AIRCRAFT

New technology could put radar watchdog on month-long missions

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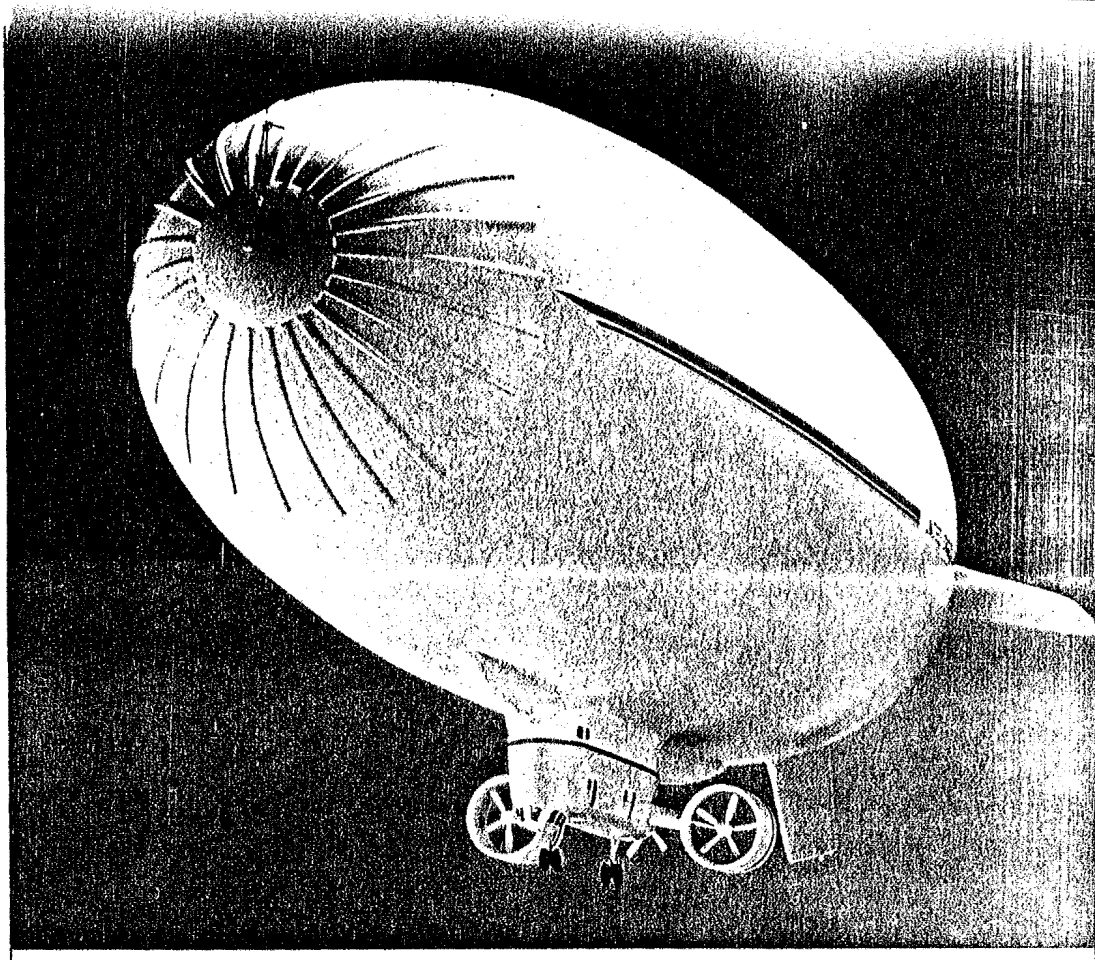


The Sentinel 5000, with ducted, swiveling main propellers and a centerline "sprint" propeller, is scheduled to make its first flight in 1990.

Blimps are back on board

A quarter century after deflating its last blimp, the Navy is bringing the airship back to life with transfusions of new technology. Last June it transformed a four-year study effort into a model airship development program by awarding $168.9 million in contracts to Westinghouse and the U.K.'s Airship Industries. In late 1990 the Sentinel 5000 blimp is scheduled to make its first flight, and six months later, to begin suitability trials.

According to Naval Air Systems Command spokesman Al Frascella, the trials will determine the "operational worth of surveillance and command, control, and communications integrated into task force operations at sea." Although the blimps could work autonomously, the Navy wants them to furnish airborne early warning to battle groups that do not have carrier-based Grumman E-2C radar aircraft. They could also provide targeting data for task force weapons. Airships, which have an endurance measured in days, would complement faster, higher-flying E-2Cs in carrier battle groups.

The trials will also gather operational, technical, and cost data for designing an operational vehicle. If Sentinel proves itself, the service intends to reopen competition for developing and producing the follow-on. Such a vehicle would probably carry improved radar and be large enough to patrol for a month without refueling. Sentinel will cruise at 40 kt for 2½ days at 5,000 ft altitude, and could be replenished from ships for longer patrols. Very large advanced airships may

eventually resemble dirigibles in having rigid composite frames, and could wear phased conformal array radar elements on the surface of the gas envelope.

Other services will be eyeing Sentinel's progress, with other missions in mind. The Coast Guard could use airships for search and rescue and, along with the Drug Enforcement Administration, for intercepting drug traffic. Patrolling borders for illegal immigrants might be a Customs Service application. More in line with the Navy, the Air Force is looking into a role for airship radar platforms in its Air Defense Initiative. And the British Ministry of Defence and the French Navy are also interested in surveillance.

The five-year development contracts cover designing and building the aircraft, supporting it during trials, and integrating E-2C avionics and GE APS-139 radar. Included are options to buy up to five more of the development model blimps.

Sentinel will stretch 423 ft, over twice the length of the familiar Goodyear or Airship Industries Skyship blimps, but only 20 ft longer than the last operational Navy gasbag, the Goodyear ZPG-3W. A diameter of 105 ft gives Sentinel a displacement of 2.35 million ft^3 compared to the 85-ft-diameter ZPG-3W's 1.49 million ft^3 and the Goodyear blimp's volume of 0.2 million ft^3. Sentinel will be appear fatter than the ZPG. It will have the same 4.03 length/diameter ratio as the Skyships, contrasted to 4.74 for the ZPG.

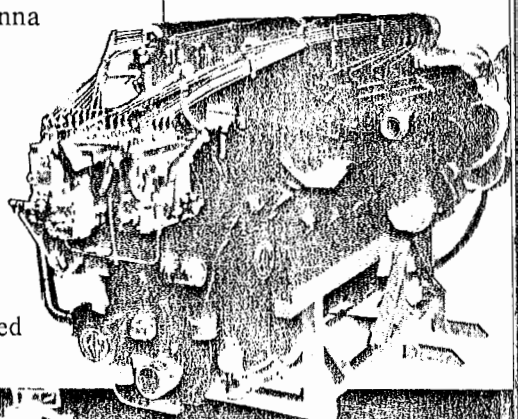
Roger Munk, technical director of Airship Industries, but no relation to 1920s airship theoretician Max Munk, claims several advantages for the "short, fat hull." It has the same drag coefficient as "the sleeker looking traditional form" of the earlier Goodyear, he says, partly because of the long, tapered tail made possible in a low-pressure, nonrigid airship by modern high-strength fabrics.

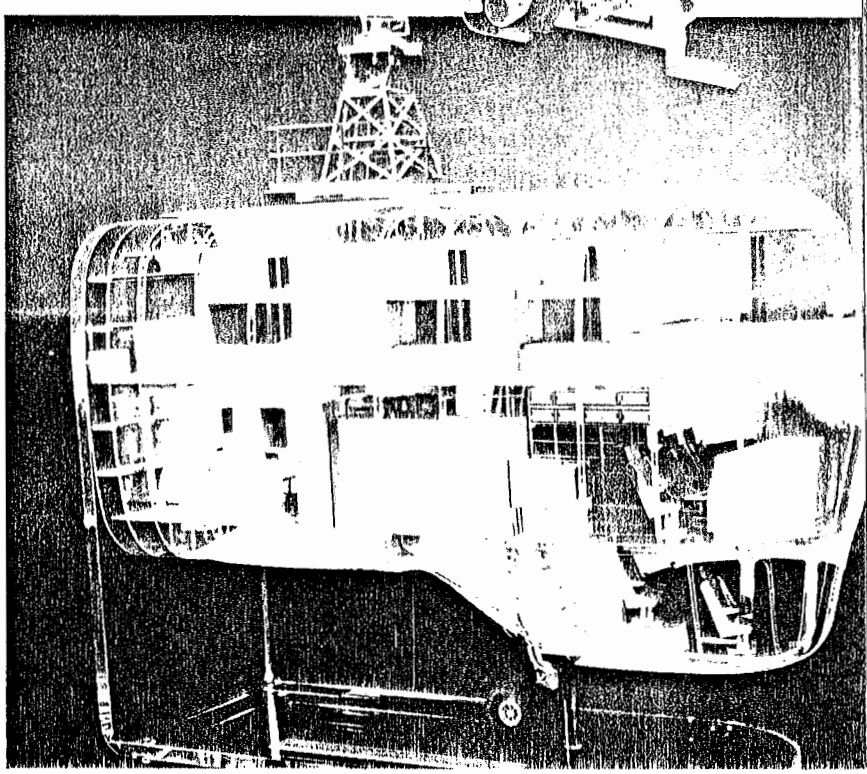
Another advantage of the pudgy shape is increased resistance of the hull to buckling while maintaining low hull gas pressure. Greater volume amidships will give more direct lift to counter the concentrated load on the envelope of the crew car and radar antenna mounted directly below. Munk says, "With a long slender hull [this load greatly] exceeds the buoyancy of the helium immediately above it and a substantial 'sagging' bending moment occurs." The bag might then buckle. To prevent this, higher envelope pressure must be maintained, leading to greater leakage and fabric stress.

Low pressure has several other advantages. "The fact is mistakes can and do happen," says Munk, "and a nonrigid airship that is undesirably reliant on maintaining hull pressure above a high minimum value is not, we consider, a safe airship. We have been able to demonstrate this buckling resistance on the Skyship 600, which as been flown at 50 kt without overall buckling or lack of control down to a hull superpressure (gauge pressure at the bottom of the hull) of 0.5 in. water, gauge, and at 30 kt down to zero hull superpressure." At zero superpressure, gauge pressure at the top of the hull is the head pressure of the buoyant gas. Sentinel will probably operate with 4 in. water, gauge. A limp blimp is desirable for low-speed ground-handling mishaps. Recalls Munk, "I've seen pilot-training incidents where [during a hard landing] the car disappeared into the envelope" and the airship rebounded with no damage done.

Mounting the radar antenna atop the gondola inside the bag will further lower the buckling moment on the top of Sentinel's hull. The gondola's rigid beam-like structure will stiffen the airship and longitudinally spread the antenna's weight. If suspended from the hull, the antenna would be "supported

(Top) The 1,800-hp BR-2000 diesels, manufactured by Italy's CRM, will run for 6,000 hr between overhauls. (Bottom) Cutaway of the forward gondola shows, from top to bottom, the car-mounted antenna, crew quarters, operations deck, and flight deck.





Sentinel 5000, at 423 ft., is over twice the length of the Skyship 600. The latter will test fly the Sentinel's fly-by-light system starting in February.

only by a limited area of the top surface fabric," notes Munk. A car-mounted antenna will be reached more easily for maintenance, have more rigid support, and have a shorter feed that reduces transmission line losses and presents a smaller lightning target.

The stubby configuration will be fairly agile for a blimp. Fore and aft taper will reduce the "apparent mass" of air that must be pushed aside when turning. And more of the vehicle mass will be close to the center of gravity, lowering rotational inertia so the airship can pivot more quickly.

Slung below the envelope, the gondola will measure 90 ft long, 16 ft wide, and 21 ft high at its tallest point. Two options are being considered for the skin to cover its carbon-composite/fiberglass frame. First is fiberglass/Nomex honeycomb-sandwich skin. An inner foil layer would serve as electrical ground and lightning protection. Ferrite radar absorbent material (RAM) packed into the honeycomb would make the airship harder to spot on radar. Munk reports Navy reservations about the honeycomb's retaining moisture and promoting corrosion. But he notes that an airship operates in a much more benign environment than the honeycomb helicopter blades with which the service is familiar. "We haven't had any problems with the honeycomb" on Skyship blimps, he says. The alternate is a carbon-epoxy skin that, Munk points out, would need an added layer of RAM and would thus weigh more.

The Navy has called for a pressurized car so crews can work more efficiently at over 5,000 ft. Pressurization will allow the airship to reach 14,000 ft. Normally it will fly at 10,000 ft, where the radar horizon is 125 n.mi. Crew quarters on the 1,400-ft^2 upper deck will consist of double staterooms for ten crew members and up to five passengers, heads, lounge, and recreation facilities. The lower deck work area will contain avionics, command information center, galley, engines, and replenishment equipment. At the forward end of the gondola, below the full length lower deck will be a short "mezzanine" flight deck. From this glazed position the airship will be navigated and controlled. Windows furnishing natural lighting in the rest of the car will be covered by RAM-coated shutters during combat.

Flight control signals will travel over redundant fiber optic cables. Fly-by-light was chosen over fly-by-wire in order to lessen the danger of disruption from a lightning strike, reduce the radar signature, and eliminate interference from the onboard warning radar. The system will be test flown in a Skyship 600 starting next February.

For attitude control an autopilot will coordinate control surface inputs with vectoring of the twin ducted props. For example, in a turn the underslung mass of gondola, engines, and radar swings outward like a pendulum, causing the airship to roll. To offset this, propellers and elevators could be differentially deflected to maintain an upright attitude and thus avoid disturbing orientation of the radar antenna. Thrust vectoring will also improve low-speed maneuverability and permit the autopilot to maintain a hover position. Furthermore, it adds a backup control. "If all [tail] control were lost, you could still point with vectored thrust and trim [fore and aft] with the ballonets" (internal air cells that maintain hull pressure), explains Munk.

Control power will come from pneumatically driven generator/motors at each surface. For safety, each control surface on the four cruciform fins will be split into two independent surfaces. Each of these, in turn, will have two actuators and three hinges.

CRM of Italy will make Sentinel's two 1,800-hp BR-2000 diesels good for 6,000 hr of running between overhauls. The engines will be carried inside the gondola, where they can be maintained in flight. Mechanical transmissions will drive shrouded propellers able to pivot $\pm 120°$ from the horizontal. For extra power to sprint up to 90 kt, a GE 1,800-hp CT7 turboprop, geared as a pusher, will be mounted externally on the aft centerline of the gondola. Such high speed in still air and the structural resilience of the design will enable the airship to keep station with the fleet during storms.

Engines will not be cross-shafted since asymmetric thrust is not a control problem on such a large, low-speed vehicle. The CRM units are light for diesels at 2 lb/hp. For missions longer than 1¼ days, diesels plus fuel are, overall, lighter than gas turbines. The same reasoning dictated a 350-hp Deutz air-cooled auxiliary power unit. Also, water recovery from diesel exhaust, to offset the weight loss from burning fuel, is an efficient and proven technology and greatly lowers the infrared signature of the blimp.

The envelope will be a tear-resistant,

light multilaminate single-ply fabric. Woven polyester Dacron will carry the load, an outer Tedlar layer will keep out the weather, and an inner Mylar layer will keep gas in. All will be bonded together with Hytrel. With only a single woven layer, "the Tedlar and Mylar take up [cross-weave] shear loads," notes Munk. Tedlar has a modulus about 1,000 times that of neoprene used on previous airships. Similar fabrics are used on the Skyships and the Westinghouse TCOM tethered aerostats. The latter's high loadings and internal pressures have operationally proven the fabric within 10% of the strength needed for the Navy airship, according to Munk. Envelope maintenance has also been low.

When asked about using higher strength-to-weight Kevlar, Munk says, "Its low extensability [stretch] requires higher accuracy" in fabricating the envelope, thus increasing the likelihood of critical stress concentrations. Kevlar support cables will be used on the Sentinel, and the nose cone and its stiffening rib "battens" will be Kevlar and fiberglass. Tailfin frames will be unidirectional glass-epoxy extrusions with envelope fabric covering and Kevlar leading edges. Horizontal fins will be canted down 12° to shed snow when the blimp is moored. This was a problem with X-tail blimps, which also had cross-axis coupling that made control more difficult when a surface was disabled.

The Sentinel demonstrator, like most military programs, has its critics. Navy auditors have questioned planning for an operational airship that would be larger and need a new radar and would therefore require a second design effort. They also note that the program reverses the usual practice of developing radar first and placing it on a proven platform, as was done with the E-3A AWACS. The Navy could argue that in this case platform operation is where work is needed to prove the concept.

No, grafting modern technology to the gentle giants of the air is not like bringing dinosaurs back to life. Given the long endurance updated blimps promise, having one on watch will be almost like having a low-flying satellite overhead. And for us civilians they hold out the prospect of returning to more elegant air travel and sightseeing.