



Finite Element Modeling in Fleet Safety Studies

NHTSA Mass-Size-Safety Symposium
February 25, 2011

May 2010 CAFE Final Rule



“NHTSA and EPA believe that it is important for the agencies to conduct further study and research into the interaction of mass, size and safety to assist future rulemakings. The agencies intend to begin working collaboratively and to explore with DOE, CARB, and perhaps other stakeholders an interagency/intergovernmental working group to evaluate all aspects of mass, size and safety.”

Objectives



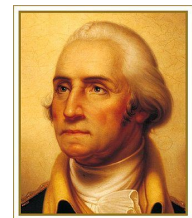
- Utilize new and existing vehicle crash models to evaluate safety of future lightweight vehicles
 - Vehicle-to-vehicle and vehicle-to-structure crashes
 - Non-standard crash conditions
 - Interaction with new and existing vehicles
 - Evaluate potential countermeasures
 - Develop safety estimates
 - Support CAFE final rule
 - Provide direction for future safety research

Lightweighting Safety Outline



- **Electricore Lightweight Vehicle Design**
 - Design MY 2020 lightweight vehicle within 10% baseline cost
 - Meet all major safety test requirements
 - Develop detailed cost analysis
- **Fleet Safety Methodology**
 - GWU to develop simulation methodology to evaluate lightweight crashworthiness with existing vehicles
 - Develop independent lightweight design and demonstrate methodology
 - Evaluate safety countermeasures
- **Evaluate lightweight vehicle designs**
 - Electricore design for 5 passenger sedan
 - Toyota Venza low and high development options under study by EPA and CARB

Feasible Amount of Mass Reduction for Light Duty Vehicles for Model Years 2017-2025



Electricore Project Objectives



- The objective of this project is to provide a design of a MY 2020 light weight vehicle.
- The design engineering study will include computer modeling to demonstrate crashworthiness of the vehicle concept.
- The proposed LDV, (Light Duty Vehicle) will be commercially feasible for high volume production (>200,000 units per year).
- The LDV will maintain retail price parity with the baseline vehicle within +10% variation while maintaining or improving vehicle size and performance characteristics.
- The Electricore team will provide a comprehensive cost estimate for the design, including both detailed direct and indirect cost estimates.

Electricore Project Team



Electricore, Inc.

- A 501(c)(3) non-profit consortium among private and public sector organizations, federal agencies, corporations, small businesses, universities, and research institutions that develops and manages multi-partnered research programs

EDAG

- The world's largest independent engineering and design development partner, EDAG Group develops customized concepts and solutions, optimized for production, to meet the mobility needs of the future.

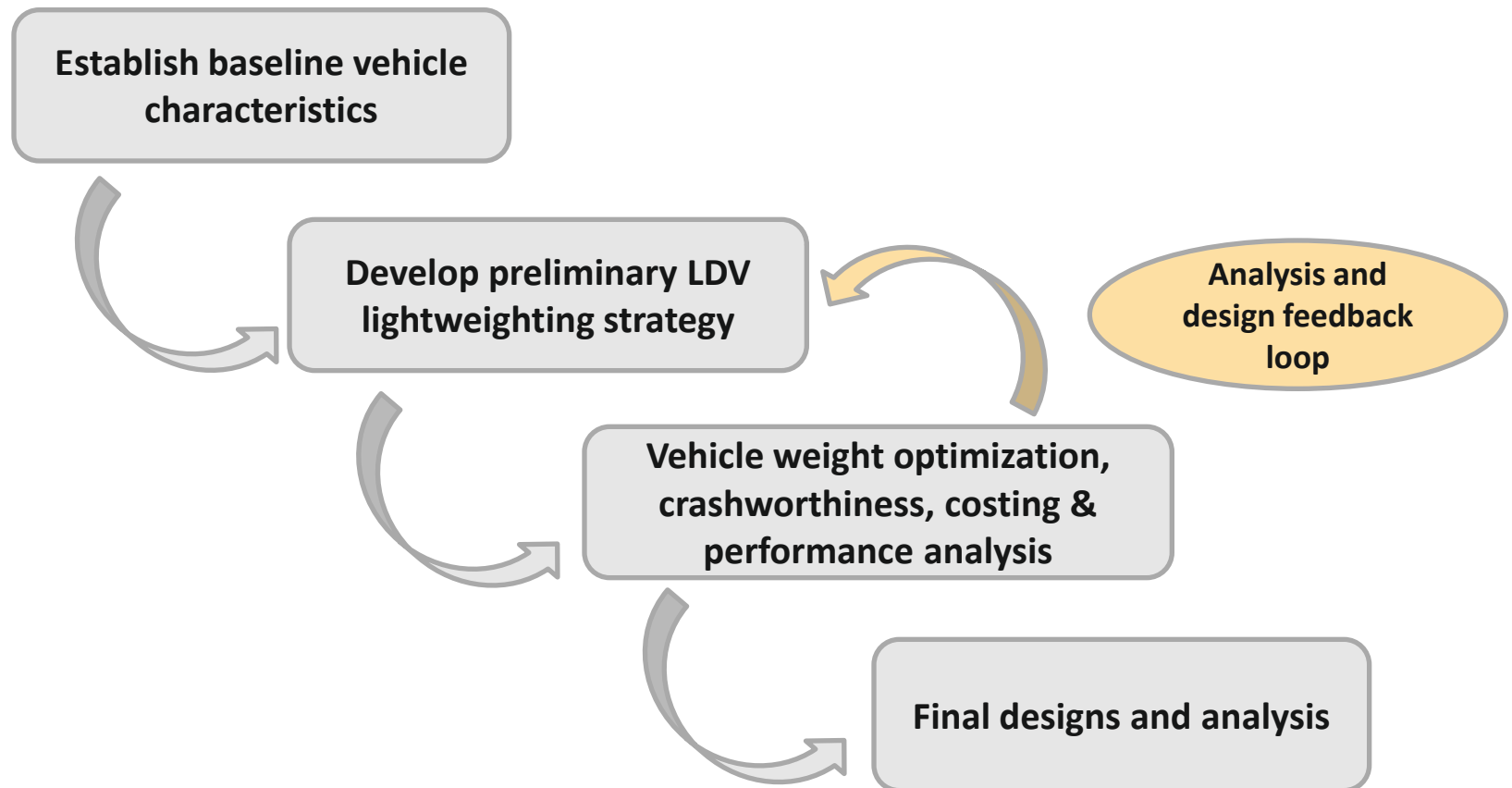
GWU National Crash Analysis Center

- The National Crash Analysis Center (NCAC) is a research center, developing advanced research methods to address and solve transportation safety problems and enhancing collaboration between academia, government, and industry worldwide.

Electricore Approach



Overall program approach is:



Electricore Baseline Vehicle



Detailed analysis of a model year 2011 Honda Accord, including:

Vehicle scanning and teardown



Vehicle mass allocations

Body Structure	387	Closures	142	Interior Systems	123	Other Systems	120	Chassis	422	Powertrain	377
Body	310	Doors	110	Seats	66	HVAC	36	Suspension	255	Engine & Transmissio	240
Bumpers	23	Hood	17	IP	31	Lighting	10	Brakes	58	Exhaust	35
Front/rear bolt on Sub-	32	Trunk Lid	15	Trim	26	Electrical	50	Wheels	77	Fuel System	24
Wind screen, Rear glass	22					Wiper Sys	6	Steering	27	Fluids	78
						Airbags, Belts	18	Pedals	5		

Wind screen, Rear glass shown under Body Structure because of its significant contribution to structural stiffness

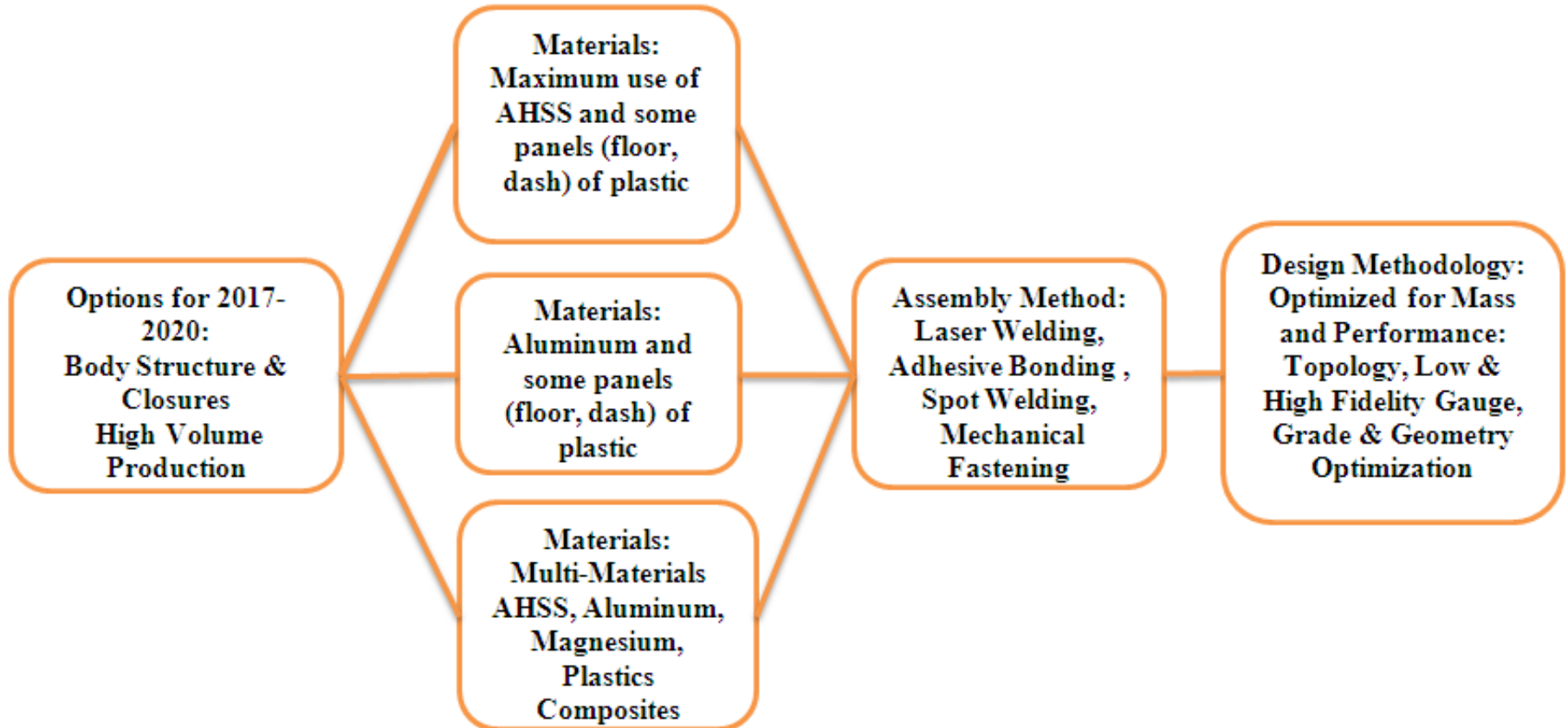
Assessment to be based on: Detailed Design & Engineering, CAE simulations to meet safety and performance goals, Future Materials, Manufacturing and Assembly Technologies

Assessment to be based on: Future Materials & Manufacturing Technologies and/or resize to meet performance goals

Electricore Preliminary LDV Lightweighting Strategy



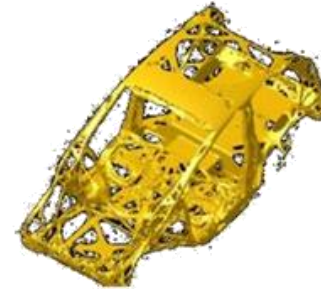
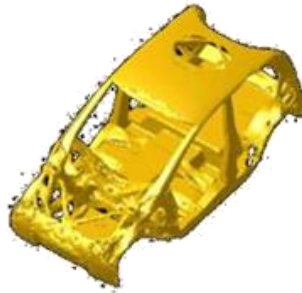
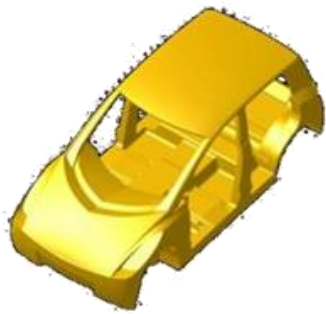
Consider weight reduction options and trade off analysis for major vehicles systems (structure & closures; powertrain; interior; etc) from a material, design and assembly standpoint



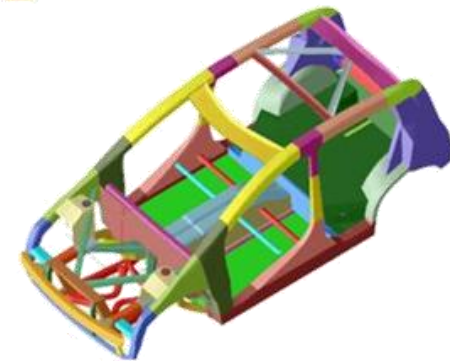
Electricore LDV Weight Optimization



Iterative design and analysis will be used to optimize the LDV design for light weight, while maintaining the crashworthiness, cost, size and performance relative to the baseline vehicle.



Topology Optimization



3G Optimization

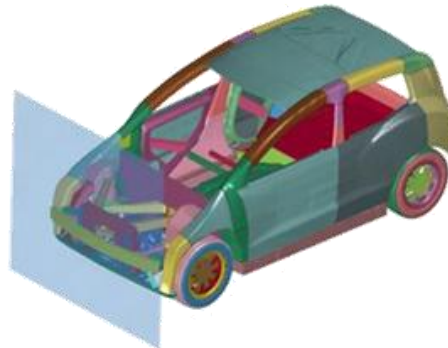


LSDYNA: Crash & Non-linear load-cases
NASTRAN: Torsion & bending

Results

HEEDS: Compare results with targets and Determine new set of variables (Geometry, Gage, Grade)

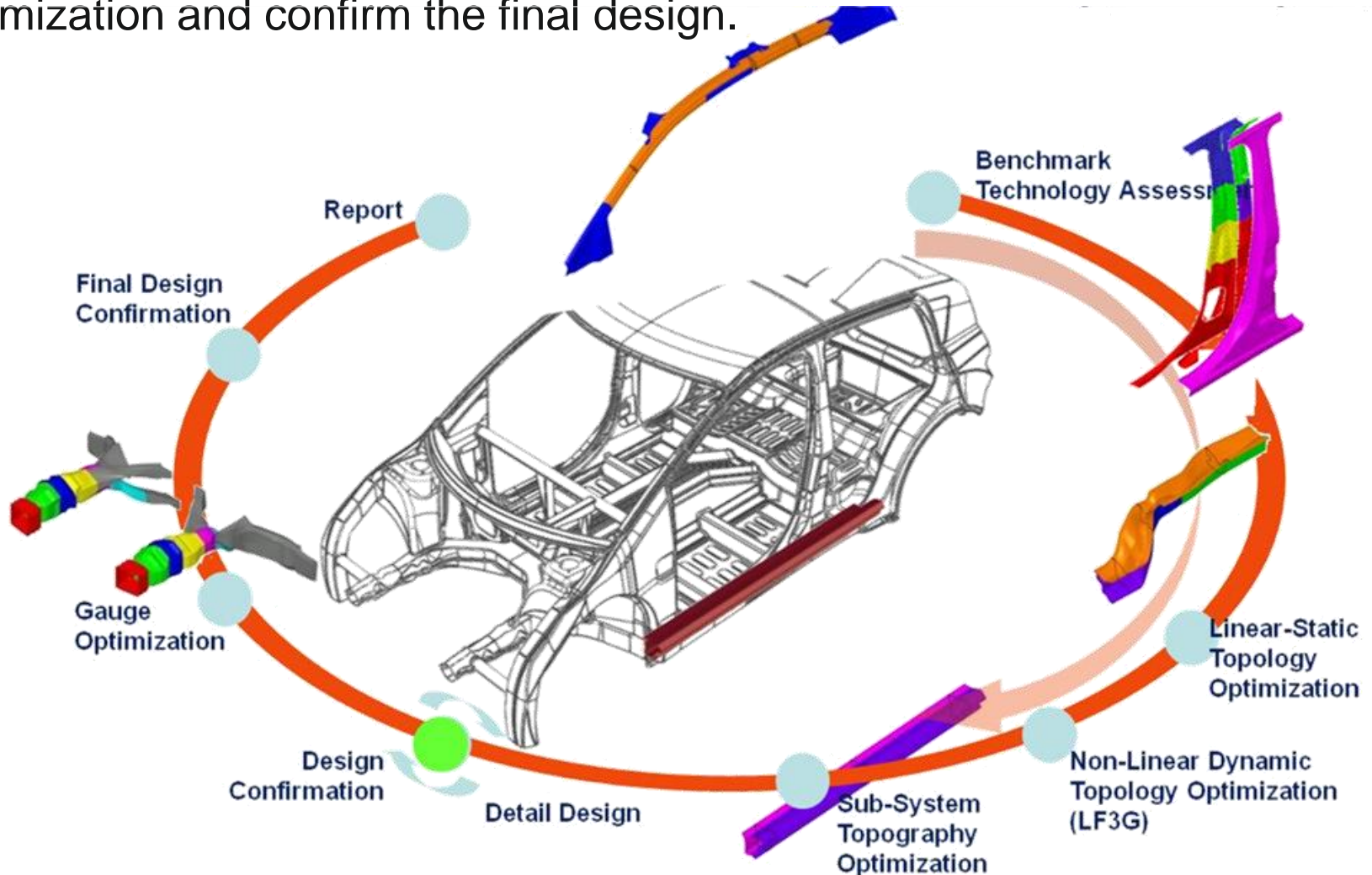
SFE: Generate Model and create Data decks for LSDYNA & NASTRAN



Final Design and Analysis



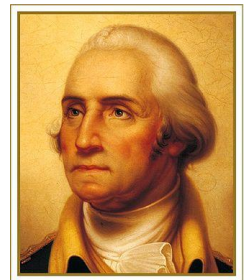
After design confirmation, Electricore team will complete the optimization and confirm the final design.

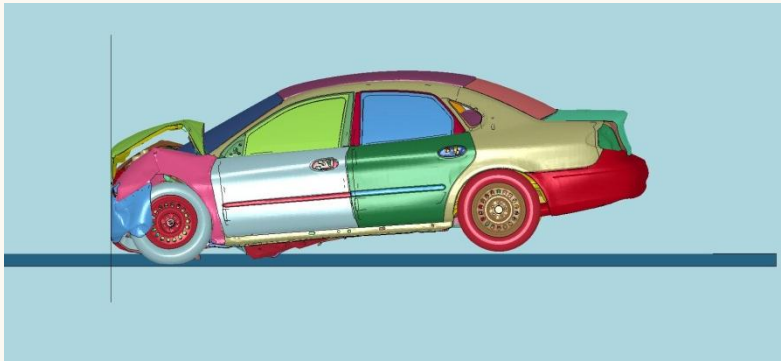


NCAC Fleet Study - Goals



- Develop methodology to evaluate fleet crash safety using existing crash models
- Develop lightweight design for mid-size vehicle finite element model
- Evaluate safety performance of baseline and the lightweighted vehicle
- Identify and evaluate potential crashworthiness countermeasures

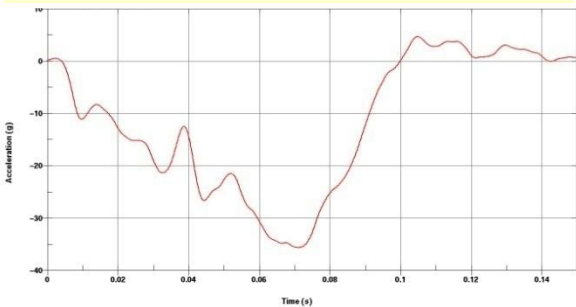




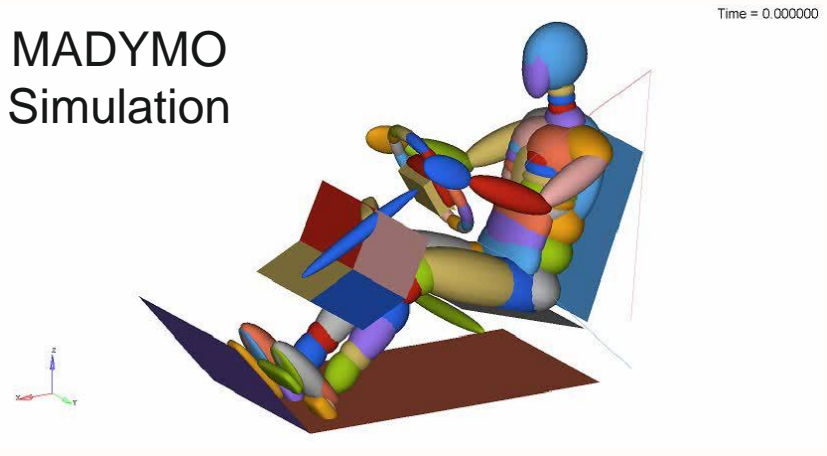
FEM
Simulation



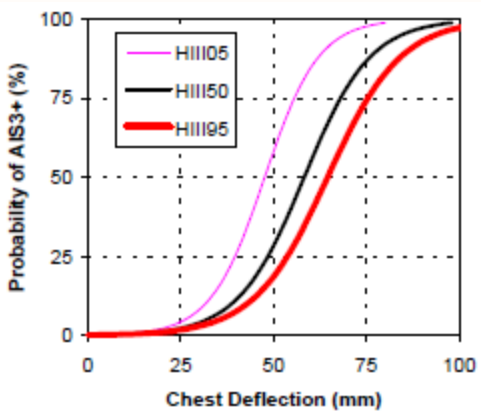
compartment crash pulse



MADYMO
Simulation



HIC15
Chest Deflection
Femur Load



R_{head}^{AIS3+}
 R_{chest}^{AIS3+}
 $R_{lower-ext}^{AIS2+}$

NCAC Vehicle Fleet - FEM Availability



**Mid-size
passenger
car**



Ford Taurus
4th generation
(MY 2000-2007)

**Small
Passenger
Car**



Toyota Yaris
2nd generation
(2005-current)

**Sport Utility
Vehicle**



Ford Explorer
3rd generation
(2002-2005)

Pickup Truck



Chevrolet Silverado
GMT900 platform
(MY 2007 → current)

FE Simulation Matrix: Total 297 Simulations

Single Vehicle Crashes: 72 Total

**(24 Baseline, 24 LW1, 24 LW2)*

Test Configuration		Vehicle Speed (mph)					
		15	20	25	30	35	40
Frontal	Frontal Impact Full Engagement (NCAP)	X	X	X	X	X	
	Frontal Impact % Offset (IIHS)		X	X	X	X	X
	Frontal Impact Center - 10" Pole	X	X	X	X	X	
	Frontal Impact Offset - 10" Pole	X	X	X	X	X	
Side	Side Impact 10" Pole - Nearside (Side NCAP - 214 Pole Test)	X	X				
	Side Impact 10" Pole - Farside (Side NCAP - 214 Pole Test)		X			X	

Front-to-Front: 120 Total

**(40 Baseline, 40 LW1, 40 LW2)*

Partner Vehicle	Target Vehicle	Vehicle Speed [Closing Speed]	Test Setup
Explorer	Taurus*	15 mph [30]	Full Engagement
Silverado	Taurus*	20 mph [40]	
Yaris	Taurus*	25 mph [50]	
Taurus	Taurus*	30 mph [60]	
Taurus	Taurus*	35 mph [70]	
			% Offset

Front-to-Side: 84 Total

**(28 Baseline, 28 LW1, 28 LW2)*

Partner Vehicle	Target Vehicle	Vehicle Speed	Test Setup
Taurus*	Explorer	25 mph	Nearside Impact
Taurus*	Silverado	35 mph	
Taurus*	Yaris		Farside Impact
Taurus*	Taurus		
Explorer	Taurus*		
Silverado	Taurus*		
Yaris	Taurus*		

Front-to-Rear: 21 Total

**(7 Baseline, 7 LW1, 7 LW2)*

Partner Vehicle	Target Vehicle	Vehicle Speed	Test Setup
Taurus*	Explorer	50 mph	Rear Impact
Taurus*	Silverado		
Taurus*	Yaris		
Taurus*	Taurus		
Explorer	Taurus*		
Silverado	Taurus*		
Yaris	Taurus*		

Lotus High Development Option



- CARB has funded Lotus Engineering to further develop the 40% lightweight Toyota Venza design
 - This study will include CAD and crash models
 - Lotus has been extremely helpful in evaluating crash simulations with existing GWU models
 - Plan to include high development model in fleet safety simulations

FEV Low Development Option



- EPA has funded FEV to continue study of the 20% lightweight Toyota Venza design
 - Will include CAD and crash models
 - Plan to include FEV model in fleet safety simulations

Project Summary



- NHTSA, EPA, and CARB are funding vehicle design studies utilizing different lightweighting goals
 - Each study will include a crash model for safety evaluation
- NHTSA will utilize new and existing vehicle models for safety evaluations of lightweight vehicles
- Results are expected to guide future vehicle safety research

THANK YOU!

Your Logo