# AMATEUR RADIO IN SPACE

MATTHEW E. NELSON, MS
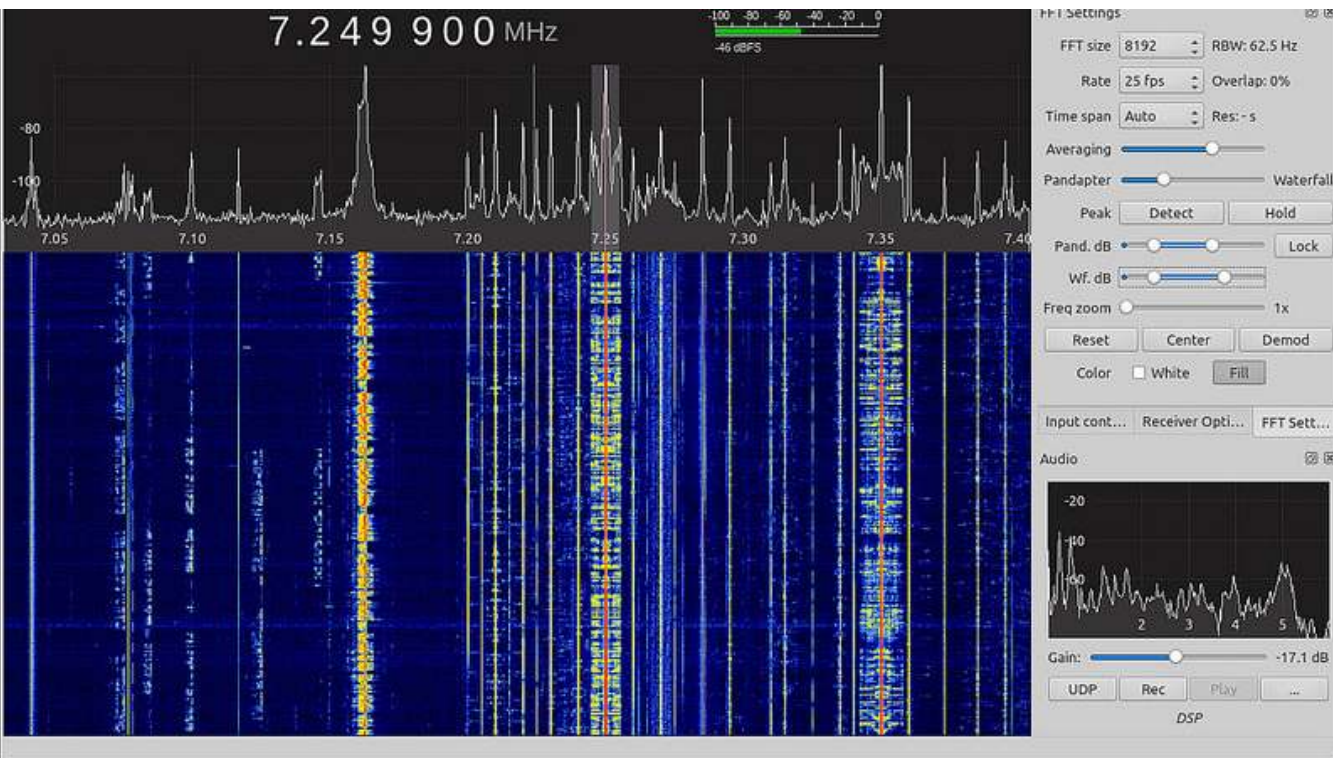
# ABOUT ME

# MATTHEW E. NELSON, KB0MGQ

- Faculty at ISU in the Aerospace Engineering Department

- Director of the Make to Innovate Program

- Assistant Director of the Iowa Space Grant Consortium

# MATTHEW E. NELSON, KB0MGQ

- Licensed amateur radio operator for 26 years (Extra for about 20 years)

- VE Testing

- Digital Modes

- SDR

- Amateur Radio in Education

# MATTHEW E. NELSON, KB0MGQ

- Private Pilot

- High Altitude Ballooning

# WHAT IS A CUBESAT?

# MISSION

- Design and fabricate a 3U cube satellite

- Operate in Low Earth Orbit for 1–3 months

- Use a Software Defined Radio and Radiometer to survey soil moisture on Earth

- Learn about aeronautical applications

- Demonstrate payload

# WHAT IS A CUBESAT

$10 \times 10 \times 10 \text{ cm}^3$

Made to be launched from an integrated deployment device (P–POD)

Often work in networks to accomplish missions but can work alone

Made to specifications by launch provider

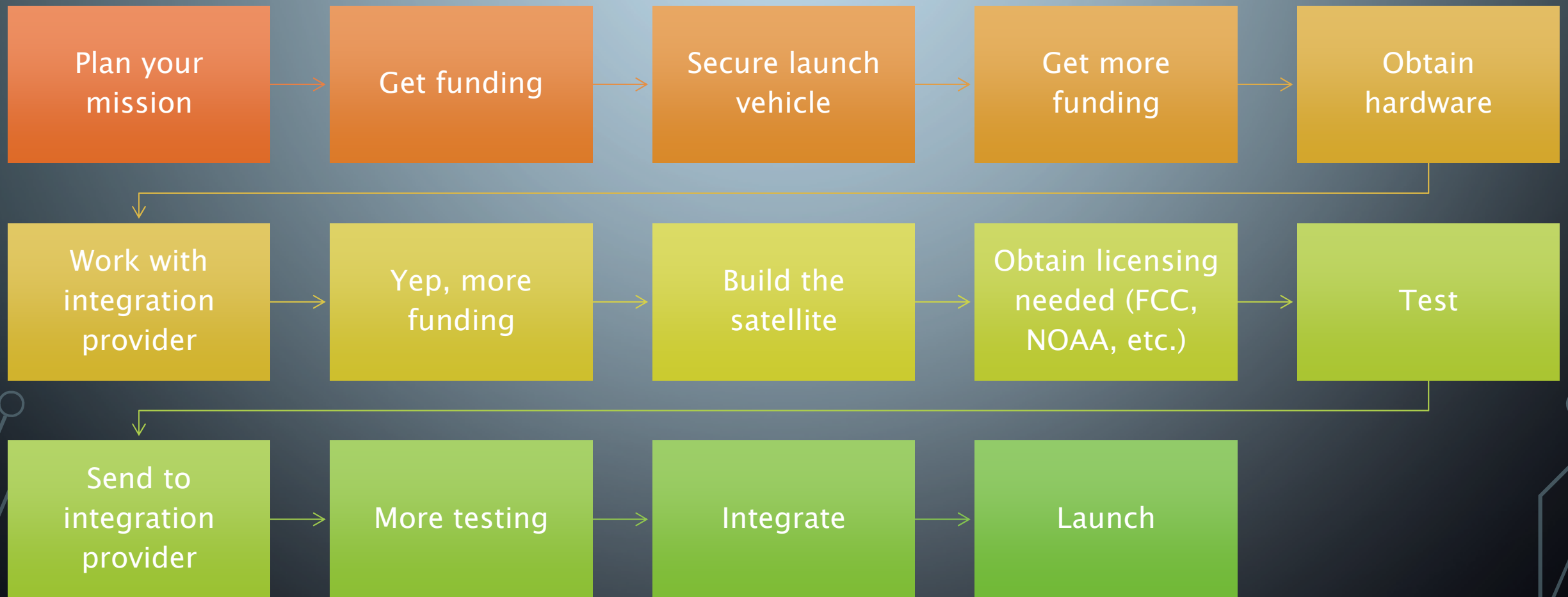Capable of anything from research to complex missions

# HOW CAN STUDENTS ACCESS SPACE?

NASA CSLI Program

- CubSat Student Launch Initiative

- Provides funding for the launch only

- Works with NASA Engineers

- 3rd party vendor

  - Nanoracks

# SO YOU WANT TO LAUNCH A CUBESAT?

| | | | | |
|---|---|---|---|---|
| Plan your mission | → Get funding | → Secure launch vehicle | → Get more funding | → Obtain hardware |
| Work with integration provider | → Yep, more funding | → Build the satellite | → Obtain licensing needed (FCC, NOAA, etc.) | → Test |
| Send to integration provider | → More testing | → Integrate | → Launch | |

# CUBESAT COSTS

- Launch ~ $100,000 (NASA CSLI grant)
- Hardware
  - ADCS – $40,000
  - Radio – $5,000
  - EPS – $14,400 (including man rating for ISS)
  - Pumpkin kit – $10,000
  - Radiometer ~ $4,000
  - C&DH ~ $500
  - Solar cells ~ $2,500

# WHAT IS CYSAT

- 3U cube satellite

- Iowa State University Undergraduates

- In the works since 2003

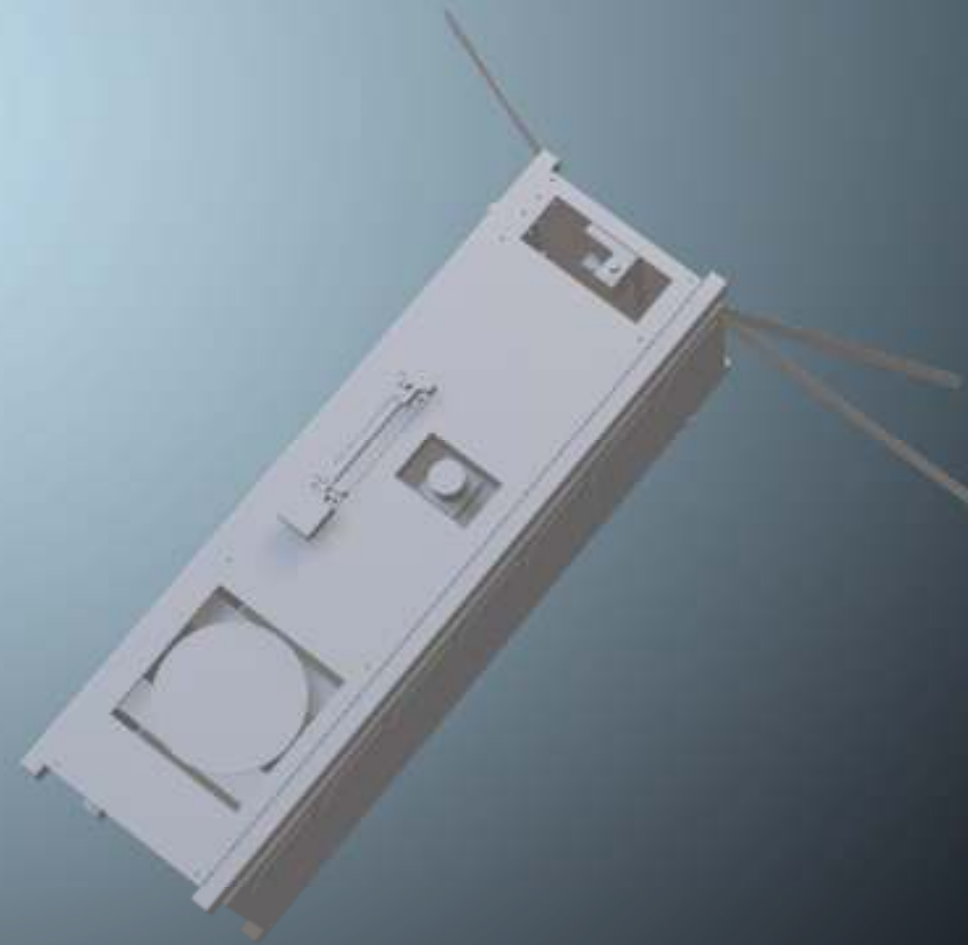- One of few teams to create payload and bus

- One satellite, two missions

Teach students to apply knowledge to aeronautical project

Demonstrate payload

# CYSAT STATS

- 3U
- ~ 2.5 kg
- Remote Sensing payload
  - Radiometer
- Amateur Radio Comms
- Payload (C&DH)
- Student designed/built frame
- First cubesat built in Iowa

# COMPONENTS

- Space-grade Aluminum Structure

- Electrical Power System (EPS)

- Attitude Determination and Control System (ADCS)

- Main CPU Board

- In-house payload
    - Radiometer
    - Software Defined Radio (SDR)
    - Antenna

- Amateur Radio Transceiver (UHF)
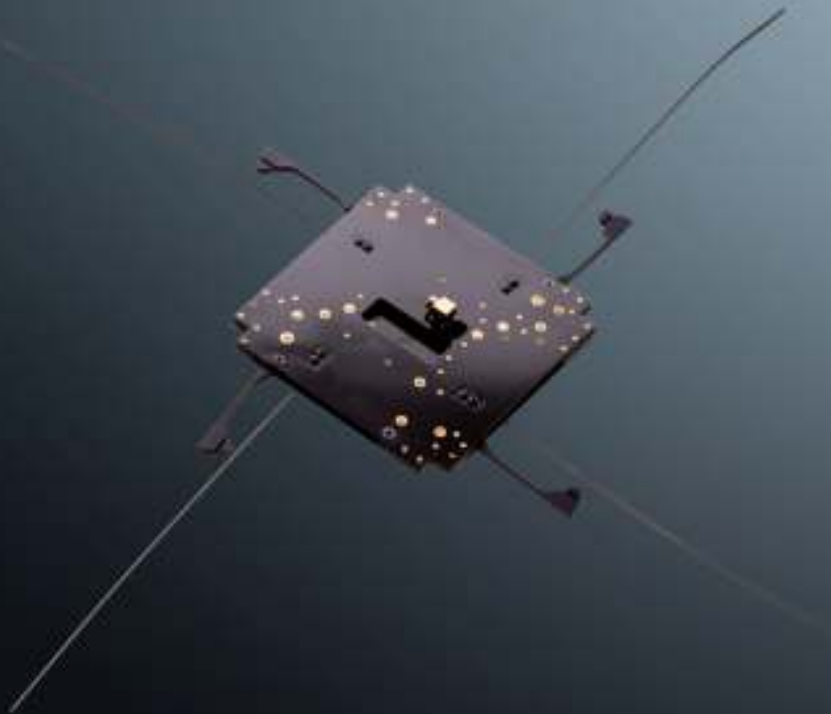
- In-house solar arrays
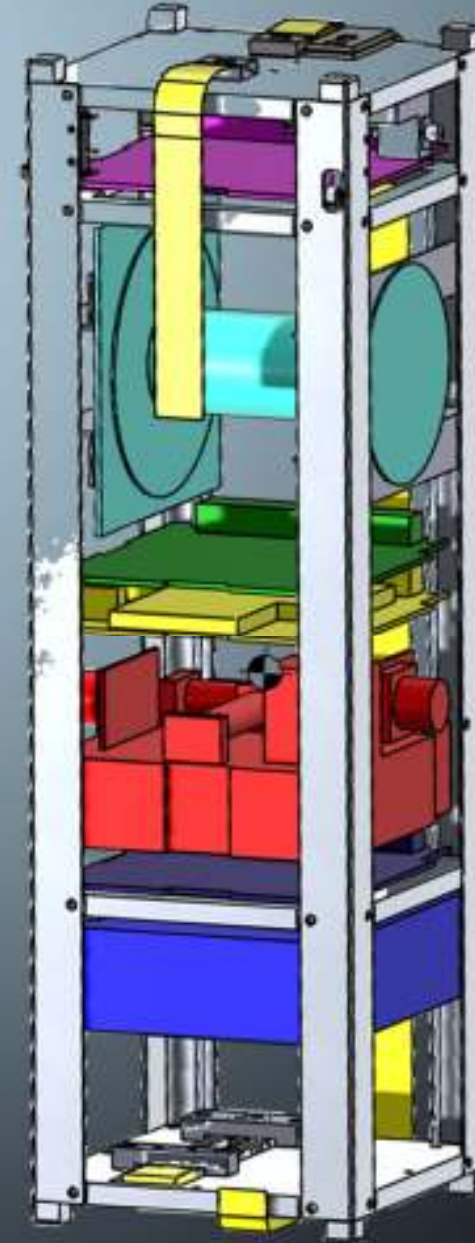
# PAYLOAD

- Software Defined Radio Radiometer
- Soil Moisture Measurement
- Custom Antenna
- 3-stage LNA amplication

# COMMUNICATIONS

- EnduroSat UHF Type II

- UHF Deployable Antenna (RHCP or LHCP)

# REGULATIONS

The International Amateur Radio Union

Since 1925, the Federation of National Amateur Radio Societies
Representing the Interests of Two-Way Amateur Radio Communication

Hans P. Blondeel Timmerman, PB2T
Satellite Advisor
Nieuwe weg 21, 4031 MN  Ingen, Netherlands
Email: satcoord@iaru.org

Date: 28 January 2019

To Matthew Nelson KB0MGQ

Dear Matthew,

In response to your coordination request dated 1 December 2018 I confirm
the IARU frequency coordination for your satellite **CySat-I**.
Coordinated frequency for up- and downlink 436.375 MHz, emission
designator 11K5F1DBN, eirp 31.4 dBm.

Planned launch date: October 2019.
Licensing administration: USA
Planned Height and Orbit: apogee 408 km, perigee 402 km, inclination
51.6403 deg, period 92.67 minutes.
Earth Command stations: W0ISU.

IARU has coordinated frequencies in bands allocated to the amateur satellite
service. All frequencies in the amateur satellite service are shared
frequencies.
Please inform me about the final launch date and the API/A number as soon
as that information becomes available.

- Under Amateur Radio several steps are needed
- Coordination with IARU
- Approval from the FCC
- FCC Submits to ITU
- ITU rubber stamps it

# GROUND STATION

- Howe Hall Ground Station

- UHF

- VHF

- 5.8 GHz (WiFi)

- Yaesu FT–817

- Kenwood TS–2000

# CURRENT STATE

- Final board revisions
  - Motherboard
  - Payload board
  - Burnout board (conversion)
- Testing
  - High altitude balloon
  - Vibration test (required)
  - Thermal bakeout test (possible)
- Integration
  - Assembly
  - Set up
  - Configuration with ground station

# TIMELINE

- Received launch opportunity from NASA in 2017 through CSLI

- Finalized system-wide designs – Spring 2018

- Sub-system design – Summer 2018

- Finalize subsystems and integrate – Spring 2019

- Handoff to launch provider – Summer 2019

- Launch – November 2019 (NG-11)
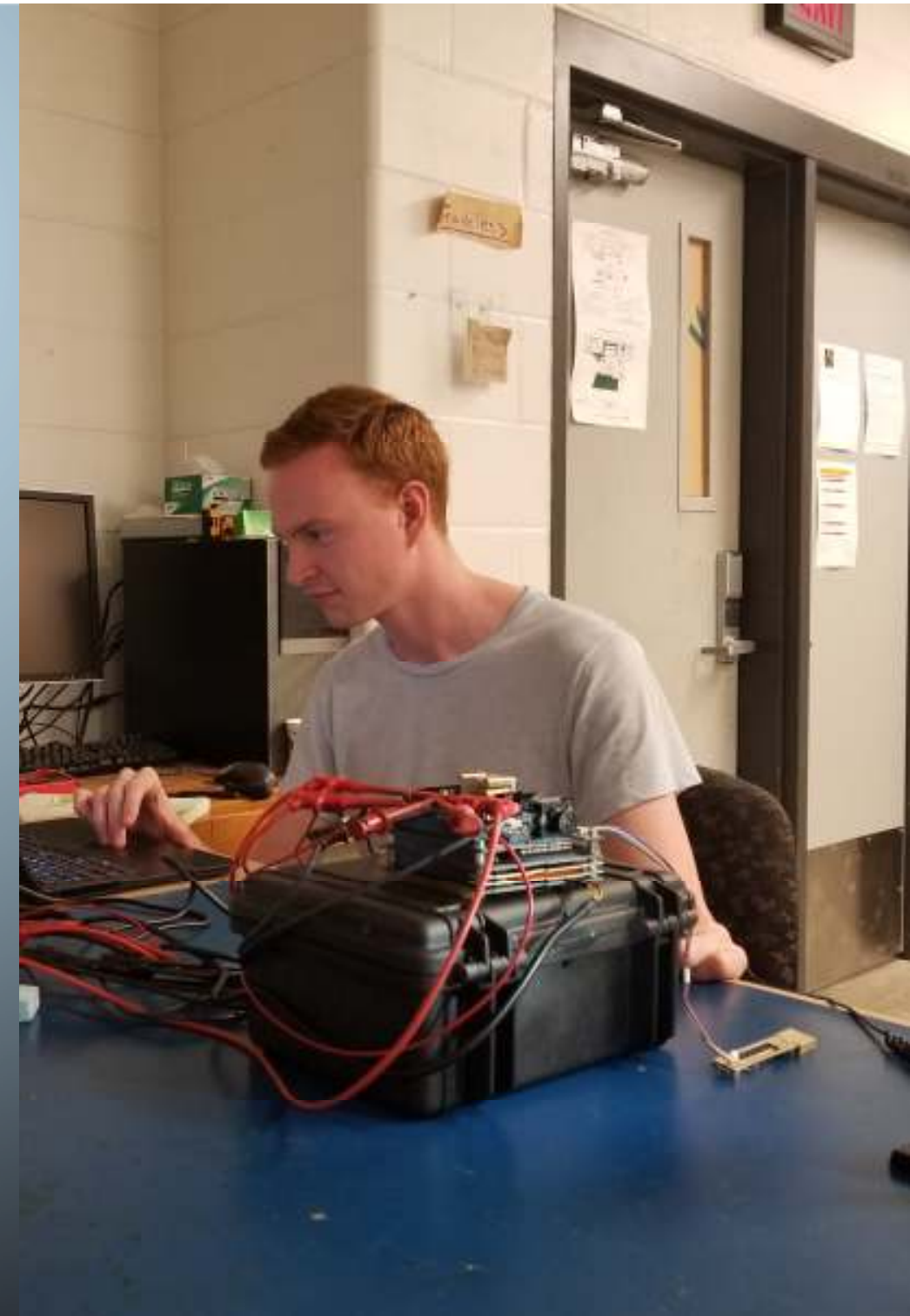
# CHALLENGES

### Licensing

NOAA

FCC – ITU

IARU

### Build–your–own payload

### Integrating COTS systems

Limited integration features

Designed to work with one set of systems

# HOW TO PUT SOMETHING IN SPACE

- Get licensed
  - Access to bandwidths
  - Imaging
- Obtain a launch
  - CSLI
  - Private Industry
- Check requirements
  - Depends on your launch and integrator
- Build
- Test
  - May be specified by integrator or launch
  - Helps mission assurance
- Launch!
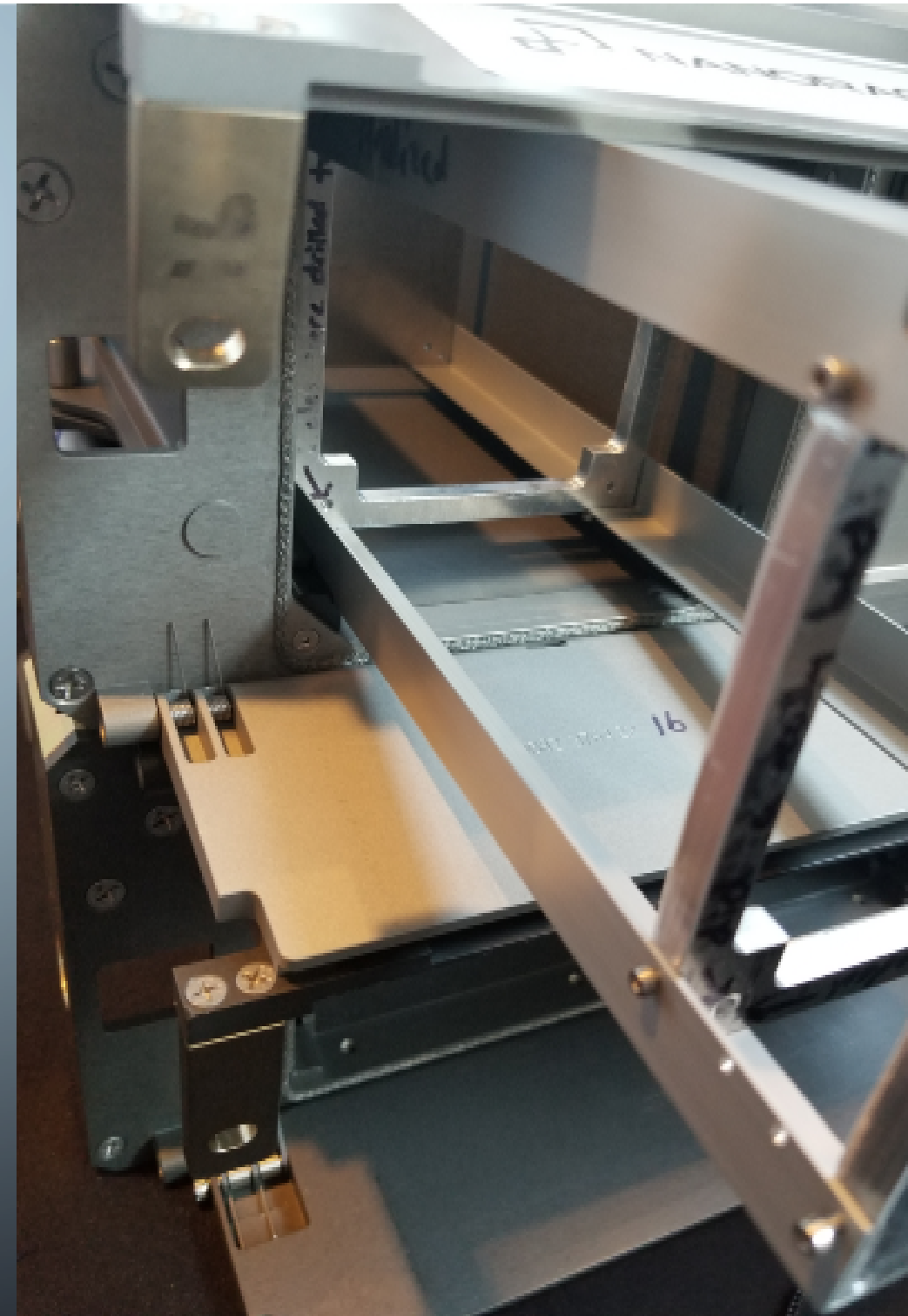
# THANK YOU!

- Questions?

# CYSAT

A 3U CUBESAT TEAM FROM IOWA STATE UNIVERSITY