The Other Guys

NASA needs a space taxi. The likely pick is SpaceX — but don't count out this Colorado company.

BY MICHAEL BEHAR

STANDING BESIDE Dream Chaser, it's hard to ignore its resemblance to the space shuttle. It's smaller—only 30 feet long from nose to tail—and the wings are upswept and canted. But in overall shape, the kinship is clear. Still, the company building this vehicle says it is not trying to make Shuttle 2.0. "We're not fixing all the shuttle's problems," avows Jim Voss, the avuncular vice president of Sierra Nevada Corporation's Space Exploration Systems division. "We're an evolutionary step from the shuttle, taking everything we learned from it and applying that to our vehicle to take [spaceflight] to the next generation."

Voss himself is a familiar figure from an earlier era of spaceflight. A former astronaut, he flew six shuttle missions and spent 163 consecutive days on the International Space Station. Now 63, he says: "I've retired three times already." When we met last November at Sierra Nevada's headquarters in Louisville, a bedroom community near Denver, he said, "I believe we're doing something important for our nation. It's the opportunity to get the United States back into launching humans into space."

Voss showed me around the bay where Sierra Nevada is constructing Dream Chaser, a seven-passenger reusable spaceplane that, if it is selected by NASA, would be carried to space atop an Atlas V rocket. After decoupling from its launch vehicle, Dream Chaser would ignite its engines to reach its final destination. It's capable of docking with the ISS, or performing a variety of multi-day missions in low Earth orbit, then returning home in a glide to a runway landing. While Dream Chaser is based on a long-established aerodynamic concept called a lifting body, it incorporates numerous innovations never before used on a manned orbital vehicle, including hybrid-fueled engines and a carbon-fiber fuselage.

With Dream Chaser, Sierra Nevada hopes to win the contract for NASA's Commercial Crew Integrated Capability program, a partnership between the space agency and commercial aerospace firms. The primary aim of the program is to furnish NASA with a reusable vehicle that can ferry astronauts to and from the ISS (cargo will also travel aboard commercial rockets). It will be the first time the U.S. government will hire a private entity to transport astronauts into space.

For the contract, worth up to $1 billion, Sierra Nevada is competing against two heavyweights pursuing conventional capsule designs. Boeing, the most experienced aerospace contractor in history, having had its hand in virtually every human spaceflight system flown by the United States, is developing the CST-100 capsule.

Opposite: Vying for the job of first commercial astronaut hauler, Dream Chaser got put through its aerodynamic paces last year when its maker, Sierra Nevada, dangled it from an Erickson Air-Crane helicopter over Jefferson County, Colorado. Former astronaut Jim Voss (above) came out of retirement to help lead the underdog effort.

The other competitor is SpaceX, led by billionaire Elon Musk, the entrepreneur who co-founded PayPal and luxury electric-car maker Tesla Motors. On May 25, 2012, the SpaceX capsule, called Dragon, made history when it became the first privately built vehicle to dock with the space station. Though the mission was unmanned, Dragon gave NASA a convincing proof-of-concept demonstration. The winning design (or designs—NASA has hinted it might choose two), set to be announced in May 2014, will proceed to the program's Phase 4, with trips to the space station commencing three years later. To date, NASA has awarded $460 million to Boeing and $440 million to SpaceX, while funding Sierra Nevada with just $212 million.

Why so little? Even though Sierra Nevada is a 49-year-old aerospace corporation with more than 2,100 employees and $1.2 billion in annual revenue, it has never built a crewed space vehicle. The company manufactures navigation and avionics equipment, microsatellites, and various components for other spacecraft. Sierra Nevada's claim to fame is the innovative sky-crane system it built for *Curiosity*, which enabled the rover to safely touch down on Mars in August 2012 (see "Dropping in on Mars," Dec. 2011/Jan. 2012).

Sierra Nevada's lack of experience in crewed spacecraft could be a NASA deal killer. "They've worked on airplane systems and on unmanned space systems but never done human spaceflight," notes James Muncy, president of PoliSpace, an

LEFT: NASA KSC. ABOVE: UNIVERSITY OF COLORADO BOULDER

aerospace consulting firm. Muncy also co-founded the Space Frontier Foundation, an advocacy group for public-private partnerships in space exploration. "This is a new thing for Sierra Nevada, which sets them up automatically as an underdog. They're a credible company, and have put together a good team. But they're not Boeing and they're not flying something now. By definition they're behind."

Voss, who leads the 200-member Dream Chaser team, defends his company: "We've flown 4,000 things on over 413 different space missions and we've never had a failure." And Dream Chaser has already made one successful flight test. In May 2012, a Sikorsky S-64 Skycrane helicopter hoisted the spacecraft aloft, carrying it from the end of a 100-foot-long steel cable. Dream Chaser "flew" for about an hour, doing roughly 115 mph at an altitude averaging 3,000 feet, while dozens of sensors embedded in its composite-fiber airframe collected performance data. A far more critical test occurs later this summer, when Dream Chaser will make its first autonomous flight at NASA's Dryden Flight Research Center in Edwards, California.

"We don't mind people perceiving us as the underdog," says Steve Lindsey, director of Dream Chaser flight operations. Lindsey was a U.S. Air Force test pilot and then an astronaut on five shuttle missions, of which he commanded three, eventually rising to chief of the NASA Astronaut Office. "It forced us to think differently, to think outside the box, to be more innovative, to come up with essentially better, faster ways of doing things, all while keeping our budget pretty low. It's a challenge—doing more with less—but it keeps us fighting."

No one at Sierra Nevada sounds resentful over the fact that the competitors often dominate the media limelight. "Each of the other companies have their place," Voss says. "One is more vocal, more show, and one is the old-school aerospace company. We are somewhere in the middle of that. We are the other guys."

Dream Chaser is the first manned spacecraft made of composite (below, left). Tooling can be changed faster for composites than for metal, so additional vehicles might be turned out quicker. Below, right: Test firing of the hybrid rocket.

THE OTHER GUYS are no slouches. Among the team members is chief systems engineer Stokes McMillan, who forsook retirement to manage Dream Chaser's pilot training program and run its flight simulator. McMillan cherishes his 32 years at NASA—where he trained crews for the first 25 space shuttle missions—but says of Sierra Nevada, "We are given a lot more freedom here." Lindsey goes further, claiming: "We have a team of people who are here not for the money, not for the job. They're here because they believe in what we're doing." I ask Lindsey why he came to Sierra Nevada. "I made the jump from NASA because I liked the Dream Chaser design, I loved the team, and I wanted to change the world," he says.

The team members work in a setting that feels more like a cash-strapped startup than a billion-dollar conglomerate.

The Dream Chaser clan is tight-knit, its members collaborating on the fly in a setting that feels more like a nimble cash-strapped startup than a billion-dollar conglomerate. They often work nights and weekends when up against a deadline. In the company's bay, hand-cranked hydraulic jacks prop Dream Chaser three feet off the floor. A technician is crouched beneath its nose, whistling while hand polishing a section of fuselage with a piece of sandpaper. Inside the spacecraft, on the flight deck, a pair of fuzzy dice hangs from the ceiling. ("They flew on our first flight test and now they are our lucky dice," says Voss.) Vise grips are clamped to bulkhead dividers where makeshift repairs are under way. At one end of the bay—beneath a floor-to-ceiling American flag—are several red rolling Craftsman tool chests, drawers slung open and ransacked.

The effort exudes garage-inventor enthusiasm. You can tell by looking at Dream Chaser's flight simulator: McMillan assembled it almost entirely from store-bought components. "It runs on seven off-the-shelf Dell computers you get at Best Buy," he says. For the cockpit view, "I've wrapped around five commercially available 60-inch plasma screens." At one point, he decided to paint the simulator's fiberglass shell. "I put out some bids and was getting offers of like $5,000 over three weeks. So, heck, me and a grad student went to a paint store and spent $69 on paint and took a weekend and did it ourselves."

For Voss, the project differs vastly from his experiences at NASA. "We move a little quicker here," he says. "The engineering staff is here, our machine shop is here." Just then, a technician rams an object into a bench grinder, filling the room with an ear-splitting screech and the stench of charred metal. "We make decisions in hours instead of weeks or months," Voss shouts over the din. He recounts a story told to him by one of his engineers, who had come to Sierra Nevada from NASA's Orion program, which is developing a crewed spacecraft for missions to the moon and Mars. To approve a single design modification, "he had to go through, I think, about 70 [review] boards and it took almost a year. I can get my management together and in an hour we can make a decision, a programmatic decision, and go on."

The inspiration (left): HL-20, here being tested in 1989 for pitch oscillations. Some HL-20 team members later helped with Dream Chaser. Ken Bowersox (middle), a former astronaut who once worked for competitor SpaceX, sees advantages to Sierra Nevada's hybrid propulsion. Right: A model is prepared for a buffering test.

Dream Chaser's lineage goes back to the very earliest spaceplanes. The concept of a lifting body—an aircraft that generates lift with its fuselage more than with its wings—is often credited to an inventive Austrian aerospace engineer named Eugen Sänger. In the mid-1930s, Sänger conjured up a manned rocket-powered spaceplane with cropped wings and convex belly—features that allow the vehicle to operate both in space, under rocket power, and in the atmosphere, where it behaves like a fixed-wing aircraft.

Sänger, working under Nazi Germany, envisioned a sub-orbital bomber, known as the Silbervogel ("silver bird"), which could zoom through the stratosphere to the edge of space, from where it would drop ordnance (New York City was the intended target), then return and glide unpowered back to Earth. While the Silbervogel never got out of the wind tunnel, it inspired many future lifting bodies, including Boeing's X-20 Dyna-Soar.

Dream Chaser's nearest cousin is the HL-20, a craft designed at NASA's Langley Research Center in Virginia in the early 1990s. (Langley engineers co-opted the design from a photograph of a Soviet spaceplane, revealed later to be the BOR-4.) At least in shape, the HL-20 and the Dream Chaser are nearly identical. (Lindsey says Sierra Nevada "actually brought in a couple of retirees who had worked on the HL-20 [at Langley] to help us.")

"The only modifications we've made are to the wings," says Voss. "Langley had more of a slab wing—an aerodynamic shape that worked really well in the atmosphere but would probably burn off on reentry." Slimming the wings enhanced Dream Chaser's inherent stability, a characteristic that allows it to naturally right itself and restore level flight.

Dream Chaser's shape—its body providing about 50 percent of total lift—is also supposed to make for smoother reentries and cushier landings than the competing designs. During reentry and at touchdown, it reaches just 1.5 Gs. A capsule, on the other hand, can hit the water at a gut-crushing 10 Gs (or possibly twice that if a navigational glitch forces what's known as a ballistic reentry). A low-G ride permits Dream Chaser to carry fragile scientific cargo with a greater margin of safety. "If you don't shake, rattle, and roll as much, you get better science," says Ed Mango, NASA program manager for Commercial Crew Integrated Capability. Drug companies are interested in growing protein crystals in microgravity, explains Lindsey. "You grow these things very carefully in orbit. If you're putting 8 Gs on them, or [they are in a capsule that is] slamming into the water or slamming into land, you can damage that payload" if it is not sufficiently buffered.

Langley engineers got as far as a full-scale mockup of the HL-20. In 2005, SpaceDev, now a subsidiary of Sierra Nevada, licensed the technology from NASA. It was SpaceDev founder James Benson who christened the project "Dream Chaser." (Voss, who admits he didn't love it when he joined SpaceDev in 2007, says the name has grown on him.)

Dream Chaser is a significant advance over the HL-20, boasting numerous features the Langley group probably never could have envisaged. For example, the navigation system permits autonomous reentries and landings: The crew could be completely incapacitated and Dream Chaser will bring them home safely.

And the vehicle will be made with carbon composite—a weave of epoxy and graphite fiber—that is half the weight of aluminum and twice as strong. Though Dream Chaser would be the first manned

SIERRA NEVADA CORPORATION (2)

LEFT AND CENTER: NASA; RIGHT: NASA EDGE/RON BEARD

spacecraft made of composite, Boeing's 787 Dreamliner passenger jet employs carbon composite in nearly half its airframe and has been flying commercially since 2011. The material is also used in unmanned spacecraft. Composite is fashioned in molds, produced much like plastic. Sierra Nevada says it could stamp out duplicate spaceplanes relatively quickly and affordably, each with a 25-mission lifespan and low-cost servicing between flights.

Perhaps the most groundbreaking technology is its propulsion: two hybrid rocket engines, which burn a non-toxic mixture of synthetic rubber and nitrous oxide—yes, laughing gas. Hybrid engines propelled *SpaceShipOne*, and now Sierra Nevada is developing them for both Dream Chaser and Virgin Galactic's *SpaceShipTwo*, which is scheduled to begin carrying paying tourists into space this Christmas. While hybrids aren't a new idea, they have never been used on a manned spacecraft for orbital missions. Because of their simplicity, safety, and reusability, Sierra Nevada believes they are superior to liquid-fueled rockets, such as those used for the shuttle's three main engines. The Dream Chaser's engines work by opening a valve that allows the liquid oxidizer, in this case nitrous oxide, into a combustion chamber packed with solid propellant, the synthetic rubber. Once in the chamber, the pressurized nitrous expands and converts to vapor. When an ignition switch in the chamber fires, the rubber combusts, ejecting hot gases through the exhaust nozzle to generate thrust.

Ken Bowersox, an astronaut on five shuttle missions who would later serve two years as a vice president for SpaceX, says, "The nice thing about a hybrid engine is that if the oxidizer just spills out, you're not necessarily going to get a fire." Bowersox is alluding to a potentially deadly hazard associated with so-called hypergolic fuels, in which the oxidizer and propellant ignite by chemical reaction: Merely mix them and they go boom. On the shuttle, "hypergols" fueled secondary engines and thrusters responsible for on-orbit maneuvers. "With hypergolic propellants, if you get a leak in one tank, they are pretty corrosive—the stuff is nasty—and it could do damage to the equipment that's near it," explains Bowersox. "You can get into a situation where you get a fire or an explosion."

Hybrid fuels are safer to handle too. "We call them 'green' propellants," says Lindsey. "The hydraulics on the shuttle were driven by auxiliary power units that used hydrazine, which is a dangerous chemical. If you ever watched the shuttle land, it would be probably 30 minutes before anybody could walk up to the vehicle. People would be in special suits to protect them. Our vehicle, when you land, you can walk right up to it because we don't have any of that on board."

Not everyone shares Sierra Nevada's enthusiasm for hybrid engines. In 2007, an explosion killed three employees at Scaled Composites, the company building *SpaceShipTwo*, during a test using nitrous oxide. The cause of the detonation remains a mystery.

"The oft-repeated claim that hybrids can't blow up is a canard—they can and do," says Gary Hudson, president of the Space Studies Institute in Mojave, California, and an expert in reusable rocket design who has founded several commercial space companies. "One problem some hybrids have is ejecting a chunk of fuel near the end of the burn that can momentarily block the nozzle throat, leading to a pressure spike that can result in a case rupture." Says Bowersox, "A hybrid doesn't worry me more or less than any other rocket. Any type of engine is intolerant of sloppiness."

Still to be resolved: whether Dream Chaser's hybrids can eliminate "black zones"—periods during flight where an abort would entail losing the vehicle and possibly its crew. During the shuttle's first two minutes off the pad, solid rocket boosters helped lift it. "We could never lose one and survive," Lindsey says. "They both had to fire all the way to the end of their trajectory." Mango puts it this way: "If something happened in those first two minutes [on the shuttle], we didn't have any way of really saving the crew." But unlike the shuttle, which had an expendable external tank—the big orange beast—feeding fuel to its main engines, the hybrid rockets on Dream Chaser will be self-contained. If a launch malfunction occurs—even during countdown—Dream Chaser can ignite its hybrid engines and escape catastrophe. "Our [commercial crew program] requirements say you must be able to always abort and get to a landing site," says Mango. "Because of its design, [Dream Chaser] is able to do that right from the pad." In this scenario, explains Lindsey, "the hybrid rocket motors would fire and run us up to roughly 20,000 feet. We would come off that, go over the top and into a glide to land back at the Shuttle Landing Facility" at NASA's Kennedy Space Center.

The scenario seems unlikely, given that the Dream Chaser's launch vehicle, the Atlas V, "has 104 [missions] in a row with no failures," Lindsey says. Assuming all goes well, Dream Chaser will arrive in low Earth orbit with two fully fueled engines. In addition to its activities with the International Space Station, Dream Chaser will retain enough power to take on other tasks. This is something the shuttle could never do: At 70 miles high, it ditched its external fuel tank, at which point the main engines became nothing more than dead weight. As for what, specifically, Dream Chaser will accomplish with all that extra fuel, "I'm thinking military applications," says PoliSpace's Muncy. The vehicle could also be used for satellite repairs, servicing the Hubble Space Telescope, or any "activities that should be done with a human in the loop," says Mango. Tourism? "It's one of our future missions," says Voss. "We'd like to use the Dream Chaser as an orbital tourism vehicle. It can carry seven people for several days. And there is a ton of room [inside] to play around, to fully experience the micro-gravity environment and floating—the kinds of things that people would want to go to space for."

Leaving home: Last spring, Dream Chaser was hauled to NASA's Dryden center in California for advanced testing (left). Above: Rex Walheim was one of four astronauts to simulate a landing.

LEFT: NASA/TOM TSCHIDA; RIGHT: NASA/DAVID C. BOWMAN

An artist's conception of Dream Chaser atop its Atlas V launcher and ready to set off, perhaps for the space station (left). Above: Newly arrived at Dryden. This summer and fall, engineers will test the vehicle's flight and runway landing systems.

LEFT: NASA; RIGHT: GETTY

AT SIERRA NEVADA, McMillan sets me up in the flight simulator's commander seat, the control stick on my left. He flips a switch and suddenly Dream Chaser is pitched forward in a steep dive, doing 300 knots at 12,000 feet, with Cape Canaveral approaching fast. The spaceplane is hyper-responsive; the slightest twitch can knock it off axis. McMillan, who is sitting at a computer station a few yards away, is talking to me through a headset. He warns, "She'll roll quickly, like a fighter jet."

At 3,500 feet I spot the runway where *Atlantis* rolled to a stop on July 21, 2011, culminating the shuttle program, with its 135 missions spanning three decades. I give the stick a gentle tug backward to level out, drop the gear, and ease Dream Chaser down. Now *that* was fun.

After a session on the simulator, it's easy to grasp the deep yearning to command a spaceship back to Planet Earth like a sovereign mariner returning from an epic voyage on the high seas. It's too early to decide who would fly Dream Chaser, but for the inaugural mission, I'd bet it would be Voss or Lindsey—both are keen on piloting the spacecraft. But first, Dream Chaser will have to prevail over numerous tests—some of the toughest now under way at Dryden, where Dream Chaser was taken in May.

Flight tests include high-speed runway tows to check landing gear, brakes, and tires. Engineers will perform a ground resonance analysis, which looks at how vibrations affect the airframe. And they'll do another helicopter captive carry. If all goes well, Dream Chaser will attempt its first free flight. The plan is for the Skycrane to release a pilotless Dream Chaser at nearly 20,000 feet, at which point the spacecraft will engage its autonomous landing system and glide back to the airfield at Edwards.

Success at Dryden—particularly during the free flight—will lead to piloted tests. That day can't come too soon for Voss and Lindsey and the rest of the Dream Chaser team. Keeping humans in space "is a huge motivator for me," says Voss. Lindsey puts it this way: "I struggle with the fact that the U.S. is out of the human spaceflight business. I want to do everything in my power to see that we get our nation back into it."

See video at *airspacemag.com/SNDC*