



Review of Computational tools (for spacecraft plasma interactions) at ESTEC

SPINE Meeting
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ESTEC

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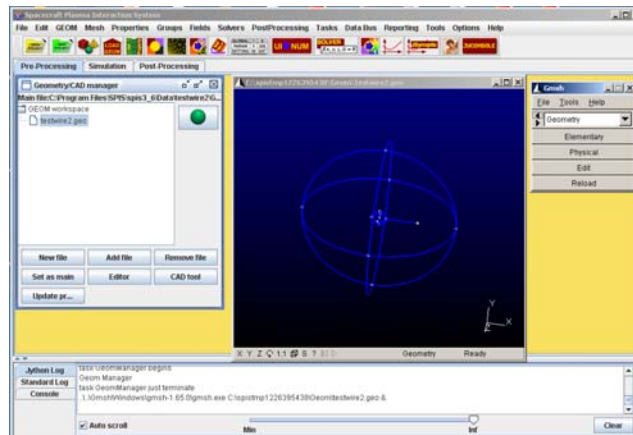
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SPIS

- Spacecraft Plasma Interaction Software
- Developed by ONERA and Artemum
- 3-D spacecraft plasma interactions



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SPIS

- Interface
 - menu driven
 - 3-d graphical outputs
- Java numerical core with Jython scripts
- Open source
- 3rd party tools
- Comprehensive physics
- Flexible, extendable
- Uses: charging, sheath effects, photoelectrons, electric propulsion interactions, active sources



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Ongoing/future developments

- SPIS time-dependent charging
 - Back-tracking
 - Barrier effects on GEO spacecraft
 - Sensors
 - Multi-physics
 - Small current collectors
 - Plasma sources
 - General improvements
 - Material input, error reporting, multiple species sources, particle reflection, neutrals



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EQUIPOT

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Session Edit View Bookmarks Settings Help

EQUIPOT (Version 1.3)

Settings:
Debye limit : THICK SHEATH
RAM_OFF      Ram speed : 0.0 km/s      Ram angle : 0.0 deg
Structure :  in SUNLIGHT      Patch : COS(sun angle) = 0.00
Structure material : alum      Patch material : kapt
Environment type : g_mag      Patch thickness : 2.500E-02 mm
Incident distribution : ISOTROPIC      Starting potential = 0.0 U
No. of points per integration : 100      First potl step dU = 100.0 U
Name of output file : TEST.OUT *** OPEN *** FIC_OFF; Patch temp = 273.0K

-----
MAIN MENU
0. QUIT
1. Change RUN control parameters
2. Select/edit MATERIAL properties
3. Select/edit ENVIRONMENT definition
4. COMPUTE equilibrium potential
5. Create an I-V TABLE
6. SAVE Settings [EQUIP.SET]
7. LOAD Settings [EQUIP.SET] and READ ENV file
9. Display HELP-FILE

Enter choice : █
```



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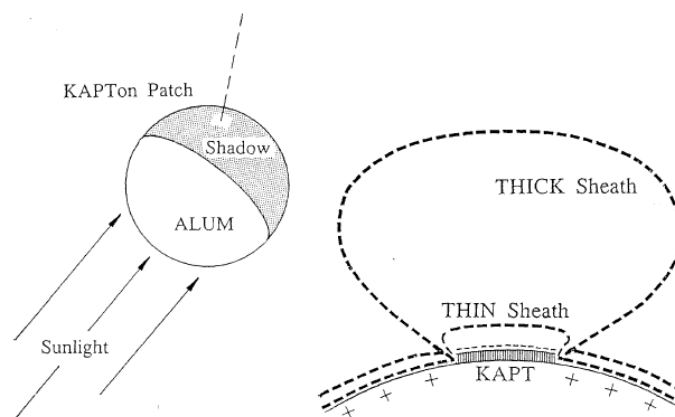
EQUIPOT

- Developed by QinetiQ
- 1-d Equilibrium Potential calculation
- Fast charging calculation
- Fortran, Menu driven
- No geometric effects.
- LEO, GEO environments, ram/wake, sunlight/eclipse
- Uses: scoping charging calculations, I-V curves
- Stand-alone or SPENVIS interface



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EQUIPOT



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DICTAT

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Session Edit View Bookmarks Settings Help

DICTAT v3.0 - Dielectric Internal Charging Threat Assessment Tool

END

User inputs were:
Planar geometry
Dielectric grounded since at inner surface
Shield material: ALUMINIUM density: 2.70 g/cm**3
Shield thickness: 0.6240 cm
Isol. metal material: SILVER density: 10.50 g/cm**3
Isol. metal thickness: 0.000 cm
Dielectric material: SURFALUM
density: 2.70 g/cm**3 conductivity: 1.00E-18 / (Ohm m)
permittivity: 1.00 breakdown field: 1.00E+07 V/m
Eg: 1.00E 15 activation energy: 0.30 eV
Delta: 0.75
Dielectric thickness: 0.6100 cm
Surface charging potential 0.000 units
Temperature: 270.0 K
Field of view: 90.0 degrees about normal
Flux isotropic
Model is FLUMIC V3.0 12/11/03
Fraction of Solar cycle=0.009 Fraction of year=0.329
Using L-shell=4.50 and E/B0= 1.00 with duration 24. hours

At Equilibrium:
Charging current= 1.0940E-15 amps/cm**2
E max= 6.2112E+06 V/m Voltage= 3.3882E+04 volts

After 24.0 hours:
Charging current= 1.0940E-15 amps/cm**2
E max= 3.2000E+04 V/m Voltage= 166.6 volts
The dielectric IS NOT liable to experience breakdown
Maximum e-field is lower than Breakdown field- 1.00E+07 V/m

Maximum current incident on the component= 1.0940E-15 A/cm**2

DICTAT Normal termination
Shell

```



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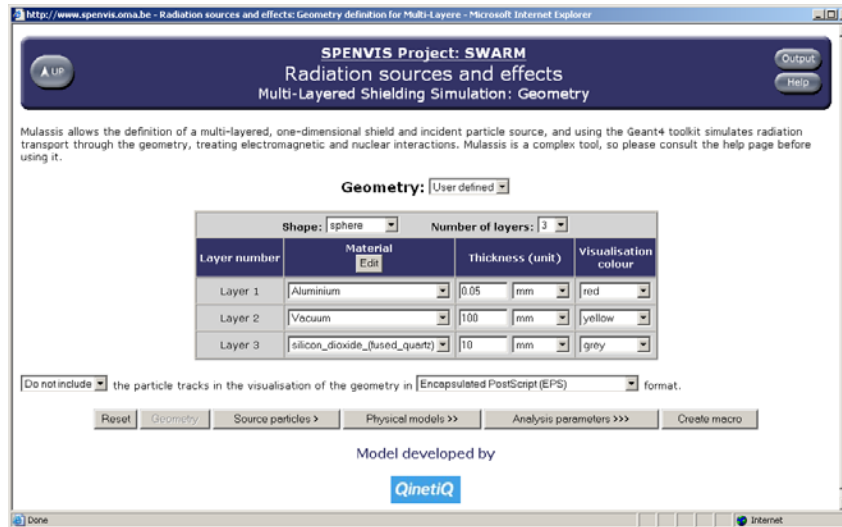
DICTAT

- Dielectric internal charging threat assessment tool
- 1-D internal charging code
- Developed by QinetiQ
- Fortran, input file in namelist format driven
- Uses: E and V due to penetrating electrons
- Fast, analytical transport equations
- Simulates dielectric plus shielding
- Planar or cylindrical geometry
- Built-in FLUMIC environment or user input
- Stand-alone or SPENVIS interface



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Mulassis



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Mulassis

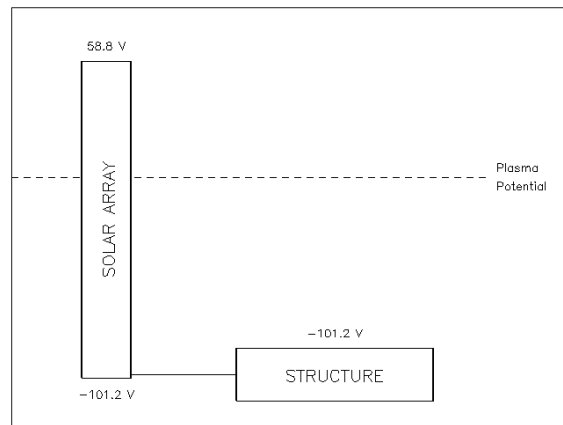
- Multi-layered Shielding Simulation
- 1-D Radiation transport code
- Developed by QinetiQ
- A Geant-4 implementation
- C++
- High accuracy Monte Carlo radiation transport
- Uses: Dose, NIEL and internal charging currents
- Command or batch file input
- Stand-alone or SPENVIS interface



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SOLARC

SOLARC Array/Structure Grounding Configuration



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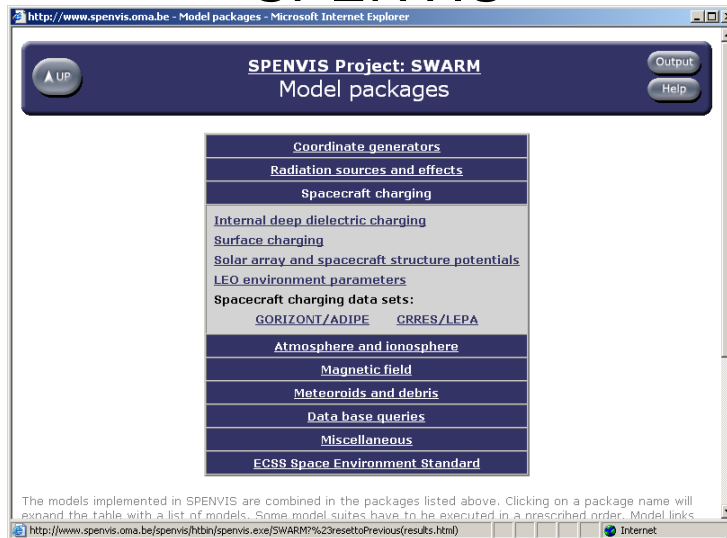
SOLARC

- Developed by AEA Technology
- Uses: Solar array currents, floating potential and surface erosion
- Calculates current balance according to voltages and collection areas.
- Run via SPENVIS



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SPENVIS



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SPENVIS

- Space Environment Information System
- Developed by BIRA/IASB
- Comprehensive access to space environment tools
- Utilities e.g. coordinate generators included
- Standard output plotting and download



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Spacecraft Plasma Interactions Guidelines and Handbook

2.5 Debye length

Plasmas remain neutral on a large scale but can have non-neutrality on a small scale. Potentials of order of the electron temperature and below are shielded from the rest of the plasma within a distance called the Debye length (λ_D). This distance also influences the dimensions of spacecraft sheaths where the potentials involved are higher.

$$\lambda_D = \left(\frac{\epsilon_0 k T_e}{n e^2} \right)^{\frac{1}{2}} \quad \text{m} \quad (5)$$

N_d is the number of particles in a Debye sphere, i.e. a sphere of radius the Debye length.

Equation: Debye length Remove

$$\lambda_D = \left(\frac{\epsilon_0 k T_e}{n e^2} \right)^{\frac{1}{2}} \quad k = 1.38 \cdot 10^{-23} \quad e = 1.60218 \cdot 10^{-19} \quad \epsilon_0 = 8.854187 \cdot 10^{-12} \quad n = 1 \cdot e6$$

$k = 1.38 \cdot 10^{-23} \quad T_e = 1000 \quad e = 1.60218 \cdot 10^{-19} \quad \epsilon_0 = 8.854187 \cdot 10^{-12}$

$n = 1 \cdot e6$

Result: 2.18173793033196

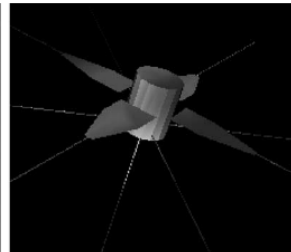
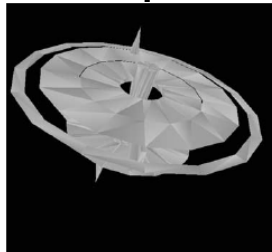
Calculate



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PICUp3D

- 3-d PIC
- Java
- Open source



- Prototype of spacecraft-plasma interaction code for SPIS
- Developed by Julien Forest (Artenum)



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NASCAP/GEO

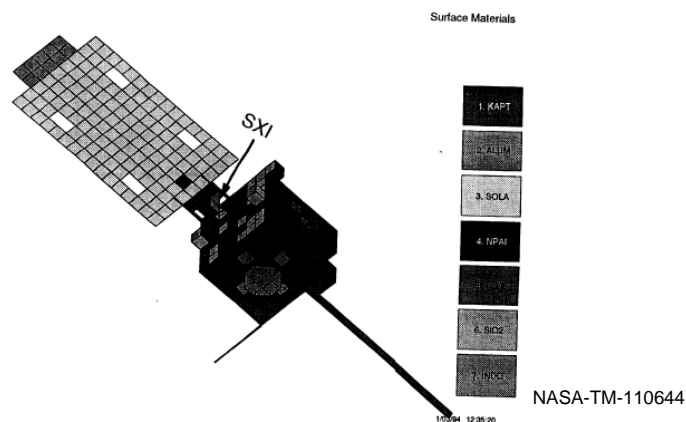
- Developed by S-Cubed for AFRL
- 3-D charging simulation for long-Debye length cases
- Fortran, Command line driven
- Geometric effects, sunlight eclipse, material effects
- Uses: Charging, GEO sheath effects, active sources, test particle tracking
- MATCHG 1-d version included
- POLAR developed for LEO polar orbits
- Now replaced by NASCAP-2K and Spacecraft Charging Handbook



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NASCAP/GEO GOES SPACECRAFT MODEL 1800 Local Time Configuration

Figure 1.



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THE END



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