



MOOG INDUSTRIAL GROUP OVERVIEW

Presented by Antonio Squitieri

February 2018

MOOG

Agenda

- Moog Inc. – The Company
- Who is the Moog Industrial Group?
- Simulation and Test Solutions and Services
- Wind Energy Solutions and Services
- Marine Solutions and Services
- Medical Solutions
- Products, Systems and Services
- We want to be your supplier of choice

Moog Inc. – The Company

MOOG

Three Operating Groups

MOOG INC.

Employees worldwide: > 10,600±

Headquartered in East Aurora, New York, USA

Publicly listed company NYSE (MOG.A and MOG.B), since 1959



**Aircraft
Group**

\$1,125 MM



**Industrial
Group**

\$843 MM



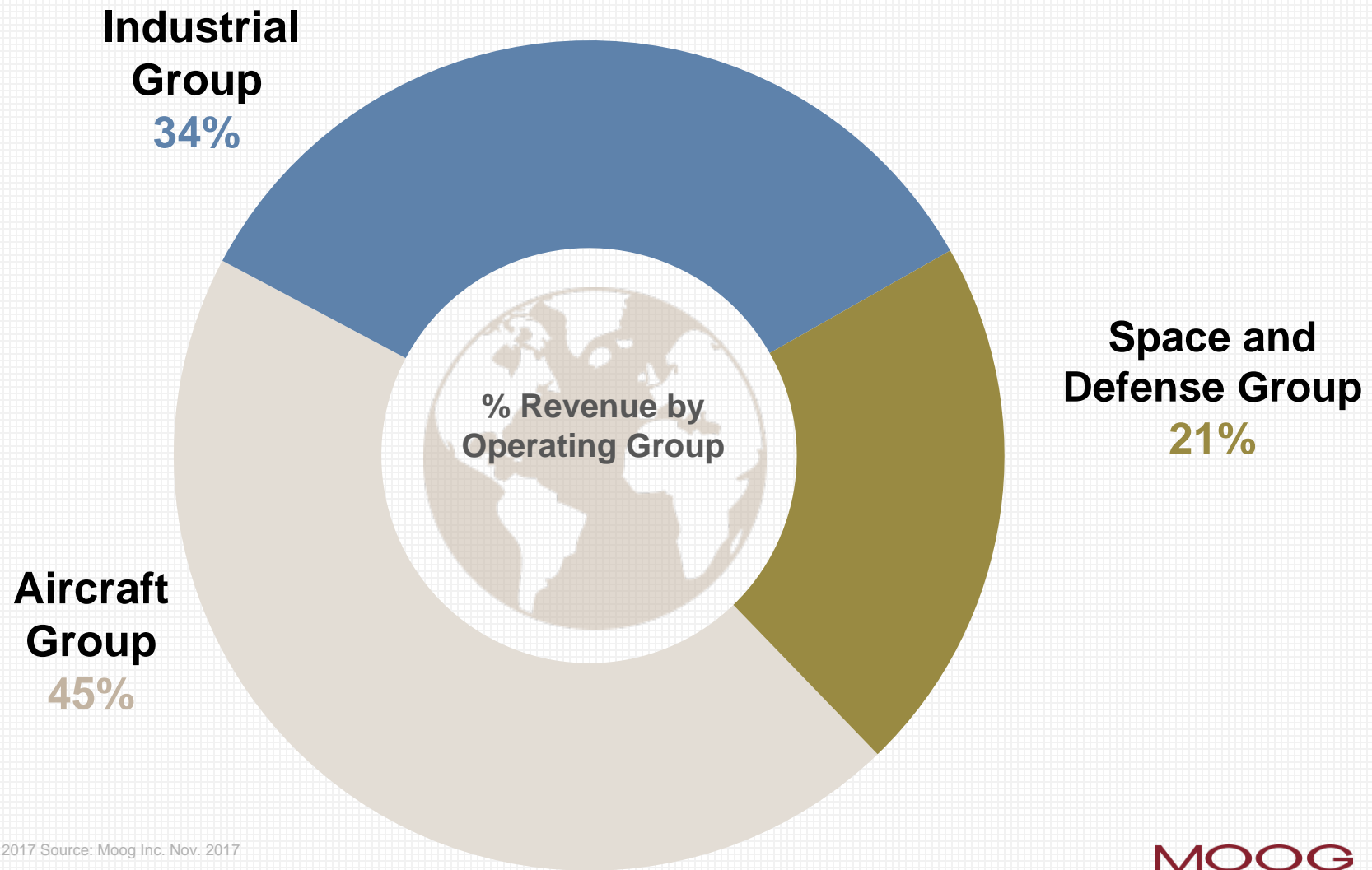
**Space and Defense
Group**

\$529 MM

\$2.5 Billion 2017 Sales*



Balanced and Diversified Revenue Stream

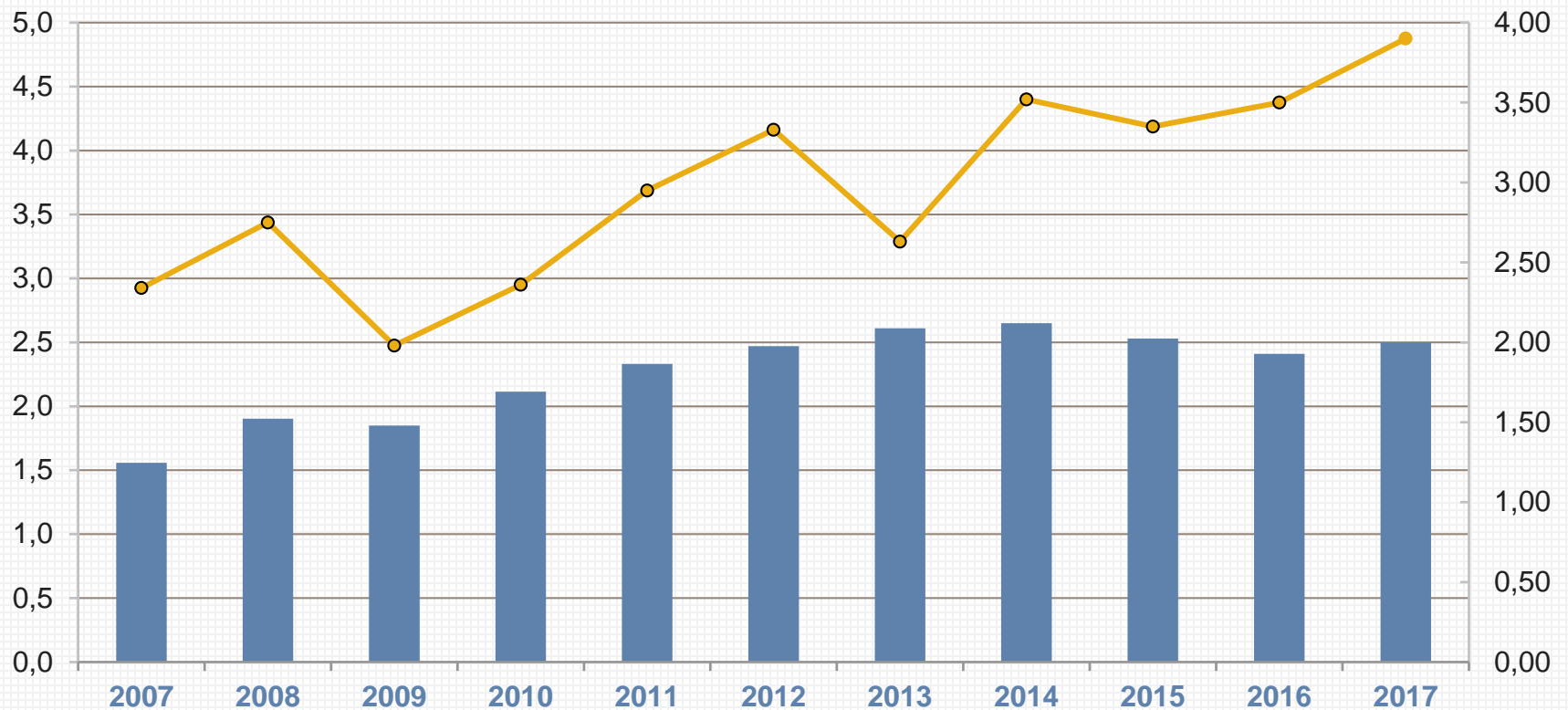


Financial Performance

***Sales**
(US\$ billions)

● Sales ● EPS

**Earnings Per
Share (US\$)**



Moog Culture

- Since our founding in 1951, the leadership has had a profound commitment to maintaining our unique company culture
- Employees in every office enjoy mutual trust and respect
- Moog teams approach work with energy, enthusiasm and the promise of success



“We are All in this Together”



“Communication is Crucial”



“Trust is a Must”



Who is the Moog Industrial Group?

MOOG

What – Products, Solutions and Services for Industrial Customers



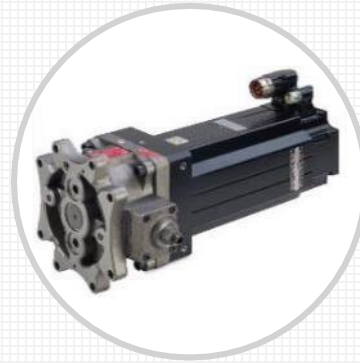
What - Motion Control and Power/Data Transmission



Electro-Hydraulic



Electro-Mechanical



Electro-Hydrostatic



Power/Data
Transmission

What - Growth and Innovation Technologies

We are investing in R&D to develop different technologies to help solve your unique problems



Haptics and force feedback technologies to help train medical professionals



Unique large motors for more efficient servo-presses



Additive manufacturing and IoT for next generation solutions

Where – Global Approach to Business





Wind Energy



Simulation

Markets – Reliable, High Performance Industrial Solutions and Services



Test



Marine





Gas and Steam
Turbines



Oil and Gas Exploration
and Production



Injection and Blow
Molding Equipment

Markets – Industrial World-Class Products and Responsive Services

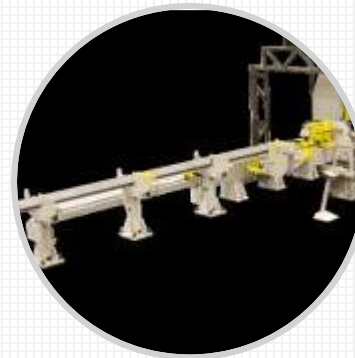


Metal Forming
Machinery and Presses

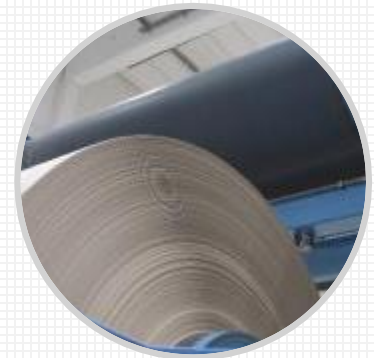
Photo: Courtesy Schuler AG



Steel Mill Equipment



Industrial Automation,
Robotics and Material
Handling



Paper, Pulp and Saw
Mill Equipment





Medical Centrifuges



Respiratory Care



Computed Tomography
(CT) Scanners

Markets – Products Used in these Medical OEMs Applications



Therapeutic
Patient Beds



Medical Pumps, Blowers
and Compressors



Infusion Pumps



Safety Software

Markets – Medical Devices

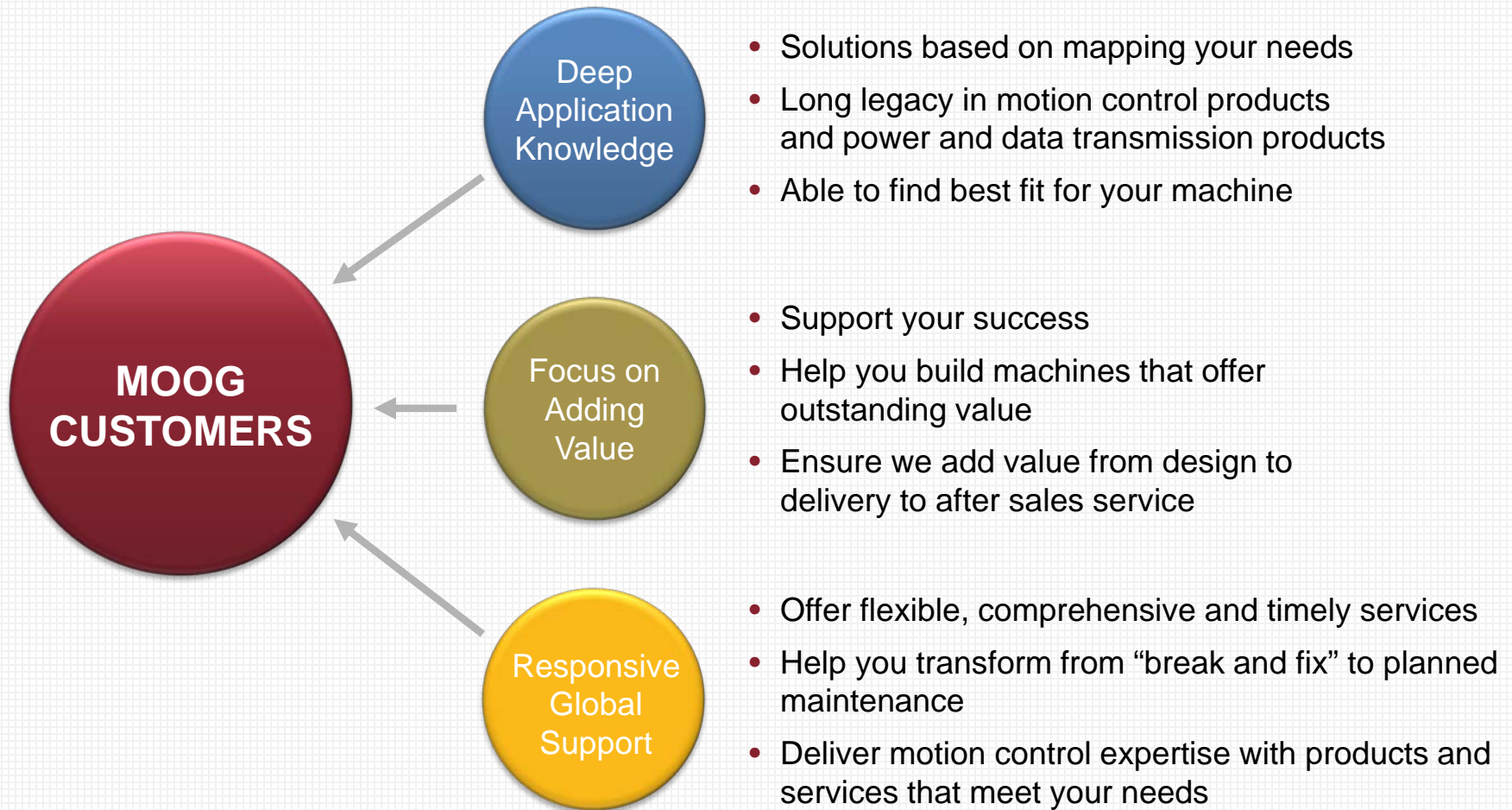


Administration Sets



Accessories

How – Meeting Customer Needs



Why Choose Industrial Products?

Moog's deep expertise coupled with our technology-neutral approach guarantees the best fit for your machine



Long legacy in motion control and power and data applications



Easily integrated, easily configured high performance products to meet your application requirements



Experts who help you find products that meet your needs



Why Choose Moog Industrial Products?

Technology-Neutral Approach

- The right motion control solution depends on the machine, the application, the region and the budget constraints
- Expertise in electro-hydraulic, electro-mechanical and electro-hydrostatic technologies, means we collaborate to find the best solution for you
- Our products, solutions and services works together seamlessly to reduce machine development time and increase flexibility

Main Advantages and Disadvantages

	EM	EH	EAS
Energy Efficiency	✓	✗	✓
Environmental Cleanliness	✓	✗	✓
Low Noise Emission	✓	✗	✓
High Forces	✗	✓	✓
No Backlash	✗	✓	✓

Example benefits of actuation technology
for a machine application



Why Choose Industrial Services?

We are the trusted motion control partner who understands your needs and offers flexible, comprehensive and timely services, resulting in excellent value



Support operation and maintenance professionals globally and locally



Provide services that help you obtain repairs and spare parts when and wherever needed



Transform maintenance by helping you move from reactive to planned



Simulation and Test Solutions and Services

Flight Simulation - Systems

Proven technology delivers greater than 99.5% system availability

- Delivering the industry's widest breadth of payloads, technologies and experience in flight simulation
- More than 700 Level D systems installed and operational worldwide
- Capacity to produce 120 14,000 KG motion systems/year



Motion Systems



G Seats



Control Loading
Systems



Automotive Test Products and Systems

Validate and launch new designs faster with more cost effective testing

- Remove product development boundaries
- React faster to market changes
- Adapt faster to new safety and environmental regulations



Controllers and Software



Simulation Tables
Hydraulic & Electric



Multi-Axis Test Systems
Electric & Hydraulic



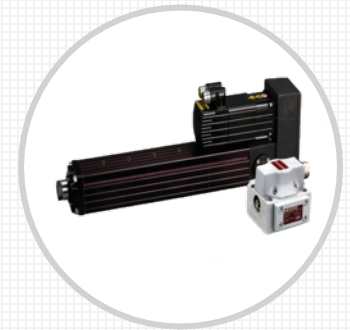
Aerospace Test – Products and Systems

Set up tests faster and run them efficiently while protecting the test specimen

- Solutions for a variety of test including iron bird, aircraft/airframe and spacecraft structural integrity, landing gear, engine casting load and many more
- Turnkey solutions for complex test subjects with increased test accuracy
- Variety of test controllers with advanced control technology and user-friendly operation



Full Scale Fatigue Testing



Electric and Hydraulic Products



Controllers and Software

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Services – Simulation and Test

Local teams in 26 countries who understand your language and provide responsive support

- OEM Factory Repair delivers uptime and like-new performance
- Flexible Parts Options: Regional stocking depots in Americas, Europe and Asia Pacific for quick delivery, on-site spares and exchange programs
- Field service support by phone, email or on-site



Responsive Support



Field Service



OEM Factory
Repair



Wind Energy Solutions and Services

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Pitch Control – Solutions for Greater Reliability, Safer Operation and Lower Operating Cost

- In-depth system expertise combined with years of experience in the energy sector
- Proven partner to leading wind turbine manufacturers and wind farm operators for pitch control solutions
- Global supply chain for production and global presence for sales and service ensuring support of customers

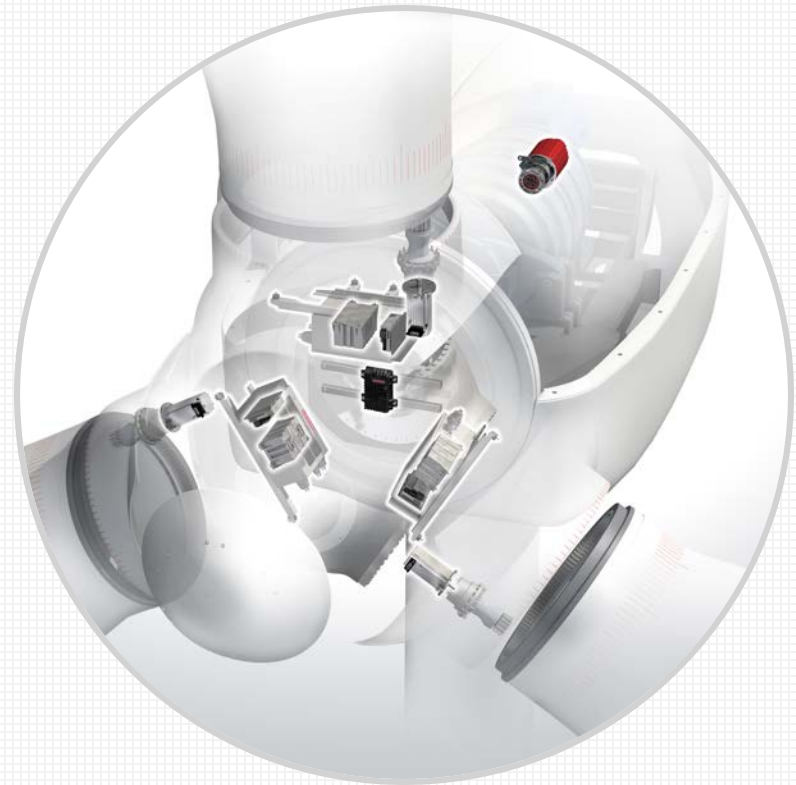
- ... reduce Levelized Cost of Energy
- ... increase reliability up to 50%
- ... minimize downtime up to 50%
- ... extend life of products and systems
- ... simplify installation and troubleshooting
- ... reduce scheduled services up to 50%
- ... enhance technical skills with training
- ... offer service and support anywhere in the world



Pitch Control – Products and Solutions

Moog Pitch System 3 provides high reliability with low maintenance to reduce downtime and enable wind turbines to generate more power, which reduces the Levelized Cost of Energy

- Electric pitch systems for on-shore and off-shore wind turbines
- Blade sensing systems
- Electric and hydraulic pitch products
- Slip ring and rotary solutions
- Multiplexers and media converters



Pitch System 3

Services – Maximum Turbine Availability with Responsive Support

Moog Global Support is our promise to help wind farm maintenance professionals worldwide to maximize availability, ensure pitch system reliability and lower the cost of energy

- Hands-on training
- Expert technical support
- OEM replacement parts and factory repairs
- Reliable retrofits and fleet upgrade projects
- Flexible service agreements



Global Support Where and
When You Need it



Marine Solutions and Services

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Marine – Products, Solutions and Services

- Specializing in providing custom electrical slip ring, fiber optic, fluid swivel, optical multiplexer and servo valve solutions
- Design and manufacture custom and built-to-order proven products for the harshest marine environments
- Providing in-house and global service and maintenance, testing and overhauls



Sonars



Subsea Oilfield Communications



Remotely Operated Vehicles



Floating Production Systems



Slip Rings



Fiber Optic Rotary
Joints (FORJs)



Fluid Rotary Unions
(FRUs)



Servo Valves

Marine – Product Offering



Multiplexers and
Media Converters



Condition
Monitoring



Floating Production
Systems



Sonars

Industrial Products, Systems and Services Overview

Electro-Hydraulic – Product Offering



Servo and
Proportional Valves



Radial Piston Pumps



Industrial Cartridge
Valves and Covers



Servo and Proportional
Cartridge Valves



Manifolds and
Hydraulic Systems





Brushless DC Motors



SmartMotor™



Servomotors and
Integrated Drive Systems

Electro-Mechanical – Product Offering (1/2)



Servo Motors



Linear Motors



Servo Drives



Machine and Motion
Controllers



Actuators



Ball and Planetary
Roller Screws

Electro-Mechanical – Product Offering (2/2)



Position Sensors



Medical/Industrial
Ultrasonic Sensors

Electro-Hydrostatic – Product and System Offerings

Hydraulic and electric technology in a self-contained package helps enable a decentralized motion control system and eliminates the need for a hydraulic power unit and complex piping



Electro-Hydrostatic Pump
Unit (EPU)



Electro-Hydrostatic
Actuation System (EAS)



Repair Services



Parts/Exchanges



Field Service

Service Offerings – Products



Training



Service Agreements



Technical Support



Retrofits



Electro-Hydraulic Products

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Electro-Hydraulic – Product Offering



Servo and
Proportional Valves



Radial Piston Pumps



Industrial Cartridge
Valves and Covers



Servo and Proportional
Cartridge Valves

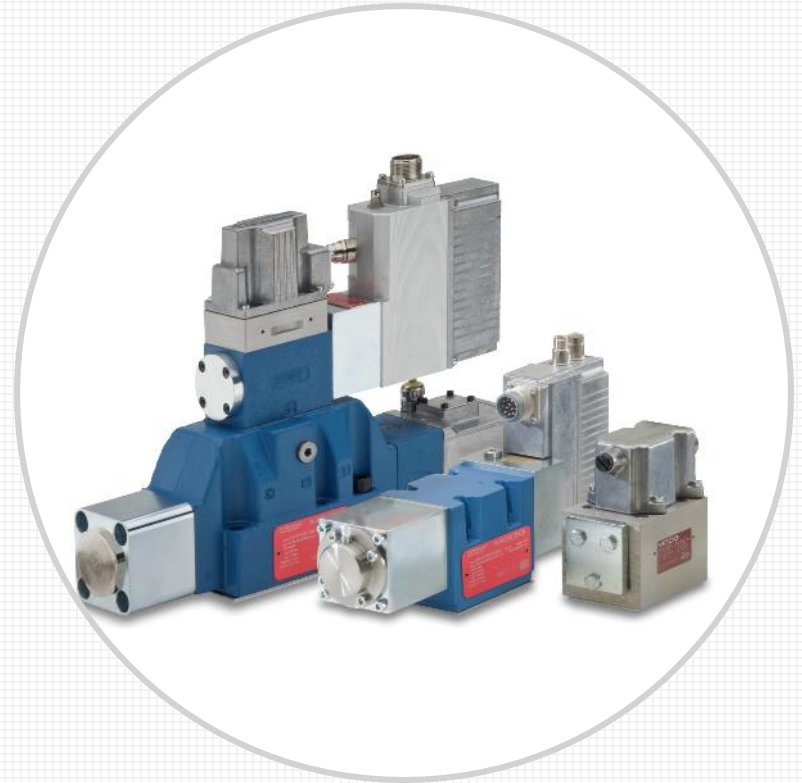


Manifolds and
Hydraulic Systems



Servo and Proportional Valves (1/2)

- Proven reliability and built-in quality for a performance advantage in many different industrial machines
- Numerous models with a range of sizes, performance characteristics and mounting options to better meet your specific requirements
- Convenient selection and configuration of digital valves using Moog configuration software to suit the application needs



Servo and Proportional Valves

Servo and Proportional Valves (2/2)

Technical Summary

- Single and multi stage valves
- Rated flows from 0.15 to 1500 l/min (0.04 to 390 gpm)
- Rated pressures up to 350 bar (5000 psi)
- Integrated pressure, force and axis control options
- Optional fieldbus interfaces
- Variants for hazardous environments



Servo and Proportional Valves

Radial Piston Pumps (1/2)

- Ideal for applications requiring robust performance, low noise, contamination-resistant design and unsurpassed reliability
- Available in various sizes, single and multiple configurations, and a wide array of control options and mounting flanges to meet your specific requirements



Radial Piston Pumps

Radial Piston Pumps (2/2)

Technical Summary

- Variable displacement piston pump
- Single and multiple pump arrangements
- Displacement: from 19 to 250 ccm/rev
- Pressure up to 350 bar permanent pressure and 420 bar pressure peak
- Broad range of compensator types
- Available as RKP with Digital Control (RKP-D) and Explosion-proof versions



Radial Piston Pumps

Industrial Cartridge Valves and Covers (1/2)

- Available as directional, pressure and check cartridge valves including covers and pilot valves
- High robustness and reliability
- Ideal for applications which require high flow rates and leakage-free control
- Re-designed cartridge valves with best-in-class nominal flow rate



Cartridge Valves

Industrial Cartridge Valves and Covers (2/2)

Technical Summary

- Rated flows up to 20,000 l/min (5400 gpm)
- Rated pressures up to 420 bar (6000 psi)
- Available sizes: NG16 to NG160
- Passive and active cartridge valves available
- Position monitored cartridge valves for safety applications



Cartridge Valves

Servo and Proportional Cartridge Valves (1/2)

- High robustness and reliability
- High flexibility through modular design
- 2- and 3-way design
- Different performance and fail-safe options available



Servo and Proportional Cartridges

Servo and Proportional Cartridge Valves (2/2)

Technical Summary

- Nominal flow rate up to 20,550 l/min at $\Delta p = 5$ bar
- Maximum operating pressure up to 420 bar (6000 psi)
- Available sizes: NG40 to NG160



Servo and Proportional Cartridges

Manifold Systems

- Application-specific manifold designs allow enhanced machine performance, reduced system cost, and meet requested safety performance level
- Compact manifold design allows a reduced envelope size and piping efforts
- Fully tested manifolds enable shortest start-up and commissioning time
- Reduced system costs with re-designed cartridge valves for pressure range up to 420 bar (6,000 psi)
- Manifolds up to 12 t



Manifold Systems

Hydraulic Systems

Scope includes:

- Manifolds, hydraulic power units, cylinders, accumulators, piping
- Axis closed loop control including hardware, software, start-up support and commissioning
- Simulation of the entire system to meet the required performance and to minimize the start-up time
- **Hardware in the Loop (HIL)** supports the software check of the closed loop control and the PLC



Hydraulic Systems

Electro-Mechanical Products

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Brushless DC Motors



SmartMotor™



Servomotors and
Integrated Drive Systems

Electro-Mechanical – Product Offering (1/2)



Servo Motors



Linear Motors

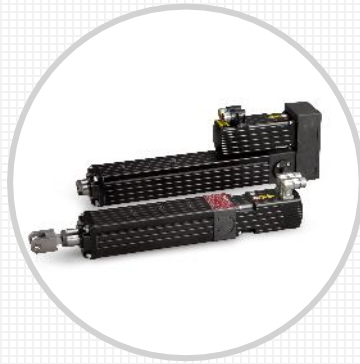


Servo Drives



Machine and Motion
Controllers





Actuators



Ball and Planetary
Roller Screws

Electro-Mechanical – Product Offering (2/2)



Position Sensors



Medical/Industrial
Ultrasonic Sensors

Silencer[®] BN Series Brushless DC Motors

- Diameters from 30.48 to 106.68 mm (1.2 to 4.2 in)
- Lengths from 33.02 to 139.7 mm (1.3 to 5.5 in)
- Continuous torques from 2.4 to 519 oz-in
- Speeds up to 20,000 rpm
- Precise, variable speed control
- Extremely quiet operation
- Long-life operation



Brushless BN Series Motors

SmartMotor™ Integrated Servo Motors

- Fully integrated motion control servo system incorporating a multi-axis motion controller
- Supports serial and many optional fieldbus protocols
- Combitronic™ technology for a parallel-processing network up to 120 axes
- NEMA 17, 23 and 34 frame sizes to meet any application requirements
- Compact, feature-rich controls allow for rapid solution development
- Wide array of standard catalog products; custom designs are also available



SmartMotor™ Integrated Servo Motors

Brushless Servo Motors

- Superior motor dynamics improving cycle time
- Modular and compact lightweight construction
- Proprietary, low cog design for smooth low speed operation
- Flexible options for easy integration
- Available as frameless package
- Custom windings and designs



Servo Motors

Compact Dynamics Servo Motors

Technical Summary

- Continuous Torque from 0.15 to 74.2 Nm
- Peak Torque from 0.5 to 240 Nm
- Speed up to up to 11,700 rpm
- Sizes 3 to 6, Flanges from 40 to 190 mm

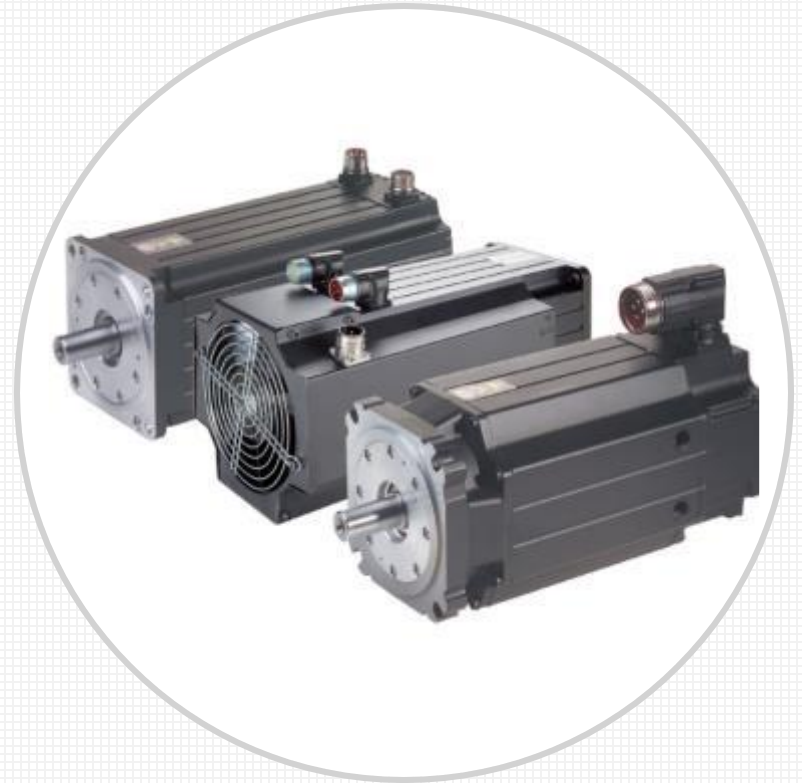


Compact Dynamics Servo Motors

Maximum Dynamics Servo Motors

Technical Summary

- Continuous Torque from 2.2 to 1,034 Nm
- Peak Torque from 10 to 2,012 Nm
- Speed up to 11,700 rpm
- Sizes 3 to 7, Flanges from 70 to 275 mm



Maximum Dynamics Servo Motors

Fastact H Servo Motors

- Comprised of air cooled (Fastact H) and liquid cooled (Fastact WH) motors
- Available in a wide range of sizes, each with multiple lengths and varying torques and speeds
- Normal and high pole count versions
- Integral feedback, including resolver or optional encoder
- Flexible and modular design available



Fastact H Brushless Servo Motor

Explosion Proof Servo Motors

Technical Summary

- Continuous Torque from 0.52 to 66.68 Nm
- Peak Torque from 1.0 to 239.3 Nm
- Speed up to 7,800 rpm
- Sizes 3 to 6, Flanges from 70 to 190 mm



Explosion Proof Servo Motors

Large Motor Solutions

- High power and high dynamic servo motors up to 1 MW Continuous Power
- Application Markets:
 - Metal Forming Servo Press
 - Industrial Machinery
 - Marine Winches and Propulsion
- Integrated system consists of high power servo motors, servo drives, controllers, an energy management system, power supplies and motion application software
- Scalable system architecture, customizable hardware and collaborative engineering support reduce machine development time and increase flexibility
- Incorporates the latest energy management and motion control knowhow



Sizes 630 and 1,000 Large Motor Solutions
for 300 T and Larger Servo Presses

Linear Motors

- Encoder with 0.01 μm resolution, optical and Hall types available
- High force motors up to (22.25 kN)
5,000 lbf force
- All electric solution with direct linear motion and only bearings that need 5 ml of oil each 6 months to maintain
- Fan cooled and liquid cooled options for maximum performance
- Available as a component in a complete system solution - includes brushless linear motors, drives, motion controllers, cabling, filters and accessories



Powerful and Precise Linear Motors

Programmable Multi-Axis Servo Drive System (MSD) (1/2)

- Available in wide variety of power sizes and various fieldbus communications that work with virtually all machine designs
- Fully digital control over position, velocity or torque for servo motors incl. synchronous, asynchronous, linear or torque motors
- Deliver the highest dynamics, total reliability, smooth low-speed performance, thermal management for operation in demanding environments



Servo Drives

Programmable Multi-Axis Servo Drive System (MSD) (2/2)

Technical Summary

- Continuous Current from 4.0 to 450 amps
- Peak Current from 8.0 to 765 amps
- Operating Voltage from 115 to 460 VAC



Servo Drives

DS2020 Single Servo Drives

- DS2020 integrates the power supply with the drive in one enclosure
- Compact design helps reduce cabinet space and installation costs
- Complete analog interface available for backwards compatibility with analog drives
- Supports single multi-turn fully digital or Sin/cos encoders and any type of resolver
- High-speed communication via field bus connection to a wide range of control systems via EtherCat and CANopen



Drive Systems

DM2020 Multi-Axis Servo Drives

- DM2020 uses one power supply with multiple single and two axis drives
- Maximum synchronization between the axes with the dual-axis layout in a single module
- High-speed field bus connection via EtherCat and CANopen
- Multi-axis architecture reduces the overall dimensions by roughly 50% compared to stand-alone configurations
- Safe Torque Off function available with independent management on all axes
- User friendly graphic interface allows rapid access to all functions for easy setup, start up and monitoring



Drive Systems

DI2020 Drive-Integrated Servo Motor

- DI2020 with on-board electronics and decentralized servo drives
- Decentralized solution allows a reduction in the number of connections
- Cost savings due to reduced wiring (no feedback cabling)
- Decentralized architecture saves up to 90% of cabinet space
- High resolution and high sampling rate of its control loops provide high accuracy and fast execution of movements



Drive Systems

DR2020 Decentralized Servo Drive

- DR2020 is a high performance drive with IP67 protection grade for liquid and dust resistant applications
 - Ruggedized for harsh working environments
 - Streamlines wire configurations and saves cabinet space
 - Single connector for power and signal
 - Safe Torque Off and Safe Brake Control safety functions
 - Fully integrable into a multi-axis configuration



Drive Systems

Motion and Machine Controllers

- Motion Controllers and Software for electric and hydraulic servo actuation applications that offer rapid set-up
- Modular design enables the solution to be scaled to the needs of the machine
- High CPU performance for fast and accurate control
- Version for harsh environments available



Motion and Machine Controllers

Machine Controller Series 600 (MC 600)

- Modular hardware design for greater precision and faster reaction time
- Choose centralized or decentralized architectures without any application software modifications
- Uses the Moog Application Software Suite with easy-to-use template library for faster application development
- Wide operating temperature range
- Scalable hardware and software structure for applications of all sizes
- Integrated with the rest of Moog products for a total solution



MC600 Machine Controller

Servo Actuators (1/2)

- Available in Inline, foldback and compact designs for effortless integration into existing systems
- Offer long-lasting performance and reliability that increases lifetime and return on investment for machine builders



Servo Actuators

Servo Actuators (2/2)

Technical Summary

- Continuous Force from 1.0 to 96 kN
- Peak Force from 3.6 to 115.6 kN
- Rod Speed up to 1,600 mm/sec
- Stroke Length up to 2,500 mm



Servo Actuators

Ball, Planetary and Inverted Roller Screws

- Available as ball screws, roller screws and inverted roller screws in a full range of sizes with a wide selection of static and dynamic loads to allow easy integration into the machine
- Extended range of accelerations (up to extremely fast duty cycles) that meet noise and vibration requirements
- Robust design suited for heavy duty applications, vibrations and harsh environments



Ball and Planetary Roller Screws

Ball Screws

Technical Summary

- Dynamic Load Rating up to 1,450 kN
- Static Load Rating up to 3,300 kN
- Diameter from 12 to 125 mm
- Stroke Length up to 6,200 mm
- Leads from 1.5 to 80 mm



Ball Screws

Roller Screws

Technical Summary

- Dynamic Load Rating up to 1,380 kN
- Static Load Rating up to 3,500 kN
- Diameter from 16 to 90 mm
- Stroke Length up to 4,000 mm
- Leads from 2 to 40 mm



Planetary Roller Screws

Inverted Roller Screws

Technical Summary

- Dynamic Load Rating up to 300 kN
- Static Load Rating up to 750 kN
- Diameter up to 48 mm
- Stroke Length up to 180 mm
- Leads from 3 to 20 mm



Inverted Roller Screws

Position Sensors

- Brushless, non-contacting technology
- Repeatability position sensing with infinite resolution
- Housed and frameless versions available
- Single cycle (± 80 deg.) or dual cycle (± 40 deg.)
- Standard size 8 (housed version) with servo clamp interface available
- Multiple channel (tandem) versions available
- Geared configurations available



Position Sensors

Ultrasonic Sensors

- Custom sensor development
- Off-the-shelf sensors for common tubing sizes/reservoirs as well as for prototyping
- The LifeGuard® line of sensors and sensing capabilities offer the perfect starting point for your engineering projects

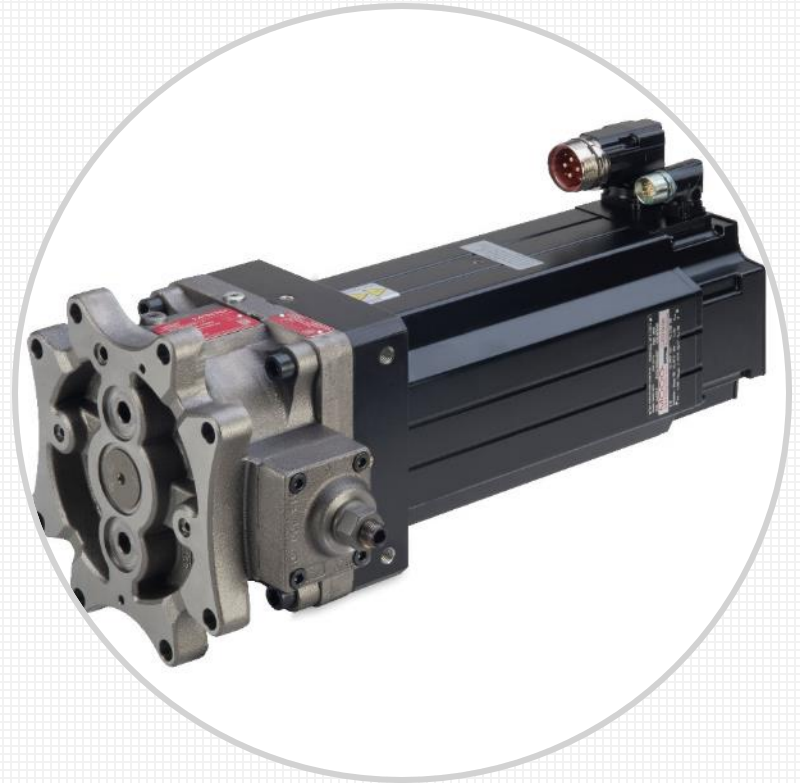


Ultrasonic Sensors

Electro-Hydrostatic Product and System Offering

Electro-Hydrostatic Pump Unit (EPU)

- Combines servo motor with radial piston pump in a compact package
- High energy efficiency reduces operating costs
- Environmental cleanliness lowers maintenance and operating costs, risk of fire
- High-force capability provides a viable alternative to electrohydraulic actuation
- Unique direct mounting manifold Interface enables reducing piping and machine footprint



Electro-Hydrostatic Pump Unit
Self Contained, Compact Product

Electro-Hydrostatic Actuation System (EAS)

- Combines the EPU with servo drives, manifolds, cylinders and other optional parts a customer may need
- Provides all of the best of both electrohydraulic and electromechanical actuation systems with the EPU as the heart of this system
- Decentralized system eliminates the need for an HPU and complex piping



Electro-Hydrostatic Actuation System (EAS)

Power/Data Transmission Products and Solutions

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Slip Rings

Products are developed for high performance environments and flexible requirements.

- Compact Slip Ring Capsules
- Ethernet Slip Rings
- High Speed Slip Ring Capsules
- Large Diameter Slip Rings
- Separates
- Slip Rings with Through Bores
- Fiber Optic Rotary Joints



Commercial – Industrial Slip Rings

Rekofa Slip Rings

- Standard Slip Rings
- Customized Slip Rings
- Signal and Data Transmission
- Slip Ring Collectors (SRK)
- Media Distributors
- Hybrid Rotary Distributors
- Industrial Carbon Brushes



Rekofa Slip Rings

Fiber Optic Rotary Joints

Fiber Optic Rotary Joints (FORJs) are to optical signals what electrical slip rings are to electrical signals, a means to pass signals across rotating interfaces, particularly when transmitting large amounts of data. Available FORJs include:

- Single Channel
- Multi-channel
- Hybrid
- Complete Rotary Interfaces



Fiber Optic Rotary Joints (FORJs)

Multiplexers and Media Converters

- Standard Multiplexers
- Condition Monitoring
- Pressure Tolerant Electronics and Optics
- Market Specific Multiplexers
- Custom Multiplexers



Multiplexers and Media Converters

Fluid Rotary Unions

- Used around the world to ensure reliable transmission of life support, process, power and control fluids
- Rated for pressures up to 1000 bar (15,000 psi) are available
- Seals based on chemical compatibility, design pressure, design temperature, required service life and acceptable leakage rate
- Can be combined with our electrical slip rings and fiber optic rotary joints



Fluid Rotary Unions (FRUs)

Sonars

Products include:

- Imaging Sonars: Multibeam
- Imaging Sonars: Mechanical
- Imaging Sonars: Side Scan
- Mechanical and Hydraulic
- Motion Reference, Positioning, and Data Transfer Systems
- Profiling Sonars: Mechanical and Multibeam
- Survey Sensors
- Controls Units
- Video Imaging



Imaging Sonars

**We want to be your
supplier of choice**

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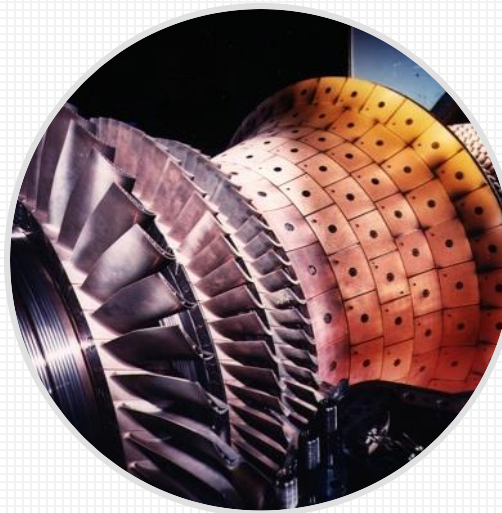


We Add Value for Our Customers

We are ready to help you address the challenges you face on your next generation machines or latest project



We support our customers' success



We specialize in motion control and power and data transmission




We offer unsurpassed expertise




We Specialize in High Performance

World class products, solutions and services that solve your machine challenges




Our world class products help you build machines that deliver outstanding value

Products



Our reliable solutions provide greater reliability and enhanced efficiency

Solutions



We understand your needs and offer flexible, comprehensive and timely services, resulting in excellent value

Services



We Are Ready to Work with You

- Motion Control Expertise and Deep Application Know-how
- World Class Products, Collaborative Solutions and Responsive Services
- Extensive global presence with a local office near you



We support our customer's success



THANK YOU

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