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**LETTER FROM AVIATION HISTORY**

**Boldly Go**

"If we can put a man on the moon, why can't we?" That stock expression, often used in frustration over some perceived ineptitude, reflects the high regard with which we view the Apollo moon landings. In most people's minds, they simply were history's greatest technological achievement. The sad fact is, four decades after Neil Armstrong first took "one small step," we lack the capacity to do it again. And if the space shuttle is retired next year as planned, the United States won't even be able to put an astronaut into orbit, much less on the moon, until the Apollo-style Orion spacecraft currently under development is ready to fly in 2015.

Many of us who grew up in the 1960s and '70s marveled at NASA's accomplishments and the continual march of progress in space expected that we'd have a lunar base and be well on our way to a manned Mars mission by now. What happened to our drive to push the boundaries of manned space exploration? Simple: We lost the vision and political will.

In his celebrated 1962 speech at Rice University, President John F. Kennedy provided the impetus for the lunar landings: "We choose to go to the moon in this decade and do other things, not because they are easy, but because they are hard; because that goal will serve to organize and measure the best of our energies and skills. ..." At the time America faced challenges no less daunting than those facing the nation today. Yet NASA took up the gauntlet, and visionary engineers delivered on President Kennedy's promise. It remains to be seen if there is any future president who can muster the political will to add to JFK's space legacy.

For now the future belongs to visionaries like Burt Rutan, profiled by Peter Garrison on p. 24. Rutan has always played the upstart, thumbing his nose at the engineering establishment and flying in the face of convention. His X Prize-winning White Knight/SpaceShipOne design provided a new paradigm for spaceflight, one centered on the ability of private enterprises to make technological leaps far more quickly and cheaply than government-sponsored entities. Soon Rutan's White Knight Two, recently on display at EAA AirVenture, will carry SpaceShipTwo on test flights, inaugurating a new era of privately sponsored suborbital trips under the aegis of Richard Branson's Virgin Galactic company.

Charles Lindbergh once wrote, "I don't believe in taking foolish chances, but nothing can be accomplished without taking some chance at all." Burt Rutan understands that perhaps better than anyone else. Here's to his next risk-taking adventure.
TOP PENCIL

MAVERICK AIRPLANE DESIGNER BURT RUTAN DOESN'T JUST THINK OUTSIDE THE BOX; HE COMPLETELY DESTROYS IT AND STARTS ANEW

BY PETER GARRISON

In a career replete with innovative designs, Burt Rutan (inset) considers SpaceShipOne (shown here) with its White Knight carrier his greatest accomplishment—so far. A pencil sketch (above-left) reflects his early thinking on the design.
North Pole, broke through unexpectedly thin ice and sank. As a kid, Burt was entranced by airplanes. He built model kits, competed in contests, regularly won. He entered at 19, had two children, and at 20 started building his first full-size aircraft in his garage. He found the airplane project more absorbing than his family—a not uncommon hazard of aircraft homebuilding—and his marriage ended after eight years. He used to say that when it came to choosing between his wife and the plane, "There was no doubt in my mind which I wanted to keep." But one forgets he married again two years later.

Burt Rutan is a solitary figure toiling in a field—aerospace engineering—where sober, mature, methodical planners and committee decisions are the rule. Designers of airplanes and spacecraft seldom make the papers to ordinary mortals their work is incomprehensible science; to be practiced in obscurity. Rutan, on the other hand, gets his name in the papers sufficiently often to be suspected of likening it. In fact, one or two of his detractors suggested that his sometimes fantastic designs are motivated more by a desire to attract attention than by critical analysis or pilloried optimism. Rutan denies it; each design, he says, is optimal for its intended use.

Rutan does like publicity, but his credentials are no less sound for that. After graduating from California Polytechnic Institute at San Luis Obispo, he went to work at Edwards Air Force Base analyzing the aerodynamics of McDonnell Douglas F-4 Phantom fighters, which were crashing in Vietnam from in-flight loss of control more often than from enemy fire. He won the prestigious Air Medal for his work. From Edwards, Rutan jumped, in 1972, into a completely different world, moving to Newton, Kan., to become chief engineer of Bede Aircraft. James B. Bede, an aeronautical engineer who sometimes let his enthusiasm get the better of him, had promised a kit airplane, the BD-5, with claims of fantastic performance occupied with an extremely low price and dizzying ease and rapidity of construction. Thanks to a great deal of uncrucial publicity, including a spread in Playboy, Bede had sold thousands of delivery position, and had turned cash depositories into a prototype that flew reluctantly when it flew at all. Bede hired Rutan to make a usable airplane out of the BD-5, and, to the extent it was possible, he did.

In the meantime, Rutan had gotten his homemade airplane flying, testing models with a "wind tunnel" on the roof of his 1966 Dodge Dart. Its unusual configuration was based on that of a Swedish fighter, the Saab Viggen. Meanwhile, my airplane has a principal lifting wing somewhere around the middle of the body, and a substantial stabilizing surface behind the Viggen. Rutan reversed the pattern, placing the main wing in the rear and the smaller surface in front. The arrangement is called a "canard" because, like a duck's (canard means duck in French), its nose sticks out far ahead of its wing. The canard arrangement did not originate with the Viggen: it had been used from time to time, beginning with the Wright brothers, with missed success. Making it work properly required the right distribution of weight and lifting characteristics between the front and rear wings. Once that was achieved, the canard worked as well as the conventional layout in most respects. In some ways it was better; in others, worse. Most aeronautical engineers who had concluded that, all in all, the conventional arrangement possessed none of the decisive advantages.

Rutan was not an engineer, however, and he saw two things in the canard arrangement that attracted him. One was safety. It could be made resistant to stalling (a loss of lift due to flow breakdown over the...
wings that has nothing to do with the engines). The other thing is its look. Engineer or not, Rutan was as susceptible to a cool look as the next guy. He would make this one his trademark.

The airplane that Rutan based on the Vair-eze— he called it the Vair-eze— flew well and looked cool, and he sold several hundred sets of plans to amateur builders. He and his wife Carolyn left Kansas and moved to California in 1974 and moved to California, settling up shop in a disused Army barracks at the Mojave airport. Mojave had been the training field during World War II, but in 1974 it was a hot, wind-swept waste- land whose main recommendations were its cheap rents, usually cloudless flying weather and long runways. But and Carolyn settled themselves the Rutan Aircraft Factory and handed out business cards bearing the motto "Proud Rutors for your Pleasure."

Mindful of the millions of dollars that had flowed into Bredes's coffers, Rutan had already been dreaming up a new project of his own. It would be smaller than the BD-5, would sell two people rather than one and would be powered by a cheap Volkswagen engine readily available from automobile wrecking yards. He called this one the Vair-eze, a name that combined a nod to the Vair-eze with a hint that the airplane would be very easy to build. After starting to con- struct it in aluminum, put out of modified BD-5 parts, he abandoned that material and switched to a surfboard-like combination of plastic foam and fiberglass. The new construction medium was light and strong, could be easily sculpted into streamlined shapes and, most important, allowed for very quick fabrication of simple structures.

The Vair-eze made Rutan's name. He sold thousands of sets of plans— not conventional blueprints, but a sort of comic-book-style narrative of construction. The slender, sweeping Vair-eze and a slightly larger successor called the Long-EZ became the vanguard of a new era of innovation in aircraft homebuilding. It sparked an interest in canards that took 20 years to cool to ambient temperature. Soon "canards guns" about Rutan became a stock phrase in the aviation press, requiring no further explanation.

Rutan moved fast. During the late '70s he produced one de- sign after another, building them all of plastic foam and fiberglass at an incredible rate. Almost all were canards. There was an STOL airplane, the Grizzly, a sailplane, Solitaire, and 18-hp single-seat rocket, Quicker, and a racing biplane. On the side he experimented with windmills and solar collectors. He and Carolyn eventually divorced. Except for the end of the settlement, he didn't mind; he was rising, rising meteorically. He built a couple of prototypes under contract to other firms, then secured half a million in venture capital and set up a new company he called Scaled, an acronym of Scaled Composites, Advanced Design to Efficient Design. The business plan was to use the rapid foam-and-fiberglass construc- tion techniques to build reduced-size prototypes of new designs. The idea caught on, and Scaled had soon built a jet tester for Fairchild and a serious-wing proof-of-concept vehicle for NASA.

Scaled got a huge break in 1982 when Breech Aircraft Company, a subsidiary of defense behemoth Raytheon, became enamored of the Vair-eze/Lang-EZ look that it hired Rutans to build a five-eights-scale prototype for a 10-seat, 350-mph canard with two 1,000-hp turbo- prop engines. The Starship, as the new project was called— normally stud Breech had cut something to the wind— looked just like a huge Long-EZ. Rutans, suddenly scaling dizzying corporate heights, became a Breech vice president, married the daughter of a Breech executive and took up golf.

The whole Starship affair— except the golf— was a disaster. Hundreds of millions were spent on certifying and testing up for the new airplane, which was built not of the traditional aluminum alloys but of epoxy-stabilized carbon fiber, like a fancy fishing pole or golf club. By the time it had been scaled up and the certification demands of the FAA had been met, its performance fell below expectations. Breech engineers privately blamed the miscalculation on Rutans, and Rutans blamed it on the FAA. Breech sold or leased only 24 of the airplanes, and eventually bought most of them back from their owners in order to sever the "liability tail" that might otherwise wag the company dog for years to come.

The marriage, Rutans's died, hastily filed better, lasting 20 months. The relationship with Breech continued for several years and pro- duced, besides the ill-fated Starship, a B-650 prototype of a small twin jet with engines mounted above the wings—a very light jet (VLJ) before its time— called Triumph. But theRP
dependent-minded Rutans was not made to be a vice president of somebody else's company. In 1988 he left Breech, taking his company, which he now simply called Scaled Composites, with him. The Tri Su project did not get beyond the proof-of-concept prototype, which ended up impaled on a pylon out- side the Scaled office at Mojave.

Until he turned his attention to spaceflight, Rutans's most famous accomplishment was Voyager, the first airplane to fly nonstop around the world without refueling. His brother Dick, along with Dick's in- nol, Jesse Yeager (no relation to right-stuff-embodify Chuck), and an unnamed craftsman named Brose Evans built the huge airplane—in wasp was that of a medium-sized airplane—in a hangar at Mojave, late in 1986 Dick and Yeager, who by that time were barely on speaking terms, rode in the cramped cabin for nine days to accomplish the feat. (Small world footnotes: The original scheme for a nonstop round-the-world flight came from Rutans's old boss Jim Sieve; and before coming to Mojave, Yeager had worked for a retired Navy captain, Robert Truss, on a project to show fun-loving people into suborbital space on surplus rockets.)

In the early 1990s Rutans created two asymmetrical airplanes. One, ARES (Agile Responsive Effective Support), was a single- engine ground attack jet with its engine air intake on one side and a Gatling gun on the other. The other, Boomergang, was a remarkable five-seat twin powered by two 260-hp Lycoming engines. With its leopards, forward-swept wing, and one-fuselage/one- boom design, the Boomergang resembled nothing else that had ever flown. The right-hand body contained a pressurized cabin and one engine in the nose. The left boom carried the other engine, plus fuel and luggage. The two engines, closely spaced laterally to prevent thrust-asymmetry problems in case of an engine failure, were staggered, the left one five feet behind the right. At the ends of the two body/booms were two vertical tails and a horizontal stabilizer that stood at the boom on the left but extended several feet beyond the fuselage on the right.

The Boomergang was a remarkable performer with double engine- out characteristics, but ironically it was in that airplane that Rutans came closest to being killed by one of his creations. The unconventional twin apparently had little conventional instrumentation; an Apple laptop served as its instrument panel. Rutans and one of his engineers, John Kilkows, took off from Moab, Utah, in marginal weather, became disoriented and recovered from a dive at what Rutans later guessed was 400 mph, breaking the landing gear out of its up-
locks from the sheer force of the pull-out.

An abortive attempt was made to turn the Boomerang into a production airplane (a similar effort had been made, years earlier, on Rutan's tandem-engine Defiant). The ill-fated Starship remains the only Rutan design to achieve certification and series production.

By the 1990s Rutan had severed his ties to the amateur airplane builders who had been his original visionaries and increasingly focused his attention on space. Sealed Composites had been building winglets and payload supports for Orbital Sciences Corporation, which was sending small satellites into orbit with a rocket plane launched from beneath a modified Lockheed L-1011 airliner. Late in the decade, Rutan designed and built Profoss, a big dragonfly-like tandem-wing airplane originally intended as a sort of atmospheric communications satellite—a plane that would circle in one place for long periods, relaying telephone calls or broadcasts. The communications application never materialized, but the single prototype has gone on to a remarkable successful career as a high-altitude research aircraft.

The announcement in 1996 of the $10 million X Prize competition set Rutan to thinking about how to achieve a minimalist extraterrestrial flight. Rival contenders for the prize proposed various methods, including simple vertical-takeoff rockets and rockets/rocketplanes (rocket/balloon combinations) and more exotic mongrel aircraft incorporating both jet and rocket propulsion. But Rutan saw that the energetics of the problem pointed to the same solution that NASA had used in the X-15 program: air-launched by a rocket plane at an altitude of nine or 10 miles from a jet-propelled mother ship, followed by a zoom climb, a ballistic ascent into space and an unpowered glide back to the airport. Besides avoiding extreme performance demands on either vehicle, this approach had the advantage of limiting the design uncertainties to the portion of the flight between takeoff and the completion of reentry.

Not that those problems were minor. The propulsive energy expended in lifting the spaceplane out of the atmosphere would have to be dissipated—that is, turned into heat—during reentry. This was always the great problem for the space shuttle, and, although an X Prize flight involved much lower altitudes and velocities, the problem of using atmospheric friction to slow a fast-moving object without burning it up remained the same. In one respect it was worse: Rutan's vehicle would be built of composite materials having much lower resistance to heat than any metal.

Rutan's solution exemplified the ingenuity that he has brought to many design challenges. Returning—without, he later said, consciously thinking about it—to a technique familiar from his teenage modeling experience, he tested variations on the principle of a "dethermalizer"—a mechanism, operated by a timer or a radio signal, that flips the horizontal stabilizer of a model glider upward, stalling the wing and building the craft in a stable, slow descent. He built several large balsa and Mylar models that he dropped from a tower in order to assess the stability of various "refrigerated" configurations. All were as stable as jalapeño peppers at slow speed, only one, however, would be stable at supersonic speed—a critical determination for which Rutan was

Voyager returns to Mojave on December 23, 1986, after its nonstop globe-girdling flight.
obliged to rely on a computer simulation, because no practical testing method was available.

I spoke with Rutan recently. He had a heart attack several years ago and a close brush with death from another heart problem, constraining pericarditis, in 2008. At the urging of his wife Tanya, he has cut down on the time he spends at Scaled Composites and upped the time he spends on the golf course. I asked him which milestones, in a career cluttered with them, stood out in his memory as the most satisfying. With visible emotion, he said, "It has to be SpaceshipOne." That, he went on, had been an extraordinarily efficient and successful program, one that, after verifying flying qualities with several gliding flights, had progressed from subsonic to supersonic flight and on to space in just six powered flights. Talking about it, he radiated amazement anew. His close friend and chief test pilot Mike Melvill had risked his life in SpaceshipOne and, in spite of some harrowing moments, had come through safely. Thinking about the project—the spaceplane is now in the Smithsonian—Burt Rutan seemed in awe of his own good fortune. It was a reaction that he might forgive only to have had to renounce his career.

Engineers come in various types, but if they were to be divided into only two, a few would be creators and the rest executors. Executors do what creators do, but something else as well. Their design thinking that doesn't already exist. Rutan is a creator. Dreamer, designer, builder, pilot and salesman, he has always been able to weigh all aspects of engineering choices—to exploit synergies among seemingly unconnected features of an aircraft, to see how one part can be made to do the work of two or three and to instinctively sense how a small loss in one place can lead to a large gain in another. In the VariEze, derived from the complication of a retractable nose wheel by the empty airplane's unconventional weight distribution, Rutan found in the nose-down parking attitude a convenient alternative to shocks. The exaggerated aileron of the Quickie's firewall allowed him to dispense with landing gear legs. By copying the cabin of SpaceshipOne into its carrier airplane, White Knight (named, by the way, after a couple of X-15 pilots), he turned the mother ship into a training simulator. Melvill, who has worked with Rutan for more than 30 years and has test-flown most of his designs, spoke of his uncanny insight into aircraft behavior. "Before a first flight" he said, "the engineers would brief me, then Burt would take me aside and tell me what would really happen. 'You'll notice this, you'll notice that.' And he was always right! He just knew intuitively everything the airplane would do, before it had flown."

Although Rutan has cut back on his work at Scaled, he has not quit entirely. It's hard to imagine that he ever would. He plays his cards close to the vest—our lunchtime conversation was punctuated with "This is not for publication"—but Burt Rutan still has some surprises up his sleeve. Of the most famous aeronautical engineers of his time, he will never allow himself to fade quietly away.

Peter Gammon is a Los-anges-based freelance writer, airline designer, software engineer, pilot and longtime reader of Flying magazine. To learn more about Scaled Composites, visit scaled.com. For more on the Rutan Aircraft Factory's products, see the collection of 1974-2002 Curated Pusher newsletters at curativedesigners.org.

THREE HORNS, FOUR WINGS AND A PRAYER

An artist's rendering shows the SpaceshipTwo/White Knight Two launch system that will send passengers into suborbit.

The workers at Scaled Composites give nicknames to the airplanes they're working on. The launch system now being prepared for Richard Branson's Virgin Galactic suborbital airline, officially designated Tier III, is familiarly called "T-Tops." Short for "Triceratops," because of its three-pointed design. The 140-foot-span carbon fiber mother ship, powered by four 6,900-pound-thrust Pratt & Whitney rockets, is currently undergoing flight testing. A problem with the landing gear's shock absorbing system, the introduction of the smartphone to the future of the aerospace industry, and the performance of the mother ship, dubbed VMS Eve by Branson, closely match predictions.

In the meantime, the SpaceshipTwo prototype nears completion. Much larger and more complex than SpaceshipOne, it is also differently configured. A lateral-directional stability problem that led to 29 uncommanded vertical rolls during one SpaceshipOne flight has been corrected by placing the passenger capsule above rather than below the wing. Because the lowering of the flight configuration was less inherently stable in the feathered descent attitude, the tail surfaces were enlarged and the boom supporting them lengthened.

One still-unsettled question is the manner in which suborbital passenger-carriers—Rutan expects to have competitors—will be certified by the FAA. And how to define the standard of safety they should meet. Rutan has suggested that any passenger-carrying suborbital flight service ought to demonstrate at least the level of safety that was achieved by Ford Tri-Motors in the 1930s. He has jokingly proposed that the conscientiousness of suborbital craft manufacturers be increased by requiring that they send their children up in them.

"At least some of them must love their children," Rutan observed.