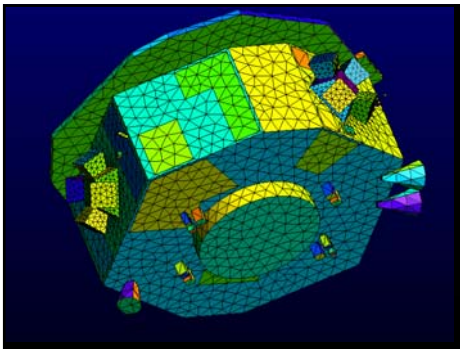

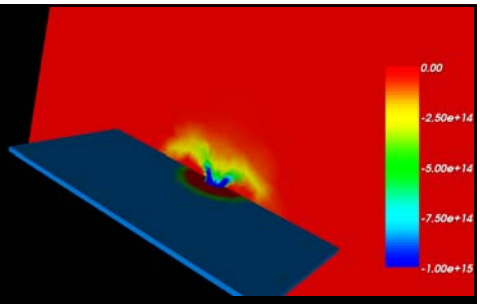

Review of Computational tools (for spacecraft plasma interactions) at ESTEC

David Rodgers / ESTEC
Simon Clucas / ESTEC
Alain Hilgers / ESTEC
John Sorensen / ESTEC

SPINE Meeting
13-14 November 2008
ESTEC

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Environment Division – TEC-EES

Contents

- Spacecraft/plasma interactions
  - SPIS
  - EQUIPOT
  - SOLARC
- Internal charging
  - DICTAT
  - Mulassis
- General
  - SPENVIS
  - SPIGH
- Heritage software
  - PICUp3D
  - NASCAP

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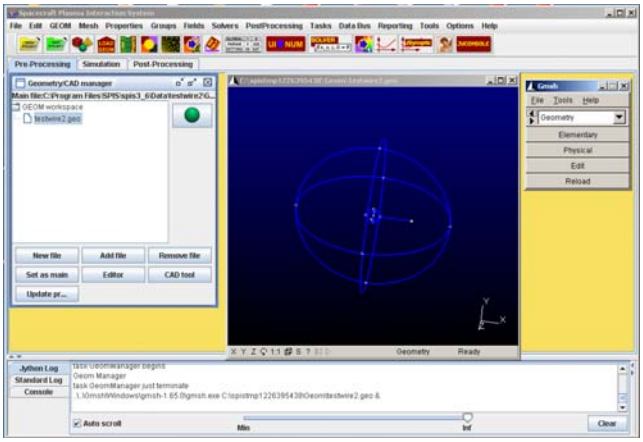
SPIS

- Spacecraft Plasma Interaction Software
- Developed by ONERA and Artenum
- 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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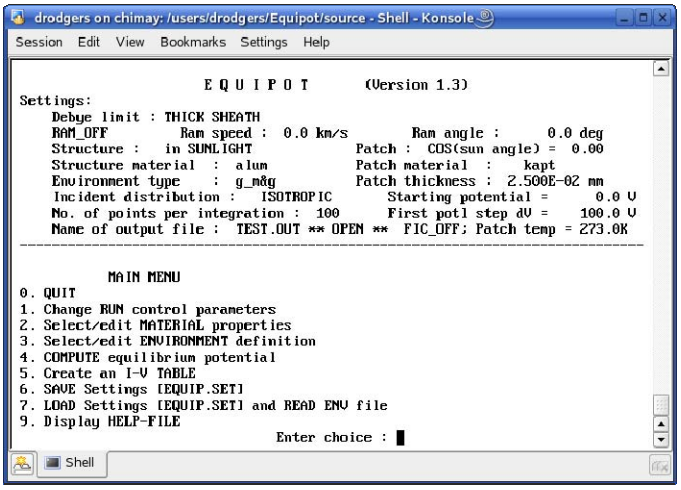
Ongoing/future developments

- 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

EQUIPOT



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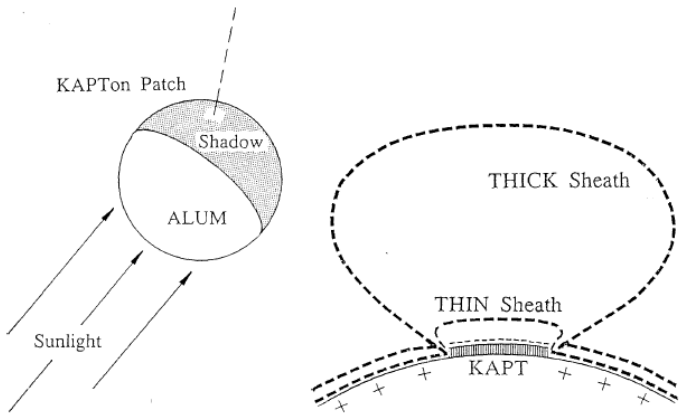
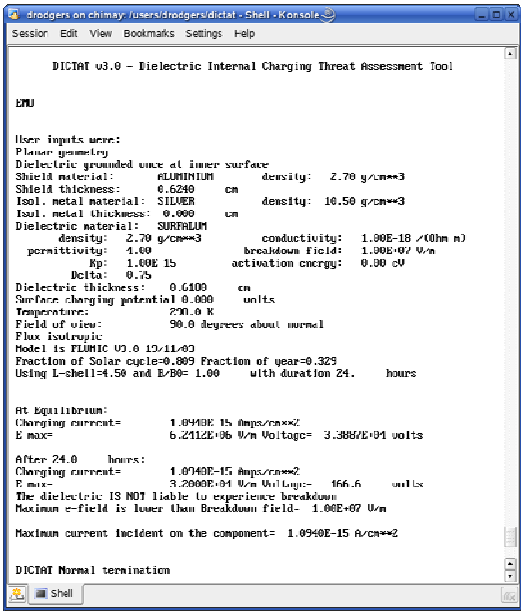
EQUIPOT

- 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

EQUIPOT



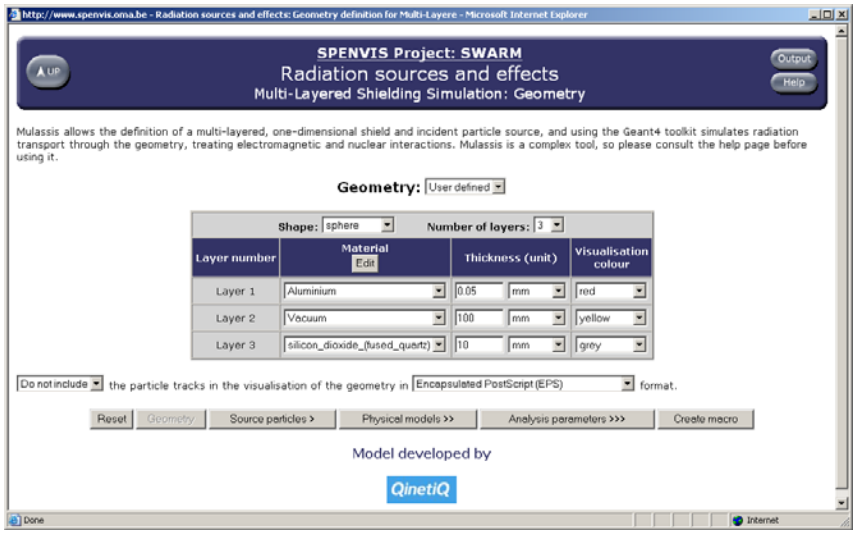
DICTAT



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

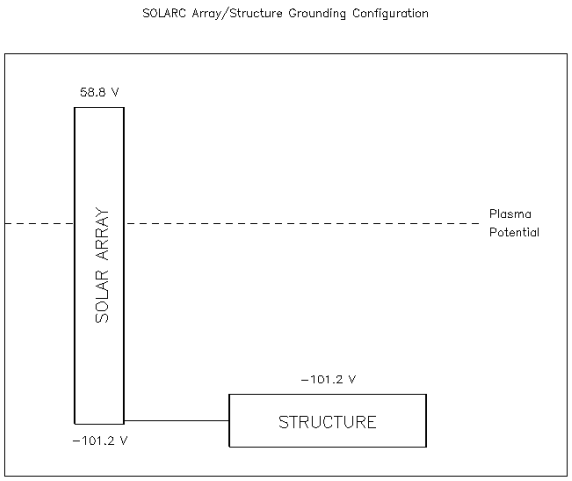
Mulassis



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

SOLARC



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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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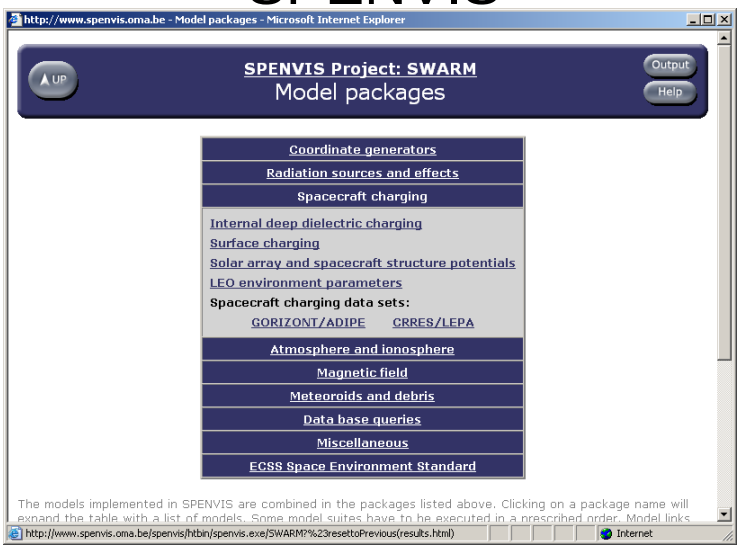
SPENVIS



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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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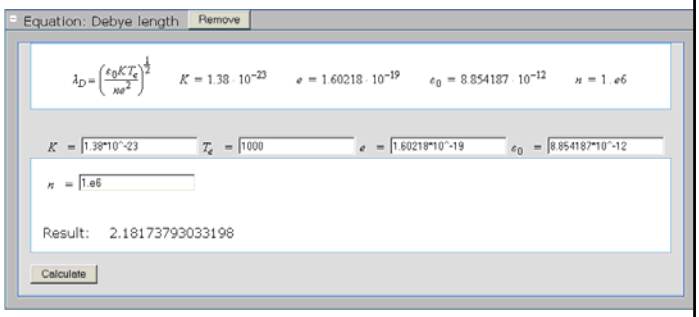
Spacecraft Plasma Interactions Guidelines and Handbook

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.

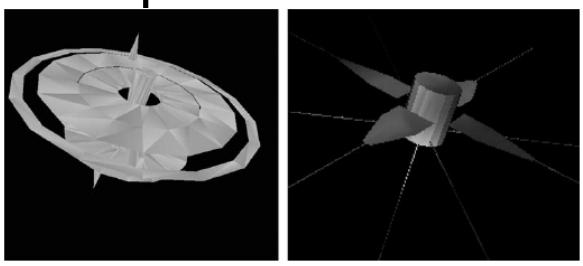
$$\lambda_D = \left(\frac{\varepsilon_0 K T_e}{n e^2}\right)^{\frac{1}{2}} \quad \text{m} \qquad (5)$$

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



PICUp3D

- 3-d PIC
- Java
- Open source



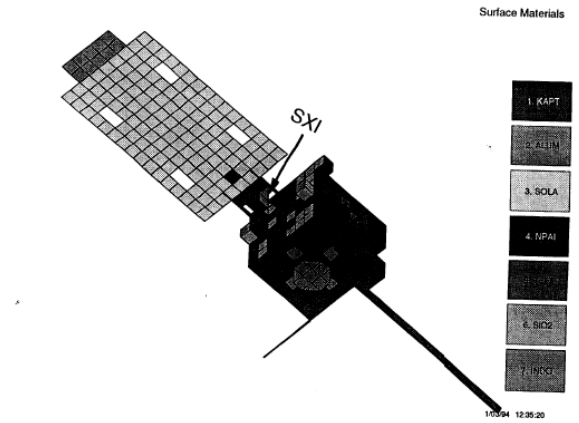
- Prototype of spacecraft-plasma interaction code for SPIS
- Developed by Julien Forest (Artenum)

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

NASCAP/GEO GOES SPACECRAFT MODEL
1800 Local Time Configuration

Figure 1.



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THE END

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