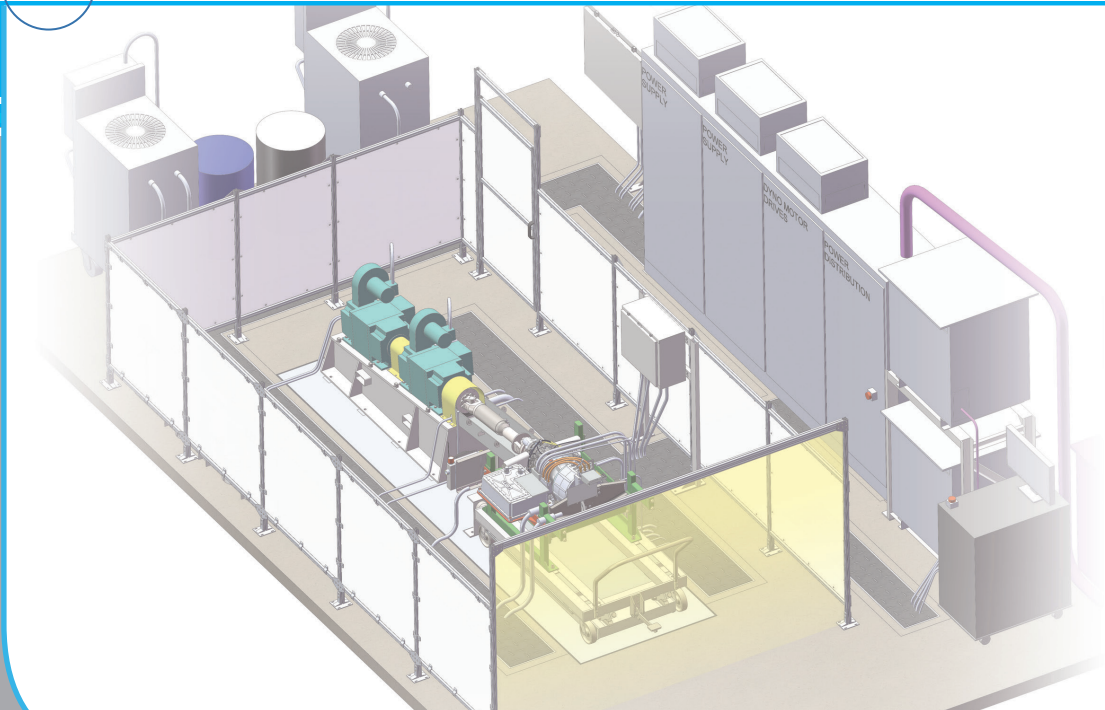


# Advanced Engineering ● ● ● Testing Solutions



## EV & Hybrid - Production Test Cells



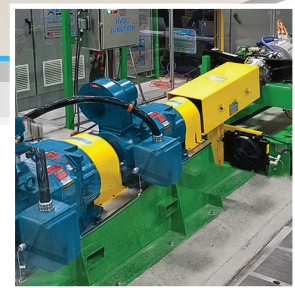
Motor Control Unit Testing



Production Software



Electric Motor Testing



Electric Powertrain Testing



## Global Leaders in Testing

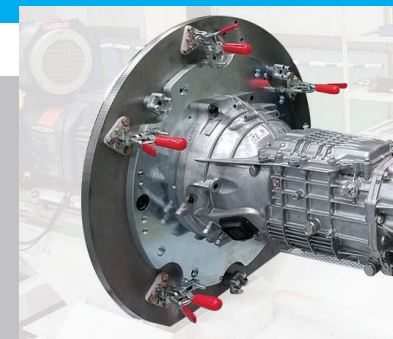
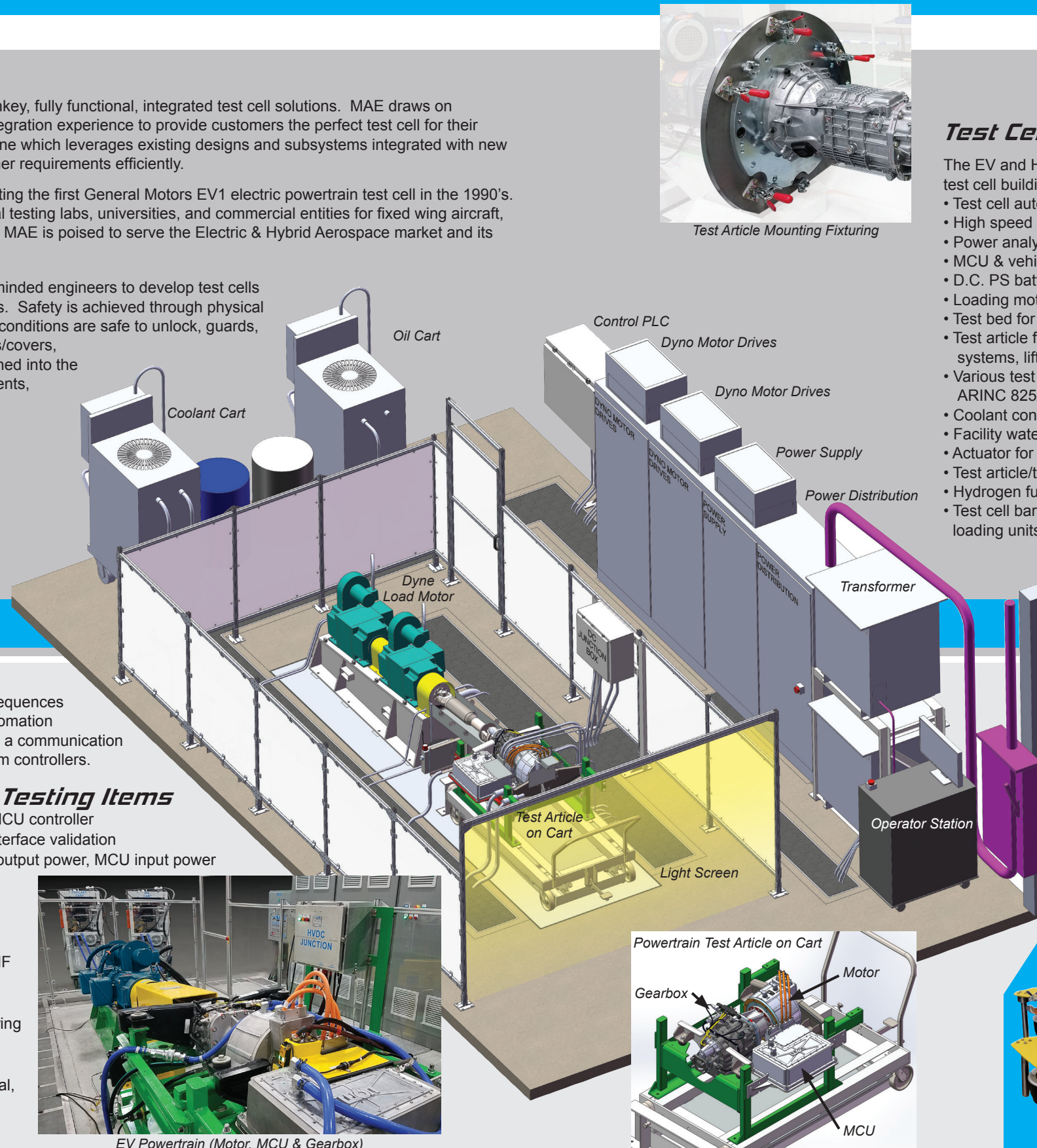
MAE is a test cell system integrator capable of supplying turnkey, fully functional, integrated test cell solutions. MAE draws on more than 35 years of equipment production and test cell integration experience to provide customers the perfect test cell for their requirements. MAE has developed its TESTCell™ product line which leverages existing designs and subsystems integrated with new designs and integrating the latest technology to meet customer requirements efficiently.

MAE was an early adopter of the EV test cell market, integrating the first General Motors EV1 electric powertrain test cell in the 1990's. MAE has delivered many solutions to NASA, military, national testing labs, universities, and commercial entities for fixed wing aircraft, rotary wing aircraft, eSTOL, VTOL, and eVTOL applications. MAE is poised to serve the Electric & Hybrid Aerospace market and its current and future testing needs.

MAE leverages our vast test cell experience and our safety minded engineers to develop test cells that are safe and meet local and national safety requirements. Safety is achieved through physical barriers, electrically lockable access barriers monitored until conditions are safe to unlock, guards, dual hand touch pads, light curtains, electrical lockable doors/covers, pressure pads, lights, lamps and sound. Safety is also designed into the high-power electrical systems with lock-out/tag-out requirements, arch flash analysis and facility interface design.

## Test Articles

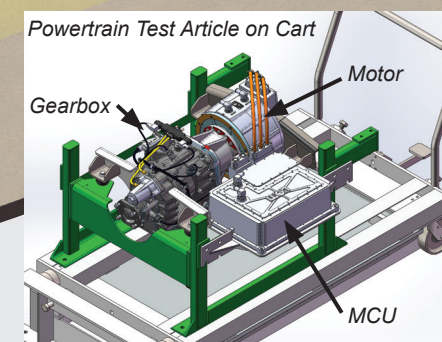
- Electric Powertrain
- Electric Motors
- Electric Motor Control Units
- Electric DC/DC Converters
- Batteries
- Fuel Cell
- Gearboxes
- Rotor & Blade



Test Article Mounting Fixturing



EV Powertrain (Motor, MCU & Gearbox)



Powertrain Test Article on Cart

## Test Sequences

### Test Cell Automation Controller

The production automation controller primary function is to sequence the testing procedure and collect data at <1,000Hz. The Automation Controller has chassis mounted signal conditioning and uses a communication backbone to interface with various remote I/O and sub-system controllers.

### Common EV & Hybrid Production Testing Items

- MCU communication interface validation and flashing the MCU controller
- MCU LV (12 -48VDC) power consumption, functional I/O interface validation
- Power & Efficiency: Test motor/gearbox shaft power, MCU output power, MCU input power
- Torque and speed regulation at various load points
- Motor regenerative cut off level
- Phase angle, shaft runout and ABS sensor
- Motor phase balance and encoder validation
- Open circuit test: Speed, parasitic torque, voltage, back EMF
- Closed circuit test: Torque, shaft lock and stall
- Insulation Test, HiPot, megger test, winding resistance
- Battery or fuel cell, voltage, loaded current, thermal monitoring
- Dynamic vibration spectral, FFT, order tracking
- Thermal temperature imaging of components
- Coolant and/or oil system heat rejection, pressure differential, leak checks
- Visual & Auditable checks: coolant leaks, cable routing, squeals and knocks

## Test Cell Components

The EV and Hybrid production product test cell is composed of various test cell building block items as well as custom test article specific items:

- Test cell automation and data acquisition control system (<1,000 Hz)
- High speed data acquisition system (>1,000 Hz to GHz)
- Power analyzer measurement systems (1 - 5MHz)
- MCU & vehicle accessory PS LV (12 - 48 VDC)
- D.C. PS battery simulator/cycler HV (200 – 1,500 VDC)
- Loading motor/dyne controls; AC, DC, eddy current, etc.
- Test bed for test article, loading motor/dyne, fixed, movable, rotatable
- Test article fixturing to test bed, adapter plates, hydraulic clamping systems, lifts and carts
- Various test article interfaces (CAN, CAN FD, ARINC 429, ARINC 825/CAN, Mil-STD-1553)
- Coolant conditioning systems for liquid and gaseous coolant medium
- Facility water or water/glycol, chiller and/or coolant systems
- Actuator for the test article and sub-systems manual control items
- Test article/test cell climate controller interfaces
- Hydrogen fuel supply systems
- Test cell barriers, safety locks, covers, guards, sensors, hydraulic loading units

## Components

Battery Simulator  
100kW - 2,500kW



Coolant/Oil Cart  
1kW - 250kW

## Electric Motor Testing

### Electric Wheel-end Production Test Stand

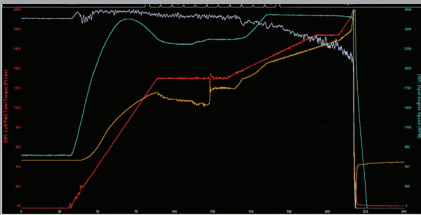




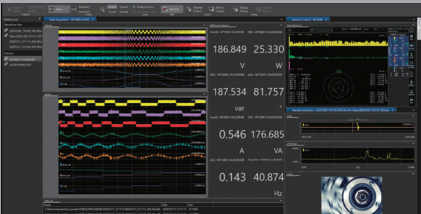
## Automation Controls System

The EV & Hybrid production product test cell operator interface and control software is composed of various MAE developed software modules attached to test cell controllers and interfaced with the operator. MAE routinely uses PLC test cell controllers in the production environment, due to their robust nature and ease of replacement parts.

The Test Cell Controller and sub-system controllers will be configured to sequence the test article through a test script and monitor safety related sensors & items, test cell sensors and test article sensors at < 1,000Hz sampling rates. Should faster sampling rates be required for items such as accelerometers, microphones, MAE will supply our highspeed DAC system which will monitor sensors at rates up to 204,800Hz. Additionally, MAE can supply our Power Analyzer and antennas DAC systems with sample rates > 1MHz to GHz range. Other electrical sensors and sub systems such as insulation HiPot tester can easily be integrated and monitored.



Operator Test Scripts and associated pass/fail criteria can easily be developed and uploaded to the Production Automation Software System. The test stand can be automated to read an RFID tag reader, bar code reader or other means to select the proper test procedure for the presented test article. Additionally, the operator can manually enter the test article or select a test sequence to be performed.



## 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](http://www.mustangae.com).