

# Development of Integrated Die Casting Process for Large Thin-Wall Magnesium Applications

Award # DE-EE0005753

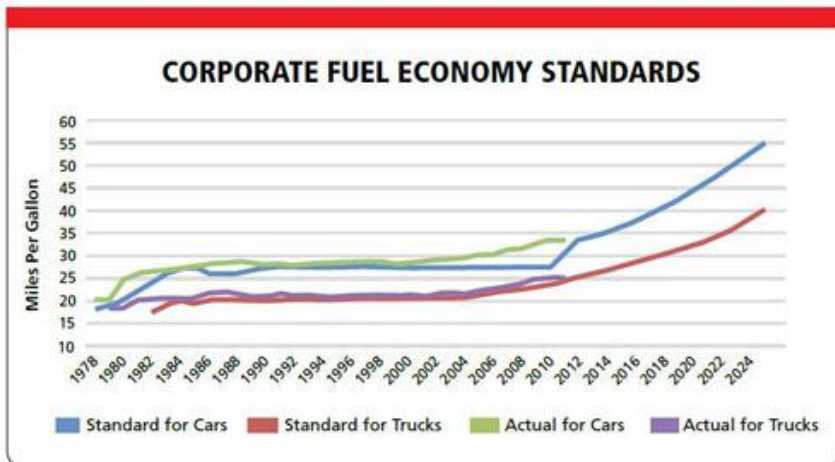
Partners: The Ohio State University, Meridian Lightweight Technologies  
September 2012 – February 2016

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Jon T. Carter, General Motors Company

U.S. DOE Advanced Manufacturing Office Peer Review Meeting  
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# Project Objective



**Problem:** CAFE standards require significant vehicle weight reductions by 2025.

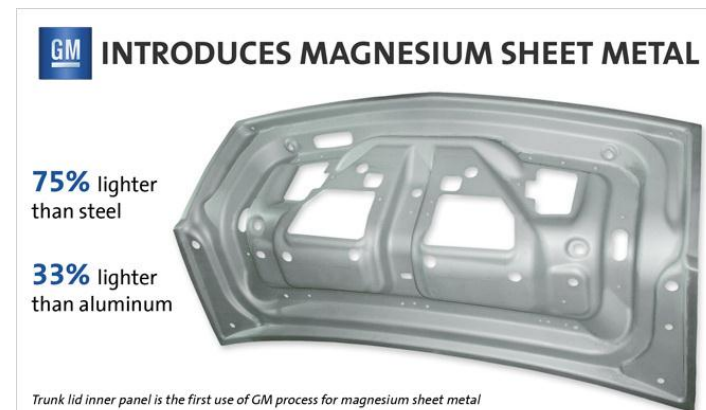
- ✓ Solution must include a manufacturing process scalable to annual production of millions of vehicles.
- ✓ Vehicles must be competitive in cost, size, quality, and performance.
- ✓ Must meet safety standards.

## **Solution: Design Magnesium die cast automotive components and develop manufacturing process**

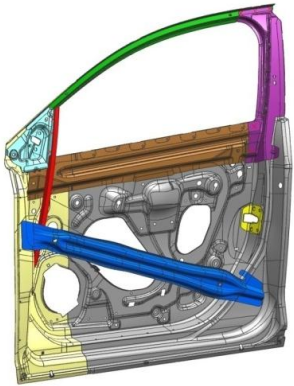
- Density of Magnesium =  $1.7 \text{ g/cm}^3$ , vs. Aluminum (2.7) and Steel (7.8)
- Die casting → metal only where you need it; minimal yield loss
- Die casting → no rolling or welding
- Die casting → scalable to mass production
- Compatible with complex geometric features

## **Objective: Design, cast, fabricate, test**

- Buick LaCrosse door
- Head-to-head comparison—Magnesium vs. Steel



# Technical Approach

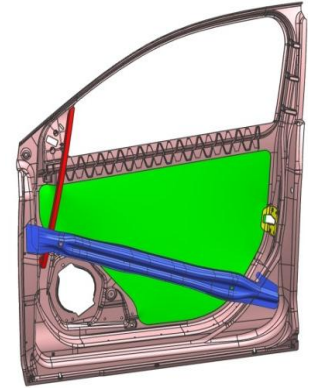


## Today

- Sheet steel pieces with different thicknesses
- Welded and hemmed together
- Stamped into shape
- Excess discarded
- Some headerless have Mg panels, but typ. >3mm

## New Approach

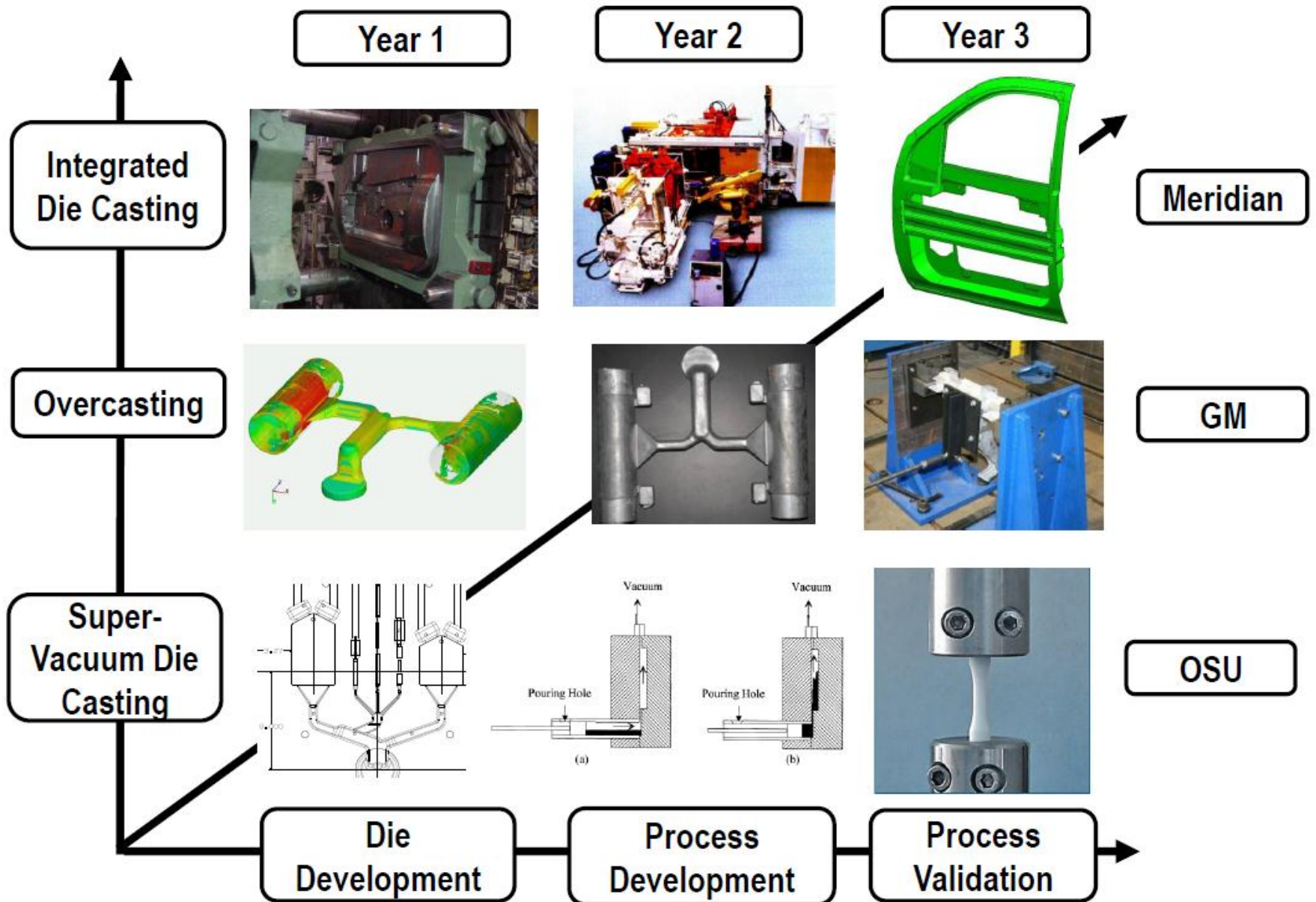
- Single Mg component + steel reinforcing bar
- Advanced Mg-Al-Sn alloy for higher strength and ductility
- Super vacuum die casting for complete fill
- Improved ductility with less entrapped air
- Meridian, EDAG, and GM have experience with die cast Mg components



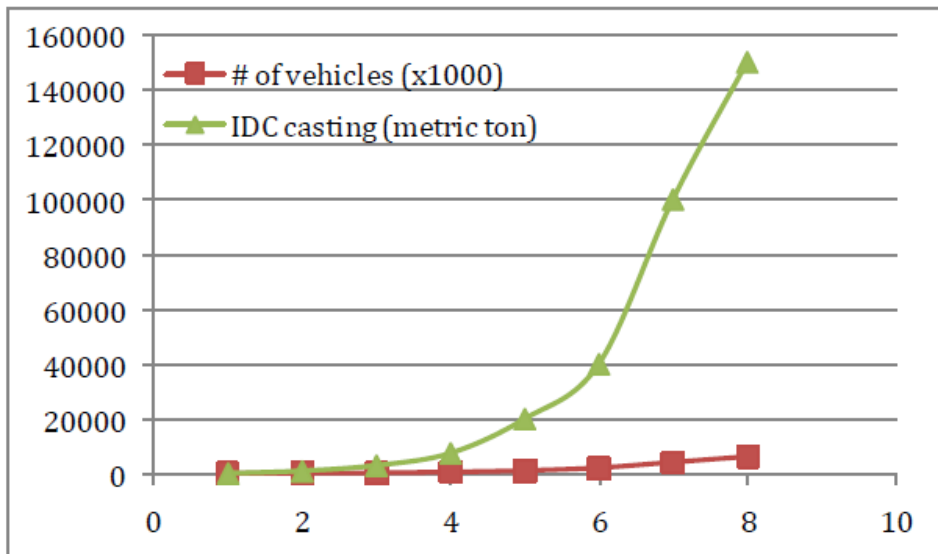
## Why this is a difficult problem:

- Low modulus of Mg → need design innovations to compensate
- Cannot cast closed sections → need design innovations to compensate
- Pushing the state-of-the-art for production wall thicknesses: 3mm → 1.5mm
- Complete filling of die cavity—significantly more difficult with thin walls
- Galvanic corrosion if Mg touches steel in wet areas
- Sharp fracture edges must be managed (ductility lower than steel or aluminum)

# Integrated Die Casting (IDC) Process Project Scope



# Transition and Deployment



Projected commercialization ramp-up in years from project completion date

Market: automotive

Applications: side doors, cars and trucks

## Benefits

- Reduced part count
- Fewer manufacturing steps
- 50% less embodied energy
- 50% less weight
- Improved fuel economy, economical route to meet CAFE standards

# Transition and Deployment (continued)

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## **Commercialization approach**

1. Implement at GM:
  - Estimate the cost penalty and door mass reduction likely with this technology
  - compare with the \$/kg-reduced for other technologies
  - implement on an appropriate car model.
2. After GM success, Meridian will aggressively market the technology to other automotive OEMs and other manufacturers

**Technology sustainment model:** Pursue continuous improvement to cut the cost penalty per unit mass reduction, and thereby allow for more widespread implementation.



# Measure of Success

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## **Success**

- A low-energy, lightweight, door technology option for car makers

## **Energy impact** (from technical energy models)

- 50% (0.1 Million Btu per door) less embodied energy than current sheet steel door.
- 7.4 kg/yr/vehicle CO<sub>2</sub> reduction through improved vehicle fuel economy due to 60% door mass.

## **Economic impact** (from technical cost models)

- Goal: \$1,500,000 cost saving per 100,000 panels vs. steel.

# Project Management & Budget

	<b>DIE DEVELOPMENT (Budget Period 1) 9/1/12 - 5/31/14</b>
<b>Task 1</b>	<b>Die design, simulation and manufacturing</b>
<b>Milestone 1</b>	Delivery of test specimen die, vacuum capability, overcasting die, and door inner die design.
<b>Gate 1</b>	Die Review (Complete cavity fill and 1.5-2 mm thin-wall capability)
	<b>PROCESS DEVELOPMENT (Budget Period 2) 6/1/14 - 4/30/15</b>
<b>Task 2</b>	<b>Casting process development</b>
<b>Milestone 2</b>	Delivery of door inner die, SVDC, overcasting and IDC process parameters and test specimens/castings.
<b>Gate 2</b>	Process Review (less than 1% porosity and 1.5-2 mm thin-wall capability)
	<b>TESTING AND VALIDATION (Budget Period 3) 5/1/15 - 2/28/16</b>
<b>Task 3</b>	<b>Testing and validation</b>
<b>Milestone 3</b>	Delivery of specimen, component and door system test results
	<b>PROJECT MANAGEMENT (All 3.5 years / entire project period)</b>
<b>Task 4</b>	<b>Project planning, coordination and reporting</b>
<b>Milestone 4</b>	Delivery of energy efficiency of integrated die casting process
<b>Gate 3</b>	Final Review (50% energy efficiency improvement, economic benefits)

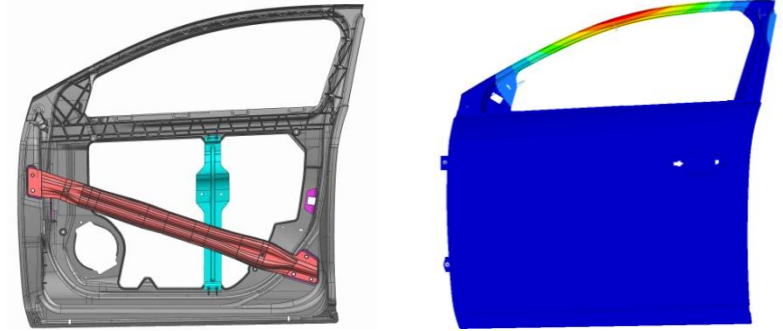
<b>DOE Investment</b>	<b>2672</b>
<b>Cost Share</b>	<b>668</b>
<b>Project Total, k\$</b>	<b>3340</b>



# Results and Accomplishments

## Status

Completing Task 1: Design, Simulation & Manufacturing



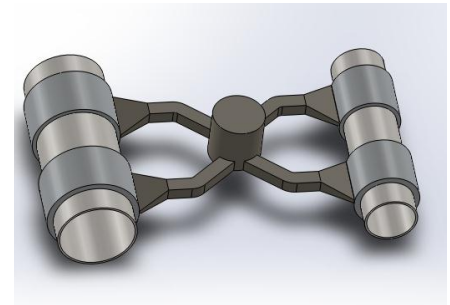
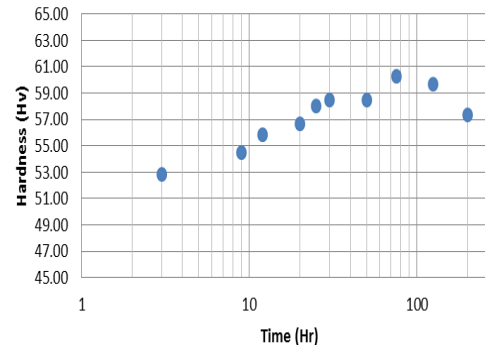
## Milestones & Results

Door designed with CAD/CAE

Tensile/fatigue specimen die tested

Overcasting die designed

Age hardening of Mg-7Al-2Sn



## Work to do

Design door die

Develop casting and heat treating processes.

Build and test doors and components.

