Jason-CS LEO Auroral Charging Analysis

Christian Imhof
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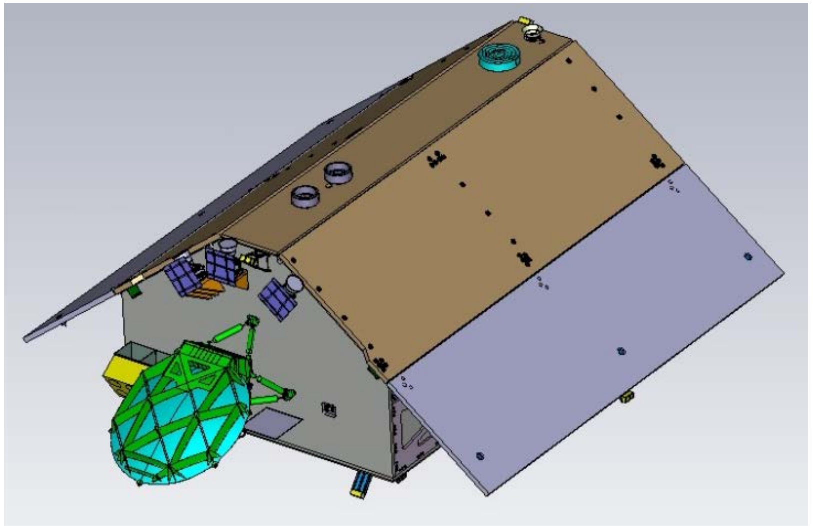
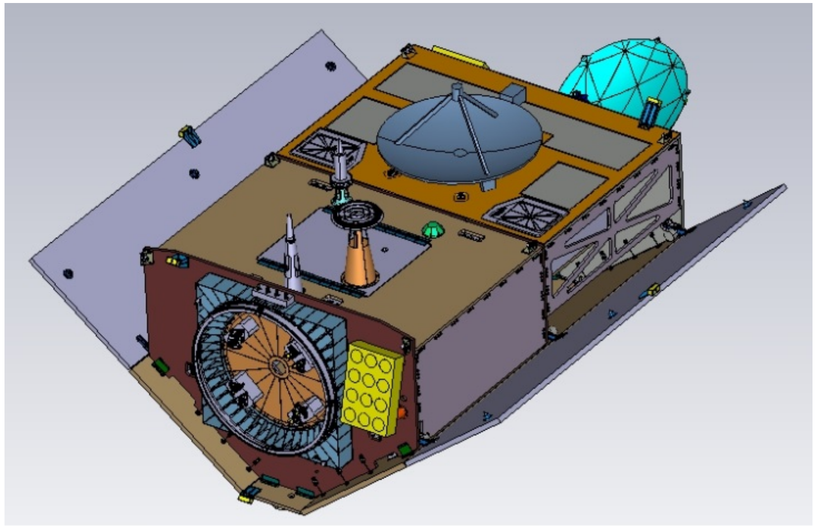
Outline

- Jason-CS Satellite Overview
- Worst Case Plasma Definition
- Modelling of the Satellite for the SPIS simulation
- Results
- Summary and Conclusion

Jason-CS Satellite Overview

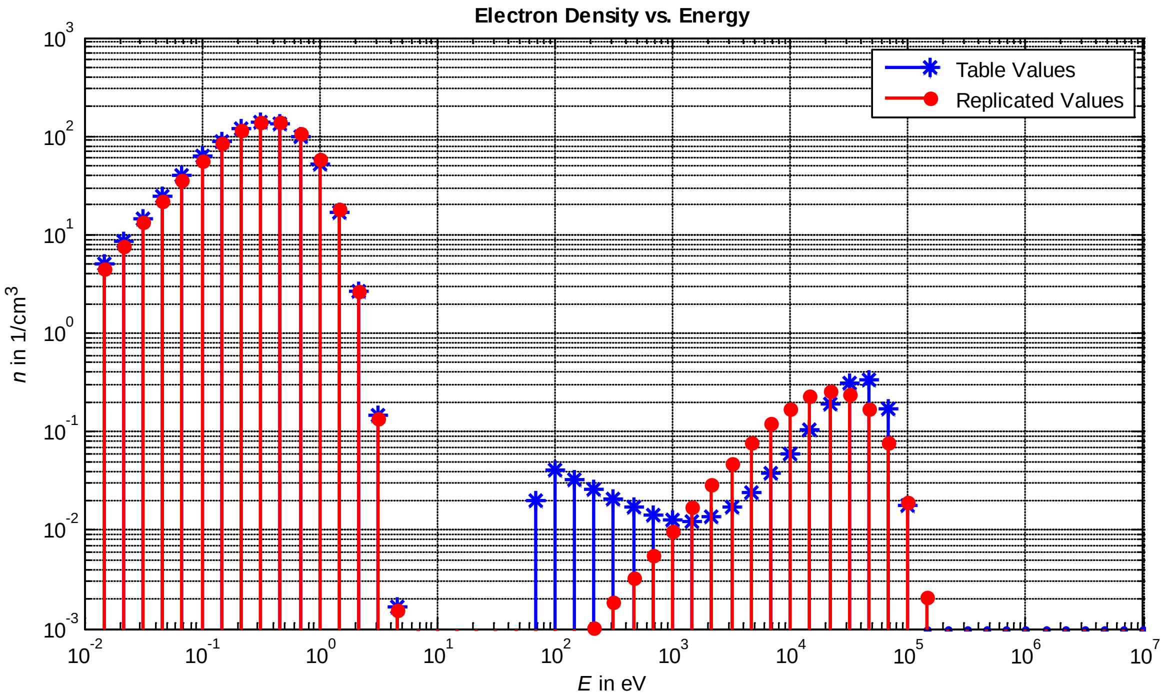
- Earth Observation Satellite
  - Main mission: High precision measurements of ocean surface topography
  - Orbit of 1336 km with an inclination of 66°
    - ➢ Passage of the auroral zone will be the worst case for the surface charging
- Geometrical Layout





Worst Case Plasma Definition

- LEO Auroral Plasma
  - Plasma definition taken according to the SPENVIS population:
    “Cold single Maxwellian and Fontheim Electrons”
  - High energy electron distribution has been matched using a Maxwellian distribution
  - Reuse of the basic definition used in heritage projects e.g. Sentinel-2 and EarthCARE



Population	Density in cm^{-3}	Energy in eV
Electrons 1	809.9	0.2156
Electrons 2	1.482	12940
Ions 1; O^+	813.4	0.2156

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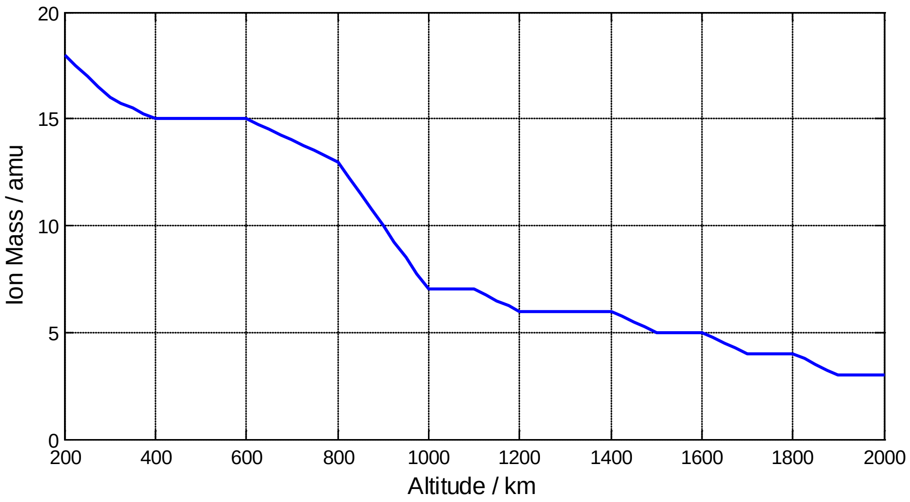
Worst Case Plasma Definition

- Orbit altitude of Jason-CS is significantly higher than for the mentioned heritage projects
  - This has an influence on the composition of the ion species
    - ➢ Average ion mass is dependent on the orbit altitude
    - ➢ LEOPOLD tool included in SPENVIS is used to determine the average ion mass
  - Ion population is modelled as a mixture of H^+ and O^+ ions
    - ➢ Even distribution is chosen which leads to a slightly increased average mass wrt. the LEOPOLD curve

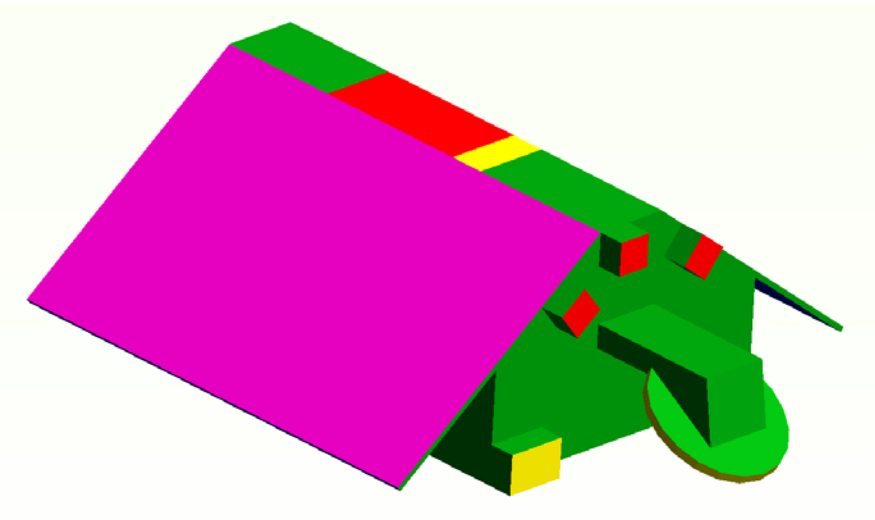


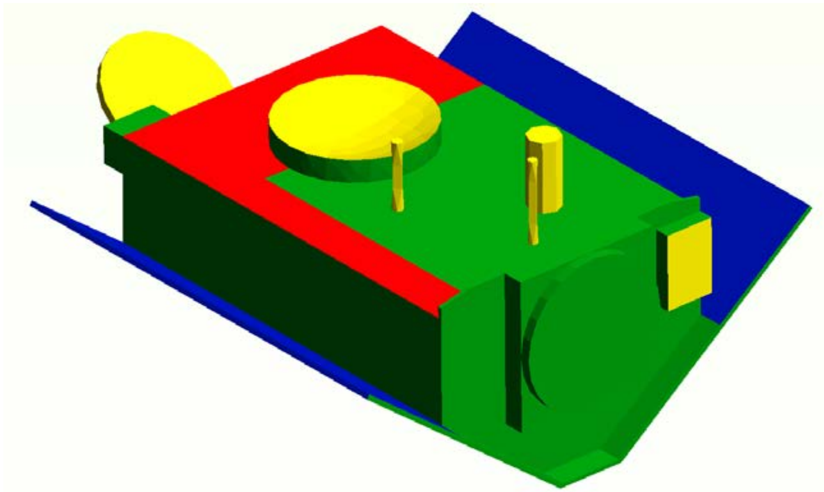
Population	Density in cm^{-3}	Energy in eV
Electrons 1	809.9	0.2156
Electrons 2	1.482	12940
Ions 1; O^+	406.7	0.2156
Ions 2; H^+	406.7	0.2156

Modelling of the Satellite for the SPIS simulation

- Geometrical Model and Material distribution

Color	Description	SPIS Material	Node #
Blue	Deployable SA rear	ITO	0 (SC Ground)
Green	Thermal Control MLI	Kapton	1
Red	Radiators; ITO Coated SSM	Teflon SSM Tapes	2
Yellow	Antennas	White Paint PSB	3
Magenta	SA front	CERS	4





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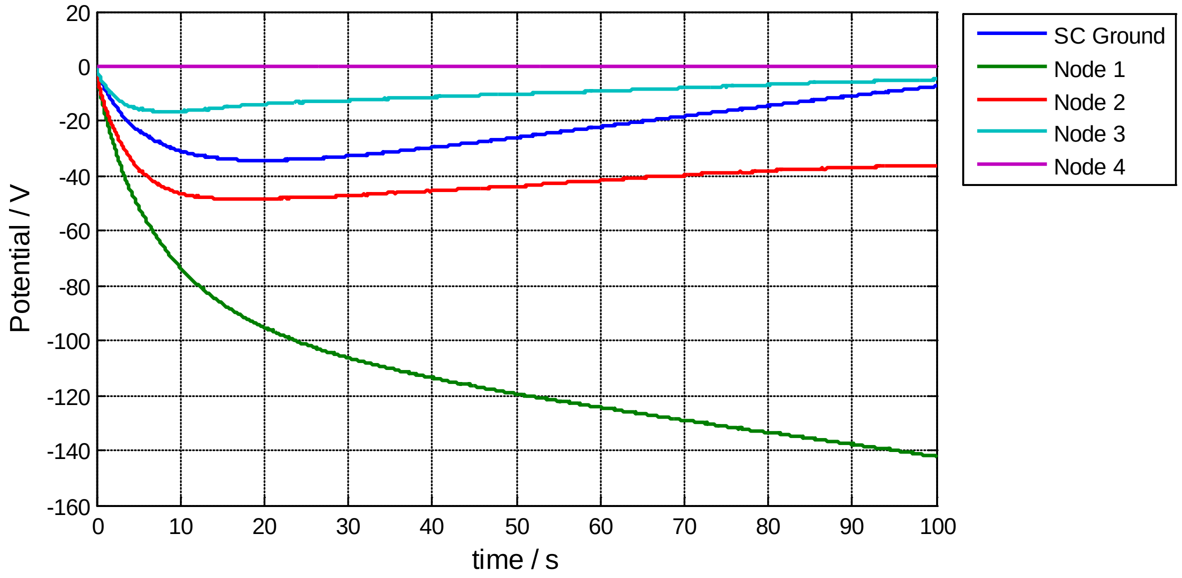
Results

- Basic Settings of the SPIS simulation
  - Ions modelled using PIC
    - ➢ Satellite velocity has to be taken into account (Ram/Wake effects)
  - Electrons modelled using fluid model (Maxwell Boltzmann)
    - ➢ Allows speed up of simulation
  - Debye Length is very small in comparison to the structure
    - ➢ Meshing on the scale of the Debye length is not feasible -> hardware resources and simulation time
    - ➢ Use of non-linear Newton solver
  - All simulations have been performed in eclipse conditions
  - Secondary emission from electrons and ions is considered
  - Simulation time of 100 s is used
    - ➢ Typical time to cross the auroral zone of about 60 – 80 seconds plus additional margin

Results – Nominal Orbit

- Time dependent potentials show an interesting behaviour
  - First 10 – 15 s are dominated by the negative charging of the Kapton surfaces which pull the ground and all other surface potentials to negative values
  - After approx. 20 s the high secondary emission on the ITO & Teflon surfaces accompanied by an increased ion current towards the negatively biased Kapton surfaces leads to a relaxation of the Ground potential
  - Kapton surfaces are still charged towards more negative potentials
- Final & intermediate potential values show no risks for ESDs on the satellite



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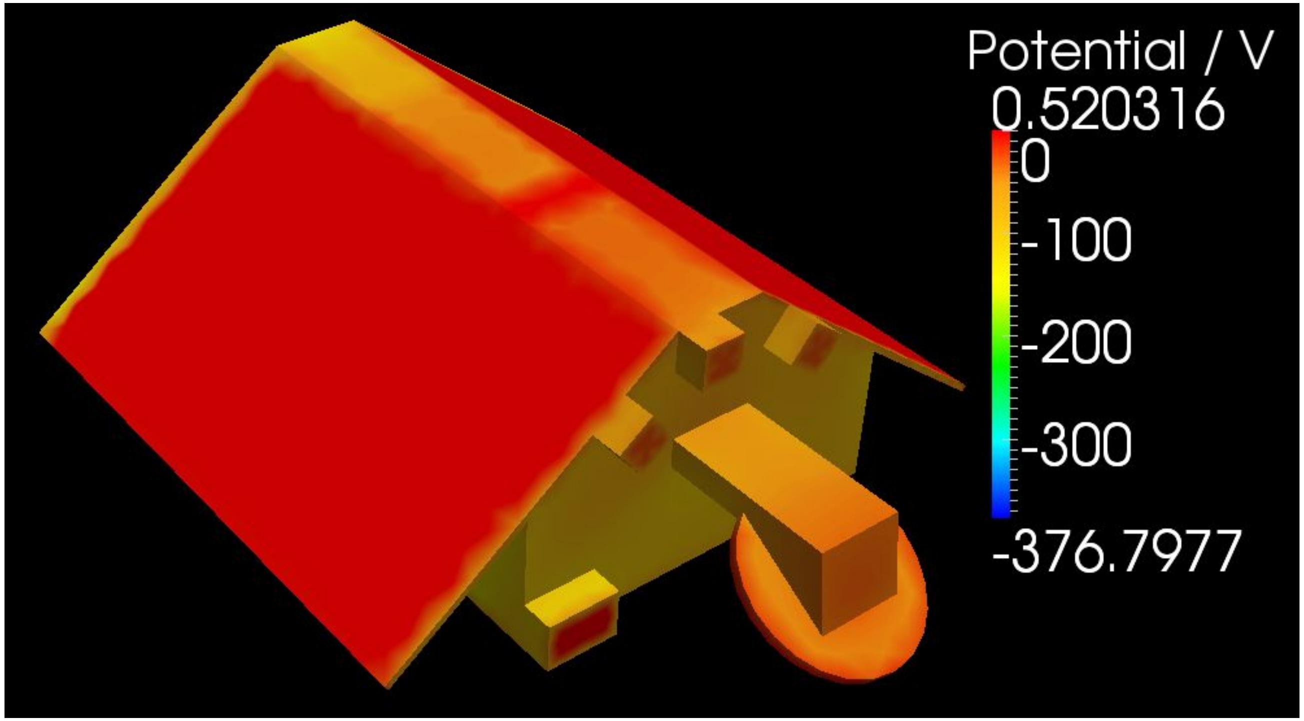
Results – Nominal Orbit

- Surface Potential Distribution
  - slightly positive potential on the SA
  - RAM surfaces show moderate potentials especially on the reflector dish of the Radiometer instrument



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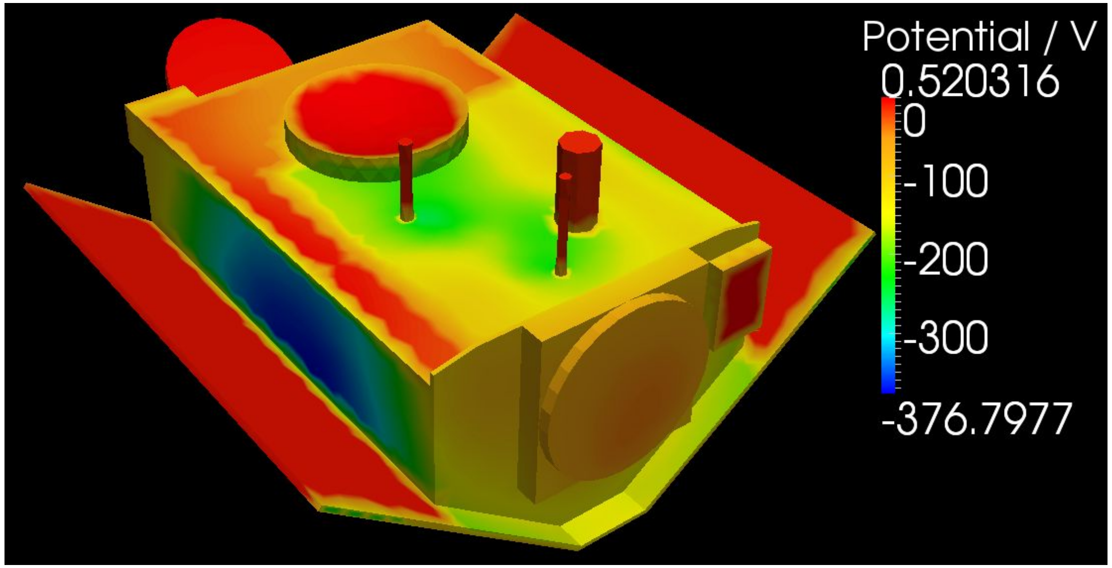
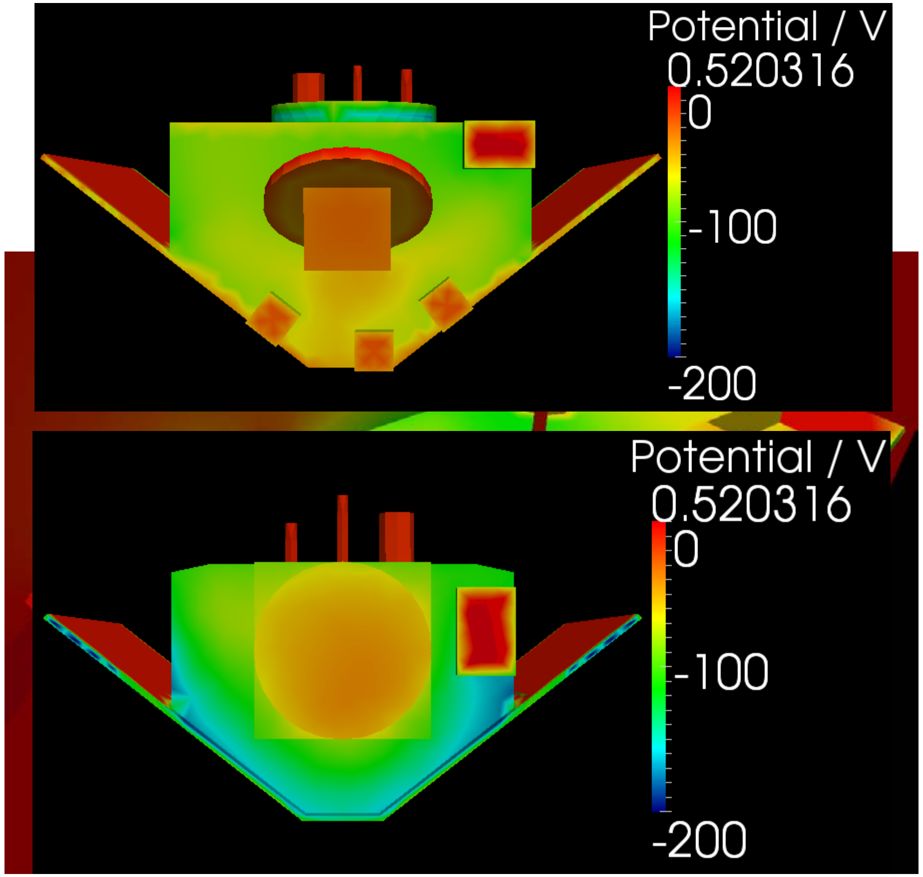
Results – Nominal Orbit

- Surface Potential Distribution
  - Ram/Wake effect is nicely visible
    - behind the dish of the Altimeter instrument
    - Between front and rear surfaces of the satellite body
  - Very low potential on the side of the body where the radiator is located
    - Due to materials with potential close to 0 V close to this part
    - Neg. potential is “shielded” -> reduced ion current
      -> higher electron current





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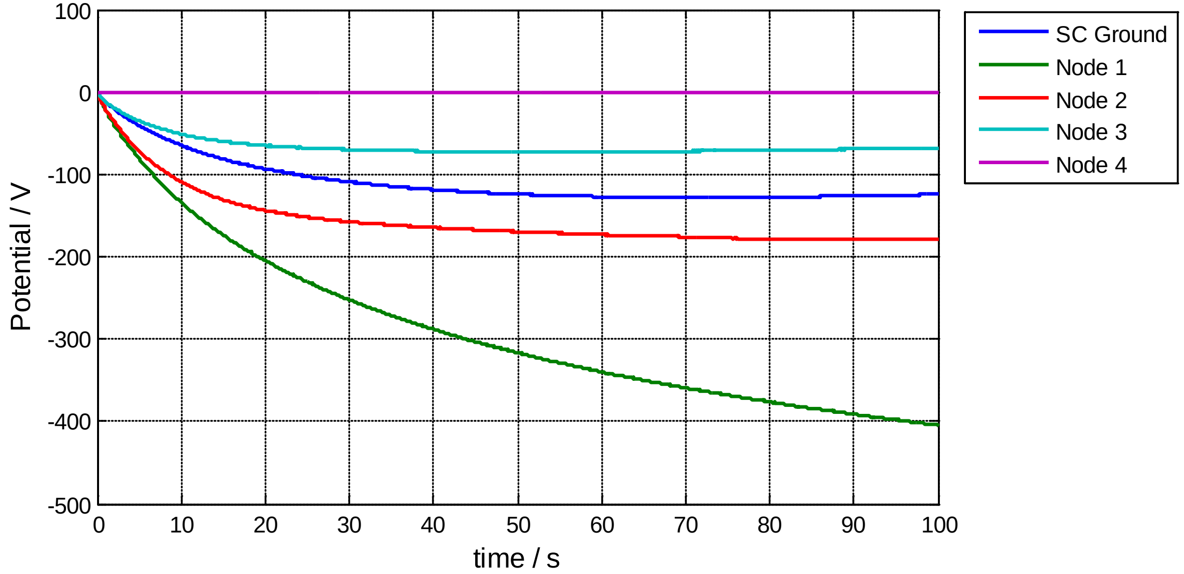
Results – Low Altitude Orbit

- Time dependent potential evolution
  - ➢ The observed behaviour at high altitude can also be seen here but less pronounced
  - ➢ Overall potentials are remarkably reduced with the ground being at a minimum of -120 V
    - ➢ Especially the Kapton MLI averaged surface potential drops down to below -400 V
- Still no critical potentials regarding direct potential gradients
  - ➢ According to ECSS slight risk for ESD on SA due to inverted potential gradient of -120 V
    - ➢ Value considered by Airbus DS is higher
  - ➢ Even if an ESD could be possible there is no risk to the system
    - ➢ SA can withstand primary arcs and secondary arcs are avoided by design



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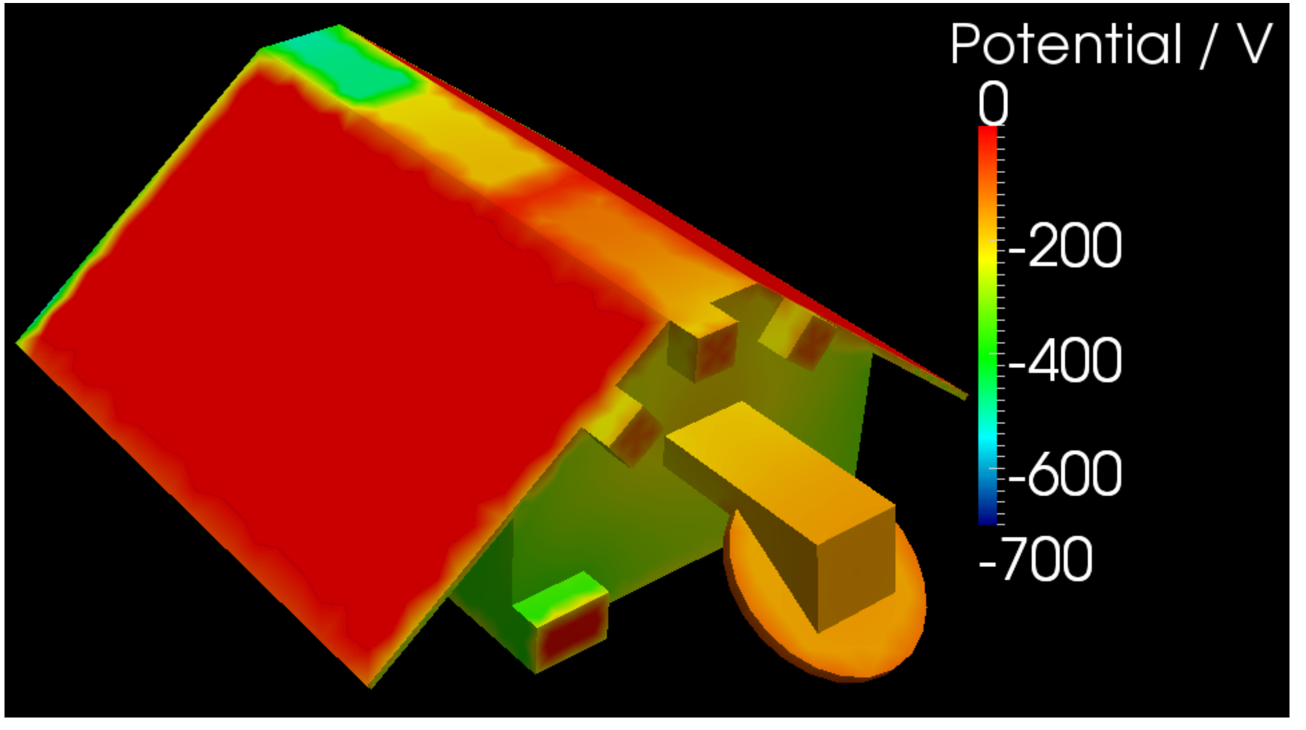
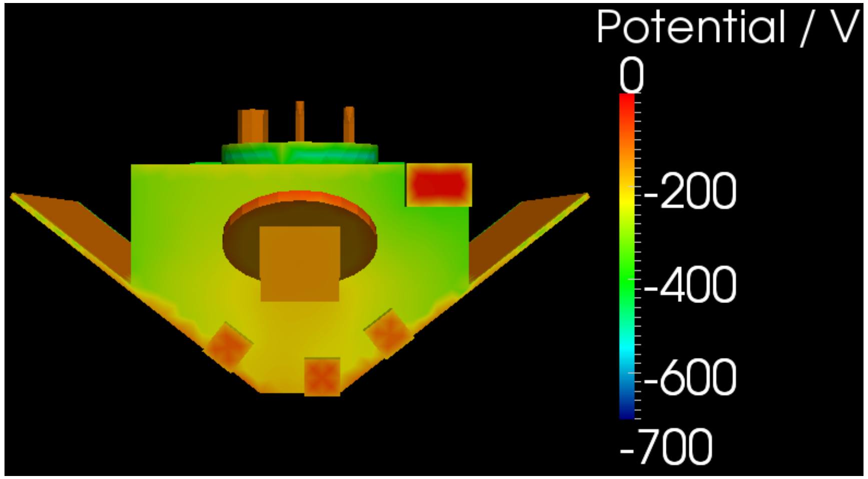
Results – Low Altitude Orbit

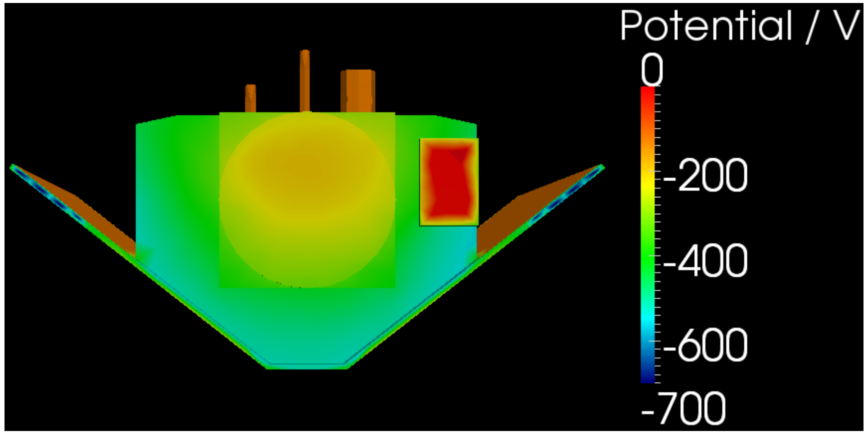
- Surface Potential Distribution
  - slightly positive potential on the SA
  - RAM surfaces are now more negative at about -150 V
  - PSB painted RO antenna still at a quite low potential

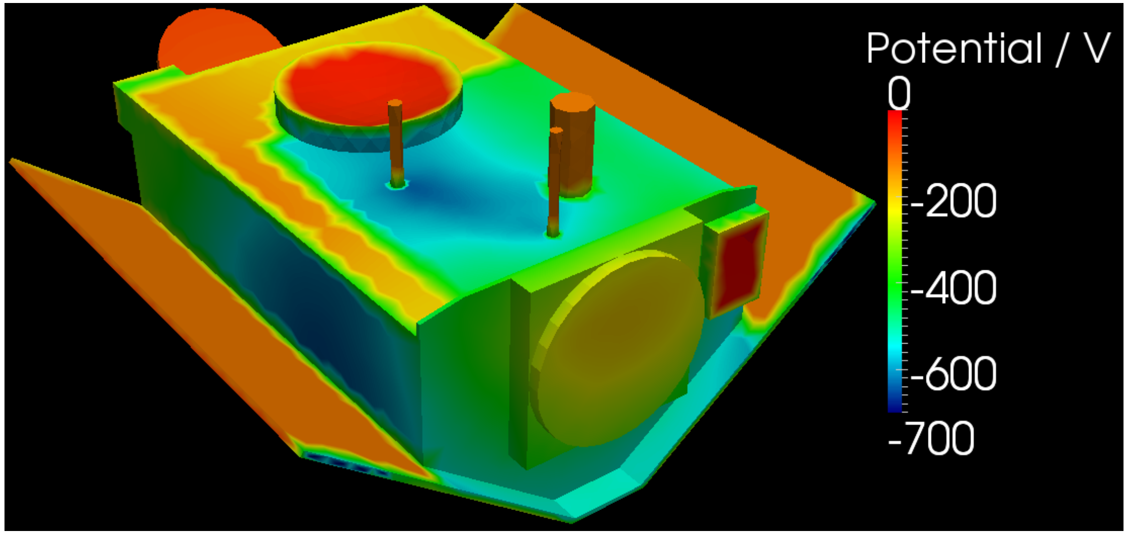


Results – Low Altitude Orbit

- Surface Potential Distribution
  - Absolute value of the minimum potential nearly doubled in comparison to nominal orbit
- All other basic observations are the same as for the high altitude nominal orbit







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Summary and Conclusion

- Worst Case satellite charging potentials calculated for the Jason-CS satellite
  - Only slight possibility of ESD on the SA due to inverted potential gradient in low altitude orbit
  - Strong influence of the average ion mass (orbit altitude) on the charging results
  - Strong negative charging on one side as a nice example why 3D charging tools are needed

- SPIS V5 feedback
  - Good tool for the prediction of satellite charging and identification of possible risks/threats
    - If threats are identified early in the project there is the possibility for material changes
    - characteristics of possible ESD pulses can be assessed and used for the definition of tests
  - Strongly improved usability of the tool with the new GUI
  - Material database shall be kept updated
    - Results of the simulations are only as good as the inputs
    - Validated material data of materials used on satellites shall be available

Thank you for your attention! Questions?