



Innovations in Flight Control Systems and Subsystems

Stick-to-Surface | Electrohydrostatic | Electromechanical |
Electrohydraulic | Electronic

aerospace
climate control
electromechanical
filtration
fluid & gas handling
hydraulics
pneumatics
process control
sealing & shielding



ENGINEERING YOUR SUCCESS.

PARKER CONTROL SYSTEMS DIVISION

EVERY OPTION. EVERY ADVANTAGE.

At Parker's Control Systems Division (CSD), we know how important innovative solutions can be. Our team can help you evaluate the technical and business options needed to engineer your success in the marketplace.

PROVEN ELECTROHYDRAULIC, ELECTROMECHANICAL,
AND POWER-BY-WIRE EXPERIENCE

ADVANCED CONTROL ELECTRONICS AND

LIFETIME PRODUCT SUPPORT

SUCCESSFUL STRATEGIC PARTNERSHIPS

ACTUATION TECHNOLOGY

TOTAL SYSTEM SOLUTIONS

TECHNOLOGY INSERTIONS

HELPING INNOVATION TAKE FLIGHT, PARKER CSD CAN PROVIDE:

- **Total system solutions**, with more efficient design, complete system integration, and optimized flight control architecture. Systems that can lower development cost through single-point procurement
- **Integrated control electronics**, including primary flight control computer, actuation control electronics, remote electronics units, motor control electronics, and inceptor interface modules
- **Actuation**, including electrohydraulic, electromechanical, electric backup hydraulic, and electrohydrostatic experience
- **Partnerships with customers and suppliers**
- **A broad range of engineering talent**, offering you optimized design solutions
- **Technology insertions**, improving reliability

OUR MARKETS

- Business jets
- Commercial transports
- Engines
- Helicopters
- Military transports and tankers
- Missiles
- Regional jets
- Strike aircraft
- Unmanned vehicles

A PROVEN STICK-TO-SURFACE SYSTEM PEDIGREE



As a team leader, partner, or subcontractor, our flight control experience extends across both military and commercial platforms, and embraces a wide range of industry-changing programs. Our experience has taught us how to identify and minimize risks effectively, create better solutions, and add value to both the product and the process.

TEAM LEADER

Parker CSD is an experienced systems team leader in all critical development stages, including definition, implementation, integration, certification, and support.

Lead system architecture development

Lead system integration testing

Support failure hazard assessment development

Support certification plan development and approval

Programs:

- Boeing P-8A Poseidon
- Bombardier CSeries
- Bombardier Q400
- Embraer 170/190
- Embraer Legacy 450/500

PARTNER

Full integration of control electronics and actuation

Simulation models, analysis, and reports

System safety assessments

Verification and validation

- Hardware
- Software

Subsystem requirements and architecture design

Programs:

- Bombardier Global Express
- COMAC ARJ21
- COMAC C919
- Hawker 4000
- Lockheed Martin F-35 Lightning II

SUBCONTRACTOR

Actuation technologies

- Hydromechanical
- Electrohydraulic
- Electromechanical
- Electrohydrostatic
- Electric backup hydraulic

Electronics expertise

- Motor control
- Remote actuator control
- Centralized actuator control

Applications

- Primary flight controls
- Spoilers
- Speed brakes
- Control surface trim
- Horizontal stabilizer trim
- Weapons bay door

Full integration qualification testing and documentation

Programs:

CSD is proud to provide a significant bill of material on most military and commercial aircraft flying today, including:

- Aerojet Tactical Tomahawk
- Airbus A330/340
- Boeing Delta IV, AH-64, C-17, V-22, F-15, F-18E/F, 737NG, 747-400, 767, 777
- Bombardier Challenger 605, Q300
- Cessna CJ4
- Embraer ERJ 135/145, Phenom 100, Phenom 300
- General Electric F110, F404, F414
- Gulfstream G200, G350/450, G500/550, G650
- Hanwha T-50
- Lockheed Martin F-16, F-22, F-35 CTOL/STOVL, Falcon, JASSM, RATTLS, Polecat
- Mitsubishi Heavy Industries F-2
- Northrop Grumman E-2C/D, X-47B
- Orbital Sciences Corporation GMD
- Pratt & Whitney F119
- Raytheon Griffin
- Raytheon/Lockheed Javelin
- Rolls-Royce LiftFan
- Sikorsky UH-60, SH-60, S-92

TOTAL SYSTEM SOLUTIONS

A unique and proven seven-step process that results in improved integration efficiency, lower system design and development cost, and enhanced system performance.

1 DEFINE

- Joint development
- System architecture and trade study
- Requirement discovery and allocation
- Physical and functional interface definition
- System safety assessment

2 ENGINEER

- System design
- Modeling and simulation
- Performance analysis and specification
- Reliability and maintainability analysis
- Risk reduction planning and prototyping
- Component design and development

3 MANUFACTURE

- Make vs. buy determination
- Supply chain management
- Lean manufacturing
- Assembly and testing

4 INTEGRATE

- Mechanical and electronic integration
- Component design verification
- Interface verification
- System integration rig testing
- Aircraft iron bird integration and ground test

5 CERTIFY

- Flight test support
- FAA/EASA/ANAC/TC regulatory agency support
- Certification documentation support

6 DELIVER

- Hardware
- Certification documentation
- Product support and technical publications
- Maintenance and fault isolation training

7 SUPPORT

- 24/7 AOG repair and overhaul
- On-site and online training
- Performance-based logistics
- Cost-per-hour programs

FLIGHT CONTROLS ON A HIGHER PLANE

Every option for every advantage

CSD can provide a wide range of system options for actuation and control electronics, including cockpit control and flight control computers through our strategic alliance and teaming arrangements.

For fixed-wing aircraft:

- Horizontal stabilizer systems
- Rudder systems
- Flap systems
- Aileron systems
- Spoiler systems
- Elevator systems
- Slat systems
- Speed brake systems
- Stability augmentation systems
- Trim actuation systems
- Weapons bay door and other mechanical drive systems

For rotorcraft:

- Main rotor actuation systems
- Tail rotor actuation systems
- Force augmentation systems
- Stability augmentation systems

For launch vehicles/missiles:

- Fin control systems
- Thrust vector controls

These options provide you with critical advantages, including:

- Improved integration efficiency
- Lower system design and development cost
- Improved system performance

EHA/EBHA INNOVATION

ELECTROHYDROSTATIC AND ELECTRIC BACKUP HYDRAULIC ACTUATION SYSTEMS



Electrohydrostatic actuation (EHA) and electric backup hydraulic actuation (EBHA) are power-by-wire systems that deliver less system weight, enhanced avionics integration, and reduced lifecycle costs. EHAs and EBHAs are self-contained hydraulic systems controlled by high-power electronics which allow the use of traditional, proven hydraulic actuation configurations for fault tolerance.



F-35 horizontal tail electrohydrostatic actuator

The product of two decades of research, development, and flight-tested reliability, Parker EHAs and EBHAs offer significant advantages:

- **Reduced system weight.** Hydraulic distribution systems are reduced.
- **Reduced power consumption.** Power is used as required, yielding a more efficient system.
- **Improved maintainability.** Hydraulic disconnections between actuation equipment and the vehicle system are eliminated.

OUR PAST

- **Boeing 757:** Developed and successfully demonstrated electrohydrostatic elevator actuator
- **Lockheed Martin HTTB:** Demonstrated aileron EHA on C-130 test aircraft
- **Lockheed Martin J/IST:** Replaced conventional F-16 flight controls with complete EHA system

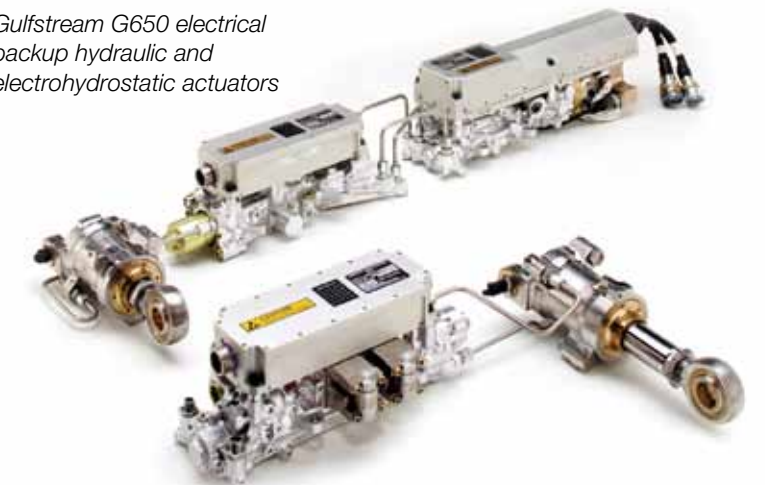
OUR PRESENT

- **Lockheed Martin F-35:** EHAs on primary flight control surfaces
- **Gulfstream G650:** EBHAs on all primary flight control surfaces

OUR FUTURE

- Optimization of aircraft flight control systems using EHA and EBHA technologies to maximize thermal management and power efficiency

Gulfstream G650 electrical backup hydraulic and electrohydrostatic actuators



Control Systems Division SpiritWorks™

How do you capture the spirit of innovation? Here at CSD, the answer is SpiritWorks™, a multi-disciplinary team of engineers and technologists charged with redefining the future of flight control. Focused on research and development, these innovative thinkers look at flight control and actuation in new ways. SpiritWorks is chartered to determine future technology directions and link CSD's research and development projects to the needs of our customers.

EMA INNOVATION

ELECTROMECHANICAL ACTUATION SYSTEMS



Adaptable high-horsepower linear actuator



Horizontal stabilizer trim actuation systems

Offering efficient, lightweight, reliable, and low-cost solutions that reduce overall power consumption and program expense, our innovative electromechanical, electronic, and motor-control and drive actuation systems are leading the way in the manned and unmanned aircraft, missile, and launch vehicle markets.



Embraer 170 horizontal stabilizer control system

There first

OUR EMA PEDIGREE

From our earliest missile wins, our EMA innovation has earned us an increasing bill of material on a wide range of programs and platforms. These include the following:

Boeing P-8A Poseidon

Bombardier Global Express

Bombardier Q400

Embraer 170/190

Embraer ERJ 145

Embraer Phenom 100

Embraer Phenom 300

Gulfstream AFCS

Gulfstream G200

Lockheed Martin FALCON

Lockheed Martin JASSM

Lockheed Martin Polecat

Lockheed Martin RATTLRS

Orbital Sciences Corporation GMD

Orbital Sciences Corporation Minotaur

Orbital Sciences Corporation Pegasus

Orbital Sciences Corporation Taurus

Raytheon/Boeing JAGM

Raytheon Griffin

Raytheon Tactical Tomahawk

Raytheon/Lockheed Martin Javelin

Using an interdisciplinary approach that combines building blocks of mechanical actuation and electronic controls with software and testing, we create a single, integrated system. Our adaptable and scalable architecture results in system and component solutions that are affordable and provide reduced lead time.

More EMA options

Whatever your EMA needs, Parker Control Systems can meet them. Our wide range of applications allows us to create systems that are Mil-standard compliant and FAA certifiable. We design and develop highly efficient linear and rotary actuation for primary and secondary control applications. Our pedigree allows us to scale our qualified designs to meet a variety of power requirements ranging from 0.25 Hp to 50 Hp.

Optional features include:

- Patented jam-tolerant designs
- Robust control electronics
- High-temperature applications for harsh environments
- Torque-summed or velocity-summed configurations
- DC brushless, AC induction, and switch reluctance motors
- Resolvers for motor-position feedback
- Position and velocity sensors

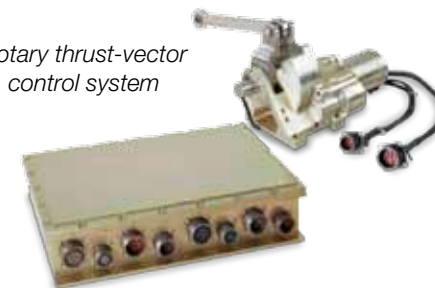
Access to the best in motor design

Our customers have access to the world's most advanced motor design facilities through Parker's Motor Design Center. This Parker center of excellence offers the capabilities needed to produce a working motor under even the most aggressive development schedules.



Raytheon/Lockheed Martin Javelin missile fin control servoactuation system

Rotary thrust-vector control system



Lockheed Martin Polecat flight control actuation system



FLY-BY-WIRE INNOVATION

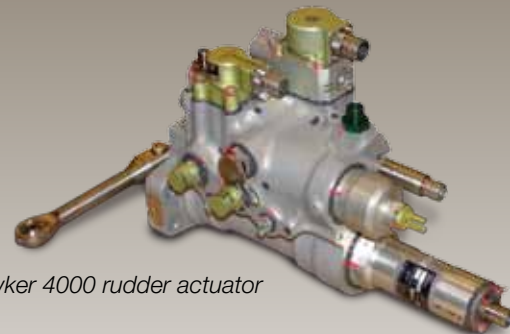
ELECTROHYDRAULIC CONTROL SYSTEMS



Our control actuation technology for primary and secondary flight control systems has been tested, proven, and trusted in commercial and military applications for decades, providing precise position control actuation solutions that are optimized for high reliability and fault-tolerant performance.

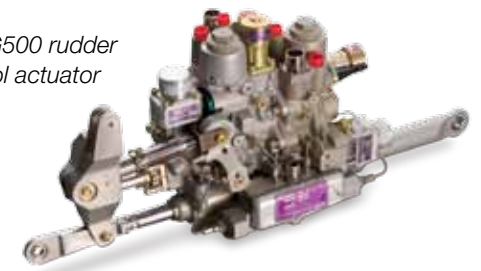


Boeing 777 rudder power control unit



Hawker 4000 rudder actuator

Gulfstream G500 rudder flight control actuator



Proven pedigree

ELECTROHYDRAULIC CONTROL

Airbus A380
Bell Boeing V-22
Boeing 737
Boeing 747
Boeing 777
Boeing AH-64
Boeing C-17
Boeing F-15
Boeing F/A-18E/F
COMAC ARJ21
General Electric 404/414
Gulfstream G500
Hawker 4000
Lockheed Martin F-16
Lockheed Martin F-22
Northrop Grumman X-47B
Pratt & Whitney F119
Rolls-Royce LiftFan™
Sikorsky H-60
Sikorsky S-92

ELECTROHYDROSTATIC ACTUATION A leader in actuation solutions

Our hydromechanical and fly-by-wire components and systems are the products of advanced material selection and efficient system packaging to provide you with the following advantages:

- Proven fault-tolerant and fail-safe design configurations
- Improved reliability through innovations in sealing and coating technologies
- Robust and reliable Jet-Pipe® EHSV and direct-drive-valve technology for precision motion control
- Dedication to low-cost solutions through lean manufacturing and processes
- Battle-tested ballistic tolerant designs
- Lightweight design solutions



F119 divergent nozzle actuator



F-22 fly-by-wire horizontal tail actuator

C-17 rudder control module



ELECTROHYDRAULIC SERVOVALVES (EHSVs) Highly respected Jet-Pipe® technology

Parker CSD is proud to design, develop, and manufacture the highly reliable Jet-Pipe®-based EHSVs. All of Parker's servovalves provide unparalleled performance due to their highly reliable Jet-Pipe® first-stage and second-stage spool design. The result is an exceptionally stable, contamination-resistant, and erosion-tolerant servovalve that's designed to last.

Our EHSV applications can be found on both commercial and military aircraft in primary and secondary flight control actuators, maingear and nosewheel steering systems, and autobrake modules. Currently Parker EHSVs are in production or qualified for use on most military and commercial aircraft being produced today.



We also manufacture a line of EHSVs for the industrial power generation marketplace that includes FM- and CE-certified valves.

ELECTRONIC CONTROL INNOVATION

ELECTRONIC CONTROLLERS

At the heart of every more-electric system is the electronics control unit, providing innovative command and control through closed-loop feedback networks. Whether in primary or backup mode, the world's new aircraft are increasingly adopting electric flight control actuation – which is why we've created a family of adaptable, scalable controllers.

Products:

- Actuation control electronics (ACE)
- Remote electronics units (REU)
- Motor control electronics (MCE)
- Inceptor interface modules (IIM)

Technologies:

- DSP and FPGA digital microprocessors
- High- or low-power control
- Failure mode detection and internal BIT functions
- Prognostics and health monitoring
- Motor-drive electronics using four-quadrant control space vector modulation and trapezoidal drives
- Active/active or active/standby designs to meet redundancy requirements
- High- and low-temperature capability
- Discrete and integrated power modules
- Regenerative energy management systems

Design standards:

- Mil-Std-1553, RS422/485, ARINC 429, IEEE 1394, and CAN communication and interface busses
- Mil-Std-461/DO-160 EMI filtering and protection
- Software for RTCA DO-178B, levels A through C
- Hardware/firmware for RTCA DO-254 levels A through C



F-35 actuation control electronics



Gulfstream G650 remote electronics unit



Gulfstream G650 motor-control electronics



Embraer Legacy 450/500 inceptor interface modules

INNOVATION IN ACTION | Electri-flying changes

Our family of adaptable and scalable controllers, critical to the more-electric trend being adopted by the world's new aircraft, is proven and flying today.

Our pedigree

Traditionally, electrically powered actuation has been used to control the flaps, as well as the trim on the primary flight surfaces and horizontal stabilizers. Parker's pedigree is well established, supplying all or some portion of the electrically powered actuation systems on Embraer's ERJ 135/145, Phenom 100/300, and the Embraer 170/190.

Our leadership

In addition, we have taken a leadership role with our system of electrohydrostatic actuators (EHAs), used to power primary flight control surfaces on the F-35 Lightning II. Jointly developed with our teammates Moog and Hamilton Sundstrand, EHAs contribute significantly to performance improvements and weight reduction at the aircraft system level.

Our commitment

As the more-electric trend continues, Parker is committed to staying at the forefront of the demand by making the necessary investment now to ensure our more-electric technology is production-ready when needed.

THE CSD DIFFERENCE

Working as a team leader, partner, or subcontractor, you can count on us to provide the innovative solutions you need in today's competitive marketplace.

Whether you've come to us for the design, development, testing, and manufacture of subcomponents, assemblies, or systems, CSD team members are committed to engineering your success through:

- Unparalleled teamwork
- Strong program management
- Innovative technical solutions
- Operational excellence
- Creative problem solving
- Off-the-shelf solutions
- Lean processes and continuous improvement
- Risk-sharing partnerships
- Lifetime product support



Cellular manufacturing streamlines operations and achieves one-piece flow by allowing team members to complete multiple operations.



Lean processes. Technicians use point-of-use tooling and kanban systems to boost efficiency.



Strategic partnerships. We build relationships with our customers and key suppliers to ensure long-term, risk-sharing partnerships.



CUSTOMIZED WORLDWIDE SUPPORT

When it comes to MRO, CSD continues to be at the forefront of customer support innovation through Parker Aerospace Customer Support Operations (CSO). CSO offers a full spectrum of services and support and will work in partnership with you to develop comprehensive programs tailored to fit your specific maintenance and aftermarket needs.

Our innovative logistics programs are designed to help airlines manage MRO costs by providing greater predictability, reduced asset costs, a single point of contact, and improved cash flow through the following:

Cost-per-hour programs for both Parker and non-Parker products, including:

- Reliability enhancements
- Spares, overhaul, and repair
- 24-hour AOG support
- Field service engineering
- Fixed maintenance pricing
- Training
- Technology insertions
- Extended warranties
- Exchange programs



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