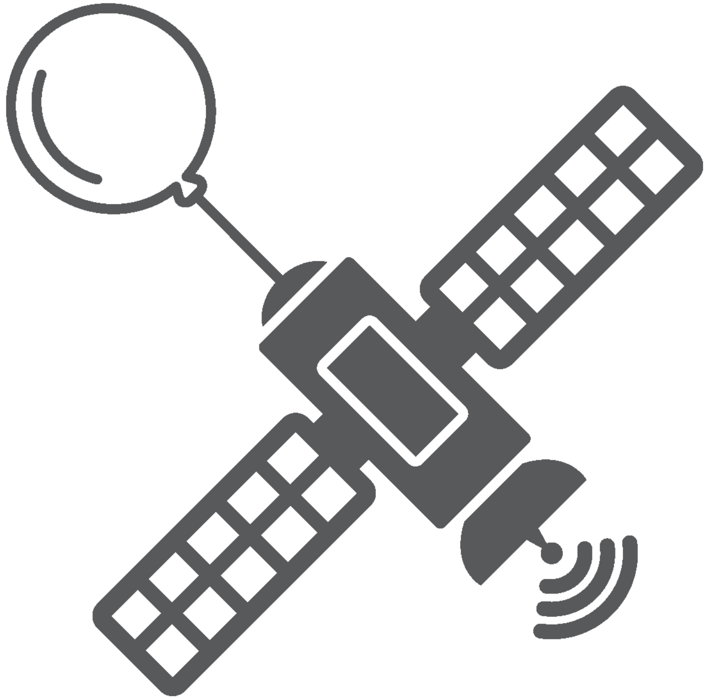


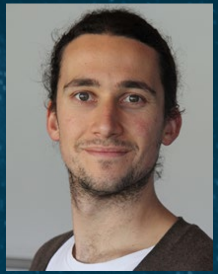
ARTES Advanced Technology: Inflatables to drag down small satellites

European Space Agency

Webinar, Wednesday 21st April, 14:00 CEST

Paul Greenway
ARTES

Sara Morales
Clean Space



Tiago Soares
Clean Space

Tiziana Cardone
Inflatable Technologies

Welcome to the Webinar!

Before we start…

- Due to the number of attendees, please **keep your microphones muted** at all times and switch off the webcam function

- You can use the **conversation function** anytime to submit your comments & questions. They will be addressed during the Q&A at the end of the webinar

Slides will be made available following this Webinar from here:
https://artes.esa.int/news/artes-advanced-technology-inflatables-drag-down-small-satellites

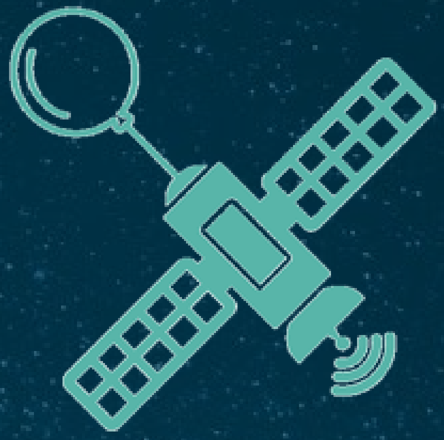
Also please note…

- Attendance is limited to companies, organisations, public bodies or non-governmental organisations residing in the participating ESA countries:

Austria, Belgium, Canada, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Luxembourg, The Netherlands, Norway, Poland, Portugal, Romania, Spain, Sweden, Switzerland and the United Kingdom

Agenda

- Introduction to ESA and ARTES
- Clean Space at ESA
- Inflatable Drag Device ARTES Advanced Technology Activity
- Inflatable Technologies for Space
- What next?
- Questions



THE EUROPEAN SPACE AGENCY

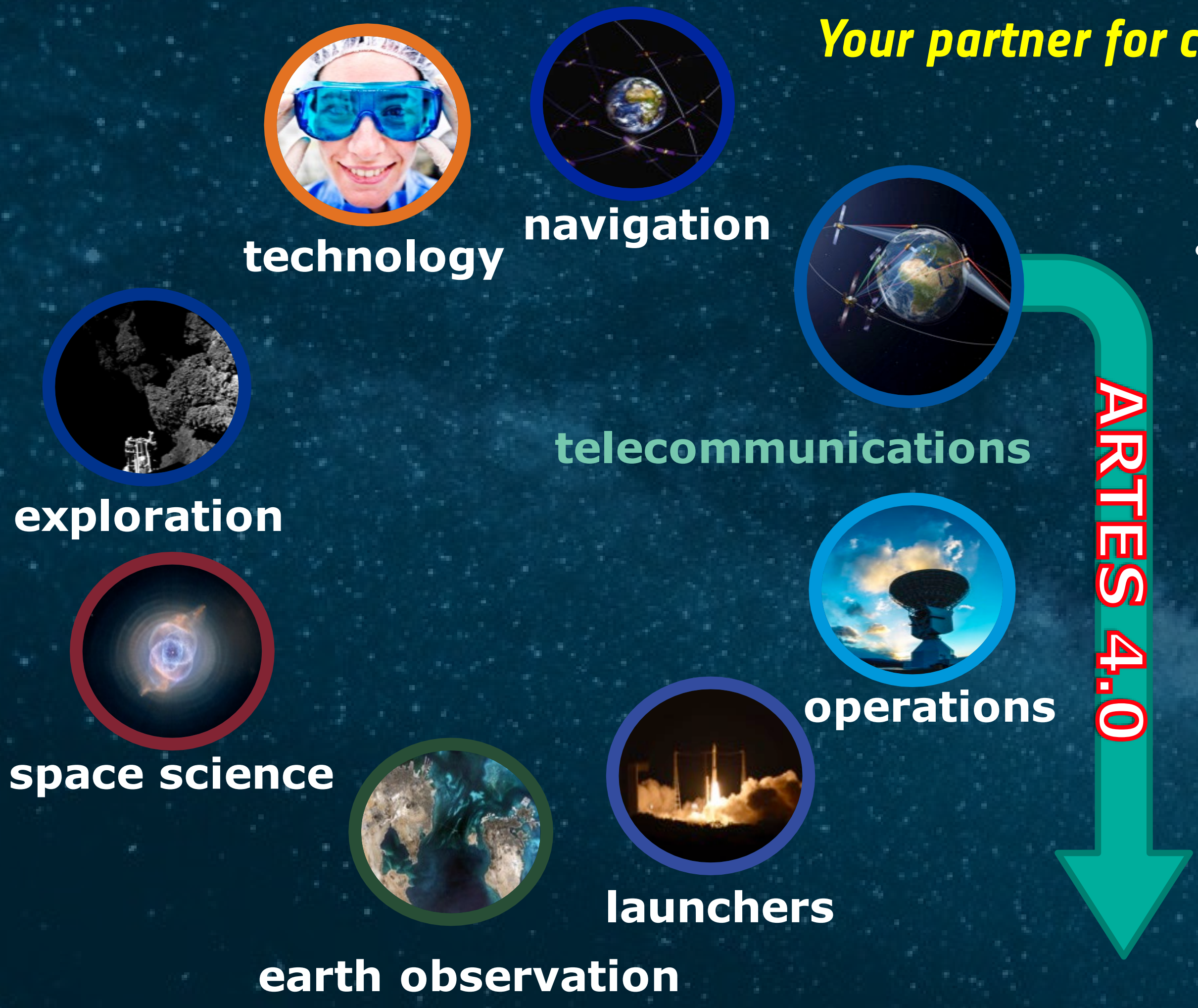
Purpose of ESA

To provide for and promote, for exclusively peaceful purposes, cooperation among European states in space research and technology and their space applications.

Facts and figures

- Over 50 years of experience
- 22 Member States, Latvia & Slovenia (associate members), Canada (Cooperation agreement)
- 8 sites across Europe and a spaceport in French Guiana
- Over 80 satellites designed, tested and operated in flight

ARTES - Advanced Research in Telecommunications Systems



Your partner for creating tomorrow's satcom solutions

- Support the **competitiveness** of European and Canadian industry on the world market
- Develop the **use of space** for the benefit of European citizens and the economy

Generic Programme Lines (GPLs)

- **F**uture **P**reparations (FP)
- **Core Competitiveness (CC)**
- **P**artnership **P**rojects (PP)
- **B**usiness **A**pplications & **S**pace **S**olutions (BASS)

Strategic Programme Lines (SPLs)

- Optical Communications ScyLight
- 4S – Space Systems for Safety and Security
- Space for 5G

https://artes.esa.int

ARTES 4.0 Core Competitiveness

Projects initiated by ESA annually

Typical end result: Breadboard, Early In-Orbit Test Flights

100% ESA funded

Open Competition

Design, Development and Demonstration of Products (hardware, software, system) in Space or Ground Segment

Projects initiated by industry any time

Typical end result: Engineering Model, Qualified Product, Flight demo

Co-funded (up to 80% for SMEs)

Direct Negotiation

Watch Video

https://artes.esa.int/core-competitiveness

The ARTES Programme: Based on Partnership

- National Delegations contribute funding from Member States
- Industry & institutions develop technology and products for the world Satellite Communications market
- ESA shares the risks and manages the contracts and activities
- Industry brings the end result to market

Clean Space at ESA - Space Debris Mitigation (1/3)

34 000 objects
greater than 10 cm

128 million objects
from greater than 1
mm to 1 cm

900 000 objects from greater
than 1 cm to 10 cm

Travelling at more than 7 km/s!

A 1 cm object can strike a satellite with the force of an
exploding hand grenade

Acting responsibly in space

Stop producing junk

Leading the European space sector

To develop the technologies required to comply with Space Debris Requirements, and thus catch an important part of this fast growing market

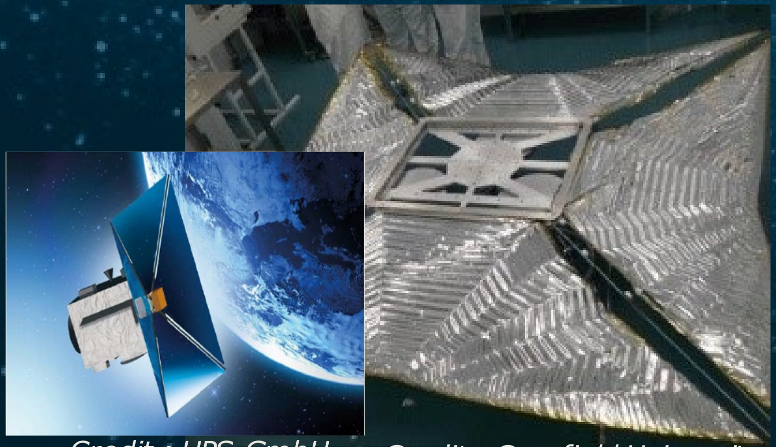
Clean Space at ESA – Passive de-orbit devices (2/3)

End Of Life Disposal Manoeuvres

Satellites in LEO shall limit their presence in the protected region (up to 2000km) to 25 years from the end of the mission or 25 years from the date of injection, if they have no Collision Avoidance Manoeuvre capabilities

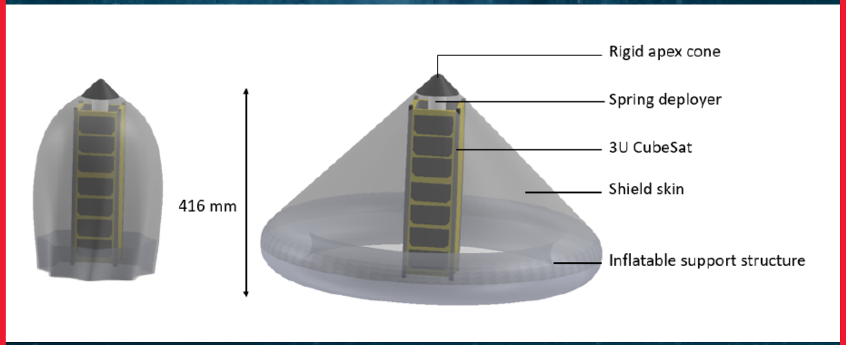
Passive de-orbit devices: devices that exploit the interaction with the Earth's atmosphere, magnetosphere or ionosphere to accelerate the decay of space objects into the atmosphere.

Drag Sail



Credit : HPS GmbH   *Credit : Cranfield University*

Inflatable Devices



Concept for 3U inflatable aeroshell, "De-orbiting Small Satellites Using Inflatables, University of Arizona"

Electrodynamic/Electrostatic Tether

Passive de-orbit devices implications and challenges (3/3)

Passive de-orbit devices characteristics:

- Simple
- Footprint on host S/C is small
- Can be autonomous systems (watchdog)
- Lightweight and reduce the overall mass of the S/C due to fuel savings
- Scalable
- Work only where the atmosphere/magnetosphere/ionosphere is present (LEO) and if satellites are not too big (<1000 kg)
- Low cost

Implications

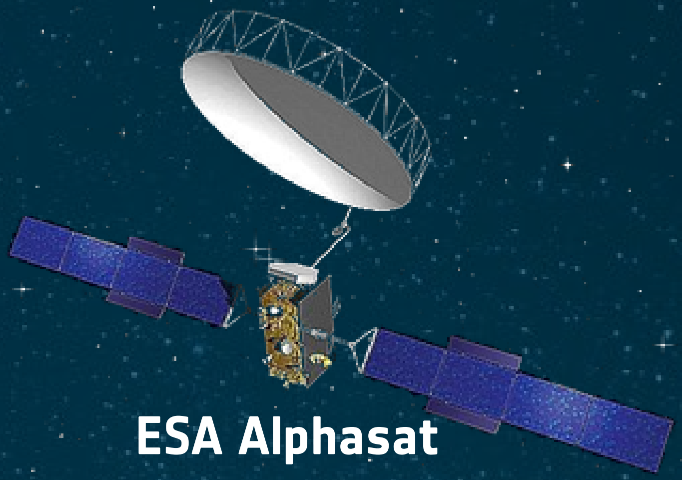
- Need surface clearance to place the device
- Lower mass and low complexity
- Limited system impacts

Challenges

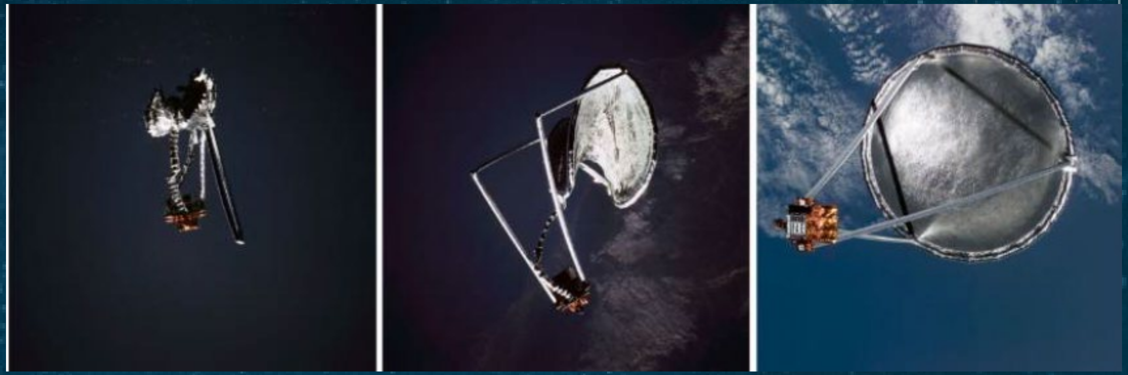
- Risk of early deployment
- Lack of manoeuvrability
- Micro meteorite impact
- Low heritage
- Detumbling after deployment
- Atomic oxygen may cause significant erosion of the device
- Lifetime + reliability of deployment

ARTES Advanced Technology – Drag Device Activity (1/3)

- New activity – ***Develop & test in-orbit an inflatable de-orbit drag device***
- Telecom constellations are major debris contributor
- Inflatable structures deployed in space are attractive, not new!
- Inflatable structures - potential for telecoms satellites:
  - not proven
  - maybe in future? - high power satellites



ESA Alphasat



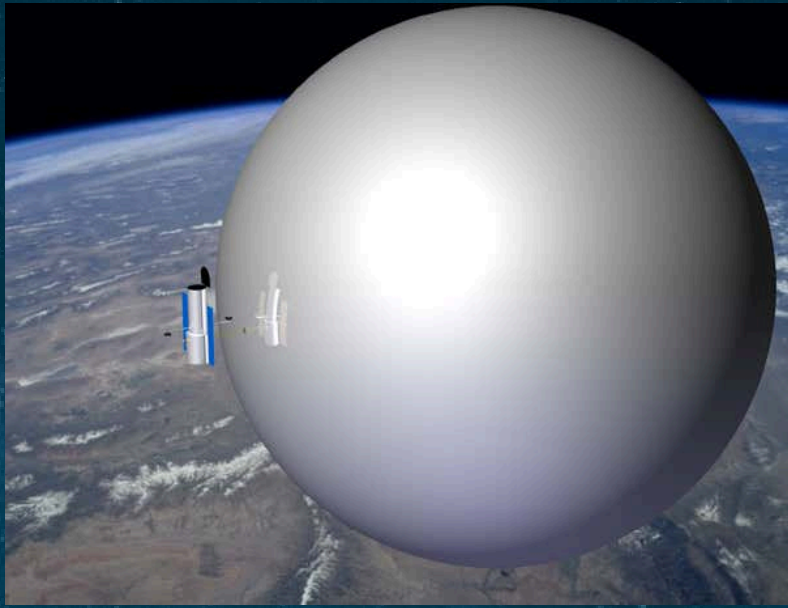
Deployment of Inflatable Antenna Experiment (image credit: NASA)

ARTES Advanced Technology – Drag Device Activity (2/3)

Drag device requirements:

- Reduce de-orbit time for small satellites by a factor of 5 & within 10 years (for altitudes 450-650km) in comparison to natural orbit decay → comply with future regulations
- Minimise mass & stowed volume
- Be simple, compatible with series production
- Compatible with existing platforms (bolt-on)
- Scalable for range of small satellites (up to 200kg)
- Incorporate backup passive actuation system (fail safe actuation)

Design configuration is open



Spherical balloon concept Image credit: Global Aerospace Corporation

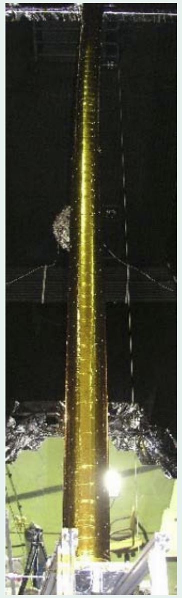
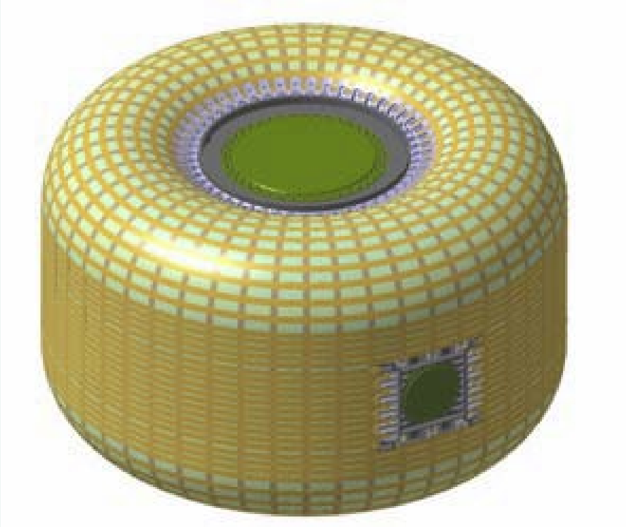
ARTES Advanced Technology – Drag Device Activity (3/3)

In-orbit test objectives:

- Embark drag device on 6U Cubesat platform or similar
- Demonstrate effectiveness in achieving accelerated de-orbiting (suitable orbit, mission lifetime to be proposed)
- Gather performance data in the space environment

- Duration: 2 - 3 years + in-orbit test
- Includes satellite platform, payload (including drag device), launch, operations
- This is a foundation for large manufacture of low cost product(s)
- Our End Vision - *"To enable simple, readily available de-orbiting product(s) for the small satellite industry"*

Space Inflatables – Technology Classifications (1/9)

Low Themo-mechanical loads	High thermo-mechanical loads
Balloons Actuators 	Heatshields & Decelerators Landing 
Support Structures 	Habitat 

Space Inflatables - State of the art: Balloons (2/9)

- Giant balloon to float through Martian atmosphere

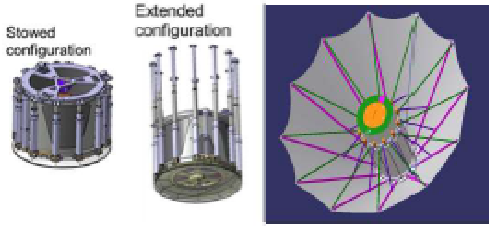
G637-001FG Preliminary activities for a Mars Balloon Probe - Mars Society Deutschland

The ARCHIMEDES (Aerial Robot Carrying High resolution Imaging, Magnetometer Experiment and Direct Environmental Sensors) probe consists of a 10 kg instrument pod attached to a 14.4m long balloon. The balloon is rolled up tightly into a small package as the probe will have to travel on another spacecraft to reach Mars.

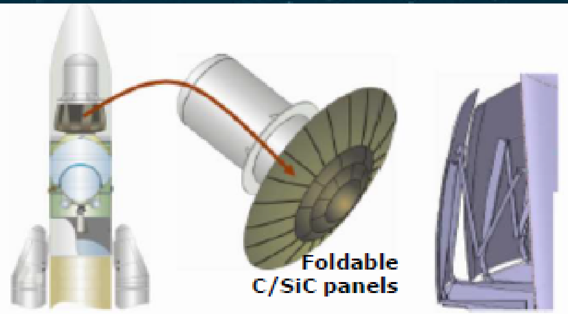
MIRIAM-2 balloon during the inflation test in the IABG

Space Inflatables - State of the art: Deployable/Inflatable aerodynamic decelerators (3/9)

Parashield, US universities, 1988
2.6m, model built, exploded at launch

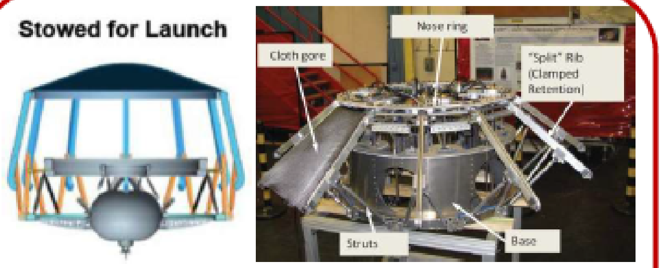


IRENE, ASI (I), 2010
3m, small scale flight test planned

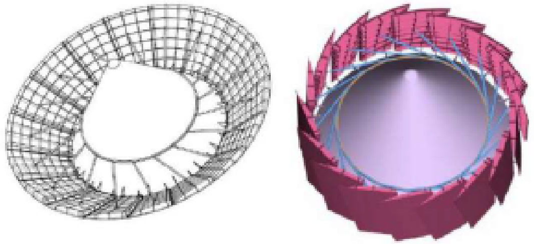


CMC hot structure, Astrium, 2003
8.5m, conceptual design

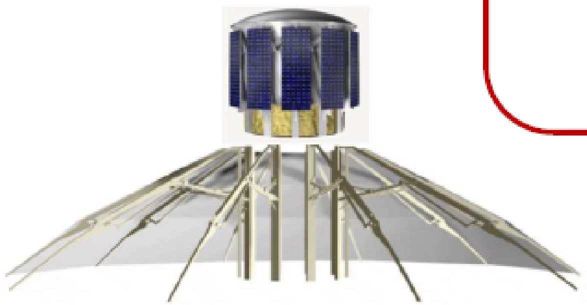
DAD concept screening



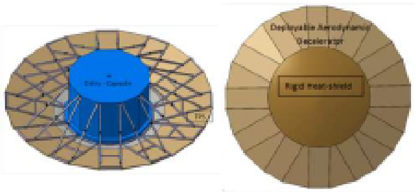
ADEPT, NASA, 2013
6m, design for Venus,
1/3 scale built & tested



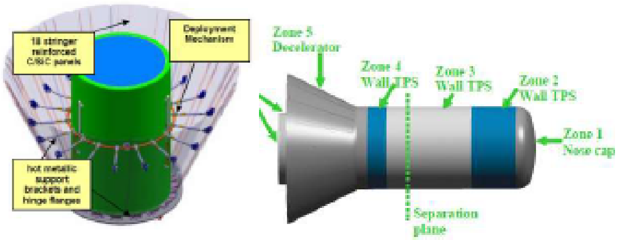
CMC rigid, Herakles, 1990s



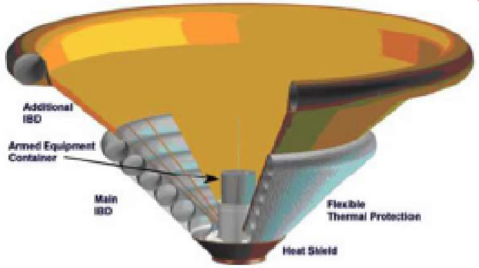
BREM-SAT2, Uni Bremen, 1996
2.24m, conceptual design



TAS-I DAD concept, 2016
7m, conceptual design

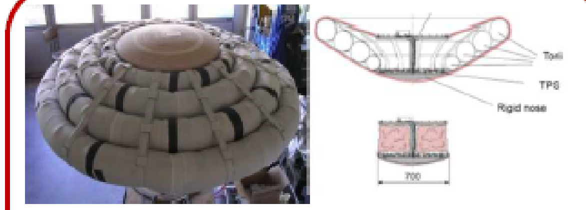


PARES, Astrium, 2004
conceptual design



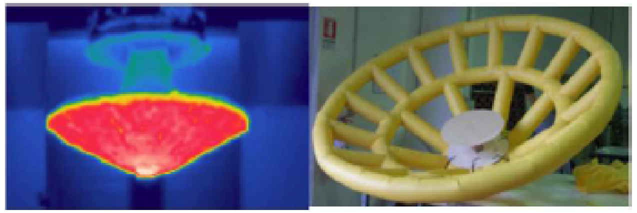
IRDT, ESA / Astrium, 2001-5
2.3/3.8m, 3 partially successful flights

IAD concept Screening



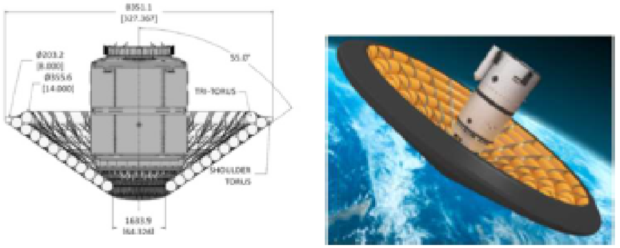
IRT-OHB, 2004
1.8m prototype built and tested

IRVE-3, NASA, 2012
3.0m, successful flight test (144kW/m²)



IRT-Aerosekur, 2004
0.6m scaled model built and tested

UHPV (Ultra High Pressure Vessel), NASA
Alternative concept to HEART



HEART (High Energy Atmospheric Re-entry Test)
8.3m/55°/3200kg NASA study P/L return

THOR (Terrestrial HIAD Orbital Re-entry)
3.7m/70°/315kg NASA study P/L return

Slide 17

ESA UNCLASSIFIEI

Space Inflatables - Airbags (5/9)

Space

NOT VENTED AIRBAG	VENTED AIRBAG
	
CIRA facility	AS facility

ARESCOSMO
DEFENCE AND SPACE

Non- Space

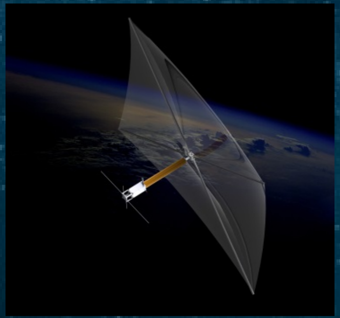
Space Inflatables - Cool Gas Generators (6/9)

- **Applications and product developmentthi**

Proba-2
- In space since 2009
- Space demonstration, 2 successful firings
- 40 nl CGG

Delfi-n3Xt
- Micro propulsion system
- 0.1 nl CGG
- For cubesats

Flat CO2 generator
- Study for Lunar Gateway
- 8 nl CO2 CGG



InflateSail CGG
- Launch in 2017
- Inflatable structure
- 3 nl CGG
- TNO used similar CGG's used on Inflatesail

Oxygen CGG
- Development for
- emergency oxygen
- 10 min 6 l/min

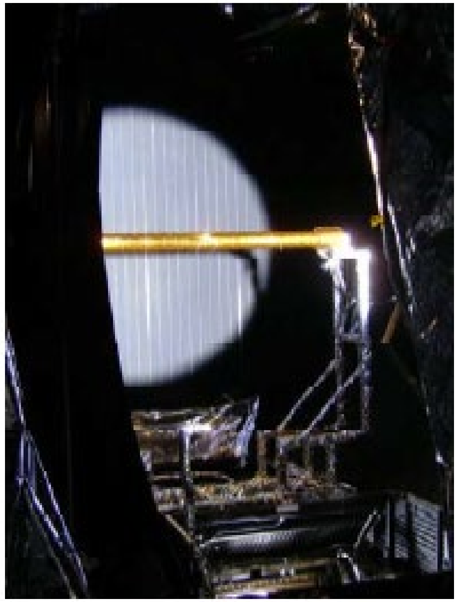
This slide is courtesy of

HDES High Density Energy Systems

Space Inflatables - Inflatable booms (7/9)

Before integration of internal Sub-Systems

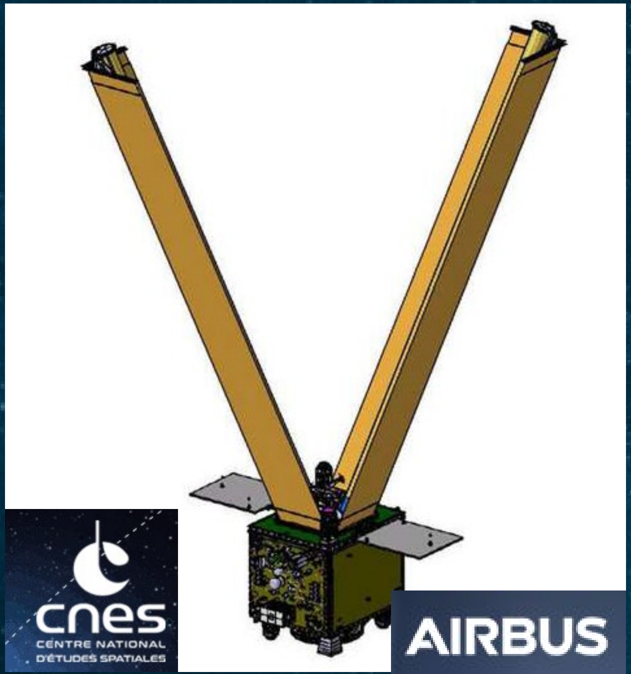
Before door closing

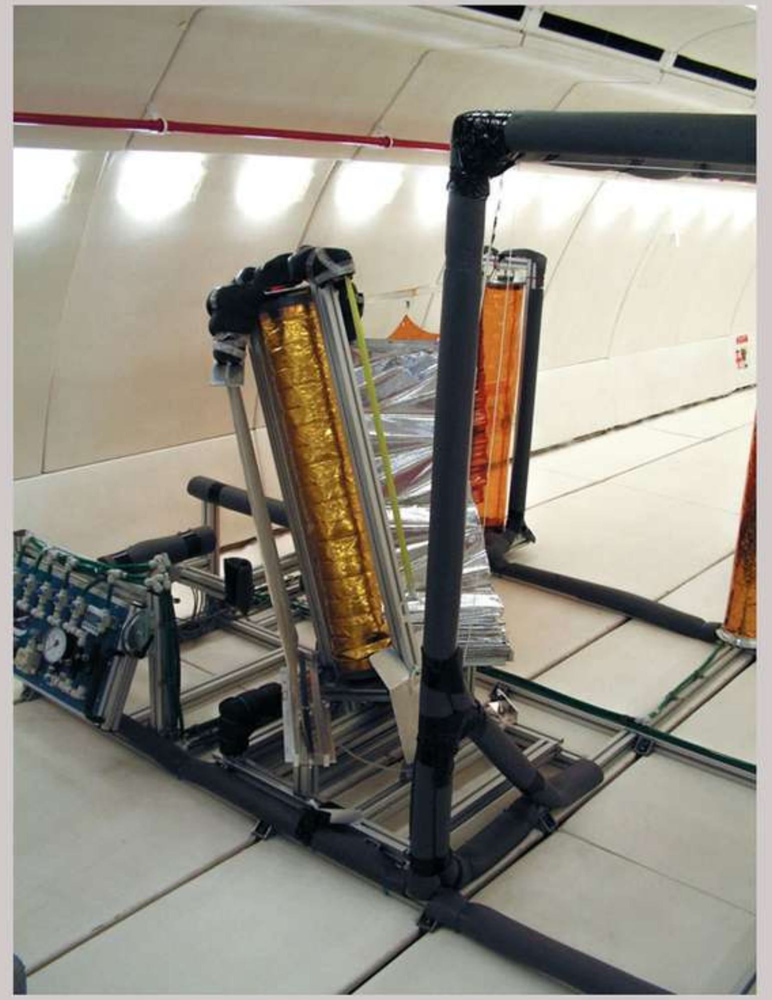


During test

Curing achieved in 16 hours
including heat up transient phases

Space Inflatables - Inflatable booms applications: IDEAS (8/9)





cnes CENTRE NATIONAL D'ÉTUDES SPATIALES
AIRBUS
arianeGROUP

Space Inflatables Inflatable Habitats (9/9)

The IMOD activity has been run until 2010 with the aim to **design, manufacture, test and validate an inflatable human habitat for Astronauts of the ISS.**

Main **Achievements** so far:

- Breadboard Module designed and manufactured (Φ3.3m)
- Breadboard failure during burst test moving from 1575 mbar to 1680 mbar (1.6 times operational pressure)

THALES

What's next?

- We have described ARTES, Clean Space, Inflatable technologies and a new ARTES Advanced Technology activity that appears in our 2021 Work Plan (full title: *In-orbit experiment of an inflatable de-orbiting drag device for small satellites*)
- ***Please contact your National Delegation*** **https://artes.esa.int/national-delegations to express interest & request activity is released**
- This will trigger Invitation to Tender (ITT) release, aiming for 2021
- Do form teams able to provide complete mission including platform, payload (including inflatable drag device), launch and in-orbit test.
- This LinkedIn Group and esa-match (in esa-star) may help
- We can support e.g. discussions/bi-laterals
- Use our esa-star system to download tender & bid
- Bids evaluated by Tender Evaluation Board (TEB) will take into account: 1 Background & experience, 2 Requirements understanding, 3 Quality of work & engineering approach, 4 Adequacy of management/costing/planning, 5 Compliance with contractual

esa-star

esa-star is available at
https://doing-business.sso.esa.int/
(use Google Chrome)

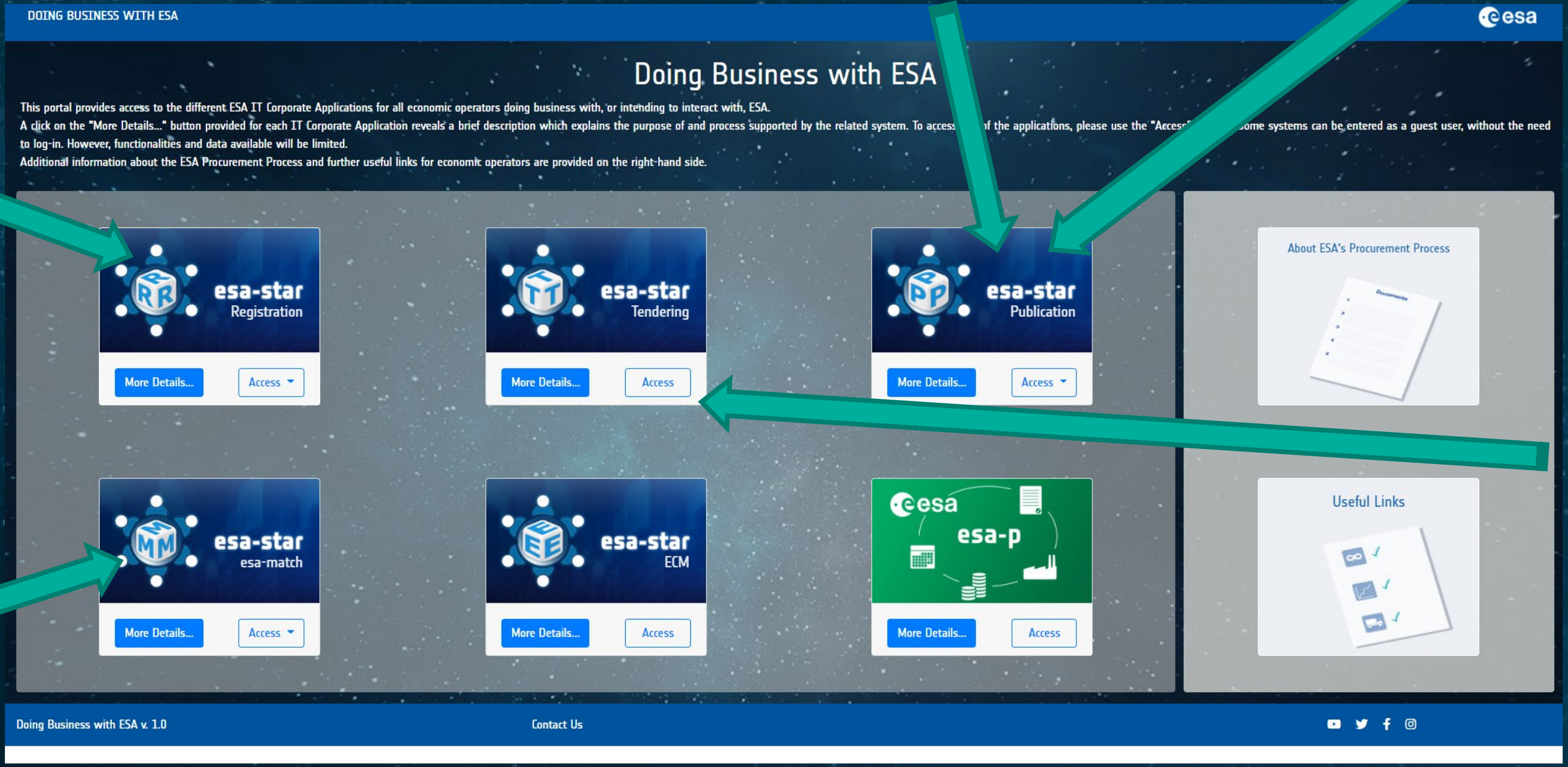
1. **Register**

2. Search for ref. 1-10621 in **Publication** - Download Tender Action Package - **2021 ARTES Advanced Technology Workplan → activity ref: 3E.003**

3. **esa-match**
New matchmaking platform for industry

4. ITT documents & proposal templates will be released in **Publication**

5. Bids to be submitted in **Tendering (national delegation support letter required)**



ARTES Advanced Technology: In-orbit experiment of an inflatable de-orbiting drag device for small satellites

Description: There are an increasing number of satellites in LEO predominantly due to large constellations required for the growing market of satcom services. To avoid orbital saturation, there is a critical need to develop simple, readily available de-orbiting devices that the small satellite industry is willing to adopt. At low orbits (<450km) atmospheric drag naturally de-orbits the spacecraft. At higher altitudes (>450 km) drag is less significant and hence there is a need to develop de-orbiting technologies. Current developments make use of deployable sails but are too complex and too bulky for small satellites (up to 200Kg).

This activity will develop and test in orbit an inflatable drag device aimed at de-orbiting small satellites (<200kg mass) within 10 years from altitude range 450-650 km to comply with future telecom regulations and international standards. The activity shall spin-in proven terrestrial technologies such as airbags from the automotive sector. It is critical that the device is as simple as possible with minimal number of mechanisms and shall be compatible with volume production requirements. It shall be developed for integration within existing platforms and scalable for a range of small satellite sizes. It shall have a low mass to volume ratio, be highly reliable and survive micrometeorite impacts. The device shall incorporate a backup passive activation system. This will enable fail safe actuation at the end of the mission or for out of control tumbling satellites. The passive actuation time period shall be tuneable commensurate with the mission lifetime.

Possible triggering mechanisms could make use of accumulated exposure to the space environment (e.g. vacuum, atomic oxygen, radiation). In-orbit testing is essential as a representative space environment including drag effects are not be possible to be simulated or tested on ground. The devices will be embarked on a 6U Cubesat platform or similar and an accelerated spacecraft deorbiting test will be carried out. Test data will be collected in the form of in-flight imagery of the deployment as well as GNSS data. In addition, de-orbiting will be tracked from ground.

Deliverables: Summary report, in-orbit experiment and test results

Budget: Up to €4M

Classification: On Request – activity will be initiated on the explicit request of at least one delegation

Procurement Policy: Open Competition to Companies, Universities, Organisations (Type C)

Thank for attending & Questions?

Feel free to contact us:

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