THE ATSA SUBORBITAL OBSERVATORY: CONCEPT AND CURRENT STATUS

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Introduction: The Atsa Suborbital Observatory will encompass a suite of interchangeable astronomical telescopes and instrumentation mounted to commercial human-tended suborbital rockets. Though a suborbital flight allows for only a short duration (3-5 minutes) above the atmosphere, the low cost of these flights and ready reusability allowed by the gentle flight characteristics of this man-rated system allow for a unique opportunity to make astronomical observations above the absorption of the Earth's atmosphere with a rugged instrument that can look close to the Sun. Current space telescopes such as Spitzer and Hubble cannot look close to the Sun without risking ruining their billion-dollar systems [1,2]; airborne telescopes, though they fly over much of the IR absorption, still must contend with telluric water overburden and cannot access the UV part of the spectrum [3]. As conceived, observations can be made using either the Atsa 2 Telescope (Figure 1) mounted in the XCOR Aerospace Lynx III spacecraft dorsal pod, or the Atsa 1 Camera on any of the Lynx models I, II, or III.

Atsa 1 Camera: The Atsa 1 Camera is an engineering pathfinder instrument. The camera is designed to demonstrate the control concept of a steerable telescope coupled to a human-piloted suborbital vehicle during flights of limited duration.

A prototype of the Atsa 1 Camera has been built and fit-tested in the engineering testbed cockpit for XCOR's Lynx Mark I spacecraft. We completed a successful fit and function test, and many lessons were learned. Following some re-design, and further fit and g-load testing, the Atsa 1 Camera will be ready for flight this year.

Atsa 2 Telescope: The next instrument planned in the Atsa program will be the Atsa 2 Telescope. It is a 27" telescope with attendant instrumentation that will be mounted in the dorsal pod of the Lynx Mark III Spacecraft. An operator, control hardware, and data acquisition hardware are all located inside the spacecraft. Flights to suborbital space can emphasize observations of Solar System objects requiring telescope pointing within that solid angle around the Sun excluded for most of the robotic telescopic spacecraft. These include observations of the Aten and inner-Earth asteroids, Vulcanoid searches, Sun-grazing comets, comets approaching the Sun through perihelion, and the planets Mercury and Venus. The initial flight hardware concept designs for the Atsa 2 Telescope and plans to house Atsa facilities in available space at the Planetary Science Institute are in progress.

Figure 1. Artist's Concept for Atsa 2 Telescope in flight

The Atsa 1 Camera Design Concept : A suborbital flight with XCOR's Lynx spacecraft will allow a window of observation above the atmosphere of only 3-5 minutes. In this time, an observer must acquire the target, track it, and accomplish whatever set of observations are planned. The Atsa 1 Camera is designed to minimize the number and complexity of these tasks.

All Lynx vehicles are piloted, and have pointing uncertainties larger than the planned telescope and instrument fields of view. This gives rise to the control problem of having two different operators trying to accomplish the same task: steering the instrument FOV onto the target. The pilot maintains gross pointing on the target, even as the operator does fine pointing. It is this control problem that the Atsa 1 Camera was designed to probe and solve.

From the outset, the Atsa team has put safety first in instrument design. Our mounting bracket is designed with a great deal of margin for g-loading; our camera system mass is much smaller than the fluid head mount's load-bearing capacity. We have no deployments apart from the unlocking and re-locking of the fluid head mount locks. Even if we fail to re-lock the mount prior to entry, the loads on the mount will not exceed what a typical television cameraman on Earth would feel with a large camera.

Figure 2. The Atsa 1 Camera in the Lynx cockpit testbed

The Atsa 1 Camera: Description: Atsa 1 consists of a 3.5" ruggedized Maksutov-Cassegrain telescope connected to a five-position filter wheel and a Xybion ISS-750 visible-NIR camera. A Cartoni fluid-head mount is used for hand-steering. The Camera is mounted onto the Lynx's armrest with a team-designed bracket. A guide camera is mounted next to the primary fore-optic. Data acquisition is done with a Dell E6400XFR ruggedized laptop computer. Power is provided from a perfect sine wave converter which takes DC volts either from the spacecraft or a battery that we provide. The adapter, the battery, and the camera control box are all mounted in the XCOR Payload A box along with the computer. User controls for data acquisition and filter wheel control are in a team-designed control box attached to the mounting bracket.

First Fit Test: The Camera was fit-tested in the engineering testbed cockpit of XCOR's Lynx suborbital spacecraft in August 2012. A successful fit was achieved (see Figure 2), and the system was successfully operated from the cockpit. The team developed checklists for the installation and removal of the system, as well as for ingress and egress of the telescope operator. The system was examined by an XCOR test pilot and by their safety officer. It was pronounced "very uninteresting" from a safety point of view.

Follow-on work: As a result of the fit-testing, we have re-configured the system so that the camera sits higher in the cockpit than in the figure, and have built a smaller control box (which will also move from its current position). We have replaced an earlier 800 mm catadioptric lens with the ruggedized Maksutov-Cassegrain telescope; we have also designed a truss for the next iteration to hold the optical elements in proper alignment through launch. Components are currently being assembled for the next fit test, due in Spring 2014 on the actual Lynx flight vehicle. We plan to conduct static g-load testing in Summer or Fall 2014.

Student Involvement: Student involvement has been a hallmark of the Atsa program so far, and will remain so for its entire life cycle. Two undergraduate summer student teams were funded by the South Carolina Space Grant Consortium to do design work, build, and testing. In the first summer, students engaged in trade studies and helped define the preliminary design. Part of this activity was participation in NASTAR Suborbital Scientist training. In Summer 2012, the second student team designed and built the control box, finalized and assembled the first system, and conducted the fit test at XCOR.

References: [1] HST Primer for Cycle 17, 2.3 Pointing Con-straints (2007). [2] Gerhz, et al., Rev. Sci. Instrum. 78, 011302 (2007). [3] Erickson, E.F. *PASP* 110: 1098-1105.