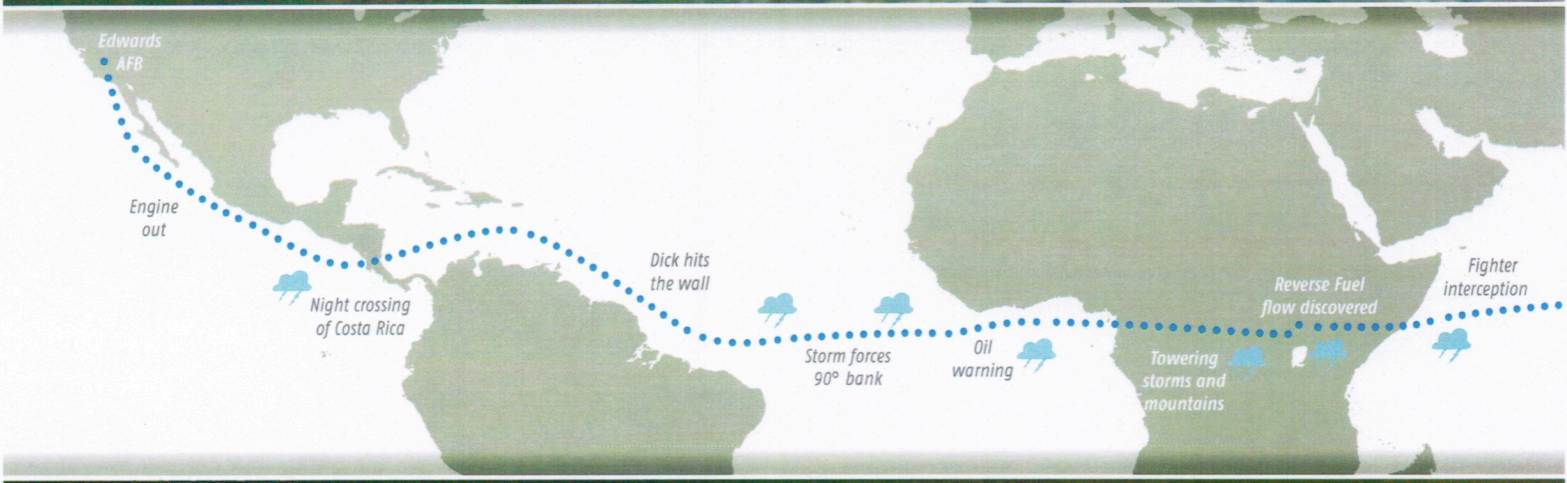

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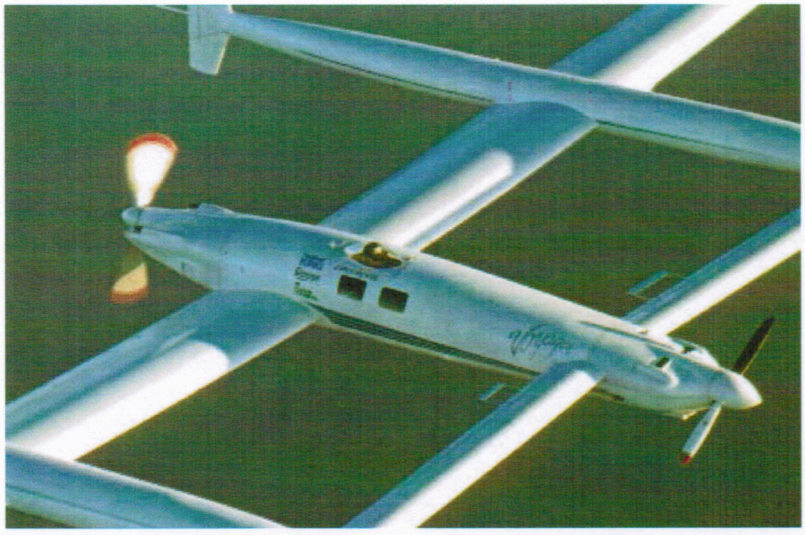
The Last First in Aviation

The legacy of Voyager

BY STEVE SCHAPIRO



THE FLIGHT OF THE Voyager still resonates 25 years after Dick Rutan, EAA 94971, and Jeana Yeager, EAA 167759, flew around the world nonstop without refueling because it was an achievement of epic proportions. It was "the last first" in aviation history. And considering the odds, they never should have made it.

"So many things went wrong, and so many events happened that could have stopped them," Mike Melvill, EAA 53387, said. "But somehow between them and us we got it sorted out to keep going."

Most people remember the 9 days, 3 minutes, and 44 seconds that began on the 3-mile long runway at Edwards Air Force Base on December 14, 1986, and concluded with a successful touchdown on the same runway in the Mojave Desert on December 23. What isn't remembered is the five years and nine months of planning, building, fundraising, and test-flying before Dick released the brakes that frosty morning to start the takeoff roll.

It's also easy to forget that once airborne, Dick and Jeana overcame obstacle after obstacle that could have ended not only the flight, but also their lives.

Not since Charles Lindbergh 59 years earlier had the world followed a single flight with such interest and enthusiasm. "The whole world watched it. People who didn't know a wing from a propeller watched it," Dick said. "That's what I was most amazed about."

A cutaway view of the Voyager's cramped cockpit.

AN IDEA OVER LUNCH

The dream began over lunch in March 1981. Dick and Jeana were preparing to start their own company and wanted Burt Rutan, EAA 26033, Dick's brother, to design an aerobatic airplane that they could sell as a kit. Burt, worried about the liability of designing such an aircraft, offered an alternative—fly around the world nonstop.

"The realization that we could accomplish arguably aviation's last milestone was the motivation to make it happen," Dick said. "I would not have done this just to set a record."

Burt thought composite construction was sufficiently advanced to design an aircraft that was light enough and strong enough to carry enough fuel to make the flight without using exotic engines.

"The historical significance was the change in primary structure materials in aviation," Dick said. "The Voyager was only possible because of the advent and availability of carbon fiber, which is five times stronger than steel and only half the weight. That introduced the next evolution—from wood and fabric to aluminum, from aluminum to composite materials."

What made the project even more remarkable than the technological advances was the human factor. Without the dedication of a few committed individuals in the beginning and then a growing team of volunteers, the Voyager would have never gotten off the ground.

Dick and Jeana talked to EAA chapters, Kiwanis clubs, and anyone who would listen in an effort to raise funds. One gentleman sent in $2 with a note that read, "Give it your best shot. We're betting on you. P.S. Don't laugh. I didn't eat lunch today."

"It was a grassroots effort without corporate sponsorship," Doug Shane, EAA 238605, president of Scaled Composites, said. "There were a lot experts and a lot of great, hard-working people from all over the country that put in their own time to make it happen. It inspired people to make those sacrifices. That to me was the greatest part of the accomplishment."

THE MAGIC DOOR

To accomplish such a milestone, it takes more than just skill. It takes a lot of luck. During the building of the Voyager, the right people tended to show up at just the right time. Jeana called this the Magic Door.

"People walked through the door, like Lt. White with the night-vision goggles," Dick said. "Had he not done that, we would have died on the first night."

Lt. White came toward the end of the program. One of the first to show up was Bruce Evans, a VariEze builder, who came to Mojave in 1982 and planned to stay a few days. He was soon hired as crew chief and quickly became indispensable in building the aircraft and throughout the testing and the record-setting flight.

Building the airplane required a lot of expensive carbon fiber, which Dick and Jeana could not afford.

PHOTOGRAPHY BY **MARK GREENBERG** AND **ANDREW ZABACK**

Enter Walt Jones, a salesman for Hercules, who wanted the company to provide the materials. "He repeatedly got thrown out of the boss' office, probably a dozen times, before the boss relented to support the program," Dick said.

When it came time to choose the engines, the Magic Door opened again. Don Bigler, the CEO of Teledyne Continental Motors, offered Dick the use of a liquid-cooled engine under development. "Had he not done that, we couldn't have made it around the world," Dick said.

Possibly the most dramatic example of the Magic Door was the day Dick had his hand on the phone, ready to dial Ed King to ask him to donate $250,000 worth of avionics. "The phone rang underneath my hand, and it was Ed," Dick recalled. "He said, 'I know what you're doing, and I would be proud if you would use my equipment.'"

FLYING THE AIRPLANE

In 1984, the test-flight phase began. "The airplane was the most horrible flying quality airplane in all aspects—its handling qualities, its structural margins, its systems—it just was a terrible airplane," Dick said. "I don't say that to say my brother who designed the airplane screwed up. Burt had to make those compromises to achieve the 29,000-mile range capability the airplane had."

Even in the slightest winds the wings would flex up and down, tossing the occupants all over a cabin the size of a telephone booth. There were times it was not controllable enough to even land.

Dick had nightmares that he would die in the Voyager. "It was an airplane that preyed on me a lot," he said. "Once my butt hit the floor and I started throwing switches, then the fear about that was gone. But before and after, I had a lot of problems with that. You know I just hated it. Once I got inside the airplane, then I was a pilot and I don't remember being afraid."

In 67 test flights covering 354 hours there were several failures that forced the Voyager to land. The flight plan for the circumnavigation attempt called for 225 hours of flight time, mostly over water. Statistically, they were bound to have problems that would force them down.

On one test flight, the Voyager flew through a rain shower. The laminar flow over the canard was disturbed, and the plane would not hold altitude. John Roncz fixed the problem with vortex generators. But they were never tested—until the Voyager flew into Typhoon Marge over the Pacific, and they worked perfectly!

Just before the four-and-a-half-day test flight in which Dick and Jeana set a closed course distance record, a prop motor failed, forcing a landing at Vandenberg Air Force Base. Had the failure occurred on the world flight over the ocean, the plane would have been lost.

Most famously was the prop separation on one of the last test flights. "That was the scariest thing," Doug said. "Those things can be devastating to the structural integrity of the airplane." The front engine threw a blade, yet the Voyager held together, in part because the engine mount had a restraint cable on it like aerobatic planes.

John spent three sleepless days designing a new metal propeller, which was more efficient than the original wood blades. Without the new props, the Voyager never would have made it.

WOULD IT GET OFF THE GROUND?

On the morning of the flight, Dick ordered 300 pounds more fuel put on board the Voyager, bringing the aircraft weight to 9,697 pounds—20 percent heavier than it had ever been flown before. At heavy weights the Voyager became dynamically unstable. The thin, 110-foot wings would flex up and down as much as 30 feet in a flapping motion in the slightest turbulence. If these oscillations occurred on takeoff it could prove disastrous.

"This was the biggest risk technically, because [the oscillations] always got worse at heavier weights," Burt said. "We knew it would be more dynamically unstable. We did not know whether it would be flyable."

As Dick advanced the throttle and the Voyager began its long, slow takeoff roll, he held the stick forward to keep the wings from oscillating.

"If you push forward as you go faster, the canard will lift down, and if the canard lifts down, it will rotate the boom, which means the whole wing won't lift. In fact we'll have negative lift," Burt said.

As the plane got faster, the negative lift forced the wingtips down, pinning them to the ground—something that had never happened before. On prior flights, the wings would droop and then slowly flex up as the airspeed increased.

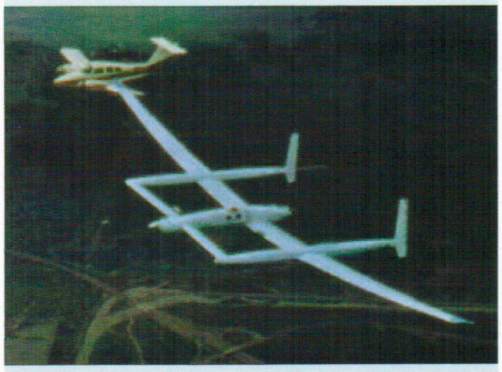
"If you take something that is unconstrained, it can flap dynamically and may diverge," Burt said. "If you put in just a subtle stop, it can't move one direction. The runway touching the wingtip absolutely kept Voyager's wings from dynamically oscillating all the way to minimum liftoff speed. You can argue that it was good that we were scraping on the runway. We had an artificial way of keeping the wings from oscillating during the takeoff roll, and it happened by accident."

After using 14,200 feet of runway, the Voyager was on its way. The damaged tips ripped off, and the plane was determined to

President Ronald Reagan awarded Burt, Jeana, and Dick the Presidential Citizens Medal, saying, "You reminded us all that aviation history is still being written by men and women with the spirit of adventure and derring-do."

Voyager by the Numbers

- **1/4 inch**: Thickness of composite fuselage
- **9 days, 3 minutes, 44 seconds** (circa **216 hours** total): Length of time in the air
- **17**: Number of fuel tanks throughout the aircraft
- **18.4 gallons**: Amount of fuel remaining at flight's end
- **72.3%**: Percentage of gross takeoff weight that was fuel
- **110 feet**: Wingspan of aircraft
- **116 mph**: Average speed around the world
- **354 hours**: Number of hours of flight testing
- **939 pounds**: Empty weight of aircraft
- **7,011 pounds**: Amount of fuel onboard at takeoff
- **9,697 pounds**: Aircraft's weight at takeoff
- **14,200 feet**: Distance of takeoff roll
- **22,000 hours**: Time to build
- **24,986 miles**: Total distance of flight



To read Jack Cox's award-winning article on the flight and to see video of the Voyager, visit www.SportAviation.org.

For more technical homebuilding content, subscribe to the free Experimenter e-newsletter at www.EAA.org/newsletter.

be safe to continue. As Dick and Jeana headed west toward the Pacific, questions about the plane's reliability and the crew's ability to handle the fatigue and cramped quarters followed them into the unknown.

"So here it is unlikely they will make it due to reliability of the engines and propellers. It's unlikely they will make it due to physical stamina. When we left them out over the Pacific, we had just gotten over another big risk—can they control it at this weight after takeoff," Burt said. "These [possible] failures meant they would probably put it in the ocean. We didn't know if we would see them again."

ONE OBSTACLE AFTER ANOTHER

The first challenge was Typhoon Marge in the South Pacific. Len Snellman, a retired National Weather Service scientist who was the weather guru for the flight, predicted the typhoon would turn when no one else did. He vectored the Voyager to the north to get the westerly tail winds. Had the typhoon not turned, "we would have had to go around the bottom side of it with head winds, and we wouldn't have had a chance of making it," Dick said.

After the typhoon, things got worse as instruments began to fail. The deck angle gauge needle broke, meaning Dick and Jeana could no longer calculate the weight of the airplane—a tool used to cross-check fuel flow.

Just before the Philippines, the ADI, an attitude gyroscope connected to the autopilot, failed. "If the autopilot went out suddenly, we'd have only a few seconds to recover control of the airplane," Jeana stated in a book she and Dick wrote after the flight. They were able to connect a backup ADI and continued the flight.

A more serious concern had been discovered before running into the typhoon, but they didn't have time to troubleshoot it. Using something called a "how-goes-it" chart, which marked nautical miles by pounds of fuel, Jeana plotted fuel flow. As long as they were above the line, they had enough fuel to get home. By the Philippines Jeana's plots had fallen below the line—they were burning more fuel than expected.

Just after they passed Sri Lanka, Jeana discovered a coolant seal leak. So the focus shifted away from the fuel burn for a short time. If the coolant seal failed, the mission would be over. Dick and Jeana considered turning around to find a landing site. But a few minutes later it stopped and they pressed on.

By the fourth day, as the Voyager approached Africa, the number crunchers in mission control were planning worst-case scenarios and thinking about alternate landing sites. It appeared there wasn't enough fuel to make it all the way home.

That's when Dick noticed fuel flowing backward from the feeder tank through the clear transfer tubes. They found the missing fuel. At the same time, the engineers in mission control had figured out what had happened. But there was no way to tell how much fuel they really had.

Doug rendezvoused with the Voyager over Kenya and inspected the damaged wingtips. The plane looked good, and Doug stayed with the Voyager until Dick started climbing over Lake Victoria. The storms over the Intertropical Convergence Zone were brewing with tops extending to 50,000 feet. Dick and Jeana went on oxygen and climbed to 20,000 feet in an attempt to get over the weather.

They also diverted to the north and would fly over Uganda. If they were caught over the civil war-ravaged nation, they would be shot down, like an airliner just a few weeks before.

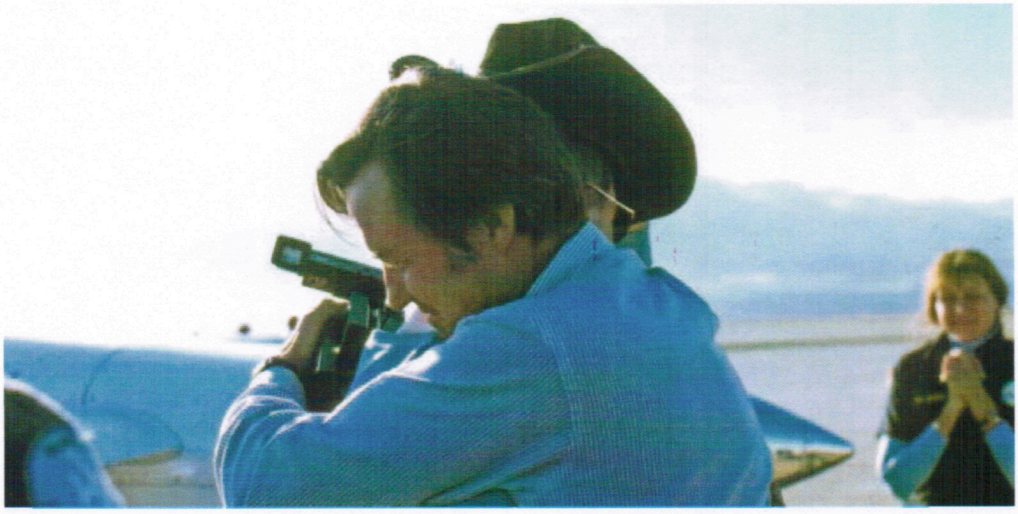
The storms intensified, and they had no choice but to pick their way through. That's when Dick realized Jeana wasn't saying anything. She had succumbed to hypoxia. He

"Records are made to be broken. Milestones are kept forever."
– Dick Rutan

shook her to keep her awake, and she kept falling asleep. As the storms subsided and Dick descended, Jeana awoke. Africa was quickly falling behind. On to the Atlantic.

That's when an oil warning light went on. The pressure was dropping and the temperature rising. Dick figured with all the hassles of crossing Africa, they forgot to add more oil. Once they did, it took half an hour to stabilize. Luckily they hadn't damaged the engine. "It was the closest—maybe second closest—that we came to ending up in the water," Dick wrote.

PHOTOGRAPHY BY **JEFREY VOCK** AND **MARK GREENBERG**



Burt and Dick hug after the completion of the flight.

As the Voyager approached Brazil, they again ran into the legendary storms of the Intertropical Convergence Zone. Even with color radar aboard, picking their way through at night was a challenge. A storm picked up one wing, and the plane began to roll to inverted. Dick could not control the airplane. He turned to Jeana and said, "Well, babe, this is it...we ain't gonna make it."

But as quickly as the storm had tossed the plane, it subsided. Dick went through the procedures to correct the 90-degree bank. They had never banked more than 20 degrees before. He put the plane in the steepest dive they had ever done in Voyager to reduce the load on the wing and then slowly rolled to level and pulled up.

As frightening as that episode was, the most harrowing part of the flight was still ahead. Just a few hours from home, the rear engine quit. The transfer pump had failed earlier, and Dick chose to draw fuel directly from wing tanks instead of replumbing the lines to put the fuel in the feeder tank, as mission control suggested.

"I thought that I had it made and could get home," Dick said. "Then the hand of Thor came down and hit me right upside the head really hard and brought me back to paying attention and making sure everything was just right and making sure we didn't make a mistake from then on in."

He put the plane in a dive to keep the propeller on the rear engine windmilling. If it stopped, there would be no chance to restart the engine. As the plane spiraled down from 8,000 feet, Dick tried to restart the front engine.

"I thought Dick was going to go into the water," Mike Melvill said. "Dick is my best friend. I was really traumatized that I was never going to see him again."

As the plane got down to 3,500 feet the front engine sputtered to life. Dick eased the nose up, fuel ran into the back engine, and it restarted as well.

Burt and Mike flew out to meet the Voyager off the coast of San Diego and escort the plane back to Mojave. At 4 a.m. Doug and Bruce left Mojave to join up as additional chase planes as a line of car headlights stretched from LA to Edwards.

After landing Dick did his usual walk-around to inspect the aircraft. He noticed a couple of brackets on the rear engine had cracked almost all the way through. "We probably just got back by the skin of our teeth because of that," Dick said. "Had that broken it would have gone through the prop and more, and we probably would have lost the airplane."

Mike and Bruce drained the fuel out of the aircraft. Out of 1,250 gallons on takeoff, only 18.4 gallons remained in the 17 tanks. They discovered some fuel had leaked from the outer wing tank on the left side.

REMARKABLE FEAT

"To me the most remarkable thing, and I'm going to give you this as a designer and a flight test engineer, is the airplane ended up performing within 1 percent of the design goal," Burt said.

"The fuel that we lost, the drag of the wingtips, and the remaining fuel, if you add them all up, it comes to a 10 percent margin," he said. "A 10 percent margin is exactly what I used as a reasonable goal when I said I'm going to design to this."

Doug found a few other aspects of the flight amazing. "It was remarkable that they were able to accomplish it the first time they attempted it. That meant that all the things had to align right. You had to have an

airplane that was good enough to fly that long without maintenance. You had to have humans that could fly the airplane that well for that long, and you had to have weather that was conducive to making it work. Any of those three things could have been the linchpin in the deal."

THE VOYAGER LIVES ON

Twenty-five years after the Voyager, many technological advances they used have become common in GA cockpits. Bose created the first active noise reduction headsets for the flight. And the aircraft was equipped with a GPS, although it wasn't used much because only four satellites were in orbit then.

"It also introduced the homebuilding world to carbon fiber," Mike said. "Everything prior to that, if it was a homebuilt and had any kind of molded parts, it was glass, not carbon. Most of us had never even heard of carbon. It was an unknown thing."

At the time, the Voyager was the largest all-composite aircraft ever built. Today, all Scaled Composites uses is carbon fiber. "And really all high-performance airplanes are all built of carbon fiber including the Dreamliner," Mike said. "You have to kind of point at the Voyager as being a pioneer at least in the use of carbon fiber."

"I think the world noticed, the EAA world certainly noticed, a group of enthusiastic homebuilders could produce something that could achieve a goal of that kind of magnitude," Mike said. "That's pretty astonishing."

"The Voyager represented the American spirit," Dick said. "A handful of people—a talented designer, a pilot who thought he could do damned near anything, a copilot, Jeana, who had the will and hardheadedness to stick through it under incredible circumstances—and we just plodded through. But that's America, and EAA promotes that type of philosophy.

"The set of circumstances came forth, and with the freedom that we have, that EAA has, you can go and build anything you want without some government telling you what to do. Do you know how precious that is? That is the larger meaning of the Voyager." EAA

Steve Schapiro, EAA 1018168, is senior editor of EAA publications. He owns and flies a Piper Cherokee Arrow that has been part of his family since his father picked it up at the factory in Vero Beach in 1968.