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Popular Science

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A three-man crew will soon climb into the spacecraftlike pressurized capsule of a strange double balloon. The boldly engineered craft aims to smash all balloon distance and duration records by circling Earth nonstop.

FIRST EVER EARTH ORBITING

BALLOON

By STUART F. BROWN

ILLUSTRATION BY JAMES IBUSUKI

One day during a four-month "weather window" beginning this November—when the sky is fair and the wind is calm—a risky balloon launch will begin inside the Loral Airdock in Akron, Ohio, a cavernous 22-story-high blimp hangar as big as seven football fields.

Launch crews will begin pumping 1.4 million cubic feet of helium into an onion-shaped polyethylene balloon that measures almost 170 feet tall when fully charged with the light and pricey gas.

Next the crews will pump ordinary air into a second balloon, this one a perfect 100-foot sphere that looks a lot like a King Kong-sized beach ball. Struts and cables connect the two balloons and provide an attachment point for the sausage-shaped pressurized capsule that houses the crew. Domed polycarbonate portholes in the walls and in the round doors on either end of the 24-foot capsule permit a peek at the three balloonists—an American, an Englishman, and a Russian—settling in amid communications equipment, air-purification paraphernalia, and the various supplies they will need to survive as long as three weeks aloft.

Christened *Earthwinds*, the colossal craft is the most complex manned balloon ever. Its mission is to fly around the world nonstop, a feat that's never been accomplished —even piecemeal—in the 117 years since Jules Verne's fictional account of an 80-day around-the-world balloon jaunt appeared. The crew will use advanced buoyancy-control technology to maintain an average altitude of about seven miles. There, the thin, cold air of the rapid-flowing jet streams will hurry them along.

The adventurers' eastward-drifting journey is projected to last between 12 and 20 days. If the attempt succeeds, it will overwhelm the distance record of 5,209 miles set during the pioneering trans-Pacific flight made by the *Double Eagle V* balloon in 1981, and far surpass the 137-hour duration record set by *Double Eagle II*, the first trans-Atlantic balloon, in 1978.

The crew for this daring venture: Larry Newman, a helium-balloon veteran who was aboard both *Double Eagle V* and *Double Eagle II* during their historic ocean crossings, is captain; Maj. Gen.

Earthwinds will drift eastward in the jet streams, rivers of air seven or eight miles above Earth. Groundspeed: about 75 mph. Airspeed: 0 mph.

Vladimir Dzhanibekov, one of the Soviet Union's most esteemed cosmonauts, is co-captain; and Richard Branson, the millionaire owner of Virgin Atlantic Airlines and Virgin Records, who was on the first Atlantic hot-air balloon crossing in 1987 and holds the Atlantic powerboat crossing record ["Transatlantic Catamaran," Nov. '85], is the pilot. He also has contributed much of the money for the roughly $2 million attempt.

To give the project its best shot at success—and ensure the survival of the crew—required equipping the craft with the latest weather and communications equipment. Satellite communications systems supplied by NASA will provide links to points worldwide. The crew will have global positioning satellite (GPS) receivers to determine the craft's precise location, which can be relayed through the Inmarsat satellite network to project headquarters in Akron. Phone calls and fax messages to and from all corners of the globe will keep the crew wired to people and events (weather updates can be printed out on the fax machine). They'll be in constant contact with a far-flung network of ham radio operators. The best weathermen in the business are supplying navigation advice (see box, Catching the Wind). And a NASA wind-shear instrument on board will gather data for atmospheric researchers.

Earthwinds' program manager, Phil Conley, is a retired major general who formerly commanded the Air Force Flight Test Center at Edwards Air Force Base in the California desert. Who on Earth put together such an ambitious and complex venture?

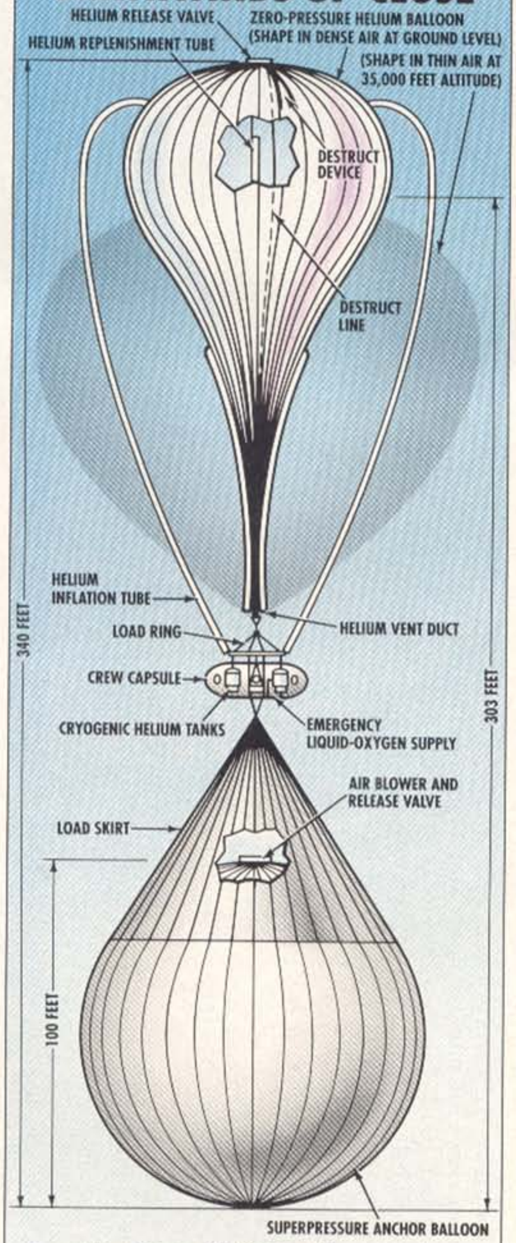
Larry Newman did.

An unflaggingly energetic Boeing 757 captain at America West Airlines, national ultralight champion, world-class hang-glider pilot, and balloonist (he also flies helicopters), Newman has been pursuing the idea of an around-the-world flight for about nine years. What took so long? Aside from fund raising, trying to get permission to fly over the Soviet Union was the biggest roadblock, Newman recalls. "Without that you can't go. Finally, Glavkosmos, the commercial launching arm of the Soviet space agency, invited me to the USSR and told me a Soviet cosmonaut should be on the mission and proposed Dzhanibekov. People at NASA told me, 'This guy has been in space five times, and he's director of cosmonaut training for the whole Soviet Union. He's like Neil Armstrong and John Glenn rolled together.' I thought, 'Sure, I'll fly with him.' "

Newman also recruited the core of the team—about 50 specialist engineers and technicians, many of them located in a group of aerospace companies scattered in the western states—who are working on a frantic timetable to design and fabricate the unorthodox flying machine.

If the truth be told, some of these participants have been overheard attempting to think up punchlines for a joke about three guys who are flying around the world in a balloon that's starting to lose altitude. One guy's from Arizona, another is Russian, and the third guy is British. They're trying to decide what—or whom—to toss out the hatch to lighten the load so they don't end up in the ocean... Punchline development has been proceeding at a snail's pace, though; the engineers are too preoccupied with making sure the three real guys get where they're going. Nobody wants to be the one who built the part that didn't work; they all realize a mistake could cost the crew members their lives.

EARTHWINDS UP CLOSE



From takeoff to its 35,000-foot float altitude, *Earthwinds'* helium balloon (shaded area) will quadruple in volume. The anchor balloon's volume will remain constant as air is pumped in or released to adjust the craft's buoyancy.

As sunset approaches on launch day, the airdock's huge clamshell doors slide almost imperceptibly on rollers and rails until the end of the building presents a gaping opening to the sky; the process takes a full five minutes. The crews move the helium balloon and its trailer out the open doors and let the tall envelope slowly rise while cables and winches control its rate of ascent. Gradually the capsule lifts off the ground, as the spherical balloon swings into place underneath it. Now the entire assemblage stands about 340 feet tall.

With the push of a button, the balloon captain severs the restraining cables, and the colossal craft rises silently into the calm evening sky, floodlights on the ground reflecting brilliantly from the upper balloon's silvery sides. Once the helium balloon's mighty lift is unleashed, there is no way to correct a snagged line or some other foul-up that could doom the craft before it even leaves the ground.

At an initial climb rate of approximately 500 feet per minute, the balloon takes about two hours to reach a 35,000-foot altitude, where it catches a northeasterly jet stream that should carry it above Boston in the early morning hours and then out over the Atlantic along the 40th parallel. The craft drifts at a ground speed of about 75 mph, while inside the capsule the crew busily monitors weather reports. The international trio is well aware that the success of the voyage depends heavily on the ongoing meteorological advice they receive.

Up and down are the only directions of flight the balloonists can actively control. After all, *Earthwinds* is predominantly a passive, drifting vehicle that obtains its mobility from rivers of moving air. The only thing the crew can do to

Balloon captain Larry Newman with his newly fabricated glass-fiber crew capsule in Scottsdale, Ariz.

influence its course is manipulate the craft's buoyancy so as to rise or sink into the most favorable wind currents.

Earthwinds looks different from conventional balloons for good reason. Ordinary helium balloons have a theoretical life span of only eight days, far short of the time needed to fly a crew nonstop around the world. Nor can conventional hot-air balloons do the job.

The two types of balloons are limited in endurance for different reasons. A hot-air balloon burns propane almost continuously to generate the heat that gives it lift. Therefore, the notion of designing a hot-air balloon to circle the globe quickly collides with this Catch 22: To carry enough propane, the balloon's hot-air envelope would have to be immense, which would in turn require burning huge amounts of propane to provide enough lift...but that much propane would be too heavy to carry...and so on.

Helium balloons are limited in duration by the daily solar cycle of warming and cooling (see box, The Physics of Balloons). When the sun warms a helium balloon, the gas expands 5 to 10 percent. This extra gas must be released to prevent the balloon from bursting. As the balloon cools at night, the resulting 5- to 10-percent loss of lift causes it to descend. At this point, the solution is to release enough ballast from the balloon to make its weight again equal to its lift, letting it maintain its "float" altitude. This venting-and-ballasting cycle can only be repeated for five to eight days, and then the ballast runs out. A longer flight would require a much heavier supply of ballast with a huge balloon to lift it, which would again increase the ballasting requirement...to a point of rapidly diminishing returns.

Pioneering designers during the past three decades have thought of two ways to extend further the endurance of unmanned scientific balloons.

Earthwinds is the first manned "balloon system" to incorporate these features, says Tim Lachenmeier, the engineer who specified its upended-dumbbell configuration. An admitted "balloonatic" and a member of the tiny world fraternity of about a dozen working balloon designers, he's employed by Raven Industries in Sioux Falls, S.D., one of two companies in the United States that makes huge high-altitude helium balloons for NASA's weather and atmospheric research. These balloons routinely float as high as 130,000 feet.

To make sure he considered all of the most reliable and proven design ideas while drafting the *Earthwinds* blueprint, Lachenmeier consulted a circle of four retired balloon gurus with more than a century of collective experience in government research programs. "The idea is not to reinvent the wheel," he explains, "but to take space-age materials and apply them to existing technology to get the job done. Our number-one concern is safety—to get these guys back alive. With the fast-track schedule we're on, this is a little like doing the whole Mercury program in six months; after all, we're going to orbit the Earth."

The first trick, and the one that makes *Earthwinds* look so outlandish, is coupling a familiar helium balloon with an air-filled "superpressure anchor balloon," the sphere located beneath the crew capsule.

A lighter-than-air balloon rises for the same reason a steel ship can float even though it's made from heavy materials. The ship floats because it weighs less than the volume of water it displaces. A balloon "floats" in the air because the helium or hot air inside it weighs less than the volume of surrounding air it displaces. Similarly, a submarine can rise, sink, or float while submerged, depending on its use of ballast to weigh less, more, or the same as the water its hull displaces.

An air-filled superpressure anchor balloon is a simple and ingenious device that, like the submarine, becomes lighter and heavier with changes in altitude, providing a helium balloon with a "variable ballast" that never runs out. *Earthwinds*' plastic-lined anchor balloon is a nonexpansible fabric sphere constructed with a new ultra-high-molecular-weight polyethylene material called Spectra, which the maker, Allied-Signal, claims has much greater strength and lighter weight than carbon or aramid fibers. A powerful electric fan can pressurize the anchor balloon with air to about 0.5 psi, while a valve permits the pressure to be released.

When *Earthwinds* takes off, the valve on the anchor balloon will be open, nearly equalizing the inside and outside pressures. As the craft nears its cruise altitude the crew will close the air valve. "The anchor balloon always has negative lift—because it's filled with air instead of helium—and it becomes effectively heavier in relation to the thinning air outside as it is dragged higher and higher," Lachenmeier explains. "It's called an anchor balloon because it adds weight to the payload as it goes up. If designed correctly, it will cause the whole system to come to a float altitude below the point where the helium balloon has to vent any gas, or we have to dump any ballast."

The craft's configuration was partly influenced by a safety concern: In the unlikely event that the pressurized anchor balloon accidentally bursts during the flight, its useless dead weight could be released to fall away only if the sphere were located beneath the capsule. A second consideration was the overhead clearance limitation imposed by the airdock's roof. Locating the crew capsule between the helium and anchor balloons, rather than suspending it beneath both of them, permits pre-launch preparations to be performed in the calm air of the vast structure.

Earthwinds will also be equipped with a supply of liquid helium to replenish any gas lost during daytime venting. Although Lachenmeier has included four cryogenic dewars, or tanks, containing a total of 3,000 pounds of liquid helium, he hopes they will be used mostly as a backup system. "If the anchor balloon stabilizes *Earthwinds*' altitude during the day-night cycle as well as we hope it will, the helium will only be needed to replace the twenty pounds of gas that escapes daily by permeating the molecular structure of the polyethylene balloon film," he says.

Really a set of high-performance thermos bottles, the dewars are being built by Cryogenic Technical Services, a Boulder, Colo., company that designs storage tanks for spacecraft. They are constructed from three shells of aluminum blanketed with a 75-layer insulating sandwich of double-aluminized Mylar film and paperlike sheets of fine glass fiber. The space between the outer two layers of aluminum forms a vacuum jacket; together the thermal barriers will eliminate helium losses due to boiling of the liquid gas. Simple ambient-air heat exchangers on the tank exteriors and outside the crew capsule warm the helium enough to convert it to a gaseous state as it is piped to the balloon.

Lachenmeier figures it's well worth bringing along a ton and a half of spare lifting gas. If it is needed, each pound of liquid helium will provide six pounds of lift, for a total of 18,000 pounds of reserve buoyancy. Any helium not used to replenish the balloon can be released to rise harmlessly to the edge of outer space, while reducing the weight of the dewars.

As the marathon journey unfolds, each of the balloonists will have ample opportunity to play TV director. He can scan an array of five small flat-screen liquid-crystal-display monitors on the wall. The images are captured by five tiny video cameras mounted inside and outside the capsule, then beamed out via a satellite link.

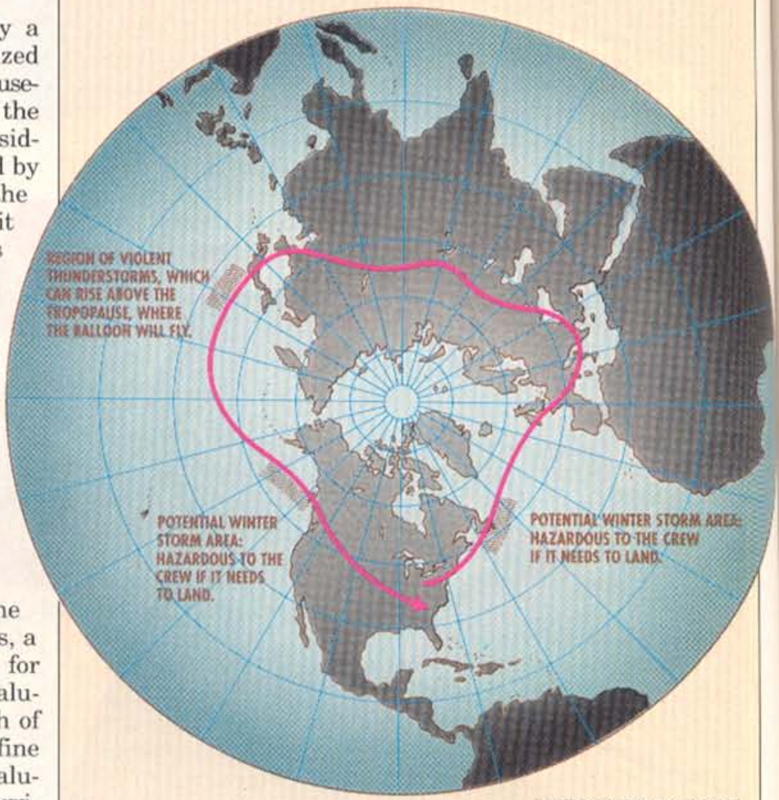
And each evening, ESPN viewers can see news spots of *Earthwinds*' trek relayed by a business jet that will make daily flybys around the balloon at 400 mph.

The activity may divert the crew from dwelling overmuch on the brutal conditions just outside the capsule.

The thin air and minus-50-degrees-F to minus-95-degrees-F temperatures at 35,000 feet would leave the crew members unconscious, freezing, and on their way to suffocation within 30 seconds if they were exposed. Therefore, a climate-control system is needed to make the capsule livable and solve some other problems at the same time.

This lightweight equipment's main component is a small gasoline-fueled engine housed in an insulated box inside the capsule. The engine breathes cabin air and runs for an hour at a time driving an electrical generator that provides current for the capsule's lights and communications equipment, and powers a high-speed electric blower

CATCHING THE WIND



ILLUSTRATIONS BY MARIO FERRO

When *Earthwinds* rises into a chill winter evening, it will be captive to the whims of the wind. Where exactly will these currents take the balloon? Weathermen can't plot the route the craft will travel with certainty, but they can place a good bet.

The crew plans to position its balloon in the jet stream, where the up-to-250-mph winds can propel it on a fairly direct circum-global route. The trick will be to synchronize the launch with optimal weather conditions—both near Earth and in the tropopause, the layer of air at about 35,000 feet, where the jet stream runs strongest.

In charge of trajectory analysis is meteorologist Bob Rice, director of special projects at Weather Services Corp. in Bedford, Mass. Armed with a history of jet-stream patterns, Rice has traced a realistic route (above) that highlights some hazardous areas through which the balloon must float. To pinpoint a launch date, he will rely on his own forecasts along with guidance from the National Oceanic and Atmospheric Administration, whose supercomputers use complex models to churn out global weather maps daily. "We'll be looking for weather traveling west to east, rather than north or south," he explains. "Then we'll look for a pattern that doesn't have any high-pressure blocks in it, which can stall over one spot for days."

Because winter weather patterns typically flow straighter and stronger than summer ones, time-consuming north-south deviations will be minimized, although even an optimal jet-stream path circles the northern hemisphere "like a bunch of sine waves," Rice says.

Once in the air, *Earthwinds* could face a number of threats. "Thunderstorms can reach up to 70,000 feet," he explains. "That's not normal winter weather, but we want to make sure the balloon isn't aiming at an overachiever." Mountains, especially the Himalayas, create whirlpools in the atmosphere that could suck the balloon downward and slam it against a mountainside. "The plan is to be well north of the Himalayas," Rice stresses, adding that the craft should be at a sufficiently high altitude to clear them if necessary.

"We also worry about icing," he continues. "Frost spread over more than two acres of balloon skin gets pretty heavy. We think that by flying in the tropopause at 35,000 to 40,000 feet where the air is drier, this will not be the problem it is under the tropopause at 30,000 feet.

"You've got to treat the balloon's course like a bowling alley," Rice concludes. "There are gutters on both sides, so just keep the damn thing out of the gutter. Where it goes in between, who cares, so long as it makes a strike."—*Judith Anne Yeaple* that pressurizes the cabin's air to the equivalent of an 8,000-foot altitude. During the five-hour periods when the engine is shut down, the box will be opened to keep the power plant and generator warmed to cabin temperature, while shutoff valves block off the system's air-inlet and exhaust-outlet pipes.

Ventilated lithium-hydroxide canisters, long used in submarines, purge carbon dioxide from the cabin air when the climate-control system is shut down. "Recycling the air for a few hours before purging it with the blower is a good thing," Newman says. "It lets some humidity from the crew's breathing build up in the capsule. When we flew across the Atlantic in *Double Eagle II*, I breathed bottled oxygen continuously for thirty-three hours. It took my respiratory system six months to recover from the awful drying effect."

Excess heat from the engine is removed by routing its liquid-cooling circuit through a heat exchanger mounted outside the capsule. Engine exhaust runs in a stainless-steel pipe through the crew's 50-gallon drinking-water reservoir, lowering exhaust temperature enough that the capsule wall's composite resins won't be harmed where the exit pipe passes through it, and using the water as a heat sink that slowly radiates warmth for the crew's comfort. (Ice water will not be served on this trip.)

Electricity from the generator also powers the fan on the anchor balloon, which can pump air into the sphere at a rate that will quickly reverse a temporary ascent to 40,000 feet that could be necessary if weight-increasing ice begins to form on the balloon at its normal float altitude.

The capsule itself is the last component the team expects to suffer any kind of structural failure during *Earthwinds'* flight. Designed and fabricated at aircraft designer Burt Rutan's company, Scaled Composites in Mojave, Calif., the 10-foot-diameter module is built from many laminations of glass fiber. The round doors at each end open from the inside so that cabin pressure continuously forces them shut against soft rubber seals. Larger in diameter than the access ports they cover, the domed doors had to be fabricated inside the capsule after its shell was completed.

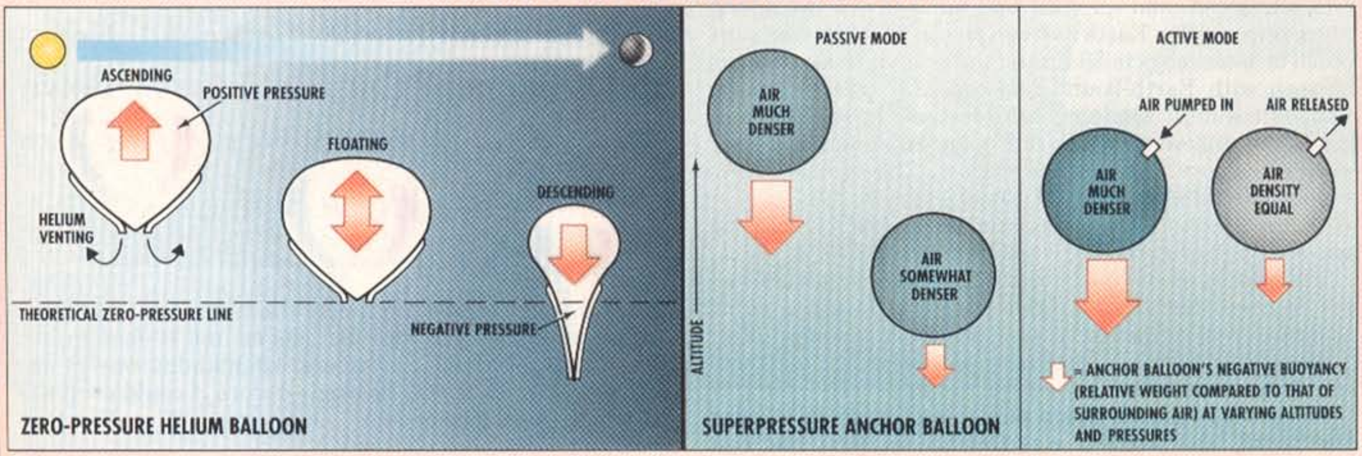
If anything, the capsule is probably much stronger than it has to be. Taking a conservative approach, Rutan called for the addition of reinforcing layers of composite that resulted in a finished weight of 2,000 pounds, a huge increase over its promised weight of 1,200 pounds. The added mass sent a lot of people rushing back to their drawing boards. "This overweight problem is a major one; it ripples through the whole design," Newman laments. "Now we have to start deciding what we're not going to take with us."

After riding the jet streams across the Atlantic and Pacific oceans, Western and Eastern Europe, the Soviet Union, perhaps Japan, and most of North America, *Earthwinds* needs only to land somewhere east of Akron to realize Jules Verne's dream that one day aeronauts would circumnavigate the globe.

A daytime landing in sunny weather would be ideal conditions for spectators awaiting the craft's arrival, but coming down through clouds or even landing at night shouldn't pose a difficult problem. When they are ready for their descent, the crew will choose a likely

[*Continued on page 96*]

THE PHYSICS OF BALLOONS



The device that pulls *Earthwinds* skyward is a helium-filled zero-pressure balloon (above left), so called because the pressure of the gas inside nearly equals the pressure of the air outside. Its envelope is made from four layers of a special high-strength and cold-resistant polyethylene film 1.5 mils thick—somewhat heavier than a dry-cleaner bag. About 100 eye-shaped gores, or strips, of polyethylene joined together by fiber-reinforced "load tapes" form the envelope's plump inverted-teardrop shape.

As an ascending zero-pressure balloon nears its float height, gas expansion due to the decreasing pressure of the thinning air around it causes helium to vent automatically from open-ended ducts at its bottom. A theoretical "zero-pressure line" can be drawn to represent the equilibrium point between the balloon's interior pressure and the outside air; in this case it falls below the duct openings and venting takes place. As the balloon continues to rise and vent helium, it reaches a point where its lift exactly equals its weight—and it floats without losing anymore helium. In this state the zero-pressure line falls at the bottom of the balloon.

A balloon that is descending (due to nighttime cooling and resulting contraction of its helium) assumes a pinched, elongated shape. The zero-pressure line indicates the bottom of the helium bubble, which no longer fills the interior. In this state, the lift provided by the reduced volume of helium is less than the craft's weight; unless ballast is dropped or solar warming occurs, the balloon will continue to descend all the way to the ground.

The superpressure anchor balloon (above right) is a tough-skinned air-filled sphere. In its passive mode, the anchor balloon contains slightly pressurized air that becomes relatively heavier as the helium balloon drags it into thinner, lower-pressure air at higher altitudes. Conversely, it becomes relatively lighter in relation to the outside air as it descends. By effectively varying its weight, the passive anchor balloon rounds off the sharp altitude peaks and valleys ordinarily traced by a helium balloon as it responds to the warming sun and the chilling night.

In the active mode, a fan and release valve add or subtract air from the anchor balloon, causing it to gain or lose weight as the helium balloon begins to ascend or descend. A well-designed active anchor balloon can hold its companion helium balloon at a steady altitude day and night.—*S. F. B.*

Earth-orbiting balloon

[Continued from page 71]

landing area with the assistance of its GPS receivers, which indicate the balloon's true location to within 10 meters.

By opening a valve and deploying a rip panel that tears its inner lining, they will deflate the anchor balloon. Next the crew will bleed gas from a valve atop the helium envelope until the balloon begins to descend; a pair of radar altimeters provide them with accurate readings of distance to the ground. As the balloon sinks closer to Earth, the three will don helmets and heavy clothing to blunt the impact of a possibly hard landing. With only plastic and foam materials used in the interior of the capsule, there is no worry about falling onto sharp metal edges.

Lightening the load

Shortly before touchdown, the 3,000-pound collapsed anchor balloon, hanging 140 feet beneath the capsule, will start dragging, lightening the craft before it reaches the ground. This has the same effect as dropping ballast at the last moment, causing the balloon to behave like an airplane flared on final approach—essentially landing itself. It's a method Newman experienced on both his *Double Eagle* flights when long hemp ropes were used to cushion the balloons' final moments of descent.

If *Earthwinds* is drifting at a high speed when it touches the ground, the captain will push a button triggering a detonator that severs the helium balloon from the capsule. As a safety measure, the destruct device is connected to its deployment button with a newly developed fiber-optic laser link that's immune to a potentially catastrophic accidental activation that could be caused by radio or electrical interference during the voyage. With the now-unfettered helium envelope heading quickly heavenward, a single metal cable still connecting it to the capsule will rip a sizable hole in its plastic skin. Once its big helium bubble escapes, the envelope will be transformed into an evanescent sheath of polyethylene fluttering to the ground nearby.

It's easy to imagine the trio of adventurers—anxious to stretch limbs cooped up for far too long—unbattening the capsule's hatches and clambering somewhat stiffly back onto terra firma. At the moment of completing a historic flight, it is customary for balloonists to kiss the ground and drink champagne. A crew that had just gone around the world might reasonably be expected to require more than one bottle. PS