
SEE YOU SPACE COWBOY ...

Welcome to Small Satellite Workshop 2025!

The University of Texas at Dallas

July 7 – 9, 2025

Context Reminder: Small satellites in LEO

- Size of spacecraft
  - Small satellite (1 ~ 100 kg)
  - cf. space shuttle, James Webb
- Altitude
  - LEO (Low Earth Orbit): 400 ~ 600 KM
  - cf. MEO, GEO, Deep space
- Purpose
  - Research and exploration
  - cf. satellite constellation for global broadband, military / surveillance, deep space exploration

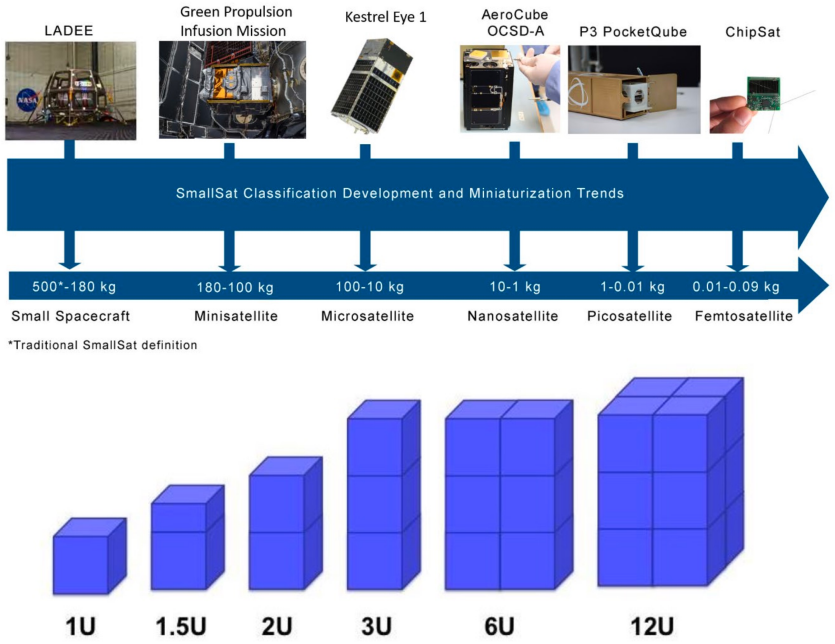

Figure 1.2: CubeSats are a class of nano- and microsatellites that use a standard size and form factor. Credit: NASA.

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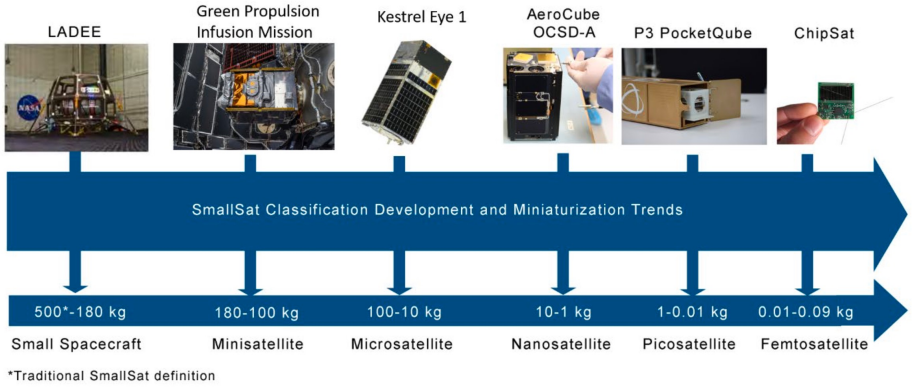
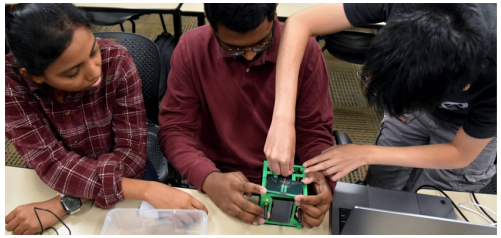


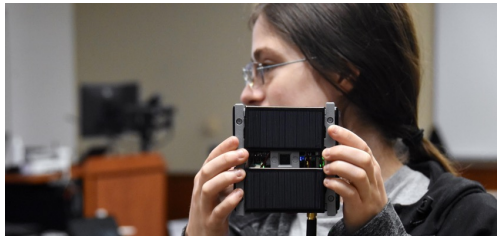
CubeSatSim (CSS) By AMSAT (@Alan Johnston)

- Working solar panels and rechargeable batteries
- Multi-channel voltage, current, and temperature telemetry
  - Transmitted via UHF band
  - Decoded using FoxTelem software
- Integrated “Low Pass Filter”
- Payload microcontroller Raspberry Pi Pico + sensors (extensible)
- Tape measure monopole, dipole, or SMA antenna

The ~~First~~ Second Space Workshop @ UTD

- 2nd Small Satellite Workshop
  - In collaboration with CS + Material Science
- Trying to be casual and fun
  - Let's be CREATIVE!
- But we put a lot of efforts in it!
  - Schedule is packed with a lot of exciting activities!
- Has an ambitious plan forward!
  - Your input matters!



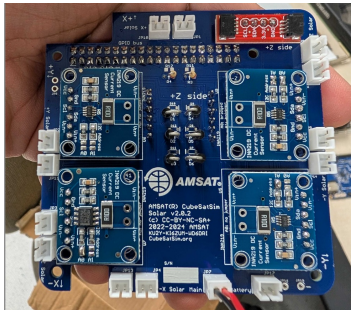


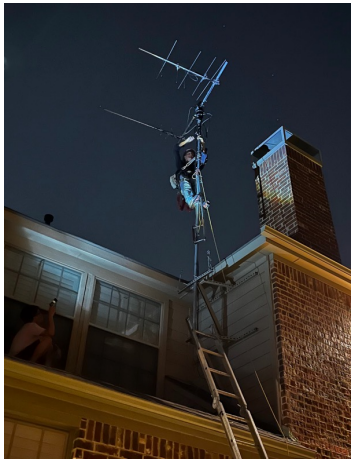
What is NEW This Year?

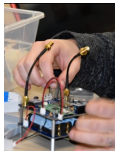
- New CubeSatSim (CubeSat Model)
  - v1.3.2 → v2.0
  - Kudos to Alan Johnston!

- New and elaborated labs
  - Four labs
  - New CubeSat, new labs!

- Access to the ground station





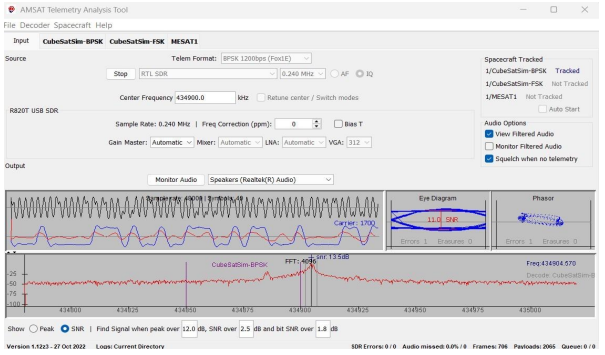


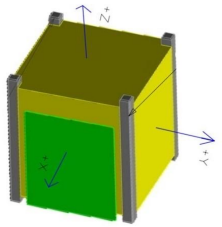
CubeSatSim (CSS) ~~v1.3.2~~ v 2.0.2

- New FM transceiver module
  - For better frequency stability and simple command and control receiver to change telemetry mode
- More Raspberry Pi Pico micro controller
- Easily connect additional sensors for the Pico
  - Using the Qwiic connector system https://www.sparkfun.com/qwiic
- Can be modified to fly as a balloon payload
- With 500mW FM output for SSTV, APRS, or CW transmissions with software support on Pico for a serial GPS module
- Redesigned for blue INA219 voltage and current sensors
- Battery board now has integrated voltage and current sensor
- Simpler electrical power system

Hands-on Labs Upgraded/Renewed

- Lab1: Finish CubeSat + Ground station building
  - Your first communication!
- Lab2: Telemetry analysis for CubeSat status monitoring
- Lab3 (optional): CubeSat status monitoring
- Lab4: CubeSat under harsh environment!

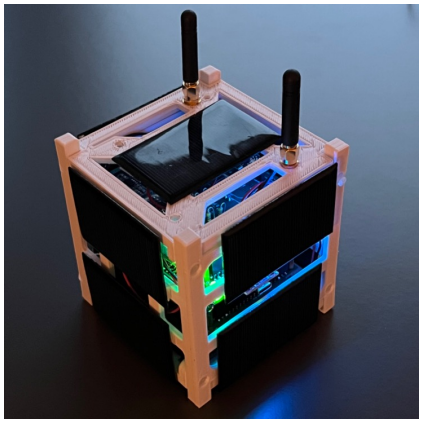




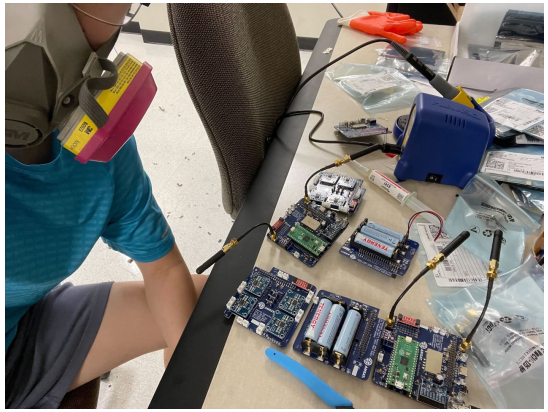
In a Closer Look

- Small satellite (CubeSat) in low-earth-orbit (LEO)
- Cyber (digital) and physical system for small space craft
- Communication between ground station and small satellite
- Physical and structural considerations

You will Build a CubeSat Model

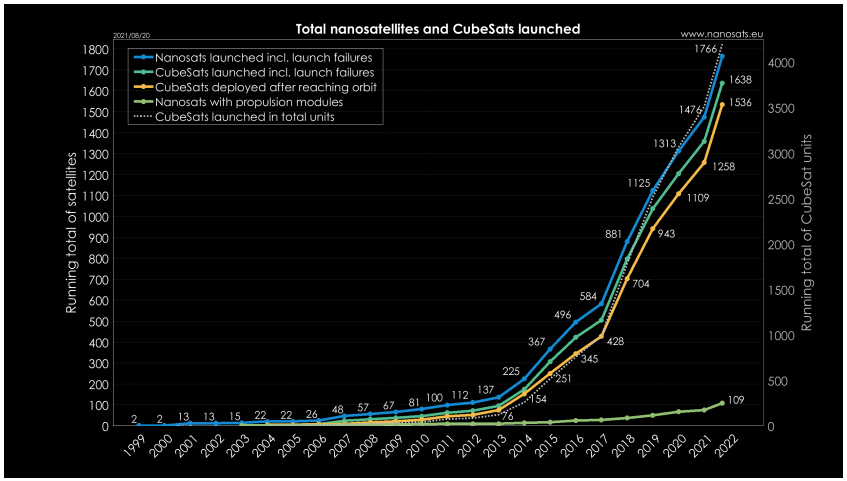


- Build your own satellite
  - Group 3 ~ 4 students
  - Although it is a half-way done already
- AMSAT CubeSatSim v2.0
  - Run on solar plane and batteries
  - Transmit telemetry via UHF band
  - Your own ground stations
- Explore what can you do with it
  - Be creative!

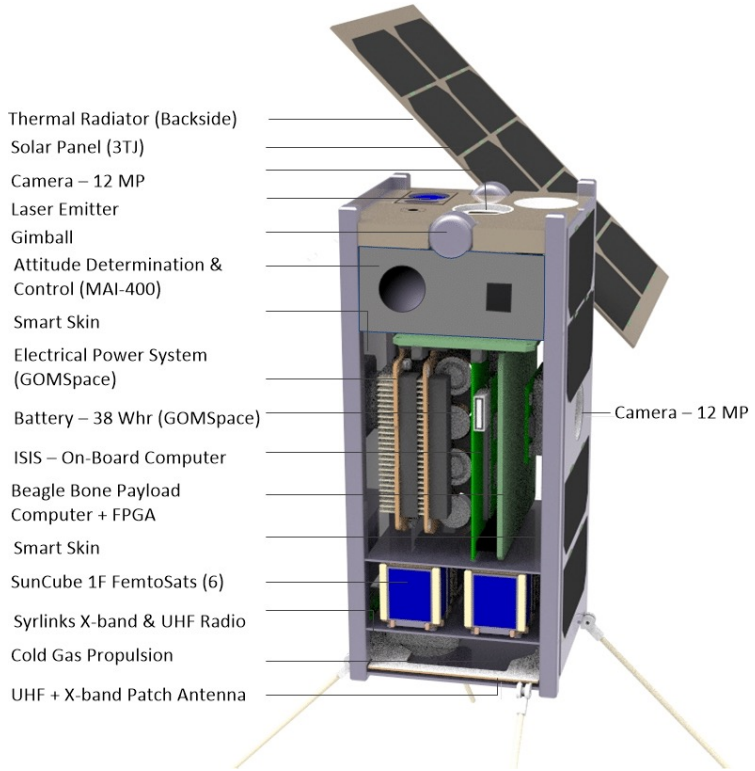


New Space Era

- Two Enablers
  - Re-usable booter technologies
  - Ever-shrinking size of techonologies



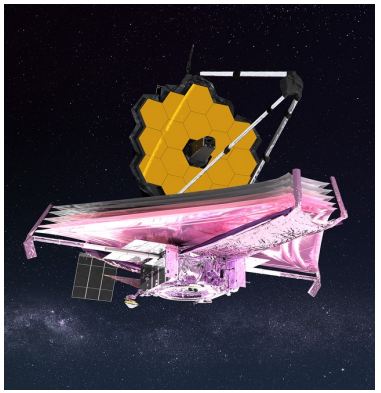
Total count of CubeSats launched as of August 2021

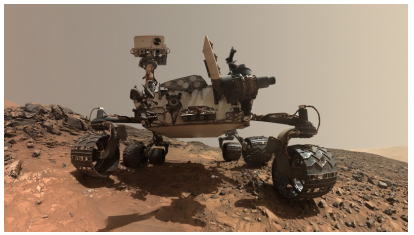


Standard 2U CubeSat
(1U: 10 cm × 10 cm × 11.35 cm)

"Traditional" Space Electronics

- Confirmed by a rigorous process
  - E.g., Rad-hardening, ruggedized components





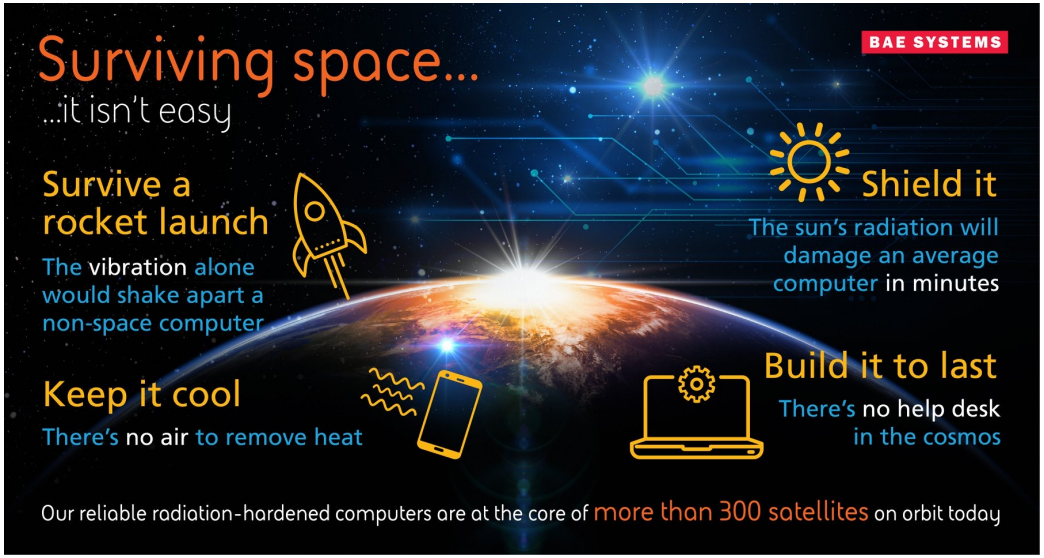
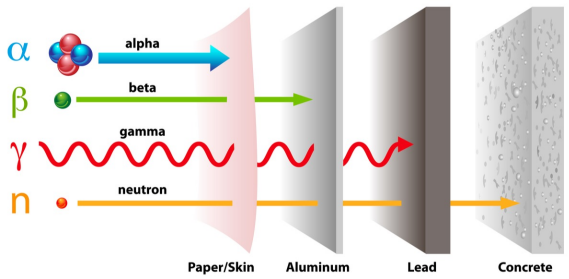


Image source: BAE systems



The Game is Turning into a New Stage

- $2M to put your CubeSat on LEO
- Big business for sweeping space debris

Space + Cyber Security

This is historical material “frozen in time”. The website is no longer updated and links to external websites and some internal pages may not work.

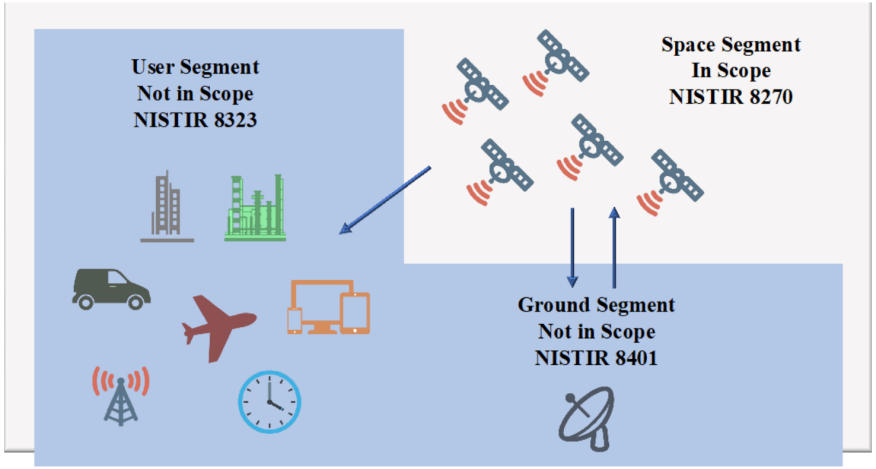
PRESIDENTIAL MEMORANDA

Memorandum on Space Policy Directive-5—Cybersecurity Principles for Space Systems

NATIONAL SECURITY & DEFENSE

Issued on: September 4, 2020

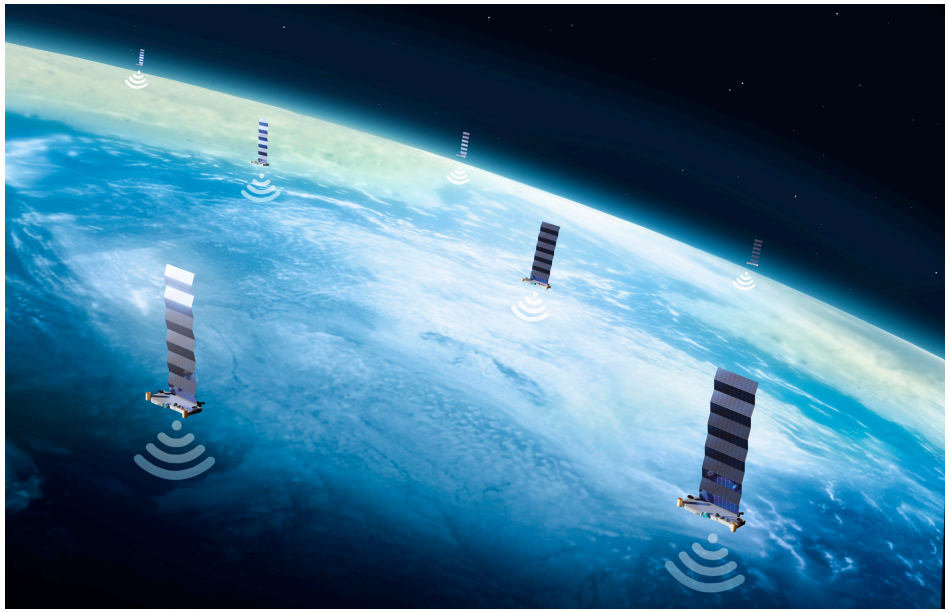
memorandum on space policy direct 5

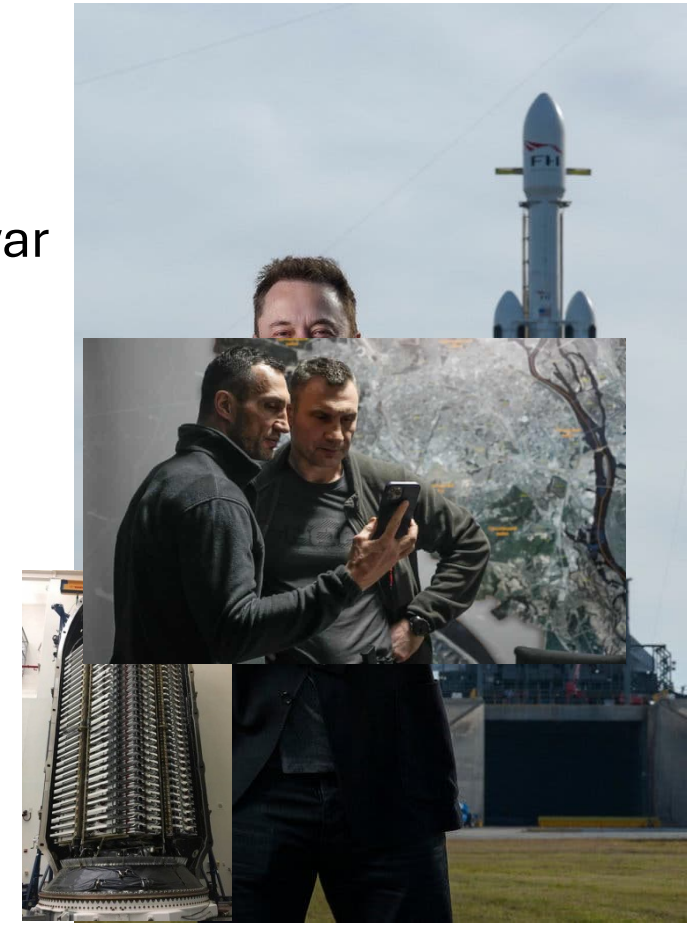


- NIST-IR 8270: Introduction to Cybersecurity for Commercial Satellite Operations
- NIST-IR 8323: Foundational PNT Profile: Applying the Cybersecurity Framework for the Responsible Use of Positioning, Navigation, and Timing (PNT) Services
- NIST-IR 8401:Satellite Ground Segment: Applying the Cybersecurity Framework to Satellite Command and Control
- NIST-IR 8441: Cybersecurity Framework Profile for Hybrid Satellite Networks (HSN)

Starlink@Ukraine

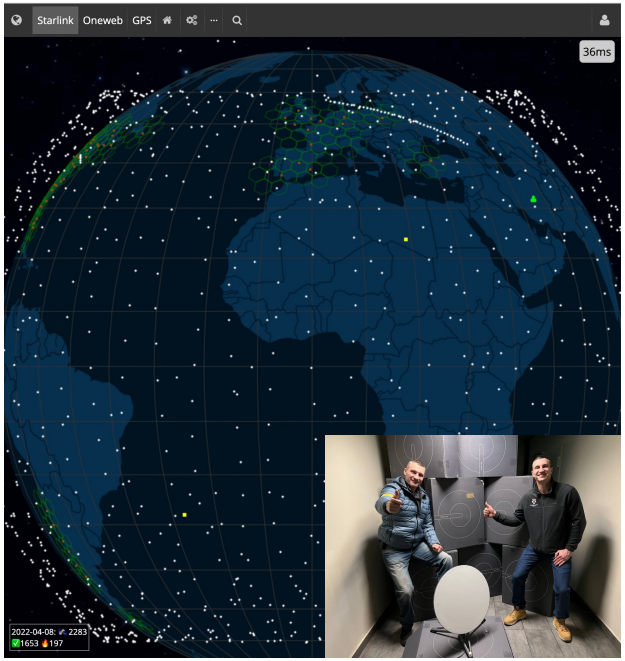
- People are still connected amongst war





Starlink@Ukraine

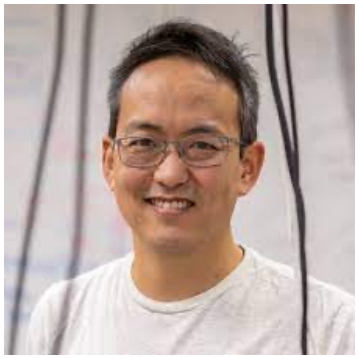
- Starlink aims to be a world-wide Internet ISP
  - Constellation with ~2000 on LEO (Low Earth Orbit)
  - ~3000 more on their ways
- Ukraine has been winning a propaganda campaign
- If you were Putin, what would you do?



Starlink satellite map - https://satellitemap.space/

Who are Behind This?

- Inter-disciplinary effort at UTD
  - CS, Material Science (DHs!)
  - Cybersecurity, Algorithm design, Material for harsh and extreme conditions



Dr. Kangkook Jee

Dr. Ovidiu Daescu

Dr. Manuel Quevedo-Lopez

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- Inter-disciplinary effort at UTD
  - CS, Material Science (DHs!)
  - Cybersecurity, Algorithm design, Material for harsh and extreme conditions

Dr. Robert Baumann

Agastya Bose

Timothy Sweet

Who Are You?

- Student demographics

Major	Count
Biomedical Engineering	1
Biomedical Engineering/ Systems Engineering and Management	1
Computer Engineering	2
Computer Science	7
Computer Science/ Mathematics	1
Electrical Engineering	5
Mechanical Engineering	1
MSEN	1
Software Engineering	1
Total	**20**

Program	Count
Bachelor	13
Bachelor, Master	1
Master	3
Ph.D.	3
Total	**20**

Who Are You?

- Student demographics

Program	Female	Male	Total
Biomedical Engineering		1	1
Biomedical Engineering, Systems Engineering and Management	1		1
Computer Engineering	1	1	2
Computer Science	2	4	6
Computer Science + Mathematics		1	1
Electrical Engineering	2	3	5
Mechanical Engineering	1		1
MSEN		1	1
Software Engineering	1		1
Total	**8**	**12**	**20**

Major	Bachelor	Bachelor/ Master	Master	Ph.D.	Total
Biomedical Engineering				1	1
Biomedical Engineering, Systems Engineering and Management		1			1
Computer Engineering	1		1		2
Computer Science	5		2		7
Computer Science + Mathematics	1				1
Electrical Engineering	4			1	5
Mechanical Engineering	1				1
MSEN				1	1
Software Engineering	1				1
Total	**13**	**1**	**3**	**3**	**20**

One International participant!

Day 1 Schedule

Time	Sessions	Description
Day 1: Monday, July 9, 2025, **Location:** ECSS 2.201		
09:00 – 10:30 AM	Session 1	Opening remark and workshop logistics (8:30 ~ 9:00 AM) • Dr. Ovidiu Daescu & Dr. Kangkook Jee My Space Journey (Dr. Kangkook Jee) • How has a system security geek become a space enthusiast? • A brief story on Dr. Kangkook Jee's space exploration
10:30 – 11:00 AM	Break	
11:00 – 12:30 AM	Session 2	Introduction to small satellite in LEO (Dr. Kangkook Jee) • Introduction to basic concepts • Small satellite operational lifecycles Small satellite components (Dr. Kangkook Jee) • CubeSat design and specification overview • Basic components for small satellite (CubeSat)
12:30 – 1:30 PM	Lunch (Jason's Deli)	

1:30 – 3:00 PM	Session 3	[Hands-on] Building your own CubeSat I
		(Agastya Bose, Timothy Sweet)
		• CubeSatSim v2.0
		  ○ Introduction (building guide)
		  ○ Hardware component assembly
		• Software image installation

3:00 – 3:30 PM	Break	
3:30 – 5:00 PM	Session 4	Tracking satellite using the UTD ground station (Dr. Kangkook Jee) • Tracking small satellite trajectories • Scheduling satellite communication with UTD ground station • Decoding downloaded satellite telemetries

- Forming up student groups
  - 6 groups 3 ~ 4 students per group
- Basic concept overviews
- Start building CubeSats

Day 2 Schedule

Time	Sessions	Description
Day 2: Tuesday, June 11, 2024, **Location:** FO 2.208		

08:30 – 10:00 AM	Session 1	Guest speaker: Jessica Thompson, US Space Force
		
		[Hands-on] Building your own CubeSat II
		• Ground station set-up
		  ○ Hardware component assembly
		  ○ Software Image setup
		• RF Communication between CubeSatSim and Ground station

10:30 – 11:00 AM	Break	
11:00 – 12:30 AM	Session 2	Satellite software and programming interface (Dr. Kangkook Jee) • On-Board Computer (OBC) and ground system overview and programing interface • Commercial and open-source solutions • **Lab challenge 1, 2, 3**
12:30 – 1:30 PM	Lunch	
1:30 – 3:00 PM	Session 3	Basic RF transmission and antenna theory (Dr. Kangkook Jee) • Modulation and Demodulation • Space RF communication • SDR programming intro
3:00 – 3:30 PM	Break	
3:30 – 5:00 PM	Session 4	[Hands-on] CubsatSim communication competition • **Lab challenge 4**

- Guest lecture: Jessica Thompson, US Space Force
- Finish building CubeSatSim
  - Conduct lab challenges
- Session on
  - Satellite software systems
  - RF communication

Day 3 Schedule

Time	Sessions	Description
-	Day 3: Wednesday, June 12, 2024, **Location:** NSERL, RL 3.204 (Session 1), FO 2.208 (Session 3, 4)	
08:30 – 10:00 AM	Session 1	Introduction to CHESS research (Dr. Manuel Quevedo-Lopez) Physical and structural considerations (Dr. Francisco Aguirre) • Small satellite form factors ○ Shielding and insulations • Launcher and launch time considerations
10:30 – 11:00 AM	Break	
11:00 – 12:30 AM	Session 2	[Hands-on] Experimenting CubeSatSim under X-ray radiations
12:30 – 1:30 PM	Lunch (ROW)	
1:30 – 3:00 PM	Session 3	Space debris and De-orbit systems (Dr. Ovidiu Daescu) • Space and orbital debris • Space governance • De-orbit systems
3:00 – 3:30 PM	Break	
3:30 – 5:00 PM	Session 4	Workshop closing (Dr. Kangkook Jee) • Student discussion • Participant survey • Closing remarks

- Different location NSERL @ ROW building
- Physical and structural considerations
- Session environmental influences on spacecraft
  - E.g., temperature variation, excessive radio exposures
- Session on space debris and de-orbiting mechanisms

Administrative Announcements

- Photo agreement
- Confirm your dietary restrictions
  - Throughout the workshop
- Feedback and survey (3rd day; at the end of workshop)

Workshop Objectives

- Small Satellites (CubeSat) on Low Earth Orbit (LEO)
- Cyber-Physical System (CPS) in outer space
  - Exposed to extreme and harsh environment
    - Temperature, radiation, micro-gravities
- RF Communication
  - RX/TX, antenna
- Physical and Structural Considerations
  - Launch time, Operational time

- Hands-on oriented!

What is Next?

- We plan to have
  - More workshops
  - Course module
  - A new course!

- We Want to Hear from You!
  - Your inputs are valuable

Image: IrishSat, Norte Dame University

Image: SpaceX

What is Next?

- Extend CubeSatSim v2.0.0
  - Flight software with more telecommands
  - More sensors: magnetometer, GPS, …
  - Research projects
- Weather balloon
- Real small satellite (CubeSat) mission?
- Yes, it is just a beginning

Image: IrishSat, Norte Dame University

Image: SpaceX

Small Satellite Workshop Resources

- The workshop material we be heavily based on external resources of the followings:
  - State of the Art Small Satellite by NASA
  - CubeSat 1-0-1 by NASA
  - KiboCUBE Academy
- Resource page
  - https://satworkshop.syssec.org/resources

Backup