Wing loading, Stall and the PC12

By John Morris

In March 2010 the FAA sent out Information for **O**perators (InFO) 10001, Safety concerns of amateur-built experimental Lancair and other amateur built airplanes possessing high wing loading and stall speeds in excess of 61 knots, (**http://www.faa.gov/other_visit/aviation_industry/airline_operators/airline_safety/info**). Specifically, this InFO addresses multiple fatal accidents and the pilot's possible lack of awareness of the slow-flight and stall characteristics of these types of high performance aircraft. I was curious about the correlation between wing loading and stall, since it referenced stall speeds greater than 61 knots (PC12 came to mind of course). But aircraft like the Lancair are smaller and lighter. Why? Not enough information. I have seen a wing loading number in the PC12 POH General specifications but never gave it any more consideration, until now. So I thought I would investigate this InFO and any possible relationship with the PC12, since the noted Lancair has a similar stall number but much lower gross weight.

First, what is the definition of **Wing Loading**? It is the loaded weight of the aircraft divided by the area[i] of the wing. Wing loading is a useful measure of the general manuvering performance of an aircraft. Wings generate lift via the motion of air over the wing surface. Larger wings move more air, so an aircraft with a large wing area relative to its mass (i.e., low wing loading) will have more lift at any given speed. Therefore, an aircraft with lower wing loading will be able to take-off and land at a lower speed (or be able to take off with a greater load). It will also be able to turn faster.

Aircraft with low wing loading tend to have superior sustained turn performance because they can generate more lift for a given quantity of engine thrust. The immediate bank angle an aircraft can achieve before drag seriously bleeds off airspeed is known as its instantanious turn performance. As the bank angle increases so does the g-force applied to the aircraft. This has the effect of increasing the wing loading and also the stalling speed. An aircraft with a small, highly loaded wing may have superior instantaneous turn performance, but poor sustained turn performance. It reacts quickly to control input, but its ability to sustain a tight turn is limited.

Speaking of g-force, it should be noted that ***Load Factor*** is lift not just generated by the aircraft's wing, but is the ratio of the lift generated by the wing, by the fuselage and by the tailplane. Measured as "g" it is the component perpendicular to the airflow of the sum of all aerodynamic forces acting on the aircraft. Part 23.337 sets limits for manuevering load factors but amateur (kit) built aircraft are not required to comply with Part 23.

Wing loading has an effect on an aircraft's climb rate. A lighter loaded wing will have a superior rate of climb compared to a heavier loaded wing, since less airspeed is required to generate the additional lift to increase altitude. A lightly loaded wing has a more efficient cruising performance because less thrust is required to maintain lift for level flight.

So far it appears that low wing loading is all good. But alas, nothing is *that* good! It also affects gust response, the degree to which the aircraft is affected by turbulence and variations in air density. A small wing has less area on which a gust can act, both of which serve to smooth the ride. A further complication with wing loading is that it is difficult to substantially alter the wing area of an existing aircraft design, except maybe for winglets. As aircraft are developed they are prone to "*weight growth*" -- the addition of equipment and features that substantially increase the operating mass of the aircraft. An aircraft whose wing loading is moderate in its original design may end up with very high wing loading as new equipment is added (see Table 1). Although engines can be replaced or upgraded for additional thrust, the effects on turning and take-off performance resulting from higher wing loading are not so easily reconciled. Of course the PC12 has an edge regarding weight growth and wing area, called Fowler Flaps. They increase the wing area while decreasing the wing loading which *still* allows for slower takeoff and landing speeds even with the higher weights since the PC12/41.

So how do you determine if an aircraft qualifies as high wing loaded or low wing loaded? See examples in Table 1

Table 1

	Gross Weight-T/O	Wing Area-Sq Ft	Wing Loading-Lbs/Sq Ft	Wing Span-Feet	Stall-Clean/Dirty-Knots
PC12/41	9039 Lbs	277.8*	32.5	53.3	86/59
PC12/45	9921 Lbs	277.8*	35.7	53.3	91/64
PC12/47/NG	10450 Lbs	277.8*	37.6	53.4	93/67
Lancair IV-P	3550 Lbs	98	36.2	35.5	NA/65
Lancair ES-P	3550 Lbs	140	25.4	35.5	NA/61
TBM 700C/850	7394 Lbs	194	38.1	42	81/65
C172 RG	2650 Lbs	174	15.2	36	54/50
Schweizer SGS 2-32	1340 Lbs	180	7.4	57	40

Weights are maximum gross weight for takeoff, standard day, sea level

*** Flower Flaps retracted. Additional approximate 36 Sq/Ft to wing area when extended**

The Schweizer SGS 2-32 is a 3-place glider with a high gross weight

There does not appear to be a"ready" answer but a little research can help. Weights but especially wing area define loading. The loading numbers from Table 1 for the Lancair show that. The FAA InFO is addressing non-Part 23 certified, stall related accidents, with high wing loading aircraft as a possible contributer. As we should already know stall is a function of critical angle-of-attack for a particular type of wing. Low(er) wing loading allows for slower takeoff and landing speeds and more sustained manuerving while turning. But without sufficient thrust to maintain a level turn, increased angle-of-attack must be applied which will increases load factor "g" force thus increasing loading and stall onset.

So which is better / safer? Better is a preference of performance, usually speed. Generally if you want to get there faster there will probably be a trade-off regarding the wing, either span, area or both. That of course will affect gross weight considerations. Safer is regulation of design criteria

(FAA) or proper understanding of design (kit built). Either type can be safe and enjoyable to fly but as always you have to know and abide by the performance limits. And sometimes the limits are not visible to us, such as high wing-loading and stall.

Whether or not the aircraft is certified by FAR's, continuing education via all of the available means is the best way to stay safe.

"A Safe Pilot is Always Learning"

John Morris-ACFT Services
www.acftservices.com

John Morris – Formerly with Simcom Training Centers-Orlando for 14 years with 1999 being the first year teaching the PC12 followed by PC12 Program Coordinator from 2000 until resigning in 2007 to start ACFT Services

ACFT Services provides training ONLY for all PC12's, no other aircraft.

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[i] Wing area is defined as the area from leading edge to trailing edge, wing tip to wing tip, but not the total surface area [top/bottom] of the wing, measured as a planform area only and is almost half of the total surface.