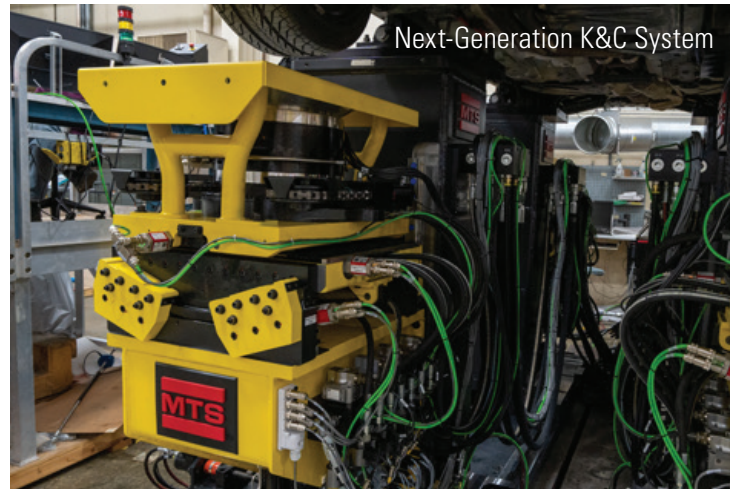


Adapt to Evolving Test Demands

OEMs and suppliers worldwide rely on MTS Systems for the testing technologies, expertise, and support they need to meet the challenges of electric and autonomous vehicle development and thrive in an intensely competitive global market. Visit Booth 2000 and explore how the growing array of MTS solutions can help you adapt to rapidly evolving test and simulation demands.



Learn more on page 2

Technology Presentation



Presenter: Christopher Flegel
System Integration Engineer
MTS Systems Corporation

Date: Day 3, Thursday
October 26, 2023

Time: Morning



Hybrid System Response Convergence (HSRC) in RPC® Connect

This presentation explores Hybrid System Response Convergence, or HSRC: a hybrid-simulation control process that allows physical and virtual simulation elements to be combined to form a comprehensive system simulation. For laboratory durability testing, HSRC enables the development of prototype vehicle and subsystem tests without requiring a dedicated vehicle road load data acquisition (RLDA) program. Eliminating the need for vehicle-specific data can speed development, reduce costs, and/or avoid the use of inappropriate data for testing. Inertially reacted and fixed-axle, full-vehicle HSRC testing is fully integrated into the latest release of MTS' RPC Connect control software.

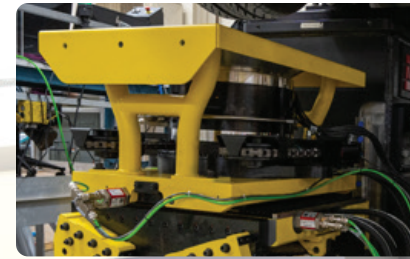
Next-Generation K&C System



High-fidelity Wheel Motion Sensors

Larger wheel motion range:

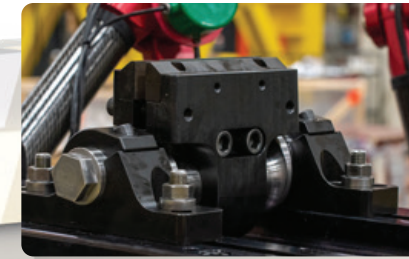
- » Longitudinal: ± 90 mm
- » Lateral: ± 90 mm
- » Vertical: ± 240 mm
- » Camber Angle: $\pm 10^\circ$
- » Spin Angle: $\pm 45^\circ$
- » Steer Angle: $\pm 45^\circ$



New Steer Input Assemblies

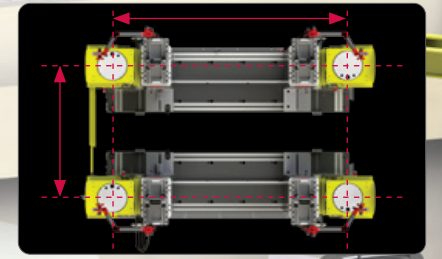
Linear-to-rotary design delivers enhanced performance for characterizing electric vehicles:

- » Increased steer angle ($\pm 50^\circ$)
- » Increased steer torque (± 1000 Newton-meters)
- » No backlash
- » Better control & safe limited speed operation



Flexible Body Clamping

- » Multiple clamp offerings with varying degrees of adjustability
- » Electric vehicle clamping featured



Increased Track Width & Wheelbase

- » Wheel Track: 1080 - 1830 mm (750 mm)
- » Wheel Base: 1800 - 3600 mm (1800 mm)

Full-featured K&C Application Software

- » K&C testing workflow
- » Multi-mode control
- » Flexible user programming
- » Analysis software



The latest addition to MTS' K&C portfolio is purpose-built for precise and repeatable passenger car and SUV suspension measurement.

Smaller, lighter and easier to install than its predecessors, this new Passenger Car K&C system performs the full spectrum of kinematics and compliance deflection measurement applications, including suspension and steering characterization, benchmarking and target setting, model verification, evaluating design changes, and diagnosing problems. As with all MTS K&C systems, system-level calibration methods are employed to ensure optimal measurement accuracy.

Ideal for characterizing fast-evolving electric vehicle designs, the next-generation Passenger Car K&C system features re-engineered steer input assemblies with increased torque and angle, new high-fidelity wheel motion sensors, new highly adjustable body clamping, increased track width and wheelbase adjustment, and a new operator's pendant for safe test vehicle installation.

State-of-the art MTS controls and software can be used to extend the utility of K&C systems to include dynamic operation, real-time hybrid simulation, and the integration of ancillary EtherCAT devices.



RPC® Connect Software

- » Dynamic operation
- » RPC time history replay
- » Playout and measurement to 10 Hz
- » Maneuver decomposition



mHIL Integration/User Interface

- » Mechanical Hardware-in-the-Loop (mHIL) integration and capability
- » CAN / dSPACE communications
- » EtherCAT communications
- » Control of ancillary devices



Hand-held Operator Pendant

- » Safety system status
- » Jog Mode to aid in spindle-coupled specimen installation
- » Specimen setup available with hydraulics on



F_z Calibration

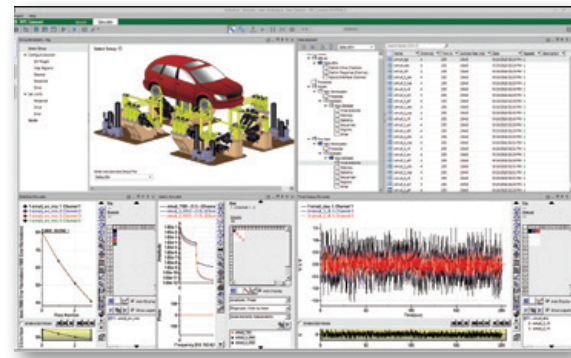
System-level Calibration

- On-system calibration for maximum accuracy:
- » 6DOF calibration @ each corner (F_x, F_y, F_z, M_x, M_y, M_z)
 - » 4-corner system calibration
 - » Fixturing provided for quickly verifying machine accuracy between formal calibration events

State-of-the-art 6DOF Road Simulation

The new Model 329i Spindle-couple Road Simulator integrates the latest in MTS hydromechanical, controls, and software innovation to achieve new levels of durability test fidelity and productivity.

- » Optimize road simulation accuracy
- » Maximize test system throughput, reliability, and operational efficiency
- » Integrate seamlessly with active vehicle systems and CAE models



RPC Connect Software

Architected to optimize durability test efficiency and productivity:

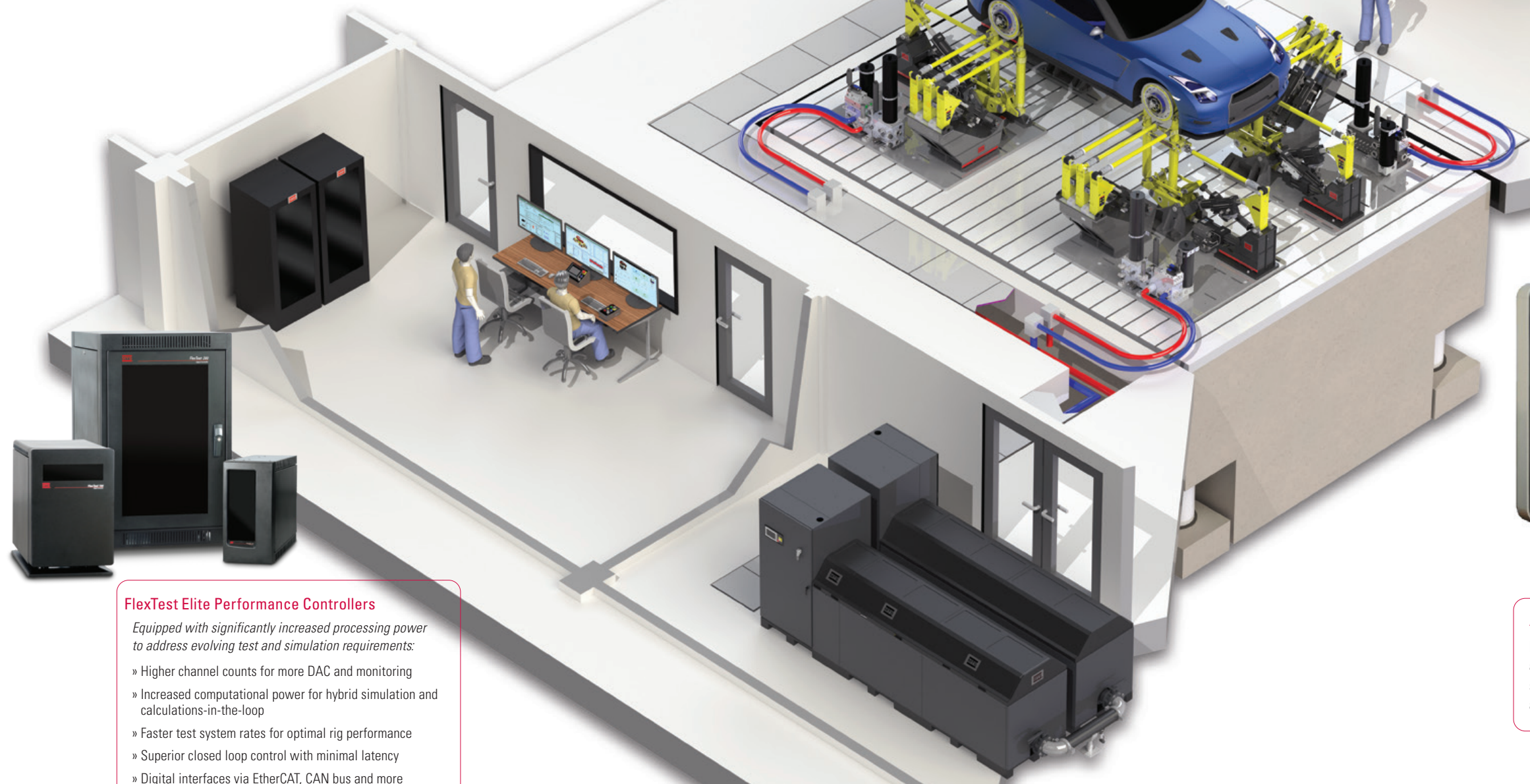
- » Productivity-enhancing user interface
- » High-throughput Test Stage
- » Supports advanced iteration methods and hybrid simulation



Refined 329i Kinematic Design

Engineered to maximize test accuracy, throughput, and rig longevity:

- » Up to 80 Hz road input
- » New, robust wrist joint design
- » High-fidelity, long-lasting MTS DuraGlide linear actuators
- » Available in passenger car and light truck configurations



FlexTest Elite Performance Controllers

Equipped with significantly increased processing power to address evolving test and simulation requirements:

- » Higher channel counts for more DAC and monitoring
- » Increased computational power for hybrid simulation and calculations-in-the-loop
- » Faster test system rates for optimal rig performance
- » Superior closed loop control with minimal latency
- » Digital interfaces via EtherCAT, CAN bus and more



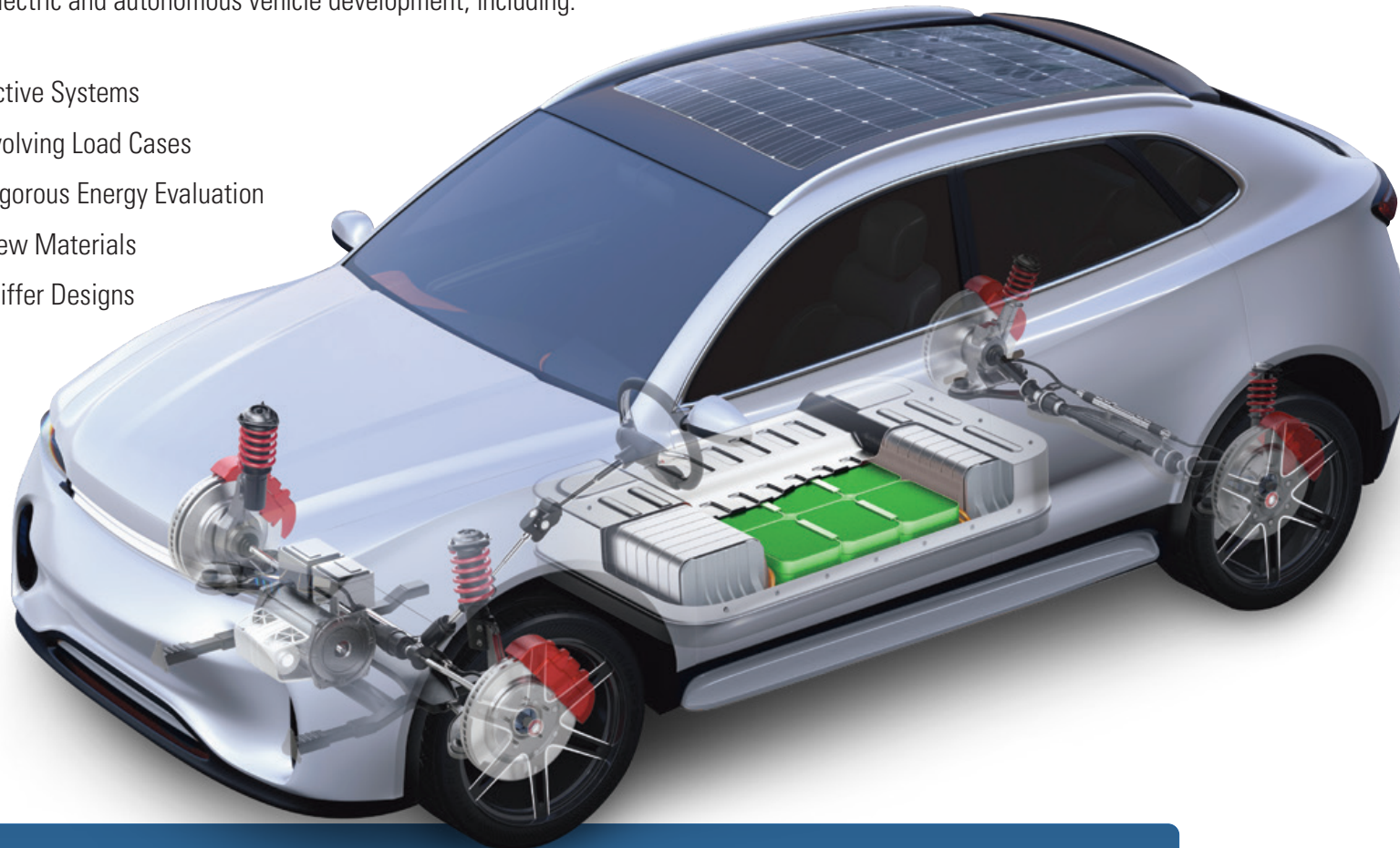
Advanced HPU System Management

MTS Multi-Pump Control Manager (MPCM) provides the ability to monitor and control multiple HPUs as a single system to improve lab operating and energy efficiency and prolong equipment life.

Electric & Autonomous Vehicle Testing Solutions

With a proven portfolio of laboratory-based testing solutions for materials, components, subsystems, and full vehicles, MTS is uniquely positioned to help vehicle OEMs and component suppliers confront the myriad challenges posed by electric and autonomous vehicle development, including:

- » Active Systems
- » Evolving Load Cases
- » Rigorous Energy Evaluation
- » New Materials
- » Stiffer Designs



Evolving Load Cases

Changing component duty cycles

Modular, Reconfigurable Component Test Solutions

Rigorous Energy Evaluation

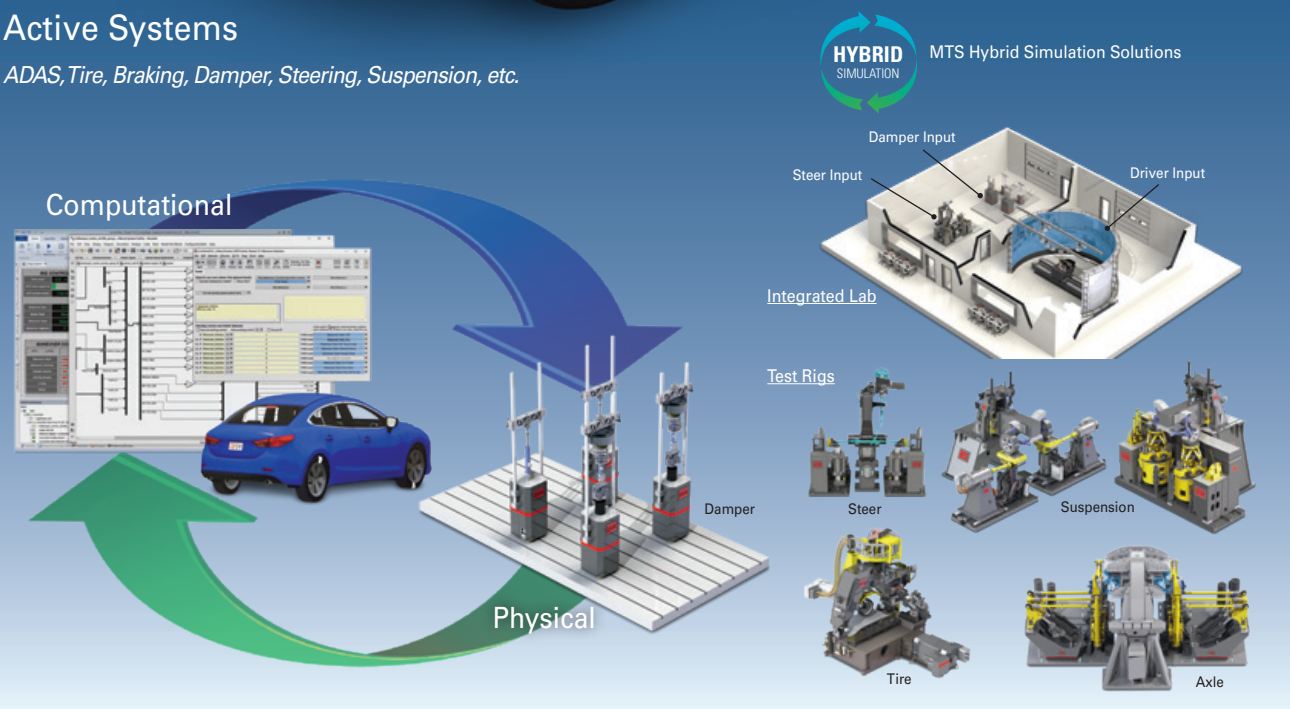
Aggressive consumption and loss targets

Flat-Trac® Dynamometer

Turnkey EV Battery Test System

Active Systems

ADAS, Tire, Braking, Damper, Steering, Suspension, etc.



New Materials

Changing body structures and dynamics

Model 329i Spindle-coupled Road Simulator

MTS Materials Test Systems

Stiffer Designs

Higher frequency duty cycles, NVH

Model 353.20 MAST

Model 853 Damper NVH Test System

Model 831.50 Elastomer Test System

MTS SafeGuard™ Ecosystem

Maximize Test Lab Safety, Efficiency & Longevity

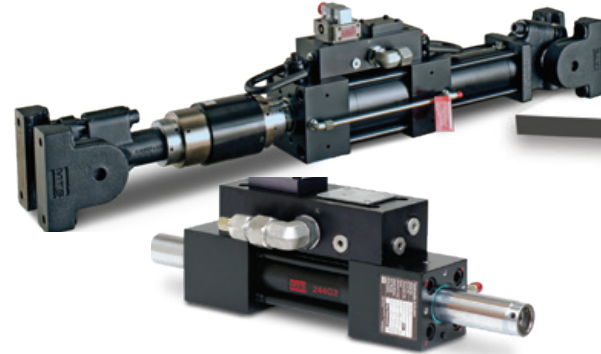
1. State-of-the-art Hydraulic Distribution

The **MTS Series 295 Isolation Hydraulic Service Manifold (ISHM)** provides smooth, controlled transitions of hydraulic pressure between the hydraulic power unit (HPU) and the test system to enhance safety and predictable control of the hydraulic system. The manifold meets Performance Level c (PLc) requirements for human safety and is able to incorporate MTS SafeGuard™ Technology to upgrade to PLd and PLe.



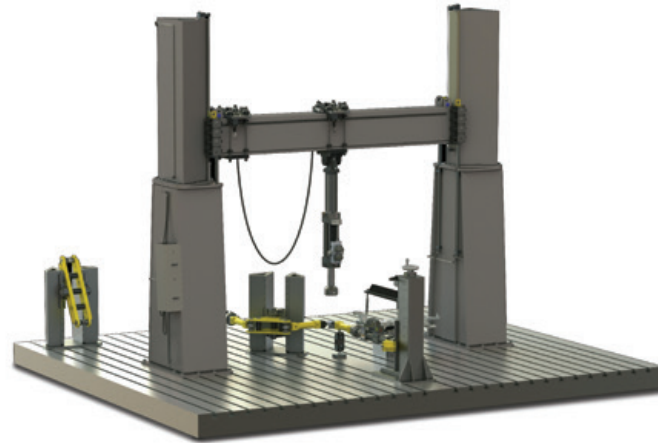
2. Durable, High-fidelity Test Actuation

MTS DuraGlide® Hydraulic Actuators are engineered to meet the unique precision and dependability demands of automotive testing. Featuring MTS SureCoat™ Rod Finishing Technology, they deliver longer performance life, higher test fidelity and increased energy efficiency.



3. Modular, Reconfigurable Test Rigs

MTS TestLine™ Solutions comprise a versatile set of modular components for creating cost-effective component and subsystem test rigs that can be easily reconfigured as requirements change. Precision-engineered for seamless integration, the TestLine portfolio includes a selection of durable load bearing components and MOCOKIT® portal frames.



4. Accessible System Service Information

MTS SmartService™ technology provides access to test system maintenance, repair, calibration, technical manuals and other critical service information at the test system. The MTS SmartService package includes near-field communication stickers for storing test system information, and a tablet for accessing and reading the information.



5. Advanced HPU System Management

MTS Multi-Pump Control Manager (MPCM) provides the ability to monitor and control multiple HPUs as a single system to improve lab operating and energy efficiency and prolong equipment life. An intuitive touchscreen interface enables close monitoring of HPU system fluid demand and precise management of fluid supplies and distribution.



6. Energy-efficient Hydraulic Power Generation

SilentFlo™ 515 Hydraulic Power Units (HPUs) feature high-efficiency motors and improved cooling circuits to achieve significant improvements in energy efficiency – up to 8% – over earlier SilentFlo models. SilentFlo 515 HPUs are easy to operate and maintain with fewer parts, accessible controls and improved filtration.



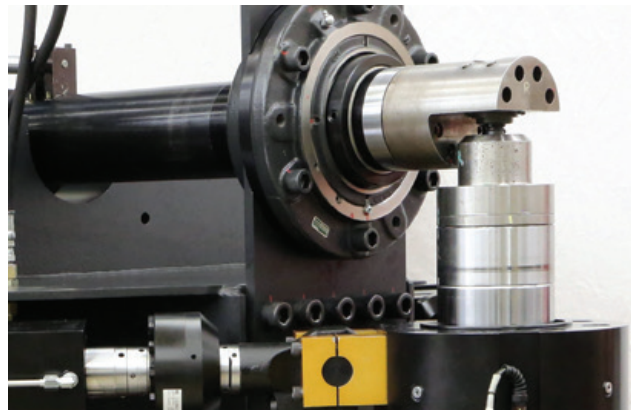
Durability Solutions

Proven, Reliable Lab-based Assessment Solutions

MTS sets the standard for providing highly accurate and repeatable correlation between the proving ground and the lab with a broad array of proven durability testing solutions. Comprising a variety of robust, multi-degree-of-freedom test rigs and industry-renowned RPC® Connect software, the MTS portfolio includes all the tools you'll need to accurately evaluate the durability of components, subsystems and full-vehicles, ranging from motorcycles to passenger cars to heavy trucks and agricultural equipment.

The MTS durability portfolio features:

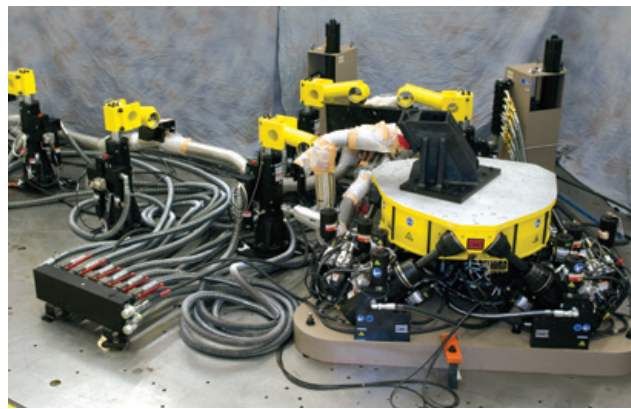
- » Model 329i Spindle-Coupled Road Simulators that provide up to six degrees of measurement and control at each of the vehicle spindles to deliver the most efficient, accurate and repeatable reproduction of even the most challenging proving ground road surfaces, maneuvers and events.
- » Model 320 Tire-Coupled Road Simulators for both early stage testing and full vehicle assessment
- » Versatile multiaxial simulation table (MAST™) systems for general component and subsystem testing
- » Numerous subsystem-specific testing solutions
- » A variety of elastomer, damper, bushing and materials test solutions
- » Leading-edge hybrid simulation solutions



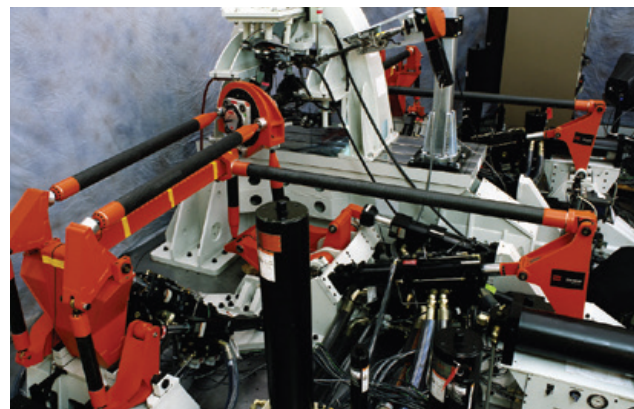
Ball Joint Test System



Damper Test Systems



Multiaxial Simulation Table (MAST) Systems



Axle Test Systems



Tire-coupled Road Simulators



Spindle-coupled Road Simulators

Expanding MAST Capabilities



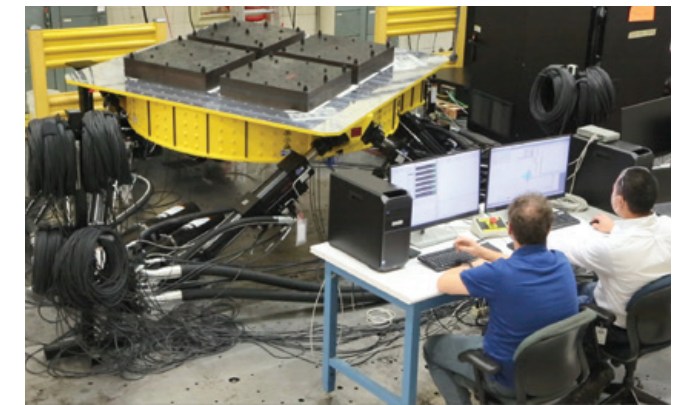
Photo courtesy of CTAG

MTS is responding to evolving test requirements for electric and autonomous vehicles, commercial trucks, and agricultural equipment with MAST systems capable of high frequencies and payloads, and an array of advanced compensation tools to optimize system fidelity.

High Frequencies - Models 353.20, 353.50 & 354.20

Address emerging electric vehicle battery testing needs and comply with various international standards.

- » Test up to 200 Hz when performing Power Spectral Density (PSD) tests and Time History (TH) replication
- » Apply force and motion in full six-degrees-of-freedom
- » Streamlined integration with third-party environmental chambers, battery cyclers - or battery management systems - and specimen monitoring systems
- » Functional safety per ISO 13849-1:2015 (Safety of machinery – Safety related parts of control systems)



Model 353.20

High Payloads - Models 353.50 & 354.20

Test larger, heavier electric vehicle, commercial truck and agricultural vehicle components, assemblies, and subsystems.

- » Test specimens up to 3000 kg (353.50) and 2000 kg (354.20)
- » Choose from a variety of standard and custom table sizes/ configurations (largest: 2.5 x 2.5-meter square)



Model 354.20

Advanced Compensation Tools - FlexTest Software (793)

Achieve the highest levels of MAST system controllability and fidelity to accelerate RPC drive file convergence.

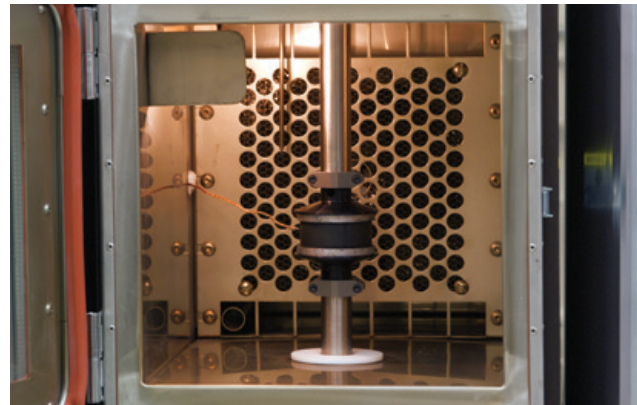
- » Degree of Freedom Control establishes a coordinate space where actuators work in 6DOF concert
- » Three-Variable Control enables simultaneous control of displacement, velocity, and acceleration variables
- » Amplitude Phase Control (APC) compensates for errors between command and feedback sine waves
- » Adaptive Harmonic Cancellation (AHC) removes distortion and generates clean sinusoidal inputs in conjunction with APC



Vehicle Dynamics Solutions

MTS offers a broad selection of test & simulation solutions designed to help you gain precise measurements earlier in the development cycle, enabling more efficient optimization of component, system and full-vehicle performance. The MTS vehicle dynamics portfolio features:

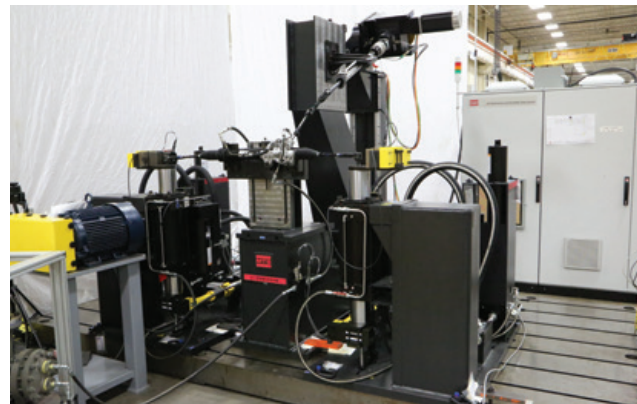
- » Flat-Trac® Roadways, which combine tire-coupled road simulation and flat-belt roadway technology to create a realistic laboratory environment for evaluating noise, vibration transmissibility, suspension performance, and fuel economy
- » MTS Kinematic & Compliance (K&C) systems for quickly and efficiently measuring key suspension parameters
- » Dynamic Kinematic & Compliance (DK&C) systems for simulating rough road inputs and transient maneuvers
- » State-of-the-art single and multi-belt wind tunnel rolling road systems for evaluating vehicle aerodynamics
- » Numerous subsystem-specific testing solutions
- » Robust and efficient tire force and moment measurement, rolling resistance measurement and tread wear simulation systems
- » A variety of elastomer, damper and materials characterization solutions
- » Leading-edge hybrid simulation solutions



Elastomer Test Systems



Tire Force & Moment Measurement Systems



Steering Test Systems



Multiaxial Simulation Table (MAST) Systems



12 Dynamic Kinematic & Compliance (K&C) Systems

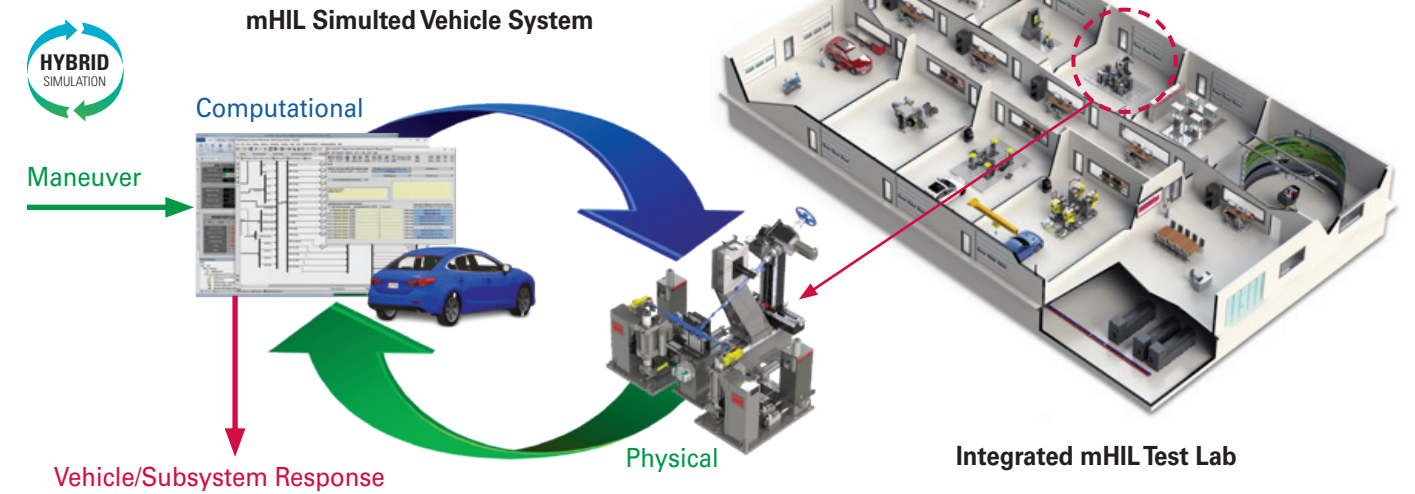


Dynamic Flat-Belt Roadways

Mechanical Hardware In-the-Loop (mHIL)

Mechanical Hardware In-the-Loop (mHIL) is a hybrid simulation technique that integrates physical components or sub-systems under test in closed loop with a computational vehicle model to establish a real-time, vehicle-level simulation environment. This simulation environment can be used in the early phases of vehicle development to subject test components or sub-systems to real-world driving or proving ground events in the test lab, well in advance of production prototypes. Early phase mHIL simulations

provide mechanical test feedback to optimize vehicle models, accelerate subjective and objective evaluation, reduce the need for rework and prototypes, and streamline proving ground validation. MTS has pursued mHIL solutions to complement a broad array of physical test systems, including damper, tire, steer, suspension, axle, and drivetrain.



Expanding MAST Capabilities

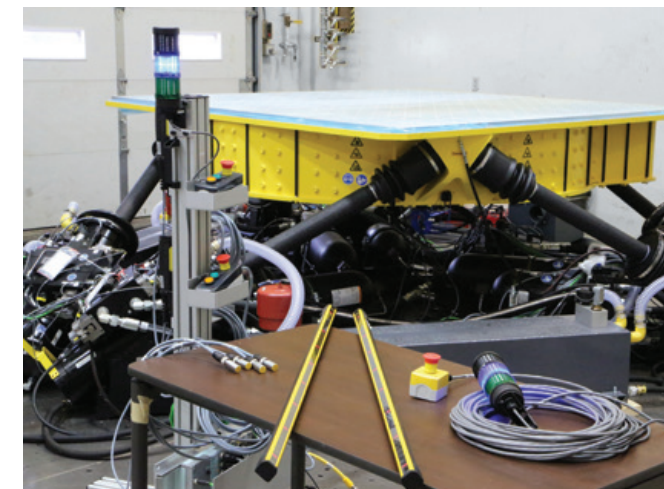
Dual-Mode MAST System

Electric and autonomous vehicles are driving an intensified focus on occupant ride comfort, prompting increased need for human-rated, 6DOF vibration simulation capabilities. To help meet these demands, the new Model 353.20 DM (Dual Mode) MAST delivers an expanded application range that includes both durability and NVH testing, and occupants-on-the-table ride comfort evaluation.

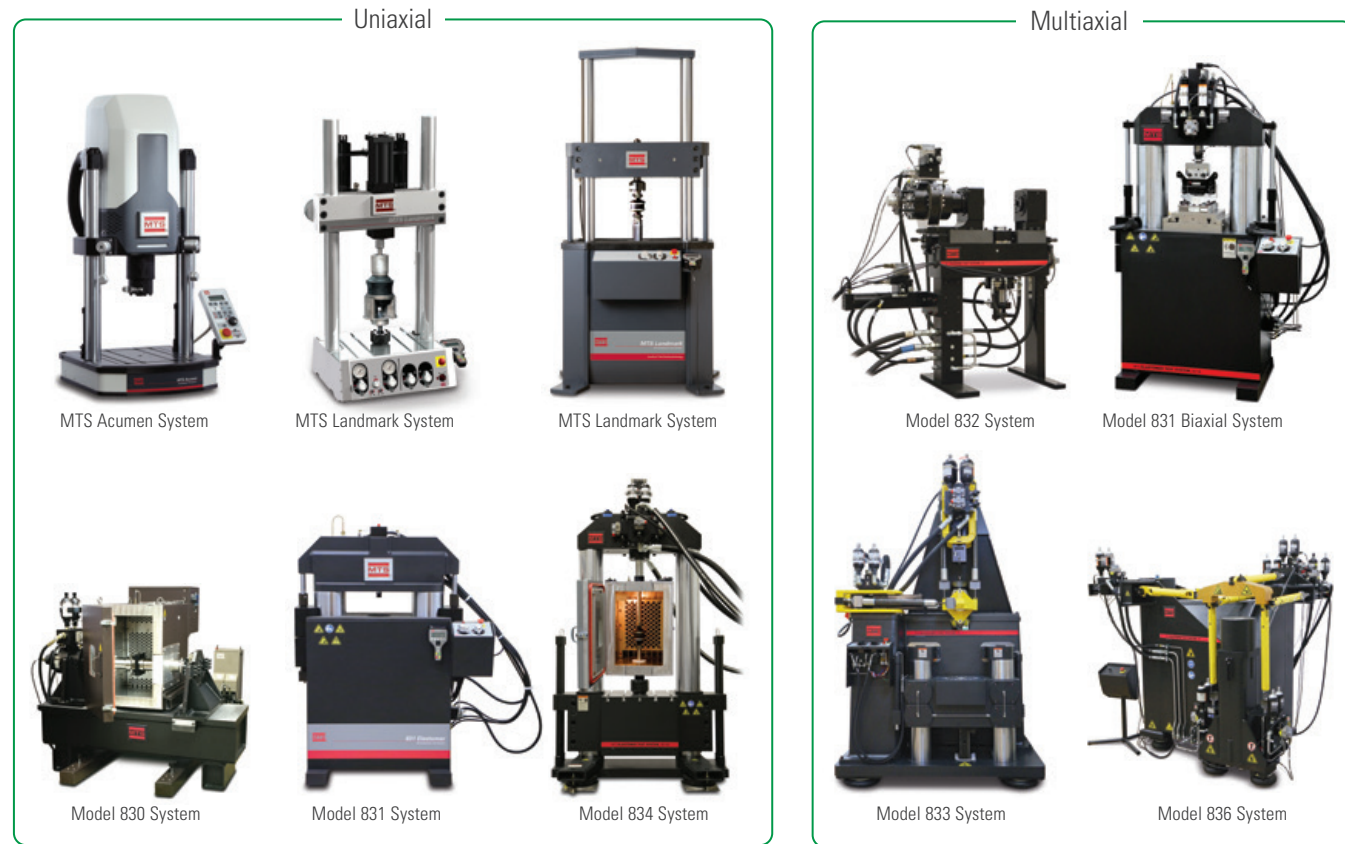
Driven by ISO 13849-1:2015 (Safety of machinery – Safety related parts of control systems), the 353.20DM integrates advanced MTS Safety PLC

technology, new hydromechanical manifolds, an array of human interfaces and test space monitoring devices to ensure safe and efficient switching between full-performance durability testing and reduced-performance ride comfort evaluation.

Available via turnkey system or 353.20 field upgrade, MTS Dual Mode MAST technology is purpose-engineered for conducting human-rated vibration simulation that complies fully with ISO 13090-1 and ISO 2631-1.



MTS Elastomer Testing Portfolio



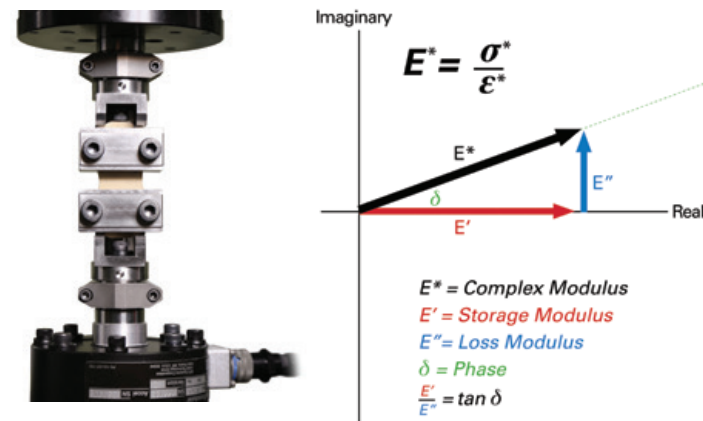
MTS Acumen® Test Systems

Ideal for automotive elastomer characterization and materials lightweighting, MTS Acumen Electrodynamic Test Systems deliver superior precision and ease of use for dynamic and static testing. Energy-efficient electrodynamic actuation enables these flexible systems to be installed quickly with minimal impact in your facility.



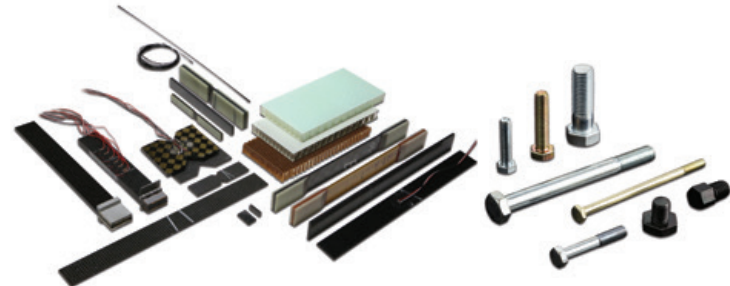
ELASTOMER CHARACTERIZATION

Measure the static and dynamic behaviors of tire materials, suspension components, and engine and exhaust mounts.



LIGHTWEIGHTING

Determine the static and dynamic properties of plastics, composites, metals, fasteners and adhesives.



The Evolving MTS Damper Portfolio

The MTS damper testing portfolio continues to evolve, adapting to meet more challenging test requirements and growing demands for improved test system efficiency. Once exclusively servohydraulic, this expanded portfolio now features both high-performance electric and servohydraulic systems to fulfill a complete range of test applications, spanning quality, characterization, friction force, noise and durability.

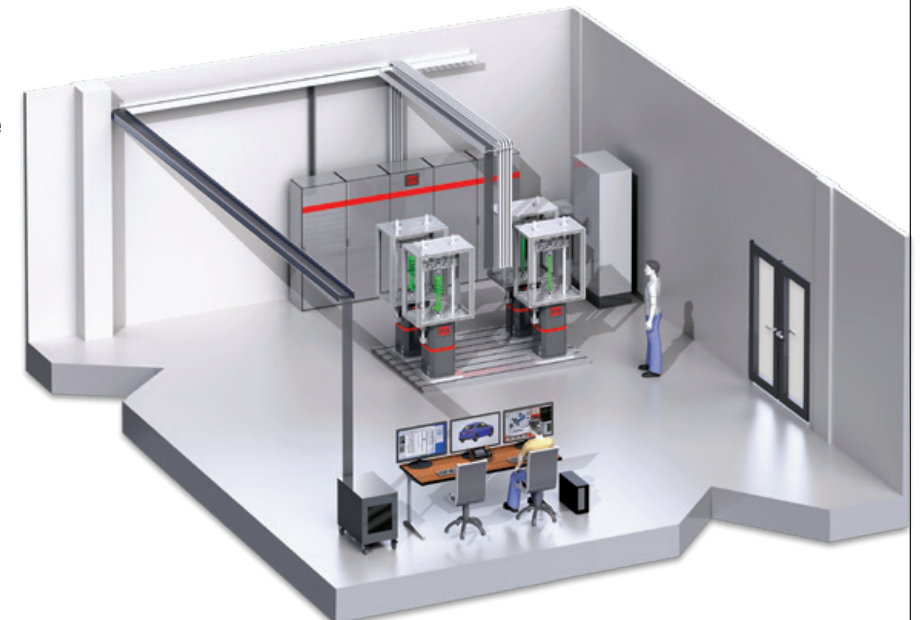


HYBRID SIMULATION mHIL Damper Test System

Accelerate Active & Semi-active System Development

Use proven mechanical Hardware-in-the-Loop (mHIL) technology to create a real-time, vehicle-level simulation environment for testing semi-active or active damper, suspension, and body control systems.

- » Enhance CAE model development
- » Conduct accurate simulations earlier in vehicle development
- » Dramatically reduce proving ground dependency, validation costs and need for prototypes



The **mHIL Damper Test System** combines a physical sub-system of components with a vehicle model adapted for damper and spring inputs.

Modular TestLine™ Solutions

Precision-engineered components for building your test stand right the first time

TestLine Solutions comprise a versatile and reliable set of modular test components and standard hardware and software tools that enable you to create cost-effective test systems that can be reconfigured as your needs change. You supply the in-house design capability and imagination, MTS provides the premium-quality products and components to help build your test solution right the first time.

Precision-engineered to the highest quality and designed for seamless integration, the modular components and the standard hardware and software used in TestLine Solutions are the same as those integrated into the most advanced MTS custom test systems.

MTS Standard Products

MTS DuraGlide Linear Actuators

MTS Application Software

MTS DuraGlide Rotary Actuators

252 Servovalves

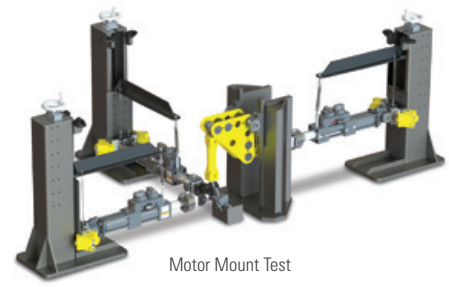
Load Cells

293 Hydraulic Service Manifold (HSM)

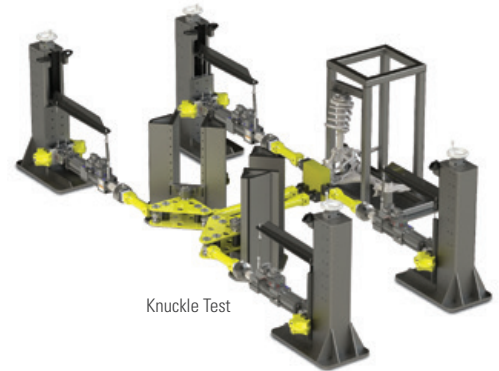
295 Isolation Hydraulic Service Manifold (IHSM)

SilentFlo™ Hydraulic Power Units (HPU)

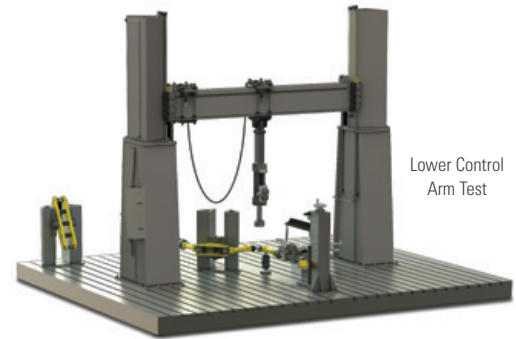
FlexTest® Controllers



Motor Mount Test



Knuckle Test



Lower Control Arm Test

MTS TestLine Components

MOCOKIT® Portal Frames

Universal Struts

Bell Crank Assemblies

Lever Assemblies

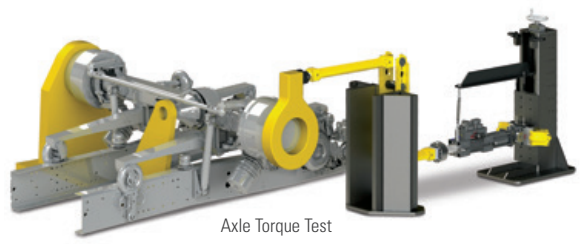
Reaction Stand Weldments

Rod End Spacer Assemblies

Rod End Block Assemblies

Rod End Spacers

Pillow Block Bearings



Axle Torque Test

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