



DUCKER WORLDWIDE

Advancing Growth

EAA Aluminium penetration in cars Final Report

March 13, 2012

Public version

- 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 analysed 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

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

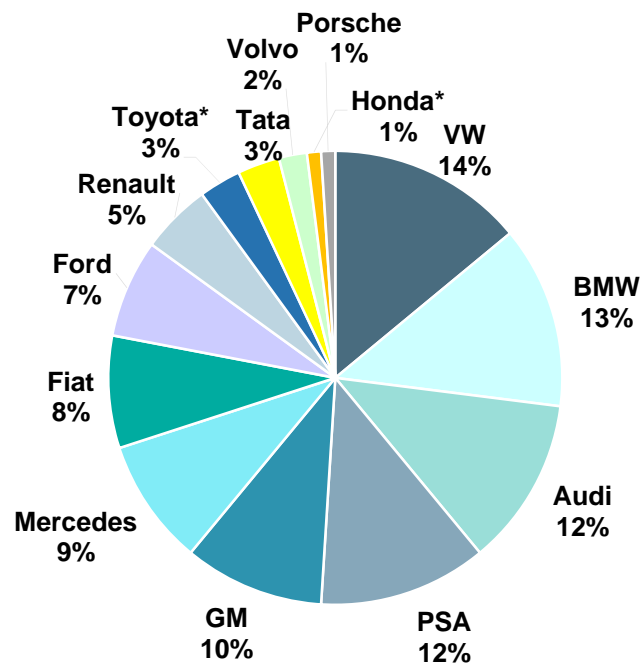
Segment	Example	Segment	Example
A	Fiat 500(312)	D	Audi A4(AU481)
	Fiat Panda(139)		Audi Q5(AU416)
B	Audi A1(AU210)		BMW 3 (F30)
	Audi TT(AU324)		Mercedes-Benz B-Class(W246)
	Citroen C3 Picasso(A58)		Mercedes-Benz C-Class(W204)
	Citroen C3(A51)		Opel Insignia(GM G3700)
	Lancia Ypsilon(846)		Peugeot 508(W2)
	Opel Meriva(GM S4470)		Porsche Panamera(970)
	Peugeot 208(A9)		Volkswagen Passat(VW471)
	Renault Clio(X98)		Volvo S60(Y283)
	Toyota Yaris(850L)	E	Audi A6(AU571)
	Volkswagen Up		Audi A7(AU573)
C	Volkswagen Polo(VW250)		Audi A8(AU641)
	Alfa Romeo Giulietta		Audi Q7(AU716)
	Audi Q3 (AU 316)		BMW 5 (F10)
	Audi A3(AU370)		BMW 7 (F01/02)
	BMW 1 (F20)		Jaguar XF(X250)
	Citroen C4(B7)		Jaguar XJ(X351)
	Ford C-Max(C344)		Land Rover Range Rover (L405)
	Ford Focus(C346)		Mercedes-Benz E-Class(W212))
	Ford Kuga		Mercedes-Benz S-Class(W221)
	Honda Civic(2HC)		Mercedes-Benz-S-Class (W222)
	Jaguar XK(X150)		Porsche Cayenne(E2)
	Land Rover Range Rover Evoque(L538)		Volkswagen Touareg(VW526)
	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)		

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

Introduction

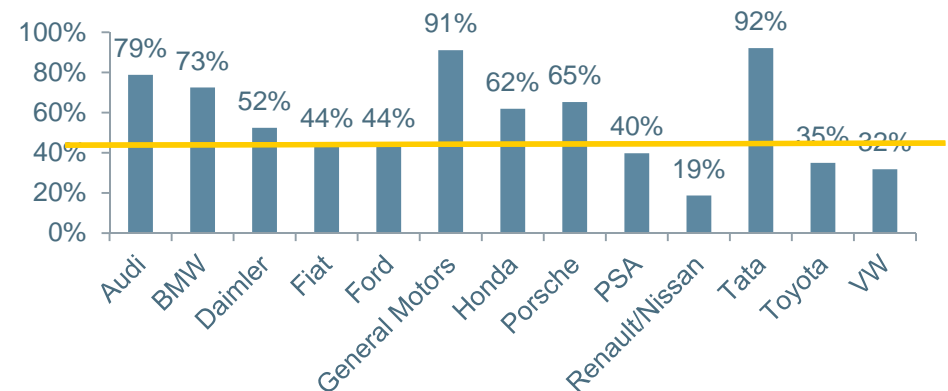
One half of the total production of these OEMs is represented by the sample

2012 Sample Vehicles Segmented by OEM



7,646,770 Sample Vehicles

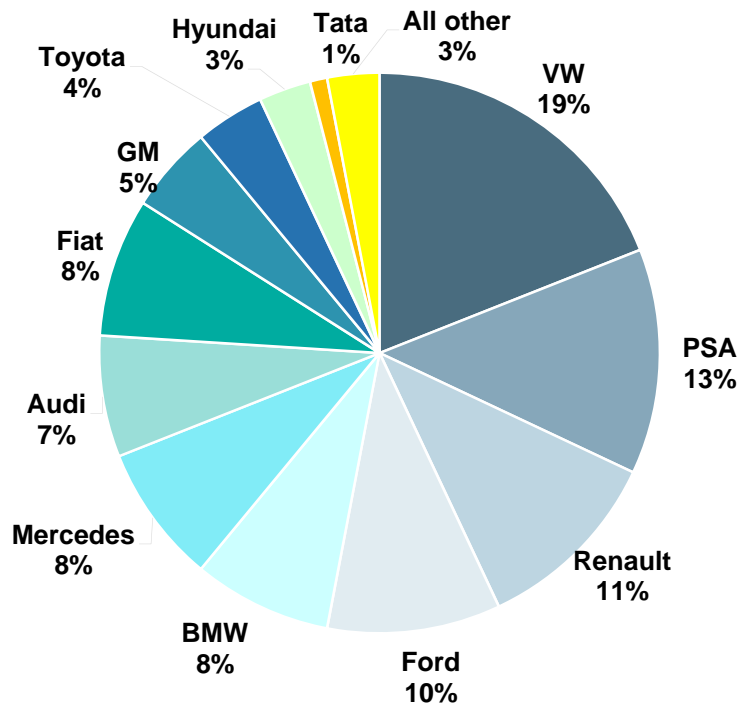
Sample Share of Total 2012 Units for These OEMs



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	

* only one vehicle in the sample

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%

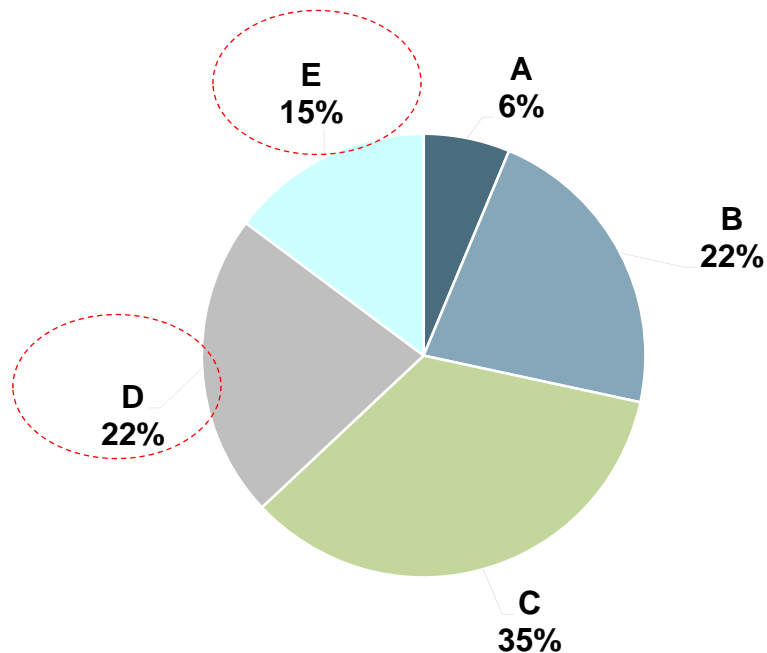
Introduction



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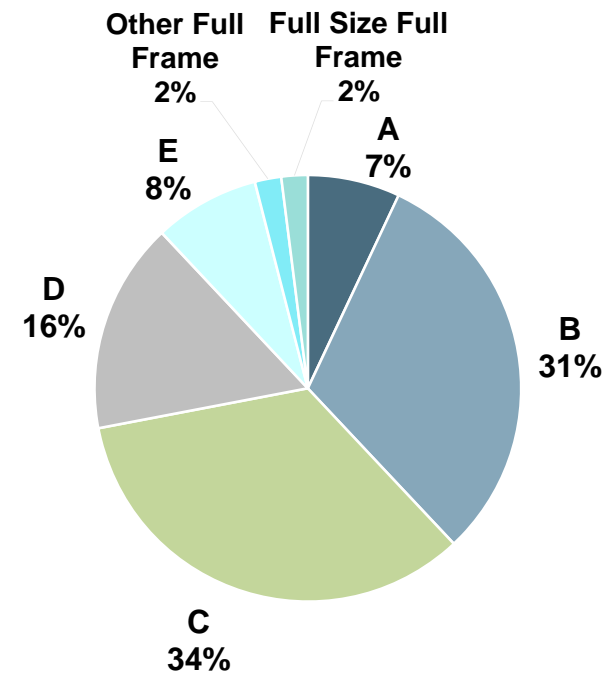
When compared to total 2012 EU light production, the sample is over weighted with D & E segment vehicles. The sample does not contain any full frame vehicles. These decisions had a negative effect on the total EU aluminum content versus the sample

Sample Vehicles
Split by Segment



7,646,770 Vehicles

Total EU Vehicles
Split by Segment



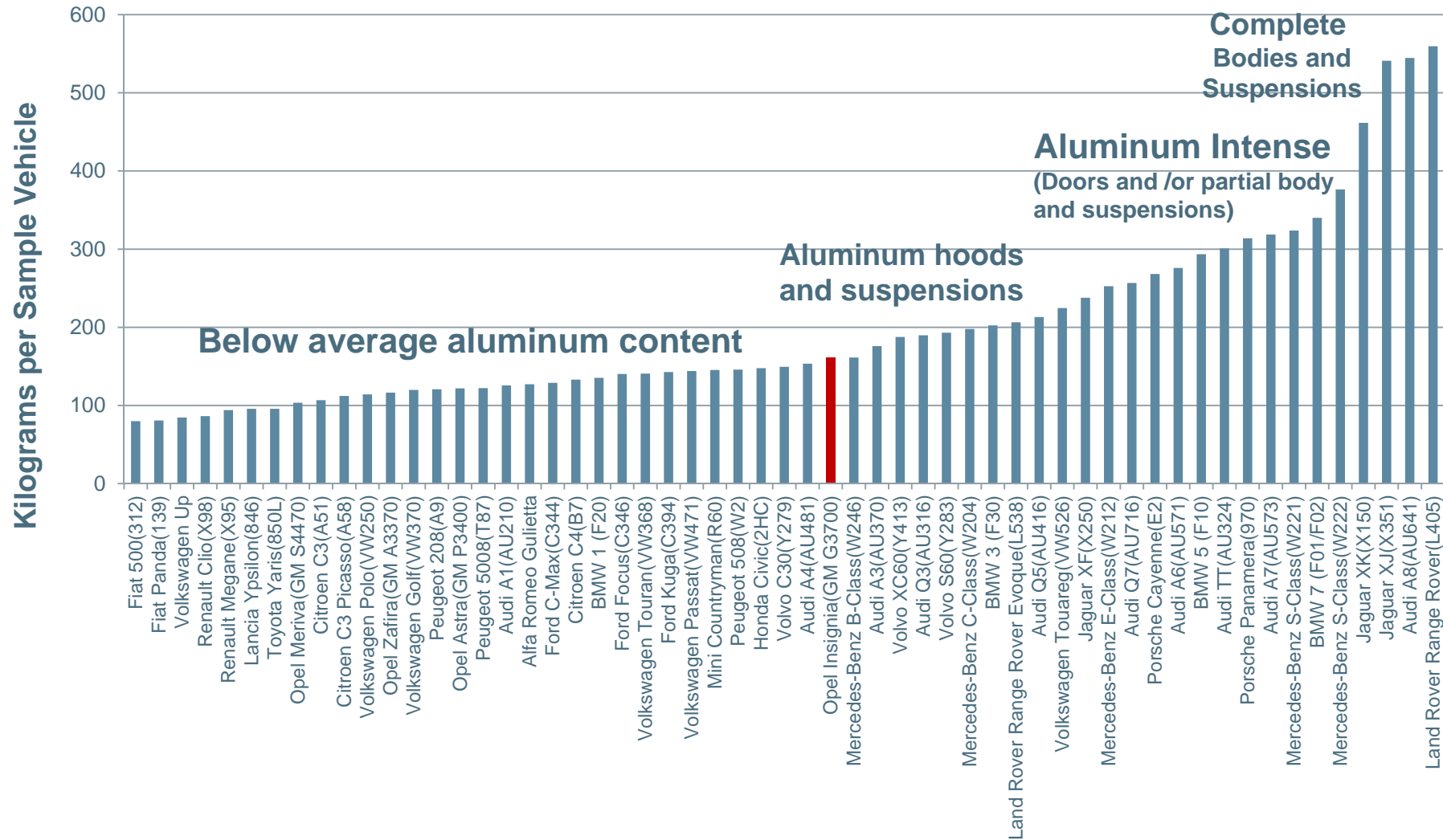
17,232,935 Vehicles

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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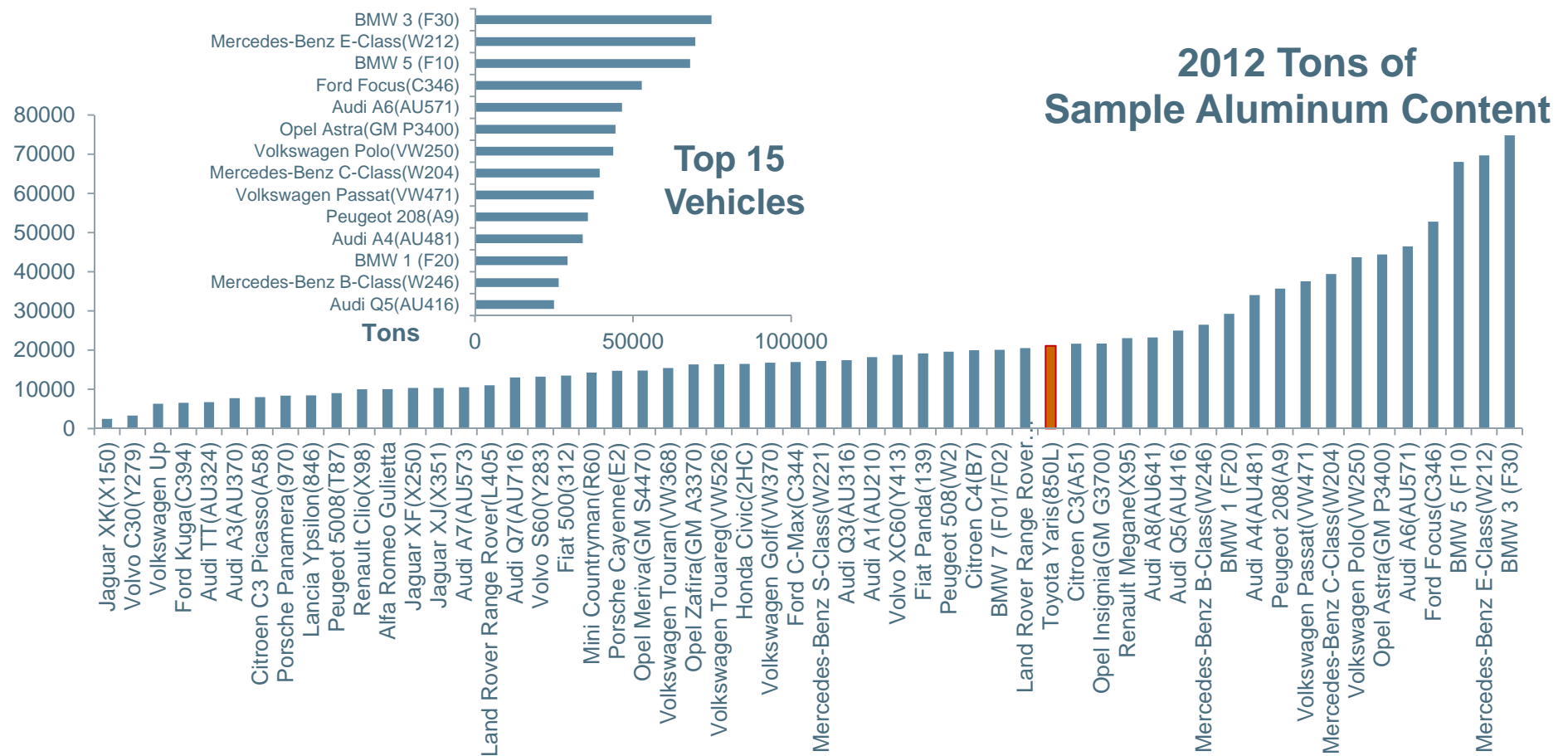
A-Segment	2012 Units	kg/vehicle	C-Segment	2012 Units	kg/vehicle
Fiat Panda(139)	237196	75.5	Jaguar XK(X150)	5304	453
Fiat 500(312)	169151	74.5	Land Rover Range Rover Evoque(L538)	99447	194.5
B-Segment			Volvo XC60(Y413)	100246	203.7
Audi TT(AU324)	22336	269.7	Audi Q3(AU316)	91888	200.9
Citroen C3 Picasso(A58)	71610	150.6	Audi A3(AU370)	43994	169.6
Peugeot 208(A9)	295702	124.3	Audi A4(AU481)	222021	139
Audi A1(AU210)	145125	119	Volvo C30(Y279)	22023	151.8
Volkswagen Polo(VW250)	383198	102.3	Honda Civic(2HC)	111766	141.3
Opel Meriva(GM S4470)	143234	102.8	Citroen C4(B7)	150235	133.7
Citroen C3(A51)	202748	109.1	BMW 1 (F20)	216375	114.6
Volkswagen Up	74964	86.2	Mini Countryman(R60)	98413	165.5
Toyota Yaris(850L)	220390	96	Volkswagen Touran(VW368)	109670	141.4
Renault Clio(X98)	115943	98.2	Ford Kuga(C394)	46099	129.3
Lancia Ypsilon(846)	88315	78	Ford C-Max(C344)	131666	133.9
D-Segment	2012 Units	kg/vehicle	Alfa Romeo Giulietta	79206	112.5
Porsche Panamera(970)	26700	306.9	Ford Focus(C346)	376222	131.9
Audi Q5(AU416)	117353	228	Peugeot 5008(T87)	73892	109.5
BMW 3 (F30)	369718	198.4	Opel Zafira(GM A3370)	140453	130.3
Mercedes-Benz C-Class(W204)	199313	202.9	Volkswagen Golf(VW370)	140323	126.8
Volvo S60(Y283)	68630	184.3	Opel Astra(GM P3400)	364879	106.3
Mercedes-Benz B-Class(W246)	164117	166	Renault Megane(X95)	245529	105.1
Peugeot 508(W2)	134499	175.6	E-Segment	2012 Units	kg/vehicle
Volkswagen Passat(VW471)	260689	147.1	Audi A7(AU573)	33007	322.3
Opel Insignia(GM G3700)	134708	148.6	BMW 5 (F10)	231809	307.3
E-Segment	2012 Units	kg/vehicle	Audi A6(AU571)	168436	287.0
Land Rover Range Rover(L405)	19717	561.3	Porsche Cayenne(E2)	54970	279.4
Jaguar XJ(X351)	19169	546.3	Audi Q7(AU716)	50719	263.2
Audi A8(AU641)	42681	538.2	Mercedes-Benz E-Class(W212)	275896	254.3
Mercedes-Benz S-Class(W222)	6224	388.0	Jaguar XF(X250)	43551	238.5
BMW 7 (F01/F02)	59088	353.4	Volkswagen Touareg(VW526)	73152	219.2
Mercedes-Benz S-Class(W221)	53061	331.7	Total	7,646,770	160.1

Executive Summary



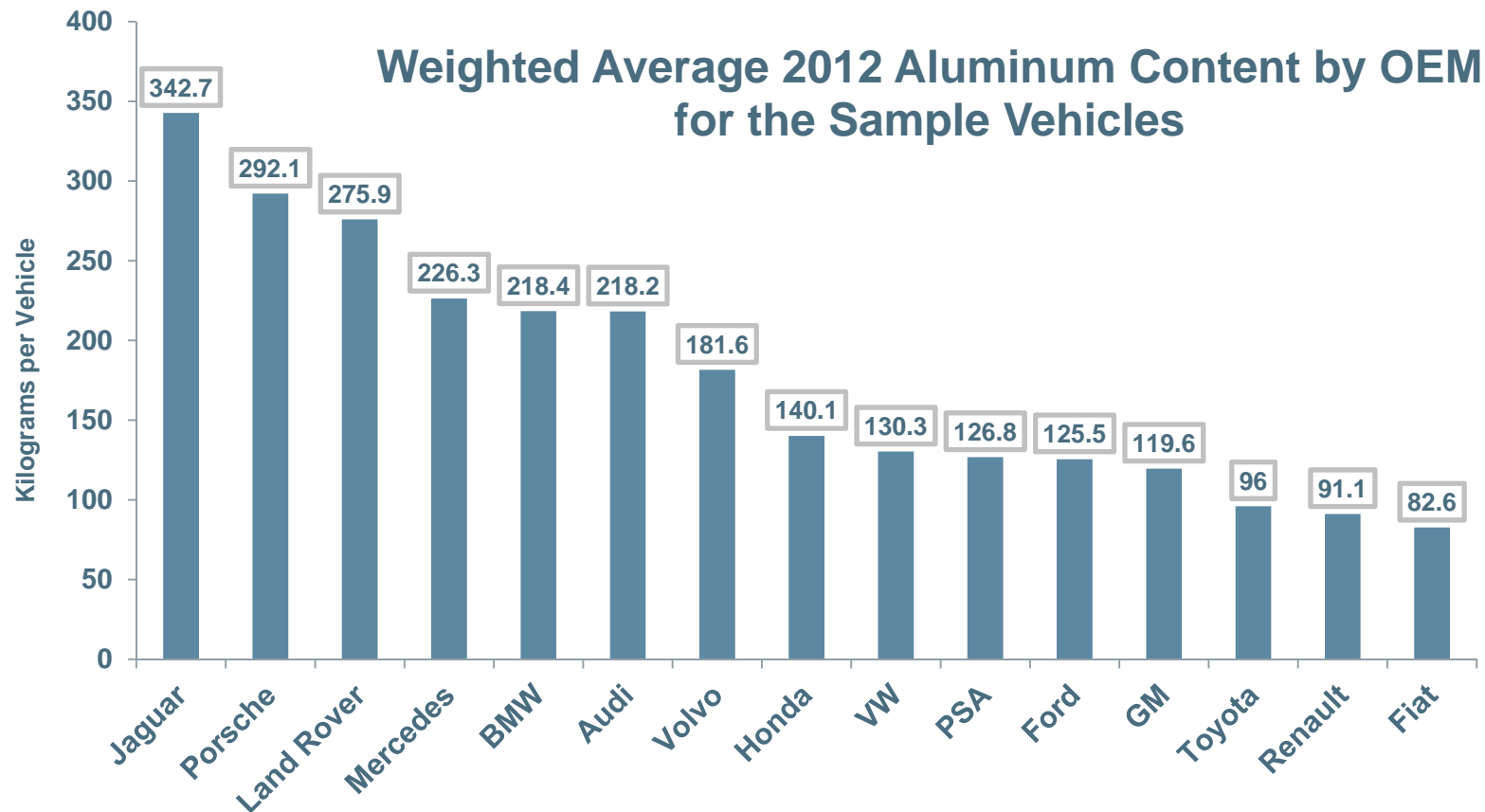
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The 2012 sample aluminum content is 1.224 million tons. The BMW 3 Series, BMW 5 Series and the Mercedes E Class are 17% of the total. 15 vehicles represent over 50% of all the sample tons. Total EU 27 aluminum content is estimated to be 2.4 million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



Executive Summary

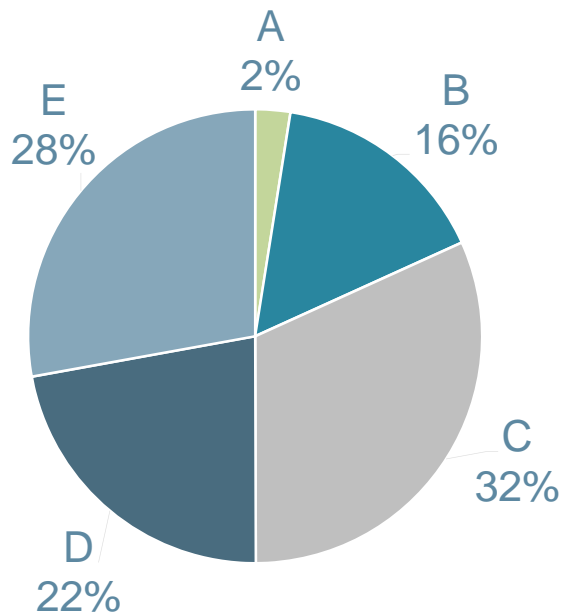
Jaguar is the aluminum content leader in the sample. Fiat has the lowest aluminum content. Ducker believes that with the proper mix adjustment, these estimates, with the possible exception of Renault, are representative of each OEM's total 2012 production



Executive Summary

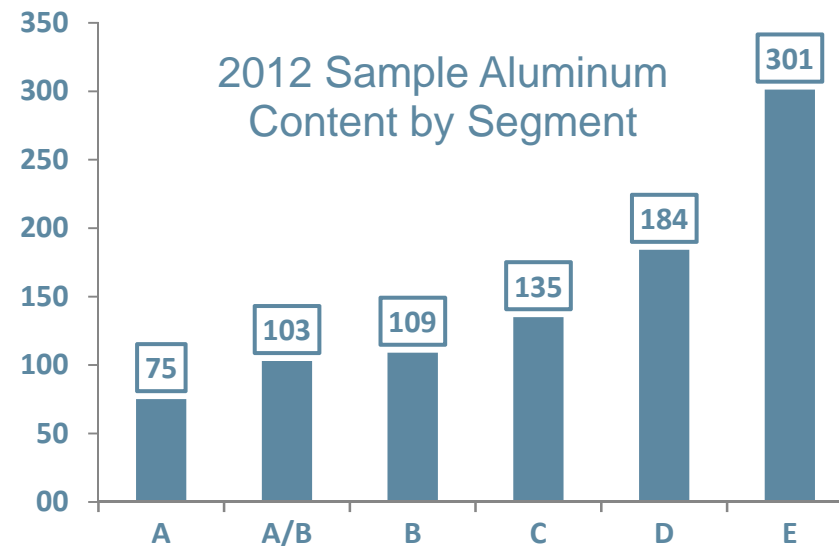


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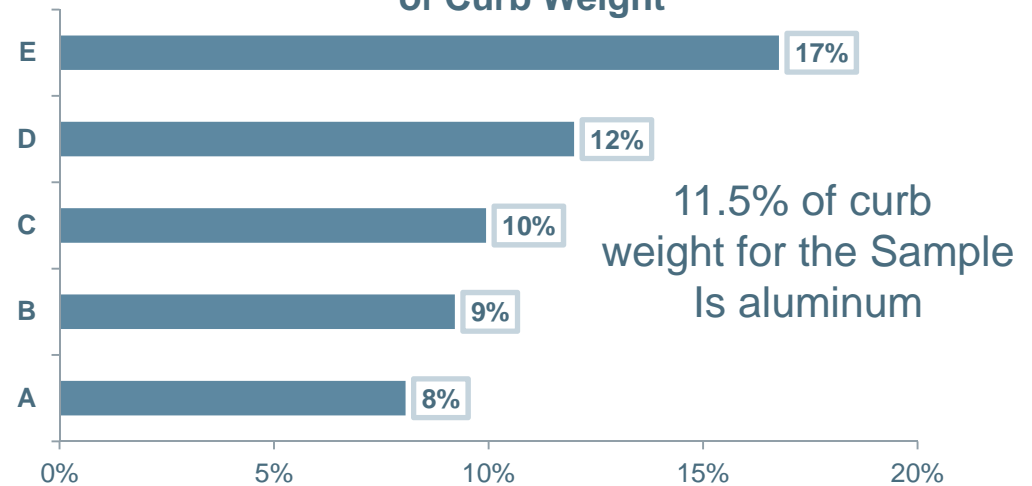


1.22 million tons or 160.1 kg per vehicle of aluminum content for the whole sample by segment

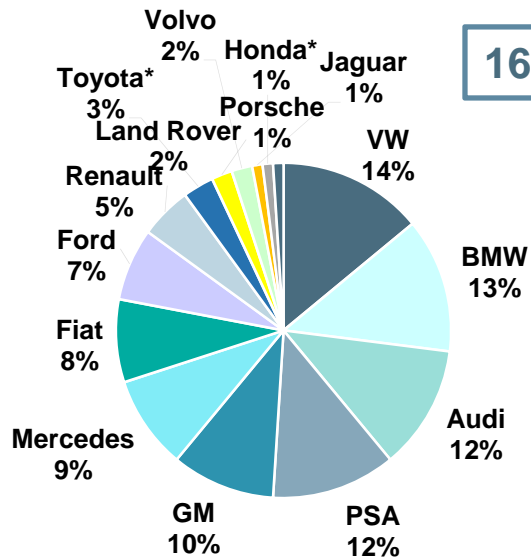
Segment	Curb Weight kg	Aluminum kg	Percent
A	930	75	8%
B	1183	109	9%
C	1358	135	10%
D	1534	184	12%
E	1795	301	17%



2012 Sample Aluminum Segment Share of Curb Weight



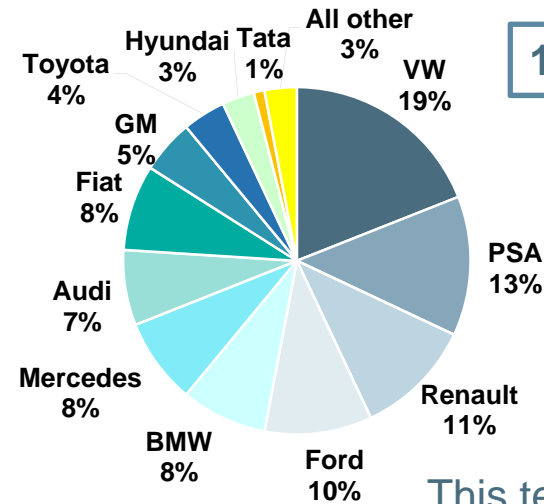
2012 Sample



160kg/vehicle

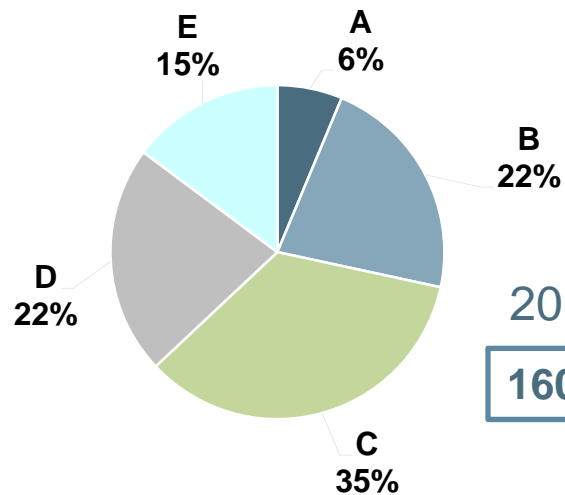
Applying the sample content per OEM to the total EU production yields

2012 Total EU



144 kg/vehicle

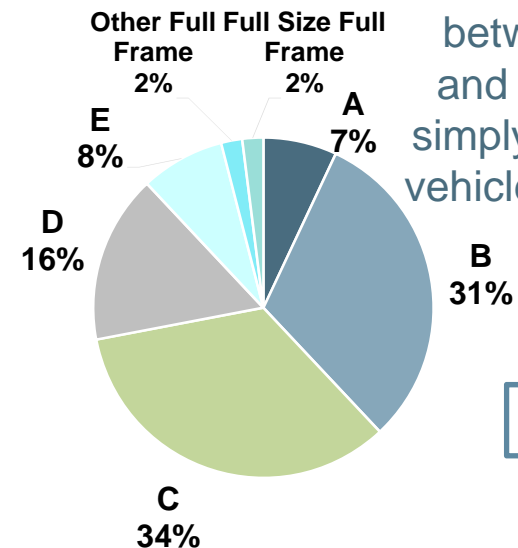
This tells us that most of the difference between the sample and the EU total was simply due to OEM and vehicle mix not content



2012 Sample

160Kg/vehicle

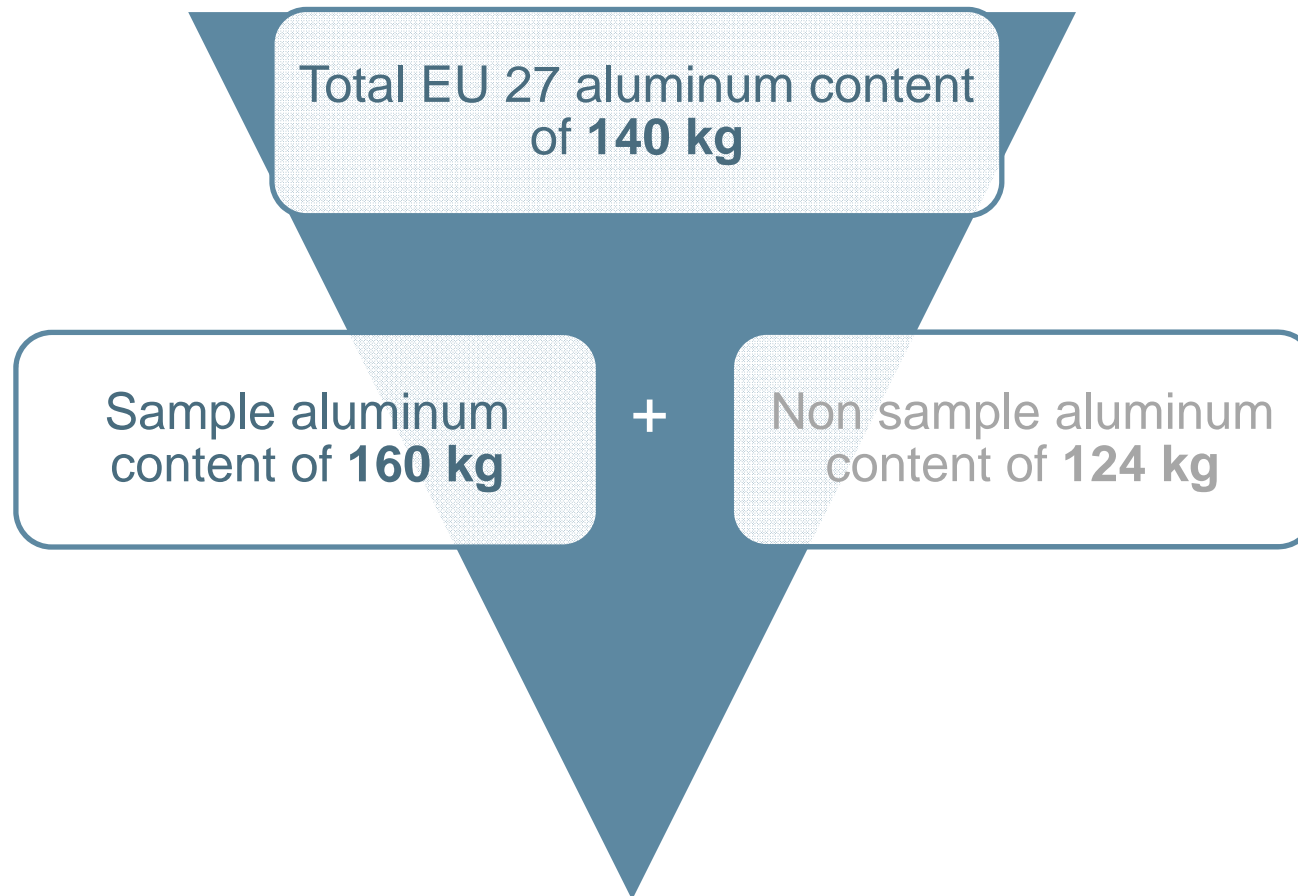
Applying the sample content per segment to the total EU production yields



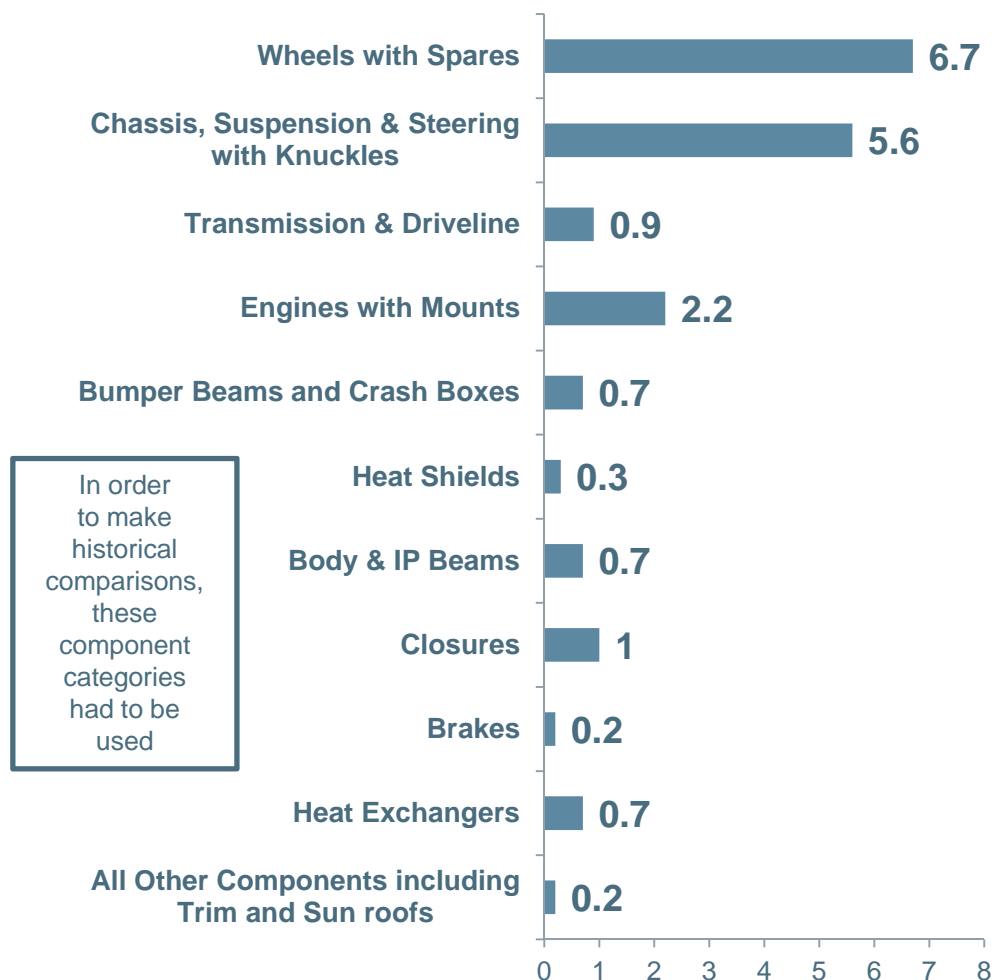
2012 Total EU

145kg/vehicle

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



2006 - 2012 EU Aluminum (kg) Content Increase



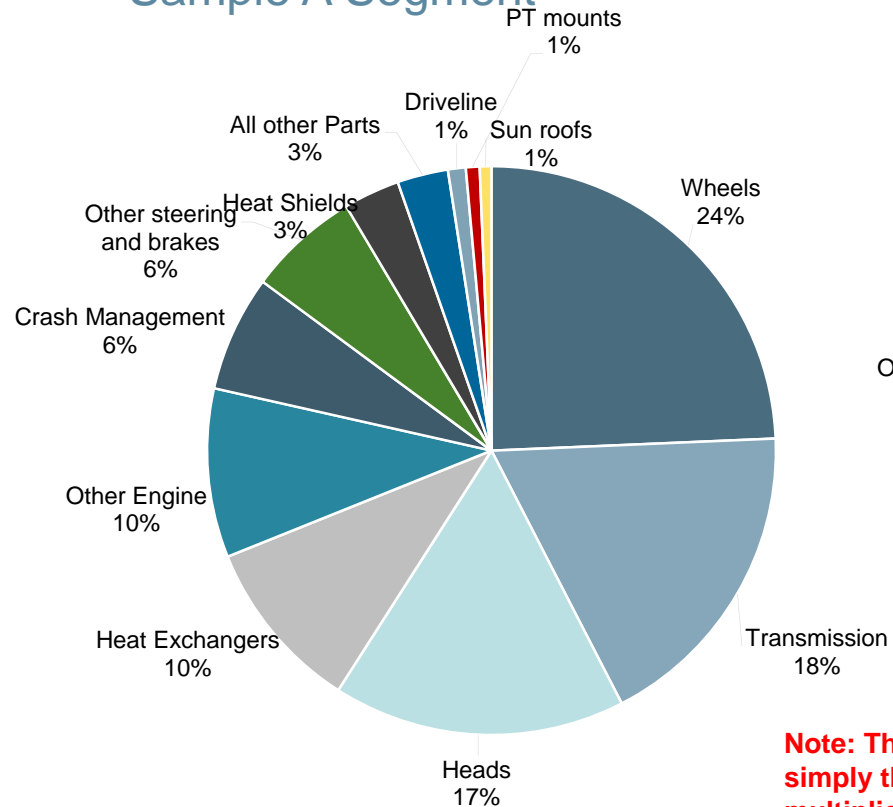
- The total increase in EU light vehicle aluminum content from 2006 to 2012 is estimated at 19.2 kg
- The increase in aluminum content over the same period in North America is estimated at only 13 kg. This is 50% of the aluminum growth experienced in North America in the period 2000 to 2006
- 40% of 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



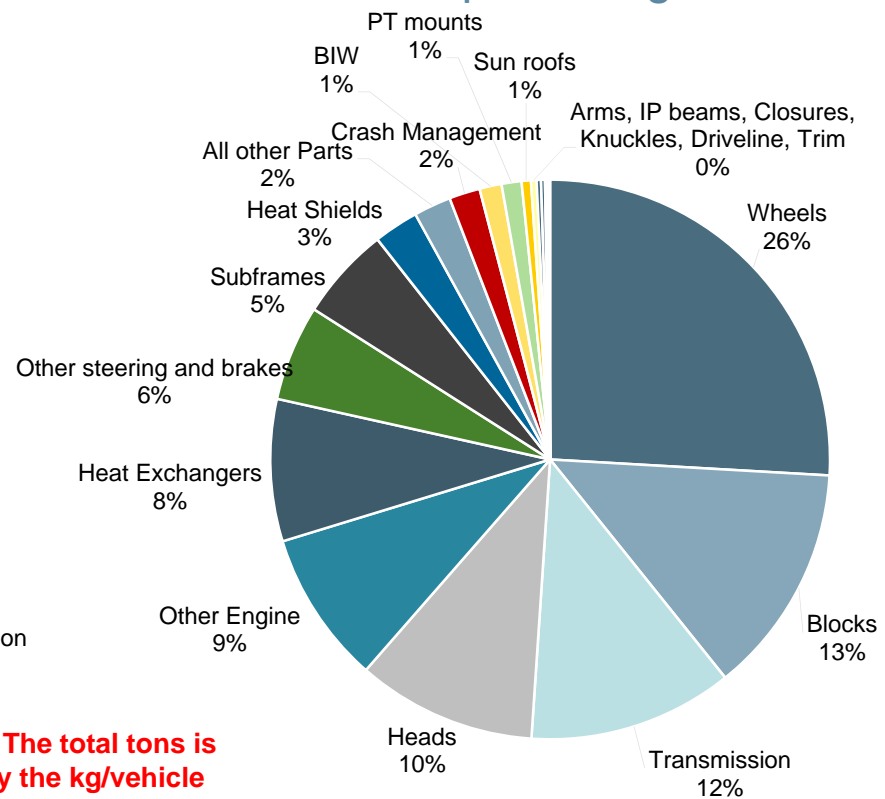
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Sample A Segment



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

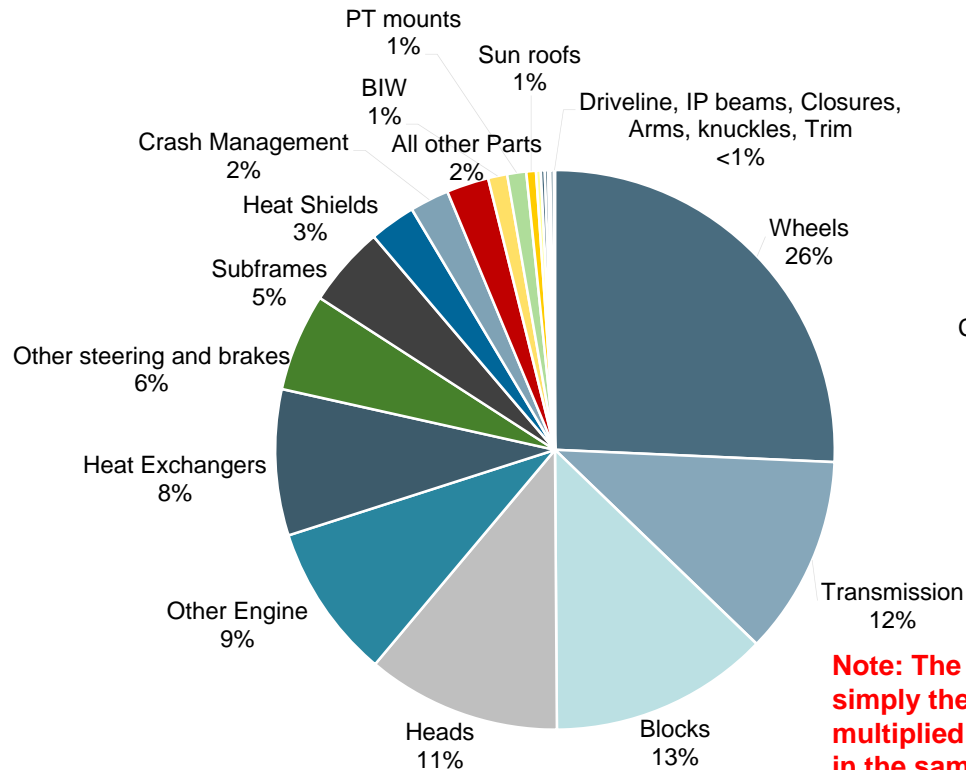
Note: The total tons is simply the kg/vehicle multiplied by the vehicles in the sample or the total EU production whichever is appropriate

Summary by Segment



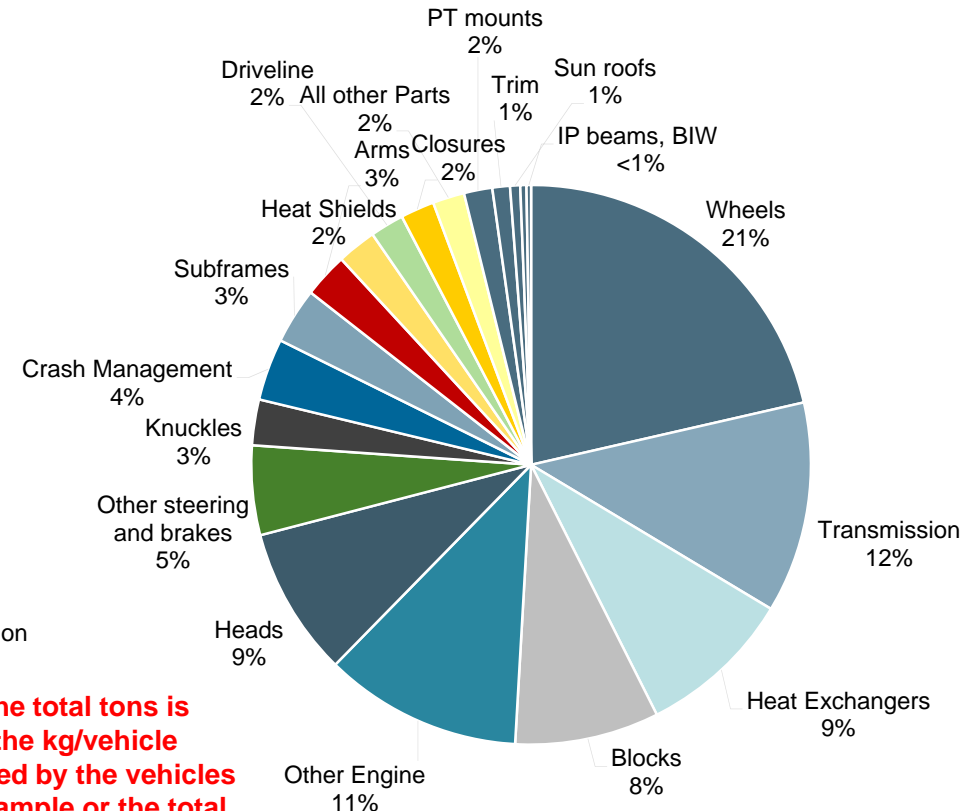
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Sample A/B-Segment



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

Sample C-Segment



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

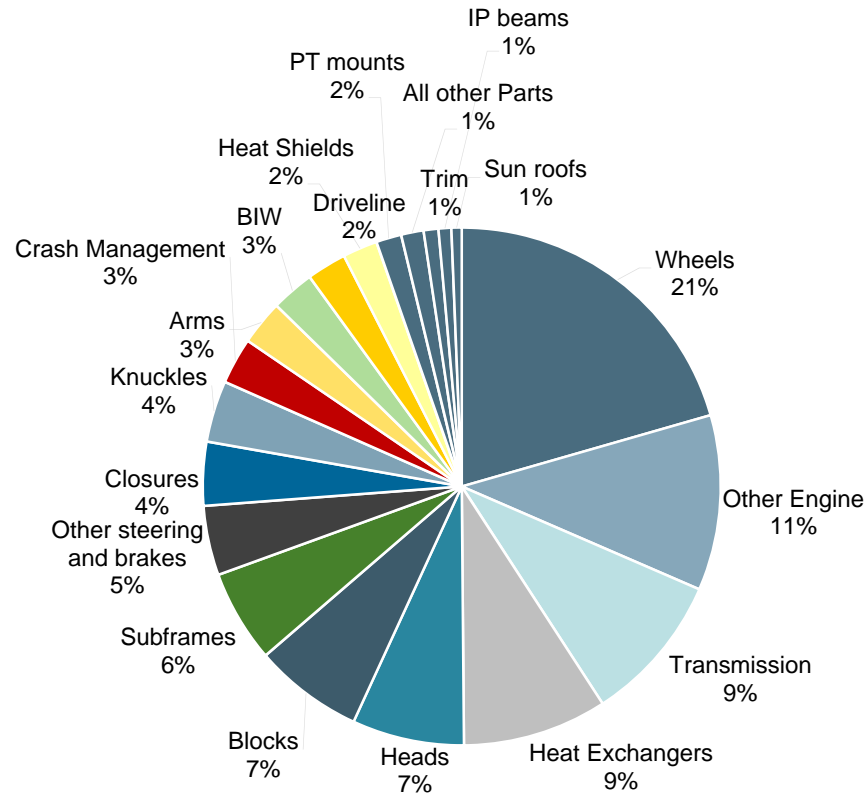
Note: The total tons is simply the kg/vehicle multiplied by the vehicles in the sample or the total EU production whichever is appropriate

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

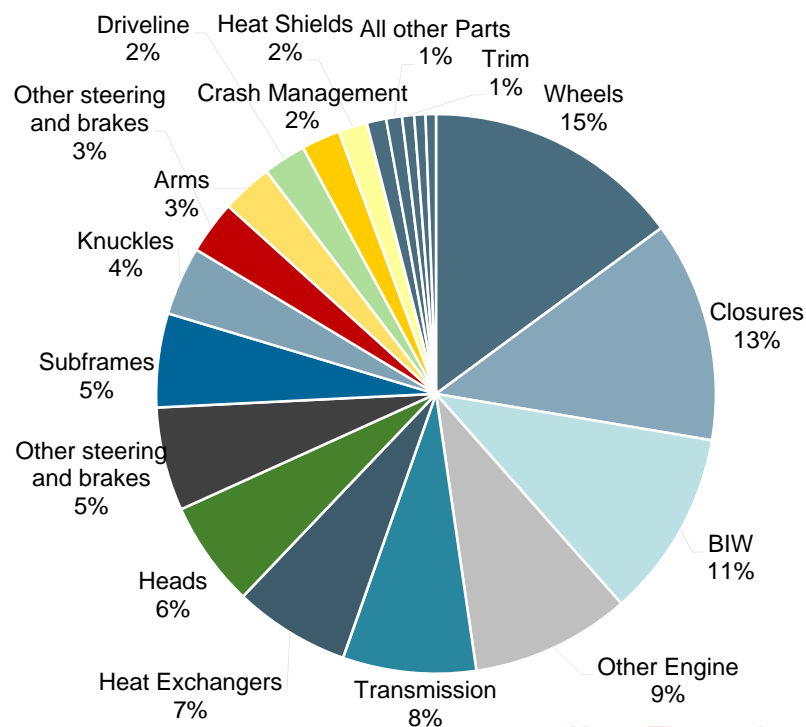
- The D segment in Europe is very similar in aluminum content to the D/E segment in North America.
- This segment is 12% aluminum as a share of curb weight
- 50% of the vehicles have aluminum hoods and bumpers, and some vehicles have partial aluminum body structures
- Aluminum content in this segment 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

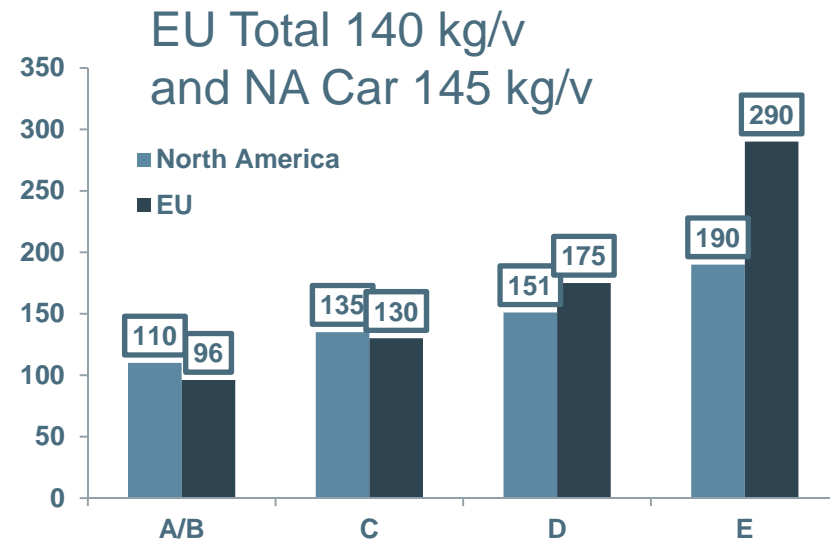
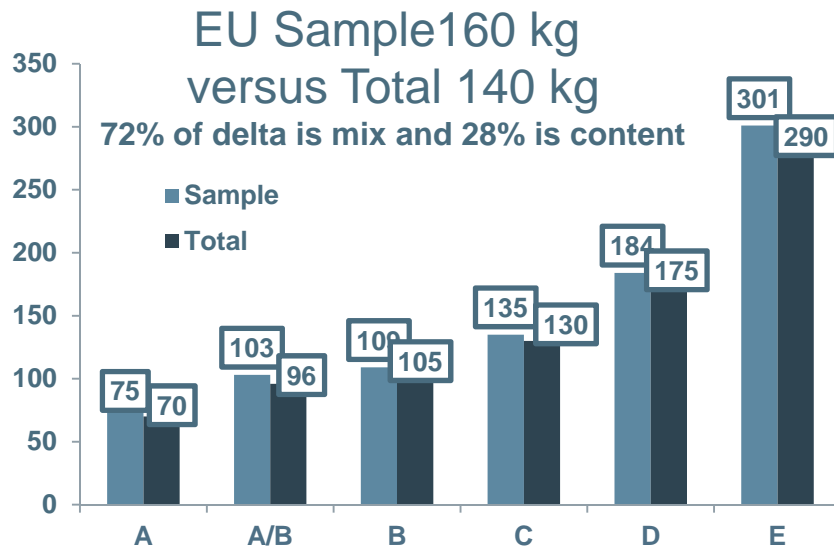
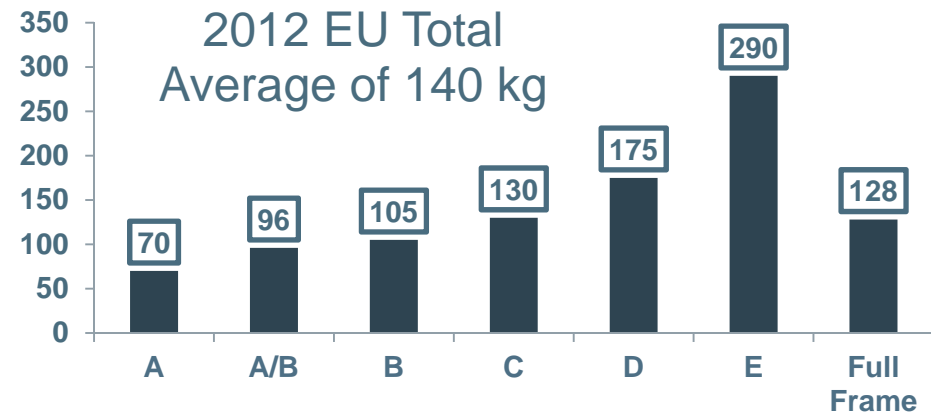
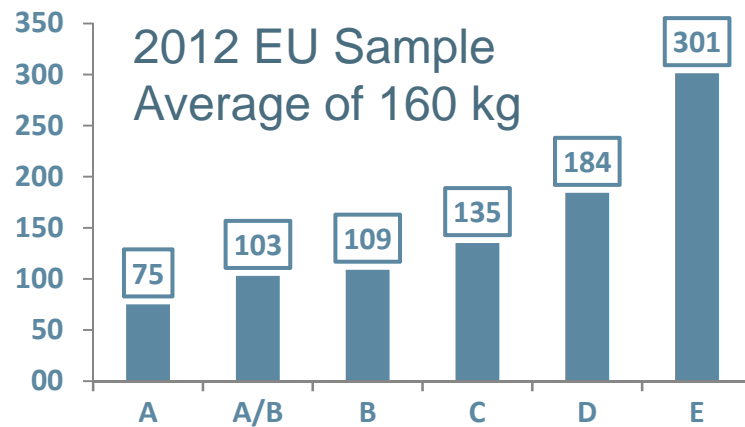
- In totality, the E Segment is not the most important segment going forward, but for the last 15 years it has been the global benchmark for new aluminum structural applications in autos
- The average content for the sample and for the entire segment is near 300kg per vehicle
- Only U.S. pickup trucks 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



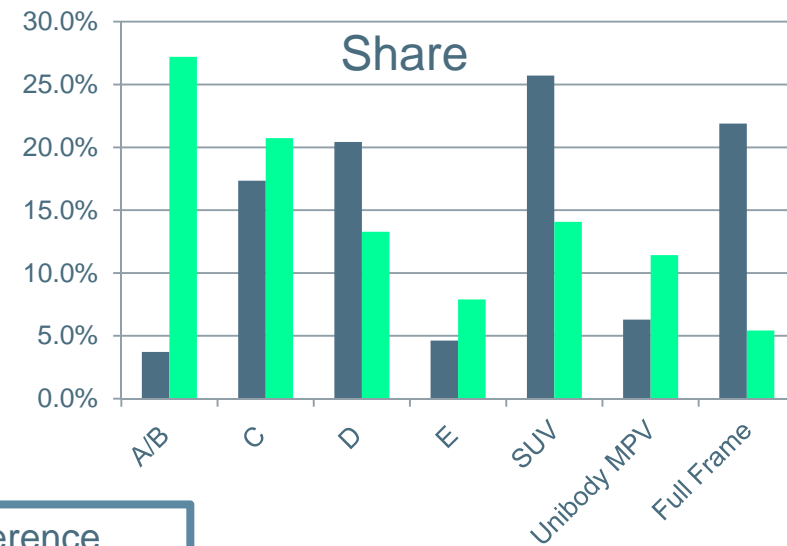
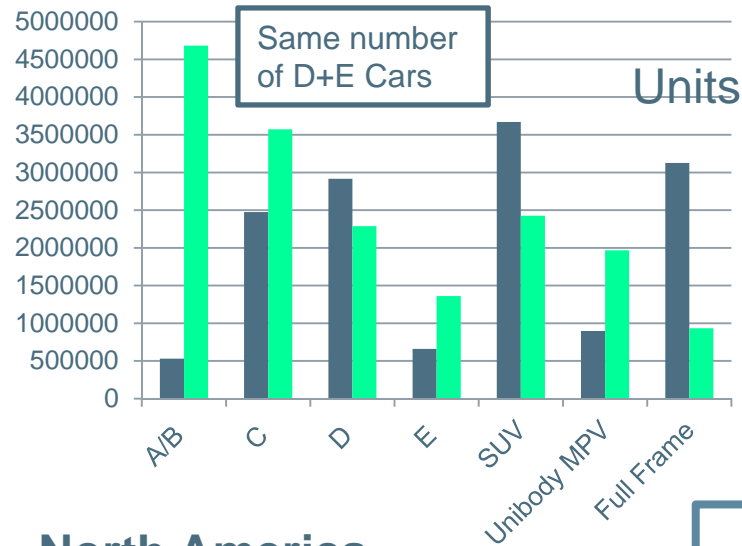
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With the exception of the E Segment, the sample average segment content differences versus total EU and versus other regions are minimal compared to the OEM mix differences which cause most of the variation

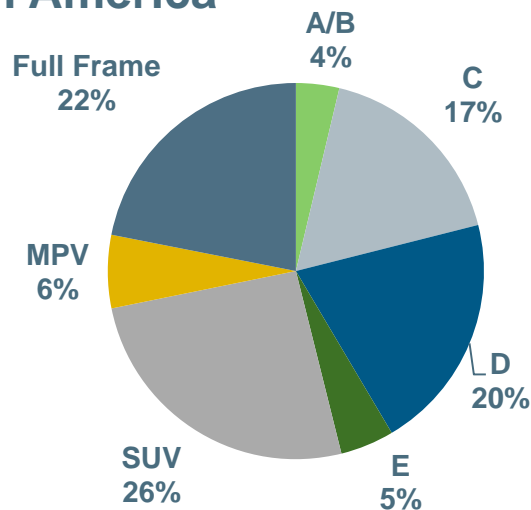


Summary by Segment

A look at the segment differences between Europe and North America

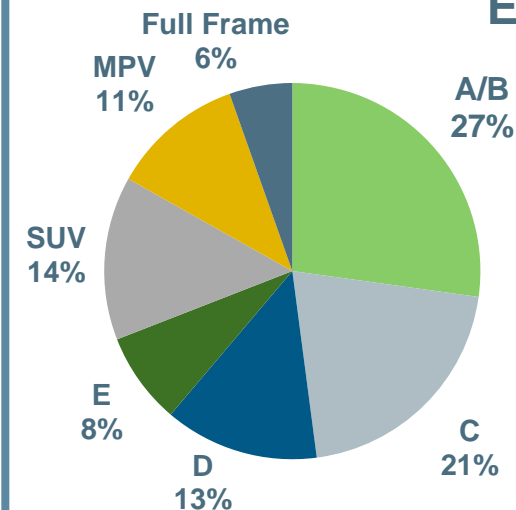


North America



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

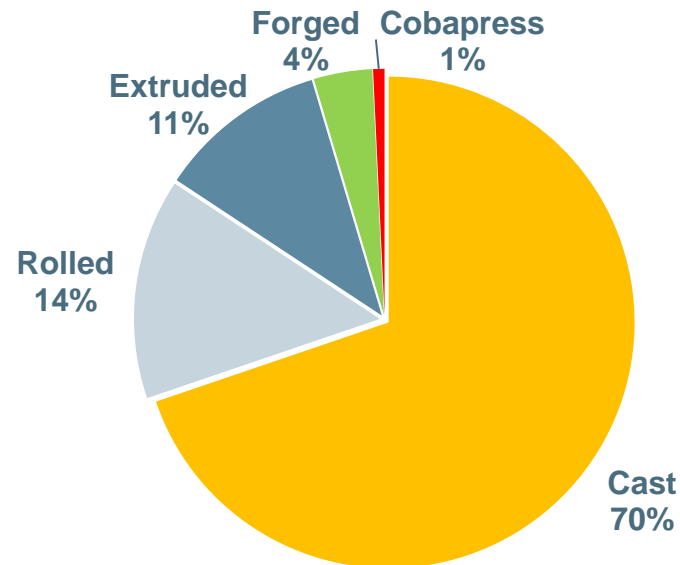
EU 27



Product Form Analysis

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

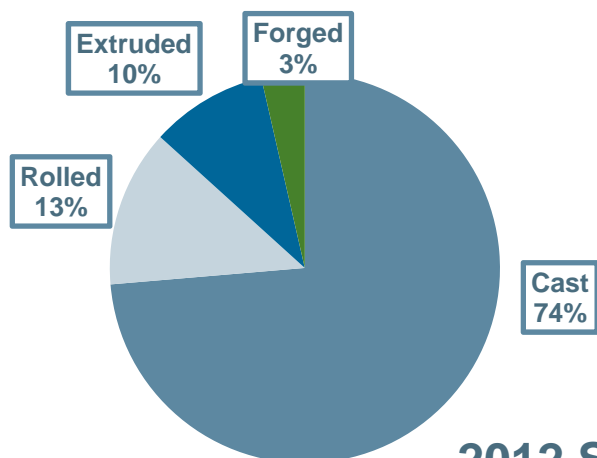


1.22 Million Tons of aluminum
for the sample segmented by
product form

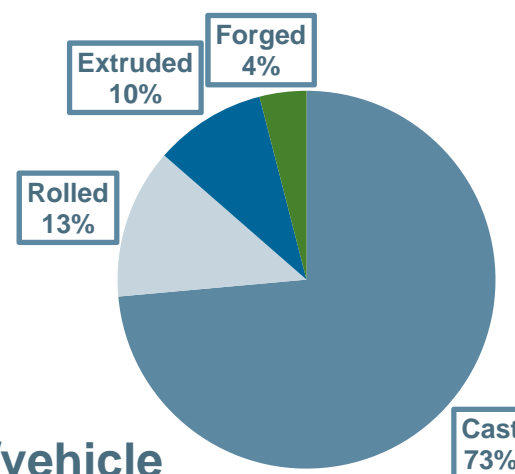
Product Form Analysis

- 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%

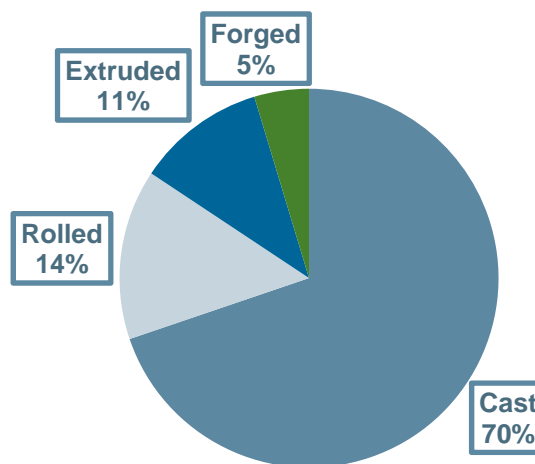
Total EU 2010 134 kg/vehicle



Total EU 2012 140 kg/vehicle

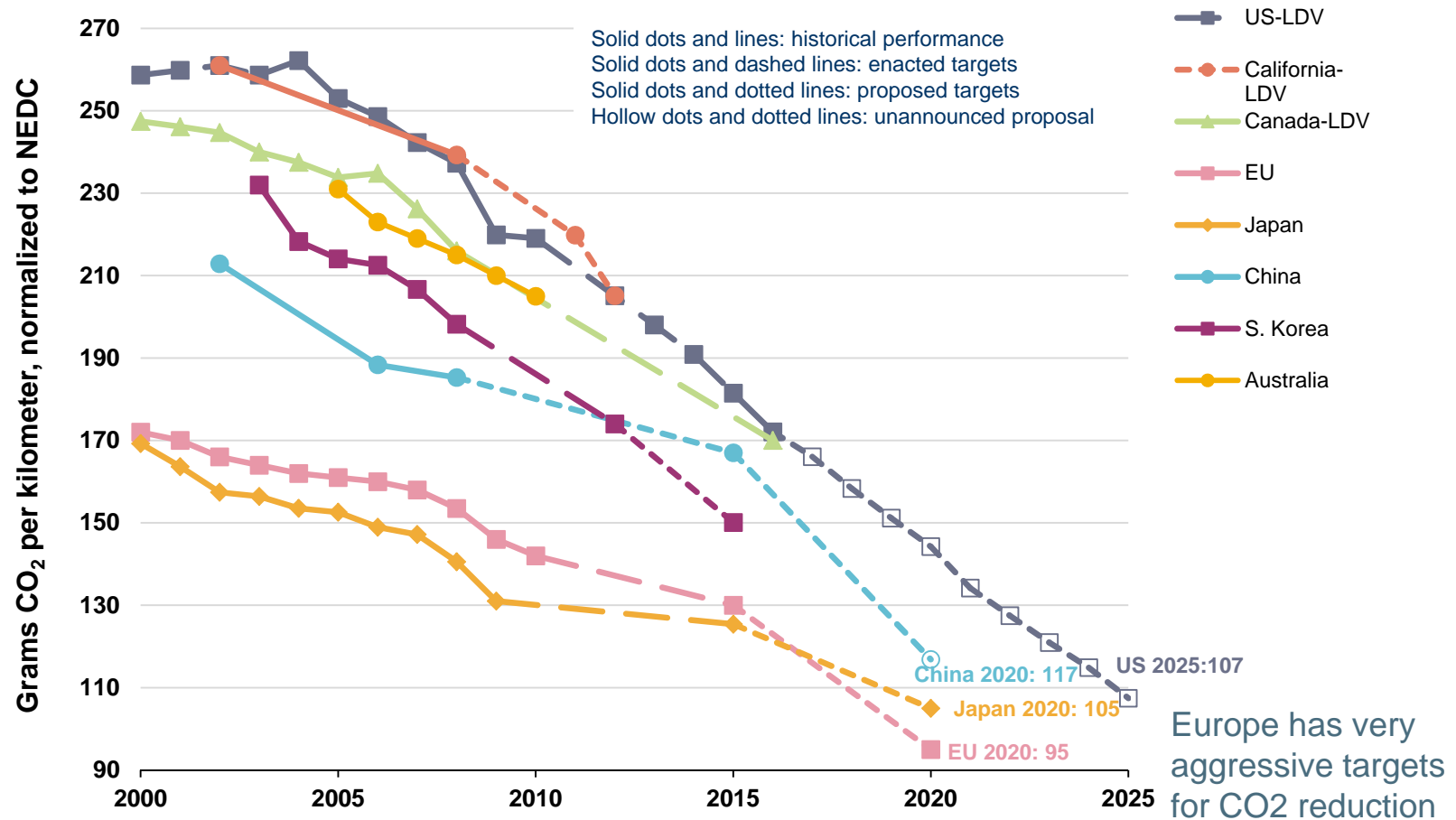


2012 Sample 160 kg/vehicle



Emissions and Fuel Economy Analysis

Global fleet CO₂ emissions performance and current or proposed standards adjusted for the European test cycle



[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 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:

100 kg of weight reduction saves 8 grams of CO2 per kilometer. This is a 5% reduction

Aluminum will provide 50% to 75% of this weight reduction

Alternative powertrain acceptance will remain at less than 10% of the solution through 2025

The estimates we have for similar requirements in the U.S. are relevant to Europe

Comments:

- 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 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%

- 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 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

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

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.

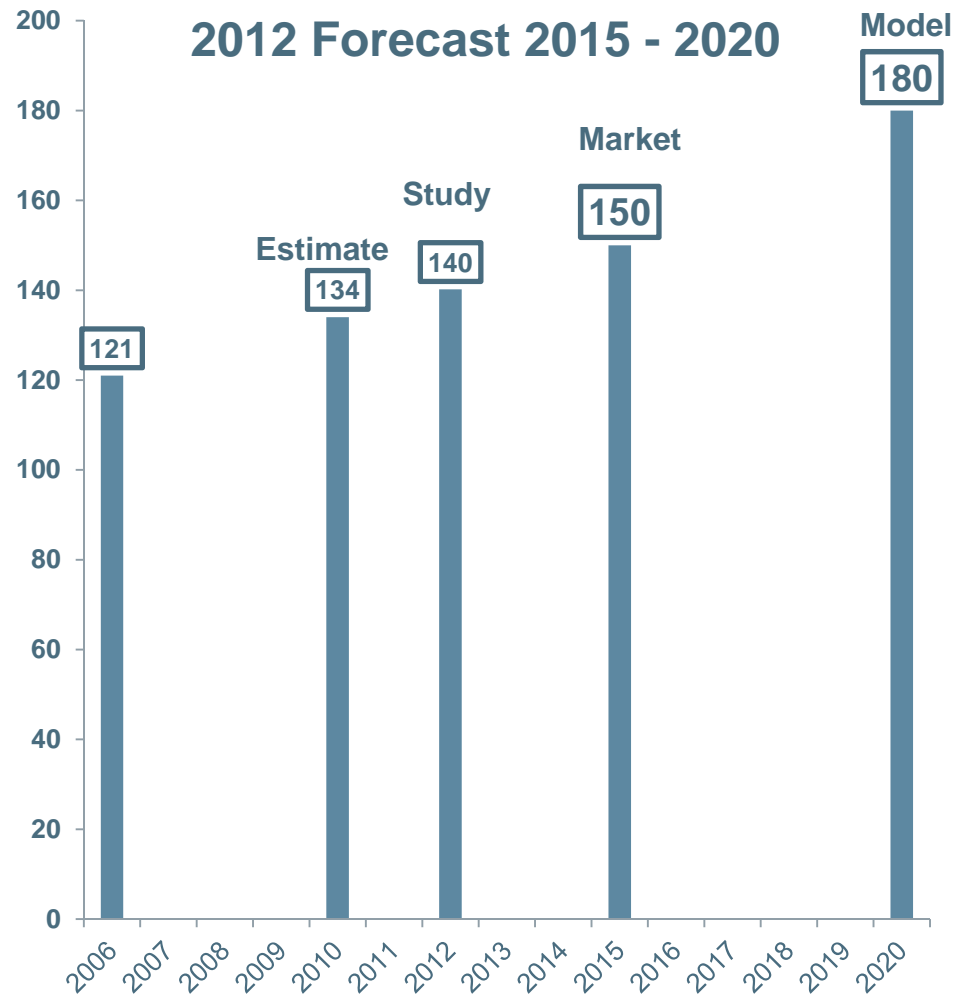
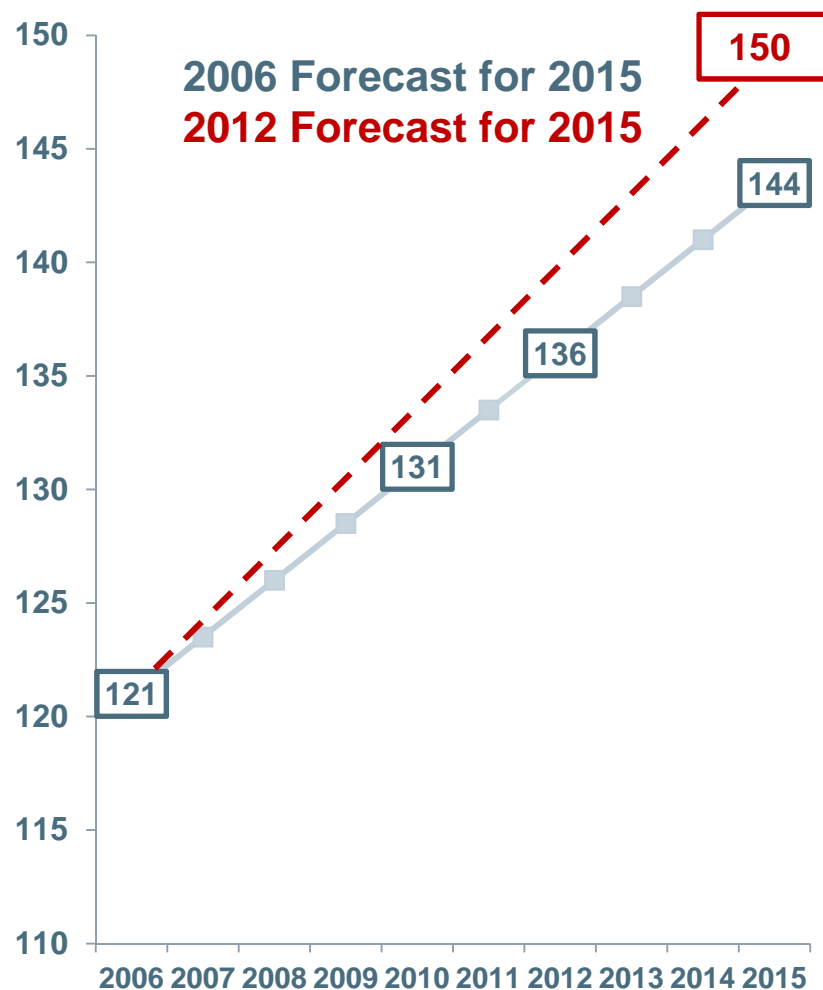
		Footprint-based regulation	Mass-based regulation
		Physical correlation	a= 0.0457
g CO2 excess	penalty (€)	8 g saved per 100 kg saved	3.43 g closer to target per 100 kg saved
]0-1]	5	0.4 € per kg saved	0.17 € per kg saved
]1-2]	15	1.2 € per kg saved	0.51 € per kg saved
]2-3]	25	2.0 € per kg saved	0.86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

Future Aluminum Content Analysis



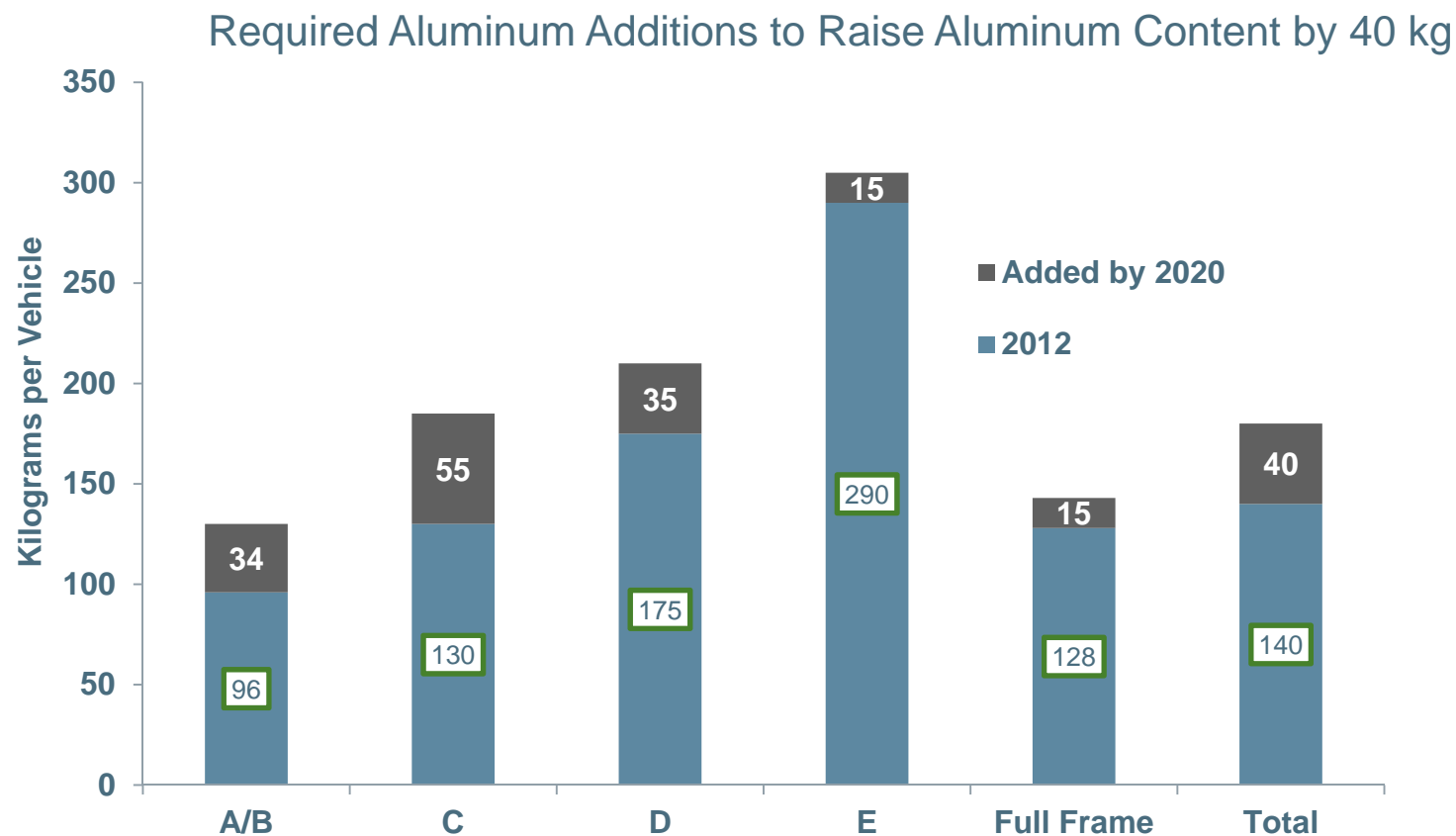
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A previous short term trend analysis predicted 144 kilograms of aluminum content by 2015. The current trend analysis and market evidence supports a forecast of 150 kg per vehicle in 2015, and the theoretical CO2 based analysis supports 180 kg by 2020



Future Aluminum Content Analysis

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.

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