Nimbus s.r.l. – Eos Xi and Metaplano

Peter Lobner, 11 February 2022

1. Introduction

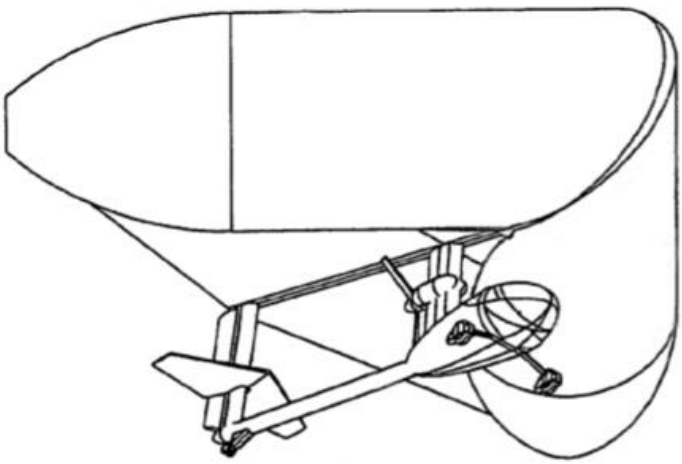
The firm Nimbus s.r.l. was established in Verona, Italy in 2006 as a spin-off from the firm A.R.I.S. spa. The first hybrid, semi-buoyant aircraft developed by Nimbus was the Eos Xi, which was first displayed at the 2007 Paris Air Show.

Today Nimbus is a private aeronautical company that designs and produces innovative remotely piloted aircraft systems (RPAS), also known unmanned aerial systems (UAS). After more than 10 years of research and development since they unveiled the Eos Xi "metaplane," Nimbus is developing a family of next generation, larger, semi-buoyant, inflated wing aircraft named "Metaplano."

The Nimbus s.r.l. website is here: http://nimbus.aero

2. The Metaplane patents

Nimbus s.r.l. filed two US patent applications in 2005 for their metaplane design concept: US8113459 and US20090108126. Both were granted in 2012. A metaplane has a buoyant wing located above a suspended fuselage.



General configuration of an inflated-wing metaplane.
Source: Adapted from US8113459, Fig. 1

The following exploded view drawing shows the major components of a metaplane: a V-shaped pneumatic chamber (16), which contains the helium lifting gas and air ballonets, and forms the forward part of the inflated delta wing; a “mounting frame” (28), which constitutes the fuselage of the aircraft; and a tensioned fabric “sail” (22, 24) that is the aerodynamic surface of the rear part of the delta wing.

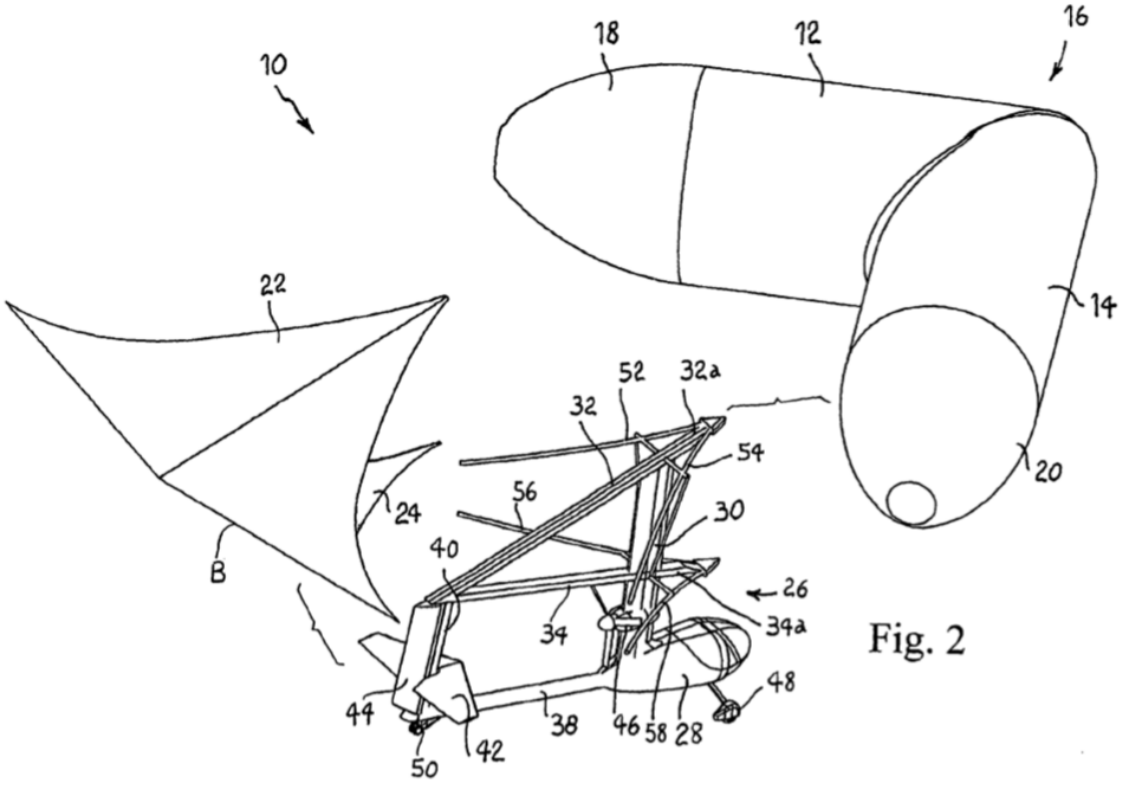


Fig. 2

Legend:

16 - V-shaped pneumatic chamber with two branches (12, 18 and 14, 20) with tapered ends, 22 & 24 – A pair of fabric sails are stretched between the tubular branches of the V and join along the tensioned “delivery edge” B, 25a & 25b – Air ballonets, 26 – The “mounting frame” (a fuselage), 28 – Pilot’s cabin, 29 – Rope or other elongated tensioning member pulling on the opposite ends of the tubular branches, 30 – Upright support beam positioned at the inner vertex of the V, 32 & 34 – Skewed longitudinal beams that connect at different heights on the upright, join at the tail, and project forward of the upright (32a & 34a) to enclose the vertex of the V-shaped pneumatic chamber, 38 – Tail boom, 40, 42 & 44 – Conventional tail plane with rudder and elevators, 46 – Propulsion engine, 48 & 50 – Landing gear, 52, 54 56 & 58 – Two pairs of stiffening rods match the profile of pneumatic chamber, adding structural strength along the attachment points with the tensioned fabric sail (22, 24)

Exploded view of a Metaplane. Source: US8113459, Fig. 2

The delta wing, consisting of the V-shaped pneumatic chamber and the fabric sail, provides aerostatic lift and, in forward flight, also provides aerodynamic lift. Aerostatic lift carries 20 to 40% of the metaplane's gross takeoff weight, with the remaining 60 to 80% being carried by aerodynamic lift. The wing is designed so that the center-of-buoyancy is close to the center-of-aerodynamic lift. The location of the buoyant wing above the fuselage provides good pendulum stability in flight due to the vertical separation between the centers-of-buoyancy / aerodynamic lift and the center-of-gravity.

As shown in patent Figure 4, the vertex of the wing is captured between the upright support beam (30) and the extensions (32a and 34a) of the skewed longitudinal beams (32, 34).

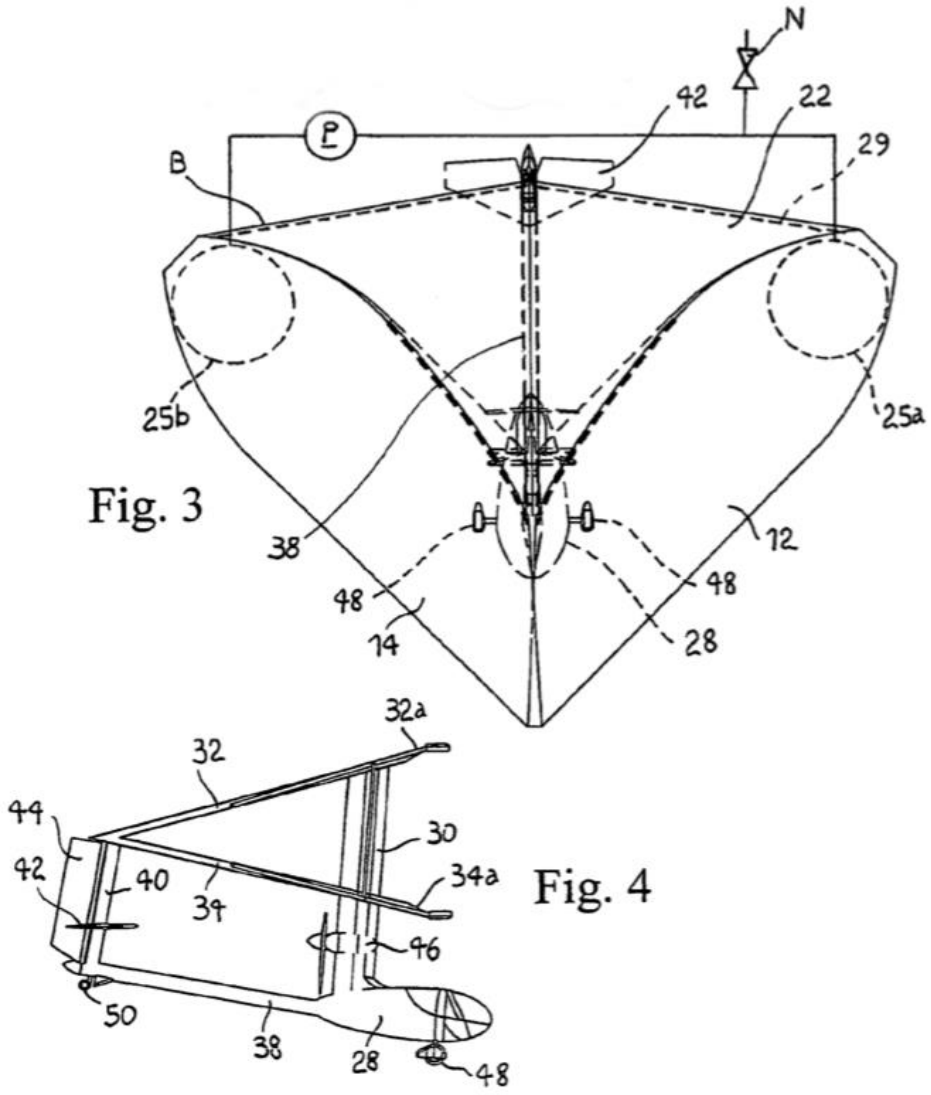


Fig. 3

Fig. 4

Plan & profile views of a Metaplane. Source: US8113459, Figs. 3 & 4

The pneumatic chamber is inflated with helium lifting gas and air ballonets (25a & 25b) that are used to control helium pressure and volume in flight. As the aircraft climbs, the pressurized ballonets are progressively deflated using control valve N (see patent Figure 3) to provide space for the helium to expand. The loss of heavier air (essentially a “ballast”) from the back of the V has several effects: the center-of-buoyancy moves aft, the center-of-gravity moves forward, and the total mass decreases. The net effect is that the metaplane’s pitch angle increases while climbing. As the aircraft descends, the air ballonets are re-pressurized with pump P (see patent Figure 3) to maintain helium pressure. The net effect is that the pitch angle decreases while descending.

The trailing edge of the delta wing (the sail) is tensioned between the tapered ends of the pneumatic chamber (18, 20) and the aft end of the skewed longitudinal beams (32, 34). The tension is established with a rope (29) or other elongated tensioning member pulling on the opposite ends of the tubular branches. The trailing edge, also known as the “delivery edge” (“B” in patent Figures 2 & 3), has no control surfaces. Flight control is accomplished with conventional rudder and elevator control surfaces on the tail plane. The vertical stabilizer (40) is a structural element that links the tail boom (38) to the skewed longitudinal beams (32, 34).

An alternate “embodiment” described in patent Figure 5 is an unmanned aircraft with a forward-facing propeller. This configuration strongly resembles the Nimbus Eos Xi.

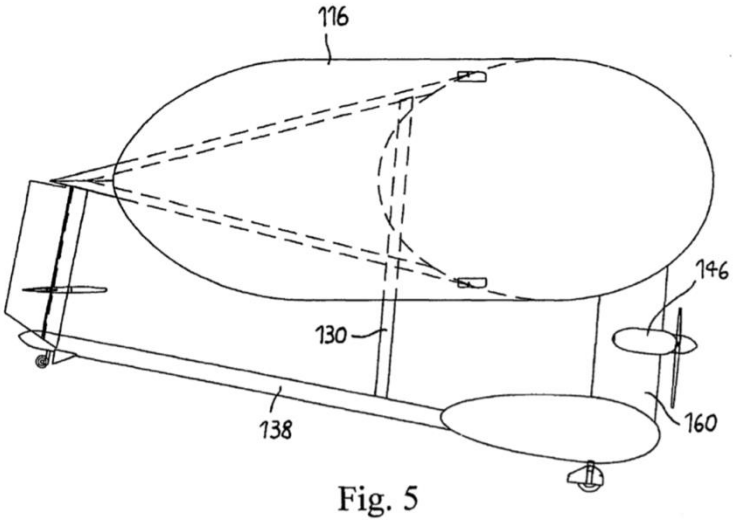


Fig. 5

Profile view of an unmanned Metaplane.

Source: US8113459, Fig. 5

3. The Nimbus Eos Xi

The Nimbus Eos Xi is a small, hybrid, semi-buoyant, inflated wing, unmanned aerial vehicle (UAV) designed for civilian use.

Nimbus Eos Xi in flight. Source: Wikipedia

With a length of 5.6 m (18.4 ft), a wingspan of 6.5 m (21.3 ft) and a height of 2.1 m (6.9 ft), the diminutive EOS Xi can carry an 8 kg (17.6 lb) payload on 3 hour missions. This aircraft has excellent short takeoff and landing (STOL) characteristics because of its buoyant wing and low wing loading. Nimbus claims the EOS Xi has a takeoff and land run of only 5 meters (16.4 ft).

Inflight, the Eos Xi exhibits inherently good stability, enabled by the craft's center-of-gravity being well below its centers-of buoyancy / aerodynamic lift. Powered by a 2-stroke petrol engine, the Eos Xi is capable of airspeeds up to 55 kph (34 mph) and can fly at speeds as low as 5 kph (3.1 mph), with the delta wing maintaining stable flight characteristics even when stalled. The Eos Xi can operate in wind and gusts up to 38 kph (23.6 mph) and reach altitudes up to 2,800 m (9,186 ft) AMSL. The control system supports remote-manual and auto-pilot flight control as well as autonomous waypoint navigation.

On the ground, the Eos Xi is heavier-than-air and it can be parked and tied down like a conventional fixed-wing aircraft.

Nimbus Eos Xi viewed from below, highlighting the leading edge of the inflated delta wing.

Nimbus Eos Xi viewed from above. The black horizontal and vertical stabilizers are part of the suspended fuselage.

Source, both photos: Nimbus

Nimbus promotes the Eos Xi for a wide range of applications, including:

- Surveillance with real-time, high-resolution, geo-referenced imagery
- Search & rescue (mainly search with a high-resolution geo-referenced imagery system)
- Environmental monitoring
- Critical infrastructure protection
- Land registry
- Aerial advertising
- Airborne communications relay

The Italian Civil Aviation Authority (ENAC) has certified the Eos Xi for use as a UAV.

The Eos Theta and Tau are larger versions of the Eos Xi, with an 8 meter (26.2 ft) wingspan and greater payload capacities (up to 90 kg).

4. The Metaplano family

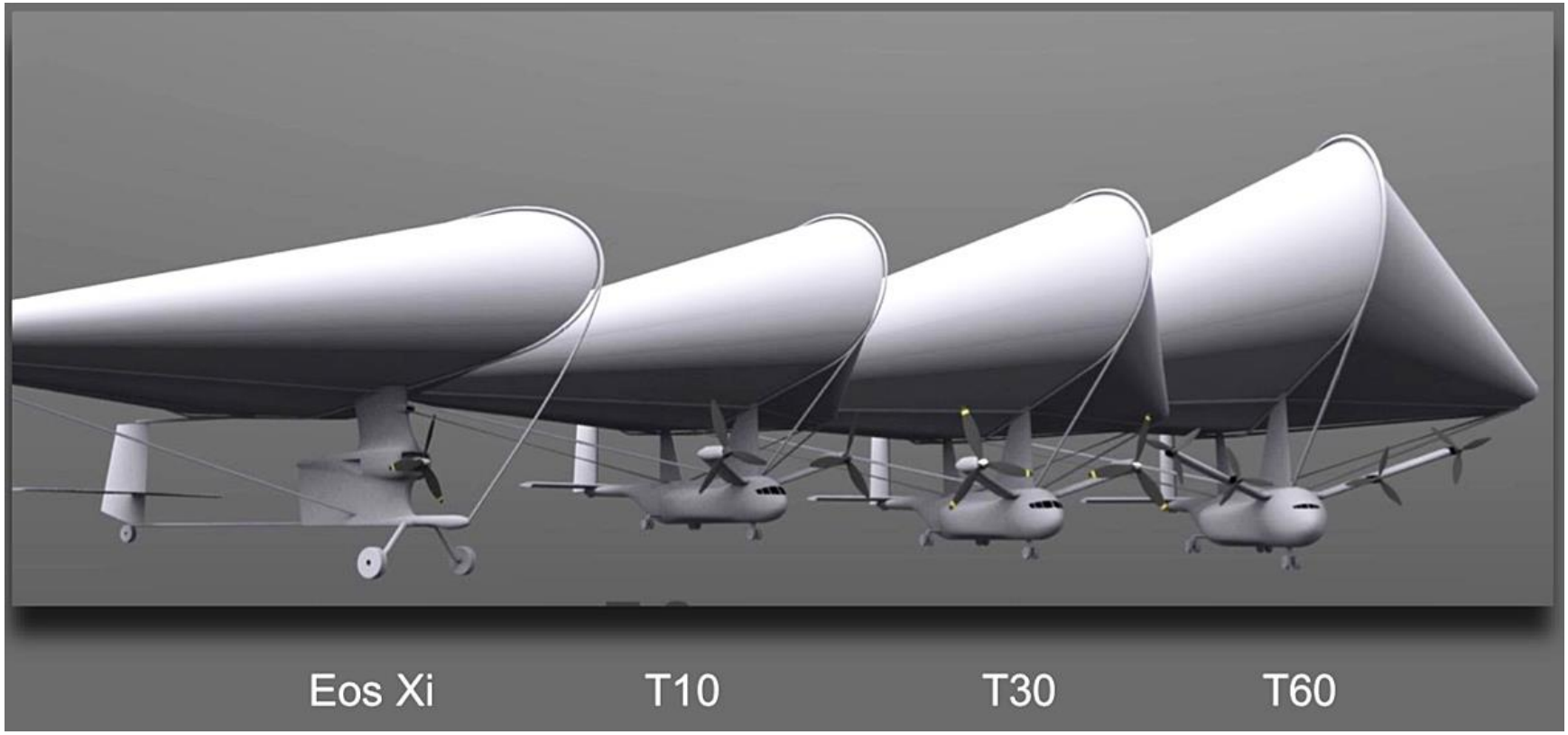
The Metaplano family of semi-buoyant aircraft builds on the basic inflated wing technology defined in the metaplane patents and demonstrated with the Nimbus Eos Xi. The smallest model, T0, is similar to the Eos Xi, with a larger payload capacity of 100 kg (220 lb). The larger models, T8, T10, T15, T30 and T60 are new designs with maximum takeoff weights ranging from 8 to 60 metric tons (8.8 to 66 tons).

Nimbus reports that all designs in the Metaplano family share the following general characteristics:

- Aerostatic lift carries 20% of the maximum takeoff weight, with the remaining 80% being carried by aerodynamic lift.
- Excellent inflight stability:
    - The location of the buoyant wing above the fuselage provides inherent pendulum stability due to the vertical separation between the centers-of-buoyancy / aerodynamic lift and the lower center-of-gravity.

    - The lightly loaded delta wing permits stable flight at steep approach angles and low airspeeds, with the delta wing maintaining stable flight characteristics even when stalled.
    - High longitudinal and lateral stability
    - Low vertical and lateral gust sensitivity
- High maneuverability
- Very short takeoff and landing (STOL) capability
- Long range and mission endurance
- No need for special ground infrastructure
    - Can operate from small airfields or unprepared fields
    - Heavier-than-air on the ground, allowing it to be treated much like a fixed-wing aircraft
- Lower fuel consumption than conventional fixed-wing aircraft
- Lower life cycle costs than conventional fixed-wing aircraft
- Can be operated as an unmanned aerial vehicle (UAV), with pilot-optional controls available in the larger models.
- Fully compliant with Italian Civil Aviation Authority (ENAC) standards

Rendering of a large Metaplano semi-buoyant aircraft in flight (general arrangement is representative of models T10 to T30)
Source: Nimbus



Eos Xi and three larger Metaplano concept aircraft: T10, T30 and T60. Source: Nimbus

General characteristics of the Nimbus *Eos Xi and the Metaplano family of semi-buoyant aircraft*

Parameter	***Nimbus Eos Xi***	***T0***	***T8***	***T10***	***T15***	***T30***	***T60***
Wing span	6.5 m (21.3 ft)	9 m (29.5 ft)	32 m (105 ft)	43 m (141 ft)	48 m (157 ft)	58 m (190 ft)	65 m (213 ft)
Weight, max takeoff	55 kg (121 lb)	100 kg (220 lb)	8,000 kg (17,637 lb)	10,000 kg (22,046 lb)	15,000 kg (33,069 lb)	30,000 kg (66,139 lb)	60,000 kg (132,277 lb)
Weight, empty		50 kg (110 lb)	4,400 kg (9,700 lb)	4,600 kg (10,141 lb)	8,400 kg (18,519 lb)	14,500 kg (31,967 lb)	25,500 kg (56,218 lb)
Weight, payload & fuel	8 kg (17.6 lb)	50 kg (110 lb)	3,600 kg (7,937 lb)	5,400 kg (11,905 lb)	6,600 kg (14,551 lb)	15,500 kg (34,172 lb)	34,500 kg (76,059 lb)
Speed, cruise	7 m/s 25 kph (15 mph)	13 m/s 47 kph (29 mph)	18-27 m/s 65-97 kph (40-60 mph)	28 m/s 104 kph (63 mph)	19-30 m/s 68-108 kph (42-67 mph)	21-33 m/s 76-119 kph (47-74 mph)	23-40 m/s 83-144 kph (51-89 mph)
Speed max	15 m/s 55 kph (34 mph)	20 m/s 72 kph (45 mph)	30 m/s 108 kph (67 mph)	36 m/s 130 kph (81 mph)	39 m/s 140 kph (87 mph)	44 m/s 158 kph (98 mph)	50 m/s 180 kph (112 mph)
Endurance, sea level loiter	3 hrs / 8 kg (17.6 lb)	8 hr / 20 kg (44 lb)	16 hrs / 500 kg (1,102 lb)	20 hrs / 700 kg (1,543 lb)	20 hrs / 1,250 kg (2,756 lb)	26 hrs / 2,700 kg (5,952 lb)	30 hrs / 2,500 kg (5,512 lb)
Endurance, 6,096 m (20,000 ft) loiter	--	--	--	--	24 hrs / 1,250 kg (2,756 lb)	30 hrs / 2,700 kg (5,952 lb)	40 hrs / 2,500 kg (5,512 lb)

Source: Nimbus

Rendering of a large Metaplano semi-buoyant aircraft in flight. Source: Nimbus

5. For more information

- "Nimbus Eos Xi," product brochure, Nimbus: http://nimbus.aero/Brochures/RPAS%20EOS%20XI_ENG.pdf
- "Metaplano – Heavy Cargo Lift program, T-Family," product brochure, Nimbus: http://www.platformuca.org/wp-content/uploads/2016/01/Metaplano-T-Family.pdf
- "Innovative kind of Unmanned Cargo Aircraft - The Metaplano," Nimbus: https://unmannedcargoaircraftconference.com/wp-content/uploads/2017/12/METAPLANO-UCA-conference_FINAL_v2.pdf

Patents

- US8113459B2, "High-security Aircraft," Inventor: Alfredo Capuani, Filed 7 July 2005, Granted 14 February 2012,

Assigned to Nimbus srl: https://patents.google.com/patent/US8113459B2/en?oq=US8113459

- US2009/0108126A1, “High-security Aircraft,” Inventor: Alfredo Capuani, Filed 7 July 2005, Published 30 April 2009, Granted 14 February 2012, Assigned to Nimbus srl: https://patents.google.com/patent/US20090108126A1/en?oq=US20090108126

Video

- YouTube vídeo “SAPR Metaplano EOS XI Nimbus,” (2:47 minutes), Nimbus s.r.l., 14 March 2016: https://www.youtube.com/watch?v=jMXlu6o4Azg
- “YouTube video, “Metaplano,” (1:11 minutes), Nimbus s.r.l., 16 April 2019: https://www.youtube.com/watch?v=IFfPPQQRam8

Other *Modern Airships* articles

- *Modern Airships - Part 1*: https://lynceans.org/all-posts/modern-airships-part-1/
    - *Voliris – V902RC, V932 NATAC, SeaBird*
- *Modern Airships - Part 2*: https://lynceans.org/all-posts/modern-airships-part-2/
    - *Solar Ship – Caracal, Wolverine*
- *Modern Airships - Part 3*: https://lynceans.org/all-posts/modern-airships-part-3/