Sparkwing

A new product family of commercial off the shelf solar arrays

Airbus Defence and Space Netherlands B.V.

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About Us

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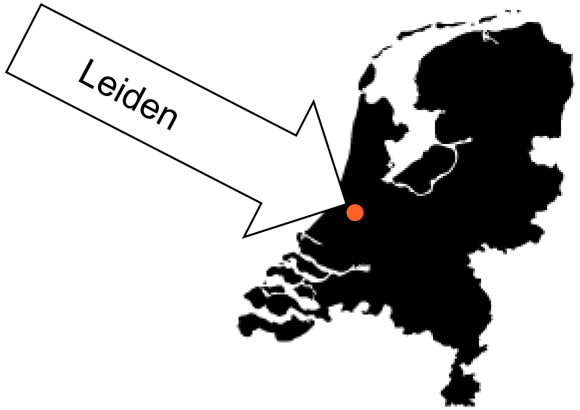

- Airbus Defence & Space Netherlands is located in Leiden
- Largest space company in The Netherlands
- ~234 employees
- > 50 years of space experience

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Why Sparkwing?

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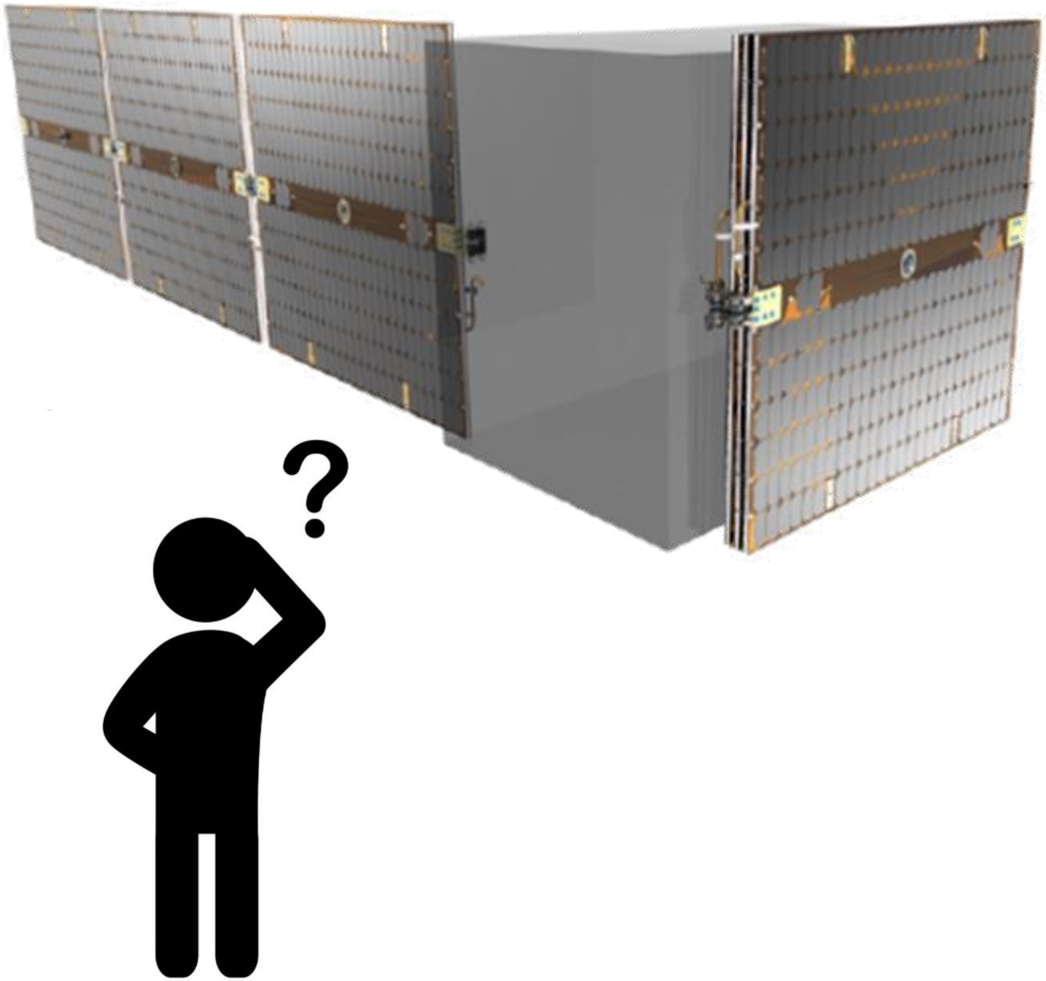
- Traditional solar arrays feature a tailored design and verification approach based on a specific requirements specification. The solar array is in this case designed to fit the satellite.
- Within the smallsat market, commercial and main performance requirements are driving the design and a short manufacturing lead time is key to success.
- In response to this market need, Airbus Defence & Space Netherlands (ADSN) has developed a modular solar array product called Sparkwing, that can be sold using a catalogue approach
- The catalogue approach enables smallsat manufacturers to select a pre-defined solar array design during the early design phase of the satellite and as such avoid expensive tailor made design solutions
- At the same time, the catalogue approach enables ADSN to follow a more industrialized manufacturing approach to reduce cost and manufacturing lead time



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Catalogue Requirements

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Low cost design solution

Manufacturing lead time < 9 months

Plug & Play integration

Design for LEO starting at 500km for 5year mission life time

Power range 100W to 2kW

Built height < 90mm

Deployment shock < 60 Nm

Deployed frequency > 2 Hz for 2p configuration with max size 700x800mm2

A ‘design to cost approach’ is demanded by smallsat market in favor of classical ‘design to mass approach’ This is trend is being stimulated by a decrease in launch costs.

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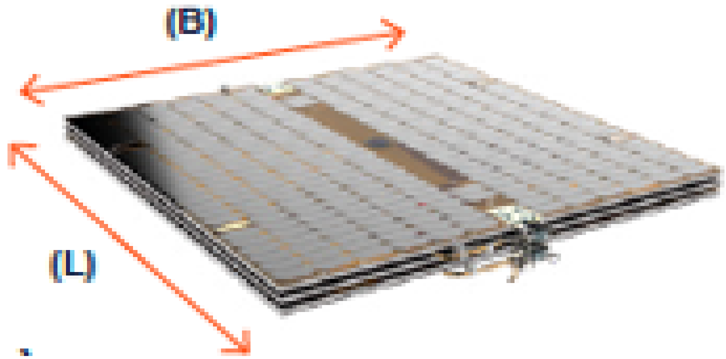
The Catalogue

- The catalogue allows customer to select between a 36V and 50V bus design
- For each bus voltage, the customer can select from different panel dimensions and combine panels with same dimensions into a 1p, 2p or 3p wing configuration.



26 cells / string design (50V PVA design)

Wattages are BOL@28C, incidence angle of 0deg

Length of panel (L)	Width of panel (B)	600	750	910	1070	1230
	570	90W (3 strings)	120W (4 strings)	150W (5 strings)	180W (6 strings)	210W (7 strings)
	800	120W (4 strings)	150W (5 strings)	210W (7 strings)	240W (8 strings)	270W (9 strings)
	965	150W (5 strings)	210W (7 strings)	240W (8 strings)	300W (10 strings)	
	1100	180W (6 strings)	240W (8 strings)	300W (10 strings)	360W (12 strings)	

19 cells / string design (36V PVA design)

Wattages are BOL@28C, incidence angle of 0deg

Length of panel (L)	Width of panel (B)	440	600	750	1000	1160
	700	66W (3 strings)	110W (5 strings)			
	800	88W (4 strings)	132W (6 strings)	176W (8 strings)	242W (11 strings)	286W (13 strings)
	965		154W (7 strings)	198W (9 strings)	264W (12 strings)	
	1100			242W (11 strings)	308W (14 strings)	

Extra option: 1070x570 = 176W (8 strings)

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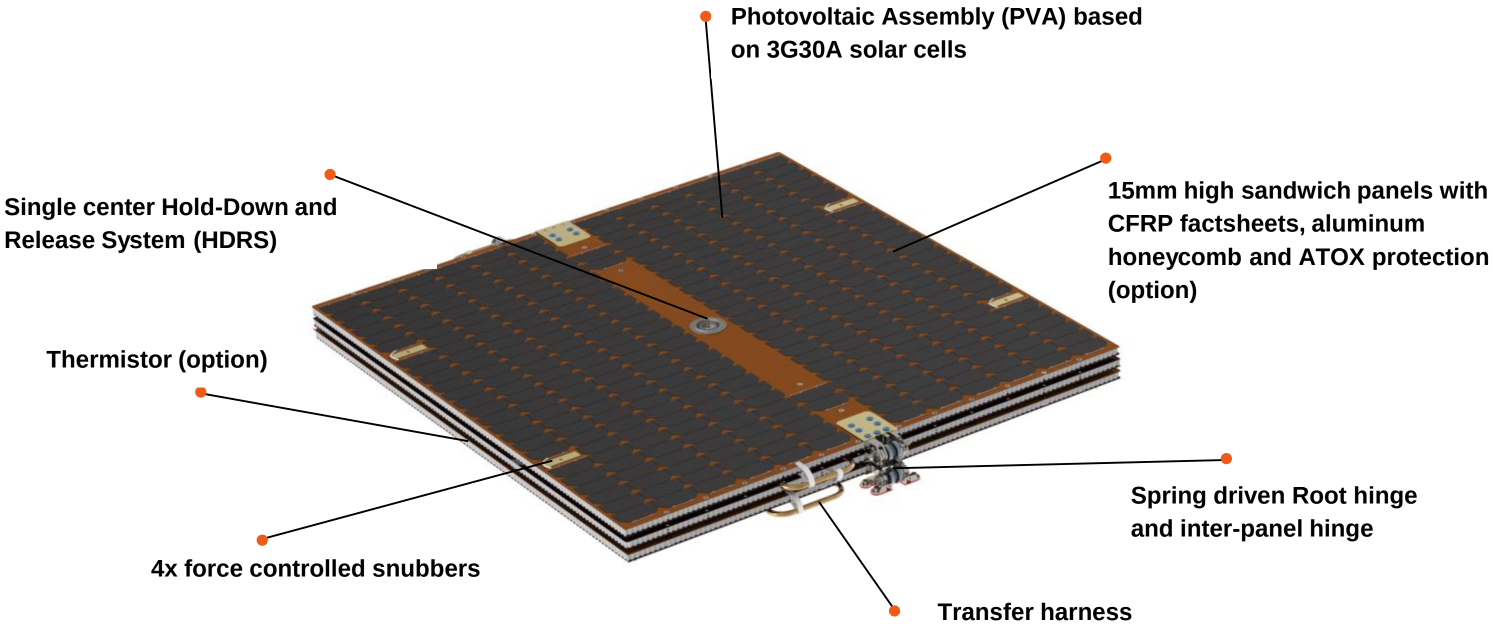
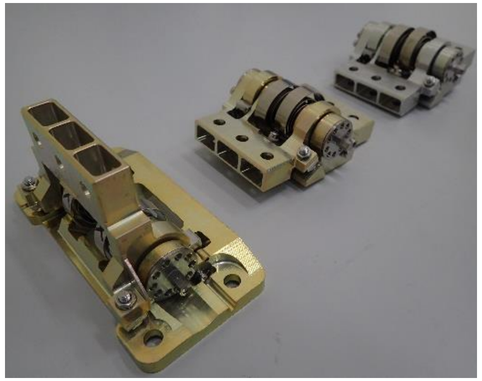
The Solar Array Design Concept (3p version shown)

- The design has been simplified to a maximum extend by implementing the following design choices:
  - ✓ Strong backbone and limitation of deployment energy allows undamped deployment to avoid the need for an active damper
  - ✓ Predict deployment trajectory using ADAMS and verify in relation to S/C surrounding structure such that complex synchronization systems to control the deployment trajectory can be avoided
  - ✓ Use single center HDRS in combination with force controlled snubbers to reduce assembly and integration complexity
  - ✓ Uniform panel substrate design without local reinforcements such that smaller panels can be machined from larger mother panel



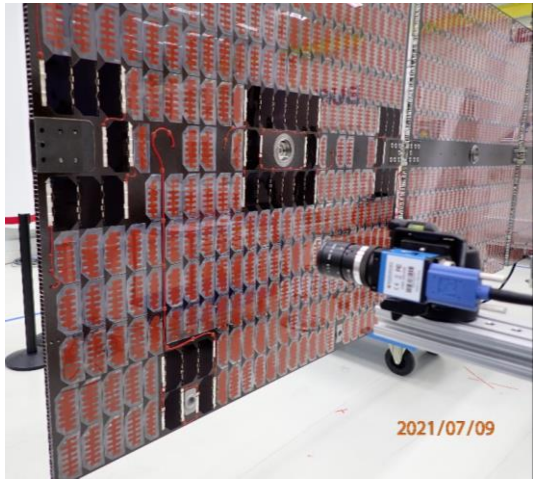
The Building Blocks



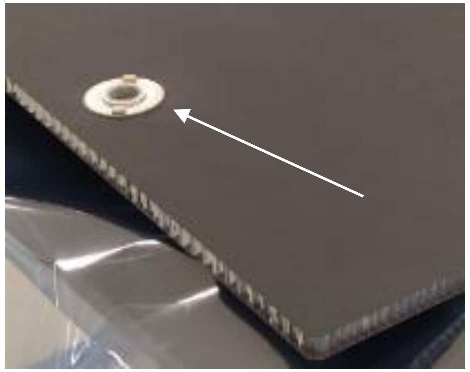
Root hinge and panel hinges specifically design to be small and stiff. Clock springs provide the required motorization

One singe HDRM to allow easy S/C integration

Very thin panels substrate design to reduce the stacked height in stowed configuration to a maximum extent



PVA based on Azur 3G30 cells to achieve high W/m2 performance



Force controlled snubber boosting the stowed frequency and eases overall S/C integration efforts

The Challenges

Design a compact SA up to 2kW with no active damper and synchronization between panels is a challenge !

More specifically, it is a challenge to keep the deployment shock under control because more power requires:

- ➢ Separation into electrical section to comply with harness de-rated current capability or larger wire gauge
  - ➢ Separation into sections or larger wire gauge increases the harness retarding torque acting on the hinge line during deployment
    - ➢ To counter this retarding torque more motorization energy is required.
      - ➢ More motorization energy increases the deployment shock

- Designing a compact and stiff inter panel hinge interface was a challenge

- Reduce the amount of acceptance testing during REC production without compromising on quality of the product

Development Approach

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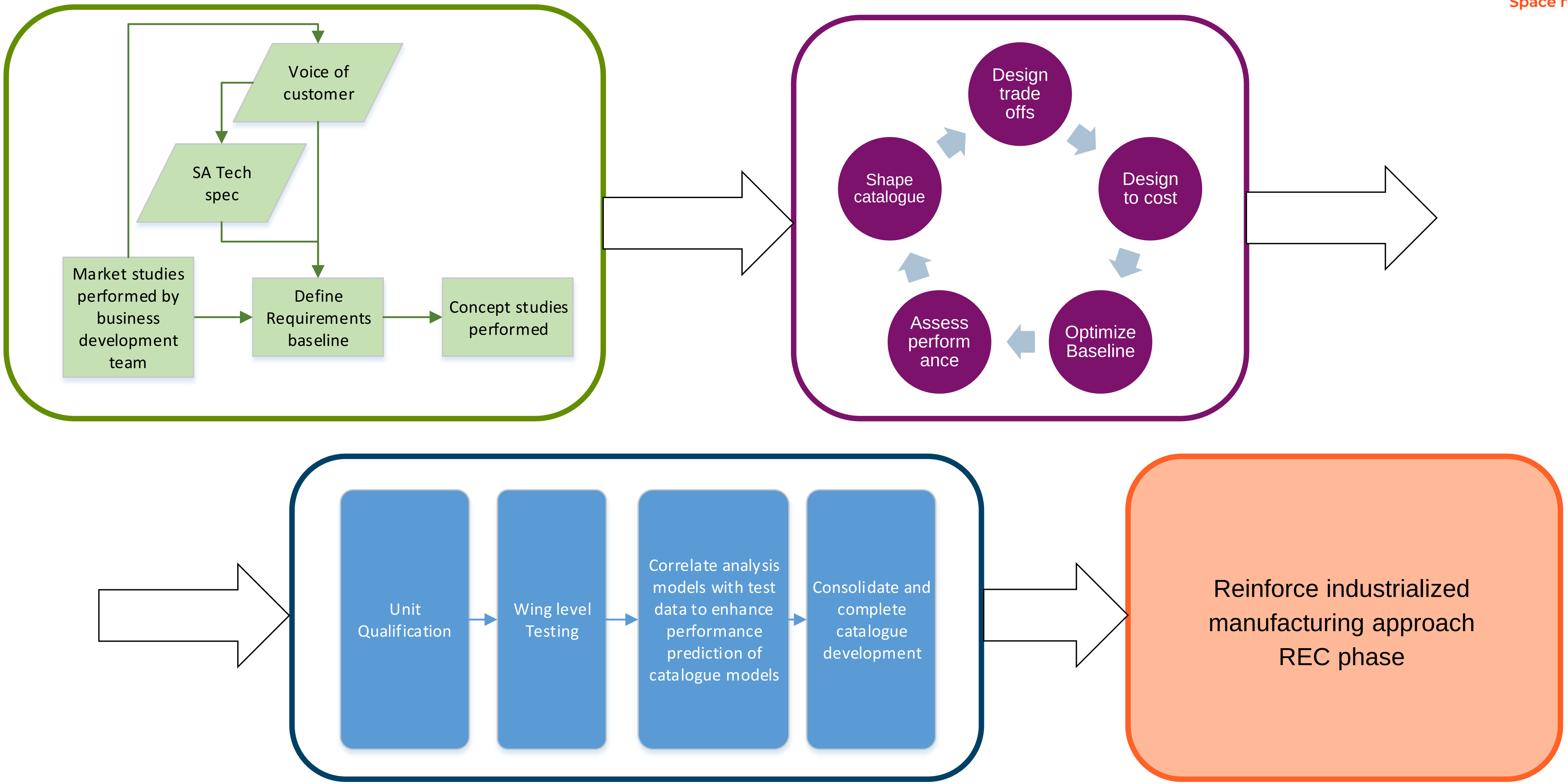
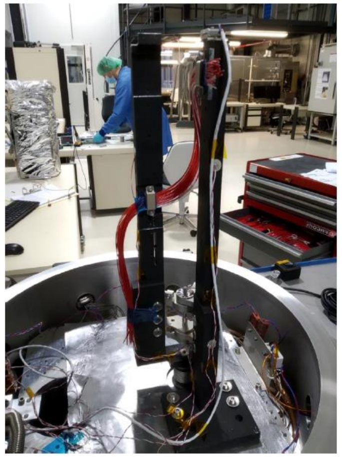
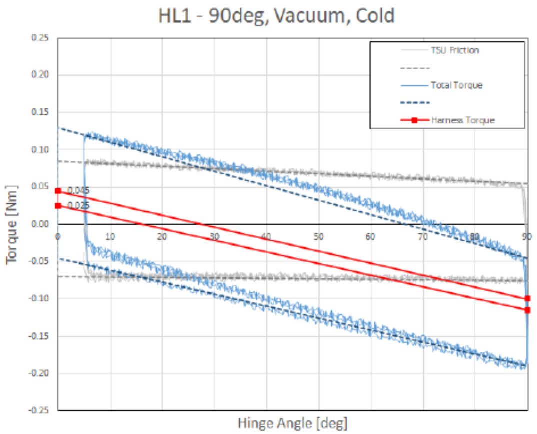
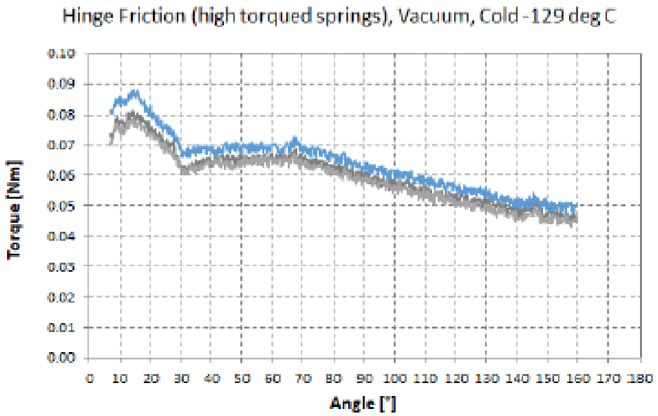


Unit Testing

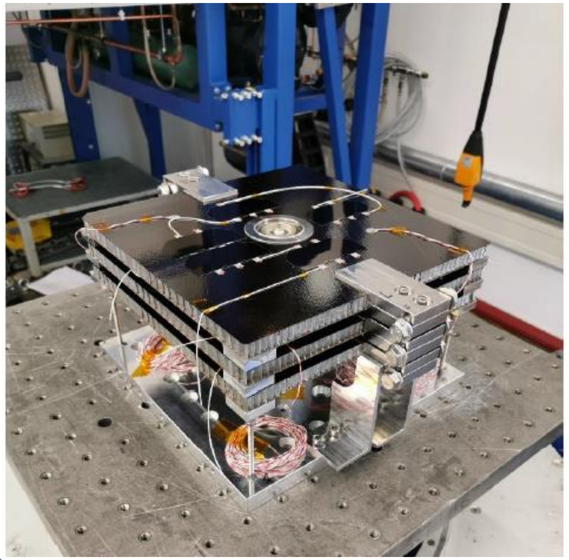




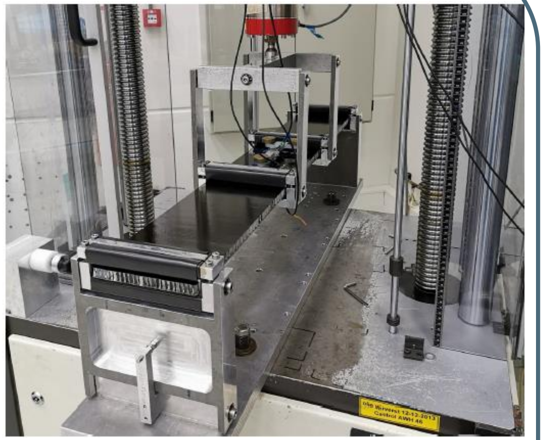
Harness retarding torque test



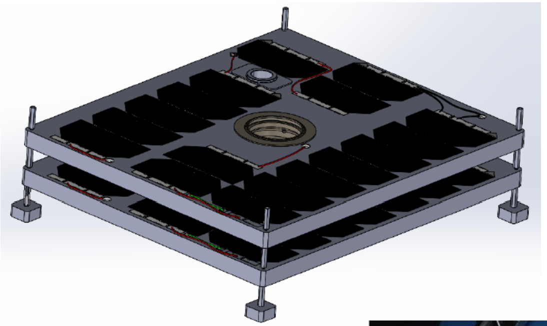
Hinge friction test in thermal vacuum



HDRM assembly testing



Substrate sample testing



PVA Testing

Development Wing Level AIT

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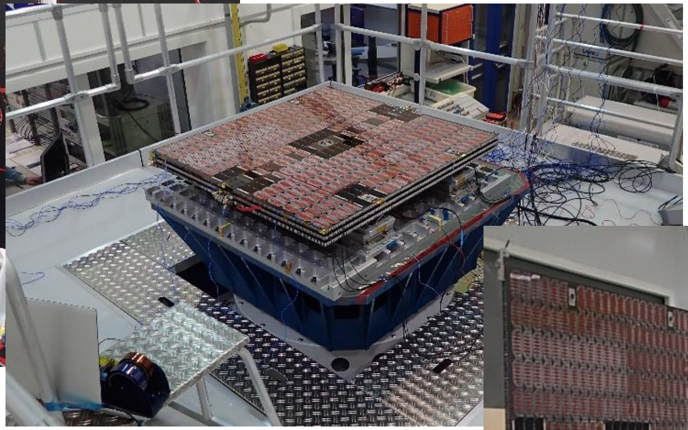
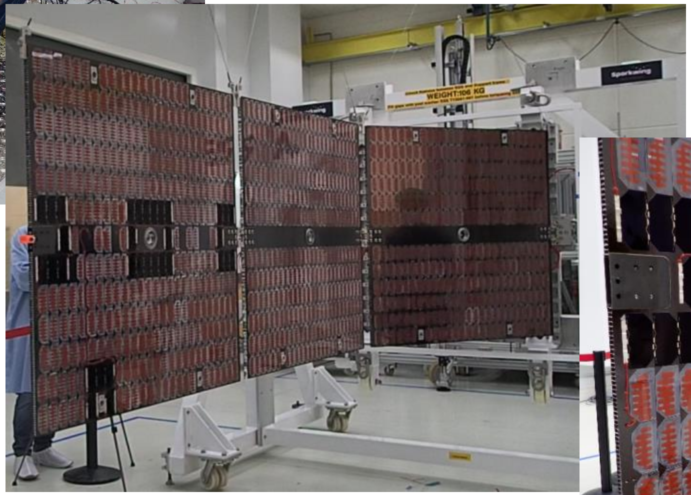
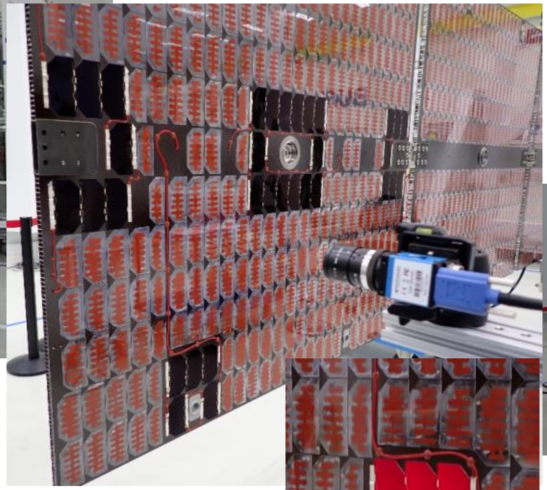
Assembly and integration

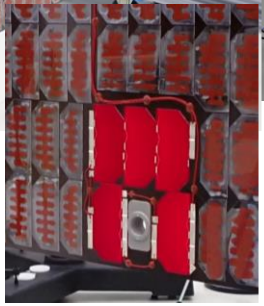


Sine vibration and acoustic noise testing

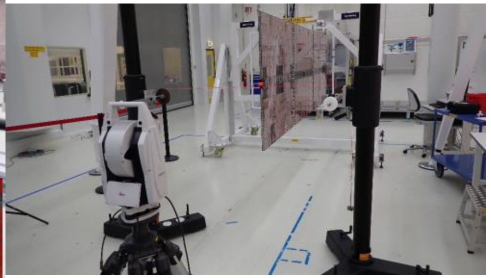


Deployment verification





Electrical Health Check & Performance measurements



Stiffness & Alignment performance

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Wing Deployment testing

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Correlation Efforts & Catalogue verification

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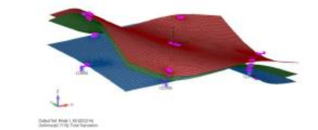
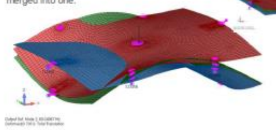
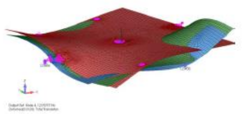
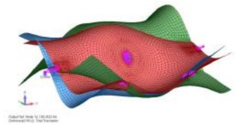
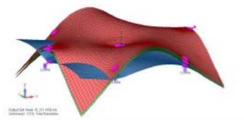
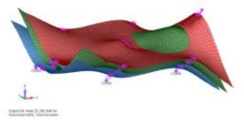
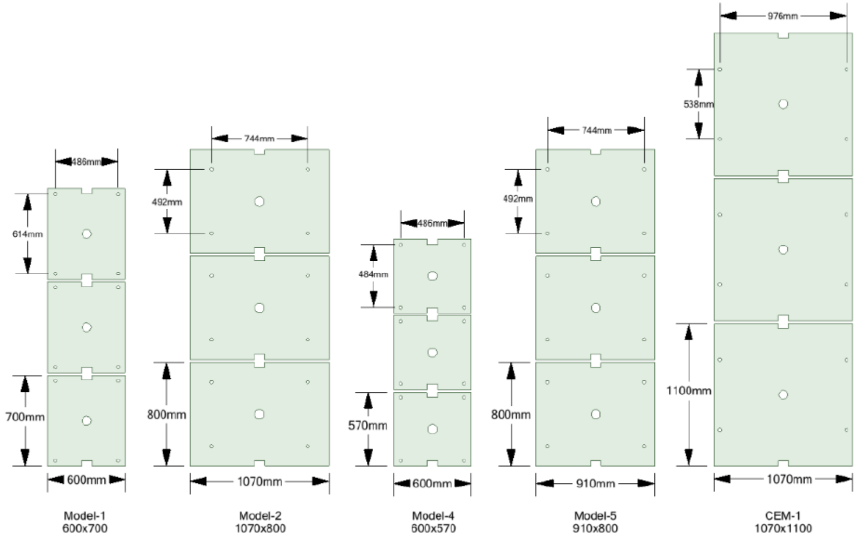
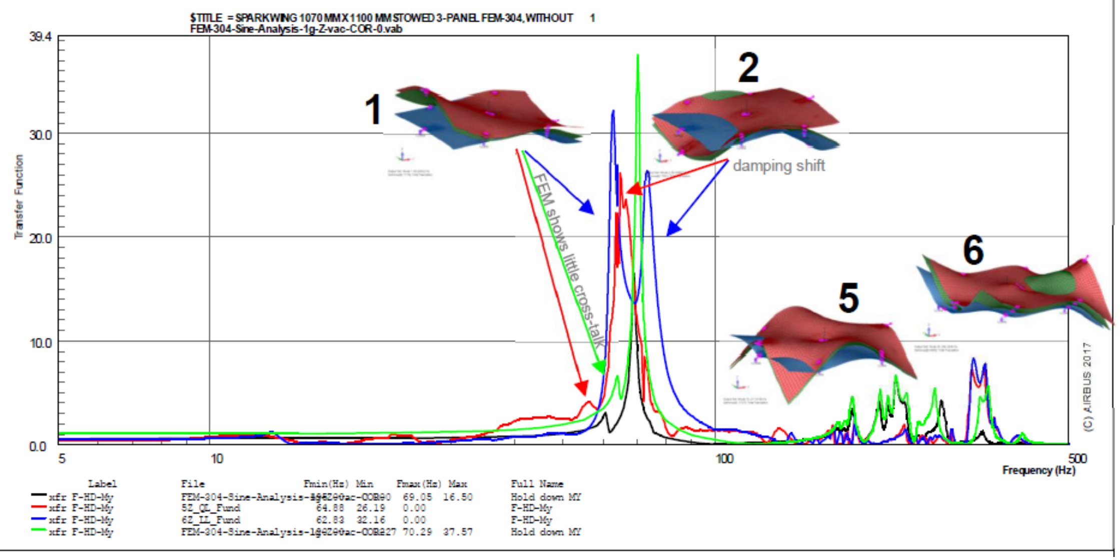
- Test results obtained from unit testing and wing level testing were used to calibrate the FEM and refine the modeling approach allowing to verify the smaller models in the catalogue by analysis
- FEM generator was established to allow analysis of catalogue models within days

ID	Description	Mode shape (Panel 1 Panel 2 Panel 3)	Frequency [Hz] (FEM pre-cor analysis, QL test run, LL test run, FEM post-cor analysis)
1	Asymetric 'diving board' bending mode Main test axis: **X** Also visible in: Z Identified by I/F Load: **HD-My**		59 61 64 64 0%
2	Symetric 'diving board' bending modes Main test axis: **Z** Also visible in: X Identified by I/F Load: **HD-Fz**	The FEM analyses shows a separate mode for panel 3 just a few Hz higher. In test results these modes have merged into one.  	64 69 70 73 4%
3	Torsion mode Main test axis: **Y** Also visible in: N/A Identified by I/F Load: **HD-Mz**		124 129 139 140 0.7%
4	Lateral bending mode Main test axis: **Y** Also visible in: N/A Identified by I/F Load: **HD-Fy, HD-Mx**		190 312 312 317 0%
5	Pogo mode Main test axis: **Z** Also visible in: N/A Identified by I/F Load: **HD-Fz**		211 212 225 225 6%
6	Longitudial bending mode Main test axis: **X** Also visible in: Z Identified by I/F Load: **HD-Fx,**		286 342 347 348 0.3%



HD-My



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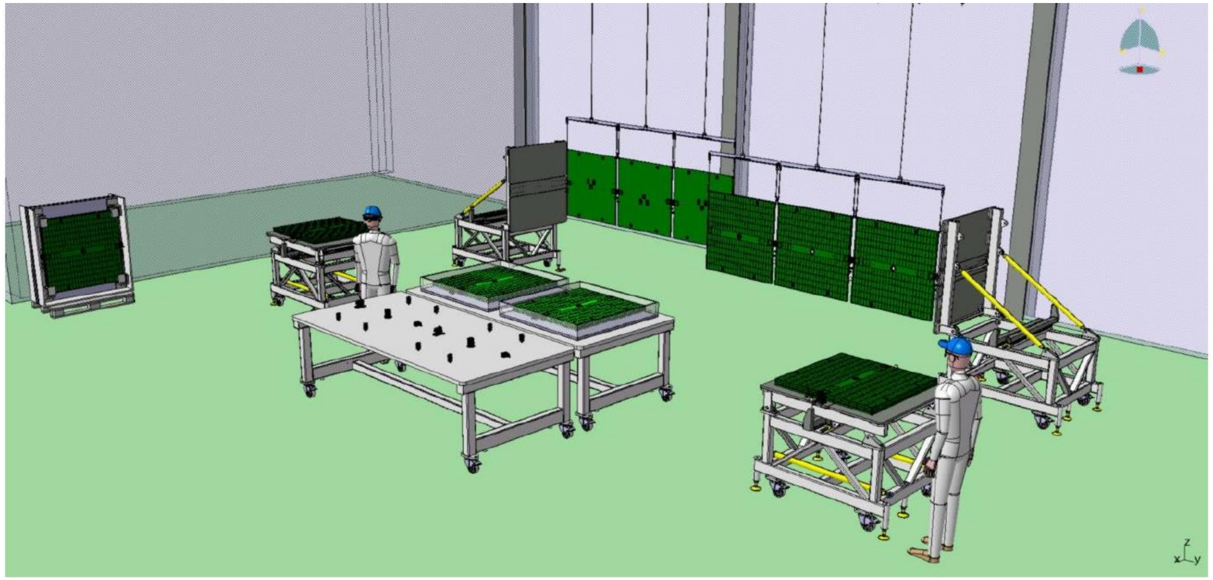
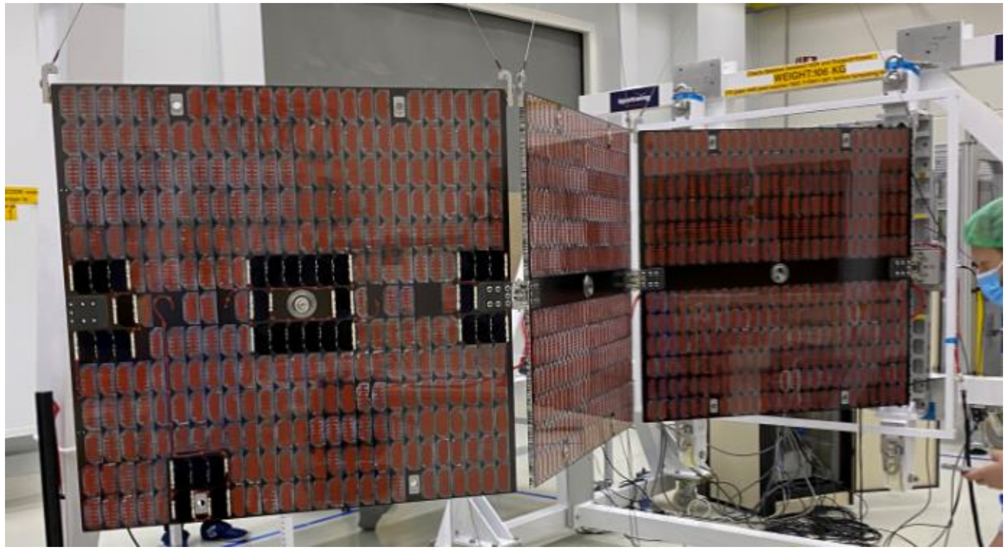
Industrialized AIT & Reduced acceptance testing

- **PVA Acceptance testing:**
  - Perform TVAC cycling for first 10x FM panels only to obtain statistical data on cell failures and associated power loss. Use data to derive statistical knock down factor to estimate worst case power performance for customers. After 10 FM panels no more TVAC testing

- **Wing level testing:**
  - Functional deployment check (hand released only)
  - Alignment + stiffness
  - Final stowage for Launch

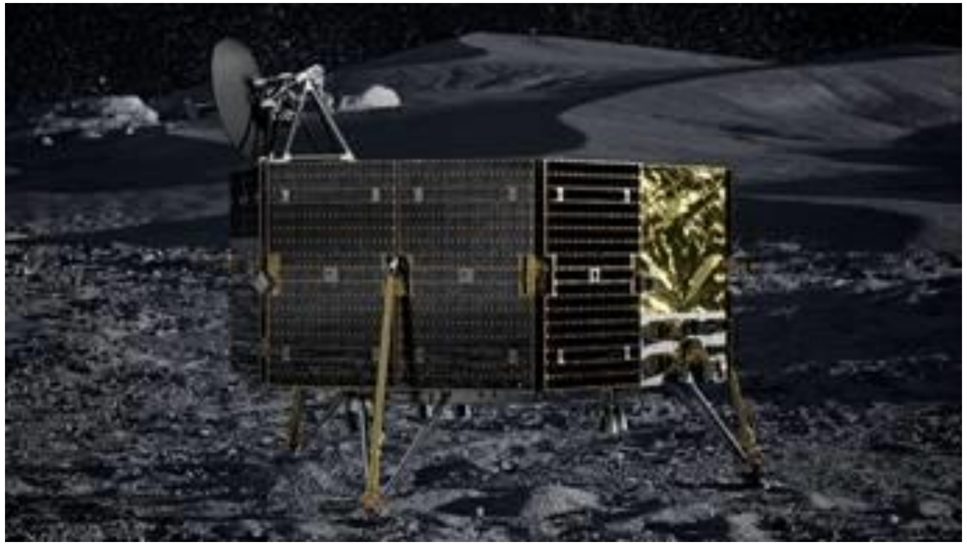
- **S/C level testing:**
  - Mount stowed wing to S/C side through single holddown
  - Perform S/C environmental test campaign
  - No deployments at S/C level





Outlook

- Several contracts have been secured in US and Europe
- First flight set will be delivered in 2022
- Continue to develop Sparkwing (Generation-2) to keep up with the smallsat market trends
- Use Sparkwing technology also for non-catalogue applications



Xelene Lunar Lander, launch in 2023
(courtesy of Masten Space Systems)

Thank You !!!

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