

35th Annual International
**NUCLEAR AND SPACE
RADIATION EFFECTS
CONFERENCE**

Newport Beach, California
July 20-24, 1998

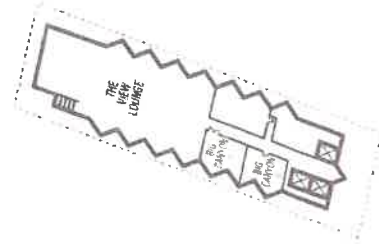


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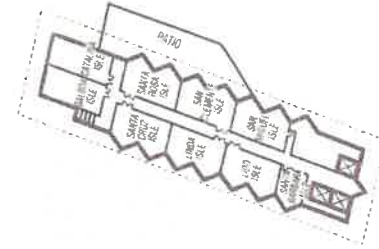
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Newport Beach Marriott

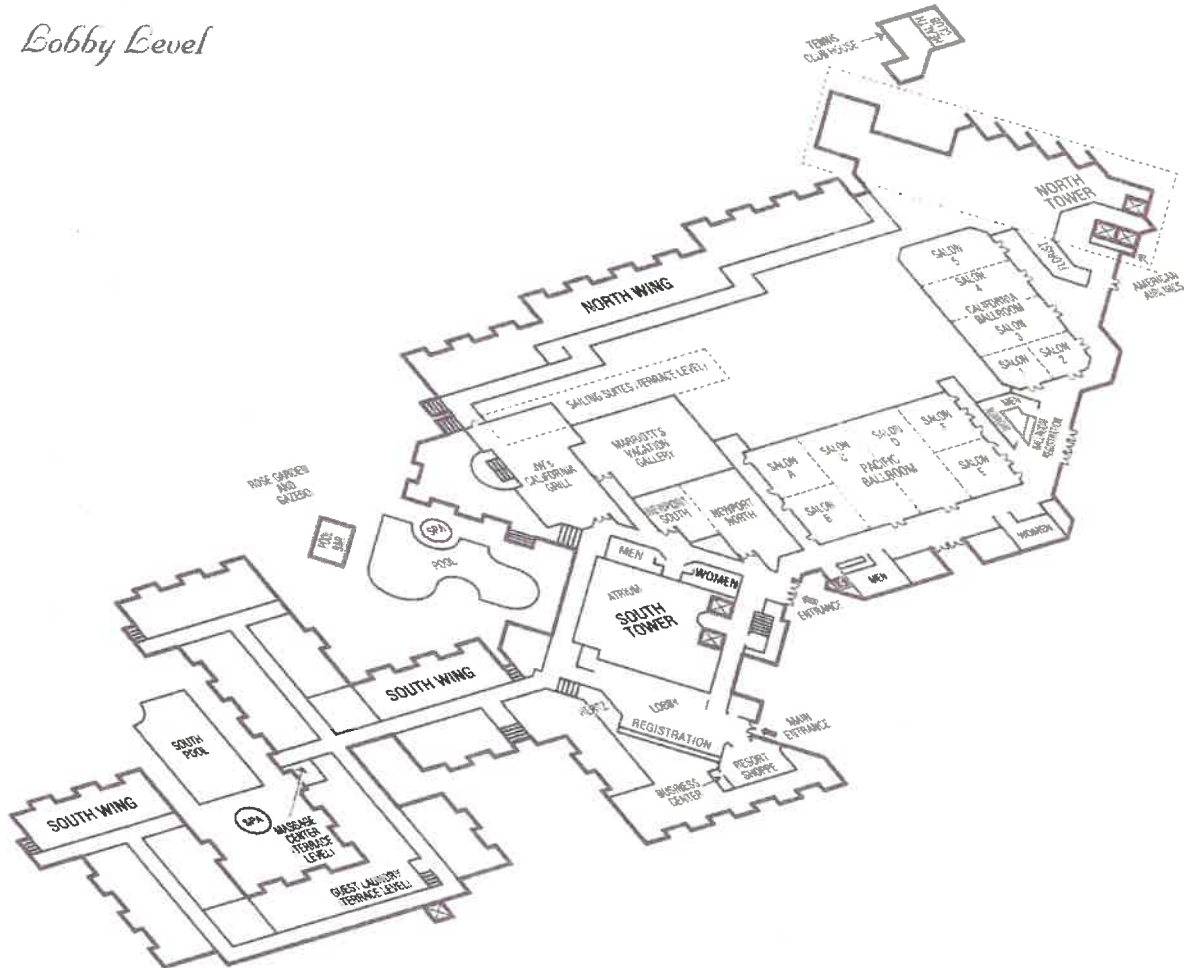
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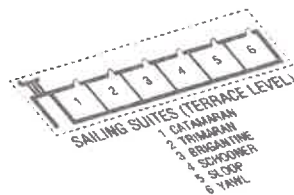
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Lobby Level



Terrace Level



Schedule

Time	Monday July 20	Tuesday July 21	Wednesday July 22	Thursday July 23	Friday July 24
7:30	[7:30] Continental Breakfast	[7:30] Continental Breakfast	[7:30] Continental Breakfast	[7:30] Continental Breakfast	[7:30] Continental Breakfast
8:15	[8:15] Short Course: Introduction James C. Pickel Pacific Ballroom	[8:15] Conference Opening Awards Presentations Pacific Ballroom	[8:15] Session E: Hardness Assurance and Testing Techniques	[8:15] Invited Paper: Intelligent Microsystems: Keys to the Next Silicon Revolution? Paul McWhorter	[8:15] Invited Paper: The Mars Pathfinder Mission and Science Results Matt Golombek
8:30	[8:30] Space Radiation Environment Dosimetry Clive S. Dyer				
8:45					
9:00		[8:45] Session A: Basic Mechanisms of Radiation Effects			
10:00	[10:00] Break		[9:20] Session F: Radiation Dosimetry	[9:20] Session H: Radiation Effects in Emerging Technologies and Photonics	[9:20] Session J: Radiation Environments
11:00	[10:30] Basic Mechanisms for the New Millennium Paul V. Dressendorfer	[10:20] Break	[10:25] Break	[10:10] Break	[10:00] Radiation Effects Data Workshop Poster Presentations Newport Room
12:00	[12:00] Short Course Luncheon	[10:50] Session B: Isolation Technologies	[10:55] Session G: Radiation Effects in Commercial Electronics and Space Systems	[10:40] Session H (continued)	
1:00		[11:55] Lunch	[12:00] Lunch	[11:40] Lunch	
2:00	[1:15] Use of Emerging Technologies in Space Systems Kenneth A. LaBel	[1:30] Session C: Single-Event Mechanisms	[12:30-10:30] Conference Social Catalina Island Beach Bash	[1:15] Session I: Single-Event Effects in Integrated Circuits	[12:30] End of Conference
3:00	[2:45] Break	[3:05] Break		[2:40] Poster Session Poster Presentations California Ballroom	
4:00	[3:15] Achieving Reliable, Affordable Systems James D. Kinnison	[3:35] Session D: Radiation Effects in Devices and Integrated Circuits			
5:00	[4:45] Wrap-up [5:00] Exam (only for students requesting CEU credit) [5:30] End of Short Course	[4:55] End of Session		[5:10] End of Session	
6:00				[5:30-7:00] Radiation Effects Committee Open Meeting Pacific Ballroom	
7:00	[6:30-9:30] Conference Registration and Reception Surf City, USA Pacific Ballroom	[7:00-10:00] Industrial Exhibit Reception California and Newport Ballrooms			
8:00					

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Chairman's Invitation



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Poster Session

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Data Workshop

Lewis M. Cohn
Defense Special Weapons Agency
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Dear Colleague,

On behalf of the NPSS Radiation Effects Committee, it is my pleasure to invite you to attend the 35th Annual International Conference on Nuclear and Space Radiation Effects to be held July 20-24, 1998, at the Newport Beach Marriott Hotel and Tennis Club in Newport Beach, California. This conference is one of the premier international Symposia on radiation effects in electronic materials, devices, circuits, and systems, and the 1998 Conference will continue the tradition of previous NSRE Conferences by offering an outstanding technical program, a one-day Short Course preceding the technical program, a Radiation Effects Data Workshop, and an Industrial Exhibit. We expect attendance by engineers, scientists, managers, and other interested persons from many nations. Highlights of the conference are given below; complete details are provided in this booklet. For World Wide Web users, additional information on the conference can be obtained by directing your browser to <http://www.ieee.org/nps/nsrec/nsrec.html>.

Newport Beach is ideally located along the beautiful Pacific Ocean in Orange County south of Los Angeles and north of San Diego. Called the "Colorful Coast," Newport Beach possesses a charming and relaxing atmosphere. The weather in July is extremely pleasant. Orange County and the nearby Greater Los Angeles and San Diego Areas provide an unsurpassed assortment of recreational and educational opportunities for you and your family.

The Technical Program Chairman, Lloyd Massengill (Vanderbilt University), and his program committee have put together an exceptional set of contributed papers that have been carefully selected by the technical program committee and arranged into 10 sessions of oral presentations, a poster session, and a Radiation Effects Data Workshop. In addition, there will be two invited talks. On Thursday, Paul McWhorter of Sandia National Laboratories will give an invited talk on "Intelligent Microsystems: Keys to the Next Silicon Revolution?" and on Friday, Dr. Matt Golombek of Jet Propulsion Laboratory will give an invited talk on "The Mars Pathfinder Mission and Science Results." Although both of these invited talks are technical in nature, they should be of interest to companions as well as attendees.

The theme of this year's Short Course, organized by Jim Pickel (Maxwell Technologies Inc.), is Rad Effects in the New Millennium— Old Realities and New Issues. The Short Course will take a look into the issues concerning microelectronics in space that we will face in the future. Subject matter to be treated in detail includes the latest measurements of the space environment, basic mechanisms of radiation effects with an emphasis on the mechanisms for emerging technologies, implications for the use of emerging technologies in space systems, and using a knowledge of radiation effects to design reliable and affordable space systems. The Short Course is scheduled for Monday, July 20.

Friday will feature a Radiation Effects Data Workshop consisting of papers emphasizing radiation effects data on electronic devices and systems and descriptions of new simulation and radiation test facilities. An Industrial Exhibit on Tuesday and Wednesday will permit one-on-one discussions between conference attendees and exhibitors on the latest in radiation-hardened electronic devices, radiation analysis and testing services, and radiation test facilities and test equipment.

Social events have been planned to give conference attendees and their guests opportunities to informally discuss radiation effects and to become better acquainted. Gary Lum (Lockheed Martin Missiles and Space Systems), this year's Local Arrangements Chairman, has put together a memorable social program. The highlight of the program will be the Wednesday afternoon main social where attendees and their companions will be whisked across the Pacific Ocean by boat to Catalina Island for a beach party. Explore the town of Avalon and the many sights of Catalina in the afternoon and work up an appetite for a barbecue dinner and dancing to surfing tunes!

Your 1998 Conference Committee has been busy working to ensure that this Conference will be regarded as one of the most technically beneficial and socially rewarding conferences. We are excited about this year's conference and look forward to seeing you in Newport Beach.

James R. Schwank
Sandia National Laboratories
General Chairman

Short Course Program

RAD EFFECTS IN THE NEW MILLENNIUM — OLD REALITIES AND NEW ISSUES

**PACIFIC BALLROOM
MONDAY, JULY 20
8:15 AM – 5:30 PM**

7:30 AM	REGISTRATION/CONTINENTAL BREAKFAST
8:15 AM	SHORT COURSE INTRODUCTION James C. Pickel <i>Maxwell Technologies Incorporated</i>
8:30 AM	SPACE RADIATION ENVIRONMENT DOSIMETRY Clive S. Dyer <i>UK Defence Evaluation and Research Agency</i>
10:00 AM	BREAK
10:30 AM	BASIC MECHANISMS FOR THE NEW MILLENNIUM Paul V. Dressendorfer <i>Sandia National Laboratories</i>
12:00 PM	SHORT COURSE LUNCHEON
1:15 PM	USE OF EMERGING TECHNOLOGIES IN SPACE SYSTEMS Kenneth A. LaBel <i>NASA Goddard Space Flight Center</i>
2:45 PM	BREAK
3:15 PM	ACHIEVING RELIABLE, AFFORDABLE SYSTEMS James D. Kinnison <i>Johns Hopkins University Applied Physics Laboratory</i>
4:45 PM	WRAP-UP
5:00 PM	EXAM (only for students requesting CEU credit)
5:30 PM	END OF SHORT COURSE

Short Course

COURSE DESCRIPTION

In the 1998 NSREC Short Course, we are going to look at the issues concerning use of microelectronics in space at the beginning of the new millennium. The course title is "Rad Effects in the New Millennium — Old Realities and New Issues." Both "old-timers" and "newcomers" will benefit from this course. Some of the old realities are that we still face the natural radiation environment of space, while support for radiation hardening has waned considerably with the end of the "cold war," and there is a push toward cheaper systems and the use of COTS. These trends drive us toward use of emerging technologies and into new ways of approaching system hardening. The denser and faster electronics require us to revisit some of the simplifying assumptions underlying our basic mechanisms understanding. Increased long-term presence of man in space and survivability of systems that have reduced design margins will require us to have better understanding and active monitoring of the radiation environment internal to satellites in space. This course will provide a review of the old realities and a stimulating overview of the new issues and will guide the student to a wealth of information on these subjects.

James Pickel is the 1998 NSREC Short Course Chairman and has assembled a team of experienced instructors that are recognized authorities in their respective fields. Instructors for this year's Short Course are Clive Dyer of the UK Defence Evaluation and Research Agency, Paul Dressendorfer of Sandia National Laboratories, Ken LaBel of the NASA Goddard Space Flight Center, and James Kinnison of the Johns Hopkins University Applied Physics Laboratory. The four Short Course segments will be one hour and fifteen minutes each, with a fifteen-minute question-and-answer period following each session. A Short Course Luncheon will be served to all registered attendees.

Continuing Education Units (CEUs)

As in previous years, 0.6 CEUs endorsed by the IEEE and the International Association for Continuing Education and Training (IACET) will be made available to qualified students. The IEEE is an Authorized CEU Sponsor member of the IACET. IEEE guidelines for offering CEU credit will be followed. To qualify, a student must be a registered attendee of the Short Course and pass a written exam with a score of 75% or greater. The exam will be given immediately following the last segment of the Short Course (5:00 PM), will be open book, and will consist of approximately 20 multiple-choice questions covering the presented material. No CEU credit will be offered to students who have not taken and passed the written exam. A certificate of completion will be mailed to all qualified students.

Short Course Chairman

James C. Pickel received his B. S. in Engineering Physics and M. S. in Physics from the University of Tennessee in 1966 and 1968 respectively. He is Chief Scientist for Electronics Technology in Maxwell Technologies Federal Division. He has been actively involved in the study of basic mechanisms and radiation effects in microelectronics for over 29 years. He joined Rockwell International in 1968 where he was one of the original researchers in the field of single event effects and developed the first SEU rate prediction models. He also performed pioneering work in understanding mechanisms and hardening IR detectors and cryogenic microelectronics. In 1984 he joined IRT Corporation, which was later merged into Maxwell Technologies. He has recently been working on developing procedures for evaluation of reliability of cryogenic electronics and in technology development for IR focal plane arrays. Mr. Pickel has numerous publications related to basic mechanisms and radiation effects in microelectronics. He has served the radiation effects community as Guest Editor, Short Course Instructor and Chairman, Awards Chairman, Session Chairman and Reviewer. He has twice received the "Outstanding Conference Paper" award for the HEART conference. He is a Fellow of the IEEE.



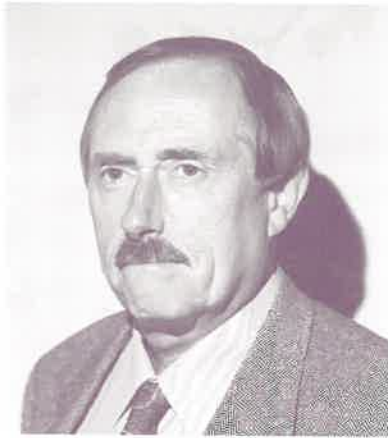


SPACE RADIATION ENVIRONMENT DOSIMETRY

Clive S. Dyer

UK Defence Evaluation and Research Agency

Clive Dyer will describe how we measure the space radiation environment with particular emphasis on the dosimetric parameters which determine radiation effects. Recent results will be presented ranging from the atmosphere, through the radiation belts to interplanetary space, and their implications for models used to predict radiation effects will be discussed. The talk will conclude with consideration of future needs and the prospects for their fulfillment.



Clive S. Dyer obtained a First Class Honours Degree in Natural Sciences from Christ's College Cambridge in 1969 and a Ph. D. in Physics from Imperial College London in 1973. He worked as a Research Associate at NASA/Goddard Space Flight Center and the University of Maryland for four years, during which he was involved in analysis of data from the Apollo and Apollo-Soyuz missions. Following this he joined the UK Ministry of Defence as a Senior Lecturer in the Department of Nuclear Science at the Royal Naval College Greenwich. In 1980 he transferred to Space Department at the Royal Aircraft Establishment Farnborough, which now forms part of the Defence Evaluation and Research Agency. For the past twelve years he has been leading a research programme in Spacecraft Environment and Protection, which includes radiation dosimetry experiments carried on a range of platforms including aircraft, Space Shuttle and several spacecraft extending to geostationary altitudes. In 1993 he was awarded the Geoffrey Pardoe Space Award of the Royal Aeronautical Society for his work on the definition of the space environment and its effects on space systems. He is currently a DERA Fellow and an Honorary Visiting Professor at the Centre for Satellite Engineering Research of the University of Surrey. Professor Dyer has authored 150 papers and reports in the field of radiation environment and effects.

SPACE RADIATION ENVIRONMENT DOSIMETRY

Introduction

- The Need for Dosimetry

The Space Radiation Environment

- Cosmic Rays
- Radiation Belts
- Solar Particles
- Secondaries

Dosimetry Requirements

- Dose and Dose Rate
- Energy and Charge Deposition Spectra
- Linear Energy Transfer
- Dose Equivalent
- Non-Ionising Energy Loss
- Particle Fluxes
- Radiation Environment Monitors
 - Passive monitors
 - Active monitors

Recent Results

- Avionics
- LEO
- GTO
- GEO
- Interplanetary

Conclusions and Implications for Models

Future Experiment Requirements and Prospects



BASIC MECHANISMS FOR THE NEW MILLENNIUM

Paul V. Dressendorfer

Sandia National Laboratories

Paul Dressendorfer will revisit basic mechanisms with an eye towards the new millennium. This talk will review the understanding of mechanisms for radiation damage in three areas – total dose, displacement effects, and single event effects. First a background will be provided on the classical, historical understanding of these mechanisms. Then there will be a discussion of recent enhancements to the understanding of those mechanisms and an up-to-date picture provided of the current state of knowledge. The impact on devices in current and emerging technologies will be described, with an emphasis on looking out into the future.



Paul V. Dressendorfer received the B. S. degree from the California Institute of Technology in 1972, and the M. S., M. Phil., and Ph. D. degrees from Yale University in 1973, 1974, and 1978, respectively. He joined Sandia National Laboratories in 1978 where he is currently manager of the Advanced Packaging Department. His research activities and publications have covered a wide range of areas including semiconductor device physics, basic radiation damage mechanisms, characterization of radiation effects, hardened technology development, hardness assurance, optoelectronic devices, and multichip modules/advanced electronic packaging. His efforts contributed to the first work unambiguously identifying the structural defects responsible for radiation-induced electrically active defects in MOS oxides and to the development and implementation of advanced radiation-hardened CMOS technology. Dr. Dressendorfer is currently Editor of the *IEEE Transactions on Nuclear Science*. He has served on program committees, been technical program chairman and general chairman for several IEEE and other conferences (NSREC, SISC, HEART, and INFOS). He has previously been a Short Course Instructor for the NSREC and the NSS. He was elected to the grade of IEEE Fellow "for contributions to the development and understanding of radiation-hardened technologies for electronic devices and circuits."

BASIC MECHANISMS FOR THE NEW MILLENNIUM

Overview

Total Dose Effects

- Background
- Recent Enhancements to Understanding
 - "Border" traps
 - Hydrogen effects/model updates
- Device Implications
 - Microdosimetry effects
 - Thin oxide structures
 - Low-dose-rate bipolar effects
 - MEMS devices
 - Other devices

Displacement Damage

- Background
- Complicating Factors
 - Defect introduction
 - Enhanced carrier generation
- Device Implications
 - Solar cells
 - Advanced Si-based devices
 - Optoelectronic devices
 - High temperature superconductors
 - Single particle damage

Single Event Effects

- Background
- Enhancements to Understanding
 - Dielectric rupture
 - Focused beam experiments
 - Simulation results
- Device Implications
 - Power MOSFETs
 - High current states
 - Other trends

Additional Implications for the Next Millennium

- Scaling Background
- Hardness Implications

Summary



USE OF EMERGING TECHNOLOGIES IN SPACE SYSTEMS

Kenneth A. LaBel

NASA Goddard Space Flight Center

Ken LaBel will discuss the implications for use of emerging technology in space systems. He will discuss a systems engineering perspective towards these technologies emphasizing both small and large system design needs. Emerging and advanced commercial technologies are becoming crucial elements in spacecraft design to meet increasingly more stringent satellite system performance requirements. Both currently used satellite design technologies and those under investigation for future space system designs will be examined. Types of technologies discussed will include microelectronics, photonics, materials, and packaging concepts. This course will examine the utilization and radiation effects implications of these technologies and discuss why device system hardening approaches should be considered. This talk is not intended to be a complete overview of emerging technologies, but a snapshot of their current and future status.



Kenneth A. LaBel is Group Leader for the Radiation Effects and Analysis Group at NASA Goddard Space Flight Center (GSFC). He has been at GSFC since 1983 and has worked in such diverse areas as ground system design, spaceflight computers and data systems, fiber optic system development, and radiation effects. Mr. LaBel has worked in the radiation effects arena since 1990 and has authored or co-authored over 30 publications ranging from the use and analysis of commercial microelectronics in the space radiation environment to ground and spaceflight experimentation on emerging technologies. Mr. LaBel is an IEEE member and is currently the Senior Member-at-Large for the IEEE Radiation Effects Steering Group.

USE OF EMERGING TECHNOLOGIES IN SPACE SYSTEMS

Overview – What is Driving the Future for Spacecraft Design

- Satellite Design
- Future of Spacecraft Design
- The IC Manufacturers' Perspective
- Overall Trends in Spacecraft Design
- The Growing Commercial Satellite World
- Small and Medium-Sized Spacecraft
- Large Satellites

Emerging Technologies for Enabling Spacecraft Performance

- Microelectronics
- Photonics
- Advanced Packaging of Electronics
- MEMS
- Materials

Examples of a Technology-Based Spacecraft

- The EO-1 Mission
- Mars Pathfinder

Limitations of Emerging Technologies

- Sensitivity of Technology
- Risks

Summary

- Satellite Architectural Structure
- Trends in Spacecraft Design and IC Manufacturing
- Emerging Technologies



ACHIEVING RELIABLE, AFFORDABLE SYSTEMS

James D. Kinnison

Johns Hopkins University Applied Physics Laboratory

Jim Kinnison will address how designers actually use knowledge of radiation effects to reach the ultimate goal: reliable, affordable space systems. The emphasis will be on those techniques actually used in space with information on the on-orbit effectiveness of the techniques. In addition, considerations for deciding when and how to use mitigation techniques will be discussed, and methods to test mitigation techniques before launch will be presented.



James D. Kinnison received his B. S. degree in Physics from Northeast Louisiana University in 1984 and his M. S. in Physics from Michigan State University in 1987. Since then, he has been a member of the technical staff of the Johns Hopkins University Applied Physics Laboratory. He has worked on a dozen spacecraft, concentrating mainly in the areas of radiation hardness assurance and component testing. Mr. Kinnison has published about 20 papers on various topics dealing with radiation effects in spacecraft electronics.

ACHIEVING RELIABLE, AFFORDABLE SYSTEMS

Overview

Sources of Space Radiation

- Major Sources of Radiation Effects
- Comparison of Different Regions of Space
- Advantages and Disadvantages of Various Orbits

Total Dose Damage

- Environment Estimation
- Spacecraft Modeling
- Hardness Requirement Determination
- Parts Selection Concerns
- Testing for Total Dose Effects
- Mitigation of Total Dose Effects

Displacement Damage

- Environment Estimation
- Parts Selection Concerns
- Testing for Displacement Damage
- Mitigation of Displacement Effects

Single Event Effects

- Description of the Various Effects
- Requirements Definition
- Testing for Single Event Effects
- Mitigation of Effects and System-Level Concerns

Alternative Approaches and Advanced Topics

Conclusions

Technical Program

TECHNICAL INFORMATION

The NSREC technical program will consist of contributed oral and poster papers, two invited papers, and a data workshop. All oral sessions will be held in the Pacific Ballroom of the Newport Beach Marriott Hotel and Tennis Club. Oral papers will be 12 minutes in length with an additional 3 minutes for questions. The Technical Sessions and chairpersons are:

- **Basic Mechanisms of Radiation Effects**

John Conley, Dynamics Research Corporation

- **Isolation Technologies**

William Jenkins, Naval Research Laboratory

- **Single-Event Mechanisms**

Paul Dodd, Sandia National Laboratories

- **Radiation Effects in Discrete Devices and Integrated Circuits**

Todd Weatherford, Naval Postgraduate School

- **Hardness Assurance and Testing Techniques**

Wesley Will, Boeing Defense and Space Group; Catherine Barillot, Alcatel Telecom

- **Radiation Dosimetry**

Steven Seltzer, National Institute of Standards and Technology

- **Radiation Effects in Commercial Electronics and Space Systems**

William Heidergott, Motorola

- **Radiation Effects in Emerging Technologies and Photonics**

Charles Brothers, USAF Research Laboratory

- **Single-Event Effects in Integrated Circuits**

James Howard, NASA Marshall Space Flight Center; Christian Poivey, Matra Marconi Space

- **Radiation Environments**

George Lasche, Constellation Technology Corporation

Poster Session

Papers that are most effectively presented visually with group discussion will be displayed from 12:00 PM Tuesday through 12:00 PM Wednesday in the Sailing Suites on the lower level of the hotel. On Wednesday afternoon, the posters will be moved to the California Ballroom, where they will be on display for the remainder of the conference. Authors will be available to discuss their work during the Poster Session from 2:40 PM to 5:10 PM on Thursday. The poster chairwoman is *Cheryl Marshall, Naval Research Laboratory*.

Radiation Effects Data Workshop

Papers in the workshop are intended to provide radiation response data to scientists and engineers who use electronic devices in a radiation environment, and for designers of radiation-hardened systems. Workshop posters can be previewed from 12:00 PM Tuesday through 12:00 PM Wednesday in the Sailing Suites on the lower level of the hotel. On Wednesday afternoon, workshop presentations will be moved to the Newport Room, where they will be on display for the remainder of the conference. The Data Workshop will be held from 10:00 AM to 12:30 PM Friday in the Newport Room, at which time the authors will be available to discuss their work. A copy of the Workshop Proceedings will be mailed to all registrants after the conference. The workshop chairman is *Lew Cohn, Defense Special Weapons Agency*.

INVITED SPEAKERS

The 1998 NSREC is pleased to feature two invited lectures. Paul McWhorter, Sandia National Laboratories, will discuss *Intelligent Microsystems: Keys to the Next Silicon Revolution?* on Thursday. Matthew Golombek, Jet Propulsion Laboratory, will discuss *The Mars Pathfinder Mission and Science Results* on Friday. One of these presentations will employ visual special effects never before seen at the NSREC. Please plan to attend both of these exciting lectures.

LATE-NEWS PAPERS

A limited number of late-news papers will be accepted and included in the poster session. The deadline for submitting late-news papers is June 5, 1998. Please submit late-news papers using the 4-page summary and 35-word abstract format, to the Technical Program Chairman, Lloyd Massengill, Vanderbilt University, Department of Electrical and Computer Engineering, Room 215 - Jacobs Hall, 400 24th Avenue South, Nashville, TN 37212, (615) 343-6677. Authors must make a convincing case that late-news papers are newsworthy as well as technically sound in order to be accepted.



- 7:30 AM **REGISTRATION AND CONTINENTAL BREAKFAST**
Registration Foyer
- 8:15 AM **OPENING REMARKS**
James R. Schwank, Conference General Chairman
Gary K. Lum, Local Arrangements Chairman
- PACIFIC BALLROOM
- 8:30 AM **AWARDS PRESENTATION**
Klaus G. Kerris, Steering Group Chairman
- 8:40 AM **TECHNICAL SESSION OPENING REMARKS**
Lloyd W. Massengill, Technical Program Chairman
- SESSION A BASIC MECHANISMS OF RADIATION EFFECTS**
- 8:45 AM Session Introduction
Chairman: John Conley, Dynamics Research Corporation
- A-1 Effects of Irradiation and Isochronal Anneal Temperature on Hole and Electron Trapping in MOS Devices**
8:50 AM *D.M. Fleetwood, P.S. Winokur, M.R. Shaneyfelt and L.C. Riewe, Sandia National Laboratories; O. Flament, P. Paillet and J.-L. Leray, CEA/DAM*
- Capacitance-voltage and thermally-stimulated-current techniques are used to estimate trapped hole and electron densities in MOS oxides as functions of irradiation and isochronal anneal temperature. Trapped-charge annealing and compensation effects are discussed.
- A-2 Space Charge Limited Degradation of Bipolar Oxides at Low Electric Fields**
9:05 AM *S.C. Witzak, R.C. Lacoe and D.C. Mayer, Aerospace Corporation; D.M. Fleetwood, Sandia National Laboratories; R.D. Schrimpf and K.F. Galloway, Vanderbilt University*
- Concentrations of low-field hydrogen transport through irradiated bipolar oxides are estimated from dopant passivation measurements. Metastably trapped charge reduces oxide degradation at high dose rates by inhibiting the transport of hydrogen ions.
- A-3 Electrical Probing of Surface and Bulk Traps in Proton-Irradiated Gate-Assisted Lateral PNP Transistors**
9:20 AM *G. Niu, G. Banerjee, J.D. Cressler and J.M. Roldan, Auburn University; S.D. Clark, NSWC*
- 46 MeV proton irradiation-induced degradation and the probing of surface and bulk traps in gate-assisted lateral PNP transistors are investigated using DC measurements and 2D numerical simulations for the first time.
- A-4 Stress Induced Leakage Current and Radiation Induced Leakage Current in Ultra-Thin Gate Oxides**
9:35 AM *M. Ceschia, A. Paccagnella, A. Cester and A. Scarpa, Universita di Padova; G. Ghidini, SGS-Thomson*
- Radiation induced leakage current (RILC) has been studied in ultra-thin gate oxides (4 nm and 6 nm) irradiated with 8 MeV electrons. The RILC dependence from total dose and gate bias voltage during irradiation has been analyzed.



- A-5**
9:50 AM **The Effects of Irradiation and Proton Implantation on the Density of Mobile Protons in SiO₂ Films**
K. Vanheusden, USAF Research Laboratory; D.M. Fleetwood, J.R. Schwank, M.R. Shaneyfelt, T.L. Meisenheimer and B.L. Draper, Sandia National Laboratories

Proton implantation into the buried oxide of Si/SiO₂/Si structures does not introduce mobile protons. The cross section for capture of radiation-induced electrons by mobile protons is two orders of magnitude smaller than for electron capture by trapped holes.

- A-6**
10:05 AM **H⁺ Motion in SiO₂: Incompatible Results from Hydrogen-Annealing and Radiation Effects Models**

R.E. Stahlbush and H.L. Hughes, Naval Research Laboratory; R.K. Lawrence, ARACOR

Properties of H⁺ derived from hydrogen-annealed oxides are incompatible with properties derived from the hydrogen model of radiation-induced degradation. Differences in H⁺ transport in various hydrogen-annealed SIMOX and thermal oxides are also discussed.

POSTER PAPERS

- PA-1** **An Investigation of the Spatial Location of Proton-Induced Traps in SiGe HBTs**

J.M. Roldan, G. Niu, W.E. Ansley and J.D. Cressler, Auburn University; S.D. Clark, NSW

The effects of 46 MeV proton-induced trap generation and their impact on SiGe HBTs from an advanced UHV/CVD SiGe BiCMOS technology are examined and discussed for the first time.

- PA-2** **Effects of Proton Irradiation on the Excitonic Lifetime of Gallium Arsenide**

S.M. Khanna, Defense Research Establishment Ottawa; S. Charbonneau, National Research Council Canada; M. Parenteau and C. Carlone, Universite de Sherbrooke

The damage constant associated with the radiative recombinational lifetime of the free exciton in GaAs is $(7.7 \pm 2.2) \times 10^{-3} \text{ cm}^2/\text{s}$, and with the nonradiative lifetime is $(6.5 \pm 2.7) \times 10^{-3} \text{ cm}^2/\text{s}$.

- PA-3** **Modeling Low-Dose-Rate Effects in Irradiated Bipolar-Base Oxides**

R.J. Graves, C.R. Cirba, R.D. Schrimpf, R.J. Milanowski and F. Saigne, Vanderbilt University; A. Michez, Universite Montpellier II; D.M. Fleetwood, Sandia National Laboratories; S.C. Witczak, Aerospace Corporation

A physical model is developed to quantify the contribution of oxide-trapped charge to enhanced low-dose-rate gain degradation in BJTs. Simulations show that space charge limited transport is partially responsible for the low-dose-rate enhancement.

- PA-4** **Fowler-Nordheim Characteristics of Electron Irradiated MOS Capacitors**

A. Candelori, A. Paccagnella and A. Scarpa, Universita di Padova; G. Ghidini, SGS-Thomson

The Fowler-Nordheim current-voltage characteristics of MOS capacitors are modified by electron irradiation, depending on the total dose and gate bias. Both positive and negative trapped charges are observed after irradiation.



PA-5 Simultaneous Enhancements of Reverse Short Channel Effect and Normal Short Channel Effect After Irradiation in nMOSFETs

T.-Y. Huang, F.-C. Jong, C.-H. Chien, M.-F. Wang and C.-Y. Chang, National Chiao Tung University, Taiwan ; J.-S. Tsang, T.-S. Chao, H.-C. Lin and W.-F. Wu, National Nano Device Laboratories

The intriguing observations that both the reverse short-channel effect and normal short-channel effect in nMOSFETs can be enhanced after irradiation are reported for the first time.

PA-6 A Comprehensive Physically Based Model for Radiation Damage in MOS Devices

P.M. Lenahan, Penn State University; J.F. Conley, Jr., Dynamics Research Corporation

We have developed a physically based predictive model for oxide hole trapping and Si/SiO₂ interface trap generation.

10:20 AM BREAK

SESSION B ISOLATION TECHNOLOGIES

10:50 AM Session Introduction

Chairman: William Jenkins, Naval Research Laboratory

B-1 Development of a Radiation Tolerant 1M SRAM on Fully-Depleted SOI

10:55 AM *E.T. Brady, S. Luu, R. Brown, L. Rockett and J. Vasquez, Lockheed Martin Federal Systems*

Fully-functional 1M SRAMs were fabricated on fully-depleted SOI using 0.5- μ m design rules. The SRAMs were evaluated for speed/power, prompt dose, SEU, and total dose hardness.

B-2 Total-Dose Radiation Hard 0.35- μ m SOI CMOS Technology

11:10 AM *S.T. Liu, Honeywell SSEC; W.C. Jenkins and H.L. Hughes, Naval Research Laboratory*

A total-dose hard 0.35- μ m SOI CMOS technology is described. Worst-case total dose radiation induced worst-case front channel and back channel threshold voltage shifts are less than 170 mV and 18 V, respectively.

B-3 A Study of the Radiation Sensitivity of Non-Crystalline SiO₂ Films Using Spectroscopic Ellipsometry

11:25 AM *B.J. Mrstik, P.J. McMarr and H.L. Hughes, Naval Research Laboratory; R.K. Lawrence, ARACOR/SFA*

Spectroscopic ellipsometry measurements were performed on noncrystalline SiO₂ films. A relation was found between the densities of the films determined from analysis of these measurements and the radiation sensitivity of the films.

B-4 Total Dose Induced Latch in Short Channel NMOS/SOI Transistors

11:40 AM *V. Ferlet-Cavrois, O. Musseau, O. Flament and J.-L. Leray, CEA/DRIF; J.L. Pelloie, C. Raynaud and O. Faynot, CEA/DTA-LETI*

Both fully and partially depleted NMOS/SOI exhibit a latch effect under total dose irradiation. Through experiments and simulations, we analyze the influence of gate length and bias during irradiation, and propose a set of solutions.



POSTER PAPER

PB-1 Radiation Hardening Ibis ADVANTOX-190 SOI Starting Wafers

W.C. Jenkins and H.L. Hughes, Naval Research Laboratory; R.K. Lawrence and P.J. McMarr, ARACOR/SFA; S.T. Liu, Honeywell SSEC; L.P. Allen, M.J. Anc and R.P. Dolan, Ibis Technology Corporation

This paper is the first report on the application of the NRL-DSWA hardening technique to ADVANTOX-190 wafers. This technique cuts back-channel threshold voltage shifts in half.

11:55 AM LUNCH

SESSION C SINGLE-EVENT MECHANISMS

1:30 PM Session Introduction

Chairman: Paul Dodd, Sandia National Laboratories

C-1 Internuclear Cascade-Evaporation Model for LET Spectra of 200 MeV Protons Used for Parts Testing

1:35 PM

P.M. O'Neill, G.D. Badhwar and W.X. Culpepper, NASA Johnson Space Center

The effective linear energy transfer in microelectronic components during proton testing is calculated with an internuclear cascade-evaporation code. The spectra are much harder than previously expected and comparable to natural space heavy ion environments.

C-2 Comparative SEU Sensitivities to Relativistic Heavy Ions

1:50 PM

R. Koga, S.H. Crain, K. Crawford and S. Hansel, Aerospace Corporation

SEU sensitivity of microcircuits to relativistic heavy ions is compared to that measured with low energy ions of comparable LET values. Varying charge generations due to different ion track structures and multiple junctions are considered.

C-3 Importance of Ion Energy on SEU in CMOS SRAMs

2:05 PM

P.E. Dodd, M.R. Shaneyfelt, F.W. Sexton, G.L. Hash and P.S. Winokur, Sandia National Laboratories; O. Musseau and J.-L. Leray, CEA/DAM

The SEU responses of 16 Kbit to 1 Mbit SRAMs irradiated with low- and high-energy heavy ions are reported. Standard low-energy heavy ion tests appear to be sufficiently conservative for the tested technologies.

C-4 Effects of Ion Energy Upon the Dielectric Breakdown Failure Mechanism in Vertical Power MOSFETs

2:20 PM

J.L. Titus and J.F. Krieg, NSWC; C.F. Wheatley, Consultant; K.M. van Tyne and D.I. Burton, Harris Semiconductor

The effect of ion energy upon SEGR is investigated using copper, niobium, and gold. Data demonstrate that the capacitor response cannot be adequately described in terms of LET. A new semi-empirical expression in terms of atomic number is presented and evaluated.

C-5 Breakdown of Gate Oxides During Irradiation with Heavy Ions

2:35 PM

A.H. Johnston, G.M. Swift and T. Miyahira, Jet Propulsion Laboratory

Gate rupture in thin oxide test structures is investigated. Multiple ion strikes are required to initiate rupture in test structures and ICs. This implies that an ion/oxide defect interaction is responsible. Testing with too few ions will underestimate susceptibility.



- C-6**
2:50 PM **Precursor Ion Damage and Single Event Gate Rupture in Thin Oxides**
F.W. Sexton, D.M. Fleetwood, M.R. Shaneyfelt, P.E. Dodd, G.L. Hash and L.P. Schanwald, Sandia National Laboratories; K.S. Krisch, Lucent Technologies

A clear difference between SEGR and ion damage is observed for thin thermal and nitrided oxides. Ion damage had no significant effect on SEGR thresholds. The data support a true single ion SEGR model.

POSTER PAPERS

- PC-1** **Energy Resolved Neutron SEU Measurements from 22 to 160 MeV**
K. Johansson, P. Dyreklev and B. Granbom, Ericsson Saab Avionics; N. Olsson and J. Blomgren, Department of Neutron Research; P.U. Renberg, The Svedberg Laboratory
- The energy dependence of the single event upset cross section for static RAMs has been measured using quasi-monoenergetic neutrons with six different energies from 22 MeV to 160 MeV. A clear energy dependence is found.
- PC-2** **Single-Event Burnout of Epitaxial Bipolar Transistors**
S. Kuboyama, K. Sugimoto, S. Shugyo and S. Matsuda, National Space Development Agency of Japan
- Single-event burnout (SEB) of bipolar junction transistors (BJTs) has been observed nondestructively. All tested NPN BJTs, including small signal transistors with thinner epitaxial substrates, were inherently susceptible to SEB phenomenon.
- PC-3** **SEU Response of an Entire SRAM Cell Simulated as One Contiguous Three Dimensional Device Domain**
P. Roche, J.M. Palau, G. Bruguier and J. Gasiot, Universite Montpellier II; K. Belhaddad, ISE France
- The first SEU response of a complete 3-D SRAM cell is presented. This simulation methodology allows verification of the accuracy of the commonly used mixed-mode technique and the study of coupling effects between all cell junctions.
- 3:05 PM** **BREAK**



SESSION D RADIATION EFFECTS IN DEVICES AND INTEGRATED CIRCUITS

3:35 PM Session Introduction

Chairman: Todd Weatherford, Naval Postgraduate School

D-1 Enhanced Low Dose Rate Sensitivity of a Low-Drop-Out Voltage Regulator

3:40 PM

R.L. Pease, RLP Research; S. McClure and J. Gorelick, Hughes Space and Communication; S.C. Witczak, Aerospace Corporation

Ionization-induced degradation of the Micrel MIC29372 low-drop-out voltage regulator is most severe at low dose rate and zero load current. Moderate load currents during or after irradiation significantly anneal the damage.

D-2 Total Dose Effects on Gate Controlled Lateral PNP Bipolar Junction Transistors

3:55 PM

Ph. Cazenave, P. Fouillat, X. Montagner and A. Touboul, University of Bordeaux; H. Barnaby and R.D. Schrimpf, Vanderbilt University; L. Bonora and J.P. David, CERT-ONERA; M.C. Calvet, Aerospatiale; P. Calvel, Alcatel Telecom

This paper presents new experimental and simulated results concerning the total dose effects on a gate controlled lateral PNP bipolar device. A structure has been designed in a commercial BiCMOS process and the influence of the gate potential during irradiation is investigated.

D-3 Challenges in Hardening Technologies Using Shallow-Trench Isolation

4:10 PM

M.R. Shaneyfelt, P.E. Dodd, B.L. Draper and R.S. Flores, Sandia National Laboratories

Challenges related to radiation hardening CMOS technologies with shallow-trench isolation are explored. Results show that trench hardening can be more difficult than simply replacing the trench isolation oxide with a hardened field oxide.

D-4 Design of Radiation-Tolerant LOCOS Isolation Using Two-Dimensional Simulation Tools

4:25 PM

R.J. Milanowski, L.W. Massengill and R.D. Schrimpf, Vanderbilt University; M. Pagey and C. Nicklaw, Dynamics Research Corp.

Optimal implant parameters for total-dose hardness of a LOCOS isolation structure are determined using two-dimensional process and device simulation. This methodology allows rapid and inexpensive exploration of alternative process designs prior to fabrication.

D-5 Current Radiation Issues for Programmable Elements and Devices

4:40 PM

R. Katz, K. LaBel and R. Reed, NASA/GSFC; A. Teverovsky, Unisys Corp; J.J. Wang, B. Cronquist, J. McCollum, W. Paolini and B. Sin, Actel Corp; R. Koga and S. Crain, Aerospace Corporation; R. Brown, Lockheed-Martin Federal Systems

State-of-the-art programmable devices utilize advanced technologies, non-standard structures, and unique elements. Reliability of the unprogrammed antifuse for heavy ions and logic upset are investigated along with radiation characteristics of new devices.



POSTER PAPERS

PD-1 Integrating Analog-to-Digital Converter Radiation Hardness Test Technique and Results

O.A. Kalashnikov, A.A. Demidov, V.S. Figurov, A.Y. Nikiforov, S.A. Polevich, V.A. Telets and S.A. Maljudin, Specialized Electronic Systems

Radiation hardness tests have been performed on an integrating ADC CMOS IC. Dose rate, total dose and structural damage test techniques and results are presented. The integrating ADC has a low radiation hardness due to its principle of operation.

PD-2 Detailed Analysis of the Radiation Response of a Data Acquisition System CMOS IC

O.A. Kalashnikov, A.A. Demidov, A.Y. Nikiforov, Y.V. Agrich, V.A. Telets and S.A. Maljudin, Specialized Electronic Systems

Dose rate and total dose tests of a CMOS Data Acquisition System IC have been performed. The correlation of IC failure to the responses of internal units: input analog circuit, RAM, channel counter and channel address register, is analyzed.

PD-3 Dose Rate and Total Dose Dependence of Low Frequency Noise Performance, I-V Curves and Sidegating for GaAs MESFETs

D.M. Hiemstra, SPAR Space Systems; A.A. Kizevi and L.Z. Hou, Nortel; C.A.T. Salama, University of Toronto

Total dose and dose rate performance of GaAs MESFET devices of various geometries, and sidegating structures at various distances and orientations, are presented. Parameters measured include low frequency noise, I-V curves, and sidegating.

4:55 PM End of Tuesday Sessions



7:30 AM **REGISTRATION AND CONTINENTAL BREAKFAST**
Registration Foyer

SESSION E HARDNESS ASSURANCE AND TESTING TECHNIQUES

8:15 AM Session Introduction

*Chairpersons: Wesley Will, Boeing Defense and Space Group
Catherine Barillot, Alcatel Telecom*

E-1 Proton Damage Effects in Linear Integrated Circuits

8:20 AM *B.G. Rax, A.H. Johnston and C.I. Lee, Jet Propulsion Laboratory*

Proton testing of linear circuits has identified devices where displacement damage causes a lower failure level than that attributed only to ionization. Proton testing may be required for circuits that use substrate and lateral pnp transistors in critical circuit functions.

E-2 Effects of Reliability Screening Tests on Bipolar Integrated Circuits During Total Dose Irradiation

8:35 AM *C. Barillot, O. Serres, R. Marec and P. Calvel, Alcatel Espace*

The effects of burn-in, HTRB, and life tests on the total dose response of three different bipolar ICs are studied. Different behaviors have been observed on one type. Results of analysis are consistent with the mechanisms previously reported for MOS devices.

E-3 Measurement Bias Dependence of Enhanced Bipolar Gain Degradation at Low Dose Rate

8:50 AM *S.C. Witczak, R.C. Laco and D.C. Mayer, Aerospace Corporation; R.D. Schrimpf, H.J. Barnaby and K.F. Galloway, Vanderbilt University; R.L. Pease, RLP Research; D.M. Fleetwood, Sandia National Laboratories*

Oxide trapped charge, field effects from emitter metallization, and high-level injection phenomena moderate enhanced gain degradation of lateral pnp transistors at low dose rates. Hardness assurance tests at elevated irradiation temperatures require larger design margins for low power measurement biases.

E-4 Study of Low-Dose-Rate Radiation Effects on a Commercial Linear Bipolar IC

9:05 AM *R.K. Freitag and D.B. Brown, Naval Research Laboratory*

The radiation-induced degradation of a commercial linear bipolar IC (LM111) has been studied using four dose rates. The time dependent behavior is consistent with a model based on binary reaction rate theory.

POSTER PAPERS

PE-1 A Way to Improve Dose Rate Laser Simulation Adequacy

P.K. Skorobogatov, A.Y. Nikiforov and A.A. Demidov, Specialized Electronic Systems

A method for improving laser simulation of dose-rate radiation is analyzed based on the application of noncoherent laser radiation. Experimental validation was performed using test structures with up to 92% surface metallization coverage.



SESSION F RADIATION DOSIMETRY

9:20 AM

Session Introduction

Chairman: Steven Seltzer, National Institute of Standards and Technology

F-1

9:25 AM

Erasure of Floating Gates in the Natural Radiation Environments in Space

P.J. McNulty and L.Z. Scheick, Clemson University; D.R. Roth, Johns Hopkins Applied Physics Laboratory

Preliminary data shows that after 160 orbits the floating gates of two UVPROMS flown on the MPTB satellite experiment have received 2% erasure.

F-2

9:40 AM

Electrical Performance and Radiation Sensitivity of Stacked PMOS Dosimeters under Bulkbias Control

C. Conneely, B. O'Connell, J. Doyle and W. Lane, National Microelectronics Research Centre Ireland; L. Adams, ESA-ESTEC

A new method for biasing stacked PMOS dosimeters has shown the potential for increased radiation dose range. Radiation sensitivity measurement has shown impressive results. The possibility of a ZTC bulkbias may also prove attractive.

F-3

9:55 AM

Irradiated Integrated Circuits Dose-Attenuation Mapping Using Optically Stimulated Phosphors for Packaging Dosimetry

L. Dusseau, G. Polge, L. Albert, Y. Magnac, J. Fesquet and J. Gasiot, Universite Montpellier II; J.C. Bessiere, CORAD

A new dose-attenuation mapping system using optically stimulated luminescent phosphors is presented. Experimental results on a dual-in-line package are compared with EGS4 transport code calculations.

F-4

10:10 AM

Charge Collection and Radiation Hardness of an SOI Microdosimeter for Space and Medical Applications

P.D. Bradley and A.B. Rosenfeld, University of Wollongong; K.K. Lee and D. Jamieson, University of Melbourne; S. Satoh, Fujitsu Research Laboratories

First results obtained using an SOI device for microdosimetry applications are presented. Microbeam and broadbeam spectroscopy methods are used for determining minority carrier lifetime and radiation damage constants. Lateral diffusion effects significantly complicate charge collection.

POSTER PAPERS

PF-1

Validation of a Comprehensive Space Radiation Transport Code

J.L. Shinn, L.C. Simonsen and J.W. Wilson, NASA Langley Research Center; F.A. Cucinotta and G.D. Badhwar, NASA Johnson Space Center; J. Miller, C. Zeitlin and L. Heilbronn, Lawrence Berkeley National Laboratory; M.A. Xapsos, Naval Research Laboratory

Validation is important in the development of the space radiation transport code HZETRN, which models many physical processes ignored in other codes. Results from laboratory and flight measurements are described with good agreement between data and theory.



PF-2 Modelling the Charge and Dose Deposition at Electronic Devices Within Spacecraft

A. Chugg and G. Randall, Matra Bae Dynamics

Solutions are proposed for several problems in the field of 3-dimensional space radiation dose and charge deposition modelling with the worked example of charging of plastic encapsulated device packages.

PF-3 Spectrum Determination Method for the Air Force Research Laboratory Co-60 Facility and Spectrum Modification Using a Pb/Al Box

J.R. Turinetti, W.T. Kemp and J.R. Chavez, USAF Research Laboratory

Methods to accurately measure the energy spectrum of the Air Force Research Laboratory's Cobalt-60 facility, spectrum modifications resulting from using a Pb/Al box, and modeling the spectrum with CEPXS/ONELD are demonstrated.

10:25 AM BREAK

SESSION G RADIATION EFFECTS IN COMMERCIAL ELECTRONICS AND SPACE SYSTEMS

10:55 AM

Session Introduction

Chairman: William Heidergott, Motorola

G-1 Possible Role for Secondary Particles in Proton-Induced Single Event Upsets of Modern Devices

11:00 AM

P.J. McNulty and M.W. Savage, Clemson University; D.R. Roth, Johns Hopkins Applied Physics Laboratory; C.C. Foster, Indiana University

Decreasing critical charge in modern COTS devices indicates that reactions other than direct spallation may contribute to proton SEU effects. Experimental measurements and simulation results on secondary particles are presented.

G-2 Emerging Radiation Hardness Assurance (RHA) Issues: A NASA Approach for Spaceflight Programs

11:15 AM

K.A. LaBel, J.L. Barth and R.A. Reed, NASA/GSFC; A.H. Johnston, Jet Propulsion Laboratory

A NASA developed approach to radiation hardness assurance of reliable space flight systems is presented. Emerging issues on enhanced low dose rate effects, single event transients, composite structures, and proton damage effects are considered.

G-3 Novel Spacecraft Instrument for In Situ Measurements of Environmental Conditions

11:30 AM

B.K. Dichter, J.O. McGarity, M.R. Oberhardt, V.T. Jordanov, D.J. Sperry, A.C. Huber and J.A. Pantazis, Amptek, Inc; E.G. Mullen, Assurance Technology Corp.; G. Ginot and M.S. Gussenhoven, USAF Research Laboratory

A new instrument is described for measurements of space environment hazards (radiation dose, dose rate, dielectric charging and single event effects). The instrument is small, light, and designed to function on many operational spacecraft.



G-4
11:45 AM

Observed Radiation-Induced Degradation of Commercial-Off-The-Shelf (COTS) Devices Operating in Low-Earth Orbit

C.I. Underwood and M.K. Oldfield, University of Surrey

Observations of single-event effects and total-dose degradation are presented for the COTS-based data handling systems of the S80/T microsatellite which has been operating in a 1320 km altitude orbit for six years.

POSTER PAPERS

PG-1

Ground Based Radiation Assessment of a GPS Receiver Payload for Use on Small Satellites

M.K. Oldfield, C.E. Underwood and M.J. Unwin, University of Surrey; R. Harboe-Sorensen, ESA/ESTEC

A state-of-the-art, low cost GPS (Global Positioning System) receiver payload has been developed using COTS devices. A description of the ground-based radiation testing of the receiver in terms of its single event effects and total dose tolerance is presented.

PG-2

Study, Design and Implementation of a Power Supply Operating Under Gamma Radiation

M. Marceau, CEA; H. Huillet, D. Ploquin and P. Marchand, GAIA Converter

A summary of a procedure for system hardening which is necessary to use industrial components is presented. Realization of a compact power supply able to support a total ionizing dose of 1 Mrad of gamma radiation is presented.

PG-3

Shielding Electronics Behind Composite Structures

B.D. Spieth, ITN Energy Systems; K. Qassim and R. Pittman, USAF Research Laboratory; D. Russell, Boeing Aerospace

Analyses, test data, and an STRV flight experiment are described in the development of low cost and low weight solutions for adding electronics shielding on composite structures.

PG-4

Dose-Depth and SEU Monitors for the STRV-1c Satellite

I. Thomson, A. Hartshorn and M. Brown, Thomson & Nielsen Electronics Ltd; L. Adams and R. Nickson, ESA-ESTEC; A. Ng, Canadian Space Agency; T. Cousins and T. Jones, Defense Research Establishment Ottawa

Small, low-power instruments developed using COTS components to monitor the Dose-Depth environment and SEUs on spacecraft such as STRV-1c are described. Data on radiation characterization and radiation tolerance of the instruments is presented.

PG-5

SEE Flight Data From Japanese Satellites

T. Goka, H. Matsumoto and N. Nemoto, National Space Development Agency of Japan

Analysis of single event effects data (SEU and SEL) from three Japanese satellites is presented. Ten years of data have been compared with predicted rates. Extreme value theory is utilized in the prediction of maximum SEU rates.

12:00 PM

End of Wednesday Sessions

12:30 PM – 1:30 PM

Buses Leave for Newport Harbor for Catalina Island Beach Bash



7:30 AM **REGISTRATION AND CONTINENTAL BREAKFAST**
Registration Foyer

INVITED PAPER **Intelligent Microsystems: Keys to the Next Silicon Revolution?**
8:15 AM *Paul McWhorter, Sandia National Laboratories*

The integrated circuit has impacted virtually every aspect of our lives. The hallmark of the microelectronics industry has been to each year produce chips that are faster, cheaper, and better. This phenomenal growth has been maintained for over thirty years now, and amounts to nothing less than a silicon revolution. We believe that today we stand on the verge of a second silicon revolution. The metrics of the second silicon revolution will be more important than simply to continue to pack more transistors onto chips. The metric of the second silicon revolution will be the incorporation of new structures, tiny machines, onto the chip, alongside the transistors. These new structures will enable the chips to not only think, but to sense, act, and communicate as well. This will enable a new generation of integrated circuit that will be able to know where it is, and know what is going on around it. The second silicon revolution has begun, and this presentation will discuss the latest results in realizing this vision of Intelligent, Integrated Microsystems.

Paul McWhorter joined Sandia's Reliability Physics department in 1985 to work in the development of predictive models for failure of integrated circuits. His research focused on the effects of the harsh radiation and thermal environments encountered in space and weapon applications on integrated circuits. Mr. McWhorter initiated Sandia's Intelligent Micromachine Initiative in 1992, and has been the technical and programmatic leader of this activity. Under his leadership this initiative has advanced the MEMS field by developing cutting edge technology for the integration of sensors, actuators and microelectronics on the same piece of silicon. He is presently serving as the Deputy Director for Sandia's Microelectronics and Photonics Center.

SESSION H **RADIATION EFFECTS IN EMERGING TECHNOLOGIES AND**
9:20 AM **PHOTONICS**
Session Introduction
Chairman: Charles Brothers, USAF Research Laboratory

H-1 **Radiation Response of a MEMS Accelerometer: An Electrostatic**
9:25 AM **Force**
L.D. Edmonds and C.I. Lee, Jet Propulsion Laboratory

Particle irradiation on the mechanical sensor of the ADXL50 microelectromechanical accelerometer shifts the output voltage. An earlier conclusion, that a dielectric below the sensor becomes charged, is extended by quantifying the effect of this charge.

H-2 **High-Fluence X-ray and Charged Particle Effects in**
9:40 AM **MicroElectroMechanical Systems (MEMS) Comb-Drive Actuators**
L.P. Schanwald, J.R. Schwank, J.J. Sniegowski, M.R. Shaneyfelt, D.S. Walsh, N.F. Smith, K.A. Peterson, P.S. Winokur, J.H. Smith and B.L. Doyle, Sandia National Laboratories

The mechanical response of MEMS microengines has been investigated in x-ray, proton, and electron total-dose environments. At very high fluence levels, proton and electron irradiation may cause temporary device lockup, while x-ray exposures have minimal effect.



- H-3**
9:55 AM **A Total-Dose Radiation Hard Diamond MIS Gas Sensor**
D.V. Kerns, W.P. Kang, J.L. Davidson, Q. Zhou, Y. Gurbuz and S. E. Kerns, Vanderbilt University
- Sensors capable of reliable detection of hydrogen gas concentration over a wide range of temperatures are designed and fabricated using an MIS structure. The total-dose radiation hardness shows minimal change in gas-sensing characteristics at 10 Mrad.
- H-4**
10:40 AM **The Effects of 3 MeV Proton and Cobalt-60 Gamma Irradiation on Light Emission in Silicon p-n Junctions**
S. Aboujja and C. Carlone, Universite de Sherbrooke; J.P. Charles, Universite de Metz; A. Houdayer, Universite de Montreal
- The effect of 3 MeV proton and 1.2 MeV cobalt gamma irradiations on the electroluminescence of forward- and reverse-biased silicon pn junctions is reported in the spectral range of 1.0 to 2.5 eV.
- H-5**
10:55 AM **Annealing Effects on Multi-Quantum Well Laser Diodes after Proton Irradiation**
Y.F. Zhao, R.D. Schrimpf, A.W. Al-Johani, R.A. Weller and K.F. Galloway, Vanderbilt University; A.R. Patwary and M.A. Neifeld, University of Arizona
- Threshold current and optical power of proton-irradiated laser diodes can recover and become better than before irradiation due to forward-bias annealing. Degradation of optical power during irradiation depends on the proton flux due to the in-situ forward-bias annealing.
- H-6**
11:10 AM **Emerging Optocoupler Issues with Energetic Particle-Induced Transients and Radiation Degradation**
R.A. Reed, J.L. Barth and K.A. LaBel, NASA/GSFC; P.W. Marshall and M.A. Carts, NRL/SFA; A.H. Johnston, JPL; C.J. Marshall, NRL; M. D'Ordine, Ball Aerospace; H.A. Kim, Jackson & Tull Engineers
- We present novel analyses of energetic particle-induced transients and degradation for optocouplers. This includes new ground test data, in-flight performance, and a discussion of emerging design issues.
- H-7**
11:25 AM **Proton Induced Transient Effects in a Metal-Semiconductor-Metal (MSM) Photodetector for Optical-Based Data Transfer**
C.J. Marshall, NRL; P.W. Marshall and M.A. Carts, NRL/SFA; R.A. Reed and K.A. LaBel, NASA/GSFC
- We present a study of proton transient effects in metal-semiconductor-metal (MSM) photodetectors which demonstrates their inherent advantage for minimizing SEEs in proton environments. Upset mechanisms and novel tools for on-orbit error rate predictions are described.



POSTER PAPERS

PH-1 Alpha Particle, Proton and X-ray Damage in Fully Depleted Junction CCD Detectors for X-ray Imaging and Spectroscopy

N. Meidinger, B. Schmalhofer and L. Struder, Max-Planck Institute

Comparisons of radiation damage by alpha particles, protons and X-rays in pn-CCD detectors for X-ray satellite missions are presented. We discuss the analysis of traps, deterioration of charge transfer efficiency and energy resolution, and detection of low oxygen concentrations in silicon.

PH-2 Dark Currents in CCD Induced by Single Interactions of 14.9 MeV Neutrons

Yu.D. Kotov, D.M. Zhamoycin and V.D. Popov, Moscow Engineering Physics Institute; M. Sasada, Tokyo Broadcasting System

Characteristics of flash events and spikes produced by single nuclear interactions of 14.9 MeV neutrons in CCD arrays were studied. On-line measurements show that the dark current distribution is essentially different from the simulated damage energy distribution.

PH-3 Response of 100% Internal Carrier Collection Efficiency Silicon Photodiodes to 1–40 keV Ions

S.M. Ritzau, H.O. Funsten and R.M. Harper, Los Alamos National Laboratory; R. Korde, International Radiation Detectors

We measure the response of 100% internal carrier collection efficiency silicon photodiodes having 60 angstrom SiO₂ passivation layers to 1–40 keV ions of H, H₂, He, Ne, and Ar.

PH-4 Radiation Effects in Ultraviolet Sensors Based on Natural Diamond

D.V.Gromov, V.S. Figurov, V.B. Kvaskov, P. P. Maltsev, A.Y. Nikiforov and V.A. Telets, Specialized Electronic Systems

Total dose and dose rate effects are investigated in ultraviolet sensors based on natural diamond with various concentrations of nitrogen impurity. Transient effects in the devices based on IIa-group natural diamond are described with a BARITT device model.

PH-5 Carrier Removal in Semiconductors

S.R. Messenger, SFA Inc; R.J. Walters, M.A. Xapsos and G.P. Summers, Naval Research Laboratory; E.A. Burke, Consultant

Carrier removal rates in p-type InP, for which much recent data exist, are found to be linearly proportional to the nonionizing energy loss. This means that carrier removal rates in p-type InP can be predicted for any particle and initial carrier concentration.

PH-6 Impact of High Energy Particles on InGaP/InGaAs Pseudomorphic HEMTs

H. Ohyama and T. Hakata, Kumamoto National College of Technology; E. Simoen and C. Claeys, IMEC; S. Kuroda, Fujitsu Ltd; Y. Takami, Rikkyo University; H. Sunaga, Takasaki JAERI

The degradation of InGaP/InGaAs pseudomorphic HEMTs by 220-MeV carbon and 20-MeV alpha ray irradiation and their recovery by subsequent isochronal annealing are investigated and compared with results obtained after electron and fast neutron irradiation.



PH-7 Proton Induced Damage in SiC Light Emitting Diodes

P.F. Hinrichsen and A.J. Houdayer, Université de Montreal; A.L. Barry, Communications Research Center Ottawa; J. Vincent, University of British Columbia

The variation of response time and light output of SiC LEDs as a function of proton fluences of energies from 2 to 500 MeV are compared with NIEL calculations and the relativistic elastic scattering cross section.

11:40 AM LUNCH

SESSION I SINGLE-EVENT EFFECTS IN INTEGRATED CIRCUITS

1:15 PM Session Introduction

*Chairpersons: James Howard, NASA Marshall Space Flight Center
Christian Poivey, Matra Marconi Space*

I-1 Single-Event Upset Effects in Optocouplers

1:20 PM *A.H. Johnston, G.M. Swift, T. Miyahira and S. Guertin, Jet Propulsion Laboratory*

Single-event upset is investigated for optocouplers. The threshold LET for devices with internal high-gain amplifiers is very low, and the response of the amplifier makes a significant contribution to the total cross section. Charge collection depths are above 40 μm .

I-2 Single Event Upsets in Implantable Cardioverter Defibrillators

1:35 PM *P.D. Bradley, University of Wollongong; E. Normand, Boeing Defense and Space Group*

Single event upsets (SEU) have been observed for the first time in an implantable medical device. The incidence and geographical variation of SEUs is well modeled by upset rate calculations attributable to the secondary cosmic ray neutron flux.

I-3 SEU Induced Errors Observed in Microprocessor Systems

1:50 PM *V. Asenek, C. Underwood and M. Oldfield, University of Surrey; R. Velazco and Ph. Cheynet, TIMA Laboratory; R. Ecoffet, CNES*

Proposed software methodologies for predicting the rate and nature of SEU induced errors in a microprocessor system while considering the task assigned to the processor are presented. Simulated results are compared with ground based radiation test data.

I-4 Proton-Induced Dielectric Breakdown of Power MOSFETs

2:05 PM *J.L. Titus, NSWC; C.F. Wheatley, Consultant*

Proton-induced dielectric breakdown of vertical power MOSFETs is reported for the first time and compared to the heavy-ion-induced dielectric breakdown response. Potential implications of proton-induced dielectric breakdown are discussed.

I-5 Extensions of the Burst Generation Rate Method for Wider Application to Proton/Neutron-Induced Single Event Effects

2:20 PM *E. Normand, Boeing Defense and Space Systems*

The Burst Generation Rate method, originally developed to calculate SEU rates due to neutrons and protons, has been extended for wider application. This extension allows cross sections for both SEU and SEL to be calculated and comparisons to be made with measured data.



POSTER PAPERS

PI-1 **A New Approach for the Prediction of Neutron-Induced SEU Rates**

C. Vial, J.M. Palau and J. Gasiot, Universite Montpellier II; M.C. Calvet, Aerospatiale Espace; S. Fourtine, Aerospatiale Avions

A new approach for SEU rate prediction in components submitted to neutron environment is presented. Two criteria, a critical LET and a limited distance in which energy must be deposited, are proposed in addition to the critical charge criterion generally used.

PI-2 **Neutron Induced Soft Errors in CMOS Memories Under Reduced Bias**

P. Hazucha and C. Svensson, Linkoping University; K. Johansson, Ericsson Saab Avionics

A custom designed 16 kbit CMOS memory was irradiated by 14 MeV and 100 MeV neutrons. SEU cross sections have been evaluated under different supply voltages and compared to those predicted by a model.

PI-3 **Digital Fuzzy Control: a Robust Alternative Suitable for Space Application**

R. Velazco, Ph. Cheynet and S. Rezgui, TIMA Laboratory; L. Peters and K. Beck, German National Research Center for Information Technology; R. Ecoffet, CNES

The intrinsic robustness to single event upset of fuzzy control digital implementations is investigated. A commercial circuit was used to implement the control part of a future ESA Mars instrument deployment vehicle. Upset fault injection experiments show the fault tolerance properties.

PI-4 **Technology Independent SEU Immune Latch**

R.M. Greene, Aerospace Design Concepts; D. Mavis, Mission Research Corporation

A new and novel SEU immune data latch is presented. Designed for the Spaceborne Reconfigurable Rad-Hard FPGA, the CRISO Latch and its test chip are described. It can be produced using most commercial CMOS processes.

PI-5 **A Simple Approach to SEU Cross Section Evaluation**

V.V. Miroshkin and M.G. Tverskoy, Petersburg Nuclear Physics Institute

A simplified method for the determination of SEU cross sections based on the results of the two-parameter SEU model is presented. The method needs only one SEU cross section measurement at proton energies in the range of 50–200 MeV.



2:40 PM – 5:10 PM
CALIFORNIA
BALLROOM

POSTER SESSION

Poster Chairwoman: Cheryl Marshall, Naval Research Laboratory



Authors will be present during this session to answer questions. Abstracts for posters are listed in this brochure under the oral sessions with which they are associated.

5:10 PM End of Thursday Sessions

5:30 PM
PACIFIC BALLROOM **Radiation Effects Committee Open Meeting**



7:30 AM **REGISTRATION AND CONTINENTAL BREAKFAST**
Registration Foyer

INVITED PAPER The Mars Pathfinder Mission and Science Results

8:15 AM *Dr. Matthew Golombek, Jet Propulsion Laboratory*

Mars Pathfinder, one of the first low-cost, quick Discovery class missions, successfully landed on the surface of Mars on July 4, 1997, deployed and navigated a small rover, and collected data from 3 science instruments and 10 technology experiments. The mission has operated on Mars for 3 months and returned 2.3 Gbits of new data. The rover has traversed 100 m clockwise around the lander, exploring about 200 square meters of the surface. This mission captured the imagination of the public, garnering front page headlines during the first week. A total of about 566 million internet "hits" were registered during the first month of the mission, with 47 million "hits" on July 8th alone, making the Pathfinder landing by far the largest internet event in history. Scientific data have been collected on geology, geochemistry, magnetic and surface material properties, atmospheric imaging and science, and rotational and orbital dynamics. This presentation will discuss these data and reveal intriguing information learned from the mission, such as the implication of a warmer, wetter past on the planet with liquid water in equilibrium with the atmosphere.

Matthew Golombek received the Ph. D. degree in geology from the University of Massachusetts in 1981. He has worked for the Jet Propulsion Laboratory since 1983 and has served as the Mars Pathfinder Project Scientist (chief scientist for the mission) since 1994. As a research scientist at JPL, Dr. Golombek has worked in Earth and planetary (including satellites) structural geology and tectonics, with recent emphasis on Mars geology in general. As the Mars Pathfinder Project Scientist, he has been responsible for the overall science content of the mission and has served as the prime interface between the project, the science community and NASA Headquarters. He chairs the Mars Pathfinder Project Science Group (the oversight group for the roughly seventy scientists working on the mission), is deputy of the Experiment Operations Team, and is a member of the management group that provides input to budget and management decisions for the project. In his role, he has had extensive interactions with the media and is responsible for organizing and arranging for the publication of Pathfinder scientific results in scientific journals (December 5, 1997 issue of Science and an upcoming issue of Journal of Geophysical Research, Planets). Dr. Golombek has served as editor or associate editor of professional journals, as organizer of scientific workshops and special sessions at national and international meetings, as a member of many NASA science advisory groups, and has published and spoken extensively on the Pathfinder mission, as well as planetary geology.

SESSION J RADIATION ENVIRONMENTS

9:20 AM **Session Introduction**

Chairman: George Lasche, Constellation Technology Corporation

J-1 Probability Model for Peak Fluxes of Large Solar Proton Events

9:25 AM *M.A. Xapsos, Naval Research Laboratory; G.P. Summers, University of Maryland; E.A. Burke, SFA Inc.*

The first predictive model of worst case solar proton event peak fluxes is presented that fully accounts for the length of the space mission and the corresponding risk.



J-2
9:40 AM

SEE Relative Probability Maps for Space Operations

E.G. Mullen, Assurance Technology Corp; G. Ginot and M.S. Gussenhoven, USAF Research Laboratory; D. Madden, Boston College

Maps of normalized SEE occurrence for low altitude satellites are produced in geographic coordinates using APEX dosimeter data. Map contours made at three levels per decade are in 50 km steps from 350–2500 km.

POSTER PAPERS

PJ-1

Correlation of GEO Spacecraft Anomalies with >2MeV Electron Excursions Measured by GOES

D.S. Toomb, SAVE Inc.; D.C. Wilkinson, NOAA; J.B. Parkinson, Aerojet

TELESTAR-401 failed following an unprecedented 1-day excursion of electrons ($E > 2\text{MeV}$) at GEO. NOAA GOES particle fluence data was used for correlation. The unpredictability of internal discharges is attributed to changing dielectric properties.

PJ-2

The GEO Total Ionizing Dose

J.R. Solin, Lockheed Martin Missiles and Space

Old estimates of the GEO total ionizing dose are updated to reflect new models of the GEO radiation environment and to account for the effects of modern IC construction.

10:00 AM – 12:30 PM
NEWPORT ROOM

RADIATION EFFECTS DATA WORKSHOP

Data Workshop Chairman: Lew Cohn, Defense Special Weapons Agency



Authors will be present at posters during this session to answer questions.

W-1

Single Event Effects on Commercial SRAM Memories and Power MOSFETs: Final Results of the CRUX Flight Experiment on APEX

J.L. Barth, NASA/GSFC; J.W. Adolphsen, UNISYS; G.B. Gee, SES Inc.

The CRUX experiment on the APEX satellite monitored single event effects on 1 Mbit and 256 Kbit SRAMs and 100 Volt and 200 Volt power MOSFETs. The final results are presented.

W-2

Honeywell Radiation-Hardened 32-Bit Processor Single Event Effects Test Results

S.C. Leavy, J.A. Mogensen, T.S. Smith and G.J. Freifeld, Honeywell; J. Brichacek, USAF Research Laboratory

We present single event effects test results for the Honeywell Radiation Hardened 32-Bit Processor. The processor was tested at board-level while executing a signal and data processing benchmark suite.



W-3 Compendium of Single Event Failures in Power MOSFETs

J.R. Coss, G. Swift and L. Selva, Jet Propulsion Laboratory; J.L. Titus, NSWC; E. Normand, D.L. Oberg and J.L. Wert, Boeing Company

This compendium updates and includes all the previous entries of power MOSFET SEEs initially prepared by Don Nichols of JPL, as well as more recent data.

W-4 Single Event Effect and Proton Damage Results for Candidate Spacecraft Electronics

K.A. LaBel, R.A. Reed and J.L. Barth, NASA/GSFC; M.V. O'Bryan, Jackson & Tull Engineers; C.M. Seidleck, Hughes/STS; P. Marshall and M. Carts, NRL/SFA; C. Marshall, NRL

We present both heavy ion and proton single event effect and proton damage ground test results for candidate spacecraft electronics. Devices tested include DRAMs, FPGAs, and fiber links.

W-5 Single Event Effects Test Results for the 80C186 and 80C286 Microprocessors and the TMS320C30 and TMS320C40 Digital Signal Processors

S.H. Crain, W.R. Crain, K.B. Crawford, S.J. Hansel and R. Koga, Aerospace Corporation

Two generations of both the 80x86 microprocessor family and the TMS320Cx0 digital signal processor family were tested for single event effects. The test results are presented here.

W-6 Heavy-Ion Testing of Single Event Effects in 12 and 16 Bit ADCs

S. Bee and G.R. Hopkinson, Sira Ltd; R. Harboe-Sorensen and L. Adams, ESA-ESTEC; A. Smith, Mullard Space Sciences Laboratory

Results are presented for heavy ion single event effects in 12- and 16-bit ADCs. The devices studied were the AD676, AD7884 and AD7893. Transient and "lingering" errors were found, as well as "bit-flips" and temporary latch-up.

W-7 Radiation Characterization of Commercially-Available 1Mbit / 4Mbit SRAMs

B. Doucin, E. Adolf, C. Poivey, C. Carlotti, Matra Marconi Space; R. Harboe-Sorensen, ESA/ESTEC; M. Bruggemann, IDA

The radiation results of a ground test program carried out on 8 state-of-the-art commercially-available 1M / 4 M SRAMs are presented. Heavy ion SEE, proton SEE, and Co-60 TID results are included.

W-8 Radiation Evaluation of 3.3 Volt 16 M-bit DRAMs for Solid State Mass Memory Space Applications

R. Harboe-Sorensen, ESA-ESTEC; M. Bruggemann, Institut fur Datenverarbeitungsanlagen; R. Muller, Max-Planck Institute; F.J. Rombeck, Dornier Satellitensysteme GmbH

We present the results of radiation testing on 6 commercially-available low-voltage 16 Mbit DRAMs. Device details, testing issues, and results for SEE and TID are presented and compared to earlier 16 Mbit tests.



W-9 Total Dose and Single Event Effects Testing of UTMC Commercial RadHard Gate Arrays

D.B. Kerwin and J.M. Benedetto, UTMC Microelectronic Systems

Results from TID and SEE testing on a UTMC RadHard gate array SEC are reported. Total dose levels greater than 200 krad(Si) and error rates of less than 1×10^{-10} errors/bit-day, with no single event latch-up were demonstrated.

W-10 High Total Dose Response of the UTMC Gate Array Fabricated at Lockheed-Martin Federal Systems

J. Benedetto, A. Bishop, M. Martin, UTMC Microelectronic Systems; N. Haddad, Lockheed-Martin Federal Systems

The radiation response of the UTMC gate array SEC was measured using a Co-60 source. The SEC remained fully functional throughout the testing. The SEC was monitored for parameter shifts. All parameters were within specified values during the tests.

W-11 Dose Rate, Total Dose, and Neutron Radiation Testing of COTS and Military Microcircuit Devices

S.G. Mulford, Raytheon Company

Radiation testing on a variety of COTS and military devices for microprocessor and peripheral support applications has been performed for the prompt narrow and wide pulse dose rate, total dose gamma and the neutron environments.

W-12 Commercial SOS Technology for Radiation Tolerant Space Applications

G. Lyons, Peregrine Semiconductor Corp.

We present a commercial ultra thin silicon on sapphire technology developed for consumer wireless applications, which also possesses excellent radiation hardness characteristics suitable for the commercial space environment.

W-13 Total Ionizing Dose Effects on Flash Memories

D.N. Nguyen, C.I. Lee and A.H. Johnston, Jet Propulsion Laboratory

The total dose degradation of commercial flash memories is affected by the internal cell structures and charge pump. Devices without internal charge pumps appear to provide improved hardness levels up to 50 krad(Si).

W-14 Total-Dose Radiation Tolerance of a Commercial 0.35 μ m CMOS Process

R.C. Lacoe, J.V. Osborn, D.C. Mayer, G. Yabiku and S. Brown, Aerospace Corporation

MOSFETs fabricated in the commercial Hewlett-Packard 0.35- μ m CMOS process are radiation-tolerant to 300 krad(Si). Substrate field oxide thresholds exceed 19 V to 300 krad. Ring oscillator delays do not change with radiation.

W-15 Dose Rate and Total Dose Dependence of the 1/f Noise Performance of an Operational Amplifier Fabricated on a Complementary Bipolar Process on Bonded Wafer

D.M. Hiemstra, SPAR Space Systems Canada

Dose rate and total dose dependencies of the 1/f noise performance of an operational amplifier fabricated on a complementary bipolar process on bonded wafer are presented.



W-16 Total Ionizing Dose Effects on Voltage-to-Frequency Converters

C.I. Lee, B.G. Rax and A.H. Johnston, Jet Propulsion Laboratory

Three VFCs were tested for TID response. A popular charge-balancing architecture converter, AD652, was most sensitive to LDR. Other astable-multivibrator architecture converters, AD537 and AD654, performed much better at HDR and LDR.

W-17 Total Dose Evaluation of State-of-the-Art Commercial Analog to Digital Converters for Space-Based Imaging Applications

J.D. Black and P.H. Eaton, Mission Research Corporation; J.R. Chavez, A.L. Wilson and K.G. Merkel, USAF Research Laboratory; R.L. Pease, RLP Research Inc.

Total dose evaluation was performed on state-of-the-art commercial A/D converters for use in a space-based imaging application. The evaluation demonstrated that four of the eleven devices met the radiation tolerant requirement.

W-18 Burn-In Effects on Total Dose Radiation Sensitivity

J. Gorelick and S. McClure, Hughes Space and Communications; R.L. Pease, RLP Research Inc.

Burn-in effects on the total dose radiation sensitivity of discrete transistors and ICs are examined. Significant differences in the behavior of different device types are observed.

W-19 Comparison of Total Ionizing Dose Effects on Micropower Op-Amps: Bipolar and CMOS

C.I. Lee, B.G. Rax and A.H. Johnston, Jet Propulsion Laboratory

Two micropower op-amps; one bipolar and one CMOS, are compared and parameters are characterized for total dose response with a 2.7 V power supply voltage. The bipolar device showed much more degradation than the CMOS device.

W-20 Effects of Input Bias on Different Commercial Technological Lines of CMOS Inverters with Respect to the Cumulated Dose

O. Quittard and F. Joffre, CEA; C. Oudea, Aerospatiale; L. Dusseau, J. Fesquet and J. Gasiot, Universite Montpellier II

The bias effects on 144 commercial CMOS inverters have been studied with respect to the cumulated dose. The "worst case" irradiation conditions, as well as the most favorable case, have been inferred from these data.

W-21 Evaluation of High Performance Converters Under Low Dose Rate Total Ionizing Dose (TID) Testing for NASA Programs

A.K. Sharma, NASA/GSFC; K. Sahu, UNISYS

This paper reports the results of low dose rate TID tests performed on several types of high performance converters including devices such as a high speed flash converter, a 16-bit ADC, and a voltage-to-frequency converter.

W-22 Radiation Testing for Space Applications at the National Physical Laboratory

A.J. Williams, M.R. McEwen and A.R. DuSautoy, National Physical Laboratory Great Britain

The electron linear accelerator at NPL can be used to simulate earth orbits for radiation testing of electronic components. This paper describes the accelerator facility and gives examples of the work carried out in recent years.



W-23 Radiation Effects Testing Facility in PSI Low Energy OPTIS Area

W. Hajdas, A. Zehnder, F. Burri and J. Bialkowski, Paul Scherrer Institut; L. Adams, B. Nickson and R. Sorensen, ESA-ESTEC

A radiation test facility constructed as an extension of the PSI Proton Facility is described.

W-24 Cocktails and Other Libations – The 88-Inch Cyclotron Radiation Effects Facility

M.A. McMahan, A. Guy, C. Lyneis and D. Xie, Lawrence Berkeley National Laboratory

The 88-Inch Cyclotron at LBNL has unique capabilities for use in radiation effects testing. Ions from protons to bismuth, as well as "cocktail" beams of several species, allow a wide range of LET with minimum tuning.

W-25 REIS-IE X-ray Tester: Description, Qualification Technique and Results, Dosimetry Procedure

A.S. Artamonov, A.I. Chumakov, N.V. Eremin, V.S. Figurov, O.A. Kalashnikov, A.Y. Nikiforov and A.V. Sogojan, Specialized Electronic Systems

The original "REIS-IE" X-ray tester for IC total-dose radiation effects is described. The qualification technique is described and tests results are presented. The dosimetry procedure is validated in "REIS-IE" vs. Cobalt-60 tests.

12:30 PM End of Conference

Conference Information

INDUSTRIAL EXHIBIT

This year's Industrial Exhibit will feature the leading suppliers of radiation-hardened products, related materials, and services. The exhibit will be held in the California and Newport Ballrooms. The exhibit will be open from noon to 5:00 PM on Tuesday, July 21, and again that evening from 7:00 PM to 10:00 PM. During the Tuesday evening session, refreshments will be provided for attendees and their guests. The exhibits will be open again during the continental breakfast on Wednesday morning, July 22. The exhibits will close at 11:00 AM Wednesday. Companies wanting additional information regarding exhibits should contact Lisa Allen at (978) 777-4247 or send E-mail to lisa_allen@ibis.com. Late registration for exhibit booth space will be accepted.

ROOMS FOR SIDE MEETINGS

Several meeting rooms are available for use by NSREC attendees during the conference week at Newport Beach Marriott Hotel and Tennis Club. Please contact the conference registration desk adjacent to the Pacific Ballroom to reserve a room for a side meeting. Arrangements for audiovisual equipment, refreshments, etc., can be made through the hotel and are the responsibility of the attendee. Contact ETC Services, Inc. at (303) 770-2055 or send an e-mail message to ETCSVC@aol.com to make a meeting reservation in advance of the conference.

MESSAGES (714) 640-4000 FAX: (714) 640-5055

A message board will be located in the lobby area outside the Pacific Ballroom for all incoming messages during the Short Course and NSREC Technical Sessions. Faxes can be sent and received through the hotel. Costs associated with faxes are the responsibility of the attendee. The Newport Beach Marriott Hotel has a business center and teleconferencing facilities.

CONTINENTAL BREAKFAST & COFFEE BREAKS

The 1998 NSREC will provide continental breakfast and refreshments at breaks during the Short Course and Technical Sessions for registered short course and technical attendees only. Continental breakfasts will begin at 7:30 AM Monday through Friday just outside the Pacific Ballroom.

RADIATION EFFECTS COMMITTEE OPEN MEETING

The IEEE Radiation Effects Committee will hold its Open Meeting in the Pacific Ballroom from 5:30 PM to 7:00 PM on Thursday, July 23. All conference attendees are encouraged to attend the Open Meeting to discuss this and future IEEE Nuclear and Space Radiation Effects Conferences. There will be an election for the Junior Member-at-Large on the Radiation Effects Committee. Nominations will be taken from the floor. All NPSS members present are eligible to vote. Refreshments will be provided.



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James R. Coss
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Mark A. Hopkins
The Aerospace Corporation

News from the Radiation Effects Steering Group (RESG)

The RESG welcomes Nick van Vonno of Harris Corporation as its newly elected Member-at-Large and Mark Hopkins of The Aerospace Corporation as the newest elected member of IEEE NPSS AdCom. A complete listing of RESG members appears on this page.

The Radiation Effects Steering Group held its annual Fall meeting on October 30 and 31, 1997, at the Newport Beach (CA) Marriott Hotel and Tennis Club, site of the 1998 Nuclear and Space Radiation Effects Conference (NSREC). The meeting agenda included reports and plans from the chairmen of the 1995 through 2000 NSRECs, as well as discussions of Radiation Effects Committee guidelines and policies.

Dennis Brown of the Naval Research Lab, Conference General Chairman, reported on the 34th annual International IEEE Nuclear and Space Radiation Effects Conference which was held July 21-25, 1997, at Snowmass Village, Colorado, in conjunction with the 2nd International Conference on High-Energy Background Radiation in Space (CHERBS). An excellent technical program was organized by the Short Course Chairman, Nick van Vonno, and the Technical Program Chairman, Allan Johnston. Seventy-nine of the ninety papers presented at the Conference were accepted for publication in the December 1997 issue of *IEEE Transactions on Nuclear Science*. The 561 attendees and 294 companions were able to fully enjoy the beauty of the Rocky Mountains and the excellent amenities offered by Snowmass Village primarily because of the outstanding work of Local Arrangements Chairwoman Teresa Farris of UPMC Microelectronic Systems. The surprising and welcome news from our 1997 Conference Committee was that the attendance was 23% higher than the attendance at the 1996 NSREC. The 1996 Conference attendance itself was 15% higher than the 1995 attendance. These figures appear to signal a dramatic turnaround from the ten-year attendance slump experienced from 1986 to 1995. Another surprise was an unexpected increase in exhibitors at our Industrial Exhibit, from 16 booths in 1996 to 26 booths in 1998.

Ron Schrimpf, 1999 Conference General Chairman, reported that the 1999 Nuclear and Space Radiation Effects Conference will be held July 12-16 at the Waterside Marriott Hotel in Norfolk, Virginia. Dan Fleetwood of Sandia National Labs is planning a tutorial short course tentatively based on the theme of total dose and single-particle effects in space electronics. The Technical Program Chairman will be Fred Sexton of Sandia National Labs. Once again there will be a Radiation Effects Data Workshop and an Industrial Exhibit. An excellent social program is being planned by the Local Arrangements Chairman, Ken LaBel of NASA Goddard.

Ron Pease of RLP Research, the 2000 Conference General Chairman, reported that plans for our Millennium NSREC are still in their infancy. The Conference will be held at a site in the Western USA. The current front-runners appear to be venues in either the Reno, Nevada, or Phoenix/Scottsdale, Arizona, regions.

In other RESG business, Janet Barth of NASA Goddard Space Flight Center was appointed Associate Guest Editor for the 1998 Conference. She will serve as Assistant Guest Editor in 1999 and Guest Editor for the December 2000 issue of *IEEE Transactions on Nuclear Science*. Teresa Farris of UPMC Microelectronic Systems was appointed Publicity Chairperson for our 1999 and 2000 Conferences. For all the most current information on the Radiation Effects Steering Group and the Nuclear and Space Radiation Effects Conference, please visit our web site at <http://www.ieee.org/nps/nsrec/nsrec.html>.

As always, the Radiation Effects Steering Group is committed to maintaining the highest technical standards for the Nuclear and Space Radiation Effects Conference so that we may continue to provide you with the latest radiation effects research as well as an opportunity for informal technical exchange.

Klaus G. Kerris
Chairman

Dale G. Platteter
Executive Vice Chairman

Awards

1997 OUTSTANDING PAPER AWARD

Single Event Gate Rupture in Thin Gate Oxides

F. W. Sexton, D. M. Fleetwood, M. R. Shaneyfelt, P. E. Dodd, and G. L. Hash, Sandia National Laboratories

1997 MERITORIOUS PAPER AWARDS

Hardness Assurance Testing of Bipolar Junction Transistors at Elevated Irradiation Temperatures

S. C. Witzak, R. C. Lacoe, and D. C. Mayer, The Aerospace Corporation; R. D. Schrimpf and K. F. Galloway, Vanderbilt University; D. M. Fleetwood, Sandia National Laboratories; J. M. Puhl and J. S. Suehle, NIST; R. L. Pease, RLP Research

1/f Noise, Hydrogen Transport, and Latent Interface-Trap Buildup in Irradiated MOS Devices

D. M. Fleetwood, M. J. Johnson, T. L. Meisenheimer, P. S. Winokur, and W. L. Warren, Sandia National Laboratories; S. C. Witzak, The Aerospace Corporation

1997 DATA WORKSHOP PAPER AWARD

Common-Source TLD and RADFET Characterization of Co-60, Cs-137, and X-Ray Irradiation Sources

M. Simons and J. Buaron, Research Triangle Institute; R. L. Pease, RLP Research; D. M. Fleetwood, J. R. Schwank, and L. C. Riewe, Sandia National Laboratories; M. F. Krzesniak and T. L. Turflinger, Naval Surface Warfare Center-Crane; W. T. Kemp and P. W. C. Duggan, Air Force Research Laboratory; A. H. Johnston and M. C. Wiedeman, Jet Propulsion Laboratory; R. E. Mills, Hughes Industrial Electronics Company; A. G. Holmes-Siedle, Radiation Experiments and Monitors; L. M. Cohn, Defense Special Weapons Agency; H. J. Doane and W. L. Lohmeier, University of Arizona

IEEE FELLOW

One member of the radiation effects community was elected to the grade of IEEE Fellow on January 1, 1998.

Harold L. Flescher

Raytheon Company

A certificate will be presented to Mr. Flescher during the conference opening on Tuesday, July 21.

RADIATION EFFECTS AWARD

Nominations are currently being accepted for the 1999 IEEE Nuclear and Plasma Sciences Society (NPSS) Radiation Effects Award. The purpose of the award is to recognize individuals who have had a sustained history of outstanding and innovative technical and/or leadership contributions to the radiation effects community.

The basis of the award is for individuals who have: (1) a substantial, long-term history of technical contributions that have had major impact on the radiation effects community. Examples include benchmark work that initiated major research and development activities or a major body of work that provided a solution to a widely recognized problem in radiation effects; and/or (2) a demonstrated long-term history of outstanding and innovative leadership contributions in support of the radiation effects community. Examples include initiation or development of innovative approaches for promoting cooperation and exchange of technical information or outstanding leadership in support of the professional development of the members of the radiation effects community.

A cash award and plaque will be presented at the IEEE NSREC at Norfolk, Virginia in July 1999. Nomination forms or additional information can be obtained from Steve Bernacki, Senior Member-at-Large for the Radiation Effects Steering Group. Mr. Bernacki can be contacted at (508) 440-2363, facsimile (508) 440-4322, or E-mail: bernacki@zeus.ed.ray.com.

Registration and Travel

CONFERENCE REGISTRATION

ETC Services, Inc.
7731 South Cove Circle
Littleton, CO 80122
(303) 770-2055
Fax: (303) 741-5890

To pre-register for the NSREC, complete the conference registration form enclosed in this booklet. Please note that the registration fees are higher if payment is received after June 19, 1998.

Mail the Conference registration form with your remittance to ETC Services, Inc. Faxed registrations will be accepted with credit card payment. The registration form, **with payment**, should be mailed to arrive no later than 7 days prior to the Conference, or arrangements should be made to hand carry fees for on-site registration. Telephone registrations will not be accepted.

Registration fees should be made payable to the "1998 IEEE NSREC" and must be in U. S. funds only. Advance payment of registration and activity fees should be by one of the following: (1) check made out in U. S. dollars and drawn on a domestically-located bank, (2) U. S. Money Order, or (3) Mastercard, VISA, or American Express credit card. Please note that there is no longer an additional charge for credit card payments.

On-site registration for the Conference will be conducted at the Registration Office outside the Pacific Ballroom on the following schedule:

Sunday, July 19	4:00 PM – 9:00 PM
Monday, July 20	7:30 AM – 5:00 PM
	7:00 PM – 10:00 PM
Tuesday, July 21	7:30 AM – 5:00 PM
Wednesday, July 22	7:30 AM – 3:00 PM
Thursday, July 23	7:30 AM – 3:00 PM
Friday, July 24	7:30 AM – 10:00 AM

REGISTRATION CANCELLATION POLICY

A \$25 processing fee will be withheld from all refunds. Due to advance financial commitments, refunds of registration fees requested after July 1, 1998, cannot be guaranteed. Consideration of requests for refunds will be processed after the conference. To request a refund, you must notify ETC Services by FAX at (303) 741-5890.

HOTEL RESERVATIONS

(800) 228-9290
or (714) 640-4000

The 1998 IEEE NSREC will be held at the Newport Beach Marriott Hotel and Tennis Club, Newport Beach, CA. The conference room rate is \$111 per night plus tax. A block of rooms is available at a special Government rate of \$93 per night plus tax for U. S. government attendees. The rate is available only for U. S. Government civilian or military personal *with proof of Government employment*. The hotel is extending conference rates from July 17 through July 27. Reservations must be guaranteed.

To make reservations, call 1-800-228-9290 or 1-714-640-4000 and ask for the "IEEE NSREC" block of rooms. **The cut-off date for room reservations is June 19, 1998. After June 19, room accommodations will be confirmed on a space-available basis only, and the conference rate cannot be guaranteed. Please book early!**



TRANSPORTATION TO NEWPORT BEACH

The most convenient airport to Newport Beach is the John Wayne/Orange County airport, which is located about ten minutes from the hotel. John Wayne Airport is currently served by eleven commercial air carriers and four commuter air carriers. Approximately 100 daily departures provide direct, non-stop service to 25 U. S. destinations. These services, along with convenient ground access (all major hotels in Newport Beach offer complimentary transportation), make John Wayne Airport a handy choice for conference participants. In addition, Newport Beach is about a one-hour drive from the Los Angeles International Airport.

Airline Discount

American Airlines is the sole official airline for the 1998 NSREC, and is offering special discounted fares for conference attendees. Rates are based on published round-trip fares within the United States and Canada. All applicable taxes, fees, and charges are the responsibility of the traveler, regardless of date of purchase or travel.

- Travel dates are between July 16 and July 27, 1998. Destinations are Los Angeles, Burbank, Ontario, Long Beach, and John Wayne (Orange County) airports.
- A 5% discount off American Airlines roundtrip excursion fares when purchased less than 60 days prior to travel, subject to all applicable restrictions.
- A 10% discount off American Airlines roundtrip excursion fares when purchased 60 days prior to travel, subject to all applicable restrictions.
- A 10% discount off American Airlines basic coach class (Y26) fares when purchased less than 60 days prior to travel, subject to all applicable restrictions.
- A 15% discount off American Airlines basic coach class (Y26) fares when purchased 60 days prior to travel, subject to all applicable restrictions.

To take advantage of these discounts, call American's Meeting Services Desk, or have your travel agent call, at (800) 433-1790 for reservations. **Reference AN#2178UM.**

Rental Car Discount

Hertz has been selected as the official rental car agency for the 1998 NSREC. Special discounted rates will apply from one week before through one week after the conference. For reservations and information call Hertz at (800) 654-2240 and mention **Meeting #24613.**

Rental Car Class	Daily Rates	Weekly Rates (5-7 days)
Compact 2-Door/4-Door	35.99/38.99	179.99/189.99
Midsize	41.99	199.99
Full Size 2-Door/4-Door	44.99/47.99	209.99/219.99

All rates include free mileage. Rates do not include tax, optional coverages, or gas refueling charges. Return car to same rental location or additional charges may apply. This program guarantees that the rate will be no higher than the special group rate. However, some people may be eligible for lower rates due to corporate discounts, government rates, etc. Hertz will check all of the rates to see what is the best option for each traveler. Rental locations are Los Angeles, John Wayne (Orange County), Ontario, and Long Beach airports.

Transportation from John Wayne Airport (Orange County)

The airport is located ten minutes from the hotel and complimentary shuttle service is provided. By rental car - Take MacArthur Boulevard south to Jamboree Road. Turn right on Jamboree Road. Continue down Jamboree to Santa Barbara Drive. Turn left on Santa Barbara Drive. The hotel will be on the right at the top of the hill.

Driving Directions from Los Angeles Airport

Driving time to Newport Beach is approximately 55 minutes on Interstate 405 (San Diego Freeway). Take San Diego Freeway (I-405) south to Corona del Mar Freeway (73). Exit on Corona del Mar Freeway, toward Corona del Mar. Continue on to Jamboree Road. Turn right on Jamboree Road. Continue down Jamboree Road to Santa Barbara Drive. Turn left on Santa Barbara Drive. The hotel will be on the right at the top of the hill.

Driving Directions from San Diego

Driving time to Newport Beach is approximately 40 minutes. Take San Diego Freeway (I-405) south to Corona del Mar Freeway (73). Exit on Corona del Mar Freeway (73). Exit on Corona del Mar Freeway, toward Corona del Mar. Continue on to Jamboree Road. Turn right on Jamboree Road. Continue down Jamboree Road to Santa Barbara Drive. Turn left on Santa Barbara Drive. The hotel will be on the right at the top of the hill.

1998 IEEE NSREC and Short Course Registration Form

Name _____
Last Name First Name Middle Initial

Name to appear on badge _____

Company/Agency _____

Mailing Address _____

City _____

State _____ Zip Code _____

Country _____

Telephone Number _____

FAX Number _____

E-mail Address _____

IEEE MEMBERSHIP

☐ I am an IEEE Member. _____
Membership Number

☐ I am not a Member, but I wish to join the IEEE.

Nonmembers must register at the nonmember rate, but if you join during the conference, you will receive a complimentary half-year membership in IEEE and in the IEEE Nuclear and Plasma Sciences Society.

CANCELLATIONS

A \$25 processing fee will be withheld from all refunds. Due to advance financial commitments, refunds of registration fees requested after July 1, 1998, cannot be guaranteed. Consideration of requests for refunds will be processed after the conference.

Mail or FAX this form and your remittance
(payable to 1998 IEEE NSREC) to:

ETC Services, Inc.
7731 South Cove Circle
Littleton, CO 80122
Telephone: (303) 770-2055
FAX: (303) 741-5890

REGISTRATION FEES

(Late fee REQUIRED if payment received after June 19, 1998)

	<u>Early</u>	<u>Late</u>	
IEEE Member			
Short Course	\$230	\$260	\$ _____
Technical Sessions	\$285	\$360	\$ _____
Non-IEEE Member			
Short Course	\$285	\$310	\$ _____
Technical Sessions	\$385	\$465	\$ _____
Full-Time Students who are IEEE Members			
Short Course	\$105	\$105	\$ _____
Technical Sessions	\$105	\$105	\$ _____

TOTAL AMOUNT ENCLOSED: \$ _____

PAYMENT OF FEES

☐ Enclosed is a check or money order in **U. S. DOLLARS ONLY**, drawn on or payable through a U. S. bank.
 Payable To: **1998 IEEE NSREC**

☐ Charge registration fees to my credit card using one of the following credit cards:

☐ American Express ☐ Master Card ☐ Visa

Card No. _____

Expiration Date _____

Cardholder
Signature _____

If your company or agency is going to pay by check at a later date, **please do not complete the credit card portion of this form.**

1998 IEEE NSREC Activities Registration Form

Conference Participant _____

Company/Agency _____

Address _____

City _____

State _____ Zip Code _____

Country _____

Telephone Number _____

FAX Number _____

Accompanying
Persons: _____
Name

Please list ages
for children under
age 21 only. _____
Name Age

Name Age

Name Age

CANCELLATIONS

To encourage advanced registration for conference activities, we will refund all activity fees for conference attendees and/or their family members who for any reason are unable to attend the conference. If your plans change after this form is submitted, notify ETC Services by FAX at (303) 741-5890 (do not FAX changes after Thursday, July 16) or notify the conference registration desk when picking up your registration materials (**but no later than 24 hours before the scheduled activity**).

Mail or FAX this form and your remittance
(payable to 1998 IEEE NSREC) to:

ETC Services, Inc.
7731 South Cove Circle
Littleton, CO 80122
Telephone: (303) 770-2055
FAX: (303) 741-5890

ACTIVITY FEES

Late fee REQUIRED if payment received after June 19, 1998. **We strongly encourage early registration; note that the number of tickets available for each event is limited.** Children must be accompanied by an adult during all tours and social events.

	Early	Late	Number Attending	Total Cost
Surf City, USA: Monday, July 20				
Adult	\$0	\$0	_____	
Child (Age 0-12)	\$0	\$0	_____	
Spanish Mission and Laguna Beach Tour: Tuesday, July 21				
Adult/Child (Age 3-13)	\$15	\$22	_____	\$_____
Child (Age 0-2)	\$0	\$0	_____	\$_____
Catalina Island Beach Bash: Wednesday, July 22				
Adult	\$30	\$37	_____	\$_____
Child (Age 3-13)	\$12	\$20	_____	\$_____
Child (Age 0-2)	\$0	\$0	_____	
Queen Mary Ocean Liner Luncheon: Thursday, July 23				
Adult/Child (Age 3-13)	\$25	\$32	_____	\$_____
Child (Age 0-2)	\$0	\$0	_____	\$_____

TOTAL AMOUNT ENCLOSED: \$ _____

PAYMENT OF FEES

☐ Enclosed is a check or money order in **U. S. DOLLARS ONLY**, drawn on or payable through a U. S. bank.
Payable To: **1998 IEEE NSREC**

☐ Charge registration fees to my credit card using one of the following credit cards:

☐ American Express ☐ Master Card ☐ Visa

Card No. _____

Expiration Date _____

Cardholder
Signature _____

Social Program

The 1998 NSREC Committee has arranged for a social program that gives you and your companions a taste of the history, natural beauty, and entertainment found in the Newport Beach area. We strongly encourage early registration for the social events; note that the number of tickets available for each event is limited. **Late fees apply if payment is received after June 19, 1998.** Children must be accompanied by an adult during all tours and social events.

Sunday, July 19
6:00 PM – 8:00 PM
Short Course Reception

Please join us for light refreshments in the California Ballroom while renewing old acquaintances. The registration desk will be open from 4:00 PM to 9:00 PM, so take advantage of this opportunity to register early. Feel free to explore parts of the conference area and the atrium in the South Wing.

Monday, July 20
6:30 PM – 9:30 PM
Surf City, USA
Conference Reception

In the California Ballroom, conference attendees and their families and guests are invited to get together, renew acquaintances and have a good time in the atmosphere of Southern California beach town tunes. From 6:30 to 9:30 PM enjoy a complimentary buffet of a variety of international delights: Italian pasta, Mexican fajitas, turkey, smoked beef and gourmet desserts. Dress is casual.

Tuesday, July 21
9:00 AM – 3:00 PM
**Spanish Mission and
Laguna Beach Tour**
Companion Event

Mission San Juan Capistrano, long-famous for its annual migration of the swallows in March, is a unique California landmark just south of Laguna Beach. Father Junipero Serra founded the mission in 1776, the seventh in a chain of Franciscan missions built along the California coast from San Diego to San Francisco. The church, graced with a massive belfry and seven domes, was dedicated in 1806 – only to be reduced to rubble six years later by a severe earthquake. The new church, a replica of the original, contains a chapel, remnants of an 18th-century Spanish encampment and other historical points of interest. Stroll through the mission courtyard and exhibits with a Mission docent and catch a glimpse of early California life. From Mission San Juan Capistrano, buses will provide transportation to Laguna Beach. Peruse the arts and craft exhibits and grab a bite to eat on your own between 12 and 3 PM. Laguna Beach has a long history as an art colony with some of the most picturesque beaches and landscapes in the world. Buses leave the hotel about 9 AM and return about 3 PM. Adults/Children (Ages 3–13): \$15 (Early)/\$22 (Late). Children under three years old are free.



Susan Hunt
*Companion Event
Coordinator*



Photograph courtesy of Newport Beach CVB



Wednesday, July 22

12:30 PM – 10:30 PM

**Catalina Island
Beach Bash**

Conference Social

We will be whisked across the Pacific from Newport Beach on the Catalina Flyer boat. Upon arrival, the island staff will greet us. Prior to heading to the Desconso Beach Club where the beach party will begin at 5:30 PM, one can explore the natural surroundings of Catalina Island. Walk or rent a bicycle or a golf cart to get around and explore the town of Avalon, tour the Catalina Island Casino landmark, or take a trip on a glass-bottom boat (reservations required for boat tours, call (310) 510-TOUR or (310) 510-2888). Between 5:30 and 8:30 PM there will be a barbecue dinner at the Desconso Beach Club, just past the Casino outside the town of Avalon. So party down and dance the evening away with the best surfin' tunes in the incredible Catalina Island environment. Casual dress and shoes are recommended. One can bring beach clothes. There is a slide and swing area for children to play and a volleyball area. However, bring a warm jacket because it may be cool when the boat returns in the evening. Transportation will be provided, leaving the hotel between 12:30 and 1:30 PM. The Catalina Flyer will leave Newport Harbor sharply at 2 PM and provide the return, leaving Avalon at 9 PM sharp. Please note that the Catalina Flyer has a capacity of 500 passengers. Tickets will be sold on a first come, first served basis. Make your reservations early! Adults: \$30 (Early)/\$37 (Late), Children: (Ages 3-13) \$12 (Early)/\$20 (Late). Children under three years old are free.



Photograph courtesy of Newport Beach CVB

Thursday, July 23

10:30 AM – 3:30 PM

**Queen Mary
Ocean Liner Luncheon**

Companion Event

Come aboard for a wonderful day of history and exploration on the grandest ship that ever sailed the ocean during World War II, the Queen Mary. You will be greeted by the ship's officer and escorted to the Royal Salon on the Promenade Deck for a slide presentation of the Queen Mary's wonders. This will be followed by an elegant meal. Following the luncheon, explore the ship from bow to stern on your own or purchase a guided tour. Enjoy the panoramic view of Long Beach and browse through colorful boutiques, both aboard the ship and ashore in the Queen's Marketplace in search of unusual gifts and souvenirs. Dress casually. Buses will leave the hotel at 10:30 AM and will return about 3:30 PM. Adults/Children (Ages 3-13): \$25 (Early)/\$32 (Late). Children under three years old are free.

**ACTIVITIES
CANCELLATION
POLICY**

To encourage advance registration for conference social activities, we will refund all activity fees for conference attendees and/or their companions who for any reason are unable to attend the conference. If your plans change after your activities registration form is submitted, to receive a refund you must notify ETC Services by FAX at (303) 741-5890 (do not FAX changes after Thursday, July 16) or notify the conference desk when picking up your registration materials (**but no later than 24 hours before the scheduled activity**).

Local Activities

GENERAL INFORMATION

Possessing a charming and relaxing atmosphere, Newport Beach is located along the beautiful Pacific Ocean in Orange County, California. The city is nestled south of Los Angeles, north of San Diego and southwest of Disneyland in Anaheim, and adjacent to John Wayne/Orange County Airport. The Mediterranean climate of balmy days and cool evenings provides a perfect year-round backdrop for an exciting IEEE NSREC and a family vacation. Surrounded by one of the largest small-boat harbors in the world and lazily stretching itself along more than six miles of scenic Pacific coastline, you'll soon discover why Newport Beach is called "The Colorful Coast."

Lido Marina Village

Located along the Newport Beach harbor, Lido Marina Village resembles a European open-air marketplace consisting of 35 shops. Browse through the art galleries, cafes and restaurants along the boardwalk. Relax with an espresso and German strudel and watch the sailboats head out to sea.

Balboa Peninsula

This is the place to be for those who enjoy outdoor activities. You can rent a bicycle or a pair of skates and cruise the boardwalk by the Balboa Bay beach. Visit the Fun Zone, a popular amusement center that includes a Ferris wheel, merry-go-round and arcade games. Treat yourself to excellent waterfront dining on the Balboa Peninsula, or visit the Balboa Pavilion landmark.

Fashion Island

Overlooking the beautiful Pacific Ocean, Fashion Island is located across the street from the conference hotel and contains over 200 stores and restaurants. Shops include Neiman Marcus, Bullock's, Bloomingdales, The Broadway, and Robinsons-May. Relax by the fountains and visit the Atrium Court, featuring more than 50 unique shops and a gourmet supermarket offering fine prepared international foods.



Photograph courtesy of the Newport Beach CVB

South Coast Plaza

Located in Costa Mesa, along Interstate 405 north of Newport Beach, South Coast Plaza is one of Southern California's largest outlet malls. It has a Bullock's, I. Magnin, Nordstrom, Robinsons-May, Saks Fifth Avenue, Sears, and many other fine retailers.

Disneyland

The Disneyland theme park is nicknamed "The Happiest Place on Earth." Disneyland encompasses more than 60 major attractions for the family. Some of the areas include Tomorrowland, Frontierland, Fantasyland, Adventureland, Critter Country, Mickey's Toontown and New Orleans Square. Located about 30 minutes from the hotel. Come see Mickey Mouse and all his friends! For hours, check at (714) 999-4565.

Knott's Berry Farm

Beginning as a humble roadside berry stand, Knott's Berry Farm, the oldest independent amusement park in the country, now offers 150 acres of family fun, with five theme areas featuring 165 rides, shows and attractions. There's Camp Snoopy for the little ones, and Boomerang, Montezuma's Revenge and Big Foot Rapids for all thrillseekers. Approximately 45 minutes from the hotel. Extended summer hours. (714) 220-5200.

Universal Studios

Universal Studios takes visitors behind the scenes of major films. A narrated tram tour shows where and how movies are made; see props, sound stages, sets and demonstrations of special effects, including a simulated earthquake of magnitude 8.3. Highlights include the "Back to the Future" and "Jurassic Park" rides and "Backdraft," a simulation of being trapped in a fiery inferno. Open daily at 9 AM. (818) 622-3801.



Big Corona Beach

What would a trip to Southern California be like without a day at the beach? Corona del Mar is the perfect beach for a family outing. Pack the beach ball and proceed south on Pacific Coast Highway and turn right on Marguerite. Proceed two blocks to Ocean Boulevard. Turn right at the stop sign and follow the signs to the Corona del Mar Main Beach entrance. A great snorkeling spot, this large family beach has fire rings, picnic tables, volleyball courts, snack bar, restrooms and showers. (714) 644-3044.



Photograph courtesy of the Newport Beach CVB

Wild Rivers Waterpark

With more than 40 exciting rides and attractions for all ages, expect a wet, fun-filled day at Wild Rivers, Orange County's largest waterpark. Plunge down the five-story Wild River Mountain, bodyboard at Thunder Cove, or challenge The Abyss, a one-minute adventure down a dark, enclosed water tube. For directions and hours, call (714) 768-9453.

Roger's Gardens

Roger's Gardens astounds the eyes and awakens the senses with its seven-and-a-half acres of perfectly manicured growing grounds, replete with blooming flowers, hanging plants, colorful shrubs, and majestic trees. This magnificent nursery contains an amphitheater, art gallery, patio furnishings, statues and pottery, antiques, and a full-service florist. Free weekly gardening seminars. (714) 640-5800.

Huntington Library, Art Collections, and Botanical Gardens

The Huntington Library houses one of the world's great collections of rare books and manuscripts, including a Gutenberg Bible, the Ellesmere Chaucer, and Benjamin Franklin's autobiography in his own handwriting. The art gallery contains 18th-century British and European paintings, rare tapestries, sculptures, and porcelains. The botanical gardens cover 150 acres and 14,000 varieties of plants, shrubs and trees. (818) 405-2141.

Richard Nixon Library and Birthplace

Discover the museum honoring America's 37th President, where dramatic presentations, exhibits, statuary, never-before-displayed photographs, and treasured memorabilia illuminate Richard Nixon's private and public life. Features 9 acres of galleries, gardens, theaters and the restored Birthplace of Richard Nixon. Open daily 10 AM – 5 PM; Sunday 11 AM – 5 PM. (714) 993-3393.

J. Paul Getty Center

This museum houses collections of Greek and Roman antiquities; pre-20th-century European paintings, drawings, sculpture and decorative arts; illuminated manuscripts; and 19th- and 20th-century American and European photographs. Architecture and garden tours are offered daily. Parking reservations are required. Open daily at 11 AM. (310) 440-7300.



Sherman Library and Gardens

Occupying more than two acres in Corona del Mar, the Sherman Library has provided one of the country's most impressive cultural and educational research centers devoted to the Pacific Southwest for the last 100 years. The gardens, accented by fountains and sculptures, showcase more than 2,000 plant species, ranging from rare desert cacti to exotic tropicals. The ultra-modern conservatory houses tropical specimens and a koi pond. The Discovery Garden, specially designed for those with impaired vision, appeals to the sense of touch and is wheelchair accessible. The gardens are open daily, and the library is open on weekdays. (714) 673-2261.

Wild Animal Park

About two hours south of the hotel, the Wild Animal Park provides an excellent opportunity to see wild animals roam freely in settings resembling their native homelands. The park has over 1,800 acres of sanctuary to see. The park includes animal shows, botanical gardens, a hidden jungle and the Wgasa Bush Line Monorail tour. Open 9 AM daily. 35 miles north of downtown San Diego, near Escondido. Take the Via Rancho Parkway exit off Interstate 15 and follow the signs to the Park. (619) 234-6541.

San Diego Zoo

While you're in the area, this is a perfect chance to check out the world-renowned San Diego Zoo. The zoo has over 4,000 rare birds, mammals, reptiles and amphibians in 100 acres of award-winning gardens. Each day the zoo offers many entertaining tours and shows. Located in Balboa Park, off Park Blvd. From Interstate 5 South, take the Pershing Drive exit. Open 9am daily. (619) 234-3153.

Golf Courses

If you're a golfer, then don't forget to pack those clubs, Newport Beach is a great place to hit the links! There are several outstanding courses in the area, below is a partial listing:

Hyatt Newporter: For a quick round of golf, try this conveniently-located 9-hole par 3. 1107 Jamboree Road. (714) 729-1234.

Newport Beach Golf Course: This 18-hole executive course has a driving range and is open nightly for golfing under the stars. (714) 852-8681.

Pelican Hill Golf Club: Two courses offer 18-hole championship play. Each course presents breathtaking canyon and ocean vistas. (714) 759-5190.



Photograph courtesy of the Newport Beach CVB

WEATHER AND CLOTHING

The Mediterranean climate of balmy days and cool evenings provides an average year-round temperature of 70°F (21°C). In July the low is typically around 62°F (17°C) and the high is around 80°F (27°C). Comfortable and casual best describes the appropriate attire for Southern California. A sweater or light jacket is suggested for the evenings, and remember to bring comfortable shoes for exploring the area's fine attractions.

1998 Conference Committee



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1999 IEEE NUCLEAR AND SPACE RADIATION EFFECTS CONFERENCE Short Course and Radiation Effects Data Workshop



**July 12-16, 1999
Norfolk Waterside Marriott
Norfolk, Virginia**

The 1999 IEEE International Nuclear and Space Radiation Effects Conference will be held July 12-16 in Norfolk, Virginia at the Norfolk Waterside Marriott. The Conference features a technical program consisting of eight to ten sessions of contributed papers describing the latest observations in radiation effects, an up-to-date Short Course on radiation effects offered on July 12, a Radiation Effects Data Workshop, and an Industrial Exhibit. The technical program includes oral and poster sessions. We welcome again the Conference on High Energy Radiation Background in Space (CHERBS), which will be held jointly with the NSRE Conference this year. The CHERBS sessions will be presented in parallel with the NSREC sessions.

Papers describing nuclear and space radiation effects on electronic and photonic materials, devices, circuits, sensors, and systems, as well as semiconductor processing technology and techniques for producing radiation-tolerant (hardened) devices and integrated circuits, will be presented at this meeting of engineers, scientists, and managers. International participation is strongly encouraged.

We are soliciting papers describing significant new findings in the following or related areas:

Basic mechanisms of radiation effects in electronic materials and devices

- Ionizing radiation effects
- Materials and device effects
- Displacement damage
- Single-event charge collection phenomena and mechanisms
- Radiation transport, energy deposition, and dosimetry
- Processing-induced radiation effects

Radiation effects on electronic and photonic devices and circuits

- MOS, bipolar, and III-V technologies
- SOI and SOS technologies
- Optical and optoelectronic sensors and transmitters
- Methods for hardened design and manufacturing
- Modeling of devices, circuits, and systems
- Particle detectors and associated electronics for high-energy accelerators
- Cryogenic temperature effects
- Novel device structures, such as MEMs

Space and terrestrial radiation effects

- Single-event phenomena in devices and circuits
- Characterization and modeling of space and terrestrial radiation environments
- Spacecraft charging

Hardness assurance technology and testing

- Testing techniques, guidelines, and hardness assurance methodology
- Radiation exposure facilities

New developments of interest to the radiation effects community

Papers in the areas of "Terrestrial Radiation Effects" and "Commercial Space Systems" are especially encouraged.

PAPER SUMMARY DEADLINE: FEBRUARY 3, 1999

Procedure for Submitting Summaries:

Authors must conform to the following requirements:

1. Submit 12 copies of (a) an abstract no longer than 35 words attached to (b) an informative summary (appropriate for a 12-minute presentation). The summary must furnish sufficient details to permit a meaningful review and clearly indicate (a) the purpose of your work, (b) significant results, and (c) how your work advances the state of the art.
2. The summary should be no less than two nor more than four pages in length, including figures and tables. *All figures and tables must be large enough to be clearly read.* Note that this is more than an abstract, but *do not exceed four pages.*
3. Type your summary using 11 point or greater type on either U. S. Standard, 8.5 in. (21.6 cm) x 11 in. (27.9 cm), or A4, 21 cm x 29.7 cm, white paper, with 1 in. (2.5 cm) margins on all four sides. Please include title, names and company affiliations of the authors, and company address (city and state). Underline the name of the author presenting the paper.
4. Obtain all corporate, sponsor, and government approvals and releases necessary for presenting your paper at an open-attendance international meeting.
5. Include a cover letter giving (a) the names, complete addresses, and telephone and FAX numbers of all authors, and (b) the session that you prefer for presentation (if you have a preference). *Authors are also encouraged to state their preference for an oral or poster presentation in the conference, or a poster at the data workshop.* However, the final category of all papers will be determined by the Technical Program Committee, which is responsible for selecting final papers from initial submissions.

Papers accepted for oral or poster presentation at the Conference will be eligible for publication in the Conference issue of the *IEEE Transactions on Nuclear Science* (December 1999), based on a separate submission of a complete paper, and subject to an independent review after the Conference. Further information will be sent to prospective authors upon acceptance of their NSREC summary. It is not necessary to be an IEEE member to present a paper or attend the NSREC. However, we encourage IEEE membership of all NSREC participants.

Radiation Effects Data Workshop: The Radiation Effects Data Workshop is a forum for papers on radiation effects data on electronic devices and systems. Workshop papers are intended to provide radiation response data to scientists and engineers who use electronic devices in a radiation environment, and for designers of radiation-hardened systems. Papers describing new simulation or radiation facilities are also welcomed. The procedure for submitting a summary to the Workshop is identical to the procedure for submitting NSREC summaries. Radiation Effects Data Workshop papers will be published in a Workshop Proceedings and are not candidates for publication in the Conference issue of the *IEEE Transactions on Nuclear Science*.

Conference on High Energy Radiation Background in Space (CHERBS): CHERBS is sponsored by the IEEE/NPSS Radiation Effects Committee, Goddard Space Flight Center and Constellation Technology Corporation. Further information can be obtained from Pam Solomon, Code 690.2, NASA Goddard Space Flight Center, Greenbelt, MD 20771; Phone (301) 286-8797; FAX: (301) 286-1681; E-mail: pamela.solomon@gsfc.nasa.gov, or visit the CHERBS website at leptm.gsfc.nasa.gov/cherbs99.html.

Norfolk: Founded in 1682, Norfolk is a city with a proud history. You can feel the grandeur of the past in the city's graceful architecture. But more importantly, you can feel the spirit of its future. Over the years the downtown skyline has evolved into something spectacular, featuring a festival marketplace, high-rise office buildings, a major hotel-convention center complex, a national maritime center and a Triple A league baseball stadium. Known as Tidewater and The Virginia Waterfront, this region is also called Hampton Roads by mariners across the world — all due to the community's essential connection to the water. Throughout Norfolk the energy that comes with positive change is apparent. You can feel it: in a walk through the six-acre, bay front Ocean View Park; in a visit to Virginia's largest zoo; at a picnic in Botanical Garden; and in any of Norfolk's fine neighborhoods. Harbor tours, museums, beaches, a botanical garden, the city zoo, restaurants, historic homes, the Virginia Waterfront International Arts Festival and shopping will fill your days and nights here in Norfolk. Choose to explore Nauticus, the National Maritime center, a hands-on family attraction that will teach you how to build a ship, gather treasures from the ocean floor and offers dozens of interactive exhibits. Norfolk's Naval Base is the largest naval installation in the world. It's the home port of more than 100 ships.

The conference hotel, the Marriott Waterside, is located adjacent to the Waterside area, just a few minutes walk from several major city attractions and 15 minutes from the airport.

More detailed tourist information is available on-line at: <http://www.vgnet.com/norfolk/> or <http://www.norfolk.va.us/>

Please visit the NSREC web site for more conference information

www.ieee.org/nps/nsrec/nsrec.html

Summaries (12 copies) must be received by February 3, 1999.

Address them to:

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Photo courtesy Norfolk CVB

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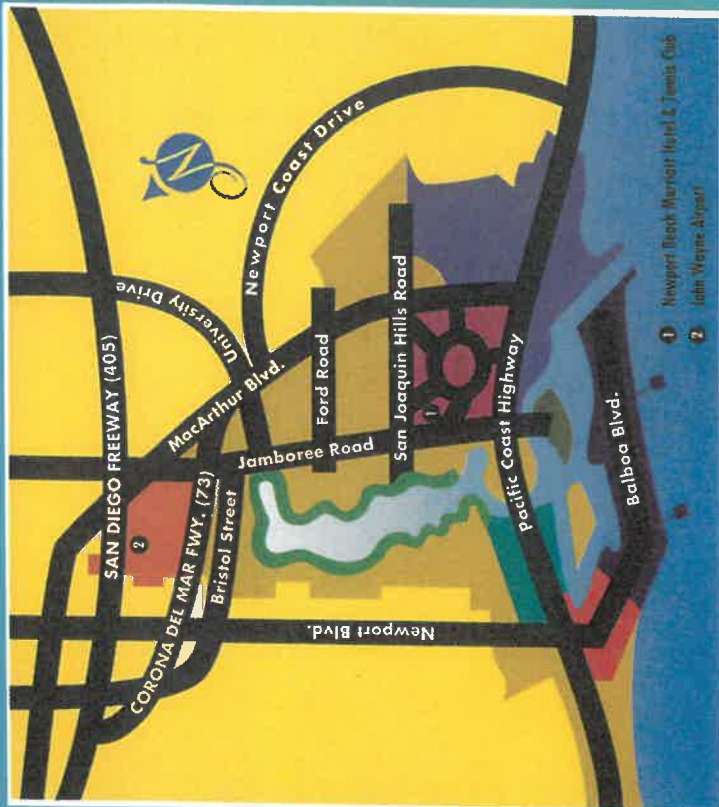
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