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Asteroid Spectral Imaging Mission (ASPECT) CubeSat to characterize resources on 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. 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. It can contribute in search for surface resources and locate candidate areas for further sampling or utilization.

ASPECT concept

ASPECT (Asteroid Spectral Imaging Mission) is a 3U CubeSat designed for deep space exploration of small Solar System bodies. 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 compositional mapping of target surface. The concept is originally developed for the ESA-NASA AIDA (Asteroid Impact & Deflection Assessment) project. In 2016 it underwent preliminary design study and was down selected as the only CubeSat payload for European AIDA component AIM-D^2 (Asteroid Impact Mission – Deflection Demonstration). ASPECT features autonomous navigation relying on inter-satellite link with the mothercraft, navigation camera, and Sun and star sensors. To assure desired spatial orientation reaction wheels are utilized while orbit is maintained using active cold gas propulsion.
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.

Spectral imager payload

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 main instrument parameters are listed in Table 1.

Table 1. The main Asteroid 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 prospection

The prospecting objectives of ASPECT (Table 2) 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 payload design and constraints on ground resolution are shown in Fig. 1.

Table 2. ASPECT scientific objectives and expected results

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

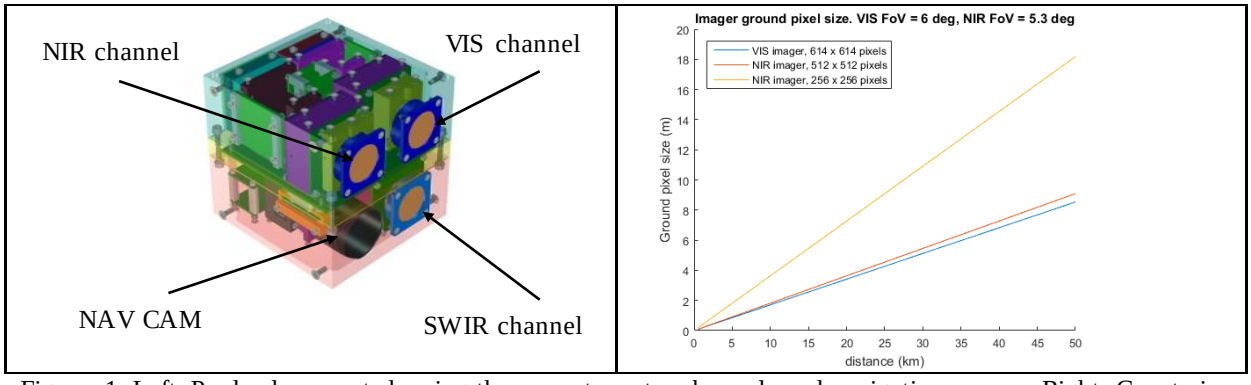

Figure. 1. Left: Payload concept showing three spectrometer channels and navigation camera. Right: Constrains on the imager resolution as a function of orbit distance.