In the September 2005 issue of *Flying*, Richard Collins wrote an excellent article on the Columbia 400. It is not easy to capture the essence of this unique aircraft in the few words and pages he is allowed. Nevertheless, Mr. Collins did a wonderful job.

The description in the article is completely accurate but gives the impression that the aircraft is a paradox on several levels. The first is that the Columbia 400 is faster than the majority of twin engine piston powered aircraft and even a few turbine-powered aircraft. The second is that this fixed gear aircraft can be more efficient than most retractable gear designs. And the final paradox, the one that I would like to address, is that the Columbia 400, a Utility Category certified aircraft, appears to have a mysteriously restricted operational speed envelope characteristic of a less capable aircraft.

The first two are not paradoxes at all and as Mr. Collins points out, they are the result of Columbia Aircraft Manufacturing's unrelenting attention to detail in drag management and efficiency. In Bend, Oregon the dirtiest four letter word in our vocabulary is "DRAG."

The third apparent paradox requires a more in depth discussion of aerodynamics and certification issues for the reader to completely understand the many issues beneath the surface of the article.

To begin, we know that the root of all certified aircraft limitations is the Federal Aviation Regulations (FAR's). The FAR's represent the FAA guidelines to design, test and certify safe consumer aircraft that meet minimum performance and strength standards.

Both the Columbia 350 and 400 are certified under the stringent FAR 23 rules for Utility category aircraft. Utility category aircraft have a greater static and fatigue strength capability than Normal category aircraft. Utility category requirements specify that an airframe withstand +4.4 / -1.76 g's versus Normal category at only +3.8 / -1.52 g's. Thus, an aircraft designed and tested to meet the Utility category requirements at maximum gross weight, as defined in the Code of Federal Regulations 14 CFR Part 23, is 30% stronger than a Normal category aircraft. The additional strength of the Columbia design allows the aircraft to have a very high initial Vne, Vno and Dive airspeed (V_{Dive}).

Mr. Collins states the Columbia 400 is a unique aircraft on many levels, not the least of which I would like to highlight is its speed envelope. With a landing configuration stall speed (V_{so}) of 60 knots and a demonstrated Dive Speed (V_{Dive}) of 262 knots, the Columbia 400 has a broader speed envelope than any similar aircraft ever certified.

Based on the aforementioned speeds, certification rules require that FAR23.321 paragraph C be applied to the Flight Loads and Design Airspeeds calculations. (FAR23.333 & .335 respectively) "Flight Loads": FAR23.321 General, (C) states - "When significant, the effects of compressibility must be taken into account." The more commonly recognized name for compressibility is Mach number effects. Now we begin to see the apparent paradox. In the Columbia 400, we have a piston-powered, single-engine general aviation aircraft that is so fast the FAR's require the calculation and compensation for Mach airspeed effects when determining design airspeeds.

To better illustrate this issue we need to look at the airspeeds and Mach numbers of a comparable aircraft in the same approximate speed regime. The Mooney M20M Bravo, an airplane design that I have some familiarity with from my tenure at the company, is acknowledged by the industry as a very strong, very fast and safe Normal category aircraft.

Comparing the airspeed limitation of the two aircraft:

Airspeed Limitations @ 12,000 ft

Mooney Bravo

V_{NE} – 195 / 195 (KCAS/KIAS)
V_{NO} – 174/174
$V_{A\ (3200\#)}$ – 123/123
V_{FE} – 109/110
V_{Dive} – 221/222

Columbia 400

V_{NE} – 235 / 230 (KCAS/KIAS)
V_{NO} – 185/181
$V_{A\ (3200\#)}$ – 152/148
V_{FE} – 120/117
V_{Dive} – 262/256

Based on this comparison one would conclude that the Columbia, by virtue of its much higher airspeed limitations, is a stronger and more capable aircraft - and you would be correct. The limitation deltas in this chart are primarily due to the higher load factor levels defined by Utility and Normal category certification under FAR23 and designed into the Columbia 400.

To illustrate the observation / paradox that Mr. Collins made see the chart below:

Airspeed Limitations @ 25,000 ft

Mooney Bravo

V_{NE} – 195 / 195 (KCAS/KIAS)
V_{NO} – 174/174
$V_{A\ (3200\#)}$ – 123/123
V_{FE} – 109/110
V_{Dive} – 221/222

Columbia 400

V_{NE} – 178 / 174 (KCAS/KIAS)
V_{NO} – 140 / 137
$V_{A\ (3200\#)}$ – 152/148
V_{FE} – 120/117
V_{Dive} – 262/256

Why the dramatic differences between the two charts? For an explanation we have to go back to FAR23.321(C) and Mach effects. The edge of the envelope that I mentioned to Mr. Collins in our pre-publication conversation was not the commonly discussed aircraft operational envelope, but in this case, the Mach envelope. The

Columbia speeds push the aircraft to the other side of the line when it comes to taking into account compressibility effects in the FAR's on airspeed limitations. The readily accepted FAA method for compensating for compressibility effects in FAR23 certification is to hold the Mach number constant from the Vn diagram altitude, (12,000ft), to the maximum certification altitude. In the case of the Columbia these mach numbers are:

Columbia 400

V_{NE} – .45 Mach
V_{NO} – .35
$V_{A\ (3200\#)}$ – 31
V_{FE} – .25
V_{Dive} – .50

As the indicated airspeed for the speed of sound decreases with altitude, so do the airspeed limitations for the Columbia 400. The rate of indicated airspeed decrease with altitude are the numbers that Mr. Collins quotes in his article and that are on the instrument panel placard - 3.5 kts / 1,000 ft for V_{NO} and 4.4 kts / 1,000 ft for V_{NE}. This being said, I must point out that this represents an extremely conservative method for compensating for the minor increase in air loads that are present due to the compressibility of the air in free flight at these velocities.

Other OEM's (e.g., Mooney Bravo , New Piper Malibu and Meridian, and Cirrus Design SR20 and 22) only list one set of speeds on their Type Certificate Data Sheets (TCDS), indicating that it was not necessary to compensate for compressibility.

Was Columbia Aircraft Manufacturing too conservative or unlucky that our higher performance pushed us into this compensation during certification? Perhaps, but as is often the case with the constraints of time and money, to develop and prove to the FAA a more elegant approach to compensating for this phenomena was not possible. We have found that the FAA is a very reasonable and logical organization when it comes to understanding that a rule intended for high altitude, high speed jets cruising at .75 and above Mach numbers does not serve the same purpose on aircraft like the Columbia 400. We have it on our docket to review this issue with the Seattle (Aircraft Certification Office) ACO and propose a more realistic method of compliance that reflects the true intent of the rule.

For now, it will remain an unusual feature of our aircraft and somewhat of a boasting point that Columbia aircraft are so fast that Mach effects had to be compensated in order to certify the aircraft.