



Cost Analysis and Concept of Operations in ITA Space Center (CEI) CubeSat Missions: A Comprehensive Review

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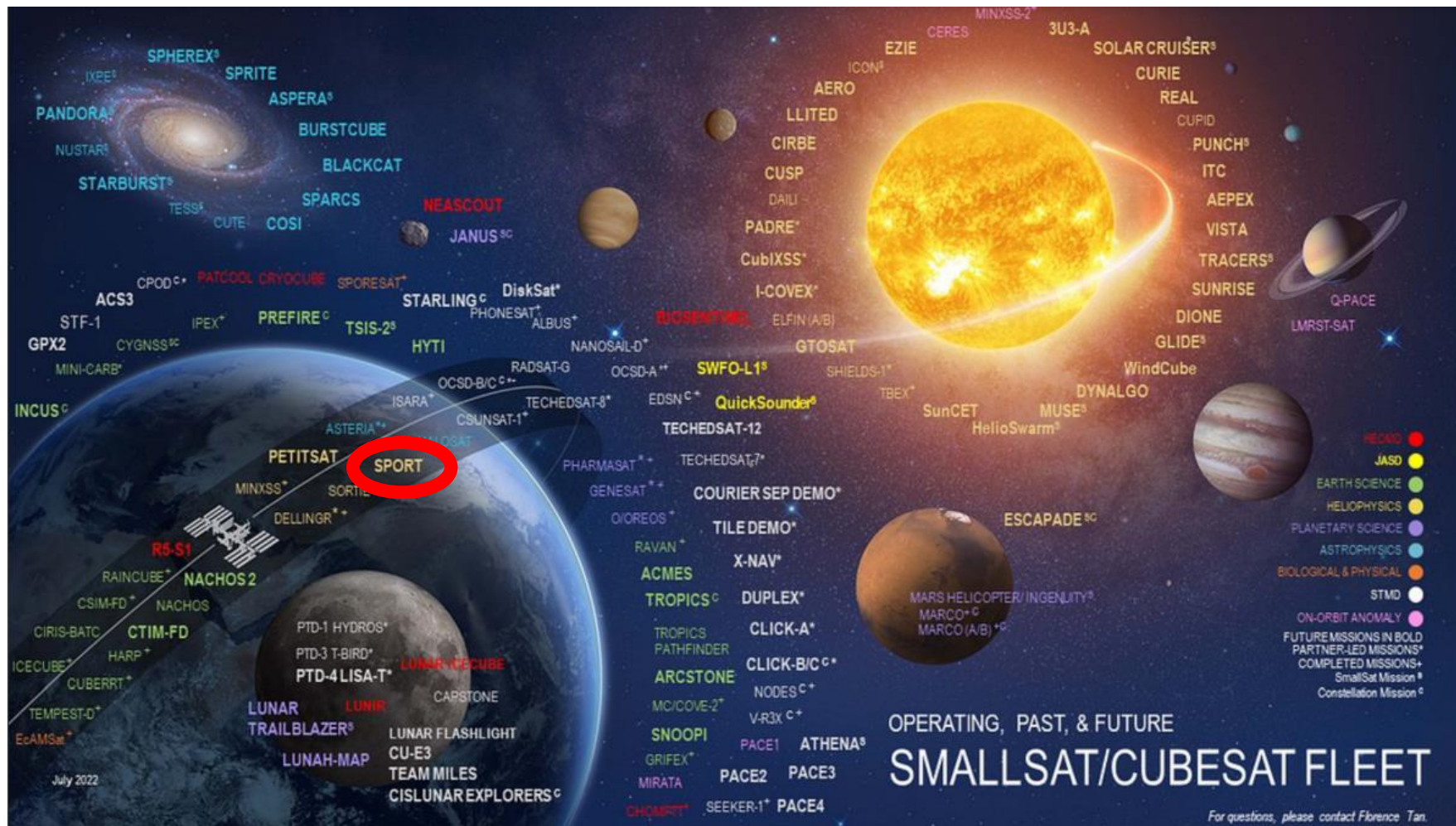
Victoria de Souza Rodrigues



Introduction



In recent years, CubeSat missions have emerged as a cost-effective and versatile solution for various applications in space exploration, Earth observation, communication, and scientific research.

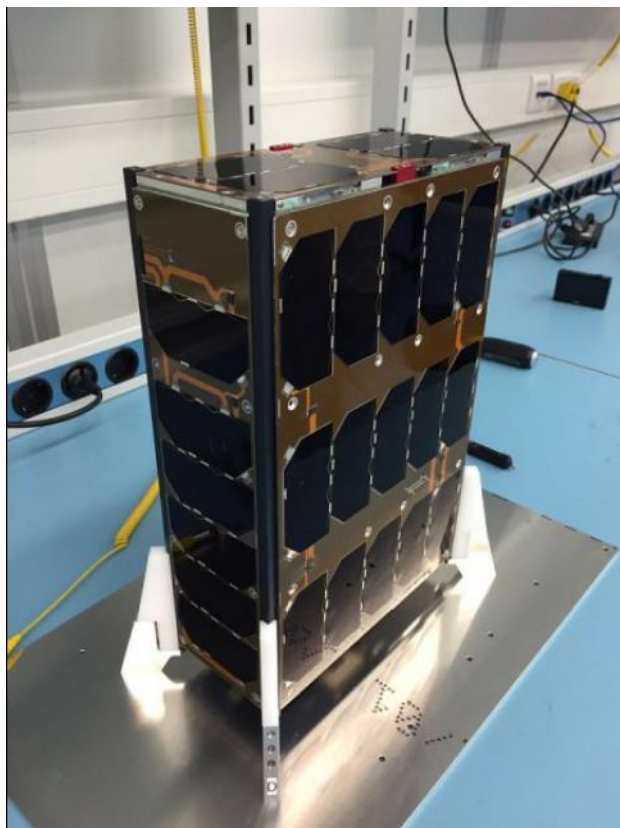




Introduction



Brief overview of the CEI CubeSat missions



ITASAT

ITASAT1

- **Mission:** Human resources training for the aerospace sector from the conception of a mission to its operation;
- **NORAD ID:** 43786;
- **Size:** 6U CubeSat;
- **Launched:** 2018-12-03;
- **Status:** Semi-operational
- **Orbit:** 573 km x 592 km, 97.77°
- **Relation between size and payload:** 6U x 4 Payloads

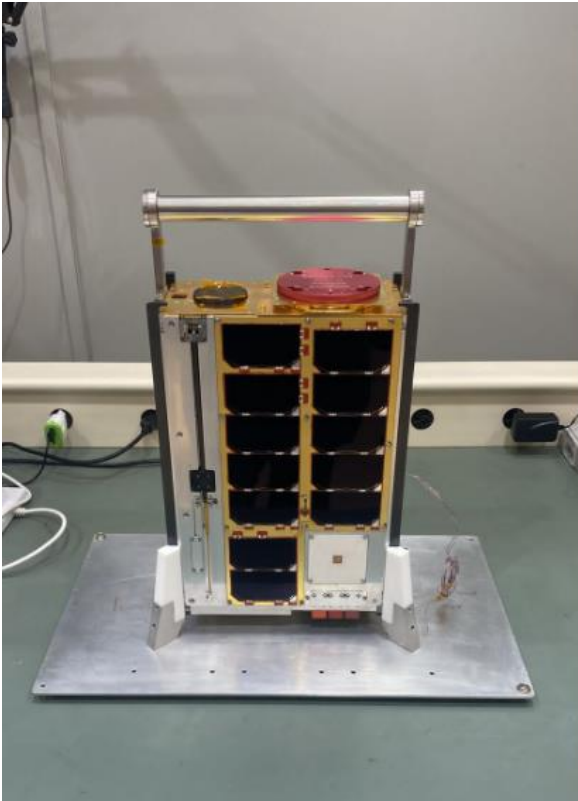


Introduction



Brief overview of the CEI CubeSat missions

SPORT (Scintillation Prediction Observations Research Task)



SPORT

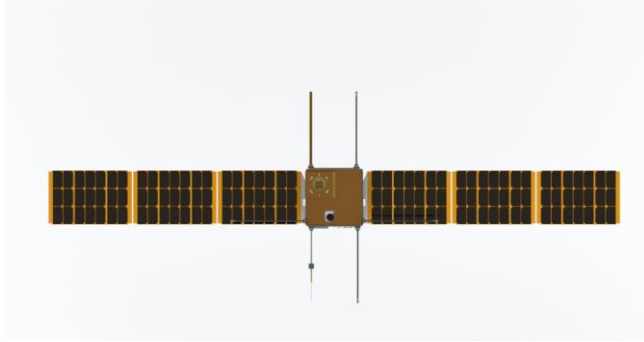
- **Mission:** Space weather mission to investigate the state of the ionosphere that leads to the growth of plasma bubbles;
- **NORAD ID:** 55129;
- **Size:** 6U CubeSat;
- **Launched:** 2022-12-29;
- **Status:** Reentry 2023-10-11;
- **Orbit:** 400 km x 400 km, 51.6°
- **Relation between size and payload:** 6U x 4 Payloads



Introduction



Brief overview of the CEI CubeSat missions



ITASAT2

- **Mission:** A satellite mission to provide a tailored source of data for the understanding of space weather spatiotemporal events and interactions and to provide a baseline geolocation option based on national needs.
- **Size:** 12U CubeSat;
- **Launch:** 1° semester of 2027;
- **Status:** Phase B
- **Orbit:** 500 km x 500 km, 56° (TBC);
- **Relation between size and payload:** 12U x 8 Payloads.



Introduction



Typical Cost drivers are:

- Size (weight in Kilograms for hardware and lines of code for software)
- Complexity (Choice of material, power, bandwidth)
- Availability of the technology (Technology readiness level, degree of design completion)
- Schedule (time available for development)

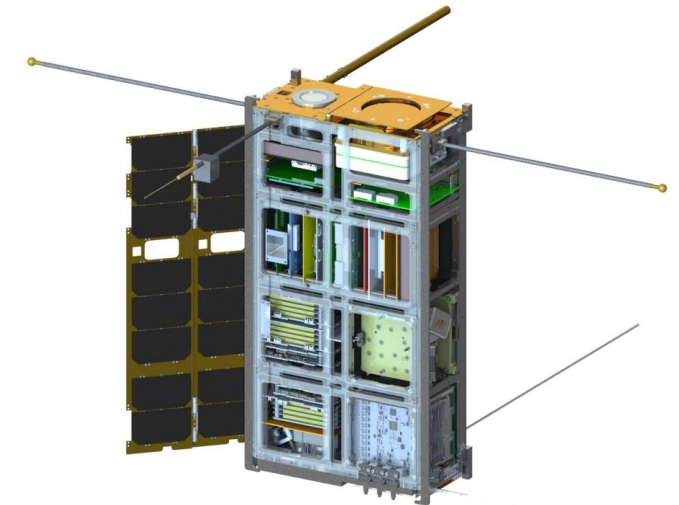
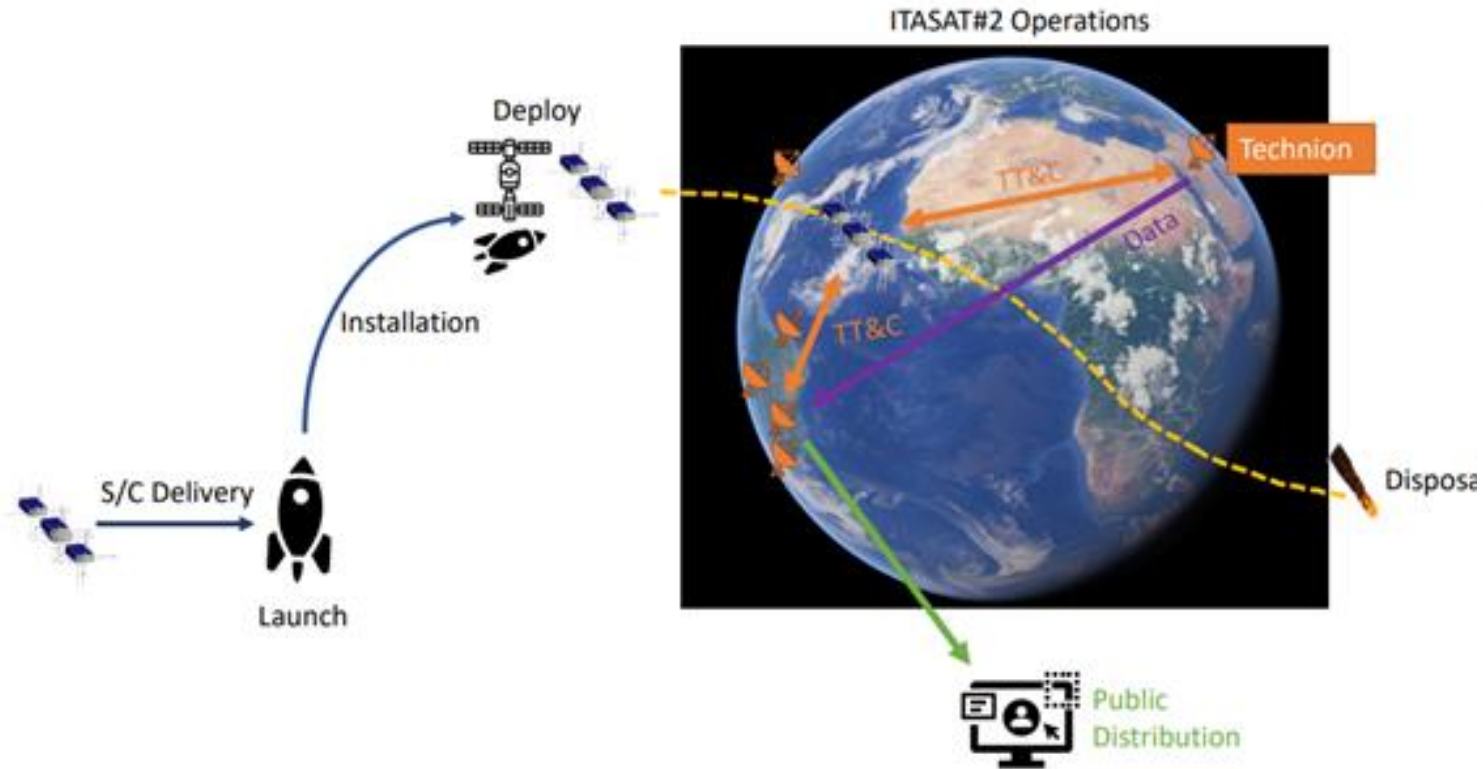
Cost Estimating Methods – 3 types		
Analogy	Parametric	Grassroots
Data Driven	Data Driven	Data Driven
Based on similarity / analogous	Statistical relationship model based on historic actuals between costs and a system or performance characteristics	Also known as “bottoms-up”
Extrapolation and adjustments to actual	Typical parametric cost models are based on mass and power	Experienced and / or knowledge from subject matter expert on proper staffing, procurements, etc...



Introduction



First Concept of Operations proposal ITASAT2



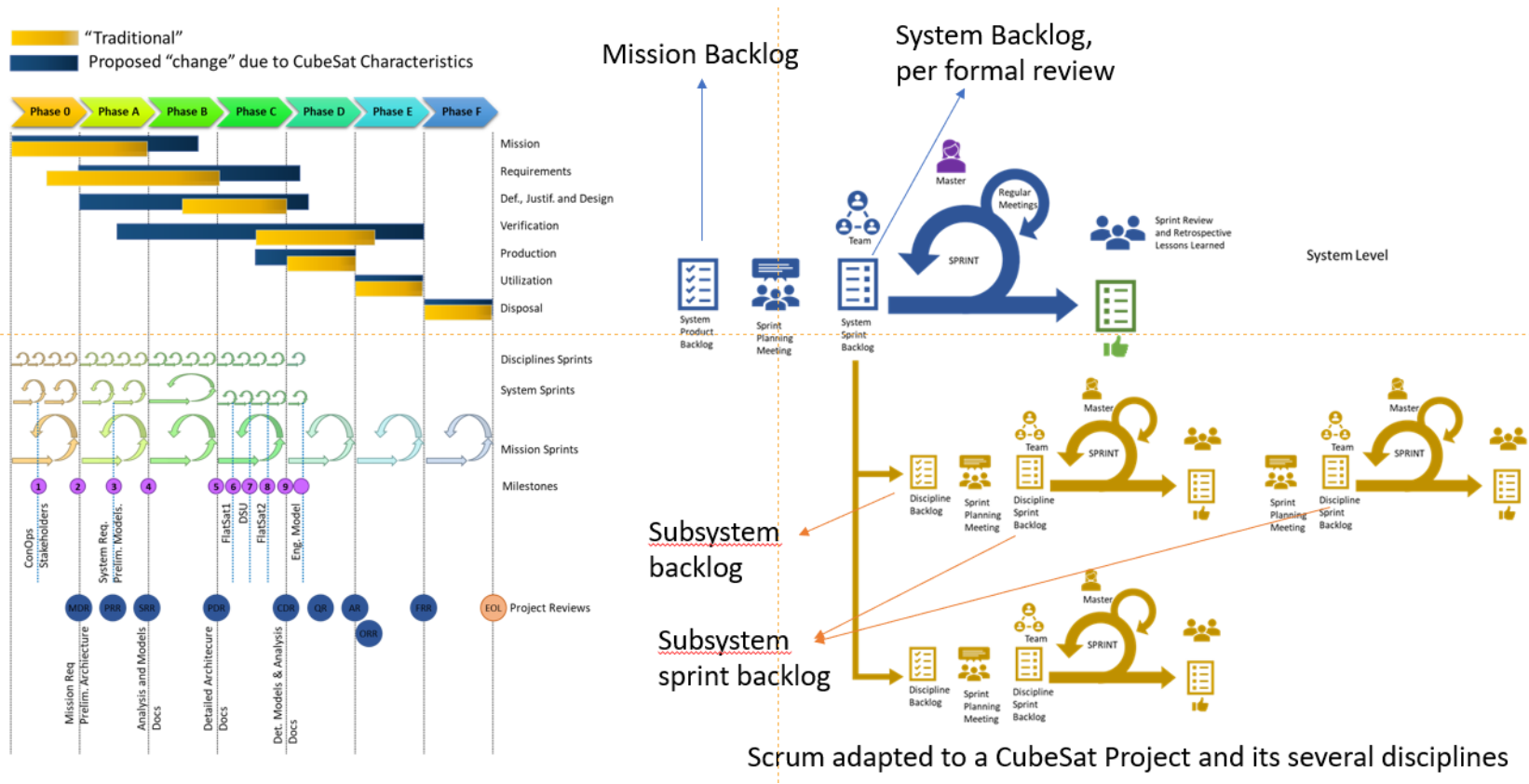
ITASAT 2 First Conception



Background



Agile methodology in the development of CubeSats mission



- Sprints of 2 weeks for each discipline**
- sprint planning
- follow up (at Half of the sprint)
- sprint review

System Backlog defined by Tech. Coordinator

Discipline backlog define from System backlog

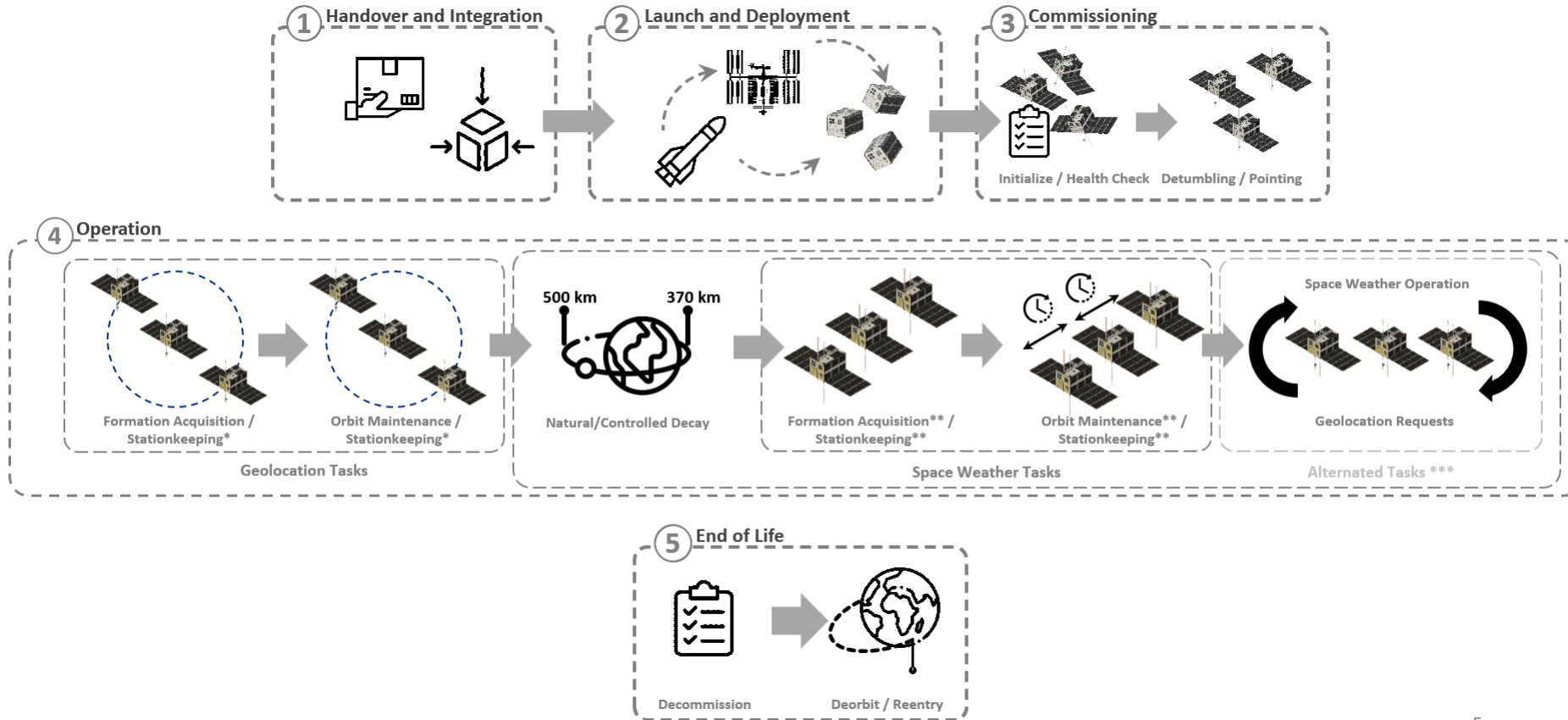
Sprint planning by the team



Concept of Operations



Current Concept of Operatiol of the ITASAT2

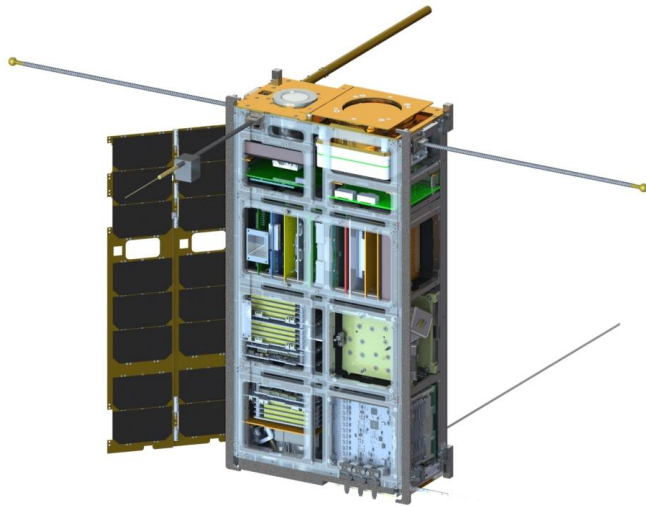




Conceptual Design



Importance of cost-effectiveness and versatility in the aerospace industry



ITASAT 2 First Conception



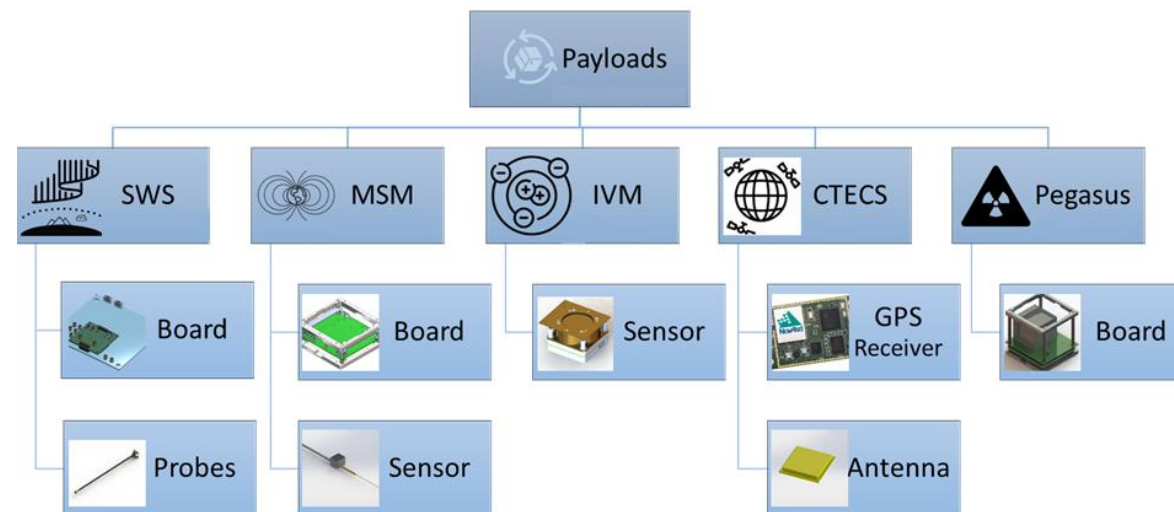
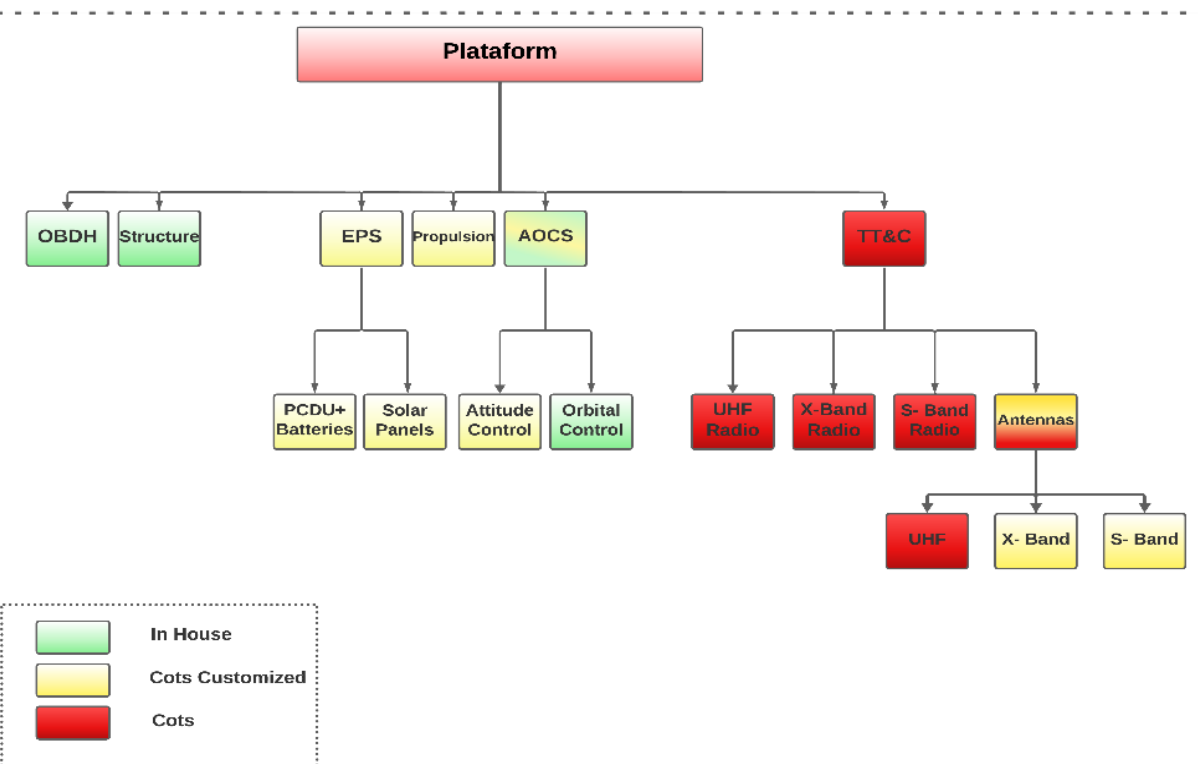
ITASAT 2 Current Conception



Cost Components



Satellite development costs





Cost Components

Launch costs



CubeSat Launch Providers / Brokerers / Mission Integrators

New launchers will be added here when they are very close to commercial missions because there are too many small rockets in development as seen from [NewSpace Index](#).

Provider	CubeSats launched	First launch	Launch cost	Additional information
Maverick Space Systems	4+	2021		Broker launches with all major US and international LV providers.
SpaceX	50+	2021	\$1M per up to 200 kg. \$275K for 50 kg.	No single CubeSat slots, but possible to attach CubeSat deployers to ESPA ports.
Astra	30+	2022		Dedicated, low-cost, orbital launch services for small satellites.
Dhruva Space	2	2022		Enabling rapid satellite deployment for multiple platform sizes and from various launch vehicle providers.
Fossa Systems	13+	2022	Starting at 18,000€ per 1P.	We put your satellites in orbit.. Own satellite deployer.
Momentum	2+	2022	\$120,000 - \$260,000 for 3U, \$230,000 - \$500,000 for 6U, \$430,000 - \$960,000 for 12U depending on inclination	Delivery service provides point-to-point transportation and deployment of the Customer payload in the desired orbit.
NASA Rideshares	10+	2022		LaunchPortal: Potential Rideshare Opportunities
Precious Payload	?	2022		Global launch reservation system for small satellites.
Exotrail	?	2023	3U: 75k€, 6U, 6UXL: 120k€, 8U: 175k€	spacedrop™ is an end-to-end launch and deployment service dedicated to nano, micro and small satellites.
LAUNCHER	6+	2023	Starting from \$20,000 per U.	With Orbiter, Launcher combines cost-effective rideshare with the flexibility of a dedicated launch.
Astrobotic	0	2024	\$1.2M per kg to Lunar orbit or surface	
GeoJump	0	2024		Payloads to GEO.
Geometric Energy Corporation	0	2024		Integration services provided by Maverick Space.
Intuitive Machines	0	2024	undefined	Our lunar transfer orbit delivery services can accommodate up to 1000 kg of payload and deliver customers into a myriad of high-energy orbits.
Responsive Access	0	2024		End-to-end, 'one stop shop' launch service, enabled by our tools and partnerships.
RIDE	0	2024		Launch provider platform, Launch-as-a-Service.
UARX Space	0	2024		We provide reliable in-space logistics, rideshare and dedicated launch services for Small Satellites, from LEO to the Moon and beyond.



Cost Components

Mission operations costs

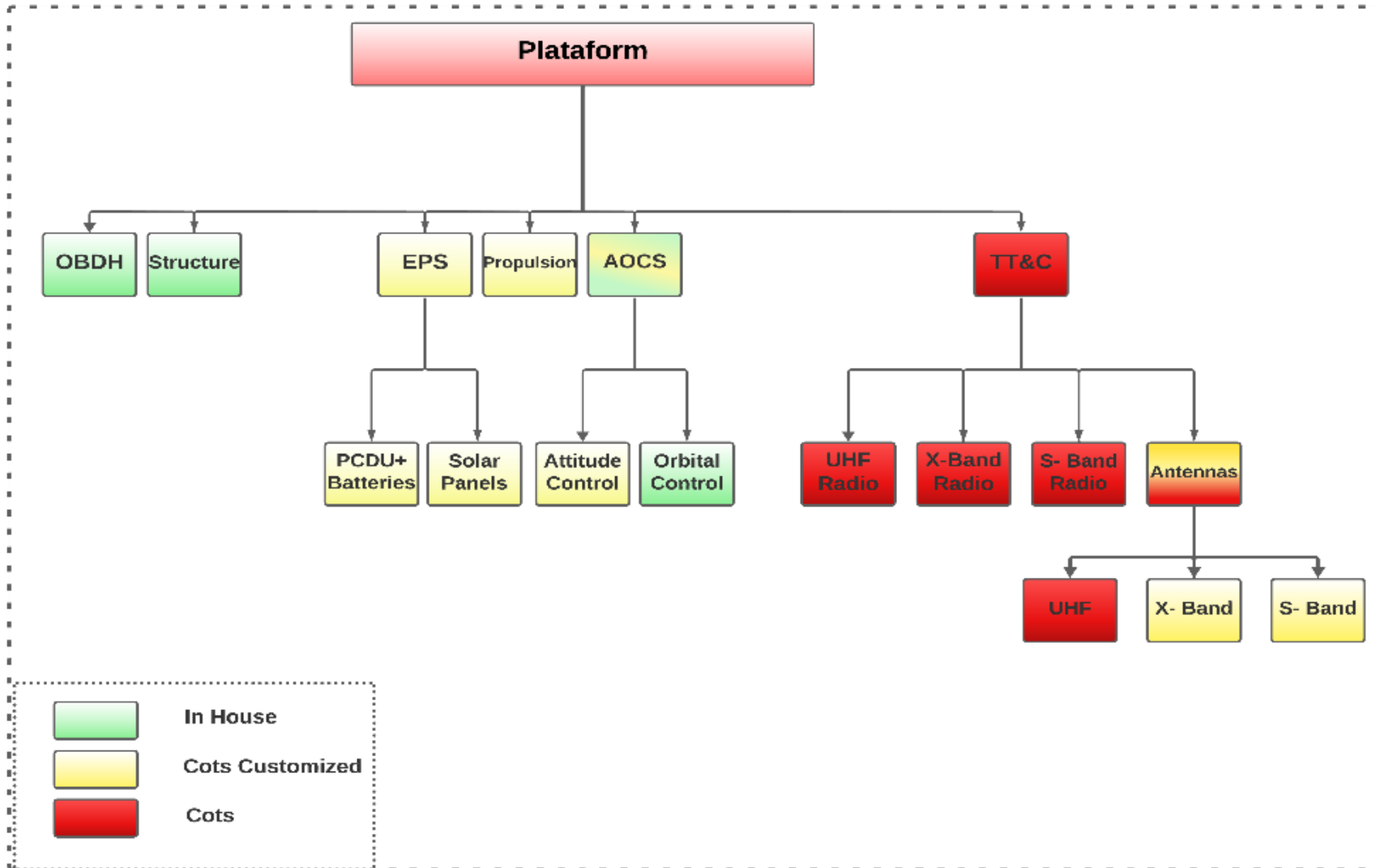


Ground Station Networks for Small Satellites

Organization	Sites active / planned	Status	Bands	Additional information
Amazon (AWS Ground Station)	2+ / 12	Operational	S, X	Easily control satellites and ingest data with fully managed Ground Station as a Service.
Astralintu	1 / ?	Operational		Space Logistics and Ground Segment Operations from 0° Latitude.
ATLAS Space Operations (Freedom)	13 / 24	Operational	VHF, UHF, S, X, Ka	Selected by BlackSky to support Earth Imaging Constellation.
Azure Orbital (Microsoft) (Azure Orbital)	? / ?	Operational		Microsoft's ground stations plus KSAT and others. Announced connection to Starlink internet.
Capricorn Space	1 / 2+	Operational	UHF, S, X	Licenses secured and commercial launch in early 2019.
Cingulan Space	1 / ?	Operational	UHF, S, X	Intelligent Ground Segment As-a-Service Provider.
CM Technology (CMT)	23+ / ?	Operational		Variety of sizes 1.5 – 7 meters with capital outlay expenses up to 90% less compared to other's technology.
CONTEC	1 / ?	Operational	VHF, UHF, S, X	Easy access through web-based operation system and one click ready to AOS.
Dhruva Space	13 / ?	Operational	VHF, UHF, S, X	Remotely operable ground station networks with continuous access, tracking and the control of space assets from anywhere on the planet.
Emposat	24+ / ?	Operational	VHF, UHF, S, X	An autonomous controllable ground network composed of 50+ sets of antennas from 16 ground stations of Emposat around the world can be used.
Goonhilly Earth Station	1 / 1	Operational	S, X	We host 2 fully agile, remotely controllable X/S Band LEO/MEO antennas at Goonhilly.
Infostellar	3+ / 22+	Operational	UHF	StellarStation satellite antenna sharing platform.
KSAT (LITE)	23 / 64	Operational	VHF, UHF, S, X, Ka, Optical (Laser)	Two levels, high availability or less stringent.
Leaf Space	11 / 15+	Operational	VHF, UHF, S, X, Optical (Laser)	Per megabyte payment. Will build dedicated network for Astrocast.
Iridium	77 / 77	Operational	S	Iridium is a global satellite communications company, providing access to voice and data services anywhere on Earth.
Arctic Space Technologies	1 / ?	Development	VHF, UHF, S, X	Cloud based ground station services.
BridgeComm	0 / 10	Development	Optical (Laser)	Optical comm network on a price per delivered bit basis.
GroundCom	0 / ?	Development		We bring complex supplementary connection for the existing space missions, reserved and dedicated connection for new missions, complex communication package, including compatible modules along with price advantage with user friendly interface.
Kratos (OpenSpace)	0 / ?	Development		A dynamic ground system will help you keep pace with changes your world with speed, capacity and flexibility.



Analyzing Cost Reduction Opportunities



- SPORT Incremental Evolution
- Propulsive Capacity
- 3 CubeSats formation flight
- 12U ~ 24kg
- Operational Lifetime: 2 years
- Operational Orbit range: 370~500 km @ 45°~56°

1. To measure ionospheric plasma movements



2. To measure ionospheric plasma density and temperature



3. To measure ionospheric plasma impedance



4. To measure small-scale ionospheric structures



5. To measure magnetic field



6. To measure the electron density



7. To measure the electric field



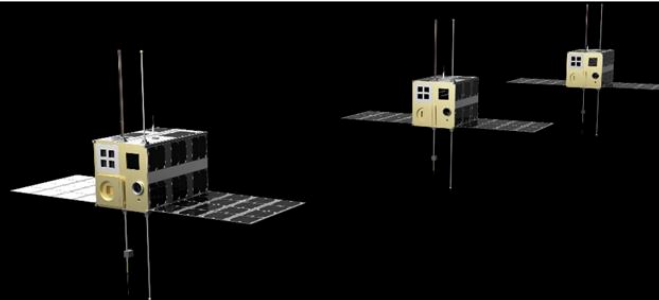
8. To measure in orbit radiation



9. To geolocate RF emitting objects

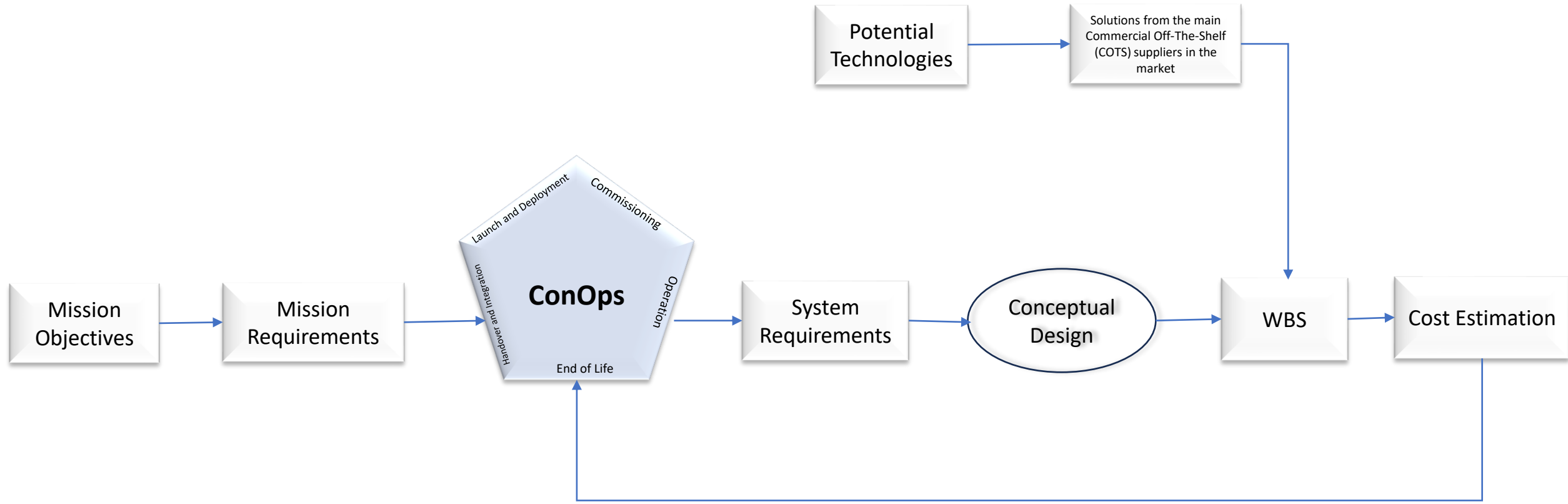


10. To perform formation flight





Method





Conclusion



How to calculate the cost through analogous missions when you have only two completed CubeSat missions?

- Our primary challenge is not having a database.
- The best way in our case is to have the most comprehensive understanding possible of the proposed mission. Following the steps proposed in the method presented.



Q & A



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