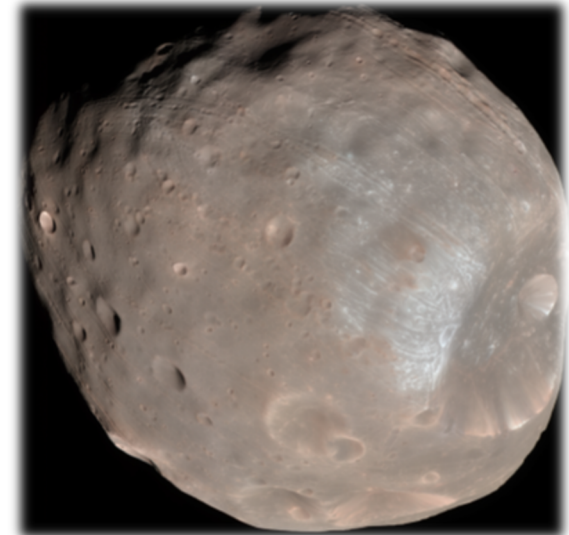
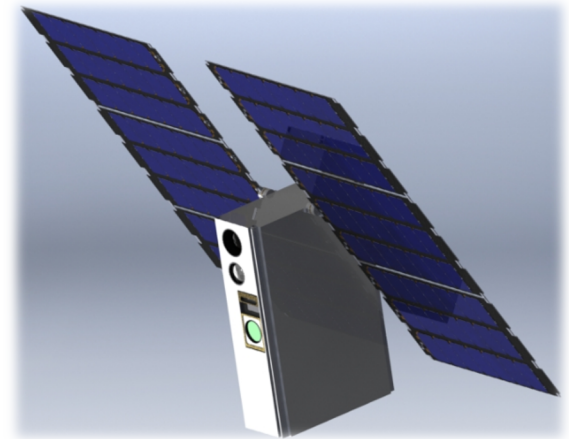
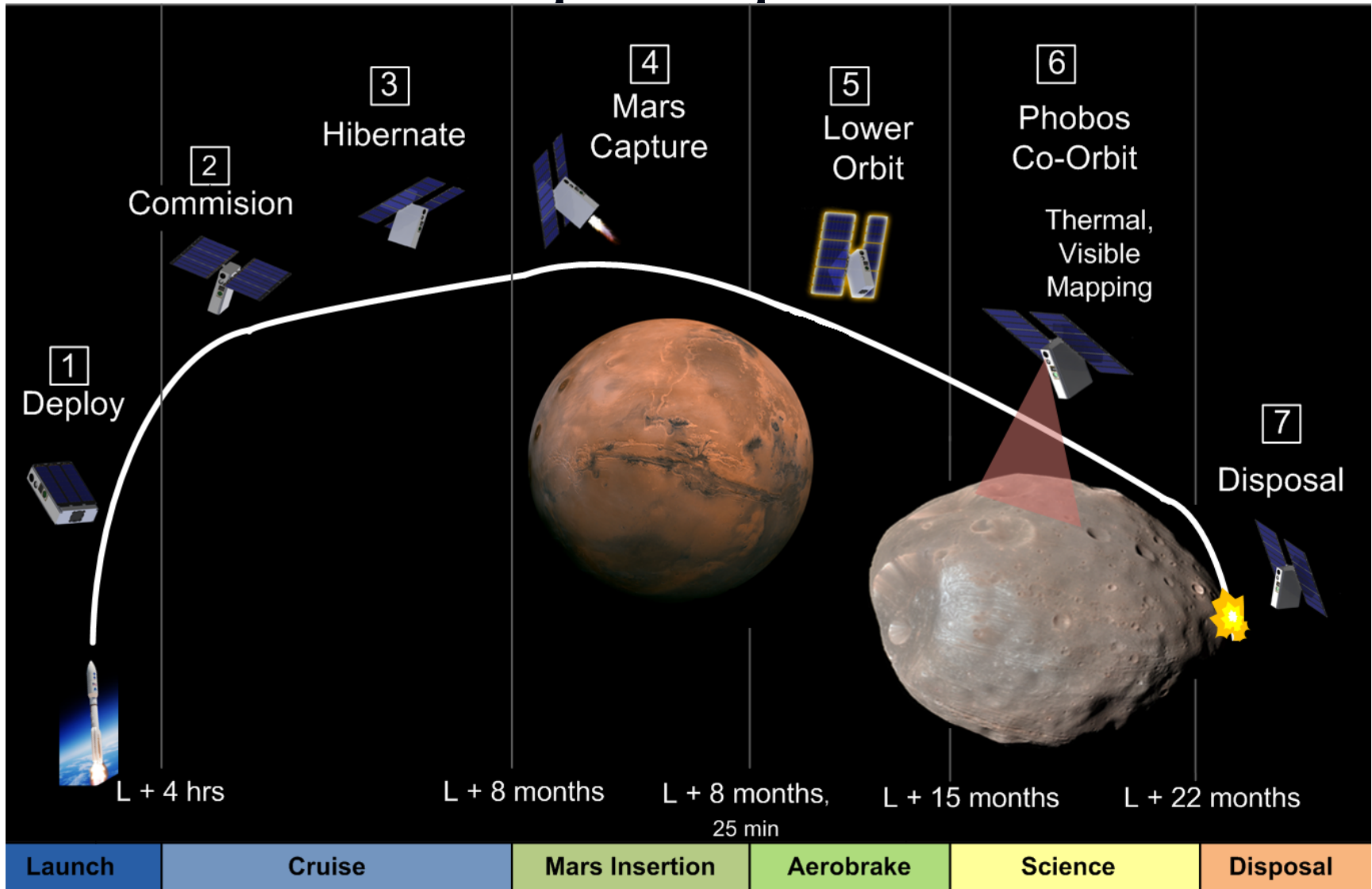


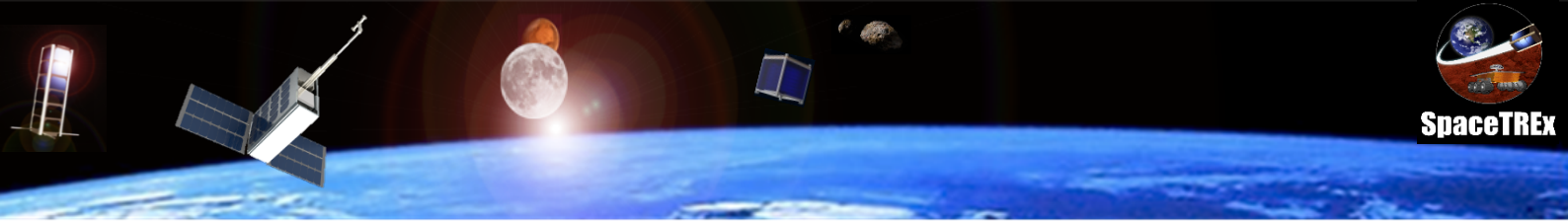
Devil's LOGIC: Mission Description

- 6U CubeSat
- Hosted payload mission to Phobos
 - Nominal Launch: Mars 2020
- Thermal and visible camera payload
- 2 year mission life
 - Potential for extended mission (3 years)
- Impulsive maneuver for Mars capture
- 7 month science mission studying Phobos
 - 15+ flyby's achievable within 7 months
 - Minimum of 5 flyby's for science mission



Concept of Operations



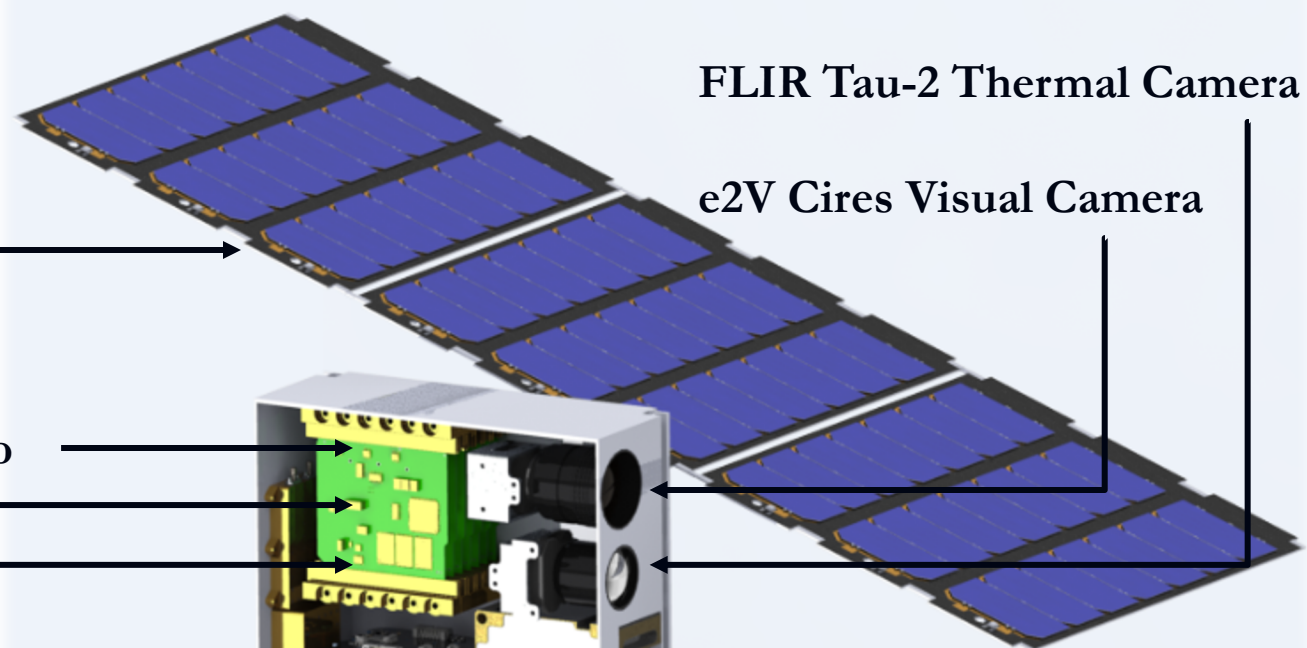


LOGIC Section View

MMA E-HaWK Solar and X-Band Reflect Array Hybrid

FLIR Tau-2 Thermal Camera

e2V Cires Visual Camera



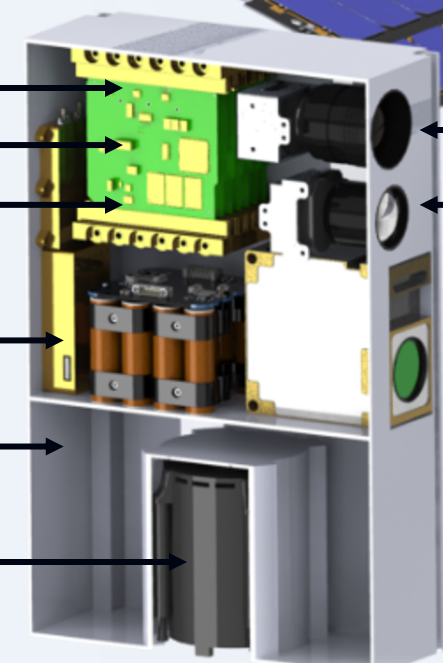
JPL IRIS V2 X-Band Radio
SpaceCube MINI CPU
Blue Canyon Tech EPS

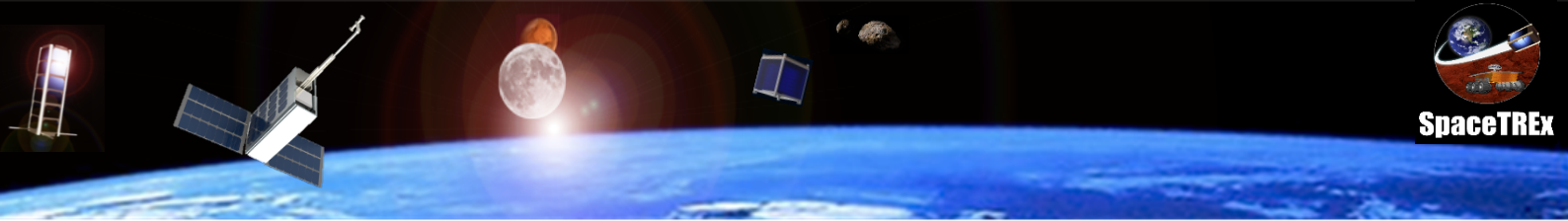
GomSpace BPX Batteries

Fuel Tank – 2400 cc

MPS-130 Green Monopropellant Thruster

Blue Canyon Tech XACT ADCS

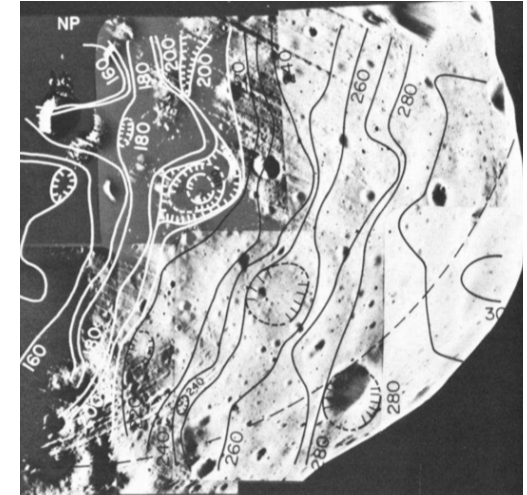




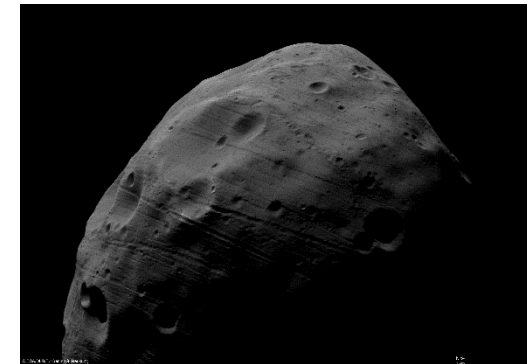
Science

- **Primary: Geo-structural features**
 - 3 temperature measurements at different times of day with 50 % coverage
 - Best data : Viking-IRTM (300m/pixel)

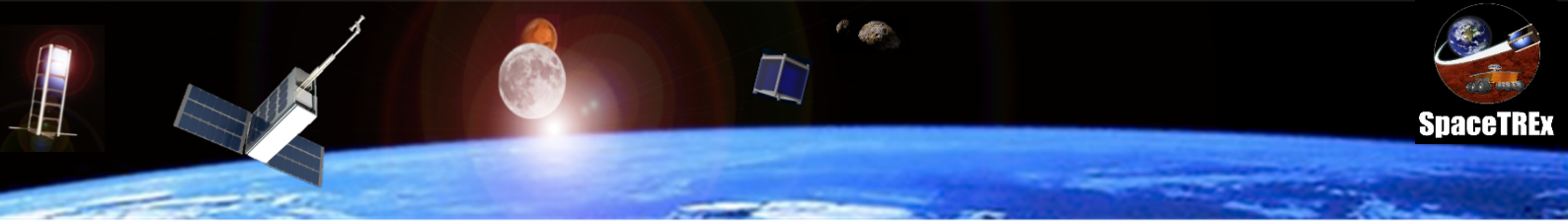
- **Secondary: Chronology of striation formation**
 - Stereo imaging at less than $1/10^{\text{th}}$ of average striation width resolution with 50% coverage
 - Best data: Mars Express-HiRise (3m/pixel)



Lunine et al. IR Observations of Phobos and Deimos



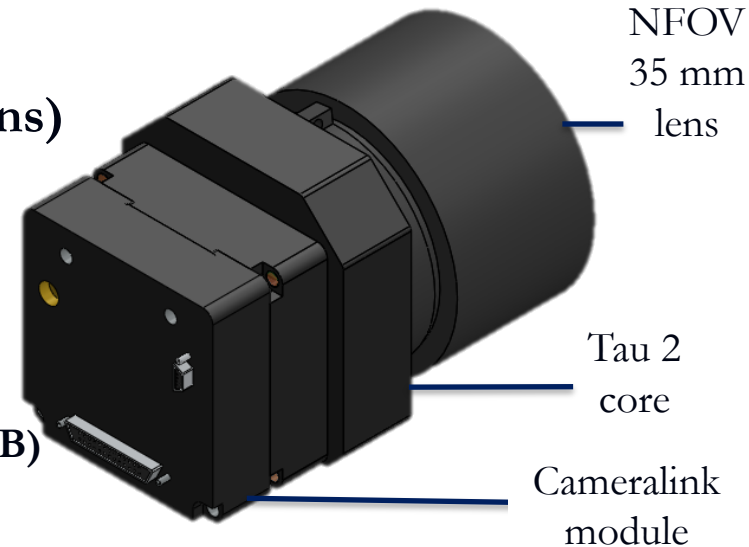
ESA/DLR/FU Berlin (G. Neukum)



Science Instruments

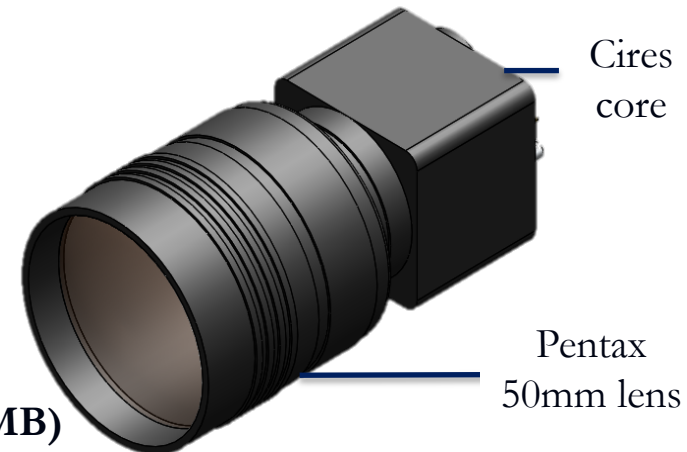
Thermal Camera

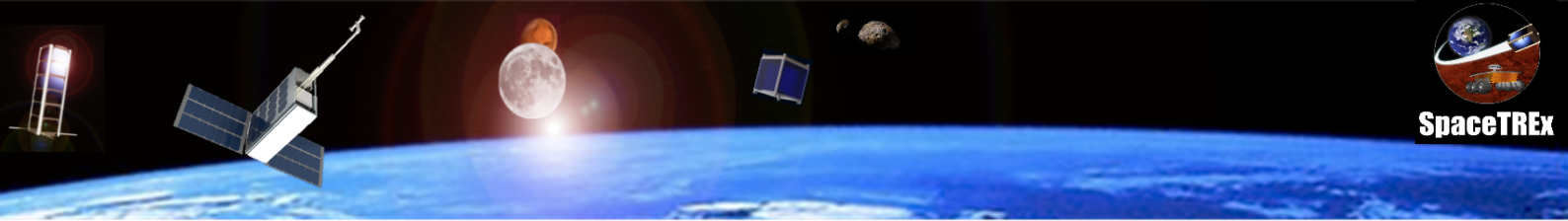
- Flir Tau 2 (Cameralink module & 35 mm lens)
 - 24.75 m/pixel achievable at 50 km altitude
 - 18° x 14° Field of View
 - NE Δ T 50 mK
- Data Return
 - 96 images nominal (40 MB)/ 48 images min (20 MB)



Visual Camera

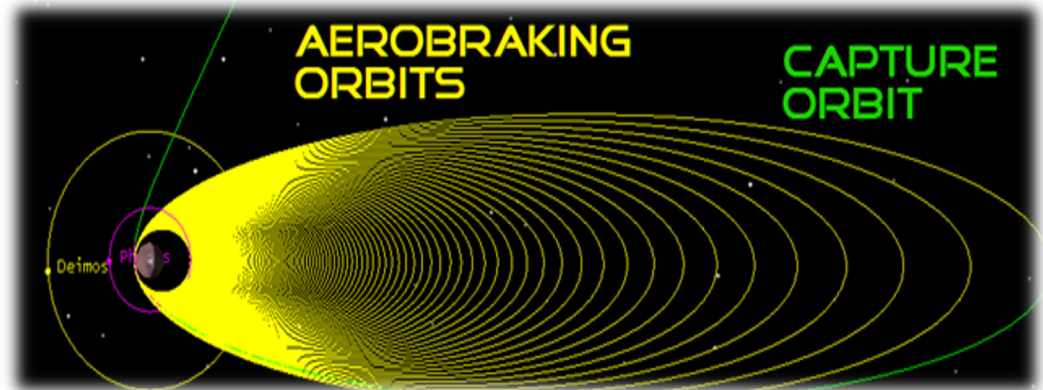
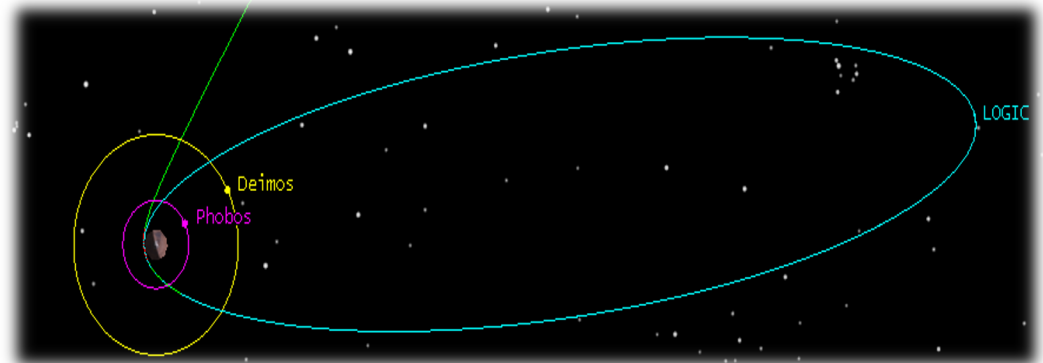
- E2V Cires (Pentax B5014A 50 mm lens)
 - 5.29 m/pixel achievable at 50 km altitude
 - 7° x 6° Field of View
 - SNR 39 dB & DNR 60 dB
- Data return:
 - 224 images nominal (367 MB)/ 112 images min (184 MB)

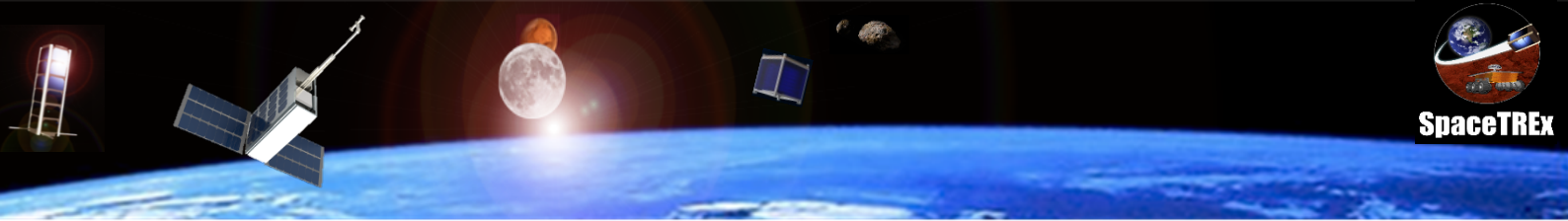




Spacecraft Trajectory

- Mars Transfer Orbit
 - 7 month cruise
- Elliptical Capture Orbit
 - 25 min burn to capture
 - Period: 13 Days 17 Hours
- Aerobraking
 - 6 – 9 Months
 - 1 - 4 m/s per pass
- Phobos Intercept
 - 7 Month Science Mission
 - 5 – 10 encounters achievable without fuel
 - Capable of 35+ encounters using propellant

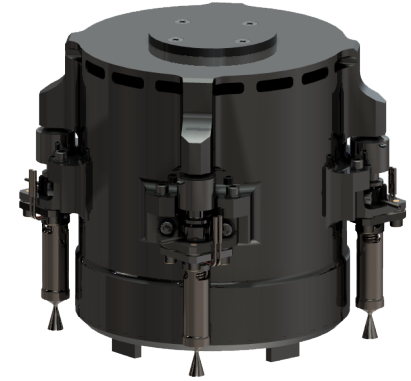




Critical Maneuvers

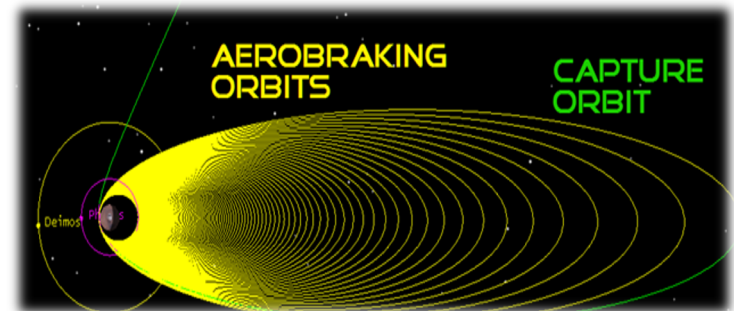
- Mars Capture

- MPS-130 Green Monopropellant Thruster
- Capture ΔV : 632 m/s
- 25 min burn



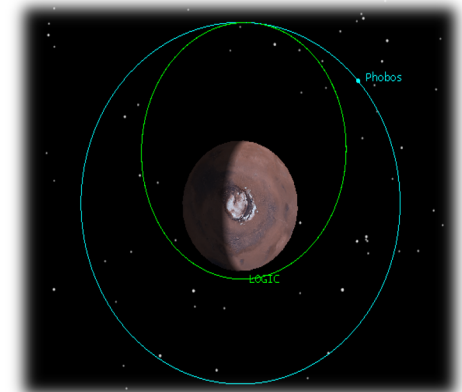
- Aerobraking

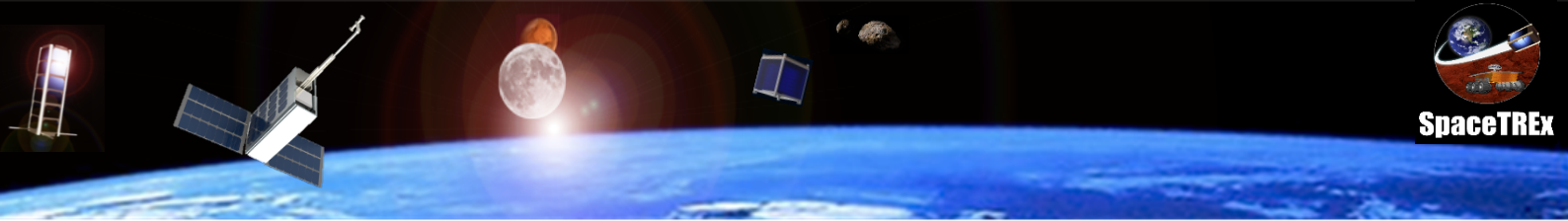
- Periapsis altitude 120 km
- Duration 190 days
- Average ΔV - 4 m/s per pass



- Phobos Intercept

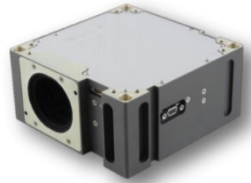
- Desired Altitude < 94 km
- 10 intercepts in 7 months
- Extra fuel can increase the frequency of intercepts





Attitude Determination & Control

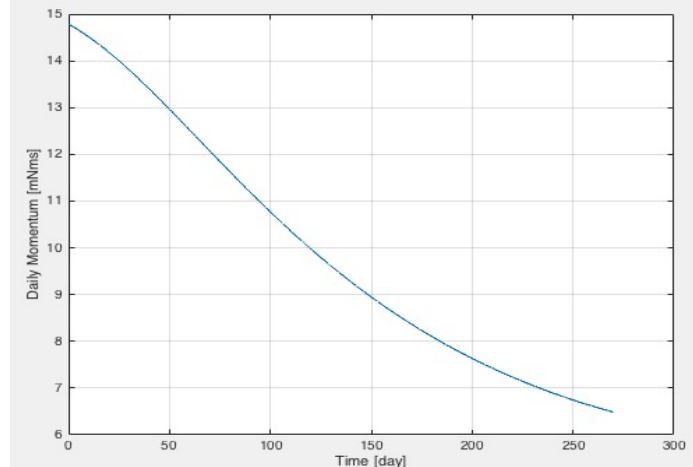
- Selected Component
 - XACT (Blue Canyon Tech)
 - Space Heritage (MinXSS)



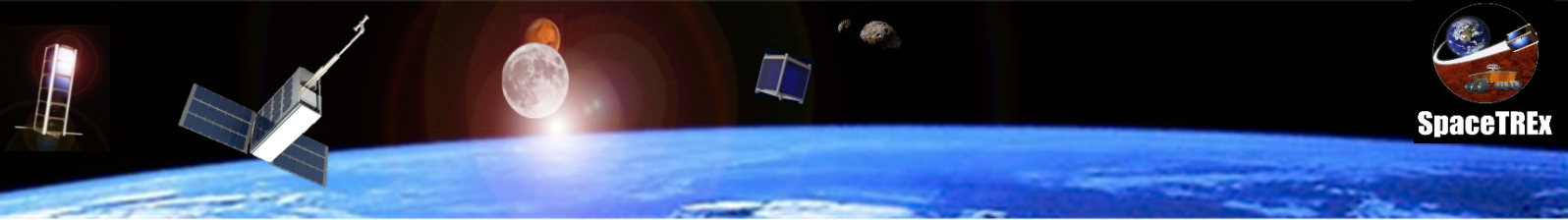
- Requirements
 - Pointing within 1 degree
 - Image Accuracy
 - Slew Rate of 1 deg/sec
 - Image Stabilization
- Desaturation Schedule
 - Thruster Desaturation
 - Delta V 90 m/s

Component Summary

Mass	0.91 kg
Volume	500 cc
Power	2 - 5 W
Radiation Tol.	16 krad
Pointing Accuracy	+/- 0.007 deg
Max. Slew Rate	4.1 deg/sec

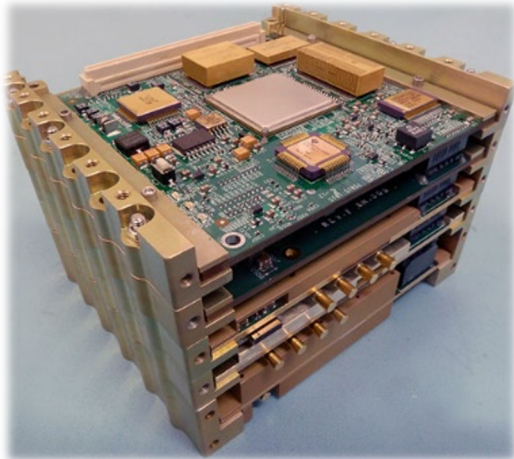


Daily Momentum Accumulation



Communications - Type and Selection

Iris V2 X band Transponder



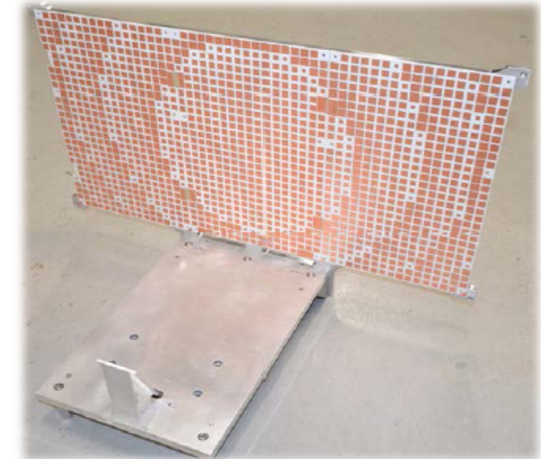
NASA JPL (MarCO)

- DSN compatibility
 - X-Band
 - UHF relay potential
- EIRP - 35 dB

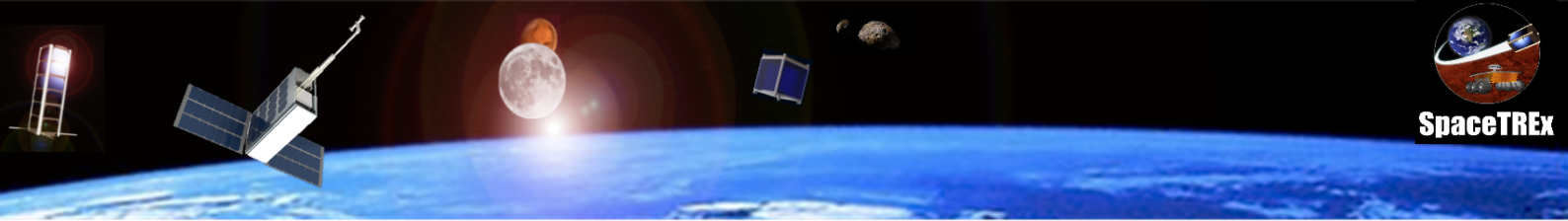
Link budget to Earth (X band)

Scenario	Distance (million km)	Downlink
Worst	200	6.4 kbps
Nominal	250	9.3 kbps
Best	300	14.5 kbps

High Gain Reflectarray



NASA JPL (MarCO)



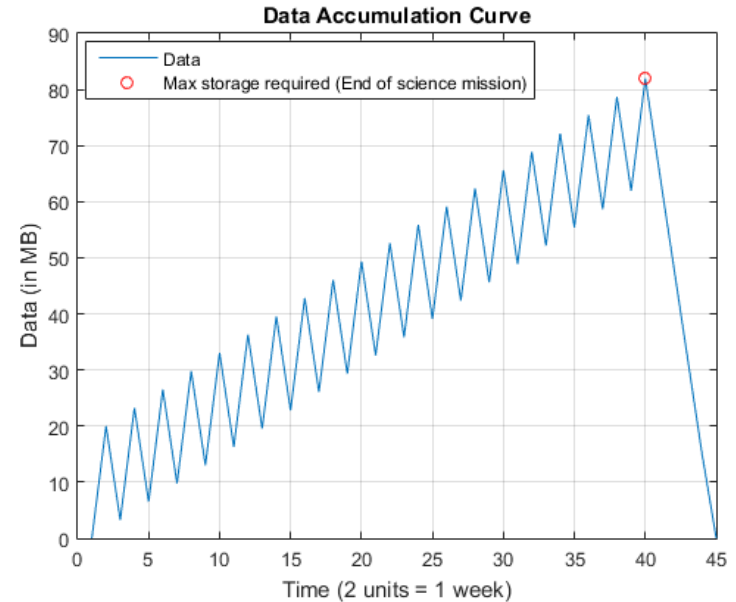
Communications - Operations

● Total Science Data

- 406 MB
- Downlink time
 - 4 hrs/week - 6 months
 - 8 hrs/week - 3 months

● Methods to Improve Performance

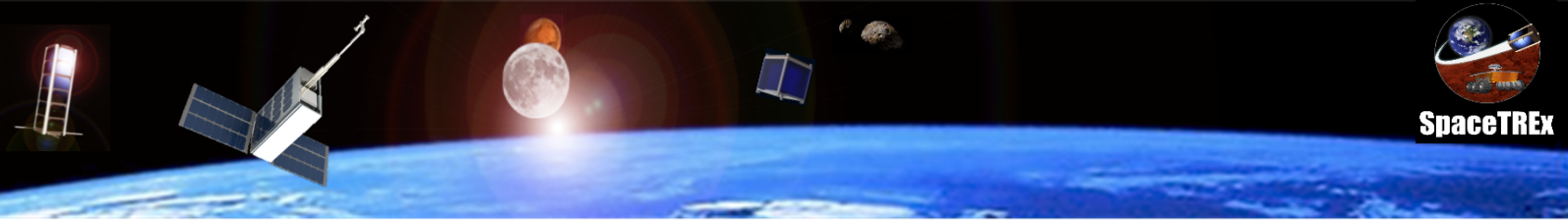
- MRO UHF Relay
- 70-m DSN antenna
- Ka-band
- Longer DSN time



Communications Summary

Mass	1.7 kg
Volume	801.06 cc
Power	35 W

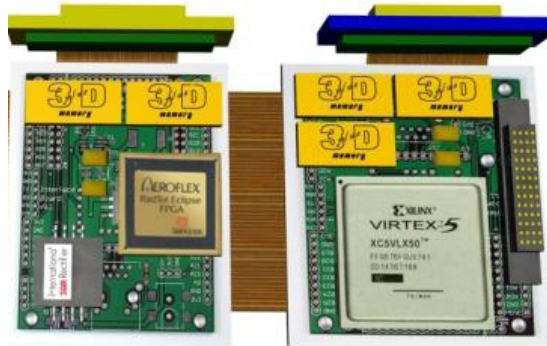
- Data downlinked within 7 months of start of science mission



Command and Data Handling

SpaceCube MINI

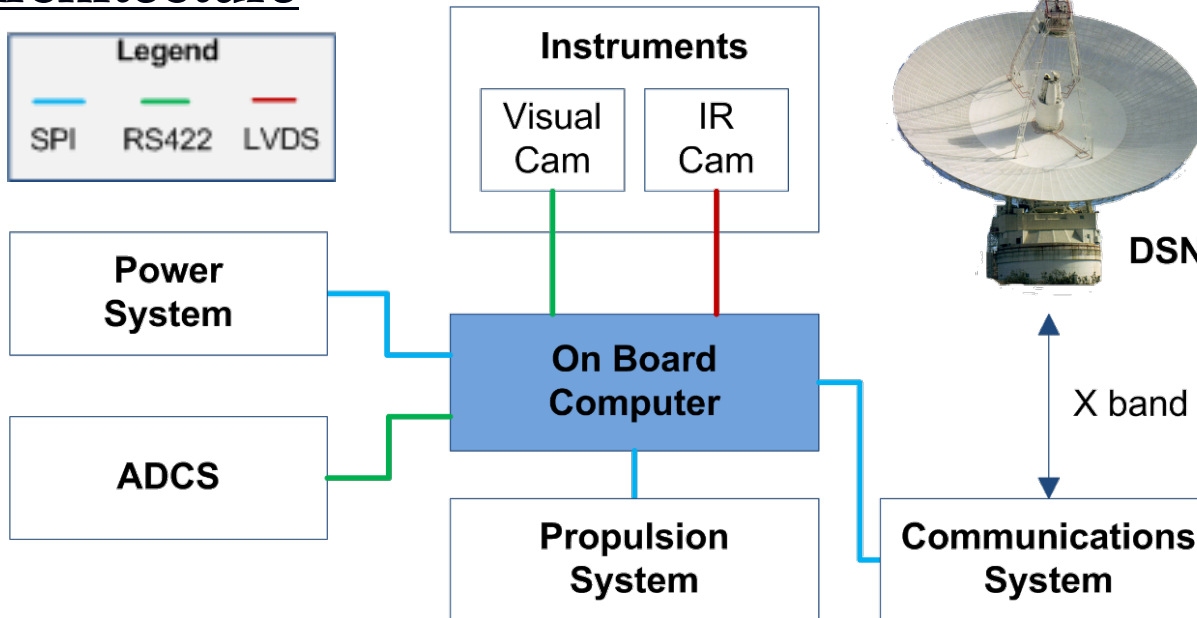
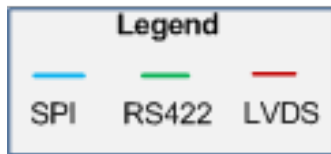
- 2000 IPS
- Built in watchdog
- Rad tolerance
 - Up to 700 krad



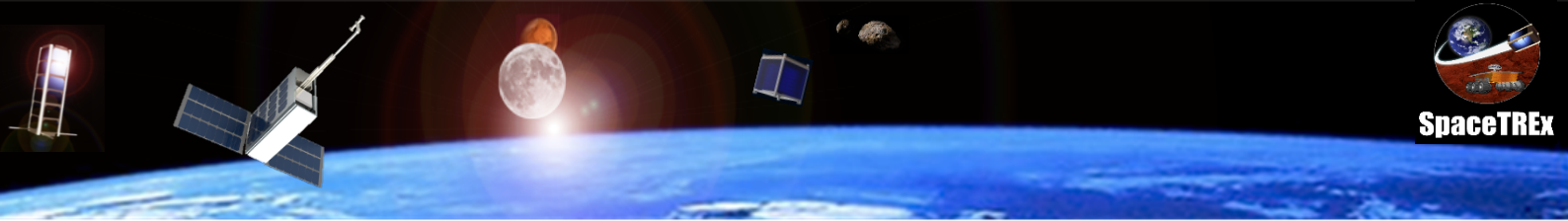
C&DH Summary

Mass	0.2 kg
Volume	100 cc
Power	5 W

Architecture

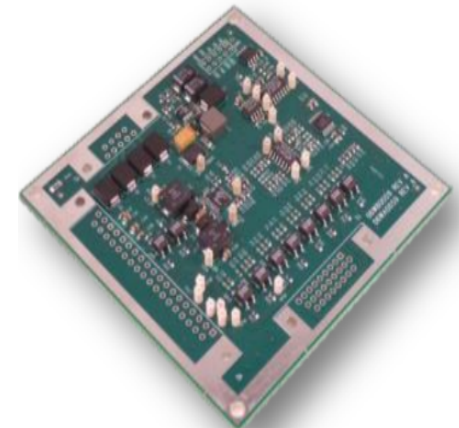
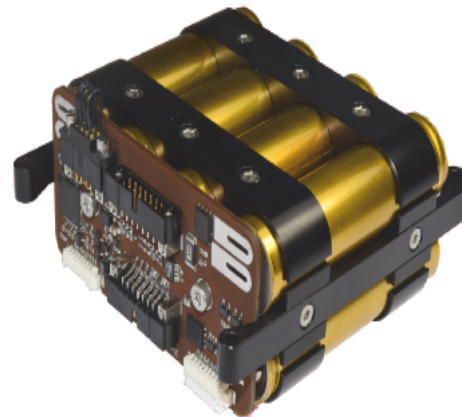
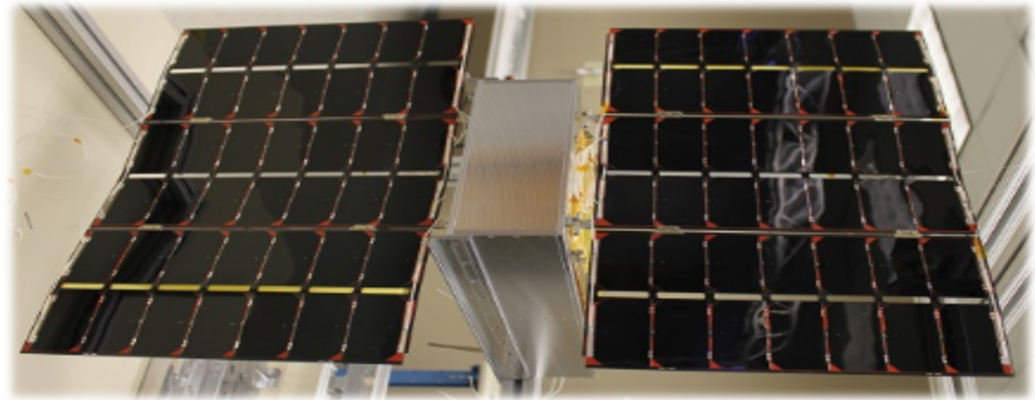


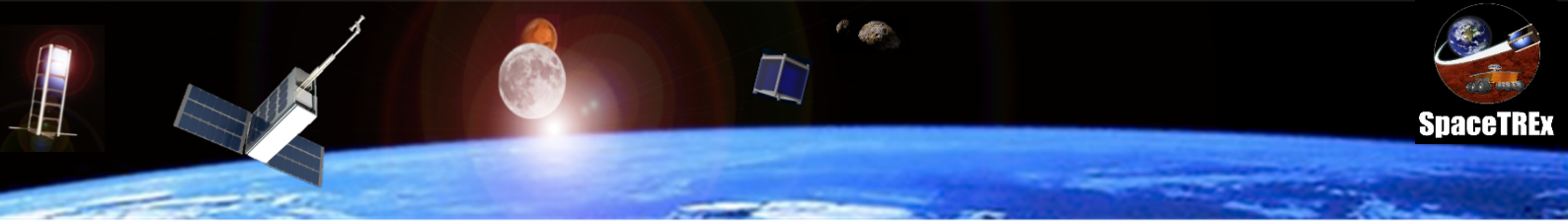
System	Interface
Iris V2	SPI
ADCS	RS-422
Camera	RS-422
IR Camera	LVDS
Prop	SPI
EPS	SPI



Power Overview

- MMA E-HaWK Solar Array
 - 75 W AOP (Earth)
 - 24 W AOP (Mars)
 - 850 g
- Gomspace NanoPower BPX
 - 154 Wh Capacity
 - 500 g / 320 cc
- Blue Canyon Tech EPS
 - 65 g / 75 cc
- System Mass and Volume
 - 1.415 kg
 - 395 cc

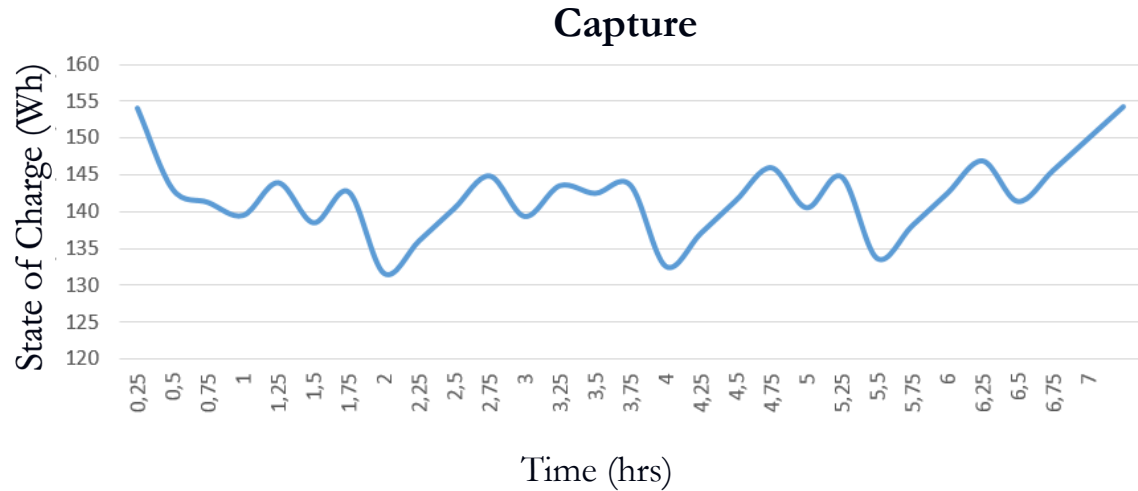




Modes of Operation

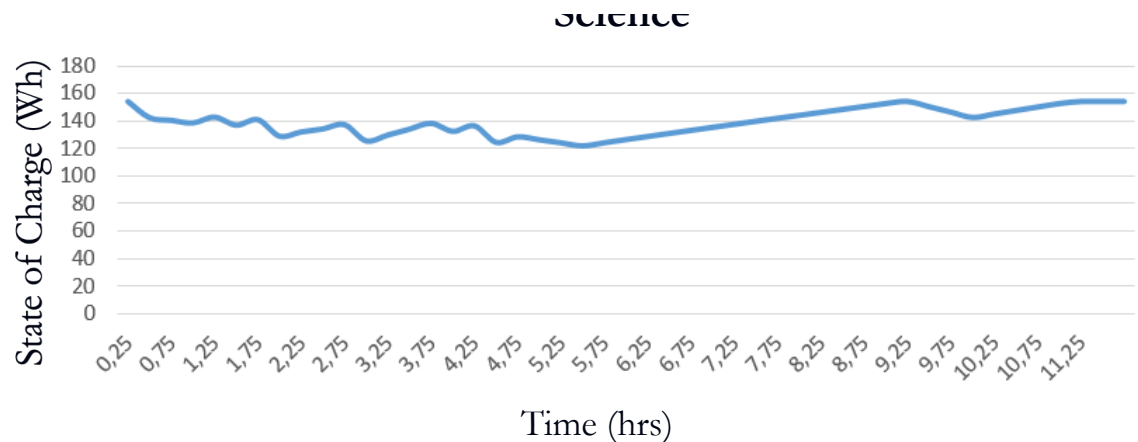
Capture: -5 % Margin

- Propulsion
- Comms Send /Rcv
- Maximum DoD 36 %



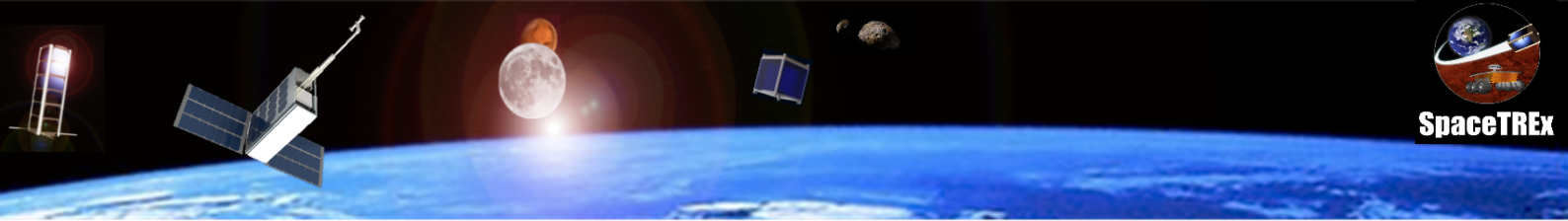
Science: 29% Margin

- Comms Send /Rcv
- Attitude Control
- Instrument Payload



Hibernate: 38% Margin

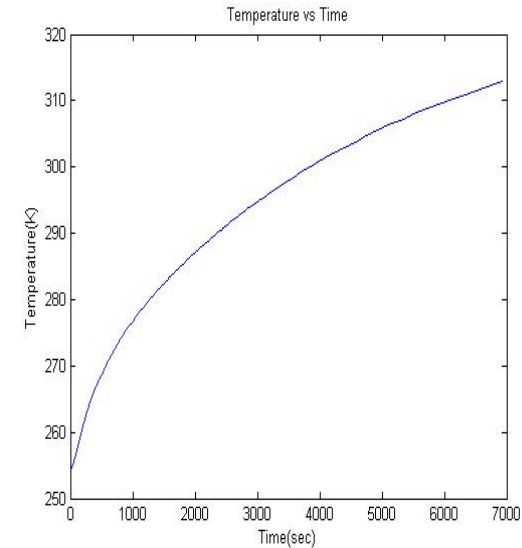
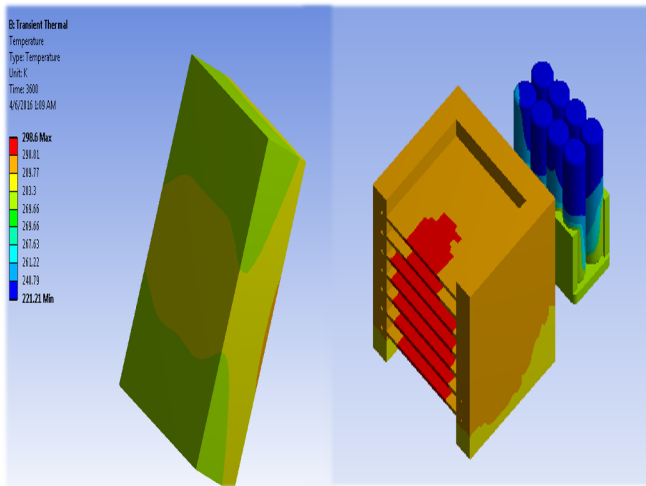
- Comms Rcv Only
- CPU Standby



Thermal

Hot Case at Mars

- 4 hr Comms window
- X-Band Transponder
 - 26 W heat generated
- CPU, EPS & Batteries
 - 15 W heat generated



Cold Case at Mars

- Mars Eclipse at Apoapsis
- Patch Heaters (0.5 W each)
 - 2 for Propellant, 1 for CPU and 1 for ADCS
 - 2 integrated into batteries
- Aluminized Kapton (200 mil)
 - $\epsilon = 0.55$
 - $\alpha = 0.35 - 0.51$

