MAE Praxair Seminar

Electrostatic Spacecraft Relative Motion Control

Dr. Hanspeter Schaub
Virginia Tech, Blacksburg, VA

Electrostatic (Coulomb) thrusting is a novel promising technology being considered to control the relative motion of spacecraft. The separation distances between craft considered range up to 100 meters. Such mission scenarios include wide field of view optical interferometery from GEO, flying small drone craft about a larger craft to perform inspection and surveillance missions, or forming large virtual structures. In 2000 a NASA NIAC study was performed Michigan Tech to investigate the natural charging that occurs with GEO satellites, as well as how well the SCATHA and ATS missions were able to actively control their charge. A surprising result of this work was that inter-spacecraft forces between two GEO satellites could achieve milli-Newtons levels with separation distances of dozens of meters.

This original research has lead to a novel thrust of spacecraft formation flying research called Coulomb formation flying. Here the electrostatic charge of the spacecraft is controlled by emitting either positive or negative charge, resulting in small inter-spacecraft Coulomb forces to control the relative motion. This mode of relative motion control requires essentially no propellant (Isp values up to 10^13 seconds), and has very small electrical power requirements around 1 Watt. The typical exhaust plume contamination issues encountered with high efficiency ion propulsion is not present with this method. This makes Coulomb control an interesting technology for close relative motion control. However, because the spacecraft are not flying in a vacuum, but rather in a space plasma environment, the effectiveness of the Coulomb thrusting concept is limited to regions where the plasma is not too cold or dense. The chief orbits considered in this study range from 4.5 Earth radii out to GEO altitudes.

This presentation will provide an overview of the Coulomb thrusting research being conducted. After discussing the basic concept with its advantages and limitations, three specific Coulomb thrusting example applications are discussed. The Coulomb tether concept replaces the physical tether connecting two craft with the electrostatic force field. The virtual Coulomb structure research investigates developing a spacecraft concept which is composed of discretely distributed spacecraft components which are connected by the Coulomb force fields. All these solutions are static as seen by the rotating Hill frame. The final application discusses a spinning 3-craft formation which yields invariant shapes under the influence of electrostatic forces.

Bio:
Dr. Schaub is an Associate Professor and an H. Joseph Smead Fellow of the Aerospace Engineering Sciences department at the University of Colorado at Boulder. He is an associate fellow of AIAA and member of AAS. His 13 years of professional interests are in nonlinear dynamics and control applications, with a special emphasis on astrodynamics. He has performed research in spacecraft attitude and control, exploiting nonlinear dynamics of control moment gyros to avoid classical CMG singularities, as well as extensive research in spacecraft formation flying dynamics and control problems. His current interests include charged relative motion dynamics and control, as well as visual servoing of autonomous vehicles. Dr. Schaub's prior work experience includes 4 years at the Sandia National Labs Intelligent Systems and Robotics Center (ISRC), and 4 years at the Virginia Tech aerospace and ocean engineering department as an assistant professor. He has authored about 40 peer reviewed papers, presented 60 conference papers, published a text book on analytical mechanics of space systems, and holds a patent on a noncontact position and orientation measurement system.

206 Furnas Hall
Wednesday, November 7, 2007
Seminar 4:00 pm – 5:00 pm