Engineering Realities: Structural Crashworthiness, Occupant Injury, and Advanced Vehicle Design

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Top-Tier Issues for Automakers

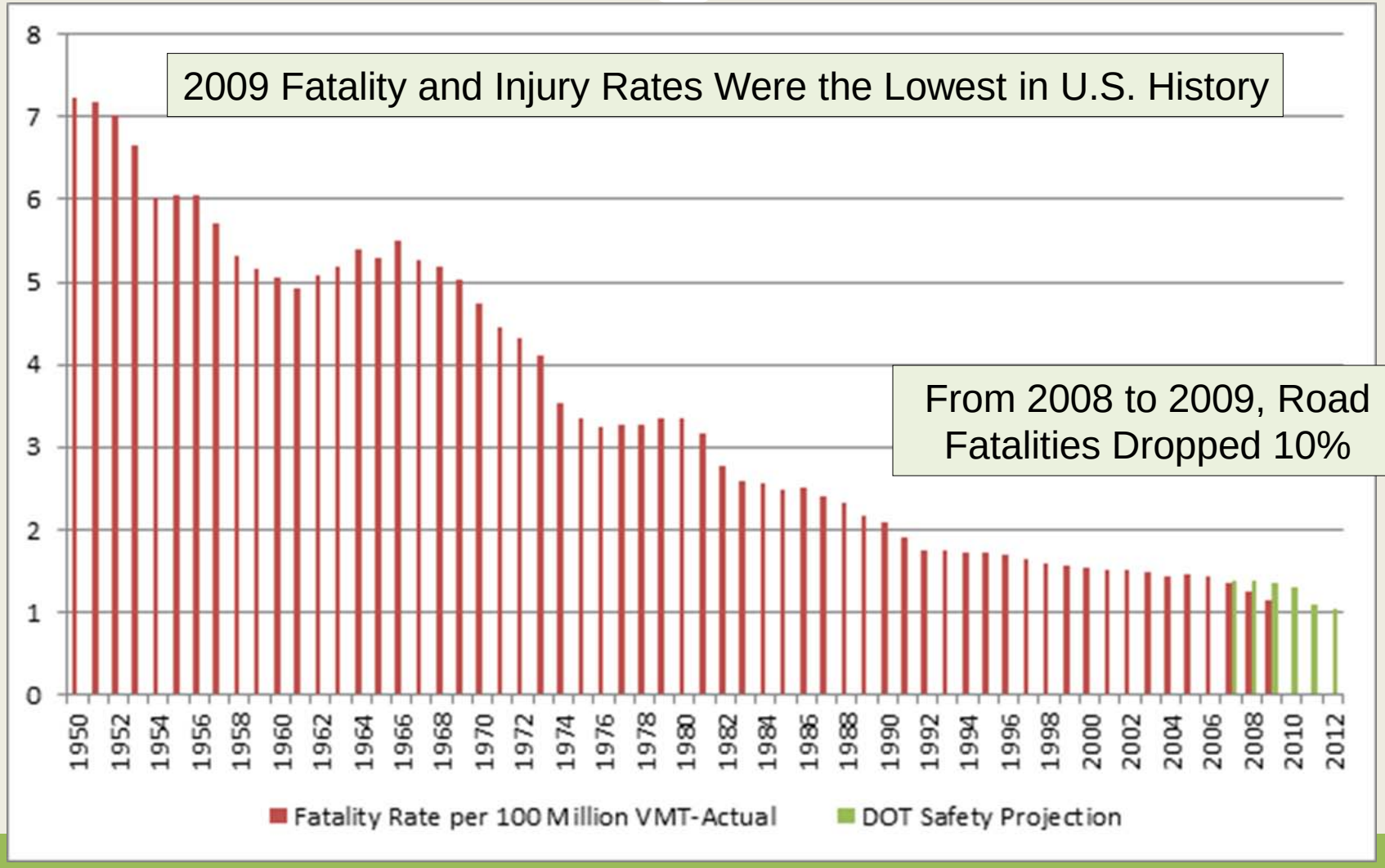
- Flexible/Adaptable Rulemaking Process Leading to a Single National Fuel Economy Program Post-2016
- Protect the Current Safety "Flight Path"
- Assure That the Studies the Agencies Rely on Reflect Real-World Constraints and Commercial Uncertainties

Process

- Single Coordinated National Program
- Realistic, Practical, Commercially Achievable Standards
- Flexible and Adaptable Rulemaking Process that Periodically Re-Assesses Future Developments Against Today's Long-Term Predictions

The Degree and Timing of Improvements Being Studied are Unprecedented

Progress Worth Preserving



Mass Reduction: Finding the Sweet Spot

- Fuel Economy/GHG Rules Must Contemplate and Balance Design/Safety Effects and Significant Mass Reductions
  - Significant Mass Reduction Requires Comprehensive Vehicle Platform Redesign
  - Potential for Real-World Safety Effects from Significant Fleet and/or Segment Mass Reductions Must be Investigated and Understood

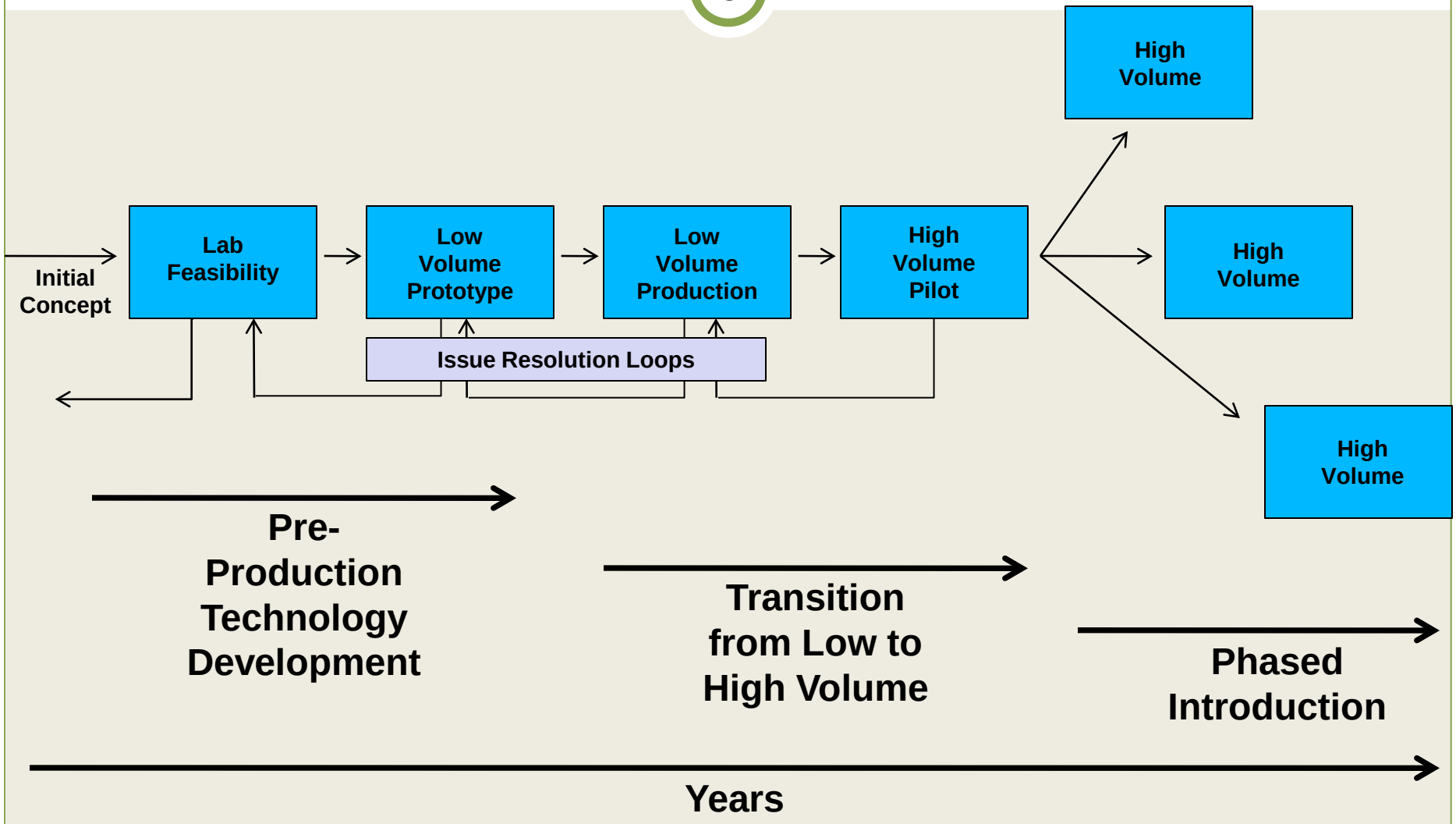
Mass Reduction: Finding the Sweet Spot

- Periodic Review is Needed to Assess
  - Improvements in Design and Material Technology
  - Consumer Affordability /Acceptance
  - Economic Viability
  - Potential Mass Increases Associated With Future Safety Requirements and Voluntarily Provided Equipment
  - Potential Safety Impacts of Significant Mass Reduction
    - Timing and Effectiveness of Advanced Crash Avoidance Technology
    - Potential Further Improvements in Crashworthiness

Design Cycle

- Automakers Typically Implement Many Major Changes at One Time (e.g. 4-6 years with mid-cycle “refresh”); Makes it Difficult to Glean Out Effects of Individual Improvements
- Major Powertrain Components Have an Even Longer Lead-time (8+ years life cycle)
- Since Plant and Process Overhauls Accompany Platform Changes, it is Difficult/Costly to Incorporate Major Improvements Mid-product Cycle
- Depending Upon Degree of Change, Plant/Processes May Take Even Longer
- Model/Platform Replacement is Phased and Does Not Occur For the Entire Product Portfolio at the Same Time

Implementation of Innovation
Managing Uncertainty



The Challenges of Advanced Materials

- Manufacturability and Lead-Time for Major Changes in Manufacturing Processes – i.e., Transition from Stamping/Welding to Casting/Bonding
- Implementation of Special Processes to Address Joining and Corrosion Issues
- Increased Demand for New Application of Materials
- NVH, Durability & Vehicle Safety Performance – Ensuring All Important Performance Requirements are Met
- Damage Identification and Reparability
- Potential Unforeseen Consequences

Recommended Lotus Study Improvements

- Examine Multiple Body Types
- Consider the Mass Efficiency of Entire Vehicle
- Address Materials Supply Issues
- Validate New Structural Designs
- Include Capital, Engineering, Development and Tooling Costs for Integration of New Materials
- Consider Manufacturer Design Cycles and Need for Pilot Introduction of New Technology/Manufacturing Processes

Lotus Study Leaves Detailed Safety Analysis to NHTSA

Comparing Lotus Costs to TAR, NAS, and SuperLightCar

NAS Estimate of Cost to Reduce Vehicle Mass (3600 lb vehicle)

1%	low $1.28/lb,	high $1.54/lb,	Ave $1.41/lb
2%	low $1.33/lb,	high $1.60/lb,	Ave $1.46/lb
5%	low $1.50/lb,	high $1.80/lb,	Ave $1.65/lb
10%	low $1.80/lb,	high $2.16/lb,	Ave $1.98/lb

Super Light Car

14% $1.55/lb, 22% $3.07/lb, 41% $6.11/lb

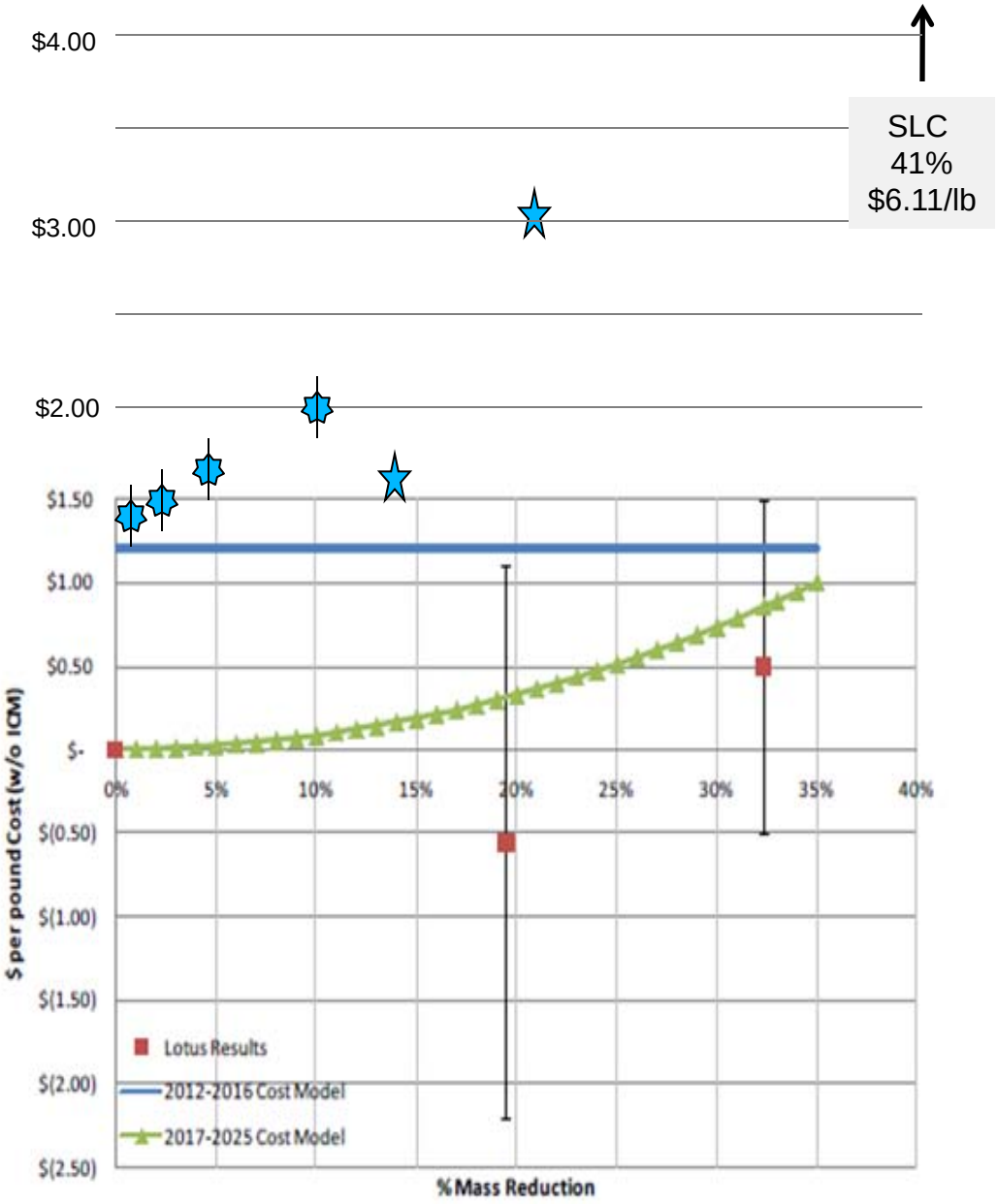


Figure 3.2-1: Mass Reduction Cost Model in Dollars per Pound in Model Year 2020 Compared to the Lotus Results and 2012-2016 Final Rule Cost.

Important Safety Studies

- NHTSA to Track/Study Real-World Safety Trends as More “Mass Reduced” Vehicles Enter the Fleet
- Determine the Best Balance Between the Rate of Mass Reduction and Potential Impact on Real-World Safety
- NHTSA to Conduct the Follow-on Studies Referenced in the 2012-16 Rulemaking and Apply Them to the 2017-2025 Rulemaking

Alliance Members