

# **Cost and Weight Analysis of Windshields Replacement**

*Final Report*

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## Abstract

An investigation was undertaken to determine the costs for replacing windshields on three top-selling vehicles that are sold in the United States having at least one option for an Advanced Driver Assist System (ADAS) feature that required a camera behind the windshield. It was furthermore desired to determine pricing differences between static calibration of the camera and dynamic calibration. Thirdly, NHTSA wanted to know what difference it made in pricing to have a windshield replaced at a dealership facility versus an independent repair outlet; to simplify the modeling for this study, it was assumed that an independent outlet was operated from a mobile service vehicle.

Three vehicles were selected to be analyzed for these purposes: The Ford F-150, the Honda CR-V, and the Subaru Outback. All three models had both “ADAS” windshields and “non-ADAS” windshields available in both original equipment manufacturer (OEM) branded glass and non-OEM or aftermarket branded glass. Ford specified a dynamic on-road calibration for the F-150 camera after windshield replacement, as did Subaru for the Outback with the dual camera EyeSight® system; Honda specified static in-shop calibration of its CR-V ADAS camera system. Static calibration was assumed to always be done in a building whether the repair was being made by an independent outlet or a dealer.

For the 3 sample vehicles indicated above, the total consumer pricing for windshield replacement at a dealership and at an independent outlet was estimated and the averages presented in Table 1.

**Table 1** Total consumer pricing for windshield replacement with an ADAS and non-ADAS windshields and the incremental cost for ADAS windshield replacements performed at a dealership and at an independent outlet

	ADAS Windshield		non-ADAS Windshield		Incremental ADAS windshield replacement	
	OEM glass	non-OEM glass	OEM glass	non-OEM glass	OEM glass	non-OEM glass
<b>Sample average</b>						
Total dealer price	\$ 1,082.52	\$ 1,241.73	\$ 1,020.84	\$ 1,171.91	\$ 61.68	\$ 69.81
Total independent price	\$ 1,075.02	\$ 1,234.22	\$ 1,009.92	\$ 1,160.99	\$ 65.10	\$ 73.23
Dealer - Independent	\$ 7.51	\$ 7.51	\$ 10.92	\$ 10.92	\$ (3.42)	\$ (3.42)

The average total price, which included overhead and profit on direct costs, for replacing an ADAS windshield was \$1,082.52, which was \$61.68 more than for a non-ADAS windshield at a total dealer price of \$1,020.84 when using OEM glass. With aftermarket glass the dealership price was \$1,241.73, or \$69.81 more than an aftermarket non-ADAS windshield replacement price of \$1,171.91. The total average independent shop consumer pricing was \$7.51 less than dealer pricing for an ADAS windshield and \$10.92 less for a non-ADAS windshield, irrespective of whether OEM or non-OEM glass is used.

As shown in Table 2 below, Honda was the highest priced OEM for ADAS windshield replacement, and it showed an incremental price difference over 3 times more than the sample-average price increment for ADAS as can be seen by comparing with Table 1; Honda’s estimated consumer pricing was \$1,424.97 for an ADAS windshield replacement with OEM glass at a dealership. It was estimated that static calibration of Honda’s camera added \$6.46 in variable costs and \$0.14 in fixed costs to its total dealer pricing due to

the additional floor space and time requirements; however labor costs were lower than for dynamic calibrations due to a lower time requirement (0.2 hours and \$4.32 for Honda versus 0.3 hours and \$6.47 for Subaru and 0.6 hours and \$12.95 for Ford). Total static camera calibration costs for Honda were estimated at \$4.87 at a dealership compared with dynamic calibration costs of \$13.09 for Ford and \$6.54 for Subaru, showing that the amount of time specified by the OEM is more critical to pricing than the process used for calibration.

Ford was estimated to be the least expensive with ADAS windshield replacement pricing of \$884.93 at a dealership with OEM glass and its incremental pricing trends for incremental ADAS pricing were most nearly in-line with industry sample averages. Subaru windshield replacements were priced slightly higher than Ford’s with an estimated total consumer price of \$937.66 for ADAS with OEM glass at a dealer. However, it was the only one of the three OEM’s to price it’s non-ADAS windshields with aftermarket glass higher than its aftermarket ADAS windshields; this could be due to Subaru’s strategy of using a single common windshield with OEM glass for both ADAS and non-ADAS applications, which may drive volume away from aftermarket replacement glass.

**Table 2** Summary of windshield replacement costs for Ford F-150, Honda CR-V, and Subaru Outback

	ADAS Windshield		non-ADAS Windshield		Incremental ADAS windshield replacement	
	OEM glass	non-OEM glass	OEM glass	non-OEM glass	OEM glass	non-OEM glass
<b>Ford F-150</b>						
Total dealer price	\$ 884.93	\$ 1,242.86	\$ 812.60	\$ 1,174.61	\$ 72.33	\$ 68.25
Total independent price	\$ 880.90	\$ 1,238.82	\$ 803.00	\$ 1,165.00	\$ 77.91	\$ 73.82
<b>Honda CR-V</b>						
Total dealer price	\$ 1,424.97	\$ 1,467.49	\$ 1,328.54	\$ 1,249.86	\$ 96.43	\$ 217.63
Total independent price	\$ 1,415.44	\$ 1,457.96	\$ 1,317.12	\$ 1,238.44	\$ 98.33	\$ 219.52
<b>Subaru Outback</b>						
Total dealer price	\$ 937.66	\$ 1,014.84	\$ 921.39	\$ 1,091.27	\$ 16.27	\$ (76.43)
Total independent price	\$ 928.71	\$ 1,005.89	\$ 909.65	\$ 1,079.53	\$ 19.06	\$ (73.65)

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## Summary of Findings

The use of cameras on vehicles to identify objects surrounding the vehicle and provide driver assistance is driving up the cost of replacing a windshield that has been cracked or chipped. The primary driver behind the cost increase of replacing an Advanced Driver Assist System (ADAS) windshield is the additional step of camera re-calibration; calibration can be performed dynamically on the road or statically in a repair shop. All of the windshield replacement cost of materials and the total consumer pricing (which includes sales, general and administrative (SG&A) and profit margin for a dealer in addition to material, labor, variable and fixed direct costs) for ADAS and non-ADAS windshields replaced at either a dealership facility or an independent mobile repair unit are summarized and presented along with the sample averages in Table 3.

**Table 3** ADAS and non-ADAS windshield replacement costs are shown for the materials and total consumer pricing when replaced at a dealership or by an independent outlet

	ADAS Windshield		non-ADAS Windshield		Incremental ADAS windshield replacement	
	OEM glass	non-OEM glass	OEM glass	non-OEM glass	OEM glass	non-OEM glass
<b>Ford F-150</b>						
Materials	\$ 556.33	\$ 842.66	\$ 524.50	\$ 814.10	\$ 31.83	\$ 28.56
Total dealer price	\$ 884.93	\$ 1,242.86	\$ 812.60	\$ 1,174.61	\$ 72.33	\$ 68.25
Total independent price	\$ 880.90	\$ 1,238.82	\$ 803.00	\$ 1,165.00	\$ 77.91	\$ 73.82
<b>Honda CR-V</b>						
Materials	\$ 971.25	\$ 1,005.26	\$ 903.29	\$ 840.35	\$ 67.96	\$ 164.92
Total dealer price	\$ 1,424.97	\$ 1,467.49	\$ 1,328.54	\$ 1,249.86	\$ 96.43	\$ 217.63
Total independent price	\$ 1,415.44	\$ 1,457.96	\$ 1,317.12	\$ 1,238.44	\$ 98.33	\$ 219.52
<b>Subaru Outback</b>						
Materials	\$ 583.62	\$ 645.36	\$ 583.62	\$ 719.53	\$ -	\$ (74.17)
Total dealer price	\$ 937.66	\$ 1,014.84	\$ 921.39	\$ 1,091.27	\$ 16.27	\$ (76.43)
Total independent price	\$ 928.71	\$ 1,005.89	\$ 909.65	\$ 1,079.53	\$ 19.06	\$ (73.65)
<b>Sample average</b>						
Materials	\$ 703.73	\$ 831.09	\$ 670.47	\$ 791.32	\$ 33.26	\$ 39.77
Total dealer price	\$ 1,082.52	\$ 1,241.73	\$ 1,020.84	\$ 1,171.91	\$ 61.68	\$ 69.81
Total independent price	\$ 1,075.02	\$ 1,234.22	\$ 1,009.92	\$ 1,160.99	\$ 65.10	\$ 73.23
Dealer - Independent	\$ 7.51	\$ 7.51	\$ 10.92	\$ 10.92	\$ (3.42)	\$ (3.42)

Three vehicles were selected to determine the costs involved with windshield replacement: the Ford F-150 which required dynamic camera calibration on its models with lane keeping assistance (LKA), the Honda CR-V which required static calibration to be done for its ADAS-equipped models, and the Subaru Outback models with the EyeSight® dual camera system which required a dynamic calibration. In speaking with industry experts, a common theme was that camera calibration costs were common for any vehicle brand, independent of whether it was for static or dynamic calibration. Furthermore, one independent repair outlet indicated that a flat fee of \$200 was charged for any vehicle model requiring ADAS calibration. However, the camera calibration cost of \$250 or less suggested by the experts was not

reflected in the consumer pricing differences between ADAS and non-ADAS windshield replacements, as discussed below.

The industry sample-average incremental pricing for ADAS windshield replacement, over a non-ADAS windshield, on the three vehicles studied was \$61.68 at a dealership service facility and \$65.10 with an independent outlet. The industry average price increment for ADAS windshield replacement over non-ADAS is the same, irrespective of whether OEM-brand replacement glass is used or aftermarket glass, with aftermarket replacement costs being \$8.13 more than with OEM glass. Material costs accounted for just over one half of the total replacement costs.

Total static camera calibration costs for Honda were estimated at \$4.87 at a dealership compared with dynamic calibration costs of \$13.09 for Ford and \$6.54 for Subaru, showing that the amount of time specified by the OEM is more critical to pricing than the process used for calibration. Independent outlet pricing for Honda's static calibration was estimated at \$6.38; dynamic calibrations for Ford and Subaru at independent shops was estimated at \$17.55 and \$8.77, respectively.

There were differences between the pricing trends of the three OEM's as well as some similarities. Ford was the lowest price manufacturer at \$884.93 and \$812.60 for dealer pricing using OEM glass which was 18% and 20% below industry average for both ADAS and non-ADAS windshields, respectively, on the F-150 and had incremental ADAS costs that were roughly aligned with industry average trends. Subaru was similarly priced to Ford for an ADAS windshield replacement when OEM glass was used with total replacement pricing of \$937.66 at a dealer, but was, in fact, the only OEM studied who offered lower ADAS incremental pricing with aftermarket glass whether replaced at a dealer or an independent shop; it's costs were 13% and 10% lower than industry average for ADAS and non-ADAS windshields, respectively, at a dealer outlet on the Outback. Furthermore, Subaru made the most of minimizing windshield part number complexity by using a single glass part number for both ADAS and non-ADAS windshields with OEM glass and two part numbers in aftermarket glass for ADAS and for non-ADAS windshields. Honda was the highest priced OEM for windshield replacement of its CR-V at \$1,424.97 for dealer pricing being 32% above industry average with OEM glass; with aftermarket glass it's pricing was \$1,467.49, or 30% above industry average, but it's incremental pricing of ADAS aftermarket glass was \$217.63 at a dealer, 3 times the industry average incremental ADAS pricing.

A model was constructed to account for the material, labor, variable, and fixed costs of replacing windshields and to estimate consumer pricing by addition of overhead for SG&A and profit margin. Material costs were identical for a dealership or an independent. Labor rates were taken from the US Bureau of Labor Statistics for automotive body and related repairers working at a dealership facility or automotive glass installers and repairers for an independent outlet to replace the windshield glass; ADAS camera calibration was done by the category of automotive service technicians and mechanics. Variable costs included the cost of ownership of a mobile service van for independent glass repair outlets, calibration equipment was assumed as a mobile electronic service tool for the dynamic camera calibrations and a static target aiming stand for camera calibrations that were done statically, and the energy costs for the building space in the case of a dealership or the service vehicle for an independent outlet. Fixed costs were for the building space of single bay in a dealership facility and for an enlarged area for static camera calibration in Honda's case at both a dealership and an independent outlet.

Because the labor rate was higher at a dealership than an independent outlet for windshield removal and installation (\$22.79 vs \$18.00) and the time required for it was over 80% of the total job, the total

consumer pricing was lower with an independent outlet than a dealership by a few dollars (or less than 1%) in all cases studied. Variable costs added roughly \$7.50 per hour to an independent's cost over a dealership, but the lower labor rate for removal and installation and the higher percentage of time for removal and installation and lower fixed costs netted out with lower independent shop costs over dealership. The total average independent shop consumer pricing was \$7.51 less overall than dealer pricing for an ADAS windshield, despite the higher variable costs associated with operating a mobile service vehicle. For non-ADAS windshields, the average independent shop was overall price was \$10.92 less than a dealership, again due to lower labor cost.

## Purpose

The primary objective of this investigation is to determine the cost and weight of replacing or repairing windshields in vehicles with and without windshield-mounted Advanced Driver Assistance Systems (ADAS) camera sensor(s). ADAS cameras are mounted to windshields to enable functionality such as pedestrian automatic emergency braking (PAEB) and lane keeping assistance (LKA). Since the cost of windshield replacement is influenced by the vehicle manufacturer's (or original equipment manufacturer (OEM)) warranty policies, OEM repair and warranty policies are also investigated, in particular with reference to guidance that prevents or restricts repairing a vehicle with windshield-mounted ADAS sensors where a standard non-OEM windshield could be used to replace the damaged windshield. The cost and time for performing alignment or calibration of ADAS cameras should also be included in the cost analysis of windshield replacements from both OEM and from non-OEM repair outlets.

## Engineering Analysis

To accomplish the objectives stated above, the following non-linear process was adopted:

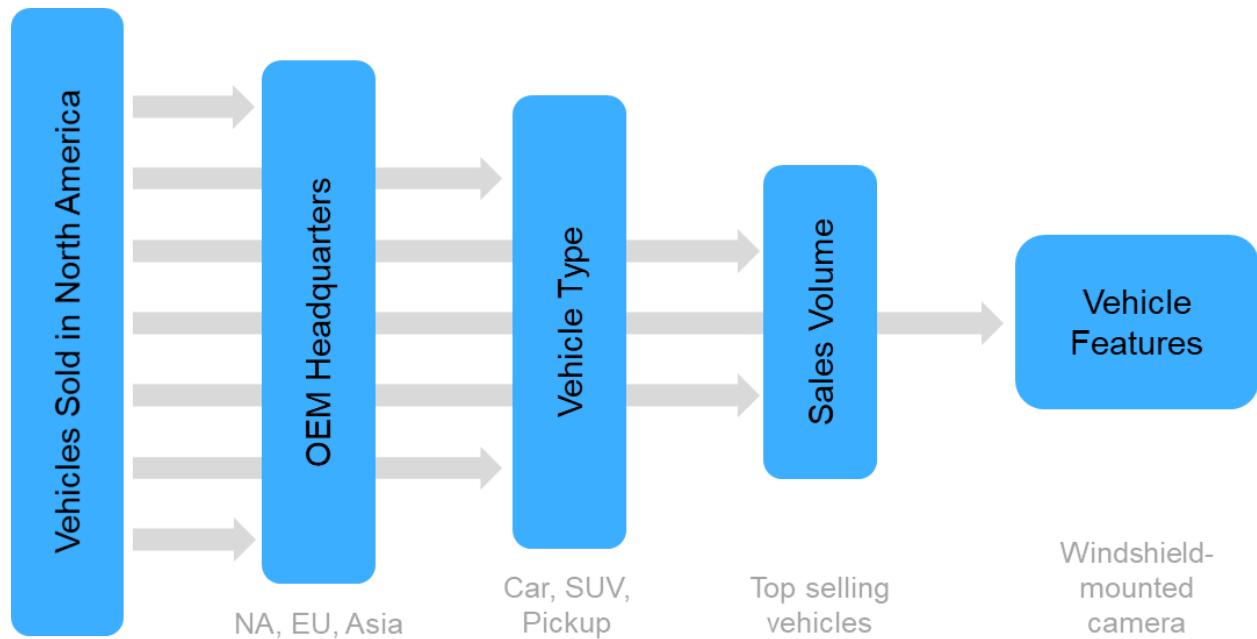
- Select vehicles for analysis that were representative of the current mainstream vehicle population and that had windshields with ADAS camera sensors and without
- Review repair guides for windshield replacements
- Review OEM warranty guides
- Interview industry experts to better understand ADAS sensor and windshield engineering specifications and manufacturing processes as well as replacement practices
- Develop a costing methodology for determining the total cost of replacing windshields
- Apply the windshield replacement cost model to the selected vehicles
- Critically analyze the repair and warranty guidance, costing results, and write a final report.

## Vehicle Selection

Ricardo and NHTSA developed a few guiding principles for the selection of vehicles to be analyzed. Specifically, vehicles should be chosen that were:

- Sold in North America and being used on American roads
- Manufactured by OEMs with headquarters in North America, Europe, and Asia
- Top selling based on average sales volumes, and with
- Recent (2018 – 2021) model year (MY) availability
- Having an ADAS package which included a camera mounted on the windshield.

The rationale for selecting top selling models was to base the study on vehicles that were most representative of those sold in North America and avoid the influences of atypical cost cutting measures that may be present on entry level models, or premium touches that might have a purely aesthetic or other function that is not central to the purposes of this study. Recent model year availability meant the vehicles included the latest technology widely available. Diversity of OEM headquarters was desired to obtain samples from manufacturers with differing engineering and assembly practices and using different supply bases. Most importantly, the vehicles were to have an ADAS package that required a camera mounted on the windshield. The vehicle selection process is shown in Figure 1.



**Figure 1** Process for making vehicle selections

The initial list of light-duty passenger vehicles sold in the US was narrowed down to a list of 23 top selling models with LKA as shown in Table 4; windshield mounted cameras were present on all the vehicles with LKA. This list was further narrowed down to a selection of 4 vehicle models highlighted with bold font in Table 4 that included a pickup truck, sport utility vehicle (SUV), and car from NA, EU, and Asian OEMs and used a variety of different ADAS systems.



**Table 4** Preliminary list of vehicles with an ADAS camera mounted to the windshield

Brand	Model	Sales Volume	Vehicle Type	OEM HQ	ADAS system	Cameras	LKA
<b>Ford</b>	<b>F-150</b>	<b>549,998</b>	<b>PUP</b>	<b>US</b>	<b>Co-Pilot360</b>	<b>1</b>	<b>O</b>
Ram	1500	503,773	PUP	US	-	1	O
Chevrolet	Silverado 1500	478,211	PUP	US	Surrond Vision	1	O
<b>Honda</b>	<b>CR-V</b>	<b>465,293</b>	<b>SUV</b>	<b>Asia</b>	<b>Sensing</b>	<b>1</b>	<b>S</b>
Chevrolet	Equinox	354,722	SUV	US	Surrond Vision	1	S
Toyota	Camry	350,013	Car	Asia	Safety Sense	1	S
Toyota	RAV4	336,922	SUV	Asia	Safety Sense	1	S
Honda	Civic	316,020	Car	Asia	Sensing	1	S
Jeep	Grand Cherokee	308,434	SUV	US	LaneSense	1	O
Toyota	Highlander	286,562	SUV	Asia	Safety Sense	1	S
Honda	Accord	285,492	Car	Asia	Sensing	1	S
Ford	Explorer	283,828	SUV	US	Co-Pilot360	1	S
Ford	Escape	282,060	SUV	US	Co-Pilot360	1	S
Tesla	Model 3	230,107	Car	US	Autopilot	1	S
Nissan	Altima	217,839	Car	Asia	Mobileye	1	O
Ram	2500	214,195	PUP	US	-	1	O
GMC	Sierra 1500	211,665	PUP	US	Surrond Vision	1	O
Toyota	Corolla	211,475	Car	Asia	Safety Sense	1	S
Jeep	Cherokee	204,417	SUV	US	LaneSense	1	O
<b>Volkswagen</b>	<b>Tiguan</b>	<b>201,279</b>	<b>SUV</b>	<b>EU</b>	<b>Driver Assistance</b>	<b>1</b>	<b>O</b>
<b>Subaru</b>	<b>Outback</b>	<b>193,406</b>	<b>Car</b>	<b>Asia</b>	<b>EyeSight</b>	<b>2</b>	<b>S</b>
Volkswagen	Jetta	155,978	Car	EU	Driver Assistance	1	O
Chevrolet	Malibu	134,771	Car	US	Surrond Vision	1	O

*Notes*

*Vehicle Type: Car, Sport Utility Vehicle (SUV), Pickup truck (PUP)*

*Lane Keeping Assistance (LKA): Standard (S), Optional (O)*

After investigating the availability of replacement windshields, three models were finally chosen for because they offered availability of both OEM and aftermarket windshields. The three vehicle models selected for further analysis are shown in Figure 2 along with specifications regarding the windshields.

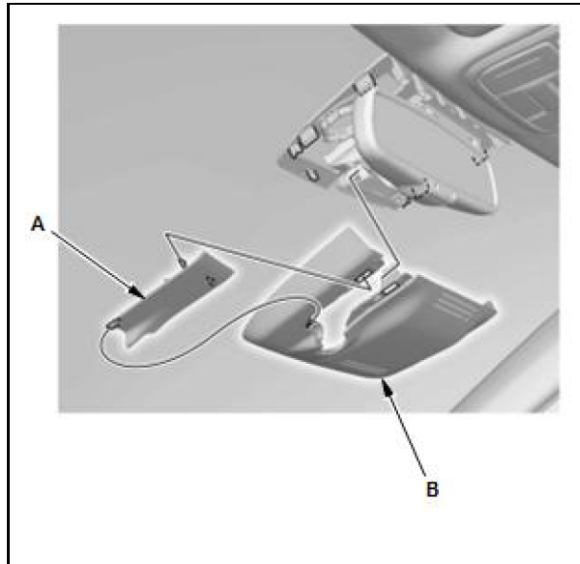


	Ford F-150	Honda CR-V	Subaru Outback
ADAS camera	Single	Single	Dual
ADAS function	LKA	LKA	LKA
ADAS windshields	5 – OEM / 5 – AM	2 – OEM / 4 – AM	1 – OEM / 2 – AM
Non-ADAS windshields	3 – OEM / 5 – AM	2 – OEM / 4 – AM	1 – OEM / 2 – AM
Notes:	LKA = Lane Keeping Assistance	OEM = Original Equipment Manufacturer	AM = Aftermarket

**Figure 2** The Ford F150, Honda CR-V, and Subaru Outback were selected for final analysis

### Windshield Repair Guides

Ricardo purchased and used Mitchell Cloud™ Glass because they contained glass replacement options and costs for both OEM and aftermarket glass along with the standard repair times and procedures for each vehicle. The information in Mitchell’s repair guides is derived from the respective vehicle OEM; an example from the Honda CR-V camera removal and installation guide is shown below.



1. Remove the sensor cover lid (A)
2. Remove the sensor cover (B).

Courtesy of HONDA, U.S.A., INC.

**Figure 3** 2019 Honda CR-V LaneWatch camera removal and installation procedures from Mitchell ProDemand®

## OEM Warranty Guides

Warranty guides were reviewed for Ford 2019 MY vehicles, the 2020MY Honda CR-V, and 2020 MY Subaru Outback with a view on warranty coverage for windshields. See the OEM Warranty Guides section under Results for details of the review.

## Industry Expert Interviews

Experts within the area of windshields and ADAS equipment were interviewed to gain deeper insight into the windshield replacement process. An ADAS systems expert indicated that the increasing number of sensors used for autonomous and assisted driving is what drives up the cost of replacing windshields, and that ADAS sensors are getting more sophisticated and therefore more expensive, for example LiDAR systems. Furthermore, it is desirable to mount ADAS sensors behind the windshield where they can be kept clean from rain, snow, and dirt by the windshield wipers and anti-reflective coatings on the inside of a windshield helps to improve the sensors field of view.

A multi-brand dealership service facility said they use an independent glass repair outlet for the windshield replacement and then do the calibration in-house for static calibrations (e.g. Honda vehicles) as needed; dynamic calibrations are done on the road by the same independent technician as for replacement and installation. The same independent glass repair outlet said they will follow OEM guidance for glass replacement branding and specifically that Subaru does not specify the need for OEM replacement glass on the Outback. In addition, they charge \$200 for a camera calibration independent of vehicle brand.

An automotive components supplier to vehicle OEMs indicated that ADAS sensors can require a heater grid to defrost the windshield in front of the camera as well as a different frit pattern which drives up windshield part number complexity on a given model. This supplier also said that aftermarket brand glass may not meet FMVSS optical clarity specifications, suggesting that OEM branded glass may be required by some OEMs in order not to invalidate warranty coverage. As vehicles continue to evolve and get smarter, they foresee a day when camera calibration and re-calibration will become automated.

## Cost & Weight Analysis

The cost and weight analysis for windshield replacement is described in terms of:

- replacing an ADAS windshield and a non-ADAS windshield
- with OEM glass and non-OEM glass
- at an OEM repair facility and a non-OEM repair facility.

An ADAS windshield is one that had a lane departure camera mounted to or directly behind and contained 'LDWS' in the Mitchell repair guide description. Non-OEM glass is also referred to as 'aftermarket' glass; an OEM repair facility is also referred to as a 'dealer' facility and a non-OEM facility as an 'independent' repair outlet. The incremental costs of ADAS windshield replacement are also described for the material costs and the total dealer and independent facility consumer prices.

Regarding the weight of replacing a damaged windshield, it goes without stating that the incremental weight for replacing a like-for-like windshield is zero. However, it does merit stating that it has been assumed that the damage to the windshield is "minor" damage such as from a rock hitting the windshield, and not a rollover accident that would require "major" repair to the vehicle. Because of the

like-for-like comparison being done on the two windshield types, and to save the expense for this investigation, no hardware was purchased to determine the absolute weights of the windshields.

The cost analysis for windshield replacement was built on the following elements:

- Materials
- Labor
- Variable overhead, and
- Fixed overhead.

Material costs are for the direct materials used in replacing a windshield (i.e., windshield and the adhesive to seal it in) and any indirect consumables such as excess adhesive. Mitchell Cloud™Glass lists multiple windshield options with prices depending on whether the windshield itself is OEM or aftermarket branded and the specifications of the particular vehicle and was used for materials pricing. Material costs were assumed the same for OEM and non-OEM repair outlets.

The labor cost is composed of direct labor time multiplied by the direct labor rate. Labor time is determined from standard repair guides and is the same for OEM and independent repair outlets. Labor rate for an OEM facility was assumed as the national average wage in 2019 for automotive body and related repairers from the US Bureau of Labor Statistics and the rate for a non-OEM facility and were assumed as the national average wage in 2019 for automotive glass installers and repairers. For ADAS calibration, a common rate for both OEM and independent outlets was assumed as the 2019 national average for automotive service technicians and mechanics. The labor rates for these categories are shown in Table 5.

**Table 5** Labor rates for dealer body repairers, independent glass installers, and calibration service technicians<sup>1</sup>

U.S Bureau of Labor Statistics	
<b>49-3021 Automotive Body and Related Repairers</b>	
Employment	Mean hourly wage
144,180	\$22.79
<b>49-3022 Automotive Glass Installers and Repairers</b>	
Employment	Mean hourly wage
19,410	\$18.00
<b>49-3023 Automotive Service Technicians and Mechanics</b>	
Employment	Mean hourly wage
655,330	\$21.58

Variable burden is comprised of overhead costs that are accrued by the hour or by the job and are related to replacing the windshield, such as special equipment, energy costs and a service vehicle for non-OEM outlets. Table 6 shows the variable requirements and the prorated hourly costs for a dealership facility and an independent outlet running a mobile service van model.

<sup>1</sup> <https://www.bls.gov/oes/current/oes493021.htm> , <https://www.bls.gov/oes/current/oes493022.htm> , and <https://www.bls.gov/oes/current/oes493023.htm> , accessed around December 18, 2020

**Table 6** Variable cost elements for equipment, service vehicle and energy requirements

	Ford		Honda		Subaru	
	OEM facility	non-OEM outlet	OEM facility	non-OEM outlet	OEM facility	non-OEM outlet
<b>Time requirements</b>						
Windshield R&I	2.7	2.7	3.3	3.3	3.3	3.3
Camera system calibration	0.6	0.6	0.2	0.2	0.3	0.3
Static			0.2	0.2		
Dynamic	0.6	0.6			0.3	0.3
Total time (hrs)	3.3	3.3	3.5	3.5	3.6	3.6
<b>Equipment requirements</b>						
Windshield R&I		Service vehicle		Service vehicle		Service vehicle
Camera system calibration						
Static			* Standard service tool * Target panels & stand	* Standard service tool * Target panels & stand		
Dynamic	Mobile service tool	Mobile service tool			Mobile service tool	Mobile service tool
<b>Service vehicle</b>						
Vehicle price, new		\$40,000		\$40,000		\$40,000
Vehicle value, EOL		\$10,000		\$10,000		\$10,000
Total service vehicle cost		\$30,000		\$30,000		\$30,000
Operational hours per year		2,000		2,000		2,000
Amoritzation period (yr)		3		3		3
Prorated service vehicle (\$/h)		\$5.00		\$5.00		\$5.00
<b>Calibration Equipment</b>						
Total equipment cost	\$1,000	\$1,000	\$20,000	\$20,000	\$1,000	\$1,000
Operational hours per year	2,000	2,000	2,000	2,000	2,000	2,000
Amoritzation period (yr)	3	3	5	5	3	3
Prorated equipment (\$/h)	\$0.17	\$0.17	\$2.00	\$2.00	\$0.17	\$0.17
<b>Energy</b>						
Windshield R&I (\$/h)	\$0.0696		\$0.0696		\$0.0696	
Camera system calibration (\$/h)			\$0.0768	\$0.0768		
Prorated energy costs (\$/h)	\$0.0696	\$2.50	\$0.0701	\$2.58	\$0.0696	\$2.50
<b>Total Variable Costs</b>						
Total variable overhead (\$/h)	\$0.24	\$7.67	\$2.07	\$9.58	\$0.24	\$7.67

Equipment requirements for ADAS windshield replacement are a mobile diagnostic service tool for calibrating the camera dynamically or an in-shop diagnostic service tool and target panels for static camera calibrations. The mobile service tool and service vehicle were amortized over 3 years and the in-shop static aiming target was amortized over 5 yrs to arrive at hourly equipment and vehicle charges. For a dealership the energy costs were for building heating, cooling, and electricity and were multiplied by the floor space needed for windshield replacement; for the purposes of this study building energy costs were estimated as 10% of the hourly fixed floor space cost. While it is acknowledged that independent glass replacement outlets may have fixed base costs in which sales and support staff work out of and inventory is stored, it was assumed that an independent outlet was operating out of a service van to simplify the model; however, in Honda’s case requiring static calibration it would take the vehicle to a facility equipped for that purpose. The independent shop model with a service vehicle has accounted for vehicle ownership and fuel costs under variable costs; vehicles were assumed amortized over a 3 year period. The energy costs for an independent, in addition to the building energy costs in Honda’s case, were estimated from the service vehicle fuel consumption and prorated by the time to complete a job over 2000 hours per year assuming total mileage accumulation of 25,000 miles per year.

Fixed overhead, shown in Table 7 as building space rates per square foot, includes floor space for replacing a windshield and floorspace for calibrating the camera statically, if required. The fixed burden for a dealership was determined by taking a commercial building cost of \$25 per square foot and multiplying by the required space and the time required, and dividing by total hours assuming 2,000 operational hours per year are available and the facility is amortized over 7 years. A Honda dealer

required floor space for both the windshield replacement and static calibration; an independent was assumed to take the vehicle to a shop for the static calibration.

**Table 7** Facility requirements and building costs

	Ford		Honda		Subaru	
	OEM facility	non-OEM outlet	OEM facility	non-OEM outlet	OEM facility	non-OEM outlet
<b>Facility requirements</b>						
Windshield R&I	Single bay		Single bay		Single bay	
Camera system calibration						
Static	n/a		13' x 33'	13' x 33'	not required; optional	
Dynamic	none		n/a	n/a	none	
<b>Fixed cost calculations</b>						
<b>Building</b>						
Area required for windshield replacement (ft <sup>2</sup> )	390		390		390	
Area for calibration (ft <sup>2</sup> )			430	430		
Building space (\$/ft <sup>2</sup> )	\$25		\$25	\$25	\$25	

The total dealer cost and the total independent cost were then the sum of their respective material, labor, variable, and fixed costs. The dealer or independent would add to its direct costs for sales, general and administration (SG&A) overhead at 100% of the direct labor rate. In addition to SG&A, the dealer or independent shop also marks up the final price tag to include a profit margin of 25% on direct costs and SG&A. The SG&A rate and the profit margin were arrived at through discussions with a dealership service manager and assumed the same for an independent outlet.

## Results

### OEM Warranty Guides

#### Ford

With reference to windshields, Ford's warranty guide states, under the section entitled "WHAT IS NOT COVERED UNDER THE NEW VEHICLE LIMITED WARRANTY?" that "Damage Caused by Use and/or the Environment" is not covered, including:

- "Stone chips, scratches (some examples are on paint and glass)
- Windshield stress cracks. However, limited coverage on windshield stress cracks will be provided for the first 12 months or 12,000 miles (whichever occurs first), even though caused by use and/or exposure to the elements".<sup>2</sup>

In addition, under the section entitled "Other Items or Conditions Not Covered" is listed "Aftermarket parts or components, sometimes installed by Ford Motor Company or an authorized Ford dealership,

<sup>2</sup> 2019 Model Year Ford Warranty Guide (Except F-650/750, Hybrid and Electric Vehicles), p. 13

may not be covered by the New Vehicle Limited Warranty.”<sup>3</sup> This stipulation would disincentivize an owner from replacing a windshield with an aftermarket brand windshield while under the 12 month/12,000 mile limited warranty coverage period.

## Honda

Honda specifically referred to “window glass” only (i.e. nothing was found in a “windshield” search) in its warranty guide for the CR-V under the section of, “This New Vehicle Limited Warranty Does Not Cover:” as noted below:

- Broken, chipped, or scratched window glass unless it is due to a defect in material or workmanship.<sup>4</sup>

## Subaru

The online Subaru Warranties for 2020 model year Subaru vehicles, under the section “What is not Covered” and subsection “Damage or Malfunction Due to Abuse, Neglect, Accident or Fire” states that “These warranties do not cover any part which malfunctions, fails or is damaged due to objects striking the vehicle, road hazards, whether on or off the road, accident, fire, neglect, abuse or any other cause beyond the control of SOA.”<sup>5</sup> (SOA refers to Subaru of America, Inc.) However, the guide does not specifically classify windshield chips or stress cracks caused by a stone hitting the vehicle as abuse or neglect. A Subaru dealer service advisor said stress cracks from a stone hitting the windshield are not covered under SOA’s limited warranties.<sup>6</sup>

Regarding replacing the windshields with OEM or non-OEM glass, the warranty guides do not specifically state that OEM glass must be used so the decision is made by repair shop.

## Costing Results

### Material Costs

Material costs for the three OEMs, shown below in Table 8, include adhesive, which was identical for all OEMs, and the glass for replacing ADAS and non-ADAS windshields with both OEM glass and aftermarket glass.

For the Ford F150 an ADAS windshield costs incrementally on average \$31.83 for OEM glass and \$28.56 more for aftermarket glass. For ADAS windshields, there were four viable options included in the Ford OEM glass average cost and five aftermarket glass options. The Ford windshields included one option for OEM glass with a ‘combination bracket’ that was much higher priced (30%) than the other ADAS options and was therefore excluded from the analysis; this made the incremental ADAS costs much more similar for OEM glass and aftermarket glass. There were three OEM glass options and five aftermarket options for non-ADAS windshields on the F-150.

The Honda CR-V windshield on average costs incrementally \$67.96 more for OEM glass of an ADAS-equipped vehicle and \$164.92 more with aftermarket glass; the reason why Honda ADAS aftermarket

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<sup>3</sup> 2019 Model Year Ford Warranty Guide (Except F-650/750, Hybrid and Electric Vehicles), p. 15

<sup>4</sup> 2020\_Honda\_Warranty\_Basebook\_Rev02\_FINAL\_-\_SIS.pdf, p.9

<sup>5</sup> <https://www.subaru.com/owners/vehicle-warranty/warranties-2020.html>, accessed June 09, 2021

<sup>6</sup> Glassman Subaru, 28000 Telegraph Rd, Southfield, MI 48034, phone communication on June 11, 2021

glass was much more expensive than OEM glass is unknown. Honda had two equivalently priced OEM glass options and four aftermarket glass options in both ADAS and non-ADAS variations.

Subaru had only one OEM glass option for both ADAS and non-ADAS Outback vehicles and the aftermarket glass was cheaper by \$74.17 for the ADAS-equipped vehicle. There were two options for both ADAS and non-ADAS aftermarket glass on the Outback; the reason why Outback aftermarket glass was incrementally cheaper for ADAS is unknown.

**Table 8** Material costs for OEM glass and aftermarket glass for both ADAS and non-ADAS windshields

	Ford			Honda			Subaru		
	Low	Average	High*	Low	Average	High	Low	Average	High
Adhesive	\$152.00	\$152.00	\$152.00	\$152.00	\$152.00	\$152.00	\$152.00	\$152.00	\$152.00
<b>ADAS Windshield</b>									
OEM glass	\$362.58	\$404.33	\$462.62	\$819.25	\$819.25	\$819.25	\$431.62	\$431.62	\$431.62
Aftermarket glass	\$460.70	\$690.66	\$873.71	\$836.60	\$853.26	\$866.63	\$431.62	\$493.36	\$555.10
<b>non-ADAS Windshield</b>									
OEM glass	\$360.15	\$372.50	\$378.67	\$683.33	\$751.29	\$819.25	\$431.62	\$431.62	\$431.62
Aftermarket glass	\$442.15	\$662.10	\$837.95	\$577.38	\$688.35	\$840.60	\$412.50	\$567.53	\$722.55
<b>Incremental ADAS</b>									
OEM glass	\$2.43	\$31.83	\$83.95	\$135.92	\$67.96	\$0.00	\$0.00	\$0.00	\$0.00
Aftermarket glass	\$18.55	\$28.56	\$35.76	\$259.22	\$164.92	\$26.03	\$19.12	-\$74.17	-\$167.45

### Labor Costs

Labor costs for replacing the windshields from ADAS and non-ADAS vehicles at dealerships and independent facilities are compared for the three vehicle OEMs in Table 9.

**Table 9** Labor costs for Ford, Honda, and Subaru ADAS and non-ADAS windshield replacement at OEM facility and independent

	Ford		Honda		Subaru	
	OEM facility	non-OEM outlet	OEM facility	non-OEM outlet	OEM facility	non-OEM outlet
<b>Time requirements</b>						
Windshield R&I	2.7	2.7	3.3	3.3	3.3	3.3
Camera system calibration	0.6	0.6	0.2	0.2	0.3	0.3
Static			0.2	0.2		
Dynamic	0.6	0.6			0.3	0.3
Total time (hrs)	3.3	3.3	3.5	3.5	3.6	3.6
<b>Labor Cost</b>						
Body shop/ Glass repairer (\$/h)	\$22.79	\$18.00	\$22.79	\$18.00	\$22.79	\$18.00
Auto service technician (\$/h)	\$21.58	\$21.58	\$21.58	\$21.58	\$21.58	\$21.58
<b>ADAS Windshield</b>	<b>\$ 74.48</b>	<b>\$ 61.55</b>	<b>\$ 79.52</b>	<b>\$ 63.72</b>	<b>\$ 81.68</b>	<b>\$ 65.87</b>
Windshield R&I	\$ 61.53	\$ 48.60	\$ 75.21	\$ 59.40	\$ 75.21	\$ 59.40
Camera calibration						
Static			\$ 4.32	\$ 4.32		
Dynamic	\$ 12.95	\$ 12.95			\$ 6.47	\$ 6.47
<b>non-ADAS Windshield</b>						
Windshield R&I	\$ 61.53	\$ 48.60	\$ 75.21	\$ 59.40	\$ 75.21	\$ 59.40



## Variable Costs

Variable costs are summarized in Table 10 for the three vehicle OEMs and for OEM facilities and independent repair facilities. As was noted above in the cost analysis section, Honda requires static camera calibration which adds significantly to the variable cost rate and therefore the ADAS windshield replacement cost in comparison to Ford and Subaru which specify dynamic calibration procedures. The non-OEM or independent shops also had higher variable costs than the OEM repair facilities due to the assumption of a mobile service vehicle model.

**Table 10** Variable costs for Ford F-150, Honda CR-V, and Subaru Outback windshield replacements at OEM and non-OEM facilities

	Ford		Honda		Subaru	
	OEM facility	non-OEM outlet	OEM facility	non-OEM outlet	OEM facility	non-OEM outlet
<b>Total Variable Costs</b>						
<b>Total variable overhead (\$/h)</b>	<b>\$0.24</b>	<b>\$7.67</b>	<b>\$2.07</b>	<b>\$9.58</b>	<b>\$0.24</b>	<b>\$7.67</b>
<b>ADAS Windshield</b>	\$ 0.78	\$ 25.30	\$ 7.25	\$ 33.52	\$ 0.85	\$ 27.60
Windshield R&I	\$ 0.64	\$ 20.70	\$ 6.83	\$ 31.60	\$ 0.78	\$ 25.30
Camera calibration						
Static	\$ -	\$ -	\$ 0.41	\$ 1.92	\$ -	\$ -
Dynamic	\$ 0.14	\$ 4.60	\$ -	\$ -	\$ 0.07	\$ 2.30
<b>non-ADAS Windshield</b>						
Windshield R&I	\$ 0.64	\$ 20.70	\$ 6.83	\$ 31.60	\$ 0.78	\$ 25.30

## Fixed Costs

Fixed costs for the three vehicles from Ford, Honda and Subaru are summarized below in Table 11. The Honda facility costs include the space required for the static camera calibration whereas Ford and Subaru specify dynamic, on-road calibrations.

**Table 11** Ford, Honda and Subaru fixed (building) costs

	Ford		Honda		Subaru	
	OEM facility	non-OEM outlet	OEM facility	non-OEM outlet	OEM facility	non-OEM outlet
<b>ADAS Windshield</b>	\$ 1.88		\$ 2.44	\$ 0.15	\$ 2.30	
Windshield R&I	\$ 1.88		\$ 2.30		\$ 2.30	
Camera calibration						
Static	\$ -		\$ 0.14	\$ 0.15	\$ -	
Dynamic						
<b>non-ADAS Windshield</b>						
Windshield R&I	\$ 1.88		\$ 2.30		\$ 2.30	

## Individual OEM Totals

Table 12 below summarizes the costs for replacing a Ford windshield with both ADAS and non-ADAS variants using both OEM glass and non-OEM or aftermarket glass. The total dealership (OEM shop) and independent (non-OEM shop) costs include both material costs as well labor, variable and fixed costs. In addition, SG&A and profit were added on as described above for both a dealership and an independent shop for the total pricing (i.e. consumer pricing). Following Table 12 are Table 13 and Table 14 with analogous figures for Honda and Subaru, respectively.

**Table 12** Summary of costs and final pricing for Ford F-150 ADAS and non-ADAS windshield replacements as well as incremental ADAS windshield replacement costs

	<b>Ford F-150</b>					
	<b>ADAS Windshield</b>		<b>non-ADAS</b>		<b>Incremental ADAS</b>	
	<b>OEM glass</b>	<b>non-OEM glass</b>	<b>OEM glass</b>	<b>non-OEM glass</b>	<b>OEM glass</b>	<b>non-OEM glass</b>
<b>Materials</b>	\$ 556.33	\$ 842.66	\$ 524.50	\$ 814.10	\$ 31.83	\$ 28.56
Labor	\$ 74.48	\$ 74.48	\$ 61.53	\$ 61.53		
Variable	\$ 0.78	\$ 0.78	\$ 0.64	\$ 0.64		
Fixed	\$ 1.88	\$ 1.88	\$ 1.88	\$ 1.88		
<b>Total dealer cost</b>	<b>\$ 633.47</b>	<b>\$ 919.80</b>	<b>\$ 588.55</b>	<b>\$ 878.15</b>	<b>\$ 44.92</b>	<b>\$ 41.65</b>
SG&A	\$ 74.48	\$ 74.48	\$ 61.53	\$ 61.53		
Profit	\$ 176.99	\$ 248.57	\$ 162.52	\$ 234.92		
<b>Total dealer price</b>	<b>\$ 884.93</b>	<b>\$1,242.86</b>	<b>\$ 812.60</b>	<b>\$1,174.61</b>	<b>\$ 72.33</b>	<b>\$ 68.25</b>
Labor	\$ 61.55	\$ 61.55	\$ 48.60	\$ 48.60		
Variable	\$ 25.30	\$ 25.30	\$ 20.70	\$ 20.70		
Fixed	\$ -	\$ -	\$ -	\$ -		
<b>Total independent cost</b>	<b>\$ 643.17</b>	<b>\$ 929.51</b>	<b>\$ 593.80</b>	<b>\$ 883.40</b>	<b>\$ 49.38</b>	<b>\$ 46.11</b>
SG&A	\$ 61.55	\$ 61.55	\$ 48.60	\$ 48.60		
Profit	\$ 176.18	\$ 247.76	\$ 160.60	\$ 233.00		
<b>Total independent price</b>	<b>\$ 880.90</b>	<b>\$1,238.82</b>	<b>\$ 803.00</b>	<b>\$1,165.00</b>	<b>\$ 77.91</b>	<b>\$ 73.82</b>

Notes: SG&A = Labor rate, Profit margin = 25%

**Table 13** Summary of costs and final pricing for Honda CR-V ADAS and non-ADAS windshield replacements as well as incremental ADAS windshield replacement costs

	<i>Honda CR-V</i>					
	<b>ADAS Windshield</b>		<b>non-ADAS</b>		<b>Incremental ADAS</b>	
	<i>OEM glass</i>	<i>non-OEM glass</i>	<i>OEM glass</i>	<i>non-OEM glass</i>	<i>OEM glass</i>	<i>non-OEM glass</i>
<b>Materials</b>	\$ 971.25	\$ 1,005.26	\$ 903.29	\$ 840.35	\$ 67.96	\$ 164.92
Labor	\$ 79.52	\$ 79.52	\$ 75.21	\$ 75.21		
Variable	\$ 7.25	\$ 7.25	\$ 6.83	\$ 6.83		
Fixed	\$ 2.44	\$ 2.44	\$ 2.30	\$ 2.30		
<b>Total dealer cost</b>	<b>\$1,060.46</b>	<b>\$1,094.47</b>	<b>\$ 987.63</b>	<b>\$ 924.68</b>	<b>\$ 72.83</b>	<b>\$ 169.78</b>
SG&A	\$ 79.52	\$ 79.52	\$ 75.21	\$ 75.21		
Profit	\$ 284.99	\$ 293.50	\$ 265.71	\$ 249.97		
<b>Total dealer price</b>	<b>\$1,424.97</b>	<b>\$1,467.49</b>	<b>\$1,328.54</b>	<b>\$1,249.86</b>	<b>\$ 96.43</b>	<b>\$ 217.63</b>
Labor	\$ 63.72	\$ 63.72	\$ 59.40	\$ 59.40		
Variable	\$ 33.52	\$ 33.52	\$ 31.60	\$ 31.60		
Fixed	\$ 0.15	\$ 0.15	\$ -	\$ -		
<b>Total independent cost</b>	<b>\$1,068.64</b>	<b>\$1,102.65</b>	<b>\$ 994.29</b>	<b>\$ 931.35</b>	<b>\$ 74.34</b>	<b>\$ 171.30</b>
SG&A	\$ 63.72	\$ 63.72	\$ 59.40	\$ 59.40		
Profit	\$ 283.09	\$ 291.59	\$ 263.42	\$ 247.69		
<b>Total independent price</b>	<b>\$1,415.44</b>	<b>\$1,457.96</b>	<b>\$1,317.12</b>	<b>\$1,238.44</b>	<b>\$ 98.33</b>	<b>\$ 219.52</b>

Notes: SG&A = Labor rate, Profit margin = 25%

**Table 14** Summary of costs and final pricing for Subaru Outback ADAS and non-ADAS windshield replacements as well as incremental ADAS windshield replacement costs

	<b>Subaru Outback</b>					
	<b>ADAS Windshield</b>		<b>non-ADAS</b>		<b>Incremental ADAS</b>	
	<b>OEM glass</b>	<b>non-OEM glass</b>	<b>OEM glass</b>	<b>non-OEM glass</b>	<b>OEM glass</b>	<b>non-OEM glass</b>
<b>Materials</b>	\$ 583.62	\$ 645.36	\$ 583.62	\$ 719.53	\$ -	\$ -74.17
Labor	\$ 81.68	\$ 81.68	\$ 75.21	\$ 75.21		
Variable	\$ 0.85	\$ 0.85	\$ 0.78	\$ 0.78		
Fixed	\$ 2.30	\$ 2.30	\$ 2.30	\$ 2.30		
<b>Total dealer cost</b>	<b>\$ 668.45</b>	<b>\$ 730.19</b>	<b>\$ 661.91</b>	<b>\$ 797.81</b>	<b>\$ 6.54</b>	<b>\$ (67.62)</b>
SG&A	\$ 81.68	\$ 81.68	\$ 75.21	\$ 75.21		
Profit	\$ 187.53	\$ 202.97	\$ 184.28	\$ 218.25		
<b>Total dealer price</b>	<b>\$ 937.66</b>	<b>\$1,014.84</b>	<b>\$ 921.39</b>	<b>\$1,091.27</b>	<b>\$ 16.27</b>	<b>\$ (76.43)</b>
Labor	\$ 65.87	\$ 65.87	\$ 59.40	\$ 59.40		
Variable	\$ 27.60	\$ 27.60	\$ 25.30	\$ 25.30		
Fixed	\$ -	\$ -	\$ -	\$ -		
<b>Total independent cost</b>	<b>\$ 677.09</b>	<b>\$ 738.83</b>	<b>\$ 668.32</b>	<b>\$ 804.23</b>	<b>\$ 8.77</b>	<b>\$ (65.39)</b>
SG&A	\$ 65.87	\$ 65.87	\$ 59.40	\$ 59.40		
Profit	\$ 185.74	\$ 201.18	\$ 181.93	\$ 215.91		
<b>Total independent price</b>	<b>\$ 928.71</b>	<b>\$1,005.89</b>	<b>\$ 909.65</b>	<b>\$1,079.53</b>	<b>\$ 19.06</b>	<b>\$ (73.65)</b>

Notes: SG&A = Labor rate, Profit margin = 25%

### Comparison of OEM Total Costs

To make comparisons between Ford, Honda and Subaru easier and to look at industry average trends, an overall summary of the material costs and the total dealership and independent shop costs and consumer prices are presented in Table 15. The first observation to be made by looking at the industry sample average pricing at the bottom of the table is that ADAS windshield replacements on average cost about \$62 - \$65 more with OEM glass and about \$70 - \$73 more with aftermarket glass than non-ADAS windshields, depending on whether a dealership is used or an independent outlet. Secondly, material costs accounted for just over one-half of those total consumer prices. The reason for the price differences between a dealer shop and an independent shop was in the models that were used to estimate their costs. A dealer was assumed to have a drive-in repair facility and employ automotive body repairers for windshield removal and installation; an independent operator was assumed to be working out of a mobile service van, which consistently added to the variable price over a dealership, but it also had lower labor rates for automotive glass installers and repairers which brought the overall cost for an independent down below that for a dealership. The calibration technician rate was the same at a dealership or independent outlet.

In comparing the individual OEMs incremental ADAS pricing, it can be observed that Subaru had the lowest costs for Outback windshield replacement and was about cost neutral on OEM glass and actually cheaper for aftermarket glass, unlike Ford and Honda. Ford added about \$30 to its incremental ADAS glass costs and dealership pricing was about \$70 higher and independent pricing about \$76 higher; for Ford OEM glass costs and windshield replacement pricing were about \$3 or \$4 higher than aftermarket

glass, unlike industry average. Honda on the other hand, was significantly higher (2.3 times) for aftermarket glass cost and pricing than OEM glass.

In looking at material costs and consumer pricing for the individual OEMs, it is apparent that material costs were the primary driver for consumer pricing of both ADAS and non-ADAS windshield replacements. Honda was 38% higher for OEM glass and 21% higher for aftermarket glass than industry averages; it's estimated average ADAS windshield replacement pricing with OEM glass was \$1424.97 at a dealer and \$1415.44 at an independent. Honda was the only OEM studied in this investigation who required a static camera calibration, adding \$2.00 to its variable costs for use of a static target aiming stand. Ford was 21% lower for OEM glass and about cost neutral for aftermarket glass costs; it's estimated average ADAS windshield replacement pricing with OEM glass was \$884.93 at a dealer and \$880.90 at an independent. Subaru was 17% lower than industry average for OEM glass and 22% lower for aftermarket glass; it's estimated average ADAS windshield replacement pricing with OEM glass was \$937.66 at a dealership facility and \$928.71 for an independent outlet. Non-ADAS windshield replacement followed similar trends to the ADAS windshields.

To summarize the results, overall ADAS windshield replacement adds from \$61.68 to \$73.23 over non-ADAS windshield replacement for the industry average consumer pricing which ranged from \$1,075.02 to \$1,241.73 for ADAS windshields and from \$1,009.92 to \$1,171.91 for non-ADAS windshields depending on whether OEM glass or aftermarket glass is used and whether the work is done by an OEM dealer or an independent automotive glass repair outlet. The cost of the windshield glass itself was the major driver behind consumer pricing differences. Windshield replacements for the Ford F-150 with OEM glass were the least expensive at roughly 20% below industry average, and had aftermarket glass that was roughly equivalent in price to the industry average. the Subaru Outback prices were slightly higher than Ford's for OEM glass but were about 20% lower than average with aftermarket glass. Honda CR-V windshields were the highest cost to have replaced at more than 30% over industry average with OEM glass and 20% with aftermarket glass.

**Table 15** Summary of overall costs and final pricing for ADAS and non-ADAS windshield replacements from Ford, Honda, and Subaru

	ADAS Windshield		non-ADAS Windshield		Incremental ADAS windshield replacement	
	OEM glass	non-OEM glass	OEM glass	non-OEM glass	OEM glass	non-OEM glass
<b>Ford F-150</b>						
Materials	\$ 556.33	\$ 842.66	\$ 524.50	\$ 814.10	\$ 31.83	\$ 28.56
Total dealer price	\$ 884.93	\$ 1,242.86	\$ 812.60	\$ 1,174.61	\$ 72.33	\$ 68.25
Total independent price	\$ 880.90	\$ 1,238.82	\$ 803.00	\$ 1,165.00	\$ 77.91	\$ 73.82
<b>Honda CR-V</b>						
Materials	\$ 971.25	\$ 1,005.26	\$ 903.29	\$ 840.35	\$ 67.96	\$ 164.92
Total dealer price	\$ 1,424.97	\$ 1,467.49	\$ 1,328.54	\$ 1,249.86	\$ 96.43	\$ 217.63
Total independent price	\$ 1,415.44	\$ 1,457.96	\$ 1,317.12	\$ 1,238.44	\$ 98.33	\$ 219.52
<b>Subaru Outback</b>						
Materials	\$ 583.62	\$ 645.36	\$ 583.62	\$ 719.53	\$ -	\$ (74.17)
Total dealer price	\$ 937.66	\$ 1,014.84	\$ 921.39	\$ 1,091.27	\$ 16.27	\$ (76.43)
Total independent price	\$ 928.71	\$ 1,005.89	\$ 909.65	\$ 1,079.53	\$ 19.06	\$ (73.65)
<b>Sample average</b>						
Materials	\$ 703.73	\$ 831.09	\$ 670.47	\$ 791.32	\$ 33.26	\$ 39.77
Total dealer price	\$ 1,082.52	\$ 1,241.73	\$ 1,020.84	\$ 1,171.91	\$ 61.68	\$ 69.81
Total independent price	\$ 1,075.02	\$ 1,234.22	\$ 1,009.92	\$ 1,160.99	\$ 65.10	\$ 73.23

## Appendix: Interview Responses

### Interview Summary – Aravind Ratnam of Sense Photonics



Interviewee Name:	Aravind Ratnam
Organization:	Sense Photonics
Role:	Senior Vice President of Product
Date:	8-FEB-21

Question	Answer
What are the incremental requirements (e.g. glass specification and tolerancing, bonding requirements, replacement or recalibration and/or alignment of camera sensors) for ADAS windshields?	<ul style="list-style-type: none"> <li>• Current windshield damage cost is in the \$300 range, but now if you damage a camera, you could be talking big money</li> <li>• Thinks that 2025 sees 80%+ of vehicles made will have "smart windshields" meaning there are sensors behind the glass</li> </ul>
Are there other ADAS sensors or modules that affect the manufacturing of windshields?	<ul style="list-style-type: none"> <li>• LiDAR</li> <li>• Anti-reflective coatings help LiDAR, especially flash LiDAR, and other light emitting sensor systems by improving angular field of view</li> <li>• HUDs adding color capability as warning and information display and alerts become richer</li> </ul>
What are the differences involved with replacing an ADAS vs non-ADAS windshield?	<p>Costs</p> <ul style="list-style-type: none"> <li>• On the low end, with ADAS, it will just be a windshield with a calibration of the camera</li> <li>• On the high end, could be a windshield plus calibration and re-alignment of a camera and/or a LiDAR involving both static and dynamic calibration/alignment</li> <li>• Where replacements might go is to just replace attached sensors and perform a more simplistic calibration Required technician training</li> <li>• Technicians getting smarter as OEM requirements go up</li> <li>• How long to calibrate? Industry aim for &lt;\$250 for recalibration so ~2-2.5hrs based on a \$90/hr rate assumption</li> </ul> <p>Time required</p> <ul style="list-style-type: none"> <li>• Steeply raked windshields may require tighter tolerancing on windshield</li> <li>• Sense Photonics needs <u>1 degree</u> tolerancing for it's behind windshield LiDAR</li> <li>• A lot of cameras and some types of LiDAR are very sensitive to installation misalignment, Mobileye is developing a new flash type LiDAR that is far more tolerant to misalignment</li> </ul> <p>Equipment required</p> <ul style="list-style-type: none"> <li>• \$30-70K capital investment for sensor calibration / alignment equipment</li> <li>• Procedures (e.g. replacement of rear-view mirror, recalibration or realignment of camera)</li> <li>• GM was initially more stringent with their sensing equipment requirements, but has been loosening them with more experience Can camera calibration and/or alignment be performed by a mobile repair unit? Is it static or dynamic? How long does it take?</li> <li>• See above comments on static and dynamic calibration/alignment, capital equipment cost, technician training, tolerancing, and time required. I got the picture that he was indicating a move away from mobile repair in general but the integration of windshield and sensors with attendant simplified calibration/alignment may allow for mobile replacement.</li> </ul>

# Interview Summary – Todd Baum of Custom Glass Solutions



Interviewee Name:	Todd Baum
Organization:	Custom Glass Solutions
Role:	Vice President of Business Development
Date:	12-FEB-21

Question	Answer
Are you aware of any differences between ADAS vs conventional or non-ADAS windshields? What generally distinguishes these two types?	<ul style="list-style-type: none"> <li>Custom Glass Solutions does a lot of aftermarket replacement glass (ARG) with ADAS sensors and without, as well as "factory" glass for specialty vehicles and RVs</li> </ul>
What are the incremental requirements (e.g. glass specification and tolerancing, bonding requirements, replacement or recalibration and/or alignment of camera sensors) for ADAS windshields?	<ul style="list-style-type: none"> <li>CGS provides a piece of glass with bracket to hold ADAS sensor(s); incremental cost of glass itself is in bracketry that holds camera, a coating delete over camera lens, plus aesthetic cover on the glass itself. Real expense comes in with calibration; OEM requirements drive up cost tremendously through calibration.</li> </ul>
What are the differences involved with replacing an ADAS vs non-ADAS windshield?	<p>Costs</p> <ul style="list-style-type: none"> <li>Insurance companies drive the lion's share of influencing the cost of windshield replacement</li> <li>An insurance co. with a "concierge" model of service might drive towards OEM replacement glass</li> <li>An insurance co. with a "cost conscious" model of service might drive towards aftermarket replacement glass</li> <li>OEMs may influence cost by voiding warranty coverage if OEM glass is not used, but Todd felt this is a smaller factor than insurance companies</li> <li>There can be a large variation in windshield cost itself depending on the number of sensors attached to the glass; calibration though makes the biggest difference in total windshield replacement costs</li> <li>CGS just manufactures glass with brackets; they do not do calibration and only have to get the brackets close enough for the dealer/installer to do the calibration</li> </ul>



# Interview Summary – Jason and David of Glassman Subaru



Interviewee Name:	Jason; David ( <i>no last names provided</i> )
Organization:	Glassman Subaru – Service Department
Role:	Service Technician; Service Manager
Date:	12-FEB-21

Question	Answer
What are the incremental requirements (e.g. glass specification and tolerancing, bonding requirements, replacement or recalibration and/or alignment of camera sensors) for ADAS windshields?	<ul style="list-style-type: none"> <li>Glassman Subaru uses Henderson Glass to replace windshields with a mobile unit and then Glassman does any needed calibration in house</li> </ul>
What are the differences involved with replacing an ADAS vs non-ADAS windshield?	<p>Costs</p> <ul style="list-style-type: none"> <li>Calibration starts at \$143, depends on VIN</li> </ul> <p>Time required</p> <ul style="list-style-type: none"> <li>"Doesn't take too long on the road," they "don't drive too far"</li> </ul> <p>Equipment required</p> <ul style="list-style-type: none"> <li>Glassman uses the Subaru certified calibration tools and equipment; Service Director not familiar with cost of equipment</li> </ul> <p>Can camera calibration and/or alignment be performed by a mobile repair unit? Is it static or dynamic? How long does it take?</p> <ul style="list-style-type: none"> <li>See above comments on mobile glass replacement followed by dynamic calibration and time required.</li> </ul>

## Interview Summary – Henderson Glass



Interviewee Name:	Anonymous
Organization:	Henderson Glass
Role:	Service Advisor
Date:	12-FEB-21

Question	Answer
Are you aware of any differences between ADAS vs conventional or non-ADAS windshields? What generally distinguishes these two types?	<ul style="list-style-type: none"> <li>Henderson Glass can replace any type of windshield and do the calibration</li> </ul>
Can ADAS windshields be repaired for small chips and/ or cracks?	<ul style="list-style-type: none"> <li>A quarter-sized or smaller chip can be repaired, without need for recalibration</li> <li>Any size crack requires replacement</li> </ul>
Is there a need to buy OEM glass for some vehicle brands and models?	<ul style="list-style-type: none"> <li>Their system will identify if an OEM replacement glass is required</li> <li>In the Subaru Outback case, OEM was not specified</li> <li>If OEM glass is <u>required</u> she recommended using insurance</li> </ul>
What are the differences involved with replacing an ADAS vs non-ADAS windshield?	<p>Costs</p> <ul style="list-style-type: none"> <li>2018 Subaru Outback, standard glass windshield w/o LDA costs \$302.15</li> <li>2020 Subaru Outback, standard glass with LKA costs \$566.84 including calibration; calibration costs \$200 (fixed price) therefore incremental glass cost is \$64.69</li> </ul> <p>Required technician training</p> <ul style="list-style-type: none"> <li>Different technicians are used to install the glass and calibrate ADAS systems</li> </ul> <p>Time required</p> <ul style="list-style-type: none"> <li>One hr for glass installation</li> <li>One hr for curing time</li> <li>One hr for calibration</li> <li>3 – 3.5 hr overall</li> </ul> <p>Equipment required</p> <ul style="list-style-type: none"> <li>Their website mentions Opti-Aim so I asked about that. Response was that some OEMs require dynamic calibration, and some require static level 1, 2, or 3; she was not familiar with the differences between the levels</li> <li>Ford specifies dynamic</li> <li>"Premium" brands like Subaru usually specify static, per OEM requirements</li> <li>The 2020 Outback required static level 1</li> </ul>

# Interview Summary – Paul Martindale of Aptiv



Interviewee Name:	Paul Martindale
Organization:	Aptiv
Role:	Global Technical Marketing Manager
Date:	19-FEB-21

Question	Answer
Are you aware of any differences between ADAS vs conventional or non-ADAS windshields? What generally distinguishes these two types?	<ul style="list-style-type: none"> <li>Comment for both BSI &amp; Windshields: GSR (Global Safety Regulations in EU) driving emergency lane keep assist by 2022 and driver awareness monitoring or OEM won't be able to sell vehicles; it would be nice for NHTSA to communize as much as possible</li> </ul>
What are the incremental requirements (e.g. glass specification and tolerancing, bonding requirements, replacement or recalibration and/or alignment of camera sensors) for ADAS windshields?	<p>ADAS driving need for:</p> <ul style="list-style-type: none"> <li>Different frit pattern which drives up part number complexity</li> <li>Heater grid in front of camera</li> <li>Application of buttons to hold cameras drives up shipping costs due to shipping density decrease</li> </ul>
What are the challenges in manufacturing ADAS glass?	<ul style="list-style-type: none"> <li>Glass made via sag or press processes</li> <li>Press gives generally better properties, but OEMs tend to resist</li> <li>CARB, years ago was requiring, or looking into requiring, tinted glass for energy efficiency, but it was horrible for optical clarity</li> <li>Ford used "Gorilla glass" on GT, and now maybe Ranger, because thinner &amp; lighter while stronger at the same time</li> <li>Check out <a href="#">Carlex</a> for press glass making</li> </ul>
Can ADAS windshields be repaired for small chips and/ or cracks?	<ul style="list-style-type: none"> <li>Chips that are in camera 'cut-out' region may be repairable as they are not in focus</li> </ul>
What differences are there between OEM and aftermarket glass? How do these differences impact ADAS system calibration or alignment?	<ul style="list-style-type: none"> <li>Replacement glass may not meet optical clarity specs, FMVSS</li> <li>Cybersecurity making it difficult to service vehicles in general and requires "keys" which can be very difficult, even for development units; Suppliers must work with OEM to access keys and do calibration development on prototype vehicles. They want to own cyber keys for their car and not allow OEM or government to "own" rights to service their vehicle.</li> </ul>
Is there a need to buy OEM glass for some vehicle brands and models?	<ul style="list-style-type: none"> <li>LIDAR application required OEM glass</li> <li>Hard to enforce customers from replacing with what they want to use</li> <li>2019 Nissan Rogue had windshield replacement, had to have camera calibrated twice to meet specs</li> </ul>
Are there other ADAS sensors or modules that affect the manufacturing of windshields?	<ul style="list-style-type: none"> <li>Rain sensor, but doesn't affect ADAS systems</li> </ul>
What are the differences involved with replacing an ADAS vs non-ADAS windshield?	<p>Costs</p> <ul style="list-style-type: none"> <li>Minimal/no difference in glass quality level, only difference in cut-outs and possible heaters for camera(s)</li> <li>Procedures (e.g. replacement of rear-view mirror, recalibration or realignment of camera)</li> <li>Checkerboards set up to define absolute placement of vehicle on road accurately adjusted</li> <li>Stereo cameras (e.g. Eyesight) more difficult to calibrate than mono</li> <li>Need software tool to put ADAS system into "calibration" mode, then drive on road through specific routes or routines</li> <li>In the future, however, all this will go away as cameras/sensors become smarter and are able to do auto-calibration; perhaps starting first with automatic end-of-assembly-line calibration</li> </ul>