**Hunt Aviation’s Gravity Plane**

Peter Lobner, 3 April 2021

## 1. Introduction

Hunt Aviation, founded by Robert D. Hunt and currently based in Pass Christian, Mississippi, developed a concept for a variable geometry hybrid airship called the “Gravity Plane.” This radical airship with variable buoyancy propulsion was introduced in Washington, D.C. at the National Business Aviation Association's annual convention in October 2003. This unveiling took place about 204 miles and 140 years from Solomon Andrews first flight with passengers in his *Aereon* variable buoyancy propulsion airship in 1863.


*Concept drawing showing the Gravity Plane at high altitude with its high aspect ratio variable geometry wings fully extended. Source: Hunt Aviation*

## 2. Conceptual design of the Gravity Plane

Hunt Aviation's hybrid "gravity-powered aircraft" conceptual design was about 50% larger than a Boeing 747 and was designed to carry about the same payload.  A Boeing 747-400F has a length of 232 ft (70.7 m), a wingspan of 211 ft (64.4 m) and a cargo capacity of 249,000 lb (113,000 kg).

Based on published descriptions circa 2004, the Gravity Plane had the following features:

- **Two large fuselage "pontoons:**" Each pontoon is divided into multiple chambers for the lifting gas (or vacuum) and the air ballast.  Primary structures are carbon fiber and the skin is comprised of multiple layers of Kevlar and epoxy.  An air-driven propulsion turbine is mounted near the tail of each pontoon.

- **A large wing center section**: This part of the craft houses the cockpit and space for the payload.

- **Variable buoyancy control system:**  The craft can be trimmed for neutral, positive or negative aerostatic buoyancy.

- **1,000 to 1,500 psi compressed air system:**  This system provides pneumatic power for pumps, valves, electrical generators, control surfaces and two external, vectored thrust, air-driven turbines for propulsion power and propulsive control during takeoff and landing.
    - Taking on compressed air increases the craft's mass and decreases its buoyancy.
    - Using (discharging) compressed air decreases the craft's mass and increases its buoyancy.

- **Two vertical axis air turbines:** These are mounted above the wing center section and are used to generate power from the forward motion of the craft through the air.
    - These turbines provide power to recharge the compressed air system during flight.

- **Variable geometry, high aspect ratio wings**:  Based on the craft's operating mode, the wings can be moved between fully extended and fully swept positions.
    - With the wings fully extended, the craft generates maximum aerodynamic lift during forward flight, whether the craft was climbing (as a positively buoyant airship) or descending (as a semi-buoyant glider).
    - With the wings fully swept, the craft generates less aerodynamic lift, but is capable of descending at higher speeds as a semi-buoyant glider with a lower lift / drag ratio.  The higher airspeed allows the vertical-axis air turbines to generate more power, but for a shorter period of time before a low altitude limit is reached.

*Gravity Plane descending at a steep angle with the wings highly swept.  Source:  Screenshot from Hunt Aviation video.*

### 3. Concepts of operation of the Gravity Plane

The Gravity Ship originally was designed to operate as follows:

- **For stability on the ground:** The Gravity Plane was ballasted for maximum negative buoyancy. Helium had been pumped from the atmospheric pressure helium cells in the pontoons into a smaller high-pressure helium storage volume. The wings were in the fully swept position to reduce the ground footprint of the craft.

- **For takeoff and ascent:** The compressed air system was fully charged prior to takeoff, contributing to the gross takeoff mass of the Gravity Plane. The buoyancy control system establishes positive aerostatic buoyancy by venting helium from the high-pressure storage volume into the atmospheric pressure helium cells in the pontoons. As the helium cells expanded, air is displaced from the pontoons, reducing the mass of the craft and achieving positive buoyancy. As the craft lifts off vertically, it is trimmed for an “up” angle-of-attack. The compressed air system drives the propulsion air turbines to produce thrust for forward flight, which enables the wings to generate aerodynamic lift while also decreasing the mass of the craft and increasing aerostatic lift. Direction on flight is controlled by aerodynamic surfaces. Speed, both forward and ascending, can be controlled by buoyancy. Maximum flight altitude is reached when the craft is neutrally buoyant at high altitude.

- **For gravity-powered descent:** The buoyancy control system establishes negative buoyancy by compressing some helium, making the Gravity Plane heavier than air. The craft becomes a semi-buoyant glider that can be trimmed for the desired flight condition. The wings can be left extended for a glide ratio of about 40:1 or swept back for a steeper and faster descent.

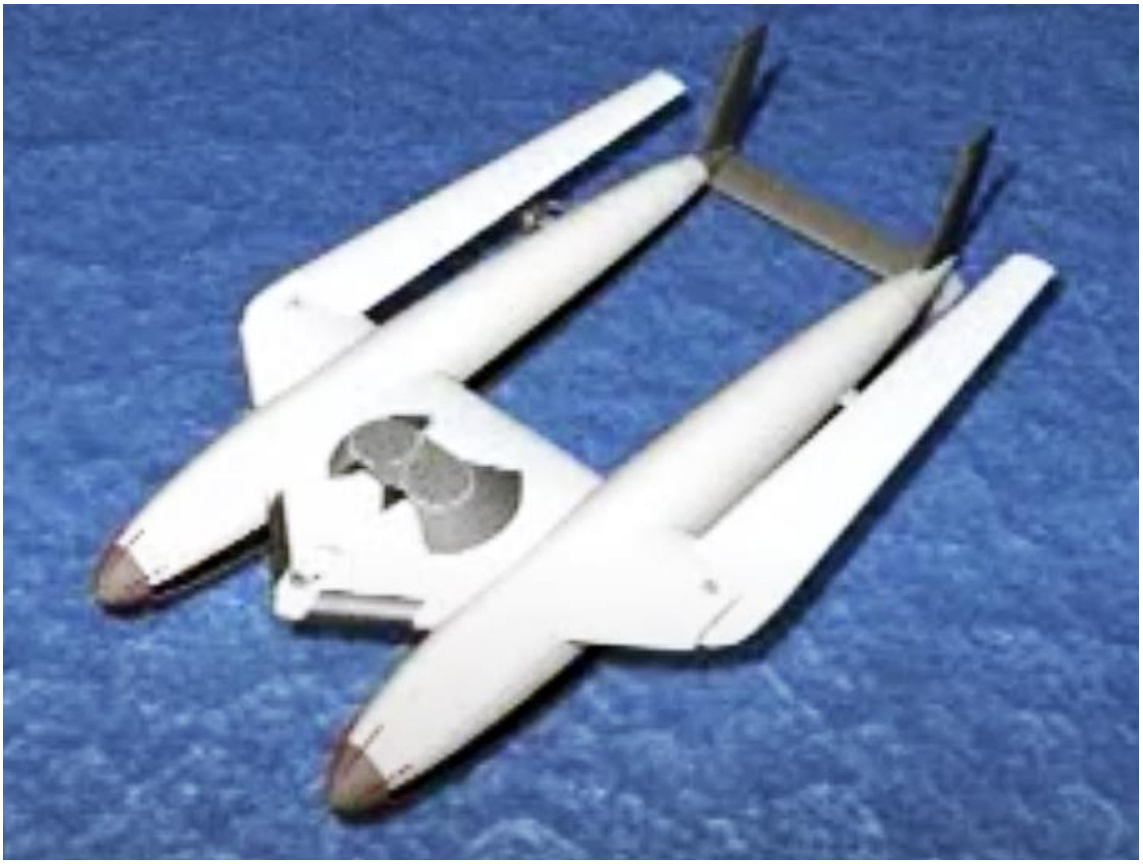
- **For a porpoising flight profile:** A descent can be terminated by using the buoyancy control system to re-establish positive buoyancy, enabling the Gravity Plane to continue flying in a desired direction as it ascends to a new, higher altitude. The repetitive cycling between a higher altitude and a lower altitude enables the Gravity Plane to exploit the forces of aerostatic lift and gravity for propulsion. Energy is required to recompress some of the helium lift gas at the start of each descent cycle. Venting helium back into the helium cells at the end of a descent requires little energy for operating a control valve.

- **For high-altitude station keeping and transits**: At altitude, the Gravity Plane can level off and hover. However, the Gravity Plane lacked a conventional propulsion system, so the prevailing wind will blow the craft downwind of its prescribed target. The gravity-driven porpoising flight profile enables the Gravity Plane to fly back to its designated station-keeping point at high altitude. The Gravity Plane also can fly between distant station keeping points or conduct a long-distance transit using the porpoising flight profile.

- **For landing:** At the end of a gravity-powered, gliding descent to a landing site, which may be on land or on water, the Gravity Plane will be trimmed for neutral buoyancy and the craft will make a vertical landing. The air-driven propulsion turbines can be used to drive the Gravity Plane to the surface and temporarily hold it there. The craft must immediately compress some of the helium lift gas and/or take on air ballast to increase its mass and establish negative buoyancy to ensure stability after landing. Hunt Aviation claims that, if managed correctly, the Gravity Plane should always land with its compressed air system tanks fully pressurized. This seems like a perpetual motion claim. It seems more likely that the compressed air tanks will be partially pressurized after landing. Hunt Aviation claims that a 20-knot wind while the craft was on the ground will be enough to turn the vertical axis turbines and recharge the compressed air supply.

This process is shown in the following video," Gravity Plane Invented by Physicist Robert D. Hunt in 2006" (5:11 minutes)

https://www.youtube.com/watch?v=FnEzJpn6ZNs



*Gravity Plane landed on the water with the wings fully swept.*
*Source: Screenshot from Hunt Aviation video.*

In his 20 Feb 2010 TED Talk, Robert Hunt, described a completely different process, called an "Atmospheric Power Cycle," for managing the variable buoyancy of the Gravity Plane. In this power cycle, a condensable heat transfer fluid is heated to a gaseous phase and subsequently cooled to a liquid phase to establish the desired buoyancy condition. You'll find this 7:57 minute TED talk at the following link: https://www.youtube.com/watch?v=BgvX9M1ud60
In 2020, the Hunt Aviation website (www.fuellessflight.com) provides the following description of the Atmospheric Power Cycle for their Gravity Plane concept.

> "Hunt Aviation promotes the future development of a revolutionary aircraft powered by the heat energy in the air at low altitude that is used to boil a heavy liquid into a lighter-than-air lifting gas in order to allow the airplane to rise to high altitude like a helium balloon. Heat rejection to complete the batch power cycle is performed at high altitude in cold air that allows

> the lifting-gas to be condensed back to the heavy liquid, at which time the aircraft becomes a glider sailing back downward towards earth. Then, at low altitude, hot atmospheric air is used to again boil the liquid to a lifting-gas and the process may be repeated indefinitely to fly in a sine wave flight pattern as long as desired. The intellectual property that makes this invention possible is the novel chemical formula for the lifting-gas that can be made into a liquid under the stated conditions that he (Robert D. Hunt) has not yet publically disclosed."

It appears that this unique power cycle and application to the Gravity Plane is covered by international patent, WO2009004439A2, "Ultra-low-temperature power cycle engine," which was filed on 19 June 2008 and published on 8 January 2009. You'll find the patent here: https://patents.google.com/patent/WO2009004439A2/en

You can download a pdf copy of the patent here: https://patentimages.storage.googleapis.com/a3/ac/d8/d433b301a227fd/WO2009004439A2.pdf

The patent does not disclose the lifting gas. The common gases that are lighter than air are hydrogen, helium, neon, nitrogen, ammonia ($NH_3$), methane (CH4) and carbon monoxide (CO). At atmospheric pressure, hydrogen, helium, neon, nitrogen, methane and carbon monoxide are condensable at cryogenic temperatures and would not be appropriate for use in the Gravity Plane. This leaves ammonia. At atmospheric pressure, ammonia is in its liquid state at temperatures below -33.6 °C (-28.5 °F). At 10 bars, the ammonia condensation / boiling point is 25 °C (77 °F).

Wikipedia reports:

> "Ammonia is sometimes used to fill weather balloons. Due to its high boiling point (compared to helium and hydrogen), ammonia could potentially be refrigerated and liquefied aboard an airship to reduce lift and add ballast (and returned to a gas to add lift and reduce ballast). Ammonia gas is relatively heavy (density 0.769 g/L at STP, average molecular mass 17.03 g/mol), poisonous, an irritant, and can damage many metals and plastics."

More likely than not, the Hunt Aviation Gravity Plane uses ammonia as its lifting gas.

Hunt Aviation developed unique, lightweight, high strength composite structural material that could be used in the Gravity Plane. This composite material is described here:
http://www.renewableone.com/fuellessflight/flf/matrixphoto.htm

The Gravity Plane was not built.

## 4. For more information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