

# Magnesium Front End Design and Development

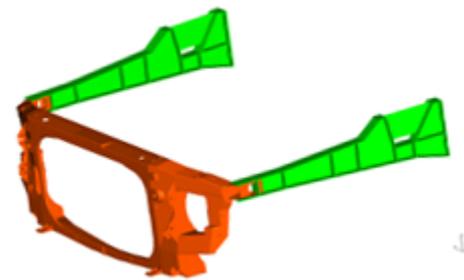
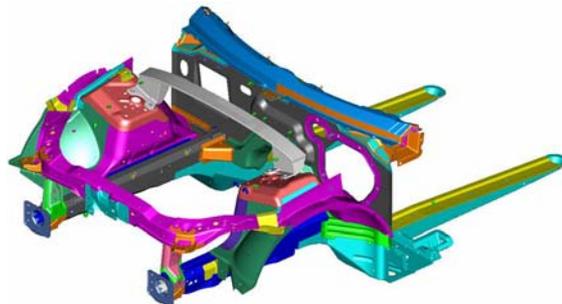
AMD 603

Project ID Im\_21\_quinn

*2009 DOE Merit Review Presentation*

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Unibody  
Architecture



3-piece  
Mg front end  
(body/frame)

# Acknowledgement

This material is based upon work supported by the Department of Energy National Energy Technology Laboratory under Award Number No. DE-FC26-02OR22910.

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# Overview

## Timeline

- Start: Oct. 1, 2006
- End: Sept. 30, 2009
- 60% complete

## Budget

- Total project funding
  - DOE: \$1.1 M
  - USAMP: \$1.5 M
- Funding received in FY08: \$282.1 K
- Funding for FY09 : \$760.9 K
- Funding for FY10: \$0  
(Project ends FY09)

## Barriers/targets

- High-volume manufacturing of magnesium-intensive structures.
- High strain-rate performance of available engineering magnesium alloys.
- Large-scale joining and corrosion protection of magnesium structures.

## Partners

- **OEMs:** Chrysler, Ford, GM
- **Design:** Cosma Engineering
- **Technical Cost Modeling:**  
Camanoe Associates

# Overall Objectives

Design and develop lightweight magnesium front end structures for unibody and body-on-frame vehicle architectures meeting the following criteria:

- Mass reduction 60% less than steel comparator; 35% less than aluminum comparator.
- Shift front-to-rear mass ratio by -1/+1 toward 50/50 (unibody)
- Determine cost parameters relative to steel baseline – target is cost neutral.
- Crash performance target: 5 star frontal, offset and side impact.

## FY2008 Targets

- Conclude 1<sup>st</sup> design iteration based on handbook material properties determined by participants and inputs from AMD604 (MFERD).
- Initiate 2<sup>nd</sup> design iteration incorporating improved material properties and fracture behavior models for magnesium alloys.
- Conduct CAE analyses of crash incorporating high strain rate properties.
- Determine cost model for basic component production.
- Determine cost models for magnesium extraction processes.

## **FY2008 Milestones**

- Completed 1<sup>st</sup> design iteration based on handbook material properties and limited knowledge of precise failure process for magnesium components.
- 1<sup>st</sup> Iteration Design Review conducted Dec. 10, 2007.
- Completed preliminary cost models for Thixomolding, Super Vacuum Die Casting (SVDC), extrusion and sheet forming.
- Developed technical framework for primary Mg production process comparison (electrolytic vs. Pidgeon process).

# APPROACH

## 1. Design

- Iterative methodology 1<sup>st</sup> using handbook or “typical” properties to achieve initial design concepts and structural envelope.
- 2<sup>nd</sup> design iteration based on best technically obtained properties from OEM and supply base, including intended manufacturing methods and materials.
- 3<sup>rd</sup> iteration incorporating the latest properties from companion “Magnesium Front End Research and Development” international project.

## 2. Technical Cost Modeling

- Classic “process-based” cost model approach developed by MIT for comparative assessment of alternatives for achieving a stated design objective.
- In this case, models are developed for component part manufacture by casting, extrusion and sheet forming; and manufacturing methods for assembly of the structures including joining and surface finishing.

## **FY2008 Accomplishments**

- First design iterations complete for unibody and body-on-frame designs.
  - unibody design: 45% mass reduction (84.3kg → 46.1 kg)
  - part count reduction: 55% (79 steel → 33 Mg, 2 Al)
  - body-on-frame design: 47% mass reduction ( 70.7 kg → 37.5 kg)
  - part count reduction: 81% (16 steel → 3 Mg)
- Identified areas for further development
  - unibody crashworthiness: falls short of IIHS and NCAP targets
  - unibody modal (stiffness) generally improved with shortfall at engine cradle attachment points.
  - durability assessment delayed to 2009.
- Technical Cost Models developed for all part forming processes (casting by Thixomolding or Super Vacuum Die Cast, extrusion and sheet forming),
- Modeling framework was developed for primary Mg production processes.

## **Future Work**

1. Design – Conclude 2<sup>nd</sup> design iteration and incorporate projected material properties and manufacturing assumptions (derived from AMD604, MFERD project) for 3<sup>rd</sup> and final design iteration.
2. Determine influence of material deformation and fracture behaviors on crashworthiness performance and implications for 3<sup>rd</sup> iteration designs – e.g. alteration of gauge to achieve crash targets and impacts on achievable weight reduction and part manufacture.
3. Complete primary magnesium extraction technical cost models.
4. Incorporate “best” manufacturing process assumptions into the cost model for producing assembled and finished Mg-intensive sub-assemblies.

## Summary

- The project has demonstrated an initial weight reduction potential for magnesium-intensive structural subassemblies approaching 47% compared to baseline steel structures, with comparable structural stiffness and vibrational modes but at reduced engine cradle attachment stiffness, and with crashworthiness that falls short of IIHS and NCAP targets, based on the current materials models.
- Part-count reduction opportunity, predicated on consolidation possible with magnesium casting technology exceeds 50% for unibody construction and could approach 80% for body-on-frame structures, thereby providing an economic justification for large scale use of Magnesium.
- Crashworthiness remains a crucial issue, due in part, to fundamental metallurgical characteristics of magnesium and components fabricated there from using established technologies.
- Technical cost models for individual component fabrication have been completed, and models will be developed for primary metal extraction and manufacturing processes.