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

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Asteroid Spectral Imaging Mission (ASPECT) is a 3U CubeSat with a visible – near infrared (VIS-NIR) spectral imager payload developed for ESA-NASA AIDA (Asteroid Impact & Deflection Assessment) project. It can be deployed on an asteroid orbit to characterize the composition of its surface. It can work in tandem with its mothercraft or fleet of other CubeSats to provide complex insight into its target asteroid properties. The payload, avionics, and cold gas propulsion units occupy each 1U space. The payload of ASPECT is a miniaturized spectral imager with primary scientific task of high resolution ~1m/px compositional mapping of target surface. Thanks to its modular design, ASPECT can be easily adopted to study other targets or to incorporate different payload of within 1U (10 cm × 10 cm × 10 cm) on the existing 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 Fig. 1. All subsystems are monitored and switchable during operations from the electrical power system.

The payload is a miniaturized spectral imager extending from the visible up to the shortwave infrared wavelengths. In contrast to more traditional spatial-scanning imaging spectrometers, the Asteroid Spectral 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 based on the space-qualified designs of the Aalto-1 Spectral Imager and Picasso VISION. 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.

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.

The main spectral imager parameters.

Parameter	VIS channel	NIR channel		SWIR channel	Notes
Field of View [deg]	6° x 6°	5.3° x 5.3°		5° circular	
Spectral range [nm]	500 – 900	900 – 1600		1600 - 2500	
Image size [pixels]	614 x 614	256 x 256		1 pixel	
No. spectral bands	Ca. 14	Ca. 24		Ca. 30	Tunable in flight
Spectral resolution [nm]	< 20 nm	< 50 nm		< 25 nm	

ASPECT scientific 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 particle size distribution
Objective 3	Evaluate space weathering effects on target by comparing mature and freshly exposed material (craters, ejecta, landslides)
Result	Information on the surface processes on airless bodies due to their exposure to the interplanetary environment
Objective 4	Identify local shock effects on target from spectral properties of crater interiors
Result	Information on the processes related to impacts on small Solar System bodies
Objective 5	Characterize possible landing sites
Result	Detailed composition and surface roughness information on potential landing sites
Objective 6	Evaluate surface areas and objects suitable for sample return or ISRU
Result	Identification of areas and objects with scientifically interesting properties