Evolution of Advanced High Strength Steels in Automotive Applications

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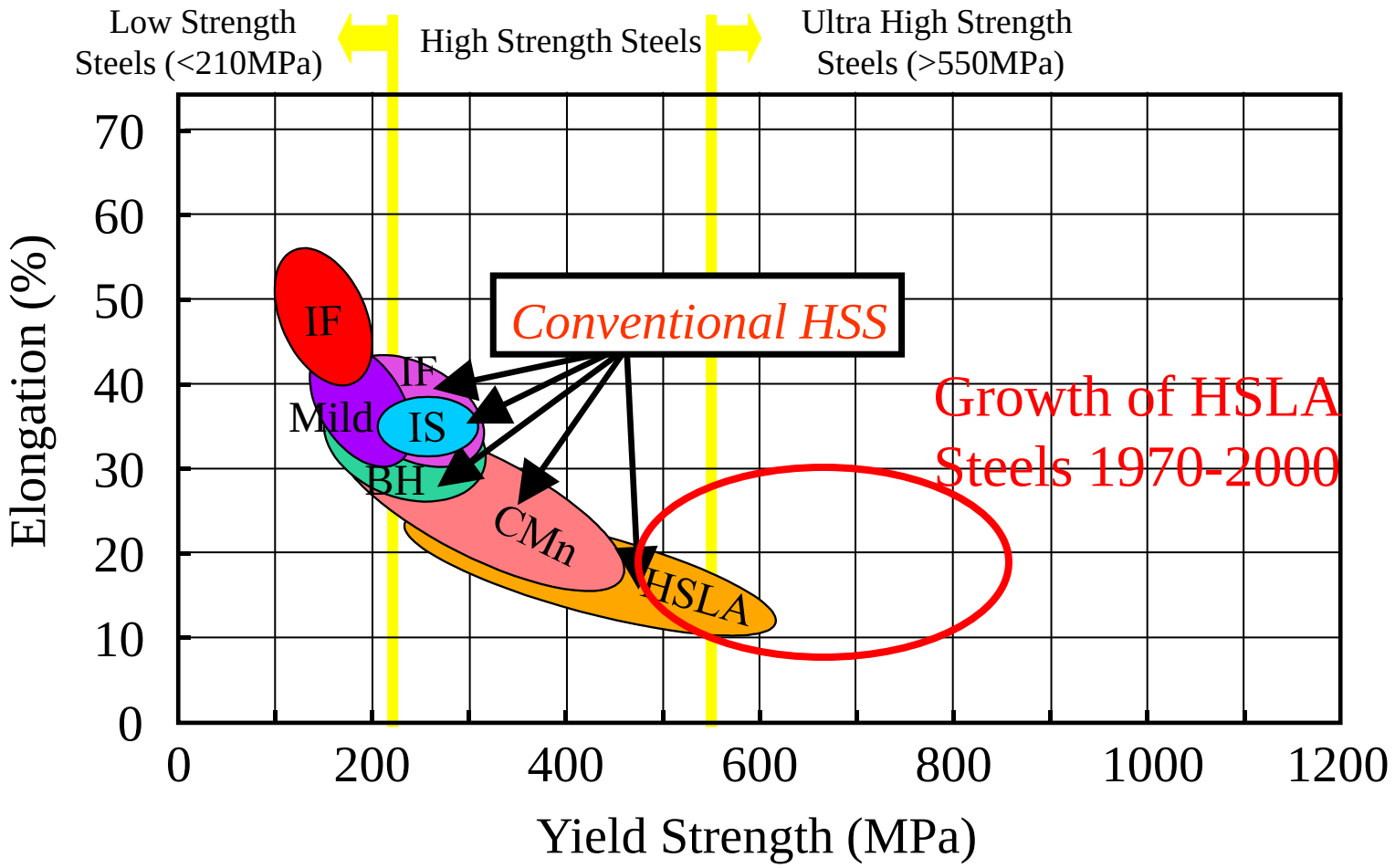
Materials Challenges – 1970's

Steel High Strength Low Alloy Technology

(Alaska Arctic Line Pipe Project, 1970s)

- Strength
- Toughness
- Weldability
- Consistency
- Low Cost

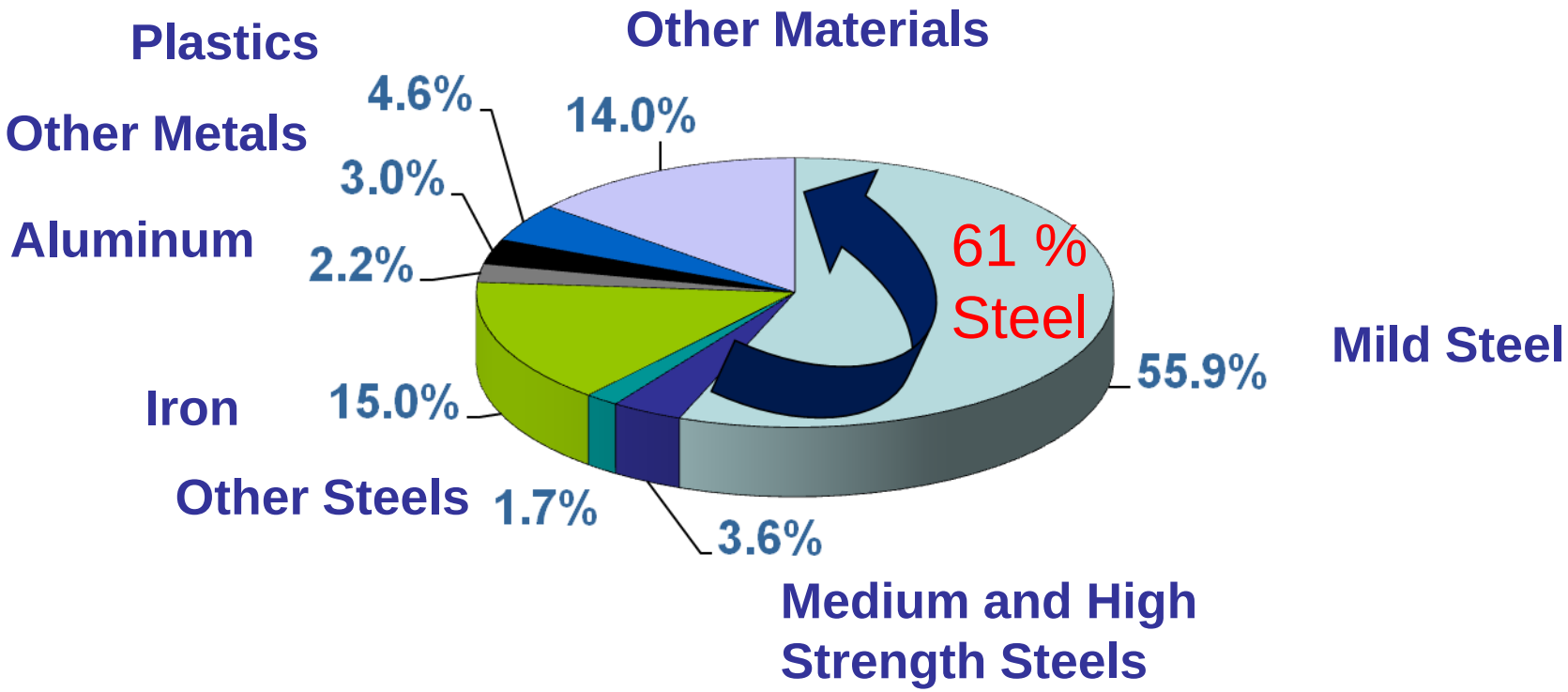
Materials Challenges – 1970-2000



Materials Content - 1975

Average 1975 Vehicle

3,900 lbs.

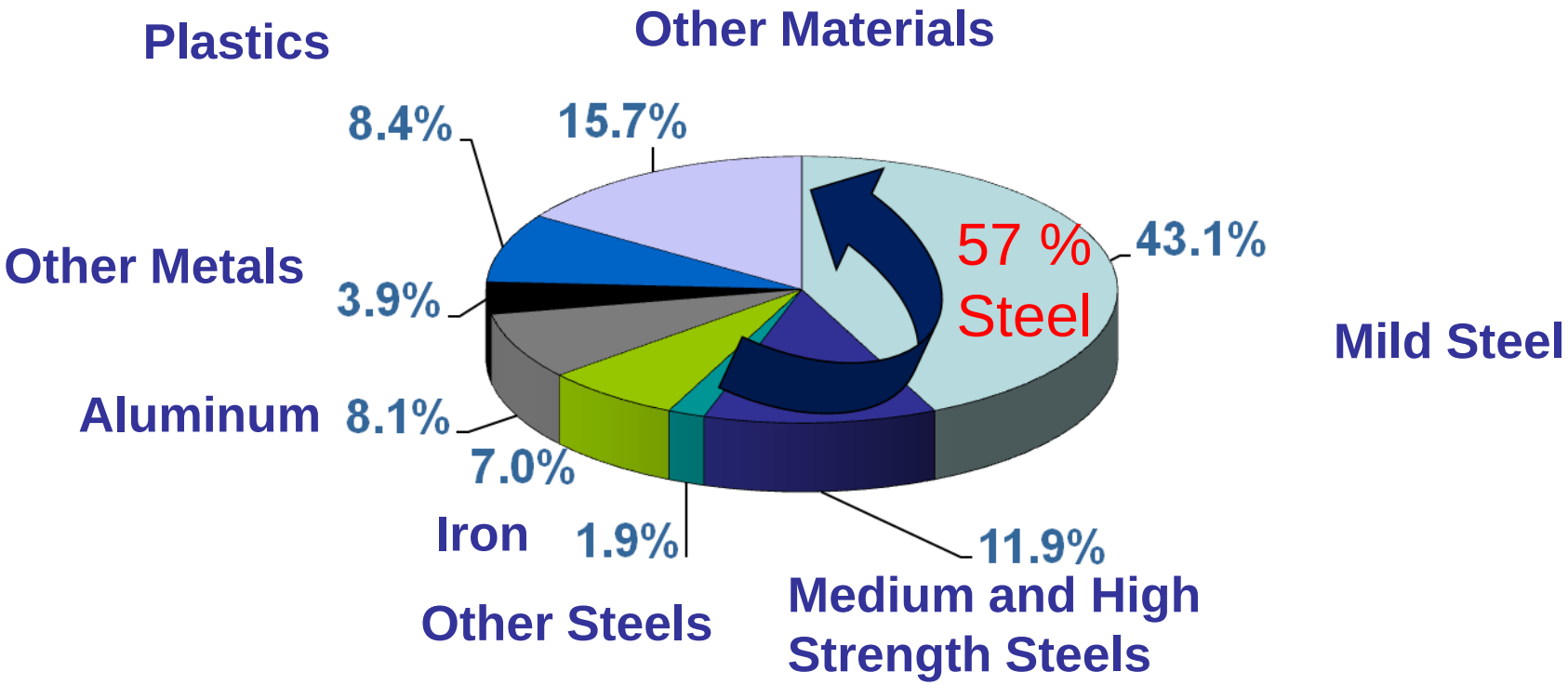


Source: Ducker Worldwide

Materials Content - 2007

Average 2007 Vehicle

4,050 lbs.



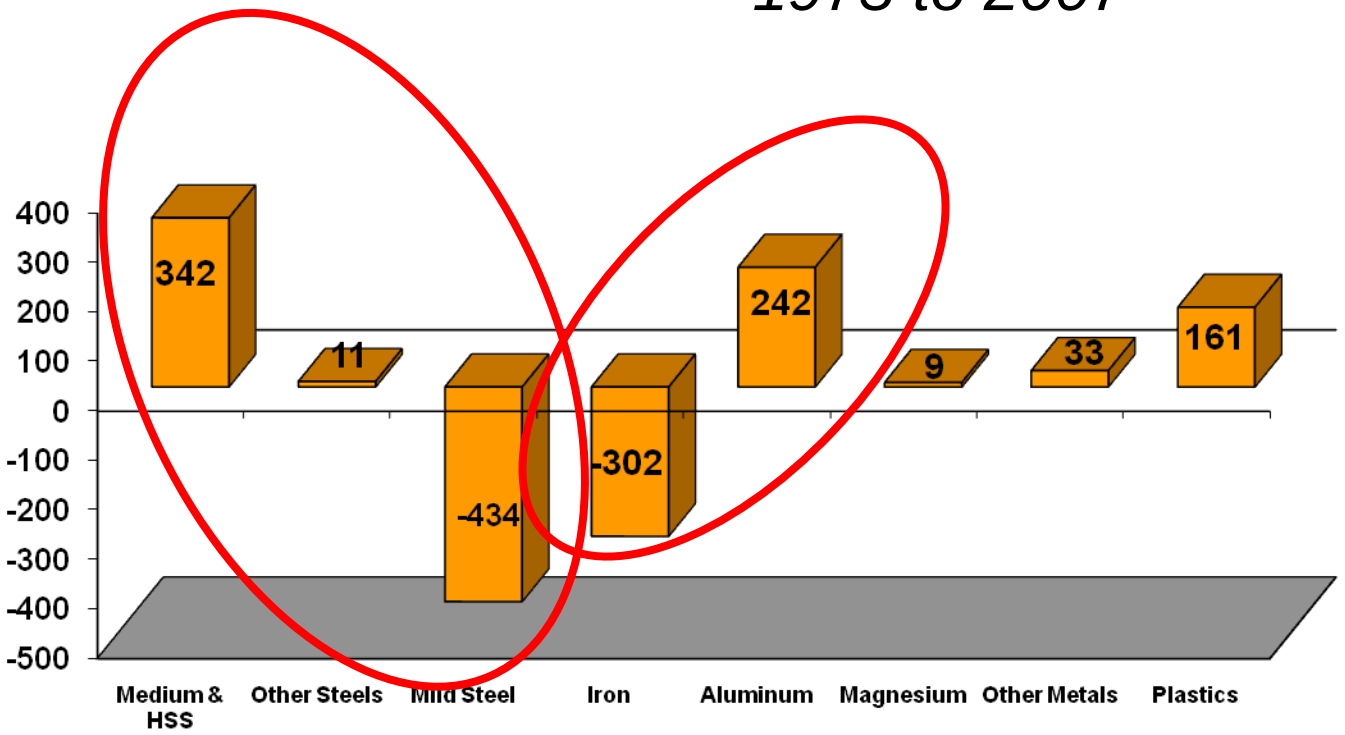
Source: Ducker Worldwide

Materials Trends in Recent History

Changes in Material Content

Pounds Per Vehicle Increases

- 1975 to 2007 -

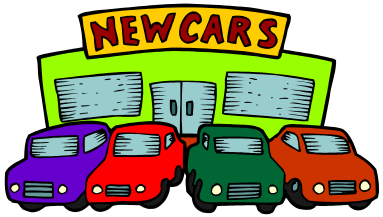


Pounds Per Vehicle Decreases

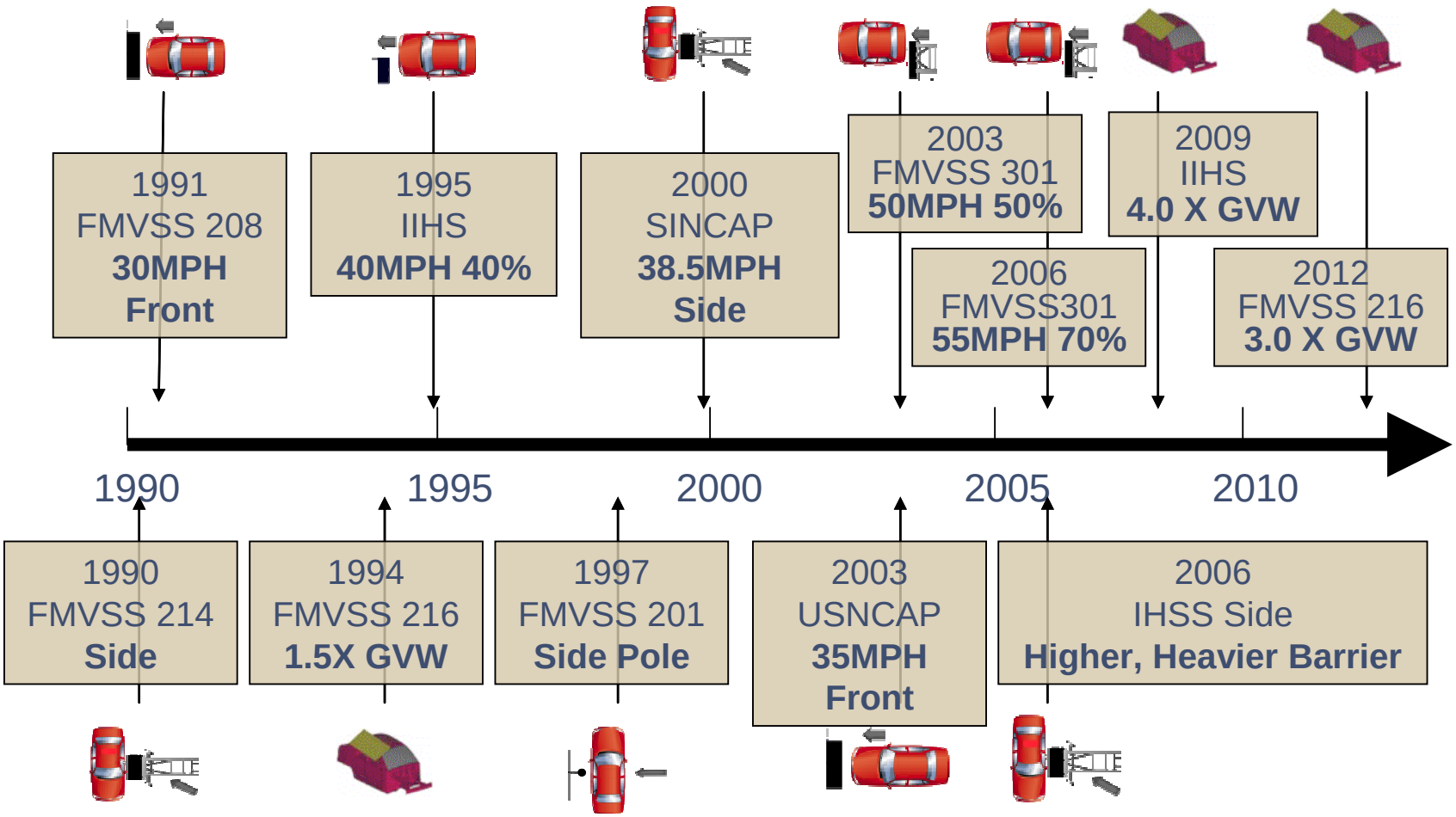
Materials Challenges – Today

Factors Influencing Material Selection

Zero Defects

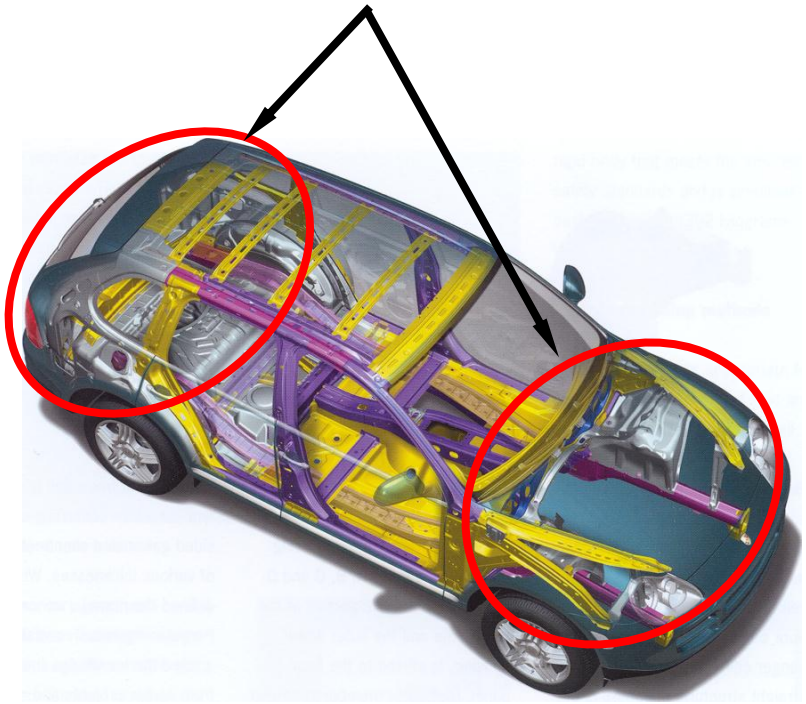


Increasing Safety Regulations

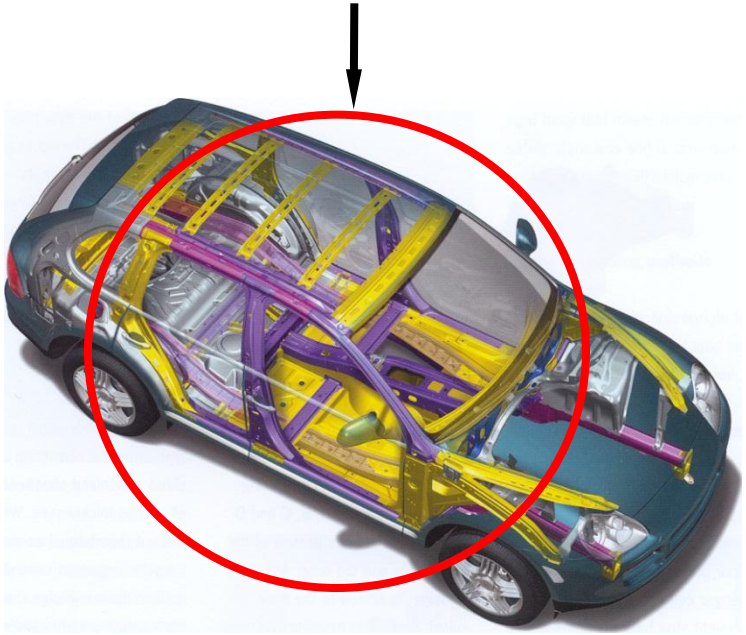


Crashworthiness Fundamentals – Two Key Zones

Energy Management Zones
(engine compartment, trunk)
deform to absorb energy



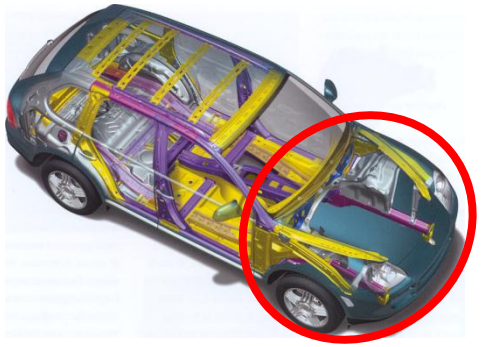
Passenger Compartment resists
deformation to prevent intrusion

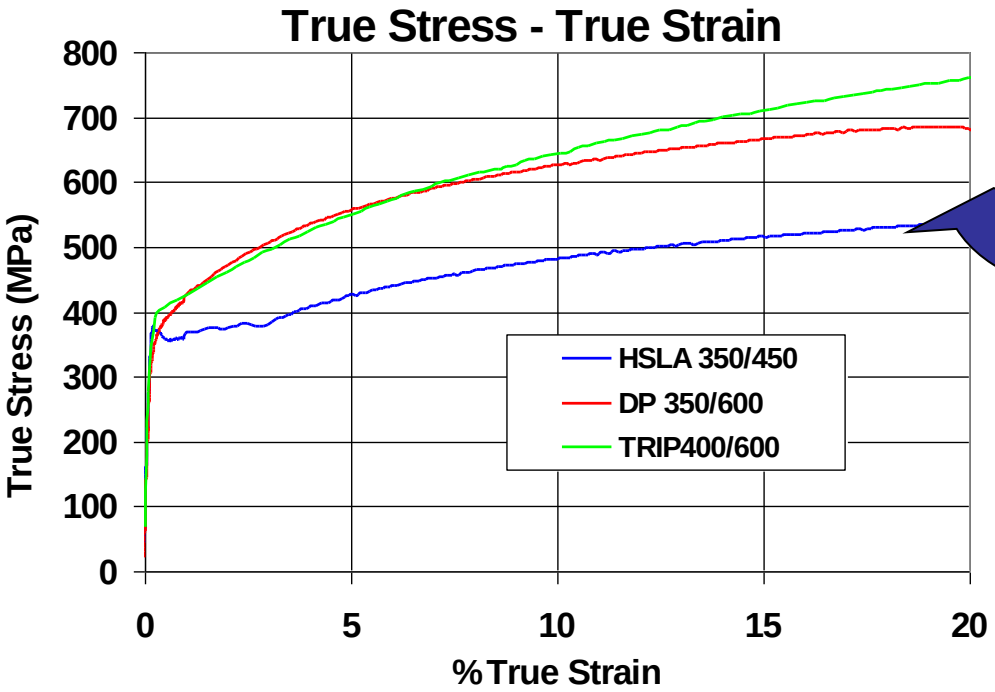


Safety

Steels for Energy Management Zone

- Highest Energy Absorbing
- Strength AND Ductility
- Dual Phase and TRIP Grades Preferred



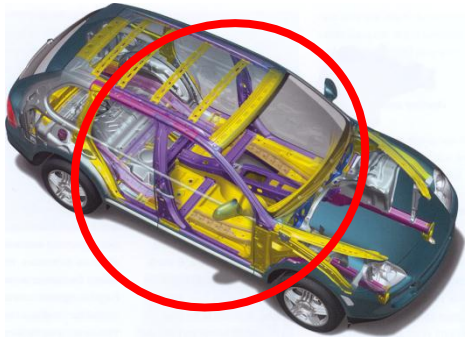


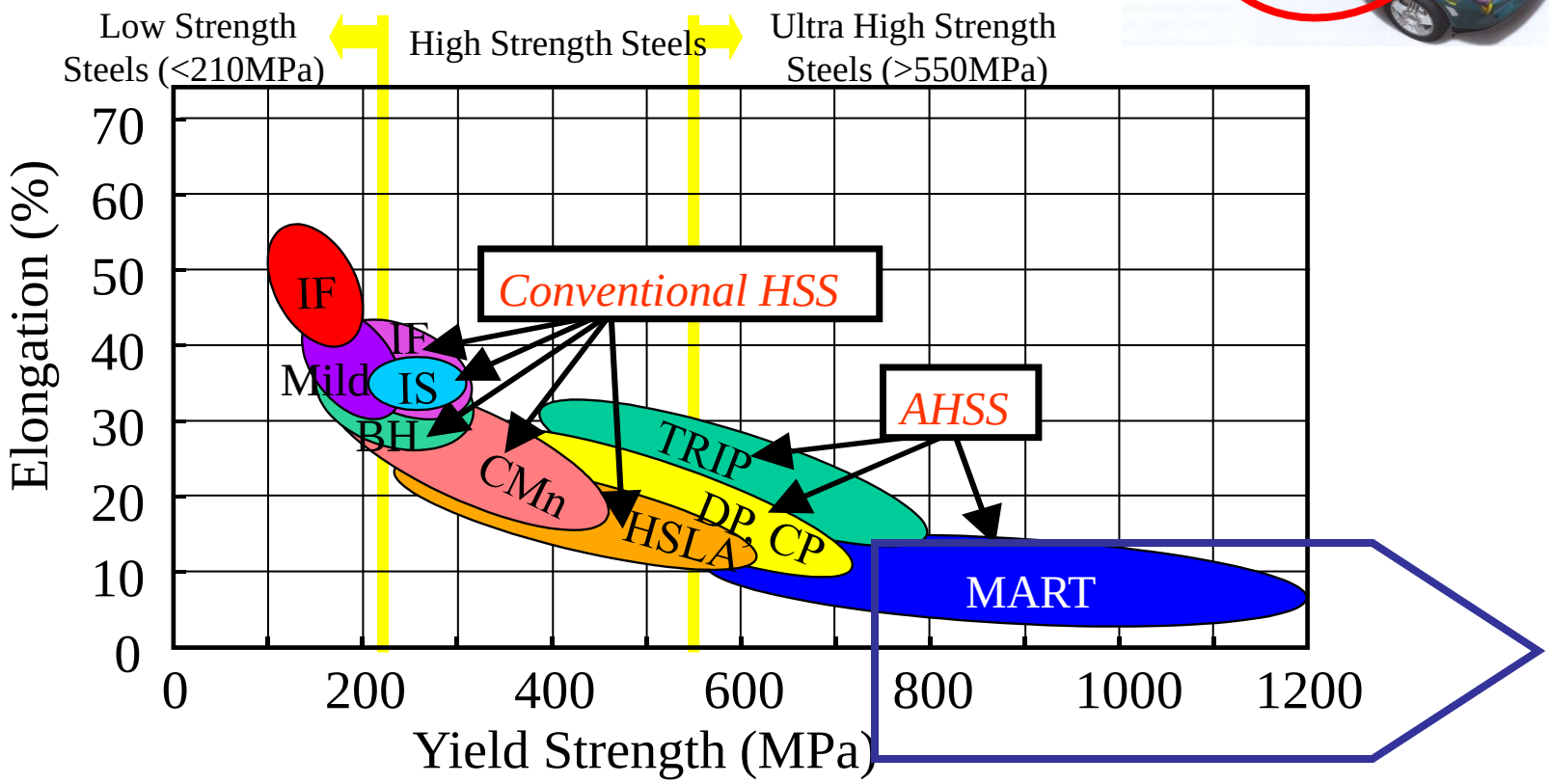
Dual Phase and TRIP are Higher Energy Absorbing Grades

Safety

Steels for Passenger Compartment Zone

- Highest Strength
- Martensite, and Boron Steels Preferred





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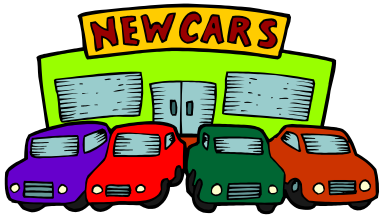


History of Mass Reduction

A Series of Global Vehicle Engineering Studies

ULSAB-AVC (2002)

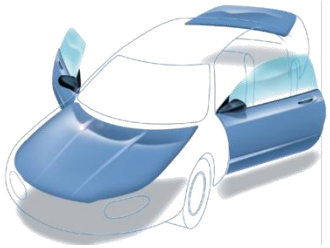
UltraLight Steel Auto Body -Advanced Vehicle Concept

- 25% mass reduction*
- Improved crash performance
- At no additional cost

ULSAS (2001)

UltraLight Steel Auto Suspensions

- 25% - 34% mass reduction*
- At no additional cost



ULSAC (2001)

UltraLight Steel Auto Closures

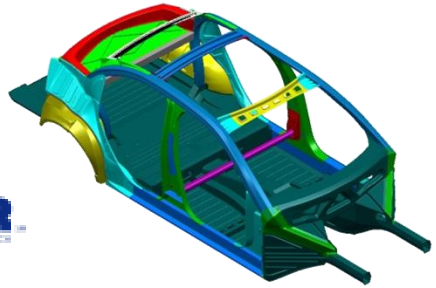
- 25% - 30% mass reduction*
- At no additional cost

* Mass Reductions versus PNGV Mild Steel Benchmark Vehicle

Source: WorldAutoSteel

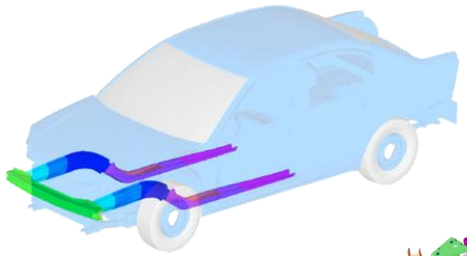
History of Mass Reduction

Domestic (Auto/Steel Partnership) DOE-Funded Engineering Projects 22% to 32% Weight Reduction, 2002-2009

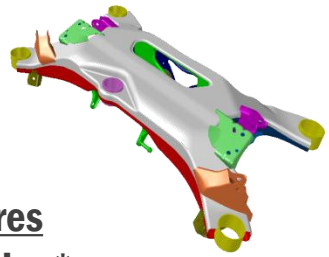


Future Generation Passenger Compartment
- 30% mass reduction *
- Improved crash performance
- At no additional cost

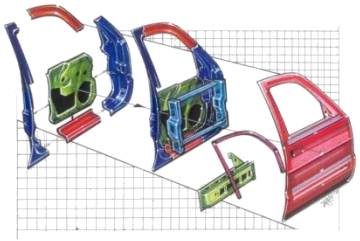
FreedomCAR Goals
50% mass reduction
same cost



Lightweight Front-End Structures
- 32% mass reduction *
- At no additional cost



Lightweight Rear Chassis
- 24% mass reduction*
- At no additional cost



Lightweight Closures
- 22% mass reduction*
- At no additional cost

* Mass Reductions versus actual OEM donor vehicles

Conflicting Direction for Mass & Government Regulations

Safety

- Higher strength / Heavier gauges

Conflicting Direction for Mass & Government Regulations

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- Higher strength / Heavier gauges

Fuel Economy / CO_2 Emissions

- Lower weight / Lighter gauges

Conflicting Direction for Mass & Government Regulations

Safety

- Higher strength / Heavier gauges

Fuel Economy / CO_2 Emissions

- Lower weight / Lighter gauges

Conflict between Safety & Fuel Economy / CO_2 Emissions

Need for Collaboration

- Many factors led to the development of the Auto/Steel Partnership and continue today:
  - CAFE regulations
  - Need for better grades of steel
  - Need for better stamping processes
  - Migration to higher cost, alternate body materials (not steel)
  - Need for uniformity/gauge tolerance too high/variation in yield strength of HSS/corrosion/formability

Auto/Steel Partnership – Decade of Development

1987 - Enabling Work at A/SP - 1999

1987
Auto/Steel Partnership Formed

1993
Initiated Tech Transfer Process

Weld Quality Endurance Test Procedure

Early 1990s
Focus on Uniform Stamping Processes
Focus on Uniform HSS
Focus on Uniform Coating Weights
Mass Targets

1996
Strain Rate

Adhesive Bonding

Light Truck Frame

Hydroforming

Body Systems Analysis

1997
Dent Resistance Procedure

Resistant Spotwelds on Galvanealed Steels

Lightweight Body Guidelines

Uniformity of HSS v. 2

Tailor Welded Blank Guidelines

1998
Fatigue Deliverables

Strain Rate Deliverables

SAE Corrosion Test Methods

1999
Kick off of Light-Weight Initiatives

Auto/Steel Partnership - Decade of Implementation

2000 - Enabling Work at A/SP - 2011

2000
Functional Build

Measurement System

2001
Light Truck Frame Joint Stiffness Study

2002
Enhanced Forming Limits

2004
Lightweight Front End Structures Phases I & II

2005
Assessing Weldability of Projection Welding

Fasteners to AHSS Using FEA

2006
Future Generation Passenger Compartment Phase 1

An Investigation of Resistance Welding Performance of AHSS

2007
Mass Efficient Architecture for Roof Strength

Temperature Effect on Impact Performance AHSS Welds

2008
Joint Efficiency and Weld Repair

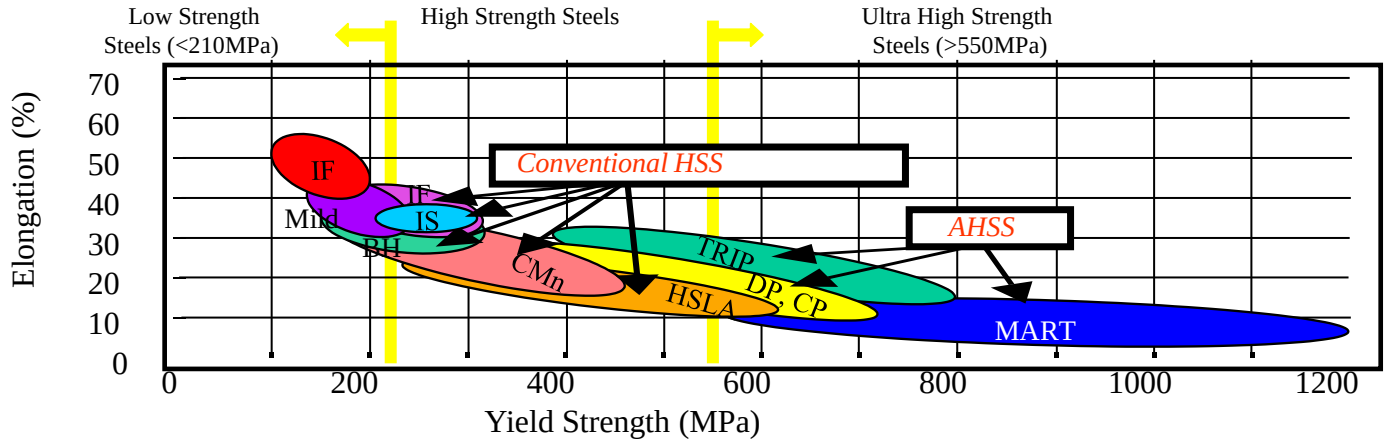
Characterization of Mechanically Sheared Edges of Dual Phase Steels

2009
Fracture Analysis of AHSS During Draw-Bending

2010
Liquid Metal Embrittlement and Hot Cracking Sensitivity of AHSS

Skid Line Simulation for Sheet Metal Surface Quality Analysis

2000 – Enabling AHSS Development - 2011



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2000 – Automotive Product Applications - 2011







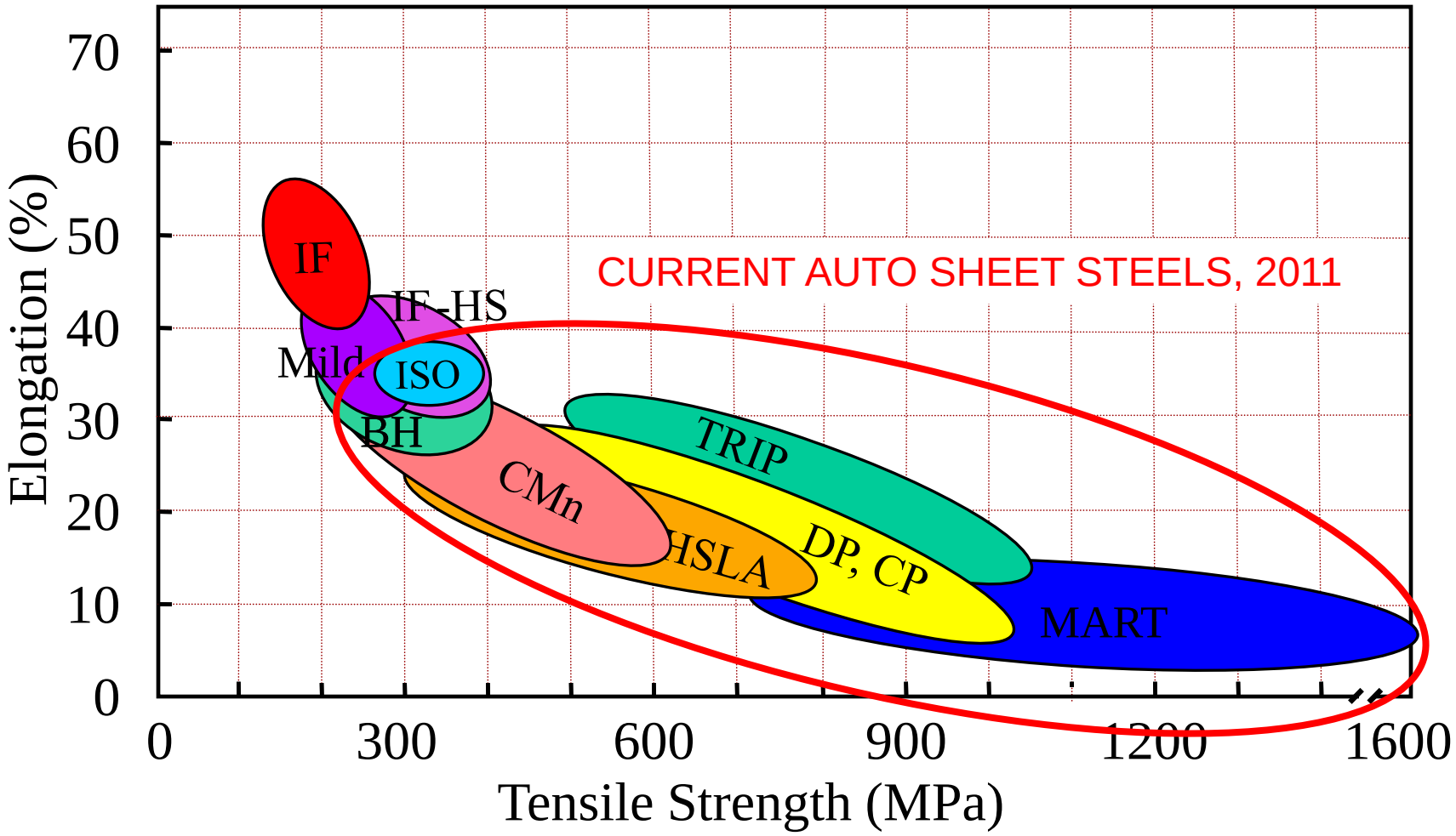


Mass Reduction Lessons Learned

<u>What We have Learned in 10 years of Lightweighting Work</u>

- AHSS grades can reduce mass and lower the carbon footprint for vehicles at low cost.
- Topology and load path optimization tools enable lower mass solutions for all materials, but take great advantage of the wide range of steel grades.
- Component substitution of AHSS yields less mass savings than holistic/system approaches.
- We must keep re-inventing steel to help satisfy increasing safety regulations, mass reduction and fuel economy targets.

HSS and AHSS for Mass Reduction



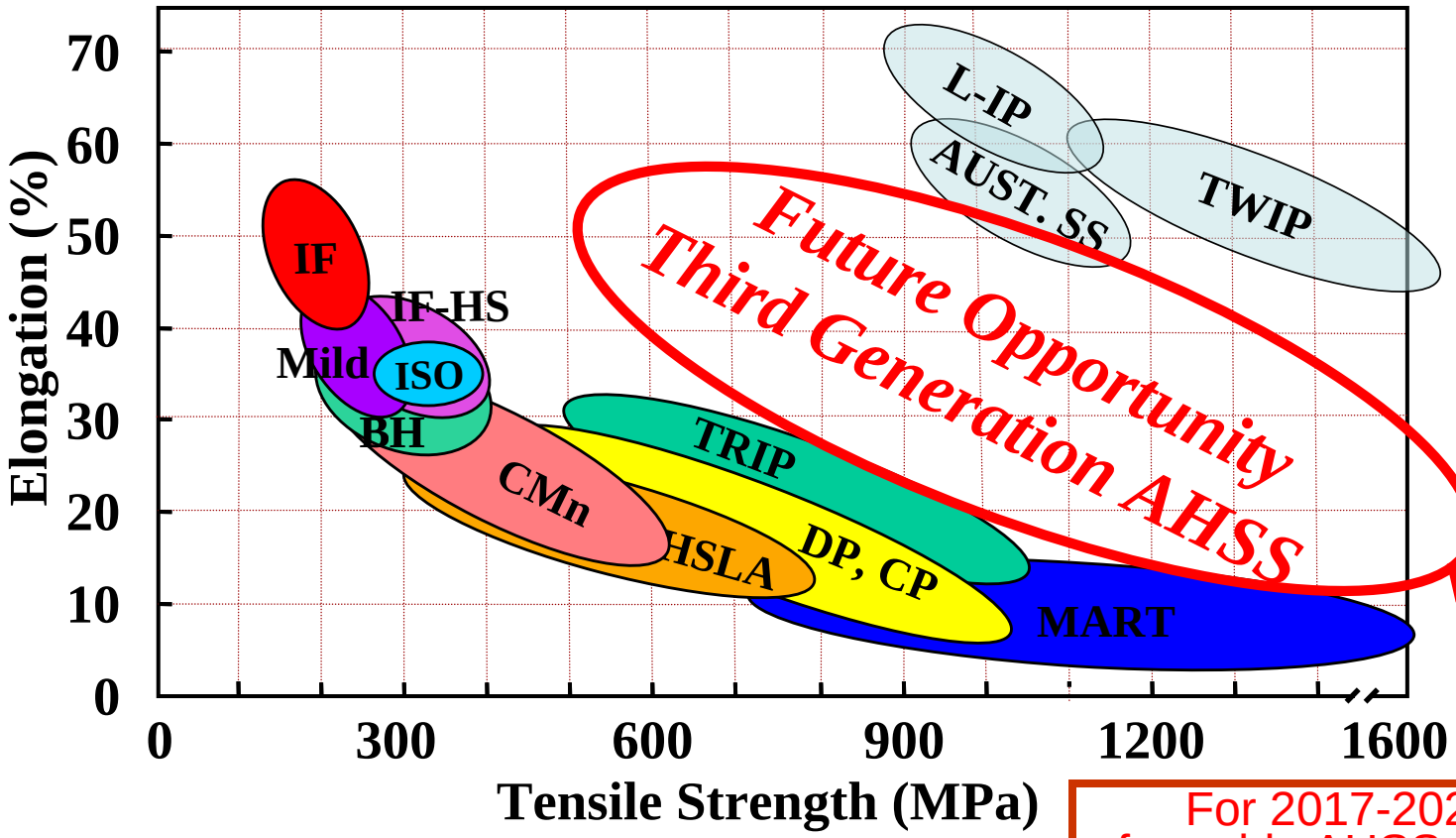
Future Vehicles and Expectations

Factors Influencing
Material Selection

Zero Defects

3rd Generation of AHSS

...we are researching a new generation of steels for the future.



For 2017-2025, new formable AHSS grades will enable more steel mass reduction

Conclusions

- AHSS content continues to grow resulting in stronger, lower-mass vehicles, without significant cost penalties.
- Mass reduction improves fuel economy and enables reduced powertrain size.
- 3rd Generation AHSS grades are being researched and will create additional mass reduction potential for steel.
- The Auto/Steel Partnership has contributed enabling technical programs that have resulted in the efficient and effective use of AHSS in automotive applications.
- The Auto/Steel Partnership provides the forum for successful pre-competitive collaboration work that brings technical solutions to the market; lighter, safer, and environmentally responsible.

Thank You

QUESTIONS?