APCO Technologies QUALITY AND EXPERIENCE

OUR COMPANY

Established in Switzerland in 1992, APCO Technologies is a project-oriented company specialised in heavy machinery for the SPACE, ENERGY, and INDUSTRY sectors. To date, the company has known a continuous growth.

QUALITY FIRST

Our success is notably due to our stringent quality policy at every scale of the projects which you are entrusting us with.

Our strategy is defined as:

- Meeting your requirements, be formulated or not.
- Developing a strong corporate culture which allows our collaborators to work and thrive in the best conditions.
- Keeping a step ahead in terms of innovation

SPACECRAFT STRUCTURES AND MECHANISMS

APCO Technologies' core competencies are in the development and manufacturing of lightweight flight structures, instruments and mechanisms for satellites. These complex elements have to survive over 15 years in a very harsh space environment (temperature, loads, radiation).

With important production capabilities and an extensive heritage acquired over two decades, APCO Technologies is a recognised partner in the space industry and beyond.

Certifications

EN 9100 : Quality Management Systems – Requirements for Aviation, Space and Defense Organizations

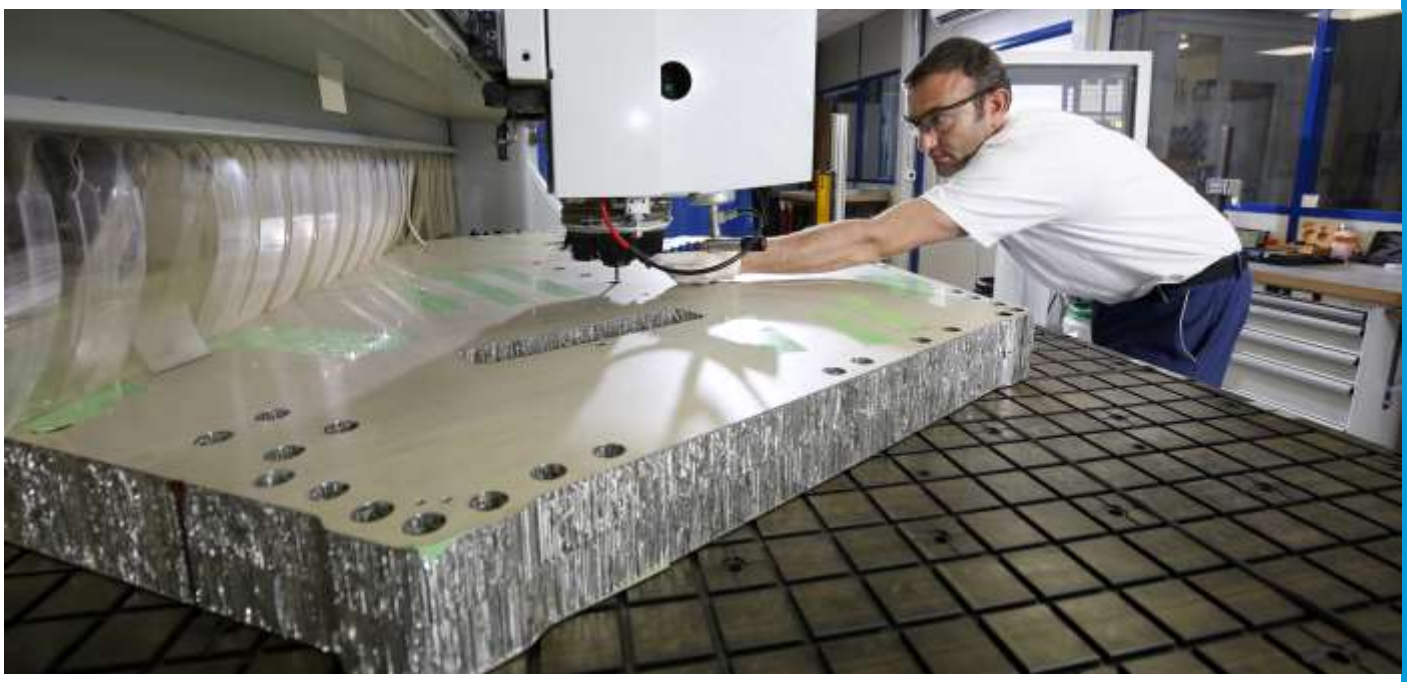
ISO 9001 : Quality Management

ISO 14001 : Environmental Management

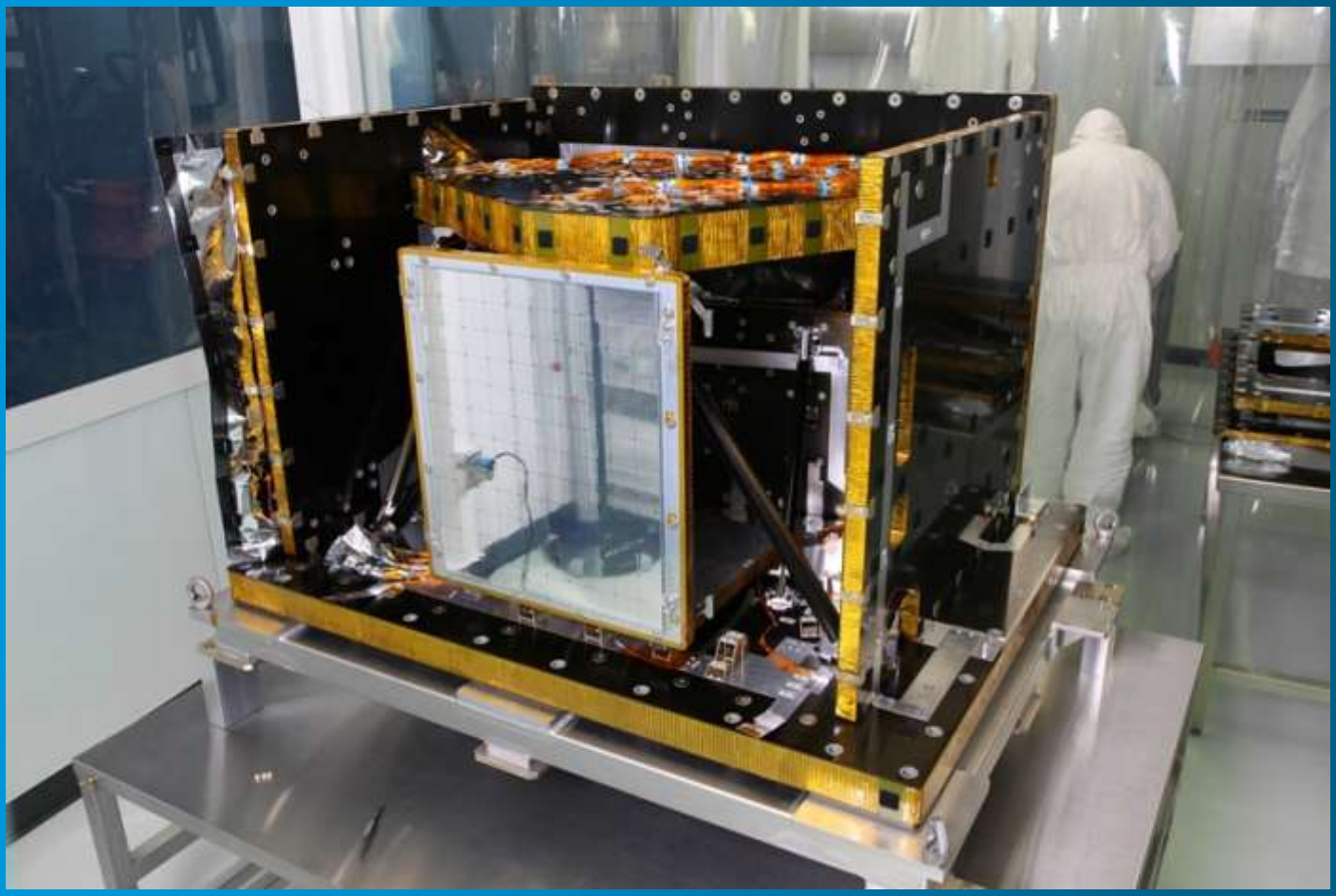
ISO 27001 : Information Security Management

OHSAS 18001 : Occupational Health and Safety Management

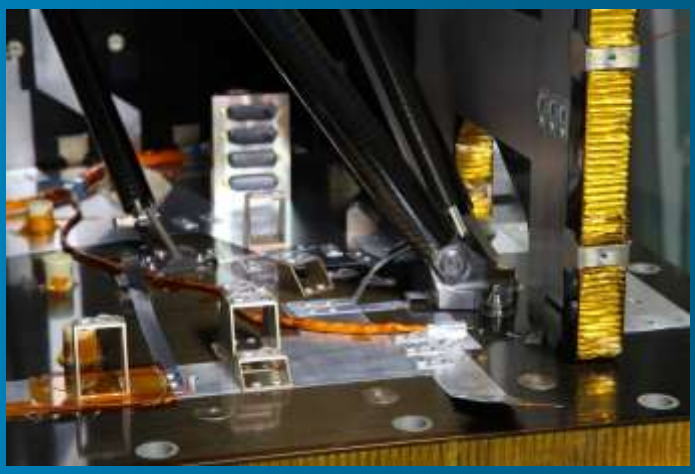
Airbus DS IPCA + : Industrial Process Control Assessment



3 - APCO Technologies - Flight Hardware



Sentinel-3 OLCI STCA



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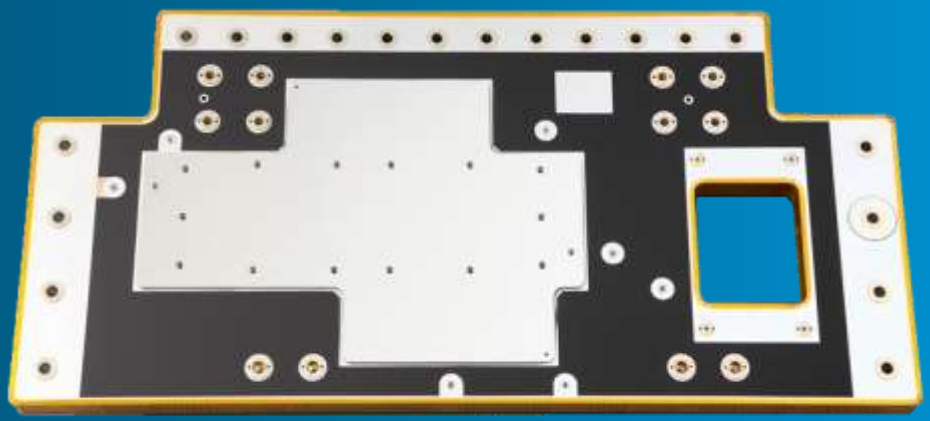


HERITAGE

SPACECRAFT STRUCTURES PROJECTS

APCO Technologies has more than 25 years of experience developing space flight structures for Satellite buses and payloads.

Among the most significant ESA programs to which APCO Technologies has contributed notably within the space Flight Hardware field, it is worth to mention the following ones (non-exhaustive list):

MTG S/C Platform Structure

Manufacturing of the MTG Aluminum / Aluminum Radiator Panels (about 48 panels in 12 months). The panel design and analysis is under APCO Technologies responsibility. Some panels include structural doublers, honeycomb reinforcements, skin splicing and up to 300 inserts (including hot bonded inserts).

SMART-1 Spacecraft Structure

Engineering, analysis, manufacture and tests of the complete flight structure made in honeycomb sandwich panels (2x models: STM and PFM) with integrated hot bonded Interface rings of the SMART-1 Spacecraft for the Swedish Space Corporation. The project included Aluminum Struts and Hydrazin thruster brackets.

Sentinel-3 SLSTR RA

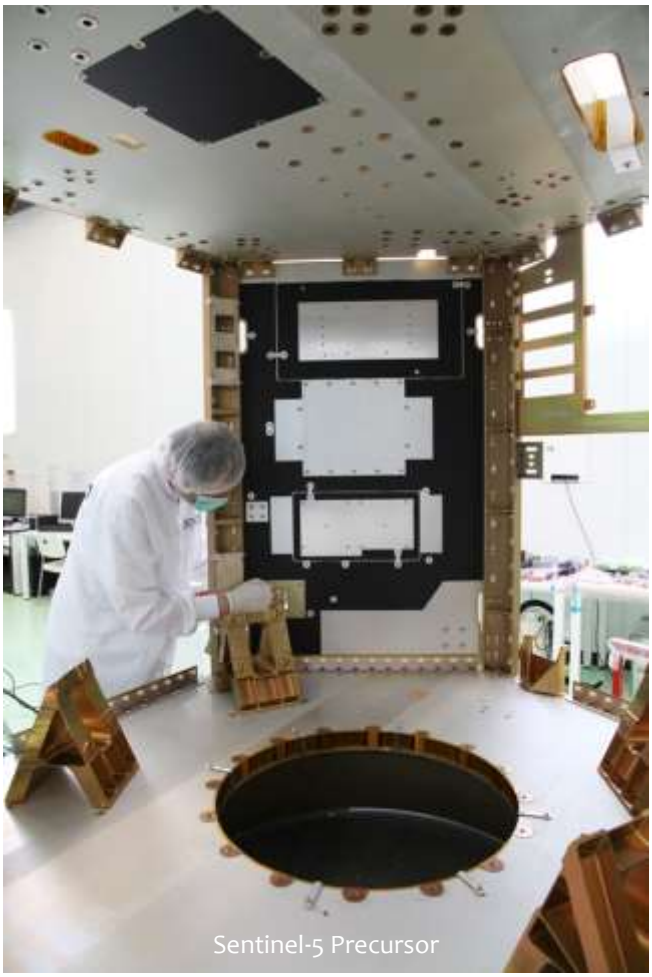
SENTINEL-3 SLSTR Radiator Assembly and Support Structure

Engineering, analysis, qualification of machined Aluminum and Aluminum / Aluminum honeycomb sandwich panels, radiators and embedded heat pipes within certain panels, qualification of inserts.

EUI OBS

EUI OBS

Engineering, analysis, qualification of inserts, manufacturing of Carbon Fibres Reinforced Panels (CFRP / Aluminum honeycomb sandwich panels), surfaced heat pipes, stand-off MLI & TC105.



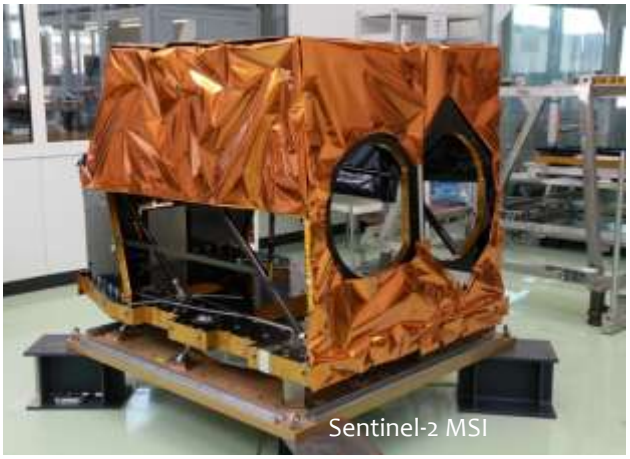
Sentinel-5 Precursor

SENTINEL-5 Precursor Structure

Qualification, manufacturing, assembly and test of the complete flight structure made of Aluminum / Aluminum sandwich panels.

SENTINEL-2 MSI Structure and MLI

Engineering, analysis, qualification, manufacturing and tests of the flight structure of the SENTINEL-2 MSI instrument made in honeycomb sandwich panels (CFRP and Aluminum). Engineering, analysis, qualification, manufacturing and tests of CFRP struts, titanium alloy nodes and inserts.

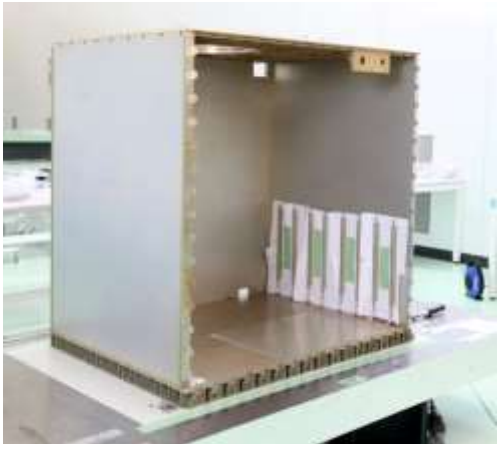

Sentinel-2 MSI

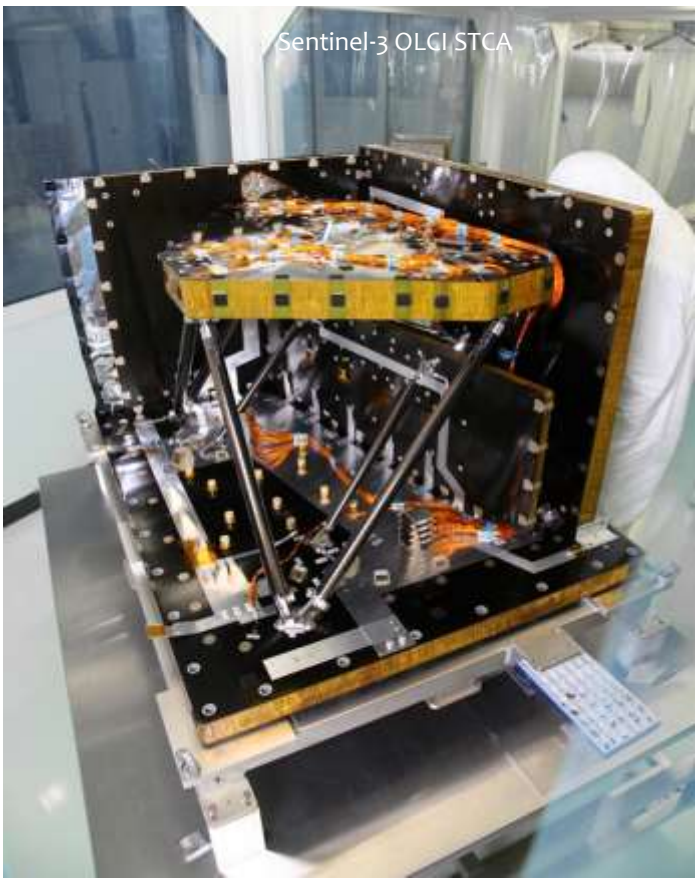
CFRP Panels Interconnection

Research and development of a new interconnection system between Carbon Fibres Reinforced Panels (CFRP / Aluminum honeycomb sandwich panels) based on the Zip Edge principle, engineering, analysis, manufacturing and tests of a prototype flight structure for ESA-ESTEC in Noordwijk (NL). The same system can be applied to Aluminum – Aluminum honeycomb sandwich panels and is currently applied in other APCO Technologies Flight Structure projects.

ACES (Atomic Clock Ensemble in Space)

Engineering, analysis, qualification of machined Aluminum and Aluminum – Aluminum honeycomb Sandwich Panels, in certain panels embedded heat pipes, hot & cold bonded inserts, qualification of inserts.


ACES


Sentinel-3 OLCI STCA

SENTINEL-3 OLCI STCA

Qualification, manufacturing and tests of the SENTINEL-3 OLCI Structure and Thermal Control Assembly (STCA) made in honeycomb sandwich panels (CFRP and Aluminum). Engineering, analysis, qualification, manufacturing and tests of CFRP struts, titanium alloy nodes and inserts.


PROBA 2

PROBA 2

Engineering, analysis, manufacture and tests of the flight structure made in honeycomb sandwich panels (CFRP and Aluminum) and development of the interconnection system in Titanium alloy between different panel materials to compensate thermal expansion compensation.

PRODUCTION & MEASUREMENT MEANS

BLANK PANEL MANUFACTURING

Over the years, we have gained the know-how and acquired the means to manufacture our own composite panels.

Autoclaves allow curing processes for production of composite components, CFRP / Aluminum or Aluminum / Aluminum honeycomb sandwich panels. Two autoclaves are today in service in our facilities in Aigle.

Prepreg elements and adhesives are stored in a monitored cold room.

Autoclaves characteristics

	Autoclave 1	*Autoclave 2*
Work envelop (Ø x L)	2000 x 3000 mm	3090 x 5000 mm
Temperature	280°C ± 1°C	250°C ± 1°C
Maximum Pressure	10 bars ± 0.1 bar	10 bars ± 0.1 bar
Maximum Vacuum	-0.9 bar ± 0.05 bar	-0.9 bar ± 0.05 bar
Number of thermal measurements points	8 / 35 TC	20
Number of vacuum points	4	12

CONTROLS & TESTS

In order to qualify flight hardware, panel samples undergo thermal cycling in a vacuum environment, reproducing conditions later encontered in space during the mission.

Lap-shear tests are performed on a 30kN traction machine, allowing the qualification of adhesive and inserts.

Thermal vacuum chamber

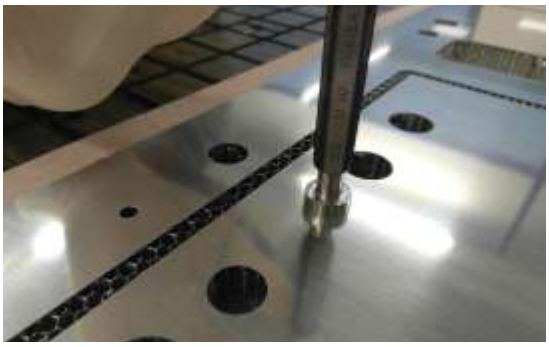
Work envelop (L x W x H)	650 x 650 x 650 mm
Nominal Test Pressure	10^{-5} bar
Pressure Range	(P_{atm} ; 10^{-9}) bar
Temperature Range	(-82°C ; +120°C)
Number of thermocouples	40
Data acquisition	Agilent 34972A

MACHINING CAPACITIES

Milling machines are used to perform machining operations on composite panels. Our newest milling machine is specifically dedicated to CFRP / Aluminum pannels machining.

Milling machines characteristics

	TNG	*EMCO Dynamill 300*
Number of axis	3	5
Work envelop (L x W x H)	2000 x 3000 x 350 mm	5000 x 3000 x 1000 mm
Precision	< 0.1 mm	< 0.01 mm
Environnement Temperature	20°C ± 1°C	20°C ± 1°C



CLEAN ROOMS & MEASURING EQUIPEMENT

Our facilities in Aigle include an ISO 7 (class 10000) cleanroom with a 4T lifting capacity, containing an ISO 5 (class 100) tent. They are notably used to assemble flight hardware.

Clean areas dimensions (L x W x H):

- ISO 7 room : 16.9 x 6.8 x 4.7 m (under crane)
- ISO 5 tent : 4.8 x 2.9 x 2.25 m

They include several measuring equipement:

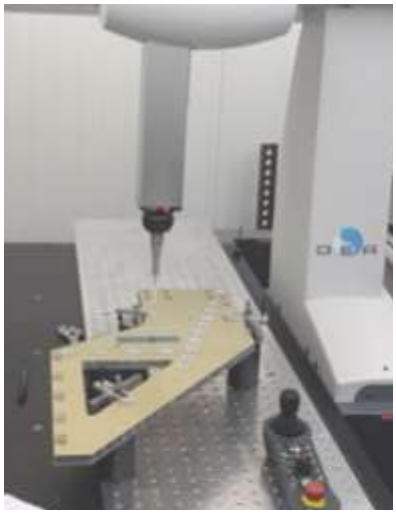
- Two 3D measurement machines
- A laser tracker
- A FARO Arm (rarely used on flight panels)

Laser Tracker characteristics

	LEICA AT401
Precision (MPE) Uxyz	±15 µm + 6 µm/m
Work distance	320 mm
Geometric Software	Hexagon PC DMIS 2017

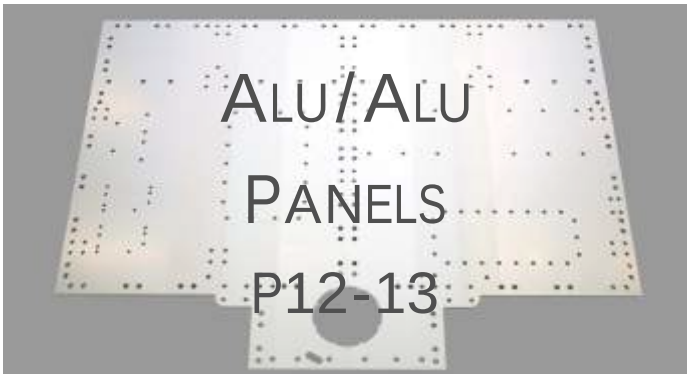
3D machines characteristics

	Dea Hexagon GHIBLI	*Wenzel LHF3020*
Measurement Head	Reinishaw PH10M-TP20	Reinishaw REVO
Work envelop (L x W x H)	2000 x 1500 x 1400 mm	5000 x 3000 x 2000 mm
ISO 10360 uncertainty of measurement	±4.5 + 5L(m)/1000 µm	±5 + L(m)/350 µm
Scanning error	/	5 µm @ 72s
Geometric Software	Hexagon PC DMIS 2017	Wenzel Quartis

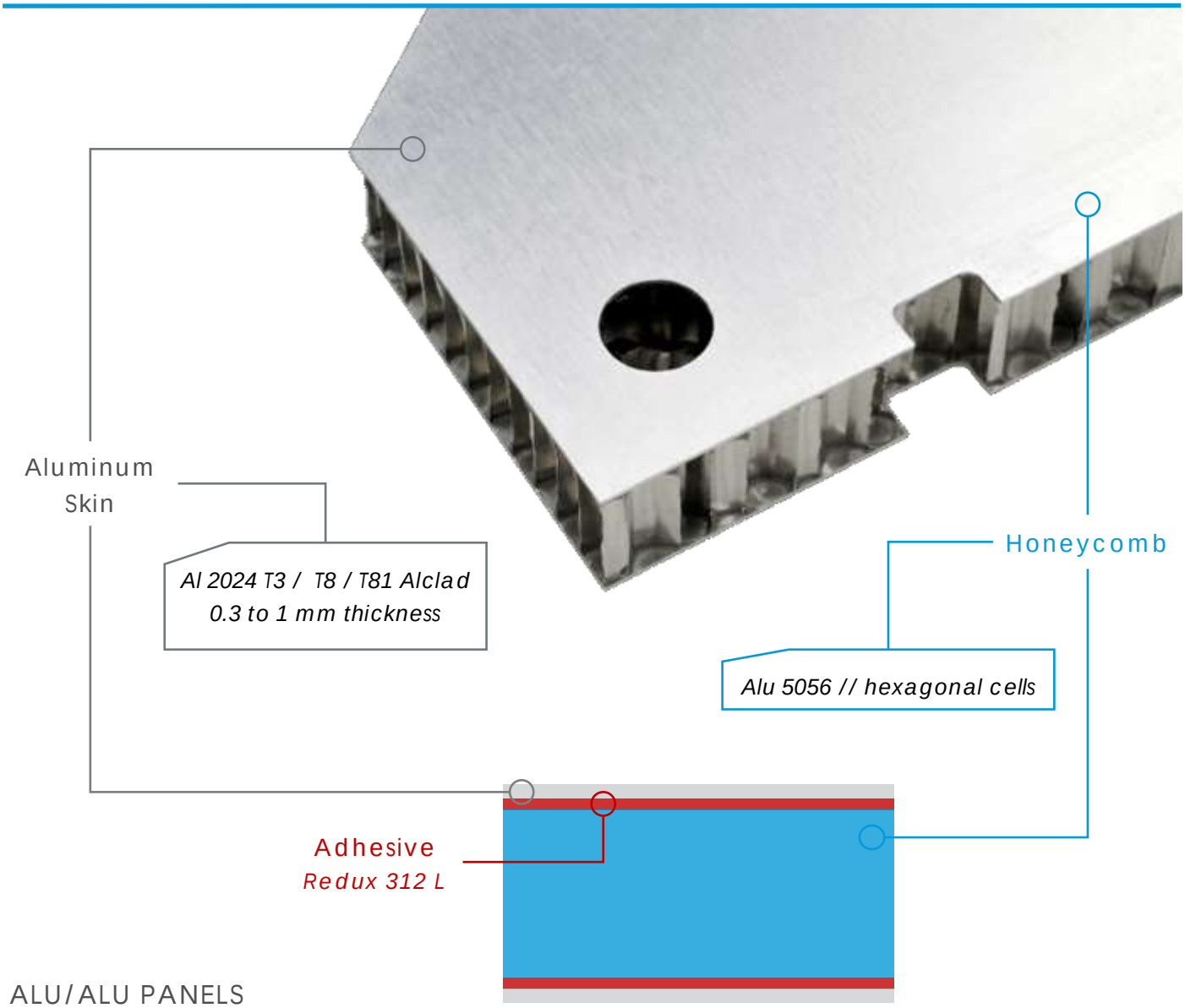


EUI OBS

Technical Characteristics



PANELS ALUMINUM / ALUMINUM



ALU/ALU PANELS

APCO Technologies has been in charge of the manufacturing of several Alu/Alu S/C structures.

Heritage panel dimensions :

- L x W : 770 x 1100 mm to 4650 x 1815 mm (Biomass)
- Thickness : 10 to 100 mm

Aluminum Skin Characteristics

Material	*Thickness (mm)*
Al 2024 T3	0.5
Al 2024 T8	0.4 to 0.5
Al 2024 T81 Alclad	0.3 to 1

Adhesive Used

Product	*Role*
Redux 312 L	Adhesive (skin/HC & skin/skin)
Redux 212 NA	Foaming adhesive (HC/HC)

Honeycomb Characteristics

Material	*Cell Size (in)*	*Sheet Thickness (in)*	*Density (lbs/ft³)*
Alu 5056	1/8	0.001 p	4.5 (72 kg/m³)
	3/16	0.0015 p	4.4 (70 kg/m³)
		0.001 p	3.1 (50 kg/m³)
		0.0007 p	2.0 (32 kg/m³)

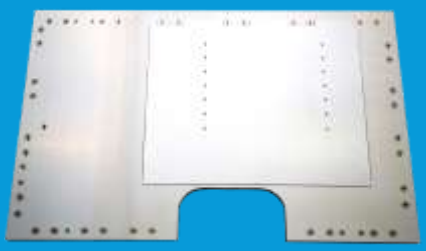
All honeycomb used are compliant with ECSS-E-30-06

HERITAGE

Sentinel-5 Precursor

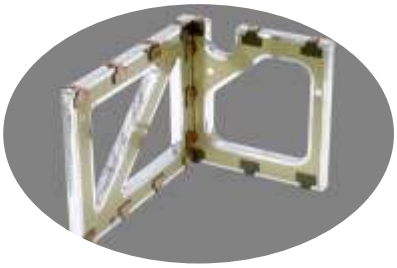
Sentinel-3 SLSTR

MTG

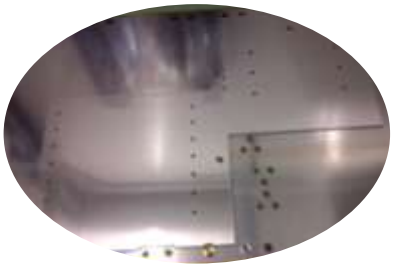


ACES

FUNCTIONNAL APPLICATIONS

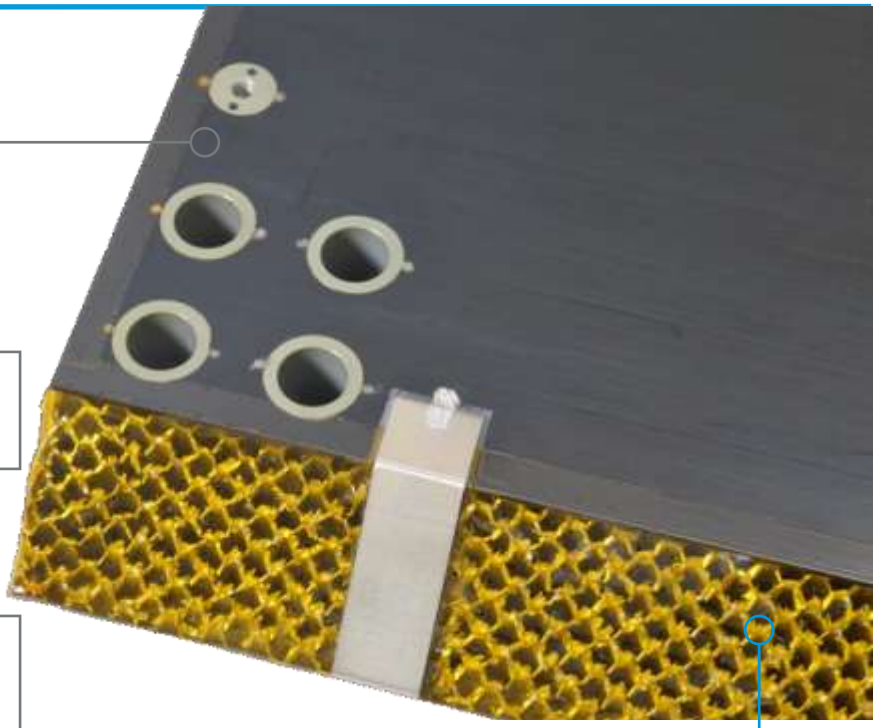


Primary & Secondary Structures



Radiators

PANELS CFRP / ALUMINUM



CFRP/ALU PANELS

APCO Technologies has been in charge of the manufacturing of several CFRP/Alu S/C structures.

Heritage panel dimensions :

- L x W : 600 x 600 mm to 1695 x 1230 mm
- Thickness : 6 to 80 mm

CFRP Skin Characteristics

System	Material	Nbr of Plies	Thickness (mm)
Epoxy	M18 / M55J	6 to 18	0.6 to 2.0
Cyanate Ester	RS-3C / M55J	6 to 12	0.6 to 1.3
	RS-3M / M55J		

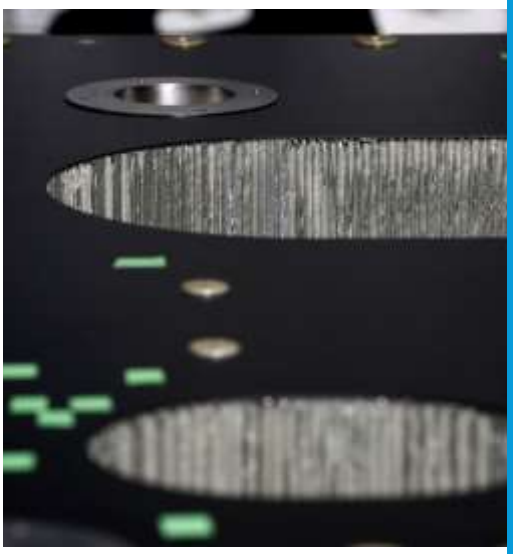
Adhesive Used

Product	Role
Redux 312 L	Adhesive (skin/HC & skin/skin)
Redux 212 NA	Foaming adhesive (HC/HC)

Honeycomb Characteristics

Material	*Cell Size (in)*	*Sheet*	*Density (lbs/ft³)*
Alu 5056	1/8	0.0015	6.1 (98 kg/m³)
		0.001	4.5 (72 kg/m³)
		0.0007	3.1 (50 kg/m³)
	3/16	0.001	3.1 (50 kg/m³)
		0.0007	2.0 (32 kg/m³)

All honeycomb used are compliant with ECSS-E-30-06



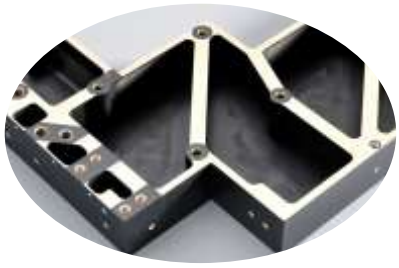
HERITAGE

Sentinel-2 MSI

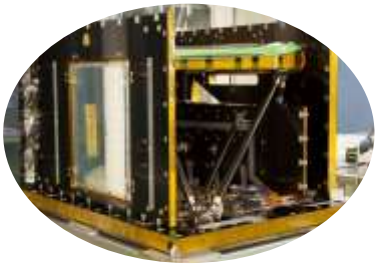
Sentinel-3 OLCI STCA

EUI OBS

FUNCTIONNAL APPLICATIONS

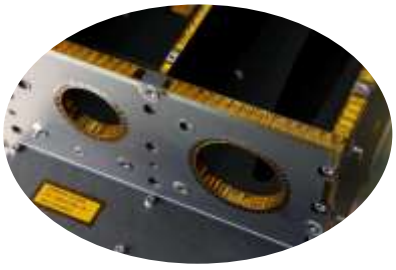


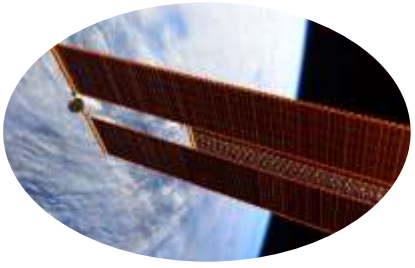
Primary & Secondary Structures



Equipment Housing

Optical / Stable Bench





Solar Array Structure Substrates

PANELS JUNCTIONS, REINFORCEMENTS

JUNCTIONS

Junctions are needed between skins or honeycombs for panels of large dimensions or in the case of structural reinforcements.

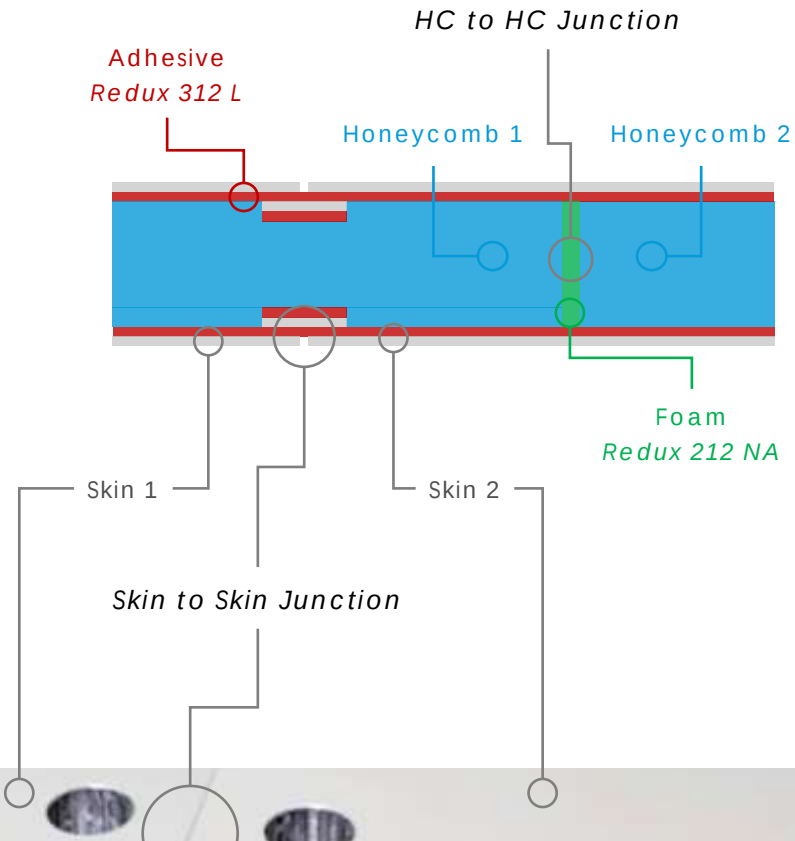
Standard dimensions for blank materials are the following:

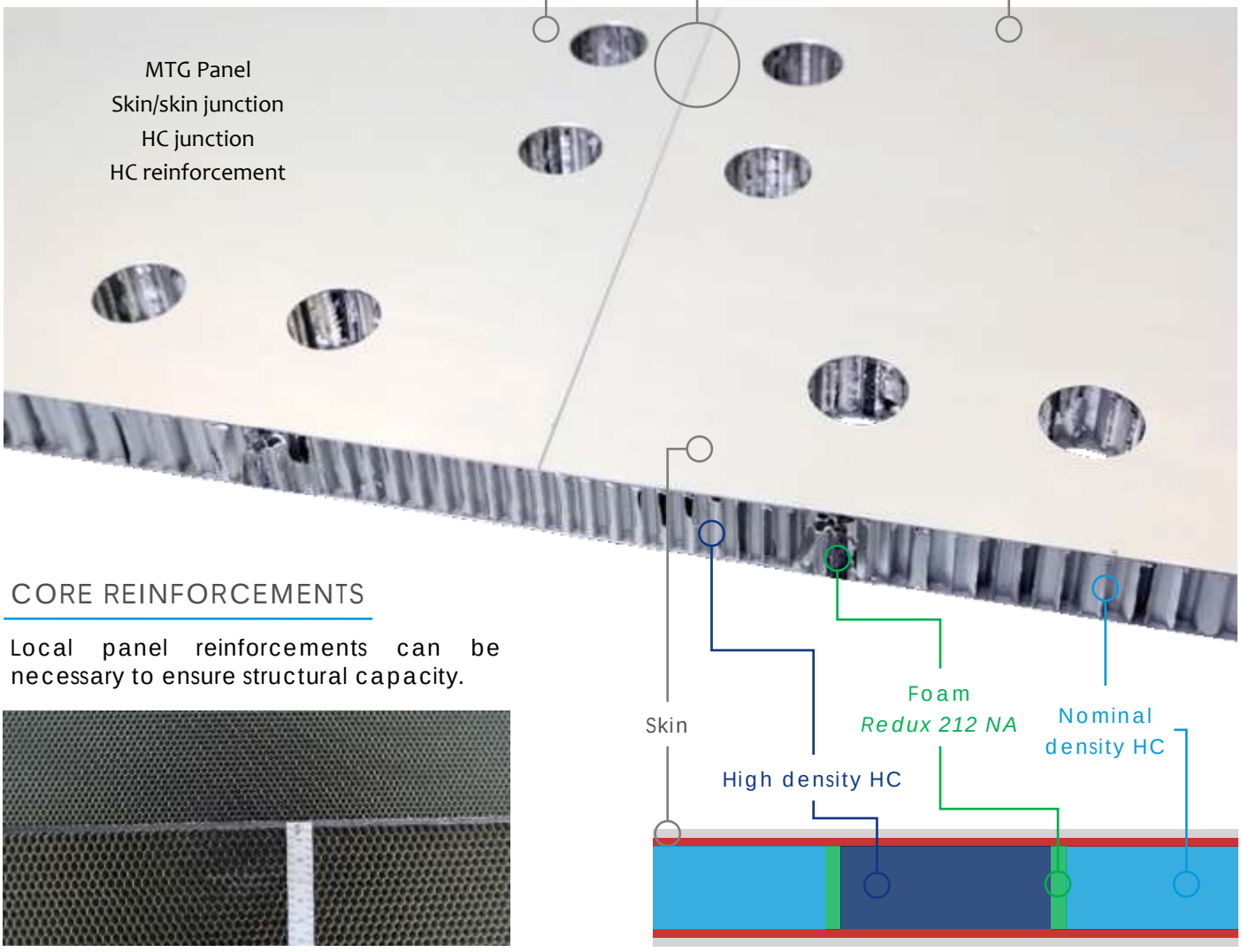
- Aluminum skin: 1219 x 2700 mm
- Honeycomb: 1220 x 2300 mm

CFRP skins being tailor-made, they are less subjects to junction.

Honeycomb bonding is ensured by foam Redux 212 NA.

X-rays inspections are later performed on foam lines to ensure correct adhesion.

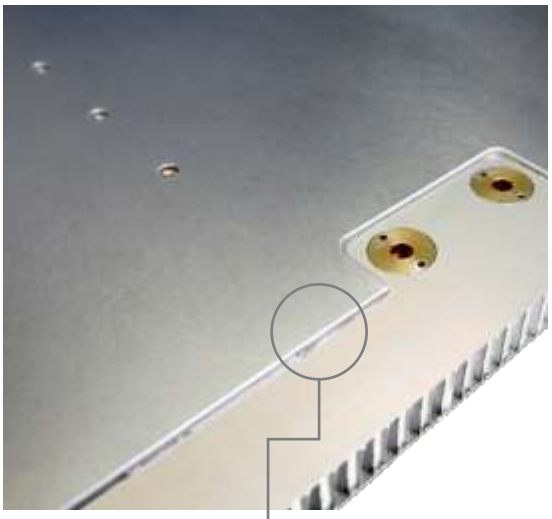




CORE REINFORCEMENTS

Local panel reinforcements can be necessary to ensure structural capacity.

PANELS DOUBLERS



External Doubler

DOUBLERS

Doublers are extra skin sheets bonded with the nominal skin in case a local structural reinforcement is needed or for thermal purposes.

Doublers can be:

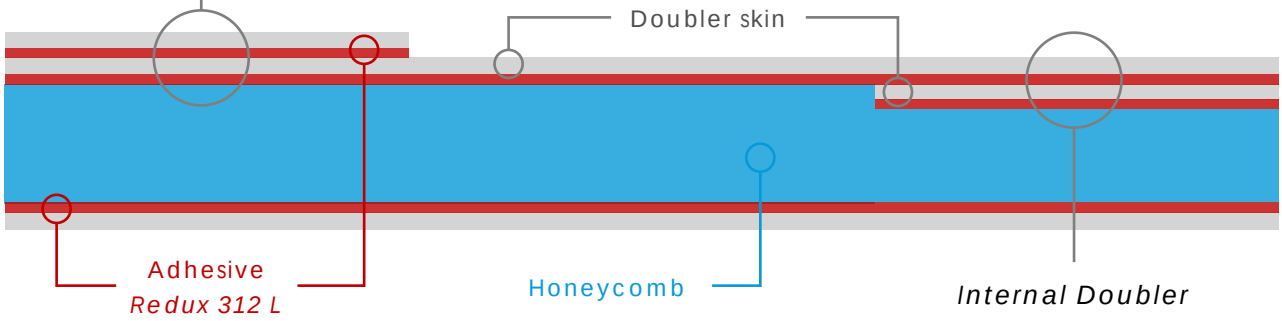
- External (thermal or structural)
- Internal (structural)

External doublers are usually selected as first choice because their installation is less complex. However APCO Technologies is qualified for and has heritage with the application of internal doublers.

Doublers are checked by ultrasound controls.

Materials Used

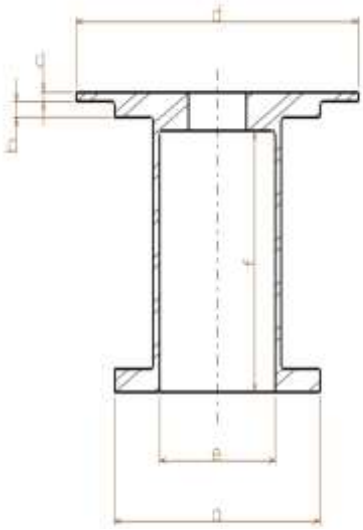
Doublers Material (Alu/Alu)		*Doublers Material (CFRP/Alu)*	*Adhesive*
Structural	Thermal	Structural	
Al 2024 T81	Al 1050	M18 / M55J	Redux 312 L



Sentinel - 5 P Panel
External thermal doubler

Sentinel - 2 MSI Structure - External structural doubler

INSERTS COLD-BONDED



Bobbin and collar insert geometrical parameters

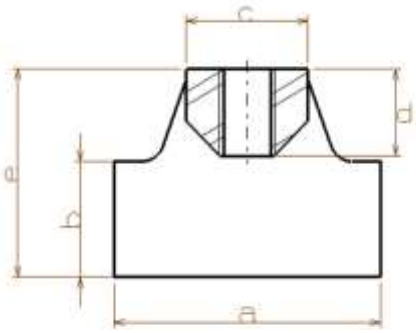
Materials Used

Insert Material	*Surface Finish*	*Potting Adhesive*	*Collar Adhesive*
Al 7075 T7351 / Al 6063 T6 / Titanium (special)	Alodine / BR127 / Black anodizing (Al 6063 T6)	STYCAST 1090 CAT.9	HYSOL EA 9321

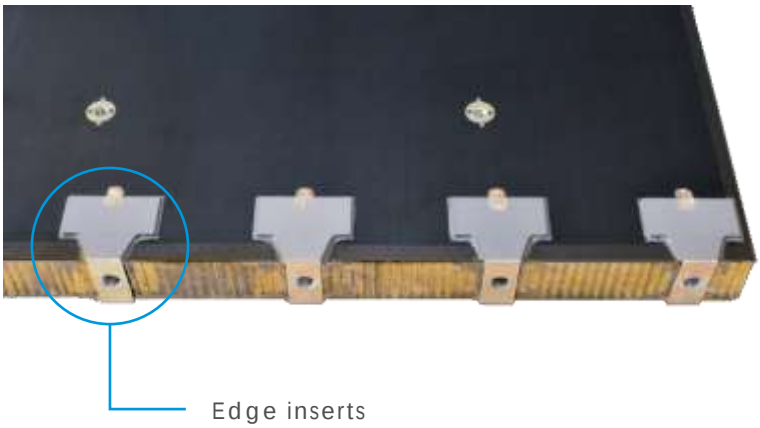
Cold-Bonded Inserts Characteristics

Type	*Blind / Through*	*Panel Thickness*	*Heritage*	*Dimensions*			
				a (diameter)	b	c, d *	e, f **
Bobbin	Blind	8	EUI OBS	11	1.5	-	-
		13	ACES	14	2	-	-
		12		11	15	-	-
		12		17.5	2	-	-
		12	MTG	14	1.5	-	-
	Through	98	Sentinel-5 P	22	3	-	-
		98		25	4	-	-
		40		22	3	-	-
		30		22	3	-	-
		30		27	3		14, 11
		50	ACES	17.5	2		10, 36
		6.2	EUI	11	1.5		
		20	MTG	17.5	1.5		
		20		22	1.5		13, 15.7
		20		26	1.5		17, 15.2
Collar		15	Sentinel-3 SLSTR	17	0.8	0.5, 23	9.9, 7.5

INSERTS COLD-BONDED

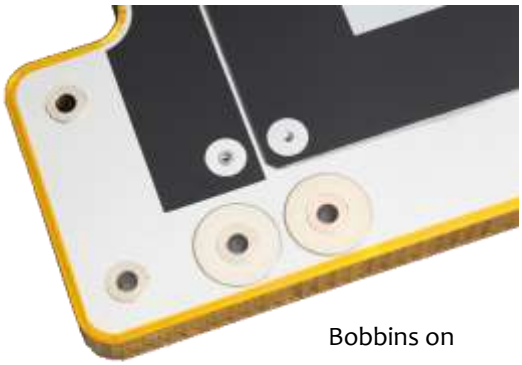


Edge Insert geometrical parameters

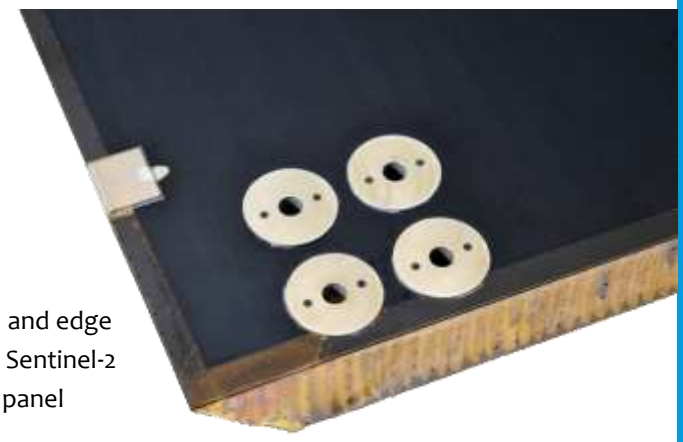


Cold-Bonded Inserts Characteristics

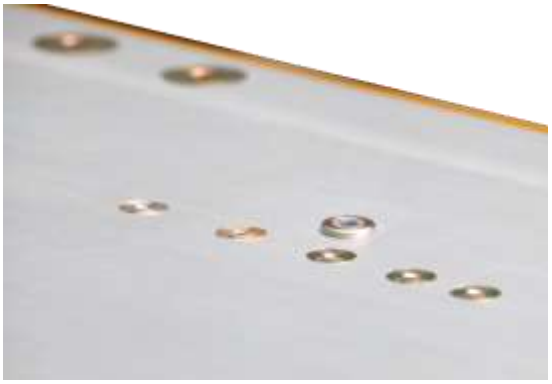
Type	*Panel Thickness*	*Heritage*	*Flange Thickness*	*Dimensions*				
				a	*b*	*c*	*d*	*e*
Edge Type 1 (In plane connec-tion)	15	Sentinel-3	1.6	24	10	10	7	19
	25	Sentinel-3	2	25	15	12	8	24
	30	Sentinel-2	1.6	40	20	15	10.9	33.9



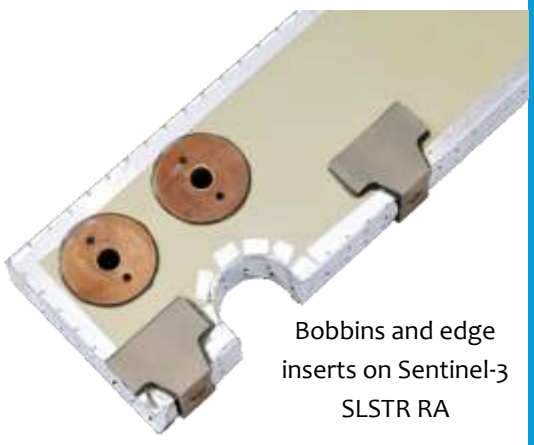
Bobbins on Sentinel-5 P panel



Bobbins and edge insert on Sentinel-2 MSI panel



Flat and counterbore bobbins on MTG panel



Bobbins and edge inserts on Sentinel-3 SLSTR RA

INSERTS HOT-BONDED & SPECIAL

Hot-bonded inserts on Sentinel-5 P

HOT-BONDED INSERTS

Unlike cold-bonded inserts which are added to the raw panel after curing and machining, hot-bonded inserts are embedded in the panel assembly before curing.

Hot-bonded inserts come in all forms, dimensions and fonctions.

Foot insert on Sentinel-2 MSI

Hot-Bonded Inserts Characteristics

Type	*Blind / Through*	*Insert Material*	*Panel Thickness (mm)*
Edge or cylindrical	Through	Al 7075 T7351 / TA6V /	8.8 to 38

Special cold-bonded Titanium edge Inserts on ATLID

INSERTS HOT-BONDED & SPECIAL

Hot-bonded edge inserts on EUI OBS

Several inserts on EUI OBS

Foot Insert on EUI OBS

SADM Insert on MTG Panel

HEAT PIPES

THERMAL CONTROL SYSTEMS

In the vacuum of space, control of heat exchanges on a satellite is complex and vital. Several methods and technologies are used in combination to increase or reduce heat fluxes and transfer heat from an area to another one.

APCO Technologies has already justified on spacecraft structures the following:

- Heat pipes
- Thermal coating
- Multilayer Insulation System (MLI)
- Reflective surfaces

Embedded heat pipes mounting

Above : Heat pipes on Sentinel-3 OLCI

HEAT PIPES

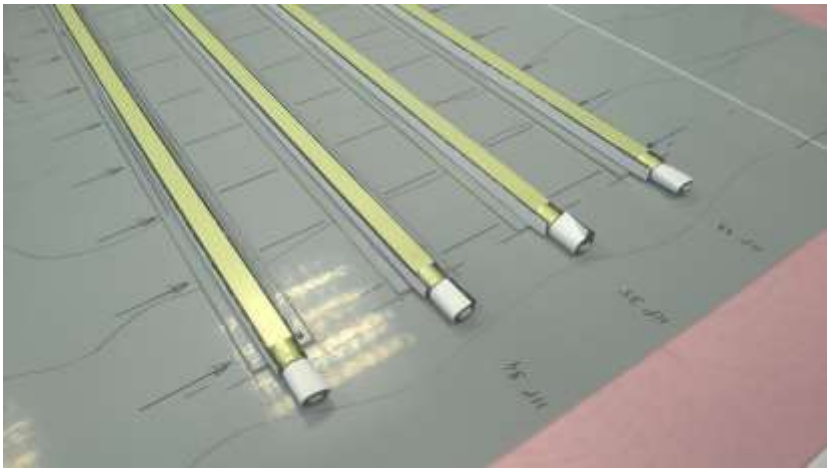
Heat pipes are two-phase heat transfer devices that transport heat from one place to another without electrical power.

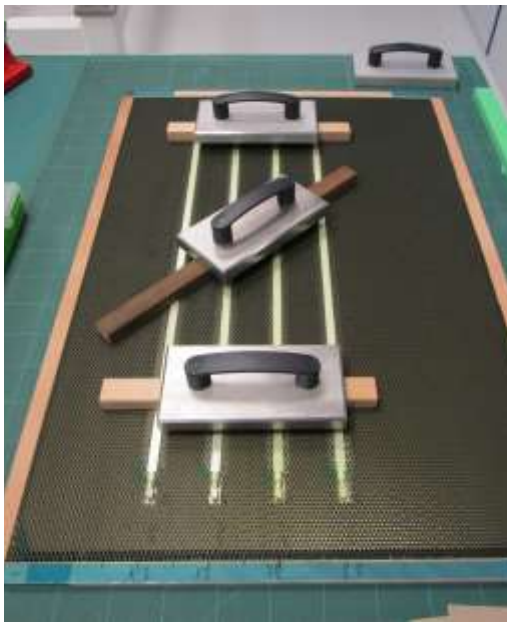
After definition and procurement of heat pipes, we integrate them in the flight hardware. They can be :

- Surface mounted
- Embedded on the honeycomb (hot-bonded)
- Loose

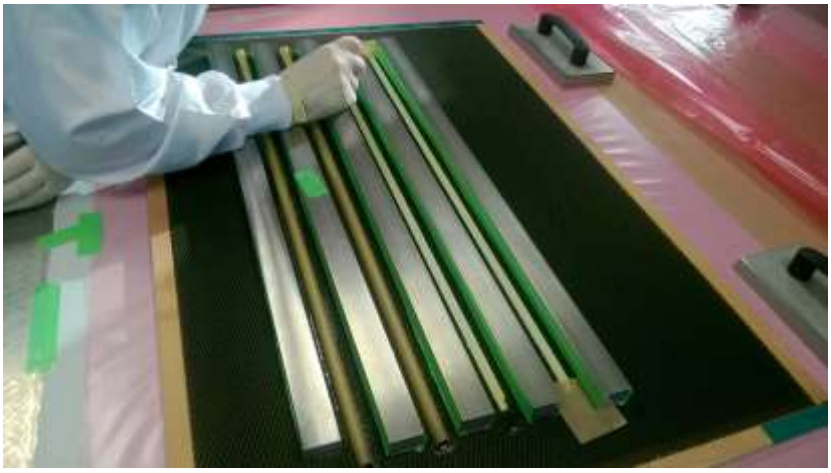
We also have the capability to assemble heat pipes together (internal / external).

Under: Embedded and surfaced heat pipes on ACES





Embedded Heat Pipes Mounting



Above: Heat pipes on EUI OBS

On the left: Surface and loose heat pipes on Sentinel-3 SLSTR

FINISHING

SURFACE FINISHING

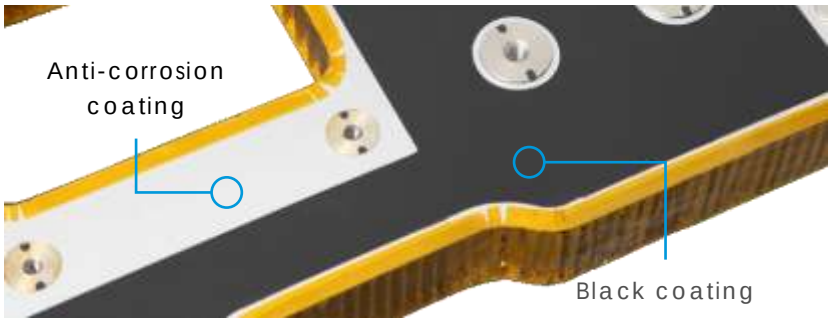
To help regulate heat transfer, surfaces can be painted with thermal coating to reach emissivity and absorptivity requirements.

Besides, aluminum surfaces are protected against corrosion. External surfaces are coated with SurTec 650 (in replacement to Alodine 1200) and internal skin surfaces currently with BR127.

APCO Technologies is able to define coating requirements.

Treatments Used

Thermal Coating	*Anti-corrosion*
MAP PUK MAP PU1 MAP PCBE	Alodine 1200 SurTec 650



MULTI-LAYER INSULATION

MLI (Multi-Layer Insulation) protects the S/C from extreme temperatures when exposed to the sun, deep space or even from its own propulsion system.

APCO Technologies is able to deliver structures equipped with MLI including stand-offs and electrical grounding.

MIRRORS AND REFLECTORS

Mirrors simultaneously reflects solar radiation and rejects internal heat. SSM (Secondary Surface Mirror) are made of flexible plastic sheets whereas OSR (Optical Solar Reflector) are made of glass and retain their performances longer.

APCO Technologies can deliver panels equipped with both OSR and SSM.

Above : SSM on Sentinel-3 SLSTR RA

On the left : OSRs on Sentinel-3 OLCI

ACHIEVEMENTS & QUALIFICATIONS

ZIP-EDGE

Zip-Edge is a innovative concept developed by APCO Technologies As its name implies, it allows simple and fast assembly of two panels together through cold-bonded edge inserts. It also can be used to create hinges, providing internal structure access and flexibility.

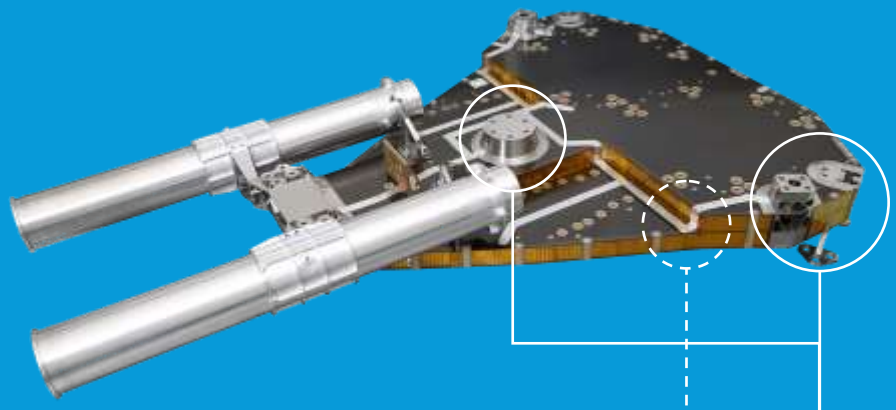
SOLAR PANELS SUBSTRATES

Solar panels are made of CFRP (M55J/RS3) / aluminum sandwich panels equipped with Solar Cell Assemblies.

To ensure electrical insulation between the cells and the conductive carbon substrate a top layer of polyamide is accommodated.

SAT AIS is the project that gave us the opportunity to develop solar panels substrates technology.


Juno solar panels, source: NASA/JPL - Caltech//KSC



DOUBLE SANDWICH & SPECIAL INSERTS

On EartCARE ATLID Stable Structure Assembly (SSA), APCO Techonologies has been in charge of the full design, analysis, manufacturing supervision, integration and testing of the structure and thermal sub-system, used to support the optical, electronic and thermal hardware, and to ensure its stability and its uncoupling of the distortions of the ATLID I/F panel.

There are two major technical achievements on this project, the "double-deck" panel and the design and bonding of special titanium inserts (see p20).

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