Life Investigation and Testing on Enceladus

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Mission Purpose

Many organizations have tried to answer the question of whether life exists on other planets, however, very few spacecraft missions have set out to answer this question. The LITE mission will explore whether life exists on Enceladus, Saturn's sixth largest moon, by studying samples from its vast water sources. Our mission is to determine if the 6 biosignatures of life: carbon, hydrogen, oxygen, nitrogen, sulphur and phosphorus are present in Enceladus's massive subterranean oceans. This mission can return a vast amount of scientific data that has the potential to explain how likely life's existence is in the solar system and beyond when the building blocks of life and a habitable environment are present.

Our Requirements

Primary Requirement 1	The LITE mission shall investigate Enceladus's ability to support life in the past, present, and future.
Secondary Requirement 1	The spacecraft shall reach Enceladus in the 2050 decade.
Secondary Requirement 2	The spacecraft shall orbit Enceladus at an altitude of 30km, which allows for sample collection and surface photography.
Secondary Requirement 3	The onboard instruments shall be able to run tests while in orbit and while landed.
Secondary Requirement 4	The spacecraft shall land in a location where passive sample collection is possible, near the poles of Enceladus.
Secondary Requirement 5	Data shall be transmitted whenever a complete set of data has been processed and a line of sight to Earth is available, in orbit and while on the surface, throughout the entire length of the mission life.
Secondary Requirement 6	The spacecraft passive collection method shall collect sample sizes no smaller than 400 mL for the instruments to accurately complete three tests.
Secondary Requirement 7	The spacecraft shall not introduce any organisms into Enceladus's ocean that may have traveled on the spacecraft.
Secondary Requirement 8	There shall be no less than six biosignature detection instruments to reduce chances of a false positive.
Secondary Requirement 9	The mission shall not cost more than 3 billion dollars.

Orbital Trajectory

The LITE Spacecraft will launch from the Cape Canaveral, Florida at 20:00:00 UTC on January 8, 2025. The Falcon Heavy launch vehicle will provide the thrust needed for the spacecraft to enter a hyperbolic orbit to Venus, which will further thrust the spacecraft via gravity assist so that the spacecraft can reach Saturn. The spacecraft will then enter a circular orbit 5.801 times the radius of Saturn in August 2028. LITE will stay in this orbit until the decade of 2050, when Enceladus's North Pole has satisfactory sunlight for image processing. A trans-orbital injection followed by an inclination burn will put LITE in the proper orbit around Enceladus for data processing. The total ΔV table and the mapping of the orbital trajectory supplied by STK will be shown below.

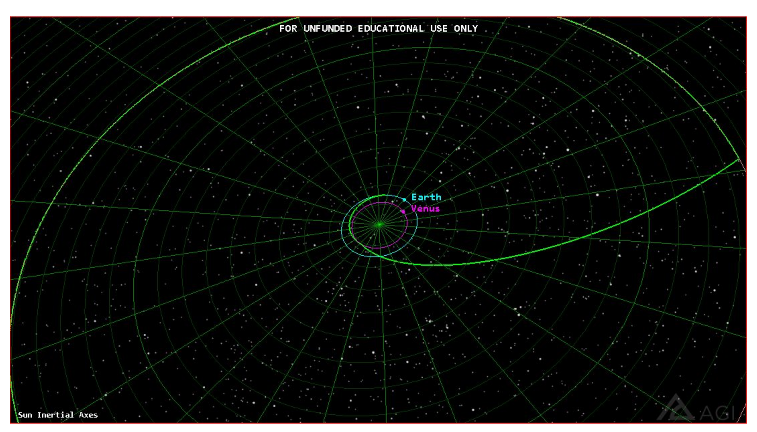


Figure 1: Orbital Trajectory of LITE Spacecraft in Sun Reference Frame

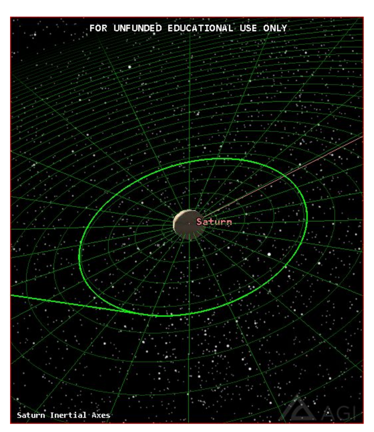


Figure 2: Orbital Trajectory of LITE Spacecraft in Saturn Reference Frame

	Earth to Venus	Venus to Saturn	Saturn to Enceladus	Inclination Burn	EDL Guidance	Station-keeping	Total ΔV
(In m/s)	176.25	3.36	2124.18	259.40	197.01	431.55	3300

Table 1: Delta-V Budget

Spacecraft Design

LITE, our mission spacecraft, is designed to act as both an orbiting research station as well as a stationary analysis platform on the surface of Enceladus.

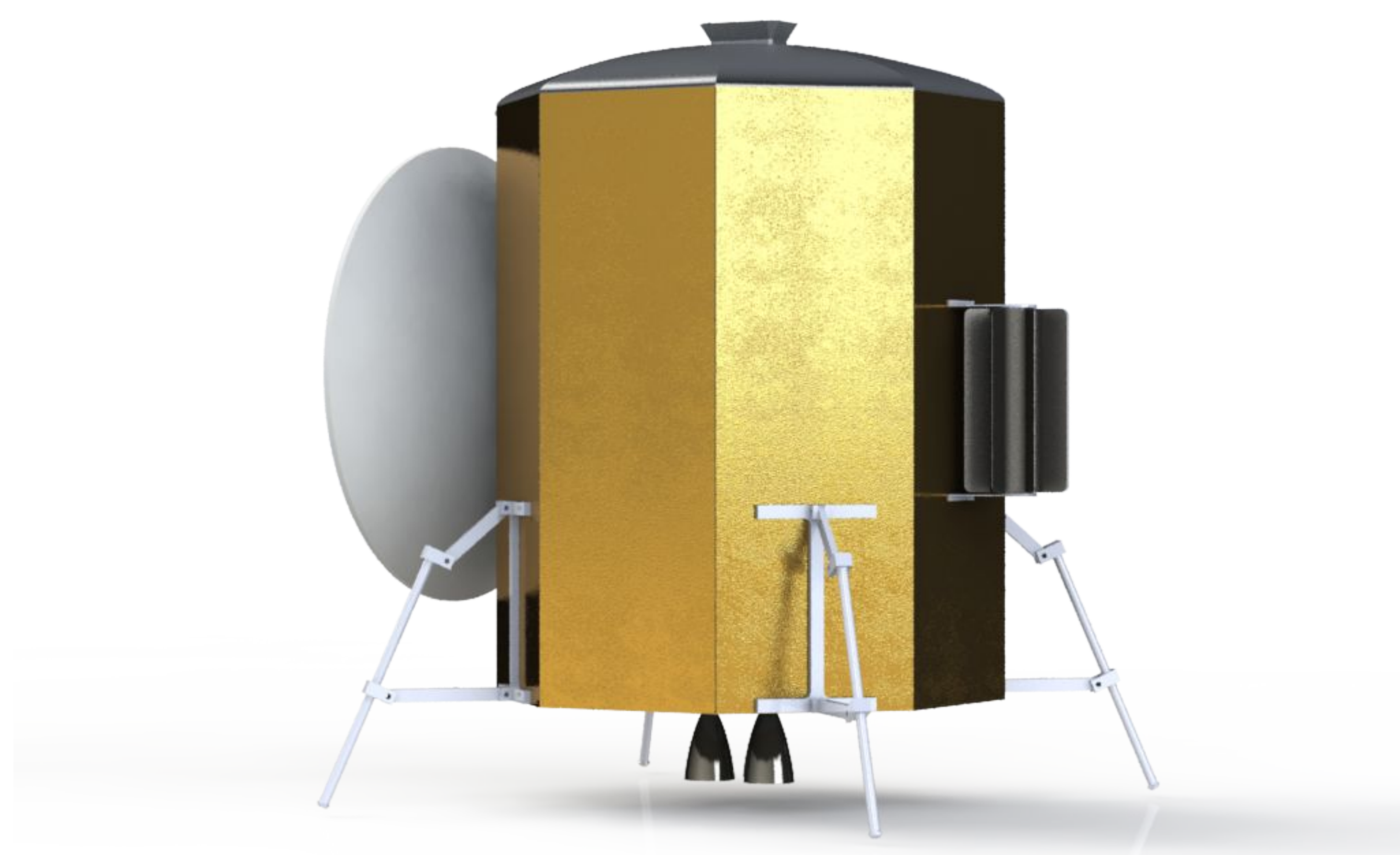


Figure 3: Up to date CAD model of the LITE spacecraft. Notable features visible from the exterior are the radioisotope thermoelectric generator (RTG), communications dish, thrusters, landing legs, sample catch funnel, and the environmental protection skin on the exterior of the primary structure.

The LITE spacecraft draws from previous missions with similar trajectories and goals, namely the Cassini-Huygens mission. Many of the components that make up the vehicle are modernized or adapted versions of proven hardware.

Once on orbit around Enceladus, the spacecraft will map the surface with onboard cameras to determine a landing site. When passing through plumes, the craft will fly prograde to orient the collection instruments appropriately to capture samples to be analyzed onboard.

The spacecraft will use its remaining propellant to deorbit and land sufficiently close to the plumes to collect ejecta. Landing legs will deploy during the EDL phase to support the craft on the surface.

Communication System

The communication system of the spacecraft needs to transmit data acquired via plumes from Enceladus. To do this, the RF communications interface board will be used to perform the uplink and downlink of all data coming from the sensors to the DSN set of 35-meter antennas on Earth. These antennas are located in New Norcia, Austria, Cebreros, Spain, and Malargue, Argentina. A steerable high-gain Norsat antenna will be used to send data from the spacecraft to the DSN antennas. A Ka-Band will be used so that higher data rates can be sent on the long link back to Earth. This allows for communication operations at a frequency of 30 GHz. The spacecraft's antenna will be approximately four meters in diameter. The time taken for communication to travel from Earth to the location of the spacecraft on Enceladus will take a bit longer than one hour, so two-way communication will not be as easy as other missions closer to the Earth. Specifications are located to the right.

Diameter	4 m
Frequency	30 GHz
Transmit Power	50 W
Efficiency	55%
Transmitter Gain	59 dBi
Link Power Budget	3.32e-14 W
EIRP	109.4 dBW

Table 2: Antenna Specifications

Payload

On-Board Instrumentation

Life Detection Instruments
- High Resolution Mass Spectrometer
- Separation Capable Mass Spectrometer
- Electrochemical Sensor Array
- Microcapillary Electrophoresis with laser induced fluorescence
- Microscope
- Nanopore

Remote Sensing Instruments
- Radar Sounder
- Laser Altimeter
- Thermal Emission Spectrometer
- Camera

Surface Instruments
- Seismometer
- Camera

Sample Collection Method

Passively collect plume fallout by having a funnel on top of the lander. Collector will have proportionally sized grates to divide sample for each instrument.The instruments on board will then test the samples for the six biosignatures of life

Sample Collection Volumes

- Assuming the biodensity is 1000 cells/L (based on current knowledge of energy supply):
- 0.6 mL needed for all instruments except nanopore to run 1 test
- 10 mL needed for 1 nanopore test run
- 1.5 year orbit - 1 complete test run for all instruments
- 2 years on surface - 3 complete test runs

Note: High life density will need less volume while low life density will need more volume. Orbit altitude will be determined by further research on the density of the plumes at various altitudes.

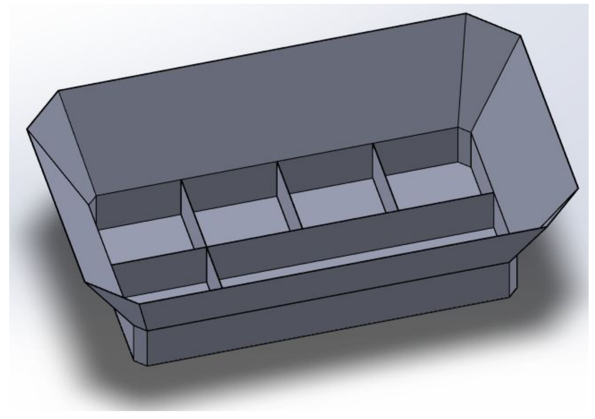
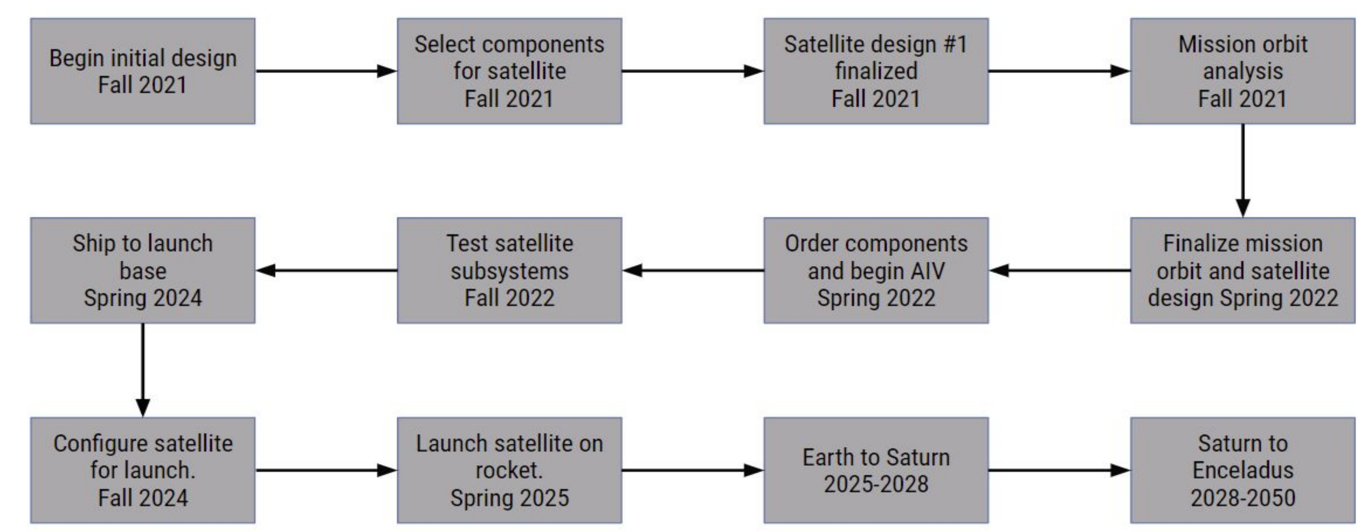


Figure 3: Plume Fallout Collection Funnel

Timeline and budget



Item	Cost (approximate)	Item Continued	Cost (approximate) Continued
Payload	$16,700,000	Fuel	$11,690,000
Communication Components	$25,050,000	Launcher	$118,570,000
Software	$16,700,000	Instruments	$41,750,000
Computer hardware	$8,350,000	Propulsions System	$183,700,000
		Total:	**$422,510,000**

Table 3: Mission Budget

Acknowledgements

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