DUCKER WORLDWIDE

Advancing Growth

EAA Aluminium penetration in cars Final Report

March 13, 2012

Public version

Introduction

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- The US arm of Ducker Worldwide has collected data on the growth and development of aluminium content in automotive light vehicle applications on a bi annual basis since 1991
- For the first time, in 2011, Ducker Europe began to collect similar data for cars in Europe
- The study was conducted in two phases
- The first Phase of the methodology had the scope to gather internal information from EAA members as well as of Ducker internal sources on the chosen components
- In Phase II interviews with parts makers and OEMs in Europe have been conducted in order to get all the missing information from Phase I, confirm or correct already existing data and clarify contradictions
- Data is collected on a “bottom-up” basis, meaning the market has been analysied on an OEM, platform-by-platform and product-by-product basis
- Primary research with OEMs, automotive suppliers, aluminum producers and other expert sources
- The contents of this report are not developed to be utilized as a “business planning document”; it was created with a trend line, marketing and public relations frame work to help educate the public on automotive applications of aluminum in Europe
- Information contained within this report should be considered “point in time;” and can change rapidly along with several external variables

Introduction

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Ducker examined all the components on this page for this study with a heavy concentration on the components in red which were chosen by the EAA members

Engines	Steering	Trim and Interiors	Transmissions	Body and Closures
Blocks	**Steering Knuckles**	**Sun roofs**	Automatic, CVT & Dual Clutch Transmission cases	**Complete body structures**
Cylinder heads	Column housings	Sport racks	Transfer Case	**Partial Body**
Oil pans	Rack & pinion housings	**Trim**	Power take off units	**Radiator supports**
Intake manifolds	Steering Wheels	Wiper Arms	Differential Carriers	**Instrument panel structures**
Pistons	Ball joint yokes	Wiper motor housings	Drive shafts	**Bumper beams**
Water pump housings	**Chassis and Suspension**	Sun roof motor housings	Yokes	**Crash boxes**
Alternator cases	**Control arms**	Starter motor housings	**Heat Transfer**	**Door intrusion beams**
Fuel rails	**Lateral links**	Seat motor housings	**Radiators**	**Front ends**
Front covers	**Sub-frames**	Seat pans	**Heater cores**	**Doors**
Bed plates	**Cross members**	Seat frames	**Transmission coolers**	**Hoods/bonnets**
Powertrain Mounts	**Cradles**	Seat tracks	**Condensers**	**Fender/wings**
Timing chain covers	**Wheels and Brakes**	Seat belt spools and retractors	**Evaporators**	**Deck lids/boots**
Accessory brackets	**Wheels**	Air bag canisters	**Compressors Housings**	**Lift gates**
Oil filter adapters	Brake calipers	Computer housings	**Compressor scrolls**	**Tailgates**
Cam covers	Master cylinders	Overhead rails	**Compressor pistons**	**Roofs**
Thermostat housings	Brake pistons	DVD enclosures	**Connection hardware**	**Shock towers**
Water outlet tubes	ABS housings	Running boards	**Oil coolers**	**Truck bed rails**
Valve Plates	Drums & rotors	Heat Sinks	**Receiver/dryers**	**Ladder Frames**
			Heat shields	

Introduction

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These 57 vehicles were chosen by the EAA members for detailed analysis

Segment	Example
A	Fiat 500(312)
	Fiat Panda(139)
B	Audi A1(AU210)
	Audi TT(AU324)
	Citroen C3 Picasso(A58)
	Citroen C3(A51)
	Lancia Ypsilon(846)
	Opel Meriva(GM S4470)
	Peugeot 208(A9)
	Renault Clio(X98)
	Toyota Yaris(850L)
	Volkswagen Up
	Volkswagen Polo(VW250)
C	Alfa Romeo Gulietta
	Audi Q3 (AU 316)
	Audi A3(AU370)
	BMW 1 (F20)
	Citroen C4(B7)
	Ford C-Max(C344)
	Ford Focus(C346)
	Ford Kuga
	Honda Civic(2HC)
	Jaguar XK(X150)
	Land Rover Range Rover Evoque(L538)
	Mini Countryman(R60)
	Opel Astra(GM P3400)
	Opel Zafira(GM A3370)
	Peugeot 5008(T87)
	Renault Megane(X95)
	Volkswagen Golf(VW370)
	Volkswagen Touran(VW368)
	Volvo C30(Y279)
	Volvo XC60(Y413)

Segment	Example
D	Audi A4(AU481)
	Audi Q5(AU416)
	BMW 3 (F30)
	Mercedes-Benz B-Class(W246)
	Mercedes-Benz C-Class(W204)
	Opel Insignia(GM G3700)
	Peugeot 508(W2)
	Porsche Panamera(970)
	Volkswagen Passat(VW471)
	Volvo S60(Y283)
E	Audi A6(AU571)
	Audi A7(AU573)
	Audi A8(AU641)
	Audi Q7(AU716)
	BMW 5 (F10)
	BMW 7 (F01/02)
	Jaguar XF(X250)
	Jaguar XJ(X351)
	Land Rover Ranger Rover (L405)
	Mercedes-Benz E-Class(W212))
	Mercedes-Benz S-Class(W221)
	Mercedes-Benz-S-Class (W222)
	Porsche Cayenne(E2)
	Volkswagen Touareg(VW526)

7,646,770 Vehicles
Representing 44.4%
of the 2012 EU forecast

Introduction

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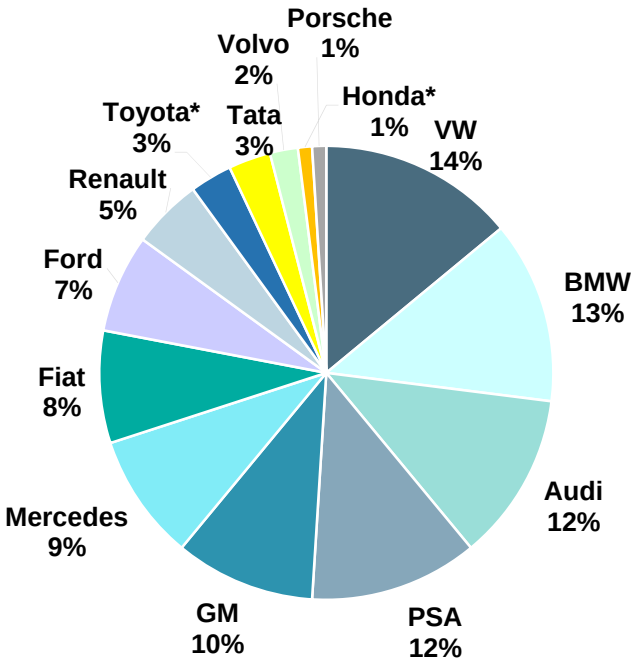
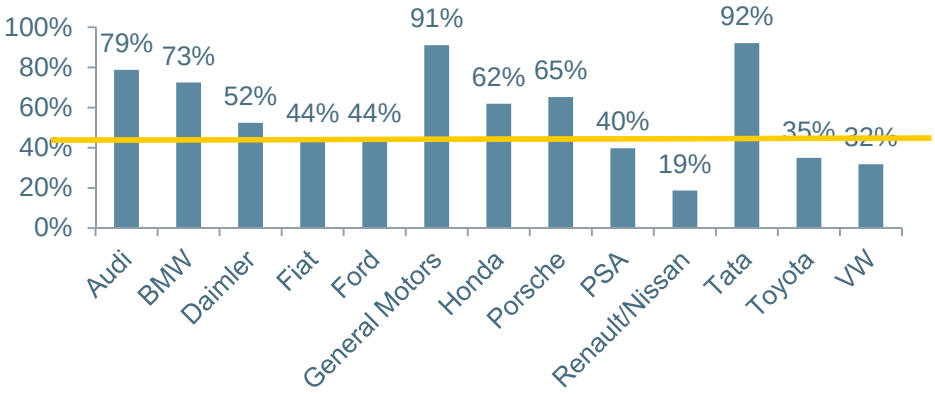
One half of the total production of these OEMs is represented by the sample

2012 Sample Vehicles Segmented by OEM



Sample Share of Total 2012 Units for These OEMs



OEM	Sample Units	OEM	Sample Units
BMW	975,403	Honda Civic	111,766
GM	783,274	Volvo	190,899
Audi	937,560	Porsche	81,670
Mercedes	698,611	Tata	187,188
PSA	929,086	Volkswagen	1,041,596
Fiat	573,868	Ford	553,987
Renault	361,472	Toyota Yaris	220,390
		Grand Total	7,646,770

7,646,770 Sample Vehicles

** only one vehicle in the sample*

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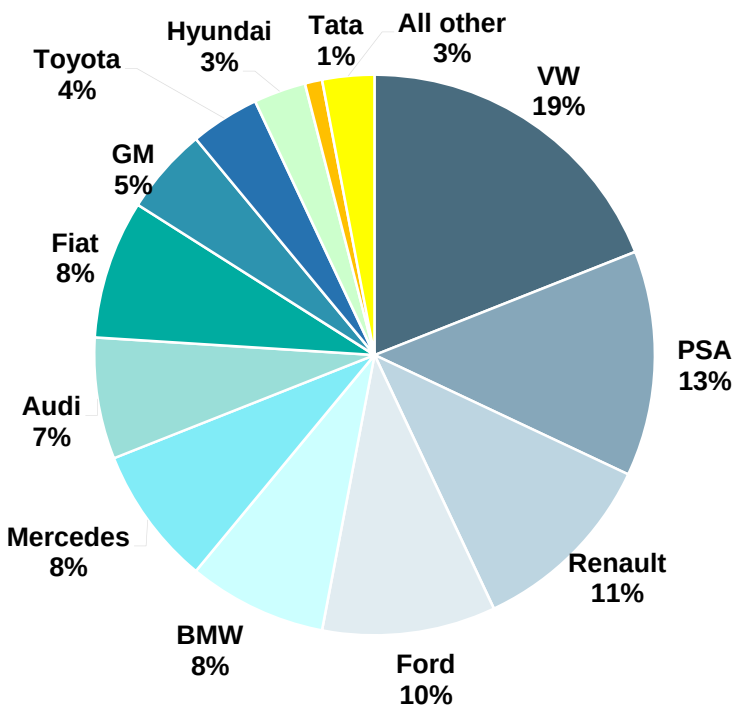
2012 EU Forecast



17,233,811 EU 27 Vehicles in 2012

- Ideally we would have put 50% of each OEMs anticipated 2012 production into the sample
- This does not take into account the selection criteria of picking only recently launched vehicles. 96% of the sample was launched in the last 62 months
- On this basis, the sample contains 56% of all the vehicles launched in the EU in the last 62 months

	Sample Share	Total EU Share
VW	**14%**	**19%**
BMW	**13%**	**8%**
Audi	**12%**	**7%**
PSA	12%	13%
GM	**10%**	**5%**
Mercedes	9%	8%
Fiat	8%	8%
Ford	7%	10%
Renault	**5%**	**11%**
Toyota	3%	4%
Tata	3%	1%
All Other	4%	6%

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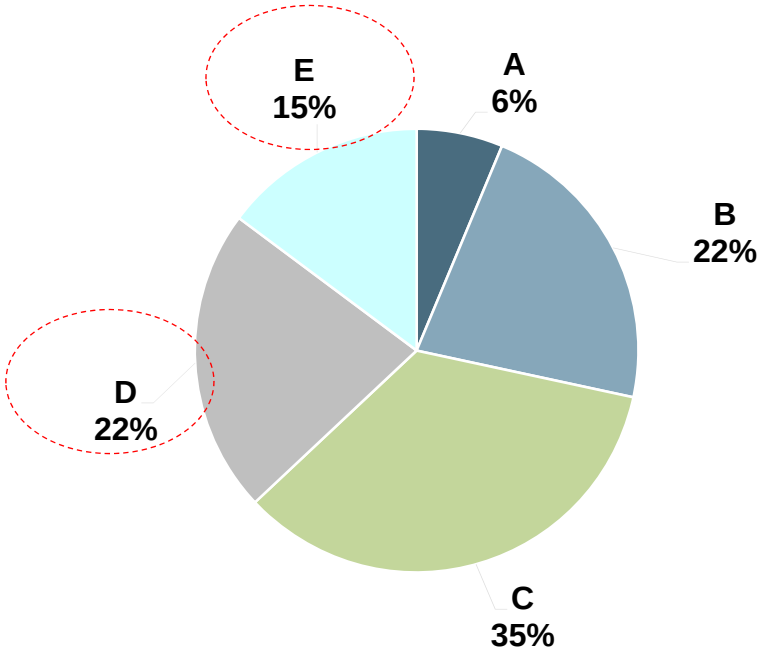
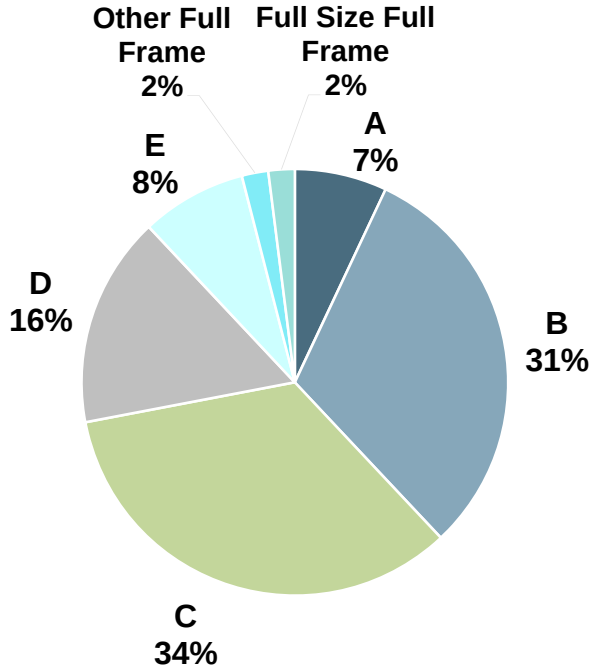
When compared to total 2012 EU light production, the sample is over weighted with D & E segment vehicles. The sample does not contain any full frame vehicles. These decisions had a negative effect on the total EU aluminum content versus the sample

Sample Vehicles
Split by Segment



7,646,770 Vehicles

Total EU Vehicles
Split by Segment



17,232,935 Vehicles

Executive Summary

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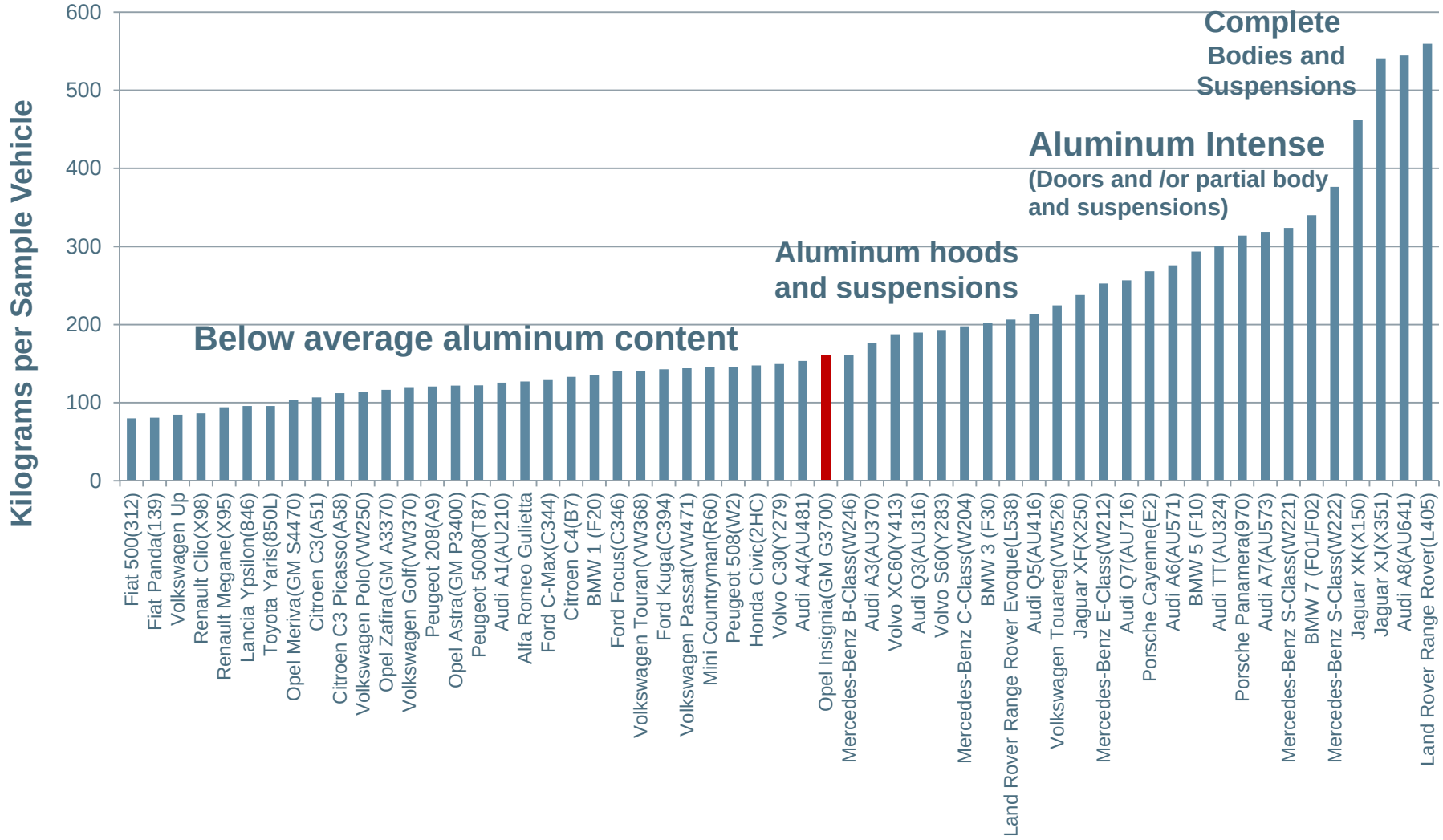
Aluminum content ranges from 74.5 kg for the Fiat 500 to 561 kg for the Land Rover Range Rover. The average is 160 kg for the sample vehicles



Executive Summary

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A-Segment	2012 Units	kg/vehicle
Fiat Panda(139)	237196	**75.5**
Fiat 500(312)	169151	74.5
B-Segment		
Audi TT(AU324)	22336	**269.7**
Citroen C3 Picasso(A58)	71610	150.6
Peugeot 208(A9)	295702	124.3
Audi A1(AU210)	145125	119
Volkswagen Polo(VW250)	383198	102.3
Opel Meriva(GM S4470)	143234	102.8
Citroen C3(A51)	202748	109.1
Volkswagen Up	74964	86.2
Toyota Yaris(850L)	220390	96
Renault Clio(X98)	115943	98.2
Lancia Ypsilon(846)	88315	78
D-Segment	**2012 Units**	**kg/vehicle**
Porsche Panamera(970)	26700	**306.9**
Audi Q5(AU416)	117353	228
BMW 3 (F30)	369718	198.4
Mercedes-Benz C-Class(W204)	199313	202.9
Volvo S60(Y283)	68630	184.3
Mercedes-Benz B-Class(W246)	164117	166
Peugeot 508(W2)	134499	175.6
Volkswagen Passat(VW471)	260689	147.1
Opel Insignia(GM G3700)	134708	148.6
E-Segment	**2012 Units**	**kg/vehicle**
Land Rover Range Rover(L405)	19717	**561.3**
Jaguar XJ(X351)	19169	546.3
Audi A8(AU641)	42681	538.2
Mercedes-Benz S-Class(W222)	6224	388.0
BMW 7 (F01/F02)	59088	353.4
Mercedes-Benz S-Class(W221)	53061	331.7

C-Segment	2012 Units	kg/vehicle
Jaguar XK(X150)	5304	**453**
Land Rover Range Rover Evoque(L538)	99447	194.5
Volvo XC60(Y413)	100246	203.7
Audi Q3(AU316)	91888	200.9
Audi A3(AU370)	43994	169.6
Audi A4(AU481)	222021	139
Volvo C30(Y279)	22023	151.8
Honda Civic(2HC)	111766	141.3
Citroen C4(B7)	150235	133.7
BMW 1 (F20)	216375	114.6
Mini Countryman(R60)	98413	165.5
Volkswagen Touran(VW368)	109670	141.4
Ford Kuga(C394)	46099	129.3
Ford C-Max(C344)	131666	133.9
Alfa Romeo Gulietta	79206	112.5
Ford Focus(C346)	376222	131.9
Peugeot 5008(T87)	73892	109.5
Opel Zafira(GM A3370)	140453	130.3
Volkswagen Golf(VW370)	140323	126.8
Opel Astra(GM P3400)	364879	106.3
Renault Megane(X95)	245529	105.1
E-Segment	**2012 Units**	**kg/vehicle**
Audi A7(AU573)	33007	322.3
BMW 5 (F10)	231809	307.3
Audi A6(AU571)	168436	287.0
Porsche Cayenne(E2)	54970	279.4
Audi Q7(AU716)	50719	263.2
Mercedes-Benz E-Class(W212)	275896	254.3
Jaguar XF(X250)	43551	238.5
Volkswagen Touareg(VW526)	73152	219.2
Total	7,646,770	**160.1**

Executive Summary

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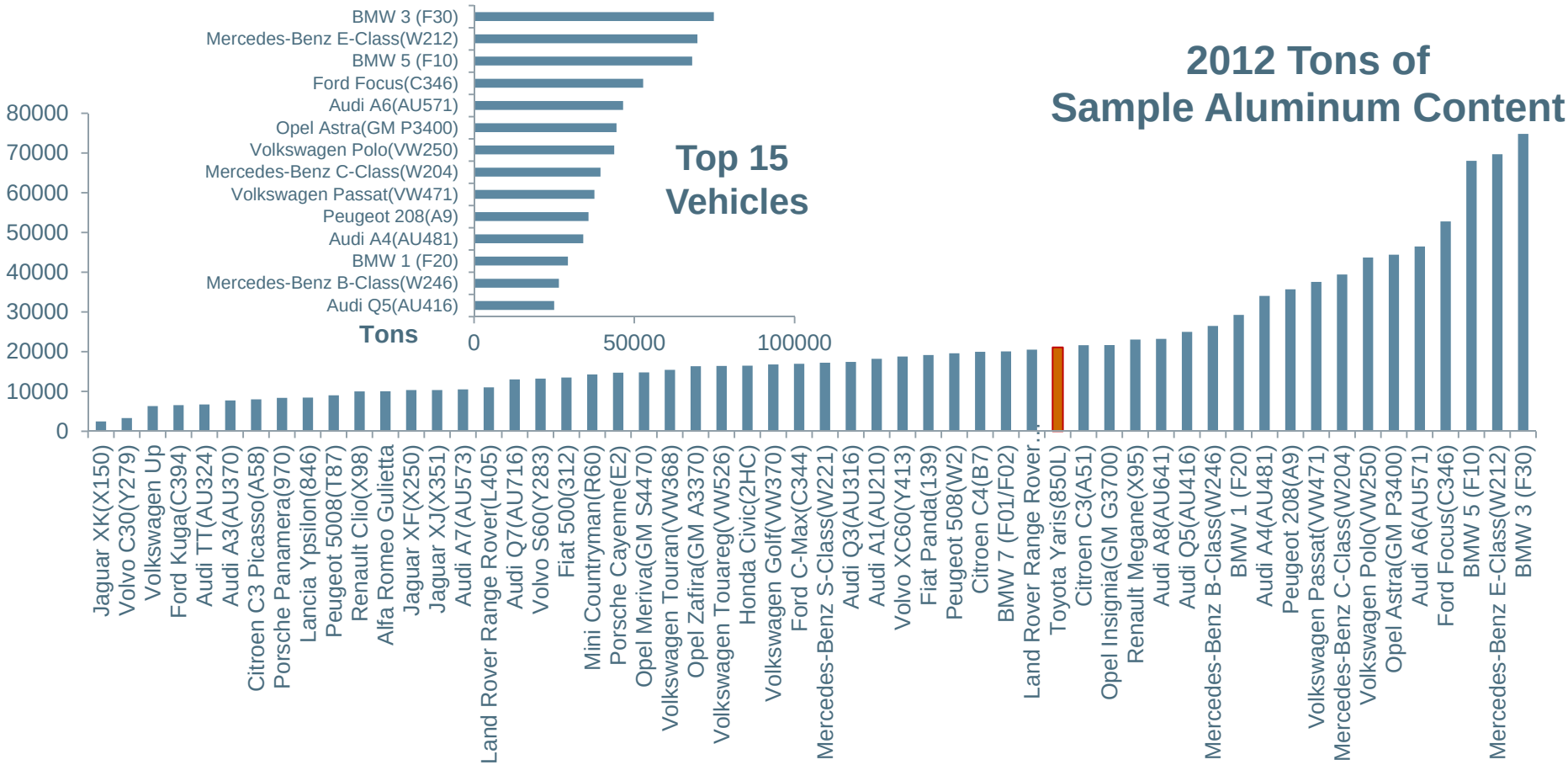
The 2012 sample aluminum content is 1.224 million tons. The BMW 3 Series, BMW 5 Series and the Mercedes E Class are 17% of the total. 15 vehicles represent over 50% of all the sample tons. Total EU 27 aluminum content is estimated to be 2.4 million tons. The sample contains 52% of the total EU 27 content



Executive Summary

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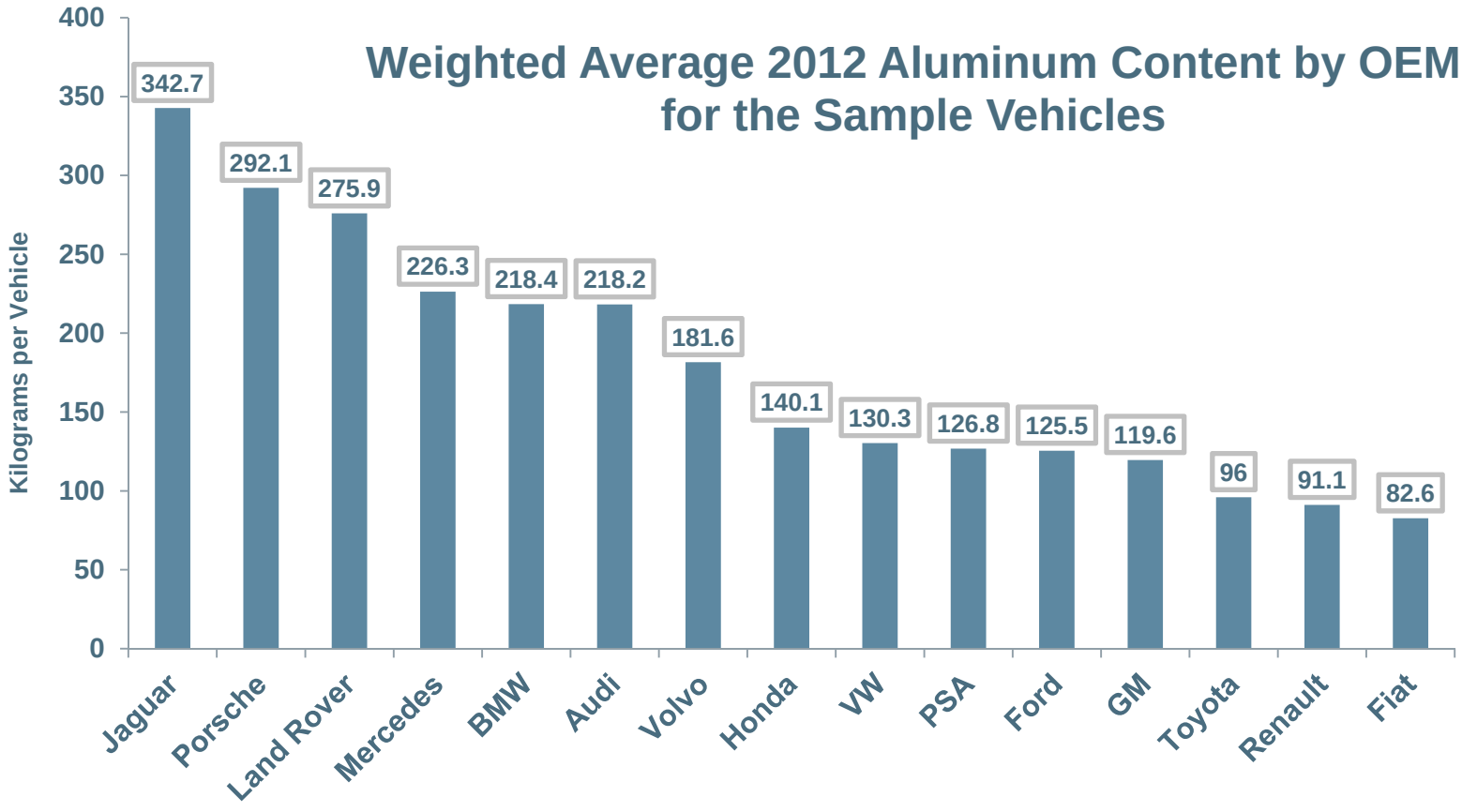
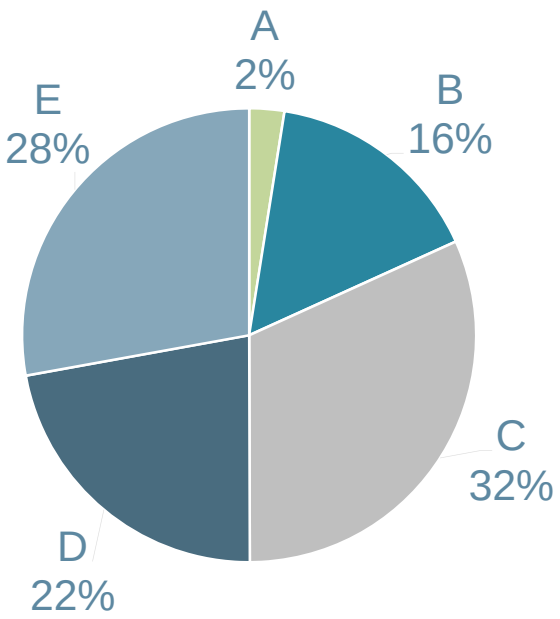
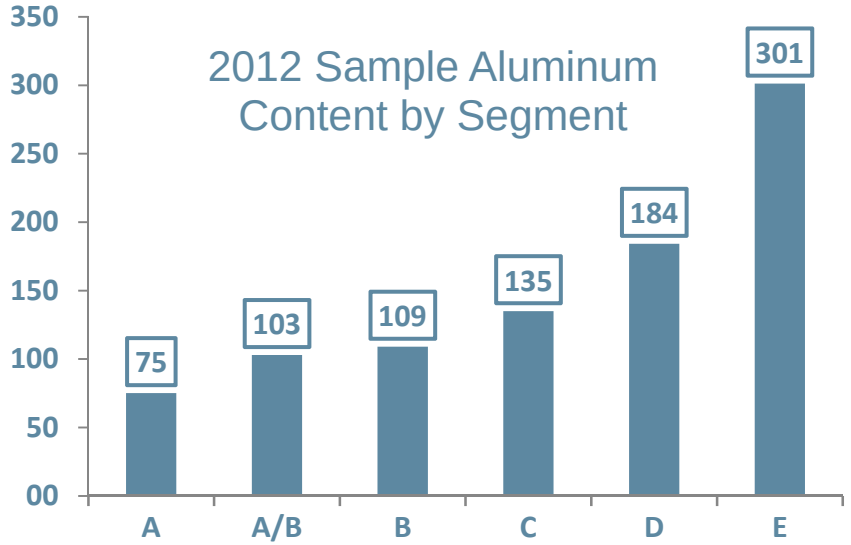
Jaguar is the aluminum content leader in the sample. Fiat has the lowest aluminum content. Ducker believes that with the proper mix adjustment, these estimates, with the possible exception of Renault, are representative of each OEM's total 2012 production



Executive Summary

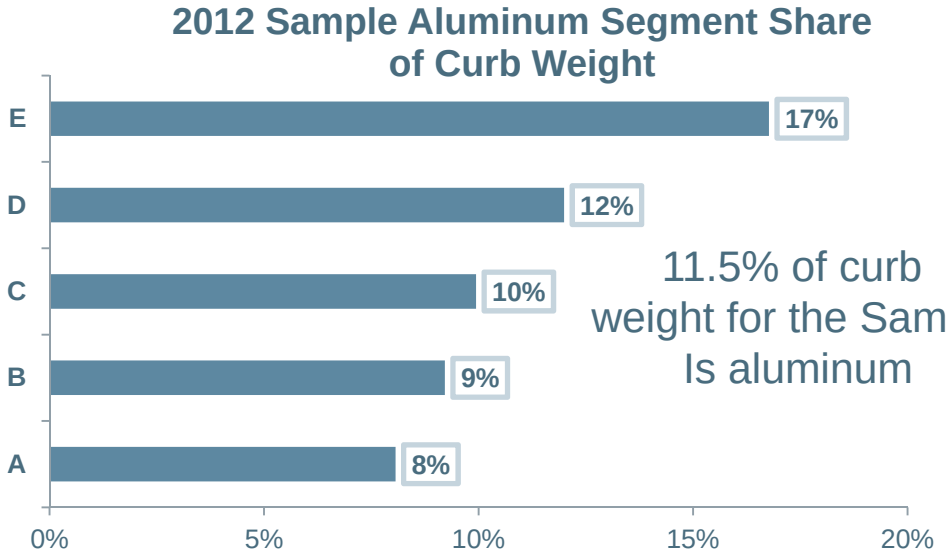
DUCKER WORLDWIDE





1.22 million tons or 160.1 kg per vehicle of aluminum content for the whole sample by segment

Segment	Curb Weight kg	Aluminum kg	Percent
A	930	75	8%
B	1183	109	9%
C	1358	135	10%
D	1534	184	12%
E	1795	301	17%



11.5% of curb weight for the Sample Is aluminum

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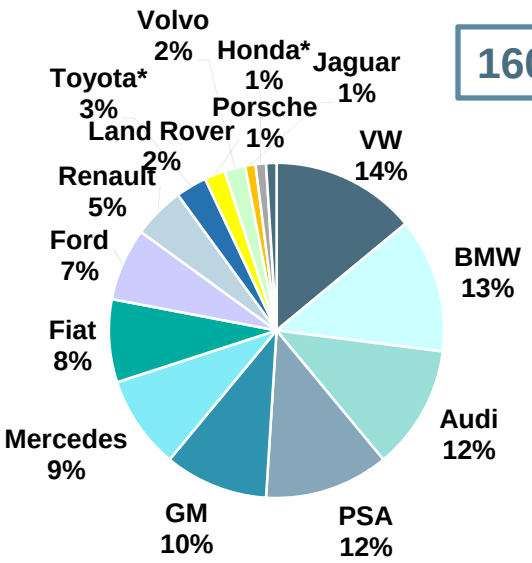
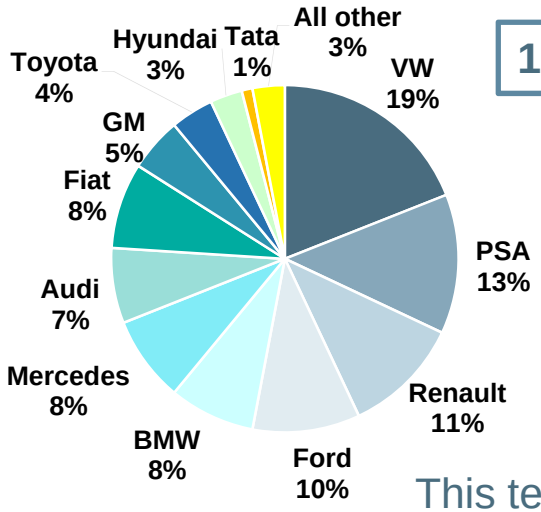
2012 Sample



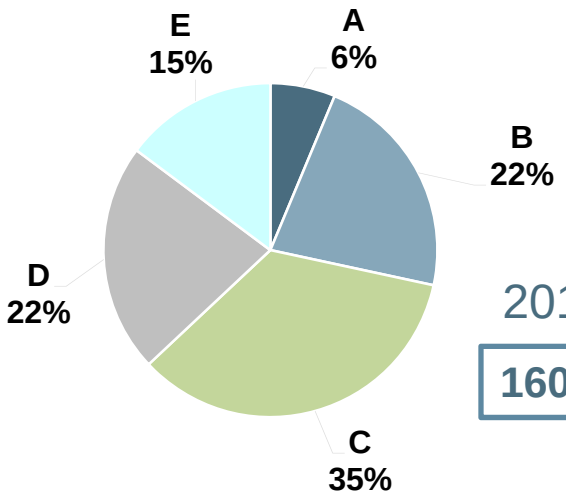
160kg/vehicle

Applying the sample content per OEM to the total EU production yields

2012 Total EU



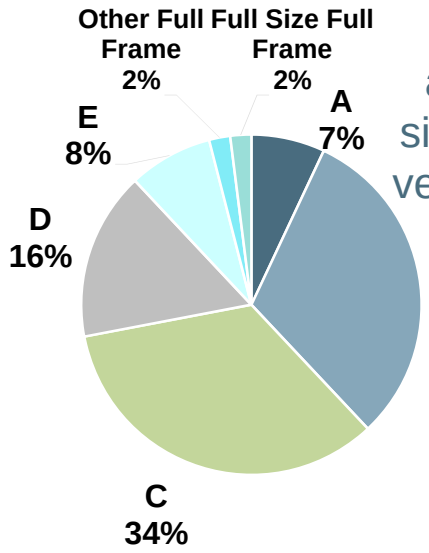
144 kg/vehicle



Applying the sample content per segment to the total EU production yields

2012 Sample

160Kg/vehicle



2012 Total EU

145kg/vehicle

This tells us that most of the difference between the sample and the EU total was simply due to OEM and vehicle mix not content

Executive Summary

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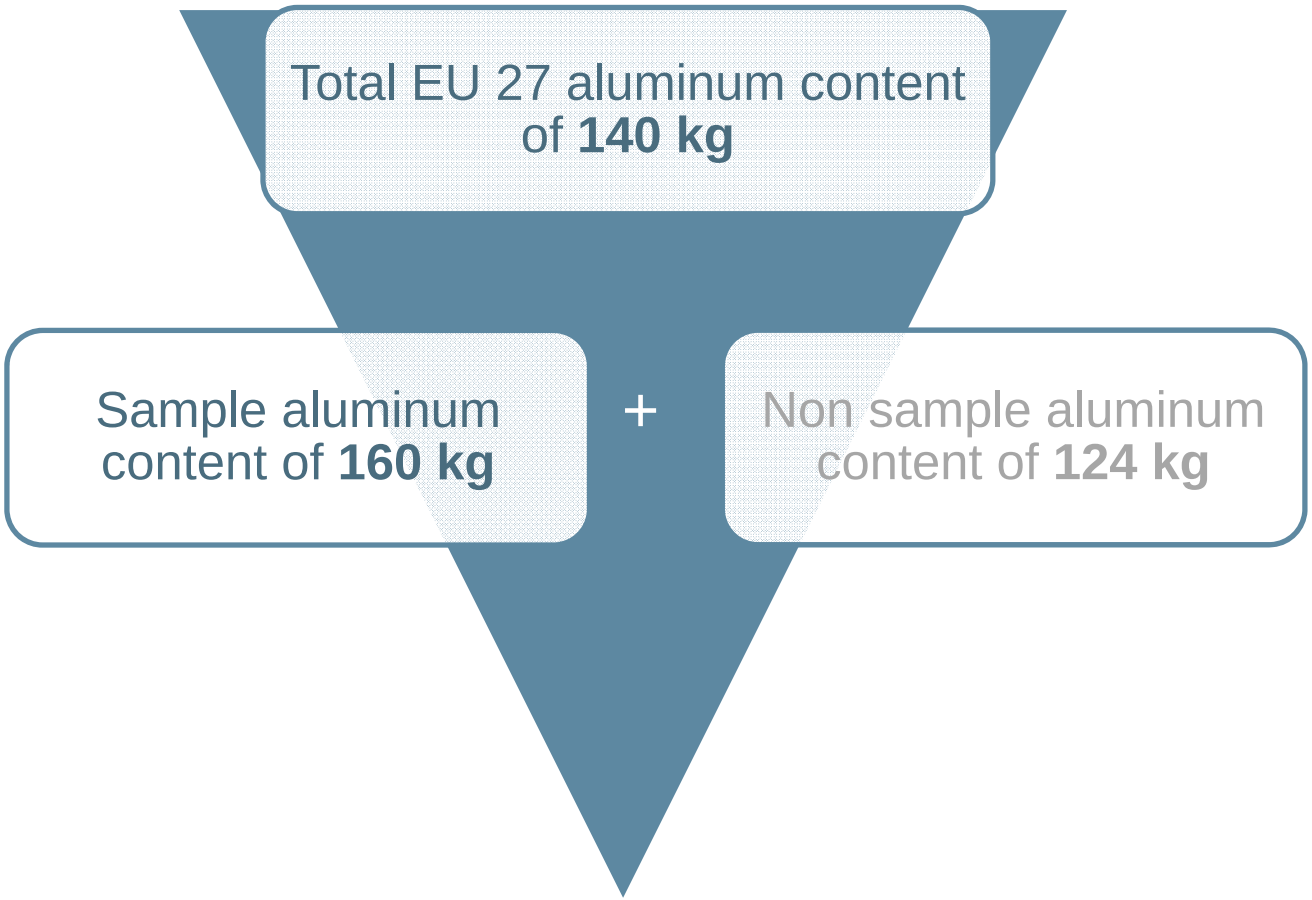
The non sample vehicles contain 24% less aluminum per vehicle than the sample vehicles. This is due primarily to OEM and mix differences, not content differences by segment for the sample and for the total production



Executive Summary

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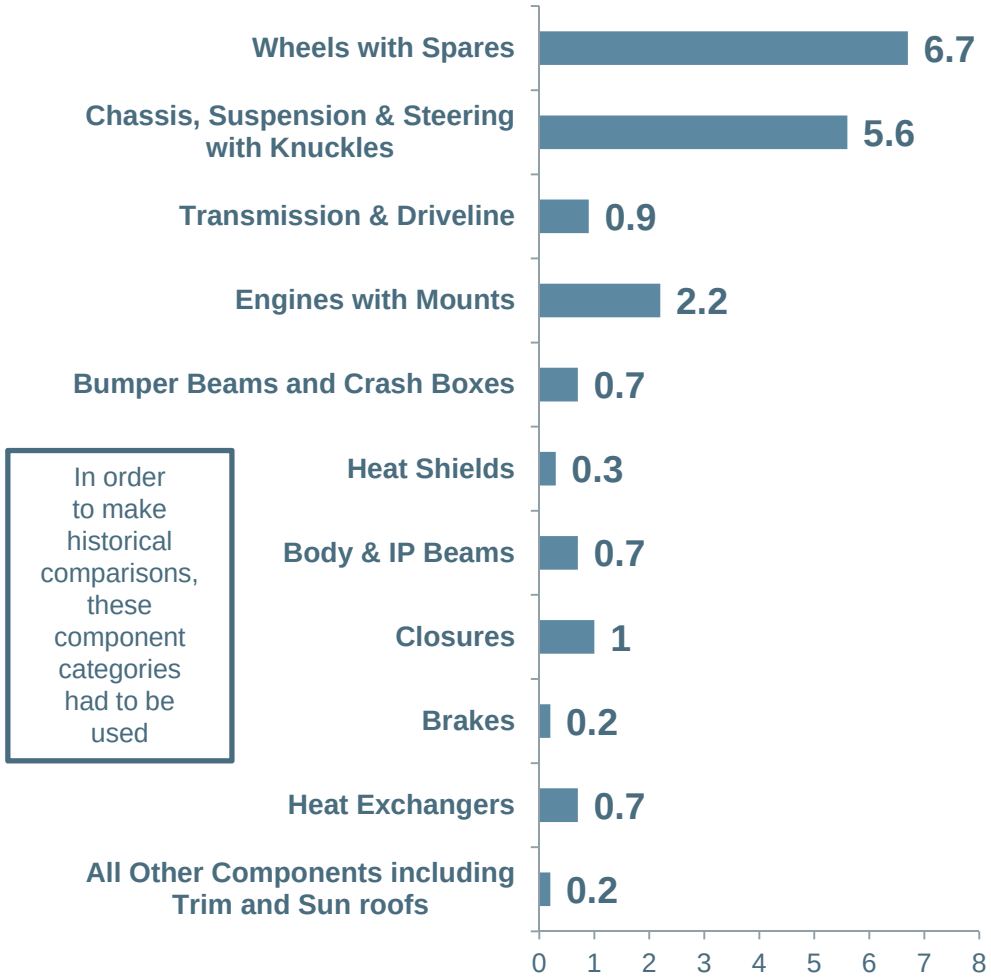
2006 - 2012 EU Aluminum (kg) Content Increase



In order to make historical comparisons, these component categories had to be used

- The total increase in EU light vehicle aluminum content from 2006 to 2012 is estimated at 19.2 kg
- The increase in aluminum content over the same period in North America is estimated at only 13 kg. This is 50% of the aluminum growth experienced in North America in the period 2000 to 2006
- 40% of the aluminum part growth (excluding wheels) in the sample is structural components. Currently, the EU leads the world in the use of high tech aluminum automotive components

Summary by Segment

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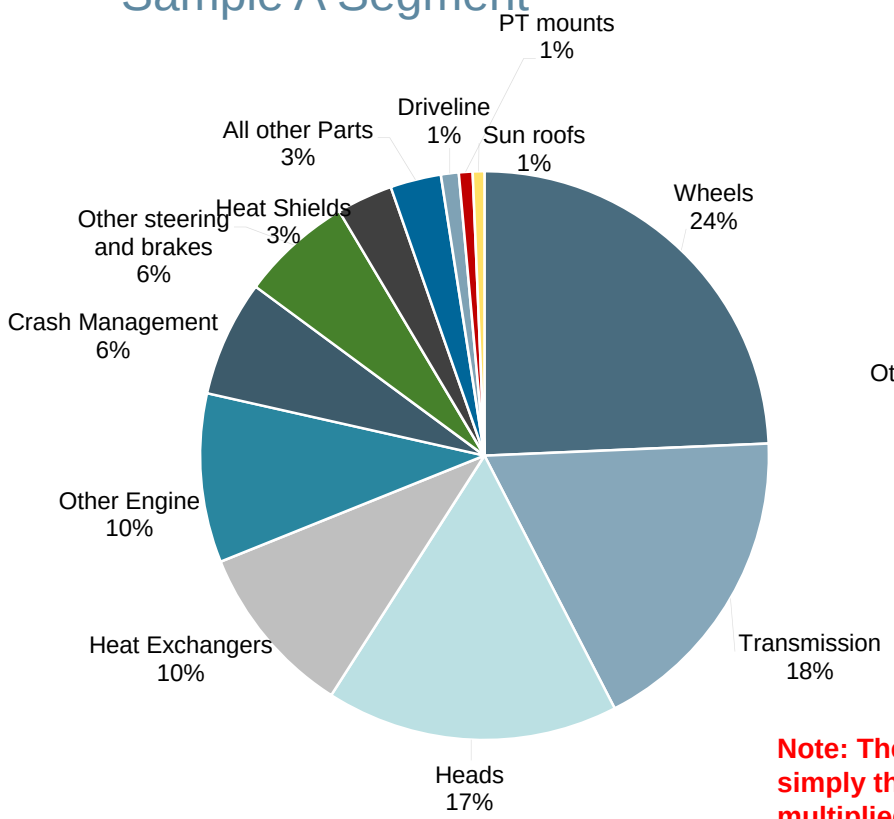
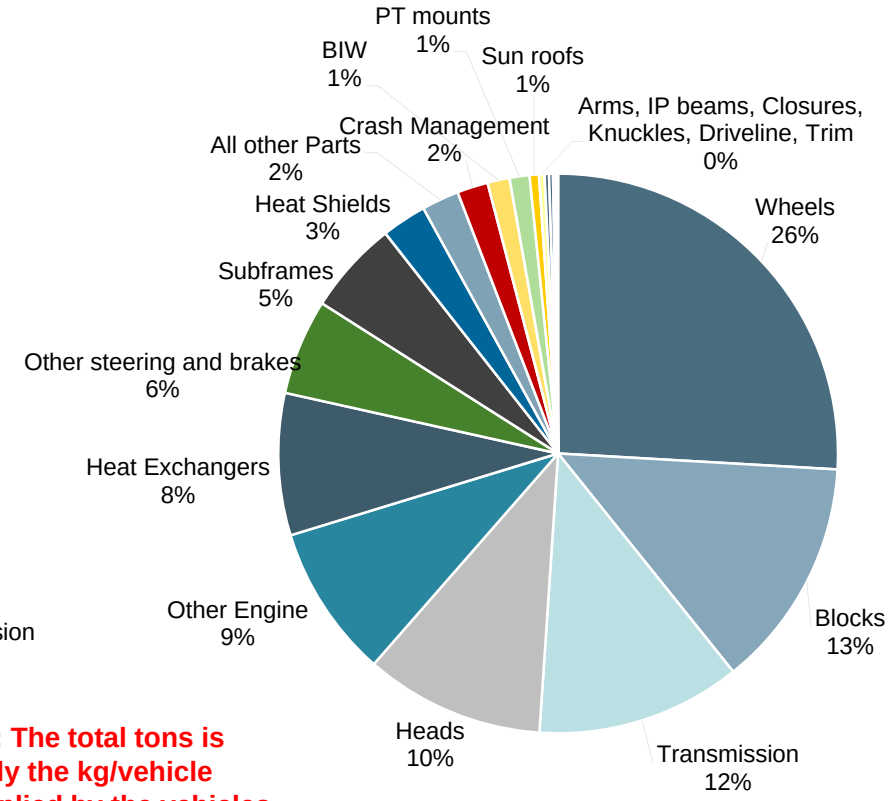
Sample A Segment



30.5 Thousand tons or 75.1 kg per vehicle of aluminum in the A Segment

Sample B-Segment



192.5 Thousand tons or 109 kg per vehicle of aluminum in the B Segment

Note: The total tons is simply the kg/vehicle multiplied by the vehicles in the sample or the total EU production whichever is appropriate

Summary by Segment

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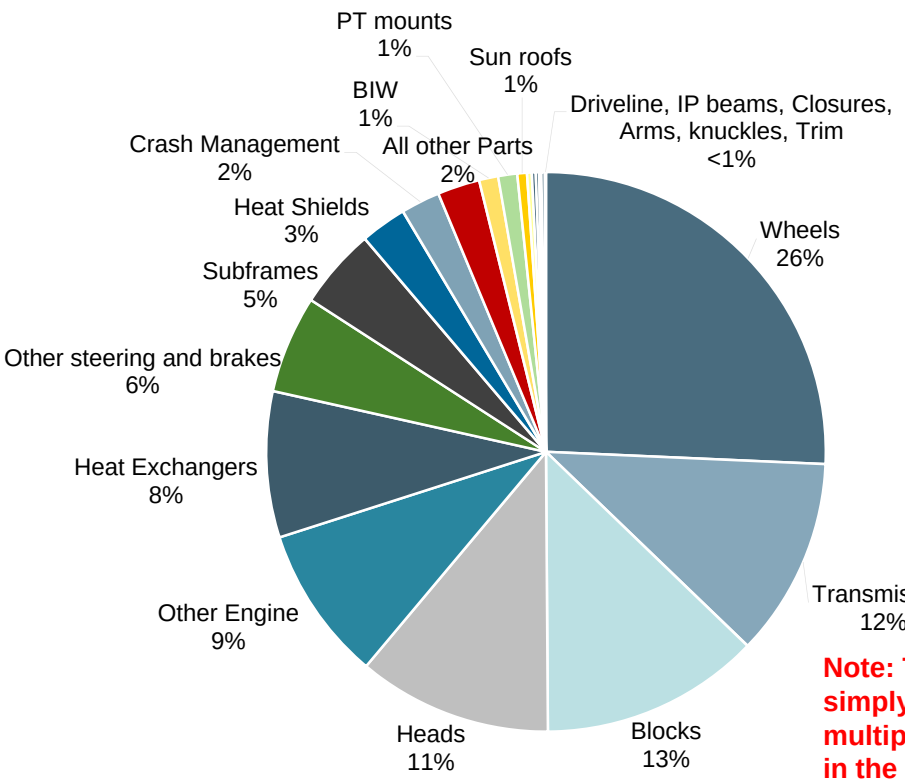
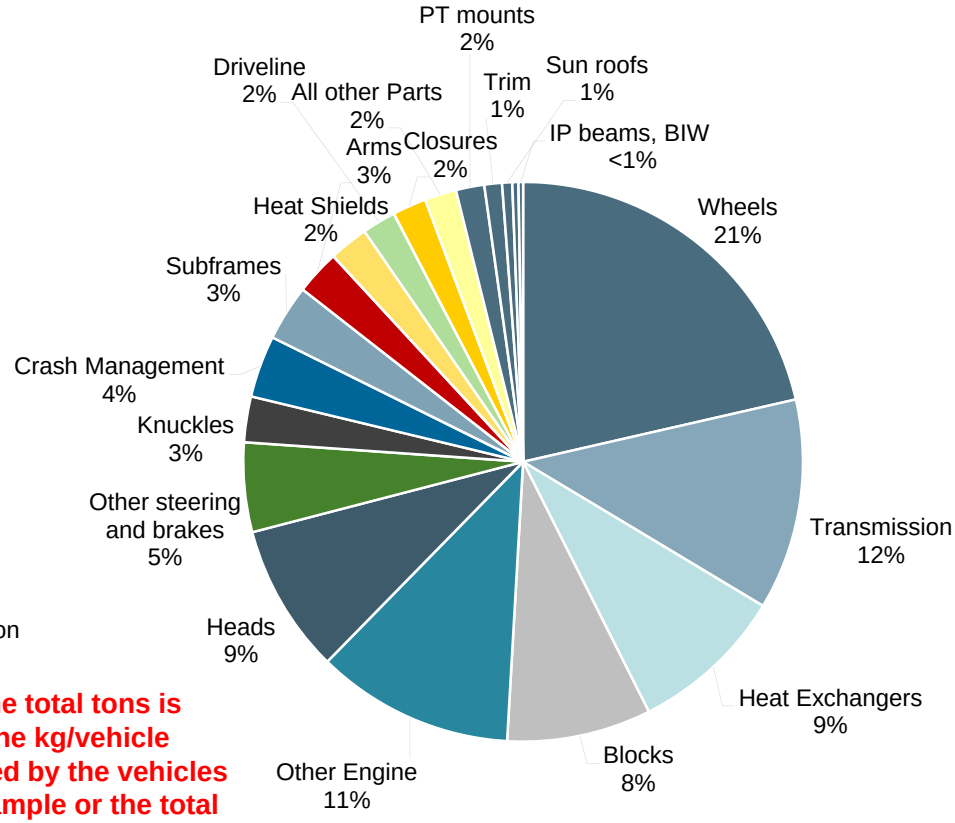
Sample A/B-Segment



Sample C-Segment



Note: The total tons is simply the kg/vehicle multiplied by the vehicles in the sample or the total EU production whichever is appropriate

223.1 Thousand tons or 103 kg per vehicle of aluminum in the A/B Segment

388.3 Thousand tons or 135.3 kg per vehicle of aluminum in the C Segment

Summary by Segment

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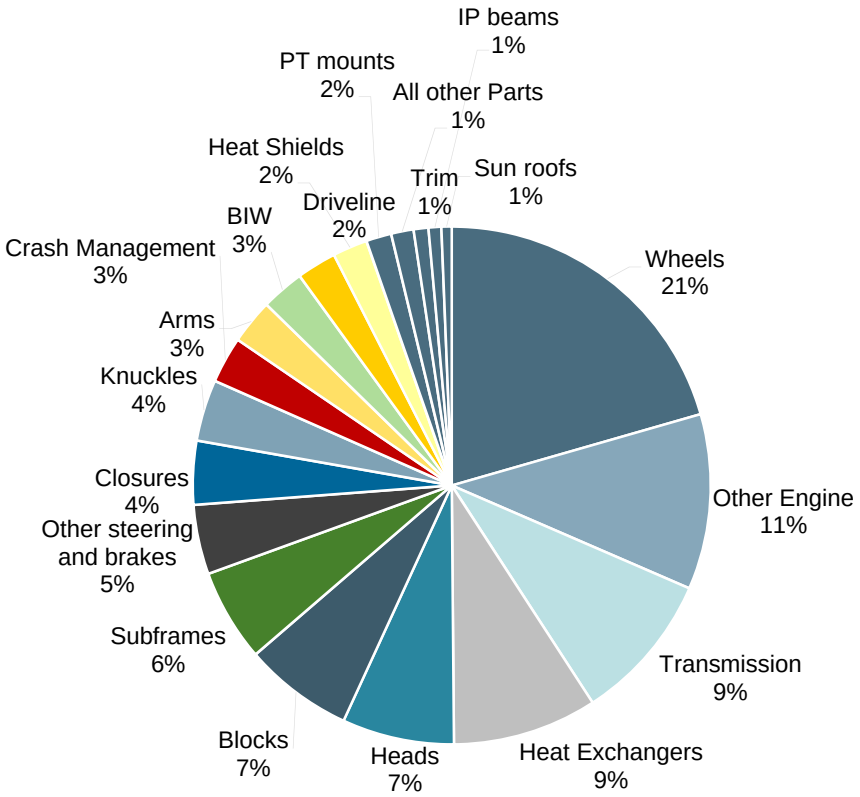
Sample D-Segment



271.8 Thousand tons or 184.2 kg per vehicle of aluminum in the D Segment

Note: The total tons is simply the kg/vehicle multiplied by the vehicles in the sample or the total EU production whichever is appropriate

- The D segment in Europe is very similar in aluminum content to the D/E segment in North America.
- This segment is12% aluminum as a share of curb weight
- 50% of the vehicles have aluminum hoods and bumpers, and some vehicles have partial aluminum body structures
- Aluminum content in this segment is ripe for continued growth.

Summary by Segment

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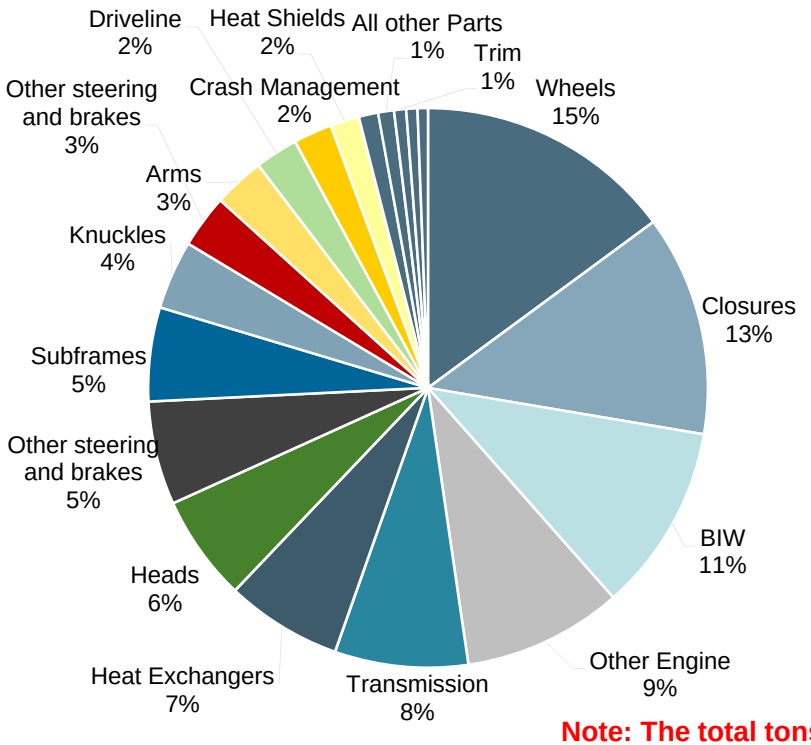
Sample E Segment



340.9 Thousand tons or 301.3 kg per vehicle of aluminum in the E Segment

Note: The total tons is simply the kg/vehicle multiplied by the vehicles in the sample or the total EU production whichever is appropriate

- In totality, the E Segment is not the most important segment going forward, but for the last 15 years it has been the global benchmark for new aluminum structural applications in autos
- The average content for the sample and for the entire segment is near 300kg per vehicle
- Only U.S. pickup trucks as a vehicle segment are likely to ever rival this European segment for aluminum content
- 40% of the components in this segment, not including wheels, are high tech structural parts
- At 17% of curb weight, aluminum penetration is nearing the practical limit in this segment

Summary by Segment

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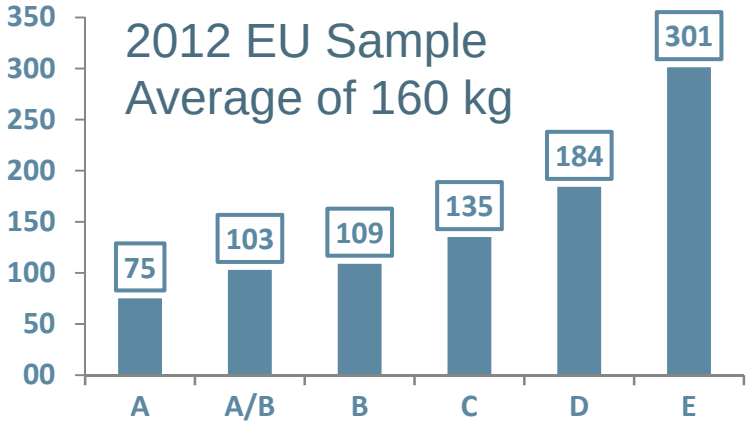
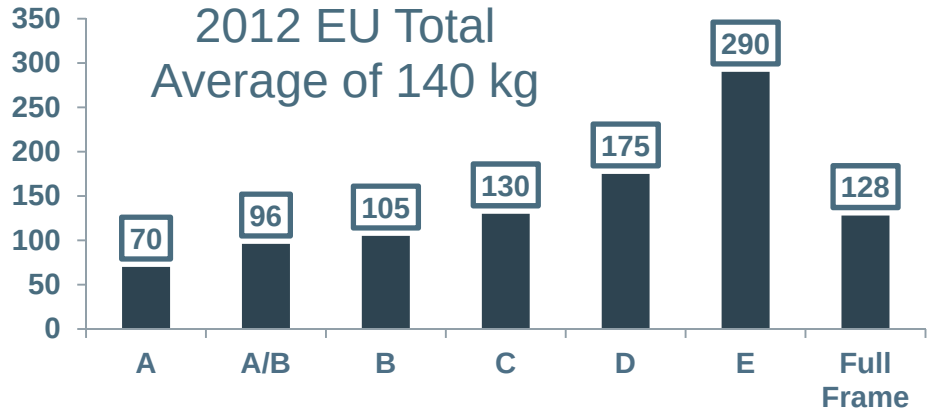
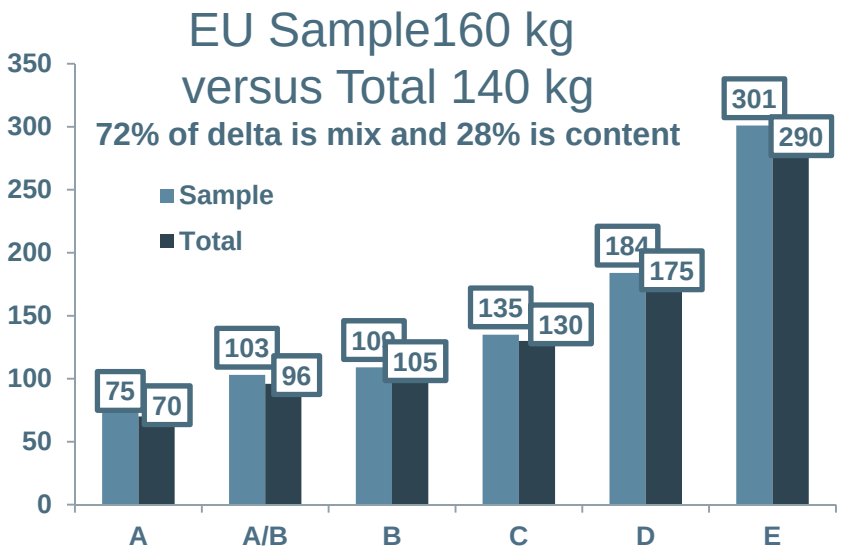
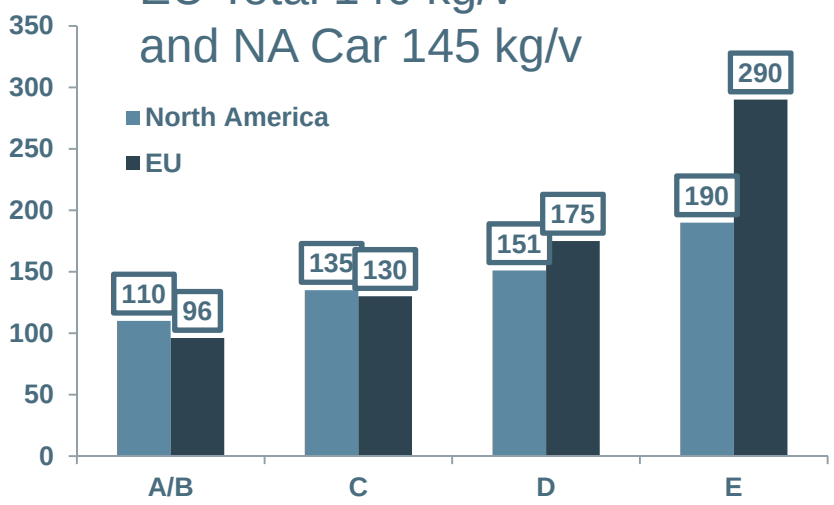
With the exception of the E Segment, the sample average segment content differences versus total EU and versus other regions are minimal compared to the OEM mix differences which cause most of the variation





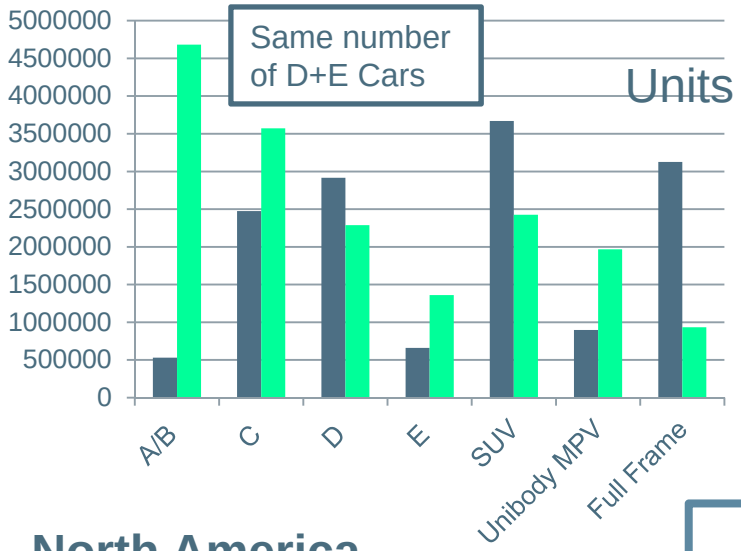


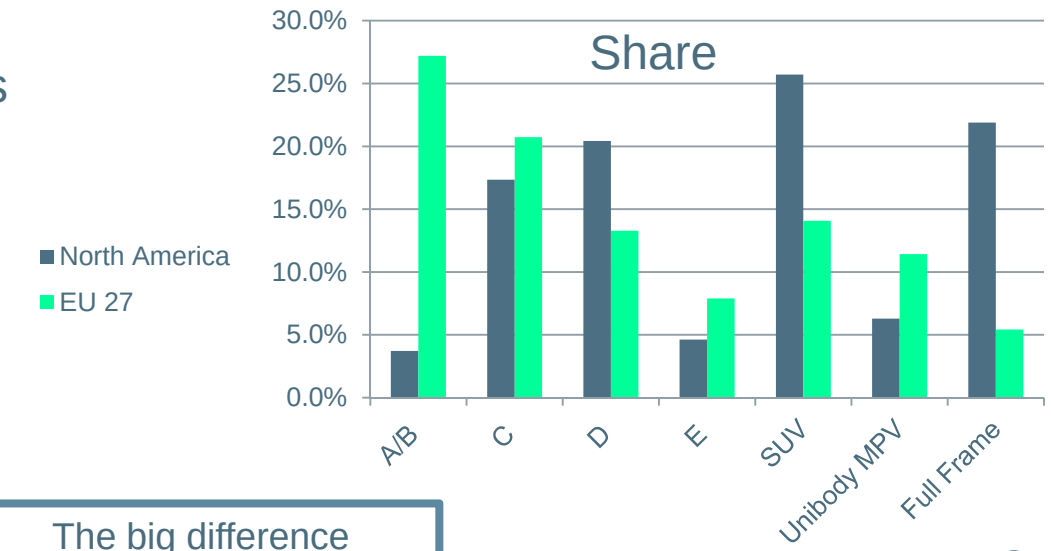


Summary by Segment

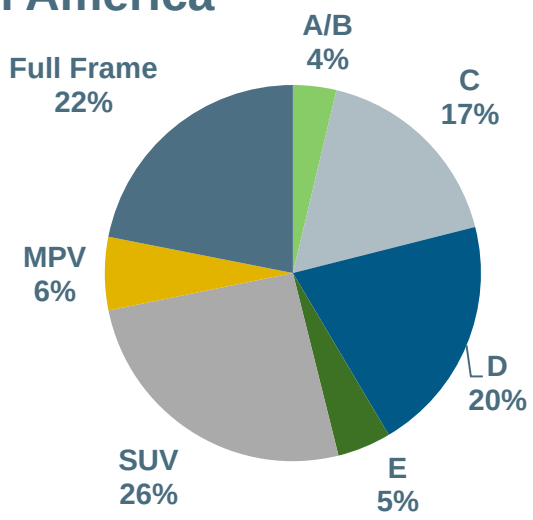
DUCKER WORLDWIDE

A look at the segment differences between Europe and North America



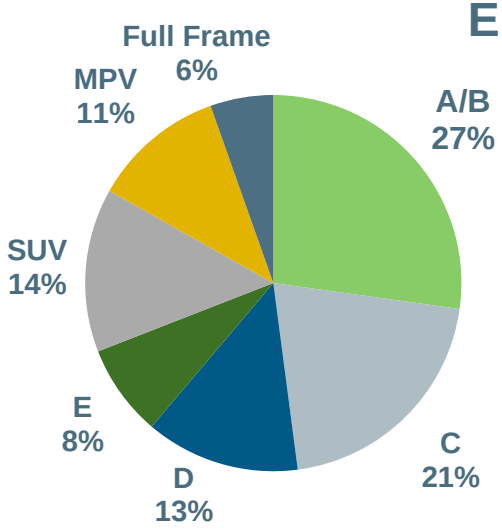


North America



The big difference between European and North American light vehicle mix is the large share of A/B vehicles in Europe and the high share of D Segment and SUVs in North America. The big difference between the full frame use is not relevant for this study

EU 27



Product Form Analysis

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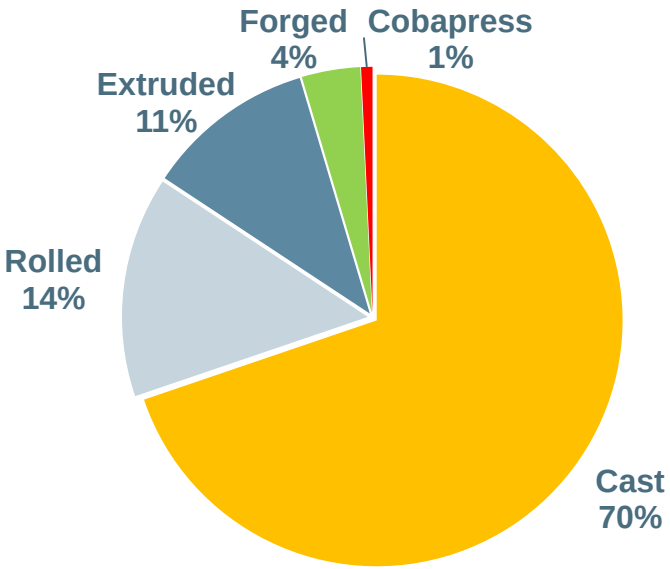
Rolled, extruded and forged wrought products were a surprisingly high 30% share of the total aluminum content in the sample. These product forms are estimated to be 27% of the total content of 2.4 million aluminum content tons

Product Forms for the
Sample of 7.65 Million Vehicles



1.22 Million Tons of aluminum for the sample segmented by product form

Product Form Analysis

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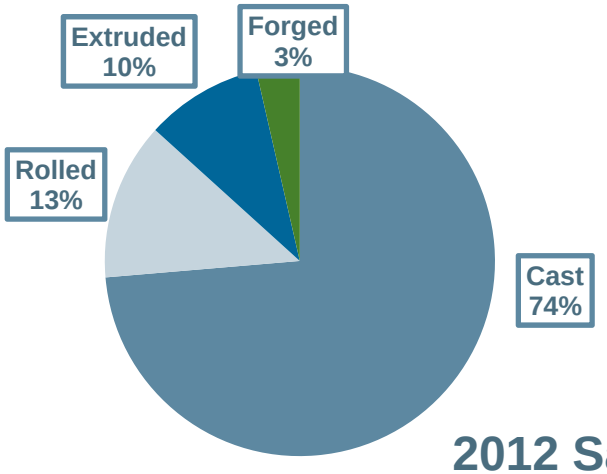
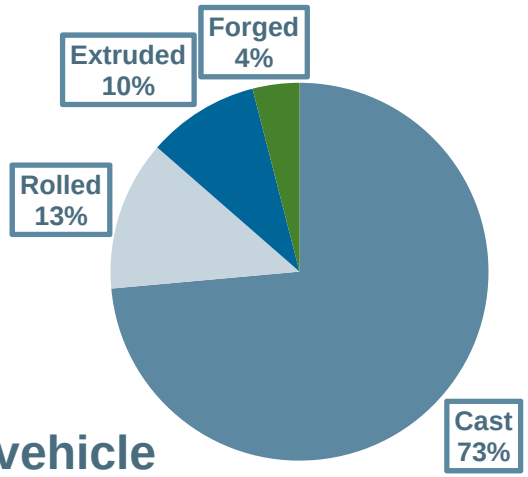
- Compared to the sample wrought product total of 30%, the 2012 Total EU wrought product share is 27% and the 2010 wrought product share is 26%

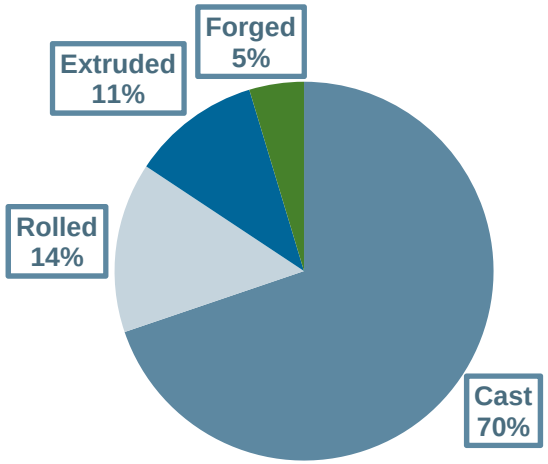
Total EU 2010 134 kg/vehicle



Total EU 2012 140 kg/vehicle



2012 Sample 160 kg/vehicle



Emissions and Fuel Economy Analysis

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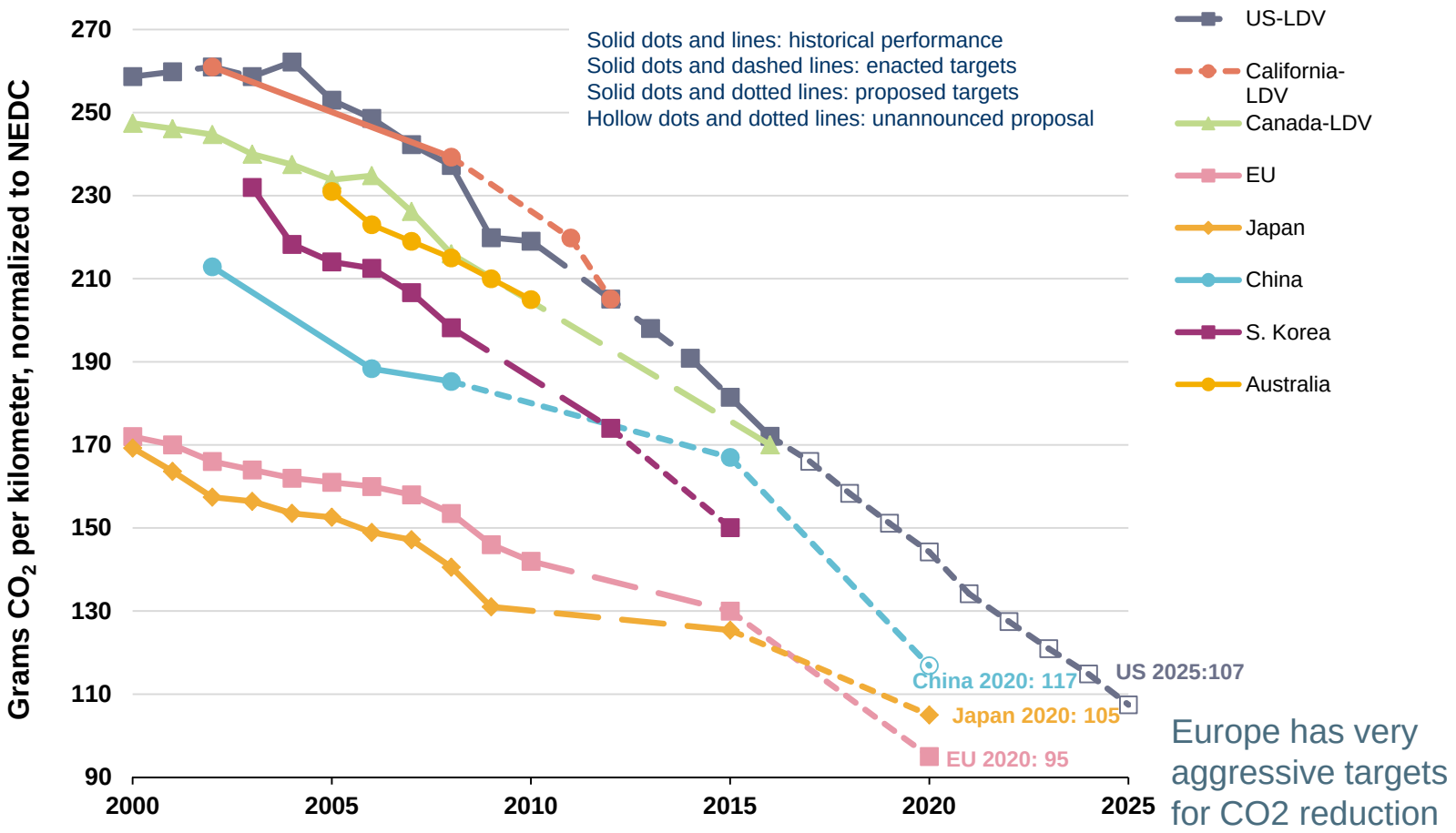
Global fleet CO_2 emissions performance and current or proposed standards adjusted for the European test cycle



Europe has very aggressive targets for CO2 reduction

[1] China's target reflects gasoline fleet scenario. If including other fuel types, the target will be lower.
[2] US and Canada light-duty vehicles include light-commercial vehicles.

Future Aluminum Content Analysis

DUCKER WORLDWIDE

Ducker has assumed several characteristics about the future in order to determine the most likely aluminum light vehicle content in Europe by 2015, 2020 and beyond

Assumptions:	Comments:
100 kg of weight reduction saves 8 grams of CO2 per kilometer. This is a 5% reduction	• Regulations will require OEMs in their totality to reduce CO2 emissions by 40 grams per kilometer over the next eight years • Average car curb weight (adjusted for new safety and comfort features) will decline by 5% between 2012 and 2025
Aluminum will provide 50% to 75% of this weight reduction	• Aluminum is 80% to 30% effective for weight reduction versus steel depending on the type of steel it replaces • Aluminum indirectly provide another 30% weight savings. Advanced high strength steel and footprint reduction will provide the remaining 20%
Alternative powertrain acceptance will remain at less than 10% of the solution through 2025	• Gasoline or diesel/electric hybrids or plug-in electric) acceptance is moving at a snails pace in Europe. Regulators are counting on a surge in acceptance, but the cost and inconvenience will inhibit consumers much more than the regulators anticipate
The estimates we have for similar requirements in the U.S. are relevant to Europe	• The similarities between EU and U.S. car characteristics, their similar CO2 reduction targets by 2020 and the overlap of OEMS strategies provides insight on what will happen to aluminum growth in Europe over the next eight - ten years • North American cars will need to add 40 kg of aluminum by 2020 and 64 kg by 2025

Future Aluminum Content Analysis

DUCKER WORLDWIDE

Except for the CO2 emissions, the similarities for vehicle characteristics and 2012 aluminum content between the EU 27 and the U.S./NA are much greater than the differences (see below). Cars in the U.S have to reduce CO2 by 30% by 2020, and 45% by 2025. The required reduction in Europe is 29% by 2020, and 48% by 2025. Cars in North America and Europe should add similar quantities of aluminum over the next 8 years on a kilogram per square meter basis, and similar quantities from 2020 to 2025

2012 Values	EU Light Vehicles	U.S.Car	U.S. Light Truck	U.S. Combined
Curb Weight kg	1372	1435	2016	1743
Footprint square meters	3.97	4.2	5	4.55
kg/square meter	346	342	419	383
Aluminum Content kg	140	145.6	165	156
Aluminum kg/m2	**35.3**	**34.7**	**33**	**34.3**
CO2/kilometer	**135***	**163****	**215****	**183****
2020 CO2/km	**95***	**113****	**163****	**132****
CO2 2012 - 2020 Delta	40*	50**	52**	51**
2025 CO2/km	70***	89**	126**	101**

*NEDC Test Cycle

**Ducker Forecast for 2025. As yet, there is no EU regulation for 2025

**EPA CAFÉ Test Cycle

Future Aluminum Content Analysis

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Analysis of the cost/benefit of lightweighting with EU Regulation EC 443/2009

- The table below shows that with a 95€ / g CO2 penalty every kg of light weighting is worth 7.6 € with a footprint based legislation and 3.26 € with a mass based legislation. The reason for the big change is that while a 100 kg weight reduction actually saves 8 g and with a footprint based regulation moves you 8 g closer to the target, it only moves you 3.43 g closer with a mass based regulation.
- Indeed with a mass based regulation each 100 kg of light weighting means a 4.57g tougher target. With a footprint based regulation the target does not shift if the mass is changing.
- Given that the cost for light weighting with aluminium is normally in the range of 2-8 €/kg (depending on the application). Obviously a cost/benefit calculation for aluminium light weighting will have a better chance for positive results with a footprint based regulation than with a mass based regulation.

		Footprint-based regulation		Mass-based regulation	
		Physical correlation		a=	0.0457
g CO2 excess	penalty (€)	8	g saved per 100 kg saved	3.43	g closer to target per 100 kg saved
]0-1]	5	0.4	€ per kg saved	0.17	€ per kg saved
]1-2]	15	1.2	€ per kg saved	0.51	€ per kg saved
]2-3]	25	2.0	€ per kg saved	0.86	€ per kg saved
]3-...]	95	7.6	€ per kg saved	3.26	€ per kg saved

Future Aluminum Content Analysis

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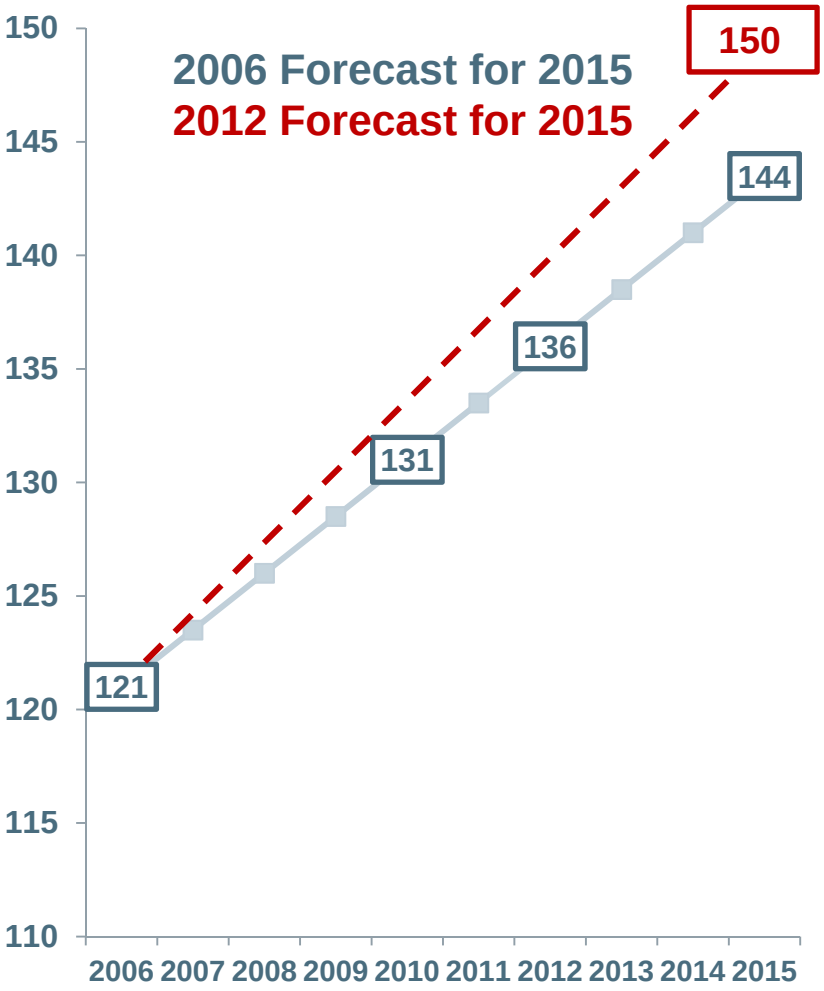
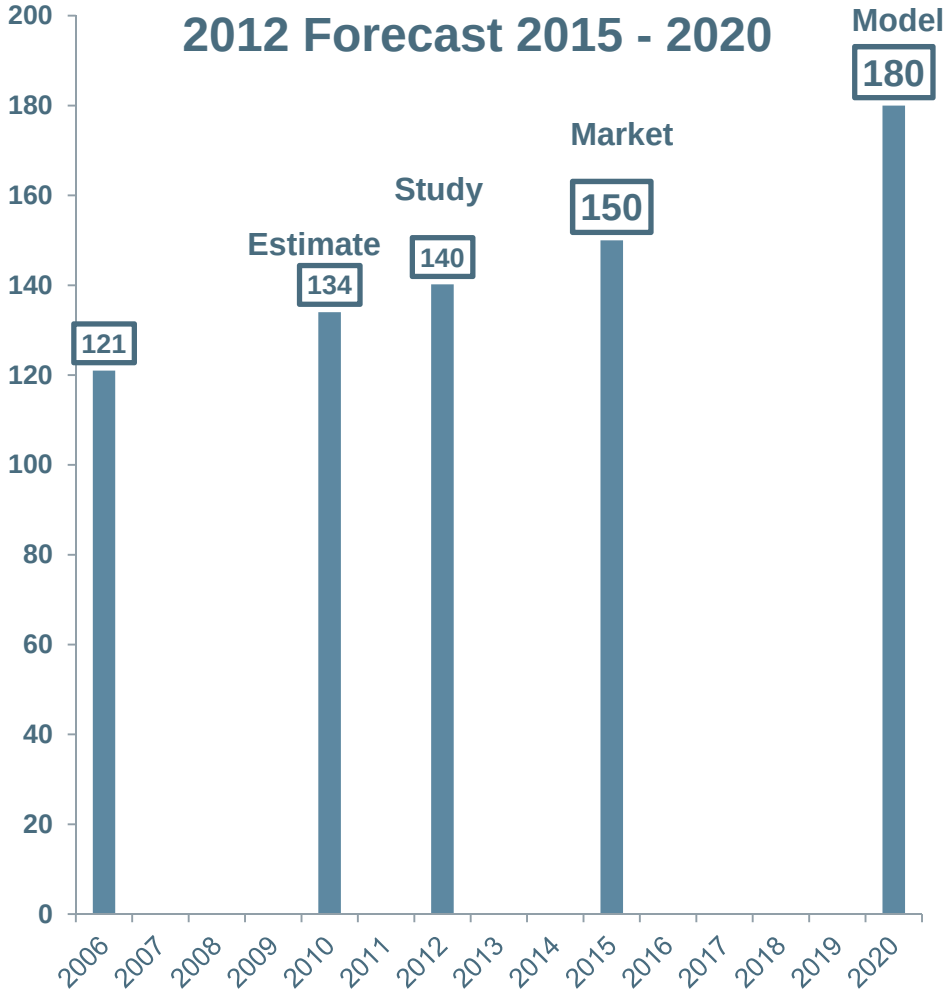
A previous short term trend analysis predicted 144 kilograms of aluminum content by 2015. The current trend analysis and market evidence supports a forecast of 150 kg per vehicle in 2015, and the theoretical CO2 based analysis supports 180 kg by 2020





Future Aluminum Content Analysis

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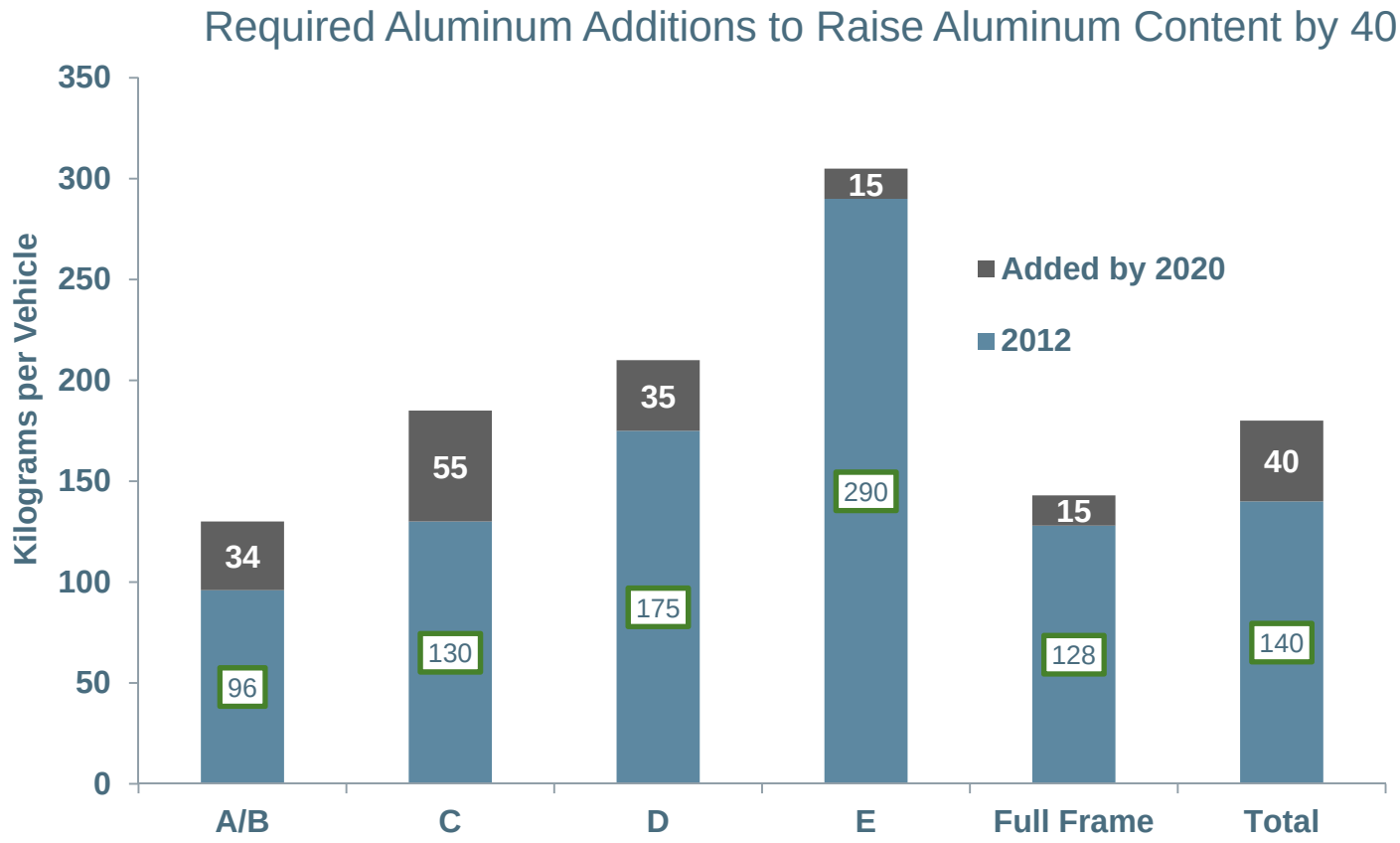
Ducker believes the aluminum additions in the A/B and C segments are more important than the additions to the D and E segments. Without the smaller vehicles, aluminum content can not get to 180 kg per vehicle



This concludes our report. Thank you.

For 50 years, Ducker Worldwide has enabled clients to navigate and thrive in a dynamic, global marketplace. Our unique and proven combination of custom market intelligence, critical thinking and strategic consulting create valuable opportunities that deliver critical results.

For more information regarding our strategic services, expertise and to learn how Ducker Worldwide can help you, please contact one of our team members at +33 1 46 99 59 60 or visit our website at www.ducker.com