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 & 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 Acquires Crossbow Technologies

In 2011, Moog acquired Crossbow Technology Inc. Crossbow, headquartered in Milpitas, California, is a designer and manufacturer of sensing and inertial management products that are integrated into mission critical navigation and guidance systems. The products are used in a variety of aerospace, defense and transportation applications.

Crossbow’s innovative use of MEMS-based technology allows them to deliver products that achieve significant improvements in performance, size, and cost over competitive products in widespread use today. Crossbow’s advanced sensing products complement Moog’s established controls business and provide a unique opportunity to offer more comprehensive systems to our customers. For more information visit www.moog.crossbow.com.

Visit Moog Aircraft Group to learn more about our fully integrated systems and tailored product solutions for flight controls, navigation and guidance, weapons bay door drive and utility actuation.

Booth # 534

Visit Moog Components Group to learn more about motion and power/data communication components for manned and unmanned applications – slip rings, fiber optic rotary joints, motors, actuators, multiplexers, optical transceivers/connectors, navigation/control and integrated solutions.

Booth # 743
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.

The DC motor driven rotary actuators are simple, low cost and take advantage of similar heritage designs. Moog’s system supports the decoy’s aggressive affordability requirements while maintaining the highest standard of reliability and quality.

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 Unveils ProtectIR

Moog is debuting the ProtectIR ISR Targeting (T) pod, which is a fully integrated, rapidly deployable COTS ISR (T) pod for use on existing fixed and heavy rotary wing aircraft. It is a valuable capability for allied air forces that want to conduct ISR operations using a flexibly-mounted ProtectIR kit.

The ProtectIR allows allied military forces to have ISR (T) dominance without significant expense. The ProtectIR is a 5th generation high-definition electro-optical infra-red (FLIR) system with a tightly integrated moving map, stores management computer, GEO location, and state-of-the-art data links. Optional payloads can be configured to include Ground Moving Target Indication (GMTI)/Synthetic aperture radar or a mobile phone tracking in a sub-136 kg (300 lb) package.

Moog can install the ProtectIR at the customer site within nine months along with training and mission planning. Moog offers this product and service capability for less than half of what other OEM’s charge for their basic ISR configuration alone.

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.

Moog Supplies Systems for Aircraft Structural and Fatigue Testing

Moog Test Systems are used by the world’s leading aerospace companies to perform iron bird full scale testing, aircraft/airframe structural tests, hydraulic system testing, loading tests for landing gear, engine casing and fin actuation, and load calibration tests. These systems include flexible control hardware and software that deliver the trusted solutions needed to ensure maximum safety and performance.

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 marine and land environments.

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

Moog Crossbow Offers High Performance Tilt Sensors

The CXTD02 is a family of high performance Tilt Sensors that offer outstanding resolution and accuracy in measuring tilt angles on an object with respect to gravity. The CXTD02 measures tilt using a triaxial MEMS accelerometer that is responsive to gravity. The triaxial accelerometer allows sensing over the entire 360° roll range and 180° pitch range. In addition, alignment, scale factor, and non-linearity compensation are computed internal to the sensor with the on-board DSP processor.

Product Features:
- Roll and Pitch Angle Measurement in Any Orientation
- 3-Axis Digital Acceleration Output
- High Accuracy
- Fully Temperature Calibrated
- ~80dB Signal to Noise Ratio

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:
- 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 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 marine and land environments.

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

The ANC1000 is Moog Crossbow’s most compact, card-level MEMS GPS-aided AHRS for embedded use within integrated navigation and guidance systems.

The ANC1000 has a small footprint volume of only 2.5 cubic inches and weighs less than 25 grams. Example applications include UAV flight control, SATCOM on the move, land vehicle and missile guidance, platform stabilization and micro-robotics.

Product Features:
- Single Card-Level Altitude & Heading Solution
- High-Reliability MEMS Sensors
- High Range Sensor Option Available
- High Accuracy < 0.2°
- Small Form Factor < 2.5 in³
- Low Power < 1.5W
- Lightweight < 25 grams
- External SAASM GPS and Magnetometer Interface
- High Vibration Immunity

Rotary and Linear Electromechanical Actuators and Controls

Moog leads the industry by designing and producing high-performance linear and rotary electromechanical (EM) actuators 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 EMA’s. This technology provides many systems advantages, including EMI immunity and weight savings.

Landing Gear Extension and Retraction Systems

Moog has an extensive breadth of actuation technology that is well-suited for many aircraft utility systems. However, unlike many other suppliers, Moog is able to tailor these products to meet unique customer requirements and provide the technical expertise to integrate and qualify the complete system.

Moog Component Group’s linear electromechanical (EM) actuators and associated controllers are especially well-suited for landing gear extension and retraction systems on helicopters or unmanned aircraft. Our linear EMA’s use high-performance brushless motors that offer favorable size and weight advantages and superior reliability. Our system controllers are based upon proven building blocks and are flexible enough to accommodate special system functionality.
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.

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 such as Ethernet and IEEE-1394 (Firewire).

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.

**Moog Acquires Protokraft**

Moog recently 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 electronic components and subsystems for short and intermediate reach harsh environment communication networks, including optical network switches, optical enterprise and storage area networks (SAN’s) and tactical optical access networks. Protokraft’s patented core 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.

Protokraft’s electronic and optoelectronic components provide numerous cost, performance and reliability advantages to harsh environment network equipment systems.

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**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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