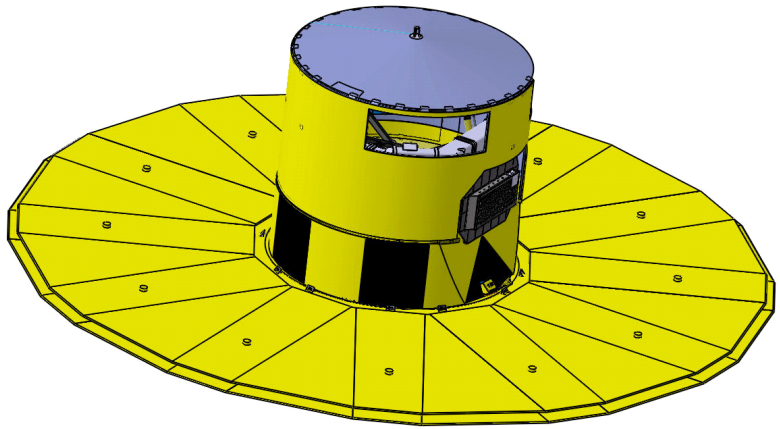
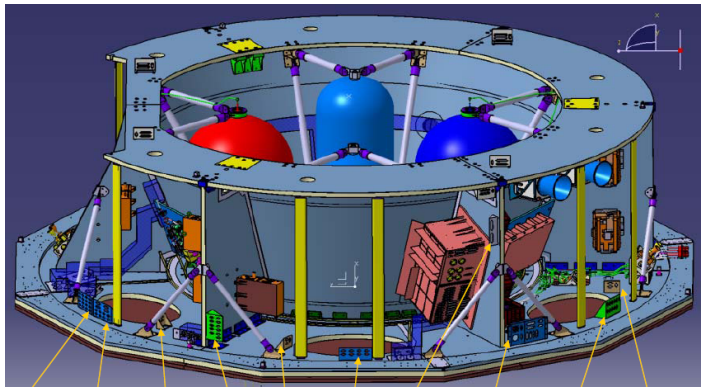
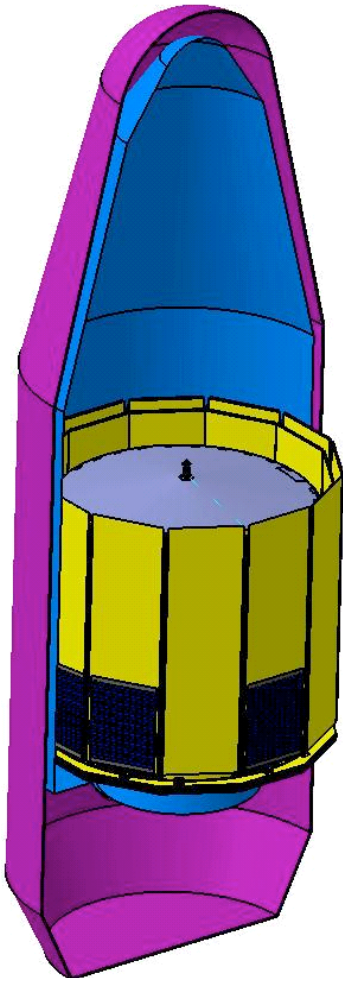
Spacecraft design

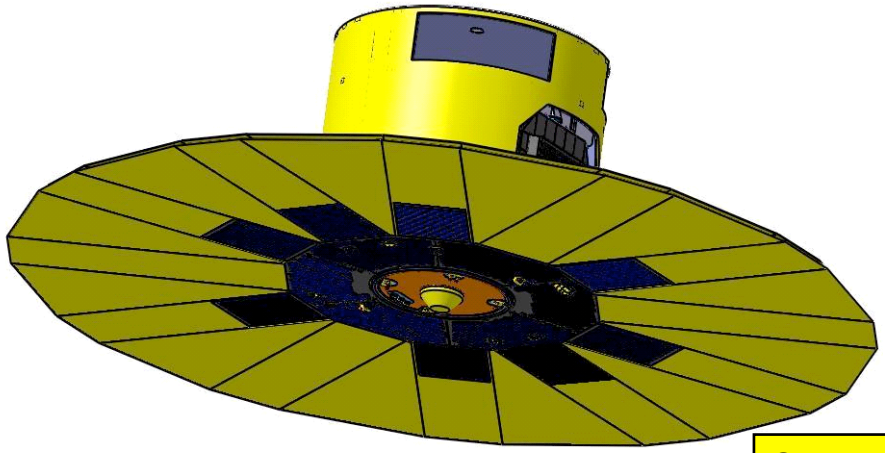
- Gaia configuration
- Key figures
- The Service Module (SVM)
- The Payload Module (PLM)
  - Torus design
  - FPA design
- Science data management architecture
- Challenges

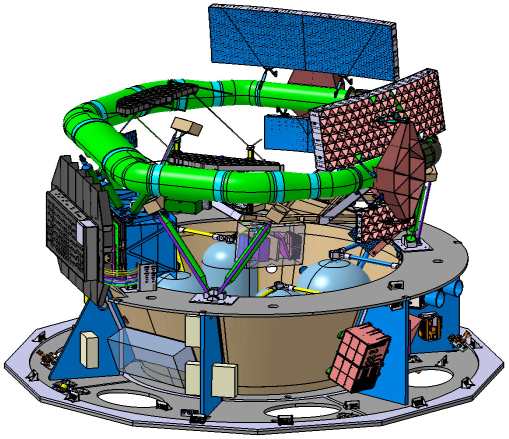
Gaia configuration











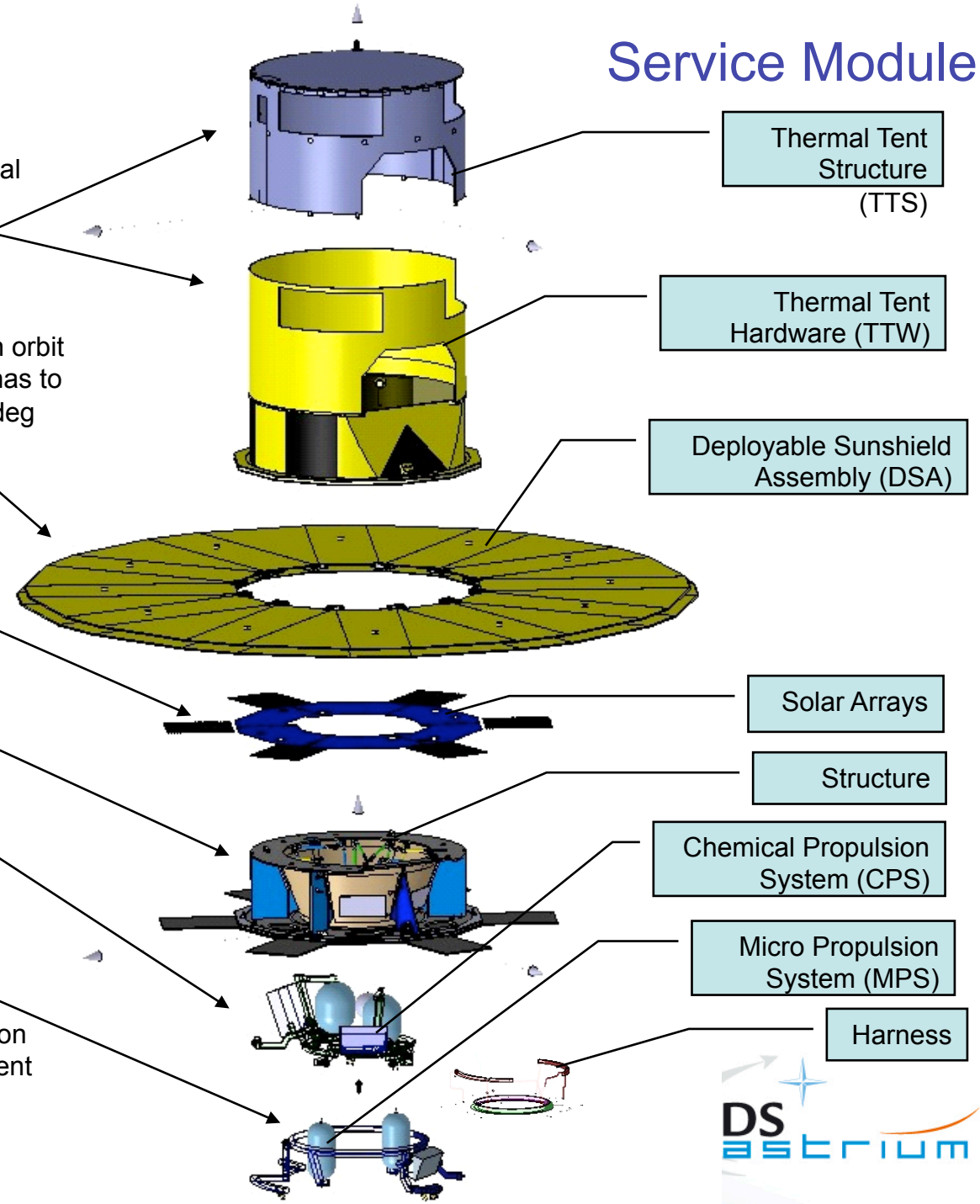
Satellite dry mass (incl. margin)	**= 1620 kg**
Propellant mass (incl. cold gas)	**= 350 kg**
Total launch mass with margins	**= 2160 kg**
Satellite power budget	**= 1750 W**
Launcher: Soyuz Fregat	

Gaia: key figures

- Primary mirrors: 1.45 m x 0.5 m
- Focal length: 35 m
- Pixel: 59 x 177 mas (10 μas ⇔ 1/6000 pixel)
- 1 μas ⇔ rotation M1 < 10 picometers at the edge
- Focal plane: 420 x 850 mm
- About 100 CCD, ~ 1 Gpixel
- Star on CCD: mean: 150, peak: 36000 (magnitude 20)
- Stellar flux: 20 000 e-/s @ V=15 ⇔ 200 e-/s @ V=20
- Sample datation accuracy: 50 ns over 6 hours.
- Tore (3 m diameter) thermal stability required ⇔ some tens of μK
- Rate measurement error < 0,9 mas/s
- Rate pointing error < 5 mas
- Attitude High Frequency Disturbance < 3.4 μas
- S/C launch mass 2.1 tons
- Solar Array capability 1.9 kW
- Mass memory capability 1 Tb
- S/C Height 3 m
- Deployed Sunshield ø = 10 m

Service Module

- The thermal tent provides a stable thermal environment and protects against micro-meteoroids ; it has large cut-outs for the instruments FoV and the FPA
- The 10 m diam. sunshield is deployed in orbit to keep the PLM in the shade of the sun ; it has to be very flat and uniform, with an overall 0.2 deg flatness requirement
- The solar array has fixed panels and deployed panels mounted on the sunshield
- The CFRP SVM structure is mainly made of lower & upper floors, a central tube including the LV/IF ring, radial panels and a DSA ring
- Bi-propellant propulsion system with 8 x 10 N thrusters for orbit correction
- Cold gas micro-propulsion to perform stable attitude control
  [1μN – 500μN] thrust range
- The harness provides electrical connection between units for power and data management

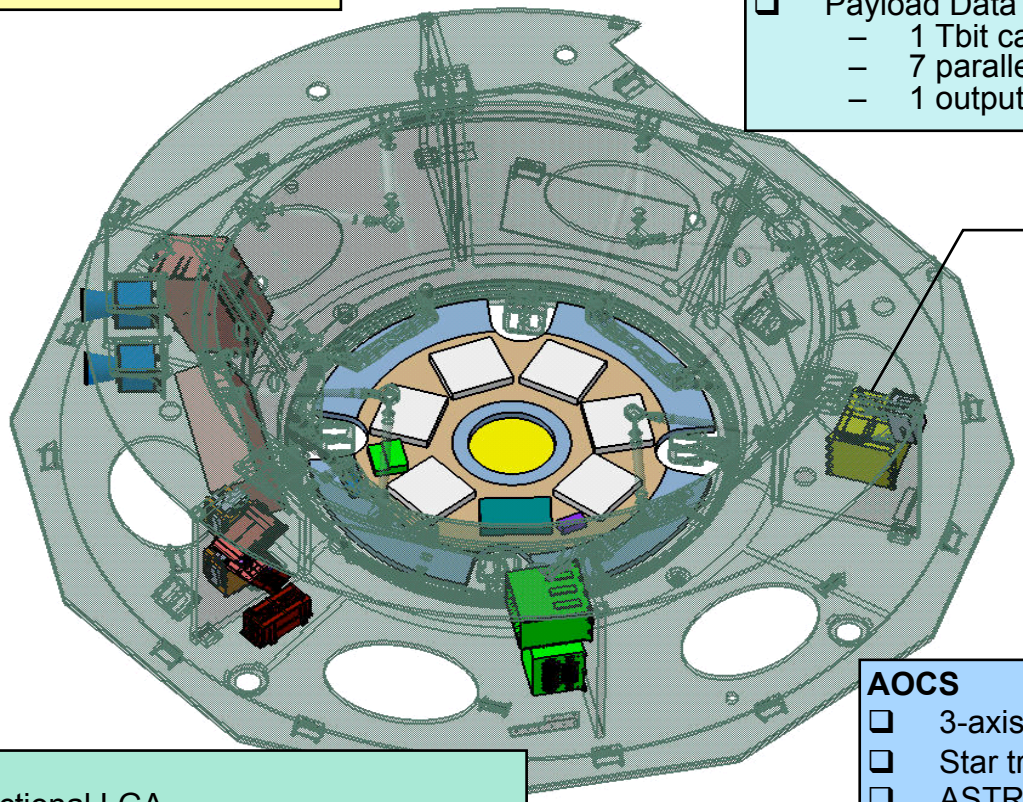


Gaia

Service Module

Power
- 72 Ah Lithium battery
- Power conditioning and distribution unit
  - 28 V regulated main bus
  - 1.9 kW solar arrays
  - Protected power lines to users

Data management
- Command & data management unit
  - ERC 32 processor (N+R)
  - 8 Gb memory for mission management
- Electrical Interface Unit
  - I/O customised with SVM and PLM units
- Payload Data Handling Unit (Mass memory)
  - 1 Tbit capacity
  - 7 parallel SpW inputs (40 Mbps each)
  - 1 output (5 to 10 Mbps)



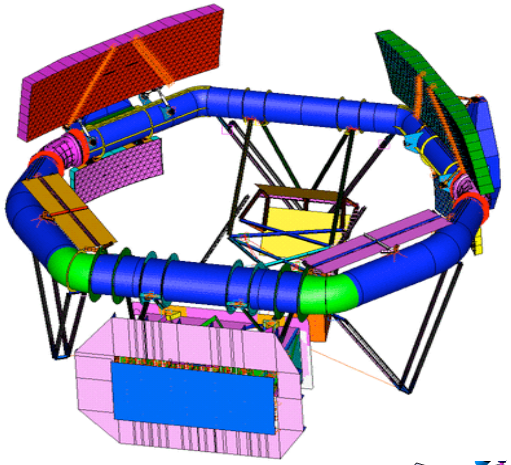
The electronic units are accommodated orthoradially in the SVM cavities
Very stable power dissipation and avoidance of conductive thermal paths minimises thermoelastic distortion

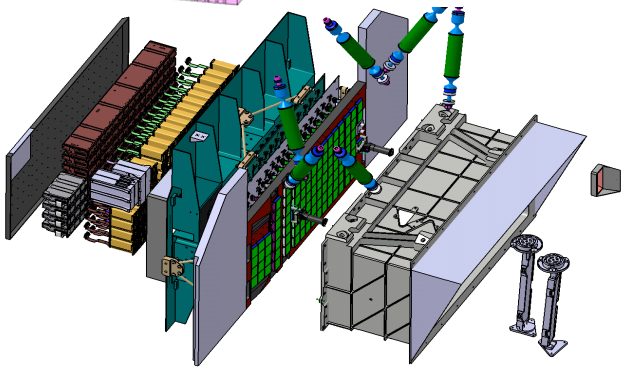
X-band TT&C
- Three omni directional LGA
- Phased Array Antenna with up to 28 SSPA
  - No mobile parts, electronically steered beam
  - TM only, 4.8 to 8.5 Mbps
- Two X band TRSP

AOCS
- 3-axis control
- Star trackers/gyro/sun sensors
- ASTRO instrument in the loop for accurate pointing
- Thrusters and micro-thrusters for attitude control

Payload Module

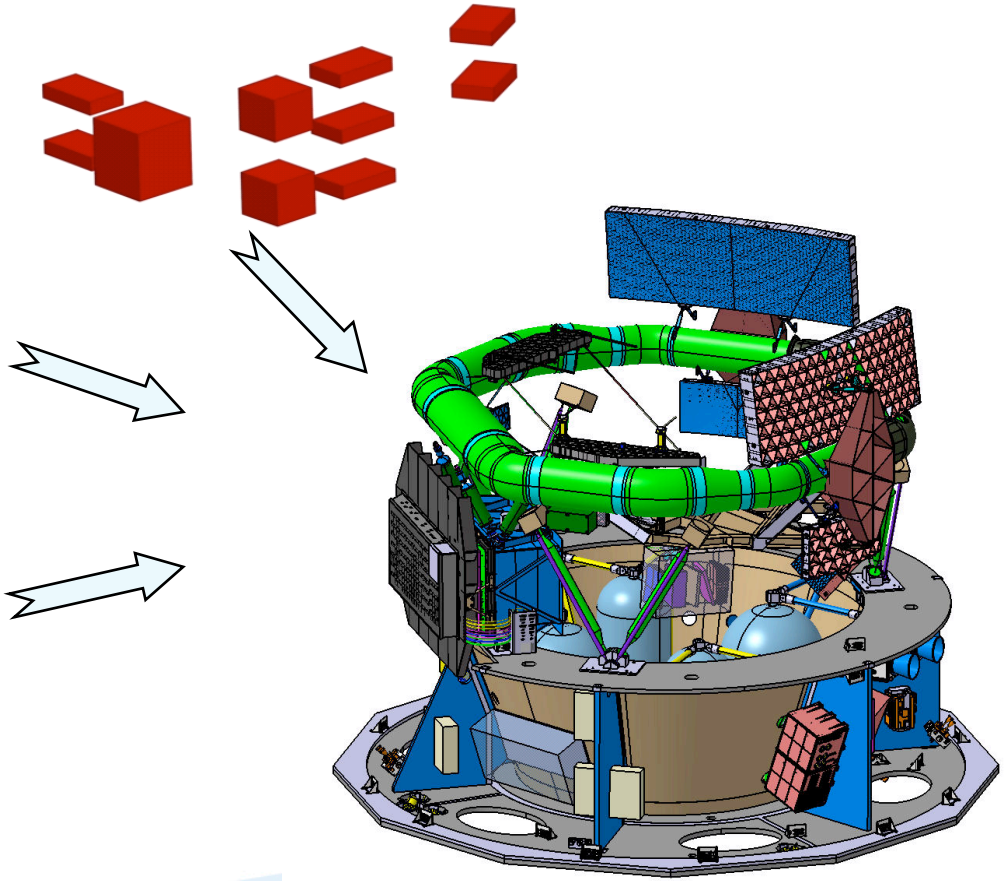
- Structure and mirrors for the optical bench made of SIC, very high thermo-mechanical stability



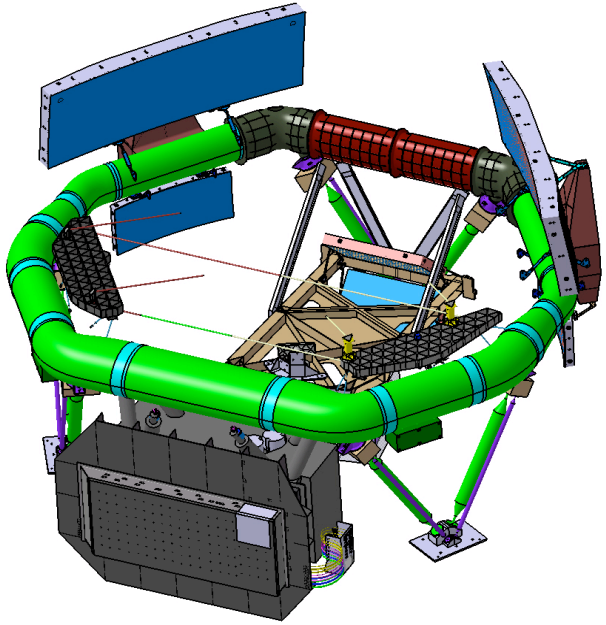


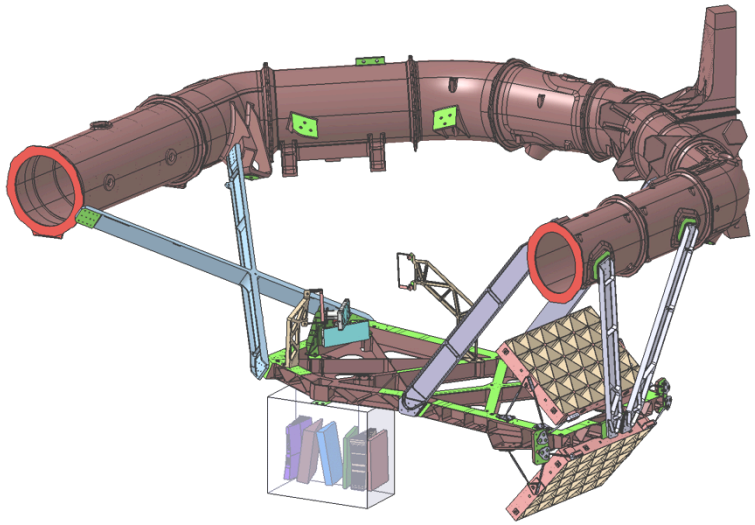
- A large focal plane with ~ 1 billion pixels. CCD passively cooled to 165 K

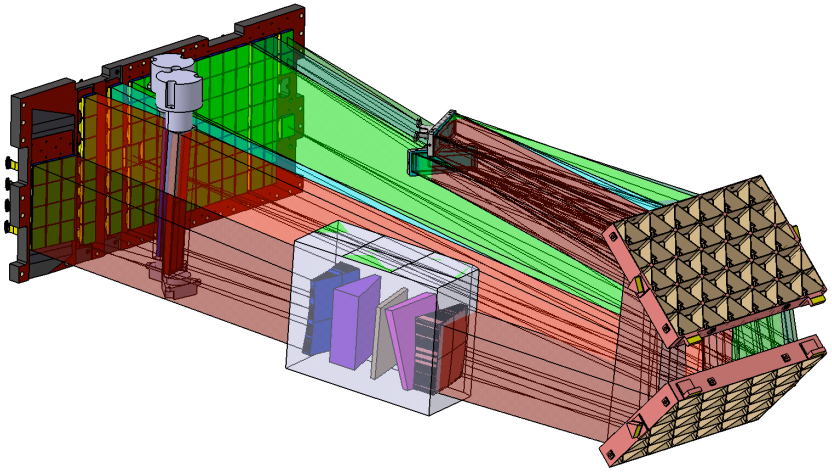
- PLM electronic units accommodated in the SVM (PDHU, VPU, CDU)

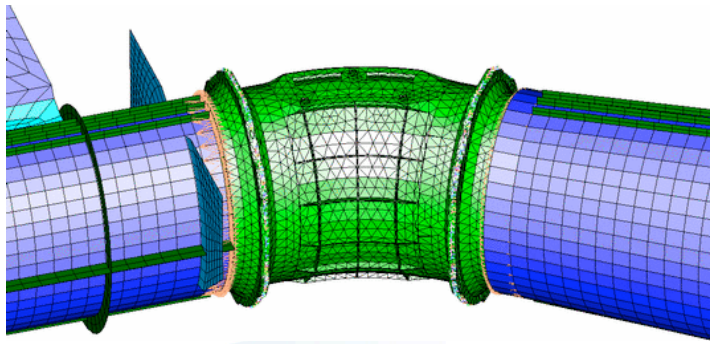


Payload module

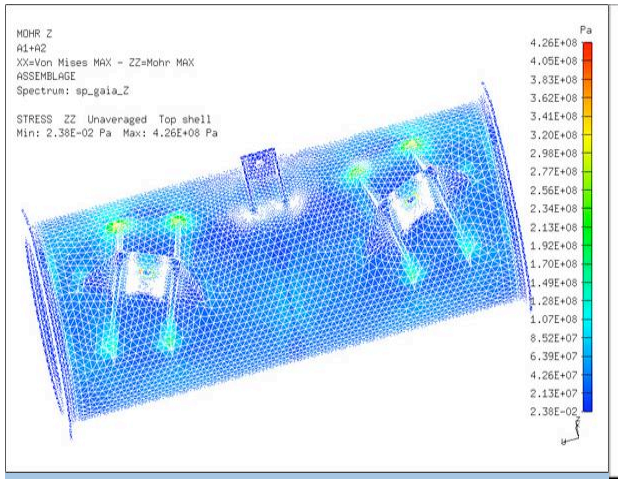


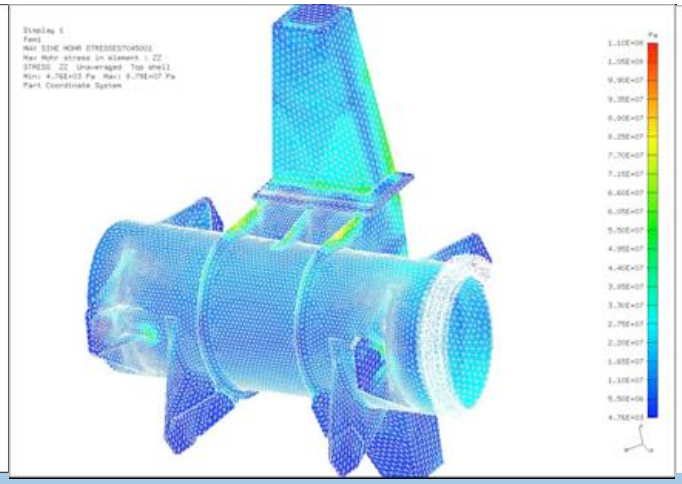


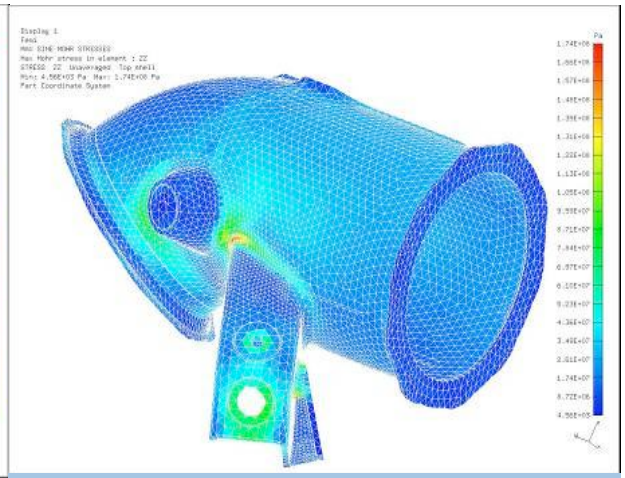


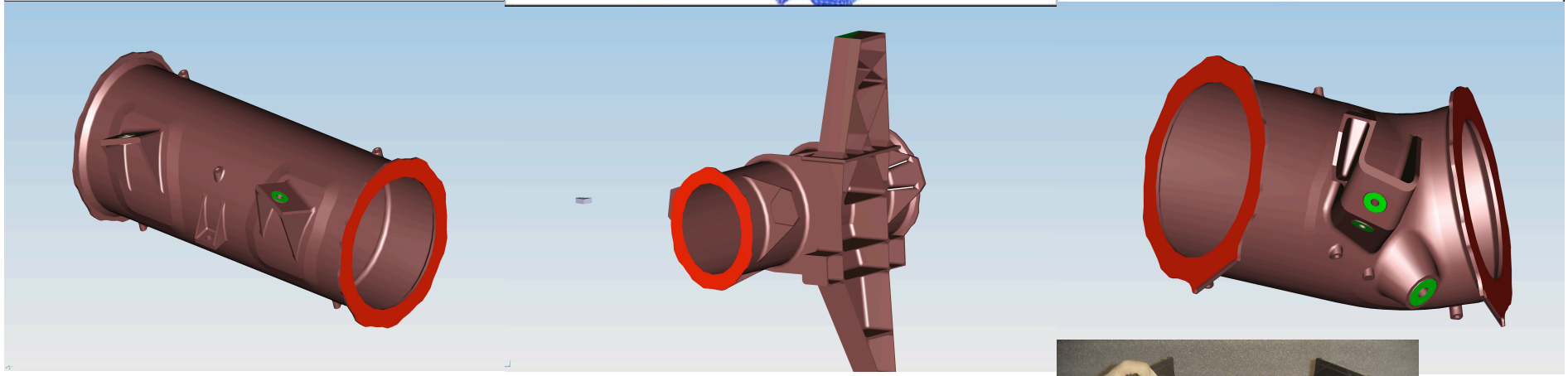


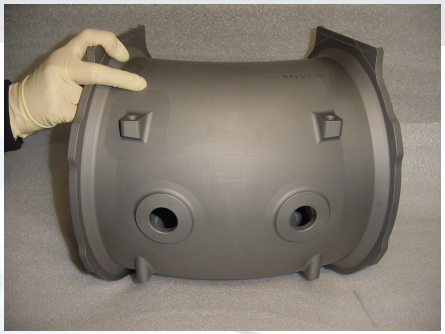
Torus design



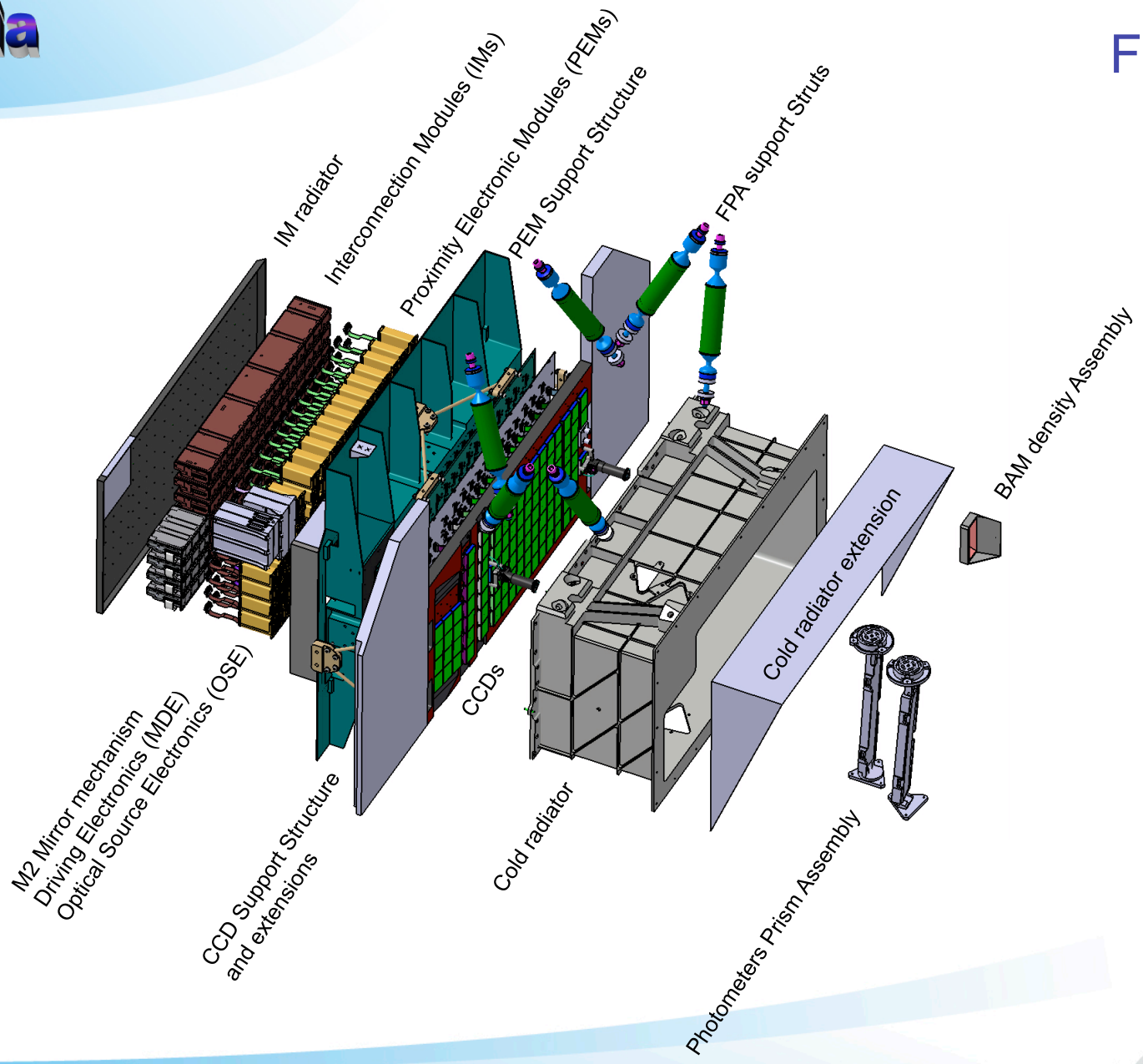






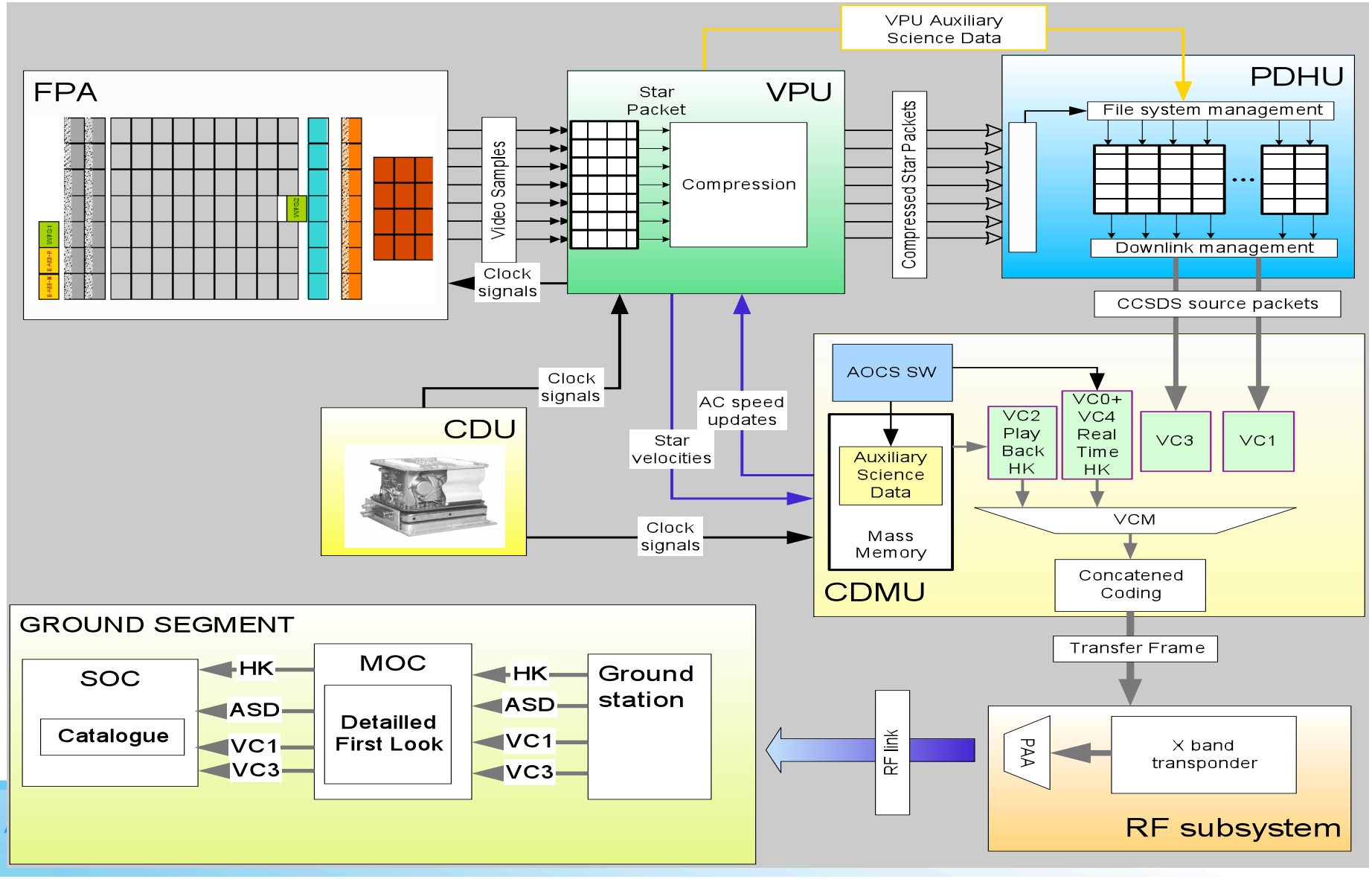


FPA design

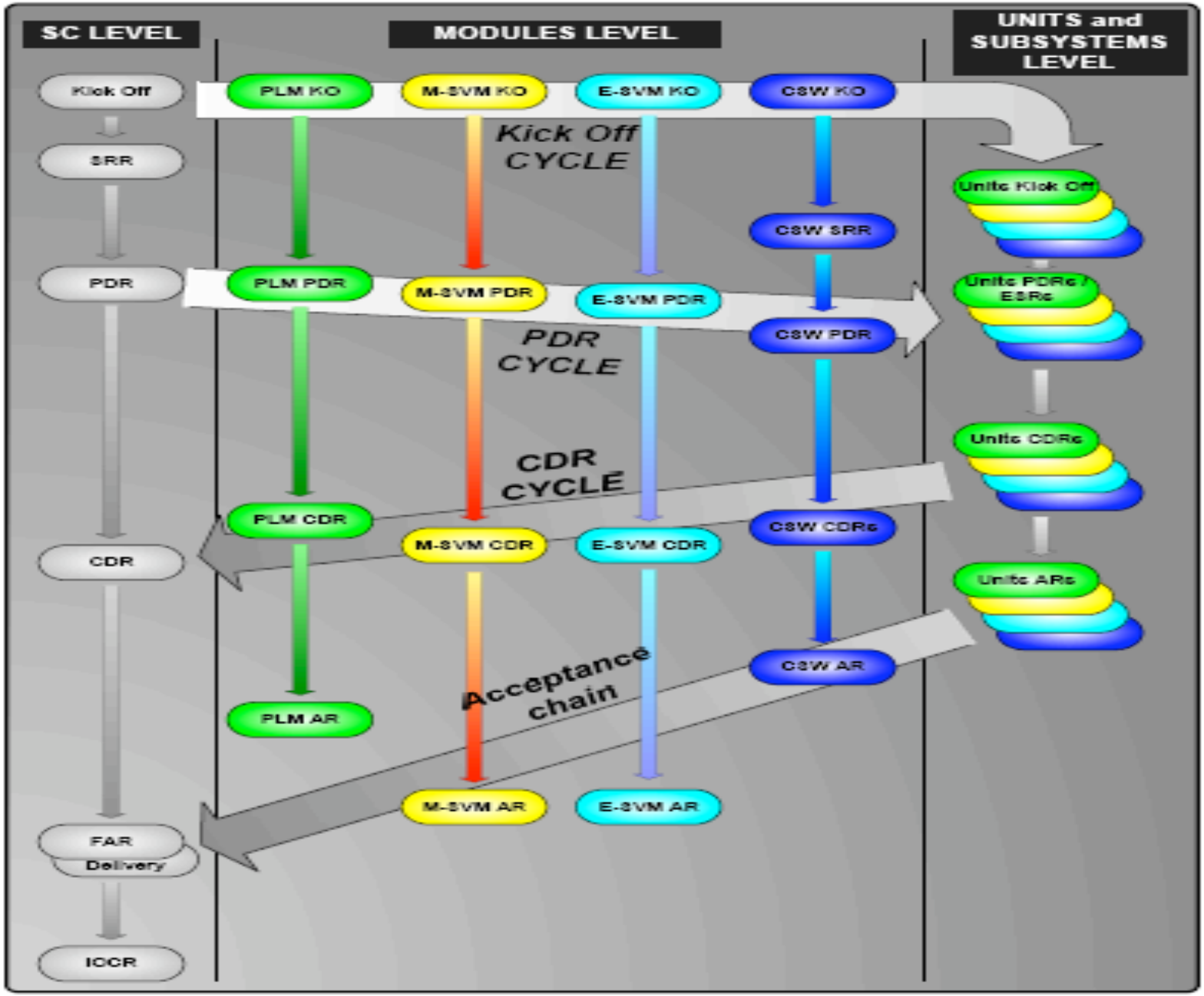

IM radiator
Interconnection Modules (IMs)
Proximity Electronic Modules (PEMs)
PEM Support Structure
FPA support Struts
BAM density Assembly
Cold radiator extension
M2 Mirror mechanism
Driving Electronics (MDE)
Optical Source Electronics (OSE)
CCD Support Structure
and extensions
CCDs
Cold radiator
Photometers Prism Assembly

Science data management architecture

- A long way from Focal Plane to SOC and DPAC…



Development cycles



Avionics Model AVM

Engineering models of electronic units on a table for functional tests

Gaia: Challenges

- Mirror polishing for targeted WFE
- Stellar flux: 20 000 e-/s @ V=15 ⇔ 200 e-/s @ V=20
- Sample datation accuracy and time correlation : 50 ns over 6 hours and 1.7 µsec accuracy UTC – OBT link.
- Basic angle stability : some tens of µK which can only be checked by analyses.
- Phase Array antenna : complex design and huge dissipation
- Micro propulsion performances : noise for low thrust demand
- Optical source electronics (used for BAM and WFS) : diodes qualification
- FPA thermal accommodation and radiation damages

Acronym list

- SVM : Service module
- PLM : Payload module
- FPA : Focal Plane Assembly
- CFRP : Carbon Fibre Reinforced Plastic
- LGA : Low Gain Antenna
- PAA : Phase Array Antenna
- SSPA : Solid State Amplifier
- TRSP : Transponder (X band)
- TM : Telemetry
- SiC : Silicon Carbide
- PDHU : Payload Data Handling Unit
- VPU : Video Processing Unit
- CDU : Clock Distribution Unit
- CDMU : Control and Data Management unit
- AOCS : Attitude and Orbit Control System
- FoV : Field Of View
- SpW : SpaceWire
- SOC : Science Operation Centre
- MOC : Mission Operation Centre
- SRR, PDR, CDR, AR : Design Reviews (System requirement, Preliminary, Critical, Final)

Gaia

Thank you

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