THE WORLD ACCORDING TO KASPER

Extended aerodynamics, judo and tumbling pigeons.

BY THOMAS A. HORNE

And this," he says, "this is my prototype." Solemnly, a photograph is slid across the table. It is a battered picture of some kind of shore bird, spreading its wings, about to land. I think he is kidding. He is not.

"You see, the wings, especially at the tips, are swept up at the trailing edge. This is what gives the bird so much lift at such a high angle of attack and which allows him to land at zero airspeed." Witold Kasper, eccentric aerodynamicist and controversial sailplane designer, is holding court. Kasper's thick East European accent adds to the ambience of mystery surrounding his creations and theories.

Kasper was born in 1908 in Krákow, Poland. By 1935, he had soloed in a glider he can remember only as the Frog. The Frog was a heavy, biplane-type glider with a truss-like fuselage and a huge skid. In spite of its weight, Kasper once was able to soar the Frog for five-and-a-half hours, and his skill in gliding was such that he was a member of the first Polish Olympic gliding team, formed in 1937. That same year, he joined the Polish air force and had his first crash.

It was a pleasure flight. Kasper wanted to attend a family reunion 150 miles away, and he wanted to fly a glider instead of take the train. On approach he deployed the spoilers, the sailplane stalled, then sideslipped to the ground from an altitude of 300 feet. The glider was destroyed, Kasper escaped with minor injuries, and he reached a turning point in his life.

It is only natural for any pilot who crashes to relive the details to help him understand just what went wrong. Kasper was a student of aerodynamics at the University of Lwów, and the problem of stalling intrigued him. Thus began a sort of obsession with finding a stall-proof design. Kasper looked to nature for his answer and began studying bird aerodynamics.

"I tell you that in Europe there is a kind of pigeon—I know a lot about pigeons because I raised them as a hobby—that they call the 'tumbling' pigeon. He tumbles for fun. Pak, pak, pak—and out. He can control it, and he never stalls. No bird stalls. If you look at high-speed motion pictures of a bird landing, you will see that the bird does four things in preparation for landing: He selects a landing spot; he dives toward it; he flares to an angle of attack of about 70 degrees; and then he hovers for a moment and settles gently to his selected spot. The first two things any airplane can do. But the last two

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Witold Kasper and his legendary sailplane, the BKB-1. Conceived in the early 1950s, completed in 1957 and flown until 1971 in numerous air shows, the BKB could do some pretty remarkable things. Kasper could make it descend at a slow speed (13 knots) and at a high angle of attack with the help of its vortex-augmented lift, a result of the wing's reflex profile. He also safely could tumble the glider at will (gasp), which he made a habit of doing in his air shows.

things are impossible for an airplane."

Kasper's study and refinement of bird aerodynamics, or what he calls extended aerodynamics, would have to wait. In September 1939, the Nazis invaded Poland and the Second World War began. Kasper, who had just received his degree in aeronautical engineering, served as a fighter pilot in a Pezetel 7-L for the brief duration of the Polish invasion. After the Nazi occupation, he fled Poland and worked as a flight instructor in Rumania.

The Russians had taken his wife prisoner and sent her to Siberia. While he was working in Rumania, the Russians approached him with an offer to work as an aeronautical engineer. He said he would, if they reunited him with his wife. But they told him that she had died. Eighteen years later, Kasper learned from a fellow escaped-Pole that his wife was alive and living in London. She sailed to Montreal, where they finally were reunited.

At the end of World War II, he had returned to Poland, but was forced to escape to Sweden in 1949 because he would not join the communist party. The Polish state police followed him, a kidnapping in mind.

"But those guys, they were dumb. They contacted my friend to find out my habits and set up the spot where the kidnapping would take place. So I knew all about it, and I also told the Swedish police." Kasper bicycled to the kidnapping spot, while the Swedish police waited in a nearby building.

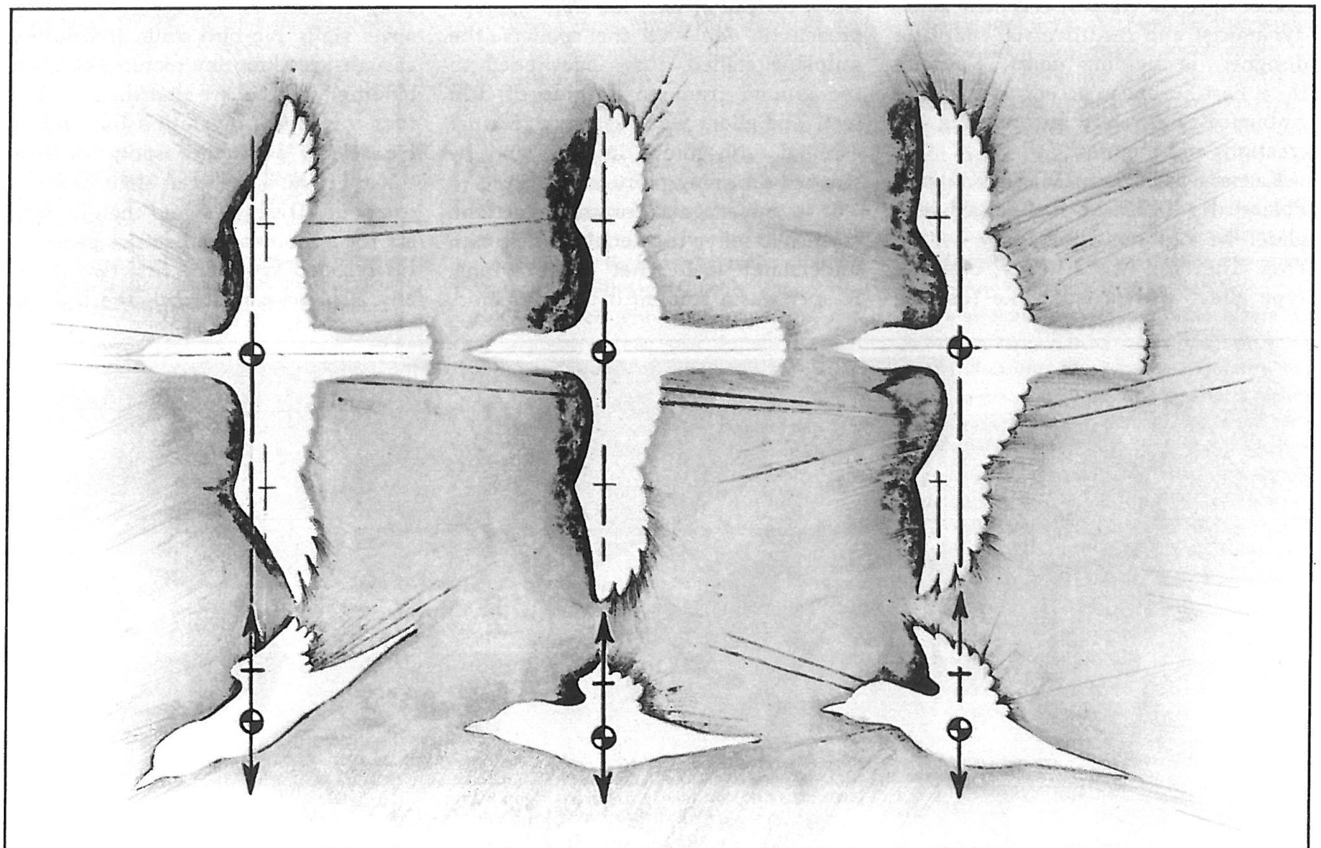
"I went there because I wanted to teach them a lesson." What the Polish state police did not know was that Kasper was an expert in the art of judo. There were three conspirators. Kasper broke three ribs on one, broke the jaw of another and dislocated the hand of the third as he threw him into a nearby pond. The trio spent three weeks in a hospital and was sent back to Poland.

"I had pity on them. I could have done much worse damage."

In 1950, Kasper moved to Canada, where he worked as an aeronautical engineer with Canadair. Shortly thereafter, Boeing hired him, and he moved to the Seattle area. He became a U.S. citizen in 1963. While at Boeing, Kasper was a central figure in the design of the flap and spoiler systems used in the 727 and the 737. High lift at low speeds is Kasper's specialty.

But back to the birds. By 1950, Kasper had figured out what he wanted for his ideal sailplane, based on what he had derived from bird study. The conventional cross-tail (cruciform tail) was ruled out. Interference and form drag from the cross-tail contribute to one third of an airplane's total drag; Kasper knew this from wind-tunnel testing. The problems of torsional bending due to tail loads also concerned him. Besides, what bird has a cross-tail?

Kasper's solution to the problem of pitch stability in a flying wing was to create a wing with a reflex profile. When viewed in cross-section, the reflex profile makes a subtly sinuous shape, the trailing edge swept upwards. This kind of wing generates lift in both



Instead of using tail-down forces to control pitch as an airplane does, the bird shifts its center of lift by moving its wings forward and back. This gives the bird pitch control, regardless of forward speed, and enables it to fly at far greater angles of attack than our usual 20-degree-or-so stall angle. It is a system that uses total lift as a control force. Oversensitive? No, because the wing is heavier at the root than it is at the tip, and the lift is greater at the tip due to the configuration of the bird's wing. The center of gravity follows the center of lift at a slow rate, making pitch response smooth.

ILLUSTRATION BY NANCY MACTIRE

directions: The curve at the fore end of the reflex wing generates lift upwards, like a conventional wing, and the curve at the aft end of the wing—the upswept trailing edge—generates lift downwards, like a conventional tail.

The total lift of the wing gave Kasper his pitch stability. Swept-back wings, washout and the addition of small triangular stabilizers at the wing tips further aided the pitch-stability characteristics of the Kasper wing. Having a reflex profile also meant that the center of lift would not travel chordwise as the airplane's angle of attack was changed.

Elevons and tip rudders gave Kasper's wing its pitching and turning power. As the stick was moved fore and aft, changing the profile of the wing tip, the center of lift shifted outboard and inboard along the wings. Because of sweep-back, this translated into rearward and foreward displacement—pitching.

For turns, one elevon would go down and the other up, creating differential lift. Or the tip rudders could be opened, or a combination of the two actions. Adverse yaw was defeated by the use of an ingenious set of anti-adverse-yaw tabs, part of the elevons. Whenever an elevon was deployed to initiate a turn, the anti-adverse-yaw tab would rise from the top of the elevon. Their function was to increase the action of the up elevon and decrease the action of the down elevon.

Directional stability? Sweep-back of the wings and end plates toed-in four degrees provided that. Roll stability? Dihedral and outwardly canted end plates and tip rudders answered that.

"What the aerodynamicists call 'stability' is not really stability at all. They call it 'dynamic stability,' which is a contradiction of terms. Dynamic means that something is moving. Stable means it is not moving. So, okay, this dynamic stability is a form of stability, but it is an *oscillating* stability. Before the airplane returns to its original position, it oscillates. That is why we have such things as autopilots and yaw-dampers. It is oscillating stability that wears a pilot out. My airplanes are truly stable because they use what I call the V-stability," Kasper continues.

"Look here," and he starts drawing. "Here is the V-stability in pitch." And he draws two wing cross-sections, one representing the inboard section, one the outboard. Lines connecting the trailing edges to the leading edges are made. As a result of washout and the difference in the wing profiles, the extensions of these lines meet in the form of a V in front of the wing.

The bird configures its wing like so for landing, causing vortex lift on top of the wing. Angle of attack—about 70 degrees; forward speed—zero. As the vortex lift decays, the bird settles to its landing.

"Now, see here." It is a top view of the Kasper wing, showing the toe-in of the end plates. Again, the extensions of imaginary lines form a V, this time representing directional stability.

"And here." A front view, showing how the end plates are canted. Once again, the V appears, this time below the airplane, showing roll stability.

"This V-stability is true stability. One movement in any axis, and the ship returns to normal. And in pitch the center of pressure [center of lift] will always seek out the center of gravity immediately." Then he leans forward. "But the main thing is that this V-stability does not require any forward airspeed to do what it does. I knew this in theory."

Kasper started work on his first sailplane, the all-wood BKB-1, in 1951. By 1957, the BKB was completed. In 1963, it was moved from Montreal to Seattle, and he began accumulating flying time, some of it at air shows.

While flight testing the BKB, Kasper noticed something unusual. He could not make the BKB spin. He tried holding aft stick pressure and crossing the controls using the tip rudders and elevons against each other; but all the sailplane would do was go into a tight spiral for one-and-a-half turns, then shoot up vertically, if he continued to hold back pressure.

"That is when I started thinking that I had an airplane that was not stalling properly. So I attached tufts of yarn to the wing and repeated the maneuver. Then I could see that, when I started to get very slow, the tufts on the wing started to move forward."

Kasper plugs in a super-8 movie projector and shows films of his tufted wing. At 50 mph (43 knots), all of the strands of yarn are plastered to the top of the wing, moving aft and indicating what everyone would agree is a normal flight condition. At about 30 mph (26 knots) some of the tufts on the leading edge begin to flop around and the ones at the trailing edge start to flip forward. From 30 on down to 15 (13 knots), all of the trailing-edge tufts are plastered to the wing, heading opposite to the direction of flight. During this whole procedure, the sailplane is mushing, but it does not stall.

Many people have seen the film, and some have rejected its authenticity. "It's in a tailslide," was the most frequent accusation. But I saw no evidence of anything other than a level flight attitude with only slight changes in apparent angle of attack.

Through this tufted-wing study, Kasper had discovered "vortex lift," the key to a stall-proof airplane and the reason birds can make a controlled landing at zero forward airspeed.

"Except for the gooney bird, which is the only bird that lands like an airplane. He flies it on."

At about this time—summer 1967—he learned that at 40 mph (35 knots), the BKB would mush at a sink rate of 500 fpm. When the angle of attack was raised, the lift coefficient, because of the more pronounced effects of vortex lift, actually increased. The sink rate at 15 mph (13 knots) decreased to 200 fpm.

In this slow-flight regime, Kasper could make the BKB's speed decrease no lower than 15 mph (13 knots), even with full aft stick. It never stalled during any of these tests, but it was capable of a dynamic stall when the stick was moved back abruptly—and of oth-

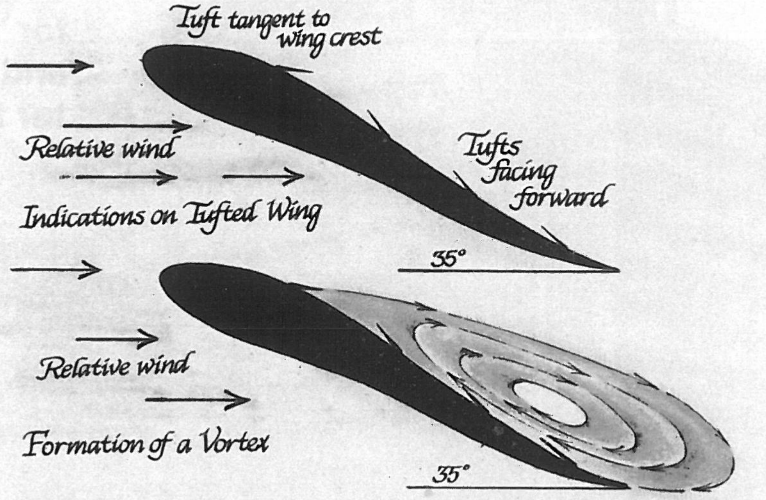
continued

er feats. But because of Kasper's V-stability, the sailplane would return to a normal flight attitude after only one oscillation, hands off. And, according to reports, all the controls were effective in the stall regime. There was no stall break as such. The BKB would only mush at a higher rate.

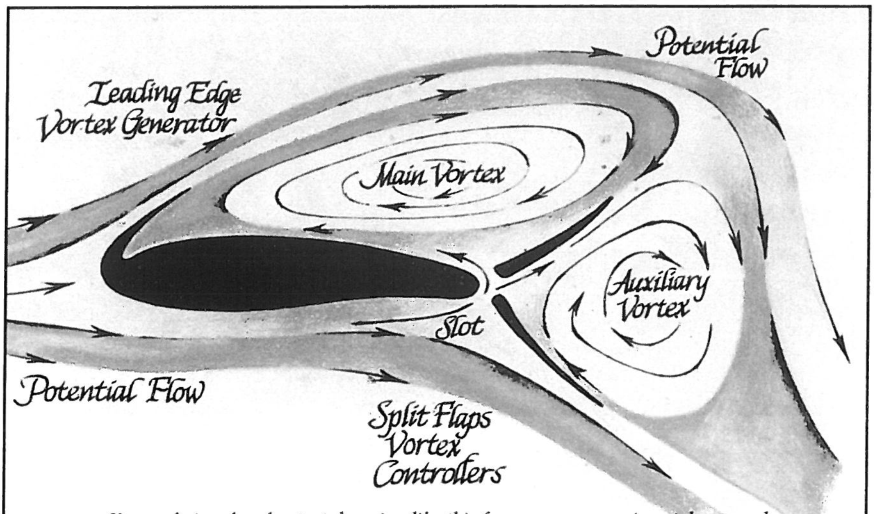
Vortex lift can only exist with a reflex-profile wing at high angles of attack. Then the vortex—a swirling mass of air above the wing's top surface—becomes fully developed. Vortex lift is a simple, yet complicated, phenomenon that even most aerodynamicists find hard to grasp, and it escapes the average pilot's understanding.

Kasper's theories demand that you discard a lot of conventional notions about aerodynamics, and that is why he often has encountered resistance to his ideas from the establishment. A new idea is a fragile thing, and the temptation to label radical new ideas as crackpot ramblings is frequently overpowering.

In the Kasperian aerodynamic world, lift is generated whenever air flows over a curved surface. Kasper's reflex profile allows air coming from beneath the airplane's wings (from the front and rear) to meet, swirl, form a self-feeding vortex and then produce a lifting action on the wing, similar to the way a parachute works. In this mushing, vortex configuration, the relative wind is coming from below; so Kasper



Note the reflex (the upswept trailing edge) profile in the formation of a vortex on the BKB wing. The Kasperwing ultralight's wing is thinner, enabling a more drastic curvature.



Kasper designed and patented a wing like this for use on an experimental, powered airplane. The leading and trailing edge devices create very high pressure differences between the bottom and top surfaces of the wing, permitting a vortex to form when the airplane is level. The Kasper flaps trap the vortices, making them more effective.

regularly speaks of angles of attack of 90 to 110 degrees.

Because of the properties of a vortex, the air is densest in the core of the vortex. The outer reaches are lighter. Kasper thinks of the resultant action as like that of a balloon, or a bubble, on top of the wing. In the vortex mode, controllability still exists because some of the vorticity effect—present along the entire wingspan but always greater at the tips—can be bled off by opening a tip rudder. Then you can turn.

Despite Kasper's reserved demeanor, he was a hot-dogger. If you are one of the few who has heard of him, it is probably because of the tumbling routine he used to perform in his airshow act. The BKB was a fantastic sailplane, and it could do other things besides generate vortex lift. The Federal Aviation Administration gave Kasper permission to perform aerobatics. There were no altitude restrictions.

"Hell, I saw old Kasper go by at 200 feet off the deck, and he tumbled that thing. He went around, and it was just like someone stuck a pair of ice tongs in his ears. Brrump. And he was around in about one or two seconds, with no loss of altitude. Then he would do a couple more and still have enough energy to climb out, come around and land. He could make it do anything. He could fly so slow and yet at such a flat glide angle, you just would not believe it. It's the kind of thing you have to see to believe," said Dick Baxter, a Seattle-area resident and experimental-aircraft enthusiast. "That was just a little over 10 years ago, at Issaquah [Washington], when he gave his last show."

Kasper recollects: "The first time I did the tumbling, it was by accident. I tried to make a loop. I pulled straight up and went inverted. Then, I pushed forward on the stick to keep it there, and it stalled, inverted. When I pulled back to recover, the glider tumbled. When I released the controls, the BKB returned to its normal flight attitude.

"I knew that no airplane ever came out of tumbling, so I wondered, 'why did the BKB?' "

He attached pitot tubes to the wing tips and tumbled again. The pitot tubes registered 40 mph (35 knots). The tips still were flying, and that meant that he had full control during the tumble. He could stop the tumbling at will.

"If a pigeon can do it, I can, too."

After the BKB came the Bekas-N,

another tailless glider with the same control system as the BKB. Its wingspan was 49 feet—nine feet longer than the BKB's—and it was meant for cross-country soaring, not the aerobatics associated with the BKB. The Bekas was completed in 1969.

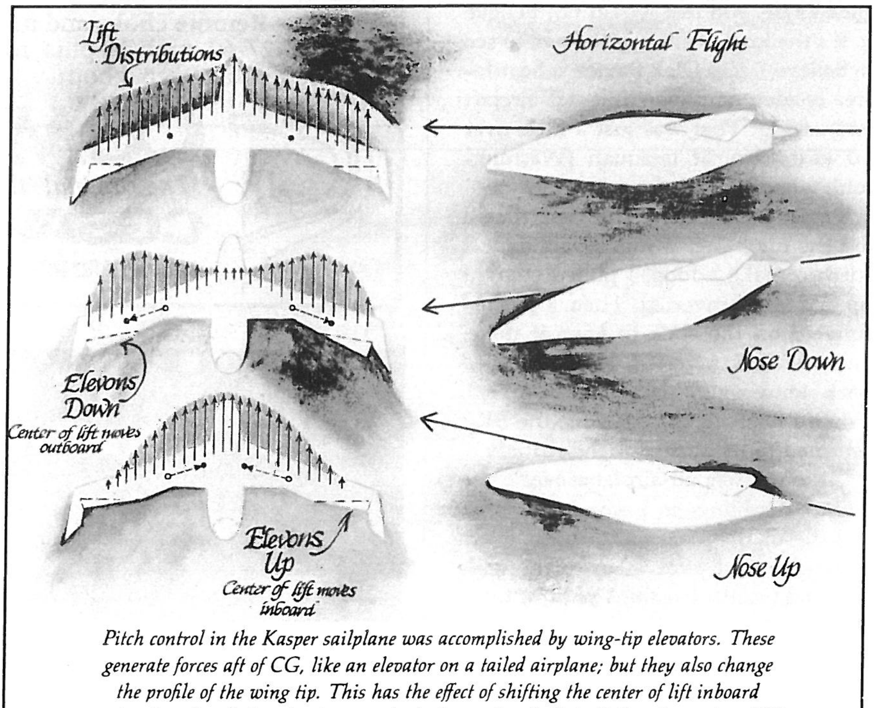
Kasper could fly these sailplanes with perfect precision; he had thousands of hours in them. But when other pilots flew Kasper's gliders, they tended to get into pilot-induced oscillations, especially in the pitch axis. Kasper's control systems were very sensitive. One movement of the controls would produce an attitude change. And once that attitude was reached, the sailplane would stabilize in the new attitude. Kasper found that pilots of conventional airplanes were making double movements of the control stick, imitating the jockeying to which they had become accustomed. This is what caused the pilot-induced oscillations.

After the Bekas came an unnamed experimental airplane with a pusher propeller. And then there was Mighty Mouse—a Cessna 150 fitted with Kasper-style end plates on the wings and flaps that had 90 degrees of travel.

Whatever happened to the BKB? Kasper was instructing an ex-Air Force and ex-airline pilot in how to fly the BKB; but what Kasper did not know was that he was an ex-airline pilot because he had received a concussion. Kasper warned him against aerobatics at this early stage of his training, but it did no good. Kasper watched as he made, first, a large loop, then a much tighter one, which ended with one mile of inverted flight. Then the BKB shot up vertically and shed one of its wings. The falling pieces overtook the rest of the ship as it lazily spun—right side up—into a swamp filled with willow trees. A willow absorbed much of the shock of impact, and the BKB came to rest in a flat attitude, partially submerged in water. Its pilot was dead.

An autopsy revealed that every blood vessel in the pilot's brain had burst, and aeromedical experts estimated that, during the tight loop, the pilot must have sustained at least 30 negative Gs. He was dead from the time he was inverted.

Whatever happened to the Bekas? Again, pilot technique was to blame, but dry rot in one of the wings played a part, too. While on tow, propwash caused one of Kasper's initiates to get himself into a pilot-induced oscillation in the pitch axis, and the Bekas lost a wing as a result. The tow pilot released the Bekas, and it settled slowly to the



Pitch control in the Kasper sailplane was accomplished by wing-tip elevators. These generate forces aft of CG, like an elevator on a tailed airplane; but they also change the profile of the wing tip. This has the effect of shifting the center of lift inboard and outboard and also, due to sweep-back, forward and aft, imitating the center-of-lift changes a bird makes. The pitching action occurs independently of forward airspeed.

ground—the pilot's hands folded in prayer—just outside the Issaquah airport's perimeter. The pilot opened the canopy and got out, unscathed. That was about five or six years ago, to the best of anyone's recollection.

Whatever happened to the experimental version with the pusher prop? An ex-B-52 pilot with 6,000 hours—most of them in heavy jets—rotated the craft on takeoff with such vigor that it climbed out at a 70-degree angle. This freaked out the pilot so much that he cut the engine to idle power at the top of his maneuver and settled slowly to the ground, mushing vertically. Kasper's reflex wing and V-stability saved this man's life because, in spite of virtually no forward airspeed, the vortex lift allowed him to settle gently. Realizing that he was about to impact the hard-surfaced runway, the pilot was able to turn the airplane by opening a tip rudder. He hit in a grassy area in a flat attitude, opened the canopy and got out, unhurt. Kasper was present for this one, too.

Mighty Mouse? Violent crosswinds and turbulence caused an overenthusiastic pilot to hit a tree and crash this one on top of a hangar. They brought him a ladder. He came down with only a nosebleed.

Mention of all these incidents causes faces around the room to drop. Unquestionably, these crashes are part of the Kasper mystique; but, despite the fact that they were pilot-induced, they feed ammunition to Kasper's critics.

In 1969, Boeing ran wind-tunnel tests on Kasper's reflex wing and found that it developed 85 percent more lift than any other airfoil. The firm learned that a transport jet using Kasper technology could carry twice the payload of a conventional jet at the same speed using one third the power.

Kasper then learned that, if a wing is made thinner, with a sharp leading edge—like a bird's—another vortex will form beneath the wing when it is flown at high speed. Because of this vortex's rotational properties, it produces negative drag, actually helping to propel the wing along. Trucks use large shields to produce this effect. Birds that migrate long distances use this feature to help them conserve energy, and so could we. Boeing's feelings? Too radical a design departure right now. Maybe in 1995.

In 1973, Saab-Scandia tested Kas-

per's ideas in a wind tunnel and a smoke tunnel. Using models and extrapolation, the researchers figured out that a DC-9 with a tail-mounted auxiliary engine could land at a forward speed of 35 mph (31 knots). Maximum coefficients of lift (C_L max) for this wing were described in the area of 25. (Coefficient of lift is a relative measure of an airfoil's lifting capabilities.)

In 1977, the National Aeronautics and Space Administration tested the Kasper wing and found that "coefficients of lift on the order of 10 were easily obtainable" and that "further study would be needed to see if there was a potential for more."

Just for comparison, it will interest you to know that the C_L max of a Cessna 172 is about 1.6. Boeing's "blown wing" (bleed air was fed over the leading edges, augmenting lift by what came to be known as the Coanda effect) achieved a C_L max of 2.3. At one time, this was a highly touted project. The BKB and the Bekas had C_L maxs of 6. A C_L max of 10 is a relatively astronomical number.

In spite of the implications to fuel savings and safety, Kasper's ideas have not been well received in America. The Europeans seem more willing to invest in the development of this technology than we are. Kasper, who speaks 12 languages, seems to be able to move more easily in European circles.

Kasper's 35-year-old dream of imitating bird flight finally was realized when Steve Grossruck of Cascade Ultralites, acting on Kasper's advice, was able to achieve stability and control at zero forward airspeed using a single-surfaced Kasper-wing profile and wing tips. This ultralight—the Kasperwing—even if aggravated into a whip-stall condition with no remedial actions, merely porpoises gently and does not have the capability of truly stalling. It only mushes.

"His wing can do what mine could not because it is thinner," says Kasper. "A thin wing with a sharp leading edge is much more efficient and has gentler pitch and stall characteristics. In the beginning—in 1912 or so—they were on the right track. They had biplanes with thin wings, and for strength they used struts and wires. Then, along came the desire for a single wing. So, for strength, they had to make heavy spars. Enclosing those spars gave us the blunt leading edge and fat profile that we have inherited to this day. It was the wrong way to go."

The more you learn about Kasper and his theories, the more the legend grows. Just as you think you understand him more, you realize that you understand him less. Even aerodynamicists—those frank enough to admit it—confess that they do not know how his theories work, only that they do.

Time dulls the memory of those close to Kasper in his heyday. Details merge and conflict, and there are so many ideas, drawings and formulas that I wonder about the organizational and managerial capabilities of Kasper and his small retinue. Beyond a doubt, Kasper is a genius. But perhaps his greatest problem has been in effectively communicating his theories to the aviation-minded public.

Witold Kasper is getting old, and I do not want him to be forgotten. He can still be seen at the Issaquah airfield, offering advice freely or just passing time. At home, he keeps chickens as pets, watches television and answers dumb questions from aviation journalists over the telephone. He also teaches self-defense courses to senior citizens. Occasionally, he will deliver a speech or attend seminars at universities and research institutions around the U.S. and Europe.

He has written a book; but, to date, publishers have not shown an interest in pursuing the project because they cannot understand his theories. The book should be published, if just for the record. I would buy a copy. In fact, I might even buy two.

The unlikely world of ultralights has become the inheritor of Kasper technology. It is a world free to improvise, free of the constraints of government or large-corporation politics. The Kasperwing ultralight carries with it some of the old Kasper mystique, and Kasper himself is very proud of the design—the first production airplane using the Kasper wing.

Someday, I know that someone will ask me if I ever knew Witold Kasper. I will say yes, I had that privilege. Then I hope I will not have to say that he was one of the greatest minds in aerodynamics who became a footnote in history because of some unfortunate crashes, a narrow-minded research community and a deep communion he had with the principles of bird flight. □