

Vibrational & Thermal Analysis of Space Instrumentation (CubeSat/MSI)

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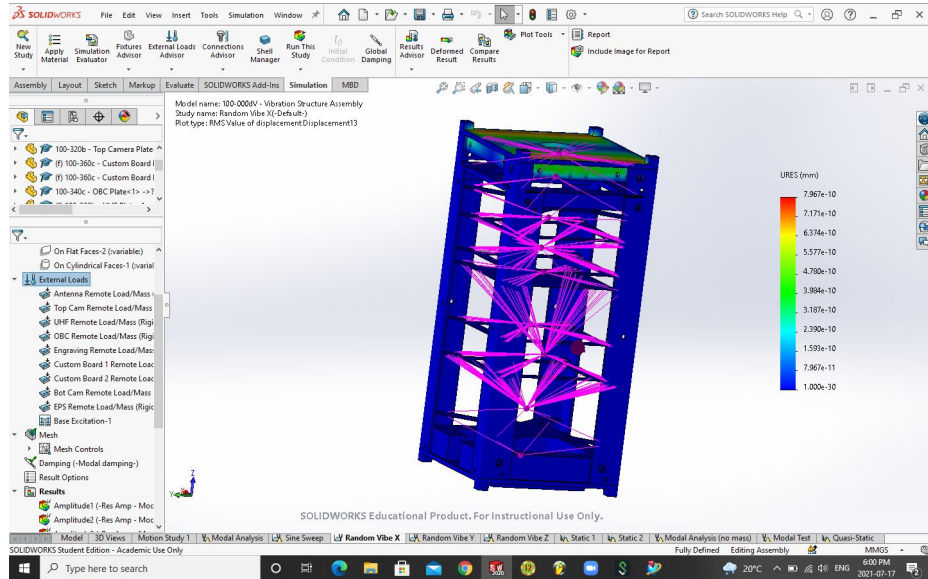
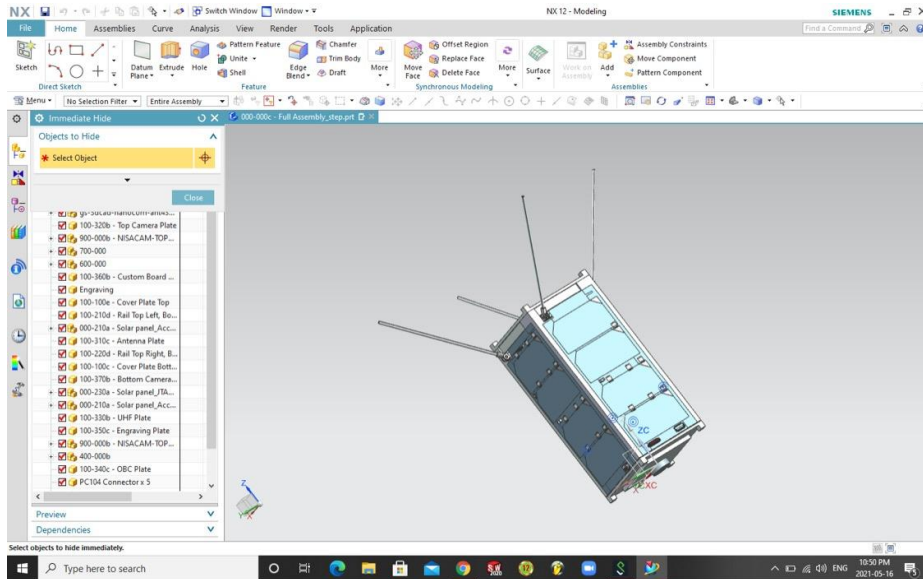
USRI 2021 - Final Research Presentation

August 20, 2021

Supervisor: Dr. Jayshri Sabarinathan

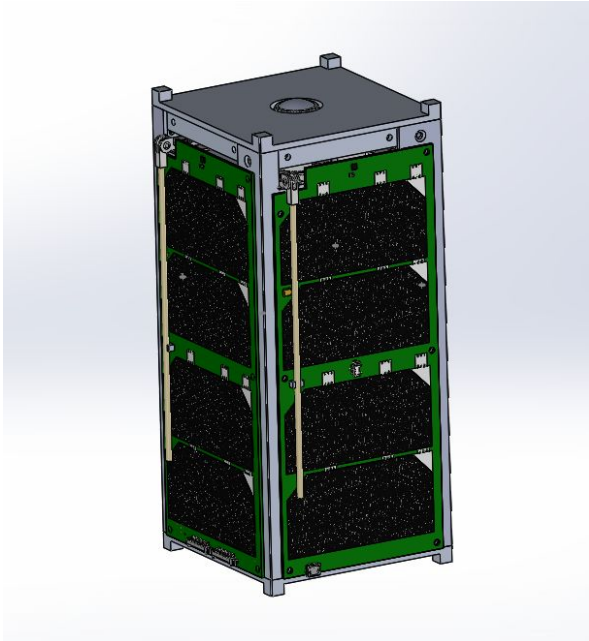
Vibration & Thermal Considerations in Space

- Challenges of the space environment
- Why vibration simulations and testing is important
- Why thermal analysis and testing is important



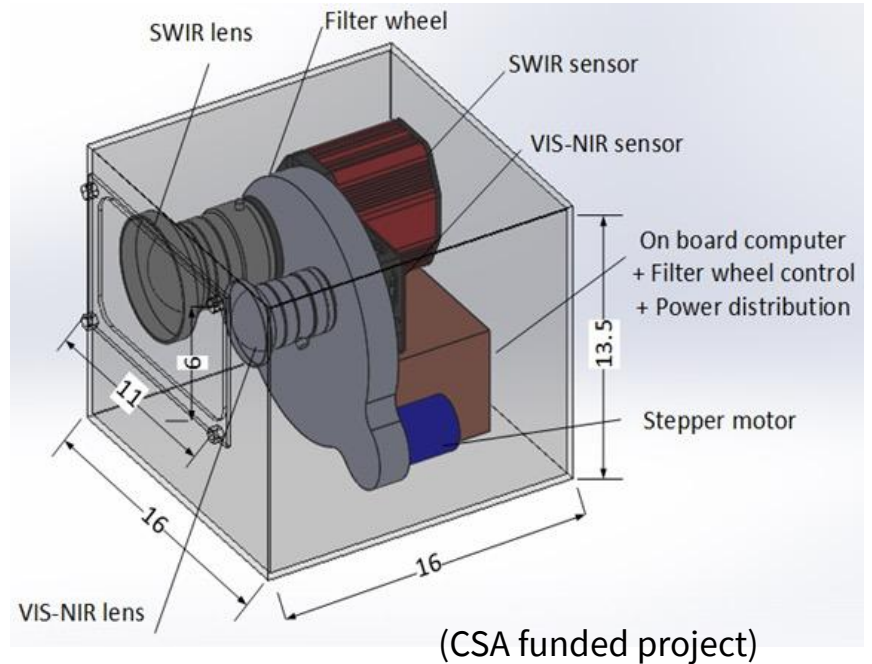
About the CubeSat and IVS-MSI

What is a CubeSat?



(CSA funded project)

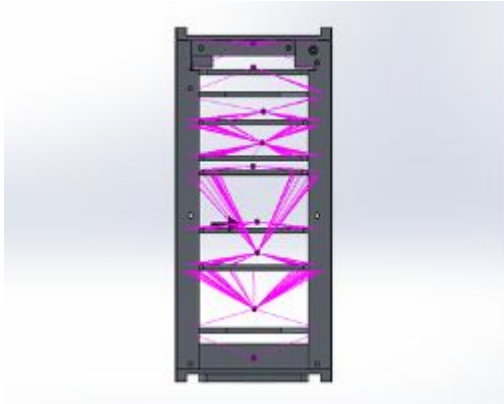
What is an IVS-MSI?



(CSA funded project)

Vibration Simulation Setup

- Why vibration simulations are important
- Setup - Solidworks
 - Simplified model with only structural components, other components simplified to point masses
 - Tested both soft-stow and hard-mount configurations



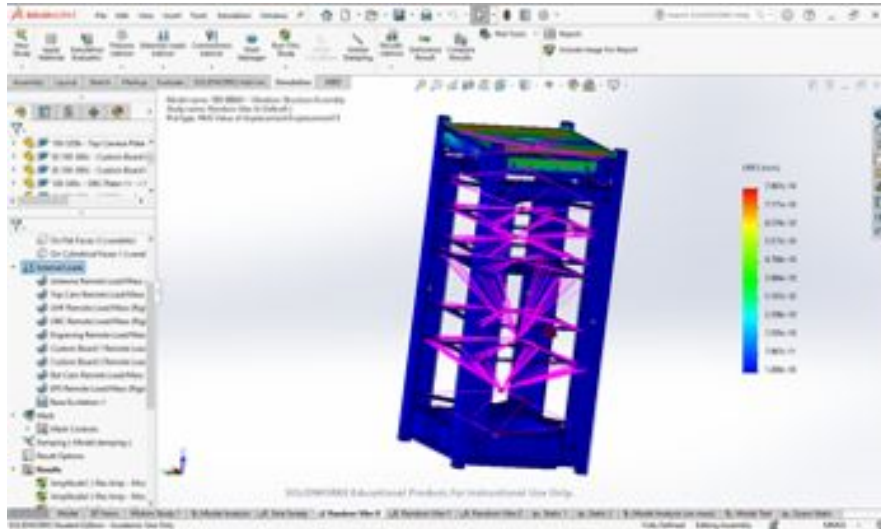
Soft-Stow Test Profile	
Frequency (Hz)	ASD (g^2/Hz)
20	4.000E-02
25	4.000E-02
31.5	4.000E-02
40	4.000E-02
50	4.000E-02
63	4.490E-02
80	5.062E-02
100	5.660E-02
125	6.200E-02
160	6.200E-02
200	6.200E-02
250	5.588E-02
315	4.102E-02
400	2.998E-02
500	2.236E-02
630	1.651E-02
800	1.206E-02
1000	9.000E-03
1250	6.034E-03
1600	3.878E-03
2000	2.600E-03
grms	5.76
Duration (sec)	60

Hard-Mount Test Profile	
Frequency (Hz)	ASD (g^2/Hz)
20	5.700E-02
153	5.700E-02
190	9.900E-02
250	9.900E-02
750	5.500E-02
2000	1.800E-02
grms	9.47
Duration (sec)	60

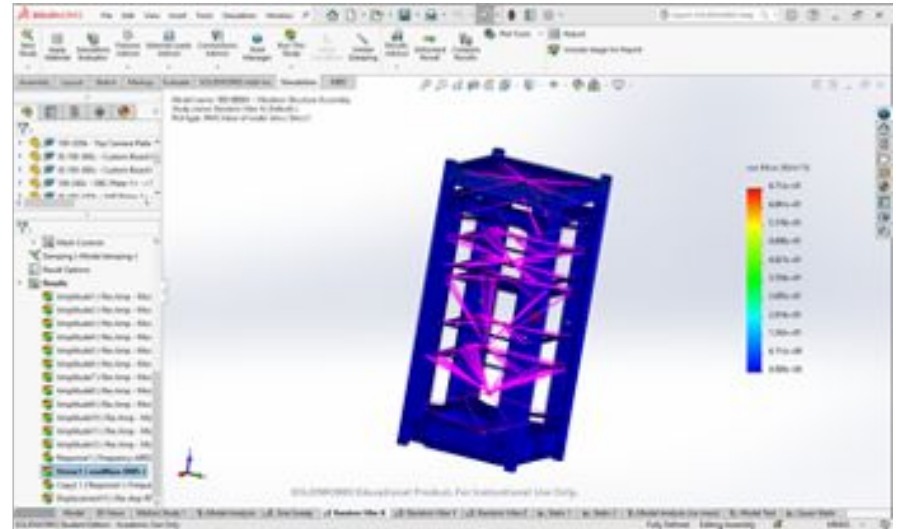
Vibration Simulation Results

Soft Stow Configuration

X displacement



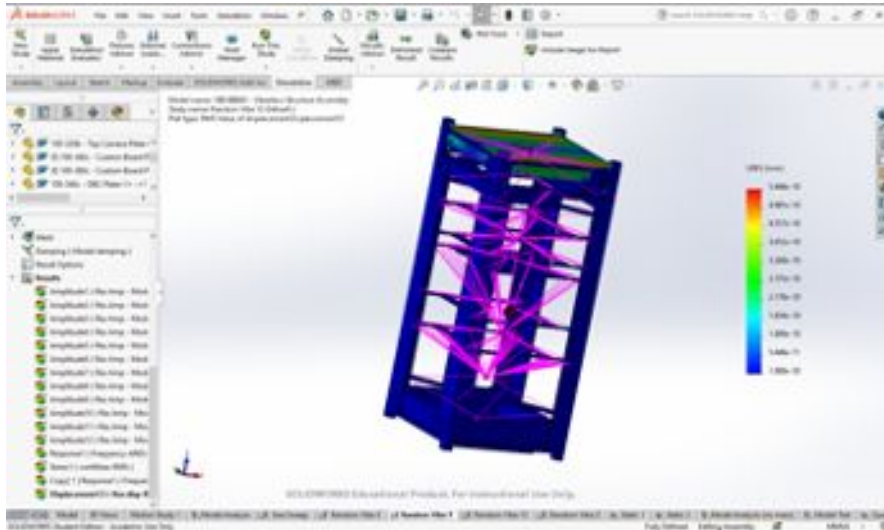
X stress



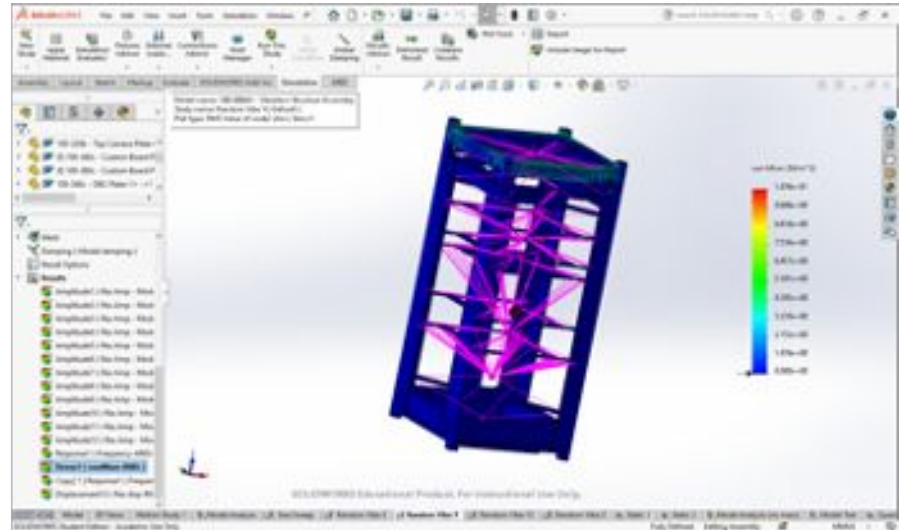
Vibration Simulation Results

Soft Stow Configuration

Y displacement



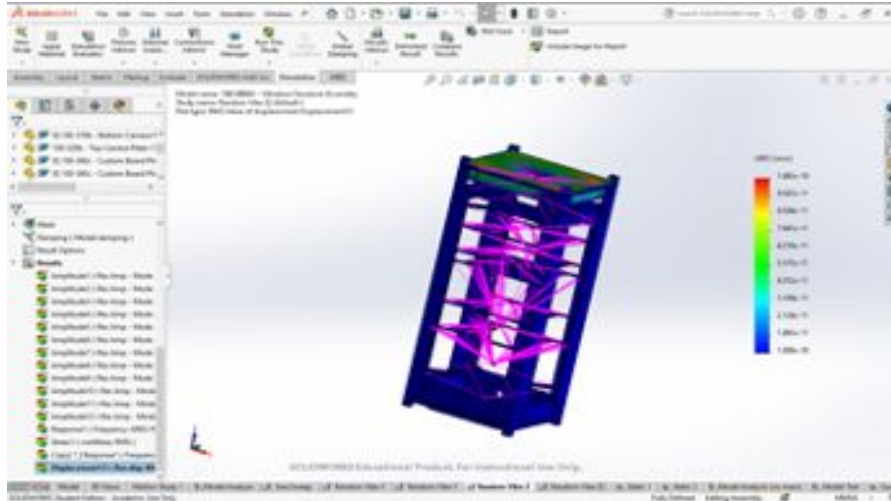
Y stress



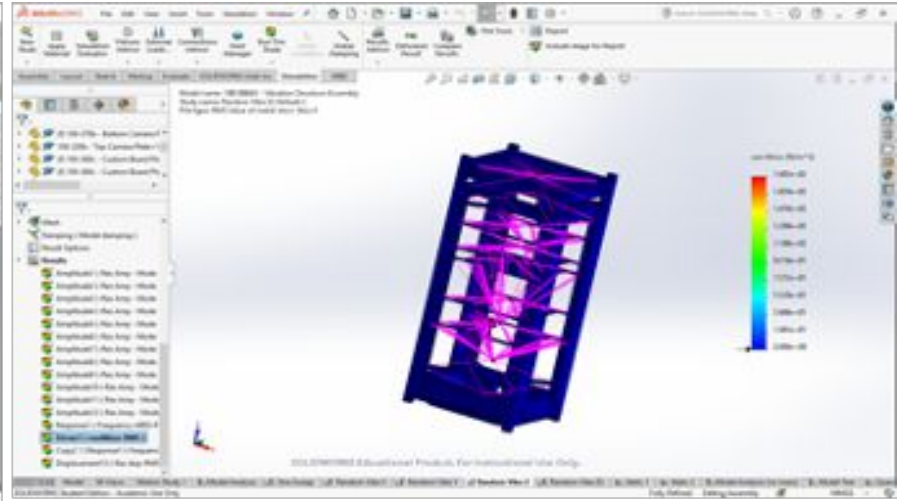
Vibration Simulation Results

Soft Stow Configuration

Z displacement



Z stress



Simulations demonstrate that the CubeSat is structurally safe

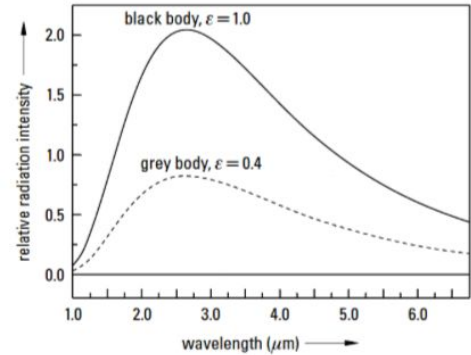
Thermal Analysis Setup

- Why thermal analysis is important
- Setup - Siemens NX
 - Simplified model with only structural components and some other thermally important components



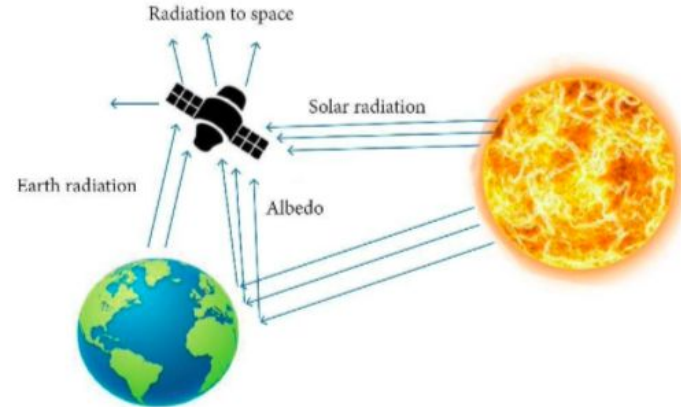
Thermal Analysis Setup

- Lots of thermal property data needed including:
 - Temperature limits
 - Material properties
 - Internal heat generation
 - External heat loads
 - Radiation



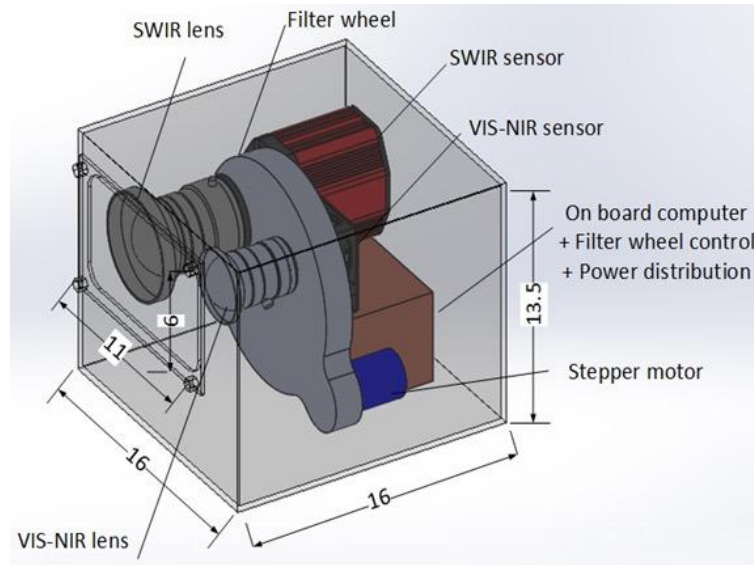
$$T_{SC} = \sqrt[4]{\frac{\dot{Q}_{solar} + \dot{Q}_{albedo} + P_{dis} + A_{Earth} \epsilon_{Earth} \sigma T_{Earth}^4 + (A_{radiator} \epsilon_{radiator} + A_{deepspace} \epsilon_{deepspace av}) \sigma T_{Space}^4}{A_{Earth} \epsilon_{Earth} \sigma + A_{radiator} \epsilon_{radiator} \sigma + A_{deepspace} \epsilon_{deepspace av} \sigma}}$$

Subsystem	Critical Component	Operational Temperatures (°C)		Survival Temperatures (°C)	
		Min	Max	Min	Max
Bus	UHF Transceiver Antenna	-30	60	-50	80
	Solar Cells	-120	150	-170	150
	S-Band Patch Antenna	TBD	TBD	TBD	TBD
	Sun Sensors (fine)	-20	70	TBD	TBD
ECU	Lithium Ion NCR18650B Batteries	0 (charging)	45 (charging)	-40	70
		-20 (discharging)	60 (discharging)	-40	70
	CPU	0	90	-55	155
	OBC	-40	85	TBD	TBD
	S-Band Transmitter	-30	60	-50	80
ADCS	Deployment Switch	-40	120	-40	120
	Magnetometer	-40	85	-40	85
	Magnetorquers X&Y	-20	70	TBD	TBD
	Magnetorquer Z	-20	70	TBD	TBD
	Reaction Wheels	-10	70	TBD	TBD
Payload	NanoCam	0	60	-40	85



IVS-MSI Vibrational & Thermal Analysis

- Vibration simulations will be very similar in method and procedure
- Thermal analysis will be very similar in method and procedure



(CSA funded project)

Next Steps

- Based on design changes for the CubeSat, the vibration simulation needs to be modified and simulated again
- Thermal analysis for CubeSat will be completed by end of October 2021
- IVS-MSI project will similarly have vibration and thermal simulations completed

Thank You

Special thanks go out to:

- Western Undergraduate Student Research Internship program
- Western Engineering
- Canadian Space Agency
- Nanoracks
- Dr. Jayshri Sabarinathan and her research group
- Alexis Pascual and Nick Mitchell



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