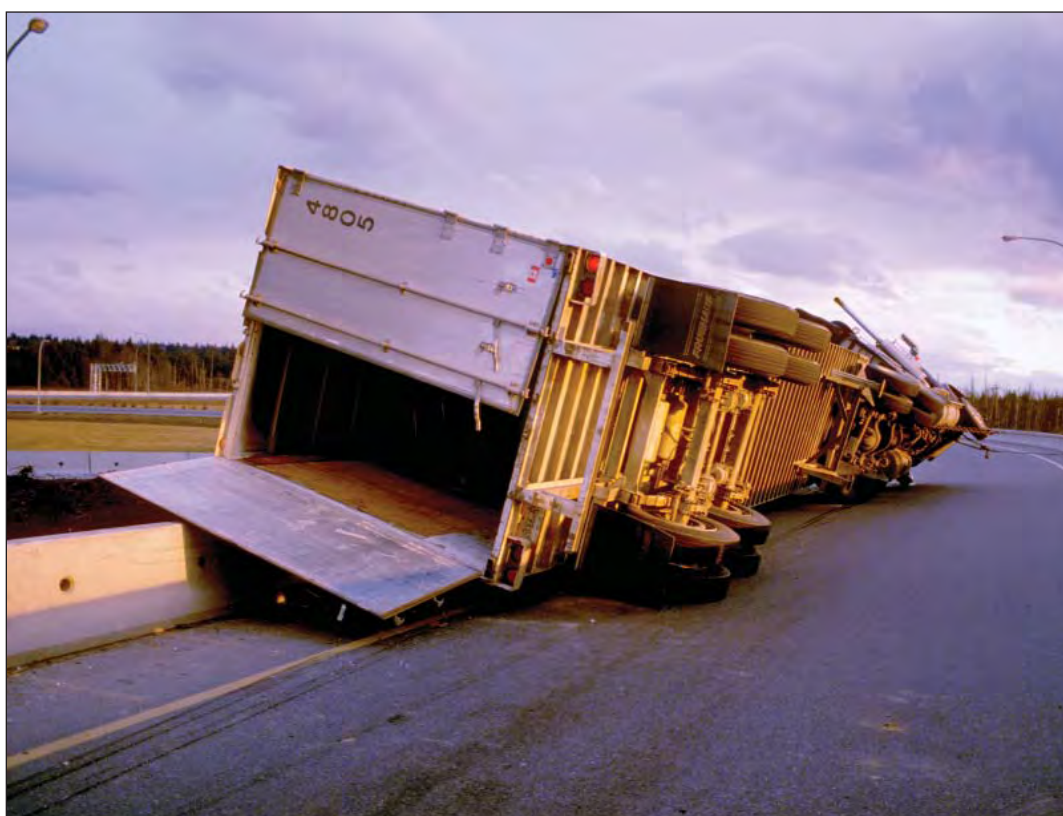


## 2017 FULL STABILITY AND THE ROAD MAP TO THE FUTURE – ARE WE STILL ON THE RIGHT ROAD?



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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.

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## EXECUTIVE SUMMARY

- Our original white paper “Roadmap for the Future” still holds value today as a benchmark reference document on stability systems for commercial vehicles. The differences between stability control systems – full stability and roll-only stability, which are still available on the market, as well as the important terms and the logic behind full stability (ESC – Electronic Stability Control) for single-unit trucks – remain essential concepts.
- Electronic stability control helps to mitigate both rollover and loss-of-control crashes on dry, wet, snow- and ice-covered surfaces, whereas roll-only stability (RSC – Roll Stability Control) delivers interventions to help mitigate rollovers on dry surfaces. Through additional sensors and braking capability, ESC delivers more information to enable a more robust intervention.
- 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.
- Since our original white paper in 2008, we’ve seen some decreases in stability-related events – rollovers and loss-of-control. This decline, however, is not as great as one would hope. The root cause is primarily due to adoption rates flatlining over the last few years, the changing mix of vehicles – more single-unit trucks being produced to meet growing construction needs – and still low penetration in the “available fleet,” or registered large trucks on the road.
- We agree with NHTSA (National Highway Traffic Safety Administration) that full stability, or ESC – which Bendix sells as Bendix® ESP® (Electronic Stability Program) – is the better stability technology because it can help drivers in more situations than roll-only stability. But we also feel the technology is even more effective than the Agency claims. This difference, delivered from our perspective, reinforces the importance of the technology and why it should not be dropped as a regulation.

- FMVSS 136 is not a burdensome regulation, as expected cost points are low, and implementation is already underway based on a number of OEMs making this technology standard. And, it's a regulation that helps solve a deadly problem still very much in evidence on our roadways.
- The current regulation is a good starting point for addressing stability situations, but leaves out single-unit or straight trucks.
- While societal impact of a regulation – along with cost implications for the fleet – are important, the addition of a technology often comes down to basic dollars and cents. The question is how much is it going to cost to add the technology, and what financial benefits are derived. While each fleet has a different need, all fleets share a common set of cost and benefit parameters that are required for consideration when evaluating whether or not to add a technology. Keep in mind that many OEMs are making safety technologies standard, which may make it easier to adopt the technology, but may also provide risks if the technology is deleted for a credit.
- Electronic Stability Control technology is not only important for today, but it is a cornerstone for the future. Current collision mitigation technologies are built on ESC as a foundation for robust performance. In the future, automated and autonomous applications – such as yard maneuvering, highway pilot, platooning, and other applications – will be built on this technology. Slower adoption may also impact a fleet's ability to retrofit technology in the future.
- Confusion in the market still exists regarding the differences in stability technology. Eliminating RSC eliminates the confusion. One system, ESC, works on all platforms for today and tomorrow.

Responsibility for the safe operation of the vehicle remains with the driver at all times. Stability control, or any safety technology, complements safe driving practices and is 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.

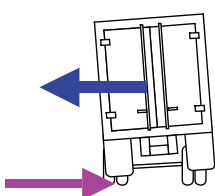
## STABILITY TECHNOLOGY – A PRIMER

When the original Bendix white paper was developed, there was a lot of confusion in the marketplace about stability control. The major arguments revolved around the cost and benefit of ESC (Electronic Stability Control), which we often refer to as “full stability,” versus roll-only stability or RSC (Roll Stability Control.) RSC – built on the ABS (Antilock Braking System) and ATC (Automatic Traction Control) system – adds an enhanced Electronic Control Unit (ECU) and a lateral acceleration sensor to help the driver mitigate situations on dry surfaces, such as when a truck goes around a curve too fast. Roll-stability systems typically brake using the tractor drive and trailer brakes – controlling the trailer brakes with a modulator valve – to mitigate a potential rollover. It’s a good system, but ESC is a better system.



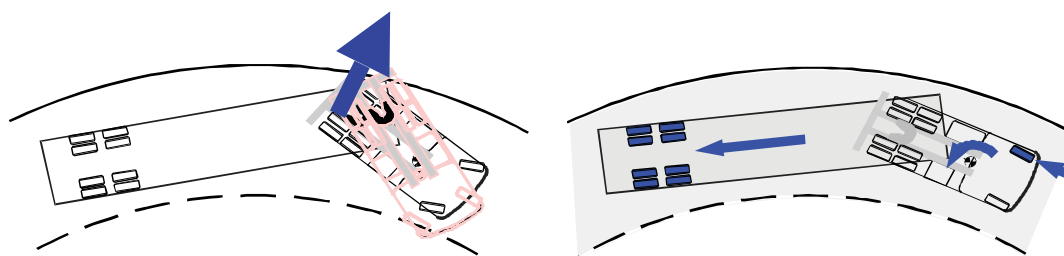
*Roll-only Stability Control, typically known as RSC, is really only effective in helping mitigate rollover situations on dry surfaces. Full Stability or Electronic Stability Control helps drivers mitigate rollover and loss-of-control situations on dry, wet, snow- and ice-covered surfaces.*

Electronic Stability Control (ESC) adds additional sensors: a steer-angle sensor, which measures driver intent (where the driver wants the vehicle to go); and a yaw rate sensor, which lets the system know which way the vehicle is going. These are in addition to the lateral acceleration sensor and an even more enhanced ECU. Full-stability systems also build upon the ABS and ATC systems on the vehicle, adding an additional traction control valve to the steer axle, along with a trailer modulator valve to provide air pulsing back to the trailer to control the trailer brakes in a stability intervention. ESC systems do more to help the driver mitigate more situations, including loss-of-control and rollover, and on more varied road conditions – dry, wet, snow- and ice-covered – than roll-only systems. More information into the system, via more sensors and a higher level of intelligence in the ECU, delivers interventions through throttle reduction and braking on the steer, drive, and trailer axles. This enables the system to deliver more support when the driver needs it.



*Figure 1: This graphic illustrates a vehicle turning to the right and the forces generated at the center of gravity (CG), noted by the blue arrow, pushing the vehicle to the left and the friction of the tire/road interface attempting to hold the vehicle on the road (lateral force), creating the tripping effect that results in a rollover.*

The best ways to mitigate rollover and loss-of-control situations are through steering and speed reduction. The optimal way to reduce speed is by applying as many brakes as possible to slow the vehicle down as quickly as possible. The best way to help the driver steer through a situation is by controlling the amount of pressure being applied to the brakes at particular wheel-ends, or not applying brake pressure at certain wheel-ends. For example, in a jackknife situation, we may want to control the brakes on one side of the steer axle and the trailer brakes, and not use the drive brakes to help the driver straighten out the combination. Figure 2 below illustrates this concept.



*Figure 2:*

*Over-steer situation without intervention*

*Over-steer situation with intervention*

ESC systems tend to deliver stronger rollover interventions than RSC systems. Why? Simply put, because a rollover starts with speed and steering input at the front of the vehicle. By virtue of having the steer angle sensor on the vehicle, the system can read the potential rollover situation sooner and react faster. An RSC system does not have a steer angle sensor and, therefore, has to wait until the lateral acceleration sensor picks up the shift in the center of gravity. Granted, this isn't necessarily a great deal of time, but time is of the essence in controlling rollovers. Earlier read of the situation means the brakes get applied sooner, helping the driver to mitigate the rollover. Plus, a full-stability system applies more brakes – remember, ESC uses the steer, drive, and trailer brakes, not just the drive and trailer brakes that a typical RSC system utilizes. More brakes, more stopping power, and earlier intervention to reduce more speed result in more help for the driver to mitigate the rollover.



*Full-stability is the premier stability technology to support all commercial vehicle applications, including vocational vehicles, such as cement mixers and motorcoaches.*

The steer angle sensor is also why full stability is the only system for single-unit chassis trucks (straight trucks, such as cement mixers or dump trucks) and buses. Getting an earlier read on a situation on straight trucks is critically important as the “instability impulse” moves quicker through a single-unit chassis than through a combination vehicle. This means a roll-only system would react too late, or need to be tuned so high that it can create further instability during intervention, which may lead to a loss-of-control and resulting crash.

Let’s take a moment to explore the “instability impulse” mentioned above. What do we mean by this term? The “instability impulse” is the signal sent through the chassis or combination vehicle that leads to a rollover or loss-of-control. People often assume that a stability event starts at the back of the combination vehicle because, in videos of rollovers, you will often see the trailer axles lift first, pulling the combination over. Well, you know what happens when you assume! The reality is that a rollover event starts at the front of the vehicle and is driven, as we noted earlier, by speed and steering input. These inputs send a signal to the back of the vehicle – the “instability impulse” – which leads to the trailer axles lifting and the resulting rollover. That’s why getting the read from the front of the vehicle is critical to enable a faster response – stopping or mitigating the instability impulse before it gets back to the trailer to begin the event.

This is also why you will find that tractor-based systems – both RSC and ESC – deliver a higher level of stability performance than trailer-based systems. The instability impulse has to reach the trailer system for it to react, which in some cases may be too late to mitigate the rollover. Given the choice of tractor-based or trailer-based only, the choice goes to the tractor-based system. However, this doesn’t mean the trailer systems are ineffective – a trailer stability system is still better than no stability system. And, when combined with a tractor-based stability system, we see the highest levels of rollover stability mitigation performance.

In a nutshell, ESC delivers the highest level of stability for commercial vehicles.

## WHAT'S HAPPENED SINCE 2008?

It's hard to believe that almost a decade has passed since Bendix initially authored its position paper on Electronic Stability Control (ESC). The piece – entitled “Road Map for the Future: Making the Case for Full Stability” – presented the logic surrounding the arguments for full stability over roll-only stability. Since then, a lot has happened regarding stability control – most all of it positive. First and foremost is NHTSA's (National Highway Traffic Safety Administration) (the Agency) long-anticipated Notice of Proposed Rulemaking (NPRM) in 2012, followed by a final rule in 2015, requiring stability on commercial vehicles.

**Why did the Agency choose full stability over roll-only? We discussed the differences earlier, but from the Agency's perspective, their research and testing soundly resolved that full stability would help prevent more crashes, reduce more injuries, and save more lives than roll-only technology. We agreed then and we remain resolute in our agreement today.**

Despite some differing opinions on the numbers developed in NHTSA's analysis – Bendix's perspective was that in their study, the Agency overestimated the effectiveness of roll-only and underestimated the effectiveness of ESC – we contend that NHTSA made the right call in its mandate decision. We don't make this assertion lightly: stability control is an area where we have extensive experience and expertise. We can examine crash data and make a compelling determination regarding the value of stability. Our experts also understand and communicate that stability control is not an end in itself: physics prevails and the technology will not prevent all rollover or loss-of-control crashes. Drivers are still a critical part of the safety equation today – they remain in control of the vehicle at all times – as they will be for the foreseeable future. That said, full stability is the better stability technology and can help drivers in more situations than a roll-only system.

FMVSS 136 took effect on August 1, 2017, requiring full-stability control on Class 7 and 8 (6x4) highway tractors. The decision, as advocated in our white paper, makes sense – ESC is a proven technology that does more than roll-only technology to help drivers mitigate rollovers and loss-of-control situations on dry, wet, and snow- and ice-covered roadways. Implementation of the mandate is over three years, with Class 8 motorcoaches requiring stability on June 24, 2018; Class 7 motorcoaches, and most of the rest of Class 7 and 8 tractors (6x2, 4x2, etc.), will require the technology by August 1, 2019.

At least that's the plan.



On January 30, 2017, President Trump signed an executive order to reduce regulations and the costs associated with regulations. The executive order, titled “Reduce Regulation and Controlling Regulatory Costs,” requires the Executive Branch – which includes the Department of Transportation (DOT), the home of NHTSA and FMCSA (Federal Motor Carrier Safety Administration) – to consider eliminating old regulations when promulgating new regulations. From the executive order:

*Times change, administrations change, and with these changes, the rules (and rulemakings) can also change.*

- “...it is essential to manage the costs associated with the governmental imposition of private expenditures required to comply with Federal regulations. Toward that end, it is important that for every one new regulation issued, at least two prior regulations be identified for elimination, and that the cost of planned regulations be prudently managed and controlled through the budgeting process.”<sup>(1)</sup>

Known as “two-for-one,” the primary intent is that if an agency wants to add a new regulation, it must drop two. A good idea, but even the best ideas can have unintended consequences, as former NHTSA Acting Administrator David Friedman wrote earlier this year:

- “Saving lives and avoiding injuries (from the Vehicle-to-Vehicle communications advanced notice of proposed rulemaking) would deliver savings of \$53 to \$71 billion, dwarfing the investments automakers would have to have to equip all vehicles with new technology (V2V communicators), therefore delivering positive net benefits within 3-5 years.
- “But under the ‘two-for-one’ executive order, those benefits just don’t matter, the lives saved and injuries avoided just don’t matter. Instead other regulations, like requiring seatbelts and brakes, would need to be repealed to offset the investment costs ... again, ignoring the lives lost and harmed along the way. And if (eliminating) those two (regulations) don’t cut the costs to industry enough, even more (regulations) would need to be eliminated, putting even more lives at risk.”<sup>(2)</sup>

Basically, this creates a potential conundrum for safety agencies. Give up current regulations – that are, today, saving lives – to bring out new regulations, or don’t bring out any regulations. While there are instances where not having a regulation is prudent, or where a regulation has outlived its usefulness and has been universally accepted as a standard component of vehicle development, safety regulations may be the exception.

Safety regulations are usually developed to solve a critical problem that is costing lives and that industry is not addressing directly – either because of cost, lack of proven technology, or misunderstanding the situation. Lack of a proven technology that will deliver results is a good reason not to create regulation. We recall the issues with commercial vehicle ABS when it was initially mandated and then rescinded – the then ABS technology simply wasn't ready for prime time. In addition, regulations should provide a reasonable cost/benefit for customers, society, and industry.

From our perspective, there is no doubt that some regulations need to be dropped – and with good reason, because they are outdated, technologically difficult to deliver, or ineffectual.

That said, there has to be more consideration given for safety regulations than just getting rid of them to make room for more. Dr. Friedman makes a good point – benefits matter for all of us who drive vehicles. It's more than dollars and cents ... it's lives saved and injuries reduced.

So, in adherence to this new Executive Order, NHTSA – in its recent “Budget Estimates for Fiscal Year 2018” – has offered up FMVSS 136, along with others, as a regulation the Agency feels can be dropped. Interestingly, the Agency failed to provide any insight regarding why this would make sense. And, as we'll discuss throughout this paper, there are a number of reasons why this particular regulation may not make sense to drop. (Why? Because stability incidents still occur, because not all manufacturers have made stability standard, and because the technology works.)

In NHTSA's budget request, the Agency is looking for \$1.8MM for its “Heavy Vehicles” program. (This is a reduction from the \$1.9MM requested, and still a drop in the bucket of their \$899MM budget request.) NHTSA justifies this request as follows:

- “... The number of traffic fatalities involving heavy vehicles (*defined here as a vehicle with a gross vehicle weight rating above 10,000 lbs*) account for more than 10% of all traffic fatalities ... Crashes involving heavy trucks often damage roadway infrastructure, close freeways, lead to subsequent multi-collision events, result in the death of other occupants, and cost millions of dollars in lost revenue to the economy.”<sup>(3)</sup>

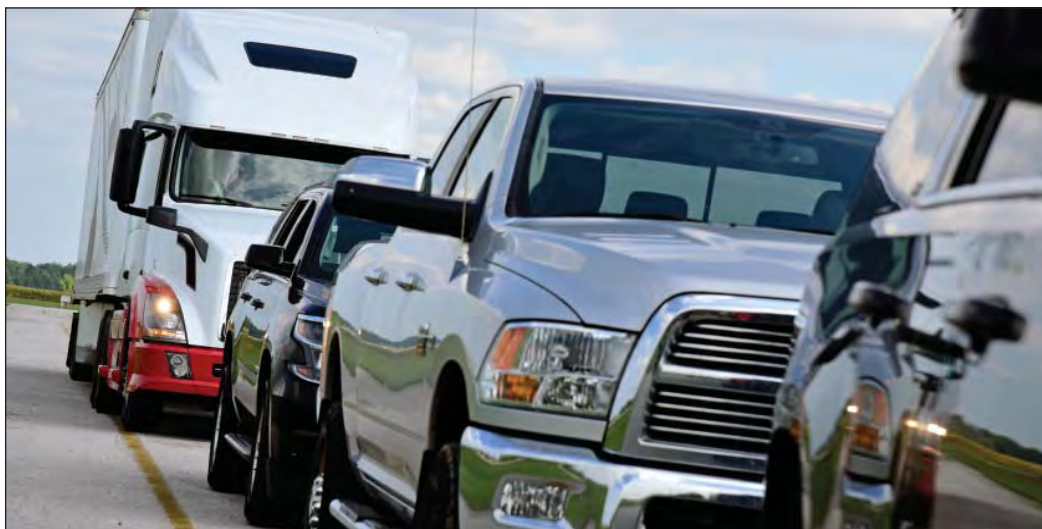
Remember that loss-of-control rollover crash of a gasoline tanker truck in Oakland, California in 2007? That crash destroyed two spans of a bridge that carried an average of 160,000 vehicles a day.<sup>(4)</sup> Luckily, the driver survived and no one was hurt in the incident. However, there was pain nonetheless. While the rebuild took only 26 days, “a state projection concluded that the connector collapse had cost \$90 million, based on a \$6 million per day economic impact estimate.”<sup>(5)</sup>

Real incident, real cost. But, regrettably, this is not the only time this has happened nor is it likely a similar incident will not happen in the future.

NHTSA also went on in their budget submission to indicate that as part of the heavy vehicles program, “(r)esearch will continue to investigate the possibility of extending stability control technology to single unit trucks and other types of heavy vehicles.” So, on one hand the Agency wants to get rid of the regulation, and on the other hand they want to continue research to expand the regulation. It’s perplexing.

While the Agency budget report may be a little confusing to read, one thing is certain: stability works and our position is that the Agency should reconsider its current recommendation to drop FMVSS 136.

Let’s explore the backdrop for our position on this issue.



*Crash or close call? In 2015, over 40,000 large trucks rear-ended passenger vehicles, according the Federal Motor Carrier Safety Administration. That’s one every 15 minutes of every hour of every day. Collision mitigation technology, built on ESC, could make the difference.*

## HAS STABILITY MADE AN IMPACT?

Looking back to 2008, when the white paper was published, according to the 2008 *Large Truck and Bus Crash Facts* from the Federal Motor Carrier Safety Administration, there were 11,283 large trucks involved in rollovers, with 5,190 large trucks involved in jackknives. Conversely, in 2015 – according to the final-release version of the *Large Truck and Bus Crash Facts* – 9,272 trucks were involved in rollovers and 4,226 in jackknives. Initial conclusions point to a decline of about 18 percent for rollovers and 19 percent for jackknives. One could conclude from the raw numbers alone that stability has helped.

*What's been happening with stability-related crashes in light of the increasing availability of stability technology? We'll update our analysis from a few months back.*

However, we need to delve deeper into the data to get a more realistic appraisal.

Let's start by taking a look at the vehicle miles traveled in each year. In 2008, large trucks traveled 310,680 million miles. In 2015, large trucks travelled 279,844 million miles – a reduction of million-miles-traveled-by-large-trucks of about 10 percent. So, the number of rollovers and jackknives decreased by a greater percentage than vehicle miles traveled – that's a positive sign for stability control.

Interestingly, vehicle-miles-traveled has been heading down since the peak of 310,680 million miles in 2008, in the midst of the Great Recession, reaching a low during the 2008–2015 time frame of 267,594 million miles in 2011. We've bounced back economically, but not as much mileagewise. This could also be indicative of changing transportation patterns – fewer and shorter runs.

Also of note, the number of registered large trucks increased over the period. In 2008, there were 10,873,275 large trucks registered. In 2015, 11,203,184 large trucks were registered – an increase of 329,909 large trucks, or about 3 percent. More trucks on the road could be indicative of more opportunities for rollover and jackknife situations. However, more trucks traveling fewer miles would not be. The average miles-per-large-truck-traveled in 2008 was 28,572.81; in 2015, it was 24,978.97 – a decline of 13 percent. More trucks traveling fewer miles.

Looking at a per-100-million-vehicle-miles traveled by large trucks, we can see the rate of rollover and jackknife incidents in the comparison years of 2008 and 2015. In this data, we find the following:

	Large trucks in rollovers per 100-million-vehicle-miles traveled	Large trucks in jackknife crashes per 100-million-vehicle-miles traveled
2008	3.63	1.67
2015	3.48	1.51
% Change	-4%	-10%

**The bottom line? While we’ve seen some decrease in rollovers and jackknives – both in terms of numbers and rates – the decrease is not as great as one might expect.**

So, what do we believe is the root cause? Three basic reasons come to mind – annual adoption rates, mix (or type) of vehicles sold, and penetration in the “available fleet”:

**First, adoption rates.** While we’ve seen steady increases in the annual take rates regarding stability since its introduction, coupled with full stability outselling roll-only stability at most OEMs, we’ve also seen a slowing in the percentage of new vehicles being built with stability technology. Basically, the industry has flatlined over the past few years at an approximate 33 percent take rate in Class 6-8 air-brake vehicles. As new vehicles are not being ordered with stability, or, in the case of where stability has been made standard – at Kenworth, Mack, Navistar, Peterbilt, and Volvo – it’s possible that fleets are opting to “delete” this option to lower the cost of their vehicle. Deleting a safety option is never a good idea, especially if there is a crash which the technology may have helped to prevent. However, there is little doubt that there are some fleets who truly feel that less-than-full stability, or even no stability, is of little concern, and so savings takes the place of safety.

**Second, mix of vehicles sold.** In recent years, as the economy has been improving and road miles decreasing, we may be seeing the mix of large trucks shifting from highway tractors to straight trucks (single-unit trucks) – especially in the oil patch, construction, and package delivery services. Stability is not yet standard on the air-brake applications (Class 6-8), though is often available as an option, and is not widely available on Class 3-6 hydraulically braked vehicles. (Keep in mind, however, that ESC technology is the only technology for straight trucks. Our 2008 White Paper reinforces this point on page 24.)

**Lastly, the penetration of stability technology in the “available fleet” – that is, all the registered large trucks (Class 6-8).** (The presumption here, as earlier, is that a registered vehicle is one that the fleet is likely to use in their operation – so it will see time on the road. While there may be exceptions, such as trucks registered but used for shows, promotions, or other non-commercial intent, these are likely few. This “registered vehicles” number provides us a good proxy of trucks likely on the road.) Taking our estimated market number of stability systems sold through 2015 – roughly about 746,000 units, of which one-third (248,418), presumably, are roll-only stability systems, and two-thirds (497,582) are full-stability systems – it’s clear that penetration in the fleet is relatively low. Only about 8 percent of the large trucks registered in 2015 have a stability-control system. (And, as we’ve discussed in the paper, roll-only stability does nothing to support loss-of-control situations – only about 5 percent of these vehicles had full stability.) Keep in mind, as well, that 78 percent of the large trucks involved in crashes were Class 7 or 8.

**There is a strong need to increase the penetration of stability control to help reduce the overall numbers of rollover and jackknife crashes. The mandate is a start to help make this happen. Losing the mandate, through the budgetary process, delay, or even deregulation, will likely lengthen the time it takes for stability adoption – slowing or eliminating any progress made in reducing rollovers and loss-of-control situations on our nation’s highways.**

All of this begs the question of what is an appropriate course of action. To that end, an alternative for the Agency is to consider regulation of collision mitigation technology, which typically requires full stability as part of the package. This is similar to the strategy the Agency used to ensure ABS became widely available on passenger cars. By requiring full stability on passenger cars – which, as in truck stability, is built upon ABS technology – the Agency was able to accomplish two objectives with one mandate.

Of course, the opposite could also take effect. Fleets could slow their decision to add advanced technology since some of the cost – the need for stability as part of the system – is not absorbed through the mandate. At Bendix, we see this as common practice in the market today. OEMs that have not made stability standard will charge a customer who wants collision mitigation for both the stability technology and the collision mitigation technology; among OEMs that have made stability technology standard, the cost to add collision mitigation is only for that technology – helping reduce costs for the fleet to add the technology.

We'll touch on costs related to the mandate later in this paper. For now, however, it's important to keep in mind that if stability is the foundation for future technologies, getting it standard on vehicles now means a lower cost path to adoption of more advanced technologies in the future.



# MEASURING STABILITY TECHNOLOGY EFFECTIVENESS – CHALLENGING NHTSA'S PERSPECTIVE



*Note: When considering why the mandate was originally proposed, it is valuable to consider the NHTSA perspective on pursuing the mandate in the first place. In the appendix to this paper, we review the comments Bendix submitted to the Agency regarding the mandate to illustrate the case for Electronic Stability Control over Roll Stability Control, utilizing the Agency's numbers, along with the analysis that Bendix provided in the original white paper. Our conclusion for the Agency remains the same today – ESC is the more effective stability technology for commercial vehicles. And, more important for tomorrow's automated and autonomous technologies, full stability is the foundation for the future. Today's Advanced Driver Assistance Systems (ADAS) are built on full stability. Tomorrow's automated vehicles will likely be as well.*

**For details on this analysis, see Appendix A. It includes our estimations supporting the original outcome of higher ESC performance. Our assessment showed a significantly greater difference – 31 percent, in fact – between ESC and RSC effectiveness, resulting in significantly more lives saved and more overall benefit.**





## THE CURRENT MANDATE – A LAUNCHING POINT WITH OPPORTUNITIES TO IMPROVE



First, even though full stability is available on Class 7 air-braked trucks, there is an absence on hydraulic vehicles – no system is readily available. Looking forward, we anticipate this will likely change, however, due to the population of Class 7 motor-coaches, some of which are hydraulically braked. This requirement for stability on hydraulically braked buses may open up the availability of full-stability control on medium-duty vehicles beyond those equipped with air brakes, closing the gap and enabling these trucks to benefit from the technology.

*While it addresses a significant heavy vehicle population, the mandate, in our view, has a drawback in that it leaves a sizable gap between Class 2 and Class 7 – the population of medium-duty trucks. The Agency, however, cannot be blamed for this missing piece.*

A second challenge – a byproduct from the mandate – is that it also omitted Class 7 and 8 single-unit trucks. These are all primarily air-braked vehicles. In some key applications, such as cement mixers and overhead bucket trucks, stability – which was ready at the time – can be quite beneficial for the vocational use. The expectation is that this exclusion, as well as one for hydraulic vehicles, will be addressed if the Agency moves forward with a collision mitigation mandate in the future. That future date, however, remains unclear and will likely require a change in administration, as it's doubtful we'll see much additional regulation forthcoming anytime soon.

And, finally, school buses were not represented as a vehicle class covered under the initial final rule. This is most disappointing because school buses do lose control, and stability can help mitigate that loss-of-control and the eventual tip-over that occurs when the bus hits a curb or guardrail. While school buses are still one of the safest modes of transportation, when they crash it is heart-wrenching. Uncertainty shrouds their inclusion in future mandates, but it's gratifying to know that some bus OEMs are starting to make the technology readily available.

## THE BOTTOM LINE FOR FLEETS IS THE BOTTOM LINE

In the 2008 White Paper we discussed “The Safety ROI of Stability Systems” beginning on page 31. In the 2017 update, we’ll take a different tack and outline what a fleet should consider when thinking about safety technologies. The basic elements in this equation can be applicable to discussions beyond stability, and may provide a framework for consideration and evaluation to fit the individual need of the fleet. At the very least, if the fleet is not considering some of these elements as they evaluate the addition of safety technologies to their vehicles, it would be beneficial to consider the missing elements to help develop a fully thought-out conclusion.

### **Costs:**

It all starts with understanding the costs of a technology, but extends well beyond just acquisition costs. In a nutshell, the costs relate to the following categories:

- *Acquisition cost of the technology:*
  - Option cost (from the OEM databook used by fleets):
    - Or, opportunity cost from a delete credit if the technology offered is standard. (See “A note on standard position of safety technologies” on page 23 for additional details.)
  - Less:
    - Discount available from OEM
    - Discount available from dealer
    - Discount available from supplier
    - Other acquisition cost discounts available
- *Installation costs:*
  - Cost to install option (if retrofit is an option versus built on vehicle):
    - Are there other options (such as stability for collision mitigation) required for the technology?

- *Taxes on the option:*
  - Federal Excise Tax (FET):
    - Less FET Discount for Technology
  - Other Federal, State, Local taxes:
    - Less Federal, State, Local Tax discounts
- *Maintenance costs over the life of the vehicle (either in-house estimates or dealer estimates):*
  - Preventive maintenance:
    - Maintenance required to keep the technology running properly. In the case of stability technology, for example, this would include realignment of the steer angle sensor when front-end work is completed.
      - Estimated parts replacement
      - Estimated labor to fix or install
  - Repair maintenance:
    - Elements that may require repair, such as the brackets for sensors or other components
      - Estimated parts replacement:
        - + Keep in mind sensor replacement costs, as most electronic sensor are not repairable and therefore need to be replaced
      - Estimated labor to fix or install parts
  - Deduct from the maintenance cost of potential warranty coverage estimates:
    - Will required repairs be covered under the vehicle manufacturer's warranty, an extended warranty, or the supplier's warranty?
  - Extended warranty costs:
    - What is the additional cost should the fleet decide to get an extended warranty from the vehicle manufacturer to cover the components?
      - Fleet should also make sure that the technology will be covered in any extended warranty – is it bumper-to-bumper or just drivetrain coverage?

- *Training costs (or cost of implementation):*
  - Technician training required for new technology:
    - Who will supply this training and how will it be accomplished?
      - Does the supplier provide support for training technicians on the new technology?
    - How much time will it take? How much will it cost?
  - Driver training required for the new technology:
    - Who will supply this training and how will it be accomplished?
      - Does the supplier provide support for training drivers on the technology?
    - How much time will it take? How much will it cost?
    - Is there a cost regarding drivers who will not drive a truck with the technology installed?
      - If so, include the acquisition costs and training of replacement drivers
  - Are new, specialized skill levels required to implement the technology?
  - Are new personnel required to implement, maintain, and service the technology?
    - How much will these resources cost (salary and benefits)?
    - Can these resources be made available via outsourcing? If so, what is the cost per year?
- *Insurance costs:*
  - Will insurance costs increase (or decrease) by adding the technology?
- *Regulatory costs or savings:*
  - Does the technology reduce (or increase) the likelihood of inspection issues?
- *Other costs:*
  - Are there other costs associated with this technology, such as requiring a different type of fuel, or a more expensive modification to the truck, to accommodate?



*Getting costs and savings into focus is important. Safety technologies cost, but they can also save – money, lives, time, and reputation.*

### **Savings:**

It's a foregone conclusion that no fleet typically adds a technology without some expectation of savings. In general, the expectation for technology ROI is to deliver a payback within 18-24 months – of course, the sooner a technology can pay for itself, the better it is for the fleet's bottom line.

Savings (or benefits) can come from a number of expected and sometimes unexpected sources. Consider savings from these areas in your calculations:

- *Savings from crashes that do not happen:*
  - This one is fairly easy. If you had crashes before the technology deployment and now you don't – or you have less severe crashes – then the savings from crashes are the benefit derived. Savings from crashes include:
    - Vehicle (tractor and trailer or truck) repair costs eliminated
    - Vehicle downtime costs eliminated
      - Revenue lost from vehicle repair resulting from a particular crash type
      - Cost of rental units to handle workload
    - Cost of cargo damaged or destroyed in crash
    - Cost of lost customer (annual customer revenue lost)
    - Replacement vehicle costs (more expensive truck to replace one lost)
    - Medical and insurance costs for injuries to the driver and others involved in a crash
    - Replacement costs for drivers who elect to leave the industry after a crash
    - Property damage and injury costs to others involved in the crash
    - Environmental damage repair costs – such as when a tanker rolls over and spills its load, requiring cleanup
    - Legal fees and settlement costs related to lawsuits that may have been avoided due to crash events not occurring
      - Also may position the fleet as more safety-conscious when it comes to other crash situations not related to a specific technology
    - Increase in insurance costs
    - Profit loss from self-insured payouts from net income

- Other areas, beyond crash costs, that may benefit the fleet financially:
  - Reduced risk profile for insurers, resulting in lower rate
  - Improvement in CSA scores from crash reduction
  - Meeting customer requirements for safety improvements, resulting in new business gained
  - Better driver retention; helping younger drivers through the learning curve
  - Data from systems to help improve driver training and prevention of other potential crash issues not directly related to the technology
  - Competitive differentiation – you’re making the investment in safety; your competitor is not. Prospects may see this as a benefit of doing business with your fleet.
  - The ability to upgrade your fleet to future technologies – retrofitting advanced driver assistance technologies will become more commonplace in the future. Having trucks equipped with a basic technology, such as stability control, means a vehicle may be more conducive to an upgrade to newer, advanced technologies as they become available. This could result in additional future savings. While it may be difficult to quantify, consider the cost of acquiring a new truck in the future with the technology compared to the ability to “bolt on” the same technology to an existing fleet vehicle.

Suffice it to say, contingent on your fleet’s operating profile, technologies can help reduce crashes. As an example, during a recent fleet visit, the leadership relayed that stability control was a “no-brainer” for their operations. They shared that, once a month, on average, they experienced a rollover. Now, with stability in place on their vehicles, the issue has evaporated. Stability technology works – saves lives, reduces injuries, reduces costs, and improves profitability.

As discussed in the original White Paper – many fleets find that if the technology helps to prevent even one crash, it will pay for the addition of the technology across their entire operation.

***A Note on Standard Position of Safety Technologies:***

There is another aspect that should be considered from the fleet perspective. More and more, we're seeing safety technologies becoming standard on commercial vehicles. For example, stability control is now standard at a wide range of tractor and trailer manufacturers, and collision mitigation technologies are finding their way into standard position at an increasing number of OEMs as well. In fact, in July 2017, Volvo made the Bendix® Wingman® Fusion™ safety technology standard on their VNL and VNR models – a first for North America – while Peterbilt, Kenworth, and Navistar have made the Bendix® Wingman® Advanced™ collision mitigation system standard on their highway vehicles. Navistar's action in October 2016 was also an industry first.

Standard position typically means that when you buy the truck, it comes equipped with the particular technology. Standard position, however, doesn't mean that fleet operators necessarily opt to buy the truck or trailer with the safety system included. Often, the vehicle manufacturer will offer a delete credit should you elect to eliminate the technology on your vehicle. (And, as is often the case, new truck sales reps may often simply match a previous spec on new orders without consideration of the safety technology addition. Delete credits can range widely – from zero dollars to thousands of dollars – depending on the particular standard system. While electing a delete credit aids in reducing the cost of the new vehicle, it comes with a potential price nonetheless. *(Visit the Bendix multimedia center at [www.knowledge-dock.com](http://www.knowledge-dock.com) to read our blog post dated November 10, 2016, titled "Check Your Spec.")*

Now, deleting options that don't impact safety can be a relatively safe thing to do, if you feel that the offering may not be applicable to your fleet. For example, should you pay extra for navigation when there are a number of off-the-shelf approaches that may be more cost-effective? However, it is prudent to pause before considering deleting a safety system.

Why? It's vital to deliberate the impact of removing a safety system merely on the premise of saving money on your initial vehicle purchase. Consider the potential issues that may occur if you delete an option that may have helped to prevent a particular situation and that situation arises. For example, you elect to delete the rear-end collision mitigation technology to save, say \$2,500 on the cost of your truck, and that particular truck rear-ends a mini-van on the highway. All other considerations aside, the cost of that single crash could be the difference between a profitable year and a loss. Take into account more than just the cost of the option. Consider the impact on your fleet's reputation, the potential downtime from the loss of a vehicle and/or driver, the cost of cargo damaged or destroyed – and, the cost of litigation from a possible lawsuit(s) that can result from the incident. In today's litigious society – without inciting fear unnecessarily – it is both prudent and highly practical to very carefully evaluate all the potential implications and resulting costs, not just the immediate savings, before electing to delete a core safety technology.



*A fleet needs to seriously consider the implications of removing a standard safety system when purchasing a new vehicle. No one can predict the future nor the impact of a crash that may have been avoided if the standard safety system had not been deleted.*



Since the initial publication of our White Paper, another big change is the introduction and advancement of collision mitigation technologies, like the Bendix® Wingman® family of solutions. In 2009, Bendix introduced Wingman® ACB – Active Cruise with Braking, our adaptive cruise control technology designed to help trucks maintain a safe following distance behind a forward vehicle. This was a significant departure from prior product generations as we added braking – not just dethrottling – to help drivers maintain following distance.

ACB brought about Bendix® Wingman® Advanced™ – A Collision Mitigation Technology, where we added collision mitigation braking along with adaptive cruise control. Wingman Advanced gave rise to Bendix® Wingman® Fusion™ – utilizing camera, along with radar, to integrate functions and deliver even higher levels of collision mitigation braking. Why care about collision mitigation when the discussion is centered around stability technology? Quite simply, because collision mitigation technology is built on a foundation of full stability. And, as we look to more automated, autonomous functionality in the future, all of this is likely to be built on a full-stability foundation as well.

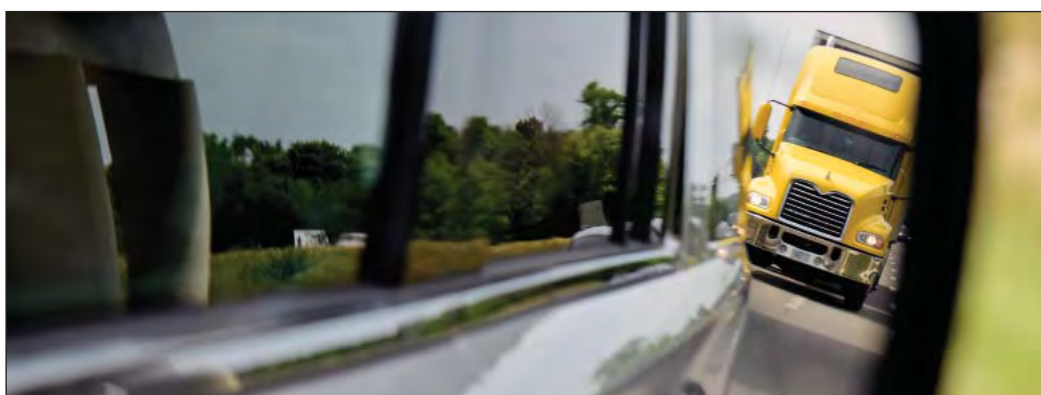
When our paper was released, automated/autonomous vehicles were still the fodder of fantasy and “some day” for most participants in the commercial vehicle marketplace. For context, in its “Federal Automated Vehicles Policy” released in November 2016, NHTSA defined five levels of automation, based on the SAE (Society of Automotive Engineers) J3016 “Taxonomy and Definitions for Terms Related to On-Road Motor Vehicle Automated Driving Systems.” You can read more about this policy and the scope of the levels in the blog post titled “Why Five?” (October 14, 2016) on the Bendix multimedia center, [www.knowledge-dock.com](http://www.knowledge-dock.com).

Today, depending on who you talk to, automated/autonomous vehicles could be here in short order. Well, at least to automation Level 3 (*where the automated system conducts some part of the driving task and monitors environment in some instances; a human driver must take back control when the system requests*). While the availability debate rages, one point remains reasonably clear – the vast majority agrees that automation Level 5 (*no driver – the automated system performs all driving tasks, under all conditions, that a human driver can perform*) is a long way off.

**It is our belief that the stability foundation of today will, for the most part, be a foundational element of automated and autonomous tractor-trailers, trucks, and buses in the future, just as it is a part of automated/ autonomous cars and light trucks. Even computer-driven trucks can lose control, or find themselves in situations that could lead to a rollover, so stability will be a part of the technology moving forward.**

It bears note that the point just raised is not merely a conclusion by Bendix. NHTSA, in its recent budget guideline, acknowledges, “In addition to their importance as stand-alone safety systems, these heavy vehicle technologies (stability control, collision mitigation) form some of the basic building blocks of highly automated vehicles ...<sup>(6)</sup>

Finally, the ability to upgrade your fleet to future technologies – retrofitting advanced driver assistance technologies – will become more commonplace. By having trucks equipped with a basic technology, such as stability control, a vehicle may be upgradeable to newer, advanced technologies – such as collision mitigation and other automated applications – as they become commercially available. Since stability control cannot be retrofitted easily or cost-effectively, it will become more important in the future that vehicles are equipped with this cornerstone technology. For the fleet, this could result in additional future savings. A “retrofit-capable truck” may be difficult for a fleet to quantify in value today, but consider the cost of acquiring a new truck in the future with the technology versus the ability to add the technology to an existing truck.



*Getting costs and savings into focus is important. Safety technologies cost, but they can also save – money, lives, time, and reputation.*

## CONCLUSION

Bendix® ESP® is a road-tested technology that has been available on the market for more than a decade and has proven performance – both from the theoretical perspective, as we discuss in the “Challenging NHTSA” section (see Appendix), and also proven in the real world. The proof is from fleets that consistently reinforce the value of the technology and how it has helped them reduce rollover and loss-of-control incidents.

Important as well is the role of full stability as the foundation for the future. Today’s advanced safety technologies are being built on ESC technology. And tomorrow’s even more automated and autonomous technologies will also incorporate full-stability control as part of their vehicle operational systems.

It’s also a cost-effective technology – adding very little to the overall price of a commercial vehicle for the amount of performance it delivers. Consider the myriad and monumental costs associated with a crash, and you realize the importance of ensuring this technology finds its way onto all large trucks.

And, last but not least, it’s still a needed technology. While the number of stability crashes is lower, the rates are still on the high side. Things become even more evident when taking into account two chilling facts: In 2015, every hour of every day, somewhere in the U.S. a large truck rolled over. And, about every two hours of every day, a large truck jackknifed. The numbers are still staggering.

Now consider one final fact: Every 15 minutes of every day, a large truck rear-ends a passenger vehicle. What does stability have to do with rear-end collisions? As mentioned, collision mitigation technology is built on top of full-stability.

*It shouldn't come as a surprise after reading this paper that Bendix remains a staunch proponent of full stability. ESC, or what Bendix sells as ESP, technology is the best technology to help fleets and drivers mitigate loss-of-control and rollover crashes.*

These, and other reasons we discussed earlier, form the basis for our position that the current stability regulation – FMVSS 136 – should not be deregulated. If anything, we concur with NHTSA's recommendation (later in their budget submission for 2018) that it should be expanded. Nothing is more devastating than a rollover – from the impact on the driver and fleet, to the costs associated with the event, to direct costs and societal costs, including traffic, environmental, and infrastructure impacts.

It's our firm belief that full stability is the key to our collective roadmap to the future. As we stand poised at the crossroads, will we continue on the road or take a detour that slows penetration and progress?

Only time will tell.



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## APPENDIX A

### **Why Full Stability Over Roll-Only Stability? Bendix' 2008 Comments to NHTSA.**

*Below are the comments Bendix submitted to the National Highway Traffic Administration (NHTSA) (the Agency) regarding the mandate to illustrate the case for Electronic Stability Control over Roll Stability Control, utilizing the Agency's numbers, along with the analysis that Bendix provided in the original white paper. Our conclusion for the Agency remains the same today – ESC is the more effective stability technology for commercial vehicles. Our original White Paper is online at [www.Bendix.com](http://www.Bendix.com).*

Effectiveness measures the impact a stability system can have in helping drivers mitigate crash situations – specifically rollover and loss-of-control situations – where the system might help. We acknowledge that no stability system will be 100% effective – in other words, it will not mitigate every crash situation. The laws of physics, vehicle condition, specific crash situation, roadway conditions and other factors can impact performance of a stability system. However, the Agency used this measure as the foundation for the cost/benefit analysis used in the Preliminary Regulatory Impact Analysis (PRIA) which accompanied the NPRM.

NHTSA's PRIA indicated a higher overall effectiveness for ESC, ranging 6-7% higher than RSC.<sup>(8)</sup> The foundation for this conclusion was a study which reviewed crashes where stability technology might have helped mitigate the situation, relying significantly on cases from the Federal Motor Carrier Safety Administration's (FMCSA) 2006 "Large Truck Crash Causation Study" (LTCCS) and presented in an analysis by the University of Michigan Transportation Research Institute (UMTRI) in 2009. (It should be noted that Bendix, while one of only two stability system developers for North American commercial vehicles, was not a participant in this study.) A revised look at the UMTRI results was also completed by the Agency in 2011, leading to the 6-7% effectiveness difference noted earlier.

While we agree with the general conclusion drawn from this work – that ESC is more effective than RSC – we believe the Agency’s results are conservative.

We base our comments on over 30 years of experience with commercial vehicle dynamics, braking and stability systems. That expertise is borne of designing, developing, testing, evaluating, and marketing systems to commercial motor vehicle manufacturers, as well as the full gamut of end users. Bendix is frequently called upon as a technology subject matter expert in a variety of forums and we have participated in investigations of commercial vehicle crashes. Based on our understanding of commercial vehicle stability system capabilities and crash investigations, we reviewed cases from the LTCCS and concluded “that the effectiveness ratings presented in the NHTSA reports under represent the performance of ESC in both rollover and loss-of-control situations, resulting in a lower difference in effectiveness between ESC and RSC (stability technology.)”<sup>(9)</sup>

The Bendix analysis, supporting the original outcome of higher ESC performance, resulted in a significantly greater difference – 31%, in fact – between ESC and RSC effectiveness.

This gap between the performance of ESC and RSC technologies is important, and we would be remiss if we did not expand our rationale regarding why we believe the gap is too narrow. Because effectiveness is integral in the cost/benefit analysis that NHTSA presented in their Preliminary Regulatory Impact Analysis, it is important to consider effectiveness directly in our response to NHTSA. We noted this fact in our analysis “Comparison of ESC and RSC case effectiveness, based on NHTSA-adjusted UMTRI LTCCS analysis vs Bendix LTCCS analyses” which we provided to the Agency in 2011.<sup>(10)</sup> A copy of this report has been submitted to the docket. What follows is a summary of our key considerations and differences.

### ***Bendix Stability Effectiveness Analysis***

Bendix first produced a stability technology effectiveness analysis as part of our initial discussions with the Agency in 2007. This study was also presented in our 2008 white paper, “Roadmap for the Future – Making the Case for Full Stability.” In this work, we determined – based on cases studied from the 2006 “Large Truck Crash Causation Study” (LTCCS) – that ESC was more effective than RSC in helping mitigate both rollover and loss-of-control crashes.



NHTSA released a study, conducted by the University of Michigan Transportation Research Institute (UMTRI) in 2009 regarding the effectiveness of stability technology on tractor-trailers (DOT HS 811 205), entitled “Safety Benefits of Stability Control Systems for Tractor-Semitrailers.” (We will refer to this study as “UMTRI” throughout the balance of these comments.)

*Note: The LTCCS provides a basis for both the Bendix and UMTRI analyses. This data was chosen because according to the FMCSA’s “Report to Congress on the Large Truck Crash Causation Study:” “No motor vehicle crash databases in the United States focus on the cause of, or factors related to, large truck crashes... The LTCCS contains the same type of descriptive data as the primary national traffic safety databases, (Fatality Analysis Reporting System (FARS) and General Estimates System (GES)) but also focuses on pre-crash factors such as driver fatigue and distraction, vehicle condition, weather and roadway problems.”<sup>(11)</sup>*

*UMTRI chose to use the LTCCS as an element for their study for the same reason that we did – it provides the most details around a crash to enable accurate, expert assessment of the effectiveness of commercial vehicle stability technology. As described in the UMTRI report: “The LTCCS crash data formed the backbone for this study because of the high quality and consistent detail contained in the case files. Included in this resource are categorical data, comprehensive narrative descriptions of each crash, scene diagrams, and photographs of the vehicle and roadway from various angles. This information allowed the researchers to achieve a reasonable level of understanding of the crash mechanics for particular cases.”<sup>(12)</sup>*

*UMTRI also recognized the importance of “expert assessment” in studying these crashes, noting that “... crashes involving loss-of-control events that can be addressed by ESC systems are more difficult to identify in the available crash data. LOC (Loss-of-Control) involving yaw instability prior to a collision is not as obvious post-crash as is rollover ... It can be very difficult for non-experts to identify yaw instability.”<sup>(13)</sup>*

*Being able to accurately assess the impact of a stability system, from our perspective, means being able to understand what factors initiated and precipitated the crash scenario, how and if a stability technology could have helped mitigate the situation and which stability technology would be most effective. This is also why we choose to utilize the LTCCS as the foundation of our original assessment.*

*There also exists, today, an inability to truly assess system performance in helping drivers avoid crashes. As noted, national databases provide information regarding crash types and counts, but there is no comprehensive database available about close-calls or near misses. Since stability systems are proactive in nature, real assessment must involve how many rollovers and loss-of-control crashes were actually prevented by the technology. We may be able to answer this question in the future as critical event reporting systems become more widely utilized. For today, however, expert review of crash cases with pre-crash details, such as those included in the LTCCS, provides the best insight regarding stability system effectiveness.*

*The analysis that follows is based on a review of the details of past crashes as provided in the LTCCS to derive effectiveness measures and net benefits per the approach NHTSA presented in the PRIA. Because commercial vehicle crashes are complex events, the actual performance of any safety technology in the field may be affected by specific factors unique to a particular crash event.*

NHTSA also released an analysis of ESC and RSC effectiveness which built upon UMTRI in 2011. The study, entitled “Effectiveness of Stability Control Systems for Truck Tractors” (DOT HS 811 437), was published in January, 2011. *(We’ll refer to this study as “Wang” throughout the balance of these comments.)* The results of the Wang analysis became the basis for the effectiveness measures used in the PRIA.

Working with the Agency, we learned more details regarding how these analyses (UMTRI & Wang) were conducted, including the actual cases and weightings used. Bendix then proceeded with this additional knowledge to review the cases in our original 2007 study and the cases used in the UMTRI & Wang studies, to determine effectiveness of both RSC and ESC in the actual crash cases used.

Our first review reexamined the UMTRI results using our experienced perspective to determine effectiveness. We determined that ESC outperformed RSC significantly, leading to the conclusion that “Bendix believes that for rollover crashes, UMTRI underestimated the weighted effectiveness of ESC and overestimated the effectiveness of RSC. For loss-of-control (LOC) type crashes, we believe UMTRI vastly underestimated the effectiveness of ESC. Interestingly, we also believe that UMTRI underestimated the effectiveness of RSC in LOC crashes. When rollover and LOC crash populations are combined, we find that UMTRI underestimated ESC effectiveness significantly. The Bendix-derived gap between ESC and RSC for the combined crash population is 27% (71%-44%); for UMTRI as adjusted by NHTSA, the gap is 5% (49%-44%).”<sup>(14)</sup>

In reviewing the crash cases used in the UMTRI and Wang analyses, along with the crash cases used in the original Bendix analysis, we discovered two key concerns.

First, the UMTRI study included crash cases which Bendix did not. These were crashes, for example, where the driver was incapacitated. Because stability systems cannot respond if there is no input from the driver, these inputs – steering, speed adjustments, or braking, for example – are critical in addition to vehicle inputs. Together they determine if intervention is warranted. In other words, if the driver drives straight into a ditch because they are incapacitated, the stability system is not going to intervene. Stability systems do not know where the truck is going in relation to the roadway, but monitor information about what the driver wants the truck to do and what the truck is doing. In these crash cases, either system – full stability or roll-only stability is not given the chance to intervene, therefore effectiveness of the system cannot be determined. This is why, in our opinion, these cases should not be included in any analysis of system effectiveness. After removing these cases, Bendix found that “the Bendix-derived gap between ESC and RSC for the combined crash population of this analysis is 29%; for UMTRI as adjusted by NHTSA, the gap is 5%.”<sup>(15)</sup>

Second, Bendix also found cases that were not included in the original UMTRI and Wang analyses – but which we did consider in our 2007 analysis. These cases were predominately loss-of-control crashes – crashes which a full stability or ESC system is designed to help mitigate. Not including those cases where ESC could have helped, in our opinion, may reduce the overall effectiveness of ESC when compared to RSC.

When combined with the cases that should not have been included, the Bendix analysis found that “the gap between ESC and RSC effectiveness in this analysis is 31%.”<sup>(16)</sup>

The following table presents a comparison of the NHTSA results (as noted in the NPRM) and the Bendix analysis results submitted to the docket:

Table 1: Comparison of NHTSA Preliminary Regulatory Impact Analysis (PRIA) and Bendix derived overall stability system effectiveness measures		
	ESC	RSC
NHTSA Effectiveness Measures (PRIA)	28-36%	21-30%
Bendix review of 2009 UMTRI used cases as published	71%	44%
Bendix review of 2009 UMTRI used cases with non-relevant cases removed	80%	51%
Bendix review of 2009 UMTRI used cases with non-relevant cases removed and additional cases added	78%	47%

We believe that the last analysis – “*Bendix review of 2009 cases used by UMTRI with non-relevant cases removed and additional cases added*” best represents what we would expect to see as real-world effectiveness measures for both ESC and RSC. We respectfully request that the Agency take this analysis into account in formulating its final rule. We will use these numbers in our rework of the NHTSA cost/benefit analysis which follows.

It is also important to note that in all the analyses presented, not only did ESC effectiveness improve, but RSC effectiveness improved as well. From our perspective, the conservative nature of the UMTRI and Wang analyses not only impacted ESC, but also RSC performance. In our opinion, both systems are more effective than reflected in the NHTSA analyses.

Our purpose in completing this analysis is not to criticize the Agency’s or UMTRI’s original work. We agree with the general finding that ESC is a more effective stability system than RSC. It is critical, however, that the magnitude of effectiveness difference between both systems be considered. The American Trucking Associations (ATA) presented in their public comments of July 24, 2012, a suggestion that the Agency consider mandating RSC for truck tractors.

This conclusion was based, in part, on the fact that the magnitude of difference between ESC and RSC system effectiveness was only 6-7%. ATA noted in their presentation that “the Effectiveness Rates for ESC and RSC as shown in Table 4, page 147 of the NPRM show an overall effectiveness percentage of 28 to 36% for ESC and 21 to 30% for RSC. ATA is not convinced that the ESC effectiveness advantage is significant enough to mandate only the ESC system for an industry as diverse as this one.”<sup>(17)</sup> ATA’s research arm, the American Transportation Research Institute (ATRI) has also presented research which supports the ATA’s position. (It should be noted, however, that ATRI based its findings on a small sample of fleets <sup>(14)</sup> as compared to the total population of over 526,000 fleets (.0027% of total fleets) and notes in the study that “...the sample cannot be considered random or unbiased.”<sup>(18)</sup> *Please see an independent third party analysis of the ATRI research methodology in Appendix A for further details regarding concerns with the approach taken by ATRI to reach their conclusions.*) To counter these perceptions, Bendix feels that it is imperative to offer an alternative effectiveness measure based on our expertise.

Our conclusion is that a wider difference in effectiveness – using the cost estimates provided in the Preliminary Regulatory Impact Analysis (PRIA) from NHTSA which accompanied the rulemaking – would likely result in a net benefit greater than originally estimated in the NPRM. We will explore this position further in the next section.

**Effectiveness and Its Impact on Cost/Benefit**

The table below presents the effectiveness estimates that NHTSA used to develop their cost/benefit analysis presented in the PRIA:

Table 2: NHTSA Stability Effectiveness as presented in the PRIA					
	Effectiveness				
Stability Technology	Overall low	Overall high	Rollover low	Rollover high	Loss-of-Control
ESC	28%	36%	40%	56%	14%
RSC	21%	30%	37%	53%	3%
Difference	7%	6%	3%	3%	11%

Source: pg. IV-3 Preliminary Regulatory Impact Analysis FMVSS 136 Electronic Stability Control Systems on Heavy Vehicles

As noted in the previous section, the magnitude of effectiveness differences between ESC and RSC overall ranged from 6-7%. Further, NHTSA presented effectiveness measures for RSC and ESC on both rollover and loss-of-control crashes. The effectiveness difference between ESC and RSC on rollovers was 3% and, for loss-of-control situations, 11%. NHTSA used the rollover and loss-of-control effectiveness measures for both ESC and RSC in the cost/benefit analysis presented in the PRIA.

Bendix feels that the magnitude of differences between ESC and RSC – based on the examination of crashes where stability would have had an impact from the Large Truck Crash Causation Study – are too low. Again, as we shared with the Agency in our analysis, it appears that ESC performance is understated vs. RSC in rollover crashes, and RSC performance is overstated in loss-of-control crashes.

Using the results of the Bendix work noted in the previous section – dropping cases where stability had no effect and including cases where stability could have helped – we determined the following effectiveness measures:

Table 3: Bendix Stability Effectiveness Analysis			
Stability Technology	Effectiveness		
	Overall	Rollover	Loss-of-Control
ESC	78%	83%	69%
RSC	47%	58%	26%
Difference	31%	25%	43%

*Source: pg. 4 Comparison of ESC and RSC case effectiveness, based on NHTSA-adjusted UMTRI LTCCS Analysis vs. Bendix LTCCS Analysis*

The overall assessment by Bendix yields improved performance for both RSC and ESC technologies in both rollover and loss-of-control crashes as compared to the NHTSA analysis. However, as noted earlier, the significance is the difference in effectiveness between the two technologies. Overall, NHTSA found a difference of 6-7%, where Bendix found a difference of 31%.

Again, we are basing our effectiveness conclusions on our unique experience and expertise understanding commercial vehicle dynamics as well as stability systems, to review the cases where we feel a stability system could have helped the driver mitigate the crash situation. This involved in-depth review of the information provided for each individual rollover & loss-of-control crash in the 2006 LTCCS. We feel strongly that these numbers are representative of what, in our best and expert evaluation, would be the effectiveness. As a result, we will use these in our rework of the NHTSA cost/benefit analysis included in the PRIA.

In order to assess the impact of improved effectiveness measures based on the NHTSA analysis, Bendix recreated, to the best of our ability, the cost/benefit evolution used by NHTSA. This model utilizes effectiveness of both ESC and RSC in rollover and loss-of-control crashes, along with average costs of the systems (as presented in the NHTSA PRIA) to determine costs to the industry, as well as overall benefit of the rulemaking.

The costs that NHTSA used were a market-weighted average cost based on feedback the Agency received from five Original Equipment Manufacturers (OEMs). The weighted average cost of an ESC system was \$1,160 and an RSC system was \$640. We will use these costs in our analysis, only changing effectiveness to gauge the impact and difference in net benefits between ESC and RSC technologies.

*(Note: We will discuss our perspectives regarding the costs of stability systems presented in the NPRM & PRIA later in this paper.)*

As the Agency has presented the details regarding both their model development and cost and benefits estimates, we won't delve into that detail here. The following table presents a summary of the results of NHTSA ESC cost/benefit analysis:

<b>Table 4: NHTSA Summary of ESC Cost-Effectiveness and Net Benefits by Discount Rate</b>				
<b>(2010 \$)</b>	<b>3% Discount</b>		<b>7% Discount</b>	
	<b>Low</b>	<b>High</b>	<b>Low</b>	<b>High</b>
Fatal Equivalents	51	63	40	50
Injury Benefits	\$ 328,197,087	\$ 405,419,931	\$ 257,409,480	\$ 321,761,850
PD & TD Savings	\$ 13,862,581	\$ 17,778,541	\$ 11,006,756	\$ 14,115,990
Vehicle Costs	\$ 113,562,400	\$ 113,562,400	\$ 113,562,400	\$ 113,562,400
Net Costs	\$ 99,699,819	\$ 95,783,859	\$ 102,555,644	\$ 99,446,410
Net Benefits	\$ 228,497,268	\$ 309,636,072	\$ 154,853,836	\$ 222,315,440

Source: pg. VI-11 Preliminary Regulatory Impact Analysis FMVSS 136 Electronic Stability Control Systems on Heavy Vehicles

Driven by injury benefits, property damage, and traffic delay savings, NHTSA found a net benefit of ESC (as the mandated technology) to range from \$155 million dollars (7% discount rate/low rollover effectiveness) to a high of \$310 million dollars (3% discount rate/high rollover effectiveness).

NHTSA also looked at alternatives in its analysis. The key alternative of concern, based on the ATA suggestion of mandating RSC for tractors, is Alternative 1 – Mandating RSC instead of ESC.<sup>(19)</sup> From the NHTSA evaluation of a potential RSC mandate, the following table presents a summary of the net benefits and cost-effectiveness of an RSC mandate.



**Table 5: NHTSA Summary of RSC Cost-Effectiveness and Net Benefits by Discount Rate**

(2010 \$)	3% Discount		7% Discount	
	Low	High	Low	High
Fatal Equivalents	31	43	24	34
Injury Benefits	\$ 199,492,347	\$ 276,715,191	\$ 154,445,688	\$ 218,798,058
PD & TD Savings	\$ 9,714,383	\$ 13,649,563	\$ 7,713,126	\$ 10,837,621
Vehicle Costs*	\$ 55,769,600	\$ 55,769,600	\$ 55,769,600	\$ 55,769,600
Net Costs	\$ 46,055,217	\$ 42,120,037	\$ 48,056,474	\$ 44,931,979
Net Benefits	\$ 153,437,130	\$ 234,595,154	\$ 106,389,214	\$ 173,866,079

As the Agency concluded, the benefits of an RSC mandate fall below those of an ESC mandate – generating a lower net benefit ranging from \$106 million to \$234 million.

The total difference between an ESC and RSC mandate is illustrated in the table on page 45.

**Table 6: Difference between ESC & RSC Cost-Effectiveness & Net Benefits by Discount Rate**

(2010 \$)	3% Discount		7% Discount	
	Low	High	Low	High
Fatal Equivalents	20	20	16	16
Injury Benefits	\$ 128,704,740	\$ 128,704,740	\$ 102,963,792	\$ 102,963,792
PD & TD Savings	\$ 4,148,198	\$ 4,128,978	\$ 3,293,630	\$ 3,278,369
Vehicle Costs*	\$ 57,792,800	\$ 57,792,800	\$ 57,792,800	\$ 57,792,800
Net Costs	\$ 53,644,602	\$ 53,663,822	\$ 54,499,170	\$ 54,514,431
Net Benefits	\$ 75,060,138	\$ 75,040,918	\$ 48,464,622	\$ 48,449,361

Source: pg. VII-3 Preliminary Regulatory Impact Analysis FMVSS 136 Electronic Stability Control Systems on Heavy Vehicles (note: Some variability may exist between columns due to rounding.)

An ESC mandate, as calculated using the NHTSA effectiveness and cost estimates, would exceed an RSC mandate by a range of \$48 million to \$75 million.

*Please note, we have not ignored the facts, as noted in the NPRM, that a full stability mandate will also help reduce the number of crashes resulting in more lives saved and less injuries. The human impact is important and illustrated by the additional “fatal equivalents” saved by an ESC mandate over an RSC mandate. This is a key driver in NHTSA’s published mission to: “Save lives, prevent injuries, and reduce economic costs due to road traffic crashes, through education, research, safety standards, and enforcement activity.”<sup>(17)</sup> Our concern in this analysis, however, is tied to the financial benefit differences using the NHTSA cost/benefit model to gauge the cost-effectiveness of an ESC mandate vs. an RSC mandate utilizing different effectiveness measures.*

In the next section, we will provide our review, using Bendix effectiveness measures for both ESC and RSC in our model simulating the NHTSA cost/benefit analysis. As noted earlier, the following table presents the Bendix-derived stability system effectiveness estimates:

Table 7: Bendix Stability Effectiveness Measures			
	Effectiveness		
Stability Technology	Overall	Rollover	Loss-of-Control
ESC	78%	83%	69%
RSC	47%	58%	26%

*Source: pg. 4 Comparison of ESC and RSC case effectiveness, based on NHTSA-adjusted UMTRI LTCCS Analysis vs. Bendix LTCCS Analysis*

Using the higher effectiveness measures contained within the Bendix NHTSA model in loss-of-control and rollover crashes, yields significantly different results from the original NHTSA results presented in the PRIA. The difference in overall effectiveness of ESC vs. RSC in the Bendix work yielded a magnitude difference of 4 - 5x the original NHTSA estimates (31% vs. 6-7% overall). The resulting net benefits reflect this difference. The value, of course, is that ESC – as derived, from the Bendix evaluation – yields a significantly higher differential over RSC in terms of net benefits. This makes the argument regarding ESC and RSC yielding too little a difference a moot point.

The net benefits of ESC using the Bendix-derived effectiveness measures are as follows:

Table 8: Bendix Summary of ESC Cost-Effectiveness and Net Benefits by Discount Rate				
(2010 \$)	3% Discount		7% Discount	
Fatal Equivalents	161		128	
Injury Benefits	\$ 1,036,073,157		\$ 823,710,336	
PD & TD Savings	\$ 40,875,513		\$ 32,454,763	
Vehicle Costs*	\$ 113,562,400		\$ 113,562,400	
Net Costs	\$ 72,686,887		\$ 81,107,637	
Net Benefits	\$ 963,386,270		\$ 742,602,699	

Source: Bendix analysis based on NHTSA PRIA calculations

**Note:** Because there is no high/low effectiveness range for rollover crashes in the Bendix analysis, only a single column is presented for each discount rate.

The net ESC benefit – using the Bendix estimates – is \$743 million at the 7% discount rate and \$963 million at the 3% discount rate – over 3x the net benefit of the NHTSA estimate. This, of course, is driven by the higher number of crashes mitigated by ESC technology. The higher number of crashes mitigated also results in more lives saved and injuries reduced, as noted by the fatal equivalents now ranging from 128 to 161 vs. 40 to 63 in the NHTSA analysis. The benefit is derived from the change in effectiveness only, as system costs are not altered from the estimates developed by NHTSA in the PRIA.

Our emphasis is not between the NHTSA and Bendix ESC estimates, but rather the overall magnitude of difference between ESC and RSC performance. Taking this into account, Bendix also re-analyzed RSC performance using the same Bendix-developed NHTSA model simulation and the Bendix-derived RSC effectiveness numbers. As before, we retained the cost measure for RSC that NHTSA determined based on its original market average cost of \$640 per system.

**Table 9: Bendix Summary of RSC Cost-Effectiveness and Net Benefits by Discount Rate**

(2010 \$)	3% Discount		7% Discount	
Fatal Equivalents	73		58	
Injury Benefits	\$ 469,772,301		\$ 373,243,746	
PD & TD Savings	\$ 20,210,062		\$ 16,046,594	
Vehicle Costs*	\$ 55,769,600		\$ 55,769,600	
Net Costs	\$ 35,559,538		\$ 39,723,006	
Net Benefits	\$ 434,212,763		\$ 333,520,740	

Source: Bendix analysis based on NHTSA PRIA calculations

As expected, the net benefits of an RSC-only alternative, based on the Bendix RSC effectiveness estimates, also increased over the NHTSA estimates. RSC net benefits now range from \$334 million to \$434 million. (As with the Bendix ESC estimates, there are no high/low for rollover effectiveness results in the Bendix numbers.)

Taking our analysis further, we will now project the net benefits of ESC over RSC, based on the Bendix effectiveness measures. The following table presents these differences:

<b>Table 10: Difference between ESC &amp; RSC Cost-Effectiveness &amp; Net Benefits by Discount Rate</b>				
<b>(2010 \$)</b>	<b>3% Discount</b>		<b>7% Discount</b>	
Fatal Equivalents	88		70	
Injury Benefits	\$ 566,300,856		\$ 450,466,590	
PD & TD Savings	\$ 20,665,452		\$ 16,408,169	
Vehicle Costs	\$ 57,792,800		\$ 57,792,800	
Net Costs	\$ 37,127,348		\$ 41,384,631	
Net Benefits	\$ 529,173,508		\$ 409,081,959	

Source: Bendix analysis

In summary, where NHTSA found a net benefit of ESC over RSC ranging from \$48 million to \$75 million, the Bendix calculated net benefits are significantly higher – ranging from \$409 million to \$529 million. Again, these estimates are based on the higher number of crashes prevented by ESC technology over RSC, along with the resulting increase in lives saved and injuries reduced. We continue to use the same original system cost estimates that NHTSA presented in its PRIA.

We feel that our analysis reinforces the performance value of ESC over RSC and supports our position, as well as the Agency’s findings, that ESC would be the more beneficial technology to mandate.

## **A Comment on System Costs**

*Note: As a whole, Bendix found the discussion of costs for stability control in the agencies original analysis to be interesting, as you'll learn below. While this analysis was developed in 2012, it's useful to review the potential savings which can accrue for both OEMs and Fleets from this particular mandate. Basically, as we've seen some increases in standardizing the technology and resulting growth in take rates, since the original NPRM for stability was issued in 2012, we're talking about a technology that today will add hundreds, not thousands of dollars to the price of a truck.*

As we've questioned the conservative nature of the Agency's effectiveness analysis, the range of OEM costs collected by NHTSA also deserves a bit of scrutiny. As one of two suppliers of power unit-based stability systems – both roll and full stability – Bendix is in the unique position of understanding the base costs of components which we provide, as a tier-one supplier, to truck manufacturers for inclusion on their vehicles.

In reviewing both the costs (RSC and ESC) provided to NHTSA by the OEMs, we are struck by the significant range of costs provided in the PRIA. Cost estimates for ESC ranged from a low of \$470/vehicle to a high of \$2080/vehicle – a multiple of 4.4x between the low and high. The cost estimates provided for RSC provide a similar wide range – from \$300 at the low end to \$1500 at the high end – an even higher multiple of 5.0x. (These costs, as we understand, are above the base cost for the ABS system which is the foundation for both ESC and RSC stability systems.) In the end, we don't see a correlation to the cost differential in the NHTSA cost estimates to the system supplied costs from Bendix to its OEM customers.


While we are unclear about all of the factors that may drive a cost differential at the OEM level, we believe this may reflect potential economies of scale for OEMs that have made stability technology standard on their highway tractors (as well as motorcoaches). The OEMs that have done so have smaller market shares than those that have not, and, as such, the market-weighted average may be skewed higher because of this difference. Along the same lines, the OEMs with larger market share have a much broader manufacturing experience with RSC. At present only two major OEMs offer RSC as a published data-book option. They may experience stronger economies of scale with RSC systems and, hence, their installed costs may be lower (and with a higher share of market) vs. those that are not offering RSC. In these situations the opposite occurs – RSC costs in the NHTSA analysis may be artificially lower due to the larger market shares of OEMs selling RSC technology.

Understandably, due to confidentiality, the Agency did not provide details regarding which OEMs provided specific cost estimates. While it is hypothetical, it is not unreasonable to question the large differential in reported costs between ESC and RSC systems.

Naturally, there is some precedent to expect a lower product cost if ESC is mandated. Our experience with ABS, when it was mandated in the late 90's, indicates a significant drop in the cost of these systems – over 50%. We expect a similar trend, though of lesser magnitude, with the cost of stability systems once mandated, which may result in a cost figure lower than the average installed costs presented by the Agency. The anticipated amount may approach the lower end of the cost spectrum presented in the PRIA – a figure in line with the “economies of scale” perspective presented above. This lower cost could increase the net benefits of the proposed rulemaking even further.


## ABOUT THE AUTHOR

Fred Andersky, director of customer solutions – Controls, and director of government & industry affairs at Bendix Commercial Vehicle Systems LLC, is a marketing professional who has spent countless hours in discussions about active safety technologies with commercial vehicle fleets and owner-operators throughout North America. Possessing a CDL in Ohio, Andersky spearheads a variety of demonstration events across the country, enabling commercial vehicle industry participants to witness, firsthand, the benefits of advanced safety technologies. During his tenure with Bendix, Andersky has become a strong advocate for active safety technologies that are designed to advance commercial vehicle safety. He has presented to, and worked alongside, a variety of industry, regulatory, and legislative groups regarding the importance of active safety technologies for commercial vehicles.



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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.

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