6U Deployable Solar Arrays for Deep Space Missions

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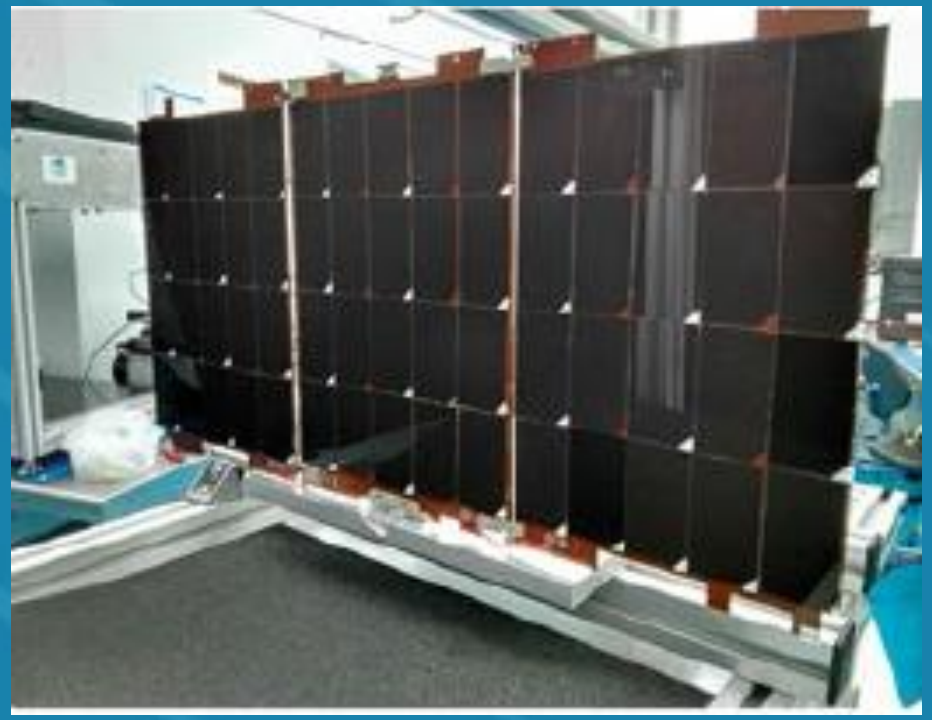


DHV TECHNOLOGY Málaga (Spain)

OUTLINE

- Short Company presentation
- 6U Mission for Deep Space
- Power needs & Radiation Hardness & Environmental requirement
- Design of solar panels
- Simulations
- Test plan
- Conclusions

Company presentation

DHV Technology is a company specialized on the design and manufacture of solar panels for small satellites

Company presentation

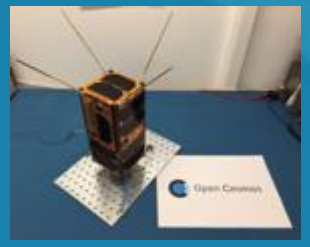
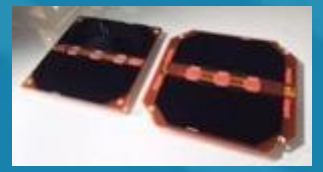
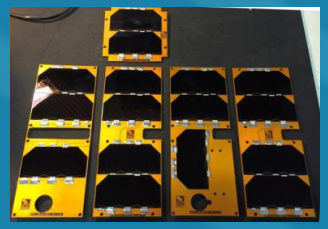
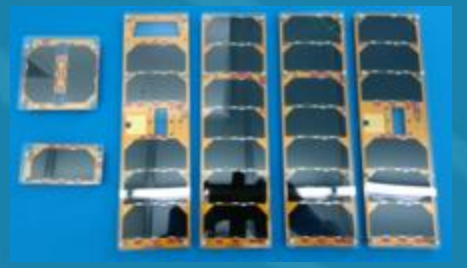
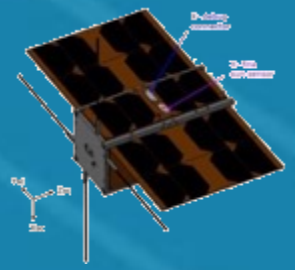
- **DHV Technology was funded on 2013, located in Malaga (Spain)**
- **Staff: 20 focused on Mechanical design, FEM analysis and simulations, solar panel testing and validation, solar cells**
- **Staff coming from high maturity markets: Photovoltaics, Defence, Electronic, Renewable companies. Since 1995 in Solar Panels**
- **Facilities: 350 m^2. ISO-7 clean room 120m^2**

Company presentation

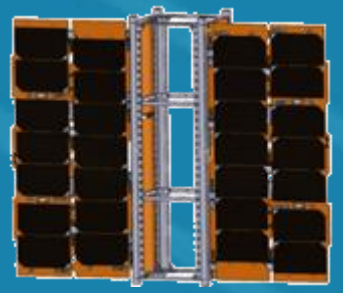
- **Solar Arrays of different architectures**

  PocketQube, CubeSat 1U, 2U, 3U, 6U, 12U

  Small Satellites

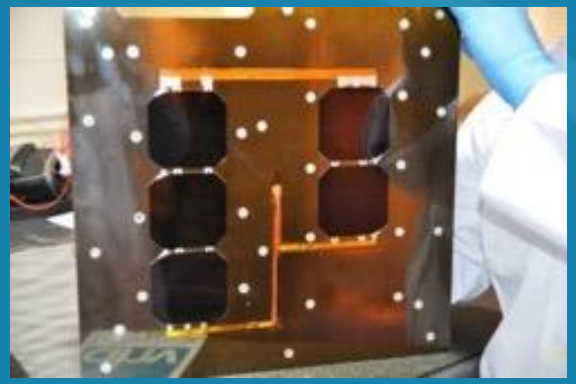


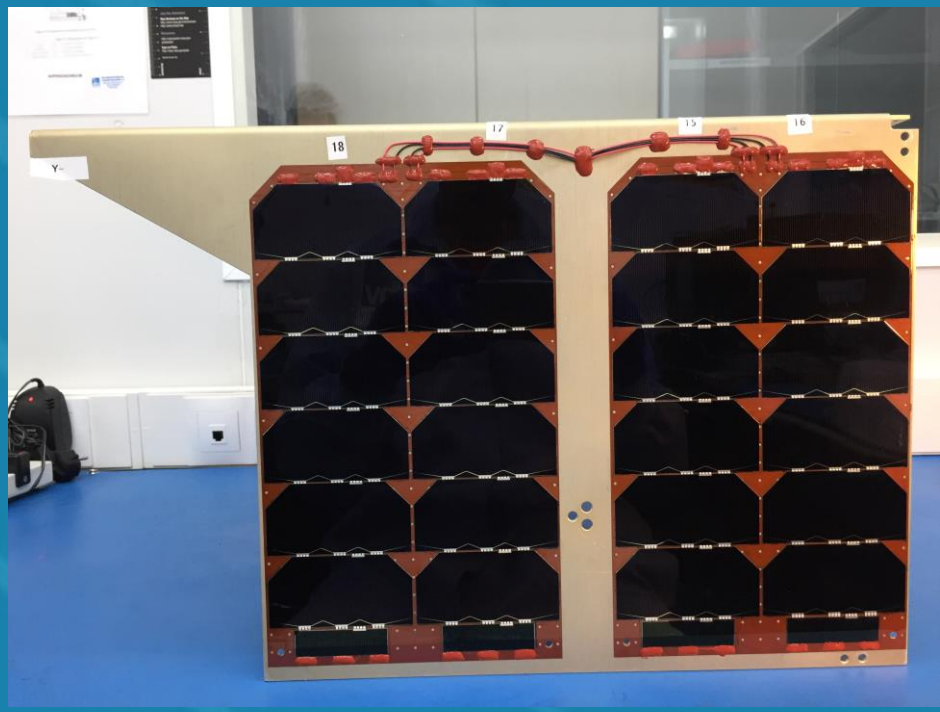




Company presentation

- **Solar Arrays for small satellite missions**

  The solar panels manufactured using CFRP over an aluminium honeycomb core or aluminium mechanical treated.

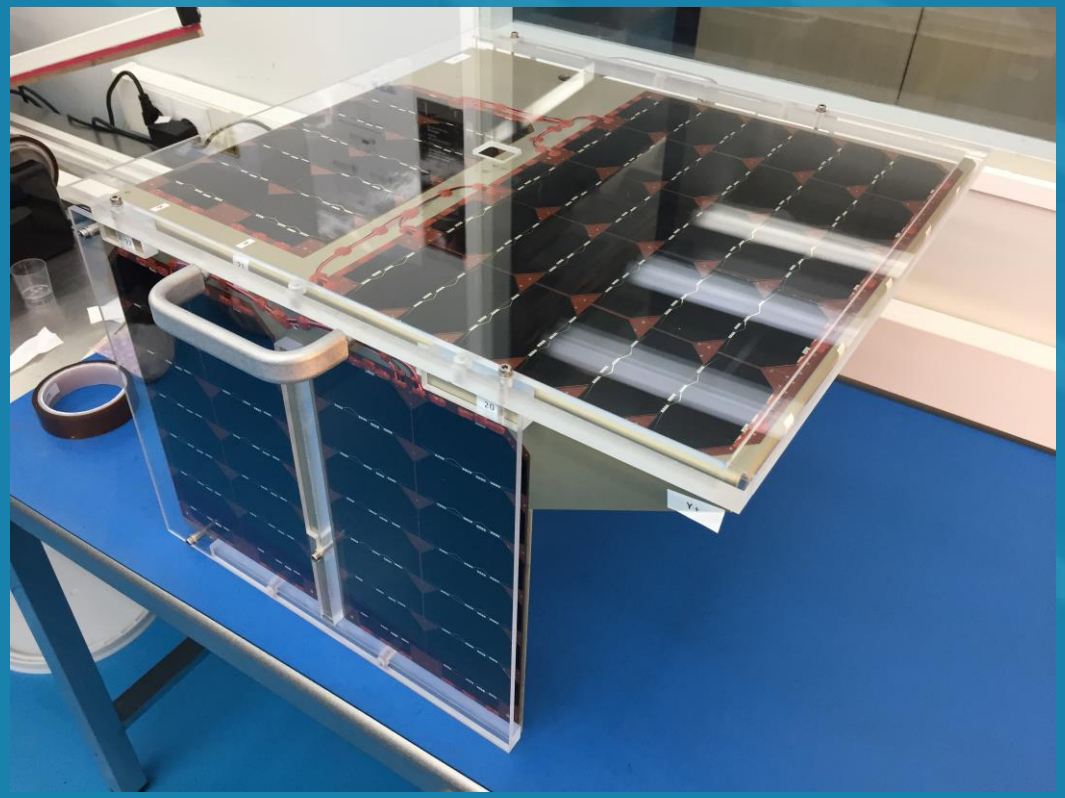


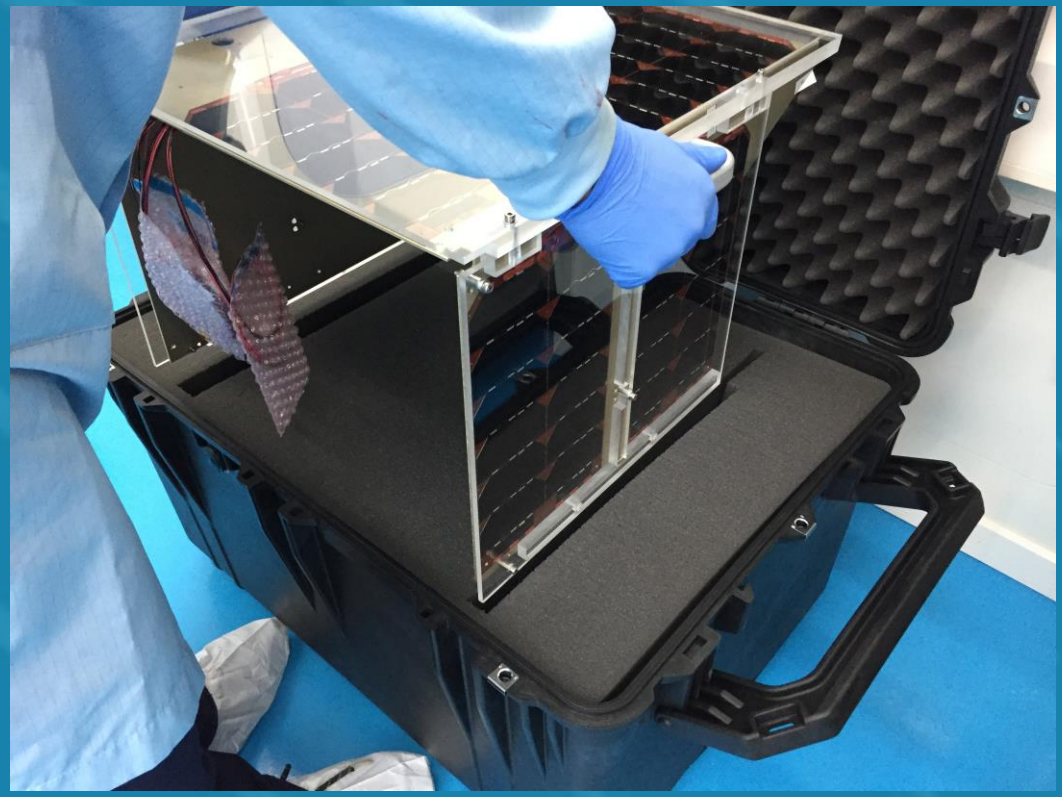


Company presentation

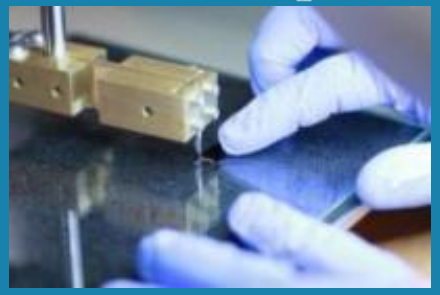
- **Solar Arrays for small satellite missions**

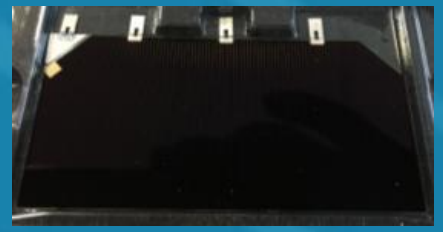
The solar panels manufactured using treated aluminium and kapton for solar cells string interconnection





Company presentation





- **Solar Cells Capabilities**
  - **Welding, Coverglass, Bypass diode**

6U Mission for Deep Space

Overview

- Initial configuration of vehicle optimized for near-term heavy-lift capability
- Completed Critical Design Review in July 2015

SLS Block 1

Capability: >70 metric tons

Height: 322 feet (98 meters)

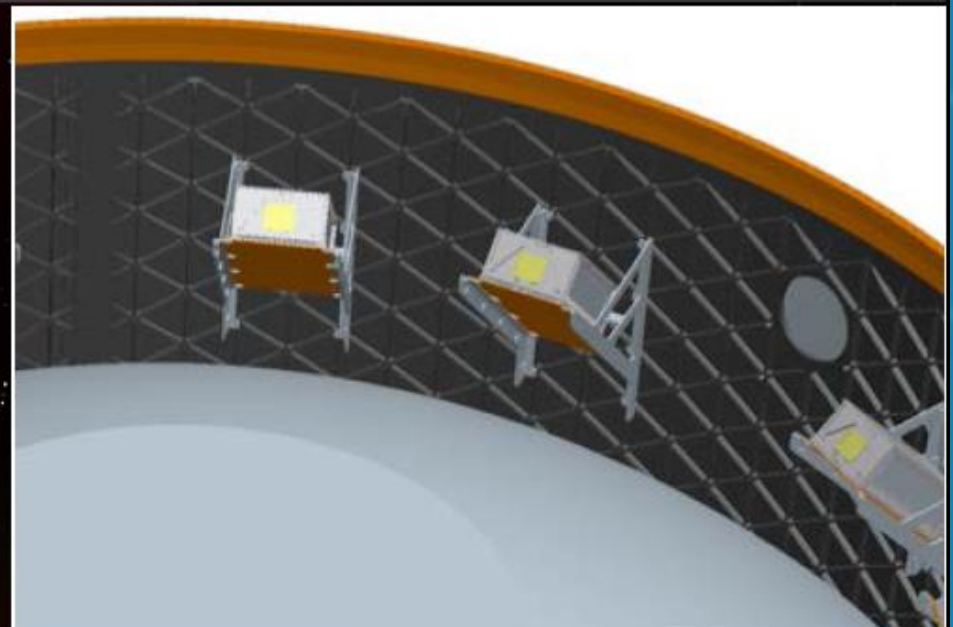
Weight: 5.75 million pounds (2.6 million kg)

Thrust: 8.8 million pounds (39.1 million Newtons)

Available: 2019

Secondary Payloads

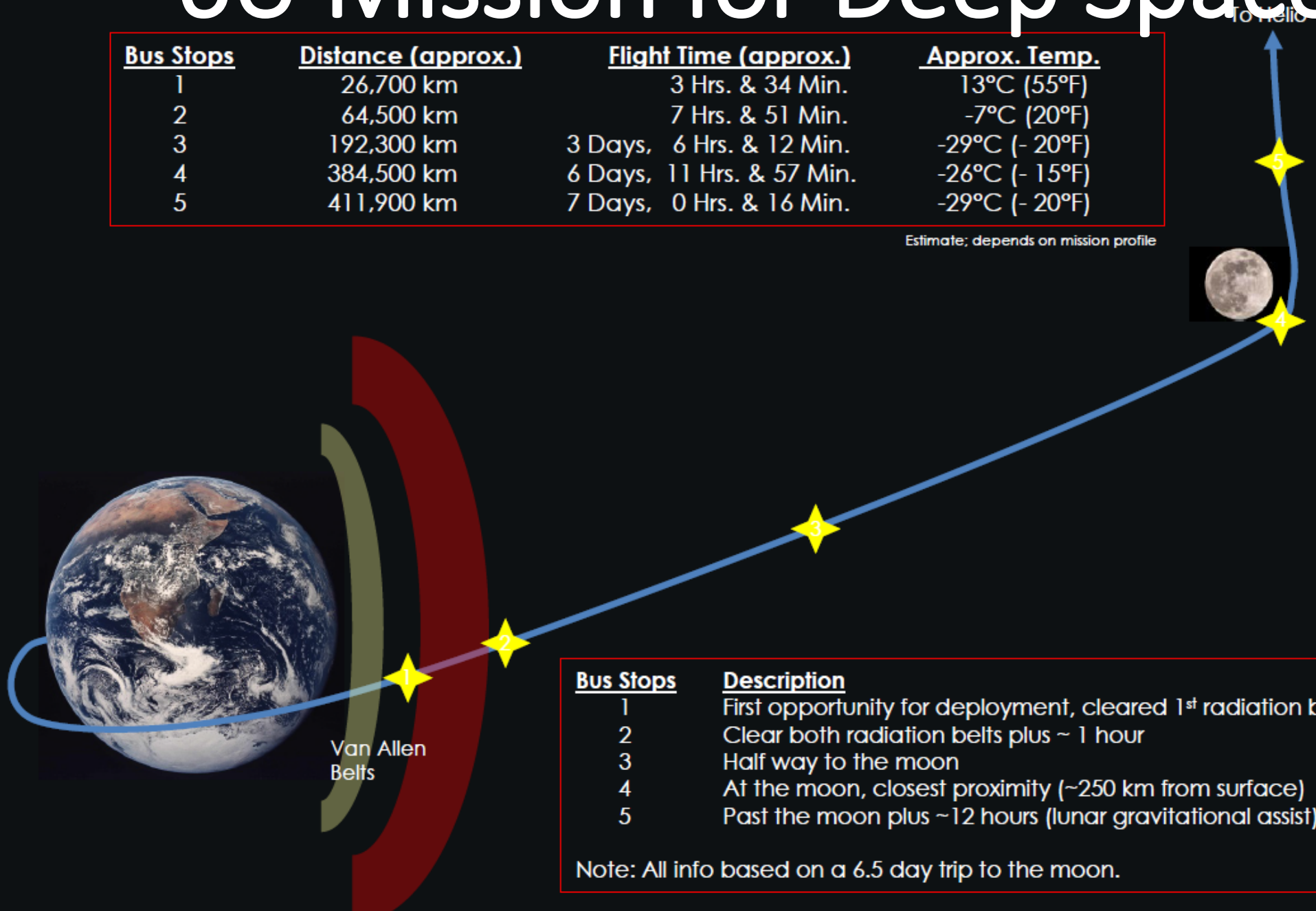
On Exploration Mission-1, SLS will include thirteen 6U payload locations of up to 14kg per CubeSat



6U Mission for Deep Space

Bus Stops	Distance (approx.)	Flight Time (approx.)	Approx. Temp.
1	26,700 km	3 Hrs. & 34 Min.	13°C (55°F)
2	64,500 km	7 Hrs. & 51 Min.	-7°C (20°F)
3	192,300 km	3 Days, 6 Hrs. & 12 Min.	-29°C (- 20°F)
4	384,500 km	6 Days, 11 Hrs. & 57 Min.	-26°C (- 15°F)
5	411,900 km	7 Days, 0 Hrs. & 16 Min.	-29°C (- 20°F)

Estimate; depends on mission profile



Bus Stops	Description
1	First opportunity for deployment, cleared 1st radiation belt
2	Clear both radiation belts plus ~ 1 hour
3	Half way to the moon
4	At the moon, closest proximity (~250 km from surface)
5	Past the moon plus ~12 hours (lunar gravitational assist)

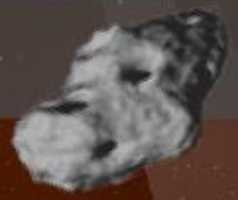
Note: All info based on a 6.5 day trip to the moon.

6U Mission for Deep Space

Moon

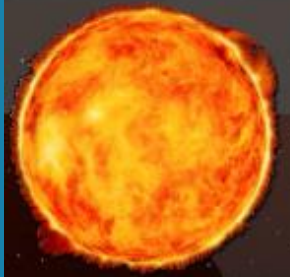
- Lunar Flashlight (NASA)
- Lunar IceCube (Morehead State University)
- LunaH-Map (Arizona State University)
- OMOTENASHI (JAXA)

Asteroid



- NEA Scout

Sun



- CuSP (Southwest Research Institute)

Earth

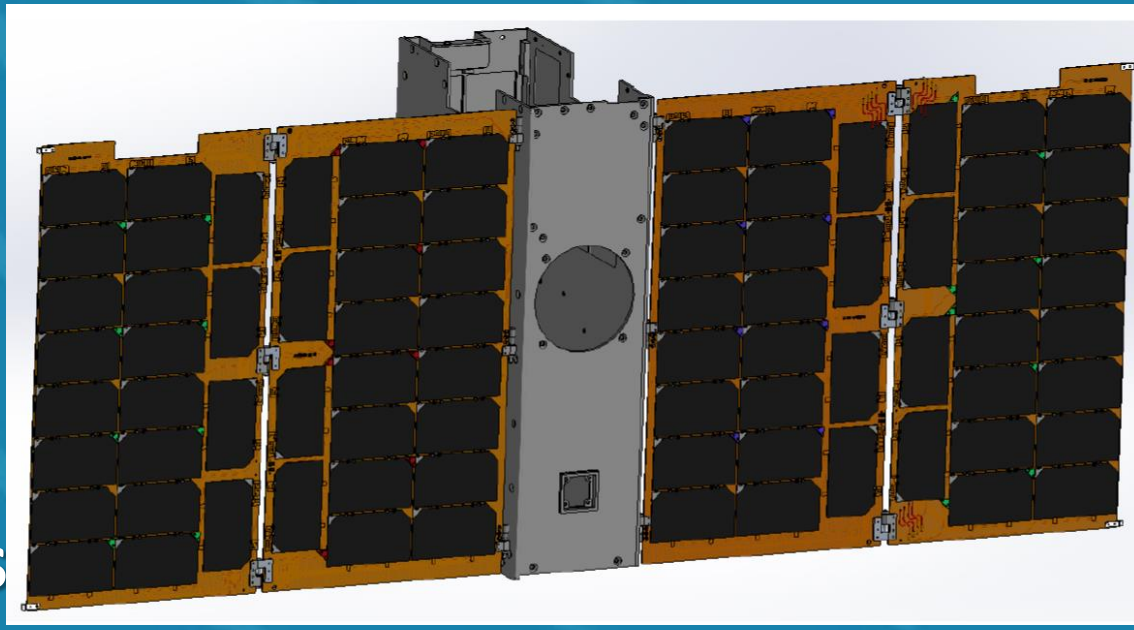
- EQUULEUS (JAXA)
- Skyfire (Lockheed Martin)

And Beyond

- Biosentinel (NASA)
- ArgoMoon (ESA/ASI)
- Three Centennial Challenge Winners (TBD)

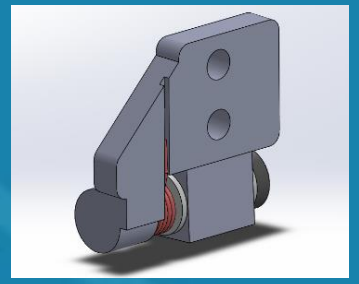
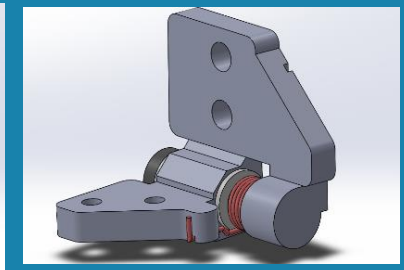
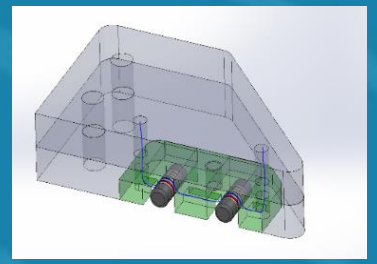
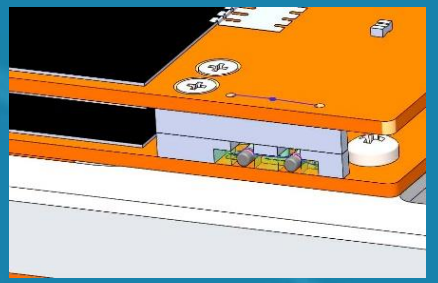
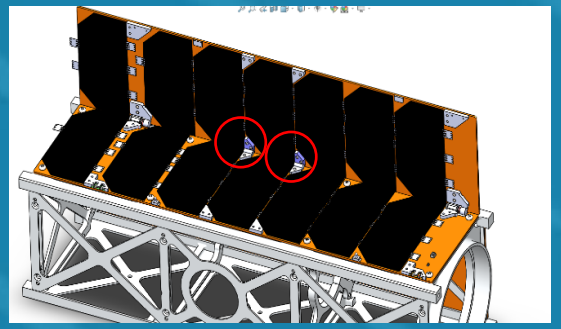
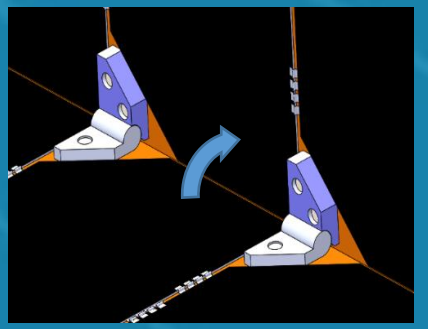
6U Power Needs, Radiation, Environmental Requirements

- 80 W BOL (5 strings 8 solar cells in series per wing. 40W)
- Two wings double deployable
- Reduced thickness (less than 5 mm in stowed configuration including everything)
- Van Allen Belts Crossing requirements
- Vibration, Shock, Vibro Acoustic and TVAC test requirements



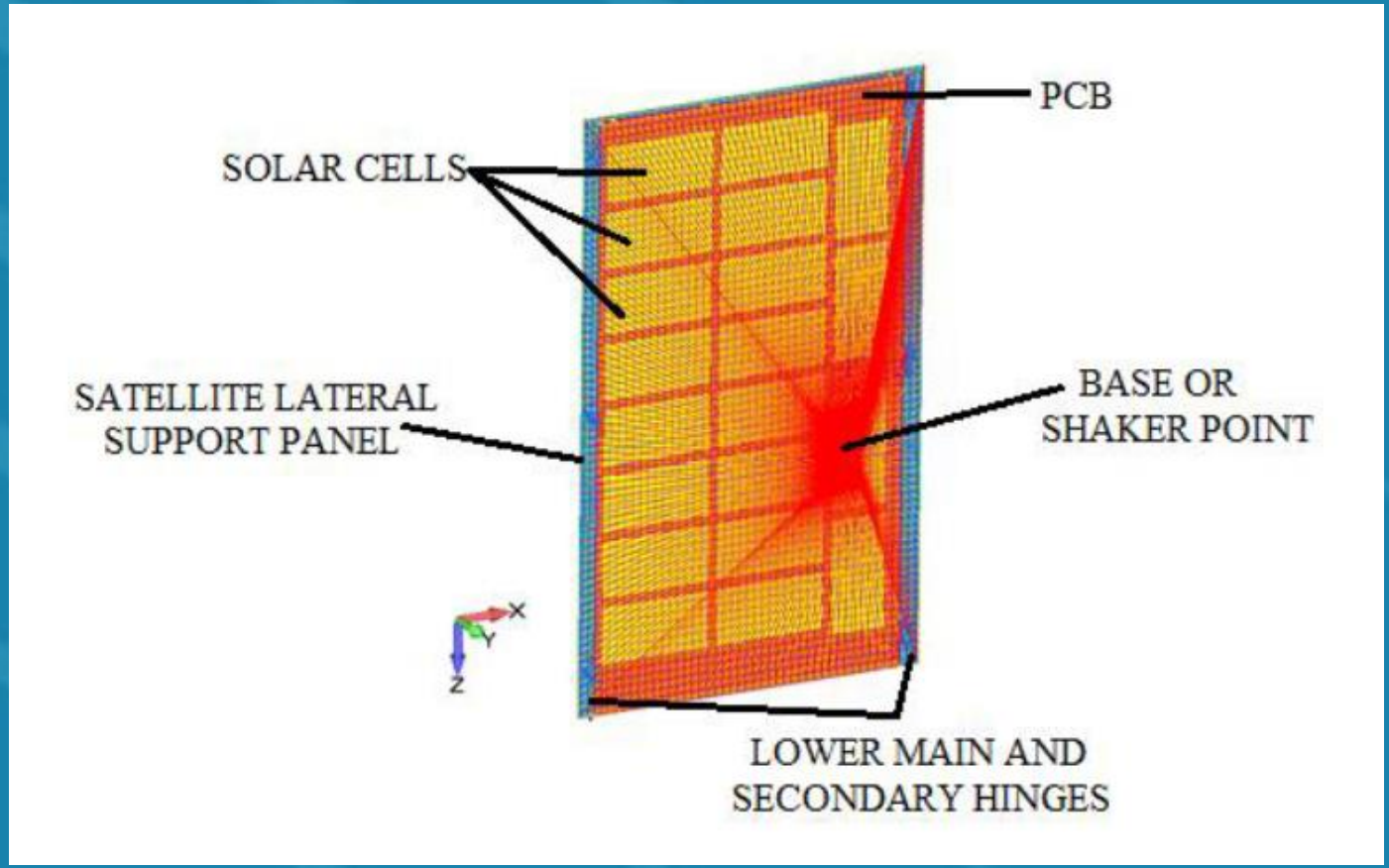
Design of Solar Panels

- Mechanical parts of the Solar Array
  - Hinges, Torsion Springs
  - Tie Down and other mechanical items
- Substrate selection
- Solar cells, connectors, sensors
- Thermal knife and associated circuitry
- Design extension to meet Interplanetary missions: RAD HARD, Special Coatings, …

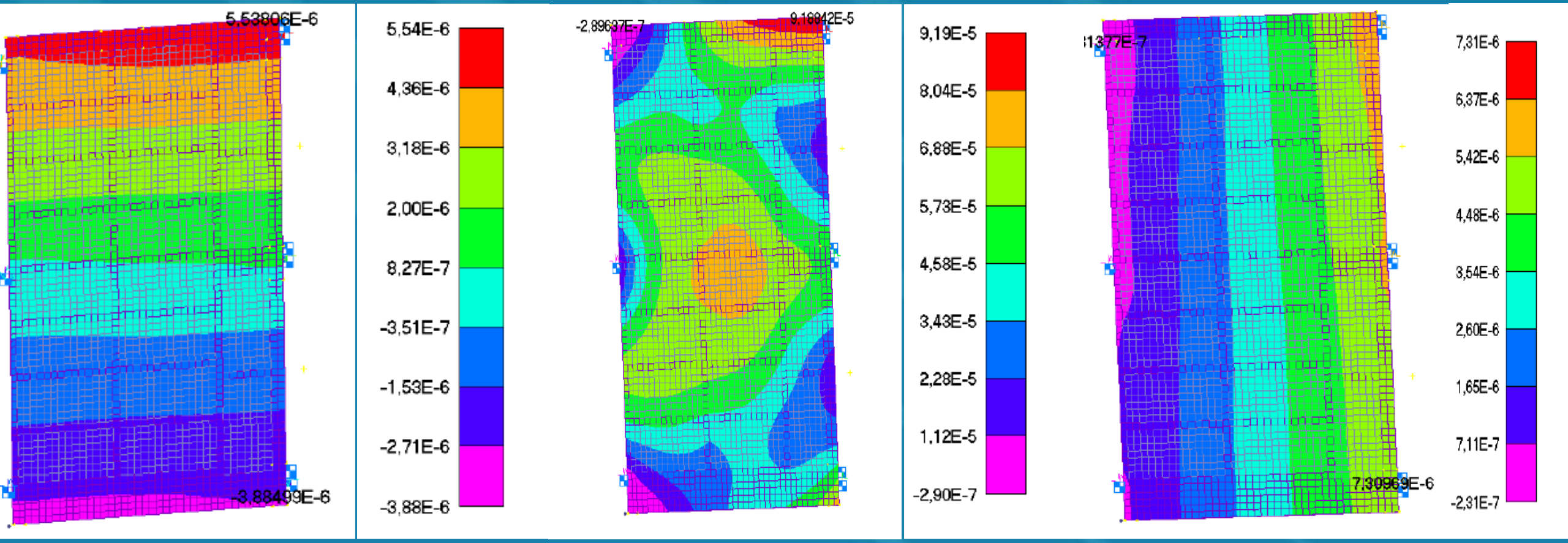
Simulations: modelling of the panels

- Substrates have been modeled with linear plate elements
- Solar cells
- Interface with panels
- Hinges, connections to the satellites
- Torsion Springs, Tie down
- First Vibration mechanical mode 140 Hz
- Static Load 45 gr

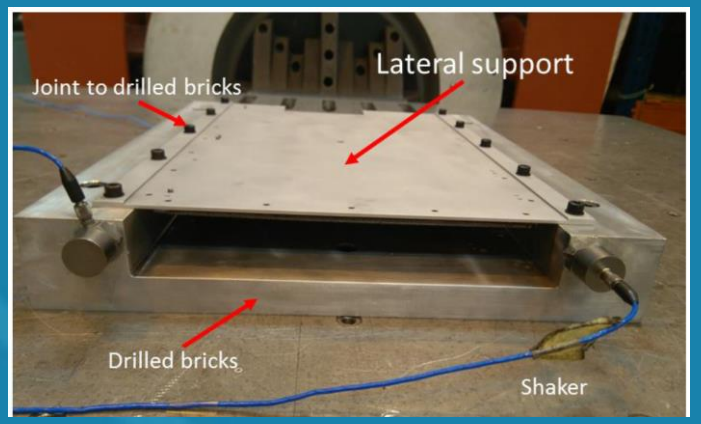


Simulations: results

Stowed model. Static loads. Displacement analysis X, Y, Z



Test plan

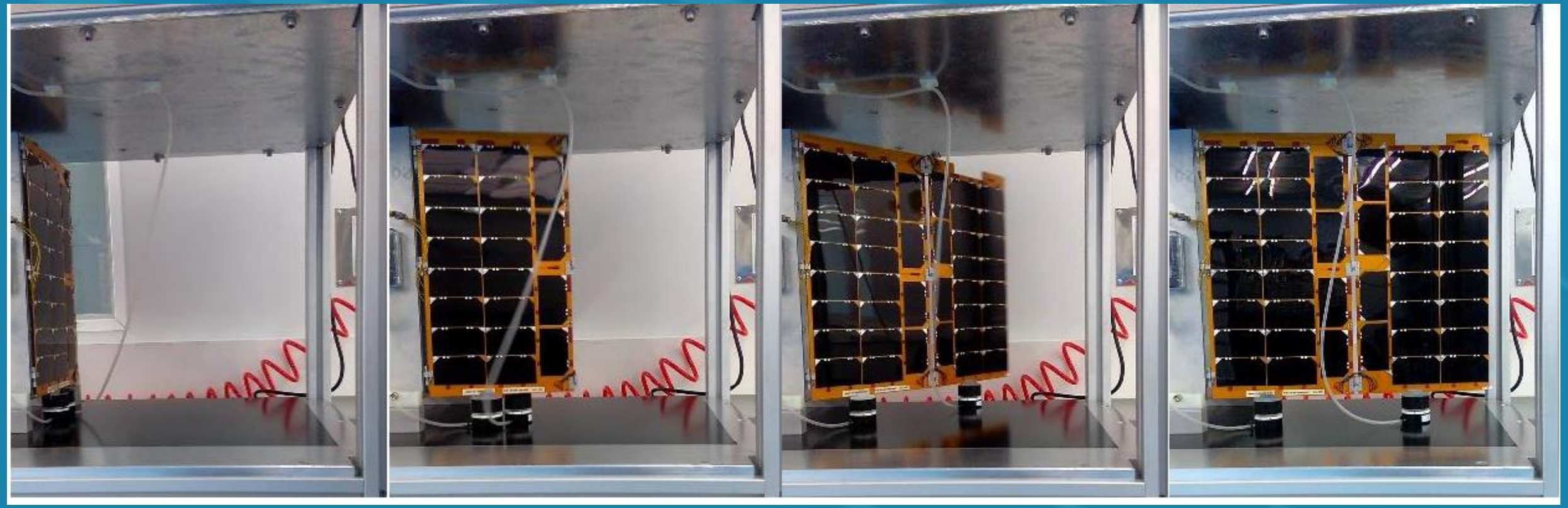


- **Mechanical and vibration tests:** (GSFC-STD-7000A standard, NASA GEVS levels.)
  - **sinusoidal vibration**
  - **random vibration**
  - **shock loads**
  - **resonance survey test**
- **Thermal and vacuum test: thermal cycling at low pressure conditions.**
- **Electric performance and over voltage test**
- **Development of Tools for Gravity compensations during deployment tests**

Test plan: deployment. GSE

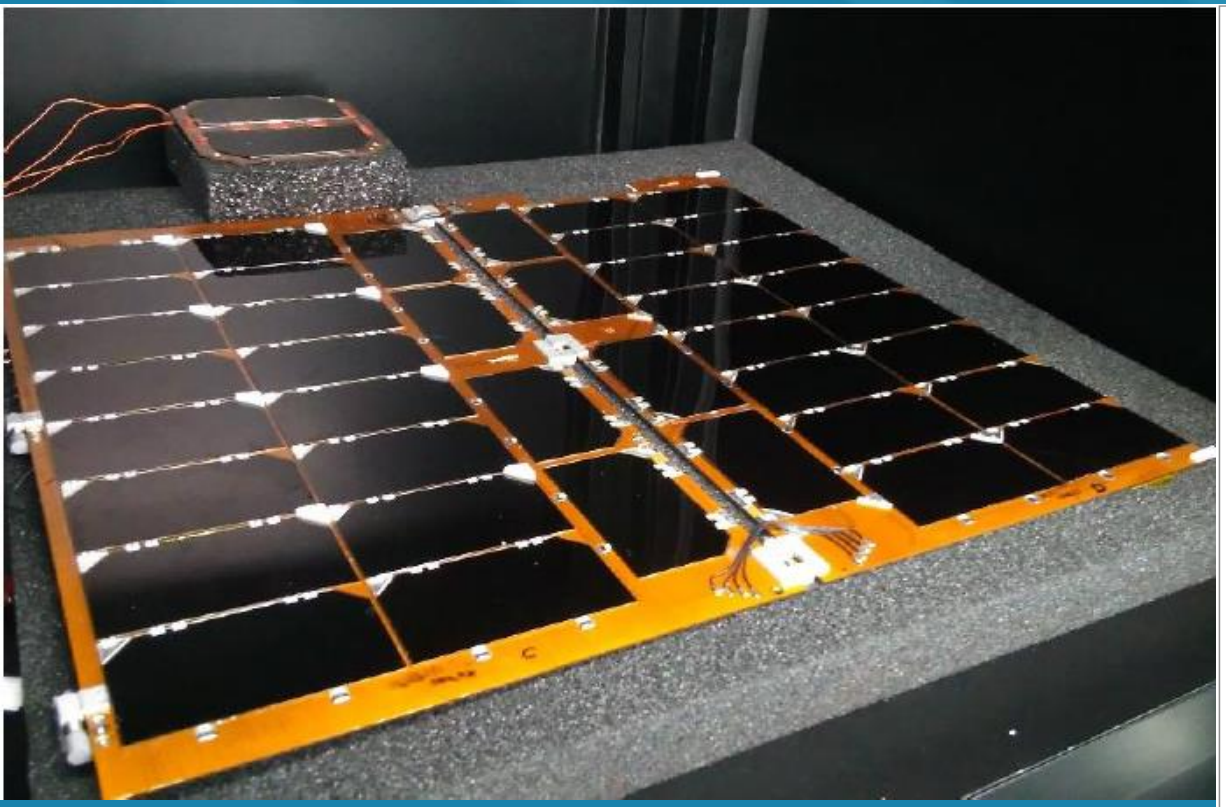
Test plan: deployment

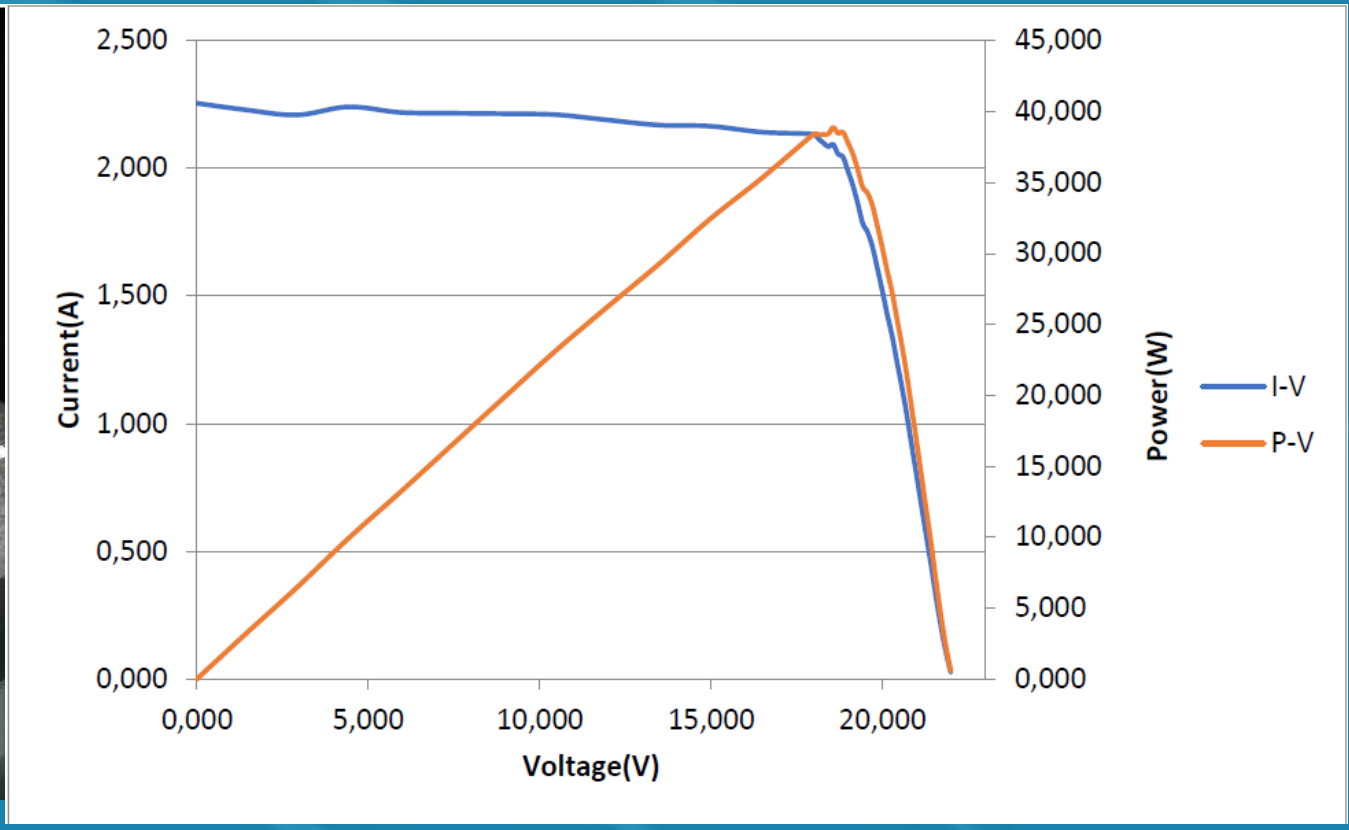
- **In house Deployment process by Ground Support Equipment**



Test plan: Flash test

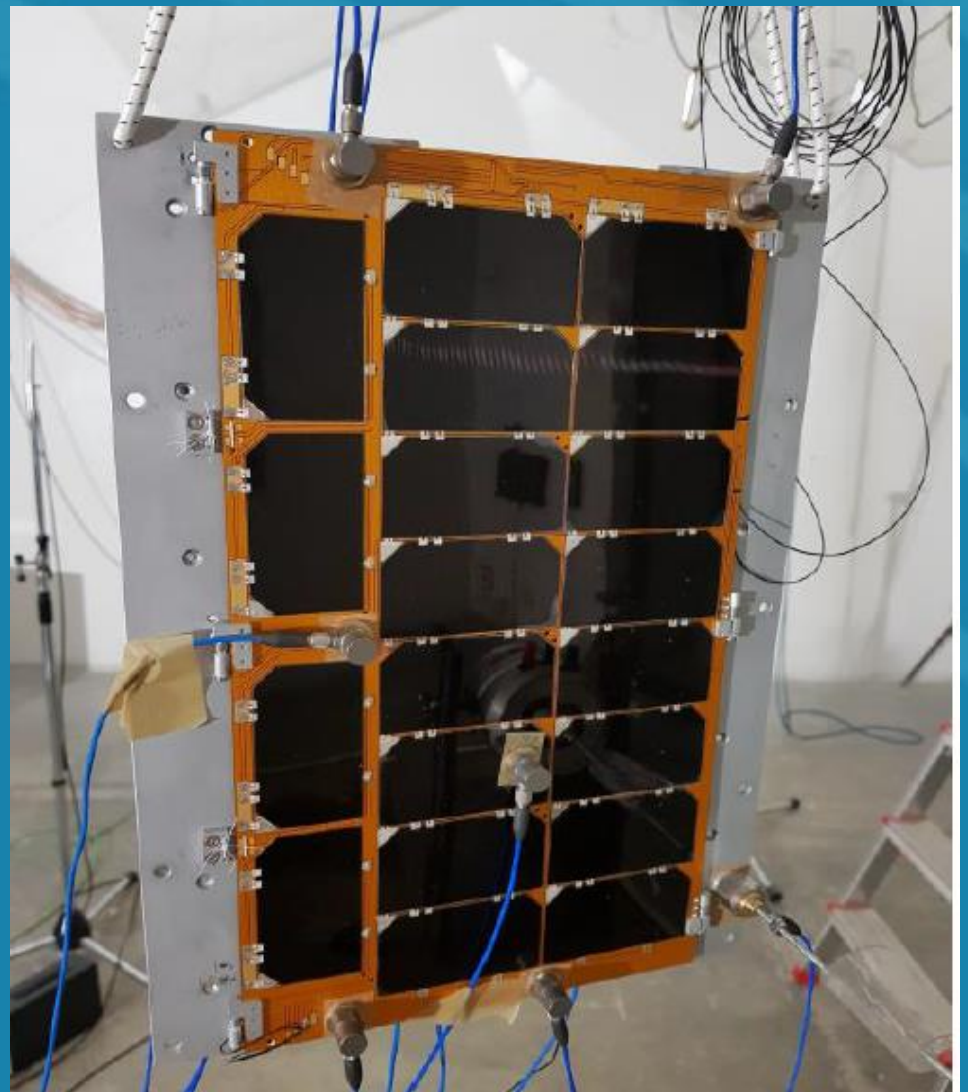
- **In house Flash IV Test: 40 W BOL per wing**





Test plan: Vibro acoustic

- **External Vibro acoustic test**



- **Structural model**
- **External Vibro acoustic test trapezoidal base: 5,7 m 7,35 m, 6,25 m and 6,3 m**
- **Height 4,90 ,**
- **Area 210 m2**
- **Volume 200 m3**

- **Plus 9 plane acoustic diffusers for a more diffuse field**

Conclusions

DHV is delivering to the market 3U & 6U for LEO but also interplanetary Missions

Full customized design according to mission requirements is always considered

FEM and mechanical simulation is a must

A dedicated test plan is carried out for each project. Engineering model is extremely recommended on a deployable cubesat mission

Acknowledgment

CDTI (Centro para el Desarrollo Tecnologico Industrial)

Contract: SNEO-20151346
Acronym: LEOSAT
Call: NEOTEC 2015
Execution: 2016-2017

Acknowledgment

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Contract: RTC-2016-4644-3
Acronym: DEEPSAT
Call: RETOS COLABORACION 2016
Execution: 2016 to 2018

Thanks so much for your kind attention

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