



Fuel Economy with **Aluminum**

The road to fuel efficiency is enabled by Aluminum.
Aluminum technology will support an additional 1.5 – 2.0 mpg save.

Todd Summe

Chief Research & Development Officer,
Novelis Inc

The Aluminum Transportation Group



KAISER
ALUMINUM

Novelis
Not just aluminum. Novelis Aluminum.™

 **HYDRO**

Aleris

RioTinto

 **Constellium**


ARCONIC
Innovation, engineered.

 **TRI-ARROWS**
ALUMINUM INC.



120+ Association Member Companies



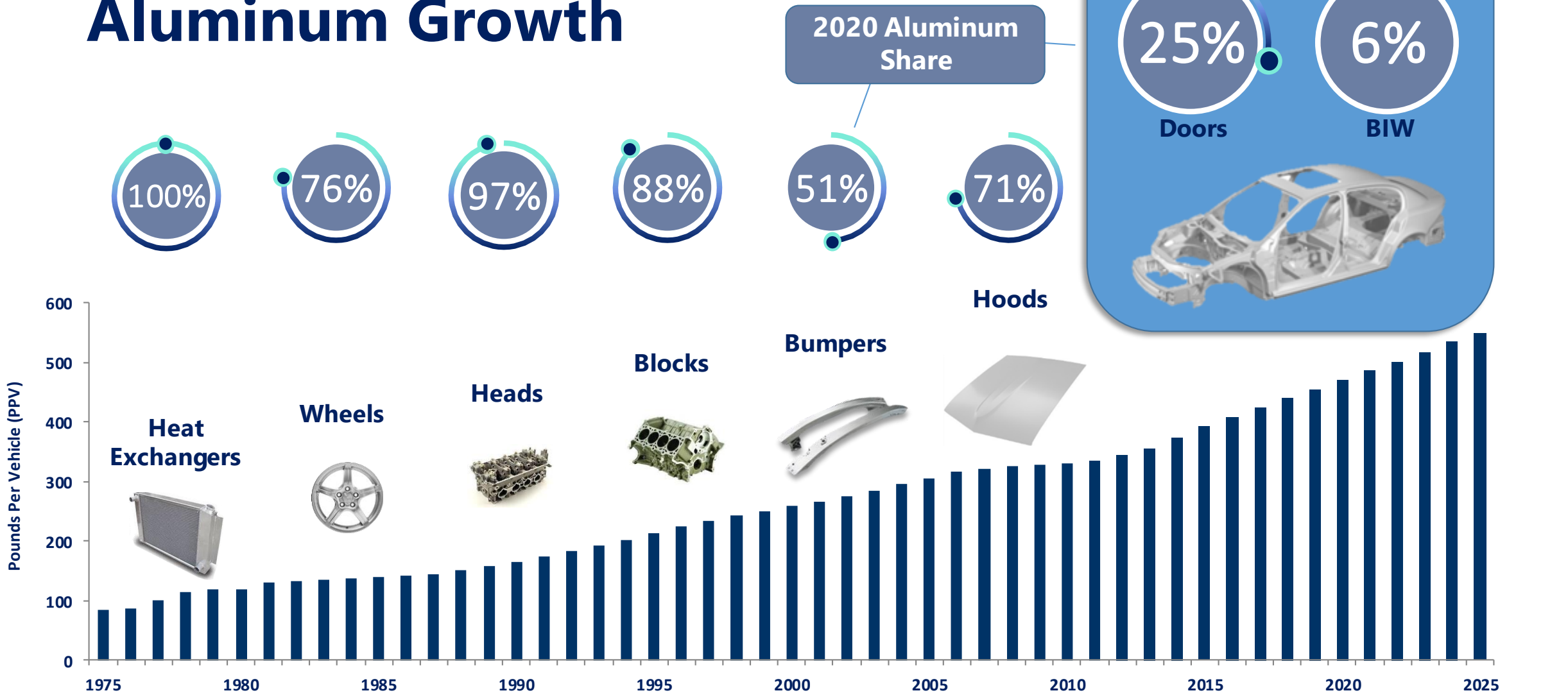
Nearly 700,000 jobs supported

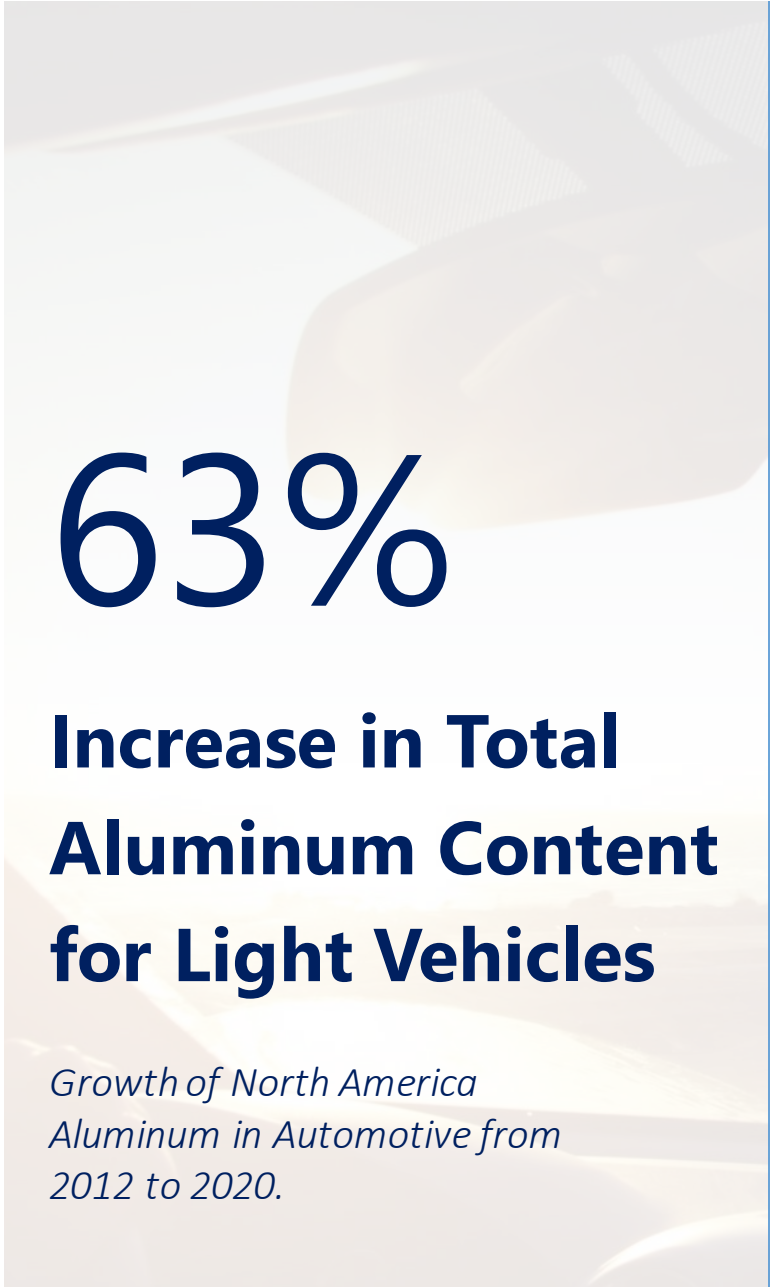


\$3B invested since 2013



50 Years of Automotive Aluminum Growth





63%

Increase in Total Aluminum Content for Light Vehicles

Growth of North America Aluminum in Automotive from 2012 to 2020.

THEN 2012

High volume sheet applications mainly hang-on parts.

PRIMARY APPLICATIONS:

Heat Exchangers, Wheels, Engine Blocks and Heads, Hoods and Decklids

NICHE APPLICATIONS:

Aluminum body, doors, bumpers and crash systems.

NOW 2020

Demonstrated in high volume for BIW applications.

APPLICATIONS:

Status Quo: Heat Exchangers, Wheels, Engine Blocks and Heads, Hoods, Decklids, Bodyside

Conversion Underway: Doors (25% of Market by 2020)

Demonstrated Next Step: High Volume Aluminum body (6% of Market by 2020)

The 2015 Ford F-150 Changed the Game

2015
IIHS

TOP
SAFETY
PICK

1.7 pts

\$395

700 lb

19%

Market Share

Market Leadership Expanded¹

Consumer Price

Reported New Model Price
Increase²

Curb Weight

Aluminum intensive body
with steel frame.¹

Fuel Economy

Up to 19% better fuel
economy¹ (3-5 mpg³)

1. Ford's Use of Aluminum in the F-Series Truck Program By George Luckey, Ford Motor Company, Presented at the Aluminum USA Conference, Oct 25-26, 2017 Nashville TN

2. <https://www.caranddriver.com/news/a15362316/all-new-2015-ford-f-150-pricing-goes-live-starts-at-26615/> [caranddriver.com] – F150 XL and XLT

3. EPA - fuel economy for 2014 and 2019.

Jaguar I-PACE



Lb

802 lb Body with doors

Al

91.5 % Aluminum Body Content by Wt.

Mi

234 mile range on a single charge.

EV

Battery box is primarily 6xxx aluminum construction

Automakers continue to refine aluminum designs.

Production Vehicle	Closures		BIW	
	Al Application	Component Weight Reduction	Al Application	Component Weight Reduction
2012 Range Rover ^{1,2}	Doors, Hood, Fender, Bodyside	est. 40%	Al intensive BIW	39%
2014 Cadillac CTS ³	Hood, Doors	est. 30%	-	-
2015 Ford F150 ⁴	Hood, Fenders, Bodyside, Doors	39%	Aluminum BIW on Steel Frame	43%
2015 Cadillac CT6 ⁵	Hood, Bodyside, Doors, Decklid, Roof	39%	Aluminum/Steel Hybrid BIW	17%
2019 Chevrolet Silverado ⁶	Hood, Doors, Tailgate	36%	-	-

1. Bad Nauheim – The all new Range Rover – L405

2. Mass Reduction for Light-Duty Vehicles for Model Years 2017-2025 – NHTSA, 2018

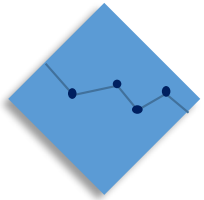
3. A2MAC1 comparing ATS steel doors to CTS aluminum doors

4. EuroCarBody 2015 – F150: The Future of Tough.

5. EuroCarBody 2015 – Cadillac CT6 – Car body benchmarking data summary

6. A2MAC1 comparing 2014 to 2019

The road ahead is enabled by Aluminum



Global Vehicle Platforms with Regional Regulations supported by the aluminum industry



Ridesharing and Autonomy supported by the aluminum advantages



Mixed Powertrain challenges supported by the aluminum advantages



Lightweighting is a key enabler for mixed powertrain platforms

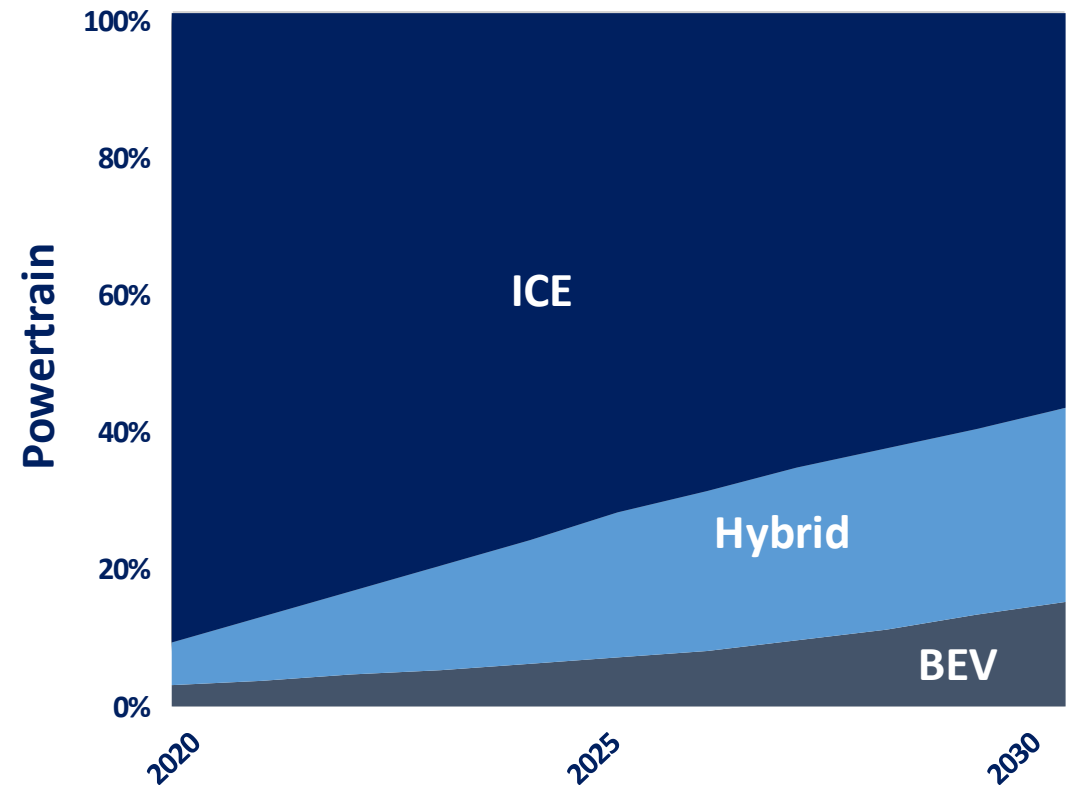
Batteries add weight and will remain heavy:

Even as cost and energy density improves – batteries will continue to weigh 880-1,300 lb in the near to midterm.¹ Lightweighting of structure can help to offset battery weight and cost.

Platform Sharing Adds Weight:

ICE, Hybrid and BEV platform sharing will drive weight addition through due to design trade offs ... structure lightweighting can help to offset weight penalty.

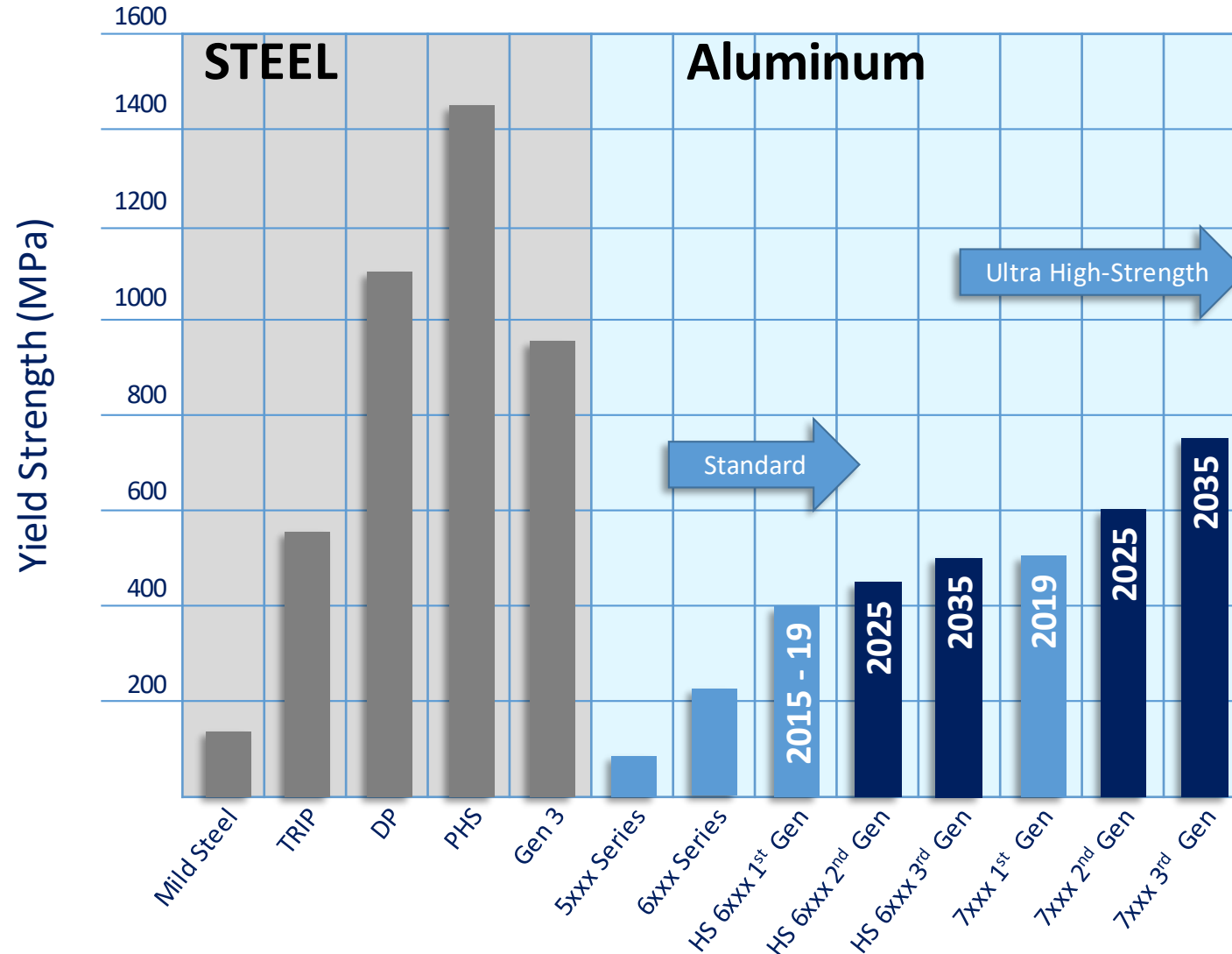
ICE Remains Significant²



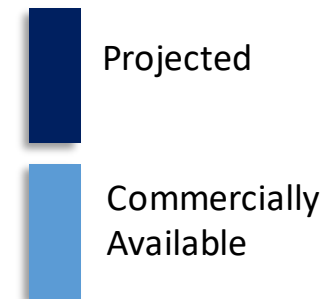
1. Boston Consulting Group (2019)

2. Average of projections from – Boston Consulting Group, US Market (2017), JP Morgan, NA Market (2018), LMC, US Market (2018), Bloomberg New Energy, US Market (2018) and others

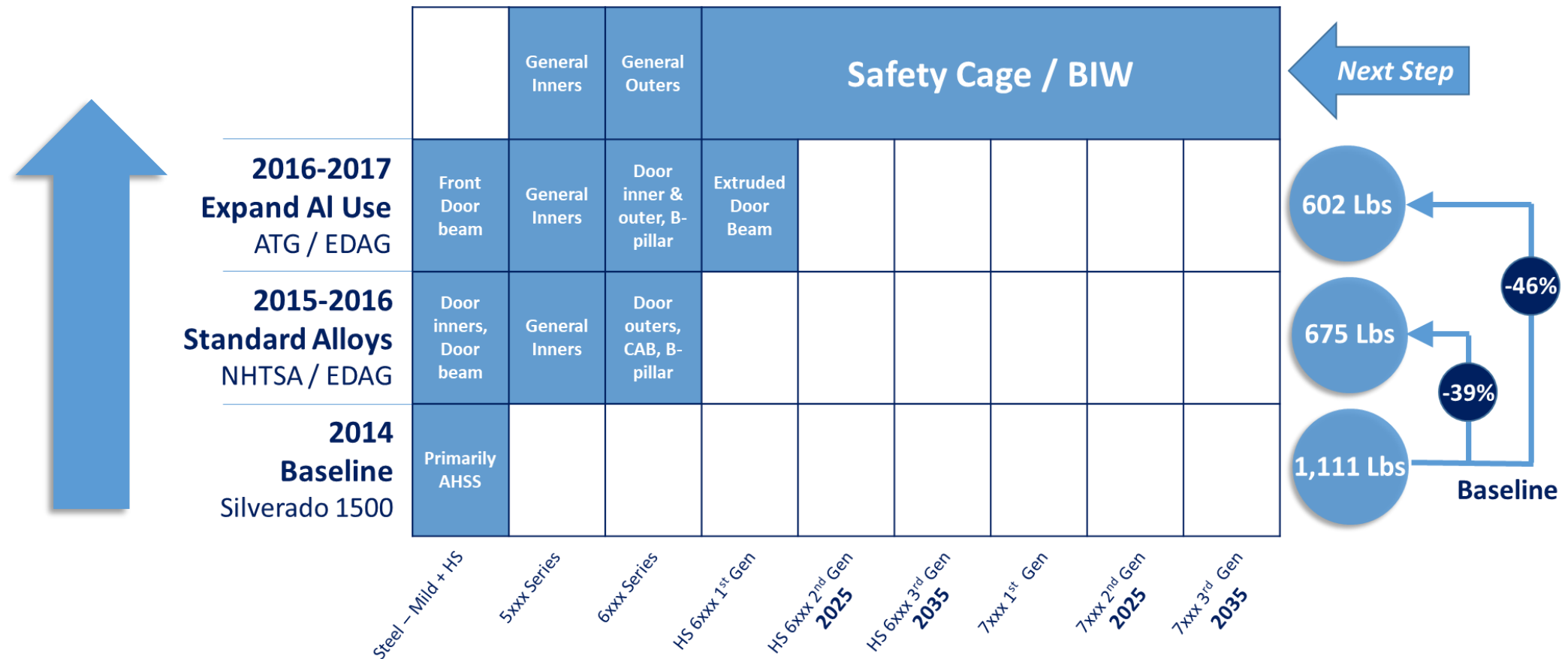
New Ultra High Strength Aluminum (UHSAL) Rises to the Challenge



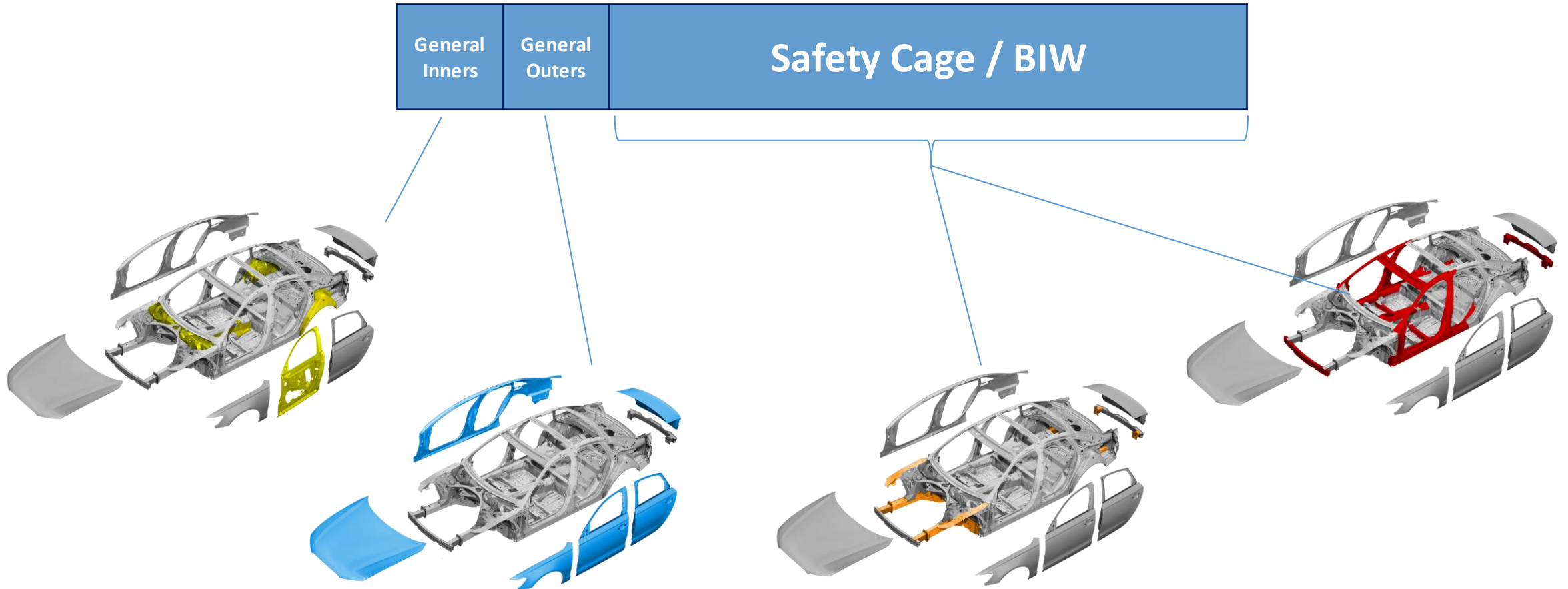
Both Sheet and Extrusion product forms rise to the challenge with new UHSAL grades.



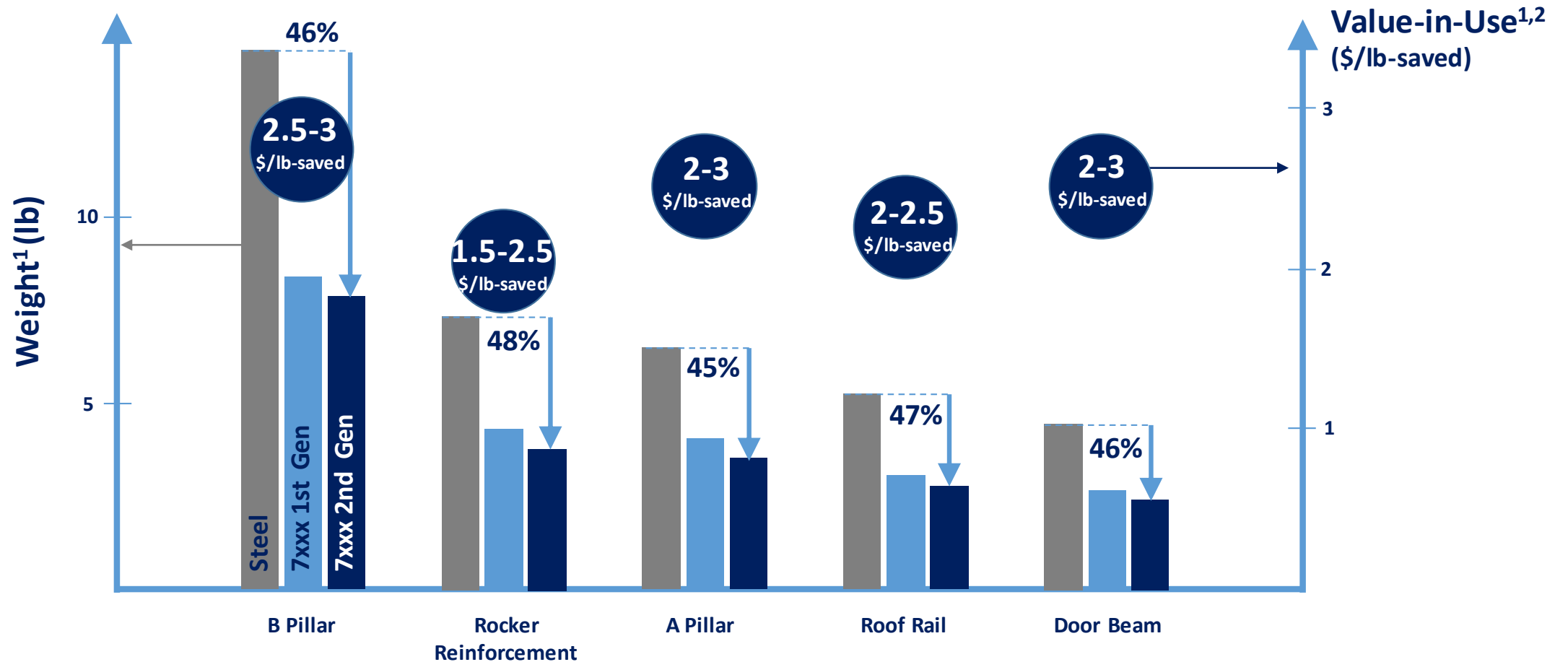
Aluminum Intensive Architectures enabled by Ultra High Strength Aluminum (UHSAL)



New High Strength Aluminum (UHSA) Application Map



Ultra High Strength Aluminum (UHSAL): Next steps with BIW



1. High Strength 7xxx Aluminum Alloys: Design and Business Case for Automotive Applications, Bad Nauheim, April 2019
2. Does not include possible cumulative secondary weight savings such as engine reduction

Key Enablers to Increasing Aluminum Value-in-Use

Joining

- Resistance Spot Welding
- Remote Laser Welding
- Multi-Material Joining

Forming

- Hot Forming
- Roll Forming
- Textures & Lubes

Recycling

- Closed Loop
- Open Loop
- End of Life

Tailored Performance

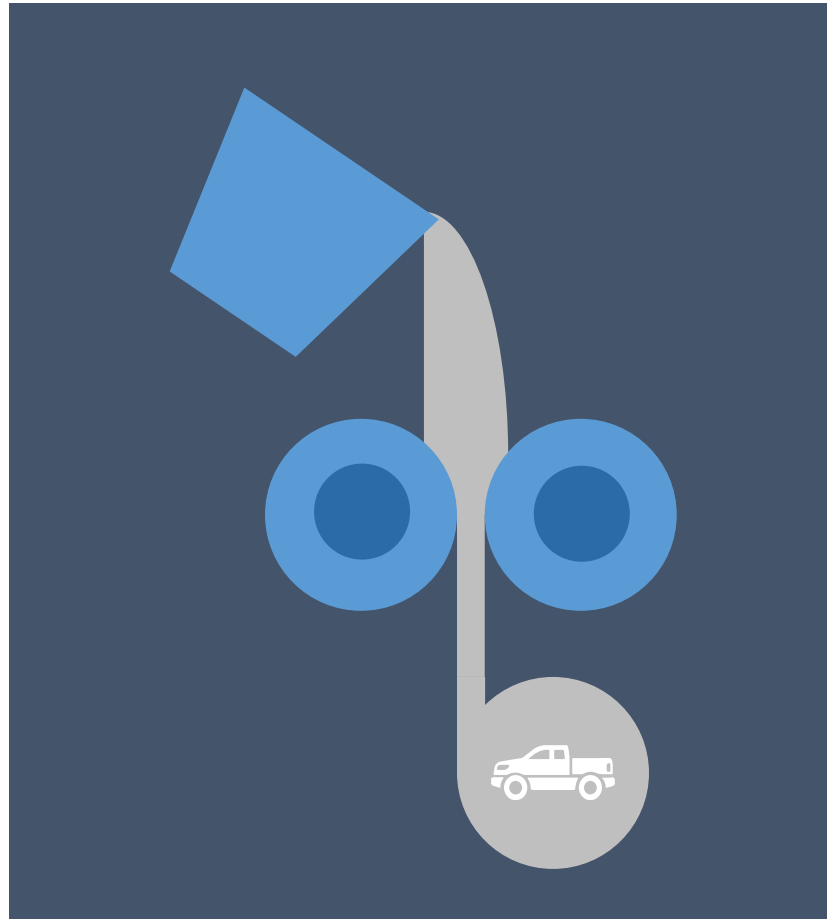
- Continuous Casting
- Tailor Rolling & Welded Blanks
- Optimized Extrusion Design
- Multi-alloy Sheet

20-40%

Value Improvement

Aluminum Continuous Casting will play an important role across the industry by 2035

Continuous Casting opens new possibilities for transformational alloys, CO₂ footprint, and production efficiency for UHSAL alloys



1.5X

*Strength increase new UHSAL
3rd Gen alloys enabled by
continuous casting*

*Significant efficiency
improvement for UHSAL alloys*

Recycling Aluminum is a key enabler for the future

70-80%

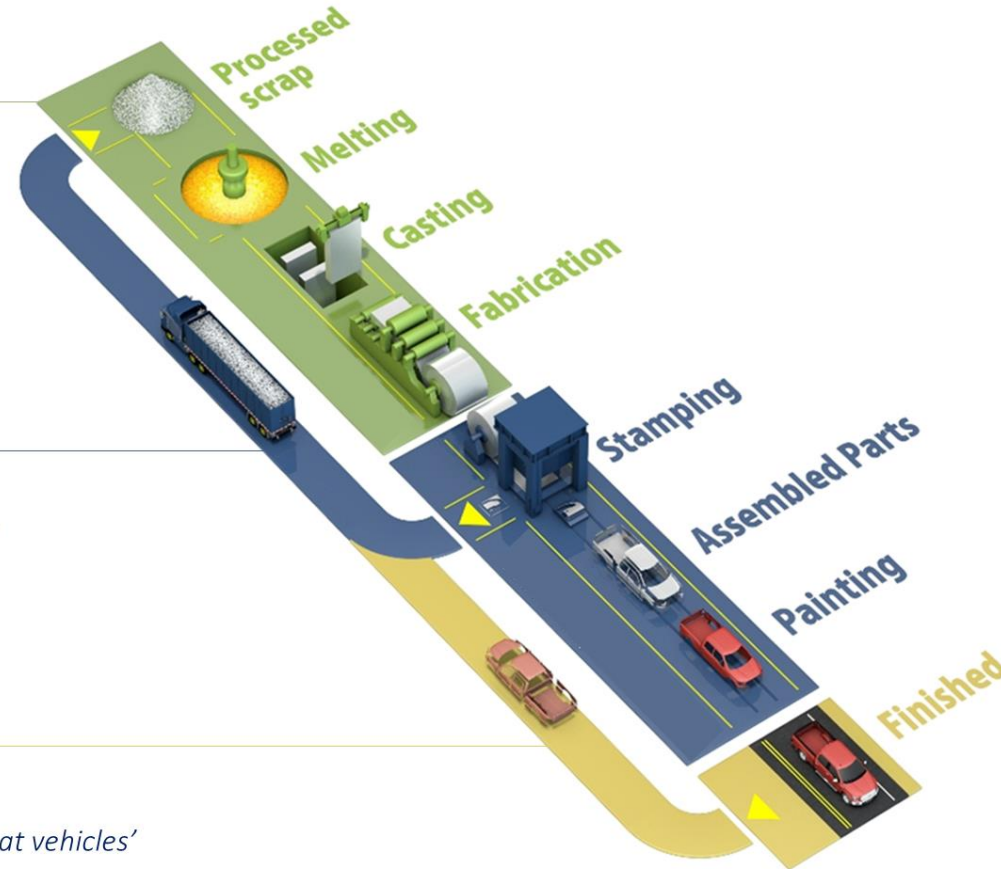
*Recycle content for new
high recycle content grades*

100%

*of production scrap can be returned to the
same material in a closed loop*

> 90%

*of aluminum parts are recycled at vehicles'
end of life¹*

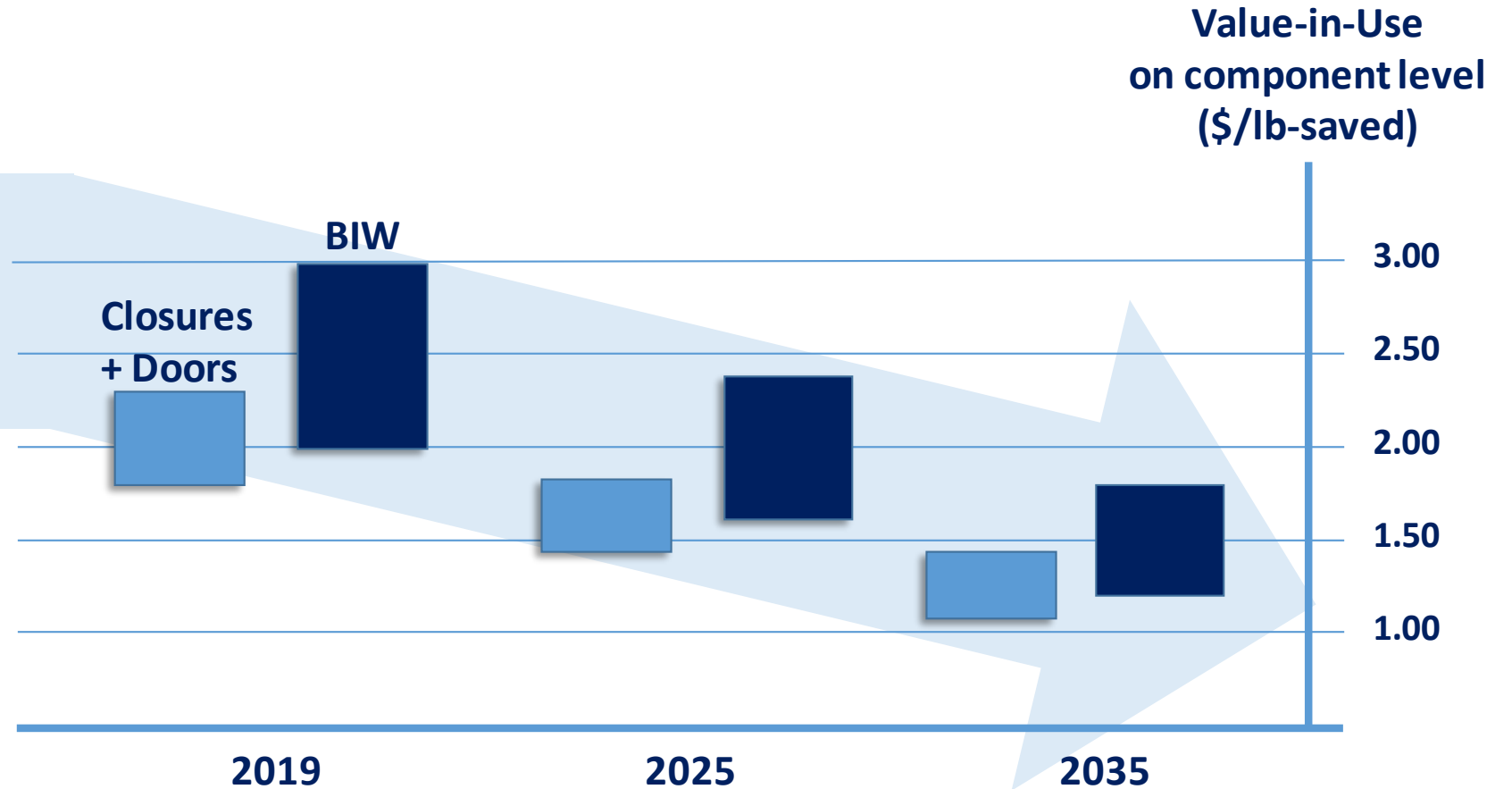


Putting it all together.

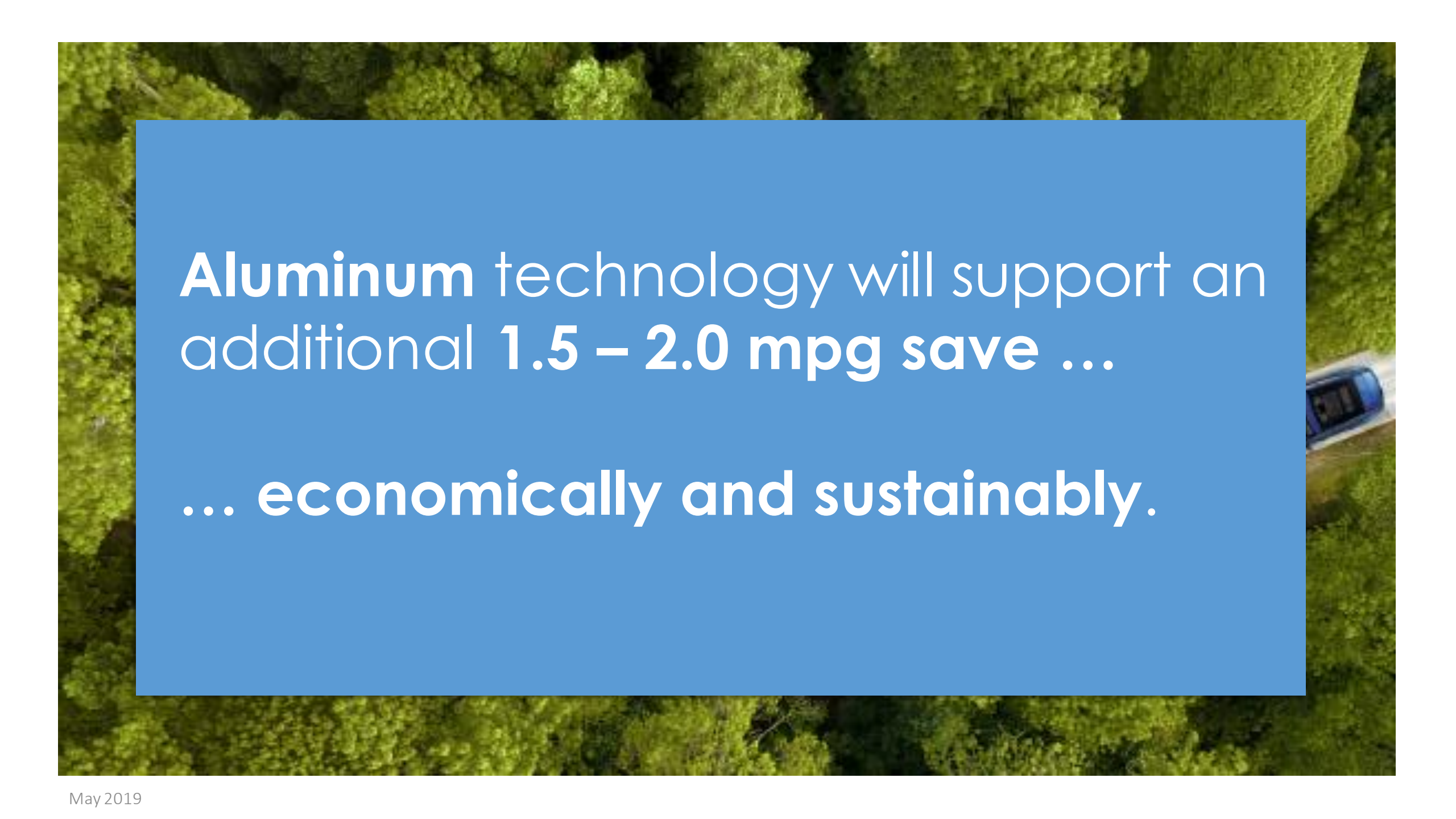
Less is more: “Lower” Value-In-Use enables broader use

Key Drivers of Value

- Design
- Advanced Alloys (UHSAL)
- Continuous Casting
- Recycling



2019: Mass Reduction for Light-Duty Vehicles for Model Years 2017-2025, High Strength 7xxx Aluminum Alloys: Design and Business Case for Automotive Applications, Bad Nauheim, April 2019 and Ultralight Door Design, Magna, 2019 – DOE Award # DE-EE0007306
2025-2035: value improvement of 20-40% from strength improvement and key enablers.



Aluminum technology will support an
additional **1.5 – 2.0 mpg** save ...
... **economically and sustainably.**

