

# Solar Panels for Cubesat Missions

2019 CubeSat Developers Workshop

April 23, 2019



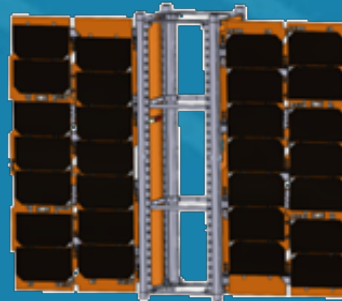
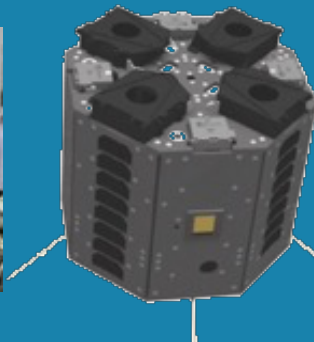
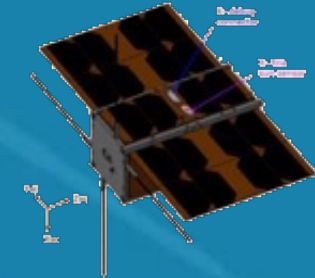
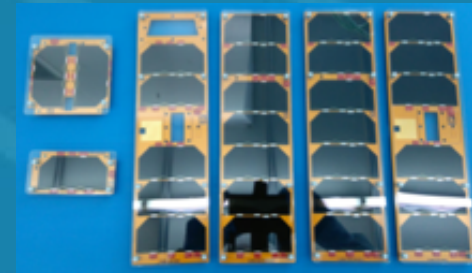
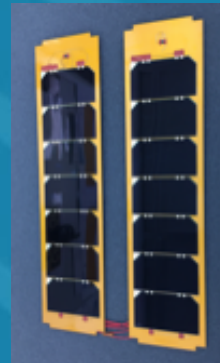
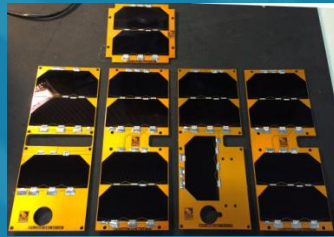
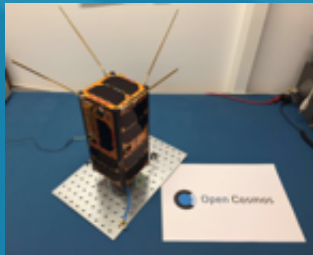
# Outline presentation

- **Company description**
- **Solar panels for CubeSat missions**



# Company description

# Technological based start-up Space photovoltaic technology



# Management Board & Founders



**Miguel A. Vazquez**

PhD on Physics University of Sevilla. More than 20 years of professional experience: University of Sevilla, Isofoton



**Vicente Diaz**

PhD on Physics Polytechnic University of Madrid. More than 25 years of professional experience: Indra, University Carlos III Madrid, Isofoton



**Francisco Rubiño**

Industrial Engineer and MBA. Over 27 years of Executive positions, operations and general management: Schott, Isofoton, Flex, Ence

# Technical Staff

- **Electronic Engineers**
- **Chemical Engineers**
- **Telecommunication Engineers**
- **Mechanical Engineers**
- **Physicists**
- **Aeronautic Engineers**

**Current employees: 25**

# Markets

- **LEO constellations**
- **LEO deployable, body mounted CubeSats**
- **Deep Space mission (Moon, Mars, asteroids research missions)**
- **GEO scientific missions**

# Markets



*SpaceWorks 2018*



# Facilities

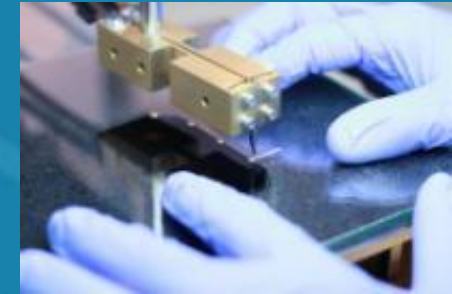
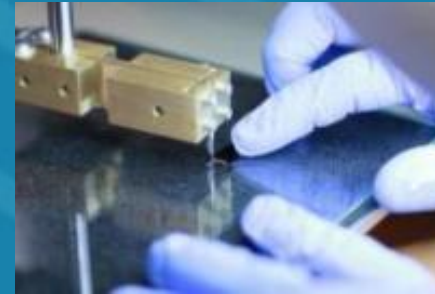
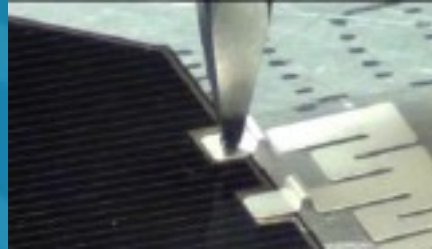
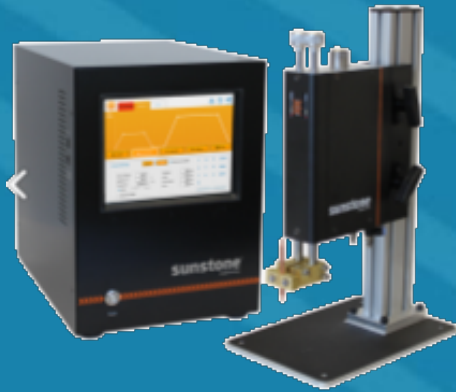
- 320 m<sup>2</sup>
- 145 m<sup>2</sup> clean room
- 115 m<sup>2</sup> ware house and others.
- 60 m<sup>2</sup> office



# Facilities



# Facilities



# Facilities





# Our customers



THE WORLD  
MERCATOR PROJECTION

0 miles 1000 2000 3000 miles

scale at the Equator

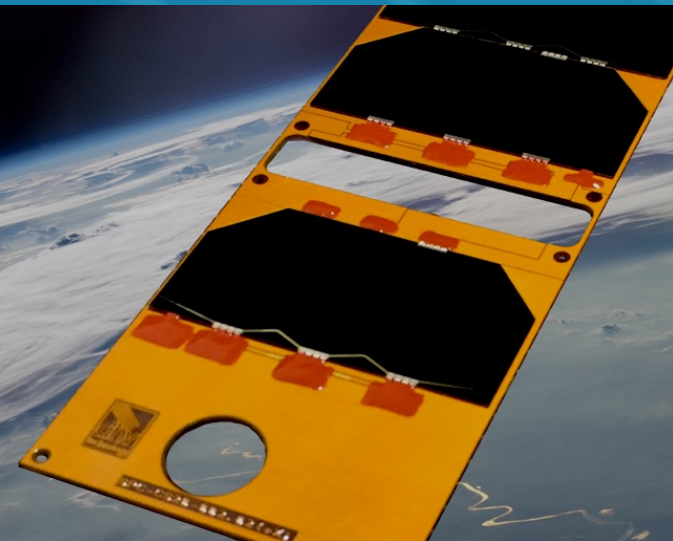
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S O U T H E R N O C E A N

# Solar Panels for CubeSat Missions



Solar Panels for Space Applications



# Flight heritage

- Solar Arrays designed and manufactures for G.A.U.S.S. Srl Rome Italy
  - First flight 19<sup>th</sup> of June 2014 620 Kms
  - Mission: **UNISAT-6**. DNPER launcher Yasni (Russia)



Solar array DHV



UNISAT 6 with DHV Technology panels

# Flight heritage

## *Open Cosmos Ltd – Solar panels for 2U Cubesats*

During the last quarter of 2015 DHV Technology has designed and manufactured the solar panels for QBEE-1, 2U CubeSat of England company Open Cosmos Ltd.

Temperature sensors have been integrated in the solar panels. The launch was on 18 May 2017 from ISS using the NanoRacks deployable system.





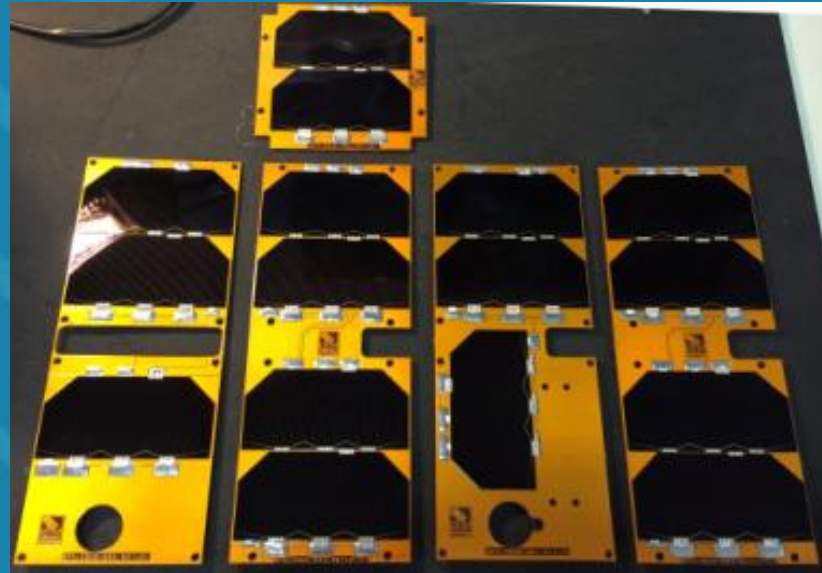
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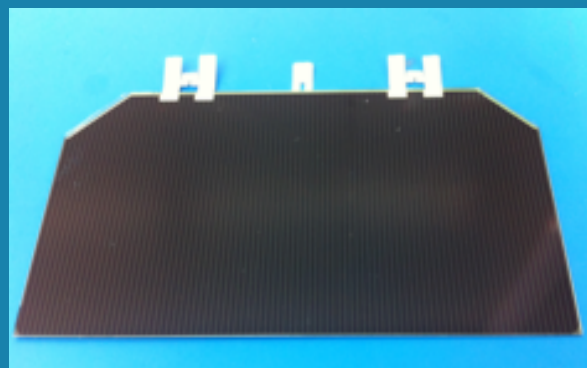
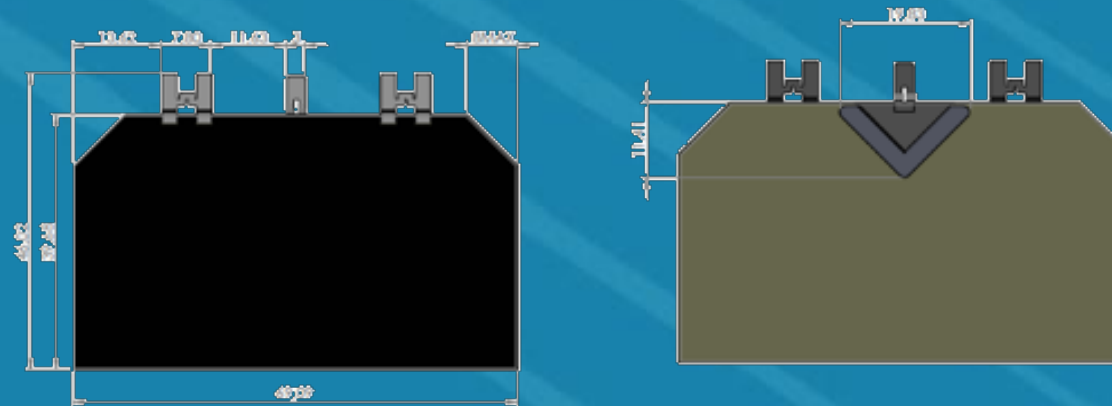




# Qualified projects

## *Cal Poly – California Polytechnic State University (USA)*

During 2017 DHV Technology has signed a contract to provide custom solar cells to CalPoly. Solar cells have been delivered in summer 2017 and will be used in the mission ExoCube2 that will be launched on 2019.



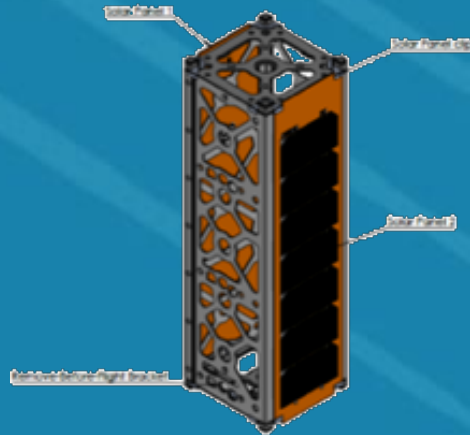
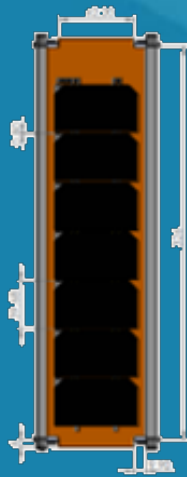


# Qualified projects

## ***OAKMAN Aerospace, Inc. (USA)***



During 2016 DHV Technology has signed a contract with Oakman Aerospace Inc. from Colorado (USA) to design and to supply 3U based mounted solar panels. Solar panels are being manufactured during 2017 and they have been delivered in May 2017.

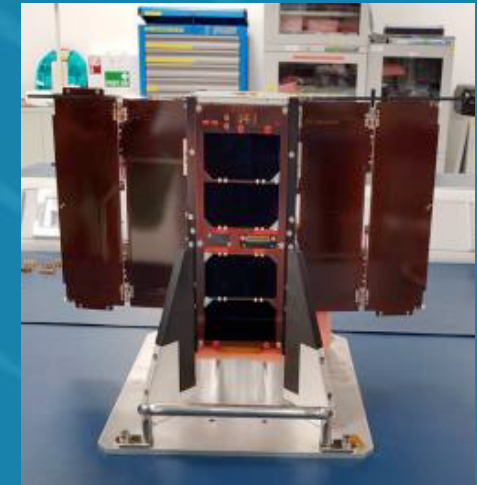
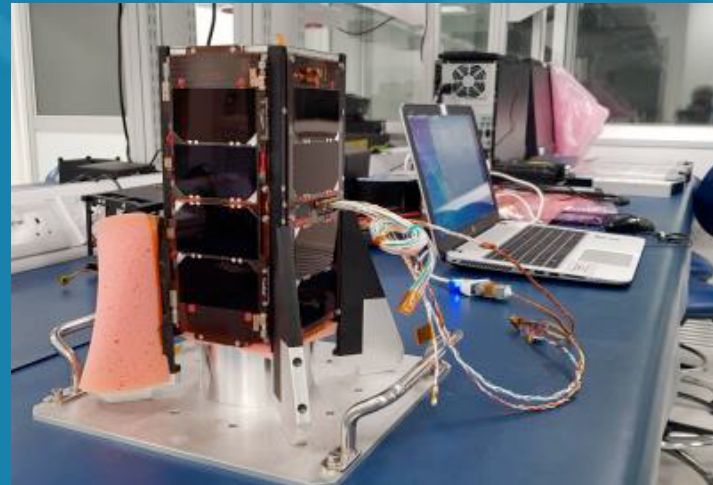
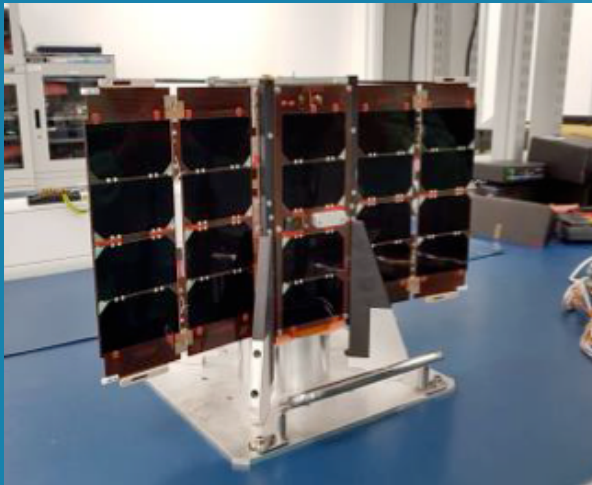


# Flight heritage

## *Nanyang Technological University*



Mission AOBA VELUX IV. This project consists of a set of double-deploy array designed and manufactured by DHV Technology. Each 2U CubeSat structure will have two deployable systems. This deployable system will include temperature sensors, photodiodes and thermal knives.



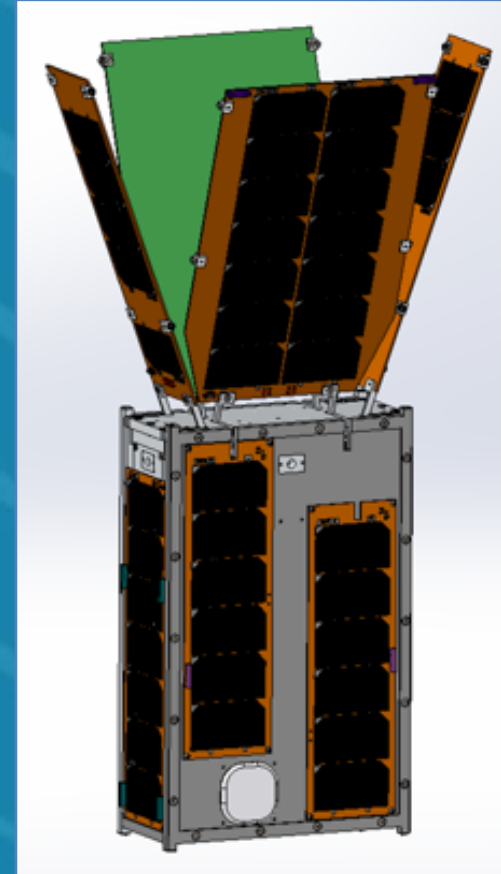
# Qualified projects

## *TRYAD mission*



Terrestrial RaYs Analysis and Detection (TRYAD) is a Cubesat mission on 6U platform developed by AUBURN University.

Multi-point Observations of Terrestrial Gamma-ray Flashes (TGFs) to test TGF Beam Models

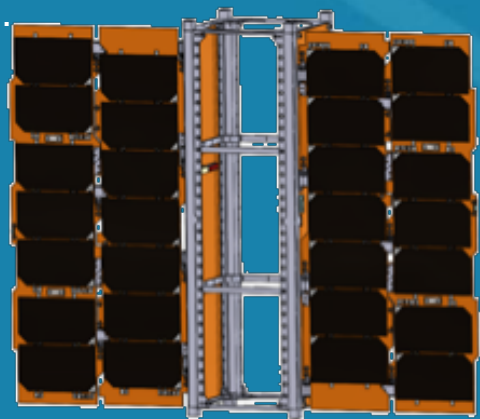


# Flight heritage

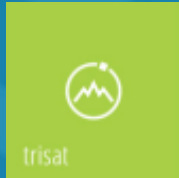
## *OHB Italia*



During 2016 DHV Technology has signed a contract with OHB Italia to design and to manufacture the double deployable 3U Cubesat solar panels for EAGLET 1 mission. The critical design review has been closed during the summer of 2017 and the solar panels have been delivered in November 2017. EAGLET 1 has been launched on 3<sup>rd</sup> December 2018 on Space X Falcon 9 rocket from Vandenvver Air Force Base California (USA).

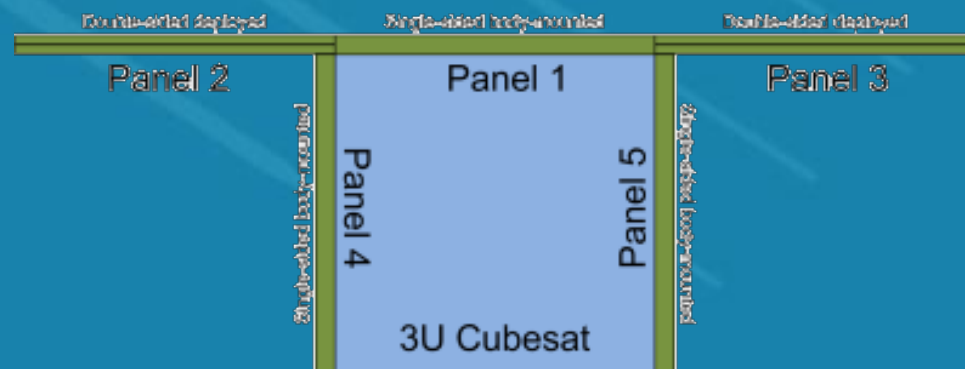


# TRISAT mission

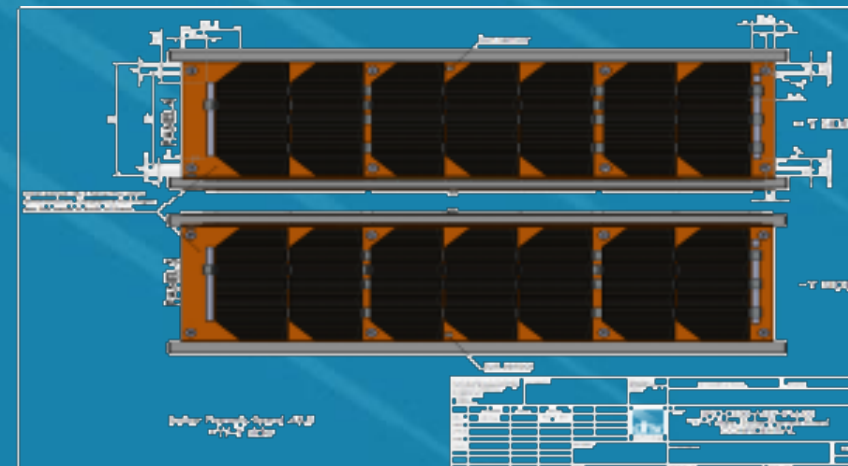
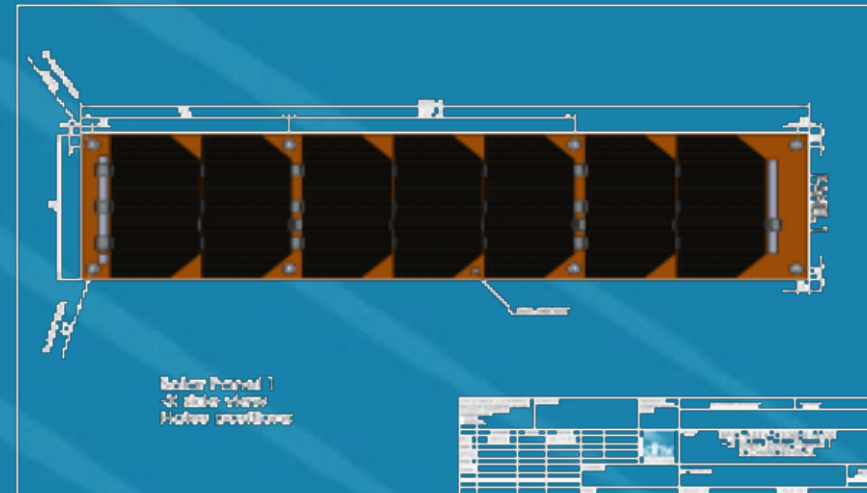
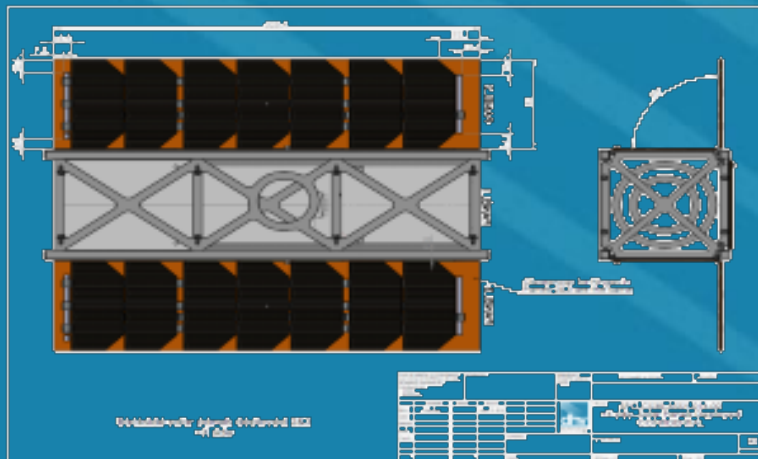
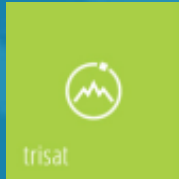


TRISAT is an educational 3U CubeSat mission lead by Maribor University from Slovenia funded by ESA

- Detect various vegetation patterns (green areas)
- Assess damage caused by natural disasters
- Detect volcanic dust.



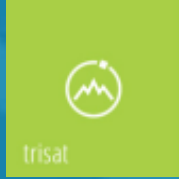
# TRISAT mission



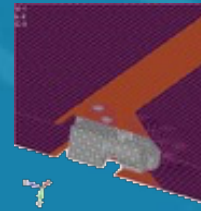
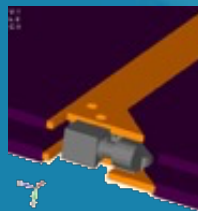
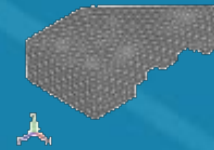
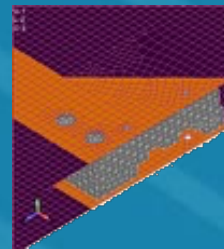
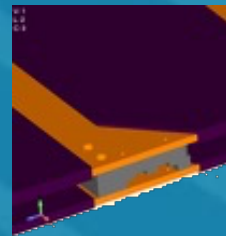




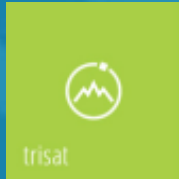
# TRISAT mission



## Simulations - FEM



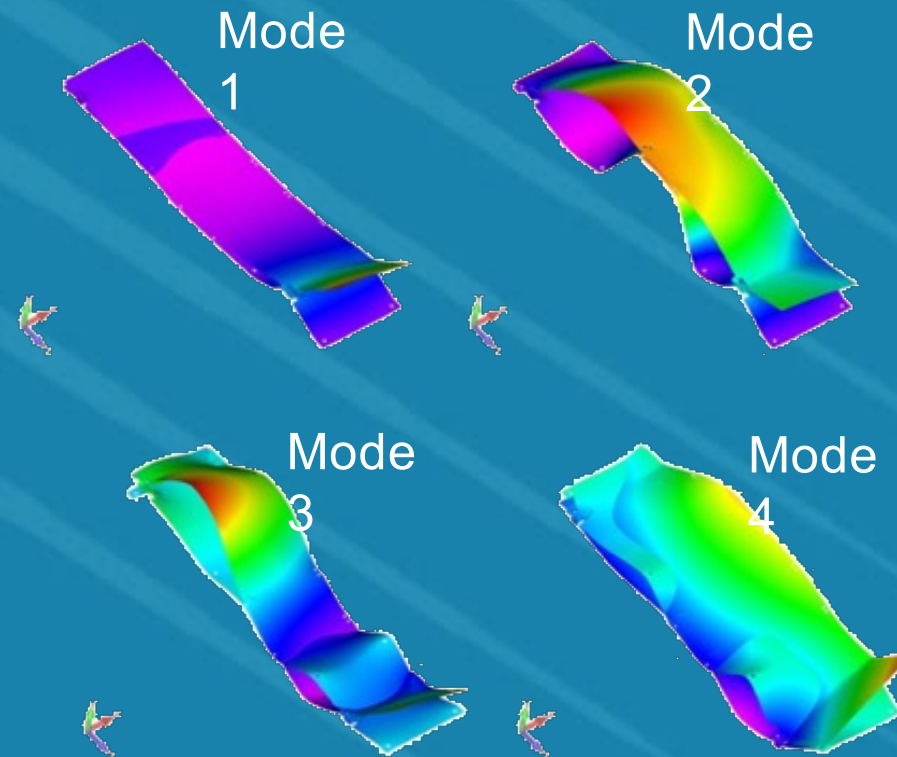
# TRISAT mission



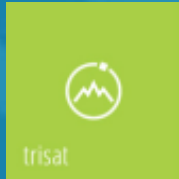
## Simulations - FEM

### Modal analysis

Nº Mode	Frequency (Hz)
1	220
2	226
3	346
4	409
5	449
6	517
7	558
8	645
9	704
10	779

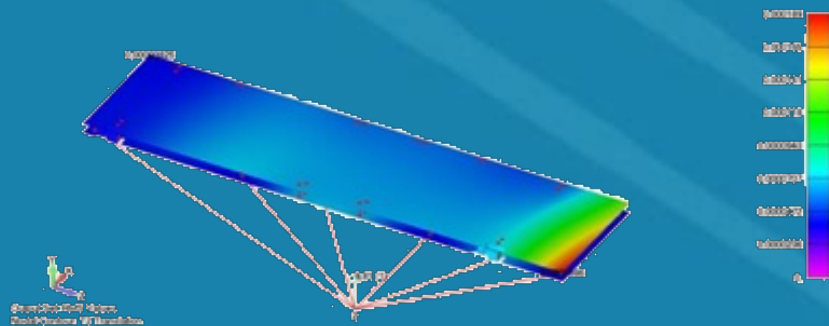


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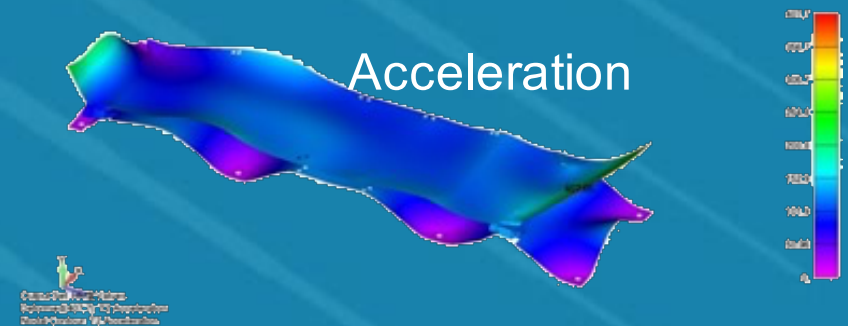


## Simulations - FEM

## Random vibration response



Translation

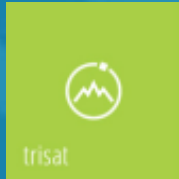


Acceleration



Stress

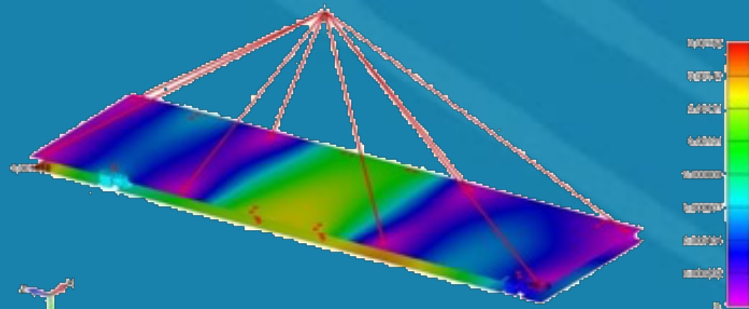
# TRISAT mission



## Simulations - FEM

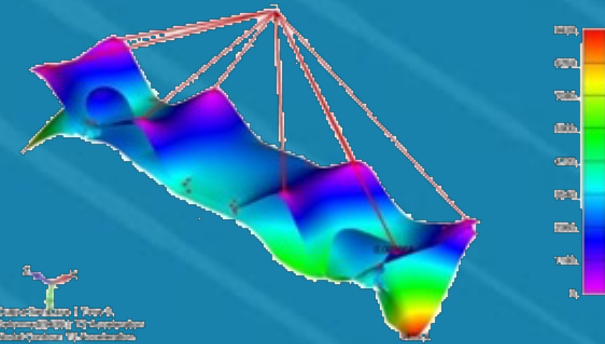
### Shock response

### Acceleration



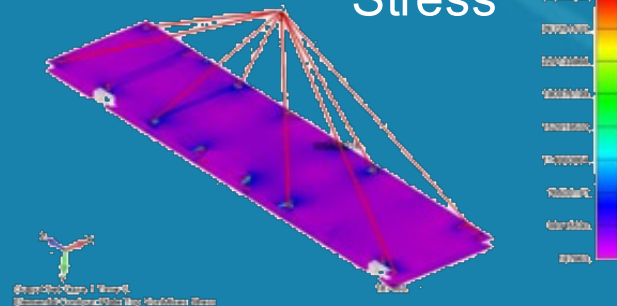
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000000000 | 1000000000  
000000000 | 10000000000

Displacements



000000000 | 100000  
000000000 | 1000000000  
000000000 | 10000000000

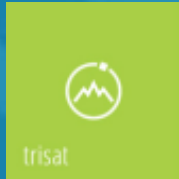
### Stress



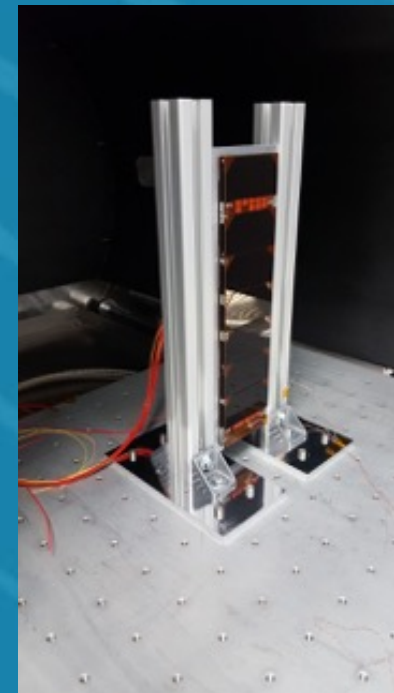
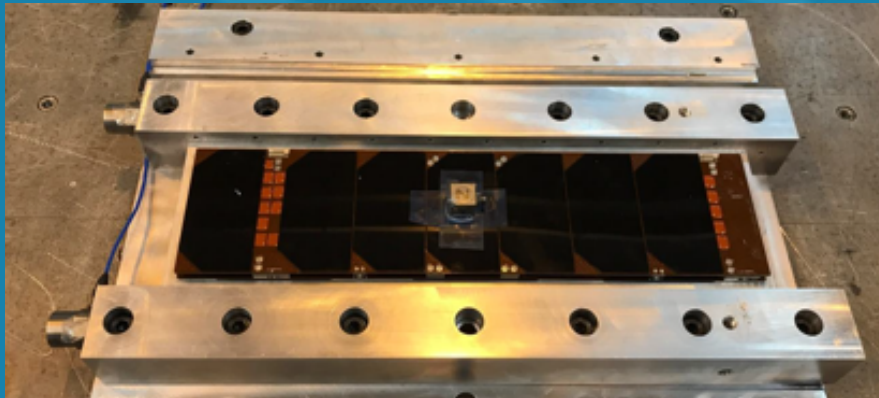
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000000000 | 1000000000  
000000000 | 10000000000



# TRISAT mission

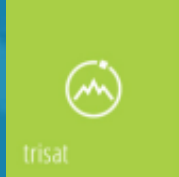


## Manufacturing of engineering model





# TRISAT mission



## Test plan

**Mechanical and vibration tests:** (GSFC-STD-7000A standard, NASA GEVS levels.)

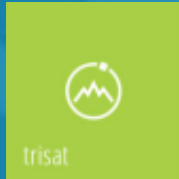
- sinusoidal vibration**
- random vibration**
- shock loads**
- resonance survey test**

**Thermal and vacuum test:** thermal cycling at low pressure conditions (-80°C/+135°C, 10<sup>-5</sup>-10<sup>-6</sup> mbar).

**Deployment tests:** -20°C / +60°C, 10<sup>-5</sup>-10<sup>-6</sup> mbar.

**Visual inspection and electric performance.**

# TRISAT mission

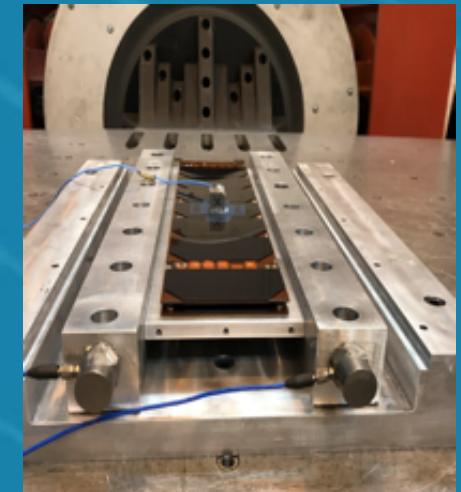
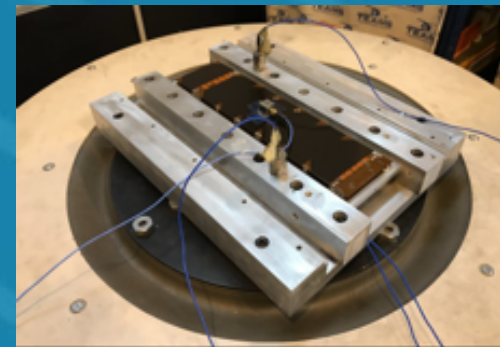


## Test plan

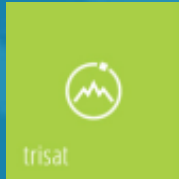
### Mechanical test – sinusoidal vibration

Mechanical test levels are designed under GSFC-STD-7000A

Test	Sinusoidal vibration		
Direction	X, Y, Z		
Sweep rate	2 oct / min / axis		
Profile	Frequency range [Hz]	Qualification levels (0-peak) [g]	Acceptance levels (0-peak) [g]
	5 – 45	1,0	0,8
	45 – 110	1,25	1,0
	110 – 125	0,25	0,20



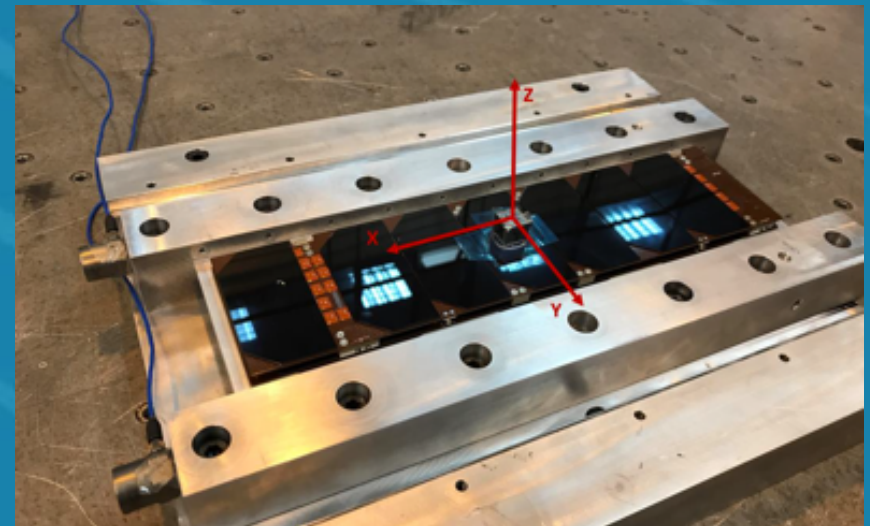
# TRISAT mission



## Test plan

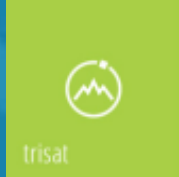
### Mechanical test – random vibration

Test	Random vibration	
Direction	X, Y, Z	
RMS acceleration ( $g_{RMS}$ )	14,1	
Test duration	120 s / axis	
Profile	Frecuency [Hz]	ASD level [ $g^2/Hz$ ] / Qualification
	20	0,026 $g^2 / Hz$
	20-50	+6dB / oct
	50-800	0,16 $g^2 / Hz$
	800-2000	-6dB / oct
	2000	0,026 $g^2 / Hz$





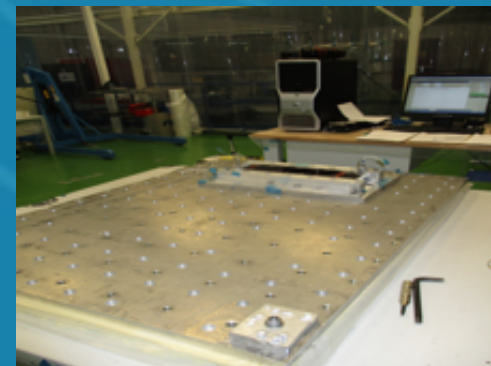
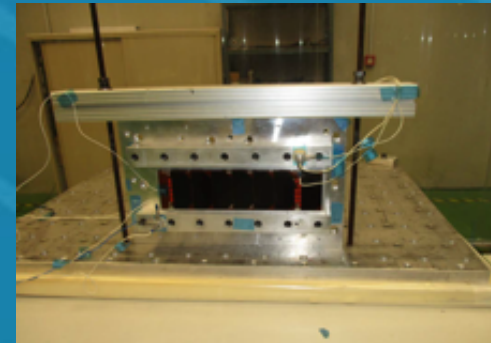
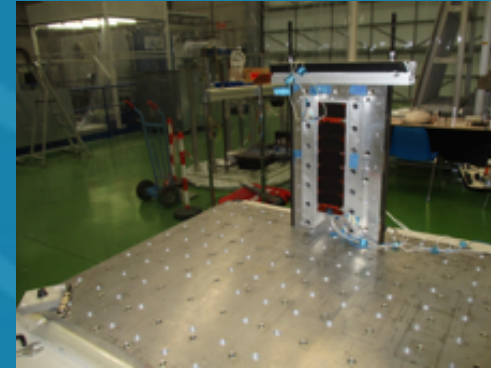
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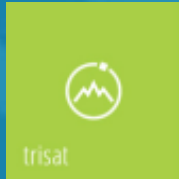
## Test plan

## Shock test

Test	Shock loads	
Direction	X, Y, Z	
Q factor	10	
Number of shocks	2 / axis	
Profile	Frequency (Hz)	Amplitude (g)
	100 - 1600	30 - 2000
	1600 - 10000	2000



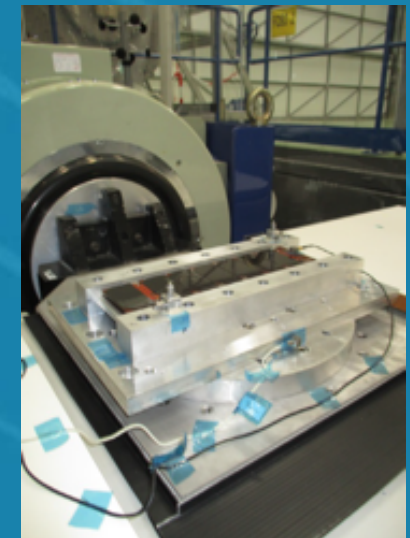
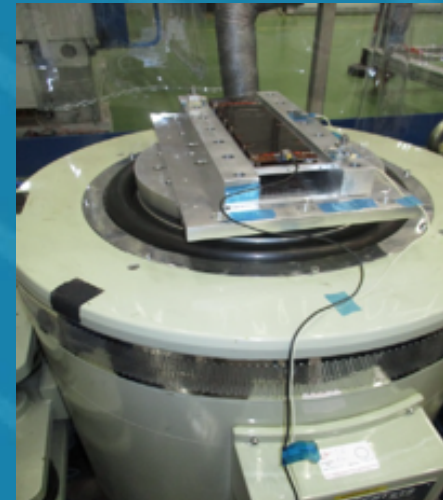
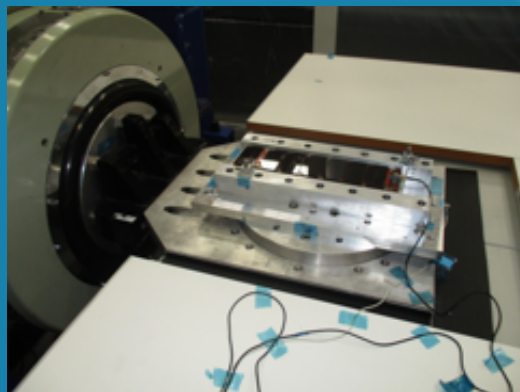
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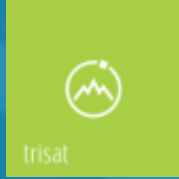
## Test plan

### Mechanical test – resonance survey

Test	Resonance survey	
Direction	X, Y, Z	
Type	Harmonic	
Sweep rate	2 oct / min / axis	
Profile	Frequency (Hz)	Amplitude (g)
	5-2000	0,4

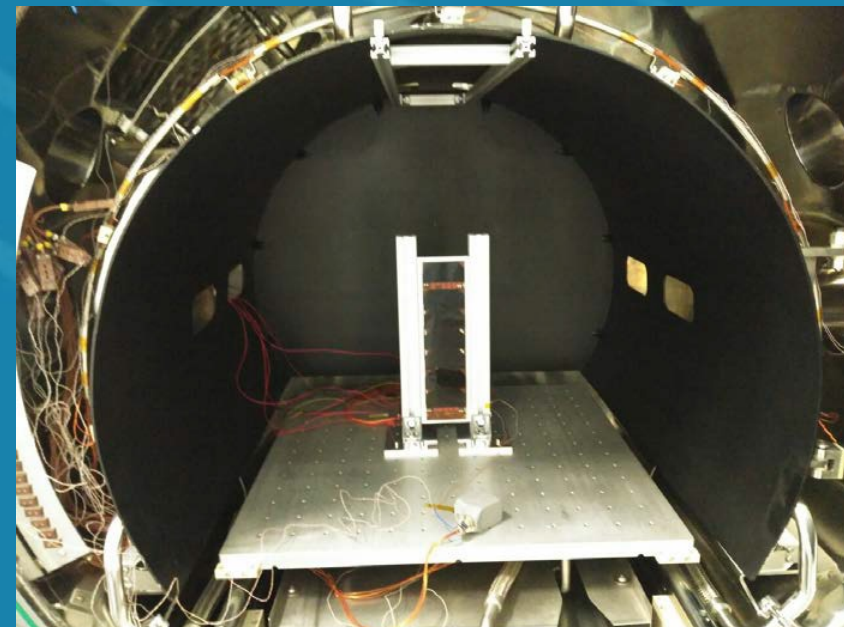
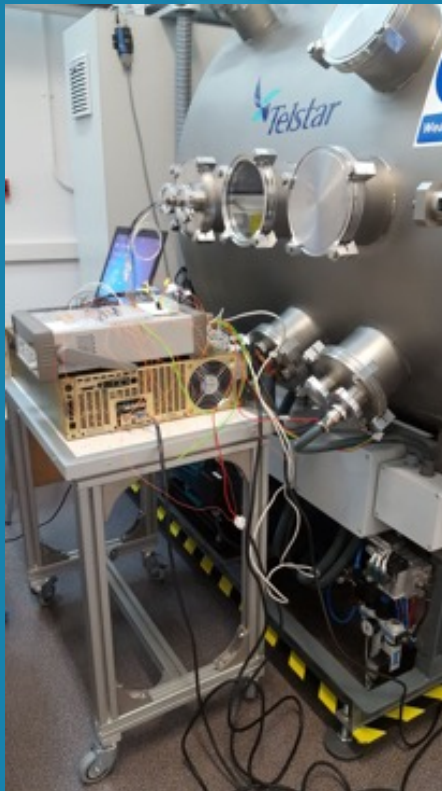


# TRISAT mission



## Test plan

TVAC test – cycling +135°C/-80°C, deployment test -20°C / +60°C



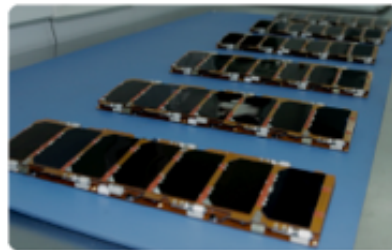
# LEO Constellation projects



## GEMINI SPACE PANEL

Double Deployable Solar Panels for 3U Cubesats  
 Designed by SPIRE GLOBAL  
 Manufactured by DHV Technology

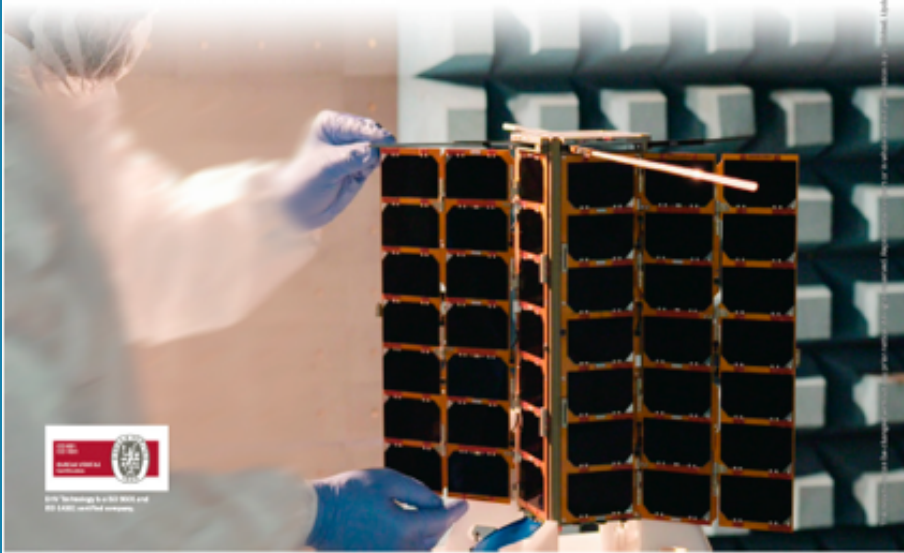
- 44 W nominal power
- One Double side panel
- Tested under launch loads
- Deployment test at low/high temp
- Successful deployment signal
- Temperature sensors



**TRL 9 – Proven at LEO constellation level**

[www.dhvtechnology.com](http://www.dhvtechnology.com)

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 00 34 951 956 837    [dhv@dhvtechnology.com](mailto:dhv@dhvtechnology.com)



DHV Technology S.A. 2012-2018 and 2019-2020 certified company



## GEMINI SPACE PANEL

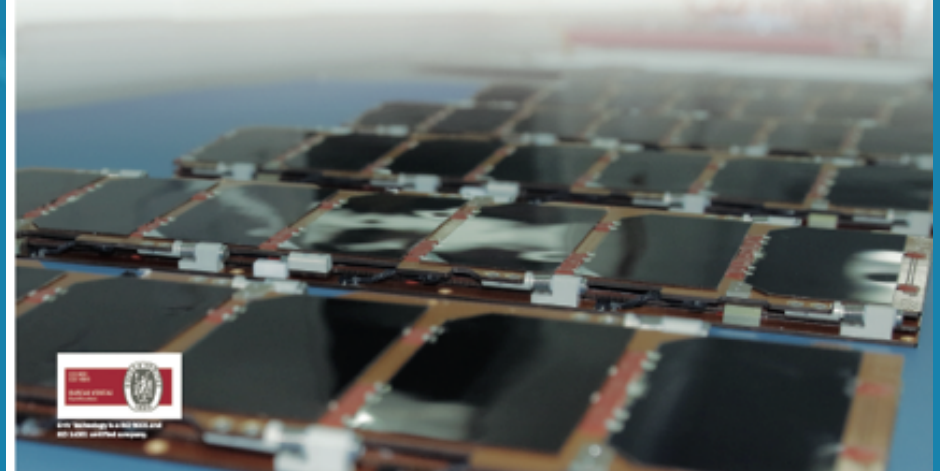
Double Deployable Solar Panels for 3U Cubesats  
 Designed by SPIRE GLOBAL  
 Manufactured by DHV Technology

### Features

Solar panel parameters	3U (double deployable)
Power (AMO WRC) 1367 W/m <sup>2</sup> ; T = 28 °C	29.6W (4 x strings)
Max Current (A)	1.7A (4 x strings)
Max Voltage (V)	17.3V (1 x string, 7 x cells)
Standard configuration	754P (7 cells x 4 strings)
Temperature sensor	LM335
Mass (g)	410 ± 10 g
Total thickness in stowed position (mm)	9.6 ± 0.2 mm
Deployed position (deg)	135°

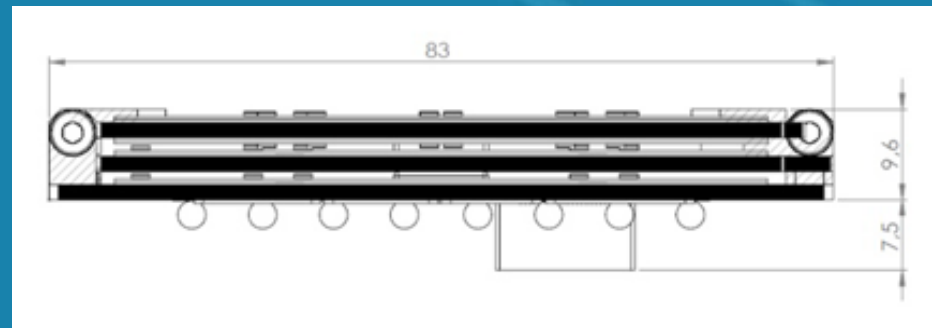
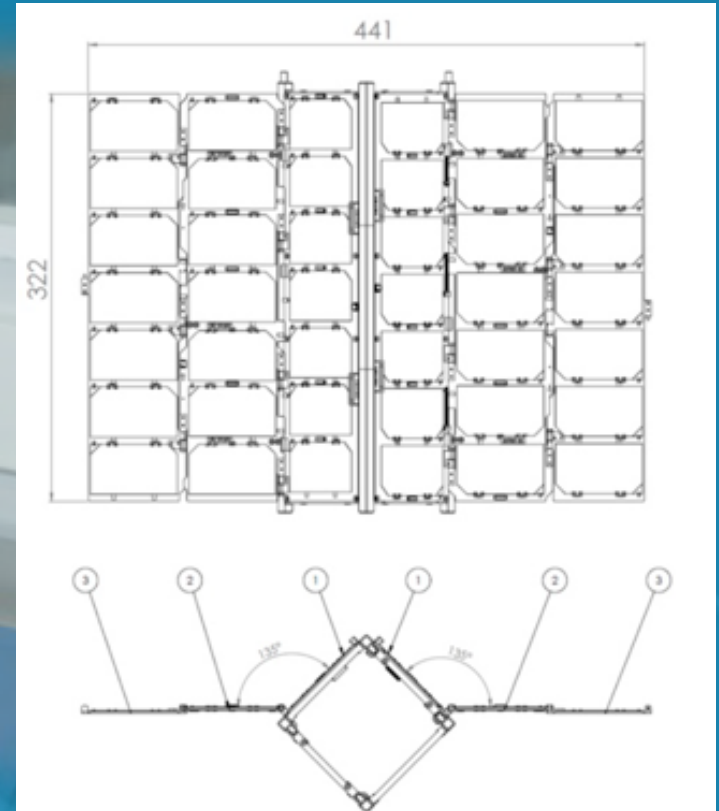
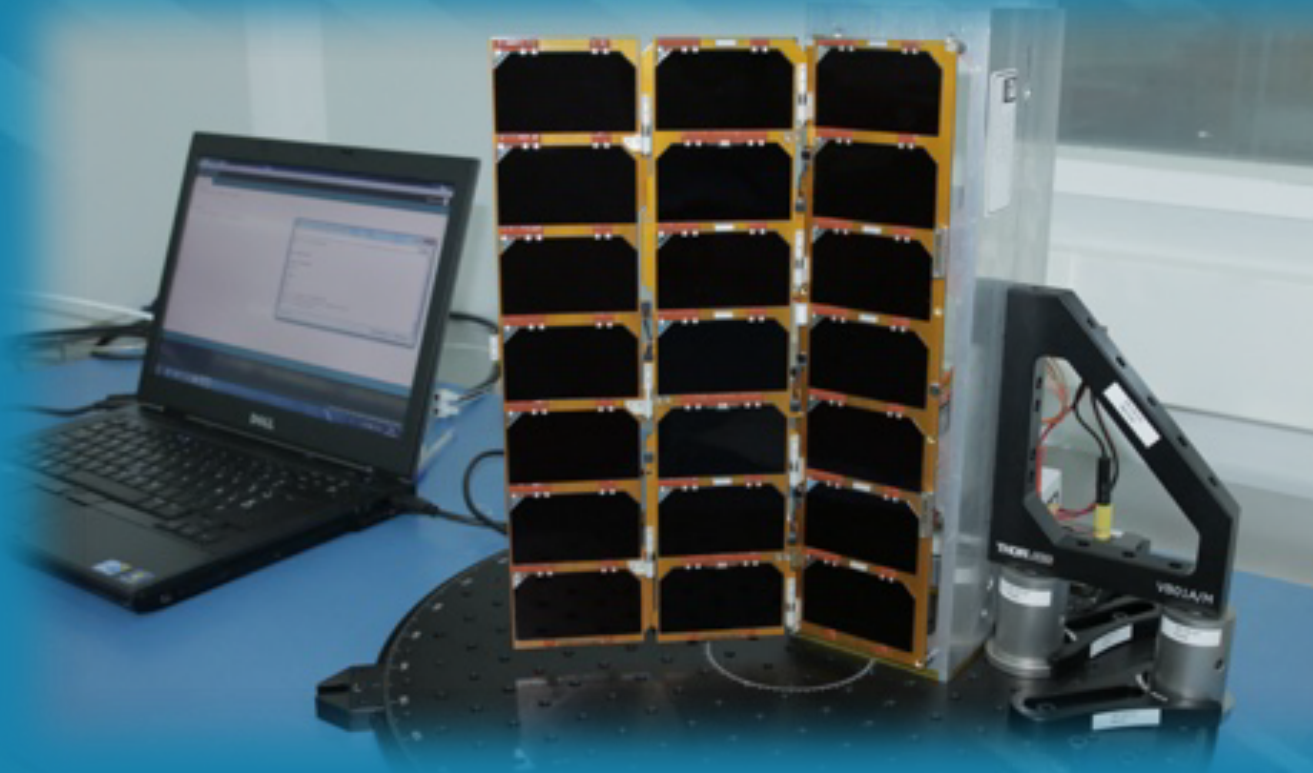
### Manufacturing

- Assembly and integration process
- Quality control process in all stages
- Manufacturing in a clean room ISO 8 level
- In mass production for satellite constellations
- Testing and qualification capabilities under request



DHV Technology S.A. 2012-2018 and 2019-2020 certified company

# LEO Constellation projects



# Deep Space projects

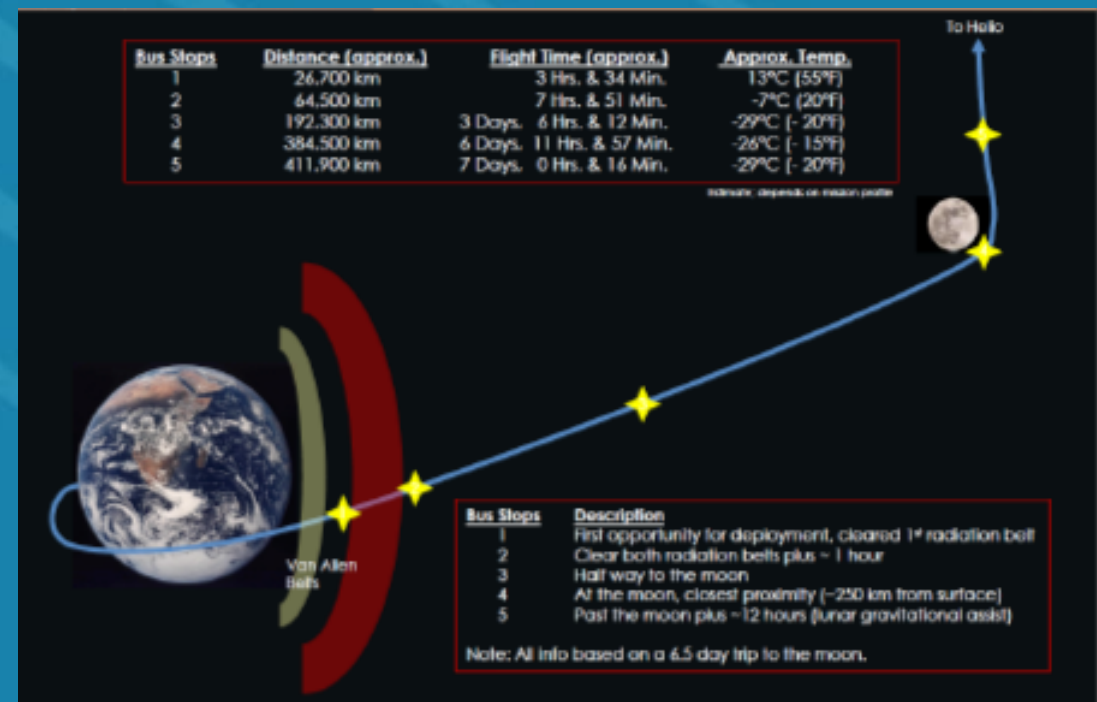


ArgoMoon mission – Argotec  
6U CubeSat platform.

Built by Argotec and  
coordinated by Italian Space  
Agency.

Secondary payload of  
Exploration Mission 1 of SLS  
from NASA.

13 missions as secondary  
payload



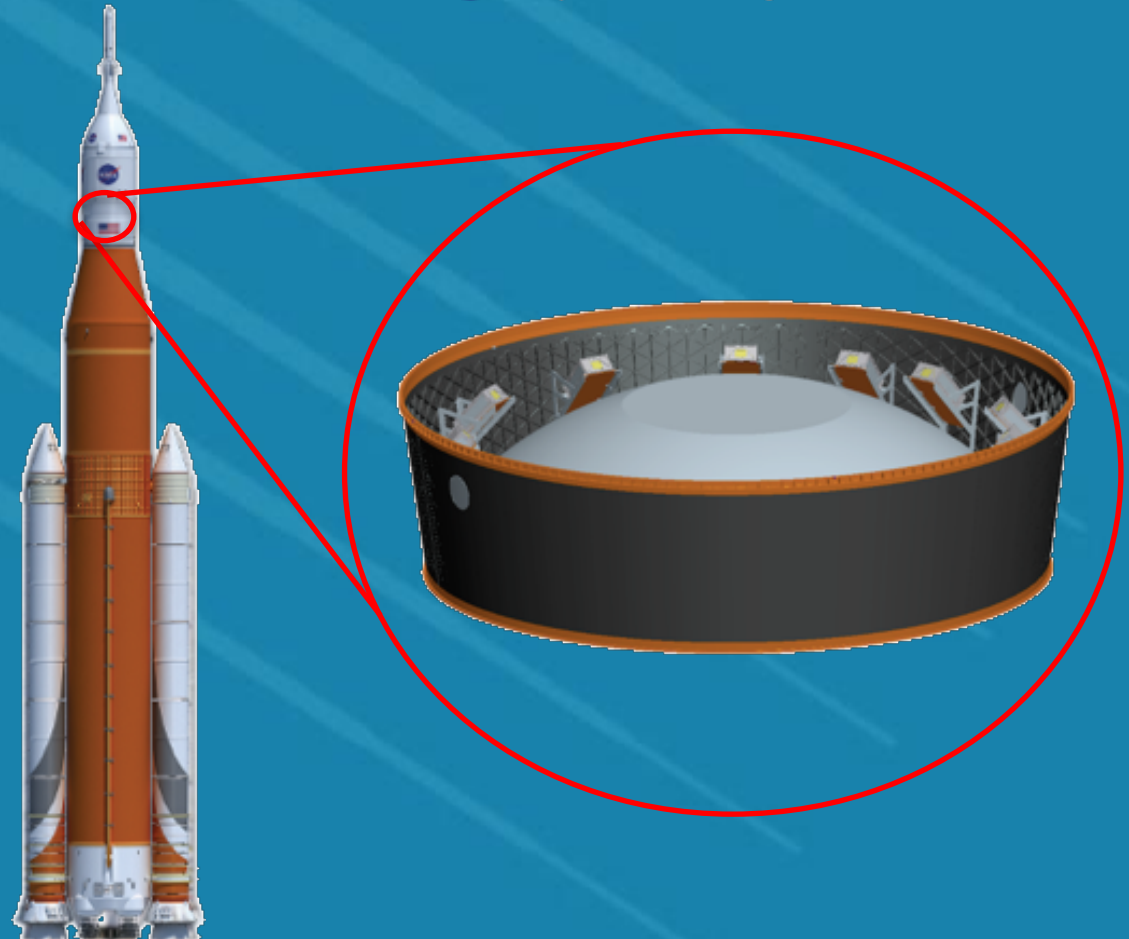
# Deep Space projects

**ArgoMoon mission – Argotec  
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**Secondary payload of  
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**13 missions as secondary  
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# Deep Space projects

**ArgoMoon mission – Argotec**

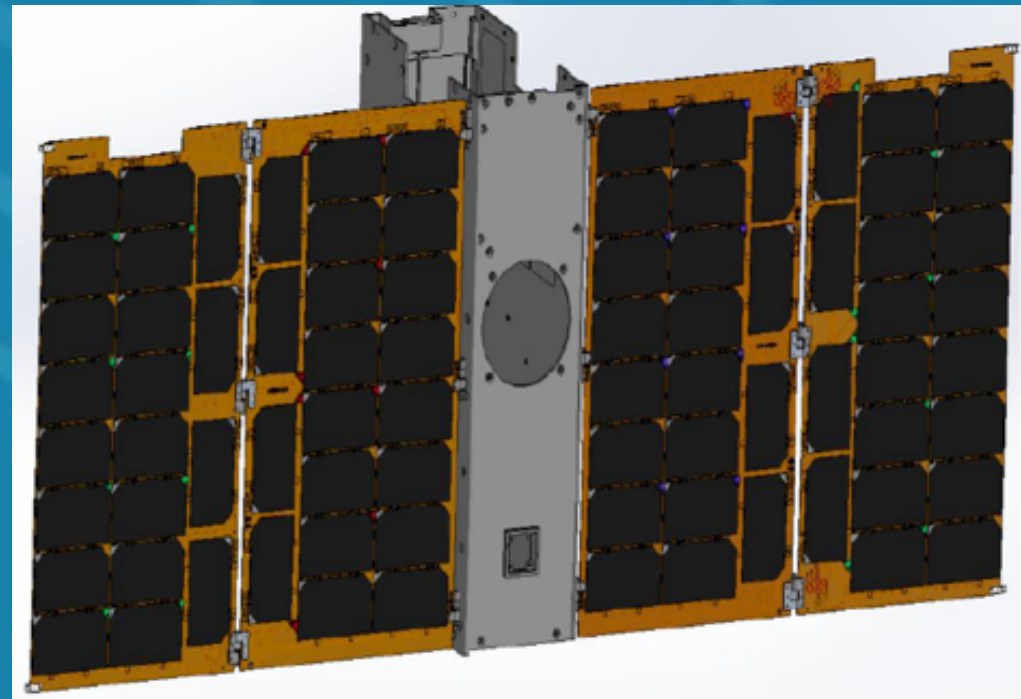
**6U CubeSat platform**

**80 W BOL**

**TRL 8**

**Vibration, Shock, Vibro  
Acoustic and TVAC tests.**

**Launch is scheduled for Q1  
2020**





# Deep Space projects

**ArgoMoon mission – Argotec**  
**6U CubeSat platform**



**80 W BOL**

**TRL 8**

**Vibration, Shock, Vibro**  
**Acoustic and TVAC tests.**

**Launch is scheduled for Q1**  
**2020**



# ANGELS mission



Angels mission – NEXEYA France & CNES

12U CubeSat platform

90 solar cells

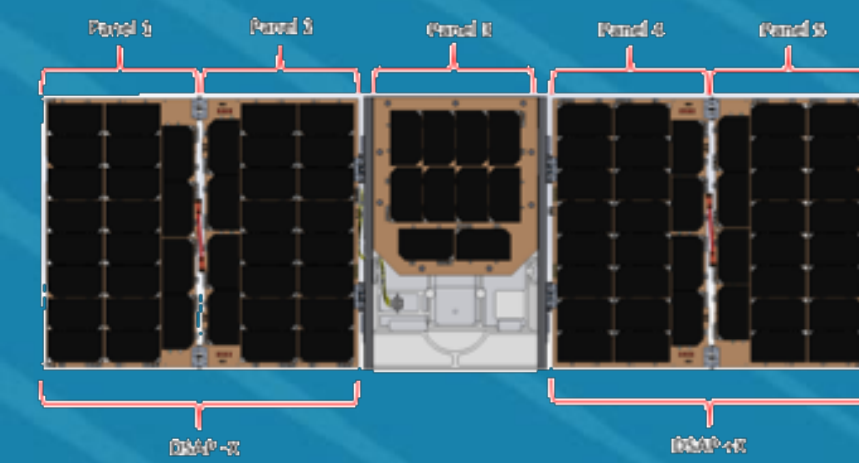
108 W BOL

TRL8 ( Q1 2019)

TRL 9 ( Q3 2019)

Vibration, Shock, and TVAC tests.

Launch is scheduled for Q3 2019





# ISIS Space and DHV Technology

From 6<sup>th</sup> August 2018, ISIS – Innovative Solutions In Space and DHV Technology are partners on Solar Panel Solutions.



This partnership will combine the expertise of ISIS as leading CubeSat and nanosatellite manufacturer and DHV's specialism in space-grade solar panels for high power satellite solutions that ISIS develops for its customers, enabling advanced applications ranging from hyper-spectral imaging to machine-to-machine communications. The DHV solar panels will be compatible with ISIS' latest 3U, 6U and 12U CubeSat platforms, as well as the larger and new 'XL' variants up to 16U satellites.



# Partners



# SSSIF 2020



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# Acknowledgement





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**LET US GIVE POWER TO YOUR SPACE MISSION !**