology, integrated collision mitigation technology, air disc brakes, oil coalescing air dryer cartridges and intelligent air dryer technology, wear-sensing technologies, and advanced trailer technologies – from air disc brakes and trailer roll stability on the trailer to improved connectivity between trailer and tractor.

Let's talk a little more about each of these areas:

- ***ESP/ESC Stability Technology* – Stability, from my perspective, is the critical functional braking technology for the future**. Two reasons support this statement:
  - First, the braking strategy of stability provides a fundamental approach to automated and autonomous vehicle braking: you need to be able to control the brakes on the tractor and the trailer – steer, drives, and trailer. Full stability does this. More important, however, is how you control the brakes on the tractor. By varying the pressure on each wheel-end, the system is able to help drivers – whether real or automated – to reduce the impact of the forces that can lead to rollovers and loss-of-control situations.
  - This doesn't mean that the brakes won't change in the future. They will. Brake control systems will evolve, but the basics of stability control will continue to be foundational to help ensure dynamic vehicle control during various events.
  - The other reason? Even automated and autonomous vehicles travel on slick surfaces and will need the value of stability to help maintain control in these situations.

- ***Integrated collision mitigation technology*** – This one almost goes without saying, since, in the basic scheme of things, that's what automated and autonomous vehicles are really trying to do – get you to your destination by avoiding collisions. But it's not just about collision mitigation technology – it's about integrated collision mitigation technology. **Integration helps optimize the performance of a forward collision mitigation system by providing more information into the system – and by being able to cross-check information from different sources**. Here's a basic fact: autonomous or driverless vehicles have to minimize their susceptibility to false interventions, and the integration of sensor technologies – such as cameras, radar, ultrasonic, and other sensors –

helps reduce these false positives. We see it already in the performance of Bendix® Wingman® Fusion™ – type systems (camera* and radar working together) delivering typically fewer false alerts than single sensor systems.

When talking about driverless commercial vehicles (again, far, far into the future), this integration is critical. Why? Because there will be not be a driver available to take over, and a false intervention in the middle of a freeway could have catastrophic results. (Heck, the way some automakers are talking, there won't be controls to help a driver take over, anyway!)

And, of course, forward-facing is only one type of collision. Integrating sensors on the rear and sides of the tractor and trailer will enable collision mitigation technologies to do even more to help in more situations – from sideswipe and backing crashes, to pedestrian, animal, and object collisions.

- ***Oil-coalescing Air Filter Cartridges and Smart Air Dryers*** – Air sustains us – without clean, available air, we cease to exist. Dramatic, yes, but this same perspective is true for an air-braked truck. Oil, moisture, and other contaminants in brake system air can gum up the works – and "gumming up the works" for truck brakes is never a good thing. However, today, the air generated for the braking system is safely used for more than just the brakes; other components, such as automated manual transmissions and emission systems use system air to facilitate their operation. As you can well imagine, contaminated air is not an option. That's why more and more OEMs are including oil coalescing air dryer cartridges (such as Bendix® PuraGuard®) as standard equipment on their new vehicles.

It's good to know that as the technology advances, reliable, trusted approaches available today will also evolve to provide the support needed to get us further down the road to autonomy.

Intelligent air dryers also become important for the future. Ensuring that the air system is performing optimally, especially with more advanced automated and autonomous systems in the future, is critical. An intelligent – or computer-equipped – air dryer helps alert the system to potential issues that may impact the performance of the system or the quality of air in the system. The last thing you want is a critical system malfunction at a critical time – resulting in, at best, a shutdown and, at worst, a crash. Making the air dryer smart and integrated as part of the system helps to prevent this issue.

- ***Along the same lines, Wear Sensors will become more important in the automated and autonomous future***. Not surprisingly, the need for the system to better understand when an issue that might impact performance will occur is extremely important for the future. A number of OEMs already enable prognostic information proactively communicated from traveling truck to repair

* Fusion's camera is powered by the Mobileye System-on-Chip EyeQ Processor with state-of-the-art vision algorithms.

center telematically. The data transmission can help diagnose what's happening on the road and either enable an over-the-air programming update, or prepare the garage for a quick service to fix the problem and get that vehicle back on the road. More of these technologies will be important in the future – especially around mission-critical components, such as brake linings, tire wear, tire pressure, sensor performance, etc.

- ***Air Disc Brakes – when it comes to stopping power, there is probably no better wheel-end system available today.*** In FMVSS 121 testing, air disc brakes consistently deliver shorter stopping distances than traditional drum brakes. This becomes very important when, for example in platooning applications, trucks are separated by relative short distances – such as about 40 ft. – while traveling at highway speeds. Also, the consistency of performance from side-to-side, along with the lack of fade and long-term durability of wear components such as pads and rotors, helps ensure that when the system needs braking, the brakes will deliver.

- ***And finally, Trailers*** – Yes, the oft-neglected trailer takes on significant importance in the future. Today the trailer is the cargo carrier. **Tomorrow, it's not only the cargo carrier, but an integral component of the combination – able to supply additional braking power and information to the system to help deliver a complete team approach to automated and autonomous functions**. So what changes for trailers tomorrow? Here are a few thoughts …

  - First, the brakes on the wheel-ends will need to be air disc brakes. Why? Same reasons noted earlier – consistent performance and maximum stopping power.
  - Second, trailer stability. While tractor stability technology provides the bulk of stability power in a tractor-trailer combination, optimum performance is achieved when stability control is on both the tractor and the trailer. Plus, the system ensures ABS availability for optimum performance and trailer control in panic stops. (Yes, old trailers without ABS will not be invited to the future.)
  - Third, and probably most important, is connectivity. Better connectivity between the trailer and the tractor will be critical. **PLC (Power Line Connector), while useful today, is not the system connector for the future. The future requires true, clean, and clear network connectivity**. The trailer system needs to be integrated with the tractor system to help ensure the trailer is ready to perform when needed – supplying information to the tractor regarding vehicles and other obstacles around and behind it, and ensuring that maximum stopping power can be applied when needed. Beyond "unit" connectivity of tractor and trailer, connectivity with the external environment – the other connected vehicles and infrastructure in the surrounding environment – will also be crucial. Because trailers can vary, information about a particular trailer will be important to ensure other vehicles know the length of that single trailer or trailer combination. And this will have to

happen automatically. Otherwise, a vehicle-to-vehicle (V2V) system on another vehicle may not realize the tractor has a trailer connected to it. This lack of information could result in a collision.

Just like a great production is not the work of only a few stars, but the result of a number of contributors: from co-stars, to set designers, to lighting technicians, and musicians, so is true for the increasingly automated vehicle – a product of not only star technologies, but supporting technologies in the background. From my perspective, it's good to know that as the technology advances, reliable, trusted approaches available today will also evolve to provide the support needed to get us further down the road to autonomy.

If the foundations for the future are available today, what are you doing with your fleet to be ready?

ADVANCING THE "4-I"s TO THE "5-I"s

November 17, 2016

You might recall presentations where I've discussed the "4-I"s of active safety and future autonomy – Information, Intelligence, Intervention, and Insight. These elements are how systems advance from simple active safety technologies through driver assistance systems to truly driverless vehicles. (Again, from my last post, driverless vehicles, in my mind, are still a long way off! But, technology will continue to advance, helping drivers in new and different ways to do their jobs safely and securely… and, most importantly, to help them get home for dinner each night.)

A quick refresher on the "4-I"s – Information, Intelligence, Intervention, and Insight:

- **Information:** Sensors (such as wheel speed sensors, radars and cameras) and outside inputs deliver information to the system to enable it to understand what is happening with the vehicle and the surrounding circumstances.
- **Intelligence:** The algorithms and logic built into the electronic control unit (ECU) that takes the information from the sensors and determines what is happening and if any action by the system is warranted.
- **Intervention:** This is the action of the system – in the case of driver assistance, expanding autonomous features and eventually driverless, this is speed and direction variation to help manage and mitigate the situation.

- **Insight:** As these are electronic elements that communicate with each other, they provide data on what is happening in a particular situation. This data can deliver insight to the fleet and driver which can be used to help better train drivers on specific issues, or better understand the circumstances in the particular incident.

Now for the fifth "I" – **Integrity**. As the Intelligent Transportation System (ITS) becomes more and more of a reality, it's important to keep in mind how this system will play into advancing driver assistance technologies. Vehicle-to-vehicle communications (V2V) and vehicle-to-infrastructure (V2I) (as well as infrastructure-to-vehicle communications) will enable vehicles to receive additional information into the system – information that initially will let the system know of the positions of surrounding vehicles, and additional information for the system as the ITS evolves. This means expanding gateways into the vehicle, which opens up the vehicle to potential hacking of the system and potential misuse of the vehicle.

We've all heard the horrific and tragic story of the lorry driver in Nice, France who drove his truck through a crowd watching Bastille Day festivities, killing 85 people. We also know that the deranged driver was fully responsible for his actions. However, what if the truck had been hacked, causing the vehicle to drive into the crowd without the driver being able to control the situation. What if it was more than one vehicle? And, what if they were tanker trucks carrying explosive or flammable cargo? Very scary thoughts, indeed.

This is why the fifth "I" – Integrity – is needed.

Integrity is the overarching "I" that is integral to each of the other "4-I"s. Integrity, according to dictionary.com, means:

- Adherence to moral and ethical principles; soundness of moral character; honesty.
- The state of being whole, entire, or undiminished.
- A sound, unimpaired, or perfect condition.

> In a nutshell – the system works as intended and cannot be interfered with except by the driver, as the driver is always in control.

Each of the "4-I"s needs to be considered from the perspective of the fifth "I." The information coming into the system needs to be unimpaired. The intelligence of the system needs to be developed, tested, and built as a whole to deliver the expected performance; the intervention needs to true and effective, and the insight delivered must be clear and ethically correct. In fact, the system itself needs to be built with integrity – it has to work properly and its function needs to be communicated and understood with clarity of what the system can, and most importantly, what the system cannot do. Lastly, the system must be built and tested with the correct security to do all in its power to prevent being hacked and used for unintended purposes.

Integrity, then, in the context of the 4, now "5-I"s, is really ensuring that the system is able to deliver the expected performance consistently, with appropriate protections integrated to avoid unintended consequences. In a nutshell – the system works as intended and cannot be interfered with except by the driver, as the driver is always in control. (Until that far-off day when driverless vehicles are more common.)

While it may not always be possible to ensure the integrity of a driver, as in the case in France, it is incumbent on system and vehicle developers to do all in their power to ensure the integrity of the system.

Information, Intelligence, Intervention, Insight, and now, Integrity – the fifth "I." Perhaps, arguably, the most important.

THE VERNACULAR OF AUTONOMY – A PRIMER

July 24, 2017

Across the industry, we're throwing a lot of terms around these days as we head down the roadway to autonomous vehicles. Some are pretty basic, but for me, some could use a little refinement. My favorite conundrum starts simply with the word, autonomous. Are we really talking about autonomous vehicles or automated vehicles? Believe it or not, there is a difference. And, for the most part, nearly everyone is using autonomous in the wrong way.

To figure this out, I went to my usual source for clarity and definition – dictionary.com. **Autonomous** means that the vehicle is navigated and maneuvered by a computer, without a need for human control or intervention, under normal road conditions. This is really the driverless vehicle of SAE (Society of Automotive Engineers) J3016 Level 5 autonomy, which the National Highway Traffic Safety Administration (NHTSA) has adopted – no driver involvement in any situation. Autonomous vehicles may not even have typical driver controls – like a steering wheel, brake pedal, or accelerator. It is a truly driverless vehicle. Examples of this at work already exist today – the monorail at Disneyland or the people movers at major airports like Chicago, Atlanta, or San Francisco. And we've all heard about off-road driverless vehicles used in mining/farming operations and, of course, the old DARPA Grand Challenge – from 2004, ’05, and ’07 – where autonomous vehicles moved through off road and urban settings. (Interestingly, no one won the 2004 challenge. And, yes, the challenge still continues, though the challenges are not all autonomous vehicle applications.)

The majority of technologies under discussion for now and the foreseeable future are automated, not autonomous. There will be a human driver involved until there isn’t one. And when that happens, it will be an autonomous vehicle.

The fact is that until we get to truly driverless vehicles, we’re not talking autonomous. Instead, we’re really referencing automated vehicle applications. Again, back to dictionary.com, where automated is defined as “to operate or control by automation.” Taking the next step, automation is defined as “the technique, method, or system of operating or controlling a process by highly automatic means, as by electronic devices, reducing human intervention to a minimum.” The key here is “reducing human intervention.” Humans are still involved in some part of the process, just in decreasing levels. This represents Levels 2-4 on the SAE and NHTSA scales. It’s important to point out that yes, you can argue that Level 4 could be driverless, and it is, but not in all circumstances: A lot depends on the operational design domain as stated in NHTSA’s 2016 “Federal Automated Vehicles Policy.”

The bottom line is that the majority of technologies under discussion for now and the foreseeable future are automated, not autonomous. There will be a human driver involved until there isn’t one. And when that happens, it will be an autonomous vehicle. Of course, when that will happen is still up for debate, but we’ll look at timing in a future blog.

Now that we’ve got that cleared up, let’s talk about some of the elements that will be part of automated – and, eventually, autonomous – vehicle developments.

- **DAS and ADAS:** DAS is the acronym for driver assistance systems – everything ranging from ABS and stability control to the current state-of-the-art collision mitigation systems. Basically longitudinal control (acceleration and braking) to help mitigate rollovers, loss-of-control, or collisions. ADAS, on the other hand, is advanced driver assistance systems, which technically means future generations of systems that will do more to help drivers in more types of situations. From my perspective, increasingly automated functions – along with lateral (steering) and longitudinal control – distinguish these systems from DAS. For example, the Bendix® Wingman® Fusion™ collision mitigation system represents a DAS system, while Otto’s automated driving system represents ADAS. At Bendix, moving toward automated vehicles is being driven by advances in both DAS and ADAS systems.

- **Sensors:** More information into the system will be critical to deliver advanced automated systems. On the vehicle, sensors will gather the information and deliver it to an ECU (intelligence), which will determine the need for intervention (either alert, or alert and deceleration). Today we use a radar and camera working together to provide the enhanced collision mitigation capabilities of the Wingman Fusion system. In the future, additional cameras and radars, along with other sensors, will work together to deliver higher levels of performance. Here are just some of the sensors you can expect:
  - **Radar:** "Radio Detection and Ranging (RADAR)" – a method for detecting the position and velocity of a distant object.[1] In practical terms for our discussion, Radar is the basic sensor that has been used in forward collision warning, adaptive cruise control, forward collision mitigation, and blind-spot detection on commercial vehicles since the introduction of VORAD® in the mid-90s. How does it work? "The electromagnetic waves emitted by the radar device are rebounded against metal surfaces or other reflecting material and can be picked up again by the radar's receiving section. The distance to the objects in the sensing range can be measured from the propagation times of these waves. The Doppler Effect (shift in frequency of the radar signal) is used to measure the relative speed. Thanks to its excellent properties in terms of fast and precise measurement of distance and relative speed, the radar sensor is … particularly well-suited for use in active and passive safety functions"[2] such as collision mitigation and blind-spot detection systems. Radars can vary in frequency, but are typically 24Ghz or 77Ghz in collision mitigation system applications and have a range of 500-600 feet in front of the vehicle.
  - **LIDAR:** We've been hearing a lot about LIDAR sensors lately, thanks to the Google car and other automated applications. LIDAR is typically the spinning sensor perched atop the Google car, or at points around the Otto truck. LIDAR (Light Detection and Ranging)[3] is a "device similar to radar in principal and operation but using infrared laser light instead of radio waves, and capable of detecting particles and varying physical conditions in the atmosphere. Unlike most radar sensors, LIDAR does not measure the object speed directly. Instead, it is calculated by differentiating the distance signal, which results in a certain delay and reduced signal quality. On the other hand, the good lateral resolution of a scanning LIDAR is far superior to the typical radar sensors used today."[4] Constantly spinning, (LIDAR) uses laser beams to generate a 360-degree image of the vehicle's surroundings. Positioning of the LIDAR can vary, depending on the vehicle. Thus far, we've seen applications where a single LIDAR is placed on the vehicle's roof (as in the Google car application), or positioned at lower points around the vehicle (as on the front bumper and toward the rear of the Otto truck application).
  - **Ultrasonic:** If you have a car with reverse sensing, you likely have ultrasonic sensors. These are typically the little circles that dot the back bumper on your vehicle and detect objects in

the vehicle path as you back up. Ultrasonic sensors are "ultra-short-range sensors with a typical range of 2.5 m (8.2 feet). Parking assist applications typically have further-developed sensors with greater ranges (up to around 4.5 m or 14.8 feet).[5]

- **Cameras:** "(A camera) uses parallax ('the apparent displacement of an observed object due to a change in the position of the observer') from multiple images to find the distance to various objects. Cameras also detect traffic lights and signs, and help recognize moving objects like pedestrians and bicyclists."[6]

- **Connectivity:** There are many definitions around connectivity – from computer systems to business operating units. One of the better definitions comes from "Business Dictionary(.com)," which defines connectivity as "(The) Measure of the extent to which the components (nodes) of a network are connected to one another and the ease (speed) with which they can 'converse.'" Putting this into context for our use, think of nodes as vehicles, infrastructure, or other elements that are connected together via a means of communications so they can easily and quickly talk to each other.

Connectivity exists today – your truck's ability to communicate back to your office via telematics to deliver data about loads, routes, safety incidents, etc. – is a form of connectivity. In the future, connectivity will tie to vehicles sharing information with each other and their surroundings (infrastructure, pedestrians) to enhance vehicle safety, as well as help improve efficiency of the transportation system and provide environmental benefits, such as improved fuel economy and reduction in emissions. Connectivity is the cornerstone of what the U.S. Government calls the "Intelligent Transportation System" or ITS. As we explore connectivity, let's review a few terms to keep in mind regarding the ITS and future autonomy.

- **Proposed FMVSS (Federal Motor Vehicle Safety Standard) 150 – NHTSA** (National Highway Transportation Safety Administration) released in December 2016 an NPRM (Notice of Proposed Rulemaking) to require light vehicles (vehicles 10,000 lbs. or less) to be equipped in the future with communications devices that enable information to be:
  - Shared between vehicles (V2V, or Vehicle-to-Vehicle) and, eventually
  - The surrounding infrastructure (V2I or I2V – Vehicle-to-Infrastructure and vice versa)
  - Pedestrians (V2P or P2V – Vehicle-to-Pedestrian and vice versa)

Let me pause a moment to explain that all these "V2Somethings" are generically referred to as V2X – or Vehicle-to-Whatever. With that as a backdrop, FMVSS 150 does not consider the V2X applications, just the V2V applications.

V2X may be an integral part of automated/autonomous vehicle development in the future. The focus of the NPRM, and the primary reason for pushing forward with a regulation to equip vehicles with this technology, is to help improve safety on the roadways, while also trying to speed implementation (as opposed to simply letting OEMs offer the capability as an option). This makes sense, as V2V as an option would take much longer to equip vehicles – you don't have much connectivity if there are not a lot of connections available!

What doesn't make sense, at least from my point of view, is not including heavy trucks and buses in the requirement. The same argument holds – more vehicles with the equipment, more connections, more opportunity to help mitigate crash situations. The good news, however, is that there is an expectation that the inclusion of heavy trucks and buses will be addressed in a future – possibly 2017 – NPRM for connected heavy vehicles.

The value of V2V from a safety standpoint ties to the ability of the system to warn drivers of potential collision situations that can't always be handled by onboard sensors. For example, a radar or camera can't see around corners. A connected vehicle, however, could receive a signal of a vehicle crossing in front of an oncoming car, alerting the driver so he or she can apply the brakes. In the future, the warning may become a brake application – on both cars and trucks.

My final point on this topic – I promise – is that target implementation of the rulemaking is scheduled two years after the final rule is issued – per the NPRM, likely in 2019. If the final rule is issued in 2019, the Agency envisions a "3-year phase-in period to accommodate vehicle manufacturers' product schedules" as noted in the NPRM. With this plan, implementation begins in 2019 and is completed in 2023.[7]

- **Basic Safety Message (BSM) – "The data (exchanged between vehicles) is known as** the "basic safety message" (BSM) … and contains vehicle dynamics information such as heading, speed, and location. The BSM is updated and broadcast up to 10 times per second to surrounding vehicles. The information is received by other vehicles equipped with V2V devices and processed to determine collision threats. Based on that information, if required, a warning could be issued to drivers to take appropriate action to avoid an imminent crash."[8] The BSM is based on SAEJ2735 Part 1 and the data elements include: vehicle size, position, speed, heading acceleration, and brake system status.

- **DSRC (Dedicated Short-Range Communications)** – "DSRC is a two-way short-to-medium range wireless communications capability that permits very high data transmission critical in communications-based active safety applications. The Federal Communication Commission (FCC) allocated 75 MHz spectrum in the 5.9GHz band for use by Intelligent Transportation Systems (ITS) vehicle safety and mobile applications."[9] This is how communications between vehicles and V2X applications happens. Take note, however, that there is major concern regarding the FCC allowing other applications – such as wireless internet – into the 5.9GHz band. In fact, this is the source of opposition for a number of groups concerned with V2V. They feel overcrowding of the band could result in lost messages at critical times. We'll watch to see how this plays out in the new administration.

- **Platooning:** You've heard, and perhaps seen, much about platooning trucks. In a nutshell, platooning is controlled drafting to gain fuel economy and, some may say, a safety benefit. Peloton Technology is the major player in this technology.

  - **Phase 1:** In the first phase of platooning (multiple phases are expected as we go down this path), you will have two trucks with two drivers; the trucks are following in close proximity using a system that will automatically bring them close together (about 12M, or 40 feet, optimally) when conditions are right for platooning. Right conditions are typically a sunny day on a limited-access highway (freeway or interstate), with minimal traffic. The system will provide longitudinal control (braking and acceleration) through DSCR communications to the rear vehicle – to enable the vehicle to quickly react to braking or acceleration by the lead vehicle. Lateral, or steering, control in the following vehicle is maintained by the driver. The lead vehicle driver has control of all functions on the vehicle and his or her changes in speed (not steering) are communicated and duplicated almost immediately by the rear vehicle.

  - **Future phases:** In future phases, the goals will likely focus on eliminating the need for the driver in the rear vehicle, as well as the potential for more than just two vehicles in the platoon. And, quite possibly, having mixed vehicles – cars, tractor-trailers, trucks, and buses – enabled to platoon together. These approaches, most likely, will require changes in regulations, as well as infrastructure (e.g., dedicated platooning lanes), to make this happen. Keep in mind – these are possibilities that have already been tested and demonstrated.

So now we've covered some of the key vernacular that you're likely to hear around the development of automated and autonomous vehicle technologies. This list, of course, is by no means complete, as there will be new terms and revisions or updates as we go along the path.

- **Deep Learning (Neural Networks)** – There's much to discuss when it comes to deep learning – anywhere from a lengthy blog to a full book. In a nutshell, we understand deep learning as advancing machine learning to a computer model that mimics the structure of the human brain. This helps make the system smarter about the situations it encounters and enables the system to quickly learn from new inputs or new system experiences. For comparison, think of all the different situations you encounter as you pilot your personal vehicle on the road today, and then consider how much better a driver you've become than when you were at 16 with a newly-minted license in hand. All that learning occurred from your experience over time. Deep learning, in a sense, will help autonomous (is it autonomous or automated?) vehicles learn from various experiences and not repeat mistakes – unlike, sometimes, we human drivers will do!

Okay, so now we've covered some of the key vernacular that you're likely to hear around the development of automated and autonomous vehicle technologies. This list, of course, is by no means complete, as there will be new terms and revisions or updates as we go along the path. This list is the perfect definition of a work in progress, but it makes for a great starting point.

Thanks to Andy Pilkington, Product Manager, Radar/Fusion at Bendix for reviewing this blog.

Sources:

1 *Dictionary.com*

2 *Bosch Automotive Handbook, 8th Edition pg.1154*

3 *Ibid pg. 1158*

4 *Ibid pg. 1158*

5 *Ibid pg. 1154*

6 *New York Times, "How Self-Driving Cars Work," 12/14/16*

7 *See Docket Number NHTSA-2016-0126 for the NPRM "Federal Motor Vehicle Safety Standards; V2V Communications" for additional details*

8 *"NHTSA Issues Notice of Proposed Rulemaking and Research Report on Vehicle-to-Vehicle Communications," U.S. Department of Transportation, Dec. 12, 2016, pg. 2*

9 *"Dedicated Short-Range Communication (DSRC), The Future of Safer Driving," U.S. Department of Transportation, pg. 1*

Like what you're reading? Want to learn more?
We welcome your thoughts: autonomous@bendix.com

WHY FIVE?

October 14, 2016

NHTSA (National Highway Traffic Safety Administration) recently came out with their “Federal Automated Vehicles Policy.” This guideline (not regulation) is designed to help the Agency get a handle on automated and autonomous vehicle development and help ensure the safe development and deployment of these technologies.

Note the key words – automated and autonomous. You may wonder, what’s the difference? I’m with you … I wondered too.

Referencing my favorite source for definitions, dictionary.com, it becomes clear why NHTSA used both terms. “Automated” is defined as “to operate and control by automation.” (Don’t you just love definitions that require another definition to make it clear?!) “Automation” is the “technique, method, or system of operating or controlling a process by highly automatic means, as by electronic devices, reducing human intervention to a minimum.” So an “automated” approach to something reduces human intervention … but it doesn’t eliminate human intervention. An automated function still needs you or me somewhere in the operational equation. Maybe a little, maybe a lot, maybe both, depending on the situation that arises.

“Autonomous” on the other hand, in reference to vehicles is defined as “navigated and maneuvered by a computer without the need for human control or intervention under normal road conditions.” In this case, autonomous means driverless – “not having a human driver in control.” Thus, an autonomous vehicle is really the same as a driverless vehicle. This can get confusing in the outside, real (non-engineering) world. Often, terms like autonomous functions, autonomous vehicles, and driverless vehicles are used to try to differentiate levels of functionality – from driver involvement most of the time, some of the time, or none of the time. The reality is, however, that driverless and autonomous are pretty much synonyms. Functions that involve the driver are really automated functions. So driver assistance systems today are really automated, not autonomous, functions – the driver still needs to be involved.

So now that we’ve cleared up the terminology, let’s talk about the title of this blog – “Why Five?”

In the Federal Automated Vehicles Policy, NHTSA has defined five (5) levels of automation, based on the SAE (Society of Automotive Engineers) J3016 “Taxonomy and Definitions for Terms Related to On-Road Motor Vehicle Automated Driving Systems.” In case you were wondering about those five levels, here they are:

- Level 0 = Human driver does everything.
- Level 1 = Automated system can sometimes assist human driver and conduct some parts of the driving task.
- Level 2 = Automated system can actually conduct some parts of the driving task, human monitors environment; human driver must take back control when system requests.
- Level 3 = Automated system conducts some part of the driving task AND monitors environment in some instances; human driver must take back control when system requests.
- Level 4 = Automated system can conduct the driving task AND monitors environment; human driver need not take back control; system can only operate in certain environments and under certain conditions.
- Level 5 = Automated system can perform all driving tasks, under all conditions that a human driver can perform them.

In Levels 0-2, the human driver monitors the environment. In Levels 3-5, the "automated driving system ('system') monitors the driving environment."

Alright, there are actually six levels, but Level 0, where the human driver does everything, really means that there are no automated functions on the vehicle. Think of any vehicle prior to the introduction of cruise control (which could be considered a Level 1 system) and you'll know where I'm coming from. (My mind goes to a 1965 Mustang "R" code – but that's a discussion for another time and place.)

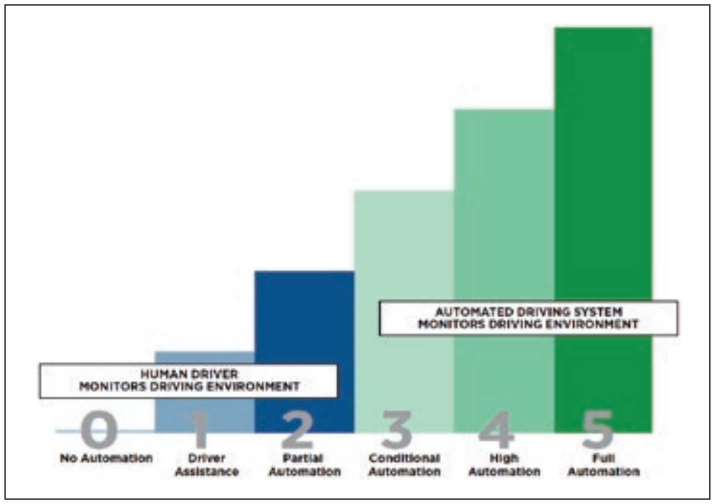
In Levels 0-2, the human driver monitors the environment. In Levels 3-5, the "automated driving system ('system') monitors the driving environment."

So five levels of automation. You know what? That's way too many levels. These levels might be good for engineers and may show a progression toward true driverless vehicles, but it's confusing. If we start using it to describe our systems to a curious public (our vehicle features a Level 3 system) it's just going to create more and more questions.

Plus, these levels mean that there are various levels of driver involvement. Think of some of the videos we've seen where the driver is able to turn his chair away from the wheel and work on his tablet, letting the system cruise on down the roadway. What happens if the driver needs to get back involved? Oh, that's easy, the system politely asks the driver to get back involved and take over control. I'll bet it will even vibrate the chair if the driver has decided not to work and take a little snooze. I know that I'm ready to take control in a situation when I wake up from a nap – don't you? (Yes, sarcasm was intended.)

In my mind, there are only two levels – driver-involved or driverless. The driver either has to be ready to take over in any situation if the system has even a minimal need for the human driver. This would cover levels 1 through 4. Even Level 4 autonomy will need a driver to be involved. Only Level 5 is truly driverless. Thus, all we need is two to describe the system – driver-involved or driverless.

Why is this important? Take a look at YouTube and see the videos of people doing crazy things with what they perceive as autonomous technologies. Sitting in the backseat and letting the car drive down the road, or reading, texting, even watching movies while the car is driving itself. Or even commercial vehicle videos of trucks with automated technologies where the driver can move away from observing the roadway and do something else. This is really scary, but probably not too surprising. We're Americans, we like to take risks and push the envelope. Give us a little automation and we'll push it to the limits. We don't adhere, we abuse. And it's all fun and cool, until someone gets killed because they overplayed the system or got the impression that the system does more than it's capable of doing from an ad, a name, a salesperson, or the media.



We, as an industry, have to communicate clearly that, until we get to driverless, the driver is still involved in vehicle operation. There are not five levels of automation, there are only two. It's simple. It's easy. And, quite frankly, it will probably save lives.

If "driver-involved" and "driverless" are too simplistic for our tech-savvy times, we can use some fancier words – it's either automated or autonomous!

Quite frankly, I'm for "driver-involved" or "driverless" … with these words I don't have to check dictionary.com, or my Funk & Wagnalls, to be sure!

(Yes, you can look up "Funk & Wagnalls" on the internet if you need to.)

THE GOOD MANDATE – ESC (ELECTRONIC STABILITY CONTROL)

November 8, 2016

Granted, it's not always easy in the trucking industry to find a mandate that's considered a good mandate. Many feel regulations are doing a great deal to inhibit the ability of truckers to do their jobs effectively and in a timely fashion. This, in turn, has led some drivers to reconsider their career choice and leave the industry – at a time when we really need drivers!

But, from my perspective, FMVSS 136 – "Electronic Stability Control for Heavy Vehicles" is different – it is what I consider a good mandate. Why? Because it will help reduce the incidence of both rollover and loss-of-control crashes for Class 7 and 8 tractors and motorcoaches in the future. If you don't think rollovers and loss-of-controls are still a problem, keep this stat in mind – in 2014, according to the "Large Truck and Bus Crash Facts 2014" over 15,000 heavy vehicles were involved in rollover and jackknife crashes. That's an average of 41 heavy trucks and buses rolling over or jackknifing every day on our nation's roadways. If you've ever seen one, you know how devastating and dangerous they can be for the driver, passengers, other vehicles on the road, the environment, and the infrastructure. Doing something to help reduce these crashes can only be a good thing. That's why this mandate is a good mandate.

What is the mandate? Let's cover the three key questions that concern everyone when it comes to regulations:

- When does it start?
- What does it cover?
- How much is it going to cost?

> The addition of the technology does not change your already-safe driving practices. Electronic Stability Control still requires a driver to be alert and practice safe driving habits. Go into a 20 mph turn at 60 mph and the system will engage, but the laws of physics take over and you are going to roll over.

Let's answer the first two questions first. NHTSA (National Highway Traffic Safety Administration) has set up a three-phase implementation schedule. Beginning August 1, 2017, all new Class 7 and 8 air-braked tractors will be equipped with Electronic Stability Control (ESC) – or what Bendix sells as Bendix® ESP® (Electronic Stability Program). You buy a new tractor manufactured after August 1 of next year and it will be equipped with electronic stability control. On June 24, 2018, all Class 8 (33,001 lbs. +) motorcoaches will be required to have ESC. And, finally, August 1, 2019, all remaining Class 7 and 8 air-braked tractors (such as 4x2 and 6x2 tractors), along with Class 7 and 8 air and hydraulically braked buses will be required to be equipped with full stability – ESC.

What's not covered is also important to keep in mind. First, single-unit trucks, or straight trucks, are not covered by the mandate. Cement mixers, dump trucks, and other single-unit chassis vehicles are not impacted by the mandate. Also, nothing in Classes 3-6 is required to have stability control. (This will likely change in the future – more on this later.) Finally, heavy-duty severe service tractors – those with a gross axle rating of 29,000 lbs. or more, as well as specialty, school buses, perimeter seating buses, and transit buses – are not covered by the mandate. Lastly, specialty slow moving tractors and buses – those that achieve a speed of 33 mph in 2 miles – are not covered.

Also, there is no retrofit requirement for ESC. Bendix doesn't retrofit the technology today and the NHTSA was wise enough to not require this for trucks out on the road or purchased before August 1, 2017. ESC is for new vehicles only.

Cost of regulation is always a concern. After two environmental mandates that have led to reduced NOx and particulate emissions, but increased the average price of a new truck by almost $20,000, you have every reason to be concerned. The bad news is that there will likely be a price increase on tractors. The good news is that it will likely be in the hundreds of dollars, not the thousands of dollars. When ABS was mandated in the late '90s, the price of ABS technology dropped significantly. Plus, today there are OEMs (Volvo, Mack, Peterbilt) who already make full stability standard on their highway vehicles.

So that's the new vehicle cost … what about maintenance? Good news here, as well! Stability control is an electronic system built on the vehicle's ABS (Antilock Braking System). Additional sensors are added, along with a more powerful electronic control unit (ECU) to help deliver throttle reduction and braking when and where it is needed on the vehicle to help the driver mitigate a loss-of-control and/or rollover situation. The stability system operates independently, but the driver can always add additional throttle reduction, braking, or steering to help avoid the situation. Because it is an electronic system, the sensors have a long life and, if they need to be changed, are replaced not repaired.

The basic maintenance that is done to keep the vehicle's braking system and tires in good shape helps to ensure that the stability system is able to operate to its fullest when needed. However, it's not totally maintenance-free – if you do a front-end alignment or other front-end work, you need to recalibrate the steer angle sensor. If you move the yaw rate/lateral acceleration sensor, such as for frame rail repairs, you need to replace the box in the same place and position and recalibrate. With the Bendix® ESP® system, this is easily done using our Bendix® ACom® diagnostic software (a free download from bendix.com).

A couple of other key points to keep in mind:

- The addition of the technology does not change your already-safe driving practices. Electronic Stability Control still requires a driver to be alert and practice safe driving habits. Go into a 20 mph turn at 60 mph and the system will engage, but the laws of physics take over and you are going to roll over.

- NHTSA went with full-stability, not roll-only stability control (RSC). ESC technology helps drivers mitigate both rollovers and loss-of-control crashes – it is the better technology. RSC only helps in rollover situations, typically on dry surfaces. Many rollovers start with a loss-of-control, especially on motorcoaches. That's why ESC was chosen over RSC for the mandate.

Lastly, what's next? Collision mitigation technology is high on NHTSA's agenda, with the expectation of a notice of proposed rulemaking likely next year (dependent, of course, on what happens with the November election!). A collision mitigation rulemaking will likely try to cover all classes from 3-8, meaning that stability control, an integral part of collision mitigation technology, will find its way onto these other vehicles. (NHTSA has already mandated stability control on class 1 and 2 vehicles.) In short, NHTSA will cover both bases with one mandate – getting stability on classes 3-6 while getting collision mitigation on all heavy vehicles. Not to worry, this regulation will likely not see implementation until the early 2020s.

Will this be the end of rollovers, loss-of-control, and jackknife crashes? No, regrettably not. But, it is a strong step in the right direction to do more to help drivers make it through the day safely.

Helping you make it home each night – that's why this is a good mandate.

Author's note: FMVSS 136, the regulation requiring stability on Class 7 and 8 tractors and motorcoaches, is on the chopping block as the Trump Administration requires elimination of two rules for every one added. This may be a mistake, as there is still a need for a low-cost, effective regulation to help commercial vehicle drivers mitigate rollover and loss-of-control situations.

GETTING TO SAFE AUTONOMOUS VEHICLE APPLICATIONS – NHTSA'S "FEDERAL AUTOMATED VEHICLES POLICY"

September 30, 2016

The National Highway Traffic Safety Administration (NHTSA) recently announced their "guidelines" for the development and deployment of autonomous vehicle technologies. While cars and light trucks get a lot of the press around driverless vehicles, this guidance is for all autonomous vehicles – Class 1-8 – that will be deployed in the U.S. Using the SAE (Society of Automotive Engineers) levels of automation, this will impact Level 2 and higher systems. A Level 2 system is defined as an automated system that can actually conduct some parts of the driving task; a human monitors environment but the human driver must take back control when system requests. This guidance, for the most part, is now in effect.

From my perspective, I'm not seeing this as in impact on current driver assistance systems like collision mitigation technologies. This guidance, however, will have an impact on potential systems down the road, such as platooning, highway pilot, yard maneuvering, and other applications that will more fully assist the driver. Plus, OEMs and suppliers are going have some additional potential reporting and are responsible should there be an issue. (Yes, fleets could see downtime if a recall is initiated, but that's really not different than today.)

Fleets will, however, have a greater burden to evaluate the technology that is being used. A lot of new players are entering the market – players that may not have the same level of testing, validation, and functional safety requirements to ensure robust performance. Since there are no "performance specifications" to be met, there is nothing to ensure proper performance of the system. It becomes more the word of the supplier or OEM. In other words, more so than in the past, buyer beware! Fleets will need to test and evaluate the technologies in their operations to ensure that they meet their needs and performance expectations.

> Overall, the guideline approach isn't a bad thing. A more flexible and nimble approach that enables technologies to get out into the field faster is a good thing. Plus, it is true – regulations take a long time – the stability mandate (FMVSS 136) took eight years to get from concept to final rule.

It's interesting that this is "guidance" but not a regulation. I'm reminded of the line from the "Pirates of the Caribbean" movies in reference to the "Pirate's Code," paraphrasing of course: "It's not like they're 'rules' … they're more like 'guidelines!'" Kind of implying that they aren't hard and fast, but flexible.

To an extent, this is what the Agency is trying to do … recognizing that autonomous vehicle technology development is moving rapidly and that regulation takes time. So, why not deliver on a need to ensure safety but also deliver flexibility to enhance innovation? That's why these guidelines will be updatable over time. And, as appropriate, NHTSA can still move forward with a formal rulemaking process to deliver hard and fast regulations.

Keep in mind that these "guidelines" do have some teeth, and that the Agency is looking to Congress to give it an even bigger bite. If an OEM or supplier puts out a technology that isn't safe, NHTSA can utilize their defect, recall, and enforcement authority. Bottom line – if the technology crashes (literally), they can enforce a recall. And, you can likely bet that if the perpetrating entity hasn't followed the guidelines in its development efforts, the Agency may come down even heavier.

The Agency also makes a point that it can initiate enforcement actions, whether or not an FMVSS (Federal Motor Vehicle Safety Standard) exists for the particular issue. If the vehicle or technology poses an "unreasonable risk to safety" the Agency can and will act. Depending on how much latitude is taken by the Agency, the industry can determine whether or not this is judiciously and effectively applied or overly applied, resulting in court actions. Scalpel or hatchet – it's the Agency's choice.

NHTSA is also asking Congress for "new tools, authorities and regulatory structures" to help ensure the Agency can be more "nimble and flexible" in responding to the rapid advances expected in technology deployment. It will be up to Congress to make this happen – and a lot will depend on the outcome of the election. Candidly, I'm not sure I see a Trump administration embracing additional legislation to help an agency regulate more, so the additional bite could be smaller than the Agency hopes.

Aside from the regulatory stick, NHTSA is really looking for more information sharing between entities and the government. The Agency is smart enough to know what it doesn't know and is really looking for OEMs, suppliers, and other players in autonomous fields to open up and provide insight as to what's happening in their development process. They want to build their knowledge and expertise, which is a good thing. As businesses, however, OEMs and suppliers develop products for sale. A level of confidentiality is needed to avoid potential competitive poaching … this can't be a key to the patent office, so there has to be a balance: knowledge sharing to a point that doesn't create a competitive disadvantage for the inventing entity while at the same time helping the Agency stay informed and up-to-date to aid in their efforts.

Overall, the guideline approach isn't a bad thing. A more flexible and nimble approach that enables technologies to get out into the field faster is a good thing. Plus, it is true – regulations take a long time. The stability mandate (FMVSS 136) took eight years to get from concept to final rule. When it comes to autonomous applications, mandating yesterday's technology tomorrow is never a productive approach, especially where safety is concerned. It does mean, however, that OEMs and suppliers need to keep these guidelines in mind throughout their autonomous application development process. This also isn't a bad thing – better to have the expectation of what the Agency will expect instead of getting blindsided after the product is on the market.

These guidelines do not have the same specificity as a regulation, so there will likely be interpretation issues. And, of course, regulations are not out of the question. Flexibility and speed, however, are good things. Will the guidance approach work? Time will tell.

In my next blog we'll get a little deeper into the details. This guidance is integral to moving forward on future autonomy … it's worth exploring!

DRIVER ASSISTANCE IS NOT DRIVER REPLACEMENT

October 28, 2016

We've all heard about the recent Tesla car crashes involving their Autopilot product. One case resulted in a fatality as the system did not detect that truck turning in front of the car, and despite Tesla's warnings that the driver should be paying attention, it appears the driver was distracted at the time of the crash. The result? Sadly, one less driver on the road.

The problem, from my perspective, is simple – driver assistance systems are being sold as driver replacement systems. Or, if not sold, they are being interpreted by the folks using the system as driver replacement systems. Tesla calls its system Autopilot – which, in my mind, does make me think of autonomous driving, not driver assistance. Autopilot on a plane flies the plane, why wouldn't a driver using an autopilot system on their car not expect the same?

We call our product Wingman®, which doesn't say pilot. It implies exactly what it is, that the system is there to help the pilot of the commercial vehicle – the driver. This is one of the reasons why every presentation that I do regarding Bendix technologies starts and ends with a reminder that the driver is always responsible for the safe operation of their vehicle. Driver assistance is there to help, but it does not replace the need for a safe and alert driver practicing safe driving habits.

There's been so much hype about autonomous driving, and promises of the driverless vehicle arriving shortly. The Google car, the Tesla Autopilot, etc. It's important to realize that this is creating a mindset that soon there will be no need for drivers, that vehicles will control themselves and we'll just be able to sit back and enjoy texting, talking, or other activities that don't involve a steering wheel, accelerator, or brakes while hurtling down the road at 60 or 70 miles per hour. Don't bet on it … It's not going to happen as quickly as folks think or would like to envision. There's too much that needs to happen outside of the technology – from regulations on the federal, not state level, regarding performance of these systems to consumer acceptance, and more importantly, understanding about what these systems can and can't do – the pathway to autonomous or driverless vehicles starts with increasing autonomy in driver assistance systems.

> The problem, from my perspective, is simple – driver assistance systems are being sold as driver replacement systems. Or, if not sold, they are being interpreted by the folks using the system as driver replacement systems.

In fact, we should redefine and clarify – driverless is driverless; autonomous typically means autonomous applications that are designed to assist, not replace, the driver. And, we need to communicate this in a very clear and meaningful way both in promoting the technologies as well as in the vehicle. If an autonomous system is in use, the driver needs to have hands on the wheel and butt in the driver seat, or the system will loudly and annoyingly alert the driver that it is going to disengage. Three times in a power cycle, the system goes dormant and the driver has to drive. We can't bury it in the operator's manual – it needs to be clear, concise, and direct. Use it properly or lose it quickly – before you or someone else gets hurt.

Don't get me wrong – I'm a big proponent of these systems and appreciate the fact that they can and do help drivers on a daily basis. But we have to keep in mind the responsibility is still with the driver. We are not at the point of driverless vehicles – in fact, we're far from it. We are, however, at the beginning of advancing systems to do more to help the driver on the road in a variety of situations. From collision mitigation today to more advanced systems that will offer lane keeping and other driver assistance technologies.

The future promises a great deal – and as a CDL holder I'm excited about the possibilities. But for now and the foreseeable future, it's driver assistance, not driver replacement.

I'm not giving up my CDL anytime soon and neither should you!

DRIVERLESS TRUCKS – WHEN? HOW? WHY?

August 28, 2017

The automotive and trucking industry has seen a boom in the development and testing of automated and autonomous technologies. Development of these systems at Bendix is driven by increasing the capabilities of advanced driver assistance systems (ADAS) to build a pathway to the future by evolution, not revolution. Today, Bendix applies these technologies to trucks to aid truck drivers. And we think that drivers, assisted by these evolving technologies, will be the foreseeable future.

This perspective and approach is nothing new for Bendix. Overpromising and underdelivering may be the purview of some venture capital companies pushing technologies that may not be quite ready for prime time to the market. But it's not the vision of a company that has seen technologies – promising to revolutionize the world – never make it past the demonstration stage. Always keep in mind, demonstration is not commercialization!

The problem is the hype regarding when we will become truly driverless – both in passenger cars and commercial vehicles. Will there one day no longer be a need for drivers? If so, when? If so, why – what benefits does the fleet gain from the loss of drivers?

Questions needing answers always provides the perfect opportunity for a little market research.

Ask and Ye Shall Receive

At Bendix, we've developed our own thoughts about when autonomous vehicles will be truly driverless, or as SAE (Society of Automotive Engineers) and NHTSA (National Highway Traffic Safety Administration) put it – Level 5 autonomy. But what we think and what you think may be different – so can we narrow the time frame and get to a realistic date? Can we determine the advantages? And how do we get there – cars or trucks?

Yes, we can. Just by asking. So we did! By doing a brief, online survey to the fleets that have attended our many demos over the past couple of years. We sought to find out what they thought. Figuring these folks are interested in advancing driver assistance technologies – by virtue of their attending demos and wanting to see what's available and what's coming down the pike – we believed it might be a good way to get a handle on questions around the automated and autonomous future. Our survey provides a directional view we think is worth sharing. Actually, we feel pretty good about the general consensus the responses indicate. That's because we've correlated them somewhat by asking similar questions of the variety of industry segment participants we present to – and the results correlate.

What did we ask? Three basic questions make up this study:

- "When do you think we'll see more than 50% of the trucks on the road being truly driverless (Level 5) and traveling coast-to-coast and all points in between?"
- "Which do you think will be first, driverless cars or driverless trucks?"
- "What do you see as the biggest advantage of driverless trucks?"

Let's look at the results and offer up a few thoughts. And we'll give you the opportunity to weigh in at the end.

When Will We Get to Critical Mass of Driverless Trucks? Between Now and Never!

Responses to question one, "When do you think we'll see more than 50% of the trucks on the road being truly driverless (Level 5) and traveling coast-to-coast and all points in between?" varied greatly, with about 15% of respondents thinking this will happen by 2030, 38% thinking by 2040, and 33% going out to 2050 and beyond. Also, about 14% of respondents indicated they thought this will never happen! So it seems it's almost anyone's guess as to when we will achieve critical mass of driverless trucks on the road – somewhere between now and never.

One point that the majority of respondents to our survey agree upon is that driverless cars will lead the way. A whopping two-thirds of respondents indicated they saw driverless cars being first.

And that's probably not too surprising. Like political punditry, speculation on the future is fraught with a basic reality: No one really knows what's going to happen until it happens. But, we all have opinions, we all have thoughts, and we all like to take a guess.

Driverless Cars Will Be First

One point that the majority of respondents to our survey agree upon is that driverless cars will lead the way. A whopping two-thirds of respondents indicated they saw driverless cars being first. Only about 17% felt that driverless trucks would happen first, while another 17% felt that there will always be drivers behind the wheel.

This result is also not too surprising – a lot of what we see in advancements today are around light vehicles. With much larger annual production rates for light vehicles than for heavy vehicles, it makes sense that cars would be first. We saw it with stability, we saw it with adaptive cruise control, and we saw it with collision mitigation on commercial vehicles. Why? A number of reasons exist, from more resources to more support. However, one clear reason is market size, which enables new technologies – and their components – an opportunity to grow rapidly, delivering larger economies of scale quickly that reduce the cost of components. Millions of cars are built annually, compared to thousands of trucks. So, components (sensors) needed to deliver a driverless experience can become more widely available in a shorter time frame and at lower costs.

One example is when we built our original adaptive cruise control technology upon an automotive radar. While we developed the commercial vehicle logic to make this work in our market, we needed a cost-effective component to make this happen. The sheer volumes available in the auto industry almost make it a quid pro quo – to get to autonomy on trucks, it has to start with cars. Cars need to lead, otherwise the technology may be too expensive to deliver to the typical fleet and will never make it to the market.

Benefits of Driverless? A Little Bit of Everything.

When asked about the biggest advantages of driverless trucks, not too surprisingly, folks were fairly evenly divided in their response. About a third of the respondents felt that driverless trucks would lower costs for the fleets. This thinking is likely driven by the fact that drivers account for a significant portion of overall costs at the fleet (reduced costs), and that driverless trucks won't be subject to Hours of Service (HOS) guidelines, resulting in improved equipment utilization.

Almost 30% of respondents went with safer roads. As we've discussed in other blogs ("By the Numbers," Parts 1 and 2 – July 6, 2017 and August 21, 2017 respectively), crash rates for large trucks have been increasing over the last few years. Driverless trucks should help reduce (possibly eliminate) crashes, so safer roads for all of us could be a likely outcome. Along the same lines, increasing penetration of driver assistance technologies – along with other efforts, including driver coaching and training, as well as stronger preventive maintenance efforts – should also help reduce crash incidents until the day we get to truly autonomous vehicles.

About a quarter of respondents indicated "more efficient freight delivery" as their perceived biggest advantage of driverless trucks. Driverless trucks are expected to save time – they can be better informed through direct communications with production equipment or loading points to help ensure delivery of goods when needed, or be ready to be accepted by the receiver. Fewer trucks waiting in queue to drop loads, fewer drivers waiting around for pickups or deliveries, specialized trailers, more hub and spoke systems, automated loading and unloading equipment, and other aspects all contribute to improving freight efficiency.

Last, but not least, on our list of biggest advantages is improved fuel economy. A little over one in 10 respondents saw this as key for driverless technologies. An autonomous vehicle would likely operate more efficiently; be able to participate easily in more fuel efficiency-gaining road approaches, like platooning; and be designed to improve fuel efficiency through advanced aerodynamics and lightweight materials. Without a driver, you don't need a cab, you don't need a sleeper, and you don't need safety structures or excess weight for added equipment to support the driver. Removing these items enables a more efficient design, and quite likely, more efficient powertrain approaches – such as renewable electric powertrains instead of fuel-guzzling diesel powertrains – to lower fuel-related costs.

Of course, there may be other advantages that we didn't list, which may sway the results a bit differently, and further research may open this up a bit. But, in the interim, given the four choices, it's interesting to see a diversity of perspective.

Wrapping It All Up …

The results of our survey yield some interesting, if not too surprising, perspectives:

- Still a lot of questions regarding when driverless reaches critical mass
- An expectation of cars leading the way
- A variety of benefits for the fleet

So what do you think? Take our survey at Survey Link:

https://www.surveymonkey.com/r/Autonomous_Future

We'll update the results in a future blog.

Who's going to be right? Only time will tell!

Matthew Manocchio, Bendix Controls Marketing Co-op (January-August 2017), contributed to this blog post.

WHY TRUCKERS ARE STILL NEEDED

March 22, 2017

Drivers, disco, and dinosaurs – what do all three have in common?

Extinction! Well, at least one would think so with all the hype around driverless vehicles happening in the near future. Transparency alert: Of course, I don't really mind the idea of dinosaurs being extinct, especially after the "Jurassic Park" series. As for disco, it just never was my cup of tea.

Drivers, on the other hand … I'm not so quick to proclaim the demise of the truck driving profession in the face of the autonomous future. Drivers have been, are, and will be the key to trucking transportation for a good while to come.

Why are drivers going to be around for longer than the technologically roaring 2020s? A few reasons come to mind:

- First, while there have been some impressive demonstrations of "driverless" technology – there were several that took center stage in 2016 – these have been just that, demonstrations. **It takes extensive, integrated development work to go from a mere demonstration, where you can control most of the variables, to commercialization in the real world, where you can't control the variables.**
- Second, the focus of a lot of these new technology companies and their automated/autonomous truck applications is really only on one application – interstate highways (better known as divided, limited-access roadways.) It's not the city driving – like in package delivery (P&D) – that's being automated. If you're a local P&D driver, I believe it's safe to say that there will be no automated function here until we truly get to Level 5. The system will still require a driver to get the vehicle from the terminal to the limited-access highway, and then from the limited-access highway back to the terminal. Let's not forget that it will also require a driver, along with their GPS, to figure out a better route when the limited-access highway is backed up with traffic. And then, likely, to drive the truck on the state route that gets him/her around the traffic jam.
- Next, the automated/autonomous ecosystem. Yes, technology makes the vehicle autonomous, but it's everything around it – from overall safety and societal acceptance to customers and regulators – that puts the technology on the road. Federal and state regulators want to make sure the technology isn't going to create issues when it's on the road – especially as far as safety for everyone else on the road is concerned. Also, not all of society is ready or interested in vehicles

that drive themselves. Plus, vehicle operators who purchase the technology are going to expect to see some kind of financial savings (ROI) for using the technology – if it doesn't pay for itself relatively quickly, they are not going to buy it. (Ask yourself, would you add a $30,000 or so adaptive cruise control with steering to your truck so you might be able to leave the seat and get a coffee? Probably not – it would be one expensive cup of coffee!) And, if the driver can't use the time not driving to do something else, due to the current regulation, the potential productivity enhancement of automated/autonomous driving won't be there – and the Feds need to let that happen.

- And finally, weather and infrastructure. If the system can't see the lines due to pooling water creating issues, or snowfall, the system isn't going to function unless it has an alternative source of information. GPS isn't accurate enough to position a truck in the center of a lane, so there must be some type of vehicle-to-vehicle (V2V), or vehicle-to-infrastructure (V2I) communication to get this done. And while we have a notice of proposed regulation for a mandate requiring V2V communications on vehicles, there's nothing yet on requiring this technology for commercial vehicles. (Current expectations call for something in 2018; however, the new administration's point of view on regulations may significantly slow that process.) And, right now there is nothing on V2I requirements, though this will be needed to help ensure vehicles know where they are in terms of lanes on the road. Bad weather is a constant possibility, so we'll have to build up the infrastructure to deliver a means of ensuring lines are visible, even when they're not.

Now don't get me wrong, evolution will occur. But it will be just that – evolution as opposed to revolution. There will be ongoing major and incremental improvements to advanced driver assistance systems over the next 20-30 years that will help drive automated trucks forward to eventual autonomy. Note the word automated – not autonomous. A human driver will still be involved in the operation of the vehicle as this evolution occurs. After all, these are driver assistance systems, not driver replacement systems.

So what can a driver expect to see in the future? For starters, technology will continue to advance – making the job easier and, most likely, safer. Today, a collision mitigation system cuts throttle and applies the brakes – controlling deceleration. In the future, we'll see more acceleration and deceleration control. Also, we'll add steering to the mix – for such things as yard maneuvering (moving and parking the tractor-trailer at the dock and bringing it back to the driver) and highway pilot (or adaptive cruise control with steering – tractor-trailers on freeways that are able to steer, brake, and accelerate on their own in this application). Expect to see more sensors integrated, along with various functions – such as collision mitigation, platooning, and sideswipe mitigation – as the systems continue to evolve. Again, these technologies are not taking the place of the driver, but helping the driver do their job safely.

Regulations will also have to change to allow the productivity potential for automated systems to be realized. This could mean drivers able to drive longer days because they are able to take rest breaks while the truck is traveling autonomously down the road. As a CDL holder, personally, I'm not sure drivers can do more than a 14-hour day, with 11 hours of driving safely, but something will likely change to help deliver on the productivity promise of automated/autonomous driving. Again, this is not an aspect I'm expecting soon, as the wheels of government tend to turn slowly at best. And, until we get to the highest automated level – where a driver is not needed in any circumstance for the vehicle to get from point A to point B – drivers will be needed to take over control when the system needs them. All this means drivers will keep their place behind the wheel, even when the automated system is operating … just in case.

> While there have been some impressive demonstrations of "driverless" technology – there were several that took center stage in 2016 – these have been just that, demonstrations. It takes extensive, integrated development work to go from a mere demonstration, where you can control most of the variables, to commercialization in the real world, where you can't control the variables.

Speaking of driverless … when do we get there? Projections regarding Level 5 driving are all over the place, but today, 2050 seems a likely time frame as to when we'll start seeing more and more truly driverless applications happen. Again, it's not like anyone is going to shut off human-driven vehicles, but it's possible that we may see a start to limits on where these vehicles can travel. As with any projection, there are always things that can change the trajectory of development – either speed it up, or slow it down. For example, if vehicles aren't communicating with each other and the infrastructure, as noted, is inadequate or absent, it might be difficult for there to be actual autonomous trucks. Or, if a new technology innovation doesn't work as planned – it is a factor or cause of a very bad crash, prompting legislators and/or regulators to decide that this needs to be more controlled through performance testing and validation – this also could slow the process. Along the same lines, a technological advancement could leapfrog development – such as newer, more high-speed computing chips, cooling systems, or sensors – and move true autonomous vehicles to commercialization.

So what should a driver, or someone who is thinking about being a driver, do? Our industry, and our economy, needs drivers. No one has that proverbial crystal ball to know what the future will bring and when, so don't let that stand in the way of a fulfilling career. If you want to drive, drive. For those of you who are already drivers, for now, don't give up your CDL anytime soon – I'm not!

WHY THE FUTURE DOESN'T HAPPEN OVERNIGHT

March 15, 2017

Optimism in technology can sometimes run rampant – remember that we were all going to be paperless by the end of the last century? Now I'm not sure what your desk looks like, but mine is a bit buried under – what else – paper! Those stacks don't mean, however, that technology isn't prevalent in my world – I tend to prefer eBooks over paperbacks – but it does reinforce the idea that there is often still going to be a use for what we may think is going away. Why is this? Because, in the case of paper, there's still a belief, need, and even a personal preference to keep using tree fodder for reading, writing, and reviewing.

So what does this have to do with the world of automated/autonomous vehicles?

Today, there's a lot of talk about automated/autonomous vehicle technologies and, if you were to believe the pundits (and those beholden to venture capitalists), we'll be riding around in driverless cars and trucks within the next 5-10 years … or sooner! For example, Ford states it will have a driverless car that won't even have controls (steering wheel, pedals, or gauges) by 2021. Whether it will be allowed on the road, or functions in rain and snow, remains to be seen. My bet is that it will be a tourist attraction at Greenfield Village long before replacing cars on the highway. I say that because it's vital to keep in mind that demonstration of a technology does not necessarily equate to the commercialization of a technology!

The one thing that the pundits seem to miss out on is that delivering driverless vehicles (or even advanced automated technologies) involves more than just the technology. Also important is the ecosystem around this technology – and it's this ecosystem that is likely to slow the process of getting to true autonomous vehicles. The technology will continue to advance, no doubt, and we'll see more automation coming fast – like water through a garden hose – but getting to truly driverless is still a long way off. Why? Because the ecosystem will impact the speed at which the technology advances – or doesn't.

Nothing happens in a vacuum. Not even automated/autonomous vehicle evolution. Not until the ecosystem supports and embraces the technology.

Before we get into elements of the automated/autonomous ecosystem, at least from my perspective, let's define an "ecosystem." As you know from past blog posts, when it comes to definitions, I always reference dictionary.com. According to this source, an ecosystem has two meanings – "1: a system, or group of interconnected elements, formed by the interaction of a community of organisms with their environment. And "2: Any system or network of interconnecting and interacting parts, as in a business."

While either definition could fit, I lean more toward the second, primarily for two words – interconnecting and interacting. To me, as we move forward in the automated/autonomous ecosystem, interconnected and interactive best describe what we're going to see happen. The elements (OK, a bit of the first definition does apply) in our ecosystem need to be interconnected – without one area connected to another and verifying, clarifying, or basically understanding the others, any one element can slow or even stop the evolution of the ecosystem. Also, the elements need to interact with each other to deliver the clarifications, verifications, and understanding between them. Bottom line – we're not going to sell or advance a technology without having customers, and customers aren't going to buy the technology if they don't believe it is safe and effective. And, if it isn't safe and effective, the government is not going to allow it on the roads. I think you get the picture: Interconnectivity of the elements, and interaction among the elements, is needed for the ecosystem to survive, evolve, and prosper.

> Delivering driverless vehicles (or even advanced automated technologies) involves more than just the technology. Also important is the ecosystem around this technology – and it's this ecosystem that is likely to slow the process of getting to true autonomous vehicles. The technology will continue to advance, no doubt, and we'll see more automation coming fast – like water through a garden hose – but getting to truly driverless is still a long way off.

Now that we've defined the term ecosystem, let's discuss the elements, at least as I define them, in the automated/autonomous ecosystem. Overall, from my perspective, there are seven elements:

- ***First, the Functional Technology*** – This is the "what it does," not necessarily the "how it does it." There are a lot of ways to make the functional aspects of automated/autonomous vehicles work – such as utilizing different types of sensors, communications, algorithms, and controls. At the center of our ecosystem are four key functional technologies – those that deliver acceleration/deceleration, steering, information/connectivity, and redundancy. These are the basic functions needed for automated/autonomous driving technologies.
- ***Next, the Customer*** – There always needs to be a buyer. And there always needs to be a value for the customer to buy. That purchase, of course, must deliver a timely return on investment (ROI). After all, while the technology is exciting, we're all in business to make money. The technology

isn't chosen for the wow, it's chosen for the what – as in what it will do to lower costs, improve productivity, drive new revenue, or all three. No return, no interest, no future.

- ***An Evolving Industry*** – Have you ever considered that perhaps we're really not in the trucking industry? We're not. At the simplest, we're in the transportation industry. The purpose of our industry is to make money by moving goods (or people) from point A to point B on time, safely, and in good condition. There are many ways of accomplishing these basic functions besides putting the goods in a trailer, hooking it to a tractor, and hauling those goods cross-country. New approaches to performing this basic task, via land, sea, and air mean that the industry continues to evolve. Look at Amazon – distribution centers on land and in the air, and drone delivery of goods may be just the beginning. As the industry evolves, you have to ask yourself, where should automating modes really be occurring to better facilitate the basic function of transportation?

- ***And the Evolving Competitive Landscape*** – No matter who you are in the industry, you've got new competitors now, and you'll have new and different competition in the future. Guess what? Those new competitors are also your customers! For a Tier 1 supplier like Bendix, our OE customers are also becoming our competitors in the technological race. For fleets, shippers are becoming competitors – look at Walmart and how they are beginning to evolve to compete with Amazon. We've also got new competitors – 10 years ago, did you ever think Google would be developing automated vehicles through its Waymo spin-off? How about Uber Freight? New players and new ways of doing things mean a lot in terms of how we have to think, prepare, and compete. For Bendix and others in the commercial vehicle marketplace, the landscape is changing. The days of a product – or a product family – remaining virtually unchanged for 20-30 years are gone. Products now need to constantly be reevaluated and reinvented to keep up and to move ahead.

> Technology will move forward, but customers will or won't buy, competition will come and go, government will regulate or deregulate, and society will weigh in, especially if safety may be compromised. These elements will work together to help enhance or, if needed, temper the advance.

- ***Government Legislation/Regulation*** – Regulations are needed to ensure a safe and level playing field for development and application, as well as ensuring the infrastructure exists to make things happen. It's not about slowing things down – it's making sure that people and property stay unharmed as the evolution occurs. And it's about making sure that evolution isn't chaotic but controlled – to an extent. Regulatory and legislative actions will happen on all levels – federal, state, and local. We're already seeing it – states that allow or don't allow testing of automated technologies on trucks. And, it's not just about regulation and legislation. It also means infrastructure to help facilitate the advancement – from something as simple as making sure lines on the road are visible to adding fiber optic cable to enable vehicle-to-infrastructure communications. Helping to make automated/autonomous vehicles happen safely, efficiently, and effectively – and enforcing the rules to ensure a level playing field – will be the role of government in this ecosystem.

- ***Safety*** – No matter how automated/autonomous systems evolve, they have to be safe for all who may be impacted by them. The rush to put technology in the marketplace should not short the need for it to work safely for those in the vehicle and on the roadway. And, just as important, those using the technology must be aware of how it works and its limitations. Never forget the Tesla crash – while we can blame the driver for not using the system properly, we have to ask – did he abuse the system or did he just not know that he couldn't do what he was doing with the technology?

- ***And finally, Society*** – The silent majority isn't so silent anymore. Voices get heard across a variety of mediums, and if folks aren't comfortable with what's happening, they'll force change – or at least let everyone know they have concerns. This can be helpful, or detrimental to an automated/autonomous future. It will sure have an impact on how quickly we get to truly driverless trucks. Your kids may be comfortable with the idea of a driverless 80,000-lb truck, but are you?

These seven elements of the ecosystem are interconnected and will be interactive. Technology will move forward, but customers will or won't buy, competition will come and go, government will regulate or deregulate, and society will weigh in, especially if safety may be compromised. These elements will work together to help enhance or, if needed, temper the advance.

You may feel differently, or feel I'm missing something here. That's good. Your thoughts and perspectives are always most welcome!

As with this entire "Future of Autonomy" blog series, we'll also explore deeper into the automated/autonomous ecosystem and delve into more detail. For now, think of the ecosystem as a whole and how it might impact your company's place in it – today and tomorrow.

Are you thinking evolution … or extinction?

Like what you're reading? Want to learn more?
We welcome your thoughts: autonomous@bendix.com

ABOUT THE AUTHOR

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Bendix safety technologies complement safe driving practices and are not intended to enable or encourage aggressive driving. No commercial vehicle safety technology replaces a skilled, alert driver exercising safe driving techniques and proactive, comprehensive driver training. Responsibility for the safe operation of the vehicle remains with the driver at all times.