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CubeSat Technology on Titan Exploration

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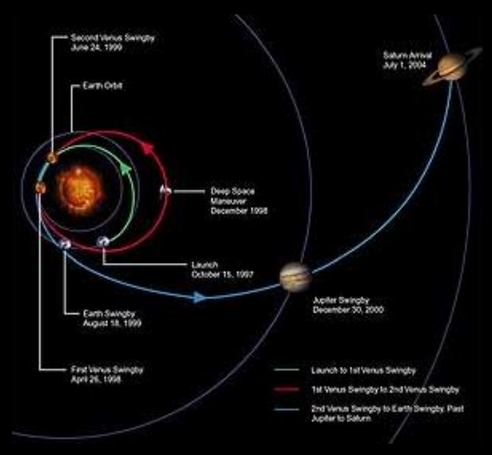


Figure.1. Travel to Titan

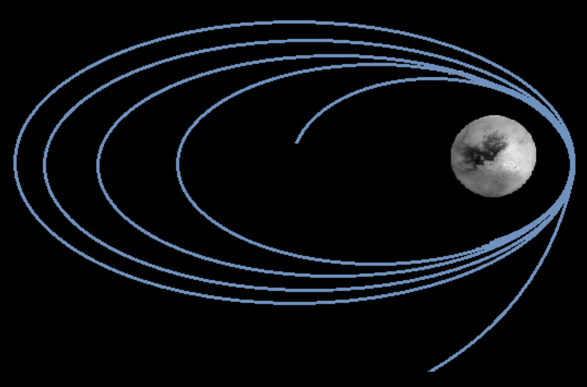


Figure.2. Aerobraking

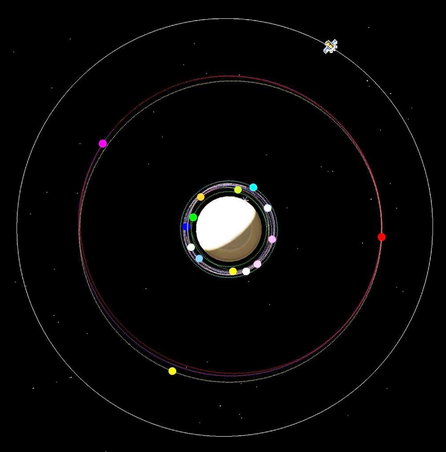


Figure.3. Mother Spacecraft and CubeSats

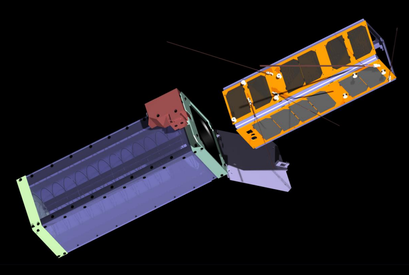


Figure.4. Deploying the CubeSats

Small satellites can be classified by their mass such as mini, micro, nano, pico and femto satellites (Table.1). CubeSats kind of standardized nano-satellites can be developed by utilizing commercial off-the-shelf technologies. They are in the shape of a 10 centimeter cube and simplified to build. Typical CubeSats have cost less than $50,000[1]. Nano-satellites can be thought as an effective choice for the interplanetary missions because of their advantages such as low cost, low weight, simple and task oriented design.

	Mini	Micro	Nano	Pico	Femto
Mass Range	100-500 kg	10-100 kg	1-10 kg	0.1-1 kg	10-100 g

Table.1. Cubesat Classification

1 U CubeSat
(10x10x10 cm)
Commercial Product

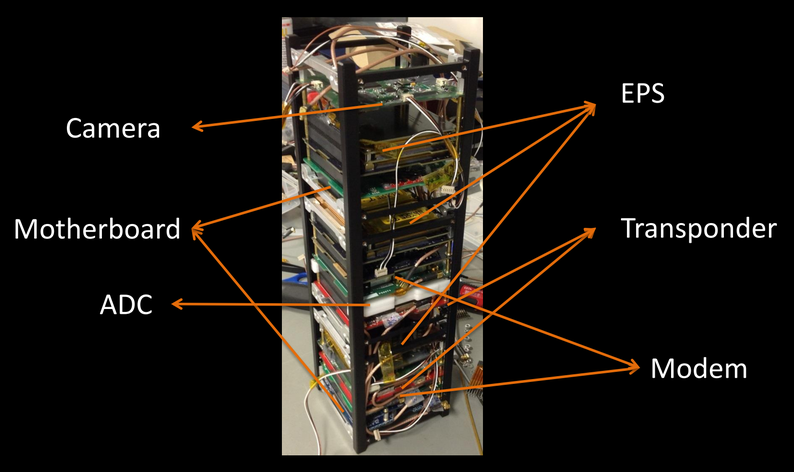


Figure.5. TURKSAT 3USAT

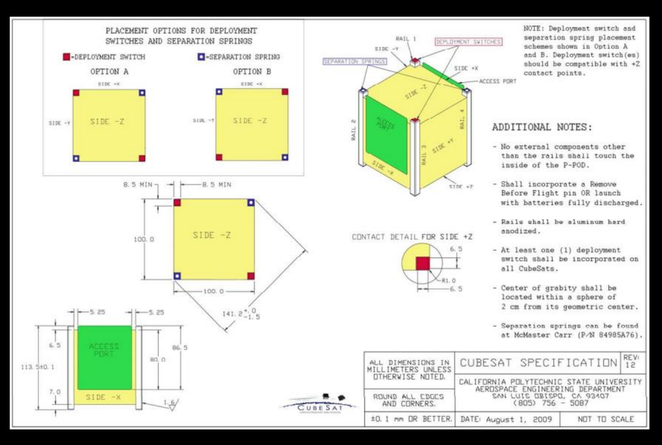


Figure.6. CubeSat Standardization

In our solar system, Titan is the only celestial body on which findings indicates evidence for liquid except Earth. Moreover, the findings of Cassini-Huygens Mission show that the atmospheric conditions and hydrological cycle form Titan's surface features similar to those on Earth, such as dunes, lakes, seas with periodically liquid methane rains. Such balance between geological and atmospheric processes may be indicating the same predicted conditions of the Earth during its primordial age. Even complex self-organizing biological systems may be formed on Titan. These specialties make Titan a unique exploration area for planetary sciences.

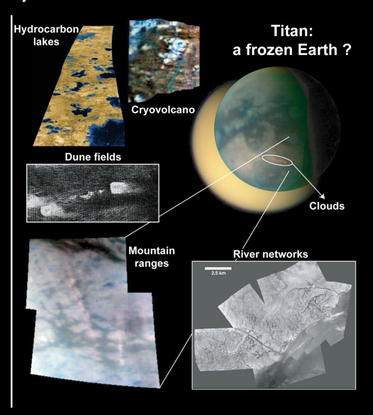


Figure.7. Titan

A comprehensive research on celestial bodies, such as Titan, can be accomplished via numerous numbers of CubeSats with various scientific instruments. Titan's cloudy weather requires that CubeSats must dive into atmosphere in order to analyze low atmosphere segments and surfaces. Depending on their instruments, CubeSats can be grouped by assigning each group to a varying specific task to increase the redundancy. For example, one group collects the temperature and pressure data from different altitudes, while another group exploring bio-signature or complex chemical compounds on Titan's atmosphere and surface. The main advantage of this idea is to allow Titan to be explored more widely compared to other options, such as lander, rover etc.

Mars Exploration Rover Mission [2]

Figure.8. Parachutes

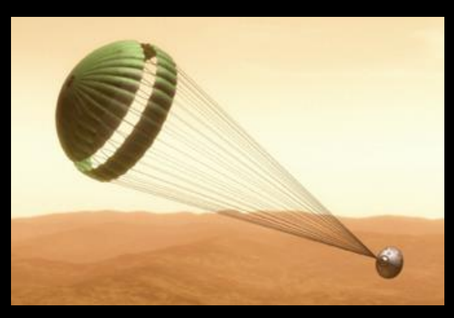
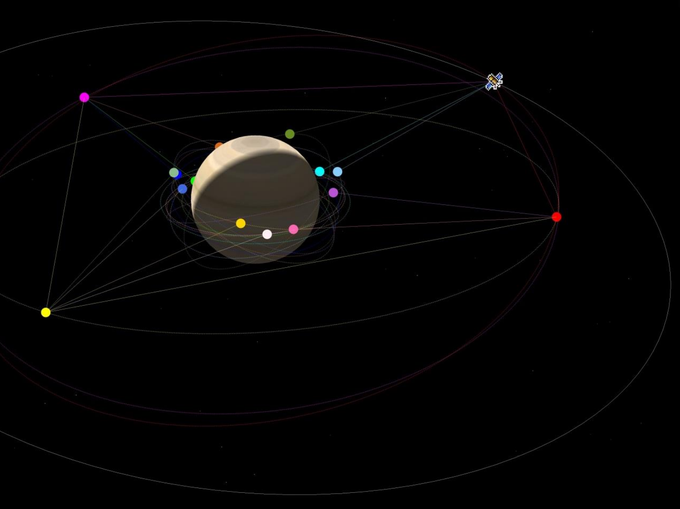


Figure.9. Airbags



CubeSats can be carried on a mother spacecraft (the station) during their journey to Titan. At the end of the journey, utilizing an aero capture maneuver will provide the mother spacecraft to pass through different layers of atmosphere and lets the CubeSats to be deployed at the desired altitudes suitable to their assigned tasks. After deploying all the CubeSats, the station will orbit Titan at suitable altitude to serve as a relay communication satellite between the CubeSats and the Earth. Among the satellites, a network using an internet like communication protocol should be established to transfer data from each satellite to the station. Atmospheric drag will circularize the orbits of the CubeSats at the deployment altitude in time. Some of the CubeSats may be designed to survive the re-entry conditions and land on the surface using parachutes and/or airbags (Figure.8-9). All of the satellites will be equipped with radioisotope power supply subsystems appropriate for CubeSats and an integrated attitude control system comprising gravity gradient boom and reaction wheels as can be seen on Table 2.

Spacecraft	Land	Power Supply	Attitude Control System
Impactor	Parachutes/ Airbags	Radioisotope	Gravity Gradient Boom and Reaction Wheels
Diver	Parachutes/ Airbags	Radioisotope	Gravity Gradient Boom and Reaction Wheels
Orbiter	-	Radioisotope	Gravity Gradient Boom and Reaction Wheels

Table.2. Subsystems of group of CubeSats

Electrical power supply is the most significant part of a space mission. Some missions about planetary exploration could use solar power because of the effective sunlight. However, like Cruosity Mission, it is needed some different power supply in our case due to distance from the Sun. In addition, the spacecraft should have effective thermal and electrical power. It can be used nuclear power which is Radioisotope Power System (RPS).

In conclusion, the advantages explained provide reduction on the mission cost and effort significantly.

[1] : *2013 International Space Apps Challenge - Hitch a Ride to Mars - Oklahoma to Mars*
[2] : *http://marsrovers.jpl.nasa.gov/home/index.html*

A large altitude range in the atmosphere remained poorly explored even after Cassini-Huygens mission, launched on 15 October 1997. After a seven year journey from launch to Saturnine system, Huygens probe, separated and successfully landed on Titan's surface on 14 January 2005. During its mission, Huygens probe took images, made spectral measurements, deduced atmospheric properties, measured physical and magnetic properties of Titan's atmosphere and surface, etc.

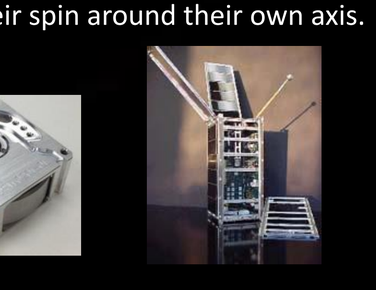


Figure.10. Huygens

In addition to the actual data obtained by Cassini-Huygens mission, the data from the future Titan missions may help scientists to understand how the Earth look like in its early ages and how life began. Much remains to be understood such as seasonal changes of the geology, atmosphere, climate, atmosphere-surface interaction and probability of existence of life on Titan.

Gravity Gradient Boom can be used to stay CubeSats in their orbits with helping the balance between gravitational and centrifugal forces. Reaction Wheels could stop their spin around their own axis.

Figure.11. Reaction Wheels

Figure.12. Gravity Gradient Boom