Innovation in the Supply Chain

Lessons from the Automotive News PACE Competition

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Gerpisa International Colloquium

Paris, June 2015 | Update of Nov 2018

Key questions

- What drives change?
  - Push = technology dynamic
  - Pull = market forces
- How manage in complex industry?
  - Change must be coordinated across levels
  - Roadmaps (originated in semiconductor industry)
- Strategies for success
  - Will do case study of Gentex later this term

Approach

- Study of an innovation competition
  - Automotive News PACE Awards
- Study of a family of innovations
  - Federal Mogul pistons
    - *Acquired 2018 by Tenneco from private equity holding by T Boone Pickett, who held through lengthy Ch 11*

What is PACE?

Global Suppliers Move to the Fore

- 25 yrs of PACE award for supplier innovation
- innovation now core to supplier strategy
    - suppliers global
    - 2-3 suppliers for many major components
- Drivers and Enablers
    - 3 drivers: emissions, safety, efficiency
    - 2 enablers: materials science, sensors/software
- “Technology Roadmaps”
    - coordinating mechanism

PACE Competition

- Supplier upheaval 1980s: new entrants in US
  - 300 European plants, 300 Japanese plants
- Begun 1994 (awards given spring 1995)
  - 25th Awards April 2019
  - Timing: Global Society of Automotive Engineers conference
- Sponsored by Automotive News (and others)
  - Initial sponsor E&Y believed management competitions were a good marketing tool, paid most of the costs
- Firms must self-select and apply
  - a modest fee (was $1,999) discourages frivolous applications

Award Criteria

- Have we seen it before?
  - how innovative?
  - supplier as innovator?
- Commercialized?
  - recent: SOP within current model cycle
- Changed the name of the game?
  - wide uptake?
  - big cost reduction?
  - rivals forced to respond?

Competition Process

- Initial (paper) screening of applications
  - Finalists announced Oct SAE Global Leadership Conference
- Each finalist visited by two judges
  - all day presentation of innovation and business case
- Each finalist vetted with customer references
  - customers see competitor technologies
  - customers can verify actual performance
- Academy Award style ceremony
  - sponsors not privy to results
  - entire process under non-disclosure agreements

Evolution of Competition

- It took about 4 years to gain momentum
    - analysis from 1999-2015
- First only US, then US+Europe, now global
    - can't analyze geography
    - more than half now outside NAFTA
- From 2001 divided into categories
    - reflected sponsor interest; judges ignore
- Innovation Partnership & Environmental Awards
    - for marketing of PACE by *Automotive News*

PACE Finalist 21 times

- 2000 Park Assist System
- 2004 Achieving Start-Stop with 14v Reversible Starter-Alternator
- **2005 Lane Departure Warning System winner!**
- **2006 StARS Micro-Hybrid system winner!**
- **2007 Multi-Beam Radar (MBR) Blind-Zone Radar Sensor winner!**
- **2008 Park 4U Semi-Automatic Parallel Parking winner!**
- 2009 Varnishing Process without Solvent for Headlamp Reflectors
- 2010 BeamAtic Premium ADB (Adaptive Driving Beam)
- 2011 Insulated Molded Lead Frame Technology; BeamAtic(R) Premium; Dual Direct Drive Front Wiper System
- 2012 Efficient LED low beam headlamp for electric vehicles
- **2012 VisioBlade® System winner!**
- 2013 BiLED Module, Air Intake Module with Integrated Water Charge Air Cooler (for Diesel emissions)
- **2014 Back-over Protection System winner!**
- 2014 Long Travel Damper Dual Mass Flywheel, Water-Cooled Air Conditioning Loop Condenser
- **2015 EG efficiency generator winner!**
- 2015 360Vue 3D surround view system, Dry friction facing formulation

20th Anniversary Celebration (2014)

PACE as a data source

Strengths / Weaknesses as Data

- Captures trade secrets & designs
- Focuses on significant innovations
- Suppliers both large & small
  - US / Canada, EU, Japan, Korea, Poland, Brazil...
- Not random sample
  - applicants self-select
  - Japanese suppliers under-represented?
- Large sample for qualitative analysis
  - 503 finalists and 201 awards (1999-2014)

Findings

- Range of innovation is wide
  - auto industry is today R&D-intensive
- Role of suppliers central
  - OEMs are integrators but increasingly innovation in conjunction with suppliers
- Innovation is repeatable
  - the ability to deliver innovations with each product cycle is central to supplier strategy

Roadmaps

How to manage decentralized innovation?

- Claim: “Roadmaps” are a central tool
  - provide timeline vs performance metrics
  - allow suppliers to communicate with customers
    - what they believe possible when
- Customers combine
  - highlight bottlenecks
  - adjust schedule

Roadmapping

- well-developed R&D management technique
  - track factors that affect technology demand
  - link back to specific performance metrics
  - link back to specific supplier capabilities that must be located or developed
- enabling coordinating innovation across firms
  - are roadmaps congruent across components?
  - highlight bottlenecks and timeline challenges

Federal-Mogul Examples

- 30-plus roadmaps
- share with trusted customers
- iterative process
  - legislative/regulatory trends
  - market trends

- from presentations made to Washington & Lee students at Plymouth Technical Center

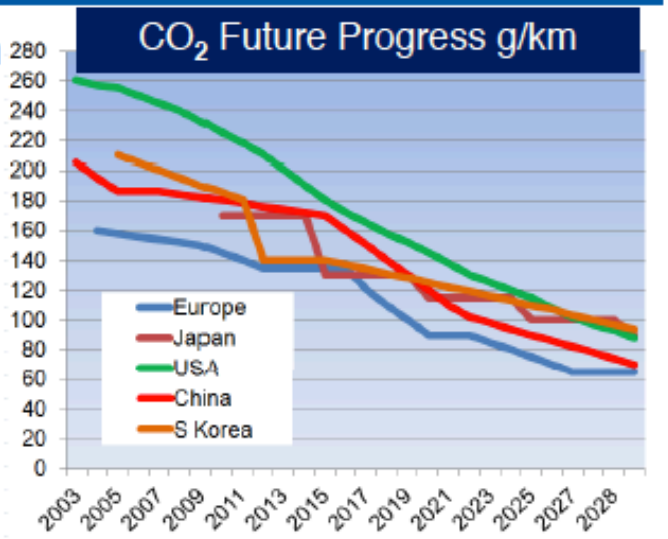
Macro Trends in Engines
The Industry Environment

Dominated by Emissions, Fuel Economy & CO_2 Reduction

CO_2: Europe 2012 130g/Km 95g/Km in 2020, with an increased focus in the USA

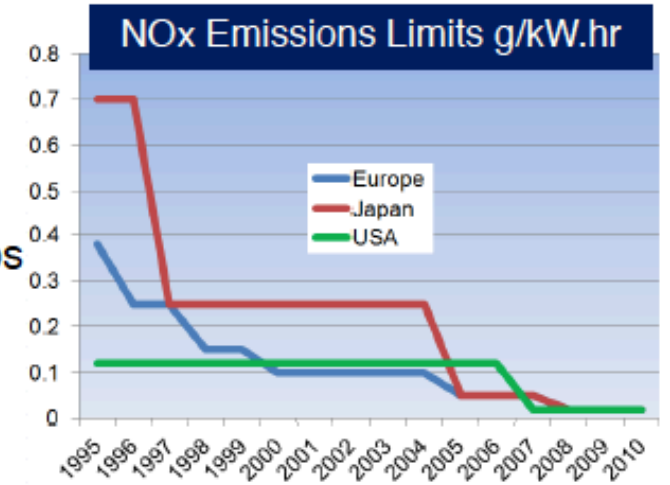
MPG: USA 2016 35.5mpg 2025 54.5mpg

Emissions: different global legislation limits and timing -
- USA - LEV (low), ZEV (zero), California Tier2 Bin5
- Europe - Euro 6, 2014
- Japan – Similar and tightening
- China, India rapidly moving to Euro 4 & 5



Engine Manufactures' Reactions?

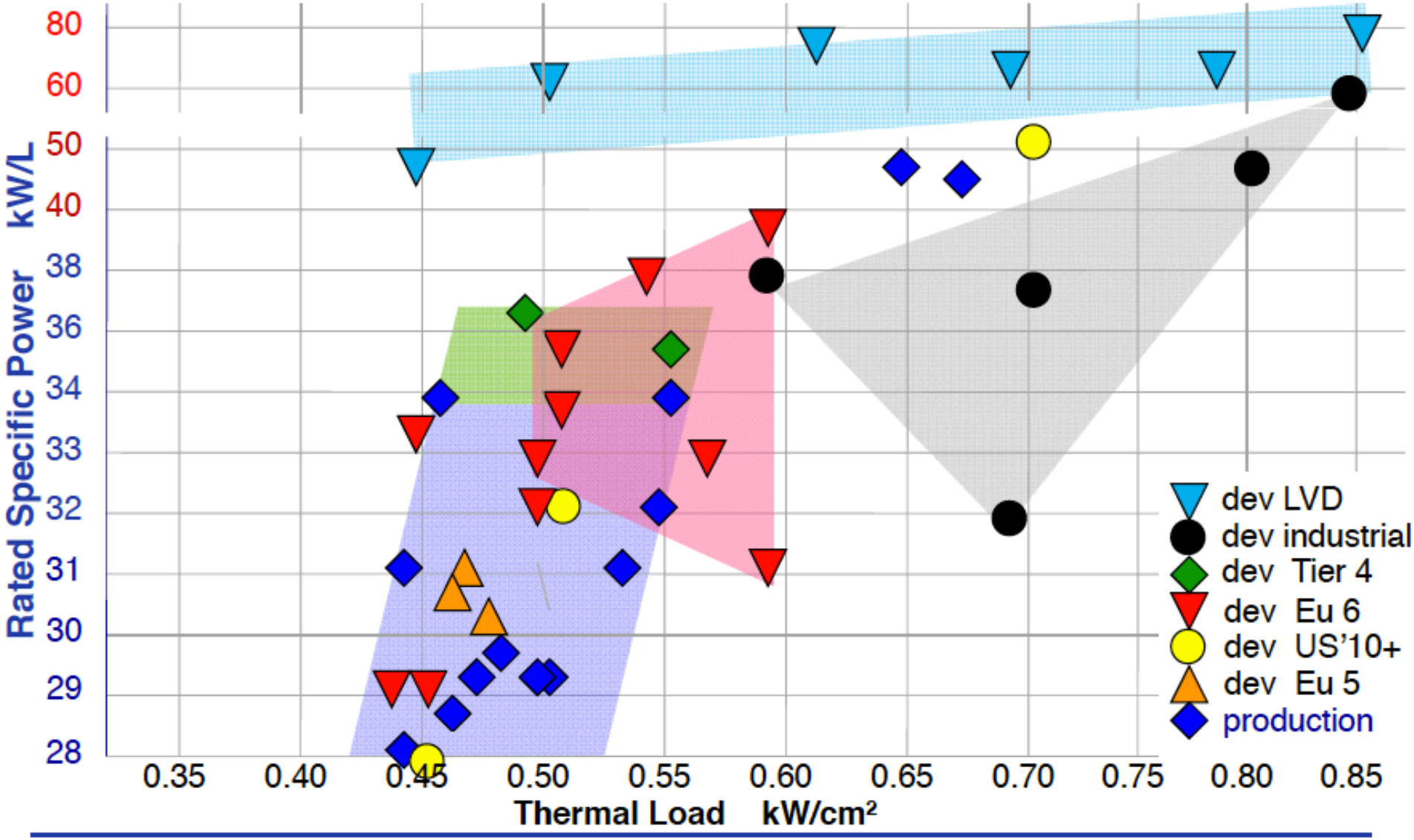
- New advanced combustion – lean, stratified charge, EGR
- Exhaust aftertreatment – catalysts, particulate filters, SCR
- Direct injection, turbochargers - 'Eco' engine downsizing
- Low friction engine components
- Reduced engine parasitic losses – smart oil & coolant pumps
- Weight reduction – vehicles, engines and components
- Alternate fuels – E85, natural gas, bio-diesel, hydrogen
- High efficiency transmissions
- Hybrids, electrics, 'start-stop'



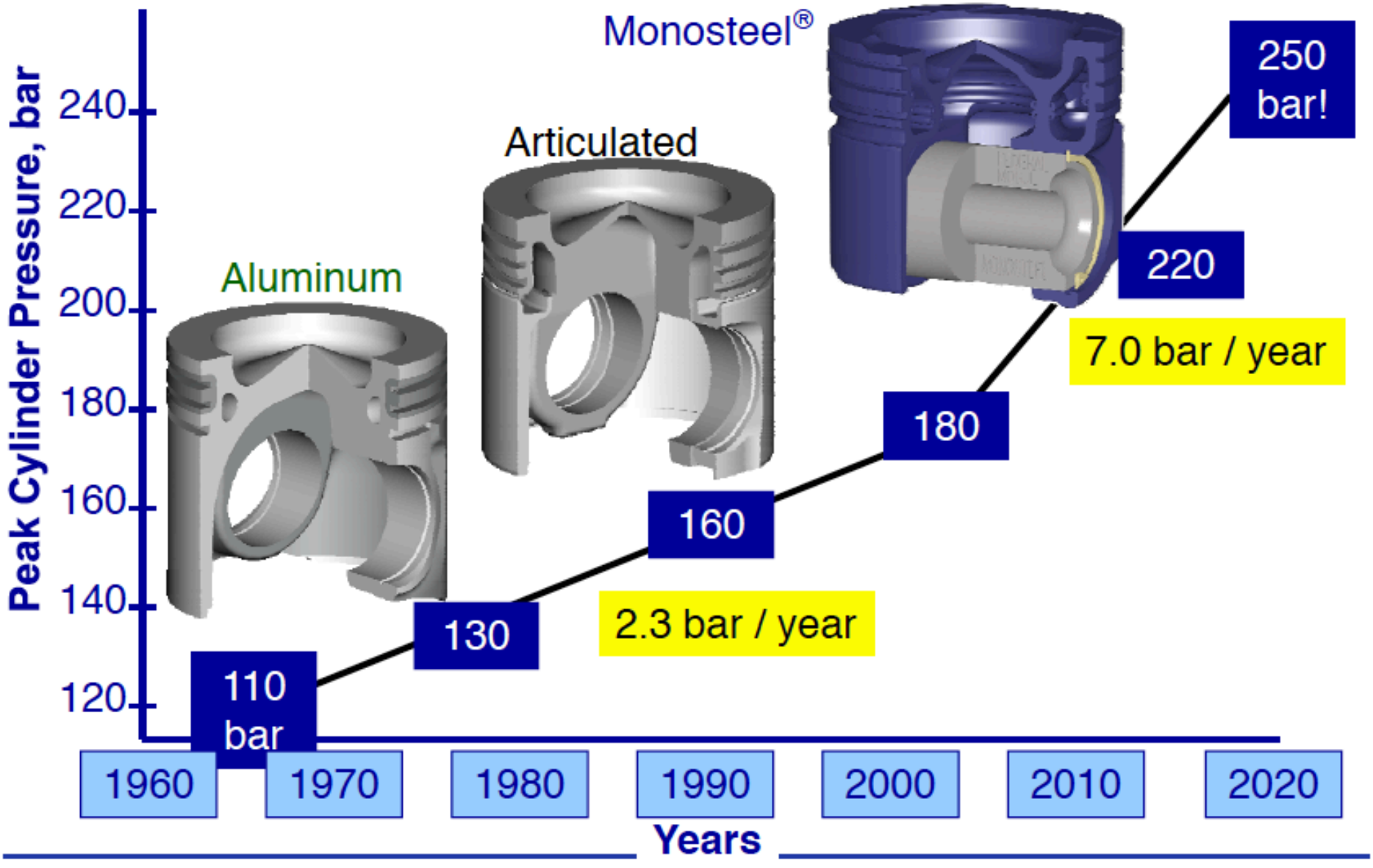
The Engine World – More Specific

	Gasoline	Diesel
Engine Technologies	Friction reduction Weight reduction Direct injection Stratified charge Turbocharging Lean dilute combustion EGR Downsizing VVA Variable flow oil pump Variable water pump	Friction reduction Weight reduction Downsizing Advanced Turbocharging Supercharging High pressure injection Multiple injections High EGR rates Temperature management Waste heat recovery NOx aftertreatment DPF particulate filter SCR selective catalytic reduction Variable flow pumps
Alternate Fuels	Bio fuels 1 gen Ethanol (E85 – E70) Bio fuels 2 gen - BTL	Bio fuels 1 gen Biodiesel (B10-B30-B100) Bio fuels 2 gen - BTL
Related Technologies	Hybrid Electrics Stop/start	

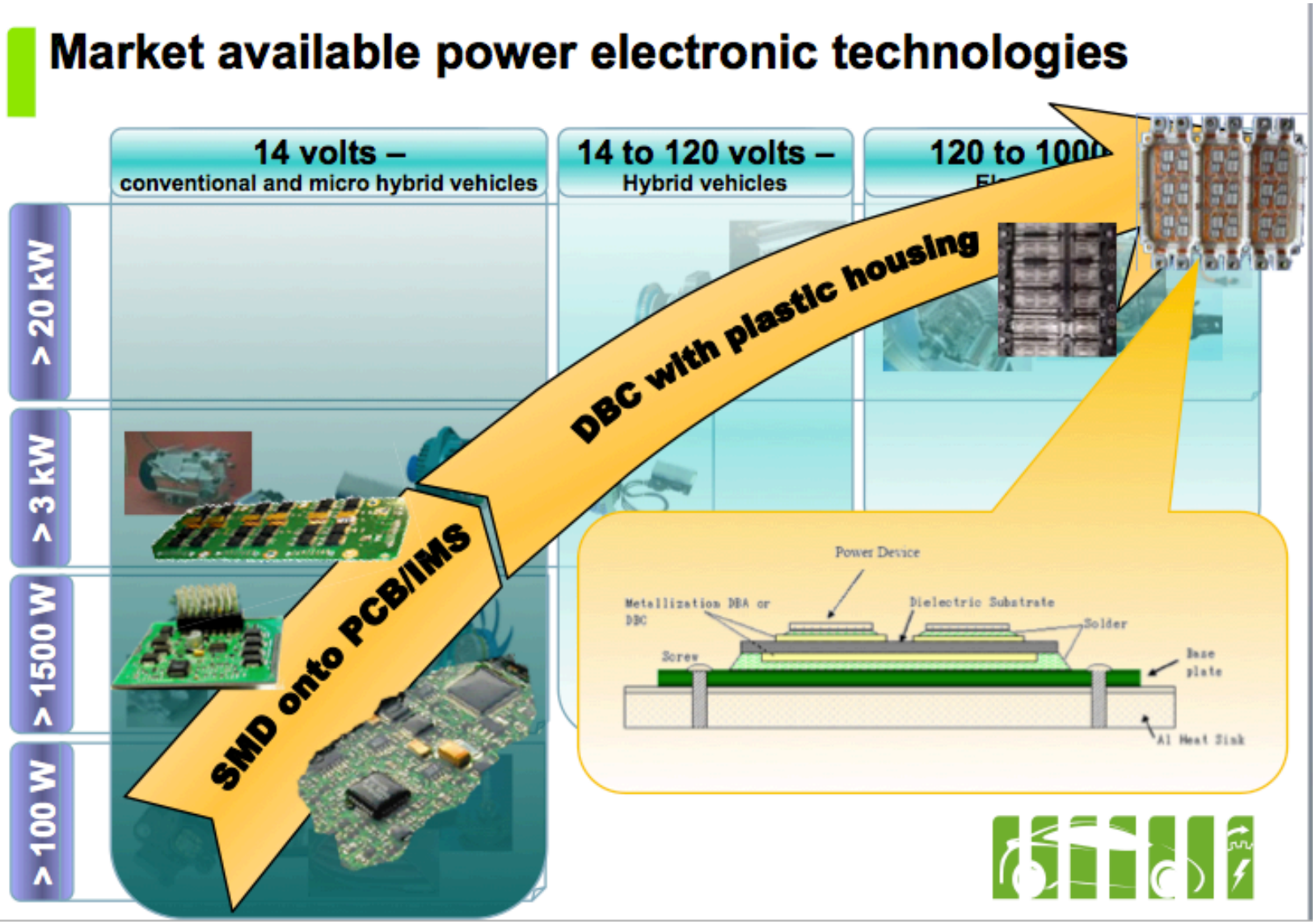
Emissions Drivers – Diesel Market Thermal Loading



Emissions Drivers – Diesel Market
Cylinder Pressure



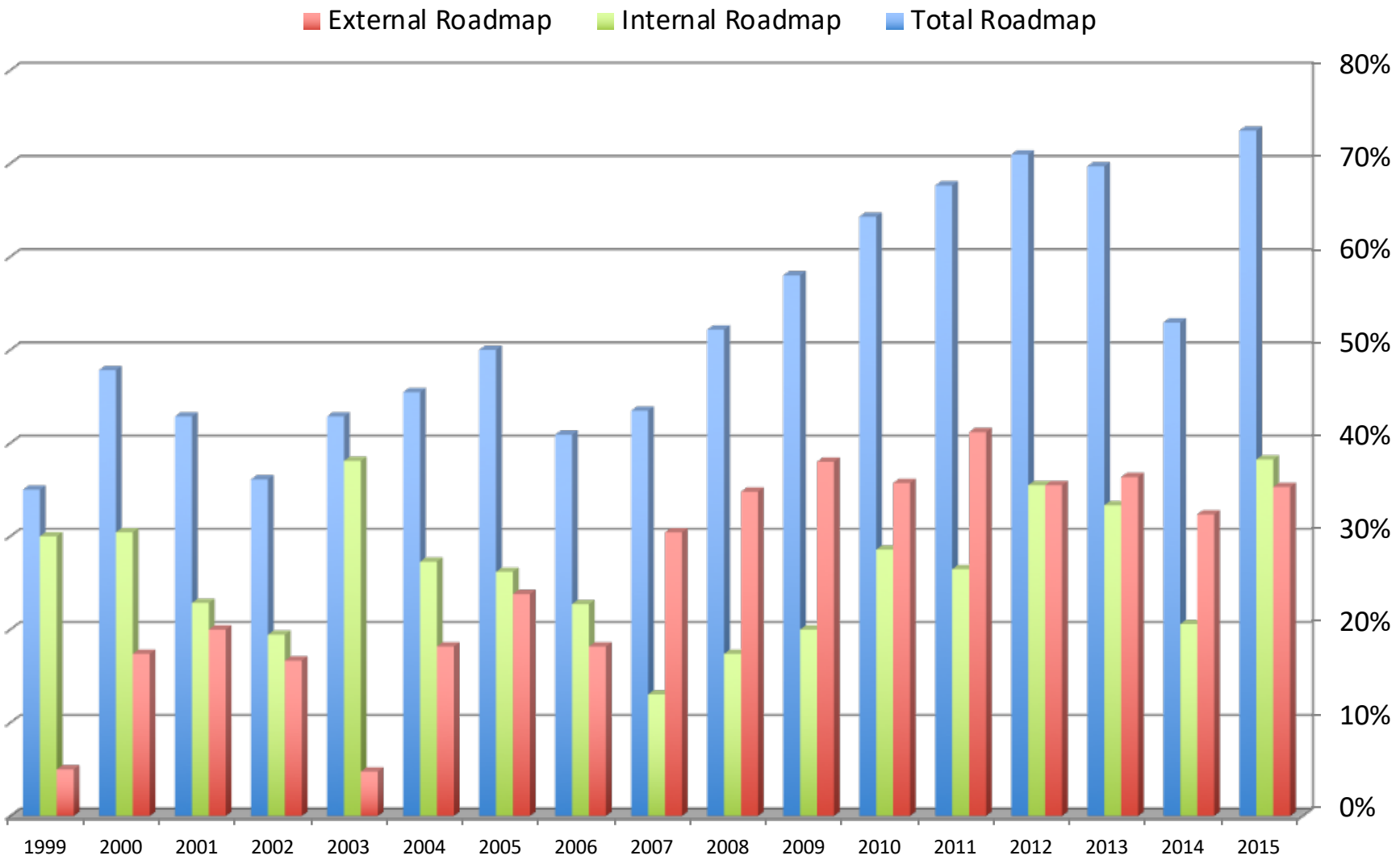
Sample electronics roadmap



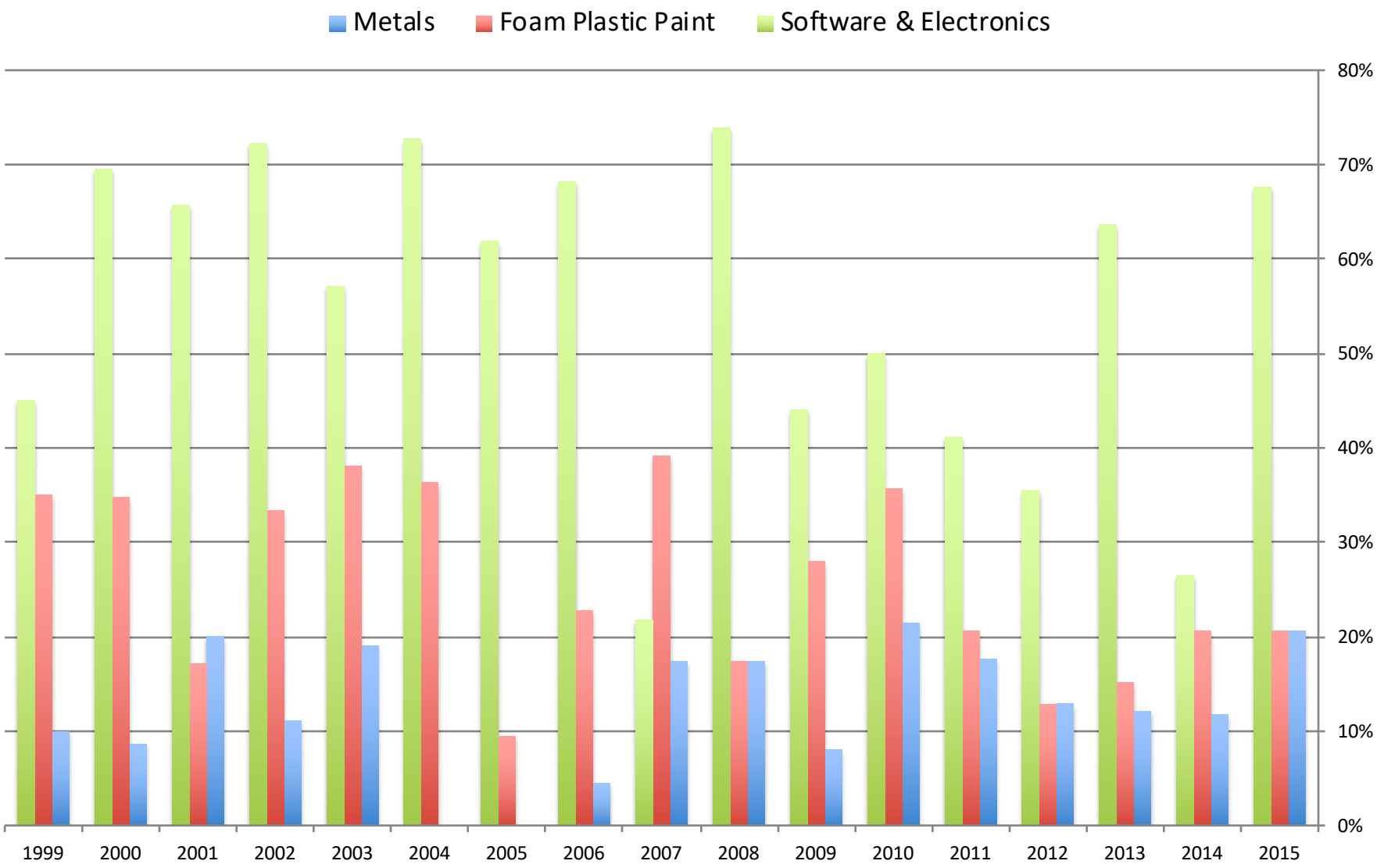
Quantitative Analysis

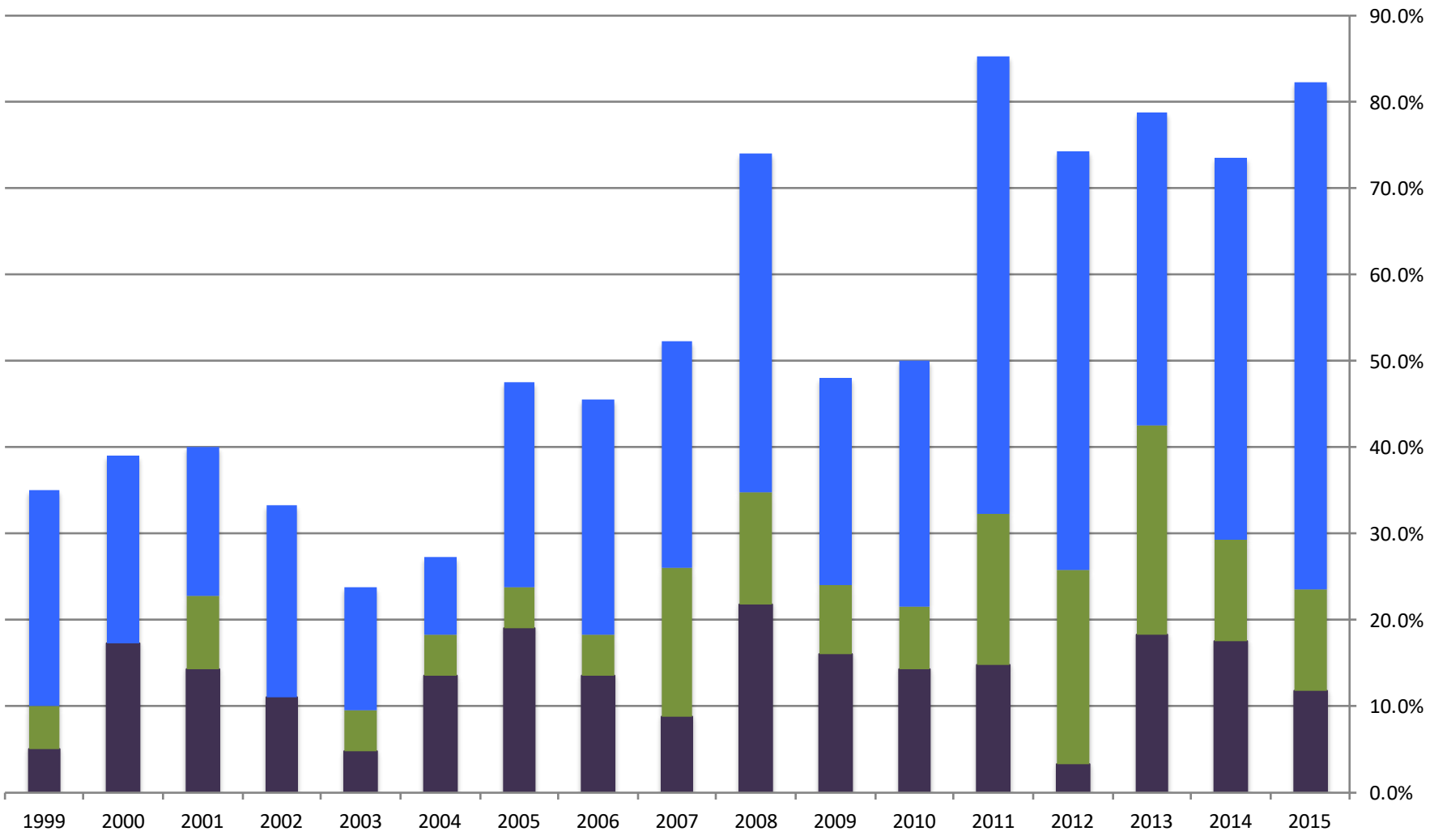
– drivers and enablers across time –

PACE Finalist Analysis: Roadmaps

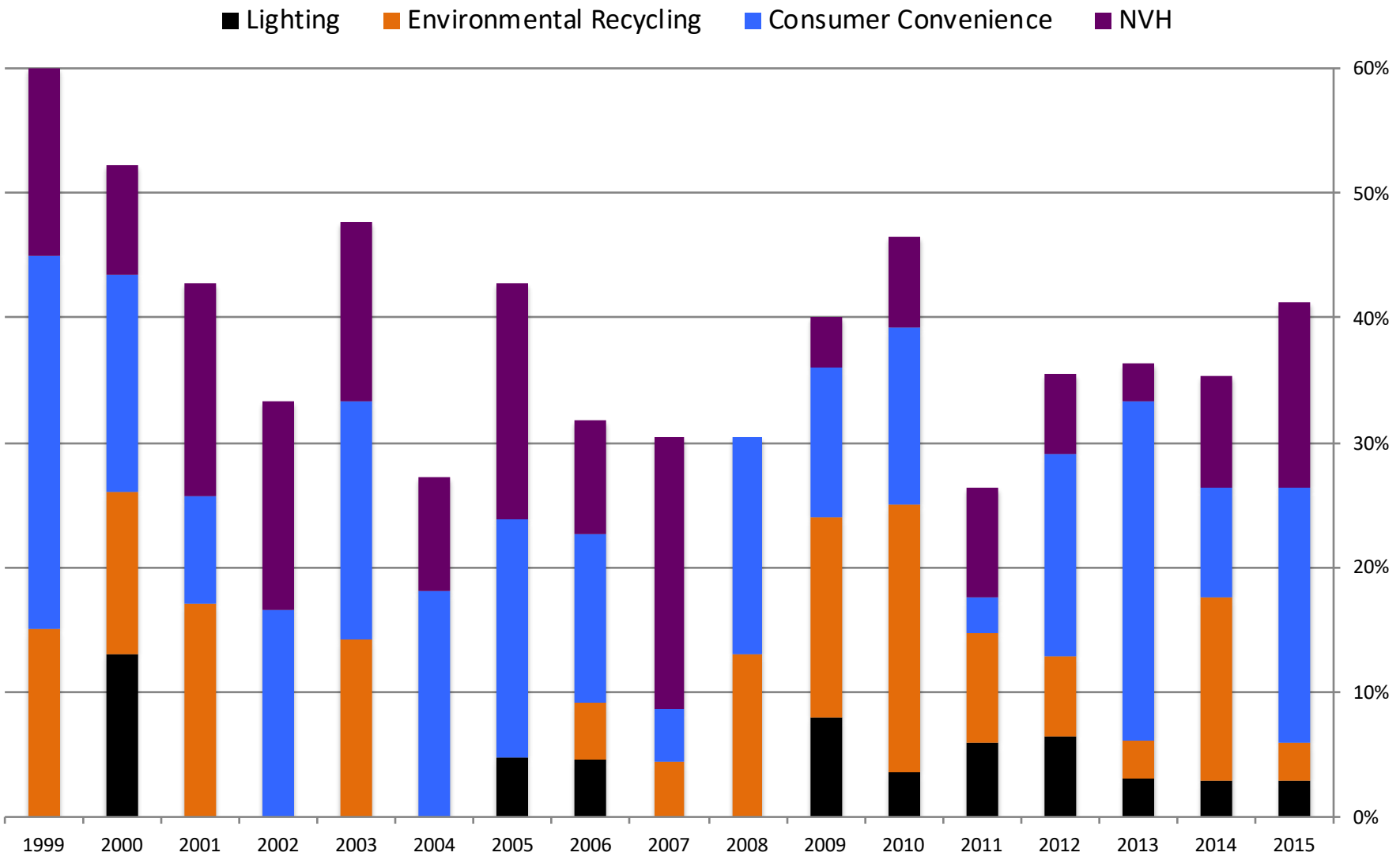


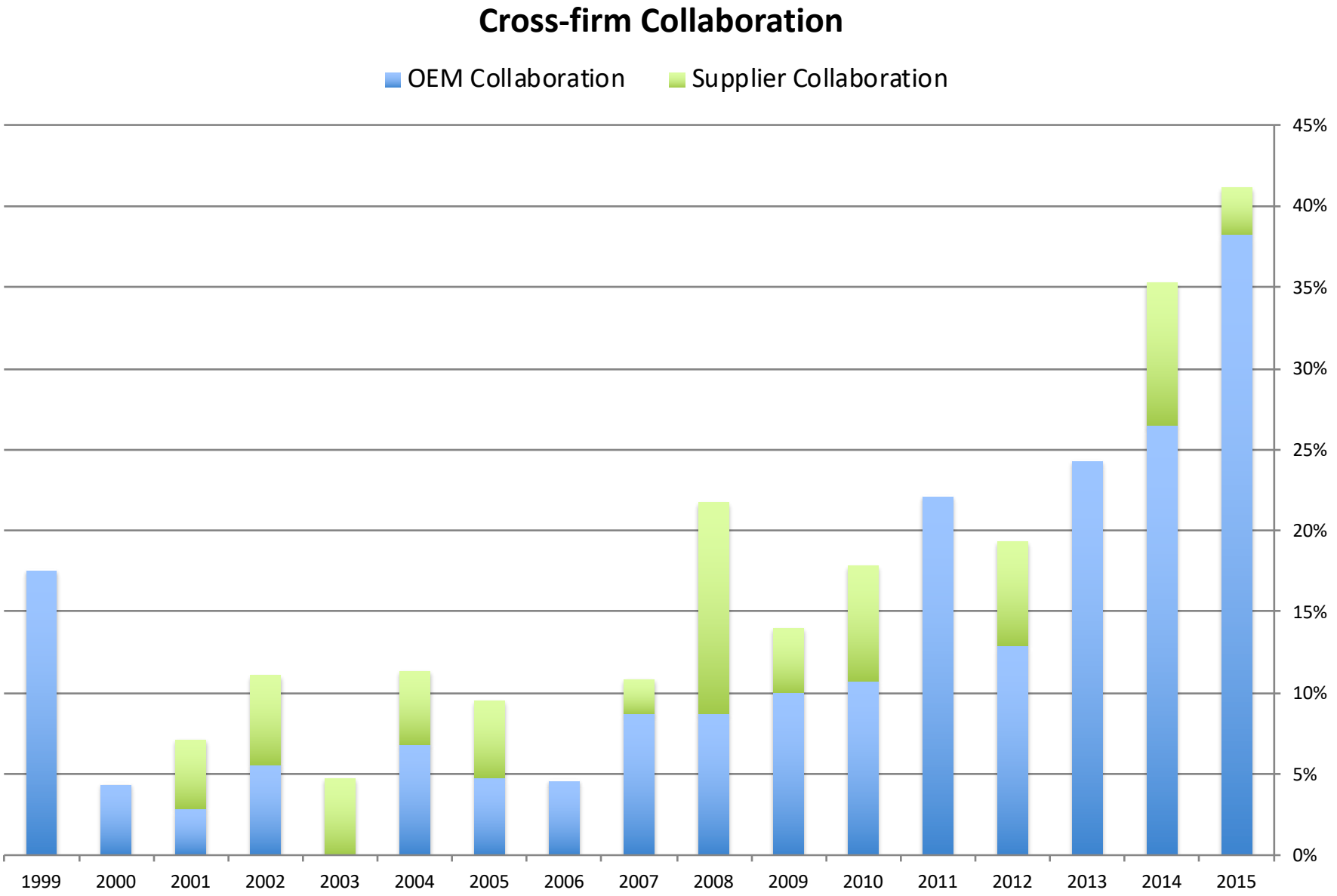
PACE Finalist Analysis: Enabling Technologies




PACE Finalist Analysis: Benefits from Innovation
Safety
Emissions
Fuel or Weight
90.0%
80.0%
70.0%
60.0%
50.0%
40.0%
30.0%
20.0%
10.0%
0.0%
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015

PACE Finalist Analysis: Misc Benefits




Cross-firm Collaboration
OEM Collaboration
Supplier Collaboration
45%
40%
35%
30%
25%
20%
15%
10%
5%
0%
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015

Time-trend Regressions

Significant Variables (1%)		Trend	t-stat	constant	t-stat
Roadmap Variables	Total roadmap	.021	6.1	.34	9.12
	External roadmap	.018	5.9	.10	3.12
Type of innovation	Idiosyncratic	-.026	-6.2	.64	13.61
	OEM collaboration	.015	4.5	-.02	-0.45
	Customer request	.014	3.1	-.03	-0.67
Driver of innovation	Fuel efficiency	.021	5.9	-.01	-0.28
	Fuel or Weight	.023	5.5	.09	2.15
	Emissions	.010	3.7	.01	0.46
Miscellaneous	Indirect supplier	-.015	-3.6	.29	6.35
Borderline Significance (5%)					
Type of innovation	Systematic	0.014	2.2	.60	8.78
	Hail Mary	-0.002	-2.5	.03	3.22
Driver of innovation	Weight	0.01	2.6	.09	2.16
	Software	-0.01	-2.3	.33	7.13
	Ceramics plastics	-0.006	-2.3	.13	4.82

Qualitative Analysis
– structured case studies –

Case Study: Hot Stamped Steel

- Ultrahigh Strenght Steel (UHS)
  - helps meet crash standards
  - helps reduce weight / improve fuel efficiency
- Tripartite Partnership for Acura MDX Door
  - Honda R&D (Ohio)
  - ArcelorMittal Tailor Blanking (US & Belgium)
  - Magna Cosma International (US & Canada)
- All three global leaders in UHS technology

Hot Stamp Technology

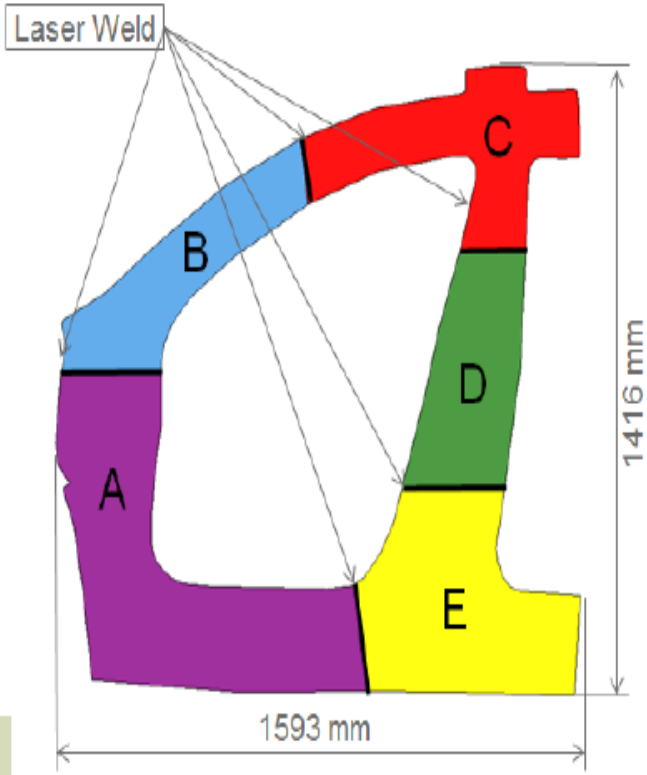
- “Soft” BSi microstructure AlSi coated steel
  - inserted into stamping press at 900ºC
  - quenching in die turns into 1500 MPA UHS steel
  - can’t directly stamp, press or punch UHS steel
- Tailor blanking: join pieces before stamping
  - overcomes steel sheet size limit
  - reduces scrap: UHS costly
  - technically challenging with coated steel

Hot Stamped Weld Design

- Use different gauges & strengths to
  - lower weight
  - lower cost

Blank A:
Gauge: 1.00 mm
Material: Usibor
Blank B:
Gauge:1.20 mm
Material: Usibor
Blank C:
Gauge:1.60 mm
Material: Usibor
Blank D:
Gauge:2.00 mm
Material: Usibor
Blank E:
Gauge:1.80 mm
Material: Ductibor

Gross Blank Mass: 14.40 Kg
Part Mass: 11.20 Kg
Material Utilization: 77.75%



Innovation Benefits

- Blank Mass Reduction 34%
- Part Mass Reduction 15%
- Material Utilization Improvement 29%
- Overall Weight Reduction 58%
- Cost Reduction 10.5%
- 5-Star-plus Crash Test Result
  - driver door could even be opened!!

Magna Roadmap

Hot Stamping

MAGNA
COSMA INTERNATIONAL

DRIVERS FOR CHANGE

- Roof crush / safety
- CAFE / CO2 = Weight Reduction
- Increased performance

Idea Generation

- Ultra high strength materials in key body structure areas
- Challenge = Economical process

Concept Evaluation and Demo

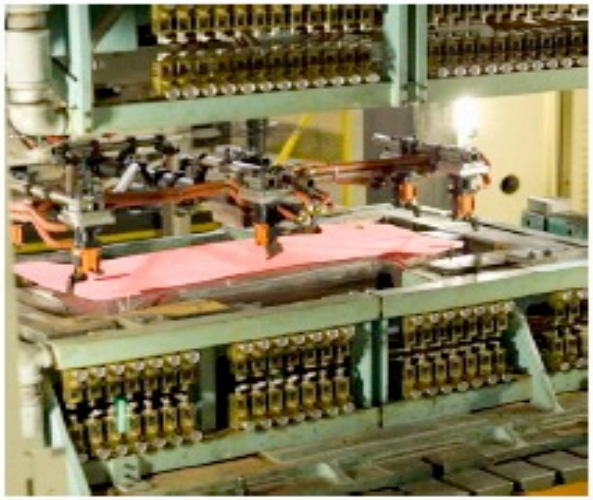
- Tooling technology
- Fundamental research = Material treatment

Product Realization and Validation

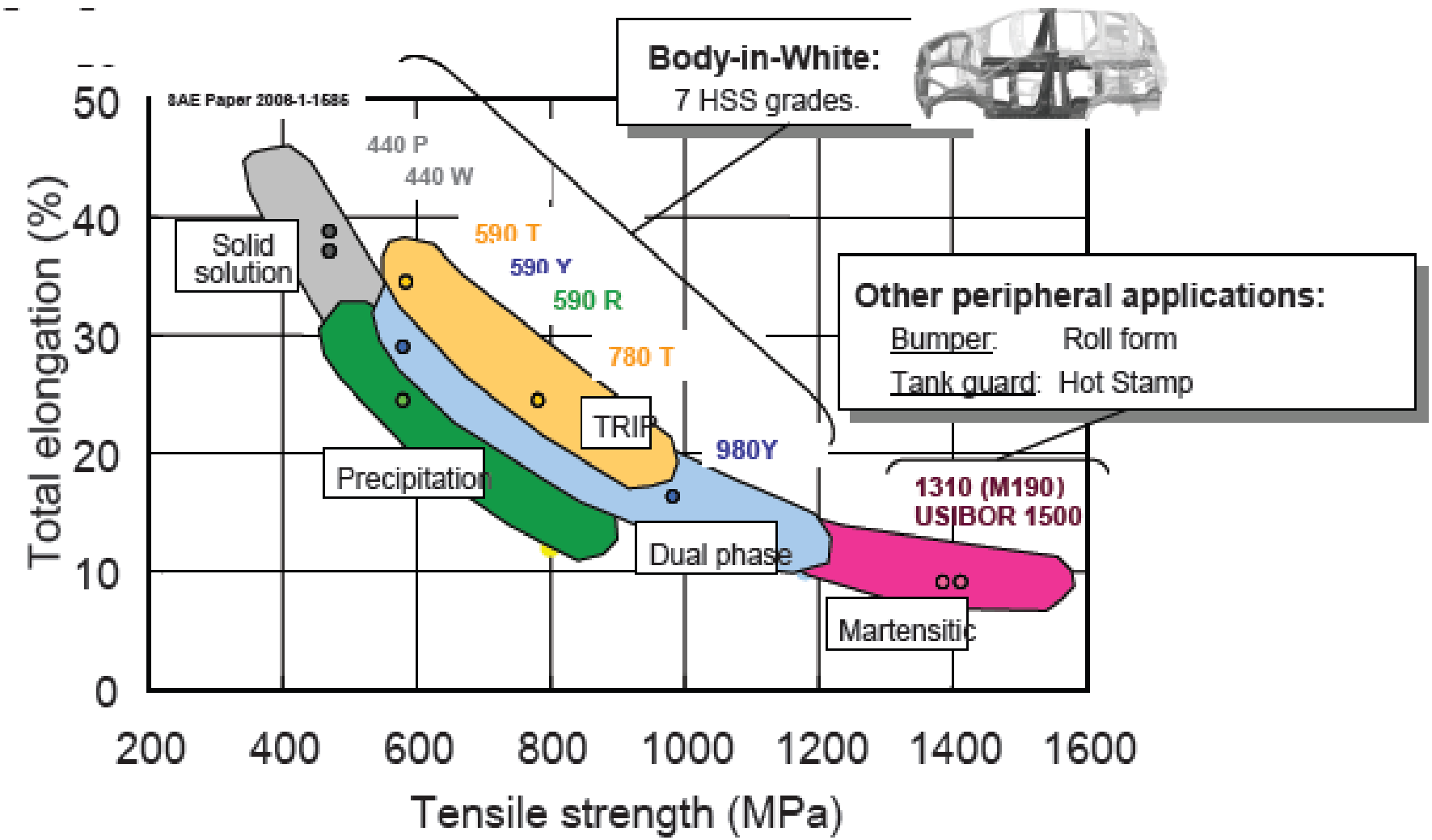
- Application research = Tooling
- Prototypes

Pre-Series Production Support

- Industrialization
- Production launch



Honda Roadmap



Conclusions

- Social Science Perspective: Supply Chain
  - Governance
  - Relational Distance
  - Modularity
  - Power Balance Assembler / Suppliers
- Engineering Perspective
  - Materials Science
  - New Engineering Tools

Economics of Innovation

- Technical Change
  - "push" factors (internal technology dynamic)
  - "pull" factors (external regulatory roadmaps)
  - "random" factors ("great inventor" innovation)
    - can innovation be repeated?
- PACE winners offer insights
  - rise of managed innovation
    - decrease in "invention"
  - regulatory pull pervasive
  - materials science, sensors, FEMA/FDS pervasive

Acknowledgments

- Thanks to Automotive News for 25 years of supplier visits!
- Thanks to Coauthor Peter Warrian, University of Toronto [*he's not seen this version*]
- Early versions presented at
  - Industry Studies Association
  - James Madison University
  - Federal Reserve Bank of Chicago Automotive Outlook Symposium Workshop