High level charging

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THE FRENCH AEROSPACE LAB

return on innovation

Introduction

- A. Older simulation (GEO Charging at gap scale) outcome
  - Microscopic physics (local charging versus global)
  - Numerical limitations:
    - Bad current statistics => backtracking needed
    - Very different time scales for absolute and relative charging: implicit solver needed

- B. Recent results
  - Backtracking + implicit circuit solver implemented inSPIS
  - More accurate simulations (time evolution and local current)
  - Comparison with NASCAP (B. Andersson, SSC)

A. Charging at gap scale

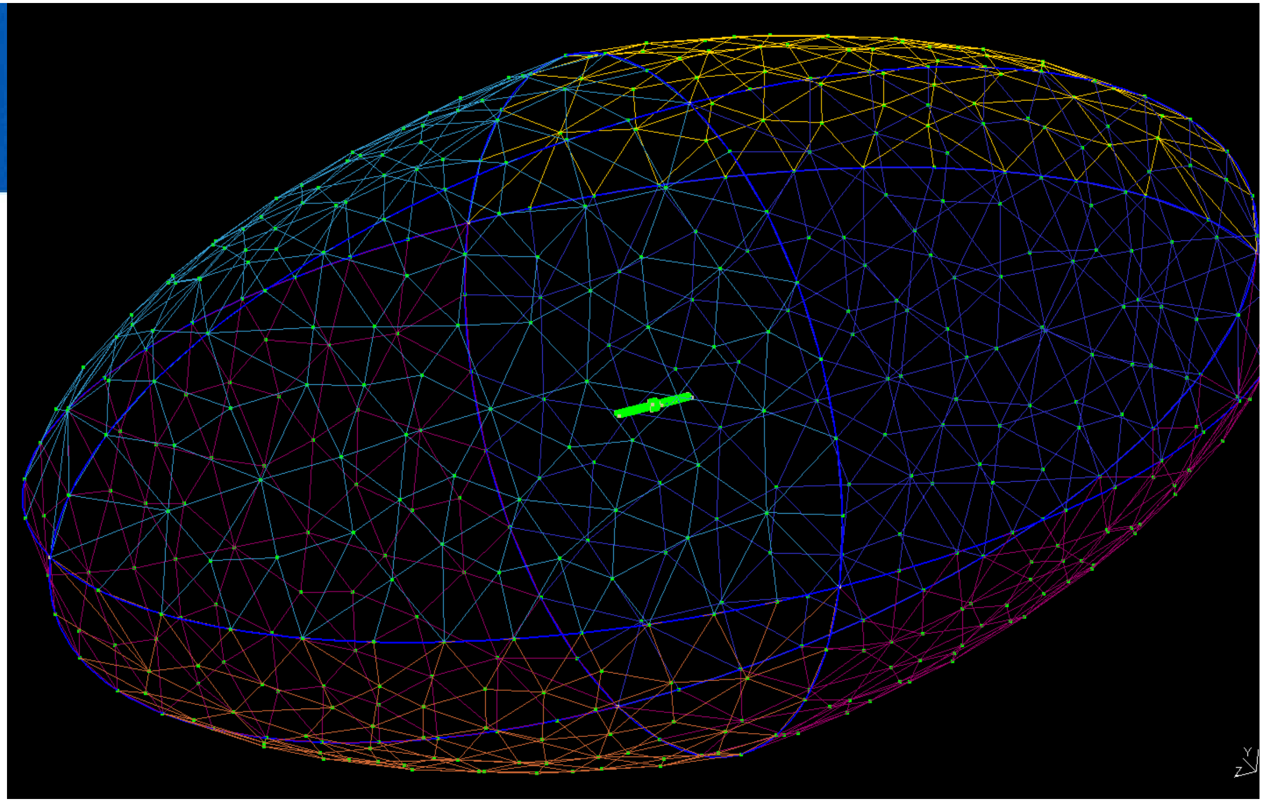
- Objective: knowledge of pre-ESD conditions
  - Is voltage gradient similar at large and small scale?

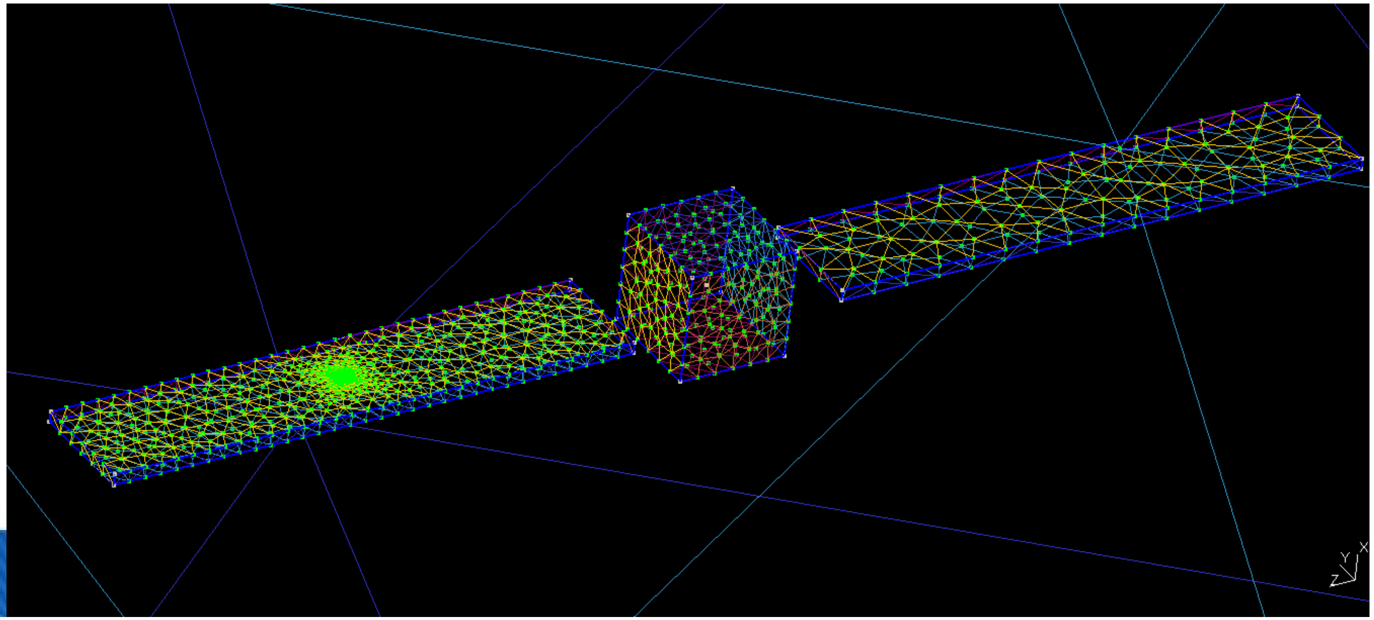
- The physics modelled
  - Typical GEO environment
  - Inverted Gradient Voltage at microscopic scale (by photo-emission here)
  - Next step = ESD start (cf. D.):
    - Field effect emission (Fowler-Nordheim law)
    - SEEE avalanche (hopping)

- CNES R&T funding

The mesh

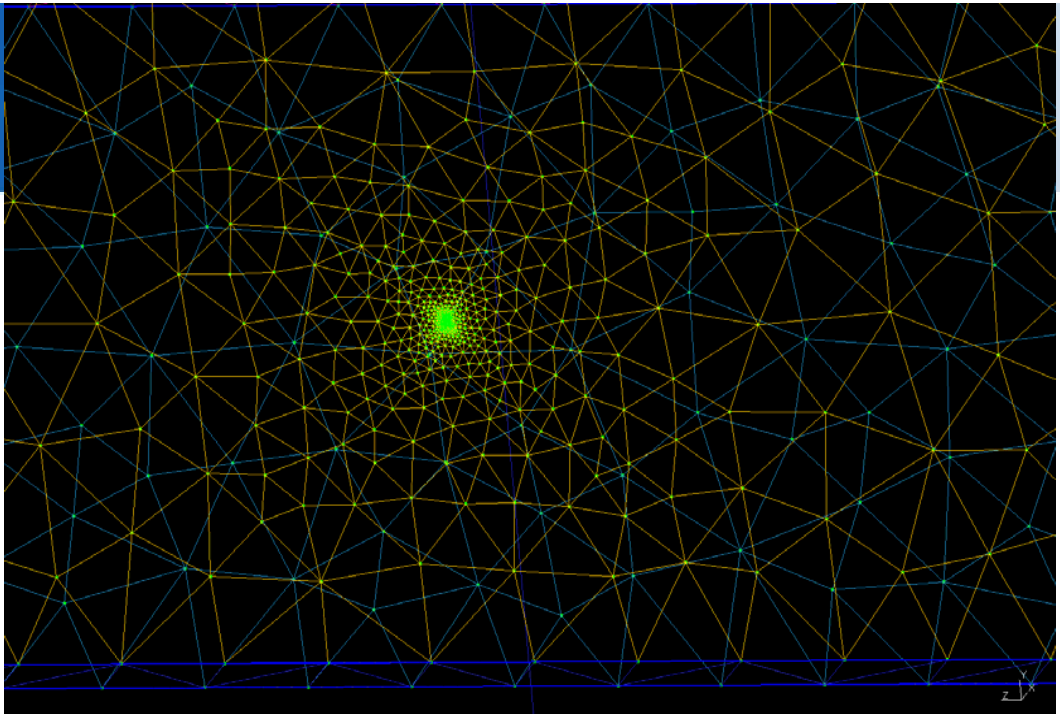
- Very large multi scale ratio
  - Box several 10s meters
  - Resolution around intercellular gap 0.3 mm
  - Ratio ~ 100,000

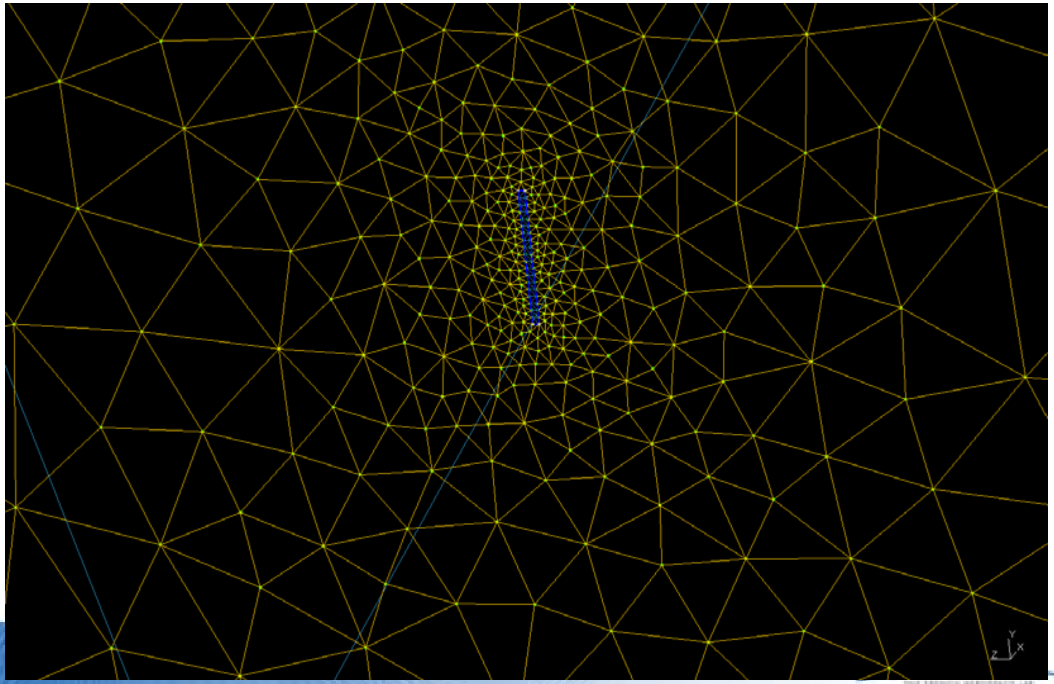




The mesh

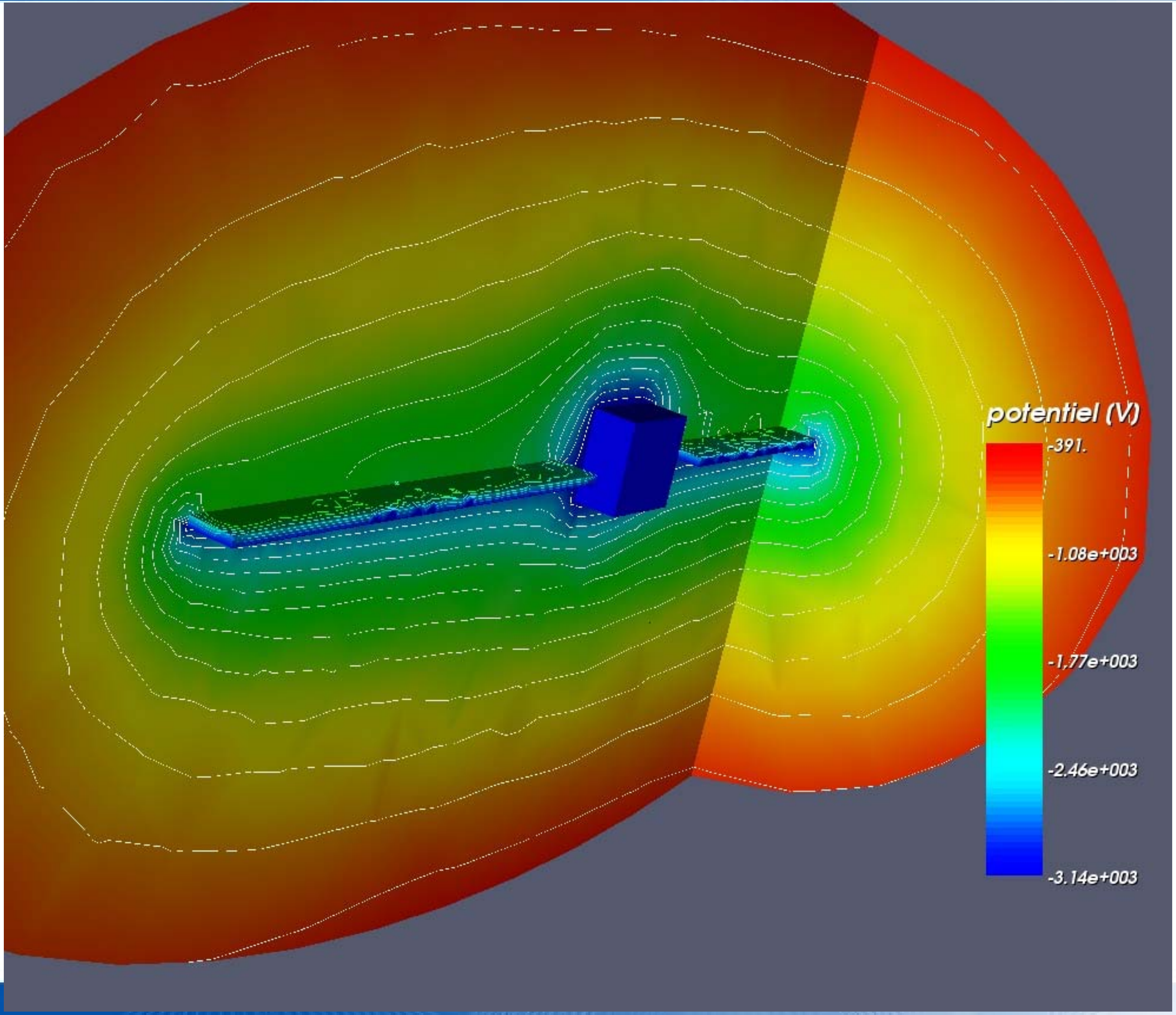
- Detail views near the gap





geom8b ok.geo

Potential map



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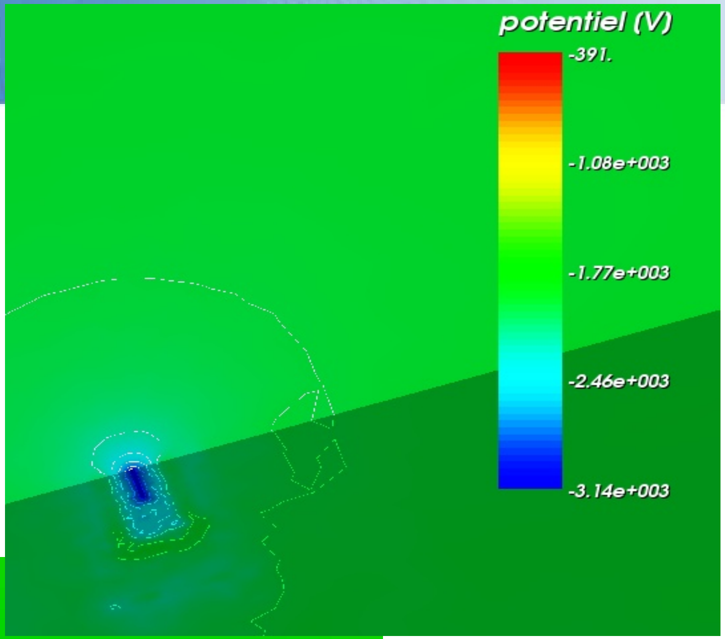
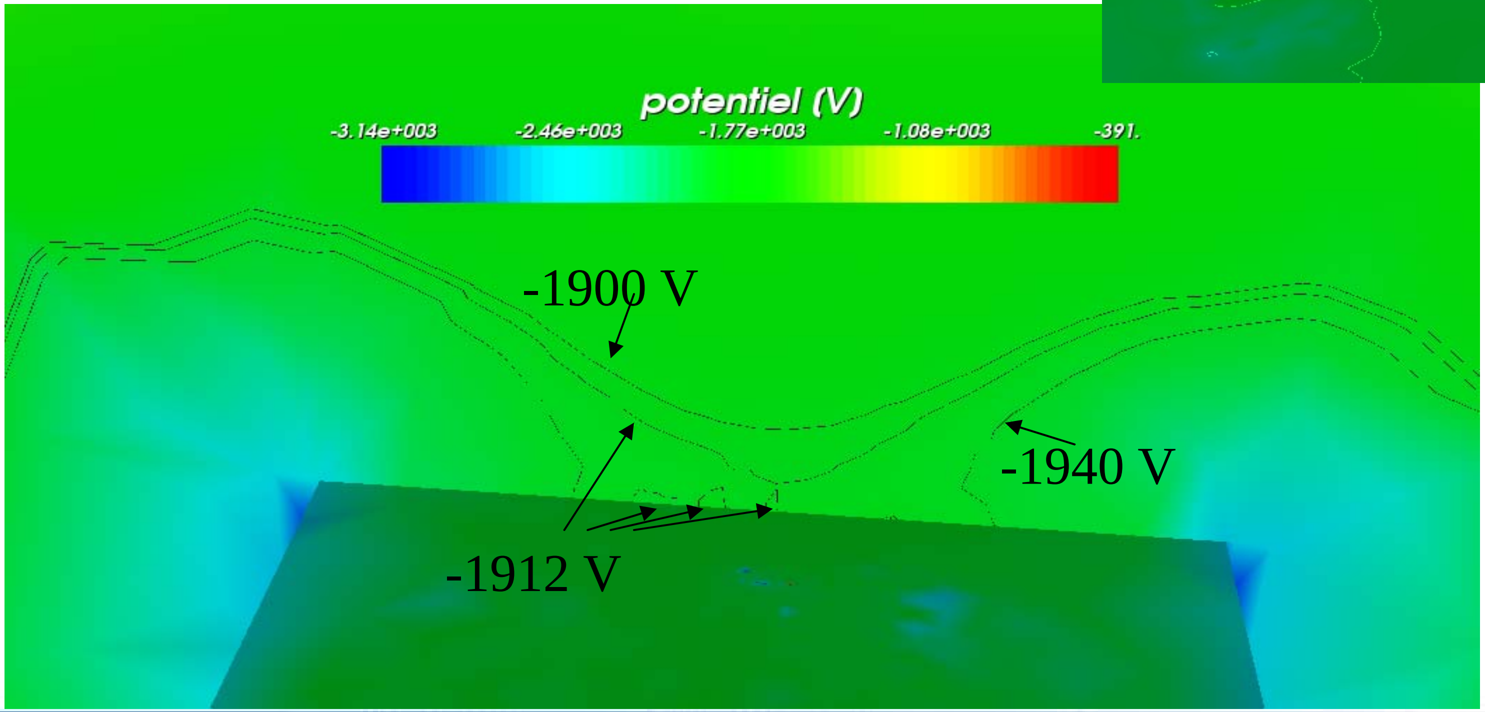
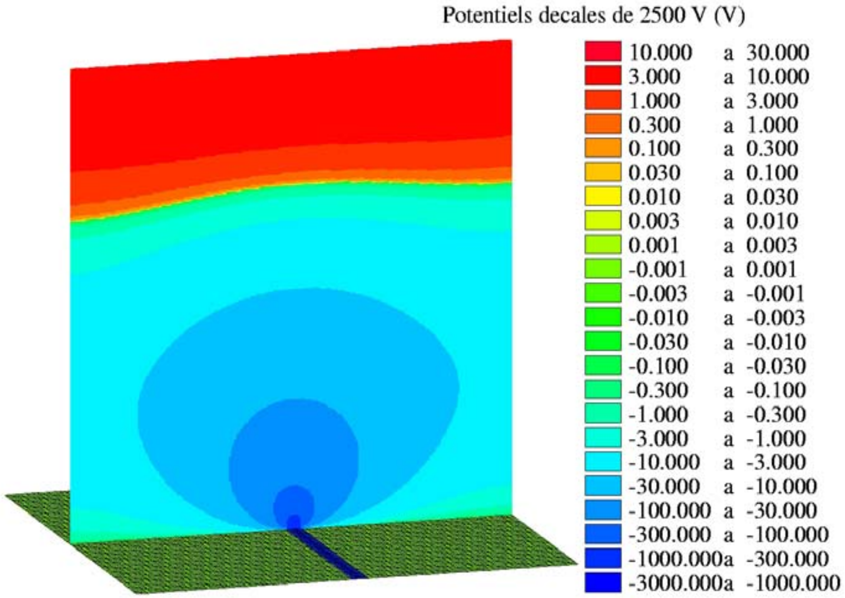
Potential details

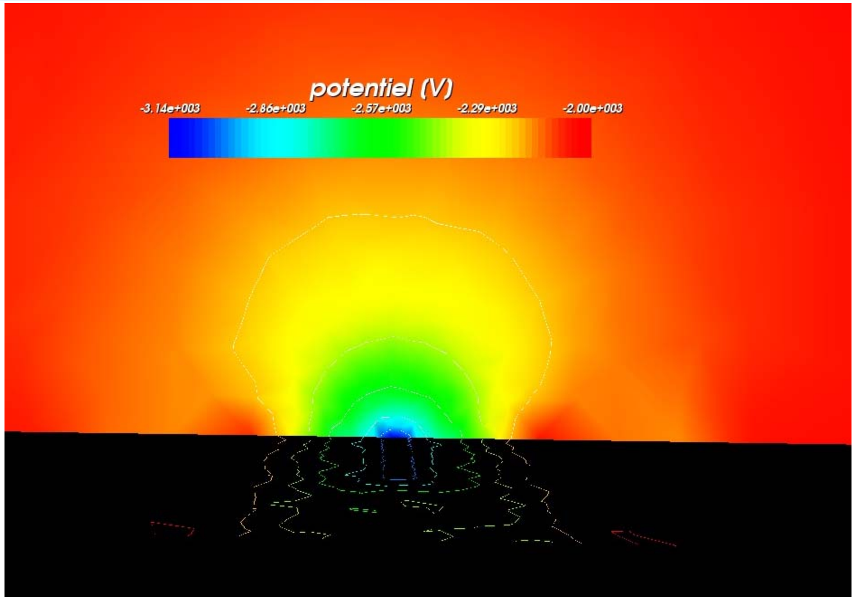
- Potential barrier
- Detail close to the gap





Charging at gap scale





- Old non self consistent surface potential, uniform surface potential (SILECS)

⇒ "potential barrier" on top of coverglasses close to the gap because of the influence of its repelling negative potential

- New self consistent surface potential (SPIS)

⇒ Coverglass surface potential more negative close to the gap (because secondary emission blocked)

⇒ Potential gradient different at macroscopic and microscopic scale

⇒ Possible explanation of different ESD triggering threshold for IVG in plasma (left hand side chart) or electrons (right hand side chart)

B. New developments

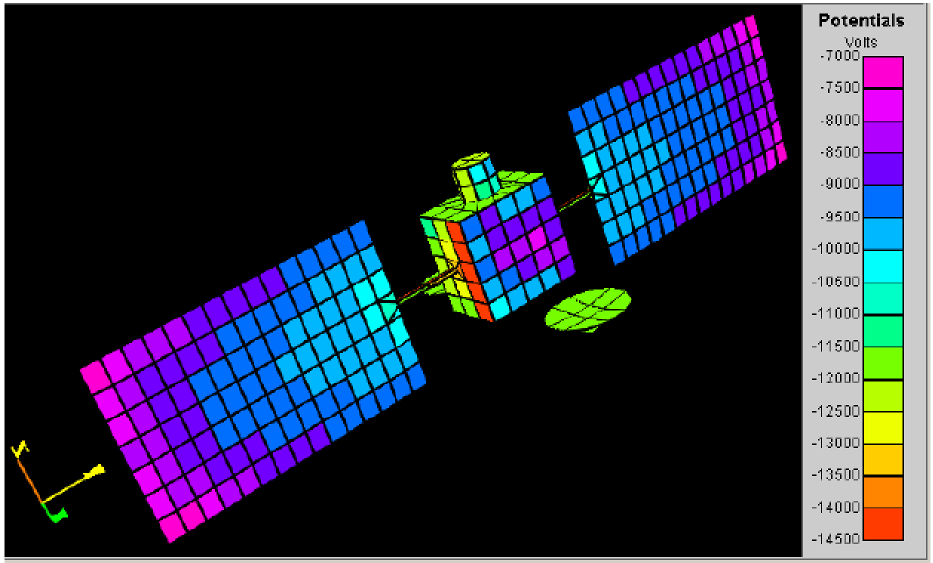
- SPIS / Time Dependent contract (ESA – ARTES / France)
- Composite volume distributions:
  - Backtracking for collected currents => improved statistics
  - Density through regular method (Boltzmann or PIC) for Poisson equation (not simply Laplace in SPIS)
- Implicit spacecraft circuit solver: stable even for very variable time constants
- Photoelectron recollection explicitly modelled

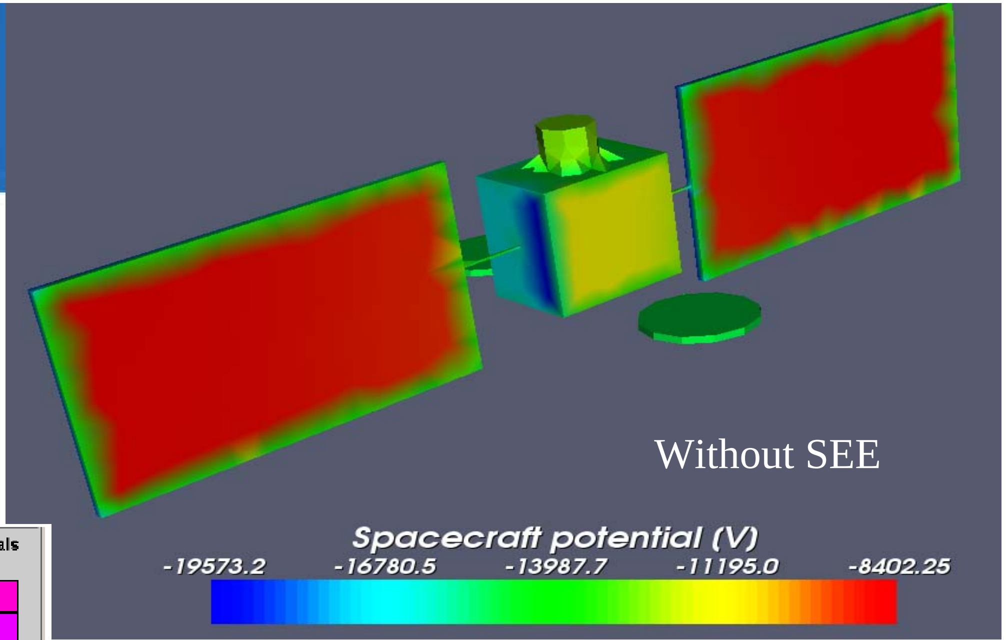
Comparison with NASCAP modelling

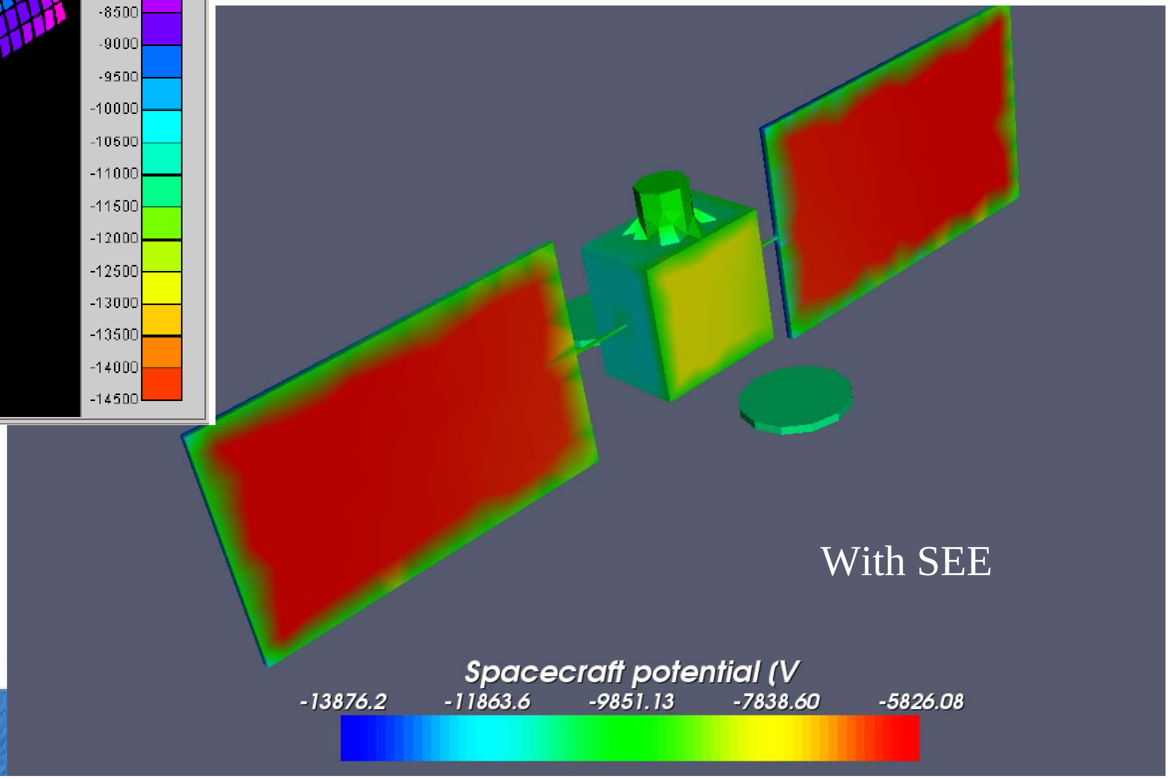
- Published model (Davis et al)
  - "Validation of NASCAP-2K spacecraft-environment interactions calculations", V. A. Davis, M. J. Mandell, B. M. Gardner, I. G. Mikellides, L. F. Neergaard, D. L. Cooke and J. Minor, *8th Spacecraft Charging Technology Conference*, Huntsville, Alabama, USA, 20-24 oct. 2003
  - Similar model with SPIS (B. Andersson, SSC)
  - Comparison of potential maps and time variation

Potential maps (t=1000s)

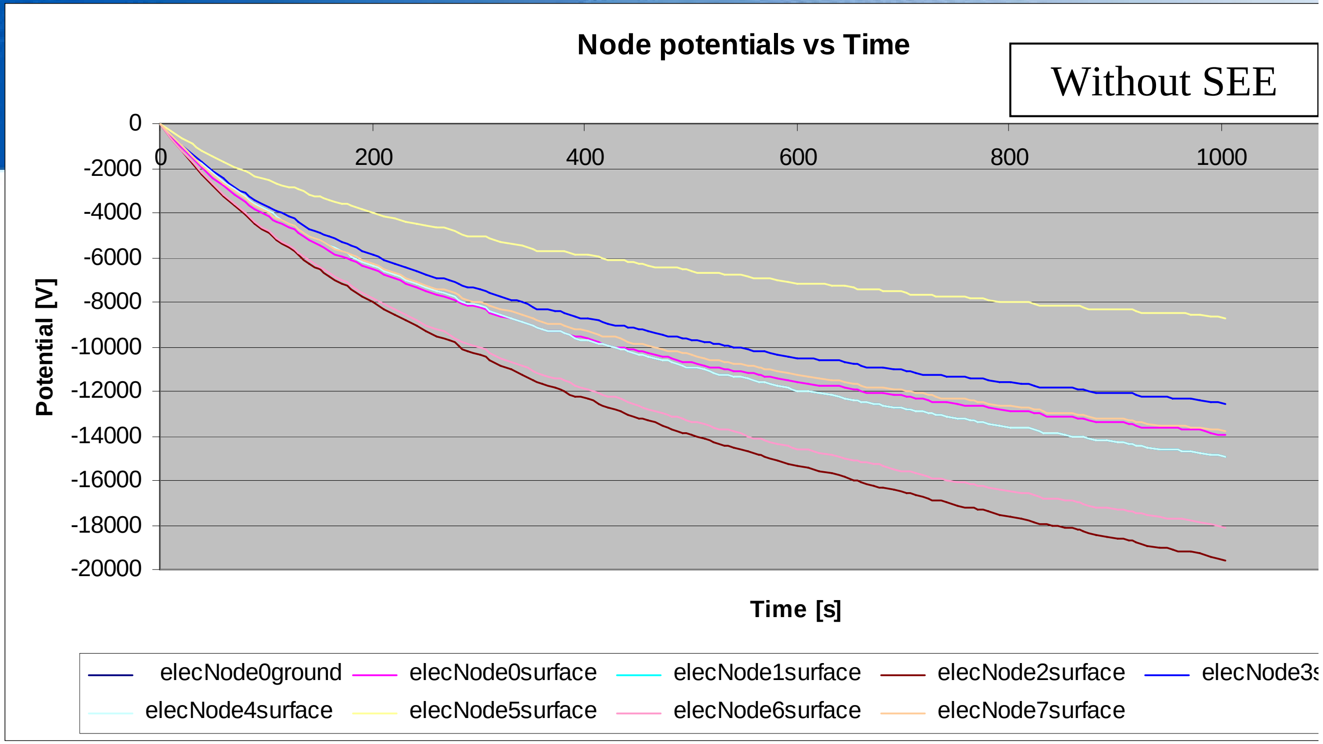
- Comparison with NASCAP







Time evolution



- Comparison with NASCAP

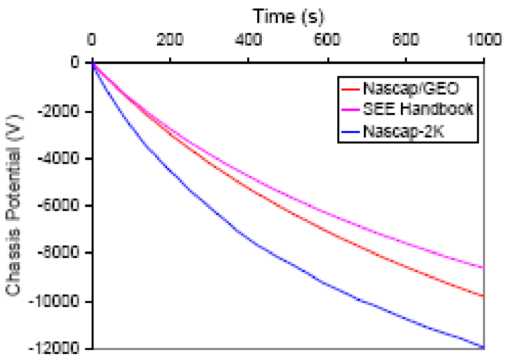
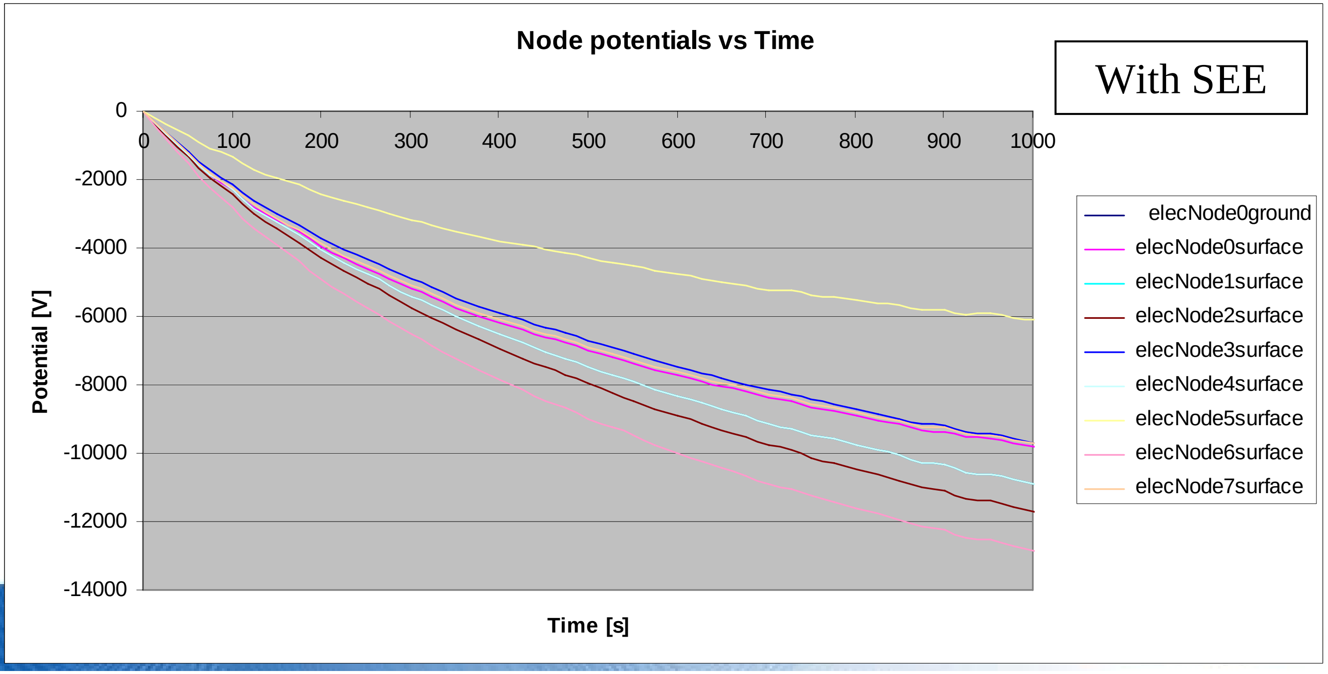


Figure 8. Comparison of chassis potential versus charging time as computed by NASCAP/GEO, SEE Handbook, and *Nascap-2k*.



Part of the s/c	Chassi	PVSA (shadow side)	OSR	PVSA (solar side)	Main SC structure	Top Antenna	Circular antennae
Material	Black kapton	Kapton	OSR	Solar Cells	Teflon	Non-conducting paint	Graphite
Absolute Charging (kV)							
NASCAP/GEO	-10.0	-8.2 to -13.1	-8.23 to -10.7	-5.2 to -7.68	-7.5 to -12.7	-8.3 to -10.3	N/A
SEE Handbook	-8.6	None in model	-7.3 to -9.6	-3.6 to -5.7	-6.8 to -11.3	-7.5 to -11.3	N/A
Nascap-2k	-12.0	-11.5 to -14.4	-10.0 to -13.7	-7.2 to -10.8	-7.9 to -14.0	-7.9 to -14.0	N/A
SPIS (With SEE)	-10.9	-12.9 (-10.9 to -13.9)	-11.7	-6.1 (-5.8 to -6.4)	-9.8 (-7.9 to -11.6)	-9.7 (-9.6 to -9.8)	-10.9
Differential charging (kV)							
NASCAP/GEO		1.8 to -3.1	1.77 to -0.7	4.8 to 2.3	2.5 to -2.7	1.7 to -0.3	N/A
SEE Handbook		None in model	1.3 to -1.0	5 to 2.9	1.8 to -2.7	1.1 to -0.3	N/A
Nascap-2k		0.5 to -2.4	2 to -1.7	4.8 to 1.2	4.1 to -2	2 to -0.2	N/A
SPIS (with SEE)		-2.0 (0 to -3.0)	-0.8	4.8 (5.1 to 4.5)	1.1 (3 to -0.7)	1.2 (1.1 to 1.3)	0

Conclusions

- GEO charging modelling now possible:
  - SC or local level
  - Realistic time behaviour modelling possible
  - Accurate current collection through backtracking
- SPIS enhancements should be available next year