



# TECHEDSAT-7 AND 10 THE LITTLE SPACECRAFT THAT COULD

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OF MARCUS MURBACH

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TES/NOW TEAM





# TECHEDSAT/NOW TEAM [1/2]



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# TECHEDSAT/NOW TEAM [2/2]



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# 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

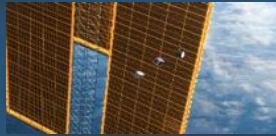
### SOAREX/TechEdSat-N Team Flight Experiments of Recent Years (2008-2020): 10+ Flights



SOAREX-6  
(2008)



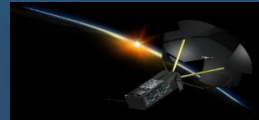
SOAREX-7  
(2009)



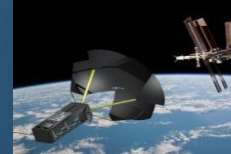
TES-1  
Oct 4, 2012



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)



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)

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

SpaceLoft-6  
Apr 5, 2012



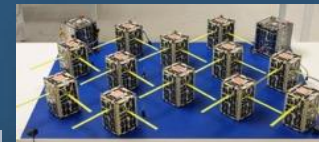
PhoneSat 2.4  
ORS-3 Minotaur 1  
Nov 20, 2013  
(still in orbit)



PhoneSat 2.5  
CRS-3 Falcon 9  
Apr 18, 2014



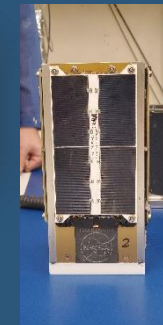
SOAREX-9  
(March 7, 2016)



EDSN  
Super Strypi  
Oct 29, 2015



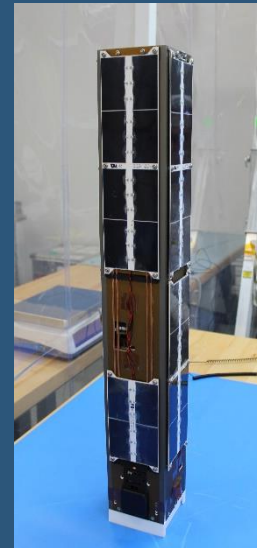
Nodes  
Orb-4 Atlas V  
Dec 3, 2015



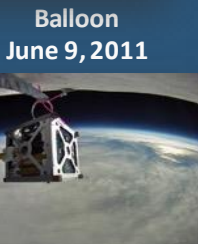
T7/P7  
Jan 17, 2021



SOAREX-8  
Terrier/Black Brant  
July 7, 2015



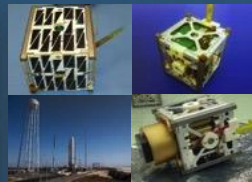
T10/P10  
Feb 15, 2020



Intimidator-5  
July 29, 2010



Balloon  
June 9, 2011





# PART 1

## TECHEDSAT-7 MISSION

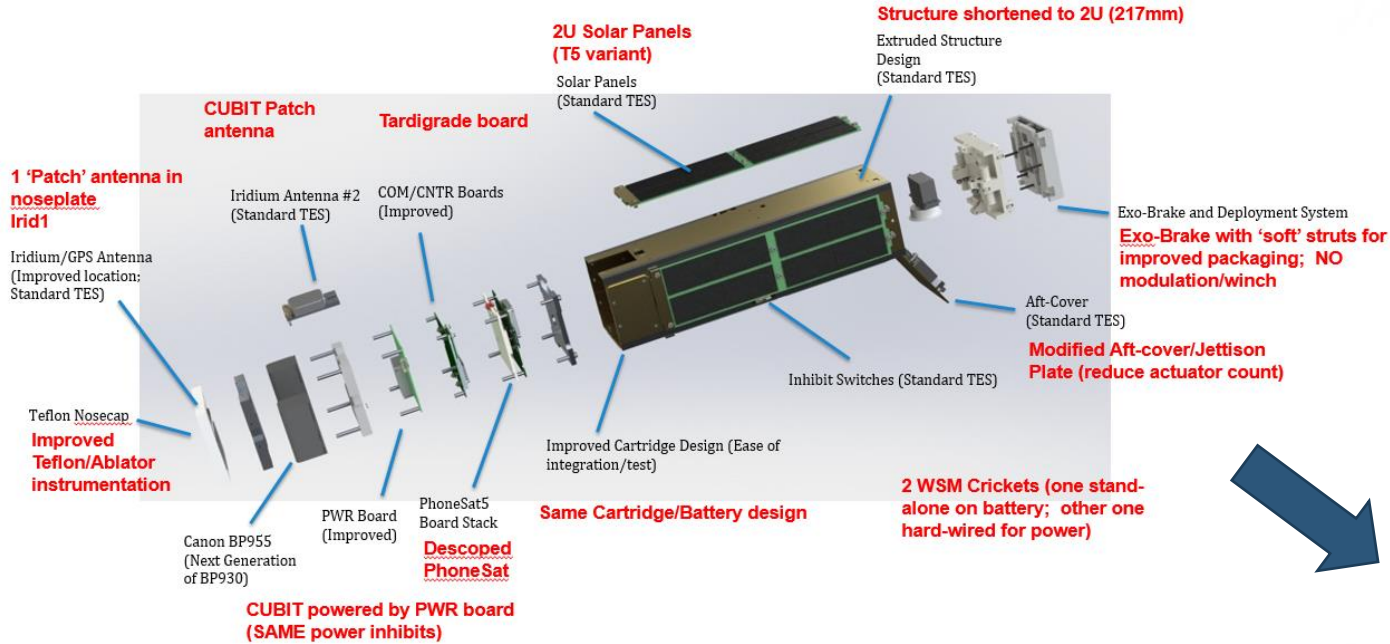


# OVERVIEW/LAYOUT

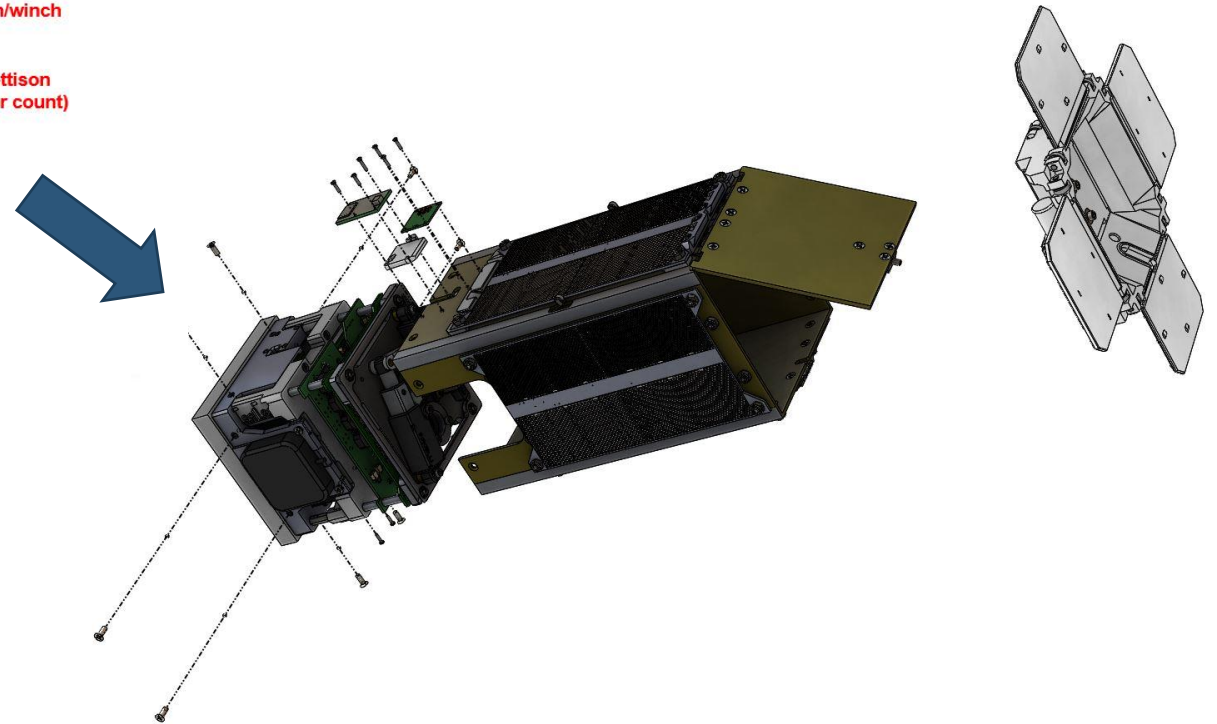


## Objectives:

- Advanced communication
- Compact exo-brake
- Rad-tolerant omni-board development
- Optical identification



Changes – TechEdSat-6 & TechEdSat-7



TechEdSat-7

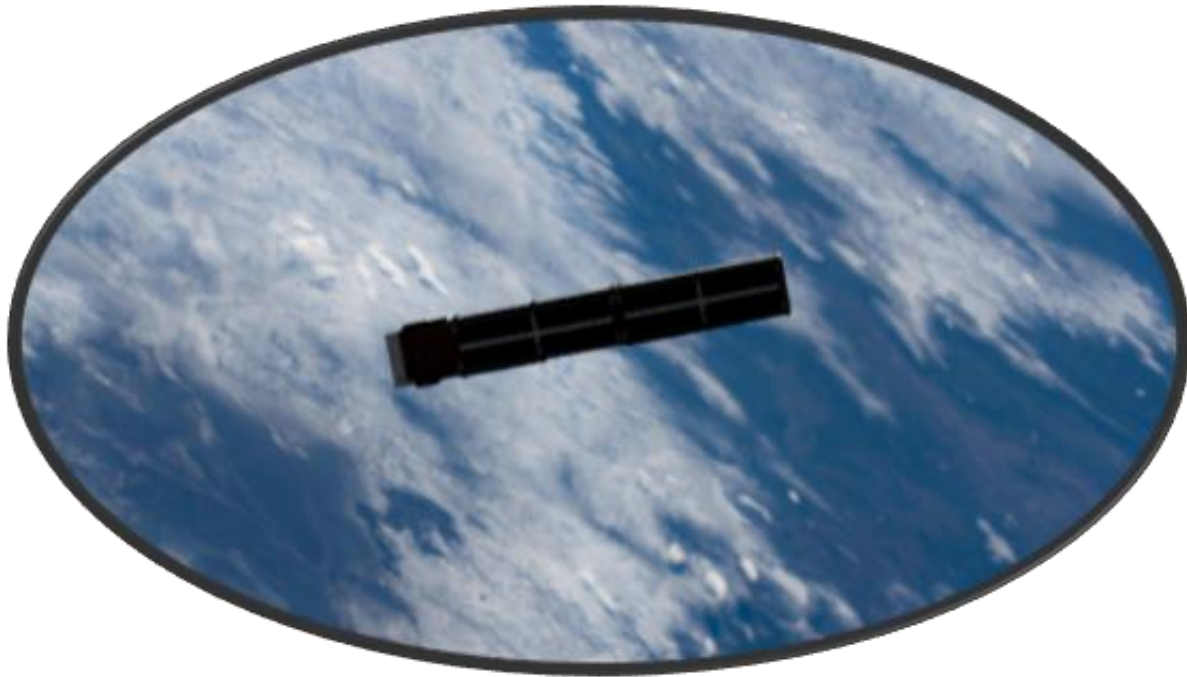


# PART 2

## 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*

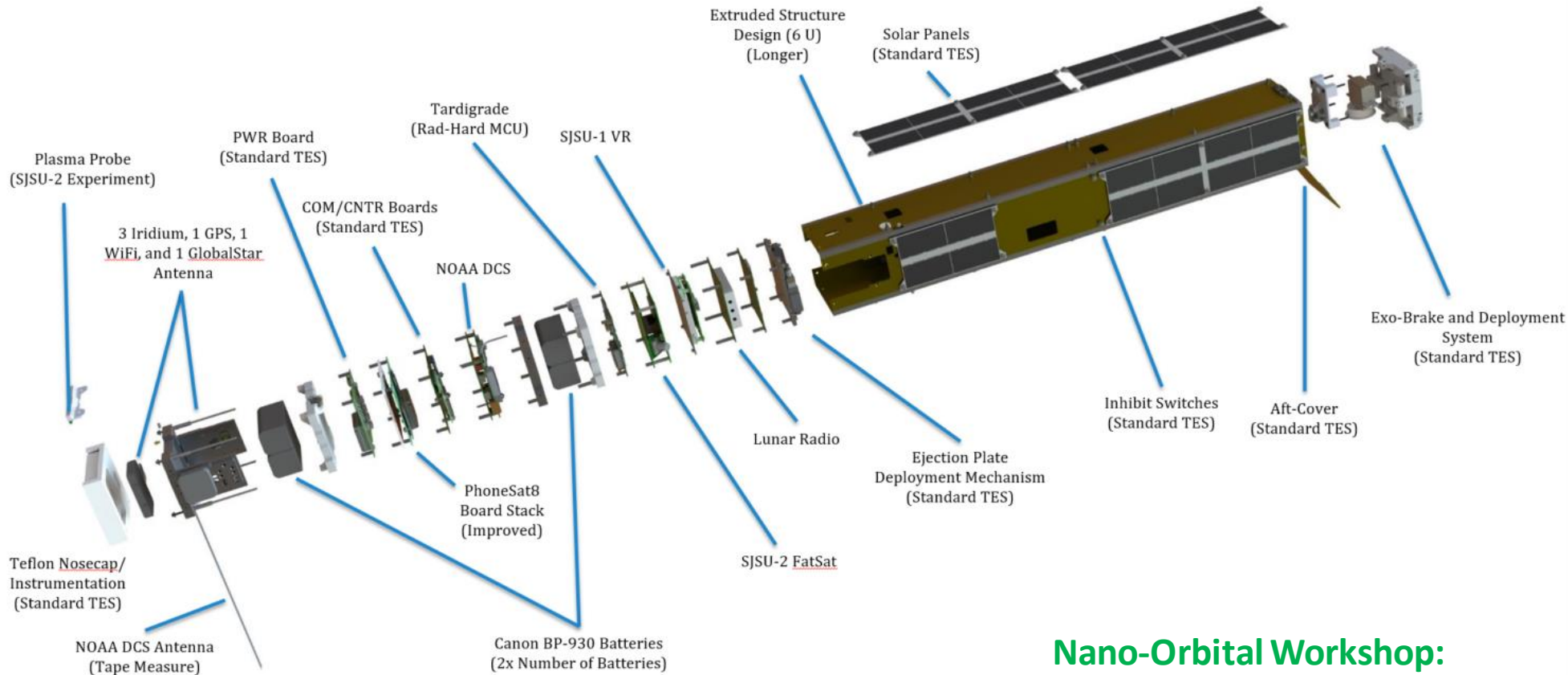


# SUCCESS CRITERIA

## 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



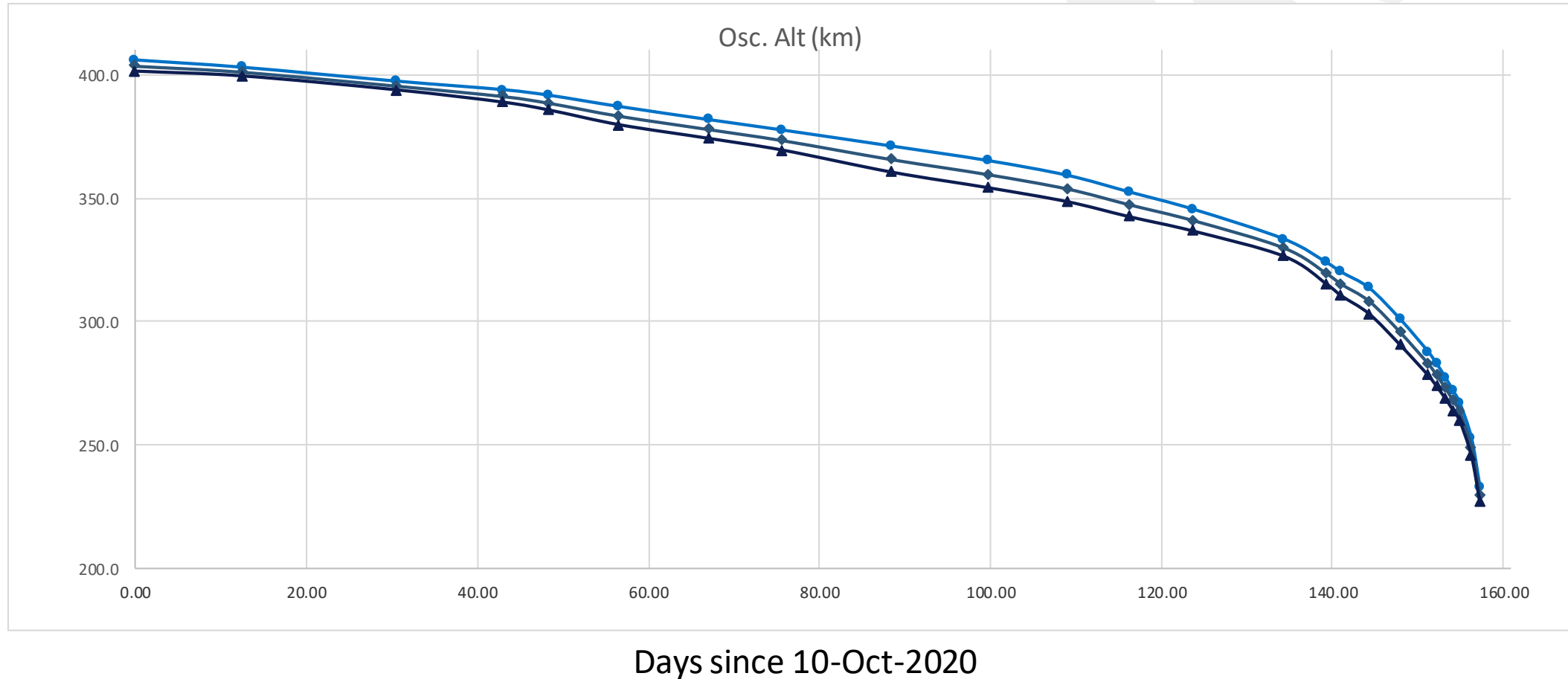
*TechEdSat-10*

## 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





# TECHEDSAT-10 RE-ENTRY

- TechEdSat-10 re-entered on **15-March-2021**
  - Its re-entry was controlled, as it followed a command **TO ACTIVATE EXO-BRAKE ON** 15-March-2021, 01:57 UTC (*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 75-80% certainty that TechEdSat-10 re-entered (i.e., altitude = 10 km) some time between 08:19-08:49 UTC



# TECHEDSAT-10 RE-ENTRY (CONT.)

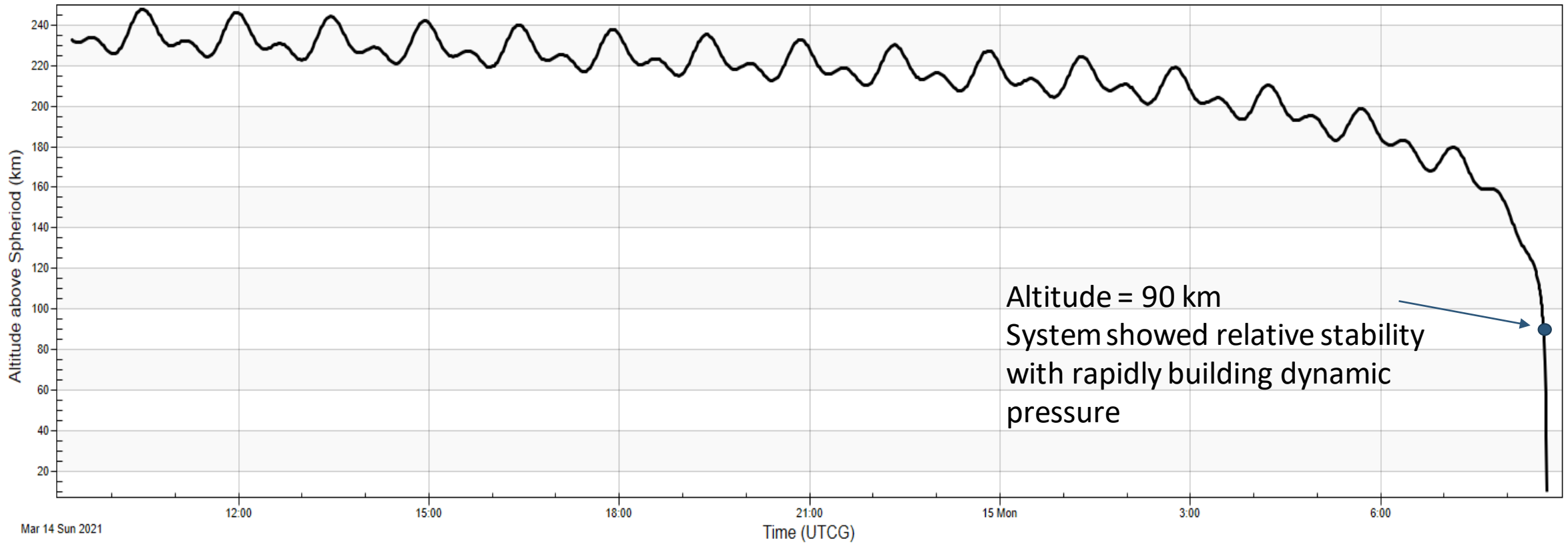
- Last TechEdSat-10 data packet was received on 15-March-2021, 08:33:57 UTC
- Associate this altitude with 90 km
- Iterate on the post-Exobrake **ACTIVATION** drag area until altitude equals 90 km on 15-March-2021, 08:33:57 UTC
- A post-exobrake drag area of  $0.40573 \text{ m}^2$  best fits these data (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

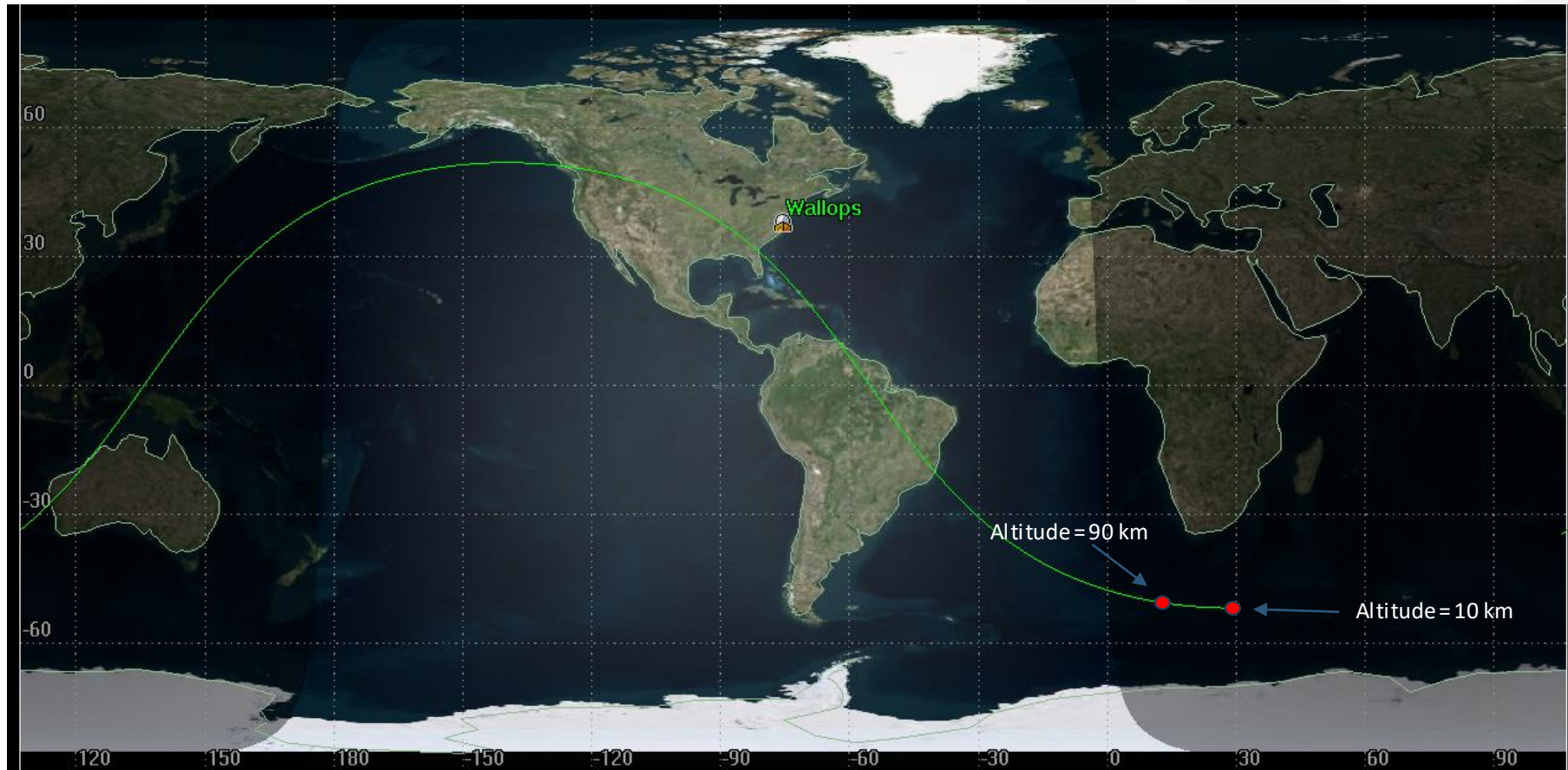


Mar 14 Sun 2021

Time (UTC)



# TECHEDSAT-10 RE-ENTRY (CONT.)





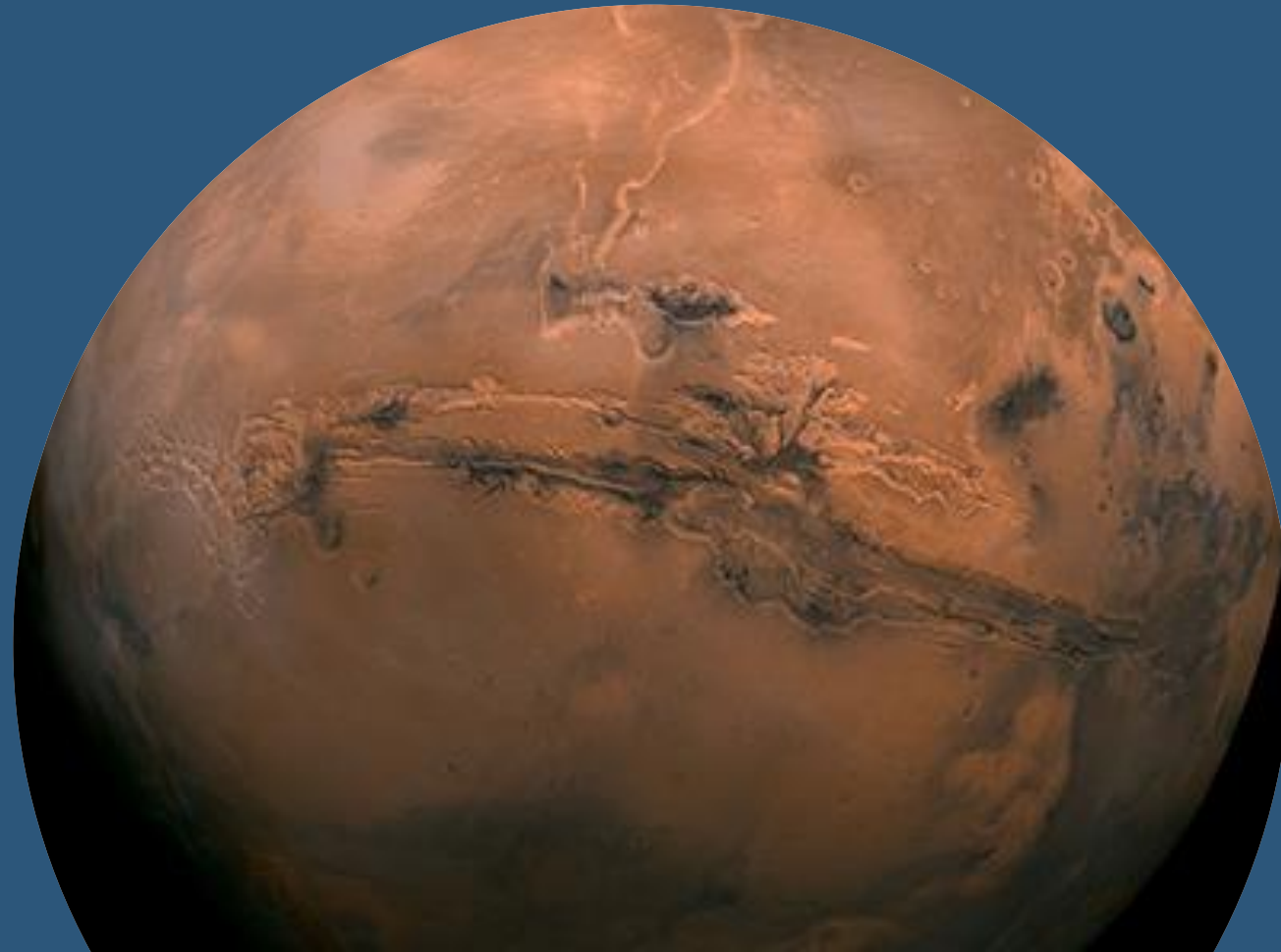
# TES-10 SUMMARY

- 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



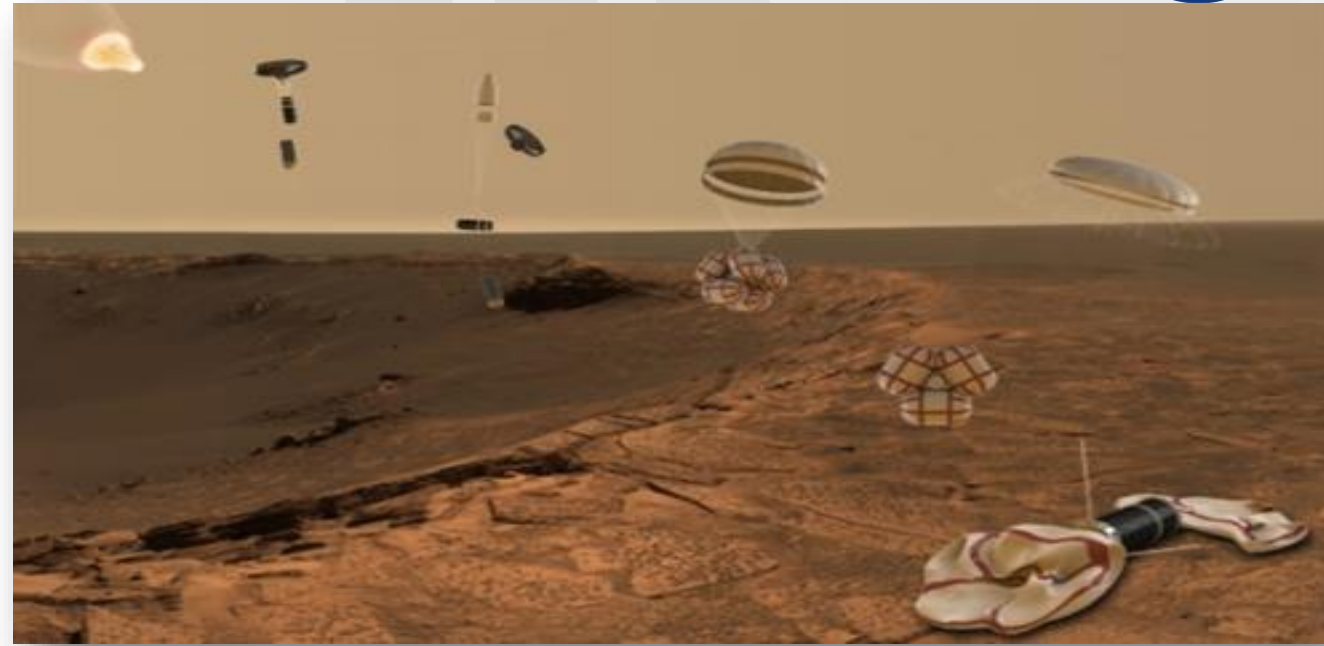
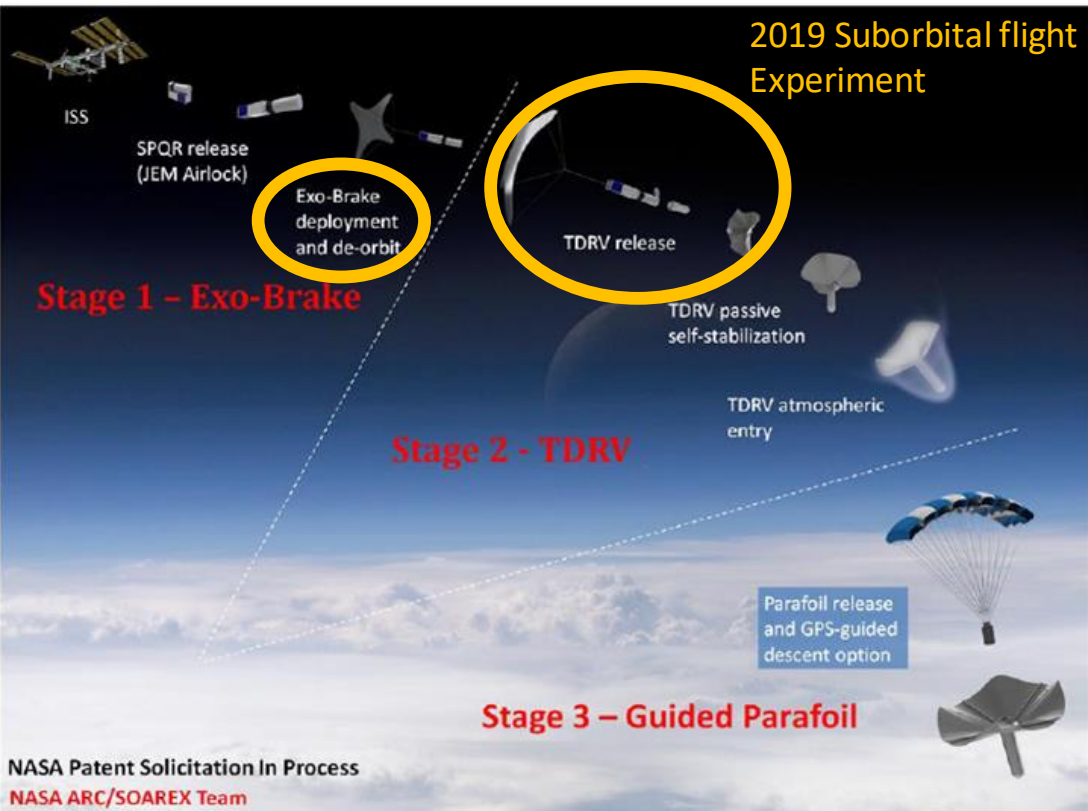
# MARS & SAMPLE RETURN



## 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!

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QUESTIONS?