U.S. Department of Transportation
National Highway Traffic Safety Administration

NHTSA

Final Regulatory Impact Analysis

Occupant Protection for Vehicles Equipped with Automated Driving Systems

Office of Regulatory Analysis and Evaluation
National Center for Statistics and Analysis

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EXECUTIVE SUMMARY

NHTSA has prepared this final regulatory impact analysis to analyze the benefits and costs of enabling manufacturers of Automated Driving System-Dedicated Vehicles[1] (ADS-DVs) to satisfy the occupant protection Federal Motor Vehicle Safety Standards (FMVSSs) without including manual steering controls, as specified in the Final Rule. ADS-DVs are represented in this analysis as vehicles that can only be controlled by an ADS; thus, in these vehicles, manual steering controls would be superfluous. The cost impacts of this rule will depend on the per-vehicle costs savings to each vehicle that would no longer need certain manual controls, times the number of vehicles produced each year that will be produced without those controls. The Agency has reliable information on the former category, given that we generally know the current costs of this equipment, but can only estimate the broader effects. Thus, NHTSA calculated the cost impacts of this final rule by analyzing the savings that would be realized by forgoing the installation of manual steering controls, along with the incremental costs of

[1] An ADS-DV is defined as "[a] vehicle designed to be operated exclusively by a level 4 or level 5 ADS for all trips within its given operational design domain (ODD) limitations (if any)." High driving automation (Level 4) is defined as "[t]he sustained and ODD-specific performance by an ADS of the entire dynamic driving task (DDT) and DDT fallback without any expectation that a user will respond to a request to intervene." Full driving automation (Level 5) is defined as "[t]he sustained and unconditional (i.e., not ODD-specific) performance by an ADS of the entire DDT and DDT fallback without any expectation that a user will respond to a request to intervene." SAE J3016_201806 Taxonomy and Definitions for Terms Related to Driving Automation Systems for On-Road Motor Vehicles.

changing safety equipment requirements for left front vehicle occupants to be equivalent to requirements in the right front seating position.

This final rule would generate increased consumer and producer surplus from net production cost savings. NHTSA was unable to quantify and monetize impact categories other than production cost impacts (e.g., incremental consumer surplus) due to data unavailability and uncertainty. The table below provides a summary of the various benefits and costs that may accrue from this rule, as well as the various factors that define the range of possible outcomes. This range illustrates the uncertainty inherent in predicting the outcome for a market that has yet to develop.

Table E-1: Ranges of Outcomes for Benefit and Cost Categories

Element	**Low Case**	**High Case**
Incremental consumer and producer surplus	***Not estimated:*** Incremental consumer and producer surplus would be low if ADS-DV purchasers place a low value on the differences in the designs of vehicles without manual steering controls relative to vehicles with manual steering controls.	***Not estimated:*** Incremental consumer and producer surplus would be high if ADS-DV purchasers place a high value on the differences in the designs of vehicles without manual steering controls relative to vehicles with manual steering controls.
Incremental fuel consumption	***Not estimated:*** Reflects low vehicle mass impact and low sales impacts over time.	***Not estimated:*** Reflects high vehicle mass impact and high sales impacts over time.
Safety impacts	***Not estimated:*** The final rule has little to no effect on demand for ADS-DVs, with little to no corresponding effect on safety relative to travel in conventional vehicles.	***Not estimated:*** The final rule has a strong effect on demand for ADS-DVs, yielding a corresponding strong effect on safety relative to travel in conventional vehicles.

Reduced production costs	***Estimated:*** Captures the cost impacts of forgoing the installation of manual steering controls, versus the incremental costs of adding safety equipment to the left front seating position. Differs from the high case by assuming a relatively low cost of manufacture and installation of manual steering controls relative to the costs of assembling a left front seating position without manual steering controls. Also differs from the high case by assuming relatively low sales impacts over time.	***Estimated:*** Captures the cost impacts of forgoing the installation of manual steering controls, versus the incremental costs of adding safety equipment to the left front seating position. Differs from the low case by assuming a relatively high cost of manufacture and installation of manual steering controls relative to the costs of assembling a left front seating position without manual steering controls. Also differs from the low case by assuming relatively high sales impacts over time.
Reduced administrative burden	***Not estimated:*** The final rule would mitigate a small number of exemption requests, or the cost impact per mitigated exemption request is low.	***Not estimated:*** The final rule would mitigate a large number of exemption requests, or the cost impact per mitigated exemption request is high.
Reduced manufacturer uncertainty	***Not estimated:*** The final rule would not reduce uncertainty in manufacturers' planning processes significantly.	***Not estimated:*** The final rule would reduce uncertainty in manufacturers' planning processes significantly.

Monetized estimated per-vehicle cost impacts are presented by vehicle type and discount rate in Table E-2 below based on a scenario presented by the Energy Information Administration[2] (EIA), in which ADS-DVs become a large share of new light-duty vehicle sales by the year 2050:

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[2] Chase, N., Maples, J., and Schipper, M. (2018). *Autonomous Vehicles: Uncertainties and Energy Implications*. Issue in Focus from the *Annual Energy Outlook 2018*. Washington, D.C.: U.S. Energy Information Administration. Available at https://www.eia.gov/outlooks/aeo/av.php (last accessed October 22, 2019).

Table E-2: Summary of Net Per-Vehicle Cost Impact Estimates (ADS-DV Cost Impacts in 2050, 2018 Dollars)

Discount Rate	Mean Net Cost Impact	5^{th}- to 95^{th}-Percentile Net Cost Impacts
0% (Effects in 2050)	-$995	-$636 to -$1,350
3% (Discounted back to 2022)	-$435	-$279 to -$590
7% (Discounted back to 2022)	-$149	-$96 to -$203

The ranges of estimates were identified within an uncertainty analysis addressing uncertainty in the average level of cost savings that would be achieved by ADS-DV manufacturers. The uncertainty analysis centered on identifying plausible ranges of per-vehicle cost savings, with corresponding assumptions regarding the distributions of values across each range (i.e., the likelihood of observing a particular value). The uncertainty analysis generated 50,000 simulated outcomes, across which the mean and percentile values reported in Table E-2 were identified.

For this analysis, NHTSA assumed that light-duty vehicle sales through 2032 (the last year specified in the baseline) would follow the identical baseline path projected in the Corporate Average Fuel Economy (CAFE) Model[3] and then would continue to grow at the average annual growth rate in the baseline from 2028-2032 (approximately 0.2 percent per year) for each year after 2032, growing to 18.7 million new light-duty vehicles sold in 2050. Because projected sales growth rates are low in the CAFE baseline, projected 2050 sales levels are relatively insensitive to the choice of interval used to select a growth rate.

[3] Detailed information on the CAFE Model, including model files, is available at https://www.nhtsa.gov/corporate-average-fuel-economy/compliance-and-effects-modeling-system.

NHTSA assumed that the share of new light-duty vehicle sales comprised of ADS-DVs would reach 31 percent in the year 2050, based on the EIA scenario described above[4]; thus, new ADS-DV sales in 2050 are assumed to be equal to 31 percent of 18.7 million vehicles, or 5.8 million. The EIA also presents a scenario with only a one-percent ADS-DV sales share among new light duty vehicles in 2050. Estimates under this alternative assumption are 1/31 as large as our central estimates--only approximately 187,000 vehicles would be affected in 2050, rather than 5.8 million.

Based on these assumptions, NHTSA estimates that the value of net cost savings to ADS-DV manufacturers and consumers under the final rule would be approximately $995 per vehicle. Discounting back to 2022 to obtain estimates of present values in 2019, total cost savings are estimated to be $2.7 billion in 2050 at a three-percent discount rate, and $0.9 billion in 2050 at a seven-percent discount rate, should all ADS-equipped vehicle sales be comprised of single-mode vehicles. These estimates represent an upper bound, where 5.8 million ADS-DVs are sold in 2050; potential sales of dual-mode ADS-equipped vehicles in place of some ADS-DVs would reduce the total production cost savings observed through forgoing manual steering controls.

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[4] Chase, N., Maples, J., and Schipper, M. (2018). *Autonomous Vehicles: Uncertainties and Energy Implications*. Issue in Focus from the *Annual Energy Outlook 2018*. Washington, D.C.: U.S. Energy Information Administration. Available at https://www.eia.gov/outlooks/aeo/av.php (last accessed October 22, 2019). The 31-percent scenario was selected for this analysis rather than the reference case (with a one-percent ADS-DV share in 2050) provided by the EIA. The reference case is a conservative scenario that serves as a baseline against which to evaluate the incremental effects of alternative scenarios. A one-percent ADS-DV share for 2050 is low enough that it essentially assumes no meaningful development of full ADS vehicles over the next 30 years; we do not expect such a scenario to be representative, but present results under this alternative case for comparison. We have applied the 31-percent figure to all ADS-DVs, based on an assumption that nearly all Level 4 and Level 5 ADS-equipped vehicles will not have manual controls by the year 2050. This assumption centers on a projection that in 2050, dual-mode ADS-DVs will be niche vehicles, with fleet-owned vehicles applied in a rideshare environment, and privately owned vehicles being selected to focus on automated driving. It is expected that such rideshare Level 4 and 5 vehicles would have little economic incentive to have manual driving control. Additionally, within their operational design domains (ODDs) Level 4 vehicles will have no need for driving controls and Level 5 vehicles can operate under full automation anywhere.

Under the alternative EIA scenario in which one percent of new vehicle sales in 2050 are comprised of ADS-DVs, the corresponding values are approximately $90 million at a three-percent discount rate, and approximately $30 million at a seven-percent discount rate.

The total incremental costs are estimated to be approximately $0.2 billion at a three-percent discount rate, and approximately $60 million at a seven-percent discount rate. Under the alternative EIA scenario in which one percent of new vehicle sales in 2050 are comprised of ADS-DVs, the corresponding values are approximately $6 million at a three-percent discount rate, and approximately $2 million at a seven-percent discount rate.

Total net cost impacts are identified by subtracting the estimated incremental costs from the estimated cost savings. Thus, at a three-percent discount rate, the total estimated net cost impact in 2050 is a savings of approximately $2.5 billion (approximately $0.9 billion at a 7% discount rate).

As a sensitivity analysis, NHTSA also considered an alternative scenario, in which ADS-DV sales in 2050 are reduced by 30 percent relative to the central assumption, with the change in sales representing sales of dual-mode ADS-equipped vehicles. This represents a case in which: (1) ADS-DV sales are split between approximately one-sixth fleet sales and five-sixths private ownership, per the EIA scenario; (2) one-seventh of fleet ADS-DV purchases in the baseline analysis are allocated to dual-mode vehicle sales (i.e., approximately 1/6 x 1/7 of total ADS-DV sales); and (3) one-third of private ADS-DV purchases in the baseline analysis are allocated to dual-mode vehicle sales (i.e., approximately 1/3 x 5/6 of total ADS-DV sales). Under this alternative scenario, total cost savings are estimated to be approximately $1.9 billion at a three-percent discount rate, and approximately $0.7 billion at a seven-percent discount rate. The corresponding values of total incremental costs are estimated to be the same across the central scenario and the alternative scenario, because incremental costs are assumed to be invariant across ADS-equipped vehicles, and would apply to the same volume of assumed vehicle sales in both scenarios. The estimated total net cost impacts under this alternative scenario are savings of approximately $1.7 billion at a three-percent discount rate, and approximately $0.6 billion at a seven-percent discount rate.

The differences in results across the two scenarios are driven by a lack of cost savings for dual-mode vehicles, as those vehicles would preserve manual steering controls. Under the alternative EIA scenario in which one percent of new vehicle sales in 2050 are comprised of ADS-DVs, the corresponding values are approximately $60 million at a three-percent discount rate, and approximately $20 million at a seven-percent discount rate.

Table E-3: Summary of Total Monetized Annual Net Cost Impact Estimates (ADS-DV Cost Impacts in 2050, Billions of 2018 Dollars, 31% ADS-DV Sales Share)

Dual-Mode Sales Share Offset	Discount Rate	Mean Cost Impact
0%	3% (Discounted back to 2019)	-$2.5
0%	7% (Discounted back to 2019)	-$0.9
30%	3% (Discounted back to 2019)	-$1.7
30%	7% (Discounted back to 2019)	-$0.6

I. INTRODUCTION

A. Background

NHTSA has prepared this final regulatory impact analysis to analyze the benefits and costs of enabling manufacturers of Automated Driving System-Dedicated Vehicles[5] (ADS-DVs) to satisfy the Federal Motor Vehicle Safety Standards (FMVSSs) without including manual steering controls, as specified in the Final Rule. ADS-DVs are represented in this analysis as vehicles that can only be controlled by an automated driving system (ADS); thus, in these vehicles, manual steering controls would be superfluous. The cost impacts of this rule will depend on the per-vehicle net cost savings to each vehicle that would no longer need certain manual controls, times the number of vehicles produced each year that will be produced without those controls. The Agency has reliable information on the former category, given that we generally know the current costs of this equipment, but can only estimate the broader effects. Thus, NHTSA calculated the cost impacts of this final rule by analyzing the savings that would be realized by forgoing the installation of manual steering controls, along with the incremental costs of changing safety equipment requirements for left front vehicle occupants to be equivalent to requirements in the right front seating position.

The following (status quo) components of ADS-DVs are assumed to be affected by the final rule: steering controls, left front seating position air bags, and dashboard warning displays

[5] An ADS-DV is defined as "[a] vehicle designed to be operated exclusively by a level 4 or level 5 ADS for all trips within its given operational design domain (ODD) limitations (if any)." High driving automation (Level 4) is defined as "[t]he sustained and ODD-specific performance by an ADS of the entire dynamic driving task (DDT) and DDT fallback without any expectation that a user will respond to a request to intervene." Full driving automation (Level 5) is defined as "[t]he sustained and unconditional (i.e., not ODD-specific) performance by an ADS of the entire DDT and DDT fallback without any expectation that a user will respond to a request to intervene." SAE J3016_201806 Taxonomy and Definitions for Terms Related to Driving Automation Systems for On-Road Motor Vehicles.

(i.e., telltales). Steering controls are considered in this analysis because they would not be necessary (or even useful) for the operation of an ADS-DV. Rather, vehicles equipped with high or full driving automation, as defined by SAE International's J3016 Taxonomy and Definitions for Terms Related to Driving Automation Systems for On-Road Motor Vehicles, would be assumed to be sufficiently capable of continually adjusting steering angles, brake pressure, and throttle without external components designed for human use. The final rule is expected to have no effect on steering control costs for dual-mode vehicles with full ADS because, by definition, manual steering controls would be required to enable dual-mode operability. Left front seat air bags are assumed to be affected by the final rule because, by eliminating driving controls, there is no steering wheel to mount the air bag. Thus, this analysis assumes the replacement air bags for the left front seat are essentially identical to the passenger air bag systems in the right front outboard seat. In addition, it is feasible that the left front seat of a vehicle with full ADS could be occupied by a child under the age of 12.[6] In this analysis, we assume the left front air bag system will offer advanced air bag out-of-position (OOP) protection equal to the right front outboard seat. Such a system, in most cases, will require an occupant classification seat sensor. This would be necessary as a precaution against the potentially injurious deployments of air bags in left front seats occupied by children under the age of 12. We note that currently both driver's seat and right front outboard passenger seats must be equipped with advanced air bag protection for OOP adult occupants.

[6] It is not NHTSA's intention that a child under the age of 12 be placed in the left front seat. In the final rule, the agency states: "[T]he driver's seat should always be occupied by an individual of legal driving age during operation. For our discussions in this document we will typically refer to these individuals as adults, although they may in some cases be legally minors."

Dashboard warning displays of air bag suppression status are currently required for the right front outboard seat equipped with an air bag suppression system. The current display is required to be visible from both outboard front seats. In this analysis, we assume that manufacturers would be required to install an additional warning display (i.e., telltale), distinct from the existing one, if the driver's seat is converted to a passenger seat with an advanced air bag utilizing suppression technology.

FMVSS compliance testing costs are assumed to be unaffected, even though the final rule may affect the amount of testing to which a vehicle is subjected. The changes resulting from this final rule could reduce testing costs by making some tests inapplicable to an ADS-DV with no manual controls, thereby reducing certification costs. For example, under the final rule, it would be unnecessary for the manufacturer of an ADS-DV to incur the costs associated with certifying compliance with FMVSS No. 204, "Steering control rearward displacement." Conversely, the changes adopted in today's rule would permit additional compliance options that lead manufacturers of ADS-DVs to incur additional certification-related costs. For example, an ADS-DV with two front outboard passenger seats would be subject to more static tests under FMVSS No. 208 than would a traditional vehicle with a driver's seat, because it would have two seats that need to meet advanced air bag requirements. However, while upfront compliance testing costs may be affected, it is likely that these costs would be amortized over the production life of the make/model, which we project to reach millions of vehicles as the ADS-DV market matures.

Accordingly, the net per-vehicle testing cost is assumed to be de minimis under a mature ADS-DV market. For example, as we stated above, there may be some differential testing cost associated with certifying a seating position to advanced air bag requirements of a passenger seat instead of a driver's seat. These differences would not be related to crash testing, because both passenger and driver's seats must pass the same crash tests. However, depending on the compliance option strategy used by a manufacturer, the passenger seat might be subjected to additional out-of-position (OOP) static air bag deployment tests. Under a typical compliance strategy, passenger seats must certify to OOP tests with a 3-year-old and 6-year-old test dummy, at 2 positions per dummy, for a total or 4 OOP tests.[7] A driver's seat, on the other hand, must certify with a single fifth-percentile female dummy, at 2 positions, for a total of 2 OOP tests. A reasonable estimate for parts and labor cost for OOP would be $2,000 per test.[8] So, a reasonable testing cost differential between certifying a passenger seat as opposed to a driver's seat would be $4,000 per vehicle model, because 2 additional OOP tests would be performed for the passenger seat. A plausible upper bound estimate would be to double this differential to $8,000 per vehicle model. At the lower bound, there would be no cost differential, because it is likely that the vehicle in question already has a passenger seating position that needs to be certified to OOP tests. It is likely that any new passenger seating position converted from a driver's position will be symmetric in geometry and interior surroundings with the existing, already-certified-as-compliant, passenger position. Thus, no additional testing would be necessary in such a case.

To identify estimates of per-vehicle incremental testing costs for a given model vehicle, we apply the upper bound of $8,000 per vehicle model discussed above. Assuming the testing costs are shared among all vehicles produced within a given generation (e.g., across five model years), per-vehicle testing cost impacts would be below ten cents for any vehicle generations

[7] This assumes an air bag suppression strategy for the 12-month-old dummy.
[8] This cost will vary by cost of air bags for both passenger and driver's seats and cost of steering column components for the driver's seat.

with sales above 80,000 (e.g., 16,000 vehicles sold per year over five years), confirming the likelihood of de minimis cost impacts.

Components associated with crash avoidance (e.g., accelerator and brake controls) are outside of the scope of this analysis because the final rule is limited in scope to standards governing crashworthiness.

B. Market Analysis

The primary quantifiable expected effect of the final rule is the reduction of production costs for ADS-DVs. For this analysis, we project annual production cost impacts for a future year (2050) in which it is plausible that ADS-DVs would represent a large proportion of total new light-duty vehicle sales (i.e., it is plausible that the ADS-DV market would reach maturity by 2050). There is considerable uncertainty in the path of ADS-DV sales shares over time.

The year 2050 was selected as the representative future year with a high ADS-DV sales share based on a scenario presented by the Energy Information Administration (EIA)[9], in which the share of new light-duty vehicle sales comprised of (Level 4 or Level 5) ADS-DVs reaches 31 percent in the year 2050. The EIA scenario assumes that sales of ADS-DVs will grow steadily over time through increasing demand by fleets (e.g., ridesharing/carsharing providers) and households. In this analysis, we also provide results for an alternative EIA scenario in which ADS-DVs represent only one percent of new light duty vehicle sales in 2050.

Under the EIA scenarios where ADS-DVs represent 31 percent of new vehicle sales, vehicle miles traveled (VMT) increase relative to the reference scenario in which only fleets

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[9] Chase, N., Maples, J., and Schipper, M. (2018). *Autonomous Vehicles: Uncertainties and Energy Implications*. Issue in Focus from the *Annual Energy Outlook 2018*. Washington, D.C.: U.S. Energy Information Administration. Available at https://www.eia.gov/outlooks/aeo/av.php (last accessed October 22, 2019).

purchase ADS-DVs (by ten percent per privately owned vehicle); in the reference and alternative EIA scenarios, fleet-owned ADS-DVs are assumed to experience very high utilization (65,000 miles per year). The VMT growth is associated with an assumed higher average fuel economy (and thus lower average marginal operating cost) for ADS-DVs, due to a higher propensity to apply battery electric or hybrid electric drivetrains. Under all scenarios, fleet-owned vehicles would be scrapped faster than conventional vehicles, due to the usage rate of 65,000 miles per year per vehicle. Conditional on a given level of travel demand, the increase in scrappage rates would be offset by a decrease in the number of vehicles required to meet travel demand, resulting in a neutral net effect on annual vehicle sales. The increase in privately owned vehicle VMT in the EIA scenario could influence scrappage rates, as well; for this analysis, we consider the ten-percent change in VMT for privately owned vehicles to be low enough that it may reasonably be offset by other technological (e.g., lower wear rates for ADS-DVs relative to conventional vehicles) and behavioral (e.g., the types of trips taken) factors.

For the central analysis, we assume that dual-mode vehicles would represent an insignificant share of sales of vehicles with full ADS by the time the market for ADS-DVs reaches maturity. Rather, we assume that in 2050, both fleet-owned and privately owned ADS-DVs will be single-mode vehicles. As a sensitivity analysis, NHTSA also considered an alternative case, in which ADS-DV sales in 2050 are reduced by 30 percent relative to the baseline, with the change in sales representing sales of dual-mode ADS-equipped vehicles. This represents a case in which: (1) ADS-DV sales are split between approximately one-sixth fleet sales and five-sixths private ownership, per the EIA scenario; (2) one-seventh percent of fleet ADS-DV purchases in the baseline analysis are allocated to dual-mode vehicle sales (i.e., approximately 1/7 x 1/6 of total ADS-DV sales); and (3) one-third percent of private ADS-DV purchases in the baseline analysis are allocated to dual-mode vehicle sales (i.e., approximately 1/3 x 5/6 of total ADS-DV sales).

NHTSA assumed that total new light-duty vehicle sales would follow the identical baseline path specified in the Corporate Average Fuel Economy (CAFE) Model[10] through 2032 (the last year specified in the baseline), and then would continue to grow at the average annual growth rate in the baseline from 2028-2032 (approximately 0.2 percent per year) for each year after 2032. The projected sales growth rate across the final five years of the CAFE baseline was selected as a compromise in balancing proximity to the out-years in the analysis and covering sufficient years to preserve stability in projected (low) sales growth rates. Ultimately, because projected sales growth rates are low in the CAFE baseline, projected 2050 sales levels are relatively insensitive to the choice of interval used to select a growth rate.

Based on these assumptions, light-duty vehicle sales are projected to grow from 17.5 million in 2019 to 18.7 million in 2050. This estimate is close to the corresponding estimate of 18.2 million light-duty vehicles sold in 2050 in the EIA scenario.

Multiplying the projected light-duty vehicle sales shares for ADS-DVs in 2050 (31 percent) by the projected total annual sales for light-duty vehicles in 2050 (18.7 million) yields our central estimate of ADS-DV sales in 2050: 5.8 million (versus 5.6 million in the EIA scenario). For estimates centering on an alternative baseline with a one-percent ADS-DV sales share in 2050, the resulting estimated impacts in 2050 are 1/31 as large as our central estimates.

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[10] Detailed information on the CAFE Model, including model files, is available at https://www.nhtsa.gov/corporate-average-fuel-economy/compliance-and-effects-modeling-system.

Thus, under an assumption of a one-percent ADS-DV sales share, only approximately 187,000 vehicles would be affected in 2050, rather than 5.8 million.

Fleet sizes for heavy-duty vehicles that could be affected by this final rule were not projected, due to a lack of market information on potential demand for heavy-duty ADS-DVs. Thus, any corresponding impacts on heavy-duty vehicles would represent an unquantified increment in addition to the quantified estimates presented in this document.

II. BENEFIT AND COST IMPACTS

A. Overview of Methods

This section discusses the methods used to calculate quantifiable benefit and cost impacts associated with the final rule, which are limited to production cost impacts.

A.1. Affected Vehicles and Equipment

The unit of analysis is the component of future years' new light-duty vehicle sales that would be comprised of ADS-DVs. Dual-mode fully automated vehicles are assumed to accrue no cost savings under the final rule because, by definition, manual steering controls would be required to enable dual-mode operability.

The following (status quo) components of ADS-DVs are assumed to be affected by the final rule: steering controls, left front seating position air bags, and dashboard warning displays (i.e., telltales). Steering controls are considered in this analysis because they would not be necessary (or even useful) for the operation of an ADS-DV. Rather, vehicles equipped with high or full driving automation, as defined by J3016, would be assumed to be sufficiently capable of continually adjusting steering angles without external components designed for human use.

Left front seat air bags are assumed to be affected by the final rule because, by eliminating driving controls, there is no steering wheel to mount the air bag. For this analysis, we consider novel center front seats with no corresponding outboard seats as equivalent to left front seats (i.e., where a driver would be seated if there were no automated driving controls). Novel center front seats would represent a front row with a single seating position aligned near the midpoint of the track width of the vehicle. We expect that such vehicle configurations would be rare; thus, not only would there be no incremental cost impact per vehicle with novel center front seats, but the total number of affected vehicles would likely be near zero. Thus, this analysis assumes the replacement air bags for the left front seat are essentially identical to the passenger air bags systems in the right front seat. In addition, it is feasible that the left front seat of an ADS-DV could be occupied by a child under the age of 12. In this analysis, we assume the left front air bag system will offer advanced air bag out of position (OOP) protection equal to the right front outboard seat. Such a system, in most cases, will require an occupant classification seat sensor. This would be necessary as a precaution against the potentially injurious deployments of air bags in left front seats occupied by children under the age of 12. We note that currently both driver's seat and right front outboard passenger seats must be equipped with advanced air bag protection for OOP adult occupants. However, right front outboard passenger seats, in most cases, include sensors to detect child occupants, while driver's seats do not.

Dashboard warning displays of air bag suppression status are currently required for the right front outboard seat equipped with an air bag suppression system. The current display is required to be visible from both outboard front seats. In this analysis, we assume that manufacturers would be required to install an additional warning display (i.e., telltale), distinct from the existing one, if the driver's seat is converted to a passenger seat with an advanced air bag utilizing suppression technology.

<u>A.2. Benefit and Cost Impact Estimation Technique</u>

NHTSA identified per-vehicle benefit and cost impacts associated with the final rule by estimating manufacturers' average costs of including steering controls and air bag suppression telltales (the elimination of which represents a benefit to manufacturers), along with the incremental cost of including passenger advanced air bags in the left front seat rather than driver advanced air bags. As detailed below, average costs of steering controls were estimated based on replacement parts costs (adjusted for marketing and retail costs associated with retail transactions). Costs of telltales and air bags were based on available cost teardown research. The net cost impact is estimated as the cost savings due to forgoing the installation of steering controls, less the cost of including an additional air bag telltale and the incremental cost of an advanced air bag in the left front seat (versus a standard air bag). There is no estimated cost savings for dual-mode vehicles. Furthermore, for our central analysis, we assume that dual-mode vehicles would represent an insignificant share of vehicle sales by the time the ADS-DV market reaches maturity.

We believe this is a reasonable assumption based on several factors. It is public information that many large vehicle manufacturers and other firms working on automated vehicle development are focused on a ridesharing business model. In this model, there is no need to have driving controls in the vehicle, as long as the vehicles are fully automated either universally, or within operational design domains that the vehicles are restricted to. In fact, there is incentive to remove the controls as cost savings and interior space savings. Additionally, the expected increased cost of ADS vehicles would provide resistance to the private ownership model. Furthermore, although the private ownership model may be more incentivized to maintain driving controls, at least initially, to satisfy consumer desires to drive, with time and proliferation of ADS vehicles, fewer people would be trained in the driving task. Thus, private ownership of ADS-equipped vehicles with manual controls might become more of a niche business. Nonetheless, we have provided alternative estimates that account for an outcome in which ADS-DV sales are reduced by 30 percent, with the change in sales representing sales of dual-mode ADS-equipped vehicles.

The primary sources of costs for the relevant steering components were online providers of original equipment for vehicles manufactured by Ford (parts.ford.com), General Motors (gmpartsgiant.com), and Fiat Chrysler (dodgeparts.com). Where feasible, a core brand and luxury brand version of a common sport utility vehicle was selected for analysis for each manufacturer; due to the lack of a corresponding luxury vehicle for Chrysler, a minivan with the same engine size and drive type was selected. The vehicles selected for the analysis are:

- 2018 Ford Explorer, 3.7L, all-wheel drive
- 2018 Lincoln MKT, 3.7L, all-wheel drive
- 2017 Chevrolet Equinox
- 2016 Cadillac SRX (final model year)
- 2017 Dodge Journey, 3.6L, all-wheel drive
- 2017 Chrysler Pacifica, 3.6L, all-wheel drive

The prices identified online are assumed to be higher than the costs of manufacturing the components by a factor of 1.51, due to retail markups. The factor of 1.51 was identified in a

NHTSA technical report for FMVSS No. 201[11]; the factor incorporates an estimated manufacturer markup of 36 percent and a dealer markup of 11 percent (1.36 x 1.11 = 1.51). For this analysis, cost impacts are assumed to include both manufacturing costs (equal to the estimated price divided by 1.51) and marketing costs (equal to the difference between the estimated price and manufacturing cost). Thus, for every dollar manufacturing costs are reduced, more than one dollar ($1.51) is estimated to accrue among consumers (via consumer surplus), manufacturers and dealers (via producer surplus).

For each of the six vehicles, prices were collected for individual components associated with steering controls that are specific to human input (i.e., not also expected to be required for manipulation by the ADS). The estimated original equipment manufacturer (OEM) (i.e., non-deflated) price for each component is the simple average of the highest and lowest quoted price. Individual components in the analysis include (not all components are on all vehicles, and some components require duplicate parts):

- Steering wheel
- Steering housing assembly
- Steering shroud assembly
- Steering column assembly
- Shaft assembly
- Steering motor
- Steering boot
- Steering wheel cover
- Horn contact
- Wheel pad harness
- Cruise control switch
- Radio switch
- Steering column seal
- Multifunction switch

[11] NHTSA (2004). *Perform Cost and Weight Analysis*. National Highway Traffic Safety Administration, Report No. DOT HS 809 842, Washington, D.C. (December).

- Switch speed control
- Control switch
- Spring tilt assist
- Column assembly fastener
- Steering level
- Steering seal
- Steering wheel bezel
- Steering wheel trim
- Cover boot

The mitigated costs (or cost savings) are assumed to accrue fully to manufacturers (via producer surplus, as the difference between sales price and cost of production grows) and vehicle purchasers (via incremental consumer surplus, as the difference between willingness-to-pay and sales price grows), consistent with economic theory. The estimated cost savings represent an incomplete share of the total incremental consumer and producer surplus under the final rule. That is, it is feasible that changes to vehicle cabin configurations would utilize the lack of manual steering controls to yield vehicle designs that are more desirable to consumers, and thus in higher demand (i.e., higher willingness-to-pay). Under higher demand, the number of vehicles sold would yield increased producer surplus (if there is any increase in price), increased consumer surplus (unless an increase in price fully matches the increase in willingness-to-pay), or both.

However, NHTSA does not have sufficient information on demand and supply for fully automated vehicles and their substitutes to estimate incremental consumer and producer surplus beyond the cost savings estimated in this section. Thus, the cost savings identified in this section serve as a partial measure of incremental consumer and producer surplus. The unquantifiable component of incremental consumer and producer surplus is recognized in Section III. We make no further assumptions on how the cost savings are allocated among producers and consumers.

NHTSA assumes no cost savings associated with the installation of forgone steering components; rather, NHTSA assumes that labor would be transferred from installing the steering components to installing whatever amenities or equipment are installed in their place. As noted above, the estimated cost savings are assumed to represent two components: (1) input cost savings to manufacturers (i.e., equal to the market price of the equipment multiplied by 1/1.51); and (2) a measure of consumer and producer surplus equal to the share of market price associated with all costs other than production costs (i.e., equal to the market price of the equipment multiplied by 0.51/1.51).

Benefit and cost impact estimates for individual vehicles are multiplied by the number of vehicles assumed to be produced in a year to generate estimates of total annual impacts. The estimated impacts are assumed to occur at the time of vehicle manufacture (i.e., cost savings are realized when the vehicle is built). Discounted cost impacts for the present value of effects in a focal year (2019, in this analysis) incorporate discount factors equal to $1/(1+r)^{t-2019}$, where *r* equals the discount rate and *t* equals the year of manufacture.

The ranges of estimates were identified within an uncertainty analysis addressing uncertainty in the average level of cost savings that would be achieved by ADS-DV manufacturers. The uncertainty analysis centered on identifying plausible ranges of the key analytical inputs, with corresponding assumptions regarding the distributions of values across each range (i.e., the likelihood of observing a particular value). The uncertainty analysis generated 50,000 simulated outcomes, across which mean and percentile values reported in the analysis were identified.

FMVSS compliance testing costs are assumed to be unaffected. For example, the final rule would make it feasible to manufacture a fully automated vehicle that has no steering controls, and thus eliminate the need to certify compliance with FMVSS No. 204, "Steering control rearward displacement." Conversely, under FMVSS No. 208, there are potentially more static tests to certify a driver's seat that has been converted to a passenger seat in a vehicle with full ADS than there would have been for the original driver's seat. However, while upfront compliance testing costs may be affected, it is likely that these costs would be amortized over the production life of the make/model, which we project to reach millions of vehicles as the ADS-DV market matures. Accordingly, the per-vehicle testing cost is assumed to be de minimis under a mature ADS-DV market. Components associated with crash avoidance (e.g., accelerator and brake controls) are outside of the scope of this analysis because the final rule is limited in scope to standards governing crashworthiness.

B. Total Benefit and Cost Impacts

B.1. Total Monetized Per-Vehicle Cost Impacts

The estimated costs of providing steering controls for the vehicles in the analysis are summarized in Table 1:

Table 1: Estimated Steering Control Costs per Vehicle (2018 Dollars)

Model	Minimum	Maximum	Average
Ford Explorer	$618.24	$1,974.45	$1,296.35
Lincoln MKT	$1,485.90	$2,559.92	$2,022.91
Chevrolet Equinox	$571.54	$673.27	$622.41
Cadillac SRX	$982.81	$1,143.55	$1,063.18
Dodge Journey	$1,474.80	$1,537.86	$1,506.33
Chrysler Pacifica	$1,143.00	$1,716.86	$1,429.93
Average Consumer Cost	***$1,046.05***	***$1,600.99***	***$1,323.52***

The estimated mean online cost of steering controls across the six vehicle models in the analysis is $1,324 (ranging from a low of $572 for the least expensive Chevrolet Equinox components to a high of $2,560 for the most expensive Lincoln MKT components).

Simons (2017)[12] offers estimates of the costs of air bag telltales and incremental components distinguishing advanced air bags from standard air bags:

Table 2: Costs of Incremental Advanced Air Bag Components (2012 Dollars)

Component	Driver Advanced Air Bag Cost	Passenger Advanced Air Bag Cost	Incremental Cost
Air Bag	$78.40	$117.88	$39.48
Seat Sensor	$0.85	$9.76	$8.91
Strain/Occupant Sensor	$0.00	$12.51	$12.51
Telltale	$0.32	$0.64	$0.32
Belt Use Sensor	$0.82	$2.35	$1.53
Total Incremental Cost (2012$)			*$62.75*
Total Incremental Cost (2018$)			***$69.23***

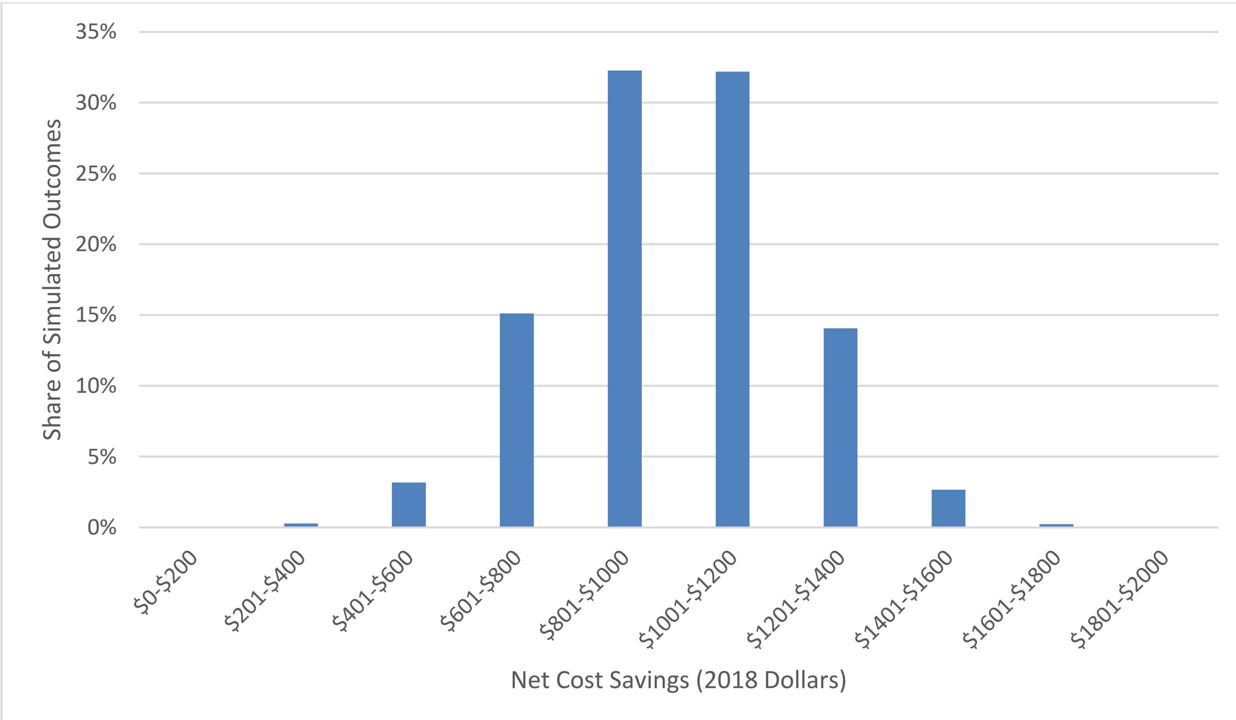
The total estimated incremental cost of: (1) providing an advanced passenger air bag in the left front seat; and (2) adding another air bag telltale is $63 in 2012 dollars. This estimate was converted to 2017 dollars using annual values for the Implicit GDP Deflator[13] (the most recent year available for the annual series), and then converted to 2018 dollars by multiplying the 2017-dollar value by the ratio of the fourth-quarter values for the quarterly series of the Implicit GDP Deflator[14] for 2018 to the corresponding value for 2017, yielding an estimate of $69 per vehicle.

[12] Simons, J.F. (2017, November). *Cost and weight added by the Federal Motor Vehicle Safety Standards for MY 1968-2012 passenger cars and LTVs*. Report No. DOT HS 812 354. Washington, D.C.: National Highway Traffic Safety Administration.
[13] https://fred.stlouisfed.org/series/USAGDPDEFAISMEI
[14] https://fred.stlouisfed.org/series/GDPDEF

NHTSA has no basis to assume any change in the type of advanced air bag system (fully low risk deployment (LRD) for all child dummy sizes or a suppression type system requiring a seat sensor for some child dummy sizes) manufacturers will install in the right front passenger position in ADS-equipped vehicles compared to non-ADS vehicles. Similarly, we would expect that ADS vehicle manufacturers would mirror the air bag type in the left front seating position when installing the air bag for the right front seating position. Although fully LRD air bags are approximately ten percent less expensive than other advanced air bags because no seat sensor is required (or an incremental cost lower by approximately four dollars), our cost estimates will assume all left front passenger air bag systems will have the higher cost system requiring a seat sensor. This results in a higher overall cost estimate.

NHTSA's estimate of per-vehicle net cost savings for ADS-DVs is specified as the per-vehicle cost savings associated with forgoing the installation of manual steering controls, less the costs of incremental advanced air bag components ($69 per vehicle, from Table 2). The cost savings represent a benefit to manufacturers, while the incremental costs represent a cost to manufacturers. To account for uncertainty in per-vehicle steering control costs, NHTSA conducted an uncertainty analysis. The uncertainty analysis involved 50,000 trials, across which 90 percent of per-vehicle steering control costs were assumed to range between 50 percent of the average minimum value in Table 1 (50 percent of $1,046, or $523) and the average maximum value in Table 1 ($1,601). The 50-percent scaling factor for the lower bound of the assumed range was selected to: (1) account for unobserved costs for constructing the left front seating position in the absence of steering controls; and (2) reflect potential economies of scale in current manufacturing processes that were not identified in the search for equipment costs. The difference between per-vehicle steering control costs and incremental advanced air bag component costs was assumed to be distributed normally, with a standard deviation equal to 20 percent of the range. The assumption regarding the spread of the normal distribution was selected to ensure that: (1) at least 90 percent of the generated values were within the assumed range; and (2) no generated values were negative. The distribution of simulated outcomes for net cost impacts is presented in Figure 2:

Figure 2: Distribution of Net Cost Impacts in the Uncertainty Analysis (Share of Simulated Outcomes, by 2018 Dollars)



Summary statistics from the sensitivity analysis are presented in Table 3:

Table 3: Net Undiscounted Per-Vehicle Cost Impacts (2018 Dollars)

Statistic	Value
Mean	$995
Median	$995
Standard Deviation	$216
5th Percentile	$636
95th Percentile	$1,350

Applying discount factors to mean undiscounted per-vehicle impacts (which are assumed to accrue during the year of vehicle manufacture) yields the following estimates of the present value of total cost impacts from the year 2050 in a reference year, 2019 in this analysis:

Table 4: Summary of Discounted Per-Vehicle Benefit and Cost Impact Estimates (ADS-DV Cost Impacts in 2050 Discounted Back to 2019, 2018 Dollars)

Discount Rate	Mean Benefit (Cost Savings)	Incremental Cost	Mean Net Cost Impact	5th- to 95th-Percentile Net Cost Impacts
3%	$465	$30	-$435	-$279 to -$590
7%	$159	$10	-$149	-$96 to -$203

Thus, estimated per-vehicle net cost impacts of the final rule in 2050 are $995 (comprised of a benefit of $1,064 and a cost of $69), equivalent to a present value of $435 in 2022 at a three-percent discount rate (a benefit of $465 and a cost of $30), and $149 at a seven-percent discount rate (a benefit of $159 and a cost of $10).

There is no estimated benefit for dual-mode vehicles. The production of dual-mode vehicles is assumed to be voluntary, and to require no change to equipment that would be present in conventional driver-operated vehicles. The estimated discounted cost impacts for dual-mode vehicles are equal to the incremental cost impacts in Table 4 above. The estimated incremental cost impacts for dual-mode vehicles represent an upper bound case, in which all dual-mode vehicles require more expensive seat sensors and additional telltales.

B.2. Total Monetized Annual Benefit, Cost, and Net Cost Impacts

The total annual benefit, cost, and net cost impacts of the final rule are identified by multiplying the total monetized benefit, cost, and net cost impacts per vehicle (as projected in the uncertainty analysis above) by the number of vehicles that would be affected by the rulemaking in a focal year (in this case, 5.8 million vehicles in 2050 for the primary scenario with no dual-mode ADS-equipped vehicle sales, 4.0 million vehicles in 2050 for the alternative scenario with 30% of ADS-DV sales shifted to dual-mode ADS-equipped vehicles; under alternatives with one-percent ADS-DV sales shares, 0.18 million vehicles in 2050 with no dual-mode sales, and 0.13 million vehicles in 2050 with 30% dual-mode sales).

Cost impacts on heavy-duty vehicles that could be affected by this final rule were not projected, due to a lack of market information on potential demand for heavy-duty ADS-DVs. Thus, any cost impacts on heavy-duty ADS-DVs would represent an unquantified increment in addition to the cost impacts presented here.

NHTSA's resulting estimates of total annual cost impacts are the means of the values across the 50,000 simulated outcomes:

Table 5: Summary of Total Monetized Annual Benefit, Cost, and Net Cost Impact Estimates (ADS-DV Cost Impacts in 2050, Billions of 2018 Dollars, 31% ADS-DV Sales Share)

Dual-Mode Sales Share Offset	Discount Rate	Mean Benefit (Cost Savings)	Incremental Cost	Mean Net Cost Impact
0%	3% (Discounted back to 2022)	\$2.7	\$0.2	-\$2.5
0%	7% (Discounted back to 20122)	\$0.9	\$0.1	-\$0.9
30%	3% (Discounted back to 2022)	\$1.9	\$0.2	-\$1.7
30%	7% (Discounted back to 2022)	\$0.7	\$0.1	-\$0.6

Discounting back to 2022 to obtain estimates of present values in 2019, the total cost savings are estimated to be \$2.7 billion in 2050 at a three-percent discount rate, and \$0.9 billion in 2050 at a seven-percent discount rate, should all ADS-equipped vehicle sales be comprised of single-mode vehicles. Under the alternative EIA scenario in which one percent of new vehicle sales in 2050 are comprised of ADS-DVs, the corresponding values are approximately $90 million at a three-percent discount rate, and approximately $30 million at a seven-percent discount rate.

The total incremental costs are estimated to be approximately $0.2 billion at a three-percent discount rate, and approximately $0.1 billion at a seven-percent discount rate. Under the alternative EIA scenario in which one percent of new vehicle sales in 2050 are comprised of ADS-DVs, the corresponding values are approximately $6 million at a three-percent discount rate, and approximately $2 million at a seven-percent discount rate.

Total net cost impacts are identified by subtracting the estimated incremental costs from the estimated cost savings. Thus, at a three-percent discount rate, the total estimated net cost impact in 2050 is a savings of approximately $2.5 billion (approximately $0.9 billion at a 7% discount rate).

Under the alternative scenario in which ADS-DV sales in 2050 are reduced by 30 percent relative to the baseline, with the balance comprised of dual-mode ADS-equipped vehicles, total cost savings are estimated to be approximately $1.9 billion at a three-percent discount rate, and approximately $0.7 billion at a seven-percent discount rate. The corresponding values of total incremental costs are estimated to be the same across the central scenario and the alternative scenario, because incremental costs are assumed to be invariant across ADS-equipped vehicles, and would apply to the same volume of assumed vehicle sales in both scenarios. The estimated total net cost impacts under this alternative scenario are savings of approximately $1.7 billion at a three-percent discount rate, and approximately $0.6 billion at a seven-percent discount rate.

C. Unquantified Impacts

This sub-section discusses the unquantified categories associated with the final rule: incremental fuel consumption impacts, safety impacts, incremental consumer and producer surplus, changes in administrative burden, and changes in manufacturer uncertainty.

C.1. Incremental Fuel Consumption

The final rule could affect per-vehicle fuel consumption by changing the mass of ADS-DVs. NHTSA expects ADS-DV mass to either decrease (due to the removal of currently required equipment) slightly or remain essentially unchanged (due to the addition of automated steering components that offset the mass savings of the removed equipment) under the final rule. NHTSA acknowledges that, in principle, ADS-DV mass could increase (if vehicle seating configurations and amenities are changed sufficiently when exploiting the reduction in design constraints when removing manual steering controls) under the final rule. Conversely, ADS-DV net mass could decrease for cases where vehicles are used for travel without occupants (e.g., automated deliveries or empty running between trips with occupants). However, we do not have data to support any specific projections in changes in vehicle mass. In any event, current corporate average fuel economy (CAFE) requirements are based on a vehicle's "footprint," and thus any change in a vehicles mass will not affect a manufacturer's obligations under that program. Finally, as stated in the NPRM, NHTSA has not attempted to address the revisions that may be necessary to provide regulatory certainty for manufacturers that wish to self-certify

ADS-equipped vehicles with flexible seating arrangements that allow for rear- or side-facing occupants or repositioned seats.

C.2. Safety

The final rule is assumed to have no effect on the per-mile risk of travel in ADS-DVs, as it does not revise, remove, or establish anything associated with their safety performance. That is, the removal of manual steering controls is not assumed to offer any direct safety benefit or detriment for travel in ADS-DVs. However, it is feasible that changes in ADS-DV demand associated with the final rule (e.g., due to changes in vehicle design or decreases in cost) could increase the use of ADS-DVs. In turn, safety outcomes associated with the final rule would be equal to the net effects of: (1) changes in per-mile fatality and injury risk for travel that is shifted from conventional vehicles to ADS-DVs; and (2) incremental fatalities and injuries for travel in ADS-DVs that would not have taken place in any vehicle otherwise. It is difficult to project net safety impacts associated with the final rule without information on: (1) per-mile fatality and injury risk for ADS-DVs and conventional vehicles over time; and (2) demand for travel in ADS-DVs and conventional vehicles as a function of ADS-DV price and design attributes. NHTSA continues to engage in various research, regulatory, and enforcement efforts associated with the safety of the automated driving system itself, but those activities are outside the scope of this rulemaking.

C.3. Incremental Consumer and Producer Surplus

NHTSA recognizes that incremental consumer and producer surplus under the final rule would accrue in addition to the production cost savings estimated in the preceding section. That is, by reconfiguring seating configurations and amenities to exploit the lack of manual steering controls, ADS-DV manufacturers would generate incremental consumer and producer surplus as consumers' willingness-to-pay increases.

However, NHTSA does not have sufficient information available on the demand and supply of ADS-DVs and their substitutes to estimate the components of incremental consumer and producer surplus that are not captured within the estimates of production cost savings. Thus, the share of incremental consumer and producer surplus not comprised of the cost savings identified in the preceding section is an unquantified benefit.

C.4. Changes in Administrative Burden

The final rule would lead to a reduction in the number of standards from which manufacturers of ADS-DVs would have to seek exemptions. The reduction in exemption requests would be associated with a reduction in administrative costs for both manufacturers and NHTSA. NHTSA does not have sufficient information to establish a specific estimate of administrative cost savings. However, the cost savings would be expected to be small relative to the production cost savings associated with the rule. For example, if the average manufacturer were to dedicate 200 labor-hours per exemption request at an average gross labor cost of $50 per hour, the average cost savings associated with a mitigated exemption request would be $10,000, or roughly the production cost savings for 20 vehicles affected by the final rule.

C.5. Changes in Manufacturer Uncertainty

A less tangible, but still important, expected impact of the final rule would be a reduction in uncertainty for manufacturers of ADS-equipped vehicles. The final rule provides clarity to manufacturers on constraints to developing FMVSS-compliant ADS-equipped vehicles. In turn, developmental paths for ADS-equipped vehicles could be implemented with greater precision and efficiency. The reduction in uncertainty could reduce not only the costs associated with manufacturing ADS-equipped vehicles, but also the time it would take to bring these vehicles to the market. An accelerated development timeline would be a benefit both to manufacturers and consumers.

III. NET BENEFITS

Net benefits represent the difference between total benefits and total costs. In regulatory analysis, net benefits are used as an absolute measure of how much better off society would be (in dollar terms) if a policy alternative were enacted; a positive value for net benefits indicates that society would be better off under the policy alternative, and a negative value indicates that society would be worse off.

In this analysis, the estimated net benefits are equal to the net cost impacts presented above, multiplied by -1:

Table 6: Total Annual Monetized Net Benefits, ADS-DV Production in 2050 (Billions of 2018 Dollars, 31% ADS-DV Sales Share)

Dual-Mode Sales Share Offset	Discount Rate	Mean Net Benefits
0%	3% (Discounted back to 2019)	$2.5
0%	7% (Discounted back to 2019)	$0.9
30%	3% (Discounted back to 2019)	$1.7
30%	7% (Discounted back to 2019)	$0.6

Under the alternative EIA scenario in which one percent of new vehicle sales in 2050 are comprised of ADS-DVs, the corresponding estimates of net benefits are approximately $80 million at a three-percent discount rate, and approximately $30 million at a seven-percent discount rate. Under an alternative scenario with 30 percent of ADS-DV sales shifted to dual-mode ADS-equipped vehicles, the corresponding estimates of net benefits are approximately $60 million at a three-percent discount rate, and approximately $20 million at a seven-percent discount rate.

IV. UNFUNDED MANDATES REFORM ACT

The Unfunded Mandates Reform Act of 1995 (Public Law 104-4) requires Agencies to prepare a written assessment of the costs, benefits, and other effects of proposed or final rules that include a Federal mandate likely to result in the expenditures by States, local or tribal governments, in the aggregate, or by the private sector, of more than $100 million annually (adjusted annually for inflation with base year of 1995).

This final rule is not likely to result in expenditures by State, local or tribal governments of more than $100 million annually. The estimated monetized annual change in costs is between -$3.7 billion and -$7.8 billion in 2050. Discounting back to 2019 yields estimates of present value in 2019 of between -$1.5 billion and -$3.1 billion at a three-percent discount rate (between -$0.5 billion and -$1.0 billion at a seven-percent discount rate).

V. REGULATORY FLEXIBILITY ACT

The Regulatory Flexibility Act of 1980 (5 U.S.C §601 et seq.) requires Agencies to evaluate the potential effects of their proposed and final rules on small business, small organizations and small Government jurisdictions.

5 U.S.C §603 requires Agencies to prepare and make available for public comments an initial and final regulatory flexibility analysis (RFA) describing the impact of proposed and final rules, respectively, on small entities. An RFA is not required if the head of the Agency certifies that the proposed or final rule will not have a significant impact on a substantial number of small entities. The head of NHTSA has made such a certification with regard to the final rule.

The factual basis for the certification (5 U.S.C. 605(b)) was included in the PRIA accompanying the NPRM and is set forth below again. In the NPRM, NHTSA requested comment on the certification. NHTSA received no comments with regard to the certification or its factual basis.

What follows is a discussion of what informed the Agency's decisions on the certification. While NHTSA is not required to issue an RFA by certifying as it did in the final rule, the Agency discusses below the issues that would be addressed by an RFA. By discussing these issues, NHTSA explains its analyses of the potential effects of this final rule on small entities.

Section 603(b) of the Act specifies the content of a RFA. Each RFA must contain:

1. A description of the reasons why action by the Agency is being considered;
2. A succinct statement of the objectives of, and legal basis for a final rule;

3. A description of and, where feasible, an estimate of the number of small entities to which the rule will apply;

4. A description of the projected reporting, recording keeping and other compliance requirements of a rule including an estimate of the classes of small entities which will be subject to the requirement and the type of professional skills necessary for preparation of the report or record;

5. An identification, to the extent practicable, of all relevant Federal rules which may duplicate, overlap or conflict with the rule;

6. Each initial regulatory flexibility analysis shall also contain a description of any significant alternatives to the rule which accomplish the stated objectives of applicable statutes and which minimize any significant economic impact of the rule on small entities.

1. Description of the reason why action by the Agency is being considered

This action is being considered by the Agency to remove regulatory barriers to ADS-DVs (i.e., ADS-equipped vehicles without manual controls) that currently exist in the occupant protection standards in a manner that maintains the safety protections the FMVSSs currently afford occupants of non-ADS vehicles. Removing regulatory barriers to the subject vehicles will reduce costs, and may encourage innovation in motor vehicle design and manufacture while maintaining safety.

2. Objectives of, and legal basis for, the final rule

NHTSA believes that removing regulatory barriers to ADS-DVs in the occupant protection standards could encourage innovation by eliminating design restrictions on these vehicles while maintaining safety. Moreover, removing barriers in the occupant protection standards will reduce the number of standards from which manufacturers of ADS-DVs will have to seek exemptions, which will lessen the administrative burden on both manufacturers and NHTSA.

The legal basis for this final rule is NHTSA's authority to promulgate FMVSS under the Vehicle Safety Act (49 U.S.C. 30111 and 30115, delegation of authority at 49 CFR 1.95).

3. Description and estimate of the number of small entities to which the rule will apply

The rule will apply to small entities that are motor vehicle manufacturers who wish to produce ADS-DVs and with conventional seating arrangements (i.e., forward-facing, front row seats). To determine if there is a significant impact on small vehicle manufacturers, we have attempted to identify if there are any such firms that exist currently and if there might be such firms in the future, within the projected time period of the economic analysis, i.e., 2050.

Business entities are defined as small businesses using the North American Industry Classification System (NAICS) code, for the purpose of receiving Small Business Administration assistance. One of the criteria for determining size, as stated in 13 CFR 121.201, is the number of employees in the firm. For establishments primarily engaged in manufacturing or assembling automobiles, light and heavy duty trucks, buses, motor homes, new tires, or motor vehicle body manufacturing, the firm must have fewer than 1,500 employees to be classified as a small business.

Current Small Manufacturers

Currently, there are at least 14 small light vehicle manufacturers in the United States. Table 1 provides information about the 14 small volume domestic manufacturers in MY 2020. All are small manufacturers, having fewer than 1,500 employees. We do not believe the small manufacturers listed in Table 1 are developing ADS systems for installation on the vehicles they manufacture. Further, we note that, in today's motor vehicle market, small vehicle manufacturers, who are less able than large manufacturers to take advantage of economies of scale to lower production costs, typically produce specialized, expensive vehicles.

Table 7: Small Volume Vehicle Manufacturers (MY 2020)[15]

Manufacturer	Type of Vehicles	Number of Employees (Appx.)	MSRP for Vehicles (Appx.)
Anteros Coachworks	Specialty Sports Cars	2	$110,000
Callaway Cars	Specialty Sports Cars	50	~$17,000 above base (GM) vehicle price
Carroll Shelby International	Specialty Sports Cars	170	$86,085-$180,995+
Equus Automotive	Specialty Sports Cars	25	$250,000+
Falcon Motorsports	Specialty Sports Cars	2	$300,000-$400,000
Faraday Future	Electric	350	$225,000
Fisker Inc.	Electric	<200	$37,499+
Karma Automotive	Electric	750	$135,000
Lucid Motors	Electric	1,100	$60,000+
Panoz	Specialty Sports Cars	<50	$159,900+
Rivian	Electric	1,300	$69,000-$72,500+
Rossion Automotive	Specialty Sports Cars	70	$80,000
Saleen Automotive	Specialty Sports Cars	170	$48,000-$100,000+
SSC North America	Specialty Sports Cars	9	$2,000,000

[15] Provided to illustrate the current population of small vehicle manufacturers. These manufacturers are not developing ADS systems for installation on their vehicles.

Current Small Developers

As there appear to be no current small vehicle manufacturers that will be affected by this rulemaking, the question remains if there are likely to be any in the future that might be affected by this rule. Through publicly available sources, the Agency has determined that 8 small entities are known to be developing ADS systems and integrating them with light vehicle platforms (see table below). The types of vehicles these firms plan to or have produced have at least one of the following three characteristics: (1) the vehicle has an unconventional seating arrangement; (2) the vehicle was not subject to the standards being modified by this rule because it is a low-speed vehicle subject only to FMVSS No. 500; or (3) the vehicle was compliant with the occupant protection standards being modified by this rule prior to being modified into an ADS-DV.

As discussed below, this rule will not impact small entities working with vehicles with the above characteristics, respectively, for the following reasons: (1) this rulemaking is not intended to remove barriers to ADS-DVs that have rear- or side-facing occupants or repositioned seats, as this would require additional research that NHTSA has not yet done; (2) the occupant protection standards that would be impacted by this rule are not barriers to the removal of manual controls from LSVs; and (3) the cost savings associated with this rule would not accrue to fully compliant non-LSV light vehicles, because they would still be equipped with manual steering controls (i.e., the vehicles would not be affected by this final rule). All of the small entities engaged in ADS development listed below meet one or more of these characteristics, and thus, this rule would not affect them.

Currently, there are 8 known small firms engaged in ADS development in the United States (see Table 2). All are small entities, having much fewer than 1,500 employees. It is noted that these small firms, which are less able than large manufacturers to take advantage of economies of scale to lower production costs, produce specialized, expensive vehicles.

Table 8: Small Firms Engaged in ADS Development[16]

Manufacturer	Employees
Apex AI	34
Argo AI	700
Local Motors	200
May Mobility	45
Next Future Transportation	14
Optimus Ride	140
Perrone Robotics	32
Voyage Auto	27

NHTSA cannot predict how many of these companies, if any, would be producing ADS-DVs in 2050, nor can NHTSA predict how the number of manufacturers producing such vehicles will change. However, we believe it is unlikely that small vehicle manufacturers would comprise a significant share of the ADS-DV market affected by the rule, due to the inherent advantages that large motor vehicle manufacturers would have in taking advantage of economies of scale associated with resource-intensive ADS technologies.

4. A description of the projected reporting, recording keeping and other compliance requirements of the rule including an estimate of the classes of small entities which will be subject to the requirement and the type of professional skills necessary for preparation of the report or record.

Reporting & Recording Impacts:

[16] Provided to illustrate the current population of small firms engaged in this area. Note that these entities are not producing vehicles that would be affected by this NPRM.

This rule does not create any new reporting or recording requirements, nor does it affect any existing reporting or recording requirements.

Compliance Impacts:

This rule does not impose any new requirements on vehicle manufacturers, including those that are small businesses. Rather, it would enable manufacturers of ADS-DVs to comply with relevant occupant protection standards by adding a new compliance option that essentially replicates the existing passenger-side requirements in all front outboard seating positions.[17] Manufacturers would still be permitted to certify to the requirements of the affected standards under the compliance options available today.

For small manufacturers of ADS-DVs, this rule would represent a slight reduction in regulatory burden.[18] To the extent a FRFA takes into account a cost savings, the rule would have a slight positive effect on ADS-DV manufacturers that opt to remove manual steering controls from ADS-DVs, as they would no longer have to address standards referencing steering controls. However, we believe that the rule would not have a significant economic impact on small manufacturers of such vehicles.

This is because in the modern motor vehicle market, small vehicle manufacturers, who are less able than large manufacturers to take advantage of economies of scale to lower production costs, typically produce specialized, expensive vehicles. Moreover, NHTSA expects

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[17] We note that all new light vehicles (other than LSVs and trailers) are statutorily required to have air bags in all front outboard passenger seating positions, regardless of the presence of manual steering controls (see section 2508 of the "Intermodal Surface Transportation Efficiency Act of 1991," PL 102-240), and that these air bags are statutorily required to minimize risk to infants, children, and other occupants by means that include advanced air bags (see section 7103 of the "Transportation Equity Act for the 21st Century," PL 105-178).

[18] We assume for purposes of our analysis here that there are no other regulatory barriers to removing manual controls, such as those that exist in the crash avoidance (100-level) FMVSS. Until NHTSA removes such other barriers, manufacturers of ADS-DVs that would be impacted by today's final rule would need to seek an exemption from these other requirements to deploy their vehicles.

that ADS-DVs will generally be far more expensive than traditional vehicles, given their relative level of sophistication and high development cost. Given these two points, we expect that any ADS-DVs that are produced by small manufacturers would be very expensive relative to the average price of a vehicle. In turn, any cost savings accruing to small manufacturers are expected to represent an insignificant share of the sales price of affected ADS-DVs. Thus, while the removal of manual steering controls represents a cost savings affecting all ADS-DV manufacturers, including small ones, NHTSA does not believe the impact would be significant.

Given that the rule would add a new compliance option for the occupant protection standards without affecting existing compliance options, and that the potential benefit of this new compliance option would likely be relatively small relative to the overall cost of manufacturing an ADS-DVs, NHTSA believes this rule would not result in a significant impact on a substantial number of small entities.

5. An identification, to the extent practicable, of all relevant Federal rules which may duplicate, overlap, or conflict with the rule

We know of no Federal rules which duplicate, overlap, or conflict with this final rule.

6. A description of any significant alternatives to the rule which accomplish the stated objectives of applicable statutes and which minimize any significant economic impact of the rule on small entities.

The final rule represents a rulemaking action that would affect small manufacturers only if they opt to remove manual steering controls from covered ADS-DVs. It would create an optional compliance pathway that does not currently exist except through a temporary exemption process (49 CFR part 555). It would relieve a minor regulatory paperwork burden for any manufacturer who opts to take advantage of the new compliance option, by enabling them to petition for exemption under part 555 for fewer standards.

Also, the anticipated economic impact on small manufacturers would not be significant, because the cost of a manual control is not large compared to the cost of the subject vehicle. No meaningful alternative is known that could achieve the stated objective of the Vehicle Safety Act with less of an economic impact.

The rule would permit the removal of manual controls from the former "driver's seat" but requires that the seating position affected by the removal must provide passenger-side occupant protection (air bag technology) to that "new" passenger-side seat. NHTSA does not believe an alternative is available that would permit the new passenger-side seat not to have an advanced air bag. Advanced air bags are required by statute for the front outboard seating positions (see § 2508 of the "Intermodal Surface Transportation Efficiency Act of 1991," PL 102-240 and §7103 of the Transportation Equity Act for 21st Century (PL 102-240 105-178). ADS-DVs could operate with a child in either (or both) front outboard seats, because there is no driver's seating position. Thus, all the occupant protection requirements that are uniquely applicable to the passenger seat in a vehicle with manual steering controls (including advanced air bags) would need to apply to both front outboard seats in an ADS-DV to ensure there is not a negative impact on vehicle safety due to the removal of the steering control.

We note, however, that all manufacturers, including small entities, are currently subject to the advanced air bag requirements for the passenger seating position. Thus, all manufacturers, including small entities, already have the skills and abilities to certify their vehicles to the advanced air bag requirements. Because they are already installing air bags on the driver-side and are installing advanced air bags on the passenger-side in their vehicles, the Agency believes that the rule would not have a significant impact on vehicle manufacturers, including small manufacturers.