Solar Arrays for long-duration missions in LEO orbit. A new approach to the market

25-27th April 2023

Tech Park of Andalusia
Severo Ochoa 13 – 29590 Malaga (SPAIN)

COMPANY OVERVIEW

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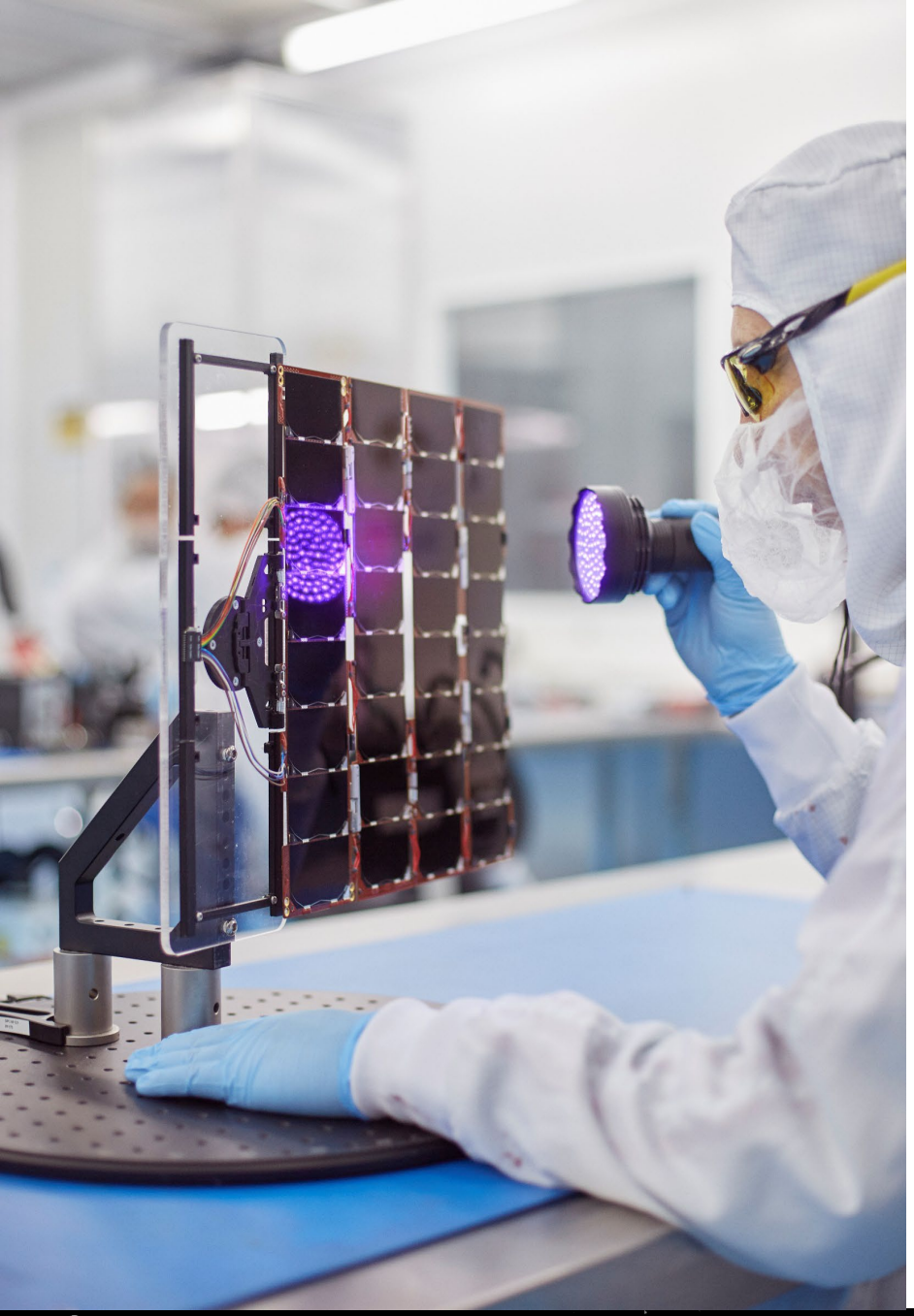

WHO WE ARE

DHV Technology is a Spain based international company that **designs and manufactures solar panels and other power subsystems for space applications**

DHV Technology supplies solar panels and fully customized solutions for the main international companies in the space sector.

Our facilities, with a total of **3700 m²**, consist of:

+ 1200 m² clean room
+ 1000 m² offices
+ 1500 m² warehouse and others

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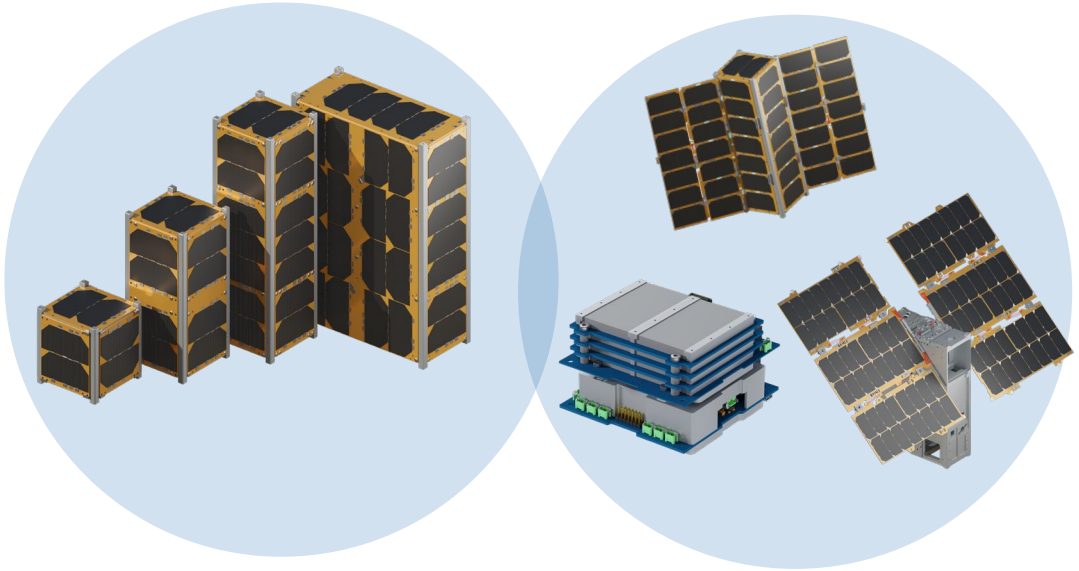
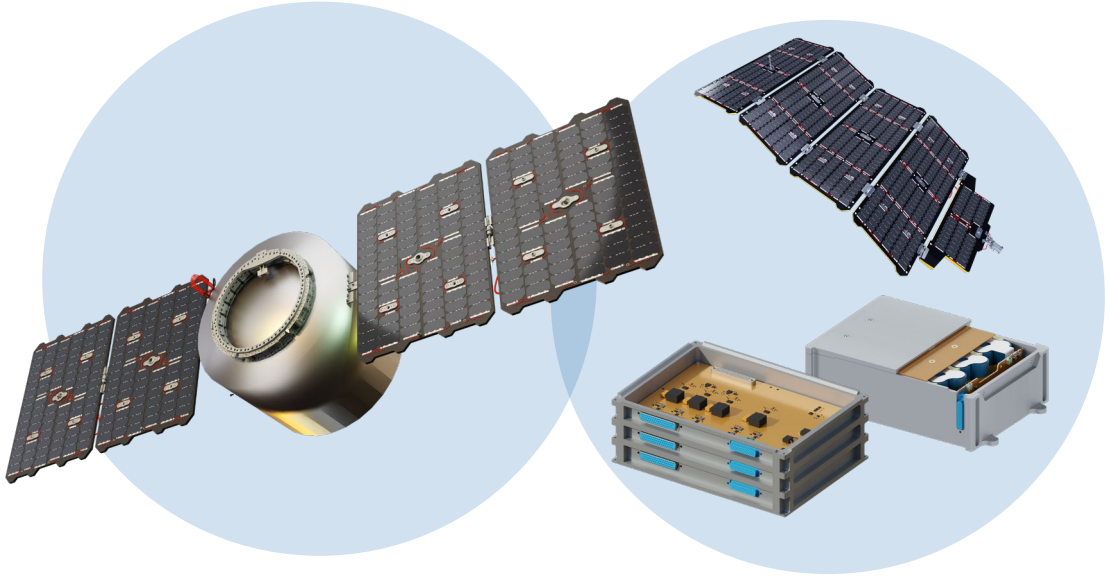
WHAT WE DO

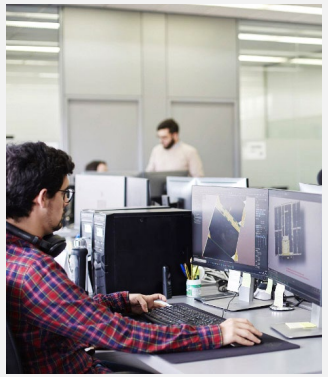
POWER SOLUTIONS FOR CUBESATS

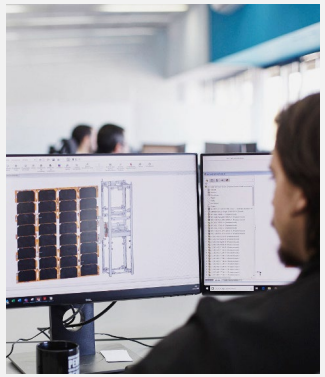


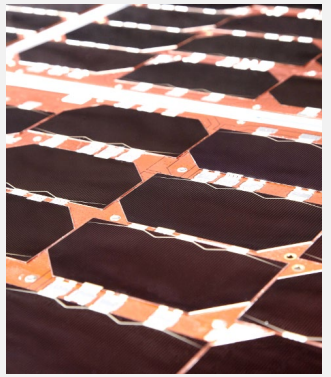
POWER SOLUTIONS FOR SMALLSATS



- Designing customized products
- Constellation projects manufacturing
- Solar panels for SmallSats and CubeSats
- Deployable solutions







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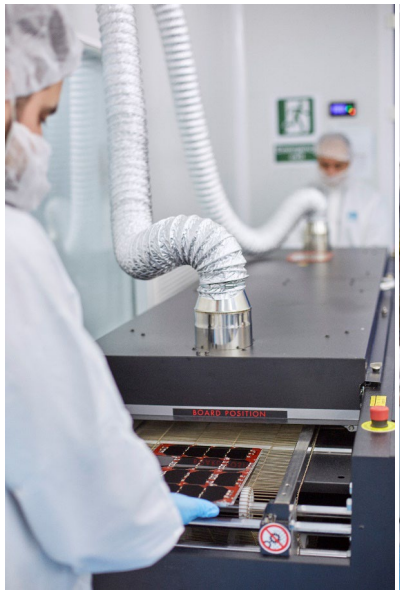
HERITAGE

250+
PROJECTS
CARRIED OUT

3000+
ACCUMULATED
DAYS IN ORBIT

200+
SATELLITES FLYING
WITH OUR SOLUTIONS



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SOLAR ARRAYS

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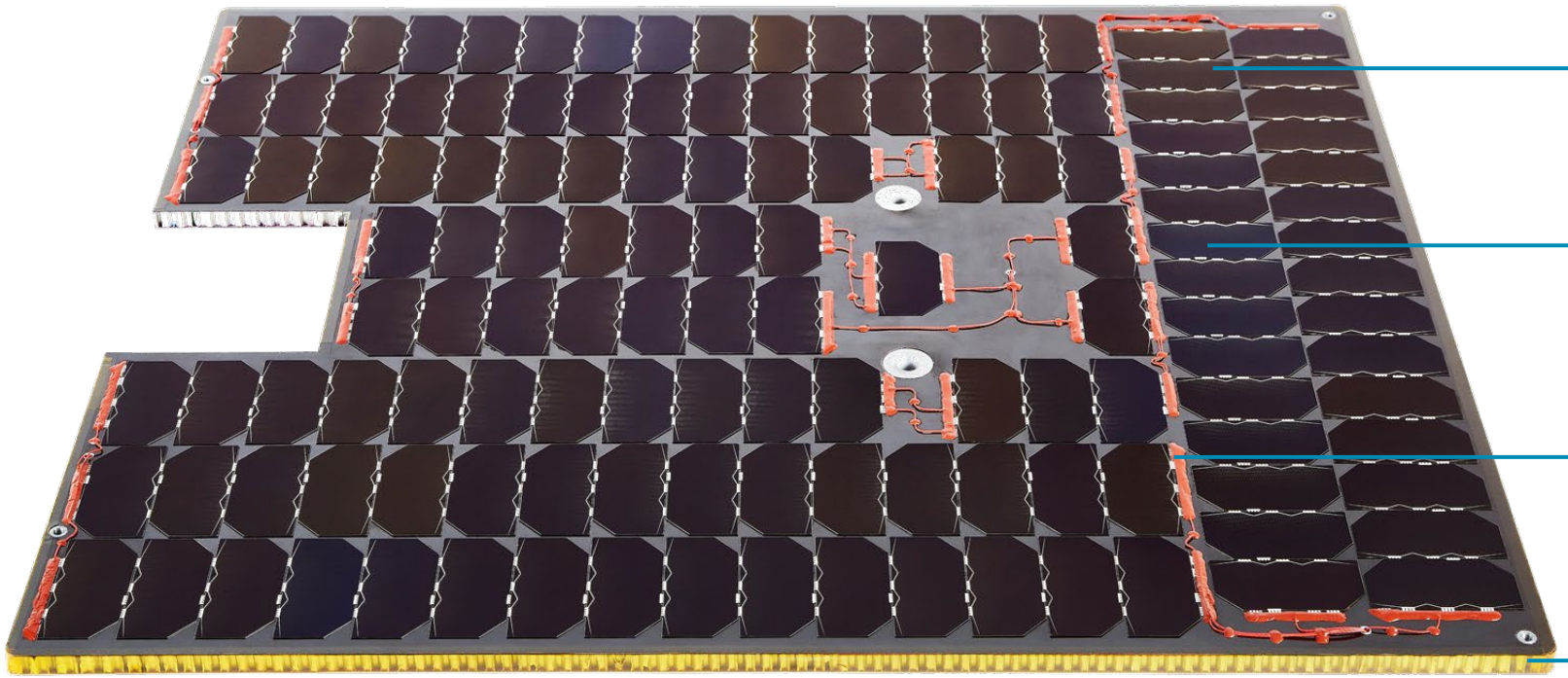
SOLAR PANELS

Typical construction



Qualified solar cells
Multi-junction cells with 30% nominal efficiency and integrated bypass diodes

Laydown design
Design the most efficient configuration to provide the maximum power

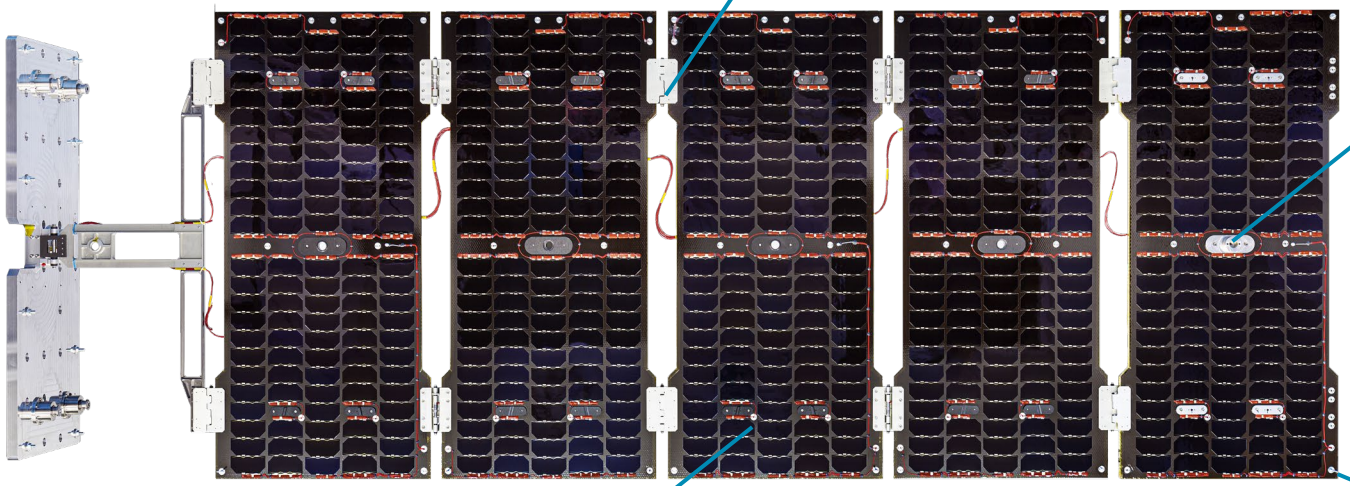
ATOX protection for LEO
Welded connections protected with silicone.

Space qualified substrates
Customized substrate with different configurations

SOLAR PANELS

Deployables

Mechanisms design
Customized hinges are designed with different opening angles, configurable torsion springs, and latching systems.



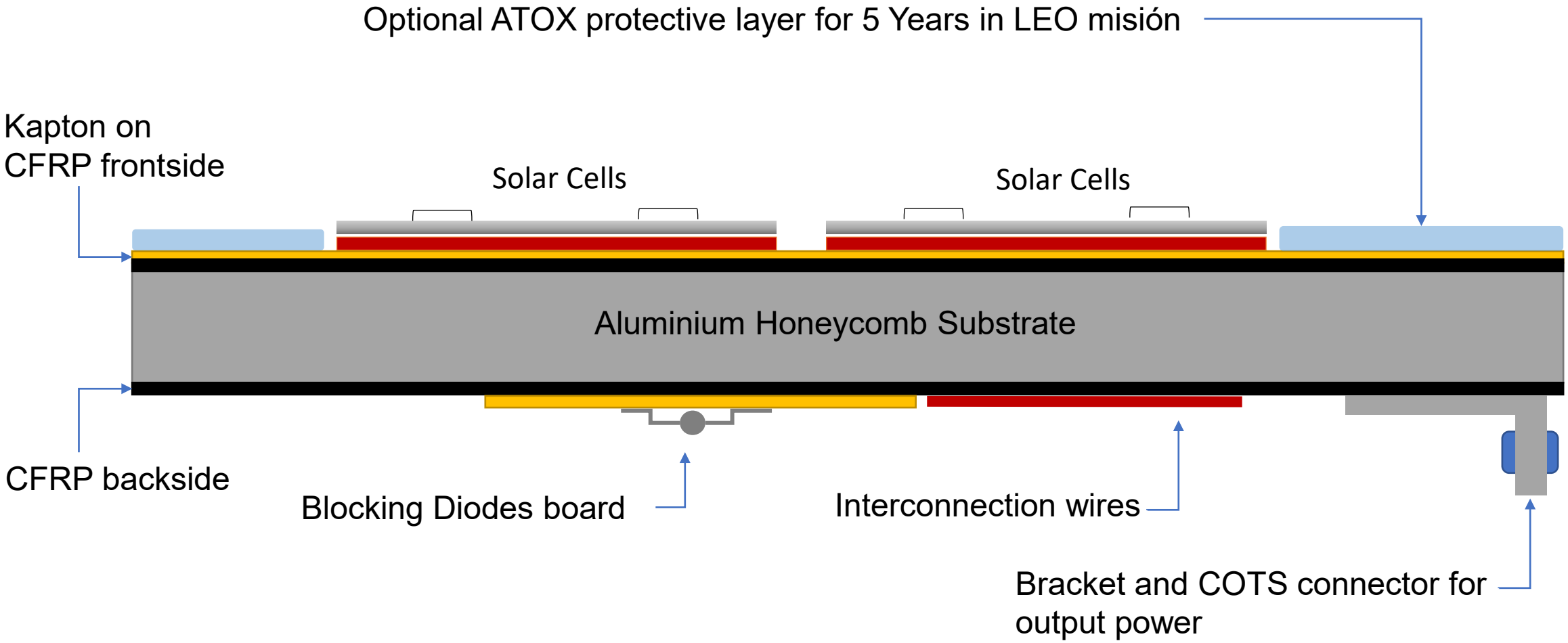
Deployment mechanism integration
HDRM integration and customized yoke design

High-performance electrical wiring
Space-qualified cables in compliance with ESCC standards.

Inserts integration
Additional integration of inserts for wiring and protection covers

SOLAR PANELS

Stack-up



SOLAR PANELS

Product Tree: Materials, process and components

- **Substrate**
  - Kapton 50 microns
  - Film Adhesive
  - CFRP lay-up 6 layers
  - Al honeycomb core
- **Mech. Elements**
  - Snubbers (Al or Ti)
  - Blind or Through-all Inserts (Al or Ti)
  - Hinges bodies (Al)
  - Helicoils (SS A2 or CuSn6) Free Running/Blocking
- **Welding, Bonding and interconnection**
  - Cells bonding: RTV Silicones
  - Cells strings: Welding
  - Wire/busbars to cells: Welding
  - Encapsulation: RTV Silicones
- **Electrical Elements**
  - MIL-PRF-19500 blocking diodes
  - Temperature sensor: Thin films Pt RTD
  - Silver plated Kovar alloy for busbars
- **Adhesives**
  - Controlled volatility Silicones
  - RTV Silicones
  - Electrically conductive adhesives
  - Thermally conductive adhesives

SOLAR PANELS Qualification status

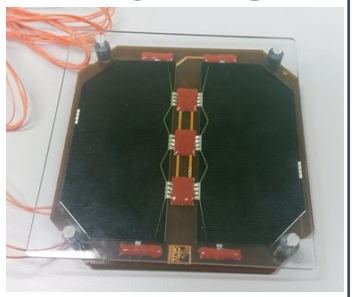
Cubesat 1U body mounted

Fatigue Thermal Cycling

-113/149 ºC

0,5 bar

7350 cycles



Technology:

Soldered interconnections

PCB substrates with Kapton coverlay.

NUSIL double side as solar cells adhesive and RTV encapsulant.

SMT JANTX blocking diodes

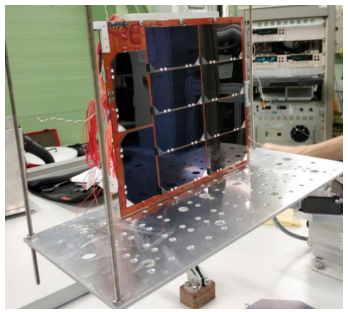
Cubesat 12 U deployable

Fatigue Thermal Cycling

-100/125 ºC

0,5 bar

15000 cycles



Technology:

Welding for strings interconnections

PCB substrates with kapton coverlay.

RTV silicone as solar cells adhesive and encapsulant.

SMT JANTX blocking diodes

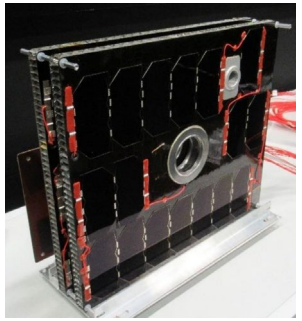
Smallsat

Fatigue Thermal Cycling

-108/112 ºC

0,5 bar

38000 cycles



Technology:

Welding for strings interconnections

CFRP-Al honeycomb substrates with kapton coverlay.

RTV silicone as solar cells adhesive and encapsulant.

Axial leads JANTX blocking diodes on kapton diode boards

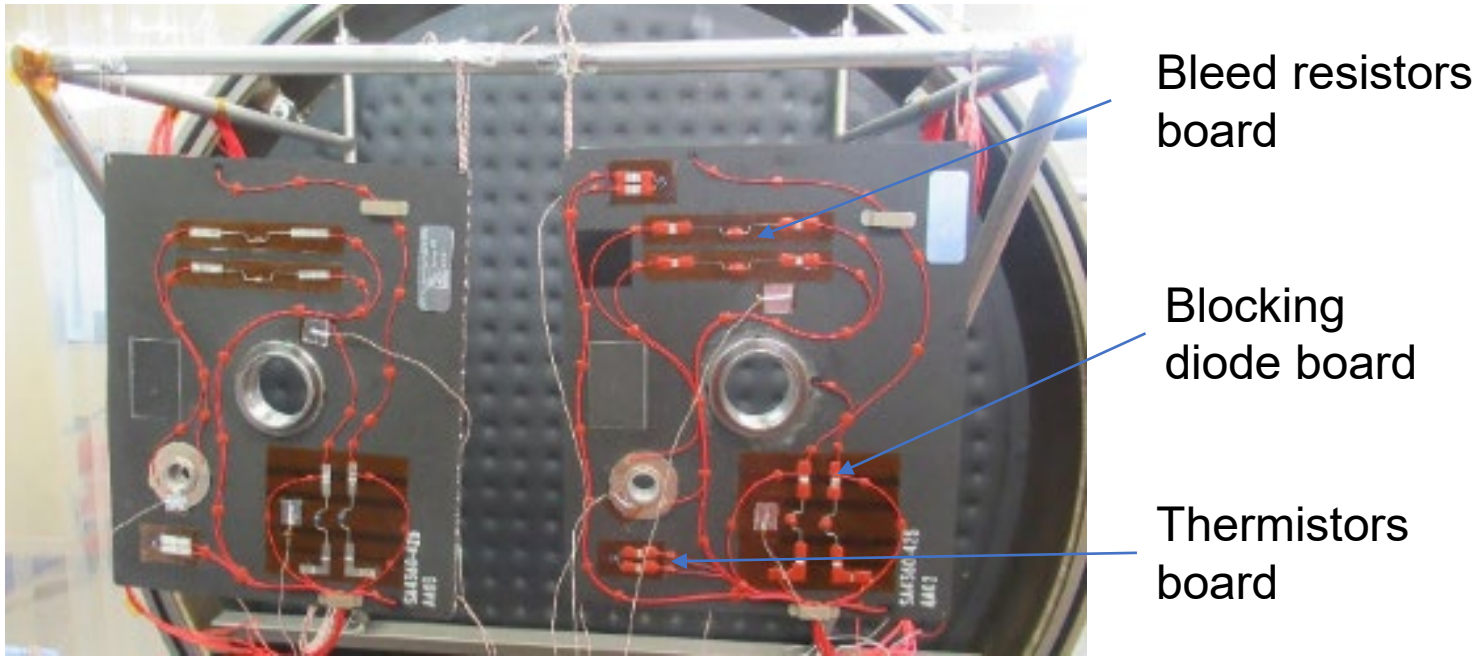
SOLAR PANELS

Qualification status

DVT Coupon. More than 38.000 thermal cycles

Sequence:

- Bakeout 24h at **+125ºC**
- TVAC 10 cycles, **-142ºC to +157ºC**
- APTC 37980 cycles, **-108ºC to +112ºC**
- TVAC 10 cycles**, -142ºC to +157ºC**



- This test was successfully passed in Q4 2022.

SOLAR PANELS

Qualification status

DVT Coupon. Tests

- **Between Blocks**
  - Visual Inspection
  - Electroluminescence Test
  - Illumination Test (I-V Curve at AM0)
  - Grounding Test
  - Thermistor measurement
  - Insulation Test (500 V, 100Mohms)
- **TVAC (Thermal Vacuum Cycling)**
  - Insulation test DVT-1 (first and last cycle)
  - Insulation test DVT-2 (second and ninth cycle)
  - Thermistor measurement (higher temperature, lower temperature, and transitions)
- **APTC (Atmospheric Pressure Thermal Cycling)**
  - Forward continuity check (both DVTs first and last day of the block)
  - Reverse continuity check (both DVTs second and penultimate day of the block)
  - Thermistor measurement (higher temperature, lower temperature, and transitions)

Test	Date	Δpmax (%)	ΔIpm (%)	ΔVpm (%)	ΔVoc (%)	ΔIsc (%)	ΔFF (%)
Reference	21/04/2021	0,00	0,00	0,00	0,00	0,00	0,00
Test 2	21/04/2021	0,00	0,00	0,00	0,00	0,00	0,00
Test 3	10/05/2021	0,39	-0,38	0,90	0,36	-0,57	0,59
Test 4	17/06/2021	-0,71	-1,44	0,67	0,44	-1,35	0,18
Test 5	28/07/2021	1,75	0,23	1,44	0,99	-0,40	1,10
Test 6	13/09/2021	0,89	0,05	0,81	0,17	-0,14	0,84
Test 7	13/09/2021	-1,67	-2,55	0,88	0,54	-2,57	0,37
Test 7b	19/01/2022	-0,34	-1,15	0,79	0,40	-1,70	0,97
Test 7d	28/01/2022	0,98	-0,12	1,08	0,51	-1,68	2,17
Test 8	19/07/2022	-0,45	-0,90	0,43	-0,24	-0,47	0,24
Test 9	10/11/2022	0,58	-0,34	0,90	0,48	0,45	-0,36
Test 10	21/12/2022	1,23	-0,60	1,82	0,72	-0,50	1,00

Table 19. Electrical Performance Parameters Deviation DVT-1 String 9

SOLAR PANELS

Qualification status

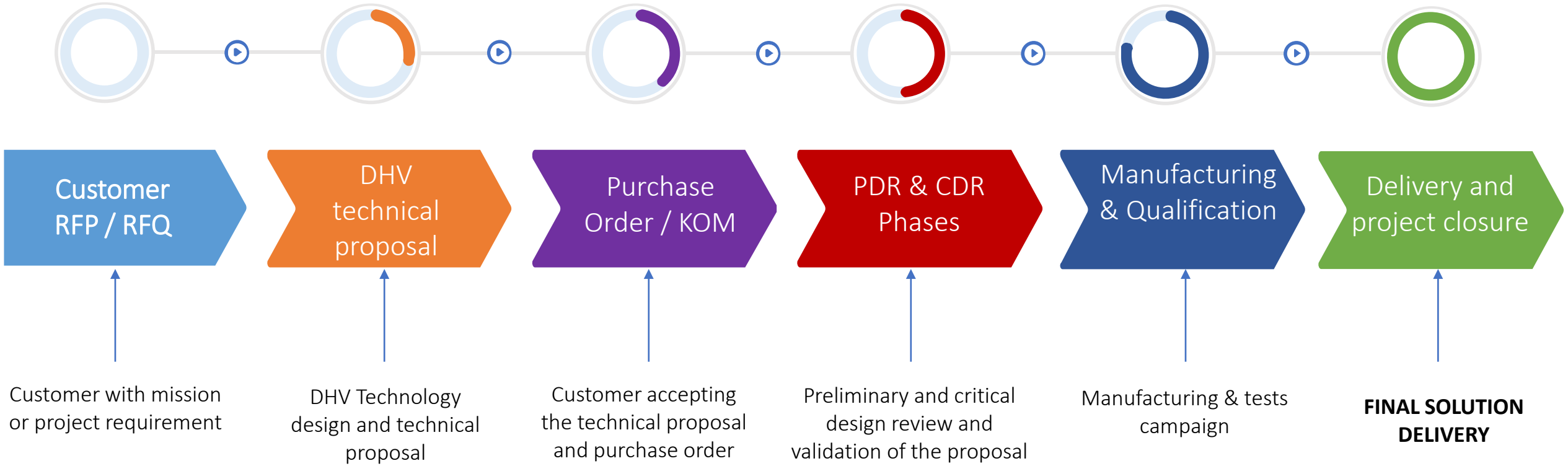
DVT Coupon. More than 38.000 thermal cycles

Results:

- Electroluminescence tests: No anomalies found.
- DVT-1 presents a degradation of 4% in power. Identified in a single cell and kept during cycles and stable.
- Epoxy adhesives were initially chosen to attach resistors. At 2800 cycles, the bleeding resistor was found broken. Decided to replace it with a silicone CV type.
- Blocking diodes performance nominal under entire cycling.
- ATOX layer on Kapton: Visual inspection OK.

DHV PROJECTS APPROACH

The projects carried out by DHV Technology usually follow this workflow:



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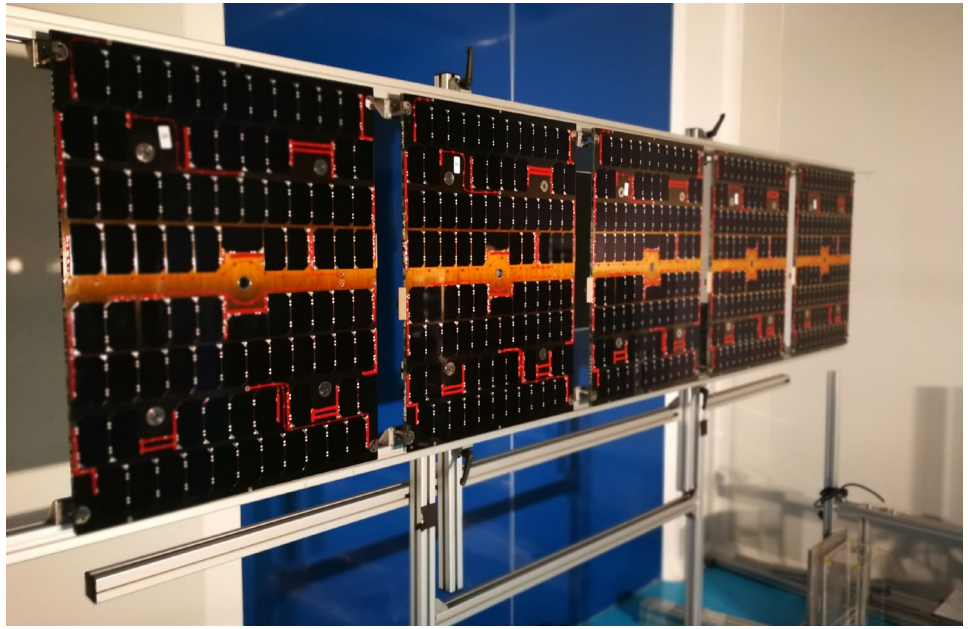
TESTING

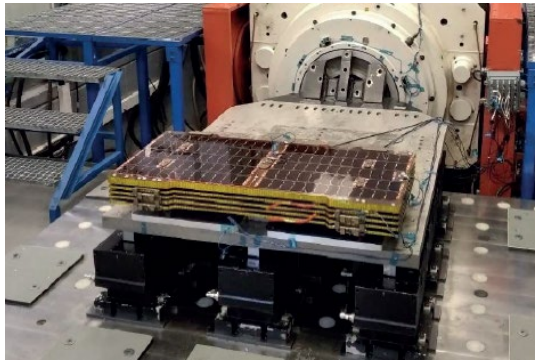
Test campaigns cover tests such as:

+ Random vibration tests (levels according to requirements)
+ Sinusoidal vibration tests
+ TVAC (vacuum chambers)
+ Functional and deployment tests (0g GSE)



Additional tests:

+ Thermal Shock tests
+ Acoustic tests
+ Radiation tests
+ Humidity tests



SEMI-AUTOMATIC LINE

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Factory automation Solar cells inspection

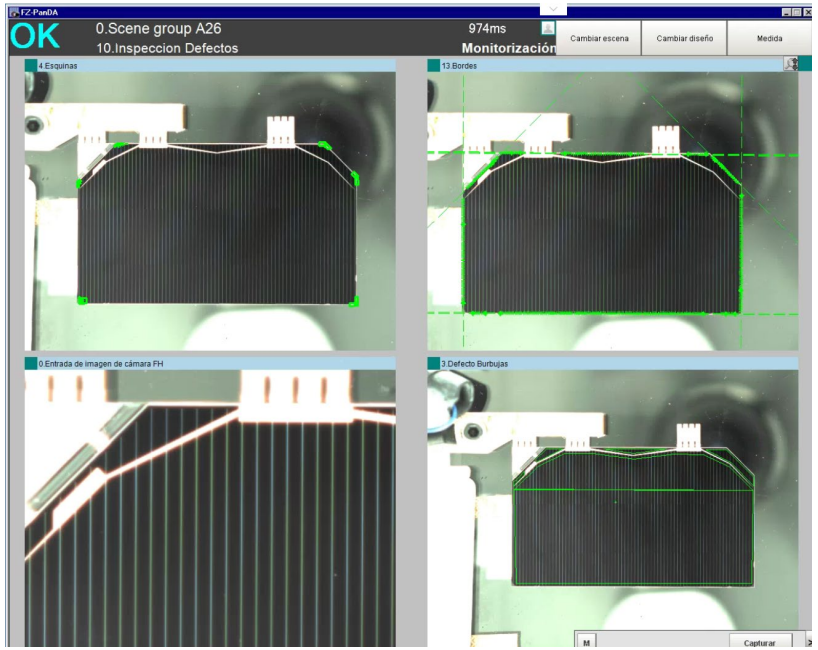
Latest inspection and handling technology:

- Scara Robot
- 3 Artificial Vision Cameras
- Position correction through cameras.
- Traceability system

Inspection capacity of 200,000 cells per year.
Four different cell types.

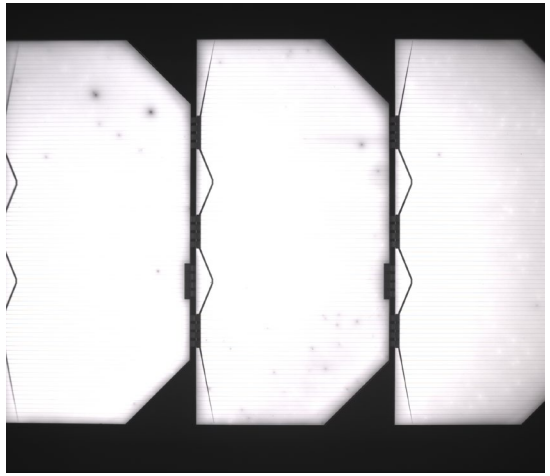
With over 30,000 inspected cells, 0% breakage during manipulation.

Identification of defects through physical inspection and Electroluminescence testing



Factory automation Solar cells strings welding

- 6 servo-drive systems with a precision of 0.01 mm.
- 4 artificial vision cameras.
- Traceability system.
- Capacity for strings of up to 32 cells in series.
- Capacity of 120,000 cells per year. 250 cells per shift.
- Identification of cells defects using electroluminescence



DHV Technology

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