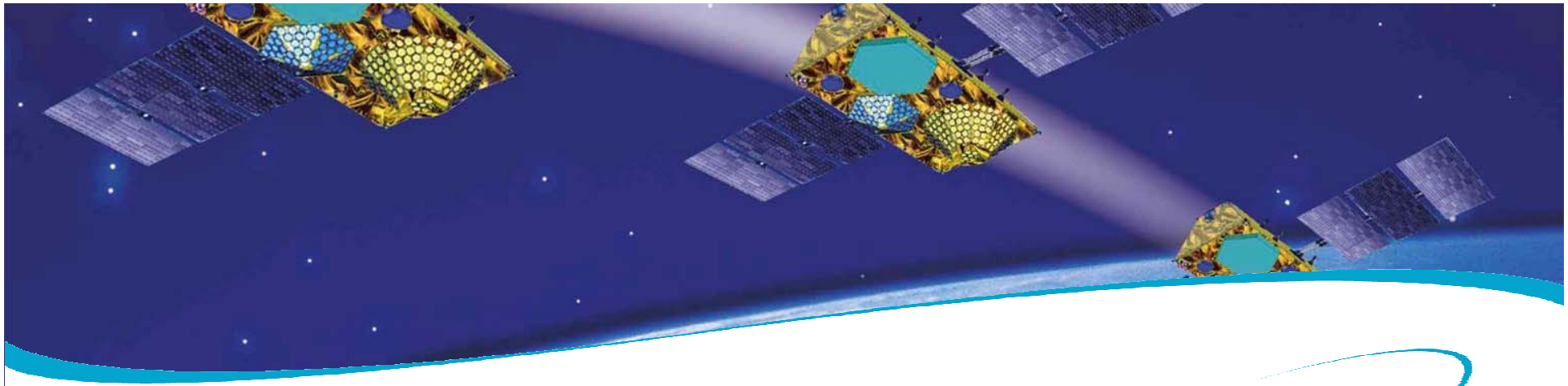


ThalesAlenia Space
A Thales / Finmeccanica Company

SPARCS tool for GEO S/C charging analysis : Brief presentation and planned evolutions

Jean-paul Dudon

SPINE meeting, 28 sept. 2009

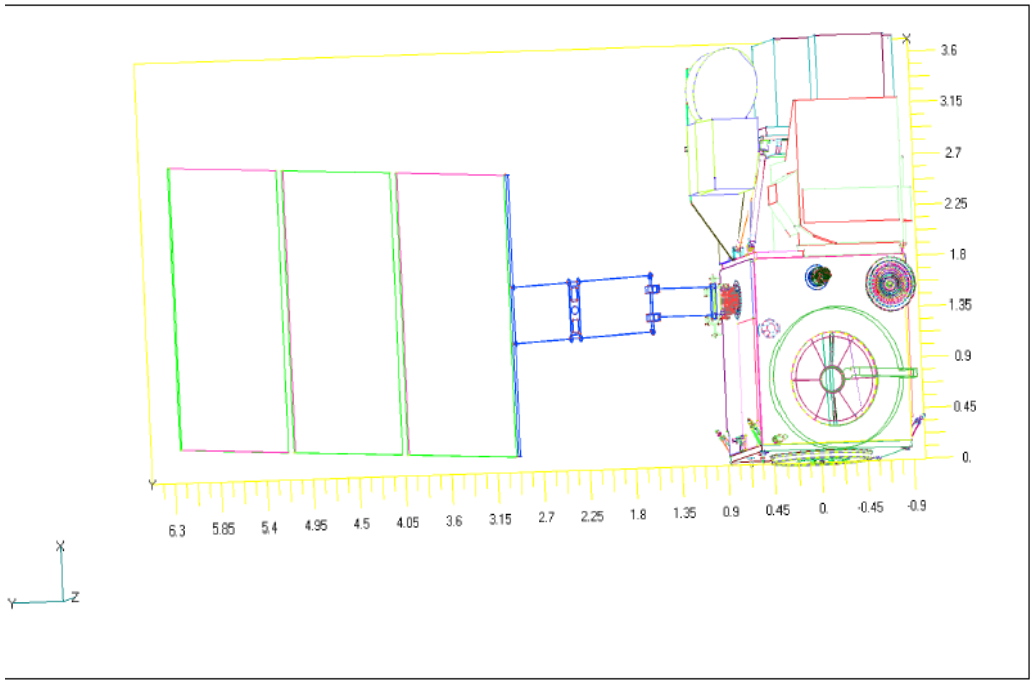
THALES

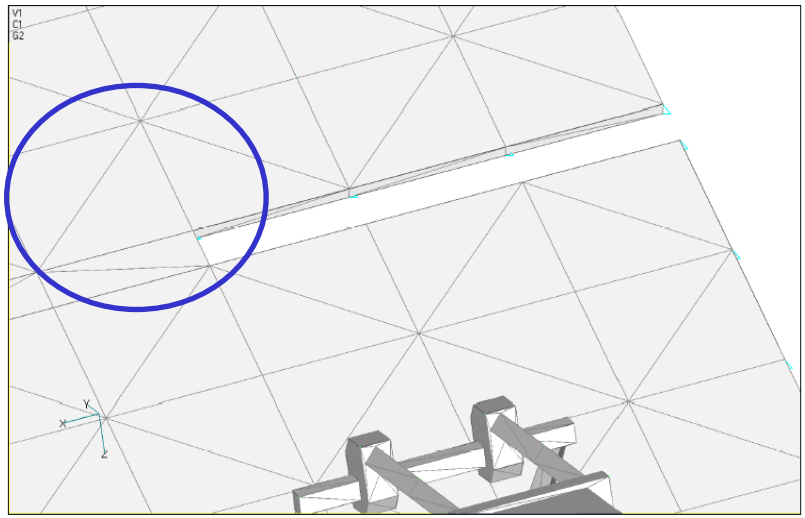
- **Brief presentation of SPARCS (SPAce chaRging Software)**
- **Planned evolutions**

Industrial needs and goals (2001/2002)

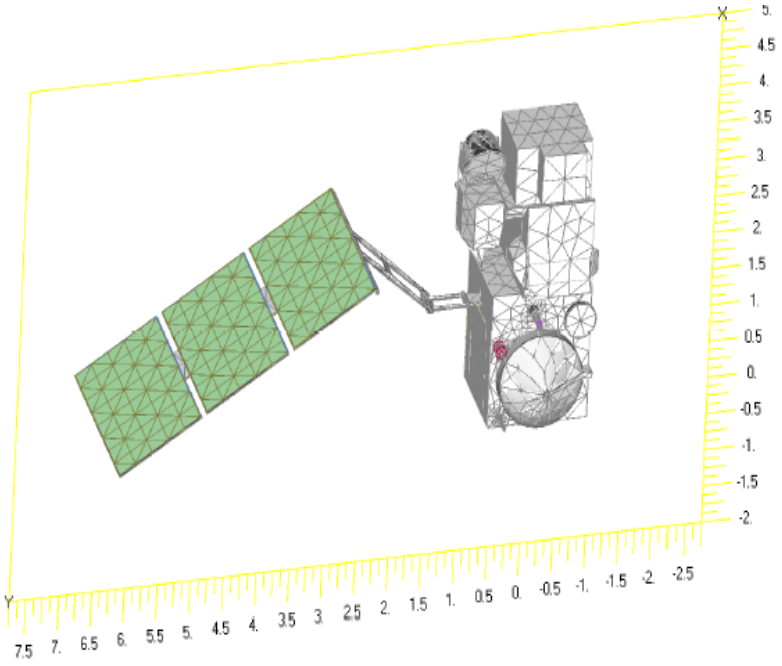
- Perform analysis for external charging for GEO/GTO orbits
  - Mandatory for ESD analysis on telecommunication satellites
- Quality
  - Accuracy of computation shall be guaranteed either by comparison with
    - existing software (NASCAP 2K, 2004) and analytical test cases (sphere)
    - test results
  - Satellite modeling directly from CAD definition
- Cost
  - Maximum use of available tools in Thales Alenia Space
  - Time computation shall be limited
  - **The tool shall be easy to take in hand and to maintain**
- Delay
  - A standard telecommunication satellite analysis shall be performed in 3 weeks
- Specific constraints
  - Availability of tools : American tools are submitted to export limitations and SPIS was not yet ready to be used by engineers in an industrial process

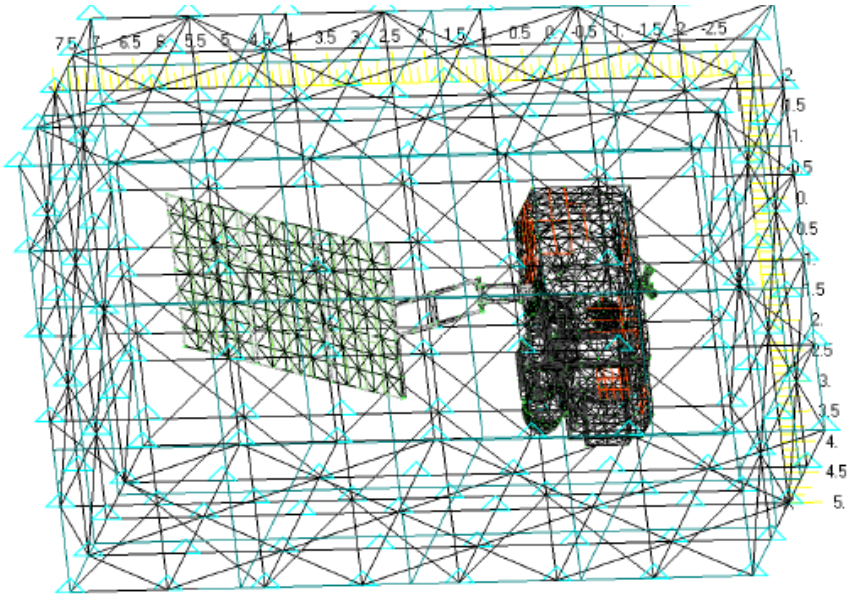
- SPARCS pre-processing (1)
  - Satellite modeling directly from CAD
    - Import of CAD file in FEMAP for meshing : .MODEL, IGES or STEP AP203
    - Connect all surfaces and attach them material properties and BC
    - Retouching some parts of the model (rotation of solar array for different config)



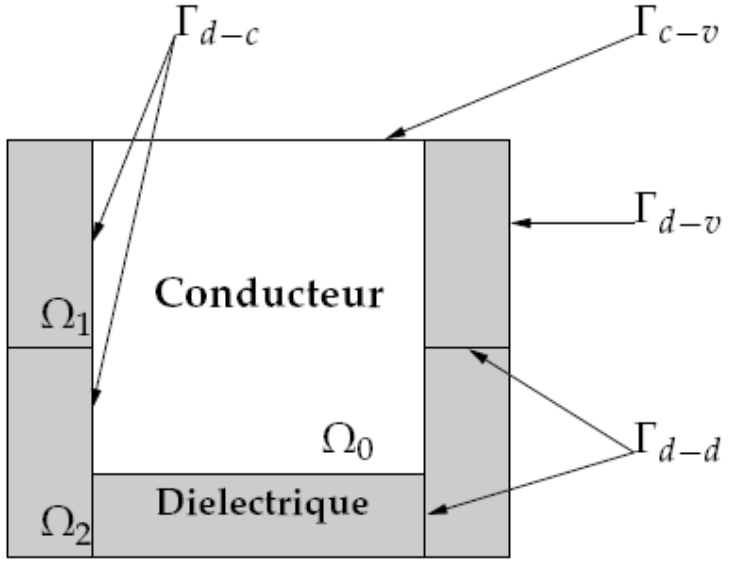


- SPARCS pre-processing (2)
  - Satellite surfaces and surrounding plasma is meshed using automated process (unstructured mesh)
    - 2D triangles on S/C surfaces and on the surrounding box (“infinity” BC)
    - 3D tetrahedrons around satellite
    - Possibility to use FEMAP, PATRAN or GMSH





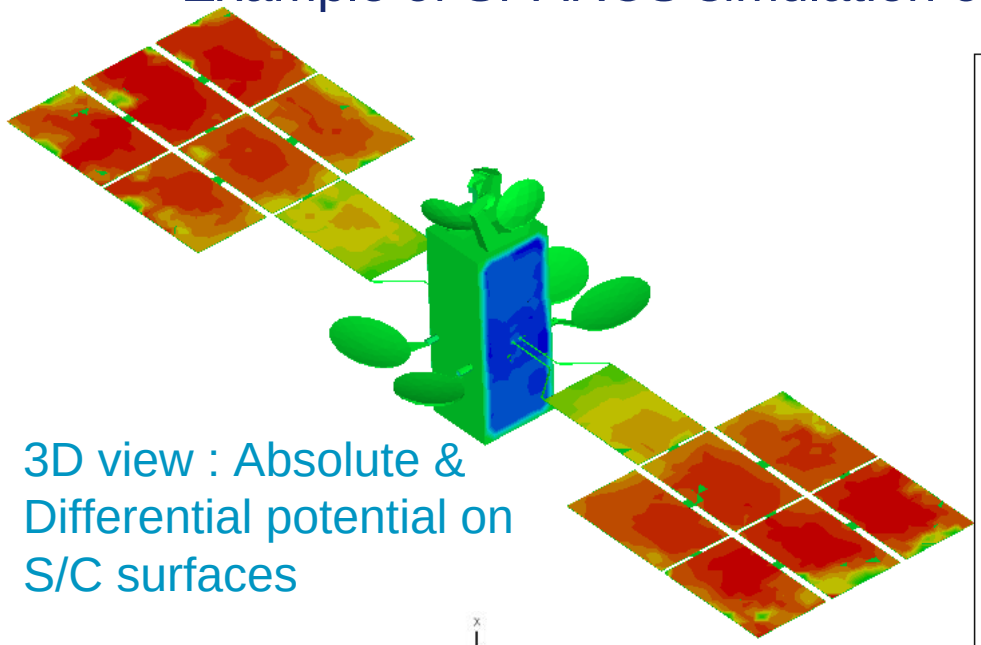
- SPARCS methods in brief
  - GEO approximation
    - λ_D>>L, collisions and *B* effect neglected
  - S/C is approximated as a perfect conductor partially covered with very thin layer of dielectric materials
  - Single or Double Maxwellian dist. for space plasma (ions & electrons)



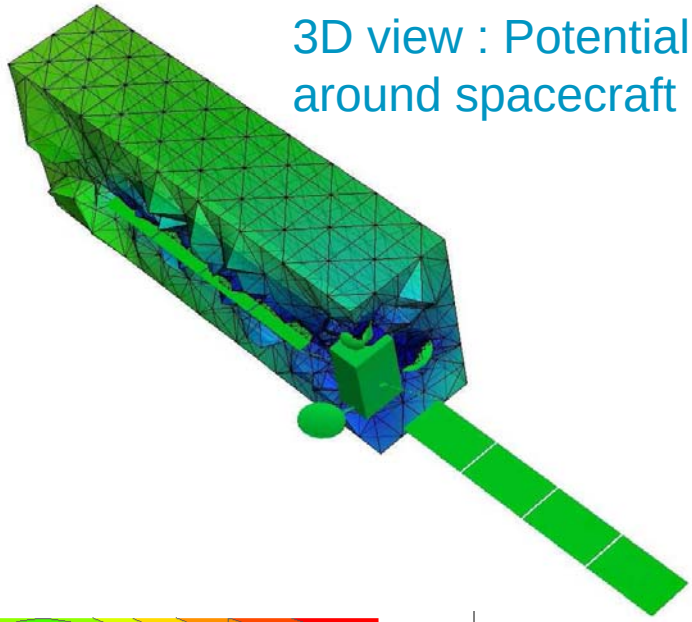
- Resolution of Vlasov-Poisson problem in the computational domain i-e in the volume between S/C external surfaces and the artificial infinite boundary
  - P1 Finite elements (surfaces) and infinite elements
  - Transient computation of the S/C absolute potential Φ_{abs} (conductor frame) and differential potential Φ_{diff} on external S/C dielectric surfaces
  - On the basis of calculation and balance of primary (plasma ions and electrons, bulk conduction) and secondary currents (ion and electron induced secondary emission, photo-emission, back scattering, recollection)
  - **Use of back-tracking algorithm for solving collected currents**

SPARCS tool for GEO S/C charging analysis

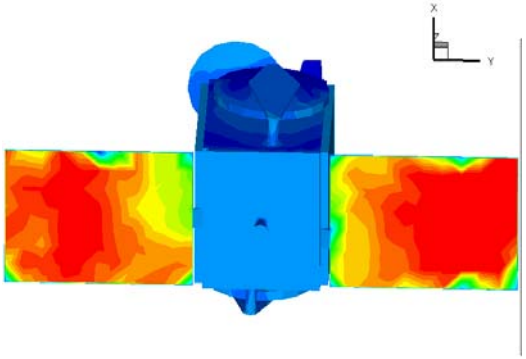
- Example of SPARCS simulation outputs

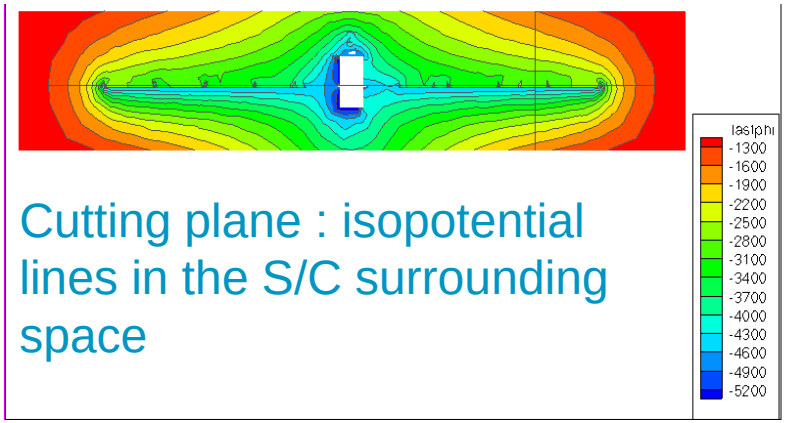


3D view : Absolute & Differential potential on S/C surfaces



3D view : Potential around spacecraft



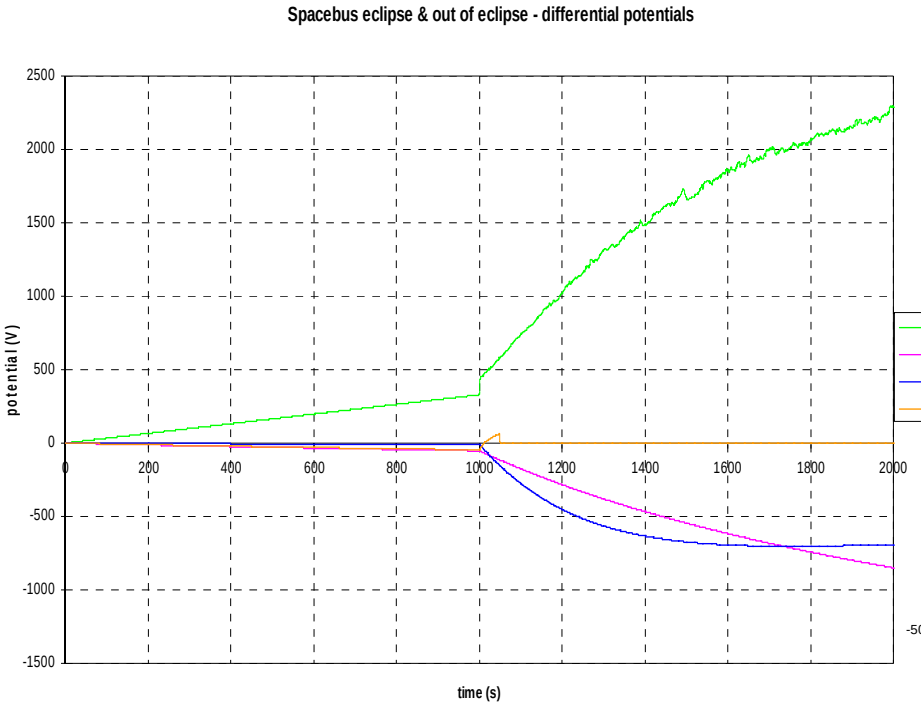


Cutting plane : isopotential lines in the S/C surrounding space

SPARCS tool for GEO S/C charging analysis

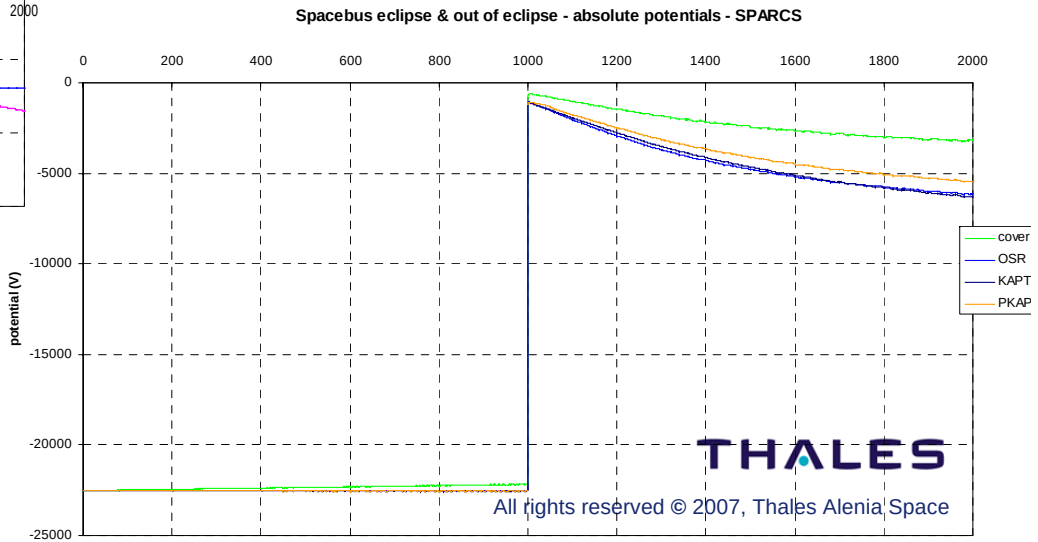
Example of SPARCS results : transient simulation

- Spacebus during eclipse & out of eclipse



2D plot vs time of Φ_{ABS} and Φ_{diff} on S/C surfaces :

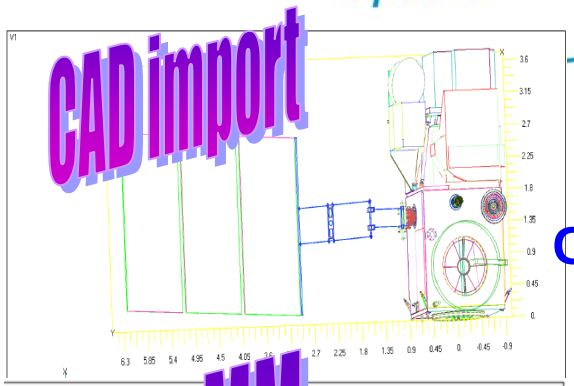
Ex : Max Φ_{diff} , Min Φ_{diff}, Φ_{diff} at user defined probe points

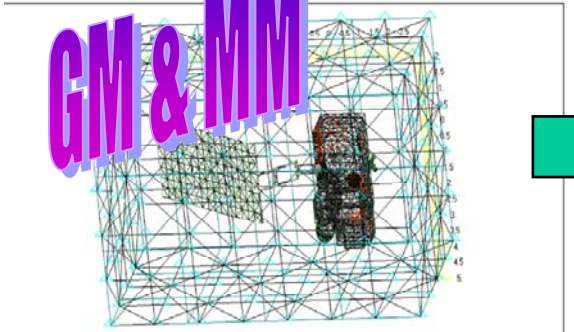


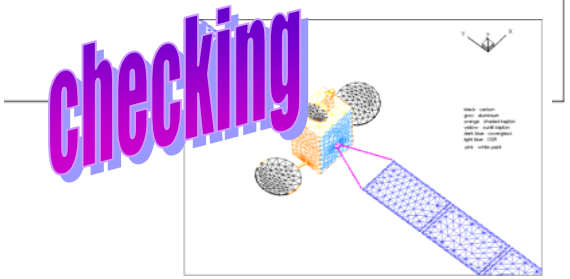
Integration in an end-to-end charging analysis tool

- Objective
  - Today SPARCS is interfaced with COTS s/w for pre and post processing, and it causes some problems
    - Reducing cost by using license free existing s/w
    - Make handling and external distribution more easy (for use or for development)
    - Simplify even more the user process
    - Add some new capabilities (e.g more assisted retouch of CAD geometriy, 3D transient animation of results, …)
  - Need for an integrated end-to-end s/w chain
- Project 2010
  - Development of an integrated S/C charging simulation chain in CIGAL2 application
    - Low cost since CIGAL2 is actually the TAS pre/post processing tool for thermal analysis
  - Technical requirement and URD is ready
  - Convergence between tools : multidisciplinary tool (Thermal / Space Environment)

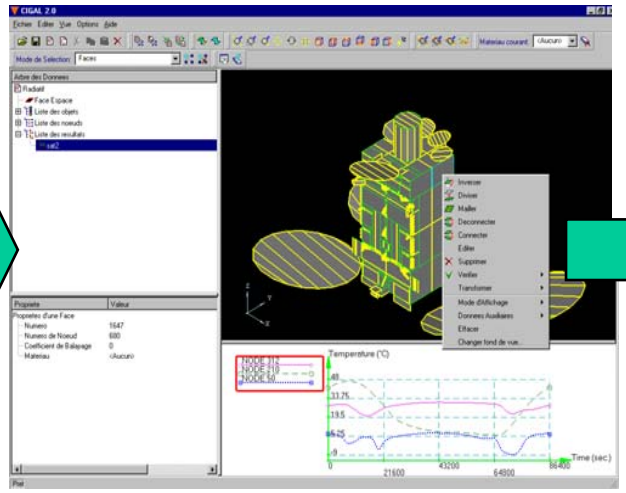
Planned evolution

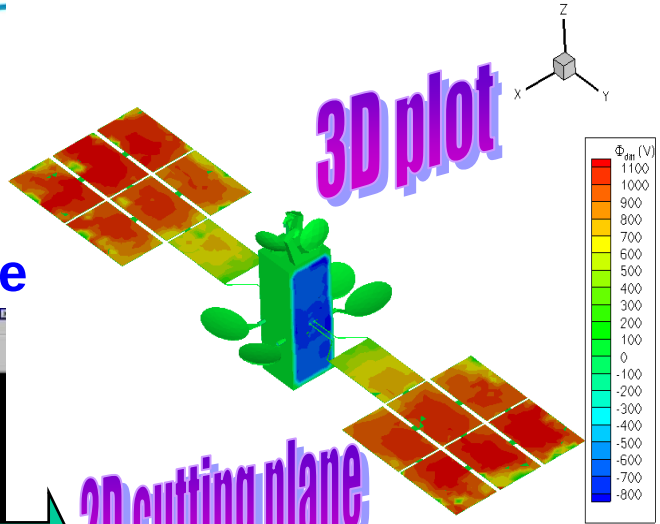


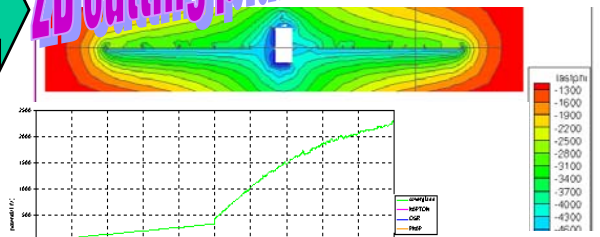


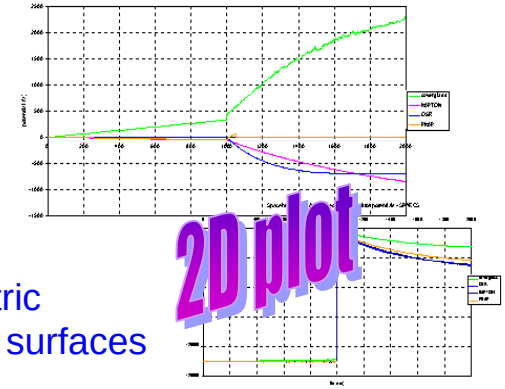


CIGAL S/C charging module









Inputs :

- Geometry/FEM mesh
- Boundary conditions (electron/ion distribution, …)
- Materials
- Run definition data

Outputs :

- Absolute and differential electric potential on SC surfaces (3D & 2D plot)
- Primary and secondary currents
- Iso-potential lines around S/C

Planned evolution

- Parallelisation using graphic card capability
  - Today SPARCS is parallelized for cluster of up to 8 processors (Open MP)
  - We intend to extend this capability by using graphic card vectorized computation process
    - Should be very interesting for back-trajectory algorithm which constitutes the major part of CPU time (Vlasov solver)
  - Goal : Reduction of CPU time for charging simulation runs
    - For a typical simulation of large telecom S/C : ~ 1500 sec of transient simulation
    - Pass from 4- 8 h to less than 1h
- Comparison with SPIS for typical telecom S/C charging analysis
  - Project for 2010 (R&T CNES proposal) : results, handling & user-friendliness , CPU time, modelling & post-pro capability
- Need to simulate S/C charging with electrical propulsion
  - Project to test SPIS capability in 2010 (R&T CNES proposal)
- Multipotential simulation (nearly achieved)
  - Possibility to define and solve different reference potential
    - Eg : Allow to fix potential on each solar cell of SA
- Adaptative time step for dynamic solver
- Better model for SEE