MICROMO
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Case Study

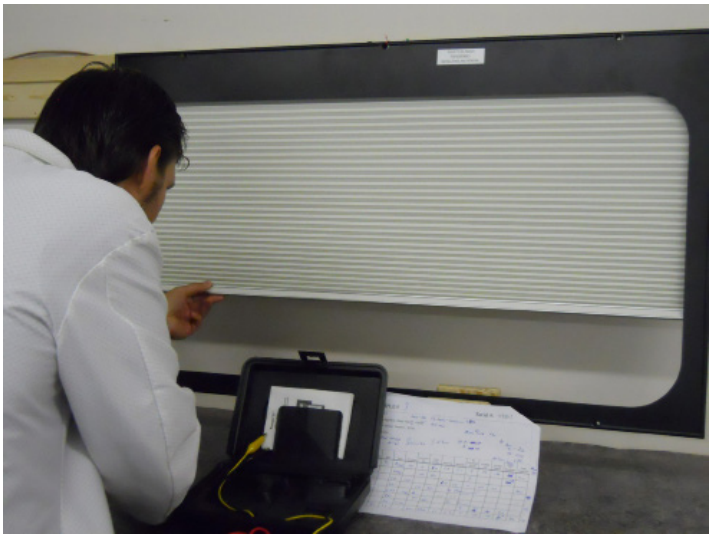
Made In The Shade

Failure-mode analysis coupled with quality gearmotors yielded an automatic window shade capable of surviving over 200,000 cycles.

Automatic window shades for personal control of daylight are one of the many definitions of luxury in private jets. It's a deceptively challenging application, requiring as it does quiet, robust operation from an ultracompact, lightweight subsystem. Aircraft window shade specialist MSA refined it to an art, turning out subsystems for numerous business jets every year. When it came time to step up their game for the commercial aviation market, however, they faced a product lifetime spec five times that of corporate aircraft products. To meet the challenge, they solicited help from their electromechanical drive systems vendor, MICROMO, which supplied not only hardware but the test and analysis expertise to complement MSA's design engineering. The result of the collaboration is a shade system that achieves more than double the lifetime required.

CASE FACTS

Organization:	**MSA**
Industry:	**Aviation**
Country:	**USA**
Challenge:	**Design a automated window shades with 100,000 life cycles.**
Solution:	**MICROMO design team matched the right gearhead and motor.**
Results:	**"In fact, after we passed 100,000 cycles, they asked me to put it in what's referred to as an out-of-plane configuration, where the shade is bent. [The gearmotor] made it to 235,000 cycles and it was still running when we stopped it."**



About 1.5-in thick, MSA's window shade systems are attached to the airframe between the fuselage and the inner wall of the cabin. At their heart is the window module, an accordion shade powered by a small DC motor. The units cover either one or two windows, and are controlled by a PC board mounted in the top bar. Including a stabilizing rail along the bottom and associated hardware such as rollers and gears, the window module weighs a matter of ounces.

In addition to being compact and lightweight, the DC micromotors used in the shade system need to provide enough muscle to move the window module not once, but around 20,000 times, the lifetime specification for the business-aircraft sector that has long been MSA's primary market. It's not an easy task. For a tiny motor, especially given the lifecycle requirements, the apparent weight of the shade is relatively high.

After more than two decades in the business, though, MSA had long since standardized their design around a 22-mm-diameter MICROMO gearmotor that let them easily meet spec and budget. MSA was satisfied with the motors and their customers were satisfied with them. The challenge arose when they found themselves in the enviable position of landing a customer in a new market—commercial aviation.

The contract involved retrofits of a major international carrier's 747 and 777 aircraft, a project designed to make its first-class cabins ultra luxurious. With significantly higher duty cycles, commercial aircraft have to meet a very different standard of use than do corporate jets. Instead of a 20,000-cycle requirement, the automated shades now needed to achieve a minimum of 100,000 cycles. In addition, the equipment had to meet the rigorous Environmental Conditions and Test Procedures for Airborne Equipment specification (DO-160) from the Radio Testing Company of America (RTCA). The order was for many hundreds of units with delivery commencing in a matter of months.

The MSA team began with the obvious approach of adapting their existing design, which had performed well in a range of corporate jet applications. The problem was that the application wasn't for corporate jets. "We had a different set of parameters," says Nick Mohat, Manager of Product Development at MSA. "The longevity requirement of the unit was five times greater than any previous application, speed was an issue, the weight of the shade was a big issue. We configured a prototype with the old motor on it and we could never get it past 30,000 cycles." He was worried, MSA was worried, and most of all the client was worried. "They said, 'If you can't get a motor to pass a 30,000-cycle test, what are you going to do about the hundred thousand cycle requirement'" The MSA design team was staring down a deadline. They needed an answer and they needed it fast.

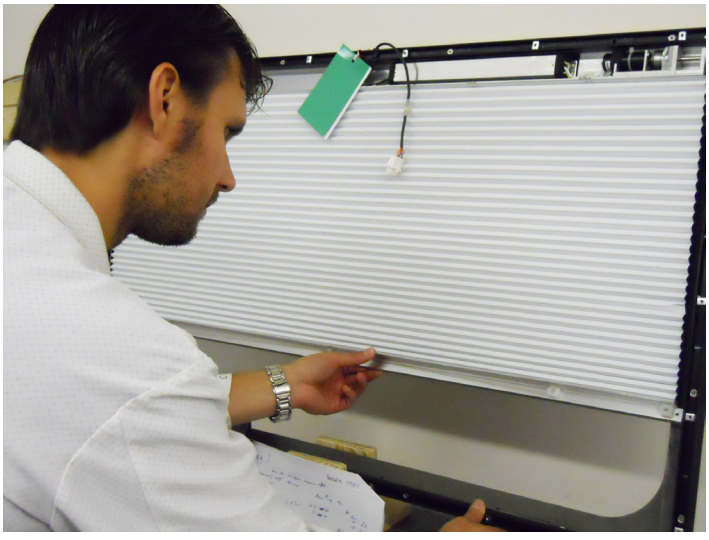
They called MICROMO.

Gearing Up

In the earlier design, the motor/gearbox solution had worked smoothly because the duty cycle was relatively low. The units had only undergone informal evaluation, not rigorous lifetime testing. Tracking down the cause of the fault required thorough failure-mode analysis.

As part of its value-added capabilities, MICROMO not only produces electromechanical drive systems but also maintains a dedicated test lab. The first step was for MSA to send in two of the failed gearmotors for study. The results were surprising the problem wasn't the motor at all. The design featured a single metal spur gear that introduced a reduction ratio to increase torque. The issue was that all the drive was essentially transmitted through that one piece of metal. In the tear-down analysis, the test lab team discovered that the face of the gear was simply shearing off over time as a result of the stress.

The solution was switching to a planetary gearbox that distributed the load among three "planet" gears. "We tested it and it did 100,000 cycles easily," Mohat says. "In fact, after we passed 100,000 cycles, they



asked me to put it in what's referred to as an out-of-plane configuration, where the shade is bent. [The gearmotor] made it to 235,000 cycles and it was still running when we stopped it."

Of course, the shade still needed to pass DO-160 testing. DO-160 is a complicated protocol that verifies equipment can survive exposure to conditions like shock and vibration, humidity, voltage spikes, water, and various types of electronic noise. Overall, the unit passed with flying colors—with the exception of the cold-soak test. It's a rigorous test for thermal robustness that involves holding the unit at -55° C for two hours, then testing it at -43° C. On this one test, the shade fell short. Here again, however, the root of the failure lay outside of the motors. "The current motor runs adequately in a cold environment," says Program Manager Joe Pedrotti. "It's the other components of the assembly that prevent the motor from completing its cycle before a timeout occurs."

And here again, MICROMO's full service partnership came into play.

The cold temperatures made the shade material brittle, which increased the friction as the shade went up and down. That changed the torque required from the motor, but the rest of the electronics in the module were not able to make that adjustment "There was too much friction in the system," says Mohat. "The PC board wouldn't supply the motor with enough current to run the shade all the way up and down.

With the input of MICROMO engineers, Mohat's group found a different motor that generates a greater amount of torque at the same voltage. The group also switched to a metal planetary gearbox that provides a 23:1 reduction ratio. "It's hoped that the motor will provide the increased torque and speed that we need to accomplish the cycle before the timeout," says Pedrotti.

The new gearmotor is definitely faster. The design that passed the lifecycle test could take the shades up and down in 6 s; the new version requires only 4 s to perform the same motion. Although MSA has not completed formal cold-soak testing of the new system, preliminary results indicate that the new design will easily perform to spec.

Throughout the R&D stage, MICROMO played an essential role in determining and solving the problems. "MICROMO has done a very good job in supporting the project," Mohat says. "I really appreciate our rep's input because he understood the problem right off. He knew his job, he suggested the right solution, and it worked."

In the end though, it all comes down to the motors. MSA's shades are providing ultimate luxury in the skies for commercial customers around the globe, courtesy of MICROMO performance. The passengers are happy, the airline is happy, and most of all, MSA is happy. "Their motors have always been something we can rely on," Mohat says. "We've always had a good experience with MICROMO motors."

For more information on MSA visit: http://www.msaaircraft.com/
For more information on the DC Motors used in this application visit MICROMO at: www.micromo.com

Inside the Solution

With the high reliability required for the commercial aviation application, MSA needed good consistency from motor to motor—and they got it. The performance actually saved them time and testing costs in the product acceptance process. "The rejection rate is such that we're comfortable using the products that we receive without putting them through a test platform," says Program Manager Joe Pedrotti.

"MICROMO motors have proven themselves to be very high quality and very consistent," agrees Nick Mohat, Industrial Designer at MSA.

To meet the lifecycle requirement:
• The 2224A036S motor a 22-mm-diameter precious-metal-commutated DC motor that generates 5 mNm of torque for a 36 V input voltage.

• The 22EK28:1 gearhead a three-planet plastic planetary gearbox that provides a 28:1 reduction ratio.

To pass the cold-soak test:
• The 2224U024SR motor, which generates the same 5 mNm of torque for an input voltage of only 24 V.

• The 20/1 gearhead a steel planetary gearhead that provides a 23:1 reduction ratio.

For over 50 years, MICROMO (FAULHABER Group) has brought together the widest range of high quality, high performance linear and rotary motion solutions, decades of micro motion expertise based on dc motor technology and full service design, sourcing and manufacturing capability on a global basis to deliver benchmark motion solutions. Call MICROMO at 800-807-9166 and let one of our Application Engineers, design a custom motion solution for your next application.