# Burt Rutan's PERSONAL SPACE

Burt Rutan wants to go high—*try sixty-two miles*—and is building a means to do just that.

By Rob Loughran

Burt Rutan made aviation history in 1986 when his airplane design Voyager completed the first non-refueled flight around the world. His latest project, Tier One, is, almost literally, out of this world. Not since the pre–Yuri Gagarin era of the early 1960s has there been such a concerted effort and concentration on sub-orbital space flight.

An incentive for sub-orbital flight has been offered by the X Prize Foundation. The first private enterprise to fly three people to an altitude of 100km; (62 miles), and then repeat the flight within two weeks wins ten million dollars—if accomplished before 1 January 2005. This X Prize reward has enticed Rutan's former company, Scaled Composites LLC, and more than 20 other private design and engineering teams to venture up to where only the two Cold War superpowers have flown. But the monetary reward isn't the only impetus. There's the engineering challenge, the drive to be the first, and the simple allure and thrill of space flight: "I want to go high," said Rutan, "because that's where the view is."

SpaceShipOne is a rocket plane, although it's registered as a glider, with a stubby 16.4 foot wingspan. SS1 is constructed of an epoxy and carbon fiber honeycomb. The hybrid rocket engine is, as the name implies, a cross between a solid-fuel and liquid-fuel rocket. The largest components—the fuel casing and oxidizer tank—are designed by Scaled Components while valves, injectors, ignition system, and controls are out-of-house hardware. All rocket motors have a *fuel* and an *oxidizer*. SS1's hybrid motor is powered by a solid fuel: hydroxyl-terminated polybutadiene; known more commonly as rubber. The liquid oxidizer is nitrous oxide, or laughing gas. These fuels can be stored safely and will not react with each other until the rubber is intensely heated in the combustion chamber and the nitrous oxide subsequently introduced: the rocket simply cannot ignite accidentally.

Another advantage is that nitrous oxide is self-pressured at room temperature, and unlike liquid nitrogen and other oxidizers, nitrous doesn't need complicated turbo pumps to reach the combustion chamber. The products of combustion (i.e., exhaust pollutants) are water vapor, carbon dioxide, nitrogen and hydrogen. Certainly more environmentally friendly than any other type of rocket fuel. The rocket controls on SS1 are simpler than a household oven: one switch arms the motor, the other fires it. There is no throttle on the rocket: it burns for about 65 seconds until it's out of fuel (which comprises roughly half of SS1's weight) then shuts down. The motor's oxidizer tank is reusable, but the fuel casing and nozzle will be replaced between flights.

The astronauts will not wear spacesuits. The shell of the cockpit, a second skin beneath SS1's hull, has redundant seals and dual paned windows. It is essentially a back-up, space-flight-worthy-casing. The sealed cockpit will be pressurized at an equivalent of 6000 feet utilizing a scrubber to dry the air and eliminate carbon dioxide. Although equipped with oxygen bottles and masks for emergencies, three men have done a three-hour simulation test in the sealed SpaceShipOne. The planned space flight is estimated to be about thirty minutes.

The nine-inch double-pane windows (sixteen in all, providing a view of the horizon) are Plexiglass on the inside and Lexan polycarbonate outside. The Plexiglass insures the pressurization while the Lexan tolerates the heat of reentry.

The aerodynamic, bullet-like SS1 didn't test in a wind tunnel. The shape was configured and refined utilizing Computational Fluid Dynamic tools. The aircraft doesn't have ejection seats—in an emergency the front hatch would be released (the same way the crew enters) and the astronauts would parachute to safety.

The craft is equipped with stick-and-rudder controls for subsonic speeds; electric controls for supersonic—when you'd need about 300 lb of torque to move the stick—and gas thrusters for positioning itself in the void of space.

SpaceShipOne will be coupled with another Scaled Composites creation, the White Knight. This gull-winged, 82 ft. wing span aircraft is powered by twin General Electric J85-GE-5 turbojets. These turbojets have afterburners, not to travel fast—White Knight's maximum speed is Mach 0.6 or about 385 mph—but to travel high. This praying-mantis-looking aircraft can accommodate an 8,000-9,000 lb. payload with up to 6,400 lbs of internal fuel capacity.

So as to withstand the pressures of high altitude flight the White Knight's cockpit is more like a submarine's than an aircraft's. It's airtight and there is no air exchange between the plane and the atmosphere. Unlike a submarine, which is designed and reinforced to withstand *outside* pressure, White Knight's cabin is highly pressurized *inside* compared to the near vacuum in which it flies. Three components keep the cockpit habitable during flight: two filters—one removes water vapor from the astronauts' sweat and breath, the other removes carbon dioxide—and oxygen replenished from a pressurized bottle.

The cockpits of both vehicles are quite similar; of course White Knight's displays relay jet info and

**Above: View inside White Knight's cockpit; Opposite: White Knight head on; Below: dramatic full front view of White Knight.**

## THE ASTRONAUTS

These private sector astronauts—NASA considers anyone flying above 50 miles an astronaut—are talented and experienced.

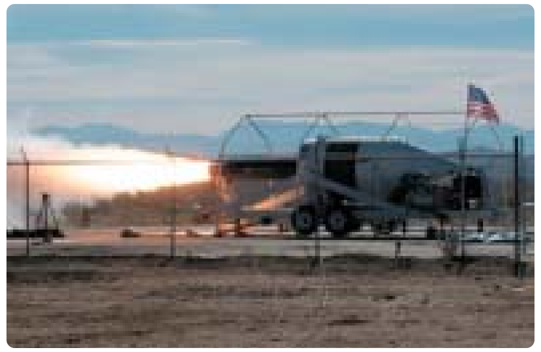
In addition to being the first to fly the Model 318 White Knight, Doug Shane has approximately 3500 hours in more than 130 types of aircraft including the T-38, F-16, F-15, and F/A-18. He is VP of Business Development, Director of Flight Operations, and Test Pilot for Scaled Composites. Doug has over twenty years experience in developmental flight testing. In 1997 he was awarded the prestigious Ivan C. Kincheloe Award by the Society of Experimental Test Pilots. Doug owns and operates a vintage 1948 Stinson 108-3.

Pete Sielbold is a Design Engineer and Test Pilot for Scaled Composites. He has twelve years of flight experience; six of those as a test pilot with 1800 hours in over thirty different types of fixed wing aircraft.

Mike Melvill has 6730 hours in 117 fixed wing and 11 rotary wing craft. He won the Ivan C. Kincheloe trophy in 1999 for testing of the Proteus 281, a high altitude research twin engine jet. Mike holds four world and national altitude and speed records, has flown around the world, and has first flight bragging rights on many aircraft including the 202 Boomerang, Rutan's high performance twin.

Brian Binnie has nineteen years in flight test with 4500 hours and 490 arrested landings on carriers. The graduate of the Navy's Test Pilot School and Naval Aviation Safety School has provided training to pilots in Finland, Italy, Malaysia and Australia. The twenty-year Naval veteran also planned and executed the *only* radar chase of the Tomahawk cruise missile.

**Above (clockwise from top left): Brian Binnie, Pete Sielbold, Doug Shane and Mike Melvill.**



**An early rocket test at the XXX facility in California.**

SS1's rocket data. But, by design, the flight and handling characteristics are comparable. Maneuvering the White Knight will prepare the astronauts for handling SpaceShipOne. The designers say that the glide characteristics of the big plane, especially, will mimic those of the capsule and help when it's time to land SS1.

SpaceShipOne is attached to White Knight's underbelly via a set of hooks front-and-back. Sway bars stabilize SS1's wings. When the sway bars and hooks are released SS1 must still be released manually: yet another redundant safety feature.

The White Knight flew publicly for the first time on Friday, 18 April 2003. SpaceShipOne was on display but didn't leave the ground. However, Rutan is not one for mockups; he hasn't unveiled previous projects until they were nearly ready to fly. Rutan said on 18 April: "There is nothing you will see today that is a mock-up. I didn't want to start the program until we knew that it could happen."

Sure enough, the White Knight and SpaceShipOne completed their first captive carry flight a month later. Although the launch system was functional for this flight, SS1 remained unmanned. The official evaluation from Scaled Composites was favorable: *Excellent two-ship stability & control throughout the envelope. No interference or vibration issues. Smooth surface flows on SS1 except around rocket nozzle. Two-ship performance was as predicted. Mach 0.53 was achieved at 48,000 ft. Climb rate at 48,000 ft. was 700 ft/min. Envelope was cleared for future manned captive carry and glide flights.*

In captive carry mode the White Knight is also a flying wind tunnel, testing control surfaces on the SS1. Future test flights will be manned captive carries up to 50,000 ft. If successful, glide flights will ensue, followed by a short test firing of the rocket which will zip SS1 up to Mach 1.2. A single astronaut will probably make SS1's first test flight to 100km.

When the mission gets the green light the White Knight will take off from the Mojave Airport with SpaceShipOne clinging to its underbelly. They will climb above 85% of the earth's atmosphere to an altitude of 50,000 feet. Much like the B-52 and the X-15 nearly a half century ago, the White Knight will release the SS1. After igniting its rocket, SS1 will power to about Mach 3.5 and an altitude of nearly sixty-three miles before beginning its return to earth.

The reentry method is ingenious.

Unlike the first two sub-orbital Project Mercury capsules which returned via parachute to splashdowns and the Space Shuttle which requires a precise angle of reentry, SpaceShipOne has a wider safety margin at much slower speeds. "We go straight into the atmosphere and the pilot can

**White Knight airborne over the desert.**



**White Knight executes a captive carry.**

reentry without touching the controls," said Rutan.

The capsule will be slowed by the wings and tails. They will rotate up, called *feathering*, which converts the SS1 from a bullet to a shuttlecock. This slows the craft by increasing the spacecraft's drag coefficient. It also slows the craft at a higher altitude, lessening the G-forces and heat of reentry. The astronauts will pull about 5g's; compare this to the 3-4g's pulled by riders of a modern super coaster. This has been dubbed "care-free" reentry.

In feathered mode the atmospheric drag automatically converts the SS1 to a proper "belly-first" position. When the wings and tails are returned to normal aircraft configuration (about 15 miles up) the astronaut can glide up to 60 miles.

Again, like the X-15, it will glide to a landing on two rear wheels and a nose skid. The only hydraulic system on the spacecraft operates the rear wheel brakes. Electricity is provided by lithium batteries; the power for attitude jets, defogging, and moving the tails is provided by dry air bottles.

When will the Tier One project fly?

Rutan has hinted he'd like to see it in action prior to the 100th anniversary of the Wright Brothers' first powered flight, 17 December 2003. In Scaled Composites' statement at the 18 April unveiling of the Tier One project Rutan commented: "I strongly feel that, if we are successful, our program will mark the beginning of a renaissance for manned space flight. This might even be similar to that wonderful time period between 1908 and 1912 when the world went from a total of ten airplane pilots to hundreds of airplane types and thousands of pilots in 39 countries. We need affordable space travel to inspire our youth, to let them know that they can experience their dreams, can set significant goals and be in a position to lead all of us to future progress in exploration, discovery and fun."

## THE X PRIZE FOUNDATION

Prize money and aviation have been linked since 1901 when Deutsch de la Meurthe offered 100,000 French francs to the first pilot able to complete an airship flight around the Eiffel Tower. Other famous incentives included the 1909 offer of 1,000 British pounds for crossing the English Channel and the $10,000 purse offered for the first Albany to New York City flight.

But the most famous and influential prize was dangled by Raymond Orteig. In 1919 he offered, "…a prize of $25,000 to be awarded to the first aviator of any Allied country crossing the Atlantic in one flight, from Paris to New York or New York to Paris… ."

This is what eventually led to Lindbergh's historic 1927 crossing of the Atlantic in the Spirit of St. Louis. This flight, historically and economically, changed aviation forever. Consider that the number of U.S. airline passengers increased from 5,782 in 1926 to 173,405 in 1929; US Air Mail increased from 97,000 lbs. to 146,000 lbs from April to September of 1927; a 400% increase in licensed US aircraft in 1927; the number of airports in the United States doubled by 1930; and the Spirit of St. Louis aircraft was viewed by *25%* of all Americans within one year of its trans-Atlantic flight.

Sub-orbital flight has traditionally been viewed as a stepping stone to space, not as a goal unto itself. But in May 1996 Peter H. Diamandis, Chairman and President of The X Prize Foundation, announced a $10 million prize. Diamandis hopes this incentive will create a private enterprise, sub-orbital flight business. As the aviation industry changed the 20th century, he expects a sub-orbital industry will lead the 21st century to viable space tourism, rapid and safe point-to-point passenger travel, world-wide same day package delivery, and low cost satellite launch. In addition, there are the intangibles of creating a new generation of heroes that will inspire students and innovators and engineers to ask,"What if?"

The X Prize Foundation describes its goals and guidelines: "The X Prize is a $10 million prize to jump start the space tourism industry through competition among the most talented entrepreneurs and rocket experts in the world. Following in the footsteps of over 100 aviation prizes offered between 1905 and 1935 that created today's multibillion-dollar air transport industry, the X Prize will be awarded to the team that designs the first private spacecraft that successfully launches three humans to a sub-orbital altitude of 100km on two consecutive flights within two weeks. All teams must be privately financed."

On 18 April Rutan was quoted, "If I'm able to do it with this little company here…there'll be a lot of other people who will say, 'Yeah, I can do it too.'"

Although the source or amount of the funding for Scaled Composites' Tier One project wasn't disclosed, *Aviation Week & Space Technology Magazine* estimates the program will cost between $20 and 30 million. Again, there's a historical precedent: Lindbergh and the other eight competitors spent a combined $400,000 in an attempt at the $25,000 purse.

**White Knight and Space Ship One on the tarmac.**