Project Definition Document

Aerospace Senior Projects (ASEN 4018 & 4028)
Fall 2003 and Spring 2004

1.0 Information

1.1 Project Title

Drag Free Technology Satellite (DRAFT Sat)

1.2 Project Customers

None

2.0 Background and Context

Satellites in the lower atmosphere are subject to large drag forces imposed by the atmosphere. This drag slows the velocity of the satellite, causing it to fall out of its orbit. By thrusting in the direction of travel, the velocity of the satellite can be held constant, preventing orbit decay. Drag Free Technology (DRAFT) will allow a satellite to follow a purely gravitational orbit free of perturbations from atmospheric drag and solar radiation pressure.

The DRAFT-Sat project was started in 2002 by a previous group of students. The 2002-2003 team built a two-dimensional prototype of the satellite subsystem, achieving two-dimensional control of a small structure on a semi-frictionless surface. The apparatus was controlled to an accuracy of 1 cm in each of the two dimensions.

The DRAFT-Sat is valuable to the satellite industry because it will dramatically improve the accuracy of an operator's knowledge of satellite position. Some of the applications of this system involve experiments in which a satellite position must be known with improved accuracy such as mapping the earth's surface. Without perturbations affecting the orbit, DRAFT would greatly simplify orbit propogation.

3.0 Objectives

3.1 Overall Objective

The overall objective of the DRAFT-Sat team is to create a spacecraft subsystem that detects surface forces on the spacecraft and provides reaction forces to counteract orbital perturbations due to surface forces.

3.2 2003-04 Objective

The primary objective of the 2003-2004 DRAFT-Sat team are to advance last year's design by designing, fabricating and testing a self contained system capable of sensing surface force perturbations and providing reaction forces in three axes to compensate for these perturbations. This system must be capable of being tested in a micro-gravity environment.

4.0 Functional Needs

4.1 Vehicle

4.1.1 The mass of the vehicle will not exceed the lift capacity of the air table used for testing purposes.

4.1.2 The size of the system will not exceed the dimensions of the air table.

4.1.3 The moment of inertia of the system will be TBD. The moment of inertia of the three axes will be within 20% of each other.

4.2 Proof Mass

4.2.1 The proof mass is to follow a purely gravitational trajectory.

4.2.2 The proof mass size is TBD.

4.3 Positional Accuracy and Stability

4.3.1 The surface force compensation system must control the position of the vehicle relative to the test mass with an accuracy of up to 1 cm.

4.3.2 The surface force compensation system must keep the vehicle position stable for up to 20 seconds in the test environment.

4.4 Self Contained/Self Supporting System

The system will run on its own independent power source and perform necessary on-board data processing.

4.5 3-Axis Control

The on-board control system will sense and provide reaction forces to counteract all translational perturbations experienced by the system to meet the accuracy guideline listed above.

4.6 Test Environment

The optimal testing environment for the system is onboard the KC-135. This will allow a near 0-g testing environment capable of verifying operation of the integrated system. The system shall provide a compatible electrical and mechanical interface with the KC-135 "vomit comet" in order to perform a final integrated microgravity test. See NASA documents AOD 33896 and AOD 33897.

An alternative integrated system test will be conducted on an air table. The air table will be able to provide a 2-D testing environment. The integrated system will be tested in this environment by verifying control in 2 DOF at a time, as well as thruster operation in the

3rd DOF. This will require two individual test runs to verify control in every axis. This testing method will also be used for pre-flight verification leading up to a possible test on the KC-135.

5.0 Anticipated Engineering Expertise

Technical Expertise	How Applied
Control Software	Real-time control subsystem (modifications from previous year)
Electrical Power System	Supply power for the system to be self-contained.
Mechanical Design	Develop structural drawings and accompanying analysis for system structure and proof mass.
Mechanical Fabrication	Structural and system level machining
Propulsion	Designing a propulsion system that can control the position of the experiment. Designing actuators to control the propulsion subsystem.
Electrical Design	Addition of microprocessor to the system for onboard processing and data storage.

6.0 Resources

6.1 Facilities

6.1.1 Space in the Discovery Learning Center.
6.1.2 Machine Shop for structure fabrication.

6.2 Additional Advisors

Dr. Scott Palo is needed for real-time data acquisition and embedded systems.

6.3 Funds

Proposal for KC-135 training and flight time.