/N-18
14411
P12

NASA Contractor Report 187088

A Charging Study of ACTS Using NASCAP

Joel L. Herr
Sverdrup Technology, Inc.
Lewis Research Center Group
Brook Park, Ohio

May 1991

Prepared for
Lewis Research Center
Under Contract NAS3-25266

National Aeronautics and
Space Administration

A CHARGING STUDY OF ACTS USING NASCAP

Joel L. Herr
Sverdrup Technology, Inc.
Lewis Research Center Group
Brook Park, Ohio 44142

E-6079

Summary

The NASA Charging Analyzer Program (NASCAP) computer code is a three-dimensional finite-element charging code designed to analyze spacecraft charging in the magnetosphere. Because of the characteristics of this problem, NASCAP can use a quasi-static approach to provide a spacecraft designer with an understanding of how a specific spacecraft will interact with a geomagnetic substorm. The results of the simulation can help designers evaluate the probability and location of arc discharges of charged surfaces on the spacecraft.

A charging study of NASA's Advanced Communications Technology Satellite (ACTS) using NASCAP is reported. The results show that the ACTS metalized multilayer insulating blanket design should provide good electrostatic discharge control. For the best current information on the ACTS design, the probability of electrostatic discharges occurring in the immediate vicinity of the ACTS antennas is shown to be minimal.

Introduction

The encounter of geosynchronous spacecraft with geomagnetic substorm environments has been widely studied as a cause of spacecraft anomalies (ref. 1). These anomalies have been attributed to the coupling of electromagnetic radiation from the arc discharges of charged spacecraft surfaces with spacecraft electronics.

Two types of charging occur, each of which can cause spacecraft surfaces to discharge. The first, called absolute charging, is characterized by the entire spacecraft being charged uniformly relative to the environment. Photoelectron emission from spacecraft surfaces and the incident plasma electron flux are sources of current which most affect the absolute charging level of a geosynchronous spacecraft. The capacitance of the spacecraft as a whole with respect to the environment is small, which allows for rapid changes in the absolute charging level of the spacecraft as charging conditions change.

The second type of charging, called differential charging, is characterized by parts of the spacecraft charging to different potentials relative to each other. The rate of differential charging is much slower than that of absolute charging because it is controlled by relatively large capacitances between dielectric surfaces and the spacecraft structure, and between different regions of the spacecraft. Differential charging is caused by such factors as different material properties, configuration effects (such as shading), and weak coupling of the surfaces with the spacecraft structure (ref. 2). Differential charging will induce discharges that are more severe than absolute charging because of the relatively large capacitances involved.

As a geosynchronous spacecraft encounters a substorm environment, it charges in a matter of seconds to an absolute charging level dependent on the plasma electron flux and photoemission rates. Differential charging then follows relatively slowly because of nonhomogeneous charging conditions. Differential charging continues until either a discharge occurs or equilibrium is established, which takes place when the net current to each surface or conductive path is zero. For equilibrium to be established, the spacecraft must ultimately charge negative to repel a portion of the more mobile incoming plasma electrons. The remainder of the electron flux is balanced by current leaving the surface through photoemission, secondary electron emission, and backscattering, and by the incoming positive ion plasma current. If a discharge occurs before equilibrium is established, the spacecraft may continually charge and discharge as the conditions necessary for a discharge are established again and again.

On the basis of past experience, a series of documents has been published jointly by NASA and the USAF which offers guidelines to help spacecraft designers minimize the differential charging of spacecraft (refs. 3 to 6). These documents show that three-dimensional numerical techniques must be used to adequately model the charging process. The NASCAP computer code (ref. 7), which was developed specifically for this purpose, conducts a numerical simulation of the charging of a spacecraft. NASCAP is an engineering design code which estimates surface voltage levels and assists in evaluating the probability and location of discharges on a particular spacecraft.

This paper describes the results of a NASCAP charging study conducted on a model of NASA's Advanced Communications Technology Satellite (ACTS). A description of the electrostatic discharge mechanisms is given including the field and potential threshold values that were monitored during the NASCAP simulation. The differential charging behavior of the model is used to identify conditions and areas on the satellite where charging may be a concern.

Discharge Mechanisms

Differential charging between spacecraft surfaces and between surfaces and the underlying structure can result in an electrostatic discharge if the generated electric fields exceed a breakdown threshold. The conditions necessary for a discharge to occur are not completely understood. However, mechanisms have been identified and breakdown criteria has been established for testing of satellite hardware and for conducting numerical modeling (ref. 3).

One such mechanism is the existence of intense electric fields between neighboring exterior surfaces resulting from the surfaces being exposed to different environmental conditions. For example, shaded dielectric areas tend to charge highly negative because of the lack of photoemission to balance the incoming plasma electron current. As a result, differential potentials develop between shaded dielectric regions and nearby sunlit areas on a spacecraft, and may result in a discharge between the two regions. A discharge between neighboring surfaces, termed "flashover" (ref. 8), results in negative charge being redistributed to space and to more positive surfaces. For simulation purposes, it is assumed that a differential of at least 5000 V across a geometric discontinuity is needed to trigger such a discharge.

Shaded areas of dielectric material are also potential sites for "punch-through" (ref. 8) discharges, or a transfer of charge from the surface to the underlying conductive structure and to space. The structure's potential is controlled by the charging of metallic surfaces elsewhere on the spacecraft and is usually positive with respect to a shaded dielectric surface. If a differential potential develops that exceeds the dielectric breakdown of the surface material, a discharge results. For simulation purposes, if the electric field across the thickness of a surface material exceeds 2×10^5 V/cm, a punch-through discharge is possible.

The charging behavior of typical solar arrays on geosynchronous spacecraft is known, under certain conditions, to form a positive or "inverted" (ref. 8) differential between the dielectric cover-glass and the metal interconnects. The solar array cover-glass has a relatively high secondary emission coefficient, and it characteristically charges less negative than the interconnect. On the basis of ground tests, inverted differentials as low as 200 to 250 V (ref. 9) may cause a discharge known as "blowoff" (ref. 8).

The existence of strong electric fields caused by discontinuities in the spacecraft design or the existence of high levels of surface charging can trigger a discharge known as "discharge to space" (ref. 8). As the name implies, charge is released to space as the "capacitor" of the spacecraft, with respect to the environment, discharges. This type of discharge is typically small and is considered minor.

The discharge mechanisms explained are considered to be surface phenomena caused by the interaction of spacecraft surfaces with the low-energy (0 to 20 keV) plasma constituents. Probable sites for these types of discharges can be identified by numerical modeling using NASCAP.

Simulation Procedure

NASCAP Description

NASCAP is a three-dimensional dynamic charging code designed to analyze spacecraft charging in the magnetosphere. NASCAP considers the important charging currents and geometric electric field effects to model the buildup of charge and electric fields on and around a spacecraft. A NASCAP model of a spacecraft is formed by combining various geometric shapes in a limited-size, three-dimensional grid. Surface voltage levels attained by the model and provided as standard output from NASCAP assist in evaluating the probability and location of discharges on the spacecraft. A complete description of NASCAP, its basic use, internal workings, and applications can be found in the literature (refs. 7, 8, and 10).

ACTS Description

ACTS is a three-axis, stabilized, geosynchronous communications satellite approximately 14-m long from north to south, and 9-m wide (fig. 1) (information provided by the ACTS Project Office, NASA Lewis Research Center, Cleveland, Ohio, 1991). The antenna farm includes a 2.2-m, 30-GHz receiving antenna reflector to the east of the satellite body and a 3.3-m, 20-GHz transmitting antenna reflector to the west. Both are inclined at approximately 25° with respect to an east-west axis. Figure 2 shows the shading by the 3.3- and 2.2-m antennas that would result at local times 1800 and 0600, respectively, during the autumn season. A 1-m steerable antenna is positioned just to the south of the rectangular satellite body. A four-panel solar array system has an area of

12.5 m^2, and will provide 1770 W of power at launch. Dual subreflectors are located above the body, beneath which are beam-forming network modules. Optical solar reflectors (OSR) cover the north and south faces of the body adjacent to the solar arrays.

Many components of ACTS are covered by a metalized thermal blanket to control differential charging. The exceptions are the areas of OSR, the solar arrays, and the front surfaces of the subreflectors and antennas. The OSR's are uncoated silica glass bonded with conducting adhesive. The front area of the solar array consists of approximately 90-percent fused silica cover-glass, and 10-percent silver interconnect. The solar array substrate is uncoated Kapton. The front surfaces of the antennas and subreflectors are coated with a layer of semiconducting paint.

NASCAP Models

For NASCAP to simulate the charging behavior of a spacecraft, the programmer must provide inputs directly related to the buildup of charge and electric fields on and around the spacecraft. This includes a geometric description, including surface material properties, and the environmental parameters.

The NASCAP geometric model of the ACTS was made to resemble the actual design of the satellite to within the restrictions of the program. These restrictions stem mainly from a limited size three-dimensional computation grid. The grid size was chosen to approximate the overall dimensions of the satellite and not the detail of each individual component (see fig. 3). NASCAP has an internal set of standard material properties for commonly used spacecraft materials. Because only the material names were provided with the ACTS description, the NASCAP default properties were used including material thicknesses. The metalized coating of the thermal blankets on ACTS is assumed to be indium - tin oxide (ITO) which is a conductive coating with a high secondary-electron yield typically used for this purpose.

Geosynchronous spacecraft encounter substorm environments typically between local times 1800 and 0600 when the spacecraft travels deep within the Earth's magnetotail. For space applications, the NASCAP programmer is able to specify the energy distribution function and angular distribution of the ambient plasma. It is assumed initially that the environment is characterized by a noncharging plasma. At time equal zero, the model encounters a "severe" single Maxwellian substorm characterized by 12-keV electrons with a density of 1.12 cm^{-3} and 29.5-KeV protons with a density of 0.236 cm^{-3}, and it begins charging. A satellite can expect to encounter a substorm with these characteristics about 10-percent of the time it is in orbit (ref. 3).

The results of three charging simulations are presented: two for an autumn 2400 local time model configuration, and the other for an autumn 1800 local time configuration. The configuration of the ACTS model for the autumn 2400 simulations was previously shown by figure 3. The simulations include an eclipse-sun transition in order to investigate transition and sun-shade induced effects. Charging was simulated for 50 min in eclipse followed by another 50 min in sunlight, with the sunlight incident normal to the antenna's and solar array's front surfaces. For the first autumn 2400 simulation, a conducting paint surface coating, cpaint, is specified for the front surfaces of the antennas. This specification assumes that the semiconducting paint layer on the ACTS antennas has a bulk resistivity less than 10^{11} Ω-cm (ref. 3). The results of this simulation are briefly compared with other "typical" NASCAP three-axis, stabilized communications satellite model charging responses found in the literature to evaluate charging as a function of design.

For the second autumn 2400 simulation, the front surfaces of the antennas are specified to be dielectric. This specification assumes that the semiconducting paint layer on the ACTS antennas has a surface resistivity of approximately 10^{16} Ω. Comparison between this and the first simulation will set a bound on possible charging responses as a function of surface properties of the antennas for an autumn 2400 local time configuration.

The configuration of the ACTS model for the autumn 1800 local time simulation is shown by figure 4. Sun is incident from the west side of the satellite casting the shadow of the 3.3-m antenna across the satellite body shading its own front surface and the 2.2-m antenna. For this simulation, the front surfaces of the antennas are specified to be dielectric. The results of this simulation will be used to determine the induced effects of shading by the inclined antennas.

Because of shading and three-dimensional field effects, a dielectric region will develop a potential distribution across its surface. For those regions depicted on the graphs to follow, the surface cell with the greatest potential difference relative to the structure is used as a worst-case representative of the region.

Simulation Results

Conducting Antennas Simulation for Autumn at Local Time 2400

Figure 5 shows the predicted charging response of the structure and the dielectric regions as a function of time. Within 10 sec after the encounter with the substorm, the plasma electrons charge the satellite as a whole to an absolute charging level of -19.7 kV with respect to the plasma potential. Differential charging then develops in eclipse because of differences in material properties - primarily thickness, secondary emission, and conductivity. Figure 6 shows the potential differences as a function of time between the dielectric regions and the structure. Positive values denote dielectric regions having a positive potential with respect to the structure.

The solar array's cover-glass charges positive with respect to the structure because of its high secondary electron yield, forming an inverted potential greater than 250 V. The cover-glass regions charge uniformly, providing for an equal probability of blowoff discharges at all cover-glass-interconnect interfaces on the arrays. All other potential differences between different dielectric regions and between dielectric regions and the structure result in electric fields below the specified discharge threshold during eclipse.

At approximately 50 min into the simulation, the transition into sunlight takes place, causing a rapid decrease in the absolute charging level of the entire satellite because of photoemission. The potential differences developed in eclipse relative to the structure remain practically unchanged during the initial encounter with sunlight. This is because the larger capacitances involved with differential charging take longer to respond to changes in charging conditions.

Differential charging again develops rather slowly, controlled by shading and three-dimensional field effects. The shaded Kapton substrate charges highly negative because of the lack of photoemission. The accumulated negative charge dominates the electrostatic field, forming a "potential barrier" (ref. 11), or "saddle-point" (ref. 7) in front of the more positive solar arrays capable of suppressing a portion of the low-energy photoelectron and secondary electron emission from the cover-glass (see fig. 7). As a result, the cover-glass charges negatively as well. The potential barrier does not extend evenly over the cover-glass. This causes a potential distribution to form across the front of the solar array. As a result, the inverted potential is greatest farthest from the main satellite body at the edges of the solar array panels. Therefore, blowoff discharges are more likely to occur at interfaces in this region during the initial 100 sec. after the encounter with the sunlight.

The fields generated by the shaded Kapton also affect the charging behavior of the rest of the satellite. The OSR's are adjacent to the solar arrays and lack photoemission. They immediately start to charge negatively along with the shaded Kapton. The structure also charges, but photoemission from the metallic main body and antennas prevent it from becoming very negative. In fact, there is enough photoemission from these areas to cause the inverted potential on the solar arrays to disappear only 110 sec after the encounter with sunlight.

Photoemission prevents the structure potential from becoming very negative, but this in turn creates large differentials between shaded dielectric regions and the structure. A punch-through discharge is possible between the OSR and the structure, which have a potential difference of 3.2 kV and an electric field of 2.5×10^5 V/cm. The potential difference between the array substrates and the structure is 9.5 kV. The substrates are therefore possible punch-through discharge sites, having an electric field of 7.5×10^5 V/cm. The 9.5-kV potential difference between the substrates and the sunlit conductive solar array booms exceeds the 5-kV flashover threshold and may, therefore, result in a discharge between the two areas.

The baseline charging response of the ACTS is similar to past NASCAP simulations of "typical" geosynchronous communications satellite models (refs. 12 and 13). The main difference is the behavior of the inverted potential on the solar arrays. The simulations mentioned modeled a mostly dielectric main satellite body. As a result, the inverted potential remains because of three-dimensional barrier effects, usually for the entire encounter with the substorm. The metalized thermal blanket design of ACTS causes the inverted potential to disappear because of photoemission from the blanket regions. Larger differentials between the structure and shaded dielectrics develop as a result, but punch-through and flashover discharges are thought to have much higher thresholds.

Dielectric Antennas Simulation for Autumn at Local Time 2400

Figure 8 shows the predicted charging response of the structure and the dielectric regions as a function of time. In eclipse, the Kapton antennas charge identically to the solar array substrate, but they have no noticeable effect on the charging behavior of the model. The solar array's cover-glass charges positive relative to the structure, forming an inverted potential of 500 V (fig. 9). Blowoff discharges are equally likely to occur at all interfaces on the array. Other differential charging results in electric fields below the discharge criteria.

The transition into sunlight rapidly decreases the absolute charging level of the model. The differentials developed in eclipse remain unchanged for the first 10 sec after the transition. The charging of the shaded Kapton substrate causes a potential distribution to form across the solar array's cover-glass, with the greatest likelihood of blowoff discharges occurring farthest from the satellite main body at the edges of the panels.

Enough metallic area is still available to provide sufficient photoelectric current to cause the inverted potential on the solar arrays to disappear at 60 sec into the sunlight simulation. Photoemission also holds the overall potential of the antenna's front surfaces positive with respect to the structure (fig. 10). In order to compensate for the increased electron current to the antennas, the structure charges slightly more negative (1.9 kV more) than in the previous simulation in order for equilibrium to be established. Other than the increased negative structure potential, the charging of the antennas is found to have little effect on the overall charging behavior of the model.

The solar array's substrate again acquires the greatest probability for punch-through discharges with an electric field of 6.8×10^5 V/cm. The potential difference between the OSR's and the structure result in an electric field of 2.2×10^5 V/cm, making those regions possible discharge sites as well. Flashover discharges may also be triggered by the 8.6-kV difference between the solar array substrate and the sunlit conductive solar array booms. All other potential differences result in electric fields below specified discharge thresholds.

Dielectric Antennas Simulation for Autumn at Local Time 1800

Figure 11 shows the NASCAP predicted charging response as a function of time. Figure 12 shows the predicted potential differences between dielectric regions and the structure.

Initially, photoemission prevents any serious absolute charging from occurring. Differential charging then develops because of shading and three-dimensional field effects as in the previous simulation. The shaded Kapton antenna surfaces charge highly negative, as does the solar array substrate. The fields generated by the antennas suppress a portion of the low-energy electron emission from nearby metallic surfaces, causing the structure to charge more negative than in the previous simulations, to -7.4 kV.

Because of the fields generated by the antennas and the solar array substrate, the level of low-energy electron emission from metallic regions is now insufficient to cause the inverted potential on the solar arrays to completely disappear. An inverted potential of 400 V remains at the end of the simulation for portions of the solar array farthest from the satellite body.

The potential difference between the array substrate and the structure, as well as those between the antenna's front surfaces and the structure, is 6.0 kV. The substrate and the antennas are therefore possible punch-through discharge sites, having an electric field of 4.8×10^5 V/cm across their thicknesses. Differentials between the antennas and the adjacent metallic areas likewise reach 6.0 kV, a charging level beyond the flashover discharge threshold. Other potential differences result in electric fields below discharge criteria.

ACTS Charging Study Results

Electromagnetic radiation from discharges in the immediate vicinity of the antennas can interfere with communications at frequencies less than 1 GHz (ref. 3). For the ACTS geometric and environmental models used, the worst-case behavior was found to occur when the antennas were specified as having Kapton dielectric front surfaces and were eclipsed as in the autumn 1800 simulation. NASCAP predicted that both punch-through discharges between the antenna's front surfaces and the structure, and flashover discharges between the antennas and adjacent metallic components, are possible under these circumstances. By ensuring that the semi-conductive coating on the antenna's front surfaces has a high surface conductivity and is properly grounded to the structure, one can minimize the possibility of discharges occurring in the immediate vicinity of the antennas. On the basis of the best current information, the semiconducting paint layer should behave more like a conductor than a dielectric.

As a comparison between the simulations shows, the probability of discharges occurring on the OSR is greater for completely conductive antennas. This is a result of the lowering of the structure potential (i.e., lowering of the potential difference between the OSR and the structure) for the autumn 1800 simulation caused by a field suppression of low-energy electron emission from metallic surfaces. Depending on the operating frequency range of the steerable antenna, discharges in this region for the case of completely conductive antennas may or may not interfere with communications.

From the standpoint of controlling blowoff discharges, the design of the ACTS metalized thermal blankets can cause the inverted potential on the solar array to disappear in sunlight if the blankets remain well connected to the structure and the antenna's front surfaces have sufficient surface conductivity. For those times during the simulations when an inverted potential did develop (i.e., during eclipse and the inital encounter with sunlight), the greater probability for blowoff discharges existed farthest from the satellite body at the outer edges of the solar arrays.

Note, that for the second simulation in which the inclined antennae front surfaces were specified as Kapton, the subreflector's front surfaces (i.e., normal toward the satellite) were specified as nonconducting paint (npaint). The NASCAP material npaint is, by default, a thin, high secondary electron yield, nonconductive coating which typically does not charge to high negative potentials even in eclipse. Had Kapton been specified instead, the lack of photoemission would have caused them to charge more negative, forming a potential barrier in front of the back (i.e., Earth normal) of the subreflectors. This would have driven the potential of the metallic back, and, in turn, made the structure more negative. As a result, the inverted potential would have remained for the entire simulation, increasing the probability of blowoff discharges on the solar arrays. Therefore, the behavior of the inverted potential on the solar array as stated in the previous paragraph is true if it is assumed that there are no shaded dielectric regions immediately adjacent to a metalized area (e.g., dielectric subreflectors).

The greatest levels of differential charging were found to occur between shaded dielectric regions and the structure. These levels could be reduced by applying a conductive coating to the solar array substrate and ensuring the conductive properties of the semiconductive paint layer on the antennas.

Sufficient grounding, shielding, and filtering techniques should be utilized to reduce the susceptibility of spacecraft electronics to the current transients produced by discharges.

Conclusions

The charging behavior of the ACTS communications satellite was simulated by using the NASCAP computer code.

A severe substorm environment was imposed on an autumn satellite configuration at local times 2400 and 1800. Then the levels of charging were monitored to identify areas on the ACTS where differential charging may result in an electrostatic discharge.

In the development of the NASCAP geometric and environmental models, emphasis was placed in determining the charging behavior of the ACTS inclined antennas. The results show that the possibility of a discharge occurring in the immediate vicinity of the antennas is minimal when the semiconducting paint layer on the antenna's front surface has sufficient surface conductivity.

The metalized multilayer insulating blanket design of the ACTS was shown to provide good electrostatic discharge control. Low-energy electron emission from the metalized blanket provides a mechanism of keeping the solar array cover-glass negative with respect to the interconnects while it is in sunlight. Discharges on the solar arrays, which have relatively low voltage thresholds, are therefore less likely to occur.

Acknowledgments

This work was sponsored by the NASA Lewis Research Center under contract NAS3-25266 with Dale C. Ferguson and David B. Snyder as monitors.

References

1. Rosen, A.: Spacecraft Charging: Environment-Induced Anomalies. AIAA Paper 75-91, Jan. 1975.
2. Purvis, C.K., et al.: Charging Rates of Metal-Dielectric Structures. Spacecraft Charging Technology - 1978, NASA CP-2071, 1978, pp. 507-523.
3. Purvis, C.K., et al.: Design Guidelines for Assessing and Controlling Spacecraft Charging Effects. NASA TP-2361, 1984.
4. Mullen, E.G., et al.: P78-2 SCATHA Environmental Data Atlas. Spacecraft Charging Technology - 1980, NASA CP-2182/AFGL-TR-81-0270, 1981, pp. 802-813.
5. Holman, A.B.: Military Standard for Spacecraft Charging-Status Report. Spacecraft Charging Technology - 1980, NASA CP-2182/AFGL-TR-81-0270, 1981, pp. 772-788.
6. Frankos, D.T.: Military Standards and SCATHA Program Update of MIL-STD-1541. Spacecraft Charging Technology - 1980, NASA CP-2182/AFGL-TR-81-0270, 1981, pp. 768-771.
7. Katz, I., et al.: The Capabilities of the NASA Charging Analyzer Program. Spacecraft Charging Technology - 1978, NASA CP-2071, 1979, pp. 101-122.
8. Mandell, M.J.; Stannard, P.R.; and Katz, I.: NASCAP Programmer's Reference Manual. (SSS-R-84-6638, Systems, Science and Software; NASA Contract NAS3-22826) 1984.
9. Ferguson, D.C.: The Voltage Threshold for Arcing for Solar Cells in LEO-Flight and Ground Test Results. AIAA Paper 86-0362, Jan., 1986. (Also, NASA TM-87259).
10. Stannard, P.R.; Katz, I.; and Mandell, M.J.: Validation of the NASCAP SCATHA Model. (SSS-R-82-5218, Systems, Science and Software, NASA Contract NAS3-22536), 1981.
11. Mandell, M.J., et al.: The Decrease in Effective Photocurrents due to Saddle-Points in Electrostatic Potentials Near Differentially Charged Spacecraft. IEEE Trans. Nucl. Sci., vol. NS-25, Dec. 1978, pp. 1313-1317.
12. Stevens, N.J.: Analytical Modeling of Satellites in Geosynchronous Environment. Spacecraft Charging Technology - 1980, NASA CP-2182, AFGL-TR-81-0270, 1981, pp. 717-729.
13. Stevens, N.J.: Modelling of Environmentally Induced Discharges in Geosynchronous Satellites. IEEE Trans. Nucl. Sci., vol. NS-27, Dec. 1980, pp. 1792-1796. (Also, NASA TM-81598).

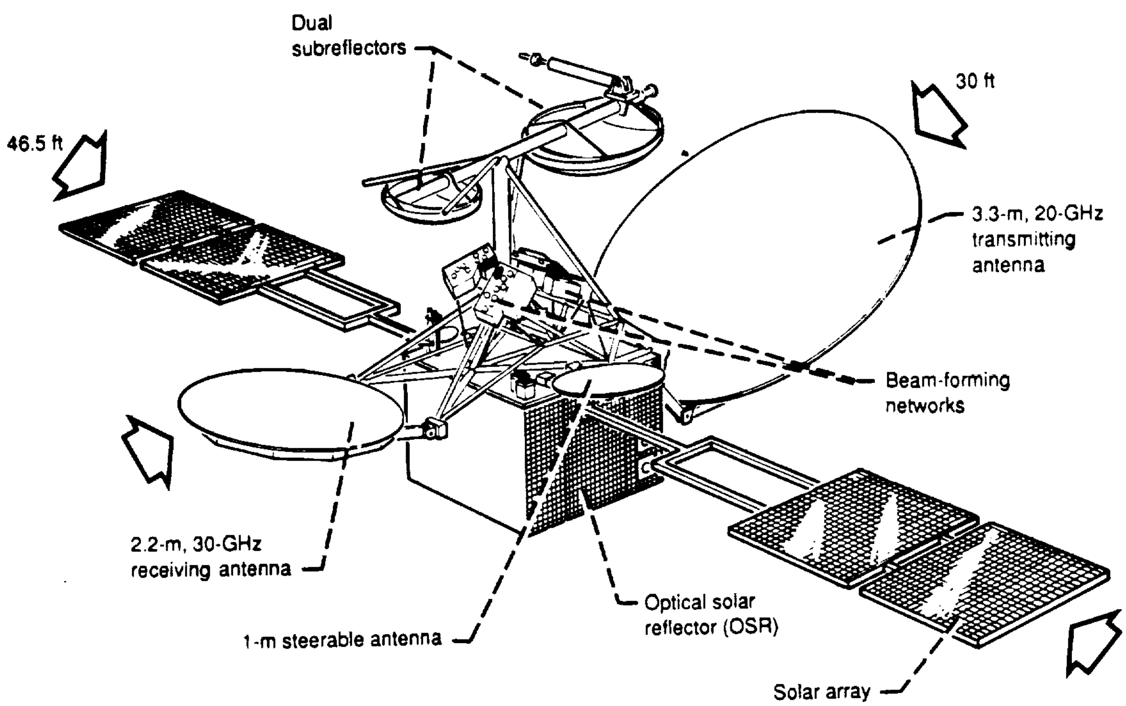

Figure 1.—ACTS geometric configuration.

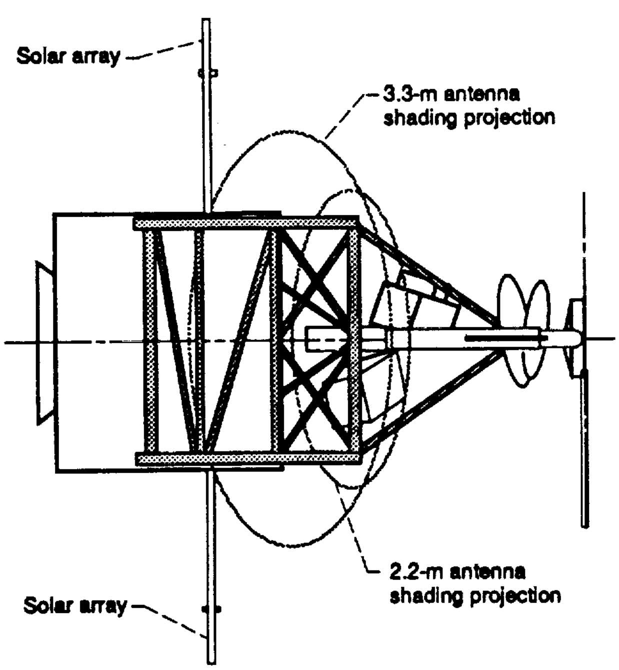

Figure 2.—Inclined antennas shading projections.

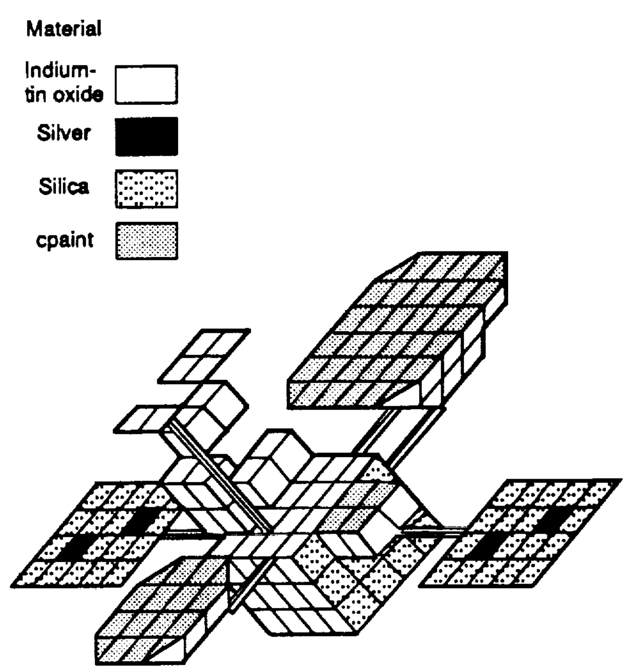

Figure 3.—NASCAP ACTS geometric model for the autumn 2400 local time satellite configuration.

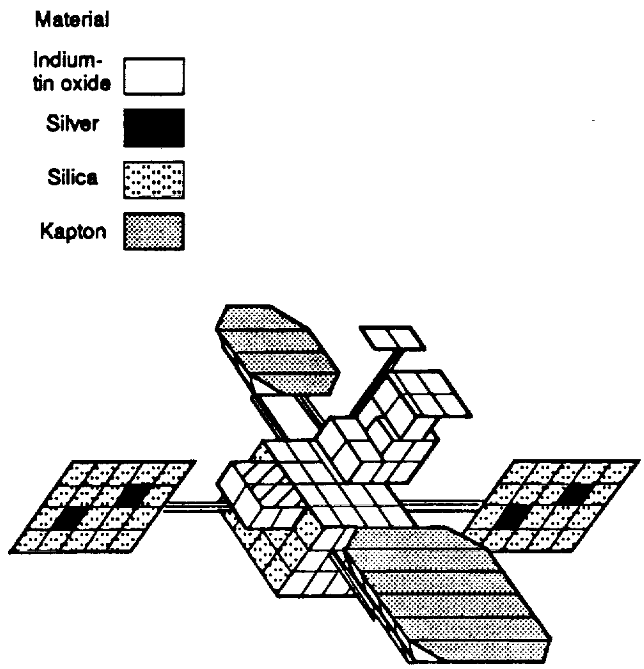

Figure 4.—NASCAP ACTS geometric model for the autumn 1800 local time satellite configuration.

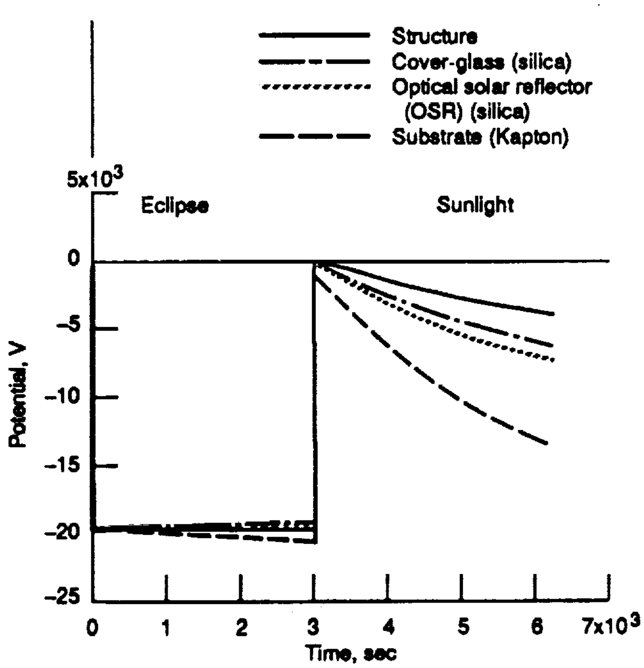

Figure 5.—NASCAP predicted satellite charging response for autumn 2400, cpaint antennas simulation.

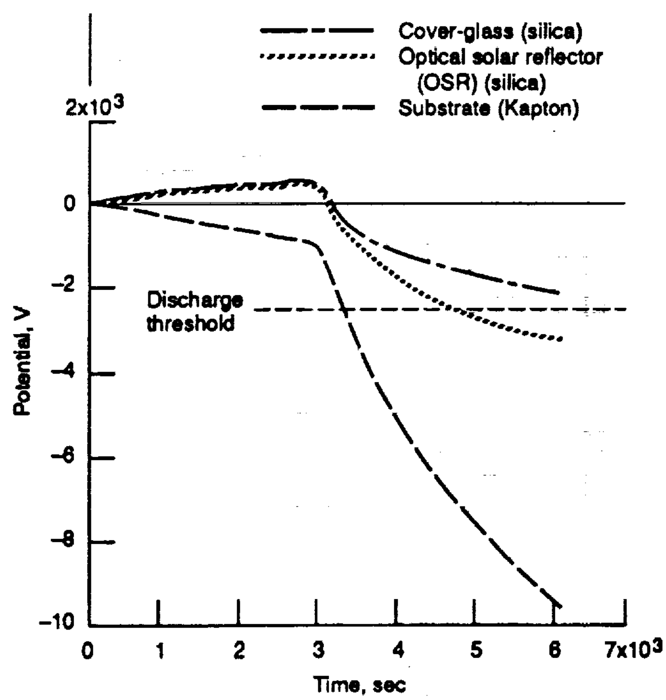

Figure 6.—NASCAP predicted potential differences between dielectric regions and structure for autumn 2400, cpaint antennas simulation. Punch-through discharge threshold shown.

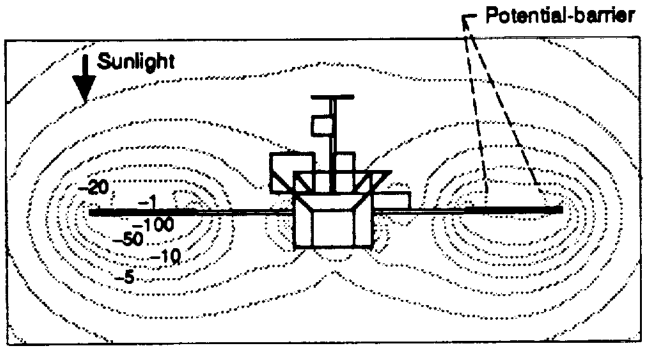

Figure 7.—NASCAP predicted potential contours showing development of "potential-barrier" above solar array cover-glass for autumn 2400, cpaint antennas simulation. Numbers shown are relative potential contour values.

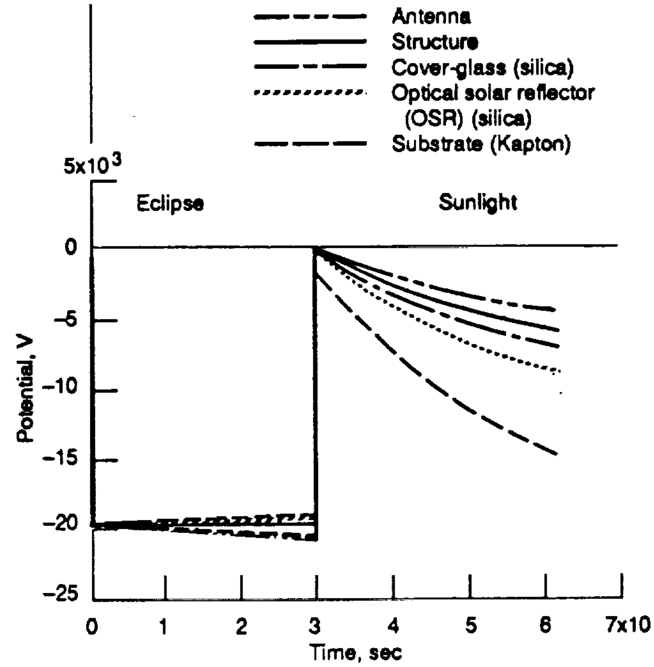

Figure 8.—NASCAP predicted satellite charging response for autumn 2400, Kapton and npaint antennas simulation.

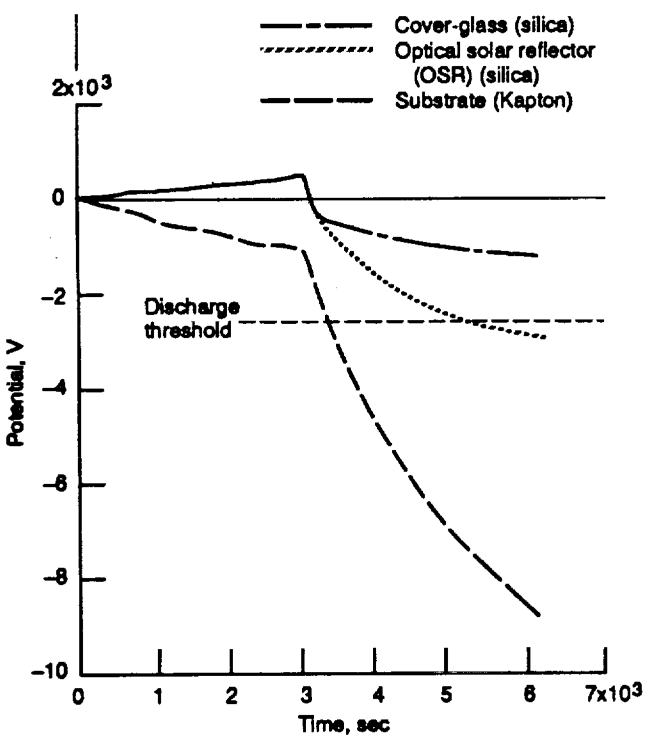

Figure 9.—NASCAP predicted potential differences between dielectric regions and structure for autumn 2400, Kapton and npaint antennas simulation. Punch-through discharge threshold shown.

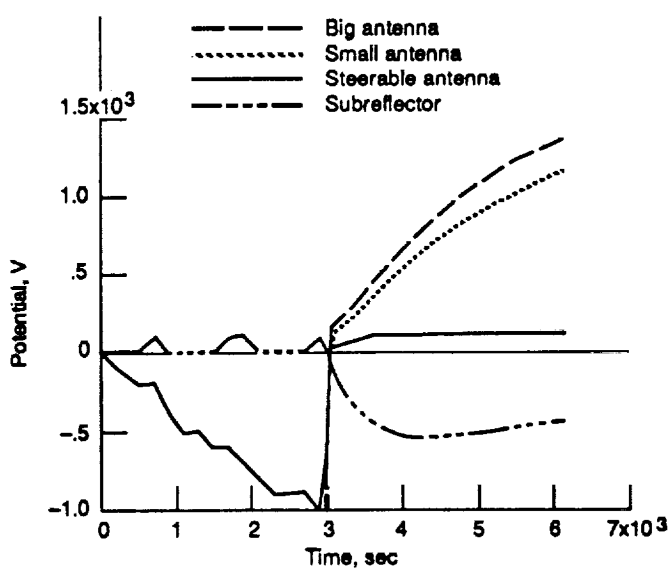

Figure 10.—NASCAP predicted potential differences between antennas and structure for autumn 2400, Kapton and npaint antennas simulation.

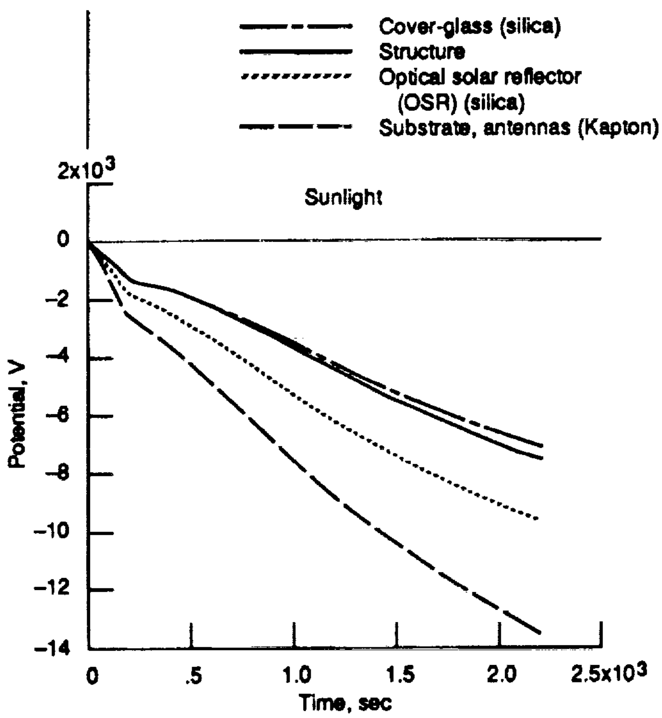

Figure 11.—NASCAP predicted satellite charging response for 1800, Kapton and npaint antennas simulation.

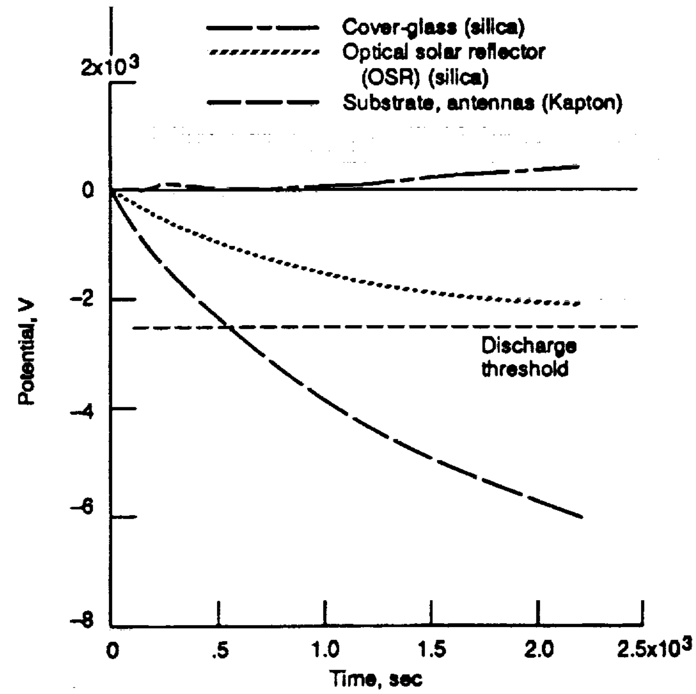

Figure 12.—NASCAP predicted potential differences between dielectric regions and structures for autumn 1800, Kapton and npaint antennas simulation. Punch-through discharge threshold shown.

NASA
National Aeronautics and Space Administration

Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
NASA CR-187088		

4. Title and Subtitle	5. Report Date
A Charging Study of ACTS Using NASCAP	May 1991
	6. Performing Organization Code
7. Author(s)	8. Performing Organization Report No.
Joel L. Herr	None (E-6079)
	10. Work Unit No.
	506-41-41
9. Performing Organization Name and Address	11. Contract or Grant No.
Sverdrup Technology, Inc. Lewis Research Center Group 2001 Aerospace Parkway Brook Park, Ohio 44142	NAS3-25266
	13. Type of Report and Period Covered
12. Sponsoring Agency Name and Address	Contractor Report Final
National Aeronautics and Space Administration Lewis Research Center Cleveland, Ohio 44135-3191	14. Sponsoring Agency Code

15. Supplementary Notes

Project Manager, Dale C. Ferguson, Power Technology Division, NASA Lewis Research Center, (216) 433-2298. Portions of this material will be presented at the 22nd Fluid Dynamics, Plasma Dynamics and Lasers Conference sponsored by the American Institute of Aeronautics and Astronautics, Honolulu, Hawaii, June 24-26, 1991.

16. Abstract

The NASA Charging Analyzer Program (NASCAP) computer code is a three-dimensional finite-element charging code designed to analyze spacecraft charging in the magnetosphere. Because of the characteristics of this problem, NASCAP can use a quasi-static approach to provide a spacecraft designer with an understanding of how a specific spacecraft will interact with a geomagnetic substorm. The results of the simulation can help designers evaluate the probability and location of arc discharges of charged surfaces on the spacecraft. A charging study of NASA's Advanced Communications Technology Satellite (ACTS) using NASCAP is reported. The results show that the ACTS metalized multilayer insulating blanket design should provide good electrostatic discharge control. For the best current information on the ACTS design, the probability of electrostatic discharges occurring in the immediate vicinity of the ACTS antennas is shown to be minimal.

17. Key Words (Suggested by Author(s))	18. Distribution Statement
ACTS Spacecraft charging	Unclassified - Unlimited Subject Category 18

19. Security Classif. (of the report)	20. Security Classif. (of this page)	21. No. of pages	22. Price*
Unclassified	Unclassified	12	A03

NASA FORM 1626 OCT 86

*For sale by the National Technical Information Service, Springfield, Virginia 22161

PAGE // INTENTIONALLY BLANK

PRECEDING PAGE BLANK NOT FILMED