



Automotive Aluminum Growth and Joining Trends

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The Aluminum Association's Transportation Group (ATG)

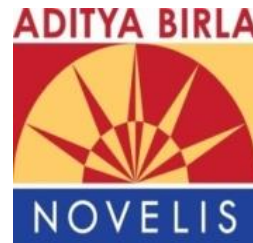
ALAW
June 4, 2014
Detroit, MI

Discussion Outline

- **Aluminum Use Forecast 2014-25 (Up-date)**
- **Joining Automotive Aluminum (Brief)**
 - Laser Welding**
 - Rivet-Bonding**
- **Experience - Production Aluminum Joining Processes**
- **Questions**

Introduction

Aluminum Transportation Group (ATG)





DUCKER WORLDWIDE

Advancing Growth

2015 North American Light Vehicle Aluminum Content Study

Executive Summary

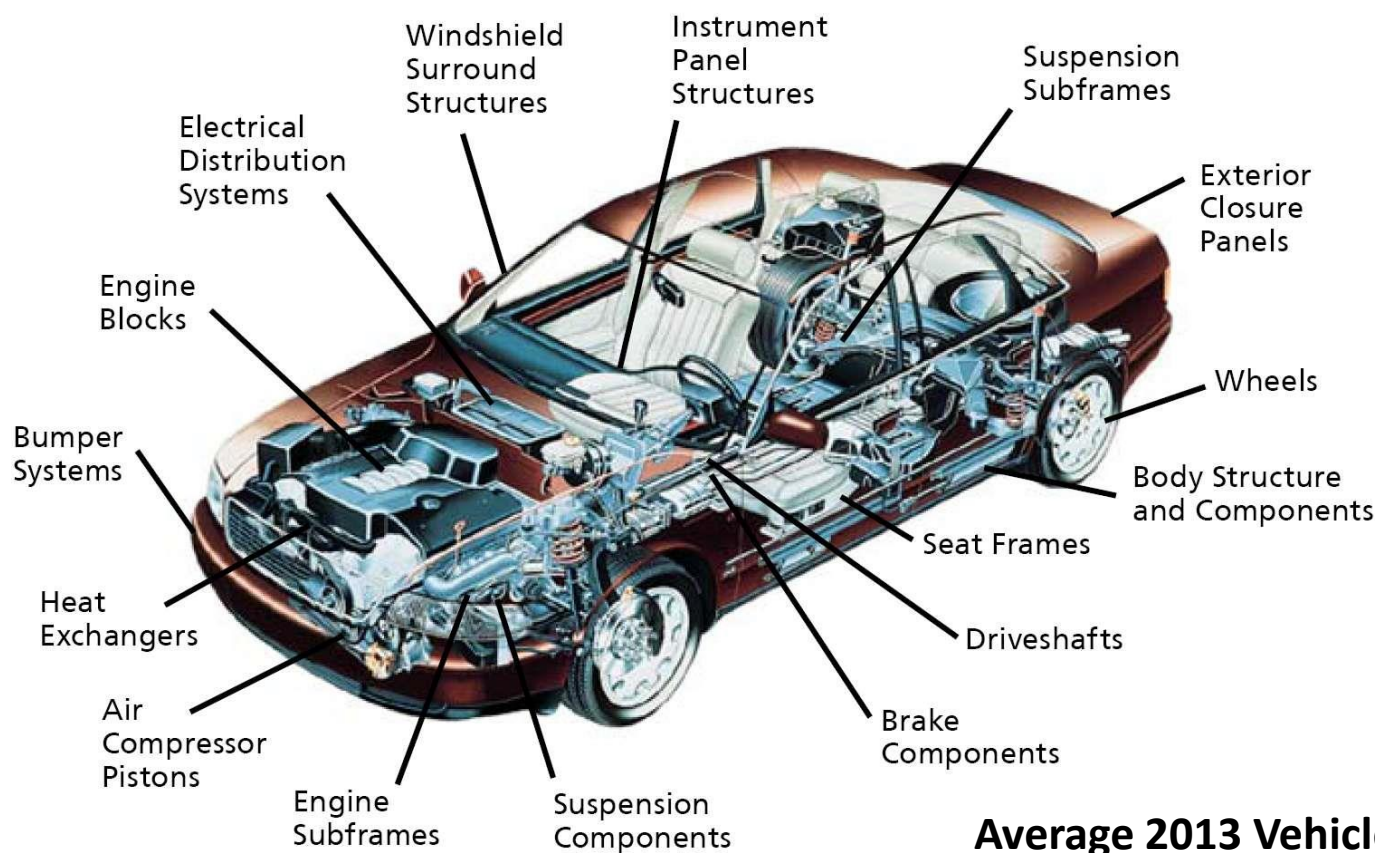
May 2014



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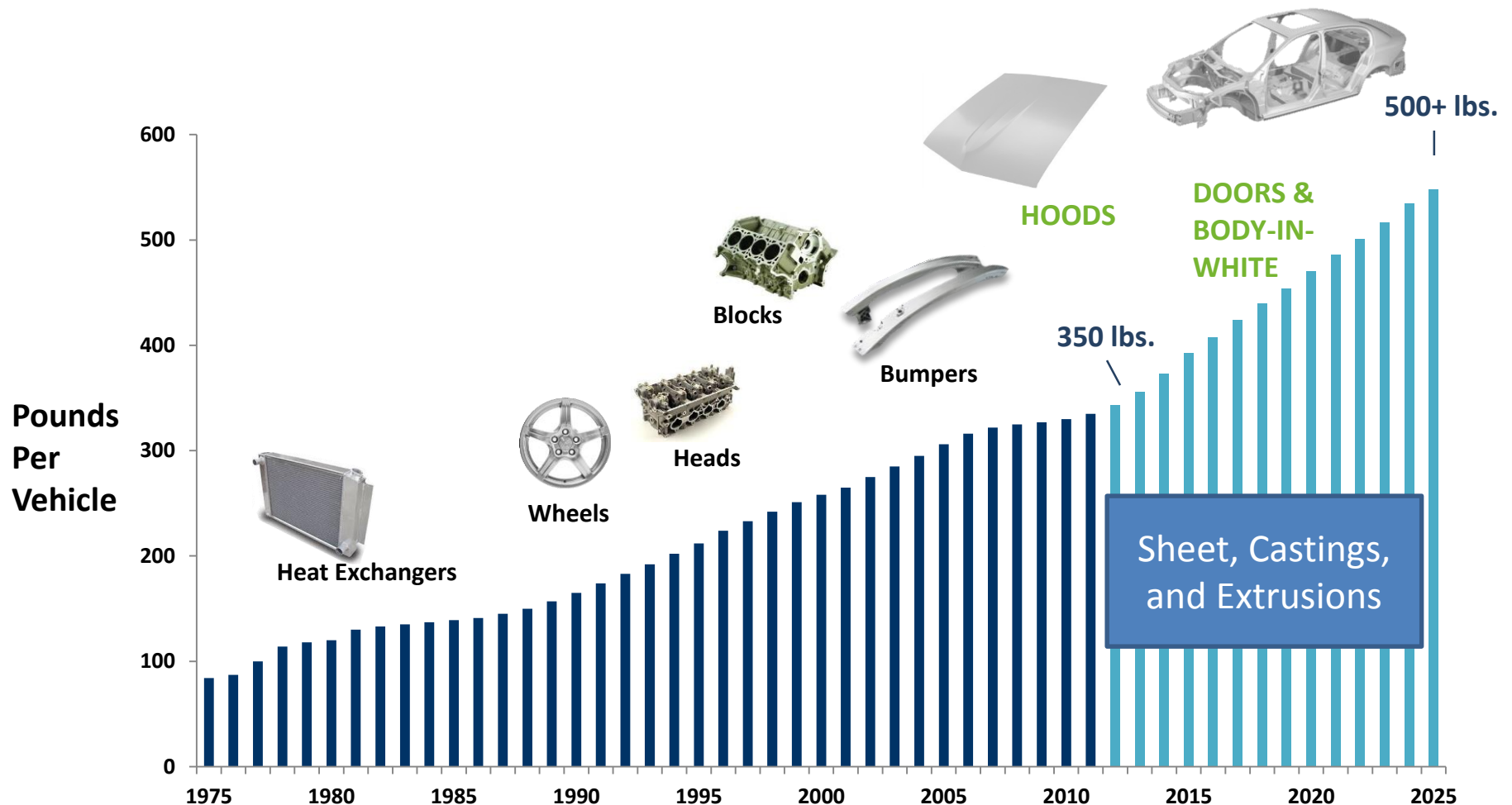
PRIVATE AND CONFIDENTIAL INFORMATION

Automotive Aluminum Today



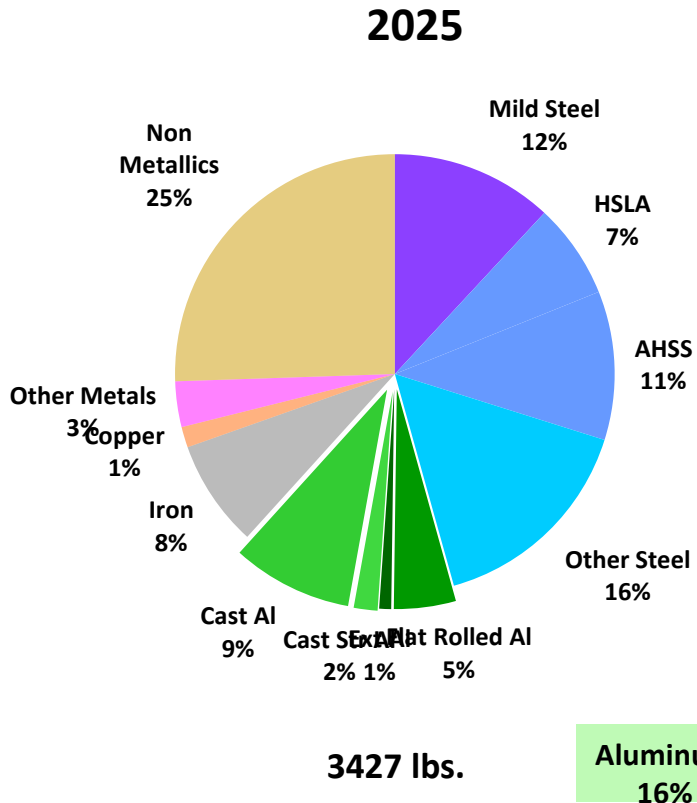
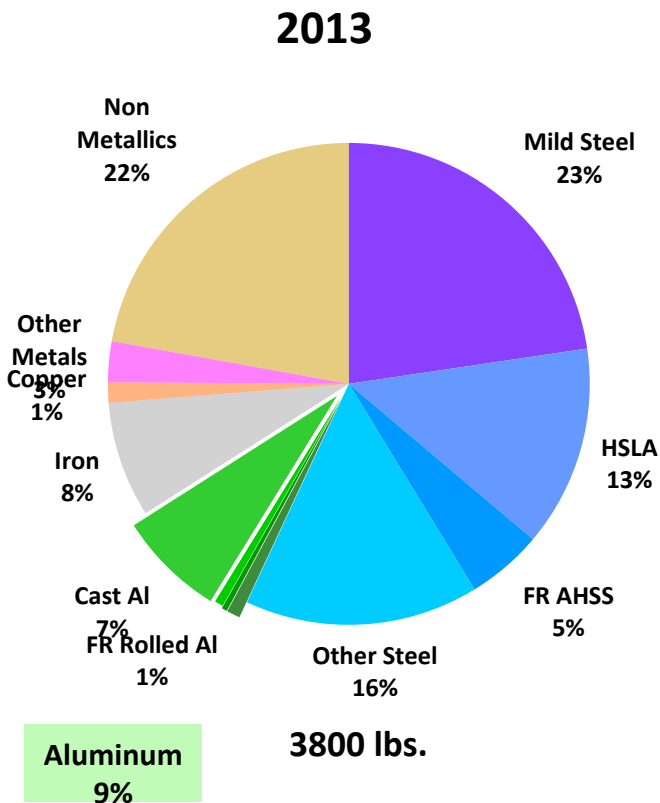
**Average 2013 Vehicle:
350 Lbs. (9%) Aluminum**

Automotive Aluminum Growth Accelerating



Source: Ducker Worldwide 2014

Automotive Material Distribution – 2013:2025



Source: Ducker

Aluminum Content Varies by Segment

2015 Vehicle Segment Average Aluminum Pounds and Share of 2015 Production:

A/B Segment

Fiat 500
Ford Fiesta



251.6 lb.'s

3% of Production

MPV Segment

Honda Odyssey
Chrysler Town & Country



396.5 lb.'s

4% of Production

C Segment

Ford Focus
Honda Civic



273.9 lb.'s

17% of Production

SUV Segment

Chevy Suburban
Jeep Grand Cherokee



410.3 lb.'s

33% of Production

D Segment

Chevy Malibu
Dodge Charger
MUSTANG



363.3 lb.'s

21% of Production

VAN Segment

Dodge Sprinter
Ford Transit



273.2 lb.'s

2% of Production

E Segment

Cadillac XTS
STING RAY



546.9 lb.'s

2% of Production

PUP Segment

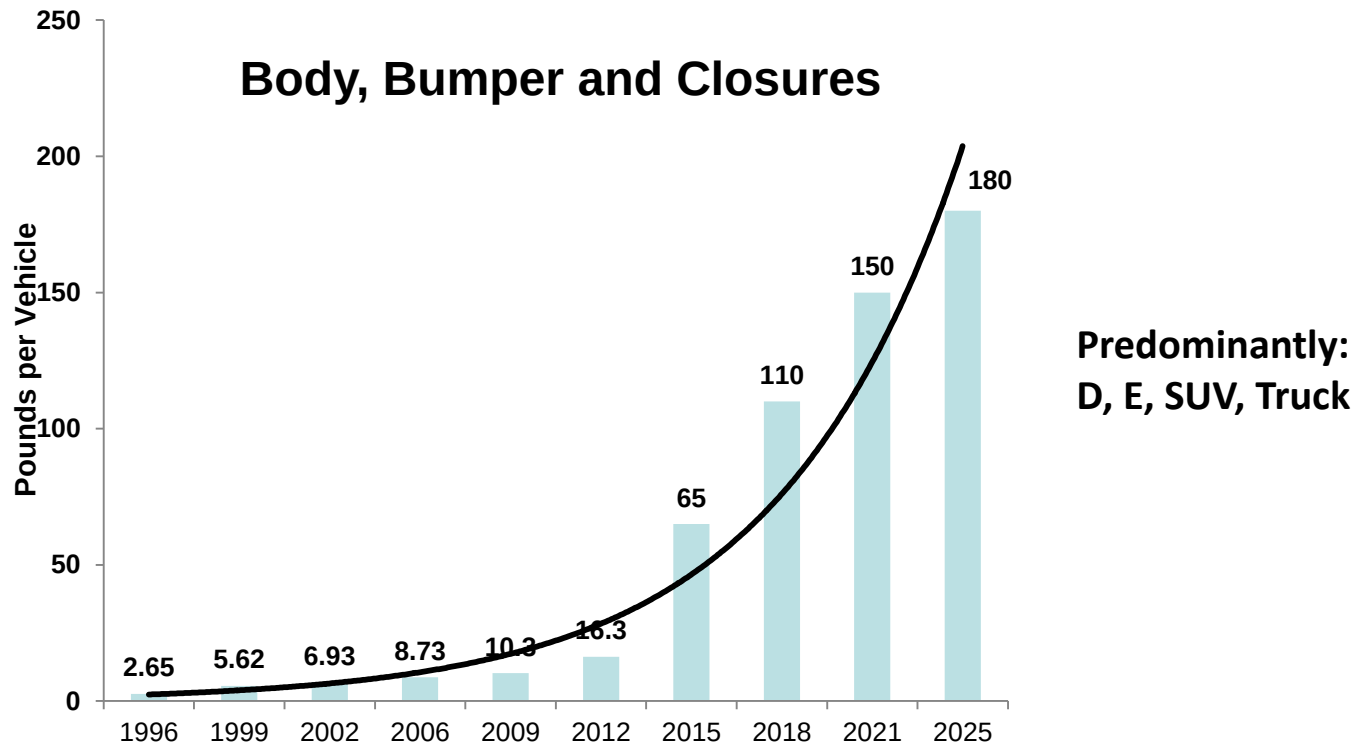
Ford F150
Ram 1500



548.9 lb.'s

17% of Production

Automotive Aluminum Wrought Products – 2012:2025 (Sheet, Extrusions)



“ Aluminum body and structural components will lead growth in content”

Aluminum Extrusion Content - Bumpers, Structures, Components

MIG Welding



Aluminum Sheet Content - Closures

Aluminum by 2025:

Closure Panels - 26%

Hoods - 85%

Gauge: 1 – 3 mm



Closure inners



Deck

Closures



Door Outer



Door Outer



Hood



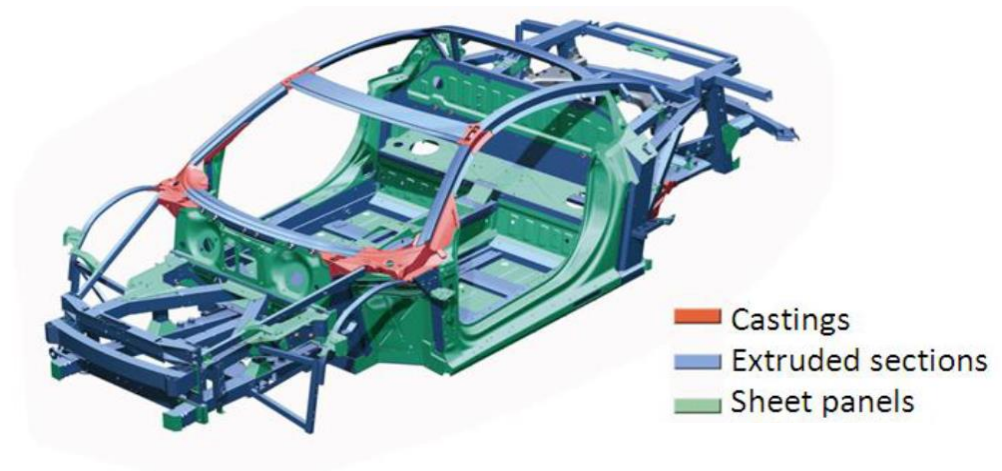
Fenders

Source: Ducker Worldwide 2014

Aluminum Body-in-White Content - Sheet, Extrusions, Castings

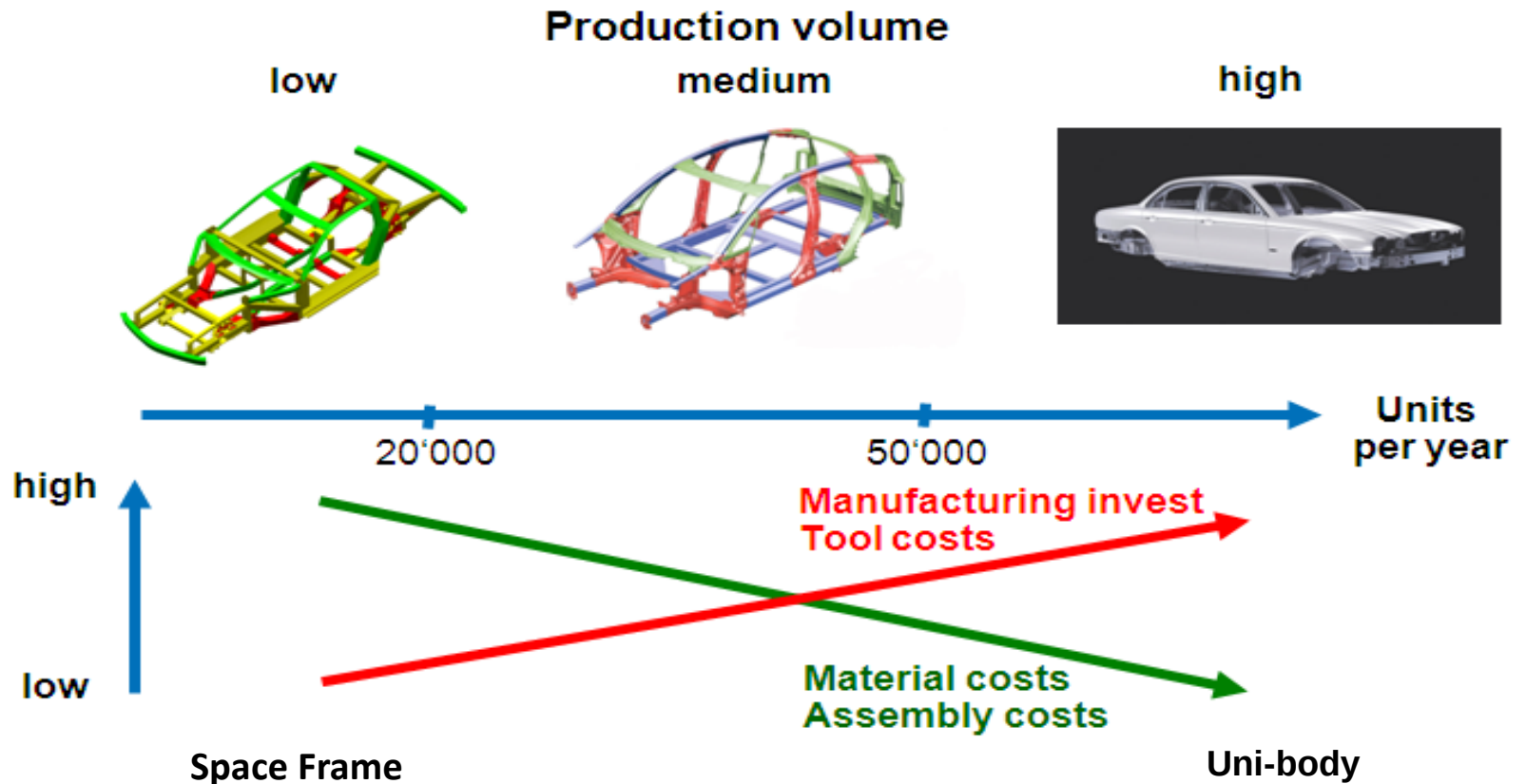
Aluminum by 2025:

BIW - 18 %



Source: Ducker

Auto Body Architecture Alternatives



Aluminum Intensive Vehicles Today

Corvette



Jaguar XJ



Land Rover



Audi A8



Tesla



Pick-up Truck



Joining Aluminum Body Sections

BIW Joining Process – A Complex Question:

Design advantages – stiffness, NVH, energy absorption, mass

Durability – fatigue, corrosion

Serviceability

Cycle time

Know-how

Manufacturing cost – consumables, energy, maintenance

Capital cost



Joining Body Structures

Industry Trends/Experience

- Significant Aluminum Growth
- Best Solution:
 - Robust Design / Robust Process
 - Structure Optimization
 - Accommodate Characteristics of Aluminum
 - Lowest cost
- Alternative processing choices:
 - Spot
 - MIG
 - Laser
 - Friction stir
 - Rivet
 - Weld-bonding
 - Rivet-bonding



*** Aluminum is different ... not difficult ... just different

Joining Aluminum Body Sections

Welding Aluminum – Critical Success Factor

(Different ... Not Difficult)

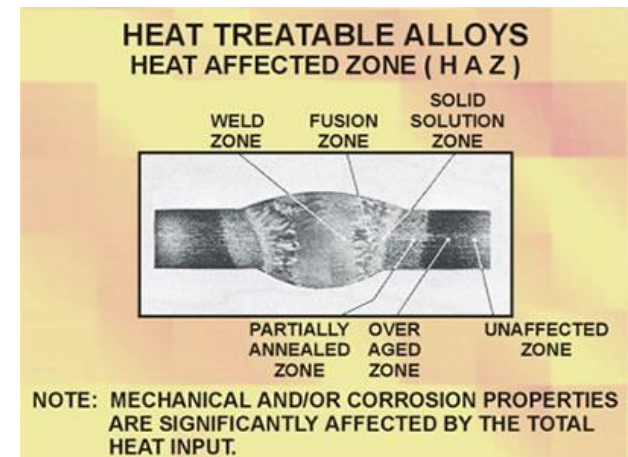
Heat Affected Zone (HAZ)

Strength reduction
alloy depletion
annealing

Fatigue strength reduction
hot tears
hydrogen porosity
oxide contamination
general contamination

Distortion

Residual Stress relief
Thermal expansion



Laser Welding Considerations

Attributes

- Weld quality

 - Reduced HAZ

 - Cosmetic

- Continuous Joint - Possible

 - (Not as effective as rivet-bonding)*

- Speed / Cycle Time

- Commonly:

 - one side access

 - stamping to extrusion or casting



Issues:

- Component positioning

 - Beam guidance

 - Gap tolerance

- Energy (reflect, conductivity)

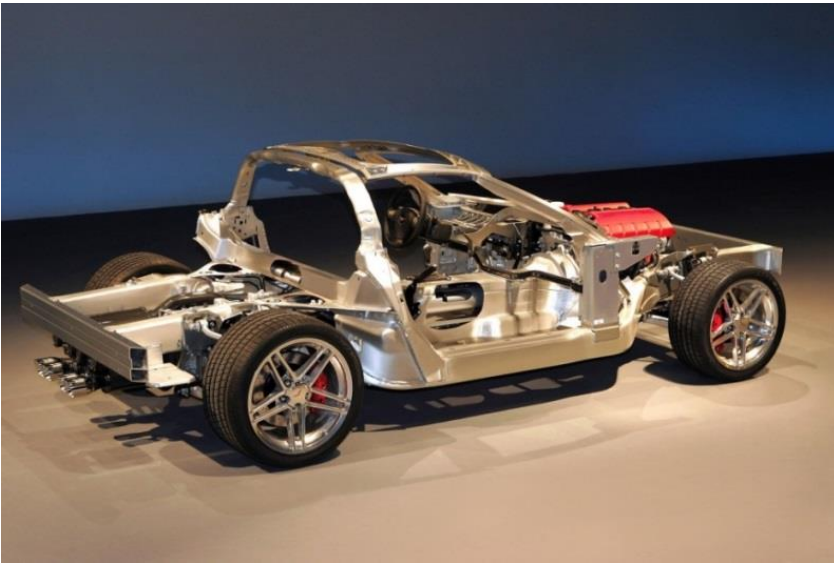
- Capital cost

- Maintenance Cost



Aluminum Auto Body Joining – Low Volume

Utilize Most Joining Processes



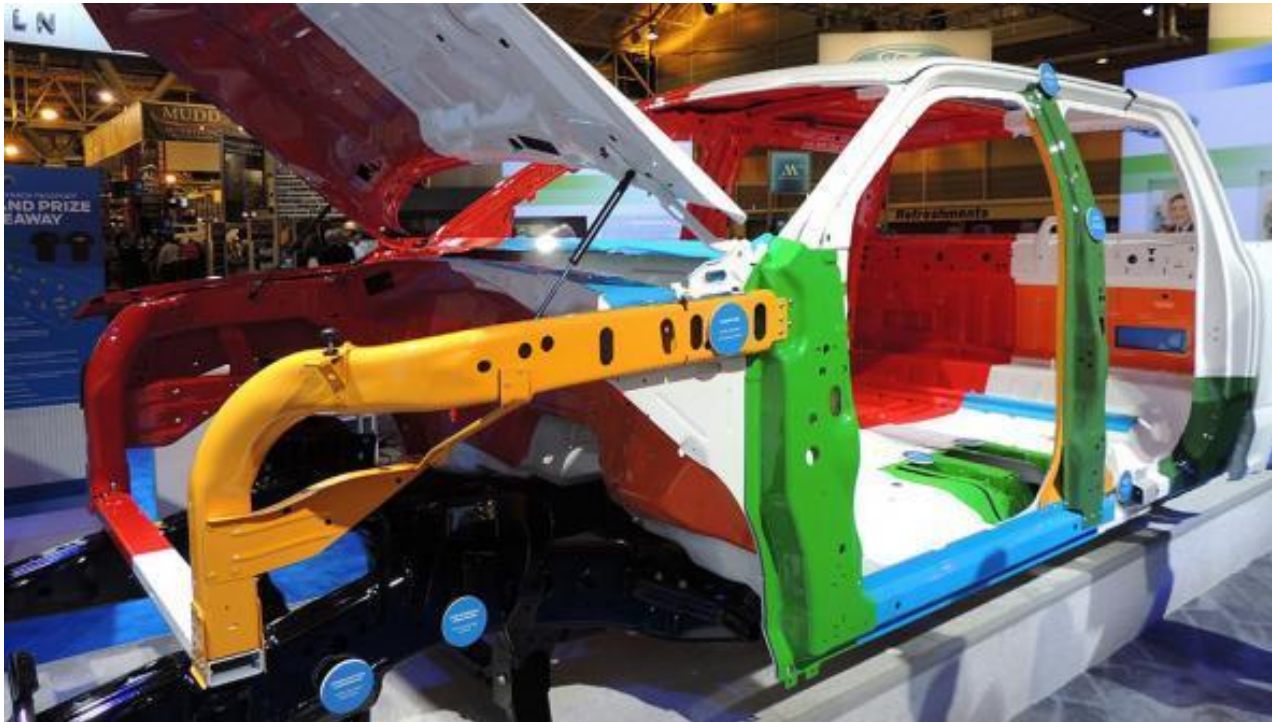
Corvette

Tesla

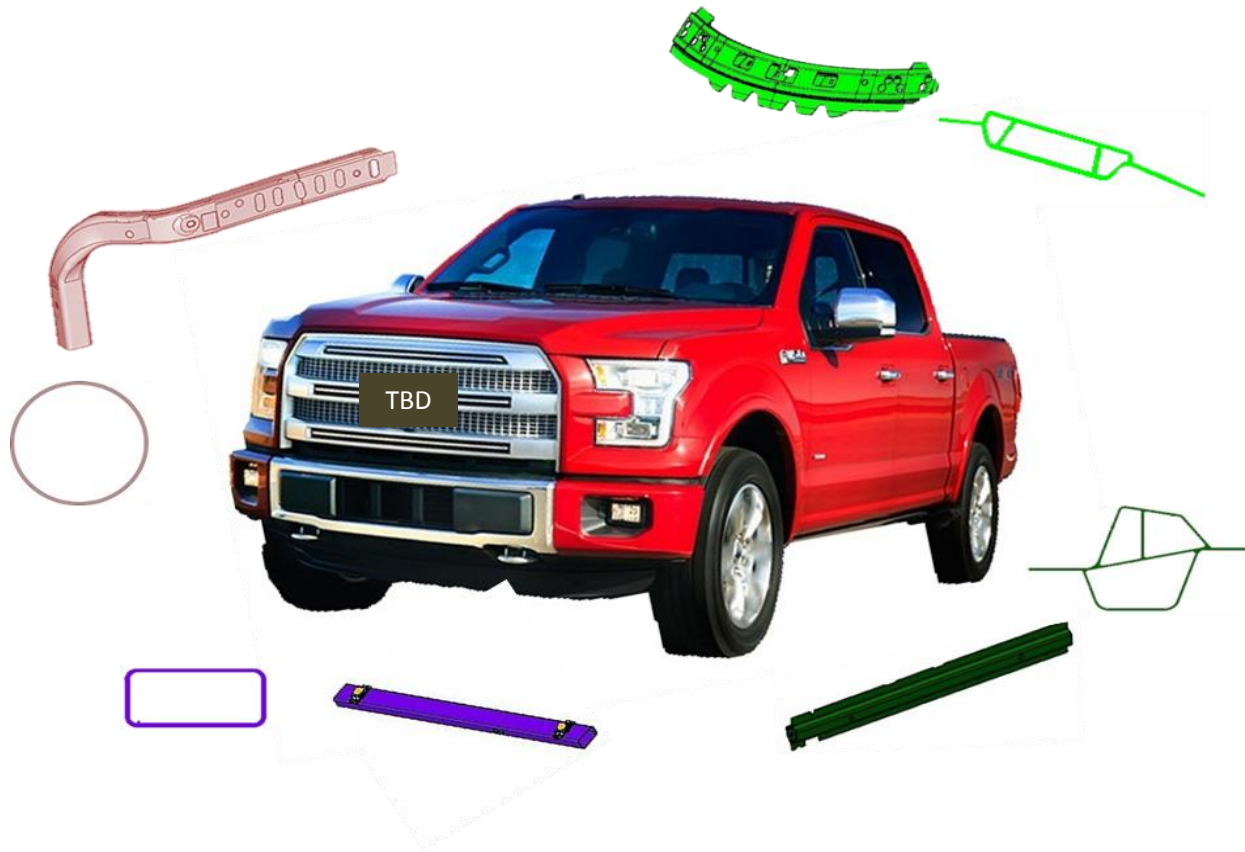


Aluminum Body Joining – High Volume

Rivet, Rivet-bonding, Weld-bonding



Aluminum Truck Body – Sheet, Extrusions

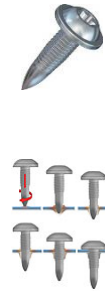
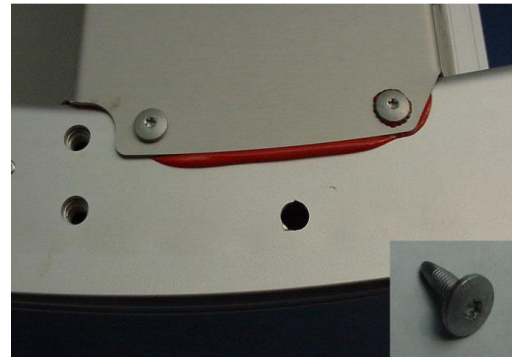


Aluminum Body-in-White Joining Process : Rivet, Rivet-bonding

Self Piercing Rivet 2 side access



Flow Screw, Tacks 1 side access



Attributes:

- No predrilling
- Gap tolerance
- Eliminate heat affected zone
- Continuous joint (with adhesive, surface pre-treatment)
- Stiffness, NVH, Energy Absorption, Mass/Cost
- Eliminate crevice corrosion
- Capital cost
- Energy consumption

Significant Automotive Growth Opportunity – Aluminum Joining

Summary:

Steel and Aluminum will Co-exist

Important Auto Materials

Significant Growth in Aluminum Joining

Structures

Closures

BIW

Joining Process “Critical”

Vehicle design

Mass Optimization, Stiffness, NVH, Energy Absorption

Cost Structure

Variable cost

Investment

MIG, Laser Welding, Rivet-Bonding

Issue: laser weld-bonding sheet structures

Thank You!

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