Europa Surface and Plume 3D eXplorer (ESP-3DX): A CubeSat mission to Search for Plumes on Europa

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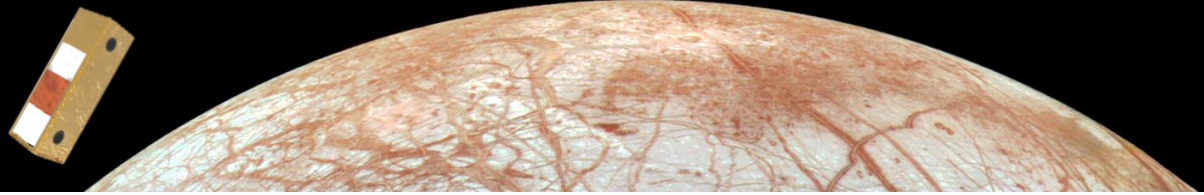
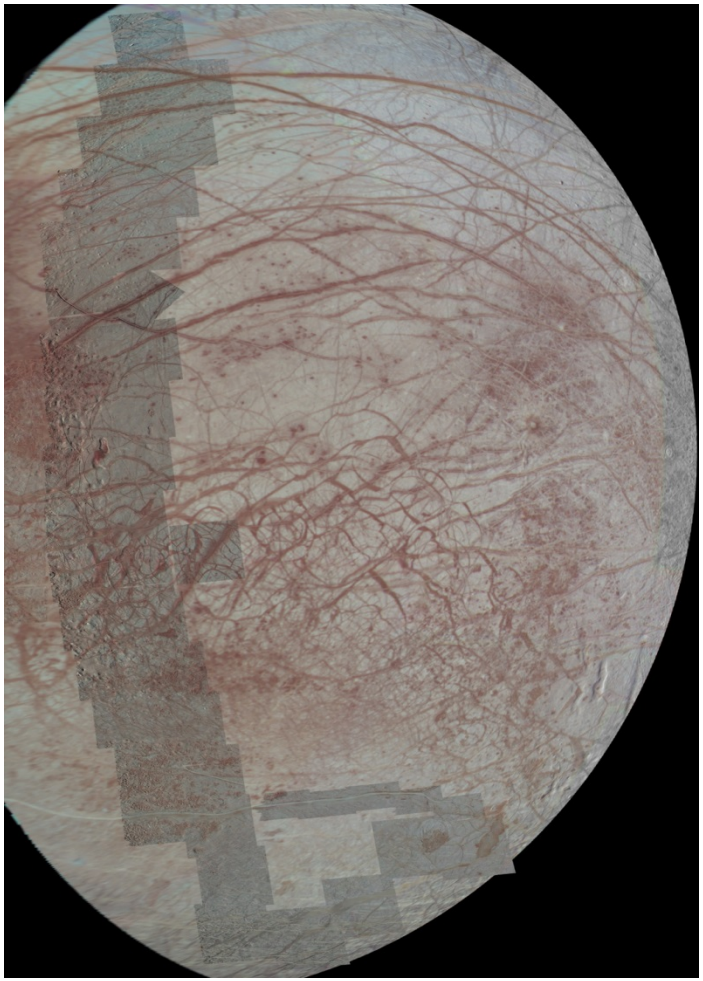
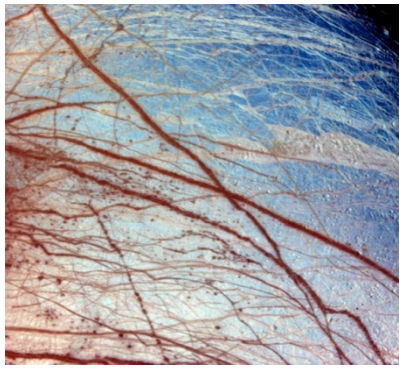
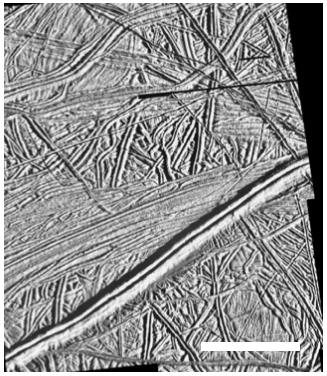
ASU JPL VACCO DRAPER LABORATORY PARAGON SPACE DEVELOPMENT CORPORATION SpaceTREx



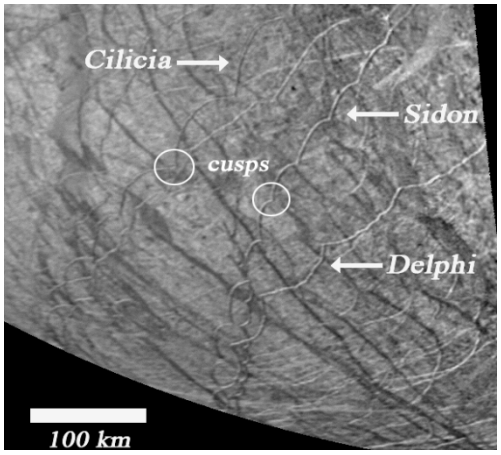
Science Objectives



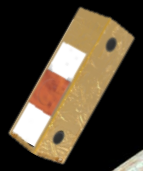


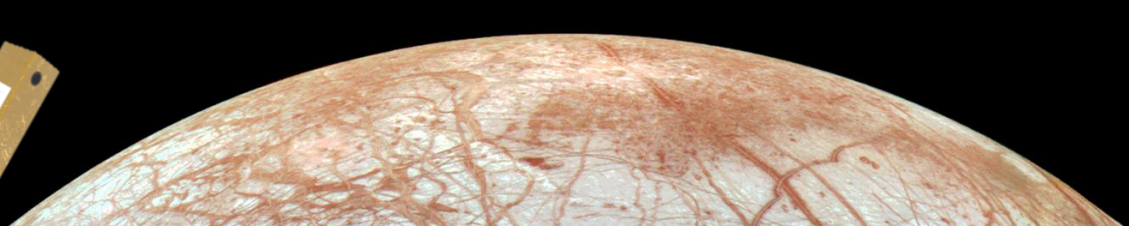


10 km

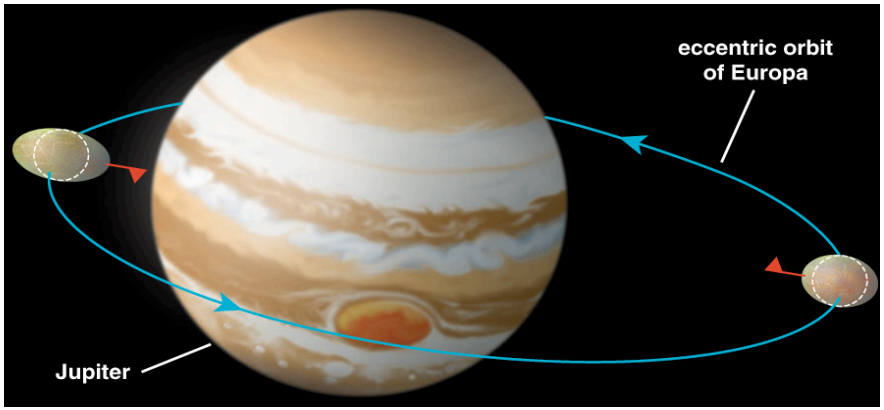


Track a fracture to obtain stereo images from ridge to regolith scale





Science Motivation



We know tides cause fractures but …

Do cracks reach water?

What forms ridges?

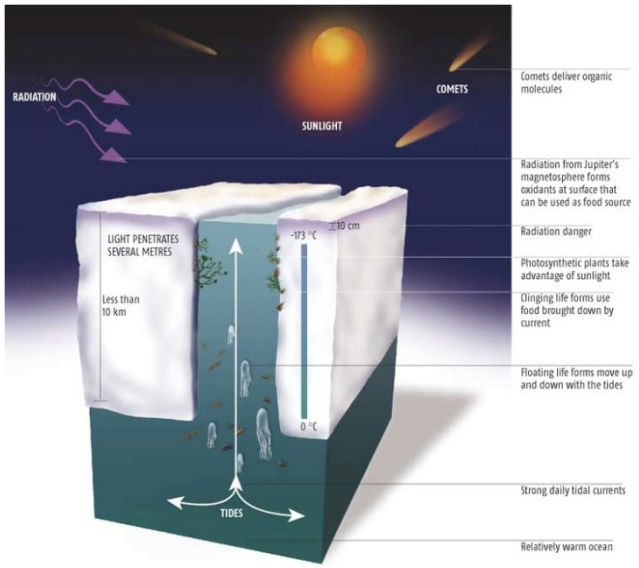
Are there plumes?

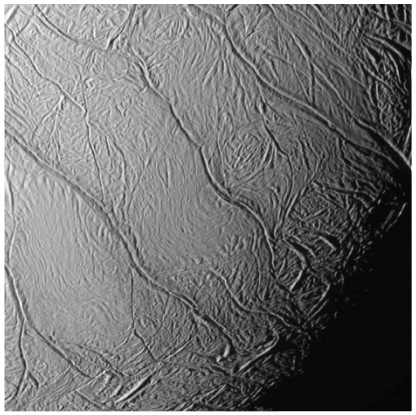
Habitability

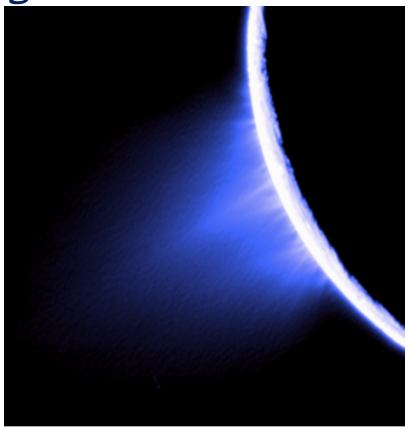
Ice shell processes

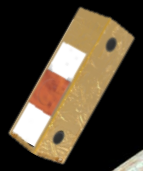
Ocean composition

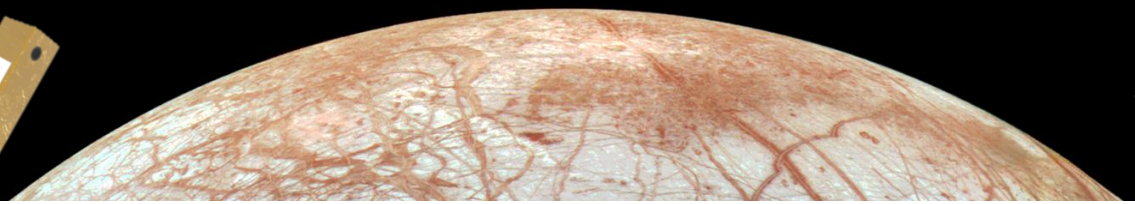
Biosignature detection







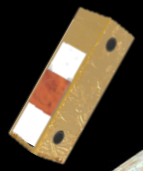


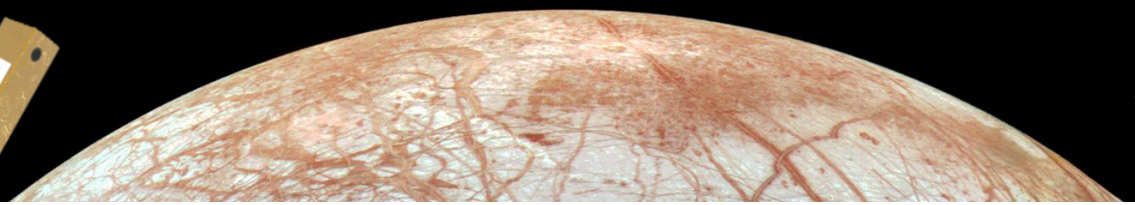


Science Team Recommendations

- Instruments Rank
- 1) Recon Camera (RC)
- 2) Stereo Topography Imager (TI)
- 3) Shortwave Infrared Point Spectrometer (SWIRS)

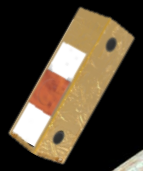
- Based on most important science questions, ASU expertise and what unique science could be done with a CubeSat
- Selected science instrument could do all three.!

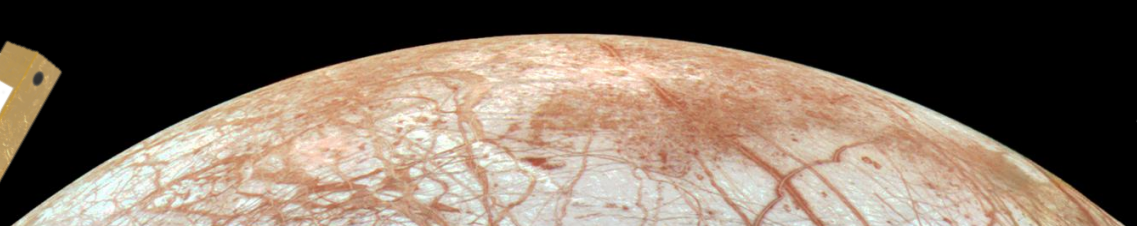




Science Traceability Matrix

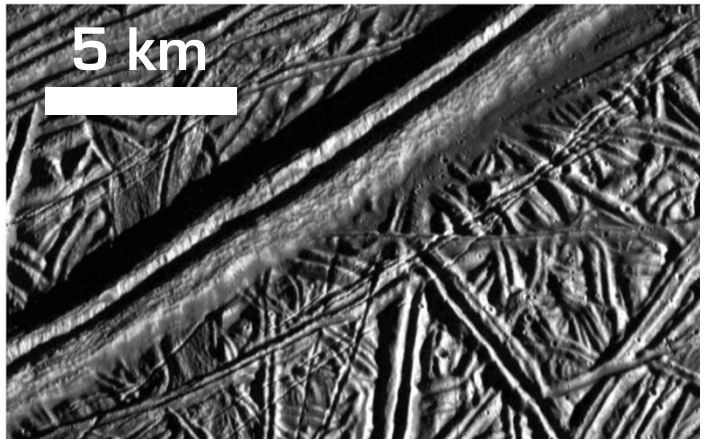
Goal	Flagship Objective [2]	Investigation	Measurement	Instr.	
EXPLORE EUROPA TO INVESTIGATE ITS HABITABILITY	ICE SHELL Characterize the ice shell and any subsurface water, including their heterogeneity, and the nature of surface-ice-ocean exchange.	Characterize the distribution of any near-surface water and the shell structure.	High-resolution or stereo topographic imaging	RC	TI
		Correlate surface features and sub-surface structure to investigate processes governing material and thermal surface-ice-ocean exchange.	Measure surface spectral reflectance	SWIRS	
			High-resolution or stereo topographic imaging	RC	TI
	COMPOSITION Understand the habitability of Europa's ocean through composition and chemistry.	Determine the role of Jupiter's radiation environment in processing materials on Europa.	Measure surface spectral reflectance	SWIRS	
		Characterize the surface expression of geochemical pathways in Europa's ocean.			
	GEOLOGY Understand the formation of surface features, including sites of recent or current activity, and characterize high science interest localities.	Determine sites of most recent geological activity.	High-resolution imaging	RC	TI
		Observe evidence for subduction near dilational bands.	High-resolution imaging	RC	TI
		Study surface block size frequency distribution.	High-resolution imaging	RC	TI





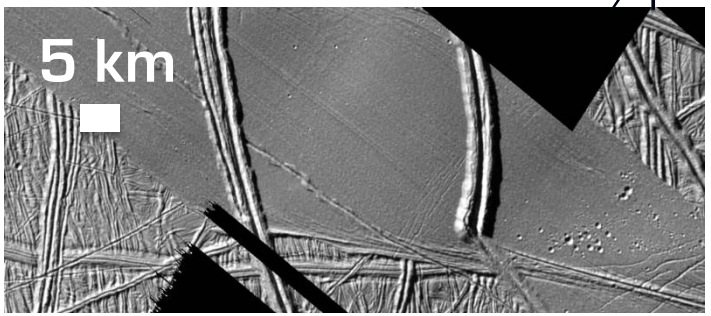
Europa Multi-flyby Mission

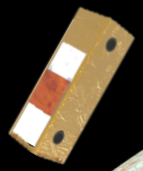
- 40+ flybys of Europa
- Near-global imagery at 50 m/pix (*EIS*)
- Will characterize landing sites with high-res and stereo imagery
- ***Imaging will not be targeted***



20 m/pix

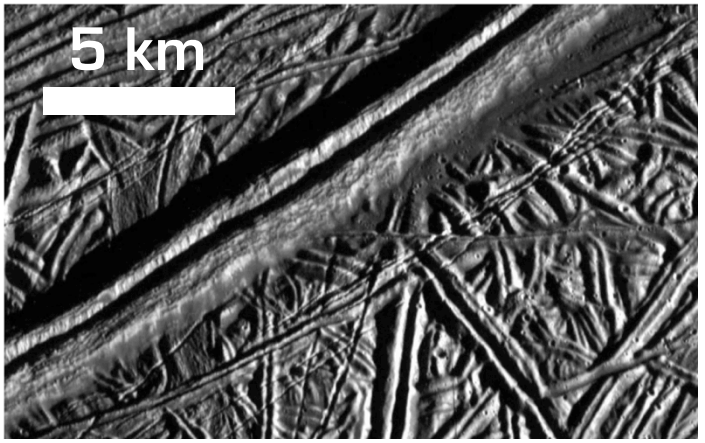
90 m/pix



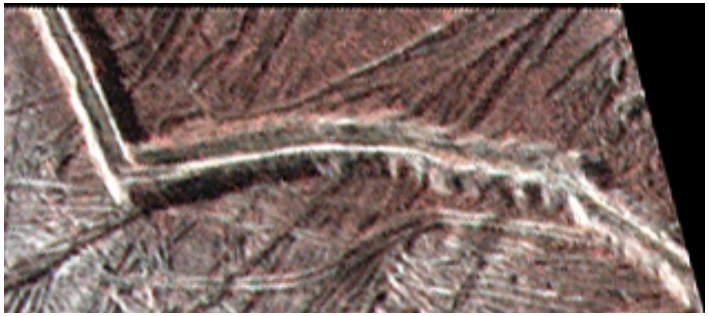


Europa CubeSat

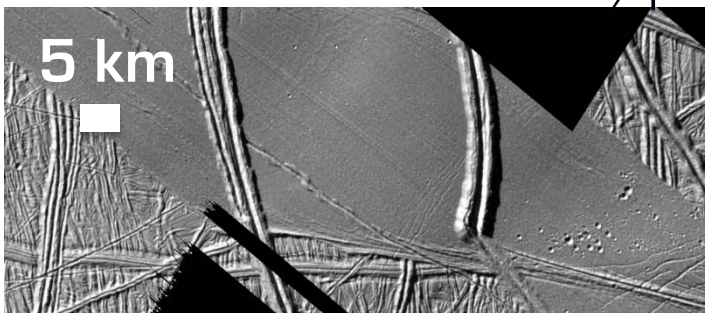
- Track a fracture over 100s of km
- Sequence of stereo images from ridge to regolith scale (1 km – 10s cm per pix)
  - Small-scale properties
  - Slopes, heights, and width
  - Morphology of ridges + central trough
- Targetable w/ in 400 km range
- Cycloid tracking w/ more propulsion



20 m/pix



90 m/pix

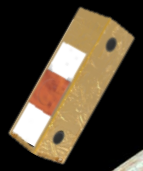


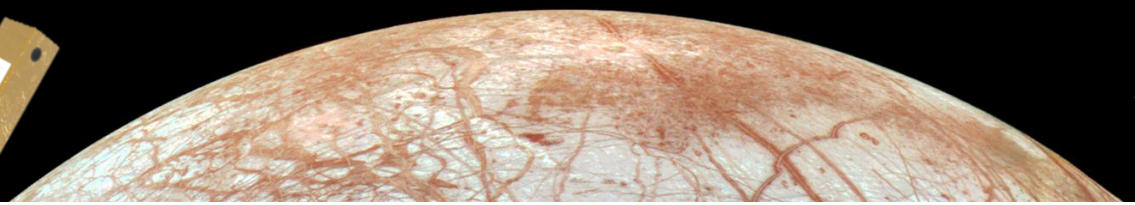
Landing Site Determination

Ice Lake

Penitents

Glaciers





ESP-3DX CubeSat Advantage

- Complement the great science coming out of the flyby mission

- 1) Science: Targeted higher res recon and stereo visible images of lineament, surface topography
  - 0.3 m to 2 m/pixel
- 2) Science: Oblique view enables peering into the lineament cracks and obtain evidence for past/present plumes
- 3) Landing Site Recon: Recon images, topography, radiation important for landing site determination

System Overview

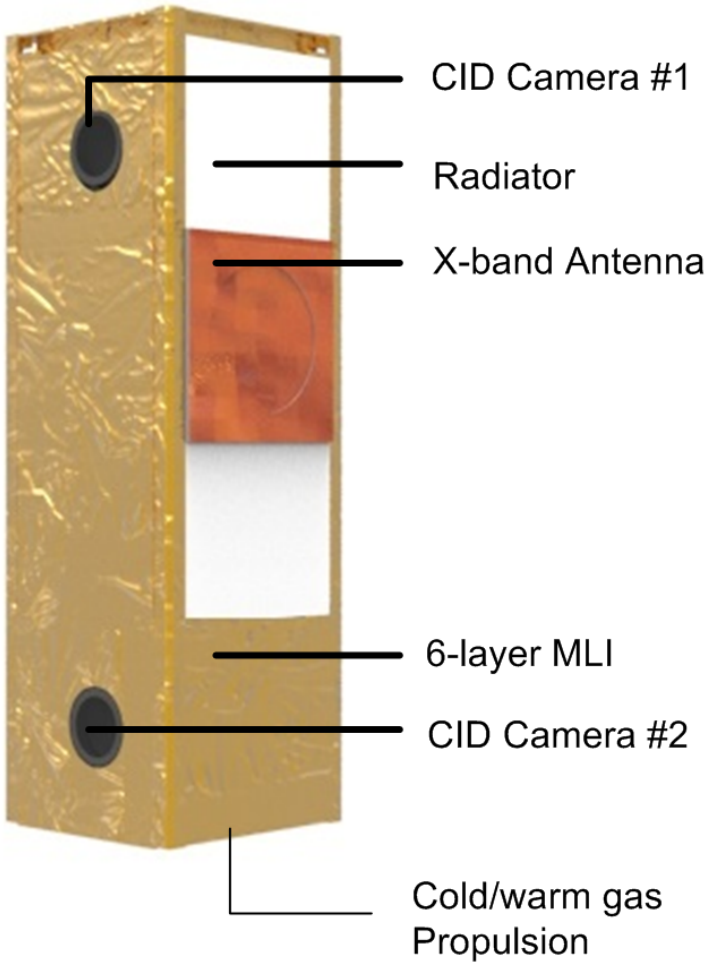
Mass: 5.2 kg spacecraft
Volume: 3U
Power: 21 W (avg.), 50 W peak
Mission: 10 hrs
Instruments: Stereo CID Cameras
Radiation Dosimeter

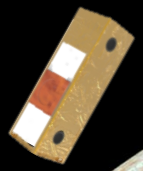
Mission:

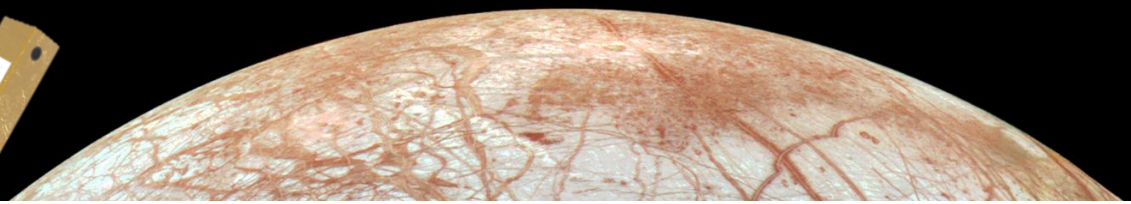
(1) High-res imaging and stereo map of a Europa linae (0.3 to 2 m/pixel)

(2) Stereo imaging of Europa surface topography, evidence for melt, plume and surface deposit

(3) Recon and radiation conditions for landing site



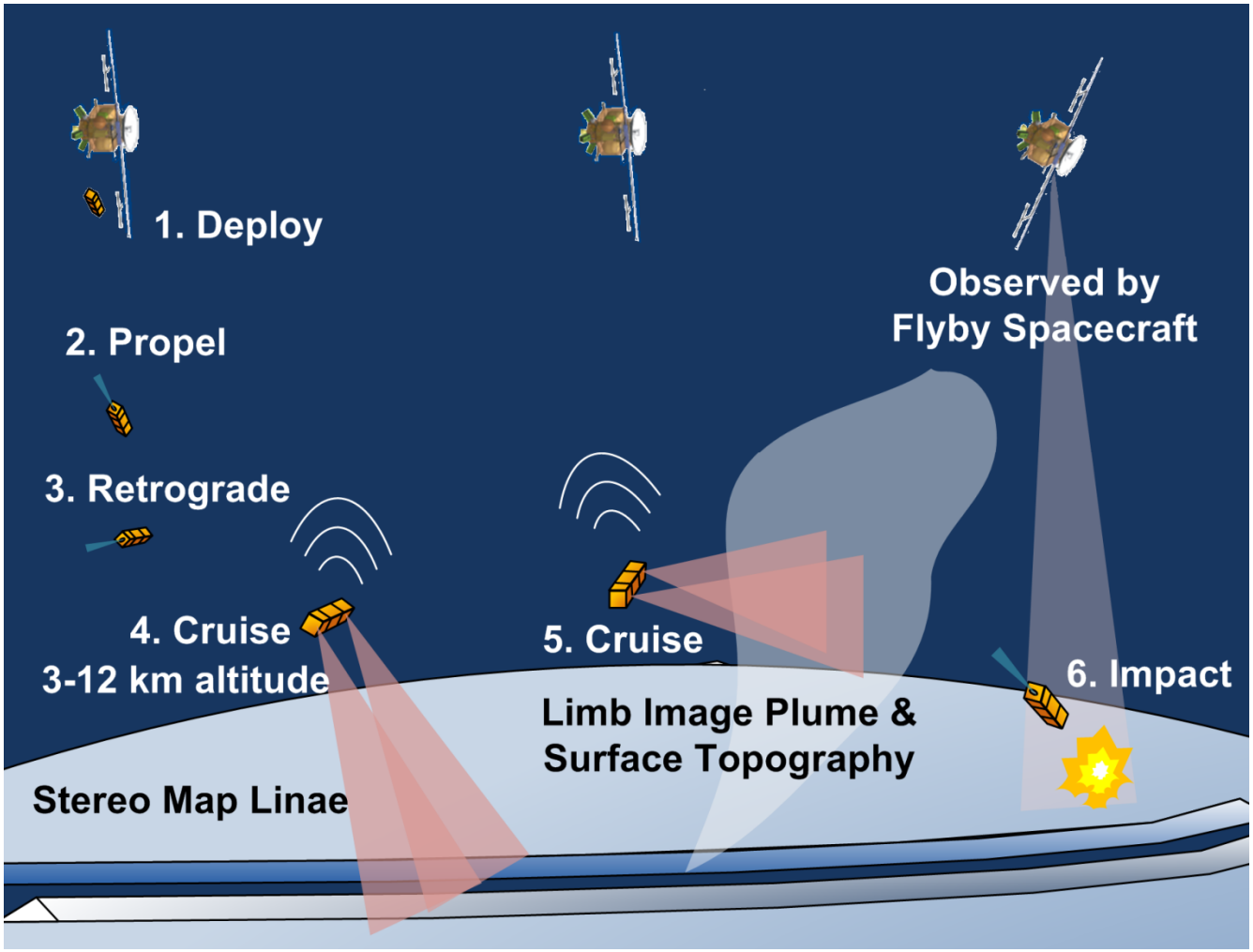




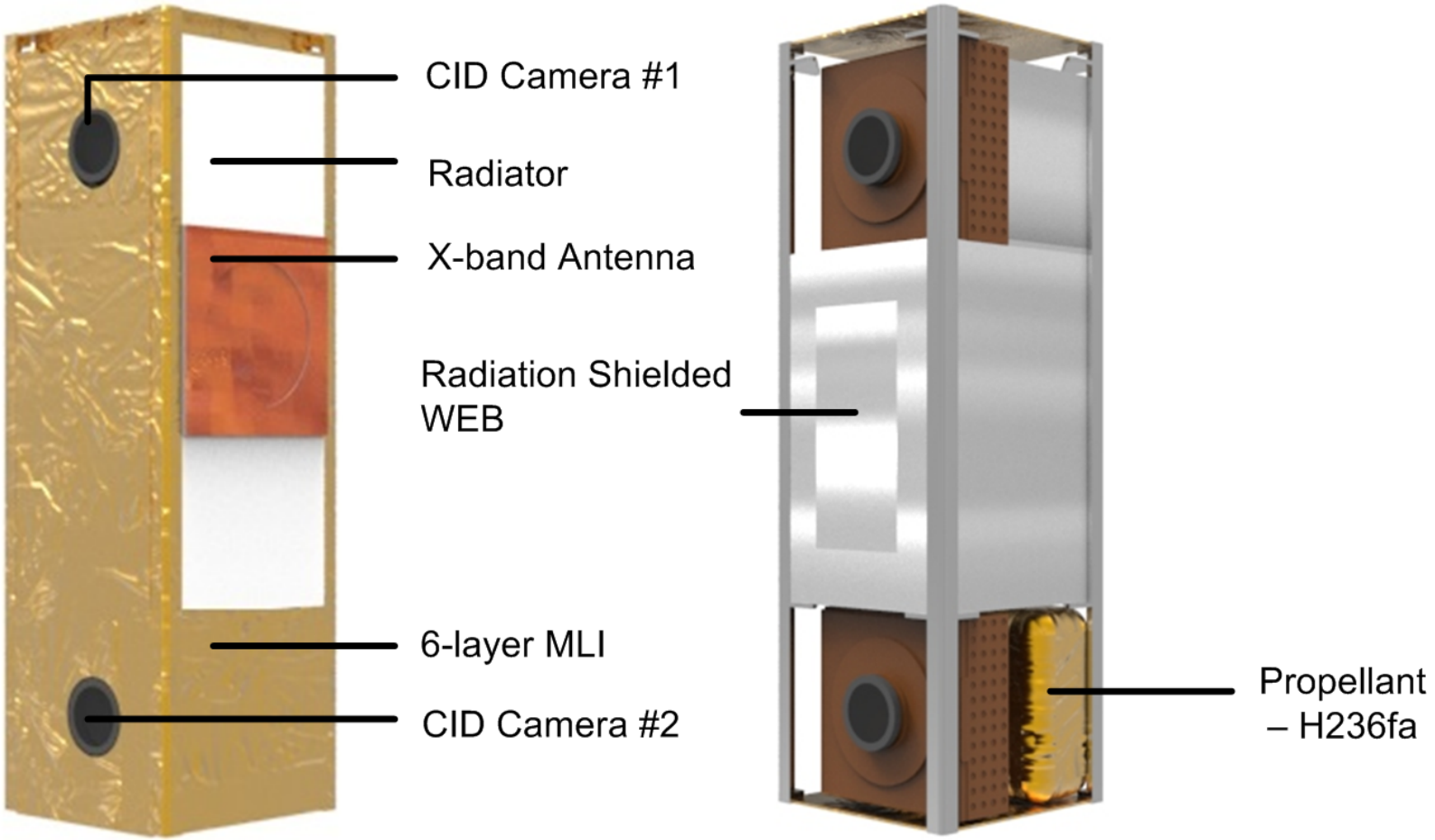
Science Data Products

- 250 – 500 stereo images (1024 × 1024 pixels)
- Radiation dose readings @ 1 Hz
- Based on data rates of 2 MBps to 4 MBps
- Main factor is separation distance from Europa Flyby Spacecraft

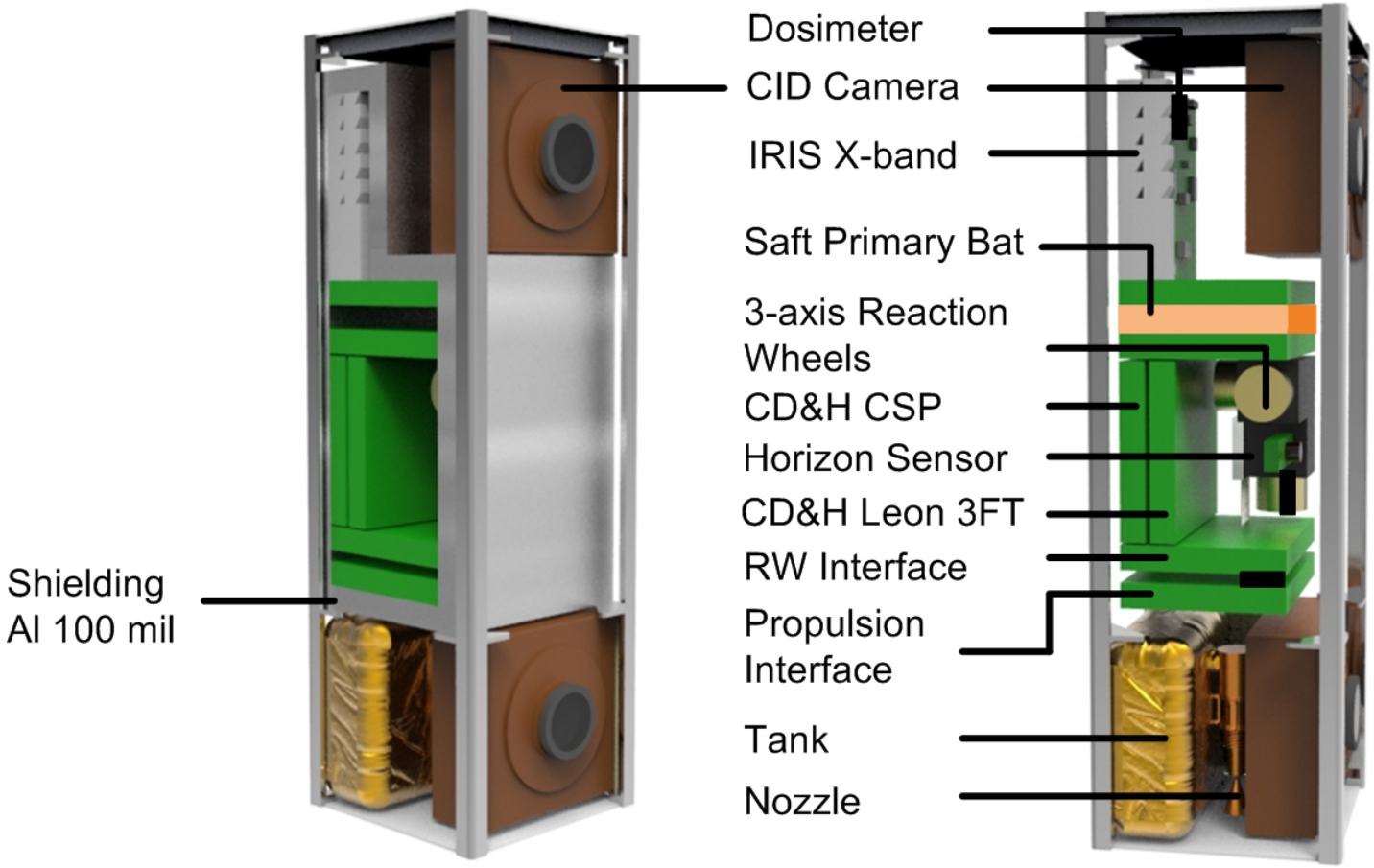
Concept of Operations



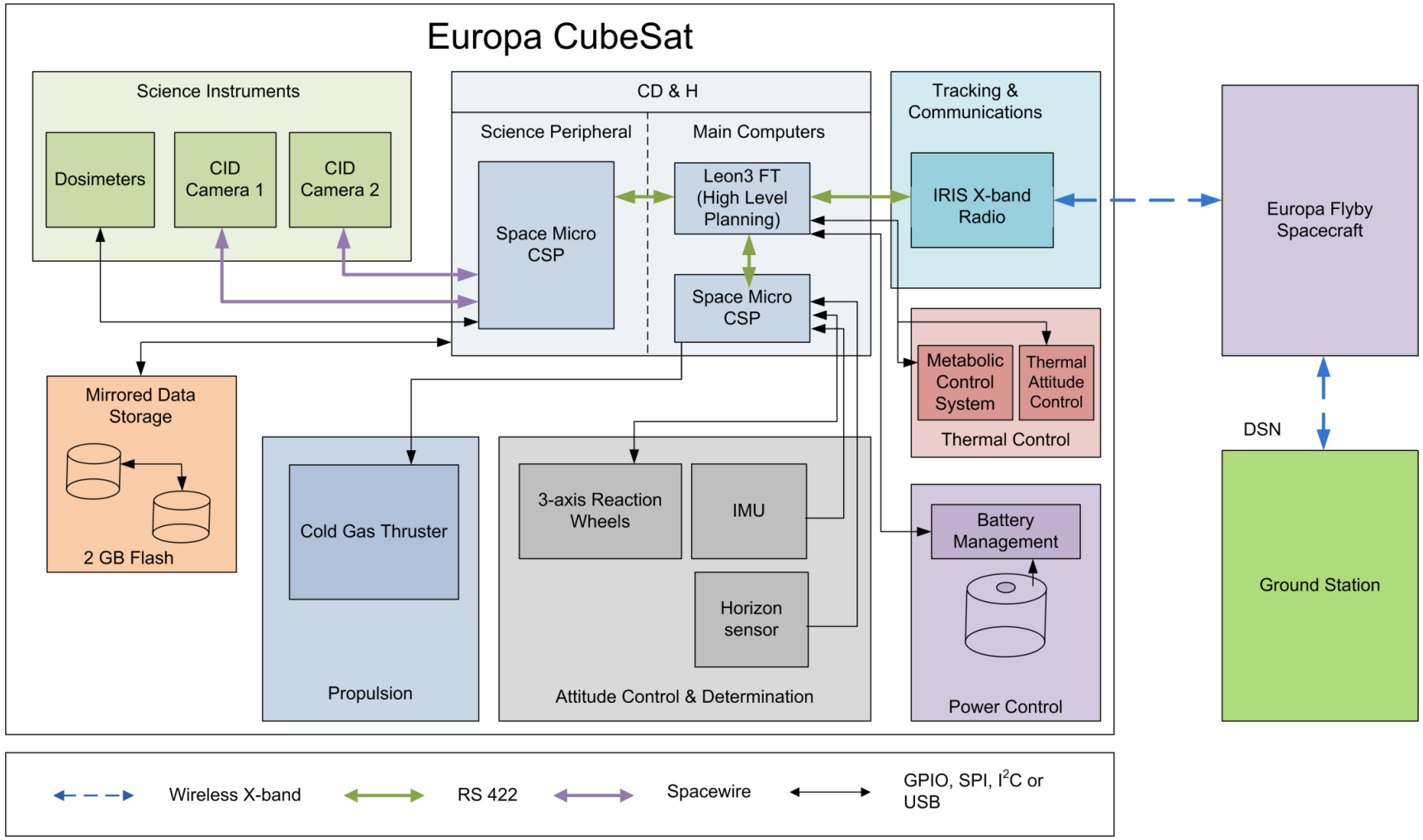
System

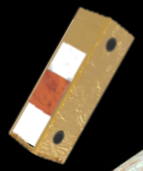

CID Camera #1
Radiator
X-band Antenna
Radiation Shielded WEB
6-layer MLI
CID Camera #2
Propellant – H236fa

System Internals



System Architecture





Mass and Volume Budget

Mass

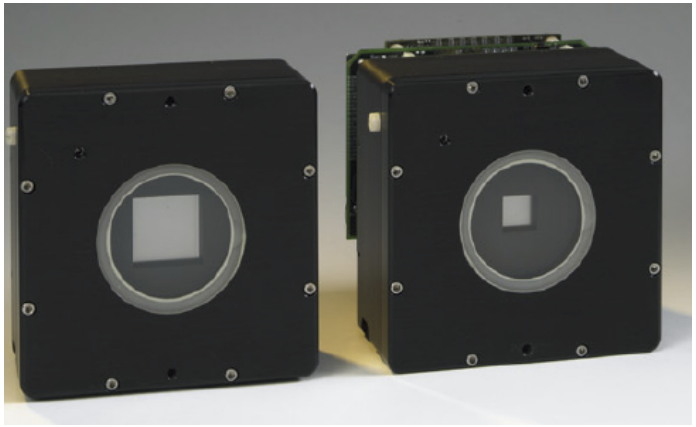
Subsystem	Mass (kg)
Communications	0.5
Onboard CPUs	0.3
Science Instruments	1.3
Power	0.6
Propulsion	0.5
Navigation	0.3
Structure	1.0
Radiation Shielding	0.5
Thermal	0.15
Total	**5.2**

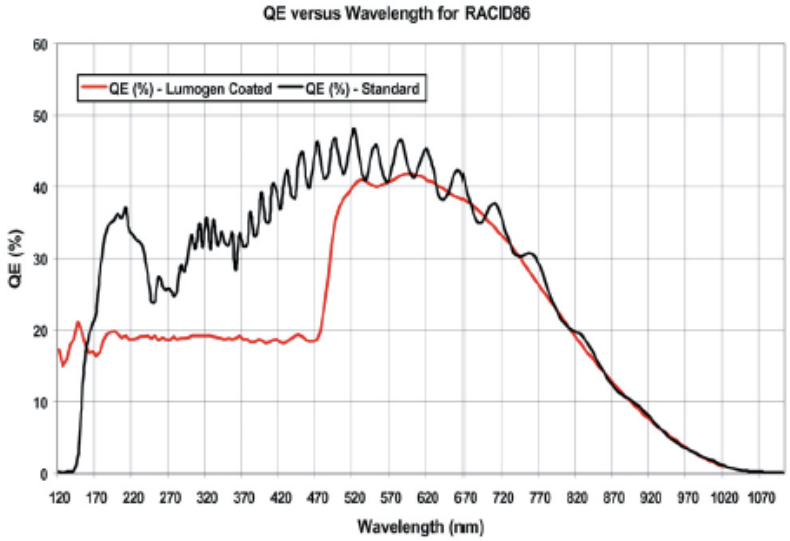
Volume

Subsystem	Volume (cm^3)
Communications	200
Onboard CPUs	120
Science Instruments	500
Power	300
Propulsion	500
Navigation	50
Structure	400
Radiation Shielding	300
Thermal	150
Total	**2520**
Margin	**26 %**

Science Instruments

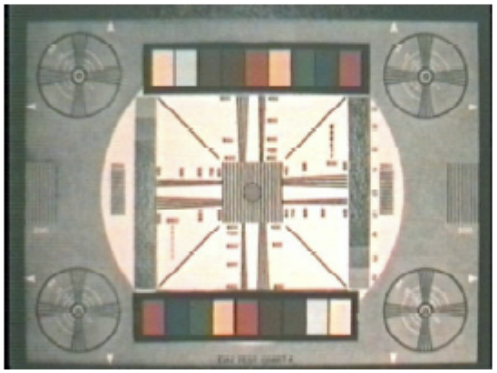
- SpectraCam 84 CID Imager
- 1024 x 1024 pixels
- Rad hardened: 5+ MRads
- Excellent dynamic range
  - 120 to 1100 nm
- Fast scan: 200 Khz
- Random access
- Target SNR: 80 %
- FOV: 45 or 60 º
- TRL 5



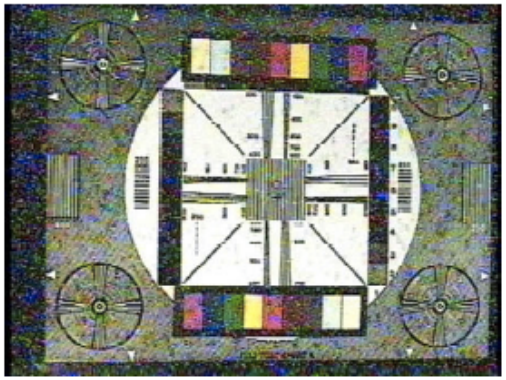


Why CID Imagers

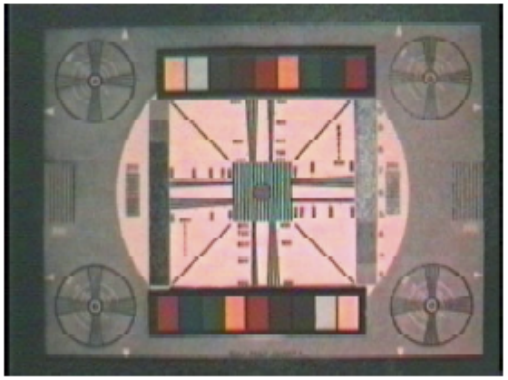
- **Naturally radiation hardened.**



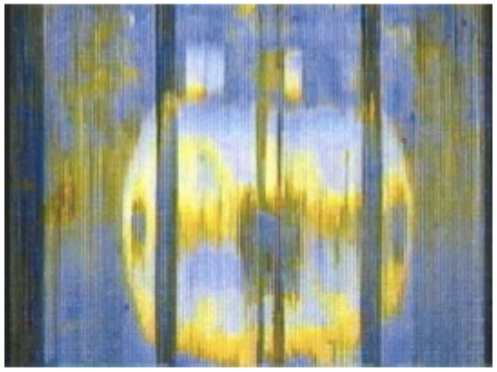
a) CID sensor, flux rate = 100krad/hr



b) CCD sensor, flux rate = 100krad/hr

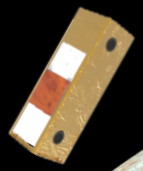


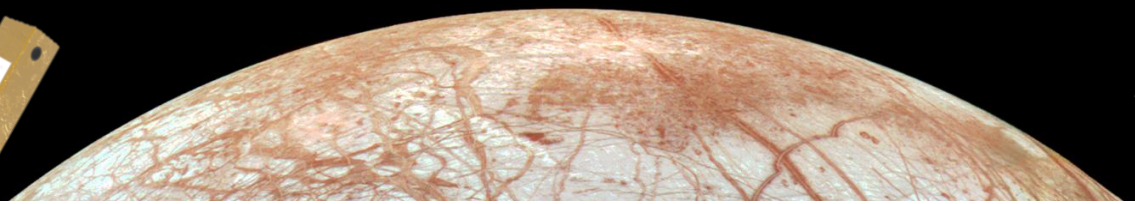
c) CID sensor, TID = 0.45Mrad



d) CCD sensor, TID = 0.1Mrad

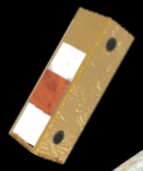
(Bhaskaran et al., 2008)

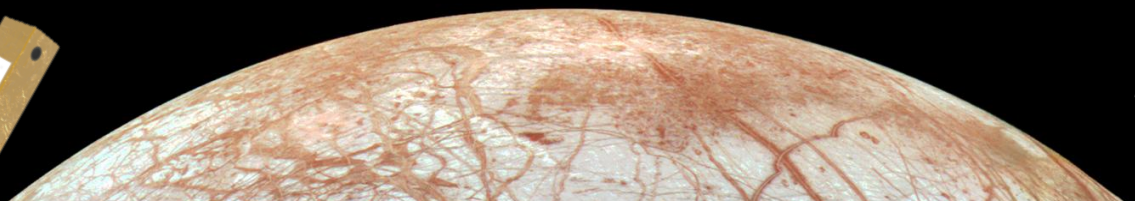




Discussion

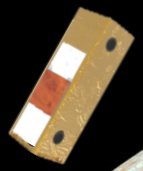
- We propose a Europa CubeSat mission concept that will help to do Decadal survey science and complement the Europa Flyby spacecraft.
  - Linea shape, topography, answer how they formed, if plumes exists
  - Shed light on the liquid ocean hypothesis
- Short of a lander it will give detail images of potential landing sites, a feel for the surface, surprises that awaits for low overall mission risk and low cost

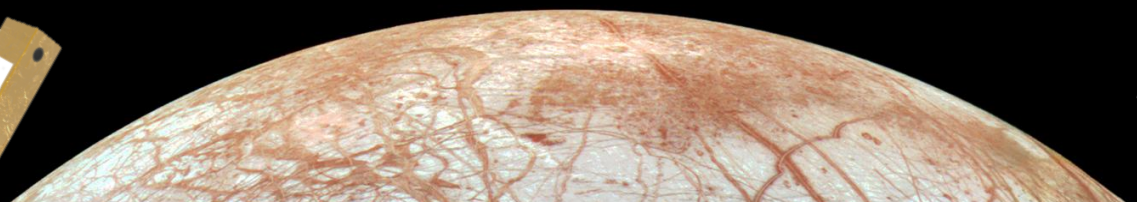




Discussion

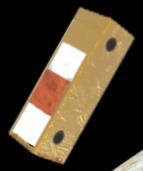
- Major development exists to take current state of the art technologies and apply them to the Europa CubeSat mission.
- The work will be a lot easier if the CubeSat PPOD is shielded heavily.
- Options are better if a 6U is considered instead of 3U.
- ASU team is eager and well qualified to tackle these challenges.

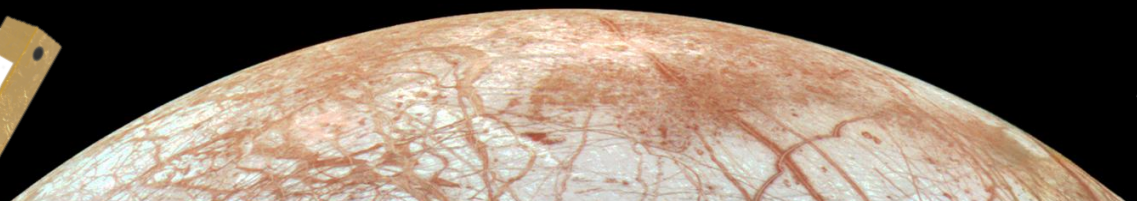




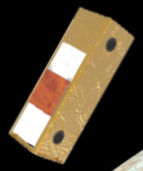
Possible Collaboration Paths with JPL

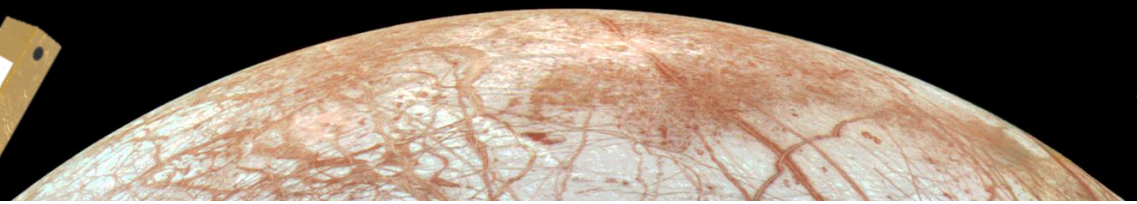
- 1) Development path for the CID cameras
- 2) Radiation mitigation strategies – shielding vs hardening
  - Look into JPL's rad hard Sphinx processor
- 3) Thermal design and control
- 4) SphereX/powered lander/hopper – alternate solution to lander





Thank You!





Questions ?