Assessment of Light-Duty Vehicle Mass-Reduction Costs

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UCDAVIS ITS

Outline

- Mass-reduction assessment in regulatory development
  - Mass-reduction assessment in US 2017-2025 GHG standards
  - Existing technical literature
- Ongoing state-of-the-art mass reduction studies
  - Major projects underway
- Policy implications

Mass-Reduction in US/CARB Regulation

- Mass-reduction assessment in US regulations involves technical contractor work, confidential business information from OEMs, and fleet safety analysis
- Technical basis, assumptions available in documents at agency websites
- US Environmental Protection Agency (USEPA) and National Highway Traffic Safety Administration (NHTSA):
  - Notice of Proposed Rulemaking (NPRM): Pages 74947 - 74962
  - Joint Technical Support Document (TSD): Pages 3-204 - 3-212
  - Documents at *http://www.epa.gov/otaq/climate/regulations.htm*
- California Air Resources Board
  - Technical Appendix Q: pages 6-20
  - Document at *http://www.arb.ca.gov/regact/2012/leviiighg2012/leviiighg2012.htm*

Mass-Reduction: Automaker Plans

- Mass reduction is expected from every automaker
- Below are public statements, anecdotes, quotes…

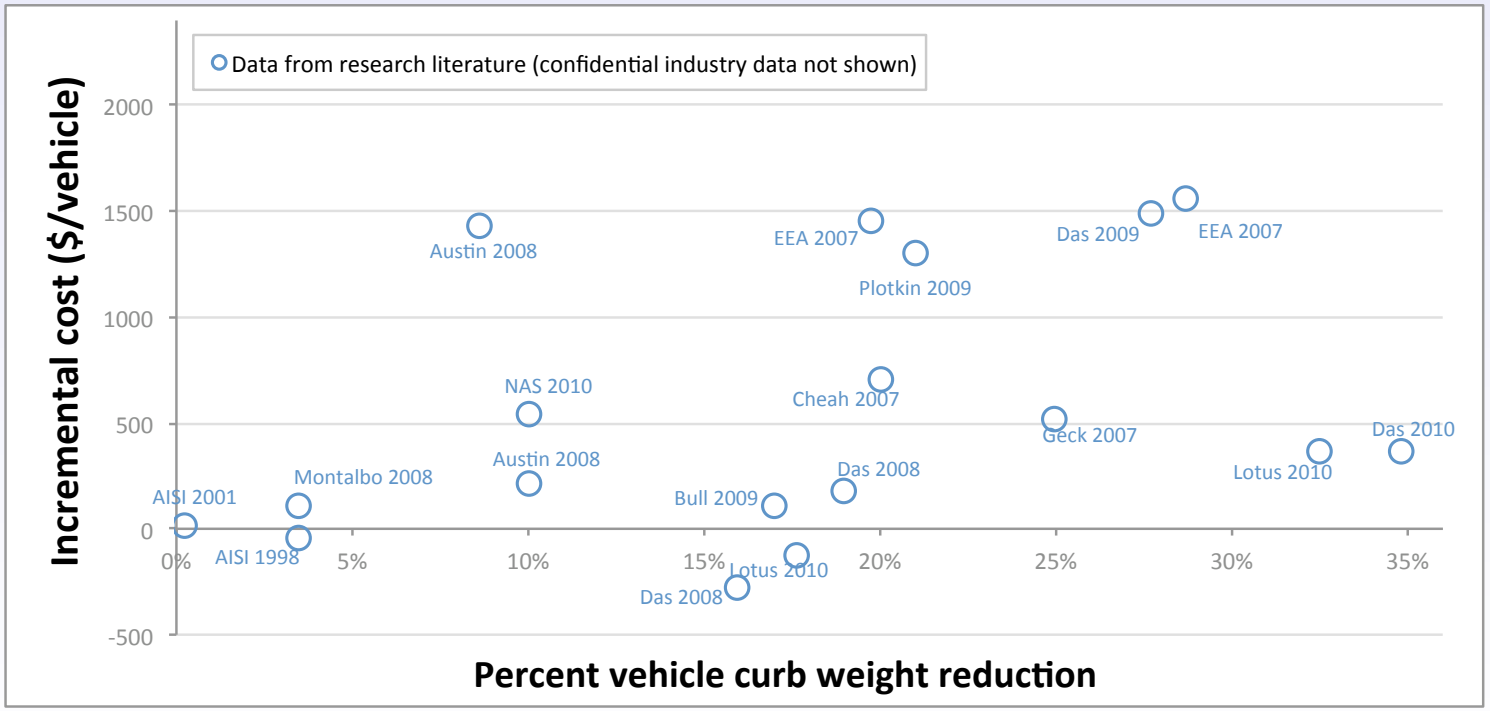
Company	Quote, statement, or commitment
Ford	• From 2011 to 2020: "Full implementation of known technology… weight reduction of 250-750 lbs" • "The use of advanced materials such as magnesium, aluminum and ultra high-strength boron steel offers automakers structural strength at a reduced weight to help improve fuel economy and meet safety and durability requirements
Toyota	• 10-30% weight reduction for small to mid-size vehicles
Volkswagen	• "Automotive light weight solutions are necessary more than ever to reduce CO_2 emissions " • "Multi-Material Concepts promise cost effective light weight solutions "
GM	• "We… are likely to use more lightweight materials in the future" • "One trend is clear - vehicles will consist of a more balanced use of many materials in the future, incorporating more lightweight materials such as nanocomposites and aluminum and magnesium."
Mazda	• Reduce each model by 220 lb by 2015; another 220 lb by 2020
Nissan	• Average 15% weight reduction by 2015 • "We are… expanding the use of aluminum and other lightweight materials, and reducing vehicle weight by rationalizing vehicle body structure
BMW	• "Lightweight construction is a core aspect for sustainable mobility improving both fuel consumption and CO_2 emissions"
Renault	• "To meet commitments on CO_2 emission levels, it is important that we stabilize vehicle weight as from now, and then start bringing it down."

Technical Literature on Vehicle Mass-Reduction

- Technical assessments on mass-reduction involve major studies by national US energy laboratories, OEM steel suppliers, OEMs with universities, etc
- Studies demonstrate diverse options for mass-reduction
  - Part-specific design or material change (e.g., hood, B-pillar)
  - Material specific alternatives (e.g., aluminum-only, HSS-only focused)
  - System level changes (e.g., entire body-in-white)
  - Full vehicle redesign and material substitution (e.g., body plus secondary effects)
- Studies differing value for regulatory assessment in terms of technical rigor, data/method transparency, comprehensiveness, crashworthiness validation

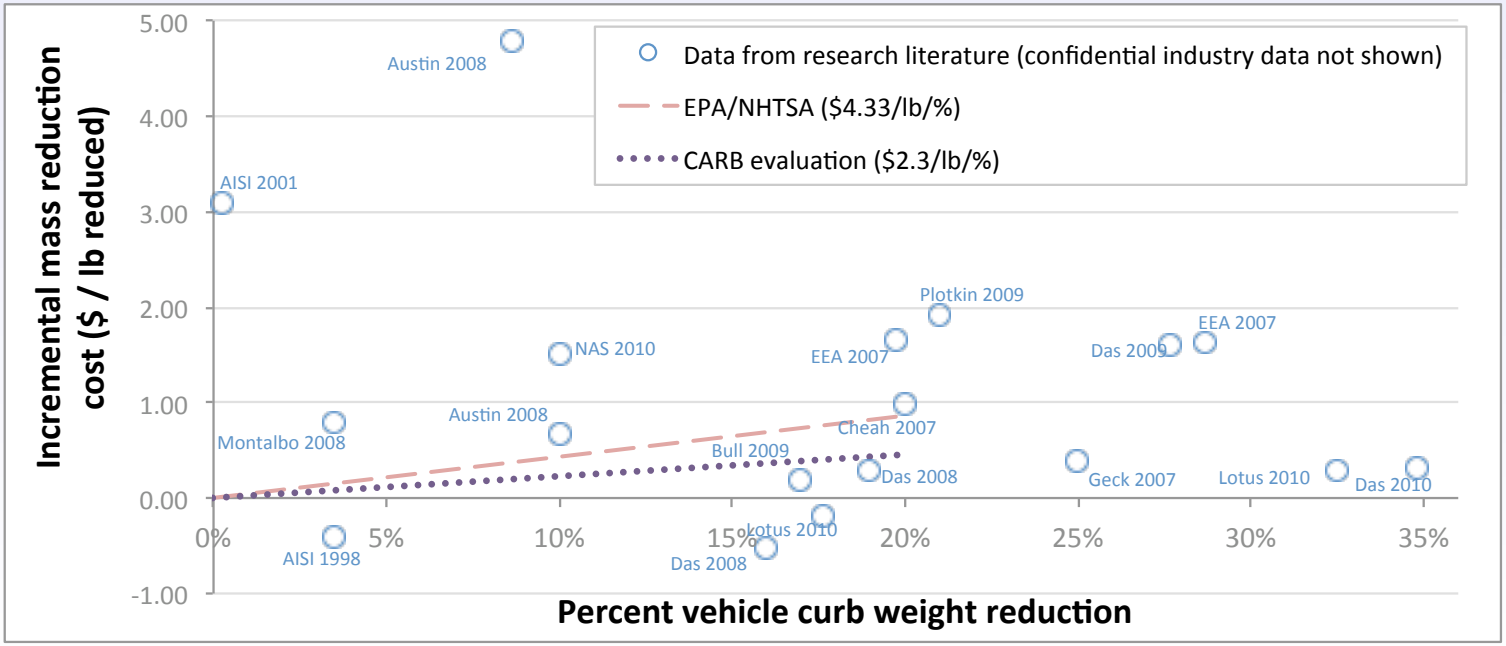
Vehicle Mass-Reduction Cost

- Technical assessments on mass-reduction involve major studies by national US laboratories, OEM steel suppliers, OEMs with universities, etc
  - Mass-cost data plotted as cost versus percent of vehicle mass reduced
  - Each data point represents a different material/design approach to mass reduction



Vehicle Mass-Reduction Cost

- US agencies collaborated to assess available studies and model costs associated with vehicle mass-reduction
  - Agencies assessed and weighted the available mass-reduction studies for redesign of vehicle models in the 2017-2025 timeframe
  - Regulation analyses apply *cost-per-pound-reduced* vs percent vehicle mass reduction
  - Ultimately, agencies projected average vehicle mass would decrease by 8-12% by 2025

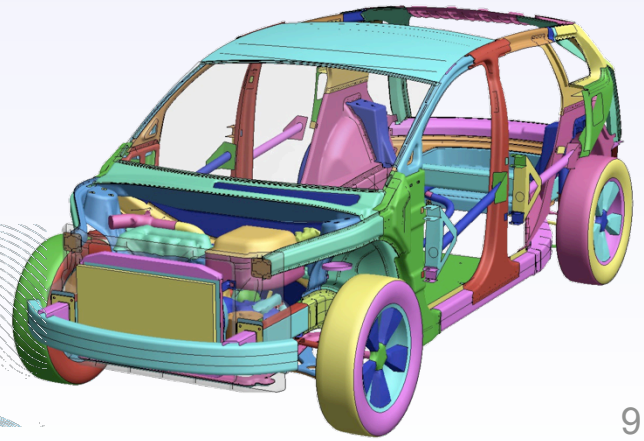


Major New Mass-Reduction Studies

- Lotus Engineering (contracted by CARB)
  - Continuation of earlier 2010 Lotus work (20% and 33% mass-reduced Toyota Venza crossover)
    - See: *http://www.theicct.org/lotus-lightweighting-study*
  - On-going work includes crashworthiness/NHTSA/NCAP validation of 33%-mass-reduced vehicle
- FEV / EDAG (contracted by US EPA, ICCT)
  - Involves development, validation, cost assessment of 20%-mass-reduced Venza
- EDAG / Electricore (contracted by NHTSA)
  - Mass-reduced mid-size vehicle (Honda Accord) ≤10% vehicle cost premium
- WorldAutoSteel "Future Steel Vehicle" (with AISI, EDAG)
  - High-Strength Steel (HSS): 12-18% mass reduction at no additional system cost
    - See: *http://www.worldautosteel.org/Environment/Future-Steel-Vehicle.aspx*

Lotus Mass-Reduction Project

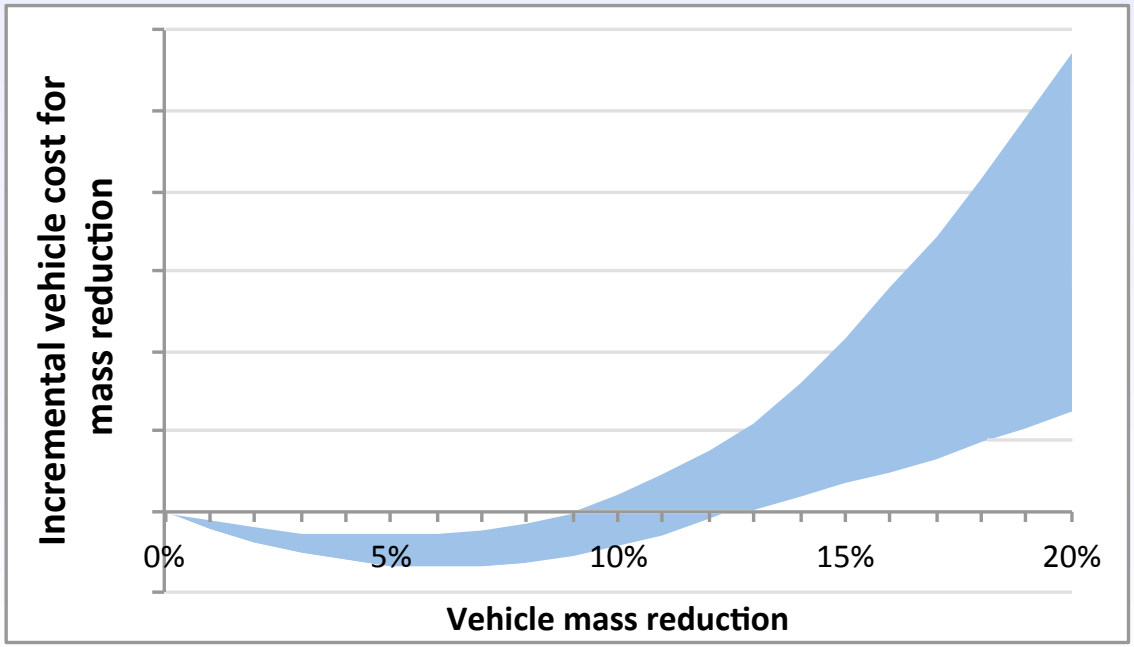
- Contracted by CARB
  - Continuation of 2010 study (*http://www.theicct.org/lotus-lightweighting-study)*
- Crashworthiness, validation:
  - Front (FMVSS 208; IIHS 3/6 mph); Side (FMVSS 214); Rear (FMVSS 301, IIHS 3/5 mph); Roof (FMVSS 216); Seat belt/restraint (FMVSS 210/213)
  - Additional 35mph car-to-car crash with NHTSA (vs. Ford Taurus; Ford Explorer)
  - Torsional stiffness: ~33,000 Nm/deg
- Engineering design:
  - Mass reduction: 242 kg body-in-white (-37% from base Venza)
  - Material: 75% alum., 12% magn., 8% steel, 5% composite (base: 100% steel)
  - Parts count ~170 (base: >400 parts)
  - Cost increase: TBD
- Peer review process: On-going



LOTUS ENGINEERING

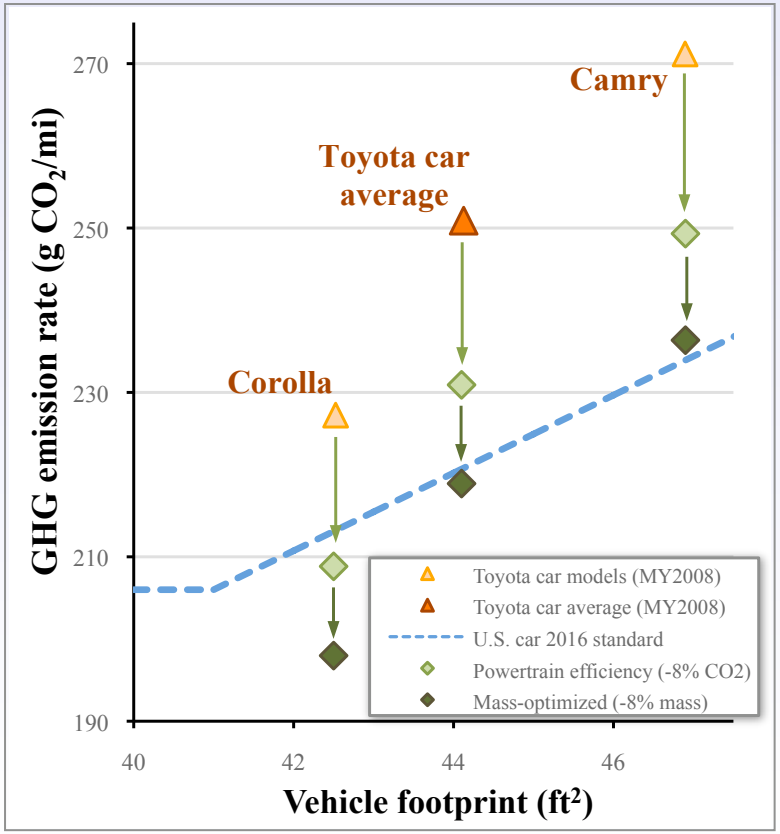
Major On-Going Mass-Reduction Studies

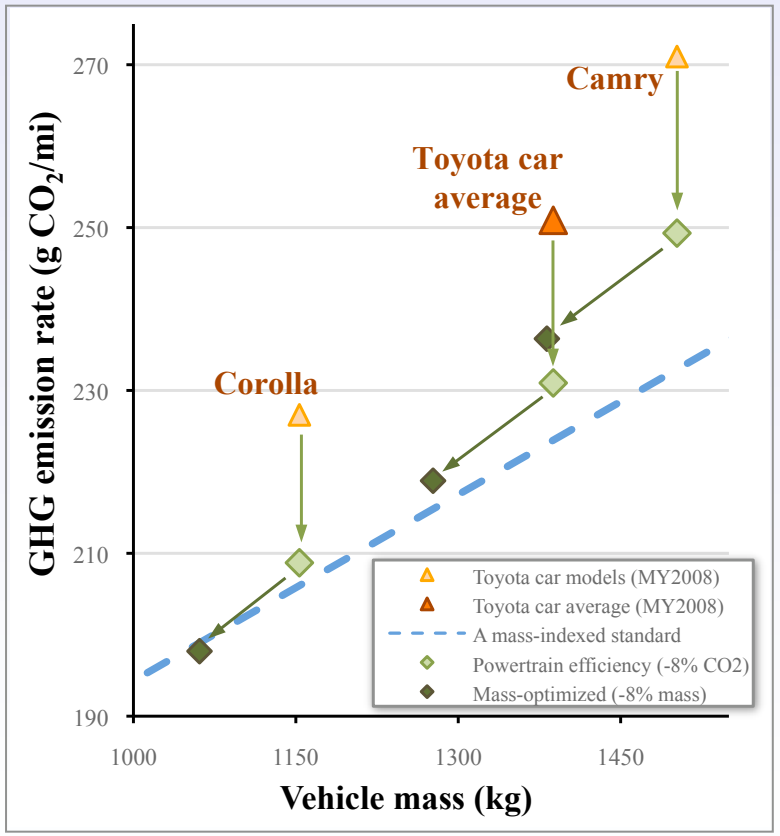
- The three Agency-contracted vehicle mass-reduction studies….
  - Advance the state-of-the-art in modeling technical potential with finite element analysis, CAD/CAE design, crashworthiness, compatibility, and cost assessment
  - Will be peer-reviewed and inform the final US GHG regulations (planned July 2012)
  - Could reveal similar average mass-cost relationship for holistically redesigned vehicles in the 2017-2025 timeframe



Mass-Reduction Policy Implication

- Some standards incentivize mass reduction more than others
  - Of course, any CO_2 regulation incentivizes improved-efficiency powertrains
  - With *same application* of mass reduction technology, there is far lower value in mass-indexed regulatory systems





Conclusion

- US agencies found strong technical basis for including mass-reduction as a prominent technology toward 2017-2025 compliance
  - All automakers intend to utilize mass-reduction toward regulatory compliance
  - Technical assessments: vehicle to reduce mass by 8-12% by 2025
- Mass reduction includes a critically important set of diverse technical approaches that can be utilized toward CO_2-reduction goals
  - Many different advanced materials, designs are being pursued across OEMs
  - The regulatory incentive to deploy the technology is weaker when regulatory standards are mass-indexed