NASA Tests
The VariEze

In Search Of A Cure For The Stall/Spin Syndrome

On July 27, 1901 Wilbur Wright made history. On his tenth glide of the day he became the first person to enter a full blown stall in a heavier-than-air aircraft at “killing height” and live to tell about it. “Killing height” is high enough to kill, too low to recover. A few days later, on August 9, Wilbur racked up still another “first” — the initial attempt to turn an aircraft with aerodynamic control systems only — as opposed to the weight shift methods employed by his predecessors. Unfortunately, the 1901 glider in which he was attempting his turn was not equipped with a means to counter what we now refer to as adverse yaw. Fortunately, the result was no worse than still another mouthful of the sands of Kitty Hawk. Lately, Wilbur had been tasting a lot of it.

These were truly momentous events in the history of aviation. Men had been stalling their flying machines before the Wrights began flying ... and they had been dying for their efforts. Lilienthal, Pilcher and others had paid the price of aeronautical progress in full measure. Finally, however, the Wrights had solved the problem ... at least within the narrow performance envelope in which they were experimenting at the time. They fitted their glider with a forward elevator because, as Orville would later write, ... it absolutely prevented a nose dive such as that in which Lilienthal and many others have met their deaths.” In their lighter loaded gliders, the forward or canard surface saved their hides on a number of occasions as they taught themselves to fly ... gently “parachuting” them down when, for example, they got themselves into a nose high, virtually zero airspeed situation and then encountered a strong gust ... !

And although they left Kitty Hawk that year so thoroughly discouraged by the adverse yaw phenomenon that Wilbur dolefully predicted it might be “a thousand years” before man learned to fly, the two had it licked within a year. By installing a movable rudder and tying it into the cables that warped the wings, they were able to make coordinated turns. With this modification of their 1902 glider, Wilbur and Orville believed they had, at last, solved the control problems of manned flight. The next year they would advance to powered flight ... and historical immortality.

So, what happened to this dearly won knowledge in the years that have followed? If, indeed, the Wright brothers had developed an aircraft configuration and control system ... in 1901 ... with which a properly trained, prudent pilot could reasonably expect to maneuver without fear of stalling and spinning in ... where did we subsequently go wrong? Throughout the short history of aviation, the stall/spin accident has been and continues to this day to be the number one killer of pilots and their passengers. (It’s true that FAA and the National Transportation Safety Board list ‘weather’ as a catchall cause for most of today’s fatal accidents, but that’s just an excuse with semantics — read the accident reports and in most cases you’ll find that no matter what caused the pilot to lose control of his aircraft, in the tragic end it was a stall/spin that did him in.)

To a great extent, “what happened” was a direct result of the Wright patents. Other configurations and other control systems were developed in order to get around them ... then Wilbur died and Orville gradually moved away from aerodynamic design ... then came World War I and the need to standardize machines so great numbers of pilots could be trained quickly and efficiently ... so that in a little over a decade and a half after the miracle at Kitty Hawk, much of what the Wrights had learned and developed there was forgotten or, at best, considered to be obsolete. Down through the years, conventional wisdom has maintained that the early Wright configurations were simply replaced by better, more advanced ones.

Now, many are beginning to wonder ... including the National Aeronautics and Space Administration. A few years ago NASA’s Langley Research Center in Hampton, Virginia obtained appropriations to begin a study of the stall/spin problems of general aviation aircraft...

Such a program for military aircraft had been going on since the 1930s, but priorities being what they were, little had been done on modern lightplanes. Initially, the new program concentrated on existing aircraft and a Beech/American/Grumman AA-1 became the workhorse. It sprouted a whole series of tail configurations, wing cuffs, strakes, dorsal and ventral fins, etc., etc. Dynamically similar models were tested in the spin tunnel, free flight radio control models were tested in the spin tunnel, free flight radio control models were put through the same tests as the real airplane, etc. A great deal was learned and, if utilized by manufacturers, will make lightplanes of the future safer than ever before.

More recently, however, the Langley studies have moved on to a different phase — a study of new and or novel configurations that might prove inherently more stall and spin resistant than conventional (tractor engined, high or low wing, tail in the rear) layouts. One configuration with promise ... shades of Wilbur and Orville ... was the canard. The foremost proponent today (or probably ever) of the canard configuration is, of course, Burt Rutan, so he was contacted and arrangements were eventually made to test the VariEze in Langley’s wind tunnels.

Recently SPORTSMAN PILOT visited the Langley Research Center to learn firsthand how the tests were going ... and to see what was planned for the future. Arrangements had been made to meet with Joe Chambers and Joe Johnson, the NASA scientists most closely associated with the project. Those of you who attend the forums at Oshkosh are familiar with Joe Chambers — he has lectured there on numerous occasions and is an enthusiastic and very knowledgeable student of what is currently taking place in the homebuilt movement.

We were given a thorough briefing on the entire stall/spin program at Langley, including a proper perspective on the VariEze testing. It is an important part of their work, certainly, but is only one of many efforts to make lightplanes safer and more efficient.

The first thing impressed upon us was that some of the test work at Langley is unique to that facility — it’s the only place in the world where certain types of experimentation are done.

Spin testing starts, appropriately enough, in a spin tunnel ... in effect, a vertical wind tunnel. Models are thrown into a rising column of air much like a kid would flip a Frisbee. The force of the air stream sus...
pends the model right out in front of the researcher so that he is able to observe it closely for hours on end, if need be. Flipped into the tunnel in a spinning motion, the models spin like crazy in their all-but-frictionless state of suspension. These are "developed spins"; the type an aircraft would be in well past what is required for FAA certification — spins some full sized aircraft aren't even capable of attaining... and the type many could not recover from if they did. Control surfaces on the models are tripped by radio control to try various recovery techniques, etc.

The spin tunnel is also used to do what Langley calls "rotary balance testing". Here a special model is used that is fully strain gauged so that air loads on every part of the aircraft can be measured. The information is fed into a computer programmed to tell researchers what effect any and every part of the airframe is having on the spin — what parts are causing it or contributing to it and what parts aren't. It was here that it was determined that a VariEze, properly loaded, is virtually impossible to spin.

A summary of some of the most important data from the rotary balance tests is shown in the two accompanying graphs. Here the yaw moment (negative for anti-spin yaw) is plotted against a parameter representing the rate of rotation of the spin. Note that the VariEze was damped (anti-spin yaw) for all angles of attack values, including the flat spin (90 degrees). The conventional airplane shows a steep spin mode at 40 degrees angle-of-attack and a flat mode at 80 degrees.

The reader should carefully note that this plot has nothing to do with departures which can result at stall, only whether the airplane will remain in a developed spin. For example, it has been shown that a VariEze can be forced into a violent departure with excessive angle-of-attack if a vertical fin (winglet) is stalled. However, it cannot remain trapped in a developed spin as the conventional aircraft can.

The "free flight" wind tunnel is a misnomer of sorts. The models tested here are not "free flight" in the sense of the turn-em-loose-and-let-em-go jobs the model airplane people do. These NASA models have an umbilical cord attached to them containing electrical wiring, a compressed air line to drive the propeller, etc. It hangs loose enough that the model can be flown freely within the confines of the tunnel — thus the name. The really fascinating aspect of this type of testing is that the models are flown by several different pilots... simultaneously! One manipulates the elevator control, another the ailerons, another the rudder! That's got to be a weird experience... and one requiring some very unique acquired skills. Langley is the only place this is done. It was in this "free flight" tunnel that one of the potential problems of the VariEze design was resolved. In tests at high angles of attack (16°), low airspeed and with extreme aft C.G., a rather pronounced rolling oscillation (wing rocking) occurred.

"This is typical of swept wings," Joe Johnson told us, "but in this case made worse by the upwash outboard of the canard."

Experimentation determined that dropped leading edge cuffs of a particular shape and dimension would cure the problem and this information was immediately transmitted to Burt Rutan. The phenomenon had been observed in N4EZ, the prototype 0-200 powered VariEze, but only at aft C.G. and only occasionally. It was showing up worse with some of the homebuilder's airplanes, presumably due to various building tolerances. Burt wanted the design to be completely free of stall departure, so he was very receptive to NASA's suggestion for a solution. Within a very short time he had built and installed a set of 38 inch long cuffs, and had his brother, Dick, do a thorough test flight evaluation of them. Their findings confirmed the NASA wind tunnel tests, so Burt promptly got the work out to his builders, strongly recommending that they add cuffs. Actual experience showed that homebuilder's VariEzes previously susceptible to stall departures were stall proof with the cuffs.

Both Chambers and Johnson were extremely proud of the fact that they had been able to make this contribution to aviation safety... and were absolutely amazed to see their work put into actual use so rapidly. Too often, NASA findings go no further than a written report. Liability concerns and certification costs often prevent lightplane manufacturers from taking advantage of what is learned at Langley and other NASA research facilities.

The final stop in the wind tunnel series is Langley's historic old full scale tunnel. As the name implies, full size airplanes are tested here.

NASA is now changing configuration of the VariEze to see if they can improve performance, including lowering canard (left photo). (NASA Photo)
The thing is a monster — with a mouth 30 feet high and 60 feet across! Built in 1931, it has the distinction of having been in continuous service longer than any other NASA wind tunnel. The hallways outside the tunnel area are lined with photographs of aircraft that have been tested in the big son-of-a-gun and, suffice it to say, the history of aviation — especially military aviation — literally passes before you as you walk by them.

From the wind tunnels, NASA researchers then go outdoors where they fly radio controlled models — with off-the-shelf model airplane radio components — and, finally, the actual aircraft. Spin testing of aircraft is done across Chesapeake Bay at the Wallops Island facility. A quick ripple through some of the spin test reports reveals some obviously hairy experiences... like "Spin became flat. Recovery controls (rudder against, stick forward, ailerons neutral) ineffective. Used recovery parachute." No doubt the event, itself, was just a tad more exciting than the write-up!

But so much for the big picture. Just what, we wanted to know, had been learned about the VariEze? The bottom line came in this comment: "Rotary balance tests in the spin tunnel show the cuffed VariEze is virtually impossible to spin... it's a radical improvement over most existing type airplanes."

The VariEze is to be the basis of an extensive research program on the canard configuration. An extremely accurate full-size VariEze has been built in Langley's model shop (a story in itself) and is currently undergoing testing in the full scale tunnel. Powered by a powerful electric motor and heavily instrumented, it will provide a bank of information that will become the baseline for future experimentation.

Once this is done, NASA will enter still another phase of tests. They will begin to modify the VariEze to determine if they can improve its aerodynamic efficiency. They have already experimented with different canard positions (high, low) and airfoils — and have much more on the way.

We later had a tour of the model shop and saw a Long-EZ wind tunnel model under construction... and were told that a full scale Defiant wind tunnel model was to be built. The Defiant will become the baseline for experimentation aimed at improving the safety record of light twins.

Joe Chambers summed up the day as follows: "The VariEze was our first toe in the water in terms of looking at canard airplanes. It has the potential of being an aerodynamically stall proof vehicle... and this is why NASA is interested in it. We think the canard is the airplane of the 1990s."

NASA's general aviation stall/spin program and its aerodynamic improvement program will be in progress for years to come... providing Congress continues to fund the work. It is of critical importance to general aviation that these programs continue and perhaps be expanded. Every reader of SPORTSMAN PILOT is urged to take every opportunity that presents itself to inform your Congressmen and Senators of what is going on at NASA Langley and insist that funding levels be maintained, if not increased.

A final personal note. Joe Chambers, John Johnson, Wayne Oakley of the model shop and others we met at Langley Research Center have been at their work there for many years — Johnson for over 30 years! I've never talked to people more genuinely enthusiastic about their work.

If ever our tax money is being spent for a worthwhile purpose by highly competent, highly motivated scientists, then this is it. We were also in other areas at Langley during our visit and found the same attitude there... but that will have to wait for a future issue.

Jack Cox
Somewhat ironic is the fact that two similarly configured canards have been tested in Langley's full scale tunnel . . . 40 years apart! This is a very early version of the Curtiss Ascender. The VariEze is, aerodynamically, a far more sophisticated (and successful) design.

(NASA Photo)

Joe Chambers, left, and Joe Johnson, NASA scientists testing the VariEze.

Another Burt Rutan design being tested by NASA is the Predator, an agricultural plane that would accomplish the same work as conventional designs on half the power. It also has better slow speed turn characteristics. Burt was commissioned to do the design by an unnamed group.

(NASA Photo)