NATIONAL ACADEMIES DESIGN OPTIMIZATION WEBINAR

MAGNA INTERNATIONAL

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Magna Corporate R&D

We are a **mobility technology company** and one of the world’s largest suppliers to the automotive industry.

It starts with a vision….

We define and create the future of mobility

Magna International

Employees: +166,000 globally

Manufacturing Facilities: 346 globally

Market Position: #1 in NA, #3 globally

Sales: $40.8 Billion USD in 2018

Collective Expertise: Competitive Advantage

- Complete Vehicles
- Body Exteriors & Structures
- Power & Vision
- Seating Systems

Collective Expertise: Competitive Advantage

- Complete Vehicles

3.3 Million Automobiles manufactured in Graz, Austria

Voiturette
1906

Alpenwagen
1919

Puch
500 / 650 / 700c / 126
1957 – 1975

Haflinger
1959 – 1974

Pinzgauer
1971 – 2000

Mercedes-Benz
G-Class
since 1979

in Production

VW Transporter
T3 4x4
1984 – 1992

VW
Golf Country
1990 – 1991

Audi
V8L
1990 – 1994

Jeep
Grand Cherokee
ZG/WG/WJ
1994 – 2004

Mercedes-Benz
E-Class
1996 – 2002

Mercedes-Benz
M-Class
1999 – 2002

Chrysler
Voyager
2002 – 2007

Mercedes-Benz
E-Class
2003 – 2006

Saab
9³ Cabrio
2003 – 2009

BMW X3
2003 – 2010

Chrysler
300 C
2005 – 2010

Jeep Grand
Cherokee
WH
2005 – 2010

Jeep
Commander
2006 – 2010

Mercedes-Benz
SLS Painted
Aluminum Body
2009 – 2014

Aston Martin
Rapide
2010 – 2012

Peugeot
RCZ
2010 – 2015

MINI
Countryman
2010 – 2016

MINI
Paceman
2012 – 2016

BMW
5 Series
since 2017

in Production

Jaguar
E-PACE
from Q4 2017

In Production

Jaguar
I-PACE
from 2018

In Production

Collective Expertise: Competitive Advantage

Power & Vision

Automotive Industry Trends

Electrification

Autonomy

New Mobility

Future Mobility Solutions

- Autonomous and semi-autonomous operation
- Sensors and Communication (V2V ,V2I)
- Cyber Security

Evolving Business Models

- Ride Sharing
- Car Sharing
- Ride Hailing

Electrification

- Fully Electric, Plugin Hybrid & Mild Hybrid
- Battery Efficiency and Fast Charging

Environmental & Safety Legislation

- Powertrain & Engine Efficiency
- Lightweighting
- Recycling
- Alternative Fuels (hydrogen & biofuels)

Magna Innovation Pillars

Smarter.

Comfort, Convenience and Connectivity

Designing and delivering an inspired, best-in-class cabin experience

Cleaner.

Efficiency and Sustainability

Optimizing the use of energy to meet the needs of our customers and our planet

Safer.

Active and Passive Safety

Engineering protection and peace-of-mind for all who share the road

Lighter.

Lightweight Material and Science

Driving performance and quality through innovative mass reduction

Affordable.

Development and Manufacturing Efficiency

Align and optimize processes for the development and manufacture of products

Magna Corporate R&D

Relative Design Optimization Projects

- Multi Material Vehicle (MMLV), with Ford
- Liteflex, Integrated Door Systems, with FCA

Design Optimization – a synthesis of product design, lightweight materials and manufacturing processes

MMLV - Advanced Vehicle

- 23.5% (364kg) full vehicle mass reduction
- 16% (43g/km) reduction CO_2eq
- Equivalent styling, safety & functionality
- Affordable lightweighting, cost not published

LiteFlex, Integrated Door System

- 40% (52.5kg) mass reduction, 4 door vehicle
- 2% (6g/km) reduction in CO_2eq
- Equivalent styling, safety & functionality
- Affordable lightweighting, $2.81 per lb. saved

Multi-Material Lightweight Vehicle

MMLV

U.S. DEPARTMENT OF ENERGY | Ford | MAGNA

LIGHTER

Lightweight
Material and Science

CLEANER

Efficiency and
Sustainability

AFFORDABLE

Development and Manufacturing Efficiency

MMLV Mach I Vehicle

MMLV Al-intensive vehicle 1,195kg
2014 Fusion Steel-intensive 1,538kg
==========
24% Mass Reduction (343kg)

Demonstrated Benefit

- 23.5% full vehicle mass reduction
- Mass reduction enabled use of 1 liter, 3 cyl. FOX engine used in B-segment Ford Fiesta
- Functionally equivalent
- Prototype Vehicles, high volume processes
- Test Validation
  - NVH
  - Durability
  - Crash Safety
- 16% reduction in GHG (43g CO_2 eq/ km)

"A synthesis of design, lightweight materials and forming processes"

MMLV Mach II Vehicle

MMLV Mg-intensive vehicle 969kg
2014 Fusion Steel-intensive 1,538kg
==========
42% Mass Reduction (569kg)

Demonstrated Benefit

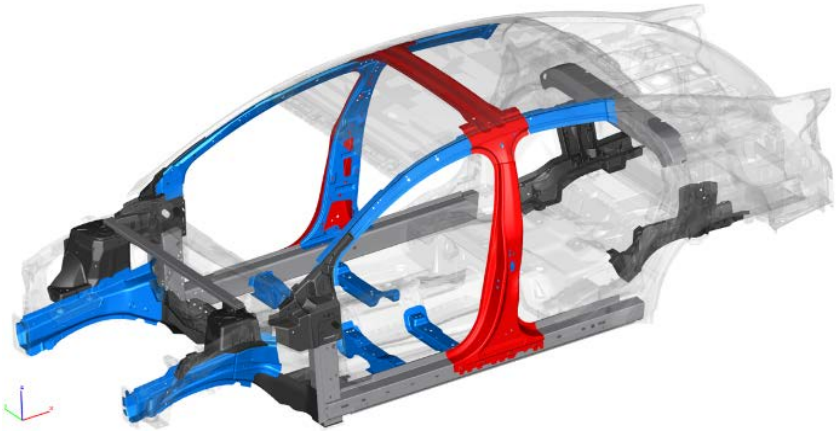
- 41.6% full vehicle mass reduction
- Mass reduction enabled use of 1 liter, 3 cyl. FOX engine used in B-segment Ford Fiesta
- Functionally equivalent
- CAE Validation of NVH, durability & crash safety
- 29% reduction in GHG (78 CO_2 eq/ km)

77 kg of Mg sheet per vehicle
closures, deck lid, roof, hood and doors.

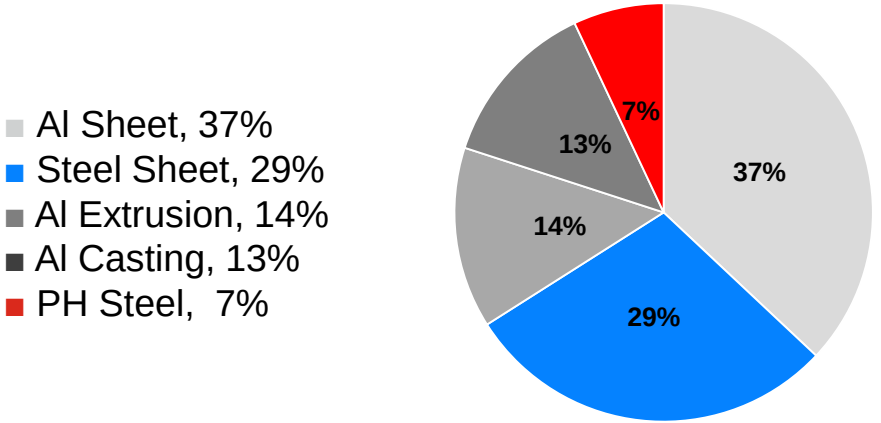
MMLV Mach I Vehicle

Body Structure, Exterior & Closures

2014 Steel-Intensive Fusion	594kg
MMLV Al-intensive	456kg
==========	==========
24% Mass Reduction	138kg



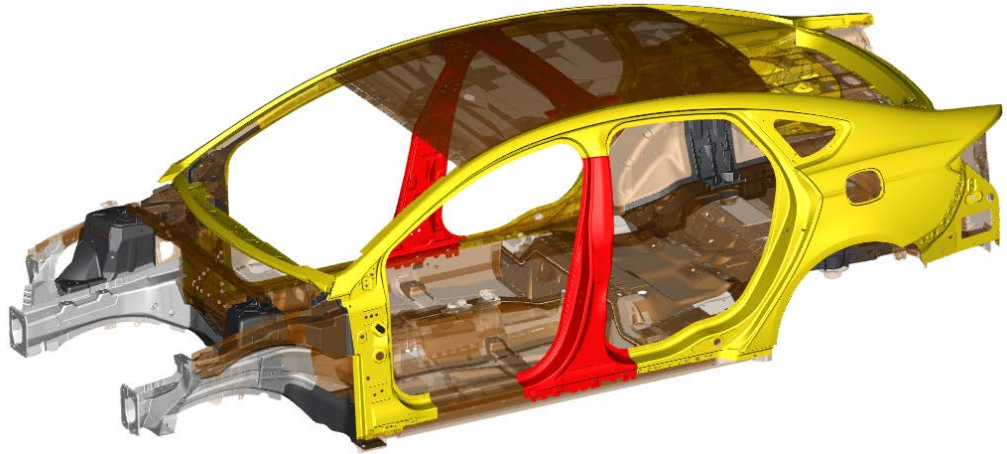
MMLV Mach I BIW



MMLV Mach II Vehicle

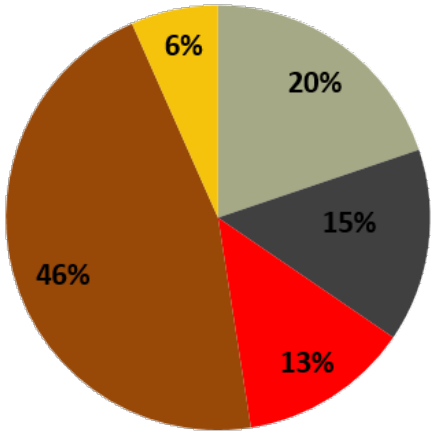
Body Structure Exterior & Closures

2014 Steel-Intensive Fusion	594kg
MMLV FRC & Mg-intensive	352kg
40% Mass Reduction	242kg



MMLV Mach II BIW

- FRC Sheet, 46%
- Al Sheet, 20%
- Al Casting, 15%
- PH Steel, 13%
- Mg Sheet, 6%

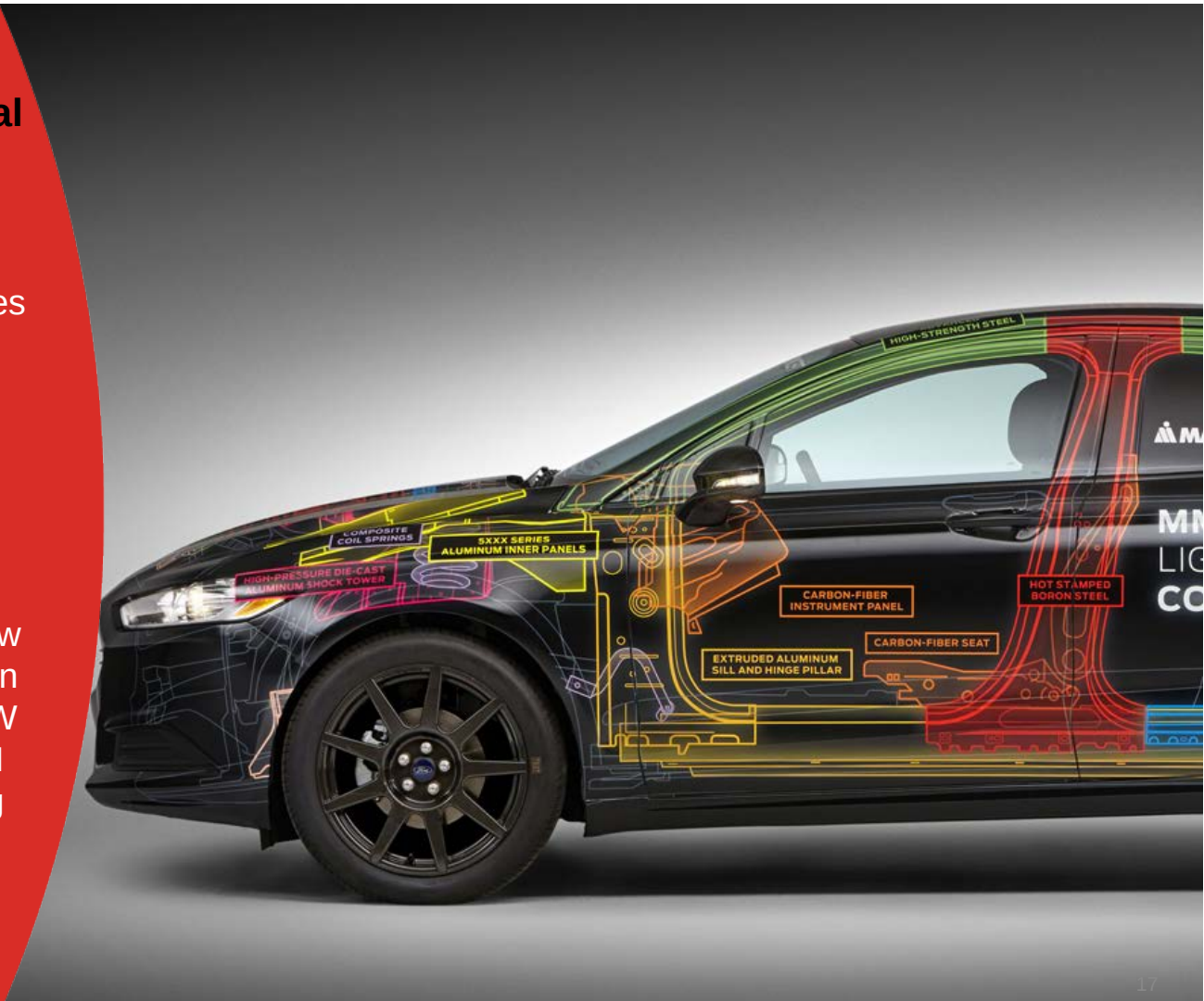


Commercialization Potential

The cost of lightweighting increases exponentially beyond 20% of full vehicle weight.

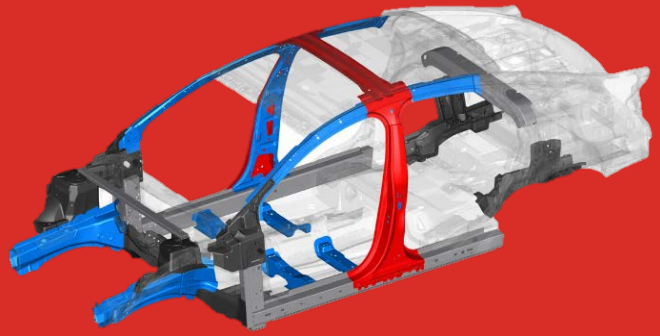
Material cost limits application to luxury segment vehicles.

Cost impact of body shop modifications to manufacture a new BIW archecture and lost production favor programs which include NEW body shop construction, new OEM entrants or contract manufacturing



Lessens Learned

MMLV Program



MMLV Mach I Vehicle

MMLV Mach II Vehicle

- The GREET models developed by Argonne National Lab correlated perfectly with the fuel savings associated with the MMLV Mach I vehicle.
- Mass Induced Fuel Reduction - w/o Engine Downsizing
  0.168 liters/100kg per 100km
- Mass Induced Fuel Reduction - with Engine Downsizing
  0.4 liters/100kg per 100km
- Typical spacing between OEM engine to 100 kg in mass difference. Minimal benefit of incremental mass reduction upto the 100 kg threshold to enable a downsized engine.
- The 343kg mass reduction associated with the MMLV Mach I C/D segment vehicle enabled use of the 1 liter, 3 cylinder engine used in the B-segment Fiesta, with no reduction in performance due to equivalent weight between Mach I and Fiesta.

Magna Corporate R&D

LiteFlex, Integrated Door Systems

LiteFlex - Drivers-side Door

2016 FCA Steel-intensive (front) 38.0kg
LiteFlex Al-intensive (front) 22.8kg
==========
Mass Reduction 15.2kg

Demonstrated Benefit
- 40% mass reduction drivers side door
- Manufactured form tooling
- Built 42 prototype doors
- Production-intent validation testing
  - durability
  - crash safety
  - NVH
  - corrosion

"A synthesis of design, lightweight materials and forming processes"

LiteFlex – 4 door vehicle

2016 FCA Steel-intensive 127.6kg
LiteFlex Al-intensive (front/rear) 78.1kg
==========
Mass Reduction 49.5kg

Demonstrated Benefit
- 39% full vehicle (4 doors) mass reduction
- Functionally equivalent
- 2% reduction in GHG (6 CO_2 eq/ km)
- CAE validation of
  - durability
  - crash safety
  - NVH

LiteFlex Door

An aluminum-intensive drivers side door

Forming Technologies

- Cold stamping
- High pressure casting
- Extrusion
- Warm forming

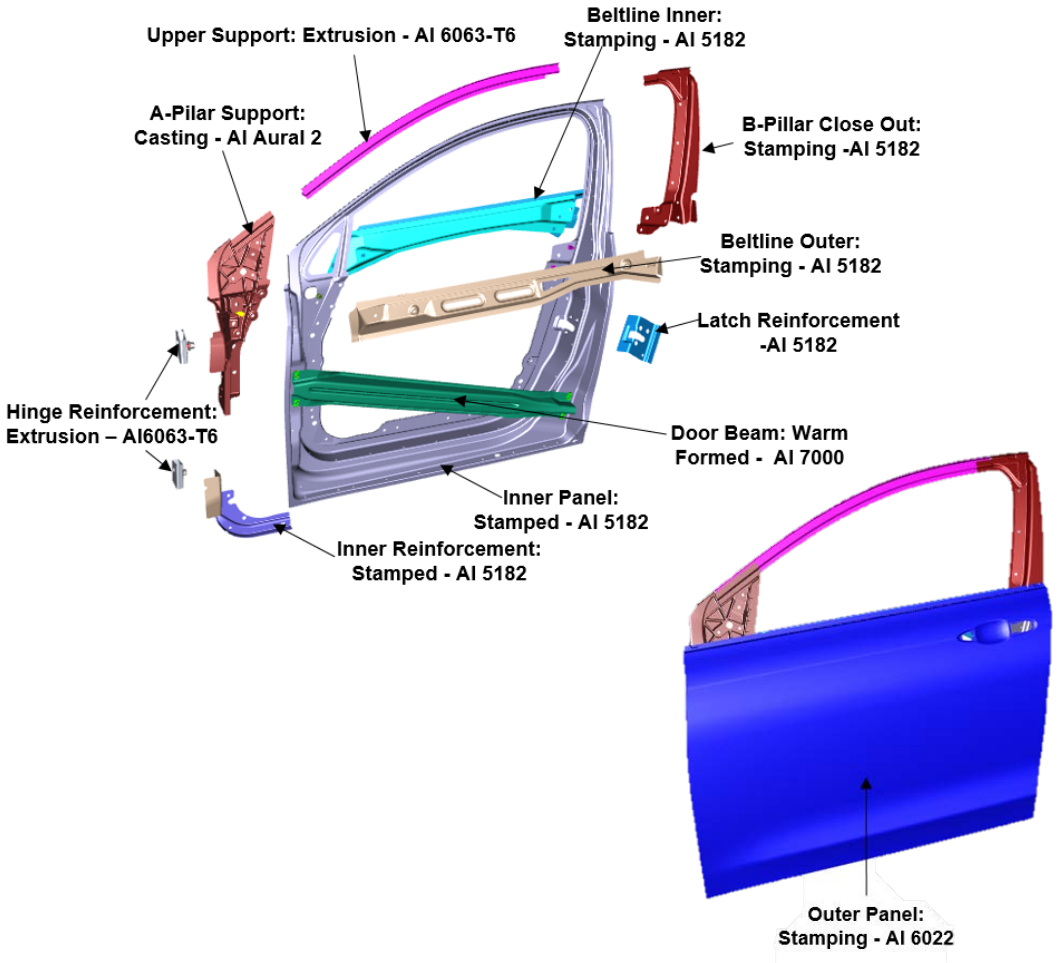
Material Usage

- 16.6kg Al sheet, 5xxx inner panels
- 7.6kg Al sheet, 6xxx outer panels
- 4.2kg Al sheet, 7xxx door beam
- 3.3kg Al casting, A-pillar support
- 1.9kg Al extrusion, upper support
- 0.2kg Al fasteners

==========

33.8kg Al per vehicle

49.5 kg mass reduction per vehicle

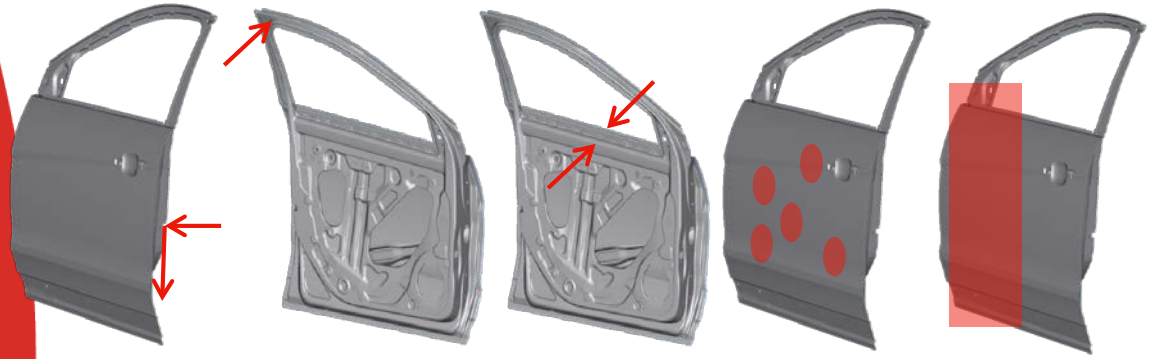


LiteFlex Door

An aluminum-intensive drivers side door

Design & Development Process

- Establish design space & objectives
- Obtain & set performance targets
- Identify desired features & function
- Cost budget constraints
- Seek part integration opportunities
- Material and Process Alternatives
- Understand load paths
- Compare architecture performance
- Infrastructure compatibility
- Service & repair
- Joining processes
- Corrosion



Sag & Set **Overcheck** **Header Stiffness** **Beltline Stiffness** **FMVSS 214**

LiteFlex Door
Summary of Results

Drivers-side Door

Mass Reduction: Minus 15.2 kg

Complete Vehicle (4 doors)

Mass Reduction: 51.2 kg per vehicle
Life Cycle Impact: 6g CO_2 per km

Equivalent or better performance, safety and styling

5-star crash, durability, NVH, corrosion, appearance, fit / finish, and other vehicle attributes

Commercialization Potential of Ultralight Door

The incremental cost of the Ultralight Door is $2.90 per pound saved, which is very competitive with competing technologies

Bolt-on closure components can be changed mid-cycle, as a refresh and do not require body shop modifications

CAFE and air quality legislation has a significant impact on the decision making process

DRIVING **EXCELLENCE.**
INSPIRING **INNOVATION.**