

SPACECRAFT CHARGING : A FRENCH EXPERIENCE

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CNES, Centre National d'Etudes Spatiales, is the French governmental space agency. As far back as January 1975, the first European telecommunications satellites SYMPHONIE-A and SYMPHONIE-B sponsored by the French and German governments experienced charging-induced anomalies. Meanwhile, NASA and Air Force had undertaken a joint comprehensive Research and Technology program on spacecraft-environmental interactions. The first Spacecraft Charging Technology Conference held in October 1976 is a reference milestone. These conferences were very helpful for defining our proper program in the domain. What is the status twenty-five years later?

In the past context of a very limited understanding of charging phenomena and related effects, CNES had been responsible for proposing mitigation techniques of the first French telecommunications satellite TELECOM-1-A launched in 1984. On this satellite spurious repeater-switch-off were attributed to environmental induced discharges. Nothing can replace actual flight experience, we understood the research program had been oriented for avoiding dielectric discharges when we experienced floating metal discharges. However thanks to our preliminary effort, it was possible in a couple of months, in tight cooperation with Industry and Laboratories to implement right solutions on TELECOM-1-B and following satellites to deliver outage free spacecraft.

This success has been the result of strict application of an ESD control plan in four points: immunity tests at unit level, electromagnetic shield between any cable and space, no floating conductor, no large area of leakage free dielectrics. These mitigation techniques were applied to all projects under CNES visibility: the French-German program of direct-broadcasting TVSAT and TDF, the four commercial telecommunications satellite TELECOM-2 and even the five low-altitude polar Earth-Observation satellites SPOT.

Results can be read in black or white. Our satellites do not suffer any more adverse charging effects, though telemetry anomalies are showing from time to time

electrostatic discharges and interference. We are still on the edge of the cliff.

Our understanding is sufficient to rapidly diagnose an ESD event and find a parade. We have normalized tests, standard methods, we are performing a continuous Research and Technology program for more than twenty years in the domain to cope with new technologies and new materials, we have acquired full understanding and characterization of electrostatic discharges seen during ground tests, physical models are available. On the other hand new items exhibit unforeseen flight anomalies, so something is lacking in our knowledge of space interactions or in capabilities of our prediction tools.

We must remain vigilant, electrostatic discharges are still alive. Moreover, some new technologies or known technologies with increased size seem more sensitive to charging. For the next future, we cannot avoid solar generators at higher voltages, active antennas and electric thrusters. Farther, tether techniques are foreseen for end-of-life de-orbiting, energy storage, orbital captures increasing plasma spacecraft interactions.

Achievement of a satisfying behavior is more dependent on individual expertise than of blind application of standards and procedures. These Spacecraft Charging Technology Conference are and remain necessary tutorial materials. Preparing a set of handbooks covering all aspects of charging is the role of space agencies. NASA opened the way with the technical handbook NASA-HDBK-4002, "Avoiding problems caused by spacecraft on-orbit internal charging effects". Standards agreed by the whole space community are needed. The frame exists with ISO-14302, "Space Systems, electromagnetic compatibility requirements" from International Organization for Standardization (ISO) and ECSS-E20, "Space engineering, electrical and electronic" from European Cooperation for Space Standardization (ECSS). Between hazards of undertesting and extra cost of overdesigns there is a narrow way for giving confidence to customers. We have still to prove that an ESD-free satellite at a reasonable cost is not utopia.