The Outback Gear and Drag

9-29-2009, C.Zavatson

In the on-going effort to reduce drag, the focus turns to an issue unique to the outback gear seen on the Lancair 320/360.

The Outback Gear

The "Outback Gear" replaced the 11.400-5 wheels with the larger and more common 5.00-5 wheels. The outback gear also brought with it changes to the landing gear doors that had some unintended consequences. The doors switched from a three piece design to a two-piece. The outback gear doors are larger and have a good deal of camber. They must 'bump out to clear the larger wheel assembly. This introduced a few problems. The highly cambered door created a large downward force on the doors. As a two piece design, the doors depend heavily on the inner gear door cylinder to keep both doors retracted. The outboard doors are very long and have a narrow cross section near the actuation attach point. The inner gear door overlaps the outboard gear door when retracted.

Figure 1, Photos of the "Outback Gear"

The Drag Problem

Unfortunately the larger areas, long moments and the flexible fiber glass materials all contribute to the rear of the outback doors opening in-flight. The leading edge might remain retracted, but the door itself twists under load. Simply giving the doors a good yank on the ground reveals their flexibility. Air to air photos show this phenomenon, but getting a really close up view provides much more detail. In-flight footage shows the results of air flow over the door.

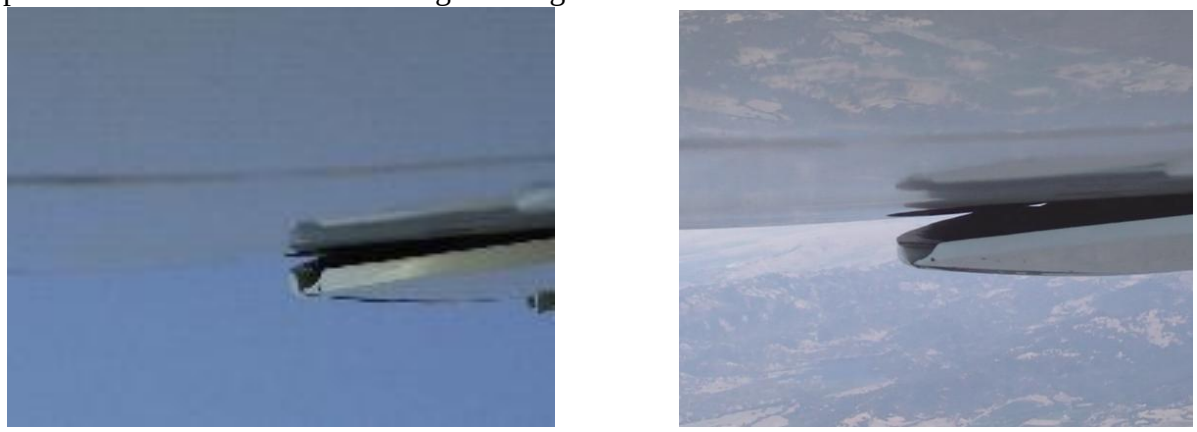

Figure 2, Original Outback Gear Doors on two different Lancair 360s

A small video camera was mounted below the wing using the middle flap hinge as an attach point. This provides an excellent vantage point to capture what happens with the doors in flight. Video clips of various flights can be viewed through the following links:

Original Door Aircraft 1 (8.5Mb)

Original Door Aircraft 2 (7.8Mb)

The famous ‘shaking door’ during an engine run-up. This is a common sight on Lancairs with the larger inner gear doors. The original doors are on the far side.
Inner Gear Door Shake (2.0Mb)

While open doors are not a safety issue, it represents an area of improvement in efficiency. They is a drag penalty for having such a large gap open up.
Prior to replacing the doors with a new design, a series of exploratory tests were conducted. The purpose was to isolate the source of the forces involved. The wheel well was completely sealed from the cabin. A bellows boot sealed the aileron pushrod and a composite cover was installed over the inner gear door cylinder. Next, the wheel well pressure was measured relative to ambient. This measurement revealed a strong negative pressure, indicating the doors were being pulled down by external low pressure rather than being pushed down by internal high pressure. Flow separation (and lack of pressure recovery) on the rear half of the doors was also eliminated as a root cause or contributing factor by tufting this area. The flow remained fully attached. The trailing edges of the original doors deflect downward through a twisting of the door itself. The degree of deflection is proportional to indicated airspeed, more speed equals more deflection. At cruise speed this can be on the order of an inch at the trailing edge.

The Solution
The approach used to solve this problem was to utilize a three piece design and improve the stiffness of the doors themselves. The new doors are made of carbon. They are geometrically identical to the original doors but have greatly increased stiffness. The new inner gear door is about half the size of the original. This enables it to exert much greater vertical force on the overlap with the center door. The center door is attached to the main gear trailing link arm using four stand-offs. A new trailing link arm was fabricated to provide mounting tabs for the new door. The wide mounting foot print provides a solid base which further adds stiffness.


Figure 3, New Carbon Door


Figure 4, New Trailing with Gear Door Attachments

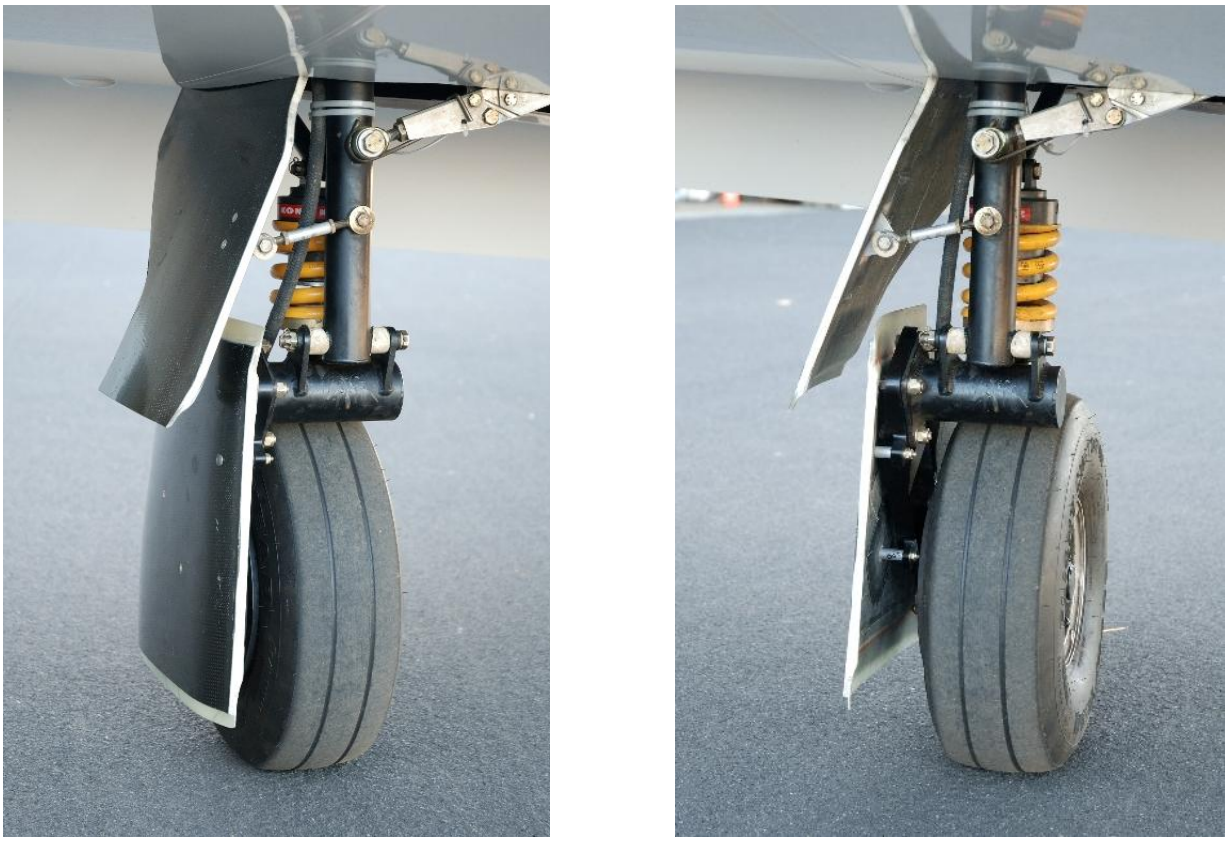

Figure 5, New Three-Piece Door

Testing

Flight test have been conducted with only the passenger side gear doors upgraded.
Multiple test flights with ever increasing speed have shown the new doors to be completely locked in the retracted position. No movement, whatsoever has been detected.
Quantifying the total reduction in drag will not conclude until the second door is completed.
The drag reduction seen thus far is less than half of the total to be expected due to the yaw generated by one closed door and one open door.
Measured airspeed at 7,500' has increased from 206 to 208 KTAS.
Flight testing of the new doors on passenger side (original doors on pilot's side)
New Door 1(10.7Mb)

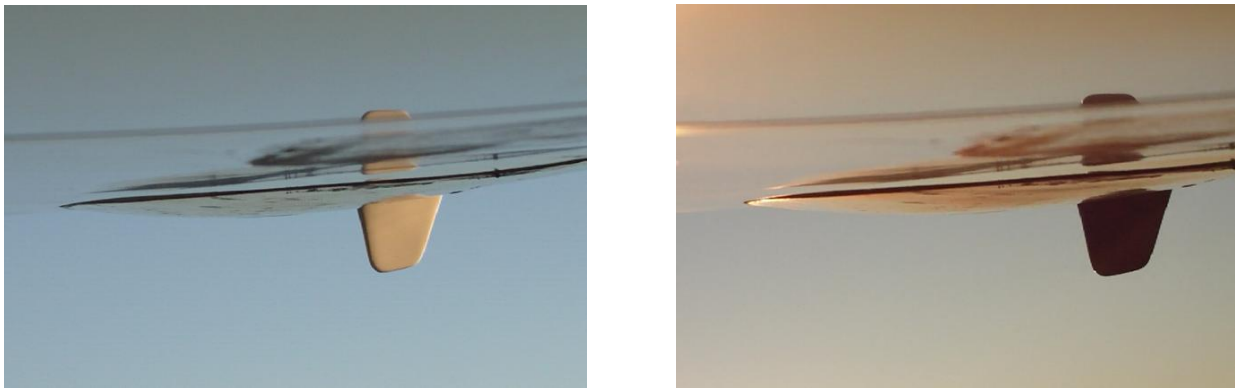

Figure 6, New Carbon Doors In-flight