Vehicle Mass Reduction and Cost Analysis - Heavy Duty Pickup Truck and Light Commercial Vans

Draft

United States
Environmental Protection
Agency

Vehicle Mass Reduction and Cost Analysis - Heavy Duty Pickup Truck and Light Commercial Vans

Draft

Assessment and Standards Division
Office of Transportation and Air Quality
U.S. Environmental Protection Agency

Prepared for EPA by
FEV North America, Inc.
EPA Contract No. EP-C-12-014 WA3-03

NOTICE

This technical report does not necessarily represent final EPA decisions or positions. It is intended to present technical analysis of issues using data that are currently available. The purpose in the release of such reports is to facilitate the exchange of technical information and to inform the public of technical developments.

United States Environmental Protection Agency

EPA-420-D-16-003
April 2016

List of Contents

DRAFT

DRAFT

DRAFT

DRAFT

DRAFT

List of Images

DRAFT

DRAFT

DRAFT

DRAFT

DRAFT

DRAFT

DRAFT

List of Tables

DRAFT

DRAFT

DRAFT

EXECUTIVE SUMMARY

The United States Environmental Protection Agency (EPA) contracted with FEV, Inc. to determine incremental direct manufacturing costs for a set of advanced medium-duty vehicle technologies. The technologies selected are on the leading edge for reducing emissions of greenhouse gases in the future, primarily in the form of tailpipe carbon dioxide (CO^2).

The purpose of this study was to evaluate the incremental costs of mass reduction levels that are feasible within a given timeframe, without sacrificing utility, performance, or safety.

It has been proven that reducing vehicle mass has a beneficial correlation to fuel economy and reduction in greenhouse gases so to the extent that cost-effective mass reduction can be achieved, techniques like those described in this report may be employed by manufacturers to reduce greenhouse gas emissions and improve fuel economy.

The scope of this study was to take the original mass reduction ideas from the previous Silverado 1500 Mass Reduction and Cost Analysis[1] and apply them to the three selected vehicles in this study:

- 2013 Chevy Silverado 2500 4WD LT Ext Cab
- 2007 Mercedes Sprinter 311 CDi
- 2010 Renault Master 2.3 DCi 125 L3H2

The methodology employed was based on a comparison and scaling approach. Results from the previous 2011 Silverado 1500 analysis were evaluated for applicability to the three light/medium duty vehicles in this study. In general this analysis did not investigate and implement alternative mass reduction ideas which were not applied to the Silverado 1500. Any exceptions to this methodology are identified within the report.

Each study vehicle was evaluated against the Silverado 1500 relative to component content and similarities (e.g. design, function, material). This was accomplished by assembling BOMs for each of the three vehicles in the same format as used on the 1500 Silverado. At each product structure level (i.e., system, subsystem, sub-subsystem and assemblies and components) a comparison evaluation was made.

Where component matches were made (i.e., between the 1500 Silverado and study vehicle), the Silverado 1500 mass reduction and cost results were applied to case study vehicle. For example if the 1500 Silverado achieved a mass reduction of 40.31% on the front lower control arm, converting from cast iron to forge aluminum, and the 2500 Silverado had a cast iron lower control arm, the same 40.31% mass reduction was taken. Using the developed incremental cost/kilogram for lightweighting the Silverado lower control, a cost estimate can be made for the 2500; mass reduction of the 2500 lower control arm multiplied by the 1500 Silverado cost/kilogram.

When differences existed between components evaluated in the Silverado 1500 and each of the three case study vehicles, the team made engineering estimates on how much of the Silverado 1500 mass-reduction concept could be applied to the similar component on the case study vehicle. This

---

[1] *FEV-P310324-02_R2.0: Mass Reduction and Cost Analysis – Light-Duty Pickup Truck Model Years 2020-2025*

DRAFT

generally happened at the assembly level were multiple mass-reduction concepts were applied. If component differences were significant (i.e., design, function, performance, material) or the component design was already similar to the mass reduced concept on the 1500 Silverado, no mass reduction was taken.

To support the development of the vehicle BOMs and acquisition of component and assembly attribute data (mass, size, material, quantity, etc.) two methods were implemented.

- For the 2500 Silverado, the vehicle was purchased and disassembled using the standard FEV teardown and BOM development methodology.
- For the Mercedes Sprinter and Renault Master, the A2MAC1 database was used to acquire the relevant vehicle, component and assembly attribute data.

The foundation of this comparison and scaling work was the Silverado 1500 Mass Reduction and Cost Analysis[1] which was based on a detailed and comprehensive teardown, BOM creation, mass-reduction technology investigation, engineering assessment of applicable ideas, and comprehensive model validation. In addition detailed, transparent and production representative cost models consisting of an extensive set of linked spreadsheets and associated macros were used to determine the Net Incremental Direct Manufacturing Cost (NIDMC) impact of the mass reduced pickup truck with respect to the production stock 1500 Silverado. The mass reduction achieved in the final solution of the 1500 Silverado analysis was 511 kilograms (20.8% vehicle mass reduction). The NIDMC impact was an increase of $2,224 resulting in an average cost per kilogram of $4.35.

Key boundary conditions for the analysis included mass production volume (i.e., 450K), manufacturing in the US, mature market conditions, and a high level of product maturity.

The results are provided in the following tables and charts which summarize the study findings.

- <u>Reference Overview</u>

  The reference for this study was: FEV-P310324-02_R2.0: Mass Reduction and Cost Analysis – Light-Duty Pickup Truck Model Years 2020-2025

DRAFT

- Vehicle Level Summaries Overview

The Vehicle Level Summaries [2] provide information on Mass Reduction and Cost at a vehicle system level. At the bottom of each table (row "a"), vehicle system mass and cost are summed establishing vehicle level results.

This study, like the original 1500 Silverado, did not include a comprehensive, full vehicle, noise, vibration and harshness (NVH) evaluation. As a result an NVH countermeasure, proportional to that applied in the 1500 Silverado study, was also applied to each vehicle in this study. The vehicle NVH countermeasure allowance is captured in row "b" of each vehicle summary table below. Row "c" of the vehicle summary table provides the vehicle total with the NVH countermeasure allowance.

The values in each vehicle summary table column were determined based on a standard assumptions and methodologies.

Mass Reduction Impact by System							
Mass Reduction New Tech "kg" (1)	Mass Reduction Comp "kg" (1)	Mass Reduction Total "kg" (1)	Cost Impact New Tech "$" (2)	Cost Impact Comp "$" (2)	Cost Impact Total "$" (2)	Cost/ Kilogram Total "$/kg"	Vehicle Mass Reduction Total "%"

Column	Explanation
Mass Reduction New Tech "kg"	Mass reduction ideas that were originated from the original Silverado 1500 Lightweighting study that were applied to the select vehicles
Mass Reduction Comp "kg"	Added weight reduction from compounding/secondary mass savings
Mass Reduction Total "kg"	Combined weight reduction from applying the new tech and the compounding/secondary mass savings
Cost Impact New Tech "$"	Cost for applying the new tech mass reduction ideas from the original Silverado 1500 Lightweighting study to the select vehicles.
Cost Impact Comp "$"	Cost for additional compounding/secondary mass savings.
Cost Impact Total "$"	Combined cost from applying the new tech and compounding/secondary cost savings.
Cost/Kilogram Total "$/kg"	"Cost Impact Total" divided by the "Mass Reduction Total" to equal a cost per kilogram.

DRAFT

[2] *See section 2.1 for a complete explanation of the Vehicle Level Summaries and Cost Curve assumptions and methodologies.*

Column	Explanation
Vehicle Mass Reduction Total "%"	Mass reduction as a percentage of the original production stock curb weight

- <u>Vehicle Cost Curve with Trendlines Overview</u>

  Cost curves with and without secondary mass savings were developed for each vehicle evaluated. In addition piecewise trendlines were developed for cost curves with secondary mass savings. The trendlines[3] formulas are located in a table directly under each chart. Cost curves and formulas include the NVH countermeasure allowance.

Column	Explanation
Cost/Kilogram Mass Reduction Formula	Average cost of cumulative mass reduction summed in order of best value (i.e., cost/kg) to least value
% Vehicle Mass Reduction	Mass reduction as a percentage of the original production stock curb weight
Trendline	Linear piecewise trendlines reprenting two general regions of vehicle mass reduction (VMR): 0 to ≈4% VMR and 4 to 20% VMR

Following are the Vehicle Level Summaries and Cost Curves for the three select vehicles used in this study. Because the 2500 Silverado was similar in primary design to the 1500 Silverado, many of the 1500 Silverado mass reduction ideas were transferable. This led to mass reduction and cost values comparable between the two vehicles. If the mass of the CNG dual fuel components (239 kg) are removed from the curb weight of the 2500 Silverado (3086 kg), the percent vehicle mass reduction increases to 20.4% versus the 1500 Silverado at 20.8% (the 1500 Silverado evaluated was <u>not</u> a dual fuel CNG vehicle). The lower cost/kilogram of the 2500 Silverado is largely associated with more absolute mass reduction coming from vehicle systems where mass reduction is more affordable (i.e., engine, transmission, brakes, suspension at $2.50-3.50/kg) versus more expensive systems like body-in-white and enclosures at $5.50-$6.00/kg (Table 0-1). The absolute mass reduction difference, for systems like Body Group A (body-in-white and enclusures), between the 1500 and 2500 Silverado was minimal due to similarities in production stock designs and component mass.

In comparion the Sprinter and Master vehicles are unibody vans with less commonality to the 1500 Silverado. Although because some of the larger system contributors to mass reduction were transferable (i.e., Body Group A, Body Group B, Suspension, Brakes), significant mass reduction was still achieved. As shown in Table 0-2 and Table 0-3, the largest contributor to vehicle mass reduction was Body Group A contributing over 50% of the overall vehicle mass reduction. This

---

[3] *See section 2.1 for a complete explanation of the Vehicle Level Summaries and Cost Curve assumptions and methodologies.*

large contribution also had a negative impact on costs increasing the average cost/kilogram for mass reduction to near \$6/kg for both van applications.

The impact of having less mass reduction concepts transferable to the van applications, compounded with the large contribution from Body Group A, is also visible on the cost curves for both the Sprinter and Master vehicles (Figure 0-2 and Figure 0-3). This is witnessed by the large gap in datapoints between ≈7% and ≈17% vehicle mass reduction.

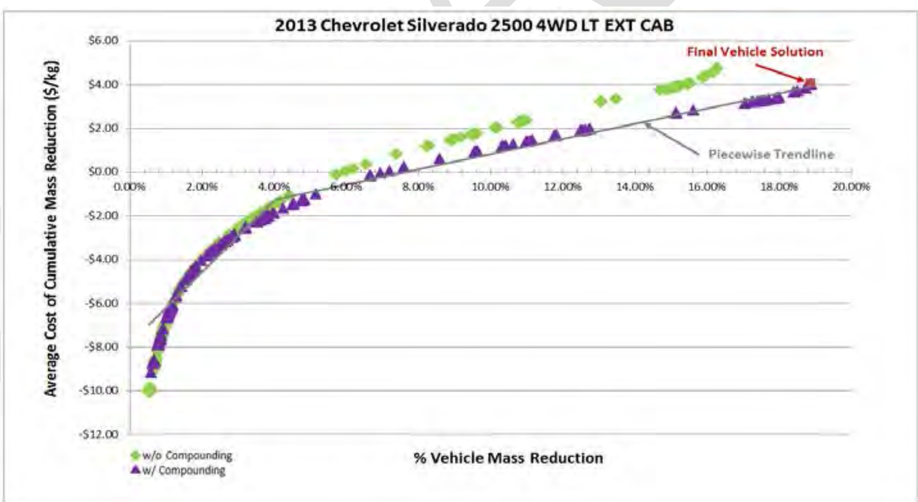
DRAFT

- <u>2013 Chevy Silverado 2500 4WD LT Ext Cab</u>

Table 0-1: Vehicle Level Summary, Silverado 2500

System	Description	Mass Reduction Impact by System: Mass Reduction New Tech "kg" (1)	Mass Reduction Comp "kg" (1)	Mass Reduction Total "kg" (1)	Cost Impact New Tech "$" (2)	Cost Impact Comp "$" (2)	Cost Impact Total "$" (2)	Cost/ Kilogram Total "$/kg"	Vehicle Mass Reduction Total "%"
00	**Silverado 2500**								
01	Engine System	63.48	8.55	72.03	-$224.28	$40.70	-$183.58	-$2.55	2.72%
02	Transmission System	33.75	4.86	38.61	-$110.67	$20.76	-$89.91	-$2.33	1.25%
03	Body System (Group -A-)	187.20	17.85	205.05	-$1,143.26	-$76.73	-$1,219.98	-$5.95	6.65%
03	Body System (Group -B-)	32.10	0.00	32.10	-$125.41	$0.00	-$125.41	-$3.91	1.04%
03	Body System (Group -C-)	2.07	0.00	2.07	$3.23	$0.00	$3.23	$1.56	0.07%
03	Body System (Group -D-) Glazing & Body Mechatronics	3.80	0.00	3.80	$1.94	$0.00	$1.94	$0.51	0.12%
04	Suspension System	113.32	12.49	125.81	-$386.64	$90.61	-$296.03	-$2.35	4.08%
05	Driveline System	25.11	0.00	25.11	$48.71	$0.00	$48.71	$1.94	0.81%
06	Brake System	54.31	2.08	56.39	-$192.82	$21.56	-$171.27	-$3.04	1.83%
07	Frame and Mounting System	0.00	32.80	32.80	$0.00	-$75.31	-$75.31	-$2.30	1.06%
08	Clutch System	0.00	0.00	0.00	$0.00	$0.00	$0.00	$0.00	0.00%
09	Exhaust System	8.68	0.48	9.16	-$21.96	$6.55	-$15.41	-$1.68	0.30%
10	Fuel System	0.65	8.21	8.86	$1.00	$12.42	$13.42	$1.52	0.29%
11	Steering System	3.54	0.00	3.54	$5.53	$0.00	$5.53	$1.56	0.11%
12	Climate Control System	1.75	0.00	1.75	$13.40	$0.00	$13.40	$7.68	0.06%
13	Information, Gage and Warning Divice System	0.25	0.00	0.25	$0.65	$0.00	$0.65	$2.62	0.01%
14	Electrical Power Supply System	12.67	0.00	12.67	-$170.81	$0.00	-$170.81	-$13.48	0.41%
15	In-Vehicle Entertainment System	0.00	0.00	0.00	$0.00	$0.00	$0.00	$0.00	0.00%
16	Vacuum Distrbution Subsystem	0.00	0.00	0.00	$0.00	$0.00	$0.00	$0.00	0.00%
17	Lighting System	0.39	0.00	0.39	-$2.02	$0.00	-$2.02	-$5.23	0.01%
18	Electrical Distribution and Electronic Control System	8.47	0.00	8.47	$61.54	$0.00	$61.54	$7.26	0.27%
19	Electronic Features System	0.00	0.00	0.00	$0.00	$0.00	$0.00	$0.00	0.00%
a	Analysis TotalsWithout NVH Counter Measures →	551.54	87.32	638.85	-$2,241.86	$40.55	-$2,201.31	-$3.45	20.70%
b	Vehicle NVH Counter Measures →	---	---	-56.95	---	---	-$170.84	---	---
c	Analysis Totals With NVH Counter Measures →			**581.90** (Decrease)			**-$2,372.16** (Increase)	**-$4.08** (Increase)	**18.86%**

(1) "+" = mass decrease, "-" = mass increase
(2) "+" = cost decrease, "-" = cost increase



Trendline Description	Cost/Kilogram Mass Reduction Formula	% Vehicle Mass Reduction Zone
With Mass Compounding/Secondary Mass Savings	$/kg =163.26*(VMR) -7.8466	0% < VMR ≤ 4.1%
	$/kg = 34.482*(VMR)-2.5938	4.1% < VMR ≤ 19%

VMR = Vehicle Mass Reduction (Silverado 2500)

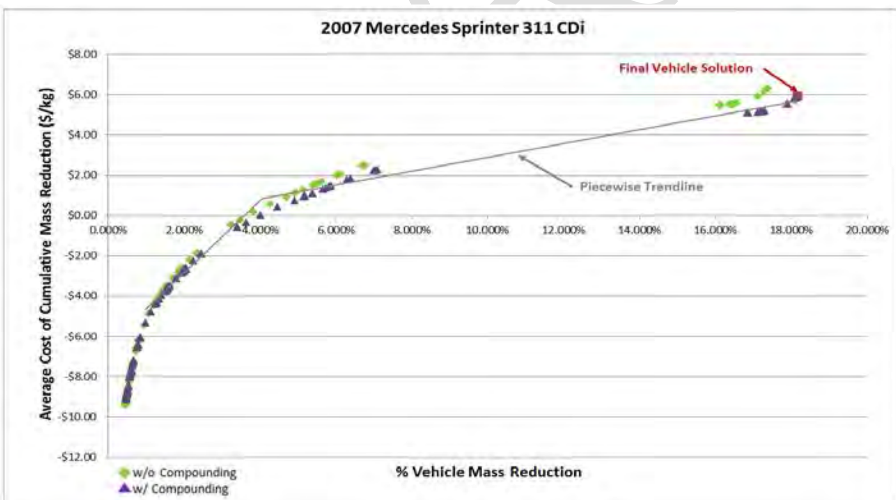
Figure 0-1: Vehicle Cost Curve w/ Trendline, Silverado 2500

- 2007 Mercedes Sprinter 311 CDi

Table 0-2: Vehicle Level Summary, Mercedes Sprint

System	Description	Mass Reduction Impact by System							
		Mass Reduction New Tech "kg" (1)	Mass Reduction Comp "kg" (1)	Mass Reduction Total "kg" (1)	Cost Impact New Tech "$" (2)	Cost Impact Comp "$" (2)	Cost Impact Total "$" (2)	Cost/ Kilogram Total "$/kg"	Vehicle Mass Reduction Total "%"
00	**Mercedes Sprinter 311 CDi**								
01	Engine System	28.49	5.07	33.56	-$98.12	$21.50	-$76.62	-$2.28	1.57%
02	Transmission System	6.84	2.14	8.99	-$8.43	$5.59	-$2.83	-$0.32	0.42%
03	Body System (Group -A-)	246.57	2.42	248.99	-$1,597.49	-$5.83	-$1,603.32	-$6.44	11.68%
03	Body System (Group -B-)	20.02	0.00	20.02	-$53.33	$0.00	-$53.33	-$2.66	0.94%
03	Body System (Group -C-)	1.17	0.00	1.17	$1.65	$0.00	$1.65	$1.42	0.05%
03	Body System (Group -D-) Glazing & Body Mechatronics	2.14	0.00	2.14	$1.10	$0.00	$1.10	$0.51	0.10%
04	Suspension System	42.02	2.04	44.06	-$110.81	$13.42	-$97.39	-$2.21	2.07%
05	Driveline System	7.45	0.00	7.45	$17.70	$0.00	$17.70	$2.38	0.35%
06	Brake System	27.75	0.52	28.26	-$110.53	$5.26	-$105.27	-$3.72	1.33%
07	Frame and Mounting System	0.00	0.00	0.00	$0.00	$0.00	$0.00	$0.00	0.00%
08	Clutch System	0.00	0.00	0.00	$0.00	$0.00	$0.00	$0.00	0.00%
09	Exhaust System	2.31	0.15	2.46	-$12.20	$2.05	-$10.15	-$4.12	0.12%
10	Fuel System	0.02	6.05	6.06	$0.18	$9.15	$9.32	$1.54	0.28%
11	Steering System	3.85	0.00	3.85	-$110.88	$0.00	-$110.88	-$28.76	0.16%
12	Climate Control System	1.16	0.00	1.16	$7.99	$0.00	$7.99	$6.90	0.05%
13	Information, Gage and Warning Divice System	0.23	0.00	0.23	$1.26	$0.00	$1.26	$5.49	0.01%
14	Electrical Power Supply System	12.96	0.00	12.96	-$184.33	$0.00	-$184.33	-$14.22	0.61%
15	In-Vehicle Entertainment System	0.00	0.00	0.00	$0.00	$0.00	$0.00	$0.00	0.00%
16	Vacuum Distrbution Subsystem	0.00	0.00	0.00	$0.00	$0.00	$0.00	$0.00	0.00%
17	Lighting System	0.39	0.00	0.39	-$2.02	$0.00	-$2.02	-$5.23	0.02%
18	Electrical Distribution and Electronic Control System	2.85	0.00	2.85	$27.22	$0.00	$27.22	$9.54	0.13%
19	Electronic Features System	0.00	0.00	0.00	$0.00	$0.00	$0.00	$0.00	0.00%
a	Analysis TotalsWithout NVH Counter Measures →	406.22	18.38	424.59	-$2,231.06	$51.14	-$2,179.91	-$5.13	19.92%
b	Vehicle NVH Counter Measures →	—	—	-37.85	—	—	-$113.55	—	—
c	Analysis Totals With NVH Counter Measures →			**386.75** (Decrease)			**-$2,293.46** (Increase)	**-$5.93** (Increase)	**18.15%**

(1) "+" = mass decrease, "-" = mass increase
(2) "+" = cost decrease, "-" = cost increase



Trendline Description	Cost/Kilogram Mass Reduction Formula	% Vehicle Mass Reduction Zone
With Mass Compounding/Secondary Mass Savings	$/kg =172.86*(VMR) -6.314	0% < VMR ≤ 4.2%
	$/kg = 34.497*(VMR)-0.5536	4.2% < VMR ≤ 18%

VMR = Vehicle Mass Reduction (Sprinter)

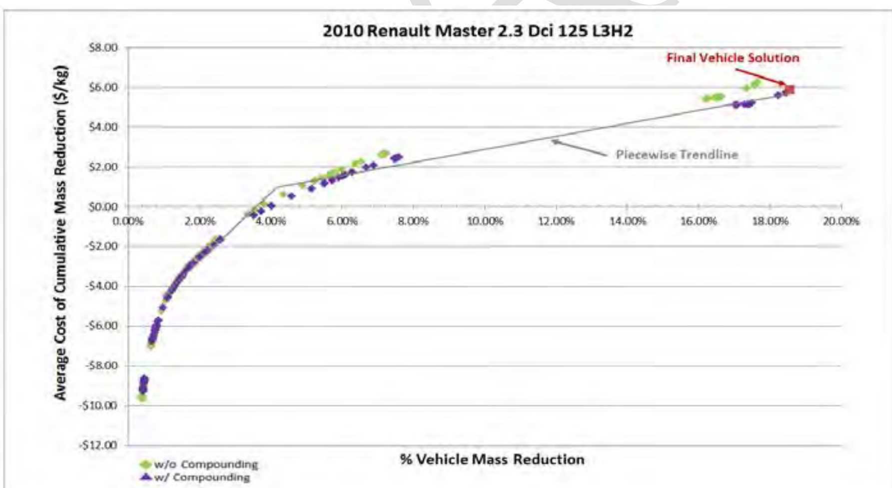
Figure 0-2: Vehicle Cost Curve w/ Trendline, Mercedes Sprinter

- <u>2010 Renault Master 2.3 DCi 125 L3H2</u>

Table 0-3: Vehicle Level Summary, Renault Master

		Mass Reduction Impact by System							
System	Description	Mass Reduction New Tech "kg" (1)	Mass Reduction Comp "kg" (1)	Mass Reduction Total "kg" (1)	Cost Impact New Tech "$" (2)	Cost Impact Comp "$" (2)	Cost Impact Total "$" (2)	Cost/ Kilogram Total "$/kg"	Vehicle Mass Reduction Total "%"
00	**Renault Master DCi**								
01	Engine System	30.51	5.46	35.98	-$132.57	$23.75	-$108.83	-$3.03	1.53%
02	Transmission System	7.00	2.43	9.44	-$10.14	$7.78	-$2.36	-$0.25	0.40%
03	Body System (Group -A-)	258.80	5.86	264.66	-$1,685.32	-$33.77	-$1,719.09	-$6.50	11.25%
03	Body System (Group -B-)	23.67	0.00	23.67	-$91.43	$0.00	-$91.43	-$3.86	1.01%
03	Body System (Group -C-)	1.62	0.00	1.62	$2.27	$0.00	$2.27	$1.40	0.07%
03	Body System (Group -D-) Glazing & Body Mechatronics	2.18	0.00	2.18	$1.12	$0.00	$1.12	$0.51	0.09%
04	Suspension System	56.87	2.86	59.73	-$140.45	$18.76	-$121.70	-$2.04	2.54%
05	Driveline System	13.38	0.00	13.38	$35.93	$0.00	$35.93	$2.68	0.57%
06	Brake System	31.34	0.60	31.94	-$123.41	$6.17	-$117.24	-$3.67	1.36%
07	Frame and Mounting System	0.00	0.00	0.00	$0.00	$0.00	$0.00	$0.00	0.00%
08	Clutch System	0.00	0.00	0.00	$0.00	$0.00	$0.00	$0.00	0.00%
09	Exhaust System	2.13	0.18	2.31	-$11.48	$2.33	-$9.15	-$3.97	0.10%
10	Fuel System	0.01	5.81	5.82	$0.14	$8.79	$8.92	$1.53	0.25%
11	Steering System	5.47	0.00	5.47	-$90.37	$0.00	-$90.37	-$16.53	0.23%
12	Climate Control System	0.59	0.00	0.59	$2.91	$0.00	$2.91	$4.96	0.02%
13	Information, Gage and Warning Dvice System	0.13	0.00	0.13	$0.66	$0.00	$0.66	$4.91	0.01%
14	Electrical Power Supply System	18.13	0.00	18.13	-$257.84	$0.00	-$257.84	-$14.22	0.77%
15	In-Vehicle Entertainment System	0.00	0.00	0.00	$0.00	$0.00	$0.00	$0.00	0.00%
16	Vacuum Distrbution Subsystem	0.00	0.00	0.00	$0.00	$0.00	$0.00	$0.00	0.00%
17	Lighting System	0.39	0.00	0.39	-$2.02	$0.00	-$2.02	-$5.23	0.02%
18	Electrical Distribution and Electronic Control System	3.81	0.00	3.81	$32.99	$0.00	$32.99	$8.65	0.16%
19	Electronic Features System	0.00	0.00	0.00	$0.00	$0.00	$0.00	$0.00	0.00%
a	Analysis TotalsWithout NVH Counter Measures →	456.06	23.20	479.25	-$2,469.04	$33.80	-$2,435.24	-$5.08	20.36%
b	Vehicle NVH Counter Measures →	---	---	-42.72	---	---	-$128.16	---	---
c	Analysis Totals With NVH Counter Measures →			**436.53** (Decrease)			**-$2,563.40** (Increase)	**-$5.87** (Increase)	**18.55%**

(1) "+" = mass decrease, "-" = mass increase
(2) "+" = cost decrease, "-" = cost increase



Trendline Description	Cost/Kilogram Mass Reduction Formula	% Vehicle Mass Reduction Zone
With Mass Compounding/Secondary Mass Savings	$/kg =170.94*(VMR) - 6.1459	0% < VMR ≤ 4.2%
	$/kg = 32.718*(VMR)-0.3747	4.2% < VMR ≤ 19%

VMR = Vehicle Mass Reduction (Master)

Figure 0-3: Vehicle Cost Curve w/ Trendline, Renault Master

1. INTRODUCTION AND PROGRAM OBJECTIVES

1.1 OBJECTIVE

The primary project objective of this study was to determine the minimum cost per kilogram for various levels of vehicle mass reduction on selected light/medium duty vehicles. The three select vehicles are:

- 2013 Chevy Silverado 2500 4WD LT Ext Cab
- 2007 Mercedes Sprinter 311 CDi
- 2010 Renault Master 2.3 DCi 125 L3H2

The approach for determining feasible component mass reduction alternatives, and the associated cost impact, was based on a comparison and scaling methodology. Results from a previously completed 2011 1500 Chevrolet Mass Reduction and Cost Analysis Project[4] were evaluated for applicability to the three case study vehicles listed above. If the mass reduction was applicable, mass and costs factors drived from the 1500 Silverado analysis where applied to the case study vehicles to establish a comparable mass reduction and incremental manufacturing cost. For many components and assemblies the mass reduction ideas were not transferable due to differences in the baseline designs and/or the mass reduction idea was already implemented. For other components and assemblies, partial applicability was determined resulting in a percentage reduction of the mass savings taken in the original 1500 Silverado analysis.

1.2 BACKGROUND

Vehicle mass reduction is considered one of many advance vehcile technologies available to help improve vehicle fuel economy and reduce greenhouse gas (GHG) emissions. Successful mass reduction must not degrade vehicle function and performance including occupant safety. To help assess the feasibility of mass reduction in light- and medium-duty trucks (i.e., pickup trucks and vans), and determine the associated cost impact, EPA contracted FEV to conduct a comparison and scaling analysis. The analysisis is founded on the results developed in a prior detailed mass reduction and cost analysis performed a 2011 Chevrolet Silverdo.

1.3 COSTING METHODOLOGY

The methodology employed was based on a comparison and scaling approach. Results from the previously completed detailed 1500 Silverado mass reduction and cost analysis were each product structure level (i.e., system, subsystem, sub-subsystem and assemblies and components) a comparison evaluation was made and evaluated for applicability to the three selected medium duty vehicles used in this study.

To support the development of the vehicle BOMs and acquisition of component and assembly attribute data (mass, size, material, quantity, etc.) two methods were implemented. For the 2500 Silverado, the vehicle was purchase and disassembled using the standard FEV teardown and BOM development methodology. For the Mercedes Sprinter and Renault Master, the A2MAC1 database was used to acquire the relevant vehicle and component and assembly attribute data.

[4] FEV-P310324-02_R2.0: Mass Reduction and Cost Analysis – Light-Duty Pickup Truck Model Years 2020-2025

DRAFT

A model consisting of an extensive set of linked spreadsheets and associated macros has been developed to perform the calculations, to track the 1500 Silverado input data, assess applicability to the medium duty trucks, and calculate the final mass reduction and net incremental direct manufacturing costs. This included independent calculations on the primary mass savings, also referred to as “Mass Reduction New Technology”, and secondary mass savings (SMS) also referred to as “Mass Reduction Compounding”.

Each study vehicle was evaluated against the Silverado 1500 relative to component content and similarities (e.g. design, function, material). This was accomplished by assembling BOMs for each of the major systems of the 1500 Silverado. At each product structure level (i.e., system, subsystem, sub-subsystem and assemblies and components) a comparison evaluation was made to determine if the component was on the vehicle being evaluated.

All calculations are based off of the Silverado 1500 analysis[5]. A high level overview of the calculations performed as follows:

- A Comparison BOM (CBOM) template was constructed using the traditional FEV system, subsystem, assembly and component hierarchy. Only items that were lightweighted in the original Silverado 1500 study were included in the CBOM.
- Each case study vehicle had its’ own set of CBOM templates for conducting the comparison and scaling analysis.
- Using BOMs created for the three new case study vehicles, a review and comparison analysis was conducted to determine if the Silverado mass reduced components existed in each comparion vehicle.
- If some portion of mass reduction was possible, component details from the case study vehicle were entered into the CBOM.
- A series of logical and attribute parameters, related to scalability and secondary mass savings, were entered in by the user supporting the algorithms used to calculate the component mass reduction and associated manufacturing costs.
- Within the CBOM templates, mass reduction and costs were summed into sub-subsystem, subsystem and system level values. In addition primary and secondary mass savings were tracked separately for use in the development of the cost curves.

[5] *FEV-P310324-02_R2.0: Mass Reduction and Cost Analysis – Light-Duty Pickup Truck Model Years 2020-2025*

DRAFT

1.4 SELECT VEHICLES

1.4.1 2013 Chevrolet Silverado 2500 4WD LT Extended CAB

- Segment: Heavy Duty Pickup Truck
- Engine: 6.0L 16V V8 GAS/CNG bi-fuel (360 hp)
- Transmission: 6 Automatic
- Drivetrain: Rear Wheel Drive
- Body Style: Crew Cab
- Doors: 4
- Seating Capacity: 5

Image 1.4–1: 2013 Chevrolet Silverado 2500 4WD LT Extended Cab

1.4.2 2007 Mercedes Sprinter 311 CDi

- Segment: Light Commercial Vehicle (LCV)
- Engine: 2.1L 16V Turbo Diesel (109 hp)
- Transmission: 6 speed manual
- Drivetrain: rear wheel drive
- Body Style: L2H2
- Doors: 5
- Seating Capacity: 2

Image 1.4–2: 2007 Mercedes Sprinter 311 CDi

DRAFT

1.4.3 2010 Renault Master 2.3 DCi 125 L3H2

- Segment: LCV
- Engine: 2.3L 16V Turbo Diesel (125 hp)
- Transmission: 6 speed manual
- Drivetrain: rear wheel drive
- Body Style: L3H2
- Doors: 5
- Seating Capacity: 3

Image 1.4–3: 2010 Renault Master 2.3 DCi L3H2

DRAFT

2. MASS-REDUCTION AND COST ANALYSIS RESULTS, VEHICLE LEVEL

2.1 MASS REDUCTION TABLE AND COST CURVE OVERVIEW

Mass Reduction Table

The first 3 columns deal with weight in kg: “Mass Reduction New Tech”, “Mass Reduction Comp” and “Mass Reduction Total”.

- Mass Reduction New Tech; are the mass reduction ideas that were originated from the original Silverado 1500 Lightweighting study that were applied to the select vehicles (e.g., change the crankshaft design to a hollow cast design to lightweight the crankshaft).
- Mass Reduction Comp; is the added weight reduction from compounding/secondary mass savings (e.g., the engine can be downsized in displacement as a result of the lower vehicle curb weight maintaining the original vehicle performance)
- Mass Reduction Total; is the combined weight reduction from applying the new technology and the compounding/secondary mass savings.

The next set of 3 columns deal with cost: “Cost Impact New Tech”, “Cost Impact Comp” and “Cost Impact Total”.

- Cost Impact New Tech; is the cost for applying the new technology mass reduction ideas from the original Silverado 1500 Lightweighting study to the select vehicles.
- Cost Impact Comp; is the cost savings as the result of compounding/secondary mass savings.
- Cost Impact Total; is the combined cost from applying the new technology and compounding/secondary cost savings.

The last 2 columns are a dollar value per kg and a percentage: “Cost/Kilogram Total” and “Vehicle Mass Reduction Total”.

- Cost/Kilogram Total; is the “Cost Impact Total” divided by the “Mass Reduction Total” to equal a cost per kilogram.
- Vehicle Mass Reduction %Total; is the percentage vehicle system mass reduction with respect to the baseline vehicle curb weight

It should be noted that an NVH countermeasure was added to the final solution to protect for additional material and cost which may need to be added back into the vehicle in selected areas as a result of lightweight adjustments. This could include additional hood insulation, body-in-white mastic, weight counterbalances, etc.

Cost Curve Chart

The cost curve consists of a dollar value per kilogram and a percentage: "Average Cost of Cumulative Mass Reduction" and "% Vehicle Mass Reduction" with a Trendline.

- % Vehicle Mass Reduction (VMR); is the percentage vehicle system mass reduction with respect to the baseline vehicle curb weight
- Average Cost of Cumulative Mass Reduction ($/kg); is the calculated cost/kg of mass reduction at a given percent vehicle mass reduction. The cost curves are developed by cumulatively summing mass reduction and associated cost impact, from "best value" to most expensive mass reduction component/assembly/subsystem ideas. Additional details on the development of mass reduction and cost impact cost curves can be found in the Silverado 1500 report[6]. Cost curves are developed with and without the addition of secondary mass savings illustrating the benefit of secondary mass savings. The "Final Vehicle Solution" point on the graph represents the sum of mass reduction and cost impact in the final solution also found at the bottom of each Vehicle Level Summary table below (i.e., Analysis Totals with NVH Countermeasures)
- Piecewise Trendlines were added to the compounding plots for each vehicle solution. From the Trendline plots the average cost per kilogram, as a function of percent vehicle mass reduction can be calculated. The Trendline formulas can be found underneath each cost curve plot.

DRAFT

[6] *FEV-P310324-02_R2.0: Mass Reduction and Cost Analysis – Light-Duty Pickup Truck Model Years 2020-2025*

2.2 SILVERADO 2500

Shown below is the Vehicle Level Summary chart (Table 2-1) by system new tech and secondary mass savings.

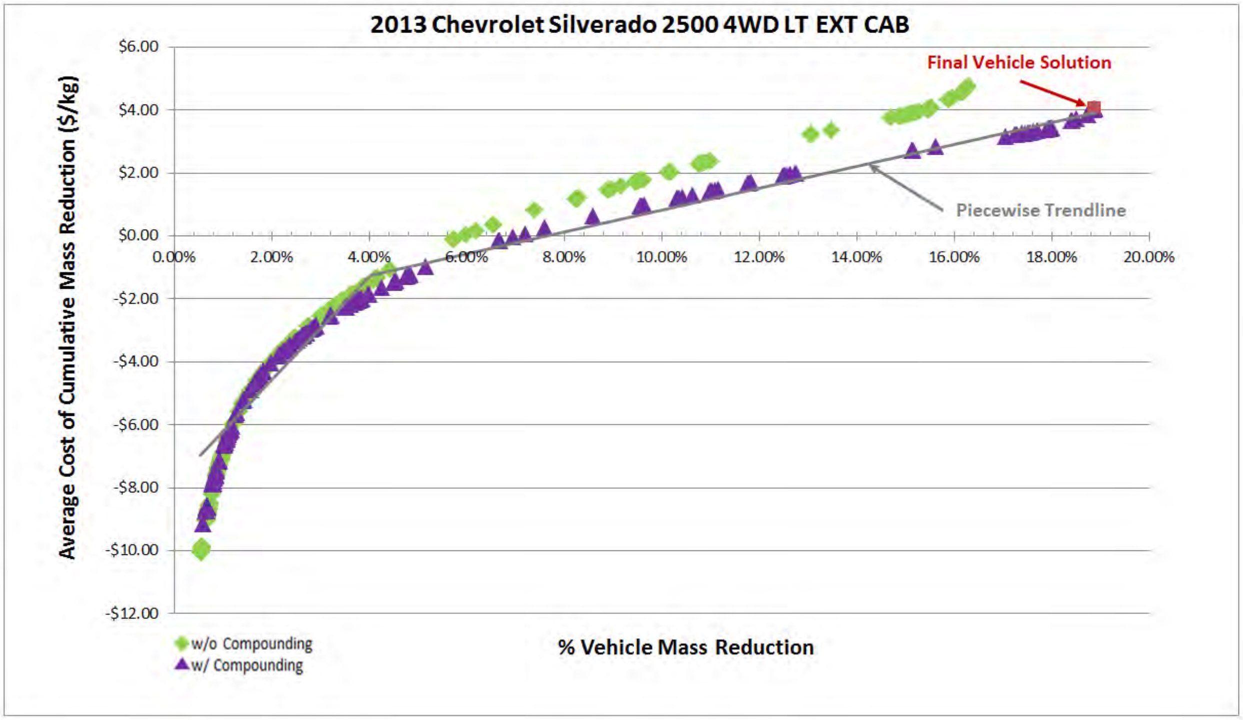
Table 2-1: Vehicle Level Summary, Silverado 2500

		Mass Reduction Impact by System							
System	Description	Mass Reduction New Tech "kg" (1)	Mass Reduction Comp "kg" (1)	Mass Reduction Total "kg" (1)	Cost Impact New Tech "$" (2)	Cost Impact Comp "$" (2)	Cost Impact Total "$" (2)	Cost/ Kilogram Total "$/kg"	Vehicle Mass Reduction Total "%"
00	**Silverado 2500**								
01	Engine System	63.48	8.55	72.03	-$224.28	$40.70	-$183.58	-$2.55	2.72%
02	Transmission System	33.75	4.86	38.61	-$110.67	$20.76	-$89.91	-$2.33	1.25%
03	Body System (Group -A-)	187.20	17.85	205.05	-$1,143.26	-$76.73	-$1,219.98	-$5.95	6.65%
03	Body System (Group -B-)	32.10	0.00	32.10	-$125.41	$0.00	-$125.41	-$3.91	1.04%
03	Body System (Group -C-)	2.07	0.00	2.07	$3.23	$0.00	$3.23	$1.56	0.07%
03	Body System (Group -D-) Glazing & Body Mechatronics	3.80	0.00	3.80	$1.94	$0.00	$1.94	$0.51	0.12%
04	Suspension System	113.32	12.49	125.81	-$386.64	$90.61	-$296.03	-$2.35	4.08%
05	Driveline System	25.11	0.00	25.11	$48.71	$0.00	$48.71	$1.94	0.81%
06	Brake System	54.31	2.08	56.39	-$192.82	$21.56	-$171.27	-$3.04	1.83%
07	Frame and Mounting System	0.00	32.80	32.80	$0.00	-$75.31	-$75.31	-$2.30	1.06%
08	Clutch System	0.00	0.00	0.00	$0.00	$0.00	$0.00	$0.00	0.00%
09	Exhaust System	8.68	0.48	9.16	-$21.96	$6.55	-$15.41	-$1.68	0.30%
10	Fuel System	0.65	8.21	8.86	$1.00	$12.42	$13.42	$1.52	0.29%
11	Steering System	3.54	0.00	3.54	$5.53	$0.00	$5.53	$1.56	0.11%
12	Climate Control System	1.75	0.00	1.75	$13.40	$0.00	$13.40	$7.68	0.06%
13	Information, Gage and Warning Divice System	0.25	0.00	0.25	$0.65	$0.00	$0.65	$2.62	0.01%
14	Electrical Power Supply System	12.67	0.00	12.67	-$170.81	$0.00	-$170.81	-$13.48	0.41%
15	In-Vehicle Entertainment System	0.00	0.00	0.00	$0.00	$0.00	$0.00	$0.00	0.00%
16	Vacuum Distrbution Subsystem	0.00	0.00	0.00	$0.00	$0.00	$0.00	$0.00	0.00%
17	Lighting System	0.39	0.00	0.39	-$2.02	$0.00	-$2.02	-$5.23	0.01%
18	Electrical Distribution and Electronic Control System	8.47	0.00	8.47	$61.54	$0.00	$61.54	$7.26	0.27%
19	Electronic Features System	0.00	0.00	0.00	$0.00	$0.00	$0.00	$0.00	0.00%
a	Analysis TotalsWithout NVH Counter Measures →	551.54	87.32	638.85	-$2,241.86	$40.55	-$2,201.31	-$3.45	20.70%
b	Vehicle NVH Counter Measures →	---	---	-56.95	---	---	-$170.84	---	---
c	Analysis Totals With NVH Counter Measures →			**581.90** (Decrease)			**-$2,372.16** (Increase)	**-$4.08** (Increase)	**18.86%**

(1) "+" = mass decrease, "-" = mass increase
(2) "+" = cost decrease, "-" = cost increase

Shown below is the vehicle cost curve w/ Trendline and secondary mass savings with description (Table 2-2).

Table 2-2: Vehicle Cost Curve w/ Trendline, Silverado 2500



Trendline Description	Cost/Kilogram Mass Reduction Formula	% Vehicle Mass Reduction Zone
With Mass Compounding/Secondary Mass Savings	$/kg =163.26*(VMR) -7.8466 $/kg = 34.482*(VMR)-2.5938	0% < VMR ≤ 4.1% 4.1% < VMR ≤ 19%

VMR = Vehicle Mass Reduction (Silverado 2500)

2.3 MERCEDES SPRINTER

Shown below is the Vehicle Level Summary chart (Table 2-3) by system new tech and secondary mass savings.

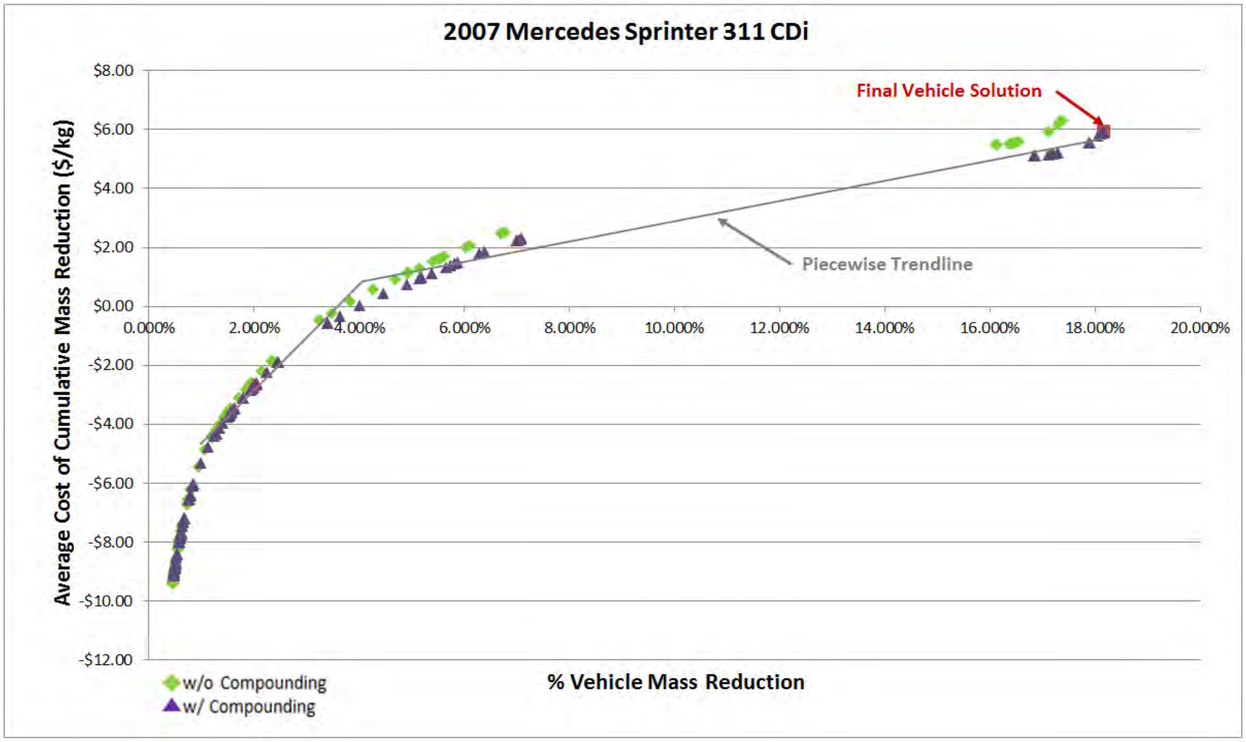
Table 2-3: Vehicle Level Summary, Mercedes Sprinter

		Mass Reduction Impact by System							
System	Description	Mass Reduction New Tech "kg" (1)	Mass Reduction Comp "kg" (1)	Mass Reduction Total "kg" (1)	Cost Impact New Tech "$" (2)	Cost Impact Comp "$" (2)	Cost Impact Total "$" (2)	Cost/ Kilogram Total "$/kg"	Vehicle Mass Reduction Total "%"
00	**Mercedes Sprinter 311 CDi**								
01	Engine System	28.49	5.07	33.56	-$98.12	$21.50	-$76.62	-$2.28	1.57%
02	Transmission System	6.84	2.14	8.99	-$8.43	$5.59	-$2.83	-$0.32	0.42%
03	Body System (Group -A-)	246.57	2.42	248.99	-$1,597.49	-$5.83	-$1,603.32	-$6.44	11.68%
03	Body System (Group -B-)	20.02	0.00	20.02	-$53.33	$0.00	-$53.33	-$2.66	0.94%
03	Body System (Group -C-)	1.17	0.00	1.17	$1.65	$0.00	$1.65	$1.42	0.05%
03	Body System (Group -D-) Glazing & Body Mechatronics	2.14	0.00	2.14	$1.10	$0.00	$1.10	$0.51	0.10%
04	Suspension System	42.02	2.04	44.06	-$110.81	$13.42	-$97.39	-$2.21	2.07%
05	Driveline System	7.45	0.00	7.45	$17.70	$0.00	$17.70	$2.38	0.35%
06	Brake System	27.75	0.52	28.26	-$110.53	$5.26	-$105.27	-$3.72	1.33%
07	Frame and Mounting System	0.00	0.00	0.00	$0.00	$0.00	$0.00	$0.00	0.00%
08	Clutch System	0.00	0.00	0.00	$0.00	$0.00	$0.00	$0.00	0.00%
09	Exhaust System	2.31	0.15	2.46	-$12.20	$2.05	-$10.15	-$4.12	0.12%
10	Fuel System	0.02	6.05	6.06	$0.18	$9.15	$9.32	$1.54	0.28%
11	Steering System	3.85	0.00	3.85	-$110.88	$0.00	-$110.88	-$28.76	0.16%
12	Climate Control System	1.16	0.00	1.16	$7.99	$0.00	$7.99	$6.90	0.05%
13	Information, Gage and Warning Divice System	0.23	0.00	0.23	$1.26	$0.00	$1.26	$5.49	0.01%
14	Electrical Power Supply System	12.96	0.00	12.96	-$184.33	$0.00	-$184.33	-$14.22	0.61%
15	In-Vehicle Entertainment System	0.00	0.00	0.00	$0.00	$0.00	$0.00	$0.00	0.00%
16	Vacuum Distrbution Subsystem	0.00	0.00	0.00	$0.00	$0.00	$0.00	$0.00	0.00%
17	Lighting System	0.39	0.00	0.39	-$2.02	$0.00	-$2.02	-$5.23	0.02%
18	Electrical Distribution and Electronic Control System	2.85	0.00	2.85	$27.22	$0.00	$27.22	$9.54	0.13%
19	Electronic Features System	0.00	0.00	0.00	$0.00	$0.00	$0.00	$0.00	0.00%
a	Analysis TotalsWithout NVH Counter Measures →	406.22	18.38	424.59	-$2,231.06	$51.14	-$2,179.91	-$5.13	19.92%
b	Vehicle NVH Counter Measures →	---	---	-37.85	---	---	-$113.55	---	---
c	Analysis Totals With NVH Counter Measures →			**386.75** (Decrease)			**-$2,293.46** (Increase)	**-$5.93** (Increase)	**18.15%**

(1) "+" = mass decrease, "-" = mass increase
(2) "+" = cost decrease, "-" = cost increase

Shown below is the vehicle cost curve w/ Trendline and secondary mass savings with description.

Table 2-4: Vehicle Cost Curve w/ Trendline, Mercedes Sprinter



Trendline Description	Cost/Kilogram Mass Reduction Formula	% Vehicle Mass Reduction Zone
With Mass Compounding/Secondary Mass Savings	$/kg =172.86*(VMR) -6.314 $/kg = 34.497*(VMR)-0.5536	0% < VMR ≤ 4.2% 4.2% < VMR ≤ 18%

VMR = Vehicle Mass Reduction (Sprinter)

DRAFT

2.4 RENAULT MASTER

Shown below is the Vehicle Level Summary chart by system new tech and secondary mass savings.

Table 2-5: Vehicle Level Summary, Renault Master

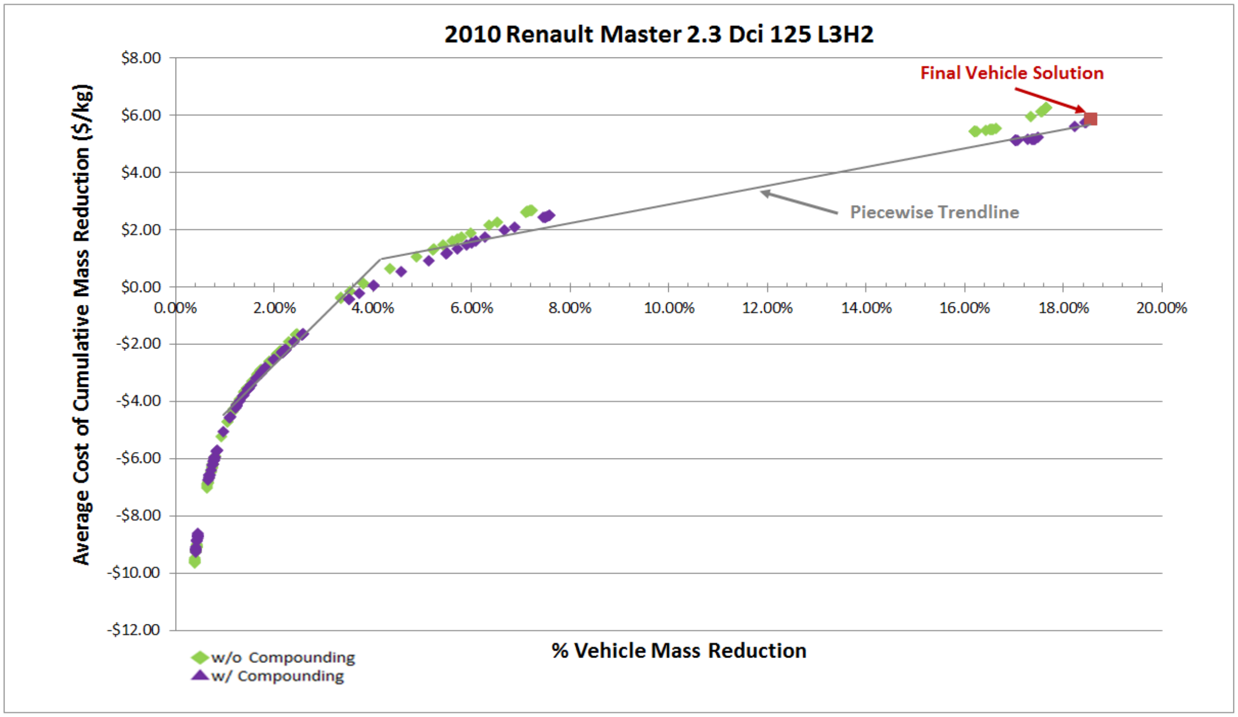
System	Description	Mass Reduction New Tech "kg" (1)	Mass Reduction Comp "kg" (1)	Mass Reduction Total "kg" (1)	Cost Impact New Tech "$" (2)	Cost Impact Comp "$" (2)	Cost Impact Total "$" (2)	Cost/ Kilogram Total "$/kg"	Vehicle Mass Reduction Total "%"
		Mass Reduction Impact by System							
00	**Renault Master DCi**								
01	Engine System	30.51	5.46	35.98	-$132.57	$23.75	-$108.83	-$3.03	1.53%
02	Transmission System	7.00	2.43	9.44	-$10.14	$7.78	-$2.36	-$0.25	0.40%
03	Body System (Group -A-)	258.80	5.86	264.66	-$1,685.32	-$33.77	-$1,719.09	-$6.50	11.25%
03	Body System (Group -B-)	23.67	0.00	23.67	-$91.43	$0.00	-$91.43	-$3.86	1.01%
03	Body System (Group -C-)	1.62	0.00	1.62	$2.27	$0.00	$2.27	$1.40	0.07%
03	Body System (Group -D-) Glazing & Body Mechatronics	2.18	0.00	2.18	$1.12	$0.00	$1.12	$0.51	0.09%
04	Suspension System	56.87	2.86	59.73	-$140.45	$18.76	-$121.70	-$2.04	2.54%
05	Driveline System	13.38	0.00	13.38	$35.93	$0.00	$35.93	$2.68	0.57%
06	Brake System	31.34	0.60	31.94	-$123.41	$6.17	-$117.24	-$3.67	1.36%
07	Frame and Mounting System	0.00	0.00	0.00	$0.00	$0.00	$0.00	$0.00	0.00%
08	Clutch System	0.00	0.00	0.00	$0.00	$0.00	$0.00	$0.00	0.00%
09	Exhaust System	2.13	0.18	2.31	-$11.48	$2.33	-$9.15	-$3.97	0.10%
10	Fuel System	0.01	5.81	5.82	$0.14	$8.79	$8.92	$1.53	0.25%
11	Steering System	5.47	0.00	5.47	-$90.37	$0.00	-$90.37	-$16.53	0.23%
12	Climate Control System	0.59	0.00	0.59	$2.91	$0.00	$2.91	$4.96	0.02%
13	Information, Gage and Warning Divice System	0.13	0.00	0.13	$0.66	$0.00	$0.66	$4.91	0.01%
14	Electrical Power Supply System	18.13	0.00	18.13	-$257.84	$0.00	-$257.84	-$14.22	0.77%
15	In-Vehicle Entertainment System	0.00	0.00	0.00	$0.00	$0.00	$0.00	$0.00	0.00%
16	Vacuum Distrbution Subsystem	0.00	0.00	0.00	$0.00	$0.00	$0.00	$0.00	0.00%
17	Lighting System	0.39	0.00	0.39	-$2.02	$0.00	-$2.02	-$5.23	0.02%
18	Electrical Distribution and Electronic Control System	3.81	0.00	3.81	$32.99	$0.00	$32.99	$8.65	0.16%
19	Electronic Features System	0.00	0.00	0.00	$0.00	$0.00	$0.00	$0.00	0.00%
a	Analysis TotalsWithout NVH Counter Measures →	456.06	23.20	479.25	-$2,469.04	$33.80	-$2,435.24	-$5.08	20.36%
b	Vehicle NVH Counter Measures →	---	---	-42.72	---	---	-$128.16	---	---
c	Analysis Totals With NVH Counter Measures →			**436.53** (Decrease)			**-$2,563.40** (Increase)	**-$5.87** (Increase)	**18.55%**

(1) "+" = mass decrease, "-" = mass increase
(2) "+" = cost decrease, "-" = cost increase

DR

Shown below is the vehicle cost curve w/ Trendline and secondary mass savings with description.

Table 2-6: Vehicle Cost Curve w/ Trendline, Renault Master



Trendline Description	Cost/Kilogram Mass Reduction Formula	% Vehicle Mass Reduction Zone
With Mass Compounding/Secondary Mass Savings	$/kg =170.94*(VMR) - 6.1459 $/kg = 32.718*(VMR)-0.3747	0% < VMR ≤ 4.2% 4.2% < VMR ≤ 19%

VMR = Vehicle Mass Reduction (Master)

DRAFT

3. MASS-REDUCTION AND COST ANALYSIS, SYSTEM LEVEL

3.1 ENGINE SYSTEM

3.1.1 Silverado 1500

3.1.1.1 Baseline Technology, Silverado 1500

The Chevrolet Silverado 1500 came equipped with a 5.3 Liter V8 producing 315 horse power and 335 ft-lbs of torque. Designated by Chevrolet as their LC9 variant, this engine features cylinder deactivation and flex fuel compatibility. Other features include aluminum deep skirt, closed deck block with cast-in liners and six bolt mains. The cam-in-block pushrod design has been outfitted with phaser-enabled variable valve timing. This naturally aspirated, port-injected layout utilizes a single runner intake manifold. All aluminum construction and plastic intake manifold are lightweight features already implemented by GM for the Gen IV Small Block in 2006 [7]. Currently, research is being done to make aluminum stronger and cast iron lighter in mass [8].

Image 3.1–1: Silverado 1500 base engine (5.3 liter LC9)
(Source: http://www.gmpowertrain.ca/product.html)

3.1.1.2 Mass-Reduction and Cost Impact, Silverado 1500

The Silverado 1500 analysis identified mass reduction alternatives and cost implications for the Engine System with the intent to meet the function and performance requirements of the baseline vehicle. Table 3-1 provides a summary of mass reduction and cost impact for select sub-subsystems

[7] GM Authority – "GM 5.3 Liter V8 Vortec LC9 Engine", accessed on April 2015, http://gmauthority.com/blog/gm/gm-engines/lc9/

[8] ENERGY.GOV – "Vehicle Technologies Office: Lightweight Materials for Cars and Trucks", accessed on June 2015, http://energy.gov/eere/vehicles/vehicle-technologies-office-lightweight-materials-cars-and-trucks

evaluated. Only sub-subsystems with significant mass savings were included and account for over 80% of the total mass savings found on the engine. Total system mass was reduced by 23.8 kg (9.92%). This increased cost by $114.63, or $4.82 per kg. Mass reduction for this system reduced vehicle curb weight by 0.97%.

Table 3-1: Mass-Reduction and Cost Impact, Silverado 1500

System	Subsystem	Sub-Subsystem	Description	Net Value of Mass Reduction: Base Mass "kg"	Mass Reduction "kg" (1)	Cost Impact NIDMC "$" (2)	Average Cost/ Kilogram "$/kg" (2)	Mass Reduction "%"	Vehicle Mass Reduction "%"
01	00	00	Engine System						
01	02	00	Engine Frames, Mounting, and Brackets Subsystem	6.07	1.10	-$0.01	-$0.01	18.18%	0.04%
01	**03**	**00**	**Crank Drive Subsystem**	**37.00**	**2.38**	**$2.95**	**$1.24**	**6.42%**	**0.10%**
01	03	01	Crankshaft	24.01	1.03	-$2.29	-$2.22	4.30%	0.04%
01	03	03	Connect Rods (Assemblies: Connecting Rod, Connecting Rod Cap)	5.41	1.07	$6.34	$5.92	19.82%	0.04%
01	03	04	Other Components	7.59	0.272	-$1.10	-$4.05	3.58%	0.01%
01	**05**	**00**	**Cylinder Block Subsystem**	**59.86**	**3.30**	**$0.80**	**$0.24**	**5.51%**	**0.13%**
01	05	01	Cylinder Block	47.15	2.93	$2.78	$0.95	6.22%	0.12%
01	05	02	Other Components	12.71	0.364	-$1.98	-$5.45	2.86%	0.01%
01	**06**	**00**	**Cylinder Head Subsystem**	**24.90**	**1.16**	**$6.06**	**$5.22**	**4.66%**	**0.05%**
01	06	20	Cylinder Head Covers	2.64	1.16	$6.06	$5.22	43.96%	0.05%
01	**07**	**00**	**Valvetrain Subsystem**	**16.26**	**0.192**	**$0.05**	**$0.26**	**1.18%**	**0.01%**
01	07	06	Camshafts	4.60	0.085	-$0.03	-$0.39	1.85%	0.00%
01	07	07	Other Components	11.65	0.107	$0.08	$0.78	0.92%	0.00%
01	**08**	**00**	**Timing Drive Subsystem**	**1.75**	**0.415**	**-$2.44**	**-$5.88**	**23.72%**	**0.02%**
01	**09**	**00**	**Accessory Drive Subsystem**	**8.27**	**1.73**	**$0.73**	**$0.42**	**20.94%**	**0.07%**
01	09	01	Pulleys	7.27	1.73	$0.73	$0.42	23.82%	0.07%
01	**10**	**00**	**Air Intake Subsystem**	**11.95**	**0.941**	**-$0.54**	**-$0.58**	**7.88%**	**0.04%**
01	**11**	**00**	**Fuel Induction Subsystem**	**1.12**	**0.00**	**$0.00**	**$0.00**	**0.00%**	**0.00%**
01	**12**	**00**	**Exhaust Subsystem**	**12.17**	**3.15**	**-$20.00**	**-$6.35**	**25.88%**	**0.13%**
01	12	01	Exhaust Manifold	12.17	3.15	-$20.00	-$6.35	25.88%	0.13%
01	**13**	**00**	**Lubrication Subsystem**	**10.55**	**3.01**	**-$11.24**	**-$3.74**	**28.53%**	**0.12%**
01	13	01	Oil Pans (Oil Sump)	7.78	2.58	-$11.29	-$4.37	33.18%	0.11%
01	13	02	Other Components	2.77	0.429	$0.04	$0.10	15.48%	0.02%
01	**14**	**00**	**Cooling Subsystem**	**24.32**	**3.31**	**-$92.06**	**-$27.78**	**13.63%**	**0.14%**
01	14	01	Water Pumps	4.68	2.43	-$94.12	-$38.71	51.91%	0.10%
01	14	04	Heat Exchangers	14.23	1.06	$2.16	$2.04	7.45%	0.04%
01	14	05	Other Components	5.41	-0.176	-$0.10	$0.58	-3.26%	-0.01%
01	16	00	Exhaust Gas Re-circulation Subsystem	0.050	0.00	$0.00	$0.00	0.00%	0.00%
01	17	00	Breather Subsystem	0.109	0.00	$0.00	$0.00	0.00%	0.00%
01	**60**	**00**	**Engine Management, Engine Electronic, Electrical Subsystem**	**5.67**	**0.886**	**$1.97**	**$2.23**	**15.63%**	**0.04%**
01	**70**	**00**	**Accessory Subsystems (Start Motor, Generator, etc.)**	**19.89**	**2.23**	**-$0.89**	**-$0.40**	**11.20%**	**0.09%**
01	70	99	Misc.	3.69	1.86	$1.53	$0.82	50.47%	0.08%
01	70	01	Other Components	16.21	0.369	-$2.42	-$6.55	2.28%	0.02%
				239.95	23.80 (Decrease)	-$114.63 (Increase)	-$4.82 (Increase)	9.92%	0.97%

(1) "+" = mass decrease, "-" = mass increase
(2) "+" = cost decrease, "-" = cost increase

3.1.1.3 Lightweighting Technology, Silverado 1500

Mass savings opportunities were identified for the following components: crankshaft, connecting rod, cylinder block, cylinder head covers, pulleys, exhaust manifolds, oil pans, water pump, radiator, and accessory drive bracket.

Crankshaft: The crankshaft mass was reduced by changing the cast crankshaft to a hollow cast design. The main bearing journals were cast with a core to remove excess material. Mass was reduced by 4.3% from 24.0 kg to 23.0 kg.

Production applications include the BMW 4.4L V8 and the Nissan 4.5L V8.

Connecting Rod: Connecting rod mass reduction was achieved by changing the primary forming operation from powder forged to billet forged. The connecting rod mass was reduced by 19.8% from 5.41 kg to 4.34 kg.

FEV validated this change by creating CAD models for both connecting rods and performing fatigue analysis. Mahle manufactures connecting rods using this technology.

Cylinder Block: Cylinder block mass was reduced by replacing cast iron bore liners with plasma liner technology. Mass was reduced by 6.2% from 47.1 kg to 44.2 kg.

Production vehicles utilizing this technology include Nissan GT-R, 2011 Shelby Mustang GT500, and VW Lupo and were used as the base technology mass reduction for the Silverado 1500 original study.

Cylinder Head Covers: Aluminum valve covers were replaced by plastic. Mass was reduced by 44.0% from 2.64 kg to 1.48 kg.

Production examples include Chrysler's 4.7L V8 and the Ford Duratec® 2.0L.

Pulleys: The idler and AC compressor pulleys were all found to have Lightweighting opportunities. The steel idler pulley was replaced with a plastic design, which reduced mass by 58.0% from 0.455 kg to 0.191 kg. Plastic idler pulleys are commonplace and have proven durability.

The AC compressor pulley was changed from steel to plastic, which reduced mass by 59.8% from 0.695 kg to 0.279 kg. The VW Polo is a production example containing a plastic AC compressor pulley and was used as the base technology mass reduction for the Silverado 1500 original study.

Exhaust Manifold: Cast iron exhaust manifolds were eliminated by replacing the components with a stainless steel fabricated assembly. Mass was reduced by 26.2% from 12.2 kg to 9.02 kg.

Production examples of fabricated manifolds include the Toyota Avensis 2.0-R4 4V and LS7 Corvette and were used as the base technology mass reduction for the Silverado 1500 original study.

Oil Pan: Mass reduction of the oil pan was achieved by replacing aluminum with magnesium. Mass was reduced by 25% from 5.27 kg to 3.96 kg. The Nissan GT-R oil pan is constructed from magnesium and was used as the base technology mass reduction for the Silverado 1500 original study.

Steel baffle plates were used to control oil flow within the oil pan region. These stamped steel plates were changed to plastic. Mass was reduced by 70.6% from 1.65 kg to 0.49 kg. The Ford Mustang utilizes plastic for this component.

Water Pump: The conventional mechanical water pump was replaced with an electric water pump. Mass was reduced by 51.9% from 4.68 kg to 2.43 kg.

Electric water pumps are found on vehicles such as the BMW 328, 528, and X3/5 and were used as the base technology mass reduction for the Silverado 1500 original study.

Radiator: The radiator found on the Silverado was designed for a range of applications. A radiator designed specifically for the 5.3L Silverado could be smaller reducing component and fluid mass. Mass was reduced by 4% from 6.79 kg to 6.52 kg. MuCell® applied to the fan shroud and fan blades, which yielded an additional mass savings of 0.32 kg.

DRAFT

Accessory Drive Bracket: The accessory drive bracket provides mounting for both the alternator and power steering pump. This aluminum component was replaced with a magnesium version and the power steering provision eliminated as this feature is no longer needed with electric power steering. Mass was reduced by 50.5% from 3.69 kg to 1.83 kg. An example of a magnesium bracket can be found on the Nissan 350Z and was used as the base technology mass reduction for the Silverado 1500 original study.

DRAFT

3.1.2 Silverado 2500

3.1.2.1 Baseline Technology, Silverado 2500

The Chevrolet Silverado 2500 came equipped with a 6.0 Liter V8 producing 360 hp and 380 ft-lbs of torque [9]. This GM LC8 engine (Image 1.4–2) is equipped with Compressed Natural Gas (CNG) compatibility. Other standard GM generation IV features include traditional cam in block design with wedge style cylinder heads and six bolt mains. The LC8 engine variant was not equipped with cylinder deactivation and utilizes a cast iron cylinder block. Components included in the CNG adaptation of this engine (i.e., fuel rail, injectors, etc.) are considered a separate system and not included in this analysis.

Image 3.1–2: Silverado 2500 base engine (6.0 liter LC8)
(Source: http://www.gmpowertrain.com)

[9] The Chevrolet Bi-Fuel CNG Silverado 2500 HD Truck. Retrieved from GM Fleet & Commercial: http://www.gmfleet.com/vehicle-overviews/fuel-efficiency/bi-fuel.html

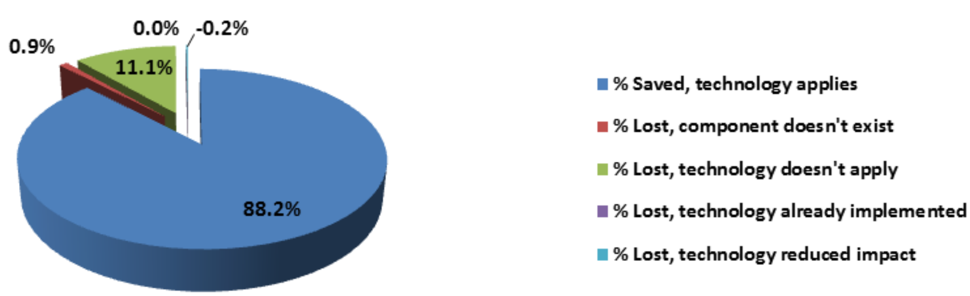
3.1.2.2 Mass Savings and Cost Impact, Silverado 2500

Table 3-2 summarizes mass and cost impact of Silverado 1500 Lightweighting technologies applied to the Silverado 2500. Total engine mass savings was 33.08 kg at a cost increase of $2.44 per kg. The total mass savings using an aluminum block in place of a cast iron block for the 2500, for a greater weight savings was 71.64kg and a cost increase of $2.58 per kg.

Table 3-2: Mass Reduction and Cost Impact for Engine System, Silverado 2500

				Net Value of Mass Reduction							
System	Subsystem	Sub-Subsystem	Description	Mass Reduction New Tech "kg" (1)	Mass Reduction Comp "kg" (1)	Mass Reduction Total "kg" (1)	Cost Impact New Tech "$" (2)	Cost Impact Comp "$" (2)	Cost Impact Total "$" (2)	Cost/ Kilogram Total "$/kg"	Vehicle Mass Reduction Total "%"
01	00	00	**Engine System**								
01	02	00	Engine Frames, Mounting, and Brackets Subsystem	0.95	0.37	1.32	$0.12	$0.60	$0.73	$0.55	0.04%
01	03	00	Crank Drive Subsystem	2.37	2.00	4.37	$2.88	$3.83	$6.71	$1.53	0.14%
01	04	00	Counter Balance Subsystem	0.00	0.00	0.00	$0.00	$0.00	$0.00	$0.00	0.00%
01	05	00	Cylinder Block Subsystem (Aluminum)	0.60	6.97	7.57	-$2.20	$21.29	$19.09	$2.52	0.25%
01	05	00	Cylinder Block Subsystem (Iron to Aluminum)	43.08	3.04	46.12	-$111.42	$26.83	-$84.59	-$1.83	1.88%
01	06	00	Cylinder Head Subsystem	1.17	1.45	2.62	$6.12	$4.39	$10.51	$4.01	0.08%
01	07	00	Valvetrain Subsystem	0.19	0.14	0.33	$0.06	$0.49	$0.55	$1.67	0.01%
01	08	00	Timing Drive Subsystem	0.44	0.00	0.44	-$2.57	$0.00	-$2.57	$0.00	0.01%
01	09	00	Accessory Drive Subsystem	0.66	0.35	1.01	$0.73	$0.00	$0.73	$0.72	0.03%
01	10	00	Air Intake Subsystem	0.87	0.00	0.87	-$0.56	$0.00	-$0.56	-$0.64	0.03%
01	11	00	Fuel Induction Subsystem	0.00	0.00	0.00	$0.00	$0.00	$0.00	$0.00	0.00%
01	12	00	Exhaust Subsystem	3.15	0.22	3.37	-$20.00	$0.78	-$19.22	-$5.70	0.11%
01	13	00	Lubrication Subsystem	2.94	0.08	3.02	-$10.70	$0.39	-$10.31	-$3.41	0.10%
01	14	00	Cooling Subsystem	4.33	0.52	4.85	-$90.22	$2.40	-$87.81	-$18.11	0.16%
01	15	00	Induction Air Charging Subsystem	0.00	0.00	0.00	$0.00	$0.00	$0.00	$0.00	0.00%
01	16	00	Exhaust Gas Re-circulation Subsystem	0.00	0.00	0.00	$0.00	$0.00	$0.00	$0.00	0.00%
01	17	00	Breather Subsystem	0.00	0.00	0.00	$0.00	$0.00	$0.00	$0.00	0.00%
01	60	00	Engine Management, Engine Electronic, Electrical Subsystem	0.93	0.00	0.93	$2.07	$0.00	$2.07	$0.00	0.03%
01	70	00	Accessory Subsystems (Start Motor, Generator, etc.)	2.40	0.00	2.40	-$0.80	$0.00	-$0.80	-$0.33	0.08%
			Original aluminum block totals	21.00	12.09	33.08	-$115.06	$34.17	-$80.89	-$2.44	1.07%
			Aluminum cyclinder block totals	63.48	8.16	71.64	-$224.28	$39.71	-$184.57	-$2.58	2.71%
				(Decrease)	(Decrease)	(Decrease)	(Increase)	(Decrease)	(Increase)	(Increase)	

Mass Savings, Select Vehicle, New Technology "kg"	21.00
Mass Savings, Silverado 1500, New Technology "kg"	23.80
Mass Savings Select Vehicle/Mass Savings 1500	88.2%



*SMS not included - has no significant impact on perecent contributions

Note: The gray shaded areas in the chart above indicate using an aluminum block in place of a cast iron block for the 2500, for a greater weight savings. This iron to aluminum weight savings will be used for all vehicle summary charts.

The Silverado 1500 engine block was aluminum and further light weighted by reducing the mass of the iron cylinder liners. General Motors selected a cast iron engine block for the Silverado 2500. Plasma cylinder liner technology does not apply to cast iron engine blocks. The Silverado 1500 mass savings associated with the cylinder liner comprises the portion of the pie titled “% Lost, technology doesn’t apply.” The flywheel and accessory bracket were both slightly larger on the 2500 series truck; therefore, saw more benefit from Lightweighting technologies. For this reason “% Lost, technology reduced impact” is a negative 1.3%. The 2500 series engine mount fastened directly to the engine block with no additional bracket as was found on the 1500 series. This is an example of “% Lost, component does not exist.”

DRAFT

3.1.2.3 System Scaling Analysis, Silverado 2500

The Silverado 2500 engine components were reviewed for compatibility with Lightweighting technologies. The results of this analysis are listed in Table 3-3.

Table 3-3: System Scaling Analysis, Silverado 2500

Silverado 1500							Select Vehicle			
System	Subsystem	Sub-Subsystem	Component/Assembly	Base Mass	Mass Savings New Tech	% of Mass Savings New Tech	Tech Applies	Base Mass	Mass Savings New Tech	Notes
01			**Engine System**	**239.95**	**23.80**	**10%**			**21.00**	
01	02	02	Engine Mount	4.00	0.55	14%	Yes	4.48	0.61	Tech **DOES** apply: AHSS applies
01	02	02	Engine Mount Bracket	0.98	0.22	22%	No			Tech does **NOT** apply: Component does not exist on 2500 series.
01	02	10	Engine Lift Bracket & Bolt	0.33	0.33	100%	Yes	0.34	0.33	Tech **DOES** apply: Mass reduction by bracket removal after installation applies.
01	03	01	Crankshaft Assembly	24.01	1.03	4%	Yes	24.19	1.04	Tech **DOES** apply: Cored crankshaft technology applies.
01	03	03	Connect Rod	4.66	1.07	23%	Yes	4.62	1.06	Tech **DOES** apply: Powder forged connecting rod; billet forged mass savings applies.
01	03	04	Piston	3.39	0.00	0%	No			Tech does **NOT** apply: Secondary mass savings applies
01	03	04	Wrist Pin	1.19	0.27	23%	Yes	1.19	0.27	Tech **DOES** apply: Tapered wrist pin techology applies.
01	05	01	Cylinder Block	46.05	2.64	6%	No			Tech does **NOT** apply: Cast Iron Block; plasma liner technology does not apply.
01	05	01	Rear Main Seal Retainer	0.79	0.30	38%	Yes	0.78	0.29	Tech **DOES** apply: Metal to plastic replacement applies
01	05	99	Cylinder Deactivation Assembly	1.19	0.36	31%	Yes	1.00	0.31	Tech **DOES** apply: Aluminum to magnesium savings applies
01	06	01	Cylinder Head	18.64	0.00	0%	No			Tech does **NOT** apply: Secondary mass savings applies
01	06	20	Valve Covers	2.28	1.16	51%	Yes	2.30	1.17	Tech **DOES** apply: metal to plastic technology applies
01	07	06	Camshaft	4.38	0.00	0%	Yes	4.37		Secondary mass savings applies
01	07	06	Camshaft Retainer Plate	0.19	0.09	45%	Yes	0.19	0.08	Tech **DOES** apply: Steel to Aluminum technology applies.
01	07	08	Phaser Wire Harness Bracket	0.14	0.11	75%	Yes	0.14	0.11	Tech **DOES** apply: Metal to plastic replacement applies
01	08	06	Front Cover	1.11	0.42	37%	Yes	1.17	0.44	Tech **DOES** apply: Metal to plastic replacement applies
01	09	01	Idler Pulley	0.46	0.26	58%	Yes	0.42	0.25	Tech **DOES** apply: Metal to plastic replacement applies
01	09	01	Crank Pulley	4.64	0.00	0%	Yes	4.54		Secondary mass savings applies
01	09	01	AC Compressor Pulley	0.85	0.42	49%	Yes	0.86	0.42	Tech **DOES** apply: Metal to plastic replacement applies
01	10	01	Intake Manifold	5.76	0.28	5%	Yes	5.67	0.27	Tech **DOES** apply: 3M glass bubble technology applies.
01	10	02	Air Filter Box	4.50	0.66	15%	Yes	4.02	0.59	Tech **DOES** apply: MuCell technology applies.
01	12	01	Exhaust Manifold	12.17	3.15	26%	Yes	12.17	3.15	Tech **DOES** apply: Fabricated exhaust manifold technology applies.
01	13	01	Oil Pan	5.47	1.41	26%	Yes	5.17	1.34	Tech **DOES** apply: Aluminum to magnesium savings applies
01	13	01	Oil Pan Baffle Plate	0.38	0.27	70%	Yes	0.38	0.27	Tech **DOES** apply: Metal to plastic replacement applies
01	13	01	Crank Cover Baffle Plate	1.27	0.90	71%	Yes	1.27	0.90	Tech **DOES** apply: Metal to plastic replacement applies
01	13	02	Oil Pick-Up Tube	0.67	0.43	64%	Yes	0.68	0.44	Tech **DOES** apply: Metal to plastic replacement applies
01	14	00	Water Pumps, Pulley, Thermostat	6.05	3.25	54%	Yes	5.94	3.19	Tech **DOES** apply: Electric water pump technology applies.
01	14	04	Engine Heat Exchanger Assembly	6.79	0.27	4%	Yes	7.35	0.29	Tech **DOES** apply: Application specific heat exchanger savings applies
01	14	04	Main Coolant Fan Assembly	2.55	0.79	31%	Yes	2.56	0.80	Tech **DOES** apply: MuCell technology applies
01	17	99	Coolant Bleed Line (Cylinder Head)	0.12	0.05	45%	Yes	0.12	0.05	Tech **DOES** apply: Metal to plastic replacement applies
01	60	03	Coil Bracket (DS)	0.56	0.44	79%	Yes	0.59	0.46	Tech **DOES** apply: Steel integrated into existing Al component savings applies
01	60	03	Coil Bracket (PS)	0.56	0.44	79%	Yes	0.59	0.46	Tech **DOES** apply: Steel integrated into existing Al component savings applies
01	70	05	AC Compressor Bracket	1.24	0.37	30%	Yes	1.27	0.38	Tech **DOES** apply: Aluminum to magnesium savings applies
01	70	99	Accessory Bracket	3.36	1.86	55%	Yes	3.65	2.02	Tech **DOES** apply: Aluminum to magnesium savings applies

If the original Silverado 1500 mass reduction concept idea was not able to be applied to the comparison vehicle it is not described in the section below.

Components with significant mass savings identified on the Silverado 2500 series include the connecting rod, exhaust manifold, crankshaft, oil pan, and water pump.

Connecting Rod

As shown in Image 3.1–3, the 1500 series with LC9 engine uses the same connecting rod as the 2500 series LC8 engine. Component masses are 4.66 kg for the 1500 versus 4.62 kg for the 2500 respectively. The factory LC8 connecting rod as well as an optimized billet forged version can be seen in Image 3.1–4. Forged C-70's strength advantage allows for mass reduction and its compatibility with the crack-break manufacturing process maintains costs. Due to similarities in component design and material, full percentage of the Silverado 1500 connecting rod mass reduction can be applied to the 2500. (Refer to Table 3-3).

Image 3.1–3: Connecting rod for 5.3 liter LC9 (Left) and 6.0 liter LC8 (Right)
(Source: FEV, Inc.)

Image 3.1–4: Connecting rod for 5.3 liter LC9 (Left) and C-70 rod (Right)
(Source: FEV, Inc.)

DRAFT

Exhaust Manifold

The LC9 and LC8 share common exhaust manifolds down to the part number (Image 3.1–5). Fabricated exhaust manifolds saves significant mass. Image 3.1–6 and Image 3.1-7 are examples of fabricated exhaust manifolds. Due to similarities in component design and material, full percentage of the Silverado 1500 exhaust manifold mass reduction can be applied to the 2500. (Refer to Table 3-3).

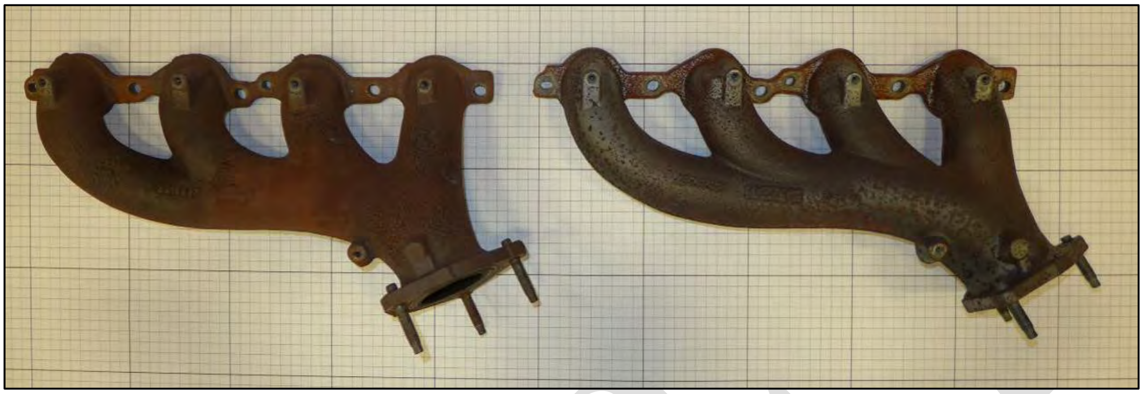


Image 3.1–5: Exhaust manifold for 5.3 liter LC9 (Left), 6.0 liter LC8 (Right)
(Source: FEV, Inc.)

Image 3.1–6: Fabricated V8 Exhaust Manifold (LS7 Corvette)
(Source: http://www.ebay.com)

DRAFT

Image 3.1-7: Fabricated Exhaust Manifold
(Source: http://www.ddperformanceresearch.com)

Crankshaft

As shown below in Image 3.1–8, the LC9 and LC8 crankshafts are very similar with the mass of the LC8 being 0.19 kg, or 0.7% more. Crankshaft coring (Image 3.1–9) for weight reduction does apply to the LC8 crankshaft. Due to similarities in component design and material, full percentage of the Silverado 1500 crankshaft mass reduction can be applied to the 2500. (Refer to Table 3-3).

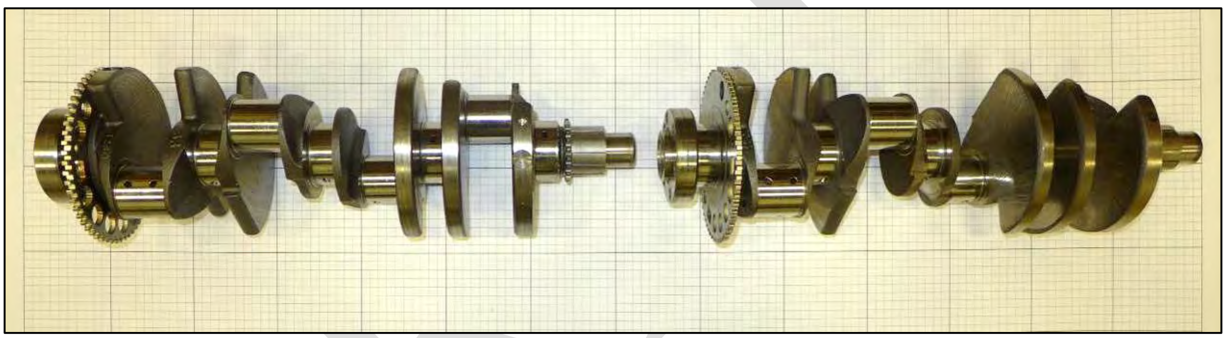


Image 3.1–8: Crankshaft for 5.3 liter LC9 (Left) and 6.0 liter LC8 (Right)
(Source: FEV, Inc.)

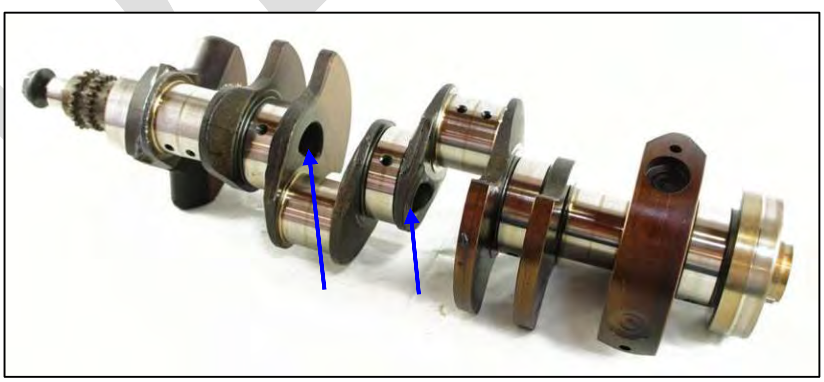


Image 3.1–9: Cored crankshaft for BMW 4.4L V8
(Source: eurochopshop.com photo)

Oil Pan

DRAFT

As shown in Image 3.1–10, the LC9 and LC8 oil pans are the same. Component masses are 5.47 kg for the 1500 and 5.17 kg for the 2500 respectively. Magnesium in this application offers a weight reduction (Image 3.1–11). Due to similarities in component design and material, full percentage of the Silverado 1500 oil pan mass reduction can be applied to the 2500. (Refer to Table 3-3).

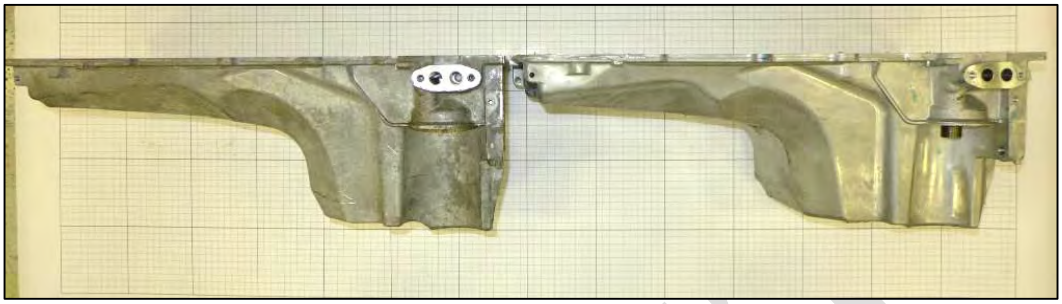


Image 3.1–10: Oil pan for 5.3 liter LC9 (Left) and 6.0 liter LC8 (Right)
(Source: FEV, Inc.)

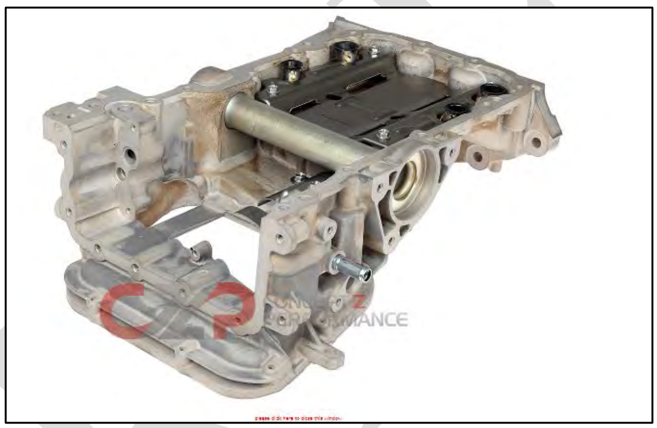


Image 3.1–11: Oil pan (magnesium) for Nissan GTR
(Source: www.conceptzperformance.com)

DRAFT

Water Pump

As shown in Image 3.1–12, the LC9 and LC8 water pumps are the same. An electric water pump offers the advantage of a tailored flow rate to match engine cooling requirements. This presents an energy savings versus directly coupled mechanical pumps, which are sized to cool engines at low engine speed and over-deliver at high engine speed. Additionally, electric water pumps coupled with electronically controlled thermostats present a mass savings (Image 3.1–13). An electric water pump in this application saves an estimated 3.19 kg and improves fuel efficiency. Due to similarities in component design and material, full percentage of the Silverado 1500 water pump mass reduction can be applied to the 2500. (Refer to Table 3-3).

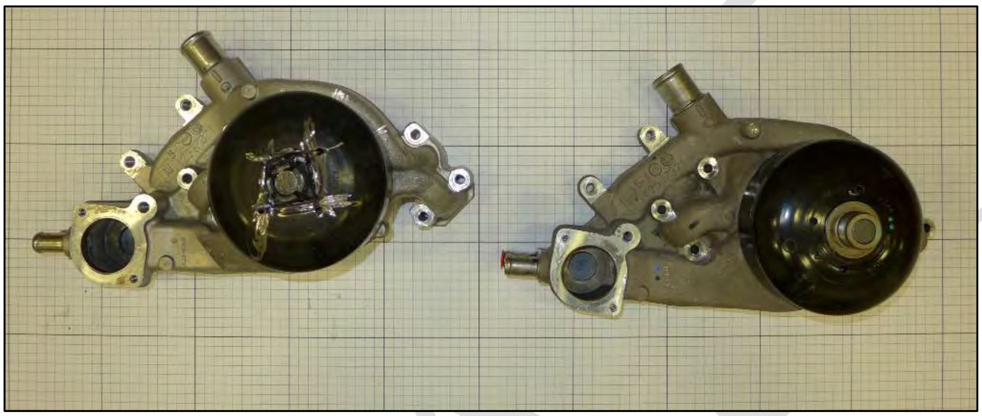


Image 3.1–12: Water pump for 5.3 liter LC9 (Left) and 6.0 liter LC8 (Right)
(Source: FEV, Inc.)

DRAFT

Image 3.1–13: Water pump assembly components, electric water pump (Left) and thermostat (Right)
(Source: left – www.daviescraig.com.au; right - www.autopartsway.com)

Accessory Bracket

As shown in Image 3.1–14, the LC9 and LC8 accessory brackets are very similar. Magnesium in this application saves weight versus aluminum. Component masses are 3.36 kg for the 1500 and 3.65 kg for the 2500 respectively. Due to similarities in component design and material, full percentage of the Silverado 1500 accessory bracket mass reduction can be applied to the 2500. (Refer to Table 3-3).

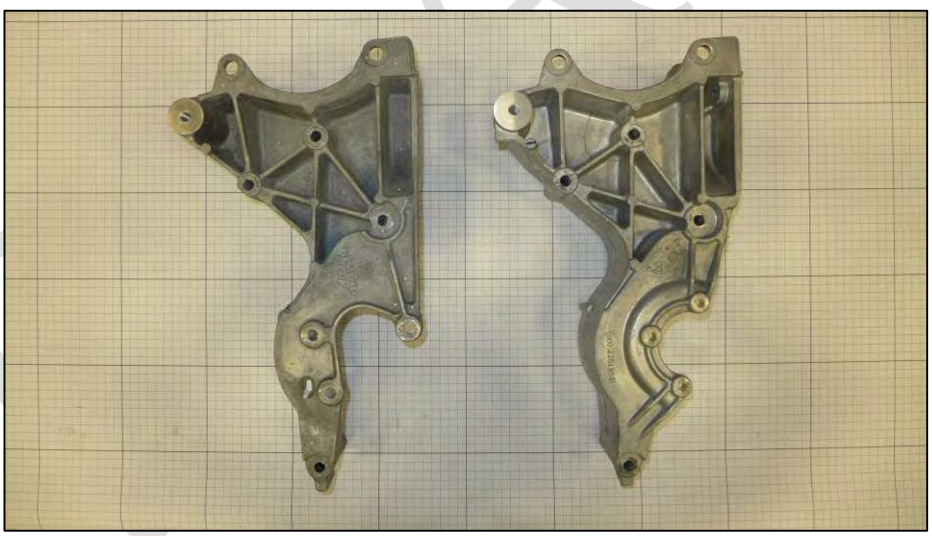


Image 3.1–14: Accessory bracket for 5.3 liter LC9 (Left) and 6.0 liter LC8 (Right)
(Source: FEV, Inc.)

DRAFT

3.1.2.4 System Comparison, Silverado 2500

Table 3-4 summarizes the Silverado 1500 and 2500 Lightweighting results. The LC8 engine weighs 50 kg more than the LC9, primarily because of its cast iron engine block. The LC8 engine did not feature cylinder deactivation, but did have a cover to replace the solenoid mechanism. Other changes included a mechanical fan instead of electric and larger pistons. A majority of the components were visually the same between the two engines. The engine block is responsible for the decrease in new technology mass savings for 2500.

Table 3-4: Engine System Comparison, Silverado 1500 and 2500

		Net Value of Mass Reduction								
System	Description	Mass Base "kg" (1)	Mass Reduction New Tech "kg" (1)	Mass Reduction Comp "kg" (1)	Mass Reduction Total "kg" (1)	System Mass Reduction "%"	Cost Impact New Tech "$" (2)	Cost Impact Comp "$" (2)	Cost Impact Total "$" (2)	Cost/ Kilogram Total "$/kg"
01	**Engine System**									
01	Silverado 1500 (LC9)	239.95	21.00	12.09	33.08	13.79%	-$115.06	$34.17	-$80.89	-$2.44
01	Silverado 2500 (LC8)	289.75	63.48	8.16	71.64	24.72%	-$224.28	$39.71	-$184.57	-$2.58

DRAFT

3.1.3 Mercedes Sprinter

3.1.3.1 Baseline Technology, Mercedes Sprinter

Mercedes Sprinter is powered by a 2.1 liter inline four-cylinder diesel engine (Image 3.1–15). The engine features common rail injection and fixed geometry turbo charging. Maximum power rating is 81kW with 280N•m of torque.

Image 3.1–15: Mercedes sprinter base engine (2.1 CDI)
(Source: www.A2mac1.com)

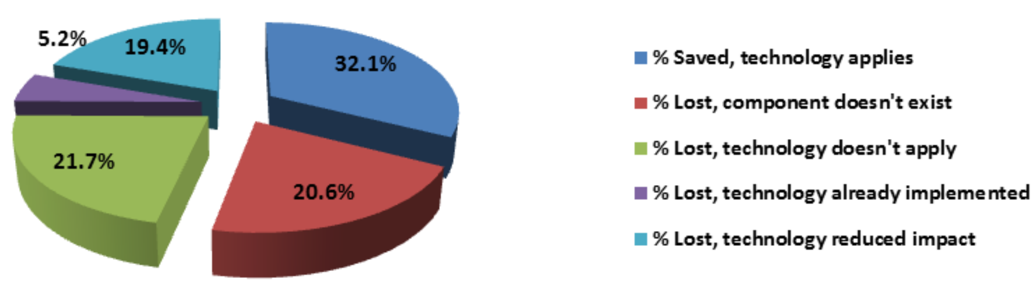
3.1.3.2 Mass Savings and Costa Impact, Mercedes Sprinter

Table 3-5 summarizes the mass and cost impact of Silverado 1500 Lightweighting technologies applied to the Mercedes Sprinter. Total engine mass savings is 13.75 kg at a cost increase of $2.01 per kg. The total mass savings using an aluminum block in place of a cast iron block for the Mercedes Sprinter, for a greater weight savings was 33.20 kg and a cost increase of $2.33 per kg.

Table 3-5: Mass-Reduction and Cost Impact for Engine System, Mercedes Sprinter

				Net Value of Mass Reduction							
System	Subsystem	Sub-Subsystem	Description	Mass Reduction New Tech "kg" (1)	Mass Reduction Comp "kg" (1)	Mass Reduction Total "kg" (1)	Cost Impact New Tech "$" (2)	Cost Impact Comp "$" (2)	Cost Impact Total "$" (2)	Cost/ Kilogram Total "$/kg"	Vehicle Mass Reduction Total "%"
01	00	00	**Engine System**								
01	02	00	Engine Frames, Mounting, and Brackets Subsystem	1.10	0.44	1.54	-0.76	0.72	-$0.05	-$0.03	0.07%
01	03	00	Crank Drive Subsystem	0.00	1.38	1.38	0.00	2.68	$2.68	$1.94	0.06%
01	04	00	Counter Balance Subsystem	0.00	0.00	0.00	0.00	0.00	$0.00	$0.00	0.00%
01	05	00	Cylinder Block Subsystem	0.07	2.88	2.95	-0.12	8.79	$8.67	$2.94	0.14%
01	05	00	Cylinder Block Subsystem (Aluminum)	20.92	1.48	22.40	-$54.11	$13.03	-$41.08	-$1.83	1.05%
01	06	00	Cylinder Head Subsystem	1.50	0.85	2.35	7.83	2.60	$10.43	$4.43	0.11%
01	07	00	Valvetrain Subsystem	0.00	0.14	0.14	0.00	0.49	$0.49	$3.57	0.01%
01	08	00	Timing Drive Subsystem	0.00	0.00	0.00	0.00	0.00	$0.00	$0.00	0.00%
01	09	00	Accessory Drive Subsystem	0.00	0.17	0.17	0.00	0.00	$0.00	$0.00	0.01%
01	10	00	Air Intake Subsystem	0.31	0.00	0.31	-0.05	0.00	-$0.05	-$0.15	0.01%
01	11	00	Fuel Induction Subsystem	0.00	0.00	0.00	0.00	0.00	$0.00	$0.00	0.00%
01	12	00	Exhaust Subsystem	0.77	0.05	0.82	-4.89	0.16	-$4.72	-$5.79	0.04%
01	13	00	Lubrication Subsystem	1.37	0.06	1.43	-8.68	0.30	-$8.38	-$5.87	0.07%
01	14	00	Cooling Subsystem	2.52	0.15	2.67	-37.46	0.68	-$36.78	-$13.77	0.13%
01	15	00	Induction Air Charging Subsystem	0.00	0.00	0.00	0.00	0.00	$0.00	$0.00	0.00%
01	16	00	Exhaust Gas Re-circulation Subsystem	0.00	0.00	0.00	0.00	0.00	$0.00	$0.00	0.00%
01	17	00	Breather Subsystem	0.00	0.00	0.00	0.00	0.00	$0.00	$0.00	0.00%
01	60	00	Engine Management, Engine Electronic, Electrical Subsystem	0.00	0.00	0.00	0.00	0.00	$0.00	$0.00	0.00%
01	70	00	Accessory Subsystems (Start Motor, Generator, etc.)	0.00	0.00	0.00	0.00	0.00	$0.00	$0.00	0.00%
				7.64	**6.11**	**13.75**	**-44.14**	**16.43**	**-$27.71**	**-$2.01**	**0.65%**
			Aluminum cylinder block totals	**28.49**	**4.71**	**33.20**	**-$98.12**	**$20.66**	**-$77.46**	**-$2.33**	**1.56%**
				(Decrease)	(Decrease)	(Decrease)	(Increase)	(Decrease)	(Increase)	(Increase)	

Mass Savings, Select Vehicle, New Technology "kg"	7.64
Mass Savings, Silverado 1500, New Technology "kg"	23.80
Mass Savings Select Vehicle/Mass Savings 1500	32.1%



*SMS not included - has no significant impact on perecent contributions

Note: The gray shaded areas in the chart above indicate using an aluminum block in place of a cast iron block for the Mercedes Sprinter, for a greater weight savings. This iron to aluminum weight savings will be used for all vehicle summary charts.

Mass savings could not be credited for components for which Lightweighting technologies did not apply. Reasons for this could be that the technology was already implemented such as in the Sprinter camshaft which was already hollow-cast. For other components the Lightweighting Technology may not apply because of part design. For example, the Sprinter crankshaft could not be hollow-cast because forging is required for strength in this diesel application. Some light weighted components of the Silverado 1500 analysis did not exist in the Sprinter, such as the flexplate, which did not exist on the manual transmission Sprinter.

3.1.3.3 System Scaling Analysis, Mercedes Sprinter

The Mercedes Sprinter Engine components were reviewed for compatibility with Lightweighting technologies. The results of this analysis are listed in Table 3-6.

Table 3-6: System Scaling Analysis, Mercedes Sprinter

Silverado 1500							Select Vehicle			
System	Subsystem	Sub-Subsystem	Component/Assembly	Base Mass	Mass Savings New Tech	% of Mass Savings New Tech	Tech Applies	Base Mass	Mass Savings New Tech	Notes
01			**Engine System**	**239.95**	**23.80**	**10%**			**7.64**	
01	02	02	Engine Mount	4.00	0.55	14%	No			Tech does **NOT** apply: Aluminum Mounts; AHSS does not apply.
01	02	02	Engine Mount Bracket	0.98	0.22	22%	Yes	1.91	0.43	Tech **DOES** apply: Stamped steel engine mount bracket. Deep draw, may require redesign for AHSS.
01	02	10	Engine Lift Bracket & Bolt	0.33	0.33	100%	Yes	0.67	0.67	Tech **DOES** apply: Assuming all lift bracket bolts are accessable for removal after engine installation. 2 of 3 lift brackets appear accessable based on engine assembly images. 3rd bracket cannot be seen in engine assembly images.
01	03	01	Crankshaft Assembly	24.01	1.03	4%	No			Tech does **NOT** apply: Forged crank for turbo application; cannot core cast.
01	03	03	Connect Rod	4.66	1.07	23%	No			Tech does **NOT** apply: Forged diesel conrod; Not Powder metal gas.
01	03	04	Piston	3.39	0.00	0%	No			Tech does **NOT** apply: Secondary mass savings applies
01	03	04	Wrist Pin	1.19	0.27	23%	No			Tech does **NOT** apply: Piston pin is already tapered.
01	05	01	Cylinder Block	46.05	2.64	6%	No			Tech does **NOT** apply: Cast Iron cylinder block; Plasma liners do not apply.
01	05	01	Rear Main Seal Retainer	0.79	0.30	38%	Yes	0.18	0.07	Tech **DOES** apply: Aluminum component; could be made from plastic.
01	05	99	Cylinder Deactivation Assembly	2.60	0.36	14%	No			Tech does **NOT** apply: 4 cylinder tubo-diesel; no cylinder decativation system.
01	06	01	Cylinder Head	18.64	0.00	0%	No			Tech does **NOT** apply: Secondary mass savings applies.
01	06	20	Valve Covers	2.28	1.16	51%	Yes	2.95	1.50	Tech **DOES** apply: Aluminum valve cover is candidate for plastic.
01	07	06	Camshaft	4.38	0.00	0%	No			Secondary mass savings applies.
01	07	06	Camshaft Retainer Plate	0.19	0.09	45%	No			Tech does **NOT** apply: Overhead cam; no retainer comparable to 1500.
01	07	08	Phaser Wire Harness Bracket	0.14	0.11	75%	No			Tech does **NOT** apply: No cam phaser.
01	08	06	Front Cover	1.11	0.42	37%	No			Tech does **NOT** apply: Front cover integrates other components. Cannot confirm plastic as material option.
01	09	01	Idler Pulley	0.46	0.26	58%	No			Tech does **NOT** apply: Components is already plastic.
01	09	01	Crank Pulley	4.64	0.00	0%	Yes	2.62		Secondary mass savings applies.
01	09	01	AC Compressor Pulley	0.70	0.42	60%	No			Tech does **NOT** apply: Pulley appears to already be plastic.
01	10	01	Intake Manifold	5.76	0.28	5%	Yes	1.09	0.05	Tech **DOES** apply: Plastic intake manifold is a candidate for glass bubbles.
01	10	02	Air Filter Box	4.50	0.66	15%	Yes	1.76	0.26	Tech **DOES** apply: MuCell applies.
01	12	01	Exhaust Manifold	12.17	3.15	26%	Yes	2.97	0.77	Tech **DOES** apply: Fabricated exhaust manifold technology applies.
01	13	01	Oil Pan	5.47	1.41	26%	Yes	4.76	1.23	Tech **DOES** apply: Aluminum oil pan could be Magnesium.
01	13	01	Oil Pan Baffle Plate	0.38	0.27	70%	No			Tech does **NOT** apply: No baffle plate could be found.
01	13	01	Crank Cover Baffle Plate	1.27	0.90	71%	No			Tech does **NOT** apply: No baffle plate could be found.
01	13	02	Oil Pick-Up Tube	0.67	0.43	64%	Yes	0.21	0.14	Tech **DOES** apply: Steel pick up tube; Technology applies.
01	14	00	Water Pumps, Pulley, Thermostat	6.05	3.25	54%	Yes	2.52	1.35	Tech **DOES** apply: All Aluminum pump and housing, steel pulley.
01	14	04	Engine Heat Exchanger Assembly	6.79	0.27	4%	Yes	2.45	0.10	Tech **DOES** apply: Could be shared with other applications.
01	14	04	Main Coolant Fan Assembly	2.55	0.79	31%	Yes	3.45	1.07	Tech **DOES** apply: MuCell Applies
01	17	99	Coolant Bleed Line (Cylinder Head)	0.12	0.05	45%	No			Tech does **NOT** apply: Component does not exist.
01	60	03	Coil Bracket (DS)	0.56	0.44	79%	No			Tech does **NOT** apply: Diesel; no coil exists.
01	60	03	Coil Bracket (PS)	0.56	0.44	79%	No			Tech does **NOT** apply: Diesel; no coil exists.
01	70	05	AC Compressor Bracket	1.24	0.37	30%	No			Tech does **NOT** apply: Mount is integrated into front cover.
01	70	99	Accessory Bracket	3.36	1.86	55%	No			Tech does **NOT** apply: Bracket does not exist

If the original Silverado 1500 mass reduction concept idea was not able to be applied to the comparison vehicle it is not described in the section below.

Key Components for mass reduction include the exhaust manifold, oil pan, and water pump assembly.

<u>Exhaust Manifold</u>

DRAFT

The Sprinter 2.1 CDI has a traditional cast exhaust manifold (Image 3.1–16). The BMW N54 is an example of a turbo engine with fabricated manifolds that can save significant mass. The base mass is 2.97 kg; with fabricated exhaust manifold in this application it saves 0.77 kg. Due to similarities in component design and material, full percentage of the Silverado 1500 exhaust manifold mass reduction can be applied to the Sprinter. (Refer to Table 3-6). Image 3.1–16 is the Silverado 1500 and Sprinter exhaust manifold.

Image 3.1–16: Exhaust manifold for Silverado 1500 5.3L LC9 (Left) and Sprinter 2.1 CDI (Right)
(Source: FEV, Inc. and www.A2mac1.com)

DRAFT

Oil Pan

The Sprinter 2.1 CDI has a deep skirt engine block and a single piece oil pan (Image 3.1–17). The Nissan GT-R [10] is an example of an upper oil pan made from Magnesium. The base mass is 4.76 kg; with Magnesium in this application it saves 1.23 kg. Due to similarities in component design and material, full percentage of the Silverado 1500 oil pan mass reduction can be applied to the Sprinter. (Refer to Table 3-6).

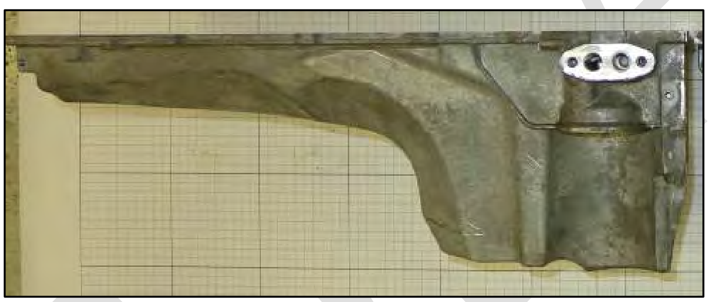


Image 3.1–17: Aluminum oil pan for Silverado 1500 5.3L LC9 (Left) and Sprinter 2.1 CDI (Right)
(Source: FEV, Inc. and www.A2mac1.com)

Water Pump Assembly

The Sprinter 2.1 CDI water pump assembly consisting of drive pulley, mechanical water pump, pump housing (integrated into timing cover) and thermostat assembly are shown in Image 3.1–19. Electric water pumps offer the advantage of tailored flow rate to match engine cooling requirements. This presents an energy savings verses directly coupled mechanical pumps, which are sized to cool engines at low engine speed and over deliver at high engine speed. Additionally electric water pumps coupled with electronically controlled thermostats present a mass savings.

---

10 *Nissan GT-R. Retrieved from Nissan Official Global Site: http://www.gtrnissan.com/*

The base mass is 2.52 kg, with an electric water pump in this application it saves and estimated 1.35 kg and has improved fuel efficiency. Due to similarities in component design and material, full percentage of the Silverado 1500 water pump assembly mass reduction can be applied to the Sprinter. (Refer to Table 3-6).The Silverado 1500 water pump is shown in Image 3.1–18.

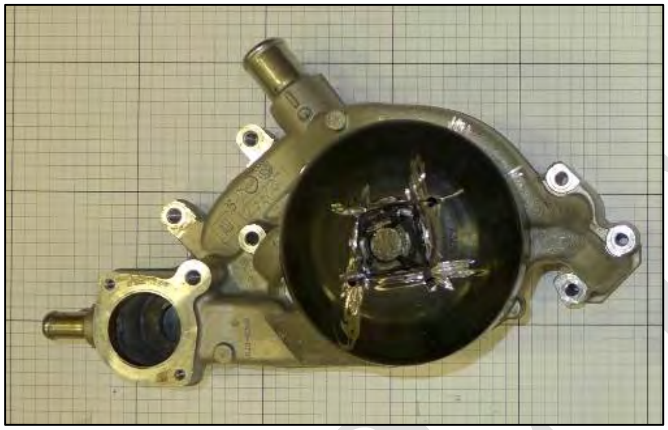


Image 3.1–18: Water pump for 5.3 liter Silverado 1500 5.3L LC9
(Source: FEV, Inc.)

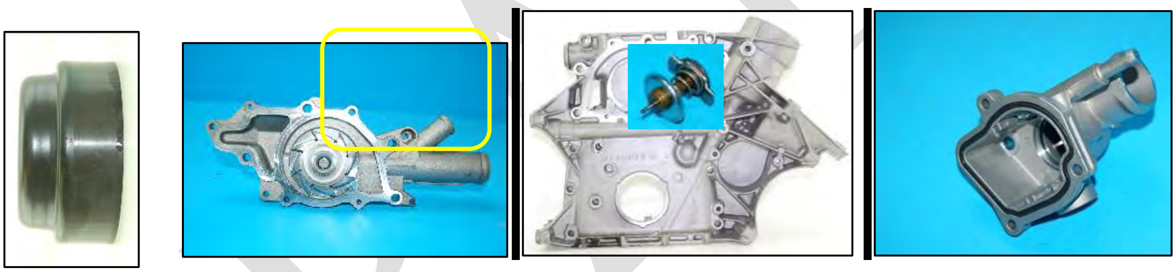


Image 3.1–19: Water pump assembly components for Sprinter 2.1 CDI
(Source: www.A2mac1.com)

DRAFT

3.1.4 Renault Master

3.1.4.1 Baseline Technology, Renault Master

The Renault Master is powered by a 2.3 liter four-cylinder diesel engine (Image 3.1–20). The engine features common rail injection and fixed geometry turbo charging. Maximum power rating is 92kW with 310 N•m of torque.

Image 3.1–20: Renault Master base engine (2.3 dCi)
(Source: www.A2mac1.com)

DRAFT

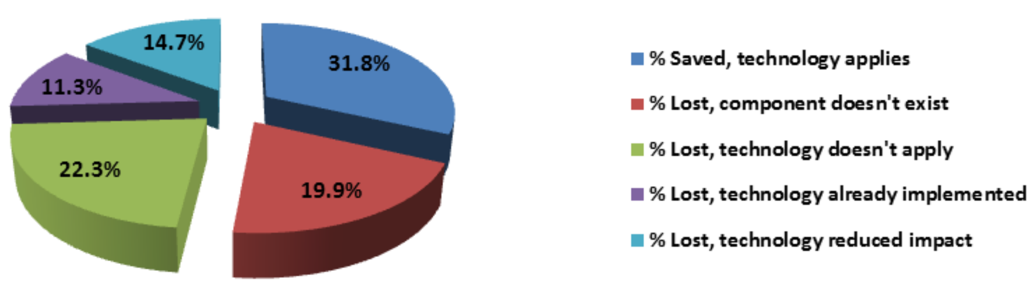
3.1.4.2 Mass Savings and Cost Impact, Renault Master

Table 3-7 summarizes mass and cost impact of Silverado 1500 Lightweighting technologies applied to the Renault Master. Total engine mass savings is 14.32 kg at a cost increase of $3.82 per kg. Cost is higher on this vehicle because plastic valve and timing covers both save cost and did not apply, plastic had already been implemented on the lubrication system, and the cooling system mass drives higher cost. The total mass savings using an aluminum block in place of a cast iron block for the Renault Master, for a greater weight savings is 35.60 kg and a cost increase of $3.08 per kg.

Table 3-7: Mass-Reduction and Cost Impact for Engine System, Renault Master

				Net Value of Mass Reduction							
System	Subsystem	Sub-Subsystem	Description	Mass Reduction New Tech "kg" (1)	Mass Reduction Comp "kg" (1)	Mass Reduction Total "kg" (1)	Cost Impact New Tech "$" (2)	Cost Impact Comp "$" (2)	Cost Impact Total "$" (2)	Cost/ Kilogram Total "$/kg"	Vehicle Mass Reduction Total "%"
01	00	00	**Engine System**								
01	02	00	Engine Frames, Mounting, and Brackets Subsystem	0.28	0.39	0.67	-$0.26	$0.63	$0.38	$0.57	0.03%
01	03	00	Crank Drive Subsystem	0.00	1.47	1.47	$0.00	$2.86	$2.86	$1.94	0.06%
01	04	00	Counter Balance Subsystem	0.00	0.00	0.00	$0.00	$0.00	$0.00	$0.00	0.00%
01	05	00	Cylinder Block Subsystem	0.00	3.27	3.27	$0.00	$9.99	$9.99	$3.05	0.14%
01	05	00	Cylinder Block Subsystem (Aluminum)	22.94	1.62	24.56	-$59.32	$14.28	-$45.04	-$1.83	1.04%
01	06	00	Cylinder Head Subsystem	0.00	0.90	0.90	$0.00	$2.71	$2.71	$3.02	0.04%
01	07	00	Valvetrain Subsystem	0.00	0.04	0.04	$0.00	$0.15	$0.15	$3.57	0.00%
01	08	00	Timing Drive Subsystem	0.62	0.00	0.62	-$3.67	$0.00	-$3.67	-$5.90	0.03%
01	09	00	Accessory Drive Subsystem	0.42	0.19	0.61	$0.63	$0.00	$0.63	$1.04	0.03%
01	10	00	Air Intake Subsystem	0.21	0.00	0.21	$0.09	$0.00	$0.09	$0.41	0.01%
01	11	00	Fuel Induction Subsystem	0.00	0.00	0.00	$0.00	$0.00	$0.00	$0.00	0.00%
01	12	00	Exhaust Subsystem	1.00	0.06	1.07	-$6.38	$0.22	-$6.16	-$5.77	0.05%
01	13	00	Lubrication Subsystem	2.21	0.11	2.32	-$15.63	$0.57	-$15.07	-$6.49	0.10%
01	14	00	Cooling Subsystem	2.69	0.30	2.99	-$47.11	$1.40	-$45.71	-$15.28	0.13%
01	15	00	Induction Air Charging Subsystem	0.00	0.00	0.00	$0.00	$0.00	$0.00	$0.00	0.00%
01	16	00	Exhaust Gas Re-circulation Subsystem	0.00	0.00	0.00	$0.00	$0.00	$0.00	$0.00	0.00%
01	17	00	Breather Subsystem	0.00	0.00	0.00	$0.00	$0.00	$0.00	$0.00	0.00%
01	60	00	Engine Management, Engine Electronic, Electrical Subsystem	0.00	0.00	0.00	$0.00	$0.00	$0.00	$0.00	0.00%
01	70	00	Accessory Subsystems (Start Motor, Generator, etc.)	0.14	0.00	0.14	-$0.92	$0.00	-$0.92	-$6.53	0.01%
				7.58	**6.74**	**14.32**	**-$73.25**	**$18.54**	**-$54.71**	**-$3.82**	**0.61%**
			Aluminum cylinder block totals	**30.51**	**5.09**	**35.60**	**-$132.57**	**$22.83**	**-$109.75**	**-$3.08**	**1.51%**
				(Decrease)	(Decrease)	(Decrease)	(Increase)	(Decrease)	(Increase)	(Increase)	

Mass Savings, Select Vehicle, New Technology "kg"	**7.58**
Mass Savings, Silverado 1500, New Technology "kg"	**23.80**
Mass Savings Select Vehicle/Mass Savings 1500	**31.8%**



*SMS not included - has no significant impact on perecent contributions

Note: The gray shaded areas in the chart above indicate using an aluminum block in place of a cast iron block for the Renault Master, for a greater weight savings. This iron to aluminum weight savings will be used for all vehicle summary charts.

Mass savings could not be credited for components for which Lightweighting technologies did not apply. Reasons for this could be that the technology was already implemented such as in the Renault oil system which already utilized plastic for the baffle plates and oil pick-up. For other components the Lightweighting Technology may not apply because of part design. For example the Renault crankshaft could not be hollow-cast because forging is required for strength in this diesel engine. Some components that were light weighted as part of the Silverado 1500 analysis did not exist in the Renault engine, such as the cylinder deactivation assembly.

DRAFT

3.1.4.3 System Scaling Analysis, Renault Master

The Renault Master engine components were reviewed for compatibility with Lightweighting technologies. The results of this analysis are listed in Table 3-8.

Table 3-8: System Scaling Analysis, Renault Master

Silverado 1500							***Select Vehicle***			
System	Subsystem	Sub-Subsystem	Component/Assembly	Base Mass	Mass Savings New Tech	% of Mass Savings New Tech	Tech Applies	Base Mass	Mass Savings New Tech	Notes
01			**Engine System**	**239.95**	**23.80**	**10%**			**7.58**	
01	02	02	Engine Mount	4.00	0.55	14%	No			Tech does **NOT** apply: Aluminum mounts; AHSS does not apply.
01	02	02	Engine Mount Bracket	0.98	0.22	22%	No			Tech does **NOT** apply: Single piece engine mount; no bracket.
01	02	10	Engine Lift Bracket & Bolt	0.33	0.33	100%	Yes	0.28	0.28	Tech **DOES** apply: Lift eye appears accessable for removal; 2nd lift eye is used as bracket and cannot be removed.
01	03	01	Crankshaft Assembly	24.01	1.03	4%	No			Tech does **NOT** apply: Forged crank for turbo application; core cast does not apply.
01	03	03	Connect Rod	4.66	1.07	23%	No			Tech does **NOT** apply: Forged diesel conrod; powder metal to forged steel does not apply.
01	03	04	Piston	3.39	0.00	0%	No			Tech does **NOT** apply: Secondary mass savings applies
01	03	04	Wrist Pin	1.19	0.27	23%	No			Tech does **NOT** apply: Piston pin is already tapered; technology does not apply.
01	05	01	Cylinder Block	46.05	2.64	6%	No			Tech does **NOT** apply: Cast iron cylinder block; Plasma cylinder liners do not apply.
01	05	01	Rear Main Seal Retainer	0.79	0.30	38%	No			Tech does **NOT** apply: Retainer is stamped steel, not Aluminum. Design is already lightweight. Technology does not apply.
01	05	99	Cylinder Deactivation Assembly	2.60	0.36	14%	No			Tech does **NOT** apply: 4 cylinder tubo-diesel; no cylinder decativation system. Technology does not apply.
01	06	01	Cylinder Head	18.64	0.00	0%	No			Tech does **NOT** apply: Aluminum cylinder head; secondary mass savings applies.
01	06	20	Valve Covers	2.28	1.16	51%	No			Tech does **NOT** apply: Component does not exist.
01	07	06	Camshaft	4.38	0.00	0%	No			Secondary mass savings applies
01	07	06	Camshaft Retainer Plate	0.19	0.09	45%	No			Tech does **NOT** apply: Component does not exist.
01	07	08	Phaser Wire Harness Bracket	0.14	0.11	75%	No			Tech does **NOT** apply: No Cam Phaser
01	08	06	Front Cover	1.11	0.42	37%	Yes	1.66	0.62	Tech **DOES** apply: Steel cover; possible in plastic. Technology applies.
01	09	01	Idler Pulley	0.46	0.26	58%	No			Tech does **NOT** apply: Part is already plastic (PA66-GF25).
01	09	01	Crank Pulley	4.64	0.00	0%	Yes	2.82		Secondary mass savings applies
01	09	01	AC Compressor Pulley	0.70	0.42	60%	Yes	0.70	0.42	Tech **DOES** apply: Pulley may be steel; cannot tell from A2Mac1; mass estimated to be same as 1500
01	10	01	Intake Manifold	5.76	0.28	5%	No			Tech does **NOT** apply: Intake Manifold is aluminum; cannot implement glass bubbles.
01	10	02	Air Filter Box	4.50	0.66	15%	Yes	1.44	0.21	Tech **DOES** apply: MuCell applies
01	12	01	Exhaust Manifold	12.17	3.15	26%	Yes	3.88	1.00	Tech **DOES** apply: Fabricated exhaust manifold technology applies.
01	13	01	Oil Pan	5.47	1.41	26%	Yes	8.55	2.21	Tech **DOES** apply: Upper Oil Pan appears to be aluminum; could be Mg. Technology apples.
01	13	01	Oil Pan Baffle Plate	0.38	0.27	70%	No			Tech does **NOT** apply: Already Plastic
01	13	01	Crank Cover Baffle Plate	1.27	0.90	71%	No			Tech does **NOT** apply: Already Plastic
01	13	02	Oil Pick-Up Tube	0.67	0.43	64%	No			Tech does **NOT** apply: Already Plastic
01	14	00	Water Pumps, Pulley, Thermostat	6.05	3.25	54%	Yes	3.15	1.69	Tech **DOES** apply: Water pump housing is integrated into cylinder block. Estimated 2kg for block reduction. Design is more compact = .85 credit.
01	14	04	Engine Heat Exchanger Assembly	6.79	0.27	4%	Yes	4.87	0.19	Tech **DOES** apply: Assumes Radiator has extra capacity for shared applications and could be optimized for the Renault. Technology applies.
01	14	04	Main Coolant Fan Assembly	2.55	0.79	31%	Yes	2.59	0.81	Tech **DOES** apply: Plastic material callouts indicate no MuCell. Technology applies.
01	17	99	Coolant Bleed Line (Cylinder Head)	0.12	0.05	45%	No			Tech does **NOT** apply: No bleed line could be identified
01	60	03	Coil Bracket (DS)	0.56	0.44	79%	No			Tech does **NOT** apply: Diesel; no coil bracket.
01	60	03	Coil Bracket (PS)	0.56	0.44	79%	No			Tech does **NOT** apply: Diesel; no coil bracket.
01	70	05	AC Compressor Bracket	1.24	0.37	30%	Yes	0.48	0.14	Tech **DOES** apply: Material callout is Aluminum; Magnesium technology applies.
01	70	99	Accessory Bracket	3.36	1.86	55%	No			Tech does **NOT** apply: Appears power steering pump bolts to engine block. Component does not exist.

If the original Silverado 1500 mass reduction concept idea was not able to be applied to the comparison vehicle it is not described in the section below.

Key Components for mass reduction include the exhaust manifold, oil pan, and water pump assembly.

Exhaust Manifold

The Renault 2.3 dCi has a traditional cast exhaust manifold. The BMW N54 is an example of a turbo engine with fabricated manifolds that can save significant mass. The base mass is 3.88 kg;

fabricated exhaust manifold in this application it saves 1.00 kg. Due to similarities in component design and material, full percentage of the Silverado 1500 exhaust manifold mass reduction can be applied to the Renault. (Refer to Table 3-8).

Oil Pan

The Renault 2.3 dCi oil pan is two-piece with upper and lower sections. The upper section is a structural aluminum component and provides stiffening for the crankcase. The Nissan GT-R is an example of an upper oil pan made from magnesium. The base mass is 8.55 kg; with Magnesium in this application it saves 2.21 kg. . Due to similarities in component design and material, full percentage of the Silverado 1500 oil pan mass reduction can be applied to the Renault. (Refer to Table 3-8).

Water Pump Assembly

The Renault 2.3 dCi water pump assembly consists of a drive pulley, mechanical water pump, pump housing (integrated into cylinder block) and thermostat assembly. Electric water pumps offer the advantage of tailored flow rate to match engine cooling requirements. This presents an energy savings verses directly coupled mechanical pumps, which are sized to cool engines at low engine speed and over deliver at high engine speed. Additionally electric water pumps coupled with electronically controlled thermostats present a mass savings. The base mass is 3.15 kg, with an electric water pump in this application it saves and estimated 1.69 kg and has improved fuel efficiency. . Due to similarities in component design and material, full percentage of the Silverado 1500 water pump assembly mass reduction can be applied to the Renault. (Refer to Table 3-8).

3.2 TRANSMISSION SYSTEM

3.2.1 Silverado 1500 Summary

The Chevrolet Silverado 1500 transmission package (6L80e) (and similar 6L90) is a 6-speed automatic transmission built by General Motors at its Toledo Transmission (also called Toledo Transmission Operations, TTO, and Power train Toledo).

The Chevrolet Silverado 1500 transmission analysis features clutch-to-clutch shifting, which eliminated the one-way clutches used on older transmission designs. Some weight reduction concepts were employed when it was designed but durability and reliability were foremost in the design process. As shown in Table 3-9, we have targeted some key areas in the unit that hold mass reduction opportunities. The total mass savings found on the transmission system mass was reduced by 34.2 kg (23.5%). This increased cost by $128.20, or $3.75 per kg. Mass reduction for this system reduced vehicle curb weight by 1.43%.

Table 3-9: Transmission System Mass Reduction Summary, Silverado 1500

DRAFT

				Net Value of Mass Reduction					
System	Subsystem	Sub-Subsystem	Description	Base Mass "kg"	Mass Reduction "kg" (1)	Cost Impact NIDMC "$" (2)	Average Cost/ Kilogram "$/kg" (2)	Mass Reduction "%"	Vehicle Mass Reduction "%"
02	**00**	**00**	**Transmission System**						
02	**01**	**00**	**External Components**	**0.02**	**0.00**	**0.00**	**0.00**	**0.00%**	**0.00%**
02	**02**	**00**	**Case Subsystem**	**30.73**	**10.66**	**-30.60**	**-17.43**	**34.69%**	**0.45%**
02	02	01	Tranmission Case	18.78	6.93	-21.38	-3.08	36.91%	0.29%
02	02	02	Transfer Housing	10.09	3.41	-4.50	-1.32	33.77%	0.14%
02	02	03	Covers	0.04	0.01	-0.13	-9.51	37.84%	0.00%
02	02	04	Transmission Fluid measurement	0.36	0.30	-1.07	-3.52	83.47%	0.01%
02	02	05	Bolts	1.30	0.00	-3.53	0.00	0.01%	0.00%
02	**03**	**00**	**Gear Train Subsystem**	**12.39**	**2.05**	**24.18**	**512.45**	**16.56%**	**0.09%**
02	03	01	Sun Gears	1.11	0.17	-3.11	-18.59	15.00%	0.01%
02	03	02	Ring Gears	3.14	0.47	-5.75	-12.21	15.00%	0.02%
02	03	03	Planetary Gears	2.03	0.30	5.85	19.18	15.00%	0.01%
02	03	04	Planetary Carriers	4.64	0.70	4.13	5.94	14.99%	0.03%
02	03	05	Bearings	1.02	0.04	23.06	518.13	4.37%	0.00%
02	03	99	Misc.	0.45	0.37	0.00	0.00	82.00%	0.02%
02	**04**	**00**	**Internal Clutch Subsystem**	**30.47**	**4.23**	**-39.94**	**-39.76**	**13.89%**	**0.18%**
02	04	01	Sprague / One-Way Clutches	2.24	0.34	-4.79	-14.28	15.00%	0.01%
02	04	03	Clutch & Brake Hubs	20.72	3.84	-34.21	-8.91	18.54%	0.16%
02	04	99	Misc.	0.59	0.06	-0.94	-16.57	9.66%	0.00%
02	**05**	**00**	**Launch Clutch Subsystem**	**20.29**	**8.62**	**-21.73**	**-2.52**	**42.49%**	**0.36%**
02	05	01	Torque Converter Asm	19.32	8.62	-21.73	-2.52	44.63%	0.36%
02	**06**	**00**	**Oil Pump and Filter Subsystem**	**7.50**	**2.42**	**-11.52**	**-7.74**	**32.27%**	**0.10%**
02	06	01	Oil Pump Asm	4.71	1.44	-12.27	-8.51	30.65%	0.06%
02	06	04	Oil Cooler	2.35	0.98	0.75	0.77	41.56%	0.04%
02	**07**	**00**	**Mechanical Controls Subsystem**	**7.14**	**0.87**	**-5.03**	**-5.76**	**12.22%**	**0.04%**
02	**08**	**00**	**Electrical Controls Subsystem**	**4.30**	**0.00**	**0.00**	**0.00**	**0.00%**	**0.00%**
02	**09**	**00**	**Parking Mechanism Subsystem**	**0.88**	**0.06**	**5.24**	**87.45**	**6.84%**	**0.00%**
02	**10**	**00**	**Misc. Subsystem**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00%**	**0.00%**
02	**11**	**00**	**Electric Motor & Controls Subsystem**	**0.00**	**0.00**	**0.00**	**0.00**	**6.68%**	**0.00%**
02	**12**	**00**	**Transfer Case Subsystem**	**28.44**	**5.27**	**-48.81**	**-152.39**	**18.53%**	**0.22%**
02	12	01	Carrier	1.95	0.29	3.60	12.31	15.00%	0.01%
02	12	02	Planetary Gears	3.66	0.49	-6.43	-13.17	13.33%	0.02%
02	12	03	Drive Gears & Shafts	12.75	2.25	-33.00	-14.68	17.63%	0.09%
02	12	04	Clutch & Brake Hubs	3.72	0.14	-20.38	-145.57	3.76%	0.01%
02	12	05	Shift Fork Assembly	1.75	1.00	9.57	9.53	57.54%	0.04%
02	12	07	Bearings & Spacers	1.19	0.88	-2.63	-2.98	74.49%	0.04%
02	12	08	Case Pump	0.63	0.21	0.46	2.16	33.97%	0.01%
02	**20**	**00**	**Driver Operated External Controls Subsystem**	**3.13**	**0.00**	**0.00**	**0.00**	**0.00%**	**0.00%**
				145.28	34.19 (Decrease)	-128.20 (Increase)	-3.75 (Increase)	23.53%	1.43%

(1) "+" = mass decrease, "-" = mass increase
(2) "+" = cost decrease, "-" = cost increase

Mass savings opportunities were identified for the following components: transmission case, transfer housing, covers, fluid measurement, sun gears, ring gears, planetary gears, planetary carriers, bearings, other components, Sprague, clutch and brake hubs, other components, torque converter, oil pump assembly, oil cooler, transfer case carrier, TC planetary gears, TC drive gears and shafts, TC clutch and brake hubs, TC shift fork assembly, TC bearings and spacers and TC case pump.

DRAFT

Transmission Case: The transmission case consists of three components bell housing, gear case and adapter: the mass of the three was reduced by changing the material from aluminum to magnesium. Mass was reduced by 36.9% from 18.8 kg to 11.9 kg.

Transfer Case Housing: The transfer case consist of two components front half and rear half: the mass of the two were reduced by changing the material from aluminum to magnesium. Mass was reduced by 33.8% from 10.1 kg to 6.68 kg.

Covers: The covers mass was reduced by changing the base grade 6061-T6 aluminum to AZ31B magnesium and go from 1 mm wall to 1.4 mm. Mass was reduced by 37.8% from 0.04 kg to 0.01 kg.

Transmission Fluid Measurement: The steel dip stick and tube mass was reduced by changing the solid steel assembly to a plastic assembly. Mass was reduced by 83.5% from 0.36 kg to 0.06 kg.

Sun Gears: The sun gears mass was reduced by changing the 8620 material to a 9310 high strength gear steel and downsizing the gears. Mass was reduced by 15% from 1.11 kg to 0.94 kg.

Ring Gears: The ring gears mass was reduced by changing the 4140 material to a 6265 high strength gear steel and downsizing the gears. Mass was reduced by 15% from 3.14 kg to 2.67 kg.

Planetary Gears: The planetary gears mass was reduced by changing the 8620 material to a 9310 high strength gear steel and downsizing the gears. Mass was reduced by 15% from 2.03 kg to 1.73 kg.

Planetary Carriers: The planetary carriers mass was reduced by changing the PM carriers with Schaeffler design 4130 stamped steel assembly. Mass was reduced by 14.9% from 4.64 kg to 3.94 kg.

Bearings: The thrust bearings mass was reduced by changing the 52100 steel to a Vespel® SP-21D composite material. Mass was reduced by 4.4% from 1.02 kg to 0.98 kg.

Sprag/One-Way Clutch : The sprag mass was reduced by changing the 8620 material to a 9310 high strength gear steel and downsizing the gears. Mass was reduced by 15% from 2.24 kg to 1.9 kg.

Clutch and Brake Hubs: The hubs mass was reduced by changing the mild steel to high strength steel with a thinner wall steel. Mass was reduced by 18.54% from 20.7 kg to 16.9 kg.

Torque Converter: The converter mass was reduced by changing the steel assembly to a cast aluminum assembly. Mass was reduced by 71.7% from 19.3 kg to 10.7 kg.

Oil Pump Assembly: The oil pump housing mass was reduced by changing the cast iron housing to aluminum housing. Mass was reduced by 30.6% from 4.71 kg to 3.27 kg.

Oil Cooler: The cooler hangers mass was reduced by changing the mild steel to aluminum hangers. Mass was reduced by 41.6% from 2.35 kg to 1.37 kg.

Transfer Case Carrier: The planetary carriers mass was reduced by changing the PM carriers with Schaeffler design 4130 stamped steel assembly. Mass was reduced by 15% from 1.95 kg to 1.66 kg.

Transfer Case Planetary Gears: The planetary gears mass was reduced by changing the 8620 material to a 9310 high strength gear steel and downsizing the gears. Mass was reduced by 13.3% from 3.66 kg to 3.17 kg.

Transfer Case Drive Gears and Shafts: The main shaft mass was reduced by changing the solid steel shaft to an extruded Mubea shaft. Mass was reduced by 17.6% from 12.8 kg to 10.5 kg.

DRAFT

Transfer Case Clutch and Brake Hubs: The hubs mass was reduced by changing the mild steel to high strength steel with thinner wall steel. Mass was reduced by 3.8% from 3.72 kg to 3.58 kg.

Transfer Case Shift Fork Assembly: The forks mass was reduced by changing the PM material to an AL-MMC 2 material. Mass was reduced by 57.5% from 1.75 kg to 0.75 kg.

Transfer Case Bearings: The thrust bearings mass was reduced by changing the 52100 steel to a Vespel® SP-21D composite material. Mass was reduced by 74.5% from 1.19 kg to 0.31 kg.

Transfer Case Pump: The pump mass was reduced by changing the steel tubes to plastic. Mass was reduced by 34% from 0.63 kg to 0.42 kg.

3.2.1.1 Silverado 2500 Analysis

The Chevrolet Silverado 2500 transmission system is very similar to the 1500, but on a larger scale due to the larger engine size (6.0 liter to 5.3 liter) and increased load requirements on the truck. The 1500 used GM's 6L80 system, while the 2500 used the 6L90 system.

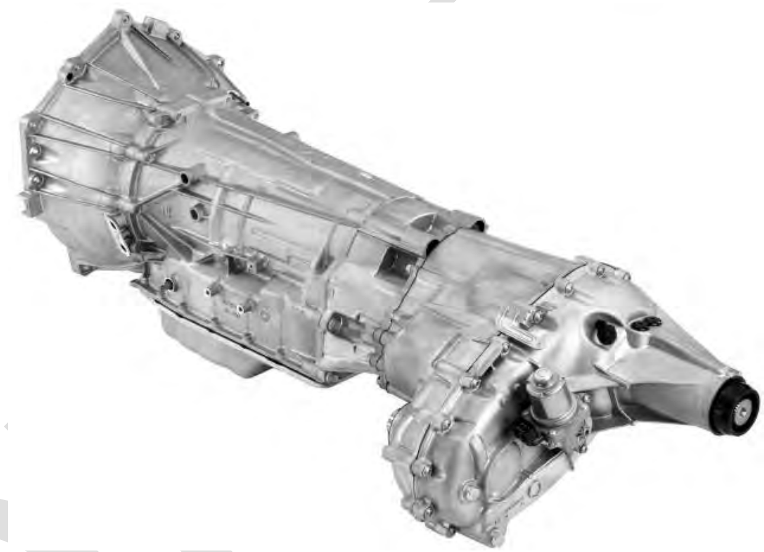


Image 3.2–1: Chevrolet Silverado transmission and transfer case
(Source: FEV, Inc.)

3.2.1.2 Silverado 2500 System Scaling Summary

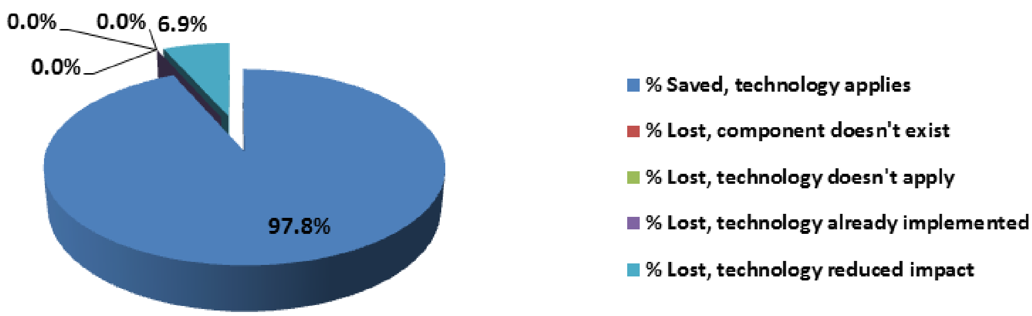
Table 3-10 summarizes mass and cost impact of Silverado 1500 Lightweighting technologies applied to the Silverado 2500. Total transmission mass savings is 38.27 kg at a cost increase of $91.38, or $2.39 per kg.

Table 3-10: Mass-Reduction and Cost Impact for Transmission System, Silverado 2500

DRAFT

				Net Value of Mass Reduction								
System	Subsystem	Sub-Subsystem	Description	Mass Reduction New Tech "kg" (1)	Mass Reduction Comp "kg" (1)	Mass Reduction Total "kg" (1)	Cost Impact New Tech "$" (2)	Cost Impact Comp "$" (2)	Cost Impact Total "$" (2)	Cost/ Kilogram Total "$/kg"	Vehicle Mass Reduction Total "%"
02	**00**	**00**	**Transmission**								
02	01	00	External Components	0.00	0.00	0.00	$0.00	$0.00	$0.00	$0.00	0.00%
02	02	00	Case Subsystem	11.71	0.90	12.61	-$34.85	$3.94	-$30.90	-$2.45	0.41%
02	03	00	Gear Train Subsystem	2.20	1.64	3.84	$10.27	$2.18	$12.46	$3.24	0.12%
02	04	00	Internal Clutch Subsystem	2.69	0.60	3.29	-$26.70	$2.81	-$23.89	-$7.26	0.11%
02	05	00	Launch Clutch Subsystem	9.18	0.72	9.90	-$23.14	$1.54	-$21.60	-$2.18	0.32%
02	06	00	Oil Pump and Filter Subsystem	1.78	0.00	1.78	-$11.74	$0.00	-$11.74	-$6.60	0.06%
02	07	00	Mechanical Controls Subsystem	0.87	0.13	1.00	-$5.00	$1.51	-$3.49	-$3.50	0.03%
02	08	00	Electrical Controls Subsystem	0.00	0.00	0.00	$0.00	$0.00	$0.00	$0.00	0.00%
02	09	00	Parking Mechanism Subsystem	0.11	0.01	0.12	$9.60	$0.57	$10.17	$86.68	0.00%
02	10	00	Misc. Subsystem	0.00	0.00	0.00	$0.00	$0.00	$0.00	$0.00	0.00%
02	11	00	Electric Motor & Controls Subsystem	0.00	0.00	0.00	$0.00	$0.00	$0.00	$0.00	0.00%
02	12	00	Transfer Case Subsystem	5.21	0.52	5.73	-$29.11	$6.72	-$22.39	-$3.91	0.19%
02	20	00	Driver Operated External Controls Subsystem	0.00	0.00	0.00	$0.00	$0.00	$0.00	$0.00	0.00%
				33.75 (Decrease)	**4.52** (Decrease)	**38.27** (Decrease)	**-$110.67** (Increase)	**$19.28** (Decrease)	**-$91.38** (Increase)	**-$2.39** (Increase)	**1.24%**

Mass Savings, Select Vehicle, New Technology "kg"	**34.493**
Mass Savings, Silverado 1500, New Technology "kg"	**33.750**
Mass Savings Select Vehicle/Mass Savings 1500	**97.8%**



*SMS not included - has no significant impact on perecent contributions

3.2.1.3 System Scaling Analysis

The Silverado 2500 Transmission components were reviewed for compatibility with Lightweighting technologies. The results of this analysis are listed in Table 3-11.

Table 3-11: System Scaling Analysis for Transmission System, Silverado 2500

Silverado 1500							Select Vehicle			
System	Subsystem	Sub-Subsystem	Component/Assembly	Base Mass	Mass Savings New Tech	% of Mass Savings New Tech	Tech Applies	Base Mass	Mass Savings New Tech	Notes
02			Transmission	145.28	34.49	24%			33.75	
02	02	01	Tranmission Case	18.78	6.93	37%	yes	19.42	7.17	Tech **DOES** apply: Base material was also aluminum and our savings was going to magnesium with the unit.
02	02	02	Transfer Housing	10.09	3.41	34%	yes	10.38	3.51	Tech **DOES** apply: Base material was also aluminum and our savings was going to magnesium with the unit.
02	02	03	Covers	0.04	0.01	38%	yes	1.95	0.74	Tech **DOES** apply: Steel covers and pan changed to magnesium
02	02	04	Transmission Fluid measurement	0.36	0.30	83%	yes	0.36	0.30	Tech **DOES** apply: Steel tub and dip stick went to carbon fiber
02	03	01	Sun Gears	1.11	0.17	15%	yes	1.27	0.19	Tech **DOES** apply: Base grade of gear steel went to high strength gear alloy and down sized in mass
02	03	02	Ring Gears	3.14	0.47	15%	yes	2.48	0.37	Tech **DOES** apply: Base grade of gear steel went to high strength gear alloy and down sized in mass
02	03	03	Planetary Gears	2.03	0.31	15%	yes	1.88	0.28	Tech **DOES** apply: Base grade of gear steel went to high strength gear alloy and down sized in mass
02	03	04	Planetary Carriers	4.64	0.70	15%	yes	8.97	1.35	Tech **DOES** apply: Base grade of gear steel went to high strength gear alloy and down sized in mass
02	03	05	Bearings	1.02	0.04	4%	yes	0.22	0.01	Tech **DOES** apply: Converted steel thrust bearings to Vespel P21
02	04	01	Sprague / One-Way Clutches	2.24	0.34	15%	yes	2.62	0.39	Tech **DOES** apply: Steal base material converted to light weight MMC
02	04	99	Clutch & Brake Hubs	20.72	3.84	19%	yes	11.95	2.22	Tech **DOES** apply: converted carbon steel hubs to light weight high strength alloy and downsized.
02	04	99	Misc.	0.59	0.06	10%	yes	0.84	0.08	Tech **DOES** apply: Base grade meterials were replaced with lightweight materials
02	05	01	Torque Converter Asm	19.32	8.62	45%	yes	20.57	9.18	Tech **DOES** apply: Base grade carbon steel replaced with aluminum
02	06	01	Oil Pump Asm	4.71	1.44	31%	yes	4.61	1.41	Tech **DOES** apply: Cas iron housing replaced with aluminum
02	06	04	Oil Cooler	2.35	0.98	42%	yes	0.88	0.37	Tech **DOES** apply: Base grade Al/steel to 304SS & 304SS and go from 1.4mm wall to 1mm
02	07	01	Valve Body Asm	6.56	0.87	13%	yes	6.52	0.87	Tech **DOES** apply: Converted aluminum to manesium
02	09	03	Pawls	0.88	0.06	7%	yes	1.60	0.11	Tech **DOES** apply: Base grade 52100 steel to a light weight MMC
02	12	01	Carrier	1.95	0.29	15%	yes	5.07	0.76	Tech **DOES** apply: Base grade Powder Metal to Stamped Steel
02	12	02	Planetary Gears	3.66	0.49	13%	yes	1.21	0.16	Tech **DOES** apply: Replace Base grade 3150 with 9310
02	12	03	Drive Gears & Shafts	12.75	2.25	18%	yes	13.44	2.37	Tech **DOES** apply: Replace Base 8620 with 6265
02	12	04	Clutch & Brake Hubs	3.72	0.14	4%	yes	0.91	0.03	Tech **DOES** apply: Replaced 4140 & PM with C61 and MMC
02	12	05	Shift Fork Assembly	1.75	1.00	58%	yes	0.90	0.52	Tech **DOES** apply: Replace PM steel with AL-MMC 2
02	12	07	Bearings & Spacers	1.86	1.56	84%	yes	1.42	1.19	Tech **DOES** apply: Converted steel thrust bearings to Vespel P21
02	12	08	Case Pump	0.63	0.21	34%	yes	0.52	0.18	Tech **DOES** apply: Steel tube to Plastic

If the original Silverado 1500 mass reduction concept idea was not able to be applied to the comparison vehicle it is not described in the section below.

Components with significant mass savings identified on the Silverado 2500 series include the transmission case and transfer housing, gears, clutch and brake hubs, torque converter, and valve body.

Transmission Case and Transfer Housing

Shown in Image 3.2–2 are the Silverado 1500 and 2500 series transmission housings. Component masses were 28.9 kg for the 1500 versus 29.8 kg for the 2500. The 2500 is a newer, heavy-duty version of the 1500 transmission. The Lightweighting Technology used on the housings was to change the aluminum material from A 308 aluminum to AZ 91 magnesium, this material is used in the 2015 Chevrolet Corvette Stingray transmission housing. Due to similarities in component design and material, full percentage of the Silverado 1500 transmission housing mass reduction can be applied to the 2500. (Refer to Table 3-11).

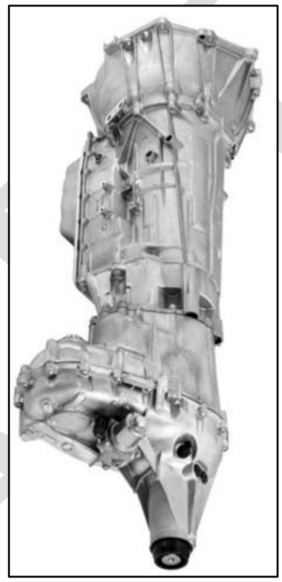



Image 3.2–2: Transmission for the Silverado 1500 (Left) and Silverado 2500 (Right)
(Source: FEV, Inc.)

Gears

Shown in Image 3.2–3 are the Silverado 1500 and 2500 series gears. Component masses are 6.28 kg for the 1500 versus 5.62 kg for the 2500 respectively. The Lightweighting Technology used on the gears was to change the 8620 and 4120 steel materials to 6265 and 9310 high strength gear steel. Some automotive companies are currently using these materials for gears that are in need of integrity help in their application. Premium material will be used as much as possible within the parameters of this study. Due to similarities in component design and material, full percentage of the Silverado 1500 gears mass reduction can be applied to the 2500. (Refer to Table 3-11).

DRAFT

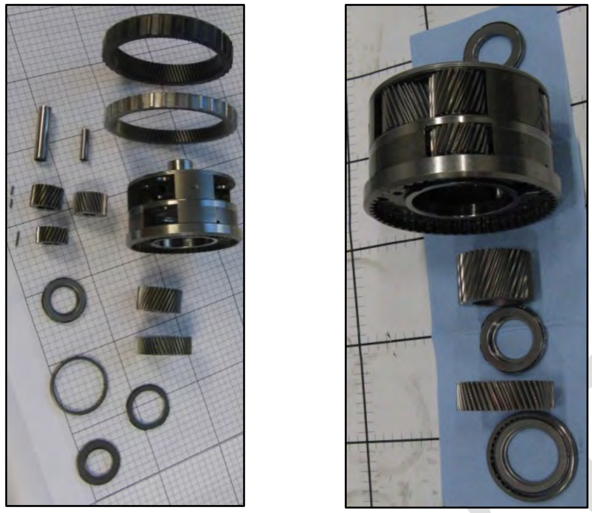


Image 3.2–3: Planet gears for the Silverado 1500 (Left) and Silverado 2500 (Right)
(Source: FEV, Inc.)

Clutch and Brake Hubs

Shown in Image 3.2–4 are the Silverado 1500 and 2500 series hubs. Component masses were 20.7 kg for the 1500 versus 11.9 kg for the 2500. The Lightweighting Technology used on the steel hubs was to use a low carbon steel that allowed ease of manufacturing. The material was changed to a higher strength grade of steel with a thinner wall to achieve weight savings. Due to similarities in component material, full percentage of the Silverado 1500 clutch and brake hub mass reduction can be applied to the 2500. (Refer to Table 3-11).

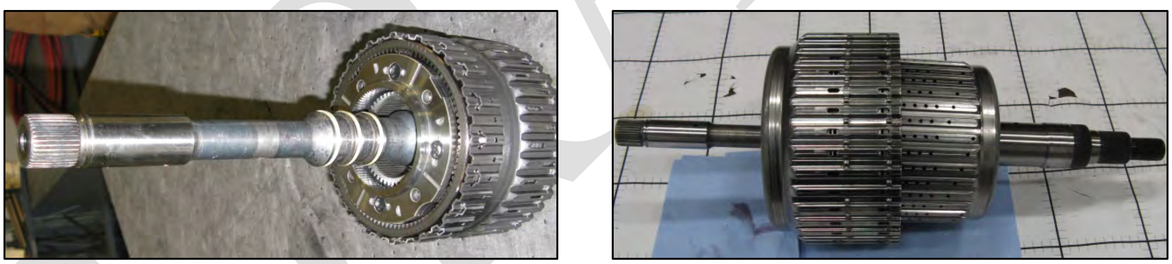


Image 3.2–4: Hubs for the Silverado 1500 (Left) and Silverado 2500 (Right)
(Source: FEV, Inc.)

DRAFT

Torque Converter

Shown in Image 3.2–5 are the Silverado 1500 and 2500 series torque converters. Component masses were 19.3 kg for the 1500 versus 20.6 kg for the 2500. The Lightweighting Technology used on the torque converters was low-carbon steel stampings for the components that go into the assembly. The weight savings for these units was achieved by going to aluminum and Metal Matrix Composite (MMC) cast converter, an example of which is shown in Image 3.2–6. Due to similarities in component design and material, full percentage of the Silverado 1500 torque converter mass reduction can be applied to the 2500. (Refer to Table 3-11).

Image 3.2–5: Steel torque converter for the Silverado 1500 (Left) and Silverado 2500 (Right)
(Source: FEV, Inc.)

Image 3.2–6: Example of a cast aluminum converter
(Source: SGF)

Valve Body

Shown in Image 3.2–7 are the Silverado 1500 and 2500 valve bodies. Component masses are 6.56 kg for the 1500 versus 6.52kg for the 2500. The Lightweighting Technology used on both bodies was to die cast the component, then machine the ports and valve holes. The weight saving technology on these components was to go to magnesium as the material. Due to similarities in component design and material, full percentage of the Silverado 1500 valve body mass reduction can be applied to the 2500. (Refer to Table 3-11).

Image 3.2–7: Valve body for Silverado 1500 (Left) and Silverado 2500 (Right)
(Source: FEV, Inc.)

3.2.1.4 System Comparison, Silverado 2500

Table 3-12 summarizes the Silverado 1500 and 2500 Lightweighting results. The majority of the components were visually the same between the two transmissions. The 2500 transmission was a little longer but fit under the same body as the 1500.

Table 3-12: Transmission System Comparison, Silverado 1500 and 2500

		Net Value of Mass Reduction								
System	Description	Mass Base "kg" (1)	Mass Reduction New Tech "kg" (1)	Mass Reduction Comp "kg" (1)	Mass Reduction Total "kg" (1)	System Mass Reduction "%"	Cost Impact New Tech "$" (2)	Cost Impact Comp "$" (2)	Cost Impact Total "$" (2)	Cost/ Kilogram Total "$/kg"
02	Transmission									
02	Silverado 1500	145.28	34.49	5.91	40.41	27.81%	-$124.61	$26.73	-$97.88	-$2.42
02	Silverado 2500	156.36	33.75	4.52	38.27	24.47%	-$110.67	$19.28	-$91.38	-$2.39

DRAFT

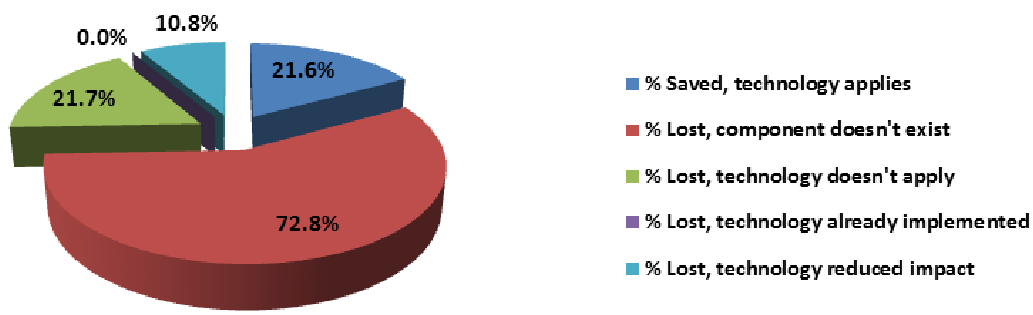
3.2.2 Mercedes Sprinter 311 CDi

Table 3-13 summarizes mass and cost impact of Silverado 1500 Lightweighting technologies applied to the Mercedes Sprinter 311 CDi. Total transmission mass savings was 8.77 kg at a cost increase of $3.39, or $.39 per kg.

Table 3-13: Mass-Reduction and Cost Impact for Transmission System, Mercedes Sprinter

System	Subsystem	Sub-Subsystem	Description	Net Value of Mass Reduction							
				Mass Reduction New Tech "kg" (1)	Mass Reduction Comp "kg" (1)	Mass Reduction Total "kg" (1)	Cost Impact New Tech "$" (2)	Cost Impact Comp "$" (2)	Cost Impact Total "$" (2)	Cost/ Kilogram Total "$/kg"	Vehicle Mass Reduction Total "%"
02			Transmission								
02	01	00	External Components	0.00	0.00	0.00	$0.00	$0.00	$0.00	$0.00	0.00%
02	02	00	Case Subsystem	5.60	0.53	6.14	-$20.58	$3.53	-$17.05	-$2.78	0.29%
02	03	00	Gear Train Subsystem	1.24	1.40	2.64	$12.15	$1.51	$13.66	$5.18	0.12%
02	04	00	Internal Clutch Subsystem	0.00	0.00	0.00	$0.00	$0.00	$0.00	$0.00	0.00%
02	05	00	Launch Clutch Subsystem	0.00	0.00	0.00	$0.00	$0.00	$0.00	$0.00	0.00%
02	06	00	Oil Pump and Filter Subsystem	0.00	0.00	0.00	$0.00	$0.00	$0.00	$0.00	0.00%
02	07	00	Mechanical Controls Subsystem	0.00	0.00	0.00	$0.00	$0.00	$0.00	$0.00	0.00%
02	08	00	Electrical Controls Subsystem	0.00	0.00	0.00	$0.00	$0.00	$0.00	$0.00	0.00%
02	09	00	Parking Mechanism Subsystem	0.00	0.00	0.00	$0.00	$0.00	$0.00	$0.00	0.00%
02	10	00	Misc. Subsystem	0.00	0.00	0.00	$0.00	$0.00	$0.00	$0.00	0.00%
02	11	00	Electric Motor & Controls Subsystem	0.00	0.00	0.00	$0.00	$0.00	$0.00	$0.00	0.00%
02	12	00	Transfer Case Subsystem	0.00	0.00	0.00	$0.00	$0.00	$0.00	$0.00	0.00%
02	20	00	Driver Operated External Controls Subsystem	0.00	0.00	0.00	$0.00	$0.00	$0.00	$0.00	0.00%
				6.84 (Decrease)	1.93 (Decrease)	8.77 (Decrease)	-$8.43 (Increase)	$5.04 (Decrease)	-$3.39 (Increase)	-$0.39 (Increase)	0.41%

Mass Savings, Select Vehicle, New Technology "kg"	31.701
Mass Savings, Silverado 1500, New Technology "kg"	6.845
Mass Savings Select Vehicle/Mass Savings 1500	21.6%



*SMS not included - has no significant impact on perecent contributions

3.2.2.1 System Scaling Analysis

The Mercedes Sprinter 311 CDi Transmission components were reviewed for compatibility with Lightweighting technologies. The results of this analysis are listed in Table 3-14.

Table 3-14: System Scaling Analysis for Transmission System, Mercedes Sprinter

Silverado 1500							Select Vehicle					
System	Subsystem	Sub-Subsystem	Component/Assembly	Base Mass	Mass Savings New Tech	% of Mass Savings New Tech	Tech Applies	Base Mass	Mass Savings	Base Mass	Mass Savings New Tech	Notes
02	**Transmission**			**145.276**	**34.493**	**24%**					**6.845**	
02	02	01	Tranmission Case	18.78	6.93	37%	yes	13.78	5.09	13.78	5.09	Tech **DOES** apply: Base material was also aluminum and our savings was going to magnesium with the unit.
02	02	02	Transfer Housing	10.09	3.41	34%	no					Tech dose **Not** apply: No transfer case in system.
02	02	03	Covers	0.04	0.01	38%	yes	1.36	0.52	1.36	0.52	Tech **DOES** apply: Steel covers and pan changed to magnesium
02	02	04	Transmission Fluid measuremer	0.36	0.30	83%	no					Tech dose **Not** apply:
02	03	01	Sun Gears	1.11	0.17	15%	yes	1.82	0.27	1.82	0.27	Tech **DOES** apply: Base grade of gear steel went to high strength gear alloy and down sized in mass
02	03	02	Ring Gears	3.14	0.47	15%	yes	1.49	0.22	1.49	0.22	Tech **DOES** apply: Base grade of gear steel went to high strength gear alloy and down sized in mass
02	03	03	Planetary Gears	2.03	0.31	15%	yes	2.13	0.32	2.13	0.32	Tech **DOES** apply: Base grade of gear steel went to high strength gear alloy and down sized in mass
02	03	04	Planetary Carriers	4.64	0.70	15%	yes	2.68	0.40	2.68	0.40	Tech **DOES** apply: Base grade of gear steel went to high strength gear alloy and down sized in mass
02	03	05	Bearings	1.02	0.04	4%	yes	0.51	0.02	0.51	0.02	Tech **DOES** apply: Converted steel thrust bearings to Vespel P21
02	04	01	Sprague / One-Way Clutches	2.24	0.34	15%	no					Tech dose **Not** apply: No sprag
02	04	99	Clutch & Brake Hubs	20.72	3.84	19%	no					Tech dose **Not** apply: manual trans, no internal clutch
02	04	99	Misc.	0.59	0.06	10%	no					Tech dose **Not** apply: manual trans,
02	05	01	Torque Converter Asm	19.32	8.62	45%	no					Tech dose **Not** apply: manual trans,
02	06	01	Oil Pump Asm	4.71	1.44	31%	no					Tech dose **Not** apply: manual trans,
02	06	04	Oil Cooler	2.35	0.98	42%	no					Tech dose **Not** apply: manual trans,
02	07	01	Valve Body Asm	6.56	0.87	13%	no					Tech dose **Not** apply: manual trans,
02	09	03	Pawls	0.88	0.06	7%	no					Tech dose **Not** apply: manual trans,
02	12	01	Carrier	1.95	0.29	15%	no					Tech dose **Not** apply: manual trans,
02	12	02	Planetary Gears	3.66	0.49	13%	no					Tech dose **Not** apply: manual trans,
02	12	03	Drive Gears & Shafts	12.75	2.25	18%	no					Tech dose **Not** apply: manual trans,
02	12	04	Clutch & Brake Hubs	3.72	0.14	4%	no					Tech dose **Not** apply: manual trans,
02	12	05	Shift Fork Assembly	1.75	1.00	58%	no					Tech dose **Not** apply: manual trans,
02	12	07	Bearings & Spacers	1.86	1.56	84%	no					Tech dose **Not** apply: manual trans,
02	12	08	Case Pump	0.63	0.21	34%	no					Tech dose **Not** apply: manual trans,

If the original Silverado 1500 mass reduction concept idea was not able to be applied to the comparison vehicle it is not described in the section below.

Components with significant mass savings identified on the Mercedes Sprinter include: the transmission case and gears. Image 3.2–8 shows the Mercedes Sprinter 311 Transmission components.

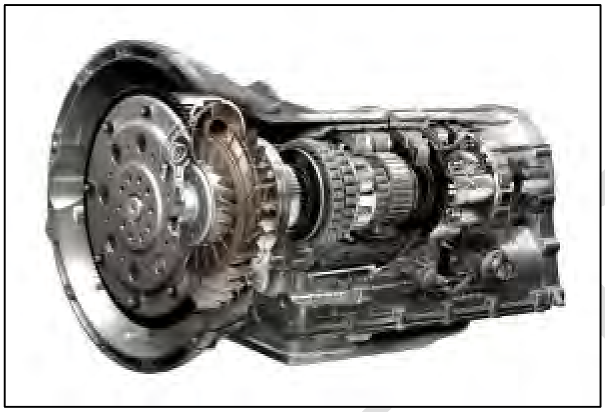


Image 3.2–8: Mercedes Sprinter 311 CDi transmission
(Source: www.A2mac1.com)

Transmission Case

Shown in Image 3.2–9 are the Silverado 1500 and 311 series Transmission Case Housings. Component masses are 18.8 kg for the 1500 versus 13.8 kg for the 311. The Lightweighting Technology used on the housings was to change the aluminum material from A 308 aluminum to AZ 91 magnesium. This material is used in the 2015 Chevrolet Corvette Stingray transmission housing. Due to similarities in component design and material, full percentage of the Silverado 1500 transmission housing mass reduction can be applied to the Sprinter. (Refer to Table 3-14).

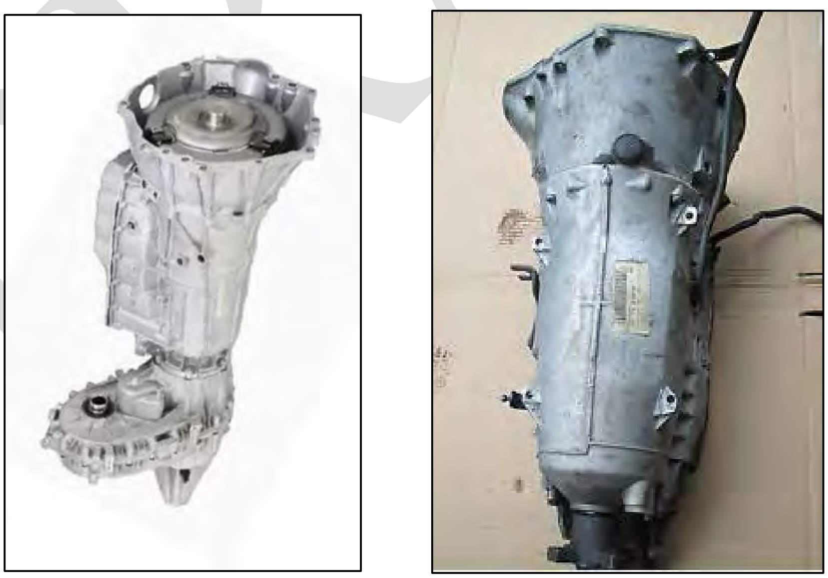


Image 3.2–9: Transmission for the Silverado 1500 (Left) and Sprinter 311 CDi (Right)
(Source: FEV, Inc.)

Gears

DRAFT

Shown in Image 3.2–10 are the Silverado 1500 and Sprinter 311 series gears. Component masses were 6.58 kg for the 1500 versus 5.44 kg for the 311. The Lightweighting Technology used on the gears was to change the 8620 and 4120 steel materials to 6265 and 9310 high-strength gear steel. Some automotive companies are currently using these materials for gears that are in need of integrity help in their application. Premium material will be used as much as possible within the parameters of this study. Due to similarities in component material, full percentage of the Silverado 1500 gears mass reduction can be applied to the Sprinter. (Refer to Table 3-14).

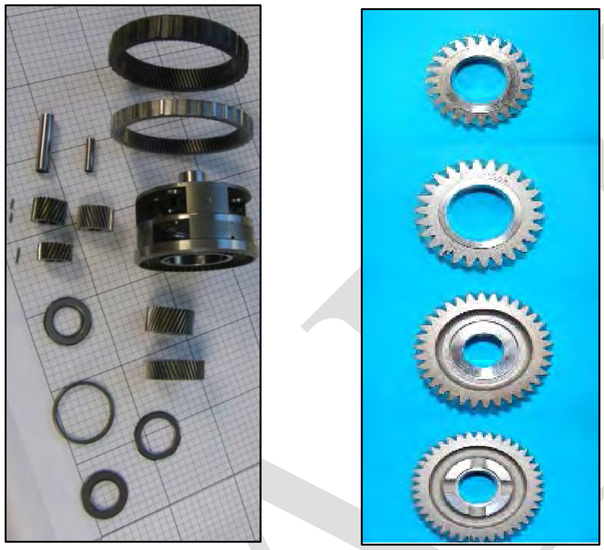


Image 3.2–10: Planet gears for the Silverado 1500 (Left) and drive gears for the Sprinter 311 (Right)
(Source: FEV, Inc.)

DRAFT

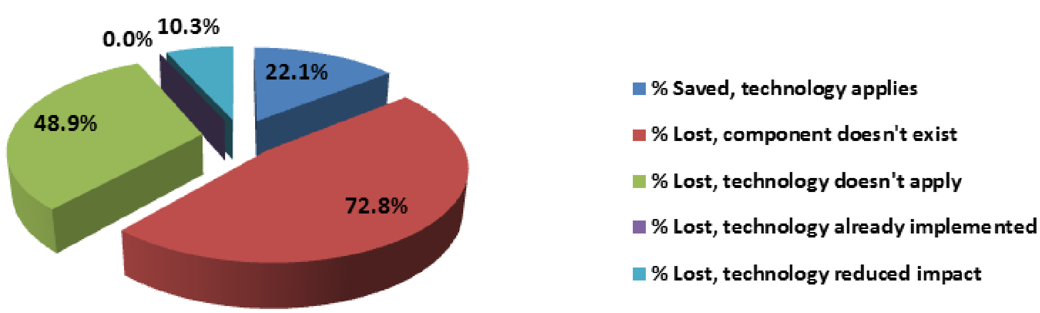
3.2.3 Renault Master 2.3 DCi

Table 3-15 summarizes the mass and cost impact of the Silverado 1500 Lightweighting technologies applied to the Renault Master 2.3 DCi. Total transmission mass savings is 9.20 kg at a cost increase of $3.11, or $0.34 per kg.

Table 3-15: Mass-Reduction and Cost Impact for Transmission System, Renault Master

				Net Value of Mass Reduction							
System	Subsystem	Sub-Subsystem	Description	Mass Reduction New Tech "kg" (1)	Mass Reduction Comp "kg" (1)	Mass Reduction Total "kg" (1)	Cost Impact New Tech "$" (2)	Cost Impact Comp "$" (2)	Cost Impact Total "$" (2)	Cost/ Kilogram Total "$/kg"	Vehicle Mass Reduction Total "%"
02			Transmission								
02	01	00	External Components	0.00	0.00	0.00	$0.00	$0.00	$0.00	$0.00	0.00%
02	02	00	Case Subsystem	5.61	0.80	6.41	-$21.00	$5.29	-$15.70	-$2.45	0.27%
02	03	00	Gear Train Subsystem	1.39	1.40	2.79	$10.86	$1.73	$12.59	$4.51	0.12%
02	04	00	Internal Clutch Subsystem	0.00	0.00	0.00	$0.00	$0.00	$0.00	$0.00	0.00%
02	05	00	Launch Clutch Subsystem	0.00	0.00	0.00	$0.00	$0.00	$0.00	$0.00	0.00%
02	06	00	Oil Pump and Filter Subsystem	0.00	0.00	0.00	$0.00	$0.00	$0.00	$0.00	0.00%
02	07	00	Mechanical Controls Subsystem	0.00	0.00	0.00	$0.00	$0.00	$0.00	$0.00	0.00%
02	08	00	Electrical Controls Subsystem	0.00	0.00	0.00	$0.00	$0.00	$0.00	$0.00	0.00%
02	09	00	Parking Mechanism Subsystem	0.00	0.00	0.00	$0.00	$0.00	$0.00	$0.00	0.00%
02	10	00	Misc. Subsystem	0.00	0.00	0.00	$0.00	$0.00	$0.00	$0.00	0.00%
02	11	00	Electric Motor & Controls Subsystem	0.00	0.00	0.00	$0.00	$0.00	$0.00	$0.00	0.00%
02	12	00	Transfer Case Subsystem	0.00	0.00	0.00	$0.00	$0.00	$0.00	$0.00	0.00%
02	20	00	Driver Operated External Controls Subsystem	0.00	0.00	0.00	$0.00	$0.00	$0.00	$0.00	0.00%
				7.00 (Decrease)	2.20 (Decrease)	9.20 (Decrease)	-$10.14 (Increase)	$7.02 (Decrease)	-$3.11 (Increase)	-$0.34 (Increase)	0.39%

Mass Savings, Select Vehicle, New Technology "kg"	31.701
Mass Savings, Silverado 1500, New Technology "kg"	7.005
Mass Savings Select Vehicle/Mass Savings 1500	22.1%



*SMS not included - has no significant impact on perecent contributions

3.2.3.1 System Scaling Analysis

The Renault Master 2.3 DCi transmission components were reviewed for compatibility with Lightweighting technologies. The results of this analysis are listed in Table 3-16.

Table 3-16: System Scaling Analysis for Transmission System, Renault Master

Silverado 1500							Select Vehicle					
System	Subsystem	Sub-Subsystem	Component/Assembly	Base Mass	Mass Savings New Tech	% of Mass Savings New Tech	Tech Applies	Base Mass	Mass Savings	Base Mass	Mass Savings New Tech	Notes
02 Transmission				**145.276**	**34.493**	**24%**					**7.005**	
02	02	01	Tranmission Case	18.78	6.93	37%	yes	13.65	5.04	13.65	5.04	Tech **DOES** apply: Base material was also aluminum and our savings was going to magnesium with the unit.
02	02	02	Transfer Housing	10.09	3.41	34%	no					Tech dose **Not** apply: No transfer case in system.
02	02	03	Covers	0.04	0.01	38%	yes	1.52	0.58	1.52	0.58	Tech **DOES** apply: Steel covers and pan changed to magnesium
02	02	04	Transmission Fluid measurement	0.36	0.30	83%	no					Tech dose Not apply:
02	03	01	Sun Gears	1.11	0.17	15%	yes	1.65	0.25	1.65	0.25	Tech **DOES** apply: Base grade of gear steel went to high strength gear alloy and down sized in mass
02	03	02	Ring Gears	3.14	0.47	15%	yes	2.48	0.37	2.48	0.37	Tech **DOES** apply: Base grade of gear steel went to high strength gear alloy and down sized in mass
02	03	03	Planetary Gears	2.03	0.31	15%	yes	1.88	0.28	1.88	0.28	Tech **DOES** apply: Base grade of gear steel went to high strength gear alloy and down sized in mass
02	03	04	Planetary Carriers	4.64	0.70	15%	yes	3.11	0.47	3.11	0.47	Tech **DOES** apply: Base grade of gear steel went to high strength gear alloy and down sized in mass
02	03	05	Bearings	1.02	0.04	4%	yes	0.52	0.02	0.52	0.02	Tech **DOES** apply: Converted steel thrust bearings to Vespel P21
02	04	01	Sprague / One-Way Clutches	2.24	0.34	15%	no					Tech dose **Not** apply: No sprag
02	04	99	Clutch & Brake Hubs	20.72	3.84	19%	no					Tech dose **Not** apply: manual trans, no internal clutch
02	04	99	Misc.	0.59	0.06	10%	no					Tech dose **Not** apply: manual trans,
02	05	01	Torque Converter Asm	19.32	8.62	45%	no					Tech dose **Not** apply: manual trans,
02	06	01	Oil Pump Asm	4.71	1.44	31%	no					Tech dose **Not** apply: manual trans,
02	06	04	Oil Cooler	2.35	0.98	42%	no					Tech dose **Not** apply: manual trans,
02	07	01	Valve Body Asm	6.56	0.87	13%	no					Tech dose **Not** apply: manual trans,
02	09	03	Pawls	0.88	0.06	7%	no					Tech dose **Not** apply: manual trans,
02	12	01	Carrier	1.95	0.29	15%	no					Tech dose **Not** apply: manual trans,
02	12	02	Planetary Gears	3.66	0.49	13%	no					Tech dose **Not** apply: manual trans,
02	12	03	Drive Gears & Shafts	12.75	2.25	18%	no					Tech dose **Not** apply: manual trans,
02	12	04	Clutch & Brake Hubs	3.72	0.14	4%	no					Tech dose **Not** apply: manual trans,
02	12	05	Shift Fork Assembly	1.75	1.00	58%	no					Tech dose **Not** apply: manual trans,
02	12	07	Bearings & Spacers	1.86	1.56	84%	no					Tech dose **Not** apply: manual trans,
02	12	08	Case Pump	0.63	0.21	34%	no					Tech dose **Not** apply: manual trans,

If the original Silverado 1500 mass reduction concept idea was not able to be applied to the comparison vehicle it is not described in the section below.

Components with significant mass savings identified on the Renault Master 2.3 DCi include the transmission case and gears. Image 3.2–11 shows the Renault Master 2.3 DCi transmission.

DRAFT

Image 3.2–11: Renault Master 2.3 DCi transmission
(Source: www. A2mac1.com)

Transmission Case

Shown in Image 3.2–12 are the Silverado 1500 and Renault Master 2.3 series transmission housings. Component masses were 18.78 kg for the Silverado 1500 versus 13.65 kg for the Renault Master 2.3. The Lightweighting Technology used on the housings was to change the aluminum material from A 308 aluminum to AZ 91 magnesium. This material is used in the 2015 Chevrolet Corvette Stingray transmission housing. Due to similarities in component material, full percentage of the Silverado 1500 transmission housing mass reduction can be applied to the Renault. (Refer to Table 3-16).

DRAFT


Image 3.2–12: Transmission for the Silverado 1500 (Left) and Renault Master 2.3 (Right)
(Source: FEV, Inc.)

Gears

Shown in Image 3.2–13 are the Silverado 1500 and Renault Master 2.3 series gears. Component masses were 6.58 kg for the Silverado 1500 versus 5.1 kg for the Renault Master 2.3. The Lightweighting Technology used on the gears was to change the 8620 and 4120 steel materials to 6265 and 9310 high-strength gear steel. Some automotive companies are currently using these materials for gears which are in need of integrity help in their application. Premium material will be used as much as possible within the parameters of this study. Due to similarities in component material, full percentage of the Silverado 1500 gears mass reduction can be applied to the Renault. (Refer to Table 3-16).

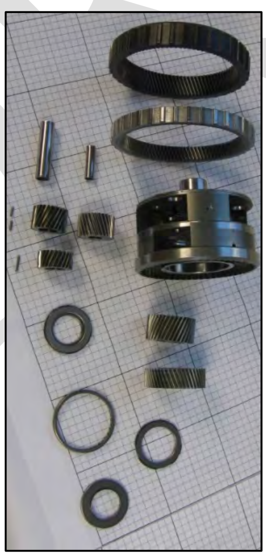



Image 3.2–13: Planet Gears for the Silverado 1500 (Left) and Drive Gears Master 2.3 (Right)
(Source: FEV, Inc.)

DRAFT

3.3 BODY GROUP -A- SYSTEM

3.3.1 Silverado 1500 Summary

The Chevrolet Silverado 1500 Body Group -A- System included the Body Structure Subsystem (Cabin); Front End Subsystem (radiator structure, extra cabin – radiator support); Front Wheelhouse Arch Liners [RH/LH], front rock shield, under hood cover, radiator; Body Closures Subsystem – front fenders (LH/RH); Body Closures Subsystem – hood assembly w/o hinges; Body Closures Subsystem – front door assemblies (RH/LH); Body Closures Subsystem – rear door assemblies (RH/LH); front bumper, rear bumper, pickup box assembly, and pickup box gate. The Body Group -A- System is made of welded steel stampings to form panels and structures.

The Chevrolet Silverado 1500 analysis identifies mass reduction alternatives and cost implications for the Body Group -A- System with the intent to meet the function and performance requirements of the baseline vehicle. Table 3-17 provides a summary of mass reduction and cost impact for select sub-subsystems evaluated. The total mass savings found on the Body Group -A- System was reduced by 207.1 kg (36.04%). This increased cost by $1,194.79, or $5.77 per kg. Mass reduction for this system reduced vehicle curb weight by 8.68%.

Table 3-17: Body Group -A- System Mass Reduction Summary Silverado 1500

				Net Value of Mass Reduction					
System	Subsystem	Sub-Subsystem	Description	Base Mass "kg"	Mass Reduction "kg" (1)	Cost Impact NIDMC "$" (2)	Average Cost/ Kilogram "$/kg" (2)	Mass Reduction "%"	Vehicle Mass Reduction "%"
03	**01**	**00**	**Body Structure Subsystem**	**207.20**	**75.40**	**-505.28**	**-6.70**	**36.39%**	**3.16%**
03	01	01	Body Structure Subsystem - Cabin	207.20	75.40	-505.28	-6.70	36.39%	3.16%
03	**02**	**00**	**Front End Subsystem**	**38.32**	**12.30**	**-62.32**	**-5.07**	**32.11%**	**0.52%**
03	02	01	Front End Subsystem (Radiator Structure)	12.90	5.70	-10.58	-1.86	44.19%	0.24%
03	02	02	Extra Cabin - Radiator Support	12.10	5.90	-52.59	-8.91	48.76%	0.25%
03	02	04	Front Wheel Arch Liners	3.70	0.36	0.17	0.47	9.81%	0.02%
03	02	10	Under Engine Closures or Rock Shields	1.52	0.13	0.09	0.72	8.67%	0.01%
03	02	11	Under Hood Covers	2.09	0.21	0.59	2.83	9.94%	0.01%
03	02	12	Tow hooks	2.25	0.00	0.00	0.00	0.00%	0.00%
03	02	13	Hood Hinges	3.75	0.00	0.00	0.00	0.00%	0.00%
03	**03**	**00**	**Body Closure Subsystem**	**153.70**	**60.00**	**-289.24**	**-4.82**	**39.04%**	**2.51%**
03	03	01	Body Closures Subsystem - Front Fenders (LH & RH)	28.90	14.50	-37.90	-2.61	50.17%	0.61%
03	03	02	Body Closures Subsystem - Hood Assembly w/o Hinges	22.70	11.00	-35.18	-3.20	48.46%	0.46%
03	03	03	Body Closures Subsystem - Front Door Assemblies (LH & RD)	57.90	20.30	-117.72	-5.80	35.06%	0.85%
03	03	04	Body Closures Subsystem - Rear Door Assemblies (LH & RD)	44.20	14.20	-98.44	-6.93	32.13%	0.60%
03	**19**	**00**	**Body Closure Subsystem**	**48.40**	**16.40**	**-70.15**	**-4.28**	**33.88%**	**0.69%**
03	19	01	Front Bumper	28.50	9.90	-23.88	-2.41	34.74%	0.41%
03	19	02	Rear Bumper	19.90	6.50	-46.27	-7.12	32.66%	0.27%
03	**26**	**00**	**Body Closure Subsystem**	**127.10**	**43.00**	**-267.80**	**-6.23**	**33.83%**	**1.80%**
03	26	01	Pickup Box Assembly	108.30	34.40	-241.45	-7.02	31.76%	1.44%
03	26	02	Pickup Box Gate	18.80	8.60	-26.35	-3.06	45.74%	0.36%
				574.72	207.10 (Decrease)	-1194.79 (Increase)	-5.77 (Increase)	36.04%	8.68%

(1) "+" = mass decrease, "-" = mass increase
(2) "+" = cost decrease, "-" = cost increase

Mass savings opportunities were identified for the following components: Body Structure Subsystem – Cabin, Front End Subsystem (Radiator Structure), extra cabin – radiator support, front wheelhouse arch (RH/LH), front splash shield, splash shield (RH/LH corner), engine cover, cover – radiator; Body Closures Subsystem – front fenders (RH/LH); Body Closures Subsystem – Hood

Assembly w/o Hinges, Body Closures Subsystem – front door assemblies (RH/LH); Body Closures Subsystem – rear door assemblies (RH/LH), front bumper, rear bumper, pickup box assembly, and pickup box gate.

Cabin: The cabin mass was reduced by using aluminum stampings that were glued, welded, or riveted together. Mass was reduced by 36.4%, from 207.2 kg to 131.8 kg.

Radiator Structure: The radiator structure mass was reduced by using aluminum stampings that were glued, welded, or riveted together. Mass was reduced by 44.2% from 12.9 kg to 7.20 kg.

Extra Cabin - Radiator Support: The extra cabin - radiator support mass was reduced by using aluminum stampings that were glued, welded, or riveted together. Mass was reduced by 48.8% from 12.1 kg to 6.20 kg.

Front Wheelhouse Arch - LH: The front wheelhouse arch – LH mass was reduced by using PolyOne® foaming agent. Mass was reduced by 10% from 1.81 kg to 1.63 kg.

Front Wheelhouse Arch - RH: The front wheelhouse arch - RH mass was reduced by using PolyOne® foaming agent. Mass was reduced by 10% from 1.81 kg to 1.63 kg.

Front Splash shield: The front splash shield mass was reduced by using PolyOne® foaming agent. Mass was reduced by 10% from 0.91 kg to 0.82 kg.

Splash Shield - LH Corner: The splash shield - LH corner mass was reduced by using PolyOne® foaming agent. Mass was reduced by 10% from 0.12 kg to 0.11 kg.

Splash Shield - RH Corner: The splash shield - RH corner mass was reduced by using PolyOne® foaming agent. Mass was reduced by 10% from .28 kg to .25 kg.

Engine Cover: The engine cover mass was reduced by using PolyOne® foaming agent. Mass was reduced by 10% from .99 kg to .89 kg.

Cover - Radiator: The cover - radiator mass was reduced by using PolyOne® foaming agent. Mass was reduced by 10% from 1.07 kg to .96 kg.

Front Fenders LH and RH: The front fenders LH and RH mass was reduced by using aluminum stampings that were glued, welded, or riveted together. Mass was reduced by 50.2% from 28.9 kg to 14.4 kg.

Hood Assembly w/o Hinges: The hood assembly w/o hinges mass was reduced by using aluminum stampings that were glued, welded, or riveted together. Mass was reduced by 48.5% from 22.7kg to 11.7kg.

Front Door Assemblies LH and RH: The front door assemblies LH and RH mass was reduced by using aluminum stampings that were glued, welded, or riveted together. Mass was reduced by 35.1% from 57.9 kg to 37.6 kg.

Rear Door Assemblies LH and RH: The rear door assemblies LH and RH mass was reduced by using aluminum stampings that were glued, welded, or riveted together. Mass was reduced by 32.1% from 44.2 kg to 30.0 kg.

Front Bumper: The front bumper mass was reduced by using aluminum stampings that were glued, welded, or riveted together. Mass was reduced by 34.7% from 28.50kg to 18.60kg.

Rear Bumper: The rear bumper mass was reduced by using aluminum stampings that were glued, welded, or riveted together. Mass was reduced by 32.7% from 19.9 kg to 13.4 kg.

DRAFT

Pickup Box Assembly: The pickup box assembly mass was reduced by using aluminum stampings that were glued, welded, or riveted together. Mass was reduced by 31.8% from 108.3 kg to 73.9 kg.

Pickup Box Gate: The pickup box gate mass was reduced by using aluminum stampings that were glued, welded, or riveted together. Mass was reduced by 45.7% from 18.8 kg to 10.2 kg.

3.3.1.1 Silverado 2500 Analysis

The Chevrolet Silverado 2500 Body Group -A- System (Image 3.3–1) is very similar to that of the 1500, even though the 1500 used for analysis was a crew cab and the 2500 an extended cab.

Image 3.3–1: Chevrolet Silverado 2500 Body Group -A- System
(Source: FEV, Inc.)

DRAFT

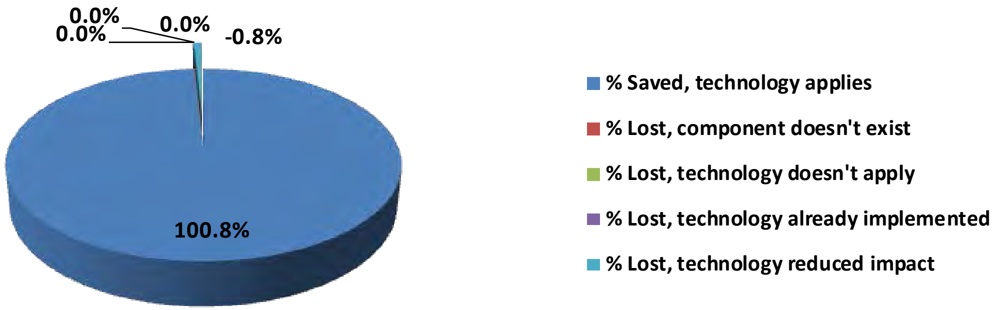
3.3.1.2 2500 System Scaling Summary

Table 3-18 summarizes mass and cost impact of Silverado 1500 Lightweighting technologies applied to the Silverado 2500. Total Body Group -A- System mass savings is 205.05 kg at a cost increase of $1,219.98, or $5.95 per kg. This system uses compounding mass reductions only.

Table 3-18: Mass-Reduction and Cost Impact for Body Group -A- System, Silverado 2500

				Net Value of Mass Reduction							
System	Subsystem	Sub-Subsystem	Description	Mass Reduction New Tech "kg" (1)	Mass Reduction Comp "kg" (1)	Mass Reduction Total "kg" (1)	Cost Impact New Tech "$" (2)	Cost Impact Comp "$" (2)	Cost Impact Total "$" (2)	Cost/ Kilogram Total "$/kg"	Vehicle Mass Reduction Total "%"
03	00	00	**Body System "A"**								
03	01	00	Body Structure Subsystem	69.50	0.00	69.50	$0.00	-$465.77	-$465.77	$0.00	2.25%
03	02	00	Front End Subsystem	12.80	0.00	12.80	$0.00	-$63.44	-$63.44	-$4.95	0.41%
03	03	00	Body Closure Subsystem	55.15	0.00	55.15	$0.00	-$297.80	-$297.80	-$5.40	1.79%
03	19	00	Bumpers Subsystem	17.85	0.00	17.85	$0.00	-$76.73	-$76.73	-$4.30	0.58%
03	26	00	Pickup Box	49.75	0.00	49.75	$0.00	-$316.24	-$316.24	$0.00	1.61%
				205.05 (Decrease)	**0.00**	**205.05** (Decrease)	**0.00**	**-1219.98** (Increase)	**-$1,219.98** (Increase)	**-$5.95** (Increase)	**6.65%**

Mass Savings, Select Vehicle, New Technology "kg"	**205.05**
Mass Savings, Silverado 1500, New Technology "kg"	**203.50**
Mass Savings Select Vehicle/Mass Savings 1500	**100.8%**



*SMS not included - has no significant impact on perecent contributions

3.3.1.3 System Scaling Analysis

The Silverado 2500 Body Group -A- System components were reviewed for compatibility with Lightweighting technologies. The results of this analysis are listed in Table 3-19.

Table 3-19: System Scaling Analysis Body Group -A- System, Silverado 2500

Silverado 1500							Select Vehicle			
System	Subsystem	Sub-Subsystem	Component/Assembly	Base Mass	Mass Savings New Tech	% of Mass Savings New Tech	Tech Applies	Base Mass	Mass Savings New Tech	Notes
03			**Body Group A System**	**574.72**	**203.50**	**35%**			**205.05**	
03	01	01	Body Structure Subsystem - Cabin	207.20	75.40	36%	yes	191.00	69.50	Tech **DOES** apply: Use Aluminum
03	02	01	Front End Subsystem (Radiator Structure)	12.90	5.70	44%	yes	13.60	6.01	Tech **DOES** apply: Use Aluminum
03	02	02	Extra Cabin - Radiator Support	12.10	5.90	49%	yes	12.30	6.00	Tech **DOES** apply: Use Aluminum
03	02	04	Front Wheelhouse Arch - LH	1.81	0.18	10%	yes	1.90	0.19	Tech **DOES** apply: Use Polyone foaming agent
03	02	04	Front Wheelhouse Arch - RH	1.81	0.18	10%	yes	1.99	0.20	Tech **DOES** apply: Use Polyone foaming agent
03	02	10	Frt Splash shield	0.91	0.09	10%	yes	0.71	0.07	Tech **DOES** apply: Use Polyone foaming agent
03	02	10	Splash Shield - LH Corner	0.13	0.01	10%	no			Tech does **NOT** apply: Not on vehicle
03	02	10	Splash Shield - RH Corner	0.28	0.03	10%	no			Tech does **NOT** apply: Not on vehicle
03	02	11	Eng Cover	1.00	0.10	10%	yes	0.81	0.08	Tech **DOES** apply: Use Polyone foaming agent
03	02	11	Cover - Radiator	1.08	0.11	10%	yes	2.56	0.26	Tech **DOES** apply: Use Polyone foaming agent
03	03	01	Body Closures Subsystem - Front Fenders (LH & RH)	28.90	10.90	38%	yes	26.80	10.11	Tech **DOES** apply: Use Aluminum
03	03	02	Body Closures Subsystem - Hood Assembly w/o Hinges	22.70	11.00	48%	yes	24.70	11.97	Tech **DOES** apply: Use Aluminum
03	03	03	Body Closures Subsystem - Front Door Assemblies (LH & RD)	57.90	20.30	35%	yes	55.20	19.35	Tech **DOES** apply: Use Aluminum
03	03	04	Body Closures Subsystem - Rear Door Assemblies (LH & RD)	44.20	14.20	32%	yes	42.70	13.72	Tech **DOES** apply: Use Aluminum
03	19	01	Front Bumper	28.50	9.90	35%	yes	30.80	10.70	Tech **DOES** apply: Use Aluminum
03	19	02	Rear Bumper	19.90	6.50	33%	yes	21.90	7.15	Tech **DOES** apply: Use Aluminum
03	26	01	Pickup Box Assembly	108.30	34.40	32%	yes	130.40	41.42	Tech **DOES** apply: Use Aluminum
03	26	02	Pickup Box Gate	18.80	8.60	46%	yes	18.20	8.33	Tech **DOES** apply: Use Aluminum

If the original Silverado 1500 mass reduction concept idea was not able to be applied to the comparison vehicle it is not described in the section below.

Components with significant mass savings identified on the Silverado 2500 included the Body Structure Subsystem – Cabin, Front End Subsystem (Radiator Structure), extra cabin (radiator support), front wheelhouse arch (LH/RH), front splash shield, engine cover, cover – radiator, Body Closures Subsystem – Front Fenders (LH/RH), Body Closures Subsystem – Hood Assembly w/o Hinges, Body Closures Subsystem – Front Door Assemblies (LH/RH), Body Closures Subsystem – Rear Door Assemblies (LH/RH), front bumper, rear bumper, pickup box assembly, and pickup box gate.

DRAFT

Cabin

Shown in Image 3.3–2 are the Silverado 1500 and 2500 cabins. Component masses were 207.2 kg for the 1500 (crew cab configuration) versus 191.0 kg for the 2500 (an extended cab). The Lightweighting Technology used on the cabin was aluminum stampings that were glued, welded, or riveted together. Due to similarities in component design and material, full percentage of the Silverado 1500 cabin mass reduction can be applied to the 2500. (Refer to Table 3-19).

Image 3.3–2: Cabin for the Silverado 1500 (Left) and Silverado 2500 (Right)
(Source: FEV, Inc.)

<u>Radiator Structure</u>

Shown in Image 3.3–3 are the Silverado 1500 and 2500 radiator structures. Component masses were 12.9 kg for the 1500 versus 13.6 kg for the 2500. The Lightweighting Technology used on the cabin is to use aluminum stampings that were glued, welded, or riveted together. Due to similarities in component design and material, full percentage of the Silverado 1500 radiator structure mass reduction can be applied to the 2500. (Refer to Table 3-19).

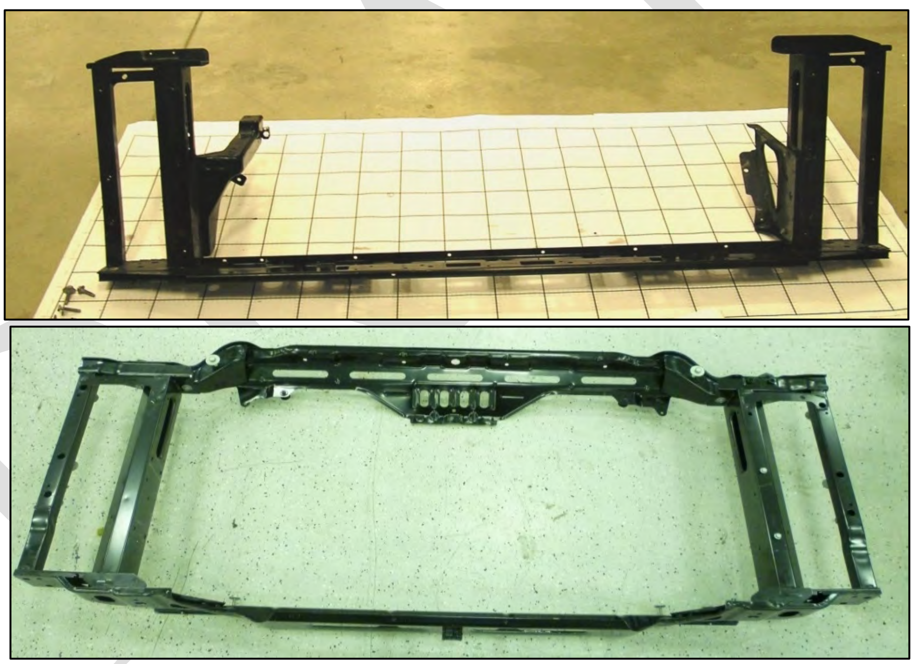


Image 3.3–3: Radiator structure for the Silverado 1500 (Top) and Silverado 2500 (Bottom)
(Source: FEV, Inc.)

DRAFT

Extra Cabin - Radiator Support

Shown in Image 3.3–4 is the Silverado 1500 and 2500 extra cabin – radiator support. Component masses were 12.1 kg for the 1500 versus 12.3 kg for the 2500. The Lightweighting Technology used on the cabin is to use aluminum stampings that were glued, welded, or riveted together. Due to similarities in component design and material, full percentage of the Silverado 1500 extra cabin – radiator support assembly mass reduction can be applied to the 2500. (Refer to Table 3-19).

Image 3.3–4: Extra cabin – radiator support Silverado 2500 (Silverado 1500 similar)
(Source: FEV, Inc.)

Front Wheelhouse Arch (RH/LH)

Shown in Image 3.3–5 are the Silverado 1500 and 2500 RH/LH front wheelhouse arches. Component masses were 3.63 kg for the 1500 versus 3.90 kg for the 2500. The Lightweighting Technology used was the PolyOne® foaming agent in the plastic to reduce the mass by 10%. Due to similarities in component design and material, full percentage of the Silverado 1500 front wheelhouse arch mass reduction can be applied to the 2500. (Refer to Table 3-19).

Image 3.3–5: RH/LH front wheelhouse arch for the Silverado 1500 (Left) and Silverado 2500 (Right)
(Source: FEV, Inc.)

DRAFT

Front Splash Shield

Shown in Image 3.3–6 are the Silverado 1500 and 2500 front splash shields. Component masses were 0.91 kg for the 1500 versus 0.71 kg for the 2500. The Lightweighting Technology used was the PolyOne® foaming agent in the plastic to reduce the mass by 10%. Due to similarities in component design and material, full percentage of the Silverado 1500 front splash shield mass reduction can be applied to the 2500. (Refer to Table 3-19).

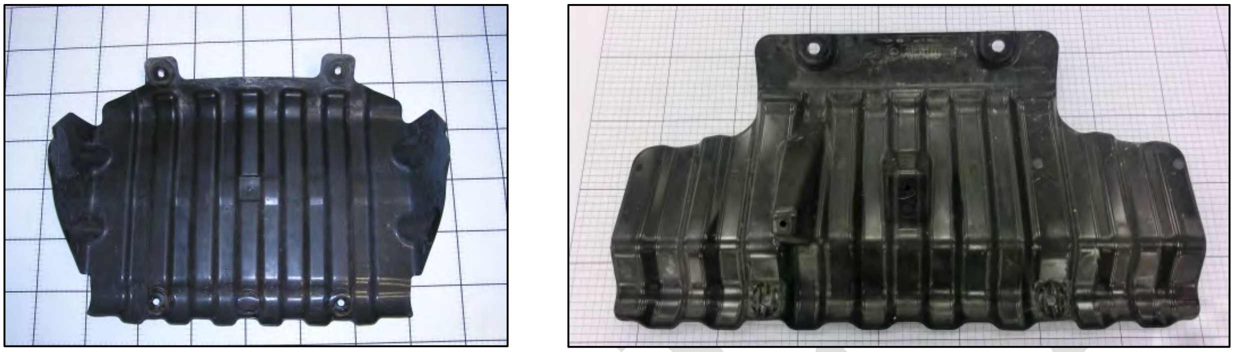


Image 3.3–6: Front splash shield for the Silverado 1500 (Left) and Silverado 2500 (Right)
(Source: FEV, Inc.)

Engine Cover

Shown in Image 3.3–7 are the Silverado 1500 and 2500 engine covers. Component masses were 1.00 kg for the 1500 versus 0.81kg for the 2500. The Lightweighting Technology used was PolyOne® foaming agent in the plastic to reduce mass by 10%. Due to similarities in component design and material, full percentage of the Silverado 1500 engine cover mass reduction can be applied to the 2500. (Refer to Table 3-19).

Image 3.3–7: Engine cover for Silverado 1500 (Left) and Silverado 2500 (Right)
(Source: FEV, Inc.)

DRAFT

Cover - Radiator

Shown in Image 3.3–8 are the Silverado 1500 and 2500 radiator covers. Component masses were 1.08 kg for the 1500 versus 2.56 kg for the 2500. The Lightweighting Technology used was PolyOne® foaming agent in the plastic to reduce the mass by 10%. Due to similarities in component material, full percentage of the Silverado 1500 radiator cover mass reduction can be applied to the 2500. (Refer to Table 3-19).

Image 3.3–8: Radiator covers for the Silverado 1500 (Top) and Silverado 2500 (Bottom)
(Source: FEV, Inc.)

DRAFT

Front Fenders (RH/LH)

Shown in Image 3.3–9 are the Silverado 1500 and 2500 RH/LH front fenders. The component masses were 28.9 kg for the 1500 versus 26.8 kg for the 2500. The Lightweighting Technology used on the front fenders were aluminum stampings that were glued, welded, or riveted together. Due to similarities in component design and material, full percentage of the Silverado 1500 front fenders RH/LH mass reduction can be applied to the 2500. (Refer to Table 3-19).

Image 3.3–9: Front fenders (RH/LH) Silverado 1500 (Left) and Silverado 2500 (Right)
(Source: FEV, Inc.)

Hood Assembly without Hinges

Shown in Image 3.3–10 are the Silverado 1500 and 2500 hood assemblies without hinges. Component masses were 22.7 kg for the 1500 versus 24.7 kg for the 2500. The Lightweighting Technology used is aluminum stampings that were glued, welded, or riveted together. Due to similarities in component design and material, full percentage of the Silverado 1500 hood assembly mass reduction can be applied to the 2500. (Refer to Table 3-19).

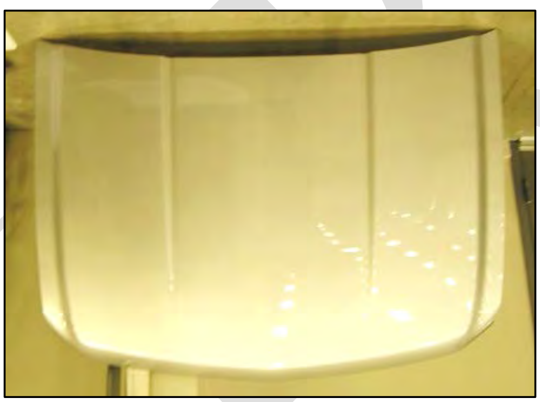


Image 3.3–10: Hood assembly without hinges, Silverado 1500 (Left) and Silverado 2500 (Right)
(Source: FEV, Inc.)

DRAFT

Front Door Assemblies (RH/LH)

Shown in Image 3.3–11 are the Silverado 1500 and 2500 RH/LH front door assemblies. The component masses were 57.9 kg for the 1500 versus 55.2 kg for the 2500. The Lightweighting

Technology used was aluminum stampings that were glued, welded, or riveted together. Due to similarities in component design and material, full percentage of the Silverado 1500 front door assembly mass reduction can be applied to the 2500. (Refer to Table 3-19).

Image 3.3–11: Front door assemblies for the Silverado 1500 (Left) and Silverado 2500 (Right)
(Source: FEV, Inc.)

DRAFT

Rear Door Assemblies (RH/LH)

Shown in Image 3.3–12 are the Silverado 1500 and 2500 RH/LH rear door assemblies. Component masses were 44.20 kg for the 1500 versus 42.70 kg for the 2500. The Lightweighting Technology used on the rear door assemblies was aluminum stampings that were glued, welded, or riveted together. Due to similarities in component material, full percentage of the Silverado 1500 rear door assembly RH/LH mass reduction can be applied to the 2500. (Refer to Table 3-19).

Image 3.3–12: Rear door assemblies for the Silverado 1500 (Left) and Silverado 2500 (Right)
(Source: FEV, Inc.)

Front Bumper

Shown in Image 3.3–13 are the Silverado 1500 and 2500 front bumpers. The component masses were 28.5 kg for the 1500 versus 30.8 kg for the 2500. The Lightweighting Technology used was aluminum stampings that were glued, welded, or riveted together. Due to similarities in component design and material, full percentage of the Silverado 1500 front bumper mass reduction can be applied to the 2500. (Refer to Table 3-19).

Image 3.3–13: Front bumper for the Silverado 1500 (Top) and Silverado 2500 (Bottom)
(Source: FEV, Inc.)

DRAFT

Rear Bumper

Shown in Image 3.3–14 are the Silverado 1500 and 2500 rear bumpers. Component masses were 19.9 kg for the 1500 versus 21.9 kg for the 2500. The Lightweighting Technology used on the rear bumper was aluminum stampings that were glued, welded, or riveted together. Due to similarities in component design and material, full percentage of the Silverado 1500 rear bumper mass reduction can be applied to the 2500. (Refer to Table 3-19).

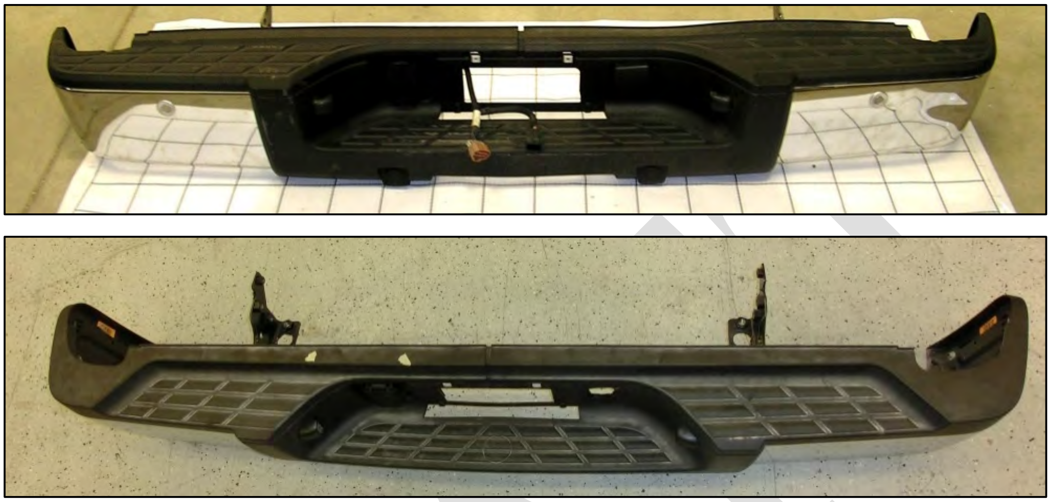


Image 3.3–14: Rear bumper for the Silverado 1500 (Top) and Silverado 2500 (Bottom)
(Source: FEV, Inc.)

DRAFT

Pickup Box Assembly

Shown in Image 3.3–15 are the Silverado 1500 and 2500 series pickup box assemblies. The component masses were 108.3 kg for the 1500 versus 130.4 kg for the 2500. The Lightweighting Technology used in the pickup box assembly was aluminum stampings that were glued, welded, or riveted together. Due to similarities in component material, full percentage of the Silverado 1500 pickup box assembly mass reduction can be applied to the 2500. (Refer to Table 3-19).

Image 3.3–15: Pickup box assembly for the Silverado 1500 (Top) and Silverado 2500 (Bottom)
(Source: FEV, Inc.)

DRAFT

Pickup Box Gate

Shown in Image 3.3–16 are the Silverado 1500 and 2500 series pickup box gates. The component masses were 18.8 kg for the 1500 versus 18.2 kg for the 2500. The Lightweighting Technology used on the pickup box gate was aluminum stampings that were glued, welded, or riveted together. Due to similarities in component design and material, full percentage of the Silverado 1500 pickup box gate mass reduction can be applied to the 2500. (Refer to Table 3-19).

Image 3.3–16: Pickup box gate for the Silverado 1500 (Top) and Silverado 2500 (Bottom)
(Source: FEV, Inc.)

3.3.1.4 System Comparison, Silverado 2500

Table 3-20 summarizes the Silverado 1500 and 2500 Lightweighting results. The majority of the components were visually the same among the two Body Group -A- systems.

Table 3-20: Body Group -A- System Comparison, Silverado 1500 and 2500

		Net Value of Mass Reduction								
System	Description	Mass Base "kg" (1)	Mass Reduction New Tech "kg" (1)	Mass Reduction Comp "kg" (1)	Mass Reduction Total "kg" (1)	System Mass Reduction "%"	Cost Impact New Tech "$" (2)	Cost Impact Comp "$" (2)	Cost Impact Total "$" (2)	Cost/ Kilogram Total "$/kg"
03	**Body Group A**									
03	Silverado 1500	574.72	0.00	203.50	203.50	35.41%	0.00	-$1,213.18	-$1,213.18	-$5.96
03	Silverado 2500	587.12	0.00	205.05	205.05	34.93%	0.00	-$1,219.98	-$1,219.98	-$5.95

DRAFT

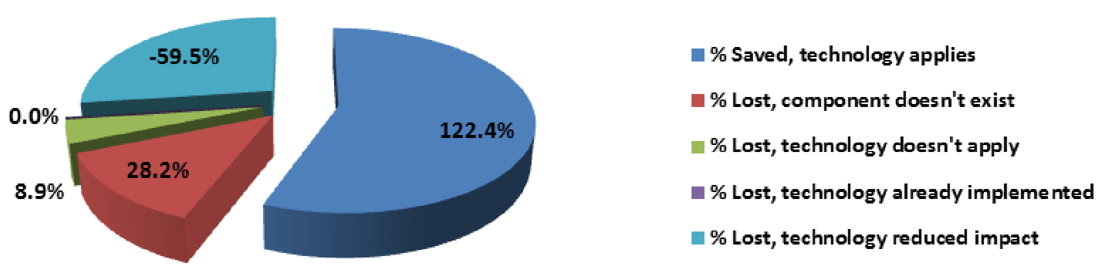
3.3.2 Mercedes Sprinter 311 CDi

Table 3-21 summarizes mass and cost impact of the Silverado 1500 Lightweighting technologies as applied to the Mercedes Sprinter 311 CDi. Total Body Group -A- mass savings was 248.99 kg at a cost increase of $1603.32, or $6.44 per kg.

Table 3-21: Mass-Reduction and Cost Impact for Body Group -A- System, Mercedes Sprinter

System	Subsystem	Sub-Subsystem	Description	Net Value of Mass Reduction: Mass Reduction New Tech "kg" (1)	Mass Reduction Comp "kg" (1)	Mass Reduction Total "kg" (1)	Cost Impact New Tech "$" (2)	Cost Impact Comp "$" (2)	Cost Impact Total "$" (2)	Cost/ Kilogram Total "$/kg"	Vehicle Mass Reduction Total "%"
03	00	00	**Body System "A"**								
03	01	00	Body Structure Subsystem	217.98	0.00	217.98	$0.00	-$1,460.73	-$1,460.73	$0.00	10.23%
03	02	00	Front End Subsystem	0.46	0.00	0.46	$0.00	$0.52	$0.52	$1.12	0.02%
03	03	00	Body Closure Subsystem	28.14	0.00	28.14	$0.00	-$137.29	-$137.29	-$4.88	1.32%
03	19	00	Bumpers Subsystem	2.42	0.00	2.42	$0.00	-$5.83	-$5.83	-$2.41	0.11%
03	26	00	Pickup Box	0.00	0.00	0.00	$0.00	$0.00	$0.00	$0.00	0.00%
				248.99 (Decrease)	**0.00**	**248.99** (Decrease)	**0.00**	**-1603.32** (Increase)	**-$1,603.32** (Increase)	**-$6.44** (Increase)	**11.68%**

Mass Savings, Select Vehicle, New Technology "	**248.99**
Mass Savings, Silverado 1500, New Technology "	**203.50**
Mass Savings Select Vehicle/Mass Savings 1500	**122.4%**



*SMS not included - has no significant impact on perecent contributions

3.3.2.1 System Scaling Analysis

The Mercedes Sprinter 311 CDi Body Group -A- components were reviewed for compatibility with Lightweighting technologies. The results of this analysis are listed in Table 3-22.

Table 3-22: System Scaling Analysis for Body Group -A- System, Mercedes Sprinter

Silverado 1500							Select Vehicle			
System	Subsystem	Sub-Subsystem	Component/Assembly	Base Mass	Mass Savings New Tech	% of Mass Savings New Tech	Tech Applies	Base Mass	Mass Savings New Tech	Notes
03			**Body Group A System**	**574.720**	**203.502**	**35%**			**248.991**	
03	01	01	Body Structure Subsystem - Cabin	207.20	75.40	36%	yes	599.00	217.98	Tech **DOES** apply: Use Aluminum
03	02	01	Front End Subsystem (Radiator Structure)	12.90	5.70	44%	no			Tech does **NOT** apply: Part on vehicle but technology does not apply
03	02	02	Extra Cabin - Radiator Support	12.10	5.90	49%	no			Tech does **NOT** apply: Part on vehicle but technology does not apply
03	02	04	Front Wheelhouse Arch - LH	1.81	0.18	10%	yes	1.72	0.17	Tech **DOES** apply: Use Polyone foaming agent
03	02	04	Front Wheelhouse Arch - RH	1.81	0.18	10%	yes	1.70	0.17	Tech **DOES** apply: Use Polyone foaming agent
03	02	10	Frt Splash shield	0.91	0.09	10%	no			Tech does **NOT** apply: Part not on vehicle
03	02	10	Splash Shield - LH Corner	0.13	0.01	10%	no			Tech does **NOT** apply: Part not on vehicle
03	02	10	Splash Shield - RH Corner	0.28	0.03	10%	no			Tech does **NOT** apply: Part not on vehicle
03	02	11	Eng Cover	1.00	0.10	10%	yes	1.20	0.12	Tech **DOES** apply: Use Polyone foaming agent
03	02	11	Cover - Radiator	1.08	0.11	10%	no			Tech does **NOT** apply: Part not on vehicle
03	03	01	Body Closures Subsystem - Front Fenders (LH & RH)	28.90	10.90	38%	yes	15.82	5.97	Tech **DOES** apply: Use Aluminum
03	03	02	Body Closures Subsystem - Hood Assembly w/o Hinges	22.70	11.00	48%	yes	17.53	8.49	Tech **DOES** apply: Use Aluminum
03	03	03	Body Closures Subsystem - Front Door Assemblies (LH & RD)	57.900	20.30	35%	yes	39.01	13.68	Tech **DOES** apply: Use Aluminum
03	03	04	Body Closures Subsystem - Rear Door Assemblies (LH & RD)	44.20	14.20	32%	no			Tech does **NOT** apply: Part not on vehicle
03	19	01	Front Bumper	28.50	9.90	35%	yes	6.96	2.42	Tech **DOES** apply: Use Aluminum
03	19	02	Rear Bumper	19.90	6.50	33%	no			Tech does **NOT** apply: Part on vehicle but technology does not apply
03	26	01	Pickup Box Assembly	108.30	34.40	32%	no			Tech does **NOT** apply: Part not on vehicle
03	26	02	Pickup Box Gate	18.80	8.60	46%	no			Tech does **NOT** apply: Part not on vehicle

If the original Silverado 1500 mass reduction concept idea was not able to be applied to the comparison vehicle it is not described in the section below.

Components with significant mass savings identified on the Mercedes Sprinter include the Front Wheelhouse Arch - LH, Front Wheelhouse Arch - RH, Engine Cover, Front Fenders LH and RH, Hood Assembly w/o Hinges, Front Door Assemblies LH and RH, and Rear Door Assemblies LH and RH.

<u>Front Wheelhouse Arch (RH/LH)</u>

Shown in Image 3.3–17 are the Silverado 1500 and Mercedes Sprinter 311 CDi RH/LH front wheelhouse arch. The component masses were 3.62 kg for the 1500 versus 3.42 kg for the Mercedes Sprinter 311 CDi. The Lightweighting Technology used on the component was applying PolyOne® foaming agent in the plastic to reduce the mass by 10%. Due to similarities in component design and material, full percentage of the Silverado 1500 front wheelhouse arch mass reduction can be applied to the Sprinter. (Refer to Table 3-22).


Image 3.3–17: Front Wheelhouse Arch for the Silverado 1500 (Left) and Mercedes Sprinter 311 CDi (Right)
(Source: FEV, Inc. and www.A2mac1.com)

<u>Engine Cover</u>

DRAFT

Shown in Image 3.3–18 are the Silverado 1500 and Mercedes Sprinter 311 CDi engine covers. The component masses were 1.00 kg for the 1500 versus 1.20 kg for the Mercedes Sprinter 311 CDi. The Lightweighting Technology used on the CDi Engine Cover was applying PolyOne® foaming agent in the plastic to reduce the mass by 10%. Due to similarities in component design and material, full percentage of the Silverado 1500 engine cover mass reduction can be applied to the Sprinter. (Refer to Table 3-22).

Image 3.3–18: CDi Engine Cover for the Silverado 1500 (Left) and Mercedes Sprinter 311 CDi (Right)
(Source: FEV, Inc. and www.A2mac1.com)

Front Fenders (RH and LH)

Shown in Image 3.3–19 are the Silverado 1500 and Mercedes Sprinter 311 CDi RH/LH front fenders. Component masses were 28.9 kg for the Silverado 1500 versus 15.8 kg for the Mercedes Sprinter 311 CDi. The Lightweighting Technology used was aluminum stampings that were glued, welded, or riveted together. Due to similarities in component material, full percentage of the Silverado 1500 front fender mass reduction can be applied to the Sprinter. (Refer to Table 3-22).

Image 3.3–19: RH/LH front fenders for the Silverado 1500 (Left) and Mercedes Sprinter 311 CDi (Right)
(Source: FEV, Inc. and www.A2mac1.com)

DRAFT

Hood Assembly w/o Hinges

Shown in Image 3.3–20 are the Silverado 1500 and Mercedes Sprinter 311 CDi hood assemblies without hinges. The component masses were 22.7 kg for the Silverado 1500 versus 17.5 kg for the Mercedes Sprinter 311 CDi. The Lightweighting Technology used was aluminum stampings that were glued, welded, or riveted together. Due to similarities in component design and material, full percentage of the Silverado 1500 hood assembly mass reduction can be applied to the Sprinter. (Refer to Table 3-22).

Image 3.3–20: Hood assembly without hinges for the Silverado 1500 (Left) and Mercedes Sprinter 311 CDi (Right)
(Source: FEV, Inc. and www.A2mac1.com)

Front Door Assemblies (RH/LH)

Shown in Image 3.3–21 are the RH/LH Silverado 1500 and Mercedes Sprinter 311 CDi front door assemblies. The component masses were 57.9 kg for the Silverado 1500 versus 39.0 kg for the Mercedes Sprinter 311 CDi. The Lightweighting Technology used on the assemblies was aluminum stampings that were glued, welded, or riveted together. Due to similarities in component material, full percentage of the Silverado 1500 front door assembly mass reduction can be applied to the Sprinter. (Refer to Table 3-22).

Image 3.3–21: Front door assemblies for the Silverado 1500 (Left) and Mercedes Sprinter 311 CDi
(Source: FEV, Inc. and www.A2mac1.com)

Front Bumper

DRAFT

Shown in Image 3.3–22 are the Silverado 1500 and Mercedes Sprinter 311 CDi front bumpers. The component masses were 28.5 kg for the Silverado 1500 versus 6.96 kg for the Mercedes Sprinter 311 CDi. The Lightweighting Technology used was aluminum stampings that were glued, welded, or riveted together. Due to similarities in component design and material, full percentage of the Silverado 1500 front bumper mass reduction can be applied to the Sprinter. (Refer to Table 3-22).

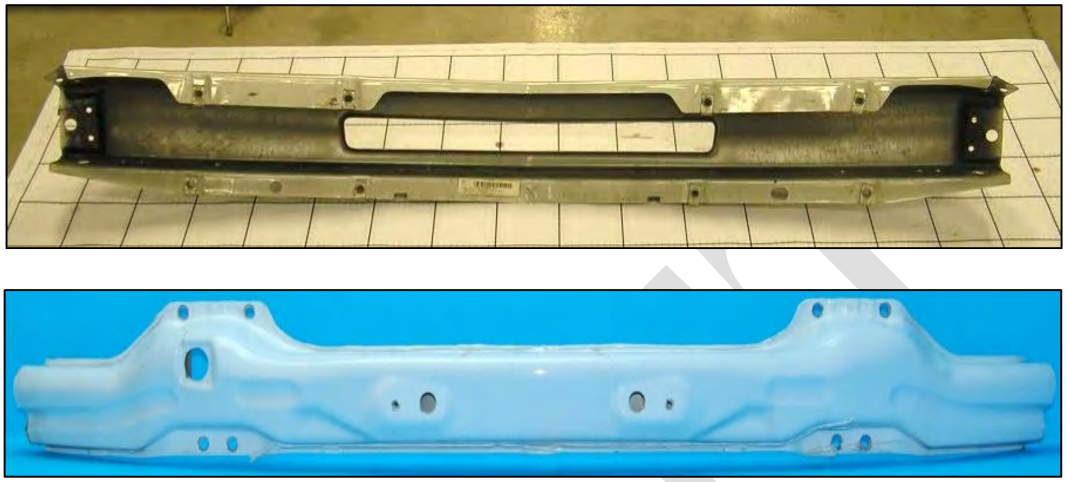


Image 3.3–22: Front bumper for the Silverado 1500 (Top) and Mercedes Sprinter 311 CDi (Bottom)
(Source: FEV, Inc. and www.A2mac1.com)

DRAFT

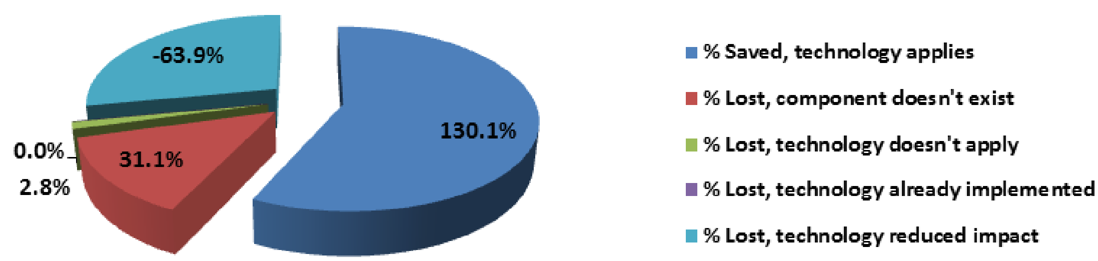
3.3.3 Renault Master 2.3 DCi

Table 3-23 summarizes the mass and cost impact of the Silverado 1500 Lightweighting technologies applied to the Renault Master 2.3 DCi. The total Body Group -A- system mass savings was 264.44 kg at a cost increase of $1,719.09, or $6.50 per kg.

Table 3-23: Mass-Reduction and Cost Impact for Body Group -A- System, Renault Master

				Net Value of Mass Reduction							
System	Subsystem	Sub-Subsystem	Description	Mass Reduction New Tech "kg" (1)	Mass Reduction Comp "kg" (1)	Mass Reduction Total "kg" (1)	Cost Impact New Tech "$" (2)	Cost Impact Comp "$" (2)	Cost Impact Total "$" (2)	Cost/ Kilogram Total "$/kg"	Vehicle Mass Reduction Total "%"
03	00	00	**Body System "A"**								
03	01	00	Body Structure Subsystem	231.80	0.00	231.80	$0.00	-$1,553.39	-$1,553.39	$0.00	9.85%
03	02	00	Front End Subsystem	0.55	0.00	0.55	$0.00	$0.37	$0.37	$0.68	0.02%
03	03	00	Body Closure Subsystem	26.44	0.00	26.44	$0.00	-$132.30	-$132.30	-$5.00	1.12%
03	19	00	Bumpers Subsystem	5.86	0.00	5.86	$0.00	-$33.77	-$33.77	-$5.77	0.25%
03	26	00	Pickup Box	0.00	0.00	0.00	$0.00	$0.00	$0.00	$0.00	0.00%
				264.66 (Decrease)	**0.00**	**264.66** (Decrease)	**0.00**	**-1719.09** (Increase)	**-$1,719.09** (Increase)	**-$6.50** (Increase)	**11.25%**

Mass Savings, Select Vehicle, New Technology "kg" **264.66**
Mass Savings, Silverado 1500, New Technology "kg' **203.50**
Mass Savings Select Vehicle/Mass Savings 1500 **130.1%**



*SMS not included - has no significant impact on perecent contributions

3.3.3.1 System Scaling Analysis

The Renault Master 2.3 DCi Body Group -A- System components were reviewed for compatibility with Lightweighting technologies. The results of this analysis are listed in Table 3-24.

Table 3-24: System Scaling Analysis for Body Group -A- System, Renault Master

Silverado 1500							Select Vehicle			
System	Subsystem	Sub-Subsystem	Component/Assembly	Base Mass	Mass Savings New Tech	% of Mass Savings New Tech	Tech Applies	Base Mass	Mass Savings New Tech	Notes
03			**Body Group A System**	**574.720**	**203.502**	**35%**			**264.657**	
03	01	01	Body Structure Subsystem - Cabin	207.20	75.40	36%	yes	637.00	231.80	Tech **DOES** apply: Use Aluminum
03	02	01	Front End Subsystem (Radiator Structure)	12.90	5.70	44%	no			Tech does **NOT** apply: Part on vehicle but technology does not apply
03	02	02	Extra Cabin - Radiator Support	12.10	5.90	49%	no			Tech does **NOT** apply: Part not on vehicle
03	02	04	Front Wheelhouse Arch - LH	1.81	0.18	10%	yes	1.27	0.13	Tech **DOES** apply: Use Polyone foaming agent
03	02	04	Front Wheelhouse Arch - RH	1.81	0.18	10%	yes	1.24	0.12	Tech **DOES** apply: Use Polyone foaming agent
03	02	10	Frt Splash shield	0.91	0.09	10%	yes	2.68	0.27	Tech **DOES** apply: Use Polyone foaming agent
03	02	10	Splash Shield - LH Corner	0.13	0.01	10%	no			Tech does **NOT** apply: Part not on vehicle
03	02	10	Splash Shield - RH Corner	0.28	0.03	10%	no			Tech does **NOT** apply: Part not on vehicle
03	02	11	Eng Cover	1.00	0.10	10%	yes	0.35	0.04	Tech **DOES** apply: Use Polyone foaming agent
03	02	11	Cover - Radiator	1.08	0.11	10%	no			Tech does **NOT** apply: Part not on vehicle
03	03	01	Body Closures Subsystem - Front Fenders (LH & RH)	28.90	10.90	38%	yes	12.85	4.85	Tech **DOES** apply: Use Aluminum
03	03	02	Body Closures Subsystem - Hood Assembly w/o Hinges	22.70	11.00	48%	yes	14.26	6.91	Tech **DOES** apply: Use Aluminum
03	03	03	Body Closures Subsystem - Front Door Assemblies (LH & RD)	57.900	20.30	35%	yes	41.89	14.69	Tech **DOES** apply: Use Aluminum
03	03	04	Body Closures Subsystem - Rear Door Assemblies (LH & RD)	44.20	14.20	32%	no			Tech does **NOT** apply: Part not on vehicle
03	19	01	Front Bumper	28.50	9.90	35%	yes	4.85	1.68	Tech **DOES** apply: Use Aluminum
03	19	02	Rear Bumper	19.90	6.50	33%	yes	12.78	4.17	Tech **DOES** apply: Use Aluminum
03	26	01	Pickup Box Assembly	108.30	34.40	32%	no			Tech does **NOT** apply: Part not on vehicle
03	26	02	Pickup Box Gate	18.80	8.60	46%	no			Tech does **NOT** apply: Part not on vehicle

If the original Silverado 1500 mass reduction concept idea was not able to be applied to the comparison vehicle it is not described in the section below.

Components with significant mass savings identified on the Renault Master 2.3 DCi include the front wheelhouse arch (RH/LH), front splash shield, engine cover, front fenders (RH/LH), hood assembly without hinges, front door assemblies (RH/LH), front bumper, and rear bumper.

<u>Front Wheelhouse Arch (RH/LH)</u>

Shown in Image 3.3–23 are the Silverado 1500 and Renault Master 2.3 DCi RH/LH front wheelhouse arches. The component masses were 3.62 kg for the Silverado 1500 versus 2.51 kg for the Renault Master 2.3 DCi. The Lightweighting Technology used was to apply PolyOne® foaming agent in the plastic to reduce the mass by 10%. Due to similarities in component design and material, full percentage of the Silverado 1500 front wheelhouse arch mass reduction can be applied to the Renault. (Refer to Table 3-24).

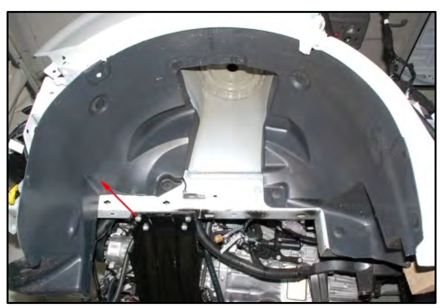


Image 3.3–23: Front wheelhouse arch for the Silverado 1500 (Left) and the Renault Master 2.3 DCi (Right)
(Source: FEV, Inc. and www.A2mac1.com)

<u>Front Splash Shield</u>

Shown in Image 3.3–24 are the Silverado 1500 and Renault Master 2.3 DCi front splash shield. The component masses were 0.91 kg for the Silverado 1500 versus 2.68 kg for the Renault Master 2.3 DCi. The Lightweighting Technology used on the front splash shield was to apply PolyOne® foaming agent in the plastic to reduce the mass by 10%. Due to similarities in component design and material, full percentage of the Silverado 1500 front splash shield mass reduction can be applied to the Renault. (Refer to Table 3-24).

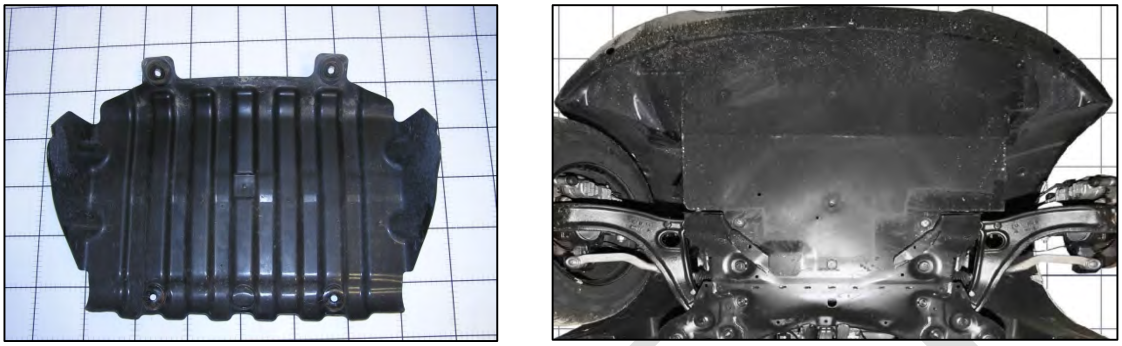


Image 3.3–24: Front splash shield for the Silverado 1500 (Left) and the Renault Master 2.3 DCi (Right)
(Source: FEV, Inc. and www.A2mac1.com)

Engine Cover

Shown in Image 3.3–25 are the Silverado 1500 and Renault Master 2.3 DCi engine covers. The component masses were 1.00 kg for the Silverado 1500 versus 0.33kg for the Renault Master 2.3 DCi. The Lightweighting Technology used on the engine cover was to apply PolyOne® foaming agent in the plastic to reduce the mass by 10%. Due to similarities in component material, full percentage of the Silverado 1500 engine cover mass reduction can be applied to the Renault. (Refer to Table 3-24).

Image 3.3–25: Engine covers for the Silverado 1500 (Left) and Renault Master 2.3 DCi (Right)
(Source: FEV, Inc. and www.A2mac1.com)

DRAFT

Front Fenders (RH/LH)

Shown in Image 3.3–26 are the Silverado 1500 and Renault Master 2.3 DCi RH/LH front fenders. The component masses were 28.9 kg for the Silverado 1500 versus 12.9 kg for the Renault Master 2.3 DCi. The Lightweighting Technology used on the front fenders was aluminum stampings that were glued, welded, or riveted together. Due to similarities in material, full percentage of the Silverado 1500 front fender mass reduction can be applied to the Renault. (Refer to Table 3-24).

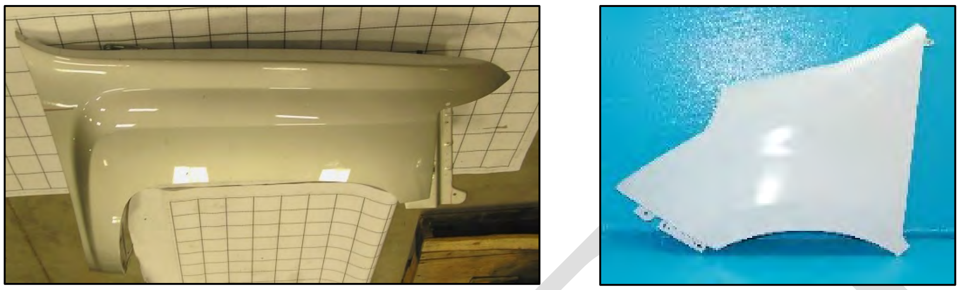


Image 3.3–26: RH/LH front fenders for the Silverado 1500 (Left) and Renault Master 2.3 DCi (Right)
(Source: FEV, Inc. and www.A2mac1.com)

Hood Assembly without Hinges

Shown in Image 3.3–27 are the Silverado 1500 and Renault Master 2.3 DCi hood assemblies without hinges. The component masses were 22.7 kg for the Silverado 1500 versus 14.3 kg for the Renault Master 2.3 DCi. The Lightweighting Technology used in the assembly was aluminum stampings that were glued, welded, or riveted together. Due to similarities in component design and material, full percentage of the Silverado 1500 hood assembly mass reduction can be applied to the Renault. (Refer to Table 3-24).

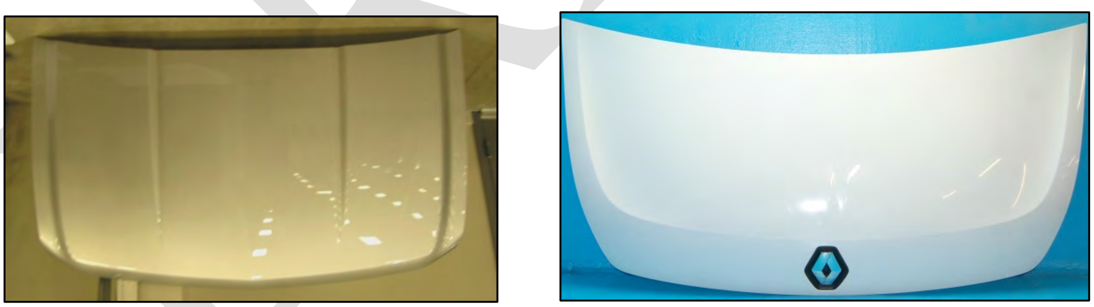


Image 3.3–27: Hood assembly without hinges for the Silverado 1500 (Left) and Renault Master 2.3 DCi (Right)
(Source: FEV, Inc. and www.A2mac1.com)

Front Door Assemblies (RH/LH)

Shown in Image 3.3–28 are the Silverado 1500 and Renault Master 2.3 DCi front door assemblies, RH. Component masses were 57.9 kg for the 1500 versus 41.9 kg for the Renault Master 2.3 DCi. The Lightweighting Technology used on the assemblies was aluminum stampings that were glued, welded, or riveted together. Due to similarities in component material, full percentage of the Silverado 1500 front door assembly mass reduction can be applied to the Renault. (Refer to Table 3-24).

DRAFT

Image 3.3–28: RH front door assemblies for the Silverado 1500 (Left) and Renault Master 2.3 DCi (Right)
(Source: FEV, Inc. and www.A2mac1.com)

<u>Front Bumper</u>

Shown in Image 3.3–29 are the Silverado 1500 and Renault Master 2.3 DCi front bumpers. The component masses were 28.5 kg for the Silverado 1500 versus 4.85 kg for the Renault Master 2.3 DCi. The Lightweighting Technology used in the front bumper was aluminum stampings that were glued, welded, or riveted together. Due to similarities in component design and material, full percentage of the Silverado 1500 front bumper mass reduction can be applied to the Renault. (Refer to Table 3-24).

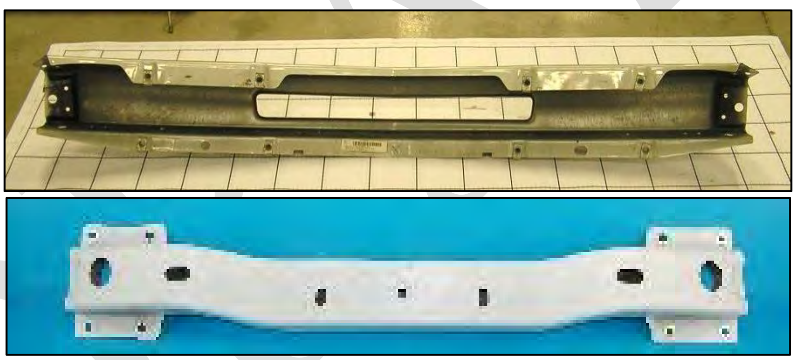


Image 3.3–29: Front bumper for the Silverado 1500 (Top) and Renault Master 2.3 DCi (Bottom)
(Source: FEV, Inc. and www.A2mac1.com)

DRAFT

Rear Bumper

Shown in Image 3.3–30 are the Silverado 1500 and Renault Master 2.3 DCi rear bumpers. Component masses were 19.9 kg for the Silverado 1500 versus 12.8 kg for the Renault Master 2.3 DCi. The Lightweighting Technology used on the rear bumper was aluminum stampings that were glued, welded, or riveted together. Due to similarities in component design and material, full percentage of the Silverado 1500 rear bumper mass reduction can be applied to the Renault. (Refer to Table 3-24).

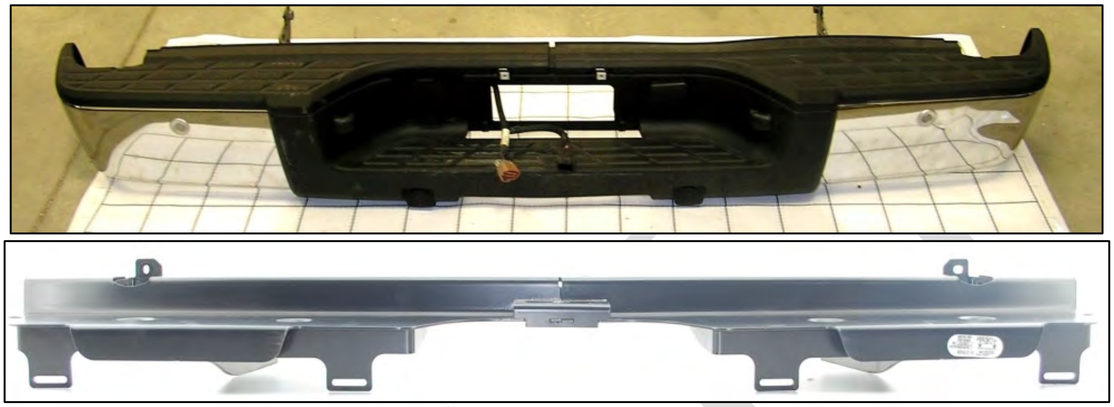


Image 3.3–30: Rear Bumper for the Silverado 1500 (Top) and Renault Master 2.3 DCi (Bottom)
(Source: FEV, Inc. and www.A2mac1.com)

3.4 BODY GROUP -B- SYSTEM

3.4.1 Silverado 1500 Summary

The Chevrolet Silverado 1500 Body Group -B- System included the vehicle interior (including the front and rear left and right door trim parts as well as the main compartment trim), all sealing/weather stripping, all seating frames and trim, the cross car beam and IP trim, and all air bags. The plastic trim parts mass was reduced by using PolyOne® foaming agent. The sealing/weather stripping mass was reduced by changing from EPDM (ethylene propylene diene monomer) rubber to TPV (thermoplastic vulcanizate). The front seating mass was reduced by changing from welded steel construction to BASF layered plastic seat frames. The rear 60/40 seat and center console mass was reduced by changing the welded steel construction to cast magnesium. The cross car beam was also changed from welded steel construction to cast magnesium. Other changes include the passenger side air bag housing going from steel to Nylon 6 plastic and the steering wheel air bag changing from a dual stage inflator to a single stage inflator.

The Chevrolet Silverado 1500 analysis identifies mass reduction alternatives and cost implications for the Body Group -B- System with the intent to meet the function and performance requirements of the baseline vehicle. Table 3-25 provides a summary of mass reduction and cost impact for select sub-subsystems evaluated. The total mass savings found on the Body Group -B- System mass was reduced by 34.02 kg (13.77%). This increased cost by $127.23, or $3.74 per kg. Mass reduction for this system reduced vehicle curb weight by 1.43%.

DRAFT

Table 3-25: Body Group -B- System Mass Reduction Summary, Silverado 1500

System	Subsystem	Sub-Subsystem	Description	Net Value of Mass Reduction: Base Mass "kg"	Mass Reduction "kg" (1)	Cost Impact NIDMC "$" (2)	Average Cost/ Kilogram "$/kg" (2)	Mass Reduction "%"	Vehicle Mass Reduction "%"
03	**05**	**00**	**Interior Trim and Ornamentation Subsystem**	**56.55**	**2.06**	**6.84**	**3.32**	**3.65%**	**0.09%**
03	05	01	Main Floor Trim	9.31	0.00	0.00	0.00	0.00%	0.00%
03	05	02	NVH Pads	12.91	0.00	0.00	0.00	0.00%	0.00%
03	05	03	Headliner Assembly	5.28	0.00	0.00	0.00	0.00%	0.00%
03	05	04	Sun Visors	1.26	0.00	0.00	0.00	0.00%	0.00%
03	05	05	Front RH & LH Door Trim Panel	9.86	0.84	2.06	2.44	8.55%	0.04%
03	05	06	Rear Door or Rear Quarter Trim Panel	5.68	0.55	1.62	2.95	9.69%	0.02%
03	05	07	Pillar Trim Lower	5.58	0.53	2.81	5.32	9.46%	0.02%
03	05	08	Pillar Trim Upper	2.83	0.14	0.35	2.46	4.97%	0.01%
03	05	09	Floor Mats - OEM	3.84	0.00	0.00	0.00	0.00%	0.00%
03	**06**	**00**	**Sound and Heat Control Subsystem (Body)**	**4.78**	**0.00**	**0.00**	**0.00**	**0.00%**	**0.00%**
03	06	01	Heat Insulation Shields - Eng. Bay & Underfloor	0.90	0.00	0.00	0.00	0.00%	0.00%
03	06	02	Noise Insulation, Engine Bay and Underfloor	1.38	0.00	0.00	0.00	0.00%	0.00%
03	06	03	Heat Shield - Transmission	0.38	0.00	0.00	0.00	0.00%	0.00%
03	06	04	Heat Shield - Fuel Tank	2.12	0.00	0.00	0.00	0.00%	0.00%
03	**07**	**00**	**Sealing Subsystem**	**14.52**	**4.72**	**32.23**	**6.84**	**32.48%**	**0.20%**
03	07	01	Front Side Door Dynamic Weatherstrip	4.90	1.59	10.86	6.83	32.45%	0.07%
03	07	02	Static Sealing	9.62	3.13	21.37	6.84	32.50%	0.13%
03	**10**	**00**	**Seating Subsystem**	**120.69**	**19.16**	**-127.89**	**-6.68**	**15.87%**	**0.80%**
03	10	01	Seat Drivers Frt	31.76	3.11	-15.00	-4.83	9.78%	0.13%
03	10	02	Seat Passenger Frt	26.77	3.10	-15.36	-4.96	11.56%	0.13%
03	10	03	Rear 60% Seat	25.86	5.55	-43.73	-7.88	21.47%	0.23%
03	10	04	Rear 40% Seat	17.24	3.35	-23.87	-7.13	19.43%	0.14%
03	10	05	Frt center seat & console	19.06	4.05	-29.93	-7.38	21.27%	0.17%
03	**12**	**00**	**Instrument Panel and Console Subsystem**	**30.84**	**6.82**	**-35.29**	**-5.17**	**22.13%**	**0.29%**
03	12	01	Cross-Car Beam (IP)	11.92	5.45	-38.15	-7.00	45.74%	0.23%
03	12	02	Instrument Panel Main Molding	7.22	0.53	1.40	2.61	7.41%	0.02%
03	12	03	Closure Panel or Knee Bolster - (IP)	6.94	0.66	1.01	1.53	9.57%	0.03%
03	12	04	Applied Decorative Trim - (IP)	2.80	0.14	0.25	1.86	4.84%	0.01%
03	12	05	Switch Pack - Instrument Panel (IP)	1.96	0.04	0.20	5.38	1.88%	0.00%
03	**20**	**00**	**Occupant Restraining Device Subsystem**	**19.64**	**1.26**	**-3.12**	**-2.47**	**6.42%**	**0.05%**
03	20	01	Seat Belt Assembly Front Row	3.96	0.00	0.00	0.00	0.00%	0.00%
03	20	03	Passenger Airbag / Cover Unit	4.03	0.62	0.99	1.60	15.43%	0.03%
03	20	06	Restraint Electronics	0.80	0.00	0.00	0.00	0.00%	0.00%
03	20	08	Seat Belts - Second Row	4.00	0.00	0.00	0.00	0.00%	0.00%
03	20	12	Curtain Airbag System	5.01	0.37	-0.31	-0.82	7.48%	0.02%
03	20	15	Tether Anchorages - Non Integrated	0.46	0.00	0.00	0.00	0.00%	0.00%
03	20	18	Steering Wheel Airbag	1.39	0.26	-3.80	-14.39	19.07%	0.01%
				247.02	34.02 (Decrease)	-127.23 (Increase)	-3.74 (Increase)	13.77%	1.43%

(1) "+" = mass decrease, "-" = mass increase
(2) "+" = cost decrease, "-" = cost increase

Columns in the "Net Value of Mass Reduction" chart above may contain combined masses of assembly hardware such as nuts, bolt, washer, etc. that were not mass reduced at the component level, and may not match base mass and mass reduction totals in text below component reduction weights.

Due to the large size of the Body Group -B- System it was not broken down per component, but rather per subsystem. Mass savings opportunities were identified for the following subsystems: Interior Trim and Ornamentation, Sealing, Seating, Instrument Panel and Console, and Occupant Restraining Device.

Interior Trim and Ornamentation Subsystem: The Interior Trim and Ornamentation Subsystem mass was made up of the front and rear right and left door trims, as well as all of the inner cabin plastic trim parts. The mass was reduced by using PolyOne® foaming agent on the plastic parts. Mass was reduced by 9.96% from 16.5 kg to 14.9 kg.

Sealing Subsystem: The Sealing Subsystem mass was made up of all the sealing/weather stripping for the doors and windows. Mass was reduced by changing from EPDM to TPV material. Mass was reduced by 27.6%, from 15.1 kg to 11.0 kg.

Seating Subsystem: The Seating Subsystem mass was reduced by using PolyOne® on all plastic trim parts. The welded steel construction on the front seats was changed to BASF plastic and glass fiber laired laminate. The welded steel construction for the 60/40 seat and the center console was also switched to cast magnesium. Mass was reduced by 40.4%, from 46.2 kg to 27.5 kg.

Instrument Panel and Console Subsystem: The Instrument Panel and Console Subsystem mass were reduced by using PolyOne® on all plastic trim parts and by changing the welded steel construction on the cross car beam to cast magnesium. Also, by changing the welded steel construction for the knee bolster reinforcement bracket to plastic. Mass was reduced by 29.42%, from 23.2 kg to 16.4 kg.

Occupant Restraining Device Subsystem: The Occupant Restraining Device Subsystem mass was reduced by using PolyOne® on all plastic parts and by changing the welded steel construction on the passenger air bag housing to DSM Akulon® Nylon 6. By also changing the steering wheel air bag dual stage inflator to a single stage inflator. Mass was reduced by 44.82%, from 1.85kg to 1.02kg.

3.4.2 Silverado 2500 Analysis

The Chevrolet Silverado 2500 Body Group -B- System is very similar to the 1500, except that the 1500 vehicle used in the original study was a crew cab and the 2500 an extended cab. This made the 1500 vehicle interior larger and the box size 5.5 feet, whereas the 2500 had a smaller interior and the box size larger at 6 feet (Image 3.4–1).

Image 3.4–1: Chevrolet Silverado 2500
(Source: FEV, Inc.)

DRAFT

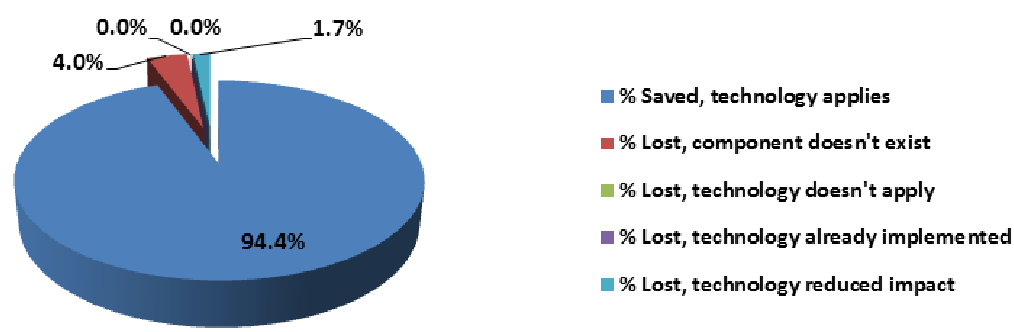
3.4.2.1 2500 System Scaling Summary

Table 3-26 summarizes the mass and cost impact of Silverado 1500 Lightweighting technologies as applied to the Silverado 2500. Total Body Group -B- System mass savings was 32.10 kg at a cost increase of $125.41, or $3.91 per kg.

Table 3-26: Mass-Reduction and Cost Impact for Body Group -B- system, Silverado 2500

				Net Value of Mass Reduction								
System	Subsystem	Sub-Subsystem	Description	Mass Reduction New Tech "kg" (1)	Mass Reduction Comp "kg" (1)	Mass Reduction Total "kg" (1)	Cost Impact New Tech "$" (2)	Cost Impact Comp "$" (2)	Cost Impact Total "$" (2)	Cost/ Kilogram Total "$/kg"	Vehicle Mass Reduction Total "%"
03	00	00	Body System "B"								
03	05	00	Interior Trim and Ornamentation Subsystem	1.64	0.00	1.64	$5.12	$0.00	$5.12	$3.11	0.05%
03	06	00	Sound and Heat Control Subsystem (Body)	0.00	0.00	0.00	$0.00	$0.00	$0.00	$0.00	0.00%
03	07	00	Sealing Subsystem	4.18	0.00	4.18	$28.58	$0.00	$28.58	$6.83	0.14%
03	10	00	Seating Subsystem	18.62	0.00	18.62	-$123.60	$0.00	-$123.60	-$6.64	0.60%
03	12	00	Instrument Panel and Console Subsystem	6.82	0.00	6.82	-$35.30	$0.00	-$35.30	-$5.17	0.22%
03	20	00	Occupant Restraining Device Subsystem	0.83	0.00	0.83	-0.22	$0.00	-$0.22	$0.00	0.03%
				32.10 (Decrease)	0.00	32.10 (Decrease)	-125.41 (Increase)	0.00	-$125.41 (Increase)	-$3.91 (Increase)	1.04%

Mass Savings, Select Vehicle, New Technology "kg"	32.10
Mass Savings, Silverado 1500, New Technology "kg"	34.02
Mass Savings Select Vehicle/Mass Savings 1500	94.4%



*SMS not included - has no significant impact on perecent contributions

3.4.2.2 System Scaling Analysis

The Silverado 2500 Body Group -B- system components were reviewed for compatibility with Lightweighting technologies. The results of this analysis are listed in Table 3-27.

Table 3-27: System Scaling Analysis Body Group -B- System, Silverado 2500

Silverado 1500							Select Vehicle			
System	Subsystem	Sub-Subsystem	Component/Assembly	Base Mass	Mass Savings New Tech	% of Mass Savings New Tech	Tech Applies	Base Mass	Mass Savings New Tech	Notes
03			**Body Group B System**	**247.02**	**34.02**	**14%**			**32.10**	
03	05	05	LH drivers door window switch cover	0.10	0.010	10%	yes	0.10	0.01	Tech **DOES** apply: Use Polyone foaming agent
03	05	05	LH drivers Door arm rest attachment cover	0.03	0.003	11%	yes	0.03	0.00	Tech **DOES** apply: Use Polyone foaming agent
03	05	05	LH drivers Door Pull handle attachment cover	0.01	0.001	17%	yes	0.01	0.00	Tech **DOES** apply: Use Polyone foaming agent
03	05	05	LH drivers Door vertical Pull handle	0.13	0.013	10%	yes	0.13	0.01	Tech **DOES** apply: Use Polyone foaming agent
03	05	05	LH drivers Door corner cover	0.06	0.006	11%	yes	0.06	0.01	Tech **DOES** apply: Use Polyone foaming agent
03	05	05	RH passenger door window switch cover	0.10	0.010	10%	yes	0.10	0.01	Tech **DOES** apply: Use Polyone foaming agent
03	05	05	RH passenger Door arm rest attachment cover	0.03	0.003	11%	yes	0.03	0.00	Tech **DOES** apply: Use Polyone foaming agent
03	05	05	RH passenger Door Pull handle attachment cover	0.01	0.001	17%	yes	0.01	0.00	Tech **DOES** apply: Use Polyone foaming agent
03	05	05	RH passenger Door vertical Pull handle	0.13	0.013	10%	yes	0.13	0.01	Tech **DOES** apply: Use Polyone foaming agent
03	05	05	RH passenger Door corner cover	0.06	0.006	11%	yes	0.06	0.01	Tech **DOES** apply: Use Polyone foaming agent
03	05	05	RH passenger Door lwr main trim	2.09	0.209	10%	yes	2.09	0.21	Tech **DOES** apply: Use Polyone foaming agent
03	05	05	RH passenger Door lwr main trim map pocket	0.50	0.050	10%	yes	0.50	0.05	Tech **DOES** apply: Use Polyone foaming agent
03	05	05	RH passenger Door lwr main trim close out	0.05	0.005	10%	yes	0.05	0.01	Tech **DOES** apply: Use Polyone foaming agent
03	05	05	RH passenger Door lwr main trim inner support brkt#1	0.28	0.028	10%	yes	0.28	0.03	Tech **DOES** apply: Use Polyone foaming agent
03	05	05	RH passenger Door lwr main trim inner support brkt#2	0.06	0.005	9%	yes	0.06	0.01	Tech **DOES** apply: Use Polyone foaming agent
03	05	05	RH passenger Door lwr main trim inner support brkt#5	0.03	0.003	11%	yes	0.03	0.00	Tech **DOES** apply: Use Polyone foaming agent
03	05	05	RH passenger Door lwr main trim inner support brkt#6	0.01	0.001	9%	yes	0.01	0.00	Tech **DOES** apply: Use Polyone foaming agent
03	05	05	RH passenger Door upr main trim	0.76	0.076	10%	yes	0.76	0.08	Tech **DOES** apply: Use Polyone foaming agent
03	05	05	LH passenger Door lwr main trim	2.09	0.209	10%	yes	2.09	0.21	Tech **DOES** apply: Use Polyone foaming agent
03	05	05	LH passenger Door lwr main trim map pocket	0.50	0.050	10%	yes	0.50	0.05	Tech **DOES** apply: Use Polyone foaming agent
03	05	05	LH passenger Door lwr main trim close out	0.05	0.005	10%	yes	0.05	0.01	Tech **DOES** apply: Use Polyone foaming agent
03	05	05	LH passenger Door lwr main trim inner support brkt#1	0.28	0.028	10%	yes	0.28	0.03	Tech **DOES** apply: Use Polyone foaming agent
03	05	05	LH passenger Door lwr main trim inner support brkt#2	0.06	0.005	9%	yes	0.06	0.01	Tech **DOES** apply: Use Polyone foaming agent
03	05	05	LH passenger Door lwr main trim inner support brkt#5	0.03	0.003	11%	yes	0.03	0.00	Tech **DOES** apply: Use Polyone foaming agent
03	05	05	LH passenger Door lwr main trim inner support brkt#6	0.01	0.001	10%	yes	0.01	0.00	Tech **DOES** apply: Use Polyone foaming agent
03	05	05	LH passenger Door upr main trim	0.76	0.076	10%	yes	0.76	0.08	Tech **DOES** apply: Use Polyone foaming agent
03	05	05	Frt dorr harness feed through	0.23	0.023	10%	yes	0.23	0.02	Tech **DOES** apply: Use Polyone foaming agent
03	05	06	RH Rear door window switch cover	0.08	0.008	10%	yes	0.03	0.00	Tech **DOES** apply: Use Polyone foaming agent
03	05	06	RH Rear Door arm rest attachment cover	0.02	0.002	10%	yes	0.02	0.00	Tech **DOES** apply: Use Polyone foaming agent
03	05	06	RH Rear Door Pull handle attachment cover	0.01	0.001	10%	yes	0.01	0.00	Tech **DOES** apply: Use Polyone foaming agent
03	05	06	RH rear door arm rest	0.27	0.027	10%	yes	0.15	0.01	Tech **DOES** apply: Use Polyone foaming agent
03	05	06	LH Rear door window switch cover	0.08	0.008	10%	yes	0.03	0.00	Tech **DOES** apply: Use Polyone foaming agent
03	05	06	LH Rear Door arm rest attachment cover	0.02	0.002	10%	yes	0.02	0.00	Tech **DOES** apply: Use Polyone foaming agent
03	05	06	LH Rear Door Pull handle attachment cover	0.01	0.001	10%	yes	0.01	0.00	Tech **DOES** apply: Use Polyone foaming agent
03	05	06	LH rear door arm rest	0.27	0.027	10%	yes	0.15	0.01	Tech **DOES** apply: Use Polyone foaming agent
03	05	06	RH rear door lwr main trim	1.53	0.153	10%	yes	1.69	0.17	Tech **DOES** apply: Use Polyone foaming agent
03	05	06	RH rear door lwr main trim map pocket	0.23	0.023	10%	yes	0.23	0.02	Tech **DOES** apply: Use Polyone foaming agent
03	05	06	RH rear door lwr main trim mounting bkt #1	0.02	0.002	10%	no			Tech does **NOT** apply: Not on vehicle
03	05	06	RH rear door lwr main trim mounting bkt #2	0.01	0.001	10%	no			Tech does **NOT** apply: Not on vehicle
03	05	06	RH rear door upr main trim	0.58	0.058	10%	no			Tech does **NOT** apply: Not on vehicle
03	05	06	LH rear door lwr main trim	1.53	0.153	10%	yes	1.69	0.17	Tech **DOES** apply: Use Polyone foaming agent
03	05	06	LH rear door lwr main trim map pocket	0.23	0.023	10%	yes	0.23	0.02	Tech **DOES** apply: Use Polyone foaming agent
03	05	06	LH rear door lwr main trim mounting bkt #1	0.02	0.002	10%	no			Tech does **NOT** apply: Not on vehicle
03	05	06	LH rear door lwr main trim mounting bkt #2	0.01	0.001	10%	no			Tech does **NOT** apply: Not on vehicle
03	05	06	LH rear door upr main trim	0.58	0.058	10%	no			Tech does **NOT** apply: Not on vehicle
03	05	07	Driver Lwr A-Pillar	0.23	0.023	10%	yes	0.23	0.02	Tech **DOES** apply: Use Polyone foaming agent
03	05	07	Passenger Lwr A-Pillar	0.22	0.022	10%	yes	0.22	0.02	Tech **DOES** apply: Use Polyone foaming agent
03	05	07	Front Driver kick plate	0.20	0.020	10%	yes	0.16	0.02	Tech **DOES** apply: Use Polyone foaming agent
03	05	07	Front Driver kick plate mount	0.18	0.018	10%	no			Tech does **NOT** apply: Not on vehicle
03	05	07	Rear Driver kick plate	0.14	0.014	10%	yes	0.12	0.01	Tech **DOES** apply: Use Polyone foaming agent
03	05	07	Rear Driver kick plate mount	0.12	0.012	10%	no			Tech does **NOT** apply: Not on vehicle
03	05	07	LH B-Pillar Lwr	0.63	0.063	10%	no			Tech does **NOT** apply: Not on vehicle
03	05	07	Front Passenger kick plate	0.21	0.020	10%	yes	0.16	0.02	Tech **DOES** apply: Use Polyone foaming agent
03	05	07	Front Passenger kick plate mount	0.18	0.018	10%	no			Tech does **NOT** apply: Not on vehicle
03	05	07	Rear Passenger kick plate	0.14	0.014	10%	yes	0.12	0.01	Tech **DOES** apply: Use Polyone foaming agent
03	05	07	Rear Passenger kick plate mount	0.13	0.012	10%	no			Tech does **NOT** apply: Not on vehicle
03	05	07	RH B-Pillar Lwr	0.63	0.063	10%	no			Tech does **NOT** apply: Not on vehicle
03	05	07	C-Pillar cover RH upr	0.34	0.034	10%	yes	0.11	0.01	Tech **DOES** apply: Use Polyone foaming agent
03	05	07	C-Pillar cover RH Lwr	0.53	0.053	10%	yes	0.87	0.09	Tech **DOES** apply: Use Polyone foaming agent
03	05	07	Small Cover piece	0.0020	0.0002	10%	yes	0.00	0.00	Tech **DOES** apply: Use Polyone foaming agent
03	05	07	C-Pillar cover LH upr	0.34	0.034	10%	yes	0.11	0.01	Tech **DOES** apply: Use Polyone foaming agent
03	05	07	C-Pillar cover LH Lwr	0.52	0.052	10%	yes	0.90	0.09	Tech **DOES** apply: Use Polyone foaming agent
03	05	07	Small Cover piece	0.00	0.000	10%	yes	0.00	0.00	Tech **DOES** apply: Use Polyone foaming agent
03	05	07	C-Pillar to C-Pillar cross trim	0.56	0.056	10%	no			Tech does **NOT** apply: Not on vehicle
03	05	08	Drivers Upr A-Pillar cover	0.35	0.04	10%	yes	0.43	0.04	Tech **DOES** apply: Use Polyone foaming agent
03	05	08	Drivers upr A-pillar mounting screw cover	0.00	0.00	0%	no			Tech does **NOT** apply: Not on vehicle
03	05	08	Driver LH Upper B-Pillar Cover	0.29	0.03	10%	no			Tech does **NOT** apply: Not on vehicle
03	05	08	Driver LH Upper B-Pillar Cover slide	0.06	0.01	11%	no			Tech does **NOT** apply: Not on vehicle
03	05	08	Driver restraint upr B-pillar bolt cover	0.01	0.00	7%	no			Tech does **NOT** apply: Not on vehicle
03	05	08	Drivers B pillar mounting screw cover	0.01	0.00	17%	no			Tech does **NOT** apply: Not on vehicle
03	05	08	Passenger Upr A-Pillar cover	0.33	0.03	10%	yes	0.40	0.04	Tech **DOES** apply: Use Polyone foaming agent
03	05	08	Passenger RH Upper B-Pillar Cover	0.28	0.03	10%	no			Tech does **NOT** apply: Not on vehicle
03	05	08	Passenger LH Upper B-Pillar Cover slide	0.06	0.01	11%	no			Tech does **NOT** apply: Not on vehicle
03	05	08	Passenger restraint upr B-pillar bolt cover	0.01	0.00	7%	no			Tech does **NOT** apply: Not on vehicle
03	05	08	Passenger B pillar mounting screw	0.00	0.00	0%	no			Tech does **NOT** apply: Not on vehicle

Table 3.4-3 Continued Next Page

Table 3-27: System Scaling Analysis Body Group -B- System, Silverado 2500

Silverado 1500							Select Vehicle			
System	Subsystem	Sub-Subsystem	Component/Assembly	Base Mass	Mass Savings New Tech	% of Mass Savings New Tech	Tech Applies	Base Mass	Mass Savings New Tech	Notes
03			**Body Group B System**	**247.02**	**34.02**	**14%**			**32.10**	
03	07	01	LH Driver Door Lower seal	0.14	0.05	33%	yes	0.14	0.05	Tech **DOES** apply: Change from EDPM to TPV
03	07	01	RH Passenger Door Lower seal	0.14	0.05	33%	yes	0.14	0.05	Tech **DOES** apply: Change from EDPM to TPV
03	07	01	LH Rear Door Lower seal	0.11	0.04	32%	yes	0.11	0.03	Tech **DOES** apply: Change from EDPM to TPV
03	07	01	LH Rear Door hinge side upr seal	0.07	0.02	33%	yes	0.07	0.02	Tech **DOES** apply: Change from EDPM to TPV
03	07	01	RH Rear Door Lower seal	0.11	0.04	32%	yes	0.11	0.03	Tech **DOES** apply: Change from EDPM to TPV
03	07	01	RH Rear Door hinge side upr seal	0.07	0.02	33%	yes	0.07	0.02	Tech **DOES** apply: Change from EDPM to TPV
03	07	01	RH rear door inside window track seal	0.52	0.17	33%	yes	0.47	0.15	Tech **DOES** apply: Change from EDPM to TPV
03	07	01	RH rear door inside window track bottom inner seal	0.16	0.05	33%	yes	0.19	0.06	Tech **DOES** apply: Change from EDPM to TPV
03	07	01	RH rear door inside window track bottom outer seal	0.30	0.10	33%	yes	0.19	0.06	Tech **DOES** apply: Change from EDPM to TPV
03	07	01	LH rear door inside window track seal	0.52	0.17	33%	yes	0.47	0.15	Tech **DOES** apply: Change from EDPM to TPV
03	07	01	LH rear door inside window track bottom inner seal	0.16	0.05	33%	yes	0.19	0.06	Tech **DOES** apply: Change from EDPM to TPV
03	07	01	LH rear door inside window track bottom outer seal	0.30	0.10	33%	yes	0.19	0.06	Tech **DOES** apply: Change from EDPM to TPV
03	07	01	LH drivers door inside window track seal	0.60	0.20	33%	yes	0.64	0.21	Tech **DOES** apply: Change from EDPM to TPV
03	07	01	LH drivers door inside window track bottom inner seal	0.19	0.06	33%	yes	0.35	0.12	Tech **DOES** apply: Change from EDPM to TPV
03	07	01	LH drivers door inside window track bottom outer seal	0.35	0.11	33%	yes	0.34	0.11	Tech **DOES** apply: Change from EDPM to TPV
03	07	01	RH passenger door inside window track seal	0.60	0.20	33%	yes	0.64	0.21	Tech **DOES** apply: Change from EDPM to TPV
03	07	01	RH passenger door inside window track bottom inner seal	0.19	0.06	33%	yes	0.35	0.12	Tech **DOES** apply: Change from EDPM to TPV
03	07	01	RH passenger door inside window track bottom outer seal	0.35	0.11	33%	yes	0.34	0.11	Tech **DOES** apply: Change from EDPM to TPV
03	07	02	Drivers Upr Outside seal	0.82	0.27	33%	yes	0.82	0.27	Tech **DOES** apply: Change from EDPM to TPV
03	07	02	Front driver door seal	2.10	0.68	33%	yes	2.10	0.68	Tech **DOES** apply: Change from EDPM to TPV
03	07	02	Rear driver door seal	1.93	0.63	33%	yes	1.07	0.35	Tech **DOES** apply: Change from EDPM to TPV
03	07	02	Passenger Upr Outside seal	0.82	0.27	33%	yes	0.82	0.27	Tech **DOES** apply: Change from EDPM to TPV
03	07	02	Front passenger door seal	2.05	0.67	33%	yes	2.05	0.67	Tech **DOES** apply: Change from EDPM to TPV
03	07	02	Rear passenger door seal	1.91	0.62	33%	yes	1.07	0.35	Tech **DOES** apply: Change from EDPM to TPV
03	10	01	Driver seat back frame	2.20	1.10	50%	yes	2.20	1.10	Tech **DOES** apply: Change from welded steel to BASF Plastic
03	10	01	Driver seat map back inner	0.49	0.05	10%	yes	0.49	0.05	Tech **DOES** apply: Use Polyone foaming agent
03	10	01	Driver Seat map back	0.64	0.06	10%	yes	0.64	0.06	Tech **DOES** apply: Use Polyone foaming agent
03	10	01	Driver Seat safety belt cover	0.04	0.00	10%	yes	0.04	0.00	Tech **DOES** apply: Use Polyone foaming agent
03	10	01	Driver seat bottom frame	3.60	1.80	50%	yes	3.60	1.80	Tech **DOES** apply: Change from welded steel to BASF Plastic
03	10	01	Driver Seat frt Nut Cover LH	0.02	0.00	10%	yes	0.02	0.00	Tech **DOES** apply: Use Polyone foaming agent
03	10	01	Driver Seat frt Nut Cover RH	0.03	0.00	10%	yes	0.03	0.00	Tech **DOES** apply: Use Polyone foaming agent
03	10	01	Driver Seat rear Bolt Cover LH	0.02	0.00	10%	yes	0.02	0.00	Tech **DOES** apply: Use Polyone foaming agent
03	10	01	Driver Seat rear Bolt Cover RH	0.07	0.01	10%	yes	0.07	0.01	Tech **DOES** apply: Use Polyone foaming agent
03	10	01	Driver seat wire harness cover	0.04	0.00	10%	yes	0.04	0.00	Tech **DOES** apply: Use Polyone foaming agent
03	10	01	Driver Seat LH Track cover	0.16	0.02	10%	yes	0.16	0.02	Tech **DOES** apply: Use Polyone foaming agent
03	10	01	Driver Seat LH Track cover end cap rear	0.02	0.00	10%	yes	0.02	0.00	Tech **DOES** apply: Use Polyone foaming agent
03	10	01	Driver Seat LH Track cover end cap frt	0.02	0.00	10%	yes	0.02	0.00	Tech **DOES** apply: Use Polyone foaming agent
03	10	01	Driver Seat LH cover	0.31	0.03	10%	yes	0.31	0.03	Tech **DOES** apply: Use Polyone foaming agent
03	10	01	Driver Seat LH cover close out	0.05	0.01	10%	yes	0.05	0.01	Tech **DOES** apply: Use Polyone foaming agent
03	10	01	Driver Seat LH cover seat belt insert cover	0.01	0.00	10%	yes	0.01	0.00	Tech **DOES** apply: Use Polyone foaming agent
03	10	01	Driver Seat LH cover lumbar knob	0.02	0.00	10%	yes	0.02	0.00	Tech **DOES** apply: Use Polyone foaming agent
03	10	01	Driver Seat LH cover recline handle	0.03	0.00	10%	yes	0.03	0.00	Tech **DOES** apply: Use Polyone foaming agent
03	10	01	Driver Seat RH cover	0.11	0.01	10%	yes	0.11	0.01	Tech **DOES** apply: Use Polyone foaming agent
03	10	02	Passenger seat back frame	2.20	1.10	50%	yes	2.20	1.10	Tech **DOES** apply: Change from welded steel to BASF Plastic
03	10	02	Pass seat map back inner	0.49	0.05	10%	yes	0.49	0.05	Tech **DOES** apply: Use Polyone foaming agent
03	10	02	Pass Seat map back	0.64	0.06	10%	yes	0.64	0.06	Tech **DOES** apply: Use Polyone foaming agent
03	10	02	Pass Seat safety belt cover	0.04	0.00	10%	yes	0.04	0.00	Tech **DOES** apply: Use Polyone foaming agent
03	10	02	Passenger seat bottom frame	3.59	1.79	50%	yes	3.59	1.79	Tech **DOES** apply: Change from welded steel to BASF Plastic
03	10	02	Frt Passenger Seat frt RH Nut Cover	0.02	0.00	10%	yes	0.02	0.00	Tech **DOES** apply: Use Polyone foaming agent
03	10	02	Frt Passenger Seat frt LH Nut Cover	0.04	0.00	10%	yes	0.04	0.00	Tech **DOES** apply: Use Polyone foaming agent
03	10	02	Passenger Seat rear Bolt Cover LH	0.06	0.01	10%	yes	0.06	0.01	Tech **DOES** apply: Use Polyone foaming agent
03	10	02	Passenger Seat rear Bolt Cover RH	0.02	0.00	10%	yes	0.02	0.00	Tech **DOES** apply: Use Polyone foaming agent
03	10	02	Passenger seat wire harness cover	0.04	0.00	10%	yes	0.04	0.00	Tech **DOES** apply: Use Polyone foaming agent
03	10	02	Pass Seat LH Track cover	0.16	0.02	10%	yes	0.16	0.02	Tech **DOES** apply: Use Polyone foaming agent
03	10	02	Pass Seat LH Track cover end cap rear	0.02	0.00	10%	yes	0.02	0.00	Tech **DOES** apply: Use Polyone foaming agent
03	10	02	Pass Seat LH Track cover end cap frt	0.02	0.00	10%	yes	0.02	0.00	Tech **DOES** apply: Use Polyone foaming agent
03	10	02	Pass Seat LH cover	0.31	0.03	10%	yes	0.31	0.03	Tech **DOES** apply: Use Polyone foaming agent
03	10	02	Passenger Seat LH cover close out	0.05	0.01	10%	yes	0.05	0.01	Tech **DOES** apply: Use Polyone foaming agent
03	10	02	Passenger Seat LH cover seat belt insert cover	0.01	0.00	10%	yes	0.01	0.00	Tech **DOES** apply: Use Polyone foaming agent
03	10	02	Passenger Seat LH cover lumbar knob	0.02	0.00	10%	yes	0.02	0.00	Tech **DOES** apply: Use Polyone foaming agent
03	10	02	Passenger Seat LH cover recline handle	0.03	0.00	10%	yes	0.03	0.00	Tech **DOES** apply: Use Polyone foaming agent
03	10	02	Passenger Seat RH cover	0.11	0.01	10%	yes	0.11	0.01	Tech **DOES** apply: Use Polyone foaming agent
03	10	03	60% Seat back frame	5.78	2.78	48%	yes	5.78	2.78	Tech **DOES** apply: Change from welded steel to mag.
03	10	03	Arm rest inner tub	0.28	0.03	10%	no			Tech does **NOT** apply: Not on vehicle
03	10	03	Arm rest frame	1.11	0.43	39%	no			Tech does **NOT** apply: Not on vehicle
03	10	03	Arm rest cup holder	0.13	0.01	10%	no			Tech does **NOT** apply: Not on vehicle
03	10	03	Arm rest cup holder retainer ring	0.09	0.01	10%	no			Tech does **NOT** apply: Not on vehicle
03	10	03	60% Seat bottom frame	4.28	2.24	52%	yes	4.28	2.24	Tech **DOES** apply: Change from welded steel to mag.
03	10	03	RH recliner cover #1	0.14	0.01	10%	no			Tech does **NOT** apply: Not on vehicle
03	10	03	RH recliner cover #2	0.24	0.02	10%	yes	0.24	0.02	Tech **DOES** apply: Use Polyone foaming agent
03	10	03	LH recliner cover #1	0.08	0.01	10%	no			Tech does **NOT** apply: Not on vehicle
03	10	04	40% Seat bottom frame	2.98	1.55	52%	yes	2.98	1.55	Tech **DOES** apply: Change from welded steel to mag.
03	10	04	40% Seat back frame	3.16	1.76	56%	yes	3.16	1.76	Tech **DOES** apply: Change from welded steel to mag.
03	10	04	RH Brkt close out #1	0.23	0.02	10%	no			Tech does **NOT** apply: Not on vehicle
03	10	04	RH Brkt close out #2	0.14	0.01	10%	yes	0.14	0.01	Tech **DOES** apply: Use Polyone foaming agent
03	10	04	LH Brkt close out #1	0.07	0.01	10%	no			Tech does **NOT** apply: Not on vehicle
03	10	05	Frt center riser	2.97	1.04	35%	yes	2.97	1.04	Tech **DOES** apply: Change from welded steel to mag.
03	10	05	LH Pivot cover outer	0.07	0.01	10%	yes	0.07	0.01	Tech **DOES** apply: Use Polyone foaming agent
03	10	05	LH Pivot cover inner	0.05	0.00	10%	yes	0.05	0.00	Tech **DOES** apply: Use Polyone foaming agent
03	10	05	RH Pivot cover outer	0.06	0.01	10%	yes	0.06	0.01	Tech **DOES** apply: Use Polyone foaming agent
03	10	05	RH Pivot cover inner	0.05	0.00	10%	yes	0.05	0.00	Tech **DOES** apply: Use Polyone foaming agent
03	10	05	RH Pivot cover inner top	0.05	0.00	10%	yes	0.05	0.00	Tech **DOES** apply: Use Polyone foaming agent
03	10	05	Bottom tub inner	0.85	0.09	10%	yes	0.85	0.09	Tech **DOES** apply: Use Polyone foaming agent

Table 3.4–3 Continued Next Page

Table 3-27: System Scaling Analysis Body Group -B- System, Silverado 2500

Silverado 1500							Select Vehicle			
System	Subsystem	Sub-Subsystem	Component/Assembly	Base Mass	Mass Savings New Tech	% of Mass Savings New Tech	Tech Applies	Base Mass	Mass Savings New Tech	Notes
03			**Body Group B System**	**247.02**	**34.02**	**14%**			**32.10**	
03	10	05	Frt wrap around close out	0.51	0.05	10%	yes	0.51	0.05	Tech **DOES** apply: Use Polyone foaming agent
03	10	05	Rear wrap around close out	0.65	0.06	10%	yes	0.65	0.06	Tech **DOES** apply: Use Polyone foaming agent
03	10	05	Cup holder	0.31	0.03	10%	yes	0.31	0.03	Tech **DOES** apply: Use Polyone foaming agent
03	10	05	Cup holder top	0.12	0.01	10%	yes	0.12	0.01	Tech **DOES** apply: Use Polyone foaming agent
03	10	05	Frt center box comp	3.77	1.66	44%	yes	3.77	1.66	Tech **DOES** apply: Change from welded steel to mag.
03	10	05	Frt center cover plt	1.60	0.81	50%	yes	1.60	0.81	Tech **DOES** apply: Change from welded steel to mag.
03	10	05	Seat frame cover handle #1	0.02	0.00	10%	yes	0.02	0.00	Tech **DOES** apply: Use Polyone foaming agent
03	10	05	Seat frame cover handle #2	0.04	0.00	10%	yes	0.04	0.00	Tech **DOES** apply: Use Polyone foaming agent
03	10	05	Center tub	1.08	0.11	10%	yes	1.08	0.11	Tech **DOES** apply: Use Polyone foaming agent
03	10	05	Divider	0.06	0.01	10%	yes	0.06	0.01	Tech **DOES** apply: Use Polyone foaming agent
03	10	05	Cup holder	0.20	0.02	10%	yes	0.20	0.02	Tech **DOES** apply: Use Polyone foaming agent
03	10	05	Center tub top ring	0.28	0.03	10%	yes	0.28	0.03	Tech **DOES** apply: Use Polyone foaming agent
03	10	05	Center tub top lid inner	0.65	0.07	10%	yes	0.65	0.07	Tech **DOES** apply: Use Polyone foaming agent
03	10	05	Center tub top lid outer	0.34	0.03	10%	yes	0.34	0.03	Tech **DOES** apply: Use Polyone foaming agent
03	10	05	Center tub top lid handle #1	0.02	0.00	10%	yes	0.02	0.00	Tech **DOES** apply: Use Polyone foaming agent
03	10	05	Center tub top lid handle #2	0.02	0.00	10%	yes	0.02	0.00	Tech **DOES** apply: Use Polyone foaming agent
03	12	01	Cross Car Beam	11.34	5.44	48%	yes	11.34	5.44	Tech **DOES** apply: Change from welded steel to mag.
03	12	01	Cross Car Beam to Floor Brkt Cover	0.10	0.01	10%	yes	0.10	0.01	Tech **DOES** apply: Use Polyone foaming agent
03	12	02	IP Main Sub Molding	1.60	0.16	10%	yes	1.60	0.16	Tech **DOES** apply: Use Polyone foaming agent
03	12	02	IP Main Molding	3.37	0.34	10%	yes	3.37	0.34	Tech **DOES** apply: Use Polyone foaming agent
03	12	02	IP Main Molding support box	0.27	0.03	10%	yes	0.27	0.03	Tech **DOES** apply: Use Polyone foaming agent
03	12	02	Elec. Breaker box cover	0.10	0.01	10%	yes	0.10	0.01	Tech **DOES** apply: Use Polyone foaming agent
03	12	03	Knee Bolster cover	0.59	0.06	10%	yes	0.59	0.06	Tech **DOES** apply: Use Polyone foaming agent
03	12	03	Knee Bolster Reinforcement brkt	0.42	0.24	57%	yes	0.42	0.24	Tech **DOES** apply: Change from steel to ABS plastic and use Polyone foaming agent
03	12	03	Glove box brkt	0.35	0.04	10%	yes	0.35	0.04	Tech **DOES** apply: Use Polyone foaming agent
03	12	03	Glove box inner tub	0.85	0.09	10%	yes	0.85	0.09	Tech **DOES** apply: Use Polyone foaming agent
03	12	03	Glove box inner tub cover	0.40	0.04	10%	yes	0.40	0.04	Tech **DOES** apply: Use Polyone foaming agent
03	12	03	Decorative glove box trim	0.05	0.01	10%	yes	0.05	0.01	Tech **DOES** apply: Use Polyone foaming agent
03	12	03	Lwr Center IP Cover	0.45	0.05	10%	yes	0.45	0.05	Tech **DOES** apply: Use Polyone foaming agent
03	12	03	Lwr Center IP Cover ashtray door	0.11	0.01	10%	yes	0.11	0.01	Tech **DOES** apply: Use Polyone foaming agent
03	12	03	Ashtray	0.08	0.01	10%	yes	0.08	0.01	Tech **DOES** apply: Use Polyone foaming agent
03	12	03	Upr glove box door	0.34	0.03	10%	yes	0.34	0.03	Tech **DOES** apply: Use Polyone foaming agent
03	12	03	Upr glove box door inner	0.26	0.03	10%	yes	0.26	0.03	Tech **DOES** apply: Use Polyone foaming agent
03	12	03	Upr glove box bucket	0.49	0.05	10%	yes	0.49	0.05	Tech **DOES** apply: Use Polyone foaming agent
03	12	03	Top IP Cover	0.29	0.03	10%	yes	0.29	0.03	Tech **DOES** apply: Use Polyone foaming agent
03	12	04	IP Driver side cover	0.15	0.02	10%	yes	0.15	0.02	Tech **DOES** apply: Use Polyone foaming agent
03	12	04	IP Passenger side cover	0.15	0.02	10%	yes	0.15	0.02	Tech **DOES** apply: Use Polyone foaming agent
03	12	04	Top IP Decretive trim	1.06	0.11	10%	yes	1.06	0.11	Tech **DOES** apply: Use Polyone foaming agent
03	12	05	IP Control Module 1 mounting brkt	0.13	0.01	10%	yes	0.13	0.01	Tech **DOES** apply: Use Polyone foaming agent
03	12	05	IP Control Module 2 & 3 mounting brkt	0.15	0.02	10%	yes	0.15	0.02	Tech **DOES** apply: Use Polyone foaming agent
03	12	05	IP Control Module 4 mounting brkt	0.09	0.01	10%	yes	0.09	0.01	Tech **DOES** apply: Use Polyone foaming agent
03	20	03	Housing Assy, Passenger Side Airbag	1.09	0.62	57%	yes	1.09	0.62	Tech **DOES** apply: Change from steel to DSM Akulon Nylon6
03	20	12	Drivers side curtain airbag mounting brkt	0.30	0.19	62%	no			Tech does **NOT** apply: Not on vehicle
03	20	12	Passenger side curtain airbag mounting brkt	0.31	0.19	62%	no			Tech does **NOT** apply: Not on vehicle
03	20	18	Front Cover, Steering Wheel Airbag Assy	0.14	0.02	10%	yes	0.14	0.02	Tech **DOES** apply: Use Polyone foaming agent
03	20	18	Bracket #1, Drivers side airbag	0.25	0.11	44%	yes	0.12	0.05	Tech **DOES** apply: Change from steel to plastic
03	20	18	Ignition Canister, Steering Wheel Airbag Assy	0.49	0.14	28%	yes	0.49	0.14	Tech **DOES** apply: Replace dual stage inflator with single stage

If the original Silverado 1500 mass reduction concept idea was not able to be applied to the comparison vehicle it is not described in the section below.

Due to the large size of the Body Group -B- System it was not broken down by component, but by subsystem. Mass savings opportunities were identified for the following subsystems: Interior Trim and Ornamentation, Sealing, Seating, Instrument Panel and Console, and Occupant Restraining Device.

Interior Trim and Ornamentation Subsystem

Shown in Image 3.4–2 are the Silverado 1500 and 2500 Interior Trim and Ornamentation Subsystems. Subsystem masses are 20.62 kg for the 1500 versus 16.51 kg for the 2500. The Lightweighting Technology used on the Interior Trim and Ornamentation Subsystem was to apply PolyOne® foaming agent in the plastic. Due to similarities in component design and material, full percentage of the Silverado 1500 interior trim mass reduction can be applied to the 2500. (Refer to Table 3-27).


Image 3.4–2: Interior Trim and Ornamentation Subsystem for the Silverado 1500 (Left) and Silverado 2500 (Right)
(Source: FEV, Inc.)

Sealing Subsystem

Shown in Image 3.4–3 are the Silverado 1500 and 2500 Sealing Subsystems. Subsystem masses were 14.5 kg for the 1500 versus 15.1 kg for the 2500. The Lightweighting Technology used on the Sealing Subsystem was to change from EPDM to TPV material. Due to similarities in component design and material, full percentage of the Silverado 1500 sealing subsystem mass reduction can be applied to the 2500. (Refer to Table 3-27).


Image 3.4–3: Sealing Subsystem for the Silverado 1500 (Left) and the Silverado 2500 (Right)
(Source: FEV, Inc.)

DRAFT

Seating Subsystem

Shown in Image 3.4–4 are the Silverado 1500 and 2500 Seating Subsystems. Subsystem masses were 48.2 kg for the 1500 versus 46.1 kg for the 2500. The Lightweighting Technology used on the Seating Subsystem was to change the welded steel construction on the front seats to BASF plastic and glass fiber laired laminate. Also, by changing the welded steel construction for the 60/40 seat and the center console to cast magnesium. Due to similarities in component design and material, full percentage of the Silverado 1500 seating subsystem mass reduction can be applied to the 2500. (Refer to Table 3-27).

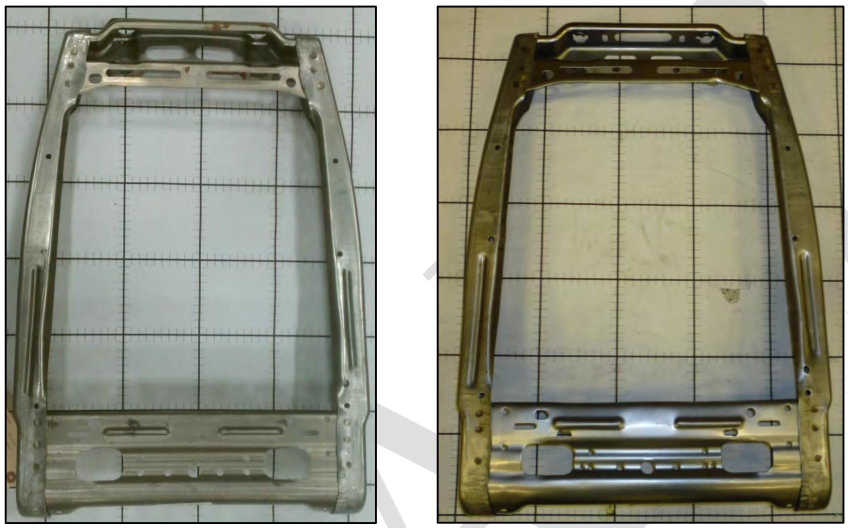


Image 3.4–4: Seating Subsystem for the Silverado 1500 (Left) and Silverado 2500 (Right)
(Source: FEV, Inc.)

Instrument Panel and Console Subsystem

Shown in Image 3.4–5 are the Silverado 1500 and 2500 series Instrument Panel and Console Subsystems. Subsystem masses were 23.19 kg for both the 1500 and the 2500. The Lightweighting Technology used on the Instrument Panel and Console Subsystem was to change the welded steel construction on the cross car beam to cast magnesium. Also, by changing the welded steel construction for the knee bolster reinforcement bracket to plastic. Due to similarities in component design and material, full percentage of the Silverado 1500 instrument panel and console subsystem mass reduction can be applied to the 2500. (Refer to Table 3-27).

DRAFT

Image 3.4–5: Instrument Panel and Console Subsystem for the Silverado 1500 (Top) and Silverado 2500 (Bottom)
(Source: FEV, Inc.)

<u>Occupant Restraining Device Subsystem</u>

Shown in Image 3.4–6 are the Silverado 1500 and 2500 series Occupant Restraining Device Subsystems (they look the same). Subsystem masses were 2.59 kg for the 1500 versus 1.85 kg for the 2500. The Lightweighting Technology used on both Occupant Restraining Device Subsystems was to change the welded steel construction on the passenger air bag housing to DSM Akulon® Nylon 6. The steering wheel air bag dual stage inflator was changed as well, to a single stage inflator. Due to similarities in component design and material, full percentage of the Silverado 1500 occupant restraining device subsystem mass reduction can be applied to the 2500. (Refer to Table 3-27).

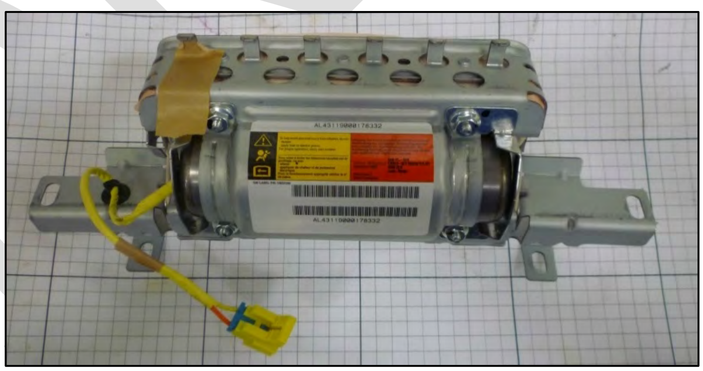


Image 3.4–6: Occupant Restraining Device Subsystem for the Silverado 1500 and Silverado 2500
(Source: FEV, Inc.)

3.4.2.3 System Comparison, Silverado 2500

Table 3-28 summarizes the Silverado 1500 and 2500 Lightweighting results. The majority of the components were visually the same among the two Body Group -B- Systems.

DRAFT

Table 3-28: Body Group -B- System Comparison, Silverado 1500 and 2500

System	Description	Net Value of Mass Reduction: Mass Base "kg" (1)	Mass Reduction New Tech "kg" (1)	Mass Reduction Comp "kg" (1)	Mass Reduction Total "kg" (1)	System Mass Reduction "%"	Cost Impact New Tech "$" (2)	Cost Impact Comp "$" (2)	Cost Impact Total "$" (2)	Cost/ Kilogram Total "$/kg"
03	**Body Group B**									
03	Silverado 1500	247.02	34.02	0.00	34.02	13.77%	-$127.22	$0.00	-$127.22	-$3.74
03	Silverado 2500	220.48	32.10	0.00	32.10	14.56%	-$125.41	$0.00	-$125.41	-$3.91

DRAFT

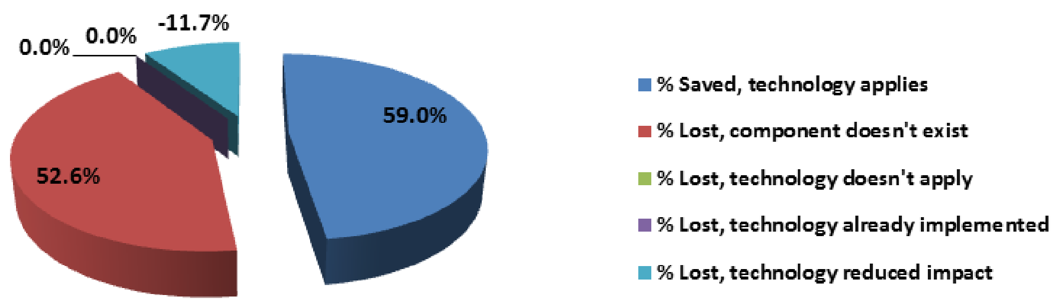
3.4.3 Mercedes Sprinter 311 CDi

Table 3-29 summarizes the mass and cost impact of Silverado 1500 Lightweighting technologies as applied to the Mercedes Sprinter 311 CDi. Total Body Group -B- System mass savings were 20.02 kg at a cost increase of $53.33, or $2.66 per kg.

Table 3-29: Mass-Reduction and Cost Impact for Body Group -B- System, Mercedes Sprinter

				Net Value of Mass Reduction							
System	Subsystem	Sub-Subsystem	Description	Mass Reduction New Tech "kg" (1)	Mass Reduction Comp "kg" (1)	Mass Reduction Total "kg" (1)	Cost Impact New Tech "$" (2)	Cost Impact Comp "$" (2)	Cost Impact Total "$" (2)	Cost/ Kilogram Total "$/kg"	Vehicle Mass Reduction Total "%"
03	00	00	Body System "B"								
03	05	00	Interior Trim and Ornamentation Subsystem	2.16	0.00	2.16	$6.23	$0.00	$6.23	$2.88	0.10%
03	06	00	Sound and Heat Control Subsystem (Body)	0.00	0.00	0.00	$0.00	$0.00	$0.00	$0.00	0.00%
03	07	00	Sealing Subsystem	1.80	0.00	1.80	$12.31	$0.00	$12.31	$6.83	0.08%
03	10	00	Seating Subsystem	7.08	0.00	7.08	-$37.27	$0.00	-$37.27	-$5.26	0.33%
03	12	00	Instrument Panel and Console Subsystem	6.67	0.00	6.67	-$36.26	$0.00	-$36.26	-$5.43	0.31%
03	20	00	Occupant Restraining Device Subsystem	2.30	0.00	2.30	1.66	$0.00	$1.66	$0.00	0.11%
				20.02 (Decrease)	0.00	20.02 (Decrease)	-53.33 (Increase)	0.00	-$53.33 (Increase)	-$2.66 (Increase)	0.94%

Mass Savings, Select Vehicle, New Technology "kg"	20.02
Mass Savings, Silverado 1500, New Technology "kg"	33.92
Mass Savings Select Vehicle/Mass Savings 1500	59.0%



*SMS not included - has no significant impact on perecent contributions

3.4.3.1 System Scaling Analysis

The Mercedes Sprinter 311 CDi Body Group -B- System components were reviewed for compatibility with Lightweighting technologies. The results of this analysis are listed below.

Table 3-30: System Scaling Analysis, Body Group -B- System, Mercedes Sprinter

Silverado 1500							Select Vehicle			
System	Subsystem	Sub-Subsystem	Component/Assembly	Base Mass	Mass Savings New Tech	% of Mass Savings New Tech	Tech Applies	Base Mass	Mass Savings New Tech	Notes
03			**Body Group B System**	**247.02**	**34.02**	**14%**			**20.02**	
03	05	05	LH drivers door window switch cover	0.10	0.010	10%	no			Tech does **NOT** apply: Not on vehicle
03	05	05	LH drivers Door arm rest attachment cover	0.03	0.003	11%	no			Tech does **NOT** apply: Not on vehicle
03	05	05	LH drivers Door Pull handle attachment cover	0.01	0.001	17%	yes	0.06	0.01	Tech **DOES** apply: Use Polyone foaming agent
03	05	05	LH drivers Door vertical Pull handle	0.13	0.013	10%	yes	0.09	0.01	Tech **DOES** apply: Use Polyone foaming agent
03	05	05	LH drivers Door corner cover	0.06	0.006	11%	no			Tech does **NOT** apply: Not on vehicle
03	05	05	RH passenger door window switch cover	0.10	0.010	10%	no			Tech does **NOT** apply: Not on vehicle
03	05	05	RH passenger Door arm rest attachment cover	0.03	0.003	11%	no			Tech does **NOT** apply: Not on vehicle
03	05	05	RH passenger Door Pull handle attachment cover	0.01	0.001	17%	no			Tech does **NOT** apply: Not on vehicle
03	05	05	RH passenger Door vertical Pull handle	0.13	0.013	10%	yes	0.06	0.01	Tech **DOES** apply: Use Polyone foaming agent
03	05	05	RH passenger Door corner cover	0.06	0.006	11%	no			Tech does **NOT** apply: Not on vehicle
03	05	05	RH passenger Door lwr main trim	2.09	0.209	10%	yes	3.30	0.33	Tech **DOES** apply: Use Polyone foaming agent
03	05	05	RH passenger Door lwr main trim map pocket	0.50	0.050	10%	yes	0.67	0.07	Tech **DOES** apply: Use Polyone foaming agent
03	05	05	RH passenger Door lwr main trim close out	0.05	0.005	10%	yes	0.59	0.06	Tech **DOES** apply: Use Polyone foaming agent
03	05	05	RH passenger Door lwr main trim inner support brkt#1	0.28	0.028	10%	no			Tech does **NOT** apply: Not on vehicle
03	05	05	RH passenger Door lwr main trim inner support brkt#2	0.06	0.005	9%	no			Tech does **NOT** apply: Not on vehicle
03	05	05	RH passenger Door lwr main trim inner support brkt#5	0.03	0.003	11%	no			Tech does **NOT** apply: Not on vehicle
03	05	05	RH passenger Door lwr main trim inner support brkt#6	0.01	0.001	9%	no			Tech does **NOT** apply: Not on vehicle
03	05	05	RH passenger Door upr main trim	0.76	0.076	10%	yes	2.54	0.25	Tech **DOES** apply: Use Polyone foaming agent
03	05	05	LH passenger Door lwr main trim	2.09	0.209	10%	yes	3.30	0.33	Tech **DOES** apply: Use Polyone foaming agent
03	05	05	LH passenger Door lwr main trim map pocket	0.50	0.050	10%	yes	0.67	0.07	Tech **DOES** apply: Use Polyone foaming agent
03	05	05	LH passenger Door lwr main trim close out	0.05	0.005	10%	yes	0.59	0.06	Tech **DOES** apply: Use Polyone foaming agent
03	05	05	LH passenger Door lwr main trim inner support brkt#1	0.28	0.028	10%	no			Tech does **NOT** apply: Not on vehicle
03	05	05	LH passenger Door lwr main trim inner support brkt#2	0.06	0.005	9%	no			Tech does **NOT** apply: Not on vehicle
03	05	05	LH passenger Door lwr main trim inner support brkt#5	0.03	0.003	11%	no			Tech does **NOT** apply: Not on vehicle
03	05	05	LH passenger Door lwr main trim inner support brkt#6	0.01	0.001	10%	no			Tech does **NOT** apply: Not on vehicle
03	05	05	LH passenger Door upr main trim	0.76	0.076	10%	yes	2.54	0.25	Tech **DOES** apply: Use Polyone foaming agent
03	05	05	Frt dorr harness feed through	0.23	0.023	10%	yes	0.05	0.00	Tech **DOES** apply: Use Polyone foaming agent
03	05	06	RH Rear door window switch cover	0.08	0.008	10%	no			Tech does **NOT** apply: Not on vehicle
03	05	06	RH Rear Door arm rest attachment cover	0.02	0.002	10%	no			Tech does **NOT** apply: Not on vehicle
03	05	06	RH Rear Door Pull handle attachment cover	0.01	0.001	10%	yes	0.22	0.02	Tech **DOES** apply: Use Polyone foaming agent
03	05	06	RH rear door arm rest	0.27	0.027	10%	no			Tech does **NOT** apply: Not on vehicle
03	05	06	LH Rear door window switch cover	0.08	0.008	10%	no			Tech does **NOT** apply: Not on vehicle
03	05	06	LH Rear Door arm rest attachment cover	0.02	0.002	10%	no			Tech does **NOT** apply: Not on vehicle
03	05	06	LH Rear Door Pull handle attachment cover	0.01	0.001	10%	no			Tech does **NOT** apply: Not on vehicle
03	05	06	LH rear door arm rest	0.27	0.027	10%	no			Tech does **NOT** apply: Not on vehicle
03	05	06	RH rear door lwr main trim	1.53	0.153	10%	yes	2.36	0.24	Tech **DOES** apply: Use Polyone foaming agent
03	05	06	RH rear door lwr main trim map pocket	0.23	0.023	10%	no			Tech does **NOT** apply: Not on vehicle
03	05	06	RH rear door lwr main trim mounting bkt #1	0.02	0.002	10%	no			Tech does **NOT** apply: Not on vehicle
03	05	06	RH rear door lwr main trim mounting bkt #2	0.01	0.001	10%	no			Tech does **NOT** apply: Not on vehicle
03	05	06	RH rear door upr main trim	0.58	0.058	10%	yes	0.65	0.07	Tech **DOES** apply: Use Polyone foaming agent
03	05	06	LH rear door lwr main trim	1.53	0.153	10%	no			Tech does **NOT** apply: Not on vehicle
03	05	06	LH rear door lwr main trim map pocket	0.23	0.023	10%	no			Tech does **NOT** apply: Not on vehicle
03	05	06	LH rear door lwr main trim mounting bkt #1	0.02	0.002	10%	no			Tech does **NOT** apply: Not on vehicle
03	05	06	LH rear door lwr main trim mounting bkt #2	0.01	0.001	10%	no			Tech does **NOT** apply: Not on vehicle
03	05	06	LH rear door upr main trim	0.58	0.058	10%	no			Tech does **NOT** apply: Not on vehicle
03	05	07	Driver Lwr A-Pillar	0.23	0.023	10%	yes	0.36	0.04	Tech **DOES** apply: Use Polyone foaming agent
03	05	07	Passenger Lwr A-Pillar	0.22	0.022	10%	yes	0.33	0.03	Tech **DOES** apply: Use Polyone foaming agent
03	05	07	Front Driver kick plate	0.20	0.020	10%	no			Tech does **NOT** apply: Not on vehicle
03	05	07	Front Driver kick plate mount	0.18	0.018	10%	no			Tech does **NOT** apply: Not on vehicle
03	05	07	Rear Driver kick plate	0.14	0.014	10%	no			Tech does **NOT** apply: Not on vehicle
03	05	07	Rear Driver kick plate mount	0.12	0.012	10%	no			Tech does **NOT** apply: Not on vehicle
03	05	07	LH B-Pillar Lwr	0.63	0.063	10%	yes	1.22	0.12	Tech **DOES** apply: Use Polyone foaming agent
03	05	07	Front Passenger kick plate	0.21	0.020	10%	no			Tech does **NOT** apply: Not on vehicle
03	05	07	Front Passenger kick plate mount	0.18	0.018	10%	no			Tech does **NOT** apply: Not on vehicle
03	05	07	Rear Passenger kick plate	0.14	0.014	10%	no			Tech does **NOT** apply: Not on vehicle
03	05	07	Rear Passenger kick plate mount	0.13	0.012	10%	no			Tech does **NOT** apply: Not on vehicle
03	05	07	RH B-Pillar Lwr	0.63	0.063	10%	yes	1.23	0.12	Tech **DOES** apply: Use Polyone foaming agent
03	05	07	C-Pillar cover RH upr	0.34	0.034	10%	no			Tech does **NOT** apply: Not on vehicle
03	05	07	C-Pillar cover RH Lwr	0.53	0.053	10%	no			Tech does **NOT** apply: Not on vehicle
03	05	07	Small Cover piece	0.0020	0.0002	10%	no			Tech does **NOT** apply: Not on vehicle
03	05	07	C-Pillar cover LH upr	0.34	0.034	10%	no			Tech does **NOT** apply: Not on vehicle
03	05	07	C-Pillar cover LH Lwr	0.52	0.052	10%	no			Tech does **NOT** apply: Not on vehicle
03	05	07	Small Cover piece	0.00	0.000	10%	no			Tech does **NOT** apply: Not on vehicle
03	05	07	C-Pillar to C-Pillar cross trim	0.56	0.056	10%	no			Tech does **NOT** apply: Not on vehicle
03	05	08	Drivers Upr A-Pillar cover	0.35	0.04	10%	yes	0.38	0.04	Tech **DOES** apply: Use Polyone foaming agent
03	05	08	Drivers upr A-pillar mounting screw cover	0.00	0.00	0%	no			Tech does **NOT** apply: Not on vehicle
03	05	08	Driver LH Upper B-Pillar Cover	0.29	0.03	10%	no			Tech does **NOT** apply: Not on vehicle
03	05	08	Driver LH Upper B-Pillar Cover slide	0.06	0.01	11%	no			Tech does **NOT** apply: Not on vehicle
03	05	08	Driver restraint upr B-pillar bolt cover	0.01	0.00	7%	no			Tech does **NOT** apply: Not on vehicle
03	05	08	Drivers B pillar mounting screw cover	0.01	0.00	17%	no			Tech does **NOT** apply: Not on vehicle
03	05	08	Passenger Upr A-Pillar cover	0.33	0.03	10%	yes	0.38	0.04	Tech **DOES** apply: Use Polyone foaming agent
03	05	08	Passenger RH Upper B-Pillar Cover	0.28	0.03	10%	no			Tech does **NOT** apply: Not on vehicle
03	05	08	Passenger LH Upper B-Pillar Cover slide	0.06	0.01	11%	no			Tech does **NOT** apply: Not on vehicle
03	05	08	Passenger restraint upr B-pillar bolt cover	0.01	0.00	7%	no			Tech does **NOT** apply: Not on vehicle
03	05	08	Passenger B pillar mounting screw	0.00	0.00	0%	no			Tech does **NOT** apply: Not on vehicle

Table 3.4–6 Continued Next Page

Table 3.4–6 Continued: System Scaling Analysis, Body Group -B- System, Mercedes Sprinter

Silverado 1500							Select Vehicle			
System	Subsystem	Sub-Subsystem	Component/Assembly	Base Mass	Mass Savings New Tech	% of Mass Savings New Tech	Tech Applies	Base Mass	Mass Savings New Tech	Notes
03	**Body Group B System**			**247.02**	**34.02**	**14%**			**20.02**	
03	07	01	LH Driver Door Lower seal	0.14	0.05	33%	no			Tech does **NOT** apply: Not on vehicle
03	07	01	RH Passenger Door Lower seal	0.14	0.05	33%	no			Tech does **NOT** apply: Not on vehicle
03	07	01	LH Rear Door Lower seal	0.11	0.04	32%	no			Tech does **NOT** apply: Not on vehicle
03	07	01	LH Rear Door hinge side upr seal	0.07	0.02	33%	no			Tech does **NOT** apply: Not on vehicle
03	07	01	RH Rear Door Lower seal	0.11	0.04	32%	no			Tech does **NOT** apply: Not on vehicle
03	07	01	RH Rear Door hinge side upr seal	0.07	0.02	33%	no			Tech does **NOT** apply: Not on vehicle
03	07	01	RH rear door inside window track seal	0.52	0.17	33%	no			Tech does **NOT** apply: Not on vehicle
03	07	01	RH rear door inside window track bottom inner seal	0.16	0.05	33%	no			Tech does **NOT** apply: Not on vehicle
03	07	01	RH rear door inside window track bottom outer seal	0.30	0.10	33%	no			Tech does **NOT** apply: Not on vehicle
03	07	01	LH rear door inside window track seal	0.52	0.17	33%	no			Tech does **NOT** apply: Not on vehicle
03	07	01	LH rear door inside window track bottom inner seal	0.16	0.05	33%	no			Tech does **NOT** apply: Not on vehicle
03	07	01	LH rear door inside window track bottom outer seal	0.30	0.10	33%	no			Tech does **NOT** apply: Not on vehicle
03	07	01	LH drivers door inside window track seal	0.60	0.20	33%	yes	0.77	0.25	Tech **DOES** apply: Change from EDPM to TPV
03	07	01	LH drivers door inside window track bottom inner seal	0.19	0.06	33%	yes	0.18	0.06	Tech **DOES** apply: Change from EDPM to TPV
03	07	01	LH drivers door inside window track bottom outer seal	0.35	0.11	33%	no			Tech does **NOT** apply: Not on vehicle
03	07	01	RH passenger door inside window track seal	0.60	0.20	33%	yes	0.77	0.25	Tech **DOES** apply: Change from EDPM to TPV
03	07	01	RH passenger door inside window track bottom inner seal	0.19	0.06	33%	yes	0.18	0.06	Tech **DOES** apply: Change from EDPM to TPV
03	07	01	RH passenger door inside window track bottom outer seal	0.35	0.11	33%	no			Tech does **NOT** apply: Not on vehicle
03	07	02	Drivers Upr Outside seal	0.82	0.27	33%	no			Tech does **NOT** apply: Not on vehicle
03	07	02	Front driver door seal	2.10	0.68	33%	yes	1.82	0.59	Tech **DOES** apply: Change from EDPM to TPV
03	07	02	Rear driver door seal	1.93	0.63	33%	no			Tech does **NOT** apply: Not on vehicle
03	07	02	Passenger Upr Outside seal	0.82	0.27	33%	no			Tech does **NOT** apply: Not on vehicle
03	07	02	Front passenger door seal	2.05	0.67	33%	yes	1.82	0.59	Tech **DOES** apply: Change from EDPM to TPV
03	07	02	Rear passenger door seal	1.91	0.62	33%	no			Tech does **NOT** apply: Not on vehicle
03	10	01	Driver seat back frame	2.20	1.10	50%	yes	3.95	1.97	Tech **DOES** apply: Change from welded steel to BASF Plastic
03	10	01	Driver seat map back inner	0.49	0.05	10%	no			Tech does **NOT** apply: Not on vehicle
03	10	01	Driver Seat map back	0.64	0.06	10%	no			Tech does **NOT** apply: Not on vehicle
03	10	01	Driver Seat safety belt cover	0.04	0.00	10%	no			Tech does **NOT** apply: Not on vehicle
03	10	01	Driver seat bottom frame	3.60	1.80	50%	yes	3.00	1.50	Tech **DOES** apply: Change from welded steel to BASF Plastic
03	10	01	Driver Seat frt Nut Cover LH	0.02	0.00	10%	no			Tech does **NOT** apply: Not on vehicle
03	10	01	Driver Seat frt Nut Cover RH	0.03	0.00	10%	no			Tech does **NOT** apply: Not on vehicle
03	10	01	Driver Seat rear Bolt Cover LH	0.02	0.00	10%	no			Tech does **NOT** apply: Not on vehicle
03	10	01	Driver Seat rear Bolt Cover RH	0.07	0.01	10%	no			Tech does **NOT** apply: Not on vehicle
03	10	01	Driver seat wire harness cover	0.04	0.00	10%	no			Tech does **NOT** apply: Not on vehicle
03	10	01	Driver Seat LH Track cover	0.16	0.02	10%	no			Tech does **NOT** apply: Not on vehicle
03	10	01	Driver Seat LH Track cover end cap rear	0.02	0.00	10%	no			Tech does **NOT** apply: Not on vehicle
03	10	01	Driver Seat LH Track cover end cap frt	0.02	0.00	10%	no			Tech does **NOT** apply: Not on vehicle
03	10	01	Driver Seat LH cover	0.31	0.03	10%	yes	0.29	0.03	Tech **DOES** apply: Use Polyone foaming agent
03	10	01	Driver Seat LH cover close out	0.05	0.01	10%	no			Tech does **NOT** apply: Not on vehicle
03	10	01	Driver Seat LH cover seat belt insert cover	0.01	0.00	10%	no			Tech does **NOT** apply: Not on vehicle
03	10	01	Driver Seat LH cover lumbar knob	0.02	0.00	10%	yes	0.04	0.00	Tech **DOES** apply: Use Polyone foaming agent
03	10	01	Driver Seat LH cover recline handle	0.03	0.00	10%	yes	0.08	0.01	Tech **DOES** apply: Use Polyone foaming agent
03	10	01	Driver Seat RH cover	0.11	0.01	10%	yes	0.31	0.03	Tech **DOES** apply: Use Polyone foaming agent
03	10	02	Passenger seat back frame	2.20	1.10	50%	yes	3.95	1.97	Tech **DOES** apply: Change from welded steel to BASF Plastic
03	10	02	Pass seat map back inner	0.49	0.05	10%	no			Tech does **NOT** apply: Not on vehicle
03	10	02	Pass Seat map back	0.64	0.06	10%	no			Tech does **NOT** apply: Not on vehicle
03	10	02	Pass Seat safety belt cover	0.04	0.00	10%	no			Tech does **NOT** apply: Not on vehicle
03	10	02	Passenger seat bottom frame	3.59	1.79	50%	yes	3.00	1.49	Tech **DOES** apply: Change from welded steel to BASF Plastic
03	10	02	Frt Passenger Seat frt RH Nut Cover	0.02	0.00	10%	no			Tech does **NOT** apply: Not on vehicle
03	10	02	Frt Passenger Seat frt LH Nut Cover	0.04	0.00	10%	no			Tech does **NOT** apply: Not on vehicle
03	10	02	Passenger Seat rear Bolt Cover LH	0.06	0.01	10%	no			Tech does **NOT** apply: Not on vehicle
03	10	02	Passenger Seat rear Bolt Cover RH	0.02	0.00	10%	no			Tech does **NOT** apply: Not on vehicle
03	10	02	Passenger seat wire harness cover	0.04	0.00	10%	no			Tech does **NOT** apply: Not on vehicle
03	10	02	Pass Seat LH Track cover	0.16	0.02	10%	no			Tech does **NOT** apply: Not on vehicle
03	10	02	Pass Seat LH Track cover end cap rear	0.02	0.00	10%	no			Tech does **NOT** apply: Not on vehicle
03	10	02	Pass Seat LH Track cover end cap frt	0.02	0.00	10%	no			Tech does **NOT** apply: Not on vehicle
03	10	02	Pass Seat LH cover	0.31	0.03	10%	yes	0.29	0.03	Tech **DOES** apply: Use Polyone foaming agent
03	10	02	Passenger Seat LH cover close out	0.05	0.01	10%	no			Tech does **NOT** apply: Not on vehicle
03	10	02	Passenger Seat LH cover seat belt insert cover	0.01	0.00	10%	no			Tech does **NOT** apply: Not on vehicle
03	10	02	Passenger Seat LH cover lumbar knob	0.02	0.00	10%	yes	0.04	0.00	Tech **DOES** apply: Use Polyone foaming agent
03	10	02	Passenger Seat LH cover recline handle	0.03	0.00	10%	yes	0.08	0.01	Tech **DOES** apply: Use Polyone foaming agent
03	10	02	Passenger Seat RH cover	0.11	0.01	10%	yes	0.31	0.03	Tech **DOES** apply: Use Polyone foaming agent
03	10	03	60% Seat back frame	5.78	2.78	48%	no			Tech does **NOT** apply: Not on vehicle
03	10	03	Arm rest inner tub	0.28	0.03	10%	no			Tech does **NOT** apply: Not on vehicle
03	10	03	Arm rest frame	1.11	0.43	39%	no			Tech does **NOT** apply: Not on vehicle
03	10	03	Arm rest cup holder	0.13	0.01	10%	no			Tech does **NOT** apply: Not on vehicle
03	10	03	Arm rest cup holder retainer ring	0.09	0.01	10%	no			Tech does **NOT** apply: Not on vehicle
03	10	03	60% Seat bottom frame	4.28	2.24	52%	no			Tech does **NOT** apply: Not on vehicle
03	10	03	RH recliner cover #1	0.14	0.01	10%	no			Tech does **NOT** apply: Not on vehicle
03	10	03	RH recliner cover #2	0.24	0.02	10%	no			Tech does **NOT** apply: Not on vehicle
03	10	03	LH recliner cover #1	0.08	0.01	10%	no			Tech does **NOT** apply: Not on vehicle
03	10	04	40% Seat bottom frame	2.98	1.55	52%	no			Tech does **NOT** apply: Not on vehicle
03	10	04	40% Seat back frame	3.16	1.76	56%	no			Tech does **NOT** apply: Not on vehicle
03	10	04	RH Brkt close out #1	0.23	0.02	10%	no			Tech does **NOT** apply: Not on vehicle
03	10	04	RH Brkt close out #2	0.14	0.01	10%	no			Tech does **NOT** apply: Not on vehicle
03	10	04	LH Brkt close out #1	0.07	0.01	10%	no			Tech does **NOT** apply: Not on vehicle

Table 3.4–6 Continued Next Page

Table 3.4–6 Continued: System Scaling Analysis, Body Group -B- System, Mercedes Sprinter

Silverado 1500							Select Vehicle			
System	Subsystem	Sub-Subsystem	Component/Assembly	Base Mass	Mass Savings New Tech	% of Mass Savings New Tech	Tech Applies	Base Mass	Mass Savings New Tech	Notes
03			**Body Group B System**	**247.02**	**34.02**	**14%**			**20.02**	
03	10	05	Frt center riser	2.97	1.04	35%	no			Tech does **NOT** apply: Not on vehicle
03	10	05	LH Pivot cover outer	0.07	0.01	10%	no			Tech does **NOT** apply: Not on vehicle
03	10	05	LH Pivot cover inner	0.05	0.00	10%	no			Tech does **NOT** apply: Not on vehicle
03	10	05	RH Pivot cover outer	0.06	0.01	10%	no			Tech does **NOT** apply: Not on vehicle
03	10	05	RH Pivot cover inner	0.05	0.00	10%	no			Tech does **NOT** apply: Not on vehicle
03	10	05	RH Pivot cover inner top	0.05	0.00	10%	no			Tech does **NOT** apply: Not on vehicle
03	10	05	Bottom tub inner	0.85	0.09	10%	no			Tech does **NOT** apply: Not on vehicle
03	10	05	Frt wrap around close out	0.51	0.05	10%	no			Tech does **NOT** apply: Not on vehicle
03	10	05	Rear wrap around close out	0.65	0.06	10%	no			Tech does **NOT** apply: Not on vehicle
03	10	05	Cup holder	0.31	0.03	10%	no			Tech does **NOT** apply: Not on vehicle
03	10	05	Cup holder top	0.12	0.01	10%	no			Tech does **NOT** apply: Not on vehicle
03	10	05	Frt center box comp	3.77	1.66	44%	no			Tech does **NOT** apply: Not on vehicle
03	10	05	Frt center cover plt	1.60	0.81	50%	no			Tech does **NOT** apply: Not on vehicle
03	10	05	Seat frame cover handle #1	0.02	0.00	10%	no			Tech does **NOT** apply: Not on vehicle
03	10	05	Seat frame cover handle #2	0.04	0.00	10%	no			Tech does **NOT** apply: Not on vehicle
03	10	05	Center tub	1.08	0.11	10%	no			Tech does **NOT** apply: Not on vehicle
03	10	05	Divider	0.06	0.01	10%	no			Tech does **NOT** apply: Not on vehicle
03	10	05	Cup holder	0.20	0.02	10%	no			Tech does **NOT** apply: Not on vehicle
03	10	05	Center tub top ring	0.28	0.03	10%	no			Tech does **NOT** apply: Not on vehicle
03	10	05	Center tub top lid inner	0.65	0.07	10%	no			Tech does **NOT** apply: Not on vehicle
03	10	05	Center tub top lid outer	0.34	0.03	10%	no			Tech does **NOT** apply: Not on vehicle
03	10	05	Center tub top lid handle #1	0.02	0.00	10%	no			Tech does **NOT** apply: Not on vehicle
03	10	05	Center tub top lid handle #2	0.02	0.00	10%	no			Tech does **NOT** apply: Not on vehicle
03	12	01	Cross Car Beam	11.34	5.44	48%	yes	11.60	5.57	Tech **DOES** apply: Change from welded steel to mag.
03	12	01	Cross Car Beam to Floor Brkt Cover	0.10	0.01	10%	no			Tech does **NOT** apply: Not on vehicle
03	12	02	IP Main Sub Molding	1.60	0.16	10%	no			Tech does **NOT** apply: Not on vehicle
03	12	02	IP Main Molding	3.37	0.34	10%	yes	5.91	0.59	Tech **DOES** apply: Use Polyone foaming agent
03	12	02	IP Main Molding support box	0.27	0.03	10%	no			Tech does **NOT** apply: Not on vehicle
03	12	02	Elec. Breaker box cover	0.10	0.01	10%	no			Tech does **NOT** apply: Not on vehicle
03	12	03	Knee Bolster cover	0.59	0.06	10%	yes	0.30	0.03	Tech **DOES** apply: Use Polyone foaming agent
03	12	03	Knee Bolster Reinforcement brkt	0.42	0.24	57%	no			Tech does **NOT** apply: Not on vehicle
03	12	03	Glove box brkt	0.35	0.04	10%	no			Tech does **NOT** apply: Not on vehicle
03	12	03	Glove box inner tub	0.85	0.09	10%	yes	0.66	0.07	Tech **DOES** apply: Use Polyone foaming agent
03	12	03	Glove box inner tub cover	0.40	0.04	10%	yes	1.11	0.11	Tech **DOES** apply: Use Polyone foaming agent
03	12	03	Decorative glove box trim	0.05	0.01	10%	no			Tech does **NOT** apply: Not on vehicle
03	12	03	Lwr Center IP Cover	0.45	0.05	10%	yes	0.69	0.07	Tech **DOES** apply: Use Polyone foaming agent
03	12	03	Lwr Center IP Cover ashtray door	0.11	0.01	10%	yes	0.06	0.01	Tech **DOES** apply: Use Polyone foaming agent
03	12	03	Ashtray	0.08	0.01	10%	yes	0.06	0.01	Tech **DOES** apply: Use Polyone foaming agent
03	12	03	Upr glove box door	0.34	0.03	10%	yes	0.22	0.02	Tech **DOES** apply: Use Polyone foaming agent
03	12	03	Upr glove box door inner	0.26	0.03	10%	yes	0.82	0.08	Tech **DOES** apply: Use Polyone foaming agent
03	12	03	Upr glove box bucket	0.49	0.05	10%	no			Tech does **NOT** apply: Not on vehicle
03	12	03	Top IP Cover	0.29	0.03	10%	yes	0.50	0.05	Tech **DOES** apply: Use Polyone foaming agent
03	12	04	IP Driver side cover	0.15	0.02	10%	yes	0.12	0.01	Tech **DOES** apply: Use Polyone foaming agent
03	12	04	IP Passenger side cover	0.15	0.02	10%	yes	0.12	0.01	Tech **DOES** apply: Use Polyone foaming agent
03	12	04	Top IP Decretive trim	1.06	0.11	10%	yes	0.50	0.05	Tech **DOES** apply: Use Polyone foaming agent
03	12	05	IP Control Module 1 mounting brkt	0.13	0.01	10%	no			Tech does **NOT** apply: Not on vehicle
03	12	05	IP Control Module 2 & 3 mounting brkt	0.15	0.02	10%	no			Tech does **NOT** apply: Not on vehicle
03	12	05	IP Control Module 4 mounting brkt	0.09	0.01	10%	no			Tech does **NOT** apply: Not on vehicle
03	20	03	Housing Assy, Passenger Side Airbag	1.09	0.62	57%	yes	3.39	1.93	Tech **DOES** apply: Change from steel to DSM Akulon Nylon6
03	20	12	Drivers side curtain airbag mounting brkt	0.30	0.19	62%	no			Tech does **NOT** apply: Not on vehicle
03	20	12	Passenger side curtain airbag mounting brkt	0.31	0.19	62%	no			Tech does **NOT** apply: Not on vehicle
03	20	18	Front Cover, Steering Wheel Airbag Assy	0.14	0.02	10%	yes	1.26	0.04	Tech **DOES** apply: Use Polyone foaming agent
03	20	18	Bracket #1, Drivers side airbag	0.25	0.11	44%	yes	0.19	0.08	Tech **DOES** apply: Change from steel to plastic
03	20	18	Ignition Canister, Steering Wheel Airbag Assy	0.49	0.14	28%	yes	1.26	0.25	Tech **DOES** apply: Replace dual stage inflator with single stage

If the original Silverado 1500 mass reduction concept idea was not able to be applied to the comparison vehicle it is not described in the section below.

Due to the large size of the Body Group -B- System it was not broken down by component, but by subsystem. Mass savings opportunities were identified for the following subsystems: Interior Trim and Ornamentation, Sealing, Seating, Instrument Panel and Console, and Occupant Restraining Device.

Interior Trim and Ornamentation Subsystem

Shown in Image 3.4–7 are the Silverado 1500 and Mercedes Sprinter 311 CDi Interior Trim and Ornamentation Subsystems. Subsystem masses were 20.6 kg for the 1500 versus 16.5 kg for the Mercedes Sprinter 311 CDi. The Lightweighting Technology used in the Interior Trim and Ornamentation Subsystem was PolyOne® foaming agent in the plastic. Due to similarities in component design and material, full percentage of the Silverado 1500 interior trim mass reduction can be applied to the Sprinter.

Image 3.4–7: Interior Trim and Ornamentation Subsystem for Silverado 1500 (Left) and the Mercedes Sprinter 311 CDi (Right)
(Source: FEV, Inc. and www.A2mac1.com)

Sealing Subsystem

Shown in Image 3.4–8 are the Silverado 1500 and Mercedes Sprinter 311 CDi Sealing Subsystems. Component masses were 14.5 kg for the 1500 versus 5.54 kg for the Mercedes Sprinter 311 CDi. The Lightweighting Technology used on the Sealing Subsystem was to change to TPV from EPDM material. Due to similarities in component design and material, full percentage of the Silverado 1500 sealing subsystem mass reduction can be applied to the Sprinter.

Image 3.4–8: Sealing Subsystem for the Silverado 1500 (Left) and Mercedes Sprinter 311 CDi (Right)
(Source: FEV, Inc. and www.A2mac1.com)

Seating Subsystem

Shown in Image 3.4–9 are the Silverado 1500 and Mercedes Sprinter 311 CDi Seating Subsystem. Subsystem masses were 48.2 kg for the 1500 versus 15.4 kg for the Mercedes Sprinter 311 CDi.

DRAFT

The Lightweighting Technology used on the Seating Subsystem was to change the welded steel construction in the front seats to BASF plastic and glass fiber laired laminate. The welded steel construction for the 60/40 seat and the center console was changed to cast magnesium. Due to similarities in component design and material, full percentage of the Silverado 1500 seating subsystem mass reduction can be applied to the Sprinter.

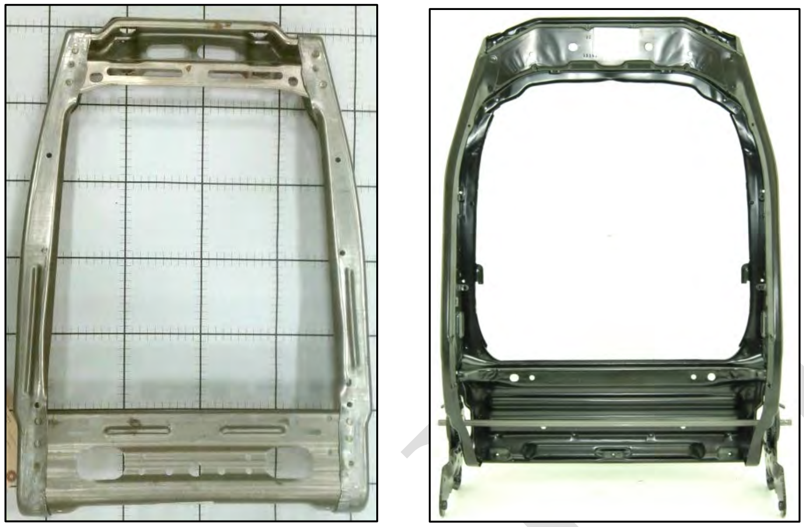


Image 3.4–9: Seating Subsystems for the Silverado 1500 (Left) and Mercedes Sprinter 311 CDi (Right)
(Source: FEV, Inc.)

Instrument Panel and Console Subsystem

Shown in Image 3.4–10 are the Silverado 1500 and Mercedes Sprinter 311 CDi Instrument Panel and Console Subsystems. The subsystem masses were 23.2 kg for the Silverado 1500 versus 22.7 kg for the Mercedes Sprinter 311 CDi. The Lightweighting Technology used for the Instrument Panel and Console Subsystem was to change the welded steel construction in the cross car beam to cast magnesium. The welded steel construction for the knee bolster reinforcement bracket was also changed to plastic. Due to similarities in component design and material, full percentage of the Silverado 1500 instrument panel and console subsystem mass reduction can be applied to the Sprinter.

DRAFT

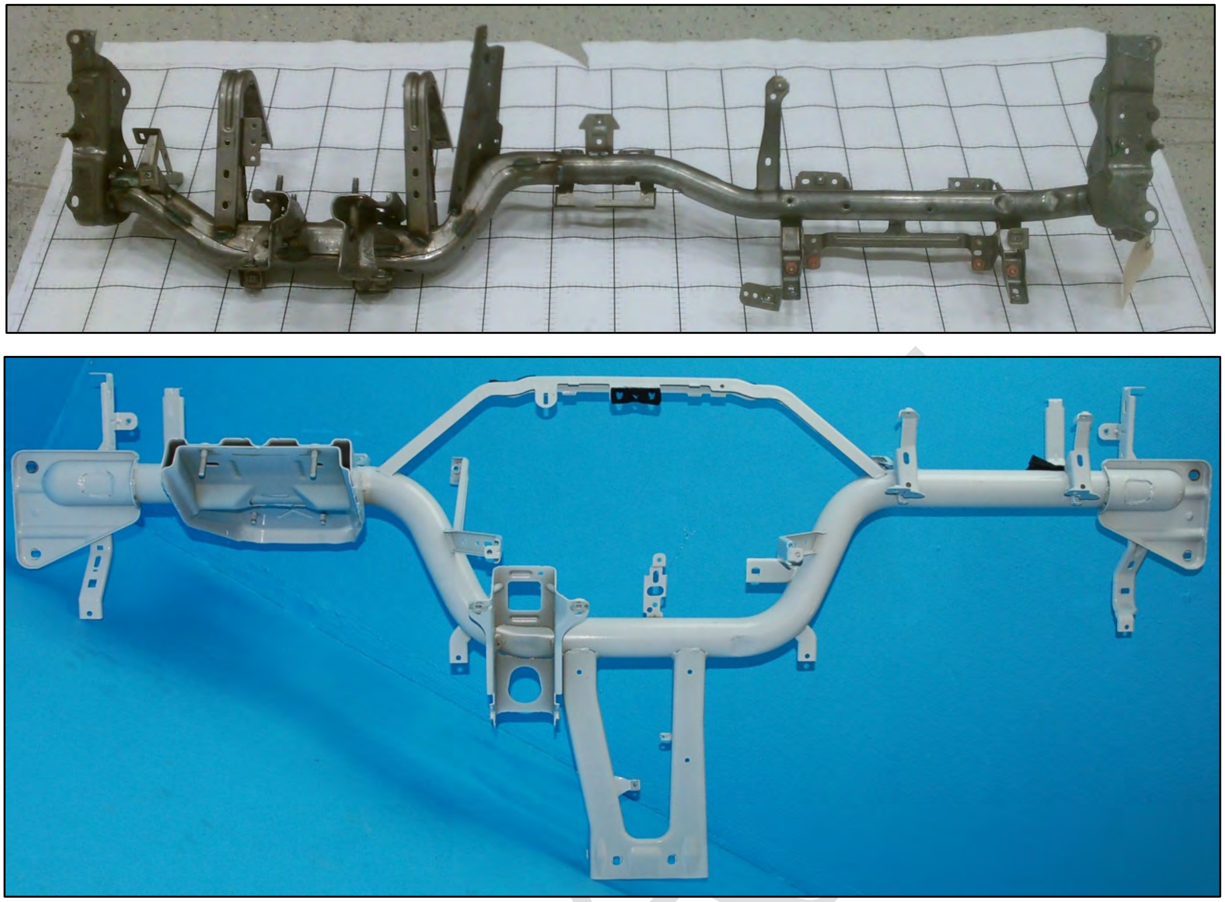


Image 3.4–10: Instrument Panel and Console Subsystems for the Silverado 1500 (Top) and Mercedes Sprinter 311 CDi (Bottom)
(Source: FEV, Inc. and www.A2mac1.com)

Occupant Restraining Device Subsystem

Shown in Image 3.4–11 are the Silverado 1500 and Mercedes Sprinter 311 CDi Occupant Restraining Device Subsystems. The subsystem masses were 2.59 kg for the 1500 versus 6.10 kg for the Mercedes Sprinter 311 CDi respectively. The Lightweighting Technology used in both the Occupant Restraining Device Subsystem was to change the welded steel construction on the passenger air bag housing to DSM Akulon® Nylon 6. The steering wheel air bag dual stage inflator was also changed to a single stage inflator. Due to similarities in component design and material, full percentage of the Silverado 1500 occupant restraining device subsystem mass reduction can be applied to the Sprinter. (Refer to

Table 3-30).

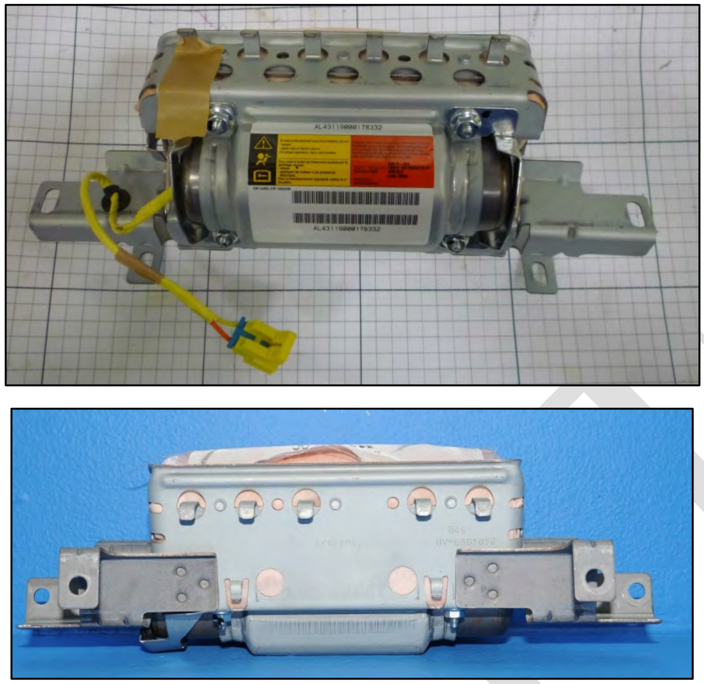


Image 3.4–11: Occupant Restraining Device Subsystem for the Silverado 1500 (Top) and Mercedes Sprinter 311 CDi (Bottom)
(Source: FEV, Inc. and www.A2mac1.com)

DRAFT

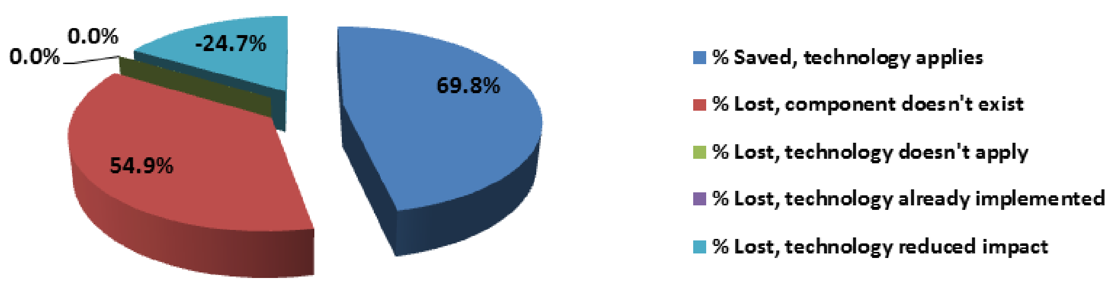
3.4.4 Renault Master 2.3 DCi

Table 3-31 summarizes mass and cost impact of Silverado 1500 Lightweighting technologies applied to the Renault Master 2.3 DCi. Total Body Group -B- Subsystem mass savings is 23.67 kg at a cost increase of $91.43, or $3.86 per kg.

Table 3-31: Mass-Reduction and Cost Impact for Body Group -B- Subsystem, Renault Master

				Net Value of Mass Reduction							
System	Subsystem	Sub-Subsystem	Description	Mass Reduction New Tech "kg" (1)	Mass Reduction Comp "kg" (1)	Mass Reduction Total "kg" (1)	Cost Impact New Tech "$" (2)	Cost Impact Comp "$" (2)	Cost Impact Total "$" (2)	Cost/ Kilogram Total "$/kg"	Vehicle Mass Reduction Total "%"
03	00	00	**Body System "B"**								
03	05	00	Interior Trim and Ornamentation Subsystem	1.21	0.00	1.21	$3.25	$0.00	$3.25	$2.68	0.05%
03	06	00	Sound and Heat Control Subsystem (Body)	0.00	0.00	0.00	$0.00	$0.00	$0.00	$0.00	0.00%
03	07	00	Sealing Subsystem	1.73	0.00	1.73	$11.81	$0.00	$11.81	$6.83	0.07%
03	10	00	Seating Subsystem	13.99	0.00	13.99	-$75.97	$0.00	-$75.97	-$5.43	0.59%
03	12	00	Instrument Panel and Console Subsystem	6.49	0.00	6.49	-$32.51	$0.00	-$32.51	-$5.01	0.28%
03	20	00	Occupant Restraining Device Subsystem	0.25	0.00	0.25	1.99	$0.00	$1.99	$0.00	0.01%
				23.67 (Decrease)	**0.00**	**23.67** (Decrease)	**-91.43** (Increase)	**0.00**	**-$91.43** (Increase)	**-$3.86** (Increase)	**1.01%**

Mass Savings, Select Vehicle, New Technology "kg"	**23.67**
Mass Savings, Silverado 1500, New Technology "kg"	**33.92**
Mass Savings Select Vehicle/Mass Savings 1500	**69.8%**



*SMS not included - has no significant impact on perecent contributions

3.4.4.1 System Scaling Analysis

The Renault Master 2.3 DCi Body Group -B- Subsystem was reviewed for compatibility with Lightweighting technologies. The results of this analysis are listed in Table 3-32.

Table 3-32: System Scaling Analysis Body Group -B- Subsystem, Renault Master

System	Subsystem	Sub-Subsystem	Component/Assembly	Base Mass (Silverado 1500)	Mass Savings New Tech (Silverado 1500)	% of Mass Savings New Tech (Silverado 1500)	Tech Applies (Select Vehicle)	Base Mass (Select Vehicle)	Mass Savings New Tech (Select Vehicle)	Notes (Select Vehicle)
03			**Body Group B System**	**247.02**	**34.02**	**14%**			**23.67**	
03	05	05	LH drivers door window switch cover	0.10	0.010	10%	yes	0.03	0.00	Tech **DOES** apply: Use Polyone foaming agent
03	05	05	LH drivers Door arm rest attachment cover	0.03	0.003	11%	no			Tech does **NOT** apply: Not on vehicle
03	05	05	LH drivers Door Pull handle attachment cover	0.01	0.001	17%	yes	0.05	0.01	Tech **DOES** apply: Use Polyone foaming agent
03	05	05	LH drivers Door vertical Pull handle	0.13	0.013	10%	yes	0.04	0.00	Tech **DOES** apply: Use Polyone foaming agent
03	05	05	LH drivers Door corner cover	0.06	0.006	11%	yes	0.21	0.02	Tech **DOES** apply: Use Polyone foaming agent
03	05	05	RH passenger door window switch cover	0.10	0.010	10%	yes	0.03	0.00	Tech **DOES** apply: Use Polyone foaming agent
03	05	05	RH passenger Door arm rest attachment cover	0.03	0.003	11%	no			Tech does **NOT** apply: Not on vehicle
03	05	05	RH passenger Door Pull handle attachment cover	0.01	0.001	17%	yes	0.05	0.01	Tech **DOES** apply: Use Polyone foaming agent
03	05	05	RH passenger Door vertical Pull handle	0.13	0.013	10%	yes	0.04	0.00	Tech **DOES** apply: Use Polyone foaming agent
03	05	05	RH passenger Door corner cover	0.06	0.006	11%	yes	0.21	0.02	Tech **DOES** apply: Use Polyone foaming agent
03	05	05	RH passenger Door lwr main trim	2.09	0.209	10%	yes	2.46	0.25	Tech **DOES** apply: Use Polyone foaming agent
03	05	05	RH passenger Door lwr main trim map pocket	0.50	0.050	10%	yes	0.36	0.04	Tech **DOES** apply: Use Polyone foaming agent
03	05	05	RH passenger Door lwr main trim close out	0.05	0.005	10%	no			Tech does **NOT** apply: Not on vehicle
03	05	05	RH passenger Door lwr main trim inner support brkt#1	0.28	0.028	10%	no			Tech does **NOT** apply: Not on vehicle
03	05	05	RH passenger Door lwr main trim inner support brkt#2	0.06	0.005	9%	no			Tech does **NOT** apply: Not on vehicle
03	05	05	RH passenger Door lwr main trim inner support brkt#5	0.03	0.003	11%	no			Tech does **NOT** apply: Not on vehicle
03	05	05	RH passenger Door lwr main trim inner support brkt#6	0.01	0.001	9%	no			Tech does **NOT** apply: Not on vehicle
03	05	05	RH passenger Door upr main trim	0.76	0.076	10%	no			Tech does **NOT** apply: Not on vehicle
03	05	05	LH passenger Door lwr main trim	2.09	0.209	10%	yes	2.46	0.25	Tech **DOES** apply: Use Polyone foaming agent
03	05	05	LH passenger Door lwr main trim map pocket	0.50	0.050	10%	yes	0.36	0.04	Tech **DOES** apply: Use Polyone foaming agent
03	05	05	LH passenger Door lwr main trim close out	0.05	0.005	10%	no			Tech does **NOT** apply: Not on vehicle
03	05	05	LH passenger Door lwr main trim inner support brkt#1	0.28	0.028	10%	no			Tech does **NOT** apply: Not on vehicle
03	05	05	LH passenger Door lwr main trim inner support brkt#2	0.06	0.005	9%	no			Tech does **NOT** apply: Not on vehicle
03	05	05	LH passenger Door lwr main trim inner support brkt#5	0.03	0.003	11%	no			Tech does **NOT** apply: Not on vehicle
03	05	05	LH passenger Door lwr main trim inner support brkt#6	0.01	0.001	10%	no			Tech does **NOT** apply: Not on vehicle
03	05	05	LH passenger Door upr main trim	0.76	0.076	10%	no			Tech does **NOT** apply: Not on vehicle
03	05	05	Frt dorr harness feed through	0.23	0.023	10%	yes	0.70	0.07	Tech **DOES** apply: Use Polyone foaming agent
03	05	06	RH Rear door window switch cover	0.08	0.008	10%	no			Tech does **NOT** apply: Not on vehicle
03	05	06	RH Rear Door arm rest attachment cover	0.02	0.002	10%	no			Tech does **NOT** apply: Not on vehicle
03	05	06	RH Rear Door Pull handle attachment cover	0.01	0.001	10%	yes	0.06	0.01	Tech **DOES** apply: Use Polyone foaming agent
03	05	06	RH rear door arm rest	0.27	0.027	10%	no			Tech does **NOT** apply: Not on vehicle
03	05	06	LH Rear door window switch cover	0.08	0.008	10%	no			Tech does **NOT** apply: Not on vehicle
03	05	06	LH Rear Door arm rest attachment cover	0.02	0.002	10%	no			Tech does **NOT** apply: Not on vehicle
03	05	06	LH Rear Door Pull handle attachment cover	0.01	0.001	10%	no			Tech does **NOT** apply: Not on vehicle
03	05	06	LH rear door arm rest	0.27	0.027	10%	no			Tech does **NOT** apply: Not on vehicle
03	05	06	RH rear door lwr main trim	1.53	0.153	10%	yes	2.44	0.24	Tech **DOES** apply: Use Polyone foaming agent
03	05	06	RH rear door lwr main trim map pocket	0.23	0.023	10%	no			Tech does **NOT** apply: Not on vehicle
03	05	06	RH rear door lwr main trim mounting bkt #1	0.02	0.002	10%	no			Tech does **NOT** apply: Not on vehicle
03	05	06	RH rear door lwr main trim mounting bkt #2	0.01	0.001	10%	no			Tech does **NOT** apply: Not on vehicle
03	05	06	RH rear door upr main trim	0.58	0.058	10%	no			Tech does **NOT** apply: Not on vehicle
03	05	06	LH rear door lwr main trim	1.53	0.153	10%	no			Tech does **NOT** apply: Not on vehicle
03	05	06	LH rear door lwr main trim map pocket	0.23	0.023	10%	no			Tech does **NOT** apply: Not on vehicle
03	05	06	LH rear door lwr main trim mounting bkt #1	0.02	0.002	10%	no			Tech does **NOT** apply: Not on vehicle
03	05	06	LH rear door lwr main trim mounting bkt #2	0.01	0.001	10%	no			Tech does **NOT** apply: Not on vehicle
03	05	06	LH rear door upr main trim	0.58	0.058	10%	no			Tech does **NOT** apply: Not on vehicle
03	05	07	Driver Lwr A-Pillar	0.23	0.023	10%	yes	0.11	0.01	Tech **DOES** apply: Use Polyone foaming agent
03	05	07	Passenger Lwr A-Pillar	0.22	0.022	10%	yes	0.14	0.01	Tech **DOES** apply: Use Polyone foaming agent
03	05	07	Front Driver kick plate	0.20	0.020	10%	no			Tech does **NOT** apply: Not on vehicle
03	05	07	Front Driver kick plate mount	0.18	0.018	10%	no			Tech does **NOT** apply: Not on vehicle
03	05	07	Rear Driver kick plate	0.14	0.014	10%	no			Tech does **NOT** apply: Not on vehicle
03	05	07	Rear Driver kick plate mount	0.12	0.012	10%	no			Tech does **NOT** apply: Not on vehicle
03	05	07	LH B-Pillar Lwr	0.63	0.063	10%	yes	0.90	0.09	Tech **DOES** apply: Use Polyone foaming agent
03	05	07	Front Passenger kick plate	0.21	0.020	10%	no			Tech does **NOT** apply: Not on vehicle
03	05	07	Front Passenger kick plate mount	0.18	0.018	10%	no			Tech does **NOT** apply: Not on vehicle
03	05	07	Rear Passenger kick plate	0.14	0.014	10%	no			Tech does **NOT** apply: Not on vehicle
03	05	07	Rear Passenger kick plate mount	0.13	0.012	10%	no			Tech does **NOT** apply: Not on vehicle
03	05	07	RH B-Pillar Lwr	0.63	0.063	10%	yes	0.89	0.09	Tech **DOES** apply: Use Polyone foaming agent
03	05	07	C-Pillar cover RH upr	0.34	0.034	10%	no			Tech does **NOT** apply: Not on vehicle
03	05	07	C-Pillar cover RH Lwr	0.53	0.053	10%	no			Tech does **NOT** apply: Not on vehicle
03	05	07	Small Cover piece	0.0020	0.0002	10%	no			Tech does **NOT** apply: Not on vehicle
03	05	07	C-Pillar cover LH upr	0.34	0.034	10%	no			Tech does **NOT** apply: Not on vehicle
03	05	07	C-Pillar cover LH Lwr	0.52	0.052	10%	no			Tech does **NOT** apply: Not on vehicle
03	05	07	Small Cover piece	0.00	0.000	10%	no			Tech does **NOT** apply: Not on vehicle
03	05	07	C-Pillar to C-Pillar cross trim	0.56	0.056	10%	no			Tech does **NOT** apply: Not on vehicle
03	05	08	Drivers Upr A-Pillar cover	0.35	0.04	10%	yes	0.25	0.02	Tech **DOES** apply: Use Polyone foaming agent
03	05	08	Drivers upr A-pillar mounting screw cover	0.00	0.00	0%	no			Tech does **NOT** apply: Not on vehicle
03	05	08	Driver LH Upper B-Pillar Cover	0.29	0.03	10%	no			Tech does **NOT** apply: Not on vehicle
03	05	08	Driver LH Upper B-Pillar Cover slide	0.06	0.01	11%	no			Tech does **NOT** apply: Not on vehicle
03	05	08	Driver restraint upr B-pillar bolt cover	0.01	0.00	7%	no			Tech does **NOT** apply: Not on vehicle
03	05	08	Drivers B pillar mounting screw cover	0.01	0.00	17%	no			Tech does **NOT** apply: Not on vehicle
03	05	08	Passenger Upr A-Pillar cover	0.33	0.03	10%	yes	0.25	0.02	Tech **DOES** apply: Use Polyone foaming agent
03	05	08	Passenger RH Upper B-Pillar Cover	0.28	0.03	10%	no			Tech does **NOT** apply: Not on vehicle
03	05	08	Passenger LH Upper B-Pillar Cover slide	0.06	0.01	11%	no			Tech does **NOT** apply: Not on vehicle
03	05	08	Passenger restraint upr B-pillar bolt cover	0.01	0.00	7%	no			Tech does **NOT** apply: Not on vehicle
03	05	08	Passenger B pillar mounting screw	0.00	0.00	0%	no			Tech does **NOT** apply: Not on vehicle

Table 3.4–8 Continued Next Page

Table 3.4–8 Continued: System Scaling Analysis Body Group -B- Subsystem, Renault Master

Silverado 1500							Select Vehicle			
System	Subsystem	Sub-Subsystem	Component/Assembly	Base Mass	Mass Savings New Tech	% of Mass Savings New Tech	Tech Applies	Base Mass	Mass Savings New Tech	Notes
03	**Body Group B System**			**247.02**	**34.02**	**14%**			**23.67**	
03	07	01	LH Driver Door Lower seal	0.14	0.05	33%	no			Tech does **NOT** apply: Not on vehicle
03	07	01	RH Passenger Door Lower seal	0.14	0.05	33%	no			Tech does **NOT** apply: Not on vehicle
03	07	01	LH Rear Door Lower seal	0.11	0.04	32%	no			Tech does **NOT** apply: Not on vehicle
03	07	01	LH Rear Door hinge side upr seal	0.07	0.02	33%	no			Tech does **NOT** apply: Not on vehicle
03	07	01	RH Rear Door Lower seal	0.11	0.04	32%	no			Tech does **NOT** apply: Not on vehicle
03	07	01	RH Rear Door hinge side upr seal	0.07	0.02	33%	no			Tech does **NOT** apply: Not on vehicle
03	07	01	RH rear door inside window track seal	0.52	0.17	33%	no			Tech does **NOT** apply: Not on vehicle
03	07	01	RH rear door inside window track bottom inner seal	0.16	0.05	33%	no			Tech does **NOT** apply: Not on vehicle
03	07	01	RH rear door inside window track bottom outer seal	0.30	0.10	33%	no			Tech does **NOT** apply: Not on vehicle
03	07	01	LH rear door inside window track seal	0.52	0.17	33%	no			Tech does **NOT** apply: Not on vehicle
03	07	01	LH rear door inside window track bottom inner seal	0.16	0.05	33%	no			Tech does **NOT** apply: Not on vehicle
03	07	01	LH rear door inside window track bottom outer seal	0.30	0.10	33%	no			Tech does **NOT** apply: Not on vehicle
03	07	01	LH drivers door inside window track seal	0.60	0.20	33%	yes	0.57	0.19	Tech **DOES** apply: Change from EDPM to TPV
03	07	01	LH drivers door inside window track bottom inner seal	0.19	0.06	33%	yes	0.12	0.04	Tech **DOES** apply: Change from EDPM to TPV
03	07	01	LH drivers door inside window track bottom outer seal	0.35	0.11	33%	yes	0.50	0.16	Tech **DOES** apply: Change from EDPM to TPV
03	07	01	RH passenger door inside window track seal	0.60	0.20	33%	yes	0.57	0.19	Tech **DOES** apply: Change from EDPM to TPV
03	07	01	RH passenger door inside window track bottom inner seal	0.19	0.06	33%	yes	0.12	0.04	Tech **DOES** apply: Change from EDPM to TPV
03	07	01	RH passenger door inside window track bottom outer seal	0.35	0.11	33%	yes	0.50	0.16	Tech **DOES** apply: Change from EDPM to TPV
03	07	02	Drivers Upr Outside seal	0.82	0.27	33%	no			Tech does **NOT** apply: Not on vehicle
03	07	02	Front driver door seal	2.10	0.68	33%	yes	1.47	0.48	Tech **DOES** apply: Change from EDPM to TPV
03	07	02	Rear driver door seal	1.93	0.63	33%	yes	1.47	0.48	Tech **DOES** apply: Change from EDPM to TPV
03	07	02	Passenger Upr Outside seal	0.82	0.27	33%	no			Tech does **NOT** apply: Not on vehicle
03	07	02	Front passenger door seal	2.05	0.67	33%	no			Tech does **NOT** apply: Not on vehicle
03	07	02	Rear passenger door seal	1.91	0.62	33%	no			Tech does **NOT** apply: Not on vehicle
03	10	01	Driver seat back frame	2.20	1.10	50%	yes	4.67	2.34	Tech **DOES** apply: Change from welded steel to BASF Plastic
03	10	01	Driver seat map back inner	0.49	0.05	10%	no			Tech does **NOT** apply: Not on vehicle
03	10	01	Driver Seat map back	0.64	0.06	10%	no			Tech does **NOT** apply: Not on vehicle
03	10	01	Driver Seat safety belt cover	0.04	0.00	10%	no			Tech does **NOT** apply: Not on vehicle
03	10	01	Driver seat bottom frame	3.60	1.80	50%	yes	4.67	2.34	Tech **DOES** apply: Change from welded steel to BASF Plastic
03	10	01	Driver Seat frt Nut Cover LH	0.02	0.00	10%	no			Tech does **NOT** apply: Not on vehicle
03	10	01	Driver Seat frt Nut Cover RH	0.03	0.00	10%	no			Tech does **NOT** apply: Not on vehicle
03	10	01	Driver Seat rear Bolt Cover LH	0.02	0.00	10%	no			Tech does **NOT** apply: Not on vehicle
03	10	01	Driver Seat rear Bolt Cover RH	0.07	0.01	10%	no			Tech does **NOT** apply: Not on vehicle
03	10	01	Driver seat wire harness cover	0.04	0.00	10%	no			Tech does **NOT** apply: Not on vehicle
03	10	01	Driver Seat LH Track cover	0.16	0.02	10%	no			Tech does **NOT** apply: Not on vehicle
03	10	01	Driver Seat LH Track cover end cap rear	0.02	0.00	10%	no			Tech does **NOT** apply: Not on vehicle
03	10	01	Driver Seat LH Track cover end cap frt	0.02	0.00	10%	no			Tech does **NOT** apply: Not on vehicle
03	10	01	Driver Seat LH cover	0.31	0.03	10%	yes	0.17	0.02	Tech **DOES** apply: Use Polyone foaming agent
03	10	01	Driver Seat LH cover close out	0.05	0.01	10%	no			Tech does **NOT** apply: Not on vehicle
03	10	01	Driver Seat LH cover seat belt insert cover	0.01	0.00	10%	no			Tech does **NOT** apply: Not on vehicle
03	10	01	Driver Seat LH cover lumbar knob	0.02	0.00	10%	yes	0.04	0.00	Tech **DOES** apply: Use Polyone foaming agent
03	10	01	Driver Seat LH cover recline handle	0.03	0.00	10%	yes	0.09	0.01	Tech **DOES** apply: Use Polyone foaming agent
03	10	01	Driver Seat RH cover	0.11	0.01	10%	no			Tech does **NOT** apply: Not on vehicle
03	10	02	Passenger seat back frame	2.20	1.10	50%	yes	9.28	4.64	Tech **DOES** apply: Change from welded steel to BASF Plastic
03	10	02	Pass seat map back inner	0.49	0.05	10%	no			Tech does **NOT** apply: Not on vehicle
03	10	02	Pass Seat map back	0.64	0.06	10%	no			Tech does **NOT** apply: Not on vehicle
03	10	02	Pass Seat safety belt cover	0.04	0.00	10%	no			Tech does **NOT** apply: Not on vehicle
03	10	02	Passenger seat bottom frame	3.59	1.79	50%	yes	9.28	4.63	Tech **DOES** apply: Change from welded steel to BASF Plastic
03	10	02	Frt Passenger Seat frt RH Nut Cover	0.02	0.00	10%	no			Tech does **NOT** apply: Not on vehicle
03	10	02	Frt Passenger Seat frt LH Nut Cover	0.04	0.00	10%	no			Tech does **NOT** apply: Not on vehicle
03	10	02	Passenger Seat rear Bolt Cover LH	0.06	0.01	10%	no			Tech does **NOT** apply: Not on vehicle
03	10	02	Passenger Seat rear Bolt Cover RH	0.02	0.00	10%	no			Tech does **NOT** apply: Not on vehicle
03	10	02	Passenger seat wire harness cover	0.04	0.00	10%	no			Tech does **NOT** apply: Not on vehicle
03	10	02	Pass Seat LH Track cover	0.16	0.02	10%	no			Tech does **NOT** apply: Not on vehicle
03	10	02	Pass Seat LH Track cover end cap rear	0.02	0.00	10%	no			Tech does **NOT** apply: Not on vehicle
03	10	02	Pass Seat LH Track cover end cap frt	0.02	0.00	10%	no			Tech does **NOT** apply: Not on vehicle
03	10	02	Pass Seat LH cover	0.31	0.03	10%	yes	0.26	0.03	Tech **DOES** apply: Use Polyone foaming agent
03	10	02	Passenger Seat LH cover close out	0.05	0.01	10%	no			Tech does **NOT** apply: Not on vehicle
03	10	02	Passenger Seat LH cover seat belt insert cover	0.01	0.00	10%	no			Tech does **NOT** apply: Not on vehicle
03	10	02	Passenger Seat LH cover lumbar knob	0.02	0.00	10%	no			Tech does **NOT** apply: Not on vehicle
03	10	02	Passenger Seat LH cover recline handle	0.03	0.00	10%	yes	0.05	0.00	Tech **DOES** apply: Use Polyone foaming agent
03	10	02	Passenger Seat RH cover	0.11	0.01	10%	no			Tech does **NOT** apply: Not on vehicle
03	10	03	60% Seat back frame	5.78	2.78	48%	no			Tech does **NOT** apply: Not on vehicle
03	10	03	Arm rest inner tub	0.28	0.03	10%	no			Tech does **NOT** apply: Not on vehicle
03	10	03	Arm rest frame	1.11	0.43	39%	no			Tech does **NOT** apply: Not on vehicle
03	10	03	Arm rest cup holder	0.13	0.01	10%	no			Tech does **NOT** apply: Not on vehicle
03	10	03	Arm rest cup holder retainer ring	0.09	0.01	10%	no			Tech does **NOT** apply: Not on vehicle
03	10	03	60% Seat bottom frame	4.28	2.24	52%	no			Tech does **NOT** apply: Not on vehicle
03	10	03	RH recliner cover #1	0.14	0.01	10%	no			Tech does **NOT** apply: Not on vehicle
03	10	03	RH recliner cover #2	0.24	0.02	10%	no			Tech does **NOT** apply: Not on vehicle
03	10	03	LH recliner cover #1	0.08	0.01	10%	no			Tech does **NOT** apply: Not on vehicle
03	10	04	40% Seat bottom frame	2.98	1.55	52%	no			Tech does **NOT** apply: Not on vehicle
03	10	04	40% Seat back frame	3.16	1.76	56%	no			Tech does **NOT** apply: Not on vehicle
03	10	04	RH Brkt close out #1	0.23	0.02	10%	no			Tech does **NOT** apply: Not on vehicle
03	10	04	RH Brkt close out #2	0.14	0.01	10%	no			Tech does **NOT** apply: Not on vehicle
03	10	04	LH Brkt close out #1	0.07	0.01	10%	no			Tech does **NOT** apply: Not on vehicle

Table 3.4–8 Continued Next Page

Table 3.4–8 Continued: System Scaling Analysis Body Group -B- Subsystem, Renault Master

Silverado 1500							Select Vehicle			
System	Subsystem	Sub-Subsystem	Component/Assembly	Base Mass	Mass Savings New Tech	% of Mass Savings New Tech	Tech Applies	Base Mass	Mass Savings New Tech	Notes
03			**Body Group B System**	**247.02**	**34.02**	**14%**			**23.67**	
03	10	05	Frt center riser	2.97	1.04	35%	no			Tech does **NOT** apply: Not on vehicle
03	10	05	LH Pivot cover outer	0.07	0.01	10%	no			Tech does **NOT** apply: Not on vehicle
03	10	05	LH Pivot cover inner	0.05	0.00	10%	no			Tech does **NOT** apply: Not on vehicle
03	10	05	RH Pivot cover outer	0.06	0.01	10%	no			Tech does **NOT** apply: Not on vehicle
03	10	05	RH Pivot cover inner	0.05	0.00	10%	no			Tech does **NOT** apply: Not on vehicle
03	10	05	RH Pivot cover inner top	0.05	0.00	10%	no			Tech does **NOT** apply: Not on vehicle
03	10	05	Bottom tub inner	0.85	0.09	10%	no			Tech does **NOT** apply: Not on vehicle
03	10	05	Frt wrap around close out	0.51	0.05	10%	no			Tech does **NOT** apply: Not on vehicle
03	10	05	Rear wrap around close out	0.65	0.06	10%	no			Tech does **NOT** apply: Not on vehicle
03	10	05	Cup holder	0.31	0.03	10%	no			Tech does **NOT** apply: Not on vehicle
03	10	05	Cup holder top	0.12	0.01	10%	no			Tech does **NOT** apply: Not on vehicle
03	10	05	Frt center box comp	3.77	1.66	44%	no			Tech does **NOT** apply: Not on vehicle
03	10	05	Frt center cover plt	1.60	0.81	50%	no			Tech does **NOT** apply: Not on vehicle
03	10	05	Seat frame cover handle #1	0.02	0.00	10%	no			Tech does **NOT** apply: Not on vehicle
03	10	05	Seat frame cover handle #2	0.04	0.00	10%	no			Tech does **NOT** apply: Not on vehicle
03	10	05	Center tub	1.08	0.11	10%	no			Tech does **NOT** apply: Not on vehicle
03	10	05	Divider	0.06	0.01	10%	no			Tech does **NOT** apply: Not on vehicle
03	10	05	Cup holder	0.20	0.02	10%	no			Tech does **NOT** apply: Not on vehicle
03	10	05	Center tub top ring	0.28	0.03	10%	no			Tech does **NOT** apply: Not on vehicle
03	10	05	Center tub top lid inner	0.65	0.07	10%	no			Tech does **NOT** apply: Not on vehicle
03	10	05	Center tub top lid outer	0.34	0.03	10%	no			Tech does **NOT** apply: Not on vehicle
03	10	05	Center tub top lid handle #1	0.02	0.00	10%	no			Tech does **NOT** apply: Not on vehicle
03	10	05	Center tub top lid handle #2	0.02	0.00	10%	no			Tech does **NOT** apply: Not on vehicle
03	12	01	Cross Car Beam	11.34	5.44	48%	yes	10.68	5.12	Tech **DOES** apply: Change from welded steel to mag.
03	12	01	Cross Car Beam to Floor Brkt Cover	0.10	0.01	10%	no			Tech does **NOT** apply: Not on vehicle
03	12	02	IP Main Sub Molding	1.60	0.16	10%	no			Tech does **NOT** apply: Not on vehicle
03	12	02	IP Main Molding	3.37	0.34	10%	yes	8.06	0.81	Tech **DOES** apply: Use Polyone foaming agent
03	12	02	IP Main Molding support box	0.27	0.03	10%	no			Tech does **NOT** apply: Not on vehicle
03	12	02	Elec. Breaker box cover	0.10	0.01	10%	no			Tech does **NOT** apply: Not on vehicle
03	12	03	Knee Bolster cover	0.59	0.06	10%	yes	0.94	0.09	Tech **DOES** apply: Use Polyone foaming agent
03	12	03	Knee Bolster Reinforcement brkt	0.42	0.24	57%	no			Tech does **NOT** apply: Not on vehicle
03	12	03	Glove box brkt	0.35	0.04	10%	no			Tech does **NOT** apply: Not on vehicle
03	12	03	Glove box inner tub	0.85	0.09	10%	yes	1.05	0.10	Tech **DOES** apply: Use Polyone foaming agent
03	12	03	Glove box inner tub cover	0.40	0.04	10%	yes	0.47	0.05	Tech **DOES** apply: Use Polyone foaming agent
03	12	03	Decorative glove box trim	0.05	0.01	10%	yes	0.39	0.04	Tech **DOES** apply: Use Polyone foaming agent
03	12	03	Lwr Center IP Cover	0.45	0.05	10%	yes	0.26	0.03	Tech **DOES** apply: Use Polyone foaming agent
03	12	03	Lwr Center IP Cover ashtray door	0.11	0.01	10%	no			Tech does **NOT** apply: Not on vehicle
03	12	03	Ashtray	0.08	0.01	10%	no			Tech does **NOT** apply: Not on vehicle
03	12	03	Upr glove box door	0.34	0.03	10%	no			Tech does **NOT** apply: Not on vehicle
03	12	03	Upr glove box door inner	0.26	0.03	10%	no			Tech does **NOT** apply: Not on vehicle
03	12	03	Upr glove box bucket	0.49	0.05	10%	yes	0.65	0.07	Tech **DOES** apply: Use Polyone foaming agent
03	12	03	Top IP Cover	0.29	0.03	10%	yes	0.83	0.08	Tech **DOES** apply: Use Polyone foaming agent
03	12	04	IP Driver side cover	0.15	0.02	10%	yes	0.13	0.01	Tech **DOES** apply: Use Polyone foaming agent
03	12	04	IP Passenger side cover	0.15	0.02	10%	yes	0.13	0.01	Tech **DOES** apply: Use Polyone foaming agent
03	12	04	Top IP Decretive trim	1.06	0.11	10%	yes	0.71	0.07	Tech **DOES** apply: Use Polyone foaming agent
03	12	05	IP Control Module 1 mounting brkt	0.13	0.01	10%	no			Tech does **NOT** apply: Not on vehicle
03	12	05	IP Control Module 2 & 3 mounting brkt	0.15	0.02	10%	yes	0.06	0.01	Tech **DOES** apply: Use Polyone foaming agent
03	12	05	IP Control Module 4 mounting brkt	0.09	0.01	10%	no			Tech does **NOT** apply: Not on vehicle
03	20	03	Housing Assy, Passenger Side Airbag	1.09	0.62	57%	no			Tech does **NOT** apply: Not on vehicle
03	20	12	Drivers side curtain airbag mounting brkt	0.30	0.19	62%	no			Tech does **NOT** apply: Not on vehicle
03	20	12	Passenger side curtain airbag mounting brkt	0.31	0.19	62%	no			Tech does **NOT** apply: Not on vehicle
03	20	18	Front Cover, Steering Wheel Airbag Assy	0.14	0.02	10%	yes	0.33	0.03	Tech **DOES** apply: Use Polyone foaming agent
03	20	18	Bracket #1, Drivers side airbag	0.25	0.11	44%	no			Tech does **NOT** apply: Not on vehicle
03	20	18	Ignition Canister, Steering Wheel Airbag Assy	0.49	0.14	28%	yes	0.77	0.22	Tech **DOES** apply: Replace dual stage inflator with single stage

If the original Silverado 1500 mass reduction concept idea was not able to be applied to the comparison vehicle it is not described in the section below.

Due to the large size of the Body Group -B- System it was not broken down per component, but per subsystem. Mass savings opportunities were identified for the following subsystems: Interior Trim and Ornamentation, Sealing, Seating, Instrument Panel and Console, and Occupant Restraining Device.

Interior Trim and Ornamentation Subsystem

Shown in Image 3.4–12 are the Silverado 1500 and Renault Master 2.3 DCi Interior Trim and Ornamentation Subsystems. The subsystem masses were 20.6 kg for the 1500 versus 12.0 kg for the Renault Master 2.3 DCi. The Lightweighting Technology used in the Interior Trim and Ornamentation Subsystem was PolyOne® foaming agent in the plastic. Due to similarities in component design and material, full percentage of the Silverado 1500 interior trim mass reduction can be applied to the Renault. (Refer to Table 3-32).

Image 3.4–12: Interior Trim and Ornamentation Subsystems for the Silverado 1500 (Left) and Renault Master 2.3 DCi (Right)
(Source: FEV, Inc. and www.A2mac1.com)

<u>Sealing Subsystem</u>

Shown in Image 3.4–13 are the Silverado 1500 and Renault Master 2.3 DCi Sealing Subsystems. The component masses were 14.5 kg for the 1500 versus 5.32 kg for the Renault Master 2.3 DCi. The Lightweighting Technology used in the Sealing Subsystem was to change to TPV from EPDM material. Due to similarities in component design and material, full percentage of the Silverado 1500 sealing subsystem mass reduction can be applied to the Renault. (Refer to Table 3-32).

Image 3.4–13: Sealing Subsystems for Silverado 1500 (Left) and Renault Master 2.3 DCi (Right)
(Source: FEV, Inc. and www.A2mac1.com)

DRAFT

Seating Subsystem

Shown in Image 3.4–14 are the Silverado 1500 and Renault Master 2.3 DCi Seating Subsystem. Subsystem masses were 48.2 kg for the 1500 versus 28.5 kg for the Renault Master 2.3 DCi. The Lightweighting Technology used in the Seating Subsystem was to change the welded steel construction on the front seats to BASF plastic and glass fiber-layered laminate. The welded steel construction of the 60/40 seat and the center console was also changed to cast magnesium. Due to similarities in component material, only a portion of the percentage of the Silverado 1500 seating subsystem mass reduction can be applied to the Renault. (Refer to Table 3-32).

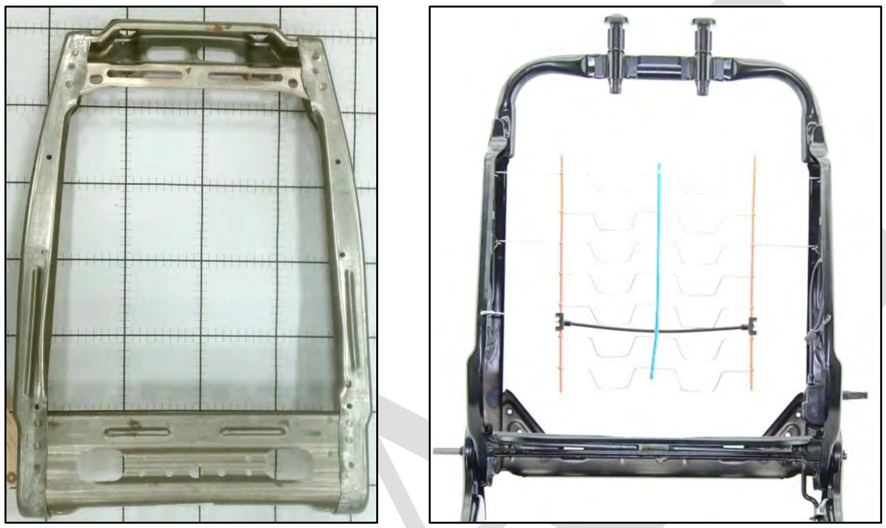


Image 3.4–14: Seating Subsystem for the Silverado 1500 (Left) and Renault Master 2.3 DCi (Right)
(Source: FEV, Inc.)

Instrument Panel and Console Subsystem

Shown in Image 3.4–15 are the Silverado 1500 and Renault Master 2.3 DCi Instrument Panel and Console Subsystems. The subsystem masses were 23.2 kg for the 1500 versus 24.4 kg for the Renault Master 2.3 DCi. The Lightweighting Technology used in the Instrument Panel and Console Subsystem was to change the welded steel construction on the cross car beam to cast magnesium. The welded steel construction for the knee bolster reinforcement bracket was also changed to plastic. Due to similarities in component design and material, full percentage of the Silverado 1500 instrument panel and console subsystem mass reduction can be applied to the Renault. (Refer to Table 3-32).

DRAFT

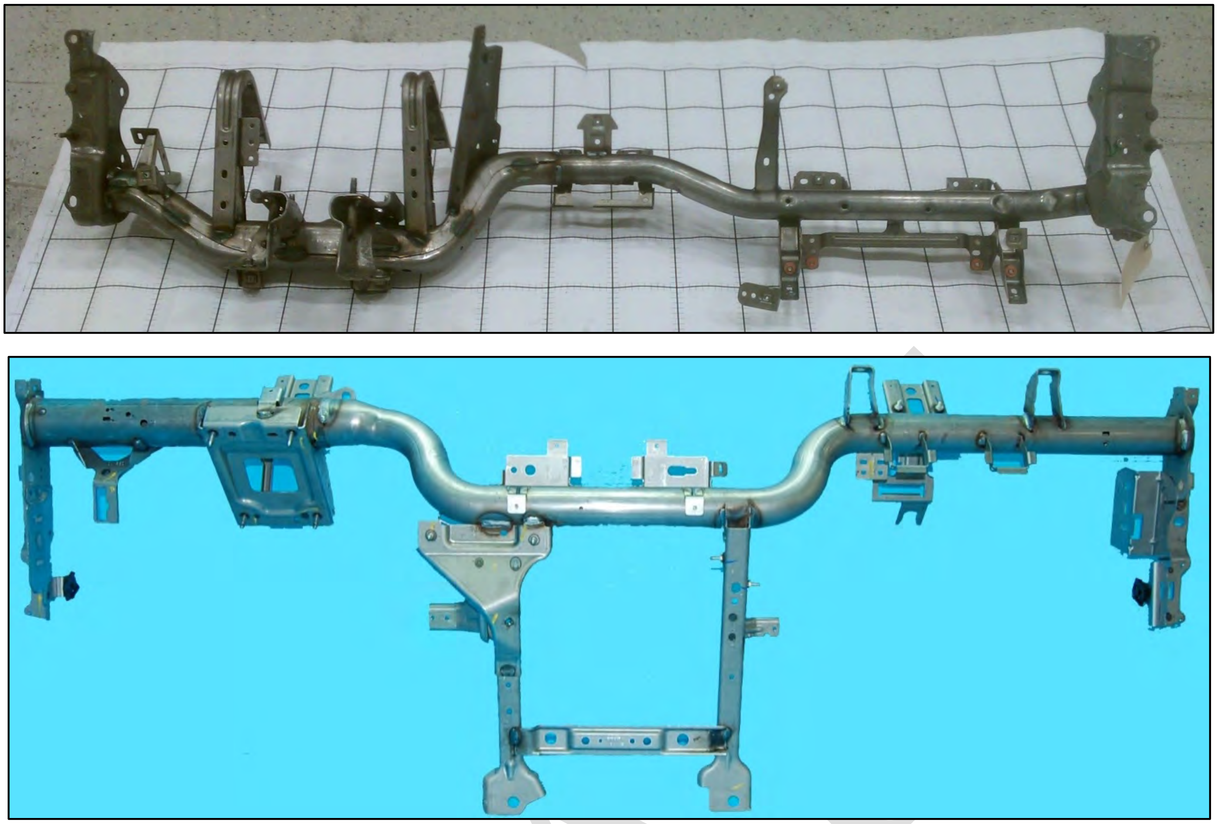


Image 3.4–15: Instrument Panel and Console Subsystem for the Silverado 1500 (Top) and Renault Master 2.3 DCi (Bottom)
(Source: FEV, Inc. and www.A2mac1.com)

<u>Occupant Restraining Device Subsystem</u>

Shown in Image 3.4–16 are the Silverado 1500 and Renault Master 2.3 DCi Occupant Restraining Device Subsystems. The subsystem masses were 2.59 kg for the 1500 versus 1.10 kg for the Renault Master 2.3 DCi. The Lightweighting Technology used in both Occupant Restraining Device Subsystems was to change the welded steel construction on the passenger air bag housing to DSM Akulon® Nylon 6. Also, the steering wheel air bag dual stage inflator was changed to a single stage inflator. Due to similarities in component design and material, only a portion of the percentage of the Silverado 1500 occupant restraining device subsystem mass reduction can be applied to the Renault. (Refer to Table 3-32).

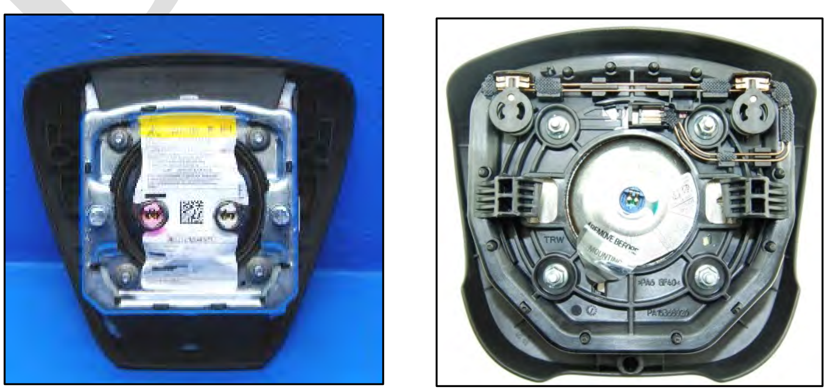


Image 3.4–16: Occupant Restraining Device Subsystems for Silverado 1500 (Left) and Renault Master 2.3 DCi (Right)

DRAFT

(Source: FEV, Inc. and www.A2mac1.com)

3.5 BODY GROUP -C- SYSTEM

3.5.1 Silverado 1500 Summary

The Chevrolet Silverado 1500 Body Group -C- System included the radiator grill, lower exterior finishers, rear closure finishers, cowl vent grill, exterior mirrors, front bumper and fascia, and rear bumper and fascia. The Body Group -C- System was made of plastic material, which is typical for these types of systems.

The Chevrolet Silverado 1500 analysis identified mass reduction alternatives and cost implications for the Body Group -C- System with the intent to meet the function and performance requirements of the baseline vehicle.

DRAFT

Table 3-33 provides a summary of mass reduction and cost impact for select sub-subsystems evaluated. The total mass savings found on the Body Group -C- System mass was reduced by 2.14 kg (5.28%). This decreased cost by $2.73, or $1.28 per kg. Mass reduction for this system reduced vehicle curb weight by 0.09%.

Table 3-33: Body Group -C- System Mass Reduction Summary, Silverado 1500

System	Subsystem	Sub-Subsystem	Description	Net Value of Mass Reduction: Base Mass "kg"	Mass Reduction "kg" (1)	Cost Impact NIDMC "$" (2)	Average Cost/ Kilogram "$/kg" (2)	Mass Reduction "%"	Vehicle Mass Reduction "%"
03	**08**	**00**	**Exterior Trim and Ornamentation Subsystem**	**12.82**	**0.99**	**1.05**	**1.06**	**7.71%**	**0.04%**
03	08	01	Radiator Grill	6.79	0.49	0.44	0.90	7.21%	0.02%
03	08	02	Lower Exterior Finishers	2.05	0.20	0.26	1.25	10.00%	0.01%
03	08	04	Upper Exterior and Roof Finish	0.68	0.00	0.00	0.00	0.00%	0.00%
03	08	07	Rear Closure Finishers	1.16	0.11	0.12	1.10	9.76%	0.00%
03	08	12	Badging	0.31	0.00	0.00	0.00	0.00%	0.00%
03	08	15	Cowl Vent Grill	1.84	0.18	0.23	1.28	9.90%	0.01%
03	**09**	**00**	**Rear View Mirrors Subsystem**	**4.28**	**0.37**	**0.94**	**2.51**	**8.73%**	**0.02%**
03	09	01	Interior Mirror	0.53	0.00	0.00	0.00	0.00%	0.00%
03	09	02	Exterior Mirrors	3.73	0.37	0.94	2.51	10.00%	0.02%
03	09	99	Misc.	0.01	0.00	0.00	0.00	0.00%	0.00%
03	**23**	**00**	**Front End Modules**	**21.08**	**0.57**	**0.50**	**0.87**	**2.73%**	**0.02%**
03	23	02	Module - Front Bumper and Fascia	21.08	0.57	0.50	0.87	2.73%	0.02%
03	**24**	**00**	**Rear End Modules**	**2.30**	**0.20**	**0.24**	**1.20**	**8.72%**	**0.01%**
03	24	02	Module - Rear Bumper and Fascia	2.30	0.20	0.24	1.20	8.72%	0.01%
				40.48	2.14 (Decrease)	2.73 (Decrease)	1.28 (Decrease)	5.28%	0.09%

(1) "+" = mass decrease, "-" = mass increase
(2) "+" = cost decrease, "-" = cost increase

DRAFT

Columns in the "Net Value of Mass Reduction" chart above may contain combined masses of assembly hardware such as nuts, bolt, washer, etc. that were not mass reduced at the component level, and may not match base mass and mass reduction totals in text below component reduction weights.

Mass savings opportunities were identified for the following components: radiator grill; bumper guard – front door; bumper guard – rear door; tailgate trim; cowl grill; cowl end cap – LH; cowl end cap – RH; exterior mirror – driver side; exterior mirror – passenger side; front fascia; front fascia – air dam; rear bumper cover – LH; rear bumper cover – RH; and rear bumper cover – center.

Radiator Grill: The radiator grill mass was reduced by using PolyOne® foaming agent. Mass was reduced by 10% from 4.89 kg to 4.40 kg.

Bumper Guard (Front Door): The bumper guard (front door) mass was reduced by using PolyOne® foaming agent. Mass was reduced by 10% from 1.14 kg to 1.03 kg.

Bumper Guard (Rear Door): The bumper guard (rear door) mass was reduced by using PolyOne® foaming agent. Mass was reduced by 10% from 0.90 kg to 0.81 kg.

Tailgate Trim: The tailgate trim mass was reduced by using PolyOne® foaming agent. Mass was reduced by 10% from 1.13 kg to 1.01 kg.

Cowl Grill: The cowl grill mass was reduced by using PolyOne® foaming agent. Mass was reduced by 10% from 1.65 kg to 1.48 kg.

Cowl End Cap (LH): The cowl end cap (LH) mass was reduced by using PolyOne® foaming agent. Mass was reduced by 10% from 0.087 kg to 0.078 kg.

Cowl End Cap (RH): The cowl end cap (RH) mass was reduced by using PolyOne® foaming agent. Mass was reduced by 10% from 0.087 kg to 0.078 kg.

Exterior Mirror (Driver Side): The exterior mirror (driver side) mass was reduced by using PolyOne® foaming agent. Mass was reduced by 10% from 1.86 kg to 1.68 kg.

Exterior Mirror (Passenger Side): The exterior mirror (passenger side) mass was reduced by using PolyOne® foaming agent. Mass was reduced by 10% from 1.86 kg to 1.68 kg.

Front Fascia: The front fascia mass was reduced by using PolyOne® foaming agent. Mass was reduced by 10% from 2.67 kg to 2.40 kg.

Front Fascia (Air Dam): The front fascia (air dam) mass was reduced by using PolyOne® foaming agent. Mass was reduced by 10% from 0.75 kg to 0.67 kg.

Rear Bumper Cover (LH): The rear bumper cover (LH) mass was reduced by using PolyOne® foaming agent. Mass was reduced by 10% from 0.47 kg to 0.42 kg.

Rear Bumper Cover (RH): The rear bumper cover (RH) mass was reduced by using PolyOne® foaming agent. Mass was reduced by 10% from 0.48 kg to 0.43 kg.

Rear Bumper Cover (Center): The rear bumper cover (center) mass was reduced by using PolyOne® foaming agent. Mass was reduced by 10% from 1.05 kg to 0.94 kg.

3.5.1.1 Silverado 2500 Analysis

The Chevrolet Silverado 2500 Body Group -C- System is very similar to the 1500.

Image 3.5–1: Chevrolet Silverado 2500 Body Group -C- System
(Source: FEV, Inc.)

DRAFT

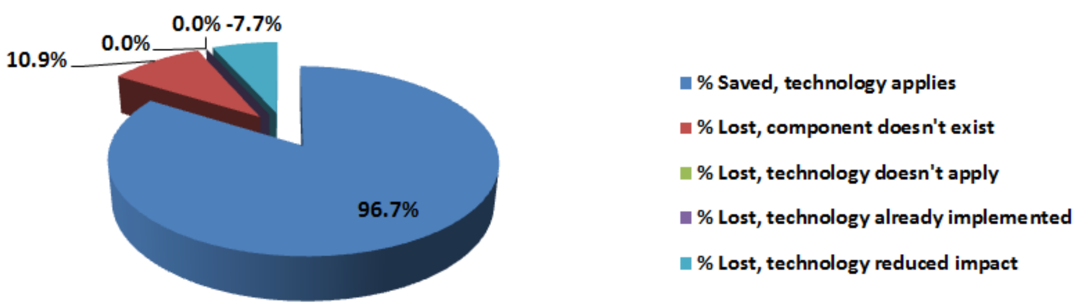
3.5.1.2 2500 System Scaling Summary

Table 3-34 summarizes the mass and cost impact of the Silverado 1500 Lightweighting technologies as applied to the Silverado 2500. Total Body Group -C- System mass savings was 2.07 kg at a cost decrease of $3.23, or $1.56 per kg.

Table 3-34: Mass-Reduction and Cost Impact for Body Group -C- System, Silverado 2500

System	Subsystem	Sub-Subsystem	Description	Net Value of Mass Reduction							
				Mass Reduction New Tech "kg" (1)	Mass Reduction Comp "kg" (1)	Mass Reduction Total "kg" (1)	Cost Impact New Tech "$" (2)	Cost Impact Comp "$" (2)	Cost Impact Total "$" (2)	Cost/ Kilogram Total "$/kg"	Vehicle Mass Reduction Total "%"
03	00	00	**Body System "C"**								
03	08	00	Exterior Trim and Ornamentation Subsystem	0.88	0.00	0.88	$0.96	$0.00	$0.96	$1.08	0.03%
03	09	00	Rear View Mirrors Subsystem	0.65	0.00	0.65	$1.64	$0.00	$1.64	$2.51	0.02%
03	23	00	Front End Modules	0.28	0.00	0.28	$0.30	$0.00	$0.30	$1.09	0.01%
03	24	00	Rear End Modules	0.26	0.00	0.26	$0.33	$0.00	$0.33	$1.28	0.01%
				2.07 (Decrease)	**0.00**	**2.07** (Decrease)	**$3.23** (Decrease)	**$0.00**	**$3.23** (Decrease)	**$1.56** (Decrease)	**0.07%**

Mass Savings, Select Vehicle, New Technology "kg"	**2.07**
Mass Savings, Silverado 1500, New Technology "kg"	**2.14**
Mass Savings Select Vehicle/Mass Savings 1500	**96.7%**



*SMS not included - has no significant impact on perecent contributions

3.5.1.3 System Scaling Analysis

The Silverado 2500 Body Group -C- system components were reviewed for compatibility with Lightweighting technologies. The results of this analysis are listed in Table 3-35.

Table 3-35: System Scaling Analysis Body Group C System, Silverado 2500

Silverado 1500							**Select Vehicle**			
System	Subsystem	Sub-Subsystem	Component/Assembly	Base Mass	Mass Savings New Tech	% of Mass Savings New Tech	Tech Applies	Base Mass	Mass Savings New Tech	Notes
03			**Body Group C System**	**40.48**	**2.14**	**5%**			**2.07**	
03	08	01	Radiator Grill	4.89	0.49	10%	yes	3.85	0.38	Tech **DOES** apply: Use Polyone foaming agent
03	08	02	Bumper Guard - Front Door	1.15	0.11	10%	yes	1.30	0.13	Tech **DOES** apply: Use Polyone foaming agent
03	08	02	Bumper Guard - Rear Door	0.90	0.09	10%	yes	1.30	0.10	Tech **DOES** apply: Use Polyone foaming agent
03	08	07	Tailgate Trim	1.13	0.11	10%	yes	0.90	0.09	Tech **DOES** apply: Use Polyone foaming agent
03	08	15	Cowl Grill	1.65	0.17	10%	yes	1.63	0.16	Tech **DOES** apply: Use Polyone foaming agent
03	08	15	Cowl End Cap - LH	0.09	0.01	10%	yes	0.10	0.01	Tech **DOES** apply: Use Polyone foaming agent
03	08	15	Cowl End Cap - RH	0.09	0.01	10%	yes	0.09	0.01	Tech **DOES** apply: Use Polyone foaming agent
03	09	02	Exterior Mirror - Driver Side	1.87	0.19	10%	yes	3.26	0.33	Tech **DOES** apply: Use Polyone foaming agent
03	09	02	Exterior Mirror - Passenger Side	1.87	0.19	10%	yes	3.26	0.33	Tech **DOES** apply: Use Polyone foaming agent
03	23	02	Bumper Corner - LH	1.12	0.11	10%	no			Tech does **NOT** apply: Part not on vehicle
03	23	02	Bumper Corner Trim - LH	0.05	0.01	11%	no			Tech does **NOT** apply: Part not on vehicle
03	23	02	Bumper Corner - RH	1.12	0.11	10%	no			Tech does **NOT** apply: Part not on vehicle
03	23	02	Bumper Corner Trim - RH	0.046	0.01	11%	no			Tech does **NOT** apply: Part not on vehicle
03	23	02	Front Fascia	2.67	0.27	10%	yes	2.09	0.21	Tech **DOES** apply: Use Polyone foaming agent
03	23	02	Front Fascia - Air Dam	0.75	0.08	10%	yes	0.68	0.07	Tech **DOES** apply: Use Polyone foaming agent
03	24	02	Rear Bumper Cover - LH	0.47	0.05	10%	yes	0.78	0.08	Tech **DOES** apply: Use Polyone foaming agent
03	24	02	Rear Bumper Cover - RH	0.48	0.05	10%	yes	0.78	0.08	Tech **DOES** apply: Use Polyone foaming agent
03	24	02	Rear Bumper Cover - CTR	1.05	0.11	10%	yes	1.00	0.10	Tech **DOES** apply: Use Polyone foaming agent

If the original Silverado 1500 mass reduction concept idea was not able to be applied to the comparison vehicle it is not described in the section below.

Components with significant mass savings identified on the Silverado 2500 series included the radiator grill; bumper guard (front door); bumper guard (rear door); tailgate trim; cowl grill; cowl end cap (LH); cowl end cap (RH); exterior mirror (driver side); exterior mirror (passenger side); front fascia; front fascia (air dam); rear bumper cover (LH); rear bumper cover (RH); and rear bumper cover (center).

<u>Radiator Grill</u>

Shown in Image 3.5–2 are the Silverado 1500 and 2500 series radiator grills. The component masses are 4.89 kg for the 1500 versus 3.85 kg for the 2500. The Lightweighting Technology used in the radiator grill was PolyOne® foaming agent in the plastic to reduce the mass by 10%. Due to similarities in component design and material, full percentage of the Silverado 1500 radiator grill mass reduction can be applied to the 2500. (Refer to Table 3-35).

Image 3.5–2: Radiator Grill for the Silverado 1500 (Top) and Silverado 2500 (Bottom)
(Source: FEV, Inc.)

<u>Bumper Guard (Front Door)</u>

Shown in Image 3.5–3 are the Silverado 1500 and 2500 series bumper guards (front door). The component masses were 1.15 kg for the 1500 versus 1.30 kg for the 2500. The Lightweighting Technology used was PolyOne® foaming agent in the plastic to reduce the mass by 10%. Due to similarities in component design and material, full percentage of the Silverado 1500 bumper guard (front door) mass reduction can be applied to the 2500. (Refer to Table 3-35).

Image 3.5–3: Bumper Guard – Front Door for the Silverado 1500 (Top) and Silverado 2500 (Bottom)
(Source: FEV, Inc.)

DRAFT

Bumper Guard (Rear Door)

Shown in Image 3.5–4 are the Silverado 1500 and 2500 series bumper guards (rear door). The component masses were 0.90 kg for the 1500 versus 1.30 kg for the 2500. The Lightweighting Technology used in the bumper guard (rear door) was PolyOne® foaming agent in the plastic to reduce the mass by 10%. Due to similarities in component design and material, only a portion of the percentage of the Silverado 1500 bumper guard (rear door) mass reduction can be applied to the 2500. (Refer to Table 3-35).

Image 3.5–4: Bumper Guard - Rear Door for the Silverado 1500 (Left) and Silverado 2500 (Right)
(Source: FEV, Inc.)

Tailgate Trim

Shown in Image 3.5–5 are the Silverado 1500 and 2500 series tailgate trim. The component masses were 1.13 kg for the Silverado 1500 versus 0.90 kg for the 2500. The Lightweighting Technology used in the tailgate trim was PolyOne® foaming agent in the plastic to reduce the mass by 10%. Due to similarities in component design and material, full percentage of the Silverado 1500 tailgate trim mass reduction can be applied to the 2500. (Refer to Table 3-35).

Image 3.5–5: Tailgate Trim for the Silverado 1500 (Left) and Silverado 2500 (Right)
(Source: FEV, Inc.)

Cowl Grill

Shown in Image 3.5–6 are the Silverado 1500 and 2500 series cowl grills. The component masses were 1.65 kg for the 1500 versus 1.63 kg for the 2500. The Lightweighting Technology used in the cowl grill was PolyOne® foaming agent in the plastic to reduce the mass by 10%. Due to similarities in component design and material, full percentage of the Silverado 1500 cowl grill mass reduction can be applied to the 2500. (Refer to Table 3-35).

DRAFT

Image 3.5–6: Cowl Grill for the Silverado 1500 (Top) and Silverado 2500 (Bottom)
(Source: FEV, Inc.)

Cowl End Cap (RH/LH)

Shown in Image 3.5–7 are the Silverado 1500 and 2500 series cowl end caps (RH/LH). Component masses were 0.18 kg for the Silverado 1500 versus 0.19 kg for the 2500. The Lightweighting Technology used was PolyOne® foaming agent in the plastic to reduce the mass by 10%. Due to similarities in component design and material, full percentage of the Silverado 1500 cowl end cap mass reduction can be applied to the 2500. (Refer to Table 3-35).

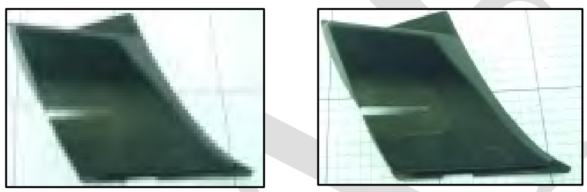


Image 3.5–7: Cowl End Cap – RH and LH for the Silverado 1500 (Left) and Silverado 2500 (Right)
(Source: FEV, Inc.)

Exterior Mirror (Driver and Passenger Side)

Shown in Image 3.5–8 are the Silverado 1500 and 2500 series exterior mirrors (driver and passenger side). Component masses were 3.74 kg for the 1500 versus 6.52 kg for the 2500. The Lightweighting Technology used was PolyOne® foaming agent in the plastic to reduce the mass by 10%. Due to similarities in component material, full percentage of the Silverado 1500 exterior mirror mass reduction can be applied to the 2500. (Refer to Table 3-35).

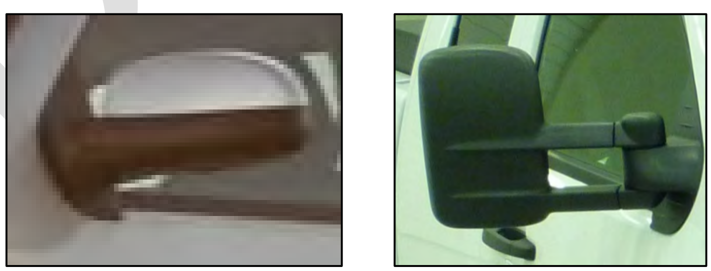


Image 3.5–8: Exterior Mirror (Driver and Passenger Side) for the Silverado 1500 (Left) and Silverado 2500 (Right)
(Source: FEV, Inc.)

Front Fascia

Shown in Image 3.5–9 are the Silverado 1500 and 2500 series front fascia. Component masses were 2.67 kg for the Silverado 1500 versus 2.09 kg for the 2500. The Lightweighting Technology used in the front fascia was PolyOne® foaming agent in the plastic to reduce the mass by 10%. Due to

DRAFT

similarities in component design and material, full percentage of the Silverado 1500 front fascia mass reduction can be applied to the 2500. (Refer to Table 3-35).

Image 3.5–9: Front Fascia for the Silverado 1500 (Left) and Silverado 2500 (Right)
(Source: FEV, Inc.)

<u>Front Fascia (Air Dam)</u>

Shown in Image 3.5–10 are the Silverado 1500 and 2500 series front fascia's (air dam). Component masses were 0.75 kg for the Silverado 1500 versus 0.68 kg for the 2500. The Lightweighting Technology used in the front fascia (air dam) is to use PolyOne® foaming agent in the plastic to reduce the mass by 10%. Due to similarities in component design and material, full percentage of the Silverado 1500 front fascia (air dam) mass reduction can be applied to the 2500. (Refer to Table 3-35).

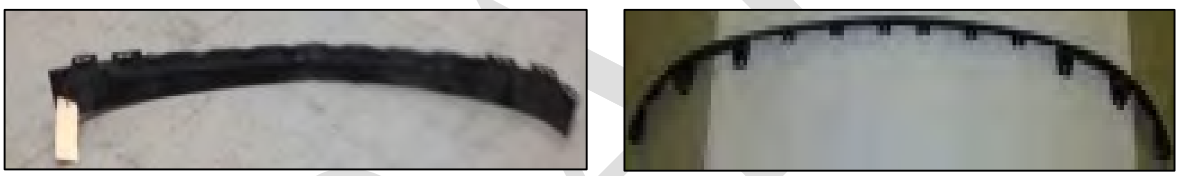


Image 3.5–10: Front Fascia - Air Dam for the Silverado 1500 (Left) and Silverado 2500 (Right)
(Source: FEV, Inc.)

DRAFT

Rear Bumper Cover (RH/LH)

Shown in Image 3.5–11 are the Silverado 1500 and 2500 series rear bumper covers (RH/LH). Component masses are 0.95 kg for the 1500 versus 1.56 kg for the 2500. The Lightweighting Technology used in the rear bumper cover was to use PolyOne® foaming agent in the plastic to reduce the mass by 10%. Due to similarities in component design and material, full percentage of the Silverado 1500 rear bumper cover (right and LH) mass reduction can be applied to the 2500. (Refer to Table 3-35).


Image 3.5–11: Rear Bumper Cover (LH/RH) for the Silverado 1500 (Left) and Silverado 2500 (Right)
(Source: FEV, Inc.)

Rear Bumper Cover – Center

Shown in Image 3.5–12 are the Silverado 1500 and 2500 series Rear Bumper Covers (center). Component masses were 1.05 kg for the 1500 versus 1.00 kg for the 2500. The Lightweighting Technology used in the rear bumper cover (center) was PolyOne® foaming agent in the plastic to reduce the mass by 10%. Due to similarities in component design and material, full percentage of the Silverado 1500 rear bumper cover (center) mass reduction can be applied to the 2500. (Refer to Table 3-35).

Image 3.5–12: Rear Bumper Cover for the Silverado 1500 (Top) and Silverado 2500 (Bottom)
(Source: FEV, Inc.)

3.5.1.4 System Comparison, Silverado 2500

Table 3-36 summarizes the Silverado 1500 and 2500 Lightweighting results. The majority of the components were visually the same among the two Body Group -C- Systems.

Table 3-36: Body Group -C- System Comparison, Silverado 2500

DRAFT

System	Description	Net Value of Mass Reduction								
		Mass Base "kg" (1)	Mass Reduction New Tech "kg" (1)	Mass Reduction Comp "kg" (1)	Mass Reduction Total "kg" (1)	System Mass Reduction "%"	Cost Impact New Tech "$" (2)	Cost Impact Comp "$" (2)	Cost Impact Total "$" (2)	Cost/ Kilogram Total "$/kg"
03	Body Group C									
03	Silverado 1500	40.48	2.14	0.00	2.14	5.28%	$2.60	$0.00	$2.60	$1.22
03	Silverado 2500	28.77	2.07	0.00	2.07	7.19%	$3.23	$0.00	$3.23	$1.56

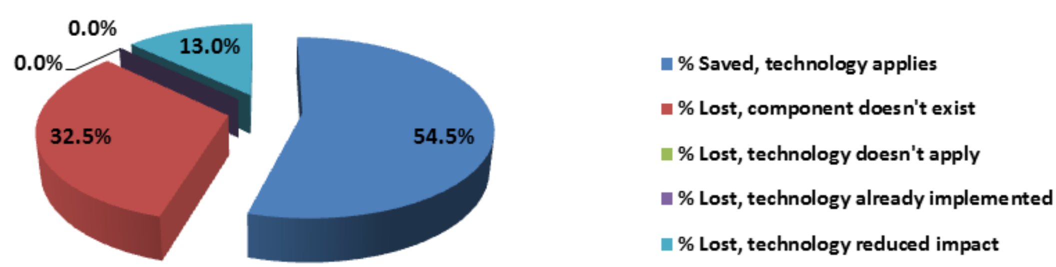
3.5.2 Mercedes Sprinter 311 CDi

Table 3-37 summarizes mass and cost impact of Silverado 1500 Lightweighting technologies applied to the Mercedes Sprinter 311 CDi. Total Body Group -C- mass savings was 1.17 kg at a cost decrease of $1.65, or $1.42 per kg.

Table 3-37: Mass-Reduction and Cost Impact for Body Group -C- System, Mercedes Sprinter

System	Subsystem	Sub-Subsystem	Description	Net Value of Mass Reduction							
				Mass Reduction New Tech "kg" (1)	Mass Reduction Comp "kg" (1)	Mass Reduction Total "kg" (1)	Cost Impact New Tech "$" (2)	Cost Impact Comp "$" (2)	Cost Impact Total "$" (2)	Cost/ Kilogram Total "$/kg"	Vehicle Mass Reduction Total "%"
03	00	00	Body System "C"								
03	08	00	Exterior Trim and Ornamentation Subsystem	0.21	0.00	0.21	$0.20	$0.00	$0.20	$0.96	0.01%
03	09	00	Rear View Mirrors Subsystem	0.28	0.00	0.28	$0.71	$0.00	$0.71	$2.51	0.01%
03	23	00	Front End Modules	0.44	0.00	0.44	$0.45	$0.00	$0.45	$1.01	0.02%
03	24	00	Rear End Modules	0.23	0.00	0.23	$0.29	$0.00	$0.29	$1.26	0.01%
				1.17 (Decrease)	0.00	1.17 (Decrease)	$1.65 (Decrease)	$0.00	$1.65 (Decrease)	$1.42 (Decrease)	0.05%

Mass Savings, Select Vehicle, New Technology "kg" **1.17**
Mass Savings, Silverado 1500, New Technology "kg" **2.14**
Mass Savings Select Vehicle/Mass Savings 1500 **54.5%**



*SMS not included - has no significant impact on perecent contributions

3.5.2.1 System Scaling Analysis

The Mercedes Sprinter 311 CDi Body Group -C- components were reviewed for compatibility with Lightweighting technologies. The results of this analysis are listed in Table 3-38.

Table 3-38: System Scaling Analysis Body Group -C- System, Mercedes Sprinter

Silverado 1500							Select Vehicle			
System	Subsystem	Sub-Subsystem	Component/Assembly	Base Mass	Mass Savings New Tech	% of Mass Savings New Tech	Tech Applies	Base Mass	Mass Savings New Tech	Notes
03			**Body Group C System**	**40.48**	**2.14**	**5%**			**1.17**	
03	08	01	Radiator Grill	4.89	0.49	10%	yes	1.60	0.16	Tech **DOES** apply: Use Polyone foaming agent
03	08	02	Bumper Guard - Front Door	1.15	0.11	10%	yes	0.49	0.05	Tech **DOES** apply: Use Polyone foaming agent
03	08	02	Bumper Guard - Rear Door	0.90	0.09	10%	no			Tech does **NOT** apply: Part not on vehicle
03	08	07	Tailgate Trim	1.13	0.11	10%	no			Tech does **NOT** apply: Part not on vehicle
03	08	15	Cowl Grill	1.65	0.17	10%	no			Tech does **NOT** apply: Part not on vehicle
03	08	15	Cowl End Cap - LH	0.09	0.01	10%	no			Tech does **NOT** apply: Part not on vehicle
03	08	15	Cowl End Cap - RH	0.09	0.01	10%	no			Tech does **NOT** apply: Part not on vehicle
03	09	02	Exterior Mirror - Driver Side	1.87	0.19	10%	yes	2.35	0.14	Tech **DOES** apply: Use Polyone foaming agent
03	09	02	Exterior Mirror - Passenger Side	1.87	0.19	10%	yes	2.35	0.14	Tech **DOES** apply: Use Polyone foaming agent
03	23	02	Bumper Corner - LH	1.12	0.11	10%	no			Tech does **NOT** apply: Part not on vehicle
03	23	02	Bumper Corner Trim - LH	0.05	0.01	11%	no			Tech does **NOT** apply: Part not on vehicle
03	23	02	Bumper Corner - RH	1.12	0.11	10%	no			Tech does **NOT** apply: Part not on vehicle
03	23	02	Bumper Corner Trim - RH	0.046	0.01	11%	no			Tech does **NOT** apply: Part not on vehicle
03	23	02	Front Fascia	2.67	0.27	10%	yes	4.43	0.44	Tech **DOES** apply: Use Polyone foaming agent
03	23	02	Front Fascia - Air Dam	0.75	0.08	10%	no			Tech does **NOT** apply: Part not on vehicle
03	24	02	Rear Bumper Cover - LH	0.47	0.05	10%	yes	0.61	0.06	Tech **DOES** apply: Use Polyone foaming agent
03	24	02	Rear Bumper Cover - RH	0.48	0.05	10%	yes	0.60	0.06	Tech **DOES** apply: Use Polyone foaming agent
03	24	02	Rear Bumper Cover - CTR	1.05	0.11	10%	yes	1.12	0.11	Tech **DOES** apply: Use Polyone foaming agent

If the original Silverado 1500 mass reduction concept idea was not able to be applied to the comparison vehicle it is not described in the section below.

Components with significant mass savings identified on the Mercedes Sprinter include the radiator grill, bumper guard (front door), exterior mirror (driver side), exterior mirror (passenger side), front fascia, rear bumper cover (LH), rear bumper cover (RH), and rear bumper cover (center).

Radiator Grill

Shown in Image 3.5–13 are the Silverado 1500 and Mercedes Sprinter 311 CDi radiator grill. Component masses were 4.89 kg for the Silverado 1500 versus 1.60 kg for the Mercedes Sprinter 311 CDi. The Lightweighting Technology used in the radiator grill was PolyOne® foaming agent in the plastic to reduce the mass by 10%. Due to similarities in component design and material, full percentage of the Silverado 1500 radiator grill mass reduction can be applied to the Sprinter. (Refer to Table 3-38).

DRAFT

Image 3.5–13: Radiator Grill for the Silverado 1500 (Top) and Mercedes Sprinter 311 CDi (Bottom)
(Source: FEV, Inc. and www.A2mac1.com)

Bumper Guard (Front Door)

Shown in Image 3.5–14 are the Silverado 1500 and Mercedes Sprinter 311 CDi bumper guard (front door). Component masses were 1.15 kg for the Silverado 1500 versus 0.49 kg for the Mercedes Sprinter 311 CDi. The Lightweighting Technology used in the bumper guard (front door) was PolyOne® foaming agent in the plastic to reduce the mass by 10%. Due to similarities in component design and material, full percentage of the Silverado 1500 bumper guard mass reduction can be applied to the Sprinter. (Refer to Table 3-38).

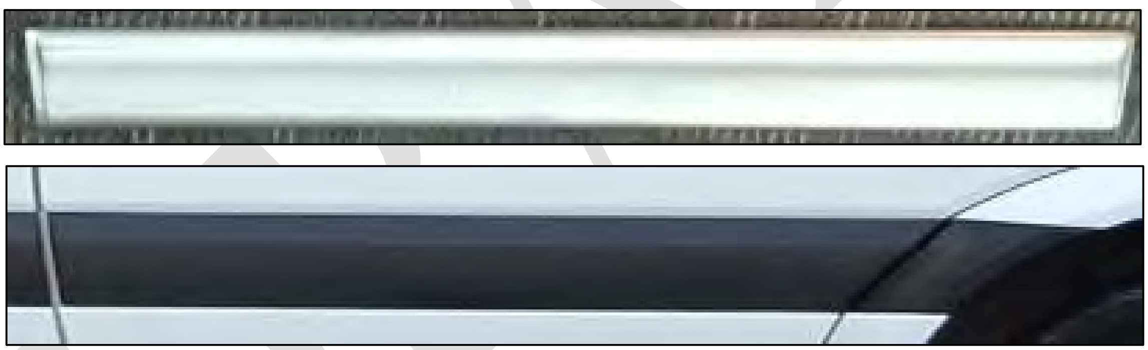


Image 3.5–14: Bumper Guard (Front Door) for the Silverado 1500 (Top) and Mercedes Sprinter 311 CDi (Bottom)
(Source: FEV, Inc. and www.A2mac1.com)

Exterior Mirror (Driver and Passenger Side)

Shown in Image 3.5–15 are the Silverado 1500 and Mercedes Sprinter 311 CDi Exterior Mirror – Driver and Passenger Side. Component masses were 3.74 kg for the 1500 versus 4.70 kg for the Mercedes Sprinter 311 CDi. The Lightweighting Technology used in the Exterior Mirrors was PolyOne® foaming agent in the plastic to reduce the mass by 10%. Due to similarities in component design and material, only a portion of the percentage of the Silverado 1500 exterior mirror mass reduction can be applied to the Sprinter. (Refer to Table 3-38).

DRAFT

DRAFT

Image 3.5–15: Exterior Mirror (Driver Side shown; Passenger Side similar) for the Silverado 1500 (Left) and Mercedes Sprinter 311 CDi (Right)
(Source: FEV, Inc. and www.A2mac1.com)

Front Fascia

Shown in Image 3.5–16 are the Silverado 1500 and Mercedes Sprinter 311 CDi Front Fascia. Component masses were 2.67 kg for the 1500 versus 4.43 kg for the Mercedes Sprinter 311 CDi. The Lightweighting Technology used in the Front Fascia was PolyOne® foaming agent in the plastic to reduce the mass by 10%. Due to similarities in component design and material, full percentage of the Silverado 1500 front fascia mass reduction can be applied to the Sprinter. (Refer to Table 3-38).

Image 3.5–16: Front Fascia for the Silverado 1500 (Left) and Mercedes Sprinter 311 CDi (Right)

(Source: FEV, Inc. and www.A2mac1.com)

Rear Bumper Cover – RH/LH

Shown in Image 3.5–17 are the Silverado 1500 and Mercedes Sprinter 311 CDi Rear Bumper Cover – RH and LH. Component masses were 0.95 kg for the 1500 versus 1.21 kg for the Mercedes Sprinter 311 CDi. The Lightweighting Technology used in the rear bumper cover was PolyOne® foaming agent in the plastic to reduce the mass by 10%. Due to similarities in component design and material, full percentage of the Silverado 1500 rear bumper cover (RH/LH) mass reduction can be applied to the Sprinter. (Refer to Table 3-38).

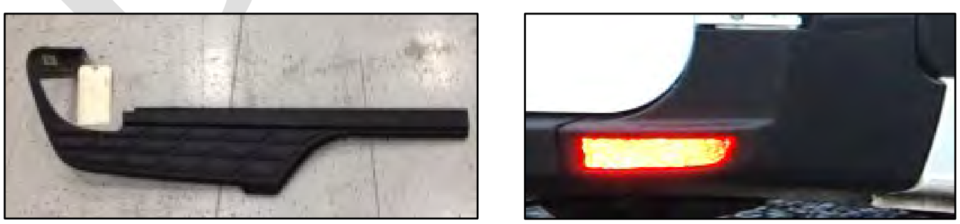


Image 3.5–17: Rear Bumper Cover (LH/RH) for the Silverado 1500 (Left) and Mercedes Sprinter 311 CDi (Right)
(Source: FEV, Inc.)

Rear Bumper Cover – Center

Shown in Image 3.5–18 are the Silverado 1500 and Mercedes Sprinter 311 CDi Rear Bumper Covers – Center. Component masses were 1.05 kg for the 1500 versus 1.12 kg for the Mercedes

Sprinter 311 CDi. The Lightweighting Technology used in the Rear Bumper Cover – Center was PolyOne® foaming agent in the plastic to reduce the mass by 10%. Due to similarities in component design and material, full percentage of the Silverado 1500 rear bumper cover (center) mass reduction can be applied to the Sprinter. (Refer to Table 3-38).

Image 3.5–18: Rear Bumper Cover – Center for the Silverado 1500 (Top) and Sprinter 311 CDi (Bottom)
(Source: FEV, Inc.)

DRAFT

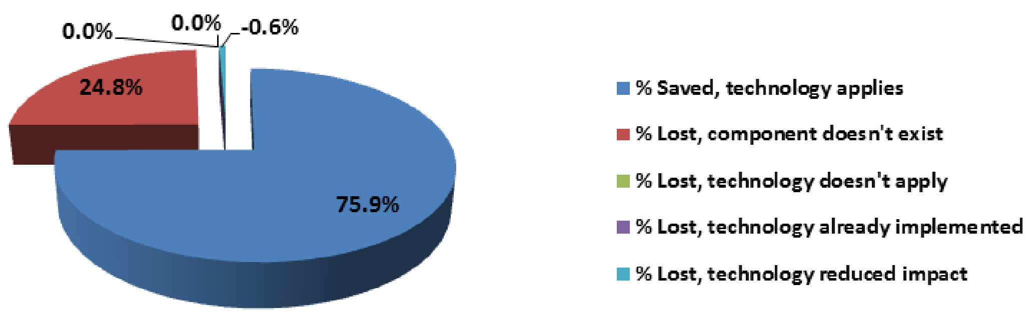
3.5.3 Renault Master 2.3 DCi

Table 3-39 summarizes mass and cost impact of Silverado 1500 Lightweighting technologies applied to the Renault Master 2.3 DCi. Total Body Group -C- System mass savings is 1.62 kg at a cost decrease of $2.27, or $1.40 per kg.

Table 3-39: Mass-Reduction and Cost Impact for Body Group -C- System, Renault Master

				Net Value of Mass Reduction							
System	Subsystem	Sub-Subsystem	Description	Mass Reduction New Tech "kg" (1)	Mass Reduction Comp "kg" (1)	Mass Reduction Total "kg" (1)	Cost Impact New Tech "$" (2)	Cost Impact Comp "$" (2)	Cost Impact Total "$" (2)	Cost/ Kilogram Total "$/kg"	Vehicle Mass Reduction Total "%"
03	00	00	Body System "C"								
03	08	00	Exterior Trim and Ornamentation Subsystem	0.40	0.00	0.40	$0.38	$0.00	$0.38	$0.95	0.02%
03	09	00	Rear View Mirrors Subsystem	0.39	0.00	0.39	$0.97	$0.00	$0.97	$2.51	0.02%
03	23	00	Front End Modules	0.52	0.00	0.52	$0.53	$0.00	$0.53	$1.01	0.02%
03	24	00	Rear End Modules	0.32	0.00	0.32	$0.39	$0.00	$0.39	$1.23	0.01%
				1.62 (Decrease)	0.00	1.62	$2.27 (Decrease)	$0.00	$2.27 (Decrease)	$1.40 (Decrease)	0.07%

Mass Savings, Select Vehicle, New Technology "kg"	1.62
Mass Savings, Silverado 1500, New Technology "kg"	2.14
Mass Savings Select Vehicle/Mass Savings 1500	75.9%



*SMS not included - has no significant impact on perecent contributions

3.5.3.1 System Scaling Analysis

The Renault Master 2.3 DCi Body Group -C- system components were reviewed for compatibility with Lightweighting technologies. The results of this analysis are listed below.

Table 3-40: System Scaling Analysis Body Group -C- System, Renault Master

Silverado 1500							Select Vehicle			
System	Subsystem	Sub-Subsystem	Component/Assembly	Base Mass	Mass Savings New Tech	% of Mass Savings New Tech	Tech Applies	Base Mass	Mass Savings New Tech	Notes
03			**Body Group C System**	**40.48**	**2.14**	**5%**			**1.62**	
03	08	01	Radiator Grill	4.89	0.49	10%	yes	2.53	0.25	Tech **DOES** apply: Use Polyone foaming agent
03	08	02	Bumper Guard - Front Door	1.15	0.11	10%	yes	0.33	0.03	Tech **DOES** apply: Use Polyone foaming agent
03	08	02	Bumper Guard - Rear Door	0.90	0.09	10%	no			Tech does **NOT** apply: Part not on vehicle
03	08	07	Tailgate Trim	1.13	0.11	10%	no			Tech does **NOT** apply: Part not on vehicle
03	08	15	Cowl Grill	1.65	0.17	10%	yes	1.11	0.11	Tech **DOES** apply: Use Polyone foaming agent
03	08	15	Cowl End Cap - LH	0.09	0.01	10%	no			Tech does **NOT** apply: Part not on vehicle
03	08	15	Cowl End Cap - RH	0.09	0.01	10%	no			Tech does **NOT** apply: Part not on vehicle
03	09	02	Exterior Mirror - Driver Side	1.87	0.19	10%	yes	1.93	0.19	Tech **DOES** apply: Use Polyone foaming agent
03	09	02	Exterior Mirror - Passenger Side	1.87	0.19	10%	yes	1.93	0.19	Tech **DOES** apply: Use Polyone foaming agent
03	23	02	Bumper Corner - LH	1.12	0.11	10%	no			Tech does **NOT** apply: Part not on vehicle
03	23	02	Bumper Corner Trim - LH	0.05	0.01	11%	no			Tech does **NOT** apply: Part not on vehicle
03	23	02	Bumper Corner - RH	1.12	0.11	10%	no			Tech does **NOT** apply: Part not on vehicle
03	23	02	Bumper Corner Trim - RH	0.046	0.01	11%	no			Tech does **NOT** apply: Part not on vehicle
03	23	02	Front Fascia	2.67	0.27	10%	yes	5.23	0.52	Tech **DOES** apply: Use Polyone foaming agent
03	23	02	Front Fascia - Air Dam	0.75	0.08	10%	no			Tech does **NOT** apply: Part not on vehicle
03	24	02	Rear Bumper Cover - LH	0.47	0.05	10%	yes	0.63	0.06	Tech **DOES** apply: Use Polyone foaming agent
03	24	02	Rear Bumper Cover - RH	0.48	0.05	10%	yes	0.63	0.06	Tech **DOES** apply: Use Polyone foaming agent
03	24	02	Rear Bumper Cover - CTR	1.05	0.11	10%	yes	1.92	0.19	Tech **DOES** apply: Use Polyone foaming agent

If the original Silverado 1500 mass reduction concept idea was not able to be applied to the comparison vehicle it is not described in the section below.

Components with significant mass savings identified on the Renault Master 2.3 DCi included the radiator grill, bumper guard (front door), cowl grill, exterior mirror (driver side), exterior mirror (passenger side), front fascia, front fascia (air dam), rear bumper cover (LH), rear bumper cover (RH), and rear bumper cover (center).

<u>Radiator Grill</u>

Shown in Image 3.5–19 are the Silverado 1500 and Renault Master 2.3 DCi radiator grills. Component masses were 4.89 kg for the Silverado 1500 versus 2.53 kg for the Renault Master 2.3 DCi. The Lightweighting Technology used in the radiator grill was PolyOne® foaming agent in the plastic to reduce the mass by 10%. Due to similarities in component design and material, full percentage of the Silverado 1500 radiator grill mass reduction can be applied to the Renault.

Image 3.5–19: Radiator Grill for the Silverado 1500 (Top) and Renault Master 2.3 DCi (Bottom)
(Source: FEV, Inc. and www.A2mac1.com)

<u>Bumper Guard - Front Door</u>

Shown in Image 3.5–20 are the Silverado 1500 and Renault Master 2.3 DCi bumper guards (front door). Component masses were 1.15 kg for the Silverado 1500 versus 0.33 kg for the Renault

DRAFT

Master 2.3 DCi. The Lightweighting Technology used in the bumper guard (front door) was PolyOne® foaming agent in the plastic to reduce the mass by 10%. Due to similarities in component design and material, full percentage of the Silverado 1500 bumper guard – front door mass reduction can be applied to the Renault.

Image 3.5–20: Bumper Guard (Front Door) for the Silverado 1500 (Top) and Renault Master 2.3 DCi (Bottom)
(Source: FEV, Inc. and www.A2mac1.com)

Cowl Grill

Shown in Image 3.5–21 are the Silverado 1500 and Renault Master 2.3 DCi cowl grills. Component masses were 1.13 kg for the 1500 versus 1.11 kg for the Renault Master 2.3 DCi. The Lightweighting Technology used in the cowl grill was PolyOne® foaming agent in the plastic to reduce the mass by 10%. Due to similarities in component design and material, full percentage of the Silverado 1500 cowl gill mass reduction can be applied to the Renault.

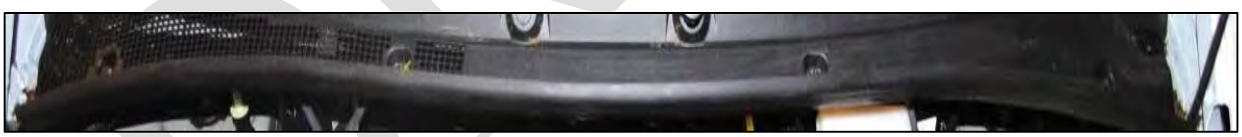


Image 3.5–21: Cowl Grill for the Silverado 1500 (Top) and Renault Master 2.3 DCi (Bottom)
(Source: FEV, Inc. and www.A2mac1.com)

Exterior Mirror (Driver and Passenger Side)

Shown in Image 3.5–22 are the Silverado 1500 and Renault Master 2.3 DCi exterior mirrors (driver and passenger side). Component masses are 3.73 kg for the 1500 versus 3.85 kg for the Renault Master 2.3 DCi. The Lightweighting Technology used was PolyOne® foaming agent in the plastic to reduce the mass by 10%. Due to similarities in component material, full percentage of the Silverado 1500 exterior mirror mass reduction can be applied to the Renault.

DRAFT


Image 3.5–22: Exterior Mirror (Driver side shown; passenger side similar) for the Silverado 1500 (Left) and Renault Master 2.3 DCi (Right)
(Source: FEV, Inc. and www.A2mac1.com)

Front Fascia

Shown in Image 3.5–23 are the Silverado 1500 and Renault Master 2.3 DCi front fascia. Component masses were 2.67 kg for the Silverado 1500 versus 5.23 kg for the Renault Master 2.3 DCi. The Lightweighting Technology used in the front fascia was PolyOne® foaming agent in the plastic to reduce the mass by 10%. Due to similarities in component material, full percentage of the Silverado 1500 front fascia mass reduction can be applied to the Renault..


Image 3.5–23: Front Fascia for the Silverado 1500 (Left) and Renault Master 2.3 DCi (Right)
(Source: FEV, Inc. and www.A2mac1.com)

Rear Bumper Cover (RH/LH)

Shown in Image 3.5–24 are the Silverado 1500 and Renault Master 2.3 DCi rear bumper covers (RH/LH). Component masses were 0.95kg for the Silverado 1500 versus 1.26 kg for the Renault Master 2.3 DCi. The Lightweighting Technology used was PolyOne® foaming agent in the plastic to reduce the mass by 10%. Due to similarities in component design and material, full percentage of the Silverado 1500 rear bumper cover (RH/LH) mass reduction can be applied to the Renault.

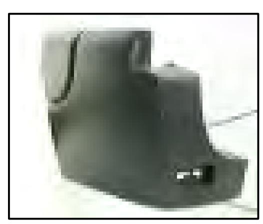



Image 3.5–24: Rear Bumper Cover – RH and LH Silverado 1500 (Left) and Renault Master 2.3 DCi (Right)
(Source: FEV, Inc. and www.A2mac1.com)

Rear Bumper Cover – Center

Shown in Image 3.5–25 are the Silverado 1500 and Renault Master 2.3 DCi rear bumper covers (center). Component masses were 1.05 kg for the 1500 versus 1.92 kg for the Renault Master 2.3 DCi. The Lightweighting Technology used in the rear bumper cover (center) was PolyOne®

DRAFT

foaming agent in the plastic to reduce the mass by 10%. Due to similarities in component design and material, full percentage of the Silverado 1500 rear bumper cover (center) mass reduction can be applied to the Renault..

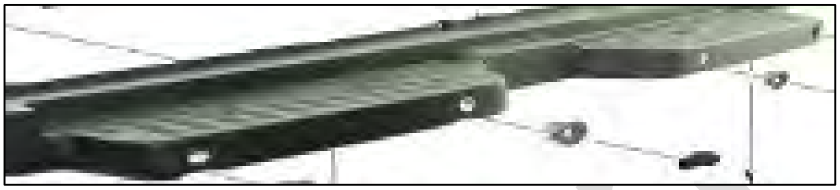


Image 3.5–25: Rear Bumper Cover (Center) for the Silverado 1500 (Top) and Renault Master 2.3 DCi (Bottom)
(Source: FEV, Inc. and www.A2mac1.com)

3.6 BODY GROUP -D- SYSTEM

3.6.1 Silverado 1500 Summary

The Chevrolet Silverado 1500 Body Group -D- System includes the Glass (Glazing), Frame, and Mechanism Subsystem; Handles, Locks, Latches and Mechanisms Subsystem; and Wipers and Washers Subsystem.

The Chevrolet Silverado 1500 analysis identified mass reduction alternatives and cost implications for the Body Group -D- System with the intent to meet the function and performance requirements of the baseline vehicle. Table 3-41 provides a summary of mass reduction and cost impact for select sub-subsystems evaluated. The total mass savings found on the Body Group -D- System mass was reduced by 4.50 kg (8.85%). This decreased cost by $2.30, or $0.51 per kg. Mass reduction for this system reduced vehicle curb weight by 0.19%.

DRAFT

Table 3-41: Body Group -D- System Mass Reduction Summary, Silverado 1500

				Net Value of Mass Reduction					
System	Subsystem	Sub-Subsystem	Description	Base Mass "kg"	Mass Reduction "kg" (1)	Cost Impact NIDMC "$" (2)	Average Cost/ Kilogram "$/kg" (2)	Mass Reduction "%"	Vehicle Mass Reduction "%"
03	00	00	Body Group D						
03	**11**	**00**	**Glass (Glazing), Frame, and Mechanism Subsystem**	**39.60**	**4.43**	**2.23**	**0.50**	**11.19%**	**0.19%**
03	11	01	Windshield and Front Quarter Window (Fixed)	15.87	1.59	0.80	0.50	10.02%	0.07%
03	11	05	Back Window Assy	6.59	1.34	0.68	0.50	20.39%	0.06%
03	11	13	Front Side Door Glass	8.39	0.00	0.00	0.00	0.00%	0.00%
03	11	14	Rear Side Door Glass	8.75	1.50	0.76	0.51	17.10%	0.06%
03	**14**	**00**	**Handles, Locks, Latches and Mechanisms Subsystem**	**5.66**	**0.00**	**0.00**	**0.00**	**0.00%**	**0.00%**
03	14	03	Hood Latch & Actuation	1.95	0.00	0.00	0.00	0.00%	0.00%
03	14	04	Side Door Latches	2.19	0.00	0.00	0.00	0.00%	0.00%
03	14	05	Rear Closure Latches	0.53	0.00	0.00	0.00	0.00%	0.00%
03	14	13	Outer Handles and Actuation	0.99	0.00	0.00	0.00	0.00%	0.00%
03	**16**	**00**	**Wipers and Washers Subsystem**	**5.61**	**0.07**	**0.06**	**0.84**	**1.32%**	**0.00%**
03	16	01	Wiper Assembly Front	4.63	0.00	0.00	0.00	0.00%	0.00%
03	16	99	Misc.	0.97	0.07	0.06	0.84	7.61%	0.00%
				50.86	4.50 (Decrease)	2.30 (Decrease)	0.51 (Decrease)	8.85%	0.19%

(1) "+" = mass decrease, "-" = mass increase
(2) "+" = cost decrease, "-" = cost increase

Mass savings opportunities were identified for the following components: windshield and front quarter window (fixed), back window assembly, rear side door glass, washer tank assembly.

Windshield: The windshield mass was reduced by replacing 2.27 mm thick glass with 1.6 mm thick using the Pilkington® laminated glass process. Mass was reduced 10%, from 15.87 kg to 14.28 kg.

Back Window: The back window mass was reduced by replacing 4.00 mm thick glass with 3.15 mm thick using the Pilkington® laminated glass process. Mass was reduced 20.39%, from 6.59 kg to 5.25 kg.

Rear Side Door Glass: The rear side door glass mass was reduced by replacing 3.85 mm thick glass with 3.15 mm thick using the Pilkington® laminated glass process. Mass was reduced 17.10%, from 8.75 kg to 7.25 kg.

Washer Tank Assembly: The washer tank assembly mass was reduced by using PolyOne® foaming agent. Mass was reduced 7.6%, from .97 kg to .90 kg.

DRAFT

3.6.1.1 Silverado 2500 Analysis

The Chevrolet Silverado 2500 Body Group -D- System was very similar to the 1500; although, the 1500 used for analysis was a crew cab and the 2500 used was an extended cab.

Image 3.6–1: Chevrolet Silverado 2500 Body Group -D- System
(Source: FEV, Inc.)

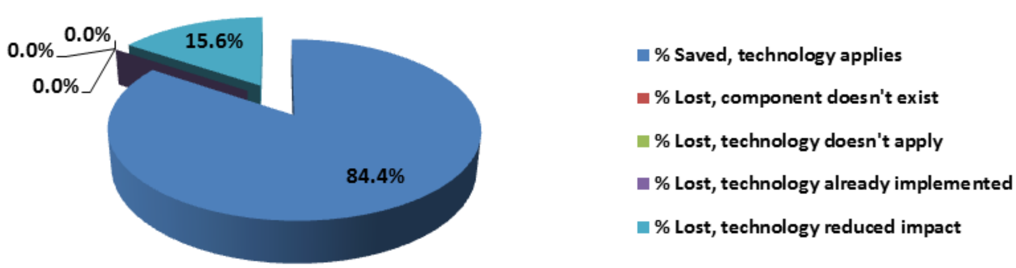
3.6.1.2 2500 System Scaling Summary

Table 3-42 summarizes mass and cost impact of Silverado 1500 Lightweighting technologies applied to the Silverado 2500. Total Body Group -D- System mass savings is 3.80 kg at a cost decrease of $1.94, or $0.51 per kg.

Table 3-42: Mass-Reduction and Cost Impact for Body Group -D- System, Silverado 2500

				Net Value of Mass Reduction							
System	Subsystem	Sub-Subsystem	Description	Mass Reduction New Tech "kg" (1)	Mass Reduction Comp "kg" (1)	Mass Reduction Total "kg" (1)	Cost Impact New Tech "$" (2)	Cost Impact Comp "$" (2)	Cost Impact Total "$" (2)	Cost/ Kilogram Total "$/kg"	Vehicle Mass Reduction Total "%"
03	00	00	Body System "D"								
03	11	00	Glass (Glazing), Frame, and Mechanism Subsystem	3.73	0.00	3.73	$1.88	$0.00	$1.88	$0.50	0.12%
03	14	00	Handles, Locks, Latches and Mechanisms Subsystem	0.00	0.00	0.00	$0.00	$0.00	$0.00	$0.00	0.00%
03	16	00	Wipers and Washers Subsystem	0.07	0.00	0.07	$0.06	$0.00	$0.06	$0.84	0.00%
				3.80 (Decrease)	0.00	3.80 (Decrease)	$1.94 (Decrease)	$0.00	$1.94 (Decrease)	$0.51 (Decrease)	0.12%

Mass Savings, Select Vehicle, New Technology "kg"	3.80
Mass Savings, Silverado 1500, New Technology "kg"	4.50
Mass Savings Select Vehicle/Mass Savings 1500	84.4%



*SMS not included - has no significant impact on perecent contributions

3.6.1.3 System Scaling Analysis

The Silverado 2500 Body Group D system components were reviewed for compatibility with Lightweighting technologies. The results of this analysis are listed in Table 3-43.

Table 3-43: System Scaling Analysis Body Group D System, Silverado 2500

Silverado 1500							Select Vehicle			
System	Subsystem	Sub-Subsystem	Component/Assembly	Base Mass	Mass Savings New Tech	% of Mass Savings New Tech	Tech Applies	Base Mass	Mass Savings New Tech	Notes
03			**Body Group D System**	**50.86**	**4.50**	**9%**			**3.80**	
03	11	01	Windshield and Front Quarter Window (Fixed)	15.87	1.590	10%	yes	15.30	1.53	Tech **DOES** apply: Thin glass using Pilkington window applications
03	11	05	Back Window Assy	6.59	1.343	20%	yes	6.35	1.29	Tech **DOES** apply: Thin glass using Pilkington window applications
03	11	14	Rear Side Door Glass	8.75	1.496	17%	yes	5.27	0.90	Tech **DOES** apply: Thin glass using Pilkington window applications
03	16	99	Washer Tank Assembly	0.74	0.074	10%	yes	0.73	0.07	Tech **DOES** apply: Use Polyone foaming agent

If the original Silverado 1500 mass reduction concept idea was not able to be applied to the comparison vehicle it is not described in the section below.

Components with significant mass savings identified on the 2500 series Silverado included the windshield and front quarter window (fixed), back window assembly, rear side door glass, washer tank assembly.

<u>Windshield</u>

Shown in Image 3.6–2 are the Silverado 1500 and 2500 windshields. Component masses were 15.9 kg for the 1500 versus 15.3 kg for the 2500. The Lightweighting Technology used in the windshield was to replace 2.27 mm thick glass with 1.6 mm thick using the Pilkington® laminated glass process. Due to similarities in component design and material, only a portion of the percentage of the Silverado 1500 windshield mass reduction can be applied to the 2500. (Refer to Table 3-43).

Image 3.6–2: Windshield for the Silverado 1500 (Left) and Silverado 2500 (Right)
(Source: FEV, Inc.)

<u>Back Window</u>

Shown in Image 3.6–3 are the Silverado 1500 and 2500 series back windows. Component masses were 6.58 kg for the 1500 versus 6.15 kg for the 2500. The Lightweighting Technology used in the back window was to replace 4.00 mm thick glass with 3.15mm thick using the Pilkington® laminated glass process. Due to similarities in component design and material, only a portion of the percentage of the Silverado 1500 back window mass reduction can be applied to the 2500. (Refer to Table 3-43).

DRAFT

Image 3.6–3: Back Window for the Silverado 1500 (Top) and Silverado 2500 (Bottom)
(Source: FEV, Inc.)

<u>Rear Side Door Glass</u>

Shown in Image 3.6–4 is the Silverado 1500 and 2500 series rear side door glass. Component masses were 8.75 kg for the 1500 versus 5.27 kg for the 2500. The 1500 and the 2500 series Rear Side Door Glass the 1500 used for analysis was a crew cab and the 2500 used was an extended cab. The Lightweighting Technology used in the Rear Side Door Glass was to replace the 3.85 mm thick glass with 3.15mm thick using the Pilkington® laminated glass process. Due to similarities in component design and material, full percentage of the Silverado 1500 rear side door glass mass reduction can be applied to the 2500. (Refer to Table 3-43).

Image 3.6–4: Rear door glass for the Silverado 1500 (Left) and 2500 (Right)
(Source: FEV, Inc.)

<u>Washer Tank Assembly</u>

Shown in Image 3.6–5 are the Silverado 1500 and 2500 series washer tank assembly. Component masses were 0.74 kg for the 1500 versus 0.72 kg for the 2500. The Lightweighting Technology used in the washer tank assembly was PolyOne® foaming agent in the plastic to reduce the mass by 7.6%. Due to similarities in component design and material, full percentage of the Silverado 1500 washer tank assembly mass reduction can be applied to the 2500. (Refer to Table 3-43).

DRAFT

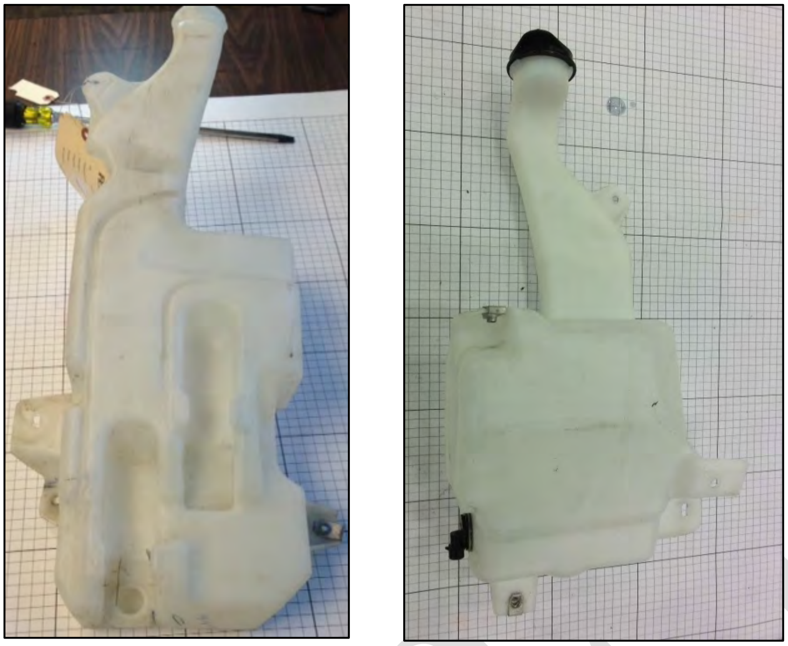


Image 3.6–5: Washer Tank Assembly for the Silverado 1500 (Left) and Silverado 2500 (Right)
(Source: FEV, Inc.)

3.6.1.4 System Comparison, Silverado 2500

Table 3-44 summarizes the Silverado 1500 and 2500 Body Group -D- system Lightweighting results.

Table 3-44: Body Group -D-System Comparison, Silverado 1500 and 2500

		Net Value of Mass Reduction								
System	Description	Mass Base "kg" (1)	Mass Reduction New Tech "kg" (1)	Mass Reduction Comp "kg" (1)	Mass Reduction Total "kg" (1)	System Mass Reduction "%"	Cost Impact New Tech "$" (2)	Cost Impact Comp "$" (2)	Cost Impact Total "$" (2)	Cost/ Kilogram Total "$/kg"
03	**Body Group D**									
03	Silverado 1500	50.86	4.50	0.00	4.50	8.85%	$2.30	$0.00	$2.30	$0.51
03	Silverado 2500	61.29	3.80	0.00	3.80	6.20%	$1.94	$0.00	$1.94	$0.51

DRAFT

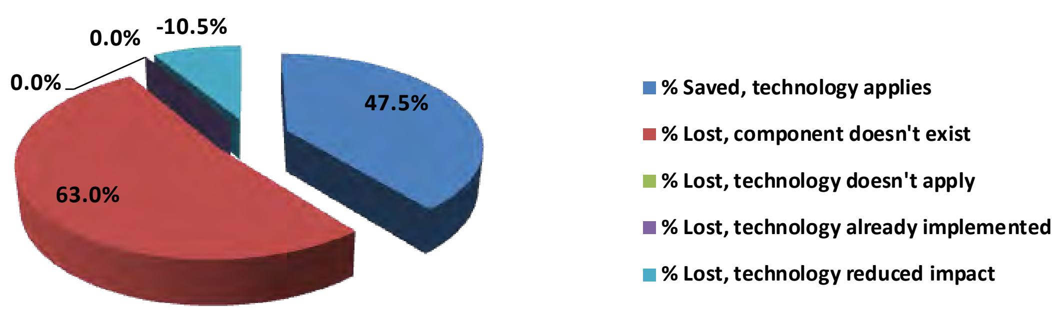
3.6.2 Mercedes Sprinter 311 CDi

Table 3-45 summarizes mass and cost impact of Silverado 1500 Lightweighting technologies applied to the Mercedes Sprinter 311 CDi. Total Body Group -D- mass savings is 2.14 kg at a cost decrease of $1.10, or $.51 per kg.

Table 3-45: Mass-Reduction and Cost Impact for Body Group -D- System, Mercedes Sprinter

System	Subsystem	Sub-Subsystem	Description	Net Value of Mass Reduction							
				Mass Reduction New Tech "kg" (1)	Mass Reduction Comp "kg" (1)	Mass Reduction Total "kg" (1)	Cost Impact New Tech "$" (2)	Cost Impact Comp "$" (2)	Cost Impact Total "$" (2)	Cost/ Kilogram Total "$/kg"	Vehicle Mass Reduction Total "%"
03	00	00	**Body System "D"**								
03	11	00	Glass (Glazing), Frame, and Mechanism Subsystem	2.06	0.00	2.06	$1.04	$0.00	$1.04	$0.50	0.10%
03	14	00	Handles, Locks, Latches and Mechanisms Subsystem	0.00	0.00	0.00	$0.00	$0.00	$0.00	$0.00	0.00%
03	16	00	Wipers and Washers Subsystem	0.07	0.00	0.07	$0.06	$0.00	$0.06	$0.84	0.00%
				2.14 (Decrease)	**0.00**	**2.14** (Decrease)	**$1.10** (Decrease)	**$0.00**	**$1.10** (Decrease)	**$0.51** (Decrease)	**0.10%**

Mass Savings, Select Vehicle, New Technology "kg"	**2.14**
Mass Savings, Silverado 1500, New Technology "kg"	**4.50**
Mass Savings Select Vehicle/Mass Savings 1500	**47.5%**



*SMS not included - has no significant impact on perecent contributions

3.6.2.1 System Scaling Analysis

The Mercedes Sprinter 311 CDi Body Group -D- components were reviewed for compatibility with Lightweighting technologies. The results of this analysis are listed in Table 3-46.

Table 3-46: System Scaling Analysis Body Group -D- System, Mercedes Sprinter

Silverado 1500							Select Vehicle			
System	Subsystem	Sub-Subsystem	Component/Assembly	Base Mass	Mass Savings New Tech	% of Mass Savings New Tech	Tech Applies	Base Mass	Mass Savings New Tech	Notes
03			**Body Group D System**	**50.86**	**4.50**	**9%**			**2.14**	
03	11	01	Windshield and Front Quarter Window (Fixed)	15.87	1.590	10%	yes	20.58	2.06	Tech **DOES** apply: Thin glass using Pilkington window applications
03	11	05	Back Window Assy	6.59	1.343	20%	no			Tech does **NOT** apply: Part not on vehicle
03	11	14	Rear Side Door Glass	8.75	1.496	17%	no			Tech does **NOT** apply: Part not on vehicle
03	16	99	Washer Tank Assembly	0.74	0.074	10%	yes	0.75	0.07	Tech **DOES** apply: Use Polyone foaming agent

If the original Silverado 1500 mass reduction concept idea was not able to be applied to the comparison vehicle it is not described in the section below.

Components with significant mass savings identified on the Mercedes Sprinter include the Windshield and Washer Tank Assembly.

<u>Windshield</u>

Shown in Image 3.6–6 are the Silverado 1500 and Mercedes Sprinter 311 CDi windshields. Component masses were 15.9 kg for the Silverado 1500 versus 20.6 kg for the Mercedes Sprinter 311 CDi. The Lightweighting Technology used in the windshield was to replace the 2.27 mm thick glass with 1.6 mm thick using the Pilkington® laminated glass process. Due to similarities in component design and material, full percentage of the Silverado 1500 windshield mass reduction can be applied to the Sprinter. (Refer to Table 3-46).

Image 3.6–6: Windshield for the Silverado 1500 (Left) and Mercedes Sprinter 311 CDi (Right)
(Source: FEV, Inc. and www.A2mac1.com)

DRAFT

Washer Tank Assembly

Shown in Image 3.6–7 are the Silverado 1500 and Mercedes Sprinter 311 CDi washer tank assemblies. Component masses were 0.74 kg for the Silverado 1500 versus 0.75 kg for the Mercedes Sprinter 311 CDi. The Lightweighting Technology used in the washer tank was PolyOne® foaming agent in the plastic to reduce the mass by 10%. Due to similarities in component design and material, full percentage of the Silverado 1500 washer tank assembly mass reduction can be applied to the Sprinter. (Refer to Table 3-46).

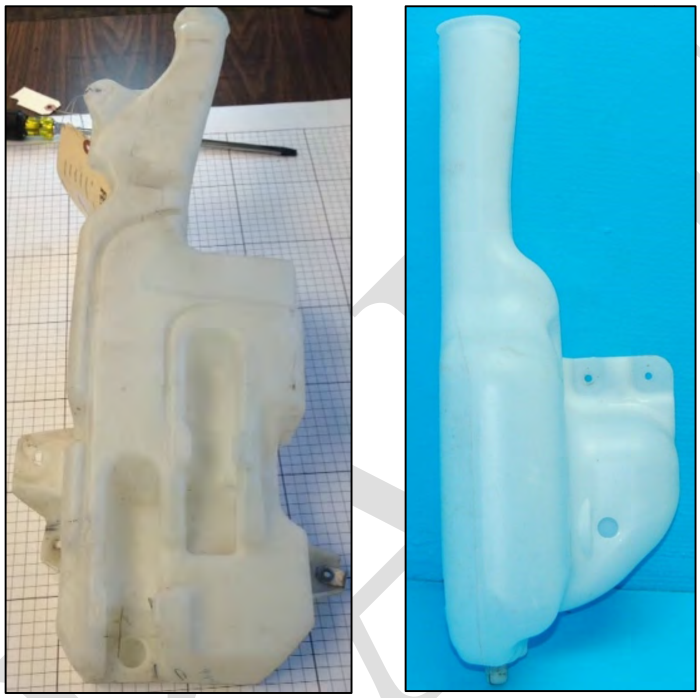


Image 3.6–7: Washer Tank for the Silverado 1500 (Left) and Mercedes Sprinter 311 CDi (Right)
(Source: FEV, Inc. and www.A2mac1.com)

DRAFT

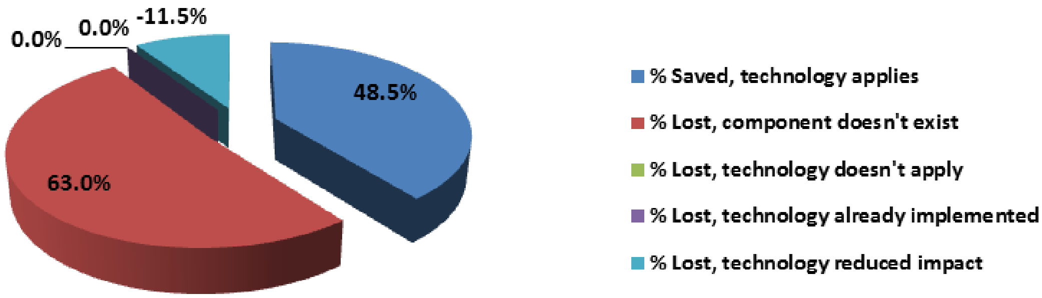
3.6.3 Renault Master 2.3 DCi

Table 3-47 summarizes mass and cost impact of Silverado 1500 Lightweighting technologies applied to the Renault Master 2.3 DCi. Total Body Group -D- system mass savings is 2.18 kg at a cost decrease of $1.12, or $0.51 per kg.

Table 3-47: Mass-Reduction and Cost Impact for Body Group -D- System, Renault Master

				Net Value of Mass Reduction							
System	Subsystem	Sub-Subsystem	Description	Mass Reduction New Tech "kg" (1)	Mass Reduction Comp "kg" (1)	Mass Reduction Total "kg" (1)	Cost Impact New Tech "$" (2)	Cost Impact Comp "$" (2)	Cost Impact Total "$" (2)	Cost/ Kilogram Total "$/kg"	Vehicle Mass Reduction Total "%"
03	00	00	**Body System "D"**								
03	11	00	Glass (Glazing), Frame, and Mechanism Subsystem	2.12	0.00	2.12	$1.07	$0.00	$1.07	$0.50	0.09%
03	14	00	Handles, Locks, Latches and Mechanisms Subsystem	0.00	0.00	0.00	$0.00	$0.00	$0.00	$0.00	0.00%
03	16	00	Wipers and Washers Subsystem	0.06	0.00	0.06	$0.05	$0.00	$0.05	$0.84	0.00%
				2.18 (Decrease)	**0.00**	**2.18** (Decrease)	**$1.12** (Decrease)	**$0.00**	**$1.12** (Decrease)	**$0.51** (Decrease)	**0.09%**

Mass Savings, Select Vehicle, New Technology "kg"	**2.18**
Mass Savings, Silverado 1500, New Technology "kg"	**4.50**
Mass Savings Select Vehicle/Mass Savings 1500	**48.5%**



*SMS not included - has no significant impact on perecent contributions

3.6.3.1 System Scaling Analysis

The Renault Master 2.3 DCi Body Group -D- system components were reviewed for compatibility with Lightweighting technologies. The results of this analysis are listed in Table 3-48.

Table 3-48: System Scaling Analysis Body Group -D- System, Renault Master

Silverado 1500							Select Vehicle			
System	Subsystem	Sub-Subsystem	Component/Assembly	Base Mass	Mass Savings New Tech	% of Mass Savings New Tech	Tech Applies	Base Mass	Mass Savings New Tech	Notes
03			**Body Group D System**	**50.86**	**4.50**	**9%**			**2.18**	
03	11	01	Windshield and Front Quarter Window (Fixed)	15.87	1.590	10%	yes	21.19	2.12	Tech **DOES** apply: Thin glass using Pilkington window applications
03	11	05	Back Window Assy	6.59	1.343	20%	no			Tech does **NOT** apply: Part not on vehicle
03	11	14	Rear Side Door Glass	8.75	1.496	17%	no			Tech does **NOT** apply: Part not on vehicle
03	16	99	Washer Tank Assembly	0.74	0.074	10%	yes	0.59	0.06	Tech **DOES** apply: Use Polyone foaming agent

If the original Silverado 1500 mass reduction concept idea was not able to be applied to the comparison vehicle it is not described in the section below.

Components with significant mass savings identified on the Renault Master 2.3 DCi included the windshield and washer tank assembly.

<u>Windshield</u>

Shown in Image 3.6–8 are the Silverado 1500 and Renault Master 2.3 DCi windshields. Component masses are 15.9 kg for the Silverado 1500 versus 21.2 kg for the Renault Master 2.3 DCi. The Lightweighting Technology used in the windshield was to replace the 2.27 mm thick glass with 1.6 mm thick using the Pilkington® laminated glass process. Due to similarities in component design and material, full percentage of the Silverado 1500 windshield mass reduction can be applied to the Renault. (Refer to Table 3-48).

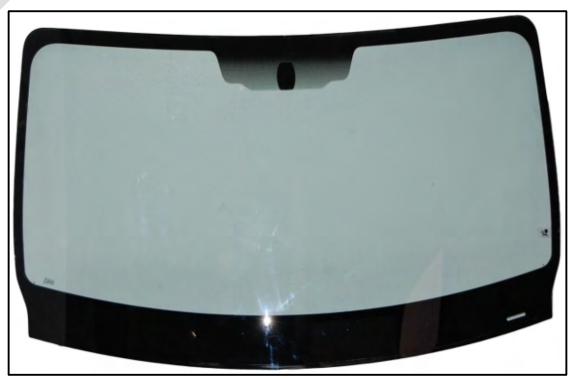


Image 3.6–8: Windshield for the Silverado 1500 (Left) and Renault Master 2.3 DCi (Right)
(Source: FEV, Inc. and www.A2mac1.com)

<u>Washer Tank Assembly</u>

Shown in Image 3.6–9 are the Silverado 1500 and Renault Master 2.3 DCi Washer Tank. Component masses are 0.74 kg for the Silverado 1500 versus .59 kg for the Renault Master 2.3 DCi

DRAFT

respectively. The Lightweighting Technology used in the Washer Tank is to use PolyOne® foaming agent in the plastic to reduce the mass by 10%. Due to similarities in component design and material, full percentage of the Silverado 1500 washer tank assembly mass reduction can be applied to the Renault. (Refer to Table 3-48).

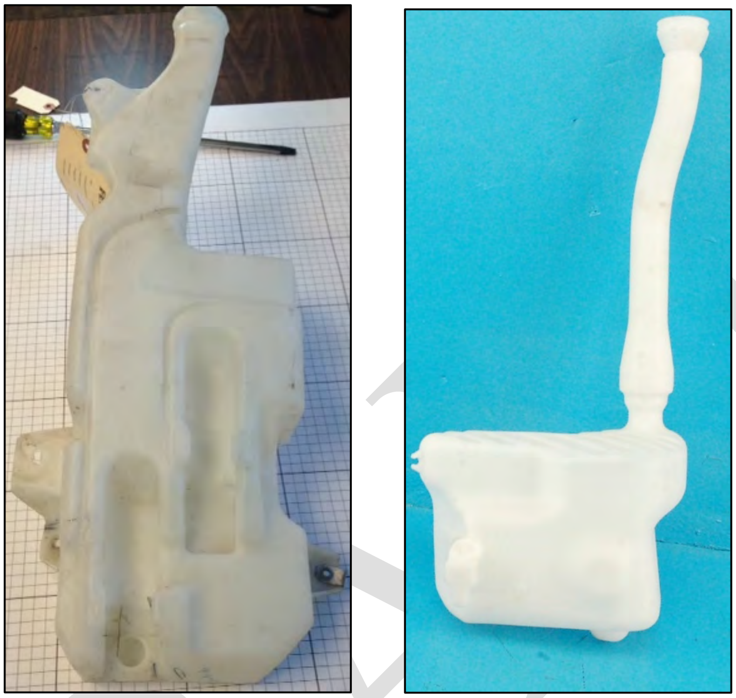


Image 3.6–9: Washer Tank for the Silverado 1500 (Left) and Renault Master 2.3 DCi (Right)
(Source: FEV, Inc. and www.A2mac1.com)

DRAFT

3.7 SUSPENSION SYSTEM

3.7.1 Silverado 1500 Summary

This summary details FEV's work and findings relative to the Suspension System to prove the design concept, cost effectiveness, and manufacturing feasibility that can meet the function and performance of the baseline vehicle (2011 Chevrolet Silverado). Table 3-49 is a summary of the calculated mass reduction and cost impact for each sub-subsystem evaluated. This project recorded a system mass reduction of 30.5% (92 kg system mass reduction) at a cost increase of $2.00 per kg ($183.78 increase). Furthermore, the contribution of the suspension system to the overall vehicle mass reduction is 3.85%.

Table 3-49: Suspension System Mass Reduction Summary, Silverado 1500

				Net Value of Mass Reduction					
System	Subsystem	Sub-Subsystem	Description	Base Mass "kg"	Mass Reduction "kg" (1)	Cost Impact NIDMC "$" (2)	Average Cost/ Kilogram "$/kg" (2)	Mass Reduction "%"	Vehicle Mass Reduction "%"
04	00	00	Suspension System						
04	**01**	**00**	**Front Suspension Subsystem**	**54.76**	**20.07**	**-77.45**	**-3.86**	**36.65%**	**0.84%**
04	01	02	Lower Control Arm	19.10	7.70	-56.78	-7.38	40.31%	0.32%
04	01	03	Upper Control Arm	4.57	3.05	-2.47	-0.81	66.77%	0.13%
04	01	04	Steering Knuckle	15.35	7.89	-12.07	-1.53	51.39%	0.33%
04	01	04	Other Components...	15.75	1.43	-6.13	-4.28	9.09%	0.06%
04	**02**	**00**	**Rear Suspension Subsystem**	**63.52**	**35.75**	**-113.47**	**-3.17**	**56.28%**	**1.50%**
04	02	01	Leaf Spring Assembly	52.43	31.46	-115.17	-3.66	60.00%	1.32%
04	02	01	Other Components...	11.08	4.29	1.70	0.40	38.69%	0.18%
04	**03**	**00**	**Shock Absorber Subsystem**	**24.36**	**6.44**	**-5.78**	**-0.90**	**26.46%**	**0.27%**
04	03	01	Front Strut Coil Spring	11.06	5.60	-2.31	-0.41	50.62%	0.23%
04	03	02	Other Components...	13.29	0.84	-3.47	0.00	6.35%	0.04%
04	**04**	**00**	**Wheel and Tires Subsystem**	**158.61**	**29.64**	**12.93**	**0.44**	**18.69%**	**1.24%**
04	04	01	Road Wheels	48.51	9.70	-28.03	-2.89	20.00%	0.41%
04	04	01	Road Tires	69.45	9.92	41.14	4.15	14.28%	0.42%
04	04	02	Spare Wheel	14.54	7.42	-7.98	-1.08	3.16%	0.31%
04	04	02	Spare Tire	16.96	2.09	8.67	4.15	3.16%	0.09%
04	04	02	Other Components...	9.14	0.50	-0.87	-1.72	3.16%	0.02%
				301.24	91.90 (Decrease)	-183.78 (Increase)	-2.00 (Increase)	30.51%	3.85%

(1) "+" = mass decrease, "-" = mass increase
(2) "+" = cost decrease, "-" = cost increase

Columns in the "Net Value of Mass Reduction" chart above may contain combined masses of assembly hardware such as nuts, bolt, washer, etc. that were not mass reduced at the component level, and may not match base mass and mass reduction totals in text below component reduction weights.

The major components contributing to the mass reduction within the Front Suspension Subsystem are the lower control arms, upper control arms, and the steering knuckles.

Lower Control Arm: The mass reduction idea for the lower control arms was to change the component material from steel to aluminum. The individual baseline component mass was 9.55 kg and the redesign mass was 5.70 kg, resulting in an overall mass savings of 7.70 kg, or 40.31%, compared to the steel units.

In 2009, General Motors offered two XFE (eXtra Fuel Economy) models for the Chevrolet Silverado and GMC Sierra that included, among other fuel saving ideas, aluminum lower control arms. The aluminum control arms were eventually switched back to cast iron due to cost reduction efforts. GM then announced that the 2014 Silverado would come equipped with aluminum control arms and aluminum knuckles.

Upper Control Arm: The mass reduction ideas for the upper control arms were to normalize the control arm based on the 2012 Dodge Durango, and then change the component material from forged steel to cast magnesium.

The normalizing process compared the Gross Vehicle Weight (GVW) of the Durango to the GVW of the Silverado and adjusted the mass of the Silverado control arm, up or down, based on the ratios of the two vehicles GVW and the component mass of the Durango control arm. As a result of this normalization process the baseline mass of the Silverado control arm was reduced by 1.72 kg.

The individual baseline component mass was 2.28 kg and the redesign mass 0.759 kg, resulting in an overall mass savings of 3.04 kg for both arms, or 66.7%, compared to the steel units.

General Motors China Advanced Technical Center (ATC) announced in May 2012 that they had successfully casted a prototype magnesium alloy control arm and noted that the part is 30% lighter than a similar part made of aluminum.

It is understood that most OEMs in the United States are reluctant to use magnesium due in part to price volatility, availability; manufacturing plants were not facilitated for magnesium processing, and recycling concerns.

Additionally, in 2001, the U.S. Department of Commerce (DoC) imposed anti-dumping duties (ADD) on magnesium in granular form imported from the People’s Republic of China (PRC). Dumping duties of 24.67% to 305.56% were determined and maintained during the first sunset review in 2006 and the second sunset review, which concluded on September 12, 2012.

Magnesium is used in the automotive and aeronautic industries. According to Asia Trade Watch, “ADD on magnesium adversely affects the American auto industry and inflates U.S. magnesium prices by approximately 50%. Increased costs have made American companies less competitive and raised industry costs for meeting stricter fuel standards for vehicles.”

Even with these concerns, magnesium represents a major opportunity for mass reduction that European OEMs are embracing.

Steering Knuckle: The mass reduction idea for the steering knuckles was to change the base component material from steel to aluminum. The individual baseline component mass was 7.67 kg, and the redesign mass 3.73 kg. This resulted in an overall mass savings of 7.89 kg for both knuckles, and 51.4% compared to the steel units.

The major component contributing to the mass reduction within the Rear Suspension Subsystem is the rear leaf spring assembly.

Leaf Spring Assembly: The mass reduction idea for the rear leaf spring assemblies was to change the base component material from steel to glass fiber reinforced plastic. The individual baseline component mass was 26.2 kg and the redesign mass 10.5 kg. This resulted in an overall mass savings of 31.4 kg for either leaf spring assemblies, or 60.0% compared to the steel units.

Liteflex® LLC, a manufacturer of OEM composite leaf springs, has supplied composite leaf springs since 1998 to support production requirements on the Sprinter commercial vehicles, namely the NCV3 Sprinter. Other customers using Liteflex® composite leafs springs are the GM Corvette and Land Rover. Liteflex® also produces composite leaf springs for heavy duty truck applications for Kenworth, Peterbilt, Freightliner, and International.

Additionally, Liteflex® states "Suspension designers realized a 55% reduction in weight when replacing two steel leaf springs with Liteflex® lightweight composite springs for a three-quarter ton 4x4 pickup. The original, all-steel design tipped the scales at 69 pounds while the hybrid steel-and-composite version weighed in at just 31 pounds."

The major component contributing to the mass reduction within the Shock Absorber Subsystem is the front strut coil spring.

<u>Front Strut Coil Spring</u>: The mass reduction idea for the Front Strut Coil Springs was to change the base component material from steel to the Mubea High-Strength Low-Alloy Steel (HSLA) steel coil. The individual baseline component mass was 5.35 kg and the redesign mass 2.73 kg. This resulted in an overall mass savings of 5.60 kg for both springs, and 50.62% compared to the steel units.

The major components contributing to the mass reduction within the Wheels and Tires Subsystem are the road wheels, road tires, spare wheel, and spare tire.

<u>Road Wheels</u>: The mass reduction idea for the road wheels was to change the base component material from aluminum to ultra-Lightweight forged aluminum. The total baseline component mass were 48.5 kg and the total redesign mass 38.8 kg. This resulted in an overall mass savings of 9.7 kg for all four wheels, or 20.0% compared to the steel units.

<u>Road Tires</u>: The mass reduction idea for the road tires was to normalize the base tires to the 2007 Ford F-150 road tires. The total baseline component mass was 69.5 kg and the redesign mass 59.5 kg. This resulted in an overall mass savings of 9.92 kg for all four tires, or 14.28% compared to the Silverado road tires.

<u>Spare Wheel</u>: The mass reduction idea for the spare wheel was to change the base component material from stamped steel to cast aluminum. The baseline component mass was 15.5 kg and the redesign mass 7.12 kg. This resulted in an overall mass savings of 8.40 kg, or 54.1% compared to the steel unit.

<u>Spare Tire</u>: The mass reduction idea for the spare tire was to normalize the base component to the 2006 Dodge Ram spare tire. The baseline component mass was 17.0 kg and the redesign mass 14.9 kg. This resulted in an overall mass savings of 2.10 kg, or 12.4% compared to the Silverado spare tire.

3.7.1.1 Silverado 2500 Analysis

Front Suspension System: The Silverado 1500 front suspension system utilizes a coil-over shock system with forged steel upper control arms, cast iron lower control arms, and a torsion bar system. The 2500 front suspension system is independent with forged steel upper control arms and cast iron lower control arms. A torsion bar is used instead of springs to allow for easy trim height adjustment.

DRAFT

Rear Suspension System: The Silverado 2500 rear suspension system utilizes an asymmetrical two-stage leaf-spring design that minimizes axle hop and enhances traction control efficiency.

Wheels and Tires: The Silverado 2500 comes standard with 17” machine-finish aluminum wheels and 17” all-season tires.

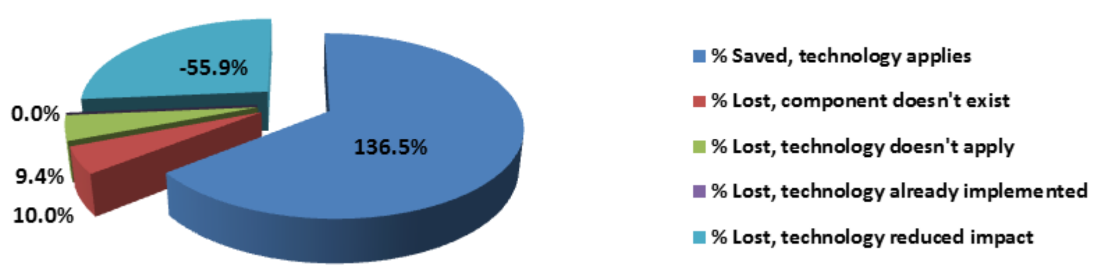
3.7.1.2 2500 System Scaling Summary

Table 3-50 summarizes mass and cost impact of Silverado 1500 Lightweighting technologies applied to the Silverado 2500. Total suspension mass savings is 113.32 kg at a cost increase of $243.15, or $1.83 per kg.

Table 3-50: Mass-Reduction and Cost Impact for Suspension System, Silverado 2500

				Net Value of Mass Reduction							
System	Subsystem	Sub-Subsystem	Description	Mass Reduction New Tech "kg" (1)	Mass Reduction Comp "kg" (1)	Mass Reduction Total "kg" (1)	Cost Impact New Tech "$" (2)	Cost Impact Comp "$" (2)	Cost Impact Total "$" (2)	Cost/ Kilogram Total "$/kg"	Vehicle Mass Reduction Total "%"
04	00	00	**Suspension System**								
04	02	00	Front Suspension Subsystem	38.56	3.53	42.08	-$42.45	$13.48	-$28.96	-$0.69	1.36%
04	03	00	Rear Suspension Subsystem	60.67	3.00	63.67	-$206.74	$32.89	-$173.86	-$2.73	2.06%
04	04	00	Shock Absorber Subsystem	0.00	0.00	0.00	$0.00	$0.00	$0.00	$0.00	0.00%
04	05	00	Wheels And Tires Subsystem	14.09	13.26	27.35	-$137.45	$97.12	-$40.33	-$1.47	0.89%
04	06	00	Suspension Load Leveling Control Subsystem	0.00	0.00	0.00	$0.00	$0.00	$0.00	$0.00	0.00%
04	07	00	Rear Suspension Modules Subsystem	0.00	0.00	0.00	$0.00	$0.00	$0.00	$0.00	0.00%
04	08	00	Front Suspension Modules Subsystem	0.00	0.00	0.00	$0.00	$0.00	$0.00	$0.00	0.00%
				113.32 (Decrease)	19.79 (Decrease)	133.10 (Decrease)	-$386.64 (Increase)	$143.49 (Decrease)	-$243.15 (Increase)	-$1.83 (Increase)	4.31%

Mass Savings, Select Vehicle, New Technology "kg"	**113.3**
Mass Savings, Silverado 1500, New Technology "kg"	**83.0**
Mass Savings Select Vehicle/Mass Savings 1500	**136.5%**



*SMS not included - has no significant impact on perecent contributions

Mass savings could not be credited for components for which Lightweighting technologies did not apply. One reason for this could be that the technology was already implemented. Some components light weighted, as part of the 1500 Silverado analysis, do not exist in the 2500 suspension system, such as the front coil springs and rear leaf spring spacer blocks.

3.7.1.3 System Scaling Analysis

The Silverado 2500 Suspension components were reviewed for compatibility with Lightweighting technologies. The results of this analysis are listed in Table 3-51.

Table 3-51: Suspension Components Scaling Analysis Results, Silverado 2500

Silverado 1500							Select Vehicle					
System	Subsystem	Sub-Subsystem	Component/Assembly	Base Mass	Mass Savings New Tech	% of Mass Savings New Tech	Tech Applies	Base Mass	Mass Savings	Base Mass	Mass Savings New Tech	Notes
04			**SuspensionSystem**	**301.2**	**83.0**	**28%**					**113.3**	
04	01	02	Lower Control Arm, LH	9.63	4.53	47%	Yes	18.45	8.68	18.45	8.68	Tech **DOES** apply: Use forged aluminum
04	01	02	Lower Control Arm, LH, Long Bushing Asm	0.39	0.16	41%	Yes	0.50	0.21	0.50	0.21	Tech **DOES** apply: Use plastic spacer & nylon bushing
04	01	02	Lower Control Arm, LH, Short Bushing Asm	0.30	0.13	41%	Yes	0.39	0.16	0.39	0.16	Tech **DOES** apply: Use plastic spacer & nylon bushing
04	01	02	Lower Control Arm, RH	9.47	4.37	46%	Yes	18.56	8.56	18.56	8.56	Tech **DOES** apply: Use forged aluminum
04	01	02	Lower Control Arm, RH, Long Bushing Asm	0.39	0.16	41%	Yes	0.50	0.21	0.50	0.21	Tech **DOES** apply: Use plastic spacer & nylon bushing
04	01	02	Lower Control Arm, RH, Short Bushing Asm	0.30	0.13	41%	Yes	0.39	0.16	0.39	0.16	Tech **DOES** apply: Use plastic spacer & nylon bushing
04	01	02	Upper Control Arm, LH	2.28	1.53	67%	Yes	3.74	2.50	3.74	2.50	Tech **DOES** apply: Use cast magnesium
04	01	02	Upper Control Arm, LH, Front Bushing Asm	0.29	0.12	40%	Yes	0.54	0.22	0.54	0.22	Tech **DOES** apply: Use aluminum spacer & nylon bushing
04	01	02	Upper Control Arm, LH, Rear Bushing Asm	0.29	0.12	40%	Yes	0.54	0.22	0.54	0.22	Tech **DOES** apply: Use aluminum spacer & nylon bushing
04	01	02	Upper Ball Joint Asm, LH	0.58	0.05	9%	No	0.00	0.00			Tech does **NOT** apply: The 1500 ball joint was normalized. No known comperable vehicle for the 2500.
04	01	02	Upper Control Arm, RH	2.28	1.53	67%	Yes	3.76	2.51	3.76	2.51	Tech **DOES** apply: Use cast magnesium
04	01	02	Upper Control Arm, RH, Front Bushing Asm	0.29	0.12	40%	Yes	0.54	0.22	0.54	0.22	Tech **DOES** apply: Use aluminum spacer & nylon bushing
04	01	02	Upper Control Arm, RH, Rear Bushing Asm	0.29	0.12	40%	Yes	0.54	0.22	0.54	0.22	Tech **DOES** apply: Use aluminum spacer & nylon bushing
04	01	02	Upper Ball Joint Asm, RH	0.58	0.05	9%	No	0.00	0.00			Tech does **NOT** apply: The 1500 ball joint was normalized. No known comperable vehicle for the 2500.
04	01	04	Knuckle, LH	7.67	3.94	51%	Yes	13.85	7.12	13.85	7.12	Tech **DOES** apply: Use forged aluminum
04	01	04	Knuckle, RH	7.67	3.94	51%	Yes	13.80	7.09	13.80	7.09	Tech **DOES** apply: Use forged aluminum
04	01	05	Front Stabilizer Bar - Mounting Bushings	0.16	0.02	14%	Yes	0.25	0.04	0.25	0.04	Tech **DOES** apply: Use nylon bushings
04	01	05	Front Stabilizer Bar - Mounting Brackets	0.46	0.22	48%	Yes	0.60	0.29	0.60	0.29	Tech **DOES** apply: Use aluminum & single bolt design
04	01	05	Front Stabilizer Bar - Mounting Bolts	0.12	0.06	50%	Yes	0.35	0.17	0.35	0.17	Tech **DOES** apply: Use single bolt design
04	02	01	Leaf Spring Asm, LH	26.22	15.73	60%	Yes	47.62	28.57	47.62	28.57	Tech **DOES** apply: Use glass fiber reinforced plastic
04	02	01	Leaf Spring Asm, RH	26.22	15.73	60%	Yes	47.62	28.57	47.62	28.57	Tech **DOES** apply: Use glass fiber reinforced plastic
04	02	01	Saddle Bracket, LH	1.30	0.81	62%	Yes	1.74	1.08	1.74	1.08	Tech **DOES** apply: Use cast magnesium
04	02	01	Saddle Bracket, RH	1.30	0.81	62%	Yes	1.74	1.08	1.74	1.08	Tech **DOES** apply: Use cast magnesium
04	02	01	Leaf Spring Spacer Block, LH	1.51	0.94	62%	No	0.00	0.00			Tech does **NOT** apply: Not on vehicle
04	02	01	Leaf Spring Spacer Block, RH	1.51	0.94	62%	No	0.00	0.00			Tech does **NOT** apply: Not on vehicle
04	02	01	Shackle Bracket Asm, LH	0.85	0.40	47%	Yes	1.45	0.69	1.45	0.69	Tech **DOES** apply: Use stamped aluminum
04	02	01	Shackle Bracket Asm, RH	0.85	0.40	47%	Yes	1.45	0.69	1.45	0.69	Tech **DOES** apply: Use stamped aluminum
04	03	01	Lower Strut Mount Asm, LH	1.16	0.42	36%	No	0.00	0.00			Tech does **NOT** apply: Not on vehicle
04	03	01	Coil Spring, LH	5.53	2.80	51%	No	0.00	0.00			Tech does **NOT** apply: Not on vehicle
04	03	01	Lower Strut Mount Asm, RH	1.16	0.42	36%	No	0.00	0.00			Tech does **NOT** apply: Not on vehicle
04	03	01	Coil Spring, RH	5.53	2.80	51%	No	0.00	0.00			Tech does **NOT** apply: Not on vehicle
04	04	01	Road Wheel	48.51	6.06	13%	Yes	54.43	6.80	54.43	6.80	Tech **DOES** apply: Use lightweight aluminum monoblock wheel
04	04	01	Road Tire	69.45	5.60	8%	No	0.00	0.00			Tech does **NOT** apply: The 1500 tire was normalized. No known comperable vehicle for the 2500.
04	04	01	Lug/Wheel Nuts	1.01	0.50	50%	Yes	2.01	1.01	2.01	1.01	Tech **DOES** apply: Use forged aluminum
04	04	01	Spare Wheel	14.54	5.30	36%	Yes	17.24	6.28	17.24	6.28	Tech **DOES** apply: Use forged aluminum
04	04	01	Spare Tire	16.96	2.09	12%	No	0.00	0.00			Tech does **NOT** apply: The 1500 tire was normalized. No known comperable vehicle for the 2500.

If the original Silverado 1500 mass reduction concept idea was not able to be applied to the comparison vehicle it is not described in the section below.

Components with significant mass savings identified on the 2500 series Silverado include the Upper Control Arms, Lower Control Arms, Knuckles, Leaf Spring Assemblies, Road Wheels, and Spare Wheel.

<u>Lower Control Arm</u>

As shown in Image 3.7–1, the Silverado 1500 series suspension system used a similar lower control arm design as the 2500 series. Component masses were 9.63 kg versus 18.45 kg, respectively. Image 3.7–2 is an aluminum billet for the 2009 Chevrolet Silverado lower control arm, which represents the mass reduction idea associated with this component. Due to similarities in component design and material, full percentage of the Silverado 1500 lower control arm mass reduction can be applied to the 2500. (Refer to Table 3-51).

Image 3.7–1: Lower Control Arm for the Silverado 1500 (Left) and Silverado 2500 (Right)
(Source: FEV, Inc. Photo)

Image 3.7–2: Aluminum Lower Control Arm
(Source: FEV, Inc. Photo)

Upper Control Arm

As shown in Image 3.7–3, the Silverado 1500 series suspension system used a similar upper control arm design as the 2500 series. Component masses were 2.3 kg versus 3.7 kg, respectively. The redesign idea for the upper control arm was to cast it out of magnesium, shown in Image 3.7–4. Due to similarities in component design and material, full percentage of the Silverado 1500 lower control arm mass reduction can be applied to the 2500. (Refer to Table 3-51).

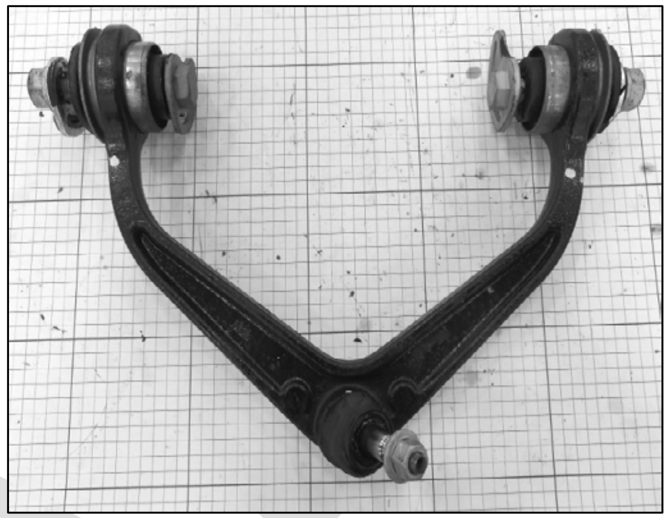


Image 3.7–3: Upper Control Arm for the Silverado 1500 (Left) and Silverado 2500 (Right)
(Source: FEV, Inc. Photo)

Image 3.7–4: Mass Reduced Upper Control Arm
(Source: http://i.ebayimg.com/t/02-05-Dodge-Ram-1500-Front-Upper-Control-Arm-Lower-Ball-Joint-Kit-Set-New/00/s/NDkyWDQ5Mg==/$%28KGrHqVHJBsFCEURKRgpBQj2sl%29HCw~~60_35.JPG)

Knuckle

As shown in Image 3.7–5, the Silverado 1500 series suspension system used a similar forged knuckle design as the 2500 series. Component masses were 7.70 kg versus 13.8 kg, respectively. The redesign idea for the knuckle was to forge it out of aluminum, shown in Image 3.7–6. Due to similarities in component design and material, full percentage of the Silverado 1500 knuckle mass reduction can be applied to the 2500. (Refer to Table 3-51).

Image 3.7–5: Knuckle for the Silverado 1500 (Left) and Silverado 2500 (Right)
(Source: FEV, Inc. Photo)

Image 3.7–6: Aluminum Knuckle
(Source: FEV, Inc. photo)

DRAFT

Leaf Spring Assemblies

As shown in Image 3.7–7, the Silverado 1500 series suspension system used a similar leaf spring design as the 2500 series. Component masses were 26.2 kg versus 47.6 kg respectively. The redesign idea for the leaf spring assembly is to change the base leaf spring material from steel to glass fiber reinforced plastic (GFRP). Image 3.7–8 is an example of a GFRP leaf spring. Due to similarities in component design and material, full percentage of the Silverado 1500 leaf spring assembly reduction can be applied to the 2500. (Refer to Table 3-51).

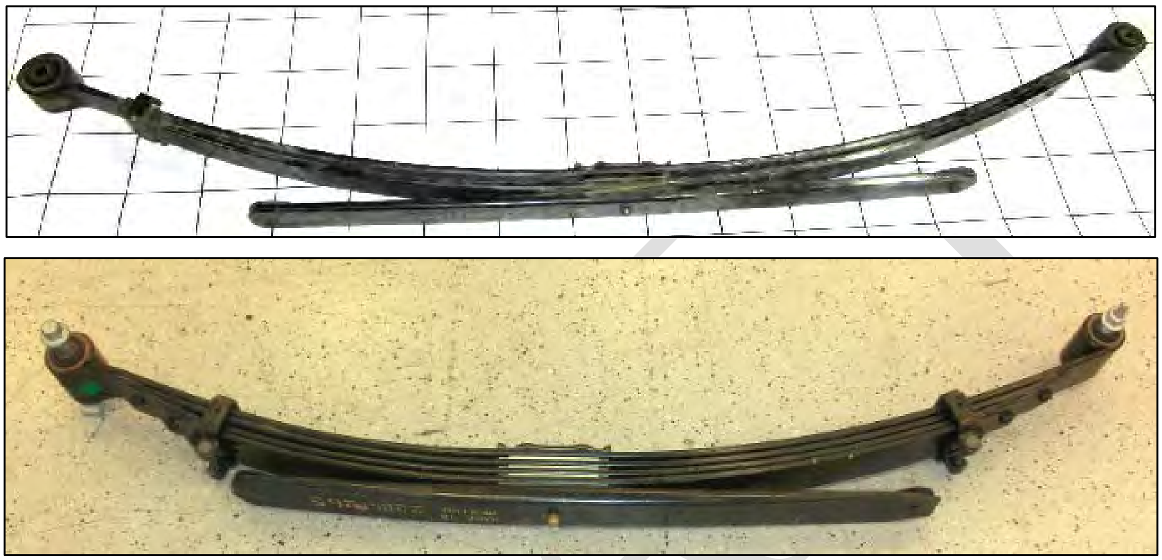


Image 3.7–7: Leaf Spring Assembly for the Silverado 1500 (Top) and the Silverado 2500 (Bottom)
(Source: FEV, Inc. Photo)

Image 3.7–8: GFRP Leaf Spring Assembly
(Source: http://www.hypercoils.com/leaf-springs.html)

DRAFT

Road Wheels

As shown in Image 3.7–9, the Silverado 1500 and 2500 share a common road wheel design. Component masses for all four wheels of the 1500 and 2500 are 48.5 kg versus 54.4 kg, respectively. The redesign idea for the road wheels was to change the base wheel material from forged aluminum to an ultra-Lightweight forged aluminum monoblock spoked wheel. Image 3.7–10 is an example of an ultra-Lightweight forged aluminum monoblock wheel. Due to similarities in component design and material, full percentage of the Silverado 1500 road wheel reduction can be applied to the 2500. (Refer to Table 3-51).

Image 3.7–9: Road Wheel for the Silverado 1500 (Left) and the Silverado 2500 (Right)
(Source: FEV, Inc. Photo)

Image 3.7–10: Ultra-Lightweight Forged Aluminum Monoblock Wheel
(Source: http://www.benzinsider.com/zenphoto/brabus-monoblock-f-g-q-wheels/The+New+BRABUS+Monoblock+F, +G+and+Q+Wheels_05.jpg.php)

<u>Spare Wheel</u>

As shown in Image 3.7–11, the Silverado 1500 and 2500 share a common stamped steel spare wheel design. Component masses for the 1500 and 2500 are 14.5 kg versus 17.2 kg, respectively. The redesign idea for the spare wheel is to change the spare wheel material from stamped steel to aluminum. Image 3.7–12 is an example of an aluminum wheel. Due to similarities in component design and material, full percentage of the Silverado 1500 spare wheel reduction can be applied to the 2500. (Refer to Table 3-51).

Image 3.7–11: Spare Wheel for the Silverado 1500 (Left) and Silverado 2500 (Right)
(Source: FEV, Inc. Photo)

Image 3.7–12: Aluminum Spare Wheel
(Source: http://www.autopartswarehouse.com/sku/Keystone_Wheels/Wheel/K16425884.html)

3.7.1.4 System Comparison, Silverado 2500

Table 3-52 summarizes the Silverado 1500 and 2500 Suspension System Lightweighting results.

Table 3-52: Suspension System Comparison, Silverado 1500 and 2500

System	Description	Net Value of Mass Reduction								
		Mass Base "kg" (1)	Mass Reduction New Tech "kg" (1)	Mass Reduction Comp "kg" (1)	Mass Reduction Total "kg" (1)	System Mass Reduction "%"	Cost Impact New Tech "$" (2)	Cost Impact Comp "$" (2)	Cost Impact Total "$" (2)	Cost/ Kilogram Total "$/kg"
04	Suspension System									
04	Silverado 1500	301.24	83.02	22.53	105.55	35.04%	-$259.57	$105.95	-$153.62	-$1.46
04	Silverado 2500	400.45	113.32	19.79	133.10	33.24%	-$386.64	$143.49	-$243.15	-$1.83

3.7.2 Mercedes Sprinter 311 CDi Analysis

The Mercedes Sprinter 311 CDi's front suspension system (Image 3.7–13) was comprised of a frame, lower control arms, shock absorber strut (not shown), stabilizer bar system, steering knuckles, and a single composite leaf spring system. The rear suspension system (Image 3.7–14) included the spring blade system and shock absorbers. Finally, the wheel system included the road wheels (Image 3.7–15), spare wheel (Image 3.7–16), and spare wheel support (Image 3.7–17).

Image 3.7–13: Mercedes Sprinter Front Suspension System
(Source: www.A2mac1.com)

Image 3.7–14: Mercedes Sprinter Rear Suspension System
(Source: www.A2mac1.com)

Image 3.7–15: Mercedes Sprinter Road Wheel Assembly
(Source: www.A2mac1.com)

DRAFT

Image 3.7–16: Mercedes Sprinter Spare Wheel Assembly
(Source: www.A2mac1.com)

Image 3.7–17: Mercedes Sprinter Spare Wheel Support
(Source: www.A2mac1.com)

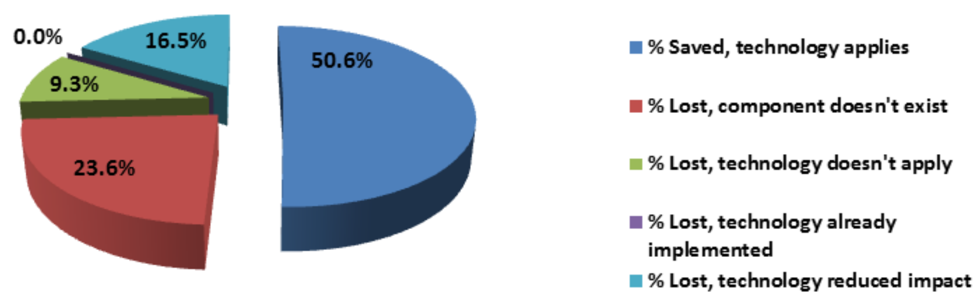
3.7.2.1 Mercedes Sprinter System Scaling Summary

Table 3-53 summarizes mass and cost impact of Silverado 1500 Lightweighting technologies applied to the Mercedes Sprinter. Total suspension system mass savings was 42.02 kg at a cost increase of $90.20, or $2.00 per kg.

Table 3-53: Mass-Reduction and Cost Impact for Suspension System, Mercedes Sprinter

System	Subsystem	Sub-Subsystem	Description	Net Value of Mass Reduction							
				Mass Reduction New Tech "kg" (1)	Mass Reduction Comp "kg" (1)	Mass Reduction Total "kg" (1)	Cost Impact New Tech "$" (2)	Cost Impact Comp "$" (2)	Cost Impact Total "$" (2)	Cost/ Kilogram Total "$/kg"	Vehicle Mass Reduction Total "%"
04	00	00	**Suspension System**								
04	02	00	Front Suspension Subsystem	15.90	1.37	17.27	-$16.03	$5.35	-$10.68	-$0.62	0.81%
04	03	00	Rear Suspension Subsystem	21.24	0.91	22.15	-$73.39	$9.95	-$63.44	-$2.86	1.04%
04	04	00	Shock Absorber Subsystem	0.00	0.00	0.00	$0.00	$0.00	$0.00	$0.00	0.00%
04	05	00	Wheels And Tires Subsystem	4.87	0.85	5.73	-$21.39	$5.31	-$16.08	-$2.81	0.27%
04	06	00	Suspension Load Leveling Control Subsystem	0.00	0.00	0.00	$0.00	$0.00	$0.00	$0.00	0.00%
04	07	00	Rear Suspension Modules Subsystem	0.00	0.00	0.00	$0.00	$0.00	$0.00	$0.00	0.00%
04	08	00	Front Suspension Modules Subsystem	0.00	0.00	0.00	$0.00	$0.00	$0.00	$0.00	0.00%
				42.02 (Decrease)	**3.13** (Decrease)	**45.15** (Decrease)	**-$110.81** (Increase)	**$20.61** (Decrease)	**-$90.20** (Increase)	**-$2.00** (Increase)	**2.12%**

Mass Savings, Select Vehicle, New Technology "kg"	**42.0**
Mass Savings, Silverado 1500, New Technology "kg"	**83.0**
Mass Savings Select Vehicle/Mass Savings 1500	**50.6%**



*SMS not included - has no significant impact on perecent contributions

Mass savings could not be credited for components for which Lightweighting technologies did not apply. Reasons for this could be that the technology was already implemented. Some components light weighted, as part of the 1500 Silverado analysis, do not exist in the Sprinter suspension system, such as the upper control arms and leaf spring spacer blocks.

3.7.2.2 System Scaling Analysis, Mercedes Sprinter

The Mercedes Sprinter Suspension System components were reviewed for compatibility with Lightweighting technologies. The results of this analysis are listed in Table 3-54.

Table 3-54: Suspension Components Scaling Analysis Results, Mercedes Sprinter

Silverado 1500							Select Vehicle			
System	Subsystem	Sub-Subsystem	Component/Assembly	Base Mass	Mass Savings New Tech	% of Mass Savings New Tech	Tech Applies	Base Mass	Mass Savings New Tech	Notes
04			**Suspension System**	**301.2**	**83.0**	**28%**			**42.0**	
04	01	02	Lower Control Arm, LH	9.63	4.53	47%	Yes	7.02	3.30	Tech **DOES** apply: Use forged aluminum
04	01	02	Lower Control Arm, LH, Long Bushing Asm	0.39	0.16	41%	Yes	0.28	0.12	Tech **DOES** apply: Use plastic spacer & nylon bushing
04	01	02	Lower Control Arm, LH, Short Bushing Asm	0.30	0.13	41%	Yes	0.22	0.09	Tech **DOES** apply: Use plastic spacer & nylon bushing
04	01	02	Lower Control Arm, RH	9.47	4.37	46%	Yes	7.01	3.23	Tech **DOES** apply: Use forged aluminum
04	01	02	Lower Control Arm, RH, Long Bushing Asm	0.39	0.16	41%	Yes	0.29	0.12	Tech **DOES** apply: Use plastic spacer & nylon bushing
04	01	02	Lower Control Arm, RH, Short Bushing Asm	0.30	0.13	41%	Yes	0.22	0.09	Tech **DOES** apply: Use plastic spacer & nylon bushing
04	01	02	Upper Control Arm, LH	2.28	1.53	67%	No			Tech does **NOT** apply: Not on vehicle
04	01	02	Upper Control Arm, LH, Front Bushing Asm	0.29	0.12	40%	No			Tech does **NOT** apply: Not on vehicle
04	01	02	Upper Control Arm, LH, Rear Bushing Asm	0.29	0.12	40%	No			Tech does **NOT** apply: Not on vehicle
04	01	02	Upper Ball Joint Asm, LH	0.58	0.05	9%	No			Tech does **NOT** apply: Not on vehicle
04	01	02	Upper Control Arm, RH	2.28	1.53	67%	No			Tech does **NOT** apply: Not on vehicle
04	01	02	Upper Control Arm, RH, Front Bushing Asm	0.29	0.12	40%	No			Tech does **NOT** apply: Not on vehicle
04	01	02	Upper Control Arm, RH, Rear Bushing Asm	0.29	0.12	40%	No			Tech does **NOT** apply: Not on vehicle
04	01	02	Upper Ball Joint Asm, RH	0.58	0.05	9%	No			Tech does **NOT** apply: Not on vehicle
04	01	04	Knuckle, LH	7.67	3.94	51%	Yes	8.55	4.40	Tech **DOES** apply: Use forged aluminum
04	01	04	Knuckle, RH	7.67	3.94	51%	Yes	8.55	4.40	Tech **DOES** apply: Use forged aluminum
04	01	05	Front Stabilizer Bar - Mounting Bushings	0.16	0.02	14%	Yes	0.18	0.03	Tech **DOES** apply: Use nylon bushings
04	01	05	Front Stabilizer Bar - Mounting Brackets	0.46	0.22	48%	Yes	0.16	0.08	Tech **DOES** apply: Use aluminum & single bolt design
04	01	05	Front Stabilizer Bar - Mounting Bolts	0.12	0.06	50%	Yes	0.11	0.06	Tech **DOES** apply: Use single bolt design
04	02	01	Leaf Spring Asm, LH	26.22	15.73	60%	Yes	16.67	10.00	Tech **DOES** apply: Use glass fiber reinforced plastic
04	02	01	Leaf Spring Asm, RH	26.22	15.73	60%	Yes	16.67	10.00	Tech **DOES** apply: Use glass fiber reinforced plastic
04	02	01	Saddle Bracket, LH	1.30	0.81	62%	No			Tech does **NOT** apply: Different design
04	02	01	Saddle Bracket, RH	1.30	0.81	62%	No			Tech does **NOT** apply: Different design
04	02	01	Leaf Spring Spacer Block, LH	1.51	0.94	62%	No			Tech does **NOT** apply: Not on vehicle
04	02	01	Leaf Spring Spacer Block, RH	1.51	0.94	62%	No			Tech does **NOT** apply: Not on vehicle
04	02	01	Shackle Bracket Asm, LH	0.85	0.40	47%	Yes	1.30	0.62	Tech **DOES** apply: Use stamped aluminum
04	02	01	Shackle Bracket Asm, RH	0.85	0.40	47%	Yes	1.30	0.62	Tech **DOES** apply: Use stamped aluminum
04	03	01	Lower Strut Mount Asm, LH	1.16	0.42	36%	No			Tech does **NOT** apply: Not on vehicle
04	03	01	Coil Spring, LH	5.53	2.80	51%	No			Tech does **NOT** apply: Different design
04	03	01	Lower Strut Mount Asm, RH	1.16	0.42	36%	No			Tech does **NOT** apply: Not on vehicle
04	03	01	Coil Spring, RH	5.53	2.80	51%	No			Tech does **NOT** apply: Different design
04	04	01	Road Wheel	48.51	6.06	13%	No			Tech does **NOT** apply: Not on vehicle
04	04	01	Road Tire	69.45	5.60	8%	No			Tech does **NOT** apply: The 1500 tire was normalized. No known comperable vehicle for the 2500.
04	04	01	Lug/Wheel Nuts	1.01	0.50	50%	Yes	0.69	0.34	Tech **DOES** apply: Use forged aluminum
04	04	01	Spare Wheel	14.54	5.30	36%	Yes	12.42	4.53	Tech **DOES** apply: Use forged aluminum
04	04	01	Spare Tire	16.96	2.09	12%	No			Tech does **NOT** apply: The 1500 tire was normalized. No known comperable vehicle for the 2500.

If the original Silverado 1500 mass reduction concept idea was not able to be applied to the comparison vehicle it is not described in the section below.

Key Components for mass reduction included the lower control arms, knuckles, leaf spring assemblies, and spare wheel.

<u>Lower Control Arm</u>

Shown in Image 3.7–18, the Silverado 1500 lower control arm used a cast iron design whereas the Sprinter used stamped steel and welded construction. Component masses were 9.63 kg versus 7.02 kg, respectively. Image 3.7–19 shows an aluminum billet for the 2009 Chevrolet Silverado lower control arm, which represents the mass reduction idea associated with this component. Due to similarities in component design and material, full percentage of the Silverado 1500 lower control arm mass reduction can be applied to the Sprinter. (Refer to Table 3-54).

DRAFT

Image 3.7–18: Lower Control Arm for the Silverado 1500 (Left) and Mercedes Sprinter (Right)
(Source: FEV, Inc. and www.A2mac1.com)

Image 3.7–19: 2009 Chevrolet Silverado Lower Control Arm Billet
(Source: FEV, Inc. Photo)

Steering Knuckles

As shown in Image 3.7–20, the Silverado 1500 Suspension System used a similar steering knuckle design as the Sprinter suspension system. Component masses were 7.67 kg versus 8.55 kg, respectively. The redesign idea for the steering knuckle is to cast it from aluminum (Image 3.7–21). Due to similarities in component design and material, full percentage of the Silverado 1500 steering knuckle arm mass reduction can be applied to the Sprinter. (Refer to Table 3-54).

Image 3.7–20: Steering Knuckle for the Silverado 1500 (Left) and Mercedes Sprinter (Right)
(Source: FEV, Inc. and www.A2mac1.com)

Image 3.7–21: Aluminum Steering Knuckle
(Source: FEV, Inc. Photo)

<u>Leaf Spring Assembly</u>

As shown in Image 3.7–22, the Silverado 1500 Suspension System used a multi-leaf spring design whereas the Sprinter used a mono-leaf design. Component masses were 26.2 kg versus 16.7 kg, respectively. The redesign idea for the leaf spring assembly is to change the base leaf spring material from steel to glass fiber reinforced plastic (GFRP). Image 3.7–23 is an example of a GFRP leaf spring. Due to similarities in component material, full percentage of the Silverado 1500 leaf spring assembly arm mass reduction can be applied to the Sprinter. (Refer to Table 3-54).

DRAFT

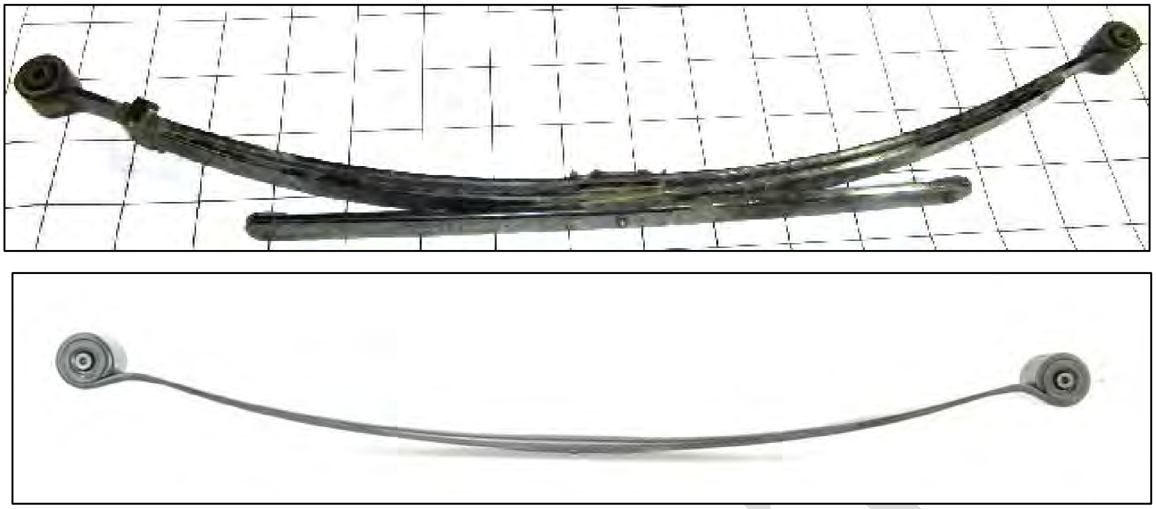


Image 3.7–22: Leaf Spring Assembly for the Silverado 1500 (Top) and Sprinter (Bottom)
(Source: FEV, Inc. and A2mac1.com)

Image 3.7–23: Glass Fiber Reinforced Plastic Leaf Spring Assembly
(Source: http://www.hypercoils.com/leaf-springs.html)

Spare Wheel

As shown in Image 3.7–24, the Silverado 1500 and Sprinter share a common stamped steel spare wheel design. Component masses were 14.5 kg versus 12.4 kg, respectively. The redesign idea for the spare wheel was to change the spare wheel material from stamped steel to aluminum. Image 3.7–25 is an example of an aluminum wheel. Due to similarities in component design and material, full percentage of the Silverado 1500 spare wheel mass reduction can be applied to the Sprinter. (Refer to Table 3-54).

Image 3.7–24: Spare Wheel for the Silverado 1500 (Left) and Mercedes Sprinter (Right)
(Source: FEV, Inc. and www.A2mac1.com)

Image 3.7–25: Aluminum Spare Wheel
(Source: http://www.autopartswarehouse.com/sku/Keystone_Wheels/Wheel/K16425884.html)

DRAFT

3.7.3 Renault Master 2.3 DCi Analysis

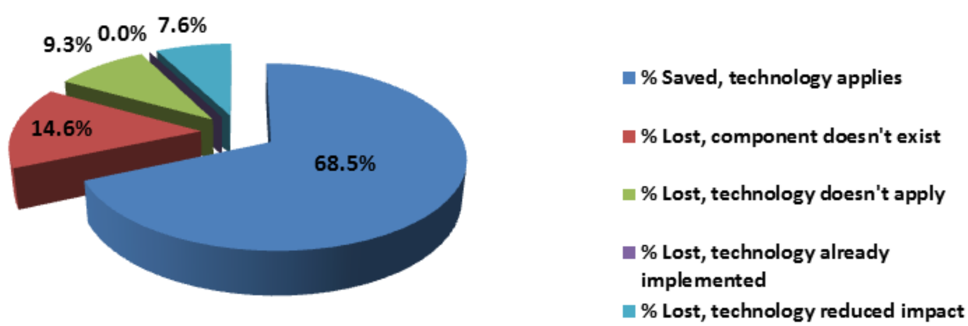
3.7.3.1 Renault Master System Scaling Summary

Table 3-55 summarizes mass and cost impact of Silverado 1500 Lightweighting technologies applied to the Renault Master. Total Suspension System mass savings was 56.87 kg at a cost increase of $111.59, or $1.82 per kg.

Table 3-55: Mass-Reduction and Cost Impact for Suspension System, Renault Master

				Net Value of Mass Reduction							
System	Subsystem	Sub-Subsystem	Description	Mass Reduction New Tech "kg" (1)	Mass Reduction Comp "kg" (1)	Mass Reduction Total "kg" (1)	Cost Impact New Tech "$" (2)	Cost Impact Comp "$" (2)	Cost Impact Total "$" (2)	Cost/ Kilogram Total "$/kg"	Vehicle Mass Reduction Total "%"
04	00	00	**Suspension System**								
04	02	00	Front Suspension Subsystem	16.99	1.60	18.59	-$15.53	$5.92	-$9.61	-$0.52	0.79%
04	03	00	Rear Suspension Subsystem	29.80	1.37	31.16	-$101.69	$14.97	-$86.72	-$2.78	1.32%
04	04	00	Shock Absorber Subsystem	4.85	0.43	5.28	-$0.25	$1.78	$1.53	$0.29	0.22%
04	05	00	Wheels And Tires Subsystem	5.24	1.00	6.24	-$22.98	$6.19	-$16.79	-$2.69	0.26%
04	06	00	Suspension Load Leveling Control Subsystem	0.00	0.00	0.00	$0.00	$0.00	$0.00	$0.00	0.00%
04	07	00	Rear Suspension Modules Subsystem	0.00	0.00	0.00	$0.00	$0.00	$0.00	$0.00	0.00%
04	08	00	Front Suspension Modules Subsystem	0.00	0.00	0.00	$0.00	$0.00	$0.00	$0.00	0.00%
				56.87 (Decrease)	**4.40** (Decrease)	**61.27** (Decrease)	**-$140.45** (Increase)	**$28.87** (Decrease)	**-$111.59** (Increase)	**-1.82** (Increase)	**2.60%**

Mass Savings, Select Vehicle, New Technology "kg"	**56.9**
Mass Savings, Silverado 1500, New Technology "kg"	**83.0**
Mass Savings Select Vehicle/Mass Savings 1500	**68.5%**



*SMS not included - has no significant impact on perecent contributions

Mass savings could not be credited for components for which Lightweighting technologies did not apply. Reasons for this could be that the technology was already implemented. Some components light weighted as part of the Silverado 1500 analysis do not exist in the Renault Master Suspension System, such as the upper control arms and rear suspension saddle brackets.

3.7.3.2 System Scaling Analysis, Renault Master

The Renault Master suspension components were reviewed for compatibility with Lightweighting technologies. The results of this analysis are listed in Table 3-56.

Table 3-56: Suspension Components Scaling Analysis Results, Renault Master

Silverado 1500							Select Vehicle			
System	Subsystem	Sub-Subsystem	Component/Assembly	Base Mass	Mass Savings New Tech	% of Mass Savings New Tech	Tech Applies	Base Mass	Mass Savings New Tech	Notes
04			**SuspensionSystem**	**301.2**	**83.0**	**28%**			**56.9**	
04	01	02	Lower Control Arm, LH	9.63	4.53	47%	Yes	8.69	4.09	Tech **DOES** apply: Use forged aluminum
04	01	02	Lower Control Arm, LH, Long Bushing Asm	0.39	0.16	41%	Yes	0.35	0.14	Tech **DOES** apply: Use plastic spacer & nylon bushing
04	01	02	Lower Control Arm, LH, Short Bushing Asm	0.30	0.13	41%	Yes	0.27	0.11	Tech **DOES** apply: Use plastic spacer & nylon bushing
04	01	02	Lower Control Arm, RH	9.47	4.37	46%	Yes	8.68	4.00	Tech **DOES** apply: Use forged aluminum
04	01	02	Lower Control Arm, RH, Long Bushing Asm	0.39	0.16	41%	Yes	0.36	0.15	Tech **DOES** apply: Use plastic spacer & nylon bushing
04	01	02	Lower Control Arm, RH, Short Bushing Asm	0.30	0.13	41%	Yes	0.28	0.11	Tech **DOES** apply: Use plastic spacer & nylon bushing
04	01	02	Upper Control Arm, LH	2.28	1.53	67%	No			Tech does **NOT** apply: Not on vehicle
04	01	02	Upper Control Arm, LH, Front Bushing Asm	0.29	0.12	40%	No			Tech does **NOT** apply: Not on vehicle
04	01	02	Upper Control Arm, LH, Rear Bushing Asm	0.29	0.12	40%	No			Tech does **NOT** apply: Not on vehicle
04	01	02	Upper Ball Joint Asm, LH	0.58	0.05	9%	No			Tech does **NOT** apply: Not on vehicle
04	01	02	Upper Control Arm, RH	2.28	1.53	67%	No			Tech does **NOT** apply: Not on vehicle
04	01	02	Upper Control Arm, RH, Front Bushing Asm	0.29	0.12	40%	No			Tech does **NOT** apply: Not on vehicle
04	01	02	Upper Control Arm, RH, Rear Bushing Asm	0.29	0.12	40%	No			Tech does **NOT** apply: Not on vehicle
04	01	02	Upper Ball Joint Asm, RH	0.58	0.05	9%	No			Tech does **NOT** apply: Not on vehicle
04	01	04	Knuckle, LH	7.67	3.94	51%	Yes	7.86	4.04	Tech **DOES** apply: Use forged aluminum
04	01	04	Knuckle, RH	7.67	3.94	51%	Yes	7.86	4.04	Tech **DOES** apply: Use forged aluminum
04	01	05	Front Stabilizer Bar - Mounting Bushings	0.16	0.02	14%	Yes	0.09	0.01	Tech **DOES** apply: Use nylon bushings
04	01	05	Front Stabilizer Bar - Mounting Brackets	0.46	0.22	48%	Yes	0.27	0.13	Tech **DOES** apply: Use aluminum & single bolt design
04	01	05	Front Stabilizer Bar - Mounting Bolts	0.12	0.06	50%	Yes	0.31	0.16	Tech **DOES** apply: Use single bolt design
04	02	01	Leaf Spring Asm, LH	26.22	15.73	60%	Yes	23.10	13.86	Tech **DOES** apply: Use glass fiber reinforced plastic
04	02	01	Leaf Spring Asm, RH	26.22	15.73	60%	Yes	23.10	13.86	Tech **DOES** apply: Use glass fiber reinforced plastic
04	02	01	Saddle Bracket, LH	1.30	0.81	62%	No			Tech does **NOT** apply: Different design
04	02	01	Saddle Bracket, RH	1.30	0.81	62%	No			Tech does **NOT** apply: Different design
04	02	01	Leaf Spring Spacer Block, LH	1.51	0.94	62%	Yes	1.01	0.63	Tech **DOES** apply: Use cast magnesium
04	02	01	Leaf Spring Spacer Block, RH	1.51	0.94	62%	Yes	1.01	0.63	Tech **DOES** apply: Use cast magnesium
04	02	01	Shackle Bracket Asm, LH	0.85	0.40	47%	Yes	0.87	0.41	Tech **DOES** apply: Use stamped aluminum
04	02	01	Shackle Bracket Asm, RH	0.85	0.40	47%	Yes	0.87	0.41	Tech **DOES** apply: Use stamped aluminum
04	03	01	Lower Strut Mount Asm, LH	1.16	0.42	36%	No			Tech does **NOT** apply: Not on vehicle
04	03	01	Coil Spring, LH	5.53	2.80	51%	Yes	4.79	2.43	Tech **DOES** apply: Use Mubea winding process
04	03	01	Lower Strut Mount Asm, RH	1.16	0.42	36%	No			Tech does **NOT** apply: Not on vehicle
04	03	01	Coil Spring, RH	5.53	2.80	51%	Yes	4.79	2.43	Tech **DOES** apply: Use Mubea winding process
04	04	01	Road Wheel	48.51	6.06	13%	No			Tech does **NOT** apply: Not on vehicle
04	04	01	Road Tire	69.45	5.60	8%	No			Tech does **NOT** apply: The 1500 tire was normalized. No known comperable vehicle for the 2500.
04	04	01	Lug/Wheel Nuts	1.01	0.50	50%	Yes	0.75	0.37	Tech **DOES** apply: Use forged aluminum
04	04	01	Spare Wheel	14.54	5.30	36%	Yes	13.35	4.87	Tech **DOES** apply: Use forged aluminum
04	04	01	Spare Tire	16.96	2.09	12%	No			Tech does **NOT** apply: The 1500 tire was normalized. No known comperable vehicle for the 2500.

If the original Silverado 1500 mass reduction concept idea was not able to be applied to the comparison vehicle it is not described in the section below.

Front Suspension System: The Renault Master's front suspension system is similar to the Silverado 1500 in that they both use a frame system with lower control arms and a stabilizer bar. The major difference between the two vehicles is the Mercedes Sprinter uses a single mono-leaf composite leaf spring, whereas the Silverado uses a coil over shock system.

Rear Suspension System: The Renault Master's rear suspension system is similar to the Silverado 1500 in that they both use a steel leaf spring system with similar mounting hardware. The major difference between the two vehicles is the Mercedes Sprinter uses a single steel blade leaf spring whereas the Silverado 1500 uses a double steel leaf spring assembly.

3.8 DRIVELINE SYSTEM

3.8.1 Silverado 1500 Summary

The Chevrolet Silverado 1500 Driveline System included these subsystems: Driveshaft, Rear Drive Housed Axle, Front Drive Housed Axle, Front Drive Half-Shafts, and 4WD Driveline Control.

The Silverado 1500 analysis identified mass reduction alternatives and cost implications for the Driveline System with the intent to meet the function and performance requirements of the baseline vehicle. Table 3-57 provides a summary of mass reduction and cost impact for select sub-subsystems evaluated. The total mass savings found on the Driveline system mass was reduced by 20.4 kg (11.1%). This decreased cost by $38.01, or $1.86 per kg. Mass reduction for this system reduced vehicle curb weight by 0.86%.

Table 3-57: Driveline System Mass Reduction Summary, Silverado 1500

				Net Value of Mass Reduction					
System	Subsystem	Sub-Subsystem	Description	Base Mass "kg"	Mass Reduction "kg" (1)	Cost Impact NIDMC "$" (2)	Average Cost/ Kilogram "$/kg" (2)	Mass Reduction "%"	Vehicle Mass Reduction "%"
05	00	00	Driveline System						
05	**01**	**00**	**Driveshaft Subsystem**	**14.31**	**2.10**	**3.38**	**1.61**	**14.69%**	**0.09%**
05	01	01	Rearward Propeller Shaft w/ Yokes (2)	7.51	0.00	0.00	0.00	0.00%	0.00%
05	01	05	Forward Propeller Shaft w/ Yokes (2)	6.80	2.10	3.38	1.61	30.92%	0.09%
05	**02**	**00**	**Rear Drive Housed Axle Subsystem**	**89.07**	**10.47**	**25.78**	**2.46**	**11.76%**	**0.44%**
05	02	01	Beam Rear Axle Assembly	66.60	7.56	0.00	0.00	11.35%	0.32%
05	02	04	Rear Drive Unit	7.56	0.00	0.00	0.00	0.00%	0.00%
05	02	05	Rear Axle Differential Carrier Assy	14.91	2.91	25.78	8.85	19.54%	0.12%
05	**03**	**00**	**Front Drive Housed Axle Subsystem**	**52.53**	**6.49**	**6.27**	**0.97**	**12.35%**	**0.27%**
05	03	04	Front Drive Unit	52.53	6.49	6.27	0.97	12.35%	0.27%
05	**04**	**00**	**Front Drive Half-Shafts Subsystem**	**27.62**	**1.36**	**2.58**	**1.90**	**4.91%**	**0.06%**
05	04	01	Front Half Shaft	27.62	1.36	2.58	1.90	4.91%	0.06%
05	**07**	**00**	**4WD Driveline Control Subsystem**	**0.29**	**0.00**	**0.00**	**0.00**	**0.00%**	**0.00%**
05	07	01	Driveline Control Unit	0.29	0.00	0.00	0.00	0.00%	0.00%
				183.82	20.42 (Decrease)	38.01 (Decrease)	1.86 (Decrease)	11.11%	0.86%

(1) "+" = mass decrease, "-" = mass increase
(2) "+" = cost decrease, "-" = cost increase

Columns in the "Net Value of Mass Reduction" chart above may contain combined masses of assembly hardware such as nuts, bolt, washer, etc. that were not mass reduced at the component level, and may not match base mass and mass reduction totals in text below component reduction weights.

Mass savings opportunities were identified for the following components: forward propeller shaft, rear axle sleeves, rear axle hubs, rear differential cover plate, rear carrier rear ring gear, front differential output shaft with hubs, front carrier, front ring gear, front differential RH and LH mounting brackets, front axle shaft, and front wheel hubs.

<u>Forward Propeller Shaft:</u> The forward propeller shaft mass was reduced by changing from a standard steel shaft to aluminum technology. Mass was reduced by 59% from 3.55 kg to 1.44 kg.

<u>Rear Axle Sleeves:</u> The rear axle sleeves mass was reduced by using extrude steel tube with varied wall thickness in strategic locations. Mass was reduced by 20% from 10.9 kg to 8.73 kg.

Rear Axle Shaft with Hub: The rear axle shaft with hub mass was reduced by using extrude steel tube with varied wall thickness in strategic locations and drilling lightening holes in the hub face. Mass was reduced by 20% from 21.4 kg to 17.1 kg.

Rear Axle Differential Cover Plate: The rear axle differential cover plate mass was reduced by changing from stamped steel to stamped aluminum. Mass was reduced by 58% from 1.87 kg to 0.77 kg.

Rear Carrier Casting: The rear carrier casting mass was reduced by changing to a welded assembly with a lighter ring gear and carrier no mechanical fasteners. Mass was reduced by 30% from 5.25 kg to 3.67 kg.

Rear Carrier Ring Gear: The rear ring gear mass was reduced by removal of material for bolts. Mass was reduced by 27% from 4.48kg to 3.27kg.

Rear Ring Gear mounting bolts: The rear ring gear mounting bolts mass was reduced by reducing the bolt count from 10 to six. Mass was reduced by 40% from 0.31 kg to 0.18 kg.

Front Differential Output Shaft with Hub: The front differential output shaft with hub mass was reduced by using extrude steel tube with varied wall thickness in strategic locations and drilling lightening holes in the hub face. Mass was reduced by 28% from 3.10 kg to 2.22 kg.

Front Carrier Casting: The front carrier casting mass was reduced by changing to a welded assembly and lighter ring gear. Mass was reduced by 30% from 4.16 kg to 2.91 kg.

Front Ring Gear: The front ring gear mass was reduced by going to a forged ring gear. Mass was reduced by 32% from 3.33 kg to 2.24 kg.

Front Ring Gear mounting bolts: The front ring gear mounting bolts mass was reduced by reducing the bolt count from 10 to 6. Mass was reduced by 40% from 0.31 kg to 0.18 kg.

Differential Mounting Bracket – Left: The left side differential mounting bracket mass was reduced by changing from cast iron to cast aluminum. Mass was reduced by 50% from 3.60 kg to 1.78 kg.

Differential Mounting Bracket – Right: The right side differential mounting bracket mass was reduced by changing from cast iron to cast aluminum. Mass was reduced by 50% from 2.63 kg to 1.31 kg.

Front Half Shaft Axle Shaft: The front axle shaft mass was reduced by using extrude steel tube with varied wall thickness in strategic locations. Mass was reduced by 25% from 4.49 kg to 3.37 kg.

Front Half Shaft Wheel Hubs: The front half shaft wheel hubs mass was reduced by drilling lightening holes in the hub face. Mass was reduced by 4% from 5.40 kg to 5.16 kg.

3.8.1.1 Silverado 2500 Analysis

The Chevrolet Silverado 2500 Driveline System is very similar to the 1500, but on a larger scale to handle the added required payload.

DRAFT

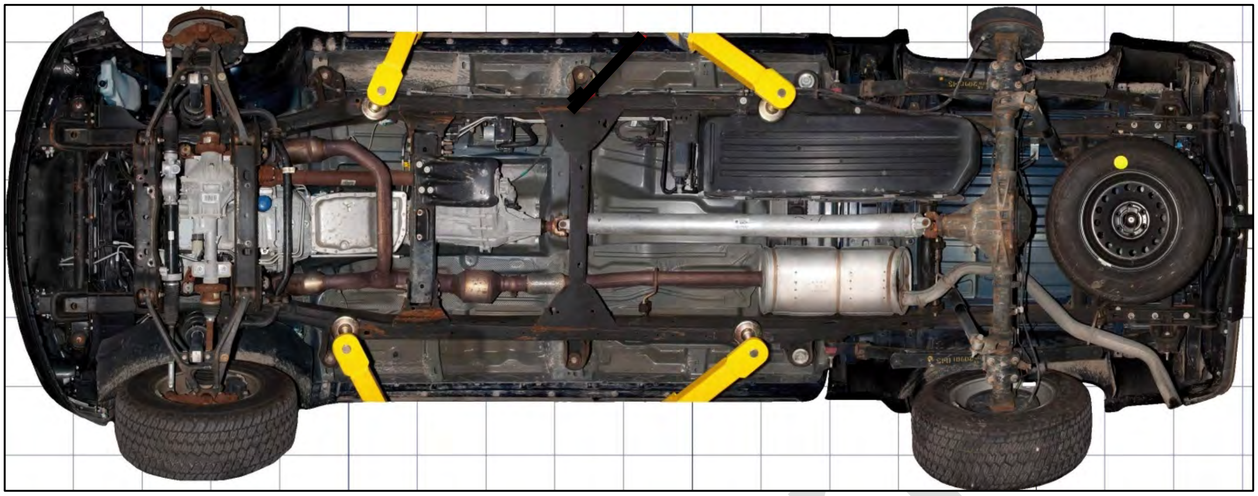


Image 3.8–1: Silverado 1500 Driveline System
(Source: www.A2mac1 database)

DRAFT

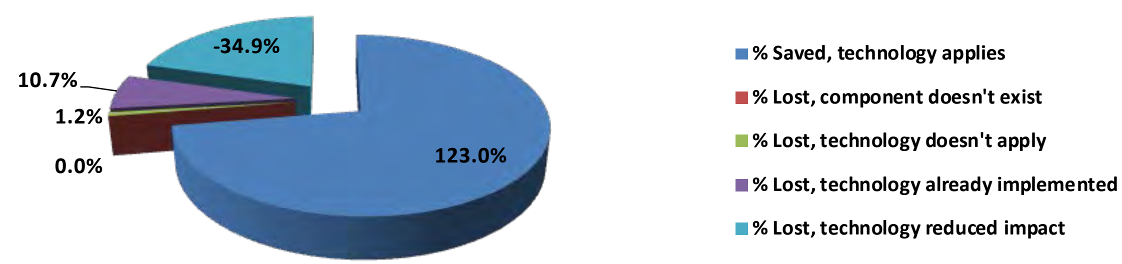
3.8.1.2 2500 System Scaling Summary

Table 3-58 summarizes mass and cost impact of Silverado 1500 Lightweighting technologies applied to the Silverado 2500. Total driveline system mass savings was 25.11 kg at a cost decrease of $48.71, or $1.94per kg.

Table 3-58: Mass-Reduction and Cost Impact for Driveline System, Silverado 2500

System	Subsystem	Sub-Subsystem	Description	Mass Reduction New Tech "kg" (1)	Mass Reduction Comp "kg" (1)	Mass Reduction Total "kg" (1)	Cost Impact New Tech "$" (2)	Cost Impact Comp "$" (2)	Cost Impact Total "$" (2)	Cost/ Kilogram Total "$/kg"	Vehicle Mass Reduction Total "%"
				Net Value of Mass Reduction							
05	**00**	**00**	**Driveline System**								
05	01	00	Driveshaft Subsystem	2.66	0.00	2.66	$4.29	$0.00	$4.29	$0.00	0.09%
05	02	00	Rear Drive Housed Axle Subsystem	9.06	0.00	9.06	$28.69	$0.00	$28.69	$3.17	0.29%
05	03	00	Front Drive Housed Axle Subsystem	11.72	0.00	11.72	$12.71	$0.00	$12.71	$0.00	0.38%
05	04	00	Front Drive Half-Shafts Subsystem	1.67	0.00	1.67	$3.02	$0.00	$3.02	$0.00	0.05%
05	07	00	4WD Driveline Control Subsystem	0.00	0.00	0.00	$0.00	$0.00	$0.00	$0.00	0.00%
				25.11 (Decrease)	**0.00** (Decrease)	**25.11** (Decrease)	**$48.71** (Decrease)	**$0.00**	**$48.71** (Decrease)	**$1.94** (Decrease)	**0.81%**

Mass Savings, Select Vehicle, New Technology "kg"	**25.11**
Mass Savings, Silverado 1500, New Technology "kg"	**20.42**
Mass Savings Select Vehicle/Mass Savings 1500	**123.0%**



*SMS not included - has no significant impact on perecent contributions

3.8.1.3 System Scaling Analysis

The Silverado 2500 driveline components were reviewed for compatibility with Lightweighting technologies. The results of this analysis are listed in Table 3-59.

Table 3-59: System Scaling Analysis Driveline System, Silverado 2500

Silverado 1500							Select Vehicle			
System	Subsystem	Sub-Subsystem	Component/Assembly	Base Mass	Mass Savings New Tech	% of Mass Savings New Tech	Tech Applies	Base Mass	Mass Savings New Tech	Notes
05			**Driveline System**	**183.82**	**20.42**	**11%**			**25.11**	
05	01	05	Forward Propeller Shaft	3.55	2.10	59%	yes	4.50	2.66	Tech **DOES** Apply: Change from steel to aluminum
05	02	01	Rear Axle Sleeves	10.92	2.18	20%	no			Tech does **NOT** Apply: variation inner wall thickness already done
05	02	01	Rear Axle Shaft w/ Hub	21.38	4.28	20%	yes	15.61	3.12	Tech **DOES** Apply: lightin shaft by making hollow with variation of inner wall thickness and putting lighting holes in hub
05	02	01	Rear Axle Differential Cover Plate	1.88	1.10	59%	yes	1.92	1.13	Tech **DOES** Apply: Change from steel to aluminum
05	02	05	Rear Carrier Casting	5.25	1.58	30%	yes	10.25	3.08	Tech **DOES** Apply: Change from steel casting to sheet steel welded assy
05	02	05	Rear Ring Gear	4.48	1.21	27%	yes	6.43	1.74	Tech **DOES** Apply: Change from stadard gear manufacturing to cold form with no machining
05	02	05	Rear Ring Gear Mounting Bolts	0.32	0.13	40%	no			Tech does **NOT** Apply: Reduce from 10 to 6 bolts
05	03	04	Front Differential Output Shaft w/ Hub	3.10	0.88	28%	yes	4.00	1.13	Tech **DOES** Apply: lightin shaft by making hollow with variation of inner wall thickness and putting lighting holes in hub
05	03	04	Front Carrier	4.16	1.25	30%	yes	9.23	2.77	Tech **DOES** Apply: Change from steel casting to sheet steel welded assy
05	03	04	Front Ring Gear	3.34	1.10	33%	yes	5.37	1.77	Tech **DOES** Apply: Change from stadard gear manufacturing to cold form with no machining
05	03	04	Front Ring Gear Mounting Bolts	0.31	0.12	40%	no			Tech does **NOT** Apply: Reduce from 10 to 6 bolts
05	03	04	Front Differential Mounting Bracket - LH	3.60	1.81	50%	yes	6.97	3.51	Tech **DOES** Apply: Change from cast steel to cast aluminum
05	03	04	Front Differential Mounting Bracket - RH	2.64	1.33	50%	yes	5.04	2.54	Tech **DOES** Apply: Change from cast steel to cast aluminum
05	04	01	Front Axle Shaft	4.50	1.12	25%	yes	5.42	1.35	Tech **DOES** Apply: lightin shaft by making hollow with variation of inner wall thickness
05	04	01	Front Wheel Hub	5.40	0.23	4%	yes	7.26	0.31	Tech **DOES** Apply: Putting lighting holes in hub

If the original Silverado 1500 mass reduction concept idea was not able to be applied to the comparison vehicle it is not described in the section below.

Components with significant mass savings identified on the Silverado 2500 included the forward propeller shaft, rear axle sleeves, rear axle hubs, rear differential cover plate, rear carrier rear ring gear, front differential output shaft with hubs, front carrier, front ring gear, front differential RH and LH mounting brackets, front axle shaft, and front wheel hubs.

Forward Propeller Shaft

Shown in Image 3.8–2 are the Silverado 1500 and 2500 forward propeller shafts. Component masses were 3.55 kg for the 1500 versus 4.50 kg for the 2500. The Lightweighting Technology used in the forward propeller shaft was to change from steel to aluminum. Due to similarities in component design and material, full percentage of the Silverado 1500 forward propeller shaft mass reduction can be applied to the 2500. (Refer to Table 3-59).

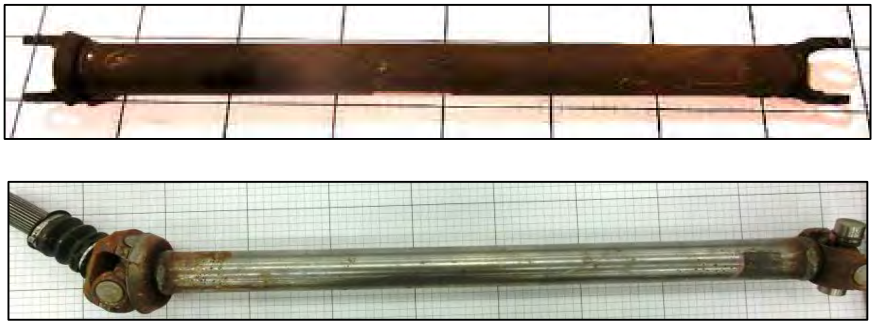


Image 3.8–2: Forward Propeller Shaft for the Silverado 1500 (Top) and Silverado 2500 (Bottom)
(Source: FEV, Inc.)

<u>Rear Axle Shaft w/ Hub:</u>

Shown in Image 3.8–3 are the Silverado 1500 and 2500 rear axle shafts. Component masses were 21.4 kg for the 1500 versus 15.6 kg for the 2500. The Lightweighting Technology used in the forward propeller shaft was to extrude steel tube with varied wall thickness in strategic locations. Image 3.8–4 is an example of an extruded tube with varied wall thicknesses. Due to similarities in component design and material, full percentage of the Silverado 1500 rea axle shaft mass reduction can be applied to the 2500. (Refer to Table 3-59).

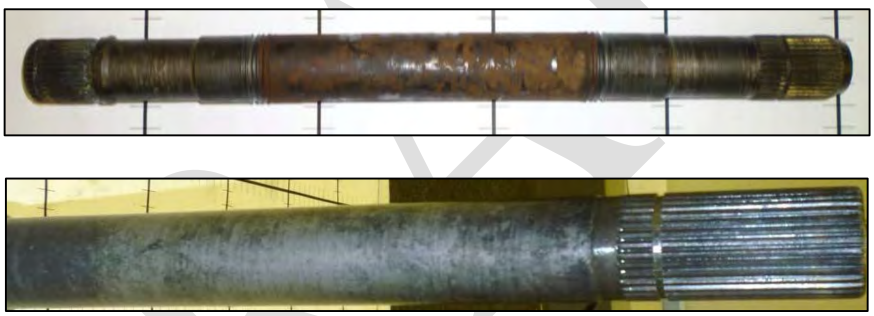
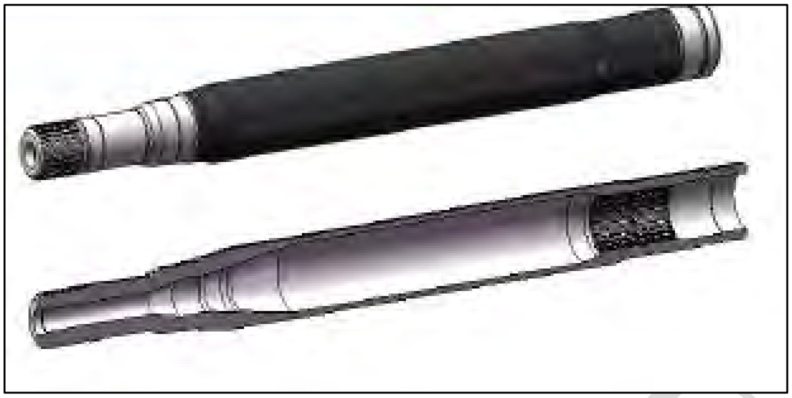


Image 3.8–3: Rear Axle Shaft Silverado 1500 (Top), Rear Axle Shaft Silverado 2500 (Bottom)
(Source: FEV, Inc.)

DRAFT



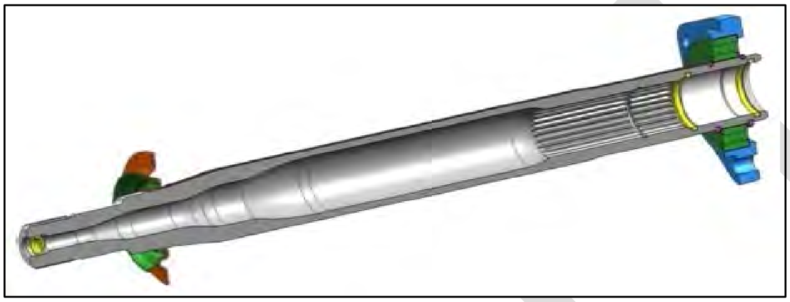


Image 3.8–4: Example of technology used on rear axle shaft of varied wall thicknesses
(Source: FEV, Inc.)

Rear Axle Differential Cover Plate

Shown in Image 3.8–5 are the Silverado 1500 and 2500 rear axle shaft cover plates. Component masses were 1.87 kg for the 1500 versus 1.91 kg for the 2500. The Lightweighting Technology used in the rear axle shaft cover plates was to change from stamped steel to stamped aluminum. Due to similarities in component design and material, full percentage of the Silverado 1500 rea axle differential cover plate mass reduction can be applied to the 2500. (Refer to Table 3-59).

Image 3.8–5: Rear Axle Cover Plate for the Silverado 1500 (Left) and Silverado 2500 (Right)
(Source: FEV, Inc.)

Rear Carrier Casting

Shown in Image 3.8–6 are the Silverado 1500 and 2500 rear carrier castings. Component masses were 5.25 kg for the 1500 versus 10.3 kg for the 2500. The Lightweighting Technology used in the rear carrier casting was the differential casting redesigned as a stamped housing and two identical halves are riveted together. The ring gear was then bolted onto the mounting flanges featured on the stamped housing. This change also allowed for mass reduction of the ring gear due to different design. Image 3.8–7 shows an example of the new stamped design. Due to similarities in component design and material, full percentage of the Silverado 1500 rear carrier casting mass reduction can be applied to the 2500. (Refer to Table 3-59).

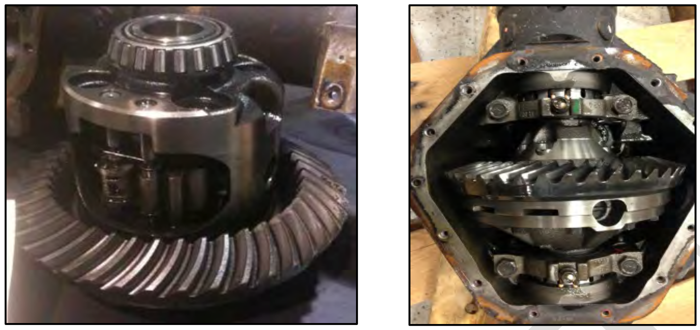


Image 3.8–6: Rear Carrier Casting for the Silverado 1500 (Right) and Silverado 2500 (Left)
(Source: FEV, Inc.)

Image 3.8–7: Example of new carrier
(Source: Schaeffler Group)

<u>Rear Carrier Ring Gear</u>

Shown in Image 3.8–8 are the Silverado 1500 and 2500 series rear carrier ring gears. Component masses were 4.48 kg for the 1500 versus 6.42 kg for the 2500. The Lightweighting Technology used in the rear carrier ring gear was the differential casting redesigned as a stamped housing and two identical halves are riveted together. The ring gear was then bolted onto the mounting flanges featured on the stamped housing. This change also allowed for mass reduction of the ring gear because of the different design. Due to similarities in component design and material, full percentage of the Silverado 1500 rear carrier ring gear mass reduction can be applied to the 2500. (Refer to Table 3-59).

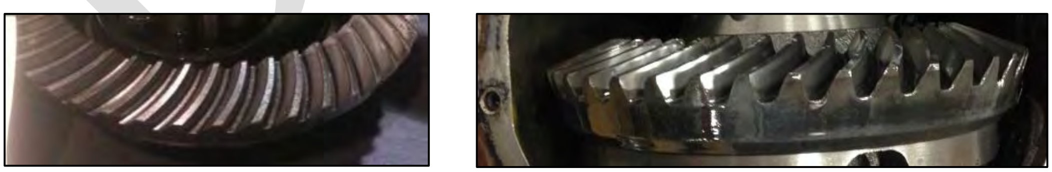


Image 3.8–8: Rear Carrier Ring Gear Silverado 1500 (Right), Rear Carrier Ring Gear Silverado 2500 (Left)
(Source: FEV, Inc.)

<u>Front Differential Output Shaft with Hub</u>

Shown in Image 3.8–9 are the Silverado 1500 and 2500 series front differential output shafts with hub. Component masses were 3.10 kg for the 1500 versus 3.99 kg for the 2500. The Lightweighting Technology used was to extrude steel tube with varied wall thickness in strategic locations and drill lightening holes in the hub face. Image 3.8–4 is an example of an extruded tube with varied wall

DRAFT

thicknesses. Due to similarities in component design and material, full percentage of the Silverado 1500 front differential output shaft mass reduction can be applied to the 2500. (Refer to Table 3-59).

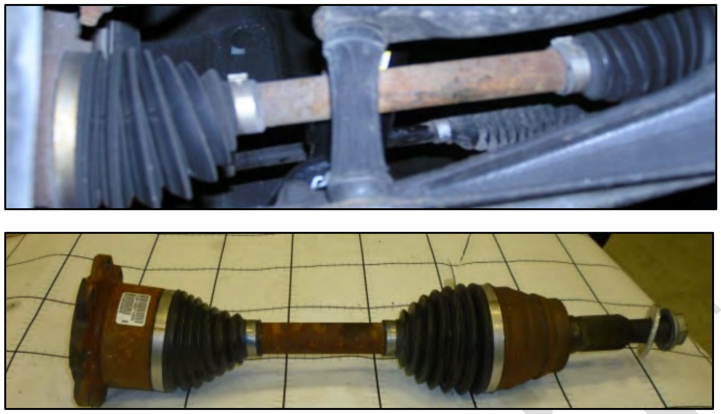


Image 3.8–9: Front Differential Output Shaft with Hub for the Silverado 1500 (Top) and Silverado 2500 (Bottom)
(Source: FEV, Inc.)

Front Carrier Casting

Shown in Image 3.8–10 are the Silverado 1500 and 2500 front carrier castings. Component masses were 4.16 kg for the 1500 versus 9.23 kg for the 2500. The Lightweighting Technology used in the front carrier casting was the differential casting redesigned as a stamped housing and two identical halves are riveted together. The ring gear was then bolted onto the mounting flanges featured on the stamped housing. This change also allowed for mass reduction of the front carrier casting due to different design. Image 3.8–11 shows an example of the new stamped design. Due to similarities in component design and material, full percentage of the Silverado 1500 front carrier casting mass reduction can be applied to the 2500. (Refer to Table 3-59).

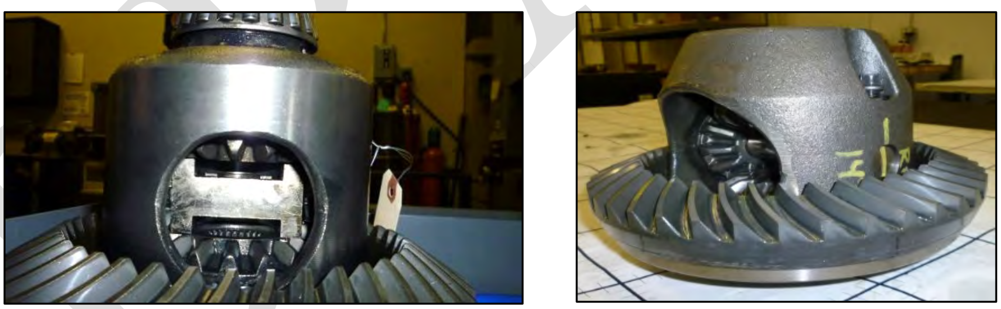
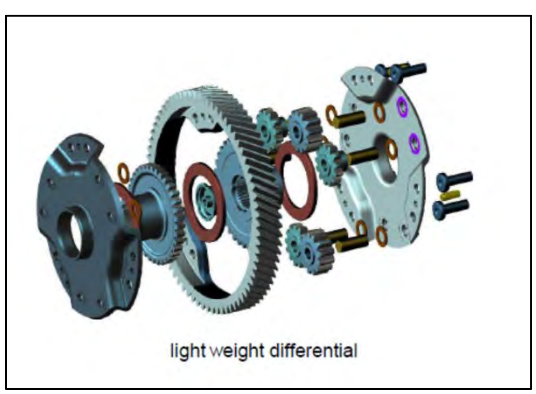


Image 3.8–10: Front Carrier Casting for the Silverado 1500 (Right) and Silverado 2500 (Left)
(Source: FEV, Inc.)



DRAFT

Image 3.8–11: New Lightweight Differential Example
(Source: Schaeffler Group)

Front Carrier Ring Gear

Shown in Image 3.8–12 are the Silverado 1500 and 2500 front carrier ring gears. Component masses were 3.33 kg for the 1500 versus 5.34 kg for the 2500. The Lightweighting Technology used in the front ring gear was the differential casting redesigned as a stamped housing and two identical halves are riveted together. The ring gear was then bolted onto the mounting flanges featured on the stamped housing. This change also allowed for mass reduction of the front carrier ring gear because of the different design. Due to similarities in component design and material, full percentage of the Silverado 1500 front ring gear casting mass reduction can be applied to the 2500.

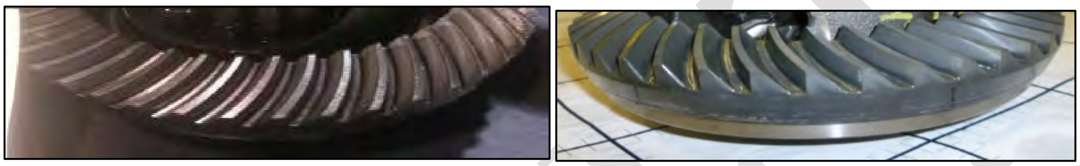


Image 3.8–12: Front Carrier Ring Gear for the Silverado 1500 (Right) and Silverado 2500 (Left)
(Source: FEV, Inc.)

Front Differential Mounting Bracket (Right and Left)

Shown in Image 3.8–13 are the Silverado 1500 and 2500 RH/LH front differential mounting brackets. Component masses were 6.23 kg for the 1500 versus 12.0 kg for the 2500. The Lightweighting Technology used in the front differential mounting brackets changed from forged steel to forged aluminum. Due to similarities in component design and material, full percentage of the Silverado 1500 rear differential mounting bracket mass reduction can be applied to the 2500. (Refer to Table 3-59).

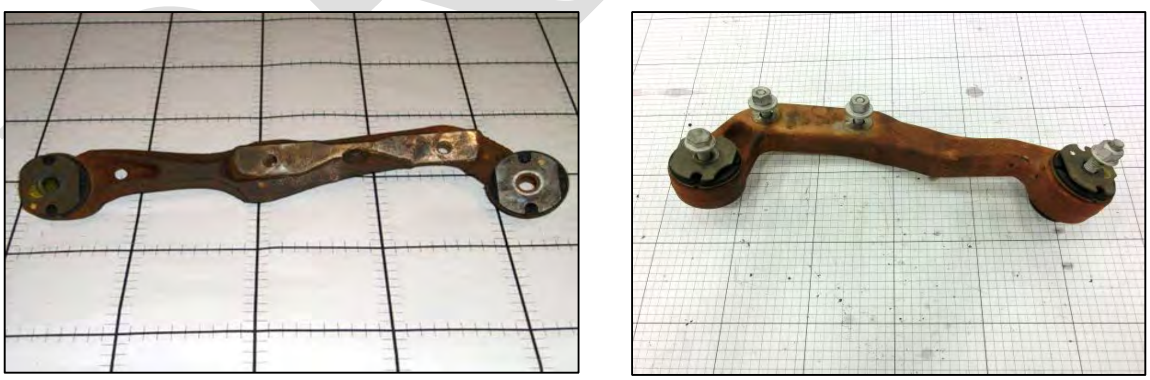


Image 3.8–13: Front Differential Mounting Bracket RH for the Silverado 1500 (Right) and Silverado 2500 (Left)
(Source: FEV, Inc.)

Front Half Shaft Axle Shaft

Shown in Image 3.8–14 are the Silverado 1500 and 2500 front half shaft axle shafts. Component masses were 4.49 kg for the 1500 versus 5.42 kg for the 2500. The Lightweighting Technology used in the front half shaft axle shaft was to extrude steel tube with varied wall thickness in strategic locations and drill lightening holes in the hub face. Image 3.8–15 shows were lightening holes

DRAFT

would be. Due to similarities in component design and material, full percentage of the Silverado 1500 front half shaft axle shaft mass reduction can be applied to the 2500. (Refer to Table 3-59).

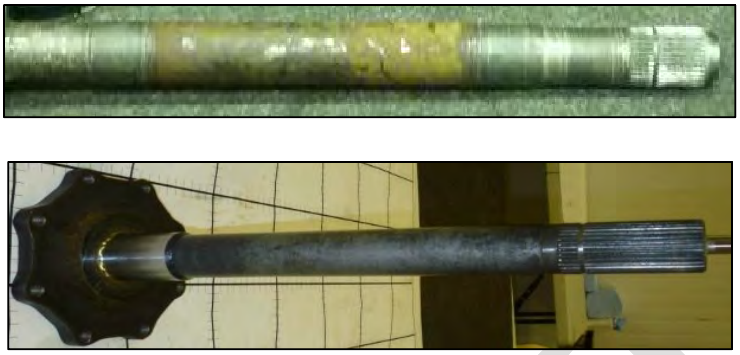


Image 3.8–14: Front Half Shaft Axle Shaft for the Silverado 1500 (Top) and Silverado 2500 (Bottom)
(Source: FEV, Inc.)

Image 3.8–15: Front Half Shaft Hub with locations for drilling lightening holes
(Source: FEV, Inc.)

3.8.1.4 System Comparison, Silverado 2500

Table 3-60 summarizes the Silverado 1500 and 2500 Lightweighting results. A majority of the components were visually the same between the driveline systems.

Table 3-60: Driveline System Comparison, Silverado 1500 and 2500

DRAFT

System	Description	Mass Base "kg" (1)	Mass Reduction New Tech "kg" (1)	Mass Reduction Comp "kg" (1)	Mass Reduction Total "kg" (1)	System Mass Reduction "%"	Cost Impact New Tech "$" (2)	Cost Impact Comp "$" (2)	Cost Impact Total "$" (2)	Cost/ Kilogram Total "$/kg"
		Net Value of Mass Reduction								
05	**Driveline System**									
05	Silverado 1500	183.82	20.42	0.00	20.42	11.11%	$37.98	$0.00	$38.01	$1.86
05	Silverado 2500	288.89	25.11	0.00	25.11	8.69%	$48.71	$0.00	$48.71	$1.94

DRAFT

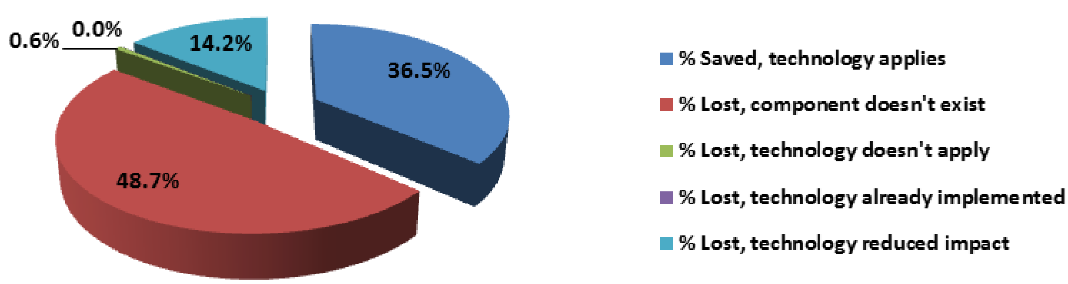
3.8.2 Mercedes Sprinter 311 CDi Analysis

Table 3-61 summarizes mass and cost impact of Silverado 1500 Lightweighting technologies applied to the Mercedes Sprinter 311 CDi. Total Driveline System mass savings was 7.45 kg at a cost decrease of $17.70, or $2.38 per kg.

Table 3-61: Mass-Reduction and Cost Impact for Driveline System, Mercedes Sprinter

System	Subsystem	Sub-Subsystem	Description	Net Value of Mass Reduction: Mass Reduction New Tech "kg" (1)	Mass Reduction Comp "kg" (1)	Mass Reduction Total "kg" (1)	Cost Impact New Tech "$" (2)	Cost Impact Comp "$" (2)	Cost Impact Total "$" (2)	Cost/ Kilogram Total "$/kg"	Vehicle Mass Reduction Total "%"
05	00	00	**Driveline System**								
05	01	00	Driveshaft Subsystem	0.00	0.00	0.00	$0.00	$0.00	$0.00	$0.00	0.00%
05	02	00	Rear Drive Housed Axle Subsystem	7.45	0.00	7.45	$17.70	$0.00	$17.70	$2.38	0.35%
05	03	00	Front Drive Housed Axle Subsystem	0.00	0.00	0.00	$0.00	$0.00	$0.00	$0.00	0.00%
05	04	00	Front Drive Half-Shafts Subsystem	0.00	0.00	0.00	$0.00	$0.00	$0.00	$0.00	0.00%
05	07	00	4WD Driveline Control Subsystem	0.00	0.00	0.00	$0.00	$0.00	$0.00	$0.00	0.00%
				7.45 (Decrease)	**0.00** (Decrease)	**7.45** (Decrease)	**$17.70** (Decrease)	**$0.00**	**$17.70** (Decrease)	**$2.38** (Decrease)	**0.35%**

Mass Savings, Select Vehicle, New Technology "kg"	**7.45**
Mass Savings, Silverado 1500, New Technology "kg"	**20.42**
Mass Savings Select Vehicle/Mass Savings 1500	**36.5%**



*SMS not included - has no significant impact on perecent contributions

3.8.2.1 System Scaling Analysis

The Mercedes Sprinter 311 CDi Driveline components were reviewed for compatibility with Lightweighting technologies. The results of this analysis are listed in Table 3-62.

Table 3-62: System Scaling Analysis Driveline System, Mercedes Sprinter

Silverado 1500							Select Vehicle			
System	Subsystem	Sub-Subsystem	Component/Assembly	Base Mass	Mass Savings New Tech	% of Mass Savings New Tech	Tech Applies	Base Mass	Mass Savings New Tech	Notes
05			**Driveline System**	**183.82**	**20.42**	**11%**			**7.45**	
05	01	05	Forward Propeller Shaft	3.55	2.10	59%	no			Tech does **NOT** Apply: No front shaft
05	02	01	Rear Axle Sleeves	10.92	2.18	20%	yes	14.15	2.83	Tech **DOES** Apply: lightin shaft by making hollow with variation of inner wall thickness and putting lighting holes in hub
05	02	01	Rear Axle Shaft w/ Hub	21.38	4.28	20%	yes	4.06	0.81	Tech **DOES** Apply: lightin shaft by making hollow with variation of inner wall thickness and putting lighting holes in hub
05	02	01	Rear Axle Differential Cover Plate	1.88	1.10	59%	yes	1.17	0.69	Tech **DOES** Apply: Change from steel to aluminum
05	02	05	Rear Carrier Casting	5.25	1.58	30%	yes	8.00	2.40	Tech **DOES** Apply: Change from steel casting to sheet steel welded assy
05	02	05	Rear Ring Gear	4.48	1.21	27%	yes	2.67	0.72	Tech **DOES** Apply: Change from stadard gear manufacturing to cold form with no machining
05	02	05	Rear Ring Gear Mounting Bolts	0.32	0.13	40%	no			Tech does **NOT** Apply:
05	03	04	Front Differential Output Shaft w/ Hub	3.10	0.88	28%	no			Tech does **NOT** Apply: No front drive system
05	03	04	Front Carrier	4.16	1.25	30%	no			Tech does **NOT** Apply: No front drive system
05	03	04	Front Ring Gear	3.34	1.10	33%	no			Tech does **NOT** Apply: No front drive system
05	03	04	Front Ring Gear Mounting Bolts	0.31	0.12	40%	no			Tech does **NOT** Apply: No front drive system
05	03	04	Front Differential Mounting Bracket - LH	3.60	1.81	50%	no			Tech does **NOT** Apply: No front drive system
05	03	04	Front Differential Mounting Bracket - RH	2.64	1.33	50%	no			Tech does **NOT** Apply: No front drive system
05	04	01	Front Axle Shaft	4.50	1.12	25%	no			Tech does **NOT** Apply: No front drive system
05	04	01	Front Wheel Hub	5.40	0.23	4%	no			Tech does **NOT** Apply: No front drive system

If the original Silverado 1500 mass reduction concept idea was not able to be applied to the comparison vehicle it is not described in the section below.

Components with significant mass savings identified on the Mercedes Sprinter included the rear axle hubs, rear differential cover plate, and rear carrier rear ring gear. Image 3.8–16 shows the Mercedes Sprinter 311 CDi driveline components.

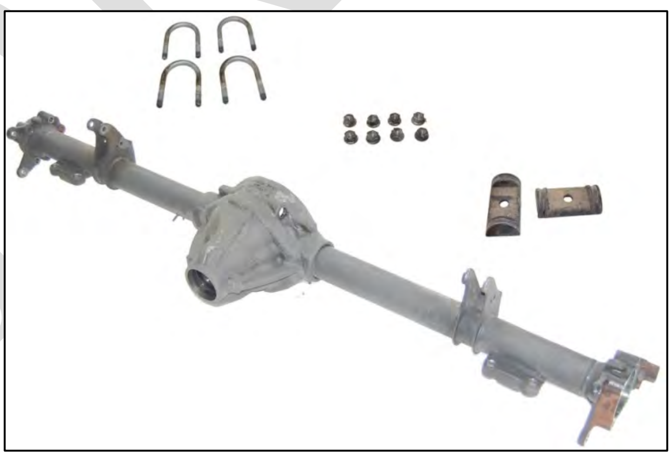


Image 3.8–16: Mercedes Sprinter 311 CDi Driveline rear axle
(Source: www.A2mac1.com)

<u>Rear Axle Sleeves</u>

Shown in Image 3.8–17 are the Silverado 1500 and Mercedes Sprinter 311 CDi rear axle sleeves. Component masses were 10.9 kg for the 1500 versus 14.2 kg for the Mercedes Sprinter 311 CDi.

The Lightweighting Technology used in the rear axle sleeves was to extrude steel tube with varied wall thickness in strategic locations. Due to similarities in component design and material, full percentage of the Silverado 1500 rear axle sleeve mass reduction can be applied to the Sprinter. (Refer to Table 3-62).

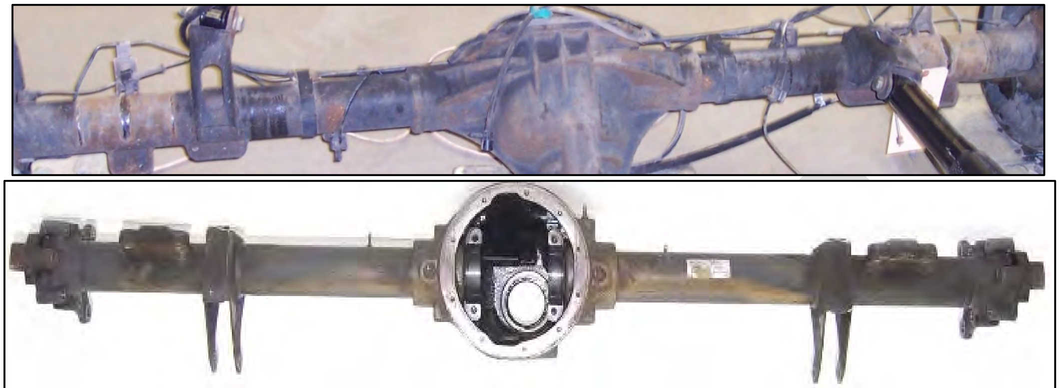


Image 3.8–17: Rear Axle Sleeve for the Silverado 1500 (Top) and Mercedes Sprinter 311 CDi (Bottom)
(Source: FEV, Inc. and www.A2mac1 database)

<u>Rear Axle Shaft with Hub</u>

Shown in Image 3.8–18 are the Silverado 1500 and Mercedes Sprinter 311 CDi rear axle shafts with hubs. Component masses were 21.4 kg for the 1500 versus 4.06 kg for the Mercedes Sprinter 311 CDi. The Lightweighting Technology used was to extrude steel tube with varied wall thickness in strategic locations. Due to similarities in component design and material, full percentage of the Silverado 1500 rear axle shaft mass reduction can be applied to the Sprinter. (Refer to Table 3-62).

Image 3.8–18: Rear Axle Shaft for the Silverado 1500 (Top) and Mercedes Sprinter 311 CDi (Bottom)
(Source: FEV, Inc. and www.A2mac1 database)

DRAFT

Rear Axle Differential Cover Plate

Shown in Image 3.8–19 are the Silverado 1500 and Mercedes Sprinter 311 CDi rear axle shaft cover plates. Component masses were 1.87 kg for the 1500 versus 1.17 kg for the Mercedes Sprinter 311 CDi. The Lightweighting Technology used in the rear axle shaft cover plates was to change from stamped steel to stamped aluminum. Due to similarities in component design and material, full percentage of the Silverado 1500 rear axle differential cover plate mass reduction can be applied to the Sprinter. (Refer to Table 3-62).

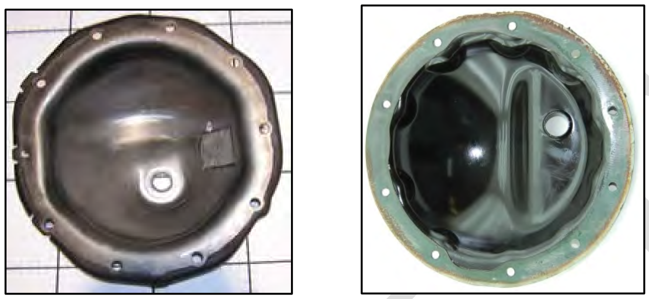


Image 3.8–19: Rear Axle Cover Plates for the Silverado 1500 (Top) and Mercedes Sprinter 311 CDi (Bottom)
(Source: FEV, Inc. and www.A2mac1 database)

Rear Carrier Casting

Shown in Image 3.8–20 are the Silverado 1500 and Mercedes Sprinter 311 CDi rear carrier castings. Component masses were 5.25 kg for the 1500 versus 8.00 kg for the Mercedes Sprinter 311 CDi. The Lightweighting Technology used in the rear carrier casting was the differential casting redesigned as a stamped housing and two identical halves are riveted together. The ring gear was then bolted onto the mounting flanges featured on the stamped housing. This change also allowed for mass reduction of the ring gear due to different design. Image 3.8–21 shows an example of the new stamped design. Due to similarities in component design and material, full percentage of the Silverado 1500 rear carrier casting mass reduction can be applied to the Sprinter. (Refer to Table 3-62).

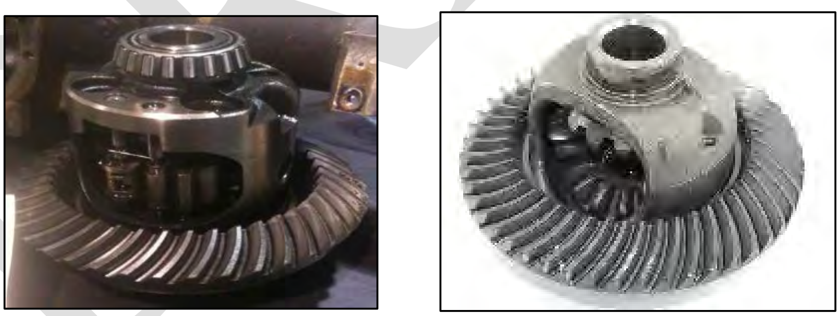


Image 3.8–20: Rear Carrier Casting for the Silverado 1500 (Left) and Mercedes Sprinter 311 CDi (Right)
(Source: FEV, Inc. and www.A2mac1 database)

DRAFT

Image 3.8–21: New Carrier Example
(Source: Schaeffler Group)

<u>Rear Carrier Ring Gear</u>

Shown in Image 3.8–22 are the Silverado 1500 and Mercedes Sprinter 311 CDi rear carrier ring gears. Component masses were 4.48 kg for the 1500 versus 2.67 kg for the Mercedes Sprinter 311 CDi. The Lightweighting Technology used in the rear carrier ring gear was the differential casting redesigned as a stamped housing and two identical halves riveted together. The ring gear was then bolted onto the mounting flanges featured on the stamped housing. This change also allowed for mass reduction of the ring gear because of the different design. Due to similarities in component design and material, full percentage of the Silverado 1500 rear carrier ring gear mass reduction can be applied to the Sprinter. (Refer to Table 3-62).

Image 3.8–22: Rear Carrier Ring Gear for the Silverado 1500 (Left) and Mercedes Sprinter 311 CDi (Right)
(Source: FEV, Inc. and www.A2mac1 database)

DRAFT

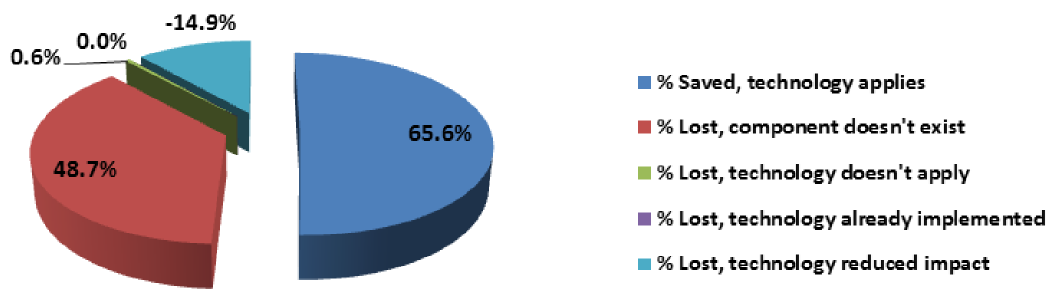
3.8.3 Renault Master 2.3 DCi

The following table summarizes mass and cost impact of Silverado 1500 Lightweighting technologies applied to the Renault Master 2.3 DCi. Total driveline system mass savings was 13.38 kg at a cost decrease of $35.93, or $2.68 per kg.

Table 3-63: Mass-Reduction and Cost Impact for Driveline System, Renault Master

				Net Value of Mass Reduction							
System	Subsystem	Sub-Subsystem	Description	Mass Reduction New Tech "kg" (1)	Mass Reduction Comp "kg" (1)	Mass Reduction Total "kg" (1)	Cost Impact New Tech "$" (2)	Cost Impact Comp "$" (2)	Cost Impact Total "$" (2)	Cost/ Kilogram Total "$/kg"	Vehicle Mass Reduction Total "%"
05	00	00	**Driveline System**								
05	01	00	Driveshaft Subsystem	0.00	0.00	0.00	$0.00	$0.00	$0.00	$0.00	0.00%
05	02	00	Rear Drive Housed Axle Subsystem	13.38	0.00	13.38	$35.93	$0.00	$35.93	$2.68	0.57%
05	03	00	Front Drive Housed Axle Subsystem	0.00	0.00	0.00	$0.00	$0.00	$0.00	$0.00	0.00%
05	04	00	Front Drive Half-Shafts Subsystem	0.00	0.00	0.00	$0.00	$0.00	$0.00	$0.00	0.00%
05	07	00	4WD Driveline Control Subsystem	0.00	0.00	0.00	$0.00	$0.00	$0.00	$0.00	0.00%
				13.38 (Decrease)	**0.00**	**13.38** (Decrease)	**$35.93** (Decrease)	**$0.00**	**$35.93** (Decrease)	**$2.68** (Decrease)	**0.57%**

Mass Savings, Select Vehicle, New Technology "kg"	**13.38**
Mass Savings, Silverado 1500, New Technology "kg"	**20.42**
Mass Savings Select Vehicle/Mass Savings 1500	**65.6%**



*SMS not included - has no significant impact on perecent contributions

3.8.3.1 System Scaling Analysis

The Renault Master 2.3 DCi driveline components were reviewed for compatibility with Lightweighting technologies. The results of this analysis are listed in Table 3-64.

Table 3-64: System Scaling Analysis Driveline System, Renault Master

Silverado 1500							Select Vehicle			
System	Subsystem	Sub-Subsystem	Component/Assembly	Base Mass	Mass Savings New Tech	% of Mass Savings New Tech	Tech Applies	Base Mass	Mass Savings New Tech	Notes
05			**Driveline System**	**183.82**	**20.42**	**11%**			**13.38**	
05	01	05	Forward Propeller Shaft	3.55	2.10	59%	no			Tech does **NOT** Apply: No front shaft
05	02	01	Rear Axle Sleeves	10.92	2.18	20%	yes	12.91	2.58	Tech **DOES** Apply: lightin shaft by making hollow with variation of inner wall thickness and putting lighting holes in hub
05	02	01	Rear Axle Shaft w/ Hub	21.38	4.28	20%	yes	25.83	5.17	Tech **DOES** Apply: lightin shaft by making hollow with variation of inner wall thickness and putting lighting holes in hub
05	02	01	Rear Axle Differential Cover Plate	1.88	1.10	59%	yes	1.92	1.13	Tech **DOES** Apply: Change from steel to aluminum
05	02	05	Rear Carrier Casting	5.25	1.58	30%	yes	8.50	2.55	Tech **DOES** Apply: Change from steel casting to sheet steel welded assy
05	02	05	Rear Ring Gear	4.48	1.21	27%	yes	7.24	1.96	Tech **DOES** Apply: Change from stadard gear manufacturing to cold form with no machining
05	02	05	Rear Ring Gear Mounting Bolts	0.32	0.13	40%	no			Tech does **NOT** Apply:
05	03	04	Front Differential Output Shaft w/ Hub	3.10	0.88	28%	no			Tech does **NOT** Apply: No front drive system
05	03	04	Front Carrier	4.16	1.25	30%	no			Tech does **NOT** Apply: No front drive system
05	03	04	Front Ring Gear	3.34	1.10	33%	no			Tech does **NOT** Apply: No front drive system
05	03	04	Front Ring Gear Mounting Bolts	0.31	0.12	40%	no			Tech does **NOT** Apply: No front drive system
05	03	04	Front Differential Mounting Bracket - LH	3.60	1.81	50%	no			Tech does **NOT** Apply: No front drive system
05	03	04	Front Differential Mounting Bracket - RH	2.64	1.33	50%	no			Tech does **NOT** Apply: No front drive system
05	04	01	Front Axle Shaft	4.50	1.12	25%	no			Tech does **NOT** Apply: No front drive system
05	04	01	Front Wheel Hub	5.40	0.23	4%	no			Tech does **NOT** Apply: No front drive system

If the original Silverado 1500 mass reduction concept idea was not able to be applied to the comparison vehicle it is not described in the section below.

Components with significant mass savings identified on the Renault Master 2.3 DCi included the rear axle hubs, rear differential cover plate, and rear carrier rear ring gear. Image 3.8–23 shows the Renault Master 2.3 DCi driveline components.

DRAFT

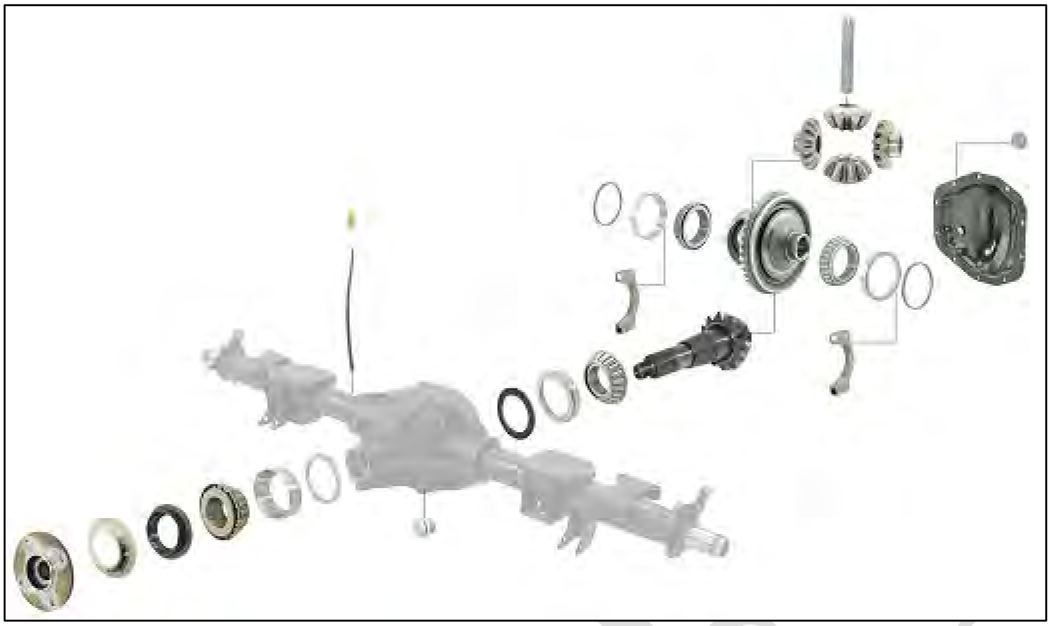


Image 3.8–23: Renault Master 2.3 DCi Rear Driveline
(Source: A2mac1.com)

<u>Rear Axle Sleeves</u>

Shown in Image 3.8–24 are the Silverado 1500 and Renault Master 2.3 DCi rear axle shafts. Component masses were 10.9 kg for the Silverado 1500 versus 12.9 kg for the Renault Master 2.3 DCi. The Lightweighting Technology used in the forward propeller shaft was to extrude steel tube with varied wall thickness in strategic locations. Due to similarities in component design and material, full percentage of the Silverado 1500 rear axle sleeves mass reduction can be applied to the Renault. (Refer to Table 3-64).

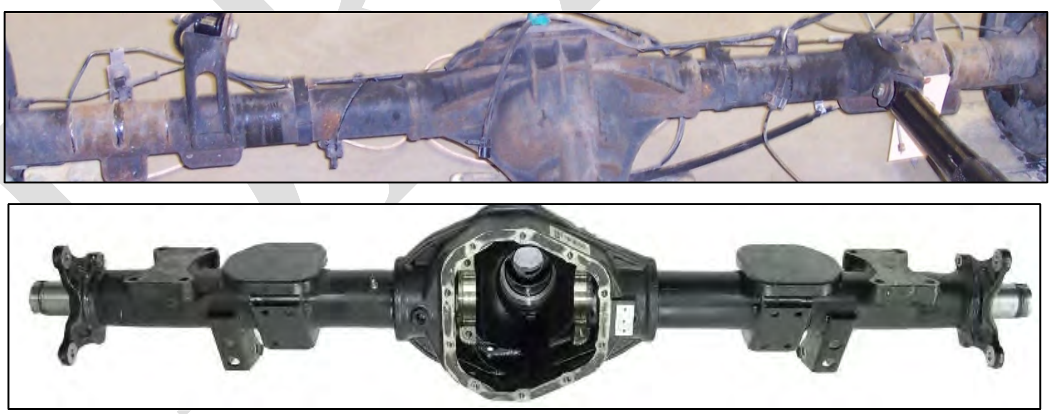


Image 3.8–24: Rear Axle Sleeves for the Silverado 1500 (Top) and Renault Master 2.3 DCi (Bottom)
(Source: FEV, Inc. and www.A2mac1 database)

DRAFT

Rear Axle Shaft with Hub

Shown in Image 3.8–25 are the Silverado 1500 and Renault Master 2.3 DCi rear axle shafts with hubs. Component masses were 21.4 kg for the 1500 versus 25.8 kg for the Renault Master 2.3 DCi. The Lightweighting Technology used was to extrude steel tube with varied wall thickness in strategic locations. Due to similarities in component design and material, full percentage of the Silverado 1500 rear axle shaft mass reduction can be applied to the Renault. (Refer to Table 3-64).

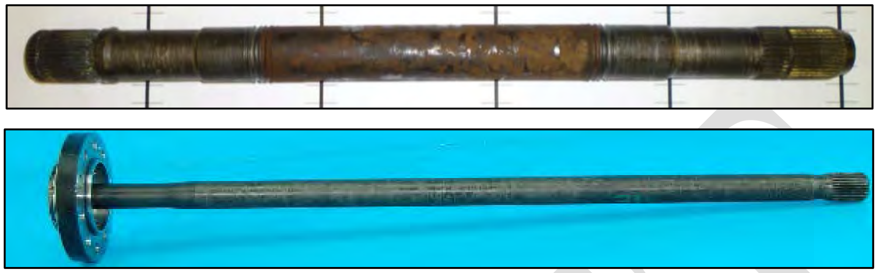


Image 3.8–25: Rear Axle Shaft for the Silverado 1500 (Top) and Renault Master 2.3 DCi (Bottom)
(Source: FEV, Inc. and www.A2mac1 database)

Rear Axle Differential Cover Plate

Shown in Image 3.8–26 are the Silverado 1500 and Renault Master 2.3 DCi rear axle shaft cover plates. Component masses were 1.87 kg for the 1500 versus 1.92 kg for the Renault Master 2.3 DCi. The lightweighting technology used in the rear axle shaft cover plates was to change from stamped steel to stamped aluminum. Due to similarities in component design and material, full percentage of the Silverado 1500 rear axle differential cover plate mass reduction can be applied to the Renault. (Refer to Table 3-64).

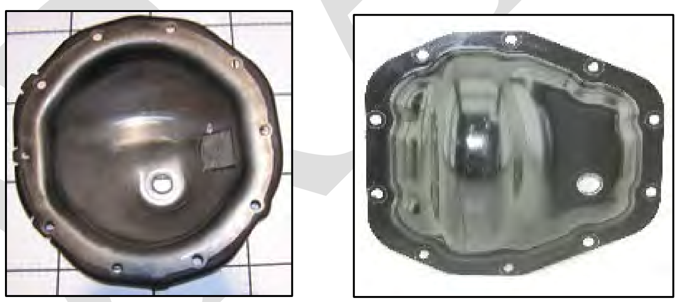


Image 3.8–26: Rear Axle Cover Plate for the Silverado 1500 (Left) and Renault Master 2.3 DCi (Right)
(Source: FEV, Inc. and www.A2mac1 database)

Rear Carrier Casting

Shown in Image 3.8–27 are the Silverado 1500 and Renault Master 2.3 DCi rear carrier castings. Component masses were 5.25 kg for the 1500 versus 8.50 kg for the Renault Master 2.3 DCi. The lightweighting technology used in the rear carrier casting was the differential casting redesigned as a stamped housing and two identical halves riveted together. The ring gear was then bolted onto the mounting flanges featured on the stamped housing. This change also allowed for mass reduction of the ring gear because of the different design. Image 3.8–28 shows an example of the new stamped design. Due to similarities in component design and material, full percentage of the Silverado 1500 rear carrier casting mass reduction can be applied to the Renault. (Refer to Table 3-64).

DRAFT

Image 3.8–27: Rear Carrier Casting for the Silverado 1500 (Left) and Renault Master 2.3 DCi (Right)
(Source: FEV, Inc. and www.A2mac1 database)

Image 3.8–28: New Carrier Example
(Source: Schaeffler Group)

Rear Carrier Ring Gear

Shown in Image 3.8–29 are the Silverado 1500 and Renault Master 2.3 DCi rear carrier ring gears. Component masses were 4.48 kg for the 1500 versus 7.24 kg for the Renault Master 2.3 DCi. The lightweighting technology used in the rear carrier ring gear was redesigning the differential casting as a stamped housing and two identical halves are riveted together. The ring gear was then bolted onto the mounting flanges featured on the stamped housing. This change also allowed for mass reduction of the ring gear because of the different design. Due to similarities in component design and material, full percentage of the Silverado 1500 rear carrier ring gear mass reduction can be applied to the Renault. (Refer to Table 3-64).

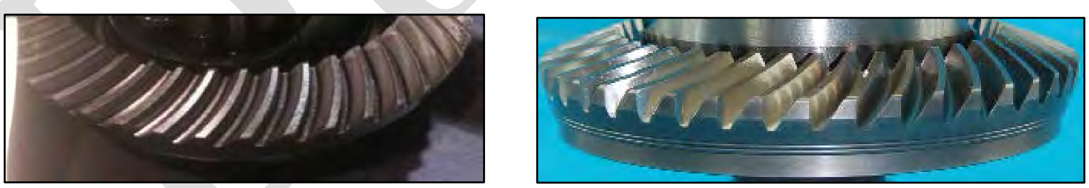


Image 3.8–29: Rear Carrier Ring Gear for the Silverado 1500 (Left) and Renault Master 2.3 DCi (Right)
(Source: FEV, Inc. and www.A2mac1 database)

3.9 BRAKE SYSTEM

3.9.1 Silverado 1500 Summary

This report details FEV's work and findings relative to the Brake System to prove the design concept, cost effectiveness, and manufacturing feasibility that can meet the function and performance of the baseline vehicle (2011 Chevrolet Silverado). In Table 3-65 is a summary of the calculated mass reduction and cost impact for each sub-subsystem evaluated. This project recorded

DRAFT

a system mass reduction of 46.65 kg system at a cost increase of $160.04 or $3.43 per kg. The contribution of the Brake System to the overall vehicle mass reduction was 1.96%.

Table 3-65: Brake System Mass Reduction Summary, Silverado 1500

				Net Value of Mass Reduction					
System	Subsystem	Sub-Subsystem	Description	Base Mass "kg"	Mass Reduction "kg" (1)	Cost Impact NIDMC "$" (2)	Average Cost/ Kilogram "$/kg" (2)	Mass Reduction "%"	Vehicle Mass Reduction "%"
06	00	00	Brake System						
06	**03**	**00**	**Front Rotor/Drum and Shield Subsystem**	**42.98**	**22.82**	**-57.95**	**-2.54**	**53.11%**	**0.96%**
06	03	01	Front Rotor	23.32	12.43	-68.42	-5.51	53.28%	0.52%
06	03	02	Caliper Housing	9.61	6.41	6.72	1.05	66.75%	0.27%
06	03	02	Caliper Mounting Bracket	4.36	2.98	1.96	0.66	68.27%	0.12%
06	03	00	Other Components...	5.69	1.01	1.79	1.77	17.72%	0.04%
06	**04**	**00**	**Rear Rotor/Drum and Shield Subsystem**	**34.26**	**18.26**	**-60.03**	**-3.29**	**53.31%**	**0.77%**
06	04	07	Rear Drum	22.09	14.15	-67.42	-4.76	64.08%	0.59%
06	04	08	Backing Plate	5.79	2.78	1.59	0.57	48.12%	0.12%
06	04	08	Wheel Cylinder Housing	0.92	0.46	6.11	13.23	50.44%	0.02%
06	04	00	Other Components...	5.46	0.86	-0.31	-0.36	15.73%	0.04%
06	**05**	**00**	**Parking Brake and Actuation Subsystem**	**4.70**	**1.45**	**-19.85**	**-13.68**	**30.87%**	**0.06%**
06	05	01	Parking Brake Lever & Frame	1.61	0.93	-3.88	-4.16	57.84%	0.04%
06	05	00	Other Components...	3.09	0.52	-15.97	-30.79	16.79%	0.02%
06	**06**	**00**	**Brake Actuation Subsystem**	**10.66**	**2.53**	**-1.32**	**-0.52**	**23.72%**	**0.11%**
06	06	02	Brake Pedal Arm	1.30	0.56	-1.11	0.00	42.56%	0.02%
06	06	02	Brake Pedal Frame	1.70	0.99	1.14	1.16	57.84%	0.04%
06	06	02	Brake Pedal Bracket Assy	0.97	0.56	-1.78	-3.17	57.88%	0.02%
06	06	00	Other Components...	6.69	0.43	0.43	1.02	6.40%	0.02%
06	**07**	**00**	**Power Brake Subsystem**	**4.24**	**1.58**	**-20.89**	**-13.21**	**37.33%**	**0.07%**
06	07	01	Vacuum Booster Assembly	4.24	1.58	-20.89	-13.21	37.33%	0.07%
06	07	00	Other Components...	0.00	0.00	0.00	0.00	0.00%	0.00%
06	**09**	**00**	**Brake Controls Subsystem**	**4.17**	**0.00**	**0.00**	**0.00**	**0.00%**	**0.00%**
06	09	01	Brake Controls	4.17	0.00	0.00	0.00	0.00%	0.00%
				101.01	46.65 (Decrease)	-160.04 (Increase)	-3.43 (Increase)	46.18%	1.96%

(1) "+" = mass decrease, "-" = mass increase
(2) "+" = cost decrease, "-" = cost increase

Columns in the "Net Value of Mass Reduction" chart above may contain combined masses of assembly hardware such as nuts, bolt, washer, etc. that were not mass reduced at the component level, and may not match base mass and mass reduction totals in text below component reduction weights.

The major components contributing to the mass reduction within the Front Rotor/Drum and Shield Subsystem were the front rotor, caliper housing, and caliper mounting bracket.

Front Rotor: The mass reduction idea for the front rotor involved making eight different changes to the baseline design. The changes included normalizing to the 2006 Dodge Ram, two-piece rotor design, drilling clearance holes in the rotor hat top and sides, changing disc material from steel to an aluminum metal matrix, changing cooling vanes from a straight to directional configuration, adding venting slots to the disc face, and adding cross-drilled holes to the rotor disc. The individual baseline component mass was 11.7 kg and the redesign mass was 5.45 kg, resulting in an overall mass savings of 12.4 kg, or 53.3% compared to the steel units.

Each of these individual rotor ideas is not unique; however, it is unique to see all of them incorporated in a single design. This redesigned rotor incorporates all the latest rotor lightweighting ideas into a single unit that captures all the potential weight-saving opportunities.

Caliper Housing: The mass reduction ideas for the caliper housing were to normalize to the 2002 Chevrolet Avalanche 1500 and then change the component material from cast iron to cast magnesium. The individual baseline component mass was 4.80 kg with the redesign mass 1.60 kg, resulting in an overall mass savings of 6.41 kg, or 66.7%, compared to the steel units.

For the caliper housing, as well as several other brake components, magnesium was the redesign material of choice. While this is not popular within the automotive industry in the United States, it is becoming much more common with the European OEMs.

Magnesium has long been used in commercial and specialty automotive vehicles. Racing cars have used magnesium parts since the 1920s. Volkswagen used, in 1936, approximately 20.0 kg of magnesium in the power train system for its Beetle.

Over the past 10 years there has been significant growth in the high-pressure die-casting sector as OEMs search for light-weighting opportunities. With advances in the creation of magnesium alloys, there are many applications for the automotive industry – particularly within brake and suspension systems.

In Europe, Volkswagen, Chrysler, BMW, Ford, and Jaguar are using magnesium as a structural lightweight material. Presently, around 14 kg of magnesium are used in the VW Passat and Audi A4 and A6 for transmission castings. Other applications include instrument panels, intake manifolds, cylinder head covers, inner boot lid sections, and steering components. In North America, the full-size GM Savana and Express vans use up to 26.0 kg of magnesium alloy.

Caliper Mounting Bracket: The mass reduction ideas for the caliper mounting bracket were to first normalize to the 2002 Chevrolet Avalanche 1500 and then change the component material from cast iron to cast magnesium. The individual baseline component mass was 2.18 kg and the redesign mass was 0.69 kg, resulting in an overall mass savings of 2.98 kg or 68.3% for both brackets compared to the steel units.

The major components contributing to the mass reduction within the Rear Rotor/Drum and Shield Subsystem were the rear drum, backing plate, and the wheel cylinder housing.

Rear Drum: The mass reduction idea for the rear drum was a combination of six different changes to the baseline design. These changes included changing the baseline material from cast iron to aluminum metal matrix composite, adding cooling fins on the external surface, cross-drilling holes in the mounting surface, cross-drilling holes in the side surface, and adding cooling slots to the side surfaces. The individual baseline component mass was 11.1 kg and the redesign mass 3.97 kg, resulting in an overall mass savings of 14.2 kg or 64.1% compared to the baseline units.

Backing Plate: The mass reduction idea for the backing plate involved changing the baseline material from steel to aluminum and then to add cooling slots to the back surface. The individual baseline component mass was 2.9 kg while the redesign mass was 1.5 kg, resulting in an overall mass savings of 4.4 kg for both backing plates or 48.3% compared to the steel units.

Wheel Cylinder Housing: The mass reduction idea for the wheel cylinder housing was to change the baseline material from cast iron to cast aluminum. The individual baseline component mass was 0.46 kg while the redesign mass is 0.23 kg resulting in an overall mass savings of 0.5 kg for both backing plates or 50.0% compared to the cast iron units.

DRAFT

The major component contributing to the mass reduction within the Parking Brake and Actuation Subsystem was the park brake lever and frame.

Park Brake Lever and Frame: The mass reduction idea for the park brake lever and frame was to change the parking brake mounting frame, cover plate, and lever from stamped steel to cast magnesium. The baseline mass for all three components was 1.61 kg and the redesign mass 0.68 kg, resulting in an overall mass savings of 0.93 kg or 57.8% compared to the stamped steel units.

The major components contributing to the mass reduction within the Brake Actuation Subsystem were the brake pedal arm, brake pedal frame, and brake pedal bracket.

Brake Pedal Arm: The mass reduction idea for the brake pedal arm was to change the baseline component material from stamped steel to glass-filled nylon. The total baseline mass was 1.5 kg and the redesign mass 0.75 kg, resulting in an overall mass savings of 0.75 kg, or 50.0%, compared to the steel unit.

Brake Pedal Frame: The mass reduction idea for the brake pedal frame was to change it from a multi-piece stamped steel welded construction to a cast magnesium design. The baseline mass was 1.7 kg and the redesign mass was 0.72 kg, resulting in an overall mass savings of 0.98 kg or 57.6%.

Brake Pedal Bracket Assembly: The mass reduction idea for the brake pedal bracket assembly was to change the side plates from stamped steel to cast magnesium. The baseline assembly mass of 1.54 kg versus the redesigned assembly mass of 0.98 kg resulted in an overall mass savings of 0.60 kg, or 36.4%.

The major component contributing to the mass reduction within the Power Brake Subsystem was the vacuum booster assembly.

Vacuum Booster Assembly: The mass reduction ideas for the vacuum booster assembly affected each internal plate as well as the outer housings. These ideas included changing the front housing, rear housing, front backing plate, and the spacer ring from stamped steel to cast magnesium. The rear backing plate idea changed the baseline material from stamped steel to stamped aluminum. The actuator shaft changes from steel to titanium and the mounting studs change from steel to aluminum. The baseline booster unit had a mass of 4.2 kg and the redesign mass was 2.7 kg, resulting in an overall mass savings of 1.5 kg, or 35.7%, compared to the steel unit.

3.9.2 Silverado 2500 Analysis

3.9.2.1 System Architecture

Front Rotor/Drum and Shield Subsystem: The Chevrolet Silverado 2500 front rotor/drum and shield subsystem used a similar architecture as the 1500. Both utilized a floating cast iron brake caliper with double pistons, brake pads, a cast iron caliper mounting bracket, a cast iron rotor, and a stamped steel splash shield.

Rear Rotor/Drum and Shield Subsystem: The Chevrolet Silverado 2500 rear rotor/drum and shield subsystem architecture was unique compared to the 1500. The 2500 utilized a cast iron drum-in-hat brake drum and rotor which allowed it to use brake shoes for the parking brake function and brake pads for stopping the vehicle, brake shoes with associated mounting hardware, brake pads, a cast iron brake caliper with double pistons, a cast iron caliper mounting bracket, and a stamped steel dust shield.

Parking Brake and Actuation Subsystem: As mentioned, the Silverado 2500 used a drum-in-hat park brake design that separated the parking brake function from the vehicle stopping function. The parking brake was engaged by a cable system directly connected to the brake shoes at one end and the actuator at the other end. The 2500 used the same park brake actuation design as the 1500, which includes a stamped steel frame and foot actuated lever.

Brake Actuation Subsystem: Both the Silverado 2500 and the 1500 used the same brake pedal and accelerator pedal design. The brake pedal and frame were of a stamped steel construction, while the accelerator pedal consisted of a set of plastic injection molded components that were assembled together.

Power Brake Subsystem: The Silverado 2500 came standard with four-wheel disc brakes with hydro-boost, whereas the 1500 used a traditional vacuum booster. Both vehicles have an ABS module and a common brake actuation design.

DRAFT

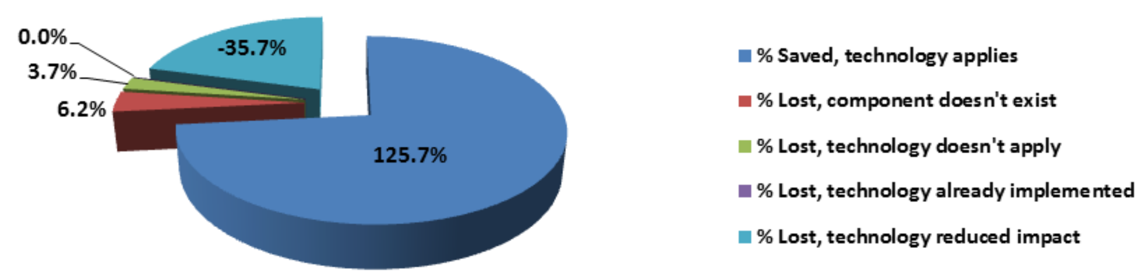
3.9.3 System Scaling Summary

Table 3-66 summarizes mass and cost impact of Silverado 1500 lightweighting technologies applied to the Silverado 2500. Total brake mass savings was 54.31 kg at a cost increase of 172.80 or $3.07 per kg.

Table 3-66: Mass-Reduction and Cost Impact for Brake System, Silverado 2500

				Net Value of Mass Reduction							
System	Subsystem	Sub-Subsystem	Description	Mass Reduction New Tech "kg" (1)	Mass Reduction Comp "kg" (1)	Mass Reduction Total "kg" (1)	Cost Impact New Tech "$" (2)	Cost Impact Comp "$" (2)	Cost Impact Total "$" (2)	Cost/ Kilogram Total "$/kg"	Vehicle Mass Reduction Total "%"
06	00	00	**Brake System**								
06	03	00	Front Rotor/Drum and Shield Subsystem	30.42	1.28	31.70	-$82.61	$12.66	-$69.95	-$2.21	1.03%
06	04	00	Rear Rotor/Drum and Shield Subsystem	20.10	0.65	20.75	-$88.23	$7.37	-$80.86	-$3.90	0.67%
06	05	00	Parking Brake and Actuation Subsystem	1.57	0.00	1.57	-$22.53	$0.00	-$22.53	-$14.39	0.05%
06	06	00	Brake Actuation Subsystem	2.23	0.00	2.23	$0.55	$0.00	$0.55	$0.24	0.07%
06	07	00	Power Brake Subsystem (for Hydraulic)	0.00	0.00	0.00	$0.00	$0.00	$0.00	$0.00	0.00%
06	09	00	Brake Controls Subsystem	0.00	0.00	0.00	$0.00	$0.00	$0.00	$0.00	0.00%
06	10	00	Auxiliary Brake Subsystem	0.00	0.00	0.00	$0.00	$0.00	$0.00	$0.00	0.00%
				54.31 (Decrease)	**1.93** (Decrease)	**56.24** (Decrease)	**-$192.82** (Increase)	**$20.03** (Decrease)	**-$172.80** (Increase)	**-$3.07** (Increase)	**1.82%**

Mass Savings, Select Vehicle, New Technology "kg"	**54.3**
Mass Savings, Silverado 1500, New Technology "kg"	**43.2**
Mass Savings Select Vehicle/Mass Savings 1500	**125.7%**



*SMS not included - has no significant impact on perecent contributions

Mass savings could not be credited for components for which lightweighting technologies did not apply. One reason for this could be that the technology was already implemented. For other components the lightweighting technology may not apply because of design. For example, the Silverado 2500 used a hydraulic brake booster whereas the 1500 used a vacuum operated brake booster. Some components lightweighted as part of the Silverado 1500 analysis did not exist in the 2500 brake system, such as the rear backing plates, rear wheel cylinders, and the side plates associated with the adjustable brake pedal height mechanism.

3.9.3.1 System Scaling Analysis

The Silverado 2500 brake components were reviewed for compatibility with lightweighting technologies. The results of this analysis are listed in Table 3-67.

Table 3-67: Brake Components Scaling Analysis Results, Silverado 2500

Silverado 1500							Select Vehicle			
System	Subsystem	Sub-Subsystem	Component/Assembly	Base Mass	Mass Savings New Tech	% of Mass Savings New Tech	Tech Applies	Base Mass	Mass Savings New Tech	Notes
06			**Brake System**	**101.0**	**43.2**	**43%**			**54.3**	
06	03	01	Front Rotor, LH & RH	23.32	12.11	52%	Yes	33.56	17.43	Tech **DOES** apply: Use two-piece aluminum/aluminum matrix metal
06	03	01	Brake Shield, LH	0.48	0.25	52%	Yes	0.67	0.35	Tech **DOES** apply: Use plastic w/slots
06	03	01	Brake Shield, RH	0.48	0.25	52%	Yes	0.68	0.35	Tech **DOES** apply: Use plastic w/slots
06	03	02	Caliper Housing, LH	4.80	3.21	67%	Yes	6.59	4.40	Tech **DOES** apply: Use cast magnesium
06	03	02	Caliper Mounting Bracket, LH	2.18	1.49	68%	Yes	2.55	1.74	Tech **DOES** apply: Use cast magnesium
06	03	02	Caliper Housing, RH	4.80	3.21	67%	Yes	6.59	4.40	Tech **DOES** apply: Use cast magnesium
06	03	02	Caliper Mounting Bracket, RH	2.18	1.49	68%	Yes	2.55	1.74	Tech **DOES** apply: Use cast magnesium
06	04	07	Rear Drum, LH & RH	22.09	13.69	62%	Yes	32.43	20.10	Tech **DOES** apply: Use aluminum matrix metal
06	04	08	Rear Backing Plate, LH & RH	5.79	1.41	24%	No			Tech does **NOT** apply: Not on vehicle
06	04	08	Wheel Cylinder Housing, LH & RH	0.92	0.46	50%	No			Tech does **NOT** apply: Not on vehicle
06	04	08	Actuation Lever, LH & RH	0.61	0.27	44%	No			Tech does **NOT** apply: Not on vehicle
06	05	01	Mounting Plate	0.77	0.44	58%	Yes	0.76	0.44	Tech **DOES** apply: Use cast magnesium
06	05	01	Cover Plate	0.41	0.23	58%	Yes	0.40	0.23	Tech **DOES** apply: Use cast magnesium
06	05	01	Park Brake Lever	0.44	0.26	58%	Yes	0.48	0.28	Tech **DOES** apply: Use cast magnesium
06	05	02	Parking Brake Cable Asm	1.73	0.52	30%	Yes	2.07	0.62	Tech **DOES** apply: Use synthetic cable
06	06	02	Accelerator Pedal Asm	2.14	0.04	2%	Yes	0.37	0.01	Tech **DOES** apply: Use MuCell®
06	06	02	Brake Pedal Frame	1.70	0.99	58%	Yes	2.49	1.44	Tech **DOES** apply: Use cast magnesium
06	06	02	Pedal Arm Asm	1.50	0.75	50%	Yes	1.57	0.78	Tech **DOES** apply: Use plastic
06	06	02	Side Plate Asm	1.54	0.56	37%	No			Tech does **NOT** apply: Not on vehicle
06	07	01	Vacuum Booster	4.24	1.58	37%	No			Tech does **NOT** apply: Not on vehicle

If the original Silverado 1500 mass reduction concept idea was not able to be applied to the comparison vehicle it is not described in the section below.

Components with significant mass savings identified on the Silverado 2500 included the front rotor, front caliper, front caliper mounting bracket, rear drum-in-hat, and the brake pedal frame.

<u>Front Rotor</u>

As shown in Image 3.9–1, the Silverado 1500 series brake system uses the same basic cast-iron rotor design as the 2500 series brake system. Component masses, for both front rotors, were 23.3 kg versus 33.5 kg, respectively. Image 3.9–2 is an approximate example of a two-piece rotor which represents the mass reduction idea associated with this component. This redesign idea comprises of an aluminum hat with side and top cross-drilling, and an aluminum Metal-Matrix Composite (MMC) disc with directional cooling fins, disc surface slotting, and disc surface cross-drilling. Due to similarities in component design and material, full percentage of the Silverado 1500 front rotor mass reduction can be applied to the 2500. (Refer to Table 3-67).

DRAFT

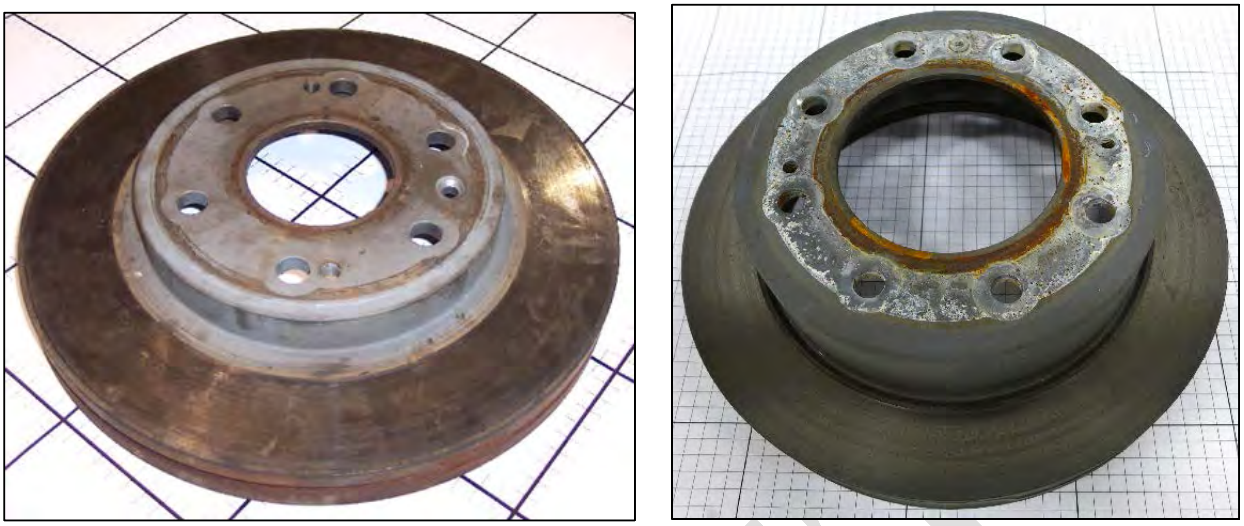


Image 3.9–1: Front Rotor for the Silverado 1500 (Left) and Silverado 2500 (Right)
(Source: FEV, Inc. Photo)

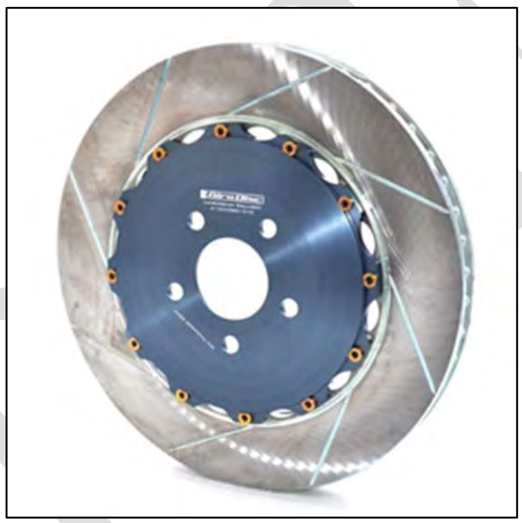


Image 3.9–2: Front Rotor Mass Reduced Component Example
(Source: http://www.girodisc.com/Girodisc-Front-2-piece-rotors-for-Mazda-RX8_p_6346.html)

<u>Front Caliper Housing</u>

As shown in Image 3.9–3, the Silverado 1500 and the 2500 share a common front caliper housing design in which both vehicles utilize cast-iron housing with dual pistons. Component masses were 4.8 kg versus 6.59 kg, respectively. Shown in Image 3.9–4, the new technology idea was to cast the caliper housings out of magnesium. Due to similarities in component design and material, full percentage of the Silverado 1500 front caliper housing mass reduction can be applied to the 2500. (Refer to Table 3-67).

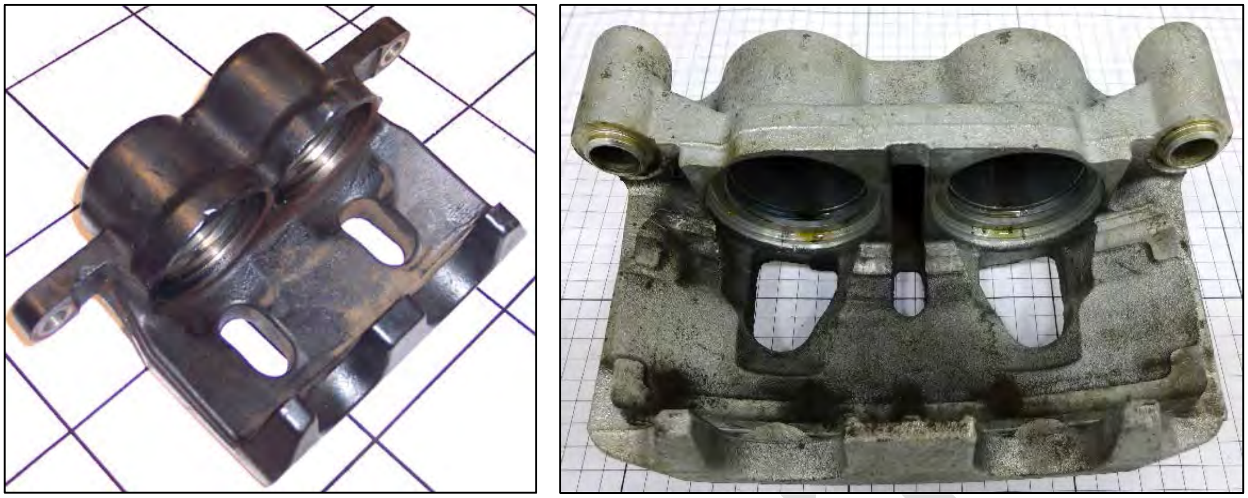


Image 3.9–3: Front Caliper Housing; 1500 Series (Left), 2500 Series (Right)
(Source: FEV, Inc. Photo)

Image 3.9–4: Front Caliper Housing Mass Reduced Component example
(Source:http://www.peterverdone.com/wiki/index.php?title=PVD_Land_Speed_Record_Bike#Caliper)

<u>Front Caliper Mounting Bracket</u>

As shown in Image 3.9–5, the Silverado 1500 and 2500 share a similar cast-iron front caliper mounting bracket design. Component masses were 2.2 kg versus 2.6 kg, respectively. Casting the bracket from magnesium saves significant mass. Image 3.9–6 is an approximate example of a cast-magnesium caliper mounting bracket. Due to similarities in component design and material, full percentage of the Silverado 1500 front caliper mounting bracket mass reduction can be applied to the 2500. (Refer to Table 3-67).

DRAFT

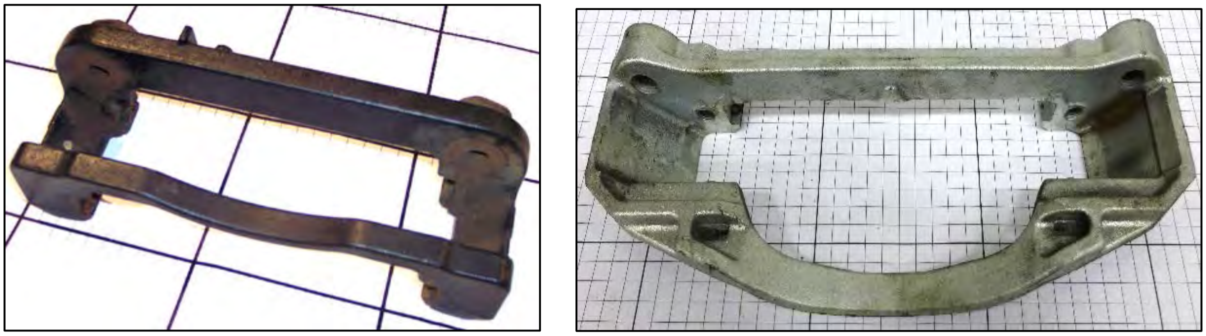


Image 3.9–5: Front Caliper Mounting Bracket; 1500 Series (Left), 2500 Series (Right)
(Source: FEV, Inc. Photo)

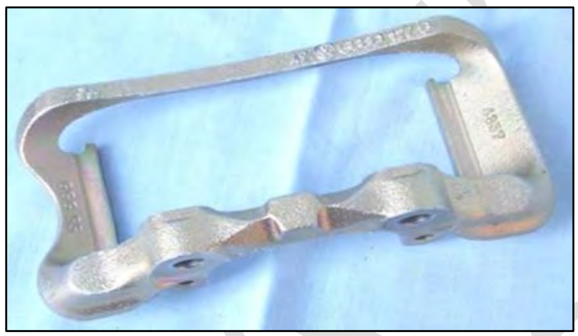


Image 3.9–6: Front Caliper Mounting Bracket Mass Reduced Component Example
(Source: http://www.gforcebuggies.com/Parts)

<u>Rear Drum-in-Hat</u>

As shown in Image 3.9–7, the Silverado 1500 uses a standard drum design for the rear brakes whereas the 2500 uses a drum-in-hat design. Component masses, for both drums, were 22.0 kg versus 32.4 kg, respectively. Although the two vehicles used a different cast-iron design, the lightweighting idea still applies and saves significant mass. Image 3.9–8 is an approximate example of an aluminum metal-matrix drum. Due to similarities in component material, full percentage of the Silverado 1500 rear drum mass reduction can be applied to the 2500. (Refer to Table 3-67).

DRAFT

Image 3.9–7: Rear Drum for the Silverado 1500 (Left) and Silverado 2500 (Right)
(Source: FEV, Inc. Photo)

Image 3.9–8: Rear Drum Mass Reduced Component
(Source: http://www.compositesworld.com/articles/metal-matrix-composites-used-to-lighten-military-brake-drums)

<u>Brake Pedal Frame</u>

As shown in Image 3.9–9, the Silverado 1500 and 2500 share a similar brake pedal frame design. Component masses were 1.7 kg versus 2.5 kg, respectively. Changing the base material from stamped steel to cast-magnesium, as is being used in the 2013 Dodge RAM 1500 Laramie Crew Cab 4x4 (Image 3.9–10), simplified the design by reducing the number of components and easing assembly. Due to similarities in component design and material, full percentage of the Silverado 1500 brake pedal frame mass reduction can be applied to the 2500. (Refer to Table 3-67).

DRAFT

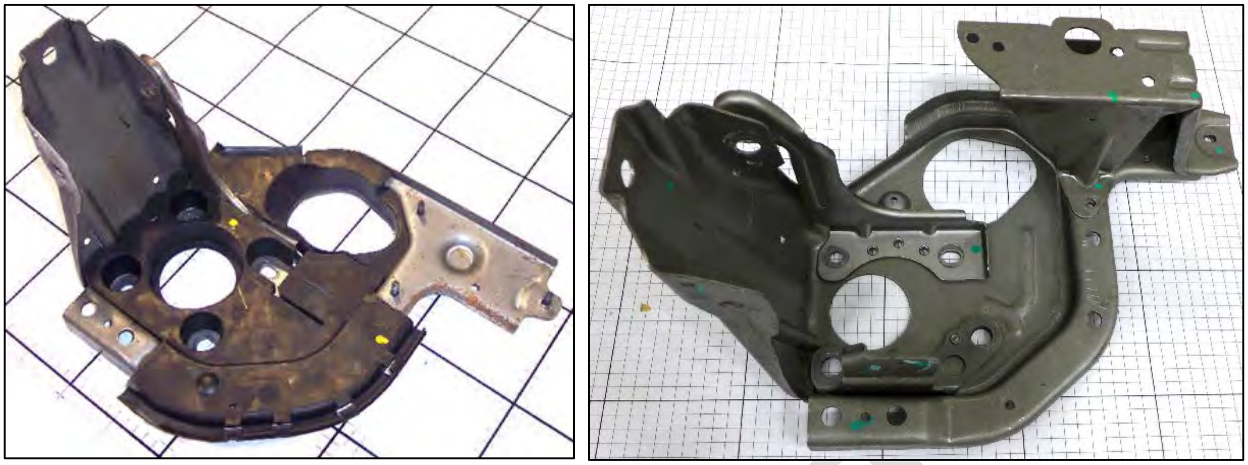


Image 3.9–9: Brake Pedal Frame; 1500 Series (Left), 2500 Series (Right)
(Source: FEV, Inc. Photo)

Image 3.9–10: Brake Pedal Arm Frame Mass Reduced Assembly Example
(Source: www.A2mac1.com)

3.9.4 Brake System Comparison, Silverado 2500

Table 3-68 summarizes the 1500 and 2500 lightweighting results for the Brake System.

Table 3-68: Brake System Comparison, Silverado 1500 and 2500

System	Description	Net Value of Mass Reduction								
		Mass Base "kg" (1)	Mass Reduction New Tech "kg" (1)	Mass Reduction Comp "kg" (1)	Mass Reduction Total "kg" (1)	System Mass Reduction "%"	Cost Impact New Tech "$" (2)	Cost Impact Comp "$" (2)	Cost Impact Total "$" (2)	Cost/ Kilogram Total "$/kg"
04	**Brake System**									
04	Silverado 1500	101.01	43.19	2.01	45.21	44.76%	-$169.66	$18.95	-$150.71	-$3.33
04	Silverado 2500	150.12	54.31	1.93	56.24	37.47%	-$192.82	$20.03	-$172.80	-$3.07

3.9.5 Mercedes Sprinter 311 CDi Analysis

3.9.5.1 System Architecture - Sprinter

Front Rotor/Drum and Shield Subsystem: The Mercedes Sprinter Front Rotor/Drum and Shield Subsystem (Image 3.9–11) used a similar architecture as the Silverado 1500. Both vehicles utilized a floating cast iron brake caliper with double pistons, brake pads, a cast-iron caliper mounting bracket, and a cast-iron rotor. One minor difference was the Sprinter does not use a splash shield.

Image 3.9–11: Mercedes Sprinter Front Rotor/Drum and Shield Subsystem
(Source: www.A2mac1.com)

Rear Rotor/Drum and Shield Subsystem: The Mercedes Sprinter Rear Rotor/Drum and Shield Subsystem architecture (Image 3.9–12) is unique compared to the 1500 architecture. The Mercedes Sprinter utilizes a cast iron drum-in-hat brake drum and rotor which allows it to use brake shoes for the parking brake function and brake pads for stopping the vehicle. This subsystem also includes: brake shoes with associated mounting hardware, brake pads, a cast iron brake caliper, a cast iron caliper mounting bracket, and a stamped steel dust shield.

Image 3.9–12: Mercedes Sprinter Rear Rotor/Drum and Shield Subsystem
(Source: www.A2mac1.com)

Parking Brake and Actuation Subsystem: As mentioned, the Mercedes Sprinter uses a drum-in-hat park brake design that separates the parking brake function from the vehicle's stopping function. The parking brake is engaged by a cable system directly connected to the brake shoes at one end and the actuator at the other end. Unlike the 1500, the Sprinter uses a hand operated lever instead of a foot operated pedal which includes a stamped steel frame and actuation lever.

Brake Actuation Subsystem: Both the Sprinter and the Silverado 1500 used similar brake and accelerator pedal designs. The brake pedal and frame were of a stamped steel construction while the accelerator pedal consisted of a set of plastic injection-molded components that are assembled together.

Power Brake Subsystem: As with the Silverado 1500, the Mercedes Sprinter used a traditional vacuum booster. Both vehicles have an ABS module and a common brake actuation design.

DRAFT

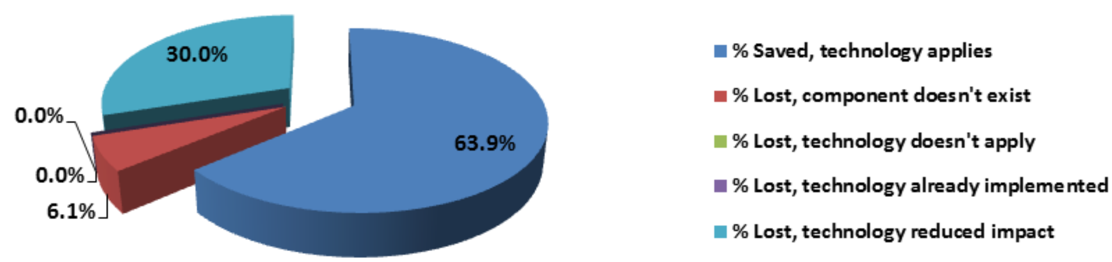
3.9.5.2 System Scaling Summary

The following table summarizes the mass and cost impact of Silverado 1500 lightweighting technologies as applied to the Mercedes Sprinter. Total brake system mass savings was 28.21 kg at a cost increase of $105.79 or $3.75 per kg.

Table 3-69: Mass-Reduction and Cost Impact for Brake System, Mercedes Sprinter

				Net Value of Mass Reduction							
System	Subsystem	Sub-Subsystem	Description	Mass Reduction New Tech "kg" (1)	Mass Reduction Comp "kg" (1)	Mass Reduction Total "kg" (1)	Cost Impact New Tech "$" (2)	Cost Impact Comp "$" (2)	Cost Impact Total "$" (2)	Cost/ Kilogram Total "$/kg"	Vehicle Mass Reduction Total "%"
06	00	00	**Brake System**								
06	03	00	Front Rotor/Drum and Shield Subsystem	18.60	0.38	18.97	-$43.07	$3.74	-$39.33	-$2.07	0.89%
06	04	00	Rear Rotor/Drum and Shield Subsystem	5.39	0.09	5.47	-$23.64	$1.00	-$22.64	-$4.14	0.26%
06	05	00	Parking Brake and Actuation Subsystem	1.23	0.00	1.23	-$17.26	$0.00	-$17.26	-$14.06	0.06%
06	06	00	Brake Actuation Subsystem	0.55	0.00	0.55	-$0.35	$0.00	-$0.35	-$0.64	0.03%
06	07	00	Power Brake Subsystem (for Hydraulic)	1.99	0.00	1.99	-$26.21	$0.00	-$26.21	-$13.20	0.09%
06	09	00	Brake Controls Subsystem	0.00	0.00	0.00	$0.00	$0.00	$0.00	$0.00	0.00%
06	10	00	Auxiliary Brake Subsystem	0.00	0.00	0.00	$0.00	$0.00	$0.00	$0.00	0.00%
				27.75 (Decrease)	**0.47** (Decrease)	**28.21** (Decrease)	**-$110.53** (Increase)	**$4.74** (Decrease)	**-$105.79** (Increase)	**-$3.75** (Increase)	**1.32%**

Mass Savings, Select Vehicle, New Technology "kg"	**27.75**
Mass Savings, Silverado 1500, New Technology "kg"	**43.39**
Mass Savings Select Vehicle/Mass Savings 1500	**63.9%**



*SMS not included - has no significant impact on perecent contributions

Mass savings could not be credited for components for which lightweighting technologies did not apply. Reasons for this could be that the technology was already implemented. Some components lightweighted as part of the 1500 Silverado analysis did not exist in the Sprinter brake system, such as the front brake shields.

3.9.5.3 System Scaling Analysis

The Mercedes Sprinter Brake system components were reviewed for compatibility with lightweighting technologies. The results of this analysis are listed in Table 3-70.

Table 3-70: Brake Components Scaling Analysis Results, Mercedes Sprinter

Silverado 1500							Select Vehicle			
System	Subsystem	Sub-Subsystem	Component/Assembly	Base Mass	Mass Savings New Tech	% of Mass Savings New Tech	Tech Applies	Base Mass	Mass Savings New Tech	Notes
06			**Brake System**	**101.0**	**43.4**	**43%**			**27.7**	
06	03	01	Front Rotor, LH & RH	23.32	12.11	52%	Yes	18.16	9.43	Tech **DOES** apply: Use two-piece aluminum/aluminum matrix metal
06	03	01	Brake Shield, LH	0.48	0.25	52%	No			Tech does **NOT** apply: Not on vehicle
06	03	01	Brake Shield, RH	0.48	0.25	52%	No			Tech does **NOT** apply: Not on vehicle
06	03	02	Caliper Housing, LH	4.80	3.21	67%	Yes	4.69	3.13	Tech **DOES** apply: Use cast magnesium
06	03	02	Caliper Mounting Bracket, LH	2.18	1.49	68%	Yes	2.13	1.45	Tech **DOES** apply: Use cast magnesium
06	03	02	Caliper Housing, RH	4.80	3.21	67%	Yes	4.69	3.13	Tech **DOES** apply: Use cast magnesium
06	03	02	Caliper Mounting Bracket, RH	2.18	1.49	68%	Yes	2.13	1.45	Tech **DOES** apply: Use cast magnesium
06	04	07	Rear Drum, LH & RH	22.09	13.69	62%	Yes	8.69	5.39	Tech **DOES** apply: Use aluminum matrix metal
06	04	08	Rear Backing Plate, LH & RH	5.79	1.41	24%	No			Tech does **NOT** apply: Not on vehicle
06	04	08	Wheel Cylinder Housing, LH & RH	0.92	0.46	50%	No			Tech does **NOT** apply: Not on vehicle
06	04	08	Actuation Lever, LH & RH	0.61	0.27	44%	No			Tech does **NOT** apply: Not on vehicle
06	05	01	Mounting Plate	0.77	0.44	58%	Yes	0.63	0.36	Tech **DOES** apply: Use cast magnesium
06	05	01	Cover Plate	0.41	0.23	58%	Yes	0.33	0.19	Tech **DOES** apply: Use cast magnesium
06	05	01	Park Brake Lever	0.44	0.26	58%	Yes	0.36	0.21	Tech **DOES** apply: Use cast magnesium
06	05	02	Parking Brake Cable Asm	1.73	0.52	30%	Yes	1.55	0.47	Tech **DOES** apply: Use synthetic cable
06	06	02	Accelerator Pedal Asm	2.14	0.04	2%	Yes	0.30	0.01	Tech **DOES** apply: Use MuCell®
06	06	02	Brake Pedal Asm	5.45	2.49	46%	Yes	1.20	0.55	Tech **DOES** apply: Use plastic
06	06	02	Vacuum Booster	4.24	1.58	37%	Yes	5.32	1.99	Tech **DOES** apply: Use cast magnesium shells, titanium actuator, aluminum studs & backing plate

If the original Silverado 1500 mass reduction concept idea was not able to be applied to the comparison vehicle it is not described in the section below.

Key Components for mass reduction include the Front Rotor, Front Caliper Housing, Front Caliper Mounting Bracket, Rear Drum-in-Hat, and the Vacuum Booster.

<u>Front Rotor</u>

As shown in Image 3.9–13, the Silverado 1500 Brake System uses the same basic cast-iron rotor design as the Mercedes Sprinter series Brake System. Component masses for both front rotors were 23.3 kg versus 18.2 kg, respectively. Image 3.9–14 is an approximate example of a two-piece rotor which represents the mass reduction idea associated with this component. This redesign idea comprises of an aluminum hat with side and top cross-drilling, an aluminum metal-matrix composite disc with directional cooling fins, disc surface slotting, and disc surface cross-drilling. Due to similarities in component design and material, full percentage of the Silverado 1500 front rotor mass reduction can be applied to the Sprinter. (Refer to Table 3-70).

DRAFT

Image 3.9–13: Front Rotor; 1500 Series (Left), Sprinter Series (Right)
(Source: FEV, Inc. and www.A2mac1.com)

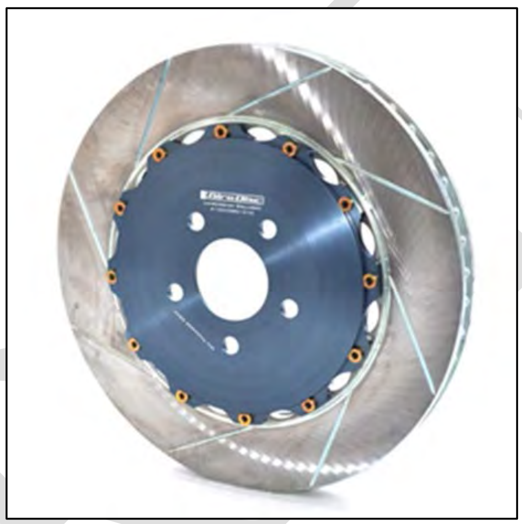


Image 3.9–14: Front Rotor Mass Reduced Component Example
(Source: http://www.girodisc.com/Girodisc-Front-2-piece-rotors-for-Mazda-RX8_p_6346.html)

Front Caliper Housing

Shown in Image 3.9–15, the Silverado 1500 and the Mercedes Sprinter share a common front caliper housing design in-which both vehicles utilize cast-iron housing with dual pistons. Component masses are 4.8 kg versus 4.7 kg respectively. Shown in Image 3.9–16, the new technology idea is to cast the caliper housings out of magnesium. Due to similarities in component design and material, full percentage of the Silverado 1500 front caliper housing mass reduction can be applied to the Sprinter. (Refer to Table 3-70).

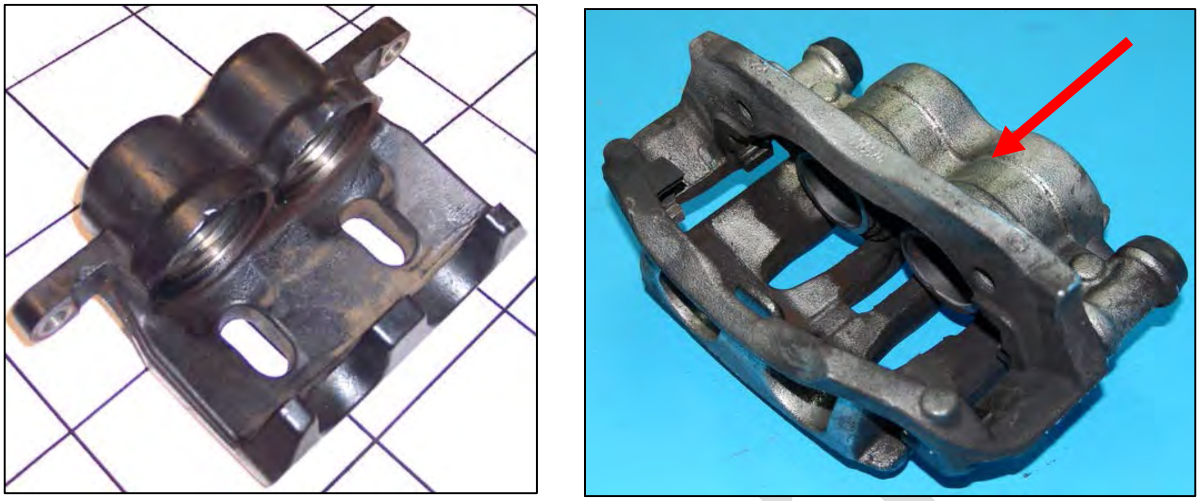


Image 3.9–15: Caliper Housing, 1500 Series (Left), Sprinter Series (Right)
(Source: FEV, Inc. and www.A2mac1.com)

Image 3.9–16: Front Caliper Housing Mass Reduced Component example
(Source: http://www.peterverdone.com/wiki/index.php?title=PVD_Land_Speed_Record_Bike#Caliper)

Front Caliper Mounting Bracket

As shown in Image 3.9–17, the Silverado 1500 and Mercedes Sprinter share a similar cast-iron front caliper mounting bracket design. Component masses were 2.2 kg versus 2.1 kg, respectively. Casting the bracket out of magnesium saves significant mass. Image 3.9–18 is an approximate example of a cast-magnesium caliper mounting bracket. Due to similarities in component design and material, full percentage of the Silverado 1500 front caliper mounting bracket mass reduction can be applied to the Sprinter. (Refer to Table 3-70).

DRAFT

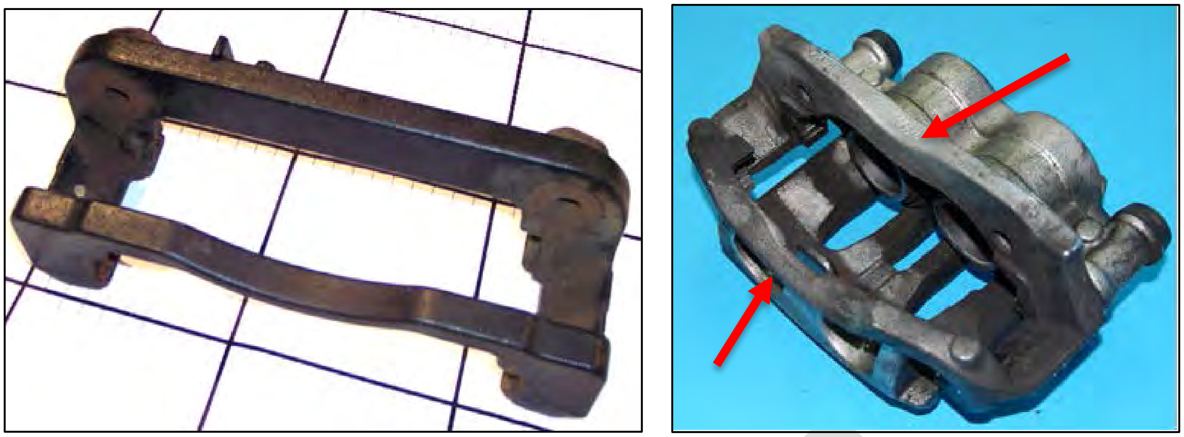


Image 3.9–17: Front Caliper Mounting Bracket for the Silverado 1500 (Left) and Mercedes Sprinter 311 CDi (Right)
(Source: FEV, Inc. and www.A2mac1.com)

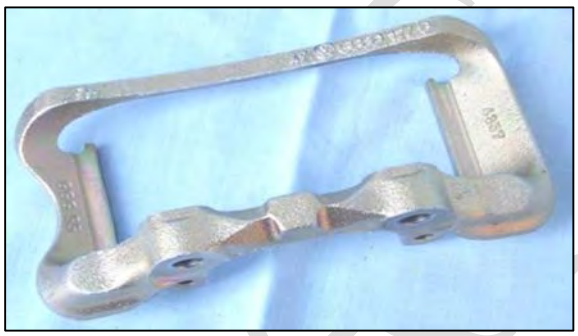


Image 3.9–18: Front Caliper Mounting Bracket Mass Reduced Component Example
(Source: http://www.gforcebuggies.com/Parts)

<u>Rear Drum-in-Hat</u>

As shown in Image 3.9–19, the Silverado 1500 uses a standard drum design for the rear brakes whereas the Mercedes Sprinter uses a drum-in-hat design. Component masses, for both drums, were 22.0 kg versus 8.7 kg, respectively. Although the two vehicles use a different cast-iron design, the lightweighting idea still applied and saved significant mass. Image 3.9–20 is an approximate example of an aluminum metal-matrix drum. Due to similarities in component material, full percentage of the Silverado 1500 rear drum mass reduction can be applied to the Sprinter. (Refer to Table 3-70).

DRAFT

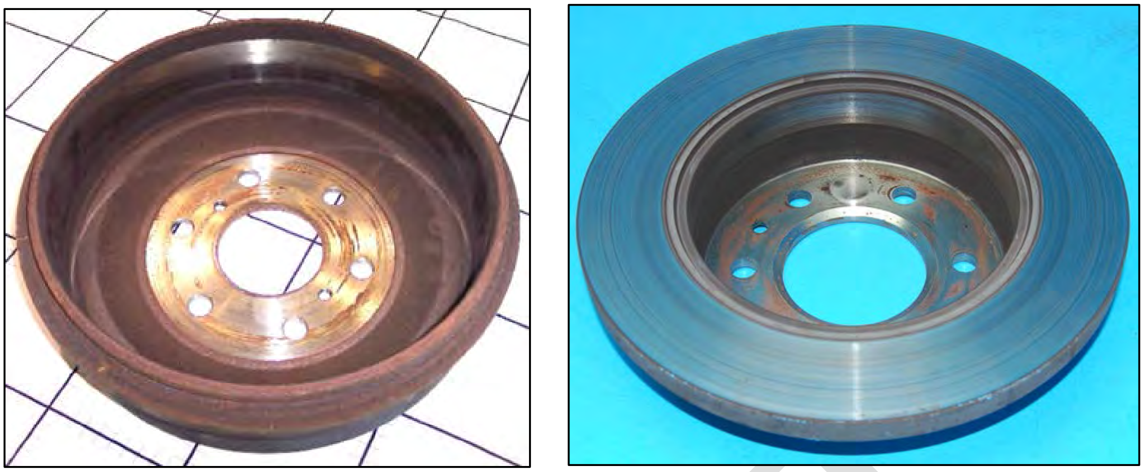


Image 3.9–19: Rear Drum; Silverado 1500 (Left) and Mercedes Sprinter 311 CDi (Right)
(Source: FEV, Inc. and www.A2mac1.com)

Image 3.9–20: Rear Drum Mass Reduced Component
(Source: http://www.compositesworld.com/articles/metal-matrix-composites-used-to-lighten-military-brake-drums)

<u>Vacuum Booster</u>

As shown in Image 3.9–21, the Silverado 1500 and the Mercedes Sprinter use a standard vacuum booster design. The vacuum booster assembly was made largely out of steel stampings and rubber bladders. The mass reduction ideas for the vacuum booster assembly affected each internal plate as well as the outer housings. These ideas included changing the front housing, rear housing, front backing plate, and the spacer ring from stamped steel to cast magnesium. The rear backing plate idea changes the baseline material from stamped steel to stamped aluminum. The actuator shaft changes from steel to titanium and the mounting studs change from steel to aluminum. Component masses for both vacuum boosters are 4.2 kg for the Silverado 1500 versus 5.3 kg for the Mercedes Sprinter. Image 3.9–22 is an approximate example of a mass-reduced vacuum booster. Due to similarities in component design and material, full percentage of the Silverado 1500 vacuum booster mass reduction can be applied to the Sprinter. (Refer to Table 3-70).

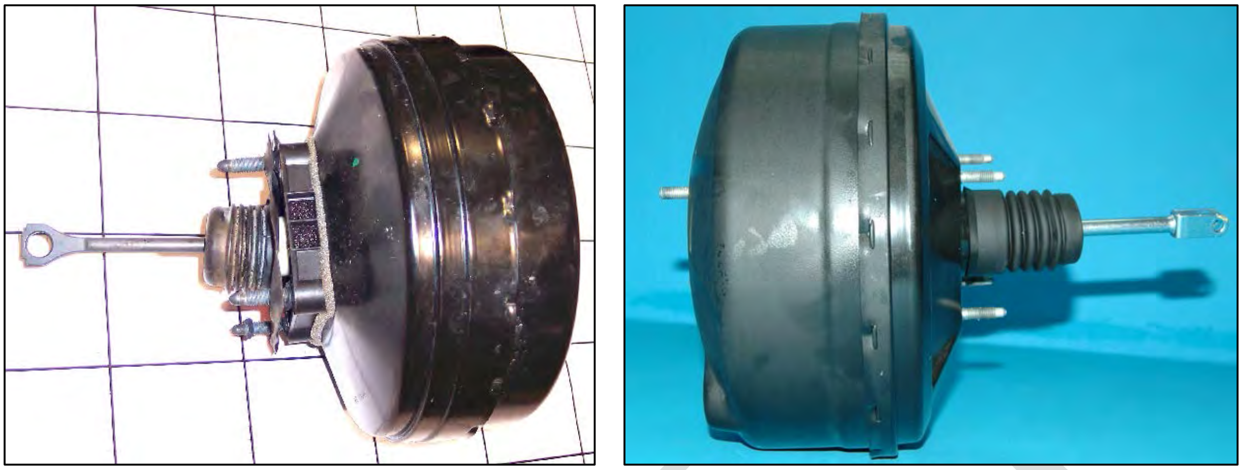


Image 3.9–21: Vacuum Booster for the Silverado 1500 (Left) and Mercedes Sprinter 311 CDi (Right)
(Source: FEV Inc. and www.A2mac1.com)

Image 3.9–22: Vacuum Booster Mass Reduced Sub-Assembly Example
(Source: http://brakematerialsandparts.webs.com/boosterrebuilding.htm)

DRAFT

3.9.6 Renault Master Analysis

3.9.6.1 System Architecture – Renault Master 2.3 CDi

- Front Rotor/Drum and Shield Subsystem
- Rear Rotor/Drum and Shield Subsystem
- Parking Brake and Actuation Subsystem
- Brake Actuation Subsystem
- Power Brake Subsystem

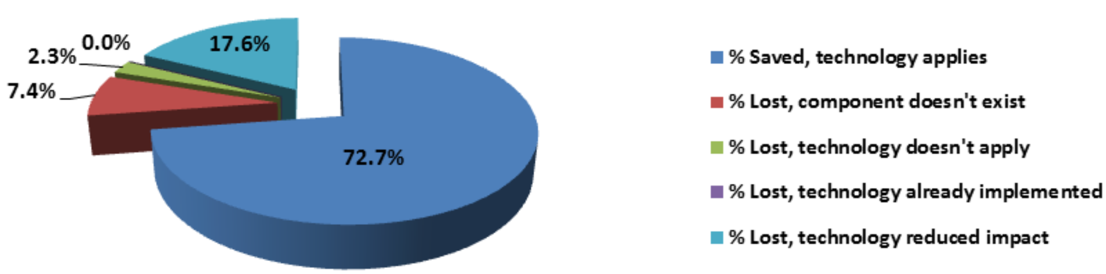
3.9.6.2 System Scaling Summary

Table 3-71 summarizes the mass and cost impact of Silverado 1500 lightweighting technologies as applied to the Renault Master. Total brake system mass savings was 31.89 kg at a cost increase of $ 117.84 or $3.70 per kg.

Table 3-71: Mass-Reduction and Cost Impact for Brake System, Renault Master

				Net Value of Mass Reduction							
System	Subsystem	Sub-Subsystem	Description	Mass Reduction New Tech "kg" (1)	Mass Reduction Comp "kg" (1)	Mass Reduction Total "kg" (1)	Cost Impact New Tech "$" (2)	Cost Impact Comp "$" (2)	Cost Impact Total "$" (2)	Cost/ Kilogram Total "$/kg"	Vehicle Mass Reduction Total "%"
06	00	00	**Brake System**								
06	03	00	Front Rotor/Drum and Shield Subsystem	19.12	0.40	19.52	-$44.23	$3.99	-$40.24	-$2.06	0.83%
06	04	00	Rear Rotor/Drum and Shield Subsystem	8.25	0.14	8.39	-$36.23	$1.58	-$34.65	-$4.13	0.36%
06	05	00	Parking Brake and Actuation Subsystem	1.89	0.00	1.89	-$18.65	$0.00	-$18.65	-$9.85	0.08%
06	06	00	Brake Actuation Subsystem	0.35	0.00	0.35	-$0.49	$0.00	-$0.49	-$1.40	0.01%
06	07	00	Power Brake Subsystem (for Hydraulic)	1.73	0.00	1.73	-$23.81	$0.00	-$23.81	$0.00	0.07%
06	09	00	Brake Controls Subsystem	0.00	0.00	0.00	$0.00	$0.00	$0.00	$0.00	0.00%
06	10	00	Auxiliary Brake Subsystem	0.00	0.00	0.00	$0.00	$0.00	$0.00	$0.00	0.00%
				31.34 (Decrease)	**0.54** (Decrease)	**31.89** (Decrease)	**-$123.41** (Increase)	**$5.57** (Decrease)	**-$117.84** (Increase)	**-$3.70** (Increase)	**1.35%**

Mass Savings, Select Vehicle, New Technology "kg"	**31.34**
Mass Savings, Silverado 1500, New Technology "kg"	**43.13**
Mass Savings Select Vehicle/Mass Savings 1500	**72.7%**



*SMS not included - has no significant impact on perecent contributions

Mass savings could not be credited for components for which lightweighting technologies did not apply. Reasons for this could be that the technology was already implemented. Some components lightweighted as part of the 1500 Silverado analysis do not exist in the Renault Master brake system, such as the rear wheel cylinders.

3.9.6.3 System Scaling Analysis – Renault Master

The Renault Master brake system components were reviewed for compatibility with lightweighting technologies. The results of this analysis are listed in Table 3-72.

Table 3-72: Components Scaling Analysis Results, Renault Master Brake

Silverado 1500							Select Vehicle			
System	Subsystem	Sub-Subsystem	Component/Assembly	Base Mass	Mass Savings New Tech	% of Mass Savings New Tech	Tech Applies	Base Mass	Mass Savings New Tech	Notes
06	**Brake System**			**101.0**	**43.1**	**43%**			**31.3**	
06	03	01	Front Rotor, LH & RH	23.32	12.11	52%	Yes	18.65	9.69	Tech **DOES** apply: Use two-piece aluminum/aluminum matrix metal
06	03	01	Brake Shield, LH	0.48	0.25	52%	No			Tech does **NOT** apply: Not on vehicle
06	03	01	Brake Shield, RH	0.48	0.25	52%	No			Tech does **NOT** apply: Not on vehicle
06	03	02	Caliper Housing, LH	4.80	3.21	67%	Yes	4.83	3.22	Tech **DOES** apply: Use cast magnesium
06	03	02	Caliper Mounting Bracket, LH	2.18	1.49	68%	Yes	2.19	1.50	Tech **DOES** apply: Use cast magnesium
06	03	02	Caliper Housing, RH	4.80	3.21	67%	Yes	4.83	3.22	Tech **DOES** apply: Use cast magnesium
06	03	02	Caliper Mounting Bracket, RH	2.18	1.49	68%	Yes	2.19	1.50	Tech **DOES** apply: Use cast magnesium
06	04	07	Rear Drum, LH & RH	22.09	13.69	62%	Yes	13.32	8.25	Tech **DOES** apply: Use aluminum matrix metal
06	04	08	Rear Backing Plate, LH & RH	5.79	1.41	24%	No			Tech does **NOT** apply: Not on vehicle
06	04	08	Wheel Cylinder Housing, LH & RH	0.92	0.46	50%	No			Tech does **NOT** apply: Not on vehicle
06	04	08	Actuation Lever, LH & RH	0.61	0.27	44%	No			Tech does **NOT** apply: Not on vehicle
06	05	01	Mounting Plate	0.77	0.44	58%	Yes	1.22	0.70	Tech **DOES** apply: Use cast magnesium
06	05	01	Cover Plate	0.41	0.23	58%	Yes	0.64	0.37	Tech **DOES** apply: Use cast magnesium
06	05	01	Park Brake Lever	0.44	0.26	58%	Yes	0.70	0.41	Tech **DOES** apply: Use cast magnesium
06	05	02	Parking Brake Cable Asm	1.73	0.52	30%	Yes	1.37	0.41	Tech **DOES** apply: Use synthetic cable
06	06	02	Accelerator Pedal Asm	2.14	0.04	2%	Yes	0.22	0.00	Tech **DOES** apply: Use MuCell®
06	06	02	Brake Pedal Frame	1.70	0.99	58%	No			Tech does **NOT** apply: Already plastic
06	06	02	Pedal Arm Asm	1.50	0.75	50%	Yes	0.70	0.35	Tech **DOES** apply: Use plastic
06	06	02	Side Plate Asm	1.54	0.56	37%	No			Tech does **NOT** apply: Not on vehicle
06	07	01	Vacuum Booster	4.24	1.51	36%	Yes	4.83	1.73	Tech **DOES** apply: Use cast magnesium shells, titanium actuator, aluminum studs & backing plate

If the original Silverado 1500 mass reduction concept idea was not able to be applied to the comparison vehicle it is not described in the section below.

Front Rotor/Drum and Shield Subsystem: The Renault Master Front Rotor/Drum and Shield Subsystem used a similar architecture as the Chevrolet Silverado 1500. Both vehicles utilized a floating cast-iron brake caliper with double pistons, brake pads, a cast-iron caliper mounting bracket, and a cast-iron rotor. One minor difference was the Master did not use a splash shield.

Rear Rotor/Drum and Shield Subsystem: The Renault Master rear rotor/drum and shield subsystem architecture is unique compared to the Chevrolet Silverado 1500 architecture. The Renault Master utilizes a cast iron drum-in-hat brake drum and rotor which allows it to use brake shoes for the parking brake function and brake pads for stopping the vehicle. This subsystem also included brake shoes with associated mounting hardware, brake pads, a cast iron brake caliper and mounting bracket, and a stamped steel backing plate.

Parking Brake and Actuation Subsystem: As mentioned, the Renault Master used a drum-in-hat park brake design that separated the parking brake function from the vehicle's stopping function. The parking brake was engaged by a cable system directly connected to the brake shoes at one end and the actuator at the other. Unlike the Silverado 1500, the Renault Master used a hand-operated lever instead of a foot-operated pedal, which included a stamped steel frame and actuation lever.

Brake Actuation Subsystem: Unique to the Renault Master, the brake and accelerator pedals mount to a plastic injection molded base. The brake pedal was a stamped steel and welded construction while the accelerator pedal consists of a set of plastic injection molded components that are assembled together.

DRAFT

Power Brake Subsystem: As with the Silverado 1500, the Renault Master used a traditional vacuum booster. Both vehicles had an ABS module and a common brake actuation design.

3.10 FRAME AND MOUNTING SYSTEM

3.10.1 Silverado 1500 Summary

The Chevrolet Silverado 1500 Frame and Mounting system includes the complete Frame Assembly.

The Chevrolet Silverado 1500 analysis identifies mass reduction alternatives and cost implications for the Frame and Mounting System with the intent to meet the function and performance requirements of the baseline vehicle. Table 3-73 provides a summary of mass reduction and cost impact for select sub-subsystems evaluated. The total mass savings found on the Frame and Mounting system mass was reduced by 23.70 kg (8.9%). This increased cost by $54.42, or $2.30 per kg. Mass reduction for this system reduced vehicle curb weight by .99%.

Table 3-73: Frame and Mounting System Mass Reduction Summary

				Net Value of Mass Reduction					
System	Subsystem	Sub-Subsystem	Description	Base Mass "kg"	Mass Reduction "kg" (1)	Cost Impact NIDMC "$" (2)	Average Cost/ Kilogram "$/kg" (2)	Mass Reduction "%"	Vehicle Mass Reduction "%"
07	00	00	**Frame & Mounting**						
07	**01**	**00**	**Frame Sub System**	**252.27**	**23.70**	**-54.42**	**-2.30**	**9.39%**	**0.99%**
07	01	01	Full Frame	242.00	23.70	-54.42	-2.30	9.79%	0.99%
07	01	03	Body Isolators	10.27	0.00	0.00	0.00	0.00%	0.00%
07	**03**	**00**	**Engine Transmission Mounting Subsystem**	**2.14**	**0.00**	**0.00**	**0.00**	**0.00%**	**0.00%**
07	03	02	Transmission Mount	2.14	0.00	0.00	0.00	0.00%	0.00%
07	**04**	**00**	**Towing and Coupling Attachments Subsystem**	**13.23**	**0.00**	**0.00**	**0.00**	**0.00%**	**0.00%**
07	04	01	Towing Provisions	13.23	0.00	0.00	0.00	0.00%	0.00%
				267.63	23.70 (Decrease)	-54.42 (Increase)	-2.30 (Increase)	8.86%	0.99%

(1) "+" = mass decrease, "-" = mass increase
(2) "+" = cost decrease, "-" = cost increase

Mass savings opportunities were identified for the following components: the full frame.

Full Frame: The frame assembly mass was reduced by changing the frame to a combination of aluminum and high strength steel. Mass was reduced by 9.79% from 242 kg to 218.30 kg.

3.10.1.1 Silverado 2500 Analysis

The Chevrolet Silverado 2500 Frame system is very similar to the 1500, but on a larger scale due to the larger engine 6.0L to 5.3L size and ability to carry a larger pay load Image 3.10–1.

Image 3.10–1: Chevrolet Silverado Frame System
(Source: FEV, Inc. Photo)

DRAFT

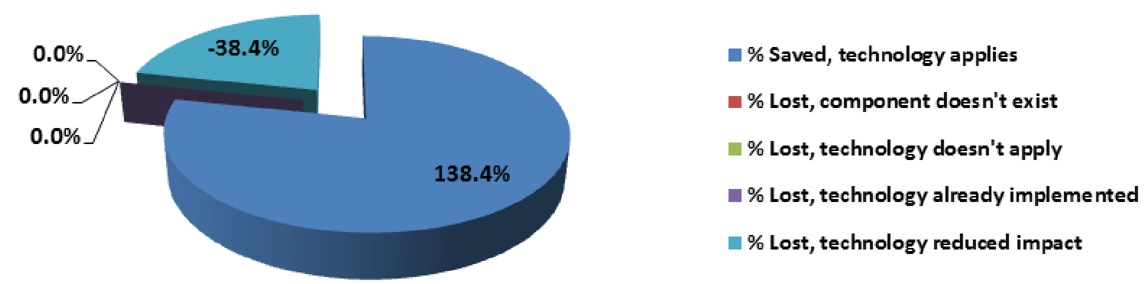
3.10.1.2 2500 System Scaling Summary

Table 3-74 summarizes the mass and cost impact of the Silverado 1500 lightweighting technologies as applied to the Silverado 2500. Total frame and mounting system mass savings was 32.8 kg at a cost increase of $75.31, or $2.30 per kg.

Table 3-74: Mass-Reduction and Cost Impact for Frame and Mounting System, Silverado 2500

				Net Value of Mass Reduction							
System	Subsystem	Sub-Subsystem	Description	Mass Reduction New Tech "kg" (1)	Mass Reduction Comp "kg" (1)	Mass Reduction Total "kg" (1)	Cost Impact New Tech "$" (2)	Cost Impact Comp "$" (2)	Cost Impact Total "$" (2)	Cost/ Kilogram Total "$/kg"	Vehicle Mass Reduction Total "%"
07	00	00	**Frame and Mounting System**								
07	01	00	Frame Sub System	0.00	32.80	32.80	-$75.31	$0.00	-$75.31	-$2.30	1.06%
07	03	00	Engine Transmission Mounting Subsystem	0.00	0.00	0.00	$0.00	$0.00	$0.00	$0.00	0.00%
07	04	00	Towing and Coupling Attach. Subsystem	0.00	0.00	0.00	$0.00	$0.00	$0.00	$0.00	0.00%
				0.00	**32.80** (Decrease)	**32.80** (Decrease)	**-$75.31** (Increase)	**$0.00**	**-$75.31** (Increase)	**-$2.30** (Increase)	**1.06%**

Mass Savings, Select Vehicle, New Technology "kg"	**32.80**
Mass Savings, Silverado 1500, New Technology "kg"	**23.70**
Mass Savings Select Vehicle/Mass Savings 1500	**138.4%**



*SMS not included - has no significant impact on perecent contributions

3.10.1.3 System Scaling Analysis

The Silverado 2500 Frame and mounting components were reviewed for compatibility with lightweighting technologies. The results of this analysis are listed in Table 3-75.

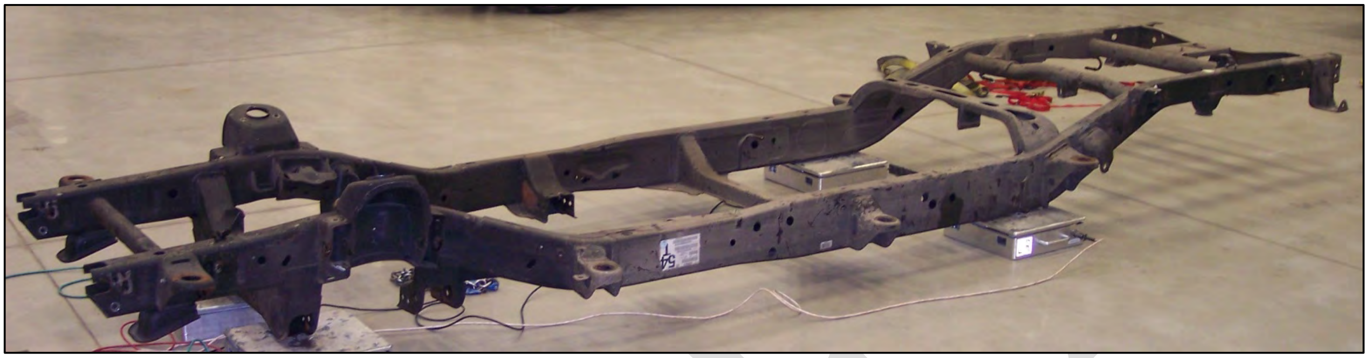
Table 3-75: System Scaling Analysis Frame and Mounting System, Silverado 2500

Silverado 1500							Select Vehicle			
System	Subsystem	Sub-Subsystem	Component/Assembly	Base Mass	Mass Savings New Tech	% of Mass Savings New Tech	Tech Applies	Base Mass	Mass Savings New Tech	Notes
07			**Frame & Mounting System**	**267.63**	**23.70**	**9%**			**32.80**	
07	01	01	Full Frame	242.00	23.70	10%	yes	334.90	32.80	Tech DOES apply: Use hydrid steel & aluminum

Components with significant mass savings identified on the Silverado 2500 included the full frame.

Full Frame

Shown in Image 3.10–2 are the Silverado 1500 and 2500 frames. Masses were 242.0 kg for the 1500 versus 334.9 kg for the 2500. Both frames were similar in configuration, although the 2500 was more robust to allow for handling a larger payload. Due to similarities in component design and material, full percentage of the Silverado 1500 full frame mass reduction can be applied to the 2500. (Refer to Table 3-75).



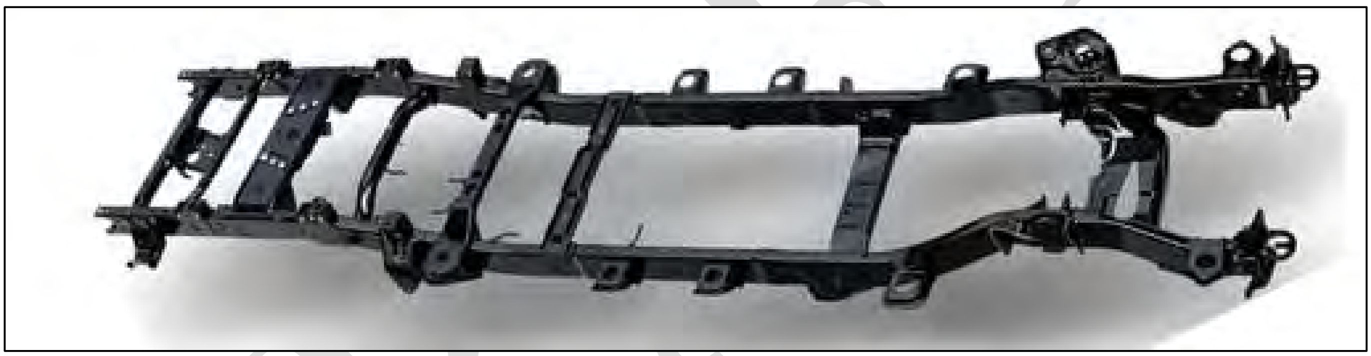


Image 3.10–2: Frame for the Silverado 1500 (Top) and Silverado 2500 (Bottom)
(Source: FEV, Inc. and Car and Driver)

DRAFT

3.10.1.4 System Comparison, Silverado 2500

Table 3-76 summarizes the Silverado 1500 and 2500 lightweighting results. The majority of the components were visually the same between the two frames. The 2500 frame is more robust to allow for handling a larger payload.

Table 3-76: Frame & Mounting System Comparison, Silverado 1500 and 2500

System	Description	Net Value of Mass Reduction								
		Mass Base "kg" (1)	Mass Reduction New Tech "kg" (1)	Mass Reduction Comp "kg" (1)	Mass Reduction Total "kg" (1)	System Mass Reduction "%"	Cost Impact New Tech "$" (2)	Cost Impact Comp "$" (2)	Cost Impact Total "$" (2)	Cost/ Kilogram Total "$/kg"
07	**Frame & Mounting**									
07	Silverado 1500	267.63	23.70	0.00	23.70	8.86%	$479.02	-$533.44	-$54.42	-$2.30
07	Silverado 2500	396.88	32.80	0.00	32.80	8.26%	-$75.31	$0.00	-$75.31	-$2.30

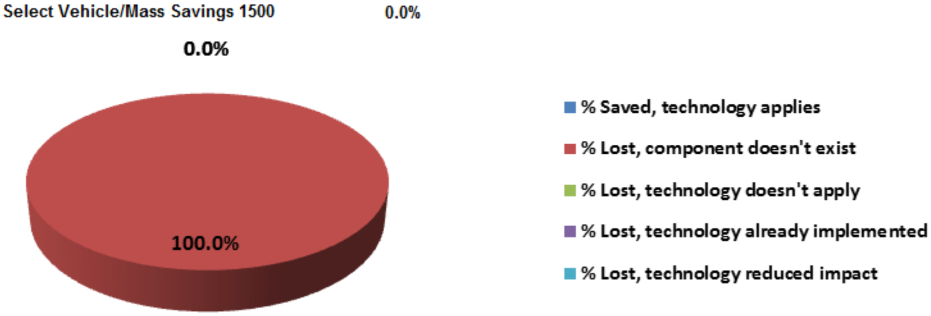
3.10.2 Mercedes Sprinter 311 CDi

Table 3-77 summarizes the mass and cost impact of the Silverado 1500 lightweighting technologies as applied to the Mercedes Sprinter 311 CDi. Total frame mass savings were 0 kg at a cost increase of $0, or $0 per kg. There is no frame assembly on the Mercedes Sprinter 311 CDi.

Table 3-77: Mass-Reduction and Cost Impact for Frame System, Mercedes Sprinter

System	Subsystem	Sub-Subsystem	Description	Net Value of Mass Reduction							
				Mass Reduction New Tech "kg" (1)	Mass Reduction Comp "kg" (1)	Mass Reduction Total "kg" (1)	Cost Impact New Tech "$" (2)	Cost Impact Comp "$" (2)	Cost Impact Total "$" (2)	Cost/ Kilogram Total "$/kg"	Vehicle Mass Reduction Total "%"
07	00	00	**Frame and Mounting System**								
07	01	00	Frame Sub System	0.00	0.00	0.00	$0.00	$0.00	$0.00	$0.00	0.00%
07	03	00	Engine Transmission Mounting Subsystem	0.00	0.00	0.00	$0.00	$0.00	$0.00	$0.00	0.00%
07	04	00	Towing and Coupling Attach. Subsystem	0.00	0.00	0.00	$0.00	$0.00	$0.00	$0.00	0.00%
				0.00	**0.00**	**0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**0.00%**

Mass Savings, Select Vehicle, New Technology "kg"	**0.00**
Mass Savings, Silverado 1500, New Technology "kg"	**23.70**
Mass Savings Select Vehicle/Mass Savings 1500	**0.0%**



*SMS not included - has no significant impact on perecent contributions

3.10.2.1 System Scaling Analysis

The Mercedes Sprinter 311 CDi frame components were reviewed for compatibility with lightweighting technologies. The results of this analysis are listed in Table 3-78.

Table 3-78: System Scaling Analysis Frame System, Mercedes Sprinter

Silverado 1500							Select Vehicle			
System	Subsystem	Sub-Subsystem	Component/Assembly	Base Mass	Mass Savings New Tech	% of Mass Savings New Tech	Tech Applies	Base Mass	Mass Savings New Tech	Notes
07			**Frame & Mounting System**	**267.63**	**23.70**	**9%**			**0.00**	
07	01	01	Full Frame	242.00	23.70	10%	no			Tech does **NOT** apply: No full frame assembly

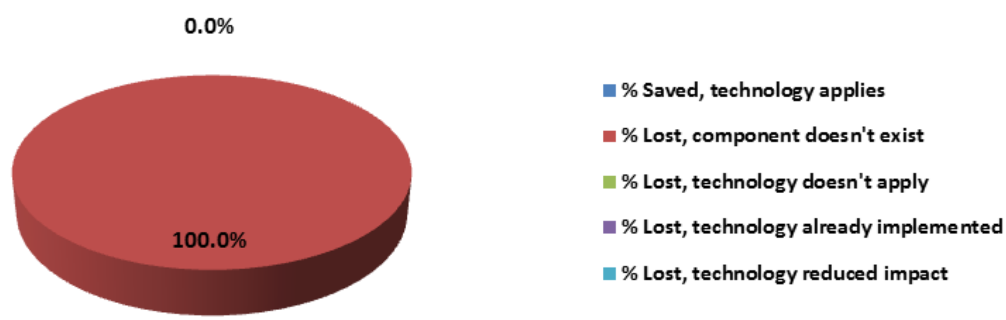
3.10.3 Renault Master 2.3 DCi

Table 3-79 summarizes the mass and cost impact of Silverado 1500 lightweighting technologies as applied to the Renault Master 2.3 DCi. Total frame mass savings were 0 kg at a cost increase of $0, or $0 per kg.

Table 3-79: Mass-Reduction and Cost Impact for Frame System, Renault Master

				Net Value of Mass Reduction							
System	Subsystem	Sub-Subsystem	Description	Mass Reduction New Tech "kg" (1)	Mass Reduction Comp "kg" (1)	Mass Reduction Total "kg" (1)	Cost Impact New Tech "$" (2)	Cost Impact Comp "$" (2)	Cost Impact Total "$" (2)	Cost/ Kilogram Total "$/kg"	Vehicle Mass Reduction Total "%"
07	**00**	**00**	**Frame and Mounting System**								
07	01	00	Frame Sub System	0.000	0.000	0.000	$0.00	$0.00	$0.00	$0.00	0.00%
07	03	00	Engine Transmission Mounting Subsystem	0.000	0.000	0.000	$0.00	$0.00	$0.00	$0.00	0.00%
07	04	00	Towing and Coupling Attach. Subsystem	0.000	0.000	0.000	$0.00	$0.00	$0.00	$0.00	0.00%
				0.000	**0.000**	**0.000**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**0.00%**

Mass Savings, Select Vehicle, New Technology "kg"	**0.00**
Mass Savings, Silverado 1500, New Technology "kg"	**23.70**
Mass Savings Select Vehicle/Mass Savings 1500	**0.0%**



*SMS not included - has no significant impact on perecent contributions

3.10.3.1 System Scaling Analysis – Renault Master 2.3 DCi

The Renault Master 2.3 DCi Frame components were reviewed for compatibility with lightweighting technologies. The results of this analysis are listed in Table 3-80.

Table 3-80: System Scaling Analysis Frame System, Renault Master

Silverado 1500							Select Vehicle			
System	Subsystem	Sub-Subsystem	Component/Assembly	Base Mass	Mass Savings New Tech	% of Mass Savings New Tech	Tech Applies	Base Mass	Mass Savings New Tech	Notes
07			**Frame & Mounting System**	**267.63**	**23.70**	**9%**			**0.00**	
07	01	01	Full Frame	242.00	23.70	10%	no			Tech does **NOT** apply: No full frame assembly

3.11 EXHAUST SYSTEM

3.11.1 Silverado 1500 Summary

The Chevrolet Silverado 1500 Exhaust system included the front crossover pipe assembly section, which includes three catalytic converters. The crossover pipe and the down pipe were made of 409 grade stainless steel. The muffler with tail pipe was made from aluminized steel. Other technologies included EPDM hangers and welded steel hanger brackets.

The Chevrolet Silverado 1500 analysis identifies mass reduction alternatives and cost implications for the Exhaust System with the intent to meet the function and performance requirements of the baseline vehicle. Table 3-81 provides a summary of mass reduction and cost impact for select sub-subsystems evaluated. The total mass savings found on the exhaust system mass were reduced by 6.34 kg (16.52%). This increased cost by $19.54, or $3.08 per kg. Mass reduction for this system reduced vehicle curb weight by 0.27%.

Table 3-81: Exhaust System Mass Reduction Summary, Silverado 1500

				Net Value of Mass Reduction					
System	Subsystem	Sub-Subsystem	Description	Base Mass "kg"	Mass Reduction "kg" (1)	Cost Impact NIDMC "$" (2)	Average Cost/ Kilogram "$/kg" (2)	Mass Reduction "%"	Vehicle Mass Reduction "%"
09	00	00	Exhaust						
09	**01**	**00**	**Acoustical Control Components Subsystem**	**38.37**	**6.34**	**-19.54**	**-3.08**	**16.52%**	**0.27%**
09	01	01	Cross Over Pipe Assembly	15.53	1.46	0.79	0.54	9.40%	0.06%
09	01	02	Expantion clamp assy	3.81	0.71	-1.09	-1.53	18.68%	0.03%
09	01	03	Muffler	19.03	4.17	-19.24	-4.61	21.91%	0.17%
				38.37	**6.34** (Decrease)	**-19.54** (Increase)	**-3.08** (Increase)	**16.52%**	**0.27%**

(1) "+" = mass decrease, "-" = mass increase
(2) "+" = cost decrease, "-" = cost increase

Columns in the "Net Value of Mass Reduction" chart above may contain combined masses of assembly hardware such as nuts, bolt, washer, etc. that were not mass reduced at the component level, and may not match base mass and mass reduction totals in text below component reduction weights.

Mass savings opportunities were identified for the following components: crossover pipe, down pipe, muffler, steel hanger brackets, and EPDM hangers.

DRAFT

Crossover pipe: The crossover pipe mass was reduced by changing the wall thickness from 1.9 mm 409 Stainless Steel (SS) wall to 1.2 mm 304SS (cannot reduce pipe wall without going to 304SS). Mass was reduced by 34.5%, from 4.2 kg to 2.7 kg.

Down pipe: The down pipe mass was reduced by changing the wall thickness from 1.9 mm 409SS wall to 1.2 mm 304SS (cannot reduce pipe wall without going to 304SS). Mass was reduced by 22.2%, from 2.1 kg to 1.6 kg.

Muffler skin and end plates: The muffler skin and end plates mass was reduced by changing the base grade aluminum/steel to 304SS and changing wall thickness from 1.4mm to 1mm. Mass was reduced by 30.8%, from 7.1 kg to 4.9 kg.

Steel hanger brackets: The steel hanger brackets mass was reduced by changing the solid steel hanger brackets to a hollow 304SS. Mass was reduced by 30.9%, from 1.5 kg to 1.0 kg.

EPDM Hangers: The EPDM hangers mass was reduced by changing the EPDM to a fiber-reinforced SGF® Hanger. Mass was reduced by 71.7%, from 0.63 kg to 0.18 kg.

3.11.1.1 Silverado 2500 Analysis

The Chevrolet Silverado 2500 Exhaust System (Image 3.11–1) was very similar to the 1500, but on a larger scale due to the larger engine size (6.0L versus 5.3L) and more exhaust being pushed through the system. The pipes used in the system had a larger diameter and a thicker wall.

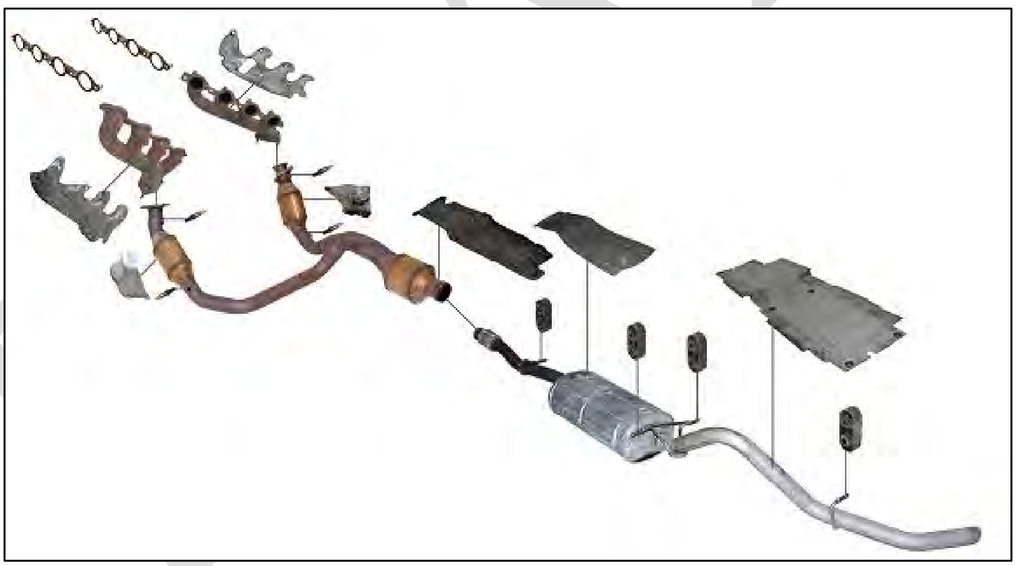


Image 3.11–1: Chevrolet Silverado 2500 Exhaust System
(Source: www.A2mac1 Database)

3.11.1.2 2500 System Scaling Summary

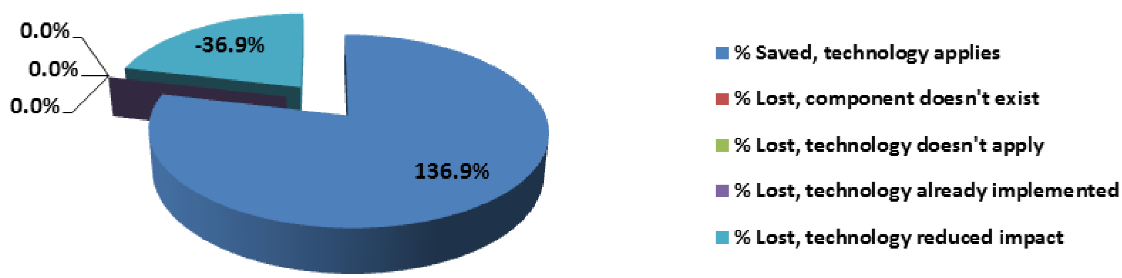
Table 3-82 summarizes mass and cost impact of Silverado 1500 lightweighting technologies as applied to the Silverado 2500. Total exhaust mass savings was 9.12 kg at a cost increase of $15.87, or $1.74 per kg.

DRAFT

Table 3-82: Mass-Reduction and Cost Impact for Exhaust System, Silverado 2500

System	Subsystem	Sub-Subsystem	Description	Net Value of Mass Reduction							
				Mass Reduction New Tech "kg" (1)	Mass Reduction Comp "kg" (1)	Mass Reduction Total "kg" (1)	Cost Impact New Tech "$" (2)	Cost Impact Comp "$" (2)	Cost Impact Total "$" (2)	Cost/ Kilogram Total "$/kg"	Vehicle Mass Reduction Total "%"
09	00	00	**Exhaust System**								
09	01	00	Acoustical Control Components	8.68	0.44	9.12	-$21.96	$6.08	-$15.87	-$1.74	0.30%
				8.68 (Decrease)	**0.44** (Decrease)	**9.12** (Decrease)	**-$21.96** (Increase)	**$6.08** (Decrease)	**-$15.87** (Increase)	**-$1.74** (Increase)	**0.30%**

Mass Savings, Select Vehicle, New Technology "kg"	**8.68**
Mass Savings, Silverado 1500, New Technology "kg"	**6.34**
Mass Savings Select Vehicle/Mass Savings 1500	**136.9%**



*SMS not included - has no significant impact on perecent contributions

DRAFT

3.11.1.3 System Scaling Analysis – Silverado 2500

The Silverado 2500 exhaust components were reviewed for compatibility with lightweighting technologies. The results of this analysis are listed in Table 3-83.

Table 3-83: System Scaling Analysis for Exhaust System, Silverado 2500

Silverado 1500							Select Vehicle			
System	Subsystem	Sub-Subsystem	Component/Assembly	Base Mass	Mass Savings New Tech	% of Mass Savings New Tech	Tech Applies	Base Mass	Mass Savings New Tech	Notes
09			Exhaust System	38.37	6.34	17%			8.68	
09	01	01	Cross Over Pipe Assembly	4.23	1.46	34%	yes	8.32	2.87	Tech **DOES** apply: Base cross pipe reduce wall thickness from 1.9mm 409ss wall to 1.2mm 304ss ((Can't reduce pipe wall without going to 304ss))
09	01	02	Down pipe to muffler	2.14	0.48	22%	yes	2.74	0.58	Tech **DOES** apply: Base cross pipe reduce wall thickness from 1.9mm 409ss wall to 1.2mm 304ss ((Can't reduce pipe wall without going to 304ss))
09	01	02	Steel hanger brkt	0.40	0.12	31%	yes	0.75	0.23	Tech **DOES** apply: Hollow exhaust hangers 304SS (pipe side)
09	01	02	Rubber hanger	0.16	0.11	72%	yes	0.32	0.23	Tech **DOES** apply: SGF for rubber Hanger Isolators
09	01	03	Muffler skin	5.48	1.69	31%	yes	5.35	1.65	Tech **DOES** apply: Base grade Al/steel to 304SS & 304SS and go from 1.4mm wall to 1mm
09	01	03	Muffler skin end plts	1.67	0.52	31%	yes	1.40	0.43	Tech **DOES** apply: Base grade Al/steel to 304SS & 304SS and go from 1.4mm wall to 1mm
09	01	03	Muffler pipe	4.13	1.27	31%	yes	6.76	2.08	Tech **DOES** apply: Base grade Al/steel to 304SS & 304SS and go from 1.4mm wall to 1mm
09	01	03	Steel hanger brkt lg	0.83	0.26	31%	yes	0.79	0.24	Tech **DOES** apply: Hollow exhaust hangers 304SS (pipe side)
09	01	03	Steel hanger brkt small	0.31	0.10	31%	yes	0.47	0.15	Tech **DOES** apply: Hollow exhaust hangers 304SS (pipe side)
09	01	03	Rubber hanger	0.48	0.34	72%	yes	0.32	0.23	Tech **DOES** apply: SGF for rubber Hanger Isolators

Components with significant mass savings identified on the Silverado 2500 included the crossover pipe, down pipe, muffler, muffler end plates, muffler pipe, steel hanger brackets, and EPDM hangers.

<u>Crossover pipe</u>

Shown in Image 3.11–2 are the Silverado 1500 and 2500 crossover pipes. Component masses were 4.23 kg for the 1500 versus 8.32 kg for the 2500. The Silverado 1500 and the 2500 series crossover pipes were similar in configuration, although the 2500 pipe diameters were larger, with a slightly thicker wall. The 2500 had a bolt on flange to the muffler, and the 1500 had the stainless steel mess coupler. Both systems also had three catalytic converters and three oxygen sensors. The lightweighting technology used in the crossover pipe was to change the stainless steel material from a 409 stainless steel to a 304 stainless steel. This allowed for a reduction in the pipe wall thickness. Due to similarities in component design and material, full percentage of the Silverado 1500 crossover pipe reduction can be applied to the 2500. (Refer to Table 3-83).

DRAFT

Image 3.11–2: Crossover Pipe for the Silverado 1500 (Left) and Silverado 2500 (Right)
(Source: FEV, Inc.)

Down pipe

Shown in Image 3.11–3 are the Silverado 1500 and 2500 down pipes. Component masses were 2.14 kg for the 1500 versus 2.74 kg for the 2500. The 1500 down pipe had a mesh stainless steel coupler to connect to the crossover pipe, whereas the 2500 did not. The 2500 pipe diameter was larger, with a slightly thicker wall. The lightweighting technology used in the crossover pipe was to change the stainless steel material from a 409 stainless steel to a 304 stainless steel. This allowed for a reduction in the pipe wall thickness. Due to similarities in component material, full percentage of the Silverado 1500 down pipe mass reduction can be applied to the 2500. (Refer to Table 3-83).

DRAFT

Image 3.11–3: Down Pipe for the Silverado 1500 (Top) and Silverado 2500 (Bottom)
(Source: FEV, Inc.)

Steel hanger brackets

Shown in Image 3.11–4 are the Silverado 1500 and 2500 steel hanger brackets. Component masses were 1.54 kg for the 1500 versus 2.01 kg for the 2500. There are slight differences as to where they were placed and the contortion of the bracket, but both serve the same purpose. The lightweighting technology used in the steel hanger brackets was to use a 304 stainless steel that allowed for a smaller diameter hanger and to hollow out the center of the bracket (Image 3.11–5). Due to similarities in component design and material, full percentage of the Silverado 1500 steel hanger bracket mass reduction can be applied to the 2500. (Refer to Table 3-83).

Image 3.11–4: Steel hanger brackets 1500 (Left), 2500 (Right)
(Source: FEV, Inc.)

Image 3.11–5: Hollow Stainless Steel Hanger Brackets Example
(Source: FEV, Inc.)

EPDM hangers

DRAFT

Shown in Image 3.11–6 are the Silverado 1500 and 2500 EPDM hangers. Component masses were 0.64 kg for the 1500 versus 0.64 kg for the 2500. There were slight differences as to the location on each respective vehicle, but both served the same purpose. The lightweighting technology used in the EPDM hanger brackets was to use an SGF® fiber reinforced hanger. This allowed for smaller, lighter weight hangers. An example is shown in Image 3.11–7. Due to similarities in component design and material, full percentage of the Silverado 1500 EPDM hanger mass reduction can be applied to the 2500. (Refer to Table 3-83).

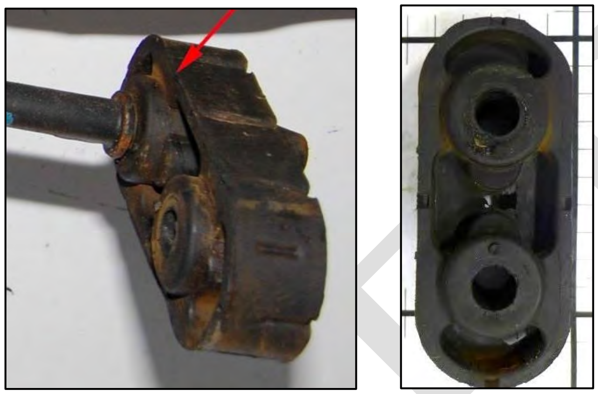


Image 3.11–6: EPDM hangers for the Silverado 1500 (Left) and Silverado 2500 (Right)
(Source: FEV, Inc.)

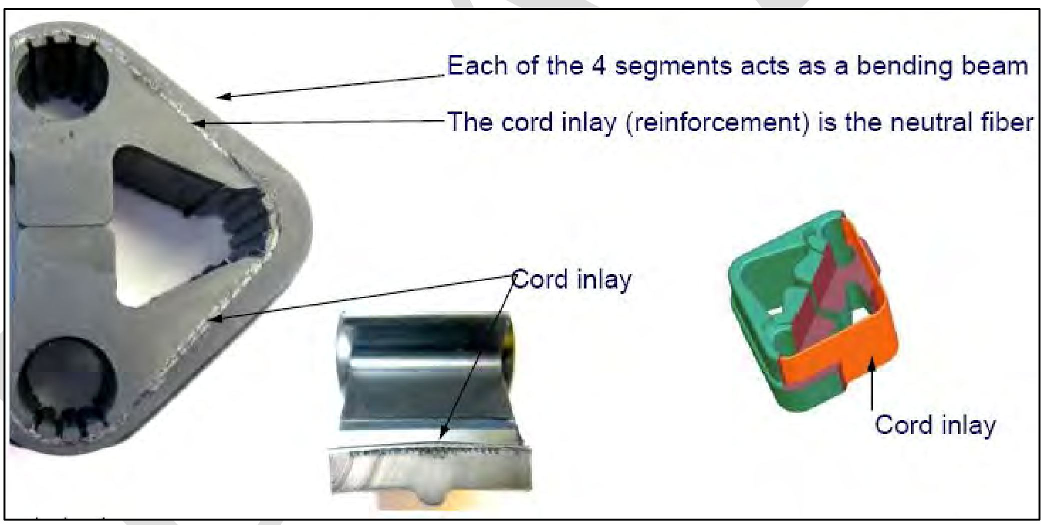


Image 3.11–7: Example of SGF® fiber reinforced hanger
(Source: SGF)

Muffler skin

Shown in Image 3.11–8 are the Silverado 1500 and 2500 muffler skins. Component masses were 5.4 kg for the 1500 versus 5.3 kg for the 2500. Both muffler skins were made of aluminized steel. The lightweighting technology used in both muffler skins was changing the aluminized steel to a 304 stainless steel that will allow for a reduced wall thickness. Due to similarities in component design and material, full percentage of the Silverado 1500 muffler skin mass reduction can be applied to the 2500. (Refer to Table 3-83).

DRAFT

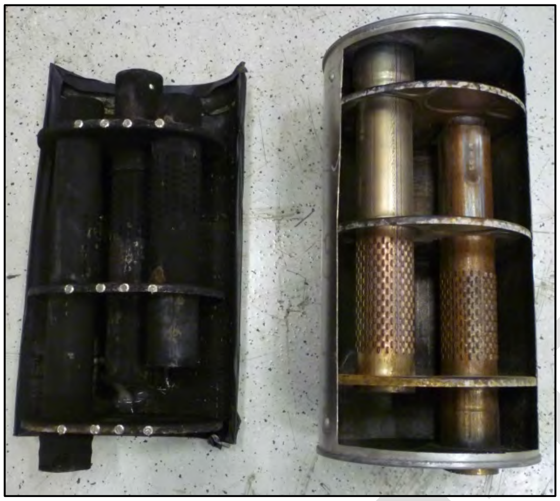


Image 3.11–8: Muffler skin for the Silverado 1500 (Left) and Silverado 2500 (Right)
(Source: FEV, Inc.)

DRAFT

Muffler end plates

Shown in Image 3.11–9 are the Silverado 1500 and 2500 series muffler end plates. Component masses are 1.6 kg for the 1500 versus 1.4 kg for the 2500 respectively. Both the mufflers are made of aluminized steel. The lightweighting technology used in both the muffler end plates is to change the aluminized steel to a 304 stainless steel that will allow of a wall thickness reduction. Due to similarities in component design and material, full percentage of the Silverado 1500 muffler end plates mass reduction can be applied to the 2500. (Refer to Table 3-83).

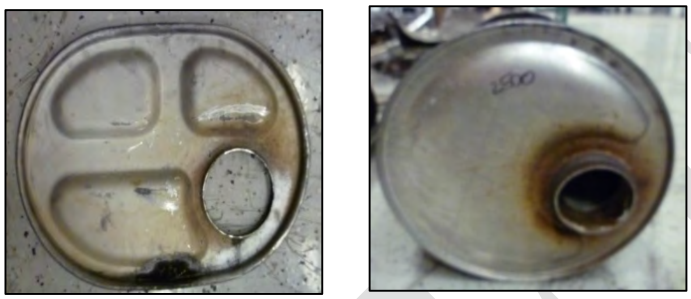


Image 3.11–9: Muffler end plates for the Silverado 1500 (Left) and Silverado 2500 (Right)
(Source: FEV, Inc.)

Muffler pipe

Shown in Image 3.11–10 are the Silverado 1500 and 2500 muffler pipes. Component masses were 4.1 kg for the 1500 versus 6.6 kg for the 2500. Both muffler pipes were made of aluminized steel. The 2500 muffler was much larger than the 1500. The lightweighting technology used in both muffler pipes was to change the aluminized steel to a 304 stainless steel which will allow a wall thickness reduction. Due to similarities in component design and material, full percentage of the Silverado 1500 muffler pipe mass reduction can be applied to the 2500. (Refer to Table 3-83).

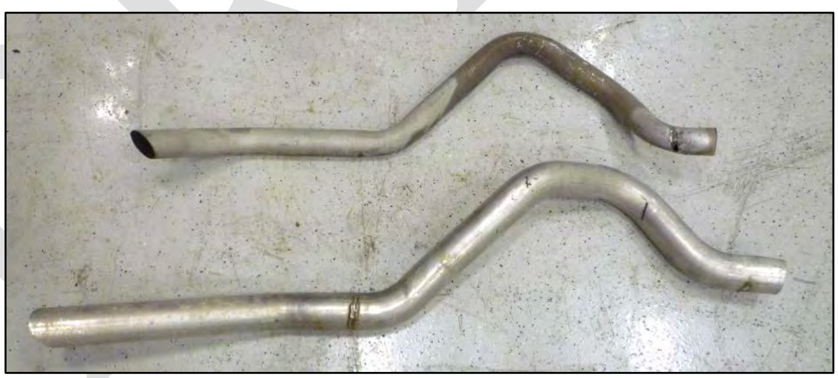


Image 3.11–10: Muffler pipe for the Silverado 1500 (Top) and Silverado 2500 (Bottom)
(Source: FEV, Inc.)

DRAFT

3.11.1.4 System Comparison – Silverado 2500

Table 3-84 summarizes the Silverado 1500 and 2500 lightweighting results. The majority of the components were visually the same between the two exhausts. The 2500 exhaust had larger diameter pipes with slightly thicker walls.

Table 3-84: System Comparison, Silverado 2500

System	Description	Net Value of Mass Reduction								
		Mass Base "kg" (1)	Mass Reduction New Tech "kg" (1)	Mass Reduction Comp "kg" (1)	Mass Reduction Total "kg" (1)	System Mass Reduction "%"	Cost Impact New Tech "$" (2)	Cost Impact Comp "$" (2)	Cost Impact Total "$" (2)	Cost/ Kilogram Total "$/kg"
09	**Exhaust**									
09	Silverado 1500	38.37	6.34	1.67	8.01	20.87%	-$19.54	$12.13	-$7.41	-$0.93
09	Silverado 2500	45.52	8.68	0.44	9.12	20.04%	-$21.96	$6.08	-$15.87	-$1.74

DRAFT

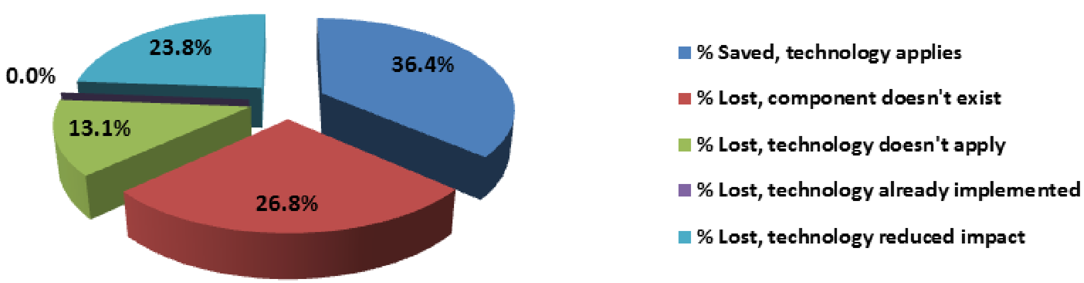
3.11.2 Mercedes Sprinter 311 CDi

Table 3-85 summarizes mass and cost impact of Silverado 1500 lightweighting technologies as applied to the Mercedes Sprinter 311 CDi. Total exhaust mass savings was 2.45 kg at a cost increase of $10.36, or $4.23 per kg.

Table 3-85: Mass-Reduction and Cost Impact for Exhaust System, Mercedes Sprinter

				Net Value of Mass Reduction							
System	Subsystem	Sub-Subsystem	Description	Mass Reduction New Tech "kg" (1)	Mass Reduction Comp "kg" (1)	Mass Reduction Total "kg" (1)	Cost Impact New Tech "$" (2)	Cost Impact Comp "$" (2)	Cost Impact Total "$" (2)	Cost/ Kilogram Total "$/kg"	Vehicle Mass Reduction Total "%"
09	00	00	**Exhaust System**								
09	01	00	Acoustical Control Components	2.31	0.14	2.45	-$12.20	$1.85	-$10.36	-$4.23	0.11%
				2.31 (Decrease)	**0.14** (Decrease)	**2.45** (Decrease)	**-$12.20** (Increase)	**$1.85** (Decrease)	**-$10.36** (Increase)	**-$4.23** (Increase)	**0.11%**

Mass Savings, Select Vehicle, New Technology "kg"	**2.31**
Mass Savings, Silverado 1500, New Technology "kg"	**6.34**
Mass Savings Select Vehicle/Mass Savings 1500	**36.4%**



*SMS not included - has no significant impact on perecent contributions

3.11.2.1 System Scaling Analysis – Mercedes Sprinter 311 CDi

The Mercedes Sprinter 311 CDi Exhaust components were reviewed for compatibility with lightweighting technologies.

Table 3-86: System Scaling Analysis for Exhaust System, Mercedes Sprinter

Silverado 1500							Select Vehicle			
System	Subsystem	Sub-Subsystem	Component/Assembly	Base Mass	Mass Savings New Tech	% of Mass Savings New Tech	Tech Applies	Base Mass	Mass Savings New Tech	Notes
09			**Exhaust System**	**38.37**	**6.34**	**17%**			**2.31**	
09	01	01	Cross Over Pipe Assembly	4.23	1.46	34%	no			Tech does **NOT** Apply: Single exhaust does not have a cross over pipe assy
09	01	02	Down pipe to muffler	2.14	0.48	22%	no			Tech does **NOT** apply: No down pipe assy. From header to SS felx assy
09	01	02	Steel hanger brkt	0.40	0.12	31%	no			Tech does **NOT** apply: With no cross over or down pipe, no steel hanger required
09	01	02	Rubber hanger	0.16	0.11	72%	no			Tech does **NOT** apply: With no cross over pipe, no down pipe and no steel hanger - no rubber hanger is required
09	01	03	Muffler skin	5.48	1.69	31%	yes	3.63	1.12	Tech **DOES** apply: Base grade Al/steel to 304SS & 304SS and go from 1.4mm wall to 1mm
09	01	03	Muffler skin end plts	1.67	0.52	31%	yes	0.89	0.27	Tech **DOES** apply: Base grade Al/steel to 304SS & 304SS and go from 1.4mm wall to 1mm
09	01	03	Muffler pipe	4.13	1.27	31%	yes	2.81	0.87	Tech **DOES** apply: Base grade Al/steel to 304SS & 304SS and go from 1.4mm wall to 1mm
09	01	03	Steel hanger brkt lg	0.83	0.26	31%	no			Tech does **NOT** apply: Steel hanger already hollow
09	01	03	Steel hanger brkt small	0.31	0.10	31%	no			Tech does **NOT** apply: Steel hanger already hollow
09	01	03	Rubber hanger	0.48	0.34	72%	yes	0.07	0.05	Tech **DOES** apply: SGF for rubber Hanger Isolators

If the original Silverado 1500 mass reduction concept idea was not able to be applied to the comparison vehicle it is not described in the section below.

Components with significant mass savings identified on the Mercedes Sprinter included the muffler, muffler pipe, and EPDM hangers. Image 3.11–11 shows the Mercedes Sprinter 311 CDi Exhaust components.

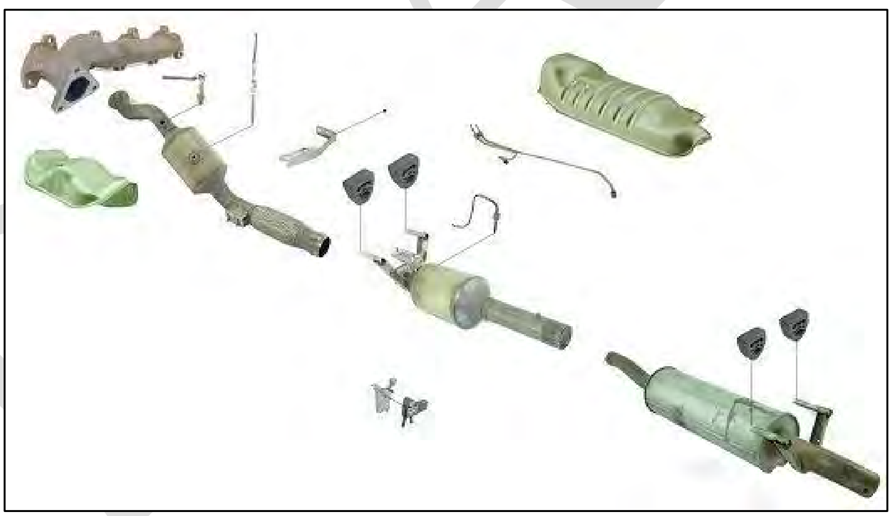


Image 3.11–11: Mercedes Sprinter 311 CDi Exhaust
(Source: www.A2mac1.com)

Muffler Skin

As shown in Image 3.11–12, the Mercedes Sprinter 311 CDi and the Silverado 1500 muffler skins are different. Component masses were 5.4 kg for the 1500 versus 3.6 kg for the Mercedes Sprinter. Both mufflers were made of aluminized steel. The Silverado 1500 muffler was much larger than the Mercedes Sprinter. The lightweighting technology used in both muffler skins was to change the aluminized steel to a 304 stainless steel, which would allow for a wall thickness reduction. Due to similarities in component design and material, full percentage of the Silverado 1500 muffler skin mass reduction can be applied to the Sprinter.

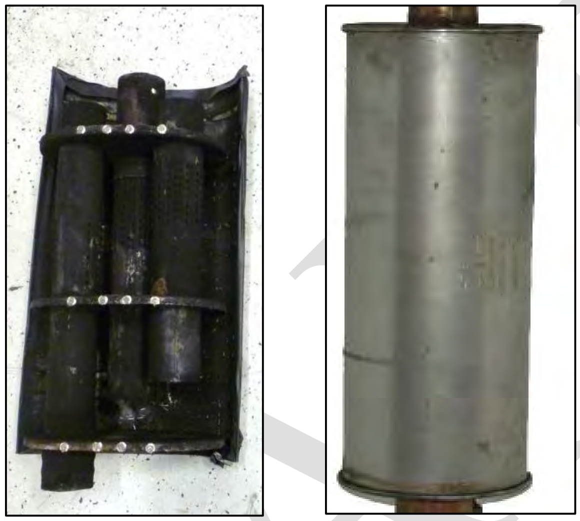


Image 3.11–12: Muffler skin for the Silverado 1500 (Left) and Mercedes Sprinter (Right)
(Source: FEV, Inc. and www.A2mac1.com)

Muffler End Plates

As shown in Image 3.11–13, the Mercedes Sprinter 311 CDi and the Silverado 1500 muffler end plates are different. Component masses are 1.6 kg for the 1500 versus 0.89 kg for the Mercedes Sprinter. Both muffler end plates are made of aluminized steel. The Silverado 1500 muffler end plates were much larger than the Mercedes Sprinter. The lightweighting technology used for both muffler end plates was to change the aluminized steel to a 304 stainless steel that would allow a wall thickness reduction. Due to similarities in component design and material, full percentage of the Silverado 1500 muffler end plate mass reduction can be applied to the Sprinter.

Image 3.11–13: Muffler end plates for the Silverado 1500 (Left) and Mercedes Sprinter (Right)
(Source: FEV, Inc. and www.A2mac1.com)

Muffler Pipe

DRAFT

The Silverado 1500 and Mercedes Sprinter muffler pipes are shown in

Image 3.11–14. Component masses are 4.1 kg for the Silverado 1500 versus 2.81 kg for the Mercedes Sprinter respectively. Both the muffler pipes were made of aluminized steel. The Silverado 1500 muffler was much larger than the Mercedes Sprinter. The lightweighting technology used in both muffler pipes was to change the aluminized steel to a 304 stainless steel that would allow wall thickness reduction. Due to similarities in component design and material, full percentage of the Silverado 1500 muffler pipe mass reduction can be applied to the Sprinter.

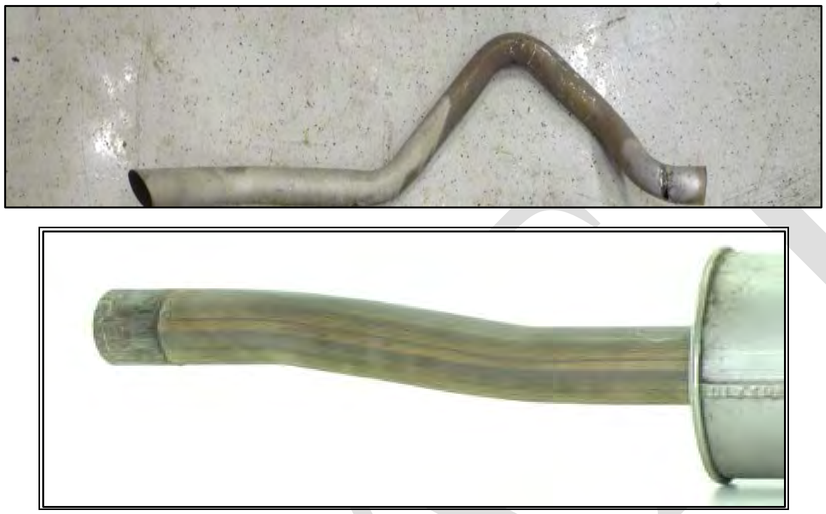


Image 3.11–14: Muffler pipes for the Silverado 1500 (Top) and Mercedes Sprinter (Bottom)
(Source: FEV, Inc. and www.A2mac1.com)

EPDM Hangers

Shown in Image 3.11–15 are the Silverado 1500 and Mercedes Sprinter EPDM hangers. Component masses are 0.48 kg for the Silverado 1500 versus 0.07 kg for the Mercedes Sprinter. The EPDM hanger for both the 1500 and the Sprinter were manufactured the same. There were slight differences to the location of the hangers on their respective vehicles, but both serve the same purpose. The lightweighting technology used in the EPDM hanger brackets was to use a SGF® fiber reinforced hanger (Image 3.11–16). This allows for smaller, lighter weight hangers. Due to similarities in component design and material, full percentage of the Silverado 1500 EPDM hanger mass reduction can be applied to the Sprinter.

DRAFT

Image 3.11–15: EPDM hangers for the Silverado 1500 (Left) and Mercedes Sprinter (Right)
(Source: FEV, Inc. and www.A2mac1.com)

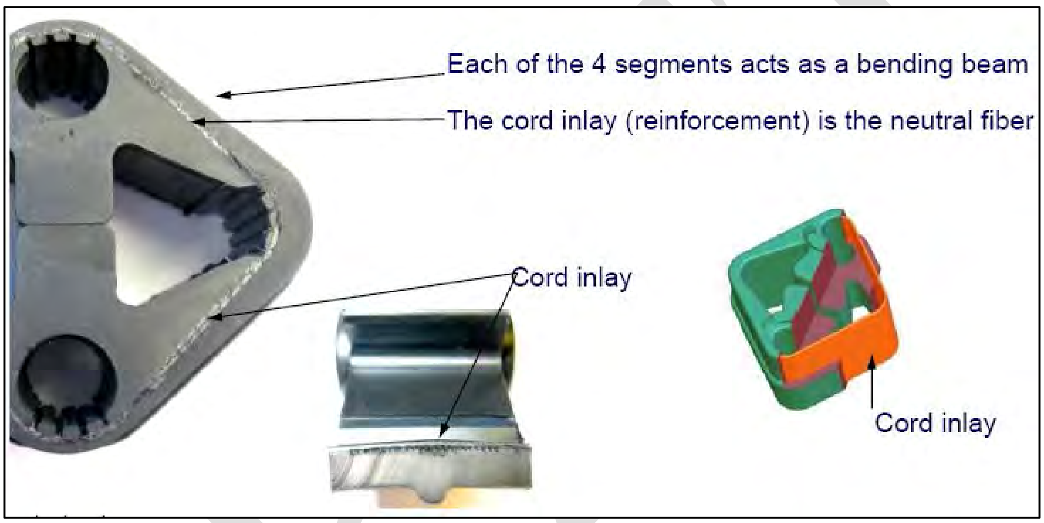


Image 3.11–16: Example of SGF® fiber reinforced hanger
(Source: SGF)

DRAFT

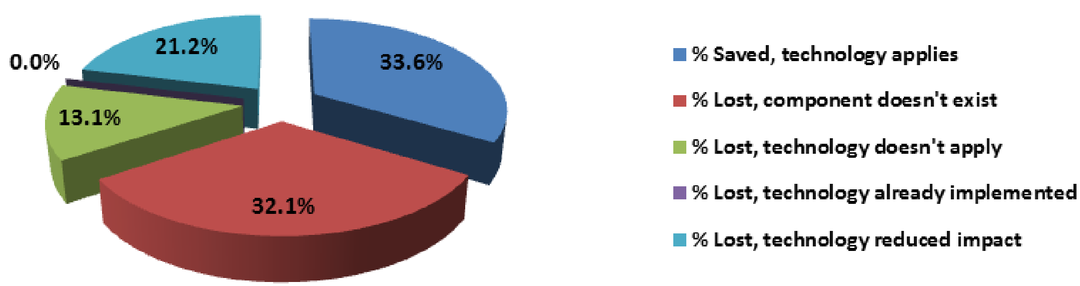
3.11.3 Renault Master 2.3 DCi

Table 3-87 summarizes mass and cost impact of Silverado 1500 lightweighting technologies as applied to the Renault Master 2.3 DCi. Total exhaust mass savings was 2.29 kg at a cost increase of $9.38, or $4.09 per kg.

Table 3-87: Mass-Reduction and Cost Impact for Exhaust System, Renault Master

				Net Value of Mass Reduction							
System	Subsystem	Sub-Subsystem	Description	Mass Reduction New Tech "kg" (1)	Mass Reduction Comp "kg" (1)	Mass Reduction Total "kg" (1)	Cost Impact New Tech "$" (2)	Cost Impact Comp "$" (2)	Cost Impact Total "$" (2)	Cost/ Kilogram Total "$/kg"	Vehicle Mass Reduction Total "%"
09	**00**	**00**	**Exhaust System**								
09	01	00	Acoustical Control Components	2.13	0.16	2.29	-$11.48	$2.11	-$9.38	-$4.09	0.10%
				2.13 (Decrease)	**0.16** (Decrease)	**2.29** (Decrease)	**-$11.48** (Increase)	**$2.11** (Decrease)	**-$9.38** (Increase)	**-$4.09** (Increase)	**0.10%**

Mass Savings, Select Vehicle, New Technology "kg"	**2.13**
Mass Savings, Silverado 1500, New Technology "kg"	**6.34**
Mass Savings Select Vehicle/Mass Savings 1500	**33.6%**



*SMS not included - has no significant impact on perecent contributions

3.11.3.1 System Scaling Analysis – Renault Master 2.3 DCi

The Renault Master 2.3 DCi Exhaust components were reviewed for compatibility with lightweighting technologies.

.

Table 3-88: System Scaling Analysis Exhaust System, Renault Master

Silverado 1500							Select Vehicle			
System	Subsystem	Sub-Subsystem	Component/Assembly	Base Mass	Mass Savings New Tech	% of Mass Savings New Tech	Tech Applies	Base Mass	Mass Savings New Tech	Notes
09			**Exhaust System**	**38.37**	**6.34**	**17%**			**2.13**	
09	01	01	Cross Over Pipe Assembly	4.23	1.46	34%	no			Tech does **NOT** Apply: Single exhaust does not have a cross over pipe assy
09	01	02	Down pipe to muffler	2.14	0.48	22%	no			Tech does **NOT** apply: No down pipe assy. From header to SS felx assy
09	01	02	Steel hanger brkt	0.40	0.12	31%	no			Tech does **NOT** apply: With no cross over or down pipe, no steel hanger required
09	01	02	Rubber hanger	0.16	0.11	72%	no			Tech does **NOT** apply: With no cross over pipe, no down pipe and no steel hanger - no rubber hanger is required
09	01	03	Muffler skin	5.48	1.69	31%	yes	3.39	1.04	Tech **DOES** apply: Base grade Al/steel to 304SS & 304SS and go from 1.4mm wall to 1mm
09	01	03	Muffler skin end plts	1.67	0.52	31%	yes	0.90	0.28	Tech **DOES** apply: Base grade Al/steel to 304SS & 304SS and go from 1.4mm wall to 1mm
09	01	03	Muffler pipe	4.13	1.27	31%	yes	2.63	0.81	Tech **DOES** apply: Base grade Al/steel to 304SS & 304SS and go from 1.4mm wall to 1mm
09	01	03	Steel hanger brkt lg	0.83	0.26	31%	no			Tech does **NOT** apply: Steel hanger already hollow
09	01	03	Steel hanger brkt small	0.31	0.10	31%	no			Tech does **NOT** apply: Steel hanger already hollow
09	01	03	Rubber hanger	0.48	0.34	72%	no			Tech **DOES** apply: SGF for rubber Hanger Isolators

If the original Silverado 1500 mass reduction concept idea was not able to be applied to the comparison vehicle it is not described in the section below.

Components with significant mass savings identified on the Renault Master 2.3 DCi included the muffler, muffler pipe, and EPDM hangers. Image 3.11–17 shows the Renault Master 2.3 DCi Exhaust components.

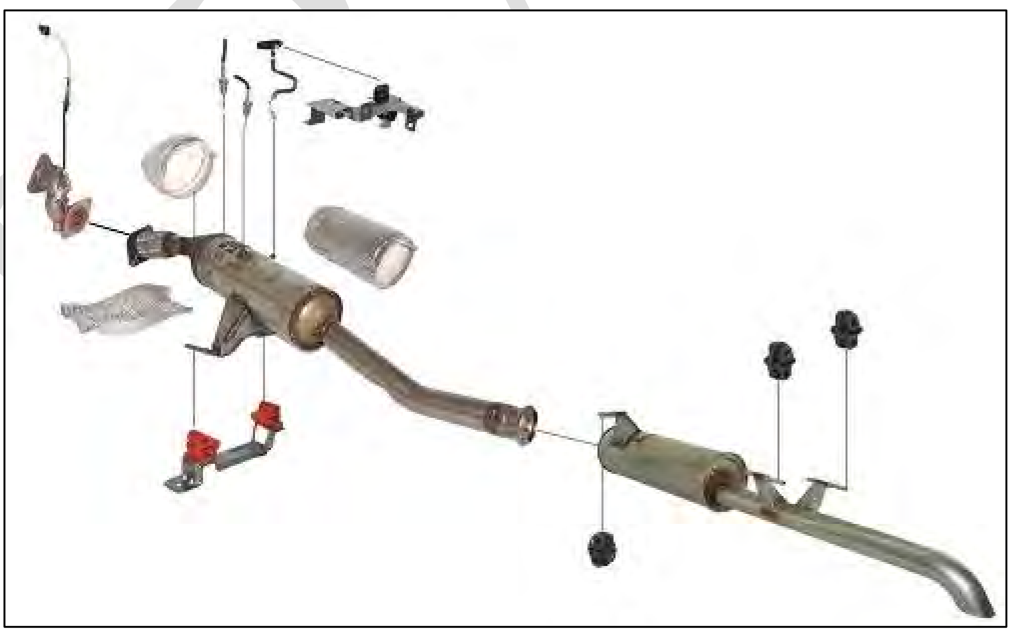


Image 3.11–17: Renault Master 2.3 DCi Exhaust
(Source: www.A2mac1.com)

Muffler Skin

As shown in Image 3.11–18, the Renault Master 2.3 DCi and the Silverado 1500 mufflers are different. Component masses were 5.4 kg for the Silverado 1500 versus 3.3 kg for the Renault Master 2.3 DCi. Both mufflers were made of aluminized steel. The 1500 muffler was much larger than the Renault Master 2.3 DCi. The lightweighting technology used in both muffler skins was to change the aluminized steel to a 304 stainless steel that will allow a reduction in wall thickness. Due to similarities in component material, full percentage of the Silverado 1500 muffler skin mass reduction can be applied to the Renault.

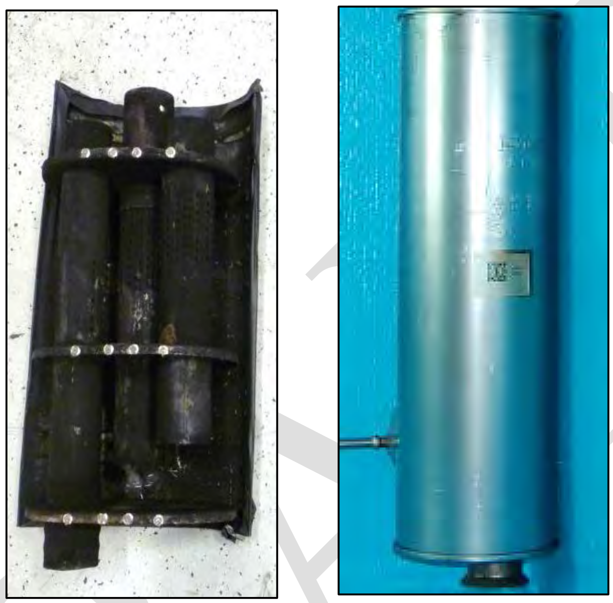


Image 3.11–18: Muffler skin for the Silverado 1500 (Left) and Renault Master 2.3 DCi (Right)
(Source: FEV, Inc. and www.A2mac1.com)

Muffler End Plates

As shown in Image 3.11–19, the Renault Master 2.3 DCi and the Silverado 1500 muffler end plates are different. Component masses are 1.6 kg for the 1500 versus .83 kg for the Renault Master 2.3 DCi respectively. Both the muffler end plates are made of aluminized steel. The 1500 muffler end plates are much larger than the Renault Master 2.3 DCi. The lightweighting technology used in both the muffler end plates is to change the aluminized steel to a 304 stainless steel that will allow of a wall thickness reduction. Due to similarities in component material, full percentage of the Silverado 1500 muffler end plate mass reduction can be applied to the Renault.

Image 3.11–19: Muffler end plates for the Silverado 1500 (Left) and Renault Master 2.3 DCi (Right)
(Source: FEV, Inc. and www.A2mac1.com)

DRAFT

Muffler Pipe

Shown in Image 3.11–20 are the Silverado 1500 and Renault Master 2.3 DCi muffler pipes. Component masses were 4.1 kg for the Silverado 1500 versus 2.6 kg for the Renault Master 2.3 DCi. Both muffler pipes were made of aluminized steel. The 1500 muffler is much larger than the Renault Master 2.3 DCi. The lightweighting technology used in both muffler pipes was to change aluminized steel to a 304 stainless steel that will allow for wall thickness reduction. Due to similarities in component material, full percentage of the Silverado 1500 muffler pipe mass reduction can be applied to the Renault.

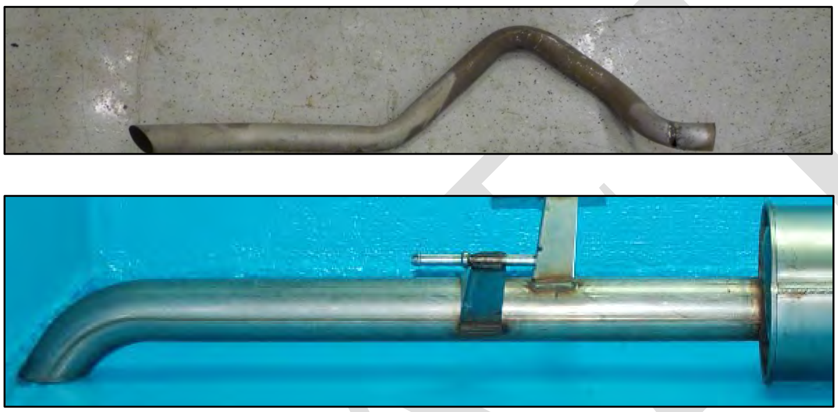


Image 3.11–20: Muffler pipes 1500 (Top), Renault Master 2.3 DCi (Bottom)
(Source: FEV, Inc. and www.A2mac1.com)

DRAFT

3.12 FUEL SYSTEM

3.12.1 Silverado 1500 Summary

The Chevrolet Silverado 1500 Fuel System included the fuel tank assembly, fuel tank shields, Fuel Subsystem, Fuel Filler Subsystem, and Fuel Vapor Subsystem. The fuel tank is made of plastic, Polyoxymethylene (POM) material with a molded in metal top ring for attaching the fuel pumping module. The rest of the Fuel System is typical for fuel systems.

The Chevrolet Silverado 1500 analysis identifies mass reduction alternatives and cost implications for the Fuel System with the intent to meet the function and performance requirements of the baseline vehicle. Table 3-89 provides a summary of mass reduction and cost impact for select sub-subsystems evaluated. The total mass savings found on the Fuel System mass was reduced by 1.61 kg (6.1%). This decreased cost by \$3.25, or \$2.02 per kg. Mass reduction for this system reduced vehicle curb weight by 0.07%.

Table 3-89: Fuel System Mass Reduction Summary, Silverado 1500

				Net Value of Mass Reduction					
System	Subsystem	Sub-Subsystem	Description	Base Mass "kg"	Mass Reduction "kg" (1)	Cost Impact NIDMC "$" (2)	Average Cost/ Kilogram "$/kg" (2)	Mass Reduction "%"	Vehicle Mass Reduction "%"
10	00	00	Fuel						
10	**01**	**00**	**Fuel Tank and Lines Subsystem**	**22.60**	**0.73**	**2.36**	**3.23**	**3.23%**	**0.03%**
10	01	01	Fuel Tank Assy	15.48	0.19	0.93	4.93	1.22%	0.01%
10	01	02	Fuel Distribution	5.09	0.37	1.30	3.50	7.31%	0.02%
10	01	03	Fuel Filler (Refueling)	0.91	0.17	0.13	0.74	18.59%	0.01%
10	01	04	Fuel Tank Control Module (FTCM)	1.12	0.00	0.00	0.00	0.00%	0.00%
10	**02**	**00**	**Fuel Vapor Management Subsystem**	**3.74**	**0.88**	**0.89**	**1.02**	**23.42%**	**0.04%**
10	02	01	Fuel Vapor Canister	2.83	0.70	0.96	1.37	24.75%	0.03%
10	02	02	Purge Valve Assy	0.91	0.18	-0.07	-0.38	19.31%	0.01%
				26.34	1.61 (Decrease)	3.25 (Decrease)	2.02 (Decrease)	6.10%	0.07%

(1) "+" = mass decrease, "-" = mass increase
(2) "+" = cost decrease, "-" = cost increase

Columns in the "Net Value of Mass Reduction" chart above may contain combined masses of assembly hardware such as nuts, bolt, washer, etc. that were not mass reduced at the component level, and may not match base mass and mass reduction totals in text below component reduction weights.

Mass savings opportunities were identified for the following components: fuel tank side - fuel pump retaining ring, fuel tank shield (bottom), fuel pumping module retaining ring, fuel filler neck, fuel filler cap housing, fuel cap, hose clamp (large), hose clamp (small), and vapor canister.

<u>Fuel Tank Side - Fuel Pump Retaining Ring:</u> The fuel tank side - fuel pump retaining ring mass was increased by adding material to the fuel tank side to allow for a threaded lip to add a POM screw on top style fuel pump retaining system used in other vehicles. A reduction will be taken in the fuel pumping module retaining ring. Mass was increased by 31.7%, from 0.139 kg to 0.183 kg.

<u>Fuel Tank Shield (Bottom):</u> The fuel tank shield (bottom) mass was reduced by using PolyOne® foaming agent. Mass was reduced by 10%, from 2.33 kg to 2.09 kg.

Fuel Pumping Module Retaining Ring: The fuel pumping module retaining ring mass was reduced by removing the steel ring and combining with a POM fuel tank ring assembly. Mass was reduced by 48.6%, from 0.247 kg to 0.127 kg.

Fuel Filler Neck: The fuel filler neck mass was reduced by changing steel for a combination plastic and PolyOne® assembly. Mass was reduced by 69.3%, from .212 kg to 0.065 kg.

Fuel Filler Cap Housing: The fuel filler cap housing mass was reduced by using PolyOne® foaming agent. Mass was reduced by 9.8%, from 0.102 kg to 0.092 kg.

Fuel Cap: The fuel cap mass was reduced by using PolyOne® foaming agent. Mass was reduced by 10.1%, from 0.079 kg to 0.071 kg.

Hose Clamp (Large): The hose clamp (large) mass was reduced by using a smaller width. Mass was reduced by 10%, from 0.02 kg to 0.018 kg.

Hose Clamp (Small): The hose clamp (small) mass was reduced by using a smaller width. Mass was reduced by 10%, from 0.004 kg to 0.0036 kg.

Vapor Canister: The vapor canister mass was reduced by normalize it to the 2013 Chevy Malibu Eco 2.4. Mass was reduced by 3%, from 1.96 kg to 1.90 kg.

3.12.1.1 Silverado 2500 Analysis

The Chevrolet Silverado 2500 Fuel System was very similar to the Silverado 1500.

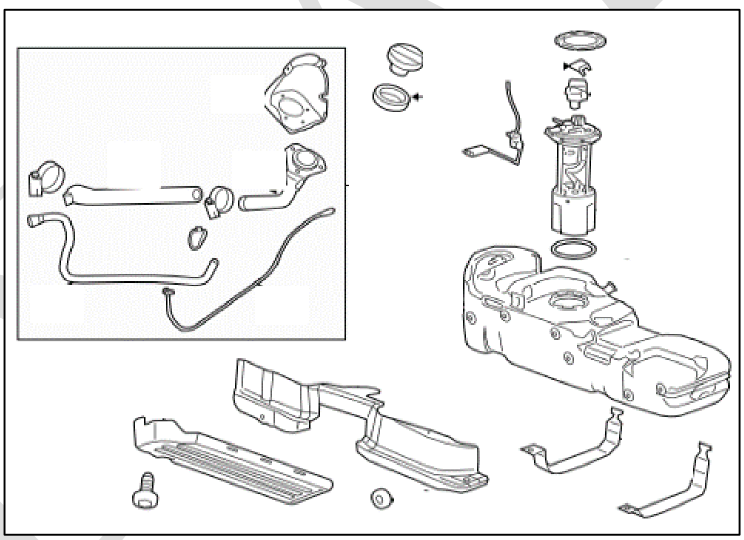


Image 3.12–1: Chevrolet Silverado 2500 Fuel System
(Source: GM)

3.12.1.2 Silverado 2500 System Scaling Summary

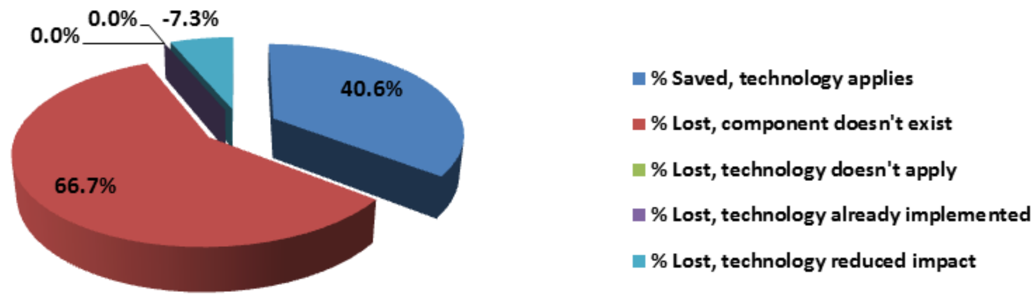
Table 3-90 summarizes mass and cost impact of Silverado 1500 lightweighting technologies applied to the Silverado 2500. Total fuel mass savings was 8.28 kg, at a cost decrease of $12.54, or $1.52 per kg.

Table 3-90: Mass-Reduction and Cost Impact for Fuel System, Silverado 1500

DRAFT

System	Subsystem	Sub-Subsystem	Description	Mass Reduction New Tech "kg" (1)	Mass Reduction Comp "kg" (1)	Mass Reduction Total "kg" (1)	Cost Impact New Tech "$" (2)	Cost Impact Comp "$" (2)	Cost Impact Total "$" (2)	Cost/ Kilogram Total "$/kg"	Vehicle Mass Reduction Total "%"
				Net Value of Mass Reduction							
10	00	00	**Fuel System**								
10	01	00	Fuel Tank and Lines Subsystem	0.59	7.62	8.21	$0.05	$11.54	$11.58	$1.41	0.27%
10	02	00	Fuel Vapor Management Subsystem	0.07	0.00	0.07	$0.96	$0.00	$0.96	$14.61	0.00%
				0.65 (Decrease)	**7.62** (Decrease)	**8.28** (Decrease)	**$1.00** (Decrease)	**$11.54** (Decrease)	**$12.54** (Decrease)	**$1.52** (Decrease)	**0.27%**

Mass Savings, Select Vehicle, New Technology "kg"	**0.65**
Mass Savings, Silverado 1500, New Technology "kg"	**1.61**
Mass Savings Select Vehicle/Mass Savings 1500	**40.6%**



*SMS not included - has no significant impact on perecent contributions

DRAFT

3.12.1.3 System Scaling Analysis – Silverado 2500

The Silverado 2500 Fuel System components were reviewed for compatibility with lightweighting technologies. The results of this analysis are listed in Table 3-91.

Table 3-91: System Scaling Analysis Fuel System, Silverado 2500

Silverado 1500							Select Vehicle			
System	Subsystem	Sub-Subsystem	Component/Assembly	Base Mass	Mass Savings New Tech	% of Mass Savings New Tech	Tech Applies	Base Mass	Mass Savings New Tech	Notes
10			**Fuel System**	**26.34**	**1.61**	**6%**			**0.65**	
10	01	01	Fuel Tank	10.75	0.00	0%	no			Tech does **NOT** Apply: componding only
10	01	01	Fuel Tank side - fuel pump ret. Ring	0.14	-0.04	-32%	yes	0.14	-0.04	Tech **DOES** apply: Remove ring and add POM to tank to make plastic ring for new POM (fuel pumping module retaining ring made out of POM to screw onto)
10	01	01	Fuel Tank Shield-Bottom	2.33	0.23	10%	yes	2.52	0.25	Tech **DOES** apply: Use Polyone foaming agent
10	01	02	Fuel Line Bracket	0.21	0.16	75%	no			Tech does **NOT** apply: No part on truck
10	01	02	Fuel Line holder on brkt	0.01	0.00	11%	no			Tech does **NOT** apply: No part on truck
10	01	02	Fuel Pumping Module	1.74	0.09	5%	no			Tech does **NOT** apply: POM already
10	01	02	Fuel Pumping Module Retaining Ring	0.25	0.12	49%	yes	0.24	0.12	Tech **DOES** apply: Remove, and combine with POM style fuel tank ring assy
10	01	03	Fuel filler neck	0.21	0.15	69%	yes	0.36	0.25	Tech **DOES** apply: Combo, plastic and PolyOne
10	01	03	Fuel filler Cap housing	0.10	0.01	10%	yes	0.09	0.01	Tech **DOES** apply: Use Polyone foaming agent
10	01	03	Fuel cap	0.08	0.01	10%	yes	0.02	0.00	Tech **DOES** apply: Use Polyone foaming agent
10	01	03	Hose clamp-Large	0.02	0.00	10%	yes	0.04	0.00	Tech **DOES** apply: Smaller width
10	01	03	Hose clamp-Medium	0.02	0.00	10%	no			Tech does **NOT** apply: No part on truck
10	01	03	Hose clamp-Small	0.004	0.00	10%	yes	0.01	0.00	Tech **DOES** apply: Smaller width
10	02	01	Vapor canister	1.96	0.06	3%	yes	2.17	0.07	Tech **DOES** apply: Normalize to 2013 Chevy Malibu Eco 2.4
10	02	01	Vapor Canister Support on frame	0.71	0.64	90%	no			Tech does **NOT** apply: Does not apply
10	02	02	Purge Valve Dust filter Support	0.04	0.00	9%	no			Tech does **NOT** apply: Does not apply
10	02	02	Purge Line - Bracket	0.23	0.17	75%	no			Tech does **NOT** apply: Does not apply

If the original Silverado 1500 mass reduction concept idea was not able to be applied to the comparison vehicle it is not described in the section below.

Components with significant mass savings identified on the Silverado 2500 included the fuel pumping module retaining ring, fuel filler neck, fuel tank shield (bottom).

Fuel Tank side - Fuel Pump Retaining Ring

Shown in Image 3.12–2 are the Silverado 1500 and 2500 fuel tank side - fuel pump retaining rings. Component masses were 0.14 kg for the 1500 versus 0.14 kg for the 2500. The mass was increased by adding material to the fuel tank side in order to allow for a threaded lip to add a POM screw on top style fuel pump retaining system used in other vehicles. A reduction will be taken in the fuel pumping module retaining ring Due to similarities in component design and material, full percentage of the Silverado 1500 fuel tank side-fuel pump retaining ring mass reduction can be applied to the 2500. (Refer to Table 3-91).

DRAFT

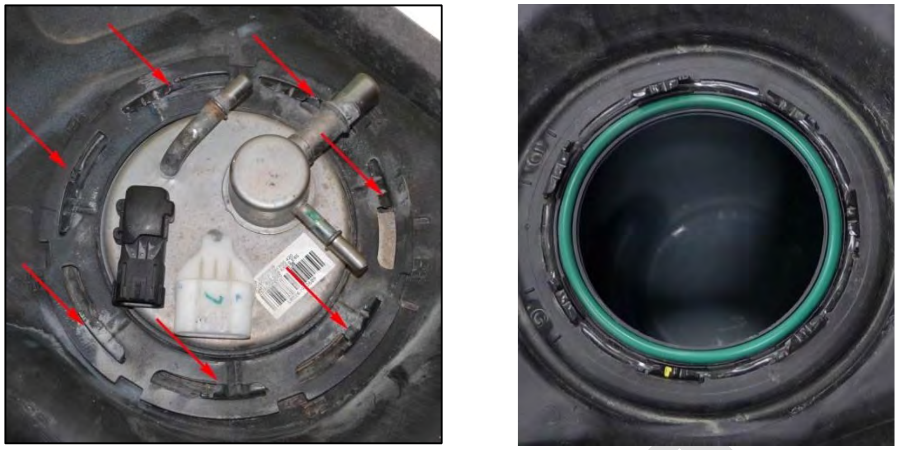


Image 3.12–2: Fuel Tank Side - Fuel Pump Retaining Ring for the Silverado 1500 (Left) and Silverado 2500 (Right)
(Source: FEV, Inc.)

<u>Fuel Tank Bottom Shield</u>

Shown in Image 3.12–3 are the Silverado 1500 and 2500 fuel tank bottom shields. Component masses were 2.33 kg for the 1500 versus 2.52 kg for the 2500. The lightweighting technology used in the fuel tank bottom shield was to use PolyOne® foaming agent in the plastic. Due to similarities in component design and material, full percentage of the Silverado 1500 fuel tank bottom shield mass reduction can be applied to the 2500. (Refer to Table 3-91).

Image 3.12–3: Fuel Tank Bottom Shield for the Silverado 1500 (Top) and Silverado 2500 (Bottom)
(Source: FEV, Inc.)

<u>Fuel Pumping Module Retaining Ring</u>

Shown in Image 3.12–4 are the Silverado 1500 and 2500 series fuel pumping module retaining rings. Component masses were 0.25 kg for the Silverado 1500 versus 0.24 kg for the 2500. The lightweighting technology used in the fuel pumping module retaining ring was to change from a steel ring system to a plastic POM screw-down system. Image 3.12–5 shows the plastic POM system. Due to similarities in component design and material, full percentage of the Silverado 1500

DRAFT

fuel pumping module retaining ring mass reduction can be applied to the 2500. (Refer to Table 3-91).

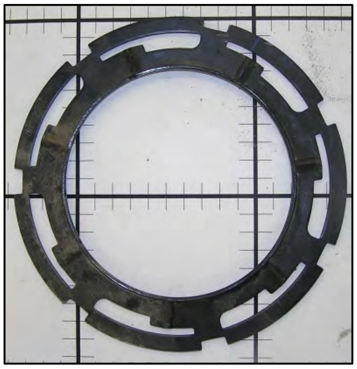


Image 3.12–4: Fuel Pumping Module Retaining Ring for the Silverado 1500 (Left) and Silverado 2500 (Right)
(Source: FEV, Inc.)

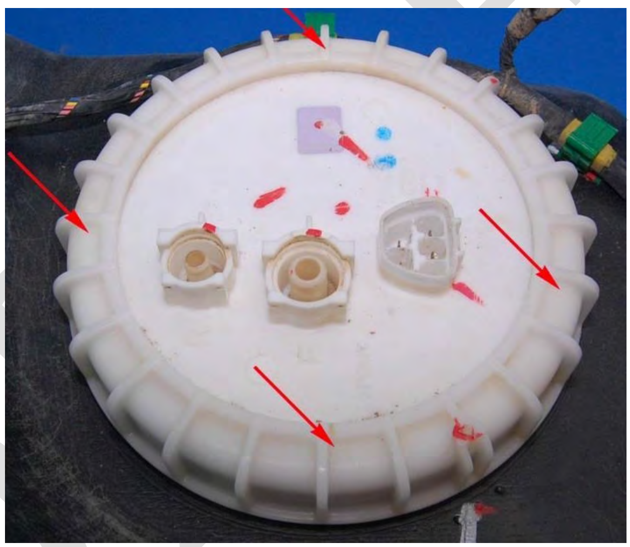


Image 3.12–5: Example of Plastic POM Fuel Pumping Module Retaining Ring
(Source: www.A2mac1.com)

Fuel Filler Neck

Shown in Image 3.12–6 are the Silverado 1500 and 2500 fuel filler necks. Component masses were 0.21 kg for the 1500 versus 0.36 kg for the 2500. The lightweighting technology used in the fuel filler neck was a combination of changing some steel components to plastic and then using PolyOne® foaming agent on the plastic to take another 10% from the mass of the plastic parts. Due to similarities in component design and material, full percentage of the Silverado 1500 fuel filler neck mass reduction can be applied to the 2500. (Refer to Table 3-91).


Image 3.12–6: Fuel Filler Neck for the Silverado 1500 (Left) and Silverado 2500 (Right)
(Source: FEV, Inc.)

Fuel Filler Cap Housing

Shown in Image 3.12–7 are the Silverado 1500 and 2500 fuel filler cap housings. Component masses were 0.10 kg for the 1500 versus 0.09 kg for the 2500. The lightweighting technology used in both was PolyOne® foaming agent in the plastic Due to similarities in component design and material, full percentage of the Silverado 1500 fuel filler cap housing mass reduction can be applied to the 2500. (Refer to Table 3-91).


Image 3.12–7: Fuel Filler Cap Housing for the Silverado 1500 (Left) and Silverado 2500 (Right)
(Source: FEV, Inc.)

Fuel Cap

Shown in Image 3.12–8 are the Silverado 1500 and 2500 series fuel caps. Component masses were 0.08 kg for the 1500 versus 0.02 kg for the 2500. The lightweighting technology used in both the fuel caps was PolyOne® foaming agent in the plastic. Due to similarities in component design and material, full percentage of the Silverado 1500 fuel cap mass reduction can be applied to the 2500. (Refer to Table 3-91).

DRAFT

Image 3.12–8: Fuel Cap for the Silverado 1500 (Left) and Silverado 2500 (Right)
(Source: FEV, Inc.)

Hose Clamps Large and Small

Shown in Image 3.12–9 are the Silverado 1500 and 2500 series hose clamps. Component masses were 0.024 kg for the 1500 versus 0.05 kg for the 2500. The lightweighting technology used in both large and small hose clamps was to exchange a clamp for a smaller one while maintaining the clamp force needed for the application. The standard hose clamp is approximately 9/16" band width. The new lighter version has a 5/16" band width. Image 3.12–10 shows an example of a lighter hose clamp. Due to similarities in component design and material, full percentage of the Silverado 1500 hose clamp mass reduction can be applied to the 2500. (Refer to Table 3-91).

Image 3.12–9: Hose clamps for both the Silverado 1500 and 2500
(Source: FEV, Inc.)

Image 3.12–10: Example of a lighter hose clamp
(Source: FEV, Inc.)

Vapor Canister

DRAFT

Shown in Image 3.12–11 are the Silverado 1500 and 2500 series vapor canisters. Component masses were 1.96 kg for the 1500 versus 2.17 kg for the 2500. The lightweighting technology used for both vapor canisters was to normalize the 2012 Chevrolet Malibu. Due to similarities in component design and material, full percentage of the Silverado 1500 vapor canister mass reduction can be applied to the 2500. (Refer to Table 3-91).

Image 3.12–11: Vapor Canister for the Silverado 1500 (Left) and Silverado 2500 (Right)
(Source: FEV, Inc.)

3.12.1.4 System Comparison – Silverado 2500

Table 3-92 summarizes the Silverado 1500 and 2500 lightweighting results. The majority of the components were visually the same between the two fuel systems.

Table 3-92: Fuel System Comparison, Silverado 1500 and 2500

		Net Value of Mass Reduction								
System	Description	Mass Base "kg" (1)	Mass Reduction New Tech "kg" (1)	Mass Reduction Comp "kg" (1)	Mass Reduction Total "kg" (1)	System Mass Reduction "%"	Cost Impact New Tech "$" (2)	Cost Impact Comp "$" (2)	Cost Impact Total "$" (2)	Cost/ Kilogram Total "$/kg"
09	**Fuel**									
09	Silverado 1500	26.34	1.61	12.19	13.79	52.37%	$3.20	$30.95	$34.15	$2.48
09	Silverado 2500	32.15	0.65	7.62	8.28	25.74%	$1.00	$11.54	$12.54	$1.52

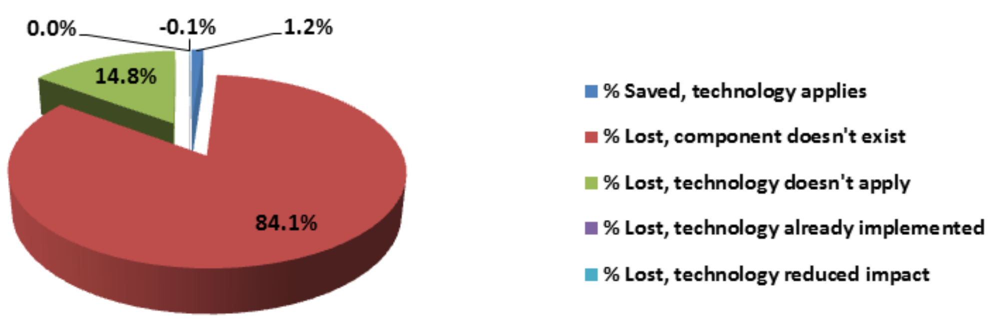
3.12.2 Mercedes Sprinter 311 CDi

Table 3-93 summarizes the mass and cost impact of the Silverado 1500 lightweighting technologies as applied to the Mercedes Sprinter 311 CDi. Total fuel mass savings were 5.47 kg, at a cost decrease of $8.42, or $1.54 per kg.

Table 3-93: Mass-Reduction and Cost Impact for Fuel System, Mercedes Sprinter

				Net Value of Mass Reduction							
System	Subsystem	Sub-Subsystem	Description	Mass Reduction New Tech "kg" (1)	Mass Reduction Comp "kg" (1)	Mass Reduction Total "kg" (1)	Cost Impact New Tech "$" (2)	Cost Impact Comp "$" (2)	Cost Impact Total "$" (2)	Cost/ Kilogram Total "$/kg"	Vehicle Mass Reduction Total "%"
10	00	00	**Fuel System**								
10	01	00	Fuel Tank and Lines Subsystem	0.02	5.45	5.47	$0.18	$8.24	$8.42	$1.54	0.26%
10	02	00	Fuel Vapor Management Subsystem	0.00	0.00	0.00	$0.00	$0.00	$0.00	$0.00	0.00%
				0.02 (Decrease)	**5.45** (Decrease)	**5.47** (Decrease)	**$0.18** (Decrease)	**$8.24** (Decrease)	**$8.42** (Decrease)	**$1.54** (Decrease)	**0.26%**

Mass Savings, Select Vehicle, New Technology "kg"	**0.02**
Mass Savings, Silverado 1500, New Technology "kg"	**1.61**
Mass Savings Select Vehicle/Mass Savings 1500	**1.2%**



*SMS not included - has no significant impact on perecent contributions

3.12.2.1 System Scaling Analysis

The Mercedes Sprinter 311 CDi Fuel components were reviewed for compatibility with lightweighting technologies. The results of this analysis are listed in Table 3-94.

Table 3-94: System Scaling Analysis Fuel System, Mercedes Sprinter

Silverado 1500							Select Vehicle			
System	Subsystem	Sub-Subsystem	Component/Assembly	Base Mass	Mass Savings New Tech	% of Mass Savings New Tech	Tech Applies	Base Mass	Mass Savings New Tech	Notes
10			**Fuel System**	**26.34**	**1.61**	**6%**			**0.02**	
10	01	01	Fuel Tank	10.75	0.00	0%	no			Tech does **NOT** Apply: componding only
10	01	01	Fuel Tank side - fuel pump ret. Ring	0.14	-0.04	-32%	no			Tech does **NOT** Apply: componenet does not exsist
10	01	01	Fuel Tank Shield-Bottom	2.33	0.23	10%	no			Tech does **NOT** Apply: componenet does not exsist
10	01	02	Fuel Line Bracket	0.21	0.16	75%	no			Tech does **NOT** Apply: componenet does not exsist
10	01	02	Fuel Line holder on brkt	0.01	0.00	11%	no			Tech does **NOT** Apply: componenet does not exsist
10	01	02	Fuel Pumping Module	1.74	0.09	5%	no			Tech does **NOT** apply: POM already
10	01	02	Fuel Pumping Module Retaining Ring	0.25	0.12	49%	no			Tech does **NOT** Apply: componenet does not exsist
10	01	03	Fuel filler neck	0.21	0.15	69%	no			Tech does **NOT** Apply: Mass reduction already done
10	01	03	Fuel filler Cap housing	0.10	0.01	10%	yes	0.13	0.01	Tech **DOES** apply: Use Polyone foaming agent
10	01	03	Fuel cap	0.08	0.01	10%	yes	0.06	0.01	Tech **DOES** apply: Use Polyone foaming agent
10	01	03	Hose clamp-Large	0.02	0.00	10%	no			Tech does **NOT** Apply: componenet does not exsist
10	01	03	Hose clamp-Medium	0.02	0.00	10%	no			Tech does **NOT** Apply: componenet does not exsist
10	01	03	Hose clamp-Small	0.00	0.00	10%	no			Tech does **NOT** Apply: componenet does not exsist
10	02	01	Vapor canister	1.96	0.06	3%	no			Tech does **NOT** Apply: componenet does not exsist
10	02	01	Vapor Canister Support on frame	0.71	0.64	90%	no			Tech does **NOT** Apply: componenet does not exsist
10	02	02	Purge Valve Dust filter Support	0.04	0.00	9%	no			Tech does **NOT** Apply: componenet does not exsist
10	02	02	Purge Line - Bracket	0.23	0.17	75%	no			Tech does **NOT** Apply: componenet does not exsist

If the original Silverado 1500 mass reduction concept idea was not able to be applied to the comparison vehicle it is not described in the section below.

Components with significant mass savings identified on the Mercedes Sprinter include the fuel filler cap housing, and fuel cap. Image 3.12–12 shows the Mercedes Sprinter 311 CDi fuel components.

Image 3.12–12: Mercedes Sprinter 311 CDi Fuel system
(Source: ww.A2mac1.com)

Fuel Filler Cap Housing

Shown in Image 3.12–13 are the Silverado 1500 and Mercedes Sprinter 311 CDi fuel filler cap housings. Component masses were 0.10 kg for the 1500 versus 0.13 kg for the Mercedes Sprinter 311 CDi. The lightweighting technology used in both the fuel filler cap housings was PolyOne® foaming agent in the plastic. Due to similarities in component material, full percentage of the Silverado 1500 fuel filler cap housing mass reduction can be applied to the Sprinter. (Refer to Table 3-94).

Image 3.12–13: Fuel Filler Cap Housing for the Silverado 1500 (Left) and Mercedes Sprinter 311 CDi (Right)
(Source: FEV, Inc. and www.A2mac1.com)

Fuel Cap

Shown in Image 3.12–14 are the Silverado 1500 and Mercedes Sprinter 311 CDi fuel caps. Component masses were 0.08 kg for the 1500 versus 0.06 kg for the Mercedes Sprinter 311 CDi. The lightweighting technology used in both fuel caps was PolyOne® foaming agent in the plastic. Due to similarities in component design and material, full percentage of the Silverado 1500 fuel cap housing mass reduction can be applied to the Sprinter. (Refer to Table 3-94).

Image 3.12–14: Fuel Cap for the Silverado 1500 (Left) and Mercedes Sprinter 311 CDi (Right)
(Source: FEV, Inc. and www.A2mac1.com)

DRAFT

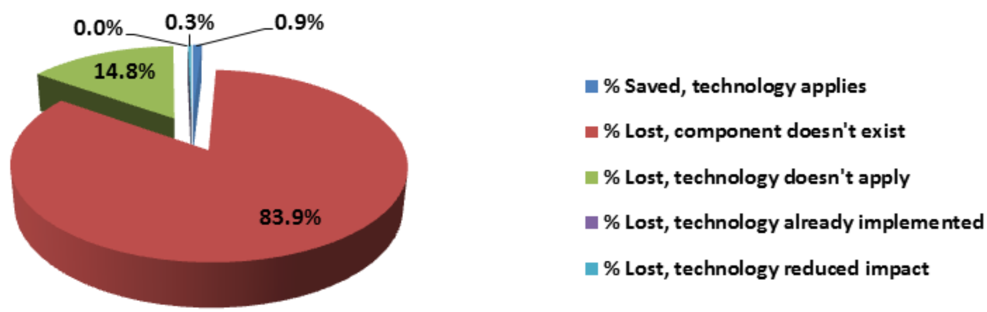
3.12.3 Renault Master 2.3 DCi

Table 3-95 summarizes the mass and cost impact of the Silverado 1500 lightweighting technologies as applied to the Renault Master 2.3 DCi. Total Fuel System mass savings was 5.24 kg at a cost decrease of $8.07, or $1.53 per kg.

Table 3-95: Mass-Reduction and Cost Impact for Fuel System, Renault Master

				Net Value of Mass Reduction							
System	Subsystem	Sub-Subsystem	Description	Mass Reduction New Tech "kg" (1)	Mass Reduction Comp "kg" (1)	Mass Reduction Total "kg" (1)	Cost Impact New Tech "$" (2)	Cost Impact Comp "$" (2)	Cost Impact Total "$" (2)	Cost/ Kilogram Total "$/kg"	Vehicle Mass Reduction Total "%"
10	**00**	**00**	**Fuel System**								
10	01	00	Fuel Tank and Lines Subsystem	0.01	5.24	5.26	$0.14	$7.93	$8.07	$1.53	0.22%
10	02	00	Fuel Vapor Management Subsystem	0.00	0.00	0.00	$0.00	$0.00	$0.00	$0.00	0.00%
				0.01 (Decrease)	**5.24** (Decrease)	**5.26** (Decrease)	**$0.14** (Decrease)	**$7.93** (Decrease)	**$8.07** (Decrease)	**$1.53** (Decrease)	**0.22%**

Mass Savings, Select Vehicle, New Technology "kg"	**0.01**
Mass Savings, Silverado 1500, New Technology "kg"	**1.61**
Mass Savings Select Vehicle/Mass Savings 1500	**0.9%**



*SMS not included - has no significant impact on perecent contributions

3.12.3.1 System Scaling Analysis

The Renault Master 2.3 DCi fuel system components were reviewed for compatibility with lightweighting technologies. The results of this analysis are listed in Table 3-96.

Table 3-96: System Scaling Analysis Fuel System, Renault Master

Silverado 1500							Select Vehicle			
System	Subsystem	Sub-Subsystem	Component/Assembly	Base Mass	Mass Savings New Tech	% of Mass Savings New Tech	Tech Applies	Base Mass	Mass Savings New Tech	Notes
10			**Fuel System**	**26.34**	**1.61**	**6%**			**0.01**	
10	01	01	Fuel Tank	10.75	0.00	0%	no			Tech does **NOT** Apply: componding only
10	01	01	Fuel Tank side - fuel pump ret. Ring	0.14	-0.04	-32%	no			Tech does **NOT** Apply: componenet does not exsist
10	01	01	Fuel Tank Shield-Bottom	2.33	0.23	10%	no			Tech does **NOT** Apply: componenet does not exsist
10	01	02	Fuel Line Bracket	0.21	0.16	75%	no			Tech does **NOT** Apply: componenet does not exsist
10	01	02	Fuel Line holder on brkt	0.01	0.00	11%	no			Tech does **NOT** Apply: componenet does not exsist
10	01	02	Fuel Pumping Module	1.74	0.09	5%	no			Tech does **NOT** apply: POM already
10	01	02	Fuel Pumping Module Retaining Ring	0.25	0.12	49%	no			Tech does **NOT** Apply: componenet does not exsist
10	01	03	Fuel filler neck	0.21	0.15	69%	no			Tech does **NOT** Apply: Mass reduction already done
10	01	03	Fuel filler Cap housing	0.10	0.01	10%	yes	0.09	0.01	Tech **DOES** apply: Use Polyone foaming agent
10	01	03	Fuel cap	0.08	0.01	10%	yes	0.04	0.00	Tech **DOES** apply: Use Polyone foaming agent
10	01	03	Hose clamp-Large	0.02	0.00	10%	yes	0.02	0.00	Tech **DOES** apply: Smaller width
10	01	03	Hose clamp-Medium	0.02	0.00	10%	no			Tech does **NOT** Apply: componenet does not exsist
10	01	03	Hose clamp-Small	0.00	0.00	10%	no			Tech does **NOT** Apply: componenet does not exsist
10	02	01	Vapor canister	1.96	0.06	3%	no			Tech does **NOT** Apply: componenet does not exsist
10	02	01	Vapor Canister Support on frame	0.71	0.64	90%	no			Tech does **NOT** apply: Does not apply
10	02	02	Purge Valve Dust filter Support	0.04	0.00	9%	no			Tech does **NOT** apply: Does not apply
10	02	02	Purge Line - Bracket	0.23	0.17	75%	no			Tech does **NOT** apply: Does not apply

If the original Silverado 1500 mass reduction concept idea was not able to be applied to the comparison vehicle it is not described in the section below.

Components with significant mass savings identified on the Renault Master 2.3 DCi included the fuel filler cap housing, fuel cap, and large hose clamp. Image 3.12–15 shows the Renault Master 2.3 DCi Fuel System components.

Image 3.12–15: Renault Master 2.3 DCi Fuel System
(Source: www.A2mac1.com)

<u>Fuel Filler Cap Housing</u>

Shown in Image 3.12–16 are the Silverado 1500 and Renault Master 2.3 DCi fuel filler cap housings. Component masses were 0.10 kg for the 1500 versus 0.09 kg for the Renault Master 2.3

DCi. The lightweighting technology used in both was PolyOne® foaming agent in the plastic. Due to similarities in component design and material, full percentage of the Silverado 1500 fuel filler cap housing mass reduction can be applied to the Renault. (Refer to Table 3-96).

Image 3.12–16: Fuel Filler Cap Housing for the Silverado 1500 (Left) and Renault Master 2.3 DCi (Right)
(Source: FEV, Inc. and www.A2mac1.com)

<u>Fuel Cap</u>

Shown in Image 3.12–17 are the Silverado 1500 and Renault Master 2.3 DCi fuel caps. Component masses were 0.08 kg for the 1500 versus 0.04 kg for the Renault Master 2.3 DCi. The lightweighting technology used in both was PolyOne® foaming agent in the plastic. Due to similarities in component design and material, full percentage of the Silverado 1500 fuel cap mass reduction can be applied to the Renault. (Refer to Table 3-96).

Image 3.12–17: Fuel Cap for the Silverado 1500 (Left) and Renault Master 2.3 DCi (Right)
(Source: FEV, Inc. and www.A2mac1.com)

3.13 STEERING SYSTEM

3.13.1 Silverado 1500 Summary

The Chevrolet Silverado 1500 Steering System includes the steering gear, steering pump, steering equipment, and steering column assembly sections. All these assemblies have weight save opportunities that will be identified.

The Chevrolet Silverado 1500 analysis identified mass reduction alternatives and cost implications for the Steering System with the intent to meet the function and performance requirements of the baseline vehicle. Table 3-97 provides a summary of mass reduction and cost impact for select sub-subsystems evaluated. The total mass savings found in the Steering System mass was reduced by

DRAFT

11.4 kg (35.16%). This increased cost by $57.21, or $5.00 per kg. Mass reduction for this system reduced vehicle curb weight by 0.48%.

Table 3-97: Steering System Mass Reduction Summary, Silverado 1500

				Net Value of Mass Reduction					
System	Subsystem	Sub-Subsystem	Description	Base Mass "kg"	Mass Reduction "kg" (1)	Cost Impact NIDMC "$" (2)	Average Cost/ Kilogram "$/kg" (2)	Mass Reduction "%"	Vehicle Mass Reduction "%"
11	00	00	Steering						
11	**01**	**00**	**Steering Gear**	**13.89**	**-1.47**	**-247.24**	**168.57**	**-10.56%**	**-0.06%**
11	01	01	Steering Gear	13.89	-1.47	-247.24	168.57	-10.56%	-0.06%
11	**02**	**00**	**Power Steering Pump**	**5.44**	**5.44**	**40.69**	**0.00**	**100.00%**	**0.23%**
11	02	01	Pump	5.44	5.44	40.69	7.48	100.00%	0.23%
11	**03**	**00**	**Power Steering Equipment**	**1.01**	**1.01**	**54.32**	**53.73**	**100.00%**	**0.04%**
11	03	01	Power Steering Tube Assembly	0.65	0.65	33.78	51.97	100.00%	0.03%
11	03	02	Heat Exchange Assy	0.36	0.36	20.54	56.91	100.00%	0.02%
11	**04**	**00**	**Steering Column Assy**	**12.17**	**14.91**	**4.76**	**0.32**	**122.47%**	**0.62%**
11	04	01	Steering column assy	10.18	3.25	0.09	0.03	31.91%	0.14%
11	04	02	Steering wheel assy	1.78	0.20	4.34	21.22	11.47%	0.01%
11	04	03	Column Cowl	0.21	0.02	0.34	15.84	10.00%	0.00%
				32.51	11.43 (Decrease)	-57.21 (Increase)	-5.00 (Increase)	35.16%	0.48%

(1) "+" = mass decrease, "-" = mass increase
(2) "+" = cost decrease, "-" = cost increase

Mass savings opportunities were identified for the following components: steering gear, pump, pump tube assembly, heat exchanger, steering column, steering wheel and column cowl.

<u>Steering Gear:</u> The steering gear mass was increased by changing from hydraulic to electric. Mass was increased by 10.6% from 13.9 kg to 15.4 kg.

<u>Pump:</u> The pump mass was reduced by eliminating it because of using electric steering unit. Mass was reduced by 100% from 5.44 kg to 0 kg.

<u>Pump Tube Assembly:</u> The pump tube assembly mass was reduced by eliminating it because of using electric steering unit. Mass was reduced by 100% from 0.65 kg to 0 kg.

<u>Heat Exchanger:</u> The heat exchanger assembly mass was reduced by eliminating it because of using electric steering unit. Mass was reduced by 100% from 0.36 kg to 0 kg.

<u>Steering Column:</u> The steering column mass was reduced by changing the steel tube fabrication to a cast aluminum component. Mass was reduced by 32% from 10.2 kg to 7.0 kg.

<u>Steering Wheel:</u> The steering wheel mass was reduced by changing a steel frame to a cast magnesium wheel. Mass was reduced by 11.24% from 1.78 kg to 1.58 kg.

<u>Column Cowl:</u> The cowl mass was reduced by changing the Polyphenylene Ether (PPE) to a PolyOne®. Mass was reduced by 10% from .21 kg to 0.19 kg.

3.13.1.1 Silverado 2500 Analysis

The Chevrolet Silverado 2500 Steering system is similar to the 1500. Because of the load and durability concerns the electric steering option was not seen to be applicable for this vehicle.

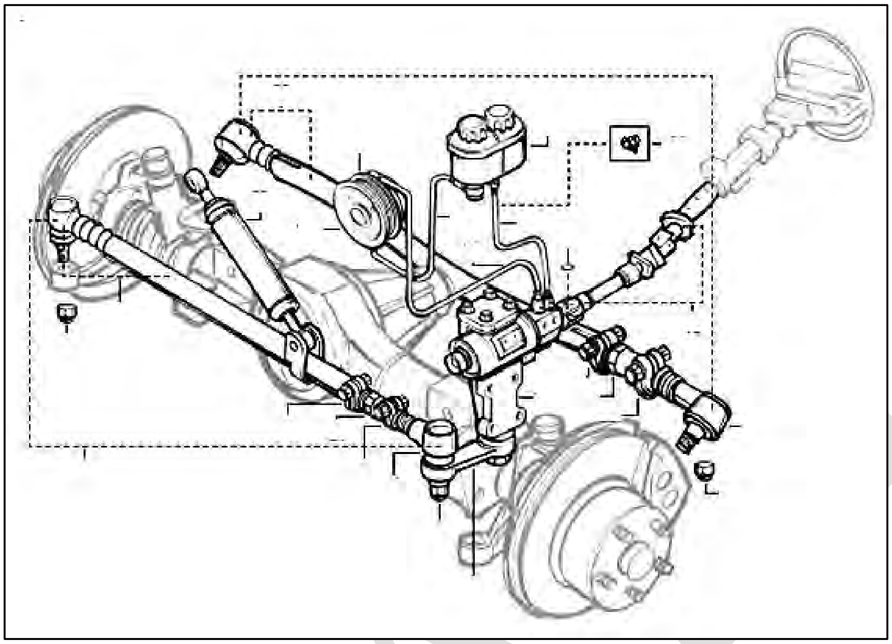


Image 3.13–1: Chevrolet Silverado Steering system
(Source: FEV, Inc.)

DRAFT

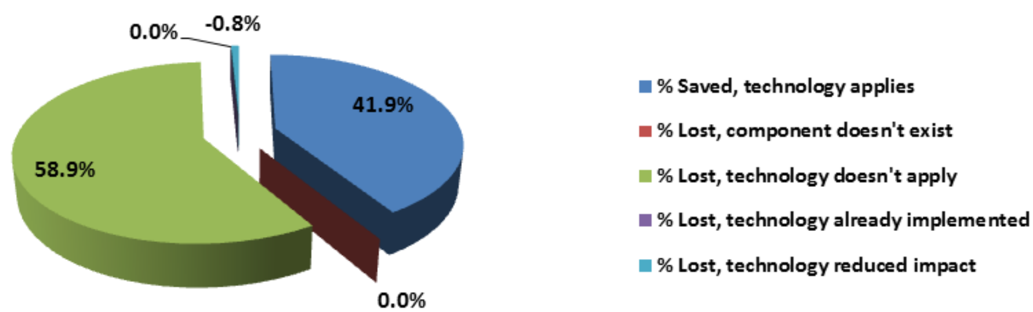
3.13.1.2 2500 System Scaling Summary

Table 3-98 summarizes the mass and cost impact of the Silverado 1500 lightweighting technologies as applied to the Silverado 2500. Total Steering System mass savings is 3.54 kg at a cost decrease of $5.53, or $1.56 per kg.

Table 3-98: Mass-Reduction and Cost Impact for Steering System, Silverado 2500

				Net Value of Mass Reduction							
System	Subsystem	Sub-Subsystem	Description	Mass Reduction New Tech "kg" (1)	Mass Reduction Comp "kg" (1)	Mass Reduction Total "kg" (1)	Cost Impact New Tech "$" (2)	Cost Impact Comp "$" (2)	Cost Impact Total "$" (2)	Cost/ Kilogram Total "$/kg"	Vehicle Mass Reduction Total "%"
11	**00**	**00**	**Stearing System**								
11	01	00	Steering Gear	0.000	0.000	0.000	$0.00	$0.00	$0.00	$0.00	0.00%
11	02	00	Power Steering Pump	0.000	0.000	0.000	$0.00	$0.00	$0.00	$0.00	0.00%
11	03	00	Power Steering Equipment	0.000	0.000	0.000	$0.00	$0.00	$0.00	$0.00	0.00%
11	04	00	Steering Column Assembly	3.541	0.000	3.541	$5.53	$0.00	$5.53	$1.56	0.11%
				3.54 (Decrease)	**0.00**	**3.54** (Decrease)	**$5.53** (Decrease)	**$0.00**	**$5.53** (Decrease)	**$1.56** (Decrease)	**0.11%**

Mass Savings, Select Vehicle, New Technology "kg"	**3.5**
Mass Savings, Silverado 1500, New Technology "kg"	**8.5**
Mass Savings Select Vehicle/Mass Savings 1500	**41.9%**



*SMS not included - has no significant impact on perecent contributions

3.13.1.3 System Scaling Analysis

The Silverado 2500 Steering System components were reviewed for compatibility with lightweighting technologies. The results of this analysis are listed in Table 3-99.

Table 3-99: System Scaling Analysis Steering System, Silverado 2500

Silverado 1500							Select Vehicle			
System	Subsystem	Sub-Subsystem	Component/Assembly	Base Mass	Mass Savings New Tech	% of Mass Savings New Tech	Tech Applies	Base Mass	Mass Savings New Tech	Notes
11 Steering				**32.514**	**8.456**	**26%**			**3.541**	
11	01	01	Steering Gear	13.89	-1.47	-11%	no			Tech dose **Not** apply: Vehicle is not a candidate for electric steering conversion because of application
11	02	01	Pump	5.44	5.44	100%	no			Tech dose **Not** apply: Vehicle is not a candidate for electric steering conversion because of application
11	03	01	Power Steering Tube Assembly	0.65	0.65	100%	no			Tech dose **Not** apply: Vehicle is not a candidate for electric steering conversion because of application
11	03	02	Heat Exchange Assy	0.36	0.36	100%	no			Tech dose **Not** apply: Vehicle is not a candidate for electric steering conversion because of application
11	04	01	Steering column assy	10.18	3.25	32%	yes	10.39	3.32	Tech **DOES** apply: The 2500 used the same sheet metal steering colum system as the Silverado 1500 is a candidate to use cast magnesium column
11	04	02	Steering wheel assy	1.78	0.20	11%	yes	1.78	0.20	Tech **DOES** apply: Very simular to Silverado 1500 rubber coated aluminum framed wheel, is agood candidate for plastic wheel.
11	04	03	Column Cowl	0.21	0.02	10%	yes	0.21	0.02	Tech **DOES** apply: Same as Silverado 1500 used Polyone as a solutin maintain integrity and reduce weight on cowls

If the original Silverado 1500 mass reduction concept idea was not able to be applied to the comparison vehicle it is not described in the section below.

Components with significant mass savings identified on the 2500 series Silverado include the, steering column, steering wheel and column cowl. Because of the load and functionality concerns the steering gear, pump, pump steering tube assembly, and heat exchanger do not apply.

<u>Steering Column</u>

Shown in Image 3.13–2 are the Silverado 1500 and 2500 steering columns. Component masses were 10.2 kg for the 1500 versus 10.4 kg for the 2500. Both steering columns were made of steel tubes and stampings welded into an assembly. The technology to lighten these units was the same. A cast aluminum assembly is being used in other segments of the automotive industry successfully and is a good application for these trucks. Due to similarities in component design and material, full percentage of the Silverado 1500 steering column mass reduction can be applied to the 2500. (Refer to Table 3-99).

DRAFT

Image 3.13–2: Steering Column for the Silverado 1500 (Left) and Silverado 2500 (Right)
(Source: FEV, Inc.)

Steering Wheel

Shown in Image 3.13–3 are the Silverado 1500 and 2500 steering wheels. Component masses were 1.78 kg for the 1500 versus 1.78 kg for the 2500. Both steering wheels were steel frames with plastic wrapping. The lightweighting technology used in both the steering wheels was the same. Due to similarities in component design and material, full percentage of the Silverado 1500 steering wheel mass reduction can be applied to the 2500. (Refer to Table 3-99).

Image 3.13–3: Steering Wheel for the Silverado 1500 (Left) and Silverado 2500 (Right)
(Source: FEV, Inc.)

Column Cowl

Shown in Image 3.13–4 are the Silverado 1500 and 2500 column cowls. Component masses were 0.21 kg for both the 1500 and the 2500. The lightweighting technology used in the column cowl was to use PolyOne® foaming agent in the plastic. Due to similarities in component design and material, full percentage of the Silverado 1500 column cowl mass reduction can be applied to the 2500. (Refer to Table 3-99).

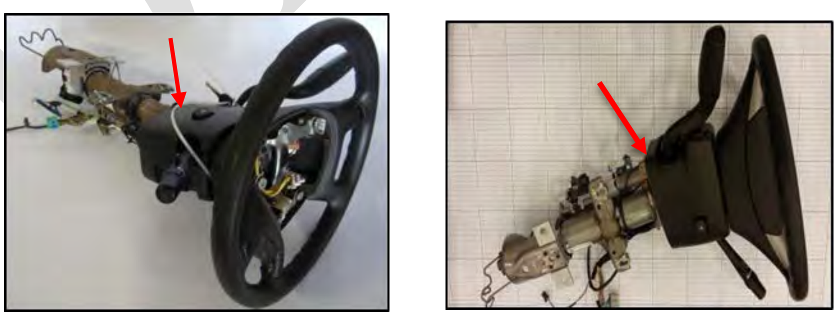


Image 3.13–4: Column cowl for the Silverado 1500 (Left) and Silverado 2500 (Right)
(Source: FEV, Inc.)

DRAFT

3.13.1.4 System Comparison, Silverado 2500

Table 3-100 summarizes the Silverado 1500 and 2500 lightweighting results. The majority of the components were visually the same between the steering. The 2500 steering was much more robust than the 1500 that it prevented consideration of the electric steering option.

Table 3-100: Steering System Comparison, Silverado 1500 and 2500

		Net Value of Mass Reduction								
System	Description	Mass Base "kg" (1)	Mass Reduction New Tech "kg" (1)	Mass Reduction Comp "kg" (1)	Mass Reduction Total "kg" (1)	System Mass Reduction "%"	Cost Impact New Tech "$" (2)	Cost Impact Comp "$" (2)	Cost Impact Total "$" (2)	Cost/ Kilogram Total "$/kg"
11	**Steering**									
11	Silverado 1500	32.51	8.46	0.00	8.46	26.01%	-$146.70	$0.01	-$146.70	-$17.35
11	Silverado 2500	49.86	3.54	0.00	3.54	7.10%	$5.53	$0.00	$5.53	$1.56

DRAFT

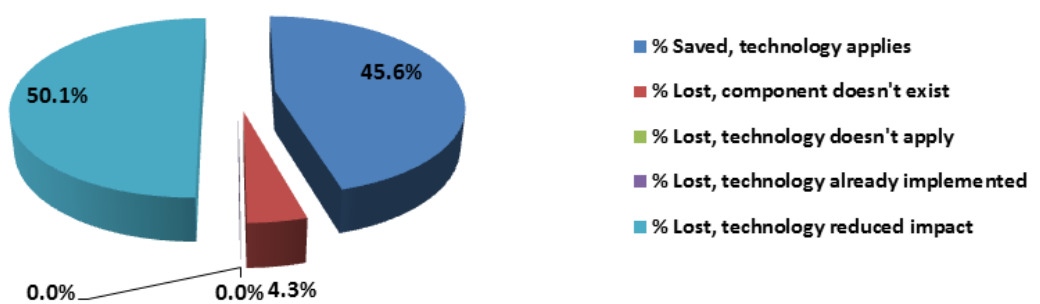
3.13.2 Mercedes Sprinter 311 CDi

The following table summarizes the mass and cost impact of the Silverado 1500 lightweighting technologies as applied to the Mercedes Sprinter 311 CDi. Total steering mass savings was 3.85 kg at a cost increase of $110.88, or $28.76 per kg.

Table 3-101: Mass-Reduction and Cost Impact for Steering System, Mercedes Sprinter

				Net Value of Mass Reduction							
System	Subsystem	Sub-Subsystem	Description	Mass Reduction New Tech "kg" (1)	Mass Reduction Comp "kg" (1)	Mass Reduction Total "kg" (1)	Cost Impact New Tech "$" (2)	Cost Impact Comp "$" (2)	Cost Impact Total "$" (2)	Cost/ Kilogram Total "$/kg"	Vehicle Mass Reduction Total "%"
11	00	00	**Stearing System**								
11	01	00	Steering Gear	-1.189	0.000	-1.189	-$200.42	$0.00	-$200.42	$168.53	-0.06%
11	02	00	Power Steering Pump	2.005	0.000	2.005	$15.00	$0.00	$15.00	$7.48	0.09%
11	03	00	Power Steering Equipment	1.362	0.000	1.362	$70.78	$0.00	$70.78	$51.98	0.06%
11	04	00	Steering Column Assembly	1.677	0.000	1.677	$3.75	$0.00	$3.75	$2.24	0.08%
				3.85 (Decrease)	**0.00**	**3.85** (Decrease)	**-$110.88** (Increase)	**$0.00**	**-$110.88** (Increase)	**-$28.76** (Increase)	**0.16%**

Mass Savings, Select Vehicle, New Technology "kg"	**3.9**
Mass Savings, Silverado 1500, New Technology "kg"	**8.5**
Mass Savings Select Vehicle/Mass Savings 1500	**45.6%**



*SMS not included - has no significant impact on perecent contributions

3.13.2.1 System Scaling Analysis

The Mercedes Sprinter 311 CDi Steering components were reviewed for compatibility with lightweighting technologies. The results of this analysis are listed in Table 3-102.

Table 3-102: System Scaling Analysis Steering System, Mercedes Sprinter

Silverado 1500							Select Vehicle			
System	Subsystem	Sub-Subsystem	Component/Assembly	Base Mass	Mass Savings New Tech	% of Mass Savings New Tech	Tech Applies	Base Mass	Mass Savings New Tech	Notes
11			**Steering**	**32.514**	**8.456**	**26%**			**3.855**	
11	01	01	Steering Gear	13.89	-1.47	-11%	yes	11.26	-1.19	Tech **DOES** apply: The Sprinter used the same steering gear system as the Silverado 1500 and electric steering is a good option
11	02	01	Pump	5.44	5.44	100%	yes	2.01	2.01	Tech **DOES** apply: The Sprinter used the same pump as the Silverado 1500 and will not need with the electric application
11	03	01	Power Steering Tube Assembly	0.65	0.65	100%	yes	1.36	1.36	Tech **DOES** apply: The Sprinter used the same power steering tube as the Silverado 1500 and tubes will not be required.
11	03	02	Heat Exchange Assy	0.36	0.36	100%	no			Tech dose **Not** apply: The Sprinter did not use a heat exchanger.
11	04	01	Steering column assy	10.18	3.25	32%	yes	4.75	1.52	Tech **DOES** apply: The Sprinter used the same sheet metal steering colum system as the Silverado 1500 is a candidate to use cast magnesium column
11	04	02	Steering wheel assy	1.78	0.20	11%	yes	1.33	0.15	Tech **DOES** apply: Very simular to Silverado 1500 rubber coated aluminum framed wheel, is a good candidate for plastic wheel.
11	04	03	Column Cowl	0.21	0.02	10%	yes	0.09	0.01	Tech **DOES** apply: Same as Silverado 1500 used Polyone as a solutin maintain integrity and reduce weight on cowls

If the original Silverado 1500 mass reduction concept idea was not able to be applied to the comparison vehicle it is not described in the section below.

Components with significant mass savings identified on the Mercedes Sprinter 311 include: the steering gear, pump, pump steering tube assembly, steering column, steering wheel, and column cowl.

Image 3.13–5: Mercedes Sprinter 311 CDi Steering
(Source: www.A2mac1.com)

Steering Gear

Shown in Image 3.13–6 are the Silverado 1500 and Mercedes Sprinter 311 steering gear. Component masses were 13.9 kg for the Silverado 1500 versus 11.3 kg for the Mercedes Sprinter 311. Due to similarities in component design and material, full percentage of the Silverado 1500 steering gear mass reduction can be applied to the Sprinter. (Refer to Table 3-102).

Image 3.13–6: Steering Gear for the Silverado 1500 (Left) and Sprinter 311 (Right)
(Source: FEV, Inc.)

Pump

Shown in Image 3.13–7 are the Silverado 1500 and Mercedes Sprinter 311 hydraulic pumps. Component masses were 5.44 kg for the Silverado 1500 versus 2.00 kg for the Sprinter 311. Due to similarities in component design and material, full percentage of the Silverado 1500 pump mass reduction can be applied to the Sprinter. (Refer to Table 3-102).

DRAFT

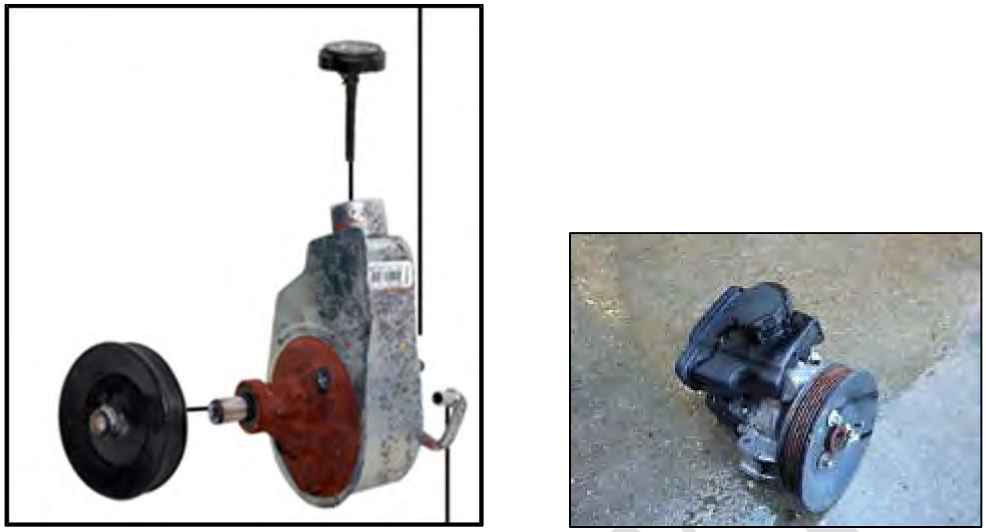


Image 3.13–7: Pump for the Silverado 1500 (Left) and Mercedes Sprinter 311 (Right)
(Source: FEV, Inc.)

Power Steering Tubes

Shown in Image 3.13–8 are the Silverado 1500 and Mercedes Sprinter 311 series power steering tubes. Component masses were 0.65 kg for the Silverado 1500 versus 1.36 kg for the Sprinter 311. Due to similarities in component design and material, full percentage of the Silverado 1500 power steering tube mass reduction can be applied to the Sprinter. (Refer to Table 3-102).

Image 3.13–8: Steering Tubes for the Silverado 1500 (Left) and Sprinter 311 (Right)
(Source: FEV, Inc.)

DRAFT

Steering Column

Shown in Image 3.13–9 are the Silverado 1500 and 311 steering columns. Component masses are 10.178 kg for the 1500 versus 4.75 kg for the 311 respectively. Both the Steering columns are made of steel tubes and stampings that are welded into an assembly. The technology to lighten these units is the same. A cast aluminum assembly is being used in other segments of the automotive industry successfully and is a good application for these trucks. Due to similarities in component design and material, full percentage of the Silverado 1500 steering column mass reduction can be applied to the Sprinter. (Refer to Table 3-102).

Image 3.13–9: Steering Column for the Silverado 1500 (Top) and Sprinter 311 (Bottom)
(Source: FEV, Inc. and www.A2mac1.com)

Steering Wheel

Shown in Image 3.13–10 are the Silverado 1500 and Mercedes Sprinter 311 steering wheels. Component masses were 1.78 kg for the Silverado 1500 versus 1.37 kg for the Sprinter 311. Both steering wheels were steel frames with plastic wrapping. The lightweighting technology used in both steering wheels was the same. Due to similarities in component design and material, full percentage of the Silverado 1500 steering wheel mass reduction can be applied to the Sprinter. (Refer to Table 3-102).

Image 3.13–10: Steering Wheel for the Silverado 1500 (Left) and Sprinter 311 (Right)
(Source: FEV, Inc.)

DRAFT

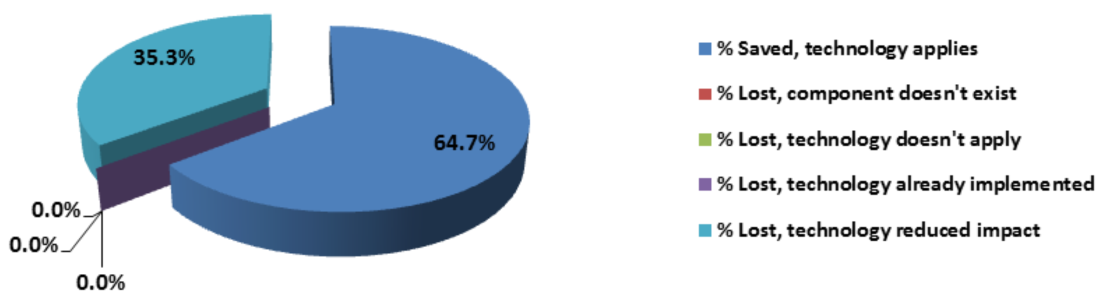
3.13.3 Renault Master 2.3 DCi

Table 3-103 summarizes the mass and cost impact of Silverado 1500 lightweighting technologies as applied to the Renault Master 2.3 DCi. Total Steering mass savings was 5.47 kg at a cost increase of $90.37, or $16.53 per kg.

Table 3-103: Mass-Reduction and Cost Impact for Steering System, Renault Master

System	Subsystem	Sub-Subsystem	Description	Net Value of Mass Reduction							
				Mass Reduction New Tech "kg" (1)	Mass Reduction Comp "kg" (1)	Mass Reduction Total "kg" (1)	Cost Impact New Tech "$" (2)	Cost Impact Comp "$" (2)	Cost Impact Total "$" (2)	Cost/ Kilogram Total "$/kg"	Vehicle Mass Reduction Total "%"
11	00	00	Stearing System								
11	01	00	Steering Gear	-1.387	0.000	-1.387	-$233.82	$0.00	-233.82	$168.53	-0.06%
11	02	00	Power Steering Pump	2.170	0.000	2.170	$16.23	$0.00	16.23	$7.48	0.09%
11	03	00	Power Steering Equipment	2.298	0.000	2.298	$123.93	$0.00	123.93	$53.93	0.10%
11	04	00	Steering Column Assembly	2.386	0.000	2.386	$3.28	$0.00	3.28	$1.38	0.10%
				5.47 (Decrease)	0.00	5.47 (Decrease)	-$90.37 (Increase)	$0.00	-90.37 (Increase)	-16.53 (Increase)	0.23%

Mass Savings, Select Vehicle, New Technology "kg"	**5.5**
Mass Savings, Silverado 1500, New Technology "kg"	**8.5**
Mass Savings Select Vehicle/Mass Savings 1500	**64.7%**



*SMS not included - has no significant impact on perecent contributions

3.13.3.1 System Scaling Analysis

The Renault Master 2.3 DCi Steering components were reviewed for compatibility with lightweighting technologies. The results of this analysis are listed in Table 3-104.

Table 3-104: System Scaling Analysis Steering System, Renault Master

System	Subsystem	Sub-Subsystem	Silverado 1500 Component/Assembly	Base Mass	Mass Savings New Tech	% of Mass Savings New Tech	Select Vehicle Tech Applies	Base Mass	Mass Savings New Tech	Notes
11			**Steering**	**32.514**	**8.456**	**26%**			**5.467**	
11	01	01	Steering Gear	13.89	-1.47	-11%	yes	13.14	-1.39	Tech **DOES** apply: The Renault used the same steering gear system as the Silverado 1500 and electric steering is a good option
11	02	01	Pump	5.44	5.44	100%	yes	2.17	2.17	Tech **DOES** apply: The Renault used the same pump as the Silverado 1500 and will not need with the electric application
11	03	01	Power Steering Tube Assembly	0.65	0.65	100%	yes	1.39	1.39	Tech **DOES** apply: The Renault used the same power steering tube as the Silverado 1500 and tubes will not be required.
11	03	02	Heat Exchange Assy	0.36	0.36	100%	yes	0.91	0.91	Tech **DOES** apply: The Renault used the same heat exchange system as the Silverado 1500 and the heat exchange will not be needed.
11	04	01	Steering column assy	10.18	3.25	32%	yes	7.05	2.25	Tech **DOES** apply: The Renault used the same sheet metal steering colum system as the Silverado 1500 is a candidate to use cast magnesium column
11	04	02	Steering wheel assy	1.78	0.20	11%	yes	1.12	0.13	Tech **DOES** apply: Very simular to Silverado 1500 rubber coated aluminum framed wheel, is a good candidate for plastic wheel.
11	04	03	Column Cowl	0.21	0.02	10%	yes	0.08	0.01	Tech **DOES** apply: Same as Silverado 1500 used Polyone as a solutin maintain integrity and reduce weight on cowls

Components with significant mass savings identified on the Renault Master 2.3 DCi include: the steering gear, pump, pump steering tube assembly, heat exchanger, steering column, steering wheel, and column cowl. Image 3.13–11 shows the Renault Master 2.3 DCi steering components.

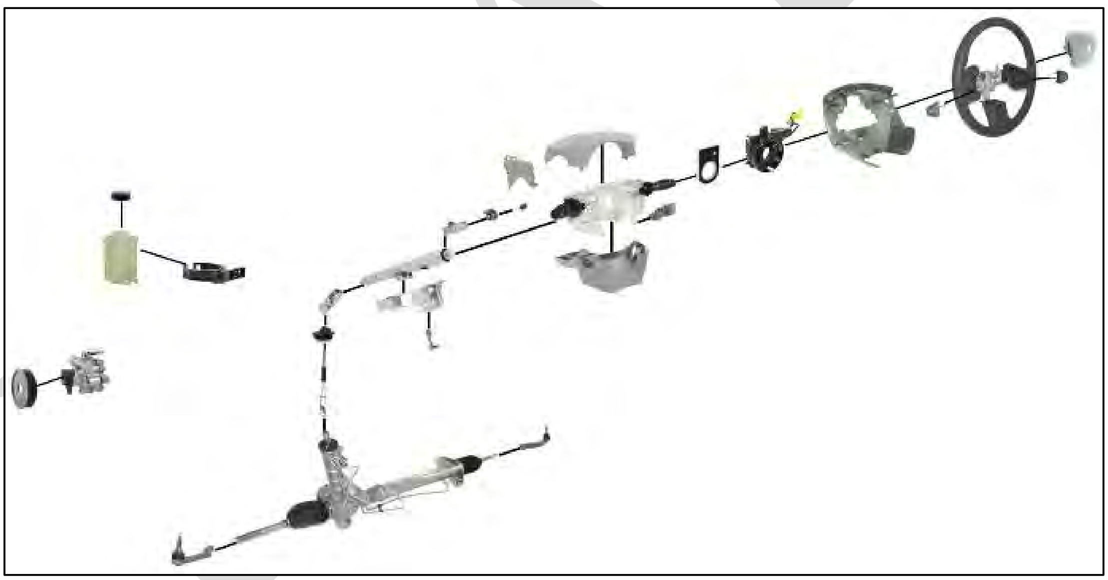


Image 3.13–11: Renault Master 2.3 DCi Steering Components
(Source: www.A2mac1.com)

<u>Steering Gear</u>

Shown in Image 3.13–12 are the Silverado 1500 and Renault Master 2.3 steering gear. Component masses were 13.9 kg for the Silverado 1500 versus 13.1 kg for the Renault Master 2.3. Due to similarities in component design and material, full percentage of the Silverado 1500 steering gear mass reduction can be applied to the Renault. (Refer to Table 3-104).

Image 3.13–12: Steering Gear for the Silverado 1500 (Left) and Renault Master 2.3 (Right)
(Source: FEV, Inc.)

Pump

Shown in Image 3.13–13 are the Silverado 1500 and Renault Master 2.3 hydraulic pumps. Component masses were 5.44 kg for the 1500 versus 2.17 kg for the 2.3. Due to similarities in component design and material, full percentage of the Silverado 1500 pump mass reduction can be applied to the Renault. (Refer to Table 3-104).

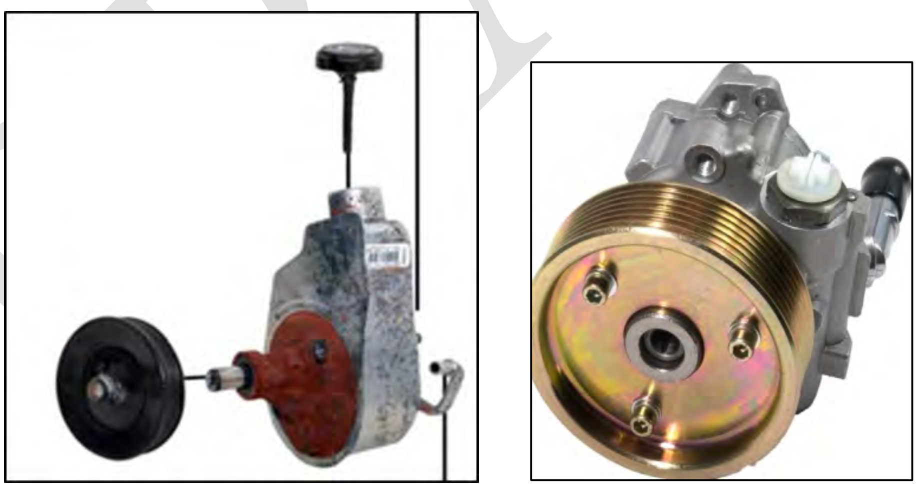


Image 3.13–13: Pump for the Silverado 1500 (Left) and Renault Master 2.3 (Right)
(Source: FEV, Inc.)

Power Steering Tubes

Shown in Image 3.13–14 are the Silverado 1500 and Renault Master 2.3 power steering tubes. Component masses were 0.65 kg for the Silverado 1500 versus 1.39 kg for the Renault Master 2.3. Due to similarities in component design and material, full percentage of the Silverado 1500 power steering tube mass reduction can be applied to the Renault. (Refer to Table 3-104).

DRAFT

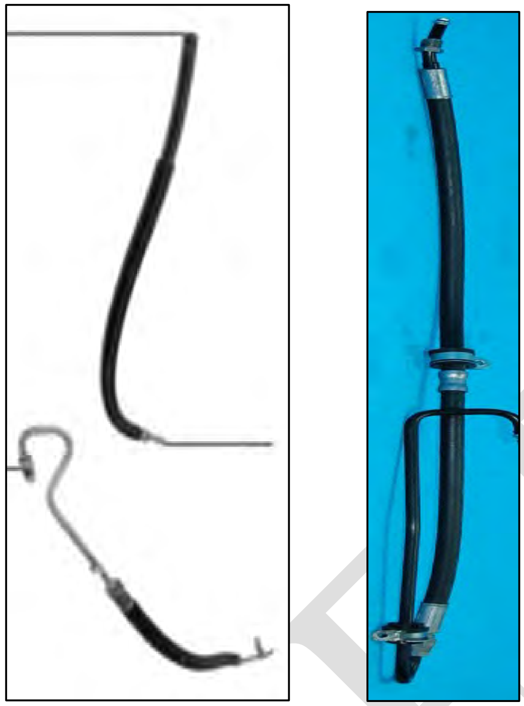


Image 3.13–14: Steering Tubes for the Silverado 1500 (Left) and Renault Master 2.3 (Right)
(Source: FEV, Inc. and www.A2mac1.com)

Heat Exchanger

Shown in Image 3.13–15 are the Silverado 1500 and Renault Master 2.3 heat exchangers. Component masses were 0.36 kg for the Silverado 1500 versus 0.91 kg for the Renault Master 2.3. Due to similarities in component design and material, full percentage of the Silverado 1500 heat exchanger mass reduction can be applied to the Renault. (Refer to Table 3-104).

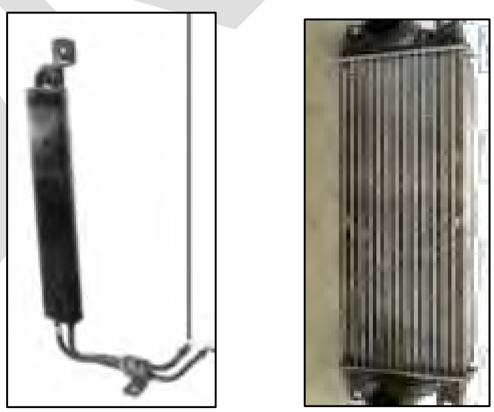


Image 3.13–15: Heat Exchangers for the Silverado 1500 (Left) and Renault Master 2.3 (Right)
(Source: FEV, Inc.)

Steering Column

Shown in Image 3.13–16 are the Silverado 1500 and Renault Master 2.3 steering columns. Component masses were 10.2 kg for the Silverado 1500 versus 7.05 kg for the Renault Master 2.3. Both steering columns were made of steel tubes and stampings welded onto an assembly. The technology to lighten these units is the same. A cast aluminum assembly is being used in other segments of the automotive industry successfully and is a good application for these trucks. Due to similarities in component design and material, full percentage of the Silverado 1500 steering column mass reduction can be applied to the Renault. (Refer to Table 3-104).

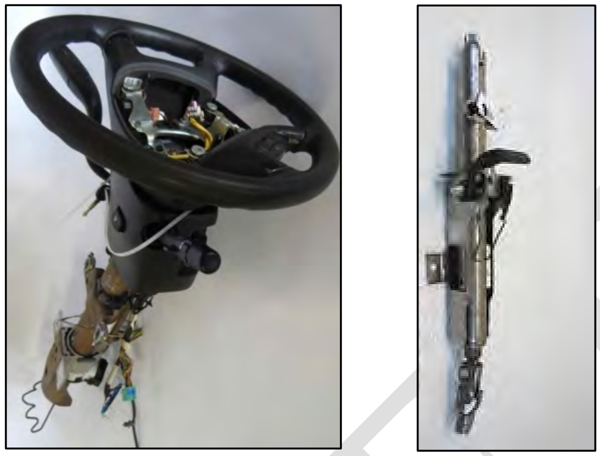


Image 3.13–16: Steering Column for the Silverado 1500 (Left) Renault Master 2.3 (Right)
(Source: FEV, Inc.)

<u>Steering Wheel</u>

Shown in Image 3.13–17 the Silverado 1500 and Renault Master 2.3 steering wheels. Component masses are 1.78 kg for the 1500 versus 1.12 kg for the Renault Master 2.3 respectively. Both the steering wheels are steel frames with plastic wrapping. The respectively technology used on both the steering wheels is the same. Due to similarities in component design and material, full percentage of the Silverado 1500 steering wheel mass reduction can be applied to the Renault. (Refer to Table 3-104).

Image 3.13–17: Steering Wheel for the Silverado 1500 (Left) and the Renault Master 2.3 (Right)
(Source: FEV, Inc.)

DRAFT

3.14 CLIMATE CONTROL SYSTEM

3.14.1 Silverado 1500 Summary

The Chevrolet Silverado 1500 Climate Control System included the air distribution duct components and HVAC main unit.

The Chevrolet Silverado 1500 analysis identified mass reduction alternatives and cost implications for the Climate Control System with the intent to meet the function and performance requirements of the baseline vehicle. Table 3-105 provides a summary of mass reduction and cost impact for select sub-subsystems evaluated. The total mass savings found on the Climate Control System mass was reduced by 1.94kg (9.5%). This decreased cost by $14.71, or $7.59 per kg. Mass reduction for this system reduced vehicle curb weight by 0.08%.

Table 3-105: Climate Control System Mass Reduction Summary, Silverado 1500

				Net Value of Mass Reduction					
System	Subsystem	Sub-Subsystem	Description	Base Mass "kg"	Mass Reduction "kg" (1)	Cost Impact NIDMC "$" (2)	Average Cost/ Kilogram "$/kg" (2)	Mass Reduction "%"	Vehicle Mass Reduction "%"
12	00	00	Climate Control System						
12	01	00	**Air Handling / Body Ventilation Subsystem**	**14.88**	**1.94**	**14.71**	**7.59**	**13.03%**	**0.08%**
12	01	02	Air Distribution Duct Components	2.89	1.43	14.02	9.82	49.49%	0.06%
12	01	04	HVAC Main Unit	12.00	0.51	0.69	1.35	4.26%	0.02%
									0.00%
12	02	00	**Heating/Defrosting Subsystem**	**0.29**	**0.00**	**0.00**	**--**	**--**	0.00%
12	02	01	Supplementary Heat Source	0.29	0.00	0.00	--	--	0.00%
12	03	00	**Refrigeration / Air Conditioning Subsystem**	**4.74**	**0.00**	**0.00**	**--**	**--**	0.00%
12	03	05	AC Lines, Receiver Drier and Accumulator	4.74	0.00	0.00	--	--	0.00%
12	04	00	**Controls Subsystem**	**0.39**	**0.00**	**0.00**	**--**	**--**	0.00%
12	04	03	Electronic Climate Control Unit	0.39	0.00	0.00	--	--	0.00%
				20.31	1.94 (Decrease)	14.71 (Decrease)	7.59 (Decrease)	9.55%	0.08%

(1) "+" = mass decrease, "-" = mass increase
(2) "+" = cost decrease, "-" = cost increase

Columns in the "Net Value of Mass Reduction" chart above may contain combined masses of assembly hardware such as nuts, bolt, washer, etc. that were not mass reduced at the component level, and may not match base mass and mass reduction totals in text below component reduction weights.

Mass savings opportunities were identified for the following components: air distribution duct and HVAC main unit.

<u>Air Distribution Duct Components:</u> The air distribution duct components mass was decreased by using Azote, from Zotefoams, Inc.® Mass was reduced by 49%, from 2.64 kg to 1.34 kg.

<u>HVAC Main Unit:</u> The HVAC main unit mass was reduced by using PolyOne® foaming agent. Mass was reduced by 4% from 10.4 kg to 9.92 kg.

DRAFT

3.14.1.1 Silverado 2500 Analysis

The Chevrolet Silverado 2500 Climate Control System is very similar to that of the Silverado 1500.

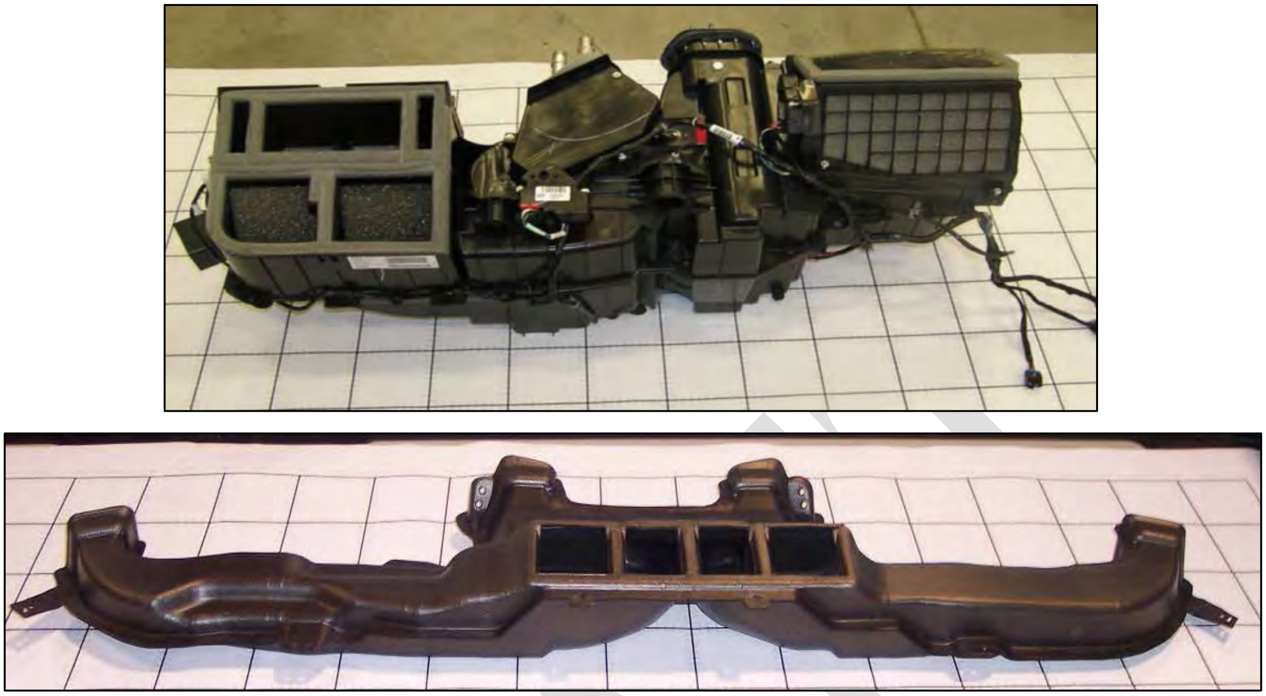


Image 3.14–1: Chevrolet Silverado 1500 and 2500 Climate Control System
(Source: GM)

DRAFT

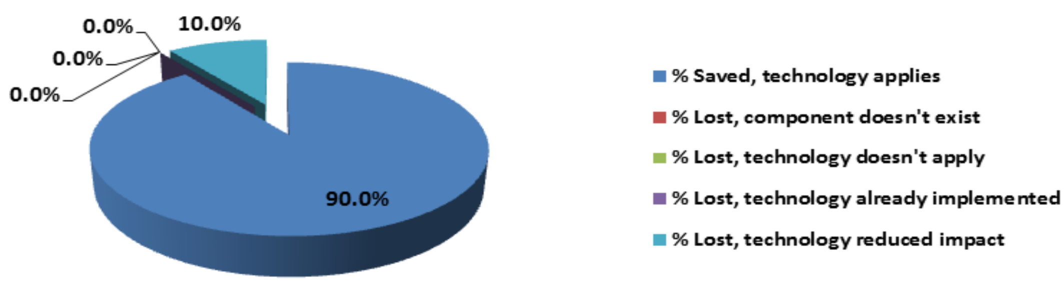
3.14.1.2 2500 System Scaling Summary

Table 3-106 summarizes mass and cost impact of the Silverado 1500 lightweighting technologies as applied to the Silverado 2500. Total Climate Control System mass savings was 1.75 kg at a cost decrease of $13.40, or $7.68 per kg.

Table 3-106: Mass-Reduction and Cost Impact for Climate Control System, Silverado 2500

				Net Value of Mass Reduction							
System	Subsystem	Sub-Subsystem	Description	Mass Reduction New Tech "kg" (1)	Mass Reduction Comp "kg" (1)	Mass Reduction Total "kg" (1)	Cost Impact New Tech "$" (2)	Cost Impact Comp "$" (2)	Cost Impact Total "$" (2)	Cost/ Kilogram Total "$/kg"	Vehicle Mass Reduction Total "%"
12	00	00	Climate Control								
12	01	00	Air Handling / Body Ventilation Subsystem	1.75	0.00	1.75	$13.40	$0.00	$13.40	$7.68	0.06%
				1.75 (Decrease)	0.00	1.75 (Decrease)	$13.40 (Decrease)	$0.00	$13.40 (Decrease)	$7.68 (Decrease)	0.06%

Mass Savings, Select Vehicle, New Technology "kg"	1.75
Mass Savings, Silverado 1500, New Technology "kg"	1.94
Mass Savings Select Vehicle/Mass Savings 1500	90.0%



*SMS not included - has no significant impact on perecent contributions

3.14.1.3 System Scaling Analysis

The Silverado 2500 Climate Control System components were reviewed for compatibility with lightweighting technologies. The results of this analysis are listed in Table 3-107.

Table 3-107: System Scaling Analysis Climate Control System, Silverado 2500

Silverado 1500							Select Vehicle			
System	Subsystem	Sub-Subsystem	Component/Assembly	Base Mass	Mass Savings New Tech	% of Mass Savings New Tech	Tech Applies	Base Mass	Mass Savings New Tech	Notes
12			Climate Control System	20.31	1.94	10%			1.75	
12	01	02	Air Distribution Duct Components	2.89	1.43	49%	yes	2.64	1.30	Tech DOES apply: Change plastic material to Zotefoams Azote
12	01	04	HVAC Main Unit	12.00	0.51	4%	yes	10.36	0.44	Tech DOES apply: Use MuCell Foam injection molding technology

Components with significant mass savings identified on the Silverado 2500 include the air distribution duct and HVAC main unit.

Air Distribution Duct Components

Shown in Image 3.14–2 are the Silverado 1500 and 2500 series air distribution duct components. Component masses were 2.89 kg for the 1500 versus 2.64 kg for the 2500. The lightweighting technology used in the air distribution duct components was Azote, from Zotefoams, Inc.®. Due to similarities in component design and material, full percentage of the Silverado 1500 air distribution duct mass reduction can be applied to the 2500. (Refer to Table 3-107).

Image 3.14–2: Air Distribution Duct Components are the same for Silverado 1500 and 2500
(Source: FEV, Inc.)

HVAC Main Unit

Shown in Image 3.14–3 are the Silverado 1500 and 2500 series HVAC main units. Component masses were 12.0 kg for the Silverado 1500 versus 10.4 kg for the 2500. The respective technology used on the HVAC main unit was PolyOne® foaming agent in the plastic. Due to similarities in component design and material, full percentage of the Silverado 1500 HVAC main unit duct mass reduction can be applied to the 2500. (Refer to Table 3-107).

Image 3.14–3: HVAC Main Units are the same for Silverado 1500 and 2500
(Source: FEV, Inc.)

DRAFT

3.14.1.4 System Comparison, Silverado 2500

The following table summarizes the Silverado 1500 and 2500 lightweighting results. The majority of the components were visually the same between the two Climate Control Systems.

Table 3-108: Climate Control System Comparison, Silverado 1500 and 2500

System	Description	Net Value of Mass Reduction								
		Mass Base "kg" (1)	Mass Reduction New Tech "kg" (1)	Mass Reduction Comp "kg" (1)	Mass Reduction Total "kg" (1)	System Mass Reduction "%"	Cost Impact New Tech "$" (2)	Cost Impact Comp "$" (2)	Cost Impact Total "$" (2)	Cost/ Kilogram Total "$/kg"
12	Climate Control									
12	Silverado 1500	20.31	1.94	0.00	1.94	9.55%	$14.71	$0.00	$14.71	$7.59
12	Silverado 2500	32.53	1.75	0.00	1.75	5.37%	$13.40	$0.00	$13.40	$7.68

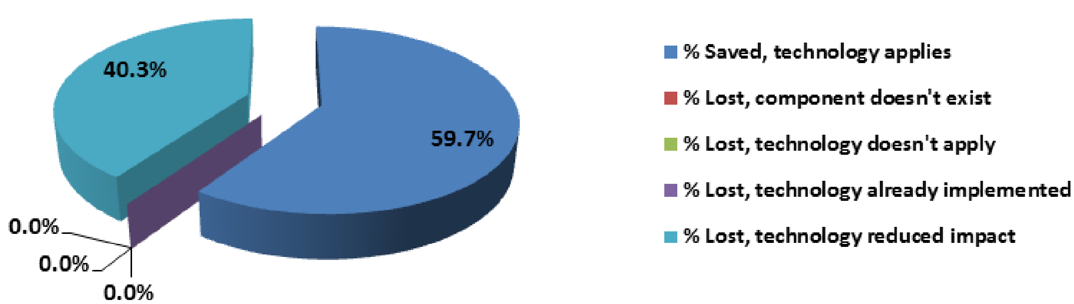
3.14.2 Mercedes Sprinter 311 CDi

Table 3-109 summarizes mass and cost impact of Silverado 1500 lightweighting technologies as applied to the Mercedes Sprinter 311 CDi. Total Climate Control System mass savings was 1.16 kg at a cost decrease of $7.99, or $6.90 per kg.

Table 3-109: Mass-Reduction and Cost Impact for Climate Control System, Mercedes Sprinter

System	Subsystem	Sub-Subsystem	Description	Net Value of Mass Reduction							
				Mass Reduction New Tech "kg" (1)	Mass Reduction Comp "kg" (1)	Mass Reduction Total "kg" (1)	Cost Impact New Tech "$" (2)	Cost Impact Comp "$" (2)	Cost Impact Total "$" (2)	Cost/ Kilogram Total "$/kg"	Vehicle Mass Reduction Total "%"
12	00	00	Climate Control								
12	01	00	Air Handling / Body Ventilation Subsystem	1.16	0.00	1.16	$7.99	$0.00	$7.99	$6.90	0.05%
				1.16 (Decrease)	**0.00**	**1.16** (Decrease)	**$7.99** (Decrease)	**$0.00**	**$7.99** (Decrease)	**$6.90** (Decrease)	**0.05%**

Mass Savings, Select Vehicle, New Technology "kg"	**1.16**
Mass Savings, Silverado 1500, New Technology "kg"	**1.94**
Mass Savings Select Vehicle/Mass Savings 1500	**59.7%**



*SMS not included - has no significant impact on perecent contributions

3.14.2.1 System Scaling Analysis

The Mercedes Sprinter 311 CDi Climate Control System components were reviewed for compatibility with lightweighting technologies. The results of this analysis are listed in Table 3-110.

Table 3-110: System Scaling Analysis Climate Control System, Mercedes Sprinter

Silverado 1500							Select Vehicle			
System	Subsystem	Sub-Subsystem	Component/Assembly	Base Mass	Mass Savings New Tech	% of Mass Savings New Tech	Tech Applies	Base Mass	Mass Savings New Tech	Notes
12			**Climate Control System**	**20.31**	**1.94**	**10%**			**1.16**	
12	01	02	Air Distribution Duct Components	2.89	1.43	49%	yes	1.53	0.76	Tech **DOES** apply: Change plastic material to Zotefoams Azote
12	01	04	HVAC Main Unit	12.00	0.51	4%	yes	9.37	0.40	Tech **DOES** apply: Use MuCell Foam injection molding technology

Components with significant mass savings identified on the Mercedes Sprinter included the air distribution duct components and HVAC Main Unit. Image 3.14–4 shows the Mercedes Sprinter 311 CDi Climate Control System components.

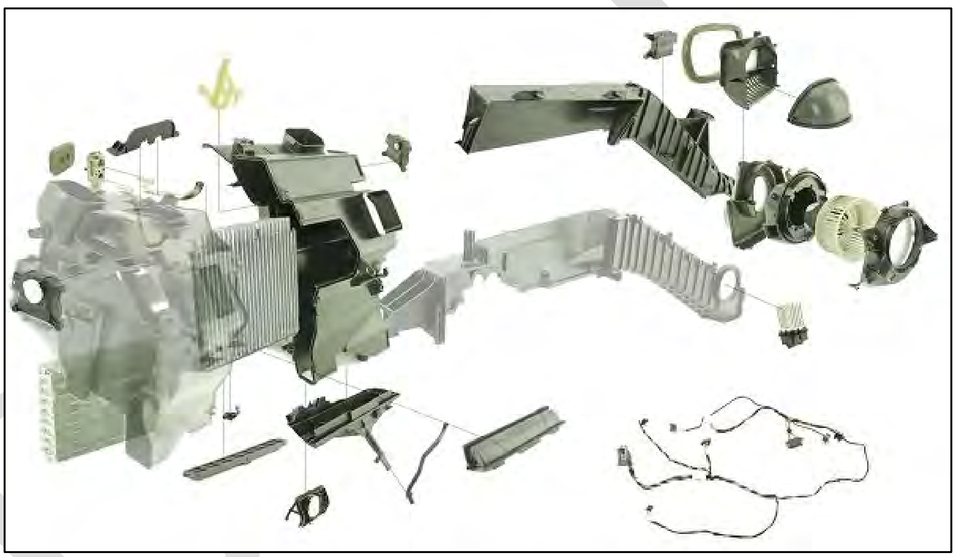


Image 3.14–4: Mercedes Sprinter 311 CDi Climate Control System
(Source: www.A2mac1.com)

<u>Air Distribution Duct Components</u>

Shown in Image 3.14–5 are the Silverado 1500 and Mercedes Sprinter 311 CDi air distribution duct components. Component masses were 2.89 kg for the Silverado 1500 versus 1.53 kg for the Mercedes Sprinter 311 CDi. The lightweighting technology used on the air distribution duct components was Azote, from Zotefoams, Inc.® Due to similarities in component design and material, full percentage of the Silverado 1500 air distribution duct mass reduction can be applied to the Sprinter. (Refer to Table 3-110Table 3-107).

DRAFT

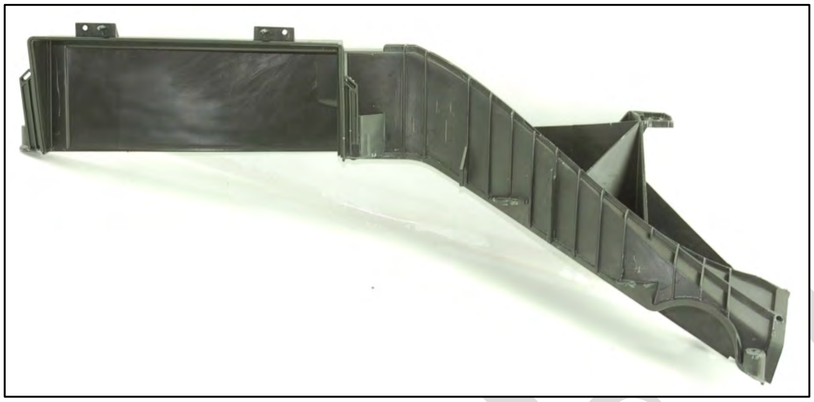


Image 3.14–5: Air Distribution Duct Components for the Silverado 1500 and 2500 (Top) and Mercedes Sprinter 311 CDi (Bottom)
(Source: FEV, Inc. and www.A2mac1.com)

HVAC Main Unit

Shown in Image 3.14–6 are the Silverado 1500 and Mercedes Sprinter 311 CDi HVAC main units. Component masses were 12.0 kg for the Silverado 1500 versus 9.37 kg for the Mercedes Sprinter 311 CDi. Both HVAC main units were made of plastic. The lightweighting technology used on both the HVAC main units was PolyOne® foaming agent on the plastic. Due to similarities in component design and material, full percentage of the Silverado 1500 HVAC main unit mass reduction can be applied to the Sprinter. (Refer to Table 3-110Table 3-107).

DRAFT

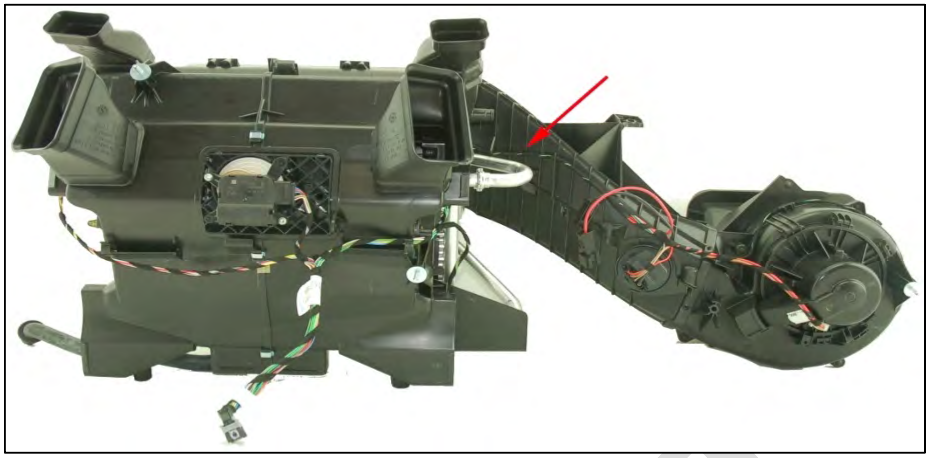


Image 3.14–6: HVAC Main Unit for Silverado 1500 and 2500 (Top) and Mercedes Sprinter 311 CDi (Bottom)
(Source: FEV, Inc. and www.A2mac1.com)

DRAFT

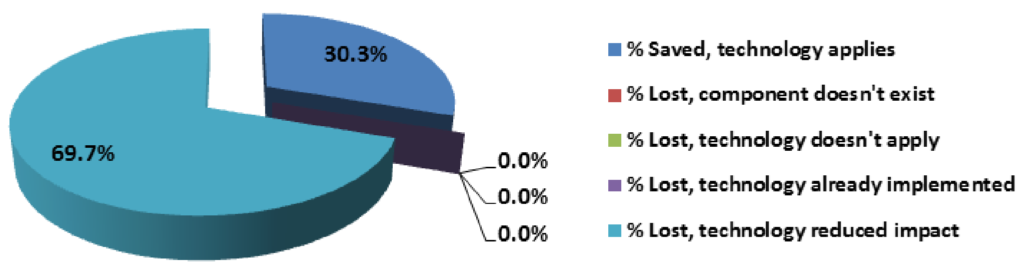
3.14.3 Renault Master 2.3 DCi

Table 3-111 summarizes mass and cost impact of Silverado 1500 lightweighting technologies applied to the Renault Master 2.3 DCi. Climate Control System mass savings was 0.59 kg at a cost decrease of $2.91, or $4.96 per kg.

Table 3-111: Mass-Reduction and Cost Impact for Climate Control System, Renault Master

System	Subsystem	Sub-Subsystem	Description	Net Value of Mass Reduction: Mass Reduction New Tech "kg" (1)	Mass Reduction Comp "kg" (1)	Mass Reduction Total "kg" (1)	Cost Impact New Tech "$" (2)	Cost Impact Comp "$" (2)	Cost Impact Total "$" (2)	Cost/ Kilogram Total "$/kg"	Vehicle Mass Reduction Total "%"
12	00	00	Climate Control								
12	01	00	Air Handling / Body Ventilation Subsystem	0.59	0.00	0.59	$2.91	$0.00	$2.91	$4.96	0.02%
				0.59 (Decrease)	0.00	0.59 (Decrease)	$2.91 (Decrease)	$0.00	$2.91 (Decrease)	$4.96 (Decrease)	0.02%

Mass Savings, Select Vehicle, New Technology "kg"	0.59
Mass Savings, Silverado 1500, New Technology "kg"	1.94
Mass Savings Select Vehicle/Mass Savings 1500	30.3%



*SMS not included - has no significant impact on perecent contributions

3.14.3.1 System Scaling Analysis

The Renault Master 2.3 DCi Climate Control System components were reviewed for compatibility with lightweighting technologies. The results of this analysis are listed in Table 3-112.

Table 3-112: System Scaling Analysis Climate Control System, Renault Master

System	Subsystem	Sub-Subsystem	Component/Assembly	Silverado 1500: Base Mass	Mass Savings New Tech	% of Mass Savings New Tech	Select Vehicle: Tech Applies	Base Mass	Mass Savings New Tech	Notes
12			Climate Control System	20.31	1.94	10%			0.59	
12	01	02	Air Distribution Duct Components	2.89	1.43	49%	yes	0.51	0.25	Tech DOES apply: Change plastic material to Zotefoams Azote
12	01	04	HVAC Main Unit	12.00	0.51	4%	yes	7.90	0.34	Tech DOES apply: Use MuCell Foam injection molding technology

Components with significant mass savings identified on the Renault Master 2.3 DCi include the Air Distribution Duct Components and HVAC Main Unit. Image 3.14–7 shows the Renault Master 2.3 DCi Climate Control System components

Image 3.14–7: Renault Master 2.3 DCi Climate Control System
(Source: www.A2mac1.com)

Air Distribution Duct Components

Shown in Image 3.14–8 are the Silverado 1500 and Renault Master 2.3 DCi Air Distribution Duct Components. Component masses were 2.89 kg for the Silverado 1500 versus 1.53 kg for the Renault Master 2.3 DCi. The lightweighting technology used on the Air Distribution Duct Components was Azote, from Zotefoams, Inc.® Due to similarities in component material, full percentage of the Silverado 1500 air distribution duct mass reduction can be applied to the Renault. (Refer to Table 3-112Table 3-107).

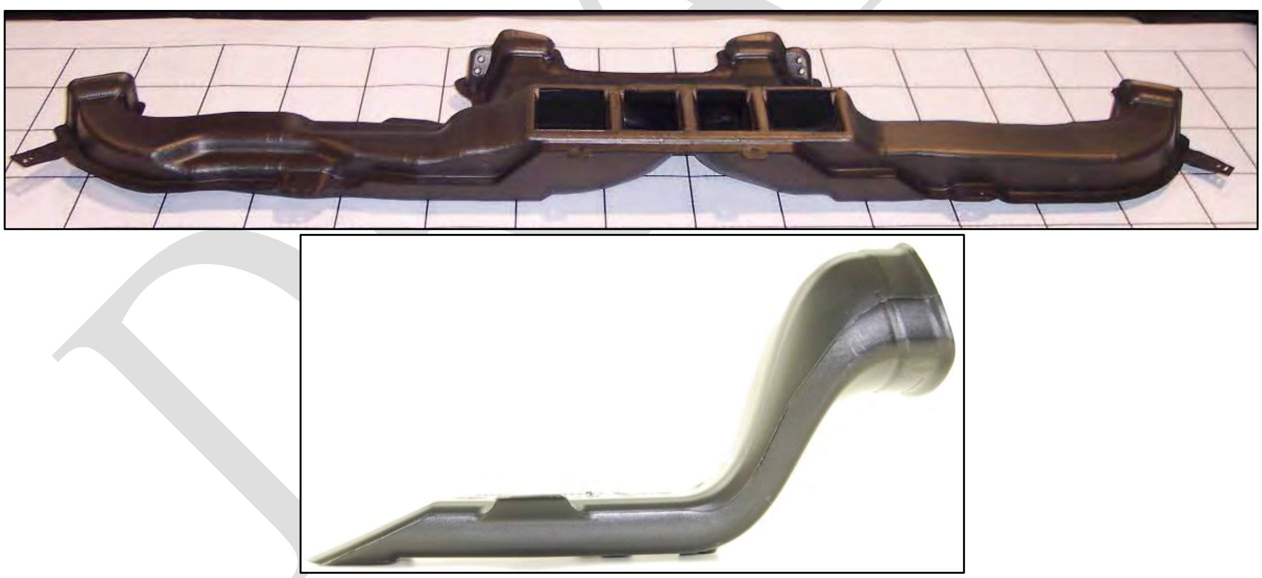


Image 3.14–8: Air Distribution Duct Components for the Silverado 1500 and 2500 (Top) and Renault Master 2.3 DCi (Bottom)
(Source: FEV, Inc. and *www.A2mac1.com*)

HVAC Main Unit

Shown in Image 3.14–9 are the Silverado 1500 and Renault Master 2.3 DCi HVAC main unit. Component masses were 12.0 kg for the 1500 versus 9.37 kg for the Renault Master 2.3 DCi. Both HVAC main units were made of plastic. The lightweighting technology used on both the HVAC main units was PolyOne® foaming agent in the plastic. Due to similarities in component design and

DRAFT

material, full percentage of the Silverado 1500 HVAC main unit mass reduction can be applied to the Renault. (Refer to Table 3-112Table 3-107).

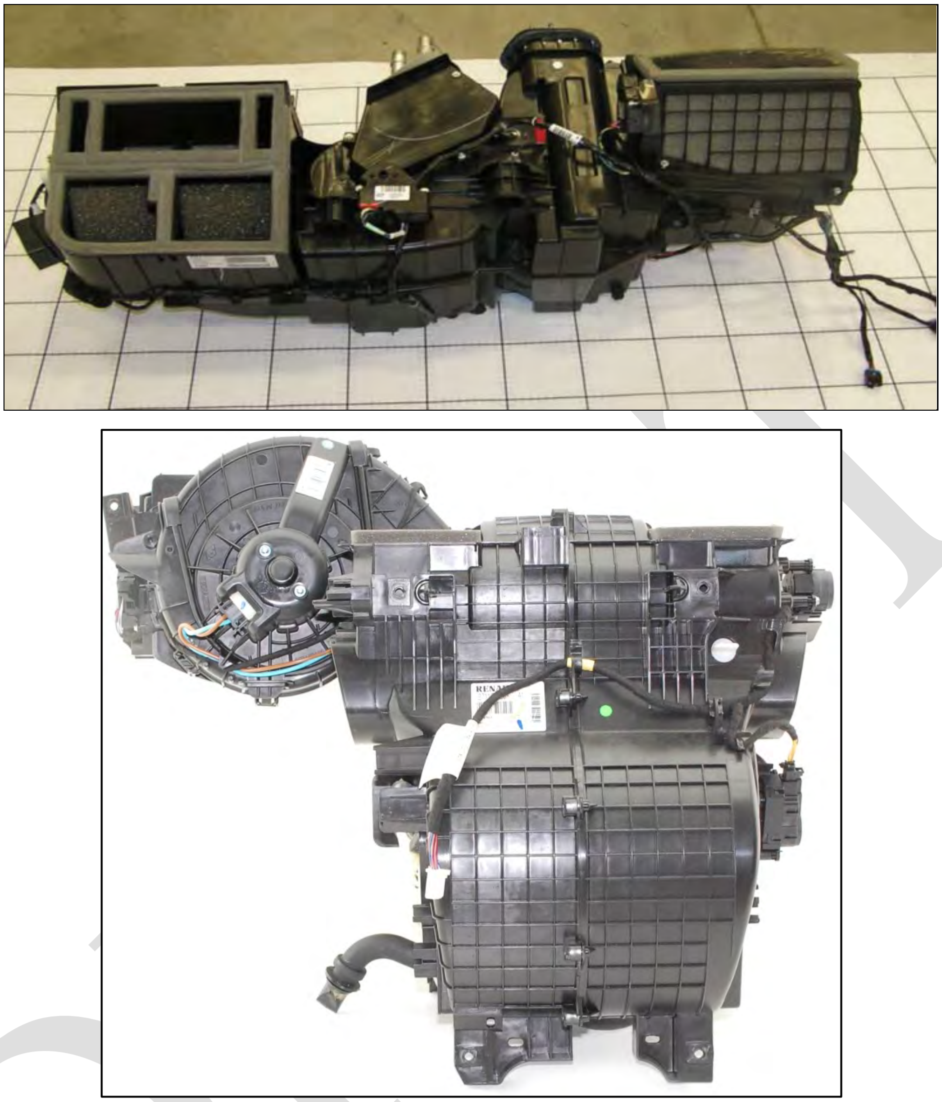


Image 3.14–9: HVAC Main Unit for the Silverado 1500 and 2500 (Top) and Renault Master 2.3 DCi (Bottom)
(Source: FEV, Inc. and A2mac1.com)

3.15 INFORMATION, GAGE AND WARNING DEVICE SYSTEM

3.15.1 Silverado 1500 Summary

The Chevrolet Silverado 1500 Information, Gage and Warning Device System included the driver information center and traffic horn assembly. The Chevrolet Silverado 1500 analysis identified mass reduction alternatives and cost implications for the Information, Gage, and Warning Device System with the intent to meet the function and performance requirements of the baseline vehicle. Table 3-113 provides a summary of mass reduction and cost impact for select sub-subsystems evaluated. The total mass savings found on the Information, Gage, and Warning Device System mass was reduced by 0.25 kg (15.72%). This decreased cost by $0.66, or $2.66 per kg. Mass reduction for this system reduced vehicle curb weight by 0.01%.

Table 3-113: Information, Gage and Warning Device System Mass Reduction Summary, Silverado 1500

System	Subsystem	Sub-Subsystem	Description	Net Value of Mass Reduction					
				Base Mass "kg"	Mass Reduction "kg" (1)	Cost Impact NIDMC "$" (2)	Average Cost/ Kilogram "$/kg" (2)	Mass Reduction "%"	Vehicle Mass Reduction "%"
13	**01**	**00**	**Instrument Cluster Subsystem**	**1.06**	**0.06**	**0.49**	**7.67**	**5.99%**	**0.00%**
13	01	01	Driver Information Center	1.06	0.06	0.49	7.67	5.99%	0.00%
13	**02**	**00**	**Traffic Horns (Electric)**	**0.52**	**0.18**	**0.17**	**0.93**	**35.64%**	**0.01%**
13	02	01	Traffic Horn Assembly - LH	0.26	0.09	0.09	0.93	35.64%	0.00%
13	02	02	Traffic Horn Assembly - RH	0.26	0.09	0.09	0.93	35.64%	0.00%
				1.58	0.25 (Decrease)	0.66 (Decrease)	2.66 (Decrease)	15.72%	0.01%

(1) "+" = mass decrease, "-" = mass increase
(2) "+" = cost decrease, "-" = cost increase

Columns in the "Net Value of Mass Reduction" chart above may contain combined masses of assembly hardware such as nuts, bolt, washer, etc. that were not mass reduced at the component level, and may not match base mass and mass reduction totals in text below component reduction weights.

Mass savings opportunities were identified for the following components: cluster mask assembly, cluster rear housing, display housing, LH/RH horn outer plastic cover, LH/RH horn outside steel cover, and LH/RH horn mounting bracket.

Cluster Mask Assembly: The cluster mask assembly mass was decreased by using PolyOne® foaming agent. Mass was reduced by 10%, from 0.18 kg to 0.16 kg.

Cluster Rear Housing: The cluster rear housing mass was reduced by using PolyOne® foaming agent. Mass was reduced by 10% from 0.20 kg to 0.18 kg.

Display Housing: The display housing mass was reduced by using PolyOne® foaming agent. Mass was reduced by 10%, from 0.25 kg to 0.22 kg.

Horn Outer Plastic Cover (LH/RH): The horn outer plastic cover LH/RH mass was reduced by using PolyOne® foaming agent. Mass was reduced by 10%, from 0.04 kg to 0.03 kg.

Horn Outside Steel Cover (LH/RH): The horn outside steel cover LH/RH mass was reduced by changing from steel to plastic and then using PolyOne® foaming agent. Mass was reduced by 78%, from 0.04 kg to 0.01 kg.

Horn Mounting bracket (LH/RH): The horn mounting bracket LH/RH mass was reduced by changing from steel to plastic and then using PolyOne® foaming agent. Mass was reduced by 78%, from 0.03 kg to 0.008 kg.

3.15.1.1 Silverado 2500 Analysis

The Chevrolet Silverado 2500 Information, Gage and Warning Device System is very similar to the 1500.

DRAFT

Image 3.15–1: Chevrolet Silverado 2500 Information, Gage and Warning Device System
(Source: FEV, Inc.)

3.15.1.2 2500 System Scaling Summary

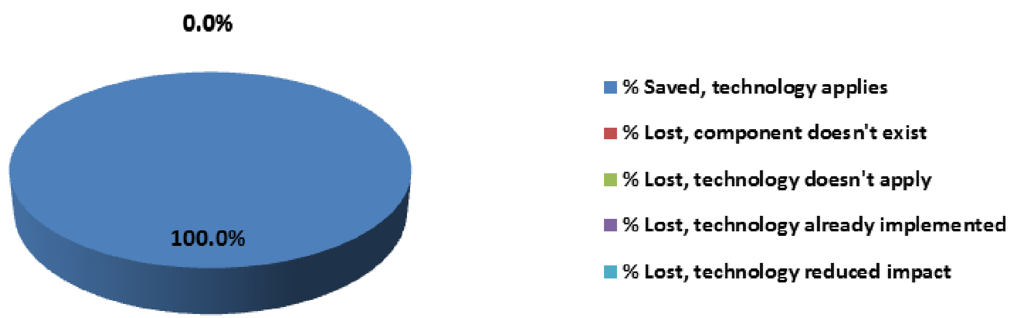
Table 3-114: Mass-Reduction and Cost Impact for Information, Gage and Warning Device System summarizes the mass and cost impact of Silverado 1500 lightweighting technologies as applied to the Silverado 2500. Total Information, Gage, and Warning Device System mass savings is 0.25 kg at a cost decrease of $.65, or $2.62 per kg.

Table 3-114: Mass-Reduction and Cost Impact for Information, Gage and Warning Device System, Silverado 2500

DRAFT

System	Subsystem	Sub-Subsystem	Description	Net Value of Mass Reduction							
				Mass Reduction New Tech "kg" (1)	Mass Reduction Comp "kg" (1)	Mass Reduction Total "kg" (1)	Cost Impact New Tech "$" (2)	Cost Impact Comp "$" (2)	Cost Impact Total "$" (2)	Cost/ Kilogram Total "$/kg"	Vehicle Mass Reduction Total "%"
13	00	00	**Information, Gage and Warning Divice System**								
13	01	00	Instrument Cluster Subsystem	0.06	0.00	0.06	$0.49	$0.00	$0.49	$7.73	0.00%
13	02	00	Traffic Horns (Electric)	0.18	0.00	0.18	$0.16	$0.00	$0.16	$0.87	0.01%
				0.25 (Decrease)	**0.00**	**0.25** (Decrease)	**$0.65** (Decrease)	**$0.00**	**$0.65** (Decrease)	**$2.62** (Decrease)	**0.01%**

Mass Savings, Select Vehicle, New Technology "kg"	**0.25**
Mass Savings, Silverado 1500, New Technology "kg"	**0.25**
Mass Savings Select Vehicle/Mass Savings 1500	**100.0%**



*SMS not included - has no significant impact on perecent contributions

DRA

3.15.1.3 System Scaling Analysis

The Silverado 2500 Information, Gage and Warning Device System components were reviewed for compatibility with lightweighting technologies. The results of this analysis are listed in Table 3-115.

Table 3-115: System Scaling Analysis for Information, Gage and Warning Device System, Silverado 2500

Silverado 1500							Select Vehicle			
System	Subsystem	Sub-Subsystem	Component/Assembly	Base Mass	Mass Savings New Tech	% of Mass Savings New Tech	Tech Applies	Base Mass	Mass Savings New Tech	Notes
13			**Information, Gage and Warning Device System**	**1.58**	**0.25**	**16%**			**0.25**	
13	01	01	Cluster Mask Assy	0.19	0.018	10%	yes	0.19	0.02	Tech **DOES** apply: Use Polyone foaming agent
13	01	01	Cluster Rear Housing	0.20	0.020	10%	yes	0.20	0.02	Tech **DOES** apply: Use Polyone foaming agent
13	01	01	Display Housing	0.25	0.025	10%	yes	0.25	0.03	Tech **DOES** apply: Use Polyone foaming agent
13	02	01	Outer plastic cover	0.04	0.004	9%	yes	0.04	0.00	Tech **DOES** apply: Use Polyone foaming agent
13	02	01	Outside stl cover	0.07	0.058	78%	yes	0.07	0.06	Tech **DOES** apply: Change from steel to plastic and use Polyone foaming agent
13	02	01	Mounting brkt	0.04	0.030	79%	yes	0.04	0.03	Tech **DOES** apply: Change from steel to plastic and use Polyone foaming agent
13	02	01	Outer plastic cover	0.04	0.004	9%	yes	0.04	0.00	Tech **DOES** apply: Use Polyone foaming agent
13	02	01	Outside stl cover	0.07	0.058	78%	yes	0.07	0.06	Tech **DOES** apply: Change from steel to plastic and use Polyone foaming agent
13	02	01	Mounting brkt	0.04	0.030	79%	yes	0.04	0.03	Tech **DOES** apply: Change from steel to plastic and use Polyone foaming agent

Components with significant mass savings identified on the Silverado 2500 include the cluster mask assembly, cluster rear housing, display housing, and horn outer plastic cover (LH/RH), horn outside steel cover (LH/RH), and horn mounting bracket (LH/RH).

<u>Cluster Mask Assembly</u>

Shown in Image 3.15–2 is the Silverado 1500 and 2500 series cluster mask assembly. Component masses were 0.19 kg for both the Silverado 1500 and for the 2500. The lightweighting technology used in the cluster mask assembly was PolyOne® foaming agent in the plastic. Due to similarities in component design and material, full percentage of the Silverado 1500 cluster mask assembly mass reduction can be applied to the 2500. (Refer to Table 3-115Table 3-107).

Image 3.15–2: Cluster Mask Assembly is the same for the Silverado 1500 and 2500
(Source: FEV, Inc.)

<u>Cluster Rear Housing</u>

Shown in Image 3.15–3 is the Silverado 1500 and 2500 series cluster rear housing. Component masses were 0.20 kg for both the Silverado 1500 and the 2500. The lightweighting technology used on the cluster rear housing was PolyOne® foaming agent in the plastic. Due to similarities in component design and material, full percentage of the Silverado 1500 cluster rear housing mass reduction can be applied to the 2500. (Refer to Table 3-115Table 3-107).

DRAFT

Image 3.15–3: Cluster Rear Housing is the same for the Silverado 1500 and 2500
(Source: FEV, Inc.)

Display Housing

Shown in Image 3.15–4 is the Silverado 1500 and 2500 Display Housing. Component masses were 0.25 kg for both the Silverado 1500 and for the 2500. The lightweighting technology used in the Display Housing is to use PolyOne® foaming agent in the plastic. Due to similarities in component design and material, full percentage of the Silverado 1500 display housing mass reduction can be applied to the 2500. (Refer to Table 3-115Table 3-107).

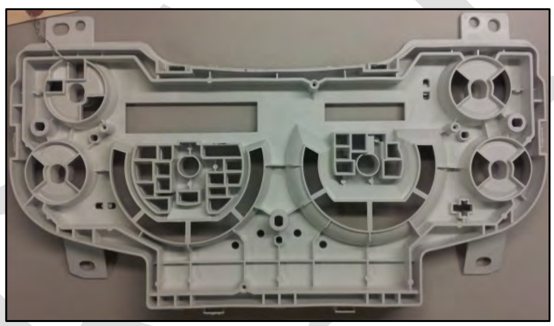


Image 3.15–4: Display Housing is the same for the Silverado 1500 and 2500
(Source: FEV, Inc.)

Horn Outer plastic covers (LH/RH)

Shown in Image 3.15–5 is the Silverado 1500 and 2500 horn outer plastic cover (LH/RH). Component masses were 0.04 kg for both the 1500 and for the 2500. The lightweighting technology used in the horn outer plastic covers was PolyOne® foaming agent in the plastic. Due to similarities in component design and material, full percentage of the Silverado 1500 horn outer plastic cover mass reduction can be applied to the 2500. (Refer to Table 3-115Table 3-107).

DRAFT

Image 3.15–5: Horn outer plastic cover (LH/RH) is the same for the Silverado 1500 and 2500
(Source: FEV, Inc.)

<u>Horn Outside steel covers RH and LH</u>

Shown in Image 3.15–6 is the Silverado 1500 and 2500 series horn outside steel cover (LH/RH). Component masses were 0.07 kg for both the 1500 for the 2500. The lightweighting technology used was to change from steel to plastic and use PolyOne® foaming agent in the plastic. Due to similarities in component design and material, full percentage of the Silverado 1500 horn outside steel cover mass reduction can be applied to the 2500. (Refer to Table 3-115).

Image 3.15–6: Horn outside steel cover (LH/RH) is the same for the Silverado 1500 and 2500
(Source: FEV, Inc.)

<u>Horn Mounting bracket RH and LH</u>

Shown in Image 3.15–7 is the Silverado 1500 and 2500 series Horn Mounting bracket RH and LH. Component masses are .04 kg for both the 1500 and 2500. The lightweighting technology used on the Horn Mounting bracket RH and LH is to change from steel to plastic and use PolyOne® foaming agent in the plastic. Due to similarities in component design and material, full percentage of the Silverado 1500 horn mounting bracket mass reduction can be applied to the 2500. (Refer to Table 3-115Table 3-107).

DRAFT

Image 3.15–7: Horn Mounting bracket (LH/RH) is the same for the Silverado 1500 and 2500
(Source: FEV, Inc.)

3.15.1.4 System Comparison, Silverado 2500

Table 3-116 summarizes the Silverado 1500 and 2500 lightweighting results. The majority of the components were visually the same between the Information, Gage, and Warning Device Systems.

Table 3-116: Information, Gage, and Warning Device System Comparison, Silverado 1500 and 2500

		Net Value of Mass Reduction								
System	Description	Mass Base "kg" (1)	Mass Reduction New Tech "kg" (1)	Mass Reduction Comp "kg" (1)	Mass Reduction Total "kg" (1)	System Mass Reduction "%"	Cost Impact New Tech "$" (2)	Cost Impact Comp "$" (2)	Cost Impact Total "$" (2)	Cost/ Kilogram Total "$/kg"
13	Info & Gage									
13	Silverado 1500	1.58	0.25	0.00	0.25	15.65%	$0.65	$0.00	$0.65	$2.62
13	Silverado 2500	1.58	0.25	0.00	0.25	15.65%	$0.65	$0.00	$0.65	$2.62

DRAFT

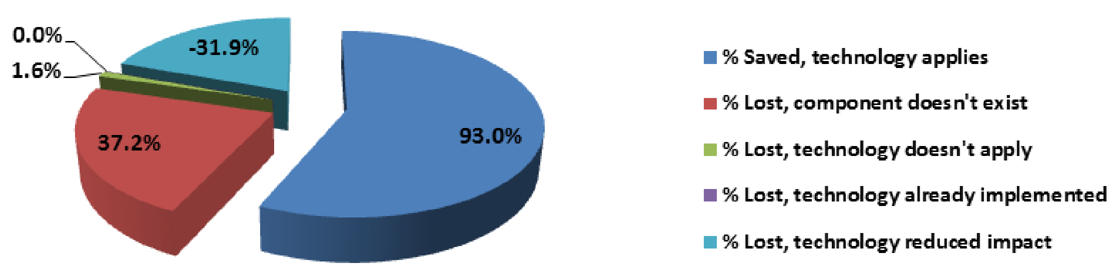
3.15.2 Mercedes Sprinter 311 CDi

Table 3-117 summarizes the mass and cost impact of Silverado 1500 lightweighting technologies as applied to the Mercedes Sprinter 311 CDi. Total Information, Gage and Warning Device System mass savings was 0.23 kg, at a cost decrease of $1.26, or $5.49 per kg.

Table 3-117: Mass-Reduction and Cost Impact for Information, Gage and Warning Device System, Mercedes Sprinter

System	Subsystem	Sub-Subsystem	Description	Net Value of Mass Reduction: Mass Reduction New Tech "kg" (1)	Mass Reduction Comp "kg" (1)	Mass Reduction Total "kg" (1)	Cost Impact New Tech "$" (2)	Cost Impact Comp "$" (2)	Cost Impact Total "$" (2)	Cost/ Kilogram Total "$/kg"	Vehicle Mass Reduction Total "%"
13	00	00	Information, Gage and Warning Divice System								
13	01	00	Instrument Cluster Subsystem	0.16	0.00	0.16	$1.28	$0.00	$1.28	$8.19	0.01%
13	02	00	Traffic Horns (Electric)	0.07	0.00	0.07	-$0.01	$0.00	-$0.01	-$0.19	0.00%
				0.23 (Decrease)	0.00	0.23 (Decrease)	$1.26 (Decrease)	$0.00	$1.26 (Decrease)	$5.49 (Decrease)	0.01%

Mass Savings, Select Vehicle, New Technology "kg"	0.23
Mass Savings, Silverado 1500, New Technology "kg"	0.25
Mass Savings Select Vehicle/Mass Savings 1500	93.0%



*SMS not included - has no significant impact on perecent contributions

3.15.2.1 System Scaling Analysis

The Mercedes Sprinter 311 CDi Information, Gage and Warning Device System components were reviewed for compatibility with lightweighting technologies. The results of this analysis are listed in Table 3-118.

Table 3-118: System Scaling Analysis Information, Gage and Warning Device System, Mercedes Sprinter

System	Subsystem	Sub-Subsystem	Component/Assembly	Silverado 1500: Base Mass	Mass Savings New Tech	% of Mass Savings New Tech	Select Vehicle: Tech Applies	Base Mass	Mass Savings New Tech	Notes
13			Information, Gage and Warning Divice System	1.58	0.25	16%			0.23	
13	01	01	Cluster Mask Assy	0.19	0.018	10%	yes	0.79	0.08	Tech **DOES** apply: Use Polyone foaming agent
13	01	01	Cluster Rear Housing	0.20	0.020	10%	yes	0.39	0.04	Tech **DOES** apply: Use Polyone foaming agent
13	01	01	Display Housing	0.25	0.025	10%	yes	0.39	0.04	Tech **DOES** apply: Use Polyone foaming agent
13	02	01	Outer plastic cover	0.04	0.004	9%	no			Tech does **NOT** apply: Outer cover is steel
13	02	01	Outside stl cover	0.07	0.058	78%	yes	0.07	0.06	Tech **DOES** apply: Change from steel to plastic and use Polyone foaming agent
13	02	01	Mounting brkt	0.04	0.030	79%	yes	0.02	0.02	Tech **DOES** apply: Change from steel to plastic and use Polyone foaming agent
13	02	01	Outer plastic cover	0.04	0.004	9%	no			Tech does **NOT** apply: Part not on vehicle
13	02	01	Outside stl cover	0.07	0.058	78%	no			Tech does **NOT** apply: Part not on vehicle
13	02	01	Mounting brkt	0.04	0.030	79%	no			Tech does **NOT** apply: Part not on vehicle

If the original Silverado 1500 mass reduction concept idea was not able to be applied to the comparison vehicle it is not described in the section below.

Components with significant mass savings identified on the Mercedes Sprinter included the cluster mask assembly, cluster rear housing, display housing, and horn outside steel cover, horn mounting bracket. Image 3.15–8 shows the Mercedes Sprinter 311 CDi Information, Gage, and Warning Device System components.

Image 3.15–8: Mercedes Sprinter 311 CDi Information, Gage, and Warning Device System
(Source: www.A2mac1.com)

<u>Cluster Mask Assembly</u>

Shown in Image 3.15–9 are the Silverado 1500 and Mercedes Sprinter 311 CDi cluster mask assembly. Component masses were 0.19 kg for the Silverado 1500 versus 0.79 kg for the Mercedes Sprinter 311 CDi. The lightweighting technology used on the cluster mask assembly is to use PolyOne® foaming agent in the plastic. Due to similarities in component material, full percentage of the Silverado 1500 cluster mask assembly mass reduction can be applied to the Sprinter. (Refer to Table 3-118Table 3-107).

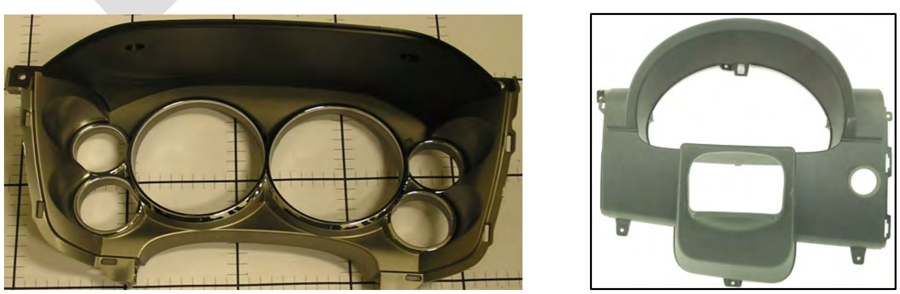


Image 3.15–9: Cluster Mask Assembly for the Silverado 1500 and 2500 (Left) and Mercedes Sprinter 311 CDi (Right)

(Source: FEV, Inc.)

DRAFT

Cluster Rear Housing

Shown in Image 3.15–10 are the Silverado 1500 and Mercedes Sprinter 311 CDi cluster rear housings. Component masses were 0.20 kg for the Silverado 1500 versus 0.39 kg for the Mercedes Sprinter 311 CDi. Both cluster rear housings were made of plastic. The lightweighting technology used on both was PolyOne® foaming agent in the plastic. Due to similarities in component design and material, full percentage of the Silverado 1500 cluster rear housing mass reduction can be applied to the Sprinter. (Refer to Table 3-118Table 3-107).

Image 3.15–10: Cluster Rear Housing for the Silverado 1500 and 2500 (Left) and Mercedes Sprinter 311 CDi (Right)
(Source: FEV, Inc. and www.A2mac1.com)

Display Housing

Shown in Image 3.15–11 are the Silverado 1500 and Mercedes Sprinter 311 CDi display housings. Component masses were 0.25 kg for the Silverado 1500 versus 0.39 kg for the Mercedes Sprinter 311 CDi. Both display housings were made of plastic. The lightweighting technology used on both was to use PolyOne® foaming agent in the plastic. Due to similarities in component design and material, full percentage of the Silverado 1500 display housing mass reduction can be applied to the Sprinter. (Refer to Table 3-118Table 3-107).

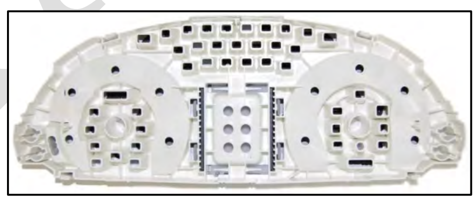


Image 3.15–11: Display Housing for the Silverado 1500 and 2500 (Left) and Mercedes Sprinter 311 CDi (Right)
(Source: FEV, Inc. and www.A2mac1.com)

Horn Outside steel cover

Shown in Image 3.15–12 are the Silverado 1500 and Mercedes Sprinter 311 CDi Horn Outside steel covers. Component masses were 0.07 kg for both the 1500 and for the Mercedes Sprinter 311 CDi. The lightweighting technology used on the Horn Outside steel cover is to change from steel to plastic and use PolyOne® foaming agent in the plastic. Due to similarities in component design and material, full percentage of the Silverado 1500 horn outside steel cover mass reduction can be applied to the Sprinter. (Refer to Table 3-118Table 3-107).

DRAFT

Image 3.15–12: Horn Outside steel cover for the Silverado 1500 and 2500 (Left) and Mercedes Sprinter 311 CDi (Right)
(Source: FEV, Inc. and www.A2mac1.com)

<u>Horn Mounting bracket</u>

Shown in Image 3.15–13 are the Silverado 1500 and Mercedes Sprinter 311 CDi Horn Mounting brackets. Component masses were 0.04 kg for the Silverado 1500 versus 0.02 kg for the Mercedes Sprinter 311 CDi. The lightweighting technology used on the horn mounting bracket was to change from steel to plastic, and use PolyOne® foaming agent in the plastic. Due to similarities in component design and material, full percentage of the Silverado 1500 horn mounting bracket mass reduction can be applied to the Sprinter. (Refer to Table 3-118Table 3-107).

Image 3.15–13: Horn Mounting bracket for the Silverado 1500 and 2500 (Left) and Mercedes Sprinter 311 CDi (Right)
(Source: FEV, Inc. and www.A2mac1.com)

3.15.3 Renault Master 2.3 DCi

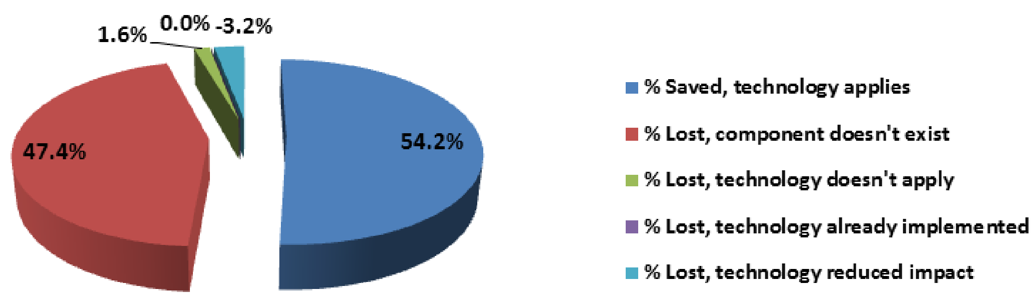
Table 3-119 summarizes the mass and cost impact of Silverado 1500 lightweighting technologies as applied to the Renault Master 2.3 DCi. Information, Gage and Warning Device System mass savings was 0.13 kg at a cost decrease of $0.66, or $4.91 per kg.

Table 3-119: Mass-Reduction and Cost Impact for Information, Gage and Warning Device System, Renault Master

DRAFT

System	Subsystem	Sub-Subsystem	Description	Mass Reduction New Tech "kg" (1)	Mass Reduction Comp "kg" (1)	Mass Reduction Total "kg" (1)	Cost Impact New Tech "$" (2)	Cost Impact Comp "$" (2)	Cost Impact Total "$" (2)	Cost/ Kilogram Total "$/kg"	Vehicle Mass Reduction Total "%"
				Net Value of Mass Reduction							
13	00	00	Information, Gage and Warning Divice System								
13	01	00	Instrument Cluster Subsystem	0.08	0.00	0.08	$0.67	$0.00	$0.67	$8.75	0.00%
13	02	00	Traffic Horns (Electric)	0.06	0.00	0.06	-$0.01	$0.00	-$0.01	-$0.15	0.00%
				0.13 (Decrease)	0.00	0.13 (Decrease)	$0.66 (Decrease)	$0.00	$0.66 (Decrease)	$4.91 (Decrease)	0.01%

Mass Savings, Select Vehicle, New Technology "kg"	0.13
Mass Savings, Silverado 1500, New Technology "kg"	0.25
Mass Savings Select Vehicle/Mass Savings 1500	54.2%



*SMS not included - has no significant impact on perecent contributions

3.15.3.1 System Scaling Analysis

The Renault Master 2.3 DCi Information, Gage and Warning Device System components were reviewed for compatibility with lightweighting technologies. The results of this analysis are listed in Table 3-120.

Table 3-120: System Scaling Analysis Information, Gage and Warning Device System, Renault Master

System	Subsystem	Sub-Subsystem	Component/Assembly	Base Mass	Mass Savings New Tech	% of Mass Savings New Tech	Tech Applies	Base Mass	Mass Savings New Tech	Notes
Silverado 1500							Select Vehicle			
13			Information, Gage and Warning Divice System	1.58	0.25	16%			0.13	
13	01	01	Cluster Mask Assy	0.19	0.018	10%	yes	0.44	0.04	Tech **DOES** apply: Use Polyone foaming agent
13	01	01	Cluster Rear Housing	0.20	0.020	10%	yes	0.34	0.03	Tech **DOES** apply: Use Polyone foaming agent
13	01	01	Display Housing	0.25	0.025	10%	no			Tech **DOES** apply: No part on vehicle
13	02	01	Outer plastic cover	0.04	0.004	9%	no			Tech does **NOT** apply: Outer cover is steel
13	02	01	Outside stl cover	0.07	0.058	78%	yes	0.05	0.04	Tech **DOES** apply: Change from steel to plastic and use Polyone foaming agent
13	02	01	Mounting brkt	0.04	0.030	79%	yes	0.02	0.02	Tech **DOES** apply: Change from steel to plastic and use Polyone foaming agent
13	02	01	Outer plastic cover	0.04	0.004	9%	no			Tech does **NOT** apply: Only one horn on vehicle
13	02	01	Outside stl cover	0.07	0.058	78%	no			Tech does **NOT** apply: Only one horn on vehicle
13	02	01	Mounting brkt	0.04	0.030	79%	no			Tech does **NOT** apply: Only one horn on vehicle

If the original Silverado 1500 mass reduction concept idea was not able to be applied to the comparison vehicle it is not described in the section below.

Components with significant mass savings identified on the Renault Master 2.3 DCi include the Cluster Mask Assembly, Cluster Rear Housing, and Horn Outside steel cover, Horn Mounting bracket. Image 3.15–14 shows the Renault Master 2.3 DCi Information, Gage and Warning Device System.

Image 3.15–14: Renault Master 2.3 DCi Information, Gage and Warning Device System

(Source: www.A2mac1.com)

DRAFT

Cluster Mask Assembly

Shown in Image 3.15–15 are the Silverado 1500 and Renault Master 2.3 DCi cluster mask assembly components. Component masses were 0.19 kg for the Silverado 1500 versus 0.44 kg for the Renault Master 2.3 DCi. The lightweighting technology used on the cluster mask assembly was PolyOne® foaming agent in the plastic. Due to similarities in component design and material, full percentage of the Silverado 1500 cluster mask assembly mass reduction can be applied to the Renault. (Refer to Table 3-120 Table 3-107).

Image 3.15–15: Cluster Mask Assembly for the Silverado 1500 and 2500 (Left) and Renault Master 2.3 DCi (Right)
(Source: FEV, Inc. and www.A2mac1.com)

Cluster Rear Housing

Shown in Image 3.15–16 are the Silverado 1500 and Renault Master 2.3 DCi cluster rear housing. Component masses were 0.20 kg for the 1500 versus 0.34 kg for the Renault Master 2.3 DCi. The cluster rear housing was made of plastic. The lightweighting technology used in the cluster rear housing was PolyOne® foaming agent in the plastic. Due to similarities in component design and material, full percentage of the Silverado 1500 cluster rear housing mass reduction can be applied to the Renault. (Refer to Table 3-120Table 3-107).

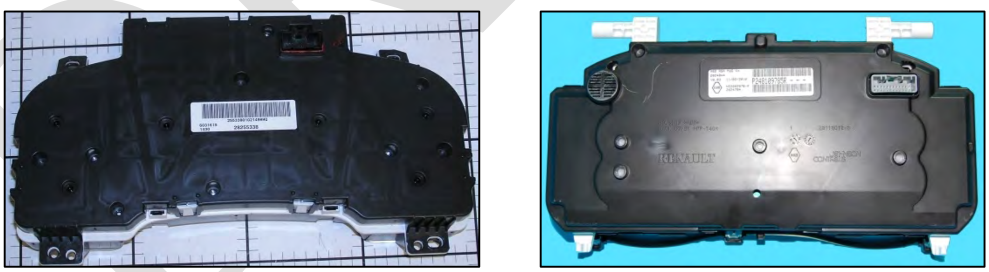


Image 3.15–16: Cluster Rear Housing for the Silverado 1500 and 2500 (Left) and Renault Master 2.3 DCi (Right)
(Source: FEV, Inc. and www.A2mac1.com)

Horn Outside steel cover

Shown in Image 3.15–17 are the Silverado 1500 and Renault Master 2.3 DCi horn outside steel cover. Component masses were 0.07 kg for the Silverado 1500 versus 0.05 kg for the Renault Master 2.3 DCi. The lightweighting technology used in the horn outside steel cover was to change from steel to plastic and use PolyOne® foaming agent in the plastic. Due to similarities in

DRAFT

component design and material, full percentage of the Silverado 1500 horn outside steel cover mass reduction can be applied to the Renault. (Refer to Table 3-120Table 3-107).

Image 3.15–17: Horn Outside steel cover for the Silverado 1500 and 2500 (Left) and Renault Master 2.3 DCi (Right)
(Source: FEV, Inc. and www.A2mac1.com)

<u>Horn mounting bracket</u>

Shown in Image 3.15–18 are the Silverado 1500 and Renault Master 2.3 DCi Horn Mounting brackets. Component masses are .04 kg for the 1500 versus .02 kg for the Renault Master 2.3 DCi respectively. The lightweighting technology used on the Horn Mounting bracket was to change from steel to plastic and use PolyOne foaming agent in the plastic. Due to similarities in component design and material, full percentage of the Silverado 1500 horn mounting bracket mass reduction can be applied to the Renault. (Refer to Table 3-120Table 3-107).

Image 3.15–18: Horn Mounting bracket for the Silverado 1500 and 2500 (Left) and Renault Master 2.3 DCi (Right)
(Source: FEV, Inc. and www.A2mac1.com)

3.16 ELECTRICAL POWER SUPPLY

3.16.1 Silverado 1500 Summary

The Chevrolet Silverado 1500 Electrical Power Supply System included the battery, battery tray, battery hold down, and auxiliary battery tray. The battery was a lead acid battery with a steel battery tray. The hold down was made of plastic and the auxiliary battery tray of steel.

The Chevrolet Silverado 1500 analysis identified mass reduction alternatives and cost implications for the Electrical Power Supply System with the intent to meet the function and performance requirements of the baseline vehicle. Table 3-121 provides a summary of mass reduction and cost impact for select sub-subsystems evaluated. The total mass savings found on the Electrical Power Supply System mass was reduced by 12.8 kg (60.6%). This increased cost by $172.73, or $13.49 per kg. Mass reduction for this system reduced vehicle curb weight by 0.54%.

Table 3-121: Electrical Power Supply System Mass Reduction Summary, Silverado 1500

DRAFT

System	Subsystem	Sub-Subsystem	Description	Net Value of Mass Reduction					
				Base Mass "kg"	Mass Reduction "kg" (1)	Cost Impact NIDMC "$" (2)	Average Cost/ Kilogram "$/kg" (2)	Mass Reduction "%"	Vehicle Mass Reduction "%"
14	**01**	**00**	**Service Battery Subsystem**	**21.12**	**12.81**	**-172.73**	**-13.49**	**60.64%**	**0.54%**
14	01	01	Battery Heat Shield & Battery Management	21.12	12.81	-172.73	-13.49	60.64%	0.54%
				21.12	12.81 (Decrease)	-172.73 (Increase)	-13.49 (Increase)	60.64%	0.54%

(1) "+" = mass decrease, "-" = mass increase
(2) "+" = cost decrease, "-" = cost increase

Columns in the "Net Value of Mass Reduction" chart above may contain combined masses of assembly hardware such as nuts, bolt, washer, etc. that were not mass reduced at the component level, and may not match base mass and mass reduction totals in text below component reduction weights.

Mass savings opportunities were identified for the following components: battery, battery tray, and auxiliary battery tray.

Battery: The battery mass was reduced by changing the lead acid battery to a lithium-ion battery. Mass was reduced by 66.7%, from 17.7 kg to 5.9 kg.

Battery tray: The battery tray mass was reduced by changing the tray from steel to plastic. Mass was reduced by 34.2%, from 1.9 kg to 1.2 kg.

Auxiliary battery tray: The battery tray mass was reduced by changing the tray from steel to plastic. Mass was reduced by 34.2%, from 0.98 kg to 0.65 kg.

DRAFT

3.16.1.1 Silverado 2500 Analysis

The Chevrolet Silverado 2500 Electrical Power Supply System was very similar to the 1500 system.

Image 3.16–1: Chevrolet Silverado electrical power supply system
(Source: www.A2mac1 database)

DRAFT

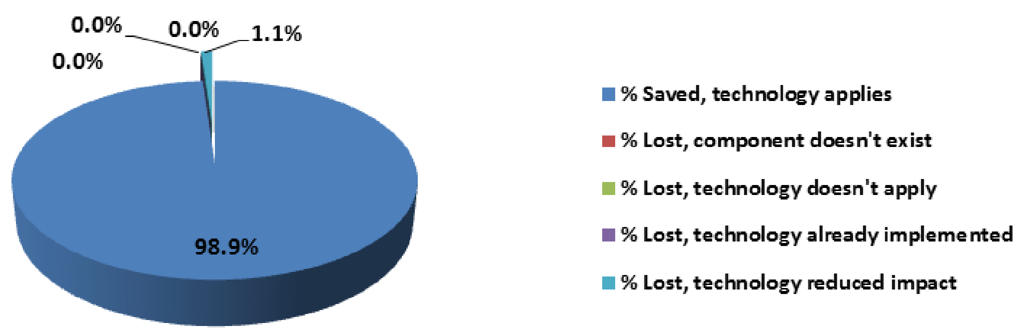
3.16.1.2 2500 System Scaling Summary

The following table summarizes mass and cost impact of the Silverado 1500 lightweighting technologies as applied to the Silverado 2500. Total Electrical Power Supply System mass savings was 12.67 kg at a cost increase of $170.81, or $13.48 per kg.

Table 3-122: Mass-Reduction and Cost Impact for Electrical Power Supply System, Silverado 2500

				Net Value of Mass Reduction							
System	Subsystem	Sub-Subsystem	Description	Mass Reduction New Tech "kg" (1)	Mass Reduction Comp "kg" (1)	Mass Reduction Total "kg" (1)	Cost Impact New Tech "$" (2)	Cost Impact Comp "$" (2)	Cost Impact Total "$" (2)	Cost/ Kilogram Total "$/kg"	Vehicle Mass Reduction Total "%"
14	00	00	Electrical Power Supply System								
14	01	00	Service Battery Subsystem	12.67	0.00	12.67	-$170.81	$0.00	-170.81	-13.48	0.41%
				12.67 (Decrease)	0.00	12.67 (Decrease)	-$170.81 (Increase)	$0.00	-170.81 (Increase)	-13.48 (Increase)	0.41%

Mass Savings, Select Vehicle, New Technology "kg"	12.672
Mass Savings, Silverado 1500, New Technology "kg"	12.807
Mass Savings Select Vehicle/Mass Savings 1500	98.9%



*SMS not included - has no significant impact on perecent contributions

3.16.1.3 System Scaling Analysis

The Silverado 2500 Electrical Power Supply components were reviewed for compatibility with lightweighting technologies. The results of this analysis are listed in Table 3-123.

Table 3-123: Electrical Power Supply System Scaling Analysis for the Silverado 1500 and 2500

Silverado 1500							Select Vehicle			
System	Subsystem	Sub-Subsystem	Component/Assembly	Base Mass	Mass Savings New Tech	% of Mass Savings New Tech	Tech Applies	Base Mass	Mass Savings New Tech	Notes
14			Electrical Power Supply System	21.12	12.81	61%			12.67	
14	01	01	Battery	17.71	11.81	67%	yes	17.51	11.67	Tech DOES Apply: Change to Lithium-Ion Battery
14	01	01	Battery Tray	1.95	0.67	34%	yes	1.94	0.66	Tech DOES Apply: Change from steel to plastic
14	01	01	Aux Battery Tray	0.98	0.34	34%	yes	0.98	0.34	Tech DOES Apply: Change from steel to plastic

Components with significant mass savings identified on the Silverado 2500 included the battery, battery tray, and auxiliary battery tray.

<u>Battery</u>

Shown in Image 3.16–2 are the Silverado 1500 and 2500 batteries. Component masses were 17.7 kg for the 1500 versus 17.5 kg for the 2500. The lightweighting technology used on the batteries was to change from a lead acid battery to a lithium-ion battery. Due to similarities in component design and material, full percentage of the Silverado 1500 battery mass reduction can be applied to the 2500. (Refer to Table 3-123Table 3-107).

Image 3.16–2: Battery for the Silverado 1500 (Left) and Silverado 2500 (Right)
(Source: FEV, Inc.)

<u>Battery Tray</u>

Shown in Image 3.16–3 are the Silverado 1500 and 2500 series battery trays. Component masses were 1.95 kg for the 1500 versus 1.94 kg for the 2500. The lightweighting technology used on the battery tray was to change from a steel tray to plastic. Image 3.16–4 shows the Ford F150 plastic battery tray for example. Due to similarities in component design and material, full percentage of the Silverado 1500 battery tray mass reduction can be applied to the 2500. (Refer to Table 3-123Table 3-107).

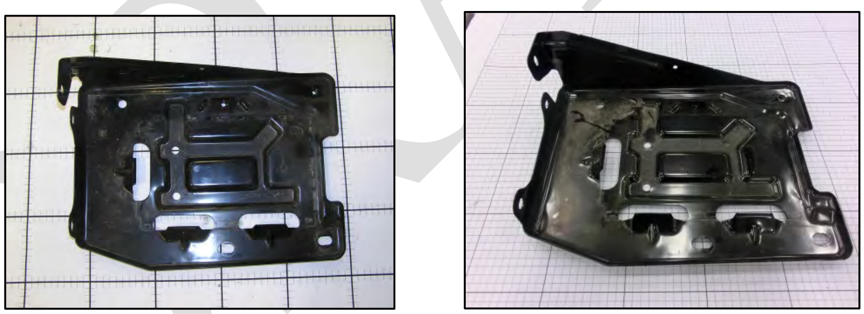


Image 3.16–3: Battery Tray for the Silverado 1500 (Left) and Silverado 2500 (Right)
(Source: FEV, Inc.)

Image 3.16–4: 2012 Ford F150 Battery Tray Assembly
(Source: www.A2mac1 database)

DRAFT

Auxiliary battery tray

Shown in Image 3.16–5 are the Silverado 1500 and 2500 series auxiliary battery trays. Component masses were 0.98 kg for both the 1500 and 2500. The lightweighting technology used on the auxiliary battery tray was to change from a steel tray to plastic. Due to similarities in component design and material, full percentage of the Silverado 1500 auxiliary battery mass reduction can be applied to the 2500. (Refer to Table 3-123Table 3-107).

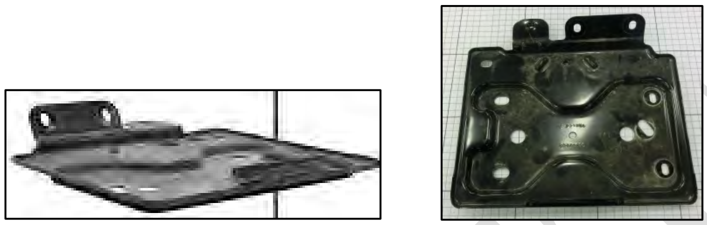


Image 3.16–5: Auxiliary battery tray for the Silverado 1500 (Left) and Silverado 2500 (Right)
(Source: FEV, Inc.)

3.16.1.4 System Comparison, Silverado 2500

Table 3-124 summarizes the Silverado 1500 and 2500 lightweighting results. A majority of the components were visually the same between the electrical power supplies.

Table 3-124: Electrical Power Supply System Comparison, Silverado 1500 and 2500

System	Description	Net Value of Mass Reduction								
		Mass Base "kg" (1)	Mass Reduction New Tech "kg" (1)	Mass Reduction Comp "kg" (1)	Mass Reduction Total "kg" (1)	System Mass Reduction "%"	Cost Impact New Tech "$" (2)	Cost Impact Comp "$" (2)	Cost Impact Total "$" (2)	Cost/ Kilogram Total "$/kg"
14	**Electrical Power Supply**									
14	Silverado 1500	21.12	12.81	0.00	12.81	60.64%	-$172.73	$0.00	-$172.73	-$13.49
14	Silverado 2500	20.95	12.67	0.00	12.67	60.49%	-$170.81	$0.00	-$170.81	-$13.48

3.16.2 Mercedes Sprinter 311 CDi

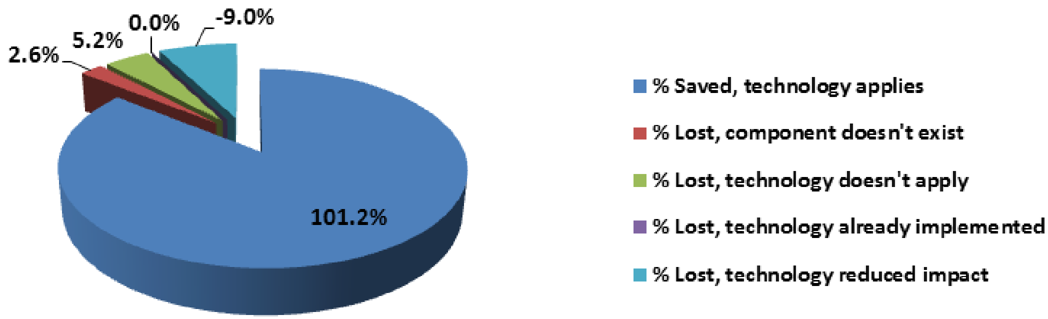
The following table summarizes the mass and cost impact of the Silverado 1500 lightweighting technologies as applied to the Mercedes Sprinter 311 CDi. Total Electrical Power Supply System mass savings was 12.96 kg at a cost increase of $184.33, or $14.22 per kg.

Table 3-125: Mass-Reduction and Cost Impact for Electrical Power Supply System, Mercedes sprinter

DRAFT

System	Subsystem	Sub-Subsystem	Description	Net Value of Mass Reduction: Mass Reduction New Tech "kg" (1)	Mass Reduction Comp "kg" (1)	Mass Reduction Total "kg" (1)	Cost Impact New Tech "$" (2)	Cost Impact Comp "$" (2)	Cost Impact Total "$" (2)	Cost/ Kilogram Total "$/kg"	Vehicle Mass Reduction Total "%"
14	00	00	Electrical Power Supply System								
14	01	00	Service Battery Subsystem	12.96	0.00	12.96	-$184.33	$0.00	-184.33	-14.22	0.61%
				12.96 (Decrease)	0.00	12.96 (Decrease)	-$184.33 (Increase)	$0.00	-184.33 (Increase)	-14.22 (Increase)	0.61%

Mass Savings, Select Vehicle, New Technology "kg"	12.960
Mass Savings, Silverado 1500, New Technology "kg"	12.807
Mass Savings Select Vehicle/Mass Savings 1500	101.2%



*SMS not included - has no significant impact on perecent contributions

3.16.2.1 System Scaling Analysis

The Mercedes Sprinter 311 CDi Electrical Power Supply components were reviewed for compatibility with lightweighting technologies. The results of this analysis are listed in Table 3-126.

Table 3-126: System Scaling Analysis Electrical Power Supply System, Mercedes Sprinter

System	Subsystem	Sub-Subsystem	Component/Assembly	Silverado 1500: Base Mass	Mass Savings New Tech	% of Mass Savings New Tech	Select Vehicle: Tech Applies	Base Mass	Mass Savings New Tech	Notes
14			**Electrical Power Supply System**	**21.12**	**12.81**	**61%**			**12.96**	
14	01	01	Battery	17.71	11.81	67%	yes	19.44	12.96	Tech **DOES** Apply: Change to Lithium-Ion Battery
14	01	01	Battery Tray	1.95	0.67	34%	no			Tech does **NOT** apply: Battery tray already plastic
14	01	01	Aux Battery Tray	0.98	0.34	34%	no			Tech does **NOT** apply: With no aux battery tray, no need to change to plastic

If the original Silverado 1500 mass reduction concept idea was not able to be applied to the comparison vehicle it is not described in the section below.

Components with significant mass savings identified on the Mercedes Sprinter included the battery. Image 3.16–6 shows the Mercedes Sprinter 311 CDi Electrical Power Supply components.

Image 3.16–6: Mercedes Sprinter 311 CDi Battery
(Source: www.A2mac1.com)

<u>Battery</u>

Shown in Image 3.16–7 are the Silverado 1500 and Mercedes Sprinter 311 CDi batteries. Component masses were 17.7 kg for the Silverado 1500 versus 19.4 kg for the Mercedes Sprinter 311 CDi. The lightweighting technology used on the batteries was to change from a lead acid battery to a lithium-ion battery. Due to similarities in component design and material, full percentage of the Silverado 1500 battery mass reduction can be applied to the Sprinter. (Refer to Table 3-126Table 3-107).

Image 3.16–7: Battery for the Silverado 1500 (Left) and Mercedes Sprinter 311 CDi (Right)
(Source: FEV, Inc. and www.A2mac1.com)

3.16.3 Renault Master 2.3 DCi

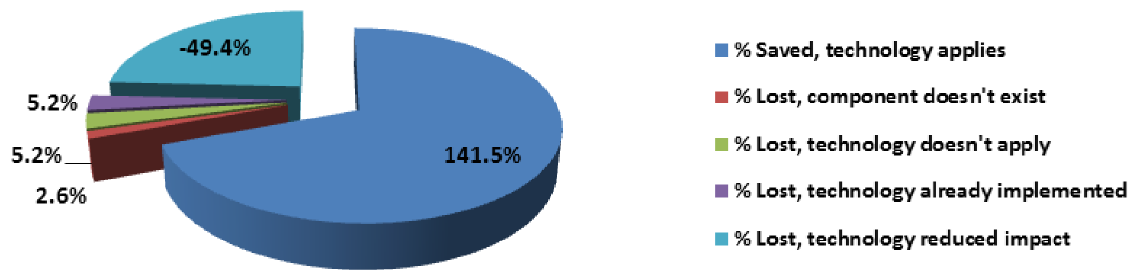
Table 3-127 summarizes mass and cost impact of the Silverado 1500 lightweighting technologies as applied to the Renault Master 2.3 DCi. Total electrical power supply system mass savings was 18.13 kg at a cost increase of $257.84, or $14.22 per kg.

DRAFT

Table 3-127: Mass-Reduction and Cost Impact for Electrical Power Supply System, Renault Master

				Net Value of Mass Reduction							
System	Subsystem	Sub-Subsystem	Description	Mass Reduction New Tech "kg" (1)	Mass Reduction Comp "kg" (1)	Mass Reduction Total "kg" (1)	Cost Impact New Tech "$" (2)	Cost Impact Comp "$" (2)	Cost Impact Total "$" (2)	Cost/ Kilogram Total "$/kg"	Vehicle Mass Reduction Total "%"
14	00	00	Electrical Power Supply System								
14	01	00	Service Battery Subsystem	18.13	0.00	18.13	-$257.84	$0.00	-257.842	-$14.22	0.77%
				18.13 (Decrease)	0.00	18.13 (Decrease)	-$257.84 (Increase)	$0.00	-$257.84 (Increase)	-$14.22 (Increase)	0.77%

Mass Savings, Select Vehicle, New Technology "kg"	18.128
Mass Savings, Silverado 1500, New Technology "kg"	12.807
Mass Savings Select Vehicle/Mass Savings 1500	141.5%



*SMS not included - has no significant impact on perecent contributions

3.16.3.1 System Scaling Analysis

The Renault Master 2.3 DCi electrical power supply components were reviewed for compatibility with lightweighting technologies. The results of this analysis are listed in Table 3-127.

DRAFT

Table 3-128: System Scaling Analysis for Electrical Power Supply System, Renault Master

Silverado 1500							Select Vehicle			
System	Subsystem	Sub-Subsystem	Component/Assembly	Base Mass	Mass Savings New Tech	% of Mass Savings New Tech	Tech Applies	Base Mass	Mass Savings New Tech	Notes
14			**Electrical Power Supply System**	**21.12**	**12.81**	**61%**			**18.13**	
14	01	01	Battery	17.71	11.81	67%	yes	27.19	18.13	Tech **DOES** Apply: Change to Lithium-Ion Battery
14	01	01	Battery Tray	1.95	0.67	34%	no			Tech does **NOT** apply: battery tray already plastic
14	01	01	Aux Battery Tray	0.98	0.34	34%	no			Tech does **NOT** apply: With no aux battery tray, no need to change to plastic

If the original Silverado 1500 mass reduction concept idea was not able to be applied to the comparison vehicle it is not described in the section below.

Components with significant mass savings identified on the Renault Master 2.3 DCi included the battery and battery tray. Image 3.16–8 shows the Renault Master 2.3 DCi electrical power supply components.

Image 3.16–8: Renault Master 2.3 DCi Battery
(Source: www.A2mac1.com)

Battery

Shown in Image 3.16–9 are the Silverado 1500 and Renault Master 2.3 DCi batteries, respectively. Component masses were 17.7 kg for the Silverado 1500 versus 27.2 kg for the Renault Master 2.3 DCi. The lightweighting technology used in the batteries was to change from a lead acid battery to a lithium-ion battery. Due to similarities in component design and material, full percentage of the Silverado 1500 battery mass reduction can be applied to the Renault. (Refer to

DRAFT

Table 3-128Table 3-107).

Image 3.16–9: Battery for the Silverado 1500 (Left) and Renault Master 2.3 DCi (Right)
(Source: FEV, Inc. and www.A2mac1.com)

3.17 LIGHTING

3.17.1 Silverado 1500 Summary

The Chevrolet Silverado 1500 Lighting system included all interior and exterior lighting. Only the front headlamps were used as a mass savings in the Silverado 1500.

The Chevrolet Silverado 1500 analysis identified mass reduction alternatives and cost implications for the Lighting System with the intent to meet the function and performance requirements of the baseline vehicle.

DRAFT

Table 3-129 provides a summary of mass reduction and cost impact for select sub-subsystems evaluated. The total mass savings found on the Lighting System mass was reduced by 0.39 kg (4.04%). This increased cost by $2.00, or $5.18 per kg. Mass reduction for this system reduced vehicle curb weight by .02%.

Table 3-129: Lighting System Mass Reduction Summary, Silverado 1500

System	Subsystem	Sub-Subsystem	Description	Net Value of Mass Reduction: Base Mass "kg"	Mass Reduction "kg" (1)	Cost Impact NIDMC "$" (2)	Average Cost/ Kilogram "$/kg" (2)	Mass Reduction "%"	Vehicle Mass Reduction "%"
17	**01**	**00**	**Front Lighting Subsystem**	**6.70**	**0.39**	**-2.00**	**-5.18**	**5.76%**	**0.02%**
17	01	01	Headlamp Cluster	6.18	0.39	-2.00	-5.18	6.25%	0.02%
17	01	04	Supplemental Front Lamps	0.52	0.00	0.00	0.00	0.00%	0.00%
17	**02**	**00**	**Interior Lighting Subsystem**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00%**	**0.00%**
17	02	02	Interior Lighting	0.00	0.00	0.00	0.00	0.00%	0.00%
17	02	07	Lighting - Instrument Panel (IP) & Consoles	0.00	0.00	0.00	0.00	0.00%	0.00%
17	02	08	Lighting - Ambient Inst. Panel (IP) & Consoles	0.00	0.00	0.00	0.00	0.00%	0.00%
17	**03**	**00**	**Rear Lighting Subsystem**	**2.74**	**0.00**	**0.00**	**0.00**	**0.00%**	**0.00%**
17	03	01	Rear Combination Lamp	2.39	0.00	0.00	0.00	0.00%	0.00%
17	03	04	Supplemental Rear Lamps	0.00	0.00	0.00	0.00	0.00%	0.00%
17	03	08	License Plate Lamp	0.03	0.00	0.00	0.00	0.00%	0.00%
17	03	09	CHMSL (Center High Mount Stop Light)	0.31	0.00	0.00	0.00	0.00%	0.00%
17	**04**	**00**	**Lighting - Special Mechanisms Subsystem**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00%**	**0.00%**
17	04	07	Rain Sensor/Daylight Sensor	0.00	0.00	0.00	0.00	0.00%	0.00%
17	04	08	Headlamp Control Module	0.00	0.00	0.00	0.00	0.00%	0.00%
17	**05**	**00**	**Lighting Switches Subsystem**	**0.13**	**0.00**	**0.00**	**0.00**	**0.00%**	**0.00%**
17	05	01	Master Lighting Switchpack	0.13	0.00	0.00	0.00	0.00%	0.00%
				9.56	0.39 (Decrease)	-2.00 (Increase)	-5.18 (Increase)	4.04%	0.02%

(1) "+" = mass decrease, "-" = mass increase
(2) "+" = cost decrease, "-" = cost increase

Columns in the "Net Value of Mass Reduction" chart above may contain combined masses of assembly hardware such as nuts, bolt, washer, etc. that were not mass reduced at the component level, and may not match base mass and mass reduction totals in text below component reduction weights.

Mass savings opportunities were identified for the following components: headlamp housings, headlamp inner reflectors.

Headlamp housings: The headlamp housings mass was reduced by using the MuCell® microcellular gas injection molding technology. Mass was reduced by 2%, from 0.73 kg to 0.71 kg per headlamp.

Headlamp housing inner reflector: The headlamp housings inner reflectors mass was reduced by replacing the reflector coating from UP-(MD60+GF20) to SABIC ULTEM™. Mass was reduced by 40%, from 0.44 kg to 0.26 kg per headlamp reflector.

3.17.1.1 Silverado 2500 Analysis

The Chevrolet Silverado 2500 Lighting system was very similar to the 1500 system.

DRAFT

Image 3.17–1: Headlamps for the Silverado 1500 (Left) and Silverado 2500 (Right)
(Source: FEV, Inc.)

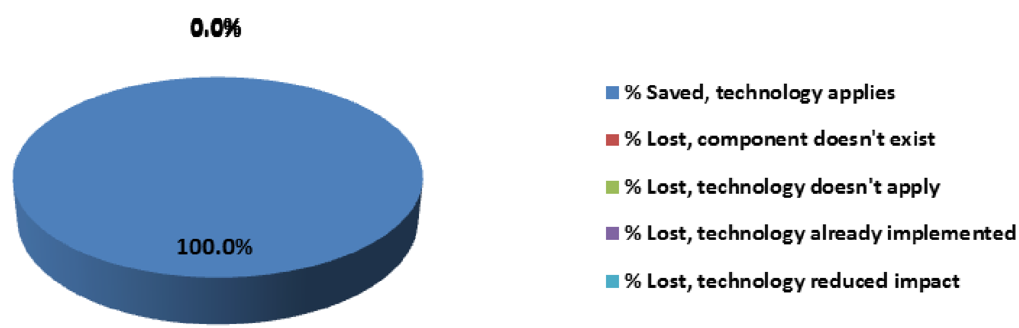
3.17.1.2 2500 System Scaling Summary

Table 3-130 summarizes mass and cost impact of Silverado 1500 lightweighting technologies applied to the Silverado 2500. Total lighting system mass savings is .39 kg at a cost increase of $2.02, or $5.23 per kg.

Table 3-130: Mass-Reduction and Cost Impact for Lighting System, Silverado 2500

				Net Value of Mass Reduction							
System	Subsystem	Sub-Subsystem	Description	Mass Reduction New Tech "kg" (1)	Mass Reduction Comp "kg" (1)	Mass Reduction Total "kg" (1)	Cost Impact New Tech "$" (2)	Cost Impact Comp "$" (2)	Cost Impact Total "$" (2)	Cost/ Kilogram Total "$/kg"	Vehicle Mass Reduction Total "%"
17	00	00	**Lighting System**								
17	01	00	Front Lighting Subsystem	0.39	0.00	0.39	-$2.02	$0.00	-$2.02	-$5.23	0.01%
17	02	00	Interior Lighting Subsystem	0.00	0.00	0.00	$0.00	$0.00	$0.00	$0.00	0.00%
17	03	00	Rear Lighting Subsystem	0.00	0.00	0.00	$0.00	$0.00	$0.00	$0.00	0.00%
17	04	00	Lighting - Special Mechanisms Subsystem	0.00	0.00	0.00	$0.00	$0.00	$0.00	$0.00	0.00%
17	05	00	Lighting Switches Subsystem	0.00	0.00	0.00	$0.00	$0.00	$0.00	$0.00	0.00%
				0.39 (Decrease)	**0.00**	**0.39** (Decrease)	**-$2.02** (Increase)	**$0.00**	**-$2.02** (Increase)	**-$5.23** (Increase)	**0.01%**

Mass Savings, Select Vehicle, New Technology "kg"	0.386
Mass Savings, Silverado 1500, New Technology "kg"	0.386
Mass Savings Select Vehicle/Mass Savings 1500	100.0%



3.17.1.3 System Scaling Analysis

The Silverado 2500 Lighting components were reviewed for compatibility with lightweighting technologies. The results of this analysis are listed in Table 3-131.

Table 3-131: System Scaling Analysis Lighting System, Silverado 2500

Silverado 1500							Select Vehicle			
System	Subsystem	Sub-Subsystem	Component/Assembly	Base Mass	Mass Savings New Tech	% of Mass Savings New Tech	Tech Applies	Base Mass	Mass Savings New Tech	Notes
17			**Lighting System**	**9.56**	**0.39**	**4%**			**0.39**	
17	01	01	LH Head lamp housing	0.73	0.02	2%	yes	0.73	0.02	Tech **DOES** Apply: MuCell® applied to Housings
17	01	01	LH Head lamp housing inner reflector	0.45	0.18	40%	yes	0.45	0.18	Tech **DOES** Apply: Change Inner Reflectors Replace UP-(MD60+GF20) with SABIC ULTEM
17	01	01	RH Head lamp housing	0.73	0.02	2%	yes	0.73	0.02	Tech **DOES** Apply: MuCell® applied to Housings
17	01	01	RH Head lamp housing inner reflector	0.45	0.18	40%	yes	0.45	0.18	Tech **DOES** Apply: Change Inner Reflectors Replace UP-(MD60+GF20) with SABIC ULTEM

Components with significant mass savings identified on the Silverado 2500 included the headlamp housings and headlamp inner reflectors.

Headlamp Housing

Shown in Image 3.17–2 are the Silverado 1500 and 2500 series headlamps. Component masses were 0.73 kg for both the 1500 and 2500. The lightweighting technology used on the headlamp housings was MuCell® microcellular gas injection molding technology. Due to similarities in component design and material, full percentage of the Silverado 1500 headlamp housing mass reduction can be applied to the 2500. (Refer to Table 3-131Table 3-107).

Image 3.17–2: Headlamp Housing for the Silverado 1500 (Left) and Silverado 2500 (Right)
(Source: FEV, Inc.)

Headlamp Inner Reflector

Shown in Image 3.17–3 are the Silverado 1500 and 2500 series headlamp inner reflectors. Component masses were 0.45 kg for both the 1500 and for the 2500. The lightweighting technology used on the headlamp inner reflectors was to change from UP-(MD60+GF20) to SABIC ULTEM™. Due to similarities in component design and material, full percentage of the Silverado 1500 headlamp inner reflector mass reduction can be applied to the 2500. (Refer to Table 3-131Table 3-107).

DRAFT

Image 3.17–3: Headlamp inner reflector for the Silverado 1500 (Left) and Silverado 2500 (Right)
(Source: FEV, Inc.)

3.17.1.4 System Comparison, Silverado 2500

Table 3-132 summarizes the Silverado 1500 and 2500 lightweighting results. A majority of the components were visually the same between the two lighting systems.

Table 3-132: Lighting System Comparison, Silverado 1500 and 2500

System	Description	Net Value of Mass Reduction: Mass Base "kg" (1)	Mass Reduction New Tech "kg" (1)	Mass Reduction Comp "kg" (1)	Mass Reduction Total "kg" (1)	System Mass Reduction "%"	Cost Impact New Tech "$" (2)	Cost Impact Comp "$" (2)	Cost Impact Total "$" (2)	Cost/ Kilogram Total "$/kg"
17	**Lighting System**									
17	Silverado 1500	9.56	0.39	0.00	0.39	4.04%	-$2.02	$0.00	-$2.02	-$5.23
17	Silverado 2500	7.86	0.39	0.00	0.39	4.91%	-$2.02	$0.00	-$2.02	-$5.23

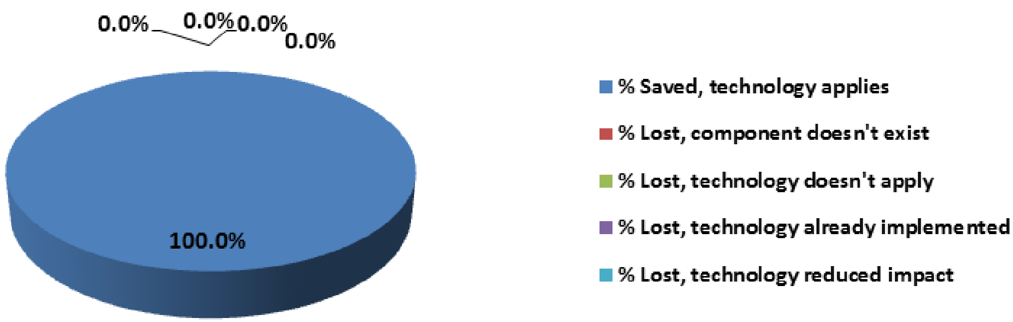
3.17.2 Mercedes Sprinter 311 CDi

The following table summarizes mass and cost impact of the Silverado 1500 lightweighting technologies as applied to the Mercedes Sprinter 311 CDi. The total Lighting System mass savings was 0.39 kg at a cost increase of $2.02, or $5.23 per kg.

Table 3-133: Mass-Reduction and Cost Impact for Lighting System, Mercedes Sprinter

				Net Value of Mass Reduction							
System	Subsystem	Sub-Subsystem	Description	Mass Reduction New Tech "kg" (1)	Mass Reduction Comp "kg" (1)	Mass Reduction Total "kg" (1)	Cost Impact New Tech "$" (2)	Cost Impact Comp "$" (2)	Cost Impact Total "$" (2)	Cost/ Kilogram Total "$/kg"	Vehicle Mass Reduction Total "%"
17	00	00	Lighting System								
17	01	00	Front Lighting Subsystem	0.39	0.00	0.39	-$2.02	$0.00	-$2.02	-$5.23	0.02%
17	02	00	Interior Lighting Subsystem	0.00	0.00	0.00	$0.00	$0.00	$0.00	$0.00	0.00%
17	03	00	Rear Lighting Subsystem	0.00	0.00	0.00	$0.00	$0.00	$0.00	$0.00	0.00%
17	04	00	Lighting - Special Mechanisms Subsystem	0.00	0.00	0.00	$0.00	$0.00	$0.00	$0.00	0.00%
17	05	00	Lighting Switches Subsystem	0.00	0.00	0.00	$0.00	$0.00	$0.00	$0.00	0.00%
				0.39 (Decrease)	0.00	0.39 (Decrease)	-$2.02 (Increase)	$0.00	-$2.02 (Increase)	-$5.23 (Increase)	0.02%

Mass Savings, Select Vehicle, New Technology "kg"	0.386
Mass Savings, Silverado 1500, New Technology "kg"	0.386
Mass Savings Select Vehicle/Mass Savings 1500	100.0%



*SMS not included - has no significant impact on perecent contributions

3.17.2.1 System Scaling Analysis

The Mercedes Sprinter 311 CDi Lighting components were reviewed for compatibility with lightweighting technologies. The results of this analysis are listed in Table 3-134.

Table 3-134: System Scaling Analysis Lighting System, Mercedes Sprinter

Silverado 1500							Select Vehicle			
System	Subsystem	Sub-Subsystem	Component/Assembly	Base Mass	Mass Savings New Tech	% of Mass Savings New Tech	Tech Applies	Base Mass	Mass Savings New Tech	Notes
17			Lighting System	9.56	0.39	4%			0.39	
17	01	01	LH Head lamp housing	0.73	0.02	2%	yes	0.73	0.02	Tech **DOES** Apply: MuCell® applied to Housings
17	01	01	LH Head lamp housing inner reflector	0.45	0.18	40%	yes	0.44	0.18	Tech **DOES** Apply: Change Inner Reflectors Replace UP-(MD60+GF20) with SABIC ULTEM
17	01	01	RH Head lamp housing	0.73	0.02	2%	yes	0.73	0.02	Tech **DOES** Apply: MuCell® applied to Housings
17	01	01	RH Head lamp housing inner reflector	0.45	0.18	40%	yes	0.44	0.18	Tech **DOES** Apply: Change Inner Reflectors Replace UP-(MD60+GF20) with SABIC ULTEM

Components with significant mass savings identified on the Mercedes Sprinter included the headlamp housing and the headlamp inner reflector. Image 3.17–4 shows the Mercedes Sprinter 311 CDi lighting components.

Image 3.17–4: Mercedes Sprinter 311 CDi Headlamp
(Source: www.A2mac1.com)

Headlamp Housing

Shown in Image 3.17–5 are the Silverado 1500 and Mercedes Sprinter 311 CDi headlamps. Component masses were .73 kg for both the 1500 and the Mercedes Sprinter 311 CDi. The lightweighting technology used on the headlamp housings is to use MuCell® microcellular gas injection molding technology. Due to similarities in component design and material, full percentage of the Silverado 1500 headlamp housing mass reduction can be applied to the Sprinter. (Refer to Table 3-134Table 3-107).

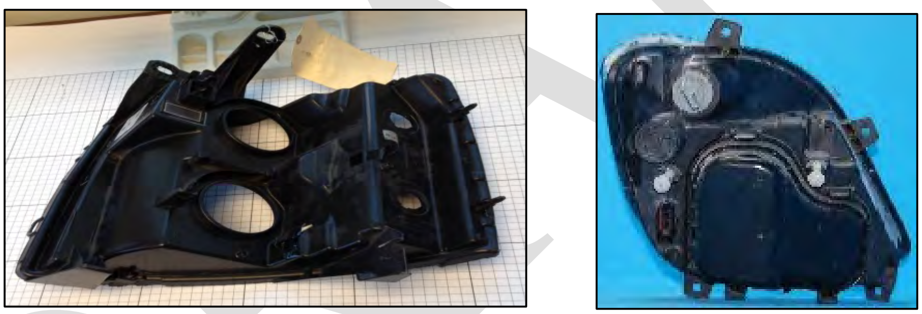


Image 3.17–5: Headlamp housing for the Silverado 1500 (Left) and Mercedes Sprinter 311 CDi (Right)
(Source: FEV, Inc. and www.A2mac1.com)

Headlamp Inner Reflector

Shown in Image 3.17–6 are the Silverado 1500 and Mercedes Sprinter 311 CDi headlamp inner reflectors. Component masses were 0.45 kg for both the Silverado 1500 and the Mercedes Sprinter 311 CDi. The lightweighting technology used on the headlamp inner reflectors was to change from UP-(MD60+GF20) to SABIC ULTEM™. Due to similarities in component design and material, full percentage of the Silverado 1500 headlamp inner reflector mass reduction can be applied to the Sprinter. (Refer to Table 3-134Table 3-107).

DRAFT

Image 3.17–6: Headlamp inner reflector for the Silverado 1500 (Left) and Mercedes Sprinter 311 CDi (Right)
(Source: FEV, Inc. www.and A2mac1.com)

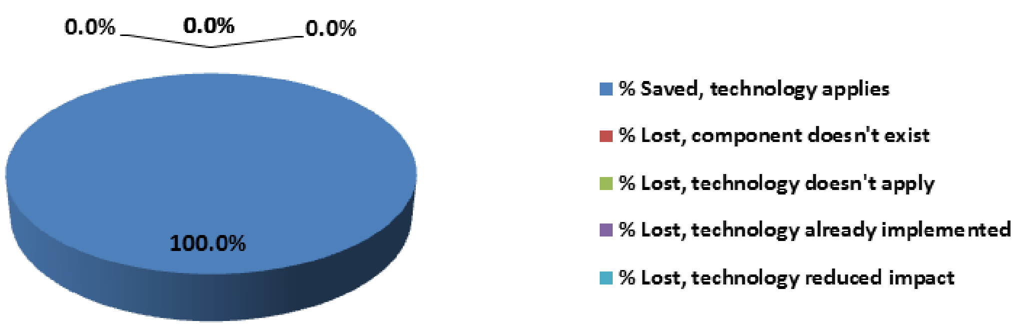
3.17.3 Renault Master 2.3 DCi

Table 3-135 summarizes the mass and cost impact of Silverado 1500 lightweighting technologies applied to the Renault Master 2.3 DCi. Total lighting system mass savings is .39 kg at a cost increase of $2.02, or $5.23 per kg.

Table 3-135: Mass-Reduction and Cost Impact for Lighting System, Renault Master

				Net Value of Mass Reduction							
System	Subsystem	Sub-Subsystem	Description	Mass Reduction New Tech "kg" (1)	Mass Reduction Comp "kg" (1)	Mass Reduction Total "kg" (1)	Cost Impact New Tech "$" (2)	Cost Impact Comp "$" (2)	Cost Impact Total "$" (2)	Cost/ Kilogram Total "$/kg"	Vehicle Mass Reduction Total "%"
17	00	00	Lighting System								
17	01	00	Front Lighting Subsystem	0.39	0.00	0.39	-$2.02	$0.00	-$2.02	-$5.23	0.02%
17	02	00	Interior Lighting Subsystem	0.00	0.00	0.00	$0.00	$0.00	$0.00	$0.00	0.00%
17	03	00	Rear Lighting Subsystem	0.00	0.00	0.00	$0.00	$0.00	$0.00	$0.00	0.00%
17	04	00	Lighting - Special Mechanisms Subsystem	0.00	0.00	0.00	$0.00	$0.00	$0.00	$0.00	0.00%
17	05	00	Lighting Switches Subsystem	0.00	0.00	0.00	$0.00	$0.00	$0.00	$0.00	0.00%
				0.39 (Decrease)	0.00	0.39 (Decrease)	-$2.02 (Increase)	$0.00	-$2.02 (Increase)	-$5.23 (Increase)	0.02%

Mass Savings, Select Vehicle, New Technology "kg"	0.386
Mass Savings, Silverado 1500, New Technology "kg"	0.386
Mass Savings Select Vehicle/Mass Savings 1500	100.0%



*SMS not included - has no significant impact on perecent contributions

3.17.3.1 System Scaling Analysis

The Renault Master 2.3 DCi lighting components were reviewed for compatibility with lightweighting technologies. The results of this analysis are listed in Table 3-136.

Table 3-136: System Scaling Analysis Lighting System, Renault Master

Silverado 1500							Select Vehicle			
System	Subsystem	Sub-Subsystem	Component/Assembly	Base Mass	Mass Savings New Tech	% of Mass Savings New Tech	Tech Applies	Base Mass	Mass Savings New Tech	Notes
17			**Lighting System**	**9.56**	**0.39**	**4%**			**0.39**	
17	01	01	LH Head lamp housing	0.73	0.02	2%	yes	0.73	0.02	Tech **DOES** Apply: MuCell® applied to Housings
17	01	01	LH Head lamp housing inner reflector	0.45	0.18	40%	yes	0.44	0.18	Tech **DOES** Apply: Change Inner Reflectors Replace UP-(MD60+GF20) with SABIC ULTEM
17	01	01	RH Head lamp housing	0.73	0.02	2%	yes	0.73	0.02	Tech **DOES** Apply: MuCell® applied to Housings
17	01	01	RH Head lamp housing inner reflector	0.45	0.18	40%	yes	0.44	0.18	Tech **DOES** Apply: Change Inner Reflectors Replace UP-(MD60+GF20) with SABIC ULTEM

Components with significant mass savings identified on the Renault Master 2.3 DCi included the headlamp housing and headlamp inner reflector. Image 3.17–7 shows the Renault Master 2.3 DCi lighting components.

Image 3.17–7: Renault Master 2.3 DCi Headlamp
(Source: www.A2mac1.com)

<u>Headlamp Housing</u>

Shown in Image 3.17–8 are the Silverado 1500 and Renault Master 2.3 DCi headlamps. Component masses were 0.73 kg for both the Silverado 1500 and the Renault Master 2.3 DCi. The lightweighting technology used on the headlamp housings was MuCell® microcellular gas injection molding technology. Due to similarities in component design and material, full percentage of the Silverado 1500 headlamp housing mass reduction can be applied to the Renault. (Refer to Table 3-136Table 3-107).

Image 3.17–8: Headlamp housing for the Silverado 1500 (Left) and Renault Master 2.3 DCi (Right)

DRAFT

(Source: FEV, Inc. and www.A2mac1.com)

Headlamp Inner Reflector

Shown in Image 3.17–9 are the Silverado 1500 and Renault Master 2.3 DCi headlamp inner reflectors. Component masses were 0.45 kg for both the Silverado 1500 and the Renault Master 2.3 DCi. The lightweighting technology used on the headlamp inner reflectors was to change from UP-(MD60+GF20) to SABIC ULTEM™. Due to similarities in component design and material, full percentage of the Silverado 1500 headlamp inner reflector mass reduction can be applied to the Renault. (Refer to Table 3-136Table 3-107).


Image 3.17–9: Headlamp inner reflector for the Silverado 1500 (Left) and Renault Master 2.3 DCi (Right)
(Source: FEV, Inc. and www.A2mac1.com)

3.18 ELECTRICAL DISTRIBUTION AND ELECTRICAL CONTROLS SYSTEM

3.18.1 Silverado 1500 Summary

The Chevrolet Silverado 1500 Electrical Distribution and Electrical Controls System included overall vehicle wiring, which includes standard copper wire with Polyvinyl Chloride (PVC) sheathing and miscellaneous brackets.

The Chevrolet Silverado 1500 analysis identified mass reduction alternatives and cost implications for the Electrical Distribution and Electrical Controls System with the intent to meet the function and performance requirements of the baseline vehicle. Table 3-137 provides a summary of mass reduction and cost impact for select sub-subsystems evaluated. The total mass savings found on the Electrical Distribution and Electrical Controls System mass was reduced by 8.47 kg (25.21%). This decreased cost by $61.44, or $7.26 per kg. Mass reduction for this system reduced vehicle curb weight by 0.35%.

Table 3-137: Electrical Distribution and Electrical Controls System Mass Reduction Summary, Silverado 1500

DRAFT

				Net Value of Mass Reduction					
System	Subsystem	Sub-Subsystem	Description	Base Mass "kg"	Mass Reduction "kg" (1)	Cost Impact NIDMC "$" (2)	Average Cost/ Kilogram "$/kg" (2)	Mass Reduction "%"	Vehicle Mass Reduction "%"
18	**01**	**00**	**Electrical Wiring and Circuit Protection Subsystem**	**33.59**	**8.47**	**61.44**	**7.26**	**25.21%**	**0.35%**
18	01	01	Front End and Engine Compartment Wiring	5.79	1.50	15.34	10.25	25.86%	0.06%
18	01	02	Instrument Panel Harness	6.88	1.70	15.91	0.00	24.76%	0.07%
18	01	03	Body and Rear End Wiring	3.52	0.95	9.37	0.00	27.10%	0.04%
18	01	04	Trailer Tow Wiring	5.23	1.42	13.91	0.00	0.00%	0.06%
18	01	05	Battery Cables	1.78	0.50	6.94	0.00	0.00%	0.02%
18	01	06	Load Compartment Fuse Box / Passive	2.95	0.27	-0.80	0.00	0.00%	0.01%
18	01	07	Interior & Console wiring	1.40	0.67	0.77	0.00	47.76%	0.03%
18	01	08	Frt & Rear door harness	1.81	1.45	0.00	0.00	0.00%	0.06%
18	01	99	Misc.	4.24	0.00	0.00	0.00	0.00%	0.00%
				33.59	8.47 (Decrease)	61.44 (Decrease)	7.26 (Decrease)	25.21%	0.35%

(1) "+" = mass decrease, "-" = mass increase
(2) "+" = cost decrease, "-" = cost increase

Columns in the "Net Value of Mass Reduction" chart above may contain combined masses of assembly hardware such as nuts, bolt, washer, etc. that were not mass reduced at the component level, and may not match base mass and mass reduction totals in text below component reduction weights.

Mass savings opportunities were identified for the following components: front bumper harness (wiring on front module); engine wire harness; power train mass cable (ground cable); alternator power cable; IP harness 1; IP harness 1 connector box bracket; IP harness 2; body and rear end wiring (complete); differential wiring; under frame/tow harness (wiring on understructure); battery cable – primary positive (starter wiring harness); battery cable – primary negative; battery cable – positive; fuse box (support); fuse box – cover; center console wiring, headliner wiring, front door harness, rear door harness.

<u>Front Bumper Harness (Wiring on front module):</u> The front bumper harness (wiring on front module) mass was reduced by changing the copper wire to aluminum wire and changing the PVC sheathing to Polyphenylene Oxide (PPO) sheathing. Mass was reduced by 42%, from 0.97 kg to 0.56 kg.

<u>Engine Wire Harness:</u> The engine wire harness mass was reduced by changing the copper wire to aluminum wire and changing the PVC sheathing to PPO sheathing. Mass was reduced by 42%, from 2.79 kg to 1.6 kg.

<u>Power train Mass Cable (ground cable):</u> The power train mass cable (ground cable) mass was reduced by changing the copper wire to aluminum wire and changing the PVC sheathing to PPO sheathing. Mass was reduced by 48%, from 0.07 kg to 0.04 kg.

<u>Alternator Power Cable:</u> The alternator power cable mass was reduced by changing the copper wire to aluminum wire and changing the PVC sheathing to PPO sheathing. Mass was reduced by 45% from 0.24 kg to 0.13 kg.

<u>IP Harness 1:</u> The IP harness 1 mass was reduced by changing the copper wire to aluminum wire and changing the PVC sheathing to PPO sheathing. Mass was reduced by 42%, from 3.75 kg to 2.16 kg.

DRAFT

IP Harness 1 Connector Box Bracket: The IP harness 1 connector box bracket mass was reduced by changing from steel to plastic and using PolyOne® foaming agent. Mass was reduced by 42%, from 0.38 kg to 0.27 kg.

IP Harness 2: The IP harness 2 mass was reduced by changing the copper wire to aluminum wire and changing the PVC sheathing to PPO sheathing. Mass was reduced by 42%, from 0.48 kg to 0.27 kg.

Body and Rear End Wiring (Complete): The body and rear end wiring (complete) mass was reduced by changing the copper wire to aluminum wire and changing the PVC sheathing to PPO sheathing. Mass was reduced by 42%, from 2.44 kg to 1.40 kg.

Differential Wiring: The differential wiring mass was reduced by changing the copper wire to aluminum wire and changing the PVC sheathing to PPO sheathing. Mass was reduced by 44%, from 0.08 kg to 0.04 kg.

Under Frame/Tow harness (Wiring on Understructure): The under frame/tow harness (wiring on understructure) mass was reduced by changing the copper wire to aluminum wire and changing the PVC sheathing to PPO sheathing. Mass was reduced by 42%, from 3.74 kg to 2.15 kg.

Battery Cable – Primary Positive (Starter Wiring Harness): The battery cable – primary positive (starter wiring harness) mass was reduced by changing the copper wire to aluminum wire and changing the PVC sheathing to PPO sheathing. Mass was reduced by 46%, from 0.44 kg to 0.23 kg.

Battery Cable – Primary Negative: The battery cable – primary negative mass was reduced by changing the copper wire to aluminum wire and changing the PVC sheathing to PPO sheathing. Mass was reduced by 46%, from 0.41 kg to 0.22 kg.

Battery Cable – Positive: The battery cable – positive mass was reduced by changing the copper wire to aluminum wire and changing the PVC sheathing to PPO sheathing. Mass was reduced by 45%, from 0.39 kg to 0.21 kg.

Fuse Box (Support): The fuse box (support) mass was reduced by using PolyOne® foaming agent. Mass was reduced by 19%, from 1.41 kg to 1.15 kg.

Fuse Box Cover: The fuse box cover mass was reduced by using PolyOne® foaming agent. Mass was reduced by 17%, from 0.45 kg to 0.37 kg.

Center Console Wiring: The center console wiring mass was reduced by changing the copper wire to aluminum wire and changing the PVC sheathing to PPO sheathing. Mass was reduced by 42%, from 0.20 kg to 0.12 kg.

Headliner Wiring: The headliner wiring mass was reduced by using flat wire. Mass was reduced by 80%, from 0.35 kg to 0.07 kg.

Front Door Harness: The front door harness mass was reduced by using flat wire. Mass was reduced by 80%, from 0.68 kg to 0.14 kg.

Rear Door Harness: The rear door harness mass was reduced by using flat wire. Mass was reduced by 80%, from 0.43 kg to 0.08 kg.

DRAFT

3.18.1.1 Silverado 2500 Analysis

The Chevrolet Silverado 2500 Electrical Distribution and Electrical Controls System is very similar to the 1500.

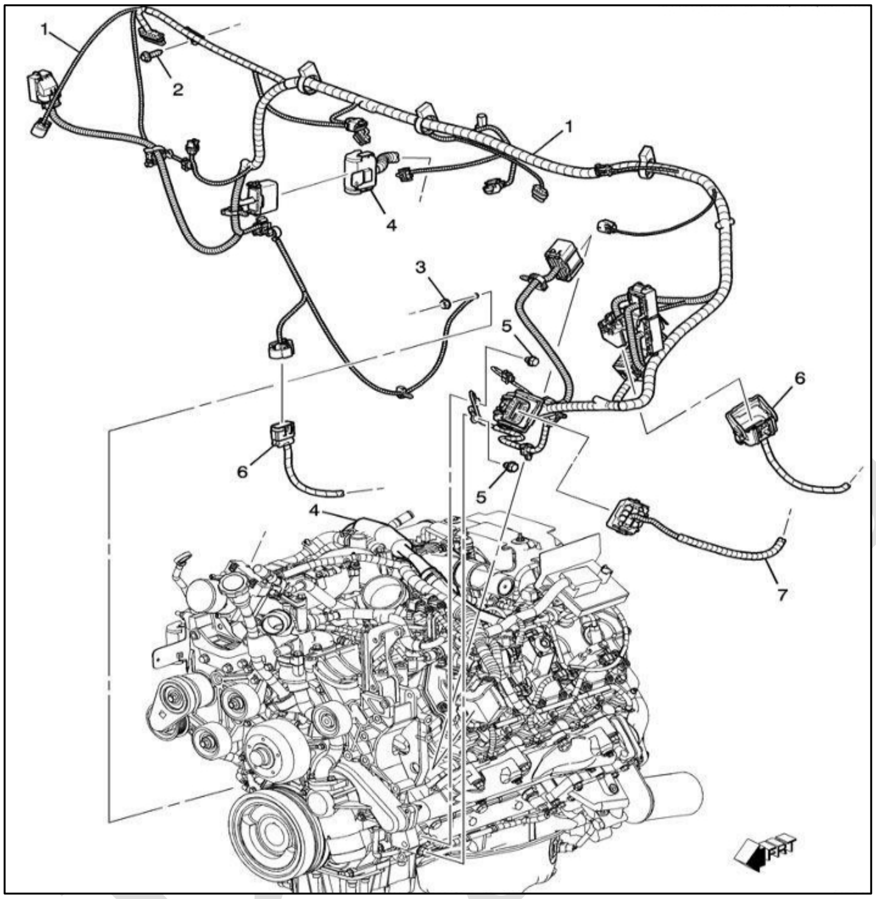


Image 3.18–1: Chevrolet Silverado engine wiring

(Source: http://parts.nalleygmc.com/showAssembly.aspx?ukey_assembly=382010)

DRAFT

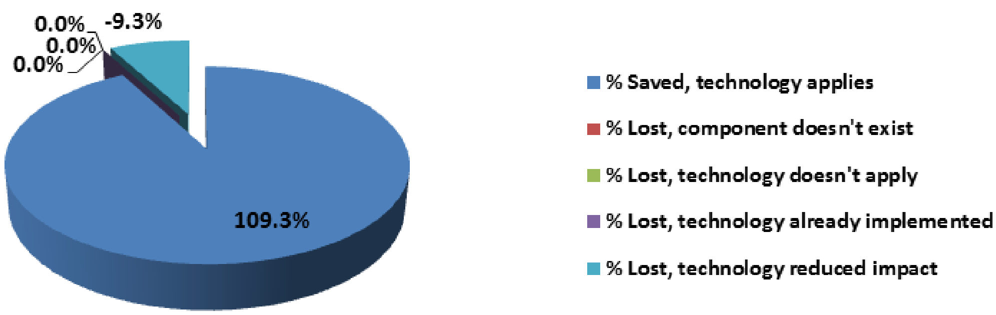
3.18.1.2 2500 System Scaling Summary

Table 3-138 summarizes the mass and cost impact of Silverado 1500 lightweighting technologies as applied to the Silverado 2500. Total Electrical Distribution and Electrical Controls System mass savings was 8.47 kg at a cost decrease of $61.54, or $7.26 per kg.

Table 3-138: Mass-Reduction and Cost Impact for Electrical Distribution and Electrical Controls System, Silverado 2500

				Net Value of Mass Reduction							
System	Subsystem	Sub-Subsystem	Description	Mass Reduction New Tech "kg" (1)	Mass Reduction Comp "kg" (1)	Mass Reduction Total "kg" (1)	Cost Impact New Tech "$" (2)	Cost Impact Comp "$" (2)	Cost Impact Total "$" (2)	Cost/ Kilogram Total "$/kg"	Vehicle Mass Reduction Total "%"
18	00	00	**Electrical Dist. and Electronic Control System**								
18	01	00	Electrical Wiring and Circuit Protection Subsystem	8.47	0.00	8.47	$61.54	$0.00	$61.54	$7.26	0.27%
				8.47 (Decrease)	**0.00**	**8.47** (Decrease)	**$61.54** (Decrease)	**$0.00**	**$61.54** (Decrease)	**$7.26** (Decrease)	**0.27%**

Mass Savings, Select Vehicle, New Technology "kg"	**8.47**
Mass Savings, Silverado 1500, New Technology "kg"	**7.75**
Mass Savings Select Vehicle/Mass Savings 1500	**109.3%**



*SMS not included - has no significant impact on perecent contributions

3.18.1.3 System Scaling Analysis

The Silverado 2500 Electrical Distribution and Electrical Controls System components were reviewed for compatibility with lightweighting technologies. The results of this analysis are listed in Table 3-139.

Table 3-139: System Scaling Analysis Electrical Distribution and Electrical Controls System, Silverado 2500

Silverado 1500							Select Vehicle			
System	Subsystem	Sub-Subsystem	Component/Assembly	Base Mass	Mass Savings New Tech	% of Mass Savings New Tech	Tech Applies	Base Mass	Mass Savings New Tech	Notes
18			**Electrical Distribution & Electrical Controls System**	**33.60**	**8.47**	**25%**			**8.47**	
18	01	01	Front Bumper Harness ((Wiring on frt module))	0.87	0.37	42%	yes	0.97	0.41	Tech **DOES** apply: Use aluminum wire & PPO sheathing
18	01	01	Engine Wire Harness	2.41	1.02	42%	yes	2.79	1.18	Tech **DOES** apply: Use aluminum wire & PPO sheathing
18	01	01	Power train mass cable (cyl ground cable)	0.07	0.03	48%	yes	0.07	0.03	Tech **DOES** apply: Use aluminum wire & PPO sheathing
18	01	01	Alternator Power Cable	0.21	0.10	45%	yes	0.24	0.11	Tech **DOES** apply: Use aluminum wire & PPO sheathing
18	01	02	IP Harness 1	3.35	1.42	42%	yes	3.75	1.60	Tech **DOES** apply: Use aluminum wire & PPO sheathing
18	01	02	IP Harness 1 connector box brkt	0.34	0.10	29%	yes	0.38	0.11	Tech **DOES** apply: Change from steel to plastic and use PolyOne foaming agent
18	01	02	IP Harness 2	0.43	0.18	42%	yes	0.48	0.20	Tech **DOES** apply: Use aluminum wire & PPO sheathing
18	01	03	Body and Rear End Wiring ((Complete))	2.17	0.92	42%	yes	2.44	1.04	Tech **DOES** apply: Use aluminum wire & PPO sheathing
18	01	03	Differential wiring	0.07	0.03	44%	yes	0.08	0.03	Tech **DOES** apply: Use aluminum wire & PPO sheathing
18	01	04	Under frame/tow harness ((Wiring on understructure))	3.33	1.42	42%	yes	3.74	1.59	Tech **DOES** apply: Use aluminum wire & PPO sheathing
18	01	05	Battery Cable - Primary Positive((Starter wiring harness))	0.39	0.18	46%	yes	0.44	0.20	Tech **DOES** apply: Use aluminum wire & PPO sheathing
18	01	05	Battery Cable - Primary Negative	0.36	0.17	46%	yes	0.41	0.19	Tech **DOES** apply: Use aluminum wire & PPO sheathing
18	01	05	Battery Cable - Positive	0.35	0.16	45%	yes	0.39	0.18	Tech **DOES** apply: Use aluminum wire & PPO sheathing
18	01	06	Fuse Box ((Support))	1.04	0.20	19%	yes	1.41	0.26	Tech **DOES** apply: Use PolyOne foaming agent
18	01	06	Fuse Box - Cover	0.45	0.08	17%	yes	0.45	0.08	Tech **DOES** apply: Use PolyOne foaming agent
18	01	07	Center console wiring	0.18	0.08	42%	yes	0.20	0.09	Tech **DOES** apply: Use aluminum wire & PPO sheathing
18	01	07	Headliner wiring	0.47	0.38	80%	yes	0.35	0.28	Tech **DOES** apply: Use flat wire
18	01	08	Frt door harness	0.83	0.66	80%	yes	0.68	0.54	Tech **DOES** apply: Use flat wire
18	01	08	Rear door harness	0.33	0.27	80%	yes	0.43	0.34	Tech **DOES** apply: Use flat wire

Components with significant mass savings identified on the 2500 series Silverado include the front bumper harness (wiring on front module); engine wire harness; power train mass cable (ground cable); alternator power cable; IP harness 1; IP harness 1 connector box bracket; IP harness 2; body and rear end wiring (complete); differential wiring; under frame/tow harness (wiring on understructure); battery cable – primary positive (starter wiring harness), battery cable – primary negative; battery cable – positive; fuse box (support); fuse box – cover; center console wiring; headliner wiring; front door harness; rear door harness.

<u>Front Bumper Harness (Wiring on Front Module)</u>

Shown in Image 3.18–2 is the Silverado 1500 and 2500 series front bumper harness (wiring on front module). Component masses were 0.87 kg for the Silverado 1500 versus 0.97 kg for the 2500. The lightweighting technology used on the front bumper harness (wiring on front module) was to change the copper wire to aluminum wire and the PVC sheathing to PPO sheathing. Due to similarities in component design and material, full percentage of the Silverado 1500 front bumper harness mass reduction can be applied to the 2500. (Refer to Table 3-139Table 3-107).

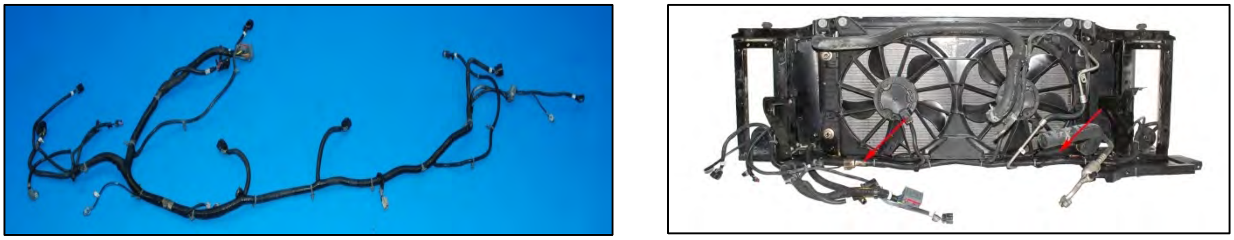


Image 3.18–2: Front Bumper Harness (Wiring on front module) for the Silverado 1500 and 2500
(Source: FEV, Inc. and www.A2mac1.com)

Engine Wire Harness

Shown in Image 3.18–3 is the Silverado 1500 and 2500 series engine wire harness. Component masses were 2.41 kg for the 1500 versus 2.79 kg for the 2500. The lightweighting technology used on the engine wire harness was to change the copper wire to aluminum wire and the PVC sheathing to PPO sheathing. Due to similarities in component design and material, full percentage of the Silverado 1500 engine wire harness mass reduction can be applied to the 2500. (Refer to Table 3-139Table 3-107).

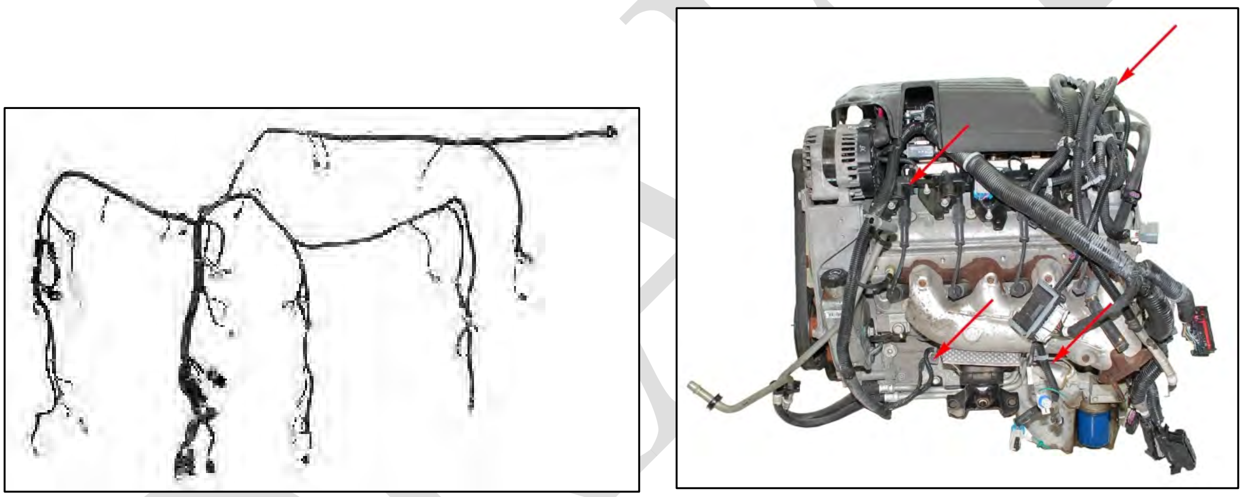


Image 3.18–3: Engine Wire Harness for the Silverado 1500 and 2500
(Source: FEV, Inc. and www.A2mac1.com)

Power train mass cable (ground cable)

Shown in Image 3.18–4 is the Silverado 1500 and 2500 power train mass cable (ground cable). Component masses were 0.07 kg for both the 1500 and 2500. The lightweighting technology used in the power train mass cable (ground cable) was to change the copper wire to aluminum wire and the PVC sheathing to PPO sheathing. Due to similarities in component design and material, full percentage of the Silverado 1500 power train mass cable mass reduction can be applied to the 2500. (Refer to Table 3-139Table 3-107).

DRAFT

Image 3.18–4: Power train mass cable (ground cable) for the Silverado 1500 and 2500
(Source: FEV, Inc. and www.A2mac1.com)

Alternator Power Cable

Shown in Image 3.18–5 is the Silverado 1500 and 2500 series alternator power cable. Component masses were 0.21 kg for the 1500 versus 0.24 kg for the 2500. The lightweighting technology used on the alternator power cable was to change the copper wire to aluminum wire and the PVC sheathing to PPO sheathing. Due to similarities in component design and material, full percentage of the Silverado 1500 alternator power cable mass reduction can be applied to the 2500. (Refer to Table 3-139Table 3-107).

Image 3.18–5: Alternator Power Cable for the Silverado 1500 and 2500
(Source: FEV, Inc. and www.A2mac1.com)

IP Harness 1

Shown in Image 3.18–6 is the Silverado 1500 and 2500 series IP harness 1. Component masses are 3.35 kg for the 1500 versus 3.75 kg for the 2500. The lightweighting technology used on IP harness was to change the copper wire to aluminum wire and the PVC sheathing to PPO sheathing. Due to similarities in component design and material, full percentage of the Silverado 1500 IP harness 1 mass reduction can be applied to the 2500. (Refer to Table 3-139Table 3-107).

DRAFT

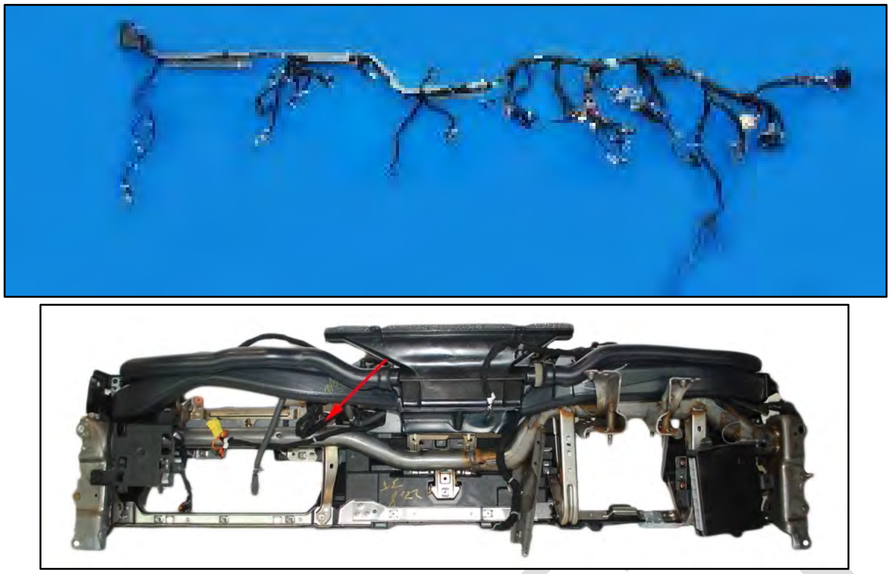


Image 3.18–6: IP Harness 1 for the Silverado 1500 and 2500
(Source: FEV, Inc. and www.A2mac1.com)

DRAFT

<u>IP Harness 1 Connector Box Bracket</u>

(No image for the Silverado 1500 and 2500 IP Harness 1 Connector Box Bracket.) Component masses for the Silverado 1500 and 2500 series IP harness 1 connector box bracket were 0.34 kg for the 1500 versus 0.38 kg for the 2500. The lightweighting technology used on the IP harness 1 connector box bracket was to change from steel to plastic and apply PolyOne® foaming agent. Due to similarities in component design and material, full percentage of the Silverado 1500 IP harness 1 connector box bracket mass reduction can be applied to the 2500. (Refer to Table 3-139Table 3-107).

<u>IP Harness 2</u>

Shown in Image 3.18–7 is the Silverado 1500 and 2500 series IP harness 2. Component masses were 0.43 kg for the 1500 versus 0.48 kg for the 2500. The lightweighting technology used on the IP harness 2 was to change the copper wire to aluminum wire and the PVC sheathing to PPO sheathing. Due to similarities in component design and material, full percentage of the Silverado 1500 IP harness 2 mass reduction can be applied to the 2500. (Refer to Table 3-139Table 3-107).

Image 3.18–7: IP Harness 2 for the Silverado 1500 and 2500
(Source: FEV, Inc. and www.A2mac1.com)

DRAFT

Body and Rear End Wiring (Complete)

Shown in Image 3.18–9 are the Silverado 1500 and 2500 series body and rear end wiring (complete). Component masses were 2.17 kg for the 1500 versus 2.44 kg for the 2500 respectively. The lightweighting technology used on body and rear end wiring (complete) was to change the copper wire to aluminum wire and the PVC sheathing to PPO sheathing. Due to similarities in component design and material, full percentage of the Silverado 1500 body and rear end wiring mass reduction can be applied to the 2500. (Refer to Table 3-139Table 3-107).

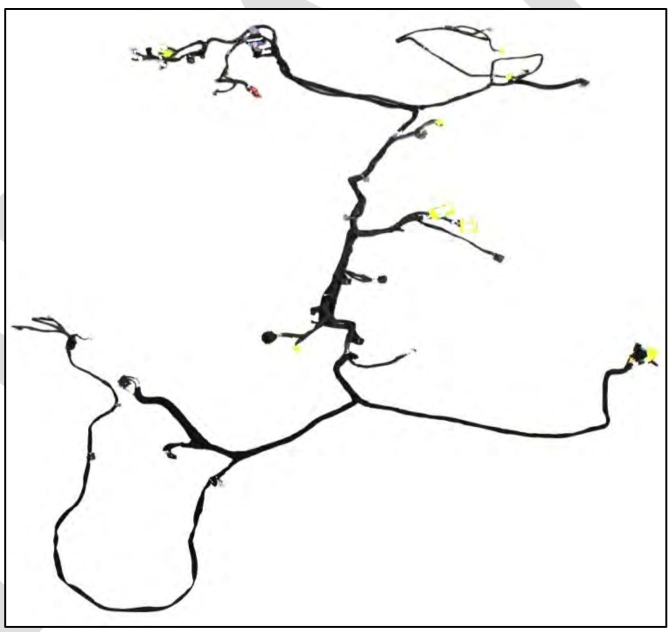


Image 3.18–8: Body and Rear End Wiring (Complete) for the Silverado 1500 and 2500
(Source: FEV, Inc. and www.A2mac1.com)

Image 3.18–9: Body and Rear End Wiring (Complete) for the Silverado 1500 and 2500
(Source: FEV, Inc. and www.A2mac1.com)

Differential wiring

Shown in Image 3.18–10 is the Silverado 1500 and 2500 differential wiring. Component masses were 0.07 kg for the 1500 versus 0.08 kg for the 2500. The lightweighting technology used on the differential wiring was to change the copper wire to aluminum wire and the PVC sheathing to PPO sheathing. Due to similarities in component design and material, full percentage of the Silverado 1500 differential wiring mass reduction can be applied to the 2500. (Refer to Table 3-139Table 3-107).

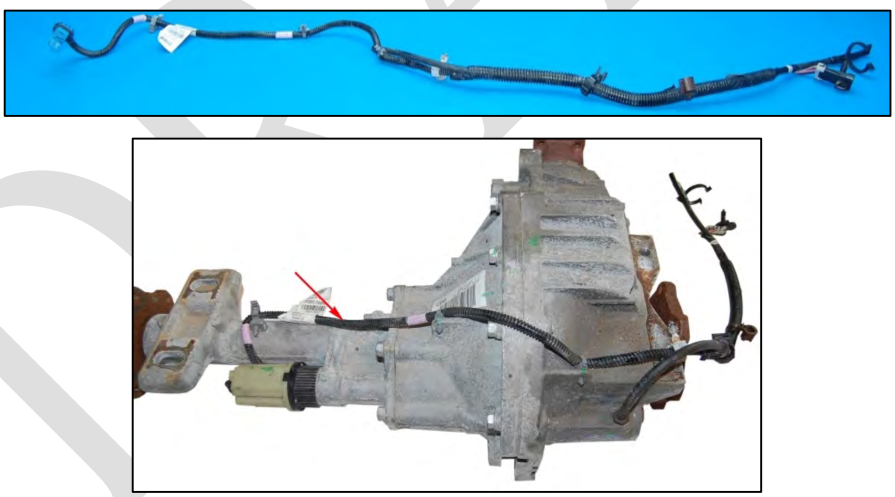


Image 3.18–10: Differential wiring for the Silverado 1500 and 2500
(Source: FEV, Inc. and www.A2mac1.com)

Under frame/tow harness (Wiring on understructure)

Shown in Image 3.18–11 is the Silverado 1500 and 2500 series under frame/tow harness (wiring on understructure). Component masses are 3.33 kg for the 1500 versus 3.74 kg for the 2500. The lightweighting technology used on the under frame/tow harness (wiring on understructure) was to change the copper wire to aluminum wire and the PVC sheathing to PPO sheathing. Due to

DRAFT

similarities in component design and material, full percentage of the Silverado 1500 under frame/tow harness mass reduction can be applied to the 2500. (Refer to Table 3-139Table 3-107).

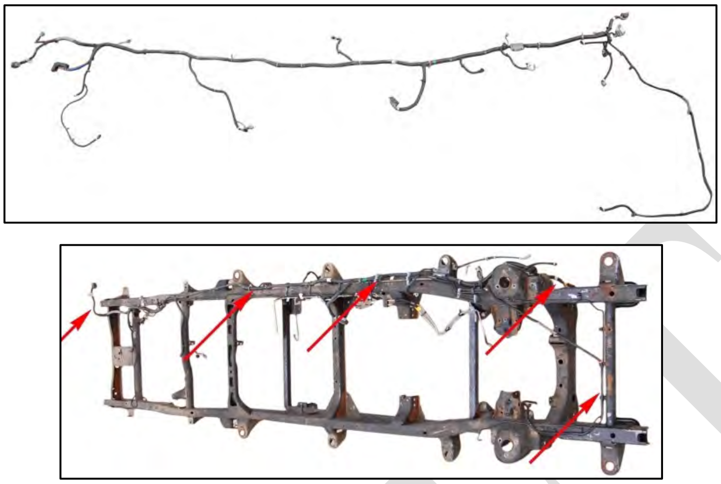


Image 3.18–11: Under frame/tow harness (wiring on understructure) for the Silverado 1500 and 2500
(Source: FEV, Inc. and www.A2mac1.com)

Battery Cable - Primary Positive (Starter wiring harness)

Shown in Image 3.18–12 is the Silverado 1500 and 2500 series battery cable – primary positive (starter wiring harness). Component masses were 0.39 kg for the 1500 versus 0.44 kg for the 2500. The lightweighting technology used on the battery cable – primary positive (starter wiring harness) was to change the copper wire to aluminum wire and the PVC sheathing to PPO sheathing. Due to similarities in component design and material, full percentage of the Silverado 1500 battery cable - primary positive mass reduction can be applied to the 2500. (Refer to Table 3-139Table 3-107).

Image 3.18–12: Battery cable – primary positive (starter wiring harness) for the Silverado 1500 and 2500
(Source: FEV, Inc.)

Battery Cable - Primary Negative

Shown in Image 3.18–13 is the Silverado 1500 and 2500 series battery cable – primary negative. Component masses were 0.36 kg for the 1500 versus 0.41 kg for the 2500. The lightweighting technology used on battery cable – primary negative was to change the copper wire to aluminum wire and the PVC sheathing to PPO sheathing. Due to similarities in component design and

DRAFT

material, full percentage of the Silverado 1500 battery cable - primary negative mass reduction can be applied to the 2500. (Refer to Table 3-139Table 3-107).

Image 3.18–13: Battery Cable - Primary Negative for the Silverado 1500 and 2500
(Source: FEV, Inc. and www.A2mac1.com)

<u>Battery Cable - Positive</u>

Shown in Image 3.18–14 is the Silverado 1500 and 2500 series battery cable – positive. Component masses were 0.35 kg for the 1500 versus 0.39 kg for the 2500. The lightweighting technology used on the Battery Cable - Positive was to change the copper wire to aluminum wire and changing the PVC sheathing to PPO sheathing. Due to similarities in component design and material, full percentage of the Silverado 1500 battery cable - positive mass reduction can be applied to the 2500. (Refer to Table 3-139Table 3-107).

DRAFT

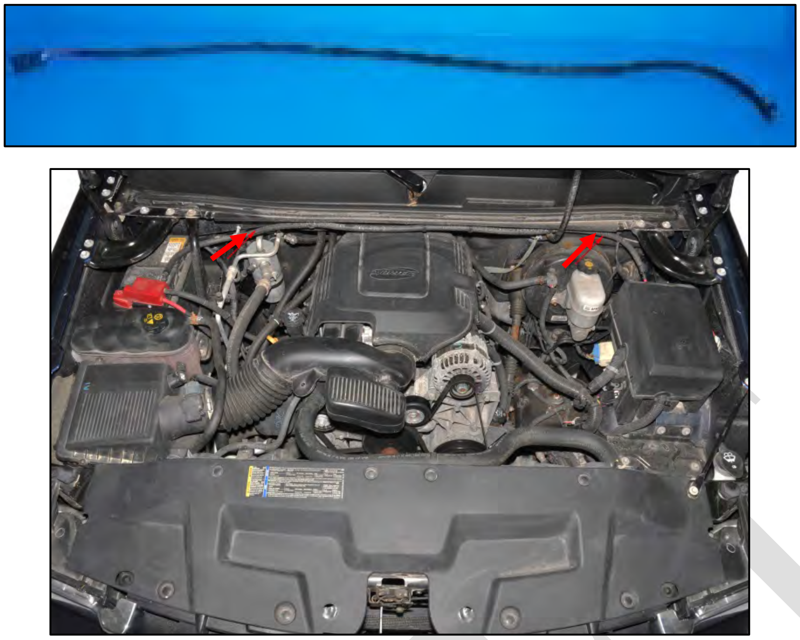


Image 3.18–14: Battery Cable - Positive for the Silverado 1500 and 2500
(Source: FEV, Inc. and www.A2mac1.com)

Fuse Box (Support)

Shown in Image 3.18–15 the Silverado 1500 and 2500 series fuse box (support). Component masses are 1.04 kg for the 1500 versus 1.41 kg for the 2500 respectively. The lightweighting technology used on fuse box (support) was to change from steel to plastic and using PolyOne® foaming agent. Due to similarities in component design and material, full percentage of the Silverado 1500 fuse box (support) mass reduction can be applied to the 2500. (Refer to Table 3-139Table 3-107).

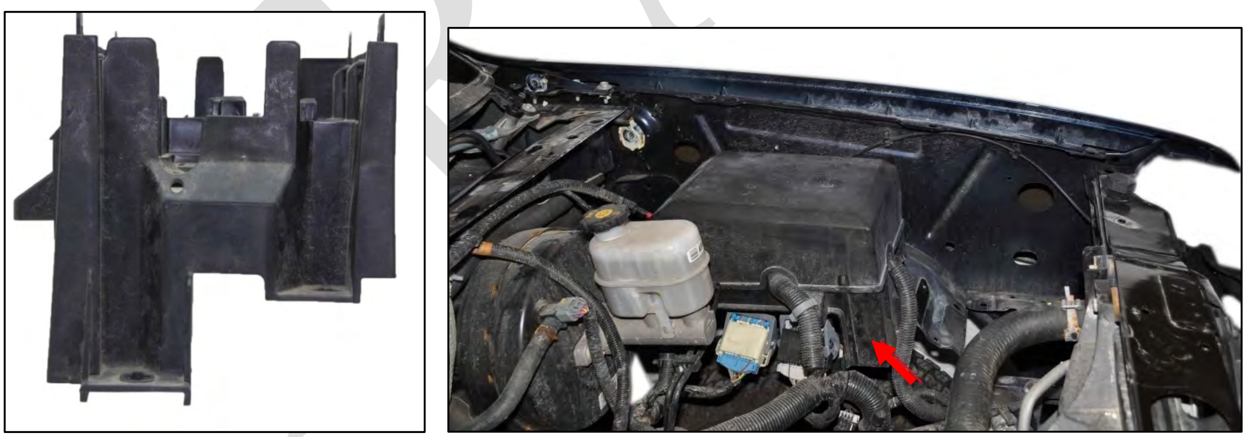


Image 3.18–15: Fuse Box (Support) for the Silverado 1500 and 2500
(Source: FEV, Inc. and www.A2mac1.com)

Fuse Box - Cover

Shown in Image 3.18–16 is the Silverado 1500 and 2500 series fuse box – cover. Component masses were 0.45 kg for both the 1500 and for the 2500. The lightweighting technology used in fuse box – cover was to change from steel to plastic and apply PolyOne® foaming agent. Due to

DRAFT

similarities in component design and material, full percentage of the Silverado 1500 fuse box-cover mass reduction can be applied to the 2500. (Refer to Table 3-139Table 3-107).

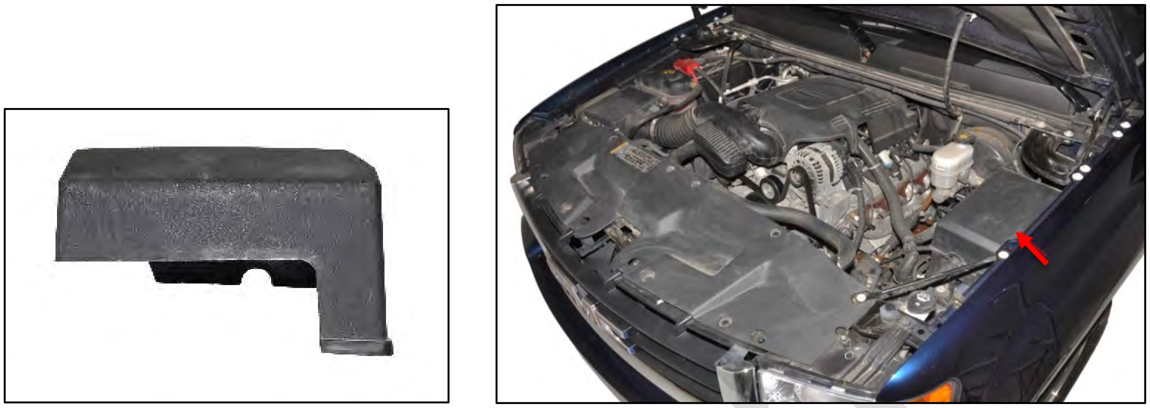


Image 3.18–16: Fuse box – cover for the Silverado 1500 and 2500
(Source: FEV, Inc. and www.A2mac1.com)

Center console wiring

Shown in Image 3.18–17 the Silverado 1500 and 2500 series center console wiring. Component masses were 0.18 kg for the 1500 versus 0.20 kg for the 2500. The lightweighting technology used on the center console wiring was to change the copper wire to aluminum wire and the PVC sheathing to PPO sheathing. Due to similarities in component design and material, full percentage of the Silverado 1500 center console wiring mass reduction can be applied to the 2500. (Refer to Table 3-139Table 3-107).

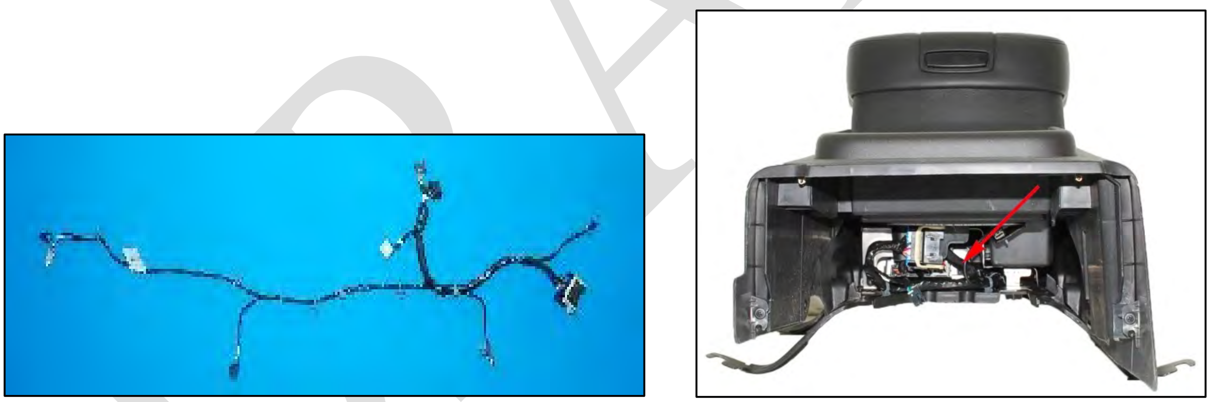


Image 3.18–17: Center console wiring for the Silverado 1500 and 2500
(Source: FEV, Inc. and www.A2mac1.com)

Headliner wiring

Shown in Image 3.18–18 is the Silverado 1500 and 2500 series headliner wiring. Component masses were 0.47 kg for the 1500 versus 0.35 kg for the 2500. The lightweighting technology used on the headliner wiring was to change the copper wire to aluminum wire and the PVC sheathing to PPO sheathing. Due to similarities in component design and material, full percentage of the Silverado 1500 headliner wiring mass reduction can be applied to the 2500. (Refer to Table 3-139Table 3-107).

DRAFT

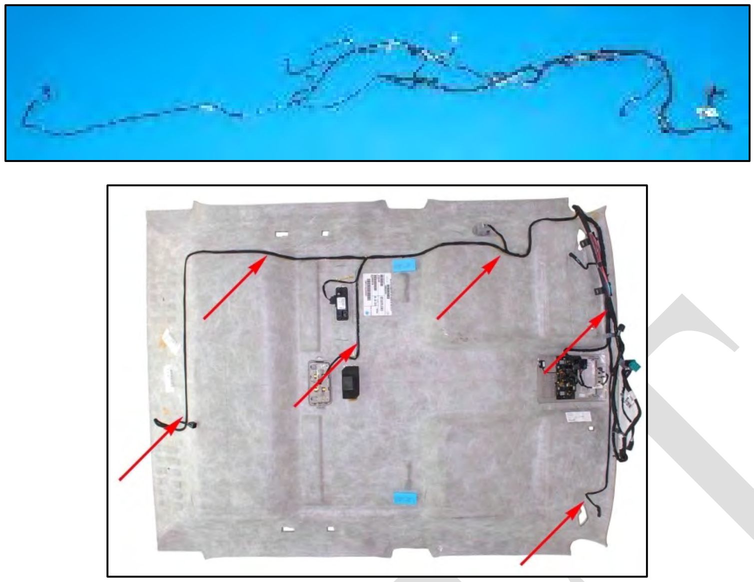


Image 3.18–18: Headliner wiring for the Silverado 1500 and 2500
(Source: FEV, Inc. and www.A2mac1.com)

<u>Front door harness</u>

Shown in Image 3.18–19 is the Silverado 1500 and 2500 series front door harness. Component masses were 0.83 kg for the 1500 versus 0.68 kg for the 2500. The lightweighting technology used on the front door harness was to change the copper wire to aluminum wire and the PVC sheathing to PPO sheathing. Due to similarities in component design and material, full percentage of the Silverado 1500 front door harness mass reduction can be applied to the 2500. (Refer to Table 3-139Table 3-107).

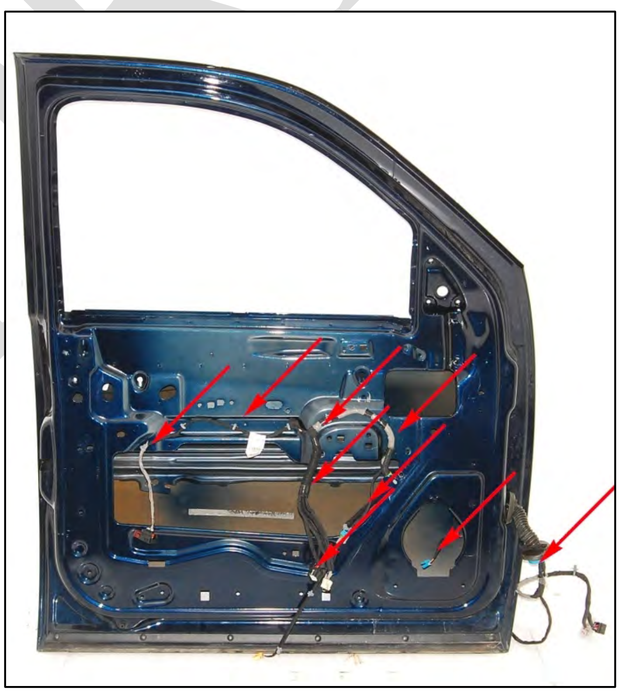


Image 3.18–19: Front door harness for the Silverado 1500 and 2500

DRAFT

(Source: www.A2mac1.com)

Rear Door Harness

Shown in Image 3.18–20 is the Silverado 1500 and 2500 rear door harness. Component masses were 0.33 kg for the 1500 versus 0.43 kg for the 2500. The lightweighting technology used in the rear door harness was to change the copper wire to aluminum wire and the PVC sheathing to PPO sheathing. Due to similarities in component design and material, full percentage of the Silverado 1500 rear door harness mass reduction can be applied to the 2500. (Refer to Table 3-139Table 3-107).

Image 3.18–20: Rear door harness for the Silverado 1500 and 2500
(Source: FEV, Inc.)

3.18.1.4 System Comparison, Silverado 2500

Table 3-140 summarizes the Silverado 1500 and 2500 lightweighting results. The majority of the components were visually the same between the two Electrical Distribution and Electrical Controls Systems.

Table 3-140: Electrical Distribution and Electrical Controls System Comparison, Silverado 1500 and 2500

		Net Value of Mass Reduction								
System	Description	Mass Base "kg" (1)	Mass Reduction New Tech "kg" (1)	Mass Reduction Comp "kg" (1)	Mass Reduction Total "kg" (1)	System Mass Reduction "%"	Cost Impact New Tech "$" (2)	Cost Impact Comp "$" (2)	Cost Impact Total "$" (2)	Cost/ Kilogram Total "$/kg"
18	Electrical Distribution & Electrical Controls System									
18	Silverado 1500	33.60	7.75	0.00	7.75	23.07%	$61.44	$0.00	$61.44	$7.93
18	Silverado 2500	33.64	8.47	0.00	8.47	25.18%	$61.54	$0.00	$61.54	$7.26

DRAFT

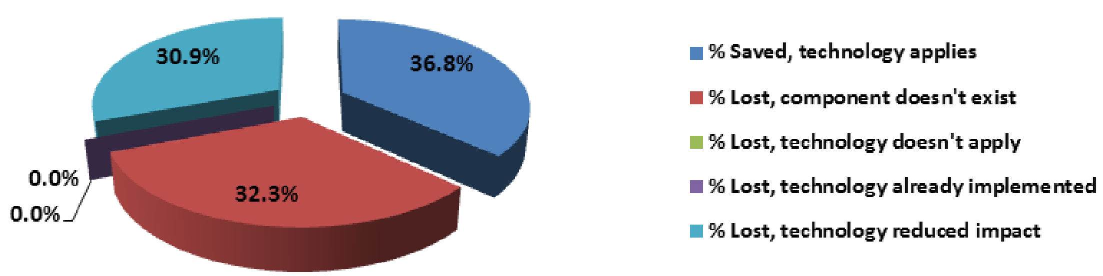
3.18.2 Mercedes Sprinter 311 CDi

Table 3-141 summarizes the mass and cost impact of Silverado 1500 lightweighting technologies as applied to the Mercedes Sprinter 311 CDi. Total Electrical Distribution and Electrical Controls System mass savings was 2.85 kg at a cost decrease of $27.22, or $9.54 per kg.

Table 3-141: Mass-Reduction and Cost Impact for Electrical Distribution and Electrical Controls System, Mercedes Sprinter

				Net Value of Mass Reduction							
System	Subsystem	Sub-Subsystem	Description	Mass Reduction New Tech "kg" (1)	Mass Reduction Comp "kg" (1)	Mass Reduction Total "kg" (1)	Cost Impact New Tech "$" (2)	Cost Impact Comp "$" (2)	Cost Impact Total "$" (2)	Cost/ Kilogram Total "$/kg"	Vehicle Mass Reduction Total "%"
18	00	00	Electrical Dist. and Electronic Control System								
18	01	00	Electrical Wiring and Circuit Protection Subsystem	2.85	0.00	2.85	$27.22	$0.00	$27.22	$9.54	0.13%
				2.85 (Decrease)	0.00	2.85 (Decrease)	$27.22 (Decrease)	$0.00	$27.22 (Decrease)	$9.54 (Decrease)	0.13%

Mass Savings, Select Vehicle, New Technology "kg"	2.853
Mass Savings, Silverado 1500, New Technology "kg"	7.749
Mass Savings Select Vehicle/Mass Savings 1500	36.8%



*SMS not included - has no significant impact on perecent contributions

3.18.2.1 System Scaling Analysis

The Mercedes Sprinter 311 CDi Electrical Distribution and Electrical Controls System components were reviewed for compatibility with lightweighting technologies. The results of this analysis are listed in Table 3-142.

Table 3-142: System Scaling Analysis Electrical Distribution and Electrical Controls System, Mercedes Sprinter

Silverado 1500							Select Vehicle			
System	Subsystem	Sub-Subsystem	Component/Assembly	Base Mass	Mass Savings New Tech	% of Mass Savings New Tech	Tech Applies	Base Mass	Mass Savings New Tech	Notes
18			**Electrical Distribution & Electrical Controls System**	**33.60**	**7.75**	**23%**			**2.85**	
18	01	01	Front Bumper Harness ((Wiring on frt module))	0.87	0.37	42%	yes	0.52	0.23	Tech **DOES** apply: Use aluminum wire & PPO sheathing
18	01	01	Engine Wire Harness	2.41	1.02	42%	yes	1.46	0.63	Tech **DOES** apply: Use aluminum wire & PPO sheathing
18	01	01	Power train mass cable (cyl ground cable)	0.07	0.03	48%	no			Tech does **NOT** apply: Not on vehicle
18	01	01	Alternator Power Cable	0.21	0.10	45%	yes	0.14	0.06	Tech **DOES** apply: Use aluminum wire & PPO sheathing
18	01	02	IP Harness 1	3.35	1.42	42%	yes	2.02	0.88	Tech **DOES** apply: Use aluminum wire & PPO sheathing
18	01	02	IP Harness 1 connector box brkt	0.34	0.10	29%	no			Tech does **NOT** apply: Not on vehicle
18	01	02	IP Harness 2	0.43	0.18	42%	yes	0.26	0.11	Tech **DOES** apply: Use aluminum wire & PPO sheathing
18	01	03	Body and Rear End Wiring ((Complete))	2.172	0.92	42%	yes	1.31	0.57	Tech **DOES** apply: Use aluminum wire & PPO sheathing
18	01	03	Differential wiring	0.07	0.03	44%	no			Tech does **NOT** apply: Not on vehicle
18	01	04	Under frame/tow harness ((Wiring on understructure))	3.33	1.42	42%	no			Tech does **NOT** apply: Not on vehicle
18	01	05	Battery Cable - Primary Positive((Starter wiring harness))	0.39	0.18	46%	no			Tech does **NOT** apply: Not on vehicle
18	01	05	Battery Cable - Primary Negative	0.36	0.17	46%	no			Tech does **NOT** apply: Not on vehicle
18	01	05	Battery Cable - Positive	0.35	0.16	45%	no			Tech does **NOT** apply: Not on vehicle
18	01	06	Fuse Box ((Support))	1.04	0.20	19%	yes	0.19	0.04	Tech **DOES** apply: Use PolyOne foaming agent
18	01	06	Fuse Box - Cover	0.45	0.08	17%	no			Tech does **NOT** apply: Not on vehicle
18	01	07	Center console wiring	0.18	0.08	42%	no			Tech does **NOT** apply: Not on vehicle
18	01	07	Headliner wiring	0.47	0.38	80%	yes	0.28	0.23	Tech **DOES** apply: Use flat wire
18	01	08	Frt door harness	0.83	0.66	80%	yes	0.13	0.10	Tech **DOES** apply: Use flat wire
18	01	08	Rear door harness	0.33	0.27	80%	no			Tech does **NOT** apply: Not on vehicle

If the original Silverado 1500 mass reduction concept idea was not able to be applied to the comparison vehicle it is not described in the section below.

Components with significant mass savings identified on the Mercedes Sprinter included the front bumper harness (wiring on front module); engine wire harness; alternator power cable; IP harness 1; IP harness 2; body and rear end wiring (complete); fuse box (support); headliner wiring; and front door harness. Image 3.18–21 shows the Mercedes Sprinter 311 CDi Electrical Distribution and Electrical Controls System components.

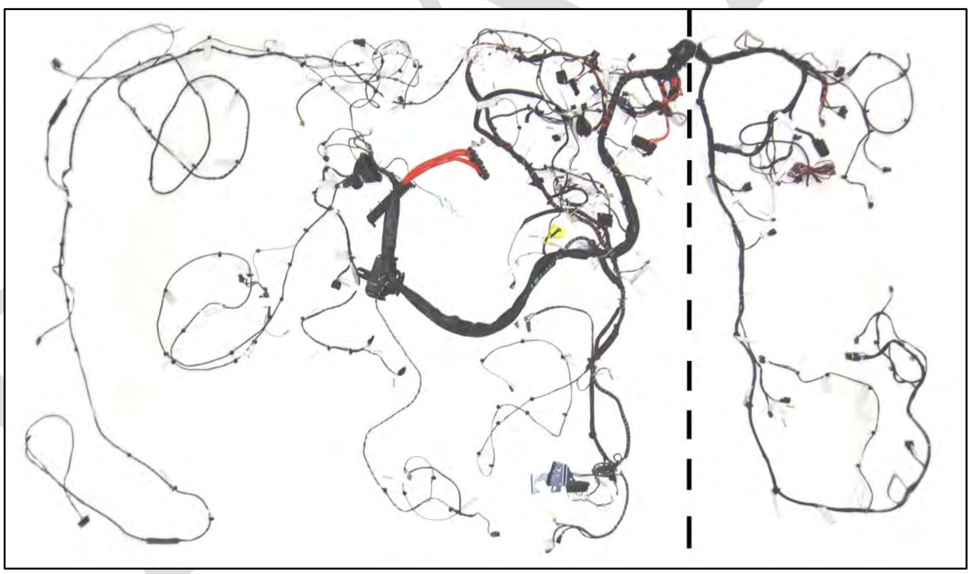


Image 3.18–21: Mercedes Sprinter 311 CDi Electrical Distribution and Electrical Controls System Components
(Source: www.A2mac1.com)

Front Bumper Harness (Wiring on front module)

Shown in Image 3.18–22 is the Mercedes Sprinter 311 CDi front bumper harness (wiring on front module). Component masses are 0.87 kg for the Silverado 1500 versus 0.52 kg for the Mercedes Sprinter 311 CDi. The lightweighting technology used on the front bumper harness (wiring on front module) was to change the copper wire to aluminum wire and the PVC sheathing to PPO sheathing. Due to similarities in component design and material, full percentage of the Silverado 1500 front bumper harness mass reduction can be applied to the Sprinter. (Refer to Table 3-142Table 3-107).

DRAFT

Image 3.18–22: Front Bumper Harness (Wiring on front module) for the Silverado 1500 and 2500 (Top) and Mercedes Sprinter 311 CDi (Bottom)
(Source: FEV, Inc. and www.A2mac1.com)

Engine Wire Harness

Shown in Image 3.18–23 are the Silverado 1500 and Mercedes Sprinter 311 CDi engine wire harness. Component masses were 2.41 kg for the 1500 versus 1.46 kg for the Mercedes Sprinter 311 CDi. The lightweighting technology used on the engine wire harness was to change from copper wire to aluminum wire and the PVC sheathing to PPO sheathing. Due to similarities in component design and material, full percentage of the Silverado 1500 engine wire harness mass reduction can be applied to the Sprinter. (Refer to Table 3-142Table 3-107).

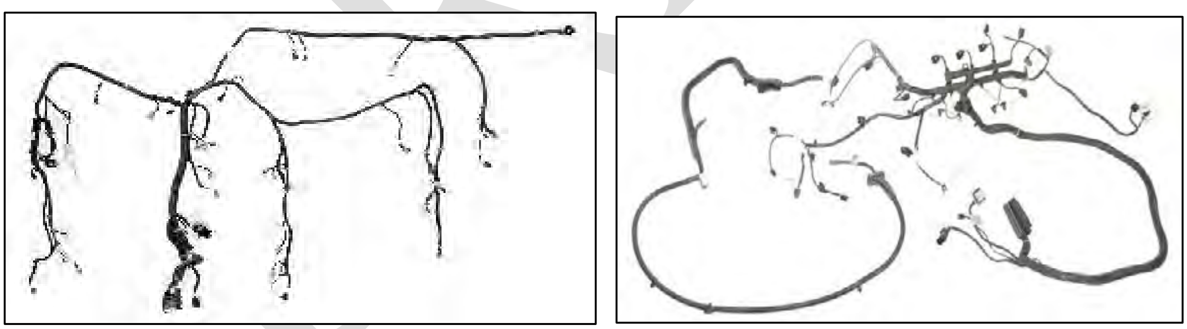


Image 3.18–23: Engine Wire Harness for the Silverado 1500 and 2500 (Top) and Mercedes Sprinter 311 CDi (Bottom)
(Source: FEV, Inc. and www.A2mac1.com)

Alternator Power Cable

(No image for the Mercedes Sprinter 311 CDi alternator power cable.) The alternator power cable is part of the main engine harness. Component masses were 0.21 kg for the Silverado 1500 versus 0.14 kg for the Mercedes Sprinter 311 CDi. The lightweighting technology used on the alternator power cable was to change the copper wire to aluminum wire and the PVC sheathing to PPO sheathing. Due to similarities in component design and material, full percentage of the Silverado 1500 alternator power cable mass reduction can be applied to the Sprinter. (Refer to Table 3-142Table 3-107).

DRAFT

IP Harness 1

(No image for the Mercedes Sprinter 311 CDi IP harness 1.) The harness is part of the main cockpit harness. Component masses were 3.35 kg for the 1500 versus 2.02 kg for the Mercedes Sprinter 311 CDi respectively. The lightweighting technology used on the IP Harness 1 was to change the copper wire to aluminum wire and the PVC sheathing to PPO sheathing. Due to similarities in component design and material, full percentage of the Silverado 1500 IP harness 1 mass reduction can be applied to the Sprinter. (Refer to Table 3-142Table 3-107).

IP Harness 2

(No image for the Mercedes Sprinter 311 CDi IP harness 2.) The harness is part of the main cockpit harness. Component masses were 0.43 kg for the Silverado 1500 versus 0.26 kg for the Mercedes Sprinter 311 CDi. The lightweighting technology used on the IP harness 2 was to change the copper wire to aluminum wire and the PVC sheathing to PPO sheathing. Due to similarities in component design and material, full percentage of the Silverado 1500 IP harness 2 mass reduction can be applied to the Sprinter. (Refer to Table 3-142Table 3-107).

Body and Rear End Wiring (Complete)

(No image for the Mercedes Sprinter 311 CDi body and rear end wiring (Complete). The harness is part of the main cockpit harness. Component masses were 2.17 kg for the Silverado 1500 versus 1.31 kg for the Mercedes Sprinter 311 CDi. The lightweighting technology used on the body and rear end wiring (complete) was to change the copper wire to aluminum wire and the PVC sheathing to PPO sheathing. Due to similarities in component design and material, full percentage of the Silverado 1500 body and rear end wiring mass reduction can be applied to the Sprinter. (Refer to Table 3-142Table 3-107).

Fuse Box (Support)

Shown in Image 3.18–24 are the Silverado 1500 and Mercedes Sprinter 311 CDi fuse boxes (support). Component masses were 1.04 kg for the Silverado 1500 versus 0.19 kg for the Mercedes Sprinter 311 CDi. The lightweighting technology used on fuse box (support) was to change from steel to plastic and apply PolyOne® foaming agent Due to similarities in component design and material, full percentage of the Silverado 1500 fuse box (support) mass reduction can be applied to the Sprinter. (Refer to Table 3-142Table 3-107).

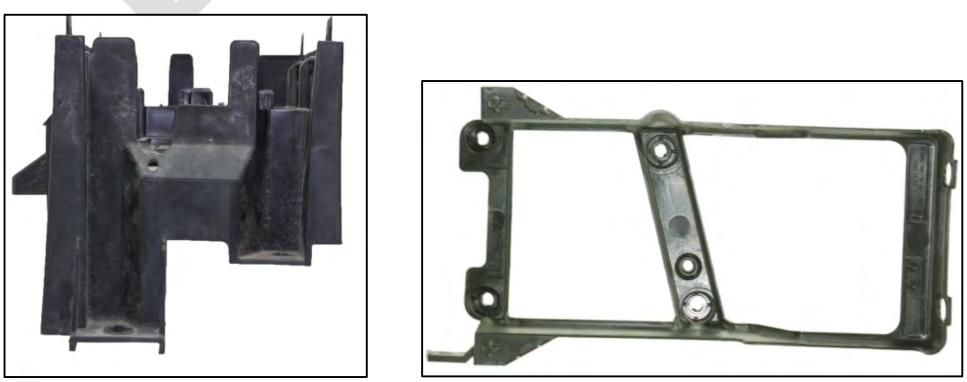


Image 3.18–24: Fuse Box (Support) for the Silverado 1500 and 2500 (Left) and Mercedes Sprinter 311 CDi (Right)

DRAFT

(Source: FEV, Inc. and www.A2mac1.com)

Headliner wiring

(No image for the Mercedes Sprinter 311 CDi headliner wiring.) The harness is part of the main cockpit harness. Component masses were 0.47 kg for the Silverado 1500 versus 0.28 kg for the Mercedes Sprinter 311 CDi respectively. The lightweighting technology used on the headliner wiring was to change the copper wire to aluminum wire and the PVC sheathing to PPO sheathing. Due to similarities in component design and material, full percentage of the Silverado 1500 headliner wiring mass reduction can be applied to the Sprinter. (Refer to Table 3-142Table 3-107).

Front door harness

(No image for the Mercedes Sprinter 311 CDi front door harness.) The harness is part of the main cockpit harness. Component masses were 0.837 kg for the Silverado 1500 versus 0.13 kg for the Mercedes Sprinter 311 CDi. The lightweighting technology used on the front door harness was to change the copper wire to aluminum wire and the PVC sheathing to PPO sheathing. Due to similarities in component design and material, full percentage of the Silverado 1500 front door harness mass reduction can be applied to the Sprinter. (Refer to Table 3-142Table 3-107).

3.18.3 Renault Master 2.3 DCi

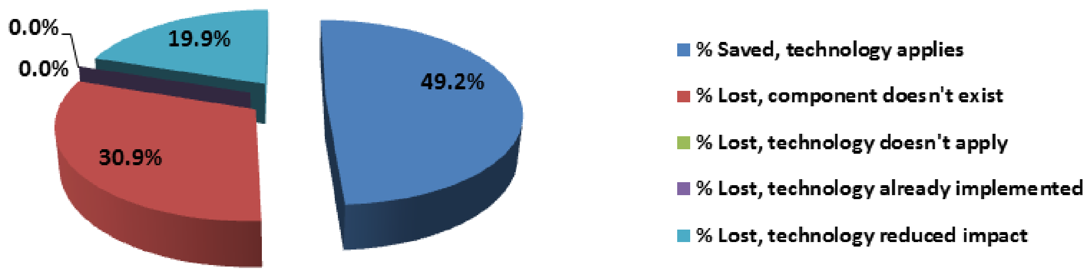
Table 3-143 summarizes mass and cost impact of Silverado 1500 lightweighting technologies applied to the Renault Master 2.3 DCi. Total Electrical Distribution and Electrical Controls System mass savings is 3.81 kg at a cost decrease of $32.99, or $8.65 per kg.

DRAFT

Table 3-143: Mass-Reduction and Cost Impact for Electrical Distribution and Electrical Controls System, Renault Master

				Net Value of Mass Reduction							
System	Subsystem	Sub-Subsystem	Description	Mass Reduction New Tech "kg" (1)	Mass Reduction Comp "kg" (1)	Mass Reduction Total "kg" (1)	Cost Impact New Tech "$" (2)	Cost Impact Comp "$" (2)	Cost Impact Total "$" (2)	Cost/ Kilogram Total "$/kg"	Vehicle Mass Reduction Total "%"
18	00	00	**Electrical Dist. and Electronic Control System**								
18	01	00	Electrical Wiring and Circuit Protection Subsystem	3.81	0.00	3.81	$32.99	$0.00	32.99	$8.65	0.16%
				3.81 (Decrease)	**0.00**	**3.81** (Decrease)	**$32.99** (Decrease)	**$0.00**	**$32.99** (Decrease)	**$8.65** (Decrease)	**0.16%**

Mass Savings, Select Vehicle, New Technology "kg"	**3.811**
Mass Savings, Silverado 1500, New Technology "kg"	**7.749**
Mass Savings Select Vehicle/Mass Savings 1500	**49.2%**



*SMS not included - has no significant impact on perecent contributions

3.18.3.1 System Scaling Analysis

The Renault Master 2.3 DCi Electrical Distribution and Electrical Controls System components were reviewed for compatibility with lightweighting technologies.

.

Table 3-144: System Scaling Analysis Electrical Distribution and Electrical Controls System, Renault Master

Silverado 1500							Select Vehicle			
System	Subsystem	Sub-Subsystem	Component/Assembly	Base Mass	Mass Savings New Tech	% of Mass Savings New Tech	Tech Applies	Base Mass	Mass Savings New Tech	Notes
18			**Electrical Distribution & Electrical Controls System**	**33.60**	**7.75**	**23%**			**3.81**	
18	01	01	Front Bumper Harness ((Wiring on frt module))	0.87	0.37	42%	yes	0.62	0.27	Tech **DOES** apply: Use aluminum wire & PPO sheathing
18	01	01	Engine Wire Harness	2.41	1.02	42%	yes	1.72	0.75	Tech **DOES** apply: Use aluminum wire & PPO sheathing
18	01	01	Power train mass cable (cyl ground cable)	0.07	0.03	48%	yes	0.18	0.09	Tech **DOES** apply: Use aluminum wire
18	01	01	Alternator Power Cable	0.21	0.10	45%	yes	0.16	0.08	Tech **DOES** apply: Use aluminum wire & PPO sheathing
18	01	02	IP Harness 1	3.35	1.42	42%	yes	2.40	1.04	Tech **DOES** apply: Use aluminum wire & PPO sheathing
18	01	02	IP Harness 1 connector box brkt	0.34	0.10	29%	no			Tech does **NOT** apply: Not on vehicle
18	01	02	IP Harness 2	0.43	0.18	42%	yes	0.31	0.13	Tech **DOES** apply: Use aluminum wire & PPO sheathing
18	01	03	Body and Rear End Wiring ((Complete))	2.172	0.92	42%	yes	1.56	0.68	Tech **DOES** apply: Use aluminum wire & PPO sheathing
18	01	03	Differential wiring	0.07	0.03	44%	no			Tech does **NOT** apply: Not on vehicle
18	01	04	Under frame/tow harness ((Wiring on understructure))	3.33	1.42	42%	no			Tech does **NOT** apply: Not on vehicle
18	01	05	Battery Cable - Primary Positive((Starter wiring harness))	0.39	0.18	46%	no			Tech does **NOT** apply: Not on vehicle
18	01	05	Battery Cable - Primary Negative	0.36	0.17	46%	no			Tech does **NOT** apply: Not on vehicle
18	01	05	Battery Cable - Positive	0.35	0.16	45%	no			Tech does **NOT** apply: Not on vehicle
18	01	06	Fuse Box ((Support))	1.04	0.20	19%	yes	0.70	0.13	Tech **DOES** apply: Use PolyOne foaming agent
18	01	06	Fuse Box - Cover	0.45	0.08	17%	yes	0.27	0.05	Tech **DOES** apply: Use PolyOne foaming agent
18	01	07	Center console wiring	0.18	0.08	42%	no			Tech does **NOT** apply: Not on vehicle
18	01	07	Headliner wiring	0.47	0.38	80%	yes	0.30	0.24	Tech **DOES** apply: Use flat wire
18	01	08	Frt door harness	0.83	0.66	80%	yes	0.45	0.36	Tech **DOES** apply: Use flat wire
18	01	08	Rear door harness	0.33	0.27	80%	no			Tech does **NOT** apply: Not on vehicle

If the original Silverado 1500 mass reduction concept idea was not able to be applied to the comparison vehicle it is not described in the section below.

Components with significant mass savings identified on the Renault Master 2.3 DCi included the front bumper harness (wiring on front module); engine wire harness; power train mass cable (ground cable); alternator power cable; IP harness 1; IP harness 2; body and rear end wiring (complete); fuse box (support); fuse box – cover; headliner wiring; and front door harness. Image 3.18–25 shows the Renault Master 2.3 DCi Electrical Distribution and Electrical Controls System components.

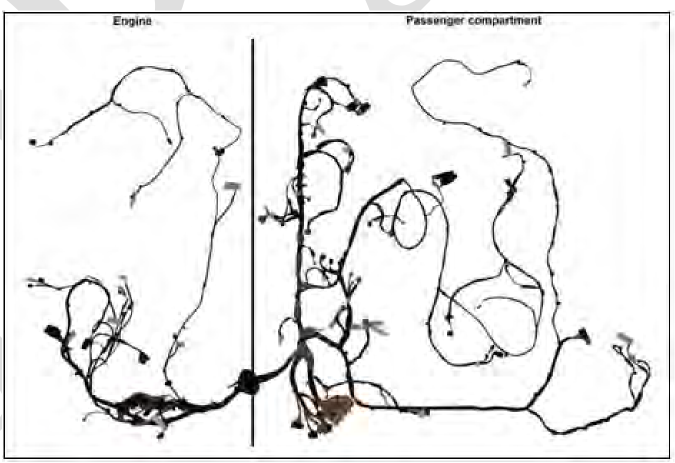


Image 3.18–25: Renault Master 2.3 DCi Electrical Distribution and Electrical Controls System
(Source: www.A2mac1.com)

Front Bumper Harness (Wiring on front module)

(No Image for the Renault Master 2.3 DCi front bumper harness (wiring on front module). The harness is part of the main cockpit harness. Component masses were 0.87 kg for the Silverado 1500 versus 0.62 kg for the Renault Master 2.3 DCi. The lightweighting technology used on the front bumper harness (wiring on front module) was to change the copper wire to aluminum wire and changing the PVC sheathing to PPO sheathing. Due to similarities in component design and material, full percentage of the Silverado 1500 front bumper harness mass reduction can be applied to the Renault. (Refer to Table 3-144).

Engine Wire Harness

Shown in Image 3.18–26 are the Silverado 1500 and Renault Master 2.3 DCi Engine Wire Harness. Component masses are 2.41 kg for the 1500 versus 1.72 kg for the Renault Master 2.3 DCi. The lightweighting technology used on the engine wire harness was to change the copper wire to aluminum wire and the PVC sheathing to PPO sheathing. Due to similarities in component design and material, full percentage of the Silverado 1500 engine wiring harness mass reduction can be applied to the Renault. (Refer to Table 3-144).

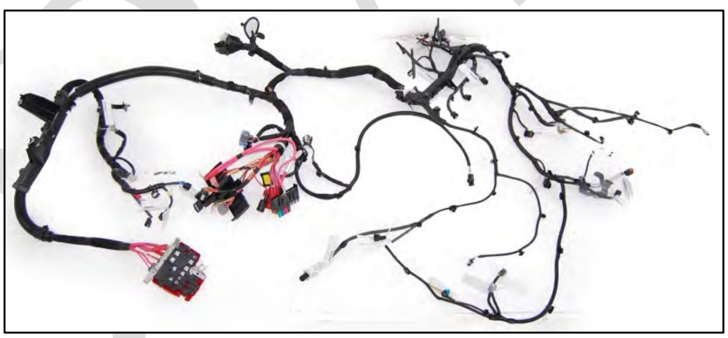


Image 3.18–26: Engine Wire Harness for the Silverado 1500 and 2500 (Top) and Renault Master 2.3 DCi (Bottom)
(Source: FEV, Inc. and www.A2mac1.com)

Power Train Mass Cable (Ground Cable)

(No image for the Renault Master 2.3 DCi power train mass cable [ground cable].) Component masses were 0.07 kg for the Silverado 1500 versus 0.18 kg for the Renault Master 2.3 DCi. The lightweighting technology used on the power train mass cable (ground cable) was to change the copper wire to aluminum wire and changing the PVC sheathing to PPO sheathing. Due to similarities in component design and material, full percentage of the Silverado 1500 power train mass cable mass reduction can be applied to the Renault. (Refer to Table 3-144).

DRAFT

Alternator Power Cable

(No image for the Renault Master 2.3 DCi alternator power cable.) The harness is part of the main cockpit harness. Component masses were 0.21 kg for the Silverado 1500 versus 0.16 kg for the Renault Master 2.3 DCi. The lightweighting technology used on the alternator power cable was to change the copper wire to aluminum wire and the PVC sheathing to PPO sheathing. Due to similarities in component design and material, full percentage of the Silverado 1500 alternator power cable mass reduction can be applied to the Renault. (Refer to Table 3-144).

IP Harness 1

(No image for the Renault Master 2.3 DCi IP harness 1.) The harness is part of the main cockpit harness. Component masses were 3.35 kg for the Silverado 1500 versus 2.40 kg for the Renault Master 2.3 DCi. The lightweighting technology used on the IP harness 1 was to change the copper wire to aluminum wire and the PVC sheathing to PPO sheathing. Due to similarities in component design and material, full percentage of the Silverado 1500 IP harness 1 mass reduction can be applied to the Renault. (Refer to Table 3-144).

IP Harness 2

(No image for the Renault Master 2.3 DCi IP harness 2.) The harness is part of the main cockpit harness. Component masses were 0.43 kg for the Silverado 1500 versus 0.31 kg for the Renault Master 2.3 DCi. The lightweighting technology used on the IP harness 2 was to change the copper wire to aluminum wire and the PVC sheathing to PPO sheathing. Due to similarities in component design and material, full percentage of the Silverado 1500 IP harness 2 mass reduction can be applied to the Renault. (Refer to Table 3-144).

Body and Rear End Wiring (Complete)

Shown in Image 3.18–27 are the Silverado 1500 and Renault Master 2.3 DCi body and rear end wiring (complete). Component masses were 2.17 kg for the Silverado 1500 versus 1.56 kg for the Renault Master 2.3 DCi respectively. The lightweighting technology used on the body and rear end wiring (complete) was to change the copper wire to aluminum wire and changing the PVC sheathing to PPO sheathing. Due to similarities in component design and material, full percentage of the Silverado 1500 body and rear end wiring mass reduction can be applied to the Renault. (Refer to Table 3-144).

DRAFT

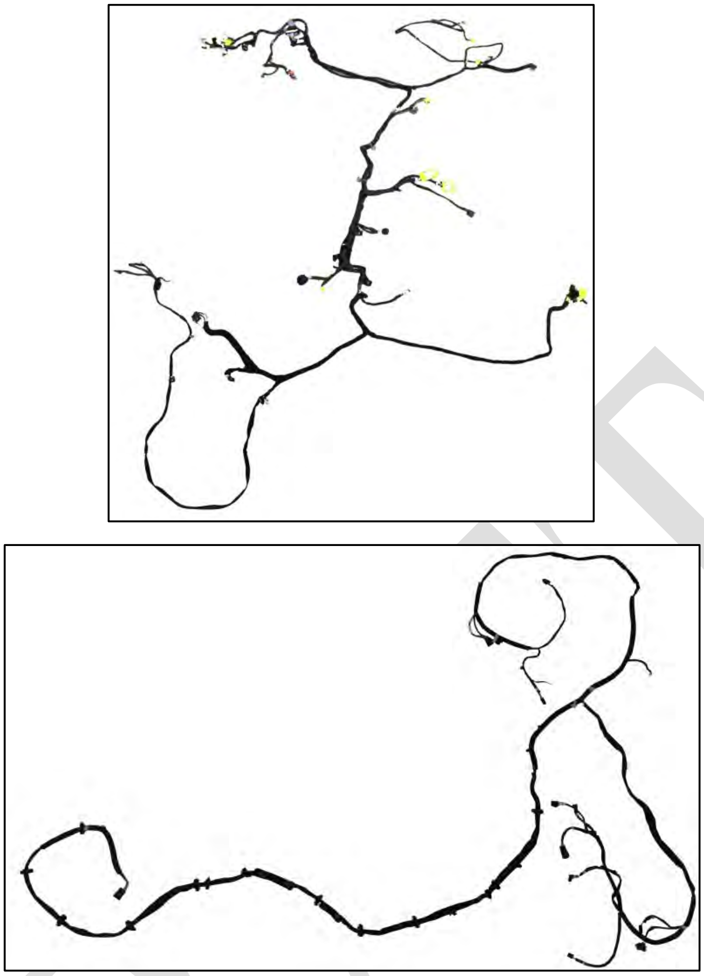


Image 3.18–27: Body and Rear End Wiring (Complete) for the Silverado 1500 and 2500 (Top) and Renault Master 2.3 DCi (Bottom)
(Source: FEV, Inc. and www.A2mac1.com)

Fuse Box (Support)

Shown in Image 3.18–28 are the Silverado 1500 and Renault Master 2.3 DCi fuse box (support). Component masses were 1.04 kg for the Silverado 1500 versus 0.70 kg for the Renault Master 2.3 DCi. The lightweighting technology used on the fuse box (support) was to change from steel to plastic and apply PolyOne® foaming agent. Due to similarities in component design and material, full percentage of the Silverado 1500 fuse box (support) mass reduction can be applied to the Renault. (Refer to Table 3-144).

DRAFT

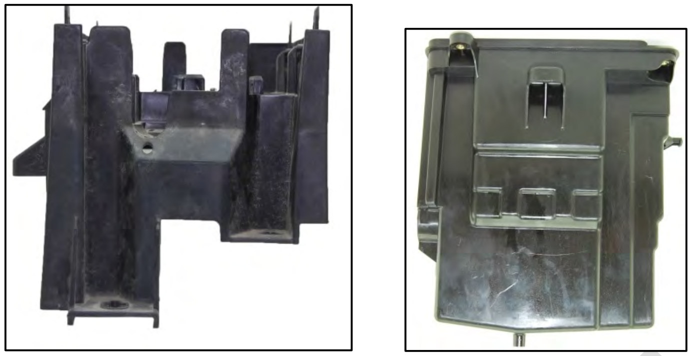


Image 3.18–28: Fuse Box (Support) for the Silverado 1500 and 2500 (Left) and Renault Master 2.3 DCi (Right)
(Source: FEV, Inc. and www.A2mac1.com)

<u>Fuse Box Cover</u>

Shown in Image 3.18–29 are the Silverado 1500 and Renault Master 2.3 DCi fuse box cover. Component masses were 0.45 kg for the Silverado 1500 versus 0.27 kg for the Renault Master 2.3 DCi. Both the Silverado 1500 and the Renault Master 2.3 DCi fuse box cover were similar in configuration. The lightweighting technology used in the fuse box cover was to change from steel to plastic and apply PolyOne® foaming agent Due to similarities in component design and material, full percentage of the Silverado 1500 fuse box cover mass reduction can be applied to the Renault. (Refer to Table 3-144).

Image 3.18–29: Fuse Box Cover for the Silverado 1500 and 2500 (Left) and Renault Master 2.3 DCi (Right)
(Source: FEV, Inc. and www.A2mac1.com)

<u>Headliner wiring</u>

Shown in Image 3.18–30 are the Silverado 1500 and Renault Master 2.3 DCi headliner wiring. Component masses were 0.47 kg for the Silverado 1500 versus 0.30 kg for the Renault Master 2.3 DCi. The lightweighting technology used on the headliner wiring was to change the copper wire to aluminum wire and the PVC sheathing to PPO sheathing. Due to similarities in component design and material, full percentage of the Silverado 1500 headliner wiring mass reduction can be applied to the Renault. (Refer to Table 3-144).

DRAFT

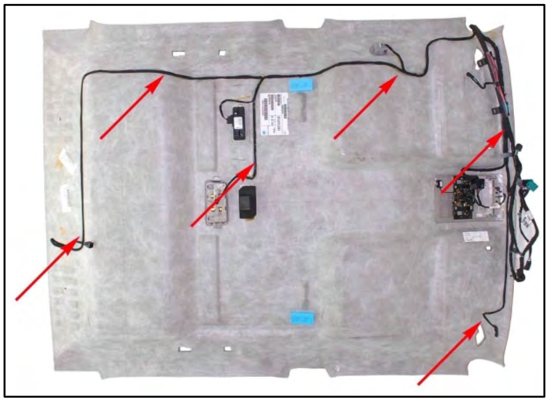
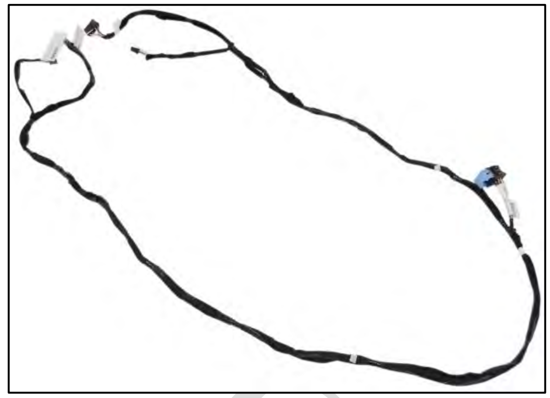



Image 3.18–30: Headliner wiring for the Silverado 1500 and 2500 (Left) and the Renault Master 2.3 DCi (Right)
(Source: FEV, Inc. and www.A2mac1.com)

<u>Front door harness</u>

Shown in Image 3.18–31 are the Silverado 1500 and Renault Master 2.3 DCi front door harnesses. Component masses were 0.83 kg for the Silverado 1500 versus 0.45 kg for the Renault Master 2.3 DCi. Both the Silverado 1500 and the Renault Master 2.3 DCi front door harness are similar in configuration. The lightweighting technology used on the front door harness was to change the copper wire to aluminum wire and the PVC sheathing to PPO sheathing. Due to similarities in component design and material, full percentage of the Silverado 1500 front door harness mass reduction can be applied to the Renault. (Refer to Table 3-144).

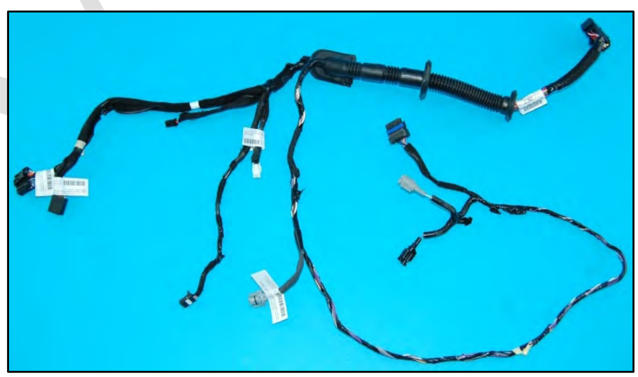



Image 3.18–31: Front door harness for the Silverado 1500 and 2500 (Left) and Renault Master 2.3 DCi (Right)
(Source: FEV, Inc. and www.A2mac1.com)

4. CONCLUSION

The primary project objective was to determine the minimum cost per kilogram for various levels of vehicle mass reduction for the medium-duty trucks/vans, up to and possibly beyond 20%. The selection criteria for the truck chosen for evaluation specified a mainstream vehicle in terms of design and manufacturing, with a substantial market share in the North American medium-duty truck market. Selecting a high-volume, mainstream vehicle increased the probability that the ideas generated and their associated costs would be applicable to other pickups trucks within the same market segment.

The Silverado 2500 total mass-reduction was 581.90 kg (18.86%). This increased cost by $2,372.16, or $4.08 per kg. Most of which came from the engine, transmission, body group a, suspension and brake systems. Mass-reduction came from changing the metals to a lighter version (i.e., cast iron to aluminum, or steel to aluminum and aluminum to magnesium). Other notable systems with mass-reductions are body group b, driveline, frame and mounting, and electrical power supply systems. Some systems had very little or no mass-reduction at all - body group c, climate control, lighting, clutch, in-vehicle entertainment, steering system and vacuum distribution systems. The steering system for example could not use the electric power steering system on the Silverado 1500 because it would affect function and performance of the baseline vehicle. Mass-reduction could not be achieved on these systems because technology did not apply and/or lightweighting of the materials were already implemented. Refer to Table 2-1 for details on each sub-system.

The Mercedes Sprinter 311 CDi total mass-reduction was 386.75 kg (18.15%). This increased cost by $2293.46, or $5.93 per kg. Most of which came from the engine, body group a, body group b, suspension, brakes and electrical power supply systems. The Body Group A had the single highest amount of mass-reduced, 248.99 kg, which came from changing the body sheet metal to aluminum. The biggest change with-in the suspension system came from the leaf spring assembly by changing from steel to glass fiber reinforced plastic. Other notable systems with mass-reductions include: transmission, driveline and electrical power supply. Some systems had no mass-reduction at all – frame and mounting, clutch, in-vehicle entertainment and vacuum distribution. The frame and mounting system for example could not use the lightweighting technologies used on the Silverado 1500 because they don't apply (i.e., Mercedes Sprinter does not have a full frame and the Silverado 1500 does). Refer to Table 2-3 for details on each sub-system.

The Renault Master 2.3 DCi total mass-reduction was 436.53 kg (18.55%). This increased cost by $2563.40, or $5.87 per kg. Most of which came from the engine, body group a, body group b, suspension and brake systems. Most of the mass-reduction came from changing the metals to a lighter version (i.e., cast iron to aluminum, or steel to aluminum and aluminum to magnesium). Other notable systems with mass-reductions include: transmission, driveline and electrical power supply. Some systems had no mass-reduction at all – frame and mounting, clutch, in-vehicle entertainment and vacuum distribution. The clutch system for example could not use lightweighting technologies used on the Silverado 1500 because they don't apply (i.e., Renault Master has a manual transmission and the Silverado 1500 has an automatic). Refer to Table 2-5 for details on each sub-system.

End of Document

DRAFT