

# ***AMD 601 High Integrity - Magnesium Automotive Components (HI-MAC)***

***USAMP  
2008 DOE Peer Review Presentation  
February 5, 2008***

***B. Cox, Chrysler Corporation (Project Leader)  
Eric McCarty, Chrysler Corporation (Presenter)***

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**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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## ***Purpose of Work***

### **□ The project goals during the 2007 time frame were:**

- Finalize the squeeze and low-pressure casting processes to deliver Mg castings by the end of the first quarter 2008 for investigation and evaluation.
- Evaluate potential of emerging (new) Mg casting technologies.
- Meet all funding and in-kind support activities in accordance with the projects original Statement of Work (SOW)
- Coordinate HI-MAC Project Activities in accordance with USAMP's previously published document: "***Magnesium Vision 2020***", and the American Foundry Society Division 6 publication: "***Magnesium Casting Roadmap***"

## *Critical Barriers to High Integrity Magnesium Casting*

### **Low Pressure Permanent Mold Casting**

- Not developed for magnesium

### **Squeeze Casting**

- Not developed for magnesium

### **Ablation**

- Not developed for magnesium

### **Metal Transfer**

- No pump to have a controlled fill of magnesium

### **Thermal Processing**

- Affordable heat treat cycles for magnesium

### **Microstructure Control**

- Affordable grain refining techniques for magnesium
- Standards for grain refinement

### **Computer Modeling**

- Lack of material property database
- Flow and solidification modeling
- Hot tearing modeling

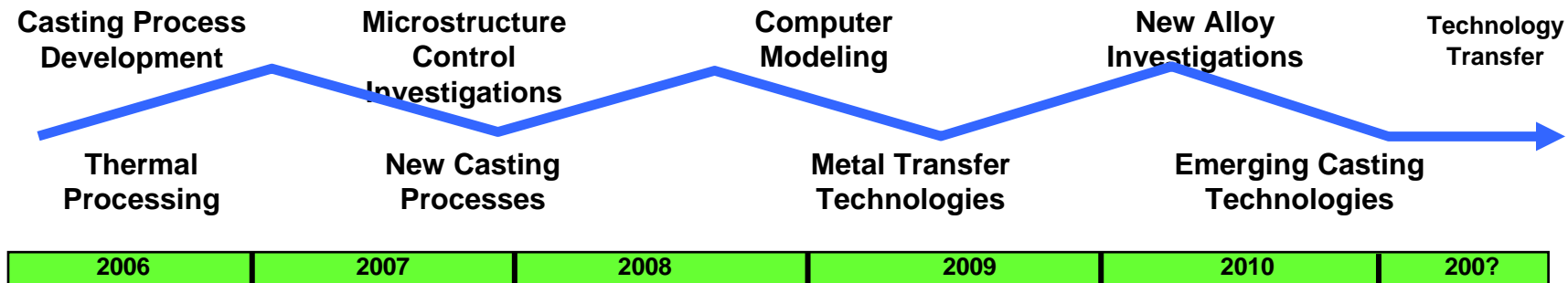
## ***Approach***

- Convert Existing Aluminum Casting Processes to Magnesium, Produce Components for Testing and Overcome Technical Barriers**
  - **Develop High Integrity Casting Processes using Magnesium to Produce Suspension and Chassis Components**
- Coordinate both the Industrial and Scientific involvement to complete all SOW items on time and within budget**
- Overcome Financial Barriers**
  - **Produce Components at Cost, Neutral or Less Than Current Aluminum Components**

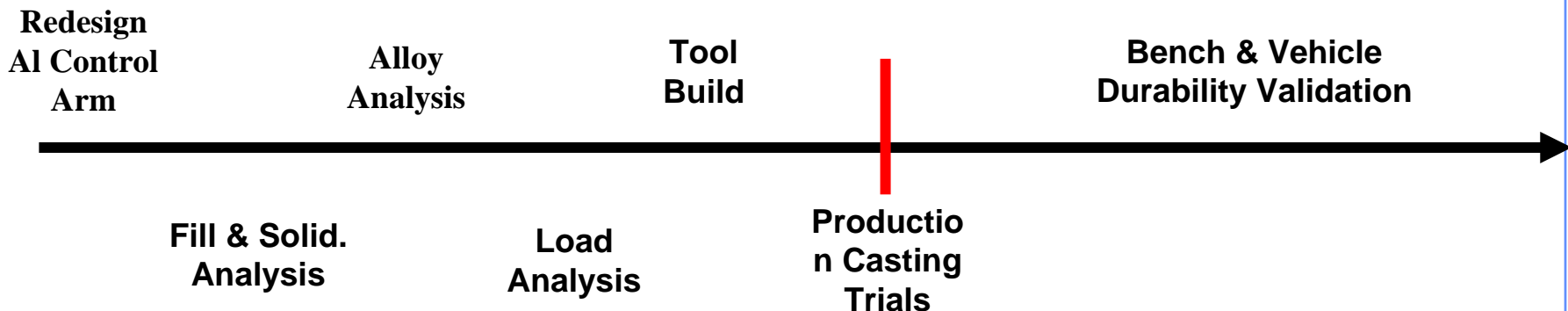
# Approach

## Dual Activity Path

### Scientific Development



### Industry Control Arm Demonstration Component



# Approach

## CURRENT STATE

- ❑ High Pressure Die Casting
  - Lack of Consistent Properties and lack of Ductility
- ❑ No process development in magnesium for squeeze casting (SC)
- ❑ Limited process development for low pressure (LP) casting of magnesium
- ❑ No process and alloy development for ablation
- ❑ No pump to transfer molten metal in controlled amounts for LP casting of magnesium.
- ❑ High Cost of Heat Treatment
- ❑ High cost of Grain Refining
- ❑ No computer modeling of flow and solidification and material properties for modeling

## ROADMAP

- ❑ Convert aluminum casting processes to magnesium
  - Squeeze Casting
  - Low Pressure Permanent Mold Casting
  - Lost Foam
- ❑ Develop ablation for use with magnesium
- ❑ Develop a pump for controlled molten transfer of magnesium
- ❑ Develop affordable grain refining techniques for magnesium
- ❑ Develop affordable heat treat cycles for magnesium
- ❑ Develop material properties for computer modeling for flow and solidification

## FUTURE STATE

- ❑ Squeeze Casting process to produce cost effective magnesium components
- ❑ LPCasting process to produce cost effective magnesium components
- ❑ Ablation Casting process to produce cost effective magnesium components
- ❑ Cost Effective magnesium grain refiners
- ❑ Cost effective heat treat cycles
- ❑ Computer models to predict flow and solidification for all of the magnesium casting processes.
- ❑ Recycling methods for all magnesium alloys
- ❑ An environmentally favorable cover gas



## ***Technical Accomplishments & Results***

- ❑ Cost expenditure match original budget numbers; In-Kind Support meets or exceeds forecasted numbers
- ❑ Project Team has 46 active participants from the Big 3; industry and academia. All support the project functions including Quarterly Review Meetings; conference calls; visits to participating project participants facilities and or Universities.
- ❑ Four new Mg casting processes have been/or are being developed and Mg front lower control arms have already been produced from two of the processes.
- ❑ Microstructure properties and modeling techniques are being identified for the different types of mg alloys that have already been cast.
- ❑ The *Magnesium Vision 2020 Document* (developed by the SCMD Project) and the *AFS Magnesium Roadmap* are used by the HI-MAC Project Team as the new Mg casting processes are developed.

# Technology Transfer

□ Technology developed from the new processes and castings cells indicated below will provide industry with entirely new concepts for reducing costs and improving the integrity of Mg castings. This technology will be transferred through publications, technical meetings, production of actual parts and the issuance of a final report. .



**Squeeze Casting Cell**



**Low Pressure Casting Cell**



**Mg Front Lower  
Control Arm**

## *Activities for Next Fiscal Year*

- Completion of the four new casting processes and cells will provide industry with higher integrity magnesium automotive castings that can be manufactured at a more economical initial set-up cost.
- The HI-MAC Project Team will provide mg castings from all four new processes by the end of the first quarter 2008 for testing and evaluation.
- The HI-MAC Project Team will continue to complete all SOW Project Tasks in accordance with the original project timing and budget costs.

## ***Relationship to FreedomCAR***

”Enable the high volume production of vehicles that are: half the mass, are more recyclable, match or surpass quality & durability versus today’s vehicles”

**HI-MAC Project will enable reduced vehicle mass by enabling use of light weight cast magnesium for highly loaded components through:**

- **Lower Manufacturing Costs**
- **Lower weight reduction of casting components. Mg is 35% lighter than aluminum, and 65% lighter than cast iron.**
- **Improved Casting Quality Requiring Lower Porosity and New Casting Methods**
- **Infrastructure Development**
- **HI-MAC Addresses the Near and Mid Term Metalcasting Development Needs Identified in the Proposed Magnesium Plan**

**HI-MAC Project Will Address Three Key Issues:**

- **Equipment Adaptation**
- **Casting Process Development**
- **Development of Casting Tools**

## Summary

- ❑ HI-MAC Project has continued the Mg Project type work that originally started with *The Structural Cast Magnesium Development (SCMD)* and the *Magnesium Powertrain Cast Component Project*.
- ❑ Within 14 months after project approval, Mg castings have been cast by four new processes. The project team will investigate the material properties from all four processes before the project is completed,
- ❑ Cost expenditures match the original budget numbers, and In-Kind support meets or exceeds forecasted numbers.
- ❑ Seven different Universities are actively involved in the HI-MAC Project, including students from Undergraduate to PhD levels.
- ❑ The *Magnesium Vision 2020* Document (developed by the SCMD Project) and the *AFS Magnesium Casting Roadmap* are used by the HI-MAC Project Team as the new Mg Casting processes were developed.
- ❑ In addition to all of the above, the HI-MAC Project will provide technical support to the Magnesium Front End Research and Development Project (AMD 604).

## ***Publications and Presentations to Date***

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- ❑ **Beckerman,C., Prediction of Porosity and Hot Tears in Magnesium Castings at Materials Science and Technology (MS&T)2007 Conference, Detroit, MI September 2007.**
- ❑ **XueY, Horstemeyer MF, McDowell DL, El Kadriri H, Fan J, Microstructure-based multistage fatigue modeling of cast AE44 magnesium alloys, Int J of Fatigue 2007 ; 29 : 666-76.**
- ❑ **El Kadiri, Xue Y, Horstemeyer MF, Jordan B, and Wang P, Fatigue Crack Growth Mechanisms in a Die Cast AM50 Alloy, Acta Materialia 2006 ; 54 :5061-76.**
- ❑ **Low Pressure Casting of Magnesium Alloys for Automotive Components; Greg Woycik, CMI Equipment & Engineering; American Foundry Society-111th Metalcasting Congress, May 15-18, 2007.**
- ❑ **Magnesium Casting Technology Update; David Weiss, Eck Industries, Inc. ; American Foundry Society-111th Metalcasting Congress, May 15-18, 2007.**
- ❑ **HIMAC; Magnesium Squeeze Casting Update ; Brian Szymanowski, Contech ; American Foundry Society-111th Metalcasting Congress, May 15-18, 2007.**
- ❑ **High Integrity Magnesium Automotive Components (HIMAC) ; Bruce Cox, DaimlerChrysler NA, American Foundry Society-111th Metalcasting Congress, May 15-18, 2007.**

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# Thank You Questions