[SSC20-WP1-02]

Towards the Use of Commercial-off-the-Shelf Small-Satellite Components for Deep-Space CubeSats: a Feasibility and Performance Analysis

Stefano Casini[1,2,*] , Iosto Fodde[1], Steven Engelen[1], Bert Monna[1], Angelo Cervone[2], Eberhard Gill[2]
[1] Hyperion Technologies BV, Vlinderweg 2, 2623 AX Delft, The Netherlands, +31 (0)15-5160905
[2] Delft University of Technology Kluyverweg 1, 2629 HS Delft, The Netherlands, +31 (0)15 27 89804
* s.casini@tudelft.nl

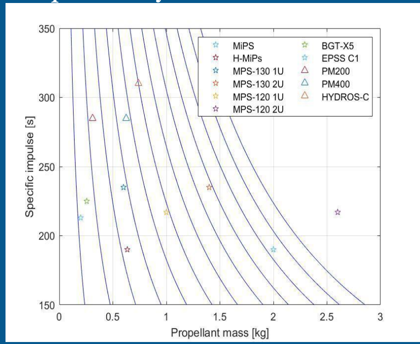
Background and Motivation

- Deep-space exploration demands can be fulfilled with CubeSats
- Near-Earth Asteroids offer multiple mission targets
- Main trends to follow: miniaturization, standardization and automation

Mission Scenario

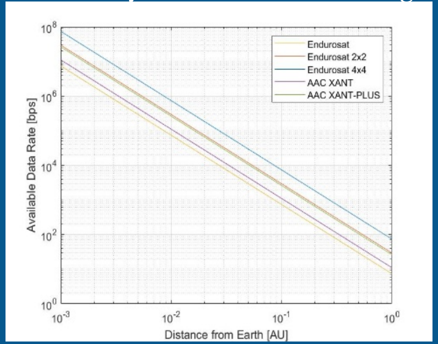
- SSGTO injection orbit, Earth escape and NEA fly-by (~300 km altitude)
- NASA-JPL Small Body Search Engine for ΔV budget, departure date and time-of-flight
- Improve NEAs dataset (dimension, shape, rotational parameters, composition, ephemerides)
- Payload composed of visible and IR cameras
- Compact CubeSat architecture (3U if possible)

Propulsion System evaluation chart



- Increasing CubeSat BOL mass from left to right (1-12 kg)
- Total ΔV =400 m/s for Earth escape and small correction maneuvers
- MPS-130 is the best compromise in terms of mass, volume, propellant toxicity and CubeSat mass for this application

Preliminary X-Band downlink budget



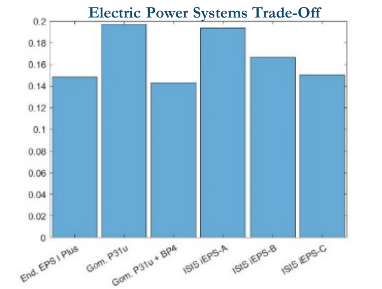
- 2 W of transmitting power (min.)
- 1dB Eb/N0 and 3dB link margin
- 34-m diameter ground antenna
- Standard losses included
- Endurosat 4x4 patch antenna offers higher data rate due to higher gain

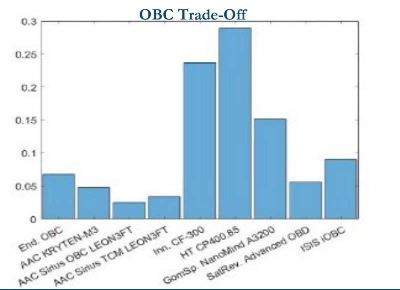
Components Evaluation and Selection

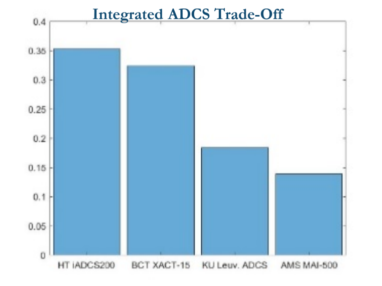
- Payload requirements: <0.8U, <500g, GSD @ 300km < 50 m/pixel
- Deployable and orientable solar panels are needed at large distances from the Sun
- Autonomous GNC via star trackers and payload camera
- Selection of other components via Analytic Hierarchy Process (AHP)

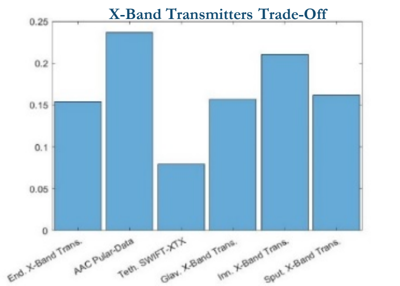
AHP for Trade-Off

- Mass and Volume selection driven parameters for all subsystems
- Each component has characterizing parameters for trade-off
- EPS – Battery Capacity (minimum required: 18.5 Wh)
- ADCS – Pointing Accuracy (required below 0.15°) and Power Consumption
- X-Band Transmitter – Transmitting Power and Power Consumption
- OBC – Clock Frequency, Power Consumption and Memory Storage









Conclusions and remarks

- Fully COTS CubeSat configuration is possible (<4kg, <3U)
- Few visible range cameras with sufficient resolution to provide a good scientific return at fly-by altitude
- Only one IR spectrometer meeting the requirements is currently available. For larger applications, integrated VIS-IR optical payloads are available
- Many optical payloads have their dedicated processor, which simplifies the design
- Available star trackers offer excellent performances for attitude determination (few arcsec accuracy), while their capabilities in detecting line-of-sight of visible bodies for autonomous navigation need to be assessed
- Integrated ADCS provide sufficient pointing accuracy both for payload and data downlinking
- Wheel desaturation and de-spinning cannot rely on magnetorquers in deep-space. Available micro-propulsion systems offer very limited desaturation capabilities and as of today an additional device shall be included (such as a resistojets-based AOCS)
- Micro-propulsion systems still limit these applications in terms of available ΔV
- Some OBC options appear mature and very performant for advanced on-board processing
- Wide range of EPS both for compact and larger applications, but few options for completely deployable and orientable solar arrays
- X-Band transmitters and antennas allow a small transmittable dataset at large distances, which shall be improved to increase the scientific return
- Mission radiation profiles different from LEO shall be described for proper radiation hardening