TECHEDSAT-7 AND 10 THE LITTLE SPACECRAFT THAT COULD

PRESENTED BY REINE NTONE JOHANSEN ON BEHALF OF MARCUS MURBACH

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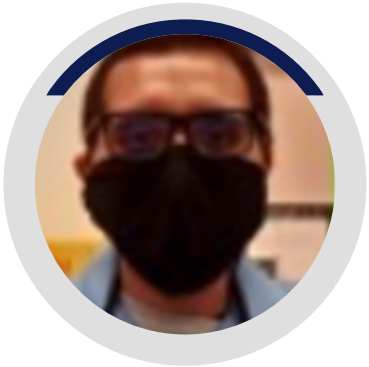
TES/NOW TEAM

TECHEDSAT/NOW TEAM [1/2]

MARCUS MURBACH

Principal Investigator

Program Manager



ALEJANDRO SALAS

Software Engineer

AVERY BROCK

Electrical Engineer

REINE NTONE JOHANSEN

Systems Engineer

TECHEDSAT/NOW TEAM [2/2]

CEDRIC PRISCAL

Software Engineer

SAMUEL ZUNIGA

Mechanical Engineer

JOSE ALVARELLOS

Orbital Mechanics Engineer

THOMAS HECTOR

Quality Assurance Officer

OUTLINE

BACKGROUND

PART 1: TECHEDSAT-7 MISSION

- Overview

PART 2: TECHEDSAT-10 MISSION

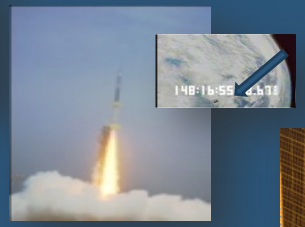
- Overview
- Mission OPS
- Reentry Data

PART 3: MARS & SAMPLE RETURN

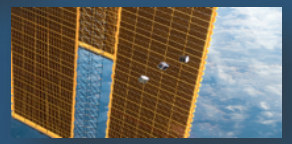
BACKGROUND

RELEVANT FLIGHT EXPERIMENTS

SOAREX-6
(2008)



SOAREX-7
(2009)



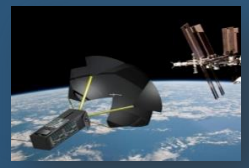
TES-1
Oct 4, 2012

SOAREX/TechEdSat-N Team

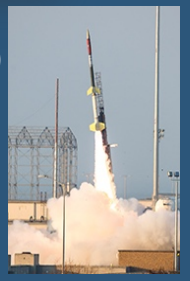
Flight Experiments of Recent Years (2008-2020): 10+ Flights

TES-2
PhoneSat
Iridium-test
Aug 21, 2013

TES-3
Aug 3, 2013
(6 wk de-orbit)



TES-4
Mar 3, 2015
(4 wk de-orbit)



SOAREX-9
(March 7, 2016)

T5/P5
Mar 6, 2017
(19 wk de-orbit)

T8/P8
Jan 31, 2019

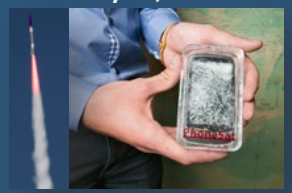
…here before

SOAREX-8
(2015)

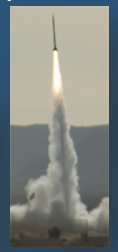
PhoneSat Team

Flight Experiments of Recent Years (2009-2015)

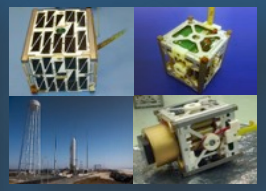
Balloon
June 9, 2011



Intimidator-5
July 29, 2010

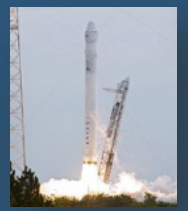


SpaceLoft-6
Apr 5, 2012

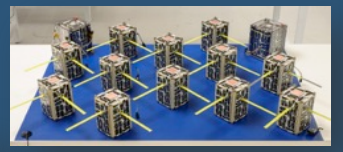


PhoneSat 1a,
1b, 2.0
Antares A-ONE
Apr 21, 2013

PhoneSat 2.4
ORS-3 Minotaur 1
Nov 20, 2013
(still in orbit)



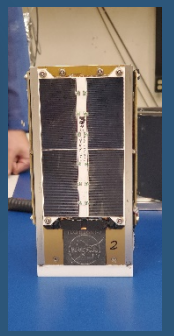
PhoneSat 2.5
CRS-3 Falcon 9
Apr 18, 2014



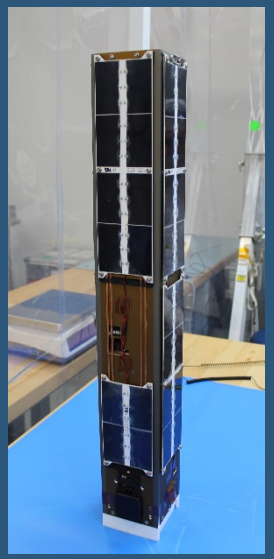
EDSN
Super Strypi
Oct 29, 2015

Nodes
Orb-4 Atlas V
Dec 3, 2015

SOAREX-8
Terrier/Black Brant
July 7, 2015



T7/P7
Jan 17, 2021

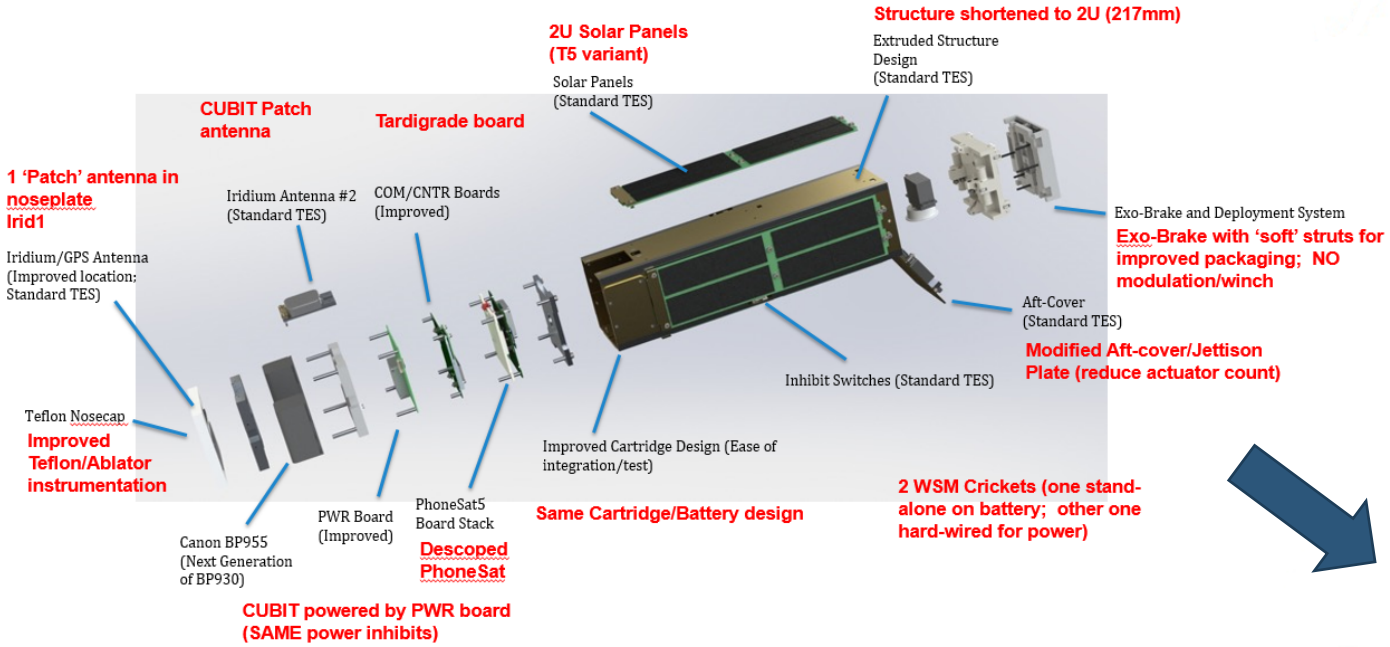


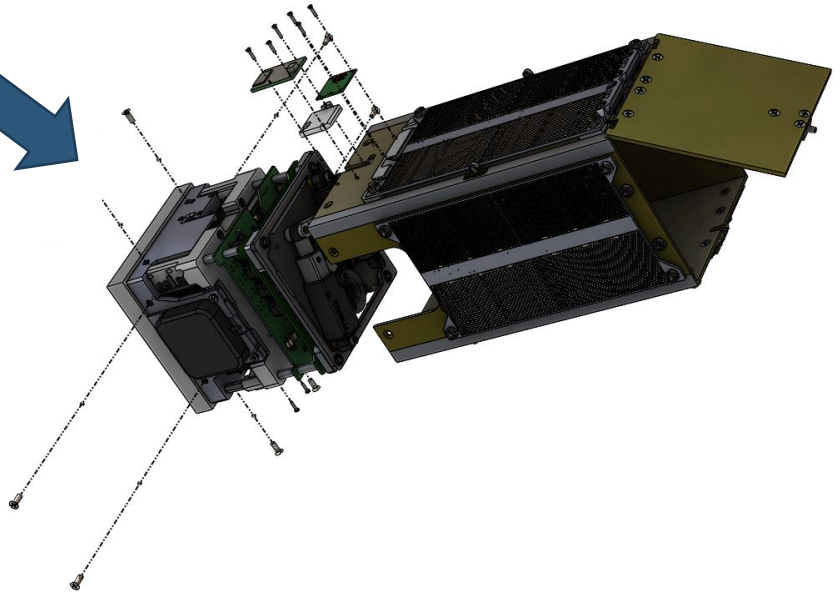
T10/P10
Feb 15, 2020

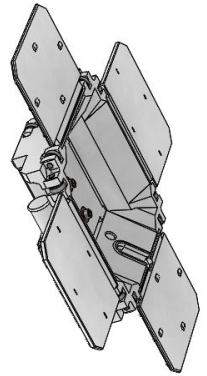
PART 1

TECHEDSAT-7 MISSION

OVERVIEW/LAYOUT







Changes – TechEdSat-6 & TechEdSat-7

Objectives: Advanced communication, compact exo-brake, rad-tolerant omni-board development, optical identification.

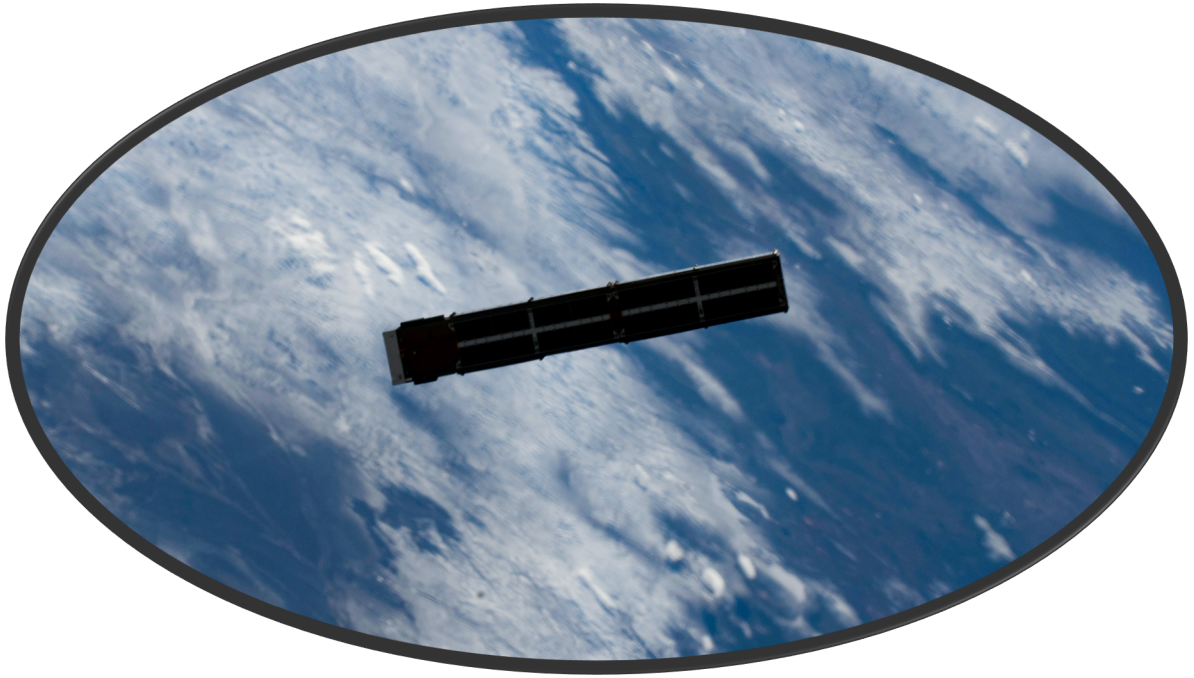
TechEdSat-7

PART 2

TECHEDSAT-10 MISSION

TECHEDSAT-10 DEPLOYMENT

- TechEdSat-10 was deployed from ISS on **July 13, 2020**
- TLE number was 45917



TES-10 t+50secs after Jettison Event

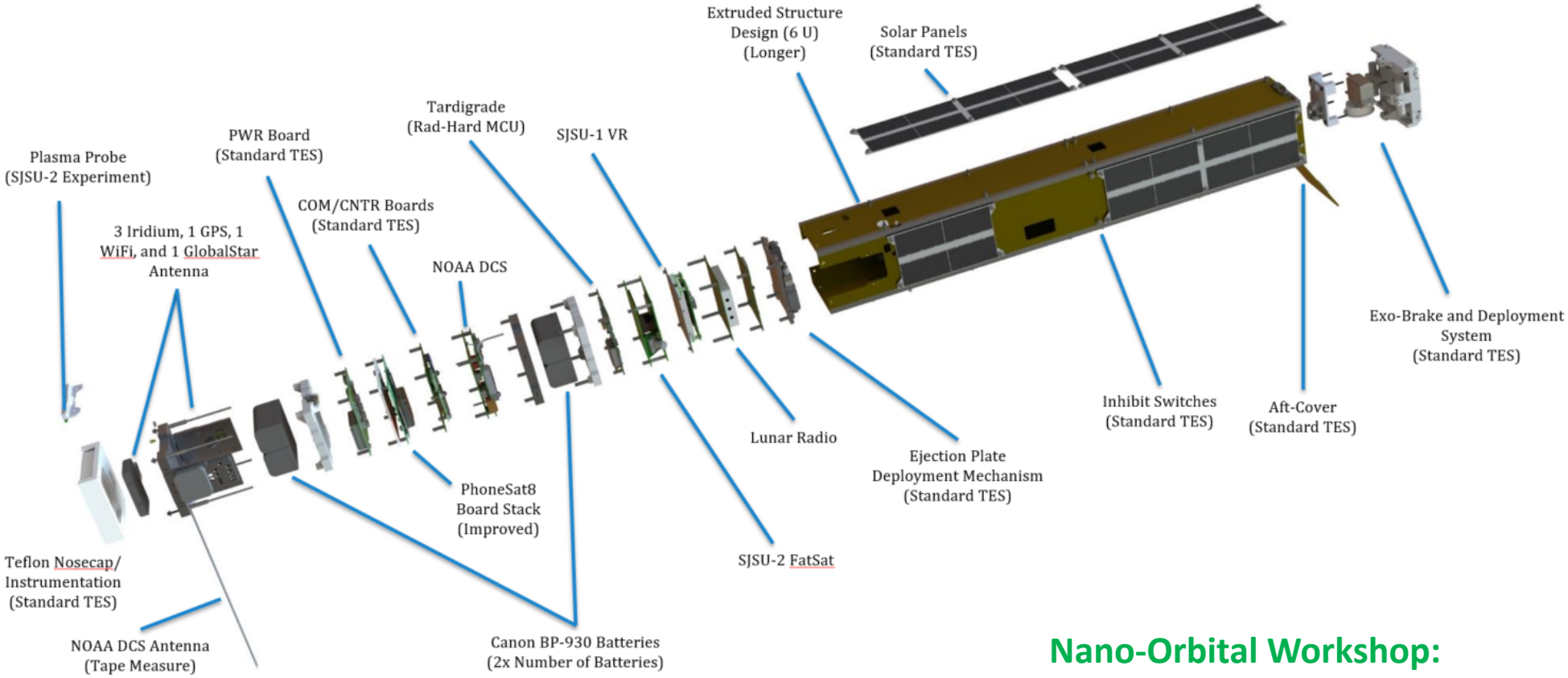
TES-10 – Environmental testing

SUCCESS CRITERIA

TES-10 ACHIEVED COMPREHENSIVE SUCCESS

- Minimum: Successful avionics system/Tracking; Exo-Brake/ NOAA minimum function
- Nominal: (Plus)Successful multiple modulations of Exo-Brake/ 1 orbit DCS Pass
- **Comprehensive**: Targeting to LOS from WFF; (Plus) Minimum capability of Secondary Tier capability

OVERVIEW/LAYOUT



TechEdSat-10

Nano-Orbital Workshop:

-Most 'powerful' NASA 6U (150W-hr)

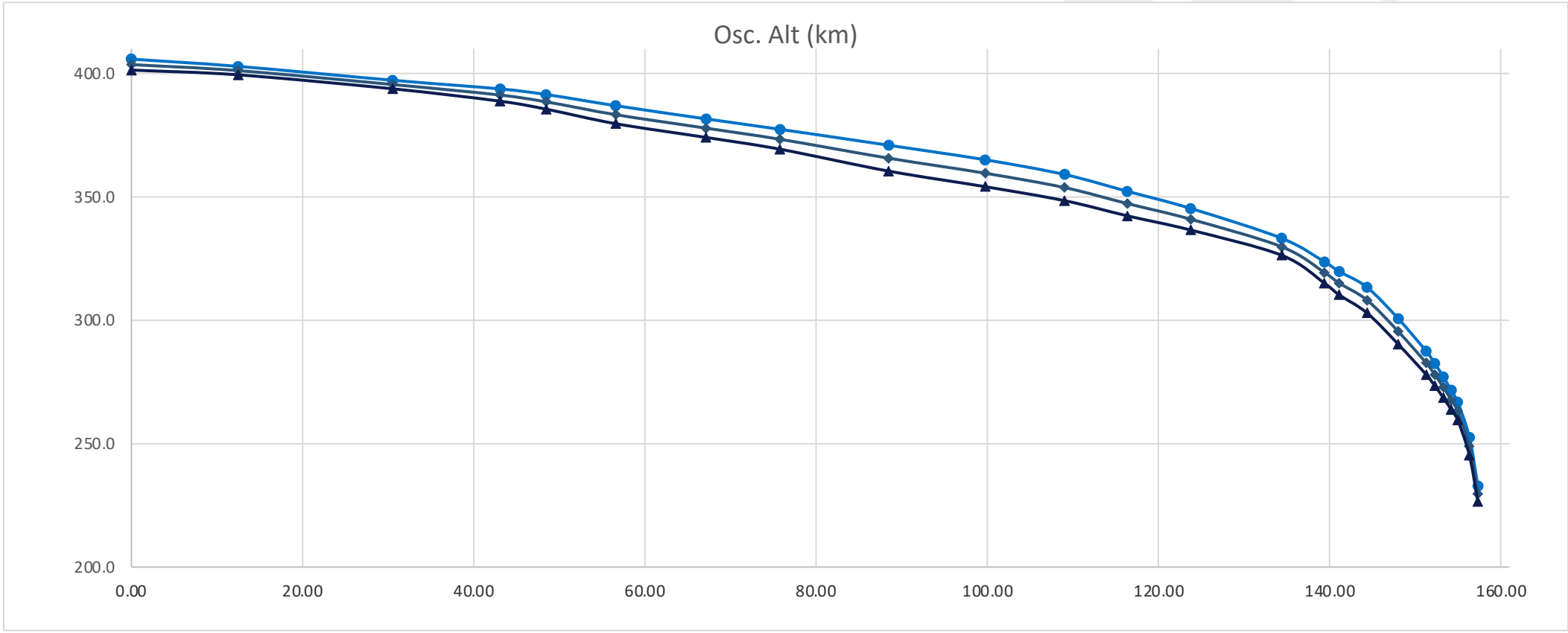
-Most vociferous (8 radios – UHF, L, S, ISM bands)
Internal/ external Wifi; Zigbee

-**Most 'brains'** (8 processors, NVIDIA TX2 GPU)

-**Most cameras** (4 including VR experiment)

-Most Exo-Brake (largest one to-date; targeting)

TECHEDSAT-10 ALTITUDE EVOLUTION



Days since 10-Oct-2020

TECHEDSAT-10 RE-ENTRY

- TechEdSat-10 re-entered on **15-March-2021**
  - Its re-entry was controlled, as it followed a command sent 15-March-2021, 01:57 UTC to activate the exo-brake (*here we need to give credit to Sanny Omar, who computed the exobrake activation time – Omar, S. R. Bevilacqua, Guidance, navigation and control solutions for spacecraft re-entry point targeting using aerodynamic drag, Acta Astronautica 155 (2019), pp 389-405*).
- 18 Space Control Squadron estimated with a 75-80% chance TechEdSat-10 re-entered (i.e., altitude = 10 km) some time between 08:19-08:49 UTC

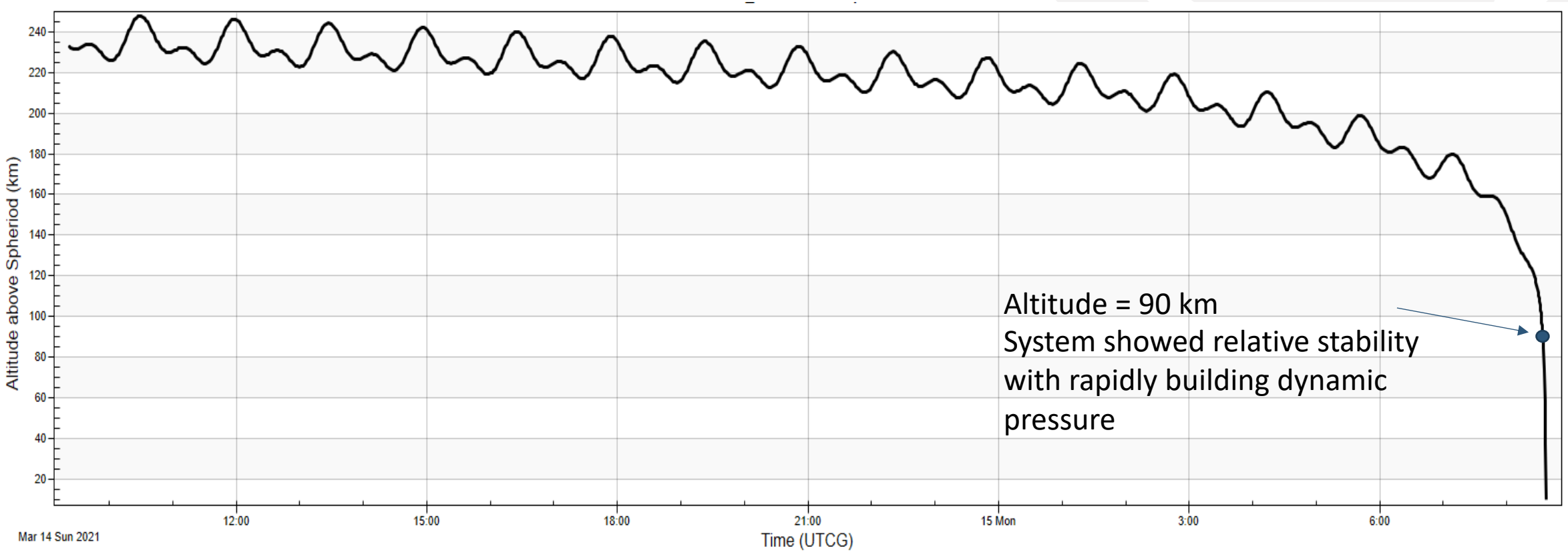
TECHEDSAT-10 RE-ENTRY (CONT.)

- Last TechEdSat-10 data packet was received 15-March-2021, 08:33:57 UTC
- Associate this altitude with 90 km
- Iterate on the post-exobrake drag area until altitude at 15-March-2021, 08:33:57 UTC equals 90 km
- A post-exobrake drag area of 0.40573 m**2 best fits these data (a 30.7% increase wrt pre-exobrake activation):

Time (UTCG)	Altitude (km)	Latitude (deg)	Longitude (deg)	Flight_Path_Angle (deg)	V_Mag (km/sec)	AltitudeRate (km/sec)	LatitudeRate (deg/sec)
3/15/2021 8:33:56.7	90.10	-50.295	11.531	-1.234	7.286293	-0.151148	-0.015838
3/15/2021 8:33:57.7	89.95	-50.311	11.625	-1.245	7.275773	-0.152291	-0.015733
3/15/2021 8:33:58.7	89.79	-50.326	11.718	-1.256	7.265224	-0.153454	-0.015628
3/15/2021 8:34:05.0	88.80	-50.423	12.308	-1.328	7.199298	-0.16133	-0.014969
3/15/2021 8:34:29.6	84.38	-50.761	14.572	-1.685	6.955155	-0.199951	-0.01253
3/15/2021 8:35:12.3	73.97	-51.213	18.387	-2.581	6.575552	-0.292951	-0.008725
3/15/2021 8:35:56.0	58.57	-51.518	22.144	-3.842	6.238283	-0.416062	-0.005319
3/15/2021 8:36:39.6	37.32	-51.684	25.745	-5.424	5.948044	-0.561427	-0.002341
3/15/2021 8:37:22.3	10.00	-51.728	29.127	-7.264	5.704975	-0.721383	0.000225

TECHEDSAT-10 RE-ENTRY (CONT.)

- TechEdSat-10 Altitude vs. time



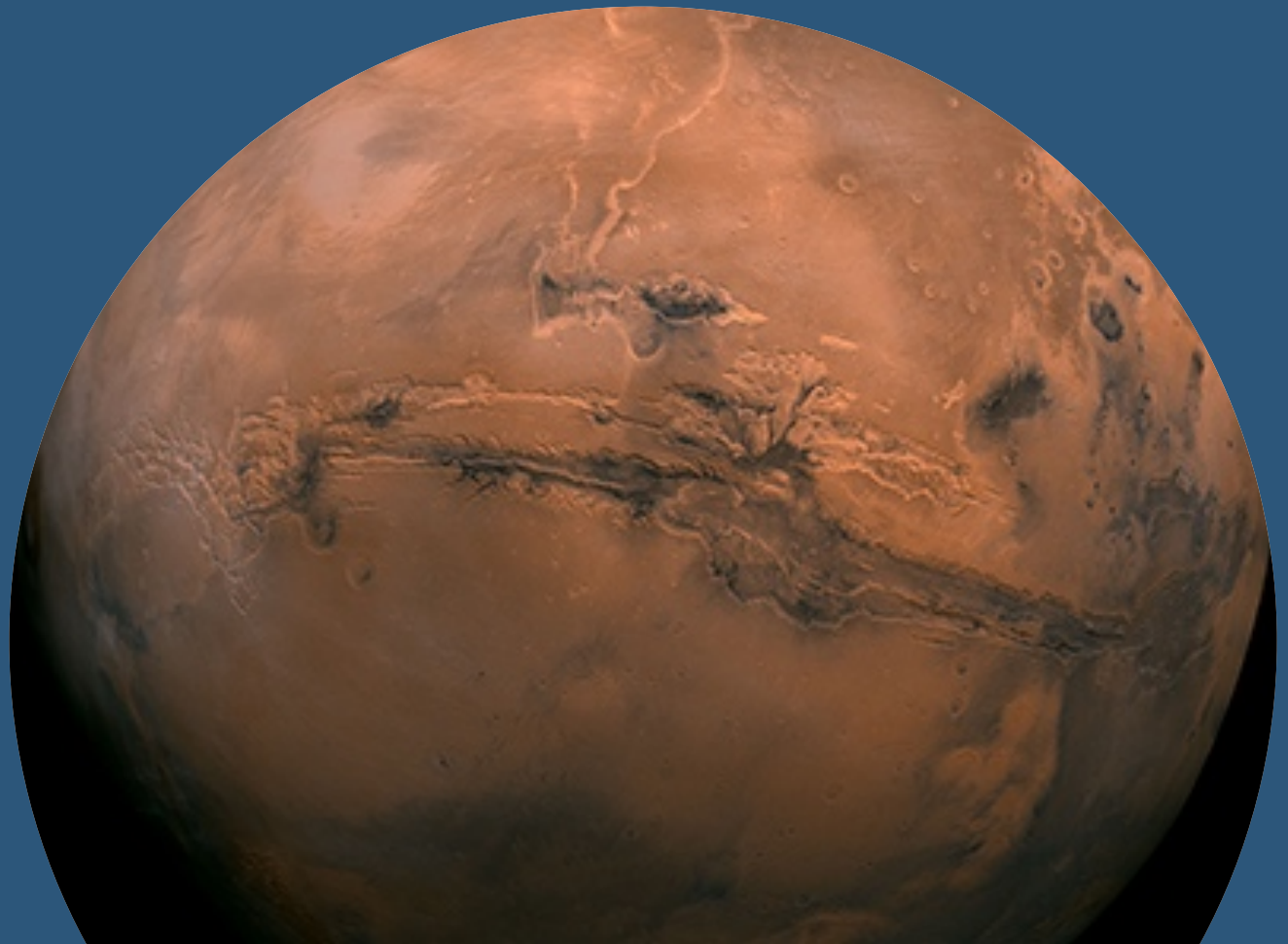
TECHEDSAT-10 RE-ENTRY (CONT.)

TES-10 SUMMARY

- TechEdSat-10 re-entered on 15-March-2021, following a command to activate its Exobrake on 15-March-2021, 01:57 UTC
- Based on the assumption that the time of last data packet reception (08:34 UTC) corresponds to an altitude of 90 km, we conclude that the post-exobrake activation drag area increased by **30.7%** per command.
- Second ‘modulated drag’ targeting experiment – with future application to on-orbit sample return, aero-pass maneuvers, etc.
- Experiments were successfully conducted.

PART 3

MARS & SAMPLE RETURN

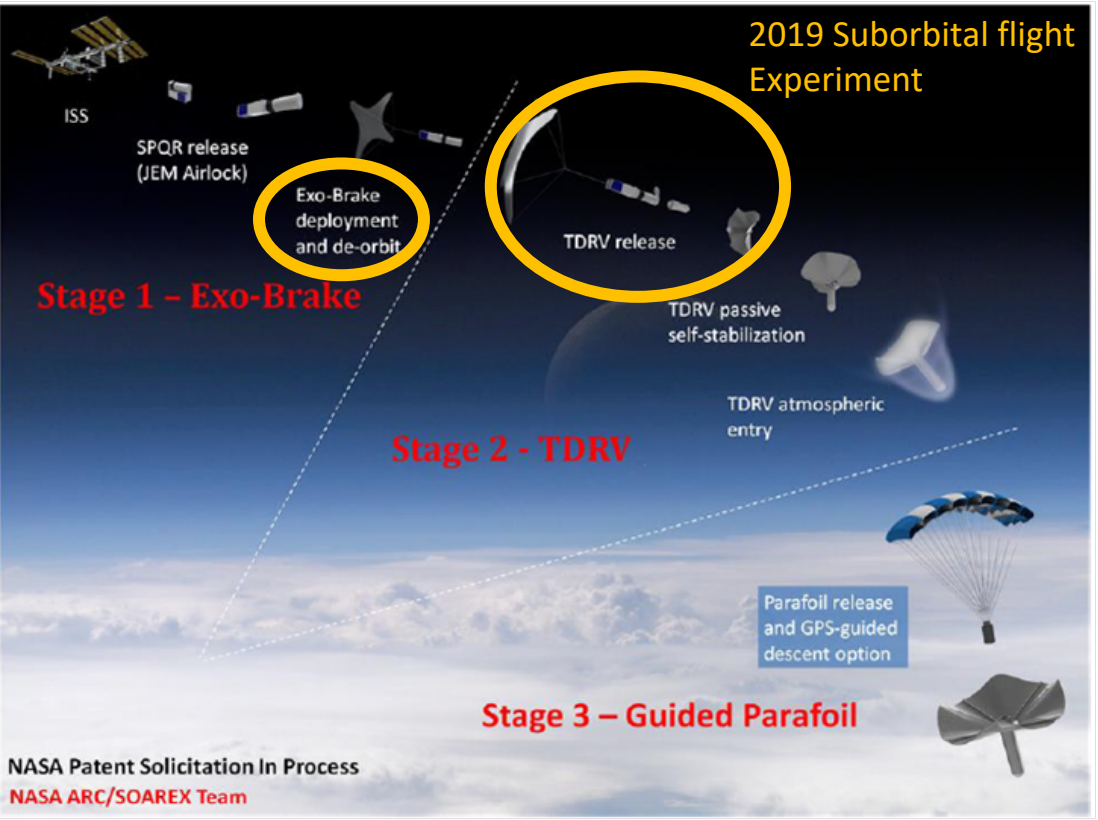


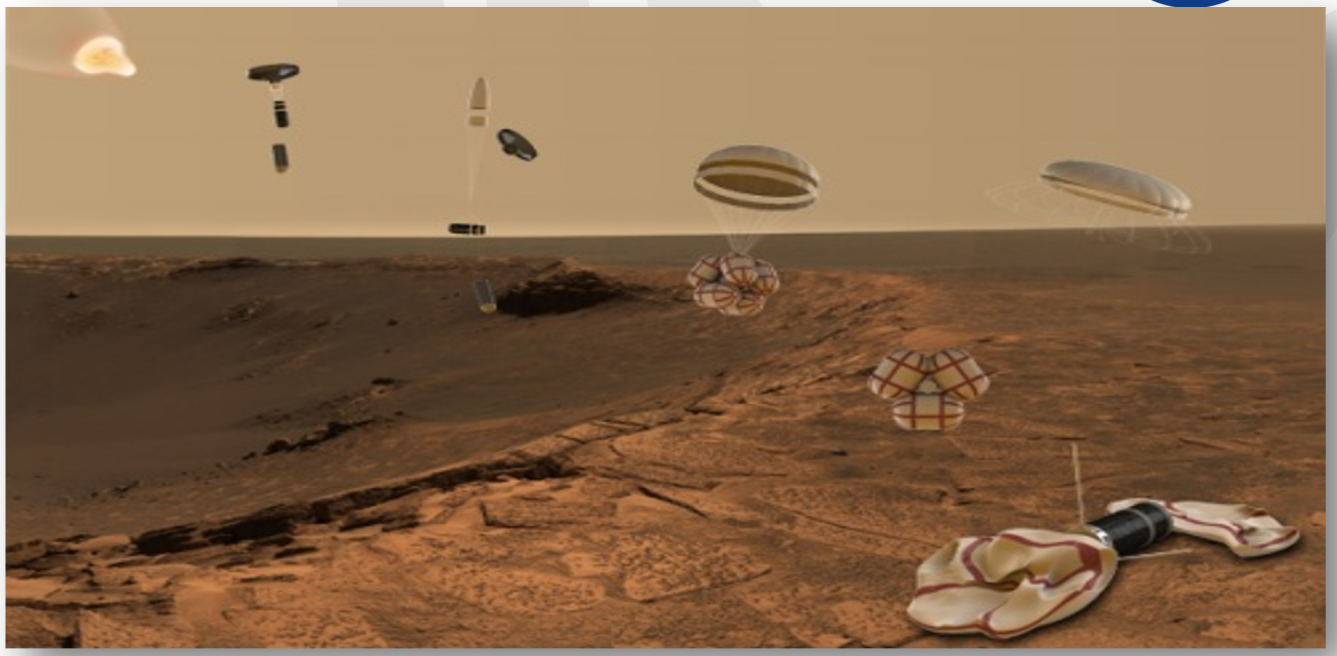
MARS & SAMPLE RETURN

ISS EDL Capabilities For Future Missions

SPQR-Small Payload Quick Return

- ❑ 3 stage concept
- ❑ Develop and Test Inexpensive deep-space/Mars surface science technologies/missions





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

THANK YOU!

QUESTIONS?