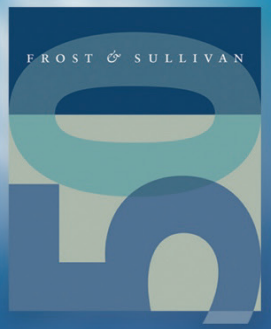
Lightweight Options and Forecast of Material Types

Global snapshot of lightweight solutions



Presented by
Vishwas Shankar

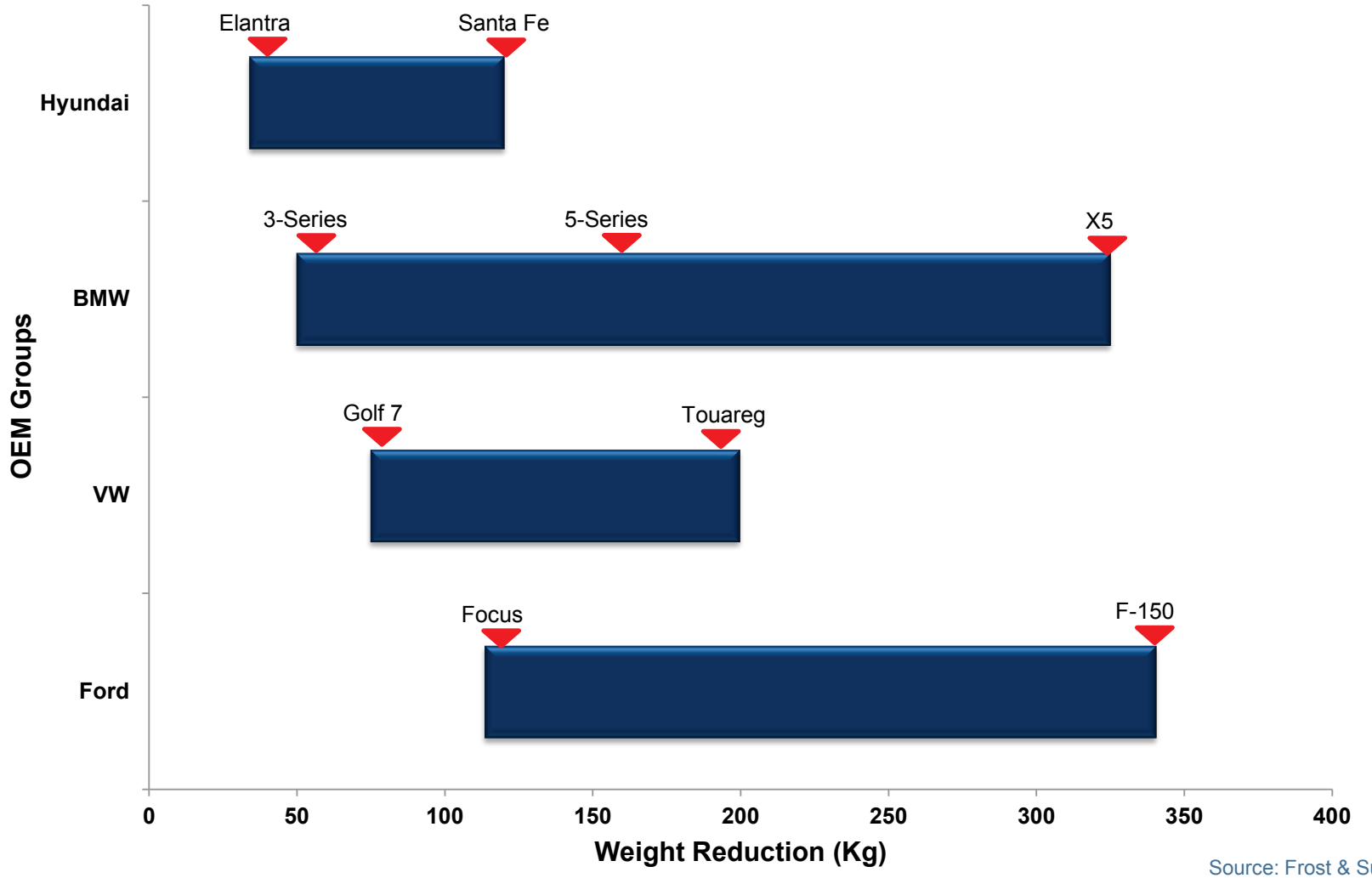
April 19, 2016

FROST & SULLIVAN

OEMs Identify 350 Kg Weight Reduction (20%) Opportunity

Global OEMs have identified to lose upto 350 kg depending on the model, segment, brand of the vehicle—en route to achieve the desired 2020 CO_2 emission / 2025 CAFE targets.

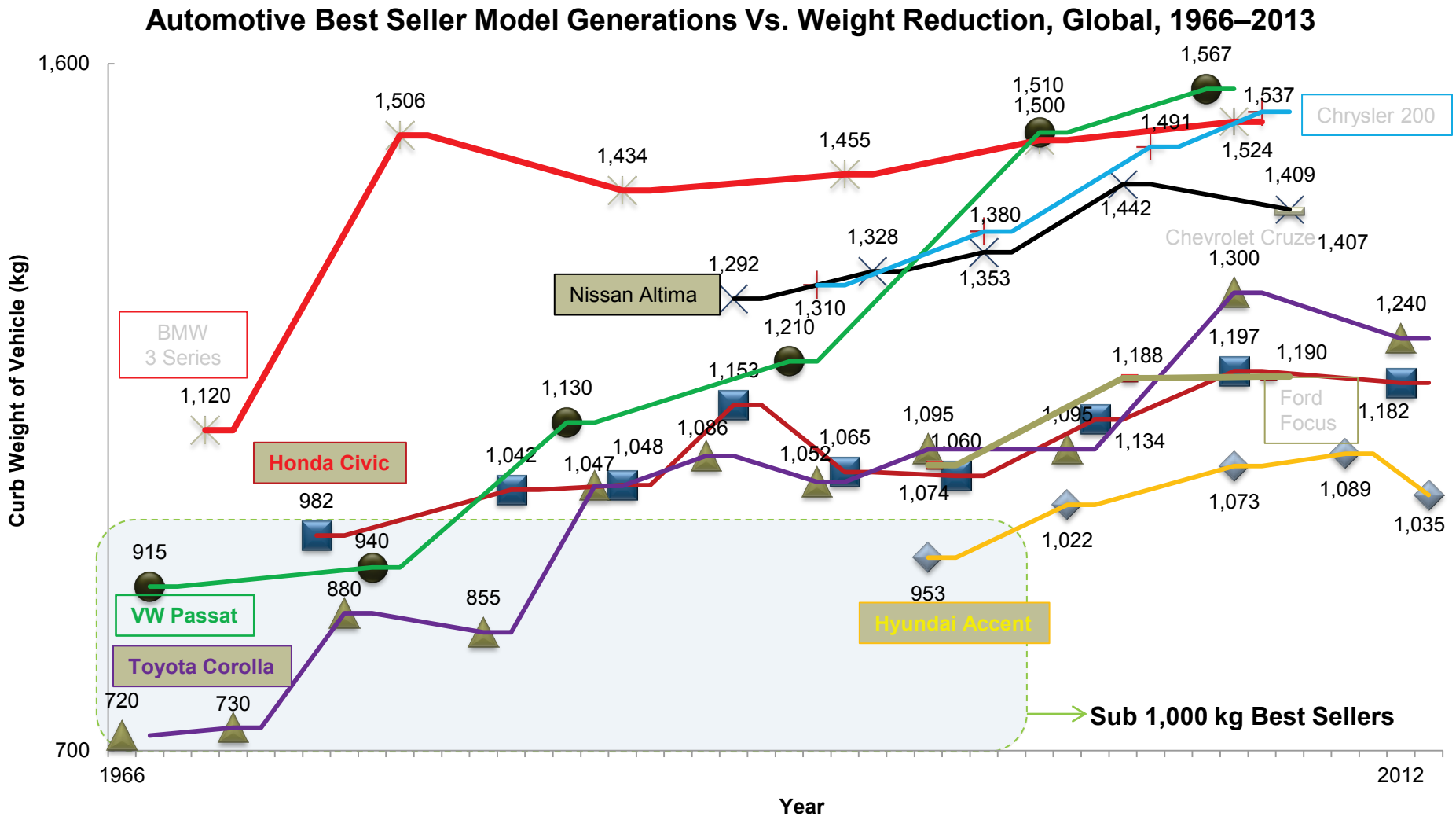
Automotive OEMs Identify Up to 350 Kg Weight Reduction, Global, 2013–2020



Source: Frost & Sullivan

50 years of Weight Trends – Global Best Selling OEM Models

1 in 2 OEMs reduced weight of their best selling model in fleet globally in the last generation.

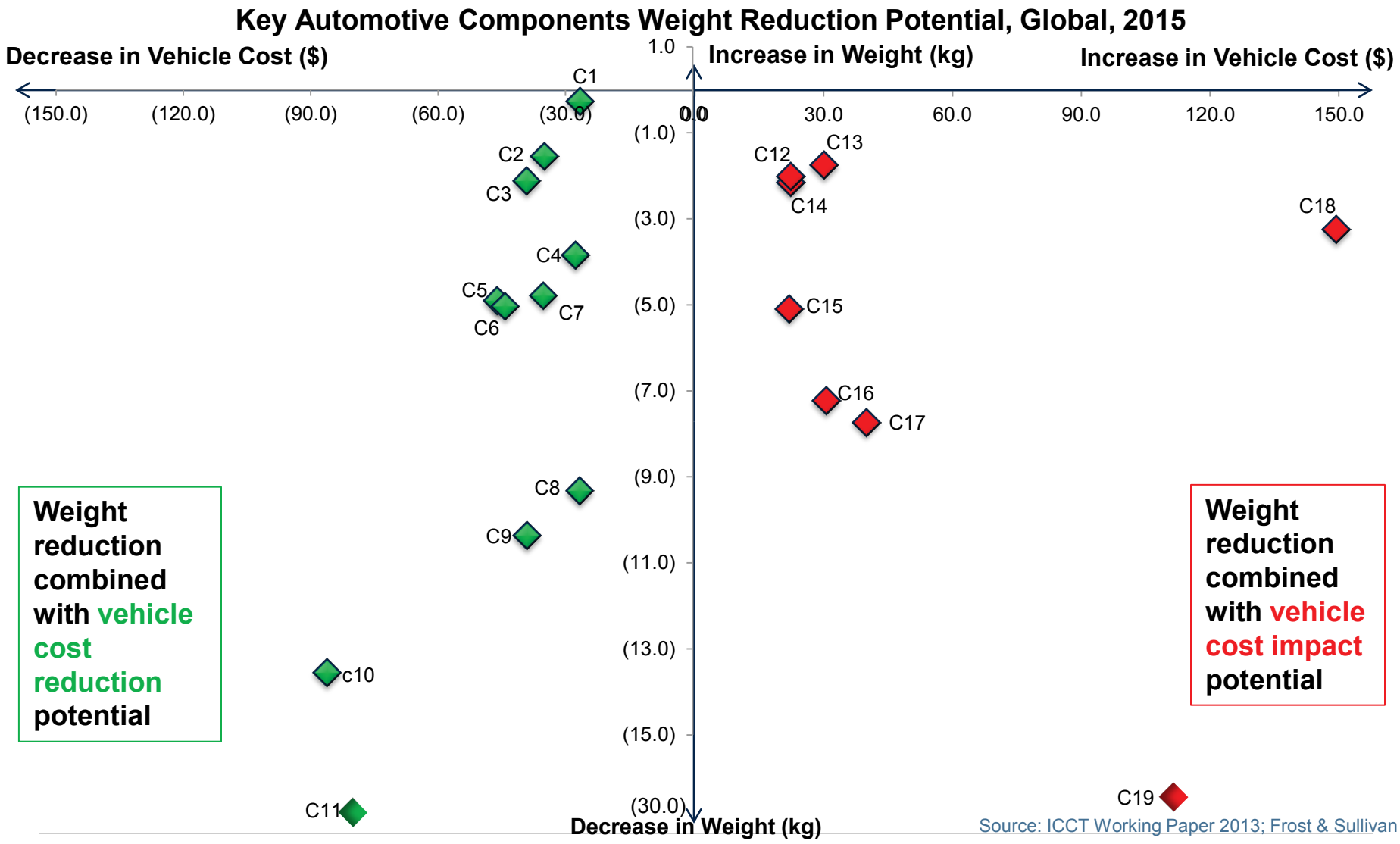


Note: Models that lost weight in the last generation

Source: Frost & Sullivan

Vehicle/System Weight Reduction Offers Cost Savings Opportunity Also

Potential opportunity to reduce costs along with saving weight (about $0.5 per kg weight reduction)

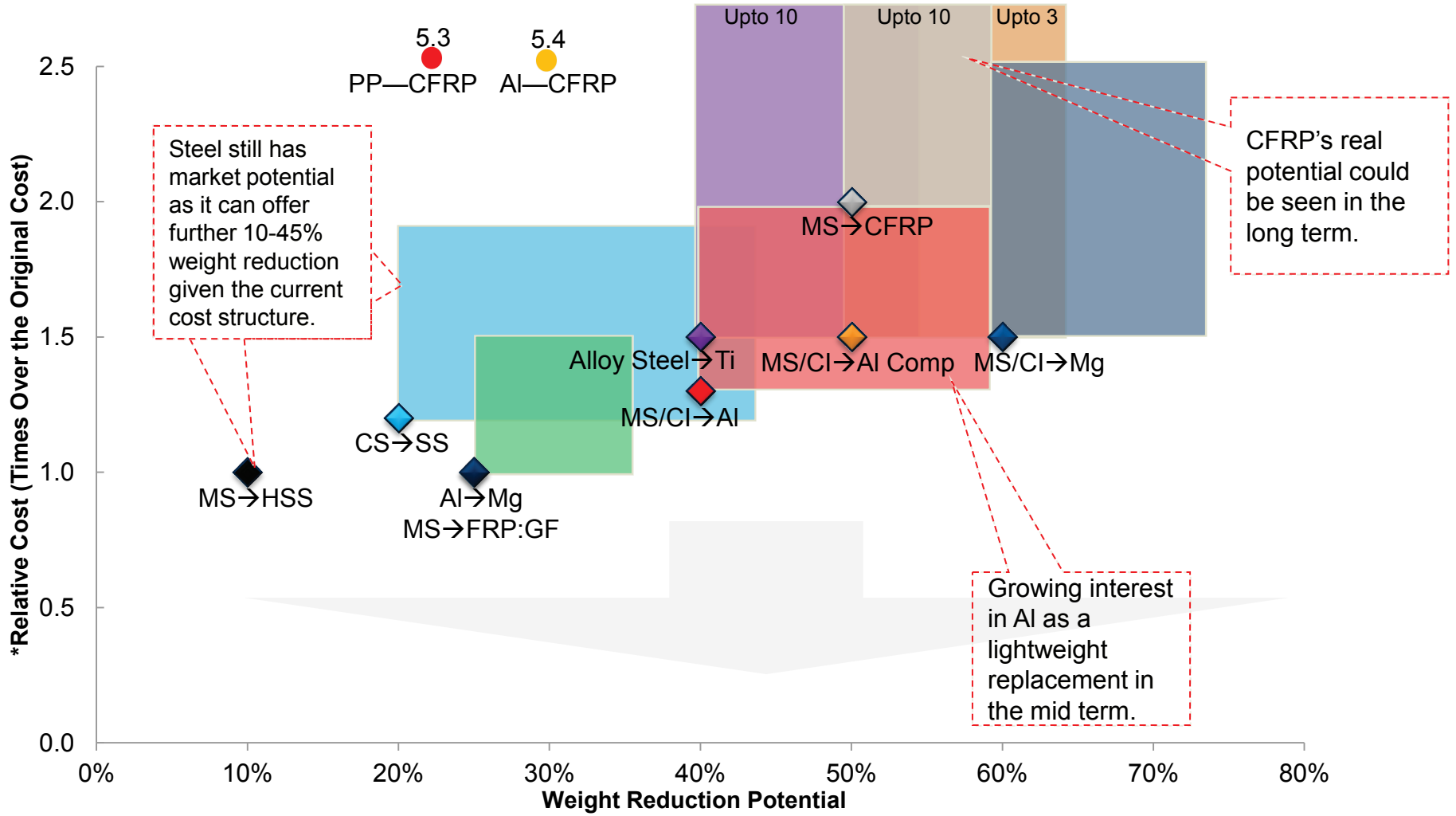


Source: ICCT Working Paper 2013; Frost & Sullivan

Material Substitution Economics—Weight Savings versus Cost Impact

Leading up to 2020, Steel has a bigger role to play, Al continues to find more acceptance than before in the short term, CFRP seen as a more sustainable mass production solution in the long term.

Automotive Material Choices Based on Weight Savings and Cost Impact, Global, 2016

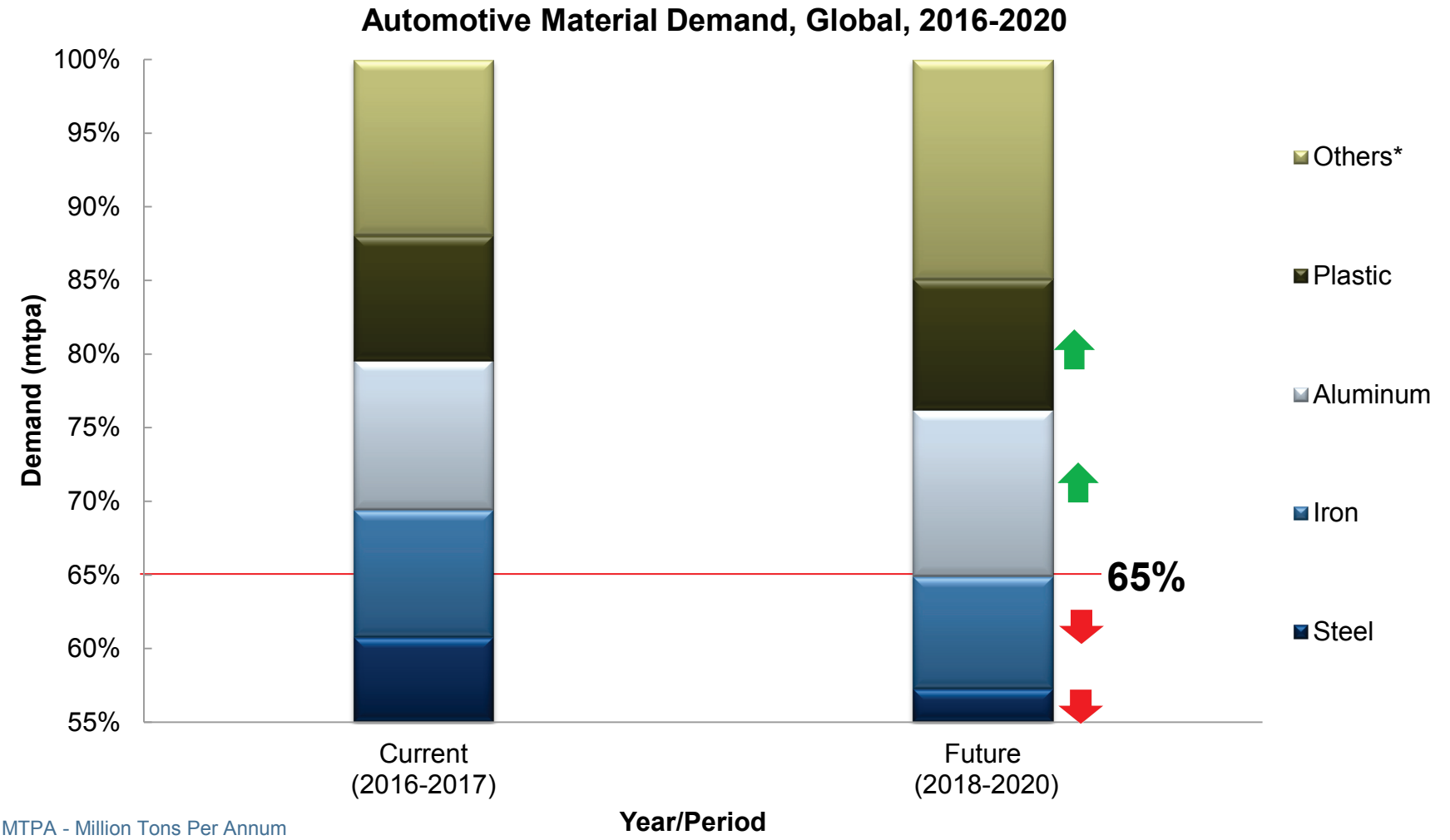


Note: *Includes both materials and manufacturing.

Source: William F. Powers; Advanced Materials and Processes 2012); Frost & Sullivan

Availability of and Demand for Steel Force OEMs to Rethink Strategy

Iron and steel automotive requirements expected to still remain 65% total demand for materials. Al, plastics expected to grow by 2020.



Key: MTPA - Million Tons Per Annum

Note: *Others include rubber, seals, glass, Cu and zinc.

Reduction Increase

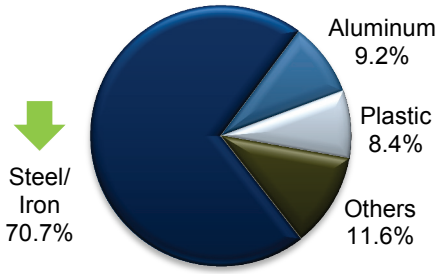
Source: Frost & Sullivan

Efficient, Sensitive, and Convenient Materials—Key to Lightweighting

Aluminum in a Multimaterial Strategy: Although steel remains the primary material choice for automotive applications, aluminum adoption is increasing.

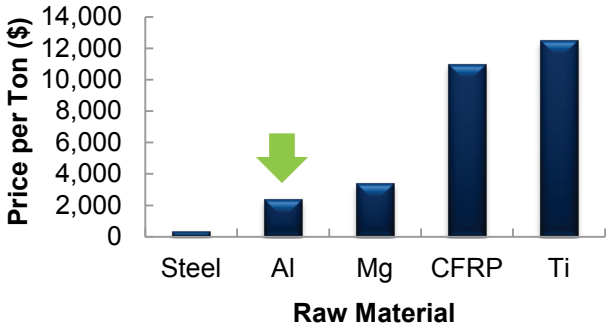
Aluminum in Passenger Vehicles: Multimaterial Strategy, Global, 2010, 2012, and 2015

Material Demand, 2010



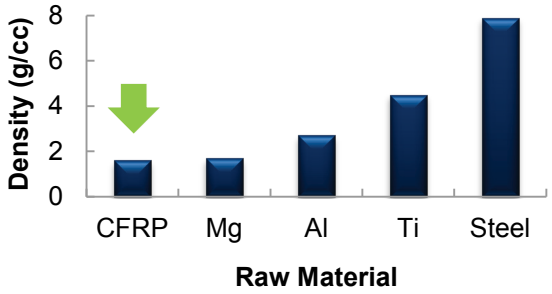
Steel has been the most popular and accepted material for more than a century.

Key Raw Material Prices, 2012



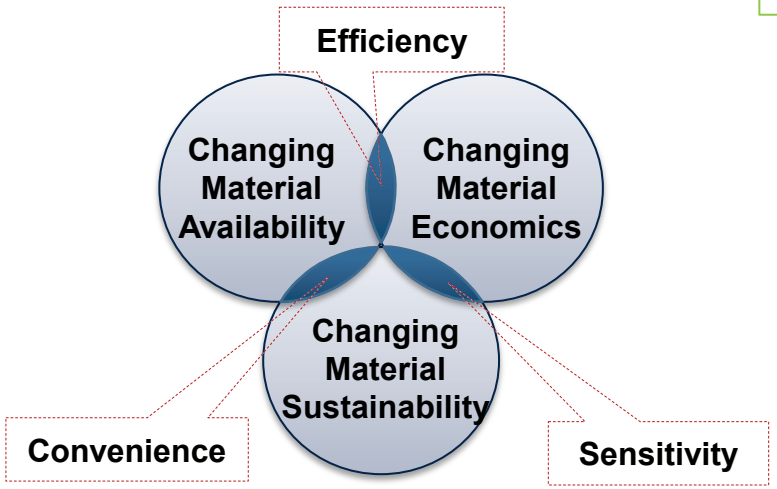
Aluminum is closest to steel in price; use of aluminum alloys is becoming widely accepted.

Lightweight Options Over Steel, 2015



CFRP is best for density but not yet price as mass-production applications are limited.

Which material is best for long-term sustainability?



Recent evidence indicates strong interest in aluminum as the material choice in hybrid construction.

Key: CFRP—Carbon Fiber-reinforced Plastic; Al—Aluminum; Mg—Magnesium; Ti—Titanium.

Source: Frost & Sullivan

Key Focus Areas and Lightweight Replacements of Key Global OEMs

Advanced grades of steel comprise the preferred choice for key BIW structures; CFRP is the preference for BIW panels, Al for small BIW parts and Powertrain; Mg for Chassis; and CFRP for Interiors by 2020.

Key Focus Areas and Materials Choice by Automotive OEMs, Global, 2013–2020

Region	North America			Europe					Asia-Pacific			
Focus Area	**NA OEM1**	**NA OEM2**	**NA OEM3**	**EU OEM1**	**EU OEM2**	**EU OEM3**	**EU OEM4**	**EU OEM5**	**APAC OEM1**	**APAC OEM2**	**APAC OEM3**	**APAC OEM4**
Body Key Structures	Steel / CFRP		Steel	Steel	Steel / CFRP	CFRP		CFRP	Steel	Steel	Steel	Steel
Body Key Panels		Steel / CFRP	CFRP		Steel	CFRP		Steel / Al	CFRP	CFRP		
Body Key FEMs		Steel			Steel	Steel	Steel	Al / CFRP				
Small Body Parts (other)	Mg	Al	Al	Mg	Al	Al	Al / Mg	Al		Mg / Al	Al / Mg	Mg
Powertrain			Al	Al	Al / Mg	Mg	Mg	Mg / Al		Al / Mg	Mg / Al	Al
Chassis		Steel / Mg		Al	Steel / Al / Mg	CFRP	Mg			Mg	Steel	Al
Interiors						CFRP	CFRP	Mg	CFRP	CFRP		Mg

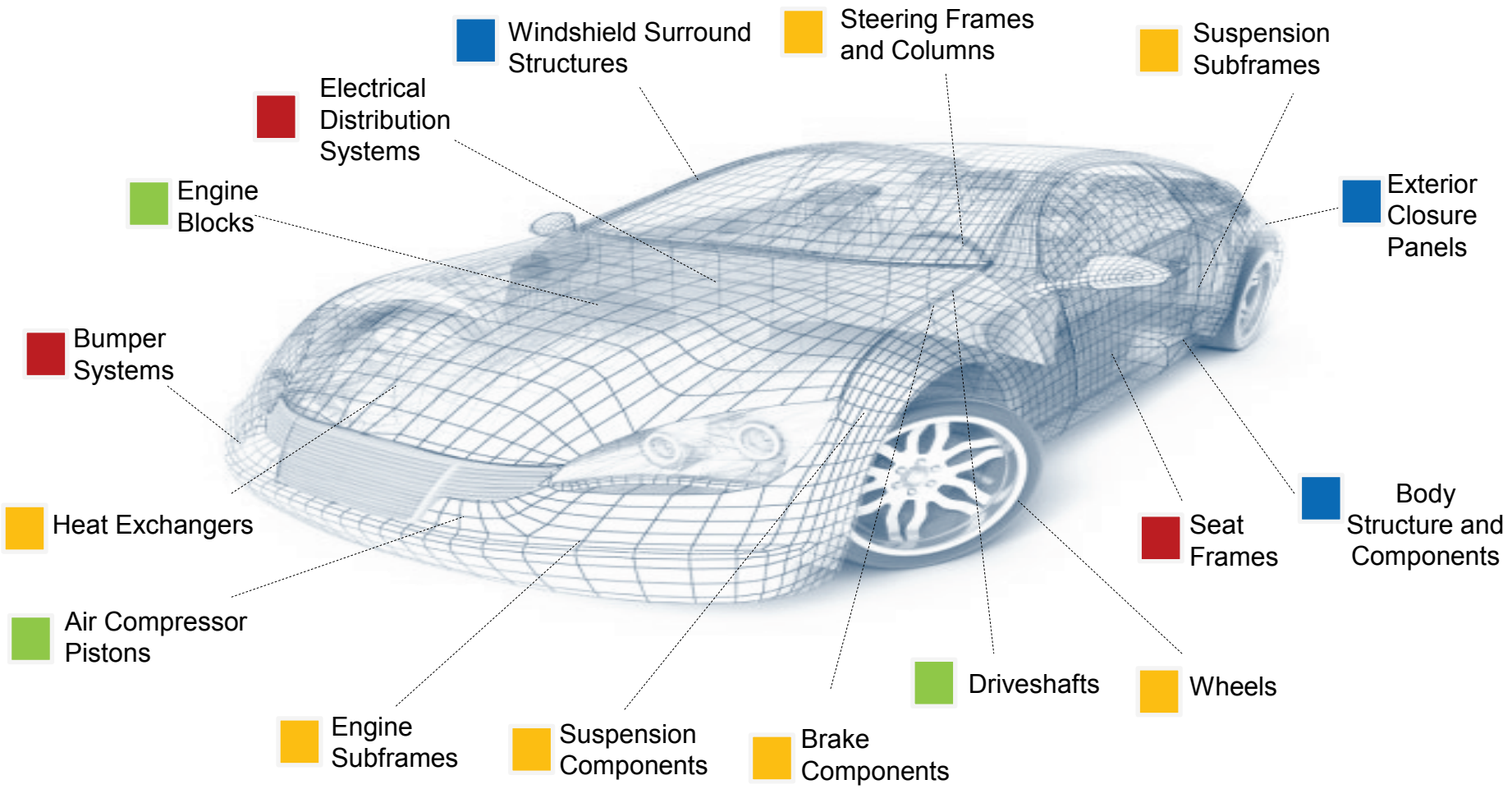
Strong Existing Pattern

Source: Frost & Sullivan

Aluminum Usage Trends in Current-generation Vehicles

Wide spread Aluminium usage in more chassis components, small body parts and powertrain components, electrical distribution systems, bumper systems, and even seat frames.

Aluminum in Passenger Vehicles Usage Trends, Global, 2015



Source: Frost & Sullivan

Material Intensity Vehicle Matrix

The Audi A4 and Ford F-150 are expected to set benchmarks for aluminum usage in future.

Aluminum in Passenger Vehicles: Material Intensity Vehicle Matrix, Global, 2015–2025

Current

OEMs

	Steel	Aluminum	CFRP
Best in Class	BMW	Audi, Tesla	-
High	Honda	Ford	VW
Moderate	GM	-	Honda

Segments

Steel	Aluminum	CFRP
D-Midsize	D-Midsize	-
C-Compact	Pickup	C-Compact
C-Compact	-	C-Compact

Models

Steel	Aluminum	CFRP
3-Series	A4, Model S, Model X, F-150	-
Insight	F-150	Golf
ATS	-	Insight

Future (Beyond 2020)

	Steel	Aluminum	CFRP
Best in Class	GM Honda	Audi, Tesla, Ford	BMW
High	-	-	VW
Moderate	Audi	-	Ford

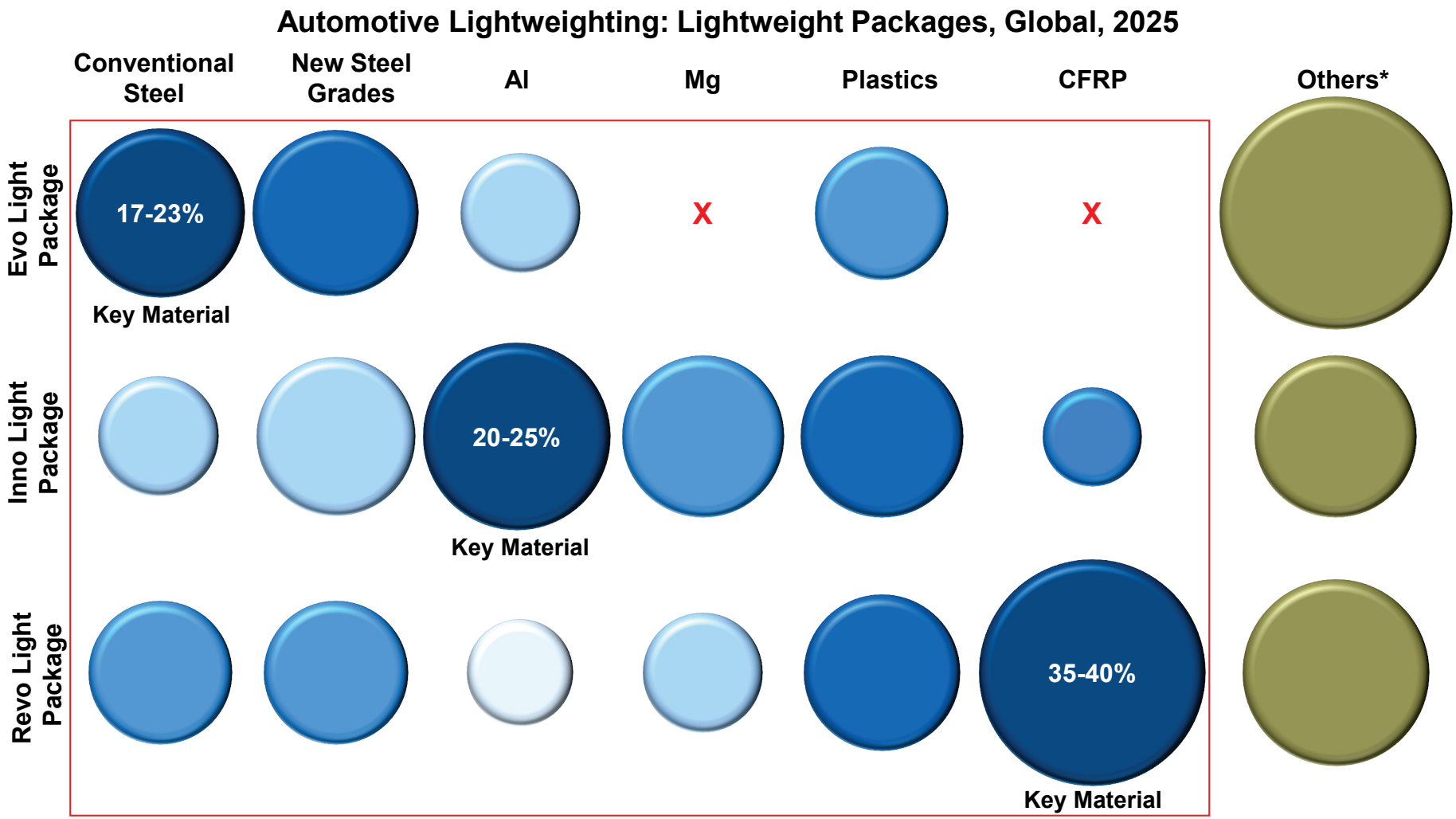
Steel	Aluminum	CFRP
C-Compact	D-Midsize, SUV, Pickup	SUV
-	Pickup	C-Compact
G-Sports	-	C-Compact

Steel	Aluminum	CFRP
ATS Insight	A4,Model X, Model S, F-150, F-250	X5
-	Explorer, Ranger (high-end)	Golf
TT	-	Focus

Source: Frost & Sullivan

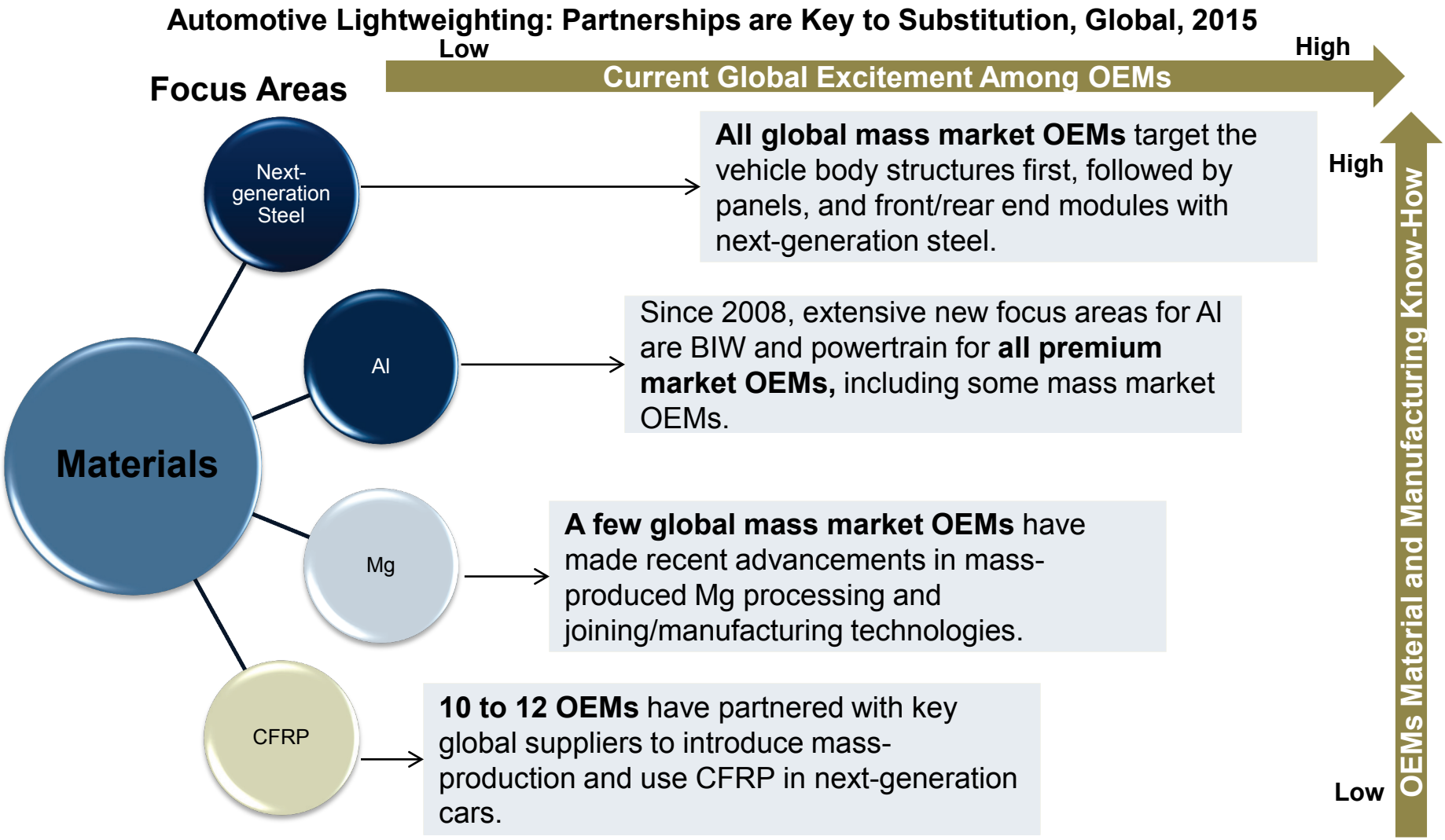
Lightweight Packages Creates Different Business Opportunities

Multiple packages within a particular brand could create a much-needed competitive advantage and attract large number of end customers as well as those looking for a product differentiation.



New Material/Joining Partnerships are Key to Material Substitution

Global mass market OEMs target vehicle body structures first, followed by panels; front/rear end modules and chassis parts are also on their radar.

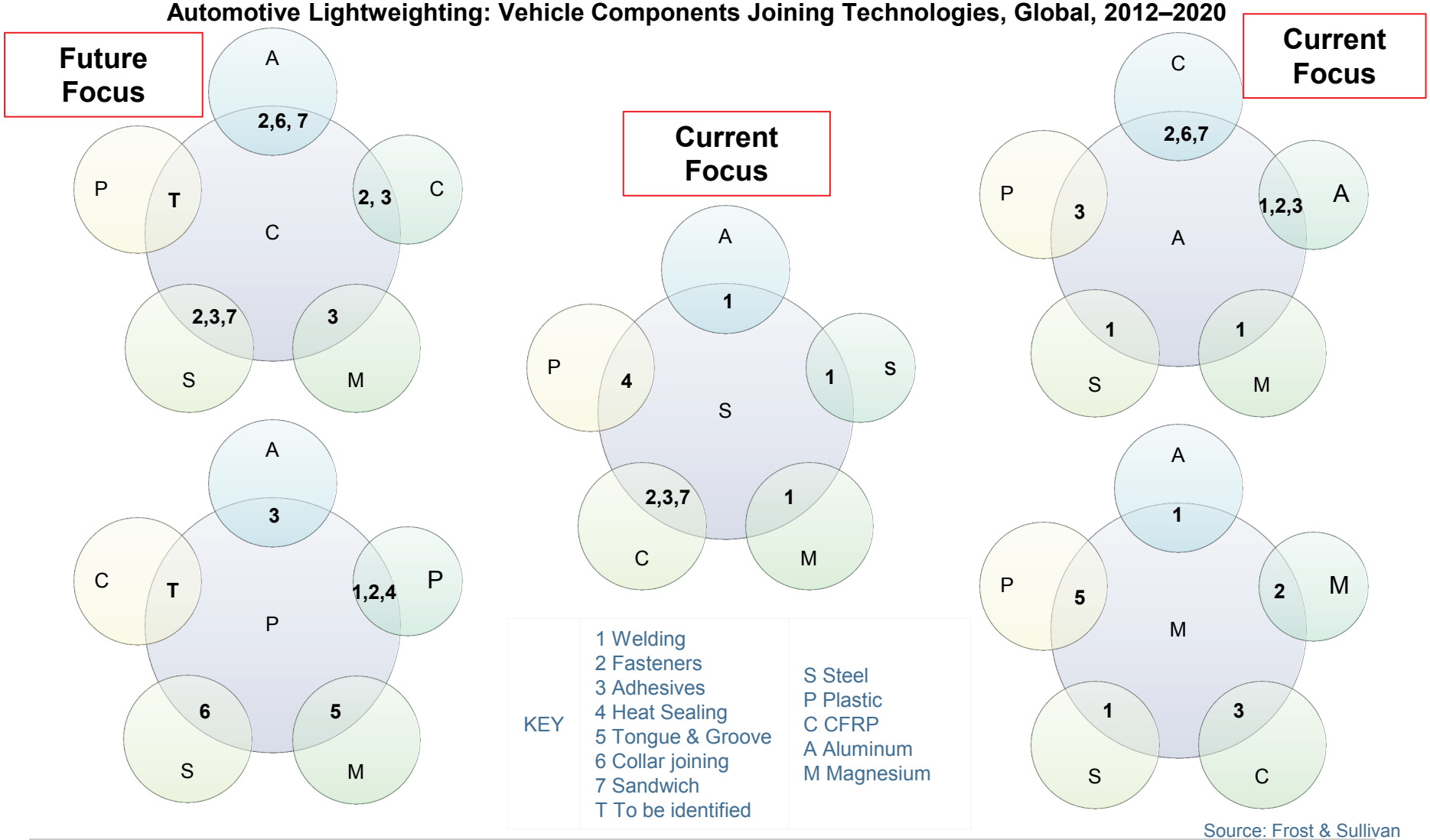


Source: Frost & Sullivan

Automotive Materials Joining Technologies—Current and Future Focus

Steel or CFRP are the center of focus, and steel-CFRP joining is attracting research as is Al-Al, Al-CFRP and plastic-plastic joining.

Automotive Lightweighting: Vehicle Components Joining Technologies, Global, 2012–2020

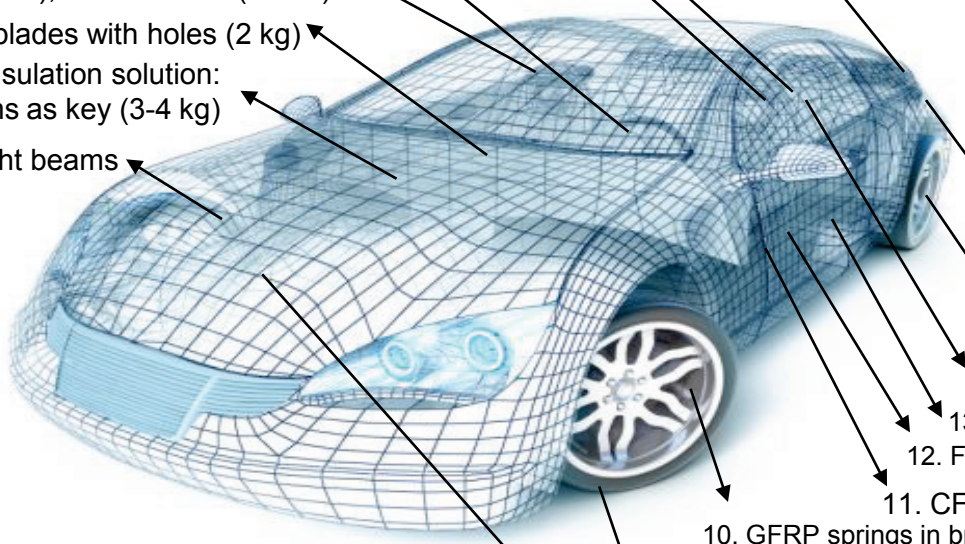


Source: Frost & Sullivan

Revolutionary Effort in Lightweighting—Out-of-the-box Thinking

OEMs and suppliers are moving towards solutions including plastic wheels, Al instead of Cu in wiring harness, fabric body panels, and composites in tires are expected in future production models.

Automotive Lightweighting: Revolutionary Effort in Lightweighting, Global, 2012–2020



1. Use of shape memory alloy (SMA) trunk opening mechanism
2. "Evolution seats" (10 kg)
3. New plastics in seat recliner (Golf) (7 kg)
4. Airbag inflator (25%) lighter
5. Planar speaker technology (magnets); fabric covers (bowls)
6. Wiper blades with holes (2 kg)
7. Three layer dash insulation solution: lightweight foams as key (3-4 kg)
*Replacing wires with light beams
8. Ethernet-based communication solution; reduces wiring complexity
9. Fiber composites in tires
10. GFRP springs in brakes (6 kg)
11. CFRP body panels acts as battery (15%)
12. Fabric body panels (40-80 kg)
13. Al wires instead of Cu
14. Polycarbonate to replace glass (50%)
15. Use of plastic in wheels (12 kg)
16. Use folding bikes made of CFRP (instead of spare wheels)

Tier I
2. Lear
4. TRW
5. JBL, Harman
6. Valeo
7. Faurecia
8. Broadcom
9. Michelin
15. BASF

OEMs
1. GM
3. VW
10. BMW
11. Volvo
12. BMW, Lotus
13. BMW
14. Fiat, Ford
15. Daimler
16. VW

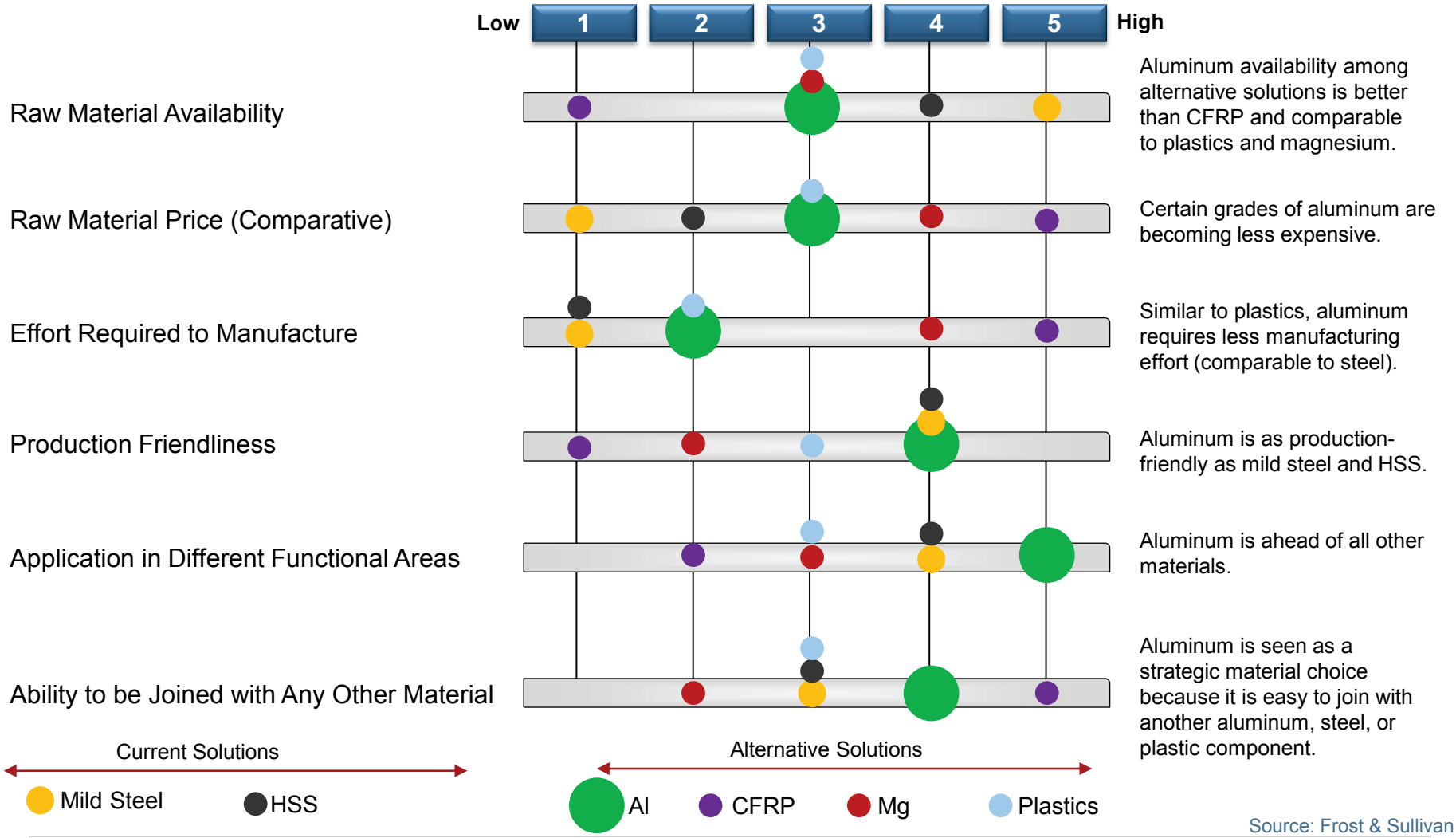
* TBA – To be Announced

Source: Frost & Sullivan

Advantages Offered by Key Materials Continue to be Re-evaluated

Commercial and technical advantages of aluminum versus next generation steel, CFRP continue to be re-evaluated with every new model/existing model generation change.

Aluminum in Passenger Vehicles: Material Advantages, Global, 2015



Source: Frost & Sullivan

Thank You!

FROST & SULLIVAN

Vishwas Shankar
Research Manager - Business Strategy & Innovation
Mobility
P: +1 248 536 2004
VishwasS@frost.com

www.frost.com/mobility