Smart

Green

Go Further

Sustainable Materials & Manufacturing
NCMS – NIST - University of Kentucky - IMTI

April 20th 2015

Dr. Matthew J. Zaluzec
Senior Technical Advisor
Global Materials & Mfg R&D

Quality

Safe

Outline

Sustainability at Ford Motor Company

- Corporate Initiatives
  - Eco-Boost Engines
  - Vehicle Light Weighting
  - Material Utilization
  - High Value Recycling
  - Green Materials

PRODUCT DEVELOPMENT STRATEGY

Near Term

Leverage Existing Technologies at High Volume

EcoBoost Engines

Electric Power Steering

6 - Speed Transmissions

Next Generation Diesels

World-Class Hybrids

Mid Term

Substantial Weight Reduction & Expand Electrification

Vehicle Weight Reduction

Auto Stop-Start

HYBRID

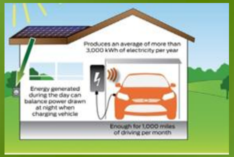
ENERGI

ELECTRIC

Long Term

High Volume Electrification and Alternative Energies

Energy Management



New Materials

Hydrogen Powered

Near Term

ECOBOOST

1.0-liter = I4

1.6-liter

3.5-liter = V8

Integrated Computational Materials Engineering

Downsize & Boost

- ✓ ***20% FE Improvement, 15% Emissions Reduction***
- ✓ ***Increased fuel efficiency and performance***
- ✓ ***Decreased Powertrain Weight***

Near Term

ECOBOOST

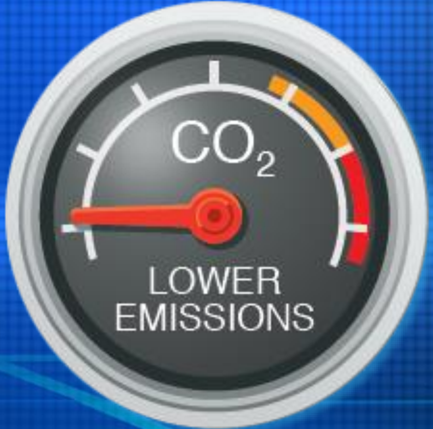
Up To

20%

FUEL ECONOMY IMPROVEMENT

Up To

15%



EMISSIONS REDUCTION

2007 2012 2020 2030

Mid Term

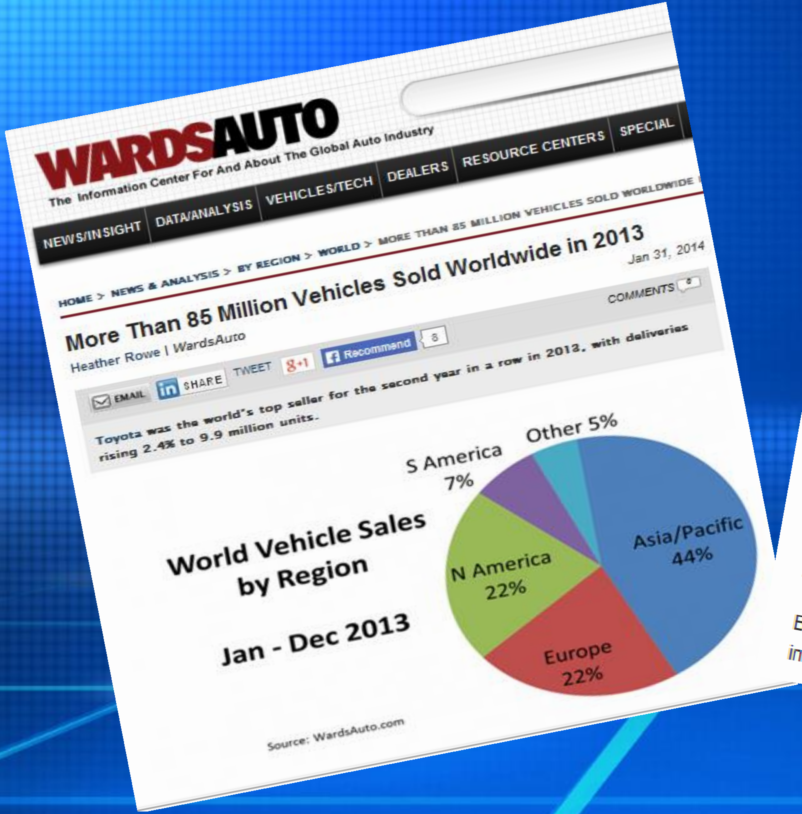
Weight Reduction of 250–750 lbs, (113 – 340) kg

- Smaller displacement engines
- Smaller components
- Lightweight materials

Weight Distribution

Future Technologies

- Degree of Electrification & Hybridization
- Start Stop Technology
- Boosted Engines
- Low Rolling Resistant Tires
- Aerodynamic Solutions



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HOME > NEWS & ANALYSIS > BY REGION > WORLD > MORE THAN 85 MILLION VEHICLES SOLD WORLDWIDE

More Than 85 Million Vehicles Sold Worldwide in 2013

Jan 31, 2014

Heather Rowe | WardsAuto

COMMENTS 0

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Toyota was the world's top seller for the second year in a row in 2013, with deliveries rising 2.4% to 9.9 million units.

THE WALL STREET JOURNAL. | BUSINESS

TOP STORIES IN BUSINESS

New Car Fuel Economy Hits Record — 4 of 12

Wal-Mart Cuts Insurance for 30,000 Part... — 5 of 12

J.C. Penney Cuts Forecast

BUSINESS

Global Car Sales Seen Rising to 85 Million in 2014

Rising Emerging Market Wealth, moderate gas prices to Drive Demand

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By MIKE RAMSEY and NEAL BOUDETTE

Dec. 16, 2013 2:10 p.m. ET

The global auto industry is expected to produce 85 million sales in 2014, up from an estimated 82 million this year, IHS IHS +0.79% Automotive said in a forecast Monday.

By 2018 sales are forecast to break 100 million, according to the unit of business-information provider IHS Inc.

85 Million Vehicles – Assume Ford Fusions

Hypothetical
(approximations !)

~93,500,000 tons of steel

~18,700,000 tons of plastics

~12,000,000 tons of aluminum

~4,250,000 tons of glass

~650,000 tons of magnesium

Note

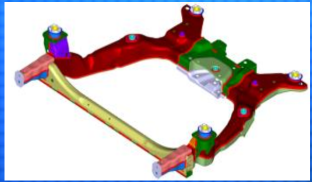
~ 75,000 tons of Carbon Fiber in Production
(Primarily Dedicated to Aerospace)

(150,000,000 lbs ~ 2 lbs /vehicle)
* CF supply expected to increase to 200 -300 M lbs

Material Deliver Weight Reduction

- ***Advanced High Strength Steel – Weight savings potential additional 7 to 10 %***
  - Most mature technology
  - Stamping, Joining & Assy Infrastructure Exists
  - Lowest cost alternative
  - Hydroforming
  - Tooling upgrades required (Hot Stamping)

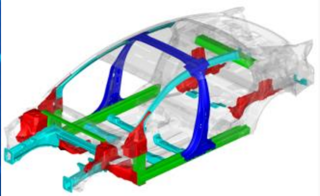
Component level up to 30% Wt Save



- ***Aluminum - Weight savings potential 40 to 50%***
  - Solid experience with Al Sheet (Closures)
  - Material cost is higher than advanced steels
  - Slight tooling upgrades required
  - Extrusions & Castings offer part consolidation opportunities

- ***Magnesium - Weight savings potential 50 to 60%***
  - Casting is currently the only economically viable manufacturing process
  - Corrosion can be an issue in some applications
  - Material supply base and converters in a state of flux
  - Sheet development in research phase

- ***Polymer Composites - Weight savings potential 10 to 60+%***
  - Good supply base for Injection Molding & sheet molded composite (SMC)
  - Class B surface and semi-structural applications
  - Carbon Fiber only starts to look promising @ $5 -8 / lb
  - Infrastructure to Make CF small and needs to grow

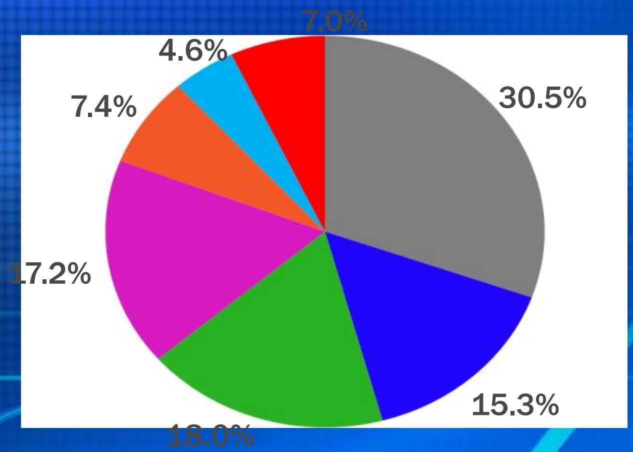


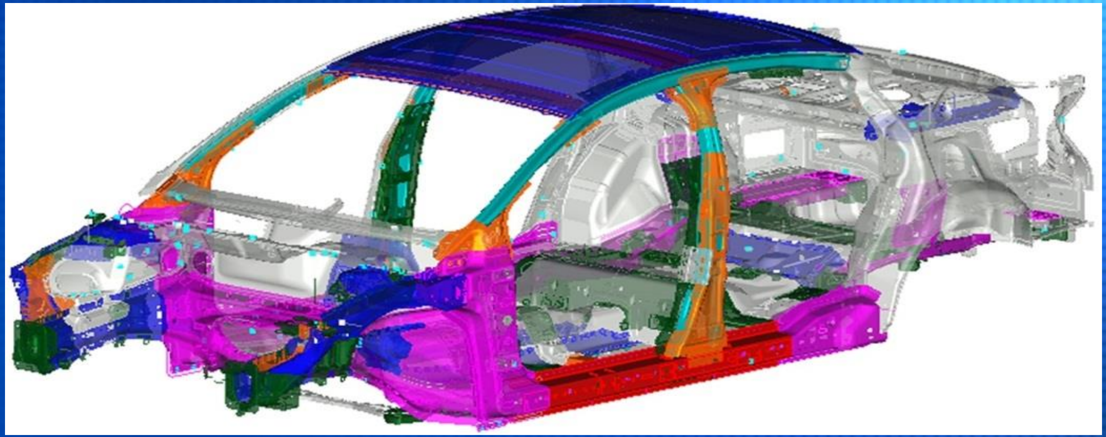
- ***Multi-Materials Lightweight Vehicles*** – Optimizing all materials systems

Advanced High Strength Steel Vehicles

Material – Ford Fusion BIW

- Mild Steel
- BH – HSLA (YS < 300)
- HSLA (YS > 300)
- DP 600
- DP 800
- DP 1000
- Boron - Martensitic



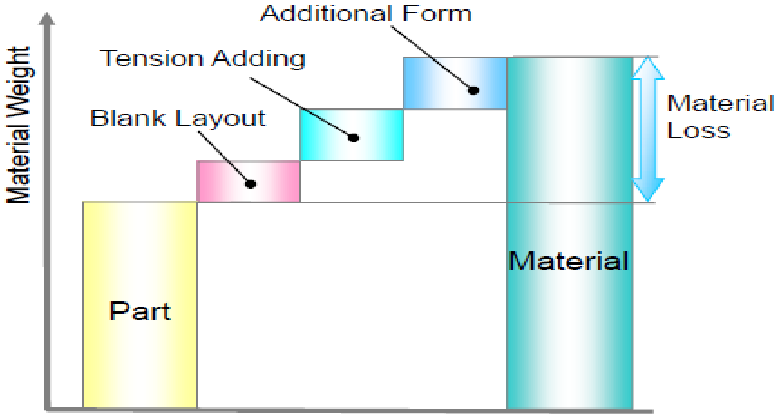


Average Yield Strength = 348 MPa

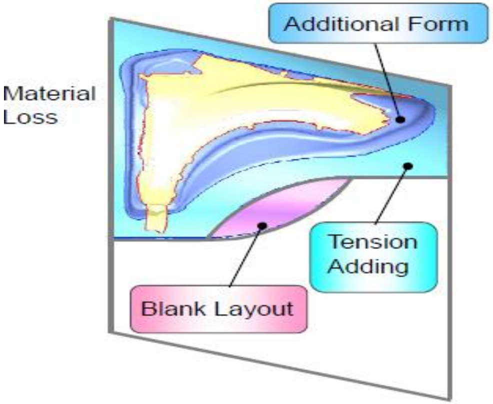
Improving Material Utilization – Sustainable Mfg

Optimized Materials Utilization - Cost Saving opportunity for Body & Stamping

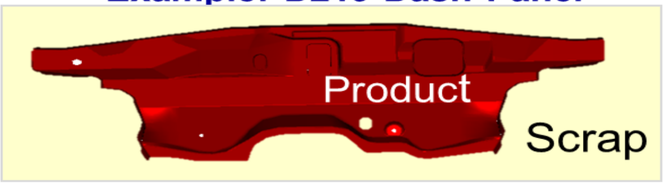
- $6 Billion/yr in steel
- 60% MU means 40% Scrap
- 1% Improvement
  - $60M annually in cost saving
  - Less Material waste
  - Sustainability



- Approach to higher MYR: Reducing 3 elements



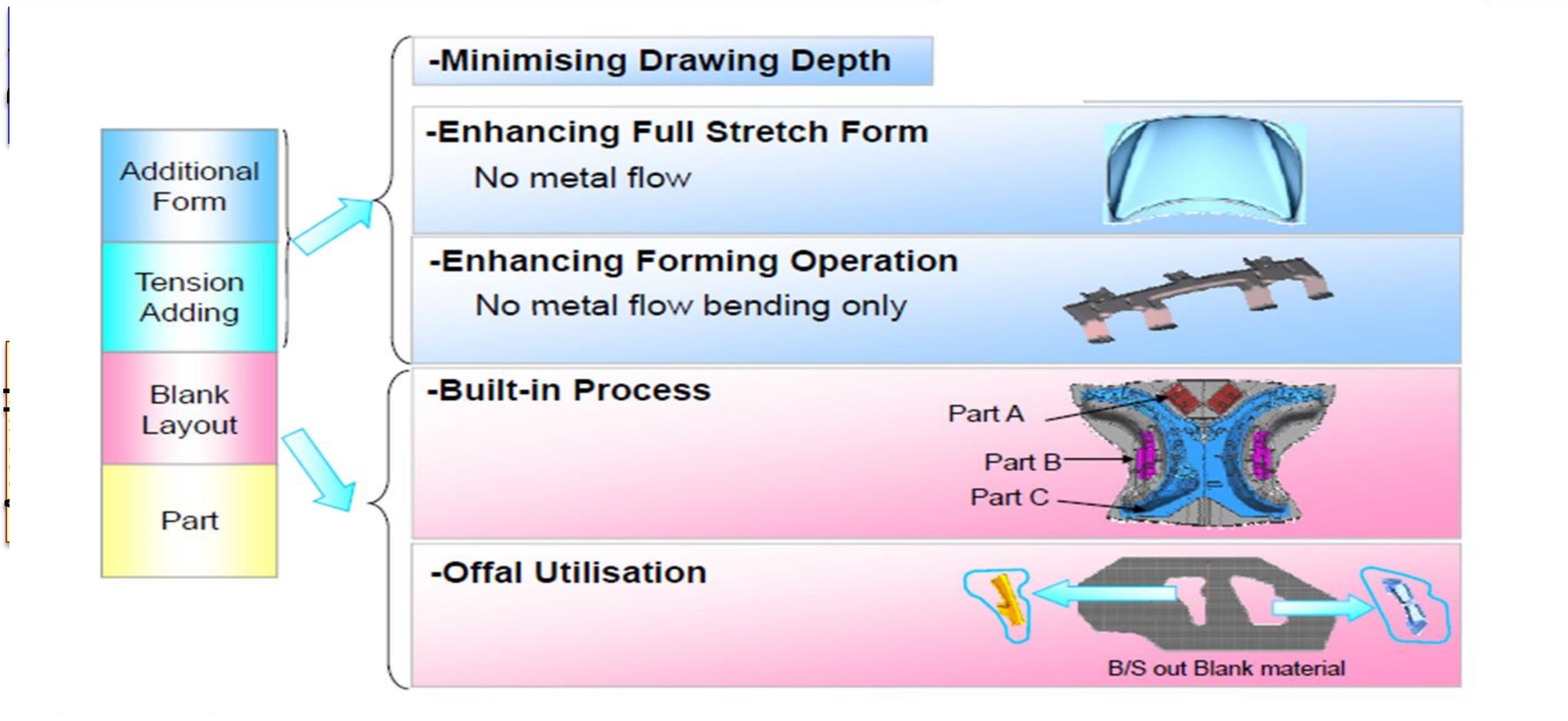
Example: D219 Dash Panel



Material Utilization: 46%

Material Utilization - Optimization Strategies

Single Part Design Single Part Process



DoE Innovative Manufacturing Initiative Proposal

RApid **F**reeform Sheet Metal **F**orming (RAFFT): **T**echnology Development and System Verification

Ford Motor Company, Dearborn, Michigan (Lead)

Northwestern University, Evanston, Illinois

The Boeing Company, Seattle, Washington

Massachusetts Institute of Technology, Cambridge, Massachusetts

Penn State Erie - The Behrend College, Erie, Pennsylvania

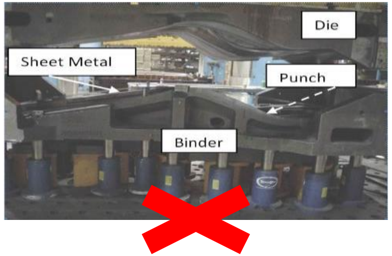
Total program value: $10.51M

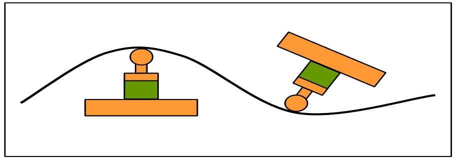
Program duration: 36 months

Innovation/Key Attribute of Idea

RAFFT is a revolutionary technology for rapid sheet metal prototyping and low-volume production where:

- A sheet blank is clamped around its periphery and gradually deformed to a complex 3D freeform part by two strategically aligned stylus-type tools that follow pre-described toolpaths;
- Geometric-specific forming dies are completely eliminated, together with their associated high cost and long lead time for engineering, construction and machining.
- The gradual local deformation provides ultimate formability, process control and process flexibility compared to conventional forming processes.





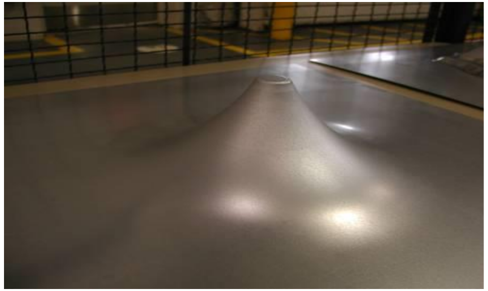
Specific Outcome of THIS Project

- A prototype RAFFT system with unique machine architecture for rapid freeform sheet forming of the sheet size up to 1.5 *m* x 1.5 *m*.
- Toolpath algorithms and control software for achieving target cycle time (< 10 *hours* for industrial parts) and dimensional accuracy (bilateral profile tolerance < 1 *mm*).
- Microstructure and performance characterization of RAFFT-formed structures.

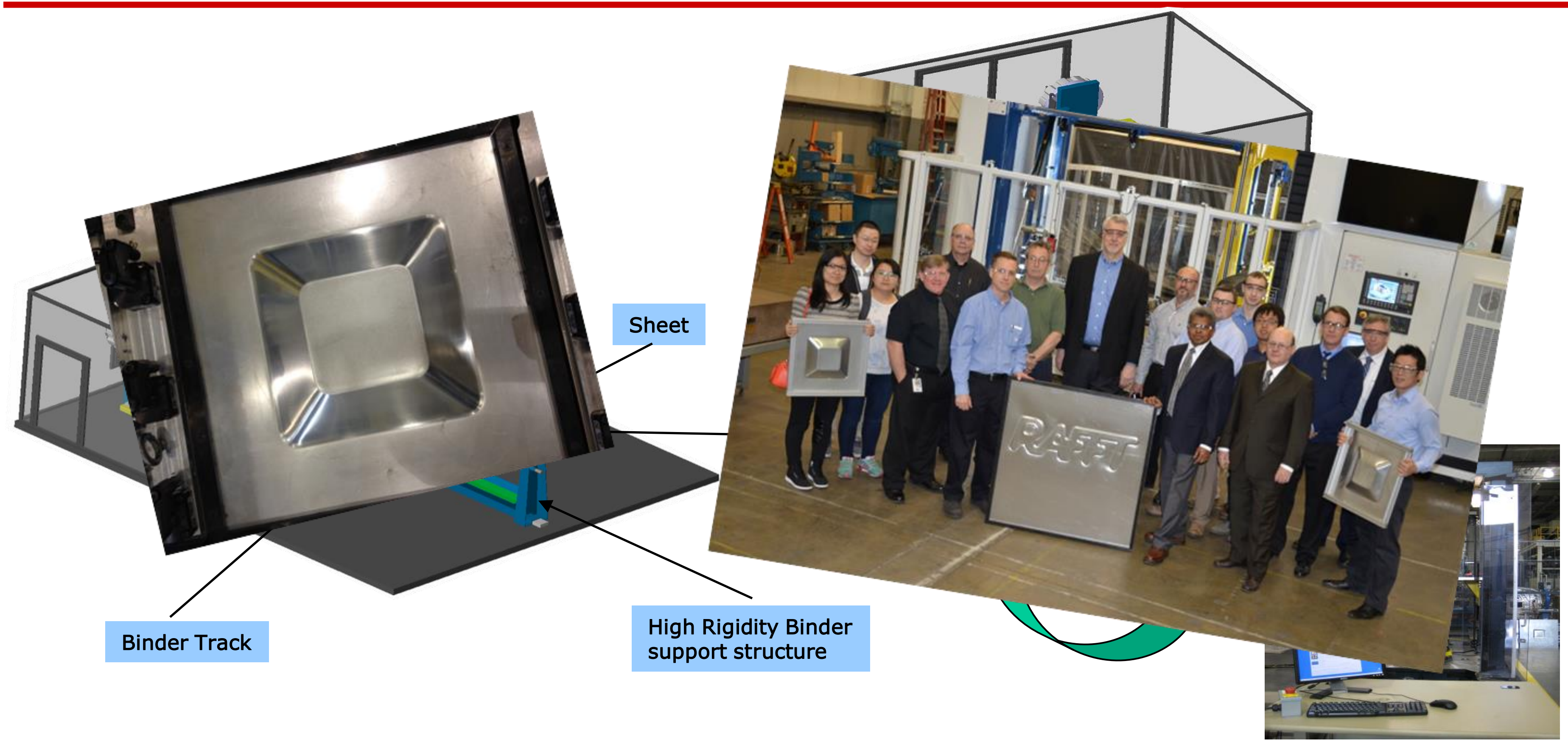
Impact if Successful

- Revolutionize the production of freeform sheet metal parts in diverse industries (e.g., aerospace, automotive, art) via distributed on-site and on-demand manufacturing
- Achieve annual **energy saving** of 15.2 *TBtu* and CO_2 reduction of 1 *MTons*.
- Achieve an annual **cost saving** of $2,360*M*.
- Reduce **total cycle time** for complex parts by 10x, from currently 8-12 *weeks* to 3-5 *days*
- Strengthen **U.S. manufacturing base** by eliminating the need for offshore fabrication of dies in low labor-cost nations

What we do today?



NG F3T Machine Concept Design



Aluminum Vehicles

Aluminum F150 – Highest Volume Production Vehicle

Aluminum Sheet

(BIW, Closures, Bed)

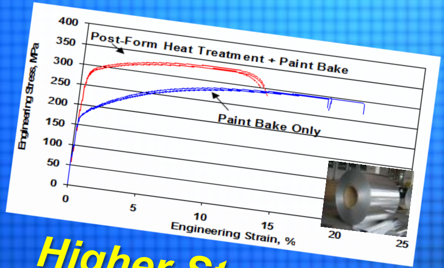
(6111, 6022, 5754, 5182)

High Strength Steel

(Frame)

Aluminum Technology Leaders

Hydroformed Aluminum



Higher Strength Aluminum

Advanced Joining (SPR's & Flow Drill Screws)

RSW Cell at RIC

Resistant Spot Welding

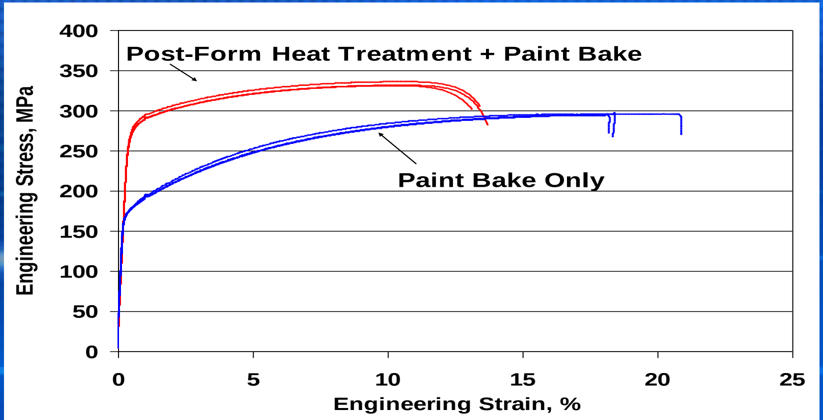
Advanced Pretreatments & Adhesives

Sustainable Mfg Technology

6xxx Al Alloy Processing - Post Form& Paint Oven Heat Treatment

Heat Treatment after stamping but prior to body construction results in significantly higher in service panel strength without introducing new and expensive alloys.

- Novel heat treatment process achieves >70 MPa increase without using new alloys.
- Higher Strength, Gauge Optimization & Materials Usage.



Paint Bake Oven Modeling

Aluminum Intensive Vehicles – Recycling Issues

- Energy to recycle aluminum is approximately 5% of the energy required to extract, process and fabricate new metal

- In order to have “closed-loop recycling”, alloys must be segregated by composition.

- Dearborn Stamping has new technology that allows for 4-way segregation.

Aluminum Sheet Products

- F150 – 700K Trucks per year (52-55 JPH)
- 500M lbs Aluminum Sheet/Yr
  - 250K t/yr
  - 21K t/mo
  - 694 t/day
  - 43 t/hr ……………(2) 8 hour shifts
  - 65% Utilization (35% closed loop recycled scrap)

500M lbs x 0.35 = 175M lbs in-plant recycled aluminum !

(A Very Valuable In-plant recycled commodity)

Mixed Material Vehicles

(Research & Development)

MMLV Vehicle Concept (23.3% mass reduction from 2013 Fusion)

Interior
CF Seats
CF IP Beam
Foamed Plastics

BIW
Vacuum Die Cast Al
AHSS & Al Sheet

Body Exterior
Al Sheet

Closures
Al, Mg & PH Steel

Tires
Narrow Tires
CF & Al Wheels

Glazing
PC & Toughened Glass

Bumpers
Al Roll Formed

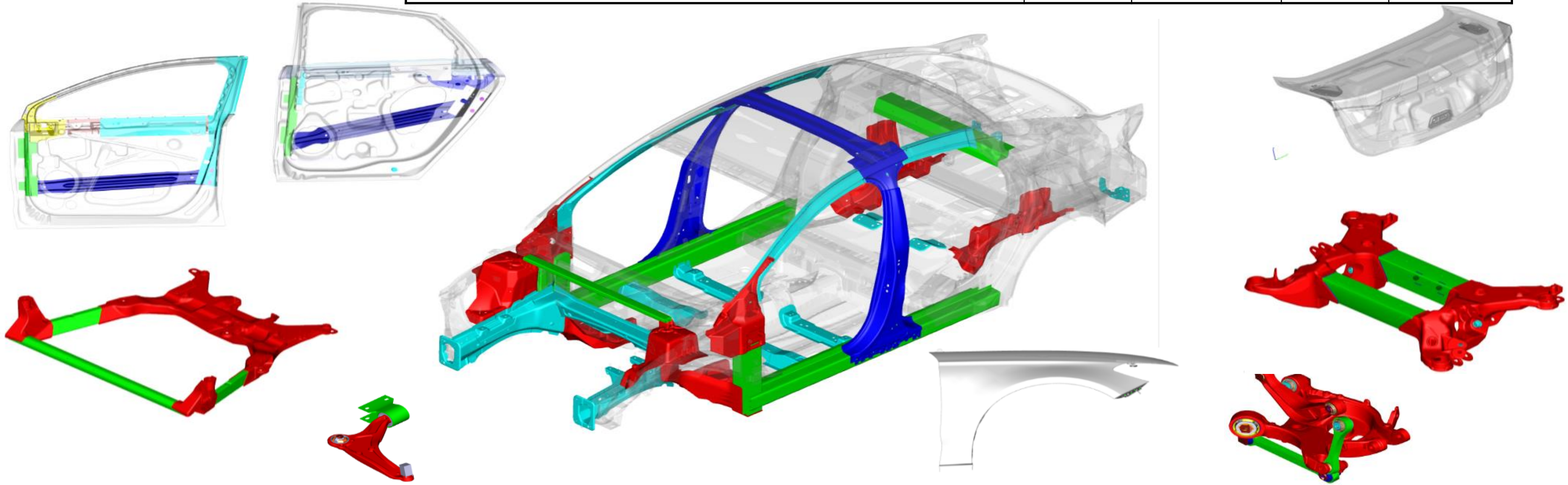
Chassis
Al Subframes
Hollow Steel, FRC & Ti Springs
Al thermal-sprayed brake rotors

Powertrain
Al & CGI block
CF – FEAD and Oil Pan
Mg – Valve Body

MMLV – Body Structure ideas

- MAGNESIUM CASTING
- HOT STAMPED STEELS
- STAMPED STEELS
- ALUMINUM CASTINGS
- ALUMINUM EXTRUSIONS
- ALUMINUM STAMPINGS

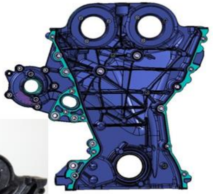
Vehicle Subsystem	Fusion (kg)	MMLV (kg)	Mass (kg)	Mass (%)
Total PMT 1 - Body Exterior and Closures	594	456	-138	-23%
Total PMT 2 - Body Interior and Climate Control	206	161	-45	-22%
Total PMT 3 - Chassis	350	252	-97	-28%
Total PMT 4 - Powertrain	340	267	-73	-21%
Total PMT 5 - Electrical	69	59	-10	-14%
Total Vehicle	**1559**	**1195**	**-363**	**-23%**



MMLV (Powertrain)

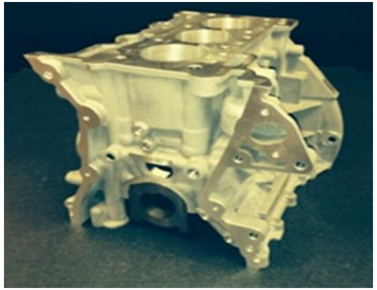
ENGINE – Weight reduction of 20% to 48% on components

- Cast aluminum engine block for 1.0 liter I3 engine with Powder Metal forged billet crackable bulkhead inserts.
  - saves 48%, 11.8 kg
- Carbon fiber structural oil pan.
  - saves 30%, 1.2 kg
- Carbon fiber front cover with mount.
  - saves 30%, 1.0 kg
- Carbon Fiber + Aluminum cam carrier.
  - saves 20%, 1.3 kg
- Forged aluminum connecting rods.
  - saves 40%, 0.7 kg




PA/CF Front Engine Cover

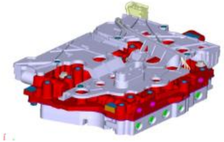
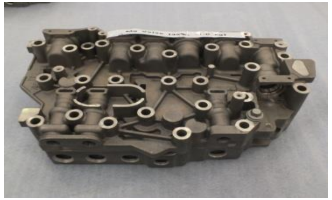
Forged Aluminum connecting rods



Bulkhead Insert in AL block

TRANSMISSION – Weight reduction of 30% to 60% on components for reduced torque automatic

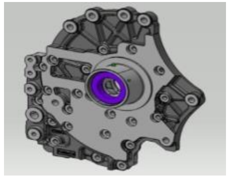
- Cast magnesium (AZ91D) case and bell housing
  - saves 30%, 5.0 kg
- Aluminum pump cover
  - saves 55%, 1.8 kg
- Cast magnesium valve body
  - saves 35%, 1.0 kg
- Steel + Aluminum clutch hub (friction spin weld)
  - saves 60%, 0.4 kg

Magnesium valve body

PA/CF Oil Pan

Aluminum + Steel Clutch Hub

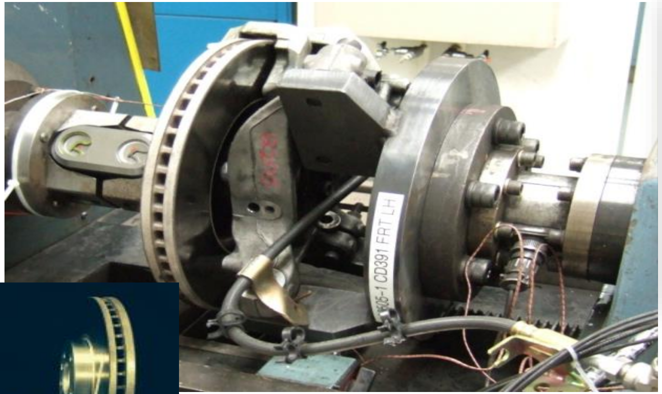


Aluminum pump cover

MMLV (Chassis)

SUSPENSION COMPONENTS – Weight reduction of ~30% on these components

- *Tall, Narrow Tires 30% save*
  - 155/70R19 new materials and constructions
- *Wheels 19 inch x5 inch 30% save*
  - cast aluminum or carbon fiber
- *Delete Spare Tire/Wheel*
- *Aluminum Brake Rotors 35% save*
  - Cast A356 Al, Thermal Spray Coated
- *Coil Springs 35% ~ 55% save*
  - hollow micro alloy steel with intensive shot peening, Glass Fiber composite
- *Stabilizer Bars 35% ~ 55% save*
  - high hardness steel, with internal and external shot peening



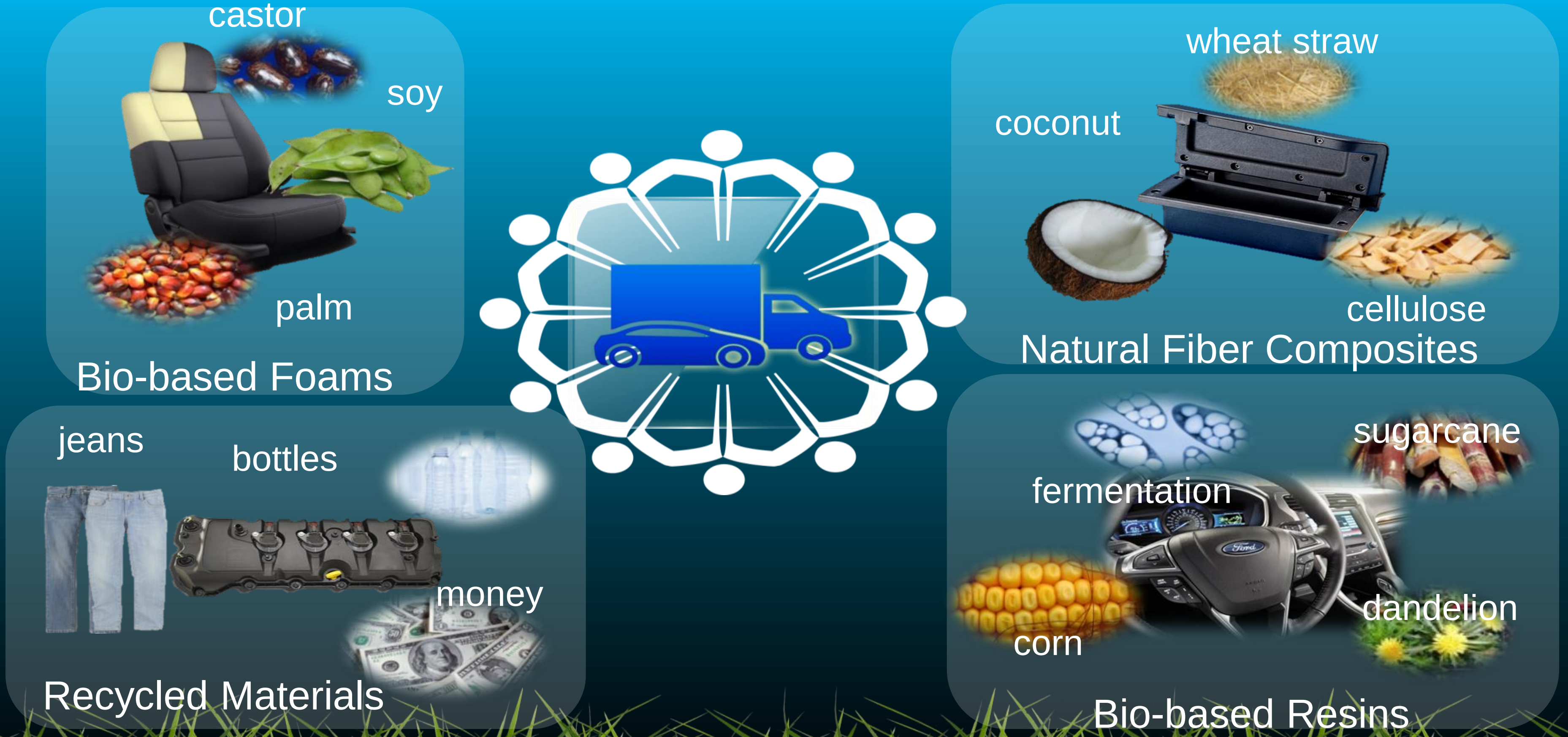
Aluminum brake rotor with thermally sprayed wear resistant coating

Evaluate composite & hollow steel coil springs

Carbon fiber wheels

Tall, Narrow Tires

Sustainable Materials Research



Soy-Based Foam

- Can we use oil from soybeans to make seats?
- Technology Overview: Use of soy polyol in formulating flexible polyurethane foam for automotive applications.

Implementation of Wheat Straw

on 2010 Ford Flex—with IAC

reduces petroleum usage by some 20,000 pounds per year and reduces CO_2 emissions by 30,000 pounds per year

Implementation of Cellulose Fiber

December, 2013—with JCI

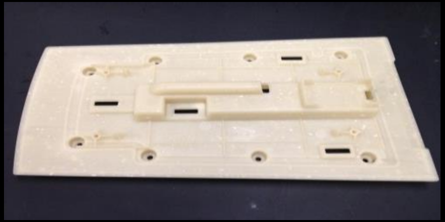
1 Origin

Cellulose is extracted from sustainably grown and harvested trees and related forestry byproducts, such as chips

2 Structure

Cellulose fiber, found in plants and trees, is one of the most common organic compounds in the world. Its fiber provides excellent reinforcement for plastic composites

3 Performance



Ford has validated cellulose reinforced plastics – supplied by forest products leader Weyerhaeuser – for performance, durability, and thermal resistance for interior components

4 Implementation

The first use of cellulose fiber for a structural component to be announced soon

Vision for Sustainable Rubber

1.) Domestic sources for elastomers


Russian Dandelions


Guayule Shrub*


Bioisoprene (Biomass)

2.) Renewable fillers


Corn Starch


Recycled Tread


Cellulose Ester

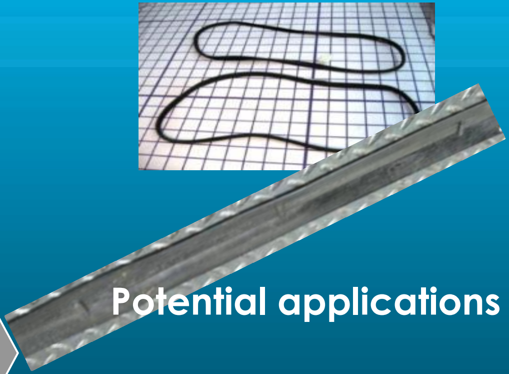
3.) Bio-based extender oils

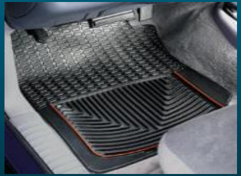

Orange Oil


Tall Oil*


Soy Oil*

Potential applications





*photos courtesy of USDA

Thank you for your attention!

Questions

Go Further

Applications

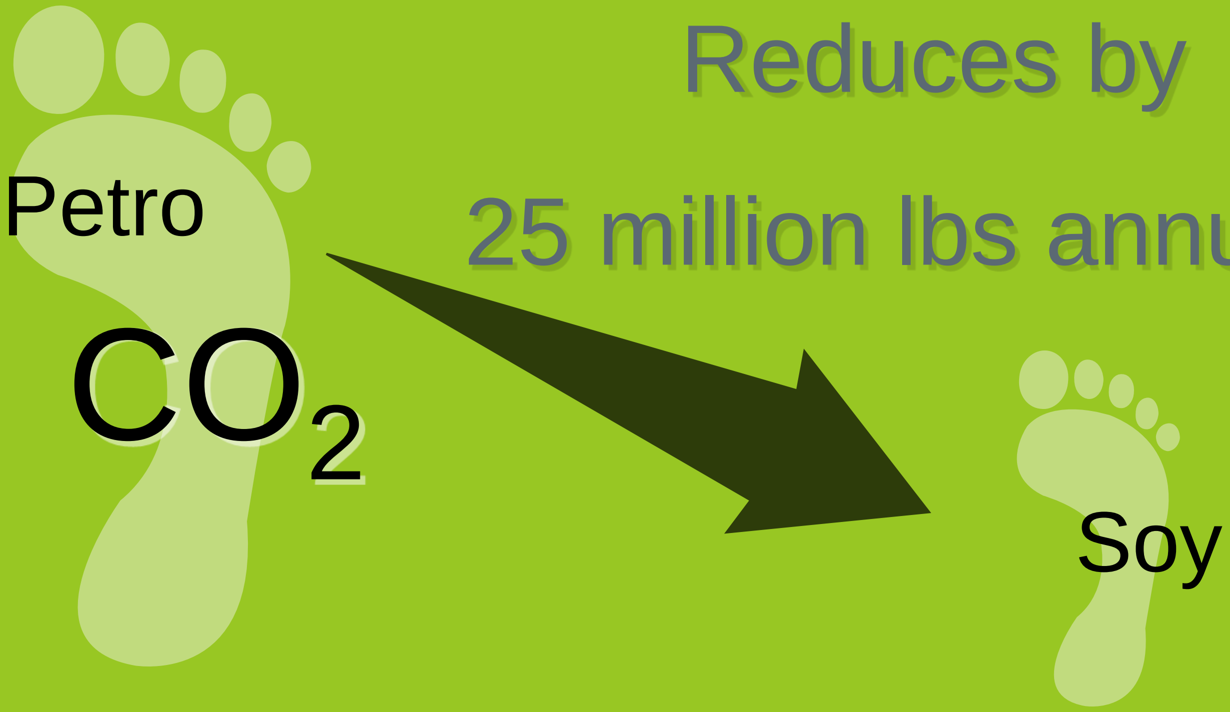
Over 30 lbs of foam per vehicle

Also rigid foam applications: package tray, energy absorption

CO_2 Emissions Reduction

Reduces by

25 million lbs annually



Implementation of Kenaf Fiber

on 2013 Ford Escape—with IAC


door bolster

Automotive Elastomer Parts

Elastomers are used in hundreds of parts in a typical vehicle including:

Gaskets and seals

Engine mounts

Hoses and tubing

Splash and underbody shields

Suspension bushings

Tires

Door weather strips

Glass run channels

Floor coverings and mats

Do Sustainable Materials Sell Cars?

Not directly yet, but….

- brand image value
- protecting the business for future unknowns
- reduce environmental impact
- next generation of customers

The Power of Collaboration

Our Heritage

"I am looking for a lot of people who have an infinite capacity to not know what can't be done"

Closing Thoughts

- Understand global needs and future trends.
- Automotive industry provides a wide array of opportunities in technical fields.
- Collaboration across discipline areas, with external companies and universities is key for success.

Production Examples

2013 Fusion – UHSS & Reinforced thermoplastic bolster

2012 Focus Body structure - 55% high-strength steel

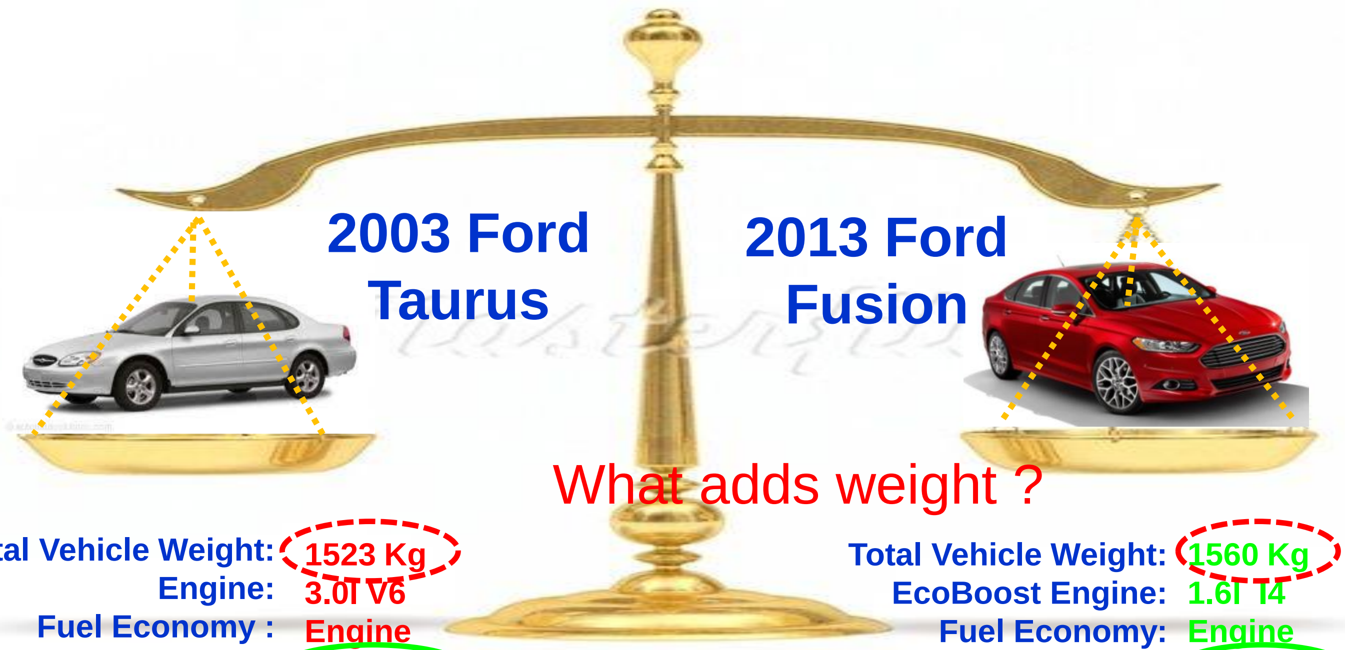
F150 - Aluminum Body, Closures and Truck bed, UHSS Frame

Flex - Natural fiber filled interior plastics

Ford Mustang: Aluminum hood, Aluminum fenders & aluminum engine with composite coated Cylinder bores

2010 Lincoln MKT: Light-weight magnesium and aluminum lift gate.

Vehicle Weight: 10 Year Comparison



2003 Ford Taurus

2013 Ford Fusion

What adds weight ?

Total Vehicle Weight: 1523 Kg
Engine: 3.0l V6
Fuel Economy : Engine
(Metro-Hwy) 21 MPG

Total Vehicle Weight: 1560 Kg
EcoBoost Engine: 1.6l I4
Fuel Economy: Engine
(Metro-Hwy) 37 MPG

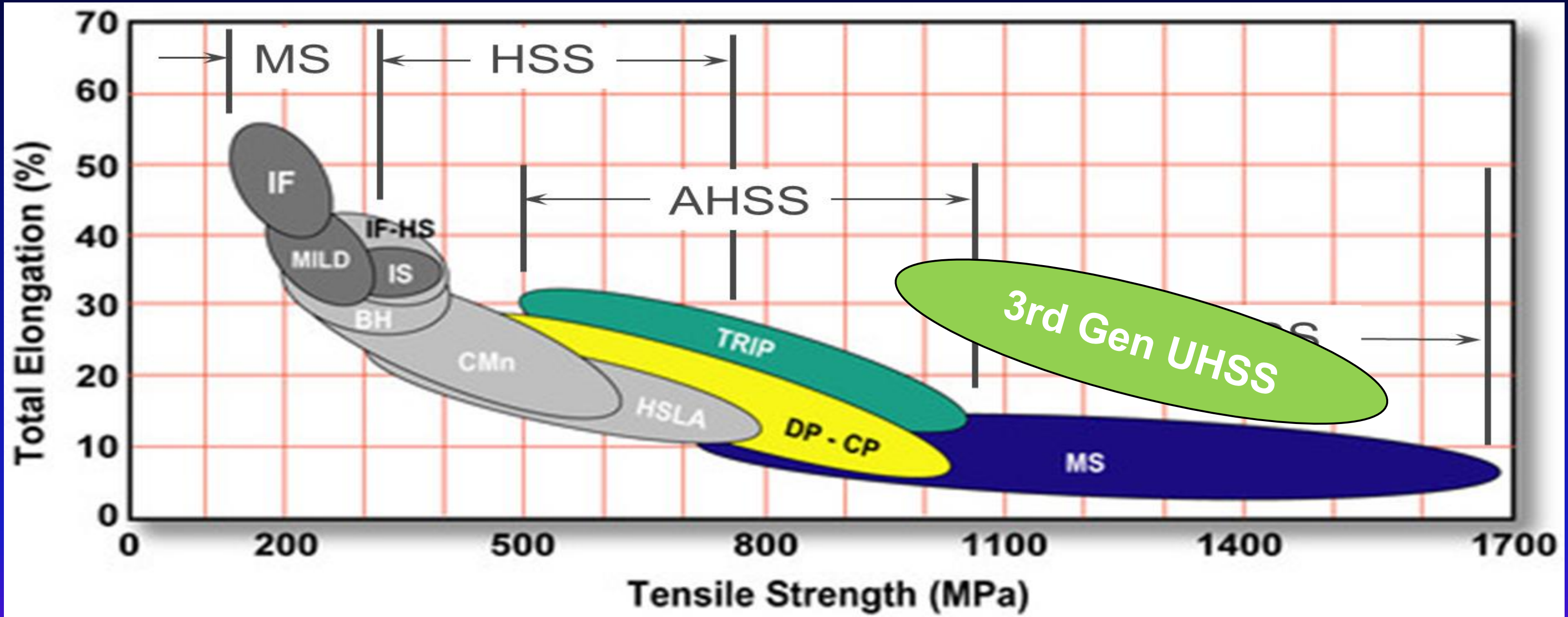
Significant FE improvement

NEW MILEAGE TARGETS FOR 2025

Automakers must comply with tough, new m.p.g. targets by 2025. The new equation uses a sliding scale for different sizes of vehicles. Here's a look at the mileage targets and estimated window-sticker fuel-economy numbers for 2025 and how they compare with current models. The new targets will be reviewed again in 2017.

Vehicle size (Example)	2012 EPA window sticker combined	Estimated 2025 window sticker combined*	2025 target combined CAFE rating
Compact car (Honda Fit)	30 m.p.g.	45 to 48 m.p.g.	61.1 m.p.g.
Midsize car (Ford Fusion)	25 m.p.g.	41 to 43 m.p.g.	54.9 m.p.g.
Full-size car (Chrysler 300)	21 m.p.g.	35 to 36 m.p.g.	48 m.p.g.
Small SUV (Ford Escape 4wd)	23 m.p.g.	36 to 38 m.p.g.	47.5 m.p.g.
Midsize crossover (Nissan Murano)	20 m.p.g.	32 to 34 m.p.g.	43.4 m.p.g.
Minivan (Toyota Sienna)	21 m.p.g.	29 to 31 m.p.g.	39.2 m.p.g.
Large pickup (Chevrolet Silverado)	17 m.p.g.	25 to 26 m.p.g.	33 m.p.g.

Steel Grades



Year 1980's……1990's……2000……….2005…...2010…….2014
(The Steel Industry continues to deliver weight saving materials)