

CAPABILITIES FOR HIGH PERFORMANCE NICHE APPLICATIONS UNITED KINGDOM





# **MOOG – MAKING THE IMPOSSIBLE POSSIBLE**

#### **ABOUT MOOG**

Founded in 1951 by Bill Moog in East Aurora, New York, Moog has had a relationship with the UK since 1958, when Moog licenced Dowty to manufacture Moog Servo Valves in Gloucestershire.

Since that time, Moog has developed a reputation throughout the world as a company with dedicated employees and market leading motion control solutions.

We operate from a modern facility in Tewkesbury, Gloucestershire, designing, manufacturing and developing Moog products and systems and assisting with their applications, both in the UK and at a global level.

The Tewkesbury site is easily accessible by road (Junction 9, M5) and by rail (Ashchurch).

We employ people with roles embracing machining, assembly and test, design and applications engineering, purchasing, logistics, sales and marketing. We view our customers as part of our business and we, as a part of theirs.

We take a collaborative approach to solving our customer's most difficult motion control problems with electric, hydraulic and hybrid solutions.

Our team is dedicated, agile, flexible and customer focused.



#### **GLOBAL FOCUS**

engineering and services network to support customers around the world.



#### MODELLING AND SIMULATION

to accurately predict system performance in advance of manufacture.



### ESTABLISHED CULTURE that encourages collaboration

and commitment.



### **EXPERTISE**





#### TRAINING

hands-on training to maximise the benefits of your Moog installation

#### **OUR APPROVALS**

Moog customers benefit from the following standards and approvals.

**FIA**: Homologation for use with the current FIA Standard ECU.

British Standards Institution: BS EN ISO 9001:2015. Registration number is FM 13218.

#### SUPPORT

to ensure your application delivers results for as long as you need.

INSTALLATION CAPABILITY

supported by our global field

engineering team.



#### FIELD SERVICE

to ensure expert support and advice is where you need it



Environment: Moog Industrial Group Tewkesbury is registered as complying with the requirements of BS EN ISO 14001:2015. Registration number is EMS 576922.



## STANDARD AND CUSTOMISED SOLUTIONS

From advanced customised miniature high performance control systems for Formula 1 racing cars and autonomous robots, to heavy duty environments such as the steel industry, to special engineered solutions for Wimbledon's retractable roof, Moog supplies precision motion control solutions to meet a range of demanding applications.



HyQ is a quadruped robot that was developed at the Advanced Robotics Department of the Istituto Italiano di Tecnologia.

Goals of the project are the design of versatile robots, the investigation of various aspects of quadrupedal locomotion, adjustable compliance, energy efficiency, compact hydraulic actuation and onboard power systems.

![](_page_4_Picture_0.jpeg)

![](_page_4_Picture_1.jpeg)

#### MOTORSPORT

Moog is an established actuation supplier to high end motor racing teams formulae including Formula 1. We also supply to a variety of other technically focused sports including yacht racing.

![](_page_4_Picture_4.jpeg)

#### NICHE PRECISION AUTOMATION

Performance-driven companies developing their next-generation machines turn to Moog for either electric or hydraulic capabilities to solve their high performance automation challenges.

![](_page_4_Picture_7.jpeg)

#### ROBOTICS

Some of the world's most advanced mechanical robots use Moog's range of products and expertise where mobility, agility, dexterity and speed are required.

![](_page_4_Picture_10.jpeg)

#### SIMULATION

Training centres around the world turn to Moog as the leading designer and manufacturer for flight simulators, entertainment and driver training simulators, control loading actuators and helicopter and fighter G-seats.

![](_page_4_Picture_13.jpeg)

#### TEST

Manufacturers and test labs can expand and set up test rigs easily, increase throughput and productivity, improve test accuracy and get results quicker, while keeping the tested specimen totally safe.

![](_page_4_Picture_16.jpeg)

#### AUTOMOTIVE

High performance car manufacturers can benefit from Moog's Formula 1 technology to deliver enhanced drivetrain, chassis, braking, steering and advanced aerodynamic systems.

![](_page_4_Picture_19.jpeg)

### POWER GENERATION, GAS AND STEAM TURBINES

With the cost of any outage critical to the profitability of a power station, Moog is equipped to offer both steam and gas turbine actuator service and repair in a timely manner in addition to our complete line of ATEX approved and explosion-proof Servo Valves.

![](_page_4_Picture_22.jpeg)

The performance of your downhole, topside, and subsea/marine equipment including ROVs can be improved with Moog's high performance motion control, surveillance and data communication solutions.

# **STANDARD PRODUCT RANGE**

Our high-performance motion control solutions, systems and components control a variety of industrial machines manufactured and installed all over the world – installations where precision, velocity, force and acceleration are critical, with ruggedised and explosion proof alternatives stocked.

![](_page_5_Picture_2.jpeg)

#### SERVO AND PROPORTIONAL VALVES

Moog servo and proportional valves are legendary for reliability and accuracy. Moog valves incorporate closed-loop control for high performance.

![](_page_5_Picture_5.jpeg)

### SERVO MOTORS

Electronically commutated synchronous AC motors with permanent magnet field excitation, specifically designed for highly dynamic servo industrial applications where positioning times of 30 msec or less are often the norm.

![](_page_5_Picture_8.jpeg)

#### CARTRIDGE VALVES

A compact design that can be used in hydraulic manifold systems for many types of industrial and mobile machinery. Ideal for applications requiring high flow rates and leak-free control.

![](_page_5_Picture_11.jpeg)

#### **RKP - RADIAL PISTON PUMPS**

The latest generation of the RKP has been optimised to provide the highest durability and low noise levels, as well low flow and pressure pulsation.

![](_page_5_Picture_14.jpeg)

#### MECHANICAL LINEAR ACTUATORS

Incorporates conventional and inverted screw designs that meet ISO accuracy for classes 1-3-5. Covering a wide range of static and dynamic loads the screws are capable of high accelerations delivering extremely short cycle times.

### SERVO DRIVES

Our MSD range of single and multiple axis servo drive systems with programmable built in PLC functionality to IEC61131 standard, with built-in functional safety.

#### **SLIP RINGS**

![](_page_5_Picture_20.jpeg)

### MOTION AND MACHINE CONTROLLERS

High performance controllers designed for demanding electric and hydraulic servo actuation applications. Industry standard fieldbus communication enables convenient integration with other machine elements such as sensors and drives.

![](_page_5_Picture_23.jpeg)

Used in any electromechanical system that requires unrestrained, continuous rotation while transferring power and / or data from a stationary to a rotating structure, improving system performance by simplifying operations and eliminating the need for external wiring.

![](_page_5_Picture_25.jpeg)

#### CUSTOM ACTUATOR PACKAGES

Moog has vast experience developing electric and hydraulic actuators for some of the world's most demanding applications.

# MINIATURE PRODUCT RANGE

Our range of other miniature proportional valves and actuators for use in motorsport and other applications requiring high performance solutions and minimized size and weight.

![](_page_6_Picture_2.jpeg)

### SERVO VALVE

Ideal for applications where very high levels of power density are required, that can not be achieved with electrical actuation. Includes: selector drum positioning, clutch, throttle control and torque control in limited slip differentials.

![](_page_6_Picture_5.jpeg)

#### LINEAR (PAS) VALVES

A closed-centre Linear Power Steering Valve which can be applied to any vehicle with a high pressure hydraulic supply. Design allows easy tuning both for the level and the linearity of assistance. Successfully applied in Formula 1, rally cars and Le Mans cars.

![](_page_6_Picture_8.jpeg)

#### CARTRIDGE DIRECT DRIVE PROPORTIONAL VALVE

A compact design that can be used in hydraulic manifold systems for many types of industrial and mobile machinery. Ideal for applications requiring high flow rates and leakfree control.

![](_page_6_Picture_11.jpeg)

#### BRUSHED AND BRUSHLESS MOTORS

Revolutionary range of miniature electric actuation technology. Includes power dense high performance brushless motors, some with integrated drive electronics, as well as direct acting linear electric motors.

![](_page_6_Picture_14.jpeg)

#### INTEGRATED MOTORSPORT SYSTEMS

Complete motorsport motion control systems, utilising either hydraulic or electrical actuation technology.

#### HYDRAULIC POWER UNITS

![](_page_6_Picture_18.jpeg)

Miniature hydraulic power units for 12 and 24 volt operation, using a high efficiency axial piston pump powered by a custom designed brushless motor. Moog's associated electronic controller provides closed-loop control of pressure in a hydraulic accumulator supplying a hydraulic system.

![](_page_6_Picture_20.jpeg)

#### ACTUATORS

Miniature actuators optimised specifically for motorsport applications. Some designs incorporate robust integral eddy-current position sensor along with external conditioning electronics. Able to withstand high temperature and vibration levels. Can be supplied without transducer or with external LVDT position sensor. Throttle actuation, gear box indexing, clutch control and turbo charger wastegate actuation.

# **TEST AND SIMULATION**

Our range of test controllers and simulation tables have been developed where increased flexibility, reliability and precision-proven solutions are required.

![](_page_6_Picture_25.jpeg)

### TEST CONTROLLERS

Moog offers a new generation of single and multichannel test controllers for structural and fatigue testing, in applications such as automotive, aero and blade testing.

![](_page_6_Picture_28.jpeg)

### SIMULATION TABLES

Hydraulic and Electric Moog Simulation Tables simulate acceleration and displacement outputs reproducing key data collected on proving grounds. Our integrated control hardware and software provides the most flexible, highest performing test equipment available.

# QUADRUPED ROBOT TAKES BIG STRIDES TOWARDS SAVING LIVES

When Researchers at the Istituto Italiano Di Technologia (IIT) wanted to bring to life their HyQ "Hydraulically actuated Quadruped", to assist humans in their response to emergencies such as search and rescue operations in dangerous places, they approached Moog for a solution.

![](_page_7_Figure_2.jpeg)

#### THE CHALLENGE

To provide the IIT with a sub miniature and extremely high response hydraulic solution to control the leg motion of the HyQ which would have to react rapidly when the legs hit the ground, enabling precise reactive control of the rigidity/ elastically of the limbs, absorbing the shock of impact, and preventing stress and damage to the centre body.

#### THE SOLUTION

The concept of "actively compliant" legs was made possible by the extremely high response of the Moog E024-LA miniature hydraulic servo valve integrated with a Moog servo actuator and additive manufactured manifold to control leg motion.

#### THE RESULT

A migration of F1 micro hydraulics technology to human emergencies providing:

- Precise reactive control of the rigidity/elasticity of the limbs of the quadruped.
- Shock absorption of impact and prevention of stress and damage to the central body.
- A robust, reliable, ultra-compact light-weight hydraulic solution capable of precise control in milliseconds.
- One of the few robots capable of doing the "flying trot" where all four legs leave the ground simultaneously.

![](_page_7_Picture_13.jpeg)

![](_page_7_Picture_14.jpeg)

COMPLEX SIMULATION

() MOOG.CO.UK () +44 (0)1684 858000 () INFO.UK@MOOG.COM

### MIGRATION OF MOOG TECHNOLOGY DEVELOPED ORIGINALLY FOR AEROSPACE AND FORMULA ONE TO HUMAN EMERGENCIES.

# CONTROLLING WIMBLEDON'S RETRACTABLE ROOFS DURING RAIN AND SUN!

When The All England Lawn Tennis and Croquet Club made the decision to install retractable roofs over the two Courts at Wimbledon they had envisaged a hydraulic solution. However following a design review with Moog, an electric solution was developed.

![](_page_9_Picture_2.jpeg)

CAPABILITY

![](_page_9_Picture_4.jpeg)

![](_page_9_Picture_5.jpeg)

![](_page_9_Picture_6.jpeg)

EM ACTUATORS, TECHNOLOGY AND SOFTWARE BRUSHLESS MOTORS

#### THE CHALLENGE

To provide an electric solution capable of moving over 1,000 tonnes of steel above 15,000 fans, within a tolerance of +/- 12.5mm over a span of 75 metres, and when not in use to occupy the minimum space.

### THE SOLUTION

To move the two sections of roof, comprising 10 "trusses" each weighing 100 tonnes. Moog provided brushless servomotors, electric actuators, servodrives, servocontrollers, control panels, main control desk, SCADA and data logging. Also design, specification development, engineering, including dynamic modelling, commissioning and future service and support.

### THE RESULT

Motion control of a unique retractable roof on an iconic building:

- Over 150 axis of control.
- Controlled movement of 10 "trusses" each weighing 100 tonnes.
- Can be fully deployed in 8 minutes.
- Demonstrates Moog's ability to provide electromechanical actuation (EMA) technology, and software.
- Completed on time for the June 2009 championships and continues to be highly reliable in rain and sun.
- Designed for long life and low maintenance.
- Serviced and supported by Moog

## CONTROLLED MOVEMENT OF 10 "TRUSSES" EACH WEIGHING 100 TONNES.

![](_page_10_Picture_1.jpeg)

# BLADE TESTING TO THE EXTREME

Researchers at the Technical University of Denmark (DTU) Large Scale Facility were looking to develop new advanced test methods to gain a better understanding of the failure in large structures.

![](_page_11_Figure_2.jpeg)

![](_page_11_Picture_3.jpeg)

![](_page_11_Picture_4.jpeg)

DTU LARGE SCALE FACILITY

### THE CHALLENGE

After soliciting proposals and securing funding from the Danish government, DTU picked Moog in the United Kingdom and its technical partners T A Savery and Qualter Hall for the project. Moog's expertise in aircraft structural testing and range of precision control systems, actuation products and engineering support services, which includes modelling and simulation capability, appealed to DTU's team. Furthermore, Moog had already developed actuation devices specifically engineered for wind turbine blades.

### THE SOLUTION

Moog's expertise with closed loop servo control and actuation helped it create a testing facility underpinned by a digital closed loop control system and application software.

To provide DTU testing flexibility, Moog and its partners designed and installed three test stands for 15m, 25m and 45m blade sizes, each configurable for DTU via the Moog system. Moog engineers also carried out the installation and commissioning of the suite of test equipment and provided training and ongoing support for DTU staff. The Moog scope of supply for the three blade test stands included the hydraulic power plant and distribution network, six hydraulic winches for the static test and a combination of eight mass resonance exciters (MREs) and linear actuator assemblies for dynamic test work. The solution also included all pipe work, hosing and actuation devices, control system electronics and application software.

### THE RESULT

Moog delivered a solution which puts realistic loads on blades, enabling DTU to go to its next level of embedding sensors and creating digital twins to model what a blade's future state might look like, preventing blade failure before it happens.

## MOOG'S SOLUTION PREVENTS BLADE FAILURE BEFORE IT HAPPENS.

# HYDRAULIC MANIPULATOR **ARM SOLUTION TO ENABLE SAFE** NUCLEAR DECOMISSIONING

When James Fisher Nuclear required a system to control the manipulator arm they had developed for nuclear decommissioning work, Moog Applications Engineers were engaged to deliver the required product performance and appropriate Moog control system.

![](_page_13_Picture_2.jpeg)

Robotics

![](_page_13_Picture_3.jpeg)

Niche Automation

![](_page_13_Picture_5.jpeg)

![](_page_13_Picture_6.jpeg)

![](_page_13_Picture_7.jpeg)

MANIPULATOR ARM ARM

![](_page_13_Picture_9.jpeg)

### THE CHALLENGE

ModuMan had been designed by JFN around conventional hydraulic actuators. To ensure maximum maintainability, vital control elements needed to be located outside the operating cell. The 6-axis manipulator arm needed to be able to grasp and move materials weighing up to 100 kg, with a reach of 2.3 m through a 270 mm diameter access port in a radioactive environment.

### THE SOLUTION

Moog delivered a control system comprising Moog servo controllers, servo drives and motion control software, as well as modelling and simulation of the product design.

### THE RESULT

## DELIVERING A SOLUTION FOR AN EXTREME RADIOACTIVE ENVIRONMENT.

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# DELIVERING AN EVOLVING HIGH-END TECHNOLOGY TO NICHE CUSTOMERS AND MEETING CHANGING REGULATIONS

Surprisingly, current Formula 1 cars weighing just 746 kg require Power Assisted Steering (PAS) systems because of the extreme levels of downforce generated at speeds of over 300 km/h.

![](_page_15_Figure_2.jpeg)

#### THE CHALLENGE

Initially, Formula 1 allowed complex software controlled PAS systems, featuring multiple redundancy for safety. However, in 2002 an FIA cost-cutting initiative, outlawed the use of any electronic controls in power steering. The teams first investigated electric motor based solutions but reverted to more 'power dense' hydraulic technology. Following this regulation change, a variety of hydromechanical approaches were tried, however these were larger than ideal and challenging to set up.

![](_page_15_Picture_5.jpeg)

#### THE RESULT

To address this issue, in 2005 Moog introduced a miniature linear hydro-mechanical power steering valve, the E243 Series, which was quickly adopted by the F1 teams.

The E243 valve, incorporated hydro-mechanical servo technology that Moog had first used in the US space programme back in the 1960s, when electronics were not considered sufficiently reliable for some critical systems.

Moog selected the power stage of a conventional servovalve, as a control element that could be integrated in the car's steering rack. Using an innovative approach, 'shaped' hydraulic ports within the E243 valve, along with springs and orifices were used to replicate software "lookup table" functionality. This approach allowed easy tuning of assistance level and system linearity, to give the driver the precise steering "feel" required.

Over the intervening years the Moog E243 valve range has been refined to reduce weight and improve controllability and today the entire F1 grid uses these tiny but essential devices.

E243-500/501 FAILSAFE SWITCHING VALVES

## SYSTEMS DEVELOPED TO REDUCE WEIGHT AND IMPROVE CONTROLLABILITY FOR TODAY'S ENTIRE F1 GRID.

THE REAL

# KEEPING THE LIGHTS ON – SERVICE AND SUPPORT FOR POWER STATIONS

When a top European provider of electricity for residential customers began to experience leakage on their Moog J085 hydraulic actuators on their steam turbines, they realised that if they didn't address the problem immediately, the long-term cost implications could soar.

#### MARKET OTHER APPLICATIONS CAPABILITY

![](_page_17_Figure_3.jpeg)

![](_page_17_Picture_4.jpeg)

### THE CHALLENGE

To improve the reliability and efficient performance of the steam turbines by minimising service-related downtime, extending duty cycles of the actuators, and providing virtually on-demand service to meet customer requirements.

### THE SOLUTION

Moog assembled a global team of experts from Italy, the United Kingdom, Japan, China and the United States, and committed to a service touch-time of just 72 hours. Moog established a dedicated workshop in Europe with specialised tools and equipment, trained technicians, and expedited repair protocols to ensure peak performance from the serviced actuator units. Moog proactively produced detailed documentation that incorporates valuable information such as on-receipt and final acceptance tests, unit photography, and recommendations on improving equipment performance.

### THE RESULT

- Delivered significant savings by dramatically reducing the risk of downtime of the steam turbines and minimising the customer's maintenance shutdown time when servicing the hydraulic actuators.
- Customer was delighted and surprised by the Moog service team's ability to work around their somewhat unpredictable schedules.
- Extended cycle times despite rugged operating conditions.

![](_page_17_Picture_13.jpeg)

## EXTENDED CYCLE TIMES DESPITE RUGGED OPERATING CONDITIONS.

## TAKE A CLOSER LOOK

Moog designs a range of products that complement the performance of those featured in this catalogue. Visit our website for more information or contact the Moog facility nearest you.

![](_page_19_Picture_2.jpeg)

![](_page_19_Picture_3.jpeg)