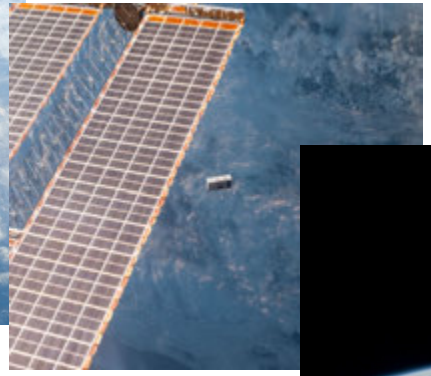
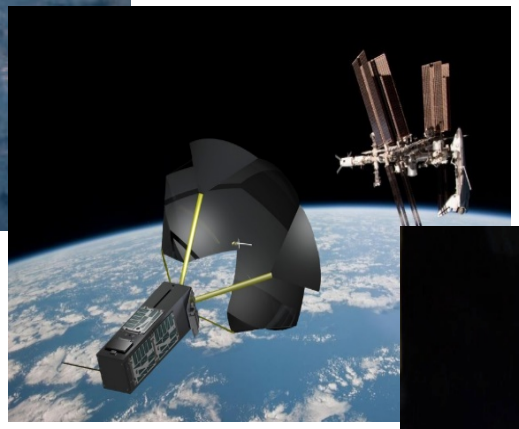
TechEdSat-N

Pioneering the Use of the International Space Station as a Nanosatellite Deployment Platform

M.Murbach, and A. Guarneros Luna

TES-Team

March 24, 2014

Outline

1.Introduction
   1. Teams/Introduction
   2. Mission/Objectives
   3. Milestones
   4. System Status
   5. Comparison TES-4 from TES-3p
   6. Exploded View/Structure
   7. Design Deltas/Doc Deltas

2. Concept of Operation
   1. Operational Concept
3. Export Control
4. Batteries/Electrical System
   1. Mechanical layout (2nd battery)
   2. Wiring diagram
5. Mechanical Interface
6. Telemetry/Transmitters
   1. Type
   2. FCC License

7. Testing Hardware Description
   1. Types (TES-3p to TES-4)
   2. Source of Requirements
   3. Cygnus levels (theoretical)
   4. Random vibration
   5. Functional Test Example

8. Post-delivery Anomaly

10. Standard Hazards (SHR)

11. Unique Hazards UHR)

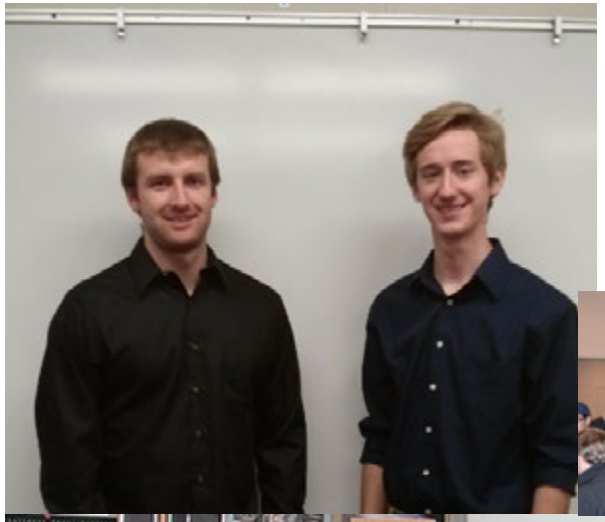
12. SVTL/Status

13. Comment Matrix

14. Avionics Subsystem

15. Back-up Material
   1. Material List
   2. Fastener Location/Map
   3. Earlier Testing

Collaboration Between NASA Ames plus Universities (SJSU, U of Idaho, ISU)



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Contributors from Universities

San Jose State University

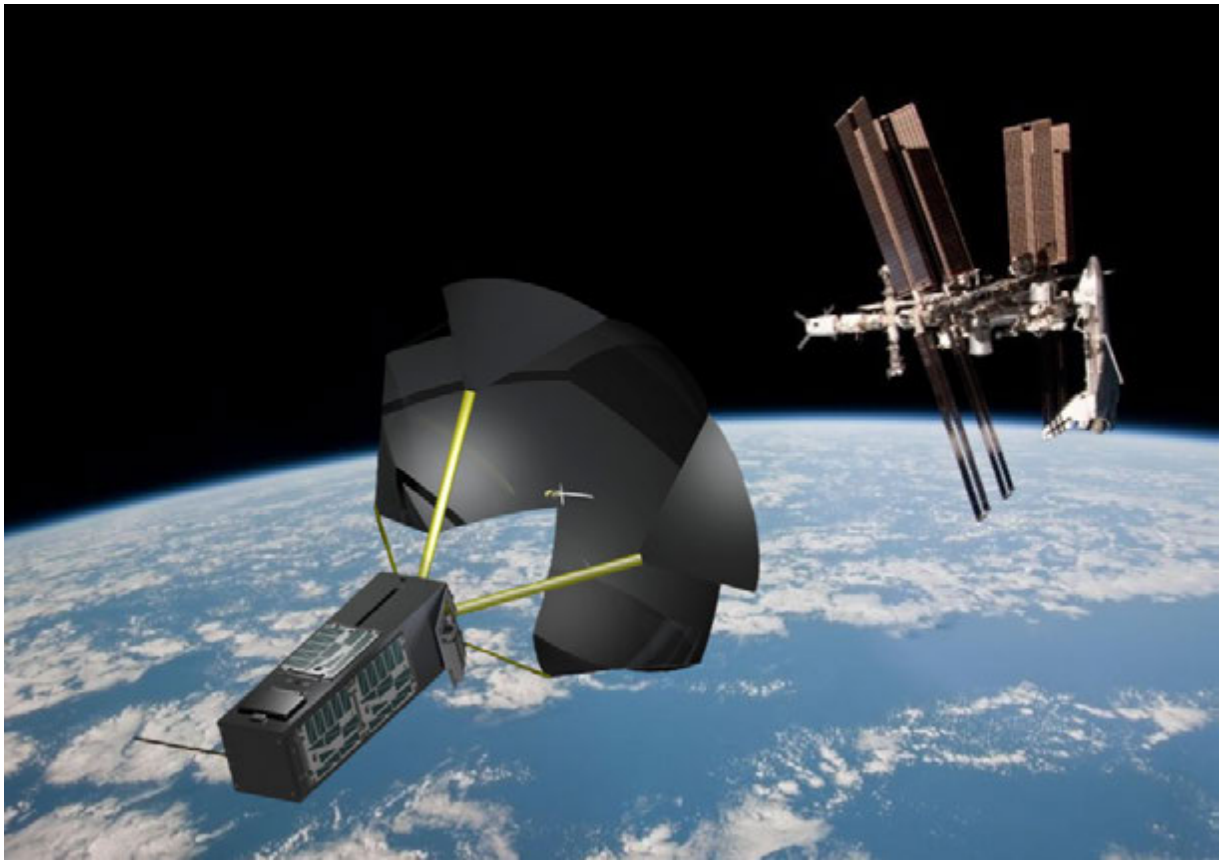
Dr. Perikles Papadopoulos

University of Idaho

Dr. David Atkinson

What is it?

- Collection of professionals, professors, and students working in a ‘skunk works’ setting
- Rapid development of 1-3U satellites for ISS jettison platform



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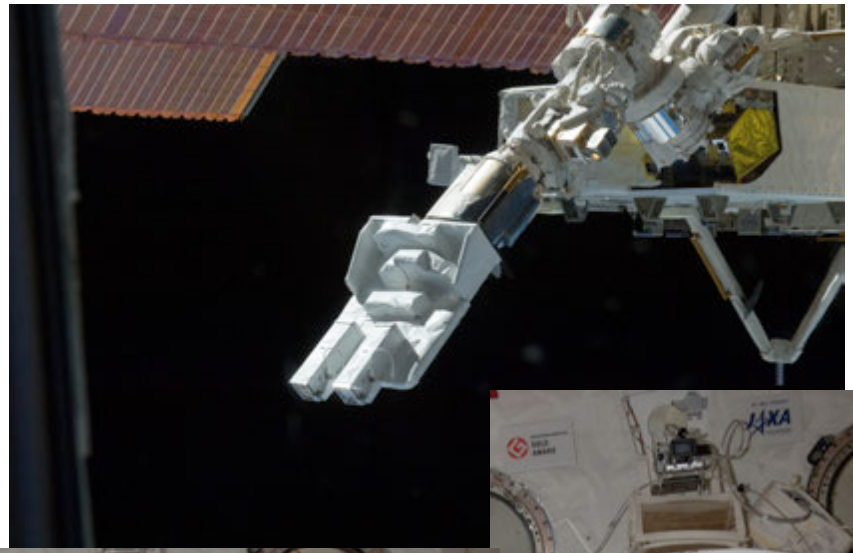
Why is it relevant?

How to use the J-SSOD, NRCSD (and future traffic models)

- **Pioneering the use of the ISS as a means of 'launching' Nano satellites.**
  - Developing key process and 'design for safety'
- **Developing key technologies**
  - RAD tolerant processor testing/ architectures
  - Manufacturing Techniques
  - Comm(e.g., Iridium)
  - De-orbit experiments



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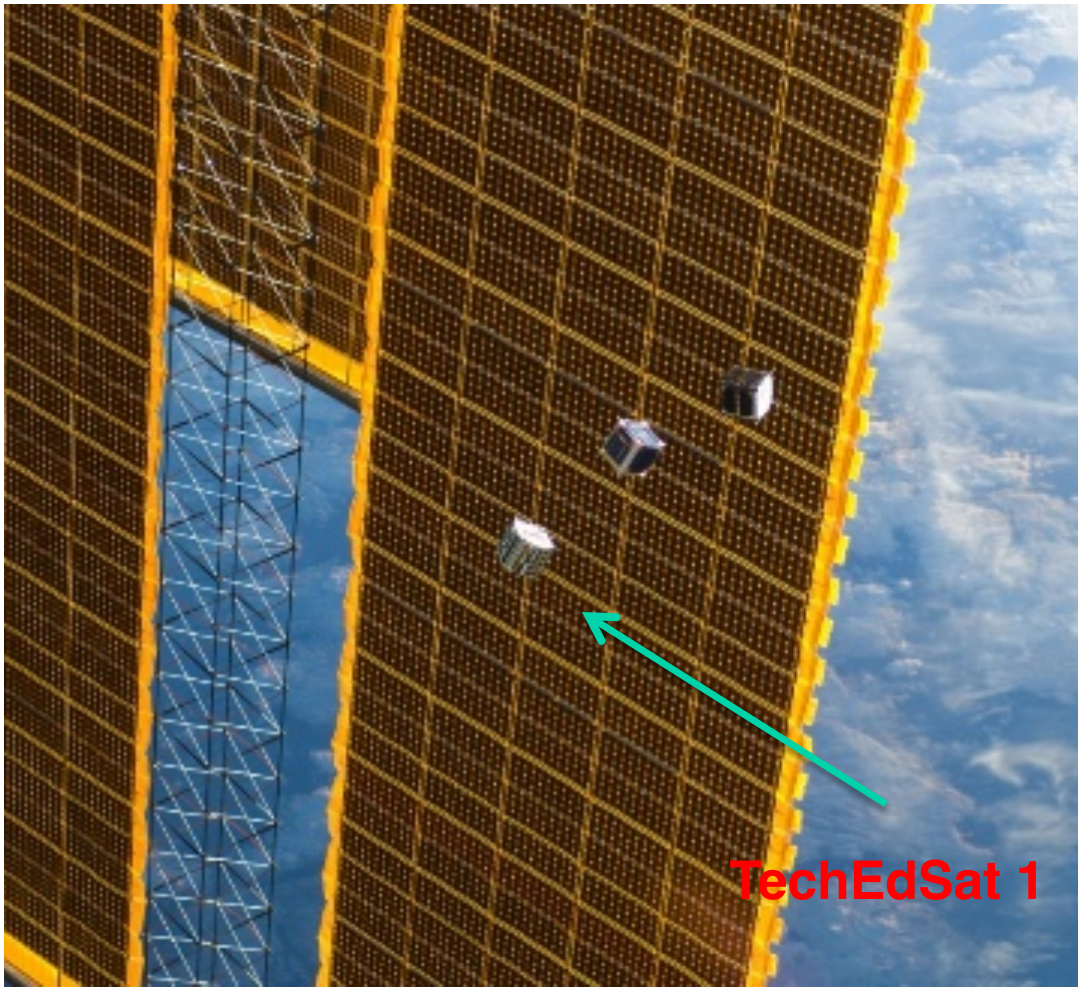
Why is it relevant?

Jettison options

- **The ISS offers a unique future path for nano satellites**
- **Recent advent of NanoRacks CubeSat Deployer (NRCSD) will markedly increase Nano satellite launch traffic**
- **NRCSD:**
  - 48U/ airlock cycle;
  - 96U/Cargo Flight
  - 3 flights per year
  - = 288U/year

Previous Flights: TechEdSat 1

- **We were 1st!**
- **Nominal Success Criteria**
- **Demonstrated ISS Safety Design for jettison from ISS**
- **Demonstrated 2-tier RAD-Tolerant Architecture (ÅAC Microtec)**
- **Comm Experiment**
  - (UHF, Iridium, OrbComm)
- **Launch Date on HTV3 August 14, 2012**
- **Jettison on October 4, 2012**
- **~7 month duration**

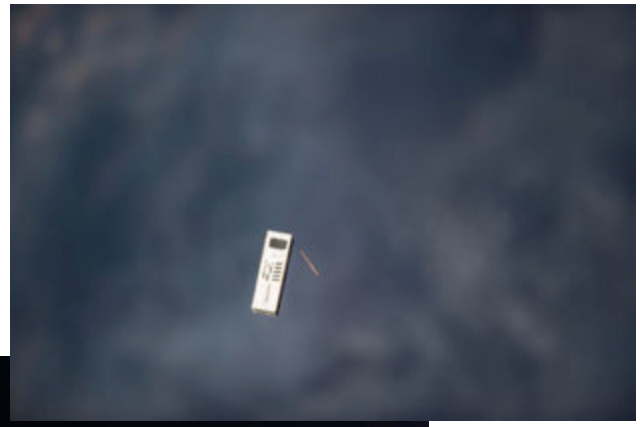


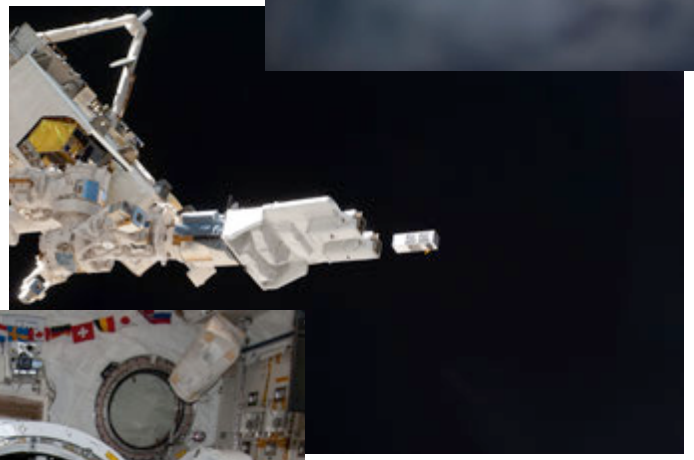
Previous Flights: TechEdSat 2

- We were 1st (Antares-1)
- Comprehensive Success Criteria
- Demonstrated Comm Experiment
- Launch on April 23, 2013 on Antares-1
- Duration: 24 hrs (by design)

Previous Flights; TechEdSat 3

- We were 1st 3U Jettisoned from ISS
- Nominal Success Criteria
- First Exo-Brake Demonstration
- Advanced Manufacturing
- Comm Experiment II
- Two Tier Architecture
- Launch August 20, 2013 on HTV4
- Jettison on November 23rd, 2014
- Re-entry on January 6, 2014





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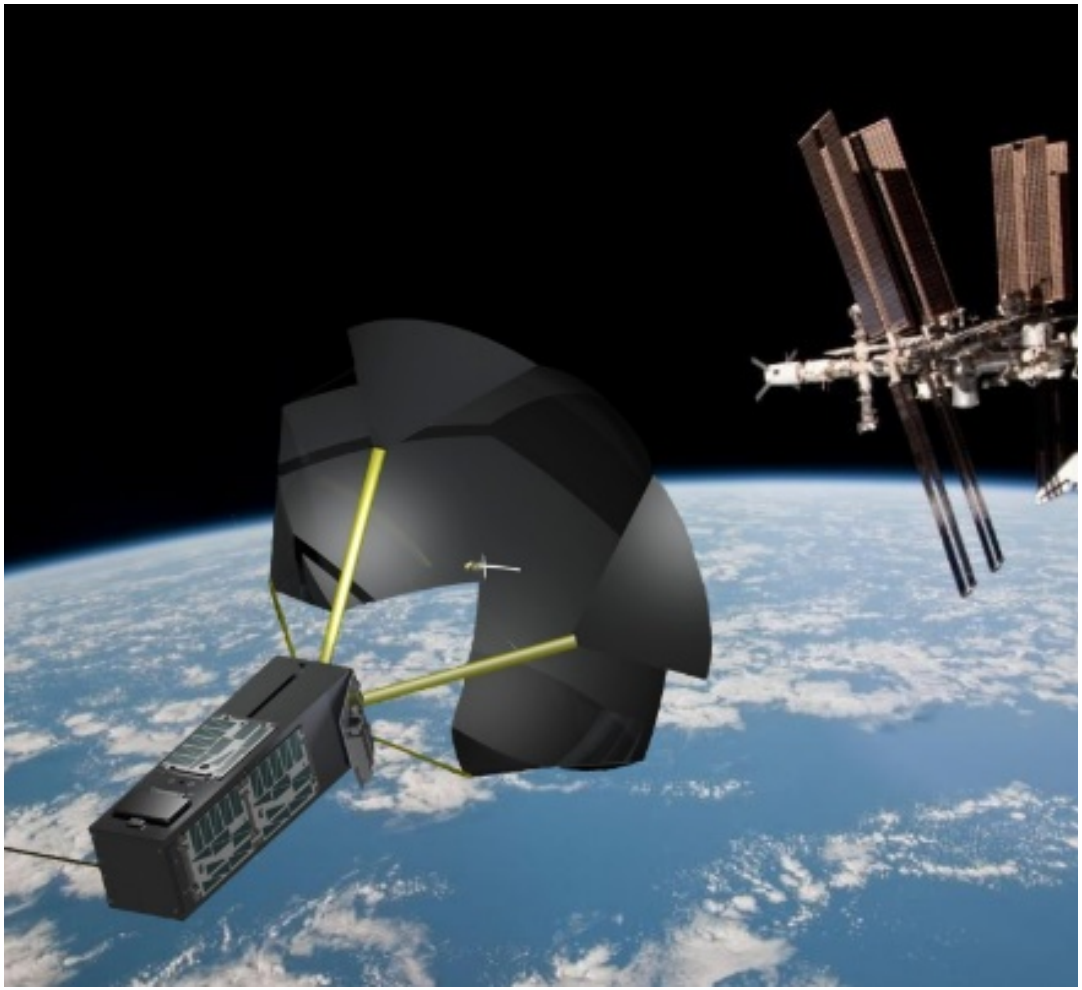
Current Flights: TechEdSat 4

- **1st NASA NanoSatellite 3U Jettisoned from the NRCSD (July 2014)**
- **Exo-Brake Demonstration**
  - B=8kg/m^2
- **Advanced Manufacturing**
- **Comm Experiment III + GPS**
- **Two Tier Architecture**



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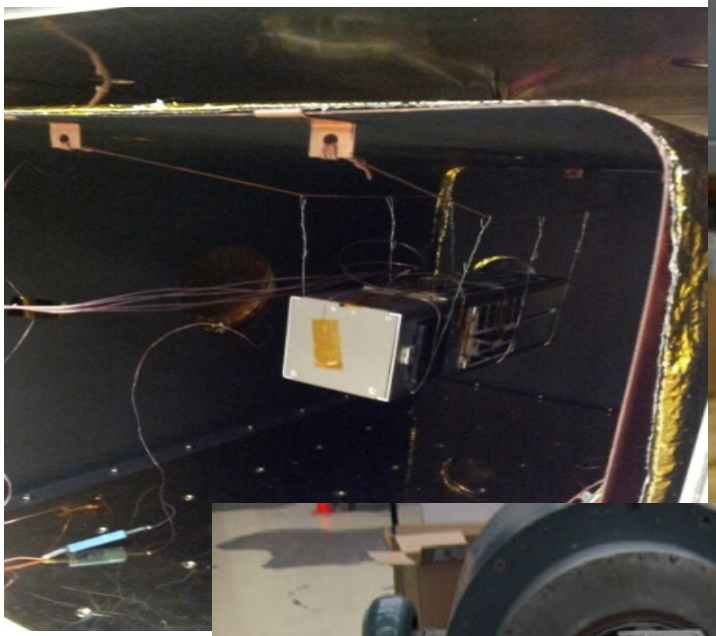
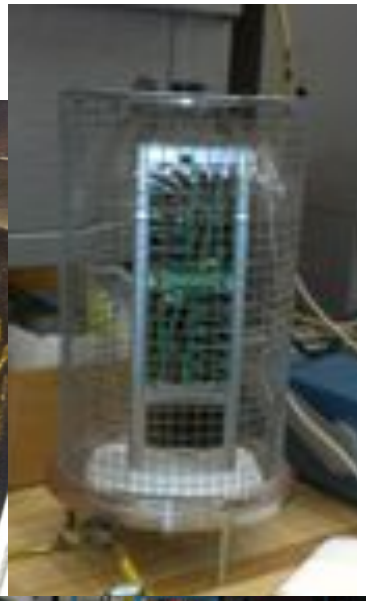
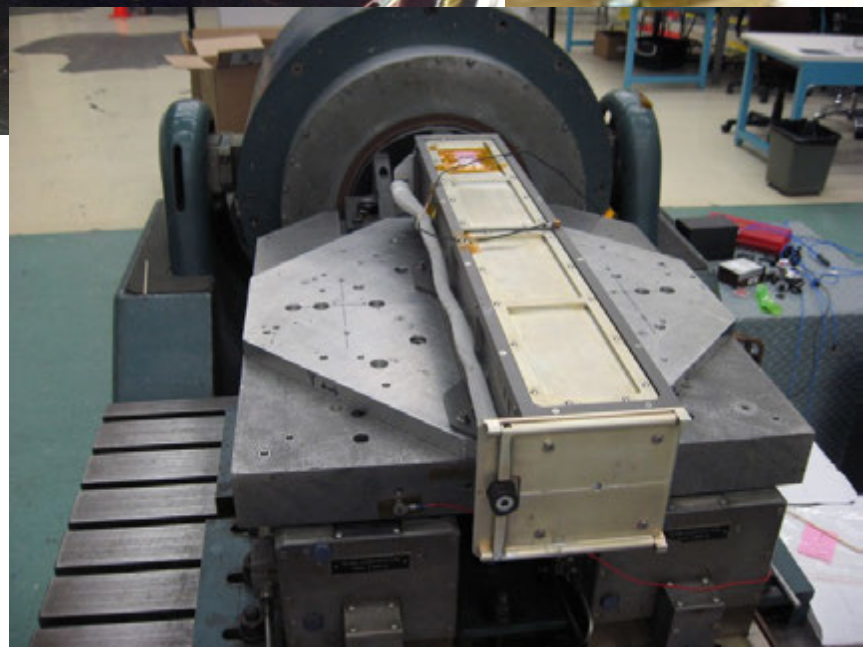
Designing for ISS Safety

Key Attributes

- **Battery/ Power System**
- **Accepted Materials: MAPTIS Database (low qty and off-gassing)**
- **Structural Integrity**
- **Shatterability**
  (e.g., solar cells)
- **Minimize hang-fire issues**
- **Testing at workmanship levels**







Test Test Test!!

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TechEdSat Document Tree/ Process

TechEdSat Project ARC

- Project Plan
  - Requirements
  - SEMP
  - Ground Ops/Safety
  - Flight Ops
  - Test Plan/Procedures
  - TM Summary
    - ODAR
    - SpaceCap Data Form
    - FCC Submittal; Approval
    - SBD Letter of Awareness (Communication system)
- ICD
- PDR (JSC Kickoff)
- CDR
- FRR

ISS Safety (JSC)

- Standard/Reference Safety Document
- ICD Verification
- PSRP Documentation
  - HR/UHR (Hazard Reports)
    - Standard Hazards
      - Sharp edges, Shatterable Materials, Outgasssing, Flammable Materials, Touch Temperature
    - Unique Hazards (4)
      - Battery, Structural Failures, Antenna Deployment, EMI

COC (Certificate of Compliance)

Delivery/Launch

COFR

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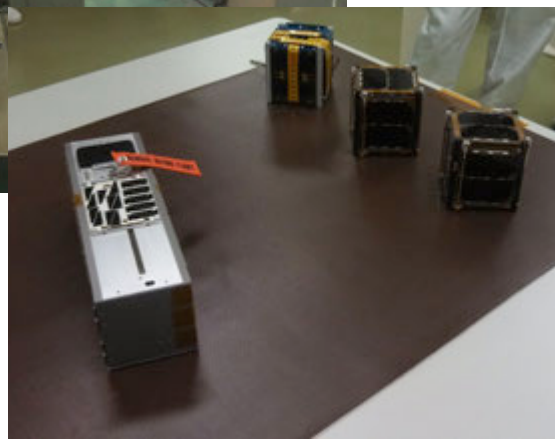
Process for ISS

- **Payload Safety Review Panel (PSRP)**
  - Four phase (0,I,II,III)
- **Hazard Reports**
  - Standard
  - Unique
- **Safety Data Package (SDP)**
- **NASA payload must produce their own SDP; Depending on complexity**
- **For other ‘they might be part of the NanoRacks NRCSD SDP’**
  - However they must pass all the criteria of SHRs and UHRs.



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Selected Documents

JSC Form 1230	Flight Payload Standardized Hazard Control Report for TechEdSat	**Rev August 10, 2010**
NSTS/ISS 13830	Payload Safety Review and Data Submittal Requirements	Rev C July 1998
SSP 52005	Payload Flight Equipment Requirements and Guidelines for Safety-Critical Structures	Rev D, March 2008
SSP 57000	Pressurized Payloads Interface Requirements Document	Rev K June 2010
JMX-2011073NC	JEM Payload Accommodation Handbook - Vol.8-Satellite Deployment Interface (For Technical Demonstration Mission)	Initial Release October 2010
JMX-2011216NC	JEM Remote Manipulator System (JEMRMS) Multi-Purpose Experimental Platform (MPEP) Interface Control Document (ICD) for Payload Users	Rev NC August 2011
EP-03	EP5 Battery Design Evaluation Form for TechEdSat	Rev B
SSP 50223	Standard Payload Integration Agreement for Pressurized Payloads	Rev A
NR-SRD-029	NanoRacks CubeSat Deployer (NRCSD) Interface Control Document (ICD)	Rev 36
N/A	CubeSat Design Specification	Rev 12 (August 2009)

Representative Standard Hazards

TES4 Hazard #	Title	Note	Status
TES4-STD_HR-1	Flammable Materials	Same as TES3-STD_HR-1	Closed to SVTL
TES4-STD_HR-2	Materials Off-Gassing	Same as TES3-STD_HR-2	Closed to SVTL
TES4-STD_HR-3	Mechanical Hazards	N/A per NanoRacks STD-CUBESAT1-001, December 6, 2013.	N/A
TES4-STD_HR-4	Touch Temperature	N/A per NanoRacks STD-CUBESAT1-001, December 6, 2013.	N/A
TES4-STD_HR-5	Shatterable Material Release	Same as TES3-STD_HR-5 (Include reference document: NR-SRD-029 NanoRacks CubeSat ICD Rev 36)	Closed to SVTL
TES4-STD_HR-6	Nonionizing Radiation	N/A per NanoRacks STD-CUBESAT1-001, December 6, 2013 Refer to TIA 1369	N/A
TES4-STD_HR-7	Lasers	N/A per NanoRacks STD-CUBESAT1-001, December 6, 2013	N/A
TES4-STD_HR-8	Noise Exposure	N/A per NanoRacks STD-CUBESAT1-001, December 6, 2013	N/A
TES4-STD_HR-9	Battery Failure	Addition of second flight –approved Canon BP-930 battery. See Unique Hazard Report TES-DOC-ISS-004B in Attachment C	Closed to SVTL

Representative Standard Hazards

TES4-STD_HR-10	Capacitors	Same as TES3-STD_HR-10 See EP-03 form in Attachment C	N/A
TES4-STD_HR-11	Electrical Power	N/A per NanoRacks STD-CUBESAT1-001, December 6, 2013	N/A
TES4-STD_HR-12	Mating/Demating	N/A per NanoRacks STD-CUBESAT1-001, December 6, 2013	N/A
TES4-STD_HR-13	Rotating Equipment	N/A per NanoRacks STD-CUBESAT1-001, December 6, 2013	N/A
TES4-STD_HR-14	Interference with Translation Paths	N/A per NanoRacks STD-CUBESAT1-001, December 6, 2013	N/A
TES4-STD_HR-15	Structure Failure	Same as TES3-STD_HR-14. See Unique Hazard Report TES-DOC-ISS-005	Closed to SVTL
TES4-STD_HR-16	Structural Failure of Sealed Containers	N/A	N/A
TES4-STD_HR-17	Structural Failure of Vented Containers	Same as TES4-STD_HR-17	Closed to SVTL

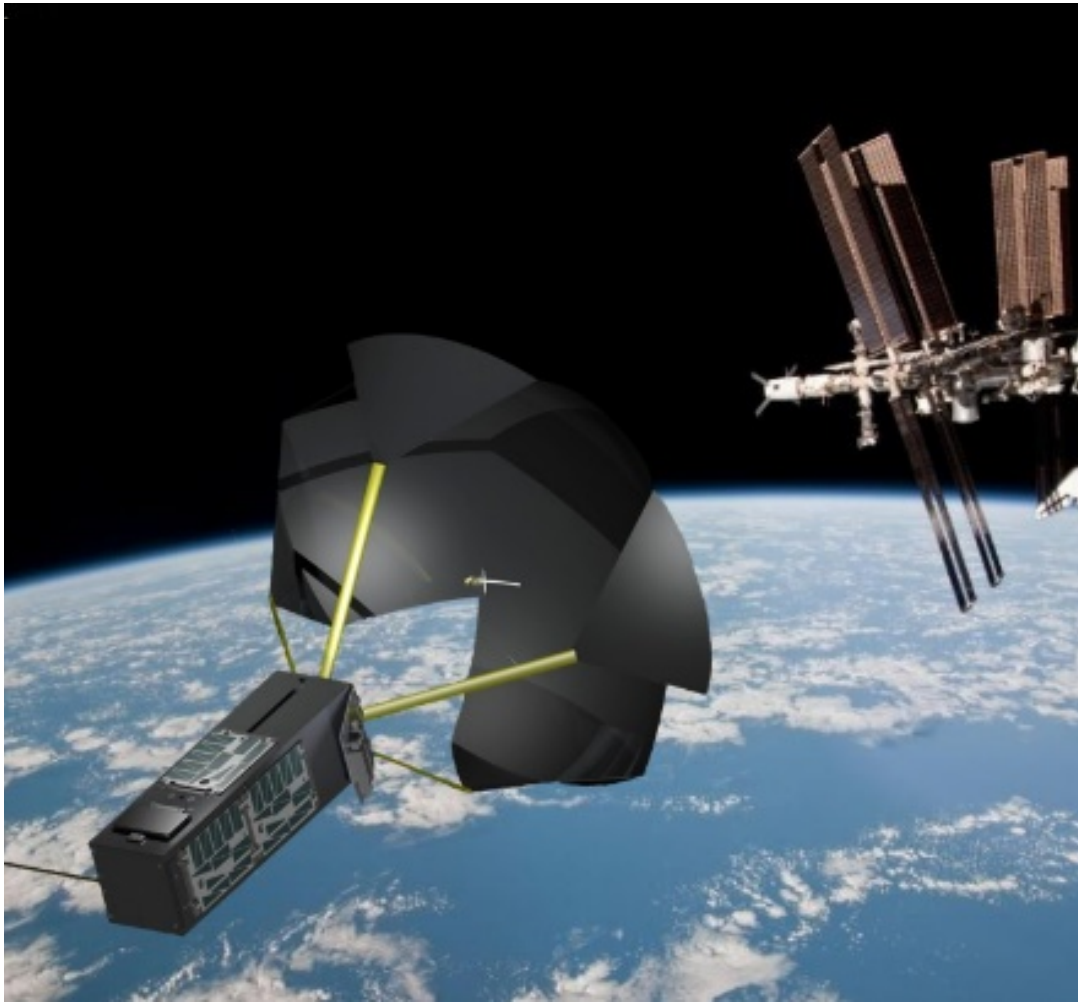
Representative Unique Hazards

Document #	Description	Notes
TES3-DOC-ISS-005C Updated to TES4-DOC-ISS-005B (in TES4_622_Attachment C_UHRS_RevA)	Structural Failure inside J-SSOD/NRCSD	Test report (TES4-TEST-ENV-009E) Fracture/Fastener Control Plan (TES4-DOC-ISS-006A) Closed to SVTL
TES3-DOC-ISS-003B	Satellite communication devices release of non-ionizing radiation	Withdrawn for TES-3p Not Applicable
TES-DOC-ISS-004B Updated to TES4-DOC-ISS-004B (in TES4_622_Attachment C_UHRS_RevA)	Rupture/Leakage of Li-Ion Battery (formerly: Rupture of Li-Ion battery and escape of electrolyte or build-up of gasses could lead to explosion. Battery description: 7.4 Volts Li-Ion, Canon, Model BP-930 with a capacity of 3AH) Difference from TES-3p: TES-4 has two batteries in parallel	EP-03 Submitted J.Jeevarajan (signed 3-19-14)
TES3-DOC-ISS-007B	Impact/collision due to inadvertently deployed hardware [inadequate satellite deployment]	Not Applicable There is no 'hangfire' concern with the NRCSD because it has a smooth internal bore and the jettison plate does not 'hang'

What is Next?

TechEdSat 5

- **Modulated Exo-Brake**
- **Target Area at Von Karman Altitude**
- **Active control (uplink/ downlink)**



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What is Next?

ISS Sample Return

SPQR-Small Payload Quick Return

- **3 stage concept**
- **On-demand sample return**

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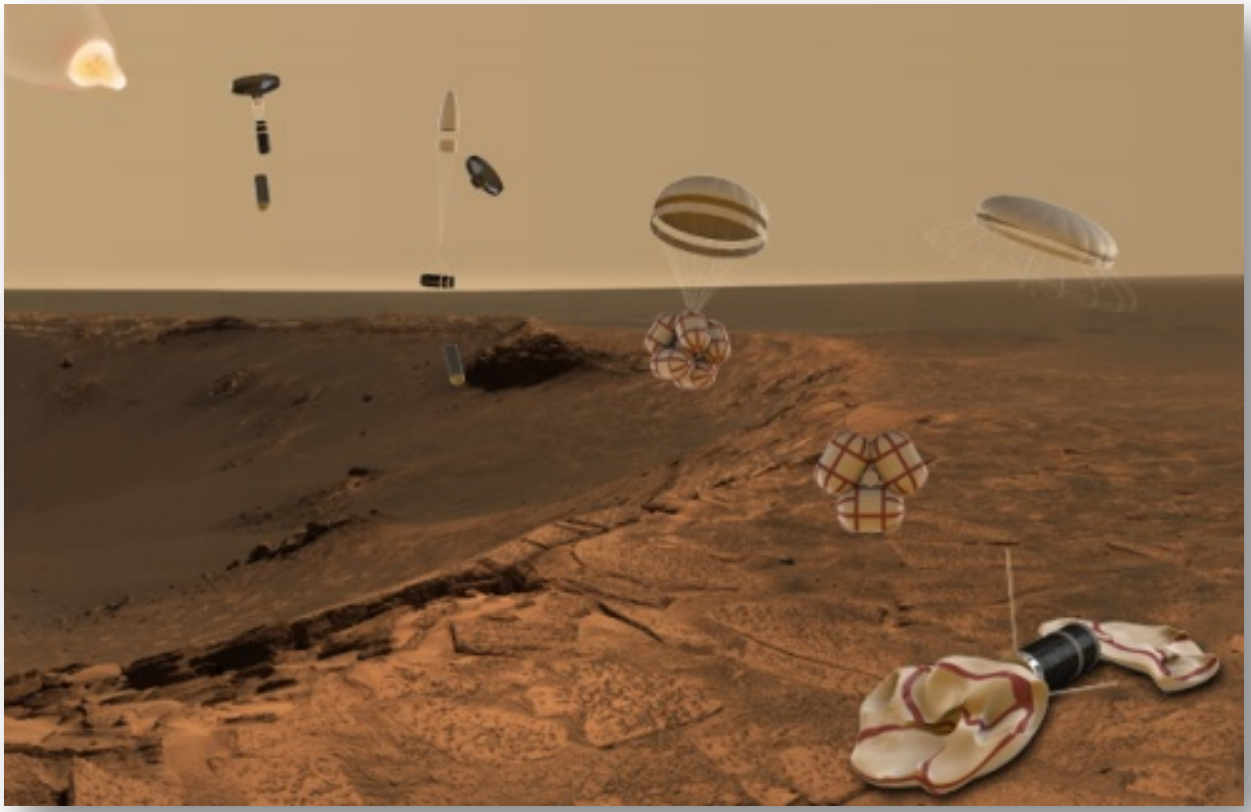
What is Next?

Atromos: Cubesat Mission to the Surface of Mars



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Summary

- **TES-N series has helped to train ~40 individual now at NASA, SpaceX, Boeing, Lockheed and …Start-ups!**
- **Several 'Firsts' for ISS deployed experiments**
- **Numerous Technologies Advanced**
  - COM
  - Fabrication
  - De-Orbit Systems
  - Architecture
- **Pioneered Safety Processes for Satellite Jettison**
- **Future Work leads to ISS Sample Return, Advance Re-entry Development ….. And Mars!**