The Race to Recover the Cup : Loss of the America's Cup to Australia in 1983 Was the 'Sputnik of Yachting,' a High-Tech Embarrassment That Galvanized U.S. Industry Into Action. This Year, American Teams--With Lots of Corporate Help--Aren't Leaving Anything to Chance.

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Some people believe the America's Cup race is an athletic contest. Nothing could be further from the truth. Competitive yachting's premier event has little to do with professional sport as we know it. It does not pretend to build character or embody the national psyche. Neither does it strive for excitement by tinkering with the rules. In a contest between yacht clubs, gentlemanly formality is more important than genuine sportsmanship. "The America's Cup is the game of life," says Dennis Conner, 43, probably the best 12-meter racer in America. "The cup is not necessarily won by the best sailor but by the organization that combines good leadership and logistics with a sound marketing strategy."

Tom Blackaller, the 46-year-old Berkeley mechanical engineer-cum-sailmaker who triannually challenges Conner for the honor of representing the United States in the race, is even more succinct: "Sailing is a cross between war and business. If you try to compete under the assumption this is a sport, you'll never know what hit you."

Conceived at the apex of the Industrial Revolution by men of lineage and substance, the America's Cup is a marriage of wealth and technology. Its heroes rarely come from behind the wheel of a boat. Yachting's pantheon is filled with men such as Harold Vanderbilt, J. Pierpont Morgan and tea merchant Sir Thomas Lipton--millionaires all, who, like the Medici of Renaissance Florence, subsidized the brightest engineers of their day in a search for boats with speed.

The elusive Baron Marcel Bich (father of the Bic ballpoint), Fiat's Gianni Agnelli and the Aga Khan continue the quest. When Western Australia's Alan Bond won the Cup in 1983 with his yacht, Australia II, he, too, entered capitalism's most exclusive club. "The America's Cup is where very successful men come to be with other very successful men," Bond says. "And where men who would like to be successful gather on the periphery."

The America's Cup began in 1851 when British industrialists invited their American cousins to a boat race around the Isle of Wight. The prize was a silver ewer of 134 ounces, worth 100 guineas. New York businessman John Cox Stevens accepted the challenge. His yacht, America, was more than a match for the British. As it sped toward victory, Queen Victoria, aboard the royal steam yacht Victoria and Albert anchored alongside the last leg of the course, peered into the mist and asked, "Who is second?" The answer set the tone for future challenges: "Ah, Your Majesty," a courtier responded, "there is no second."

For the next 132 years, American yachtsmen made a habit of being first. Through 24 consecutive defenses of the cup, they emerged triumphant. But in September, 1983, the American yacht Liberty was beaten four races to three by challenger Australia II. The baroque ewer's new home would be Perth, Australia; the longest winning streak in the history of organized sport was over.

Loss of the America's Cup meant almost nothing at all to most Americans. Football season had started, and the World Series was two weeks off. But in corporate board rooms across the land, alarums began to clang. America had not lost a boat race; it had been out-high-teched by rubes from the Antipode: men who incessantly squawked "G'day, mate," called every woman Sheila and adopted as their national symbol a lowly marsupial.

Not since Dwight Eisenhower's farewell address had the military-industrial complex been so steamed. The Naval Ship Research and Development Center in Bethesda, Md., wanted to know why Liberty had lost. In December, 1983, it summoned Nils Salvesen, a marine hydrodynamicist who could predict from a warship's blueprints its future performance at sea. "My presentation lasted an hour, but the conclusion was obvious," Salvesen remembers. "Our naval architects failed to utilize technology already available." Heiner Meldner, a Lawrence Livermore Laboratory weapons specialist who devised a program by which sails could be analyzed by computer, put the loss in its true perspective. Warned Meldner: "Australia II is the Sputnik of yachting."

Three years ago, the America's Cup was a bauble enshrined in the fusty New York Yacht Club, seen only by the rich and famous. Today, it is the focus of a high-stakes technological race. In 1983 only seven syndicates entered the competition. Next month, 14 will challenge the Royal Perth Yacht Club's new Australia III. By the end of the race, $170 million will have been spent in pursuit of the cup. The combined budgets of the six American syndicates alone total $61.7 million.

Dozens of U.S. corporations have enlisted in the effort to bring the America's Cup home. Ford, General Motors and Chrysler; Allied-Signal; Digital Equipment and Hewlett-Packard; Grumman; MCI; the Mondavi Winery, and Pacific Telesis are donating cash, technical services or computer time. Government agencies are prohibited from supporting commercial ventures, but since national pride is at stake, the Naval Academy permits the San Diego Yacht Club's technical consultants to use the Superintendent's Conference Room for meetings.

The Flight Research Institute in Seattle, composed almost entirely of Boeing engineers, has adapted the software used to test experimental Boeing aircraft to assess performance characteristics of 12-meter yachts. The Manufacturing Industry Systems division of McDonnell Douglas in Cypress has developed three-dimensional, computer-generated hull shapes that show the stress points and flow patterns of a yacht under sail. Peter Lissaman, vice president of AeroVironment Inc. in Monrovia, took time off from his pet project--the development of a battery-powered pterodactyl that can flap its wings and fly--to write a computer program predicting the amount of time necessary to sail a 12-meter upwind in gales of varying strength.

"The reputation we have as a high-tech company isn't hurt by being associated with an event as technologically challenging as the America's Cup," says Dennis Murphy, director of Advanced Manufacturing Technology for Douglas Aircraft. "Football is for beer drinkers.

"People forget how much planes have in common with sailboats," Murphy says. "The only thing that distinguishes aerodynamics from hydrodynamics is that water can't be compressed. We're constantly borrowing from each other.

"That portion of a ship's hull covered by water is called its 'wetted surface,' as is the outside of a plane. An airplane's waterline runs from the tip of the fuselage back to its tail. Both planes and ships measure distance in nautical miles. The aerodynamic principle that lifts an airfoil also powers a sail."

The principles of hydrodynamics are nearly identical to those of aerodynamics, agrees Blackaller, who will helm the challenger from San Francisco's St. Francis Yacht Club when trial competition for the 1987 America's Cup race begins next month in the Perth yacht club's port city of Fremantle. "But sailboats are

more complicated than airplanes, because they operate in the transition zone where the wind and water meet. Anybody can take off in an F-14 Tomcat. Set the flaps at 11 degrees, and when the revolutions reach 40,000 hit the deck going 185 knots. I could learn the routine in 10 minutes. I'd like to see a carrier pilot try to jibe around the wing mark after the same amount of time."

There is nothing mysterious about the forces that propel a boat. The sail of a boat, like the wing of a plane, has curved edges. When wind blows across the surface, lift identical to that which keeps an airplane aloft occurs on the sail's leeward (away from the wind) side. This pulling force, called lift, combines with the push of the wind on the sail to send the boat skimming forward. Boats can't sail directly into the wind, but they can head to within 45 degrees of the direction from which the breeze is blowing. By tacking--sailing a zigzag course into the wind--a boat eventually will arrive upwind of its original location.

Tacking to windward can be difficult, since the direction of the wind and the force with which it blows are always changing. But the sailor who adjusts, or trims, his sails can maintain a fairly constant speed. When a boat is running with the wind behind it, the mainsail should be at a right angle to the direction of the boat. When the wind blows from the side, a boat can sail across wind by extending the mainsail to a 45-degree angle to the direction of travel. A boat tacking upwind keeps its mainsail almost parallel to the direction of travel.

The size of the sails and strength of the wind influence the speed of a vessel. So, too, does the drag caused by displacement--the water pushed aside as the hull and keel move through the ocean. The principal factor determining maximum speed, however, is length at the waterline. As a boat moves through the water, waves moving perpendicular to the bow begin to form. The distance between bow waves increases with the speed of the boat. The maximum velocity of a boat--its hull speed--comes just before it "hits the wall" and falls into a trough between bow waves at either end of its waterline. In nautical miles per hour, the hull speed of a sailboat is about 1 times the square root of the waterline length in feet. So a vessel with a waterline of 36 feet has a hull speed of about 7 1/2 knots.

Because yachts are not bought off the shelf in sizes small, medium and large, ocean races have a handicap that allows boats of varying size to compete. The exception is the America's Cup, a race between "12-meters," or twelves, whose dimensions are governed by more than a century of tradition.

In the 12-meter formula, waterline length, sail area and displacement are balanced so that a change in one requires a compensating change in the others. To add sail area you must reduce waterline length; if waterline length is increased, then extra ballast must be added. The quotient of the formula is a constant--38.37 feet, or 12 meters. The idea behind the rule is to produce boats that are nearly identical, making the America's Cup competition more a test of sailing skill than designer innovation. But over the last two decades, the formula actually has stimulated competition among designers bent on building ever faster boats.

Though built to exact specifications, and individually certified by Lloyd's Registry in London, each 12-meter is unique, the product of an intricate brainteaser solved by art and science. In heavy weather, in which winds gust to 20 knots, a large boat with moderate sail area performs best. Large sails on a smaller boat are necessary, however, on days when a skipper must search for a passing breeze. Since no one can predict the winds a year before a race, the naval architect must strike a balance between extremes.

When match cup racing resumed after World War II, the yacht Columbia was chosen by the New York Yacht Club to defend against the British challenger. It had a deep, rounded profile and was typical of the period in that its long rudder extended from the stern to the tip of the keel. Columbia paid a high penalty in drag because of the large amount of wetted surface below the waterline.

The 1964 defender, Constellation, was much faster. Its bow angled sharply back to a much smaller keel. A scalloped stern further reduced wetted surface. The rudder remained connected to the keel, but because its smaller surface area produced less drag, the yacht felt more maneuverable.

A revolutionary advance in design came with Intrepid three years later. A hull less than half the size of Columbia's allowed it to sail extremely fast. But the most innovative improvement was the shift of the rudder from the trailing edge of the keel to the back of the stern. A pivoting vertical fin, called a trim tab, extending from the rear of the keel added an extra measure of lift when the boat sailed to windward. But it was the placement of the rudder far away from the boat's center of gravity, the keel, that allowed faster turning. Intrepid, clearly, was a superior vessel, and it beat the Australian challenger Dame Patie, 4 to 0.

And there the evolution stopped. Yachts in the next four America's Cups were exact copies of Intrepid. Inertia set in because one naval architect active in 12-meter design, Britton Chance, inadvertently saddled yachting's aristocracy with a lemon in 1974.

The reduction in wetted surface on Intrepid minimized friction caused by water clinging to the hull, but it did not address the equally vexing problem of vortex drag. When wind or water race past the end of a surface, they tend to curl around the edge and form a spiraling vortex. You can see a vortex when an airplane lands in foggy weather and vapor flares around the tip of a wing. The East Indiamen freighters of Holland and Britain (see box, page 27) that dominated international trade throughout the 18th Century consistently suffered from the vortex concentrated behind their pointed sterns.

Designers of American Clippers discovered in 1840 that the vortex, and the sucking drag it produced, could be minimized if it was spread out along a slightly squared stern. In 1974, Chance squared the underwater portion of the stern on a yacht named Mariner after tank tests showed that the principle that worked for Clippers also could benefit a twelve. Alas, Mariner wallowed like a garbage scow when it finally hit the water and was quickly eliminated as a potential America's Cup defender.

The nature and control of a vortex is still being debated in the automobile industry. Some engineers say the squared hindquarter of a Corvette is more aerodynamic; others insist the tapered rear of a Porsche 911 produces less drag. For blue-water sailors, however, it was all hooey. Enough science! Why tinker with the Intrepid design, they argued, when it consistently beats the Aussies and Brits?

In 1975, NASA scientist Richard Whitcomb discovered the drag-reducing properties of winglets. Because of the Mariner fiasco a year earlier, however, yachtsmen remained skeptical and stuck with the standard keel--a long vertical fin that was swept back along the leading edge, flat on the bottom with a trim tab adjoining the trailing edge. Not so Alan Bond. After meeting with Dutch hydrodynamicists, Bond and Australian designer Ben Lexcen emerged convinced that a wing-keeled boat could beat the Americans.

John Bertrand, the young engineer Bond named captain of Australia II, thought the new keel grotesque. "Bondy saw my dismay before I even had time to speak," he wrote in his 1985 account of Australia's cup victory. "He said, 'John, do you really believe that in 20 years airplanes are going to look as they do today?' He knew how conscious I was of the speed of modern development, and his words had the effect of wrecking the argument I had not yet had time to voice."

The winged keel accomplished several objectives simultaneously. Making the keel wider at the bottom, and heavier (since winglets weigh several thousand pounds), lowered the center of gravity, allowing Australia II to grip the water tighter when it tilted to the side on an upwind tack. A more efficient distribution of ballast meant that the keel didn't have to be so big--a huge plus, since a reduction in wetted surface area decreased drag. Essentially, the winged keel meant that a lightweight ship could carry a lot of sail area, accelerate quickly in light wind, yet remain stable when the wind began to gust. All this while keeping within the limitations of the 12-meter design formula.

Dennis Conner in defeat acknowledged Australia's accomplishment, but in private he agreed with America's yachting establishment that the margin of victory came from the Australian boat's radically shaped keel. The keel of a standard 12-meter boat resembles an inverted shark fin that tapers gently toward the tip; the keel of Australia II not only reversed the configuration but also added two horizontal fins at the bottom. "Australia II was a major breakthrough, not a marginal improvement in design," Conner says. "There have been 39 twelves built since the '83 cup race. Every one of them has a winged keel."

Arvel Gentry mounted a slide tray atop a viewer, slapped at the rheostat and said with a devilish grin, "You've just got to see my photographs."

A computer-generated image of a keel flashed up. "Pretty spectacular, no?" he said with a wink. It looked like a lead pancake, but Arvel obviously thought different. "Look how compact it is--how short both forward and aft," he said, his eyes fixed with the wistful look that usually accompanies snapshots of grandchildren. "In a maneuvering situation before the race or when you have to start tacking, the boat with this type of keel is going to be able to turn faster."

Gentry, 53, heads Boeing's aerodynamics computing department, which develops computer programs for airplane design. Over the last two years he has spent 1,500 hours of his spare time helping design--without pay, on weekends and after work--the perfect keel.

"Several years ago, I had about 10 Boeing engineers over for some brainstorming. Since one of the most aerodynamic shapes is a cylinder, one proposed that the keel be a hollow eight-foot-long tube. We debated having two keels, side to side or fore and aft. In the end we agreed there was no logical alternative to winglets.

"The problem with winglets is that they have to be designed correctly," explained Gentry, now silhouetted by the luminescence from a nearby computer. "You put winglets down there, it adds area, and surface friction goes up. But there they have to go, because we've got 42,000 pounds of lead that has to go somewhere. The goal is to shape that blob of lead so that it will counterbalance the force of the wind on the sails without causing additional drag."

If the list of consultants advising the various syndicates reads like a Who's Who in aviation, it is because naval and aeronautical engineers are constantly trading ideas. After the 1967 cup race, in which Intrepid picked up speed and maneuverability by moving the rudder back from its keel, commercial aviation began experimenting with "center-of-gravity management." It found that if fuel tanks in the tail section were emptied before the tanks in the wing, the plane's center of gravity would move forward as the flight progressed. Because the pilot didn't have to turn the rudder as much, there was less drag and therefore a greater saving of fuel. The theory that made Intrepid a better boat became central to the design of the Concord and the B-1 bomber.

"The America's Cup has moved away from being a sport where the skill of the crew counts," says Lawrence Livermore's Meldner. "You need the best scientific minds to win. I'm spending more computer time on this 12-meter than I would designing a submarine. If we win, it will be because we controlled the knowledge base."

Scientists exert an inordinate amount of influence over yacht design this year because veteran helmsmen no longer can rely on experience. For more than 130 years the fate of the America's Cup has been decided by an autumn race in New England. Every competitive 12-meter yacht built in this century has been designed specifically for the 16- to 18-knot winds off the coast of Newport, R.I. The Australian port town of Fremantle is located in the "Roaring 40s," a latitude of strong and unpredictable winds.

The interior desert of Western Australia governs the winds off Fremantle. Heat rising off the desert creates a vacuum that is filled every afternoon by a 25-knot wind that has traveled across 5,000 miles of Indian Ocean. The wind is called "the Doctor" because it brings relief from the heat, but in the process of cooling the land it creates four-foot swells that form a green-and-white froth as they near the coast.

Three California yachts hope to race Australia III. The San Diego Yacht Club's Stars and Stripes is considered by most observers to be the best, probably because it is backed by a $15-million budget and sailed by Dennis Conner. The boat representing San Francisco's St. Francis Yacht Club is a wild card in that it was designed entirely by a Cray XMP-48 computer, which lovingly named it R-1. The Eagle Challenge, mounted by the Newport Harbor Yacht Club in Orange County, has a respected helmsman in Olympic gold medalist Rod Davis, but the engineering shortcuts made necessary by limited financing could affect its performance in Perth.

Francis Clauser, a 73-year-old retired Caltech physicist who signed on as the Eagle's chief scientist in September, 1984, thought he had produced the ultimate racing hull when the computers at Offshore Technology outside Escondido began spitting out numbers last April. "This is good," he mumbled to himself. "This is great," he finally smiled. Trailing the printout behind him, he rushed back to the tow tank where his model hull was floating. "It's a 20% improvement over everything else we've tested," he said, waving the data in front of Gary Thomson, president of the Eagle Challenge syndicate. "If we build one more boat, I think we can win the America's Cup."

Studded with 18 computer sensors, the model was pulled through the water at 5 knots, then at 8 and finally 11. Forgetting the heart attack he had suffered only the week before, Clauser ran the length of the tank each time. "My job is to circumvent the 12-meter rule, not by cheating, but with superior design. If I can keep the waterline at 12 meters but make the boat think it's much longer, then it will go faster."

The model that bobbed in the water got its speed from a bulbous bow that jutted forward 10 feet just under the waterline. It seemed to be giving a raspberry. But what the model lacked in aesthetic charm, it gained in speed. The underwater protuberance dramatically reduced wave drag by causing the bow wave to crest in front of the hull.

"In towing tank tests on Eagle I, we never could go faster than 9 1/2 knots because a great train of waves would come rushing down the tank and almost swamp the boat," Clauser says. "My boat could run the tank at 11 knots and leave the surface almost like a millpond. The boat could have cleaned up anything at 10 knots; at 20 it would have been untouchable."

Thomson couldn't raise the extra money. Francis Clauser's superboat was never built. Instead of going to Perth, Clauser will spend the rest of the year dabbling with a wave-making machine in the basement of a Caltech science building. "I hoped to use fundamental science to build a faster boat," Clauser says with some bitterness. "But 12-meter design is dominated by empirical people. Johan Valentijn (who has built five 12-meters, the most recent of which is Eagle) was negative about the boat because it was different from anything he was used to. Rod Davis didn't want a fast boat because, very frankly, he felt it would detract from the role he played. He said openly that he wanted to win by his skill and not by having a special boat. And so they dismissed the results of my tests and said the boat was a pipe dream."

In a contest between science and intuition, the winner is not even in doubt. "Designing 12-meters used to be 80% art and 20% science," Valentijn sighs. "The ratio now is 75% science and 25% art. I didn't even own a personal computer until 1983. It cost $30,000 to develop Magic (a lightweight boat rejected in favor of Valentijn's Liberty, which ultimately challenged Australia II) back then. My design budget for Eagle is $500,000."

Even J. P. Morgan might blanch at the bills incurred by the syndicates. A 1:3 scale model for tank testing costs $16,000. Offshore Technology charges $20,000 a day to use its tank and computers. A 12-meter hull, which actually measures about 65 feet from the tip of the bow to the stern and weighs about 24 tons, goes for $400,000. Add an equal amount for sails, plus $300,000 for rigging and spare parts. "The money spent by the U.S. Navy for a new hull form is significantly less than the dollars being spent for the America's Cup," says Daniel Savitsky, director of the Davidson Laboratory at Stevens Institute of Technology in Hoboken, N.J.

Much of the money is spent on research already conducted by other syndicates. Valentijn estimates that 75% of the $61.7 million budgeted by the six U.S. syndicates could be saved if the nation's yacht clubs and their corporate sponsors could unite behind a single U.S. challenger. That will never happen. A study by Chapman College estimates that a successful Eagle Challenge could add $1 billion--"the equivalent of (revenues from) 10 Super Bowls"--to the economy of Orange County. Art Latno, the executive vice president of Pacific Telesis, which supports the Golden Gate crew, is even more bullish. "A victory for our boat in Perth would bring $1.5 billion into the Bay Area when we host the race in 1991."

The size of the America's Cup purse encourages inventive spying and intense secrecy. "Who told you that?" is the usual response to questions beginning "Is it true . . . ?" Heiner Meldner will volunteer more information on the stealth radar-resistant bomber than about the St. Francis sailboat. "If I told you who we have been working with, then you'd know what areas we've been thinking about," he explains. Gary Mull midwifed the mother computer that downloaded plans for R-1. "You cannot imagine the paranoia and psychosis that precede an America's Cup race," he admits. "I have a rubber stamp that says, 'Top Secret--Burn Before Reading.' "

Each of the three California syndicates has its own style. That of Dennis Conner's Sail America might be described as Late Tan Son Nhut. For the past nine months San Diego's cup hopefuls have berthed their boats outside Honolulu in a guarded compound littered with rusting Quonset huts and cannibalized military vehicles. Picture yourself in Hue during the 1968 Tet Offensive and you'll capture the mood. Everyone wears a game face. Skylarking is taboo. They call the place Camp Conner.

The real nerve center for Sail America is located west of Pearl Harbor in a penthouse apartment sparsely furnished with one twin bed, a Digital Microvax II computer, several PCs and a couple of chairs. The floor is littered with computer manuals. Mounds of data teeter precariously. A large stack of notebooks lends perspective to the clutter. Robert Hopkins lives here.

A former Olympic sailing coach who is the liaison between the boat crew and the technical experts, he is conversant on all subjects save one. What's in the notebooks, Bob? "Our blood," he responds coldly. "It belongs to the people who give us money. Don't expect me to give anything away."

The notebooks, in fact, contain a Velocity Prediction Program. Based on thousands of hours of computer analysis, hundreds of design variables and results gained from testing different hull forms on the water, the program allows a syndicate to systematically decide, for example, which of its four practice boats is the one that might have a one- or two-second edge in match cup racing.

The outcome of an America's Cup race is determined by seconds. A boat that can go 1,000 yards in 993 seconds will increase its lead by 10 seconds a mile over a boat that sails 1,000 yards in 1,000 seconds. If speeds were constant over the course of an entire race, the faster boat would win by 240 seconds, or four minutes. That rarely happens. If the skipper of the faster boat chooses the wrong sail or tacks more often than necessary, he will lose his advantage, if not the race. No computer program can eliminate human mistakes made under pressure. But an accurate VPP can lead to the selection of the best possible boat and minimize mistakes by telling the helmsman in advance what he should do in certain situations.

Sail America's search for an accurate VPP began at Science Applications International, a defense-oriented think tank headquartered in La Jolla. It combined a U.S. Navy program used to assess the performance of warships with two others used to handicap sailboats. "The Navy has VPPs, but they're not very accurate," says hydrodynamicist Salvesen. "A ship's weaponry is more important than its speed, but speed is everything for a 12-meter, so our VPP must be accurate to within 1%."

Based on experiments with the man-powered Gossamer Condor, AeroVironment had data that quantified the relationship between the air mass dragged behind a moving object and the object's ability to maneuver. Their data was added to the VPP along with the results of tow tank tests on 36 different hull models and hundreds of computer-simulated match races. "Comparing two models in a tow tank doesn't tell you which one is better," says SAI engineer Carl Scragg. "You'll know which goes down a tow tank faster, but not which one will go around a race course the fastest."

"Our VPP proved its value earlier this spring," Hopkins says. "We had put a new keel on a boat, which performed as expected downwind. But upwind it only went 8.53 knots instead of the 8.6 knots we had predicted. For every minute we spent tacking we were losing seven feet. We began playing with the numbers and found that the optimum trim tab setting we had been using on the old keel needed an adjustment of 2 degrees. It took the people on the boat six days to identify the problem. We needed only two to solve it on the computer."

Though all the challenging syndicates jealously guard their designs, it's certain that the upcoming America's Cup will see some of the most innovative vessels ever built. British designer David Hollom has added a large bustle, or double chin, to the underside of the hull on the Royal Thames Yacht Club's entry, Crusader II. The asymmetrical bulge is supposed to minimize pitching fore and aft in the heavy sea off Fremantle. San Francisco promises that R-1 will be a "revolutionary, not evolutionary" 12-meter, and such could be the case, since R-1 initially came equipped with a second rudder beneath its bow.

Shaping the hull of a racing yacht like the belly of a laughing Buddha may not bring victory, but neither is it being prejudged, since designs that succeed in the America's Cup have a way of showing up elsewhere in industry.

In the summer of 1984, engineers at Douglas Aircraft in Long Beach began experimenting with winglets in earnest. They confirmed that what worked for Australia II also helped the DC-10. Winglets reduced drag, whether they were at the bottom of a keel or on the tip of a wing. Winglets allowed Australia II to reduce the size of its keel, while improving hull speed, stability and turning capacity. A DC-10 with winglets used 3% less fuel.

Douglas Aircraft today is taking orders for the successor to the DC-10, the winglet-equipped MD-11. Within a few years the technology that brought Australia the America's Cup will allow airplanes to fly more economically across the United States.

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