Accelerating the Adoption of Advanced Driver Assistance Systems (ADAS): "Tech-Celerate Now" Phase 1

U.S. Department of Transportation
Federal Motor Carrier Safety Administration

January 2024

FOREWORD

The Federal Motor Carrier Safety Administration (FMCSA) partnered with leading trucking industry associations to initiate a new program that aims to reduce truck-involved crashes and crash severity through expanded use of advanced driver assistance systems (ADAS). In February 2020, the program was branded as FMCSA's "Tech-Celerate Now" to improve industry awareness and positive perception—with the goal of increasing voluntary adoption of ADAS technologies. Tech-Celerate Now was based on a series of tasks, including generating and disseminating surveys, analyzing ADAS returns-on-investment (ROI) using a customized ROI calculator, and a large-scale industry outreach program.

NOTICE

QUALITY ASSURANCE STATEMENT

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16. Abstract **Advanced driver assistance system (ADAS) technologies can positively impact large truck safety; however previous research indicates that barriers to ADAS technology adoption still exist within the trucking industry. Barriers such as awareness, acceptance, and uncertain return on investment (ROI), are likely hindering adoption. FMCSA launched a program, branded as Tech-Celerate Now, to accelerate adoption of ADAS technologies. Tech-Celerate Now encompassed further research into ADAS technology adoption barriers; a national outreach, educational, and awareness campaign; and data collection and analysis. This report documents the findings from Phase 1 of the program's research and data analysis as well as the activities undertaken to increase awareness, understand perception, and measure program impacts. A comparison of pre- and post-outreach activity survey results shows a positive increase in awareness and adoption of certain ADAS technologies.**		
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LIST OF ACRONYMS, ABBREVIATIONS, AND SYMBOLS

Acronym	Definition
AAA	American Automobile Association
ACC	adaptive cruise control
ADS	automated driving system
ASC	adaptive steering control
ADAS	advanced driver assistance systems
AEB	automatic emergency braking
API	application programming interface
ATA	American Trucking Associations
ATRI	American Transportation Research Institute
CDL	commercial driver's license
CMV	commercial motor vehicle
FCW	forward collision warning
FET	Federal excise tax
FMCSA	Federal Motor Carrier Safety Administration
FMVSS	Federal Motor Vehicle Safety Standards
LDW	lane departure warning
MACRS	modified accelerated cost recovery system
MCMIS	Motor Carrier Management Information System
NHTSA	National Highway Traffic Safety Administration
NMFTA	National Motor Freight Traffic Association
NSTSCE	National Surface Transportation Safety Center for Excellence
OEMs	original equipment manufacturers
OOIDA	Owner-Operator Independent Drivers Association
PDO	property damage only

Acronym	Definition
ROI	return-on-investment
RP	recommended practice
TCN	Tech-Celerate Now
TMC	Technology & Maintenance Council
TRB	Transportation Research Board
USDOT	U.S. Department of Transportation
VTTI	Virginia Tech Transportation Institute
VIN	vehicle identification number

EXECUTIVE SUMMARY

In September 2019, the Federal Motor Carrier Safety Administration (FMCSA) initiated a new outreach program focused on increasing awareness of the benefits of advanced driver assistance system (ADAS) technologies among truck drivers and commercial motor vehicle fleets. The FMCSA partnered with trucking industry associations and consultants to execute the program including: Noblis, Inc.: the American Trucking Associations (ATA), ATA's Technology & Maintenance Council (TMC), the American Transportation Research Institute (ATRI), the Owner-Operator Independent Drivers Association (OOIDA) Foundation, the Virginia Tech Transportation Institute (VTTI), the marketing firm Global-5, and Kittelson & Associates (KAI). FMCSA tasked the team to explore barriers to adoption and ways to accelerate the adoption of ADAS by the trucking industry because of the demonstrated potential of ADAS technologies to assist drivers, resulting in reduced fatalities, injuries, and crashes. In February 2020, the project was branded as FMCSA's "Tech-Celerate Now" program to improve industry awareness and perception with the goal of increasing the voluntary adoption of ADAS.

The Tech-Celerate Now program identified and then categorized ADAS technologies into four functional groups to help with education, understanding and industry outreach efforts. These include:

- **ADAS braking systems**. This performance category includes technologies such as automatic emergency braking, and adaptive cruise control systems.
- **ADAS steering systems**. This performance category includes lane keep assist, lane centering, and adaptive steering control, all of which help drivers maintain proper vehicle control and traffic spacing.
- **ADAS warning systems**. This performance category includes lane departure warning, forward collision warning, and blind spot detection, and is oriented toward alerting drivers.
- **ADAS monitoring systems**. This performance category includes driver- and road-facing cameras and camera-based mirror systems.

FMCSA's Tech-Celerate program is planned for execution over two phases—with this Report summarizing results from the first phase. The first phase was conducted over 29 months and consisted of five components:

- Conducting research on technical and market barriers to adoption.
- Developing outreach and educational materials oriented toward fleets and owner/operators unaware of ADAS benefits.
- Developing ATA TMC Recommended Practices and Position Papers for fleet owner/ operators relative to the adoption, use and maintenance of ADAS technologies.
- Conducting a national outreach campaign for fleets to encourage ADAS awareness and adoption.
- Completing data collection and analysis of industry trends, technology trends, and deployment rates from surveys of drivers and motor carrier executives.

A planned second phase will include an expanded national outreach and education campaign, measure ADAS safety impacts and the effectiveness of the campaign, and provide annual reporting on activities.

This final report summarizes Phase 1 activities including identifying barriers to ADAS adoption and the results of the post-outreach activity (Year One) industry survey and comparison with the Baseline survey to identify changes in perceptions and adoption of each type of ADAS.

BARRIERS TO ADAS ADOPTION

Based on a review of prior work and engagement with stakeholders, initial results indicated that many of the ADAS technologies reviewed in the report have common barriers that need to be overcome to accelerate their adoption in the commercial motor vehicle industry. The researchers recommended the following actions for accelerating the adoption of promising ADAS technologies:

- To address barriers reported by truck drivers and owner-operators, there needs to be improved coordination between researchers, safety advocacy groups, and truck drivers. Drivers and decision-makers, in small fleets in particular, need to perceive a clear direct net benefit from increased adoption. For example, truck drivers have identified a potential loss of driver control as a significant concern in adopting ADAS technologies. Additionally, demonstrating benefits to those drivers with an extensive safe driving record may be challenging. Activities such as hands-on ADAS demonstrations with drivers and fleet managers may give valuable first-hand experience where familiarity with specific ADAS technologies is lacking.
- To address technical barriers, (1) collaboration with ADAS suppliers is needed to encourage choices for the trucking firm's desired combination of ADAS technologies rather than limited "bundled"[1] packages, and (2) more collaboration with the USDOT and scientific organizations is needed to conduct more research on documenting the effectiveness and performance of specific ADAS technologies.
- Driver acceptance is an important factor in adoption for both drivers and fleets. For example, better defining and addressing concerns about reliability and technology maintenance (issues that were mentioned as potential barriers) could help support adoption of ADAS technologies.
- To address market-based barriers, multiple suggestions were developed including (1) industry stakeholders, including technology suppliers and fleet managers, should emphasize that ADAS are designed to serve as the driver's backup and to ***assist*** the professional driver in responding to safety critical situations; and (2) additional data is needed to understand factors in fleet purchase decisions, including financial considerations, when selecting ADAS from offerings by truck original equipment manufacturers (OEMs).

[1] Truck manufacturers generally offer combinations of ADAS technologies (such as AEB and LDW) as a "bundled" package option rather than allowing fleets to purchase the technologies separately. Fleets that do not really want to purchase one of the technologies (e.g., LDW) end up feeling like they are over-paying for the ADAS technology (e.g., AEB) that they really want.

NATIONAL OUTREACH AND TRAINING MATERIAL DEVELOPMENT

Informed by the barriers to adoption research, the team developed a national outreach campaign plan to accelerate the voluntary adoption of ADAS technologies. The plan identified target audiences and key messages, outreach products, brand development, and campaign activities and events. Project outreach included several core activities to targeted audiences: articles published in trade industry periodicals; presentations at conferences, seminars, and committee meetings; and developing and staffing a booth at conference exhibits. To further support outreach and voluntary adoption, the team created key training materials, which are available on the project web site (https://www.fmcsa.dot.gov/tech-celeratenow):

- two training guidebooks (referred to hereafter as "guides"),
- four videos that individually focus on the four ADAS technology performance categories, and
- a Tech-Celerate Now ADAS technology-specific return-on-investment (ROI) calculator.

The project team tracked outreach metrics from project initiation to help measure the effectiveness of the outreach campaign. Estimated audience reach totaled 3.6 million contacts. Through a series of radio promotions[2] of the Tech-Celerate Now program the listener base across four shows was estimated to make up 3.2 million of the total 3.6 million contacts. This illustrates the significant reach to the project's truck driver audience.

RECOMMENDED PRACTICES

To further support accelerating the adoption of ADAS technologies, three TMC Recommended Practices (RP) and one information report (IR) were developed to provide guidance on technician training, use of ADAS data, and use of human-machine interfaces with ADAS:

- RP 18XX(T), Selection and Specification of ADAS.
- RP 5XX(T), Technician Training Guidelines for ADAS.
- RP 547(T), Guidelines for ADAS Nomenclature.
- Information Report (IR), Recommendations Regarding Inspection and Enforcement for Automated Commercial Vehicles.

Given the process and timeframe to develop the Recommended Practices, the new Recommended Practices will be released in final published form after the conclusion of the first phase. See TMC's Recommended Practices web site (https://tmc.trucking.org/tmc-recommended-practices) for current information.

[2] Discussing the Tech-Celerate Now program on the Dave Nemo trucking satellite radio show.

DATA COLLECTION AND ANALYSIS

Despite considerable documentation of the efficacy of ADAS technology in the automotive industry, there is still uncertainty within the trucking industry. Uncertainty about reliability, usability, maintenance requirements, and ROI are the primary factors contributing to slow adoption and negative perception of the technologies.

Baseline pre-outreach campaign surveys and Year One or post-outreach surveys were used to collect industry data for two groups: motor carrier executives and drivers. In the Baseline survey results, awareness was determined to be a significant obstacle in increasing adoption. To understand how awareness, perceptions, and adoption changed as a result of the Tech-Celerate Now outreach campaign, the team developed and distributed a Year One or post-outreach survey to identify changes and to analyze the impacts of outreach and education efforts.

Several additional questions were added in the Year One survey to better document perceptions and adoption level changes over time. These included workforce-related questions to understand how truck drivers viewed carrier recruitment and employment by fleets either using or not using ADAS technologies. Key findings from comparing the two surveys include:

- The majority of motor carrier executives and owner-operator independent drivers familiar with Tech-Celerate Now program reported learning of the Program through their trade association's outreach.
- Carrier executives were more likely than drivers to have learned about the program through email blasts, online advertisements, and industry meetings while drivers were more likely to have learned about it through trade association outreach, radio, podcasts, and news articles.
- The findings from the baseline survey conducted prior to the Program's outreach activities indicated that efforts in outreach should concentrate on drivers to increase awareness, positive perception, and adoption of ADAS technologies.
- The comparison of the baseline, pre-outreach, survey to the "Year One" post-outreach survey indicates a positive change in the awareness among drivers, with an increase of 52 to 60 percent. For the carrier survey, awareness on average was similar in post-outreach survey (79 percent) as with the baseline (80 percent).
- Road-facing cameras, forward collision warning, automatic emergency braking, and lane departure warning systems were among the technologies with highest levels of awareness, while adaptive steering control and active lane centering assist had lower awareness levels.
- In both the carrier and driver surveys, respondents who indicated they were reached by the Tech-Celerate Now program reported higher awareness levels as compared to those who were not aware of the program.
- In the "Year One" post-outreach carrier survey, 85 percent of respondents exposed to Tech-Celerate Now outreach activities reported being familiar with ADAS compared to 80 percent in the baseline.

- Similarly, for the post-outreach driver survey, those who heard about the program had an average ADAS awareness level of 72 percent as compared to 52 percent in the baseline.
- Since the survey was not able to identify the causality of these changes, a direct question was included in the post-outreach survey to ask respondents if the program had a positive impact on their ADAS purchasing decision**. Of those who had heard of Tech-Celerate Now since its introduction less than 2 years earlier, 4 percent of drivers and 13 percent of carrier executives indicated that the program positively influenced an ADAS purchase decision.**

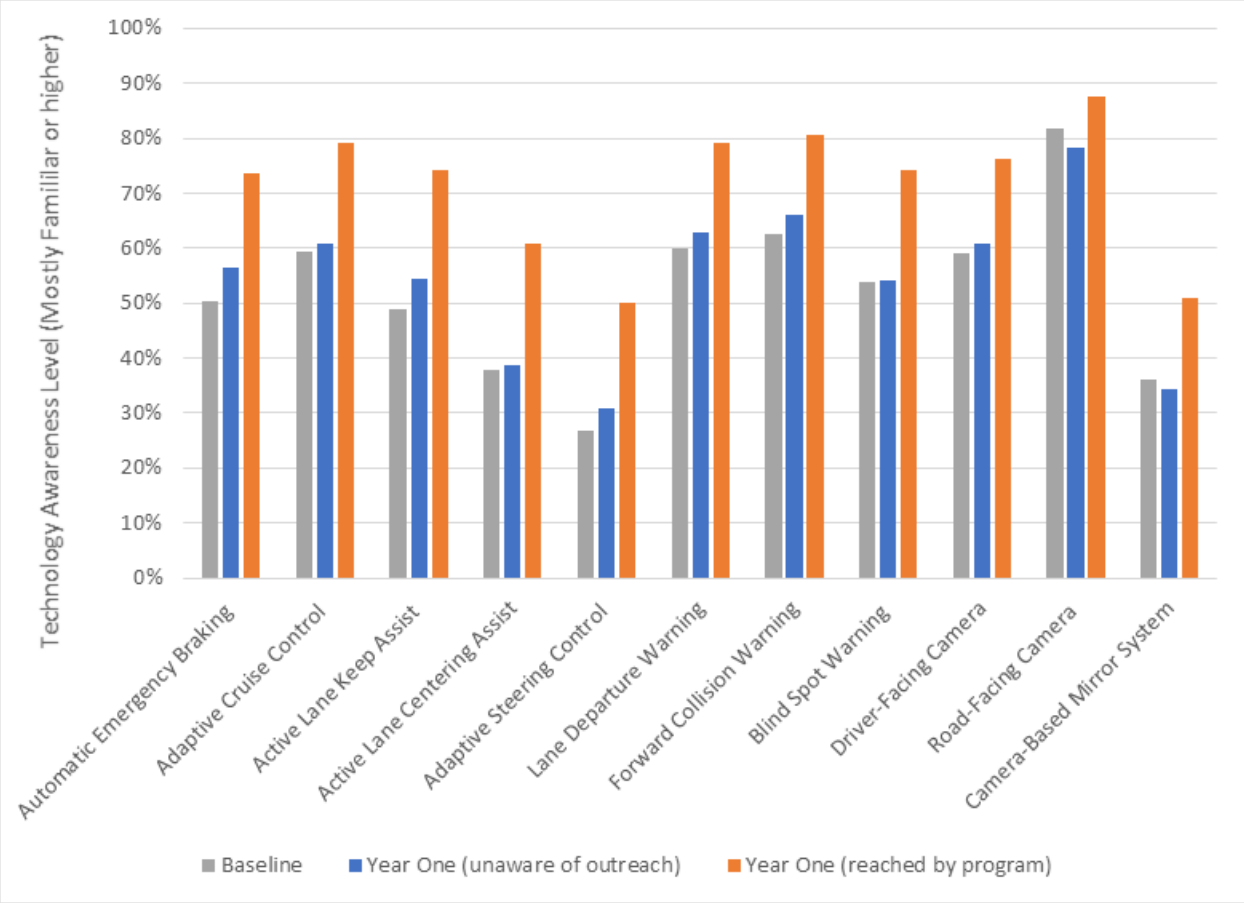

Figure 1. Bar graph. ADAS awareness comparison: Drivers reached by Tech-Celerate Now.

- Carrier executives reported a higher perception of safety improvements from ADAS as compared to drivers. The ADAS warning technologies and road-facing cameras were considered by both drivers and carrier executives to have higher expectations for improvements to safety than ADAS "active" technologies or inward-facing cameras. Notably, certain technologies were perceived as potentially harmful to safety by a sizeable proportion of respondents, particularly drivers. Over 50 percent of driver respondents perceived active steering control, driver-facing cameras, and automatic

emergency braking as harmful to safety, suggesting that these ADAS technologies have barriers not faced by other technologies.

- Increases in ADAS adoption resulting from the Tech-Celerate Now (TCN) program varied. Carrier survey respondents generally reported a slight increase in adoption. Adoption levels for driver respondents was higher across all ADAS technologies. Based on results from both carrier and driver surveys, road-facing cameras and lane departure warning were among the ADAS technologies with higher increases in Year One adoption levels compared to other ADAS technologies. In addition, when examining the highest adoption response category (adoption in 75 to 100 percent of tractors within the respondent's fleet), sizeable increases were observed in the driver survey in road-facing cameras (36 to 50 percent), forward collision warning (14 to 26 percent) and lane departure warning (12 to 23 percent). Carrier survey results were more mixed but road-facing cameras also had a large increase in the proportion reporting wide adoption (52 to 73 percent). It is worth noting that measurement of changes in adoption from surveys is both self-reported and does distinguish among causal factors (e.g., whether due to TCN, reduced cost of the technologies, greater availability, or many other factors). Further the reported changes in adoption rates do not represent market-wide measures since respondents' fleet sizes vary significantly.
- Carrier executives understand that driver acceptance and positive perception of ADAS technologies are crucial in recruiting and retaining drivers. In fact, carrier executives ranked driver acceptance of technologies as one of the top three factors considered when deciding to install ADAS technologies. The other two are the possibility of lower insurance premiums and technology purchase costs.

PROJECT CONCLUSION

Phase I research identified technical, market, and other barriers to adoption of ADAS and made progress in supporting future adoption through outreach activities and development of supporting resources for carriers and drivers. The survey analyses identified factors and trends showing the differences in perceptions across drivers and carrier executives for each ADAS technology and assessed the influence of outreach efforts on measures such as awareness. Survey results showed higher ADAS awareness levels in those who had been reached by Tech-Celerate Now and evidence that some ADAS purchase decisions were positively influenced by the program. The project results provide a better understanding of factors influencing ADAS adoption and perceptions.

1. INTRODUCTION

Recent reports from the U.S. Department of Transportation (USDOT) show that large truck crashes involving fatalities have increased over the past 5 years. The Federal Motor Carrier Safety Administration's (FMCSA) Large Truck and Bus Crash Facts 2020 shows that from 2016 to 2020, the number of large trucks involved in fatal crashes increased 6 percent from 4,562 to 4,842.[(1)] From 2016 to 2020, large truck involvement in fatal crashes per 100 million miles traveled by large trucks increased 1.3 percent (1.58 to 1.60). In the last 5 years, there has been a 6 percent increase in the total fatalities involving large trucks. According to FMCSA's Motor Carrier Management Information System (MCMIS), in 2020, 58,518 large trucks were involved in injury crashes, and 116,612 were involved in towaway crashes. The National Highway Traffic Safety Administration (NHTSA) preliminary estimates of crash fatalities for 2021 showed a 17 percent increase from 2020 for large truck fatal crashes.[(2)] It is important to consider that there are multiple factors that contribute to crash occurrences, and the statistics presented show the overall magnitude of impacts without classification of individual causes. Advanced driver assistance system (ADAS) technologies have the potential to enhance drivers' avoidance of crashes in certain scenarios, but for benefits to be realized, acceptance and system performance also need to be considered.

The 2017 American Automobile Association (AAA) Foundation for Traffic Safety study, performed by the Virginia Tech Transportation Institute (VTTI), on "Leveraging Large Truck Technology and Engineering to Realization Safety Gains" found that safety benefits of adopting ADAS technologies could outweigh the costs.[(3)] The study further showed cost effectiveness for certain ADAS technologies. FMCSA's Tech-Celerate Now program, the subject of this report, builds upon prior work such as recommendations made in the report, "Research and Testing to Accelerate Voluntary Adoption of Automatic Emergency Braking (AEB) on Commercial Vehicles."[(4)]

1.1 BACKGROUND / PROJECT SCOPE OVERVIEW

In September 2019, the Federal Motor Carrier Safety Administration (FMCSA) initiated a new outreach program focused on increasing awareness of the benefits of advanced driver assistance system (ADAS) technologies among truck drivers and commercial motor vehicle fleets. The FMCSA partnered with trucking industry associations and consultants to execute the program including: Noblis, Inc., the American Trucking Associations (ATA), ATA's Technology & Maintenance Council (TMC), the American Transportation Research Institute (ATRI), the Owner-Operator Independent Drivers Association (OOIDA) Foundation, the Virginia Tech Transportation Institute (VTTI), the marketing firm Global-5, and Kittelson & Associates (KAI). FMCSA tasked the team with exploring barriers to adoption and ways to accelerate the adoption of ADAS by the trucking industry because of the demonstrated potential of ADAS technologies to assist drivers, resulting in reduced fatalities, injuries, and crashes. In February 2020, the project was branded as FMCSA's "Tech-Celerate Now" program to improve industry awareness and perception with the goal of increasing the voluntary adoption of ADAS.

The Tech-Celerate Now program identified and then categorized ADAS technologies into four functional groups to help with education, understanding and industry outreach efforts. These include:

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FMCSA's Tech-Celerate program is planned for execution over two phases—with this Report summarizing results from the first phase. The first phase was conducted over 29 months and consisted of five components:

- Conducting research on technical and market barriers to adoption.
- Developing outreach and educational materials oriented toward fleets and owner/operators.
- Developing ATA TMC Recommended Practices and Position Papers for fleet owner/ operators relative to the adoption, use and maintenance of ADAS technologies.
- Conducting a national outreach campaign for fleets to encourage ADAS awareness and adoption.
- Completing data collection and analysis of industry trends, technology trends, and deployment rates from surveys of drivers and motor carrier executives.

A planned second phase will include an expanded national outreach and education campaign, measure ADAS safety impacts and the effectiveness of the campaign, and provide annual reporting on activities,

1.2 OBJECTIVE OF REPORT AND STRUCTURE

The purpose of this report is to inform stakeholders, such as decision-makers, USDOT, and industry trade associations, of the progress made in promoting adoption of ADAS in the first phase of the Tech-Celerate Now program. The final report summarizes Phase 1 activities, results of the Year One industry survey and comparison with the Baseline survey; adoption of each type of ADAS; and the impact of the outreach campaign on awareness and motivation to purchase ADAS technologies and a market forecast.

This final report includes the following sections:

- Section 2. A summary of Tech-Celerate Now Phase 1 activities relating to research on barriers to adoption, development of training and educational materials, and outreach that includes high-level results and findings.
- Section 3. An assessment of impacts on ADAS awareness, perception, and adoption. This section provides a description of the survey methodology, a summary of the Baseline survey results, and details of the Year One post-outreach campaign survey results.
- Section 4. A summary of the program Phase 1 outcomes that highlights key project accomplishments and discussion of impacts from Tech-Celerate Now.
- Appendix A. The Baseline and Year One surveys.
- Appendix B. An accounting firm perspective on tax and financial considerations applicable to ADAS purchase decisions.

Readers interested in the high-level information from the Phase 1 activities should read the Executive Summary and Section 4. Readers interested in the details of Phase 1 should read the report in its entirety.

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2. SUMMARY OF ACTIVITIES UNDER TECH-CELERATE NOW

This section is for the reader that is interested in a summary of the Tech-Celerate Now program tasks and highlights of products developed and outreach results. Each of the tasks is summarized, other than data collection and analysis, which is presented in Section 3. Information presented covers the life of the project to include how the project team overcame COVID-19 pandemic challenges when in-person outreach events where not feasible.

2.1 TASK 2: RESEARCH ON TECHNICAL AND MARKET BARRIERS TO ADOPTION OF ADAS

Task 2 focused on identifying the technical and market barriers that impede the widespread adoption of the four ADAS categories—braking systems, steering systems, warning systems, and monitoring systems—and making appropriate recommendations for overcoming these barriers. Technical barriers are defined as factors or issues that impact the ADAS's ability to function as intended, including any negative effects of hardware or software. Market barriers are defined as factors or issues impacting the acceptance of the ADAS that are unrelated to the hardware or software functioning as intended. To accomplish this task, the research team used the four-step approach shown in Figure 2.

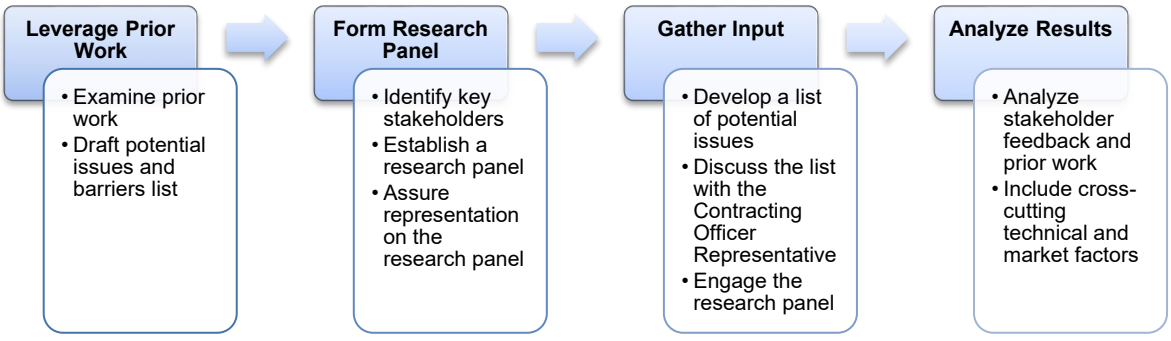

Figure 2. Flow chart. Task 2 data collection and analysis process.

Many of the ADAS technologies reviewed in this report have common barriers that need to be overcome to accelerate their adoption in the commercial motor vehicle industry (see Figure 3). The researchers recommended actions for accelerating the adoption of these promising ADAS technologies. A summary of key findings is included below.

To address truck drivers and owner-operator acceptance adoption barriers, survey results reported that there needs to be improved coordination between researchers, safety advocacy groups, and actual truck drivers. Drivers recommended collecting more data to better understand their concerns leading to the lack of adoption (e.g., false activations, maintenance costs, and lack of evidence of lower insurance premiums). Finally, driver and safety technology training, including training related to ADAS technologies, needs to be improved.

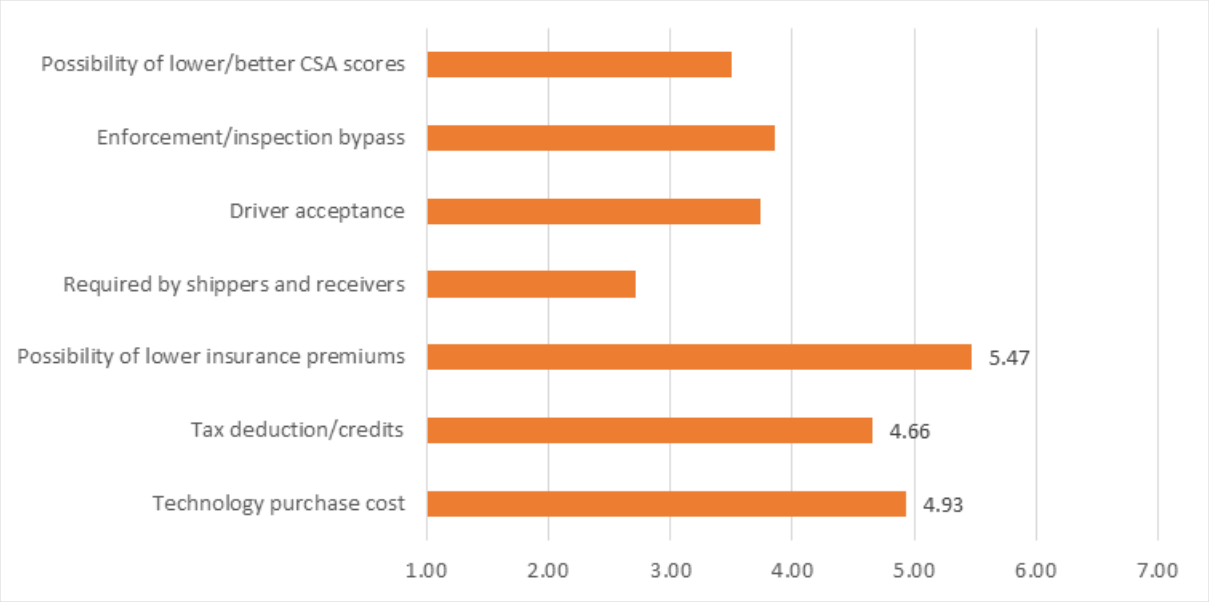

Figure 3. Bar graph. Most influential factors in deciding to purchase ADAS (1=least important, 7=most important).

To address technical barriers, collaboration with ADAS suppliers is needed to encourage standalone versus pairing/bundling of ADAS technologies options (e.g., ADAS developers potentially consider warning technologies without automatic pairing with an active ADAS). Additionally, stakeholders could work with the USDOT to add flexibility to the Federal Motor Vehicle Safety Standards (FMVSS) to ease the implementation of ADAS (e.g., camera-based mirror systems). Finally, there is a need for continued collaboration with the USDOT and scientific organizations to conduct more research on the effectiveness of many of these ADAS technologies.

Research is also needed to understand driver acceptance factors. According to drivers and owner-operators, there is a need to assess and convey the characteristics of each technology, such as effectiveness, reliability, and maintenance, to support informed adoption decisions. In addition, some barriers relate to the way that ADAS is marketed. Industry stakeholders should emphasize that ADAS are designed to serve as the driver's backup (see Figure 4) and to ***assist*** the professional driver in responding to safety critical situations (i.e., reinforce that the idea that the technologies can truly assist, rather than replace, the driver). Second, additional data is needed to understand why fleets elect to remove ADAS from "standard" packages offered by most OEMs (i.e., understand why some fleets elect to not include ADAS in their new truck purchases). Third, data is needed to identify truck models and market segments with low ADAS adoption rates and analyze why adoption is lagging (i.e., understand why some medium and heavy-duty vehicle operations trail adoption compared to other operations). Fourth, fleets need additional guidance on how to effectively use ADAS data to identify and support training needs on using and maintaining ADAS technologies. Fleets also need resources to enhance understanding of financial considerations, such as the potential return-on-investment of using ADAS, and on methods to support realization of potential lower insurance costs based on ADAS or data

provided by the ADAS. These resources may be in the form of management tools and guides to help address current challenges and barriers. Finally, additional outreach efforts are needed to provide hands-on ADAS demonstrations with drivers and fleet managers/executives so that they can have first-hand experience of ADAS capabilities (i.e., allow drivers and managers firsthand ADAS experiences).

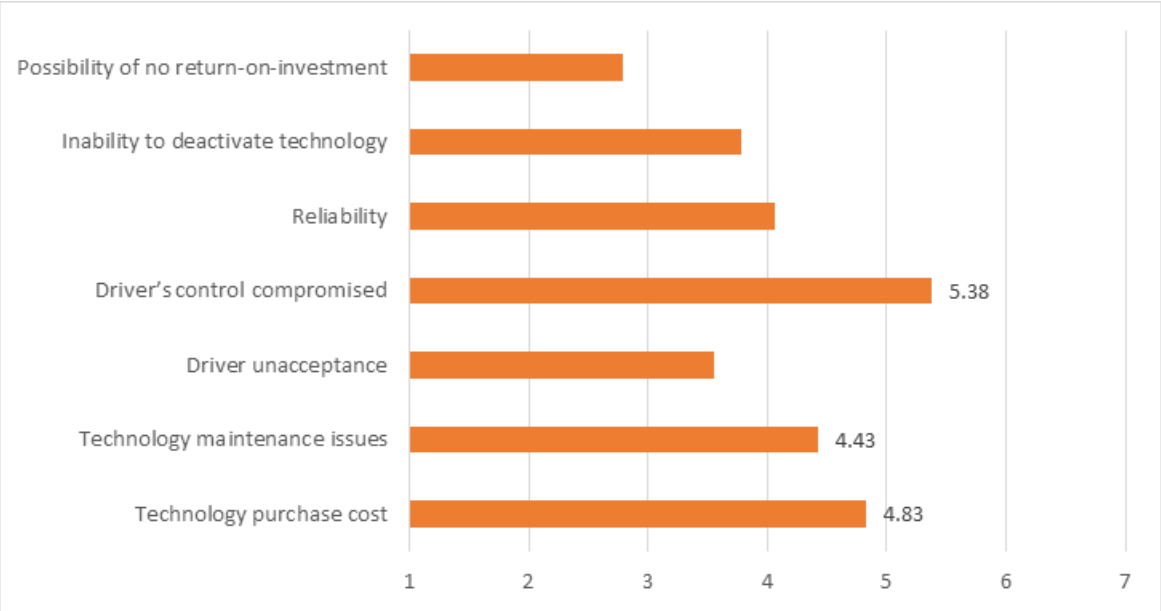

Figure 4. Bar graph. Most influential factors in deciding to NOT purchase ADAS (1=least important, 7=most important).

2.2 TASK 3: DEVELOPMENT OF TRAINING MATERIALS

In Task 3, the team developed outreach and training materials to better inform fleet managers and owner-operators of the benefits of including ADAS technologies when purchasing new heavy-duty vehicles. Three sets of materials were created: (1) two guides (or brochures), (2) four videos that individually focus on the four ADAS technology performance categories, and (3) a Tech-Celerate Now ADAS-specific return-on-investment (ROI) calculator. Information about the project web site (https://www.fmcsa.dot.gov/tech-celeratenow) and outreach metrics for these training materials are presented in Section 2.4.

2.2.1 Guides

The first set of materials developed to support education and outreach were two guides: ROI and truck operator safety (Figure 5). The ROI guide is a four-panel brochure designed for fleet managers and owner-operators to show how their operation can leverage ADAS technologies to save money and save lives. An example of an ADAS technology (driver- and forward-facing video) ROI calculation is provided in the ROI guide to illustrate the benefits of using the ROI calculator. The ROI guide builds on an existing one developed prior to the Tech-Celerate Now ROI calculator (see Section 2.2.3); however, the guide provides information consistent with the ROI calculator and the URL provided in the guide links to the calculator. The safety guide is a three-panel brochure designed as a truck operator's guide to ADAS and how they can use the

technology to prevent crashes. Owner-operators and fleet owners will benefit from both guides. Company drivers will benefit from the safety guide.

Figure 5. Photograph. Return-on-investment and truck operator safety educational guides.

Electronic versions of the two guides were produced in Section 508-complaint Adobe (.pdf) files downloadable from the Tech-Celerate Now web site. Hard copies were produced for distribution at the fall 2021 in-person conferences and annual meetings where team members gave project presentations and/or exhibited the project booth.

2.2.2 Videos

The second set of materials created consisted of four videos, one for each ADAS performance category: braking, steering, warning, and monitoring (see Figure 6). Each video shows clips featuring specific technologies in use and includes crash and benefit statistics for the ADAS performance category. The four training/outreach videos are posted on the Tech-Celerate Now web site in Section 508-compliant format, and have been featured in numerous team presentations. The Tech-Celerate Now program has been presented at a wide range of conferences and expositions reaching a broad audience base, as noted in Table 1 below. Key demographics participating in these events include those within the trucking industry—fleet owners, manufacturers and suppliers, and shipping logistics companies—as well as those connected with freight operations, such as academia and State and local Departments of Transportation. The project team's comprehensive outreach approach including all sectors of the trucking industry, small and large fleets, as well as owner-operators and truck drivers, in project outreach events and material development was fundamental to increase awareness and widespread adoption of ADAS.

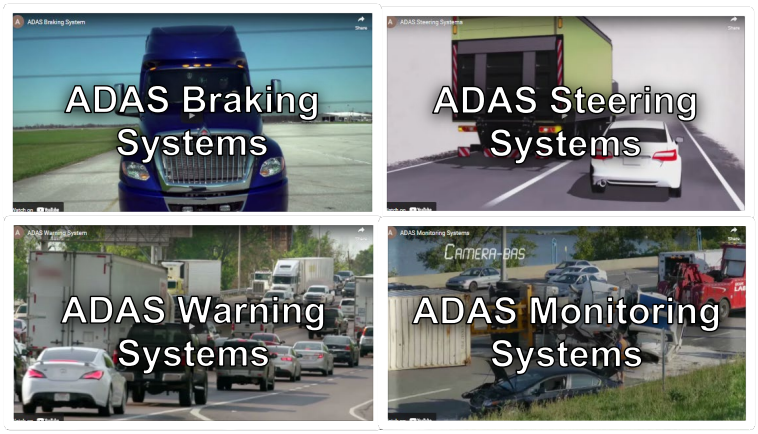

Figure 6. Photograph. Thumbnails of the four ADAS technology videos.

Early in the project, the team proposed outreach booth exhibits and presentations at the Mid-America Trucking Show (MATS) in March 2020, and the Great American Trucking Show (GATS) in August 2020, which are primarily owner-operator focused events. Unfortunately, due to COVID-19 these two shows were cancelled in 2020 and 2021. Owner-operators and truck drivers, however, were represented in other project areas. For example, OOIDA contributed input on the barriers to ADAS adoption analysis to ensure the owner-operator and truck driver views were included. OOIDA provided review and feedback on the two guides and four videos developed. The OOIDA Foundation was a speaker at the Tech-Celerate Now/Partners for Automated Vehicle Education (PAVE) webinar. As part of the joint webinar, leading trucking company executives shared their perspectives on their experience with ADAS technologies such as forward collision warning, automatic emergency braking, lane keeping assist, adaptive cruise control, camera-based mirrors, and blind spot warning systems. The PAVE webinar included testimonials on ADAS technologies from leading trucking company executives (see Figure 7). Furthermore, OOIDA was instrumental in getting driver feedback for the Baseline and Year One surveys (see Section 3).

Figure 7. Screen shot. PAVE webinar title slide.

Table 1. Demographics reached at outreach events.

Event	Fleet Owners	Truck OEMs	Logistics Companies	Providers/Tier 1, 2, 3 Suppliers	Academia	State and Local DOTs
TMC Fall 2021 Meeting	**Yes**	**Yes**	**Yes**	**Yes**	No	No
Partners for Automated Vehicle Education (PAVE) public webinar September 2021	**Yes**	No	No	No	**Yes**	**Yes**
Women in Trucking (WIT) Accelerate! Conference November 2021	**Yes**	**Yes**	**Yes**	No	No	No
ATA Management Conference and Exposition October 2021	**Yes**	**Yes**	**Yes**	**Yes**	No	No
National Tank Truck Carriers Tank Truck Week October 2021	**Yes**	No	No	**Yes**	No	No
Truckload Carriers Association (TCA) Truckload 2021	**Yes**	**Yes**	**Yes**	**Yes**	No	No

2.2.3 ROI calculator

Previous efforts to develop ROI calculators evolved from calculations of industry benefits and focused on a narrow set of ADAS technologies which were relatively mature. As described earlier, ADAS technologies are evolving quickly and the methods of adoption integration into a fleet can lead to differences in individual benefits. Therefore, it is important for an ROI tool to offer flexibility in *both* the combinations of technologies being considered and the benefits that a particular combination of technologies might achieve. To remedy this limitation, the project team developed a flexible, web-based Tech-Celerate Now ROI calculator that supports individual fleet adoption decisions of ADAS technologies and is located on the Tech-Celerate Now web site. The Tech-Celerate Now ROI calculator is based on the VTTI ROI calculator co-sponsored by FMCSA and the National Surface Transportation Safety Center for Excellence (NSTSCE). The VTTI ROI calculator currently targets advanced safety technologies such as automatic emergency braking, lane departure warning, and video-based onboard safety monitoring.

Expanding on this existing tool, the Tech-Celerate Now ROI calculator supports any combination of 11 different ADAS technologies and is designed for ease-of-use and access by the stakeholder community (see Figure 8). The Tech-Celerate Now ROI calculator also utilizes pre-populated ranges provided by industry (e.g., OEMs, suppliers) for key data points such as price, training, coaching, and crash risk to increase usability. Key to the ROI calculator is a feature which allows fleet managers and owner-operators to replace industry averages with their own data and to adjust the potential effectiveness of a combination of ADAS technologies at mitigating or preventing crashes. This feature allows fleet managers to test different conditions

when there is uncertainty about the costs or benefits of a particular package of technologies. The ROI calculator uses a 5-year timeframe for calculating the ROI, and includes important factors such as depreciation, taxes, and insurance liability. The ROI calculator does not save user data in order to protect privacy; however, users can download a PDF version of their results for reference.

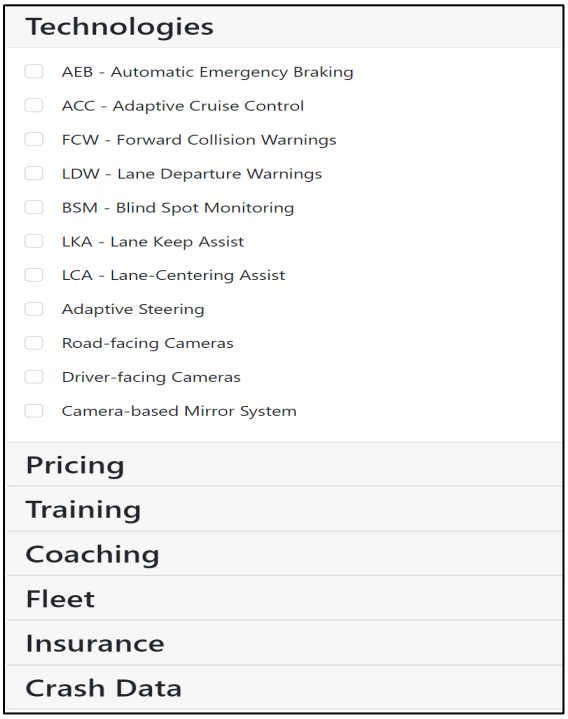

Figure 8. Screen shot. Tech-Celerate Now data entry screen.

While the ROI calculator is a powerful and flexible tool to help support industry decision-making, there are several key pieces of information that it does not incorporate. First, while insurance liability is included in the tool, insurance premiums are not. It may take several years for insurance premiums to adjust after adoption of ADAS, and therefore it mostly fell outside the timeframe of the tool. Second, litigation costs can be impacted by some ADAS technologies, and due to the highly variable nature of these costs across industry they were not incorporated into the tool. Finally, the tool makes assumptions about time and effort required to train and coach drivers using ADAS technology. While these costs are built into the tool in terms of cost, it is up to the user to make assumptions about their impacts on effectiveness. With additional data it may be possible and to help guide users on the expected cost and benefits of training and coaching to improve the validity of the tool.

2.2.4 Additional Financial and Taxation Considerations for ADAS Adoption

Based on an outside analysis provided to the Tech-Celerate research team by CliftonLarsonAllen (CLA)—an accounting firm well known within the trucking industry—carriers and truck drivers should be aware of several financial realities that can affect the perceived net cost of purchasing ADAS technologies on trucks.

As is well known by fleets and owner-operators, any components newly installed by a truck OEM has a mandatory 12 percent Federal excise tax (FET) added to the full cost associated with the purchased technology. For example, a safety technology that initially is priced at $2,500 will now cost $2,800. While the trucking industry has argued against the application of the FET on safety investments, the 12 percent tax is still a financial reality for OEM-installed equipment. Nevertheless, after-market components typically experience high installation labor costs as they are often less efficient than relatively automated OEM processes, which also can benefit from common components across ADAS technologies. Further complicating the OEM versus aftermarket decision-making is section 4051 of the Internal Revenue Code (26 U.S.C. § 4051), which states that if the after-market accessory is installed within six months of the original truck purchase, the 12 percent FET still applies.

State and local sales taxes are another important consideration as they often add between 4 and 10 percent to the final purchase price. As noted in the CLA paper, the trucking industry has some specific carve-outs in the tax codes. With State and local sales tax, there are a lot of full or partial exemptions. For example, motor carriers in Wisconsin are provided a full up-front exemption if certain criteria are met. That would mean even though the Wisconsin sales tax rate is 5 percent, a Wisconsin motor carrier would not pay any sales tax on eligible purchases. Minnesota is an example of eligibility for partial exemptions. Minnesota provides a partial sales tax exemption for motor carriers based on the miles driven in the State compared to the total miles driven everywhere. So, if a motor carrier has 40,000 miles in Minnesota and 100,000 miles everywhere, the motor carrier would only pay 60 percent of the 6.875 percent sales tax.

Fortunately, safety technologies that are interdependent with the truck can depreciate the equipment over a 3-year period. The net effect is to help reduce the motor carrier's taxable income.

The taxation landscape, at all jurisdictional levels, is complex and comes with both positive and negative financial outcomes. The CLA paper in Appendix C provides high-level guidance to potential ADAS purchasers and suggests that outside financial expertise may be needed to assist in ADAS adoption decisions.

2.3 TASK 4: DEVELOPMENT OF RECOMMENDED PRACTICES

The purpose of Task 4 is to develop TMC Recommended Practices to provide guidance on training, use of data from, and human-machine interfaces with ADAS. The project was tasked with developing and proposing new Recommended Practices (if none are available) or proposing revisions to Recommended Practices (if existing ones are available) on the following three topics:

1. Description of the recommended commercial driver training that should be provided regarding automatic emergency braking and lane departure warning systems.
2. Description of the data typically available from automatic emergency braking and lane departure warning systems, the ways in which the data are available to fleets, the metrics or flags that a fleet should look for in the data, and the recommended actions that could be taken if a metric or flag signals problems (e.g., coaching or training).

3. Standardization of methods for how automatic emergency braking and lane departure warning systems should alert commercial drivers or intervene in different situations.

2.3.1 TMC Recommended Practice Development Process

TMC employs a hierarchical committee structure to develop and/or update Recommended Practices. At the top level, there is TMC's Board of Directors, which establishes "Study Groups" to identify the need for Recommended Practices in key functional areas of technical activity. TMC's Board of Directors also may establish ad hoc committees. While the committees do not engage in Recommended Practice development, they do identify needs statements, position papers and information reports that can be used by Study Groups in their task of identifying worthy candidates for Recommended Practice development—especially when the subject matter crosses multiple functional areas of vehicle engineering and maintenance such as corrosion, education, and future truck design.

These Study Groups are ongoing committees that identify industry challenges with respect to equipment and maintenance. If a Study Group decides that a particular problem merits attention, it votes to create a short-term subcommittee or "Task Force" to solve it. TMC has 15 active Study Groups overseeing nearly 100 Task Forces. These Task Forces solve problems usually through the development of a TMC Recommended Practice. However, a Task Force may decide the best solution is a technical session, mini-technical session, or an information report. The typical life-span of a Task Force is about 2 years.

The process of initiating or revising any Recommended Practice begins with a written request to TMC's technical director or study group chair, or an oral request at the appropriate study group's meeting. Study Groups only meet at TMC general meetings, which presently occur twice a year at events known as the Council's Annual and Fall Meetings.

Task Force creation is followed by task force meetings to develop the Recommended Practice, which is subject to public comment and subsequent revision before TMC publication. The Task Forces, in the course of their work, determine whether the Recommended Practices to be developed involve maintenance and/or engineering/specification. It is likely that Recommended Practices of both varieties will be developed.

2.3.2 Status of Recommended Practices Developed or Revised Under the Project

Four Task Forces were created under this project to develop four new Recommended Practices. Given the process and timeframe to develop the Recommended Practices, the four new Recommended Practices will be finalized after the project period of performance. Drafts of two are in process, one is in the balloting process, and a position paper has been published for one. The Recommended Practices developed under this project are presented in Table 2. This table includes information about the study group, task force, objectives, and related topic (1), (2), or (3). See TMC's Recommended Practices web site (https://tmc.trucking.org/tmc-recommended-practices) for current information.

Table 2. Recommended practices to be developed.

Study Group	Task Force/ Project Title	Scope	Objectives and ADAS Relevance
S.18	ADAS Selection and Specification CREATED 9/2020—determined that ADAS considerations need to be completely separate from those for Automated Driving Systems (ADS).	Develop a recommended practice for the selection and specification of ADAS technologies in medium- and heavy-duty commercial fleets.	Seeks to provide an understanding of the decision-making process related to fleet specifications for adopting ADAS technologies. Will identify operational characteristics particular to fleet modes of operation, equipment types and vocational applications as relating to the selection of the most effective ADAS technologies for a particular fleet profile. Topics (1), (2), (3)
S.18	Automated Truck Inspection and Enforcement CREATED	Develop guidelines for maintenance and safety inspections for automated medium- and heavy-duty commercial trucks including compliance with North American Standard Out-Of-Service criteria.	Work cooperatively with the Commercial Vehicle Safety Alliance in aligning industry practices with those of the law enforcement safety inspection community. Scope will include all ADAS technologies as well as higher levels of Automated Driving Systems. Topics (1), (2), (3)
TBD	ADAS Terminology CREATED	This Task Force will develop a common library of ADAS terminology as applicable to the trucking industry.	The objective is to promote use of common naming terms for ADAS technologies throughout the industry. Topics (1), (3)
TBD	Technician Training for ADAS Systems CREATED	This Task Force will make recommendations for training requirements for technicians servicing ADAS technologies in medium- & heavy-duty commercial vehicles.	The Task Force will identify topical areas for a training program to develop knowledge and skills of technicians. Topics (1), (3)

In addition to the four new Recommended Practices to be developed, the project team worked with TMC to create new Recommended Practices or to revise existing Recommended Practices to incorporate ADAS technologies. Similar to Table 2, information about these Recommended Practices under consideration for development pertaining to ADAS are provided in Table 3.

Table 3. Recommended practices considered for development pertaining to ADAS.

Study Group	Task Force/Project Title	Scope	Objectives and ADAS Relevance
S.5	ADAS Return on Investment (ROI) Calculator REVIEW OF VTTI CALCULATOR ONGOING	This Task Force will develop recommendations on a standard methodology to determine ROI from adoption of ADAS technologies in medium- and heavy-duty commercial vehicle fleets.	The Task Force will review the ROI Calculator developed by the Virginia Tech Transportation Research Institute (VTTI), and make recommendation regarding its adoption and/or modifications to the calculator to make it industry-relevant. Topics (1), (2), (3)
S.1	Next Generation Tractor/Trailer Electrical Interface CREATED	This Task Force will work to create backward-compatible, future-looking definition of tractor to trailer interface connections.	The objective is improved safety, autonomous operation, enhanced diagnostics, and increased durability. It will consider both wired and wireless connectivity. It will address the need to maintain fail-safe ADAS component command and control channels across the combination vehicle. Topic (2)
S.7	Next Generation Trailer Electrical Architecture CREATED	This Task Force will work to create backwards-compatible, future-looking trailer electrical architecture.	The objective is improved safety, autonomous operation, enhanced diagnostics, and increased durability. It will consider both wired and wireless connectivity to provide a futureproof, reliable, and easily maintained electrical and information network on trailers, in parallel with development of connection recommendations being developed under the S.1 Task Force. Topic (2)

Study Group	Task Force/Project Title	Scope	Objectives and ADAS Relevance
S.12	Open Telematics API CREATED	This Task Force will develop a Recommended Practice for standardized Open Telematics API for retrieving telematics logs and data, utilizing a schema developed by the National Motor Freight Traffic Association (NMFTA) Inc.	This project would enable development of secure communications of the data generated by trailer-installed technologies across the TMC RP 1226 connector to include protection of ADAS systems. Topic (2)
S.17	Collision Repair Roadmap	Task Force will develop a roadmap/flowchart for the steps needed to take a truck or trailer involved in a collision and make it road ready and safe for service. The flowchart will consider safety, cost, and equipment utilization, and identify areas for future Task Force development.	This project was expanded to include addressing specific ADAS system and component considerations that must be addressed to return a vehicle to full and safe operational status following a collision incident. Topics (1), (2), (3)
S.5	Pre-Service Vehicle Inspection	This Recommended Practice provides equipment users a form which contains most of the standard items to be inspected prior to a truck or tractor being put into service or when returned to service following significant repairs.	Inspection of ADAS functionality and confirmation of proper ADAS system configuration/settings added to the inspection checklists. Topics (1), (3)
TBD	ADAS Preventive Maintenance Guidelines PROPOSED	This Task Force will develop recommendations for inspection and troubleshooting of ADAS technologies.	The Task force will develop a systematic approach to both preventive maintenance inspection of ADAS technologies as well as diagnostic troubleshooting for repair/replacement. Topics (1), (3)

As the process of Recommended Practice development unfolded in pursuit of the three topical objectives in Task 4, TMC came to the realization that there is great diversity across the various ADAS systems developers and in how those systems are incorporated into vehicle designs and ADAS feature performance. These variations are present even for the same ADAS system across different model offerings by an individual OEM, such as in a model destined for long-haul over the road uses versus one intended for a vocational use such as ready-mix concrete. In addition, the telematics data messaging sets vary across OEMs and telematics system providers, and in terms of their data services to fleets.

As a result of these investigations, the various Study Groups realized that while the standardization objectives are desirable long-term aims, immediate Recommended Practice developments were needed to lay the groundwork upon which these goals can be achieved. For example, identifying the nomenclature used by various systems will assist in training drivers and technicians in what can be expected from the response of the system. Examples include lane departure warning/lane keeping assist features or the automatic emergency braking system of the particular model they are assigned to, even potentially relating to the differences across model years. To achieve successful safety outcomes, TMC has come to the realization over the course of this project that "standardization" is most likely to occur within a fleet as a result of how they specify and set parameters of ADAS features. The options for ADAS technologies and their set parameters must match the utilization profile for that particular fleet. TMC has already conducted panels during its public meetings to educate fleets to these findings. As a direct result of the development of the position paper on Automated Truck Inspection and Enforcement there ensued a very robust, although yet to be resolved, debate among fleets, OEMs and system suppliers/service providers regarding messaging standardization. These Recommended Practice development efforts will both continue as described above and will likely lead to additional Recommended Practice development projects. These future Recommended Practice development projects will be needed for both successful deployment of ADAS and improved education of fleets, technicians, and drivers.

2.4 TASK 5: NATIONAL OUTREACH CAMPAIGN TO PROMOTE ADAS

A plan for the national outreach campaign was developed to accelerate the voluntary adoption of ADAS technologies. The plan included target audiences and key messages, outreach products, brand development, and potential campaign activities and events. The team adjusted the activities and schedules at the onset and throughout the COVID-19 pandemic for outreach continuity. Project outreach included several core activities to targeted audiences: develop articles to be published in trade industry periodicals; give presentations at conferences, seminars, and committee meetings; and develop and staff the booth at exhibits. Outreach metrics have been tracked from project initiation to help measure the effectiveness of the outreach campaign.

In addition to the education and training materials developed and core outreach activities, early in the project initiation, the team developed a project Tech-Celerate Now Flyer to promote branding and promote ADAS adoption and developed a Tech-Celerate Now web site to support project awareness and distribute training and educational materials. Project flyers were distributed initially at TRB 2020 and the TMC 2020 Annual Meeting & Transportation Technology Exhibition February 2020 meeting. The project web site was launched in late April 2021 to coincide with the project's Year One launch.

2.4.1 Project Outreach

A total of four articles were developed by the project team members and published in a leading trade journal. Topics included benefits of integrating automatic emergency braking (a critical component of ADAS), increasing driver awareness of ADAS acceptance and understanding safety benefits, and Recommended Practice development. Presentations were given at six in-person conferences and annual meetings, and numerous industry and committee meetings over the course of the project. Presentations included project background, ADAS technologies, and overall findings from the Baseline year survey and findings from the barriers to ADAS adoption. Although the project team planned several in-person engagements in the Baseline or first year of the project, due to COVID-19 pandemic limitations and restrictions, the project team had to pivot to webinar-based and virtual meetings to continue the outreach campaign and to keep ADAS adoption and awareness at the forefront of fleet owners and drivers. In addition, team members used targeted social media messaging to keep interest and awareness in Tech-Celerate Now via X (formerly Twitter), LinkedIn, TMC Connect, and the Tech-Celerate Now web site. In fall 2021, in-person engagement resumed. A project booth was designed and developed to promote adoption and awareness of ADAS technology through showcasing the videos and distributing hard copies of the two guides to booth visitors (see Figure 9).

Figure 9. Photograph. Visitors at the Tech-Celerate Now booth at the ATA Management Conference & Exhibition, October 2021.

2.4.2 Outreach Metrics

Team members tracked and analyzed all outreach activity early in the project life cycle to gauge the effectiveness of the outreach campaign and possible impact of training materials on the awareness and adoption of ADAS.

Figure 10 through Figure 15 describe the Tech-Celerate Now program outreach impact over the life of the project. Figure 10 provides a high-level overview of notable measurements for all forms of outreach that was developed as part of a slide deck for FMCSA leadership to promote the impact of the ADAS project. Figure 11 shows total contacts for all outreach and Figure 12 shows in-person versus remote instructional outreach. The team's ability to pivot to virtual or remote outreach activities in March 2020 provided continuity to outreach efforts, while the eventual resumption of in-person outreach events enabled the team to access a significant customer base. Apparent in both Figure 14 and Figure 15 is the significant audience reached through a series of radio promotions of the Tech-Celerate Now program (abbreviated TCN in the figures below); the listener base across four shows was estimated to make up 3.2 million of the total 3.6 million contacts. This illustrates the significant reach to the project's truck driver audience.

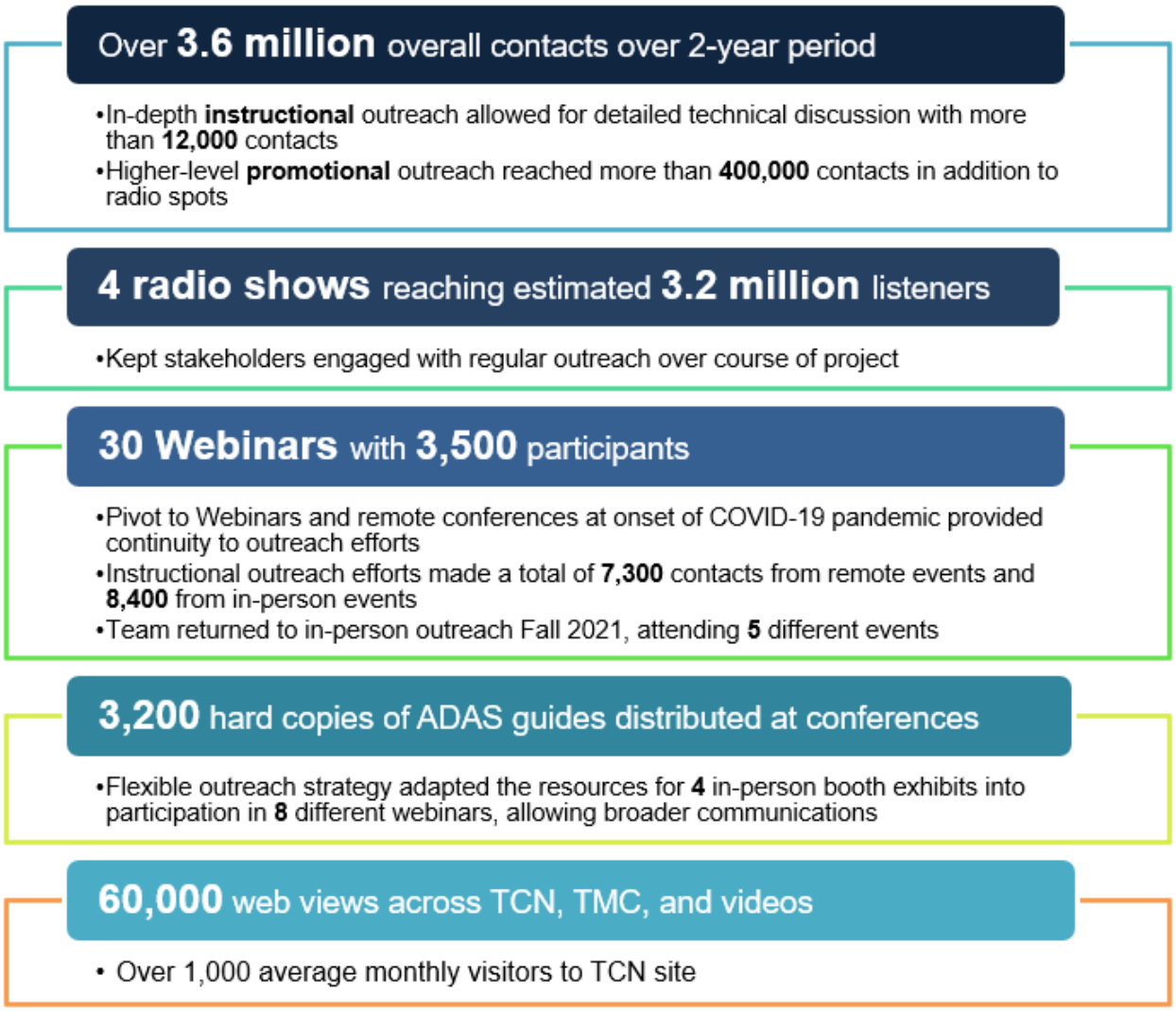

Figure 10. Illustration. ADAS outreach highlights.

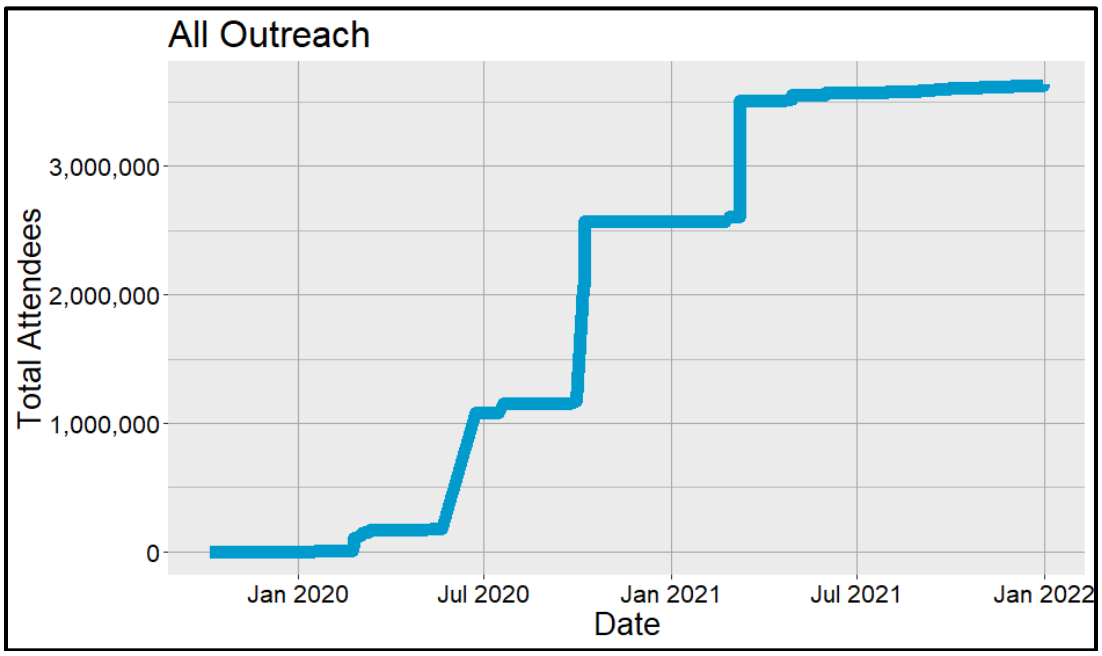

Figure 11. Line graph. All outreach efforts.

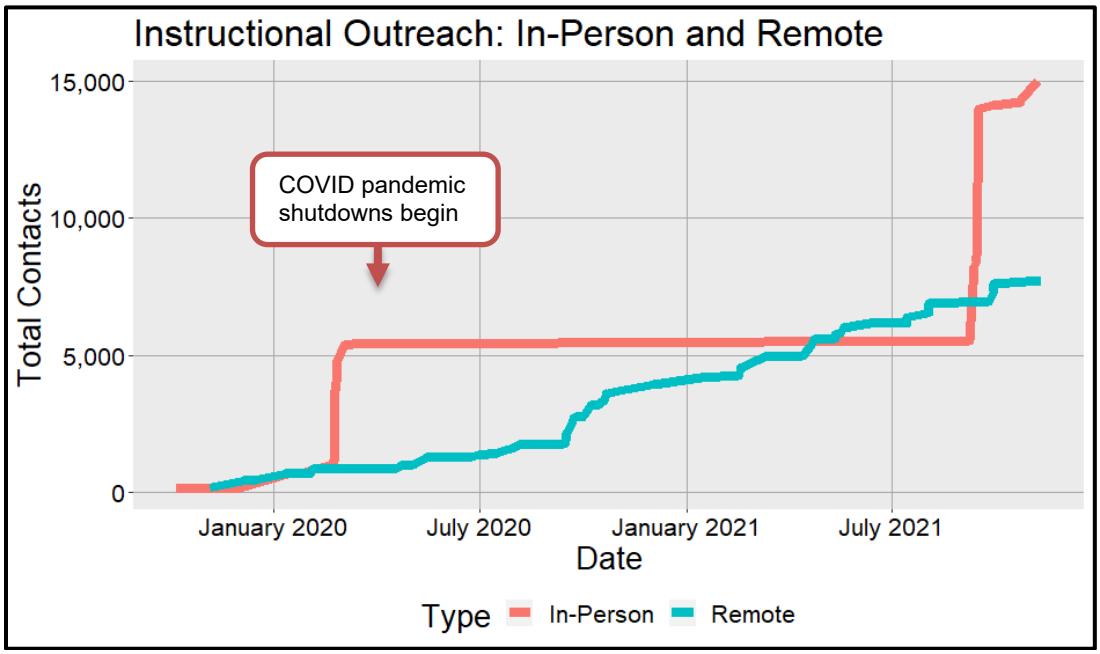

Figure 12. Line graph. In-person and remote instructional outreach.

Figure 13 provides further details for the promotional and instructional outreach categories. The types of activities included under each outreach category are described. Events were categorized to emphasize the diversity of outreach activities that were conducted, and the different types of audiences they were intended to reach. For example, while meetings with interested stakeholders do not reach as many contacts as press releases or radio shows, they allow for a much deeper discussion of the Tech-Celerate Now program and are targeted to be more effective at reaching out to narrowly tailored audiences.

Additionally, it is worth noting that the number of contacts is taken from conservative estimates: where attendee counts are only available as estimates, the lower value of the range was used; if no estimates are available, then a value of zero was input so as to not overstate reach. Additionally, the number of contacts

represents a count of persons reached and includes the same individuals reached via multiple activities over the life of the project. It does not represent 3.6 million unique individuals.

- **Promotional outreach** provides high-level information about ADAS—targets program awareness, name recognition, and nontechnical details
  - *Email* includes web blasts and newsletters
  - *Radio* highlights appearances on Dave Nemo's Truck Talk
  - *Reporting* includes news articles and other press coverage
  - *Site Views* tracks visitors to TCN homepage
- **Instructional outreach** provides deeper dive into ADAS—targets implementors, specific benefits, deployment tips and guidance
  - *Meetings* include discussions with interested stakeholders or partners
  - *Presentations* include conferences and other large groups
  - *Webinars* include ADAS discussions on dedicated online-only forums
- Figures represent a **conservative estimate** of outreach hits—low values taken from attendance ranges, some panels and events left blank instead of guessing at attendees

Figure 13. List. Promotional and instructional outreach categories.

Finally, Figure 14 shows a log count of contacts by engagement type and Figure 15 shows a linear count of the number of outreach events of each type that were held. The logarithmic display of the top chart allows visualization of the diversity of contacts reached; while nearly 200 contacts were made through meetings discussing the Tech-Celerate Now program, for example, over 150,000 contacts were made through email blasts. As discussed above, these different forms of outreach allow for contacts to be made with a diverse range of contexts and with content tailored to specific audiences. The variation of efforts further encourages robust engagement with the program from audiences who may learn of it through a multitude of formats. The lower chart shows the number of events that were conducted in each category. For example, there were 44 ADAS-related presentations conducted, the most of any individual type of outreach. In this graph, the count of the "Site Views" column relates to the number of web site and social-media–related reports created by the team; because the web sites were continuously operated over the course of the outreach drive, monthly view tallies and impact reports were used to summarize their reach.

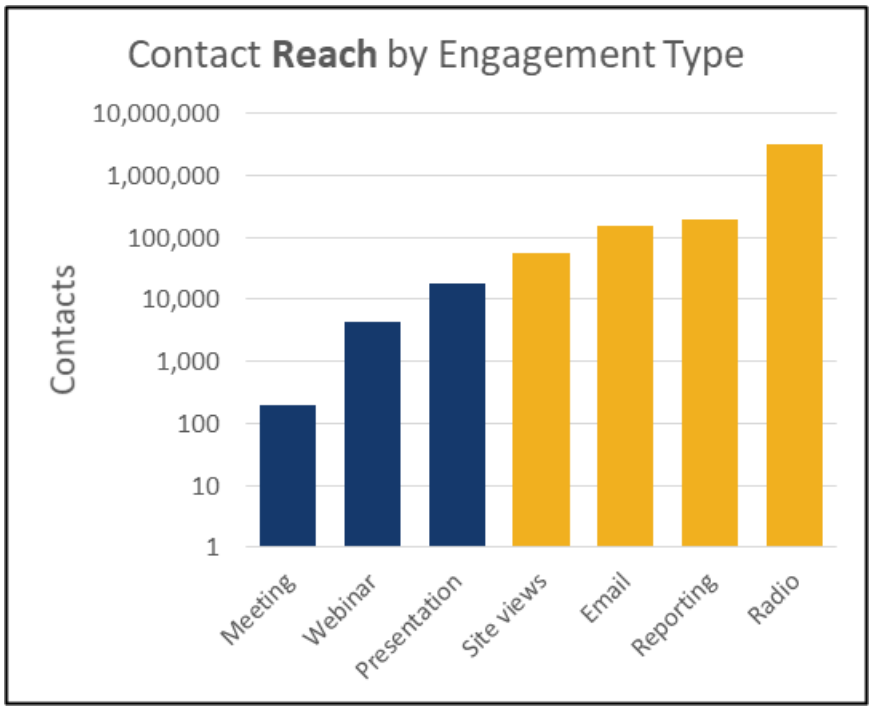

Figure 14. Bar graph. Contact reach by engagement type.

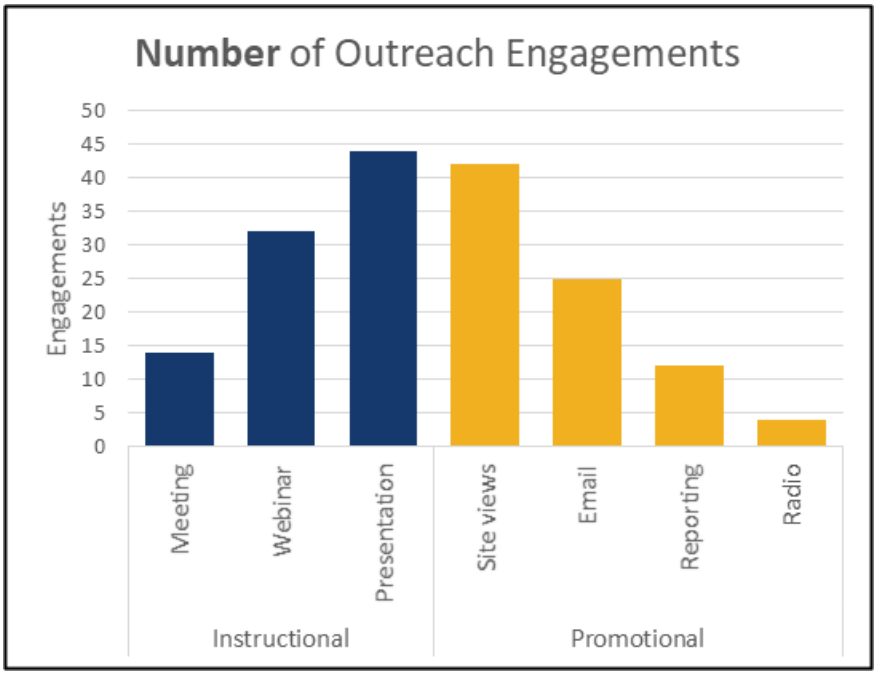

Figure 15. Bar graph. Number of outreach engagements.

Outreach activities included the maintenance and promotion of webpages related to the Tech-Celerate Now program, as well as the online distribution of the guides and videos created under Task 3. The view counters for the videos through December 2021 can be seen in Table 4.

Table 4. Video view counts through December 2021.

Video	Total views
Warning Systems	263
Steering Systems	248
Camera-based Monitoring Systems	293
Braking Systems	410
Total	*1,214*

Site visits were also reported and are summarized in Table 5. The TMC web site views specifically account for periods during which the homepage featured a Tech-Celerate Now promotional banner advertising the program. The LinkedIn outreach relates to an innovative promotional campaign for truck drivers promoting the hashtag "#BogieLovesADAS;" Bogie is the name of the dog featured in the videos and was chosen to promote the program (e.g., ADAS, like Bogie, is a trusted companion for truck drivers) in a way that was more likely to attract attention and click-through via social media (see Figure 16).

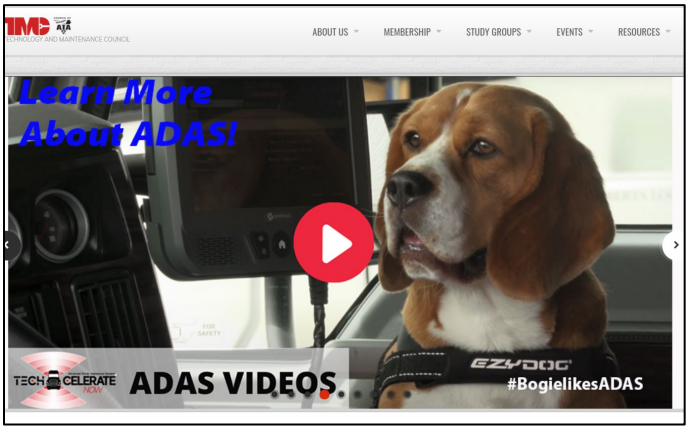

Figure 16. Photograph. A promotional still from the ADAS video guides featuring Bogie the dog.

Table 5. Web site views through December 2021.

Site	Views
Tech-Celerate Now web site	9,024
TMC web site	21,404
TMC Connect	1,987
LinkedIn Outreach	26,496

This section presented a summary of project outreach metrics from outreach engagements, and instructional and promotional materials. The following section (Section 3) will present a further analysis of outreach impacts based on data collection and analysis from survey responses.

3. ASSESSING IMPACTS ON ADAS AWARENESS/PERCEPTION/ADOPTION

3.1 METHODOLOGY

This section provides a summary of the Baseline survey results, a detailed assessment of the Year One post-outreach campaign survey results, and a comparison of both summaries. A summary of the 2 years of survey data and comparison analysis quantifies the impacts of Tech-Celerate Now on ADAS awareness, perception, and adoption among drivers and carrier executives.

3.1.1 Objectives

Despite considerable documentation of the efficacy of ADAS technology in the automotive industry, there is still uncertainty within the trucking industry. Uncertainty about reliability, usability, maintenance requirements, and ROI are the primary factors contributing to slow adoption and negative perception of the technologies. In the Baseline survey, awareness was determined to be the primary obstacle in increasing adoption, and potentially safety, in the trucking industry. To understand how awareness, perceptions, and adoption changed during the Tech-Celerate Now program tenure, the team developed and distributed a second or Year One survey to identify changes and to analyze the impacts of outreach and education efforts.

3.1.2 Design/Targeted Groups for Survey Respondents

Tech-Celerate Now developed Baseline and Year One surveys to collect industry data for two groups:

- Motor Carrier Executives: This category represents all non-driver staff ranging from safety and maintenance directors to company CEOs. Most motor carrier executives influence decisions in technology system investments.
- Drivers: This category represents both company drivers and owner-operators. Owner-operators make technology investment decisions while company drivers do not. Company drivers however may choose employers based on equipment technologies.

In the post-outreach campaign Year One study, the research team developed a customized survey for each group (Appendix A). The surveys were pre-tested with group representatives and subsequently revised based on feedback. The motor carrier executive ("carrier") survey was distributed among ATA and TMC partnering carriers and the driver survey was distributed among OOIDA members. Both surveys were also made publicly available on the Tech-Celerate Now web site and promoted via national media outlets, social media, and other industry outreach.

3.1.3 Baseline and Year One Survey Questionnaires

To develop the post-outreach campaign Year One survey, the Baseline survey was revised, consisting of two separate questionnaires each with driver and carrier-executive specific questions. The surveys also differed in questions about specific technologies reflecting differences in driver and carrier perspectives. Rank-order questions addressing driver preferences differed in language to reflect employer/employee relationships, but questions about technology purchase were submitted to both groups since many driver respondents are owner-operators and thus make technology purchasing decisions.

3.1.4 Aggregate Adoption Rates

Recognizing the detailed sales and adoption data that ADAS suppliers possess, the research team added a complimentary third survey to the Tech-Celerate Now research. The third survey, informally called the Affiliates Survey, was disseminated to known ADAS technology vendors as well as truck OEMs. The survey sought insight on annual sales numbers for the relevant supplier technologies, as well as supplier estimates on future sales and adoption trends. The first Affiliates survey generated approximately 25 responses. A second Affiliates survey was distributed towards the end of the Tech-Celerate Now program (in concert with the Year One survey), in order to assess supplier sales changes over the Tech-Celerate Now program. The second survey was less successful; generating slightly fewer than 12 responses.

3.2 BASELINE SURVEY SUMMARY

In 2020, Tech-Celerate Now developed two targeted Baseline surveys designed to collect industry data on the state of ADAS in trucking, which yielded 726 usable responses from the driver survey and 200 from the motor carrier executives survey. The results of this Baseline Industry Survey showed that differences between carrier executives and drivers existed for awareness, adoption, and expected safety outcomes of ADAS technologies.

The Baseline Survey Results revealed that financial concerns were the primary factor in the decision to purchase ADAS technologies for both groups (see Figure 17 and Figure 18). Additionally, driver impacts were also found to influence the decision to adopt technologies for both drivers and carriers. The Baseline survey revealed that carriers were concerned over drivers' unwillingness to operate trucks with ADAS technologies installed. Both carrier executives and drivers reported concerns with complications in operating the technologies. From these findings, Tech-Celerate Now prioritized positive messaging for increasing acceptance by drivers and carriers alike.

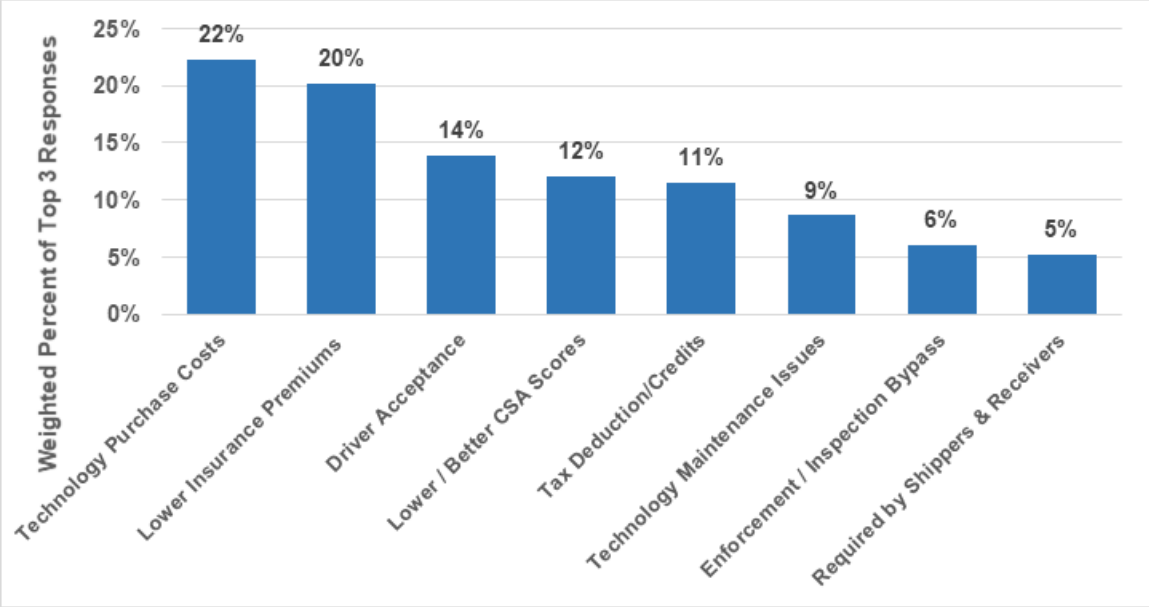

Figure 17. Bar graph. Motor carrier executives: Top-ranked issues impacting ADAS adoption.

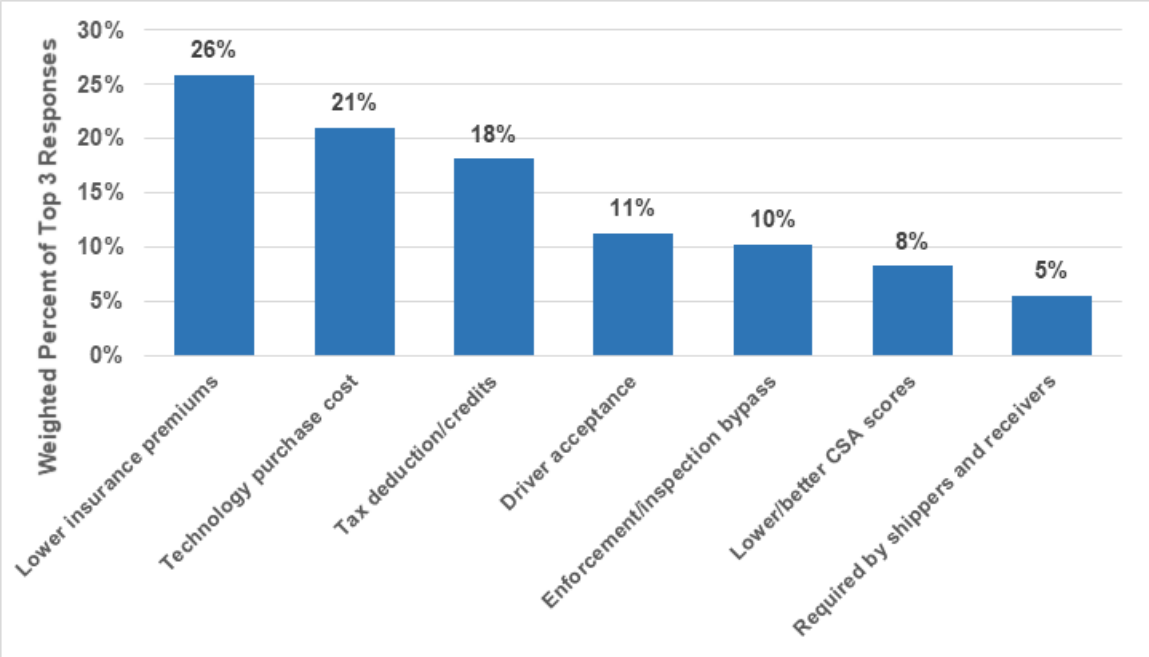

Figure 18. Bar graph. Truck drivers: Top-ranked issues impacting ADAS adoption.

3.2.1 Awareness

The Baseline survey revealed that, in general, trucking executives were more aware of ADAS technologies than drivers, but trends in awareness of specific technologies were mirrored in both groups. Driver respondents' awareness was on average approximately 11 percent lower than carrier executives. Among drivers, unfamiliarity was highest for Adaptive Steering Control, where 35 percent of driver respondents reported never having heard of this technology.

Among carrier executives, unfamiliarity was highest for blind spot warning and steering technologies overall. Unfamiliarity of steering technologies in both groups is indicative of the relatively new emergence of these technologies. Between 95 and 100 percent of trucking executives reported being at least "slightly familiar" with all the ADAS technologies. One hundred percent of executives reported being at least "slightly familiar" with Lane Departure Warning.

These results from the Baseline survey informed the decision to focus efforts on increasing awareness among drivers.

3.2.2 Safety Perception

More than 43 percent of respondents from both carrier and driver Baseline surveys reported that air disc brakes would have a very large positive impact on safety. As air disc brakes were interpreted as a primary braking technology and not an assistance system, it was not included in the later ADAS categories. Both surveys also showed positive perceptions (see Figure 19 and Figure 20) for blind spot warning systems, despite low adoption rates. This finding offers a potential opportunity for increasing utilization of blind spot warning systems.

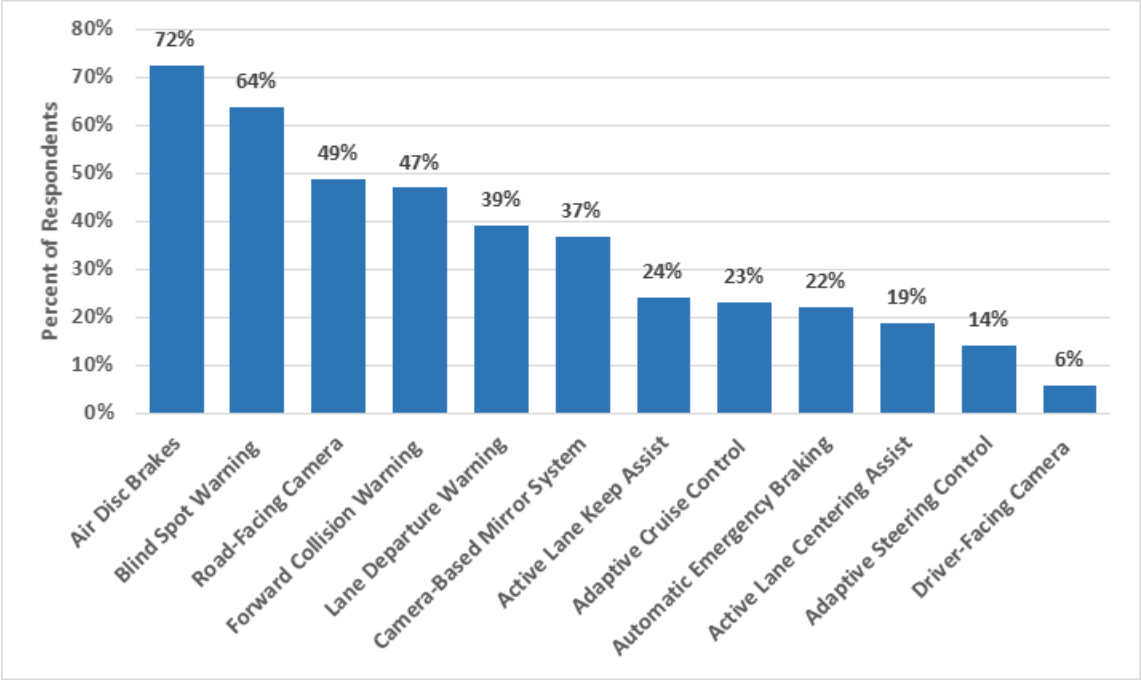

Figure 19. Bar graph. Truck drivers: Very large / moderate expected improvement in safety outcomes.

Carriers (see Figure 20) rated warning systems as being a positive technology in improving safety, 14 percent higher on average than drivers.

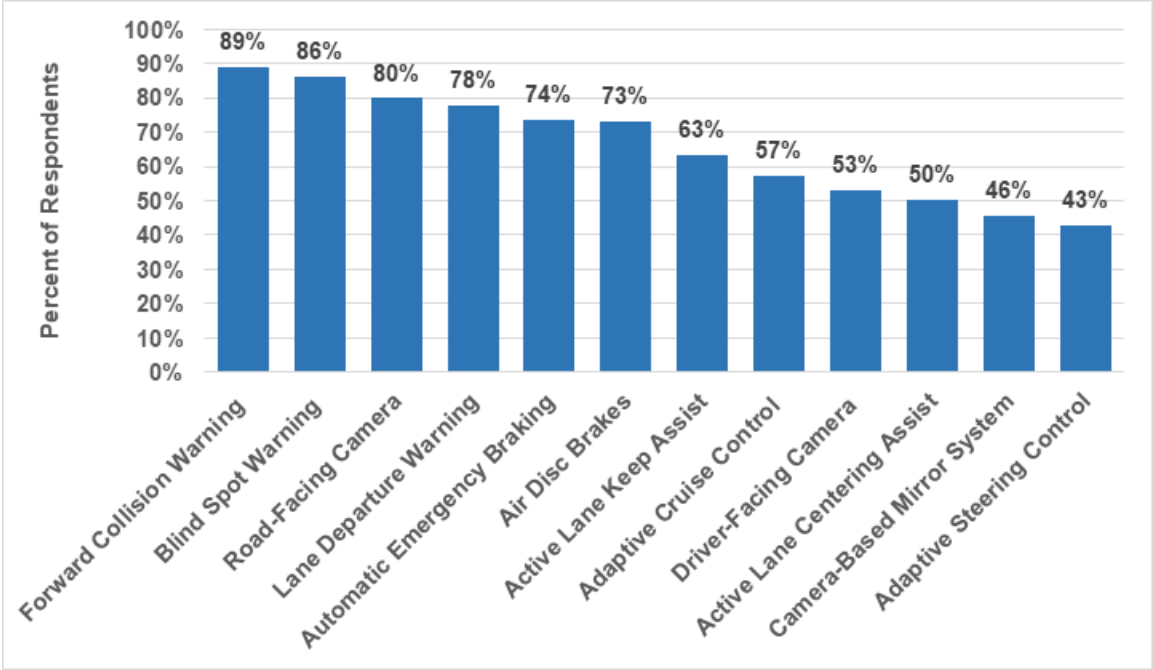

Figure 20. Bar graph. Motor carrier executives: Very large / moderate expected improvement in safety outcomes.

3.2.3 Adoption Perception

In the Baseline survey, respondents were asked to rank which technologies they thought would be most likely to be adopted industry wide. Braking systems consistently ranked highest for industry adoption among both carrier and executive respondents. Drivers perceived air disc brakes to be most likely adopted industry-wide while carrier executives indicated automatic emergency braking most likely to be adopted

industry wide. Warning systems also ranked highly in perceived industry adoption. Both carriers and drivers ranked forward collision warning systems likely to be adopted industry wide.

3.2.4 Factors in Adoption

Both groups reported financial factors and as the largest motivator/inhibitor to ADAS adoption. Because of this finding, the Tech-Celerate Now ROI calculator and/or its outputs are critical to the program. Driver acceptance was also ranked highly as a factor in the decision to purchase ADAS technologies.

Despite market research indicating that external pressure can be a powerful motivator in the decision to purchase ADAS, both groups ranked the "Required by Shippers and Receivers" lowest among factors impacting their decision to adopt.

Truck drivers commented that their biggest concern in adopting ADAS technologies is the loss of driver control (see Figure 21). Tech-Celerate Now should emphasize the positive impact of ADAS in enhancing driver control to reduce the negative perception that ADAS minimizes the role of the driver. New technologies provide drivers with more information and tools on the road, increasing power and control as a driver.

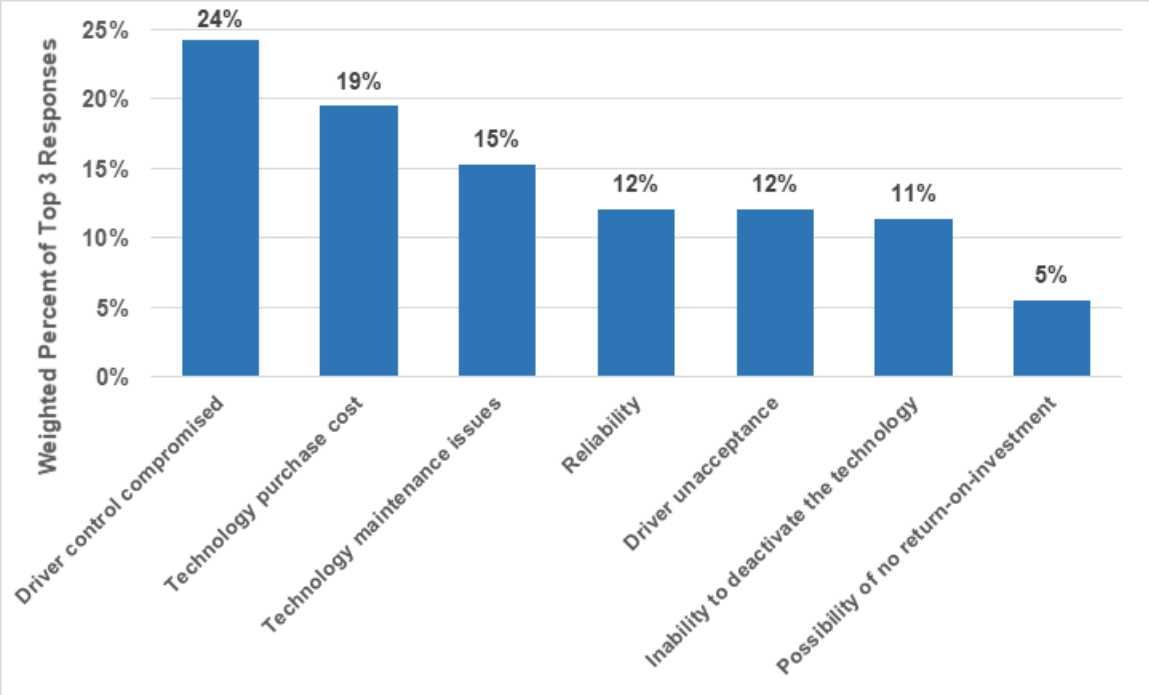

Figure 21. Bar graph. Truck drivers: Top-ranked reasons for not adopting ADAS technologies.

3.2.5 Adoption Levels

Road-facing cameras were the most adopted technology among both driver and carrier respondents. Fifty-one percent of carriers reported adoption of this technology at the highest level (75 to 100 percent of fleet), and 36 percent of drivers reported adoption at this level.

Active steering systems had the least adoption among both carriers and truck drivers. This could be due to these technologies being newer compared with braking or warning systems.

Among the ADAS monitoring technologies, the lowest adoption was camera-based mirror systems; both groups exceeded 80 percent reporting the lowest adoption level (0 percent of fleets). This could also be

due to the newness of this technology. The second-least adopted technology was driver-facing cameras with 54 percent of carriers and 85 percent of drivers reporting the lowest adoption level. Survey respondents stated that driver-facing cameras were perceived as an invasion of a driver's privacy.

3.3 YEAR ONE SURVEY / ASSESSMENT OF IMPACTS

At the completion of the full analysis of the Baseline survey, it was clear to the researchers that several adjustments would be needed in the post-outreach campaign Year One survey, in order to better document perceptions and adoption level changes over time. These included workforce-related questions to understand how truck drivers viewed carrier recruitment and employment with fleets with and without ADAS technologies.

The Year One survey was developed based on Baseline survey results and addressed key differences in driver and carrier executive respondent groups. The goal of the Baseline survey was to identify overall trends in awareness and adoption for both groups. These findings along with other feedback were considered in developing the revisions to the second Year One survey. The Year One survey explored the ability to identify trends between groups across an approximately 18-month interval between spring 2020 and fall 2021.

The response rate for the Year One driver survey mirrored that of the Baseline and was higher among driver respondents than carrier executives. The carrier survey resulted in 145 complete responses and reflected industry professionals ranging from senior executives to maintenance technicians. The driver survey produced in a more robust sample of 646 complete survey responses. As the format of the survey was similar to the Baseline survey, a lower number of responses may be attributed to the reluctance to complete a recurring survey, or even the potential for recipients to believe they had already responded.

3.3.1 Awareness

Tech-Celerate Now Program Awareness

In Year One, awareness for the Tech-Celerate program was higher among carrier executives than for drivers. Forty-eight percent of carrier executives reported having heard of the program, while 29 percent of drivers reported having heard of it. Awareness among carrier executives was highest among those representing large fleets (over 1000 trucks) with over 60 percent reporting awareness of the program (Figure 22).

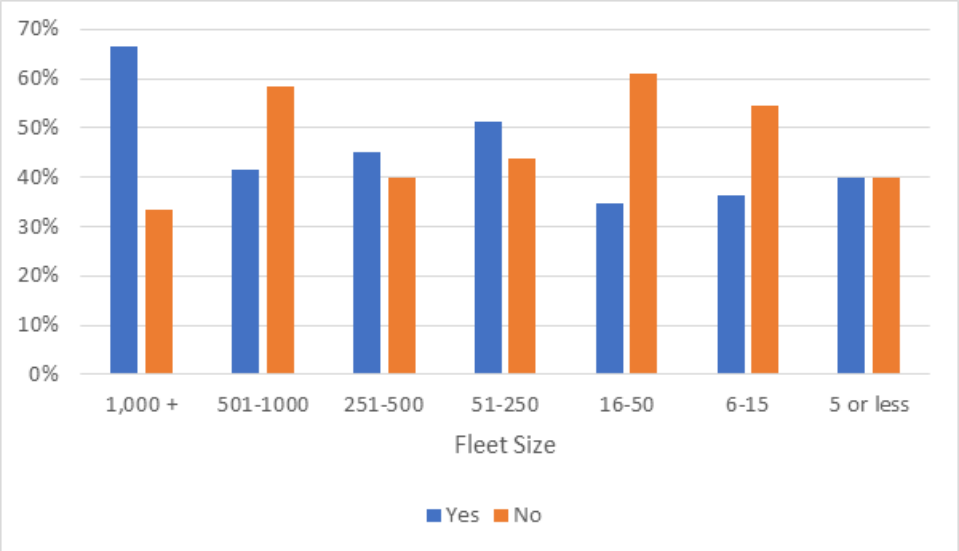

Figure 22. Bar graph. Carrier executive awareness of Tech-Celerate Now program by fleet size (number of trucks).

Driver awareness varied less by fleet size though like carriers, the largest proportion of drivers aware of Tech-Celerate Now represented large fleets (between 100 and 1000 trucks) as well (see Figure 23). The second highest proportion of drivers aware of Tech-Celerate Now reported having between two and five trucks in their fleet and were likely owner-operators. It is unsurprising that owner-operators would be aware of Tech-Celerate Now because they likely research and educate themselves when deciding whether to adopt ADAS technology.

Figure 23. Bar graph. Driver awareness of Tech-Celerate Now program by fleet size (number of trucks).

Of respondents familiar with Tech-Celerate Now, the majority in both groups reported learning of Tech-Celerate Now through association outreach. Carriers were more likely than drivers to have learned about the program through email blasts (i.e., Eblasts), online advertisement and industry meetings while drivers were more likely to have learned about it through association outreach, radio, podcasts, and news articles (Figure 24).

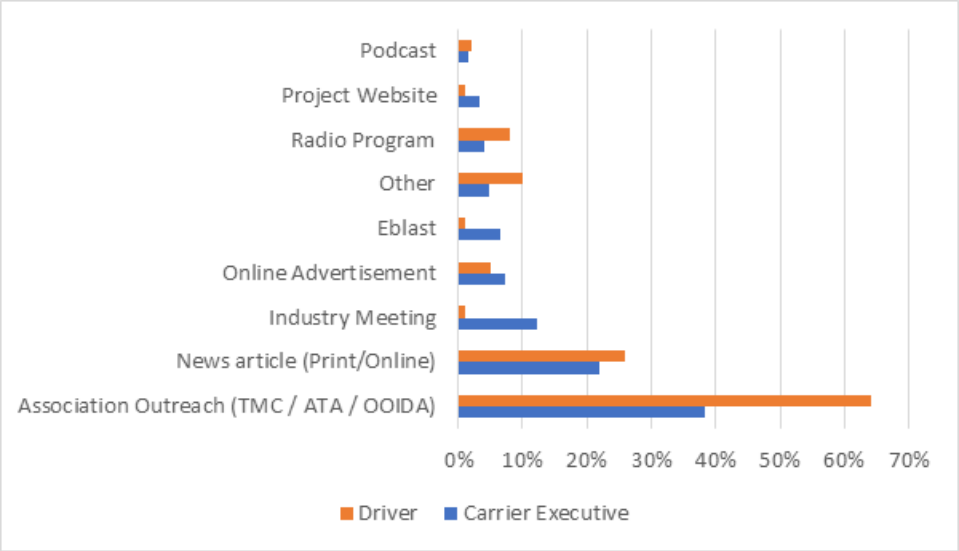

Figure 24. Bar graph. Impacts of outreach.

Influence of Tech-Celerate Now Program Outreach

Respondents were asked whether the Tech-Celerate Now program positively influenced their decision to purchase ADAS technologies. While this direct question has a limited ability to capture purchase decisions over a relatively short period of time (i.e., Tech-Celerate Now introduced less than 2 years prior to Year One survey, and web site and materials released earlier in Year One), it enabled exploring whether awareness of the Tech-Celerate Now program would be associated with positive adoption choices in respondents. Of the 204 respondents in the driver survey, 4 percent stated that the program had positively influenced a purchase decision. In the carrier survey, of the 69 respondents aware of the program, 13 percent indicated a positive influence on a purchase decision. It is important to note that while the surveys were widely distributed, it is possible that drivers and carrier executives who are more actively engaged in ADAS may have been more likely to hear about and participate in the surveys. There was also an opportunity to further examine subgroups that may benefit from outreach.

Also, to gauge the outreach efforts related to the awareness of informational and educational materials developed by Tech-Celerate Now, survey respondents were also asked whether they downloaded videos or guides produced by Tech-Celerate Now. Of the 204 driver respondents aware of Tech-Celerate Now, 26 percent indicated they had accessed materials, videos, or web site content. Fourteen percent of the carrier respondents who were aware of the program had accessed the outreach content. Most respondents answering yes to this question represented small to midsize fleets for both carrier and driver groups, but program content had reached across a wide range of fleet sizes.

Technology Awareness in Respondents Reached by Tech-Celerate Now

Carrier executives were in general more aware of all ADAS technologies than drivers, averaging 79 percent of respondents at a mostly familiar or higher level, and reported the highest awareness for road- and driver-facing cameras as well as lane departure warning systems. Awareness among carrier executives was lowest for adaptive steering control, active lane centering assist, and camera-based mirror systems (Figure 25). When compared to Baseline survey results, carrier executives who indicated they were aware of the Tech-Celerate Now program had higher technology awareness levels. Others who were not aware of the program outreach had generally lower technology awareness levels, which were often lower than the Baseline. In Year One, there was higher awareness in ADAS monitoring systems technologies (Table 6) as compared to the Baseline, but overall awareness levels were similar (79 percent versus 80 percent in Baseline).

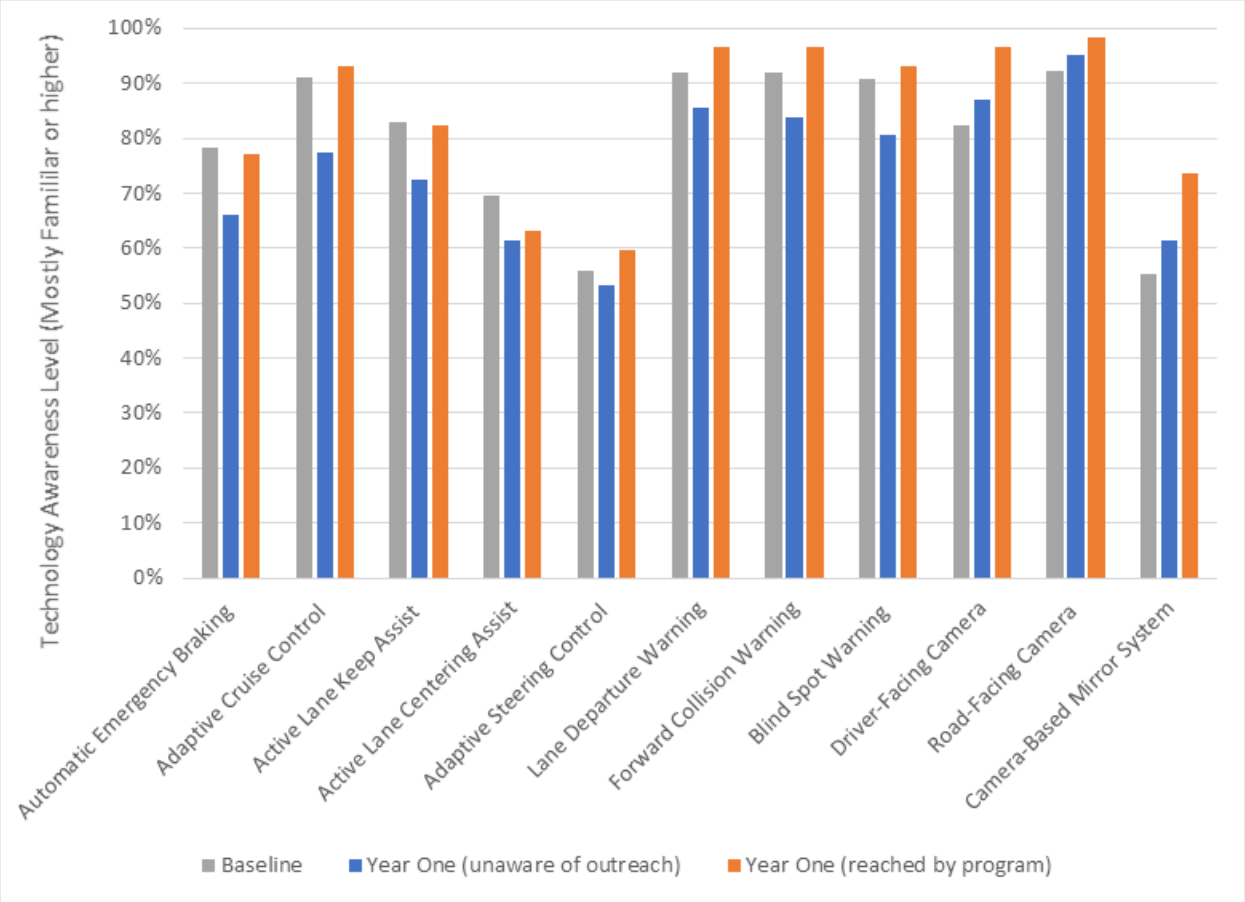

Figure 25. Bar graph. Carrier executive awareness of ADAS technologies.

Table 6. Carrier executive survey: Proportion reporting mostly familiar or higher awareness.

ADAS Category	Baseline	Year One (overall)	Year One (reached by program)
Braking	85%	78% (-7%)	85% (0%)
Steering	70%	65% (-5%)	68% (-1%)
Warning	91%	88% (-3%)	95% (+4%)
Monitoring	77%	85% (+8%)	89% (+13%)
Overall	*80%*	*79% (-1%)*	*85% (+4%)*

The findings from the Baseline survey indicated that efforts in outreach should concentrate on drivers to increase awareness, positive perception, and adoption of ADAS technologies. The findings from the Year One survey indicate that awareness, as measured by the proportion responding "mostly familiar" or higher, has in fact increased by a large amount among drivers who indicated they were aware of the Tech-Celerate Now program. However, it is unclear how much of the differences are due to the distribution of drivers choosing to complete the survey or other underlying trends, since the surveys cannot identify causality. Others who were not aware of the program outreach had generally similar technology awareness levels to the Baseline. It should be noted that increased awareness is one factor in adoption and does not capture acceptance levels. Driver respondents were, in general, less aware than carrier executives of ADAS technologies, averaging 60 percent of respondents with mostly familiar or higher awareness, and the highest awareness levels in this group were for road-facing cameras, and the ADAS warning

technologies (Table 7). Awareness was lowest for adaptive steering control, active lane center assist, and camera-based mirror systems (Figure 26).

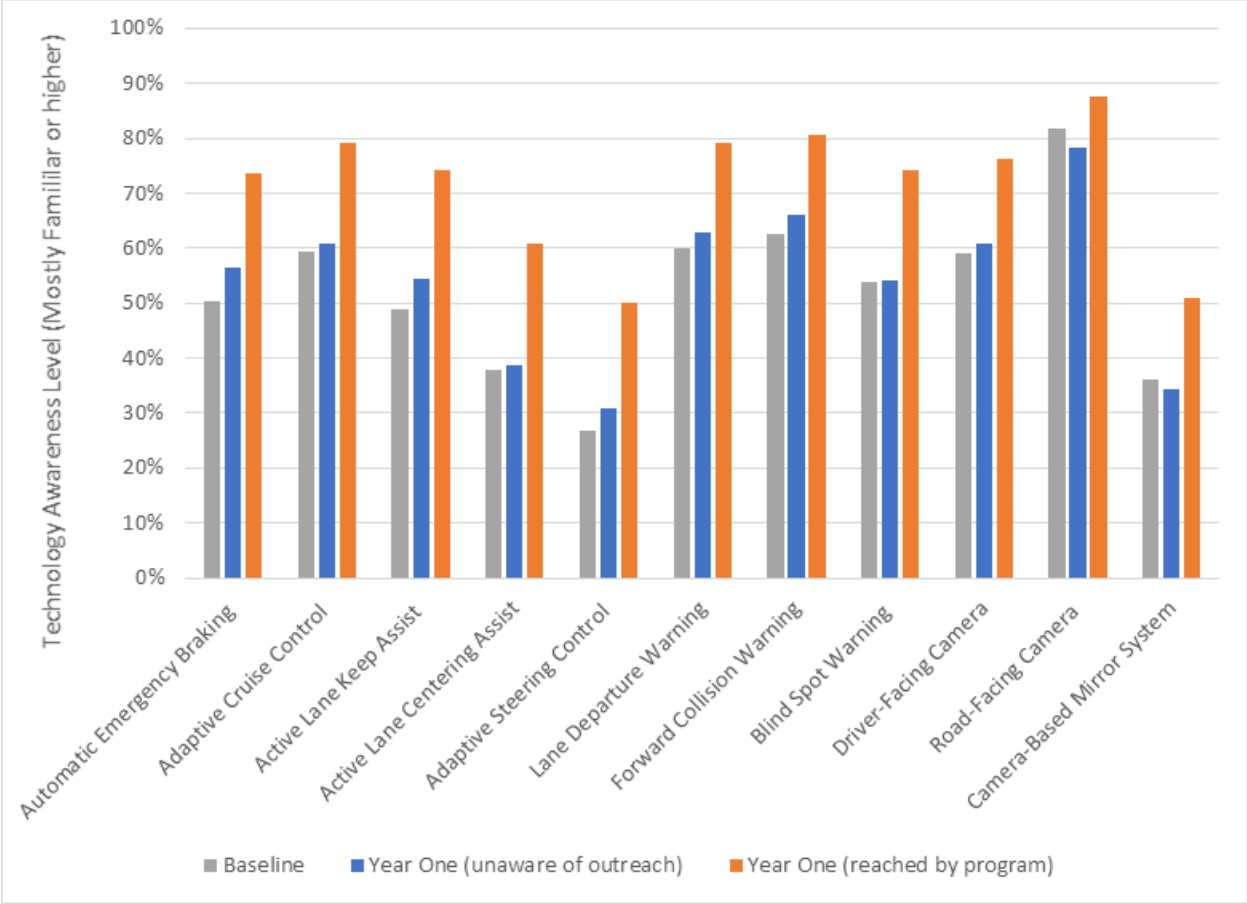

Figure 26. Bar graph. Driver awareness of ADAS technologies.

Table 7. Driver survey: Proportion reporting mostly familiar or higher awareness.

ADAS Category	Baseline	Year One (overall)	Year One (reached by program)
Braking	55%	64% (+9%)	76% (+22%)
Steering	38%	48% (+10%)	62% (+24%)
Warning	59%	67% (+8%)	78% (+19%)
Monitoring	59%	63% (+4%)	72% (+13%)
Overall	*52%*	*60% (+8%)*	*72% (+19%)*

3.3.2 Perception

Safety Improvement Perception

Carrier executives perceived all three ADAS warning technologies (lane departure warning, forward collision warning, and blind spot warning) as having the greatest positive expected impact on safety. When compared to the Baseline survey, carrier executives had a similar to slightly lower perception of achieving at least moderate safety improvements from ADAS technologies (Figure 27). The greatest differences in levels between Year One and Baseline expectations of moderate safety improvements were

in driver-facing cameras (53 percent versus 41 percent) and forward collision warning (89 percent versus 77 percent).

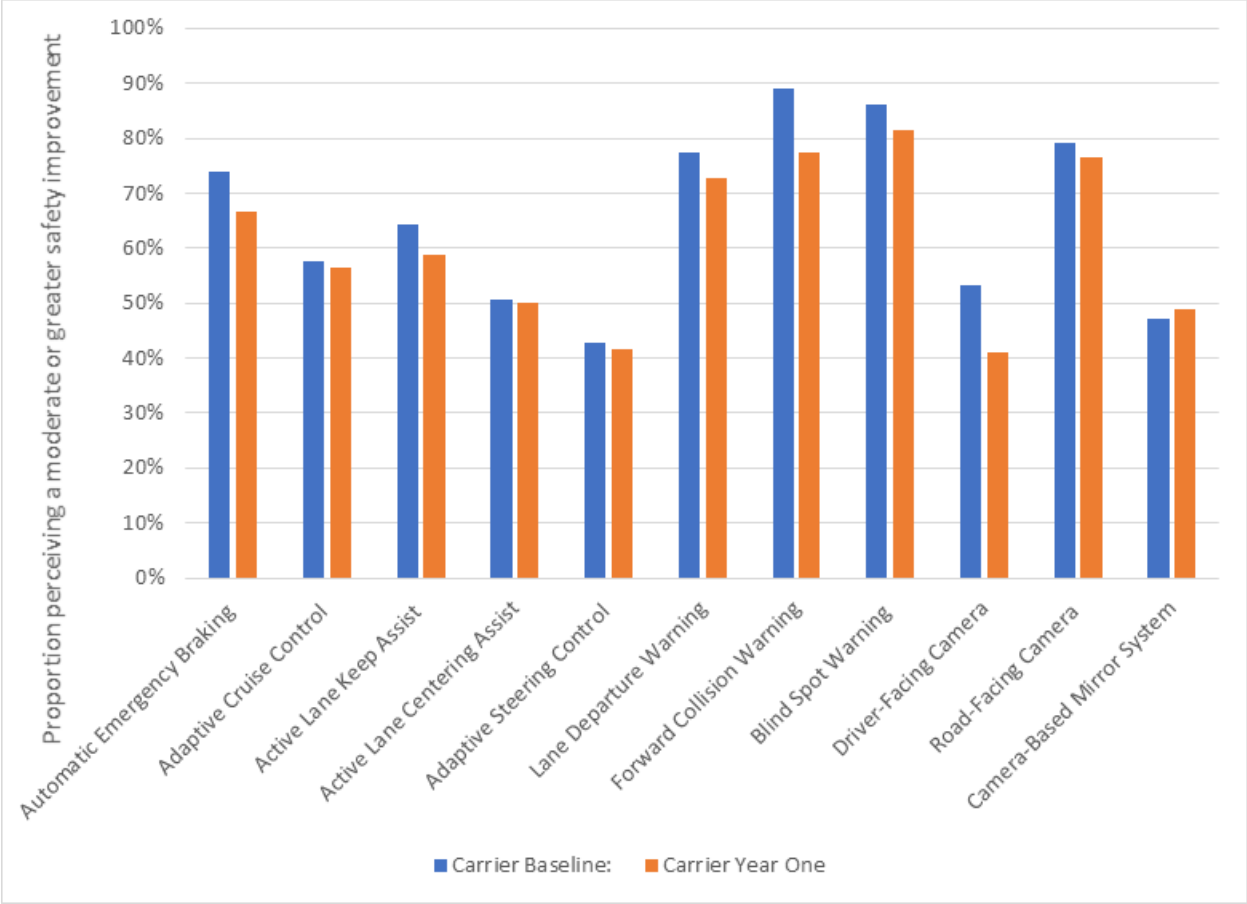

Figure 27. Bar graph. Carrier executive safety perception.

Drivers perceived road-facing cameras and the ADAS warning technologies as having the greatest positive expected impact on safety (Figure 28). When compared to the Baseline survey, driver respondents had a similar to slightly lower perception of achieving at least moderate safety improvements from ADAS technologies. The greatest difference in levels between Year One and Baseline expectations of moderate safety improvements was in camera-based mirror systems (38 percent versus 26 percent).

Importantly, over 40 percent of driver respondents perceived active steering control, driver-facing cameras, and automatic emergency braking as harmful to safety. Research to understand these perceptions would be valuable to influence future adoption.

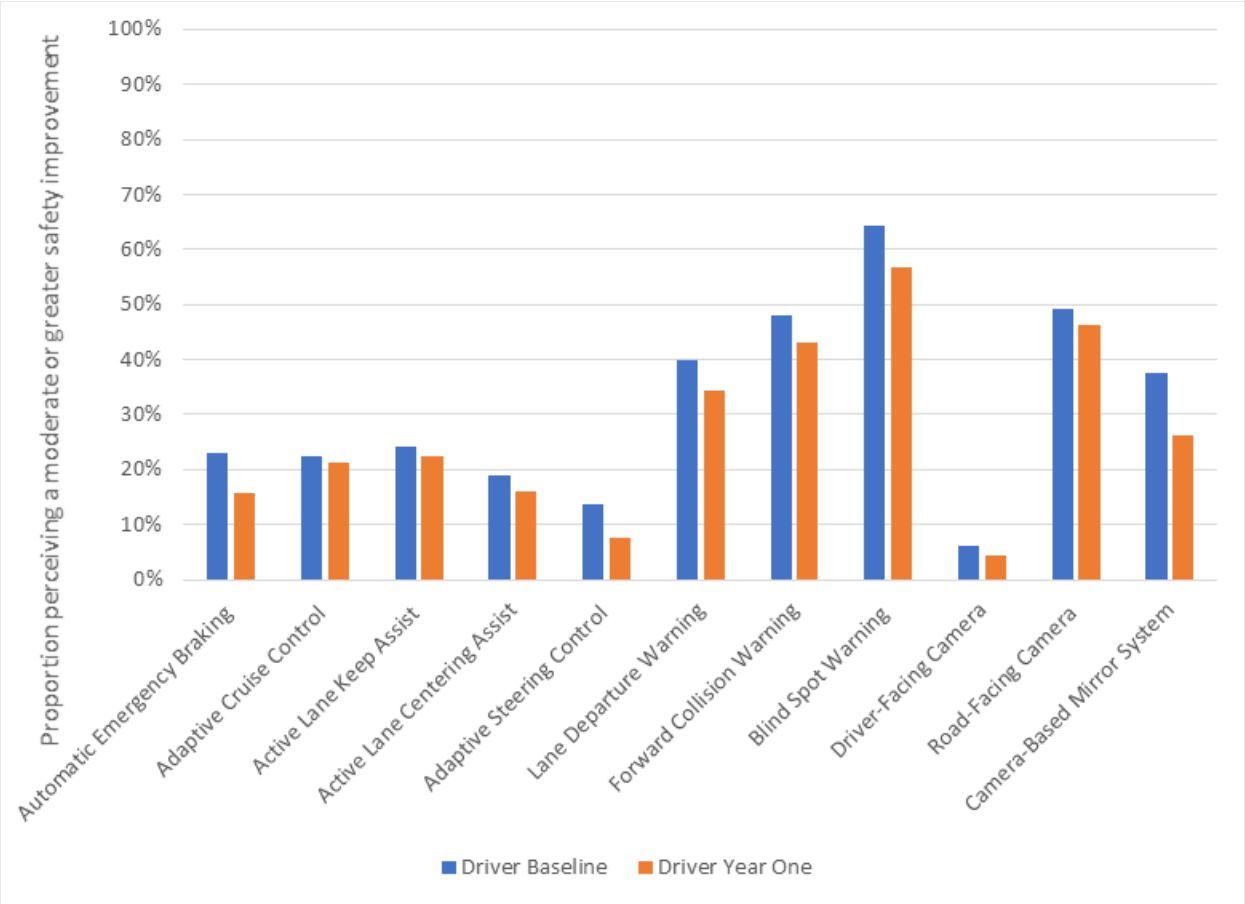

Figure 28. Bar graph. Driver safety perception.

The wide variation in perceptions of safety improvements from ADAS, even for technologies with similar levels of awareness, suggests that other factors have an important influence. While the surveys are not able to establish causality, they suggest that variations such as driving environment and experiences are potential influences in the perception of safety improvements from each ADAS technology. For example, the relatively higher perceptions associated with warning-only ADAS technologies supports the finding that driver's control being compromised is a key factor in decisions not to adopt ADAS.

Perception of Industry Adoption Trends

In forecasting industry trends, both driver and carrier executive respondents reported Camera-based mirror systems as most likely to be adopted industry wide (Table 8). Both groups also ranked adaptive steering control in the top three technologies likely to be adopted by the trucking industry as whole. Drivers indicated their belief that driver-facing cameras would also be adopted industry wide.

Table 8. Industry-wide adoption likeliness: Top three ranked technologies.

Carrier Executives	Drivers
• Camera-Based Mirror System • Adaptive Steering Control • Blind Spot Warning	• Camera-Based Mirror System • Driver Facing Camera • Adaptive Steering Control

While these results focus on perceptions of safety improvements and expected industry adoption, it is also important to rely not only on perceptions but also examine objective data to further assess the factors in ADAS adoption.

3.3.3 Year One Adoption Analysis

The survey question asking respondents to indicate the percentage of tractors installed with each ADAS technology recognized the challenge in providing a precise number, and instead used a choice of ranges for the response. To assess changes in reported adoption in the post-outreach campaign Year One survey results, a composite adoption level metric was used to calculate an average of respondents' adoption level from the category-based choices in the survey. A midpoint value was assigned to each of the response choices (see Table 9) and a weighted average of these values were then calculated based on the proportion of respondents with each choice. This serves to provide a basis for comparison across ADAS technologies and surveys, but it is important to note that it does not represent an overall fleet adoption level since respondents' fleet sizes vary, and there is not an ability to analyze an individual respondent's adoption over time.

Table 9. Adoption category response and level.

Survey Response	Midpoint Adoption Level
0%	0
1–10%	5.0
10–25%	17.5
25–50%	37.5
50–75%	62.5
75–100%	87.5

When compared to the Baseline survey, carrier executives generally reported a slight increase in adoption level in Year One. The average adoption level increased by 2.9, from 23.7 to 26.6, with the greatest increase observed in road-facing cameras (54.2 to 67.9) and lane departure warning (31.3 to 36.5). The technologies most adopted were road-facing cameras, forward collision warning, and adaptive cruise control (Figure 29). The least-adopted technologies reported in the Year One survey were camera-based mirror systems, active lane center assist, and adaptive steering control.

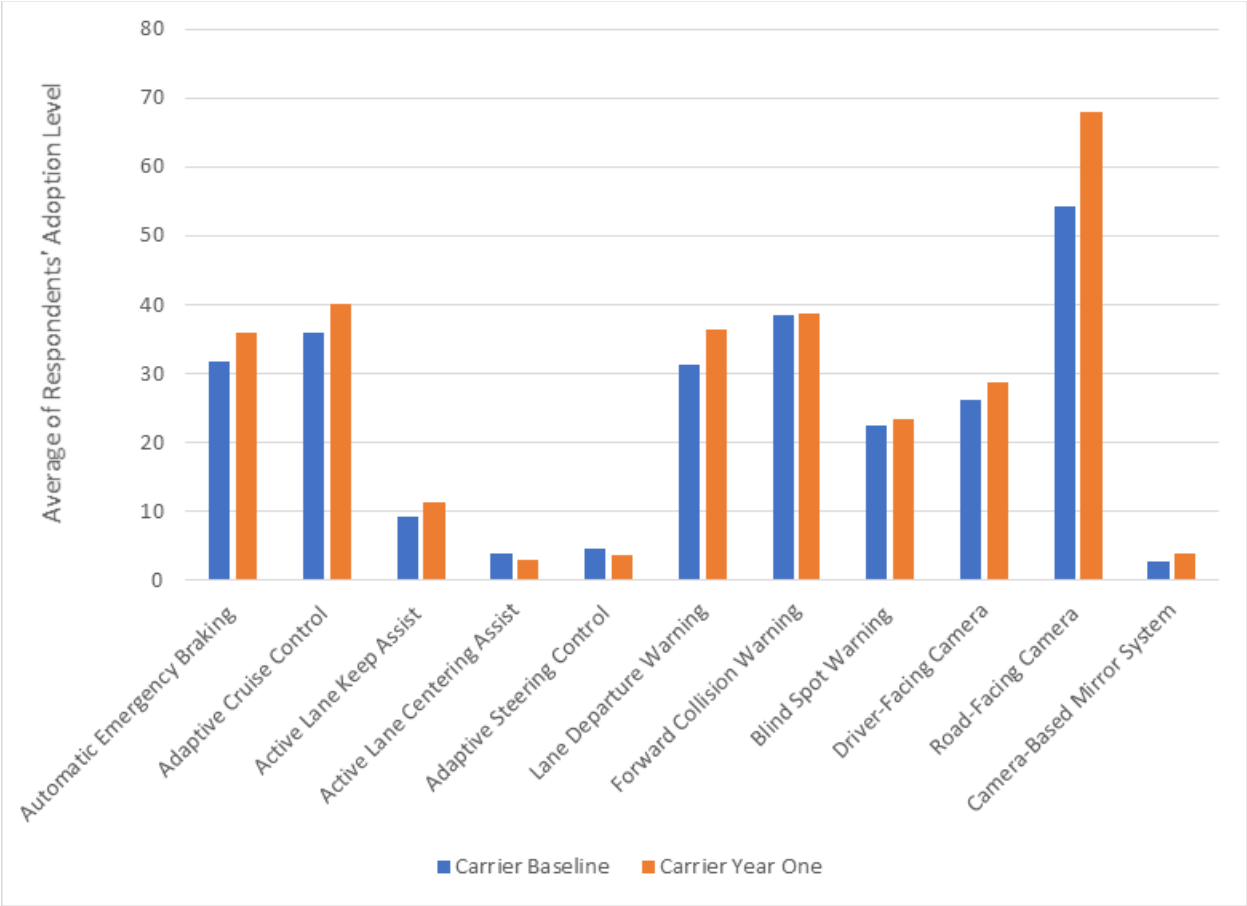

Figure 29. Bar graph. Baseline vs. Year One adoption levels among carrier respondents.

In the driver survey, post-outreach campaign Year One adoption levels were higher across all ADAS technologies when compared to the Baseline (Figure 30). Averaged across all ADAS technologies, the adoption level in Year One increased by 6.0, to 18.8 as compared to the Baseline value of 12.8. Large increases in adoption levels were observed in road-facing cameras (38.0 to 49.8), forward collision warning (18.1 to 28.0), lane departure warning (15.8 to 24.8), and blind spot warning (8.0 to 16.3).

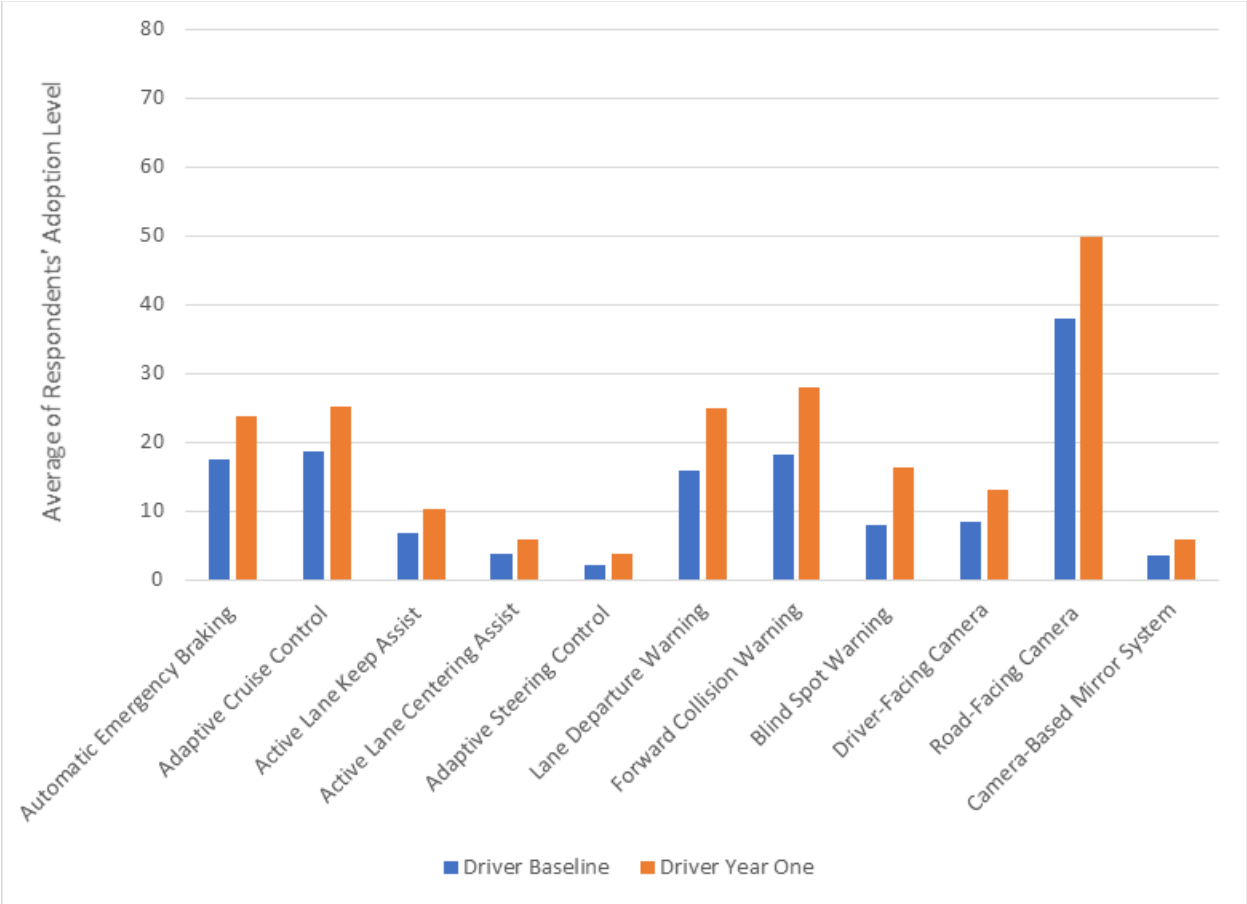

Figure 30. Bar graph. Baseline vs. Year One adoption levels among driver respondents.

Adoption Category Comparison

In addition to the composite adoption level, another method of analysis examined the changes in the proportion of respondents with no adoption, where awareness and early-stage outreach may be of value, and high/widespread adoption, where awareness outreach is likely unnecessary. An adoption comparison from Baseline to Year One can be found in the magnitude of differences in the highest (75–100 percent, indicating widespread adoption in their fleet) and lowest (0 percent, indicating no adoption on any tractors) categories reported in the driver survey. The proportion of driver respondents reporting no installed tractors declined (Figure 31), and the proportion of respondents reporting widespread adoption (75–100 percent of fleet) increased (Figure 32), from Baseline to Year One for all technologies. It should be noted that since the respondents are not paired between Baseline and Year One, these trends are indicative of shifts in adoption overall and not of individual fleet changes or absolute values.

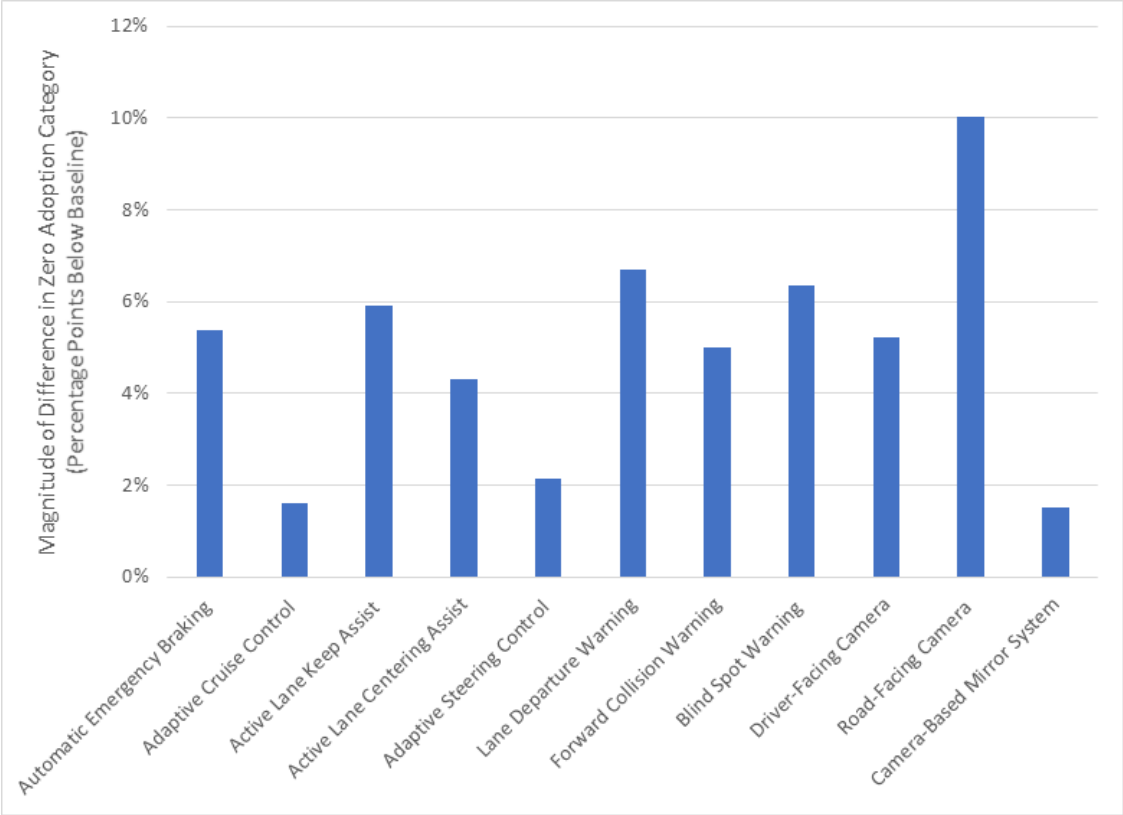

Figure 31. Bar graph. No adoption category, Year One vs. Baseline driver survey.

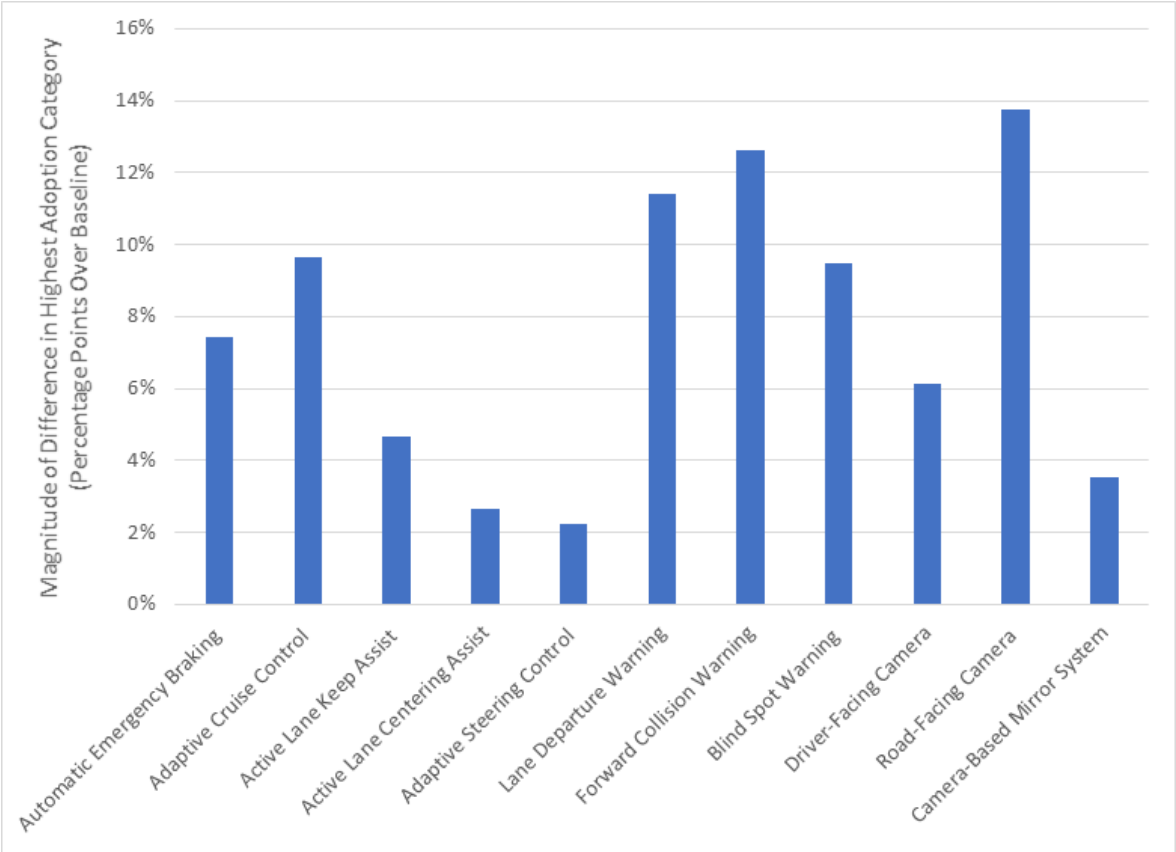

Figure 32. Bar graph. Widespread adoption category, Year One vs. Baseline driver survey.

Table 10 shows the overall proportion of respondents reporting the highest adoption level (75–100 percent of fleet) of each technology in Baseline and Year One driver surveys. At Year One, the ADAS technologies with the highest widespread adoption in the driver survey were road-facing camera, forward collision warning, and lane departure warning.

Table 10. Proportion of driver respondents reporting highest adoption level in Baseline and Year One.

ADAS Technology	Baseline	Year One
Automatic Emergency Braking	14%	22%
Adaptive Cruise Control	13%	22%
Active Lane Keep Assist	4%	9%
Active Lane Centering Assist	2%	4%
Adaptive Steering Control	0%	3%
Lane Departure Warning	12%	23%
Forward Collision Warning	14%	26%
Blind Spot Warning	5%	14%
Driver-Facing Camera	8%	14%
Road-Facing Camera	36%	50%
Camera-Based Mirror System	2%	6%

Table 11 shows the overall proportion of respondents in the Baseline and Year One carrier surveys reporting widespread adoption within their fleet. Changes from Baseline to Year One were more mixed than the results from the driver survey, with both increases and decreases. However, road-facing cameras were also the ADAS technology with the highest levels of widespread adoption in the carrier survey. While the absolute percentage values were low, adaptive steering control and active lane center assist were noted as technologies where the proportion of fleets with widespread adoption were lower in Year One.

Table 11. Proportion of carrier executive respondents reporting highest adoption level in Baseline and Year One.

ADAS Technology	Baseline	Year One
Automatic Emergency Braking	23%	28%
Adaptive Cruise Control	21%	28%
Active Lane Keep Assist	4%	7%
Active Lane Center Assist	2%	0%
Adaptive Steering Control	3%	1%
Lane Departure Warning	21%	27%
Forward Collision Warning	29%	28%
Blind Spot Warning	13%	13%
Driver-Facing Camera	24%	30%
Road-Facing Camera	52%	73%
Camera-Based Mirror System	1%	3%

Overall, averaged across all ADAS technologies, the results from the post-outreach campaign Year One survey indicate a general increase over the Baseline survey. This is the case in both the composite adoption level measure as well as in the proportion reporting widespread adoption in their fleet, for the driver and carrier executive respondent groups (see Table 12).

Table 12. Average change in adoption from Baseline to Year One.

Survey	Composite Adoption Level Increase, on Average	Increase in Reported Widespread Adoption Category
Driver Survey	+6.0	+8%
Carrier Survey	+2.9	+4%

3.3.4 Workforce Issues and Opportunities

Carrier executives understand that driver acceptance and positive perception of ADAS technologies is crucial in recruiting and retaining drivers. In fact, carrier executives ranked driver acceptance of technologies as one of the top three factors considered when deciding to install ADAS technologies. Because of this, driver perception of technologies is emphasized in the sections below.

Drivers indicated that they prefer to operate trucks with adaptive cruise control, had moderate opinions on active lane keep assist, and low views of automatic emergency braking.

Sixty percent of drivers surveyed were owner-operators leased to motor carriers or independent. Since this subset of drivers decide for themselves whether to install ADAS technologies, the top-ranked factors in the decision are given in Table 13.

Table 13. Factors in decision to purchase ADAS technologies.

Category	Carrier Executive	Owner-Operator
Top Three Incentives to Purchase	• Possibility of lower insurance premiums • Technology purchase costs • Driver acceptance	• Possibility of lower insurance premiums • Technology purchase cost • Tax deductions or credits
Top Three Disincentives to Purchase	• Technology purchase Cost • Driver unacceptance • Technology maintenance issues	• Technology purchase cost • Tax deductions or credits • Driver unacceptance

3.4 RELATING ADOPTION TO SAFETY BENEFITS

To better assess safety benefits, several safety and crash-related questions were added to the post-outreach campaign Year One survey. These questions focused on anecdotal or documented safety improvements that were associated with ADAS technologies utilized by carrier respondents. In theory, the carrier survey data could provide unique insight into improvements in carrier crash rates associated with adoption rates for technologies.

In general, the carrier responses to the safety and crash survey questions were sparse. This may be due in part to reluctance to provide company-specific crash and mileage information in a general web-based survey. Secondarily, the sparse responses were associated with carriers' inability to document and draw direct connections between crash reduction and specific ADAS technologies.

4. SUMMARY OF OUTCOMES

4.1 KEY PROJECT ACCOMPLISHMENTS

Findings from the Task 2 effort "Research on Technical and Market Barriers to Adoption of ADAS" informed the content and products developed during the Tech-Celerate Program tenure. Products, materials, and the overall outreach effort were targeted to carriers, fleet managers, owner-operators, truck OEMs, ADAS technology vendors, and truck drivers. Additionally, four TMC Task Forces were created under this project to develop four new Recommended Practices. Recommended Practices provide guidance on training, use of data from, and human-machine interfaces with ADAS technologies. Three topics areas were pursued under Tech-Celerate Now for automatic emergency braking and lane departure warning systems: (1) commercial driver training, (2) data available and how to use these data from these ADAS, and (3) standardize warnings to alert commercial driver or to intervene in certain situations. Given the process and timeframe to develop the Recommended Practices, the four new Recommended Practices will be finalized after the project period of performance. Readers can find up-to-date status at TMC's Recommended Practices web site (https://tmc.trucking.org/tmc-recommended-practices). Members of the trucking industry provide input and feedback to each Recommended Practice development.

Significant effort was devoted to the national outreach campaign to promote ADAS awareness and adoption. Early in the project initiation, the team developed a Tech-Celerate Now Flyer to promote branding and promote ADAS adoption (available on the project web site), and developed a Tech-Celerate Now web site to support project awareness and distribute training and educational materials. These materials were also shared at numerous presentations (online and in-person), webinars, and available in hard copy when the Tech-Celerate Now booth was exhibited at conferences and annual meetings. Team members used targeted social media messaging to keep interest and awareness in Tech-Celerate Now via X (formerly Twitter), LinkedIn, TMC Connect, and the Tech-Celerate Now web site.

Furthermore, a total of four articles were developed by project team members and published in leading trade journals. Products developed include (1) two guides (or brochures), (2) four videos that individually focus on the four ADAS technology performance categories, (3) a Tech-Celerate Now ADAS-specific return-on-investment (ROI) calculator, and (4) a Tech-Celerate Now booth for exhibits.

Previous efforts to develop ROI calculators evolved from calculations of industry benefits and focused on a narrow set of ADAS technologies which were relatively mature and weigh heavily toward societal benefits rather than those accruing directly to the fleets and owner-operators. To remedy this limitation, the project team developed a flexible, web-based Tech-Celerate Now ROI calculator that supports individual fleet adoption decisions of ADAS technologies and is located on the Tech-Celerate Now web site. The Tech-Celerate Now ROI calculator is based on the VTTI ROI calculator co-sponsored by FMCSA and NSTSCE.

Team members tracked and analyzed all outreach activity early in the project life cycle to gauge the effectiveness of the outreach campaign and possible impact of training materials on the awareness and adoption of ADAS. Notable measurements for all forms of outreach include:

- Over 3.6 million overall contacts over 2 years.
- Four radio shows reaching an estimated 3.2 million listeners illustrating significant reach to commercial drivers.
- Thirty webinars with 3,500 participants.

- Roughly 3,200 hard copies of ADAS guides distributed at conferences and annual meetings.
- Approximately 60,000 web views across the Tech-Celerate Now web site, TMC Connect web site, and video views.

The team's ability to pivot to virtual or remote outreach activities in March 2020 provided continuity to outreach efforts, while the eventual resumption of in-person outreach events enabled the team to access a significant customer base. Outreach was divided into promotional and instructional to emphasize the diversity of outreach activities that were conducted, and the different types of audiences they were intended to reach. Promotional outreach provides high-level information about ADAS targeting program awareness, name recognition, and nontechnical details. Types of promotional outreach included email, radio, articles and press releases, and web site views. Instructional outreach, on the other hand, provided deeper dives into ADAS targeting implementers, specific benefits, deployment tips, and guidance. Types of instructional outreach included meetings, presentations, and webinars. The outreach metrics represent a conservative estimate so as not to overstate the program's reach.

The total video view counts through December 2021 were 1,214. The team noticed the highest view counts shortly after the videos were uploaded to the Tech-Celerate Now web site (April 2021) and the time preceding, during and immediately after a conference. Web site visits were also recorded. The Tech-Celerate Now web site had a total of 9,024 views; TMC Connect that featured ADAS on a sliding window totaled 1,987, and the TMC web site total 21,404. LinkedIn Outreach total 26,496 views. The TMC web site views specifically account for periods during which the homepage featured a Tech-Celerate Now promotional banner advertising the program. The LinkedIn outreach relates to a promotional campaign promoting the hashtag "#BogieLovesADAS;" Bogie is the name of the dog featured in the video and was chosen to promote the program (i.e., ADAS, like Bogie, is a trusted companion for truck drivers) in a way that was more likely to attract attention and click-through via social media.

4.2 COMPREHENSIVE METHODOLOGY FOR ASSESSING ADAS & TECH-CELERATE NOW

The Tech-Celerate-Now program was initiated to increase the understanding and acceptance of targeted ADAS technologies. Unlike Level 4 and 5 autonomous systems which are still under research and development, ADAS technologies are fully vetted and available in the marketplace.

The Tech-Celerate Now program was designed to assess initial levels of industry awareness, perception and ADAS adoption—measures that combine to represent industry "acceptance." While the performance of ADAS continues to improve as the technologies mature, previous research[(5)] has indicated that market barriers around awareness, acceptance, and ROI rather than performance barriers may be holding back adoption. In order to identify and address potential market barriers, Tech-Celerate Now began by assessing acceptance levels through the development of the Baseline Survey.

Baseline survey findings and input from the industry advisory committee informed the development of outreach strategy and messaging. This outreach prioritized the education of both carriers and drivers to positively influence acceptance according to a five-point Likert scale of awareness and attitudes toward ADAS technology. A third "Affiliates" survey was distributed to ADAS technology suppliers and the findings were used to corroborate information and data collected in the Baseline survey.

Messaging focused on product information, efficacy, and industry impacts. Outreach channels included both print media, broadcast media, and the internet. The materials and outreach products were highlighted at industry events, news articles, press releases, webinars, and meetings. Notably, the outreach efforts

emphasized both focused stakeholder groups at meetings and webinars as well the wide reach to over 3 million listeners through radio channels with good reach to the driver population.

A second post-outreach campaign "Year One" survey was developed, tested, and distributed as a follow-up to the Baseline survey. The Year One survey served as a program evaluation assessment; it documented changes over time in the awareness, perceptions, and adoption levels described above. While other unrelated activities in the ADAS marketplace may have influenced carriers and drivers, the survey results were analyzed to examine the Tech-Celerate Now program's potential influence in adoption factors in the driver and motor carrier executive groups.

The analyses of both surveys found in Section 3 document the impacts associated with the Tech-Celerate Now program. In general, the Tech-Celerate Now program activities had a positive overall impact on the awareness of ADAS technologies for both truck drivers and motor carrier executives and a small positive stated influence on ADAS adoption decisions. While Section 3 provides detailed analyses of the changes in driver and motor carrier acceptance, the following findings summarizes Tech-Celerate Now program success.

Awareness & Perception Improves

To corroborate the positive influence of the Tech-Celerate Now program, the surveys queried respondents on awareness of the program. Across the 11 primary ADAS technologies, dramatic differences in initial awareness of carriers and drivers were noted. Carriers were generally more aware of ADAS technologies than drivers. It is likely that the formal communication channels used by carrier executives, (e.g., State and national industry associations, meetings, and supplier outreach), are more extensive than those used by truck drivers, particularly over-the-road drivers. As is the case with "awareness," perceptions and perspectives initially varied widely across the ADAS technologies, with drivers having the most expansive ranges on the like/dislike continuum.

Increase Focus on Truck Drivers

The survey analysis conveyed higher awareness and positive perception among carrier executives than drivers for ADAS technologies. Adoption levels for carriers reflect an awareness on the part of carriers that truck drivers have potential concerns about the use of active safety systems. The primary concern among drivers is that many ADAS technologies may take control away from the driver. It is clear that carriers are hesitant to implement technologies and programs that might hurt driver recruitment and retention. This is especially apparent because carriers have consistently ranked "driver control is compromised" as one of their top three concerns.

Outreach Channels Matter

All outreach formats and tools had some positive impact, but association communications and meeting presentations generated the largest response. Carriers were more likely than drivers to have learned about the program through blast email campaigns, online advertisements, and industry meetings while drivers were more likely to have learned about it through association outreach, radio, podcasts, and news articles. Driver and industry-based outreach is an important mechanism to support adoption due to increased credibility, sharing of first-person peer driver experiences. Since driver acceptance (and influence from experiences shared in peer-to-peer exchanges) plays a large role in adoption, these outreach channels are likely to assist in both gathering and sharing information that will support ADAS enhancement and adoption decisions.

Warning Systems Still Considered Beneficial

While the Tech-Celerate Now program primarily focused on active safety systems, the warning systems included in Tech-Celerate Now were still viewed as beneficial by both carriers and drivers; carriers had considerably higher positive perceptions of safety improvements for these systems.

ADAS Adoption is Increasing

Over the Tech-Celerate Now program time period, technology adoption by carriers and truck drivers have generally increased, with certain technologies having a more substantial increase. Carrier respondents reported an increase in average adoption level from 23.7 to 26.6, along with an increase of 8 percent in the category representing widest adoption. In the driver survey, the average adoption level across technologies was 18.8 in Year One as compared with 12.8 in Baseline. The proportion of drivers reporting the highest adoption level was also higher by an average by 8 percent over Baseline results.

More Emphasis on Insurance Education & Industry Participation

Given the annual double-digit increases in truck insurance rates, both truck drivers and motor carriers identified "lower insurance rates" as a primary motivator for adopting ADAS technologies. Unfortunately, commercial auto insurance utilizes loss history and crash history to establish rates, and increased safety via adoption of ADAS requires multiple years of crash and safety data—post-adoption—to positively impact insurance costs. Future activities could include engagement with the insurance industry to identify messaging and new strategies for addressing carrier and driver needs for insurance cost relief.

Formalize Communications and Data Sharing with Industry Suppliers

The Tech-Celerate Now program engaged ADAS suppliers and truck OEMs throughout the research. As noted, the "Affiliates Survey" was conducted outside of the program scope—but generated important insights for the research.

It was determined that many supplier activities and marketing materials target motor carriers exclusively, and do not address truck driver issues and concerns. This exacerbates the issue that truck drivers do not have adequate, accurate information on how ADAS technologies work, and this may create driver-shortage and driver-retention issues for carriers considering ADAS investments.

Any future phase of Tech-Celerate Now should formalize and expand interactions with suppliers to educate them on key messaging that allays driver concerns with driver-targeted messaging.

4.3 SAFETY IMPACTS IN THE FUTURE

The research in this project has identified technical, market, and other barriers to adoption of ADAS and have made progress in supporting future adoption in outreach and development of supporting resources. In addition, the survey analyses identified factors and trends showing the differences in perceptions across drivers and carrier executives for each ADAS technology, and assessed the influence of the Tech-Celerate Now outreach efforts on measures such as awareness. Survey results showed higher ADAS awareness levels in those who had been reached by Tech-Celerate Now and evidence that some ADAS purchase decisions were positively influenced by the program. Based on key influential factors identified such as driver acceptance and financial considerations, continued work would benefit future adoption by better understanding the driving factors contributing to acceptance or unacceptance, and supporting financial decision-making with resources such as the ROI calculator. The combination of these efforts in this project has resulted in a better understanding of factors influencing ADAS adoption and perceptions.

While progress has been made, results from this project will also help inform further efforts needed to continue addressing ADAS adoption barriers.

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APPENDIX A: SURVEY QUESTIONNAIRES

BASELINE DRIVER AND CARRIER SURVEY

For the Baseline, the same survey was provided to drivers and carriers.

Assessing Trucking Industry Perspectives on Advanced Driver Assistance Systems

The American Transportation Research Institute (ATRI) – working with the Federal Motor Carrier Safety Administration and other trucking industry stakeholders – is researching advanced driver assistance system (ADAS) technologies, relating to awareness, deployment rates, perspectives, and concerns. Results of this survey will be reported through the new ADAS fleet adoption program, "***Tech-Celerate Now***," to support industry safety goals.

Tech-Celerate Now includes the following ADAS performance categories jointly identified by government and industry to improve transportation safety, new technology education, and the driving experience for truck drivers.

ADAS – Braking
- Automatic Emergency Braking
- Air Disc Brakes
- Adaptive Cruise Control

ADAS – Steering
- Active Lane Keep Assist
- Active Lane Centering Assist
- Adaptive Steering Control

ADAS – Warning
- Lane Departure Warning
- Forward Collision Warning
- Blind Spot Warning

ADAS – Monitoring
- Driver-Facing Camera
- Road-Facing Camera
- Camera-Based Mirror System

Your input on the following questions will provide critical insight on assessing trucking industry perspectives for accelerating the adoption of ADAS.

Your survey responses will be kept completely CONFIDENTIAL and only reported in the aggregate. Thank you for participating in this important research.

Demographics

1. Please indicate your primary role in trucking:
   - ❑ Truck Driver
   - ❑ Safety Manager
   - ❑ Maintenance / Engineering
   - ❑ Operations
   - ❑ Accounting & Finance
   - ❑ Senior Executive
   - ❑ Other (please specify):

2. What is your age?
   - ❑ Younger than 25
   - ❑ 25 – 44
   - ❑ 45 – 64
   - ❑ 65+

3. What is your gender?
   - ❑ Male
   - ❑ Female

4. How many years have you worked in the trucking industry?
   - ❑ Less than 1 year
   - ❑ 1 – 5 years
   - ❑ 6 – 10 years
   - ❑ 11+ years

5. How many power units are operated by your fleet? (check one)
   - ❑ Less than 5
   - ❑ 6-15
   - ❑ 16-50
   - ❑ 51-250
   - ❑ 251-500
   - ❑ 501-1000
   - ❑ 1,000+
   - ❑ Don’t know

6. Which sector of the trucking industry do you operate in? (check one)
   - ❑ For-hire
   - ❑ Private
   - ❑ Don’t know

7. If you operate in the for-hire sector, what is your primary type of business? (check one)

   ❑ Truckload
   ❑ Less-than-Truckload
   ❑ Specialized
   ❑ Other (please specify):

8. What is the primary vehicle configuration that you typically drive, or is used in your fleets? (check one)

   ❑ 5-axle Dry Van
   ❑ 5-axle Refrigerated Trailer
   ❑ 5-axle Flatbed
   ❑ 5-axle Tanker/HazMat
   ❑ 5-axle Bulk/Food
   ❑ Straight Truck
   ❑ Longer Combination Vehicles (Doubles, Triples, etc.)
   ❑ Other (please specify):

9. What is your average length of haul? (check one)

   ❑ Local (less than 100 miles per trip)
   ❑ Regional (100-499 miles per trip)
   ❑ Inter-regional (500-999 miles per trip)
   ❑ Long-Haul (1,000+ miles per trip)

10. Please describe your awareness / knowledge level for the following *Tech-Celerate Now* technologies:

Technology	Never Heard of It	Slightly Familiar	Mostly Familiar	Very Familiar	Expert on It
Automatic Emergency Braking	❑	❑	❑	❑	❑
Air Disc Brakes	❑	❑	❑	❑	❑
Adaptive Cruise Control	❑	❑	❑	❑	❑
Active Lane Keep Assist	❑	❑	❑	❑	❑
Active Lane Centering Assist	❑	❑	❑	❑	❑
Adaptive Steering Control	❑	❑	❑	❑	❑
Lane Departure Warning	❑	❑	❑	❑	❑
Forward Collision Warning	❑	❑	❑	❑	❑
Blind Spot Warning	❑	❑	❑	❑	❑

Technology	Never Heard of It	Slightly Familiar	Mostly Familiar	Very Familiar	Expert on It
Driver-Facing Camera	❑	❑	❑	❑	❑
Road-Facing Camera	❑	❑	❑	❑	❑
Camera-Based Mirror System	❑	❑	❑	❑	❑

11. Please rank-order which *Tech-Celerate Now* technologies you think will see large-scale industry adoption from 1st to 12th (1 = first adopted; 12th is last)

Technology	Rank
Automatic Emergency Braking	
Air Disc Brakes	
Adaptive Cruise Control	
Active Lane Keep Assist	
Active Lane Centering Assist	
Adaptive Steering Control	
Lane Departure Warning	
Forward Collision Warning	
Blind Spot Warning	
Driver-Facing Camera	
Road-Facing Camera	
Camera-Based Mirror System	

12. Please indicate which *Tech-Celerate Now* technologies are most effective in improving on-the-road safety:

Technology	Will Harm Safety	Little to No Improvement	Slight Improvement in Safety	Moderate Improvement in Safety	Very Large Improvement in safety
Automatic Emergency Braking	❑	❑	❑	❑	❑
Air Disc Brakes	❑	❑	❑	❑	❑
Adaptive Cruise Control	❑	❑	❑	❑	❑
Active Lane Keep Assist	❑	❑	❑	❑	❑
Active Lane Centering Assist	❑	❑	❑	❑	❑
Adaptive Steering Control	❑	❑	❑	❑	❑

Lane Departure Warning	❑	❑	❑	❑	❑
Forward Collision Warning	❑	❑	❑	❑	❑
Blind Spot Warning	❑	❑	❑	❑	❑
Driver-Facing Camera	❑	❑	❑	❑	❑
Road-Facing Camera	❑	❑	❑	❑	❑
Camera-Based Mirror System	❑	❑	❑	❑	❑

13. Please indicate the percentage of truck tractors in your fleet that have *Tech-Celerate Now* technologies already installed:

Technology	0%	1-10%	10-25%	25-50%	50-75%	75-100%
Automatic Emergency Braking	❍	❍	❍	❍	❍	❍
Air Disc Brakes	❍	❍	❍	❍	❍	❍
Adaptive Cruise Control	❍	❍	❍	❍	❍	❍
Active Lane Keep Assist	❍	❍	❍	❍	❍	❍
Active Lane Centering Assist	❍	❍	❍	❍	❍	❍
Adaptive Steering Control	❍	❍	❍	❍	❍	❍
Lane Departure Warning	❍	❍	❍	❍	❍	❍
Forward Collision Warning	❍	❍	❍	❍	❍	❍
Blind Spot Warning	❍	❍	❍	❍	❍	❍
Driver-Facing Camera	❍	❍	❍	❍	❍	❍
Road-Facing Camera	❍	❍	❍	❍	❍	❍
Camera-Based Mirror System	❍	❍	❍	❍	❍	❍

Percentages refer to the Percentage of Trucks Installed

14. Please rank order the following benefits that would influence your decision to purchase and use any or all Tech-Celerate Now technologies (1 = highest importance; 8 – lowest importance).

Reason for Adoption	Ranking
Technology Purchase Costs	
Tax Deduction/Credits	
Lower Insurance Premiums	
Required by Shippers & Receivers	
Driver Acceptance	
Enforcement / Inspection Bypass	
Lower / Better CSA Scores	
Technology Maintenance Issues	

15. Please tell us if you have experienced difficulties in purchasing *Tech-Celerate Now* technologies on new trucks or for aftermarket add-on?

16. Do you have any additional thoughts or comments on the use or impact of *Tech-Celerate Now* technologies in safety performance, productivity and compliance?

If you would like an advance copy of this research report, please provide:

Name:
Company:
Email:

Thank You! We greatly appreciate your participation.

Please return completed survey to ATRI via
fax (**651-631-9500)** or email (**dmurray@trucking.org**)

YEAR ONE DRIVER AND CARRIER SURVEYS

For the follow-up survey, the following additional questions were added. The questions shown are taken from the Driver survey; for the Carrier survey, the same questions were added, but they were reframed to ask how ADAS technologies influenced driver recruitment efforts, rather than how ADAS technologies influence willingness to work for a carrier. For brevity, questions appearing in the previous section are not repeated below.

1. Which ***best*** describes your type of operation?
    - ❑ Owner-operator (own authority)
    - ❑ Owner-operator (leased to motor carrier)
    - ❑ Company driver
    - ❑ Fleet owner
    - ❑ Retired
    - ❑ Other

10. Have you heard of the FMCSA-sponsored "Tech-Celerate" program, that includes team members OOIDA, ATA and ATRI?
    - ❑ Yes
    - ❑ No
    - ❑ Uncertain

11. If you are aware of Tech-Celerate Now, how did you hear about it? (check all that apply)
    - ❑ News article (print and/or online)
    - ❑ Industry Meeting
    - ❑ Project Website
    - ❑ Online Ad
    - ❑ Radio Program
    - ❑ Podcast
    - ❑ Eblast
    - ❑ Association Outreach (TMC / ATA / OOIDA / etc.)

12. Have you seen "Tech-Celerate" materials, videos and/or the Tech-Celerate web site?
    - ❑ Yes
    - ❑ No
    - ❑ Uncertain

13. Did the Tech-Celerate program information positively influence your decision to purchase safety technologies?
    - ❑ Yes
    - ❑ No
    - ❑ Uncertain

19. If you were selecting a carrier to work for, what technologies would ***encourage*** you to work for that company? Please rank-order from 1st to 13th (1 = most likely to encourage me; 13th = least likely to encourage)

Technology	Rank
Automatic Emergency Braking	
Adaptive Cruise Control	
Active Lane Keep Assist	
Active Lane Centering Assist	
Adaptive Steering Control	
Lane Departure Warning	
Forward Collision Warning	
Blind Spot Warning	
Driver-Facing Camera	
Road-Facing Camera	
Camera-Based Mirror System	
None	

20. If you were selecting a carrier to work for, what technologies would ***discourage*** you from working for that company? Please rank-order from 1st to 13th (1 = most likely to discourage me; 13th = least likely to discourage me)

Technology	Rank
Automatic Emergency Braking	
Adaptive Cruise Control	
Active Lane Keep Assist	
Active Lane Centering Assist	
Adaptive Steering Control	
Lane Departure Warning	
Forward Collision Warning	
Blind Spot Warning	
Driver-Facing Camera	
Road-Facing Camera	
Camera-Based Mirror System	
None	

22. If you decide ***not*** to purchase these technologies, please rank-order from 1st to 7th the following reasons that might influence your decision ***not*** to purchase: (1 = highest importance, 2 = next highest, etc.)

Reason for Adoption	Ranking
Technology Purchase Cost	
Technology Maintenance Issues	
Driver Unacceptance	
Driver's Control Compromised (i.e., AEB, ACC, or the like taking control from the driver)	
Reliability	
If you were not able to deactivate the technology	
Possibility of no return-on-investment	

24. Can you provide your fleet's crash numbers and mileage from 2019, separated by crash type (such as rear-end, run-off-road, sideswipe, etc.) and crash severity (property damage only, injury, and fatal)?
    a. Yes
    b. No

25. If yes, how total many crashes did you or your fleet have in 2019?

Crash Type	Total	# of PDO Crashes	# of Injury Crashes	# of Fatal Crashes
Total Crashes				
Preventable				
Rear-end				
Run off Road				
Sideswipe				
Head-on				
Rollover				
Pedestrian				

Please list your IFTA mileage from 2019 _____

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APPENDIX B: TRUCKING FIRM ACCOUNTING FACTORS – PERSPECTIVES ON ADAS ADOPTION DECISIONS

The CLA team was commissioned by the Tech-Celerate Now research team to identify financial- and tax-related issues and opportunities associated with the adoption of safety technologies in the trucking industry. The analysis included herein reflects CLA's insights and expertise that arises from working closely with motor carriers firms over several decades.

CliftonLarsonAllen LLP (CLA), Transportation & Logistics Industry Team

https://www.claconnect.com/industries/transportation-and-logistics

TRUCKING FIRM ACCOUNTING FACTORS – PERSPECTIVES ON ADAS ADOPTION DECISIONS

In the Senate bill H.R. 3684, more commonly referred to as the infrastructure bill, and the word "technology" appeared more than 250 times. It's easy to see where things are going and have been for some time already. Companies, drivers, insurance companies, and others want technology on tractors that promote safety and reduce consequences of driver fatigue. According to the Insurance Institute for Highway Safety, 4,119 people died in 2019 in crashes with heavy commercial vehicles (tractors), which was a 31 percent increase from 2009. In those crashes the tractor occupant's fatality percentage increased by 51 percent from the same time period. There are several companies testing fully autonomous tractors and while that technology may be years away from reality there are several systems used in those tractors that are currently available that deserve some attention:

- Automatic emergency braking – OEM installed
- Adaptive cruise control – OEM installed
- Lane keep/centering assist – OEM installed
- Onboard safety monitoring system (with road-facing cameras) – Aftermarket

When considering the investment in various accessories, there are some key terms that are used to help understand the potential benefit in adopting these accessories:

- Depreciation: a method to represent the useful life of the asset purchased, whereby spreading the expense over the useful life.
- Return on investment (ROI): a performance measure that evaluates the financial return for a given cost of an investment.
- Federal excise tax (FET): a tax assessed on the sale of specific goods or services, of which new tractors, trailers, and accessories are subject to, at a current rate of 12 percent.
- State and local sales tax: a tax assessed by a State or local jurisdiction on a specific good or service. Generally, the sales tax rate is between 4 and 10 percent.

- Tax credit: a tax credit is a dollar-for-dollar reduction of the income tax you owe. Tax credits are more beneficial than tax deductions because they directly reduce the amount of tax a taxpayer owes.

Costs, Benefits and Potential Credits

It's probably obvious that these systems use many of the same sensors and accessories, so it would make financial sense to put them all onto new tractors when possible to avoid needing to retrofit in the future. Below is a summary of estimated costs when installed on a new tractor, as many of these accessories are currently only available when installed by the OEM. Onboard safety monitoring systems are an exception to this, and are currently installed aftermarket.

Technology	Hardware Cost	Excise Tax	Other	Total Costs
Automatic Emergency Braking	$2,500	$300		$2,800
Adaptive Cruise Control	$665	$80		$745
Lane keeping/centering assist	$2,500	$300		$2,800
Onboard safety monitoring system (with road-facing cameras)	$550		$1,207	$1,757

*$1,207 is the estimated additional costs related to the internal employee cost of one and a half hours of training per driver, to provide coaching and development over the life of the equipment.
This estimated pricing information was provided by the American Trucking Association, which gathered fleet self-reporting off-the-shelf retail estimates based on experience and dealer input.

When looking at the overall costs of these accessories, there are multiple components in the price when considering how and where to implement. These accessory costs are mainly comprised of the actual hardware cost, labor to install, Federal excise tax, and State sales tax (if applicable). We also need to consider whether these accessories are to be installed by the tractor manufacturer (OEM) or if they'll be installed aftermarket, as there are differences in the cost to consider. For accessories installed by the OEM, the accessory cost and labor to install the hardware are typically combined together. Here's an example of what installing an automatic emergency braking system could look like if done by the OEM compared to aftermarket.

If an automatic emergency braking system is installed by the OEM, the cost of the hardware and the installation would be combined together to come up with the estimated cost of $2,500. Since the automatic emergency braking system would be installed on a new tractor, that $2,500 would be subject to the 12 percent Federal excise tax as well as any State and local sales tax (predicated upon the State or jurisdiction of purchase).

If that same automatic emergency braking system would be installed aftermarket, the costs may look a little different. There is still the actual hardware cost, but the labor to install the accessory is likely higher depending upon the accessory. The OEM is likely more efficient installing these accessories as they can incorporate it into the original build process, not having to disassemble portions of the tractor for installation. Thus, instead of the system costing an estimated $2,500 combined, it may end up costing $3,500 for example. The hypothetical $3,500 cost could include the hardware costs of $2,000 and an estimated $1,500 in labor for installation. Since the system was installed aftermarket, it would not be subject to the 12 percent Federal excise tax (assuming

it was installed more than six months after the original purchase) but would still be subject to any State and local sales tax laws.

Federal Excise Tax

The Federal excise tax on tractors is a 12 percent tax imposed on the retail sale of a new tractor (as well as trailers and accessories). Generally, accessories installed aftermarket, such as onboard safety monitoring systems, would be exempt from Federal excise tax. However, if the accessories are installed within six months of the original purchase the FET would still apply in accordance with section 4051 of the Internal Revenue Code (26 U.S.C. § 4051). This Federal excise tax was first imposed in 1917 as a way to help fund World War I and is the highest percentage excise tax imposed on a product or good. In the last few years, there has been a push to repeal the Federal excise tax on new tractors and trailers to promote tractor manufacturing and as a way to incentivize the purchase of safer and more fuel-efficient tractors. In 2021, the Modern, Clean, and Safe Trucks Act of 2021 was introduced to the Senate and referred to the Committee of Finance. If passed, it could reduce the cost of a new tractor by more than $20,000.

State and Local Sales Tax

State and local sales tax is similar to the Federal excise tax, a percentage-based tax on a product or service. The State sales tax rate can range from 3 to 9 percent, with the local sales tax adding up to another 1 percent. There are only a handful of states that don't impose a sales tax (Alaska, Delaware, Montana, and Oregon), so odds are these accessories would be subject to sales tax.

Trucking is a unique industry and has some specific carve-outs in the tax codes. With State and local sales tax, there are a lot of full or partial exemptions. For example, motor carriers in Wisconsin are provided a full up-front exemption if certain criteria are met. That would mean even though the Wisconsin sales tax rate is 5 percent, a Wisconsin motor carrier would not pay any sales tax on eligible purchases. Minnesota is an example of eligibility for partial exemptions. Minnesota provides a partial sales tax exemption for motor carriers based on the miles driven in the State compared to the total miles driven everywhere. So, if a motor carrier has 40,000 miles in Minnesota and 100,000 miles everywhere, the motor carrier would only pay 60 percent of the 6.875 percent sales tax.

There are many unique sales tax exemption rules for motor carriers. These exemptions are a great way for motor carriers to reduce the cost of operating and enable them to be more competitive.

Taking a Tax Deduction

After the accessories have been purchased, these items can be either depreciated or potentially expensed to help reduce the motor carrier's taxable income. Apart from the onboard safety monitoring system, the other systems are interdependent with the tractor and would be depreciable over a 3-year class life. The onboard safety monitoring system and road-facing cameras would be depreciable over a 5-year class life. Under normal modified accelerated cost recovery system (MACRS) depreciation, a taxpayer would be allowed to deduct 33.33 percent of the eligible cost for an asset in the 3-year asset class and 20 percent of the eligible cost in the 5-year asset class. The motor carrier may be able to choose to utilize bonus depreciation or Section

179 and fully depreciate these accessories in the year they are placed in service for an immediate tax benefit for Federal tax purposes.

Bonus depreciation is available on 100 percent of the cost through 2022 and is scheduled to phase out ratably 20 percent each year from 2023–2026 (80 percent deduction in 2023, 60 percent in 2024, 40 percent in 2025, and 20 percent in 2026). If bonus depreciation is elected, all the assets purchased in a class life need to be elected, so it is considered an all or nothing. For example, a motor carrier purchases six new tractors for $900,000 (3-year life class life) and elects bonus depreciation. The motor carrier would deduct $900,000 of bonus depreciation on their tax return and have $0 of eligible costs for the regular MACRS deduction. The motor carrier does not have the option to only elect one of the tractors for bonus depreciation, it would have to elect bonus depreciation on all six tractors in the 3-year class life. In the future when bonus depreciation is no longer at 100 percent, any eligible cost that would not be subject to bonus depreciation would be subject to the normal MACRS rules.

Section 179 allows a taxpayer to immediately write-off or expense up to $1,050,000 in qualifying purchases in 2021 ($1,080,000 in 2022). Unlike bonus depreciation, Section 179 has a lot of flexibility in the sense that taxpayers can choose what amount of accelerated depreciation is desired. Using the same fact pattern above, if the motor carrier purchased the six new tractors, they could choose to expense any amount of Section 179 from $0 to $900,000. If they chose to take $600,000 of Section 179, the remaining $300,000 would be subject to the normal MACRS deduction of $100,000 (33.33 percent of $300,000). Note that Section 179 does have limitations and is subject to a phase out if a taxpayer goes above a certain spending limit each year.

What is the Real Cost?

Too often the focus on these accessories is on the upfront cost, including hardware, labor, excise, and State and local sales tax. We encourage potential motor carriers to give equal attention to the various benefits that can result from adopting these accessories, such as:

- Insurance and legal costs: insurance costs and claims are one of the highest costs incurred by a motor carrier. In the event of litigation and a possible “nuclear” verdict, there is no telling how much these technologies could really be saving you. For instance, road-facing cameras as well as onboard safety monitoring systems have already saved many companies from litigation costs by showing proof of no fault by the carrier involved. Recently a jury in Nassau County Florida handed down the first billion-dollar verdict as the result of a large tractor accident-related fatality. While the facts in that case are extreme, it is not uncommon to see multi-million-dollar verdicts in large tractor accident litigation, which makes it extremely important to promote safe driving and have accessories on tractors that does the same.
- Administrative costs: a company with a safer fleet experience less administrative time and cost needed to manage claims and driver situations.
- Increased customer satisfaction and retention.
- Increased efficiency and reduced driver fatigue due to fewer incidents on the road.

Expanding on an earlier example, here is a more inclusive analysis of the real cost of automatic emergency braking for a motor carrier with 50 tractors in their fleet.

Hardware and Installation	$2,500
Federal Excise Tax	$300
Sales and use tax*	$125
Gross Upfront Cost per Tractor	$2,925
Tractors in Fleet	50
Gross Upfront Cost	$146,250
Tax Savings **	($58,844)
Net Upfront Cost	$91,406

* Assumed State sales tax cost of 5.0%

** Assumed Federal and State blended tax rate of 37.5%

As you can see from this illustration, the total out of pocket cost of the accessory is 62.5 percent of the gross cost. This results in the motor carrier needing to recognize $91,406 in indirect benefits merely to break even. According to an FMCSA study, the average cost of an accident with no injuries approximates $117,000. FMCSA also found that automatic emergency braking systems prevent between 16 and 53 percent of rear-end striking crashes. One can infer that if a 50-tractor fleet adopts automatic emergency braking in their fleet and can avoid a single rear end collision, it could save the company approximately $25,594 ($117,000 less $91,406). If this were the case–not only has the company prevented an incident, kept the driver on the road and delivered their customers' goods, but the avoidance of this incident has more than paid for the cost of the equipment, and results in an estimated ROI of 28 percent ($25,594 divided by $91,406).

How Would a Potential Tax Credit Look?

While legislative proposals could require some of these accessories be implemented on new motor vehicles, they are difficult to mandate with pre-existing motor vehicles. One way to incentivize companies and drivers to implement these accessories into their used equipment could be by using Federal tax credits. Congress has used tax credits to incentivize certain behaviors in the general public for years. Tax credits are a powerful tool, and a way that could help reduce the cost of implementing these accessories aftermarket.

To get some insight as to how these tax credits could work to implement some of these safety accessories, let's look at the energy tax credits that have been available for years. Congress has laid out various accessories and energy updates that have qualified for tax credits, and indicated that if taxpayers purchase and install these, they can either claim a percentage of the overall cost as a tax credit or a credit up to a certain dollar threshold depending upon the type of upgrade being done.

An example of this is if a taxpayer were to install solar panels on a nonresidential building. That taxpayer would be eligible for a tax credit for up to 26 percent of the cost and would be allowed to depreciate 87 percent of the cost (reduce the total cost of the panels by 50 percent of the credit). If a taxpayer were to install $100,000 of solar panels, they would be eligible for a $26,000 tax credit and would have an $87,000 asset to depreciate. In some examples, Congress

has also limited the amount of the tax credit to a certain dollar amount, such as $500 for certain nonresidential energy credits. A tax credit modeled after this could work well to incentivize taxpayers to install aftermarket safety accessories.

There has been an increased emphasis on motor vehicle and highway safety for several years. The push for safety and its ties with technology has been evident looking at recent legislative proposals, with things like mandating automatic emergency brakes on new motor vehicles to various studies around crash causation. Investing in these accessories now could put you ahead of the curve for a future that might be inevitable.

REFERENCES

[1] Federal Motor Carrier Safety Administration (2022). *Large truck and bus crash facts 2020* (Report No. FMCSA-RRA-22-005). https://www.fmcsa.dot.gov/safety/data-and-statistics/large-truck-and-bus-crash-facts-2020

[2] National Highway Traffic Safety Administration (2021). Traffic safety facts annual report tables.

[3] Camden, M.C., Medina-Flintsch, A., Hickman, J.S., Miller, A.M., & Hanowski, R.J. (2017). *Air disc brakes: Leveraging large-truck technology and engineering to realize safety gains (Technical report)*. Washington, D.C.: AAA Foundation for Traffic Safety. https://aaafoundation.org/air-disc-brakes-leveraging-large-truck-technology-engineering-realize-safety-gains/

[4] Grove, K., Camden, M., Krum, A., & Hanowski, R. (2020). *Research and testing to accelerate voluntary adoption of automatic emergency braking (AEB) on commercial vehicles* (Report No. RRT-18-013). Federal Motor Carrier Safety Administration. https://rosap.ntl.bts.gov/view/dot/49335

[5] Grove, et al. (2020)