

Space Power Workshop 2019

Torrance Marriott Redondo Beach, CA

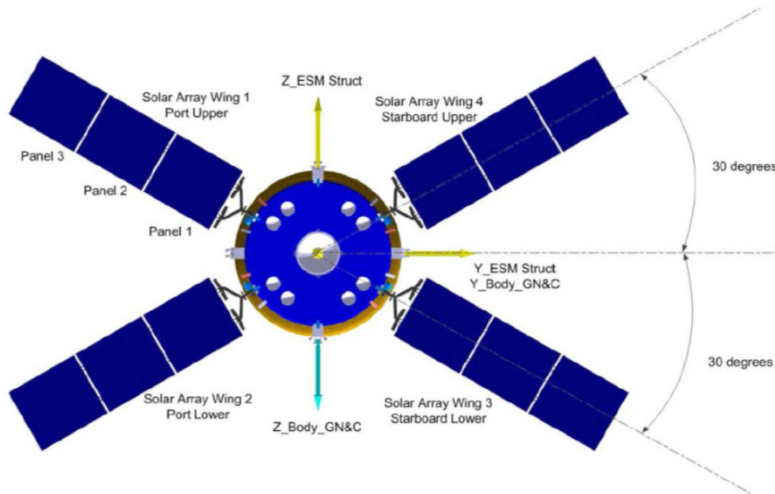
Multi Purpose Crew Vehicle – Photo Voltaic Assembly (PVA) from development to Flight

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Presentation outlook

- The MPCV mission
- PVA description
- Qualification results
- Main results
- Flight manufacturing and acceptance status



The MPCV Missions (from PVA perspective)

Design Reference Mission	Specifics	Mission Time (days)	Further Requirements	Envelope Time & Radiation Environment	Consolidated Mission
1. Uncrewed Lunar Flyby	LEO 185 x 1806 km Lunar Flyby Orbit (LO) 100 - 200 km	10			<u>Lunar + ISS</u>
2. Crewed High Lunar Orbit (HLO)	LEO 185 x 5600 km High Lunar Orbit (HLO) 1000 – 10 000 km	14	<u>ESA.MSA.0084</u> <i>"The SM shall provide active vehicle transit operations for a min. of 21 days for lunar missions"</i>	21 days Lunar environment: Solar particle events and Galactic cosmic rays (SPE and GCR)	
3. Uncrewed Lunar surface	Low lunar orbit (LLO) 100 km	7	<u>ESA.MSA.0002</u> <i>"The SM shall support an Orion Spacecraft loitering uncrewed in LLO for at least 7 days"</i>		
4. ISS	278 - 460 km (LEO)	216	<u>ESA.MSA.0006</u> <i>"Min. 6 days active"</i> <u>ESA.MSA.0007</u> <i>"Min. 210 days being docked"</i>	216 days LEO: Trapped electrons and protons, Van Allen Belts, solar particle events	

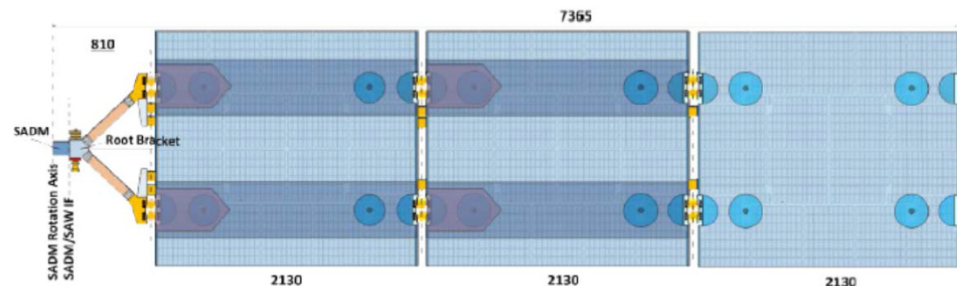
Photo Voltaic Assembly (PVA) Technology Challenges

- Technological challenges
 - US standard size SCA's
 - Extreme low temperature, qualification environment for lunar mission (-205° C)
 - High bus voltage compared to heritage mission (LEO – ISS)
 - Difficult definition of common “boundaries”
- Main suppliers / partners
 - Solaero (US), solar cell assemblies manufacturer
 - Airbus DS NL for the substrate
 - ESA (The Netherlands), Airbus Toulouse – ITS (France) test facilities for qualification and acceptance

MPCV Photo Voltaic Assembly (PVA)

- Leonardo responsible for design, qualification and production of PVA for the MPCV Solar Array
- Contractual customer is Airbus DS Netherlands B.V.
- Spacecraft prime is Airbus DS Bremen
- Solar cell assemblies are CFI from Airbus - LMC (Solaero)
- NASA – ESA joint program

- PVA Key facts
 - 14904 solar cells installed on a total area of 49 m² area
 - 12 panels 2,1 m x 1,9 m each, ~ 70 kg mass x wing (including substrate and mechanisms)
 - More than 11 kW EOL SS developed power @ 125 V bus voltage

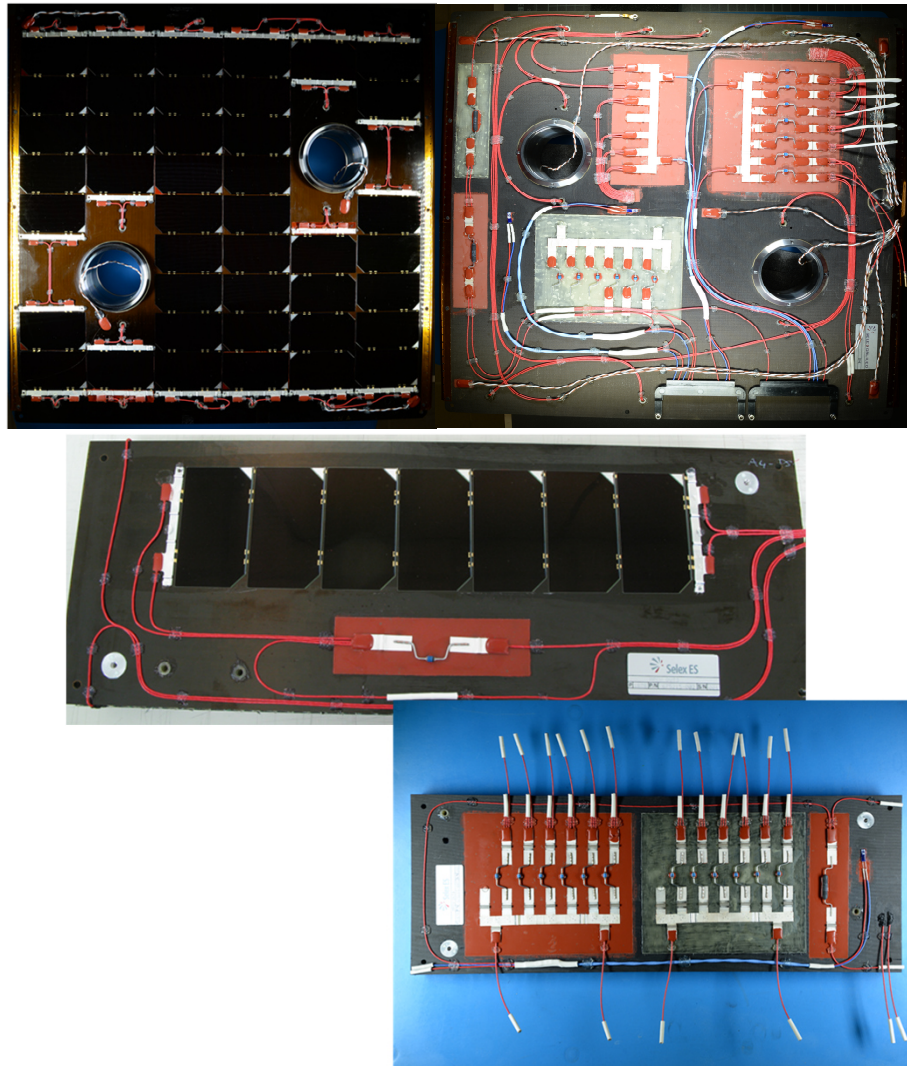


Courtesy of ADSNL

Main results

- Main achievements
 - Qualification for the worst case lunar environment completed
 - QM model successfully delivered
 - ESM1 PVA successfully delivered and SA under S/C integration
 - ESM2 PVA under manufacturing
- Next events
 - ESM2 acceptance test campaign to be completed within Q4 2019
 - Likely change of the thermal vacuum temperature acceptance profile
 - Delta qualification for covering future LEO missions

DVT models qualification



- A number of DVT coupon have been manufactured for qualifying baseline and backup technologies
- Issues discovered at the beginning of the qualification campaign were covered by delta activities
- Extensive TV cycles
 - 10 cycles @ $-214^{\circ}\text{C}/+150^{\circ}\text{C}$
 - 350 cycles @ $-177^{\circ}\text{C}/+150^{\circ}\text{C}$
 - 13 cycles @ $-214^{\circ}\text{C}/+150^{\circ}\text{C}$
- Simulation of long term storage conditions
 - 30 days @ 60°C and 90% RH

QM panels



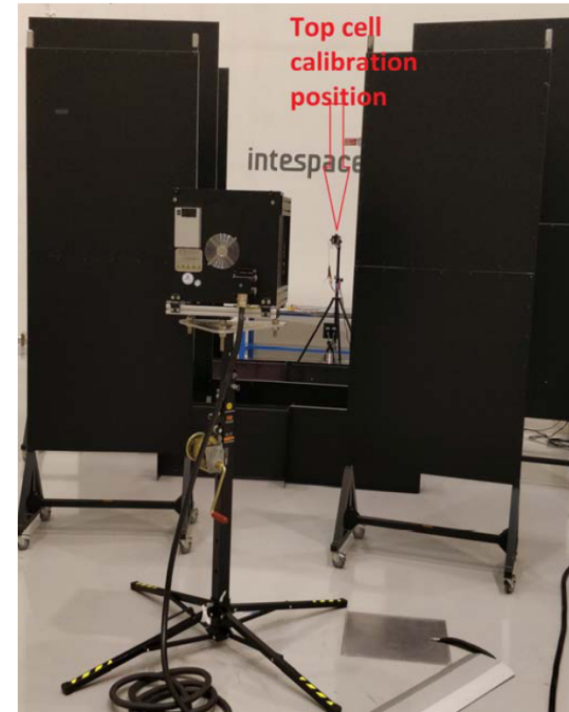
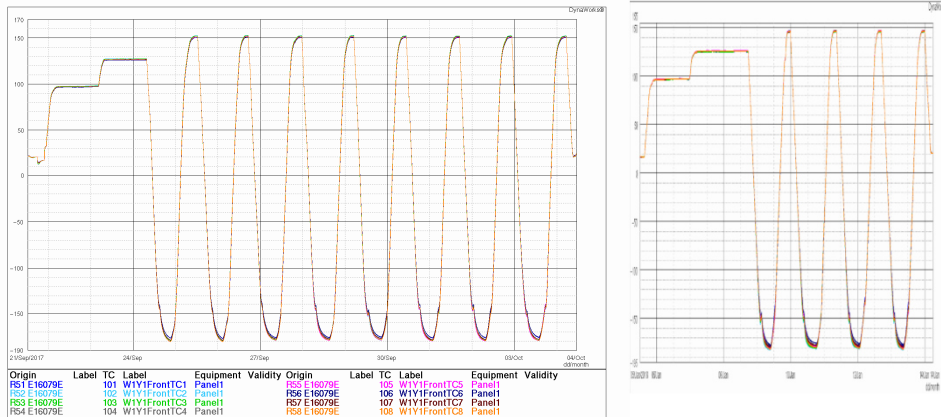
- Partly integrated by Leonardo (PVA only)
- Submitted to a full mechanical environmental qualification
- Integrated onto the MPCV Qualification Model S/C
- Not 100% representative because of the change of the substrate manufacturing technology (Airbus proprietary)

ESM1 and 2 panels



- Three sections per panel
- ESD safe design (limitation of worst case maximum differential voltage)
- 12 panels delivered in batch of 3 (ESM 1)
- 6 panels under manufacturing (ESM 2)

ESM1 panels



- 12 panels delivered in batch of 3
- (P)FM and FM acceptance sequence
- TV acceptance test successfully completed and final inspection and repairing performed on Customer site
- Extensive use of ESA portable flasher system for power performance comparison pre and post TV test

Acknowledgments

The authors wish to thank the highly motivated Leonardo Solar Array Team who contributed to the achievement of this outstanding result

- Francesco Creatini (former Leonardo employee)
- Fausto Mangiarotti
- Paolo Palladino
- Romina Malvito
- Barbara Bettinelli
- Alex Pravettoni
- Alex Vancini
- Simone Porta
- Ivan Serati
- Loretta Pesce
- Vincenzo D'Acunti
- Romano Romani

and many others.