Ultra-Light Structures
Status of development & potential applications
(40EE)

Astrium Space Transportation
Hervé GUENAT / Olivier LE COULS

ESA Techno/Innovation Days - Feb, 18th 2010

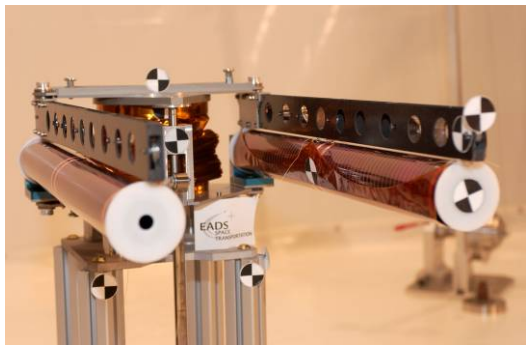
All the space you need

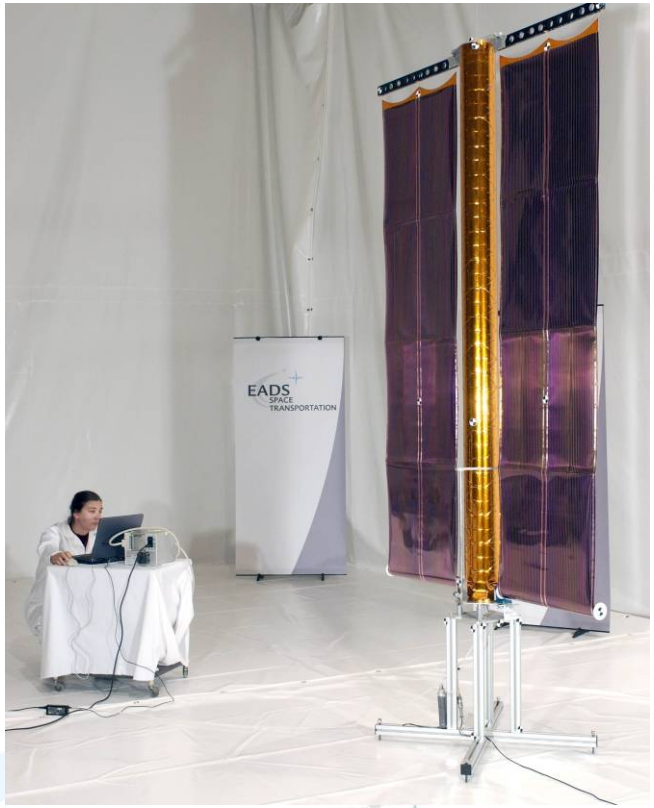
EADS astrium

Ultra-light structures

- Also called Gossamer technologies
- Inflatable & rigidizable structure selected at Astrium

- Main advantages
  - low volume in folded configuration
  - low mass
  - low manufacturing costs





- Technological breakthrough

Potential Space Applications

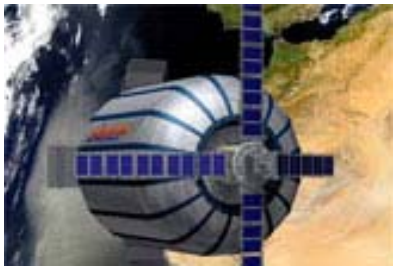
Long duration

Short duration

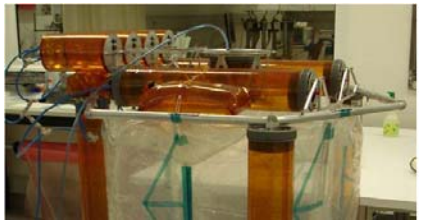
Low thermo-mechanical loads

High thermo-mechanical loads

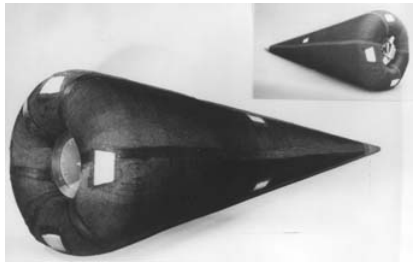
Appendages for satellites orbital infrastructures and probes



Actuators



Habitats



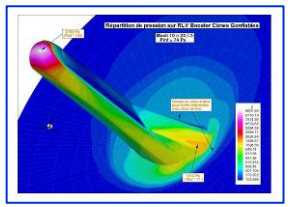
Decoys

Re-entry shields
Aerodynamic appendixes

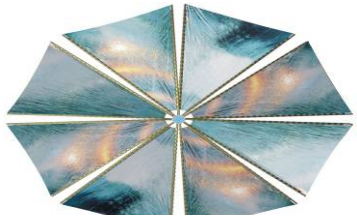
Buoys

Airbags

Balloons



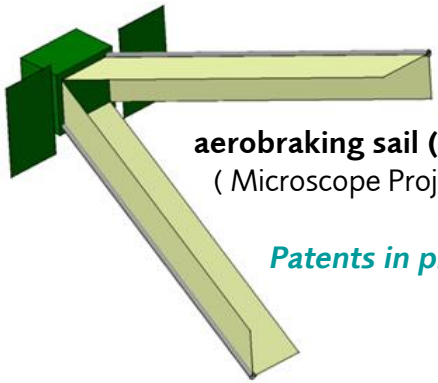
Appendages for satellites orbital infrastructures and probes



Solar Sails

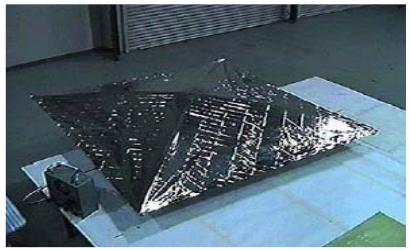
(Lavochkine Association)

- Potential applications investigated at EADS-ST
  - deployable booms
  - aerobraking system
  - solar array
  - Sunshield
  - antenna,
  - solar sail,
  - …

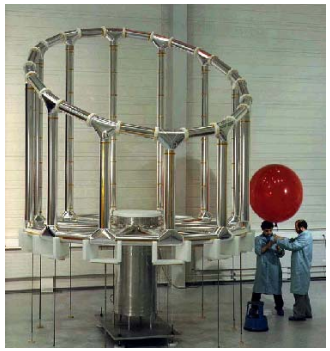


aerobraking sail (Astrium-ST)
(Microscope Project – CNES)

Patents in progress



(L'Garde)



1/3-scale model of the FIRST's thermal shield skeleton
(Contraves / ESA contract)

Solar array
(Teledesic)

Antenna reflector
(Contraves / ESA contract)

■ Roadmap :

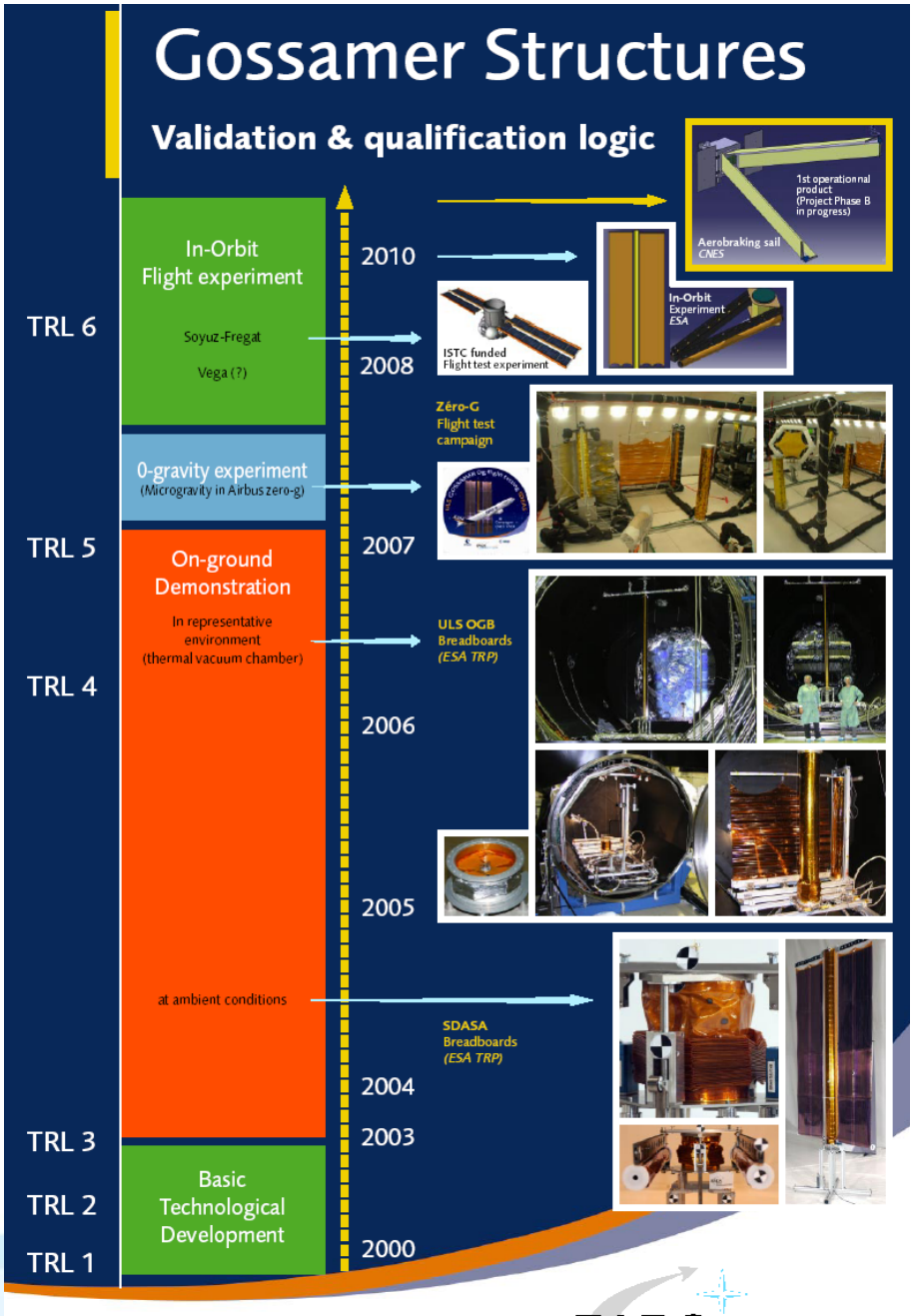
Validation & qualification logic

Generic development approach
(representativity of 2D applications)

Step-by-step approach:
to develop demonstrator based on

- **Central inflatable and rigidizable boom**
- Lateral stretched membranes deployed by mechanisms

Flight testing is a key issue to demonstrate the maturity of this technology



All the space you need

EADS astrium

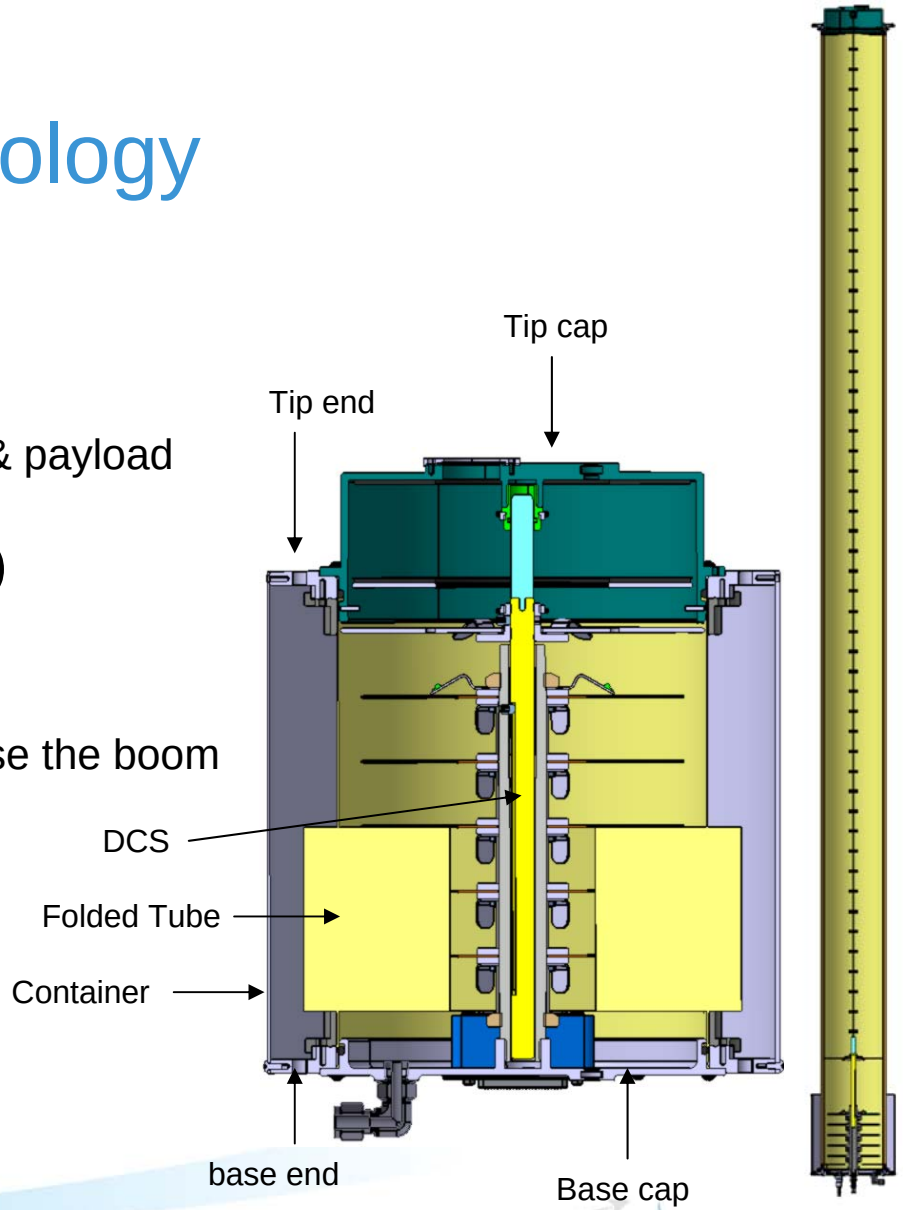
TRP "ULS" - Boom Technology

- Rigidization process
  - In-orbit Polymerisation of the composite walls after deployment
- Main drivers for material & resin chemistry
  - Long storage duration (on ground)
    - → choice of photoinitiated polymerization
  - Outgassing / Viscosity (Manufacturing)
    - → development of tailored resin family (COPO)
  - Mechanical properties
    - → Enhancement possible using hybrid fabrics (Glass + PBO / Glass + Carbon)

Supported by
TRP "POCS"
Polymerization Of Composite In Space

TRP ULS Boom Technology

- Main integrated subsystems
  - Caps & ends
    - → Tightness + interfaces with Platform & payload (membranes)
  - Deployment Control System (DCS)
    - → Straight and smooth deployment
  - Curing system
    - → To provide light and heat to polymerise the boom
  - Thermal Insulation (foldable)
    - → To limit gradients and curing power
- Main external subsystems
  - Hold-Down system
  - Inflation system



Booms validations plan (TRP ULS)

	OGB#1 1m	OGB#2 3m	OGB#4 4.5m	OGB#7 1m	OGB#8 1m	New OGD 3m	0gB1 1m
Manufacturing	X	Long booms Compatible	Long booms Compatible	X	X	Long booms Compatible	X
Folding	X	X	X	X	X	X	X
Depressurization			X				
Deployment	Air	Air	Air & Vac.	Air		Air	Air+0g
Thermal Vacuum			With sun	X		With sun	
Rigidization			Therm.+ Vac.		Air	Therm. + Vac.	
Mechanical characterization	Not rigidized Bending + burst	Bending not rigidized	X		Rigid. Bending+compression	Rigid. Dynamic	

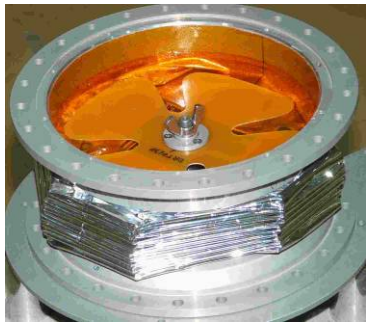
Membranes & 2D struc. Validation Plan

	OGB#5 1m	LSAP	0gLSAP 1m
Manufacturing	X	X	X
Folding	X	X	X
Deployment (air / vacuum / Zero-G)	Air Air + 0g Vacuum	Air	Air + 0g
Thermal vacuum			
Rigidization			
Mechanical characterization			

ULS – On-Ground Breadboards (OGB)

OGB # 1
Boom

OGB # 1
Before folding

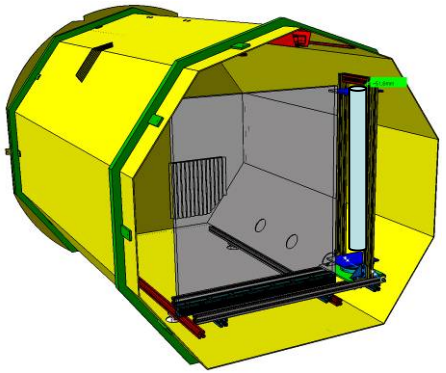


OGB # 1
folded

OGB # 2
Boom joint

OGB # 2
folded

OGB # 5
Membrane



EADS astrium

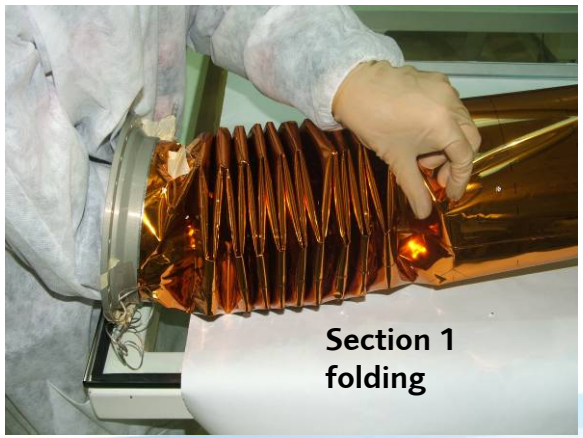
ULS – On-Ground Breadboards (OGB)

OGB # 4
Rigidization

Internal layer

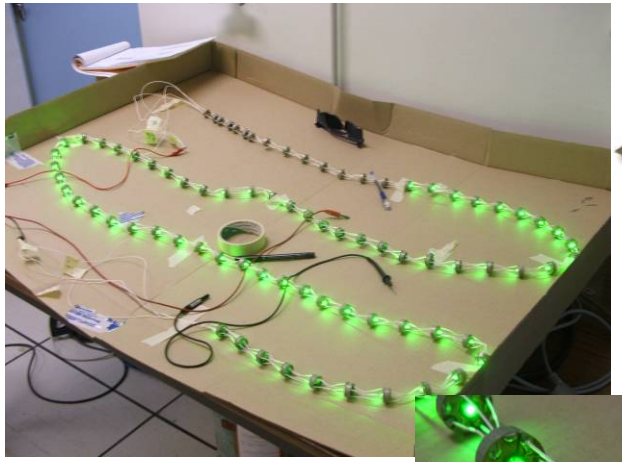
Structural layer

spacer

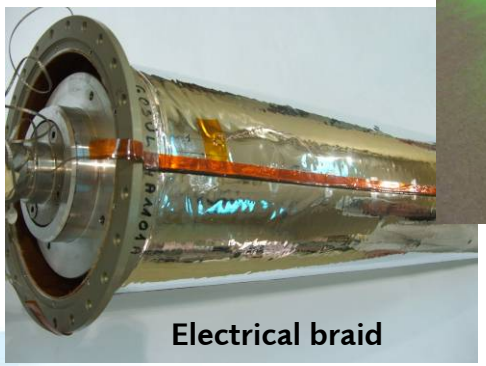


Section 1 folding

- 4,471 m long
- 160 mm diameter
  - DLI
  - active resin formulation
  - electric braids



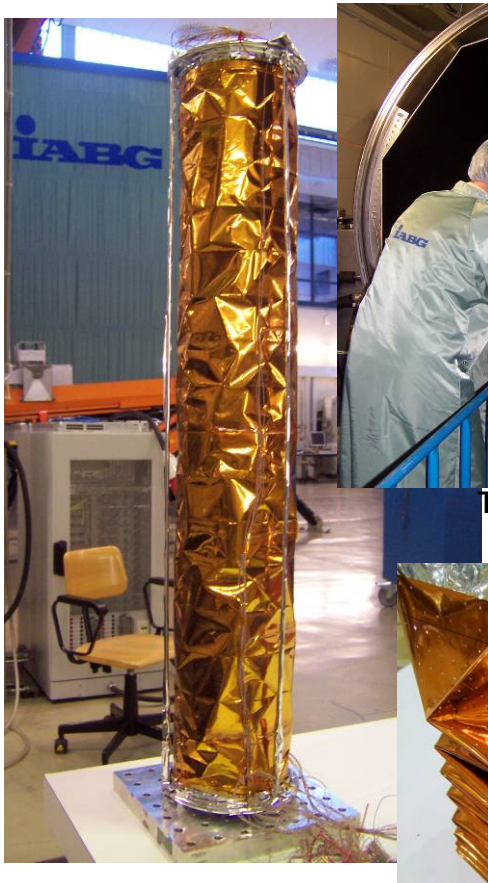
Curing system



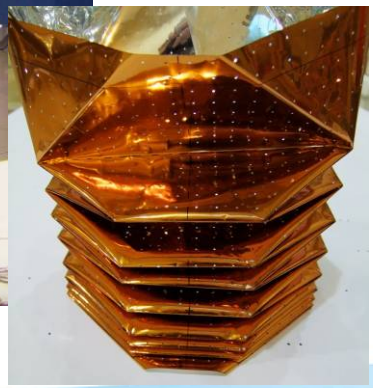
Electrical braid

ULS – On-Ground Breadboards (OGB)

OGB # 7
Thermal vacuum validation

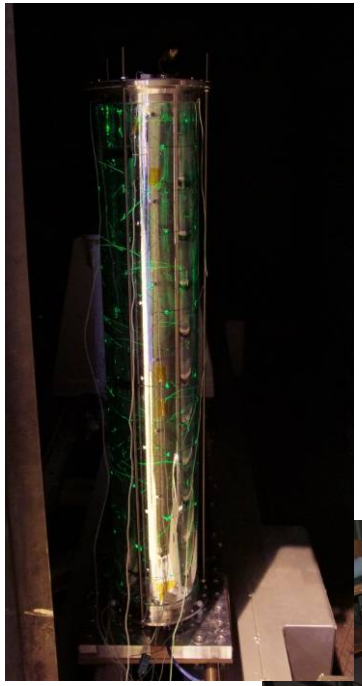


Thermal vacuum test



Thermal layer

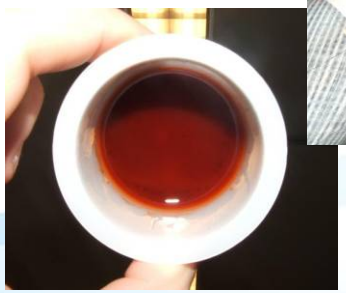
OGB # 8
Air Rigidization



Rigidization

Compression test

Impregnated structural layer



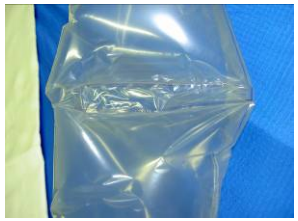
Resin + photoinitiator

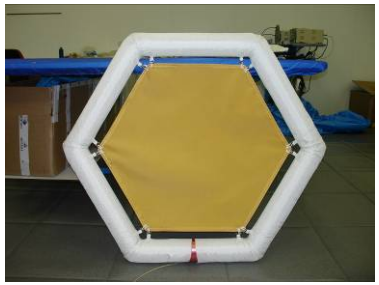
ULS – On-Ground Breadboards (OGB)
Large Size Application Package (LSAP)

Reduced scale

(assembly technology validation)

Folded

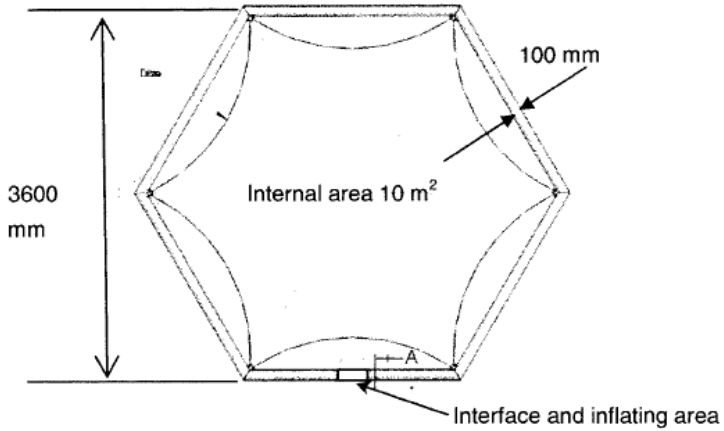




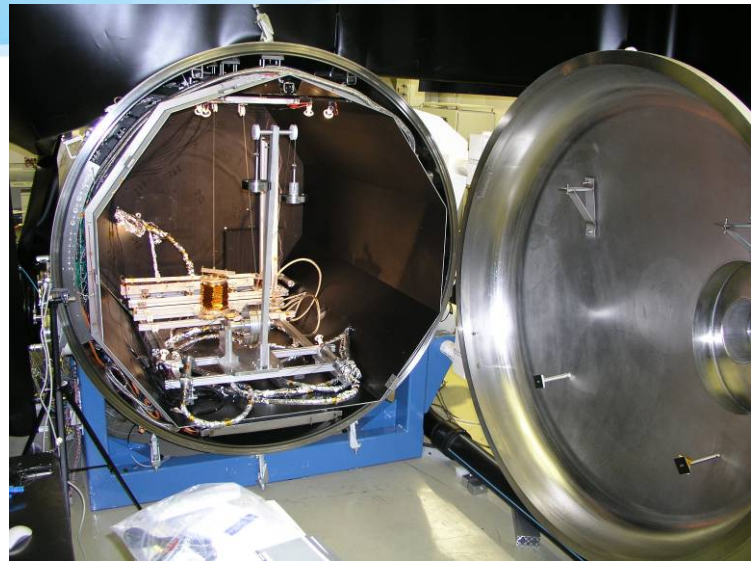
Stitched

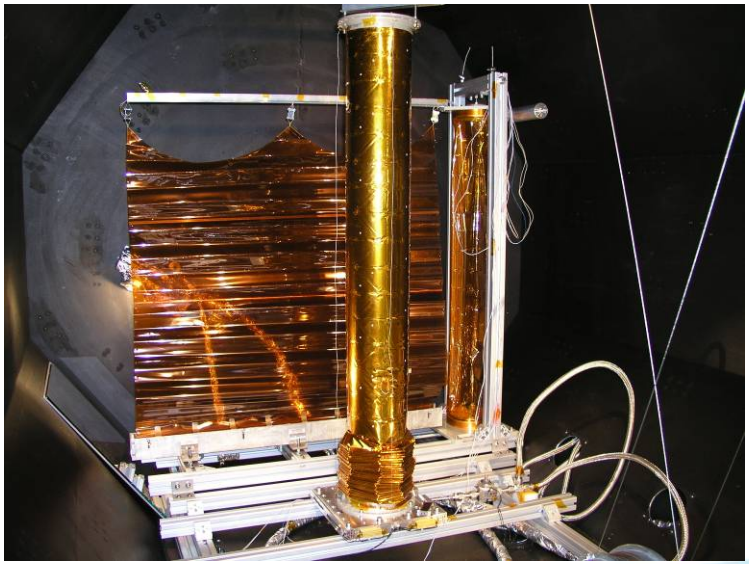
Full scale

(*hexagonal torus with 10 m² inside area*)



ULS (Tests at IABG)



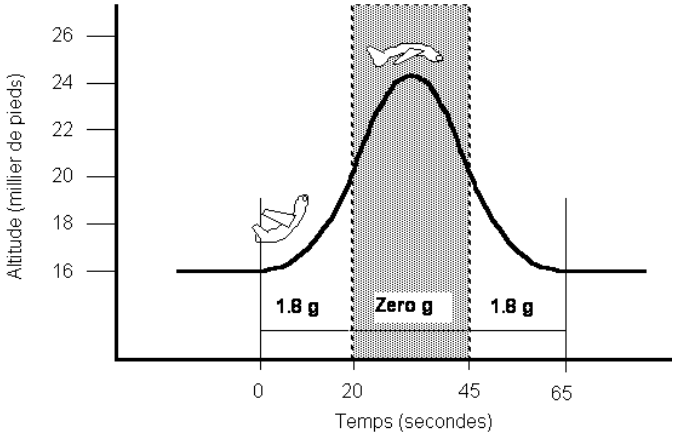


Deployment in vacuum (IABG)

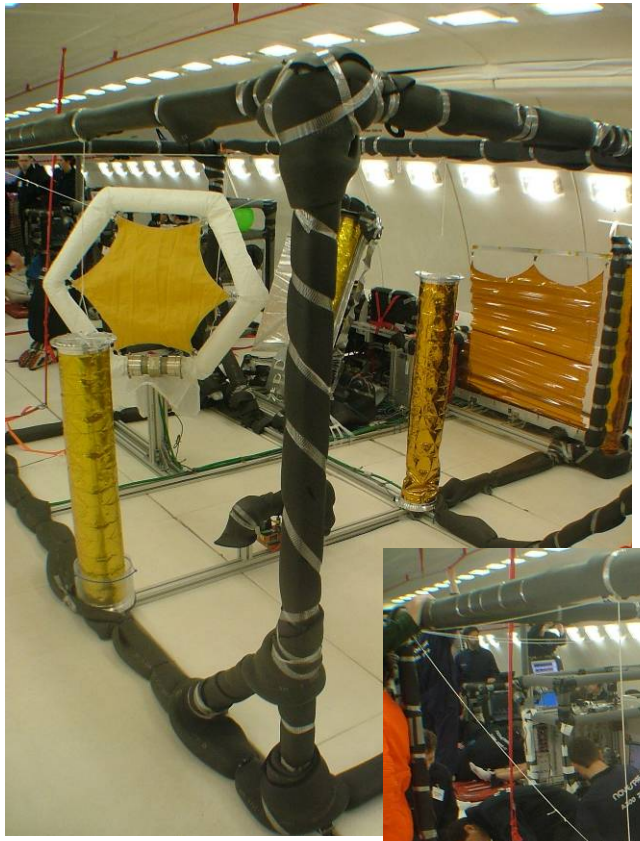
Thermal vacuum rigidization of OGB#4 with sun simulation (IABG)

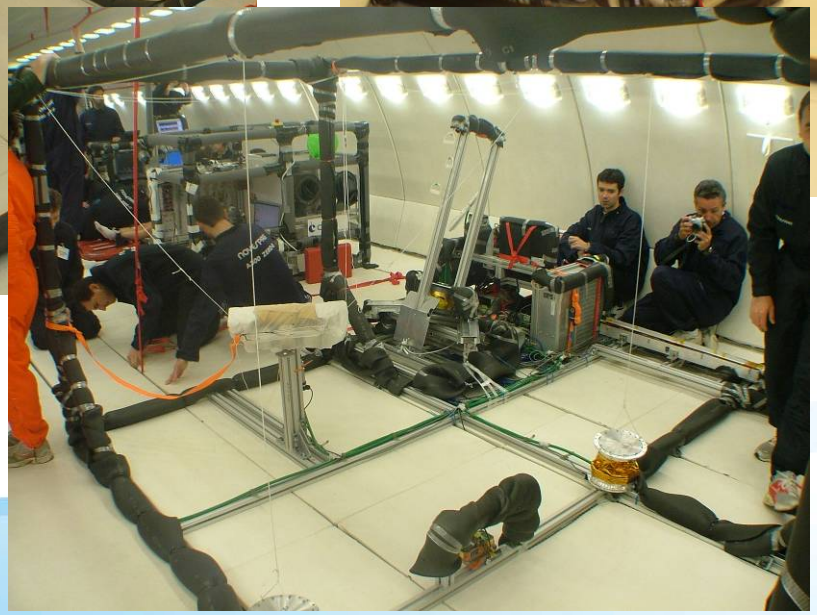
0-g flight test campaign CNES/ESA (March 2007)

- **Deployment Tests of tubes & membranes:**
  - **CNES funded flight test campaign**
  - **CNES funded specimens** = complement to specimens tested on ground in the frame of the IDEAS aerobraking system
    - o **0gTUB** => alu laminate tubes (3)
    - o **0gMEM** => membrane with the aerobraking sail's folding pattern
  - **ESA funded specimens** = similar to those tested on ground during ULS Phase 2B
    - o **0gB1** => same definition as OGB#1 + spacer & DLI
    - o **0gB5** => retrofited OGB#5
    - o **0gLSAP** => reduced scale of LSAP OGB



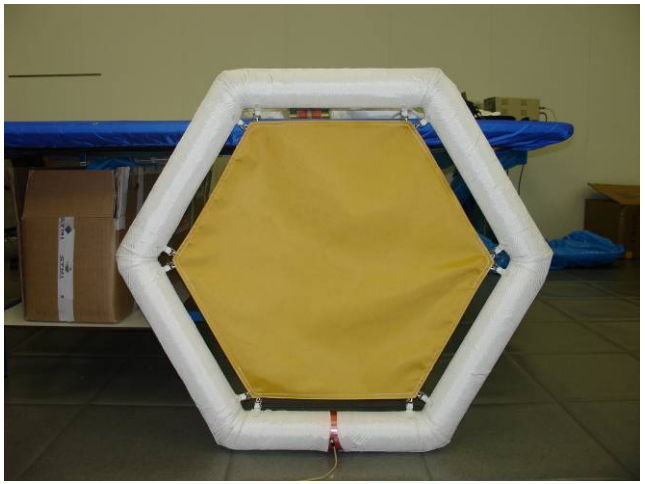
Test bench lay-out
(with deployed specimens)





ULS Test specimens (deployed)

OgB1 = 1m breadboard



OgLSAP = 1m breadboard

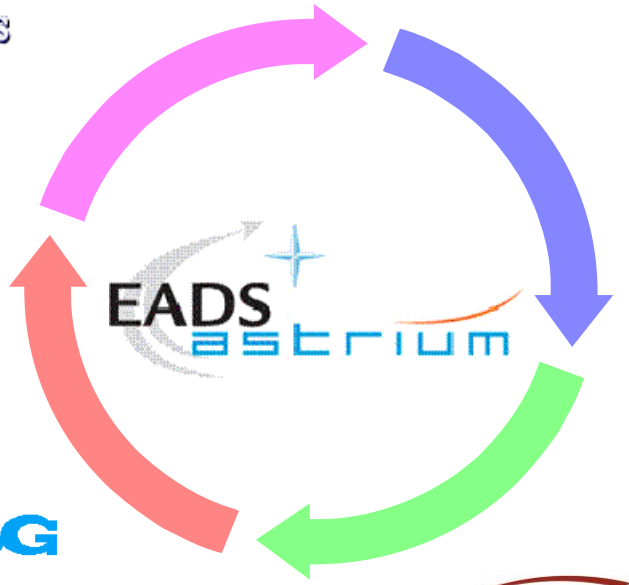
Boom validation status

- Manufacturing / Folding
  - Assembly technique compatible for long booms (L>10m)
- Depressurization (launch phase)
  - Achieved: TRL5 (Not sensitive effect)
- Deployment
  - Achieved: TRL4/5 (Straight & smooth)
- Thermal design
  - Achieved: TRL5 (partly) Expected: full TRL5
- Rigidization
  - Achieved: TRL4 Expected: TRL5
- Mechanical design
  - Achieved: TRL4 (partly) Expected: full TRL4
- Folded dynamics
  - Not studied
- Hold-Down and Release System
  - Achieved: paper studies
- Inflation System
  - Achieved: paper studies (validation and qualification logic for inflatable technologies)

Astrium-ST Partners

Astrium-ST as Prime Contractor

with the support of most skilled European partners



MC Bernasconi Consultants

Materials & Technologies

R.S.A. Réactions Sélectives et Applications — inasmet tecnalia

Rigidization

LAVOCHKIN ASSOCIATION

Design & analysis, manufacturing, testing

IABG

Testing (TV chambers)

KONGSBERG

Mechanical engineering

SENER

Inflatable Capture Mechanism

seibersdorf research — Ein Unternehmen der Austrian Research Centers.

ONERA

Materials & testing

UNIVERSITÉ DE NANTES

Theoretic approaches in mechanics

Samtech

Prospective structural analyses (partnership agreement)

ZODIAC

Assembly techniques

EADS astrium

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