Magnesium Front End Design And Development (AMD603)

USAMP
2008 DOE Peer Review Presentation
February 28, 2008

Principal Investigator: Dr. Alan A. Luo
General Motors R&D

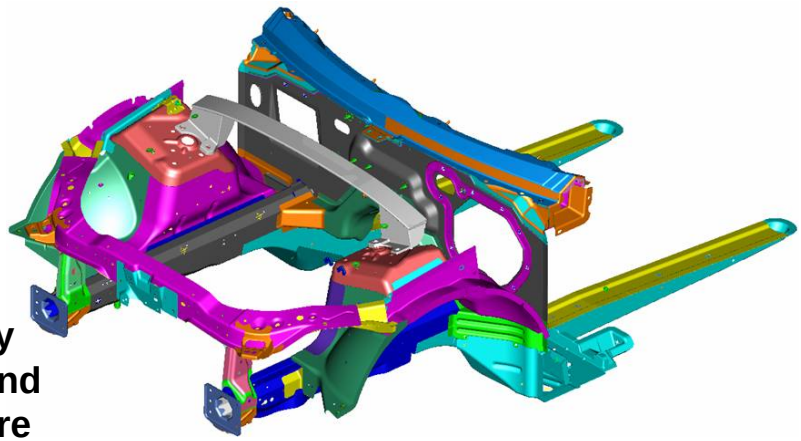
Eric McCarty, Chrysler Corporation (Presenter)

This presentation does not contain any proprietary or confidential information

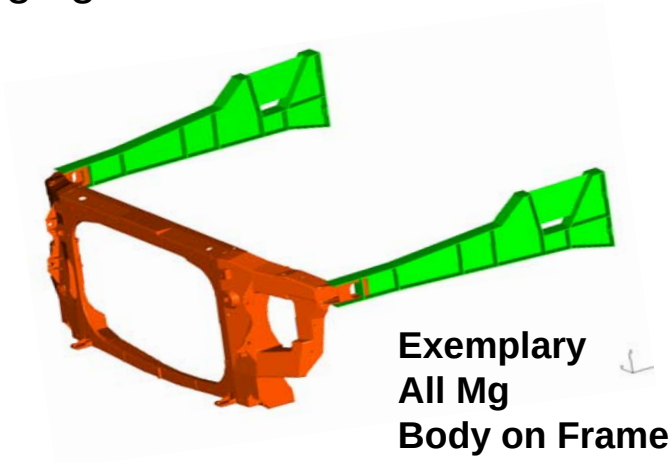
- This material is based upon work supported by the Department of Energy National Energy Technology Laboratory under Award Number DE-FC26-02OR22910.
- This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

Purpose

Provide a rigorous design formalism for automotive magnesium front-end structures, rooted in CAD/CAE methodologies acceptable to USAMP OEM companies. Simultaneously apply technical cost-modeling principles and "enabling technology" data assuring that such designs are indeed practical to construct and eventually manufacture, given emergence of such technologies. While the objectives of the project are closely linked to AMD604, insofar as theoretical opportunities for magnesium in weight reduction of vehicle structures, and accompanying fuel economy benefits, the necessity of maintaining the proprietary nature of such designs limits the practicality of extensive international cooperation and leveraging.



Steel Unibody Front End Structure



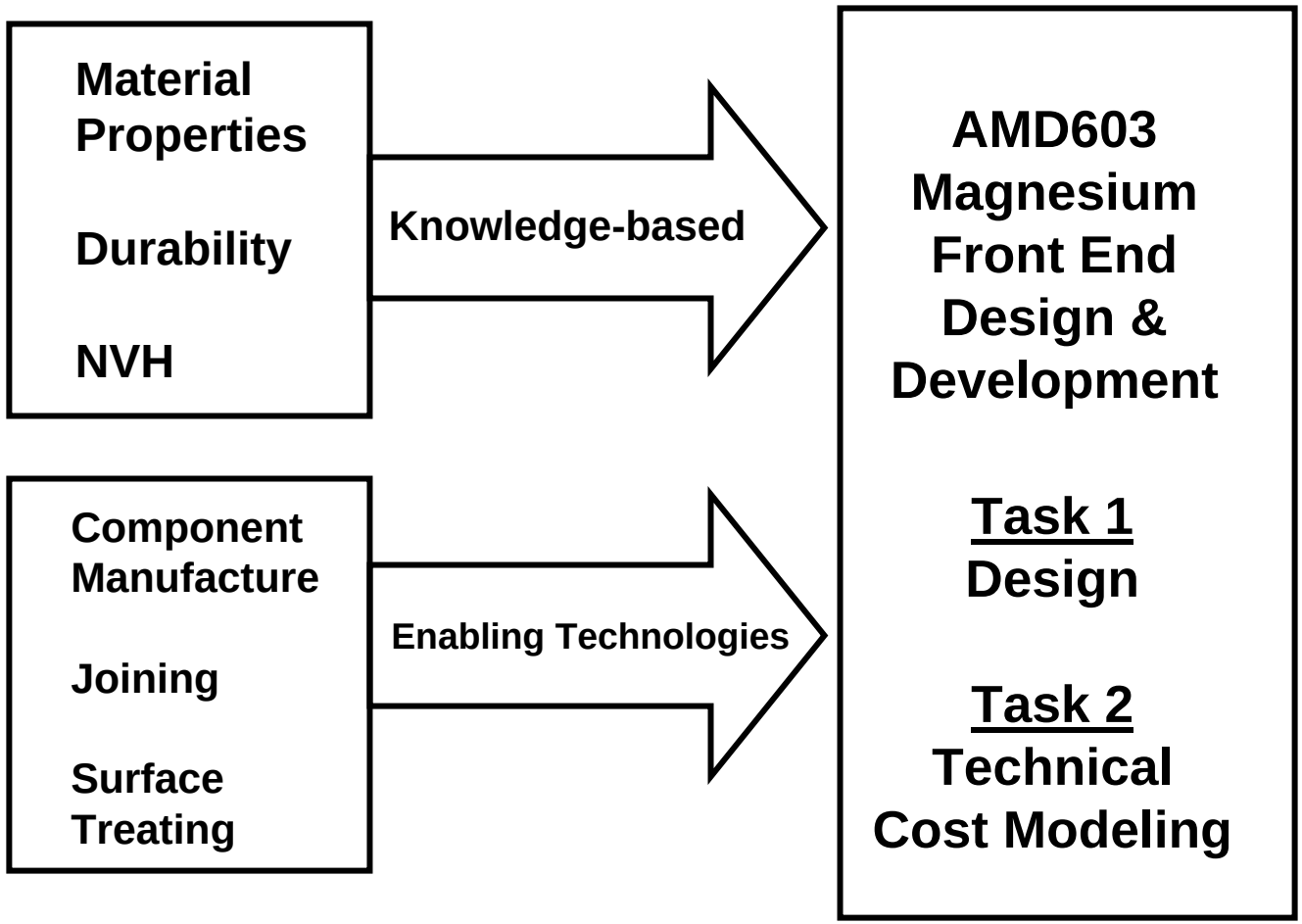
Exemplary All Mg Body on Frame Substructure

edm2@chrysler.com

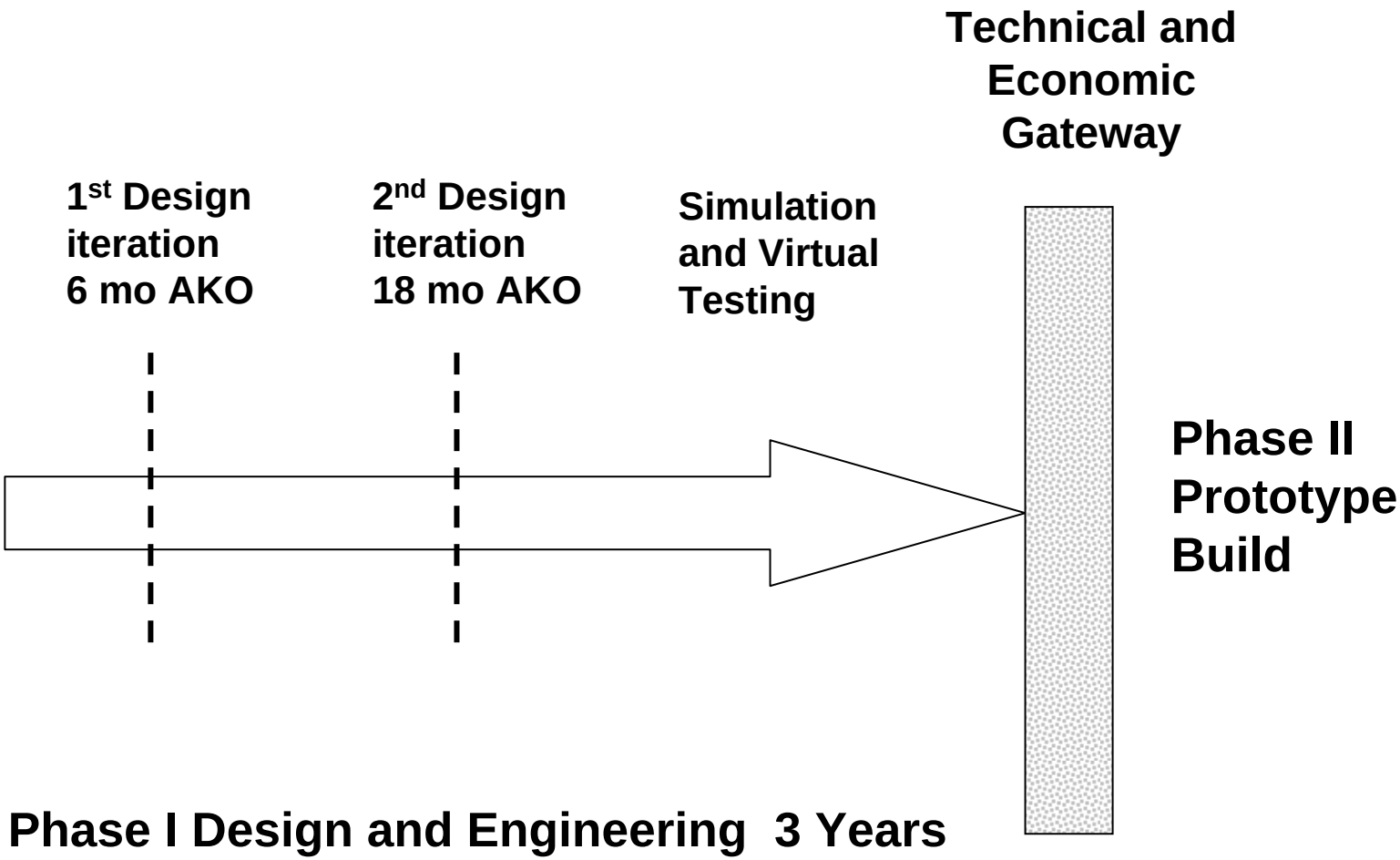
Barriers

- Absence of a design formalism for integrating various magnesium components into a unitized structure.
- Limited knowledge with regard to the high-strain rate mechanical performance of the various magnesium components as would impact “crashworthiness” of such structures.
- Limited knowledge with regard to expected fracture behavior of the constituent magnesium components and associated assemblies, and effect on crashworthiness.
- Lack of manufacturing formalism for large-scale integration of constituent pieces into acceptable structures including surface treating, joining and finishing.
- Absence of a “spot weld” analog which enables fabrication of baseline steel structures at low cost.

Approach


Material Properties
Durability
NVH
Knowledge-based
Component Manufacture
Joining
Surface Treating
Enabling Technologies
AMD603 Magnesium Front End Design & Development
Task 1 Design
Task 2 Technical Cost Modeling

Approach (cont.)



Accomplishments

- OEM Kickoff November 1, 2006
- Suppliers Selected and Contracts Issued
  - Design – Cosma Engineering, Troy, MI
  - Technical Cost Modeling – Camanoe Assoc., Cambridge, MA
- First Design Iteration Completed, Dec. 2008; Design Review Held. (Unibody Design)
  - 1st iteration based on handbook and "best" data from OEM's
  - Part count reduction 58% (79 steel pieces → 31 Mg, 2 Al)
  - Mass reduction – 46% (84.3 kg → 45.9kg)
  - Crashworthiness – based on limited fracture behavior data
    - NCAP 35 mph barrier – comparable to steel
    - IIHS 40 mph offset barrier- acceptable or good rating
  - Modal Analysis – comparable to steel
  - 5 mph bumper – acceptable; corner impact to be adjusted
  - Stiffness - acceptable

Accomplishments (cont.)

Body-on-Frame Design

- Structural elements and basic design determined
- Interacts with Ultra-large Casting Project (AMD406)
- Limited requirements for joining – 3 major structural castings
- Greater reliance on threaded fasteners for joining
- Unique “corrosion protection” scheme to be employed
- Substantial weight reduction over steel baseline

Technical Cost Modeling

- Cost modeling framework adopted
- Inputs from AMD604 manufacturing Tasks to Camanoe Assoc.
- Bill of Process and Materials from Cosma under development

Technology Transfer

- Improved generic design methodologies permit magnesium-intensive structures to be designed for a variety of automotive applications.
- Knowledge flow is through OEM's to supply base and eventually to entire industry.
- Improved materials knowledge from AMD604 and AMD702, 703 aids designers in perfecting and improving design methodology.
- Manufacturing methods improvements (AMD604) from US and International collaborators aid the design community.
- Associations (e.g. NADCA, TMS, IMA) can ultimately provide "design guides" for employing greater amounts of magnesium in structural applications.

Activities for Next Fiscal year

- Complete cost technical cost models for primary Mg production (i.e. Pidgeon Process vs. Electrolytic).
- Begin acquisition of process data for component production from principal methods: die casting, sheet forming and extrusion.
- Complete 2nd design iteration using process and materials properties information feedback from Task Teams by 12/08.
- Refinement of knowledge base on manufacturing assumptions for unibody and body-on-frame structures.
- Increased emphasis on CAE for body-on-frame structure.

Summary

1. Initial design of Mg-intensive unibody front-end structure completed using handbook and OEM-supplied properties data.

2. Weight reduction of 46% relative to steel baseline achieved with non-optimized properties and designs.

3. 58% part count reduction due to consolidation.

4. Acceptable or “good” crashworthiness behaviors estimated from baseline data without imposed failure criteria for magnesium alloys.

5. Acceptable mechanical stiffness and vibrational modes determined.

6. Cost-modeling effort initiated and data acquisition process underway.