Advanced Solutions for the Next Generation of Unmanned Vehicles

Moog is a global supplier of integrated systems and critical control products for the aerospace and defense industry. For the past 60 years, we have been supplying innovative and reliable solutions for aircraft and ground-based systems.

Our aircraft solutions include flight control, navigation and guidance, weapons bay door drive, landing gear extension, utility actuation, payload gimbals, and data and power transmission products. Our ground-based solutions include tracking systems, imaging systems, sensor nodes and stabilization systems.

We are continuously investing to extend the depth of our systems capability while simultaneously expanding our core component expertise to take on the challenges of a changing industry. Over the last few years, we have added MEMS-based gyros and IMU products to complement our flight control solutions, video and data multiplexers to complement our slip ring and fiber optic rotary joint offering, and imaging systems to complement our ground-based pan and tilt solutions.

Moog Expands Solutions for Harsh Environment Network Equipment Systems

Moog has acquired Protokraft, a company that designs and manufactures electronic and electro-optic components and subsystems for use in harsh environment networking equipment applications. Products include components for short and intermediate reach harsh environment communication networks, including optical network switches, optical enterprise and storage area networks (SANs) and tactical optical access networks. Moog Protokraft’s patented technology enables robust electronic and optoelectronic components to be packaged directly into cylindrical or rectangular connector shells. These electronic components are optimized for Fast Ethernet, Fiber Channel, Gigabit Ethernet, Serial FPDP and 10 Gigabit Ethernet networking applications.

Moog Protokraft’s components provide numerous cost, performance and reliability advantages to today’s network equipment systems. One of the new applications for this technology is situational awareness – allowing a user to stitch multiple images together and provide multiple operators with a 360° view of their environment on a single monitor.

Moog Crossbow Introduces Integrated Guidance, Navigation and Control System for Unmanned Aircraft

Moog Crossbow recently introduced the GNC1000, a highly integrated guidance, navigation and control system that includes Autopilot, Flight Control Computer, Actuation Control, Attitude Heading and Reference System and Air Data. While robust in features, the GNC1000 is compact, light-weight and low power; making it ideal for a wide range of unmanned platforms. The system core is based on Moog’s proprietary avionic solutions currently operating aboard large commercial transports and high end business jets. Because of its highly configurable nature, the GNC1000 is easily integrated into a variety of vehicle architectures.

Product Features:

- Highly customizable; all in a single compact box
- Multi-function Autopilot
- PowerPC platform for hosting flight control laws
- Tactical grade IMU
- Full INS and attitude solution
- Built-in air data system
- Flexible general purpose I/O
- Ruggedized design complying to DO-160G and MIL-STD-810G and MIL-STD-461F
- Low power (<7W) and light weight (<3lbs)
INTEGRATED SYSTEMS FOR UNMANNED AIRCRAFT

Systems Integrator for X-47B Primary Flight Control Systems

Moog is the Primary Flight Control Actuation Systems Integrator for Northrop Grumman’s X-47B unmanned combat air system. The system includes a fully redundant architecture featuring multifunction system controllers and modular electrohydraulic (EH) actuators. The system controller features a high speed 1394 bus interface, redundancy management, and full digital closed loop control for all flight surfaces and advanced vehicle functionality. The high-dynamic dual tandem EH actuators position the aileron, elevon and spoiler flight control surfaces.

Miniature Air Launched Decoy (MALD) Fin Control Actuation System (CAS)

Moog has entered into production of the MALD fin CAS and Wing Deployment Actuation Assembly for Raytheon Missile Systems. MALD is a low-cost, long range, expendable air-launched vehicle that mimics the radar signature and flight characteristics of fighter aircraft and bombers to deceive a threat air defense system. Moog’s actuation solution leverages multiple programs with commonality to keep the system affordable. The COTS-based digital controller controls the three independent fin actuators and the wing deployment mechanism. It is very ruggedized to operate in the air-launched environment intended, with high radar emissions.

All Electric Primary Flight Control Actuation System for Mantis Unmanned Air System

Mantis is an advanced technology demonstrator for Medium Altitude Long Endurance (MALE) Unmanned Air Systems (UAS) jointly sponsored by the UK MOD and industry. It celebrated its first flight in October 2009 and has completed operational testing in Australia. Moog was selected by vehicle prime contractor BAE Systems to design, manufacture and integrate an “All Electric” primary flight control actuation system to control aileron, elevator and rudder flight surfaces. To meet the program’s aggressive development schedule – contract award to hardware delivery in less than 9 months – Moog developed a modular system architecture which included common electromechanical (EM) actuator designs, high power EM drives, and a remote electronics unit for distributed control. Moog also leveraged this same modular solution for the aircraft’s nose wheel steering.

X-43 (Hyper X) Flight Control Actuation System

Moog was selected by Alliant Techsystems (ATK) to design and qualify the flight control actuation system for NASA’s X-43A Hypersonic Research Aircraft, Hyper-X. Moog’s system includes a multi-axis system controller and electromechanical linear actuators to control the rudder and wing flap surfaces. In addition, Moog also provided actuation and control for the engine cowl inlet door allowing the flow of oxygen into the supersonic combustion ramjet or scramjet engine, during flight. Hyper-X is a NASA-sponsored research program to develop and demonstrate air-breathing hypersonic flight. Hyper-X successfully reached its test speed goal of Mach 9.6 breaking its own Guinness World Record.
Moog Concludes Successful Flight Tests of Stores Management System

Moog completed successful flight demonstrations for the Third Generation (G3) Stores Management System (SMS) at the U.S. Army Yuma Proving Grounds. The G3 SMS is a super lightweight system (sub 4lbs), capable of a variety of communication protocols, able to perform sensor-seeker slave and perform real-time launch acceptability regions for precision weapons. The G3 is the first off-the-shelf SMS to be fully compatible with Lockheed Martin’s HELLFIRE® AGM-114 Romeo missile. The system was integrated onto both an MD-500 and Cessna C-208 aircraft in less than 3 weeks and flew over 12 sorties and conducted over 35 target engagements against a variety of fixed targets.

The SMS flight demonstrations were supported by employees from Moog’s newly formed Integrated Defense Systems (IDS) business. The business focuses on Moog’s capabilities in the integration of complex weapons systems for either newly manufactured or existing assets. Moog and its partners will function as an agile prime in support of OEMs who seek rapid, high-value solutions for integrating complex weapons systems on board fixed-wing, rotary-wing, naval or land-based platforms regardless of quantities.

Rotary and Linear Electromechanical Actuators and Controls

Moog leads the industry by designing and producing high-performance linear and rotary electromechanical actuators (EMA) for aerospace and defense applications. Our actuation products are used to control flight surfaces and position sensors on aircraft, missiles and space vehicles; provide stabilization and aiming for land and sea based gun turrets; steer antennas in high bandwidth communication systems; and provide control for various utility applications.

Moog is able to offer precision actuation solutions with rare earth brushless motors, planetary gears and smart servo controllers with integral position control or utility actuation solutions with DC motors, spur gears and analog amplifiers with external position control.

A technology initiative currently underway allows us to offer a fiber optic communication interface for our EMAs. This technology provides many systems advantages, including EMI immunity and weight savings.

Weapons Bay Door Drive Systems for Military Aircraft

With a broad range of technologies and extensive experience designing and integrating mission critical actuation systems for military aircraft, Moog is uniquely qualified to design and integrate weapons bay door drive systems on today’s modern aircraft. Moog’s actuation and control technology base includes electromechanical, electrohydraulic and rotary mechanical with a portfolio of proven products including closed loop controls, hydraulic or electric power drives, geared rotary actuators, gearboxes, angle boxes, position sensors, uplock assemblies, stop modules, and interconnecting torque tubes. Motors, whether hydraulic or electric, can be fixed or variable speed servo-controlled devices, depending on the application.

Advanced Electronic Controls for Aerospace and Defense

Moog is a leading supplier of electronic controls for mission critical applications in the aerospace and defense industry. Our state-of-the-art systems are used wherever precision control is required, including aircraft flight control, launch vehicle thrust vector control, aiming and stabilization, and missile steering. Our expertise includes advanced digital control, distributed system architectures, high power drives, redundancy management and designs for harsh environments. We have designed, qualified and provided certification support to civil and military level A standards. Our products are well suited for both OEM and product upgrade programs.
Moog Crossbow Offers Affordable MEMS GPS/IMU Solutions

The Moog Crossbow NAV440 is an integrated GPS and Attitude & Heading Reference System (AHRS) that utilizes low drift MEMS-based inertial sensors with GPS aiding to provide unmatched price and performance. Developed in response to years of extensive application experience in a wide variety of commercial and COTS-military airborne, marine and land applications, the NAV440 also incorporates many new and enhanced design features. Typical applications include navigation, control and stabilization in manned and unmanned aircraft, marine and land environments.

Moog Crossbow Offers Mil-Qualified Ground Vehicle INS/GPS System

Moog Crossbow’s GNAV540 integrates field proven MEMS-based inertial sensors with an embedded Military Grade SAASM GPS receiver to provide system integrators with a lower cost, high accuracy GPS/IMU system option for use in demanding military applications. The GNAV540 is designed to combine the functions of attitude and heading determination with GPS in a compact environmentally sealed enclosure. The GNAV540 improves performance with enhanced EMI protection and input power filtering. Typical applications include navigation, control and stabilization in military vehicle, marine and land environments.

Moog Crossbow Introduces New Card-Level MEMS-Based Attitude Heading and Reference System (AHRS)

The ANAV200 is Moog Crossbow’s most compact, card-level MEMS GPS-aided AHRS for embedded use within integrated navigation and guidance systems. The ANAV200 has a small footprint volume of only 7 cubic inches and weighs less than 80 grams. Example applications include UAV flight control, SATCOM on the move, land vehicle and missile guidance, platform stabilization and micro-robotics.

Moog Crossbow Fiber Optic Vertical Gyro Supports Critical Aircraft Navigation and Guidance Applications

The VG700MB is a MIL-Qualified vertical gyro used for measuring roll, pitch and heading angles in dynamic environments. VG700MB applications include avionics, platform stabilization, land vehicle guidance, and control of sophisticated robotic systems. Moog Crossbow has fielded thousands of systems worldwide for use by the US DOD and Coalition Forces. Major customers include the IAI family of Searcher, Hunter, and Heron family of Unmanned Aircraft which utilize the VG700MB for primary navigation and control. The VG700MB incorporates Moog Crossbow’s third generation Fiber Optic Rate Gyro technology providing superior performance, reliability, and long term stability.

Product Features:
- High reliability MEMS sensors
- High range sensor option available
- High accuracy < 0.2°
- Small form factor < 7in3
- Low power < 1W
- Lightweight < 80 grams
- External SAASM GPS and integral 3-axis solid statemagnetometer interface

Product Features:
- Complete GPS-Aided AHRS Solution
- Accuracy < 0.2 deg
- Output Data Rate > 100Hz
- High-Range Sensor Options (400 deg/sec and 10g)
- WAAS and EGNOS Enabled GPS
- Low Power < 4W
- Rugged Sealed Enclosure

Product Features:
- Integrated SAASM or C/A Code GPS aiding
- Ethernet or RS-422 output
- MIL-C-38999 connector
- Internal or remote magnetometer
- Low Power < 4W
- High Reliability, MTBF > 25,000 hours
- Rugged & sealed enclosure meeting MIL-STD-810 and MIL-STD-461 EMI

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Product Features:
- MIL-Qualified Vertical Gyro
- Fiber Optic Gyro Stability <20°/hr
- Stabilized Roll and Pitch Angle Outputs
- Optional Relative Heading Output (206 Model)
- Environmentally Sealed Enclosure
- MIL-STD-810E, MIL-STD-461D
Moog Test Controller at the Heart of Aero Test System Supporting F-35 Structural & Fatigue Testing

In 2011, BAE Systems took delivery of F-35 test article AJ-1 at its structural test center in Yorkshire, UK. The test article, an instrumented fully production-representative version of the F-35A, will be subjected to two life cycles of spectrum fatigue loading in support of structural certification and service life analyses. Hydraulic actuators will apply the service loads to the airframe using a state-of-the-art control system to ensure safety of the specimen and operators is maintained at all time.

The loading actuators are controlled by a digital multi-channel, closed loop servo system supplied by Moog. The Moog test controller is integrated with a data acquisition system so that specific data logging actions can be carried out automatically. The design of the system accommodates the test being run “unattended” for round-the-clock operation. A comprehensive safety system is embodied as part of the controller so that in the event of any system malfunction, the test loads are removed under full system control without risk to the test specimen. With a capacity of 2,000 channels, the data acquisition system is configured to log strain gauges, displacements and loads.

Moog Supplies Systems to AgustaWestland for Helicopter Structural and Fatigue Testing

Advanced aerospace test systems are required to create and measure forces to simulate and test real-time durability and resistance of helicopter components, especially fatigue tests on the rotor, hub and blades. Recent initiatives from Moog include the development of a system supplied to AgustaWestland to perform a wide range of structural and fatigue tests for helicopter rotor blades.

To meet AgustaWestland’s demanding specifications, Moog supplied an aerospace test controller with six servo channels, incorporating the latest quad core IPC processor and a real-time ethernet platform to enable playback of the complex loading spectrum on the helicopter blade. The system’s real-time Ethernet platform increases the functionality of servo controllers and boosts the performance of aerospace testing, providing faster graphics, accurate synchronization of up to 500 control channels, reduced latency time and complete management of many safety procedures to eliminate risk on the test specimen. It provides the test system with a high bandwidth and an unprecedented level of safety, and is particularly suited for high performance aircraft, helicopters and spacecraft testing.

Moog Receives Test System Orders from Airbus

Moog has received an order from Airbus in Hamburg, Germany to supply 11 Moog test systems to provide a test capacity of 136 control channels. This order is in addition to those placed previously under a 10-year framework contract between Airbus and Moog for the exclusive supply of multi-channel test systems for structural testing of aircraft.

The multi-channel test systems enable Airbus to develop a single platform across all of its structural testing facilities in Germany, United Kingdom and France. The test controllers and software will be used for both static and dynamic structural tests. The test systems will provide a standardized and trans-national platform, making service and support easier and faster. The new systems will be configured with real-time ethernet, offering Airbus more flexibility, higher bandwidth, increased data speed, more reliability and faster test set-up. The Moog test systems can support civil aircraft, military aircraft and technology projects.

Hindustan Aeronautics Selects Moog Test Controllers for Helicopter Component Testing

Moog Industrial Group announced that the company has been awarded a contract to supply a substantial number of portable test controllers with a single channel to Hindustan Aeronautics Limited (HAL). The test equipment will be deployed for helicopter component testing in HAL’s Rotary Wing Research and Design Center. The tests that will be performed with the new test controllers include fatigue and endurance tests on rotor blades, flight controls and transmission systems.

The digital portable test controllers supplied to HAL offers the following significant advantages:

- Can be operated standalone directly through the display and operating panel, eliminating the need for test software and a PC
- Incorporates a unique control-loop technology for high performance control of force, displacement and acceleration
- Users can plug the controller and run with or without external test software, making this an ideal solution for easy replacement or an upgrade to digital control.

The portable test controllers also feature a large 640x480 VGA color display to monitor tests and allow operators to set-up and make simple adjustments in between tests or in real-time. Additionally, the user can reproduce tests and store test data on the onboard hard disk. The test controllers can accommodate a maximum of four channels for future expansion and can enable manual control, constant amplitude tests and high performance handling of complex testing formulas.
Slip Rings and Fiber Optic Rotary Joints for Aerospace and Defense

Slip rings are used in systems that require unrestrained, continuous rotation while transmitting power and/or data from a stationary device to a rotating structure. Today’s sophisticated battlefield requirements depend on Moog’s slip rings for high bandwidth, high-reliability and long-life operation. With over 10,000 baseline designs, models are available in standard and custom configurations.

Fiber Optic Rotary Joints (FORJ) pass optical signals across rotating interfaces while maintaining the advantages of fiber such as high bandwidth capability and EMI immunity. These products are designed for high-performance operation in extreme environments, including shock and vibration, temperature, humidity and dust. Configurations include: off-axis, singlemode and hybrid FORJ/slip ring assemblies. Electrical to optical media converters are available for end-to-end solutions.

Air Moving Solutions

Moog Air Moving Solutions designs and manufactures high performance efficient cooling products to solve difficult thermal, airflow and acoustic problems for use in rugged aerospace and military applications. These products are aerodynamically designed for optimized efficiency and acoustics and are combined with Moog’s high-efficiency motors for the lowest overall system power usage.

Position Sensors

Moog supplies a variety of resolvers, synchros and rotary variable differential transformers (RVDT) for use in demanding military and aerospace environments. These rugged and reliable devices provide accurate position and velocity feedback as well as commutation, without the structural or temperature restrictions imposed by other electronic feedback devices. They are resistant to the shock and vibration levels often encountered in military and aerospace applications and exhibit high immunity to electrical noise. They are available in various configurations with a large selection of standard models. Our engineering department is available to provide applications assistance and to tailor custom solutions to meet challenging program needs.

High Performance Brushless DC Motors

Moog is a market leader in the design of fractional horsepower servo and torque motors. We offer motors in brush-type, two-phase brushless and three-phase brushless configurations. All utilize high-energy permanent magnets and high-permeable armature lamination materials in producing fast servo response and high starting torque for demanding applications such as gimbaled positioning systems. Reliability and long life are hallmarks of our products. Available in frameless configurations for direct drive systems, or housed with optional gearheads, these motors are designed and proven in aircraft, missile, armored vehicle and naval systems.
Moog Expands Motor Solutions with SmartMotor™

Moog has expanded its motor line with SmartMotor™ – a highly programmable, integrated servomotor system that includes a motor, an encoder, an amplifier, a controller, RS232/RS485 communication and IOs. This motor combines programmability ease, networking capability, highly flexible and expandable I/O and high power density servo performance. The SmartMotor has been used successfully in unmanned solutions when extremely precise positioning is required in bumpy and unstable environments.

Multiplexers Optimize Video and Data Communications

Moog Components Group designs compact and rugged video/data multiplexers and fiber optic transmission systems for a wide array of unmanned platforms. These products are well suited for remotely operated vehicles, explosive ordnance disposal robots, radar, ground vehicles and electro-optic targeting and surveillance pods.

To exploit the full bandwidth of fiber, multiplexing combines many signals of various types — video, serial data, network data, control lines — onto one optical fiber. Multiplexers that combine a number of signals electrically are typically called time division multiplexers (TDM); discrete parts of each input signal is assigned a time slot in the outgoing data stream. Moog has a wide range of TDM options that allow multiple electrical channels to be multiplexed onto one or more optical fibers.

We also produce multiplexers that combine a number of optical signals onto one or two fibers. These multiplexers use wave division multiplexers (WDM) because they transmit different signals on different wavelengths of light on the same optical fiber.

Both multiplexing techniques can be used separately or together to simplify optical transmission systems and reduce cost, improve reliability, reduce weight and improve performance. Multiplexed systems also simplify system upgrades since numbers of channels and channel bandwidth is a function of the electronics rather than the transmission line or components. Moog multiplexers accommodate the ever-increasing data rates needed for digital video and industrial data protocols, as well as high speed networks.

Moog Integrated Gimbal Axis Assemblies

Moog Components Group provides innovative solutions for applications that require gimbal actuation. As the aerospace and defense industries continue to expand the limits of high performance, reliability and compact product designs, we offer higher level solutions that maximize performance of individual components and integrate them into an efficient packaged option.

This assembly is used to rotate each axis of a gimbal assembly for precise pointing and tracking. Integrated gimbal axis assemblies must be compact, lightweight, provide high torque and resolution with high stiffness and minimal friction to meet performance objectives over wide temperature ranges. They typically use direct drive torque motors and include slip rings to transfer data and power. Moog’s capability to provide an integrated assembly is built on a legacy of working with customers on numerous successful programs.
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