Application of space plasma measurement data to spacecraft charging analysis

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Spacecraft bus voltage has increased recently as size of spacecraft increases. Modern commercial satellite nowadays uses more than 10kW electricity and a voltage of 100V is used as generating and delivery voltage of solar array. Even for recent Earth observation satellites, a large satellite, such as Daichi, is being used. For these high power and high voltage satellite, there are numerous accidents due to spacecraft charging. Many GEO commercial satellites suffers accident where they lose a part of power instantaneously because of short-circuit of solar array due to arc discharge. Triggering source of these accidents is charging of spacecraft insulating material. The spacecraft potential is determined by various parameters such as surrounding space environment, surface material, satellite geometry, etc. Development of spacecraft charging analysis tool that considers these elements is now underway in US, Europe and Japan.

In Japan, a group of JAXA, KIT and others is developing Multi-Utility Spacecraft Charging Analysis Tool (MUSCAT). During the development, an important agenda is to formulate database regarding space plasma environment. Important outputs of spacecraft charging analysis tool is spacecraft body potential with respect to the surrounding plasma and the potential difference between the spacecraft body and surface insulator. These potential differences change as space plasma environment, e.g. density and temperature, changes. In GEO and PEO, the level of spacecraft charging under nominal quiet conditions is negligible. Serious spacecraft charging occurs only during special cases where magnetospheric substorm or aurora occurs. Various mitigation methods are taken against the spacecraft charging and arcing. These methods are based on assumption that the duration of spacecraft charging is limited only to a fraction of satellite lifetime. Therefore, estimating the duration of spacecraft charging is very important from the viewpoint of cost-effective design.

Spacecraft charging analysis tools give electric potential of various points on satellite surface. By identifying the combination of plasma parameters to cause serious spacecraft charging and knowing the probability of appearance of such environment, we can estimate the charging duration in orbit. We have carried out statistical data analysis of LANL satellites regarding GEO plasma environment. By combining with the charging analysis done by NASCAP/GEO, we estimated the charging duration of WINDS (to be launched in 2007) to be 12 hours in 5 years lifetime. Currently, we are carrying out a similar statistical data analysis on PEO plasma environment. The satellite measurement data we are using is data of SSJ/4 onboard DMSP. We are analyzing data of 30 to 30keV precipitation electrons. The results will be presented in the conference.