National Aeronautics and Space Administration

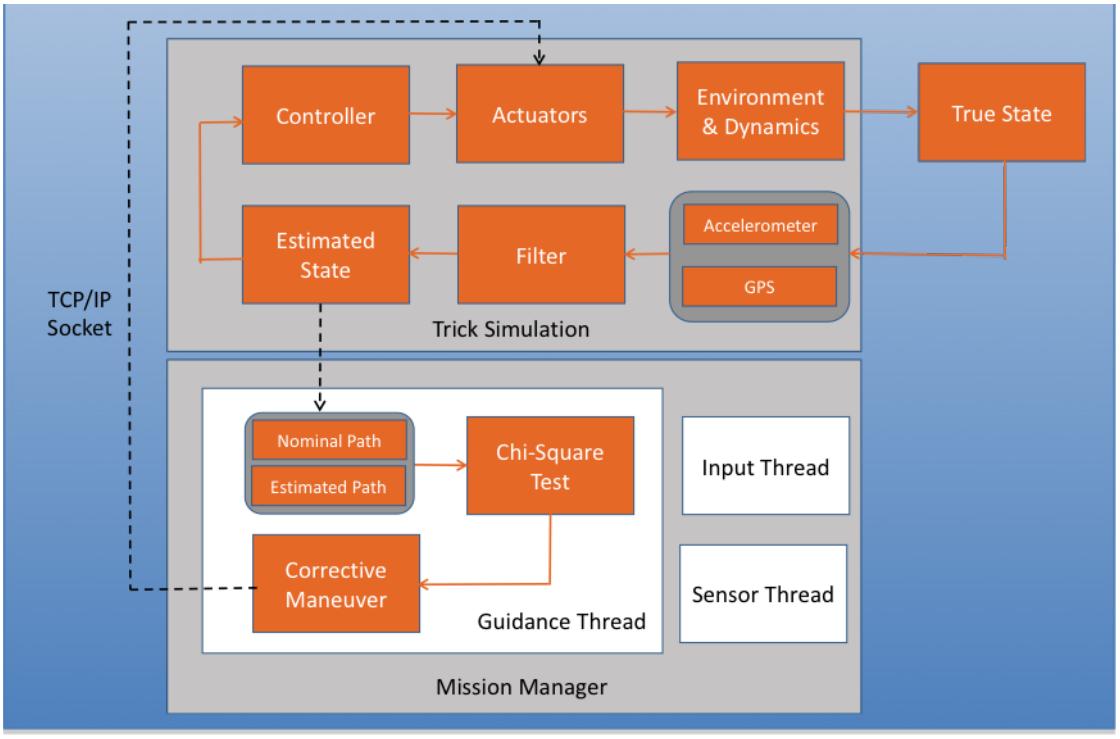
NASAfacts

CubeSat Autonomous Rendezvous and Docking Software

Mission Manager Software for Proximity Operations

The CubeSat Autonomous Rendezvous and Docking Software (CARDS) project has developed and tested standalone software that performs the mission manager functions for CubeSat proximity operations. Flexible and configurable mission manager software is needed to achieve a robust and reusable core proximity guidance, navigation, and control (GNC) system. CARDS is intended for use on twin cooperative maneuverable small satellites, such as CubeSats. CARDS provides algorithms and executable software for conducting GNC automation, maneuver monitoring and planning, and contingency diagnosis and response, including trajectory abort if necessary. The software will be flown on a two-satellite proximity operations technology demonstration mission known as Prox-1 in 2016.

CARDS is an onboard executable software module that is intended for semi-autonomous handling of small satellite proximity operations at separation distances of .6 miles (1 kilometer) to 6.2 miles (10 kilometers). CARDS interfaces with a core GNC system by monitoring sensor and actuator telemetry, constructing maneuver plans, and providing high-level instructions to execute a prescribed flight path. CARDS monitors the projected and desired



Block diagram for CubeSat mission manager software as tested in simulated environment

trajectories which deviate from each other due to unmodeled perturbation forces and sensor and actuator limitations. If the projected trajectory deviates from the desired trajectory by more than an operator-provided tolerance, a new trajectory is planned and CARDS schedules a maneuver correction. Alternately, if the deviation from the desired trajectory is too large, if there is a risk of collision, or upon receipt of an abort maneuver command, CARDS places the maneuvering vehicle into a safe holding pattern relative to the target vehicle, notifies the human operator, and waits for further instructions.

CARDS was developed using a dynamic analysis tool that was created, modeled, and tested using NASA's Trick Simulation environment. The CARDS executable software was ported onto a low power ARM 9 microprocessor running a generic Linux OS. The processor was chosen as a realistic low cost candidate for a CubeSat flight computer, in order to demonstrate that CARDS can be run in real-time on a CubeSat flight system. The embedded system was tested with measurement inputs matching the simulated test cases, and the execution of the hardware-in-the-loop software was demonstrated to match the simulated results. The CARDS software will be made available through NASA's Autonomous Rendezvous and Docking Software Warehouse for future use.

The ability for small satellites to safely maneuver near other objects is a critical enabling capability for on-orbit inspection, servicing, repair, and assembly of structures in space, reducing the need for hazardous and costly human spacewalks. Scientifically, multi-vehicle formations have many applications. Performing a mission with a formation of low-cost small satellites is encompassed within the capability of semi-autonomous maneuverability that is included in this research.

The University of Texas at Austin, Georgia Institute of Technology, and NASA's Johnson Space Center are collaborators on the CARDS project.

This project is funded through the SmallSat Technology Partnerships, a program within the Small Spacecraft Technology Program (SSTP). The SSTP is chartered to develop and mature technologies to enhance and expand the capabilities of small spacecraft with a particular focus on communications, propulsion, pointing, power, and autonomous operations. The SSTP is one of nine programs within NASA's Space Technology Mission Directorate.

For more information about the SSTP, visit:
http://www.nasa.gov/smallsats

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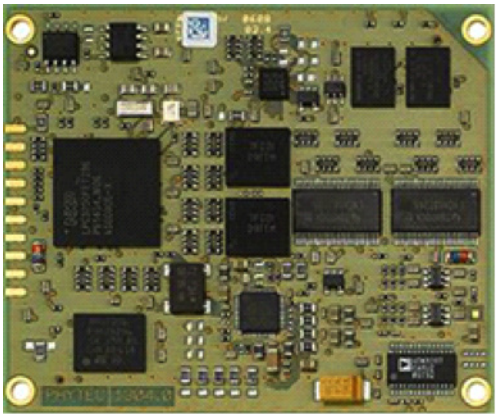

Example ARM 9 target (phyCore)

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