GEO simulations with SPIS and result comparison with American spacecraft charging codes

Swedish Space Corporation

Presented by

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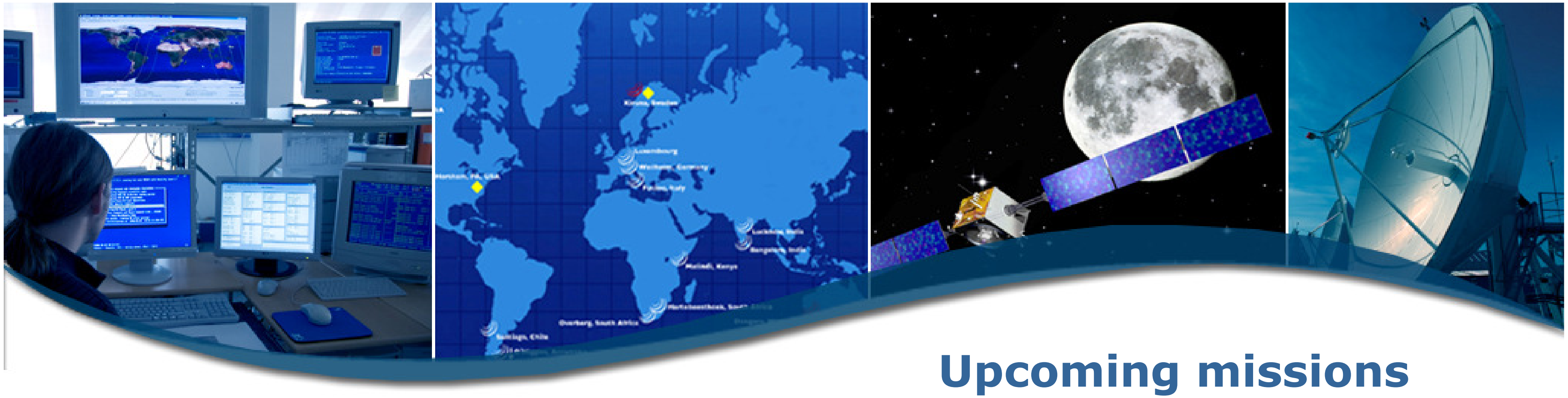
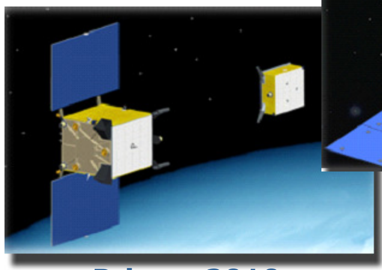


Upcoming missions

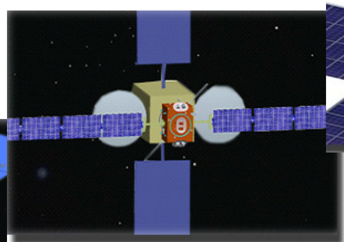
Satellites for:

- Telecommunication
- Earth observation
- Climate research
- Technical development

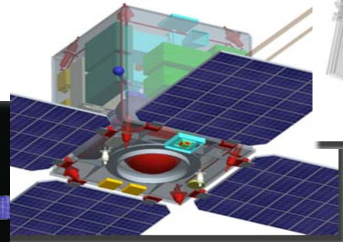


Prisma 2010

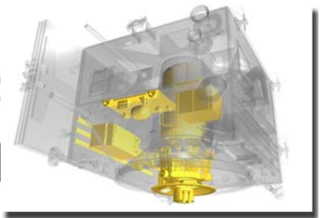
Small GEO 2012



Smart OLEV 2012

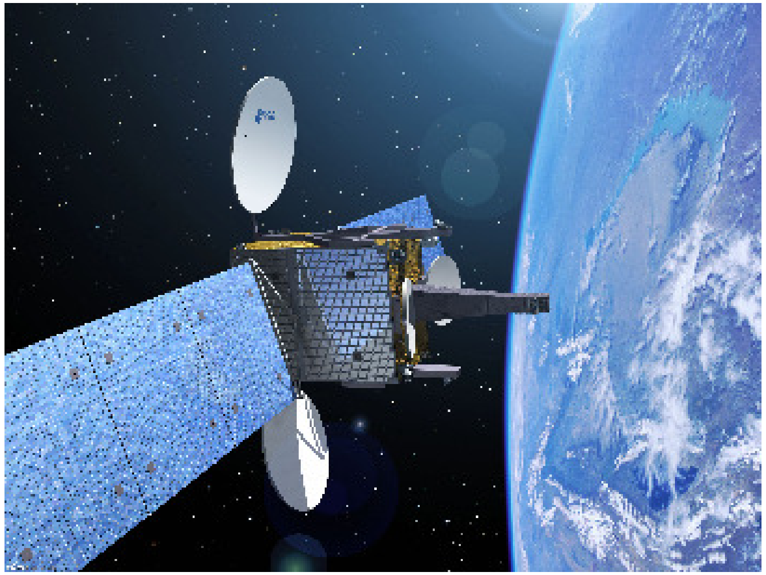


PROBA-3 2013



Premier 2016

Small GEO – An introduction



Small GEO illustration (Courtesy of OHB)

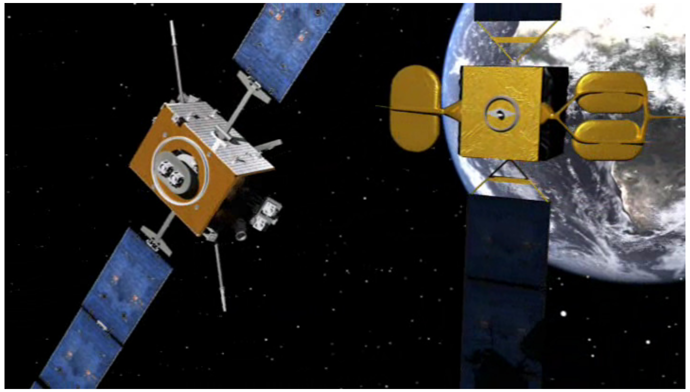
The Small GEO platform supports:

- 300 kg payload mass
- 3kW payload power
- Total wet mass: 1.5 tons or 2.5 tons
- Lifetime 15 years

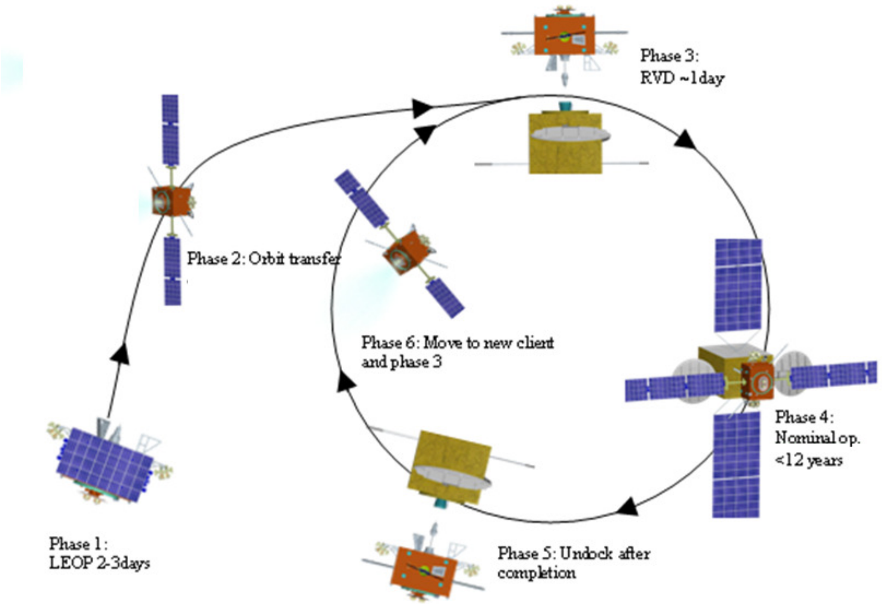
The Small GEO program:

- General purpose small geostationary satellite platform.
- Currently being developed by a consortium led by the OHB System (Germany), Oerlikon Space (Swizerland), LuxSpace (Luxemburg) and SSC.
- SSC responsebilities: EP, AOCS
- First launch scheduled to 2012.

SMART-OLEV – An introduction



SMART-OLEV illustration (Courtesy of OSS)



The SMART-OLEV program:

SMART-OLEV life extension satellite

- **Wet mass ~1000kg**
- **Service lifetime ~12 years**

SSC in partnership with Kayser-Threde (Germany) and Sener (Spain) is developing the SMART-OLEV life extension satellite.

Provided service: Docks with GEO communications satellites at the end of their propellant life and provides attitude and orbit control functions for up to 12 additional years.

Marketed by Orbital Satellite Services (www.orbitalsatelliteservices.com)

SPIS validation by applying Davis test case from 2003

From 8th Spacecraft Charging Technology Conference, 2003:

VALIDATION OF NASCAP-2K SPACECRAFT-ENVIRONMENT
INTERACTIONS CALCULATIONS

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Abstract

The recently released *Nascap-2k*, version 2.0, three-dimensional computer code models
interactions between spacecraft surfaces and low-earth-orbit, geosynchronous, auroral, and

American codes:

NASCAP/GEO

SEE Handbook

NASCAP-2k

Required SPIS updates:

- Multi-physics (By JF Roussel, Onera)

- NASCAP-2k materials not covered for in SPIS (JF Roussel, Onera and B Andersson, SSC)

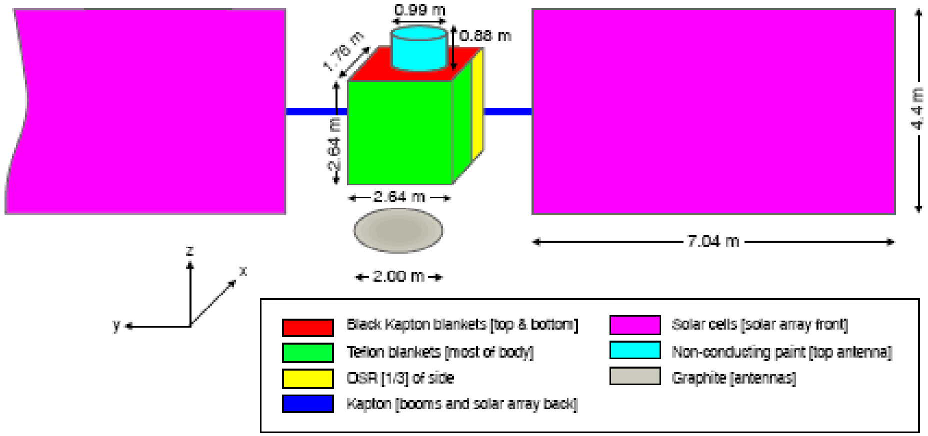
Environmental inputs

90% worst case environment for geosynchronous orbits as defined in C.K. Purvis, H.B. Garrett, A.C. Whittlesey, N.J. Stevens, *Design guidelines for assessing and controlling spacecraft charging effects*, NASA TP 2361, p. 3, 1984. .

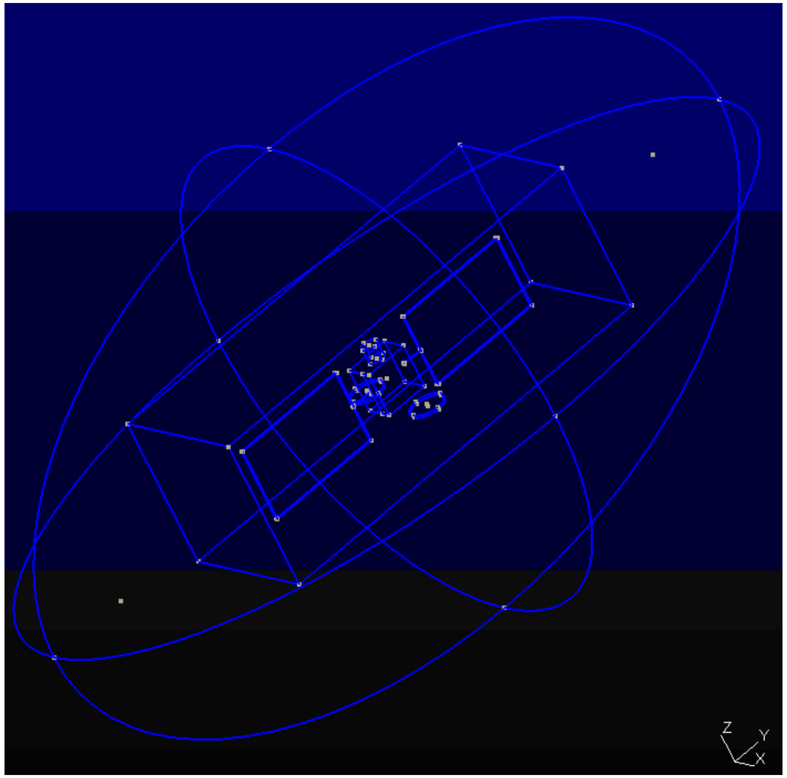
	Temperature (keV)	Density (cm^{-3})
Ions	29.5	0.236
Electrons	12.0	1.12

Used geometry model

Davis geometrical model

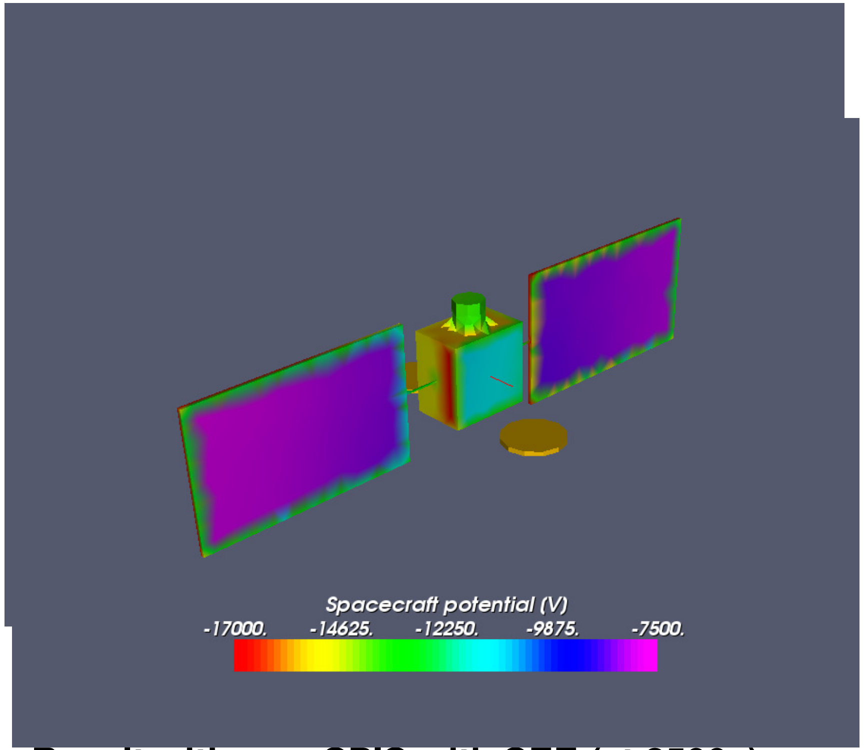


Used GMSH model



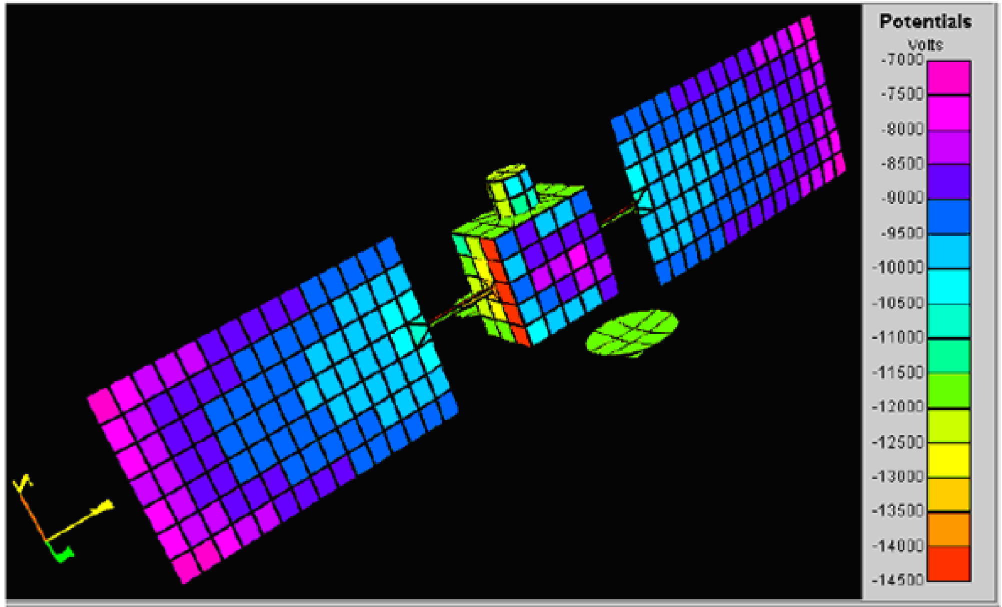
3D Charging Layout

SPIS



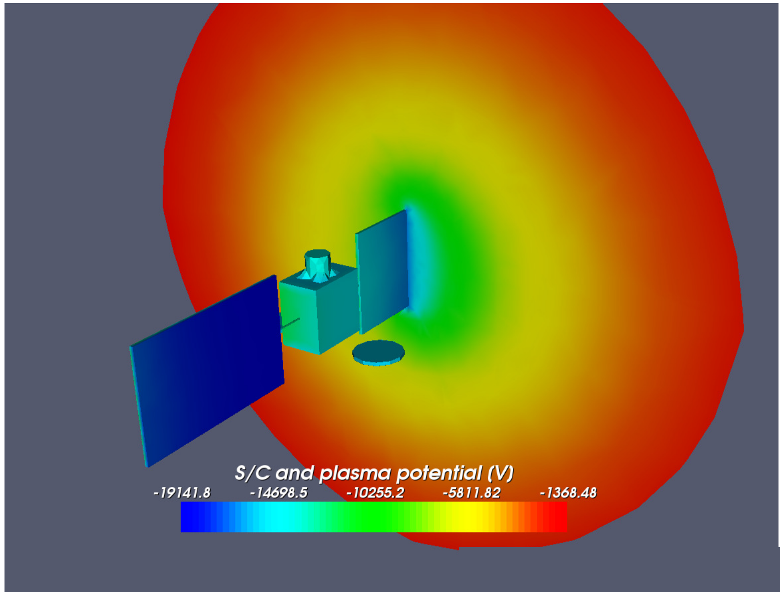
Result with new SPIS with SEE (at 2500s)

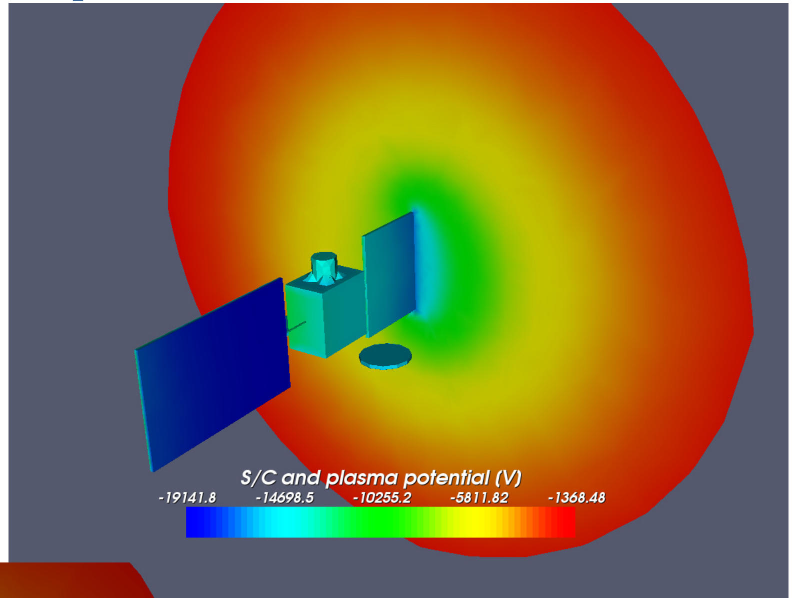
Davis

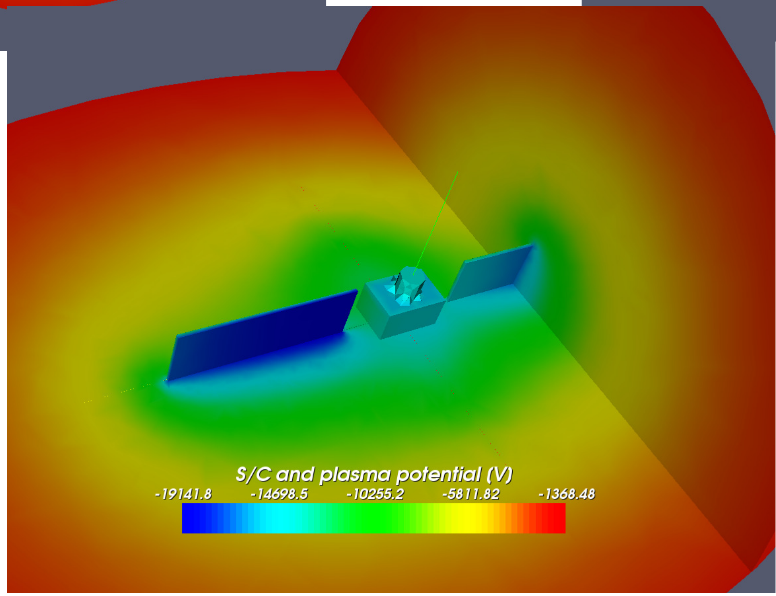


Result with NASCAP-2k (at unknown time but possibly at 1000s)

3D Charging Layout



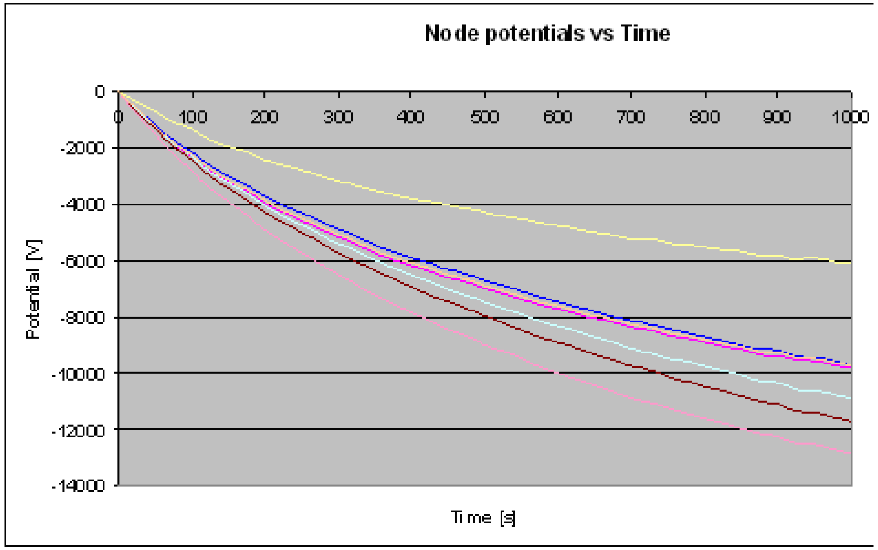




Result with new SPIS with SEE (at 2500s)

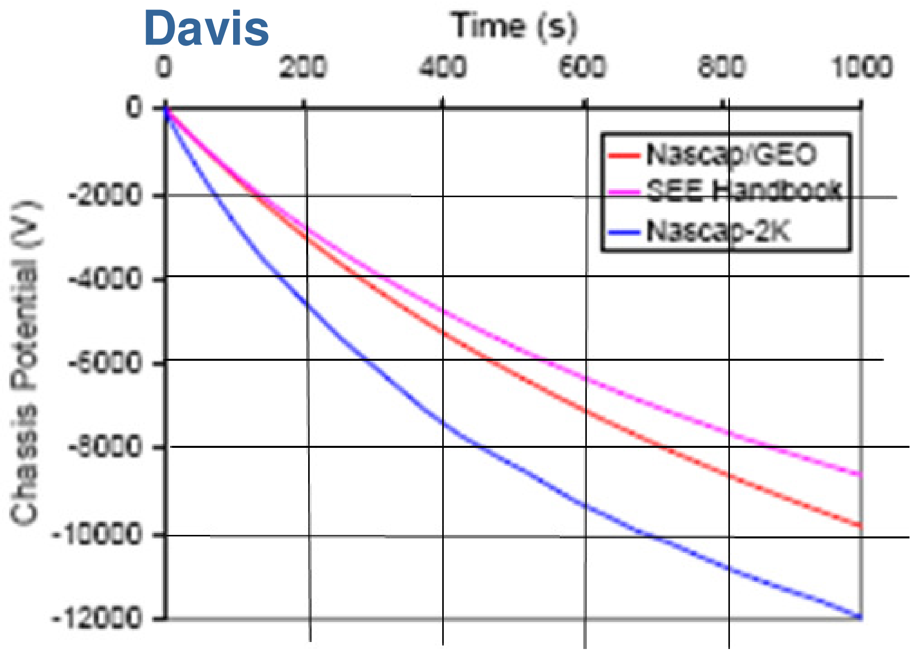
Charging trend curves

SPIS



Result with new SPIS with SEE (up to 1000s). Node 0, Node 1 and Node 4 are overlapping.

Davis



Comparison of chassis potential versus charging time (up to 1000s)

- **Node 0 = Main spacecraft box (Teflon)**
- **Node 1= Top and bottom of spacecraft box (Black kapton)**
- **Node 2 = OSR (OSR)**
- **Node 3 = Top antenna (Non conductive paint)**
- **Node 4 = Circular antennas (Graphite)**
- **Node 5 = SA solar side (Solar cells)**
- **Node 6 = SA shadow side (Kapton)**
- **Node 7 = SA booms (Kapton)**

Ranging of spacecraft charging potentials

The results at 1000s summarized in the same table format for NASCAP/GEO, SEE Handbook, Nascap-2k and SPIS with SEE ("Chassi" is assumed to be surfaces cover with black kapton but also Teflon surfaces are well inline).

Part of the s/c	Chassi	SA (shadow side)	OSR	SA (solar side)	Main s/c structure	Top Antenna	Circular antennae
Material	Black kapton	Kapton	OSR	Solar Cells	Teflon	Non-conducting paint	Graphite
Absolut 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

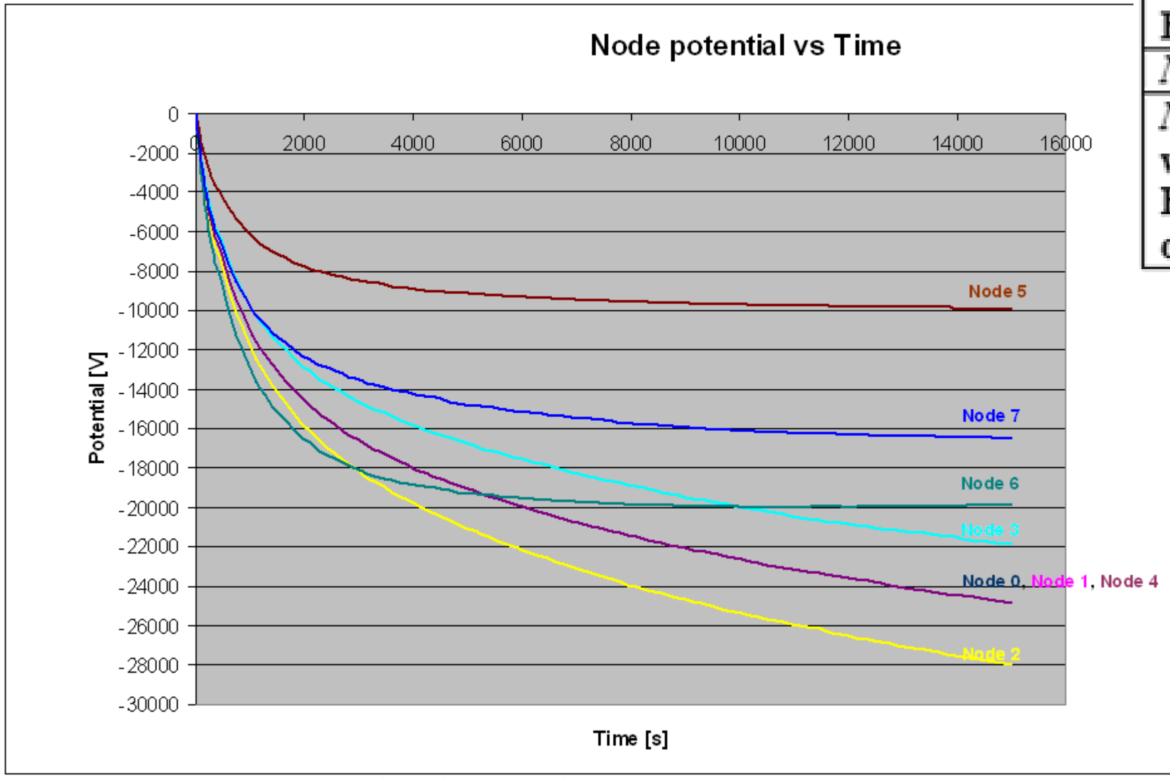
Spacecraft potentials at equilibrium

Davis

Comparison of equilibrium solutions (kV)

	Chassis	Max Differential	
		Positive	Negative
NASCAP/GEO	–20.3	10.8	–2.5
SEE Handbook	–17.8	10.4	–0.14
Nascap-2k	–19.5	7.8	–3.6
Nascap-2k with Handbook object	–19.2	9.4	–0.06

SPIS



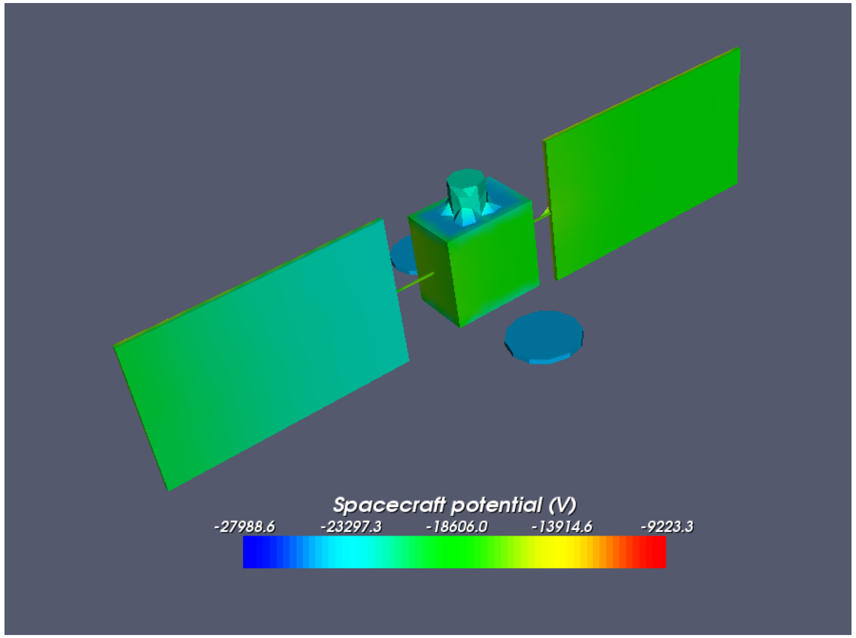
Result with new SPIS with SEE (up to 15 000s).
Node 0, Node 1 and Node 4 are overlapping.

Node 0 = Main spacecraft box (Teflon)
Node 1= Top and bottom of spacecraft box (Black kapton)
Node 2 = OSR (OSR)
Node 3 = Top antenna (Non conductive paint)
Node 4 = Circular antennas (Graphite)
Node 5 = SA solar side (Solar cells)
Node 6 = SA shadow side (Kapton)
Node 7 = SA booms (Kapton)

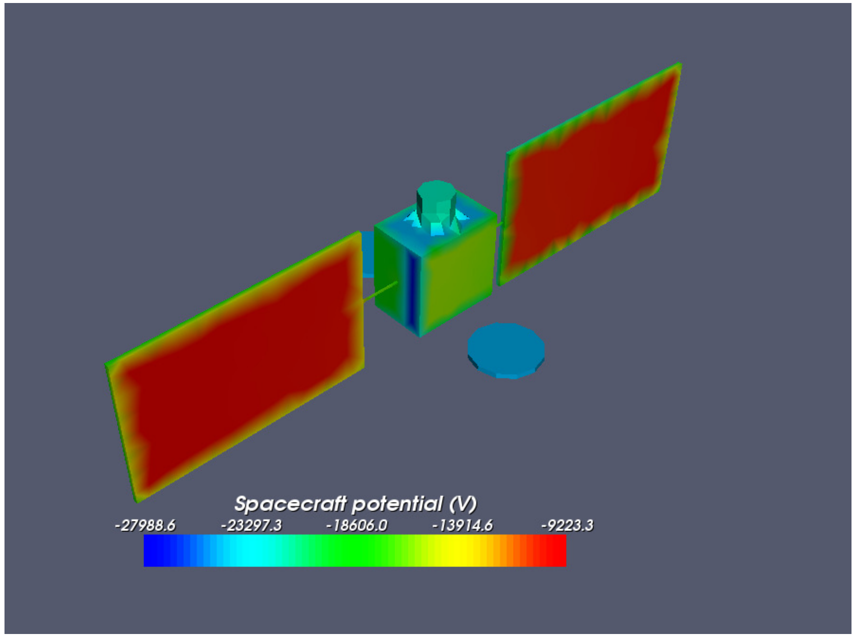
Spacecraft potentials at equilibrium

SPIS

Backside



Solar side



Result with new SPIS with SEE (at 15 000s)

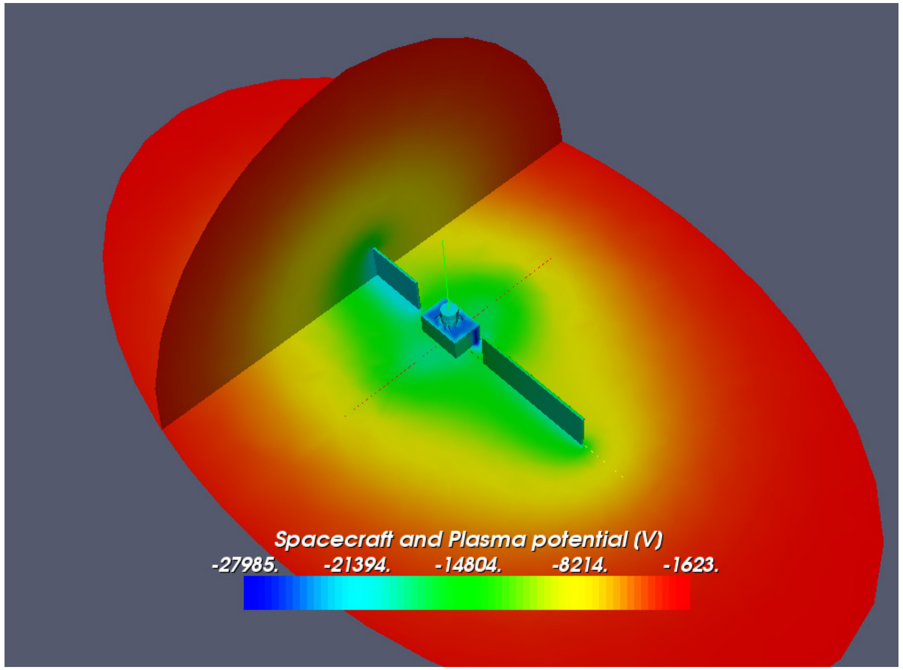
Still significant conducting nodes:

Main spacecraft box (Teflon), Top and bottom of spacecraft box (Black kapton), OSR (OSR), Top antenna (Non conductive paint), Circular antennas (Graphite)

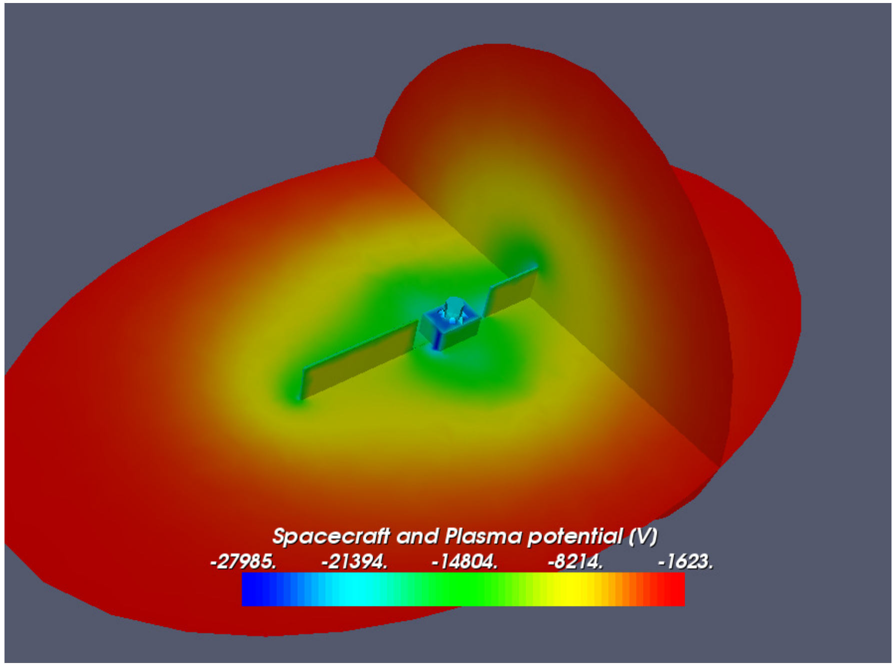
Spacecraft potentials at equilibrium

SPIS

Backside



Solar side



Result with new SPIS with SEE (at 15 000s)

Conclusion

- The article used as reference for SPIS validation uses NASCAP/GEO, SEE Handbook and NASCAP-2k.

- Same inputs (environment and geometry) have been used as far as possible.

- SPIS results are well inline with result generated by the American codes, especially NASCAP/GEO and NASCAP-2k that are most accurate.

- Reaching equilibrium for all spacecraft nodes have not been possible. Some troubleshooting still required.

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