The Coming Era of Scientific Deep Space Smallsat And CubeSat Exploration

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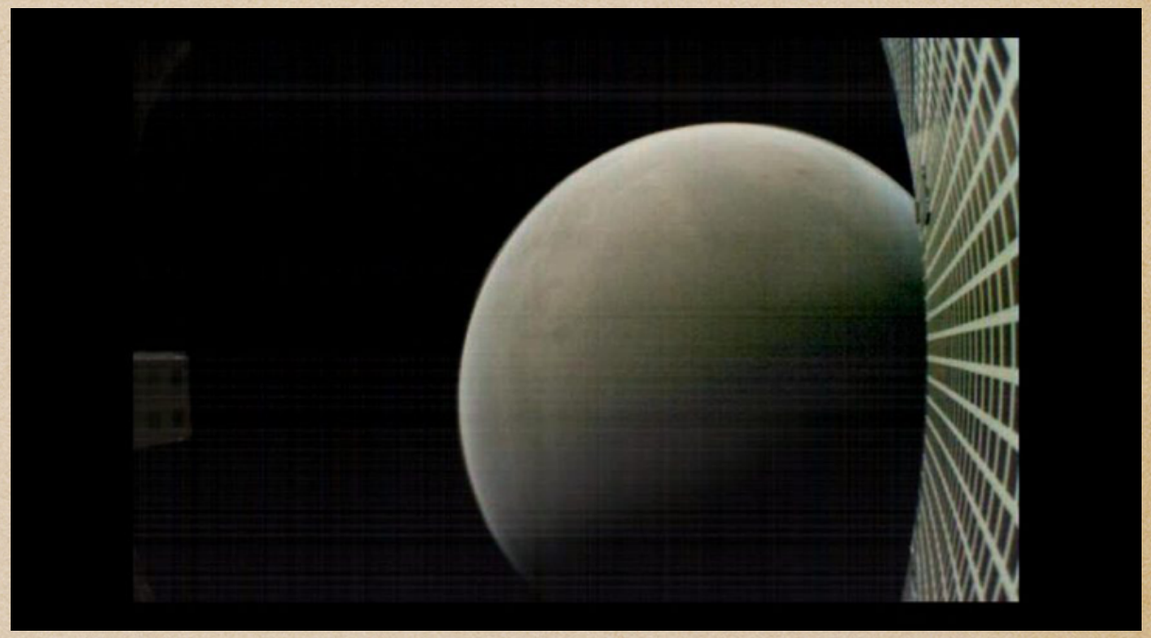
Bright Future

- MarCOs accomplished relay mission and post-Mars flight
- Many concept studies and proposals
- It's time for the era of unique science from deep space



What might the next era look like?

Unique Science from Deep-Space Smallsats and CubeSats is Coming

- Platforms are more capable (power, telecommunications, thermal, pointing, autonomy, compute capability, ...)
- Miniaturized instruments, with lower power
- Deployables will further extend capabilities without "breaking" laws of physics

Cubesat-sized Instruments – 2012 and 2019

Technology	Selva* and Krejci, 2012	Freeman 2019	Justification
Atmospheric Chemistry Instruments	Problematic	Feasible	PICASSO, IR sounders
Atmos Temp and Humidity Sounders	Feasible	Feasible	CiRAS
Cloud Profile and rain radars	Infeasible	Feasible	RainCube
Earth Radiation Budget radiometers	Feasible	Feasible	SERB, RAVAN
Gravity Instruments	Feasible	Feasible	Need a demo mission
Hi-res Optical Imagers	Infeasible	Feasible	Planetlabs
Imaging microwave radars	Infeasible	Feasible	Ka-Band 12U design
Imaging multi-spectral radiometers (Vis/IR)	Problematic	Feasible	AstroDigital
Imaging multi-spectral radiometers (μWave)	Problematic	Feasible	TEMPEST-D, TROPICS
Lidars	Infeasible	Feasible	Lunar Flashlight
Lightning Imagers	Feasible	Feasible	RaioSat
Magnetic Fields	Feasible	Feasible	InSPIRE
Multiple direction/polarization radiometers	Problematic	Feasible	HARP Polarimeter
Ocean color instruments	Feasible	Feasible	SeaHawk
Precision orbit	Feasible	Feasible	CanX-4, -5
Radar altimeters	Infeasible	Feasible	SNoOPI
Scatterometers	Infeasible	Feasible	GNSS refl. (CyGNSS)

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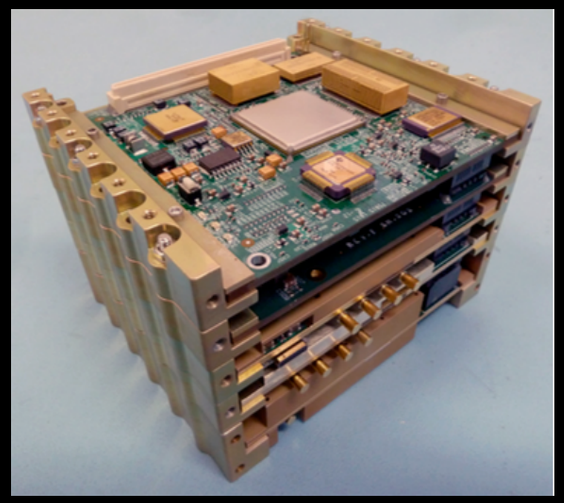
*Selva and Krejci, A survey and assessment of the capabilities of Cubesats for Earth observation, Acta Astronautica, 74, 50–68 (2012)

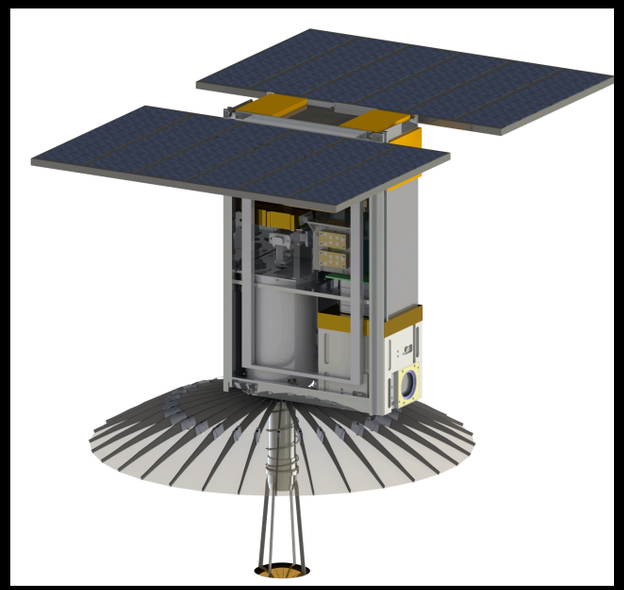
Earth Science slide courtesy of Tony Freeman, CubeSat Developer's Conference 2019

JPL Technologies and Capabilities

IRIS Radio



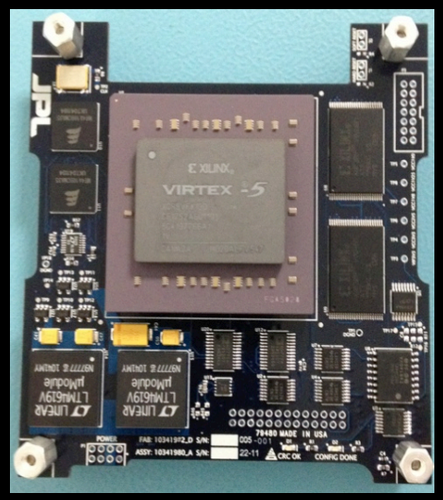
Deployable Reflector



Sphinx C&DH

DSN Communications and Navigation Protocols

OnBoard Data Reduction

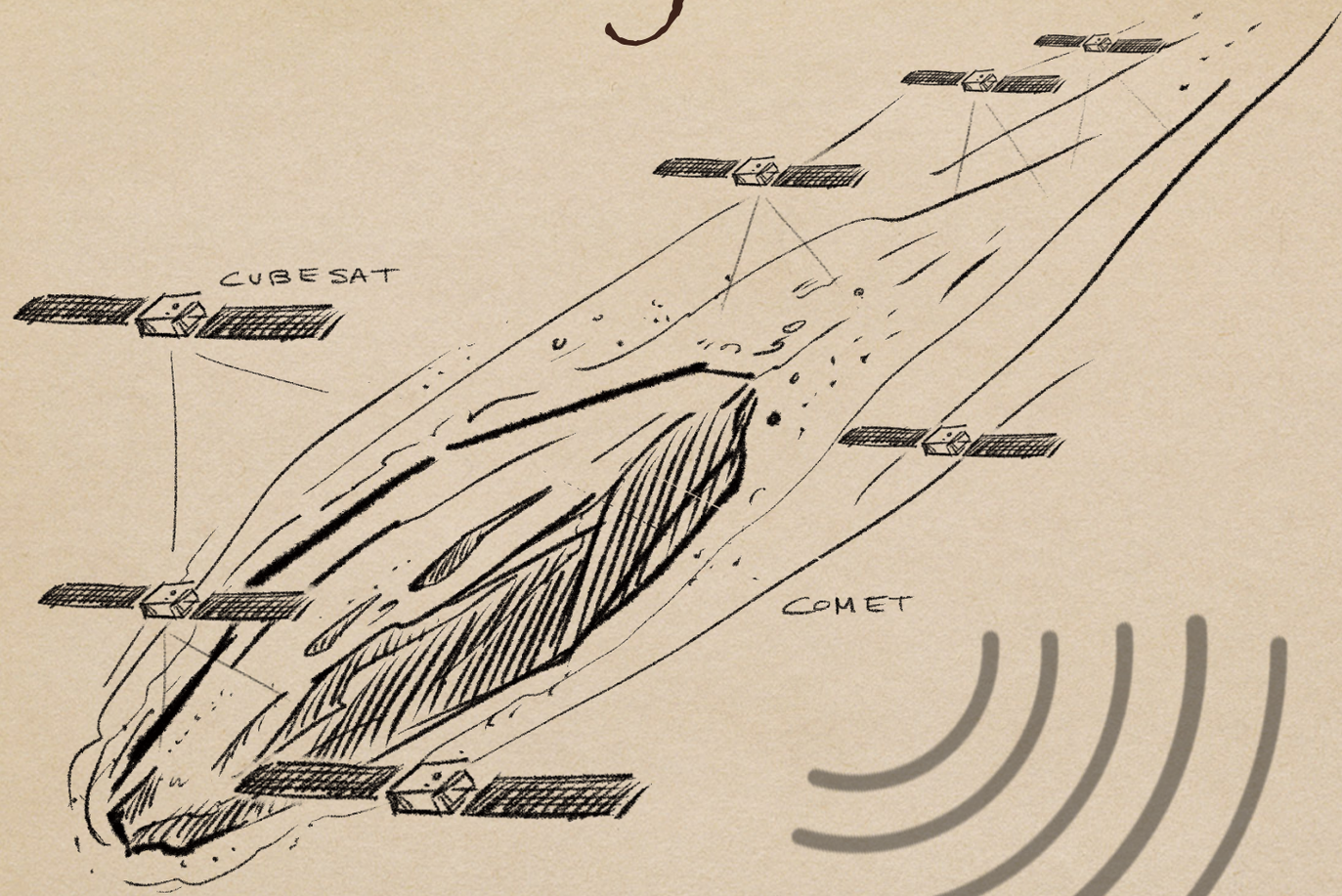


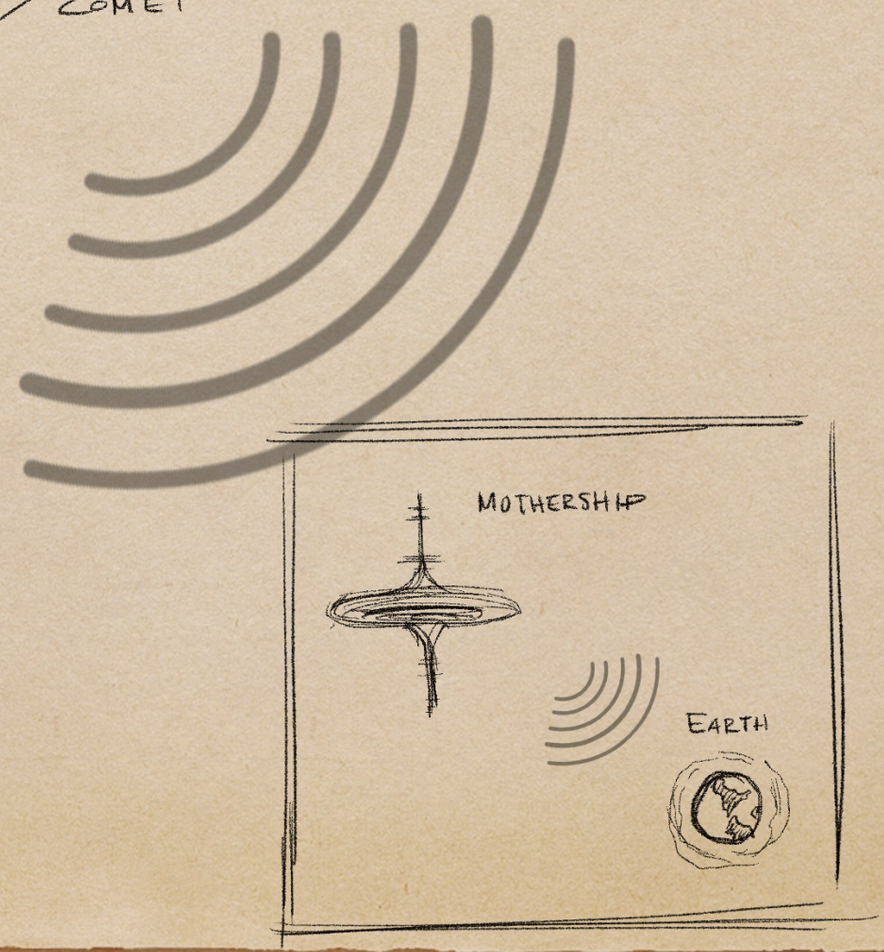
CubeSat Development Lab

Jet Propulsion Laboratory
California Institute of Technology

Slide courtesy of Tony Freeman, CubeSat Developer's Conference 2019

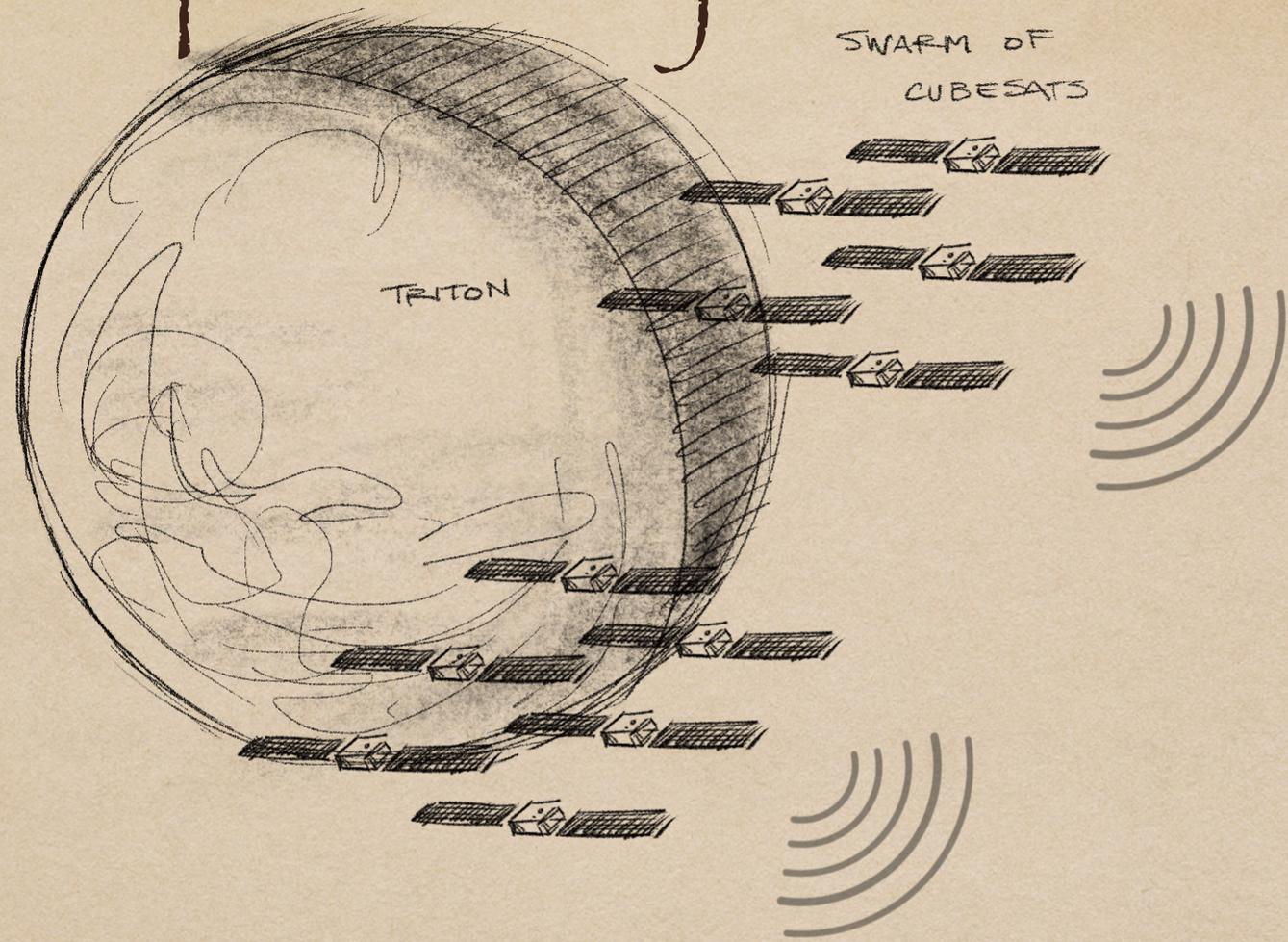
Small Body Characterization

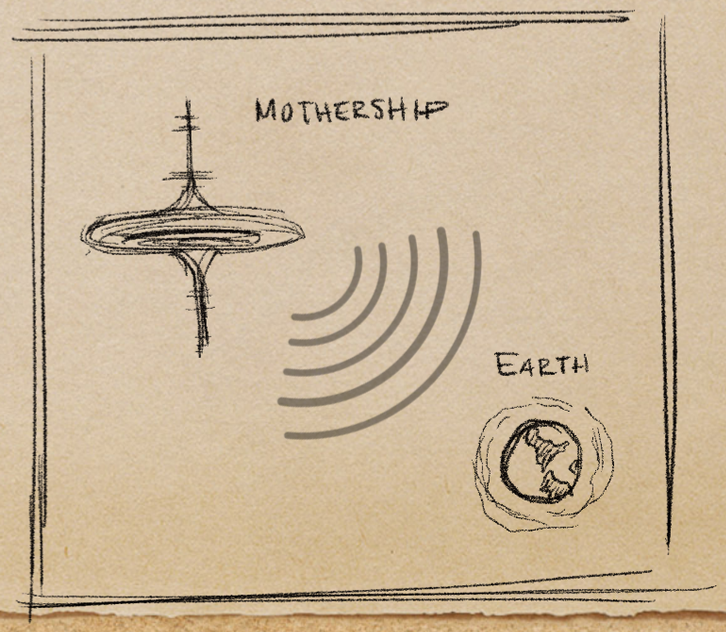




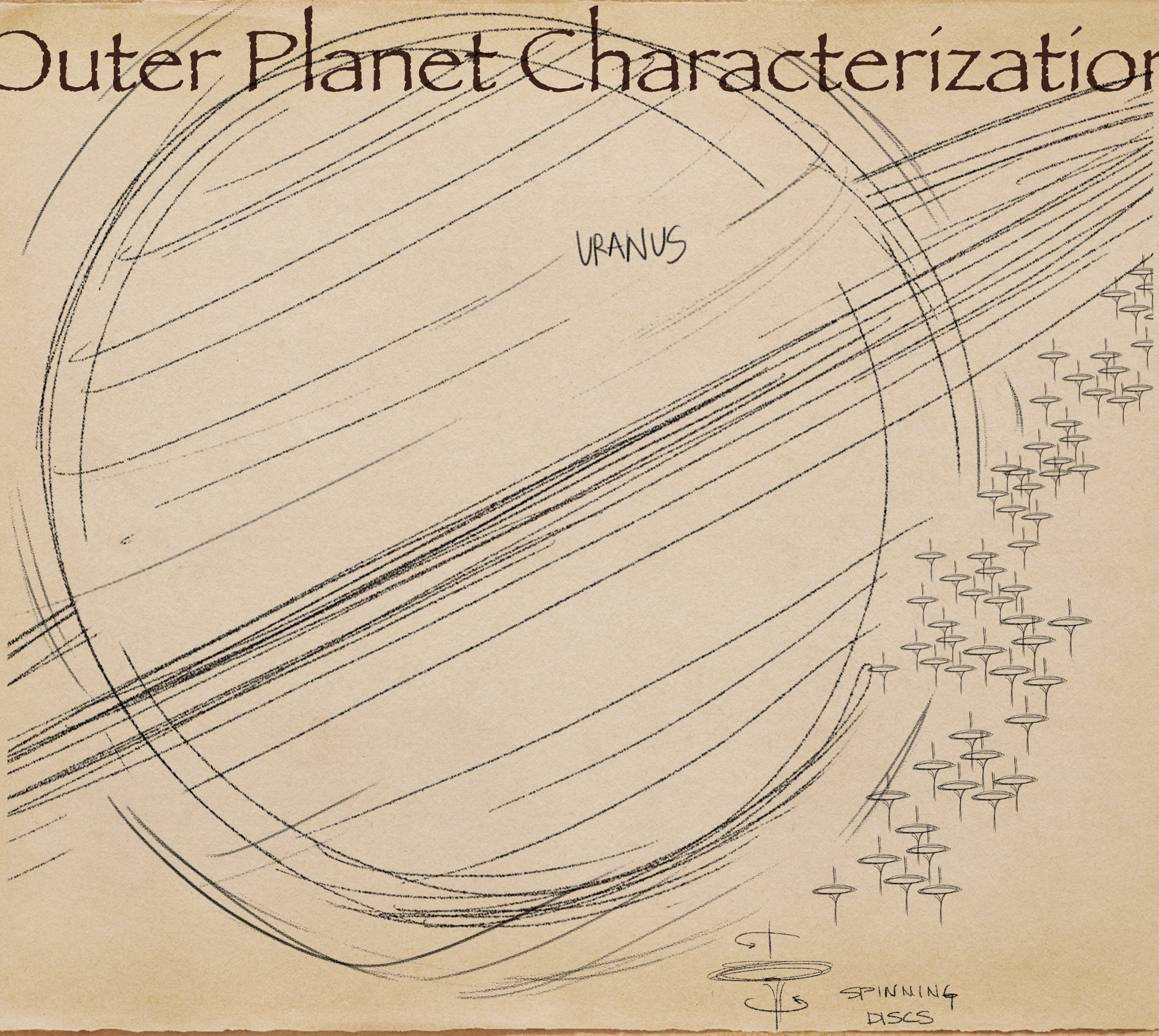
Sketches courtesy Kat J. Park, The Studio, JPL

Deep Space Object Characterization

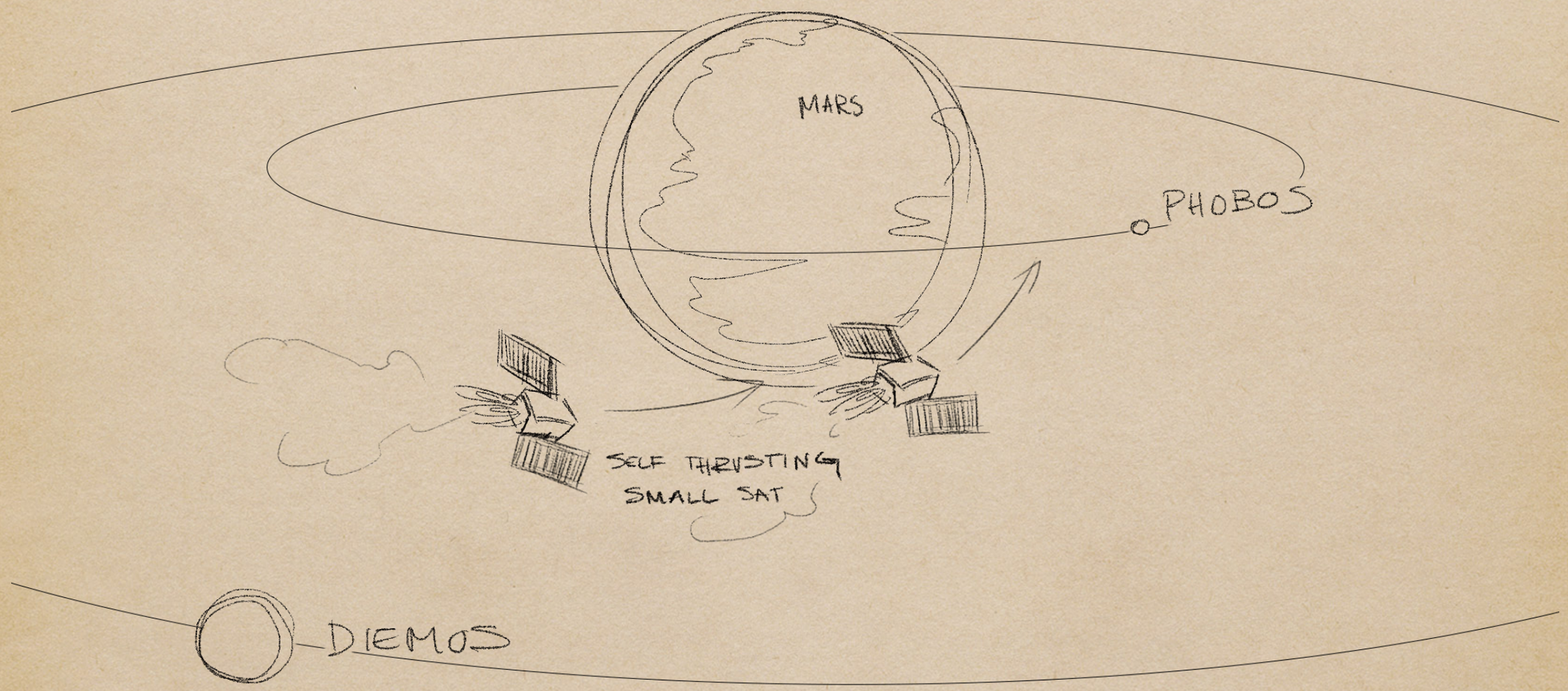




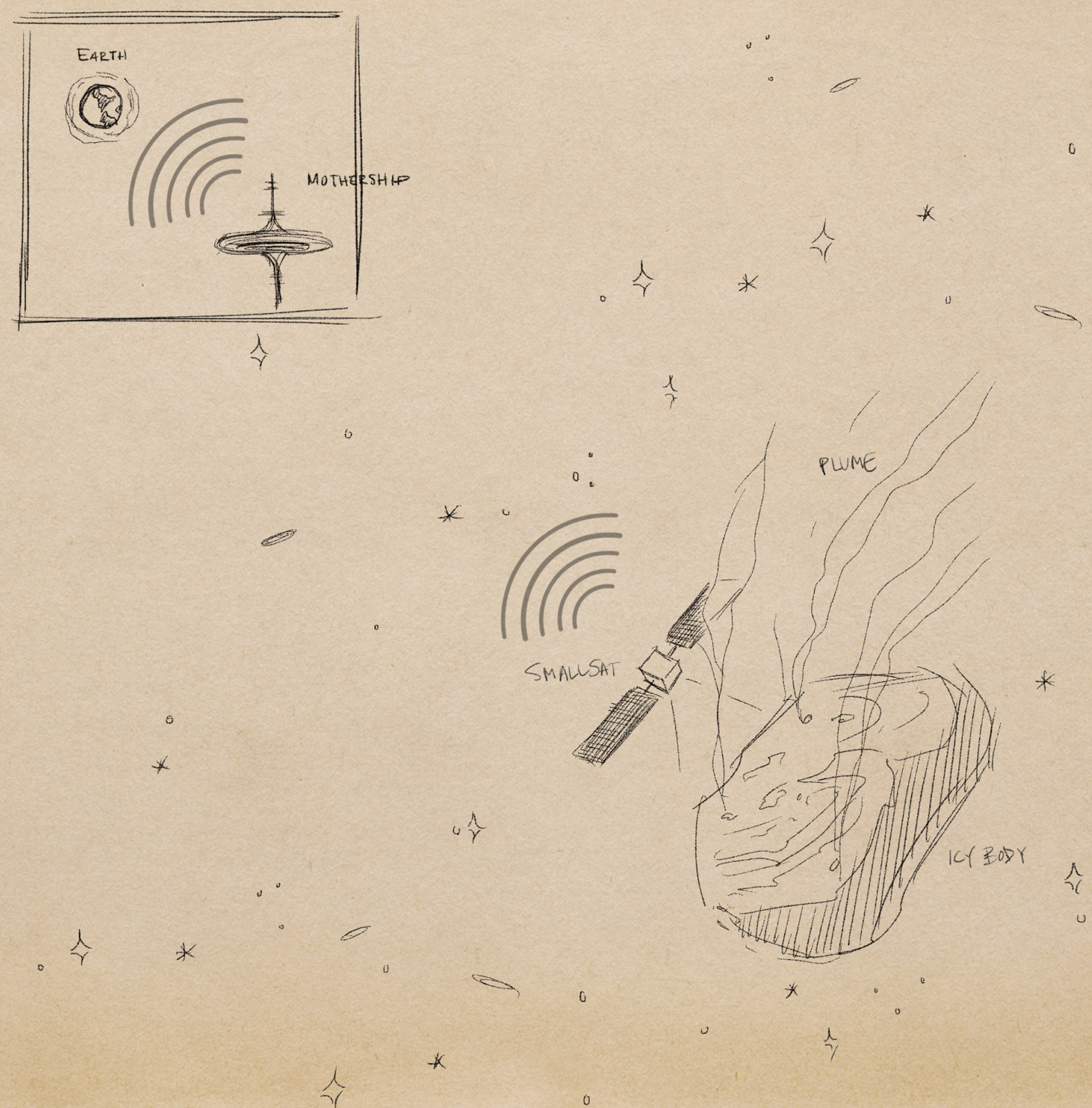
Outer Planet Characterization



Achieve Orbit Around a Planet Such as Mars Via Own Propulsion

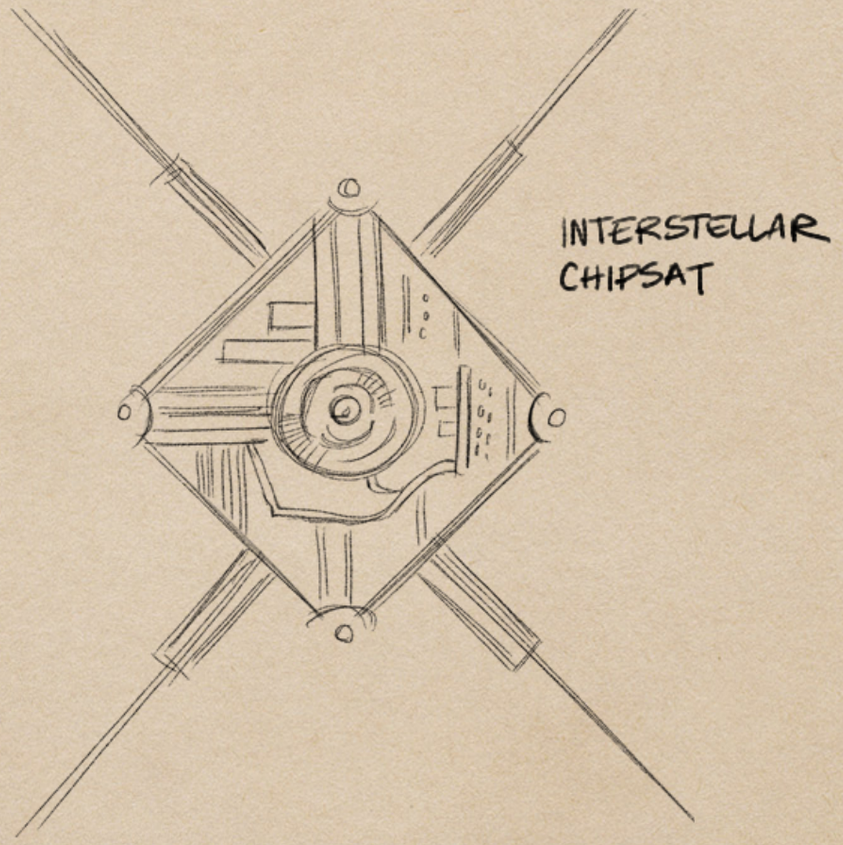


Risky Environment Exploration



Individual Observations of Single Targets Over Long Periods of Time

Interstellar Exploration



One day soon, all deep space missions will use multiple SmallSats and CubeSats. Single platform science and missions will be the exception.