Aluminum technologies at Ford and the value of AMAP for next steps

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Aluminium Messe Düsseldorf

Lightweight Technologies Forum

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Outline

- Weight saving goals
- Ford's aluminum history
- Outlook: potential development steps for Aluminum and how Ford pursues it within AMAP
- Current status of the AMAP cluster, Ford's involvement and Ford's expectations for AMAP's development in the next phase

Lightweighting - Goals

✓ indicates stage completed

Version 2010/11

2007 NEAR TERM Begin migration to advanced technology	2011 MID TERM Full implementation of known technology	2020 LONG TERM Continue leverage of hybrid technologies and deployment of alternative energy sources	2030
✓ Significant number of vehicles with EcoBoost engines	EcoBoost engines available in nearly all vehicles	Increased percentage of internal combustion engines using renewable fuels	
✓ Electric power steering	Electric power steering – high volume	Volume expansion of hybrid technologies	
✓ Dual-clutch and six-speed transmissions replace four- and five-speeds	Six-speed transmissions – high volume	Cotninued leverage of plug-in hybrid and battery electric vehicles	
✓ Flexible-fuel vehicles	Weight reduction of 250–750 lbs.	Introduction of fuel cell vehicles	
✓ Additional hybrid applications	Engine displacement reduction facilitated by weight reductions	Clean electric/hydrogen fuels	
✓ Increased unibody applications	Additional aerodynamics improvements	Continued weight reduction through use of advanced materials	
✓ Introduction of additional small vehicles	Increased use of hybrids		
✓ Battery management systems	Introduction of battery electric and plug-in hybrid vehicles		
✓ Aerodynamics improvements	Vehicle capability to fully leverage available renewable fuels		
✓ Stop/start systems (micro hybrids)	Diesel use as market demands		
✓ CNG/LPG prep engines available in select markets	Increased application of stop/start		

Source: http://ophelia.sdsu.edu:8080/ford/09-05-2011/microsites/sustainability-report-2010-11/issues-climate-plan-overview.html

Ford Go Further

Aluminum Closures at Ford

Ford Motor Company has a long tradition in lightweight aluminum closures:

Ford F150
Aluminum hood - highest volume in industry

Ford Mondeo
Aluminum/ magnesium liftgate

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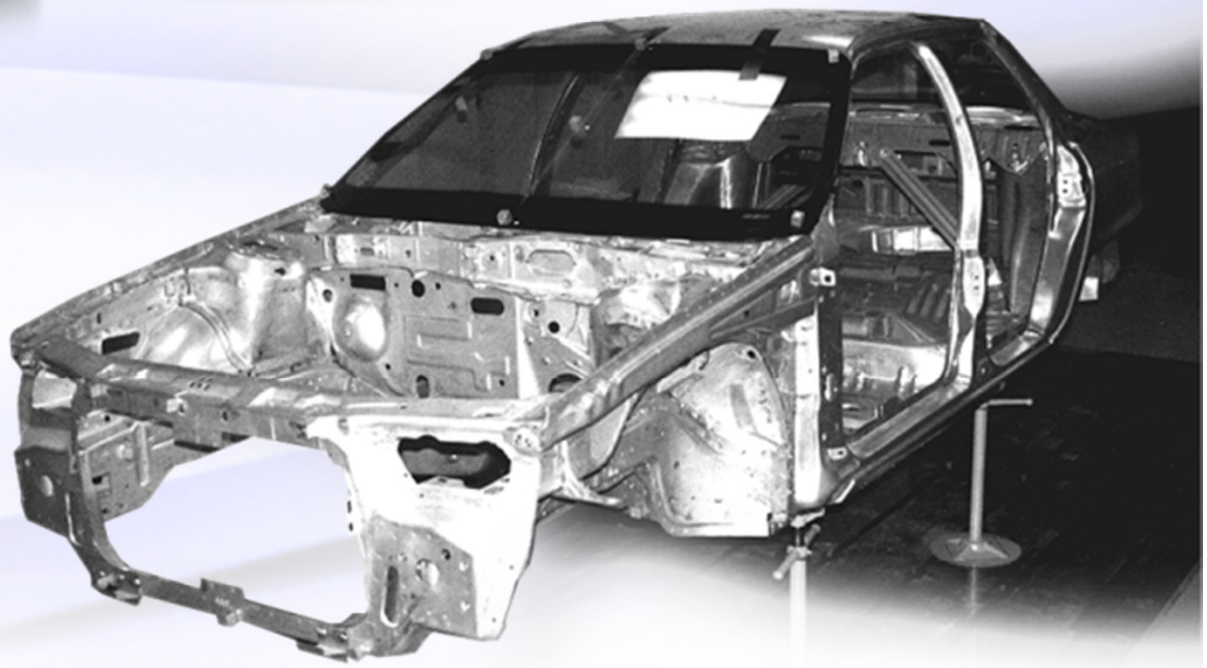
Aluminum BIW at Ford – AIV Sable (1992)

1992

AIV Sable

Al body-in-white

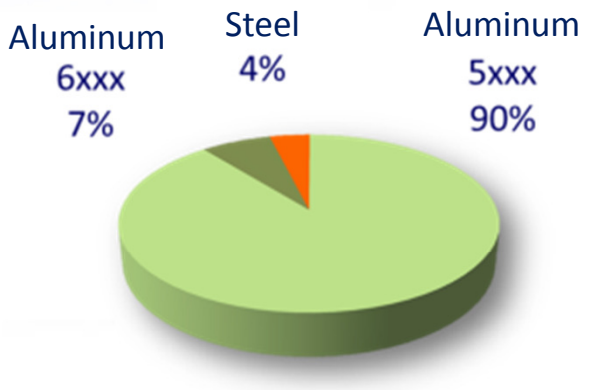
Steel design



Aluminum BIW at Ford – AIV Sable (1992)

	Mercury Sable [kg]	AIV [kg]	Weight-saveing [%]
Frame	270,3	145,2	46,3
Bumper	6,4	2,7	57,8
Doors and closures	94,1	50,3	46,5
Body-in-white	**371**	**198,2**	**46,6**

The AIV was primarily spot-welded and weld-bonded, with rivets and fusion welding used only where spot-welding was not feasible.



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Aluminum BIW at Ford – P2000 (1998)

1998

Ford P2000

Unibody with

Al design

Aluminum BIW at Ford – P2000 (1998)

	Ford Taurus [kg]	P2000 [kg]	Weight-saving [%]
Frame	287,7	135,6	52,9
Doors and closures	110,2	46,3	58,0
Body-in-white	**397,9**	**181,9**	**54,3**

- The front shock tower and the front subframe rear attachment were designed as castings.
- These parts were joined to the sheet parts with a combination of self-piercing rivets and adhesive bonding.

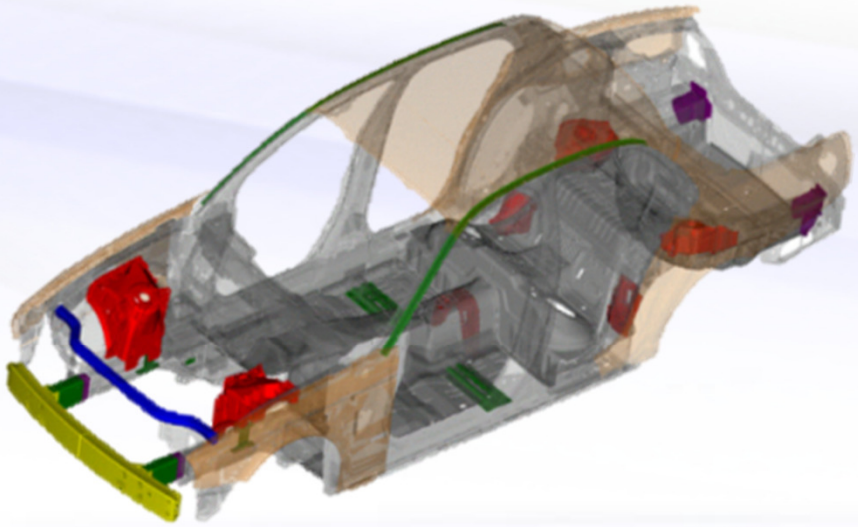
Aluminum BIW at Ford – Jaguar XJ (2003)

2003
Jaguar XJ

Materials

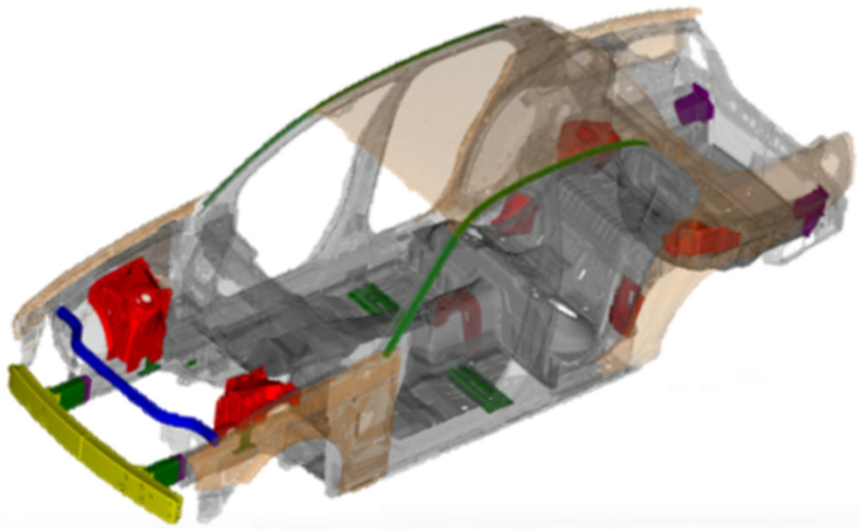
- 5000
- 5000 hydroformed
- 6000
- 6000 extrusions
- 7000

Unibody, design adapted for **Al**



Aluminum BIW at Ford – Jaguar XJ (2003)

- The aluminum body shell of the Jaguar XJ from 2003 weighs 220 kg – the weight saving compared to steel equivalent was nearly 40%
- For joining 3,200 self-piercing rivets and more than 120m of adhesives were used
- Aluminum high-pressure die castings were e.g. used for the shock towers
- An hydroformed aluminum extrusion was used for the front-end radiator support




F150
Light ? weight
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F150 and Lightweighting - Motivation

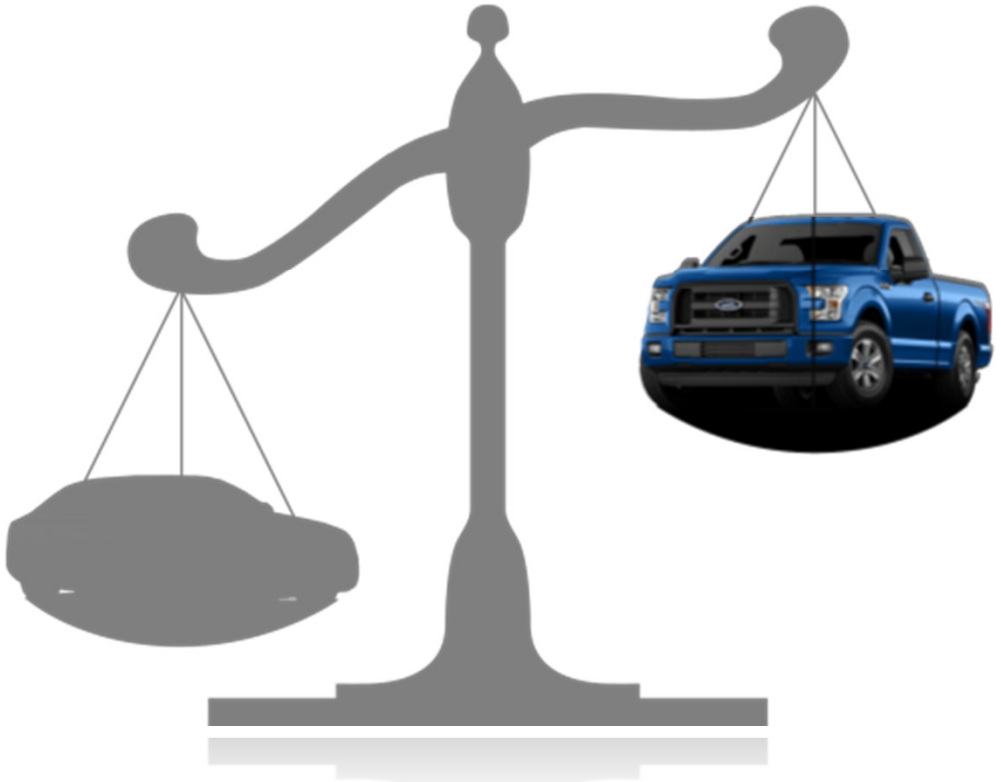
Customer requirements

- Durability
- Payload up to **1500kg**
- Trailer load up to **5530kg**
- Mileage
- Driving dynamics
- Costs

Light weighting addresses all customer requirements listed!

Ford F150 and Lightweighting

- 4x4 Regular Cab 6.5ft
- 3.5L Ti-VCT V6
- Length 5316 mm
- Width 2024 mm
- L x W 10,76m²
- **Curb weight: 1954kg**



F150 is lighter than a **typical luxury class limousine!**

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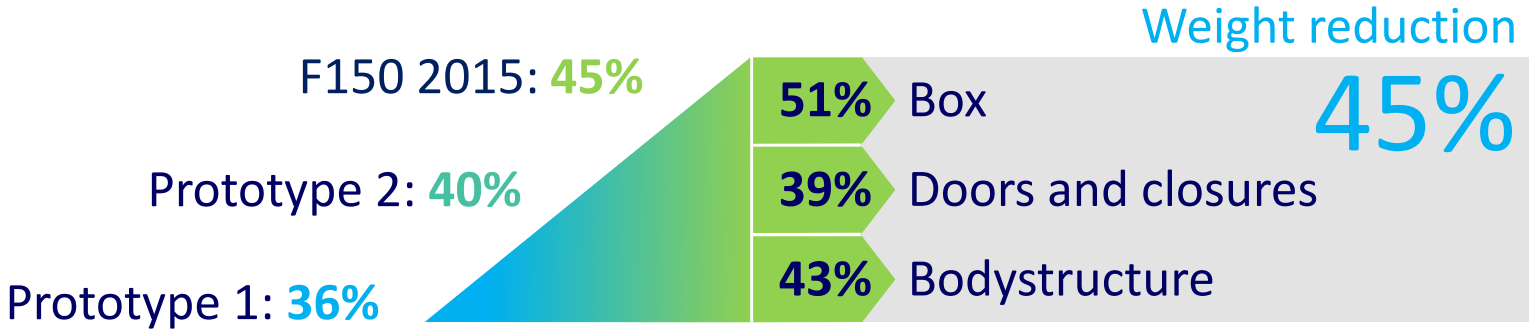
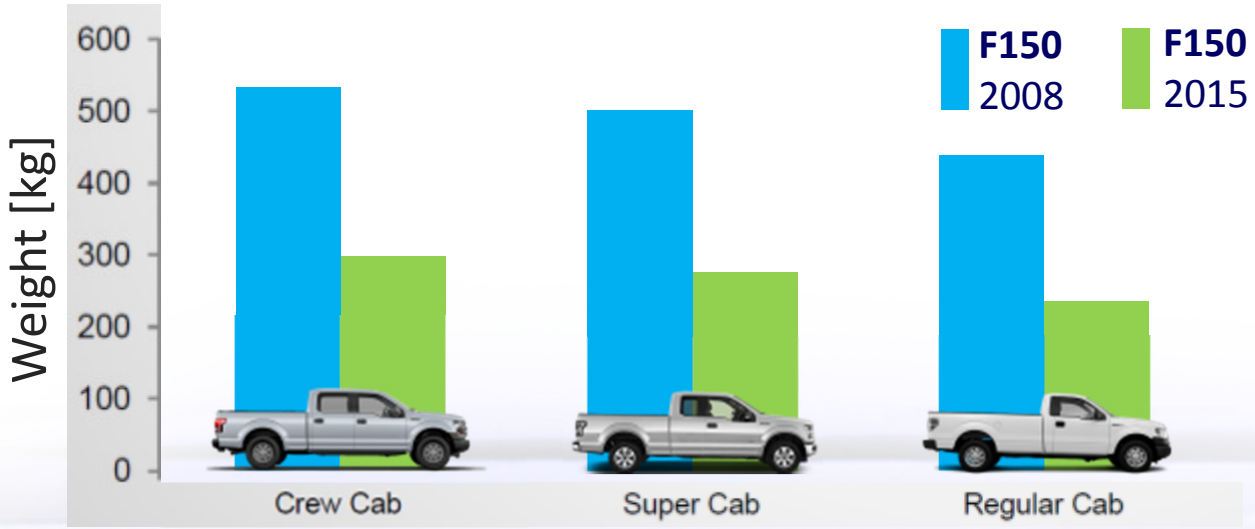
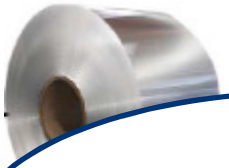
Ford F150 – Weight Reduction



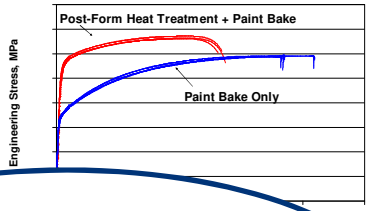


Challenges and Opportunities for High Volume Applications

Joining Technologies
SPRs, FDS, Clinching,
RSW, Adhesives



Availability of Al sheet



Al specifications

Aluminum in Mass Production

Recycling
4-way separation
of aluminum alloys

Forming technologies
Lubricants
Hydroforming

Paint

The First Aluminum BIW in Mass Production

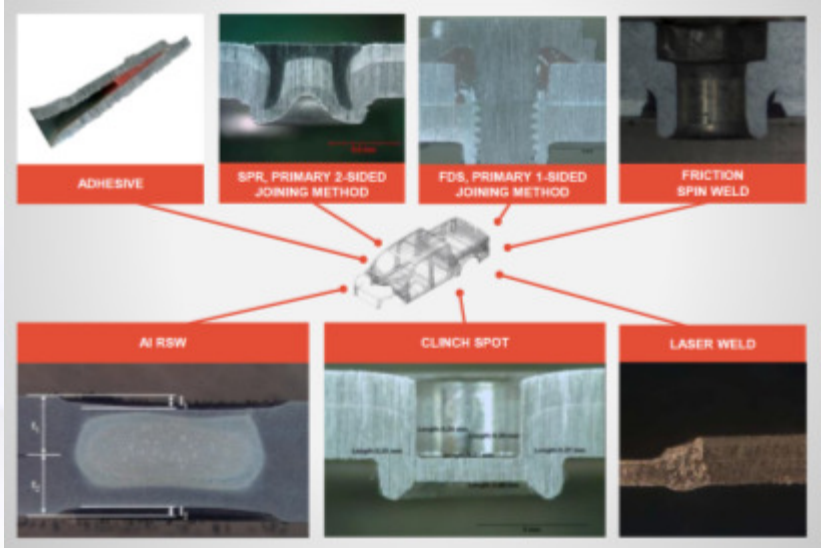
„Mass Production“ of aluminum bodies was so far some 30.000 – 60.000 per year…

The annual volume of the **F150** is **one magnitude higher** and exceeds the number of all **worldwide** built aluminum bodies combined.

Joining

F150 2008 – 2014 (Gen. 12)

- 2959 spot welds (steel)
- 39m adhesive bonding
- 3m laser welding (steel)
- 96m MIG welding



The New F150 2015 (Gen. 13)

- 98 spot welds (Al)
- 110m adhesive bonding
- 3m laser welding (Al)
- 2270 self-piercing rivets
- 196 flow-drill screws
- 120 clinches

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Recycling Concept

Mixing of Al-alloys

Low scrap value

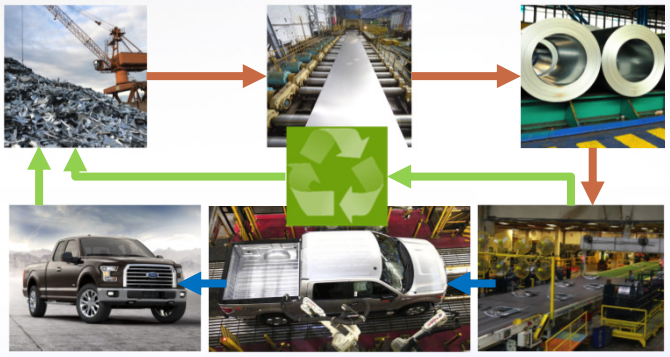
Recycling one Al-alloy into itself

High scrap value

4 chemical compositions/scrap streams were defined.

→ **„Multi Supplier Tolling“**

→ **10 different Al-Materials**

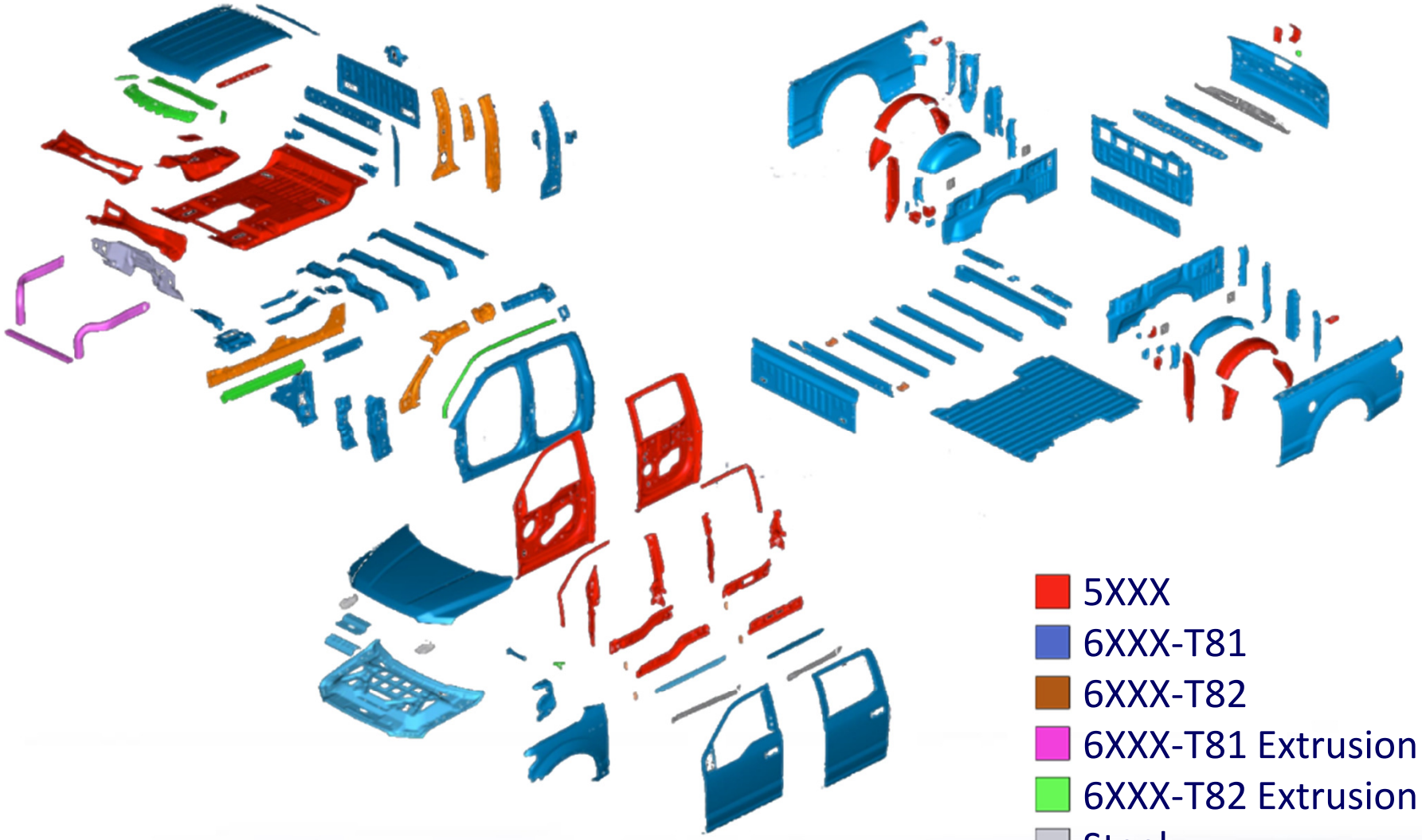


Ford F150 – High Strength by Post Forming Heat Treatment

		Sheet 6XXX-T81	Sheet 6XXX-T82	Extrusion 6XXX-T81	Extrusion 6XXX-T82
Yield strength	[MPa]	180	300	150	310
Tensile strength	[MPa]	312	330	310	340
Elongation	[%]	12	8	10	9

T81: 6XXX Aluminium “Paint Bake”
T82: 6XXX Aluminium “FULL AGED – PFHT”

Ford F150 - Materials in Body-in-White



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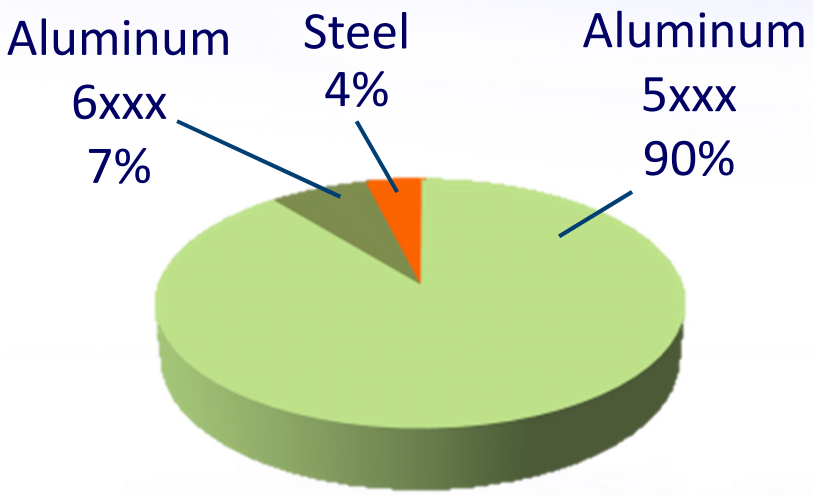
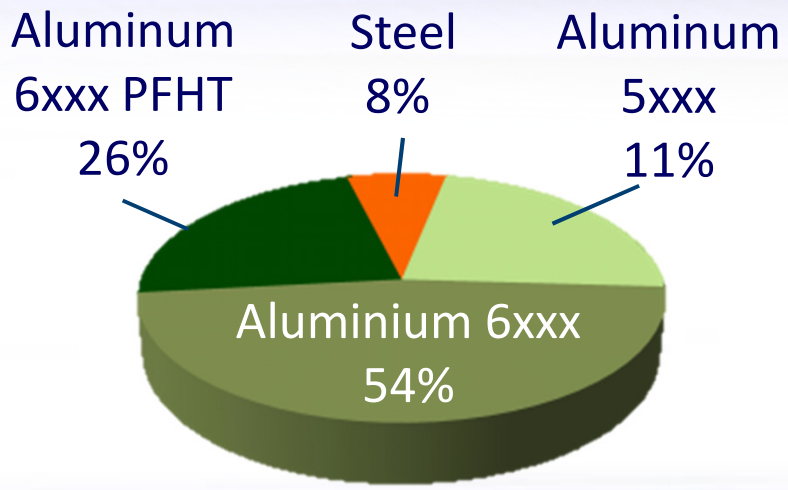
Aluminum Grades

1992 AIV Sable Bodystructure



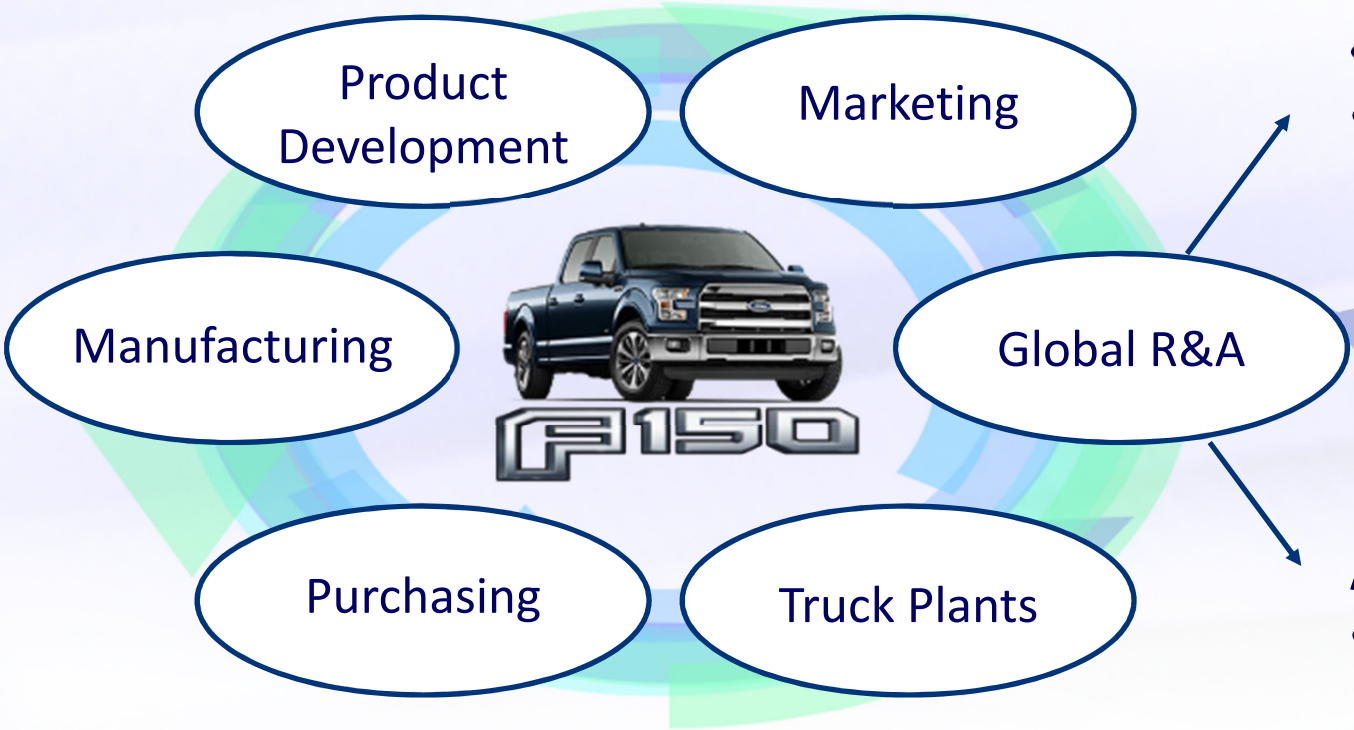
2015 F-150 Bodystructure



F150 – Role of the Global R&A Team

Dearborn

- Manuf. Techn.
- Prototype Build
- Materials & Specifications



Aachen

- CAE Technologies

Aluminum at Ford: Next Steps

- The F150 Aluminum body was a breakthrough
- Aluminum proofed to be a very efficient solution for weight saving in mass production
- Therefore, Ford will expand the use of aluminum

Next milestone:

Super Duty MY 2017

But…

Aluminum at Ford: Next Steps

"Everything can always be done better than it is being done."

Henry Ford, 1923

- There is still a lot of potential for the advancement of Aluminum technologies with respect to weight saving and cost
- Strong research efforts needed

…Let‘s have a look to the evolution of steel technologies

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Evolution of Steel Technologies

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Evolution of Aluminum Technologies for BiW

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Cooperation with External Partners

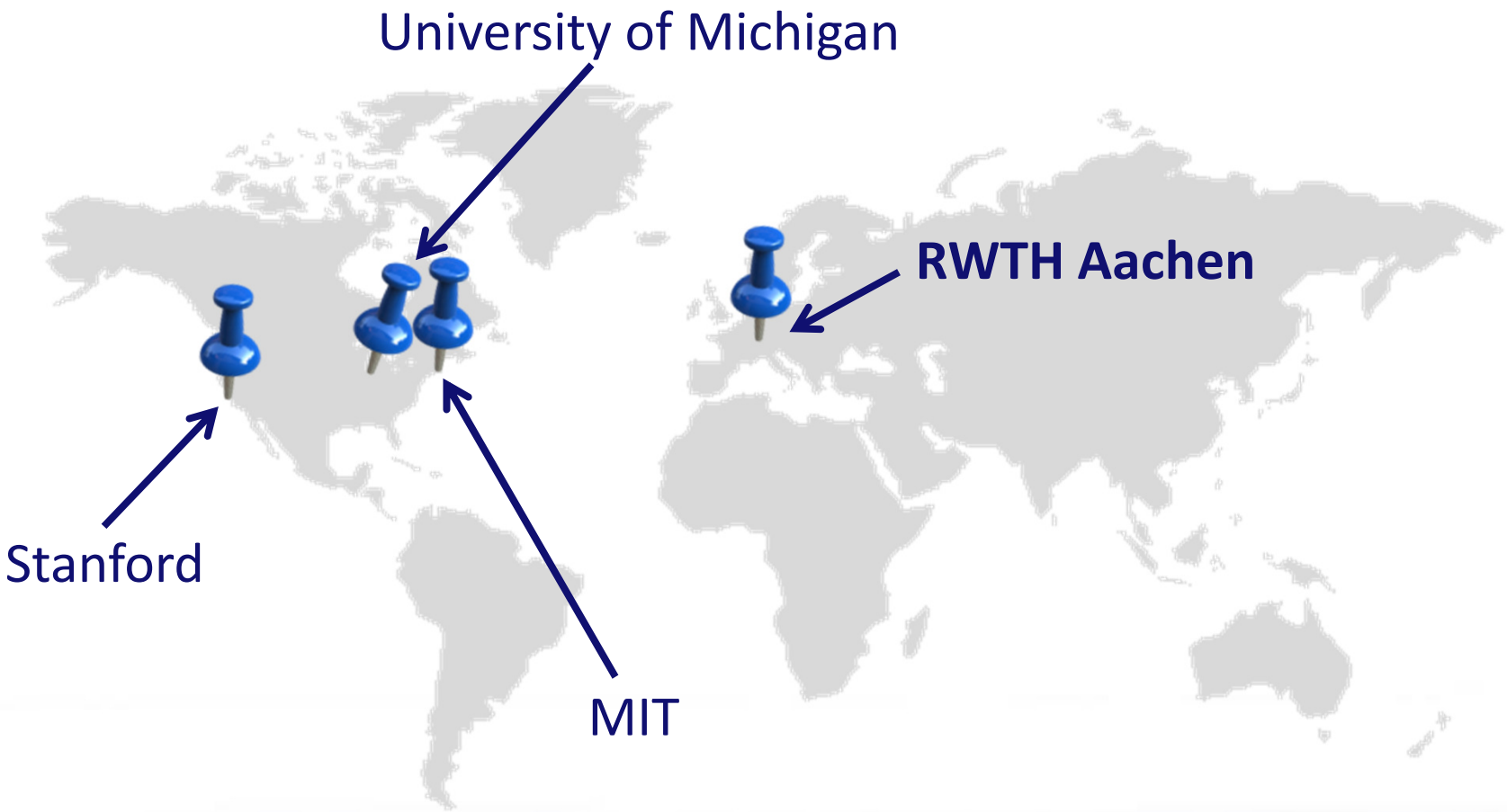
Motivation:

- No organization has sufficient internal resources for technical leadership in all areas of interest

- Companies that most effectively leverage external resources will gain competitive advantage

Cooperation with Universities

Ford has multiple university cooperations, but the most important strategic alliances are:



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Why AMAP?

Having already several research networks, what is the specific interest of Ford to invest in **AMAP**?

Excellent opportunity to build up an **university/industry network** covering the whole value chain for aluminum.

Ford's Involvement in AMAP Projects

Aluminum –
next development steps

- Higher strength Al-alloys
- New Joining Technologies
- Advanced Casting Technologies
- Tailored properties

AMAP projects

High Strength Aluminum for mass production (8/2013 – 10/2016)

→ AMAP alloy 2030? (project definition started)

Al-castings and integration in sheet metal structures (project start 2016)

Al structures with tailored properties/TRBs (project start 2016)

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AMAP Status and Ford's Expectations - Organization

1. Infrastructure including own building was set up ✓
2. Separate projects started -> Co-operation within projects, use of the know-how of the project consortium only ✓
3. X-project information exchange -> use of the know-how of the whole AMAP team (✓)
4. AMAP partners provide access to the experts in their company/institute -> use the know-how pool of all partner companies/institutes in order to bring Al-technologies to the next stage
5. Ford would welcome if AMAP could foster an intensified co-operation between the Aluminum suppliers – as the steel industry did in the 90s in response to Al-body structures (e.g. ULSAB study followed by ULSAC, ULSAS etc.)

AMAP Status and Ford's Expectations – New Partners

Powerful consortium established especially with strong expertise in materials.

New partners welcome bringing expertise along the whole Aluminum process chain, but especially:

- Joining technologies supplier
- OEMs from other sectors, notably transportation (railway, aerospace)
- Part producers (tailored properties, extrusions, hot forming...)


F150
Thank you for listening!
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