Abstract

Drift Recovery and Station Keeping for the CanX-4 & CanX-5 Nanosatellite Formation Flight Mission

Joshua Zachary Newman
Master of Applied Science
Graduate Department of Aerospace Science and Engineering
University of Toronto
2015

Canadian Advanced Nanospace eXperiment 4 (CanX-4) and Canadian Advanced Nanospace eXperiment 5 (CanX-5) are a pair of identical formation flying nanosatellites that demonstrated autonomous sub-metre formation control at ranges of 1000 to 50 m. This capability is crucial to the future use of coordinated microsatellites in applications such as synthetic aperture radar and optical interferometry, on-orbit servicing of other spacecraft, and gravitational and magnetic field science. Groups of small, relatively simple spacecraft can also replace a single large and complex one, reducing risk through distribution of instruments, and saving money by leveraging non-recurring engineering costs.

To facilitate the autonomous formation flight mission, it is necessary that the two spacecraft be initially brought within a few kilometres of one another, with a low relative velocity. Complicating this is the fact that the CanX-4&5 spacecraft were released separately from their launch vehicle, drifting thousands of kilometres apart in the time it took to fully commission one spacecraft. Therefore, a system to calculate fuel-efficient recovery trajectories and produce the corresponding spacecraft commands was required. This system should also be extended to provide station keeping capabilities in the time between formation experiments, to keep the spacecraft safely separated without allowing their distance to grow large again.

In this thesis, the overall drift recovery strategy is outlined, and the design of the controller is detailed. A method of putting the formation into a passively safe state, where the spacecraft cannot collide, is also presented. Monte-Carlo simulations are used to estimate the fuel losses associated with navigational and attitude errors. Finally, on-orbit results are presented, validating both the design and the error expectations.