EPA issues new fuel-efficiency standard; Autos must average 54.5 mpg by 2025

By Juliet Eilperin, Published: August 28

The Obama administration announced strict new vehicle fuel-efficiency standards Tuesday, requiring that the U.S. auto fleet average 54.5 miles per gallon by 2025, an uncontroversial move that, unlike other administration energy policies, was endorsed by industry and environmentalists alike.

The new rules, announced by Transportation Secretary Ray LaHood and Environmental Protection Agency administrator Lisa P. Jackson, expand on existing standards requiring American-made cars and light trucks to average 34.5 mpg by 2016. They will significantly cut U.S. oil consumption and greenhouse gas emissions by the time they are fully implemented, according to the EPA.
Vehicle Response to 54.5mpg Challenge

- Lightweighting is an important end-use energy efficiency strategy in transportation. For example a 10% reduction in vehicle weight can improve fuel efficiency by 6%–8% for conventional internal combustion engines or increase the range of a battery-electric vehicle by up to 10%.

- Composites can offer a range of mass reductions over steel ranging from 25 to 30% (glass fiber systems) up to 60 to 70% (carbon fiber systems).

Specific stiffness and specific strength for various materials: carbon fiber reinforced polymer (CFRP) composites and glass fiber reinforced polymer (GFRP) composites.

University of Cambridge, [http://wwwmaterials.eng.cam.ac.uk/mpsite/interactive_charts/spec-spec/basic.html](http://wwwmaterials.eng.cam.ac.uk/mpsite/interactive_charts/spec-spec/basic.html)
Why Lightweighting?

“Excess weight kills any self-propelled vehicle. There are a lot of fool ideas about weight . . . Whenever anyone suggests to me that I might increase weight or add a part, I look into decreasing weight and eliminating a part!” – Henry Ford, 1922

Every automotive manufacturer is pursuing lightweighting as a key strategy to reduce fuel consumption—irrespective of the powertrain technology pathway.
Carbon fiber reinforced polymer (CFRP) composites have the greatest weight reduction potential if cost and manufacturing issues can be solved.

“It is claimed for the new process, that the car bodies can be manufactured with a great savings in time, and also that a very light and durable body is attained.”
Clean Energy Manufacturing Innovation
Institute for Composites and Structures

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• Increase speed/throughput
• Reduce embodied energy
• Enable recycling
• Enable technology and approaches
  – Innovative design concepts
  – Modeling & simulation tools
  – Effective joining
  – Defect detection
IACMI Goals: Fiber Reinforced Polymer Composites for Vehicle Applications

Technical Goals

• 25% lower CFRP cost
• 50% reduction in CFRP embodied energy
• 80% ability to recycle composite into useful products

Specific Approach

• Adoption of carbon fiber composites in mass-produced platforms (≥100,000 units/year) by the end of Year 5
• Advance multiple technologies incorporating continuous fiber reinforcement to achieve cycle times under 3 minutes within 5 years, with one or more technologies under 90 seconds
• Drive down the fabricated cost of continuous carbon fiber structural parts by 50% or more within 5 years, including reduction in material and process costs
• Develop robust simulation and modeling tools that accurately and reliably predict the performance and costs of each major process and its resulting composite structures
How Will IACMI Vehicle Technology Area (VTA) Achieve Its Goals?

- Knowledgeable and dedicated professional staff
- State-of-the-art automotive composite process facilities at manufacturing scale
- Integration of participant teams in the vehicle supply chain
  - OEM, Tier 1, material suppliers, SMEs
- Identification and support for leading-edge projects
- Access to facilities for proprietary projects
- Workforce development opportunities
Michigan Is Strategically Located and the Leader in US Auto Production and R&D

>70% of automotive production occurs in IACMI states

>70% of US auto R&D in Michigan alone
State of Michigan Support

- **Michigan Economic Development Corporation** — MEDC
  - Develop automotive strategic plan
    - Demographics and vehicle market
    - Vehicle design
    - Connected vehicles
    - Powertrain and propulsion technologies
    - Manufacturing and supply chain
    - Material and joining technologies
  - Establish collaboration center across supply chain
    - OEM-tiers-suppliers-tooling-fabricators-design-testing
  - Leverage expertise to attract federal and industry investment
  - Develop talent in materials engineering, modeling, simulation, systems engineering and skilled trades
    - Michigan State, Michigan, Michigan Tech, Wayne State
    - Community Colleges: Lansing CC, Macomb CC, Alpena CC
  - $15M investment in IACMI-VTA 5 years
Vehicles Technology Area: Resources

- Michigan State University Resources (lab scale)
  - Composite Materials and Structures Center
  - Composite Vehicles Research Center
  - 22,500 ft² facility for analysis, characterization, processing and testing
  - Faculty, research staff, Postdocs, graduate students
- Scale-up facility (MSU operated)
  - Located in 40,000 ft² proximate to ALMMI/LIFT to foster IMI collaboration and multi-material solutions
  - Centrally located in Detroit
  - MI State-(MEDC) funded full-scale equipment and facilities

**Automation**
- Processes, in situ thermoplastic infusion

**Models**
- For preforming, infusion, cure kinetics, performance

**High strain rate testing, NDE, mesoscale molding, netshape preforming, ICME processing and performance**

**Low-cost carbon fiber (LCCF), lab-scale intermediates and composites fabrication, NDE, recycling**

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MI-Vehicles Technology Area: MSU Resources and Expertise

- Composite Materials and Structures Center
- Composite Vehicles Research Center
- MSU—Applied Research Laboratory, ITAR/EAR Compliant
  - Research, characterization, testing, development facilities
- Polymer composite processing and modeling
- Process development, modeling and manufacturing-liquid systems
- Additive manufacturing of thermoplastic composites
- Multifunctional composites (nanoparticles)
- Joining—adhesive bonding, mechanical fastening, bolt design
- Surface treatments and sizing of reinforcing fibers and adherends
- Biobased structural composites
- Modeling and structural analysis (static, crash, impact, fire, fatigue)
- Dynamic characterization and design
- NDI, NDE in-situ, and remote sensing
MSU—Composite Materials and Structures Center

7,500 ft² Composite Characterization Laboratory and processing laboratory with over $5M in equipment for polymer and composites fabrication and testing

Full-time staff
  - Three professionals and two technicians

Education and training of engineers and scientists
  15+ Faculty and 25+ student researchers

Outreach to industry and government
  - Fabrication, testing and characterization capability
  - Research staff for short-term contract and applied research
  - Faculty and students for long-term research

http://www.egr.msu.edu/CMSC/
MSU—Composite Vehicle Research Center

Center of Excellence for the research, design, and implementation of composites for lightweight, durable, cost-effective, efficient, and safe vehicles

- Emphasis on composite vehicle systems, subsystems, and components
- Intersection of composites and vehicle technologies
- ITAR-compliant off-campus facility
- “Design validated by experiment”
- Integration of analytical, numerical, and experimental approaches

Focal Areas:
- Impact and crash resistance
- Design and manufacturing – liquid molding
- Multifunctional composites
- Composites joining – bonded and bolted
- Multi-scale damage modeling
- Wireless health monitoring
- Structural optimization
Vehicle Scale-up Facility (Detroit Area)

- OEMs and Tier 1 Industries met over a 24 month period to identify what was necessary to achieve large-scale production of polymer composites for automotive applications

- Shared facility located in epicenter of automotive R&D
  - Easy and flexible access

- Production-scale equipment to demonstrate production rates >100,000 parts/year

- Automated preprocessing of composite constituents and post-processing of composites parts at scale

- Integrated in-situ recycling of offal
IACMI-VTA Process Capabilities

- Large part fabrication
  - Injection over-molding of structural inserts
  - HP-RTM (epoxy, PU) and variants
  - HP-RTM (thermoplastic)
  - Prepreg compression molding (thermoset & thermoplastic)
  - Thermoplastic and thermoset compression over-molding with structural inserts

- Material formulation
  - Hot-melt prepreg line
  - Thermoplastic recycling regrind/recompound

- Preforming
  - Automated cutting
  - Thermoplastic tape layup
  - Preforming press
  - Thermoplastic consolidation

- Finishing
  - Waterjet
  - Multiaxis trim router
Vehicle Technology Area

Example IACMI Enterprise Project
**Project Organization & Integration**

- **Lab Scale**
  - Year 1: Lab-scale alt. precursor
  - Year 2: Precursor pilot line

- **Intermediate Scale**
  - Year 2: Composite mat's meet CTQ’s
  - Year 3: 1-h full-scale run meets CTQ’s

- **Full Scale**
  - Year 3: 1st part production lot

- **Automated composite process**
- **Composite mat's meet CTQ’s**
- **Improved CF conversion process**
Automated composite process

Lab Scale

Intermediate Scale

Full Scale

Fast curing resins
Automated lamination
NDE of ply orientation
Hi-speed robotic transfer
Joining

Fast curing resins
Automated lamination
NDE of ply orientation
Hi-speed robotic transfer
Joining

Internal mold release
Scrap reclamation
Cure monitoring
Alternative carbon fiber
Integration and scale-up

Lab-scale alt. precursor
Precursor line
Improved CF conversion process

Lab-scale alt. precursor
Precursor line
Improved CF conversion process

1st part production lot

Year 1

Year 2

Year 3

Automated composite process

Composite mat's meet CTQ's

1-hr full scale run meets CTQ's

1st part production lot

to Discontinuous fiber products
Automated composite process
Lab Scale
- Prepreg process
- Lamination
- Nesting, kitting

Intermediate Scale
- Preforming, draping
- Cure kinetics
- Dimensional stability

Full Scale
- End-to-end process model

Lab-scale alt. precursor

Intermediate Scale
- 1-hr full scale run meets CTQ's
- Improved CF conversion process

Integration and scale-up
- Alternative carbon fiber
- Cure monitoring
- Hi-speed robotic transfer

Design Modeling
- Topology optimization
- Manufacturability (assembly, joining)
- Mechanical performance
- Durability
- Crash performance

Process Modeling
- Fast curing resins
- Automated lamination
- NDE of ply orientation
- Lab-scale alt. precursor
- Internal mold release
- Scrap reclamation
- Cure kinetics
- Composite mat's meet CTQ's
- 1st part production lot

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**Example Automotive Process:**
High-Pressure Resin Transfer Molding

**Project Elements Addressed by IACMI**

- Reduce cycle time from 5–8 min to under 3 min (3–4X faster)
- Increase component size to floor pan with fast cure resins
- Rapid manufacturing of continuous fiber preforms with controlled fiber orientations. Optimization of fiber orientation, textile forms, and automation
- Fiber wetting, adhesion via sizing improvements
- Development of material waste reduction and recycling strategies
- Characterization of part internal microstructure before, during, and after processing in order to develop robust simulation tools to minimize fiber placement variability, fiber volume, risk of fiber wash, and location of injection ports
- Training on high pressure RTM equipment
- Opportunity for proprietary material and/or process development

Source, KraussMaffei Technologies GmbH
Example Automotive Process: Compression Molding of Continuous Fiber Prepreg

**Project Elements Addressed by IACMI**

- Development of large parts employing CARBON and/or GLASS fiber and unidirectional preform molding of prepregs targeted at 3 min part cycle for parts the size of a roof
- Draping simulation, rheological characterization, property determination to form the basis for process modeling and simulation
- Enhanced robotics for cutting, kitting, and stacking for complex parts at less than 3 min cycle times
- Optimized cutting paths and part design and high-speed tape laying to minimize waste
- Combination of continuous and discontinuous fiber prepreg materials in a single molding process
- Hands-on training of technicians/engineers
- Opportunity for proprietary material and/or process development

Source, Schuler

Source, Composites World
Example Automotive Process: Insert/Overmold Injection Molding

Project Elements Addressed by IACMI

- Unit operations of structural injection molding, with long fiber reinforced thermoplastic (LFRT)
- Molding into a cavity having an insert (continuous fiber preform, composites, etc.) in performance-critical locations
- Experimental data generated to correlate with modeling & simulation
  - Preform and resin characteristics; mold design (e.g., injection ports); and process parameters
  - Effects on performance and quality of molded parts (minimum part thickness, matrix-rich zones, etc.)
- Precompounded and in-line compounded (including with reclaimed carbon fiber and microfibers) variants will be assessed
- Hands-on training of technicians/engineers
- Opportunity for proprietary material and/or process development
**Example Cross-Cutting Project**

**Composite Joint Design and Multi-material Attachment Technology Project:** Develop process-specific joint and interface design incorporating both adhesive bonding and mechanical fastening for FRP/metal joints

**Adhesive Bonding**
- Potential reduction in weight & cost
- Preferred over mechanical fastening
- Eliminates stress concentrations due to holes

**Types of Adhesive Joints**
- **a)** Lap-Joint
- **b)** Double Lap-Joint
- **c)** Butt Joint
- **d)** Scarf Joint
- **e)** Corner/L-joint
- **f)** T-/Pi- Joint

**Mechanical Fastening**
- Required for repair, reassembly
- FRP composites require special hole design & fasteners to avoid hole-initiated damage

**Objectives**
- Quantify the performance of tailorable, multifunctional, adhesively bonded structural composite joints. Includes Pi-, lap-, and dissimilar materials
- Model mechanical response under static and dynamic conditions
- Develop high speed surface prep and fabrication methods
We welcome the opportunity to answer your questions, provide operational, facility and technical information!

**Ron Averill** — Design Optimization: structures, manufacturing, crash design, optimization

**Jay Jayaraman** — Polymer composite molding, extrusion of thermoplastics, nanocomposites and thermoplastic elastomers; solid state forming; polymer foams and foamed composite

**Mahmood Haq** — Computational Design: tailorable materials / multiscale materials, adhesively bonded and bolted hybrid composite joints, NDE

**Al Loos** — Manufacture of composites by RTM, VARTM, and RFI. Expertise in resin infusion process simulation models, mechanics of composite materials.

**Sharon Xiao** — Composite damage – crashworthiness simulation, progressive composite fatigue model, residual properties of damaged composites

**Michael Rich** — CMSC and CVRC facility operation, research, testing, fabrication