The SSA Instrument on SPARC-1 – A Star Tracker for Detection and Orbit Determination of Resident Space Objects

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ABSTRACT

The number of resident space objects (RSO) in near-Earth space is increasing rapidly. The number of active satellites exceed 2000 to date, and tracked objects at present (roughly larger than 10 cm in diameter) is about an order of magnitude larger. If smaller pieces of space debris are included as well, down to sizes of 1 cm, the number of objects expand to an estimated ~300,000, all of which can be harmful to orbiting spacecraft. To meet the increasing requirement for space management, there is a pressing need for a global network of precise space situational awareness (SSA) sensors that can provide up-to-date orbital information in all regions of the near-Earth space. In low Earth orbit, radar facilities typically provide the most accurate measurements, but they are expensive and restricted to one space segment only; a global network would require the inclusion of more cost-efficient solutions. Ground-based optical sensors can provide some support, but they are limited by for example clear weather requirements.

The SPARC-1 (Space Plug-and-play Architecture Research Cubesat) mission is a joint US – Sweden research effort on spacecraft architecture and instrumentation that is due for launch in May 2019. One of the main payloads is the novel SSA (Space Situational Awareness) instrument, a software-modified star tracker intended for detection and orbit determination of RSOs. The instrument is designed as a proof-of-concept of the star tracker as an autonomous SSA sensor, capable of detecting RSOs in the vicinity of the host spacecraft, providing adequate orbital parameters of the observed objects, and identifying these from a catalogue of space objects. As star trackers are key components in most contemporary spacecraft designs, used for attitude determination, the possibility of extracting additional SSA data from these sensors holds great potential in the quest for a global sensor coverage for SSA purposes. By a minor change in how the star tracker operates, we could potentially greatly enhance the number of individual SSA sensors in space, creating a space-based network capable of monitoring the orbital evolution of both spacecraft and space debris populations. This will be particularly important in low Earth orbit, where the densities are the highest.

We here provide a general overview of the SSA instrument and the mission objectives, as well as a summary of the preliminary results from the SPARC-1 mission. We will show example observations from the orbital phase of the mission, along with the initial orbit determination and object identification of a set of observed RSOs. We also discuss the observational plan for the mission, the different imaging modes available, and the requirements posed on the observations in terms of the signal-to-noise ratio, range, relative angular velocity etc. Finally, we will provide an initial evaluation of the prospect of star trackers as an additional source of SSA data.