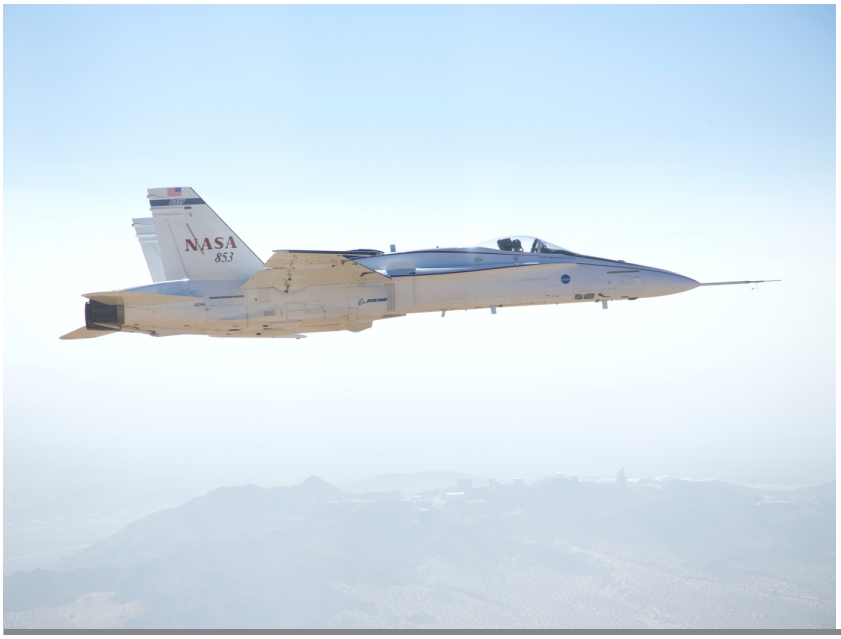



National Aeronautics and Space Administration

NASA

TECHNOLOGY SOLUTION

Mechanical and Fluid Systems

# Active Flow Control System for Simple-hinged Flaps

## Less cruise drag, better fuel economy

Conventional high-lift systems allow transport aircraft to safely operate at low speeds for landing and takeoff. These high-lift devices, such as Fowler flaps, are complex, heavy, and have high part counts. Fowler flap mechanisms also protrude externally under the wings, requiring external fairings, which increase cruise drag. Simple-hinged flaps are less complex, and an ideal choice for low-drag cruise efficiency. However, simple-hinged flaps require high flap deflections to achieve lift comparable to Fowler flaps. These flap deflections cause severe adverse pressure gradients, which generate flow separation that is difficult to control.

In response to these challenges, NASA developed the High Efficiency Low Power (HELP) active flow control (AFC) system. This simple, elegant invention can control flow separation resulting from the high flap deflections required by simple-hinged flap systems – making such flaps a viable option for aircraft designers. Aircraft with simple-hinged flap systems will achieve reduced cruise drag, thereby increased fuel efficiency.

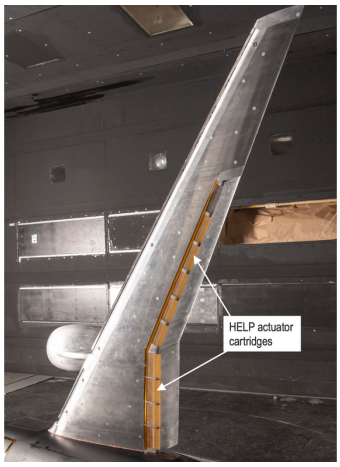
### BENEFITS

- Enables use of simple-hinged flap systems in aircraft design: By attenuating strong adverse pressure gradients encountered by highly deflected simple-hinged flaps while using relatively low pneumatic power, NASA's HELP AFC system makes the use of simple-hinged flaps feasible.
- Improved fuel efficiency: The ability to replace Fowler flaps with simple-hinged flaps eliminates the cruise-drag penalty associated with Fowler flap systems' decreasing fuel burn.
- Low maintenance: HELP actuators do not have any moving parts, and are essentially maintenance free.
- Reduced size and part count: NASA's HELP AFC system has the potential to decrease aircraft weight and part count by enabling simpler flap deployment operation.
- Reduced noise: The elimination of slotted (i.e., Fowler) flaps minimizes airframe noise.

## THE TECHNOLOGY

Although simple-hinged flaps represent optimal high-lift systems for reducing cruise drag, previous attempts to design flow control systems enabling such technology in transport aircraft have been unsuccessful. This is largely because such systems generally require a tradeoff between (a) the ability to achieve the required lift performance, and (b) possessing sufficiently low pneumatic power to enable feasible aircraft system integration (i.e., avoiding excess weight penalties associated with high pneumatic power). For example, electrically powered AFC systems (e.g., plasma actuators, synthetic jet actuators) have practical power requirements, but with limited control authority, making such systems ineffective for highly deflected flaps. On the other hand, circulation control systems can provide necessary lift for airfoils or wings with high flap deflections, but require too much pneumatic power for aircraft integration. NASA's HELP AFC system represents a breakthrough in flow separation control technology – to efficiently achieve necessary lift performances while requiring low pneumatic power relative to alternative flow control techniques.

NASA's HELP AFC system uses a unique two-row actuator approach comprised of upstream sweeping jet (SWJ) actuators and downstream discrete jets, which share the same air supply plenum. The upstream (row 1) SWJ actuators provide good spanwise flow-control coverage with relatively mass flow, effectively pre-conditioning the boundary layer such that the downstream (row 2) discrete jets achieve better flow control authority. The two row actuator system, working together, produce a total aerodynamic lift greater than the sum of each row acting individually. The result is a system that generates sufficient lift performance for simple-hinged flaps with pneumatic power requirements low enough to enable aircraft integration.




HELP actuator cartridges on the NASA High-Lift Common Research Model (CRM-HL). Testing proved that HELP flow control actuators were very effective in controlling the substantial flow separation on a simple-hinged flap system with a 50 degree flap deflection.

## APPLICATIONS

The technology has several potential applications:

- Aerospace: Simple-hinged control surfaces (e.g., flaps and rudders) for commercial and military aircraft
- Marine Vessels: Simple-hinged flap control surfaces for marine vessels
- Spacecraft: Enhancing lift for bluff bodies, such as those associated with planetary reentry vehicles
- Urban Air Mobility (UAM): Vertical and/or short take-off and landing wings in the UAM industry
- Engines: Flow separation and/or distortion control for compact diffusers upstream of engine inlets

## PUBLICATIONS

Patent No: 11,884,381

"Comparative Study of Active Flow Control Strategies for Lift Enhancement of a Simplified High-Lift Configuration" Veer N. Vatsa, Benjamin Duda, John C. Lin, Latunia P. Melton, David P. Lockard, Matthew O'Connell, & Judith A. Hannon , 06/14/2019, https://ntrs.nasa.gov/api/citations/20200002623/downloads/20200002623.pdf

"Wind Tunnel Testing of Active Flow Control on High-Lift Common Research Model" John C. Lin, Latunia P. Melton, Judith A. Hannon, Marlyn Y. Andino, Mehti Koklu, Keith B. Paschal, & Veer N. Vatsa, 06/14/2019, https://ntrs.nasa.gov/api/citations/20200002632/downloads/20200002632.pdf

"Testing of High-Lift Common Research Model with Integrated Active Flow Control" John C. Lin, Latunia P. Melton, Judith A. Hannon, Marlyn Y. Andino, Mehti Koklu, Keith B. Paschal, & Veer N. Vatsa, 08/25/2020, https://arc.aiaa.org/doi/10.2514/1.C035906

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