TechEdSat-1 (ISS Jettison Oct. 4, 2012)
(HTV-3 July 12,2012)

TechEdSat-3 (ISS Jettison Nov. 20, 2013)
(HTV-4 Aug 3, 2013)

TechEdSat-4 (ISS Jettison March 4, 2015)
(Antares-120 July 13,2014)

SJSU Virtual Reality, View from a Cube Satellite

Integration: October 17, 2018

Launch Date: December 5, 2018

Launch Vehicle: SpaceX CRS-16

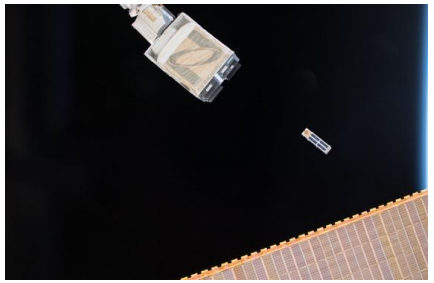
Jettison Date: January 31st, 2019

April 25, 2019

Presented By:

Jesus Ramiro Rosila Mares

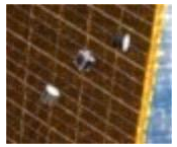
TechEdSat Team



TechEdSat-6 (ISS Jettison Nov 20,2017)
(ATK-8 Nov. 12, 2017)

TechEdSat-5 (ISS Jettison March 6,2017)
(H-II Dec 9, 2016)

SOAREX-8, 9



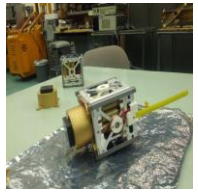
TechEdSat-N and SOAREX Flight Series

SOAREX-6
2008

SOAREX-7
2009

TES-1
Oct 4, 2012

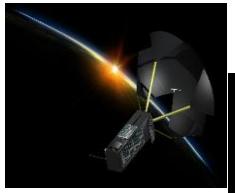
First US Nanosat deployed off ISS
PSRP process mastered
Rad-tolerant processor demo



TES-2
Iridium test
Aug 21, 2013

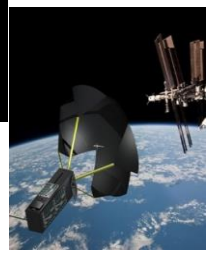
First Iridium in-space COM demonstration

First Exo-Brake Deployed from a cubesat



TES-3
Aug 3, 2013
(6 wk deorbit)

Evolution of TES-3 Iridium modem
Uplink/via email demonstrated
Exo-Brake II



TES-4
Mar 3, 2015
(4 wk deorbit)

WSM1, AIM Camera
X-Band, ISM-Band, P5 alpha, ISM-Camera and Full ExoBrake

SOAREX-8 During test (WFF)
July 7, 2015

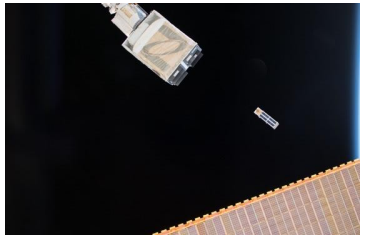
WSM2, AIM Camera
ISM-Band, P5 alpha, ISM-Camera

SOAREX -9 (WFF)
March 3, 2016

Modulated Exo-Brake
Improved positional/target accuracy
Improved Targeting, WSM2, ISM Band

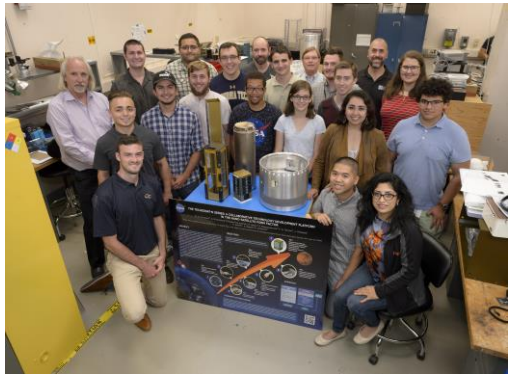
TechEdSat5/PhoneSat5
March 6, 2017

First cubesat commanded and target for re-entry, ISM band, WSM2



TechEdSat-6 (ISS Jettison Nov 20,2017)
(ATK-8 Nov. 12, 2017)

Recent Years of Flight Experiments (2008-2015):
6 Flights +1(SOAREX8&9) +PhoneSats 1-4



First Lunar and Mars radio, control board with magnetorquers, VR and Nvidia board, rad-tolerant power board.

Launch Date: December 5, 2018; Launch Vehicle: SpaceX CRS-16; Jettison Date: January 31st, 2019

Let’s Load and Go

VR Team

NASA

Ali Guarneros Luna (Co-PIA/SMA), Marc Murbach (PI), Alejandro Salas, Cedric Priscal, and TechEdSat Team.

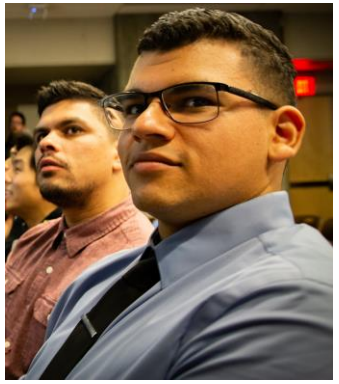
SJSU Professors

Dr. Periklis Papadopoulos, Robert Bruce, Nanci Solomon

Students

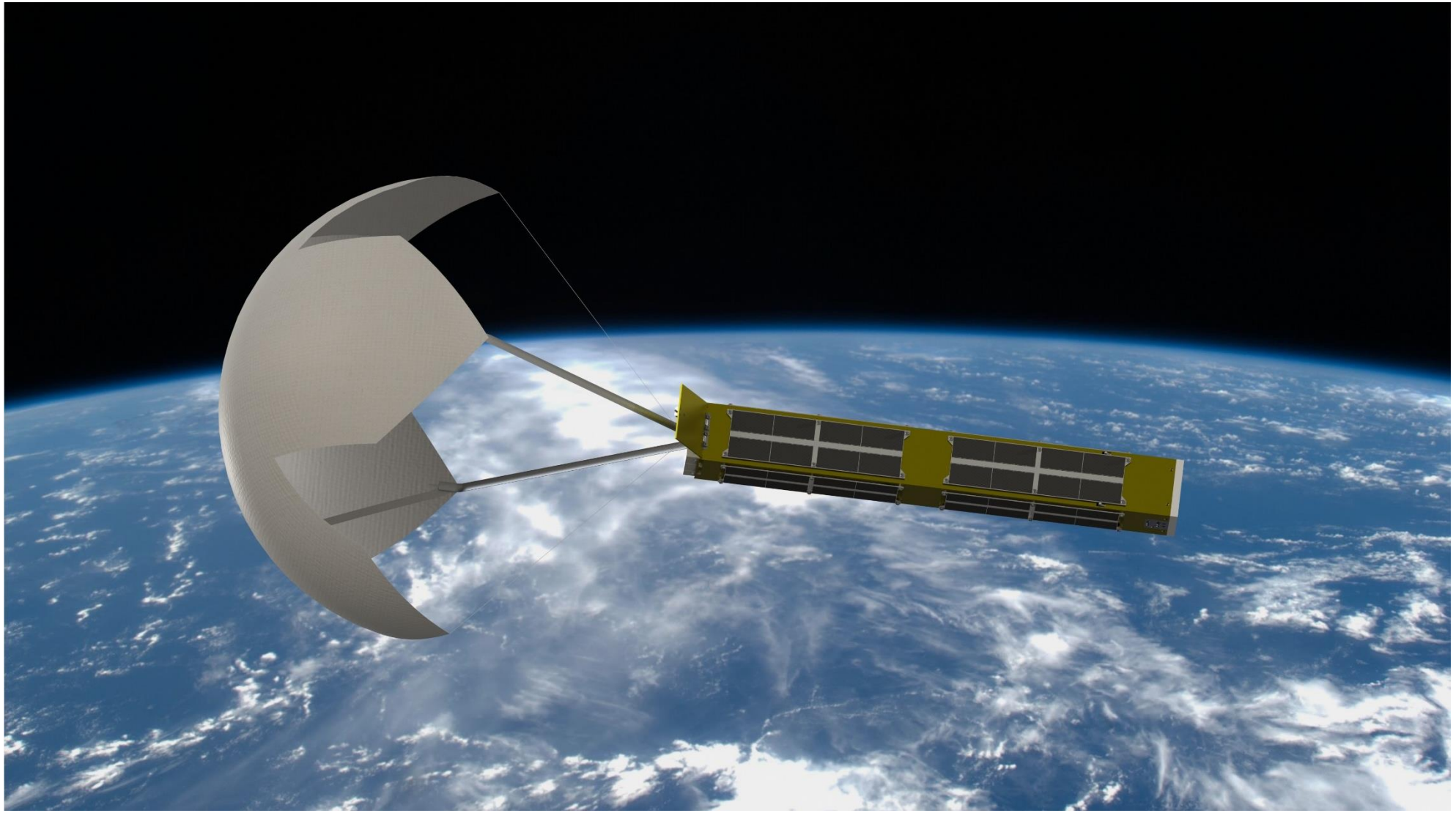
Roberto Rosila Mares, Jesus R. Rosila Mares, Reine Ntone Sike, Johnny A. Barajas, Bernardo Soriano-Gama

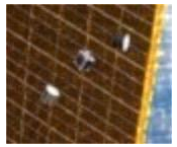
TES/P Team Summer 2017



TechEdSat Team 2018

TechEdSat-8



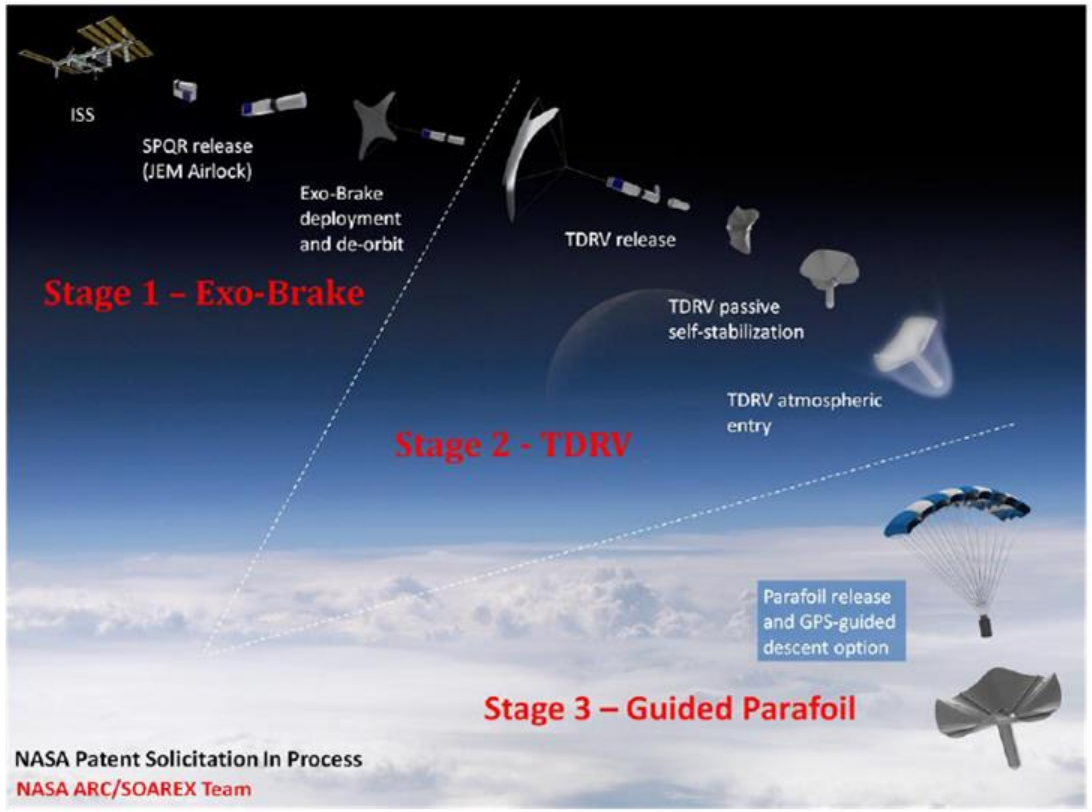


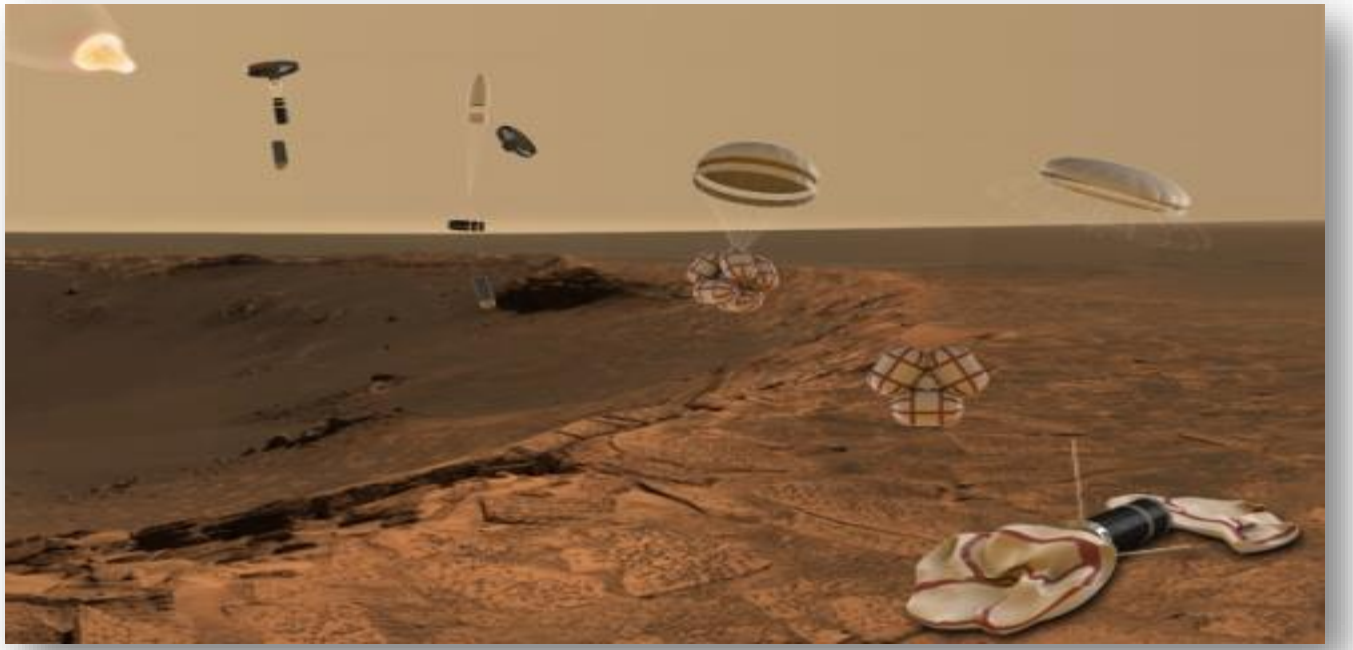
Background

ISS EDL Capabilities For Future Missions

SPQR-Small Payload Quick Return

- 3 stage concept
- Rapid Development and Test of **science and technology**

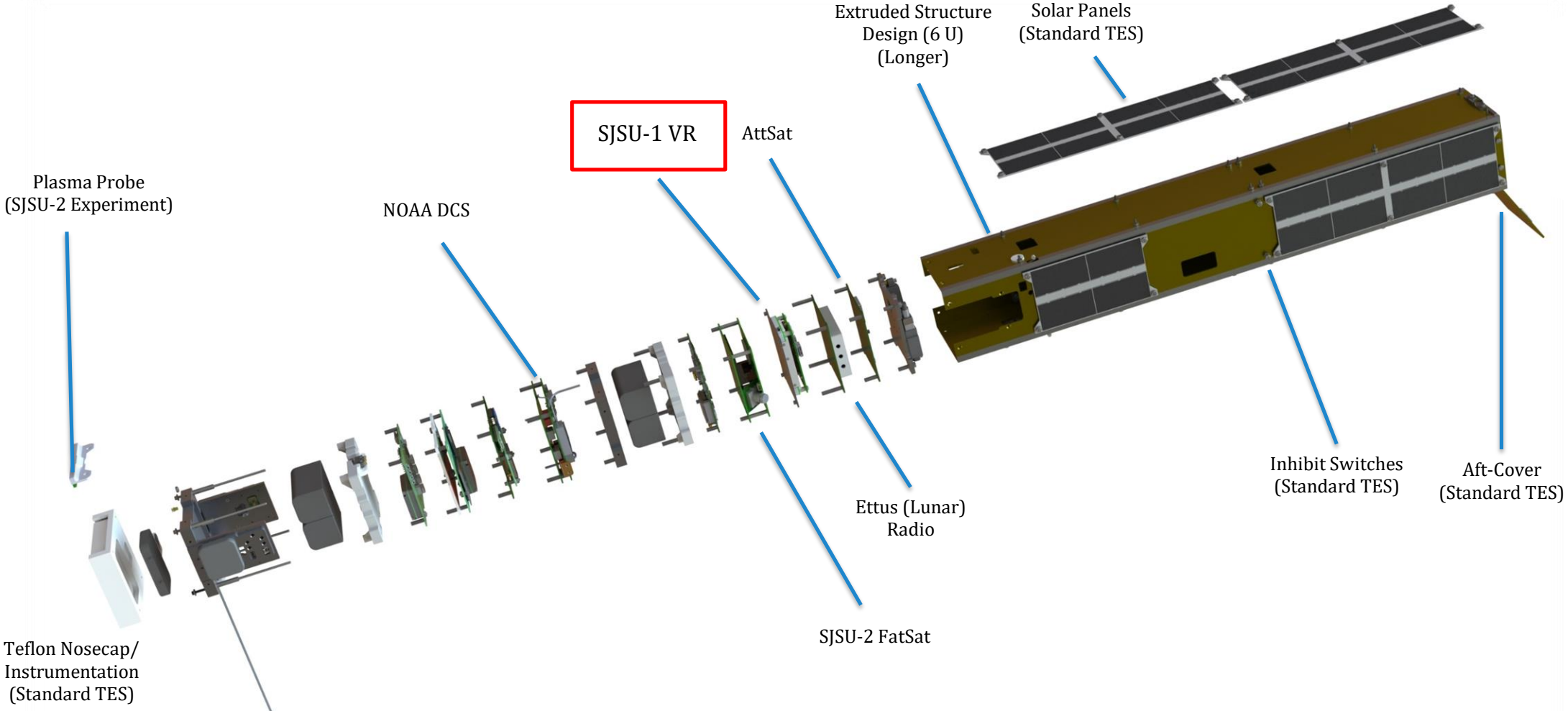




Atromos: Cubesat Mission to the Surface of Mars

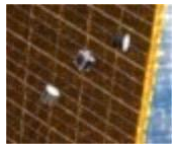
- **Mission Attributes**
  - Self-stabilizing re-entry probe (TDRV-Tube Deployed Re-Entry Vehicle)
  - EDL Technique for small probes
  - Nuclear option for mission longevity

TES-8 Exploded View



Nano-Orbital Workshop: **8 radios** (3 Iridium; 1 Globalstar; GOES/DCS/Mars Radio, Wifi-to-ground; Internal Zigbee sensor network; Lunar Radio/SDR), **4 cameras** (including VR), banjo-magnetorquer, Plasma experiment; **8 processors** (including NVIDIA/TX2), modulated **Exo-Brake**.

VR (SJSU Experiment)



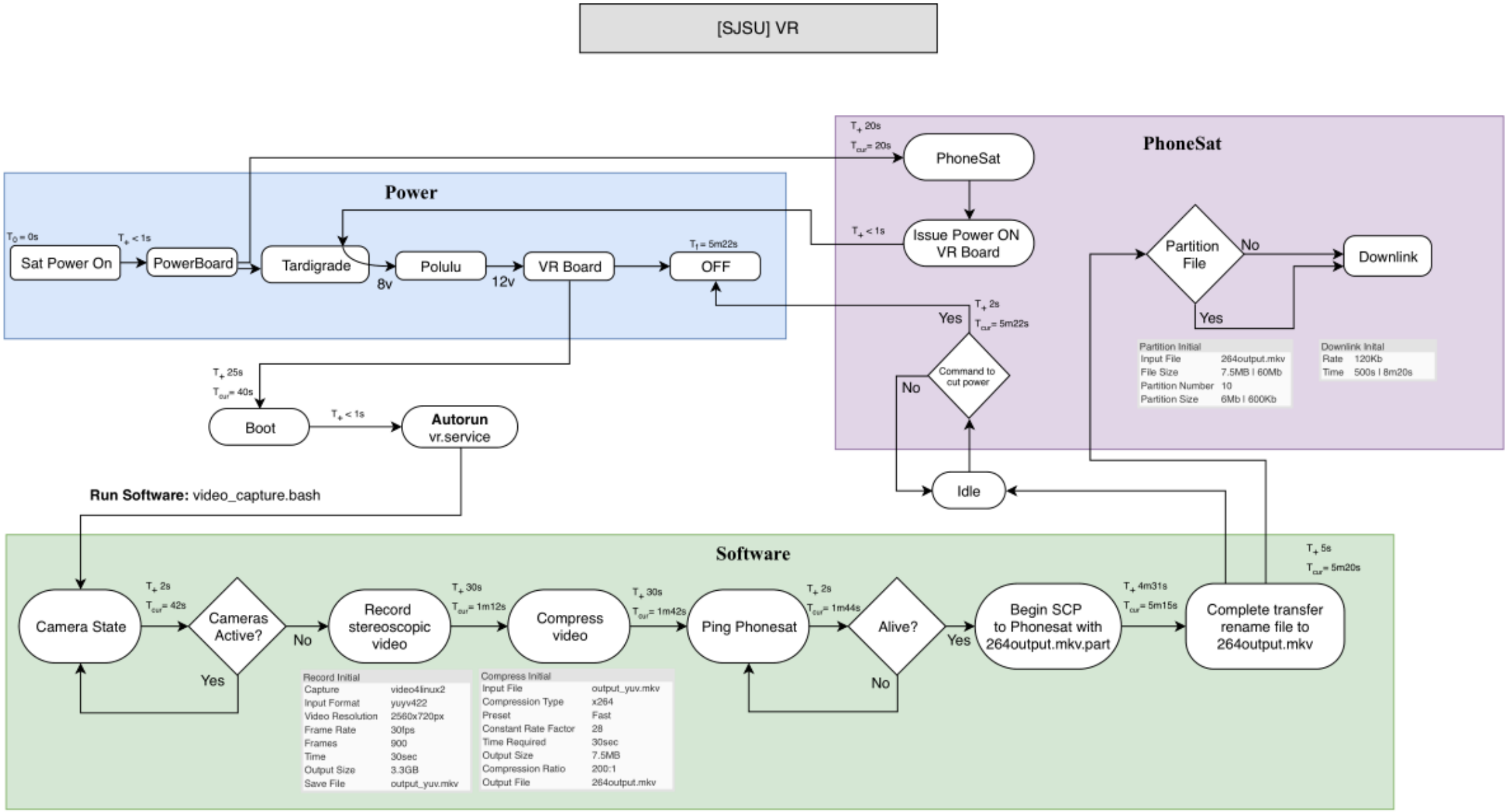
VR Research Experiment

Mission Goal of VR Team

- Obtain **Stereoscopic video** of the exterior of ISS as TES-8 was jettisoned from the NanoRacks Deployer (NRCSD).
- Command TES-8 via Iridium to turn on PhoneSat and command VR to record videos.
- VR provides the ability for millions to experience space missions remotely in 3D.
- Combined with **NVIDIA's TX2 AI compute engine**, it can become a powerful next-gen tool for local real-time **analysis and decision making**.
- Transfer image data to Intel Edison Board
- Analyze packets send via Iridium vs. SBAND
- **Validate NVIDIA** TX2 edge (local) onboard computing capabilities
  - Measure system performance
  - Capture, encode, packetize stereo HD video

Bernardo and Austin working on TechEdSat 8

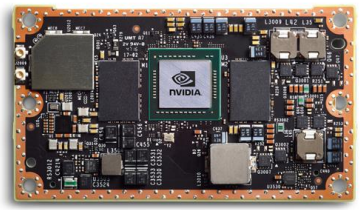
SJSU Software Diagram



Environmental Testing

Computing

Raspberry PI 3, ODROID-N2, NVidia TX2

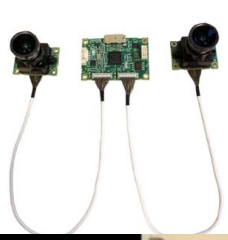


Daughter board

AVerMedia's EX731-AA/N1, Connect Tech's Orbitty Carrier

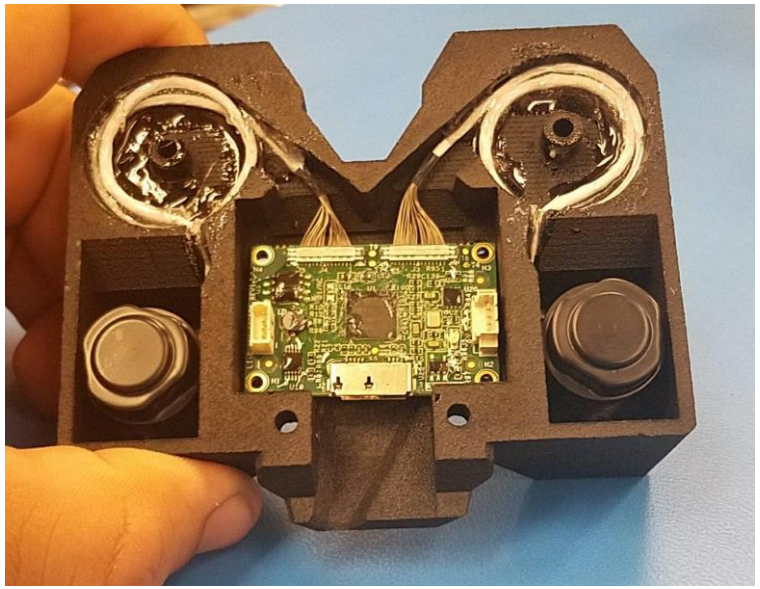
Camera

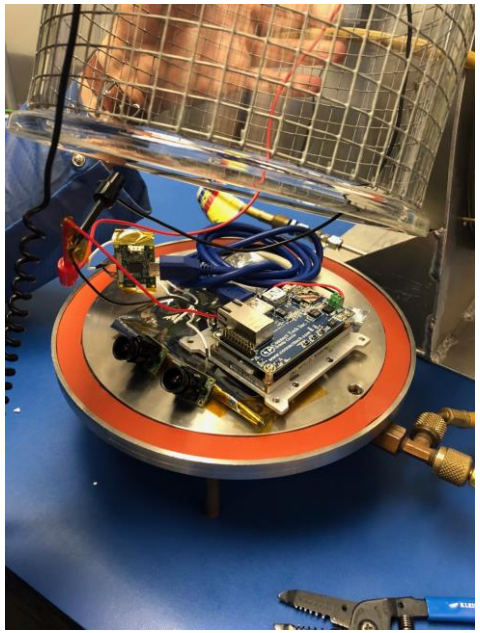
ZED Stereo Camera, LI-OV580-STEREO

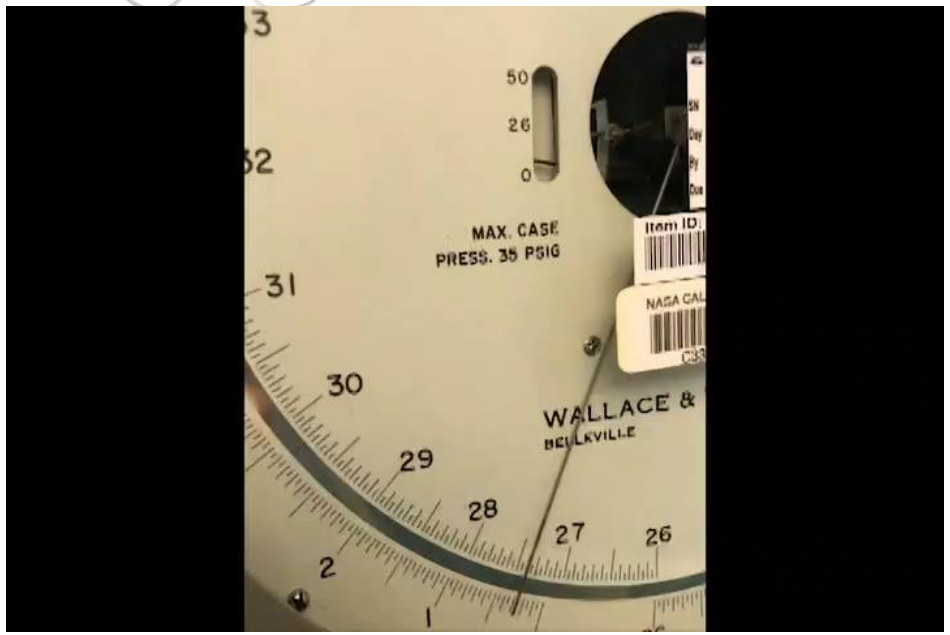


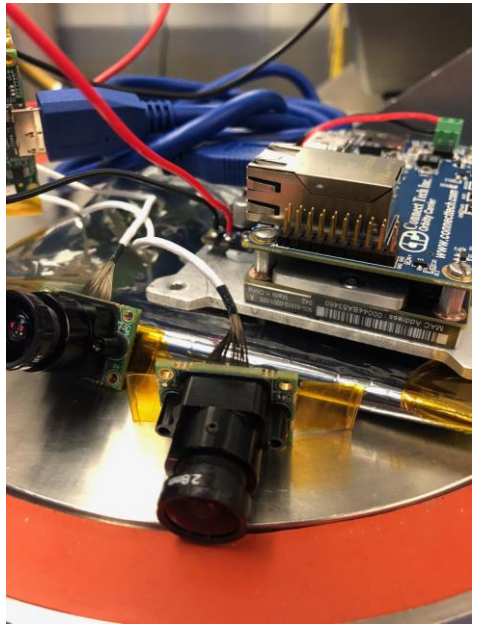
Choices between software.

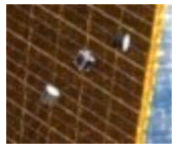
C++, Shell/Unix, Bash script.





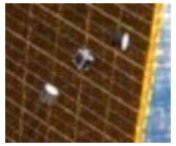






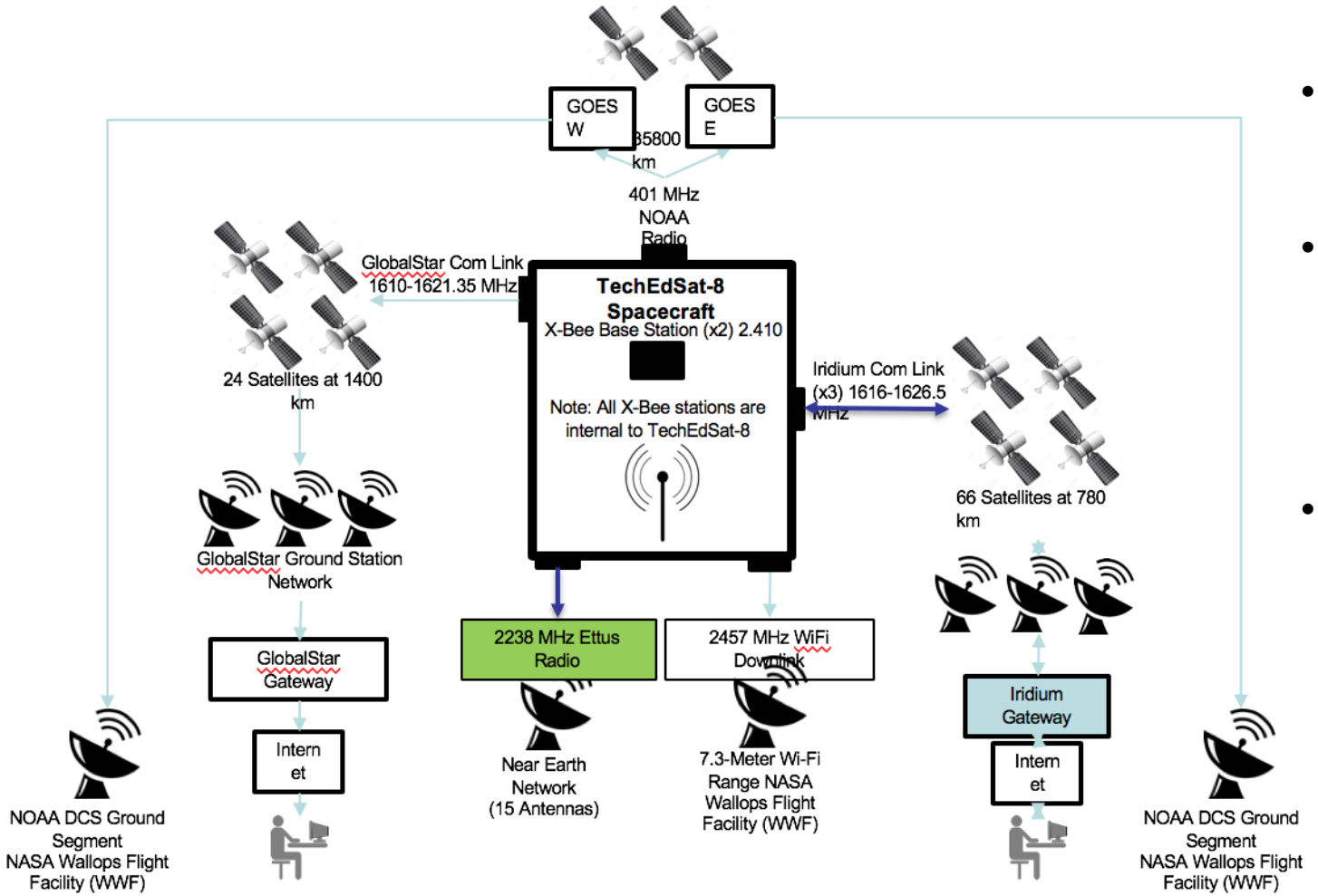
Pre-flight validation test

Pre-flight test validation with more than 200:1 compression ratio.

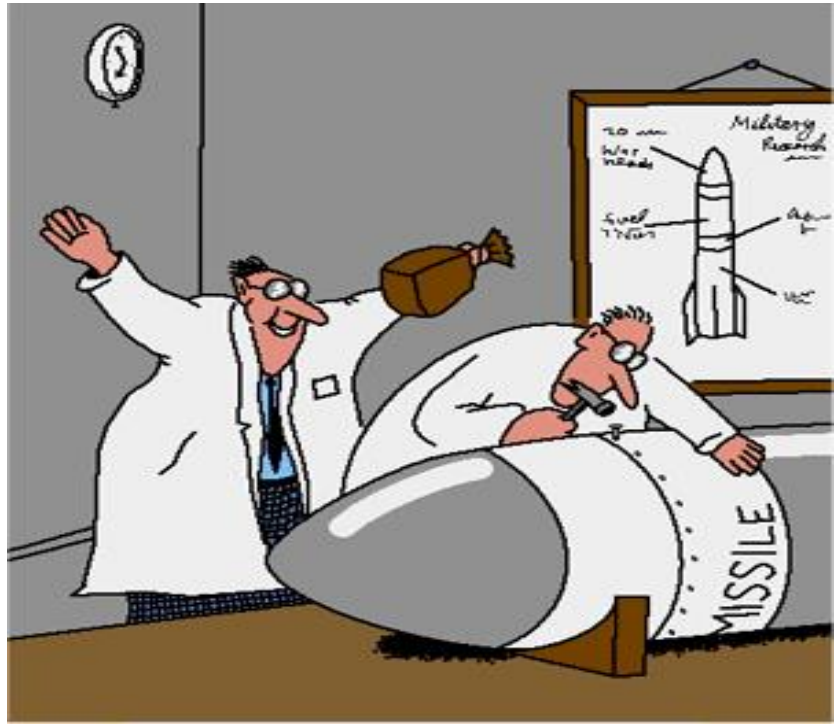


Transmitting from Space

How to bring data down for VR Experiment



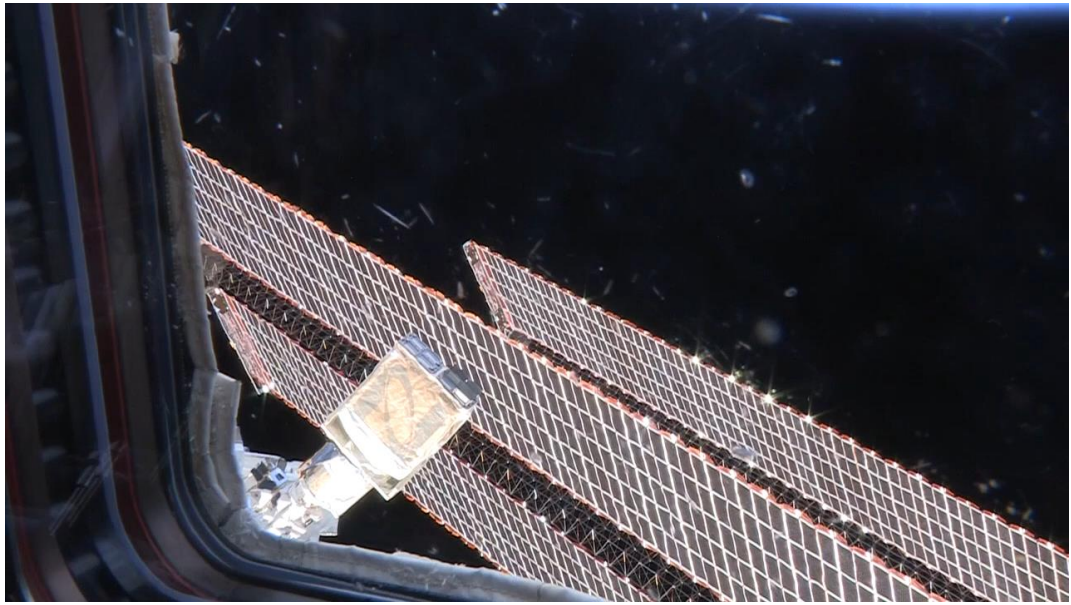
- **NEN-compatible S-band**
  - uses SDR transmitter (ETTUS) intended for use in one of the EM-1 nanosat payloads
- **LEO applications**
  - ~15 ground antennas scattered over the globe
  - Increase of the downlink capability of current generation nano-sats
- **TechEdSat-8 experiment**
  - transmit data gathered from the VR (Virtual Reality) experiment, during which >200:1 compression techniques would be used
  - validate the COM system of a ‘pathfinder’ EM-1 payload
  - high volumes of optical data would be processed on-board with the NVIDIA TX2 system, compressed, and downlinked.

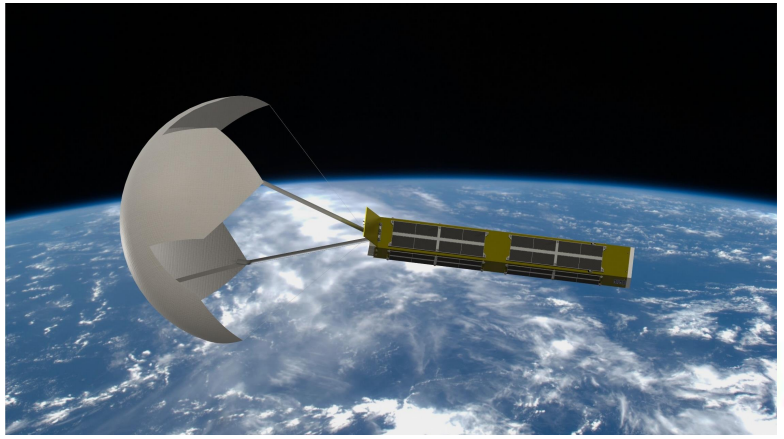


CONOPS

CONOPS

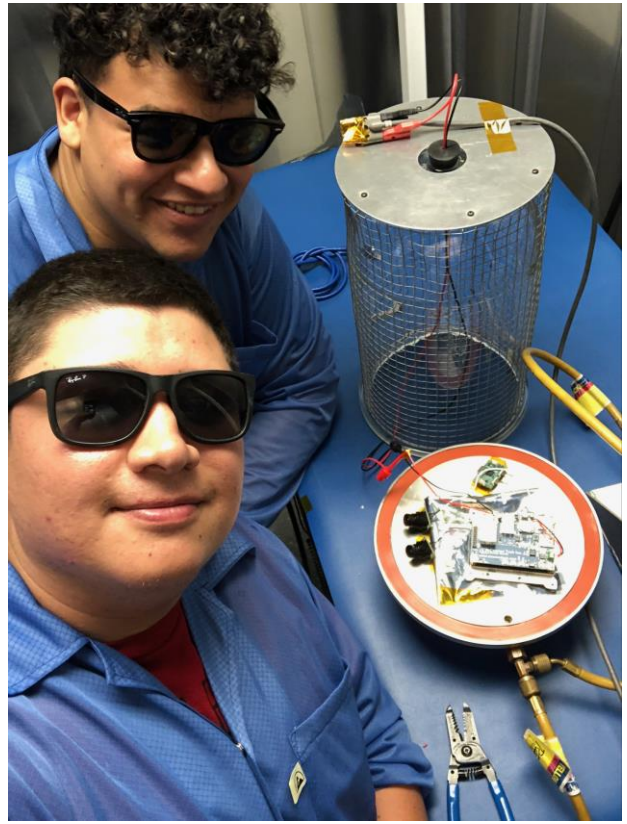
- Nanosat is jettisoned from the ISS/NRCSD
- TES-8 powers the core microprocessors/Iridium/VR/ Cameras
- Records for 30sec (after 42 sec latency)
  - 30 Frames/sec
  - Video resolution 2560x720pixels
  - Total data 3.3GB
- NVIDIA/TX2 performs 200:1 compression to result in 7.5MB (60 Mb)
- Wifi transmission to the PhoneSat/Intel-Edison
- Phonesat partitions compressed file 10x resulting in 6Mb/file
- Wait for Iridium-1,2 command to downlink compressed data to NEN(Near Earth Network) antennas at 125Kb/s
- Repeat 10 times

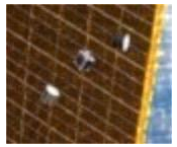




Future Considerations & Iterations

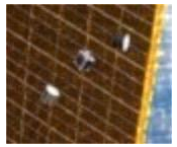
- **More functions** to the Sub system, such as different video types, frame rates, size.
- Different cameras/position on Satellite
- **More cameras** around the whole system. Truly get a full VR experience of the satellite.
- Eventually be able to use this as the eyes to the satellite for later **attitude control designs**.
- First demonstration
  - **Power cycling**, **thermal management**, **data processing**, and **data transfer**
- Compression of very large data for optical instruments (e.g. **hyperspectral**)
- AI algorithms to determine which data sets manipulate and send to ground station
- Coupled with **high data rate downlink capability** (e.g. Use of NEN with S-Band and/or X-BAND Capability; Limited laser com)





Summary of TechEdSat-8 Mission VR Experiment

- One of the first flight demonstrations of a **COTS graphics GPU** (256-core NVIDIA/TX2) is described
- Flown as a sub-experiment on the **TechEdSat-8 nano-sat** (NASA Ames) and deployed on Jan 31, 2019
- TES-8 is a series nano-sat, with **150W-hr power system** and **8 transmitters** developed as a Nano—Orbital Workshop (**NOW**) to rapidly involve innovative technologies.
- The NVIDIA/TX2 experiment collected **3.3 GB of ISS video data** from the VR experiment and successfully compressed **200:1** using the **H.264 algorithm**.
- The **5.3MB compressed file** was then to be downlinked via an experimental SDR s-band – but **power system** anomaly before the downlink carried out (after 2 successful weeks of operation, partial down link via iridium)
- Minimum use of **high transistor density GPU** appears VIABLE as long as it is used sparingly (due to **radiation effects**, it should be powered 'OFF' unless needed)
- Future tests planned on **TES10, 12** with enhanced SW and revised power subsystem and Lunar Radios



Special Thanks

San Jose State University

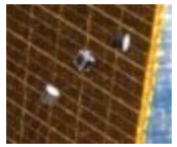
AE Department

CS Department

NASA Ames Research Center

Space Project Facility

Small Spacecraft Technology Program



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- ISS Conference 2018-The TechEdSat-N Series: A Collaborative Technology Development Platform in the Nano-Satellite Form Factor http://amz.xcdsystem.com/4F14E44B-BC41-E69B-DFAF5A1B1627A0EA_abstract_File10384/PDFUpload_185_0720010551.4.pdf