

Solar Ship Inc.

Peter Lobner, Updated 3 April 2021

1. Introduction

Solar Ship Inc. was founded in 2006 by CEO Jay Godsall in Ontario, Canada. The company produces solar-powered, semi-buoyant, hybrid aircraft, aerostats, and large volume hangers (operating bases). The 100% solar-powered, semi-buoyant, hybrid aircraft are designed for transporting heavy loads with excellent short takeoff and landing (STOL) performance, minimal need for ground support, and very low operating cost. These capabilities make the Solar Ship family of hybrid aircraft particularly useful for meeting critical transportation needs in isolated regions of the world that lack basic infrastructure and reliable access to other modes of transportation.

The Solar Ship website is here: <https://www.solarship.com>

In 2015, the Chinese firm Kuang Chi Science invested in Solar Ship and described the relationship as follows: “Kuang Chi Science and Solar Ship will work together to develop the transportation platform, emergency response station and telecommunication technologies in remote areas. Through this investment, Kuang Chi will be able to target the global market by utilizing Solar Ship’s existing marketing and service network, and integrate Kuang Chi’s near-space technologies into local economy.”

In December 2016, Jay Godsall challenged Lockheed Martin to an intercontinental race between the two firm’s airships: a solar-electric powered Wolverine vs. an LMH-1 hybrid airship. Lockheed didn’t accept this challenge. At the Toronto cargo airship conference in March 2019, he proposed an industry-wide challenge to actually demonstrate by July 2021 airships that can move a 3 metric ton (6,614 lb) standard 20 foot intermodal container configured as a mobile medical lab 300 km (186 mi) to a remote location. This capability does not exist in 2019, but would be of great value if it did.

2. The Solar Ship product line

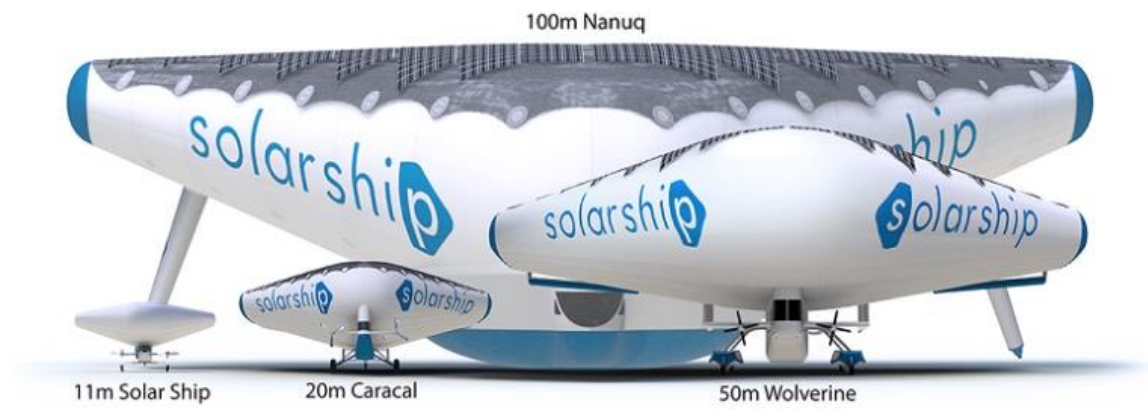
Solar Ship has developed and flown several sub-scale, semi-buoyant aircraft prototypes, including an 11-meter “Zenship” prototype with an inflated delta wing planform and impressive performance. The original business plan was to develop a family of semi-buoyant aircraft that would be based on a scale-up of the 11-meter prototype. The three larger aircraft in this family are named:

- Caracal
- Wolverine
- Nanuq

For all aircraft in this family, aerostatic lift from helium provides less than half of the lift required for flight. Aerodynamic lift from the inflated fabric wings provides the majority of the lift. These aircraft also could fly when the envelope is filled with air instead of helium, but with little or no cargo.

These electrically-powered airships receive power from a thin-film solar cell array installed on the upper wing surface and from an on-board battery system that provides energy storage. The airship’s on-board electrical system can provide emergency electrical power to users in the field.

A family portrait circa 2016 is shown in the following graphic.



*The family of Solar Ship semi-buoyant, hybrid aircraft circa 2016.
Source: Solar Ships via SustainableSkies.org, 21 Sep 2016*

Since 2016, the designs of Caracal, Wolverine and Nanuq have changed significantly, with the latter two departing greatly for their original simple delta planform. In the following sections, we'll look at the prototypes and the individual models in the Solar Ship family of semi-buoyant aircraft.

3. The Prototypes

Solar Ship built a range of prototypes as it developed the hybrid aircraft configurations for its production aircraft.



Several prototypes. Source: SustainableSkies.org



Prototype circa 2011. Source: Screenshot from Solar Ship video

The 2011 video, “Solar Ship – Hybrid Aircraft,” provides a look at the 11-meter “Zenship” prototype and the 20-meter Caracal prototype. You can watch that video here:

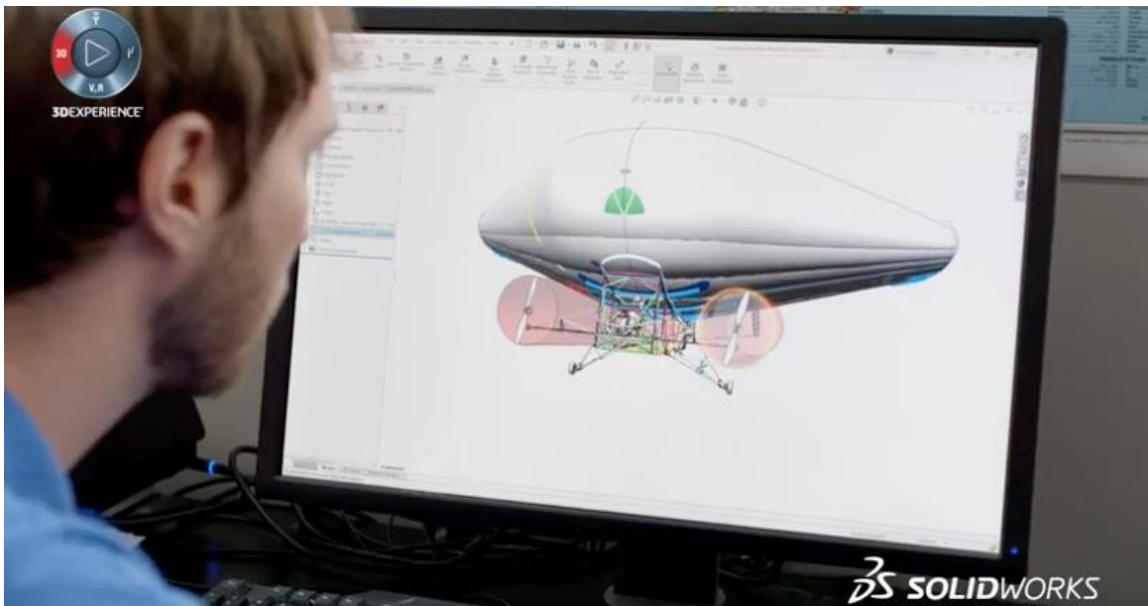
https://www.youtube.com/watch?v=9OFa_ANhiiY

The 2014 video, “Solar Ship Inc. in Brantford,” provides a look at the Solar Ship facilities after its move to Brantford, Ontario, and a glimpse of the formal test and evaluation (T&E) program for the 20-meter Caracal. You can watch that video here:

<https://www.youtube.com/watch?v=yrStvYrMzbn>

SOLIDWORKS, by Dassault Systems, is the 3-D software design tool used by Solar Ships to design and optimize their semi-buoyant, hybrid aircraft. You can watch the 2017 video, “Born to Design: Solar Ship - Innovation Takes Flight – SOLIDWORKS,” at the following link:

<https://www.youtube.com/watch?v=HGsnSh5pfUU>



*Using SOLIDWORKS for design of a Solar Ship.
Source: Screenshot from Solar Ship video*

4. Caracal

The original 20-meter Caracal prototype was a refinement of the 11-meter “Zenship” prototype, with various safety and controllability improvements. Its primary mission is to deliver critical cargo into isolated places for disaster relief and medical emergencies. The aircraft flies on 100% solar power and it can provide emergency power in the field. Caracal is designed to fly as a drone or piloted on 200 km (124 mile) missions with a 200 kg (441 lb) payload.



*Original 20-meter Caracal prototype design, circa 2016.
Source: Solar Ship*

In 2014, the 20-meter Caracal prototype, powered by a 60 kW (80 hp) electric motor, demonstrated its extreme STOL capabilities by operating out of a 100 meter (328 feet) soccer field carrying 1.8 metric tons (1,800 kg, 3,968 lb) of cargo.



*20-m Caracal prototype during the 2014 soccer field test.
Source: Screenshot from Solar Ship video*



*Two views of the 20-meter Caracal prototype at the factory.
Source: Screenshot from Solar Ship video*





The 20-meter Caracal prototype in flight.
Source: SustainableSkies.org



The 20-meter Caracal prototype.
Source: Screenshot from Solar Ship video

Solar Ship's formal test and evaluation program (T&E) for the 20-meter Caracal found issues that needed fixing in the production version of this aircraft. This process resulted in the next-generation 24-meter Caracal, which retains the same general inflated delta wing planform and is representative of the planned production version.

In September 2016, Solar Ship announced the sale of two Caracal and two Wolverine semi-buoyant hybrid aircraft to Manaf Freighters for disaster relief missions in Africa. These sales are contingent on the respective aircraft receiving certification from Canadian aviation authorities.

5. Wolverine

The original 50-meter Wolverine design was a scale-up of the 11-meter "Zenship" prototype's inflated delta wing planform. The Wolverine is designed to deliver a 5,000 kg (11,023 lb) payload over a range of 500 km (311 miles) on solar-electric power. Solar Ship reports that this is six times more than the payload of a turbo-prop powered Cessna Caravan, at less than half the operating cost of a much smaller Cessna 172. Wolverine is designed to carry a standard 20 foot shipping container (a 20 foot equivalent unit, TEU) and can be outfitted with floats for amphibious operations

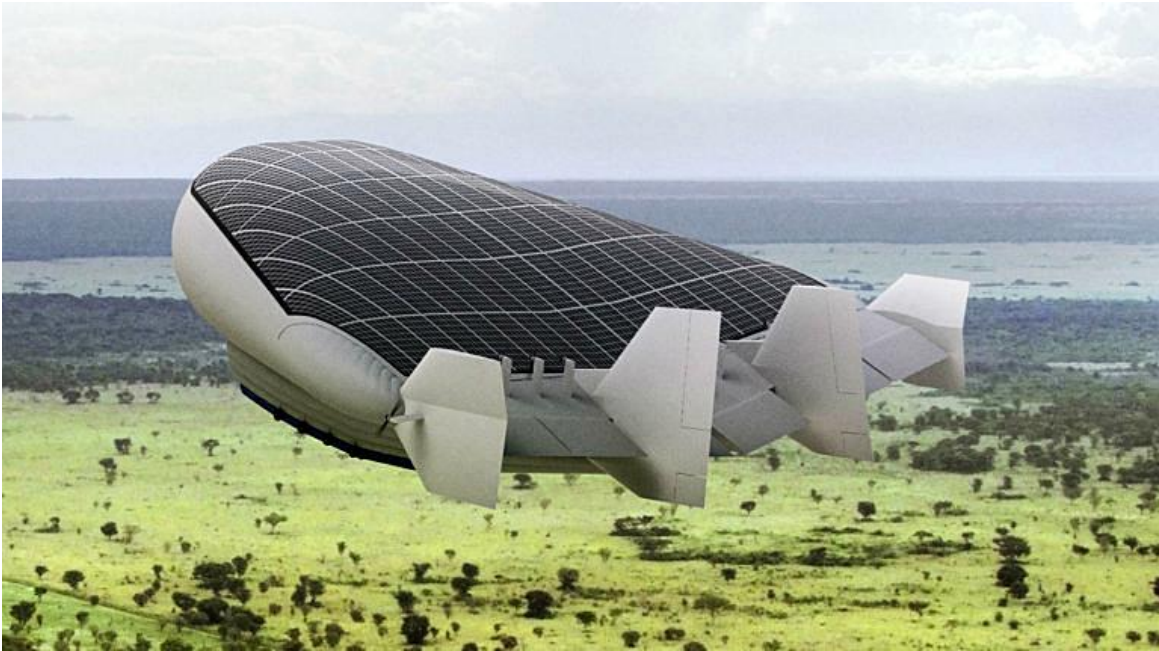


Original 50-meter Wolverine design, circa 2016.

Source: Solar Ship

In June 2017, Solar Ship Inc. conducted the first demonstration flight for a Wolverine under a program with Defense Research and Development Canada (DRDC), a research agency of the Department of National Defense. Under this program, a Wolverine prototype based on a scale-up of the Caracal design was tested for a number of

capabilities including cargo, long endurance surveillance and reconnaissance, and low speed search and rescue.



*Rendering of the original Wolverine design, circa 2016.
Source: Solar Ship*

The original Wolverine design did not pass T&E. Solar Ship reported:

“T&E using CFD and small prototypes produced a clear pattern showing the original delta wing was not able to overcome stability issues, but a longer, reshaped aircraft could be made stable. The improvements to make the aircraft inherently stable had the added benefit of improving efficiency, allowing the aircraft to consume less energy in flight. The newly shaped aircraft would carry very large loads at very low cost, and it could land amphibiously on both unprepared ground or water, safely and stably.”

The next-generation Wolverine has a significantly different shape that has passed T&E, though it has not been produced at full scale. Development of a commercial-scale design is in progress.



*Rendering of current Wolverine design, circa 2019.
Source: Solar Ship*

6. Nanuq

The original 100-meter Nanuq design was a scale-up of the 11-meter “Zenship” prototype’s inflated delta wing planform. On solar-electric power alone, the Nanuq is designed to carry more cargo than a four-engine Hercules fixed-wing transport at 10% of the operating cost.



*A rendering of the original 100-meter Nanuq, circa 2016.
Source: Screenshots from Kuang Chi Science product video.*



*A rendering of the original 100-meter Nanuq, circa 2016.
Source: Screenshots from Kuang Chi Science product video.*

Based on experience with the Wolverine T&E process, the design of Nanuq was changed to a shape that has been scaled from the next-generation Wolverine. T&E completion is expected in 2021, with an in-service date dictated by market demand and funding.



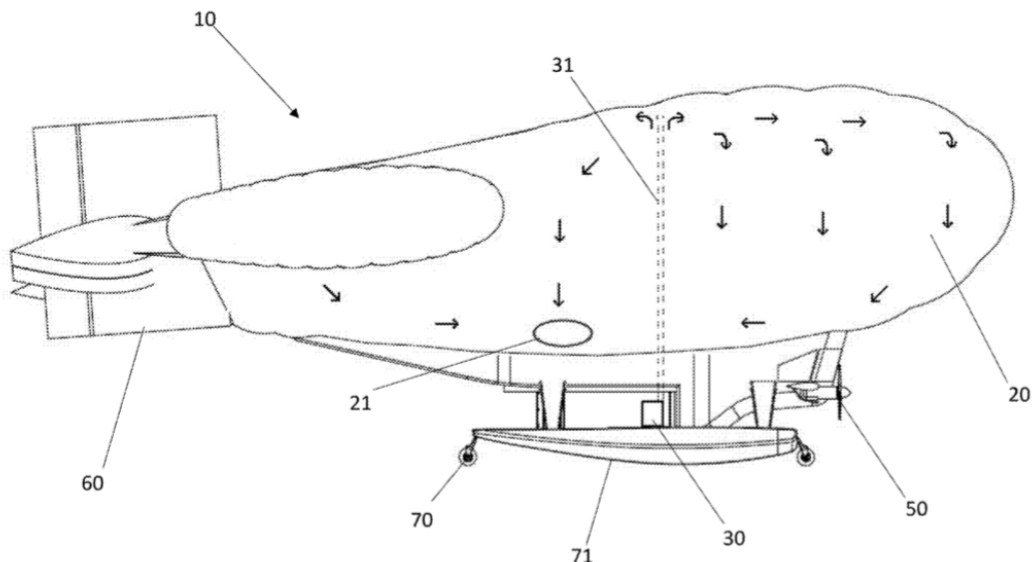
*Rendering of the current Nanuq design, circa 2019.
Source: Solar Ship*

7. Hydrogen-regenerating solar-powered airships

Solar Ship Inc. has been granted several patents related to a hydrogen-regenerating solar-powered airship that uses an air-hydrogen mixture as the lifting gas, with the concentration of hydrogen maintained above the upper flammability limit in air (75%), but below about 90% to avoid difficulties in maintaining a high purity level. Solar Ship has put the system through T&E and results indicate that a solar electric-powered airship with a hydrogen-regenerating system will be able to outperform any other known aircraft system in terms of cost.

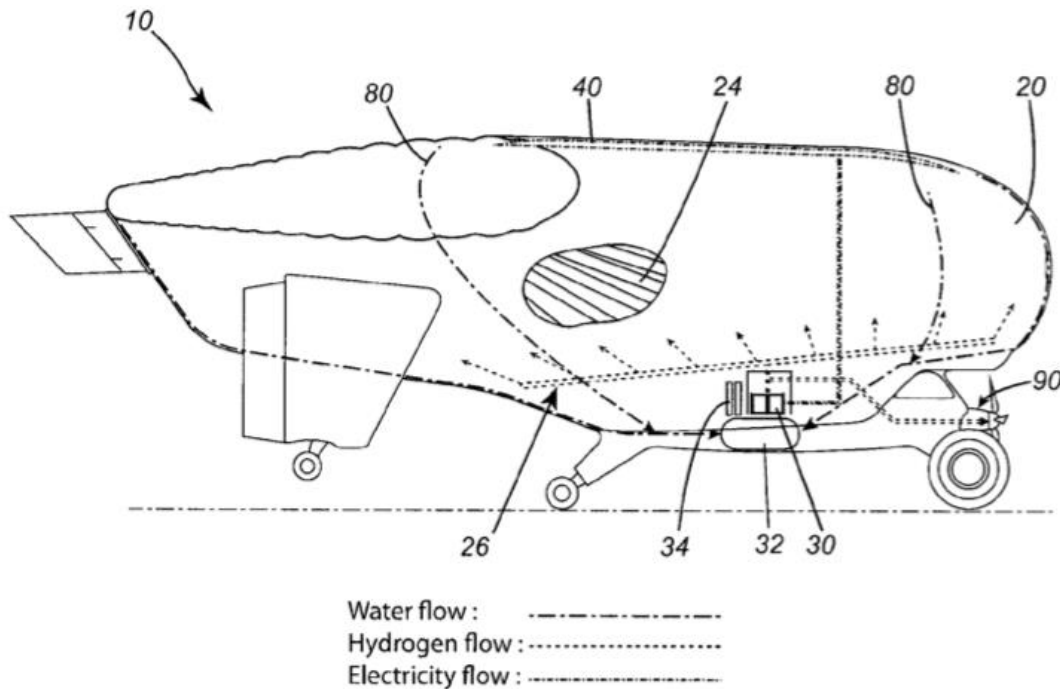
All of the patents offer the same general description of the hydrogen-regenerating system. The following description is from US patent US10427772B2:

“An aircraft comprising a hydrogen-containing envelope, a water-collection system for collecting water from the envelope, an electrolyser to convert the water collected using the water-collection system into hydrogen, and a hydrogen-replenishment system for replenishing the envelope with hydrogen generated using the electrolyser. In one embodiment, generated hydrogen is also supplied to a hydrogen-fueled propulsion system for propulsion of the aircraft.”



Source: US10427772B2, Figure 3

In the above implementation from US patent US10427772B2, the airship (10) has a vent valve (21) located low on the envelope preferentially vents heavier air from the envelope to the ambient atmosphere, while the hydrogen stratifies higher in the envelope. The electrolyzer (30) produces pure hydrogen from water. The pure hydrogen is delivered to the envelope by a distribution manifold (31) until sensors determine that hydrogen concentration in the envelope is within desired limits.



Source: US9527569B2, Figure 3

In the above implementation, from US patent US9527569B2, water is stored in a reservoir (32) and used by the electrolyzer (30) to produce pure hydrogen, which has two uses. Hydrogen is discharged to the envelope (20) via a distribution header (26) to maintain the desired hydrogen concentration. Hydrogen also is delivered to hydrogen fuel cells (24), which generate electricity for propulsion (90) and aircraft systems, supplementing the power generated by the solar array (40) on the top of the envelope.

8. For more information

- Tyler Hamilton, “Toronto start-up designs solar-powered hybrid aircraft,” Toronto Star, 14 October 2011: https://www.thestar.com/business/2011/10/14/hamilton_toronto_startup_designs_solarpowered_hybrid_aircraft.html
- Jonathan Kalan, “Solar ship aims to soar,” BBC, 18 November 2018: <https://www.bbc.com/future/article/20130111-solar-ship-set-to-soar>
- Ben Forrest, “Solar Ship challenges Lockheed Martin to airship race,” Skies Magazine, 12 December 2016: <https://skiesmag.com/news/solar-ship-challenges-lockheed-martin-airship-race/>
- Claudia Nieroda, “Connecting The North: Interview With Solar Ship CEO Jay Godsall,” NATO Association of Canada, 21 February 2017: <https://natoassociation.ca/connecting-the-north-interview-with-solar-ship-ceo-jay-godsall/>

9. Patents

- US10427772B2, “Hydrogen-regenerating solar-powered aircraft,” filed 4 November 2016, granted 1 October 2019: <https://patents.google.com/patent/US10427772B2/en?q=10427772>
- US2017/0073058A1, “Hydrogen-regenerating solar-powered aircraft,” filed 4 November 2016, granted 1 October 2019: <https://patents.google.com/patent/US20170073058A1/en?q=20170073058>
- US9527569B2, “Hydrogen-regenerating solar-powered aircraft,” filed 19 September 2013, granted 27 December 2016: <https://patents.google.com/patent/US9527569B2/en?q=9527569>
- US20150246717A1, “Hydrogen-regenerating solar-powered aircraft,” filed 19 September 2013, granted 27 December 2016: <https://patents.google.com/patent/US20150246717A1/en?q=20150246717>