CUSTOMISED SOLUTIONS FOR DEMANDING MATERIAL TEST AND SIMULATION APPLICATIONS
MOOG AUSTRALIA TEST & SIMULATION CAPABILITIES

MOOG INC
Moog Inc. is a worldwide designer, manufacturer, and integrator of precision motion control products and systems.

Our expertise combined with close customer collaboration is the key to more rapid, reliable and versatile performance testing. From human-rated tests to electric actuation to hexapod configurations, we provide leading-edge technology to meet our customer’s needs and enable their creativity.

ARC FUNDING - WE UNDERSTAND
The Australian Research Council (ARC) administers the National Competitive Grants Program (NCGP), which supports the highest-quality fundamental and applied research and research training through national competition - http://www.arc.gov.au/grants

Applications for funding is a long process and engaging early maximises your success rate in being awarded with an ARC grant.

- Last minute requests for ROM prices increases the risk of a response that compromises your business case in the University pre-submission review and selection process (Notice of intent, expression of interest etc.)
- Early engagement allows for a considered response supported by preliminary cost/performance trade studies and realistic project delivery timeframes.

Use our expertise to support your business case development
- Leverage Moog background and experience in the execution of similar projects
- Provide a reality check via performance estimation
- Creative innovation and differentiated capability for your faculty as opposed to "me too" systems from a catalogue
- Solutions based on Moog’s standard building blocks and customised products in conjunction with a strong collaboration with other companies and subject matter experts ensures a total solution perspective. Creativity and innovation is still incorporated using building blocks which ensures best value for money.

A CUSTOMISED APPROACH TO TEST SOLUTIONS
Moog offers a customised approach to test systems, maximising value for University test labs through appropriate performance estimation, cost/performance trade studies and solution design.

1. Analyse test requirements
   a. Static, Quasi-static or dynamic testing
   b. Force, displacement and test frequency or velocity requirements
   c. Load definition
   d. Safety & specimen protection
   e. Refurbishments vs. new solution
   f. Matlab and Simulink or computer-based simulation ensuring performance, pre or post ARC award.

2. Identify constraints
   a. Power limit
   b. Footprint or mechanic envelope
   c. Project delivery times
   d. Budget

3. Develop a solution
   a. Define scope for Moog and solution partner if required
   b. Performance estimation and trade studies ensuring requirements are achieved within defined constraints
   c. Develop a solution using Moog building blocks, customised and ancillary products for Moog scope of work
   d. Close collaboration with solutions partners, leveraging Moog expertise in the test and simulation industry
   e. Validation of solution through factory testing and on-site commissioning

CUSTOMISED PRODUCTS
Customised or bespoke products to fulfil test requirements within project restraints
1. Servo-hydraulic actuators for Static, Quasi-static or Dynamic testing
   - Stall forces up to 4500kN at various strokes
   - Design pressures up to 700Bar
   - Symmetric or Asymmetric design with cushions
   - Low Friction seals
   - Integrated position transducer and load cell
   - Mounts: pedestal, clevis, swivel, transition, front flange
   - Moog servo valve matched to test requirements

2. Hydraulic Service Manifolds
   - Pressure block and bleed
   - Low-High selection with optional soft transition
   - Pulsation damping accumulators
   - Control system integration

3. Hydraulic Power Units
   - Pressure and flow to meet requirements
   - Various cooling and filtration designs
   - Optional power limitation techniques: soft start, VSD’s
   - Optional noise limiting designs
   - Fully integrated with Moog Test controller for maximum flexibility and safety

MOOG EXPERTISE USED TO DEVELOP CUSTOMISED TEST SOLUTIONS
1. Simple Harmonic Motion Analysis
   - Captures performance requirements
   - Complete system approach - Actuator Performance Limit
   - Load behaviour estimate - Load Line
   - Simple and customised Excel

2. Basic Dynamic Simulation - Simulation X
   - Quick and easy interface
   - Number of standard blocks and functions
   - Extensive fluid power and controls library
   - Reliable and cost effective

3. Complex Simulations - Moog Analysis and Simulation Toolbox
   - Based on MATLAB/Simulink
   - Extensive library of Moog standard test building blocks
   - Dedicated team of highly skilled engineers available to support local teams
   - Models and library elements validated by real applications

WHAT MOVES YOUR WORLD

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Our products

Iron Bird
Dynamic functional testing on fuel tanks, antennas, turrets and more

Aerospace
Spacecraft structure

Easy integration with Aircraft/airframe
Static/Fatigue Rated Options
4-Posters Test
DOF 2 – 8 depending on your requirements
Lower energy consumption and lifecycle costs

Built in test features
Safer, more reliable performance

Component and subsystem structural performance
Ride quality assessment of seat systems, cockpit modules and entire vehicles

Dynamic functional testing on fuel tanks, antennas, turrets and more

Electric and Hydraulic tables available
DOF 2 – 8 depending on your requirements
Better replication range, greater customisation
Safer, more reliable performance
Lower energy consumption and lifecycle costs
More user-friendly software

Your benefits at a glance:
- Unique force-loop model for exacting control and faster testing
- User-friendly operation for maximum flexibility in your test lab and less set-up time.
- Easily configurable fail-safe safety features to protect test articles and maintain testing.
- Expandable to ensure you can upgrade when required.

Expanding range of test controllers giving you maximum flexibility in your test lab and less set-up time

<table>
<thead>
<tr>
<th>SERIES</th>
<th>MODULAR TEST CONTROLLER</th>
<th>PORTABLE TEST CONTROLLER</th>
<th>AUTOMOTIVE TEST CONTROLLER</th>
<th>AEROSPACE TEST CONTROLLER</th>
</tr>
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<tbody>
<tr>
<td>KEY APPLICATIONS</td>
<td>Materials and Components</td>
<td>Aerospace Automotive (durability and fatigue) Vibration, shock Performance Evaluation</td>
<td>6-Posters Test Systems 4 Degree of Freedom (DOF) Test Rig Durability and fatigue testing Shock and performance evaluation Elastometric testing</td>
<td>Iron bird Aircraft/Surfacecraft/structure integrity Loading gear engine casing, fire actuation loading Load Calibration</td>
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Moog Test Controllers at a Glance
- Supported by Moog Integrated Test Suite Software enabling you to set up and run more tests faster and more efficiently.
- Replication, live sweep and vibration modules also available.
- Supports both electric, hydraulic and pneumatic test systems.

Motion Systems

For a wide range of payload applications

<table>
<thead>
<tr>
<th>RANGE</th>
<th>MOTION BASES</th>
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</thead>
<tbody>
<tr>
<td>PAYLOADS</td>
<td>1,000 kg to 16,000 kg</td>
</tr>
</tbody>
</table>

| KEY APPLICATIONS | Noise and vibration testing Component and subsystem structural performance Ride quality assessment of seat systems, cockpit modules and entire vehicles Dynamic functional testing on fuel tanks, antennas, turrets and more |

Moog Test Bases at a Glance
- Electric and Hydraulic tables available
- DOF 2 – 8 depending on your requirements
- Quick installation and commissioning and smaller footprint
- Better replication range, greater customisation
- Safer, more reliable performance
- Lower energy consumption and lifecycle costs
- More user-friendly software

Advantages
- Provides high fidelity and the smallest turn around on your test rig.
- High reliability with digital control loops that do not drift or deteriorate
- Easy integration with control hardware, vibration tables and G-loads
- Redundant mechanical and software safety architecture
- Built in test features recording performance parameters
- Easy to install, use and maintain
- Simple support via Moog Simulation Software
- Extensive global support.

HYDRAULIC TEST ACTUATORS

Moog Hydraulic Test Actuators with Hydrostatic, or Polymer Bearings to deliver higher reliability, less maintenance and increased dynamic performance for test laboratories looking for a competitive edge.

<table>
<thead>
<tr>
<th>RANGES</th>
<th>TEST ACTUATOR</th>
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<tbody>
<tr>
<td>Type of Bearing</td>
<td>Hydrostatic or Polymer Bearing</td>
</tr>
<tr>
<td>Dynamic Force Rating (kN)</td>
<td>Up to 2000</td>
</tr>
<tr>
<td>Stroke Length (mm)</td>
<td>Up to 1500</td>
</tr>
<tr>
<td>Pressure (bar)</td>
<td>Up to 350</td>
</tr>
<tr>
<td>Duty</td>
<td>Static/Fatigue Rated Options</td>
</tr>
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Moog Test Actuators at a Glance
- Innovative 8 pocket hydrostatic bearing increases side load capacity to 60% of stall output and reduces energy requirements, with manifold house.
- Oil-cooled polymer bearing improves side load capacity to 15% of stall output, compared to 10% with traditional polymer bearing design.

Advantages
- Higher level of dynamic performance, reliability, and longevity.
- Advanced coating used on the rod significantly improves seal wear for long life and less maintenance.
- Manifold houses all of piping in the actuator, removing the need for most of the exterior piping.

FULL SCALE FATIGUE TESTING FOR BAE HAWK 127

When the Australian government made the decision to purchase the BAE Hawk Mk.127 Lead-in Fighter for the Royal Australian Air Force, the Australian Defence, Science and Technology Organisation (DSTO) was tasked with completing a full-scale fatigue test in conjunction with BAE Systems and looked to Moog for a solution. Fatigue testing is a critical requirement for military aircraft to determine the life span of safe, economical and serviceable airframes beyond the specified flying hours.

The Challenge
To create a specialised actuator design capable of achieving critical performance parameters required that are not possible to achieve with standard industrial cylinders. These include low friction, high duty cycles and structural rigidity. Moog also needed to develop a unique abort manifold for static and dynamic testing that is superior to what was previously available.

The Result
Key features of the servo actuators
- Realistic and repeatable test processes
- An extensive database of measured values for a variety of solutions
- Customised sealing and bearing solutions including elastomer seals, laminar and hydrostatic.
- Modular construction for ‘active’ [load-loop] abort or conventional ‘passive’ fixed orifice abort.
- Optimised transition from normal control to abort to minimise structural disturbances.
- Developed under aircraft standard Failure Mode, Effects and Criticality Analysis for optimal reliability.
- Extensive static and dynamic performance testing.

Aircraft test systems demonstrate Moog capabilities for improving motion control and safety for material test applications. The requirements for high performance servo-actuators, controlled abort and digital system control are also common for a variety of applications ranging from flight simulators to lab controls to high speed injection moulding machines. Moog is now a system supplier for these applications.
OUR PROJECTS

INSTRON 2 AXES MACHINE UPGRADE AT UNIVERSITY OF SYDNEY
When Sydney University required an upgrade of a unique 2 axes machine to new specifications for research, they looked to Moog Australia for a solution.

The Challenge
To cycle the specimen in closed loop position/force/stress in both the axial and torsional axes up to 100kN. Moog Australia had never upgraded a machine like this before including closed loop strain control. The existing motion control system was faulty and had to be replaced. Moog Australia were asked to supply a new two axes strain transducer to interface with our Portable Test Controller (PTC) and Moog Integrated Test Suite (MITS) to expand the control to include strain.

The Solution
Moog Australia performed a system audit to determine what was required for the upgrade. After the audit it was identified the following was required:
- A Single channel PTC, MTS, cables and dual channel strain transducers
- An Upgrade of Servovalves (2 off)
- Replacement of filter element
- Check, repair and recharge of existing accumulators
- Removal of existing pressure transducers
- Rewiring of existing clamping controls
- Supply of PTC and 4m cable assembly for jog function.
- Extra installation, commissioning and training

The Result
By reviewing the machine requirements in a holistic sense, customer requirements and system reliability, we were able to implement a solution that optimised the system and enhanced performance. This is a unique machine in Australia with the combination of closed loop position (torque) and Torsional strain. Moog Australia also provided training to ensure that the customer would be self-sufficient.

CENTRAL QUEENSLAND UNIVERSITY - 4.5MN TEST SYSTEM FOR TRAIN COMPONENT RESEARCH
When Central Queensland University Centre for Railway Engineering (CRE) required a large capacity hydraulic servo test system to be used to validate design standards for train components, they looked to Moog Australia for assistance in the design and supply of a high performance solution.

The Challenge
The challenge was to provide a hydraulic system which could meet a peak flow demand of 7700 lpm (specimen test profile - sinusoidal 10kHz ± 2mm) that utilised the existing hydraulic system at CRE which limited to 550 lpm and 350 bar. The challenge needed to address the control (supply state implementation), accumulator supply/dischage and supply and return line state conditions in order to ensure cavitation did not occur.

The Solution
Moog provided a servo controlled hydraulic system which included a high capacity discharge accumulator bank, a custom designed return line pneumatic piston vessel and a fatigue rated 4.5MN servo actuator. The servo actuator included an integral position/presure feedback sensor, system manifold and a high performance Moog STX stage servo proportional valve.

The Control system was modelled using Simulation X to validate the hardware selection, correct sizing of the accumulator capacity, hydraulic line sizing and return line cavitation mitigation in order to meet the 4 cycle sinusoidal test conditions – 0.25 Hz ± 2MN/27mm, 2Hz ±2MN/72mm, 5Hz ± 2MN/200mm and 2 Hz ± 3.1MN/9mm.

The control platform was a Moog STX series industrial controller. The STX assembly featured 4 ±2.5kHz digital servo controllers plus 16/16 DO expansion cards and 16/16 DI expansion cards to interface into the safety and control management system of the test. The tests were managed via a Moog SCS 59 interface in the CQU host controller test management software.

The Result
After calibration of the system and optimisation of the control model the system has run in excess of 1 million cycles. The test parameters and control concept enables a laboratory rig to reliably emulate realistic heavy train conditions.

The test hardware setup provides CQU with the capability to test and better qualify new designs of rail couplings. The qualification of the test regime enables the rail coupling to be tested under a full load spectrum within a laboratory environment providing significant savings in the development time of new coupling designs when compared to the previous drop hammer and iterative in field methodology previously used.

TESTING LOADS ON REINFORCED CONCRETE SLABS AT CURTIN UNIVERSITY
When Curtin University Western Australia were considering options for a new reinforced concrete slab load test system, they approached Moog Australia for a flexible solution to utilise and optimise existing hardware.

The Challenge
To supply a highly flexible reconfigurable test system capable of static and cyclic tests for a variation of beams from 110mm thick concrete slabs to 300mm deep pre-cast members. To achieve this project required utilising a wide selection of 700bar rated double acting hydraulic cylinders (10 tones to 500 tones) and feedback sensors and the inclusion of 2 axes of closed loop servo hydraulic control, while maintaining the option of adding extra axes in the future.

The Solution
Moog supplied and commissioned a system based on the Moog Portable Test Controller (PTC) and a 2 axis hydraulic service manifold. Moog Australia delivered hands on training on the new system commissioning so that Curtin University were confident in its operation before leaving site and site acceptance was signed off by both parties.

The Result
Key features of the Moog Portable Test Controller (PTC):
- A 4 axis stand alone desktop controller with a 10" display
- Designed to provide high performance closed loop control (position/force) of dynamic and static tests
- User-friendly interface that allows configuration of axes for independent or master/slave control and run tests.
- Can be networked with other Moog controllers to extend axes count.

Key features of the two-axis Hydraulic Service Manifold (HSM):
- Allows for mounting and isolation of desired servo valves for each axis
- Filtration to ensure longevity of the system

The capability to coordinate multiple axes allows researchers to implement classic beam analysis with two different loads at different points on the beam, or two deflections of non-uniform beams by measuring force to determine stiffness at the two points.

FILTRATION TO ENSURE LONGEVITY OF THE SYSTEM
When the National Measurement Institute (NMI) required an upgrade of the only GEC Avery Load Cell Calibrating Machine in Australia they looked to Moog Australia for a solution.

The Challenge
To upgrade the GEC Avery Load Cell Calibration Machine which would allow test and calibration of load cells accurately in compression or tension up to 5MN by putting actual weights onto four stacks. These stacks were controlled in servo hydraulic closed loop position control via a lock-up table. Moog Australia had never upgraded a machine like this before as the requirements and machine were unique and not well documented. The existing hydraulics and electronics were old and unreliable.

The Solution
Moog Australia replaced the system with a 4 axes Moog Servo Controller (MSC) control system including a high level operator interface screen for controlling the load cell calibration. The solution was able to interface with existing valves and transducers, but had additional capacity to drive other axis, could perform extensive diagnostics and provided a high performance closed loop control for 4 axes (2ms) with complex sequencing. Moog Australia also provided training to ensure the NMI would be self-sufficient.

The Result
Key features of the Moog Servo Controller (MSC):
- Fully programmable multi-axis controller
- MACS (Moog Axis Control Software)
- Suitable for electric and hydraulic axes
- Integrated PLC functionality
- Flexible control structure
- Analog and CANbus communications
- Designed for high speed loop closure times of ~1ms

Moog can provide a customised high performance solution with state of the art digital motion control products and technology that are locally supported by an experienced team. Flexible control structure within the Digital Controller allows the implementation of an intelligent control including but not limited to look up table (LUT) algorithms, reading CSV load file, complex sequencing, interlocks and universal interface. Moog’s digital motion control solutions allows you to modernise old platforms adding new life and versatility to old platforms.
TAKE A CLOSER LOOK.

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