Thales Alenia Space Stratobus

Peter Lobner, 3 April 2021

1. Introduction

The Stratobus is a stratospheric, autonomous, solar-powered, non-rigid airship intended for use as a pseudo satellite at a geostationary position at 20 km (65,616 feet) altitude where it can perform a variety of functions, including ISR (intelligence, surveillance, and reconnaissance), communications, environmental monitoring and navigation. Stratobus airships are designed to communicate with ground stations, satellites in orbit and other Stratobus airships to form an extended airborne network.

The project has its genesis with the Pégase competitiveness cluster in southern France. This network of major firms in the aeronautics and space industry in the Provence-Alpes-Côte d'Azur region has pooled its resources related to unmanned aerial vehicles (UAVs), balloons and stratospheric aircraft to launch a new dirigible industry in France. The Stratobus project is led by the Franco-Italian firm Thales Alenia Space, which is a business sector of Thales Group. Airbus Defense & Space, Zodiac Marine, Airstar Aerospace and renewable energy institute CEA-Liten are partners on this project.

The Thales Group website is here: https://www.thalesgroup.com/en/

2. The start of the Stratobus project

Studies of the technical feasibility and business model of Stratobus started in 2010. The project was selected in 2016 by the French Ministry of Industry and Digital Technology to be part of the New Industrial France program. In April 2016, the official launch of the Stratobus program occurred at the Cannes headquarters of Thales Alenia Space, on the site of the Pôle Aéronautique d'Istres. As the prime contractor, Thales Alenia Space received a 17 million Euro (about 19 million dollar) contract from the French government for a 2-year key technology development effort that included development of a demonstrator airship that would make its first flight in 2018, followed by a one-year flight test program. In 2016, market availability for a

production Stratobus was projected to be 2020. The planned demonstrator airship was not completed under this contract.

3. An early version of Stratobus (circa 2016)

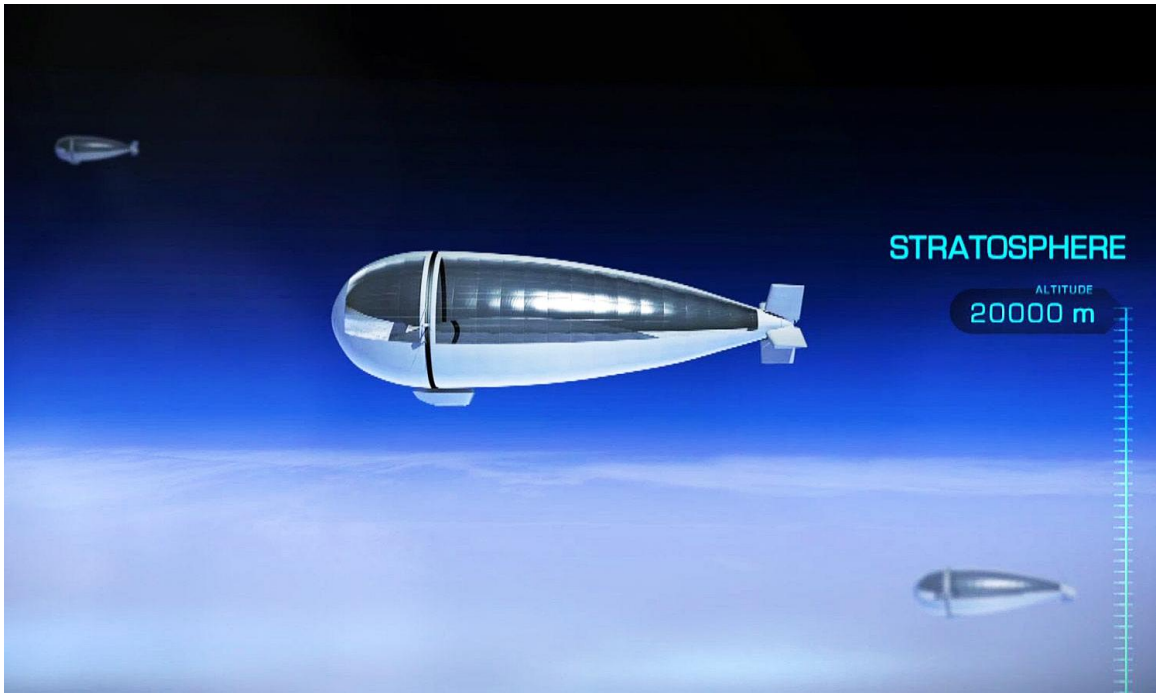
At the time the program was launched in 2016, the Stratobus was conceived as an airship 100 meters (328 feet) long, 33 meters (108 feet) in diameter, with a total vehicle weight of less than 5,000 kg (11,023 lb), and a payload of 250 kg (551 lb). A hybrid solar electrical / regenerative fuel cell (RFC) system was selected to power the airship systems 24/7 and deliver 5 kW of power to the payload. Stratobus is designed to operate at an altitude is 20 km (65,600 feet), where the winds are moderate and the air density is adequate for propeller propulsion for station keeping. Mission duration is one-year, limited primarily by the need for periodic maintenance, which included lifting gas replenishment. The vehicle is expected to have a five year operating lifetime.

Key technologies that need further development are envelope materials and regenerative fuel cells (RFCs).

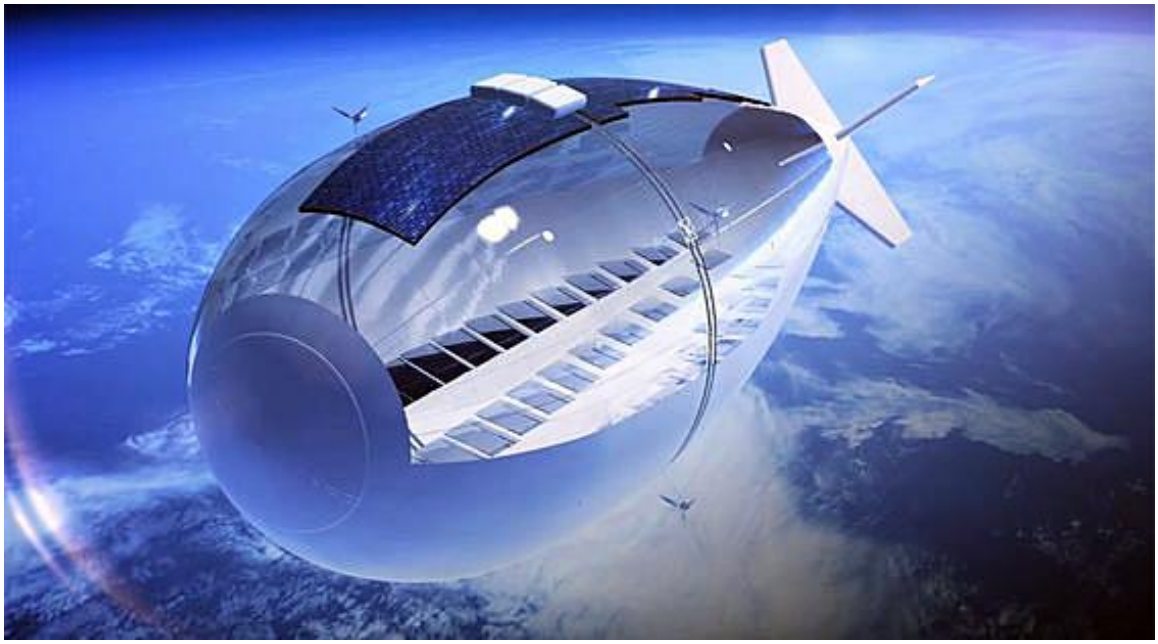
The circa 2016 design incorporated the following innovative features:

- **Transparent envelope section**: Sunlight passes through the clear sections of the envelope, reflects off of concentrator mirrors within the envelope, and is directed to solar panels inside the envelope. This allows a reduction in the size and weight of the solar panels and also protects the solar cells from degradation by the stratospheric environment. This design is explained in detail in Thales Alenia Space patent US9650122B2, "*Balloon comprising photovoltaic means and a solar concentration device*," which was filed in 2011 and granted on 16 May 2017. You can read this patent here: https://patents.google.com/patent/US9650122B2/en
- **Engines and equipment pods attached to a large ring around the hull**: The ring allowed the hull to rotate independently to align the solar collectors to the sun and maximize electricity generation.

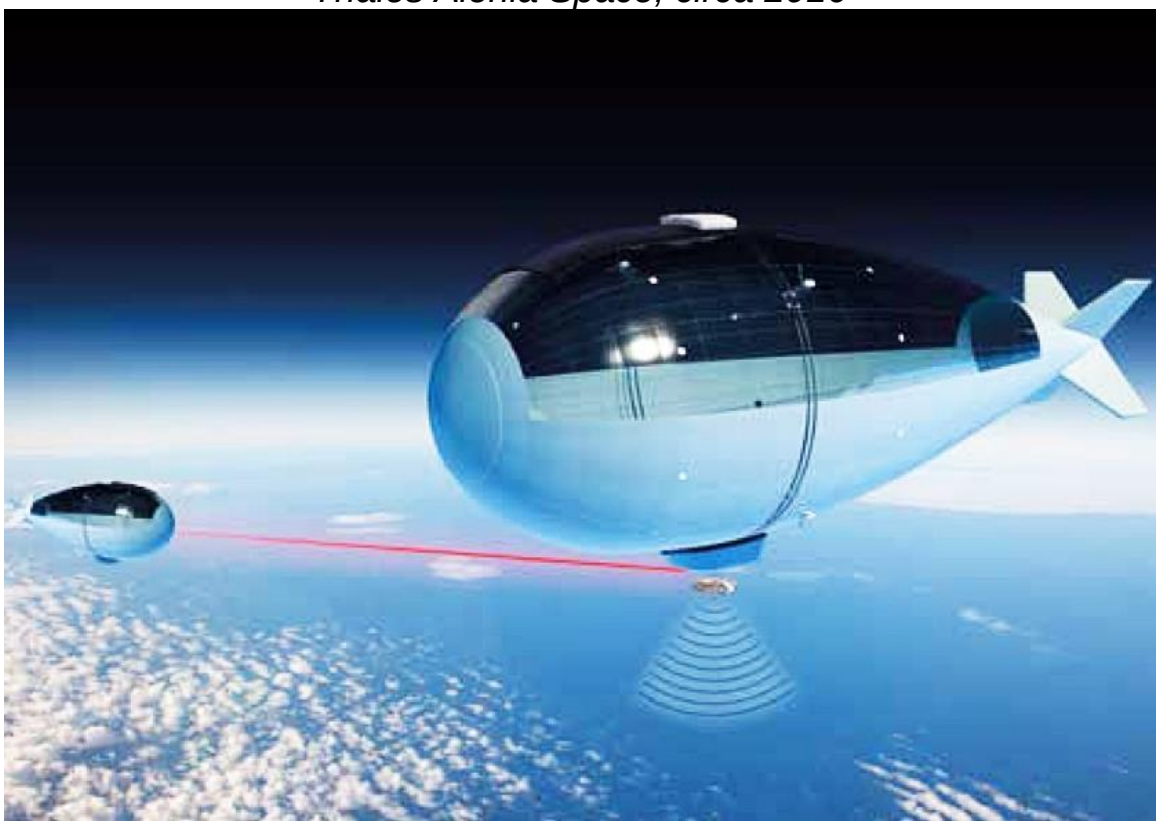
Concept drawing of the Stratobus designs circa 2016 are shown in the following graphics.



The Stratobus envelope has a circular cross-section with a large transparent section and a circumferential ring at the center of gravity supporting the engines and equipment pods.
Source, both graphics: Thales Alenia Space, circa 2016



Above: Stratobus with the transparent section of the envelope rotated to improve solar power generation at low sun angles.
Below: Stratobus showing air-to-ground wireless and airship-to-airship laser data links. Source, both graphics:
Thales Alenia Space, circa 2016



4. The current version of Stratobus (circa 2017 and later)

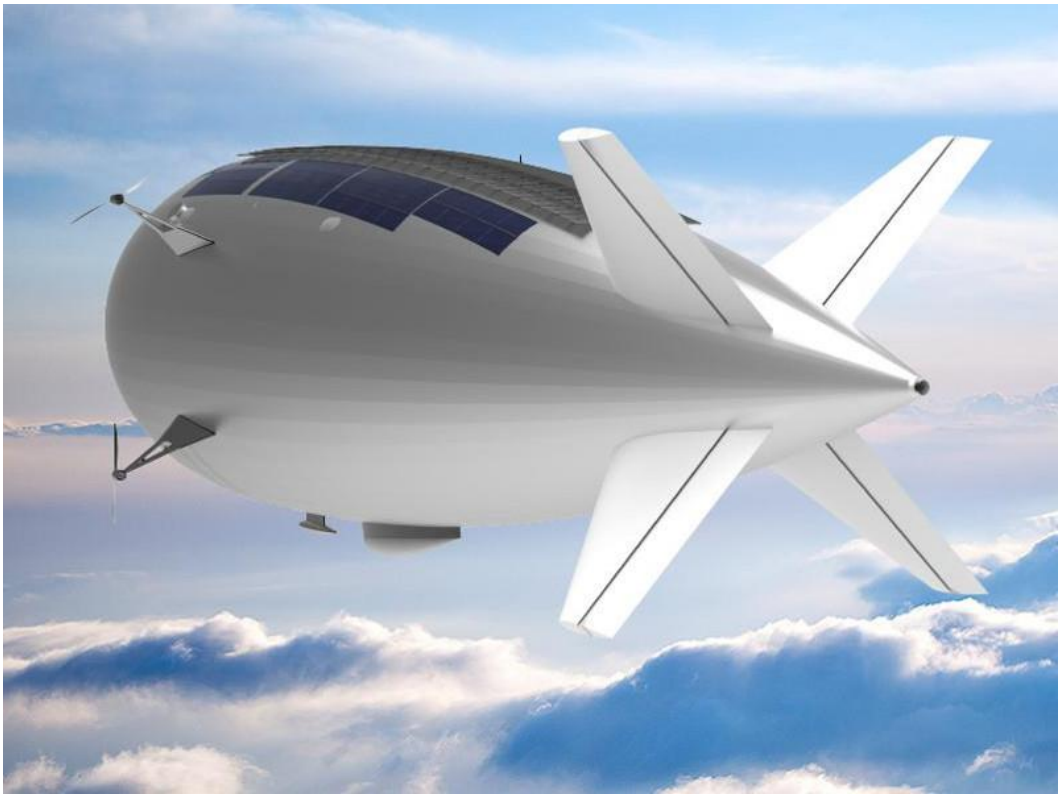
By 2018, the design of the Stratobus had evolved significantly. The novel ring was deleted and the engines and equipment pods were in fixed locations, attached to the non-rigid envelope. The transparent envelope and solar concentrating PV system was abandoned and replaced by lightweight, flexible PV arrays installed on the top surface of the envelope. In July 2018, Thales Alenia Space added the US firm Southwest Research Institute (SwRI) to the Stratobus team. SwRI managed the US Hi-Sentinel stratospheric airship program.

Source: Thales Alenia Space, circa 2017

The Stratobus hull has grown to 140 meters (460 feet) long and 33 meters (108 feet) in diameter. The envelope volume is about 86,000 cubic meters (3,037,000 cubic feet). The operating altitude remains at 20 km (65,600 feet), where the line-of-sight horizon is 500 km (310 miles) away. The four electric motor-driven propellers operate 24/7 to maintain a precise geo-location in winds of up to 90 kph (56 mph), with position managed by a GPS navigation system.

The Stratobus is recoverable on the ground for post-mission maintenance. A replacement airship would be launched to continue the mission without interruption. With a five year expected vehicle lifetime, a Stratobus could conduct five missions before being retired.

Source, both graphics: Thales Alenia Space, circa 2018



Above: Stratobus stern quarter view.
Below: Airship-to-airship laser data links.
Source, both graphics: Thales Alenia Space, circa 2018

In January 2020, Thales Alenia Space and Thales signed a contract with the France's defense procurement agency (Direction Generale de l' Armement, DGA) for a full-scale, autonomous Stratobus demonstrator airship that is capable of flying in the stratosphere and demonstrating its capabilities to perform a variety of ISR missions. The first flight demonstrator airship is expected by the end of 2023, five years later than the demonstrator that was ordered in the original 2016 Stratobus contract, but was not built.

5. The Stratobus hybrid electric power system

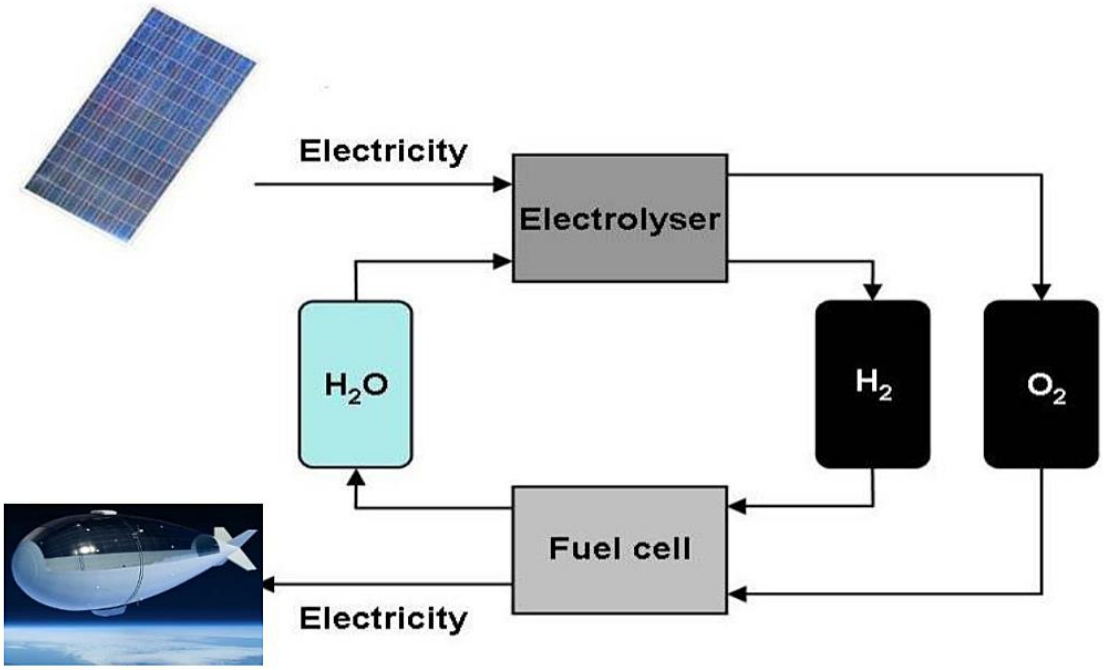
The hybrid electric power system provides 24/7 power to airship systems and the mission payload. The original requirement was to support a 250 kg payload with 5 kW of power. That requirement may be extended to a 450 kg payload and 8 kW of power.

During daylight hours, a 1,000 m^2 (10,764 ft^2) photovoltaic (PV) array on the top surface of its hull provide the power needed for the airship's electronic systems, the four electric propulsion motors, the mission payload and for charging the RFC system. The RFC system provides power at night and as a supplement the PV array during low light times of the day

In 2018, Thales Alenia Space reported validation of their PV array technology, which has the following attributes:

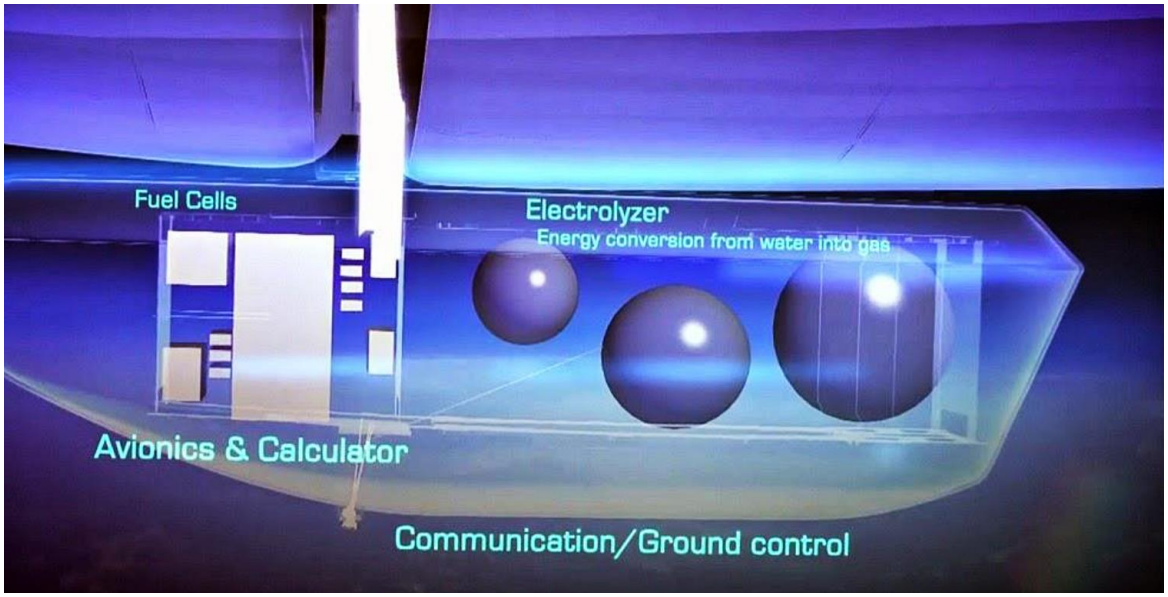
- Flexible
- Low-cost
- Lightweight modules weighing less than 800 g/m^2 (0.16 lb/ft^2)
- High power output of more than 200 W/m^2 (18.6 W/ft^2)
- Large surface area of over 4 m^2 (43 ft^2) per module
- PV cell efficiency of over 24%.
- High stability of encapsulation materials to UV radiation and ozone
- Low relative power loss after repeated thermal cycling

The Norwegian firm Prototech has been developing the Stratobus hydrogen-oxygen RFC system, which operates based on the following process.



RFC system process diagram. Source: Protech

This system consists of the following key components: the hydrogen / oxygen fuel cell for power generation, a high pressure electrolyser for splitting water and producing hydrogen and oxygen from solar power during daylight hours, and separate storage tanks for hydrogen, oxygen and water. These components are installed in an equipment module on Stratobus as shown in the following diagram.



RFC equipment arrangement. Source: Protech

Basic performance specifications for the Protech RFC system are:

- Nominal power generation: > 50kW
- Energy storage: > 900 kWh
- Specific energy: > 650 Wh/kg
- Round trip efficiency: about 50%

6. For more information

- F. d'Olivira, et al., "High-Altitude Platforms — Present Situation and Technology Trends," Journal of Aerospace Technology and Management, Vol. 8, No. 3, July/Sept. 2016: https://www.scielo.br/scielo.php?script=sci_arttext&pid=S2175-91462016000300249
- Jarle Farnes, "Regenerative Fuel Cell System for HAPS - Stratobus paves the way for RFCS for HAPS and space," conference paper at HAPS4ESA, October 2017: https://www.researchgate.net/publication/325594627_Regenerative_Fuel_Cell_System_for_HAPS_-_Stratobus_paves_the_way_for_RFCS_for_HAPS_and_space
- "Stratobus: Why This Stratospheric Airship Already is Being Called a 'Swiss Knife' in the Sky," Thales, 22 May 2018: https://www.thalesgroup.com/en/worldwide/space/magazine/stratobus-why-stratospheric-airship-already-being-called-swiss-knife-sky
- "Thales Alenia Space Validates Solar Array Technology for Stratobus Autonomous Stratospheric Airship," Thales Alenia Space press release, 16 October 2018: https://www.thalesgroup.com/en/worldwide/space/press-release/thales-alenia-space-validates-solar-array-technology-stratobus-tm
- "Stratobus Autonomous Stratospheric Airship," Air Force Technology: https://www.airforce-technology.com/projects/stratobus/
- "Thales Alenia Space and Thales Sign Concept Study Contract With French Defense Procurement Agency for Stratobus Type Platform," Thales, 8 January 2020: https://www.thalesgroup.com/en/worldwide/space/press-

release/thales-alenia-space-and-thales-sign-concept-study-contract-french
- Christina Mackenzie, “French military taps Thales to study ISR sensor options for ‘Stratobus’ airship,” DefenseNews, 10 January 2020: https://www.defensenews.com/global/europe/2020/01/10/french-military-taps-thales-to-study-isr-sensor-options-for-stratobus-airship/

7. Videos

- “Stratobus: halfway between a drone and a satellite,” (5:20 minutes), Thales, April 2016: https://www.youtube.com/watch?v=nvmkendJI2Y
- “Stratobus: direct access to the stratosphere,” (1:06 minutes), January 2020, here: https://www.facebook.com/ThalesAleniaSpace/videos/stratobus-direct-access-to-the-stratosphere/562522000995480/