Spacecraft Environment Interactions

This report describes work conducted for the first 4 1/2 years of a contract to support research into the interactions of space systems with the space environment. This report covers theoretical and calculational research in support of the SPEAR 3 program using the EPSAT and DynaPAC computer codes. Analysis of CHAWS and PASP Plus flight data is discussed.

Introductory graduate textbook in spacecraft design and how space environment affects operations in space, for space scientists and engineers.

Natural space and atmospheric environments pose a difficult challenge for designers of technological systems in space. The deleterious effects of environment interactions with the systems include degradation of materials, thermal changes, contamination, excitation, spacecraft glow, charging, radiation damage, and induced background interference. Design accommodations must be realistic with minimum impact on performance while maintaining a balance between cost and risk. The goal of applied research in space environments and effects is to limit environmental impacts at low cost relative to spacecraft cost and to infuse enabling and commercial off-the-shelf technologies into space programs. The need to perform applied research to understand the space environment in a practical sense and to develop methods to mitigate these environment effects is frequently underestimated by space agencies and industry.

Applied science research in this area is critical because the complexity of spacecraft systems is increasing, and they are exposed simultaneously to a multitude of space environments.

A summary of the problem of spacecraft charging by the ambient space plasma environment is presented. Some results of the Air Force/NASA spacecraft charging technology investigation are highlighted. Details of an Air Force/NASA spacecraft-environment interactions technology investigation are presented. This investigation will develop an environmental technology base for application to the development of next-generation large dimension, high power spacecraft. (Author).

The breakup of the Space Shuttle Columbia as it reentered Earth's atmosphere on February 1, 2003, reminded the public--and NASA--of the grave risks posed to spacecraft by everything from insulating foam to space debris. Here, Alan Tribble presents a singular, up-to-date account of a wide range of less conspicuous but no less consequential environmental effects that can damage or cause poor performance of orbiting spacecraft. Conveying a wealth of insight into the nature of the space environment and how spacecraft interact with it, he covers design modifications aimed at eliminating or reducing such environmental effects as solar absorptance increases caused by self-contamination, materials erosion by atomic oxygen, electrical discharges due to spacecraft charging, degradation of electrical circuits by radiation, and bombardment by micrometeorites. This book is unique in that it bridges the gap

between studies of the space environment as performed by space physicists and spacecraft design engineering as practiced by aerospace engineers.

Some might think that the 27 thousand tons of material launched by earthlings into outer space is nothing more than floating piles of debris. However, when looking at these artifacts through the eyes of historians and anthropologists, instead of celestial pollution, they are seen as links to human history and heritage. Space: The New Frontier for Archeologists Handbook of Space Engineering, Archaeology and Heritage, published this month by CRC Press Taylor and Francis Group, brings together 43 anthropologists, historians, physicists, and engineers, a scientific team as culturally diverse as the crew of any science fiction cruiser. They offer a range of novel historical and technological perspectives on humankind's experience in space. This ambitious work presents an informative, thought-provoking, and educational text that discusses the evolution of space engineering, spacecraft reliability and forensics, field techniques, and mission planning, as well as space programs for the future. The book is edited by a pair of scientists from different sides of the campus: Ann Garrison Darrin, aerospace engineer and NASA veteran and Beth Laura O'Leary, anthropologist and member of the World Archaeological Congress Space Heritage Task Force. The handbook delves into the evolution of space archaeology and heritage, including the emerging fields of Archaeoastronomy, Ethnoastronomy, and Cultural Astronomy. It also covers space basics and the history of the space age from Sputnik to modern day satellites. It discusses the cultural landscape of space, including orbital artifacts in space, as well as objects left on planetary surfaces and includes a look at the culture of Apollo as a catalog of manned exploration of the moon. It also considers the application of forensic investigation to the solving of cold case mysteries including failed

Mars mission landing sites and lost spacecraft, and even investigates the archaeology of the putative Roswell UFO crash site and appraises material culture in science fiction.

The Spacecraft Charging Technology Conference was held at the Naval Postgraduate School, Monterey, California, from 31 October to 3 November 1989. This was the fifth in a series of meetings jointly sponsored by the Air Force and NASA to deal with spacecraft environment interactions. The Meeting was attended by 108 people with 60 talks presented. The majority of the speakers have chosen to present their work in these two volumes. Volume 1 contains pages 1 through 333, Volume 2 contains pages 334 through 624 ... Spacecraft, Spacecraft charging, Space environment, Space plasma, Interactions.

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The proceedings published in this book document and foster the goals of the 11th International Space Conference on “Protection of Materials and Structures from Space Environment”

ICPMSE-11 to facilitate exchanges between members of the various engineering and science disciplines involved in the development of space materials. Contributions cover aspects of interaction with space environment of LEO, GEO, Deep Space, Planetary environments, ground-based qualification and in-flight experiments, as well as lessons learned from operational vehicles that are closely interrelated to disciplines of atmospheric sciences, solar-terrestrial interactions and space life sciences.

The present status of low energy magnetospheric plasma interactions with space systems is reviewed. The role of predictions in meeting user needs in assessing the impact of such interactions is described. In light of the perceived needs of the user community and of the current status of modeling and prediction efforts, it is suggested that for most user needs more detailed statistical models of the low energy environment are required. In order to meet current prediction requirements, real-time in situ measurements are proposed as a near-term solution. (Author).

This book provides a comprehensive introduction to the physical phenomena that result from the interaction of the sun and the planets - often termed space weather. Physics of the Space Environment explores the basic processes in the Sun, in the interplanetary medium, in the near-Earth space, and down into the atmosphere. The first part of the book summarizes fundamental elements of transport theory relevant for the atmosphere, ionosphere and the magnetosphere. This theory is then applied to physical phenomena in the space environment. The fundamental physical processes are emphasized throughout, and basic concepts and methods are derived from first principles. This book is unique in its balanced treatment of space plasma and aeronomical phenomena. Students and researchers with a basic

mathematics and physics background will find this book invaluable in the study of phenomena in the space environment.

The definitive guide to the modern body of spacecraftcharging knowledge—from first principles for the beginner tointermediate and advanced concepts The only book to blend the theoretical and practical aspects ofspacecraft charging, Guide to Mitigating Spacecraft ChargingEffects defines the environment that not only creates the aurora,but which also can have significant effects on spacecraft, such asdisruption of science measurements and solar arrays fromelectrostatic discharge (ESD). It describes in detail the physicsof the interaction phenomenon as well as how to constructspacecraft to enhance their survivability in the harsh environmentof space. Combining the authors' extensive experience in spacecraftcharging—and in their provision of design support to NASA,JPL, the commercial satellite market, and numerous otherprojects—this incredible book offers both a robust physicsbackground and practical advice for neophytes in the field andexperienced plasma physicists and spacecraft engineers. In addition to containing numerous equations, graphs, tables,references, and illustrations, Guide to Mitigating SpacecraftCharging Effects covers: Solar cell technology, especially higher voltage arrays, and thenew design approaches that are appropriate for them Information about the space plasma environment New analytic computer codes to analyze spacecraft charging Spacecraft anomalies and failures which emphasized designs thatare of greater importance than others

Exploitation of space for military purposes will increase in the Shuttle era when large, high-powered space systems will be deployed by military astronauts. The space environment will be a critical factor in the deployment, operation, and survivability of these new systems. A major

concern is that a new system might be fielded in space with a costly environmental failure mode engineered into the basic design. The technology program described here addresses space environmental interactions on large-dimension high-power satellites to provide technology solutions that will insure against potential system failure. (Author).

Examination Thesis from the year 2009 in the subject Physics - Electrodynamics, The University of Surrey, course: Electronic Engineering, language: English, abstract: The Space radiation environment in GEO has always been a severe challenge to the spacecraft industry. The Spacecraft Environment interaction has been the topic of deep investigation since 1970s to onwards. Very harsh space environment affects the spacecraft in various ways. The current project presents an overview of the characteristics of space radiation environment, its effects on spacecraft electronics and spacecraft operations. The elements of the space radiation environment such as Galactic Cosmic Rays (GCRs), Solar flare protons and trapped electron belt in GEO are explained comprehensively. The effects of hazardous space radiation environment on a GEO spacecraft including spacecraft charging, Total Ionizing Dose (TID), internal charging and Single Event Effects (SEE) are introduced with necessary details. The space radiation environment models currently available are critically analysed and explained in the light of the work of different space researchers. The limitations and risks involved with these models are briefly introduced. The spacecraft design mitigation techniques and design guidelines are presented to help the spacecraft community build the spacecraft capable of surviving in hazardous radiation environment. Then some case studies of GEO satellite anomalies are also briefly explained. The ESA based Space Environment Information System (SPENVIS) software package is utilized for analyzing the temporal, spatial and diurnal

variations of radiation environment in geostationary orbit and the simulation results are compared with GOES data. A detailed space radiation environment analysis for a Pakistani geostationary communication satellite Paksat-1R has been undertaken including the trapped electron flux estimation, solar proton flux estimation, Solar cell degradation and cover glass require

A NATO Advanced Study Institute (ASI) on the Behavior of Systems in the Space Environment was held at the Atholl Palace Hotel, Pitlochry, Perthshire, Scotland, from July 7 through July 19, 1991. This publication is the Proceedings of the Institute. The NATO Advanced Study Institute Program of the NATO Science Committee is a unique and valuable forum, under whose auspices almost one thousand international tutorial meetings have been held since the inception of the program in 1959. The ASI is intended to be primarily a high-level teaching activity at which a carefully defined subject is presented in a systematic and coherently structured program. The subject is treated in considerable depth by lecturers eminent; in their :(ield and of international standing. The subject is presented to other scientists who either will already have specialized in the field or possess an advanced general background. The ASI is aimed at approximately the post-doctoral level. This ASI emphasized the basic physics of the space environment and the engineering aspects of the environment's interactions with spacecraft.

Nascap-2k is a three-dimensional computer code that models interactions between spacecraft and plasma environments in low-Earth, auroral, geosynchronous, and interplanetary orbits. Previously, we reported on the accuracy of Nascap-2k's charging and current collections calculations by comparing computed currents and potentials with analytic results, and by

comparing Nascap-2k results with published calculations using the earlier lower resolution codes, NASCAP/GEO, NASCAP/LEO, and POLAR. Here we examine the accuracy and limitations of two new capabilities of Nascap-2k: modeling of plasma plumes such as generated by electric thrusters and enhanced PIC computational capabilities. Nascap-2k models one or more ion engine plumes in full three-dimensional geometry, including plume-plume plume-spacecraft interactions. The primary thruster beam, parameters describing the neutral efflux, and the initial charge-exchange plume are imported from a Plume Tool generated file. Nascap-2k generates and tracks charge-exchange ions to obtain plasma densities and calculates potentials consistent with plasma densities and object surfaces. Nascap-2k's PIC capability has been expanded to include boundary injection, particle splitting, and substep charge deposition. We use calculations for simple geometries to explore the accuracy and limitations of these capabilities.

This Computer Aided Engineering tool package will aid spacecraft developers by adding a user-friendly interface to two spacecraft charging analysis codes, namely NASCAP/GEO NASA Charging Analyzer Program, Geosynchronous Orbits and POLAR 1.1 Potentials of Large Orbiting Spacecraft in the Auroral Region. The software package contains four major, independent programs. They are a model definition program with a specialized interface to ANVIL 5000, separate interactive control programs for analyzing models in different environments using either NASCAP/GEO or POLAR 1.1 and a graphics display program to present the calculation results using MOVIE. BYU DYNA-MOVIE. (kr).

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As commercial and military spacecraft become more important to the world's economy and defense, and as new scientific and exploratory missions are launched into space, the need for a single comprehensive resource on spacecraft charging becomes increasingly critical. Fundamentals of Spacecraft Charging is the first and only textbook to bring together all the necessary concepts and equations for a complete understanding of the subject. Written by one of the field's leading authorities, this essential reference enables readers to fully grasp the newest ideas and underlying physical mechanisms related to the electrostatic charging of spacecraft in the space environment. Assuming that readers may have little or no background in this area, this complete textbook covers all aspects of the field. The coverage is detailed and thorough, and topics range from secondary and backscattered electrons, spacecraft charging in Maxwellian plasmas, effective mitigation techniques, and potential wells and barriers to operational anomalies, meteors, and neutral gas release. Significant equations are derived from first principles, and abundant examples, exercises, figures, illustrations, and tables are furnished to facilitate comprehension. Fundamentals of Spacecraft Charging is the definitive reference on the physics of spacecraft charging and is suitable for advanced undergraduates, graduate-level students, and professional space researchers.

This publication presents the proceedings of ICPMSE-6, the sixth international conference on Protection of Materials and Structures from Space Environment, held in Toronto May 1-3, 2002. The ICPMSE series of meetings became an important part of the LEO space community since it was started in 1991. Since then, the meeting has grown steadily, attracting a large number of engineers, researchers, managers, and scientists from industrial companies, scientific institutions and government agencies in Canada, U. S. A. , Asia, and Europe, thus becoming a true international event. This year's meeting is gaining even stronger importance with the resumption of the ISS and other space projects in LEO, GEO and Deep Space. To reflect on these activities, the topics in the program have been extended to include protection of materials in GEO and Deep Space. The combination of a broad selection of technical and scientific topics addressed by internationally known speakers with the charm of Toronto and the hospitality of the organizers brings participants back year after year. The conference was hosted and organized by Integrity Testing Laboratory Inc. (ITL), and held at the University of Toronto's Institute for Aerospace Studies (UTIAS). The meeting was sponsored by the Materials and Manufacturing Ontario (MMO) and the CRESTech, two Ontario Centres of Excellence; Air Force Office of Scientific Research (AFOSR/NL); MD Robotics; EMS Technologies; The Integrity Testing Laboratory (ITL); and the UTIAS. This report summarizes the results of the spacecraft environment interaction investigation. The objectives of this investigation were to characterize environmental

interaction technology and to determine the adequacy of present military standards and handbooks for future, large AF missions. The characterization of the technology status was accomplished by literature searches and key-expert questionnaires. The determination of military standard adequacy was accomplished by considering interactions with five concepts synthesized from those available in the MSSTP. Based on these concepts studies, critical interactions were identified. The available military documentation was searched for applicability. A recommended document development plan was prepared along with a discussion of technology gaps. Keywords: Spacecraft, space environmental-interactions, space structures, high-power space systems, Astronauts, military handbooks, standards.

The main objective is to conduct data analyses of SEPAC data and computer modeling to investigate spacecraft environment effects associated with injection of electron beam, plasma clouds, and neutral gas clouds from the Shuttle Orbiter. To understand the dependence of spacecraft charging potential on beam density and other plasma parameters, a two dimensional electrostatic particle code was used to simulate the injection of electron beams from an infinite conductor into a plasma. The ionization effects on spacecraft charging are examined by including interactions of electrons with neutral gases. A survey of the simulation results is presented and discussed. Lin, C. S. Unspecified Center...

Electromagnetic compatibility and regulatory compliance issues are subjects of great

importance in electronics engineering. Avoiding problems regarding an electronic system's operation, while always important, is especially critical in space missions and satellite structures. Many problems can be traced to EM field disturbances as interference from unintended sources and other electromagnetic phenomena. As a result, stringent requirements are to be met in terms of electromagnetic emissions levels. The inclusion of this electromagnetic environment in the design of a multimillion mission can lead to a system that is able to withstand whatever challenge the environment throws at it. Failure to do so may lead to important data corruption or loss, destruction of expensive instruments, waste of resources, and even a total mission failure. Research in this area focuses on the studying of the applications of electromagnetic compatibility and electromagnetic interference in the space industry. Recent Trends on Electromagnetic Environmental Effects for Aeronautics and Space Applications will provide relevant theoretical frameworks and the latest empirical research findings in electromagnetic compatibility and electromagnetic interference (EMC/EMI) for the aerospace industry. This book examines all the necessary information for all matters that can possibly affect the system design of a spacecraft and can be a useful reference to space system engineers and more. While highlighting topics such as artificial intelligence, electromagnetic testing, environmental shielding, and EMC modelling techniques, this book is ideal for professionals, spacecraft designers, science and data processing managers, electrical and mechanical

engineers, EMC testing engineers, and researchers working in the aerospace industry along with practitioners, researchers, academicians, and students looking for necessary information for all the matters that can possibly affect the system design of a spacecraft.