Small Satellites Deployable solar panels for Deep Space Missions

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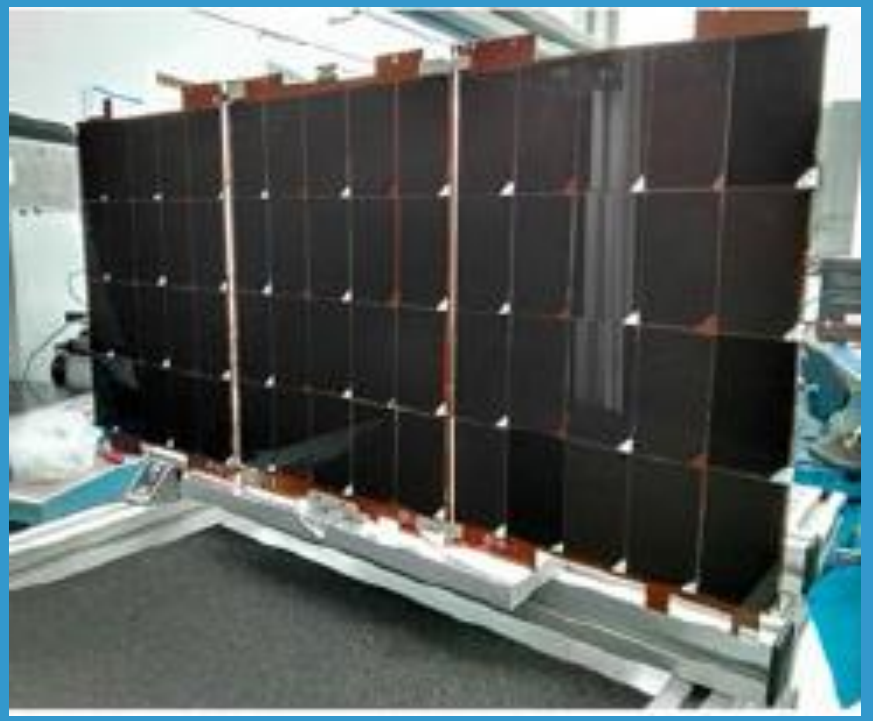


DHV TECHNOLOGY Málaga (Spain)

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

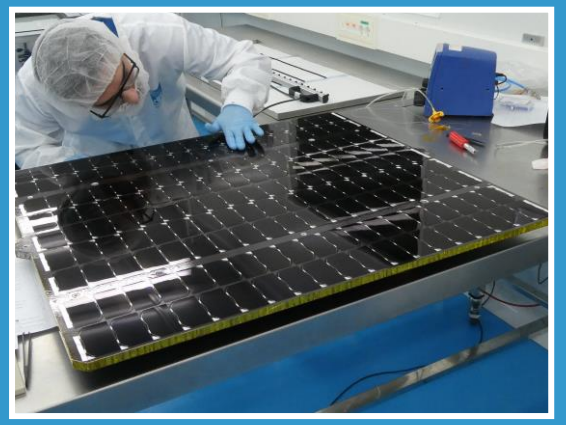
- DHV Technology was funded on 2013, located in Malaga (Spain)
- Staff: 54 focused on Mechanical design, FEM analysis and simulations, solar panel testing and validation, solar cells
- Staff coming from high maturity markets: Photovoltaics, Defence, Electronic, Renewable companies. Since 1995 in Solar Panels
- Facilities: Offices 1.400 m^2. ISO-7 clean room 1.200m^2 warehouse 850 m^2

Company presentation

- Welding, coverglass & bypass diodes performed in-house
- Solar panels are assembled and welded in-house
- On-site dry storage lockers for completed assembly storage prior to delivery

Company presentation

- Solar panels manufactured using manual or semi-automated processes
- DHV Technology manufactures solar panels using CFRP over an aluminium honeycomb core.
- Future capabilities include fully automated solar cell placement and bonding
- DHV Technology is developing end-to-end automated production capacity that streamlines inspections, inventory transactions, welding & encapsulation and final testing

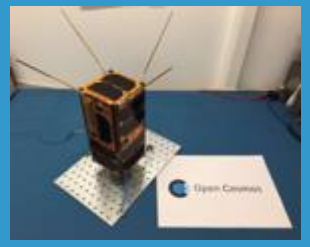
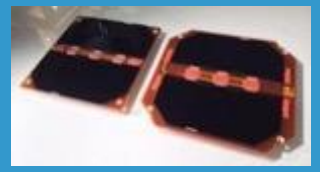
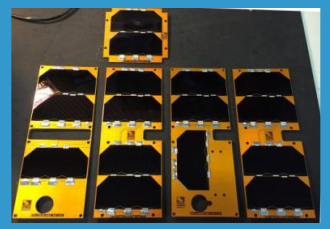
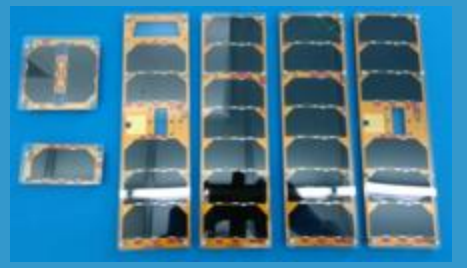
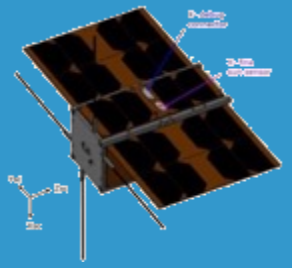


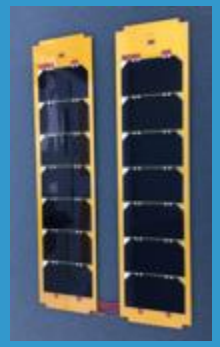
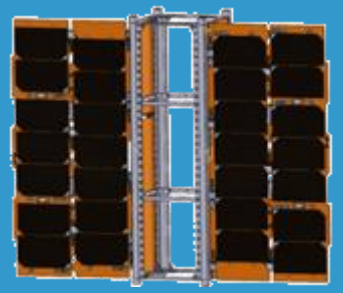
Company presentation

- **Solar Arrays of different architectures**

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

  Small Satellites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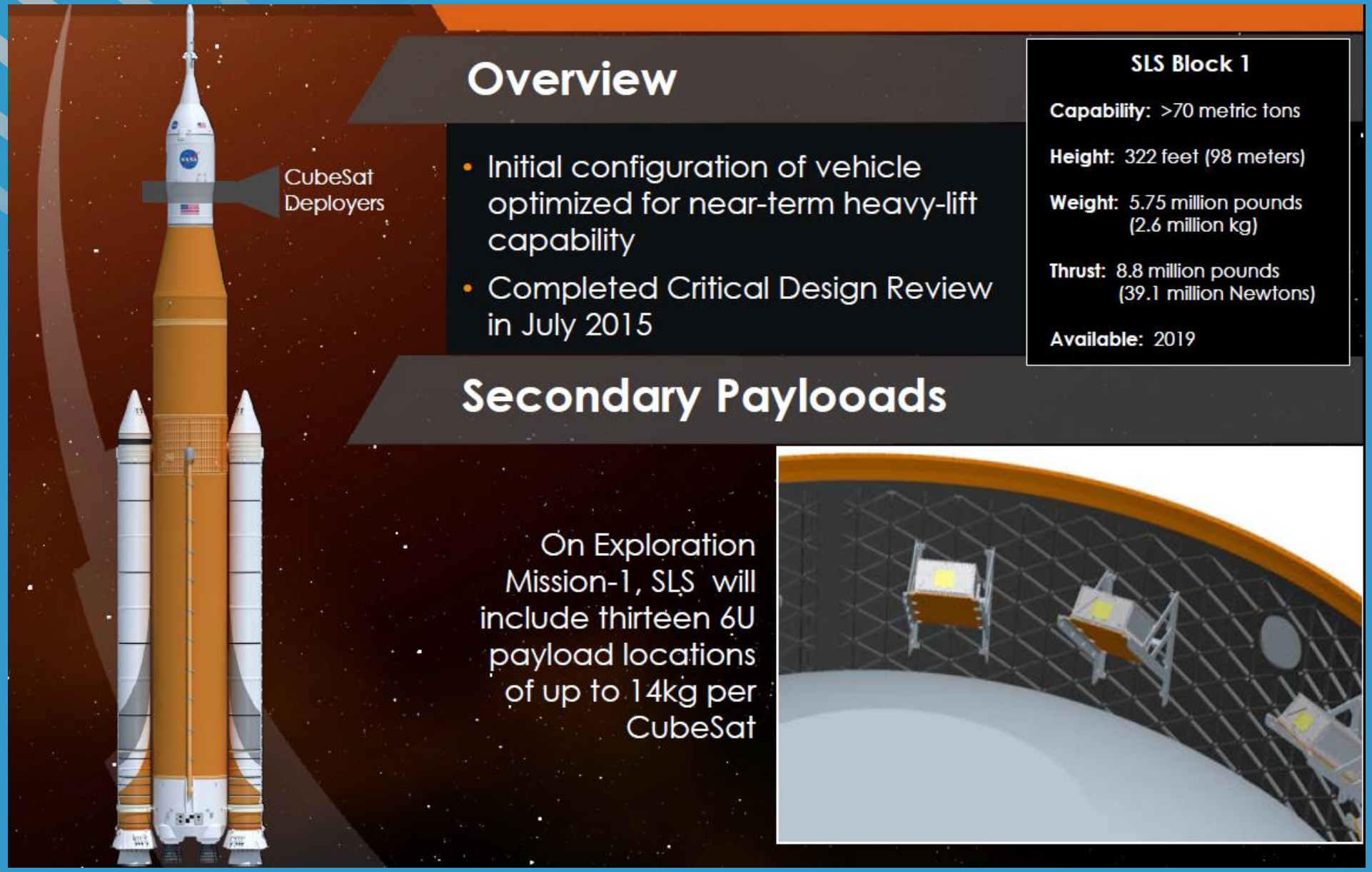
OUTLINE

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

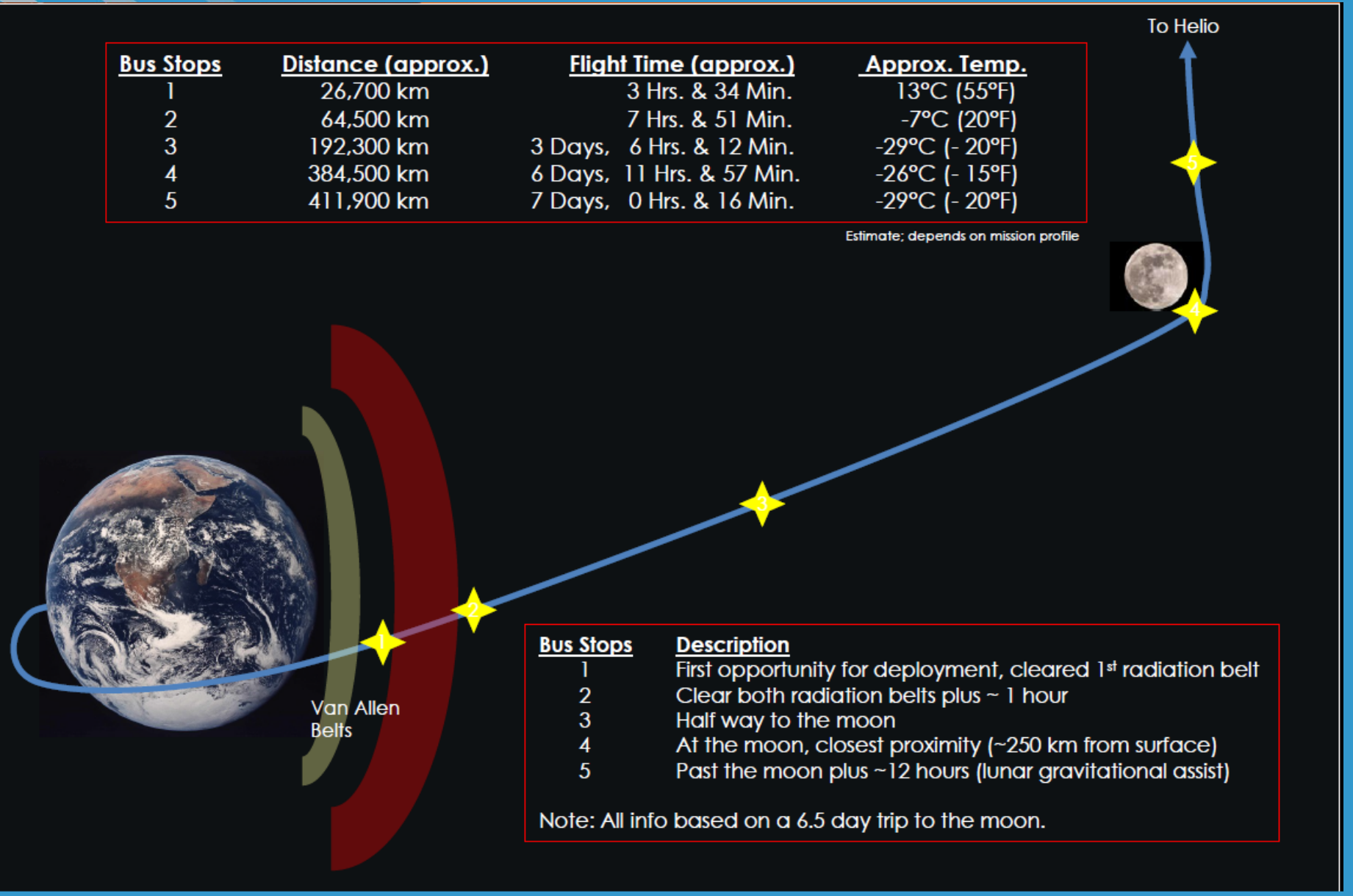
6U Mission for Deep Space



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.

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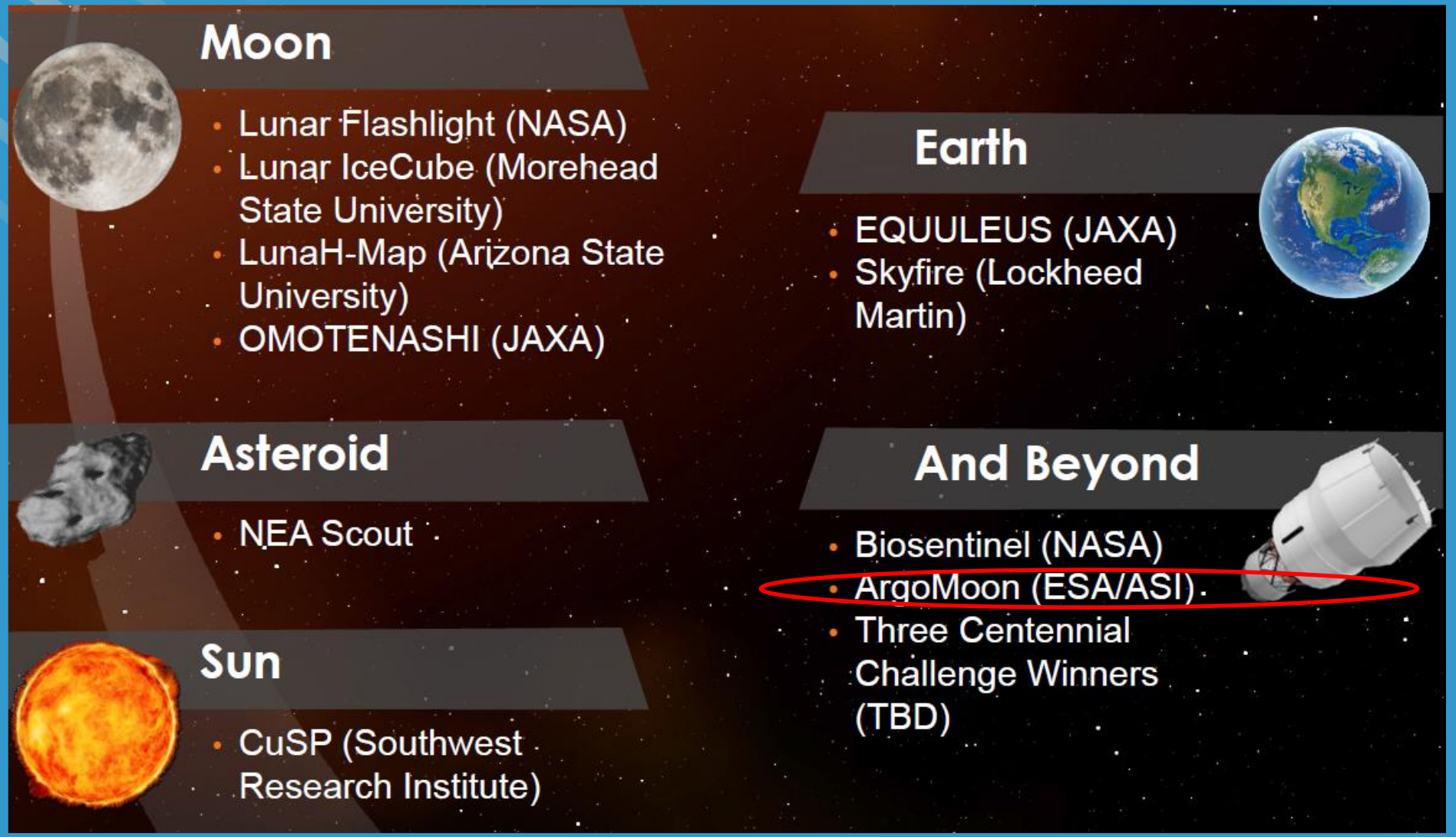
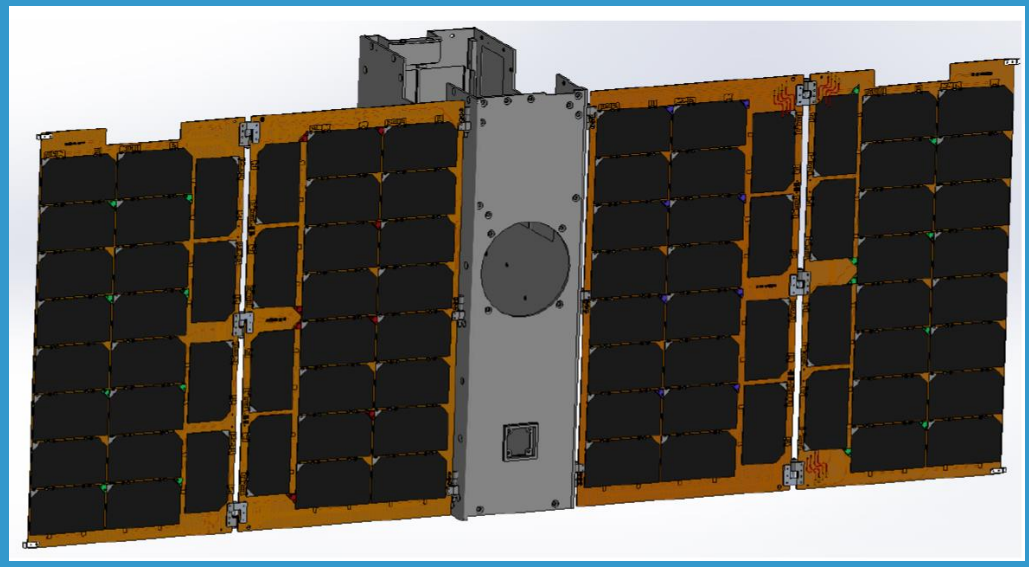
6U Mission for Deep Space



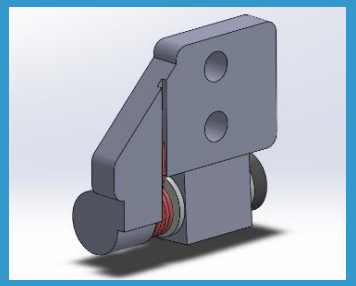
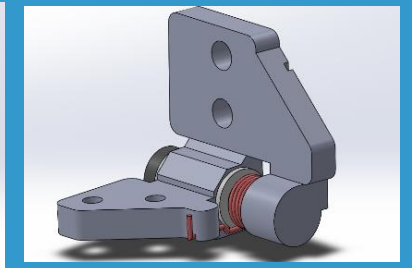
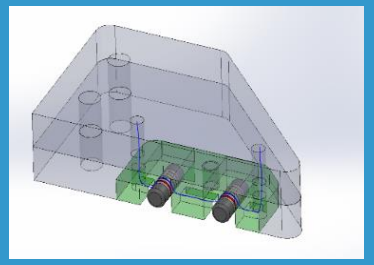
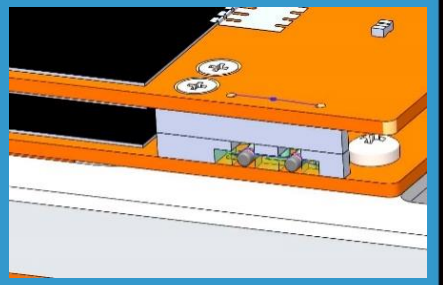
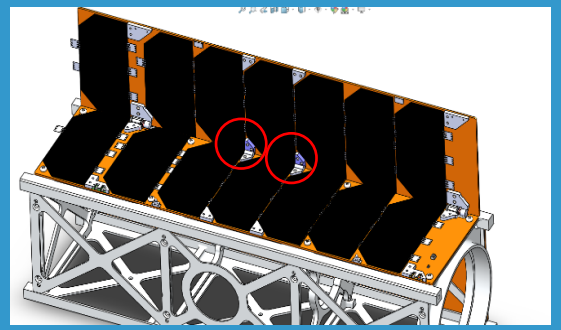
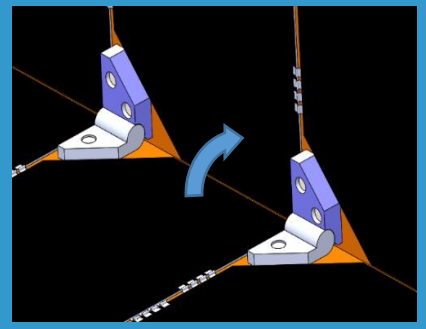
Power Needs, Radiation, Environmental Requirements

- 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



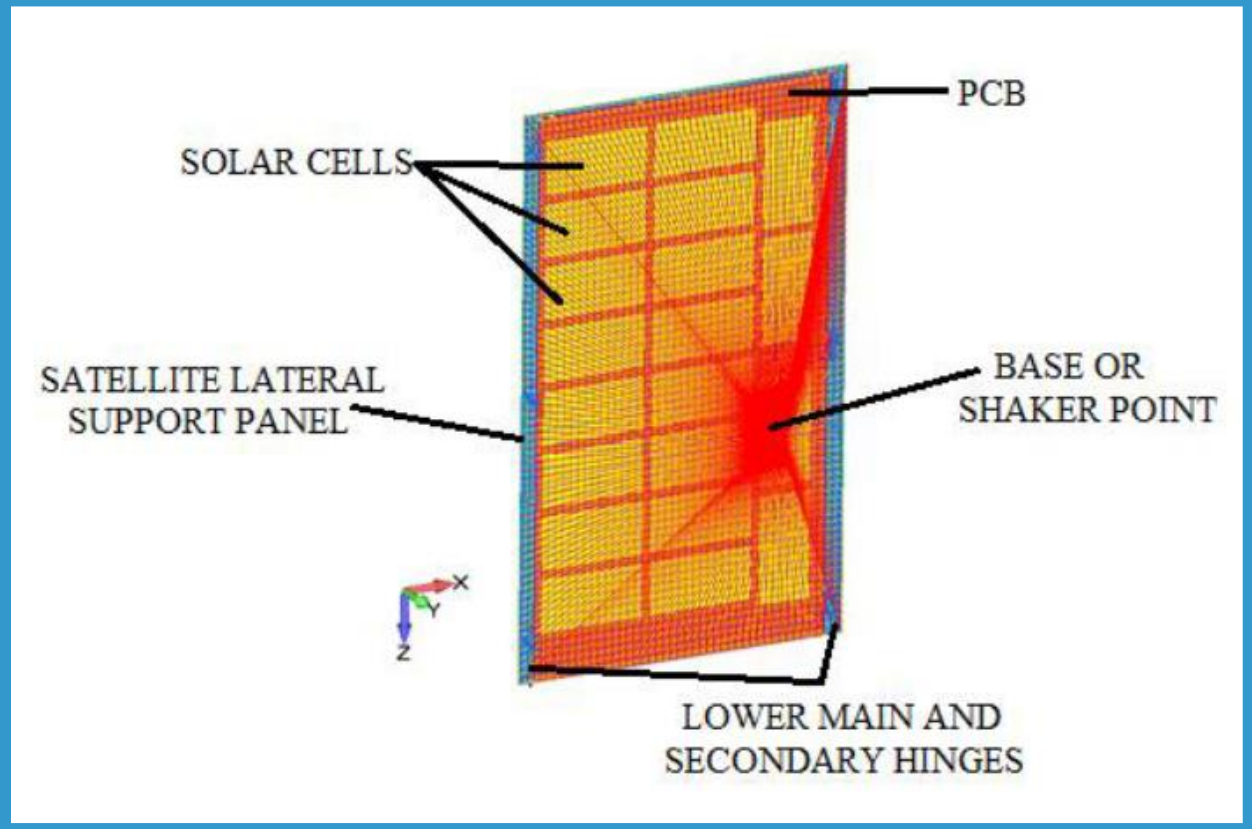
Design of Solar Panels

- 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, …

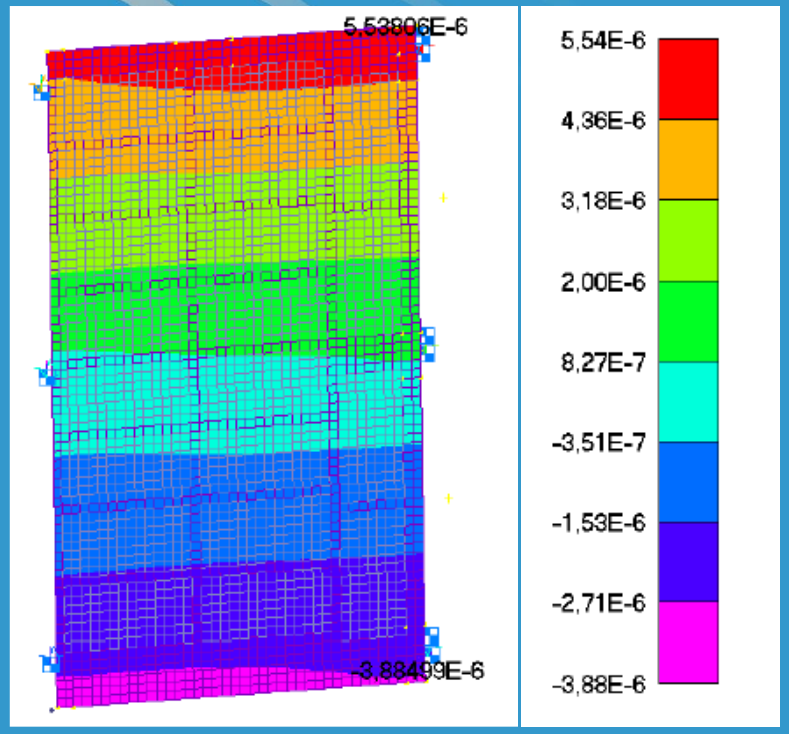
Simulations: modelling of the panels

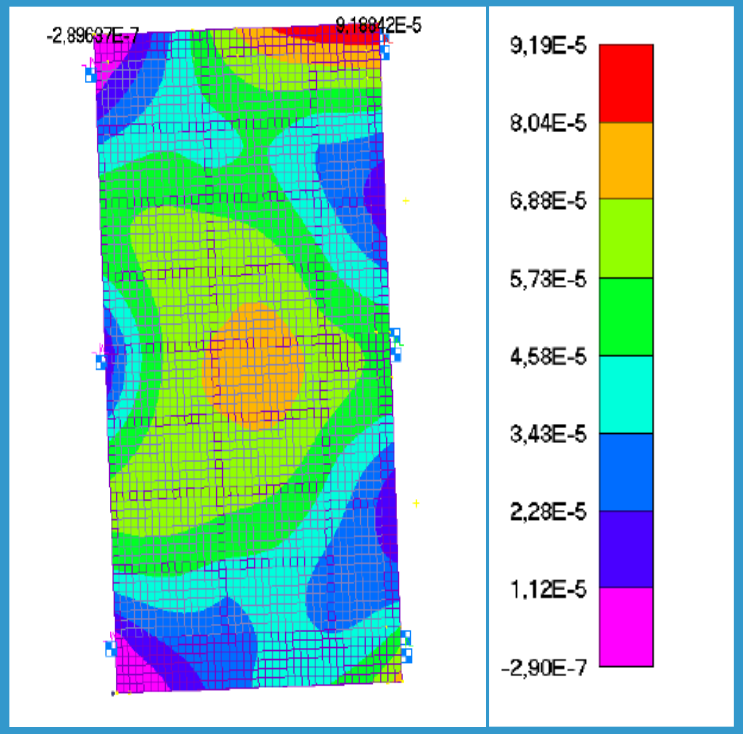
- Substrates have been modeled with linear plate elements
- Solar cells
- Interface with panels
- Hinges, connections to the satellites
- Torsion Springs, Tie down
- First mode 140 Hz
- Static Load 45 g

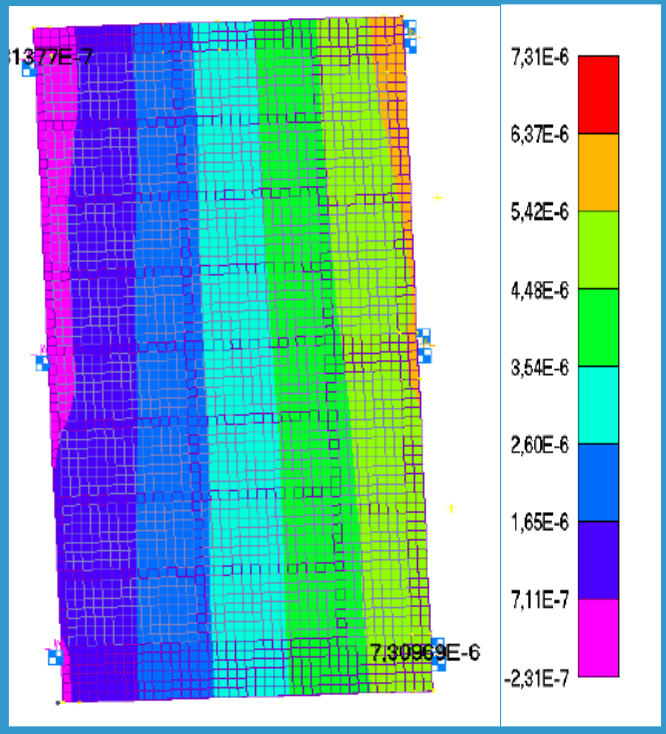


Simulations: results

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

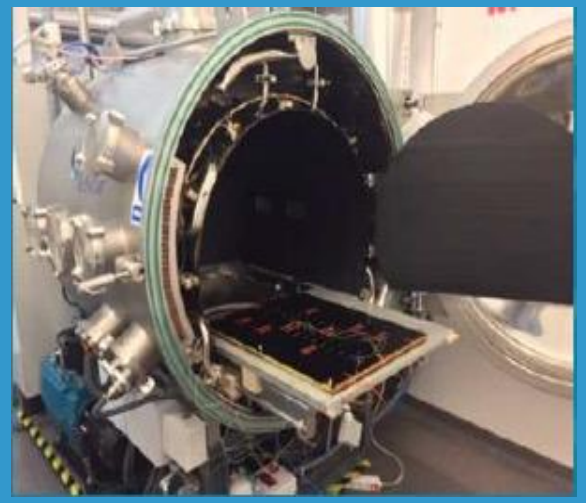






Test plan

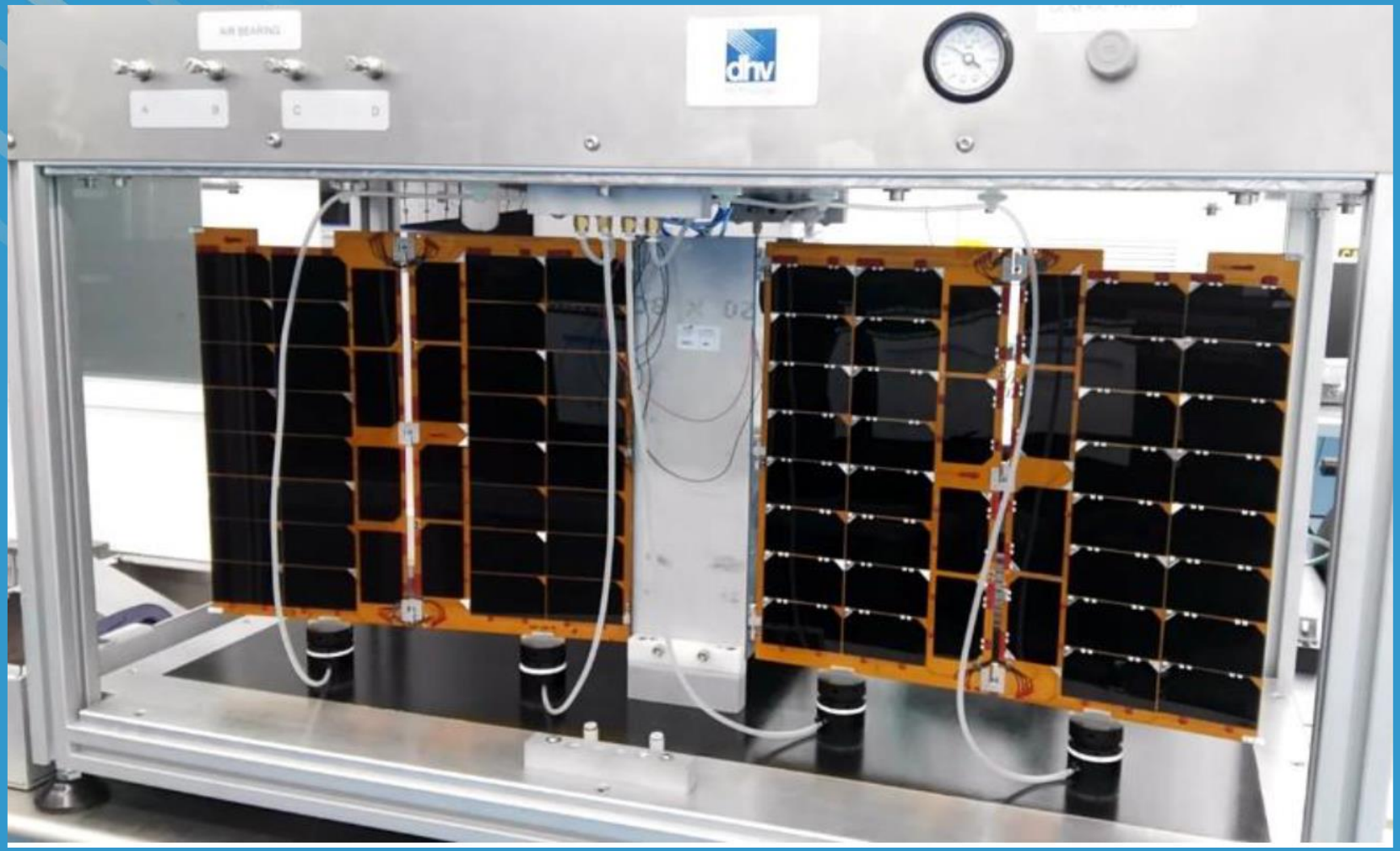
- **Mechanical and vibration tests:** (GSFC-STD-7000A standard, NASA GEVS levels.)
  - **sinusoidal vibration**
  - **random vibration**
  - **shock loads**
  - **resonance survey test**



- **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



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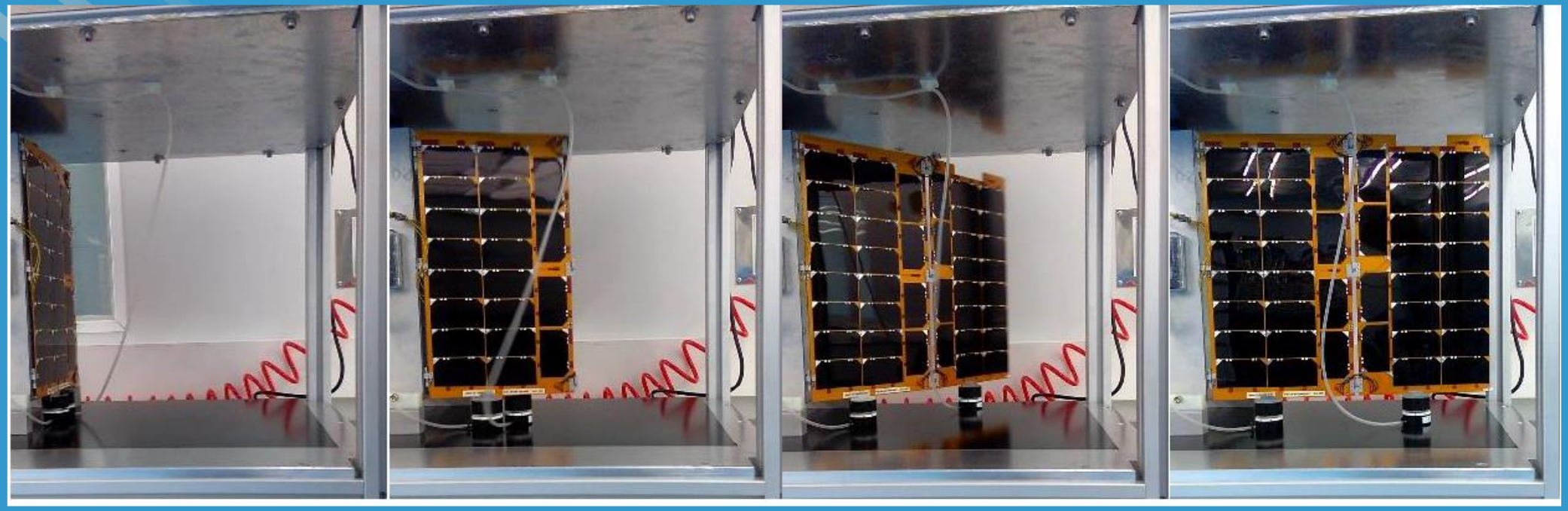
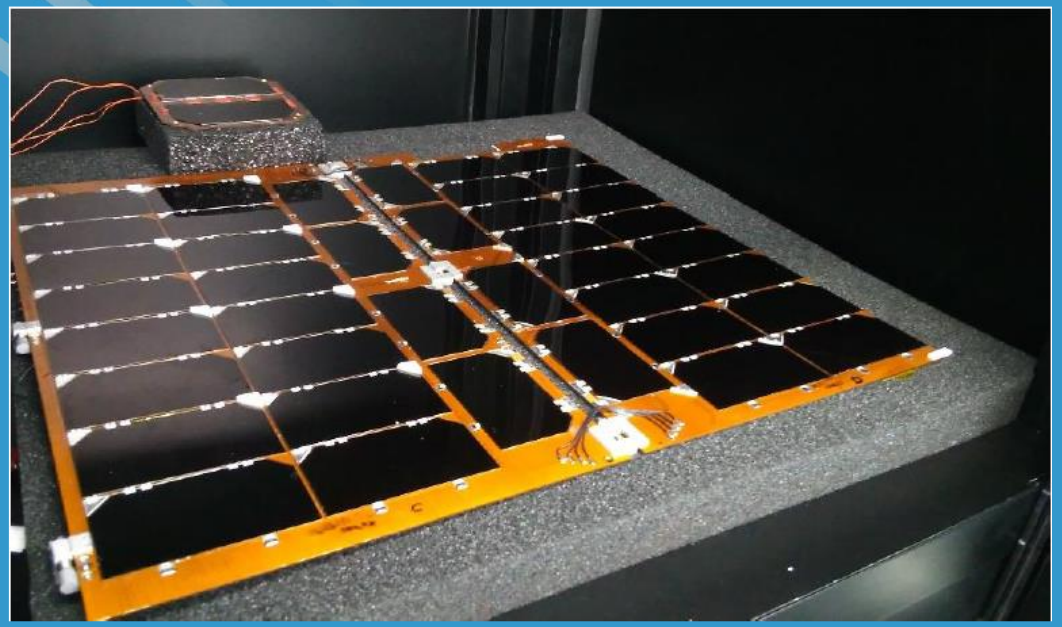
Test plan: deployment GSE

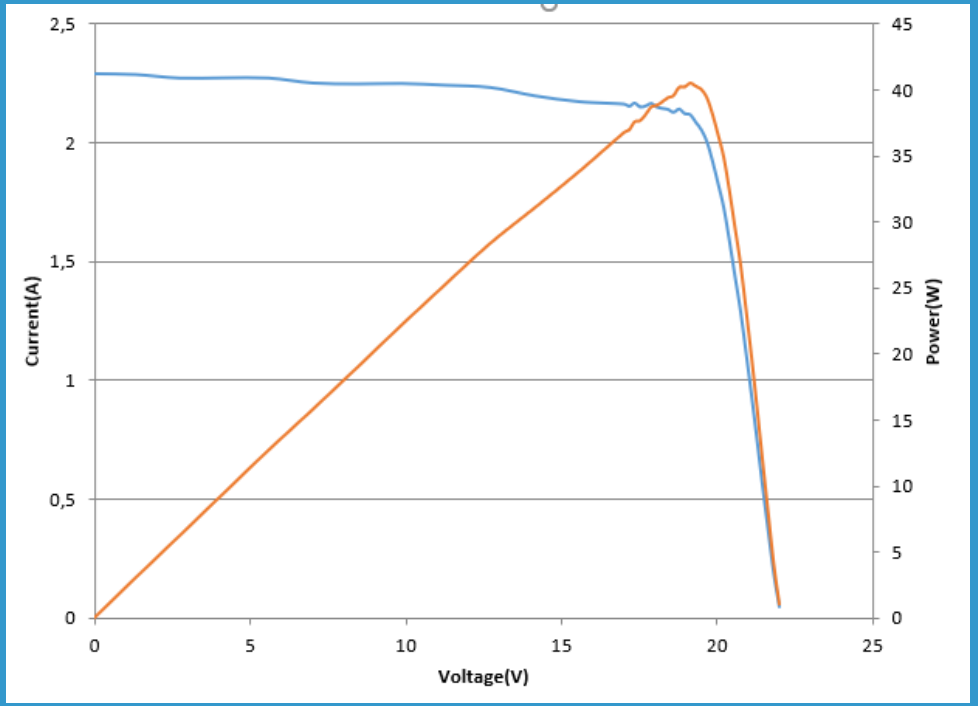
- **In house Deployment process by Ground Support Equipment**



Test plan: IV test

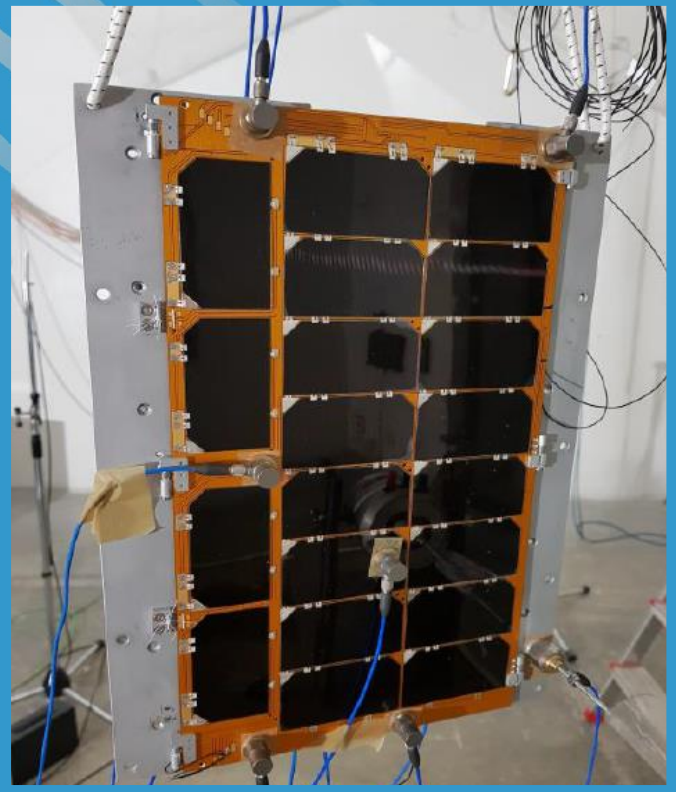
- **In-house Flash IV Test: 40 W BOL per wing**





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**

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Conclusions

- DHV is delivering to the market Solar Panels for Small Satellites and Cubesats 3U,6U, 12U for LEO but also interplanetary Missions

- Full customized design according to mission requirements is considered
- and executed

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

Thanks so much for your kind attention

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