



Aluminum – The Safety Advantage

The Aluminum Association, Inc.
Aluminum Transportation Group

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The Automotive Challenge

Global transportation goals:

- Improve transportation safety
- Reduce fuel consumption
- Reduce CO₂ emissions
- Affordability

Downweighting Advances Transportation Goals

Weight Reduction with Aluminum

- Improved safety
 - Avoid downsizing
 - Increase crush space without increasing weight
 - Reduced kinetic energy
- Improved fuel economy
 - 10% “achievable”
- Cost-effective (with inclusion of secondary weight savings)
- Reduced life-cycle CO₂ Emissions
 - 20% achievable

Why Reduce Vehicle Weight?



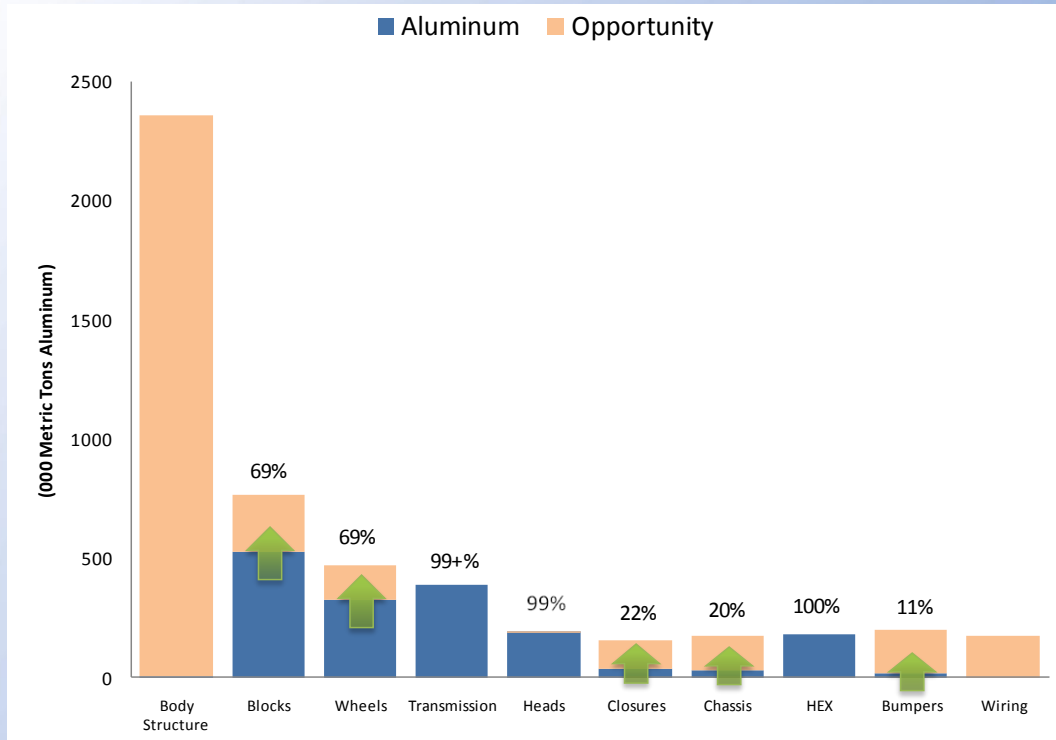
Weight Reduction Improves Fuel Economy

	Fuel Economy Improvement / 15% Weight Reduction (EPA Combined Drive Cycle)			
	Passenger Vehicle		Truck	
	Base Engine	Downsized Engine	Base Engine	Downsized Engine
Gasoline	5.0 %	10.0 %	5.3 %	7.1 %
Diesel	5.9 %	9.5%	5.4 %	7.0 %
PEV	9.5 % *	N.A.	8.6 % *	N.A.
PHEV	9.5 % *	N.A.	8.6 % *	N.A.

* Miles/KWH

Source: Ricardo Consulting Engineers,
study for the Aluminum Association

Aluminum Weight Reduction Opportunities:



High AL penetration today

Transmissions

Heads

HVAC

Wheels

Blocks

Practical AL Growth

Closures

Body-in-white (BIW)

Chassis Structures

Bumpers

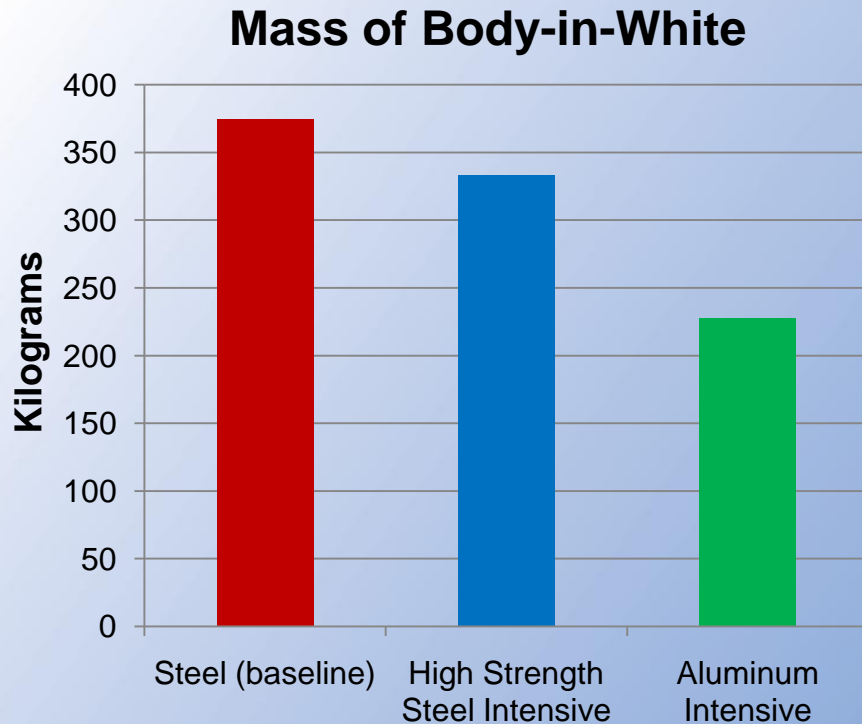
Note: 1 Lb. of Aluminum replaces approx. 2 Lb. Iron or Steel

Weight Reduction Studies

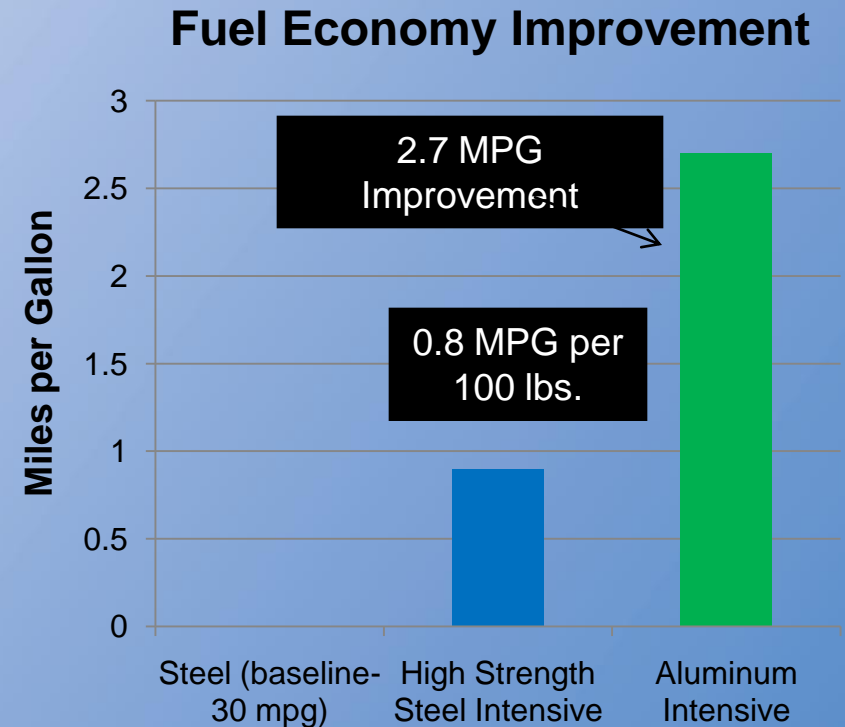
- Aluminum sponsored Auto Body Studies
 - IBIS and Aachen
 - 40-45% Body weight reduction
 - 15% total vehicle (550 Lbs w/secondary)
 - 10% fuel economy improvement
 - No size reduction

Research Study	Weight Reduction (BIW and Closures)
IBIS (2008)	45%
Aachen (2010)	40%
Lotus (2010)	42%

Weight Savings Translate to Fuel Economy Improvement



Source: ika - University of Aachen and the European Aluminium Association (EAA)



Source: Aluminum Association calculated based on ika mass reduction data; assumes 23% secondary weight savings, 27.5 MPG base vehicle 2010

Downweighting - Cost Competitive



Aluminum Body Reduces EV Cost by \$775

- **10% Mass Reduction: 9% reduction in battery size**
- **Low Mass Aluminum Structure Achieves:**
 - Weight reduction potential: **147 Kg** (19%)
 - Reduce battery cost: **\$ 900 – \$ 1,950** (@ \$750/KWh)
 - Expected aluminum structure cost premium: **\$ 630**
 - **Net cost savings = \$775**
 - Reduced energy consumption: **1.3 KWh / 100 Mi per 100 Kg**

Aluminum and Vehicle Safety



DRI Study – Vehicle Configurations

3,500 virtual collisions with SUV

- 595 single vehicle crashes
 - 175 rollovers
 - 420 hit fixed object
- 2,905 two vehicle crashes:
 - 1,750 hit “Accord”
 - 1,155 hit other “Explorer”



Conducted by Dynamic Research, Inc (DRI)
and The Aluminum Association, Inc.

Safety Improvement with Downweighting

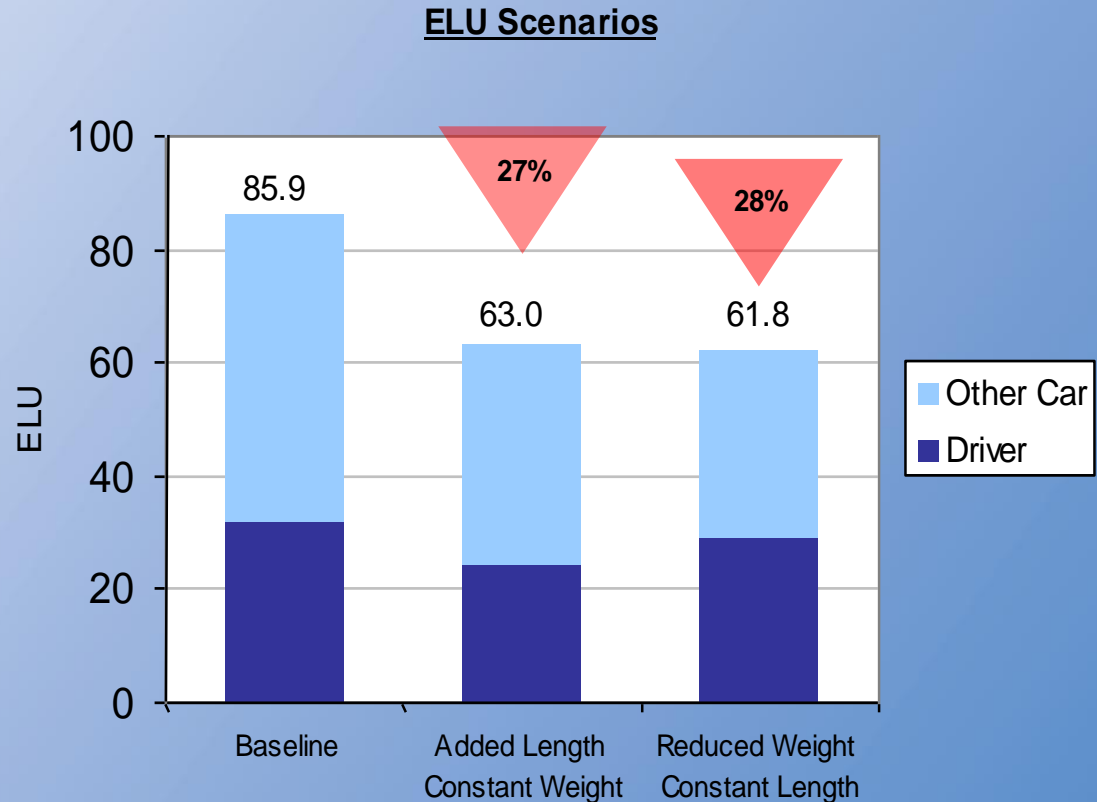
Study Conclusions:

Engineering –

Lighter, slightly larger vehicle is safer

Size (not weight) –

better predictor of safety



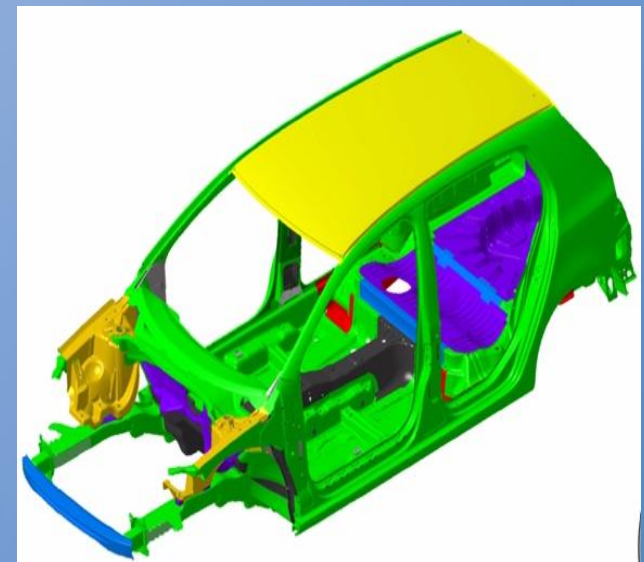
Adding crush space without adding weight improves safety 27%

Conducted by Dynamic Research, Inc (DRI)
and The Aluminum Association, Inc.



STIFFNESS RELEVANCE AND STRENGTH RELEVANCE IN CRASH OF CAR BODY COMPONENTS

**Public version of official report
83440 by ika
May 2010**

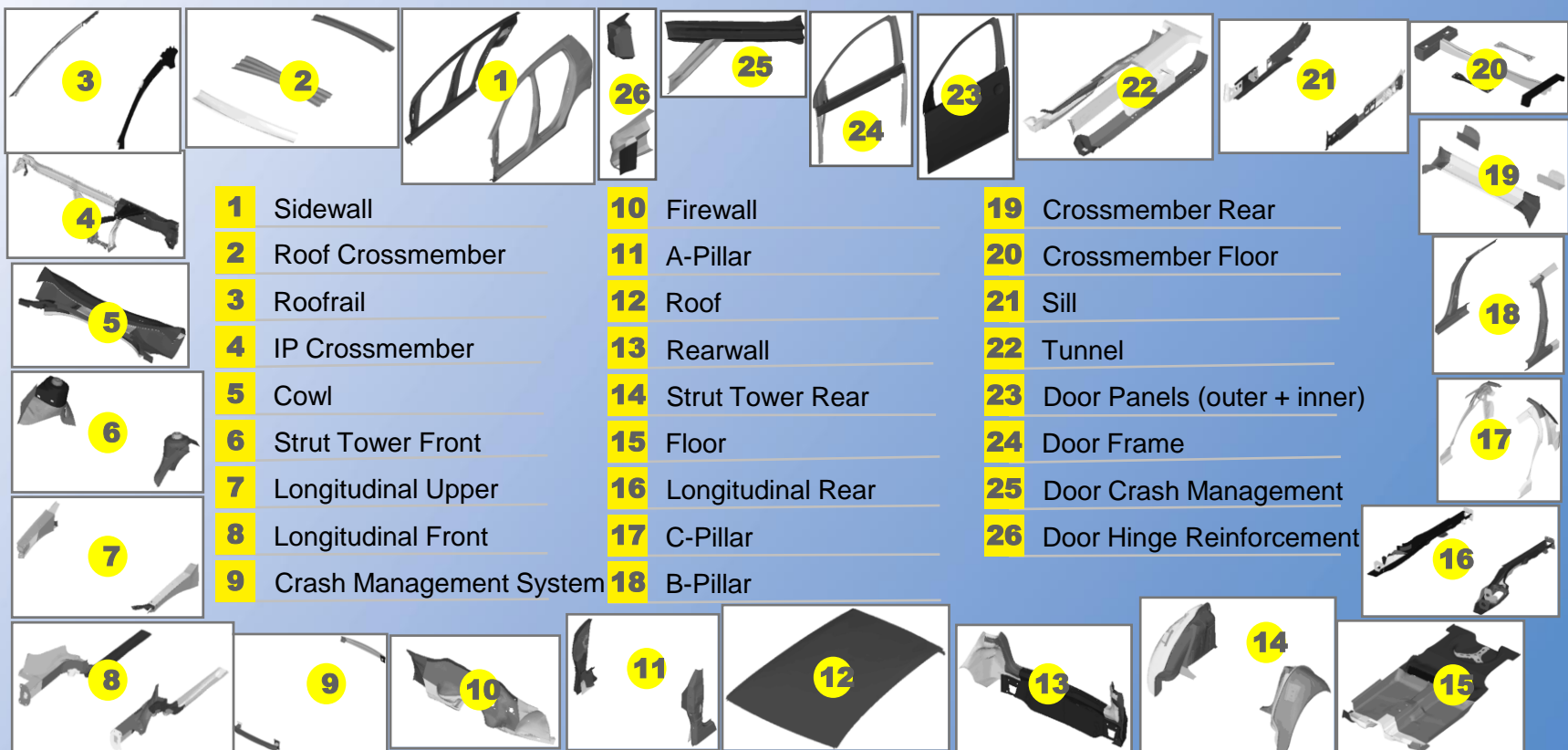


**Source: ika - University of Aachen and
the European Aluminium Association (EAA)**

Lightweight Potential of Aluminum vs. High-Strength Steel

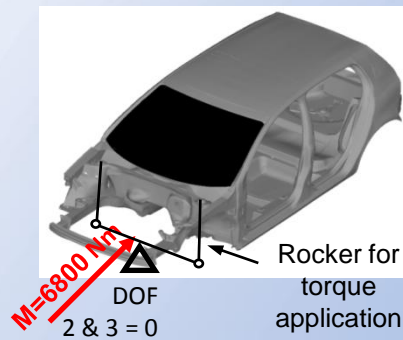
- Objective
 - Determine maximum weight saving potential of steel and aluminum in automotive
 - No Safety compromise
 - No NVH compromise

26 Components for Quantitative Evaluation



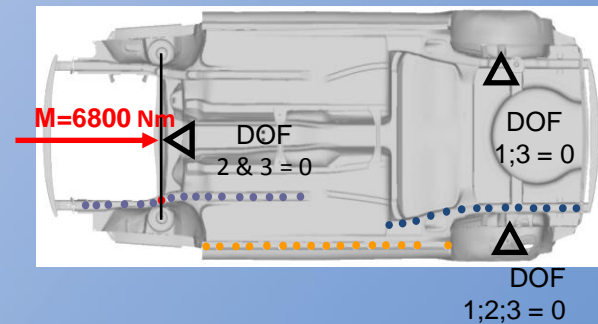
Stiffness Load Cases (NVH)

Static Torsional Stiffness

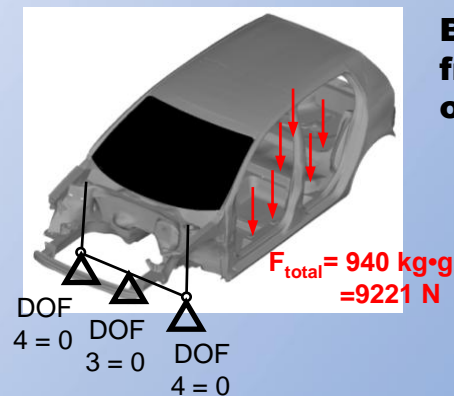


Torsional stiffness
from deflection of
evaluation
point on front
longitudinal

Bottom

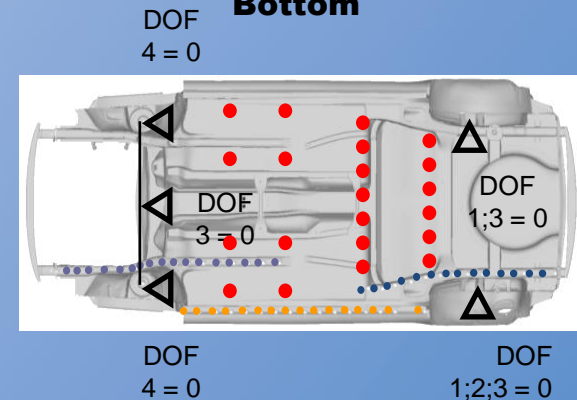


Static Bending Stiffness



Bending stiffness
from maximum deflection
of bending

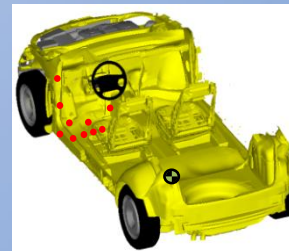
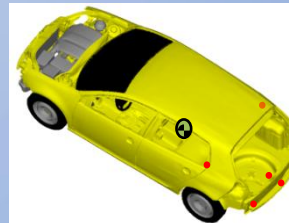
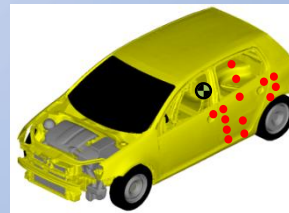
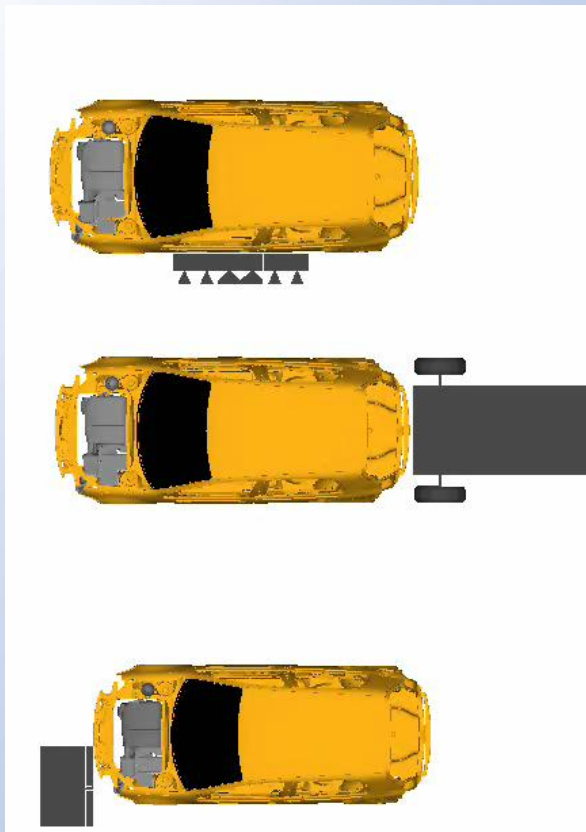
Bottom



- Load/force application
- Deflection measured
- Deflection measured
- Deflection measured

Strength Load Cases (Safety)

Evaluated Using European and U.S. Crash Standards



Euro NCAP Side Crash

- Velocity 50 km/hr
- EEVC moving deformable barrier

FMVSS 301 Rear Crash

- Velocity 48 km/h
- Rigid moving barrier
- 0% offset

Euro NCAP Front Crash

- Velocity 64 km/h
- EEVC deformable barrier
- 40% offset

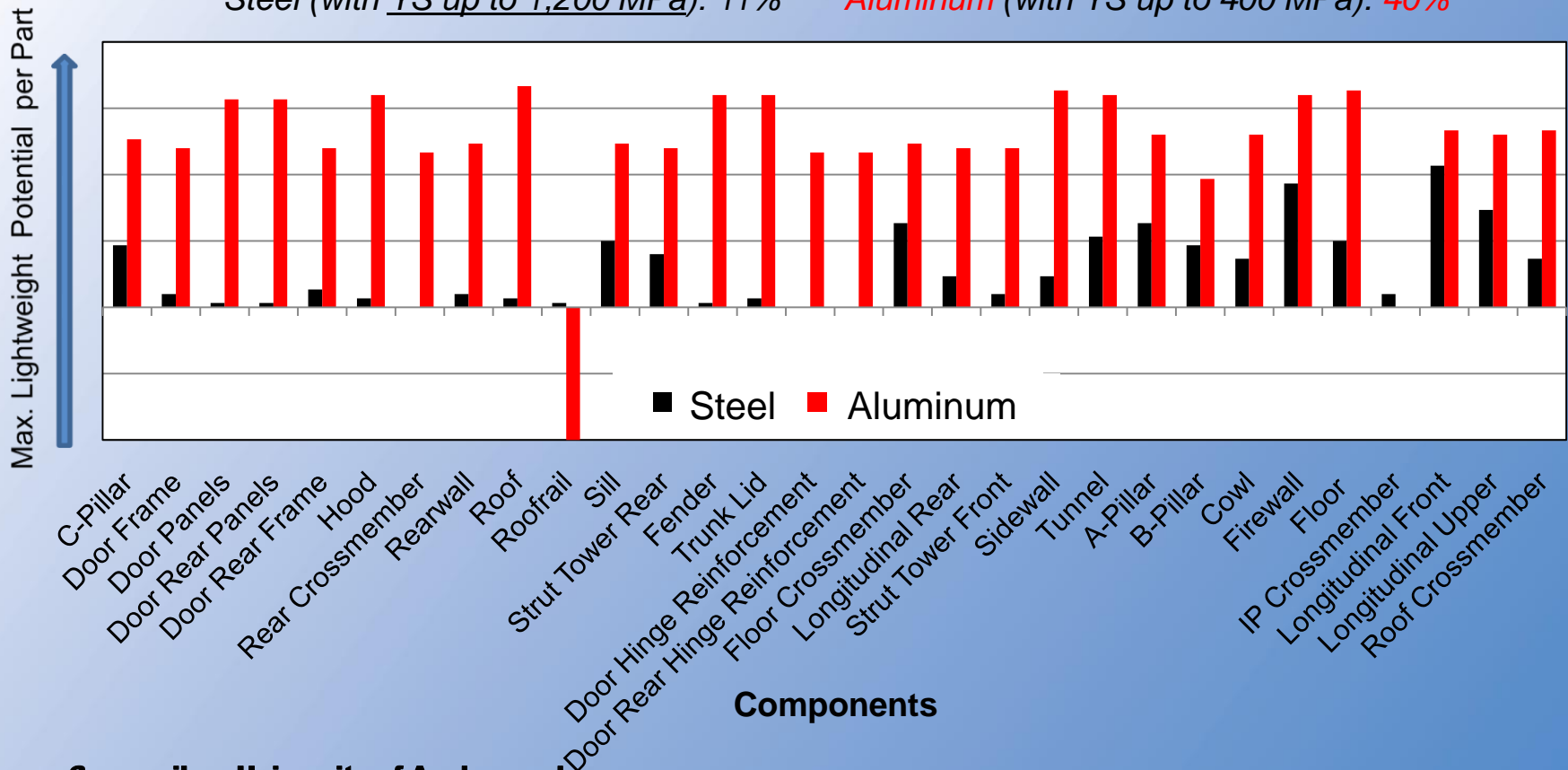
 Acceleration Evaluation Point

 Intrusion Evaluation Point

BIW Lightweighting Potential

Total maximum weight reduction compared to reference car:

Steel (with YS up to 1,200 MPa): 11% Aluminum (with YS up to 400 MPa): 40%



Source: ika - University of Aachen and European Aluminium Association (EAA)

Weight Reduction Can Be Safe

Key Findings:

For most components strength not the limiting factor for conversion to aluminum

Significant weight reduction achievable without compromise on safety

Weight reduction potential (BIW and closures)

- High-strength steel (with YS up to 1,200 MPa) = **~11%**
- Aluminum (with YS up to 400 MPa) = **~40%**

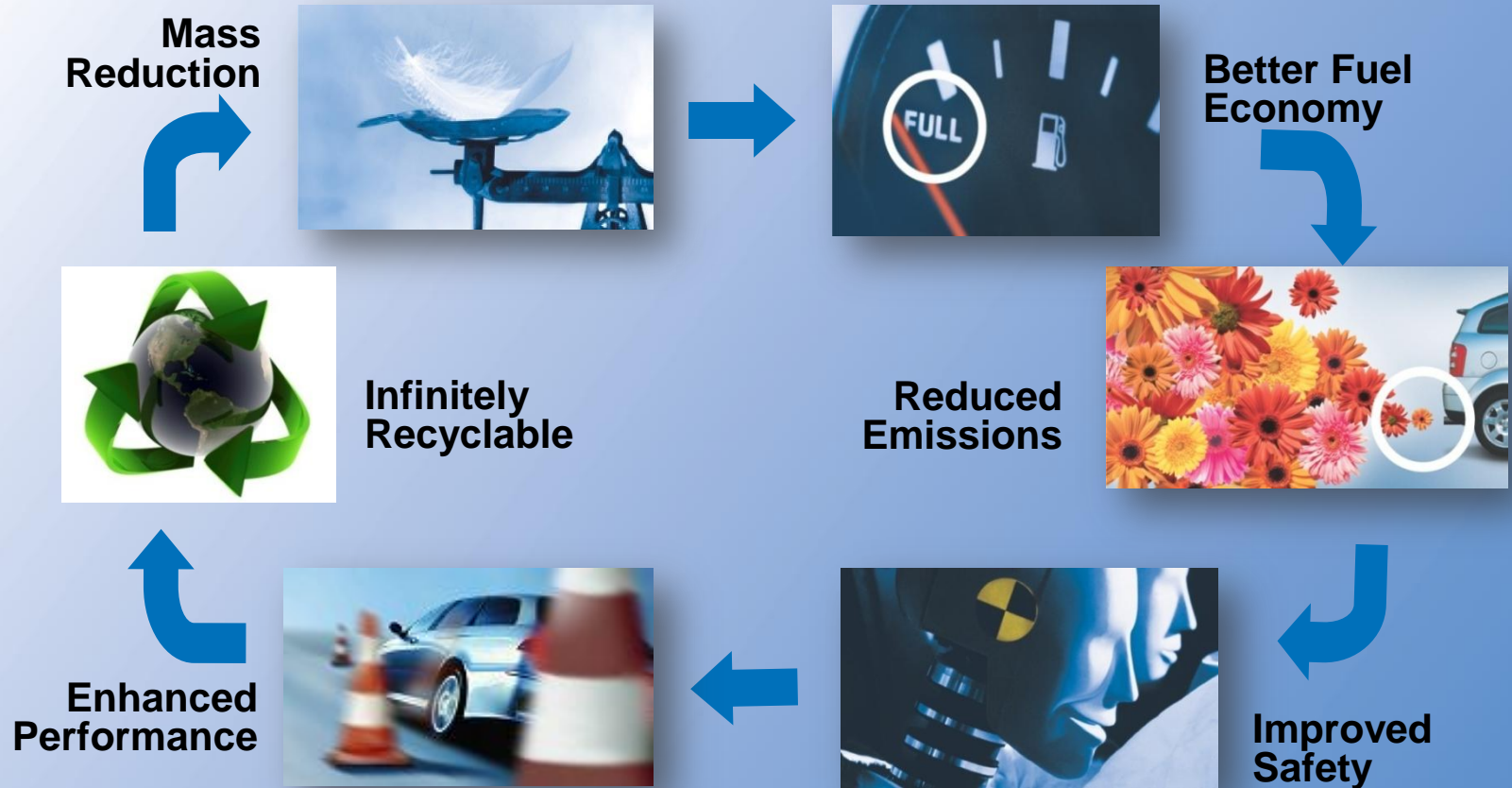
Full study available at EAA website:

<http://www.eaa.net/en/applications/automotive/studies/>

Automotive Aluminum Weight Reduction Facts

- Weight reduction **critical** to achieving 2025 objectives
 - Safety
 - Fuel economy
 - Emissions
- Proven aluminum components can achieve:
 - **15%** weight reduction (total vehicle)
 - **10% MPG** improvement (MPG)
- Weight reduction **additive** to other fuel economy improvements
 - Including: Diesel, Hybrid, Electric, Aero, Tires, etc.
- Weight Reduction **enhances fleet safety**
- Weight reduction with aluminum **cost competitive** with other fuel economy technologies

--- Thank You ---



Aluminum Builds a Better Vehicle