THE ATSA SUBORBITAL OBSERVATORY: CONCEPT AND CURRENT STATUS. Luke S. Sollitt[1,2], Ryan Boodee[1], Angelica McNerny[1], Adam Klingenberger[3], and Faith Vilas[2], 1 The Citadel, Charleston, SC, USA (Luke.Sollitt@citadel.edu); 2 Planetary Science Institute, Tucson, AZ, USA; 3 Clemson University, Clemson, SC

Introduction: The Atsa Suborbital Observatory will encompass a series of astronomical telescopes 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 else they risk ruining their billion-dollar systems; 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.

The Atsa 1 Camera is an engineering pathfinder instrument for the eventual Atsa Suborbital Observatory. The instrument is to prove out the control concept of a steerable telescope coupled to a human-piloted suborbital vehicle during flights of limited duration. A physical description of the instrument is given in an accompanying abstract.

A prototype of the Atsa 1 Camera has been built and fit-tested in the engineering testbed cockpit for XCOR Aerospace's Lynx spacecraft. A successful fit and function test was achieved, and many lessons were learned. The re-designed Atsa 1 Camera should be ready for flight this year after further fit and g-load testing.

Figure 1. Artist's Concept for Atsa 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 as an engineering pathfinder instrument to minimize the number and complexity of these tasks.

The Lynx vehicle is piloted, and has a pointing uncertainty larger than the planned observatory's field 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 explore 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.

The Atsa 1 Camera System: 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. All optical components are mounted to a truss. Data acquisition is done with a Microsoft Surface Pro 2 tablet 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 included as touchscreen controls in the tablet computer.

The Camera was fit-tested in the engineering testbed cockpit of XCOR's Lynx suborbital spacecraft in August 2012 [1]. A successful fit was achieved 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."

Recent work: As a result of the fit-testing, we have re-configured the system so that the camera sits higher in the cockpit than previously. We have replaced an earlier 800 mm catadioptric lens with the ruggedized Maksutov-Cassegrain telescope; we now also mount the optical elements to a truss to maintain proper alignment through launch. A touchscreen tablet computer replaces the control box, a pair of video screens, and the former control computer. A Payload A truss has been built to accommodate the camera control box and power system. Components are currently being assembled for the next fit test, due in early 2015 on the actual Lynx flight vehicle.

Figure 2. The re-designed Atsa 1 Camera

Future plans: It is hoped that the team will conduct static g-load testing as well as control tests in zero-g flights in 2015. Static g-load testing will make use of the NASTAR Center's Phoenix human-rated centrifuge, exposing the system to loading consistent with expected launch loads, as well as contingency loads to simulate emergency situations. The Phoenix Centrifuge can simulate with a high degree of accuracy the load conditions experienced by suborbital payloads and researchers during all phases of a mission (launch and entry) apart from zero-g.

The team has also applied to fly aboard a zero-g aircraft on parabolic flights to simulate the conditions a researcher will experience in the zero-g portion of the flight, where data must be collected. It is expected that the human researcher will be affected by the g-loads experienced on launch, but will nonetheless be responsible for highly precise tasks immediately after the onset of zero-g. The short-duration suborbital flights on which Atsa will fly will require that the telescope operator be able to efficiently control the telescope under these anomalous conditions. The purpose of the zero-g flights will be to simulate these conditions to better understand the control response and the human interface.

Student Involvement: Student involvement has been a hallmark of the Atsa program so far, and will remain so for its entire life cycle. Three undergraduate summer student teams have been funded by the South Carolina Space Grant Consortium to do design work, build, and testing. Other students during the academic year have been involved as well. In the first summer, students engaged in trade studies and helped define the preliminary design. The second student team designed and built the initial control box, finalized and assembled the first system, and conducted the fit test at XCOR. After the second team's summer experience, another student (Boodee) helped to design the truss system for the new telescope. The third summer team (Klingenberger) replaced the control box and former computer with the tablet computer, and re-designed the control system to work on a touchscreen. Most recently, an academic-year student (McNerny) has worked to define the guide scope and integrate it into the design.

References: [1] Sollitt L. S. et al. (2014), *LPS XLV*, Abstract #2236.