Development and Future Vision of Multi-Utility Spacecraft Charging Analysis Tool (MUSCAT)

Shinji Hatta[1]; Takanobu Muranaka[1]; Satoshi Hosoda[1]; Jeongho Kim[1]; Mengu Cho[1]; Hiroko, O Ueda[2]; Kiyokazu Koga[2]; Tateo Goka[3]

[1] KIT; [2] JAXA; [3] ISTA/JAXA

http://laseine.ele.kyutech.ac.jp/

The final version of Multi-Utility Spacecraft Charging Analysis Tool (MUSCAT) is released in March, 2007. MUSCAT is a computation tool to analyze spacecraft-plasma interaction including charging status corresponding to spacecrafts in Low Earth Orbit (LEO), GEo stationary Orbit (GEO) and Polar Earth Orbit (PEO).

The loss of ADEOS-II, a PEO satellite with bus voltage of fifty volt, occurred on October, 2003. Japan Aerospace Exploration Agency (JAXA) determined that the loss is ributed to interaction between the plasma environment and its multi layer insulation (MLI) around high power wire harness. Through the investigation process of ADEOS-II, it was revealed that charging of a PEO satellite could cause serious failure including total loss.

In order to prevent power system failure due to charging like what occurred on ADEOS-II, quantitative analysis from the viewpoint of charging-arcing issue on the early stage of satellite designing phase is necessary. Electric potential of a satellite body with respect to ambient plasma and differential voltage of each surface component with respect to the satellite body potential are the most important elements to consider charging-arcing issue.

Satellites in PEO are exposed to unique plasma environment including low energy (0.1˜0.2 eV) ionospheric plasma and high-energy auroral zone particles. In LEO with a low inclination angle, low energy particles are dominant. On the other hand in GEO, high-energy particles are dominant. Therefore, an analyzing tool developed for PEO can be used both for LEO and GEO with minor modification.

In Japan, Space Plasma Simulation Group promotes 'Geospace Environment Simulator (GES)' project using the Earth Simulator, one of the fastest computer at present in the world. A computer code for simulating plasma environment surrounding a satellite is under construction as a component of GES. As GES uses full Particle-In-Cell (PIC) method for computation of environment around spacecraft, it requires long computation time even for the Earth Simulator. Therefore, although GES is very powerful, it is not useful for easy use like parametric runs in spacecraft designing phase.

In the situation mentioned above, JAXA decided to develop its own charging analysis tool that can calculate charging status of a polar orbiting satellite jointly with Kyushu Institute of Technology (KIT). The numerical tool is named MUSCAT. It is used to evaluate the risk of charging in spacecraft design phase, to determine appropriate parameter settings of ground tests by calculating the worst-case charging potential, and to determine whether a given satellite failure is due to charging or not.

The final version has already included all important features to simulate space environment. The features are 1) smart GUI, 2) numerical functions to simulate physical phenomena, 3) fast computation function and 4) code validation by experiment and by computation with super computer. As for 1), MUSCAT users can now build a satellite model including not only its geometry but also material properties of the surface with user friendly GUI. As for 2), MUSCAT includes effects of photoelectron emission, secondary electron emission, double Maxwellian distribution of background plasma in GEO, auroral electron current and conductive current. As for 3), MUSCAT can work on SMP parallel workstation. And 4), the computation result by MUSCAT shows very good agreement with code validation experiment using a vacuum chamber as well as with full PIC computation by GES group.

In addition to the validations mentions above, we have conducted trial computation of charging analysis on Greenhouse gases Observing SATellite (GOSAT) with MUSCAT. One purpose of the computation is prediction of charging status of GOSAT for real satellite design including ground test. The other is performance assessment of MUSCAT.

The details of the final version are reported in the conference.