U.S. DEPARTMENT OF
ENERGY

Office of
ENERGY EFFICIENCY &
RENEWABLE ENERGY

The Challenges of Lightweighting Vehicles

(and how the government is here to help)

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First, why lightweight?

Compliance with Regulations

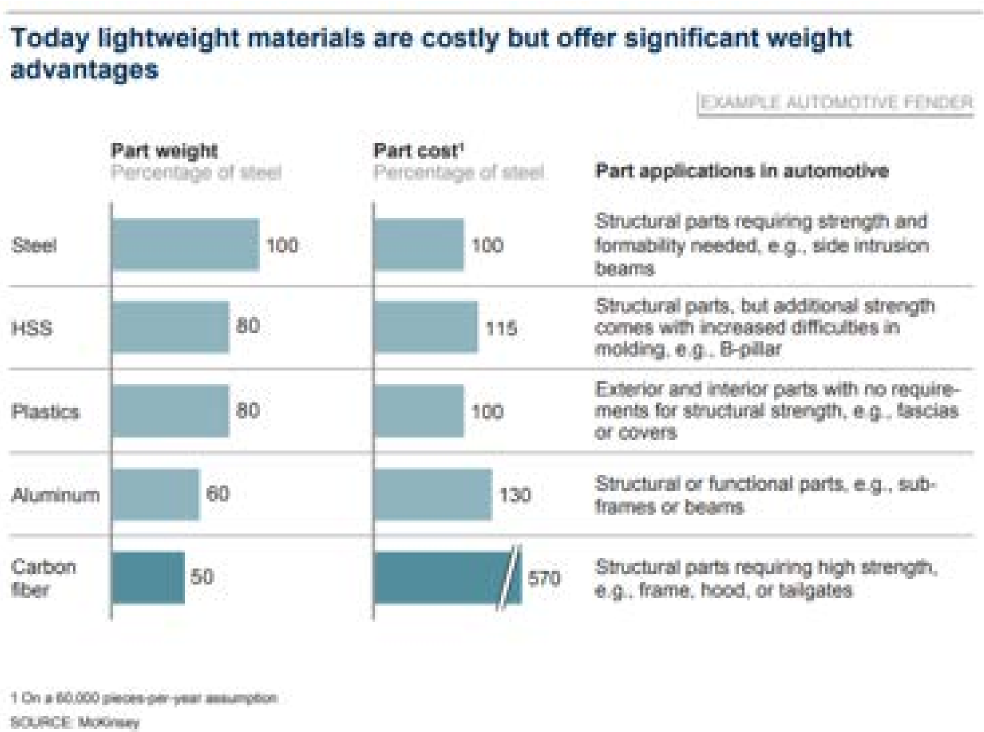
Delight Consumers

Lightweight Vehicles are a Reality

When cost is not a constraint, extreme lightweighting can be achieved.

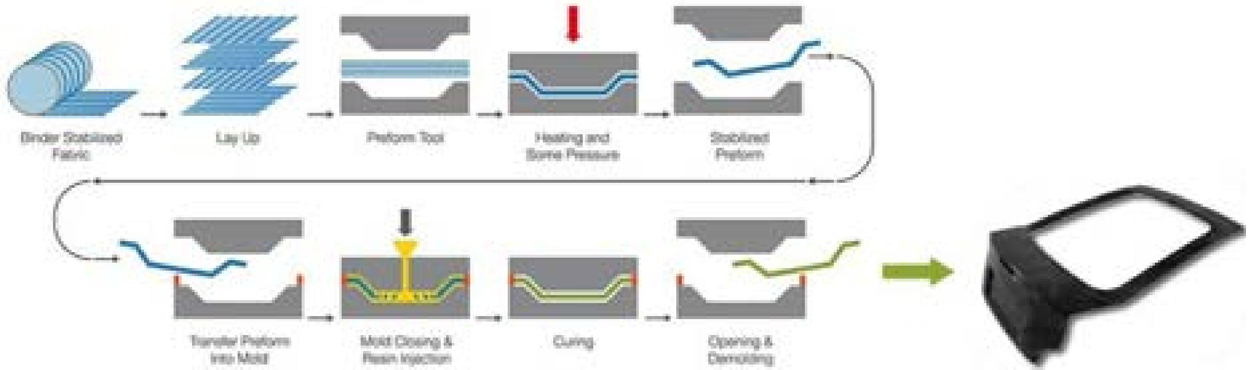
Challenge: Cost of Materials

Lightweight materials – such as raw magnesium, the rare earth elements that are used in magnesium alloys, carbon fibers, and even aluminum – are more expensive than traditional steel components on a raw material basis.



Challenge: Cost of Processing

- Carbon Fiber Composite components have a long cycle time

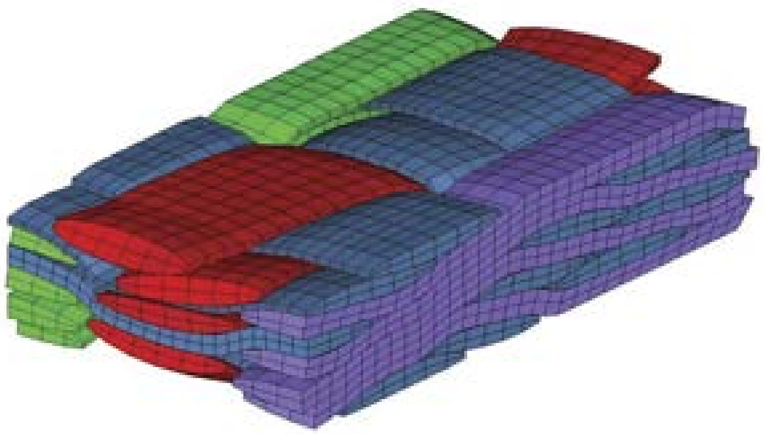


- Magnesium sheet alloys, high strength aluminum, and AHSS have low room temperature ductility

Challenge: Designing Multi-Material Vehicles

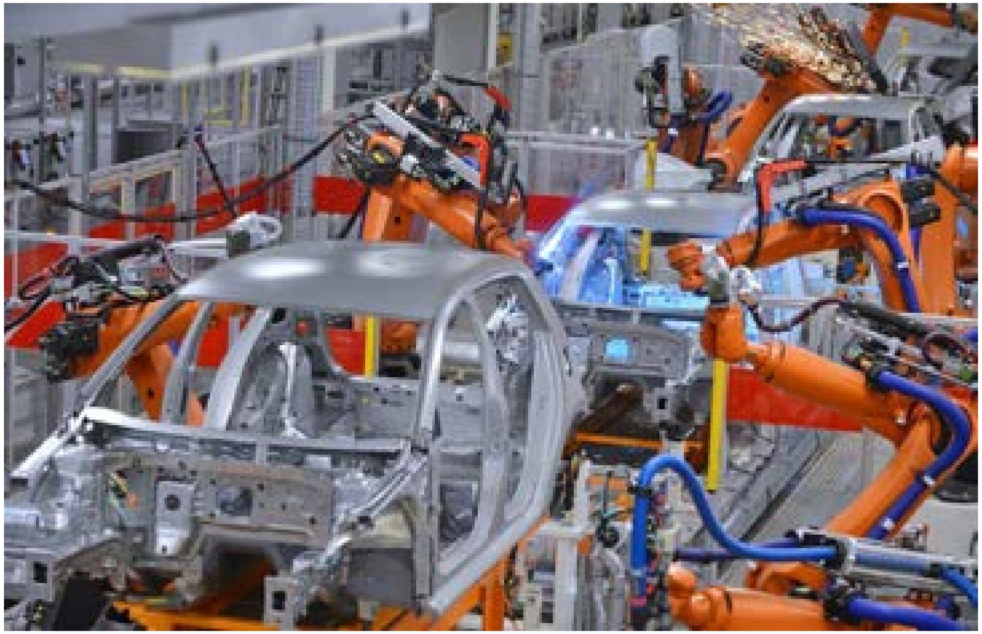
DP 350/600 HSLA 350/450

Experience designing components made from single phase steel and predicting and testing their performance is not always applicable to new lightweight materials.



Challenge: Manufacturing Multi-Material Vehicles

Legacy systems for capturing scrap for recycle, priming and painting, and welding components into assemblies don't apply to multi-material structures.



Challenge: Joining Lightweight Materials

- Coefficient of Thermal Expansion mismatch
- Formation of brittle intermetallics
- Liquid Metal Embrittlement
- Galvanic Corrosion
- Heat affected zones destroy properties
- Stress concentration
- Extra processing steps for pilot holes and surface cleaning
- Lack of NDE techniques and in-line process controls

So should we give up on lightweighting?

"I'm with the government, and I'm here to help"

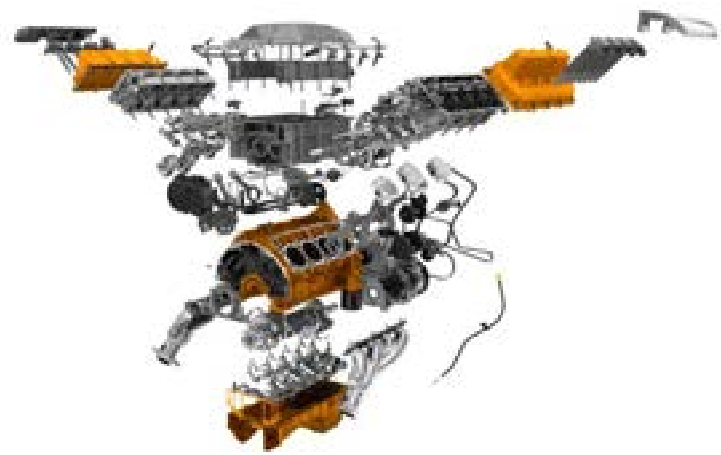
Materials Technology Program

Lightweight Materials enable an improvement in fuel economy through vehicle mass reduction.

Research areas include:
- Sheet Metals (Al, AHSS, Mg)
- Carbon Fiber Composites
- Multi-Material Joining

Propulsion Materials enable an improvement in fuel economy through increased engine efficiency.

Research areas include:
- Cast Metals (Al, Cast Iron, Stainless Steel)
- High Temperature Alloys (500 – 1100 C)



Program Goals: 25% glider weight reduction at less than $5 / lb-saved and 25% improvement in high temperature component strength by 2025.

Low Cost Carbon Fiber

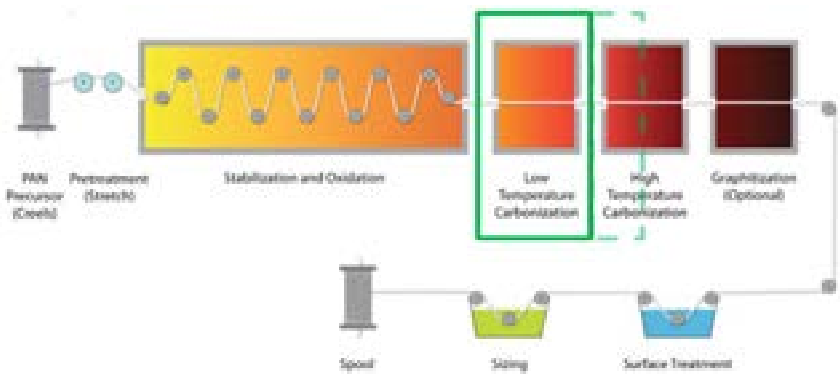
Close Proximity Electromagnetic Carbonization (CPEC)

Oak Ridge National Laboratory, Oak Ridge, TN

Other Participants: RMX Technologies, 4M Industrial Oxidation. C.A. Litzler Company

Objective

Develop a faster and more efficient carbonization process to reduce energy consumption in the carbon fiber conversion process and therefore total carbon fiber cost.



October 2015 – September 2018

Total DOE budget: $4.5M

Innovations

- Uses electromagnetic coupling to directly heat the fiber, rather than surrounding gas.
- Without the need for insulation, furnace wall temperature remains lower than 125C after 30 min of operation as compared to 400 – 600C

Impacts

- Reduce unit energy consumption (kWh/kg) by 50% and operational costs by 25%.
- Produce the same or better quality carbon fiber and demonstrate scale up.
- Projected full scale cost savings of CPEC based upon current capabilities is 48-51% of conventional carbonization.

Low Cost Mg Sheet

Low-Cost Mg Sheet Component Development and Demonstration

USAMP, Southfield, MI

Other Participants: AET Integration, Inc., Camanoe Associates, Fuchs, Henkel Technologies, Quaker Chemical Corporation, PPG Industries, Vehma International of America, Xtalic Corporation, Oak Ridge National Lab., Pacific Northwest Nat. Lab, The Ohio State University, University of Florida, University of Illinois, University of Michigan, University of Pennsylvania

Objective

Demonstrate the feasibility of producing Mg sheet components, with the potential of achieving a mass reduction of 55% compared to conventional stamped steel sheet, with a fully accounted integrated component cost increase of no more than $2.50/lb. saved.

(Door from MFERD Project)

October 2016 – March 2020
Total project budget: $6.75M
DOE Cost Share: $6.56M

Innovations

- Utilizing ICME to design non-rare earth experimental alloys with increased ductility targeting room temperature formability.
- Evaluating and improving pre-treatments, lubricants, coatings, and joining processes to enable greater use of using existing Mg-alloy sheet in automotive manufacturing.

Impacts

- Addresses the major cost barriers to Mg implementation
- Simultaneously and holistically addresses major Mg challenges in cost, corrosion, modeling, and manufacturing.

Designing with AHSS

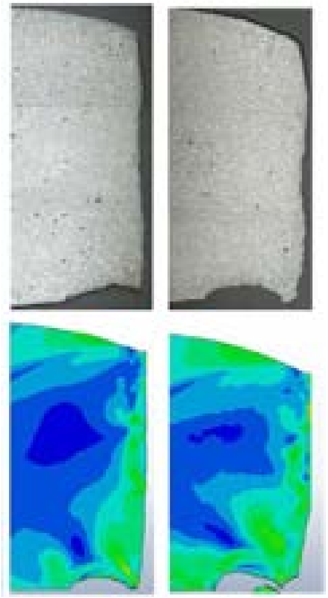
Enhanced Sheared Edge Stretchability of Advanced / Ultra High Steels

Pacific Northwest National Lab, Richland, WA

Other Participants: US Steel, Oakland University

Objective

Enhance the sheared edge stretchability of AHSS/UHSS by developing quantitative and predictive models of the microstructure effects on sheared edge fracture



October 2014 – September 2017

Total project budget: $2.25M

DOE Cost Share: $1.35M

Innovations

- Developing microstructurally-informed models of deformation and fracture for advanced high strength steels
  - Phase strength disparity can be a primary factor influencing the shearing induced edge damage (i.e., plastic strain, voids) for AHSS
- Applying models to develop manufacturing process configurations that reduce trimming damage and increase formability in subsequent processes

Impacts

- Increasing formability allows advanced steels to reduce weight in a broader range of components.
- Coupled computational/experimental approach delivers a validated process simulation tool to the community

Manufacturing Multi-Material Assemblies

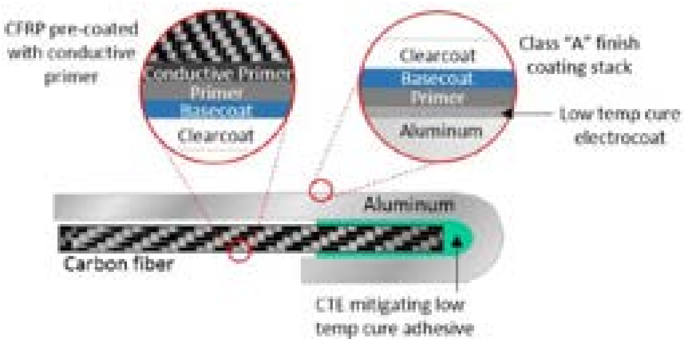
Corrosion Control in CFRP Composite-Aluminum Closure Panel Hem Joints

PPG, Allison Park, PA

Other Participants: Ford Motor Company, Ohio State University

Objective

Develop new coatings and adhesives that cure between 150 and 180° C, new joint geometries, and establish and validate corrosion characterization techniques that enable demonstration and implementation of Al door outer / CFRP door inner hem flange joints.



October 2016 – September 2019

Total project budget: $3M

DOE Cost Share: $2.2M

Innovations

- Investigation of the effect of geometry, adhesive cure, and differential thermal expansion of CFRP and aluminum on the stress and robustness of the dissimilar material joint.
- Determination of the appropriate balance of primer conductivity to allow for e-coating of CFRP while preventing galvanic corrosion

Impact

- Low-cure electrocoat and adhesive technology that enable CFRP processing through an existing paint line and enable more widespread CFRP use beyond closure panels.

Material Technology Roadmap

Increasing Need for R&D ←

↑ Increasing Impact on Reducing Vehicle Mass

Material	Critical Challenges				
Multi-Material Systems Enablers	High Volume Joining (Fusion, Mechanical, Adhesives)	Engineered Surfaces (Corrosion, Wear, Friction)	Predictive Modeling	NDE & Life Monitoring	Recycling
Carbon-Fiber Composites	Low-cost High-Volume Manufacturing	Low-Cost Fibers	Predictive Modeling	Joining, NDE, Life Monitoring & Repair	Recycling (OFFAL / Vehicle)
Aluminum	Low-cost Al Manufacturing Processes	Improved Alloys (Body/Powertrain) for Performance & Manufacturing	Joining Mixed Al Products	Recycling Vehicle	
Ultra High-Strength Steels	Improved Alloys for Room Temp Forming	Weldability for Dissimilar Steel Alloys	Predictive Modeling (Formability, Crash)		
Magnesium	Low Cost Feedstock, Low Carbon Footprint Production	Galvanic Corrosion Protection	Improved Alloys for Energy Absorption	Manufacturing (Sheet and Extrusions)	Recycling
Glazings	Low Cost Feedstock for Polymer Glazings	Low Temp Processed Chemically Toughened Glass	Durable, Scratch Resistant, UV Resistant Coatings		
Metal / Ceramic Composites	Feedstock Cost	Compositing Methods	Powder Handling	Compaction	Machining & Forming

Thank You

Questions for me?

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EERE'S VEHICLE TECHNOLOGIES OFFICE (VTO)

Vehicle Technologies Office

Electrification

Materials Technology

Advanced Combustion Systems & Fuels

Energy Efficient Mobility Systems

Technology Integration

Analysis, Comms, & Operations

VTO develops advanced transportation technologies that:

- ✓ Improve energy ***efficiency***
- ✓ Increase domestic energy ***security***
- ✓ Reduce operating ***cost*** for consumers & business
- ✓ Improve global ***competitiveness*** of US economy

Joining of Dissimilar Lightweight Materials

Goal: Enable the use of the right lightweight material for the application by identifying, validating, and demonstrating joining techniques appropriate for a wide library of material combinations. At cycle time, at cost, meeting corrosion requirements, strength requirements, and aesthetic requirements.

	Al	CFRP	Mg
AHSS	VFAW, FBJ, RSR, RSW, SPR, FAST	Adhesive	FSW, USW
Al	FAST	FBJ, RSR, Low Temp Adhesives	Arplas, Clinch, BSR, FSW, RSW
CFRP			FSI, F-SPR

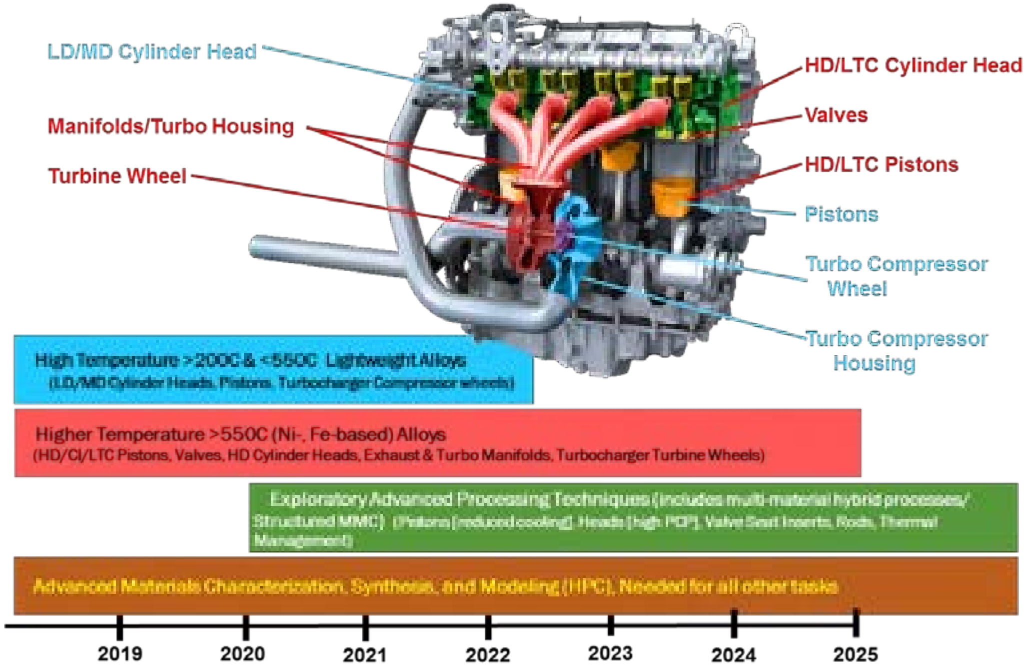
- Mechanical Fastening
- Solid State Joining
- Intermediate materials
- Fusion Welding

Currently 15 active projects supported by $15M in DOE funding

Powertrain Core Materials Program

Goal: Enable powertrain weight reductions and efficiency improvements over a wide range of vehicle classes

Utilizes ICME approach to address materials needs for critical engine components



Impacts:

Enable 15% powertrain weight reduction though a combination of lightweight material utilization and increased engine power density (HP/Kg)

Enable expanded design space for next generation high efficiency engines

HPC4EnergyInnovation

HPC4 Energy Innovation

Lawrence Livermore National Laboratory

BERKELEY LAB

Oak Ridge National Laboratory

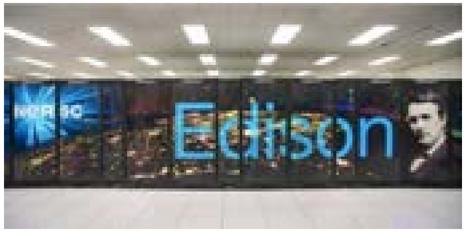
HPC4 Manufacturing

HPC4 Transportation

HPC4 Materials

- Leverages the vast HPC capabilities at the national labs to partner with industry and address critical challenges
- DOE labs possess 4 of the top 10 HPC systems worldwide and broad expertise in their application and dedicated teams of expert practitioners
- Some larger companies use HPC, but struggle to stay current – few small to medium companies use HPC

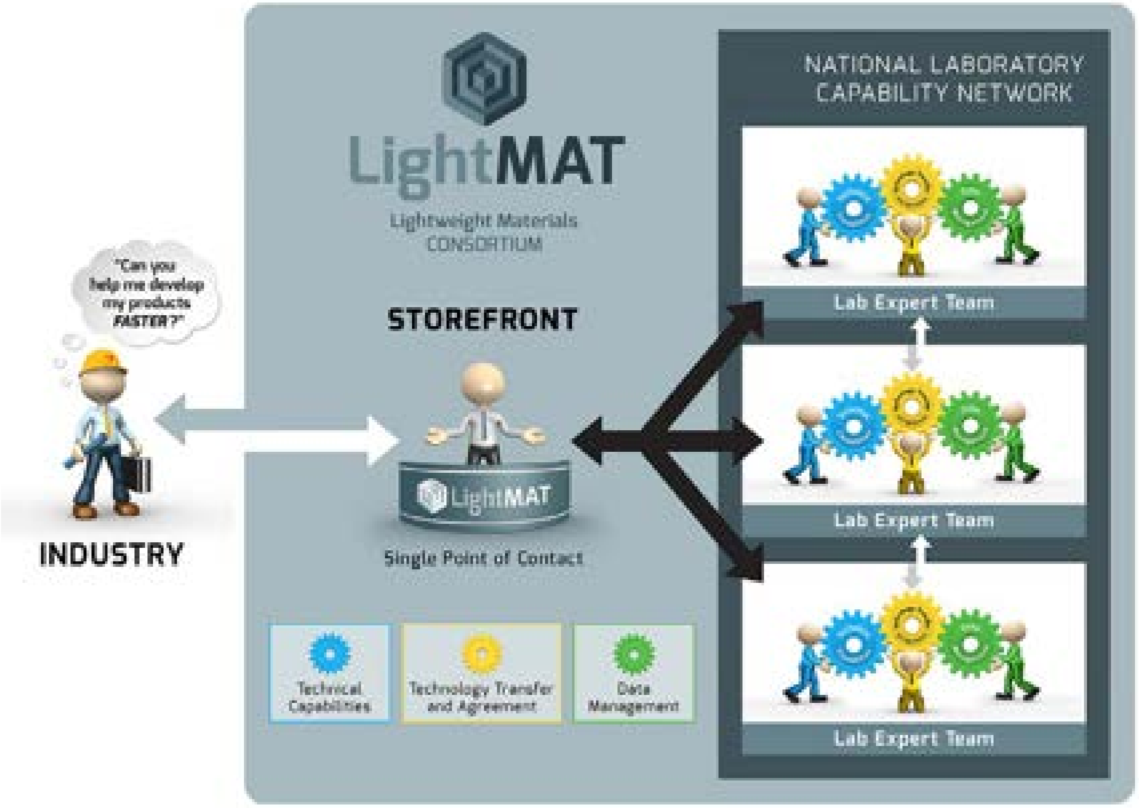
This program introduces the power of HPC to US companies at low risk.



Energy Materials Network: LightMAT

Facilitating connections between industry and the National Labs by:

- Building a network of **unique National Lab resources**
- Providing a **single point of contact** and concierge
- Managing materials **data and tools**
- **Streamlining** the agreements process



http://LightMAT.org

World Class Materials Network

- Capability catalog listing lightweight metals, composites, and joining in place at: https://lightmat.org

- Network is continuously expanded to support a broader selection of LW materials capabilities

Materials R&D Program - Funding Sources

- **Primary Funding Sources:**
  - Funding Opportunity Announcements (FOAs)
    - Solicitation for specific technology topic areas
  - Annual Operating Plans (AOPs)
    - Standard performance agreement between EERE and the National Laboratories
  - LightMAT Directed Funding Assistance Program
    - Industry users approach LightMAT (or vice versa) and develop project plan with concierge at no cost
  - High Performance Computing (HPC) for Manufacturing
    - Leverage the vast HPC capabilities at the national laboratories to partner with industry and address critical challenges
  - High Performance Computing (HPC) for Materials
    - Designed to enable a step change in the cost, development time, and performance of materials
- **Secondary Funding Sources:**
  - Small Business Innovation Research (SBIR)
  - Small Business Voucher (SBV)
  - Technology Commercialization Fund (TCF)