



*Credit: U.S. Army / Maj. Robert Fellingham*



*Credit: MAG Aerospace*



*Credit: U.S. Navy*

## MISSION CRITICAL DEFENSE SOLUTIONS

EQUIPPING THOSE WHO DEFEND FREEDOM

# MOOG DEFENSE

EQUIPPING THOSE WHO DEFEND FREEDOM  
ACROSS MULTI-DOMAIN OPERATIONS

SPACE

AIR

LAND

SEA



## LAUNCH VEHICLES

- Power & Control Electronics
- Thrust Vector Control Systems
- Chemical & Cold Gas Engine Systems
- Main Engine Fluid Controls
- Secondary Payload Adaptors & Delivery Systems
- Vehicle SoftRide® Isolation

## SPACECRAFT & PAYLOAD DELIVERY SYSTEMS

- Propulsion Systems
- Integrated Flight Avionics
- Structures & Isolation Solutions
- On-board Mechanisms & Control Electronics
- Spacecraft Bus Solutions

## ROTARY WING

- Weapon Stores Management Systems (SMS)
- Missile Launchers & Simulators
- Flight Control Systems
- Vibration Control
- Slip Rings

## FIXED WING

- Weapon SMS
- Flight Control Systems
- Motion Control for ISR Search Radar
- Stabilized Motion Control for Turrets
- Engine Control Systems
- Media Converters/Ethernet Switches
- Missile Launchers & Simulators
- Automatic Runway FOD Detection

## MISSILES & KILL VEHICLES

- Thrust Vector Control
- Fin Control
- Wing Deploy
- Integrated Propulsion Systems & Fluid Control
- Seeker Motors
- Avionics & Sensor Integration
- Structures & Isolation Solutions
- Control Electronics

## UAS

- Flight Control Systems
- Weapon SMS
- Missile Launchers & Simulators
- Actuators
- Vehicle Management Systems
- Hybrid Electric UAV

## RADAR

- Radar Multi-Axis Positioning Systems
- Cooling Equipment Units
- Slip Rings

## COMBAT & TACTICAL VEHICLES

- Reconfigurable Integrated-weapons Platform
- Turret Weapon Systems & Integration
- Stabilized Motion Control
- Fire Control
- Ammunition Handling
- Large Caliber Weapon Control Systems
- Modular Countermeasure Directors
- Multi-Mission Payload Systems
- Short Range Air Defense
- C-UAS Solutions

## LAUNCHERS

- EH to EM Conversions & Upgrades
- High Voltage Elevation & Azimuth Control
- Directed Energy
- Weapon SMS
- Slip Rings

## SUBMARINES

- Valve Actuation
- Hull Mechanical Actuation
- Servo Valves
- Torpedo Steering
- Periscope Actuation
- Optronics Rotary Joints

## SURFACE VESSELS

- EM Actuation
- Weapon SMS
- Stabilized Motion Control for Turrets
- Gun Control Units
- Active Stabilization
- Ammunition Handling

## AUV / UUV

- Propulsion Systems
- Steering & Dive Control Systems
- Subsea Utility Motors

## SUSTAINMENT SERVICES

- OEM Product Support
- Modernization & Upgrades
- Service & Support
- Training
- Engineered Solutions

## SPACE

- LEO/MEO/GEO & Beyond
- DOD
- Commercial
- Civil

## ROTARY WING

- Black Hawk
- V-22
- Seahawk
- S-92 | S-76
- AW129 | AW159
- V-280
- MD 530F
- Bell 407

## FIXED WING

- F-35
- AC-130J Ghost Rider
- Caravan
- Eurofighter
- AT-802
- OA-1K
- MC-145B
- Scorpion
- Bronco II
- PreISR
- Digital Airfield Solutions
- KF-21 Boramae
- T-50 Golden Eagle

## MISSILES & KILL VEHICLES

- Tactical & Strike Systems
- Hypersonic Missile Systems
- Long Range Ballistic Missiles
- Air & Missile Defense

## UAS

- Predator
- Gray Eagle
- MQ-25

## RADAR

- G/ATOR
- AN/TPY2
- Sentinel
- AN/TPQ-53
- MEADS
- Aegis
- TRML-4D

## COMBAT & TACTICAL VEHICLES

- M-SHORAD
- LAV-AT/25
- Stryker
- CV90
- PZH 2000
- Bradley
- MLIDS
- Abrams
- M113AS4
- RCH 155
- CWS-Heavy
- Ariete C2
- Centauro II
- Jaguar
- Piranha V
- CASEAR 155
- K9 Thunder SPH
- K9 Vajra Howitzer
- K21 IFV
- K2 Black Panther

## LAUNCHERS

- MML
- HIMARS
- MLRS

## SUBMARINES

- Seawolf Class
- Virginia Class
- Ohio Class
- Columbia Class
- Collins Class
- Scorpene Class
- Dreadnought Class
- Barracuda Class
- Mark 48 Torpedo
- Mk54 Torpedo

## SURFACE VESSELS

- Ford-class Aircraft Carrier
- Littoral Combat Ship
- Frigate Types 45/23/122-125
- K30
- Nimitz Class Carriers
- Chevallier CT40 c-UAS
- Evolved Cape Class Patrol Boat
- Hobart Class Destroyer

## AUV / UUV

- XLUUV
- UUV-FoS
- Echo Ranger
- Echo Voyager
- CLASSIFIED
- RMMV

CAPABILITIES

EXPERIENCE

MULTI-DOMAIN SUSTAINMENT SERVICES

# AIR

## MISSILE CONTROLS

From tactical to strategic missiles, from close air support to long range hypersonic, Moog leads the industry in providing precision flight control actuation systems and thrust vector control.

## MOOG CAPABILITIES

- Actuation and control electronics
  - Thrust vector control
  - Fin control
  - Wing deploy mechanisms
  - Fin lock and deploy solutions
- Integrated propulsion systems and fluid control systems
  - Liquid and cold gas propulsion
  - Kill vehicle and booster propulsion components
- Avionics and sensor integration
- Structures and shock/vibration isolation solutions
- Integrated, additively manufactured structures
- Power distribution and management
- Arm/disarm switches
- Seeker motors, resolvers, and slip rings

## TACTICAL THEATER AND LONG RANGE MISSILE PLATFORMS

- HELLFIRE    • Tomahawk
- TOW

## INTERCEPTOR AND KILL VEHICLE STEERING

Today's sophisticated Ballistic Missile Defense (BMD) Systems rely on Divert and Attitude Control Systems (DACS) to steer the Kill Vehicle (KV) through the final intercept trajectory. At the heart of the DACS are Moog thruster valves which precisely meter the flow of propellant and oxidizer to the rocket engines used for KV steering.

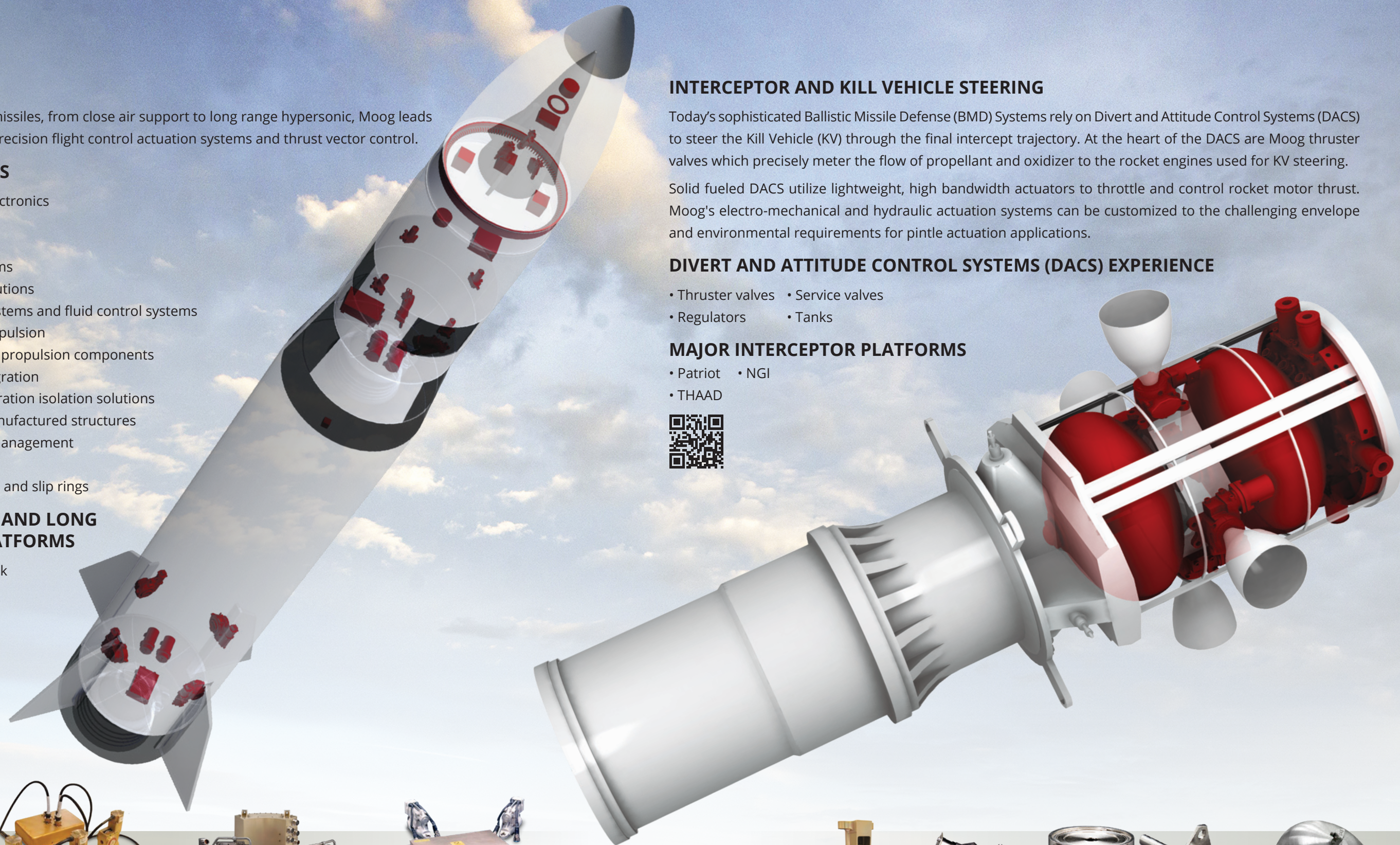
Solid fueled DACS utilize lightweight, high bandwidth actuators to throttle and control rocket motor thrust. Moog's electro-mechanical and hydraulic actuation systems can be customized to the challenging envelope and environmental requirements for pintle actuation applications.

## DIVERT AND ATTITUDE CONTROL SYSTEMS (DACS) EXPERIENCE

- Thruster valves    • Service valves
- Regulators        • Tanks

## MAJOR INTERCEPTOR PLATFORMS

- Patriot    • NGI
- THAAD



TACTICAL CONTROL ACTUATION SYSTEM



LONG RANGE FIN AND WING DEPLOY ACTUATION



SUPERSONIC CONTROL ACTUATION SYSTEM



HYPERSONIC CONTROL ACTUATION SYSTEM



PROPULSION MODULES



PINTLE ACTUATOR



THRUSTER VALVES



REGULATORS



SERVICE VALVES



PROPELLANT TANKS

# AIR (CONTINUED)

## WEAPON STORES MANAGEMENT SYSTEMS (SMS)

The Third Generation Weapon Stores Management System (SMS) is a Modular Open System Approach (MOSA) compliant COTS weapons control system that seamlessly integrates with aircraft sensors and mission management systems to provide the crew with a superior fire-control solution.

This proven, lightweight rugged system is an affordable solution to stores management on air, land and sea platforms. The SMS leverages Moog's extensive experience in systems integration, internal software development, weapons technology, and fire control solutions. SMS software is approved as non safety-critical DO-178C DAL E.

The flexible modular design of the SMS enables fast delivery, rapid integration and future upgrades to the sensors, avionics and weapons ensuring the SMS's value for future mission requirements and weapons expansion.

Additionally, Moog offers a Missile Simulator (MSL SIM) with a flightworthy rail-mount design that simulates different types of AGM-114 HELLFIRE® missiles.



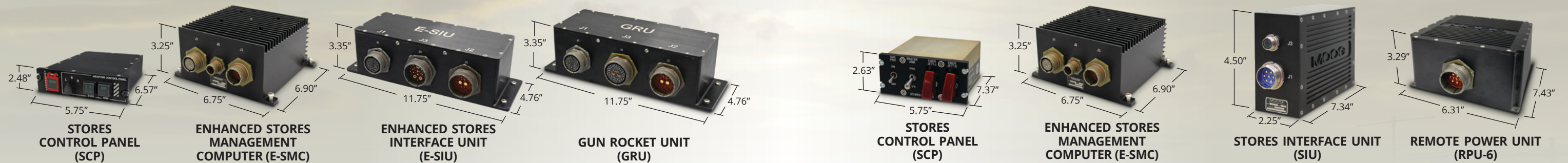
**BLACK HAWK PLATFORM  
SMS INTEGRATION**



**MOOG'S LIGHTWEIGHT DUAL  
RAIL LAUNCHER (DRL) WITH  
HELLFIRE INTERFACE UNIT  
[46 LBS.]**

**WEAPON SMS  
ON OA-1K SKY WARDEN**

## DIGITAL SMS COMPONENTS

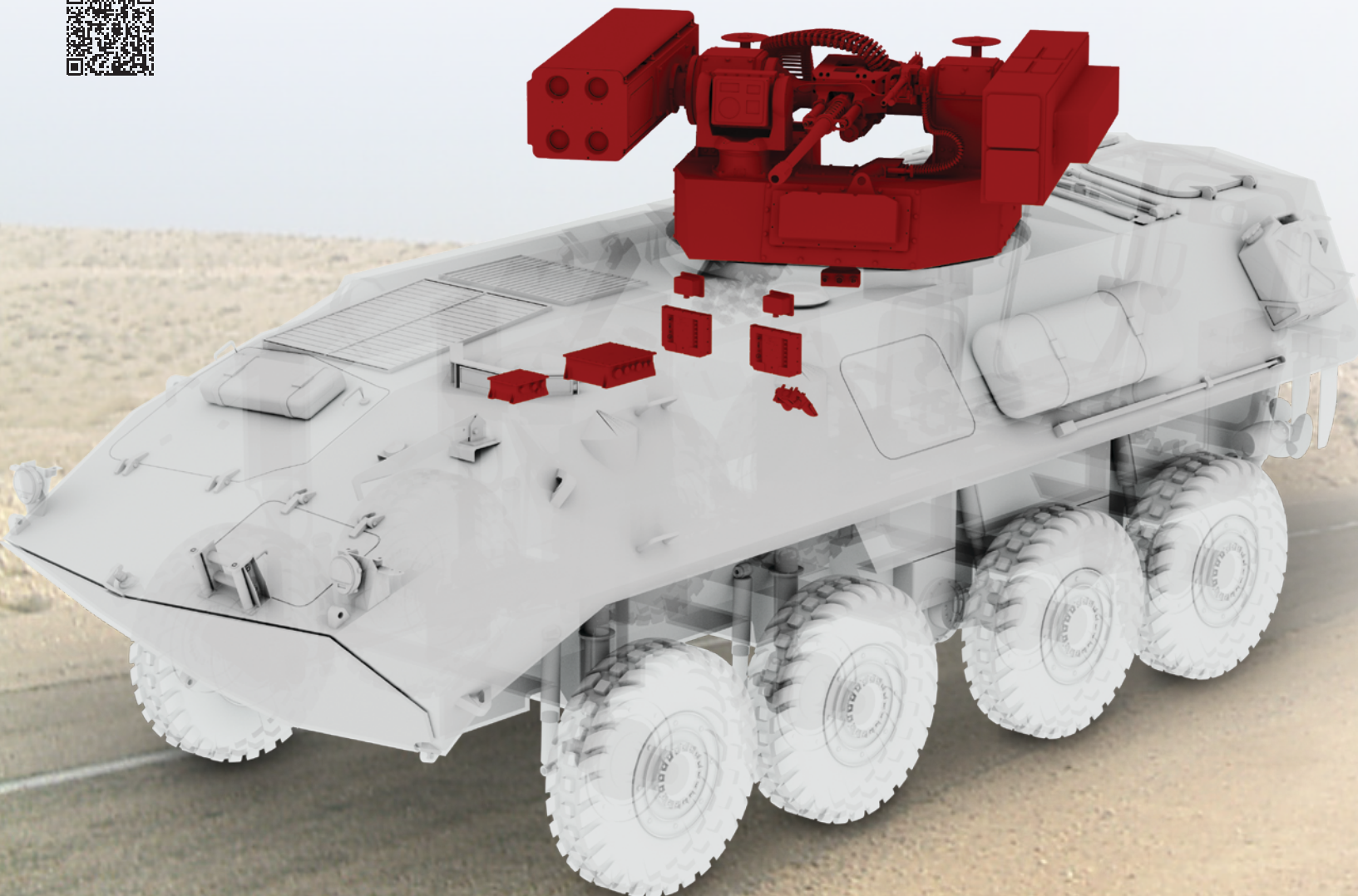


# LAND

## RECONFIGURABLE INTEGRATED-WEAPONS PLATFORM (RIwP®)

RIwP is an innovative, multi-domain remote weapons platform offering unmatched capacity and capability. Multiple weapon options and in-field weapon reconfigurability guarantee tailored overmatch in every combat situation. Engineered with many advanced features, RIwP includes high-performance target acquisition technology and world-class pointing/stabilization accuracy. This ensures U.S. and allied forces see first, engage first and achieve mission success. Designed to be weapon, sight, and platform agnostic RIwP accommodates firepower growth to support mission requirements. With survivability in mind the turret allows the warfighter to reload under armor.

RIwP offers air defense, anti-armor, or multi-mission capabilities via medium caliber and indirect fires, available in various configurations. RIwP can be utilized on medium-sized platforms such as wheeled/tracked armored fighting vehicles, robotic combat vehicles, and containerized platforms.



## LAND (CONTINUED)

### FLEXIBLE MISSION PLATFORM (FMP™)

The Flexible Mission Platform is a payload, mission, and platform agnostic system. FMP allows users to host the weapon, sensor, or other mission package of their choice from the vehicle, ship, container, or trailer of their choice.

FMP is built around Moog's world-renowned military motion control technology. Options include integration of Moog's high-performance stabilization and weapon stores management systems (SMS), providing missile firing capability to suit any mission.



### WEAPON SMS

In addition to being at the heart of the FMP solution, Moog's Weapon SMS is customizable for air, land, and sea applications. Successful test fires have been conducted from trailers, and military vehicles. SUVs and vans can also be weaponized.

(see more on Moog's proven Weapon SMS solution for air platforms on pages 6 and 7)



Credit: Lockheed Martin



### HIGH-SPEED MODULAR COUNTERMEASURE DIRECTOR (MCD)

The MCD is a mission adaptable, flexible, proven, and high-performance element of an Active Protection System (APS).

**The Challenge:** APSs are typically based on an operational concept of detect, discriminate (classify), decide, and then defend. Effective threat defeat relies on the very highest response times from all elements of the system. The countermeasure must be aligned in an extremely fast and predictable manner to defeat a range of incoming threats. Moog's MCD meets this challenge.

**The Solution:** MCD is a proven and highly flexible approach to the increasingly varied threat scenarios now being faced on the modern battlefield. The MCD system comprises the necessary interfaces, control electronics, embedded motion and safety software, as well as a full motion payload positioning mount – all specifically optimized for hard-kill systems.

**Flexible:** Payload, response times, and performance can be readily adapted from a suite of proven designs. Integration is assured by proven real-time networking and other vehicle architecture connectivity options.

**Scalable:** Configure with other effectors from non-lethal to SHORAD – all within one system concept.

**Fast:** When configured for hard-kill systems, response times for simultaneous elevation and traverse (0-90 degrees) can be reduced to well under 100ms.



# LAND (CONTINUED)

## TURRETED WEAPON SYSTEMS

Moog designs, manufactures and integrates weapon systems, sub-systems and products for a variety of global military vehicle platforms. You can gain access to the expertise in fire control, gun control, weapon stabilization, and weapons integration found on over 30 of the world's leading military vehicle platforms including manned and unmanned turrets and remote weapon stations. Small, (e.g. 12.7mm) medium (e.g. 30mm) and large caliber (e.g. 155mm) weapons are equally supported by Moog technology.



SUBSYSTEMS



1 DIGITAL DUAL AXIS CONTROLLER

2 ELEVATION ACTUATOR

3 GUN CONTROL UNIT (GCU)

4 SLIP RING

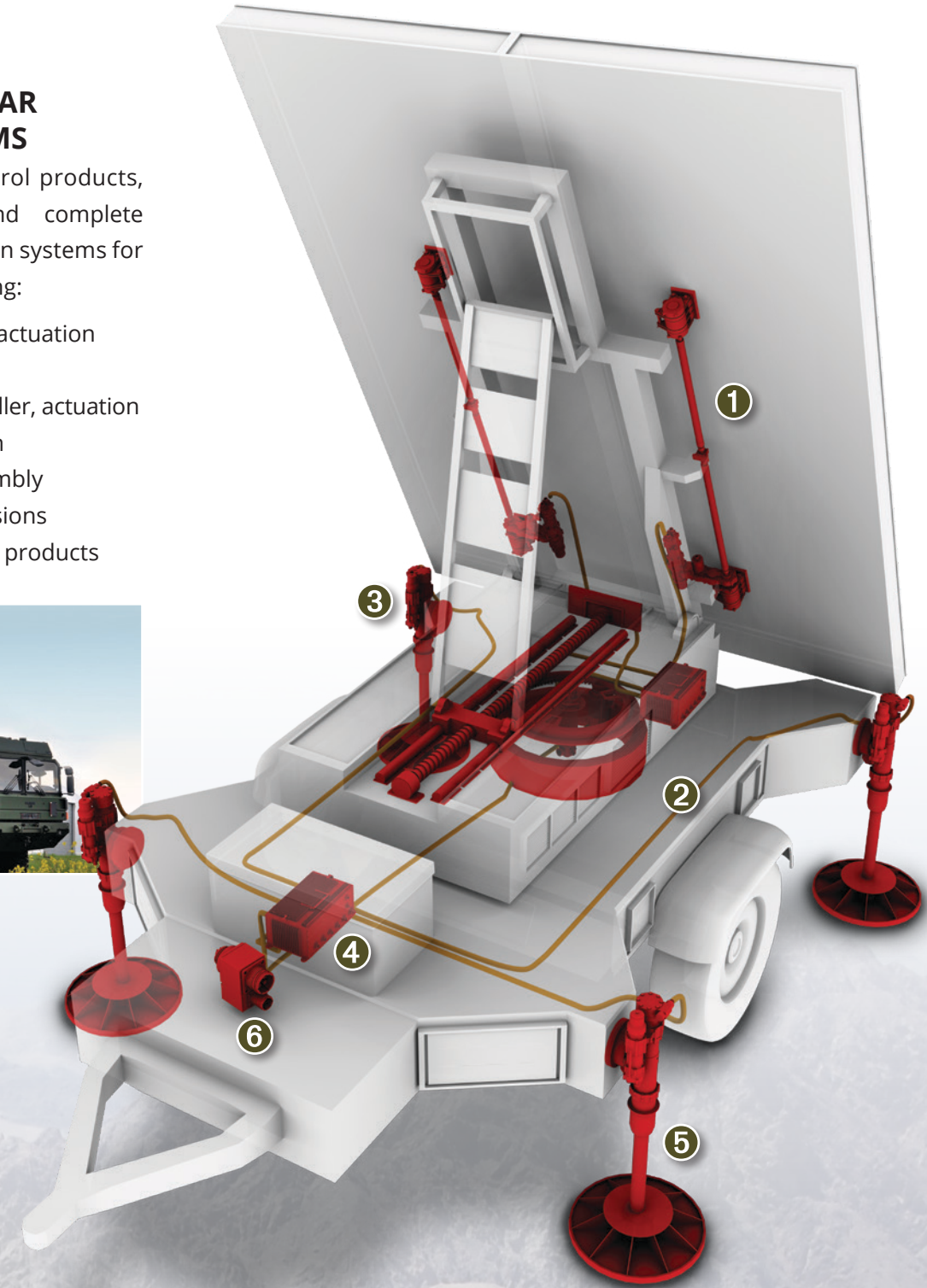
5 FIRE CONTROL COMPUTER

6 TRAVERSE ACTUATOR

## EXPEDITIONARY RADAR DEPLOYMENT SYSTEMS

Moog provides motion control products, integrated subsystems, and complete single and multi-axis actuation systems for land radar platforms, including:

- Antenna elevation and fold actuation
- Point and stare actuation
- Azimuth drive motor, controller, actuation
- Automatic leveling actuation
- Integrated rotary joint assembly
- Hydraulic to electric conversions
- Communication networking products



1 ELEVATION ACTUATOR

2 SLIP RING/ INTEGRATED ASSEMBLY

3 AZIMUTH ACTUATOR

4 CONTROLLERS

5 LEVELING ACTUATOR

6 ETHERNET MEDIA CONVERTER

## LAND (CONTINUED)



### LAUNCHERS, OEM, AND CONVERSIONS AND UPGRADES

Moog is an OEM for existing and future launcher programs providing elevation and azimuth precision control as well as power and data transmission. Moog also works closely with vehicle manufacturers and the armed forces to upgrade, convert, and reset existing assets. Our modeling, hardware, software, mechanical and production engineering teams are experts in both electromechanical (EM) and electrohydraulic (EH) motion control systems and technologies, providing system upgrades to meet strict space, weight, and power constraints.

We have developed patented high-redundancy, fail-safe, EM actuation systems offering users reassurance in power failure conditions.

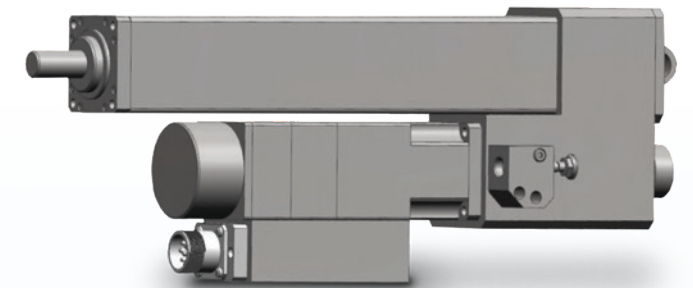


### ELECTRIC MODULAR ACTUATOR AND CONTROLLER (MAC)

Driven by the need to reduce crew fatigue, increase reliability, enhance performance, and purchase with green/sustainability in mind, many of the low power and less complex functions in modern defense platforms are moving from traditional manual, pneumatic, or hydraulic control to electric actuation. Whether considering rotary or linear actuation, the Moog MAC family is designed to meet the required levels of reliability and affordability, as well as the rigorous demands of shock, vibration and EMC.

Comprised of a range of low power motors and actuation systems available with optional embedded electronic controls which can be applied to variety of applications such as:

- Antenna elevation and fold actuation
- Missile pod movement
- Travel lock
- Gun cocking
- Ammunition bunker doors
- Sight protection covers
- Ammunition handling mechanisms



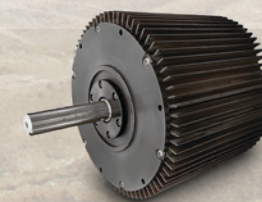
The MAC design is based on a set of building blocks that allow flexibility of implementation and application and also offers the platform manufacturer an element of consistency from one, two, or even more axes of control. With typical powers from 50w to 1kw, the newly developed MAC builds on Moog Defense Systems' heritage of our more complex systems, but packaged in a simple, rugged, easy to use format.

### RADAR COOLING EQUIPMENT

Our line of brushless DC fan motors provide extremely reliable cooling for critical defense radar equipment. As a crucial element of U.S. national missile defense, such systems operate in some of the harshest environments on earth, and when called upon absolutely must function as designed every single time. Moog provides greatly enhanced manufacturability, reliability and performance to this mission essential equipment. We also supply associated electronic controls for cooling systems, providing a complete turnkey solution to the customer.



*Credit: Missile Defense Agency*



FAN MOTOR



CONTROLLER AREA NETWORK SPLITTER



CONTROLLER



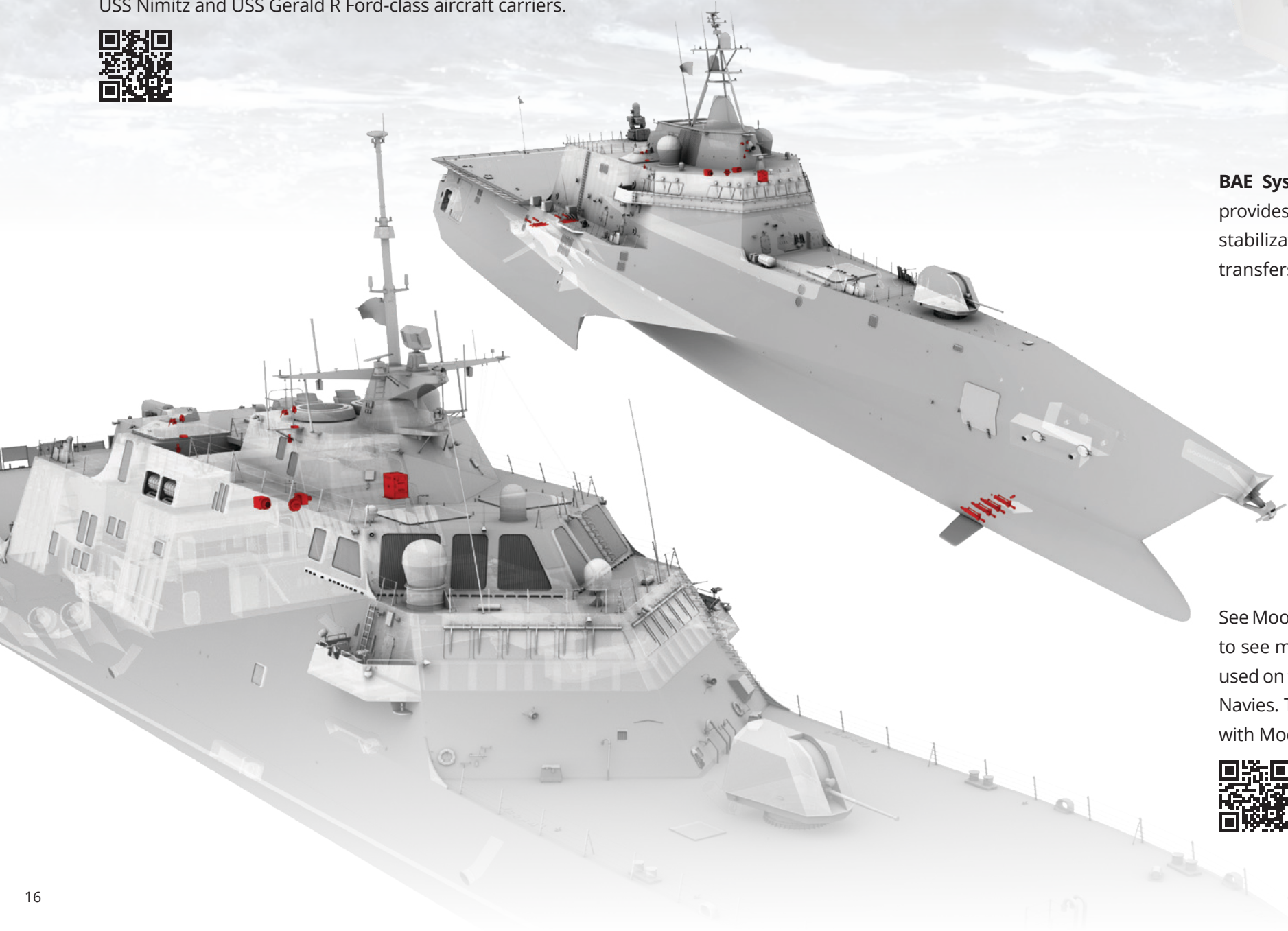
# SEA

## SURFACE SHIP WEAPONS SYSTEMS

Moog is a leading supplier delivering high-precision motion control and electronic solutions to many of the world's naval forces.

Comprehensive systems are engineered to perform reliably in the harshest of marine environments, providing the long-life and dependability our customers require. Extending our customers' investments even further is the scalability and upgradeability designed into every component and system along with through life support. Many of Moog's precision technologies are integrated into littoral and blue water ships. On-board these ships, Moog's premier electromechanical turret drive actuation, stabilization and slip ring technologies are incorporated into various weapon platforms. Moog provides hydraulic throttle control servo-actuators, electromechanical actuators (EMA), and direct drive valves (DDV) on arresting gear for aircraft landing.

Moog actuation is also found in mission critical surface ship applications such as the propulsion plants of both USS Nimitz and USS Gerald R Ford-class aircraft carriers.



## MULTI-AXIS AMMUNITION HANDLING

Moog heritage is responsible for the design, manufacture and integration of precision ammunition handling systems for a variety of applications including naval gun ammunition. Our ammunition handling systems involve complex mechanical integration, linear and rotary actuation and sophisticated, ruggedized motor control technologies.



**BAE Systems' Mark 8 Mod 1 Naval gun:** Moog provides the high performance motors for aiming stabilization and ammunition loading. The slip ring transfers power and data.

**Rheinmetall's MLG27 naval gun mount:** Moog provides the electric gun /turret drives, motion sensors along with the power and stabilization electronics. The slip ring transfers power and data.

See Moog technology in action. Follow the link below to see multi-axis Ammunition Handling Technology used on the Type 23 Frigate by the Royal and Chilean Navies. This ship features the Mk8, Mod 1, 4.5" gun with Moog ammunition handling drives.



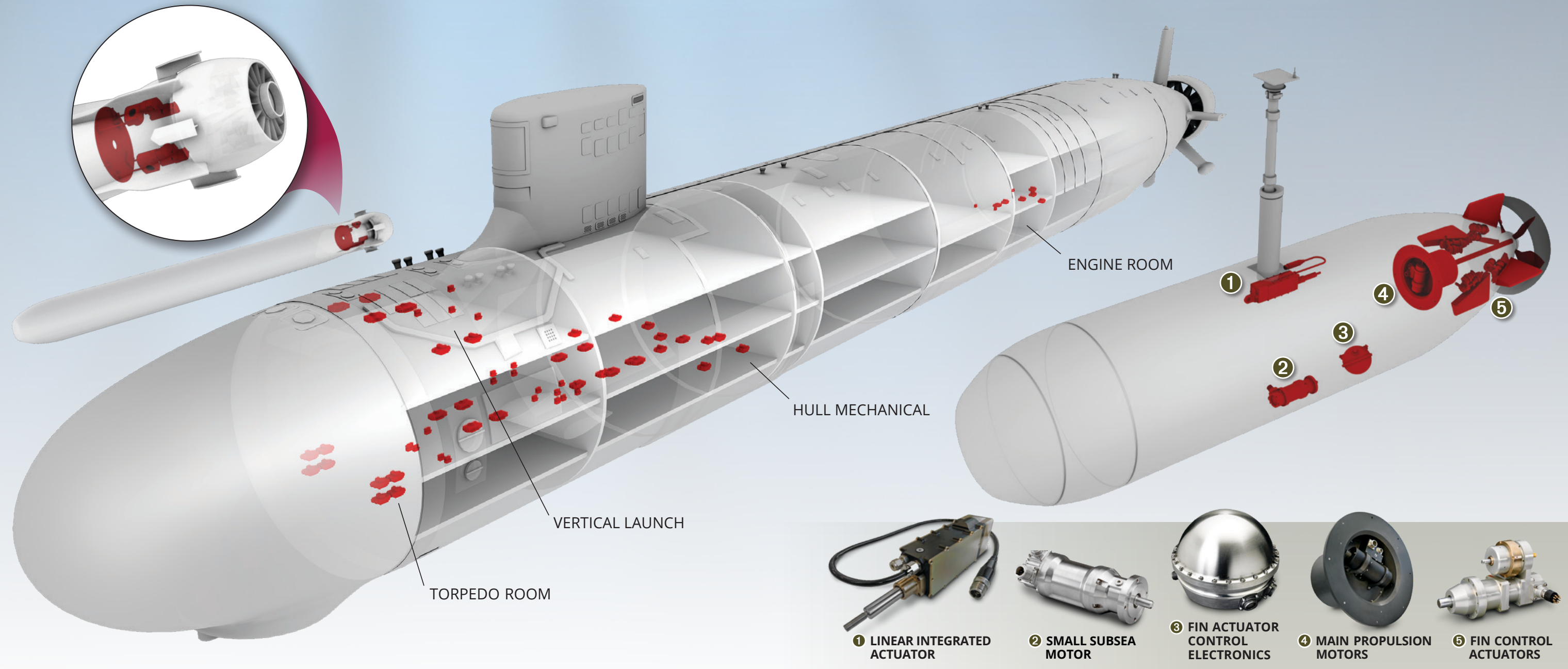
## SEA (CONTINUED)

Moog is a major supplier of hydraulic, electromechanical and pneumatic motion control systems for submarines, aircraft carriers, and other naval vessels. The company has designed and manufactured hundreds of critical control systems that operate valves, open and lock hatches and provide propulsion for these platforms.

### SUBMARINE ACTUATION

Moog's legacy supplying actuation in U.S. Navy submarines extends more than 50 years, from the USS George Washington-class all the way to today's USS Virginia-class and the Columbia-class, including hydraulic steering controls for the MK48 torpedo.

Additionally, Moog supplies critical components to other naval customers across the globe. These programs include the French Barracuda-class, United Kingdom Dreadnaught-class, and the Australian Collins-class submarines.



### AUTONOMOUS UNDERSEA VEHICLE PROPULSION AND CONTROLS

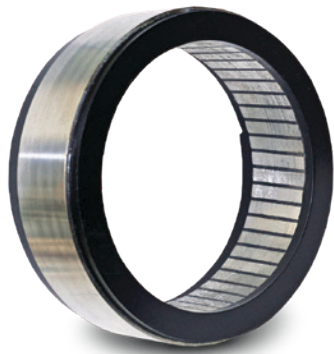
For ROV and AUV platforms Moog provides motors, controllers, actuators, servovalves, and other equipment. We are making investments in future technologies to support these platforms. Moog facilities in the United States, Canada, Germany, Australia, and the United Kingdom are dedicated to the marine and naval industries. If your application is in a challenging environment where performance really matters, Moog has the reliable, low-risk solution to ensure mission success and provide propulsion for these platforms.

# DEFENSE PRODUCTS



## ROTARY JOINTS AND SLIP RINGS

These high performance products are used in systems that require unrestrained, continuous rotation while transmitting power, data and media from a stationary device to a rotating structure. High bandwidth options include Ethernet, high definition video and other industry standard formats. Moog also has solutions including fiber optic rotary joints, fluid rotary unions and position sensors.



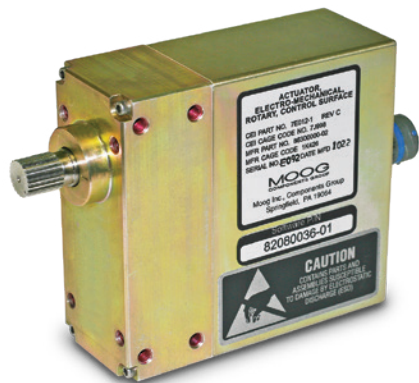
## DIRECT DRIVE DC TORQUE MOTORS AND ALTERNATORS

Frameless torque motors are used in defense applications that require high power density and quick accelerations. The motors are optimized to minimize input power for maximum efficiency. Alternators in the same mechanical configuration can be used for mobile power generation.



## RESOLVERS

Moog offers rugged resolvers that provide accurate positioning and velocity feedback, as well as commutation of brushless motors. These models withstand the shock and vibration levels often encountered in aerospace and military applications. They are used for vertical integration with motors and slip ring assemblies.



## ACTUATORS

Multi-purpose actuators are available in both rotary and linear configurations and are standard building blocks in a variety of systems. Some of our actuators integrate servo electronics. These actuators are used on air, ground and unmanned applications.

## HIGH SPEED DATA COMMUNICATIONS

Moog provides innovative components and communication sub-systems for both copper and optical fiber based systems used in harsh environments. Moog meets the demanding high speed and secure networking equipment requirements of today's modern defense systems. The product range includes electro-optical transceivers, link extenders, Ethernet media converters and switches, data aggregators and multiplexer/ de-multiplexer solutions.



## INTEGRATED MOTION ASSEMBLIES

Our higher level solutions range from simple combinations of individual products to sophisticated electromechanical assemblies including the motor, drive electronics, slip rings, fiber optic rotary joints, fluid/pneumatic swivels and RF rotary joints. Moog's single-axis gimbal stage supports most payloads, and all the rotary components are integrated into one assembly. This design reduces set-up time and simplifies the installation process.



# MOOG TOTAL SUPPORT OFFERINGS

Our comprehensive global sustainment program broadly includes OEM product support, OEM modernization and upgrades, service and support, training and Engineered Solutions supporting industry's wide range of defense products across multi-domain operations. As an OEM supplier, Moog is the logical choice for follow-on product support.

## OEM PRODUCT SUPPORT

- Spares
- Repair and overhaul
- Software support – revision changes, etc.
- Parts and kits
- Logistics



## MODERNIZATION AND UPGRADES

- Upgrades
- Obsolescence management
- Additive manufacturing

## SERVICE AND SUPPORT

- Public-Private Partnerships (P3)
- OEM employed Field Service Reps (FSR)
- Joint venture experience
- Licensing
- Data – technical information, drawings
- Documentation



## TRAINING

- Maintenance
- Operators/Operations
- Simulation
- Subsystem integration
- Theory of operation
- Test equipment
- Training support

## ENGINEERED SOLUTIONS

- Reverse engineering
- Repair and overhaul of non-Moog hardware
- Tech insertion
- Additive manufacturing



# EQUIPPING THOSE WHO DEFEND FREEDOM



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