Modelling Plasma - Planetary surfaces – S/C interactions with SPIS

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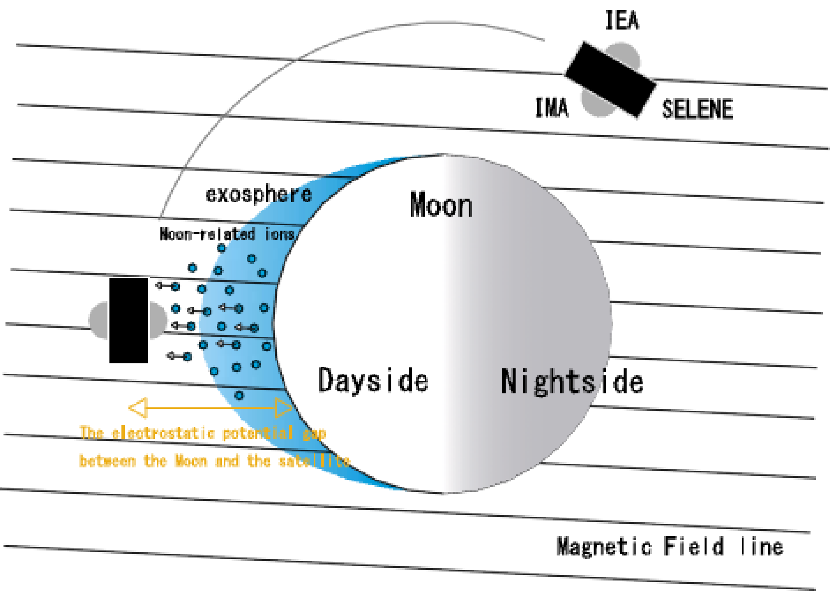
Rationale

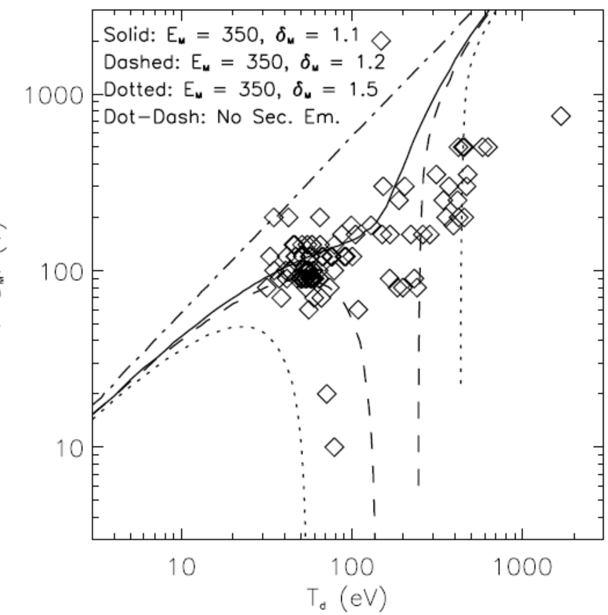
– Solar System missions (EJSM, Bepi Colombo, ESA Lunar Lander, Asteroids exploration, etc ...) will be concerned with planetary surfaces potentials

- affects charged particles trajectories → distributions measured by plasma intruments at S/C
- affects plasma driven desorption processes of particles from the surface (e.g. icy moons)
- affects near surface electro-magnetic environment : dust charging, differential charging of landed / permanent human based systems resulting in potential hazards

→ Need for a modelling capability addressing missions (and science) related aspects may arise

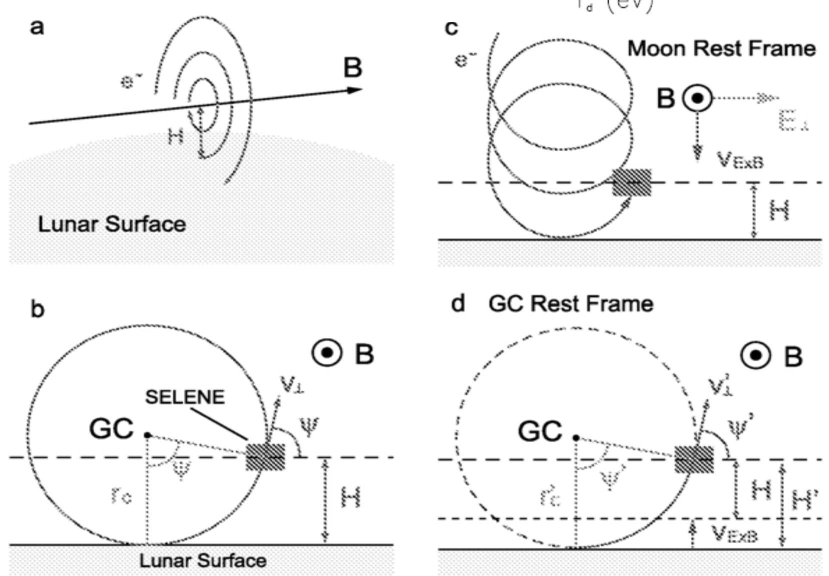
Rationale : Moon case





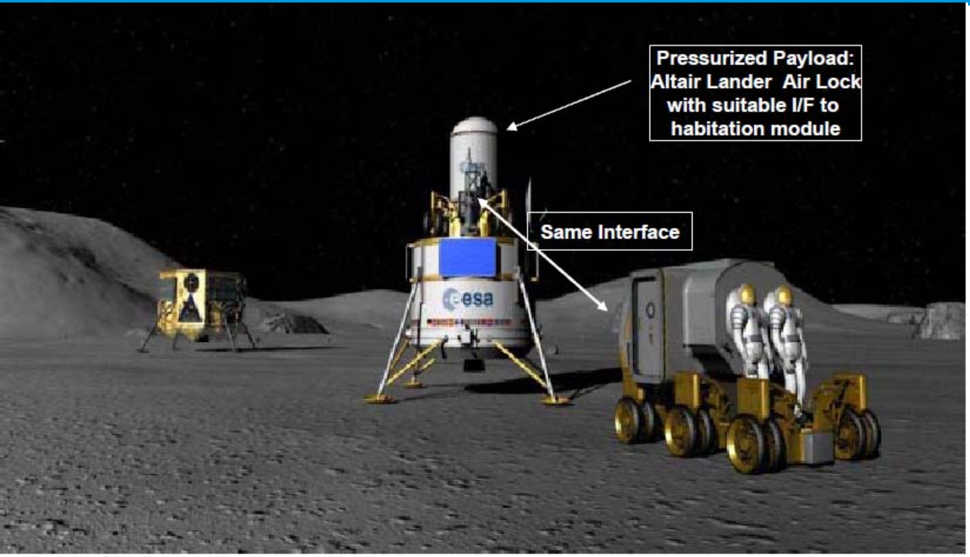
Surface potential : a few 100V <0 on the nightside in the tail lobes and plasma sheet from LP/ER data (Halekas et al 2008)

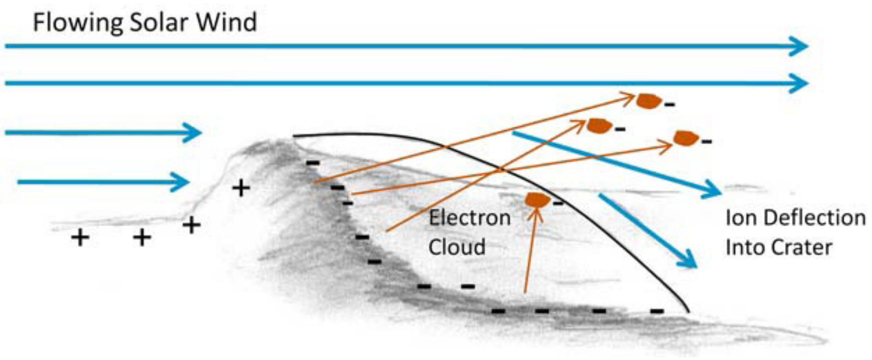
400eV accelerated ions measured with KAGUYA/MAP-PACE at 100km (Tanaka et al 2009)



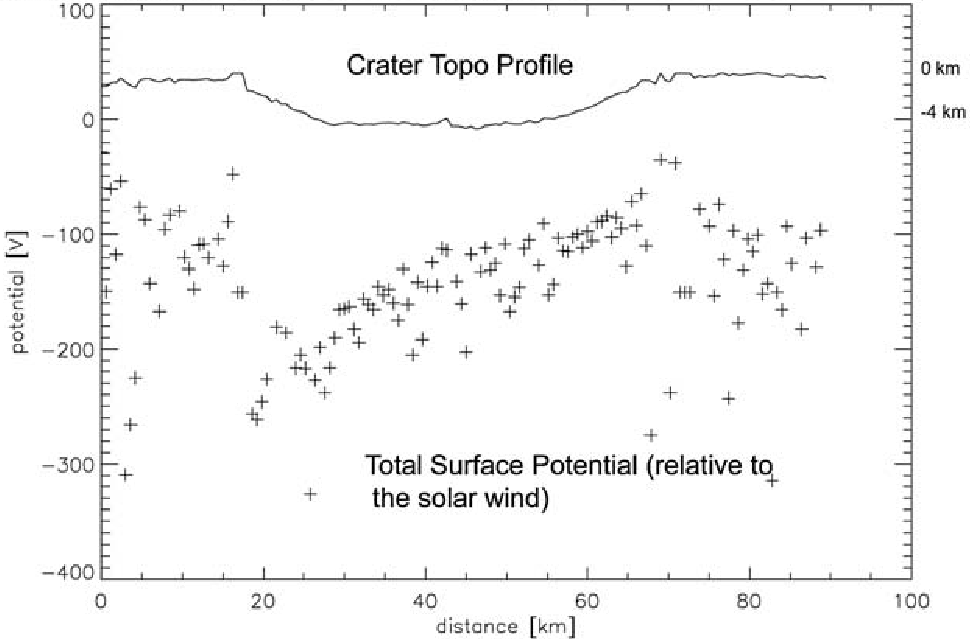
Absorbed electrons measurements with KAGUYA/MAP-PACE in the plasma sheet (Harada et al 2010)

Rationale : Moon case

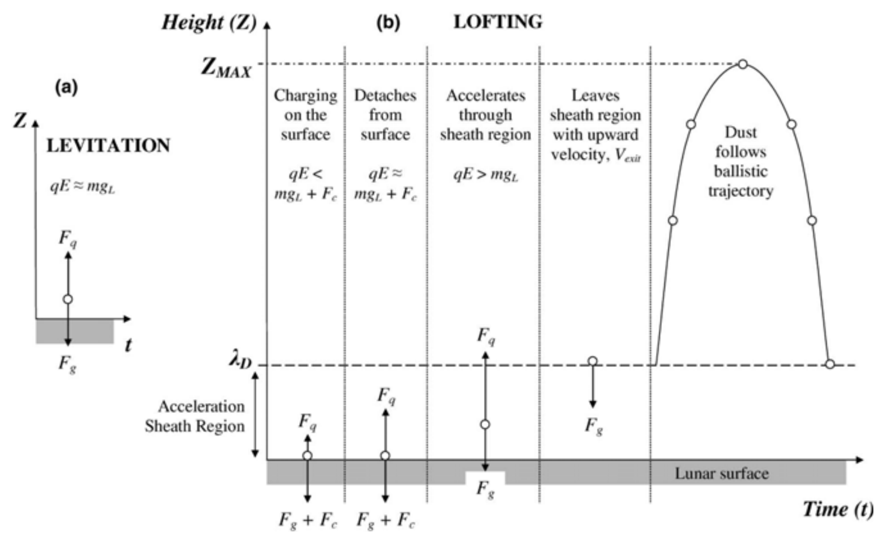




Negative charging inside polar Lunar craters near the terminator (LP/ER) (Farrell et al 2010)



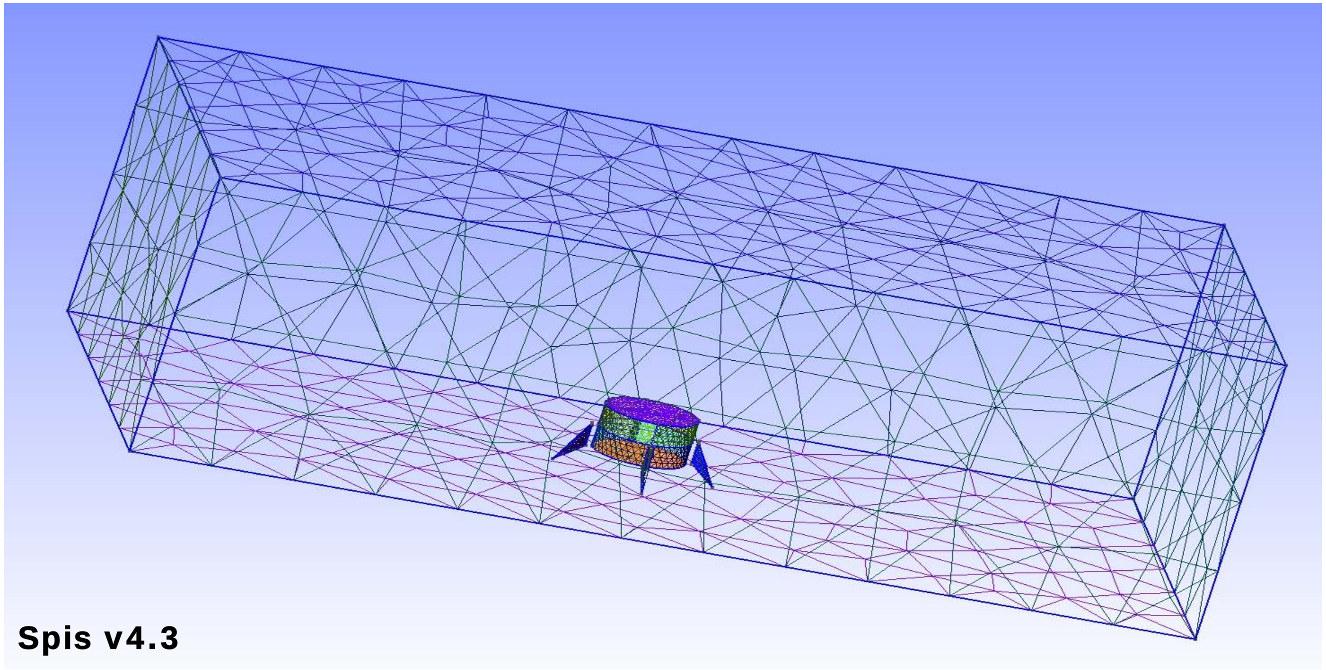
Dust charging (Stubbs et al 2006)



Modelling Example 1 : Lander case

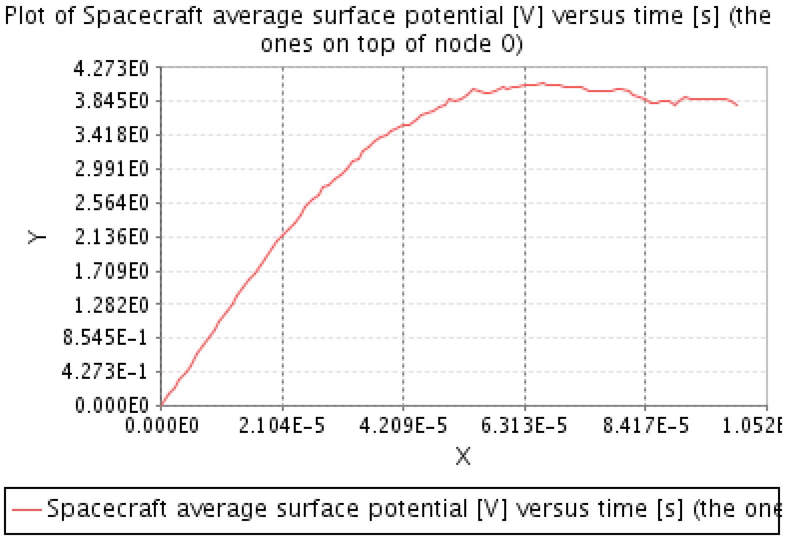
PIC-PIC approach :

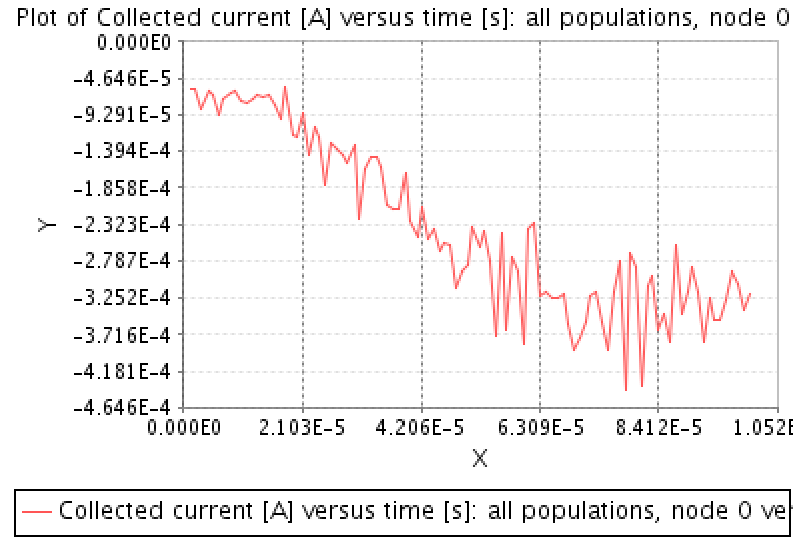
- **Moon in 'a' plasma sheet (ne=ni=0.1cm^{-3}, Te=Ti=1keV, Vorb = 1km/s)**
- **Nightside (no photoemission)**
- **Secondary electrons (no hoping)**

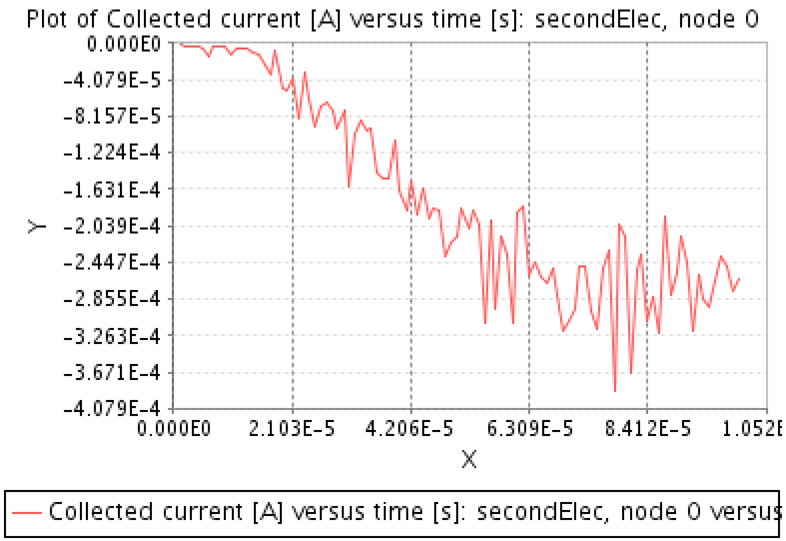


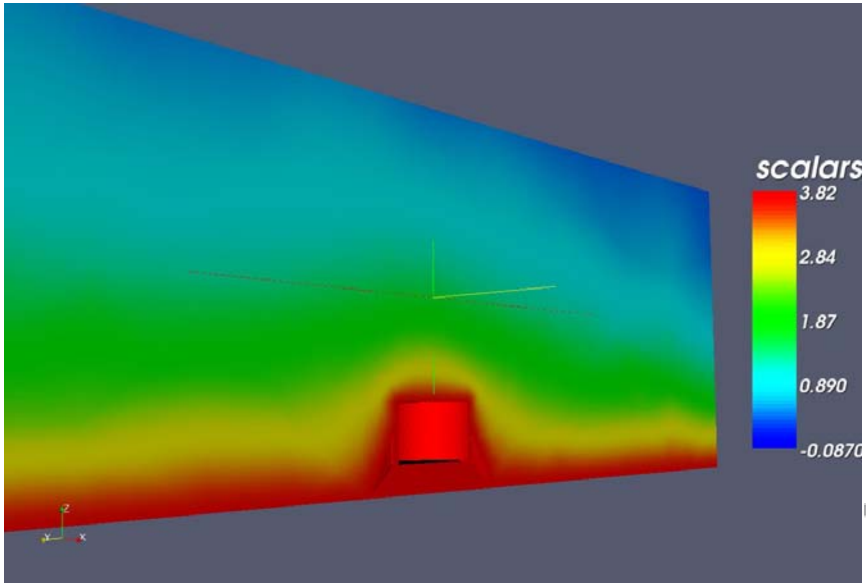
- **Lunar Surface = bottom boundary**
- **Symmetrical boundaries conditions on lateral boundaries → 'reflect' near surface conditions**
- **Moon surface = OSR, Lander = Kapton !!**
- **Box size = 40x20x20m, Lander diameter = 1.75m, tetrahedron number ~ 12000**

Modelling Example 1 : Lander case









Modelling case 2 : Orbiter

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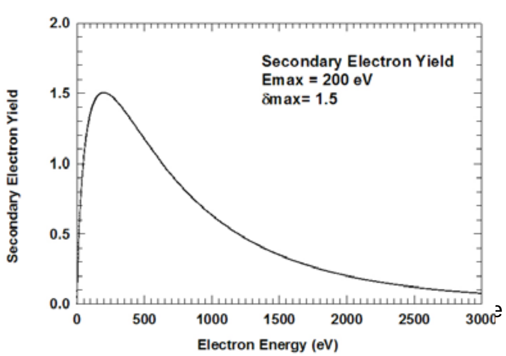
1. Potential differences between surfaces and S/C during measurements in planetary environments : EJSM, Bepi Colombo, etc … BUT also needs B structure
2. When S/C altitude << Object Radius → flat surface, boundary. Otherwise more problematic.
3. Distance S/C surface >> Debye length → require multi-scale/grid approach
4. Interactions with neutrals, charged particles, photo and electron-impact ionization will change the current balance between the surface and the S/C
5. Specific surface processes have to be considered (e.g. sputtering, psd) as sources of charged particles

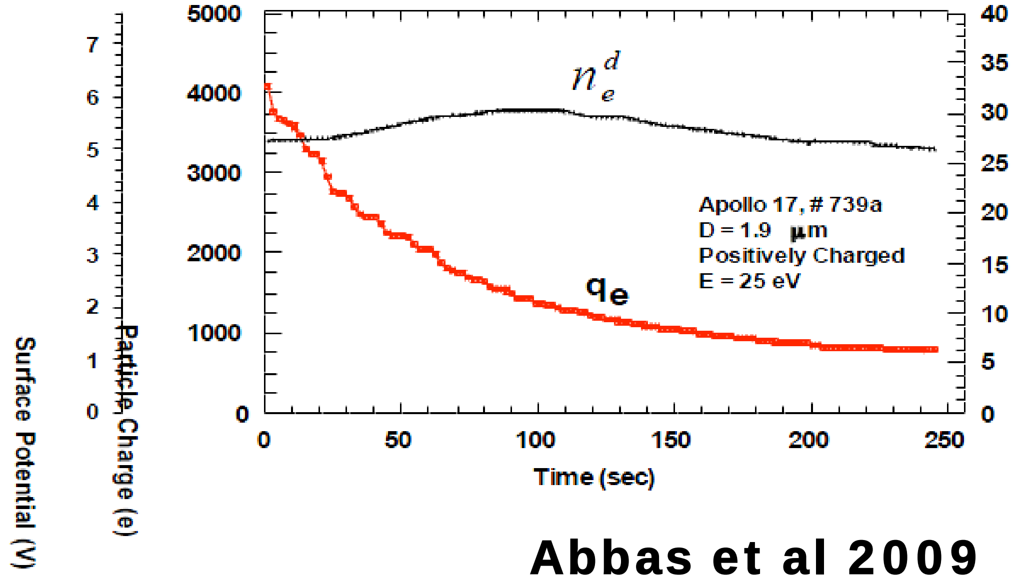
Modelling case 3 : dust charging

1. Relevant to : dust instrumentation, dust impacts, electrostatic interaction of dust with materials and related hazards assessment (abrasive effect on materials, contamination of life support systems, reduced visibility and optical quality)
2. Modelling needs :

- dust charging processes :photoemission, ions/electrons sticking, SEE
- dust transport : gravity and surface electric fields
- interaction with materials : adhesion (cause mechanical friction), charged dust coatings (e.g. solar panels on rovers)

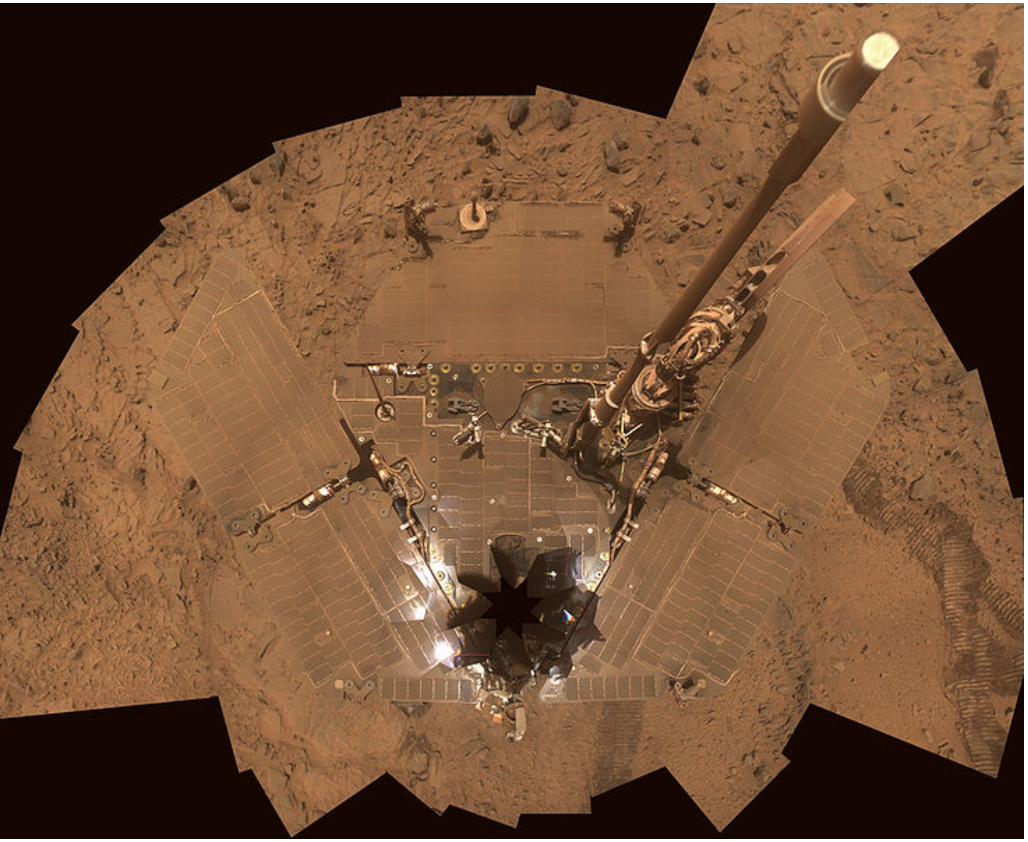
→ Need for a dusty SPIS (Lunar Lander, ExoMars ...) ?



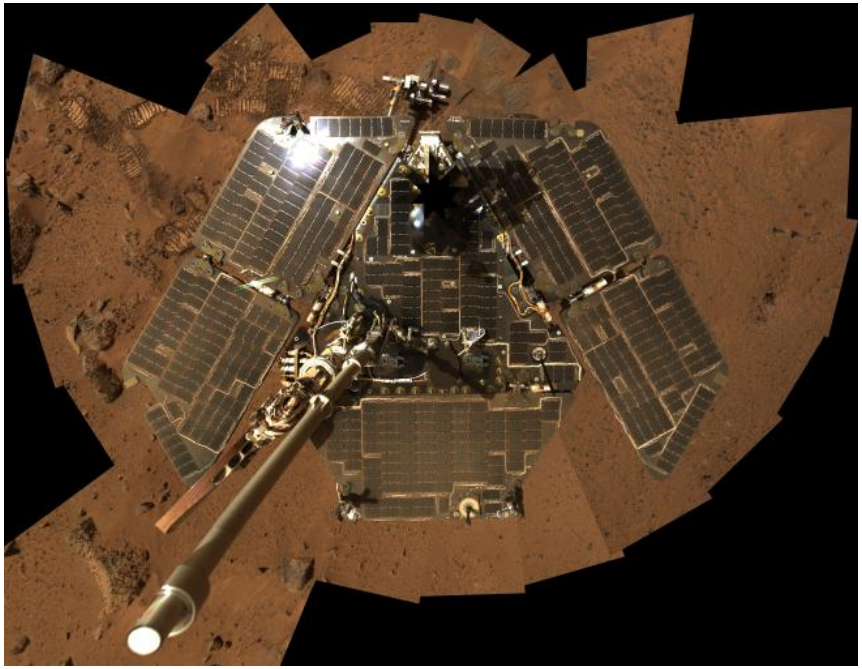


Abbas et al 2009

Modelling case 3 : dust charging



Spirit Rover, October 2007



Conclusion : Possible new requirements for SPIS

- Ability to account for a new class of materials : planetary/dust surface with same physical/electrical properties than S/C materials + e.g. porosity/absorption, sticking coefficients ...
- Ability to account for various (near surface) plasma distributions wrt open space (particles absorption, planetary shielding, leading/trailing effects, etc ...)
- Ability to easily input/modify SEE parameters
- Ability to solve a circuit describing several floating objects : S/C potentials, surface wrt plasma
- Ability to include various B configurations
- Ability to simulate charging and transport in large regions in space (~ x100km)
- Ability to model charging, transport and interactions of micron size particles with S/C surfaces

→ New and interesting challenges wrt science missions support