Flight Platform Test

Context: SCoPEx will use a new flight platform that has not flown before. There are significant technical challenges in developing it as an operational vehicle independent of the challenges of the actual solar geoengineering experiment. Only a few propelled balloon systems have flown in the stratosphere. SWRI's HiSentinel and High Altitude Airship were both high velocity (>15 m/sec) airships. Balloon operators have told us about a few other simple gondolas with propellers that are analogous to SCoPEx but we do not have access to details of those systems.

Flight Platform Test will test the capabilities of this new platform to perform future outdoor solar geoengineering experiments but will not carry systems for releasing or measuring particles. Instead, it is a development test flight aimed at verifying operation of the platform, controls, and communications.

Harvard will operate the gondola which will hang from a zero-pressure stratospheric balloon with an approximate volume of 350K cu ft (90 ft inflated height and 90 ft inflated diameter). A balloon vendor will be responsible for all launch, flight, termination, and recovery operations. The flight platform test will have a float duration of 4-6 hours at an altitude of 65000 ft.

Objective: To test the flight platform (Figure 1) and subsystems for powering, running, and communicating with the flight platform. A successful platform test means demonstrating:

(a) Heading control stability
(b) The ability to drive at the design velocity of 3 m/s and to cover >3 km of distance
(c) The ability to fly a path such as given in Figure 2, and to fly through an arbitrary reference point with accuracy of 10 m
(d) The ability to ascend and descend the rope system as commanded, and to hold an absolute altitude within 10 m over 30 minutes
(e) Reliable operation of the flight computer and power systems with component temperatures not going beyond their limits.

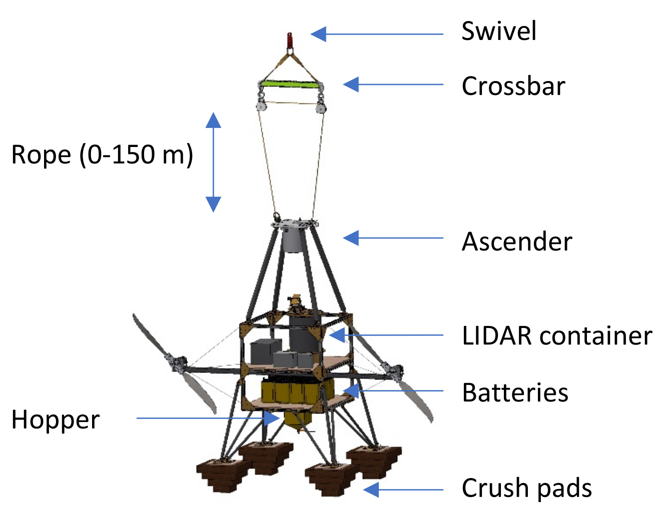

Figure 1: A representation of the flight platform. The final configuration may have subsystem packaged differently.

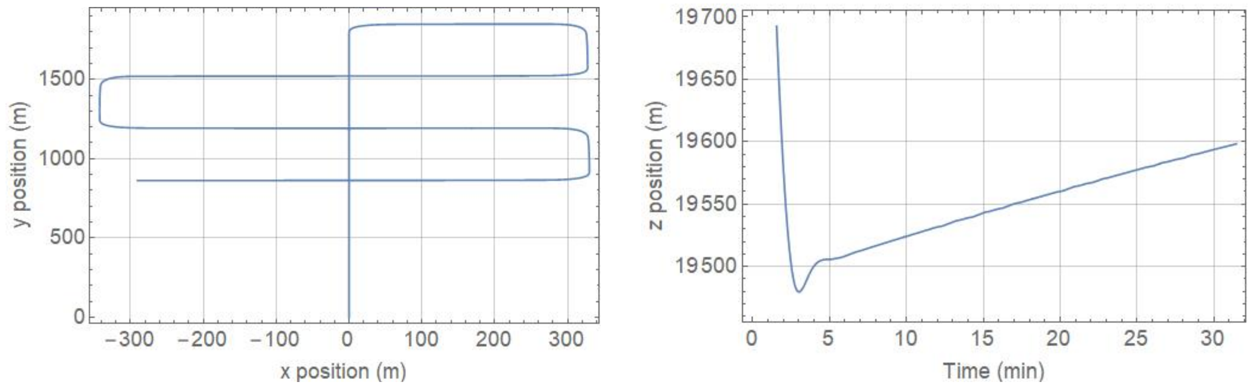

Figure 2: (left) A top down view of the proposed flight maneuvers over a 35-minute window. x and y are in the horizontal plane. (right) The vertical position expected without any ascender or hopper vertical trimming over the same 35-minute platform maneuver.

Systems included:

System	Description
Gondola	An aluminum and carbon fiber frame with a ballast hopper for coarse altitude control. The hopper hardware and communication will be under Harvard control and the actions will be managed by the balloon operator. Total mass of frame, all mounted systems, and hopper: 600 kg
Ascender	For fine altitude control using an ascender built by Atlas Devices. 10 mm diameter, 300+ m length rope. Range of motion: 0-150 m. Max speed: 10 m/min
Propulsion	For repositioning the payload. Max airspeed: 3 m/s Twin propellers from Sensenich, 1.88 m diameter, 1500 RPM, 32 N each MDM-5000 brushless servo motors from Montevideo Technology 1543 W rated power, 12 NM peak torque
Power	28 V and 100 V DC power supplies will power all systems on the Harvard payload. Each 28 V (100 V) battery box has a capacity of 60 Ah (15 Ah). There will be 4 (2) battery boxes for the 28 V (100 V) supply giving a total energy of 24 MJ (10 MJ) when fully charged.
Flight computer	Raspberry Pi 4 will run an interrupt driven real time software architecture that has been developed through many Harvard atmospheric research missions. The flight computer will receive commands, supervise onboard components, log data, and run an algorithm to operate the propellers.
Communication	2 Global star GSP-1700 satellite phones, 9600 bps will facilitate communication between ground equipment and the payload. Ground control software will display incoming data from the payload and communicate with the payload.
Wind	A Styrofoam sphere wind pendulum which takes data using a Raspberry Pi camera will be used to collect data on relative winds.
LIDAR Container	The instrument container will fly with no instrument inside. A resistive heating element will be placed inside, and heat load data will be collected

Subsystems not a part of the platform test: Sprayer, POPS, LIDAR and other scientific instruments