Design, Manufacturing & Qualification of 6U Deployable Solar Arrays for Deep Space Missions

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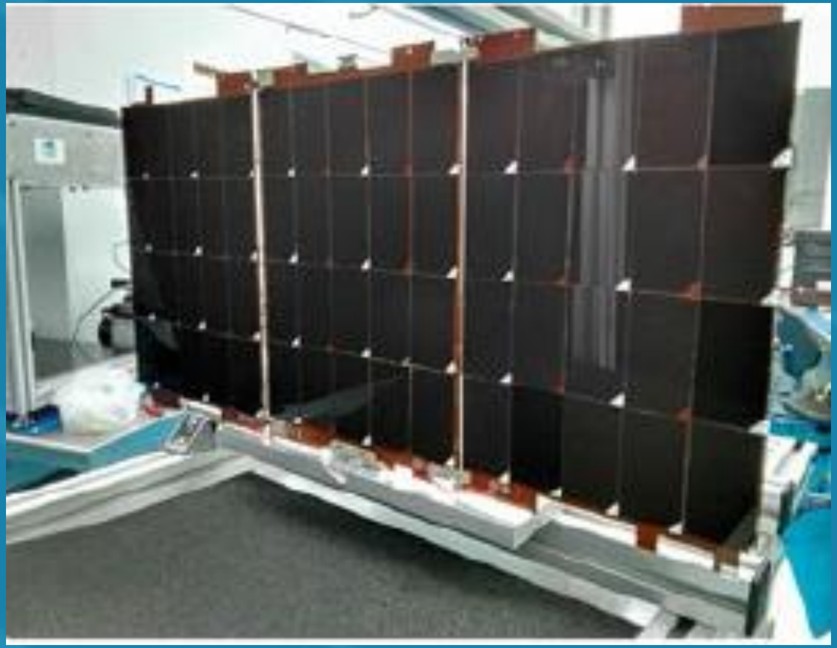


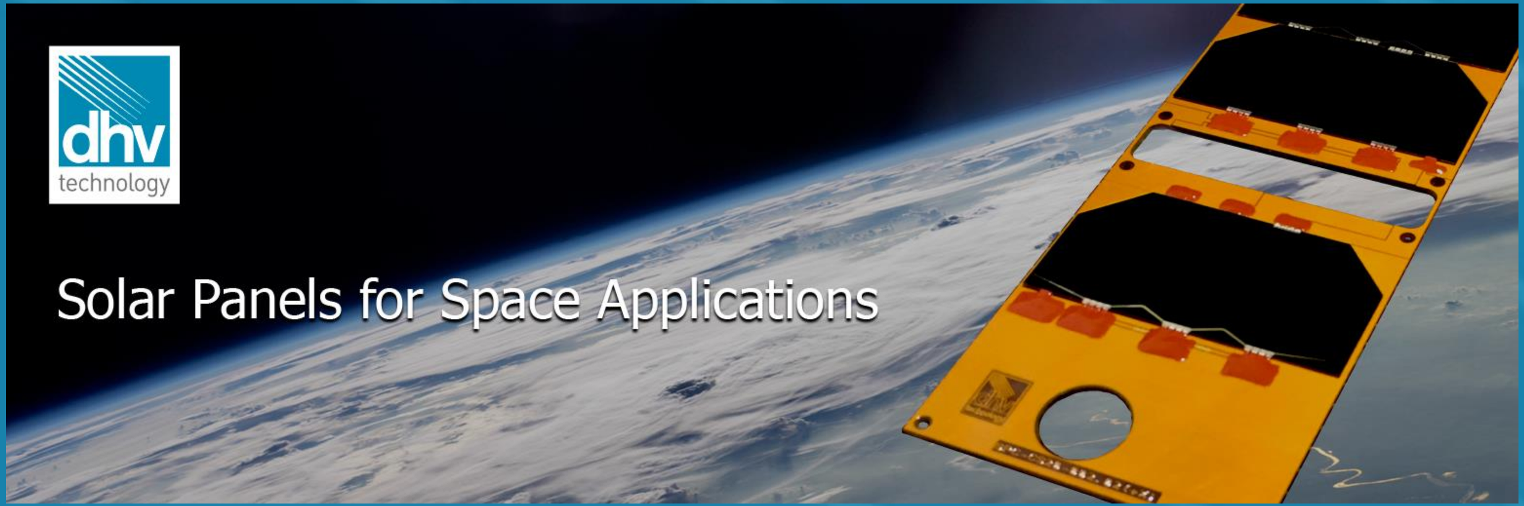
DHV TECHNOLOGY Málaga (Spain)

OUTLINE

- **Short Company presentation**
- **6U Mission for Deep Space**
- **Power needs & Radiation Harness & 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

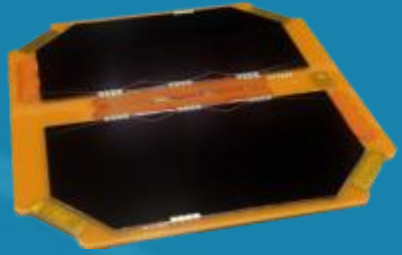
- **DHV Technology was funded on 2013, located in Malaga (Spain)**
- **Staff: 20 focused on Mechanical design, FEM analysis and simulations, solar panel testing and validation, solar cells**
- **Staff coming from high maturity markets: Photovoltaics, Defence, Electronic, Renewable companies. <u>Since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

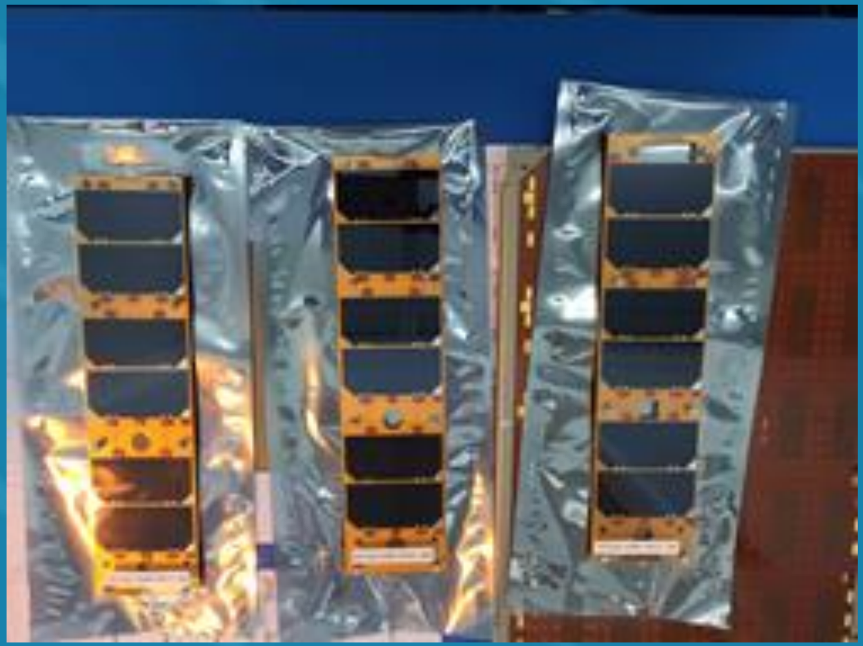
Company presentation

- **Solar Arrays of different architectures**

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

  Small Satellites

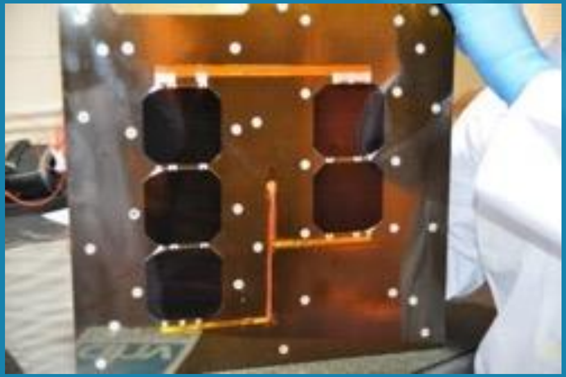


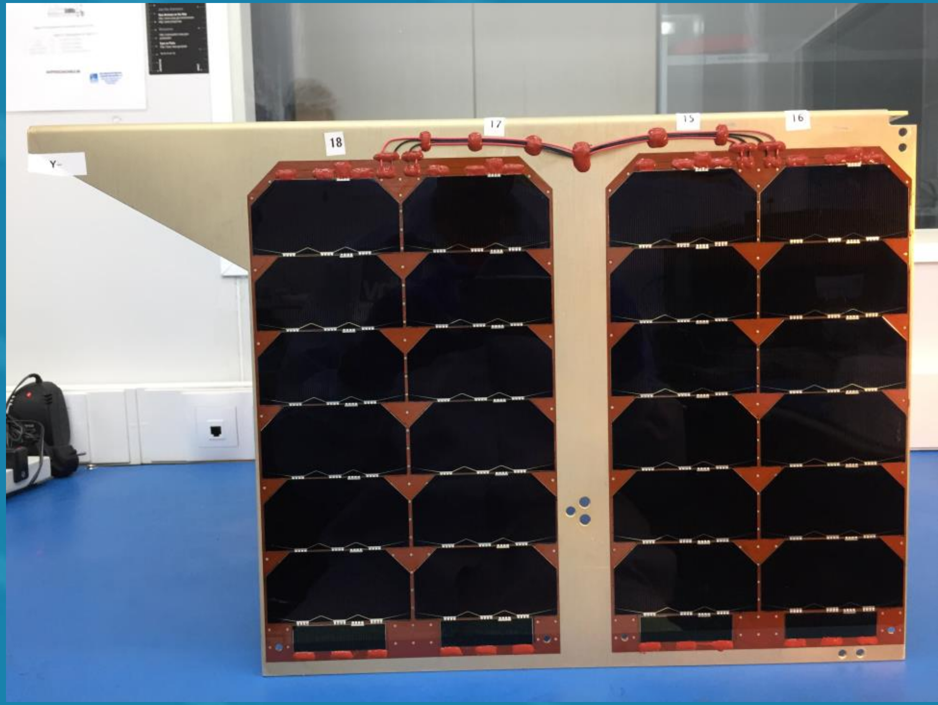


Company presentation

- **Solar Arrays for small satellite missions**

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

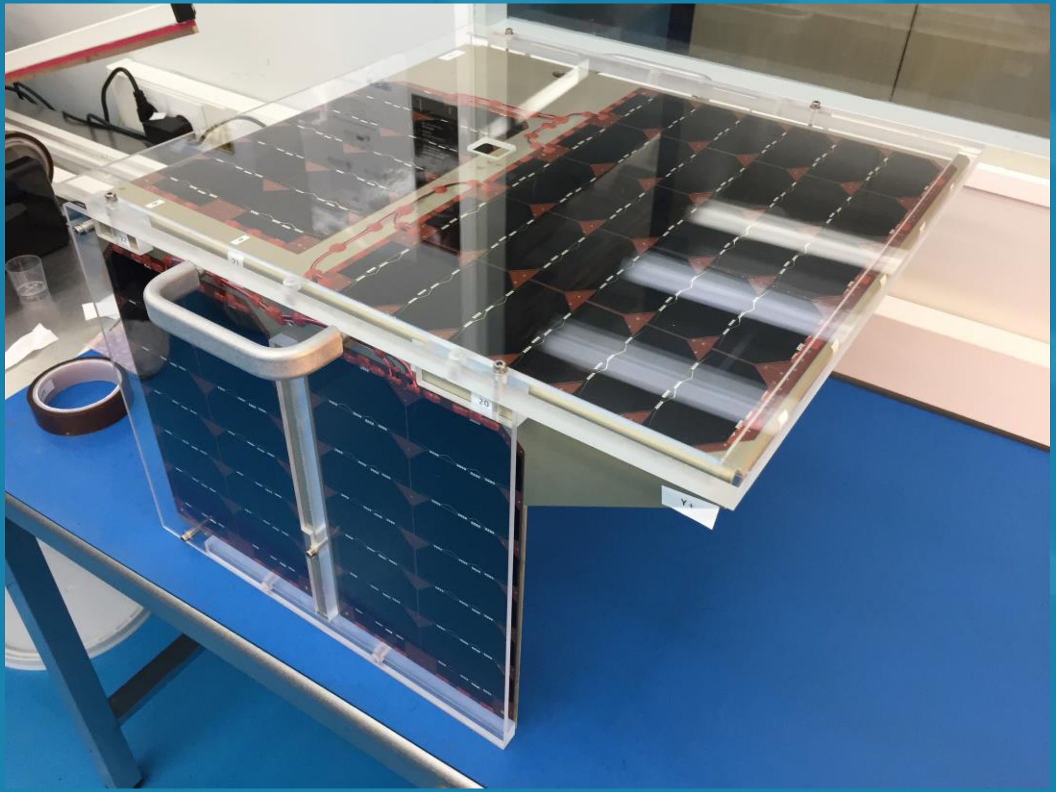


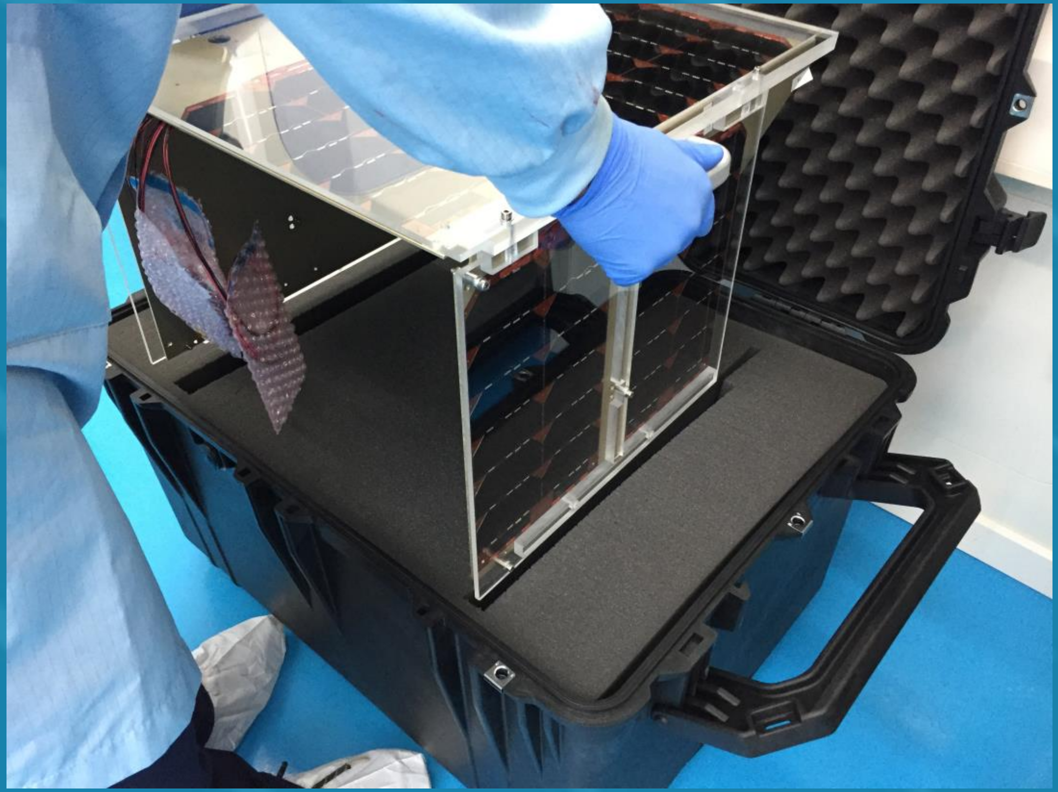


Company presentation

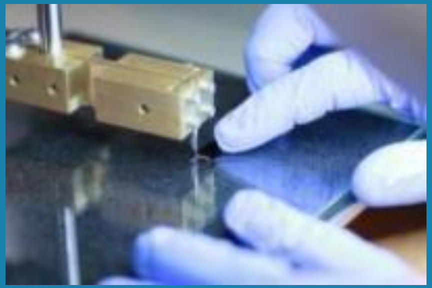
- **Solar Arrays for small satellite missions**

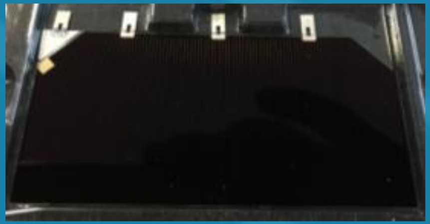
The solar panels manufactured using treated aluminium and kapton for solar cells string interconnection





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)

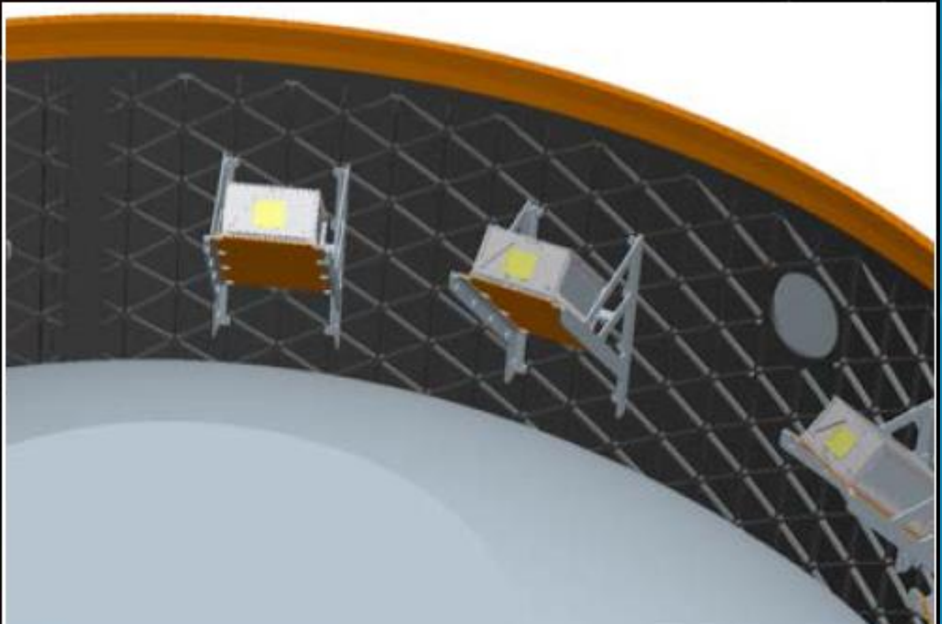
Weight: 5.75 million pounds (2.6 million kg)

Thrust: 8.8 million pounds (39.1 million Newtons)

Available: 2019

Secondary Paylooads

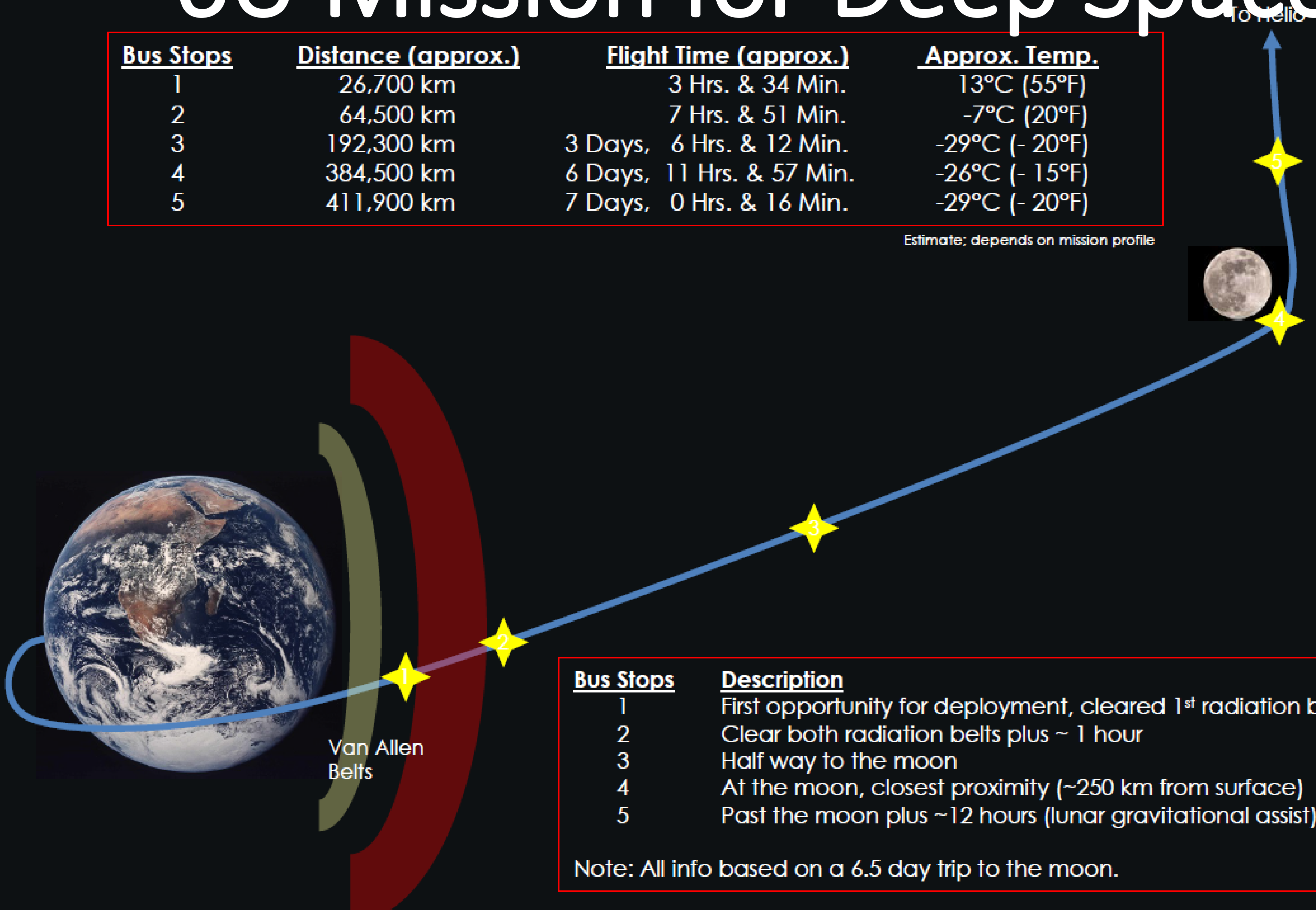
On Exploration Mission-1, SLS will include thirteen 6U payload locations of up to 14kg per CubeSat



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



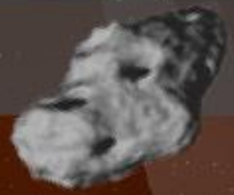
Bus Stops	Description
1	First opportunity for deployment, cleared 1st radiation belt
2	Clear both radiation belts plus ~ 1 hour
3	Half way to the moon
4	At the moon, closest proximity (~250 km from surface)
5	Past the moon plus ~12 hours (lunar gravitational assist)

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

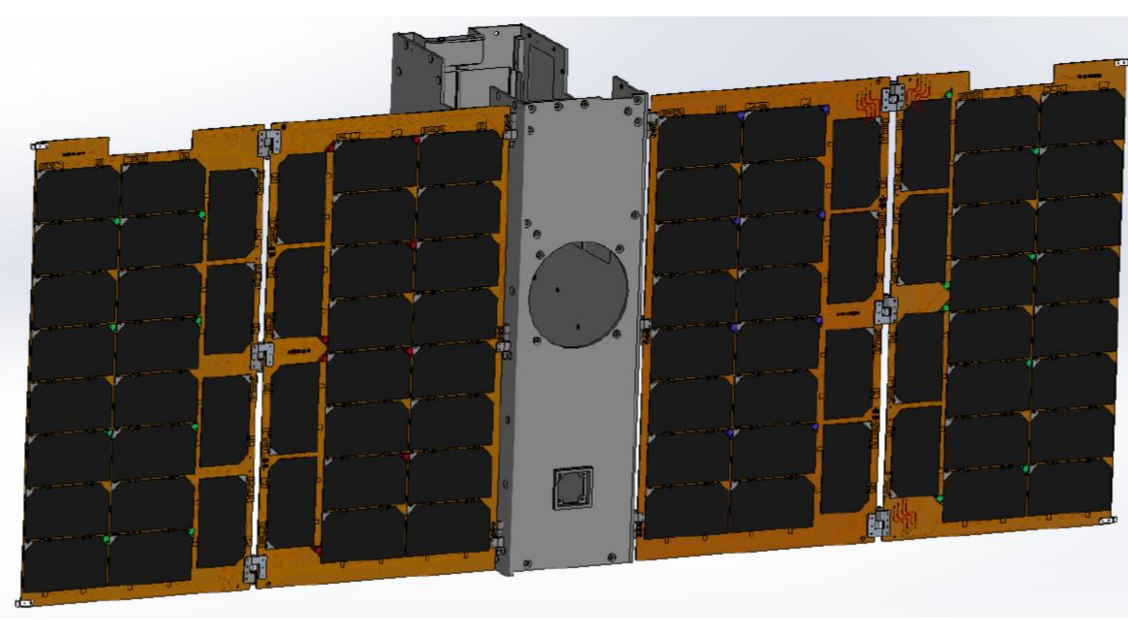
- EQUULEUS (JAXA)
- Skyfire (Lockheed Martin)

And Beyond

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

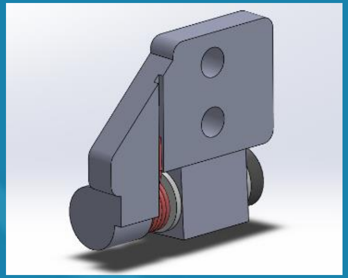
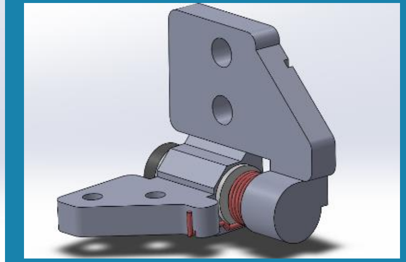
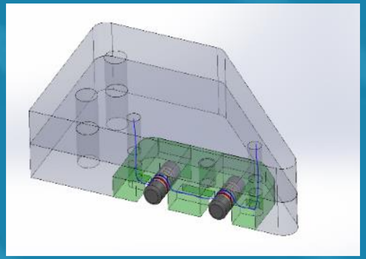
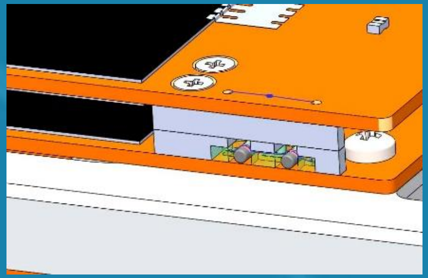
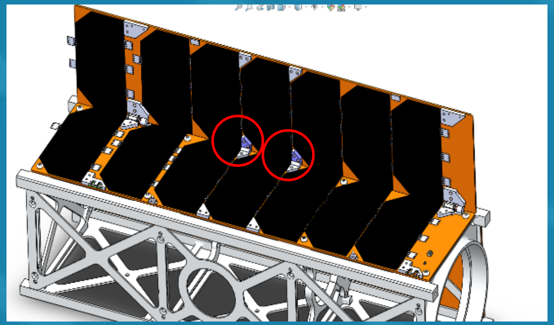
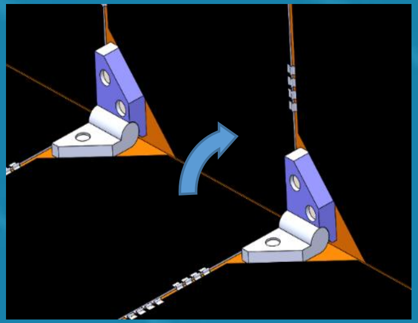
6U Power Needs, Radiation, Environmental Requirements

- **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 Acoustinc and TVAC test requirements**



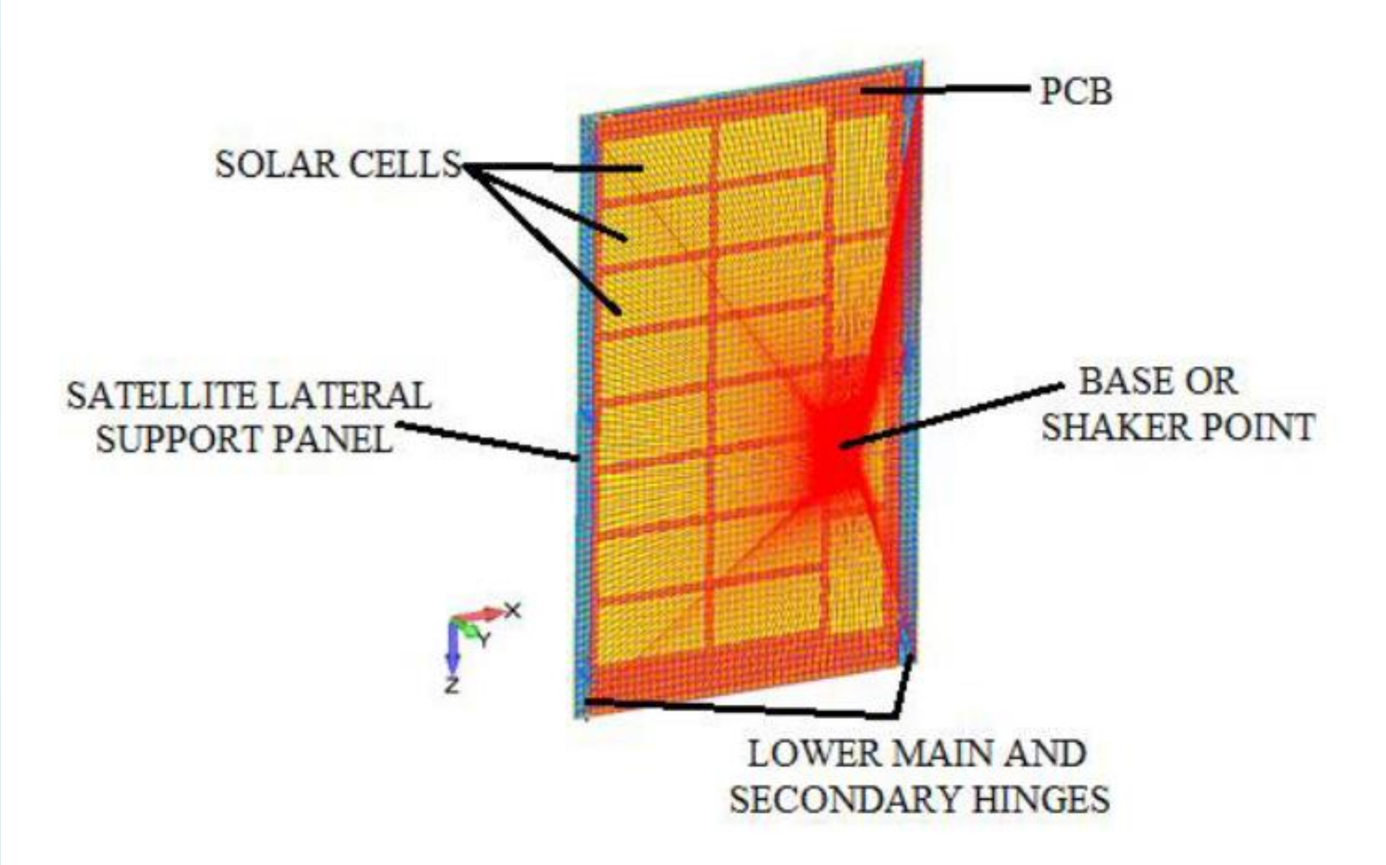
Design of Solar Panels

- **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, …**

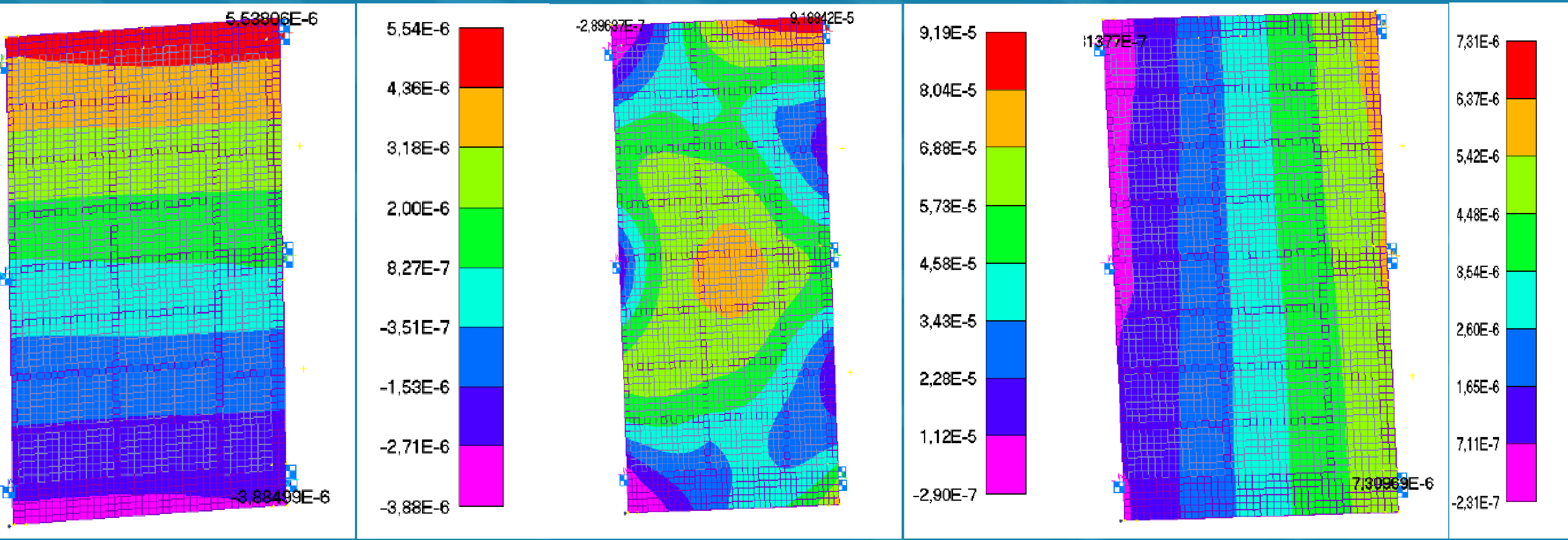
Simulations: modelling of the panels

- **Substrates have been modeled with linear plate elements**
- **Solar cells**
- **Interface with panels**
- **Hinges, connections to the satellites**
- **Torsion Springs**
- **Tie down**



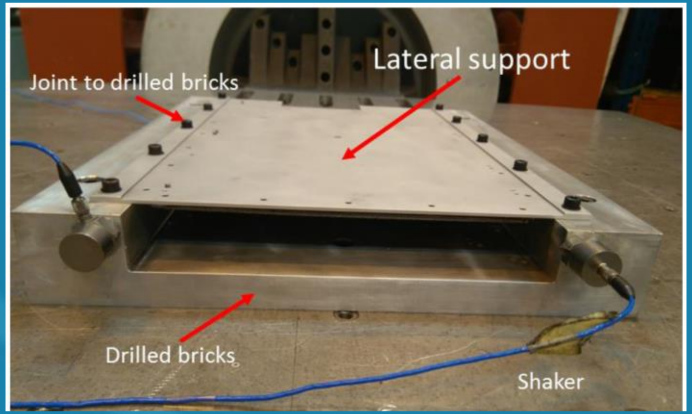
Simulations: results

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**



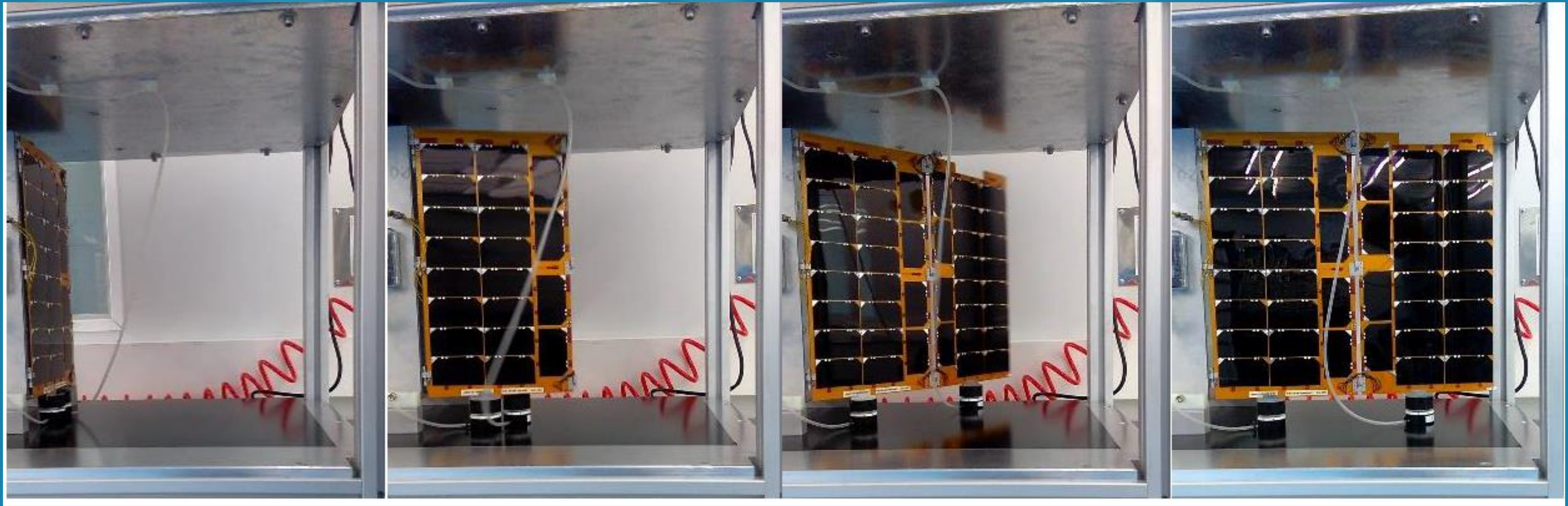
- **Thermal and vacuum test: thermal cycling at low pressure conditions.**

- **Electric performance and over voltage test**
- **Development of Tools for Gravity compensations during deployment tests**

Test plan: deployment. GSE

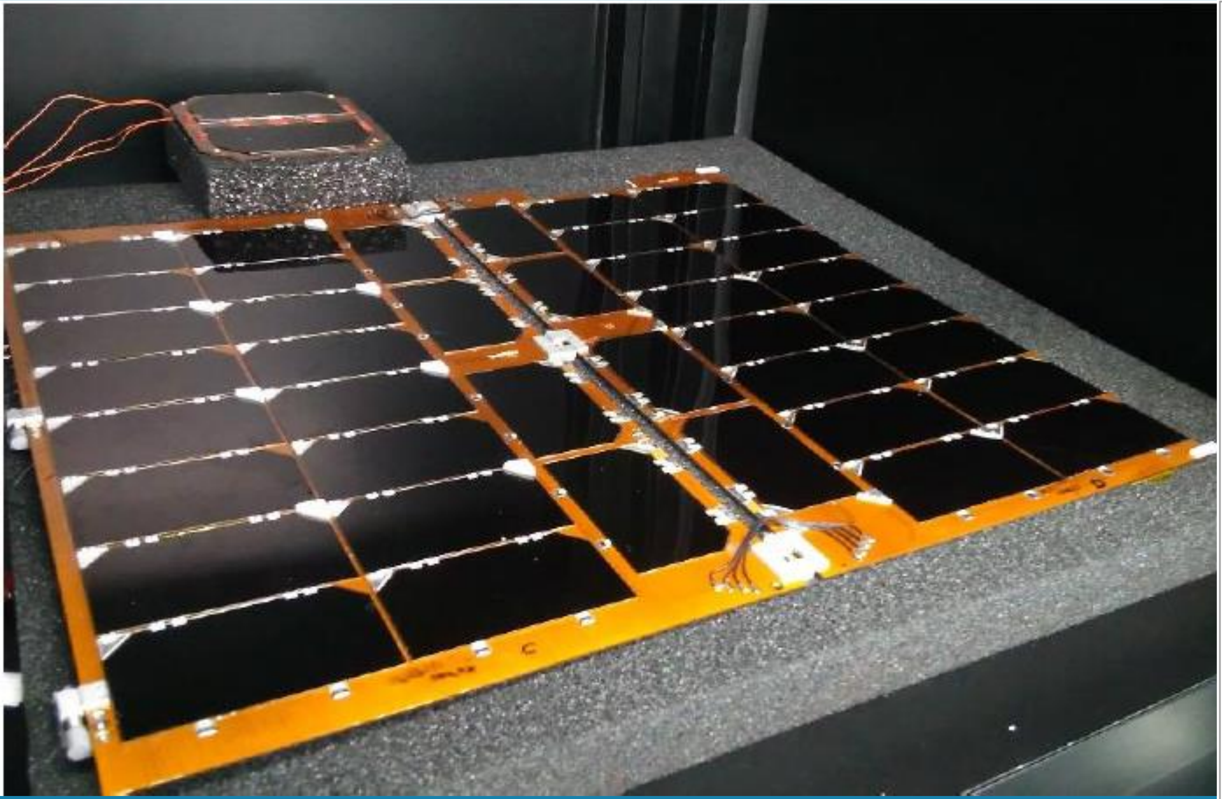
Test plan: deployment

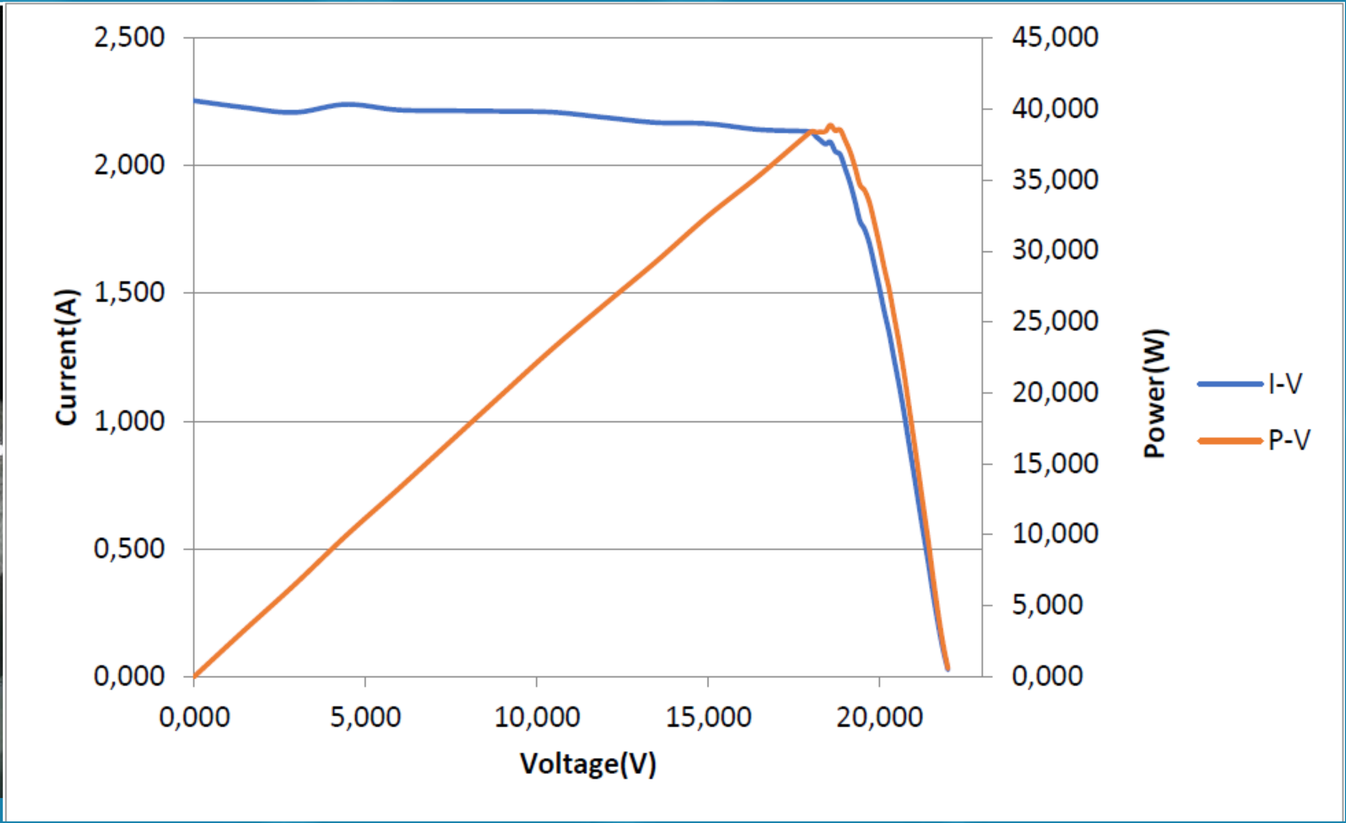
- **In house Deployment process by Ground Support Equipment**



Test plan: Flash test

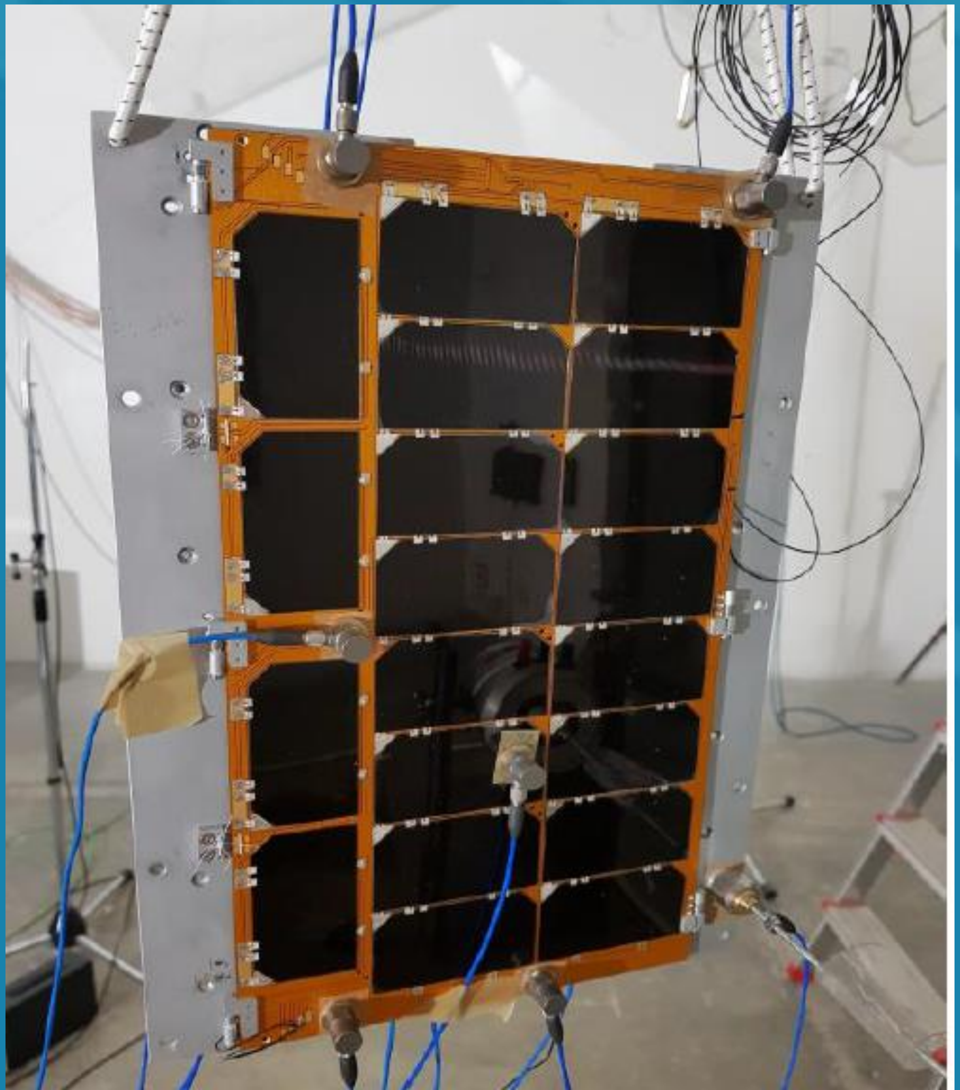
- **In house Flash IV Test: 40 W BOL per wing**





Test plan: Vibro acoustic

- **External Vibro acoustic test**



- **I a chamber of: 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

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Acronym: DEEPSAT
Call: RETOS COLABORACION 2016
Execution: 2016 to 2018

GOBIERNO DE ESPAÑA
MINISTERIO DE ECONOMÍA Y COMPETITIVIDAD

Thanks so much for your kind attention

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