SPACIAL S. A. – lenticular airships

Peter Lobner, updated 8 March 2022

1. Introduction

SPACIAL S. A. was an airship manufacturing company founded by Mario Sánchez-Roldan and located near Lake Toluca, Mexico. After starting work on his first large, lenticular airship in 1973, Roldan first contacted Michael Walden in 1977 and laid the groundwork for a collaboration between SPACIAL and Walden's US firm, Lighter Than Air Solar (LTAS). Roldan and Walden first met in person in July 1979 at the AIAA 3rd Lighter-Than-Air Systems Technology Conference in Palo Alto, CA.

In this collaboration, Roldan was the main designer and engineer. Michael Walden's primary role was as co-designer of the geodesic rigid space frame for the airship's hull. Walden used his SIZ-3 computer code for establishing the displacement sizing of the airship and the corresponding strut lengths and detailed geodesic design of the rigid frame. Walden worked from his LTAS office in Las Vegas, Nevada and never visited the SPACIAL facilities.

The first product of this collaboration was Walden's geodesic rigid space frame design for a 24-meter (78.7-foot) diameter airship Roldan was planning to build. Roldan and Walden reviewed this design and the SIZ-3 computer code during their July 1979 meeting in Palo Alto. Roldan adopted Walden's rigid space frame in the design of his first airship, which became known as the MLA-24-A.

The next collaboration product was the geodesic rigid space frame design for Roldan's XEM-4 remotely controlled, subscale, rigid airship test model, which was built in 1981. This flying model was used to validate the designs of the MLA-24-A and the subsequent MLA-32-A and MLA-32-B rigid airships. SPACIAL financed the design, construction and flight-testing of the MLA-series airships and the XEM-4. No funding was provided by LTAS.

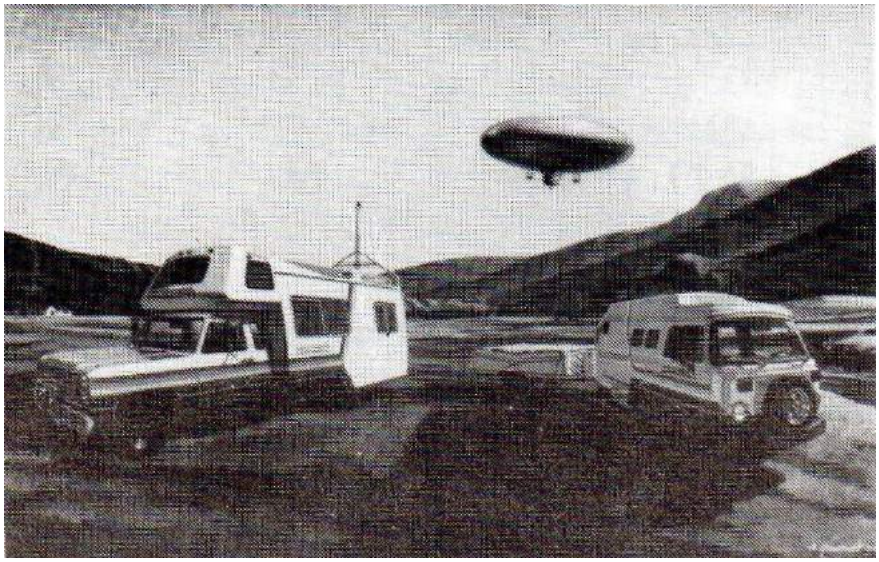
Roldan died in a car accident in 1990, a month after his MLA-32-B was destroyed in Mexico following an emergency landing. Shortly thereafter, SPACIAL's airship activities ceased along with their collaboration with Walden.

The collaboration helped validate the SIZ airship design code and some of the lenticular, rigid hull design features favored by Walden / LTAS. The MLA-34-A/B airships were 80% of the size of the Walden / LTAS T-90 Tourer airship, which they proposed for nearly silent aerial tourism over the Grand Canyon. However, the SPACIAL airships did not have a density controlled buoyancy (DCB, variable buoyancy) system, a fully automated mass transfer unit (MTU) for pitch, roll and CG control at all airspeeds, and did not have a rigid composite aeroshell as found in contemporary Walden / LTAS airship designs.

Special thanks to Michael Walden and the Airship Association for their thoughtful input for this article on SPACIAL airships.

2. MLA-24-A (1976 – 1985)

Design work on SPACIAL's first airship started in 1973, with the rigid, lenticular hull design being finalized after the July 1979 meeting between Roldan and Walden.

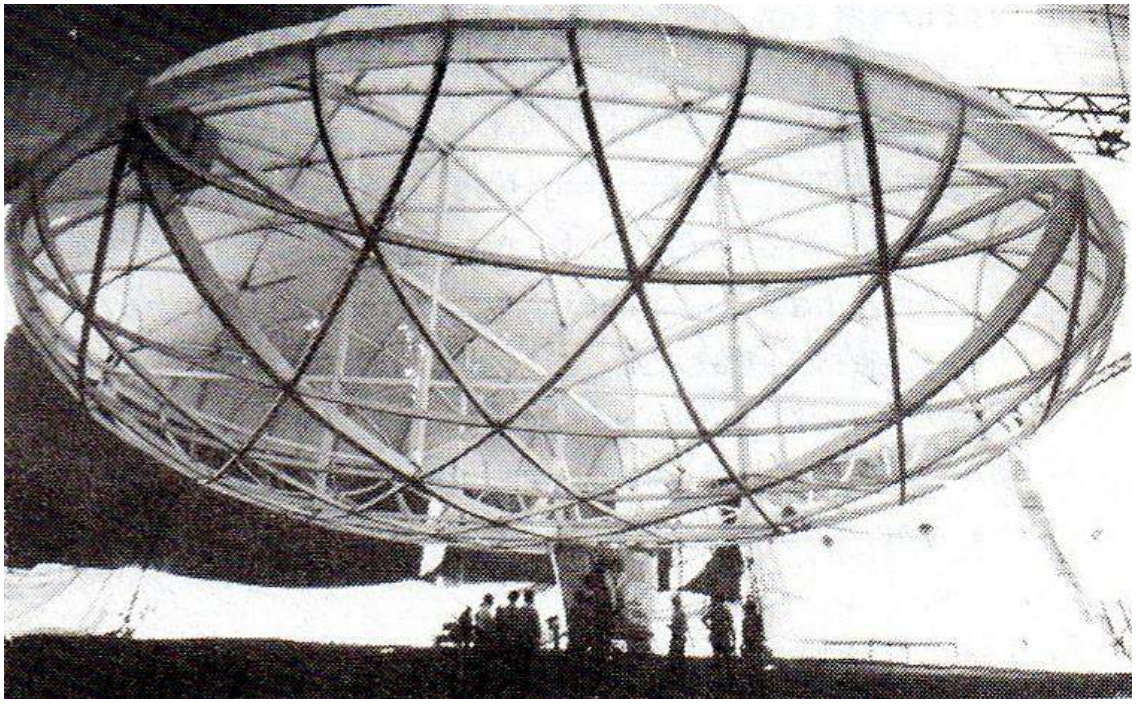


Rendering of the MLA-24-A with ground support vehicles and mobile mooring mast. Source: The Journal of the Airship Association, No. 68, June 1985

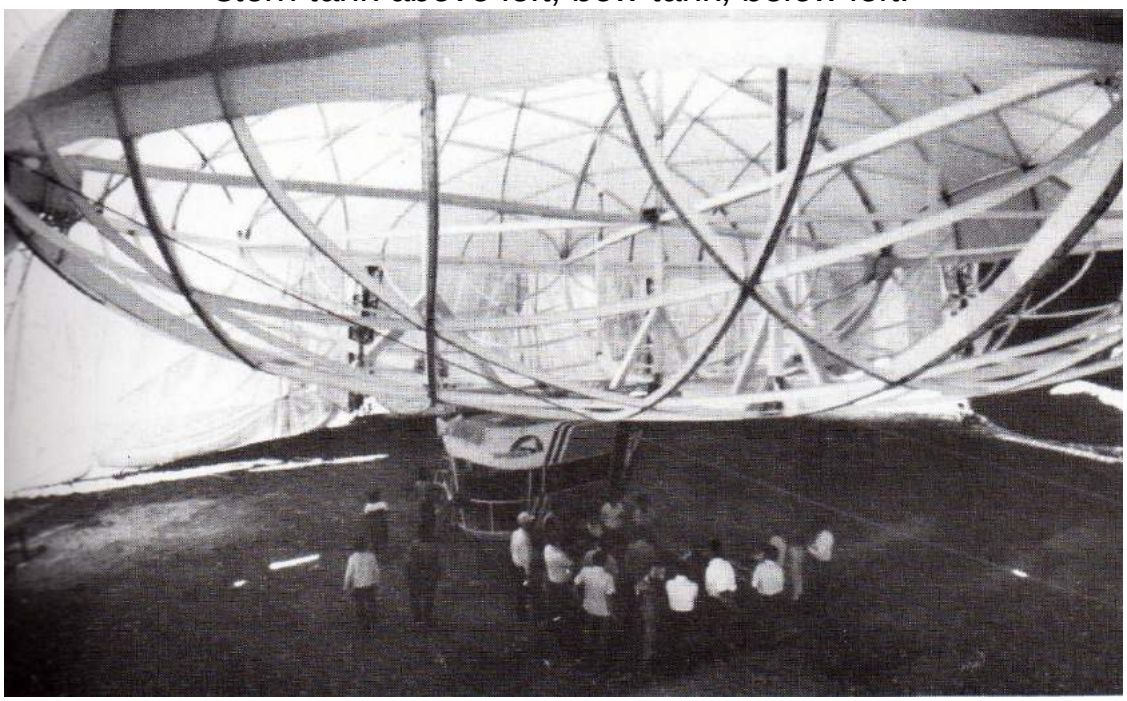
MLA-24-A general characteristics

Parameter	MLA-24-A
Airship type	Rigid, lenticular (lens-shaped), ellipsoid with NACA 0012 profile
Hull structure	Tubular aluminum geodesic frame, steel, Kevlar cables, nylon fabric skin. The aluminum geodesic frame was foam covered to prevent the gas cells from chaffing.
Diameter	24 m (78.7 ft)
Height	11 m (36 m)
Volume	2,505 m^3 (88,463 ft^3)
Lift gas	Helium in 6 multi-layer gas cells (Mylar, saran, polyethylene)
Gross lift	1,915 kg (4,222 lb) @ 1,928 m^3 / 68,100 ft^3 inflation
Gross weight	1,497 kg (3,300 lb), calculated
Useful static lift	418 kg (922 lb)
Dynamic lift (thrust from engines)	363 kg (800 lb)
Total vertical lift	781 kg (1,722 lb)
Accommodations	Suspended gondola for one pilot & five passengers + a toilet
Propulsion system	• Two 67 kW (90 hp) McCullock two-stroke engines driving ducted, vector thrust propellers that could rotate between 30° up and 120° down from the horizontal. • Engines were mounted forward of the CG to help control the lenticular airship's "pitch proposing" tendency by vectoring thrust and also using the pitch trim control.
Aerodynamic controls	"Beaver-tail" elevator on the hull trailing edge & a single ventral fin with rudder
Ballast	200 kg (440 lb) water
Pitch trim control	Shift water ballast between two tanks, fore and aft, at the 0° and 180° positions on the rim, along the longitudinal centerline

Source: adapted from The Journal of the Airship Association, No. 68, June 1985



MLA-24-A in its hanger during construction, highlighting the geodesic space frame hull designed by Michael Walden. Stern quarter view above. Bow quarter view below. Note that the gondola is attached and the outer skin is on the top half of the hull. The water ballast tanks are visible at the rim: stern tank above left; bow tank, below left.



Source, both photos: The Journal of the Airship Association, No. 68, June 1985

The MLA-24-A gondola, with aluminum frame & Kevlar skin, weighed 400 lb (181.4 kg). Note the boarding door & ramp at the back. Barcel was a sponsor. Source: The Journal of the Airship Association, June 1985

Work on the airship continued into 1985. Edwin Mowforth reported, "At the end of May 1985, after twelve years of design and construction, the MLA-24-A was inflated and virtually complete; then, as a final modification, the lower cover was removed to install anti-surge netting around the gasbags, and it was in this condition that the ship and its canvas-covered hangar were caught in a midnight gale…" The MLA-24-A was destroyed and the SPACIAL hangar, workshops, models and much of the local airport were damaged.

The details of the severe wind event and the destruction of the MLA-24-A were described in more detail in a 28 June 1985 letter from Roldan to the Airship Association, as reported in their June 1985 Journal. Most of that letter is reproduced below:

> "We floated our airship and found out that when banking, diving or climbing the gas cells would shift place and invade other

areas putting the LTA out of trim, so we decided to have nets so this would not occur.
Removing the bottom cover with gondola and engines, we erected scaffolding to tie the nets and were doing so when the night of the 31st May we had a terrible squall in the area which took off roofings of houses and even 20 inch diameter trunk trees from the ground; our hangar was covered with very strong grade canvas but was unable to handle the said 80 mile winds never seen before in the place.

The damage was very significant because, as I mentioned, we had the bottom cover removed so the lift was tremendous and the ties broke sending the structure against the beams of the hangar and tripping the scaffolding over itself, the gas cells were ruptured by torn aluminum pieces of structure - so the gas was lost also. The pieces of ripped canvas acted like whips lashing the structure and top cover, totaling it. Fortunately it was 11:30 at night and the crew had left, so nobody was injured.

Needless to say, the sorrow among the team, causing some of them to cry (I myself wanted to also) but I can't surrender to show weakness among them, the only thing was to go to every one and shake hands asking if they were willing to go ahead and give it another try and all said – YES!!

So here we are ready to start again. Fortunately, we had insurance (not enough as usual), and have settled our claim. We are changing building site to a more calm weather and better facilities, also instead of a 24 m diameter we are going to build it 32 m, which will give as about 6,000 m^3 gas capacity and allow a payload of 1 ton at 12,000 ft. (the new site is at 8,500 ft). I will keep you posted."

3. XEM-4 (1981 - 1990)

The XEM-4 was a remotely controlled, subscale, rigid airship model with a fabric covered geodesic frame hull and an internal lift gas cell. It was built in 1981 to support development of SPACIAL's full-scale airships and operated throughout the 1980s. At the July 1983 AIAA 5th Lighter-Than-Air-Conference in Anaheim, CA, Roldan showed a film of the XEM-4, with sufficiently powerful engines, flying fully aerobatic maneuvers "to the delight of the attendees" who are reported to have called it "the airship of the year."

XEM-4 with the SPACIAL MLA-32-B in the background, circa late 1980s. Note the similar triangular geodesic design of the fabric-covered rigid space frames. The XEM-4's gondola and ducted fan propulsors match the configuration on the MLA-32-A/B. The logo on the XEM-4 is an advertisement for their Mexican sponsor Barcel, a maker of potato chips and other confectionery and snack foods. Source: Walden Aerospace

4. MLA-32-A (1985 - 1988)

SPACIAL scaled-up their MLA-24-A design for their second airship, the MLA-32-A, which was built at Toluca in the repaired canvas-covered hangar originally built for the MLA-24-A. It was a tight fit.

MLA-32-A general characteristics

Parameter	**MLA-32-A**
Airship type	Rigid, lenticular, similar to MLA-24-A
Hull structure	Tubular aluminum geodesic frame, steel, Kevlar cables, nylon fabric skin, similar to MLA-24-A
Diameter	32 m (105 ft)
Height	12 m (40 ft)
Volume	5,940 m^3 (209,769 ft^3)
Lift gas	Helium in multi-layer gas cells
Payload	3.2 metric tons (3.5 tons)
Accommodations	Suspended gondola for one pilot & up to 20 passengers
Propulsion system	• Two engines, with thrust vectoring similar to those on the MLA-24-A • Engines were mounted forward of the CG
Maximum speed	75 kph (46 mph)
Aerodynamic controls	“Beaver-tail” elevator on the hull trailing edge & single ventral fin with rudder
Ballast	Water
Trim control	Shift water ballast as on MLA-24-A
Endurance	3 hours

In February 1988, the inflated airship was moored outdoors on a gusty day, at a field elevation of 2,591 m (8,500 ft) MSL, when it broke free from its mooring and could not be restrained by the ground crew. The airship made a two-hour unplanned, unmanned first flight, reaching an altitude of nearly 6,096 meters (20,000 feet) MSL. The flight ended after a gas cell ruptured, followed by a gradual descent and a hard landing not far from where the airship originally broke free. The primary damage was to the mooring fitting and the gondola.

Lessons learned included: gondola & mooring structures were weak, the ventral fin was subject to damage from the ground, and water ballast in the trim system was not protected against freezing at high altitude.

5. MLA-32-B (1988 – 1990)

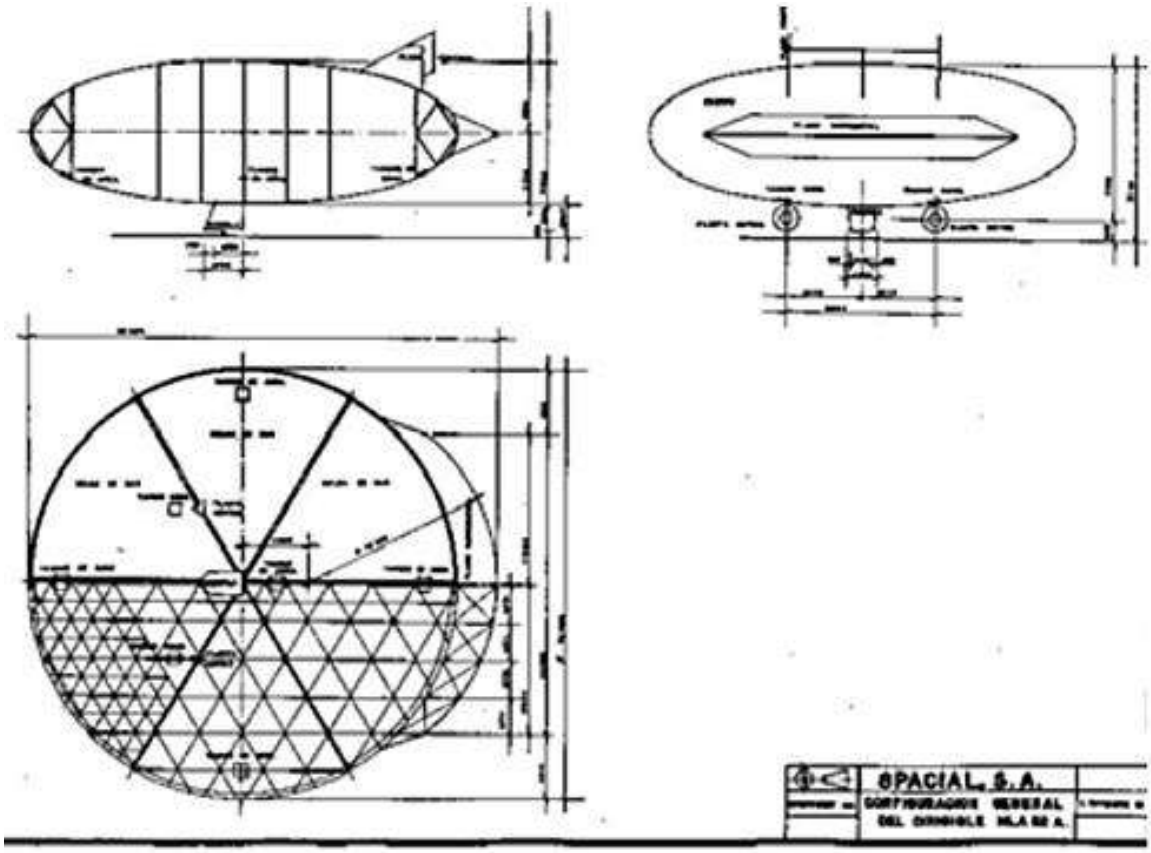
Repairs to the MLA-32-A were initiated in 1988 and the updated airship was renamed the MLA-32-B. Changes made included:

- Strengthened the gondola & mooring point structures.
- Removed the ventral fin and replaced it with three dorsal fins, with rudders on the two outer fins.
- Moved the elevator from the beaver-tail to the top of the three dorsal fins.
- Rebuilt a solid beaver-tail
- Used a new lifting gas cell material
- Used a new trim control system with movable lead shot ballast

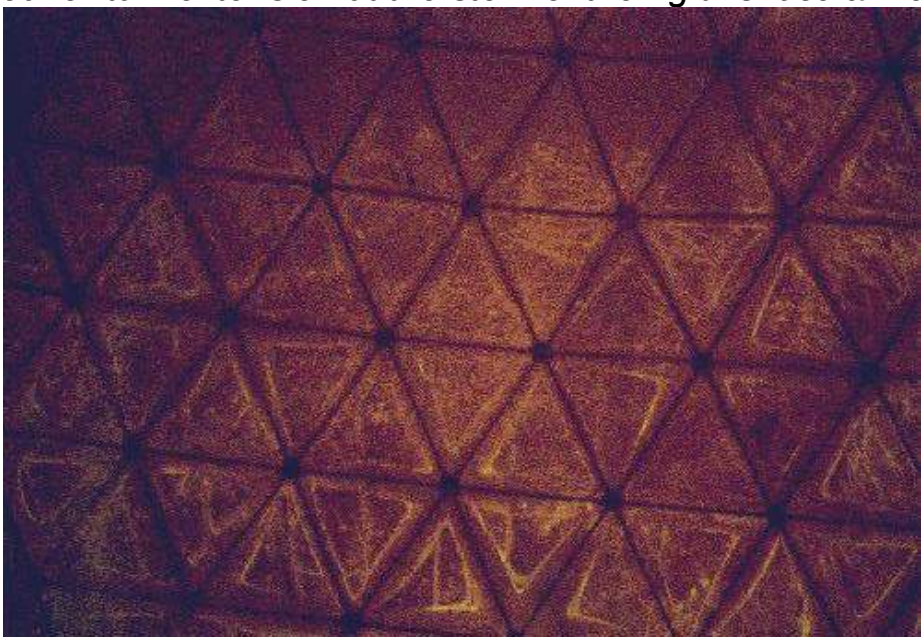
The first manned flight took place on 24 June 1989, when the SPACIAL MLA-32-B became the first new manned rigid airship to fly in over 50 years. The MLA-32-B also was the first large lenticular airship to make a successful flight. These milestones were key results of the collaboration between Mario Roldan and Michael Walden.

The engines for the MLA-32-B were a major compromise. Michael Walden said, “The engines we ACTUALLY wanted for the MLA-32-B were two 600 hp German aero-diesels being developed at the time.” However, the installed engines likely were similar to the MLA-24-A engines, which had a power rating of 67 kW (90 hp). Edwin Mowforth reported that: “The airship was clearly underpowered, and flying was discontinued until more powerful engines – of 90 kW (120 hp) – could be fitted, but these proved to be unobtainable, so smaller Hirth units were fitted instead.”

Thousands of people saw the MLA-32-B fly when it was airborne over a stadium full of soccer fans in Mexico City during an advertising flight for the Mexican potato chip and snack company Barcel.



SPACIAL three-view drawing (side, top, stern) of the MLA-32-B. Note the geodesic frame design in the top view. Also note the "beaver-tail" extension at the stern of the rigid lenticular hull.



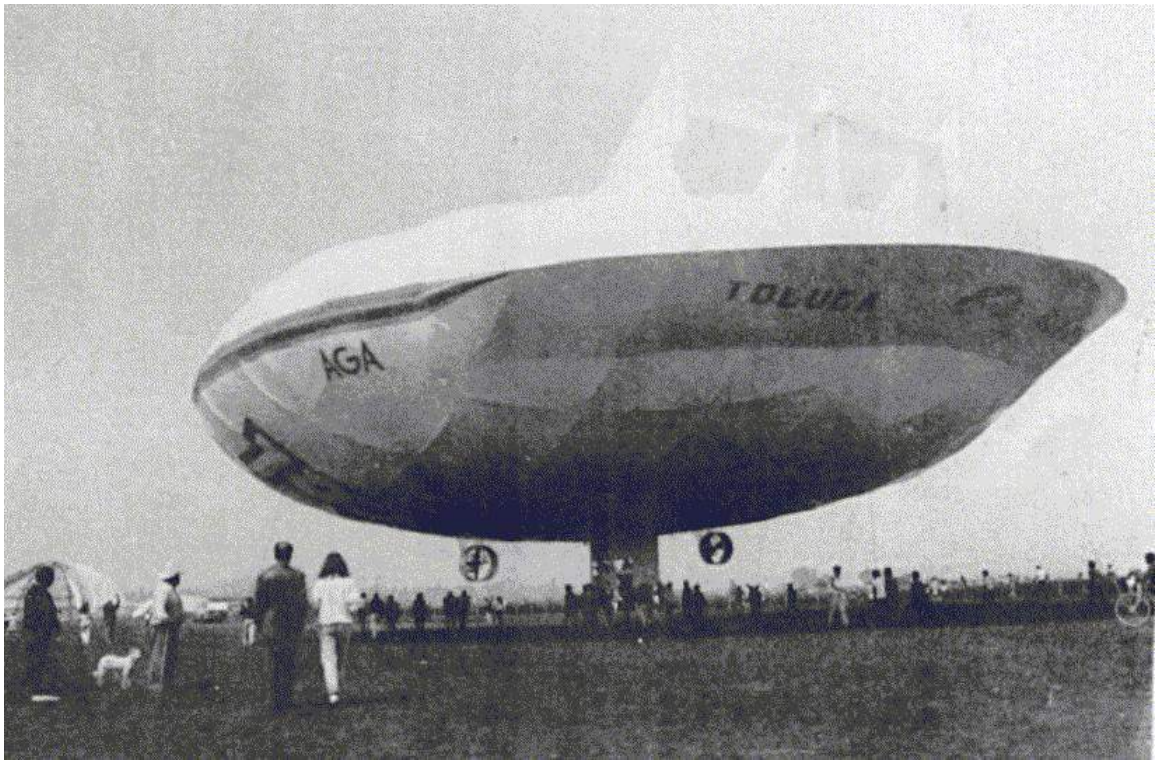
MLA-32-B interior view of the rigid geodesic frame structure. Source, both graphics: Walden Aerospace

MLA-32-B in its tight-fitting hangar, which originally was designed for the smaller MLA-24-A.

The "gondola trench" that allowed the larger MLA-32-A and 32-B to be lowered enough to be built and housed in the hangar. Source, both photos: Walden Aerospace

Stern quarter view of the MLA-32-B on the ground, under the control of its ground crew.

Details of the MLA-32-B suspended gondola and the two ducted propellers that provided main propulsion and vectored thrust for control. Source, both photos: Walden Aerospace



Stern quarter view of the MLA-32-B on the ground, under the control of its ground crew.

Details of the MLA-32-B tail showing the three vertical stabilizers, two rudders on the outboard vertical stabilizers, and the horizontal stabilizer with the elevator. Note the sharp "beaver-tail" chine forming the trailing edge of the hull, with no control surfaces.
Source, both photos: Walden Aerospace

Mario Sánchez-Roldan in the cockpit of the MLA-32-B before first flight. Source: video screenshot from Walden Aerospace

MLA-32-B at liftoff, first flight. Source: Walden Aerospace

MLA-32-B first flight. Source: Walden Aerospace

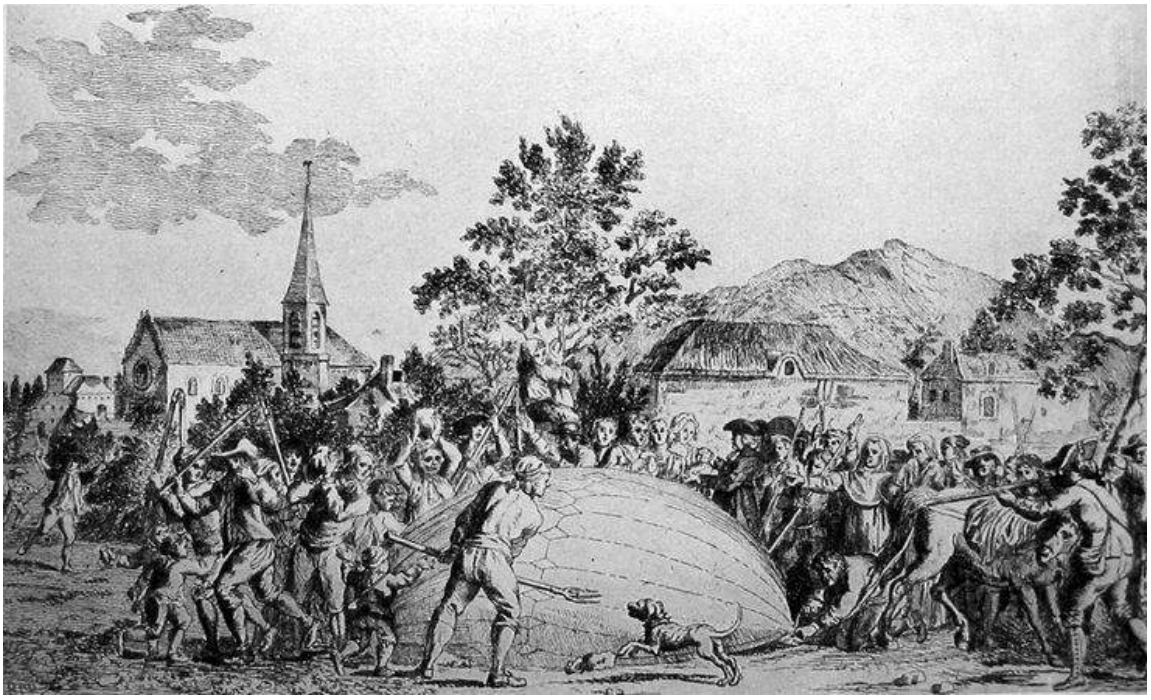
MLA-32-B in flight. Source: Jürgen Bock, et al., AIAA (2019)

The rigid, geodesic space frame hull proved to be very strong. The airship survived a dramatic encounter with a 35-knot crosswind that appears to have resulted in a temporary loss of control.

MLA-32-B lifting off at a steep angle, showing the Barcel logo. Source, both photos: Walden Aerospace

On its last flight in 1990, the MLA-32-B had an engine problem and was forced to make an emergency landing in an open field occupied by Aztec farmers, who attacked and destroyed the airship. Michael Walden reported that Roldan had been in a chase vehicle with extra fuel and tools in case of emergency and rescued the pilot from under the gondola. Roldan reported, “There were people with axes, guns and machetes walking away with parts of the ship!” A 1997 Las Vegas Sun news article reports Walden making the following comment about the destruction of the MLA-32-B:

> "I was in good company," Walden said with a laugh, showing an illustration of a balloon being pitchforked by French farmers in the 1800s. "All the best airships have been destroyed by nervous farmers."



Walden’s illustration of farmers destroying a balloon.

SPACIAL’s insurance company refused to pay claims for damage caused by 'wild indigenous people'.

Shortly after the loss of the MLA-32-B, Roldan and Walden started discussing the next improved version of the airship. However, Roldan died in a car accident a month later. Shortly thereafter, SPACIAL’s airship activities ceased along with their collaboration with Walden.

6. For more information

- “News – Spacial, Mexico, MLA-24-A,” & correspondence from Mario Roldan, Airship - The Journal of the Airship Association, No. 68, June 1985
- “Airship of the Future,” Las Vegas Sun, 7 June 1997: https://lasvegassun.com/news/1997/jun/07/airship-of-the-future/
- Achmed A. W. Khammas has written an historical overview of Michael Walden, LTAS and the collaboration with SPACIAL. You’ll find that article translated from German to English here: https://lynceans.org/wp-content/uploads/2020/12/Khammas_Book-of-Synergy_Walden-LTAS-histoy.pdf
  The original article in German is in Teil C (Part C) of *Buch der Synergie*, which you will find at the following link: http://www.buch-der-synergie.de/c_neu_html/c_11_17_solarluftschiffe_01.htm
- Edwin Mowforth, “An Introduction to the Airship,” 3rd edition, p. 116 - 117, ISBN 0-9528578-6-2, The Airship Association, 2007
- Charles Luffman, “LTA Solutions - A Lighter-than-air Aircraft Design/Engineering Practice - Lenticular Airships An Exposition,” LTA Solutions, 7 May 2015: https://docplayer.net/64482432-Lta-solutions-a-lighter-than-air-aircraft-design-engineering-practice-page-1-of-16-lenticular-airships-an-exposition.html
- Jürgen Bock, “Morphology and Evolution of the Lighter-Than-Air Technology and Airships,” Noon Balloon, No. 120, pp. 11 – 14, Naval Airship Association, Winter 2018: https://650a8e8c-0be3-466b-9728-1ece39a725e3.filesusr.com/ugd/fbd712_0a9ac44ff2a7400db5c949ffb28ed611.pdf
- Jürgen Bock, Uwe Apel & Richard Van Treuren, “Lenticular Cargo Airships: The Case for Carbon-Free Fuel Operation,” AIAA Aviation Forum, AIAA 2019-2862, 14 Jun 2019: https://arc.aiaa.org/doi/10.2514/6.2019-2862

Other *Modern Airships* articles

- *Modern Airships - Part 1*: https://lynceans.org/all-posts/modern-airships-part-1/
    - Walden Aerospace / LTAS - Lenticular, toroidal, variable buoyancy airships
- *Modern Airships - Part 2*: https://lynceans.org/all-posts/modern-airships-part-2/
- *Modern Airships - Part 3*: https://lynceans.org/all-posts/modern-airships-part-3/