

Micro-Link 1 (ML-1)

~~NanoSpace-1~~: Spacecraft Architecture and Design after Concluding Phase B

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² Ångström Space Technology Centre (ÅSTC)



5th Round Table on Micro Nano
Technologies 2005

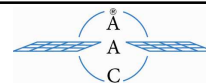
Acknowledgment:

Peter Rathsman, Swedish Space Corporation (SSC)

Swedish National Space Board (SNSB)

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Spacecraft Summary



- Less than 10 kg satellite comprising
 - Multifunctional spacecraft design
 - Distributed, redundant, and scalable system architecture
 - >40 MMS silicon modules
 - 3 axis stabilized (~70 m/s ΔV)
 - Li-Ion batteries
 - CAN, SpaceWire (SpW)
 - 1 Mbit/s telemetry downlink (S-band)

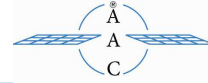


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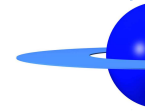
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Sida 2

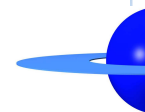
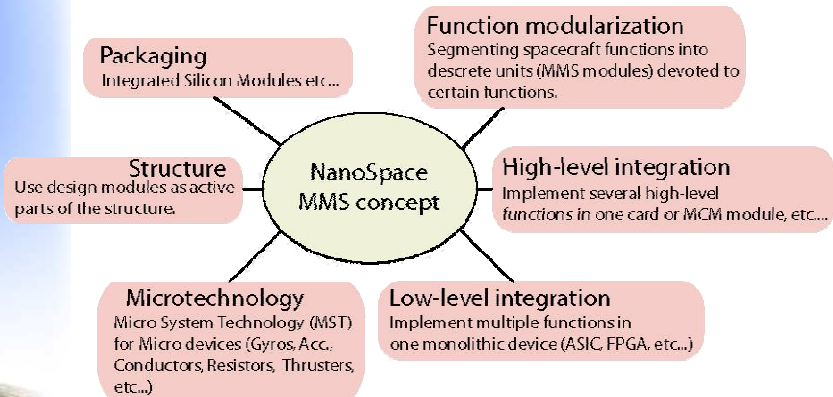
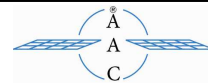
Mission Outline



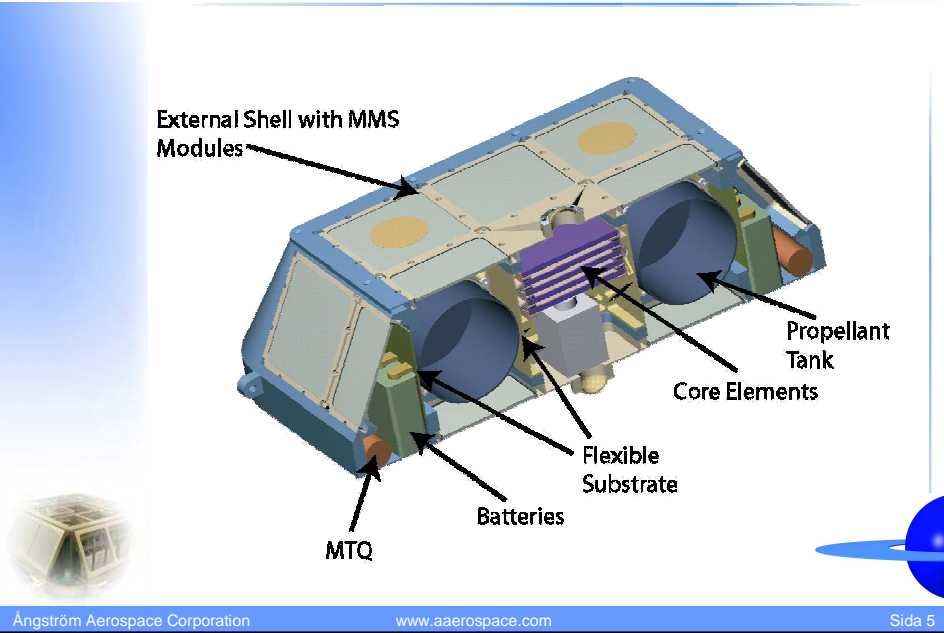
- *Phase 1* – System commissioning, both satellites
- *Phase 2* – Separation / docking manoeuvres
- *Phase 3* – Close-range formation flying
- *Phase 4* – Near-range flying
- *Phase 5* – High accuracy pointing test / verification
Precision pointing using Cold Gas Microthrusters
- *Phase 6* – Orbital change manoeuvre and post-formation flying



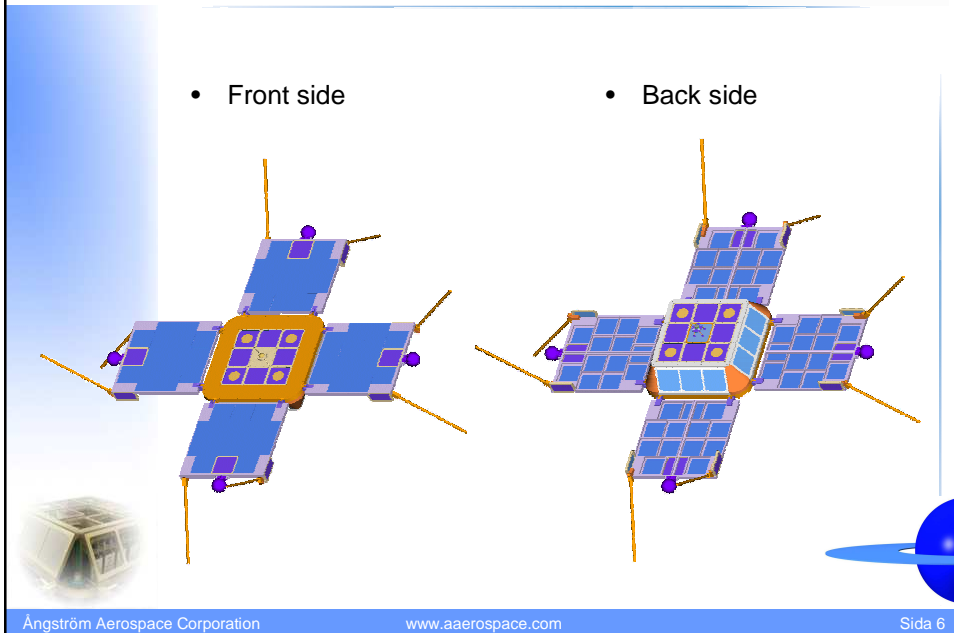
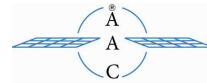
Systems Design Strategy (1)

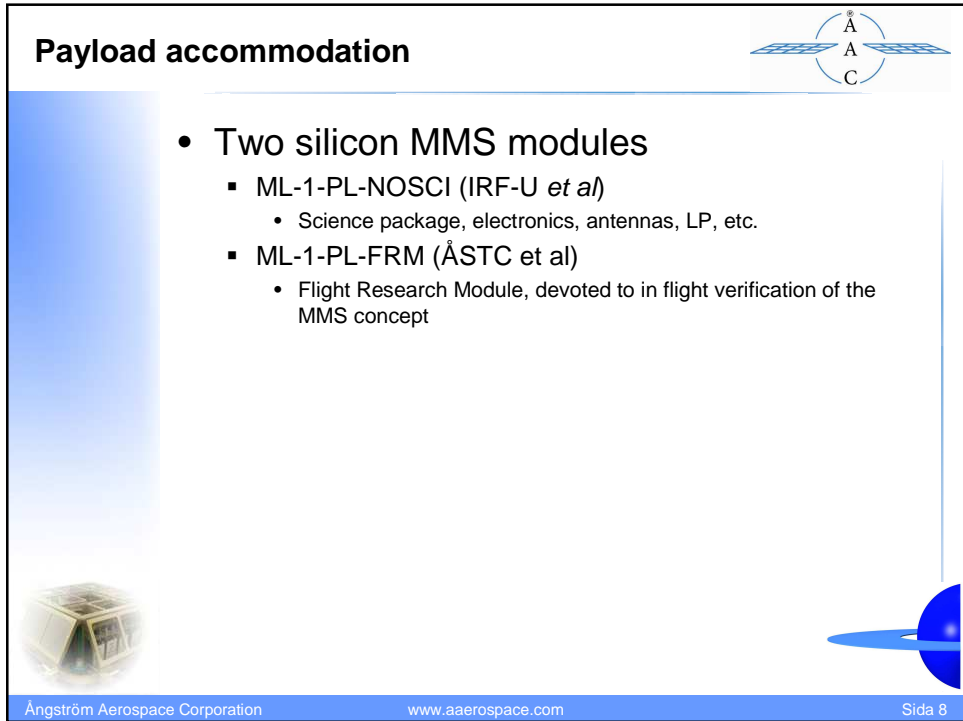
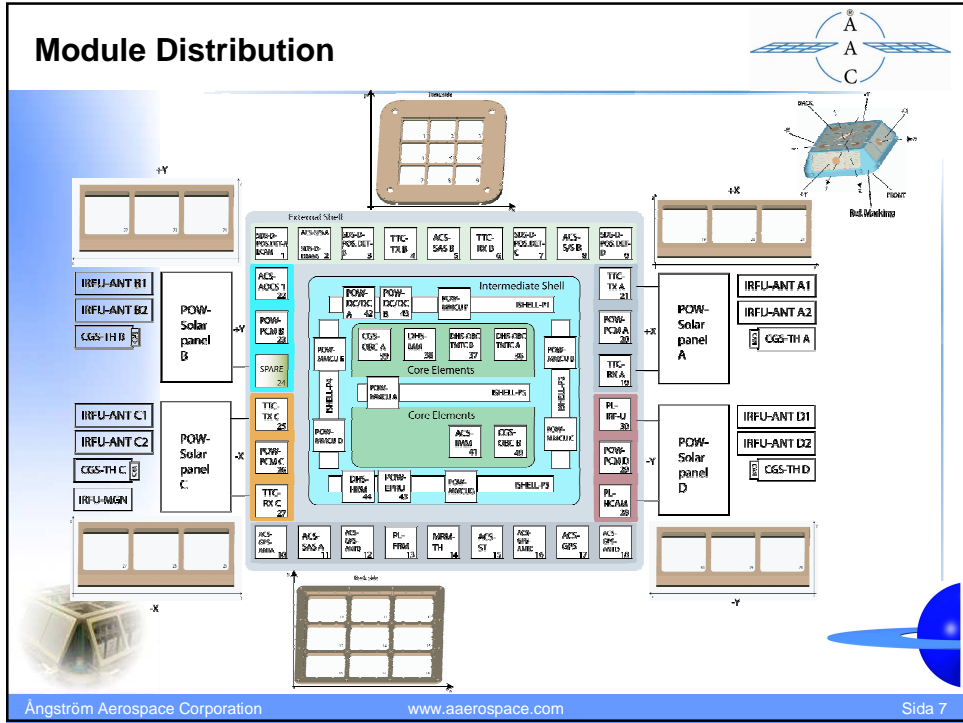


Systems Designs Strategy (2)

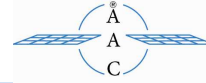


Flight Configuration



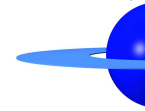


Mass budget

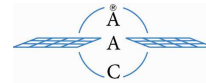


- **Spacecraft**
 - Wet mass, 9937 gram (incl. 20% margin)
 - Dry mass, 9073 gram (incl. 20% margin)
 - Dry mass, 7561 gram (excl. margin)

- Host docking I/F 2000 gram (incl. 20% margin)



Power Budget



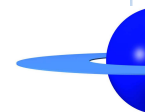
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	Standby			Safe			Precision			Nominal		
	Default	Margin	Total	Default	Margin	Total	Default	Margin	Total	Default	Margin	Total
No TRX	9.5	1.9	11.4	16.6	3.32	19.92	33.85	6.77	40.62	27.1	5.42	32.52
TRX	19.5	3.9	23.4	26.6	5.32	31.92	43.85	8.77	52.62	37.1	7.42	44.52

Solar Power ~64 W

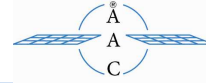
Batteries

- Sony Hard carbon 18650 (Li-Ion)
- BOL, 173 Whrs
- EOL, 156 Whrs

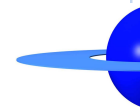
Battery time, 14 hours (safe mode).



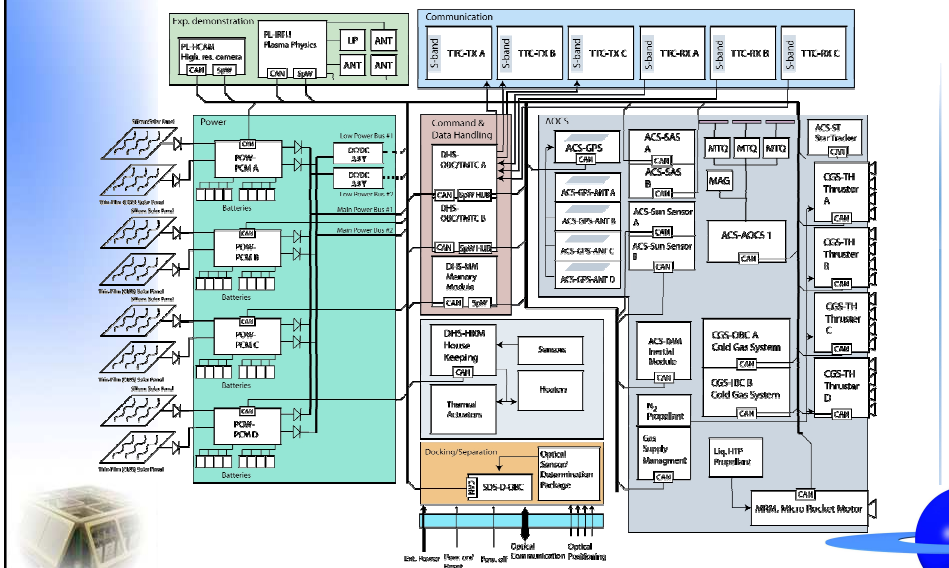
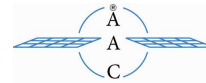
Link Budget



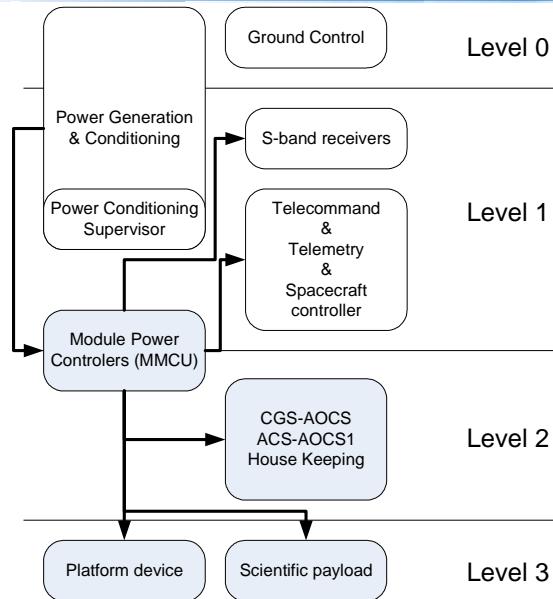
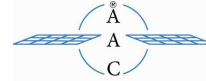
- Uplink
 - 14.5 kB/s (116 kbit/s)
 - Spacecraft receiver <0.5 W
 - 3 m parabola antenna
 - QPSK
- Downlink
 - 131 kB/s (1 Mbit/s)
 - Spacecraft transmitter 10 W
 - 2 W RF out
 - GMSK
 - Distance 1400 km



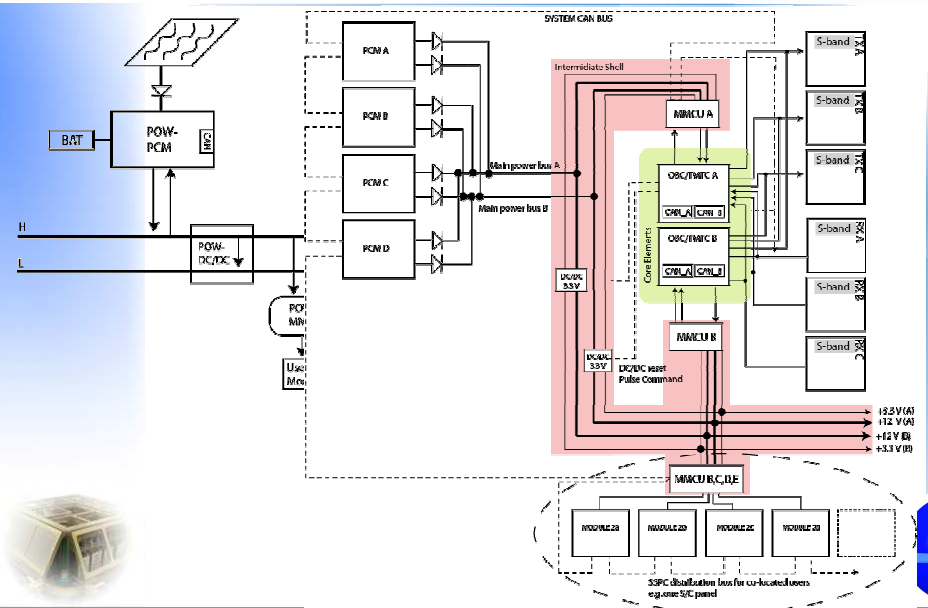
Avionics Block Diagram



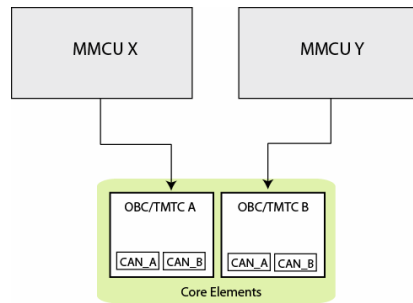
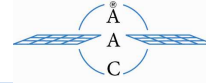
Electrical Design



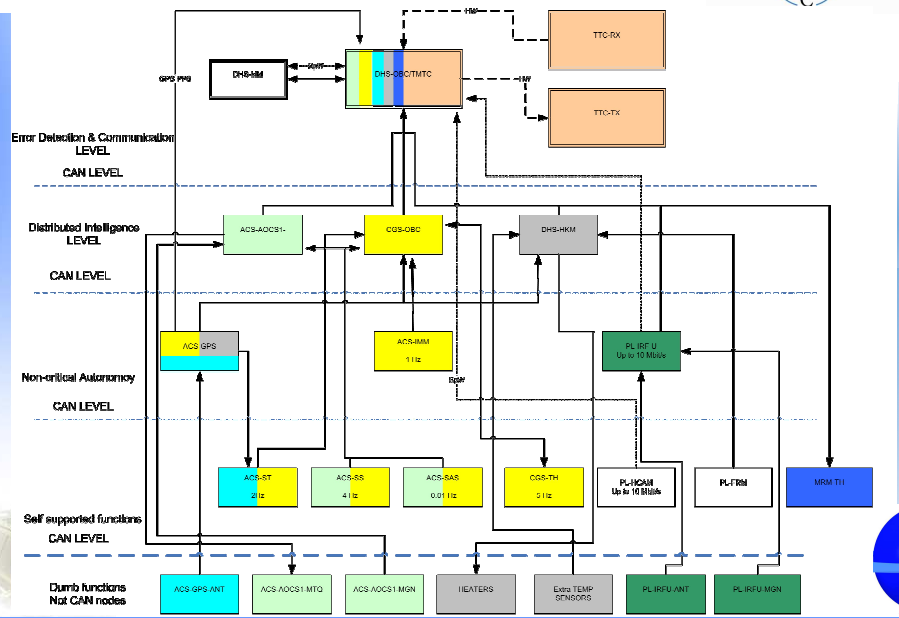
Power System Hierarchy



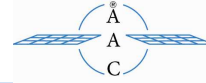
Electrical Redundancy



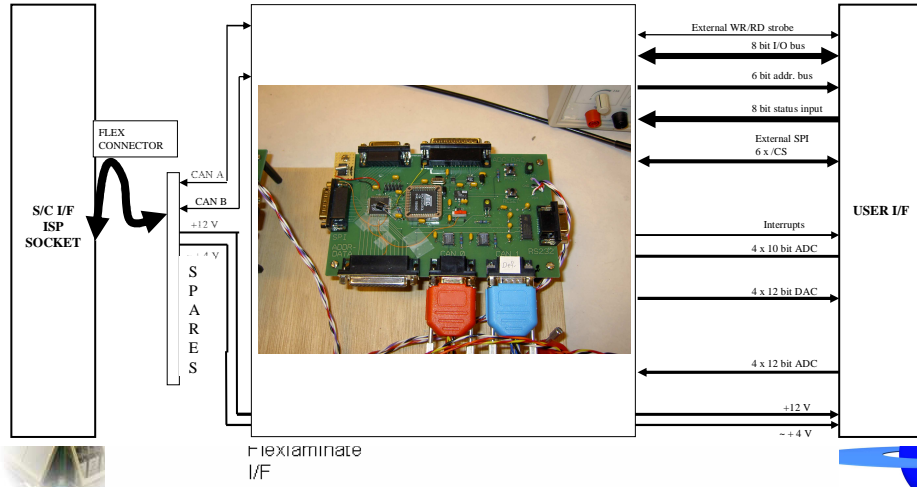
Data distribution



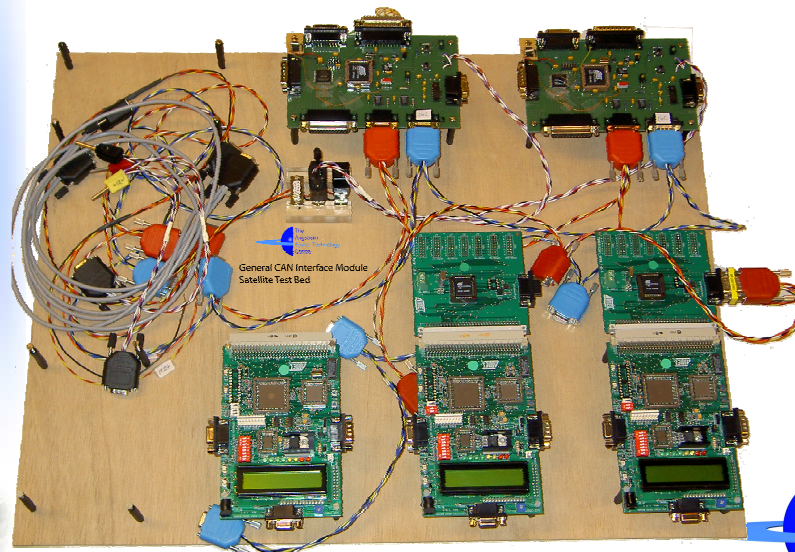
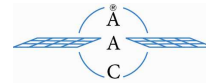
General S/C I/F Module



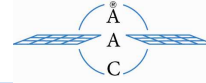
- CAN & SpaceWire Interface Module (CSIM)
 - Standardized user interface



S/C communication bus test system, CSIM



Data bus definition



- 28 modules using CSIM
- 5 modules using CAN, SpaceWire in dedicated FPGA
- Group addressing to reduce bus latency and traffic
- Local 48 bit SCET
- CAN bus load simulated by KTH (MDA) to 27% with all systems going (worst case)

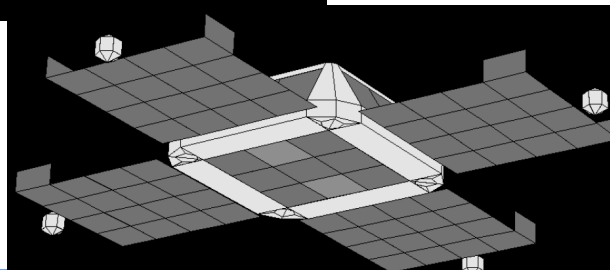
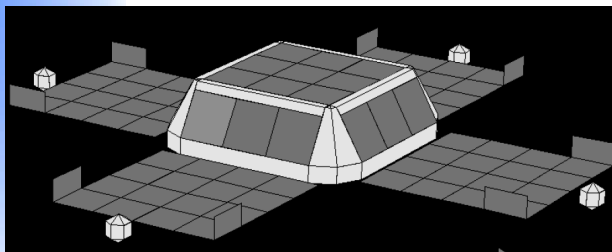
L	Originator								Group								Destination								Message Type								P
28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0					



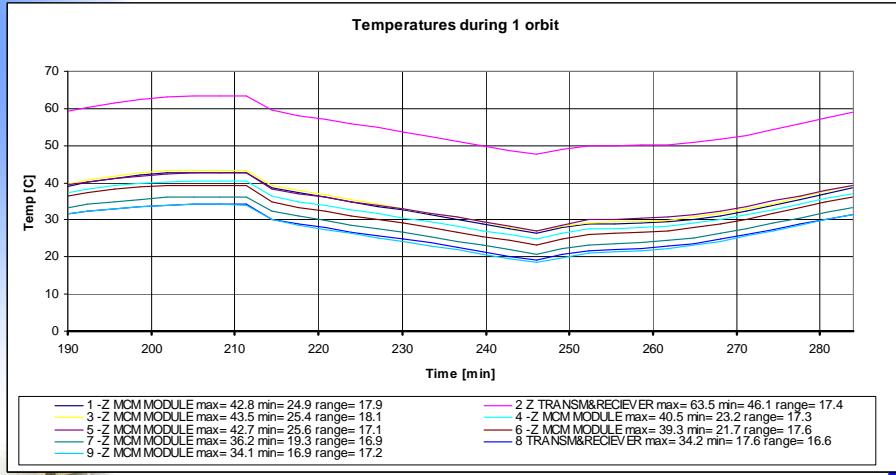
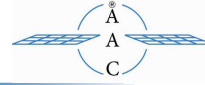
Thermal Control



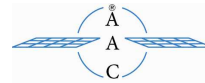
- Performed by Swedish Space Corporation (SSC) with inputs from ÅSTC using THERMICA



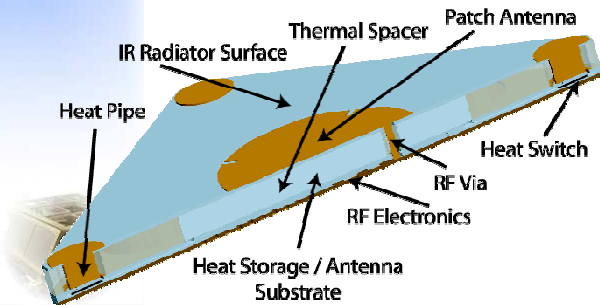
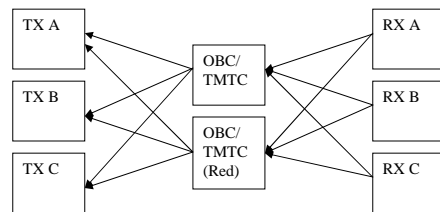
Thermal Control (2)



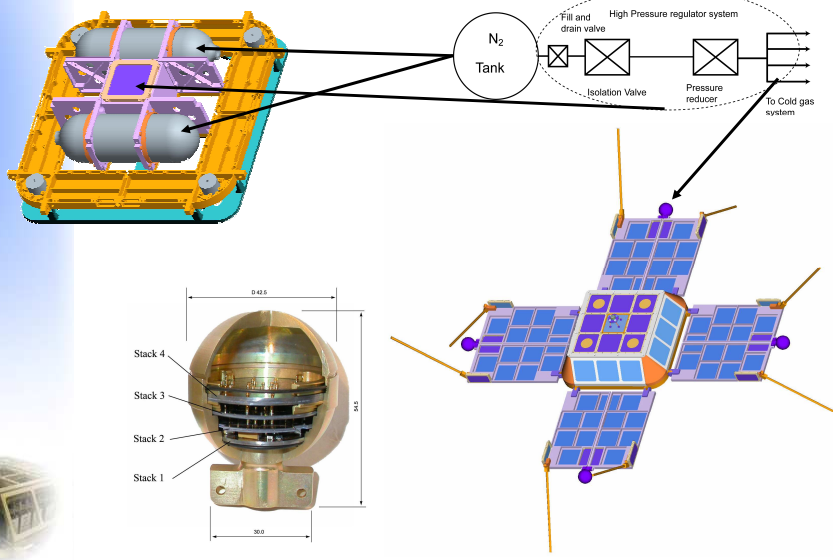
Telemetry, tracking & Control



- Distributed s-band communication architecture



Cold Gas Micro Thrusters

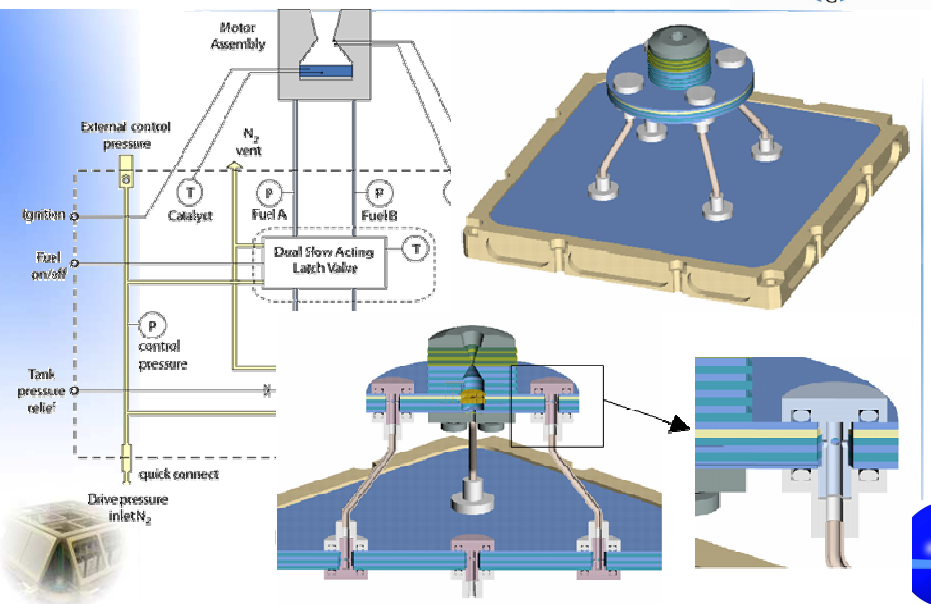
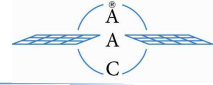


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Sida 23

Micro Rocket Motor

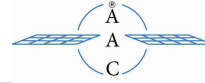


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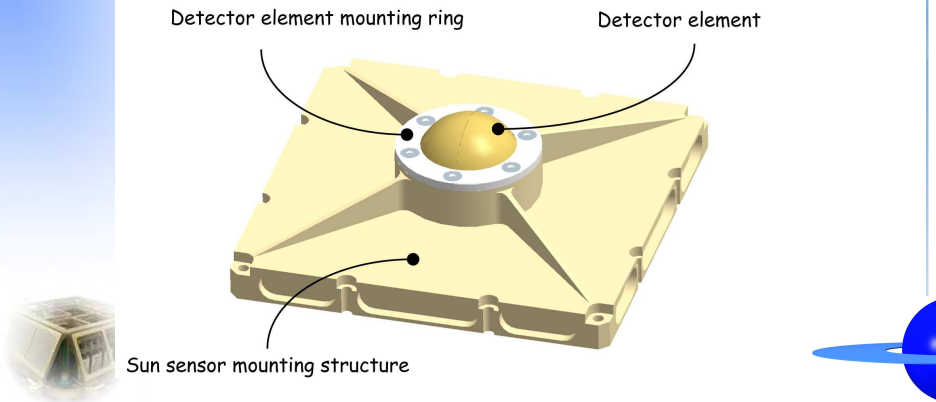
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Sida 24

3D-Sun Acquisition Sensor



- Power: 100 mW
- 0-90 deg elevation
- 0-360 deg azimuth

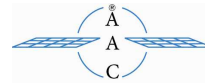


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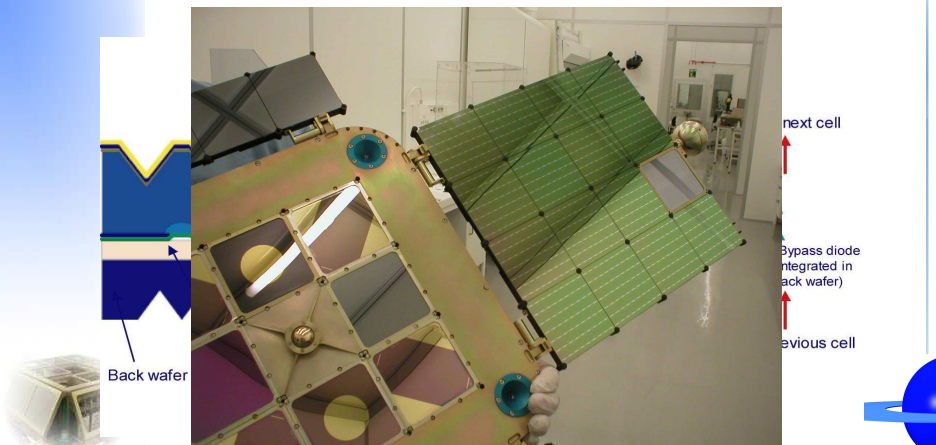
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Sida 25

Silicon Solar Cells



- Total Power 64 W, 16 W per panel
- Estimated efficiency, 16%

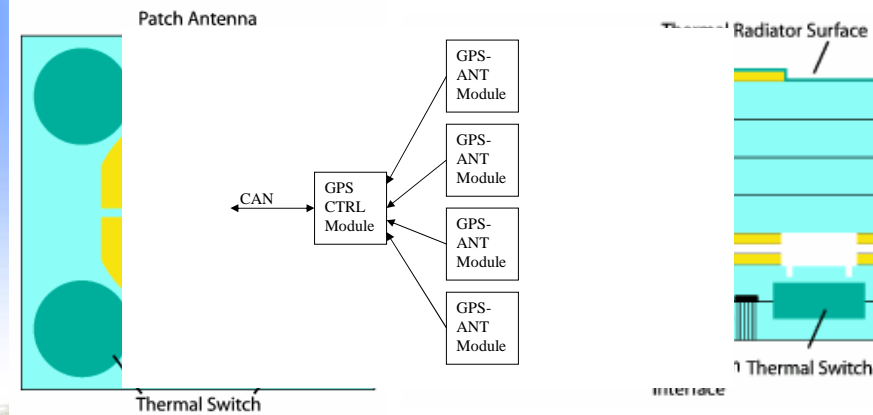
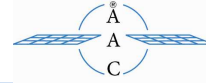


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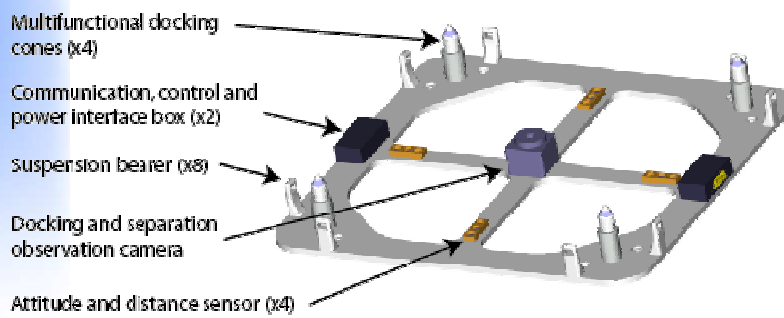
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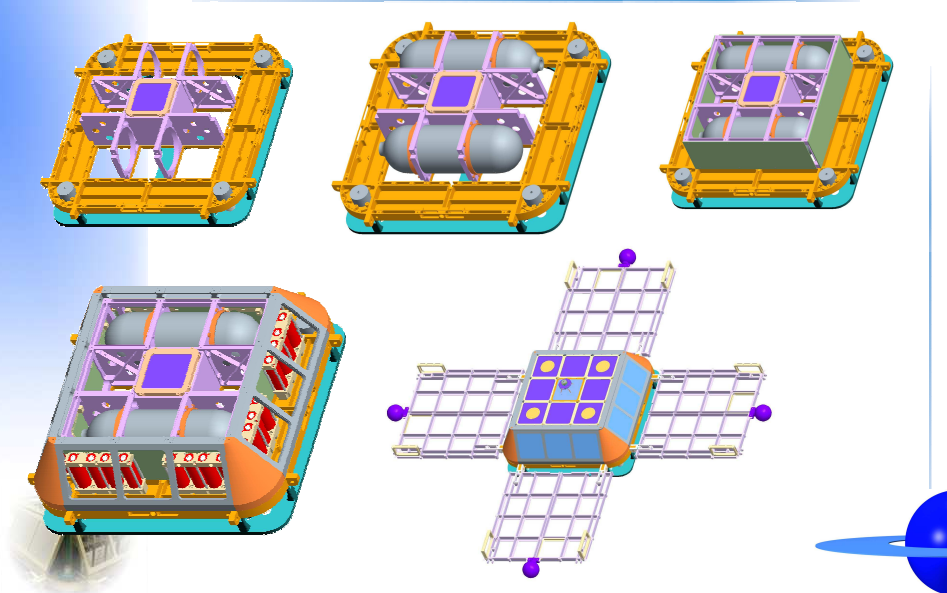
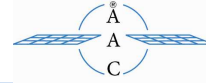
GPS Antenna design



Separation & Docking (SDS)



Structure (STR)

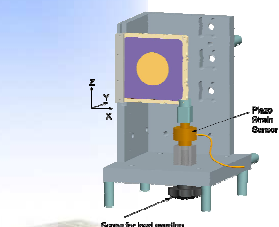
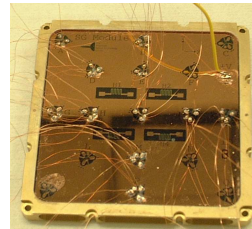
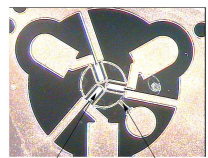
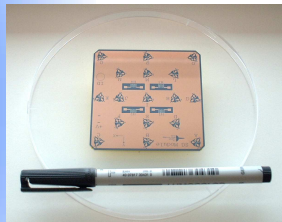
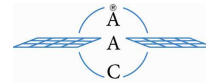


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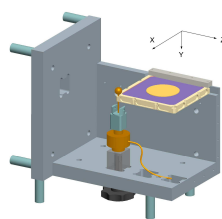
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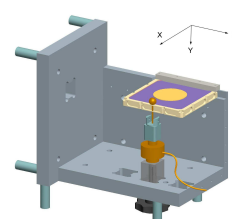
STR Module Tests - setup



Shearing



Warping



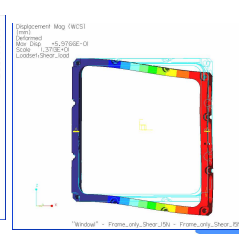
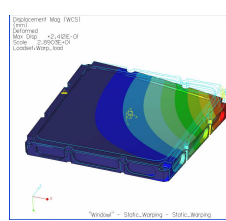
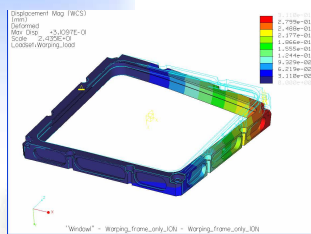
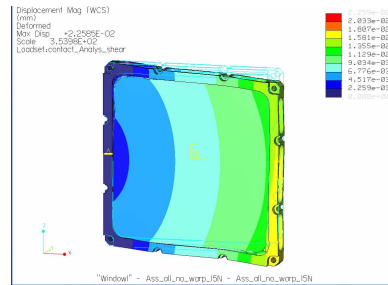
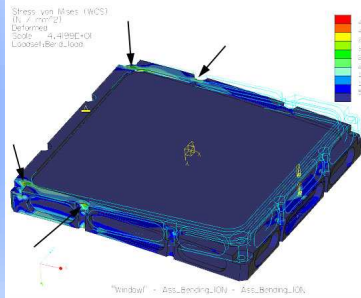
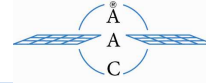
Bending

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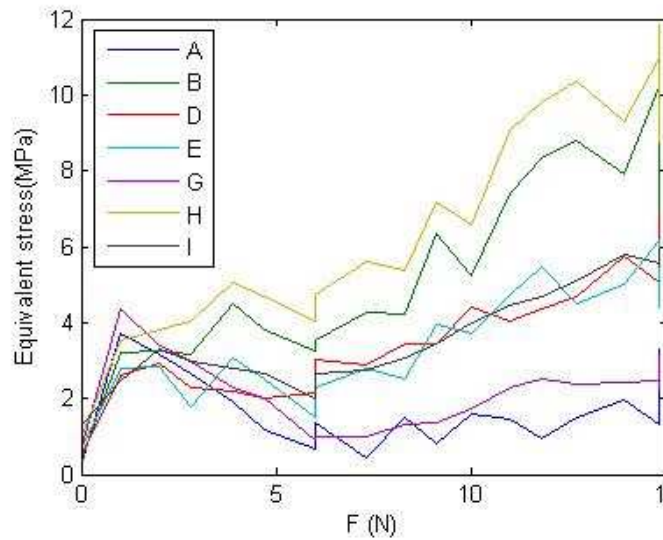
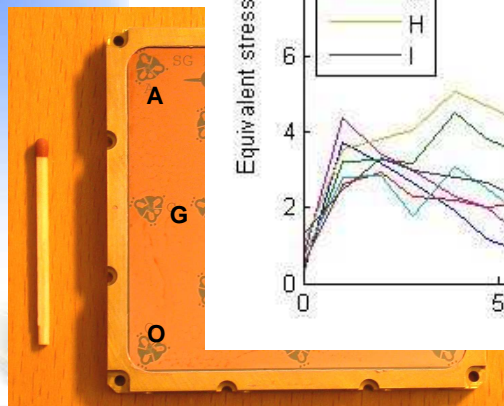
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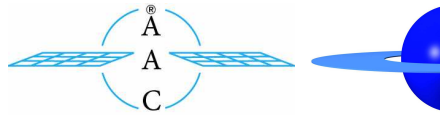
Sida 30

STR Module Tests - sim



STR Module Tests - Results





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