YORKSCIENCE

CLYVIA simulates, saves satellites

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Man is becoming more and more dependent on satellites for long-distance TV transmission and communication between computers. During the last decade dozens of satellites have been put into orbit yearly, numbering about 150 at present.

A growing number of these spacecraft have malfunctioned or been damaged for reasons unknown until recently. Scientists have discovered that tremendous voltages may build up and suddenly discharge on the surface of these spacecraft, causing serious damage.

The problem of spacecraft charging is now being investigated here at York.

Satellites are continually being placed in geostationary orbits around the Earth to provide instantaneous television, telephone and data communication over long distances.

A geostationary orbit is an equatorial orbit located at 50,000 km above the earth's surface, rotating at the same speed as the Earth. The satellite, in effect, remains stationary over a fixed spot on the Earth. It will remain in such an orbit essentially forever and can act as a permanent relay tower for communications.

Recently satellites such as INTELSAT, DSD, ANIK, CTS (Hermes) and others have experienced unexpected difficulties. On one type of satellite a fictitious command would be received by the satellite's on board computer telling it to de-spin. If this were not corrected from a ground station within 50 minutes the satellite would be in danger of going into an irreversible tumble.

Catastrophic power failures deactivating the main communications system, spurious signals and damage to telemetry amplifiers are a few of the problems that have occurred for no obvious reasons.

Upon close examination by scientists these problems were often found to occur under specific conditions, particularly during magnetic substorms.

A magnetic substorm involves a localized plasma cloud filled with highly energetic particles forming high above the Earth's surface.

Substorms are still of unknown origin, but are associated with the aurora. A spacecraft is always surrounded by a "sea" of positive and negative electricity, picking up these charges. Since much of the surface of most satellites is non-conducting, electrical charges of up to 20,000 volts can accumulate. Under certain conditions this voltage will discharge like a lightning bolt and may cause serious damage by providing false signals, overloading electronic components or punching holes through spacecraft.

To study the problems of surface charging, a model must first be devised. Dr. Jim Laframboise of CRESS (Centre for Research in Experimental Space Science) and the Physics Department here at York has created CYLVIA, an acronym for CYLindrical Voltages in the Ionosphere and Above, and LOCHG, for LOcal CHarGing.

These are computer simulation programs providing a numerical

Teflon patches

analysis of electrical charging which can occur on a spacecraft. "We can examine the charging characteristics of many types of satellites, for example, an aluminum satellite with teflon patches or one with gold parts, etc.," explained Dr. Laframboise.

The most serious problems of satellite charging frequently occur when satellites enter the Earth's shadow, an event that is still not well understood.

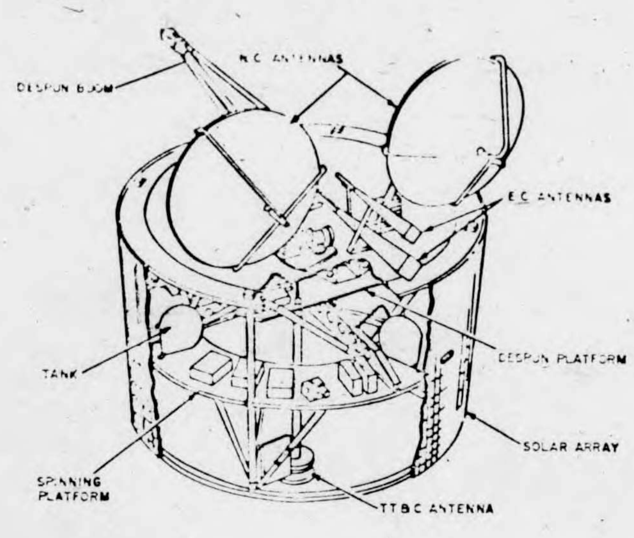
It is known that a satellite will often charge up to thousands of volts on its dark side (the side hidden to the sun), but its sunlit side may remain nearly neutral because "photons" (particles of light) cause excess electrons to "boil off" its surface.

"The most serious charging effects occur for many satellites in the Magnetosphere's midnight-to-dawn sector, which is fortunate for coast-to-coast broadcasts of hockey games," Dr. Laframboise noted.

Last year a satellite called

computer analyses

SCATHA (Spacecraft Charging At High Altitudes) was sent into orbit as part of a joint effort of the United States Air Force and NASA. The purpose of SCATHA is to study the phenomenon of spacecraft charging. Experiments were onboard to investigate why a satellite in space becomes charged. An electron beam system and a thermionic emitter ejected negative charges (electrons) from SCATHA, while a Plasma Gun ejected both electrons and positively charged Xenon atoms. The latter experiment was found to be most effective in discharging high voltage from spacecraft.



DSCS satellite

Dr. Laframboise has been funded by the USAF to study spacecraft charging using computer analyses. A major contribution by Dr. Laframboise's group was the discovery of multiple possibilities for charging voltages under the same set of external conditions, and that the actual satellite voltage may jump suddenly from one to another.

An attempt is being made in conjunction with SCATHA to completely model these situations using computers. Laframboise hopes that CYLVIA and LOCHG (his computer modelling programs) "will be able to help someone with a spacecraft design, that is, the programs will be able to tell if there is a charging problem, and if so, how to change the design."

The major problem with the computer models is that actual situations appear to be very sensitive to slight changes in conditions. "The surface voltages on spacecraft cannot be accurately and reliably predicted at the present time."

In Dr. Laframboise's opinion the most likely reason why the problem of satellite charging was not foreseen earlier was the near-termination of scientific exploration of Earth's Magnetosphere in the 1960's. At that time an anti-science public attitude was picked up by politicians, making it very difficult to obtain funding for space research.

The termination of the Alouette and ISIS satellite programs and cancellation of Polaire (a recently proposed Canadian research satellite) are causing Canada to lose knowledge which could prevent other expensive surprises in the future.

Although five years of intense effort have not yet produced a panacea for the problem of spacecraft charging, Dr. Laframboise is confident that "the problem is now clearly recognized; satellite design changes are being made to reduce the buildup of high voltages, more parts are being made conductive and there is considerable progress in materials. The problem won't disappear but will gradually fade away with time and effort."

Laframboise warns that there are many additional problems of spacecraft charging that must be looked at. The computer programs CYLVIA and LOCHG are being expanded to account for these. For example, there is concern that plasma surrounding proposed solar power satellites can "short-out" their power systems by causing large leakages of currents around them. The plasma can cause damage by focussing into beams of energetic particles which can cause surface coatings to be blasted off. A new concern is that the Space Shuttle may charge up to several thousands of volts as it passes through the auroral zone. This problem has been identified only recently and its possible consequences are not yet clear.