DANDE System Level Testing Background Document
UN5-SYS-903.0

DANDE

Drag and Atmospheric Neutral Density Explorer
Colorado Space Grant Consortium

Contact: Bruce Davis, Testing Lead
@colorado.edu
Cell:

The Drag and Atmospheric Neutral Density Explorer (DANDE) is a satellite being built by the Colorado Space Grant Consortium (CoSGC) for the 5th University Nanosat Competition (UN5) sponsored by the Air Force Research Laboratory (AFRL). Currently, the satellite is undergoing flight assembly and will present to the Air Force Research Lab for the Flight Competition Review (FCR) in January of 2009. DANDE is being considered among 10 other universities for a launch opportunity. **The DANDE team is looking for support for two upcoming tests: a system level vibration test and a thermal vacuum test on the separation subsystem. Perspective testing dates: Spring 2009**

Spacecraft:
DANDE is a spherical satellite built to measure atmospheric drag from an altitude of 350-200km. The spin stabilized satellite has two sensing packages: a mass spectrometer neutral density instrument which measures both atomic composition and wind directions, as well as an accelerometer suit with the ability to measure in track decelerations with a precision of 10 nano-g's. The DANDE team consists of 40 students with a core management team of 6 graduate students.

Physical Size
DANDE is a 50kg spacecraft and consists of two main parts: The space-sector-sphere which contains the flight instruments and supporting electronics. In addition, the space-sector-LAB is a separating bracket which interfaces the sphere to the launch vehicle. Upon launch vehicle separation, both the sphere and LAB components will eject as one unit. After a given time, the DANDE sphere sector will discard the LAB initiating the science mode.

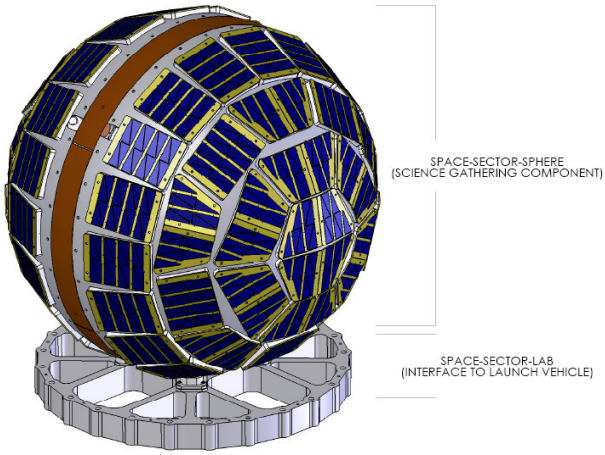

Figure 1: DANDE Spacecraft

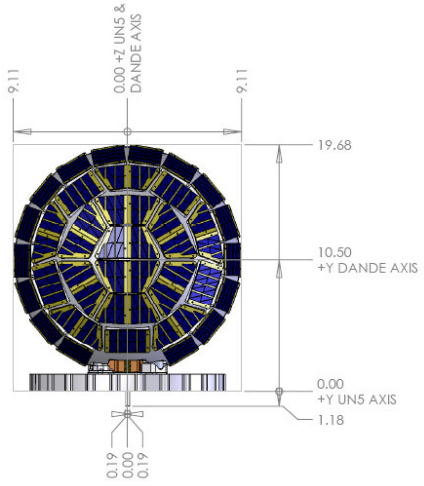

Figure 2: DANDE Physical Envelope (in)

Vibration Test:

The DANDE team completed the first full level vibration test at Ball Aerospace in March of 2008. The results were excellent in that the spacecraft structure survived the required structural loading for both a sine-burst and random profile. There was however a missed requirement in that the fundamental natural frequency of the spacecraft was 15Hz below our minimum requirement. The team has since enhanced aspects of the structure and is looking to re-perform **a natural frequency test** to verify that the structure now meets this requirement. In addition, the team would like to **perform the random and sine burst profiles in a single axis** to verify that the structural changes still meet the primary requirements. Additional tests in the Y direction is requested if the facility is available.

Test Outline:

	TEST	TYPE	PARAMETERS	FUNCTION
Campaign 1	1*	Sine Sweep, Z Direction	20 to 2000 Hz at 0.25g	Record Frequency Profile Z
	2	Sine Sweep, Y Direction	20 to 2000 Hz at 0.25g	Record Frequency Profile Y
	3	Sine Sweep, X Direction	20 to 2000 Hz at 0.25g	Record Frequency Profile X
	4	Sine Burst, X Direction	24g @ 25Hz, 5-cycle, -6dB	Structural Test (characterization)
	5	Sine Burst, X Direction	24g @ 25Hz, 5-cycle, -3dB	Structural Test (characterization)
	6	Sine Burst, X Direction	24g @ 25Hz, 5-cycle, 0dB	Structural Test (full level)
	7	Sine sweep, X Direction	20 to 2000 Hz at 0.25g	Verify Frequency Profile X
	8	Random, X Direction	Random Profile, -12dB, 30sec	Structural Test (characterization)
	9	Random, X Direction	Random Profile, -6dB, 30sec	Structural Test (characterization**)
	10	Random, X Direction	Random Profile, 0db, 120 sec	Structural Test (full level**)
	11	Sine sweep, X Direction	20 to 2000 Hz at 0.25g	Verify Frequency Profile X
Campaign 2***	12	Sine Sweep, Y Direction	20 to 2000 Hz at 0.25g	Record Frequency Profile Y
	13	Sine Burst, Y Direction	24g @ 25Hz, 5-cycle, -6dB	Structural Test (characterization)
	14	Sine Burst, Y Direction	24g @ 25Hz, 5-cycle, -3dB	Structural Test (characterization)
	15	Sine Burst, Y Direction	24g @ 25Hz, 5-cycle, 0dB	Structural Test (full level)
	16	Sine sweep, Y Direction	20 to 2000 Hz at 0.25g	Verify Frequency Profile Y
	17	Random, Y Direction	Random Profile, -12dB, 30sec	Structural Test (characterization)
	18	Random, Y Direction	Random Profile, -6dB, 30sec	Structural Test (characterization**)
	19	Random, Y Direction	Random Profile, 0db, 120 sec	Structural Test (full level**)
	20	Sine sweep, Y Direction	20 to 2000 Hz at 0.25g	Verify Frequency Profile Y

*Vibration table in the vertical configuration, **Notching induced during these random profiles,
***Additional testing not required but beneficial to generate data for competition review

Figure removed

Figure 3, UN5 random vibration test specification

Spacecraft Requirements:

The test will be performed on flight hardware. Warning and abort limits to be set ensuring that spacecraft does not exceed structural limits of 40gs. Notching will occur during the random profile and scaling during the sine burst to ensure limits are met. This spacecraft will be undergo NASA ESD certifications as well as contamination & control measures to ensure the safety to the flight hardware.

Data Sensors:

Sensor placement TBD. To be provided by vibration facility

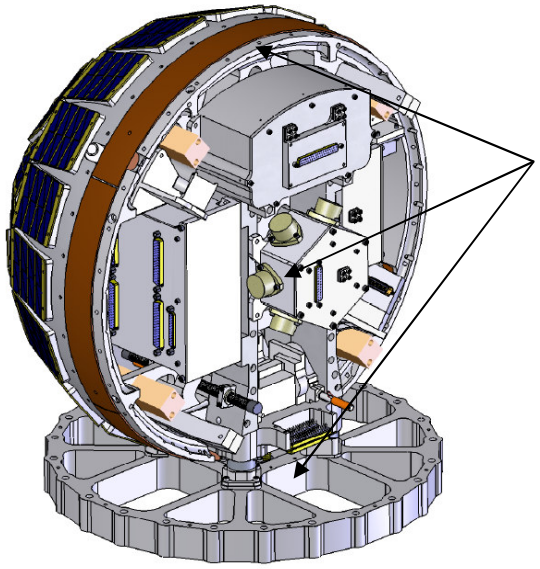

Figure 4, DANDE Sensory Placements

Table Setup:

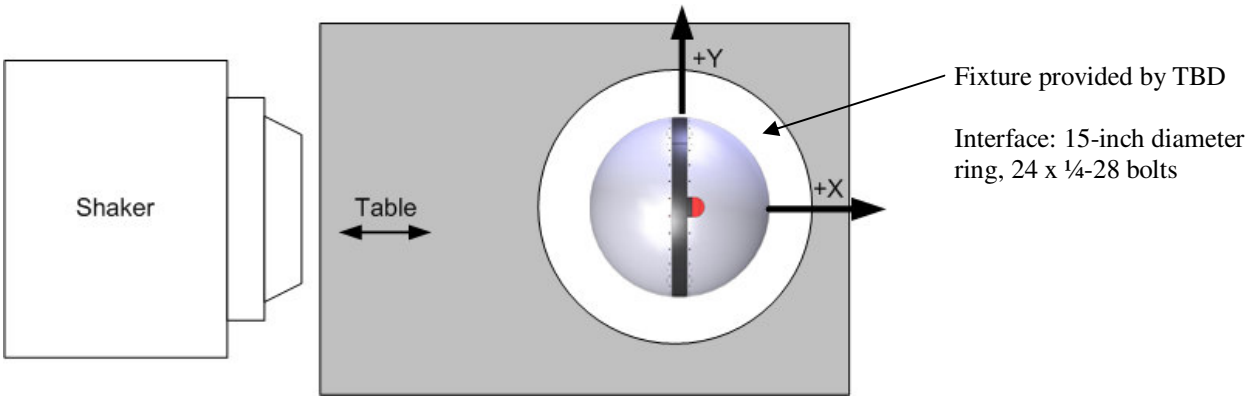

Figure 5, DANDE Vibration Table Setup, X-Axis

Thermal Vacuum Test:

The DANDE team designed the separation system which consists of two SpaceDev (formerly Starsys) low-show release mechanisms and a CU developed 4-point kinematic mounting system and electronic boxes. The system has passed vibration and microgravity testing and **we are looking to perform separation tests in vacuum at three steady state temperatures**. The test will be used to observe the environmental characteristics of the separations system used under steady state operating conditions. Specifically, testing cold, hot, and nominal conditions of the separation system will be conducted while using the flight separation mechanisms and the EDU superstructure. The spacecraft will not be a need to perform aliveness test between tests, or abide by NASA ESD and cleanliness standards.

Bake Out Requirements to be discussed

Test Outline:

PHASE 1 (Cold Separation Test, Battery Box Thermal Balance Characterization)

1. Install/verify temperature sensors on DANDE EDU structure
    a. 4 thermal couples on: mechanism, paraffin actuator, release bolt, LAB
    b. 1 on battery box
    c. 1 on EPS box
2. Install DANDE EDU into chamber with battery box and EPS
3. Pump environmental chamber to 10E-5 (torr) and 0°C
4. Fire separation system
5. Perform thermal balance test
6. Bring chamber back to ambient conditions
7. Take out DANDE EDU and reset device

PHASE 2 (Hot Separation Test)

1. Install/verify temperature sensors on DANDE EDU structure
    a. 4 thermal couples on: mechanism, paraffin actuator, release bolt, LAB
    b. 1 on battery box
    c. 1 on EPS box
2. Install DANDE EDU into chamber with battery box and EPS
3. Pump environmental chamber to 10E-5 (torr) and 60°C
4. Fire separation system
5. Bring chamber back to ambient conditions
6. Take out DANDE EDU and reset device

PHASE 3 (Nominal Separation Test)

1. Install/verify temperature sensors on DANDE EDU structure
    a. 4 thermal couples on: mechanism, paraffin actuator, release bolt, LAB
    b. 1 on battery box
    c. 1 on EPS box
2. Install DANDE EDU into chamber with battery box and EPS
3. Pump environmental chamber to 10E-5 (torr) and 15°C
4. Fire separation system
5. Bring chamber back to ambient conditions
6. Take out DANDE EDU and reset device

Chamber Requirements:

Figure 6, Thermal Vacuum Requirements

	Temperature (°C)	Pressure (torr)
Cold	0	<10-5
Hot	60	<10-5
Nominal	15	<10-5

Test Setup:

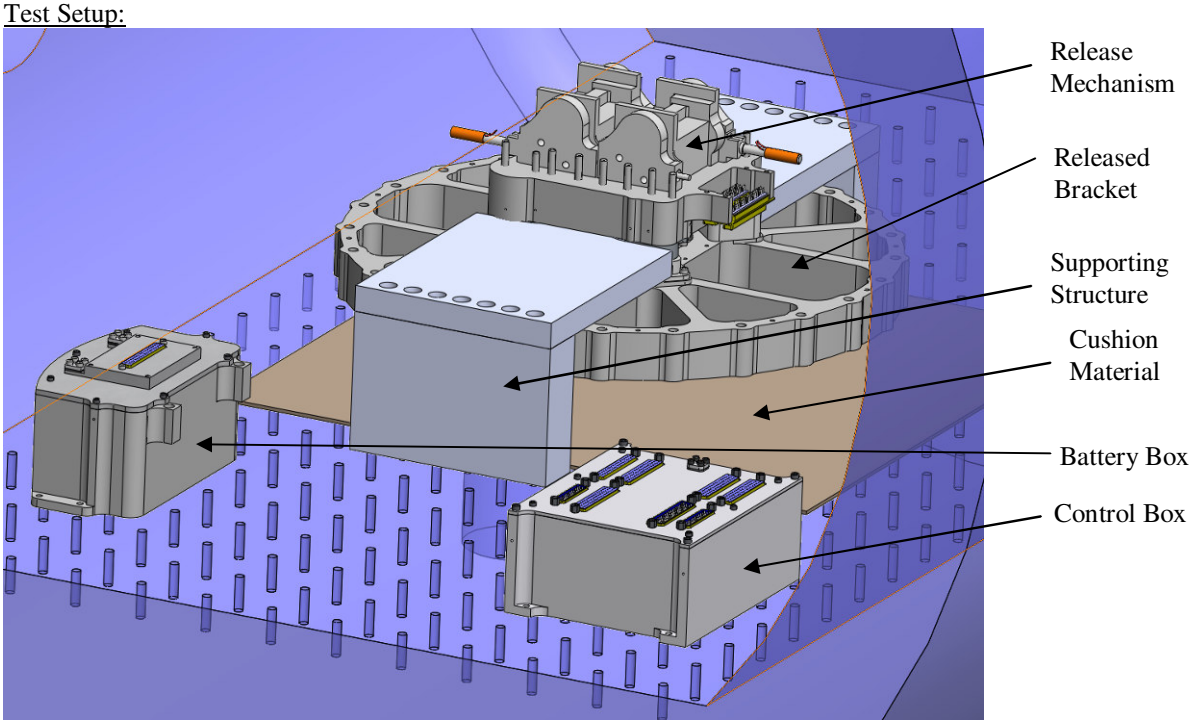

Figure 7, DANDE TVAC Chamber Setup, (undeployed)

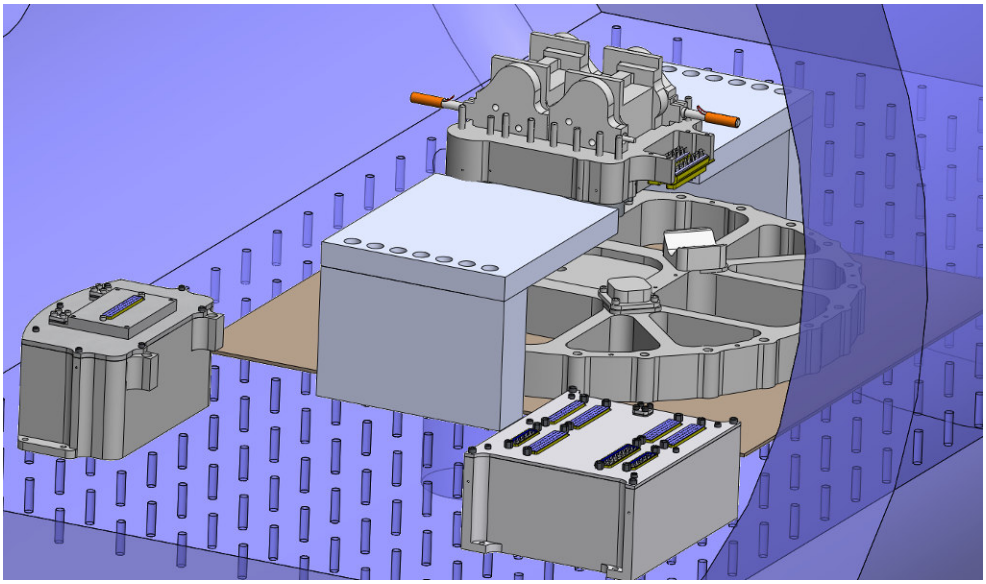

Figure 8, DANDE TVAC Chamber Setup, (deployed)

Cleanliness Requirements:
To be determined

Data Sensors (thermal):
To be provided by chamber facility

- DATA 1: Equivalent TVAC chamber
- DATA 2: EPS BOX
- DATA 3: Battery Box
- DATA 4: Paraffin Actuator thermal coupler
- DATA 5: Release bolt thermal coupler
- DATA 6: Separation thermal coupler
- DATA 7: Release structure thermal coupler