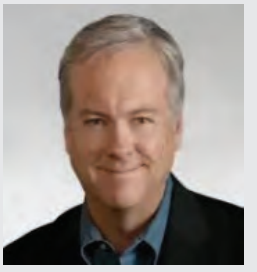
BRIEFING: CHAPTER 1

VIPs

Burt Rutan



Doug Shane

Mike Melvill

Jargon & Other Stuff

E-Ticket — E-tickets entered the American lexicon as a term signifying the ultimate in thrills. It originated at Disneyland, which sold ticket books with coupons ranging from A (mundane) to E (exciting). Astronaut Sally Ride described her first trip to space as "a real 'E' Ticket ride!" Interestingly, in the '90s Burt owned an Enstrom helicopter – with a registration number of N8ET. This was Burt's way of saying that a ride with him at the controls would rise to the level of an "ET"—E-Ticket ride. He even printed up "Dizzyland" E-ticket coupons for nervous passengers and added Mojave Land to the theme park areas. This gives you an early look into Burt's sense of humor.

The Velocity Vector (Navy) or Flight Path Marker (Air Force) — The term "cue" is frequently used as a generic term for these cockpit display items. The value of this cue is that it shows the pilot where he's headed, and if displayed on a Head-up Display or HUD, as shown, the cue will be 'live in the scene'—meaning it will show where that heading is in relation to, say the ground, or runway. It is an invaluable aid to the pilot's situational awareness. Particularly for the Navy types around the aircraft carrier and for everyone flying in weather.

Transonics — that region of airspeed between subsonic and supersonic speeds. Depending on the vehicle, it can be narrow or broad and is described in terms of Mach Number or the speed of sound. Roughly transonics is the regime from 0.8M to 1.3M and tends to produce erratic forces on the vehicle that are difficult to predict.

Mach Number — Often just written as M. By definition, the speed of sound is '1'. But since different parts of an airplane or spaceship can be closer to this number than others, there is a region called transonics where the airflow over the vehicle is a mix of both subsonic and supersonic flow. In terms of miles per hour (mph) or Knots (1kt=1.15mph), the speed of sound at sea level is

770mph or 670kts. The transonic region from 0.8M to 1.3M covers airspeeds between 610-915mph or 530-790kts.

Feather — The name given to the *SS1*'s configuration designed for re-entry into the atmosphere. It looks like we break the ship in half and is covered in detail in Chapter 7.

Nitrous — Shorthand for nitrous oxide or N_20 or "laughing gas" used by dentists. It provides the source of oxygen for the rocket motor. Not a common choice as liquid oxygen is the usual favorite. Chapter 16 goes into the details.

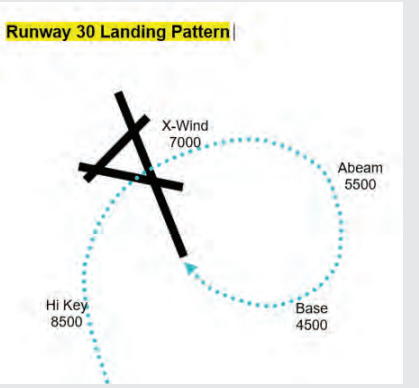
***Extra 300* —** A 2-seat acrobatic aircraft we used for G-tolerance training as well as chasing (following) the spaceship around the landing pattern.

Landing Pattern:

Hi-Key — A point overhead in the landing pattern where the spaceship still has 360 degrees of turn to make to land.

Lo-Key — A location abeam the intended point of landing with 180 degrees of turn left to go.

'Base' or the '90' — 90 degrees of turn remaining before you're lined up with the runway. The landing pattern used by *SS1* is described in Chapter 18.



Chapter 1

There I Was...

"Those who dare to fail miserably can achieve greatly."

— *John F. Kennedy*

"Stand by for the FIRE switch on my mark." I heard myself say the words, staring at the switch.

"Three." I was still looking at it.

"Two." It hadn't moved. Still there, waiting for me to continue. I reached forward and flipped up the cover guard.

"One." The cadence was pretty good, and I hoped my voice isn't giving away my apprehension. But there was a tell-tale pause.

Oh, what the hell. I put my head back into the seat.

"Mark." My finger rocked the switch forward, and I quickly returned both hands to the control stick.

During ground firings of the rocket motor, there was just the briefest pause between hitting that switch and the rocket motor roaring to life. More than once, we had reflexively jumped in the control van as that dragon woke. And the very first time we fired it, I remember very distinctly thinking the less-than-professional assessment: *Holy crap! Are we going to be able to fly this thing?*

To space—no less.

And it wasn't going to be guided by some fancy computer, but rather the old-fashioned way, hand flown just like a regular airplane.

So, the demon was alive again. This time I wasn't safely behind some monitor in a ground bunker, but about 50,000 feet in the air—some six feet in front of where all of our carefully crafted thermodynamics were doing their thing. That tended to be the language of the rocket engineers, but as far as I was concerned, I was sitting in front of a well-behaved bomb. There would be many memorable mo-

WHERE IN TIME

2003			1st Glide Flight *SS1*	**1st Powered Flight *SS1*—Landing from Hell**

ments during the program, and this one had my full attention.

After selecting the fire button, there was a purposeful hissing sound followed by what seemed to me the start of World War III. The jolting, jerking, bone-jarring roar that swept over the vehicle had turned my little friend into something nasty and impatient, with big sharp teeth. And with it, I slid some six inches back and up in the pilot seat and needed all of my available reach just to keep hold of the control stick.

That aggressive displacement I experienced in the cockpit produced a fleeting reminder of a popular ad by Southwest Airlines at the time, where the captain announces, once safely airborne, that "You are now free to roam about the country." Heh.

Competing with this little bit of humor was the more imploring and alarming *Holy Mother of God!*

There's a military saying, there are no atheists in a three-man foxhole. About a minute before release from the mother ship, I was earnestly trying to become an honorable member of this desperate group. I wore the St Christopher medallion and made the sign of the cross, hoping that these last-minute offerings might provide me some favor. With my rusty religion secured with as much sincerity as I had time to muster, my first cognitive thought was that we were going up.

Good.

Up is good, because otherwise in a few seconds, any horizontal acceleration would soon exceed the structural limits of the spaceship and destroy all hopes of going to space. Practicing these profiles in the fixed-based simulator, we were like Einstein or Chuck Yeager, making sage evaluations of airspeed, angle-of-attack, and attitude while assessing rocket-motor health from the propulsion page display. At this point, I felt more like Scooby-Doo scrambling around in the back of a truck, and all I could do was tell you that we were climbing. And while climbing is good, it was maybe too good because the nose felt like it was really, really coming up fast. But that impression, I knew from my Navy days being slammed off the flight deck by catapult, can also be part of the inner-ear confusion as it experiences three and a half instantaneous Gs from front to back. For reasons covered later, the vehicle was far lighter in weight than it ever would be flown again under power. The rocket motor didn't care though and still woke up, ready to kick some ass, producing full thrust and its version of mayhem. This was going to be one heck of an E-Ticket ride! I believe the next impressionable thought, as undeserving as I felt of his interest, was, *Jesus save me!*

The vehicle did some sort of jolting, lurching thing, and the indicator I was now staring

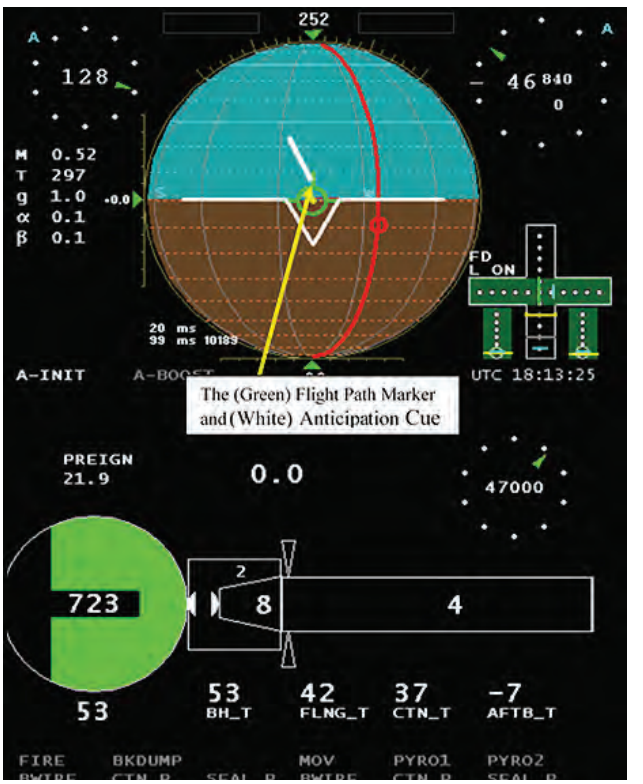


Figure 1: SS1 TONU display with (green) FPM and (white) Anticipation Cue.

at, the anticipation vector, a line which grows out of something else called the Flight Path Marker. These display cues may be unfamiliar territory for the non-aviation reader. The FPM indicates where the aircraft is going, and the anticipation cue is a useful predictor of where that might be in the next five seconds.

SIDEBAR

The idea of a director telling the pilot where the aircraft is going may seem unnecessary to those not part of the aviation community. The common notion that the airplane goes where the nose is pointed has many exceptions, including aerobatics, for example. The FPM clarifies for the pilot these exceptions, and the anticipation vector provides a little more magic by predicting where the aircraft will soon be. This is certainly of considerable value in a highly dynamic environment.

The anticipation vector was no longer showing me going straight up but instead aimed off to the side by about thirty degrees. "Fog of war" is a common term for the confusion that can reign when your senses are being flooded. That rocket motor had similarly and ungraciously lowered my IQ to that of a mushroom. I had no intuitive idea whether those snappy predictor gyrations were due to thrust asymmetry, trim asymmetry, unintentional control inputs, or even wind shear. They could maybe be something more sinister, like the start of transonics. If taking a multiple-choice exam, I'd probably select E—all the above.

SIDEBAR

Welcome to transonics. That's the name given to the region between subsonic flight (think airliners) and supersonic flight (where rockets need to go). It's a region that is difficult to model and unpredictable, and so variable that the general idea is to get through it as quickly as possible. That was our plan, anyway. Just for completeness, transonics for *SpaceShipOne* was vaguely defined as the region between Mach 0.80 to 1.3 or so. Mach is just a fancy name for how fast something is traveling compared to the speed of sound. The frequently used example is that the victim will never hear the bullet that kills him. Why? Because it's traveling faster than the speed of sound.

In the simulator, this problem is handled by reaching over for the yaw trim controller with the left hand and giving it a click or two. Unfortunately, I was still stuck with the belief that I could influence the vehicle's trajectory with the conventional stick and rudder controls. And along with that belief, I concluded it would take both of my hands on the stick to have any influence. So, what would have been my friend, the yaw trim controller, was dismissed. While I could still move the stick, what I wasn't picking up on was the fact that all I was doing was stretching control cables and possibly bending structural components but having no influence whatsoever on *SS1*'s trajectory or attitude. The vehicle had transformed itself from a relatively passive glider to a fire-breathing beast with ugly intentions.

It had all happened fast—within five seconds or so—and my highly trained pea-brain was having trouble assimilating the chaotic dynamics that were rapidly becoming overwhelming.

But before I could rationalize any of that, the anticipation cue careened off in the other direction. Whatever was messing around with me just decided to reverse itself. In the simulator, around the five-second mark, I would report "under control." This informational bit of banter now seemed amusingly naïve. Besides, talking on the radio had just fallen to the bottom of my survival list. I felt like I had just survived two back-from-the-brink escapades

and might outlast this experience when the vehicle's nose snapped left. Please excuse my French, but—Holy sh*t! To those who grew up in airplanes, having the nose wander off in any direction, let alone snap, was part of what most would consider unacceptable behavior and is usually followed by nasty things pilots don't like—like spins. I never wanted to be a cowboy, but now knew how one might feel.

I was now in the heart of the maelstrom, shock waves forming unevenly over the vehicle and in the process having their version of fun with the flight controls. I was starting to feel just along for the ride and couldn't seem to keep the nose tracking with the stick, so I started dancing on the rudder pedals and finally utilized the yaw trim controller. I had a little initial success but soon found myself over-controlling the situation, and *SS1* was back off to the races, as the saying goes. Somewhere I could almost hear Burt in Mission Control saying something cheerful like, "Boy, I bet he's having so much fun!"

And meaning it.

About this same time, my attention returned to the pitch rate of the vehicle, and I was alarmed to see that if I couldn't get it under control—like right now!—I would be on my way to doing a supersonic loop-de-loop. Crikey! That would be very bad and unlikely to impress those who had arrived to see what Burt was up to on the one-hundredth anniversary of the Wright Brother's first flight. So, while still pushing forward on the stick (for no good reason at that point), I also began to trim nose down with the hope of stopping this trend before I ended up in Albuquerque or somewhere.

But with the exertion of high aerodynamic loads on the large tails, the independent electric motors moving those stabilators (stabs) were trimming at different rates. The good news was that all of this trimming helped curtail the pitch rate of the vehicle. The bad news was that the stabs were now asymmetrical, and the effect of that was to start to roll the spaceship. I tried to use more rudder trim, but I was either too impatient, or the rate was too slow to have any effect. I made another stab with the rudders, with no impact, on correcting what I felt was fast becoming unglued.

As the little spaceship continued to do whatever it felt like, my own DNA had taken over, and there was no longer much rhyme or reason to anything that I was doing. From somewhere below me, Mike Melvill (in a low chase aircraft), my other compatriot in this adventure, had keyed the radio and announced, "You look great!"

I loved hearing those words of comfort. Mike is a pretty funny guy, and I enjoyed a brief moment of amusement because his words sounded utterly disconnected from my present struggles.

Back in *SS1*, I was still trying to remain focused, because, from my shrinking vantage point, I was still essentially out of control. In review, Doug Shane had been making all of our previously rehearsed calls, and even now, I can only remember the first one, announcing "five seconds." Apparently, when I start load shedding, the first thing that happens to me is that I go deaf.

By FAA regulation, the engine burn time was limited to only fifteen seconds, so all of this happened at a rapid clip. Even bull-riding cowboys are only required to hold on for eight seconds.

By now, I had tried about every combination of manual and electric trim control available to keep the vehicle on some semblance of a controlled trajectory. I had no idea how long the burn had been going and wondered how long fifteen seconds could possibly last. The vehicle was now cruising along at Mach 1.2, which was one for the record books, but I was losing confidence that I could keep it up much longer.

It was about at that point that I noticed something flashing. Red lights flashing. Those were the annunciating lights from the automatic shutdown device of the motor, which had been programmed to snuff the dragon after the allocated fifteen seconds.

The next thing I knew, I was straining forward against the shoulder harness at minus one and a half Gs. With the motor suddenly shut down, the dominating effect was now the aerodynamic drag acting on the vehicle, causing this reversal of G forces.

Whew, I thought for a moment, it's over.

I was wrong.

Although the vehicle was still climbing, it was also decelerating and back on its way through that same nasty gauntlet of transonics that I had so much fun with just moments before—to maintain Burt's view on these things. Preparations for this flight had been extensive despite the limited capabilities of our simulator. However, this sudden reversal back through the dark valley of dancing shock waves was not something I had thought through. In hindsight, it was a surprising neglect, and now it was déjà vu all over again.

It was somewhat subtle at first, but from the back of the cabin spread a welcome peacefulness, laying its gentle hand over the head of the bull, and calming its agitated state. The craft, while still climbing, had decelerated through all of the transonic stuff, back into the well-understood and predictable subsonic environment. While troubled dreams are my stock and trade, once in a blue moon, I get the delicious other kind where I can fly. Not Superman zipping-around flying, but a much more sublime skill where, if I concentrate just right, I can drift up off the floor and, with some magic mix of karma and thought, float on up into the sky. The tail end of the previous thrashing I had endured was a lot like this—a welcome reprieve from the harsh, sharp teeth of that motor and the gremlins of transonics. By then, the little ship had rolled over, upside-down, into an inverted, zero-G climb, and, just like that dream, I was set free of my troubles, and for about ten seconds, I watched the earth gently drift away below me in the cradled peace of weightlessness.

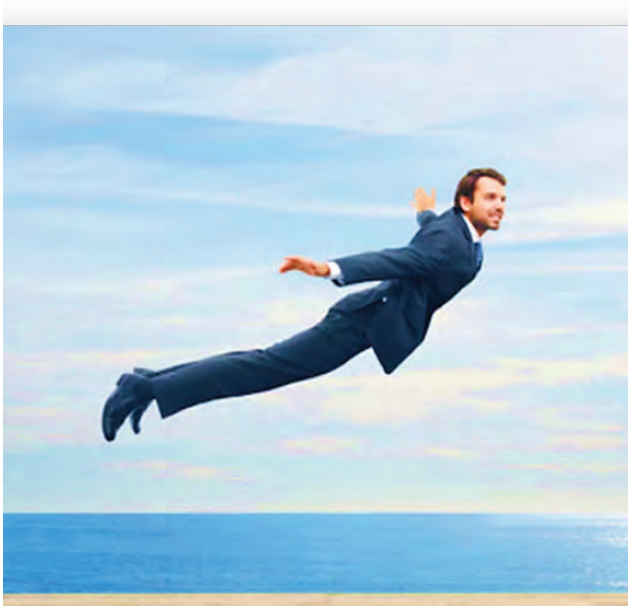


Figure 2: The Wonderful Feeling of Falling Up.
Image from Spirita and Dreams—Spirita.blogspot.com

It was a brief preview of the intoxicating experience I hoped to experience later as the program matured.

And now there were about seventy-thousand feet registered on the altimeter. I was relishing the new quiet of the cockpit, which is when I noticed that I was breathing rather hard. I remember reading somewhere that X-15 pilots had had their heart rates measured near two hundred beats per minute, and now I knew why. For the first time since I remember saying "mark," I was able to collect myself to key the radio and report "that was quite a wild ride from Mr. Rutan."

I converted the vehicle into what we called the "feather" configuration—literally breaking the vehicle in half—while the ship was

still upside down and opened the forward dump vents to deplete the remaining nitrous oxide from the main oxidizer tank. The vehicle rolled upright in a graceful fashion. But instead of settling into the familiar feather mode, I had experienced on my previous flight, it picked up a vigorous roll oscillation, bouncing between thirty degrees left and right like a metronome. Later it was concluded that the nitrous vents, at the root of each wing, were blowing along the leading edge of the surface and exciting the motion. It was yet another concerning development, and it wasn't apparent that the oscillation wasn't building. *It sure would be nice to have one thing go normal without a big surprise attached to it.*

As the nitrous eventually ran out, the lateral motion stopped, and the feather "elevator mode" returned, where the vehicle's configuration seems to be confusing for both the craft and the pilot. I thought of it as similar to falling in a bathtub. Now descending through about forty-five thousand feet again, mission control concurred that it was time to unfeather and reconfigure the vehicle back to a glider. The wing was locked back down around thirty-five thousand feet, and I enjoyed a relatively leisurely descent down into the landing pattern.

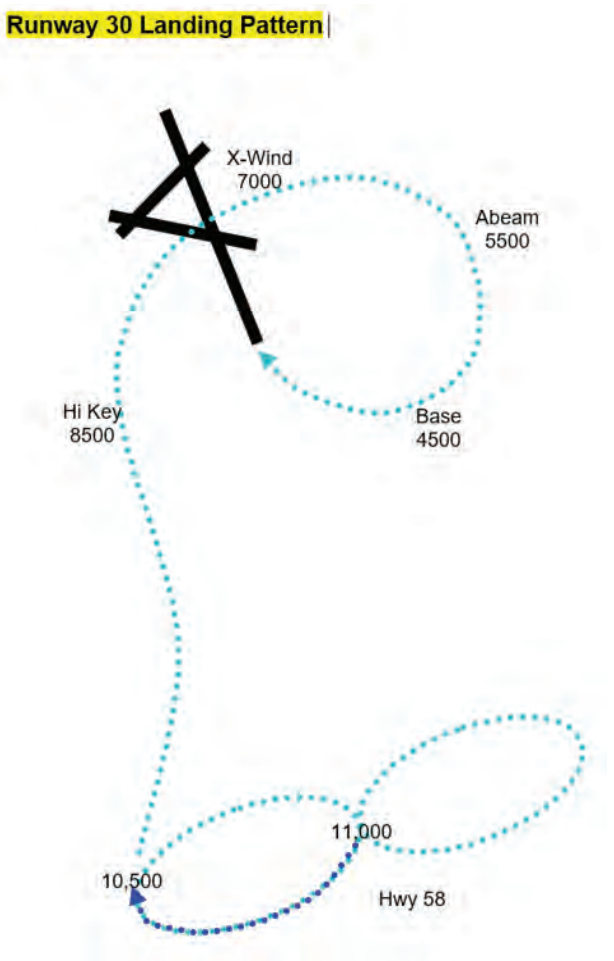


Figure 3: 11P landing pattern.

I was flying pretty much the same pattern used in my previous flight; Mike was on my right-wing, flying an aerobatic aircraft known as the Extra 300. He was there to provide assurance, and in the end, some wheel-height calls. We made a couple of radio exchanges, and things were looking sweet. I got a good start at hi-key and was still looking good at lo-key. Then through the 90 with plenty of altitude, gear to go and now three green. There were some eleven thousand feet of concrete in front of me to land. Mike honored the occasion with "congratulations," and a comical "cleared to land" as though—now a glider—I had any other options.

Mike had a sense of humor that could leave me in stitches, and I couldn't help but appreciate his current commentary as the final stages of this milestone flight was coming to a close. I admit that during the previous months of work, study, and preparation, there were a few moments when I indulged and imagined that it was all over, and things had pretty much worked out as planned. This would be a stretch since it was viewed as the highest-risk flight of the program; even Doug Shane estimated it to be five to ten times riskier than any other. So, for the most part, we would consider the day to be a success if we just got the motor to ignite.

That we had turned the corner by going vertical, achieved supersonic speeds, and recovered nicely with the unique feather configuration was really, well, way over the top. The culmination of this flight was going to be a great day

for everyone who had worked so long and hard on the program. There would be a well-earned and enjoyable sense of accomplishment and achievement to be played out and enjoyed not only by the Scaled Composites staff but by all of our supporters who had come to Mojave to see the sights that SS1 might bring their way. Burt's vision for the last six years, arm-in-arm with our benevolent financial angel, Paul Allen—who had made his presence known for the first time—would punctuate the event with an exclamation point!

It was, after all, December 17, 2003, the hundredth anniversary of the Wright Brother's first flight at Kitty Hawk that marked the birth of aviation. We were now in the arena, proclaiming that privately financed entrepreneurs could provide the same incentive to the world of aerospace. It was all starting to look like it was going to fall ever so nicely into place like some storybook ending where good prevails, and the darkness is swept aside.

There was magic in the air.

That is, until I crashed *SpaceShipOne*.

It was then that the other side of the coin came sneering at me very personally—the menace.