B-SSIPP: 2019 High-Altitude Balloon Flight of SSIPP

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Abstract
The SwRI Solar Instrument Pointing Platform (SSIPP) is a miniature solar observatory designed to fly aboard rocket-powered suborbital vehicles and high altitude balloons. SSIPP is a self-contained payload that provides an arcsecond-level conditioned solar beam to in-development instruments. Analogous to ground observatories, SSIPP contains a standard 1" hole pattern optics bench for rapid instrument development. Fine pointing is achieved using a tip/tilt mirror and photosensitive feedback to acquire and track the Sun within a 5-degree cone about the main aperture. During flight aboard rocket-powered vehicles, course pointing is achieved by vehicle pilot or autonomous attitude control system. The SwRI Course Azimuth Pointer (SCAmP) was developed to solve the problem of course pointing SSIPP during high altitude balloon flight. This novel, reaction-wheel-less, low-mass, low-power, low-cost system is designed to provide sub-degree pointing during float. On Nov. 1st, 2019 SSIPP and SCAmP were flown together as the primary payload, dubbed B-SSIPP, on a World View Enterprises high altitude balloon and were successfully recovered. We overview the development and in-flight performance of both systems.

Concept
The objective of the SSIPP program is to reduce barriers to entry for new instrumentation in suborbital flight by providing a well-defined observatory-like optical table environment rather than requiring complete custom builds. B-SSIPP adapts the SSIPP observatory-like environment for high altitude ballooning. The system forms a complete, flexible "miniature solar observatory" that can support novel investigations with simple buildup of optical instrumentation on a standard table. B-SSIPP includes the original SSIPP agile mirror and fine pointing feedback system, an actively heated enclosure, and a "steering cupola" that accomplishes the coarse pointing function. The SSIPP fine pointing system comprises a flat fast-steering mirror, a non-interference solar limb sensor, and a sophisticated active feedback loop implemented in software. SSIPP itself can be used in manned suborbital rocket flight or as part of the complete B-SSIPP balloon gondola.

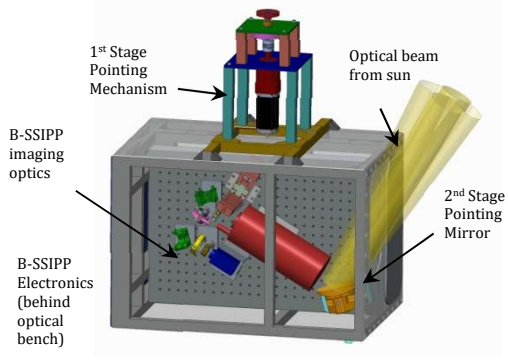

Figure 1: The B-SSIPP 1st stage controls azimuthal solar pointing to < 1°. The 2nd stage pointing provides a stabilized beam (2") to a custom instrument on a small internal optical table. B-SSIPP is extensible for larger instruments, external mounting for access to VUV observations, and celestial pointing with a star tracker rather than sun sensor.

2019 Flight Results
The B-SSIPP balloon mission launched on Nov. 1st, 2019, demonstrating all comprehensive success criteria of active control of both coarse and fine pointing, commanding, stability, survivability and end-to-end data acquisition by a solar instrument on the platform. Upon reaching a reaching a float altitude of 97,000 ft., B-SSIPP immediately locked onto the solar disk, with 75 minutes of near-continuous observations. During the 5-hour flight, the two pointing systems were successfully demonstrated, with SCAmP autonomously measuring the physical characteristics of its suspension system in flight and using them to dynamically develop a control law, and the SSIPP 2nd stage successfully locking onto the solar disk. B-SSIPP demonstrated autonomous operation throughout the science window, successfully locking onto and tracking the Sun.

Status
B-SSIPP is being re-developed at SwRI's Boulder, CO solar heliostat laboratory to mature pointing control electronics. The B-SSIPP technology will be implemented for a scientific flight as part of a larger platform (the BRIDE mission being developed for the H-FORT program).

Acknowledgement:
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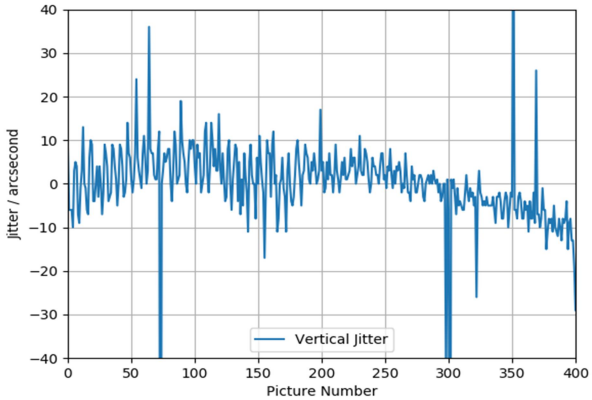

Figure 2: B-SSIPP pointing performance during autonomous operations on float.