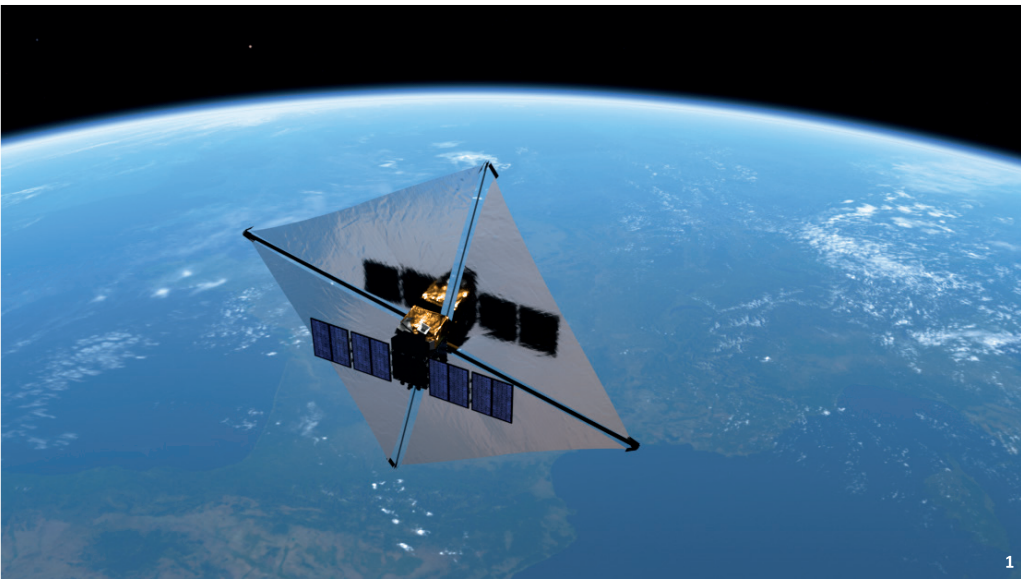
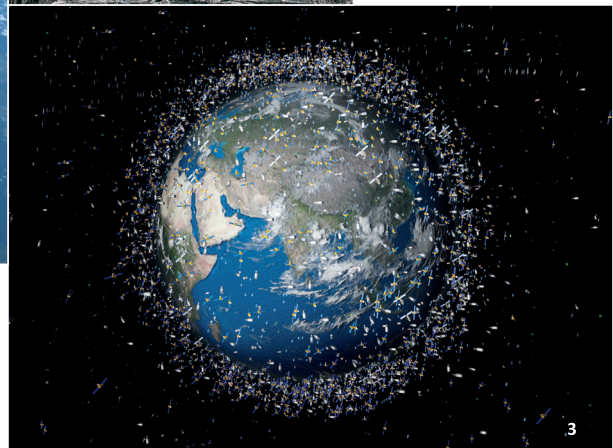
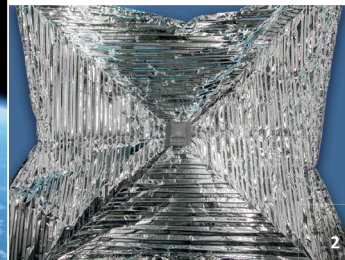


## ADEO Deployable De-orbit Sail Subsystem

### Passive De-orbiting for Clean Space Missions



1: Animation of ADEO-L onboard ALTIUS Satellite (Satellite: © QINETIQ, Animation: © HPS)  
2: 2.5 m<sup>2</sup> ADEO-N sail (deployed configuration)  
3: Impression of the increasing amount of objects in the low earth orbit (© Image by ESA)



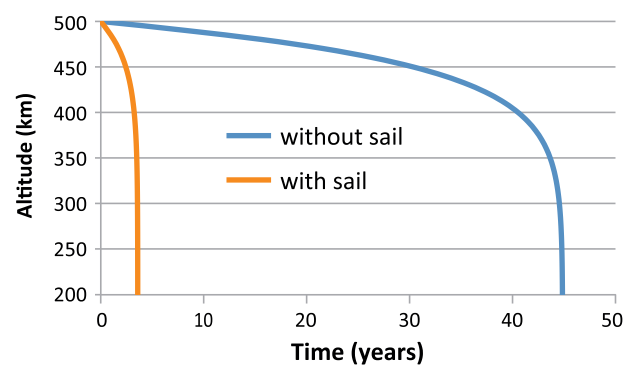
HPS Germany is a “turnkey supplier” for commercial passive de-orbiting subsystems based on deployable sails enabling **CleanGreen space missions** through utilizing residual atmosphere by drag-sails to decelerate for significantly quicker annihilation in reentry fire. Based on the collaboration with renowned partners and contracted by ESA as well as funded by the Bavarian Ministry of Economics and the German space Agency DLR, HPS developed the complete ADEO-product family for the return all kinds of spacecrafts and satellites:

**ADEO-L (Large for satellites between 100-2000 kg)**  
**ADEO-N (Nano for nanosats and larger: 1-100 kg)**  
**ADEO-M (Medium class: overlapping L- and N-class)**

Unique features of ADEO are:

- **ultra-light weight** (lower mass than additional propellant for active de-orbiting)
- **scalable sail size** (1,5 m<sup>2</sup> to > 100 m<sup>2</sup>) tailored to each spacecraft mass
- **generic** (standard interfaces with adjustable interface brackets to spacecraft)
- **completely passive** (no need for active control, if demanded: own battery with dead man switch).

ADEO is always - no exemption to this rule! - cheaper than any other solution for accelerating descent.



#### De-orbit Example:

- 500 kg mass
- 500 km orbit
- De-orbit without sail: 45 years
- De-orbit with sail (25 m<sup>2</sup>): 4 years

A collaboration of:



Funded/  
co-funded by:



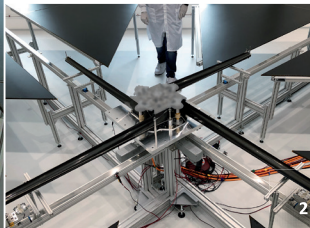


1: Section of ADEO-L Engineering Model (deployment testing on ground)

#### Technical Features:

- Motorized deployment
- Own deployment control electronics
- Optional: own battery for automatic deployment in case of satellite failure
- No onboard GNC required
- Dragsail area: 25 m<sup>2</sup> (customizable from 5 m<sup>2</sup> to 100 m<sup>2</sup>)
- Subsystem Mass: 9,2 kg (depending on sail size)
- Subsystem Dimensions: 43 cm x 43 cm x 18 cm
- Materials withstand > 25 years de-orbiting time (UV, ATOX, space debris impact, thermal gradients, etc.).

## ADEO-L AND ADEO-M



2: ADEO-L Engineering Model (deployment test on ground)

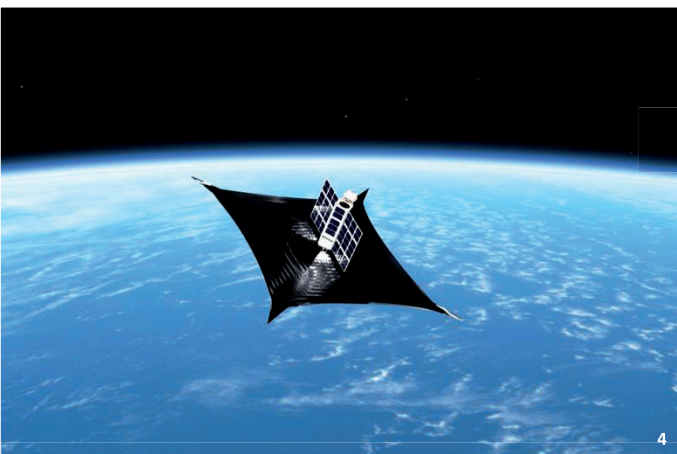
3: Animation of 25 m<sup>2</sup> ADEO-L with a 0.8 m x 0.6 m x 1.2 m satellite with a satellite mass of 300 kg during atmospheric entry

#### General Description:

- Scalable drag-augmentation subsystem to passively de-orbit satellites between 100 kg and 2000 kg, within 25 years (or much shorter, if needed)
- Customizable sail areas depending on spacecraft mass and de-orbit time needs.

#### Recent Project Examples:

- ADEO-1 (2014-2017, in contract to ESA): development of an Engineering Model; extensive test program (deployment in hot and cold TVAC conditions, vibration, rapid decompression, numerous material level testing).
- ADDA (2017, in contract to ESA): detailed dynamical analysis considering various perturbations (tumbling, SRP, ...); theoretical verification that de-orbiting via dragsails is possible.
- ADEO-2 (2018-2021, in contract to ESA): development of a first PFM ready for integration and launch in 2021/22.
- ADEO-L1: targeted for an IOV-flight in 2021/22.

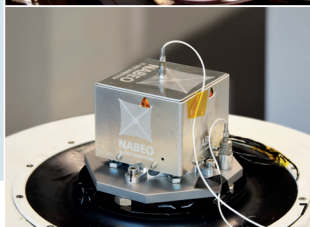
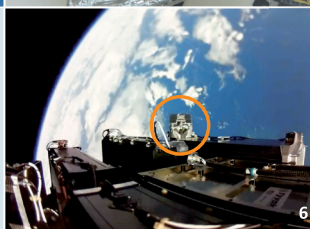
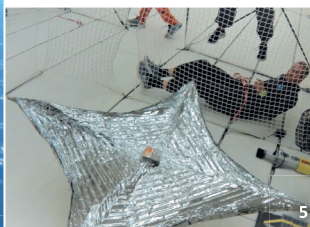


4: Animation of ADEO-N de-orbiting a 3U-Cubesat (Cubesat: © ORORATEC, Animation: © HPS)

#### Technical Features:

- Initiation of the deployment via a simple signal
- Two-step deployment: 1) out of the box; 2) sail deployment (allowing the subsystem also to be used in e. g. 6U, 12U cube satellites).
- Dragsail area: 1,5 m<sup>2</sup> - 5 m<sup>2</sup>
- Stowed size: 10 cm x 10 cm x 6-10 cm (0,6-1U)
- Mass: 1 kg.

## ADEO-N



5: ADEO-N parabolic flight campaign end 2019

6: ADEO-N1 launched in 11/2018 onboard ELECTRON (stowed configuration shortly before deployment) (original picture source: Rocket Lab USA)

7: ADEO-N1 during vibration qualification test in stowed configuration (©test performed at Fraunhofer EMI)

#### General Description:

- Dragsail for cubesat/nano-satellite applications (1 kg - 100 kg satellites)
- Completely passive de-orbiting without GNC within 25 years or much shorter
- Customizable sail areas depending on spacecraft mass and de-orbit time needs.

#### Recent Project Examples:

- ADEO-N1 (NABEO, 2018-2019): First mission called "Pride of Bavaria" (deployment of 2.5 m<sup>2</sup> dragsail, launched on Rocket Lab Electron mission called "It's Business Time" in November 2018 from New Zealand (development co-funded by the Bavarian Ministry of Economic Affairs; launch sponsored by Rocket Lab and Ecliptic, USA).
- Parabolic Flight (2019-2020): Detailed investigation of deployment behavior under 0-g, tailoring of design w.r.t. reliability and mass (project co-funded by the German Space Agency/German Ministry of Economics).
- Next launch targeted for mid 2021.