



***D**RAG AND **A**TMOSPHERIC **N**EWTRAL **D**ENSITY **E**XPLORER (DANDE)*

**Colorado Space Grant Consortium
and
CU Aerospace Engineering Sciences**

Space Grant Open House Fall 2012

**August 2012
Boulder, Colorado**



DANDE Impact

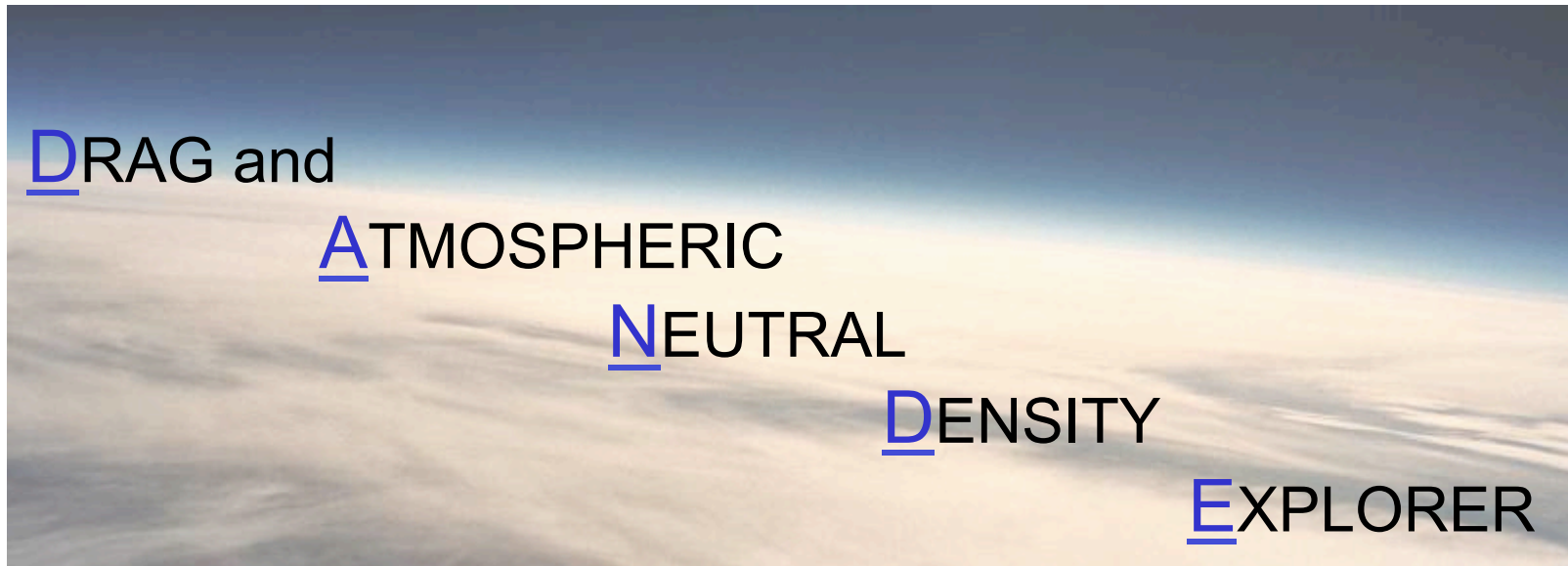
STUDENTS, UNIVERSITY, INDUSTRY

- Represent College and University as quality institution with outstanding students and research
- Over 100 students involved
 - Estimated over 100 students total involved from concept through flight operations
 - Graduate and Undergraduates from AES, ECE, ME, CS
 - Faculty mentors have added significant support to the students and project!
- Industry involvement has been critical to the success of the program from mentoring to in kind donation of testing facilities





DANDE Mission



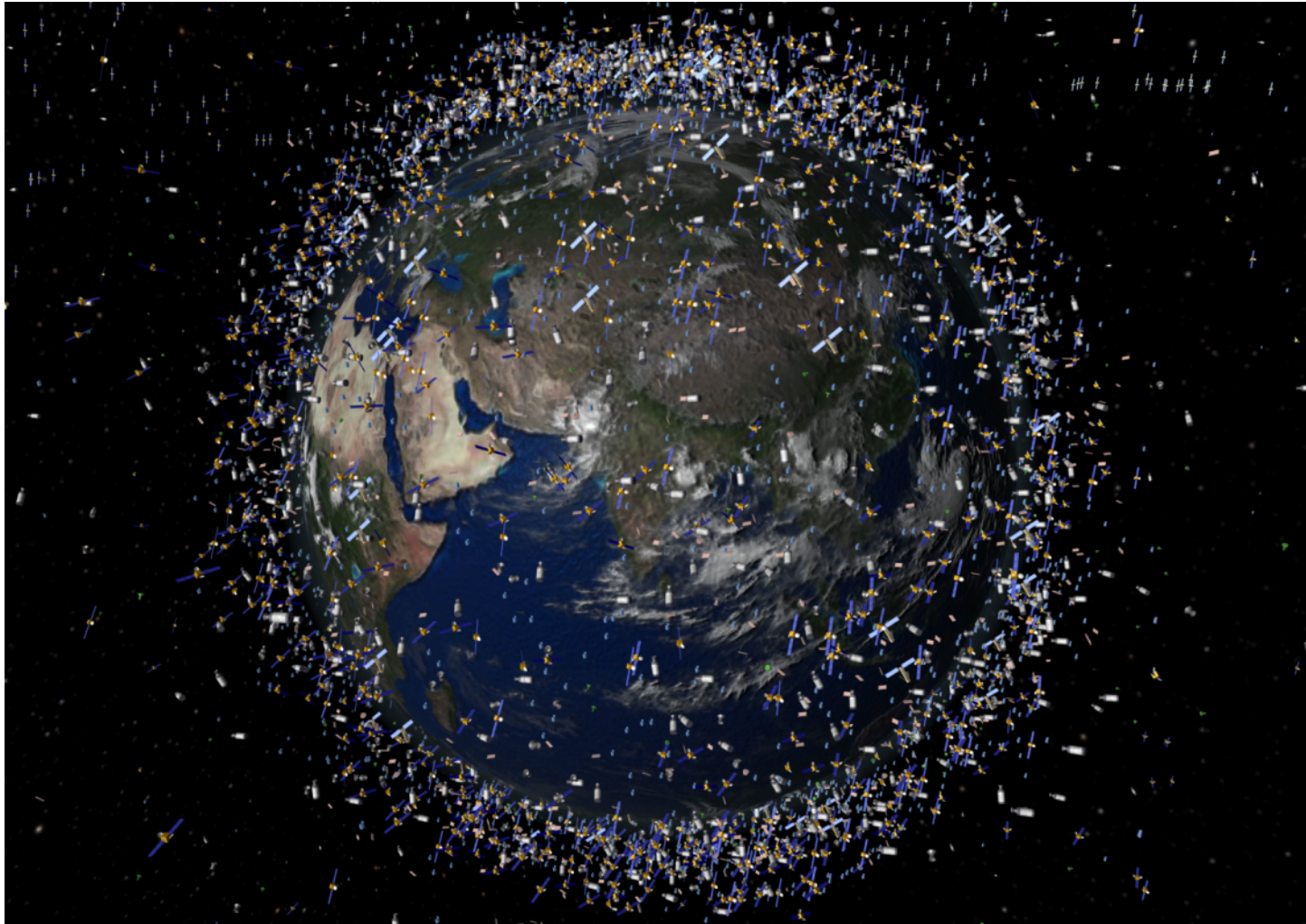
Mission Statement

Explore the spatial and temporal variability of the neutral thermosphere at altitudes of 350 - 200 km, and investigate how wind and density variability translate to drag forces on satellites.



Operational Importance of Drag

The density of the atmosphere in this region varies greatly (300% to 800%*) due to space weather and not yet understood coupled processes.



- Forbes et. Al. "Thermosphere density response to the 20-21 November 2003 solar and geomagnetic storm from CHAMP and GRACE accelerometer data", Journal of Geophysical Research, Vol. 111, June 2006
- European Space Agency Debris Tracking

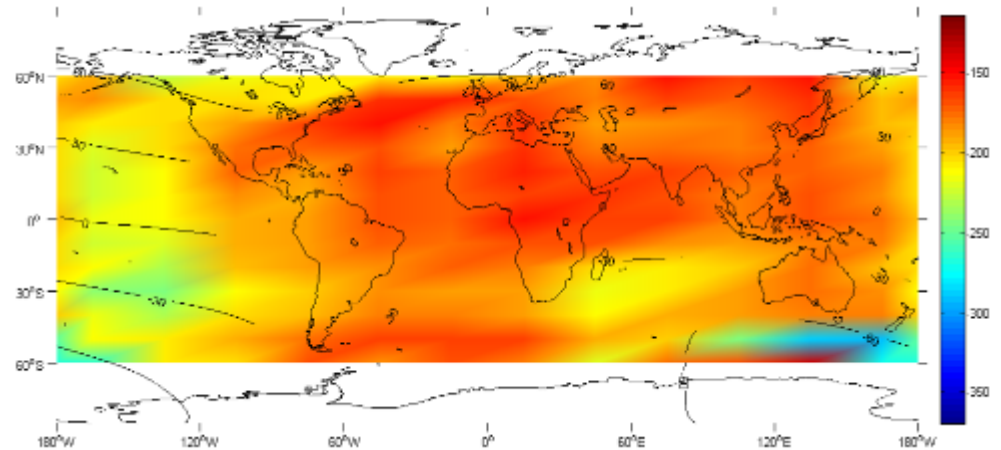


Prediction Capability Development

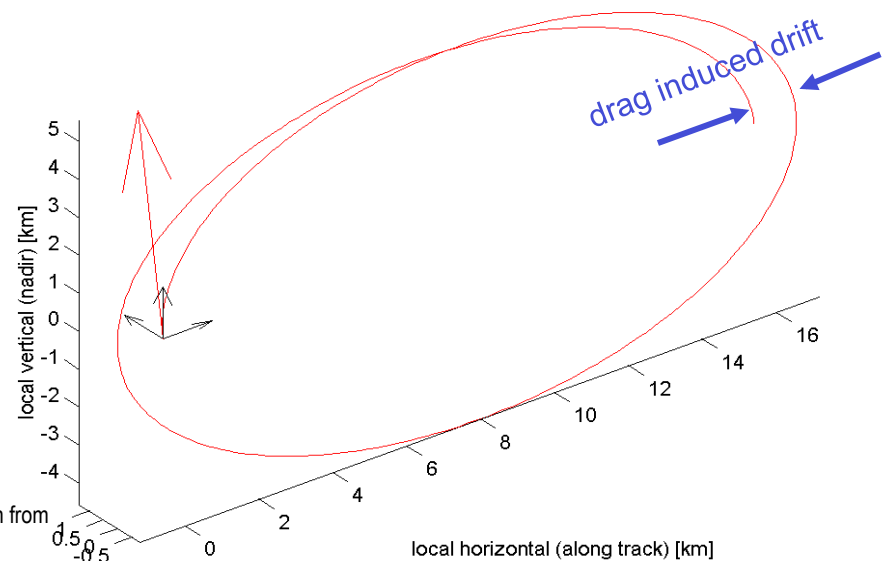
Improved Thermospheric Model and First-Ever Measurements

- Better Prediction and Near Real Time Observations
- Low cost to deploy
- Validation and improvement of models
 - HWM (NRL)
 - TIME-GCM (NOAA)
 - HASDM (AFRL/A9A)
- Improved drag coefficient modeling
- End goal – transfer to small satellite community interested in precise orbit operations in LEO

Storm response of CHAMP E/W winds



Relative Orbit of Two Separating Spacecraft



•Forbes et. Al. "Thermosphere density response to the 20-21 November 2003 solar and geomagnetic storm from CHAMP and GRACE accelerometer data", Journal of Geophysical Research, Vol. 111, June 2006

•European Space Agency Debris Tracking



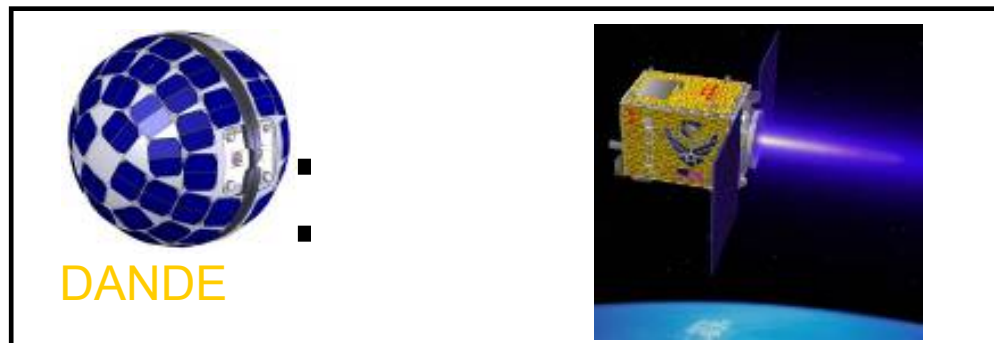
DANDE Project Benefits

"I am interested in studying the many areas of density variations which we currently have little or no knowledge about..."

-Bruce Bowman
Air Force Space Command



as



DANDE will measure density, composition, and wind along its orbit



Satellite Drag

Satellite drag measurements suffer from errors caused by

- Unknown acceleration contribution from in-track winds

$$\vec{a} = \frac{A_{sc} \cdot C_D \cdot \rho \cdot \|\vec{V}_w - \vec{V}_{sc}\|^2}{M_{sc}} (-\hat{V}_T)$$

$$-\vec{V}_T = (\vec{V}_w - \vec{V}_{sc})$$

- coefficient of drag accuracy

$$C_D = \frac{2dp}{M_{gas} V_T}$$

DANDE is designed to address these issues and provide acceleration, composition, and wind measurements simultaneously along with a well determined drag coefficient at ~350 km

CHALLENGING Minisatellite Payload

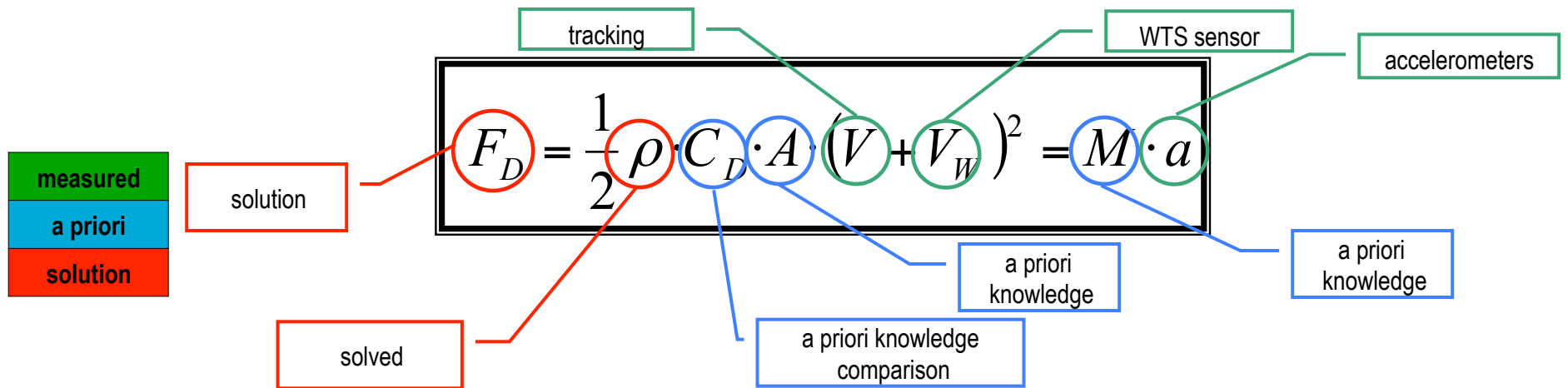
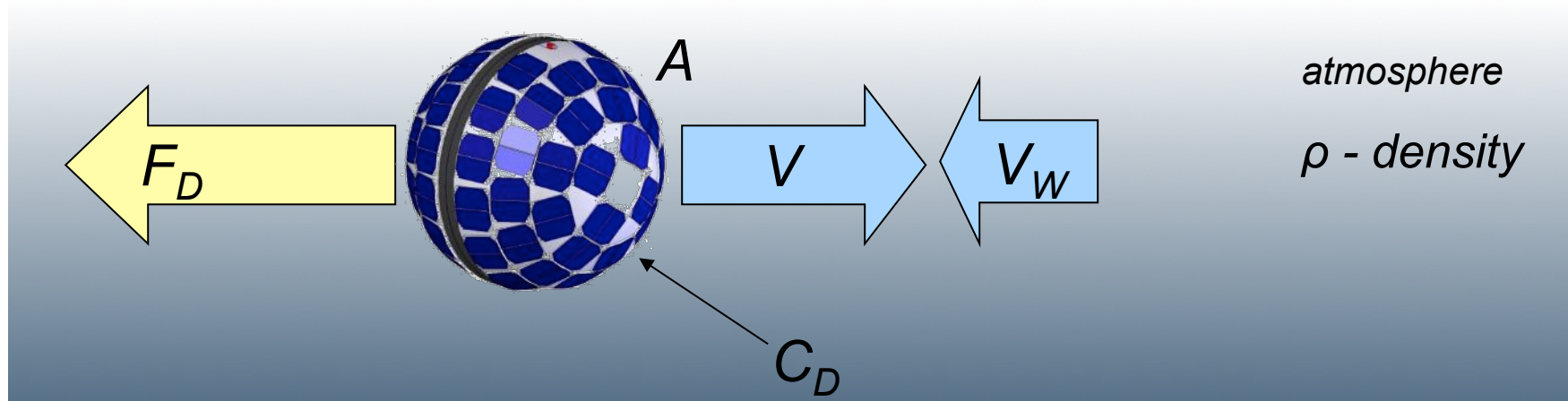


Starshine I





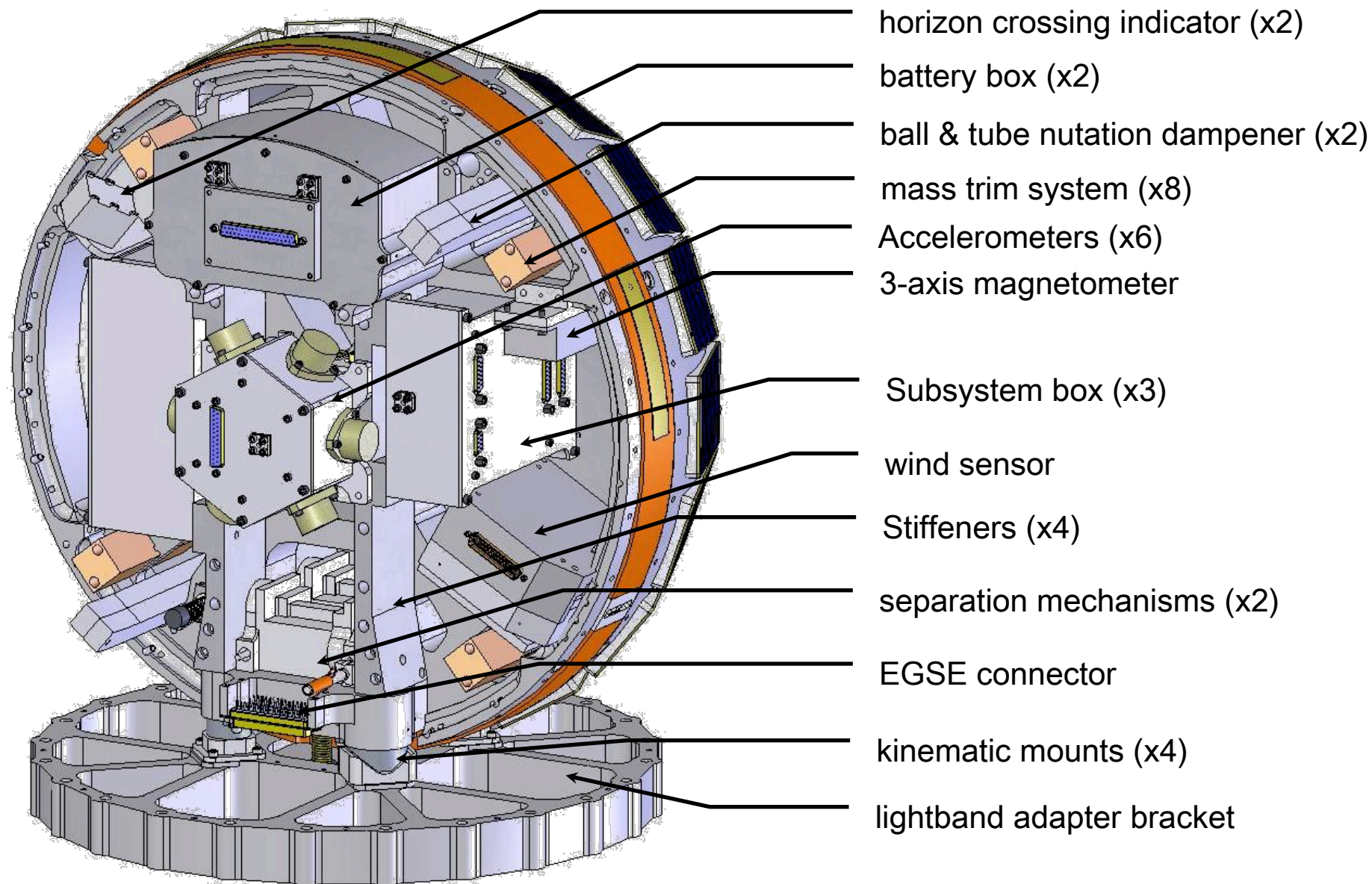
How Measurements are Made



- Identifying all components of the constituents of the drag equation.
- With a near-spherical shape, an a-priori physical drag coefficient may be calculated and a physical density can be obtained from the measurements

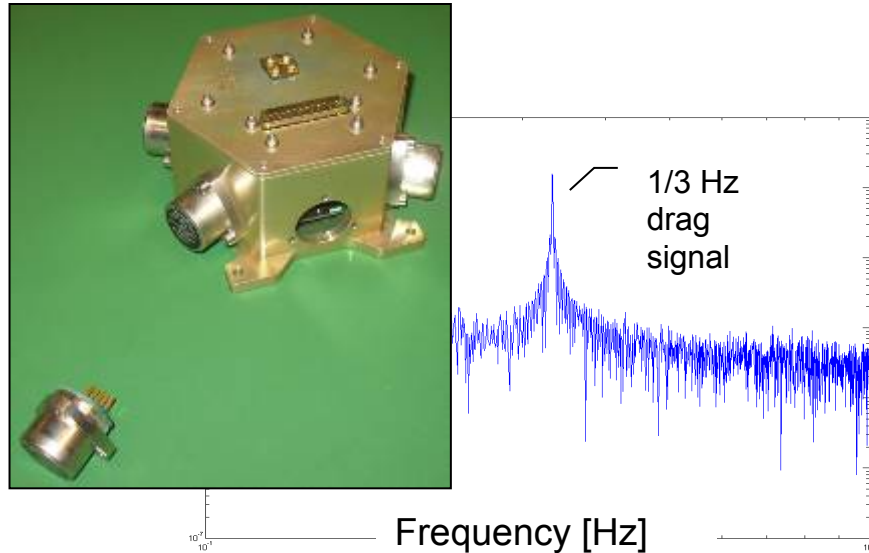


Inside of DANDE



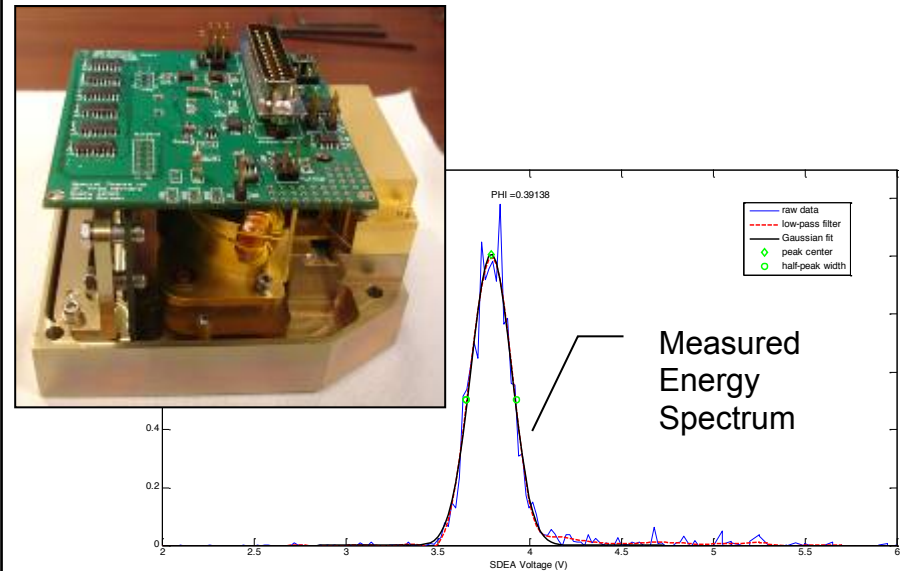


Dual Instrument Approach



Accelerometer Subsystem

As the spacecraft rotates, it modulates the drag signal to a known frequency. The unique accelerometer subsystem takes advantage of this by filtering the noise from unwanted frequencies and processing the data onboard from all accelerometers. This provides the sub- μg precision required for drag measurements.



Wind and Temperature Spectrometer

This instrument was invented by Dr. Fred Herrero at NASA Goddard and implemented for the DANDE platform by students at CU with NASA support. It is capable of measuring the wind direction and magnitude, atmospheric temperature, as well as the $\text{O}:\text{N}_2$ ratio.



DANDE's Future

