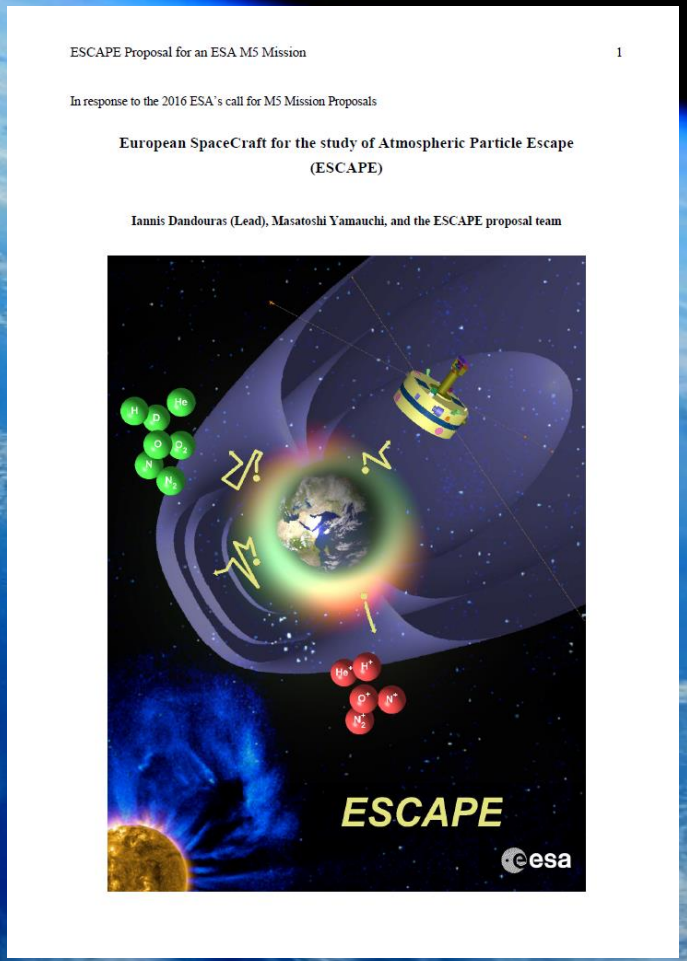
M5 Call (2016) - Technical Evaluation

Proposal 16: ESCAPE (I. Dandouras)

European Spacecraft for the study of Atmospheric Particle Escape



ESCAPE Proposal for an ESA M5 Mission 1

In response to the 2016 ESA's call for M5 Mission Proposals

European SpaceCraft for the study of Atmospheric Particle Escape (ESCAPE)

Iannis Dandouras (Lead), Masatoshi Yamauchi, and the ESCAPE proposal team

16 ESCAPE (Description)

Main science objectives:

- Study of the composition and flux of the atmospheric escape from Earth and understand its effect on the evolution of the atmosphere.
- ESCAPE will measure both neutrals and superthermal ions of major atmospheric species H, HE, O, N, O_2, N_2, NO and CO_2 in the exosphere/upper ionosphere, plasmasphere and correlated with EISCAT 3-D observations

Mission profile:

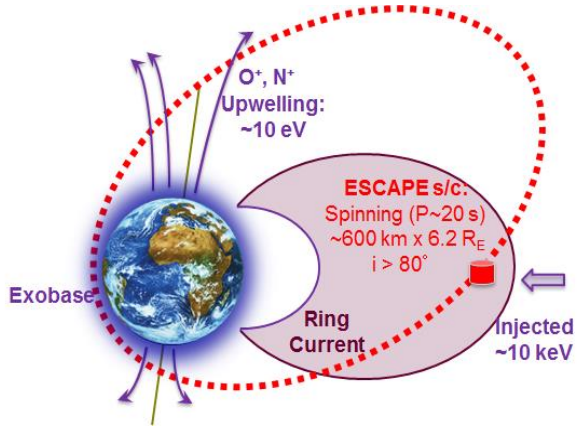
- Launch with Ariane 62; initial orbit 800 x 33,000km i=90°, orbit apogee must stay below GEO, Flat spin stabilised.
- 1° rotation manoeuvre/day to maintain sun pointing, -0.21°/day evolution of the line of Apsides (230° / 3 years)
- Deorbit: ΔV= 20m/s for a <25year re-entry. ΔV= 87m/s for a controlled re-entry using a hydrazine engine.

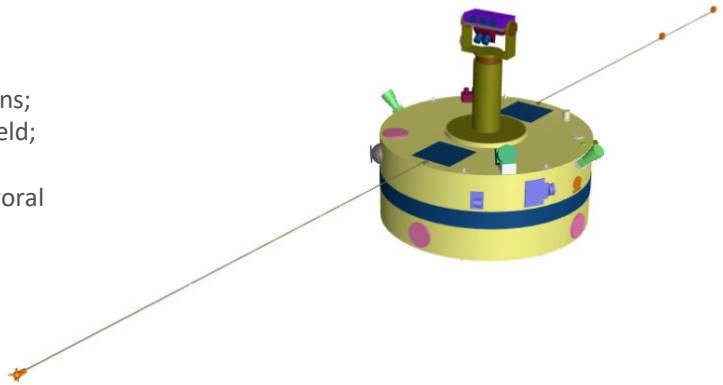
Spacecraft (1 S/C, 490 kg, 300 W):

- One S/C flat spin stabilised (20-24s period), 691kg total mass (incl. margin & p/l), 451.4W (incl. margin & p/l)
- 339kg dry mass (incl. margin, excl. p/l), 137W operating, 300W transmitting (incl. margin excl. P/L)
- 120kg Xe +50kg Hydrazine +34kg margin propellant
- S-band TTC antennas and 6 patch X-band antennas, 4 of which are operating on the rotating sides. 30W RF power.
- Despun platform for Remote sensing Instruments, situated on the cold side.
- DPU, booms and ASPOC subsystems considered ESA CFI.

Payload (150 kg, 150 W, 12 instruments):

- 12 instruments (9 in-situ, 3 remote sensing), 148kg, 152W (incl. margin)
- 10Gbytes Memory required, 19Gbit data/day, Data Rate: 135kbps nominal, 546kbps peak
- 9 In-situ instruments: INMS: neutral isotopes & cold ion isotopes; WCIMS: neutral (total), cold ions; MIMS: light hot ions; NOIA: heavy hot ions; EMS: energetic ions; ESMIE: hot electrons; SLP: SC potential, plasma density; MAG: magnetic field; WAVES: electromagnetic and electrostatic waves.
- 3 Remote Sensing Instruments: UVIS: UV emission over line of slight; ENAI: line of sight integrated ENA flux; AMC: Auroral emission over line of sight





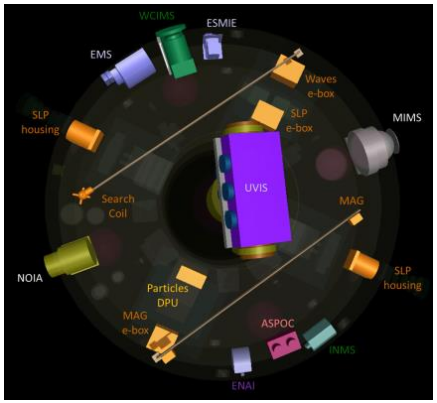
Implementation scheme & ESA contribution:

- **Role of ESA**: Launcher, S/C incl. de-spun platform, 2 DPU, booms, ASPOC, MOC and SOC
- **Role of Member States:** Instruments, Sweden EISCAT
- **Role International Partner(s):** US & Japan for Instruments

16 ESCAPE (Evaluation)

S/C Major challenges & critical issues:

- Chemical Cleanliness and Contamination constraints, in particular N+ and will require a nitrogen free propulsion system, sensitivity to H or O was not clearly defined, contamination due to the cryogenic upper stage of the Ariane 62 should be checked. An additional concern would be any leakage from the hydrazine tank during operations.
- Ariane 62 injection into a 800x33000km, i=90° orbit is considered to be the on the limits of feasibility due the A62 cryogenic restart-ability issue.
- 5mm Al shielding to keep the radiation dose 35-40 krad, which is still challenging
- Sun pointing flat spin satellite, has no ESA flight heritage in recent years but should not pose major problems

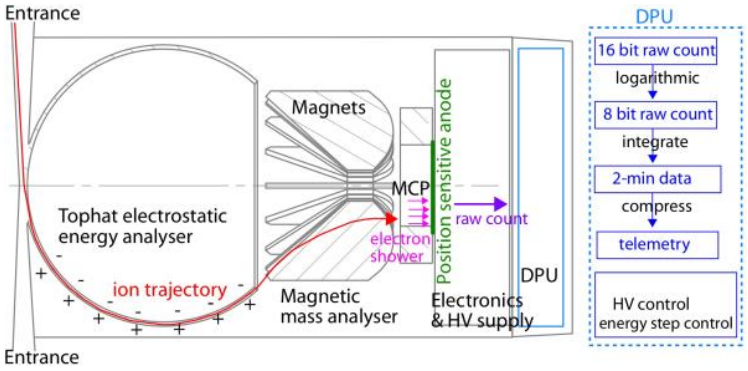


P/L Major challenges & critical issues:

- Complex payload with 2 instruments on a despun platform, 2 DPUs on for the main S/C, one for the platform.
- Accommodation with free FoV for particle instruments, Electromagnetic cleanliness, Contamination control, Radiation damage
- EMS is a critical instrument since its data should trigger via the S/C DPU the switch off of the particle instruments in the radiation belts…

Qualification status (S/C and P/L):

- The flat spin s/c and de-spun platform is <TRL 6 for current platforms.
- Long wire probes and many high voltage instruments.



Programmatic aspects:

- A different ground station every year do to the rotation of the line of Apsides
- The injection orbit may require a propulsion module to reach; however, all but noble gasses=contamination

Clarity of implementation scheme, split of responsibilities and interfaces:

- **Role of ESA**: Launcher, S/C incl. despun platform and pointing mechanism, MOC, SOC
- **Role of Member States:** Instruments
- **Role International Partner(s):** Instruments from US & Japan

16 ESCAPE (Summary)

Cost	M€
ESA Project Team	23
Industrial Cost	102
Payload Contribution (ESA)	7
Mission Operations (MOC,SOC)	70
Launcher	73
Contingeny	29
Total EaC (ESA)	**304**

Summary Evaluation		Comment
Mission profile	Y	Questionable ability to launch with A62 to the desired orbit
Spacecraft design	Y	Nitrogen cleanliness
Spacecraft TRL	Y	New Platform, Spin and despun platform, 2 propulsion systems
Payload design	Y	nitrogen cleanliness
Payload TRL	Y	Complex interface management
GS & Science Ops.	Y	Progressive Orbit would require changing GS every year
Programmatic / Cost	G	Estimated within the M5 class
Implementation Scheme	G	o.k.
General summary	Y	**Feasibile within the M5 scheme**

Sharing of Responsibility

Element	ESA	MS / (SL)		Int. Partner / SL		comment
Launcher	X					
S/C	X					
P/L	X	X		X		ESA provides the booms
G/S & OPS	X					
other						

Conclusion of Evaluation:

1: Orbit is on the edge of feasibility to be launched by Ariane 62 (limits of cryogenic upper stage)
2: Flat spin spacecraft with despun platform requires a new platform development & Payload TRL 4-6 can be developed in time
3: Mission estimated that it fits M5 ESA budget
4: Nitrogen cleanliness needs further investigation during phase A to ensure feasibility and for enabling the mission selection.