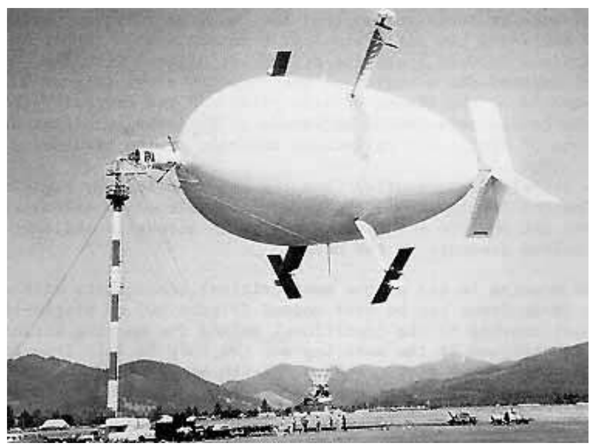
AeroLift, Inc. - Cyclocrane & Cyclo-Cruiser

Peter Lobner, updated 8 March 2022

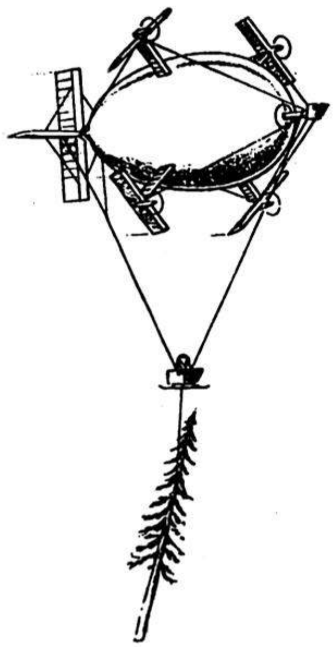
1. Introduction

In 1978, while working on the Aerocrane with its inventor, Donald Doolittle, Arthur Crimmins developed the idea for the Cyclocrane. Unlike the Aerocrane, which had a vertical axis of rotation, at 90° to its horizontal direction of travel, the Cyclocrane had a horizontal axis of rotation, in line with its direction of travel. This latter arrangement overcame Magnus effect instabilities that were inherent in the Aerocrane design. In both the Cyclocrane and the Aerocrane, the aerostat carries the weight of the vehicle, the pilot's cab and about half the weight of the payload. The wing airfoils generate the thrust vector needed to carry the balance of the payload weight and fly.

Aerocrane (L) & Cyclocrane (R).
Sources: Vertifile (L) & Rob Crimmins (R)

In 1979, Arthur Crimmins established the firm AeroLift Inc. to develop Cyclocrane heavy lift airships with Donald Doolittle serving as the design engineer. Their initial objective was to build the Cyclocrane hybrid airship and demonstrate that it could conduct aerial logging at remote sites that were inaccessible by conventional means.
In 1980, Crimmins filed a US patent application for his invention of the Cyclocrane and also secured $4 million in initial funding from four Canadian logging companies: MacMillan Bloedel, Pacific Forest Products, BC Forest Products and Silver Grizzly Logging.

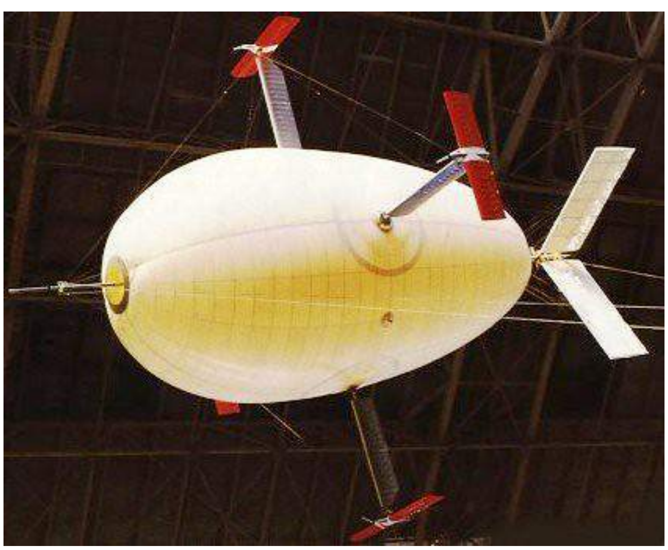


The fledgling firm had the resources to start developing the Cyclocrane. It was publicly traded on the Vancouver, Canada stock exchange.

In 1983, AeroLift received an $850,000 contract from the US Forest Service (USFS) to demonstrate a logging prototype. The performance goal for logging operations was a Cyclocrane with a 16-ton sling load capacity.

Source (left): A.G. Crimmins via UNIDO, 1983

The first working model of the Cyclocrane was a subscale 50-foot (15.2-meter) device that was flown indoors in 1979, in a blimp hangar at the Lakehurst Naval Air Station in New Jersey. Howard C. Curtiss, a Princeton University professor of mechanical and aeronautical engineering, specializing in helicopter dynamics, was involved in the Lakehurst tests and reported that the large aerodynamic forces generated by the Cyclocrane's wings provided gust stability equal to that of helicopters with an equal slingload.



Source: Rob Crimmins

In June 1981, Crimmins moved the company to Tillamook, Oregon and set up operations at Hangar B at the former Naval Air Station Tillamook blimp base, on Blimp Boulevard. Hangar B is the largest free-standing, clear-span wooden structure in the world.

The AeroLift facility in Tillamook, OR.
Source: Rob Crimmins

There were two proof-of-concept versions of the Cyclocrane, both 178 feet (54.25 m) long with a 2-ton (1.8 metric ton) sling load design capacity. Work on the original version was started in 1981. It was severely damaged before its first flight while moored outdoors during a severe windstorm on 23 October 1982. The rebuilt and modified second Cyclocrane made its first unmanned flights in August 1984 followed by the first tethered manned flight on 15 October 1984 and the first manned free flight on 23 October 1984.

The two versions are visually distinguishable by the following features:

- The original version had an inverted Y-shaped tail assembly. The rebuilt version had a ring-shaped tail that was wire-braced to the central axle.
- The original version had an engine-driven propeller at the tip of each rotating wing. The rebuilt version had an engine-driven propeller at the tip of only two wings

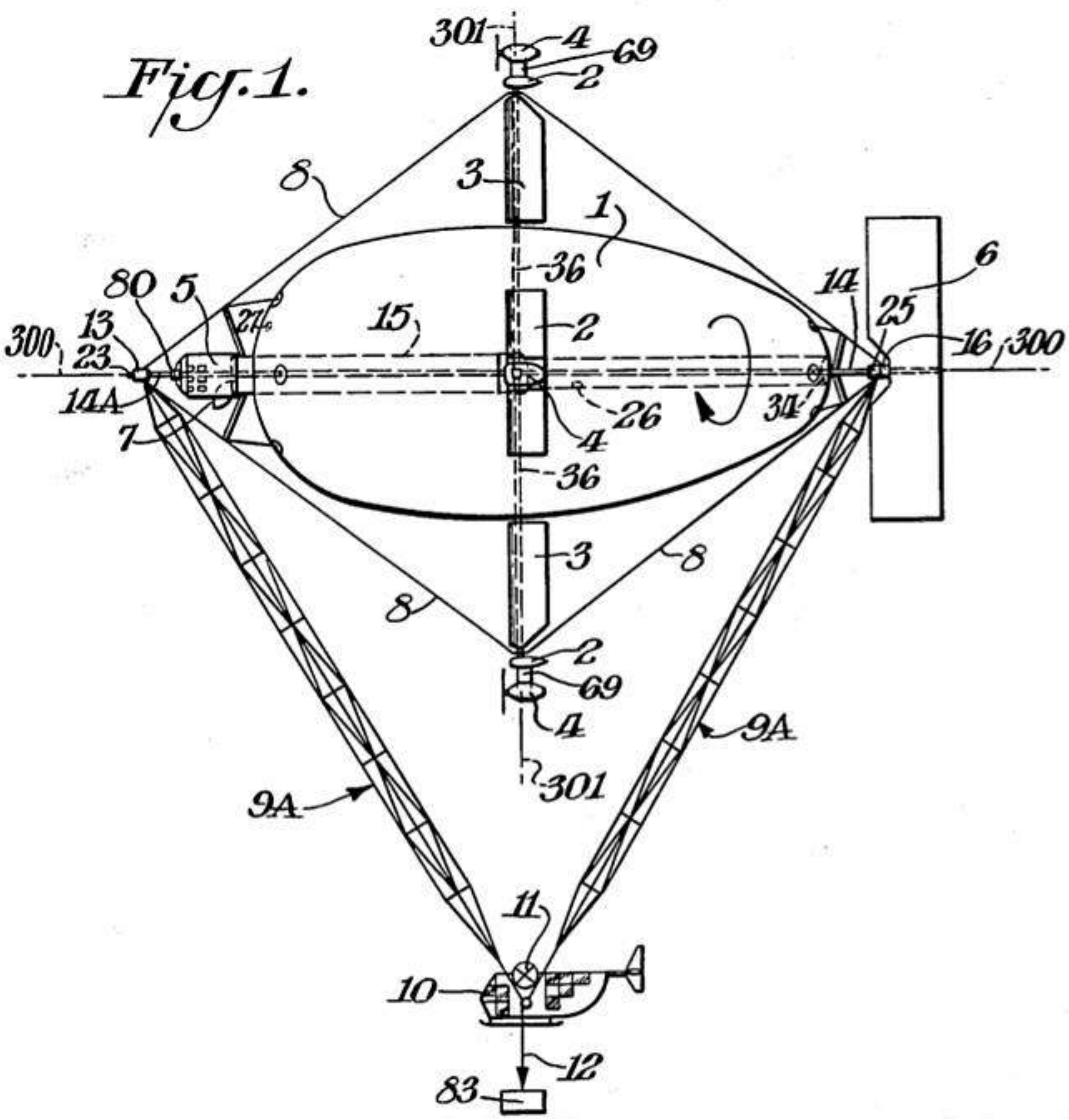
Under contracts with the USFS and the US military, including the Defense Advanced Research Projects Agency (DARPA), Aerolift continued flying the Cyclocrane until 1990.

After military funding ended in 1990, AeroLift closed shop. No production Cyclocranes were ordered.

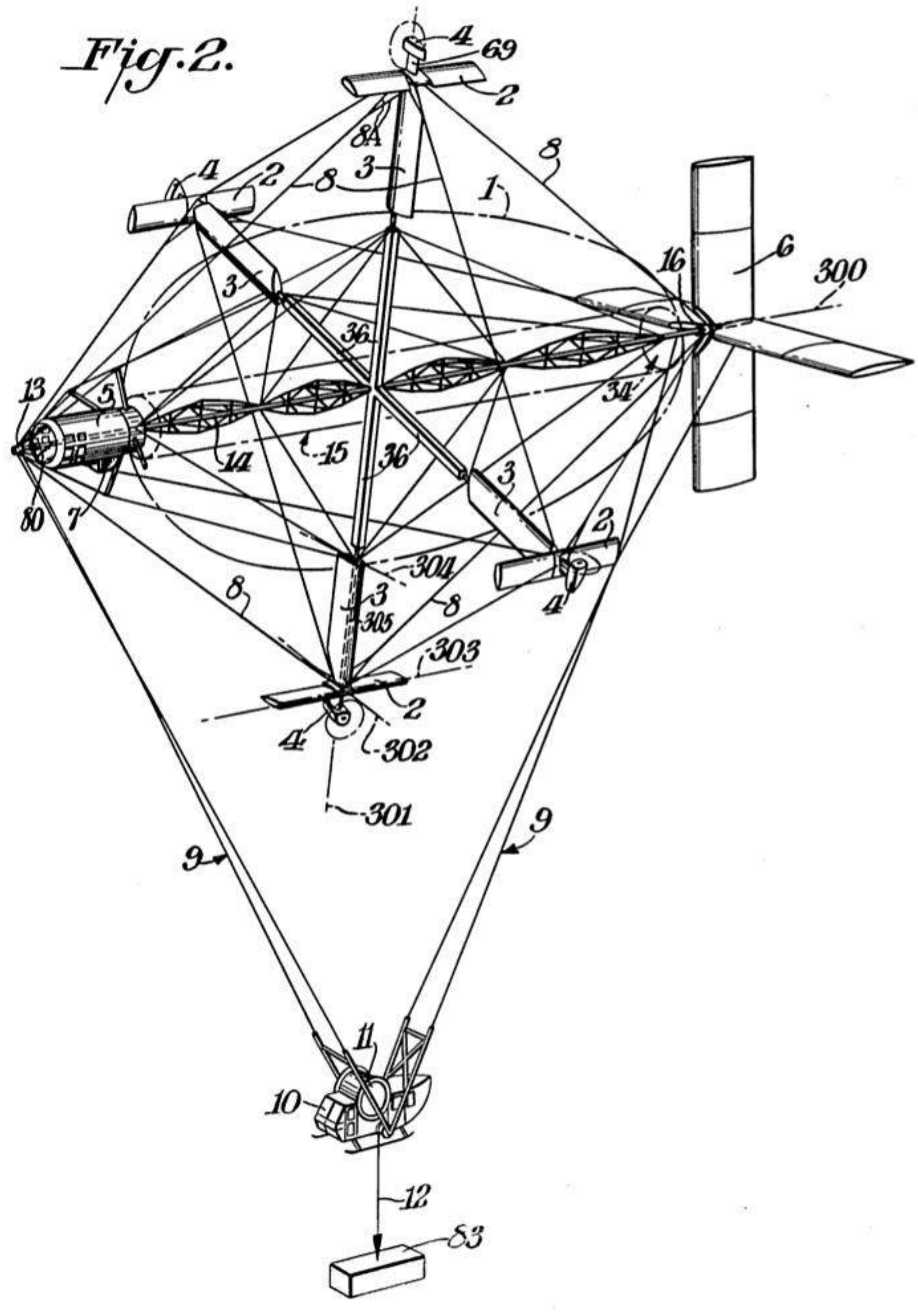
2. Basic design of a Cyclocrane

Arthur Crimmins filed a patent application for his Cyclocrane invention on 14 November 1980. Patent US4482110A, "Cyclorotor composite aircraft," was granted on 13 November 1984 and assigned to International Cyclocrane Licensing. You can read this patent here: https://patents.google.com/patent/US4482110A/en?oq=4482110

Fig. 1.



Side view of the Cyclocrane with the wings (2), blades (3) and engines (4) in the full-forward position for non-rotating flight at maximum airspeed. Source: Patent US4482110A



Isometric view of the Cyclocrane with the wings (2), blades (3) and engines (4) in the athwartship position for rotating flight at maximum rpm while hovering at zero airspeed. Source: Patent US4482110A

With reference to patent Figures 1 and 2, it is immediately apparent that the Cyclocrane is a novel airship design. It is comprised of a blimp-sized, ellipsoidal helium envelope (1) and a set of four T-shaped, blade / wing / engine units (2, 3, 4 & 69) extending radially from the midsection. The engines can rotate this whole assembly at speeds up to 13 rpm. A non-rotating tail assembly (6) stabilizes the airship and points it into the wind when moored. A non-rotating crew cab is located at the nose (5) and the primary crew cab is suspended under the airship (10) on cables (9A) attached via bearings to the central axis (14) of the airship. The payload (83) is carried as a sling load, attached either below the crew cab (12) or suspended separately from the aerostat.

Fig. 11.

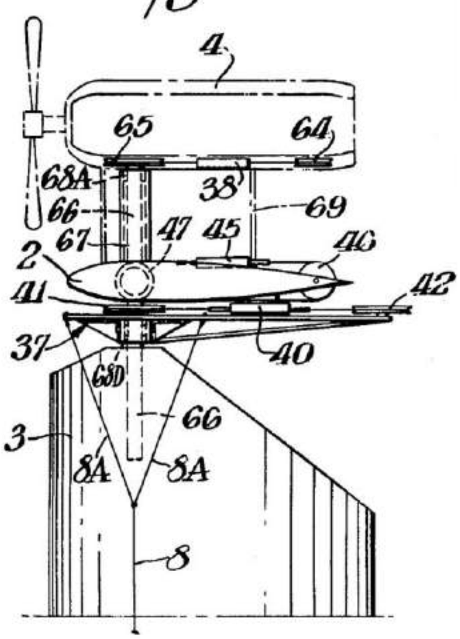


Figure 11 shows the drive systems of the adjustable wing airfoil (2) and blade airfoil (3). The wing airfoil angle-of-attack is set by an actuator (45) and pully (47) that pivot the wing on its spar. The blade angle-of-attack is set by an actuator (38) and pully (65) that pivot the blade actuation shaft (66).

The main airfoil support cables (8, 8A) are tensioned guy wires attached to the yoke (37, a fixed structural support member) and connect to the nose and tail of the aerostat and between adjacent blade /airfoil / engine assemblies (see Figs. 1 & 2).

Closeup of a wing airfoil and engine unit on the tip of a blade airfoil. Source: Screenshot from Rob Crimmins video

4. Flying a Cyclocrane

Aerostatic lift from helium carries the weight of the vehicle, the pilot’s cab and half the weight of the payload. The wing airfoils generate the aerodynamic lift needed to carry the balance of the payload weight. The wingtip engines provide the power to rotate the whole vehicle on its longitudinal axis at up to 13 rpm when hovering and maintain a constant 60 mph (97 kph) relative wind over the wing airfoils.

When rotating, the four wing airfoils function as a controllable-pitch cycloidal propeller (a “cyclorotor”) that can generate a thrust vector in any direction perpendicular to its horizontal axis of rotation. The blade airfoils function as a controllable-pitch rotor that can generate a longitudinal thrust vector.

The flight control system includes the following control functions:

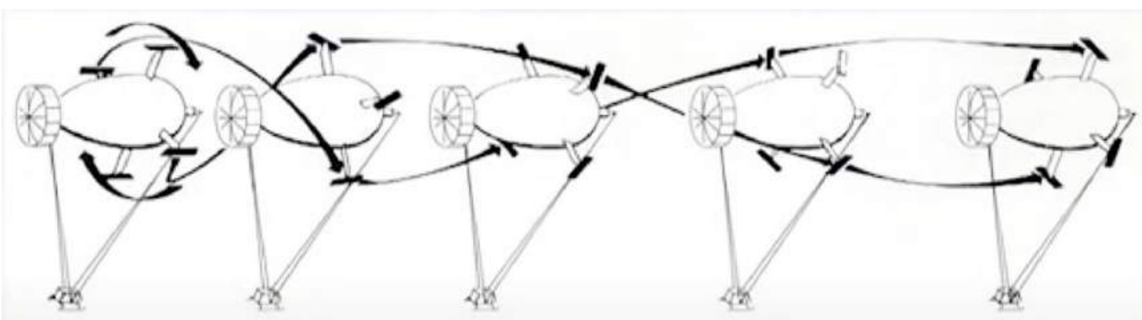
- The blade airfoils have both collective and cyclic controls.
    - A collective blade command adjusts all blades to a common angle-of-attack. In hover, blade collective provides a forward or reverse thrust vector that is directly in line with the horizontal axis of the vehicle. This thrust vector is the means for accelerating from a hover.
    - A cyclic blade command adjust the angle-of-attack of specific blades based on their positions in a rotational cycle to provide thrust for yaw and pitch control.
- The wing airfoils and the engines are rigidly connected and are controlled to point directly into the relative wind.
    - They point perpendicular to the vehicle’s longitudinal axis when hovering (at zero airspeed).
    - They point in line with the vehicle’s longitudinal axis at maximum airspeed.
- Engine speed is controlled to maintain a constant relative wind speed of 60 mph from hover to maximum airspeed.
- The wing airfoils have cyclic controls that adjust wing angle-of-attack based on its positions in a rotational cycle.
    - The wings at the top and bottom of their rotational cycle are adjusted together to deliver lift or a downforce and are used to carry one-half of the payload weight and execute climb, descend and altitude hold commands.

- The wings at the sides of their rotational cycle are adjusted together to a neutral position during forward flight, or to deliver a side-force.

At the start of a flight, a Cyclocrane is hovering at zero airspeed attached to its payload, which is still on the ground. The wing airfoils / engines have been rotated and are aligned with the plane of rotation, perpendicular to the longitudinal axis of the aerostat. To pick up the load, the wingtip engines initiate vehicle rotation at up to 13 rpm, which increases the relative wind over the wing airfoils. As they rotate, the wing airfoils at the top and bottom of the rotation are automatically trimmed to generate lift, while the wings at the sides are trimmed to a neutral position.

To accelerate from hover, the blade airfoils are trimmed to generate longitudinal thrust. As forward airspeed increases, the wing airfoils / engines gradually rotate forward to match the changing direction of the relative wind and the vehicle's rate of rotation gradually decreases to maintain the relative wind at 60 mph.

When the airship reaches its maximum airspeed of 60 mph, the wing airfoils / engines are pointing directly forward and vehicle rotation has stopped. The top and bottom wings now function as conventional, fixed airfoils and provide the same lift that the four wings previously generated as part of a rotating cycloidal propeller.



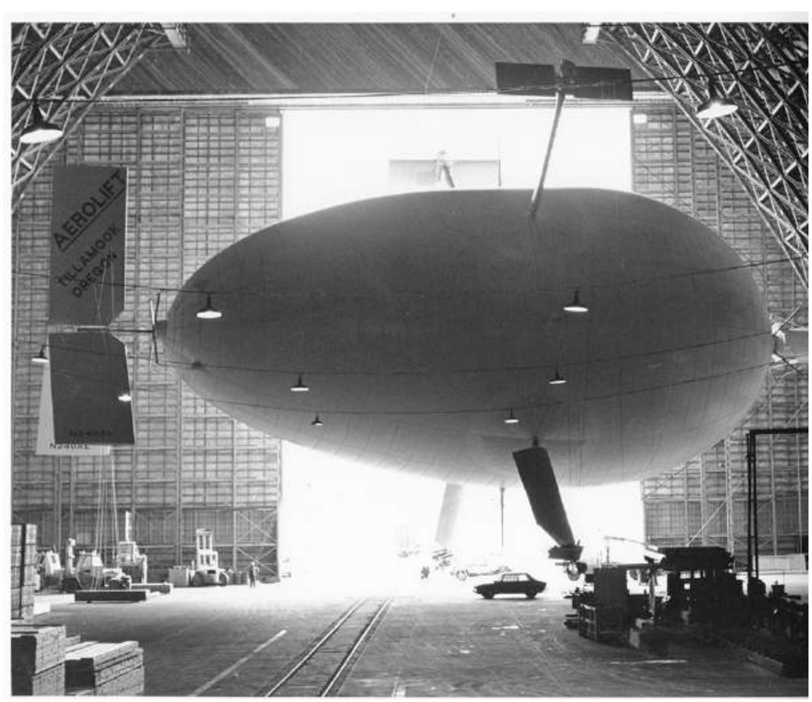
Cyclocrane wing orientation changes while accelerating from a rotating hover (left) to a non-rotating cruise flight at maximum speed (right). Source: Screenshot from Rob Crimmins video

When approaching the destination, wing rotation is restarted as the airship slows and the relative wind starts moving aft. At the delivery site, the rotating wing airfoils are adjusted to generate a downward thrust to counteract the positive buoyancy of the airship and transfer the full load of the payload to the ground so the sling can be safely disconnected from the load. As they rotate, the wing airfoils at the top and bottom of the rotation are automatically trimmed to generate the downforce, while the wing airfoils at sides are trimmed to a neutral position.

With the external load disconnected, the buoyant airship can fly to its next destination with the rotating wing airfoils continuing to generate downward thrust. In this way, Cyclocrane load exchanges (pickup and delivery) are accomplished without an exchange of ballast and the airship can fly safely with or without an attached load.

5. The 1st Cyclocrane (1980 to 1982)

Construction of the original proof-of-concept Cyclocrane was started in 1981. This large-scale vehicle was designed to lift a 2-ton (1.8 metric ton) payload. It is distinguishable from the design in patent US4482110A by its inverted Y-shaped tail in place of a cruciform tail



The original Cyclocrane in its hangar. Source: Rob Crimmins

After being rolled out of its hangar in August 1982 and docked at the mooring mast, final installation work was performed outdoors and tests were conducted on the airship systems.

The original Cyclocrane at its mooring mast in 1982 in Tillamook, OR.
Source, both photos: Rob Crimmins

While moored, a severe windstorm on 23 October 1982 severely damaged the Cyclocrane before it had a chance to make its first flight. In winds approaching 90 mph, the vehicle separated from its mooring mast. Tether cables that remained attached pulled the craft to the ground, damaging the wing structure and the envelope. The damaged airship was salvaged, repaired and modified to become the second Cyclocrane.

The original Cyclocrane after breaking free from the mast during a storm, 23 October 1982. Source, both photos: Rob Crimmins

6. The 2nd Cyclocrane (1982 to 1990)

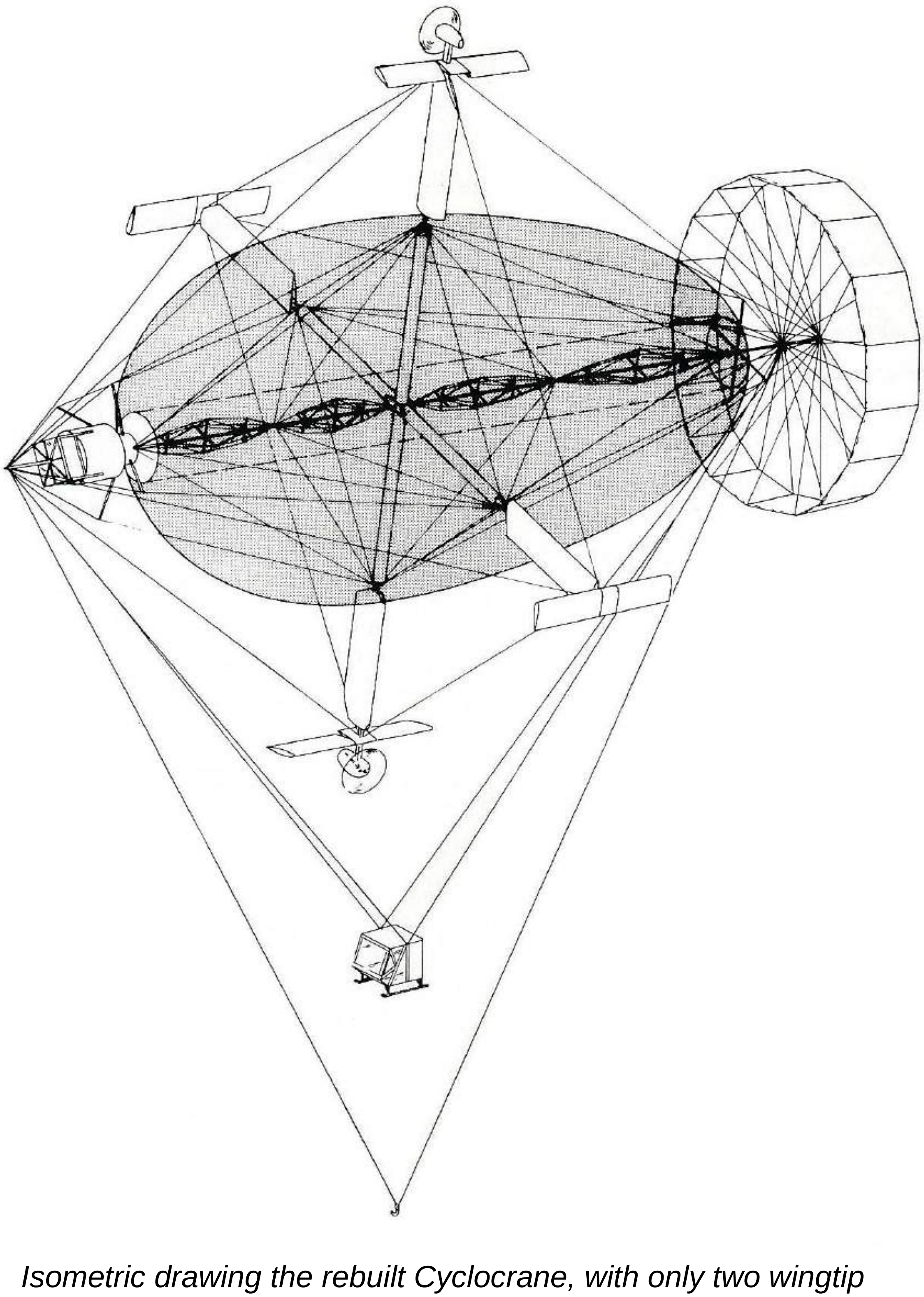
The rebuilt Cyclocrane was different from the original Cyclocrane in the following respects:

- A wire-braced, symmetrical ring-tail replaced the inverted Y-tail. This was done to resolve a torque problem caused by the original design.
- There were only two engines on the wingtips. Before the first flight, A.G. Crimmins reported that this was done because the original version was felt to be overpowered.
- Updated telemetry system.

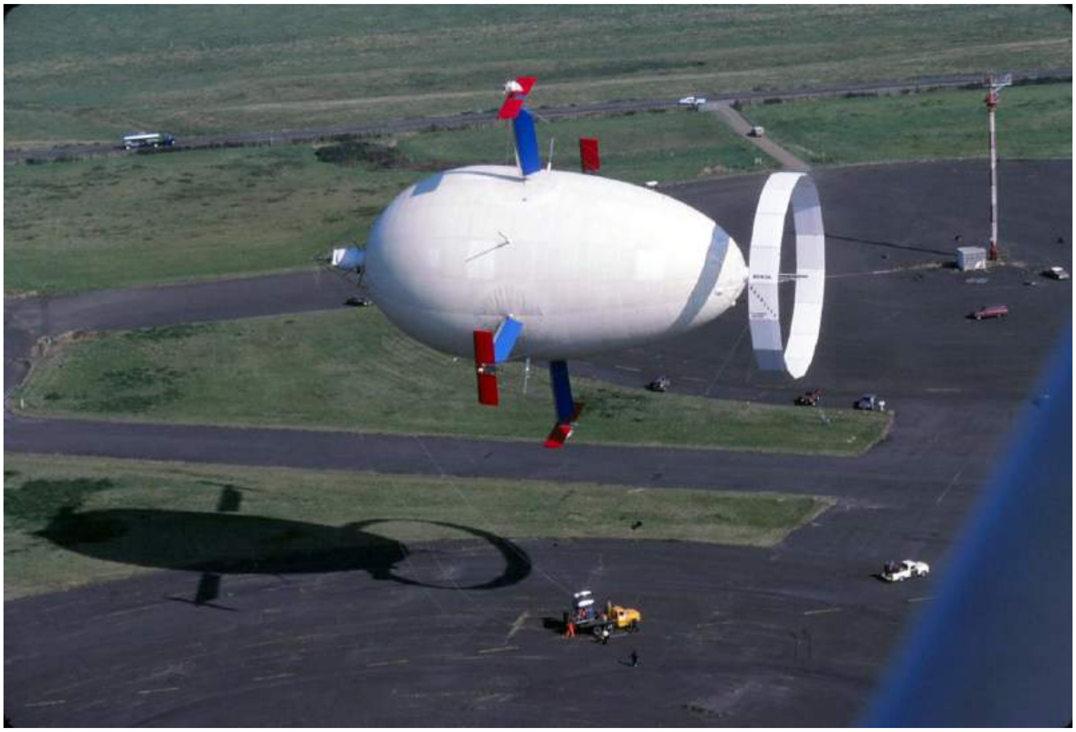
In addition, the mooring system was modified to grip the airship in three locations.

General characteristics of the second Cyclocrane

Parameter	Cyclocrane
Airship type	Hybrid, composite, semi-rigid aircraft
Length, overall	178 feet (54.25 m) overall
Length, aerostat	136 feet (41.45 m)
Diameter, aerostat	68 feet (20.73 m)
Height, overall	255 feet (77.72 m) overall, from payload hook to uppermost engine
Lift gas	Helium
Envelope volume	330,000 ft ^{3} (9,300 m ^{3}) helium volume
Helium lift @ 1.06 kg per m ^{3} at STP	About 21,733 lb (9,858 kg)
Accommodations	4 crew in a suspended crew cab
Propulsion system	2 × Textron Lycoming AEIO-320 4-cylinder, horizontally opposed, air-cooled, aerobatic piston engines @ 150 hp (110 kW) each, mounted on two of the four wings.
Rotational speed	13 rpm (design), 10 rpm (actual)
Translational speed, max	60 mph / 97 kph (design), 45 mph /72 kph(actual)
Payload	2 tons (design), 1 ton (actual)



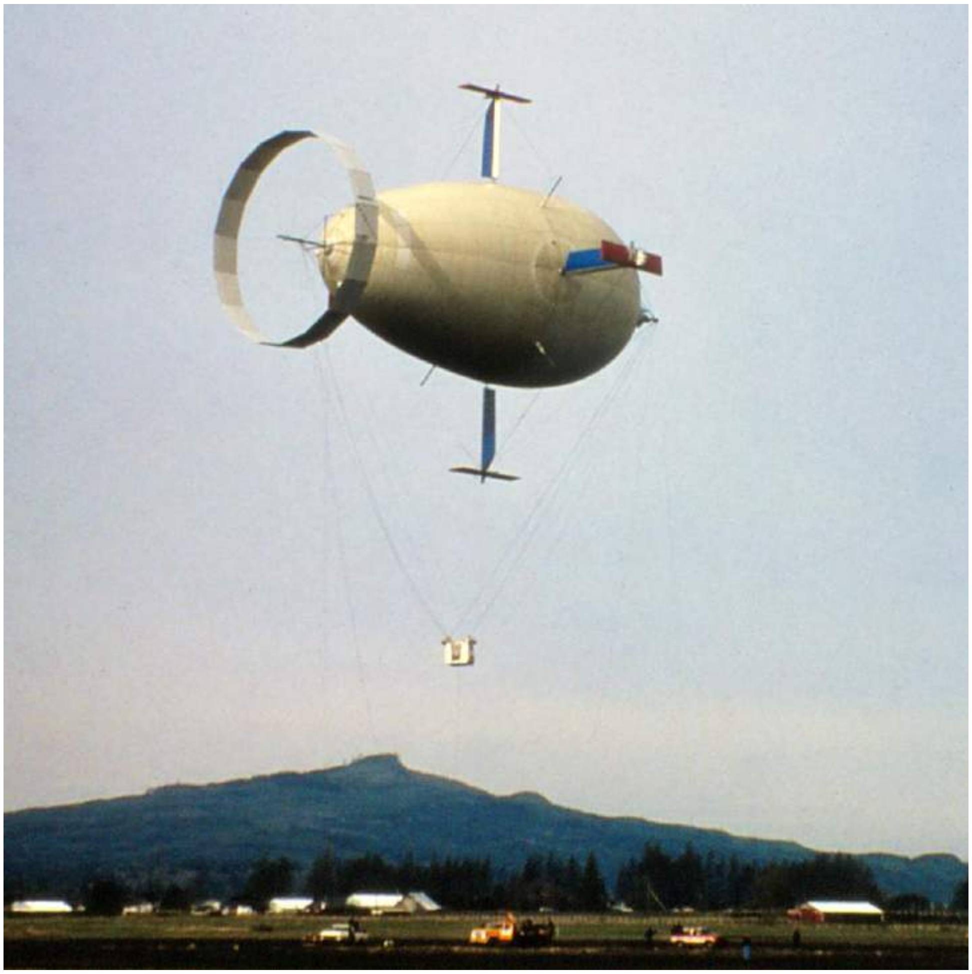
Isometric drawing the rebuilt Cyclocrane, with only two wingtip engines and a ring-tail. Source: Rob Crimmins



The rebuilt Cyclocrane. The wing airfoils are red,
the blade airfoils are blue. Source: Rob Crimmins

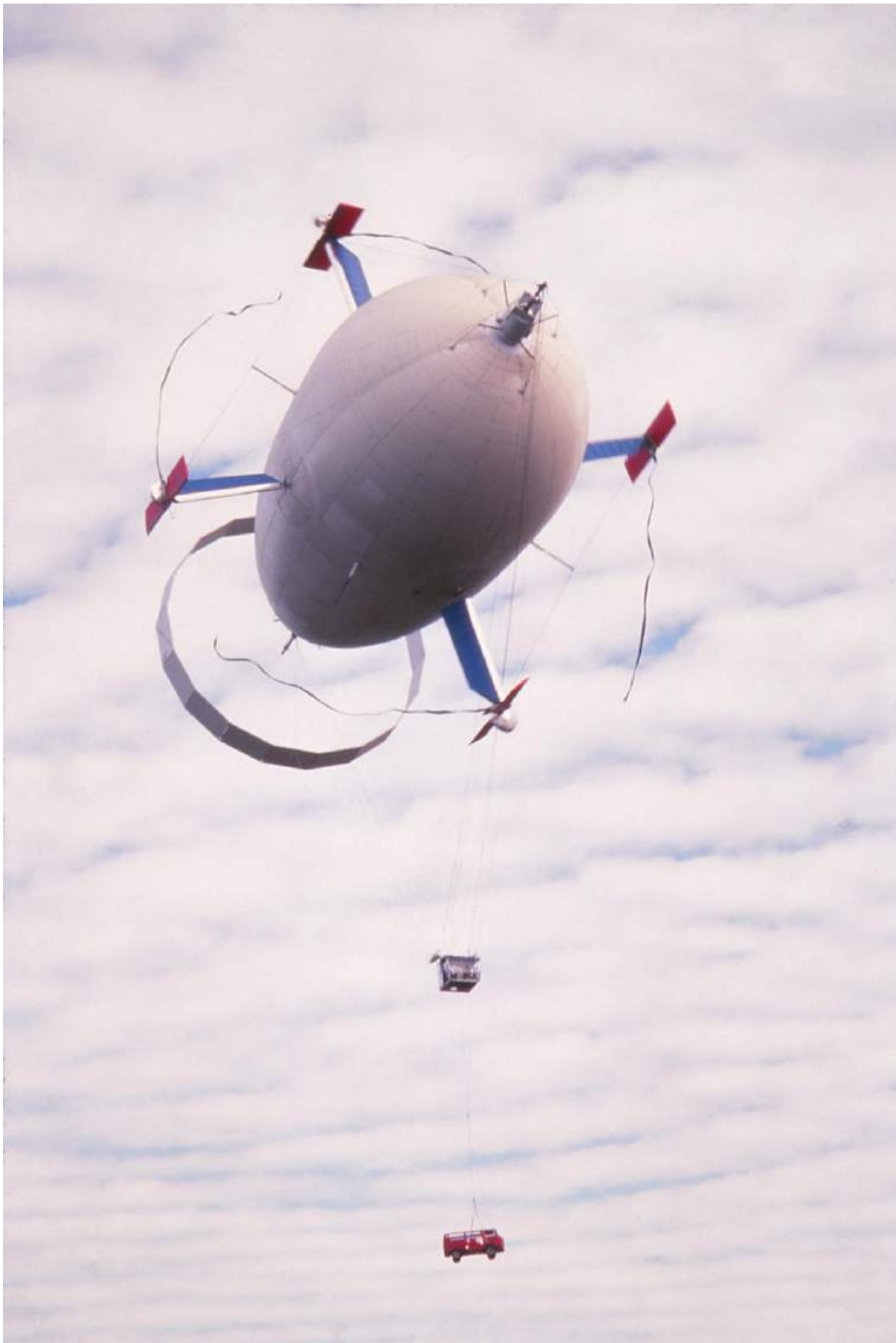
The rebuilt Cyclocrane made its first unmanned flights in August 1984 followed by the first manned tethered flight on 15 October 1984 and the first manned free flight on 23 October 1984. The crew consisted of the pilot, J.J. Morris, a flight engineer to monitor the automatic functioning of the vehicles engines, hydraulics and flight control systems, a co-engineer who also has flight controls to assist the pilot if needed, and a computer operator to handle the on-board, real-time data acquisition system and analysis of data.

The 2nd Cyclocrane demonstrated that it was underpowered with only two engines, which could only rotate the vehicle at 10 rpm, fast enough to generate a relative wind of 45 mph over the wings, instead of the intended 60 mph. With the reduced lift, the 2nd Cyclocrane could not lift the intended 2-ton payload, but succeeded in lifting a 1-ton Volkswagen minibus.



First flight. Source: Rob Crimmins

Closeup of the crew cab. Source: Rob Crimmins



The rebuilt Cyclocrane in flight. The crew cab is suspended beneath the aerostat and a 1-ton VW minibus is attached as a sling load. Source: Rob Crimmins

7. Plans for production Cyclocranes and Cyclocruisers

Cyclocranes

The performance goal for logging operations was a Cyclocrane with a 16-ton (14.5 metric ton) sling load capacity. Scaling from the 2-ton proof-of-concept vehicle, a 16-ton logging vehicle could be achieved by doubling the length, to 356 feet (108.5 m) overall. In 1985, AeroLift was planning to begin production of such vehicles at a unit price of about $5 million, with initial delivery not occurring before 1987. None were built for Cyclocrane's industrial logging sponsors, the Forest Engineering Research Institute of Canada (FERIC), or the USFS.

The Cyclocrane attracted significant interest from the US military in the mid-1980s. Cyclocrane test flights in 1985 were funded under a $630,000 defense contract. The Army Aviation Systems Command, with some support from the USFS, awarded AeroLift a $1-million contract in 1986 for the preliminary design of a 35-ton (31.8 metric ton), 100 mph (161 kph) Cyclocrane propelled by turbo-prop engines. Also, in 1986, the US Congress supported additional funding for Cyclocrane supportability, maintainability and vulnerability research. By this time, AeroLift had accumulated 20-hours of flying time on their proof-of-concept Cyclocrane.

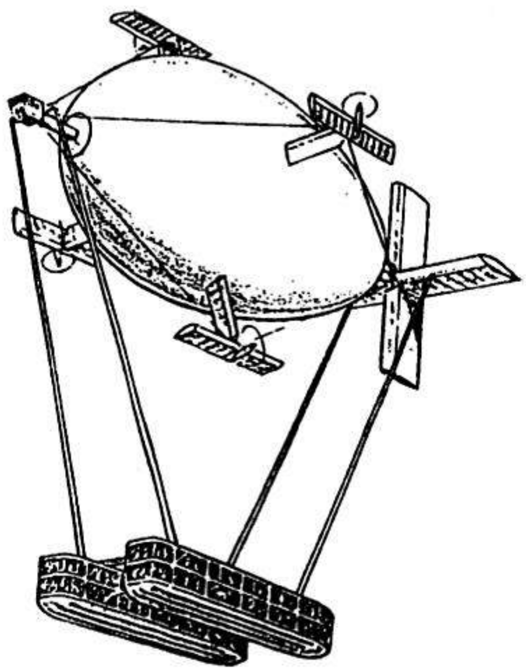
Military funding ended in 1990 with no orders for a military version of the Cyclocrane.

The Cyclo-Cruiser

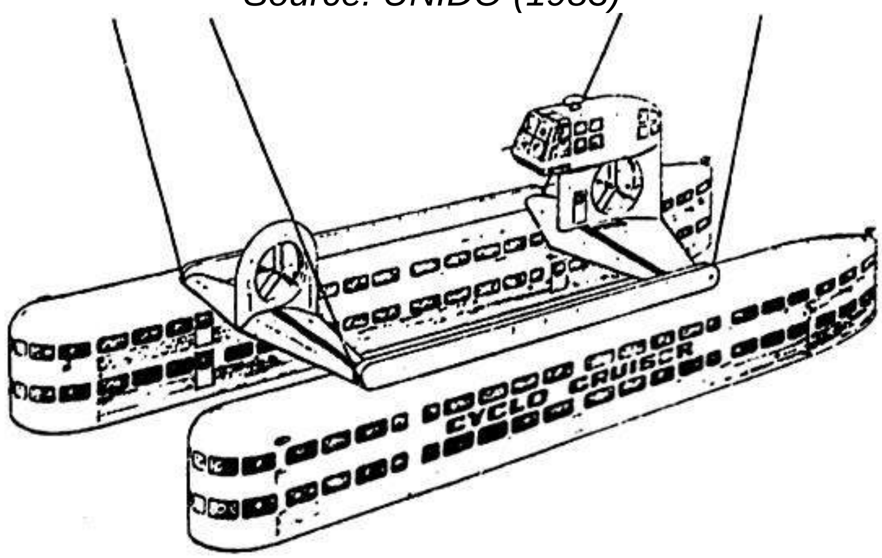
The Cyclo-Cruiser is a passenger-carrying application as a mass transit vehicle operating on relatively short distance routes. In this role, a 50-ton (45.4 metric ton) slingload Cyclocrane would carry up to 550 passengers at 118 mph (190 kph) in detachable dual, two-tier cabins.

A 1983 UNIDO report explains: "With detachable passenger modules, the ground space requirements for passenger service would be modest. In operation, the incoming Cyclo-Cruiser would release its passenger module at a special berth and re-connect to an out-going module that already has been boarded with passengers. This would ensure quick turn-around times and high vehicle utilization.” In 1983, the round-trip airfare for Los Angeles to Las Vegas flights (270 miles one-way) was estimated to be half the price of scheduled airline service ($31 vs $61).

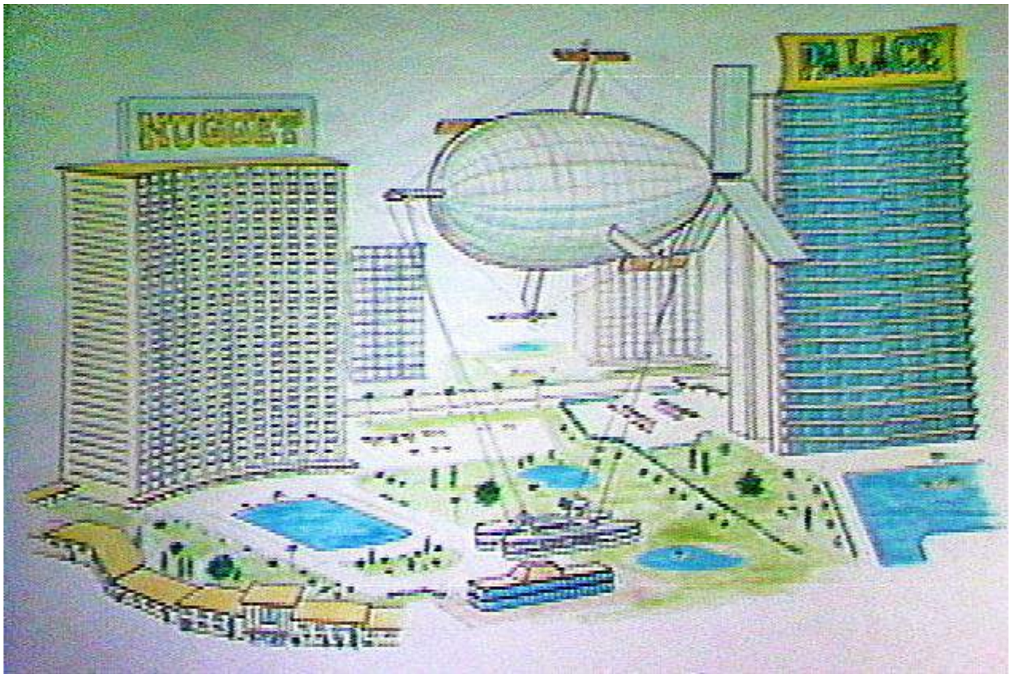
No Cyclo-Cruiser was ordered.



Cyclo-Cruiser with wings aligned for hovering flight.
Source: UNIDO (1983)



Cyclo-Cruiser dual passenger cabins. Source: UNIDO (1983)



Cyclo-Cruiser people-mover concept.
Source: Illustration by Bob Caufman via Rob Crimmins

8. For More Information

- "The Cyclocrane - a hybrid airship invented by Arthur Crimmins, Jr. and Donald Doolittle": Robert A. Crimmins blog site: https://www.robcrimmins.com/home/engineering/the-cyclocrane/
    - Robert Crimmins, "The Cyclocrane," 22 October 2013
    - Malcom Browne, "The Whirly-Blimp Takes Flight," Discover magazine, November 1982
- Mark Ardema, "Vehicle Concepts and Technology Requirements for Buoyant Heavy-Lift System," NASA Technical Paper 1921, September 1981: https://ntrs.nasa.gov/api/citations/19810022643/downloads/19810022643.pdf
- Anthony J. Dolman, "Current and Possible Future Developments in Lighter-Than-Air (LTA) System Technology," United Nations Industrial Development Organization (UNIDO), Section 7.3, "The Cyclo-Crane," pp. 184 - 187, 1983: https://open.unido.org/api/documents/4793600/download/CURRENT%20AND%20POSSIBLE%20FUTURE%20DEVELOPMENTS%20IN%20LIGHTER-THAN-AIR%20

- Barry Gross, “Three Inventors' Variations on Theme of Blimps,” The Washington Post, 18 March 1985: https://www.washingtonpost.com/archive/business/1985/03/18/three-inventors-variations-on-theme-of-blimps/8cf0268e-ae73-4674-95e8-842c2255eacf/
- John Lienhard, “Engines of Our Ingenuity, No. 311: The Cyclocrane,” University of Houston's College of Engineering: https://www.uh.edu/engines/epi311.htm
- Aviation Week & Space Technology magazine:
    - 17 November 1980, “Cyclo-Crane Developed for Heavy-Lift,” p. 71
    - 6 August 1984, “Cyclo-Crane Balloon / Helicopter Begins Tests,” pp. 70 – 71
    - 15 April 1985, “Cyclo-Crane Heavy-Lift Vehicle Completes Initial Flight Tests,” p. 66

Videos

- YouTube video, “Cyclocrane 1st Flight” (2:41 minutes), KATU TV, 16 October 1984: https://www.youtube.com/watch?v=uWfX9wAiMm4
- YouTube video, “Cyclocrane Heliostat” (6:58 minutes), 11 November 2008: https://www.youtube.com/watch?v=cWLhH3wsxUo
- YouTube video, “The Cyclocrane” (17:48 minutes), Rob Crimmins, 23 October 2013: https://www.youtube.com/watch?v=CiU71GFs4Fs

Additional Cyclocrane patent

- Patent US5090637, “Helium Purification System for Lighter-Than-Air Craft,” Inventor: Willard Haunschild; filed on 14 April 1989; granted on 25 February 1992 and assigned to International Cyclocrane Licensing. You can read this patent here: https://patents.google.com/patent/US5090637A/en

Other *Modern Airships* articles

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