Relative Navigation, Microdischarge Plasma Thruster, and Distributed Communications Experiments on the FASTRAC Mission


The University of Texas at Austin

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Surrey Space Centre, University of Surrey, UK
Outline

• Mission Overview
• Objectives
• Research Effort
• Satellite Design
• Mission Support
• Budget
• Mission Timeline
• Facilities
• Participation
Mission Overview

- Formation
- Autonomy
- Spacecraft with Thrust, RelNav, Attitude, and Crosslink

GPS Constellation

FASTRAC Nanosatellites

With Thruster
Without Thruster

17th Annual AIAA/USU Conference on Small Satellites
August 11-14, 2003
Logan, UT
Objectives

Mission Statement
The purpose of the FASTRAC mission is to investigate enabling technologies for satellite formations; these will include thrust, relative navigation, attitude, and crosslink. This will be achieved by taking data on orbit with a network of ground stations and processing the data for evaluation.

Mission Objectives

• Demonstrate effectiveness of the Micro-discharge Plasma Thruster
  – Extend the Life of one Vehicle by imparting an altitude separation between the two satellites \( \geq 5\% \) of their initial altitude

• Demonstrate GPS Relative Navigation
  – Demonstrate realtime, on-orbit relnav solution to an accuracy of \( \pm 1\text{km} \) versus post-processed solution

• Demonstrate Two-way Intersatellite Crosslink with verified data exchange

• Demonstrate Distributed Ground Station Network
  – Receipt of satellite data from both satellites by at least 2 ground stations, at least one of which is remotely commanded
Research Effort

Microdischarge Plasma Thruster Experiment
• Demonstrate a measurable increase in orbit lifetime using an array of MPTs
• Achieve at least 5% altitude difference between the Nanosats
• Characteristics
  • Specific Impulse ~500 s
  • Exit exhaust Mach number in vacuum ~5
  • Temperature ~1000 K
  • Discharge chamber pressure ~1.013E+05 Pa (1 atm)
Research Effort

**Microdischarge Plasma Thruster Experiment**

- Microdischarge creates plasma
- Mass ~2 kg
- Propellant – Xenon
- Voltage Requirement ~300 to 1000 V
- Size without tank ~1x1x1 cm
- Tank Size 5 cm diameter and 13.3 cm height.
- Less than 2 watts of power
- Tank mass ~415 grams
- 2-D Converging-Diverging nozzle
- Tank pressure ~5 atm
Research Effort

On-Orbit Relative Navigation

- GPS Orion Receiver
- Transmit Raw Observables Directly
- Ground Post-Processing
  - Accuracy Assessment
- Constellation Simulator
  - Extensive Hardware-in-the-Loop Validation
- No Control Attempted
  - Demonstrates Capability
Research Effort

Distributed Communications System

• Multiple Stations Available for Tracking
  • Demonstrate Effectiveness for Formations
• Requires Coordinated Scheduling
• Based on Santa Clara University RACE System
  • Remote Accessible Communications Environment
  • TCP/IP Comm. Standards
Satellite Design

• Structure

• 2 Hexagonal Isogrid Structures
• Structural Components
  – 19x 22cm side panels with reinforcement bars
  – Attachment to separation system built in to base of structure
  – Lightband Separation system
• Material: Al 6061-T6
• Fasteners: Military spec 1.905cm length and 0.218cm diameter screws with corresponding washers and nuts
Satellite Design

• Separation System
  • Mechanical interface
    • Direct attachment to structure through mounting plate
    • Integration with 15” Lightband system
    • Motor driven Separation /Non-pyrotechnic
  • Electrical interface
    • 15 Pin Socket Connectors
    • 10.4 W motor operating power
    • Satellite initiate separation
Mission Support

• Dynamic Analysis
  • Analytical Graphics Satellite Tool Kit used for Dynamic Analysis tasks
  • Orbit Characteristics
    – Altitude: 350 km, 400 km
    – Inclination: 30 deg, 51.6 deg, 90 deg
    – Circular (e=0), Right Ascension=0, Argument of Perigee=0

• Orbit Lifetime Determination
  – Jacchia-Roberts Atmosphere model
  – 70x70 gravity model
  – Solar and Lunar effects
  – Schatten Solar flux and Geomagnetic index predictions for 2006
  – Lifetime determined to be approximately 3-4 months worst-case
Mission Support

• Ground Station

• Located at Univ. of Texas at Austin
• V-band (12.25dB) and U-band (16.6dB)
### FASTRAC COST BUDGET: 07/31/03

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Mission Timeline

- **Launch**
- **Shake-down Validation**
- **Stack Configuration**
- **Separation**
- **RelNav (real-time)**
  (once in this region, RelNav will take place when possible)
- **Plasma Thruster**
- **Secondary**
- **Re-entry (due to drag)**

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**Legend**
- Orange: Subsystem active
- Red: Objective accomplished
- Blue diamond: Major event

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August 11-14, 2003
Logan, UT
Facilities

• University of Texas at Austin: Satellite Design Lab

• University of Texas at Austin: GPS Lab

• University of Texas at Austin: Plasma Research Lab

• Santa Clara University: Robotic Systems Lab
Participation

• Student Participation
  • Texas Space Grant Consortium
  • Partnerships with Public High Schools
  • Amateur Radio Community
  • Web Site - Data and Outreach
  • Educational and Academic Impact
    • Senior design projects
    • GPS technology courses

• Outreach
  • Community Activities
    • K-12 talks & demonstrations
    • General audiences
  • Technical Conferences
    • Summer, 2003
  • Publications
    • College of Engineering
    • Department Newsletter
    • The Daily Texan