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SPACE SYSTEMS SYMPOSIUM (D1)
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UWE: A ROADMAP TO PICO-SATELLITE FORMATION FLYING

Abstract

Distributed cooperating multi-satellite systems offer interesting, innovative application potential in Earth observations, as well as in telecommunications. A very interesting application field is space weather research, where a satellite formation can be used to realize large scale multi-point measurements of the upper atmospheric layers (Ionosphere, Thermosphere) of the Earth. The required high spatial and temporal resolution, as well as the observation of three-dimensional processes, demands a formation of at least 3 satellites, thus offering an ideal application case for a distributed pico-satellite system.

Modern miniaturization techniques allow realization of satellites of continuously smaller masses, thus enabling cost-efficient implementation of distributed multi-satellite systems. This contribution details a roadmap to realize in several precursor missions a technology base of crucial components to realize as final step such a pico-satellite formation in orbit. The University Würzburg has already realized as preparation in the University Würzburg's Experimental satellite (UWE) program single, complete satellites at only 1 kg mass. These missions emphasized crucial components for formation flying, like communication on basis of internet protocols (UWE-1, launched 2005) and attitude determination (UWE-2, launched 2009). Currently UWE-3 is realized as demonstration mission for attitude control capabilities, while UWE-4 is in the design phase for orbit control based on electric propulsion systems (e.g. vacuum arc thrusters). Technology challenges and approaches are outlined to meet related mission requirements in the space weather context.

A satellite formation is characterized by autonomously controlled relative positions between the space vehicles. This demands appropriate relative navigation sensors, extremely robust control strategies and sufficient communication resources for data exchange. The additional effort in formation control is on the other side compensated by higher availability and fault tolerance compared to traditional single spacecrafts.

To realize such a networked satellite system, an orbit control based on relative position and attitude of each satellite is outlined in order to enable Earth observations based on multipoint measurements. Combination of optimal control strategies for coordination of relative motion are designed and evaluated to enable a robust flow of information in the network of satellites and ground stations, using ad-hoc networks in space. Thus, the planned in-orbit satellite formation demonstration is expected to open up significant application potential for future distributed satellite system services in Earth observation.