Asteroid Spectral Imaging Mission (ASPECT) CubeSat to characterize asteroid surfaces

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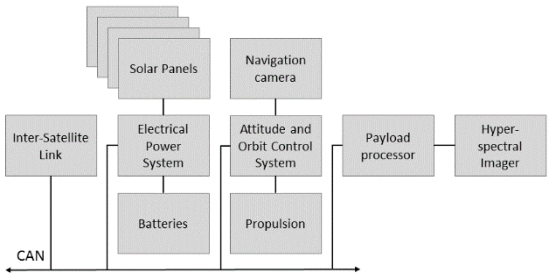
Introduction

Asteroid Spectral Imaging Mission (ASPECT) is a 3U CubeSat with a visible – near infrared (VIS-NIR) spectral imager payload. The concept was originally developed for ESA-NASA AIDA (Asteroid Impact & Deflection Assessment) project. Currently, participation in other small body missions is being investigated. ASPECT can be deployed on an asteroid orbit to characterize the composition of its surface with sub-meter spatial resolution. It can work in tandem with its mothercraft or fleet of other CubeSats to provide complex insight into asteroid properties. The payload, avionics, and cold gas propulsion units occupy each 1U space. An extended 6U version with provision for second payload is being currently developed.

Platform

The operation infrastructure is centered on the S-band radio link, which provides the satellite attitude control location data from the mothercraft, as well as access directly to all the other subsystems of the satellite, negating the need for a traditional failure-prone hub, e.g. an Onboard Computer, to access the subsystems. The system architecture, space-qualified subsystem modules, structural components and the platform software are currently used in the Reaktor Space Lab's Hello World in-orbit demonstration satellite. The ASPECT platform avionics, including the S-band radio equipment, batteries, attitude and orbit control, and the electrical power system, are integrated in a 1U module to minimize external connections and to simplify the system. Also included in the platform section are solar panel connections and all required harnessing. The CubeSat platform will be a radiation-hardened and single-event effect (SEE) resistant to guarantee reliable operation for at least 3 month mission period. The satellite system block diagram is depicted in figure below. All subsystems are monitored and switchable during operations from the electrical power system.



ASPECT high-level system block diagram.

Payload

The primary payload of ASPECT is a miniaturized spectral imager with primary scientific task of high resolution ~1m/px compositional mapping of target surface. The spectral range is extending from the visible (VIS) up to the near (NIR) and shortwave (SWIR) infrared wavelengths. In contrast to more traditional spatial-scanning imaging spectrometers, the ASPECT imager utilizes tunable Fabry-Perot Interferometers (FPI) to select the imaged wavelengths. When multiple snapshots are combined, a spectral datacube is formed, where the wavelength bands are separated in the time domain. The instrument is an evolution of the space flight-proven designs of the Aalto-1, Hello World, and Picasso VISION spectral imagers.

The VIS and NIR channels are imaging spectrometers, while the SWIR channel only measures a single point. The target wavelength range is 500 - 900 nm for the VIS channel, 900 - 1600 nm for the NIR channel and 1600 - 2500 nm for the SWIR channel. All three channels have dedicated FPIs optimized for the desired wavelength range. The targeted spectral resolution is ca. 10 - 50 nm. All three channels can be operated simultaneously and are independent of each other.

Thanks to its modular design, ASPECT can be easily extended to 6U configuration in order to incorporate secondary payload of 1-2U dimensions.

The main ASPECT imager parameters.

Parameter	VIS channel	NIR channel	SWIR channel	Notes
Field of View [deg]	10° x 10°	6.7° x 5.3°	5° circular	
Spectral range [nm]	500 – 900	900 – 1600	1600 - 2500	
Image size [pixels]	1024 x 1024	640 x 512	1 (non-imaging)	
No. spectral bands	Ca. 14	Ca. 24	Ca. 30	Tunable in flight
Spectral resolution [nm]	< 20 nm	< 40 nm	< 50 nm	

Science and ISRU

The prospecting objectives of ASPECT are based on the capabilities of the payload – the VIS-NIR imaging spectrometer. The payload allows for global compositional mapping and imaging of the target asteroid with sub-meter resolution. The spectral range of 500-2500 nm covers most common silicate mineral (olivine, pyroxene, and plagioclase) absorption bands related to Fe^{2+} ions in their structure. Additionally, ASPECT can also detect hydrated minerals as serpentine using ~700 nm Fe^{3+} absorption features. Direct presence of -OH an H_2O can be detected at 1400 and 1900 nm respectively. Additionally, observations at various phase angle allows for estimation of surface roughness.

ASPECT prospecting objectives and expected results	
Objective 1	Map the surface composition of the target
Result	Composition and homogeneity of the target surface
Result	Identification and distribution of volatiles
Objective 2	Photometric observations and modeling of the target
Result	Surface roughness / particle size distribution
Objective 3	Characterize possible landing sites
Result	Detailed composition and surface roughness information on potential landing sites
Objective 4	Evaluate surface areas and objects suitable for sample return or ISRU
Result	Identification of areas and objects with desired properties