The 36,201 FT *(deep)* Man

It was one of the last great feats of exploration: Diving alone, in a sub, to the bottom of the Mariana Trench. For three years the quest consumed an idealistic engineer and a single-minded record-setter. This is their untold story.

BY ANDY ISAACSON

PHOTOGRAPH BY DOUGLAS ADESKO

THE MAVERICK Engineer Graham Hawkes and his team show off their latest invention: *Super Falcon.*

THE 36,201FT (deep) MAN

WHEN STEVE FOSSETT strapped himself inside a two-seat stunt plane and took off into a bluebird Nevada morning on September 3, 2007, he was on the verge of his most remarkable achievement. The famed aviator, the only person ever to travel around the world nonstop and alone by both plane and balloon, was in the final stages of planning a journey to the deepest part of the Pacific Ocean. If successful, he would be the first to reach the bottom of the Mariana Trench—36,201 feet down, 190 miles southwest of Guam—since U.S. Navy Lt. Don Walsh and Swiss engineer Jacques Piccard in 1960. The consummate record-setter, Fossett wanted to gain the spot, called Challenger Deep, alone.

At the start of the project, there wasn't a submersible in the world that could dive much below 21,000 feet. The water pressure at the bottom of the ocean is a crushing 16,000 pounds per square inch, nearly the atmospheric pressure on the surface of Venus. Fossett's search for a sub capable of withstanding those conditions led him to an engineer named Graham Hawkes. After a career at the forefront of deep-sea exploration, the British-born Hawkes had begun work on a new type of submersible, one that cruised through the ocean more like an airplane than a hot-air balloon, as traditional subs do. He had successfully tested three prototypes on shallow missions, setting a solo dive record of a thousand feet in the process. But in an age of robotic exploration, he had struggled to finance his manned projects.

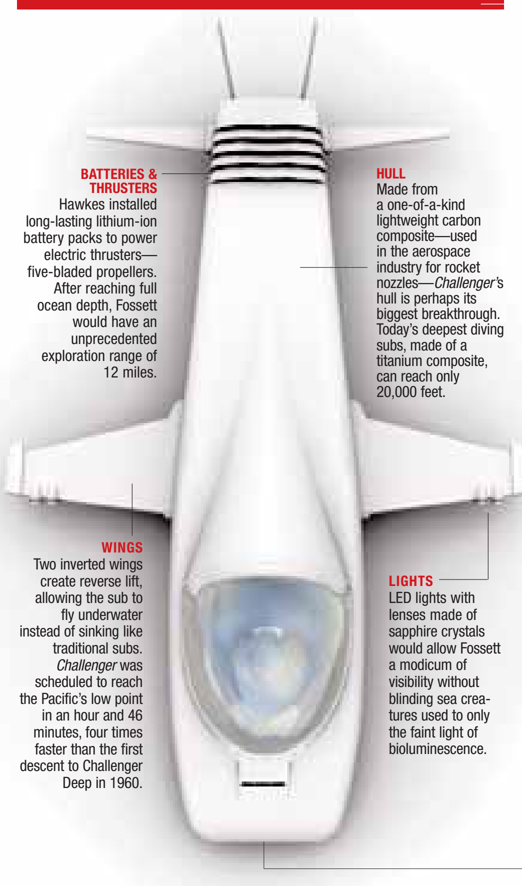
Fossett first called Hawkes in early 2000. It was apparent from the start, however, that the two had conflicting agendas. Most notably: Hawkes wanted to be in the driver's seat. "Look back to the early days of aviation," he says. "The guys designing the aircraft were the same guys building it and the same guys flying it. The whole challenge was one ball of wax." Hawkes offered to build two subs—one for himself and one for his client—but Fossett declined. He wasn't interested in a Walsh-Piccard reprise. ("I'm not a passenger type of person," he once said.) Hawkes then offered to test the sub fully before handing it over to Fossett. "That probably ended any chance of our becoming buddies," Hawkes recalls. Fossett responded with a wry smirk and insisted on retiring the machine to the Smithsonian after a single deep dive. A deal could not be reached.

It took more than four years for Hawkes to reconsider his position. "Ultimately, Steve was right," he says. "His argument was, 'I'll get the record, you'll get the technology.' I came to realize that that was fair." Hawkes reached out to Fossett in November 2004, and the two met at Fossett's palatial vacation home in Carmel, California. "We presented Steve with various records that I felt we could help him break in addition to Challenger Deep, but he was only interested in the big one," Hawkes says. "He liked that this would be a record no one could ever beat." They agreed that Fossett would finance research and development of the sub, called *Deep Flight Challenger,* after the Royal Navy vessel that surveyed the trench in 1951. Hawkes would own the intellectual property. Fossett would get the record. The project would be kept secret until the very last minute.

HAWKES OCEAN TECHNOLOGIES occupies a modest, low-lying office complex in a marina on the San Francisco Bay. The workshop, a cluttered 2,000-square-foot space, resembles the stockroom of an air and space museum, with cold cement floors, shelves stocked with parts, and a few computers rendering CAD drawings. Hawkes's first breakthrough, *Deep Flight 1,* rests by the door. Sleek and lightweight, with a pair of stubby inverted wings, the microsubmersible dove to 3,000 feet in 1996, laying the groundwork for *Challenger* a decade later.

Deep Flight *Challenger*

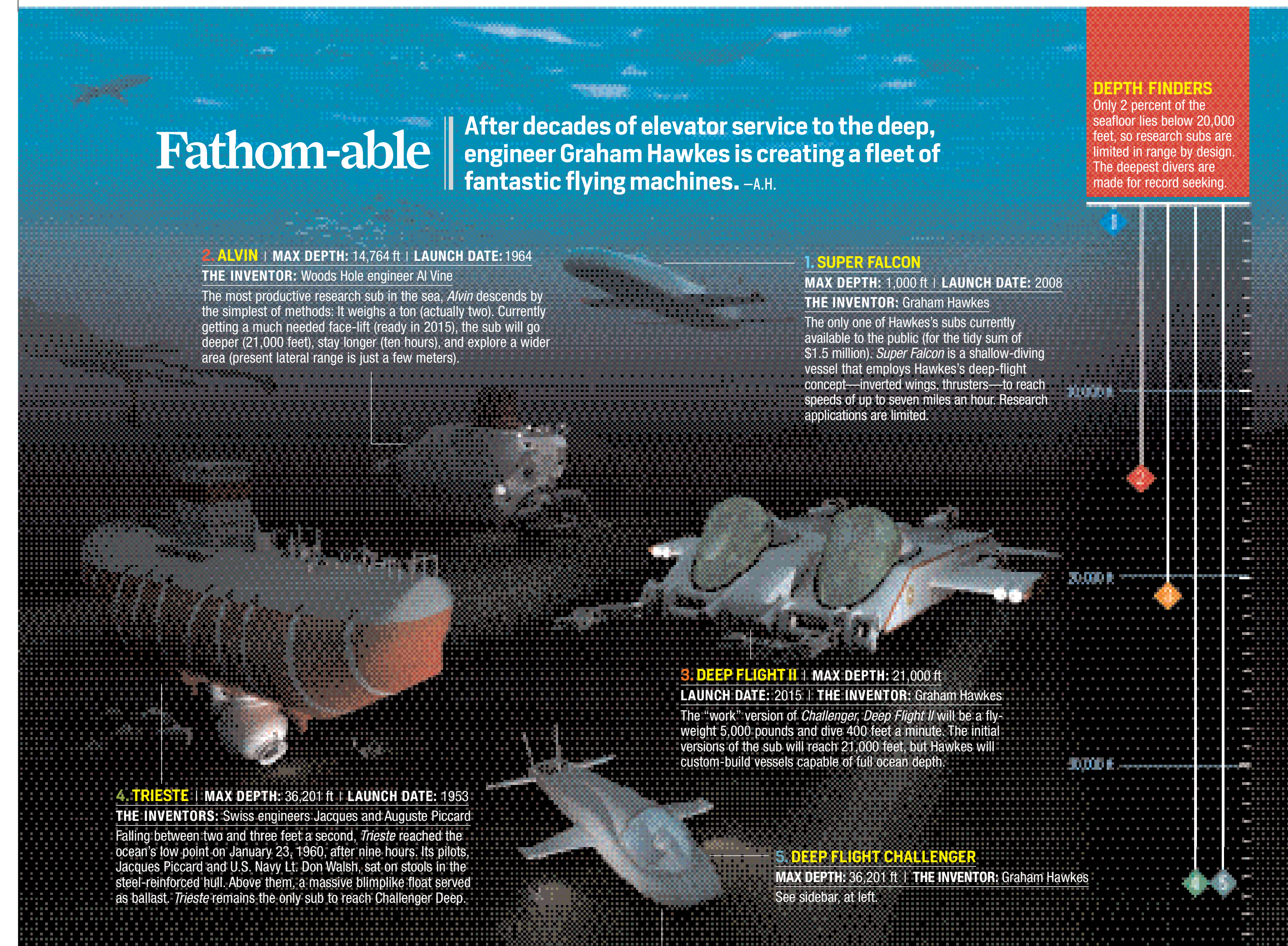
Three years in the making, *Deep Flight Challenger* was intended for one purpose: transporting record-seeker Steve Fossett (right) to the bottom of the Pacific Ocean. Designed by Graham Hawkes, *Challenger* uses stubby inverted wings to "fly" through the water, descending at speeds of 350 feet a second. Many of the craft's most stunning advancements, including its body materials and thrusters, have been incorporated into Hawkes's later designs (see "Fathom-able," at right). –ANNE HAY



On the day I visit, Hawkes is dressed casually in a sweater and jeans, with disheveled hair and a couple days' worth of stubble. The 61-year-old engineer doesn't care much for chitchat, preferring instead to occupy his mind with the task of solving problems. "We can be at a dinner party," says his wife, Karen, "and I'll look over at Graham, staring off into the distance, using his hands to shape something in the air. When I ask him where he is, he'll say he just designed a critical part of a submersible." On his first ski trip Hawkes was so unhappy with his boots that he devised a new pair. He is chronically searching for his car keys, wallet, and glasses, Karen says, devoting little mental space to "the mundane details of life."

A born engineer, Hawkes wasn't always interested in the sea. But after graduating from England's Borough Polytechnic Institute in 1969, he saw opportunity in the deep and took a job designing underwater swimmer delivery vehicles for the British Special Forces. "Ocean engineering was so backwards that I knew I could just make leaps and bounds," he says. In 1979 Hawkes invented the Wasp, an atmospheric diving suit for offshore oil workers, and in 1981, the *Mantis,* a microsubmersible with mechanical arms. Throughout the 1980s he designed multiple versions of *Deep Rover*—one of which was used by owner James Cameron to film *Aliens.* But after creating more than 60 robotic

PHOTOGRAPH BY BART NAGEL. INFOGRAPHICS BY EMILY COOPER



microsubs for the offshore oil and gas industries, Hawkes shifted his focus to manned submersibles. He wanted to go underwater himself.

The world of manned ocean exploration has long been dominated by a handful of government-backed oceanographic institutions operating five subs. The Russians own *Mir 1* and *2;* France, *Nautile;* the Japanese, *Shinkai 6500.* (China has also reportedly neared completion of a submersible that could reach 23,000 feet.) The U.S. Navy maintains the oldest and most productive vessel, *Alvin,* a three-person sub built in 1964 and operated by the Woods Hole Oceanographic Institution. All of these vessels work in much the same way: A devoted support ship drops the heavy sub overboard. Loaded with steel weights, the craft sinks. After the scientists inside do some close-range exploring—*Alvin's* current floor time is around four hours—the pilot jettisons the weights, and the sub surfaces.

In Hawkes's view, these submersibles are like mainframe computers, too heavy and expensive to be practical. (*Alvin,* which Woods Hole is spending $21 million to update, weighs 35,200 pounds and requires a crew of 30.) Hawkes blames the subs' design (or lack thereof) for the sorry state of ocean exploration. "We've explored 5 percent of the seas—at best," he says. "I love *Alvin,* but who dreams of diving in an underwater elevator?" Hawkes's deep-flight concept is his answer to the status quo. With inverted wings and five-prop thrusters, the subs weigh one-seventh as much as traditional manned submersibles, travel seven times as far, and cost much less to own and operate. According to Hawkes, they also "bridge the imagination gap" for a new generation of private underwater explorers. "There is something about the freedom to fly that strikes a chord with the human spirit," he says. "People intuitively understand it. It sets them daydreaming."

In Fossett, Hawkes found a kindred spirit, someone who immediately understood the value of his flying submersibles. He also found a piggy bank for what he now calls his "era of experimentation." "I always thought that building a sub to go to full ocean depth would be what I'd do when I was 90," he says. "For a submersible engineer, reaching 37,000 feet is the holy grail."

DURING THE FIRST MISSION to Challenger Deep, Piccard and Walsh dove in *Trieste,* a then revolutionary bathyscaphe designed by Piccard's father, Auguste. But after a four-day journey to the dive site through rough Pacific seas, the vessel wasn't in top form. "[It] looked like a victim of battle rather than an undersea laboratory," Piccard wrote in the August 1960 edition of *National Geographic.* Confined to a 50-foot-diameter spherical hull, Piccard and Walsh descended "at the speed of an elderly elevator," sitting on stools and eating Hershey's chocolate bars. Suddenly, at 32,500 feet, they heard a sharp cracking sound; the cabin trembled. "Could we have encountered an undersea monster?" Piccard asked. "Could it be shrimps?" (It was a damaged Plexiglas viewing port—not life threatening.) After nine hours, *Trieste* landed with a thud on a layer of diatomaceous ooze. It was, as

The sub *breached* the surface like *a whale.*

Piccard wrote, "a region of eternal calm, an immense mysterious domain where the fish of the deeps open their avid eyes in the darkness." After spotting a foot-long fish with round eyes on the top of its head, and red shrimp, they dropped lead pellets and returned to the surface.

Fifty years later, *Challenger* had a far more graceful flight plan. *Cheyenne,* the catamaran that Fossett sailed to an around-the-world record in 2004, was retrofitted to ferry the ultralight sub from San Francisco across the Pacific to the Mariana Trench. Strapped stomach-down, Fossett would fall aggressively at seven miles an hour in a thousand-foot-wide spiral. After one hour and 46 minutes, an acoustic beam would detect the seafloor nearly seven miles down. A hundred and fifty feet before touching bottom, Fossett would flip a switch, the lead weights would drop off, and the craft would become slightly positively buoyant—lighter than the water it travels through. By activating the sub's thrusters, Fossett could explore up to 12 miles of the seafloor and locate the absolute deepest spot on the planet.

If *Challenger's* descent was straightforward, its construction was anything but. To limit costs, Hawkes scavenged for parts. He bought lithium-ion batteries in China similar to the one used in the Tesla electric car. He covered the wing lights in repurposed sapphire crystal. For buoyancy, he custom-ordered blocks of syntactic foam, an epoxy embedded with billions of microscopic glass spheres. "Cost a fortune," Hawkes says. "Only half a dozen companies in the world build deepwater flotation, but they had never been this deep. We said, 'We'll give you the contract if you'll give us some samples.' Three of them couldn't resist the challenge."

Designing the hull presented the greatest hurdle. At 36,201 feet deep, the sub would have to withstand 16,000 pounds of pressure per square inch. The *Trieste* survived the crushing force by brute strength: Its spherical hull was reinforced with thick steel walls. Most conventional submersibles today, including *Alvin* and *Shinkai 6500,* use lighter titanium, but the material can't handle pressures much below 20,000 feet. Hawkes would need to design a new composite material four times stronger than titanium.

Fortunately, Hawkes knew that a U.S. Navy scientist named Jerry Stachiw had been secretly working on the same problem at the National Deep Submergence Facility, in San Diego, two decades earlier. At the time the Navy was interested in developing lightweight, cylindrical hulls for unmanned vessels that could dive below 20,000 feet, and Stachiw had researched different composites, including ceramics, glass, and carbon. Hawkes called up Stachiw, since retired, and asked him to be a consultant on the project. "It just happened that the diameter of the cylindrical hull we were looking for was very close to the one Jerry had been developing," says Hawkes. "So we picked up where he left off. We'd just need to push the strength of materials another 10 to 20 percent and we were home free."

Hawkes subcontracted the hull to a company in California that builds composite materials for industrial applications. "They were very, very confident," Hawkes recalls. "I gave then a set of numbers. They gave me a margin that they expected to hit. But they didn't get there. It was just failure after failure."

ONCE A MONTH Fossett drove up from Carmel to check on *Challenger's* progress, usually arriving in some exotic car—an Aston Martin, or a Mercedes McLaren—that Hawkes's engineers took great interest in. Fossett was accustomed to delays in his projects, and his feelings about the sub's setbacks were inscrutable. "There was no small talk," Hawkes recalls. "I'd say, 'We had a failure here, and this is what we need to do to fix it.' He'd just sit there and"—Hawkes nods his head up and down—"seem to agree, but you had no idea."

By age 63, Fossett, who built his fortune as an aggressive commodities trader, had set 115 new world records. His public image was that of a balding, paunchy man standing alongside expensive machines in jumpsuits. (Richard Branson once described him as "a sort of half android, half Forrest Gump.") There was Fossett in a gray outfit after completing his solo, round-the-world hot-air balloon journey; in a yellow suit, next to the glider he flew into the stratosphere; in a white Virgin Atlantic onesie, waving beside the single-engine jet aircraft in which he circumnavigated the globe, nonstop, on one tank of gas.

But whatever drove Fossett to devote himself so completely to record setting remains a mystery. Publicly, he was demure. "I have a very low boredom threshold," he once said. "It's internal. It doesn't lend itself to explanation." Will Hasley, co-author of Fossett's autobiography, suspects that an explanation lies in Fossett's roots as a Boy Scout (an organization he supported throughout his life, serving on the national board). "I think part of his drive as an adult was still as a Boy Scout getting merit badges," Hasley says. "Only the merit badges were world records."

Hawkes recalls Fossett's single-mindedness vividly. "I remember thinking, It's such a shame that the guy writing the checks doesn't get satisfaction out of the process," he says. "We're engineers, so there is pleasure in the process. The guy's so focused, all he wants to hear is, 'We're done, we're moving on.'"

Engineer and financier danced around differences in style—Hawkes pushing for more flair, Fossett reining him in. "I'd say, 'Well, if you're going down there, let's not put on blaring lights and destroy the eyeballs of all the creatures. Let's try something more subtle.' And he would ask, 'How much would that cost?' Steve was adamant that he did not want to pay for unnecessary R&D. He was singularly focused on his record. Which meant getting down and back safely"—Hawkes corrects himself—"no, getting down alive. I would now, knowing him, drop the word 'safely.'"

As the project progressed, Hawkes tried to convince Fossett that *Challenger* meant more than a record. "We'd sit at lunch and I'd say, 'Steve, if you look at the path of human development: We had to explore the continents. We had to sail across the seas. We had to go into space. And we have *(Continued on page 75)*

LIFTOFF Hawkes pilots *Super Falcon* in the San Francisco Bay.

PHOTOGRAPHS BY ANDY ISAACSON

(Continued from page 52)

to go down there. Circling the globe on one tank of gas is optional. Circling the globe in a balloon is a brilliant, beautiful piece of science art, but it's optional. Getting human access to full ocean depth is not optional.'

"He began to agree with me, but perhaps he was already heading there. To take credit for influencing Steve Fossett," Hawkes chuckles, "is a little optimistic."

A YEAR INTO the project, Jerry Stachiw, the hull consultant, died. A year later, with millions invested, Fossett was growing impatient. He wanted to press forward by eliminating safety precautions required for commercial subs. "An escape for the pilot is mandatory for anything you sell," Hawkes says. "We didn't build one. Steve didn't want any costs associated with a likely unnecessary."

Hawkes wanted to continue testing the materials' strength. The carbon composite hull had successfully reached a safety factor of 1.5 (the American Bureau of Shipping strength and performance standard for commercial vessels), but Hawkes hoped to reach 2. "I wanted this thing to be bulletproof. But Steve said, 'No, we've spent enough money, go with what you've got.'"

To those who knew him, Fossett was not a daredevil. He was meticulous and methodical, and he carefully planned his endeavors to minimize risk. "Everything he's done, he's taken a calculated risk with," Richard Branson has said. But this was not the first time Fossett disagreed with his engineer about safety. According to Hasley, the record-setter and Burt Rutan debated the readiness of Virgin Atlantic, the single-engine aircraft Fossett piloted around the world in 2005. Rutan, the engineer, wanted another six months of testing. "Steve said, 'I know that the plane is safe enough. You've minimized the risk enough for me to take possession of it.' Steve would do his own rating of the risk level he was willing to take. He would sometimes believe, OK, this is the safety I need to feel comfortable."

In May 2007 *Challenger* was ready for its first full-scale trial. Hawkes secured a test facility at the Applied Research Laboratory Building at Penn State, where the Navy tests torpedoes. Hawkes and his team of six were there, as was Fossett. In previous tests the engineers had built scale models to evaluate material strength. Implosions would occur without warning, jolting the ground and rattling their nerves. This test would simulate a depth of 37,000 feet with 16,000 pounds per square inch of pressure. It was late in the day when *Challenger* was lowered into a tank, its systems running, lights flashing, and life support systems in full operation.

Everything appeared to go smoothly. The hull survived, intact. But as the sub was lifted out of the tank someone noticed a small crack in the glass observation dome. It was, Hawkes reflected, "a spectacular failure." Fossett was stoic. Hawkes was perplexed. "The data from the test was difficult to understand," he says. "Some of it was so anomalous that I dismissed it. Steve wanted answers right then, and I didn't have them. It was intense. We were all shell-shocked."

Hawkes was desperate to figure out why the glass had failed, but it wasn't until the next morning, once Fossett had left and his team had gone to the facility to dismantle the sub, that he had a moment alone to review the data. "OK, Graham, I said, supposing this anomalous stress pattern data wasn't anomalous but was real. What could that mean? Suddenly this lightbulb went off in my head: *Oh my God.*"

It occurred to Hawkes that if the glass dome sealing the hull was beveled and did not sit flush on its titanium base, the pressure would have been distributed unevenly, causing the dome to crack. "They're about to dismantle the sub and we'll never know, so I ran a quarter mile to the facility and beat the hell out of the door. I couldn't speak I was so out of breath. I said, 'Don't dismantle this thing, I've got to get inside!'"

Challenger was still dripping wet. Hawkes needed to climb into the cockpit to check if there was space between the dome and the titanium rings. "I figured if the gap was four-thousandths of an inch or more, that would account for it. The guy that runs the place was dubious. He lifted the glass and I climbed inside and said, 'OK, put the glass back on.' They're like, 'You don't have life support, are you gonna be all right?' I said, 'Put the freaking glass on. I'll give you hand signals!'"

Hawkes, now reclining inside the hull, fished for a dollar bill in his pocket. "I couldn't see the gap, so I wanted to see if I could poke a bill in between the rings. And damned, it went in. So I got another one. If two got in, that was a big problem. Two went in. I didn't have any more dollars. I got them to open the glass. 'Anyone have a dollar?' I asked. They're all fussing for bills. Well, I got seven of these things in."

The error was an embarrassment for Hawkes—a manufacturing issue, not a design failure—but it would set the project back several months and hundreds of thousands of dollars. "Steve was really disappointed," Hawkes says. "I thought it was over. But at that point he was more interested in time than money."

Fossett, having now spent $3 million, was eager to manage the project more closely. "He saw his risk areas as the design and testing," Hawkes recalls. "He would consistently ask, 'Is the design done?' When I said yeah, he said, 'Well, the job of your team is kind of done.' 'Like hell it is,' I said. 'The devil's in the details.'" Fossett eventually fired the project manager. "That kind of made matters worse," Hawkes says. "Still, I was surprised about how it went forward with him micromanaging. We just wanted to get this thing done."

Then, a little over two years ago and a few weeks before the initial open-water test for *Challenger,* Fossett took off in a two-seat Super Decathlon from the Flying M Ranch in Nevada, heading south along U.S. Route 395. He never returned. The next day Hawkes received word of his disappearance and rallied the team to western Nevada for a ground search. Back in the Bay Area, Karen Hawkes scrambled to enlist helicopters and volunteers for the effort. After six futile days scouring the rugged terrain by truck and on foot, they returned home. In November 2007 an Illinois court declared Steve Fossett dead. His plane was found a year later by a hiker out on a morning walk.

THIS SPRING AN unmanned submersible operated by Woods Hole became one of the first vessels to reach Challenger Deep since Piccard and Walsh in 1960. The hybrid remotely operated vehicle (HROV), named *Nereus,* was tethered to a surface ship via a hair-thin cable that provided electrical power and transmitted high-speed broadband video and data. "We're on the verge of being able to do an awful lot of this exploration the way we've been exploring Mars—with fairly smart robotic vehicles that can go around and investigate and report back," says Laurence Madin, director of research at Woods Hole. National Geographic Explorer-in-Residence Robert Ballard, who discovered the *Titanic* in 1985, is just as bullish on the future of unmanned exploration. "I'm not looking for a spiritual experience while diving," Ballard says. "I'm looking for discoveries. I'm looking for results."

Dan Howard, superintendent of the Cordell Bank National Marine Sanctuary, recently spoke with Hawkes about using his flying machines for deep-ocean research. Howard sees certain advantages to manned exploration—including depth perception, peripheral vision, and on-the-spot evaluation—but he questions Hawkes's approach. "Graham's selling point was how deep and how fast his submersibles travel," Howard says. "Our question to him was, How slow can it go? How maneuverable is it at very low speeds?"

Ultimately, perhaps Hawkes's best defense for his deep-flight technology may be sentimental, rather than scientific. "You send a robot to explore Mars," he says, "but would you build a robot to climb Everest?" The exploration of our planet, Hawkes believes—the quest to reach and discover new frontiers on Earth—is a fundamentally human endeavor. And as *Challenger* neared completion, Fossett had come to agree. "Initially the idea was a one-shot dive and then it goes in the Smithsonian," Hawkes says. "Then the program sort of changed. Steve would talk about forming a foundation for underwater exploration."

Challenger is still housed in Hawkes's San Francisco workshop, but the unfinished vessel now belongs to Fossett's estate. If Hawkes wanted to continue the project, he'd have to come up with a substantial amount of cash he doesn't have. "Maybe it's a self-protection mechanism, but I'm not devastated," he says. "The numbers work. I understand the process now. For an engineer, that's 99 percent of it." Hawkes has started designing "work" versions of the sub that can accommodate two passengers and include functions useful to researchers, such as robotic arms. And two years ago, Tom Perkins, a Silicon Valley venture capital titan, paid Hawkes $1.5 million to develop *Super Falcon,* a two-person submersible that Perkins could launch from his megayacht, *The Maltese Falcon.* Hawkes built two, one for Perkins and another for himself, using much of the same technology, hardware, and systems he'd devised for *Challenger.* "Steve brought this technology up to speed," Hawkes says. "He has paved the way for others to explore."

Hawkes sees *Super Falcon* as his greatest achievement. He calls it "a sculpted piece of beauty" and a manned sub for the digital age. Perkins, whose fortune was built with a keen eye for technology (like Google), agrees, calling it a masterpiece. John Scully, the former CEO of Apple Computer, said of the sub after a test ride: "If Apple wanted to build an underwater spaceship, this is the one it would build."

Early one morning this past summer, I visited Hawkes in Monterey, California, to dive in *Super Falcon.* Hawkes had spent a month operating the sub from a dock in Monterey Bay, training would-be recreational pilots and pitching influential people—ocean researchers, politicians, capitalists. The day I was there, he was coaching Greg Bemis, an entrepreneur who owns salvage rights to the notorious R.M.S. *Lusitania.*

Super Falcon looks like something between a hammerhead shark and George Jetson's hatchback. "This is not your father's submersible," Hawkes announced. His team of three engineers and interns slid the 4,000-pound sub down a boat ramp from the back of an SUV. After a Zodiac towed it out of the marina, Hawkes took over using a single joystick.

The visibility was terrible that day—a thick green plankton bloom clouded our view of Monterey's kelp forest—but we were flying nonetheless, traveling through the currents the way most subsea creatures do, with the exception, perhaps, of the chambered nautilus and humans in conventional subs. After dipping down 70 feet, Hawkes pointed the vessel up, pressing me into my seat as the water gradually lightened above my head. We breached the surface like a whale and floated lazily in the harbor. Sea lions eyed us warily.

As *Super Falcon* reached the boat ramp, with water dripping off its wingtips, I thought about a moment in Hawkes's workshop a few months before. We were standing in front of what's left of *Challenger.* Propped up by metal beams, the hull was surprisingly small, hardly bigger than the five-foot-eleven Fossett. It looked like a cast-aside piece of scrap metal, not a one-of-a-kind carbon composite. Hawkes looked down at the sub, taking the measure of a three-year labor of love that he cannot afford to buy back and fly himself. "What you're looking at," he said, "is a moon launch, and the rest of the world is just trying to reach orbit." s