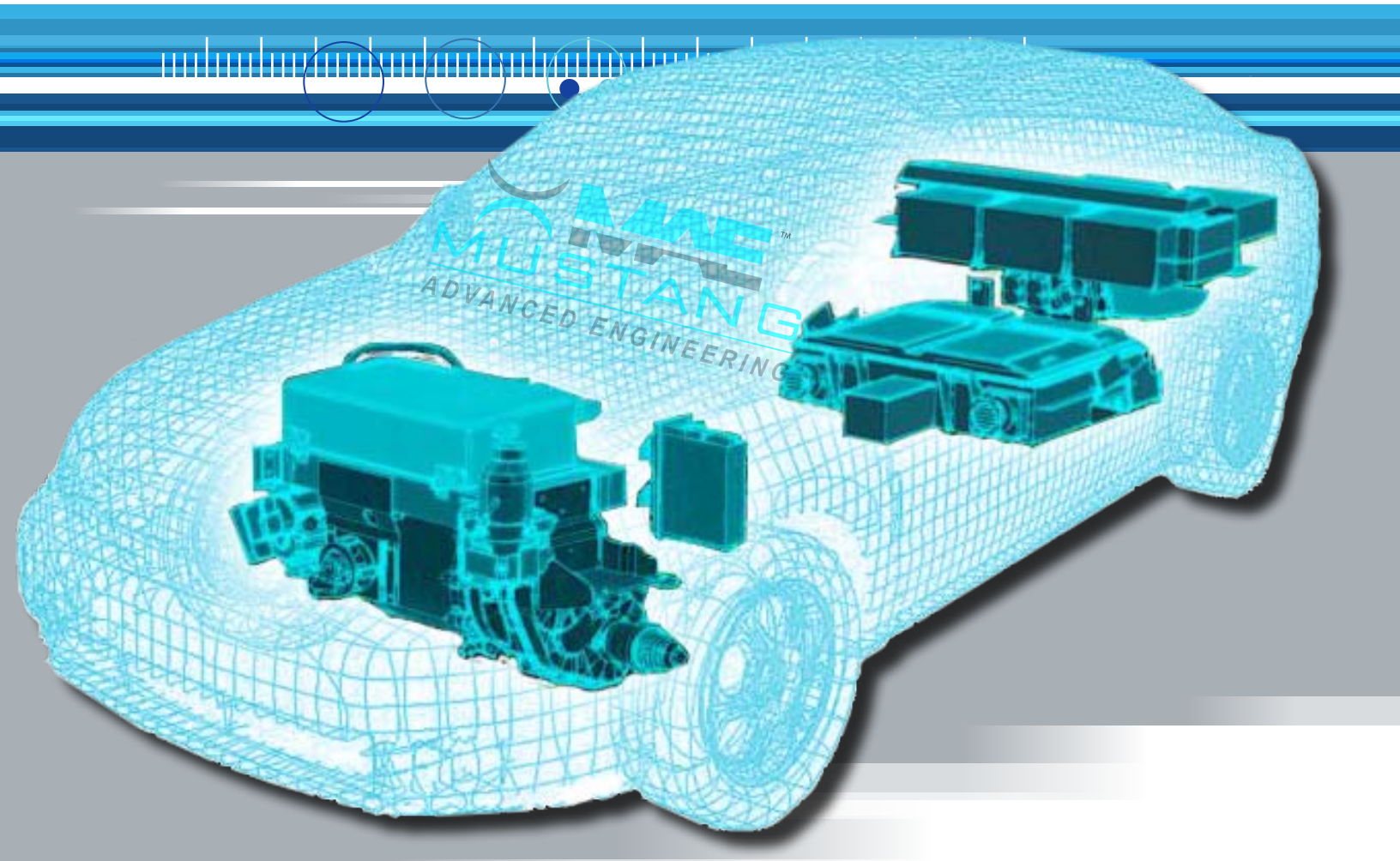
Advanced Engineering

Testing Solutions

Testing & Simulation Solutions for Hybrid Electric Vehicles



MAE MUSTANG
ADVANCED ENGINEERING

Putting the Hybrid Development Puzzle Together

Mustang Advanced Engineering has the right resources and products to assist you in the engineering, development and validation of your hybrid vehicle systems.

Products, Engineering, Solutions

Right now, virtually every automotive OEM and tier supplier around the world is in a race to develop the next generation hybrid electric vehicle powertrain system or sub-system to satisfy all of the conflicting demands for driving performance, improved fuel economy, effective and efficient power management, and reduced vehicle exhaust emissions.

Rapid hybrid systems development in today's globally competitive business environment can often feel like a daunting puzzle. Solving the puzzle requires highly-sophisticated and technically-advanced testing and simulation systems to test and validate each component or sub-component independently, using Hardware-in-the-loop (HIL) simulation to take the place of missing elements of a powertrain system.

Mustang Advanced Engineering has the right resources and products to assist you in the engineering, development and validation of your hybrid vehicle systems. As a leading supplier of testing and simulation solutions for the development of powertrains and powertrain components, MAE has been involved in the development of advanced HEV testing and simulation test systems from the very beginning. MAE delivered one of the industry's first hybrid electric vehicle test systems for GM's EV1 program in the late 1990's. When the competition was just learning what a hybrid was, Mustang was delivering more systems for Allison Transmission's hybrid vehicle powertrain development.

Since then, MAE has continued to develop industry leading hardware and software for testing applications ranging from AC Engine Dynamometers, Electric Motor Test Systems, Inverter Test Systems, Battery Simulation Systems, Full Powertrain Test Systems, and Complete End of Line Multi-function Test Stands for production testing and validation.

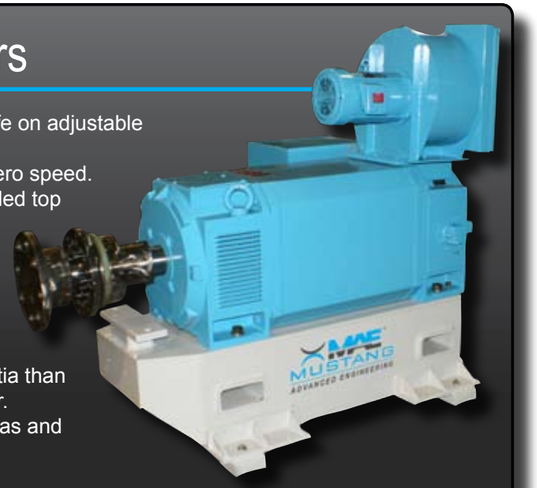
So when you are looking for a solution to a difficult simulation challenge or have a missing piece to your hybrid puzzle, turn to the experts at MAE. Our experts can assist with consulting, engineering assistance, performance & validation products and testing services.

MAE Hybrid Development Products

- AC Engine Dynamometers
- Electric Motor Test Systems
- Inverter Test Systems
- Battery Simulation Systems
- Full Powertrain Test Systems
- EOL Multi-function Test Stands

Hybrid Electric Vehicle Development Products

AC Engine Dynamometers



- Designed for optimal performance and longer life on adjustable frequency power.
- Provides continuous constant torque down to zero speed.
- Custom designs for any base speed and extended top speeds.
- Capable of handling the most demanding applications from fractional to 1,000-hp.
- Compact and lightweight design.
- 150% maximum overload torque from zero speed to base speed for 1 minute.
- High torque to inertia ratio - up to 80% less inertia than the corresponding standard NEMA frame motor.
- Capable of high speeds due to lower rotor inertias and high power density.

Electric Motor Test Stands

- Dynamic Load and Motor AC Dynamometers from Fractional to +1,000 hp
- Speed ranges up to 20,000 rpm
- Full range of cooling & conditioning modules available
- Environmental and climatic chambers
- Precision power measurement and full integration of power analyzers
- Modular design approach

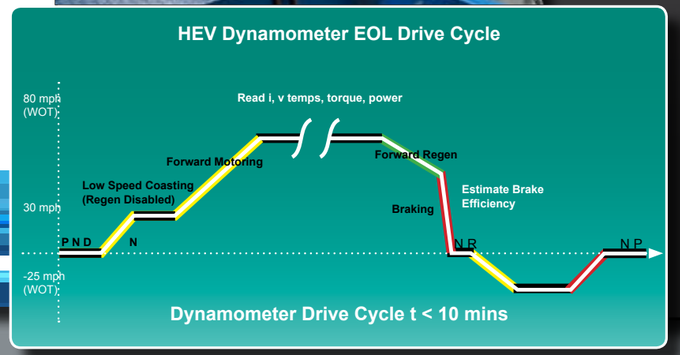
Inverter & Battery Test Stands

- Systems for validation of power electronics and energy storage systems
- Energy recovery batteries
- Electric motor emulators
- Pre-fabricated containerized test cells

EOL Validation Multi-Function Test Systems

MAE has extensive experience in the field of production/in-process testing and offers a variety of products and services to support your HEV production testing requirements. MAE's engineers will work closely with your team to custom tailor a solution to solve virtually any production testing challenge.

MAE has developed systems to handle multi-function vehicle testing, production electronic & wire harness testing, chassis sensor and electronic testing, production engine and transmission testing and many other applications. MAE can upgrade your existing production line hardware and software, interface with existing databases or supply a complete turnkey HEV EOL testing and validation solution.

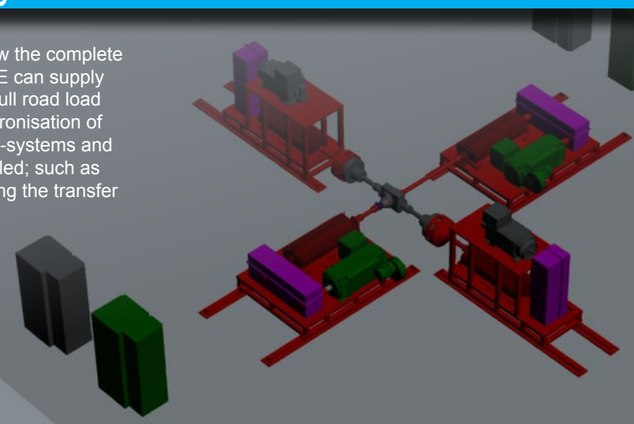


HEV Drive cycle validates

- PRND interface
- TCM Parking
- MCM-DLCM interface and operation
- HV Validity
- BMS installation
- GWM verifes DCDC, SRS, OSC

Full Powertrain Test Systems

MAE offers full powertrain test systems that allow the complete powertrin to be tested outside of the vehicle. MAE can supply complete turnkey systems to precisely simulate full road load and inertia simulation with accurate speed synchronisation of the powertrain inputs and outputs. Control of sub-systems and powertrain test articles are independently controlled; such as shifting the axles, shifting the transmission, shifting the transfer case, and controlling the input motor (Engine).



Full Powertrain Test Systems

- Modular AC Motor Dynes
- Engine or AC Motor Input
- Power Analysis
- Engine Emulation and Inertia Simulation
- Battery Simulation
- Cooling and Conditioning Modules
- Data Acquisition

HEV Project Spotlight

Full Hybrid Simulation Systems

Application Highlights - Full Hybrid Electric Vehicle test stands used in the EV1 electric vehicle development

- Dual-ended, high-torque 400 HP AC dynamometer
- Dual torque meters on each shaft
- High speed 7:1 gearbox with top speed of 15,000 rpm
- Full regeneration of power to power grid
- Isolation transformer
- DC power supply capable of 0 to 600 VDC and 0 to +/- 500 Amps
- 12-diode bridge controller
- Multi-phase isolation transformer for Zig-Zag configuration
- Chiller and cooling system for test article
- Power analyzer
- Data acquisition and boom box
- Distributed PC control cystem controlling
- Dyne motor controller
- DC power supply
- Chiller cooling system
- Power analyzer
- Data acquisition and boom box
- Test Cell interface

HEV Project Spotlight

Hybrid Electric Drive Test Systems

Application Highlights - (2) Hybrid Electric Drive Test Stands

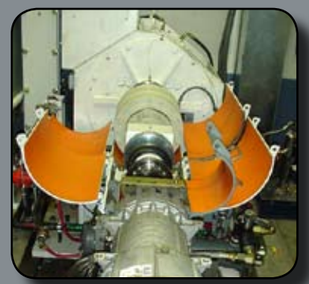
System #1

- 315-hp Input capable of 12,000 rpm
- 635-hp Output Variable Speed AC Dyne Motor capable of 4,000 rpm
- Input dyne capable of 1,100 lb-ft of torque
- Output dyne capable to absorb 6,600 lb-ft of torque

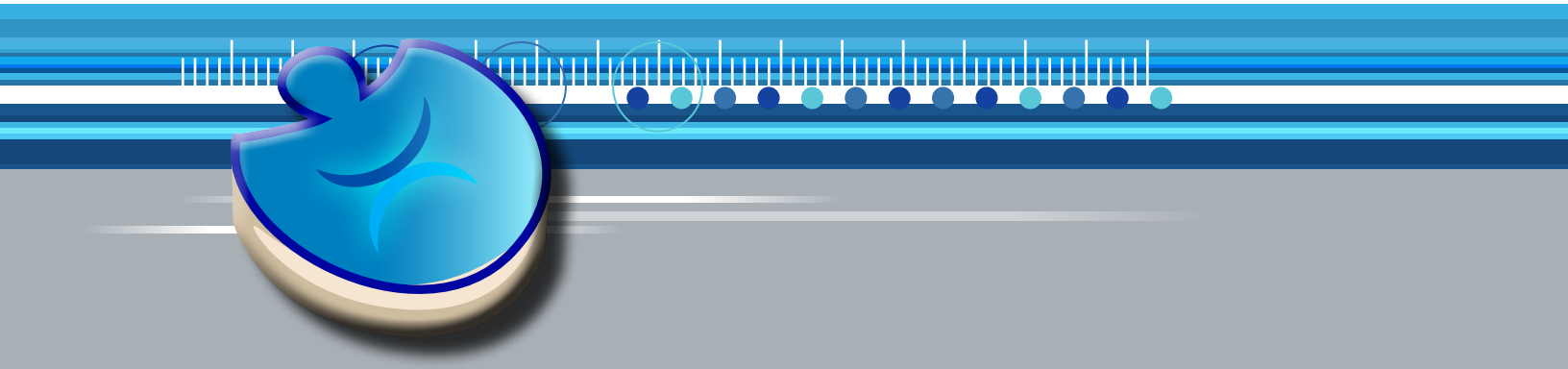
System #2

- 315-hp Input capable of 12,000 rpm
- 350-hp Output Variable Speed AC Dyne Motors capable of 4,000 rpm
- Input dyne capable of 1,100 lb-ft of torque
- Output dyne capable to absorb 3,300 lb-ft of torque

- Dyne Motors were liquid cooled with integrated oil reservoirs, cooling columns and pumps as required to cool the motors.
- Tandem & individual control of each system.
- Road-load & engine emulation simulation
- ModBus & CAN Interfaces
- R&D dyno for hybrid transmission development and standard transmission testing.
- To Test: Ev-40, Ev-50, MD-3000, HD-4000, and others.
- The systems are used to calibrate and test virtually all of the currently available Allison Transmissions, as well as future productions.
- 21 test modes of operation for these units.
- Systems capable to test Hydraulic retards.



MUSTANG ADVANCED ENGINEERING



About MAE

Mustang Advanced Engineering is a leading provider of comprehensive testing solutions for the development and testing of engines, powertrain systems and complete vehicles. Founded in 1975, Mustang has long been a trusted source of expertise in measurement and testing technologies for the global industrial market. World-class product offerings, custom design support and technical assistance, backed by a dedicated factory service team, has positioned MAE among the global leaders in providing advanced testing solutions.

As a global leader in the design, manufacturing, and integration of advanced testing and measurement systems, MAE has delivered and continually supports literally thousands of test systems to virtually every corner of the globe.

Our mission is to achieve the highest possible level of customer satisfaction by providing innovative technical solutions and product designs and by striving to achieve perfection in product quality, delivery and service. At MAE, our customers are our highest priority - we do everything in our power to satisfy our customers. Our entire organization understands that the customer comes first and nothing else is more important.

To learn more about how MAE can help solve your most demanding testing challenges contact one of our sales engineers or visit www.mustangae.com.

ISO 9001:2000 Certified

Offices Worldwide

U.S. Corporate Headquarters
Mustang Advanced Engineering
2300 Pinnacle Parkway
Twinsburg, OH 44087
Phone: (330) 963-5400
Fax: (330) 425-3310
Email: sales@mustangae.com

www.mustangae.com

Rev. 05182010