

# 42nd ANNUAL INTERNATIONAL NUCLEAR & SPACE RADIATION EFFECTS CONFERENCE

July 11 ~ 15, 2005

Sheraton Seattle Hotel and Towers

Seattle, Washington



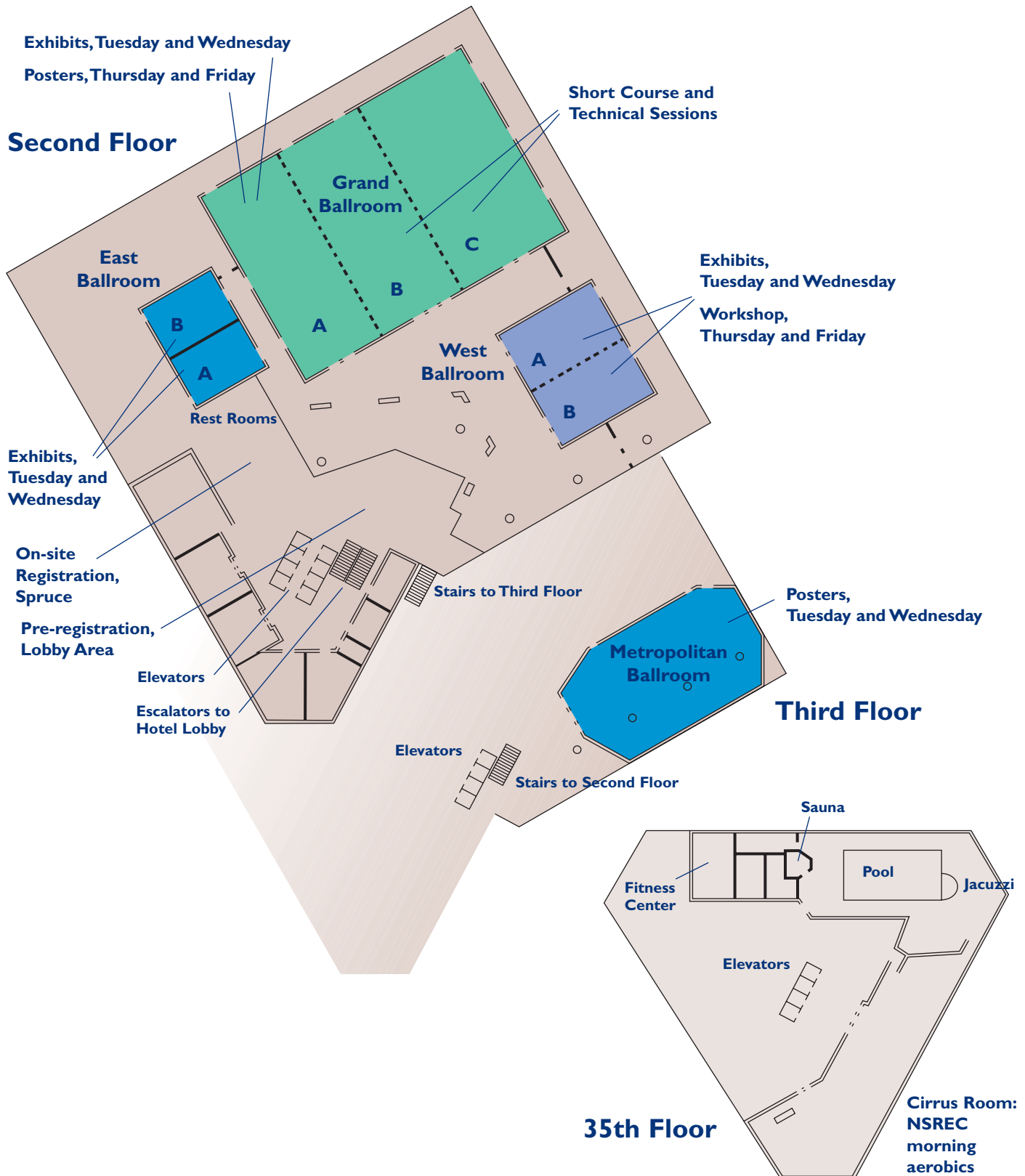
Sponsored By IEEE/NPSS Radiation Effects Committee



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NASA Electronic Parts Program • Jet Propulsion Laboratory

# Conference Facilities

## Sheraton Seattle Hotel & Towers



# Schedule

Time	Monday July 11	Tuesday July 12	Wednesday July 13	Thursday July 14	Friday July 15
7:30	[7:30] Continental Breakfast, Grand Ballroom A	[7:30] Continental Breakfast, Lobby Area	[7:30] Continental Breakfast, Lobby Area	[7:30] Continental Breakfast, Lobby Area	[7:30] Continental Breakfast, Lobby Area
8:00	[8:00] <b>Short Course Introduction</b> Allan Johnston Grand Ballroom B and C				
8:15	[8:15] <b>Part 1 – Device Scaling and Interpretation of the Semiconductor Roadmap</b> Scott Thompson	[8:15] <b>Conference Opening</b> Grand Ballroom B and C	[8:15] <b>Invited Talk The 2004-2005 Eruption of Mount St. Helens: What Next?</b> Stephen D. Malone Grand Ballroom B and C	[8:30] <b>Invited Talk The Hubble Telescope's Top Ten Scientific Discoveries</b> Mario Livio Grand Ballroom B and C	[8:15] <b>Invited Talk Optimizing the Performance of Organic Electro-Optic Materials for Space Applications</b> Larry R. Dalton Grand Ballroom B and C
8:30					
9:00		[8:55] <b>Session A Single-Event Effects: Mechanisms and Modeling</b>	[9:20] <b>Session E Radiation Effects in Devices and Integrated Circuits</b>	[9:35] <b>Session H Dosimetry and Facilities</b>	[9:20] <b>Data Workshop West Ballroom</b>
9:30	[9:45] Break, Lobby Area		[9:55] Break, Grand Ballroom A, East and West Ballrooms		
10:00	[10:15] <b>Part 2 – Single-Event Effects in Advanced CMOS Technology</b> Robert Baumann	[10:00] Break, Grand Ballrm A, East and West Ballrooms	[10:20] <b>Session E (continued)</b>	[10:25] Break, Lobby Area	
10:30		[10:30] <b>Session A (continued)</b>			
11:00				[10:50] <b>Session I Hardness Assurance</b>	
11:30					
12:00	[11:45] Short Course Luncheon, Grand Ballroom A and East Ballroom B	[11:45] Lunch	[11:50] Lunch	[11:55] Lunch	[11:50] End of Conference
12:30					
1:00	[1:00] <b>Part 3 – Total Dose Effects in Modern Integrated Circuit Technologies</b> Hugh Barnaby	[1:15] <b>Session B Basic Mechanisms of Radiation Effects</b>	[1:00] <b>Session F Single-Event Effects: Devices and Integrated Circuits</b>	[1:25] <b>Session J Photonics</b>	
1:30					
2:00					
2:30	[2:30] Break, Lobby Area	[2:35] Break, Grand Ballroom A, East and West Ballrooms	[2:35] Break, Lobby Area	[2:30] <b>Poster Session Grand Ballroom A</b>	
3:00	[3:00] <b>Part 4 – Single-Event Transients in Linear Integrated Circuits</b> Steve Buchner	[3:05] <b>Session C Space Radiation Environments and Effects</b>	[3:00] <b>Session G Hardness by Design</b>		
3:30					
4:00		[3:55] <b>Session D Terrestrial and Atmospheric Radiation Environments and Effects</b>	[4:05] End of Session		
4:30	[4:30] Wrap-up		[4:30 to 10:15] Conference Social <b>Tillicum Village Cruise and Show</b>		
5:00	[4:45] Exam (for students requesting CEU credit only)	[4:45] End of Session		[5:00] End of Session	
5:30	[5:15] End of Short Course			[5:15 to 6:30] Radiation Effects Committee Open Meeting Grand Ballroom B and C	
6:00		[6:00 to 10:00] Industrial Exhibits Reception 6:00 Cocktails 7:00 Buffet Grand Ballroom A and East and West Ballrooms			
6:30					
7:00					

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# Chairman's Invitation



*"Welcome to Seattle! Many thanks to the volunteers, authors, exhibitors and attendees who have made the IEEE NSREC such a stimulating and essential meeting for those working in the field of radiation effects."*

Fred Sexton  
General Chairman

On behalf of the IEEE Nuclear and Plasma Sciences Society Radiation Effects Committee, I invite you to attend the 42nd annual IEEE Nuclear and Space Radiation Effects Conference (NSREC). This year's conference will be held at the Sheraton Hotel and Towers in downtown Seattle, WA, July 11-15, 2005. We 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. Engineers, scientists, managers, and other interested parties from around the world will attend. Some highlights of the Conference are given below; complete details are provided in this booklet. Additional information on the conference is available on the Web at <http://www.nsrec.com>.

The Technical Program Chairman, Mike Xapsos (NASA/GSFC), and his program committee, have assembled an excellent set of contributed papers that are arranged into ten sessions of oral and poster papers, and a Radiation Effects Data Workshop. The Workshop consists of papers emphasizing radiation effects data on electronic devices and systems and descriptions of new simulation and radiation test facilities. In addition, there are three outstanding invited talks of general interest to both conference attendees and their companions.

Allan Johnston (JPL) has organized this year's Short Course with a theme of "Evolving Issues for the Application of Microelectronics in Space." The Short Course is an excellent learning opportunity to those who are new to the Radiation Effects community and need a quick introduction to the field, as well as those who want to stay abreast of current issues. The Short Course will start with Monday morning sessions devoted to the International Semiconductor Roadmap, and a tutorial on Terrestrial Radiation Effects. Afternoon sessions will focus on Total Dose Effects in Modern Integrated Circuits and Single Event Transients in Linear Integrated Circuits. Attendees can earn Continuing Education Credits at the conclusion of the Short Course.

This year's Industrial Exhibit, organized by Nazik Maloyan (International Rectifier), will permit one-on-one discussions between conference attendees and exhibitors on the latest developments in radiation-hardened and radiation-tolerant electronic devices, radiation analysis and testing services, and radiation test facilities and equipment. On Tuesday evening, attendees and their companions are invited to a reception that showcases the Industrial Exhibit.

Social events have been planned to give Conference attendees and their guests many opportunities to informally discuss radiation effects and to become better acquainted. Kay Jobe (Boeing Space Systems), this year's Local Arrangements Chairman, has put together a memorable social program. The Wednesday evening social is a visit to Tillicum Village on Blake Island, where attendees will sample authentic local cuisine and be entertained by dances and songs recounting the history and tradition of the Native American culture. There will also be time for exploring the island before returning to the conference hotel. We strongly encourage you to register as early as possible for the social events since some of them are limited in the numbers we can accommodate.

Seattle, with its combination of water, hills, and lush greenery set against a backdrop of distant mountains, is one of America's most spectacular urban areas. This easily accessible and pedestrian-friendly city has numerous fine restaurants, interesting museums, and a vigorous arts scene in the downtown area. Unique attractions draw visitors and locals alike, such as the Pike Place Market, featuring the famous "flying fish," the Experience Music Project, a Paul Allen hands-on museum of rock-and-roll, and the Space Needle, which offers a 360° view of the city and its environs. Cycling and walking trails interlace the urban area, and local ferries interconnect nearby islands, providing yet another fun and unique way to tour the area. There are many other attractions that are within easy driving distance.

We are excited about this year's conference and look forward to seeing you in Seattle!

# Short Course Program

## EVOLVING ISSUES FOR THE APPLICATION OF MICROELECTRONICS IN SPACE

### GRAND BALLROOM B AND C - MONDAY, JULY 11

- 7:30 AM     **REGISTRATION/CONTINENTAL BREAKFAST**
- 8:00 AM     **SHORT COURSE INTRODUCTION**  
Allan Johnston *Jet Propulsion Laboratory*
- 8:15 AM     **PART 1 – DEVICE SCALING AND INTERPRETATION OF THE SEMICONDUCTOR ROADMAP**  
Scott Thompson *University of Florida*
- 9:45 AM     **BREAK (LOBBY AREA)**
- 10:15 AM    **PART 2 – SINGLE-EVENT EFFECTS IN ADVANCED CMOS TECHNOLOGY**  
Robert Baumann *Texas Instruments*
- 11:45 AM    **SHORT COURSE LUNCHEON  
(GRAND BALLROOM A AND EAST BALLROOM B)**
- 1:00 PM     **PART 3 – TOTAL DOSE EFFECTS IN MODERN INTEGRATED CIRCUIT TECHNOLOGIES**  
Hugh Barnaby *Arizona State University*
- 2:30 PM     **BREAK (LOBBY AREA)**
- 3:00 PM     **PART 4 – SINGLE-EVENT TRANSIENTS IN LINEAR INTEGRATED CIRCUITS**  
Steve Buchner *QSS/NASA Goddard Space Flight Center*
- 4:30 PM     **WRAP-UP**
- 4:45 PM     **EXAM (only for students requesting CEU credit)**
- 5:15 PM     **END OF SHORT COURSE**

# Short Course

## **COURSE DESCRIPTION**

This one-day Short Course will address several evolving problems that are important when modern microelectronic devices are used in space. The motivation stems from the rapid evolution of microelectronic device design and manufacturing. This has allowed devices to be designed with very high density, extreme complexity and markedly improved performance. Although those manufacturing trends improve some aspects of radiation hardness, they also raise new issues and concerns that impact their performance in space that have not been addressed in previous short courses at this conference. Much of the material presented in the course will emphasize scaling effects, and the likely effects of continued progression on device scaling on radiation susceptibility in space environments. Four different talks will be presented. The first two talks will be given by experts in the semiconductor industry, providing special insight into scaling effects, technology evolution and soft-error sensitivity of unhardened commercial microelectronics. The pace of change in this industry is affected by economic factors and capitalization costs as well as technical requirements. The last two talks will be given by experts in the radiation effects community, discussing two specific issues – total dose effects and single-event transients in linear circuits – that will include hardened devices as well as commercial devices. This short course will provide a cohesive set of talks for designers, radiation effects engineers, component specialists and other technical and management personnel that are involved in developing space systems. Allan Johnston of the Jet Propulsion Laboratory, the 2005 Short Course Chairman, has organized a highly qualified team of lecturers for these topics. This is a unique opportunity for NSREC attendees to benefit from the expertise of the instructors as well as the in-depth coverage and perspective provided by the short course forum. Each lecturer will develop the core content of their respective topics from initial background material, allowing the course to benefit both new and experienced engineers, scientists and managers. In-depth notes will be provided.

## **CONTINUING EDUCATION UNITS (CEUs)**

For those interested in Continuing Education Units (CEUs), 0.6 CEUs, endorsed by the IEEE and the International Association for Continuing Education and Training (IACET) will be available. The IEEE is an authorized CEU sponsor member of the IACET. IEEE guidelines for CEU credit will be followed. To qualify for CEU credit a person must be a registered attendee of the Short Course and must pass a written examination with a score of 75% or better. The examination will be given after the last segment of the Short Course. It will be open book, consisting of approximately 20 multiple-choice questions covering the material presented in the Short Course. A certificate of completion will be mailed to all students who request and qualify for it.

## **SHORT COURSE CHAIRMAN**



*Allan Johnston  
Short Course Chairman*

**Allan Johnston** received B.S. and M.S. degrees in physics from the University of Washington. He began his career at Boeing Aerospace Corporation, performing research studies on radiation effects in microelectronics and optoelectronics. He joined the Jet Propulsion Laboratory in 1992, where he supervises applied research on radiation effects in microelectronics. His interests include ionization and single-event upset effects in semiconductor devices, with particular emphasis on low dose-rate effects, latchup, applications of advanced technologies in space, device scaling and radiation effects on optoelectronics. He has been the author or coauthor of more than 80 papers in refereed journals. He received the Outstanding Paper award at the IEEE Nuclear and Space Radiation Effects Conference (NSREC) in 1999, Meritorious Paper Awards in 1995 and 1996, and the Distinguished Poster Paper award in 1987. He published invited papers on latchup in the IEEE Transactions on Nuclear Science (TNS) in 1996, on device scaling at the RADECS-1997 and RADECS-2002 Conferences, and on optoelectronics in the TNS in 2003. He has been active in the IEEE Nuclear and Radiation Effects Conference, serving as Short Course Instructor for four conferences, Local Arrangements Chairman, Short Course Chairman, and Awards Chairman. He was Technical Program Chairman for the 1997 NSREC, and General Chairman for the NSREC in 2003. He is a Fellow of the IEEE.



**Scott E. Thompson** was an Intel Fellow, Director of Logic Technology and responsible for next generation process integration, yield and transistor design from 1992 to 2004. Thompson joined Intel in 1992 and worked on Intel's 0.35, 0.25, 0.18, 0.13 and 0.09-micron high performance logic process technologies. Thompson managed Intel's 90 nm strained Si and low k dielectric programs. Thompson and co-workers were the first to publish at the International Electron Device Meeting (IEDM) in 2002 on a 90 nm logic technology which introduced high levels of strain for significant mobility enhancement using SiGe. This 90 nm strained Si logic technology is currently in production on 300 mm wafers to fabricate all of Intel's advanced microprocessors. In 2004, Thompson became a faculty member in the Department of Electrical Engineering at University of Florida. His current research interests are on advance transistors focusing on Strained Si and Ge channel MOSFETs and carbon nanotube transistors. Thompson has authored or co-authored 40 publications and holds 13 patents.

## DEVICE SCALING AND INTERPRETATION OF THE SEMICONDUCTOR ROADMAP

Scott Thompson  
*University of Florida*

Prof. Scott Thompson, University of Florida, will discuss trends in transistor technology for nanoscale devices. The era of simple device scaling is over, with progress now being made via new materials and changes in device structures. The session begins with a discussion of scaling for CMOS logic devices that are expected to be in production during the next five years, including strained silicon, high-k gates and general scaling issues for nano-scale CMOS. Trends and predictions will be compared with the Semiconductor Industry Association Roadmap. This will be followed by a discussion of long-term topics that are ahead of initial projections, as well as some that are off the main stream, but offer high potential for advances in scaling and performance. These include carbon nanotubes, silicon nanowires, and single-electron devices for both logic and memory applications.

### Introduction

#### Mega Trends for Silicon CMOS

#### Fundamentals of CMOS Scaling

- Scaling Factors
- Voltage Limitations
- Short-Channel Effects
- The ITRS Roadmap

#### Silicon Nanotechnology

- Scaling Extended to the Nanometer Regime
- Strained Silicon
- New Structures: Multiple Gates, Fully Depleted CMOS, nanotubes
- Infrastructure and Marketing Realities

#### Scaling Predictions

- CMOS in 2010
- The Next Era: CMOS after 2010

### Summary





**Robert Baumann** received the B.A. (1984) with honors in physics from Bowdoin College and the Ph.D. (1990) in electrical engineering from Rice University, researching ferroelectric process development and integration for opto-electronic applications. He joined Texas Instruments in 1989 where he made significant contributions to the understanding of alpha and neutron effects including the discovery that activation of  $^{10}\text{B}$  in BPSG by low energy neutrons is a significant source of soft errors in advanced technologies. Most of the semiconductor industry has since followed suit, eliminating BPSG from advanced technologies. He is currently a Distinguished Member of the Technical Staff, focused on radiation effects in advanced SRAM and logic devices. Robert was one of the primary authors of the International JEDEC JESD-89 specification that has become the defacto industry standard for radiation effects testing of commercial electronics. Robert co-chairs an SIA experts' panel on radiation effects regarding the International Traffic in Arms Regulations (ITAR) and its potential for inadvertently capturing commercial technologies. Robert was recently elected to Fellow of the IEEE for "For contributions to the understanding of the reliability impact of terrestrial radiation mechanisms in commercial electronics."

## SINGLE-EVENT EFFECTS IN ADVANCED CMOS TECHNOLOGY

Robert Baumann  
*Texas Instruments*

Dr. Robert Baumann, Texas Instruments, will discuss the extensive work done by integrated circuit manufacturers to deal with terrestrial radiation effects from neutrons produced in the upper atmosphere, and alpha particles emitted by materials within integrated circuits and packages. Those issues became relevant more than twenty years ago, and are now mainstream concerns of the commercial electronics industry. He will discuss mechanisms, test structures and test methods used to determine soft-error rates for commercial devices, as well as the JEDEC Test Standard used by manufacturers to measure and validate soft-error rates. The effects of device scaling on soft-error susceptibility will also be discussed. The talk will conclude with a comparison of the environments and issues considered by manufacturers to the more severe environments encountered in space.

### Introduction

#### Effects Causing Soft Errors

- Particle Interactions: LET
- Alpha Particles
- Atmospheric Neutrons

#### Radiation Effects in Devices

- Charge Collection
- Soft Error Effects and Definitions
- SEU, MBU and Functional Interrupts
- Latchup

#### SER Radiation Testing

- Testing Philosophies
- Neutron Testing
- Alpha Particle Testing
- Field Testing

#### Scaling and SER Sensitivity

- Memories
- Logic
- Frequency Effects

#### Mitigation Methods

- Processing
- Error Detection and Correction

#### Redundancy

#### Summary and Conclusions



**Hugh Barnaby** is currently an assistant professor in Electrical Engineering at Arizona State University. His specialties include: semiconductors for hostile environments; analog/mixed signal circuit design and test; device physics and modeling; microelectronic device and sensor design and manufacturing. He received a Ph.D., 2001, and M.S.E., 1999, both in electrical engineering from Vanderbilt University, and a B.A in mathematics from the University of California at Berkeley in 1992. His current research focuses on the analysis, modeling, and experimental characterization of extreme environment (i.e. radiation, low and high temperature) effects on semiconductor devices and integrated circuits. He has served as an active researcher in the radiation effects field for almost 12 years in both industry and academics, presenting and publishing more than 60 papers during this time. Prior to his move to ASU, he was an assistant professor at the University of Arizona, researching a wide range of topics from micro- and bio-electronic device processing and fabrication to analog and mixed signal circuit design and test. Dr. Barnaby, a senior member of the IEEE, also worked as a staff scientist for the microelectronics division at Mission Research Corporation in Albuquerque, N.M., where he performed radiation effects and reliability analysis on VLSI digital and analog/mixed-signal circuits. He was the session chairman for Devices and ICs at this conference in 2002 and on the awards committee in 2003.

## TOTAL DOSE EFFECTS IN MODERN INTEGRATED CIRCUIT TECHNOLOGIES

Hugh Barnaby  
*Arizona State University*

Prof. Hugh Barnaby, Arizona State University, will discuss several key issues associated with deep sub-micron and non-classical devices as well as advanced materials in the space radiation environment. There are, as outlined in the ITRS roadmap, numerous challenges ahead for commercial industry in its effort to track Moore's Law down to the 45 nm node and beyond. While many of the classical threats posed by the space radiation environment have been diminished by aggressive semiconductor scaling, the question remains whether there may be unknown, potentially worse threats, lurking in the deep sub-micron regime. In this course, Dr. Barnaby will provide a basic overview of some of the materials, devices, and designs that are being explored or, in some cases, used today. He will review space radiation threats and how the impact of radiation is characterized. The last part of the course will include a detailed discussion of what we know now about how modern devices and materials respond to radiation and how we may assess, through the use of advanced analysis and modeling techniques, the relative hardness of future technologies.

### Introduction

#### Emerging Materials and Devices

- Advanced CMOS
  - Nanoscale Bulk CMOS
  - Fully Depleted SOI FETs
  - Transport-Enhanced FETs
- Advanced Bipolar Devices
- Non-Volatile Memories

#### Radiation Effects Overview

- The Space Environment
- Total Dose Effects
  - Oxide Trapped Charge
  - Interface Traps
- Displacement Damage

#### Radiation Effects on Modern Technologies

- Radiation Effects on Gate Dielectrics
  - Ultra-Thin Oxides
  - High-K Dielectrics
- Advanced CMOS
- High-Electron Mobility Transistors
- Emerging Non-Volatile Memories

### Summary

# Short Course Monday



**Steve Buchner** received his B.S degree from Princeton University and a Ph.D. in physics from the University of Pennsylvania in 1975, then accepted a post-doctoral appointment at the University of Maryland. In 1977 he joined Martin Marietta Laboratories where he worked in the fields of infrared detectors and radiation effects in integrated circuits. His main effort at Martin Marietta Laboratories was devoted to developing the pulsed laser as a tool for studying single event effects. In 1993 he joined the Radiation Effects Group at the Naval Research Laboratory where he continued his work with the pulsed laser. While at NRL he began to use heavy ions and protons at accelerator facilities to study single events. In 2001 he joined the Radiation Effects and Analysis Group as a contractor at NASA/GSFC in Greenbelt, Maryland. He is currently assigned to various NASA space missions to assist in defining the radiation threat and, where possible, mitigating it. Dr. Buchner has published extensively in the IEEE Transactions on Nuclear Science and has presented numerous papers at conferences.



**Dale McMorrow** received a B.S. Degree in Chemistry from Spring Hill College, Mobile, AL in 1979, and a Ph.D. in Physical Chemistry from Florida State University, Tallahassee, FL in 1984. He joined the technical staff at the Naval Research Laboratory in December 1988. His current research interests include use of ultrafast nonlinear-optical spectroscopic techniques to probe the details of inter-molecular dynamics and excited-state photophysical processes of liquids, solutions, and glasses, and the development, characterization and application of laser-based methodologies for simulating single-event phenomena in microelectronic devices and complex integrated circuits. Recent emphasis has been on characterization of the physical mechanisms responsible for the single-event response of III-V semiconductor devices, and the development of two-photon absorption as a tool for interrogating single-event phenomena. He has authored over 100 papers in refereed journals. Dale has served as a session chair at the IEEE Nuclear and Space Radiation Effects Conference (NSREC) and the Single-Event Effects Symposium, Technical Chair for the Single-Event Effects Symposium, and was awarded the best paper award for NSREC 2003.

## SINGLE-EVENT TRANSIENTS IN LINEAR INTEGRATED CIRCUITS

Steve Buchner

*QSS/NASA Goddard Space Flight Center*

Dale McMorrow

*Naval Research Laboratory*

The final session will discuss transients in linear integrated circuits that are produced when they are exposed to high-energy particles. This is a complex problem that affects many types of hardened linear circuits as well as unhardened commercial devices that are selected and qualified for space applications. Dr. Buchner will discuss mechanisms and circuit-related issues for linear transients, testing methods, and special diagnostic techniques, including the use of pulsed lasers to determine the sensitive regions within complex linear circuits that produce output transients. Examples of the effects of transients in fielded space systems will also be discussed.

### Introduction and Background

#### Analog SET Generation

- Energy Deposition
- Charge Collection
- Circuit Response and Critical Charge

#### SET Simulation via Computer Modeling

- Device Simulators Combined with Circuit Simulators
- Circuit Simulators and Macromodels

#### Experimental Techniques for Measuring ASETs

- Broad-Beam Accelerator Testing
- Focused Ion Beams
- Pulsed Lasers

#### ASET Studies Using a Combinations of Pulsed Laser Tests, Heavy Ion Tests and Simulation

- ASET Dependence on Parasitic Elements
- Long and Short Duration Transients
- Data Presentation

#### ASET Examples

- Op-amps
- Comparators
- Hardness Assurance
- Mitigation Methods

### Summary

# Technical Program

## TECHNICAL INFORMATION



*"The NSREC 2005 technical program will contain the latest developments in the field of nuclear and space radiation effects. This international forum will provide attendees the opportunity for valuable technical and social interactions."*

Michael Xapsos,  
NASA Goddard Space Flight Center,  
Technical Program Chairman

The NSREC technical program will consist of contributed oral and poster papers, three invited papers, and a data workshop. All oral papers will be 12 minutes in length with an additional 3 minutes for questions. The technical sessions and chairpersons are:

- **Space Radiation Environments and Effects**  
*Chair: Ali Mohammadzadeh, European Space Agency / Netherlands*
- **Terrestrial and Atmospheric Radiation Environments and Effects**  
*Chair: Clive Dyer, QinetiQ / England*
- **Basic Mechanisms of Radiation Effects**  
*Chair: Patrick Lenahan, Penn State University*
- **Photonics**  
*Chair: Heidi Becker, Jet Propulsion Laboratory*
- **Dosimetry and Facilities**  
*Chair: Ewart Blackmore, TRIUMF / Canada*
- **Single-Event Effects: Mechanisms and Modeling**  
*Chair: Vivian Zhu, Texas Instruments*
- **Single-Event Effects: Devices and Integrated Circuits**  
*Chair: Kevin Warren, Vanderbilt University*
- **Hardness Assurance**  
*Chair: James Howard, Jackson & Tull Chartered Engineers/NASA/GSFC*
- **Hardness by Design**  
*Chair: Mark Baze, Boeing*
- **Radiation Effects in Devices and Integrated Circuits**  
*Chair: James Felix, Sandia National Laboratories*

## POSTER SESSION

Papers that are most effectively presented visually with group discussion will be displayed as posters from 12:00 PM Tuesday, July 12 through 11:50 AM Friday, July 15. Authors will be available to discuss their work during the Poster Session Thursday, July 14. The poster chair is Joe Benedetto, ATK Mission Research Corporation.

## RADIATION EFFECTS DATA WORKSHOP

Papers in the data workshop are intended to provide radiation response data to scientists and engineers who use electronic and photonic devices and circuits in a radiation environment, and to designers of radiation-hardened systems. Workshop posters can be viewed from 9:00 AM Thursday, July 14 through 11:50 AM Friday, July 15. Authors will be available to discuss their work during the Data Workshop Session Friday, July 15. A copy of the Workshop Record will be mailed to all registered attendees after the conference. The data workshop chair is Mark Hopkins, The Aerospace Corporation.

## INVITED SPEAKERS

Dr. Stephen Malone, Research Professor of Geophysics at the University of Washington and Director of the Pacific Northwest Seismograph Network, will discuss the 2004-2005 eruption of Mount St. Helens and what can be expected next. Astrophysicist Dr. Mario Livio of the Space Telescope Science Institute will present highlights of the Hubble Space Telescope's scientific discoveries. Dr. Larry Dalton, Professor of Chemistry and Electrical Engineering at the University of Washington and Director of the National Science Foundation Science and Technology Center on Materials and Devices for Information Technology Research, will describe performance optimization of organic electro-optic materials for space applications.

## LATE-NEWS PAPERS

A limited number of late news papers will be accepted and included in the Poster Session and the Radiation Effects Data Workshop. The deadline for submission is June 1, 2005. Detailed instructions for submitting a late-news summary to the technical program committee are available on the NSREC website at [www.nsrec.com](http://www.nsrec.com).

# Technical Program Tuesday

GRAND BALLROOM B and C	8:15 AM	<b>OPENING REMARKS</b> <i>Fred Sexton, Sandia National Laboratories, General Chairman</i>
	8:20 AM	<b>AWARDS PRESENTATION</b> <i>Ron Schrimpf, Vanderbilt University, Radiation Effects Steering Group Chairman</i>
	8:50 AM	<b>TECHNICAL SESSION OPENING REMARKS</b> <i>Michael Xapsos, NASA/GSFC, Technical Program Chairman</i>
<b>SESSION A</b>		<b>SINGLE-EVENT EFFECTS: MECHANISMS AND MODELING</b>
	8:55 AM	<b>SESSION INTRODUCTION</b> <i>Chair: Vivian Zhu, Texas Instruments, Inc.</i>
<b>A-1</b>		<b>Direct Measurement of Transient Pulses Induced by Laser Irradiation in Deca-Nanometer SOI Devices</b>
9:00 AM		<i>V. Ferlet-Cavrois, P. Paillet, A. Torres, O. Faynot, C. Jahan, L. Tosti, CEA; D. McMorrow, J. S. Melinger, A. R. Knudson, Naval Research Laboratory</i>
		This paper presents transient responses of 40-50 nm gate length SOI devices under pulsed laser irradiation. Measured transients are very short, about 30 ps, and the collected charge is small compared to older generation devices.
<b>A-2</b>		<b>Variation of Digital SET Pulse Widths and the Implications for Single Event Hardening of Advanced CMOS Processes</b>
9:15 AM		<i>J. Benedetto, P. Eaton, D. Mavis, ATK Mission Research; M. Gadlage, T. Turflinger, NAVSEA Crane</i>
		Single event transient (SET) pulse widths in digital ICs are measured using a variable-delay temporal-latch test structure. We show for the first time that there is a wide distribution of SET pulse widths created.
<b>A-3</b>		<b>Comparison of Heavy Ion and Proton Induced Combinatorial and Sequential Logic Error Rates in a Deep Submicron Process</b>
9:30 AM		<i>M. J. Gadlage, T. L. Turflinger, NAVSEA Crane; P. H. Eaton, J. M. Benedetto, ATK Mission Research</i>
		By comparing data from two test chips, we are able to compare the combinatorial logic error rate to the sequential logic error rate in a simple digital circuit created in a 0.18 $\mu\text{m}$ CMOS technology.
<b>A-4</b>		<b>On-Chip Characterization of Single Event Transient Pulse Widths</b>
9:45 AM		<i>B. Narasimham, V. Ramachandran, B. L. Bhuvu, R. D. Schrimpf, W. T. Holman, L. W. Massengill, W. H. Robinson, Vanderbilt University; A. F. Witulski, J. D. Black, Vanderbilt University Institute for Space and Defense Electronics</i>
		A new on-chip Single Event Transient (SET) test structure has been developed that can autonomously measure the width of random SET pulses. Simulation results show measurement granularity of 65 ps for 0.13 $\mu\text{m}$ technology.

# Technical Program Tuesday

10:00 – 10:30  
GRAND BALLROOM A AND  
EAST AND WEST BALLROOMS

BREAK

**A-5**  
10:30 AM

## **The Contributions of Nuclear Reactions to Single Event Upset Cross-Section Measurements in a High-Density SEU Hardened SRAM Technology**

*K. M. Warren, R. A. Weller, R. A. Reed, D. R. Ball, M. L. Alles, L. W. Massengill, R. D. Schrimpf, M. H. Mendenhall, C. L. Howe, B. D. Olson, Vanderbilt University Institute for Space and Defense Electronics; N. F. Haddad, S. E. Doyle, BAE Systems; D. McMorrow, J. S. Melinger, W. T. Lotshaw, Naval Research Laboratory*

Nuclear reactions are included in the modeling of the SEU response of a SRAM memory using GEANT4-based simulations. A mechanism for low LET, low cross-section SEU measurements is identified.

**A-6**  
10:45 AM

## **Simultaneous SE Charge Sharing and Parasitic Bipolar Conduction in a Highly-Scaled SRAM Design**

*B. Olson, Vanderbilt University; D. Ball, K. Warren, L. Massengill, Vanderbilt University Institute for Space and Defense Electronics; N. Haddad, BAE Systems; D. McMorrow, Naval Research Laboratory*

Single event induced charge sharing with a parasitic bipolar turn-on is seen in a commercially available 0.25  $\mu\text{m}$  10-T hardened SRAM cell. This has significant impact on radiation hardening by design in submicron technologies.

**A-7**  
11:00 AM

## **Simulation Analysis of the Bipolar Amplification Induced by Heavy-Ion Irradiation in Double-Gate MOSFET**

*K. Castellani-Coulié, D. Munteanu, J-L. Autran, Université de Provence, France; V. Ferlet-Cavrois, P. Paillet, CEA/DAM/DIF*

The sensitivity to heavy ions of Double-Gate transistors is evaluated by numerical simulation and compared with Single-Gate Fully-Depleted SOI devices. The influence of various parameters on the bipolar gain is studied to understand downscaling influence.

**A-8**  
11:15 AM

## **Radiation Induced Leakage Current in Floating Gate Memory Cells**

*G. Cellere, A. Paccagnella, Padova University; L. Larcher, Modena and Reggio Emilia University; A. Visconti, M. Bonanomi, STMicroelectronics*

Single ions impacting on thin (10 nm)  $\text{SiO}_2$  layers generate tracks of defects which may result in a RILC effect. We are demonstrating and modeling this phenomenon by using Floating Gate memories and innovative simulation tools.

**A-9**  
11:30 AM

## **A New Back Junction Approach For Reducing Charge Collection in 200 GHz SiGe HBTs**

*G. Niu, H. Yang, M. Varadharajaperumal, Y. Shi, Auburn University; J. Cressler, R. Krishivasan, Georgia Tech; P. Marshal, Consultant; R. Reed, Vanderbilt University*

We present a new back junction approach for reducing SEU-induced charge collection in SiGe HBTs, and demonstrate its effectiveness in a state-of-the-art 200 GHz SiGe HBT using full 3-D device simulation.



# Technical Program Tuesday

## POSTER PAPERS

### PA-1 Rate Predictions for Single Event Effects – Critique II

*E. L. Petersen, Consultant; R. Lawrence, BAE Systems; S.T. Liu, Honeywell;  
L. W. Massengill, Vanderbilt University; P. J. McMarr, D. McMorrow, Naval  
Research Laboratory*

The SEU cross section curve depends on surface, not bulk properties. This fact needs to be included in upset rate calculations and interpretation of laboratory results. A designer understanding these properties can predict upset rates.

### PA-2 A New Single Event Upset Figure of Merit

*P. Calvel, A. Luu, C. Barillot, R. Marec, N. Reau, Alcatel Space; E. Normand, Boeing;  
P. Adell, Vanderbilt University; C. Chatry, TRAD; R. Ecoffet, CNES*

This paper provides a new Figure of Merit (FOM) in order to estimate the Single Event Upset (SEU) rate on orbit. Good agreement is observed with calculations performed with the OMERE code.

### PA-3 Prediction of SOI Single-Event Effects Using a Simple Physics-Based SPICE Model

*D. E. Fulkerson, E. E. Vogt, Honeywell*

A one-dimensional model describes the junction currents that determine circuit response to ionizing radiation. The one-dimensional model gives a good fit to two-dimensional and three-dimensional predictions and experimental SEU data.

### PA-4 Straggling and Extreme Cases in the Energy Deposition by Ions in Thin Silicon Layers

*J. Barak, A. Akkerman, Soreq NRC*

Variations in energy deposited by ions in thin silicon layers are calculated using Monte Carlo and convolution methods. For the delta-electrons we use either a detailed spectrum, considering solid state effects, or a semi-analytical spectrum.

### PA-5 Monte Carlo Study of Radiation-Induced Energy Deposition in Scaled Microelectronic Structures

*C. L. Howe, Vanderbilt University; R. A. Weller, R. A. Reed, R. D. Schrimpf,  
L. W. Massengill, K. M. Warren, D. R. Ball, Vanderbilt University Institute for Space and  
Defense Electronics; M. H. Mendenhall, Vanderbilt/Free Electron Laser; K. A. LaBel,  
NASA/GSFC; J. W. Howard Jr., Jackson & Tull Chartered Engineers*

Geant4-based calculations show dramatically different trends in energy deposition for ions having energies near ground test environments versus those found in space. These trends are shown to depend on device geometry and material composition.

### PA-6 The Effect of Metallization Layers on Single Event Susceptibility

*A. S. Kobayashi, D. R. Ball, K. M. Warren, M. H. Mendenhall, R. D. Schrimpf,  
R. A. Weller, Vanderbilt University*

Monte-Carlo radiation transport simulations are used to investigate the effects of metallization layers on the radiation hardness of a memory technology. From statistically significant ensembles, the most interesting events are analyzed using 3-D TCAD simulations.

# Technical Program Tuesday

**PA-7      Coupled Electro-Thermal Simulations of Single Event Burnout in Power Diodes**

*A. M. Albadri, R. D. Schrimpf, D. G. Walker, S. V. Mahajan, Vanderbilt University*

A coupled electro-thermal model is utilized to investigate single-event burnout (SEB) in power diodes. The results indicate that a device may fail catastrophically when radiation-generated carriers cause local heating.

**PA-8      Transient  $V_t$  Shift During Single-Event Particle-Strike and its Impact on SER**

*P. Jain, Texas Instruments, India; R. Baumann, Texas Instruments, Inc.*

We report a transient  $V_t$  shift in transistors of SRAM cell induced because of the single-event particle strike. The  $V_t$  shift, attributed to a transient body-effect, significantly alters the critical time to flip.

**PA-9      Analysis of Angular Dependence of Proton-Induced Multi-Bit Upsets in a Synchronous SRAM**

*N. Ikeda, S. Kuboyama, S. Matsuda, Japan Aerospace Exploration Agency; T. Handa, Computer Software Development Co.*

Angular dependence of proton-induced Multi-Bit Upsets in a synchronous SRAM is reported. Experiments showed that MBU cross section depended on proton energy, incident direction, and physical arrangement of sensitive transistors in adjacent cells.

**PA-10      Single Event Upset-like Fault Injection: a Comprehensive Framework**

*F. Faure, R. Velazco, P. Peronnard, TIMA Laboratory*

An approach to reproduce radiation ground testing results for the study of micro-processor vulnerability to SEU is described in this paper. Resulting cross-sections fit very well with measured ones.

**PA-11      Radiation Induced Breakdown in 1.7 nm Oxynitrided Gate Oxides**

*S. Gerardin, A. Cester, A. Paccagnella, University of Padova; G. Gasiot, P. Roche, P. Mazoyer, STMicroelectronics*

We present new experimental data about the radiation induced breakdown in 1.7 nm gate oxides. A critical account of testing procedures is given. Substrate doping type, bias polarity and area dependence are considered.

**PA-12      A New Analytical Approach to Estimate the Effects of SEUs in Configuration Memory of SRAM-based FPGAs**

*L. Sterpone, M. Violante, Politecnico di Torino, Dip. Automatica e Informatica*

We present an analytical approach to estimate the effects of SEUs in the configuration memory of SRAM-based FPGAs. The approach provides the same accuracy of fault injection and is three orders of magnitude faster.

11:45 AM – 1:15 PM      LUNCH

# Technical Program Tuesday

## **SESSION B BASIC MECHANISMS OF RADIATION EFFECTS**

**1:15 PM** SESSION INTRODUCTION

*Chair: Patrick Lenahan, Penn State University*

### **B-1 NBTI and Radiation Effects in High- $\kappa$ Alternative Dielectrics**

**1:20 PM**

*X. J. Zhou, D. M. Fleetwood, Vanderbilt University; J. A. Felix, Sandia National Laboratories; E. P. Gusev, C. D'Emic, IBM T. J. Watson Research Center*

We report the combined effects of irradiation and negative bias temperature instability (NBTI) for MOS capacitors with high- $\kappa$  dielectrics. Differences in post-irradiation NBTI were observed with differences in materials and irradiation bias.

### **B-2 An Investigation of Electron and Oxygen Ion Damage in Si npn RF Power Transistors**

**1:35 PM**

*A. P. Gnana Prakash, J. D. Cressler, Georgia Institute of Technology*

The effects of 8 MeV electrons, and 60 MeV and 95 MeV oxygen ions on the electrical properties of Si npn RF power transistors have been investigated as a function of fluence.

### **B-3 Proton-Induced Damage in Gallium Nitride-Based Schottky Diodes**

**1:50 PM**

*A. P. Karmarkar, D. M. Fleetwood, R. D. Schrimpf, R. A. Weller, Vanderbilt University; B. D. White, L. J. Brillson, Ohio State University; U. K. Mishra, University of California at Santa Barbara*

Proton irradiation decreases Schottky barrier height and doping concentration and increases ideality factor and series resistance in n-GaN Schottky diodes. 1.0-MeV protons cause greater damage than 1.8-MeV protons. Annealing treatments partially recover the displacement damage.

### **B-4 Verification of Radiation Induced Oxide and Interface Trap Buildup Using Combined Bipolar and MOS Characterization Methods in Gated Bipolar Devices**

**2:05 PM**

*X. J. Chen, H. J. Barnaby, Arizona State University; R. L. Pease, RLP Research; R. D. Schrimpf, Vanderbilt University; D. G. Platteter, NAVSEA Crane; M. R. Shaneyfelt, Sandia National Laboratories*

Using post-radiation bipolar and MOS responses, the radiation-induced oxide defect buildup is estimated for gated bipolar devices. MOS sub-threshold and bipolar gate sweep techniques are employed to estimate the energy distribution of interface traps.

### **B-5 Electrical Stresses on Ultra-Thin Gate Oxide SOI MOSFETs after Irradiation**

**2:20 PM**

*A. Cester, S. Gerardin, A. Paccagnella, University of Padova; E. Simoen, C. Claeys, IMEC*

Accelerated electrical stresses on SOI MOSFETs after heavy ion irradiation produce faster device degradation than in non-irradiated devices, including early gate oxide breakdown, sudden shift of the threshold voltage and larger transconductance decrease.

# Technical Program Tuesday

## POSTER PAPERS

### **PB-1 Radiation Effects in Pentacene Based Thin-Film Transistors**

*G. Theriot, R. Devine, AFRL-VSSE; J. W. Tringe, Lawrence Livermore National Laboratory; E. Brandon, Jet Propulsion Laboratory; L. Zhou, T. N. Jackson, Pennsylvania State University*

Electrical data on irradiated pentacene based field effect transistors is reported. We observe that radiation reduces the effect of voltage time bias on the threshold voltage and on the channel mobility degradation.

### **PB-2 Two-dimensional Methodology for Modeling Radiation-Induced Off-State Leakage in CMOS Technologies**

*I. Sanchez, H. J. Barnaby, Arizona State University; M. L. Alles, Vanderbilt University*

An analytical approach using simple 2D simulations is presented to obtain parameters for the parasitic MOSFET and to estimate the leakage current due to trapped charge in Shallow Trench Isolation used in sub-micron MOSFETS.

### **PB-3 Common Origin for Enhanced Low-Dose-Rate Sensitivity and Bias Temperature Instability Under Negative Bias**

*L. Tsetseris, R. D. Schrimpf, D. M. Fleetwood, Vanderbilt University; R. L. Pease, RLP Research, Inc.; S. T. Pantelides, Vanderbilt University and Oak Ridge National Laboratory*

Existing models do not explain enhanced low-dose-rate sensitivity (ELDRS) in linear bipolar devices at negative oxide electric fields. First-principles calculations suggest hydrogen release in Si can cause both ELDRS and NBTI.

### **PB-4 Criteria for Identifying Radiation Resistant Semiconductor Materials: An Application to Radioisotope Powered Batteries**

*S. R. Messenger, E. A. Burke, SFA, Inc.; G. P. Summers, University of Maryland Baltimore County and Naval Research Laboratory; R. J. Walters, J. H. Warner, Naval Research Laboratory*

We review the concept of "concentration of primary defects" (CPD), evaluate its potential for characterizing the response of different irradiated materials, and propose an alternative which is applied to the design of a radionuclide battery.

2:35 – 3:05 PM

GRAND BALLROOM A AND  
EAST AND WEST BALLROOMS

BREAK

## **SESSION C**

3:05 PM

## **SPACE RADIATION ENVIRONMENTS AND EFFECTS**

### **SESSION INTRODUCTION**

*Chair: Ali Mohammadzadeh, European Space Agency / Netherlands*

### **C-I**

3:10 PM

### **High-Energy Trapped Particle Environments at Jupiter: An Update**

*I. Jun, H. Garrett, Jet Propulsion Laboratory; R. Evans, Gibbel Corporation*

Measurements from particle sensors onboard Galileo - the Energetic Particle Detector (EPD) and the Heavy Ion Counter (HIC) - are used to update models of the energetic trapped electron and heavy ion environments at Jupiter.

# Technical Program Tuesday

- C-2**  
3:25 PM **A Model for Mars Radiation Environment Characterization**  
*A. Keating, LIP and ESA/ESTEC; A. Mohammadzadeh, P. Nieminen, J.-P. Huot, E. Daly, ESA/ESTEC; D. Maia, FCUP; M. Pimenta, LIP and Instituto Superior Técnico*

A model for Mars radiation environment mapping is presented. New features include Geant4 particle transport, time, position, solar longitude, solar cycle modulated cosmic ray and solar particle event spectra, 4-D atmosphere and geology.

- C-3**  
3:40 PM **GRAS: a General-Purpose 3D Modular Simulation Tool for Space Environment Effect Analysis**  
*G. Santin, H. Evans, P. Nieminen, E. Daly, ESA/ESTEC; V. Ivanchenko, CERN*

GRAS (Geant4 Radiation Analysis for Space) is a modular, extendable tool for space environment effect simulation. Analyses include cumulative ionizing and NIEL doses, effects to humans, charging, fluence and transient effects in 3D geometry models.

## POSTER PAPERS

- PC-1**  
**Microdosimetry of the UVPROM experiment on MPTB: Recent Advances in Small Volume Analysis**  
*L. Scheick, Jet Propulsion Laboratory; P. McNulty, Clemson University; B. Blake, Aerospace; D. Roth, JHU/APL*

The final analysis of the UVPROM experiment aboard the MPTB mission is presented. The effects of space radiation are analyzed in terms of overall dosimetry, microdosimetry, extreme value theory, and recently developed image analysis techniques.

- SESSION D**  
3:55 PM **TERRESTRIAL AND ATMOSPHERIC RADIATION ENVIRONMENTS AND EFFECTS**  
SESSION INTRODUCTION  
*Chair: Clive Dyer, QinetiQ / England*

- D-1**  
4:00 PM **Parameterization of Neutron-Induced SER in Bulk SRAMs from Reverse Monte Carlo Simulations**  
*F. Wrobel, P. Iacconi, LPES-CRESA Université de Nice*

We used a reverse Monte Carlo method for calculating SEU cross section. A parameterization of the Soft Error Rate is given as a function of the sensitive volume size and the critical charge.

- D-2**  
4:15 PM **Neutron-Induced Single Event Upsets in Advanced Commercial Fully Depleted SOI SRAMs**  
*J. Baggio, V. Ferlet-Cavrois, P. Paillet, D. Lambert, CEA-DAM/DIF; F. Wrobel, LPES-CRESA Université de Nice; K. Hirose, H. Saito, Institute of Space and Astronautical Science; E. W. Blackmore, TRIUMF*

The SEU sensitivity of 0.2  $\mu\text{m}$  Fully Depleted SOI devices is investigated for proton and neutron irradiations in a large energy range (14-500 MeV). Both measurements and simulations confirm the very low sensitivity of this technology.

# Technical Program Tuesday

**D-3**  
**4:30 PM**      **Measurements of the Atmospheric Radiation Environment from CREAM and Comparisons with Models for Quiet Time and Solar Particle Events**

*C. S. Dyer, F. Lei, A. Hands, S. N. Clucas, QinetiQ*

Flight data on neutron fluxes and dose rates obtained over a wide range of latitudes and altitudes are compared with several models of atmospheric radiation for both quiet-time and solar particle events.

## POSTER PAPERS

**PD-1**      **Neutron-Induced SEU In Bulk SRAMs: Monte Carlo Simulations Including Neutron-Silicon and Neutron-Oxygen Interactions**

*D. Lambert, J. Baggio, V. Ferlet-Cavrois, O. Flament, H. Duarte, CEA; G. Hubert, N. Buard, T. Carrière, EADS; F. Saigne, J. Boch, B. Sagnes, Université Montpellier II; F. Wrobel, LPES-CRESA Université de Nice*

This paper investigates the sensitivity of SRAMs to neutrons. For the first time, the technology sensitivity is analyzed using experiments and Monte Carlo simulations with both n-Si and n-O interactions and diffusion-collection modeling.

**PD-2**      **Conformal Coating for Shielding Against Naturally Occurring Thermal Neutrons**

*J. P. Spratt, R. Leadon, Full Circle Research, Inc.; S. Aghara, NASA Center for Applied Radiation Research; B. Fu, J. D. Lichtenhan, Hybrid Plastics, Inc.*

Calculations and experimental data on the shielding effectiveness of a new conformal coating against thermal neutrons are presented. This coating reduces significantly the thermal neutron threat to COTS ICs in a cost-effective manner.

**4:45 PM**      **END OF TUESDAY SESSIONS**



# Technical Program Wednesday

## INVITED TALK

8:15 – 9:15 AM

GRAND BALLROOM B and C



## The 2004-2005 Eruption of Mount St. Helens: What Next?

*Stephen D. Malone, Ph.D. Research Professor of Geophysics, University of Washington and Director of the Pacific Northwest Seismograph Network*

After 18 years of repose Mount St. Helens again came to life in late September 2004 with an intense earthquake sequence, small explosions and renewed dome growth that continues into 2005. What is going on now at Mount St. Helens is probably very similar to its activity of the past several thousand years, a combination of violent explosions and comparatively mild viscous lava extrusions forming dome complexes. The recent activity provides us with a natural laboratory to study in detail the process of volcanic dome growth and may allow us to better anticipate why and when such activity changes to the far more hazardous explosive phase.

This talk will emphasize the recent activity and the questions arising from it, questions such as the following: How can dome growth be sustained over periods of many months without an obvious source of new magma? Is the very intense sequence of earthquakes before and during dome growth related to fluid interactions or to brittle rock fracturing? What, if any are the signs of this volcano changing its eruptive behavior from benign to dangerous or are we safe for another 100 plus years?

**Dr. Malone** has been studying Northwest volcanoes since the early 1970s when he joined the faculty at the University of Washington following his graduate studies in geophysics at the University of Nevada in Reno. After studying glacier-quakes on Mount Rainier and Mount St. Helens and a thermal transient on Mount Baker this topic came to the forefront in 1980 with the explosive eruptions of Mount St. Helens. Dr. Malone was in charge of the seismic monitoring during and since the beginning of this activity and pioneered the use of volcanic earthquakes to predict eruptions at Mount St. Helens subsequent to the famous one on May 18, 1980. He also studies regular tectonic earthquakes and earthquake hazards, but continues to be fascinated by volcanic earthquakes and participates as a critical member of the US Geological Survey Mount St. Helens monitoring team of the Cascades Volcano Observatory.

Dr. Malone is a member of the American Geophysical Union and the Seismological Society of America, of which he has been vice president and is currently president. He has been vice chairman and chairman of the Council of the National Seismic System and a member of the National Research Council Committee on Seismology. He has contributed chapters to two books on volcano seismology, published over 100 articles in professional journals and has been an associate editor of the Journal of Volcanology and Geothermal Research.

9:15 – 9:20 AM

## Announcements

# Technical Program Wednesday

## **SESSION E** **9:20 AM** **RADIATION EFFECTS IN DEVICES AND INTEGRATED CIRCUITS** **SESSION INTRODUCTION**

*Chair: James Felix, Sandia National Laboratories*

### **E-1** **9:25 AM** **Total Ionizing Dose Effects on Deca-Nanometer Fully-Depleted SOI Devices**

*P. Paillet, V. Ferlet-Cavrois, A. Torres, O. Faynot, C. Jahan, L. Tosti, CEA; M. Gaillardin, S. Cristoloveanu, IMEP-ENSERG*

Total ionizing dose effects are investigated for the first time in deca-nanometer fully-depleted SOI devices. The charge trapping and the influence of device architecture are investigated in transistors with and without external body contacts.

### **E-2** **9:40 AM** **Proton Radiation Effects in Vertical SiGe HBTs Fabricated on CMOS-compatible SOI**

*T. Chen, A. K. Sutton, B. M. Haugerud, J. P. Comeau, M. Bellini, Q. Liang, J. D. Cressler, Georgia Institute of Technology; J. Cai, T. H. Ning, IBM; P. W. Marshall, Consultant; C. J. Marshall, NASA/GSFC*

Proton radiation effects in vertical SiGe HBTs fabricated on CMOS-Compatible SOI are investigated. Proton radiation is found to increase base leakage, delay Kirk effect, increase frequency response, and introduce positive collector-buried oxide interface charge.

**9:55 – 10:20 AM**  
**GRAND BALLROOM A AND**  
**EAST AND WEST BALLROOMS**

**BREAK**

### **E-3** **10:20 AM** **Anomalous Differences Between Gamma and Proton Radiation Damage in 200 GHz SiGe HBTs**

*A. K. Sutton, B. M. Haugerud, A.P. Gnana Prakash, J. D. Cressler, Georgia Institute of Technology; C. J. Marshall, NASA/GSFC; P. W. Marshall, Consultant; R. L. Ladbury, Muñiz Engineering, Inc.; R. Guarín, A. J. Joseph, IBM*

Gamma and proton radiation damage in 200 GHz SiGe HBTs is compared. Damage factor calculations, gain degradation, and excess base current results indicate more collector-base junction damage for gamma, and more emitter-base junction damage for protons.

### **E-4** **10:35 AM** **Effects of Heavy Ion Exposure on Nanocrystal Nonvolatile Memory** *T. R. Oldham, QSS Group, Inc.; M. Suhail, P. Kuhn, E. Prinz, Freescale Semiconductor, Inc.; H. Kim, Muñiz Engineering, Inc.; K. A. LaBel, NASA/GSFC*

Advanced nanocrystal nonvolatile memories have been exposed to heavy ion bombardment. They appear to be promising candidates for future spacecraft electronics.

### **E-5** **10:50 AM** **Charge Loss from Programmed FG Cells Following Irradiation with Different TID Sources**

*G. Cellere, A. Paccagnella, Padova University, A. Visconti, M. Bonanomi, STMicroelectronics; A. Candelori, INFN; S. Lora, ISOF-CNR*

We irradiated programmed floating gate (FG) devices with different radiation sources. The resulting charge loss can degrade the stored information and depends on the irradiation source: strong dose enhancement phenomena were found after X-ray irradiation.

# Technical Program Wednesday

**E-6**  
11:05 AM **Radiation-Induced Off-State Leakage Current in Commercial Power MOSFETs**

*J. A. Felix, M. R. Shaneyfelt, P. E. Dodd, B. L. Draper, J. R. Schwank, Sandia National Laboratories*

Significant increases in the off-state leakage current of p-channel VDMOSFETs are observed after exposure to ionizing radiation. Potential mechanisms related to an increase in the reverse biased leakage current of the gated diode are discussed.

**E-7**  
11:20 AM **Total Dose Performance of a I-V Body-Driven Amplifier Fabricated in a 3.3-V/0.35- $\mu$ m Non-Hardened PD-SOI CMOS Process**

*S. C. Terry, J. D. Vandersand, B. J. Blalock, J. A. Richmond, R. L. Greenwell, S. C. Bunch, University of Tennessee; D. R. Hogue, Boeing, K. G. Merkel, Air Force Research Laboratory*

The performance of a body-driven operational amplifier, irradiated to 500-krad TID, is presented. Measurement results indicate that body driving is a viable design technique for ultra-low voltage ( $< 1$  V), radiation-tolerant analog applications.

**E-8**  
11:35 AM **Arsenic Ion Implant Energy Effects on CMOS Gate Oxide Hardness**

*B. L. Draper, M. R. Shaneyfelt, R. W. Young, R. Dondero, Sandia National Laboratories*

Under conditions that were predicted as "safe" by well-established TCAD packages, radiation hardness can still be significantly degraded by a few lucky arsenic ions reaching the gate oxide during self-aligned CMOS source/drain ion implantation.

## POSTER PAPERS

**PE-1** **Effect of High-Temperature Electron Irradiation in Thin Gate Oxide FD-SOI n-MOSFETs**

*K. Hayama, K. Takakura, H. Ohyama, Kumamoto National College of Technology; J. M. Rafi, Institut de Microelectrònica de Barcelona; A. Mercha, E. Simoen, IMEC; C. Claeys, IMEC and KU Leuven*

The effect of high-temperature electron irradiation in thin gate FD-SOI n-MOSFETs is presented. A detailed pre- and post-irradiation characterization and evaluation of the electrical device performance are discussed taking into account the floating body effect.

**PE-2** **Total Dose Radiation Response of CMOS Compatible SOI MESFETs**

*J. Spann, T. Thornton, J. Yang, A. Balijepalli, H. Barnaby, X. J. Chen, Arizona State University; D. Alexander, W. Kemp, S. Sampson, Air Force Research Laboratory; M. Wood, SPAWAR Systems Center*

The characteristics of SOI MESFETs fabricated using a CMOS process have been measured up to a TID of 5 Mrad(Si). The observed changes are explained in terms of increased fixed oxide charge and trap density.

# Technical Program Wednesday

## **PE-3 The Effects of Proton Irradiation on the Operating Voltage Constraints of SiGe HBTs**

*C. M. Grens, B. M. Haugerud, A. K. Sutton, T. Chen, J. D. Cressler, Georgia Institute of Technology; P. W. Marshall, Consultant; C. J. Marshall, NASA/GSFC; A. J. Joseph, IBM*

We investigate the impact of proton irradiation on operating voltage constraints in SiGe HBTs under several operating bias conditions. Degradation comparisons for different irradiated bias conditions are presented for two SiGe HBT technology generations.

## **PE-4 Capacitive MEMS Switch Measurements and Implications for Radiation Tolerance**

*J. F. Kucko, J. C. Petrosky, Y. K. Yeo, Air Force Institute of Technology; J. R. Reid, Air Force Research Laboratory*

We investigated RF MEMS switches using a novel measurement technique that provides insight to physics responsible for changes in operating characteristics. It is clear these switches are extremely radiation tolerant.

## **PE-5 Displacement Damage Effects on the Forward Bias Characteristics of SiC Schottky Barrier Power Diodes**

*R. D. Harris, M. O. Patton, Analex Corporation; A. J. Frasca, Wittenberg University*

Commercial SiC Schottky barrier power diodes have been subjected to 203 MeV proton irradiation and the effects of displacement damage on the I-V characteristics have been observed. The diodes show excellent resistance to radiation damage.

11:50 AM – 1:00 PM LUNCH

## **SESSION F SINGLE-EVENT EFFECTS: DEVICES AND INTEGRATED CIRCUITS** 1:00 PM SESSION INTRODUCTION

*Chair: Kevin Warren, Vanderbilt University*

### **F-1 Single-Event Upset in Flip-Chip SRAM Induced by Through-Wafer, Two-Photon Absorption** 1:05 PM

*D. McMorrow, W. T. Lotshaw, J. S. Melinger, Naval Research Laboratory; S. Buchner, QSS Group, Inc.; J. D. Davis, R. K. Lawrence, N. Haddad, J. H. Bowman, R. D. Brown, D. Carlton, J. Pena, J. Vaquez, BAE Systems; K. Warren, Vanderbilt University Institute for Space and Defense Electronics; L. W. Massengill, Vanderbilt University*

The single-event upset response of an SEU-immune designed SRAM 10-transistor cell is mapped in two dimensions via carrier injection by two-photon absorption through the back (substrate) surface in the flip-chip mounted device.

### **F-2 Analysis of Single Event Effects in CMOS Devices Using Heavy Ion Microbeam and Ion Electron Emission Microscope Techniques** 1:20 PM

*J. M. Baker, G. K. Lum, L. Robinette, Lockheed Martin Space Systems Company; R. Milanowski, N. Hall, J. Azarewicz, The Titan Corporation; G. Vizkelethy, B. L. Doyle, Sandia National Laboratories*

We present the results and analysis of Single Event Upset (SEU) and Single Event Latchup (SEL) tests using a combination of magnetically focused heavy ion beam and an Ion Electron Emission Microscope (IEEM).

# Technical Program Wednesday

- F-3**  
1:35 PM **Effects of Technology Scaling on the SET Sensitivity of RF CMOS Voltage-Controlled Oscillators**  
*Y. Boulghassoul, L. W. Massengill, A. L. Sternberg, B. L. Bhuva, Vanderbilt University*

We have analyzed single-event transient effects in a high-speed VCO design applicable to mixed-signal RF. Our findings quantify operational-frequency dependence of the circuit sensitivity, yet show ineffective frequency derating for SET mitigation in newer technologies.

- F-4**  
1:50 PM **Investigation of Multi-Bit Upsets in a 150 nm Technology SRAM Device**  
*D. Radaelli, H. Puchner, P. Chia, S. Wong, S. Daniel, Cypress Semiconductor*

MBU results from accelerated SER measurements performed with a mono-energetic neutron beam were investigated in relationship with the memory core P-Well tapping scheme. Tapping effectiveness on SBU and MBU, and “preferred” MBU shapes were analyzed.

- F-5**  
2:05 PM **SEU Induced Error Propagation in FPGAs**  
*K. S. Morgan, D. E. Johnson, B. H. Pratt, M. J. Wirthlin, Brigham Young University; M. P. Caffrey, P. S. Graham, Los Alamos National Laboratory*

This paper characterizes the dynamic cross section of an FPGA in terms of the persistent and non-persistent components. These cross sections are measurable and have been measured for several designs using fault-injection and proton testing.

- F-6**  
2:20 PM **Autonomous Bit Error Rate Testing at Multi-Gbit/s Rates Using a Circuit for Radiation Effects Self Test (CREST)**  
*P. Marshall, Consultant; M. Carts, C. Siedleck, R. Ladbury, Muñiz Engineering, Inc.; S. Currie, B. Randall, K. Fritz, B. Gilbert, The Mayo Foundation; R. Reed, Vanderbilt University; K. Kennedy, C. Marshall, K. LaBel, NASA/GSFC; R. Krithivasan, J. Cressler, Georgia Institute of Technology; D. McMorrow, Naval Research Laboratory; S. Buchner, QSS Group, Inc.*

SEE testing at multi-Gbit/s data rates usually requires sophisticated test equipment and complex set-up for at-speed testing with capture of complex burst error information. We demonstrate a self test circuit implemented in IBM 5AM SiGe.

## POSTER PAPERS

- PF-I**  
**Radiation-Induced Multi-Bit Upsets in SRAM-Based FPGAs**  
*P. Graham, H. Quinn, J. Krone, M. Caffrey, Los Alamos National Laboratory; S. Rezgui, Xilinx Corporation*

This paper provides a methodology for estimating the proton static cross-section for multi-bit upsets (MBUs) in Xilinx FPGAs and describes a methodology for determining MBU effects on TMR-protected circuits. Experimental results are provided.

# Technical Program Wednesday

## **PF-2 SEU Sensitivity of Virtex Configuration Logic**

*M. Alderighi, S. D'Angelo, N. Mancini, G. R. Sechi, IASF-INAF; A. Candelori, INFN; F. Casini, S. Pastore, Sanitas EG, s.r.l.; A. Paccagnella, University of Padua*

A heavy ion radiation test has been performed to evaluate the SEU sensitivity of Virtex configuration logic. Previously unreported failure mechanisms have been observed and classified and their corresponding cross sections measured.

## **PF-3 Complex Upset Mitigation Applied to a Re-configurable Embedded Processor**

*S. Rezgui, C. Carmichael, Xilinx Inc.; K. Somervill, NASA Langley; G. Swift, Jet Propulsion Laboratory; J. George, The Aerospace Corporation*

Soft-core processors implemented in SRAM-based FPGAs, while attractive to spacecraft designers, require upset mitigation. Here we investigate a proposed solution involving two levels of scrubbing plus triple modular redundancy and measure its in-beam efficacy.

## **PF-4 Catastrophic Latchup in a CMOS Operational Amplifier**

*F. Irom, T. F. Miyahira, Jet Propulsion Laboratory*

We report catastrophic single-event latchup results for a CMOS operational amplifier. Thermal and optical imaging and current distribution were used to identify latchup-sensitive regions. We conclude that catastrophic events are because of latchup, not snapback.

## **PF-5 Asymmetric SEU in SOI SRAMS**

*P. J. McMarr, SFA Inc.; M. E. Nelson, K. J. Delikat, US Naval Academy; S. T. Liu, D. Nelson, Honeywell; H. Hughes, Naval Research Laboratory*

Partially depleted 0.15  $\mu\text{m}$  silicon-on-insulator SRAMS were exposed to heavy ions, 14 MeV neutrons and protons. The LET threshold was determined and a comparison between neutron and proton upsets is presented.

## **PF-6 Laser Simulation of Single Event Effects in Pulse Width Modulators**

*A. Chugg, M. Moutrie, R. Jones, MBDA UK Limited; R. H. Sorensen, ESA/ESTEC; S. Mattsson, S. Larsson, Saab Ericsson Space*

Laser testing assists in identifying the sources of PWM SEE sensitivity and reveals new details of PWM SEE behavior, such as enhanced sensitivity during output switching and delayed onset of latch-up near the SEL threshold.

2:35 – 3:00 PM  
LOBBY AREA

**BREAK**



# Technical Program Wednesday

## SESSION G HARDNESS BY DESIGN

3:00 PM

### SESSION INTRODUCTION

*Chair: Mark Baze, Boeing*

**G-1**

3:05 PM

### **A New Total-Dose Effect in Enclosed-Geometry Transistors**

*R. N. Nowlin, S. R. McEndree, A. L. Wilson, ATK Mission Research; D. R. Alexander, Air Force Research Laboratory*

We present data showing a novel total-dose effect in enclosed-geometry transistors. A model for this new effect is described.

**G-2**

3:20 PM

### **Sequential Circuit Design for Radiation Hardened Multiple Supply Voltage Integrated Circuits**

*J. K. McIver III, L. T. Clark, Arizona State University*

Low power radiation hardened sequential circuits supporting multiple  $V_{DD}$  and a low standby power state, with no compromise in speed are presented. The design provides up to 80% energy reduction while maintaining SEE hardness.

**G-3**

3:35 PM

### **HBD Using Cascode-Voltage-Switch-Logic (CVSL) Gates for SET Tolerant Digital Designs**

*M. C. Casey, B. L. Bhuva, L. W. Massengill, Vanderbilt University; J. D. Black, Vanderbilt University Institute for Space and Defense Electronics*

Cascode-Voltage-Switch-Logic family of gates are evaluated for single event environments. Simulation results show excellent SET pulse termination. Novel design approaches are explored combining static and CVSL gate logic for improved radiation tolerance.

**G-4**

3:50 PM

### **Single Event Mitigation in Combinational Logic Using Targeted Data Path Hardening**

*V. Srinivasan, A. L. Sternberg, W. H. Robinson, B. L. Bhuva, L. W. Massengill, Vanderbilt University; A. R. Duncan, NAVSEA Crane*

A technique is proposed to selectively harden complex combinational logic circuits to single event upsets. Propagation paths with sensitive nodes are identified and hardened while minimizing impact on circuit performance.

## POSTER PAPERS

**PG-I**

### **Hardness-by-Design Approach for 0.15 $\mu\text{m}$ Fully Depleted CMOS/SOI Digital Logic Devices with Enhanced SEU/SET Immunity**

*A. Makihara, M. Midorikawa, T. Yamaguchi, T. Yokose, Y. Tsuchiya, T. Arimitsu, HIREC; H. Asai, Y. Iide, H. Shindou, S. Kuboyama, S. Matsuda, Japan Aerospace Exploration Agency*

We designed logic cells hardened for SEUs/SETs using hardness-by-design methodology on OKI's 0.15  $\mu\text{m}$  Fully Depleted CMOS/SOI commercial process and evaluated the sample devices. Excellent hardness was achieved up to LET of 64 MeV/(mg/cm<sup>2</sup>).

# Technical Program Wednesday

## **PG-2 RHBD Techniques for Mitigating Effects of Single Event Hits Using Guard-Gates**

*A. Balasubramanian, B. L. Bhuva, L. W. Massengill, Vanderbilt University; J. D. Black, Vanderbilt University Institute for Space and Defense Electronics*

This paper presents design techniques to mitigate the effect of Single Event Transients (SET) using guard-gates. Design approaches for addressing combinational logic hits and storage cell hits are presented.

## **PG-3 Hardening Low-Power Asynchronous Control Circuits**

*J. Teifel, Sandia National Laboratories*

This paper evaluates techniques to mitigate Single Event Transient (SET) effects in low-power asynchronous control circuits. We compare resistive-hardening methods in a SOI 0.35  $\mu\text{m}$  process and hardened-by-design methods in a CMOS 0.13  $\mu\text{m}$  process.

## **PG-4 HBD Isolation Techniques for Multiple Node Charge Collection Mitigation**

*J. D. Black, M. L. Alles, A. F. Witulski, L. W. Massengill, Vanderbilt University Institute for Space and Defense Electronics; A. L. Sternberg, B. L. Bhuva, Vanderbilt University; J. Benedetto, ATK Mission Research*

A 3-dimensional TCAD model is designed to measure charge collection at multiple nodes in a common well. Guard contacts are shown to mitigate the charge collection and to more quickly restore the well potential.

## **PG-5 Accurate SPICE Models for CMOS Analog Radiation-Hardness-by-Design**

*C. L. Champion, Teradyne, Inc.; G. S. La Rue, Washington State University*

A new accurate modeling technique provides SPICE models for edgeless and other FETs for analog radiation-hardness-by-design. Currents, output resistances and capacitances agree well with measured data. Analog design techniques using arbitrary gate geometries are explored.

4:05 PM      END OF WEDNESDAY SESSIONS

# Technical Program Thursday

## INVITED TALK

8:30 – 9:30 AM

GRAND BALLROOM B and C



## The Hubble Telescope's Top Ten Scientific Discoveries

*Mario Livio, Space Telescope Science Institute*

In its fifteen years of operation, the Hubble Space Telescope has allowed us to observe properties of the universe humans have been able to probe, until very recently, only with their thoughts. A brief summary of a few of the highlights of Hubble's discoveries will be presented. A broad range of topics, from the solar system and the lives of stars to supermassive black holes and cosmology will be covered. Those discoveries that have significantly advanced our understanding of the cosmos will be emphasized.

**Dr. Mario Livio** is a senior astrophysicist and former Head of the Science Division at the Space Telescope Science Institute (STScI), the institute which conducts the scientific program of the Hubble Space Telescope. He received his Ph.D. in theoretical astrophysics from Tel Aviv University in Israel, was a professor in the Physics Dept. of the Technion-Israel Institute of technology from 1981 until 1991, and joined STScI in 1991. Dr. Livio has published over 400 scientific papers and received numerous awards for research, for excellence in teaching, and for his books. His interests span a broad range of topics in astrophysics, from cosmology to the emergence of intelligent life. Dr. Livio has done much fundamental work on the topic of accretion of mass onto black holes, neutron stars, and white dwarfs, as well as on the formation of black holes and the possibility to extract energy from them. During the past five years Dr. Livio's research focused on supernova explosions and their use in cosmology to determine the rate of expansion of the universe, and the nature of the "dark energy" that causes the cosmic expansion to accelerate.

In addition to his scientific interests, Dr. Livio is a self-proclaimed 'art fanatic' who owns thousands of art books. In the past few years, he combined his passions for science and art in three popular books: "The Accelerating Universe," which appeared in 2000, "The Golden Ratio," which appeared in 2002, and "The Equation that Couldn't Be Solved," that will appear in September 2005. The first book discusses 'beauty' as an essential ingredient in fundamental theories of the universe. The second tells the story of the amazing appearances of the peculiar number 1.618... in nature, the arts, and psychology. The third book explores the role of symmetries in human perception, in science, in visual arts and music, and even in the selection of mates. Dr. Livio lectures very frequently to the public. He has given 15 full-day seminars to the public at the Smithsonian Institution in Washington D.C. During the past four years he has given public lectures at the Hayden Planetarium in New York, The Maryland Institute College of Art, the Cleveland Museum of Natural History, the Berlin Planetarium, and the Edinburgh Planetarium, among many others. His book "The Golden Ratio" has recently won him the "Peano Prize" for 2003, and the "International Pythagoras Prize" for 2004, as the best popular book on mathematics.

9:30 – 9:35 AM

## Announcements

# Technical Program Thursday

## SESSION H

9:35 AM

### DOSIMETRY AND FACILITIES

#### SESSION INTRODUCTION

*Chair: Ewart Blackmore, TRIUMF / Canada*

## H-I

9:40 AM

### Semiconductor Materials and Detectors for Future Very High Luminosity Colliders

*A. Candelori, INFN Sezione di Padova*

Recent results from the CERN RD50 Collaboration on emerging technologies and detector structures for the development of radiation-hard detectors at the Super-LHC upgrade and, in general, for very high luminosity colliders are reported and discussed.

## H-2

9:55 AM

### Edge on Face-to-Face Paired (EOFFP) MOSFETs for Synchrotron Microbeam Dosimetry

*A. B. Rosenfeld, M. Lerch, I. M. Cornelius, G. Takacs, N. Painuly, University of Wollongong; E. Siegbahn, E. Brauer-Krish, A. Bravin, ESRF; A. Holmes-Siedle, REM Oxford; T. Kron, Peter Macallum Cancer Institute*

Monte Carlo simulations resolved problems in the design of new geometries of silicon MOSFET probes. The probes show improved spatial resolution and dosimetric control of X-ray synchrotron microbeam radiation therapy.

## H-3

10:10 AM

### The Role of Fixed and Switching Traps in Response and Long-Term Fading of Implanted and Unimplanted Gate Oxide RADFETs

*A. Haran, N. Refaeli, Soreq NRC; A. Jaksic, Tyndall National Institute*

The origins of significant differences in radiation response and post-irradiation annealing between implanted and unimplanted gate oxide RADFETs varying in oxide thickness were studied in detail. These differences are rationalized by dissimilarities in charge-traps-density build-up.

## POSTER PAPERS

## PH-I

### Online Dosimetry Based on Optically Stimulated Luminescence Materials

*J.-R. Vaille, P. Garcia, J. Boch, F. Saigne, L. Dusseau, University of Montpellier; F. Ravotti, M. Glaser, CERN; S. Matias, Oncogard; K. Idri, CRLCC Val d'Aurelle; E. Lorfevre, CNES*

A version of the OSL sensor specifically developed to monitor the dose online in radiation facilities is presented and calibrated with  $^{60}\text{Co}$ . The lowest dose measurable at the extremity of a 20 m cable is 3.4 mGy.

## PH-2

### Response of Lead Metaniobate Acoustic Emission Sensors to Gamma Irradiation

*K. E. Holbert, Arizona State University and Los Alamos National Laboratory; S. Sankaranarayanan, Arizona State University; S. S. McCready, Los Alamos National Laboratory*

Recalibration of gamma-irradiated acoustic emission sensors showed a sensitivity decrease of 8.4% per 100 kGy. Exposure of lead metaniobate specimens, the sensor ferroelectric material, revealed a capacitance increase and piezoelectric voltage coefficient ( $g_{33}$ ) decrease with gamma dose.

# Technical Program Thursday

## **PH-3 Microdosimetry Simulations within Heterogeneous Structures**

*A. Wroe, A. B. Rosenfeld, I. M. Cornelius, University of Wollongong; V. L. Pisacane, J. F. Ziegler, M. E. Nelson, US Naval Academy; F. Cucinotta, NASA Johnson Space Center; M. Zaider, Memorial Sloan Kettering Cancer Centre; J. F. Dicello, Johns Hopkins University*

The microdosimetric spectra produced by a proton radiation field traversing heterogeneous structures, such as spacecraft shielding, is of importance to the biological effect of the radiation and the subject of this GEANT4 radiation transport study.

10:25 – 10:50 AM  
LOBBY AREA

**BREAK**

## **SESSION I HARDNESS ASSURANCE**

10:50 AM SESSION INTRODUCTION

*Chair: Jim Howard, Jackson & Tull Chartered Engineers/NASA/GSFC*

### **I-1 Dose-Rate Sensitivity of Modern CMOS Transistors**

10:55 AM

*S. C. Witczak, R. C. Lacoe, J. V. Osborn, S. Brown, S. C. Moss, The Aerospace Corporation*

Radiation-induced edge-leakage current in nMOSFETs from several technologies is examined as a function of dose rate. Transistors from TSMC 0.18- $\mu\text{m}$  process exhibit enhanced low-dose-rate sensitivity, while transistors from the HP 0.5- $\mu\text{m}$  process do not.

### **I-2 Evaluating TM1019.6 ELDRS Screening Methods Using Gated Lateral PNP Transistors**

11:10 AM

*R. N. Nowlin, ATK Mission Research; R. L. Pease, RLP Research; D. G. Platteter, G. W. Dunham, J. E. Seiler, NAVSEA Crane*

The total-dose response of gated lateral PNP transistors is presented for the first time for the various ELDRS-related test conditions of TM1019.6. Our data confirm the TM1019.6 ELDRS tests are conservative for these devices.

### **I-3 Estimation of Low Dose Rate Degradation on Bipolar Linear Integrated Circuits Using Switching Experiments**

11:25 AM

*J. Boch, F. Saigné, J. R. Vaillé, L. Dusseau, Université Montpellier II; R. D. Schrimpf, Vanderbilt University; E. Lorfèvre, CNES; C. Chatry, TRAD*

The low dose rate response of bipolar integrated circuits is evaluated on the basis of switching experiments. This time-saving approach is shown to provide a good estimation of the degradation.

### **I-4 Effects of Particle Energy on Proton and Neutron-Induced Single-Event Latchup**

11:40 AM

*J. R. Schwank, P. E. Dodd, J. A. Felix, F. W. Sexton, G. L. Hash, M. R. Shaneyfelt, Sandia National Laboratories; J. Baggio, V. Ferlet-Cavrois, P. Paillet, CEA/DIF; E. Blackmore, TRIUMF*

The effect of proton energy on single-event latchup (SEL) at elevated temperatures and estimating neutron-induced SEL in terrestrial environments from proton measurements are investigated. Implications of these results for proton hardness assurance testing are discussed.

# Technical Program Thursday

## POSTER PAPERS

### PI-1 Statistical Methods for Large Flight Lots and Ultra-High Reliability Applications

*R. Ladbury, Muñiz Engineering, Inc.; J. Gorelick, Boeing Space Systems*

We present statistical techniques for evaluating random and systematic errors for use in flight performance predictions for large flight lots and ultra-high reliability applications.

### PI-2 Pseudo and Local SELs Observed in Digital LSIs and Their Implications for SEL Test Methods

*S. Kuboyama, H. Shindou, S. Matsuda, Japan Aerospace Exploration Agency;  
T. Hirao, Japan Atomic Energy Research Institute*

For complex digital LSIs, non-destructive pseudo and local SELs were found. Those were identified by the photo-emission microscope. The SEL test method on those LSIs is discussed to correctly evaluate them.

### PI-3 The Effects of Aging on MOS Irradiation and Annealing Response

*M. P. Rodgers, D. M. Fleetwood, R. D. Schrimpf, Vanderbilt University*

Significantly increased threshold voltage rebound is observed for packaged, fully processed, nMOS transistors relative to original tests in 1988. These results are attributed to passivation of oxide traps during device aging.

11:55 AM – 1:25 PM LUNCH

## SESSION J PHOTONICS

### 1:25 PM SESSION INTRODUCTION

*Chair: Heidi Becker, Jet Propulsion Laboratory*

### J-1 Hardness Assurance Methods for Radiation Degradation of Optocouplers

1:30 PM

*A. H. Johnston, T. Miyahira, Jet Propulsion Laboratory*

Reverse-recovery time is shown to correlate with LED displacement damage. Phototransistor electrical characteristics can be combined with recovery time measurements for hardness assurance in optocouplers when direct measurements of the LED output are not possible.

### J-2 Transient Radiation Effects in Ultra-Low Noise HgCdTe IR Detector Arrays for Space-based Astronomy

1:45 PM

*J. C. Pickel, PRT, Inc; R. A. Reed, R. A. Weller, M.H. Mendenhall, R. D. Schrimpf, Vanderbilt University; R. Ladbury, G. Gee, B. Fodness, Muñiz Engineering, Inc.; P. W. Marshall, Consultant; T. M. Jordan, EMP Consultants; M. McKelvey, R. McMurray, K. Ennico, C. McCreight, NASA/ARC; A. Waczynski, E. Polidan, S. Johnson, NASA/GSFC*

We present measurements of proton-induced single event transients in ultra-low noise HgCdTe IR detector arrays being developed for space-based astronomy and compare to modeling results.



# Technical Program Thursday

**J-3**  
2:00 PM **Further Measurements of CTE Effects in CCDs at Low Operating Temperatures**

*G. Hopkinson, Sira Technology Ltd; A. Short, I. Zayer, ESA/ESTEC; C. Vetel, EADS Astrium SAS*

Trap emission times and optical spot profiles have been measured for large-format CCDs at -70 to -130°C. There is evidence for charge re-trapping by fast traps. Trap filling using a charge-injection gate is also discussed.

**J-4**  
2:15 PM **Hot Pixel Formation and Annealing Behavior in CCDs Irradiated at -83°C**

*C. J. Marshall, R. A. Kimble, J. Yagelowich, NASA/GSFC; P. W. Marshall, Consultant; A. Waczynski, E.J. Polidan, S. D. Johnson, G. Delo, A. M. Russell, Global Science and Technology; R. A. Reed, Vanderbilt University; D. Schlossberg, T. Beck, Sigma; Y. Wen, R. J. Hill, SSAI*

A Hubble Space Telescope Wide Field Camera 3 E2V CCD was irradiated while operating at -83°C and the dark current studied as a function of temperature while the CCD was warmed to +30°C.

## POSTER PAPERS

**PJ-1** **Displacement Damage Correlation of Proton and Silicon Ion Radiation in GaAs**

*J. H. Warner, G. P. Summers, Naval Research Laboratory, and University of Maryland Baltimore County; S. R. Messenger, SFA Inc.; R. J. Walters, Naval Research Laboratory*

We present the first results of displacement damage correlation between 2 MeV protons and 22 MeV silicon ion damage in p<sup>+</sup>n GaAs solar cells. The photovoltaic response agrees well in terms of displacement damage dose.

**PJ-2** **Radiation-Induced Effects in a New Class of Optical Waveguides: Air-Guiding Photonic Crystal Fibers**

*S. Girard, J. Baggio, J-L. Leray, CEA DIF*

We investigated the attenuation induced by an X-ray pulse (dose rate > 10 MGy/s) in a microstructured optical fiber with a photonic bandgap at 1550 nm. Results are compared to standard silica-based single-mode fiber responses.

**PJ-3** **Radiation-Tolerant Raman Distributed Temperature Monitoring System for Large Nuclear Infrastructures**

*A. Fernandez Fernandez, P. Rodeghiero, B. Brichard, H. Ooms, F. Berghmans, SCK-CEN, Belgian Nuclear Research Centre; A. H. Hartog, A. P. Leach, K. Williams, P. Hughes, Sensa*

We demonstrate the high radiation tolerance of a Raman distributed fiber optic temperature sensor, up to total gamma doses in excess of 300 kGy, using a double-ended configuration and commercially-available optical fibers.

# Technical Program Thursday

**POSTER SESSION**  
2:30 – 5:00 PM  
GRAND BALLROOM A

INTRODUCTION



*Chair: Joe Benedetto, ATK Mission Research*

5:00 PM      END OF THURSDAY SESSIONS

5:15 – 6:30 PM  
GRAND BALLROOM B and C

**RADIATION EFFECTS COMMITTEE OPEN MEETING**

# Technical Program Friday

## INVITED TALK

8:15 – 9:15 AM

GRAND BALLROOM B and C



## Optimizing the Performance of Organic Electro-Optic Materials for Space Applications

*Larry R. Dalton, Departments of Chemistry & Electrical Engineering,  
University of Washington, Seattle, Washington*

In the past year, the performance of organic electro-optic materials has been improved dramatically to electro-optic activity of 300 pm/V at telecommunication wavelengths. This improvement has been guided by quantum and statistical mechanical calculations exploring the systematic optimization of molecular first hyperpolarizability and the product of chromophore number density and acentric order parameter. This development will be briefly reviewed and the possibility for further short term improvements of organic electro-optic materials will be discussed. Also, relevant to the practical application of organic electro-optic materials are issues of thermal and photochemical stability and stability in the presence of space radiation. Characterization of such properties will be discussed. Advantages of organic electro-optic materials are that conformable and flexible devices can be fabricated, devices can be fabricated by soft and nanoimprint lithography, and a variety of novel device structures can be readily fabricated. Such devices include ring microresonator and photonic crystal structures and organic electro-optic materials that have been incorporated into silicon photonic circuitry for active control of light.

**Larry Dalton** currently serves as George B. Kauffman Professor of Chemistry and Electrical Engineering at the University of Washington. He also directs the National Science Foundation Science and Technology Center on Materials and Devices for Information Technology Research as well as the Department of Defense MURI Center on Polymeric Smart Skin Materials. Current research interests focus on the nanoscopic engineering of electronic and photonic devices from organic electroactive materials and particularly electro-optic materials. Recent awards include the Chemistry of Materials Award and Richard C. Tolman Medal from the American Chemical Society and Distinguished Alumni Award from Michigan State University. He received his Ph.D. in Chemistry from Harvard University in 1971.

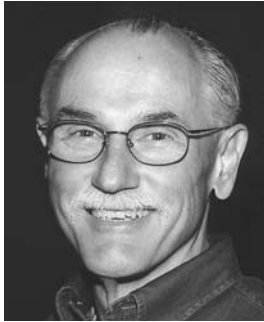
9:15 – 9:20 AM

## Announcements

# Technical Program Friday

**DATA WORKSHOP**  
9:20 – 11:50 AM  
WEST BALLROOM

## INTRODUCTION



*Chair: Mark Hopkins, The Aerospace Corporation*

**W-1 Extreme Latchup Susceptibility in Modern Commercial-off-the-Shelf (COTS) Monolithic 1M and 4M CMOS Static Random-Access Memory (SRAM) Devices**

*T. Page, Raytheon; J. Benedetto, ATK Mission Research*

Recent SEE testing of 1M and 4M monolithic SRAMs at Brookhaven National Laboratories has shown an extreme sensitivity to single event induced latch-up. We have observed SEL at the minimum heavy ion LET available,  $0.375 \text{ MeV-cm}^2/\text{mg}$ .

**W-2 Single Event Transients in Operational Amplifiers**

*J. George, R. Koga, S. Crain, P. Yu, The Aerospace Corporation*

A number of bipolar operational amplifiers have been evaluated for single event effects for possible use in a space application. Various trigger thresholds were used to estimate the distribution of transient amplitudes.

**W-3 Single Event Effects Test and Analysis Results from the Boeing Radiation Effects Laboratory (BREL)**

*J. L. Wert, E. Normand, D. L. Oberg, Boeing Phantom Works; D. Underwood, M. Vallejo, Boeing IDS; C. Kouba, NASA Johnson Space Center; T. E. Page, W. M. Perry, Raytheon*

We describe the results of single event effects testing conducted by the Boeing Radiation Effects Laboratory on a variety of devices. The data include SEU, SEL and SEFI cross sections induced by both heavy ions and protons.

**W-4 The Effects of Device Metal Interconnect Overlayers on SEE Testing**

*J. L. Wert, E. Normand, Boeing Phantom Works; C. Hafer, Aeroflex Colorado Springs*

Technology advances in wafer processing and design, new device requirements and improved modeling necessitates the need for a careful determination of LET at, and through, the critical silicon region of interest during SEE testing.

# Technical Program Friday

## **W-5 Recent Single Event Effects Results for Candidate Spacecraft Electronics for NASA**

*M. V. O'Bryan, M. A. Carts, C. M. Seidleck, S. D. Kniffin, R. L. Ladbury, C. Poivey, H. S. Kim, J. D. Forney, T. Irwin, Muñiz Engineering, Inc.; K. A. LaBel, C. J. Marshall, A. B. Sanders, D. K. Hawkins, S. R. Cox, NASA/GSFC; C. Palor, Orbital Sciences Corporation; J. W. Howard Jr., Jackson & Tull Chartered Engineers; S. P. Buchner, T. R. Oldham, QSS; P. W. Marshall, Consultant*

Vulnerability of a variety of candidate spacecraft electronics to proton and heavy ion induced single event effects is studied. Devices tested include digital, linear bipolar, and hybrid devices.

## **W-6 Results of Single-Event Effects Measurements Conducted at the Jet Propulsion Laboratory**

*F. Irom, T. F. Miyahira, Jet Propulsion Laboratory*

This paper reports recent Single-Event Effects results obtained at the Jet Propulsion Laboratory. Devices tested include digital, analog, and CMOS.

## **W-7 Single Event Upset Characterization of the SMJ320C6701 Digital Signal Processor Using Proton Irradiation**

*D. M. Hiemstra, B. Miladinovic, F. Chayab, MDA Space Missions*

Experimental single event upset characterization of the Texas Instruments SMJ320C6701 Digital Signal Processor using proton irradiation is presented.

## **W-8 Part II: Dynamic Single Event Upset Characterization of the Virtex-II Field Programmable Gate Array Using Proton Irradiation**

*D. M. Hiemstra, F. Chayab, MDA Space Missions*

The proton induced SEU cross-section of additional functional blocks of the Virtex-II FPGA are presented. The upset cross-sections are used to estimate upset rates in the space radiation environment.

## **W-9 Dynamic Single Event Upset Characterization of the Virtex-II Pro's Embedded IBM PowerPc405 Using Proton Irradiation**

*F. Chayab, D. Hiemstra, R. Ronge, MDA Space Missions*

The proton induced SEU cross-section of the IBM PowerPc405 embedded in Xilinx's Virtex-IIPro FPGAs is reported. This upset cross-section is used to estimate upset rates in the space radiation environment.

## **W-10 Heavy Ion SEE Characterization of COTS 0.22 $\mu\text{m}$ Field Programmable Gate Arrays**

*R. Koga, K. Crawford, P. Yu, J. George, S. Crain, M. Zakrzewski, The Aerospace Corporation*

Single event effect vulnerabilities of currently available commercial-off-the-shelf field programmable gate arrays (FPGAs) were measured. They are compared with those observed in older COTS devices as well as with some radiation hardened devices.

# Technical Program Friday

**W-11 Single Event Upset Characterization of the ESP603 Single Board Space Computer with the PowerPC603r Processor Using Proton Irradiation**

*H. Rufenacht, K. A. Le, J. Gazdewich, EMS Technologies; D. M. Hiemstra, R. Ronge, T. Klincsek, MDA Space Missions*

Experimental single event upset characterization of the ESP603 Single Board Computer and PowerPC 603r microprocessor using proton irradiation is presented. Comparison with previous heavy ions test results are made.

**W-12 Validation and Testing of Design Hardening for Single Event Effects Using the 8051 Microcontroller as a Test Vehicle**

*J. W. Howard Jr., Jackson and Tull, Chartered Engineers; K. A. LaBel, NASA/GSFC; M. A. Carts, C. Seidleck, Muñiz Engineering, Inc.; J. Gambles, University of Idaho*

A CMOS Low Power Radiation Tolerant (CULPRiT) design is evaluated for SEE mitigative techniques against two commercial devices using the 8051 microcontroller as a test vehicle.

**W-13 SEE and TID Results for a Commercially Fabricated Radiation Hardened Clock Generator Circuit**

*C. Hafer, V. Schnathorst, J. Pfeil, T. Meade, T. Farris, A. Jordan, Aeroflex Colorado Springs*

Hardness results for this RadHard-by-Design, PLL-based, single chip, clock network and clock generator solution are presented. The product tested was Aeroflex Colorado Springs' RadClock™ clock generator circuit designed for harsh space environment applications.

**W-14 Single Event Effects Testing of a PLL and LVDS in a RadHard-By-Design 0.25 micron ASIC**

*M. Hartwell, C. Hafer, P. Milliken, T. Farris, Aeroflex Colorado Springs*

SEE testing performed on PPL and LVDS circuits resulted in both being immune to SEL up to an LET of 108 MeV-cm<sup>2</sup>/mg. The SET error rate for the PLL is less than one per 260 days.

**W-15 Radiation Hardness Evaluation of a Class V 32-Bit Floating-Point Digital Signal Processor**

*R. Joshi, R. Daniels, Texas Instruments, Inc; M. Shoga, SAIC; M. Gauthier, ICS Radiation Technologies*

The SEU, SEL and TID test results of SMV320C6701, a 32-bit, floating-point digital signal processor are reported in this paper. The proton SEU rates extrapolated from the heavy ion SEU rates are also presented.

**W-16 Radiation Belt Modeling for Spacecraft Design: Model Comparisons for Common Orbits**

*J.-M. Lauenstein, Muñiz Engineering, Inc.; J. L. Barth, NASA/GSFC*

We present the current status of radiation belt modeling, providing model details and comparisons with AP-8 and AE-8 for commonly used orbits. Improved modeling of the particle environment enables smarter space system design.

# Technical Program Friday

**W-17 The Ionizing Radiation Environment on the International Space Station: Performance vs. Expectations for Avionics and Materials**

*S. Koontz, NASA Johnson Space Center; P. Boeder, C. Pankop, B. Reddell, Boeing*

The role of structural shielding mass in the design, verification, and in-flight performance of International Space Station (ISS), in both the natural and induced orbital ionizing radiation (IR) environments, is reported.

**W-18 The Impact of Substrate Bias on Proton Damage in 130 nm CMOS Technology**

*B. M. Haugerud, S. Venkataraman, A. K. Sutton, A. P. Gnana Prakash, J. D. Cressler, Georgia Institute of Technology; G. Niu, Auburn University; P. W. Marshall, Consultant; A. J. Joseph, IBM*

The effects of proton irradiation on 130 nm CMOS is investigated. The impact of substrate bias is reported. A comparison is drawn between this work and previously reported 180 nm CMOS.

**W-19 Total Ionizing Dose Effects on the Analog Performances of a 0.13  $\mu\text{m}$  CMOS Technology**

*V. Re, M. Manghisoni, G. Traversi, Università' di Bergamo and INFN; L. Ratti, V. Speziali, Università' di Pavia and INFN*

This paper presents a study of the ionizing radiation tolerance of static, signal and noise parameters of 0.13 micron CMOS transistors, in view of the application to the design of rad-hard analog integrated circuits.

**W-20 Total Dose Degradation of the LP2953 Low-Dropout Voltage Regulator**

*T. F. Miyahira, B. G. Rax, A. H. Johnston, Jet Propulsion Laboratory*

Low dose-rate tests of the LP2953 regulator show wide variability between lots, with catastrophic failure of 4 krads(Si) for applications with high load current. Proton damage must also be taken into account for space applications.

**W-21 Supervisory Circuits in a Mixed Neutron and Gamma Radiation Environment**

*Y. Zong, F. J. Franco, J. A. Agapito, A. H. Cachero, Universidad Complutense de Madrid; J. Casas-Cubillos, M. A. Rodríguez-Ruiz, CERN; A. C. Fernández, J. G. Marques, Portuguese Research Reactor, Instituto Tecnológico e Nuclear*

Evolution of commercial microprocessor supervisory circuits under neutron and gamma radiation is studied. Increase of period and duty cycle for watchdog timer, existence of threshold voltage hysteresis, and the shift of TTL trigger level is observed.

**W-22 Total Ionizing Dose Effects on Bipolar & CMOS Devices**

*R. M. Rivas, A. H. Johnston, B. G. Rax, L. Z. Scheick, H. Becker, Jet Propulsion Laboratory*

This paper describes Total Ionizing Dose (TID) test results achieved at JPL. Bipolar and CMOS device samples were tested exhibiting significant degradation and failures at different irradiation levels. Linear technology showed low dose dependency (ELDRS).

# Technical Program Friday

## **W-23 Recent Total Ionizing Dose Results and Displacement Damage Results for Candidate Spacecraft Electronics for NASA**

*D. Cochran, S. Kniffin, R. L. Ladbury, Christian Poivey, T. L. Irwin, M. A. Carts, M. O'Bryan Muñiz Engineering, Inc.; S. Buchner, QSS Group Inc.; C. Palor, Orbital Sciences Corporation; B. DiBari, Jackson & Tull; K. A. LaBel, C. Marshall, R. A. Reed, A. B. Sanders, D. Hawkins, R. J. Flanigan, S. R. Cox, NASA/GSFC; P. W. Marshall, Consultant*

Vulnerability of a variety of candidate spacecraft electronics to total ionizing dose and displacement damage is studied. Devices tested include optoelectronics, digital, analog, linear bipolar devices, hybrid devices, Analog-to-Digital Converters (ADCs), and Digital-to-Analog Converters (DACs).

## **W-24 Compendia of Radiation Test Results of Integrated Circuits**

*P. Layton, E. Patnaude, G. Williamson, L. Longden, C. Sloan, Maxwell Technologies, Inc.*

TID data taken for existing space products is presented. The data were collected to evaluate these devices for radiation effects in space environments.

## **W-25 Total Ionizing Dose and Proton Radiation Testing on a COTS Interline CCD with Microlens**

*P. P. K. Lee, D. A. Thompson, D. L. Modney, ITT Industries Space Systems LLC*

Commercially fabricated Interline CCD's were TID tested with  $\gamma$  and proton radiation. Materials used for microlenses applied to the array surface were also irradiated on fused silica substrates. Device and material performance degradations are presented.

## **W-26 Secondary Neutron Fluence in Radiation Test Beams at The Northeast Proton Therapy Center**

*E. W. Cascio, J. M. Sisterson, The Northeast Proton Therapy Center at Massachusetts General Hospital*

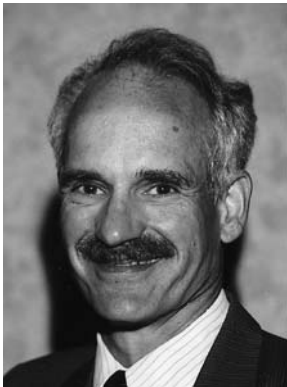
The fluence of secondary neutrons in the radiation effects test beams at The Northeast Proton Therapy Center is characterized.

11:50 AM      END OF CONFERENCE





Ronald D. Schrimpf  
Chairman



Tim Oldham  
Executive Vice Chairman

The forty-second annual Nuclear and Space Radiation Effects Conference (NSREC) will be held at the Sheraton Seattle Hotel and Towers in Seattle, Washington. July is a delightful time of year to be in Seattle, so you will want to make your travel plans early. The conference hotel is located in the heart of downtown, within easy walking distance of many of Seattle's most popular attractions. Fred Sexton and his 2005 conference committee have put together a strong technical program, as well as social events that will provide frequent opportunities for discussing radiation effects with friends, old and new.

Janet Barth of NASA Goddard Space Flight Center is the 2006 Conference General Chairman. Janet has selected the Marriott Sawgrass Resort in Ponte Vedra Beach, near Jacksonville, Florida, as the conference site. This location is ideal for golfers, as well as those who love beaches or historical sites.

Lloyd Massengill of Vanderbilt University is the 2007 Conference General Chair; he has chosen the Hilton Hawaiian Village Hotel in Honolulu, Hawaii. This will be the first visit of NSREC to Hawaii, so start thinking about submitting a paper!

The amount of lead time required to plan a conference is increasing and it currently takes more than three years to plan each NSREC. Paul Dodd of Sandia National Labs will chair the 2008 Conference and he is currently considering sites. He will host the spring meeting of the RESG at the J. W. Marriott Resort in Tucson, Arizona.

As always, papers presented at the NSREC are eligible for publication in the December issue of the *IEEE Transactions on Nuclear Science*. However, the paper submission and review process have changed dramatically this year with the move to a fully electronic process managed through the IEEE's Manuscript Central. It is particularly important for authors to note that they must upload their papers to the Manuscript Central web site **before the conference**. This upload must be completed by midnight, Friday, July 8, 2005 for consideration for publication in the December TNS Special Issue. Detailed instructions can be found at <http://www.nsrec.com/editmsg.htm>.

During the fall RESG meeting in Seattle, Jim Felix of Sandia National Laboratories was selected as Assistant Guest Editor for the December issue of the *IEEE Transactions on Nuclear Science*. Jim received his Ph.D. from Vanderbilt University; we're very pleased that he has agreed to perform this important job.

Keep visiting our web site at [www.nsrec.com](http://www.nsrec.com) for author information, paper submission details, vendor links, on-line registration, and the latest NSREC information.

# RESG NEWS

## ARE YOU A MEMBER OF IEEE?

Now is the time to join the Institute of Electrical and Electronics Engineers (IEEE) and the Nuclear Plasma Sciences Society (NPSS). Why? First of all, you get to be a member of the largest professional engineering society in the world. **About 60% of NSREC attendees are IEEE members.** Full membership in IEEE costs \$153. NPSS membership is \$16. NPSS members receive a free subscription to *NPSS News* and have an opportunity to purchase a subscription to the *IEEE Transactions on Nuclear Science* (electronic or print) for an additional \$50.

NPSS members get to vote in our NSREC elections, held at the annual open meeting on Thursday of the conference. If that is not enough, **members receive a significant discount on registration fees** for the NSREC and Short Course. With a subscription to IEEE Xplore, members can search and view digital copies of NSREC papers (published since 1989) from an on-line web-based database. What are you waiting for? Apply for membership at <http://www.ieee.org> or visit the IEEE registration desk.

## NSREC PUBLICATIONS

NSREC has three publications each year:

- **IEEE Transactions on Nuclear Science.** This IEEE journal is the official archive of research papers presented at the NSREC Conference. A six issue/year subscription is \$1035 (only \$50 for IEEE/NPSS members).
- **Radiation Effects Data Workshop Record.** Published each year in October, this IEEE proceedings has become the source for radiation test data on semiconductor components. A copy of the Workshop Record is available for \$188 (\$94 IEEE members).
- **NSREC Short Course Notebook.** Published each July, this notebook contains tutorial presentations on the basic physics of radiation effects in circuits and systems. It includes the instructor's notes and text, given to participants of the annual Radiation Effects Short Course. The *Archive of Radiation Effects Short Course Notebooks 1980-2003* is available on CD-ROM for \$200 (\$160 IEEE members). To obtain individual copies of this CD, please visit the IEEE *on-line Catalog and Store* at <http://shop.ieee.org/store> or contact IEEE Service Center at 732-981-1393. Ask for IEEE product order code EC146.

A complimentary copy of the *2005 IEEE Radiation Effects Data Workshop Record* and one issue of the *IEEE Transactions on Nuclear Science* will be mailed to each NSREC technical session attendee.

## RADIATION EFFECTS COMMITTEE ANNUAL OPEN MEETING

You are invited to attend the IEEE Radiation Effects Committee's Annual Open Meeting on Thursday, July 14, from 5:15 – 6:30 PM in the Grand Ballroom B and C. All conference attendees and spouses are encouraged to attend. We will discuss the 2005 conference and future IEEE Nuclear and Space Radiation Effects Conferences. There will be an election for the Junior Member-at-Large on the Radiation Effects Steering Group. Nominations will be taken from the floor. All IEEE NPSS members present are eligible to vote. Refreshments will be provided.

# Awards

## 2004 OUTSTANDING CONFERENCE PAPER AWARD

### **Production and Propagation of Single-Event Transients in High-Speed Digital Logic ICs**

*Paul E. Dodd, Marty R. Shaneyfelt, James A. Felix, and James R. Schwank (Sandia National Laboratories).*

## 2004 MERITORIOUS CONFERENCE PAPER AWARDS

### **Charge Enhancement Effects in NMOS Bulk Transistors Induced by Heavy Ion Irradiation**

*V. Ferlet-Cavrois (CEA/DIF), G. Vizkelethy (Sandia National Laboratories), P. Paillet, A. Torres (CEA/DIF), J. R. Schwank, M. R. Shaneyfelt (Sandia National Laboratories), J. Baggio (CEA/DEF), and J. du Port de Pontcharra (CEA LETI)*

### **Issues for Single-Event Proton Testing of SRAMs**

*J. R. Schwank, P. E. Dodd, M. R. Shaneyfelt, J. A. Felix, G. L. Hash (Sandia National Laboratories), V. Ferlet-Cavrois, P. Paillet, J. Baggio (CEA/DIF), P. Tangyunyong (Sandia National Laboratories), and E. Blackmore (TRIUMF)*

## 2004 DATA WORKSHOP PAPER AWARDS

### **Effect of Passivation on the Enhanced Low Dose Rate Sensitivity (ELDRS) of National LMI 24 Operational Amplifiers**

*John E. Seiler, Gary W. Dunham, Dale G. Platteter (NAVSEA Crane), Ron L. Pease (RLP Research), Michael C. Maher (National Semiconductor Corporation), and Marty R. Shaneyfelt (Sandia National Laboratories)*

## IEEE FELLOWS

Two distinguished members of the radiation effects community were elected to the grade of IEEE Fellow on January 1, 2005.

### **Robert Christopher Baumann**

*Texas Instruments*

Robert's citation reads, "for contributions to the understanding of the reliability impact of terrestrial radiation mechanisms in commercial electronics."

### **Lloyd Wilson Massengill**

*Vanderbilt University*

Lloyd's citation reads, "for contributions to radiation effects in microelectronics."

# Awards

## **2004 IEEE NPSS EARLY ACHIEVEMENT AWARD**

**Dr. Robert Reed**

*Vanderbilt University/Institute for Space and Defense Electronics (formerly of NASA/GSFC)*

This award recognizes outstanding achievement during the first ten years of the recipient's career. Robert's citation reads "for contributions to measurement and modeling based solutions of particle induced damage and soft error problems in high speed microelectronic and photonic technologies for satellite applications."

## **2004 RADIATION EFFECTS AWARD**

The 2004 Radiation Effects Award was presented to Jim Ramsey, NAVSEA, Crane Division (retired) during the opening ceremonies of the 2004 conference. Jim's citation reads "*for visionary leadership of radiation-effects programs and for meritorious service to the radiation-effects community.*"

## **2005 RADIATION EFFECTS AWARD**

The winner of the 2005 Radiation Effects Award will be announced Tuesday morning, July 12.

## **2006 RADIATION EFFECTS AWARD**

Nominations are currently being accepted for the 2006 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 2006 IEEE NSREC at Ponte Vedra Beach, Florida in July 2006. Nomination forms are available electronically in PDF Format or in Microsoft Word format at <http://www.nsrec.com/nominate.htm>. Additional information can be obtained from Steve Clark, Member-at-Large for the Radiation Effects Steering Group. Steve can be reached at 505-846-6067, [steven.clark@kirtland.af.mil](mailto:steven.clark@kirtland.af.mil).

# Conference Information

The 2005 IEEE NSREC will be held at the Sheraton Seattle Hotel and Towers nestled in the city's vibrant core. The hotel features a restaurant and lounge, a fully-equipped fitness center, an indoor swimming pool, and 840 guest rooms providing maximum comfort and convenience.



## **ROOMS FOR SIDE MEETINGS**

Several meeting rooms are available for use by any registered conference attendee at the Sheraton on a first come, first served basis. *NSREC encourages side meetings to be scheduled at times other than during technical sessions.* Contact ETC Services at 720-733-2003 or send an e-mail to [etcservices@qwest.net](mailto:etcservices@qwest.net) to make side meeting reservations in advance of the conference. *You must register for the conference before a side meeting room can be reserved!*

All audio/visual equipment and refreshments must be coordinated through the hotel and are the responsibility of the attendee. To make a side meeting reservation during the conference, see the NSREC Registration Desk staff.

## **MESSAGES**

**206-621-5945**  
**FAX: 206-621-8441**

A message board will be located in the lobby just outside the conference room for all incoming messages during the NSREC. Faxes can be received through the hotel's guest fax but there must be a cover sheet stating the recipient's name, noting the NSREC conference, and advising the total number of pages being sent. There is a fee for incoming guest faxes.

## **CONTINENTAL BREAKFAST AND COFFEE BREAKS**

The 2005 IEEE NSREC will provide continental style breakfasts and refreshments at breaks during the NSREC Short Course and Technical Sessions. Breakfast every day will begin at 7:30 AM for *conference registered attendees only*.

## **BUSINESS CENTER**

The Sheraton Seattle Hotel and Towers has a Business Center located on the 2nd floor. The Business Center is open 24 hours (with room key access) and staffed during normal business hours. Services available are: outgoing fax machine, computer stations with internet access, laptop internet access outlets, and printers. Costs associated with the Business Center services may be charged to your room or paid by cash or credit card.

# Registration and Travel

## CONFERENCE REGISTRATION

To pre-register for NSREC, complete the conference registration form enclosed in this booklet, or register on-line at [www.nsrec.com](http://www.nsrec.com). Please note that registration fees are higher if payment is received after June 10, 2005.

**ETC SERVICES, INC.  
2254 EMERALD DRIVE  
CASTLE ROCK, CO 80104**

**720-733-2003  
FAX: 720-733-2046  
ETCSERVICES@QWEST.NET**

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 seven days prior to the conference, or arrangements should be made to hand carry fees for on-site registration. Telephone registrations will not be accepted. You can also register via the internet, provided all of the credit card information is included. Go to the NSREC web site for on-line registration at [www.nsrec.com](http://www.nsrec.com).

**Registration fees should be made payable to the "2005 IEEE NSREC" and must be in U.S. funds only.** There are three ways to remit advanced payment of registration and activity fees: 1) check made out in U.S. dollars and drawn on a U.S. bank, 2) U.S. Money Order, or 3) Mastercard, VISA, or American Express credit card.

## ON-SITE REGISTRATION HOURS

On-site registration for the conference will be located at the dedicated Registration Desks in the Spruce Room (pre-registration is in the lobby area). The following is the schedule for on-site registration:

<b>Sunday, July 10</b>	<b>5:00 PM – 9:00 PM</b>
<b>Monday, July 11</b>	<b>7:30 AM – 4:00 PM 6:00 PM – 9:00 PM</b>
<b>Tuesday, July 12</b>	<b>7:30 AM – 5:30 PM</b>
<b>Wednesday, July 13</b>	<b>7:30 AM – 3:00 PM</b>
<b>Thursday, July 14</b>	<b>7:30 AM – 3:00 PM</b>
<b>Friday, July 15</b>	<b>7:30 AM – 10:00 AM</b>

## REGISTRATION CANCELLATION POLICY

A \$25 processing fee will be withheld from all refunds. Due to advance financial commitments, refunds of registration fees requested after June 10, 2005 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 720-733-2046 or e-mail at [etcservices@qwest.net](mailto:etcservices@qwest.net).

# Registration and Travel

## HOTEL RESERVATIONS AND INFORMATION

### SHERATON SEATTLE HOTEL AND TOWERS

**1400 SIXTH AVE  
SEATTLE, WASHINGTON  
98101**

**206-621-9000  
TOLL-FREE: 800-325-3535  
FAX: 206-447-5525**

The 2005 IEEE NSREC will be held at the Sheraton Seattle Hotel and Towers. The best of Seattle is found just outside their front doors, from exciting nightlife to gourmet restaurants, world-class shopping, and of course, the heart of the financial district. The beautiful hotel rooms have the popular Sheraton Sweet Sleeper Bed, adjustable task chairs, ample workspaces, two line telephones, coffeemaker, iron/board, cable TV, hair dryer and high-speed internet access in all rooms. The hotel has an excellent restaurant and lobby lounge. The famous Pike Place Market is within walking distance.



The group rate is \$155.00 + 15.6% tax for single and double occupancy. Additional adults are \$20.00 + tax per person, children 18 and younger are free when sharing a room with their parents. In line with the current convention hotel government per diem guidelines, a limited number of rooms are available at the prevailing government rate of \$127.00 + tax, single/double occupancy. Early check out is \$75.00 if given less than 24 hours notice before departure.

## MAKING RESERVATIONS

All room rates are subject to a 15.6% state and local tax. All rooms must be guaranteed with a credit card or deposited by check. The cut-off for IEEE NSREC reservations is **June 10, 2005**. After the cut-off date, room accommodations will be confirmed on a space available basis and the room rate will be higher! **WE STRONGLY SUGGEST EARLY RESERVATIONS SINCE THIS IS SEATTLE'S HIGH SEASON!**

Reservations can be made by calling the Sheraton directly at 206-621-9000 or 800-325-3535. Alternatively, reservations can be made on-line at the NSREC web site ([www.nsrec.com](http://www.nsrec.com)), by clicking on the link to the Sheraton hotel registration web site. This will take you directly to the IEEE NSREC block of rooms.

## AIRPORT AND TRANSPORTATION INFORMATION

The SeaTac International Airport is located south of Seattle and the Sheraton Seattle Hotel and Towers. Directions within the airport are well marked. Taxi service is \$25.00 - 30.00 one-way from SeaTac to the Sheraton.

## AIRPORT SHUTTLE

Gray Line's "Downtown Airporter" offers an excellent airport/downtown hotel shuttle service @ \$10.25 one way, \$17.00 roundtrip. Reservations can be made in advance or on-site at the airport. An inside ticket counter is found at the south end of the baggage claim area. For more information, see the website: [www.graylineofseattle.com](http://www.graylineofseattle.com)

# Registration and Travel

## DRIVING DIRECTIONS

**Traveling from the Seattle-Tacoma International Airport:** Take Interstate 5 North and exit at Seneca Street (use the left lane off the exit ramp). Turn right onto Sixth Avenue. The hotel will be located 3 blocks down, on the right.

**Traveling from the EAST:** Take Interstate 90 to Interstate 5 North and use the Madison Street Exit. Turn left onto Madison Street, and then turn right onto Sixth Avenue. Proceed for four blocks to the hotel which will be on your right.

**Traveling from the NORTH:** Take Interstate 5 South and use the Union Street Exit. Proceed for 1 block and turn right on Sixth Avenue. The hotel will be located on the right.

## PARKING

A parking garage is located below the hotel (but is not owned by the hotel) @ \$25.00 PLUS TAX per day with in and out privileges. The entrance is on 6th Avenue JUST TO THE NORTH of the hotel's main entrance.

## RENTAL CAR DISCOUNT

**AVIS**

**AWD # A606096**

This is one city where we suggest that you DON'T get a car. Much is within walking distance from the hotel and the public transportation is convenient and inexpensive. However, for those who really need their freedom (to get up and go), a discount has been arranged with Avis as follows:

Class	Car type	Daily (per day)	Weekend (per day)	Weekly
A	sub-compact	\$40.99	\$25.99	\$167.99
B	compact	\$44.99	\$26.99	\$179.99
C	intermediate	\$48.99	\$28.99	\$195.99
D	fullsize 2-dr	\$49.99	\$29.99	\$207.99
E	fullsize 4-dr	\$52.99	\$30.99	\$219.99
G	premium	\$56.99	\$35.99	\$230.99
H	luxury	\$66.99	\$68.99	\$278.99
V	minivan	\$66.99	\$68.99	\$278.99
W	sport utility	\$66.99	\$68.99	\$278.99
K	convertible	\$66.99	\$68.99	\$278.99

The above rates are guaranteed. Return to the same renting location or additional surcharges may apply. All rates include unlimited free mileage. Weekend daily rates are available from noon Thursday - Monday at 11:59 PM (vehicle must be checked out by 3:00 PM Sunday).

Rates are available from July 4, 2005 to July 22, 2005.

Should a lower qualifying rate become available at the time of booking, Avis is pleased to offer a 5% discount off the lower qualifying rate or the meeting rate, whichever is lowest. The attendee must use the assigned Meeting Avis Discount Number and meet Avis rate requirements to receive the discount. (Rate discounts are available at all corporate and participating licensee locations.)

Rates do not include any state or local surcharges, tax, optional coverages or gas refueling charges. Renter must meet Avis' age, driver, and credit requirements.

Reservations can be made by calling 1-800-331-1600 or online at [www.avis.com](http://www.avis.com).



# Industrial Exhibits



Nazik Maloyan  
Industrial Exhibits Chairman

The 2005 exhibits will be held at the Sheraton Seattle Hotel and Towers, in Grand Ballroom A and East and West Ballrooms, Seattle, Washington on July 12 and 13, 2005. We are looking forward to another well-attended conference and excellent traffic through the exhibit areas. **This year NSREC is sponsoring a raffle on behalf of exhibitors.** The raffle drawing will include wonderful prizes and will be open to registered attendees only. Information on how to enter the raffle will be available in your registration information. Catered functions will also be held in each of the exhibit areas.

For additional information, contact:

Nazik Maloyan	Phone: 310-726-8412
International Rectifier	Fax: 310-726-8183
	Email: <a href="mailto:nmaloyan@irf.com">nmaloyan@irf.com</a>

Or contact us through the internet at: [www.nsrec.com/exhibit.htm](http://www.nsrec.com/exhibit.htm)

Booth Spaces: \$2,200 per 8' x 10' area. Included in this cost is:

- A link to your company's web page on the NSREC exhibitor page
- One (1) complimentary conference registration per 8' x 10' space rented
- Two (2) complimentary exhibitor badges granted to the exhibit area for booth staffers (additional exhibitor badges \$100 each)
- Exhibitor Reception July 12, 2005

## EXHIBIT HALL HOURS

Set-Up:	Monday, July 11	4:00 PM - 7:00 PM
	Tuesday, July 12	7:00 AM - 8:45 AM
Show Hours:	Tuesday, July 12	9:00 AM - 4:30 PM
		10:00 PM - 10:30 PM (conference break)
		2:35 PM - 3:05 PM (conference break)
		6:00 PM - 10:00 PM (exhibitor reception)
		<i>6:00 PM cocktails, 7:00 PM buffet</i>
	Wednesday, July 13	9:00 AM - 1:00 PM
		9:55 AM - 10:20 AM (conference break)
Raffle Drawing:	Tuesday, July 12	9:30 PM
Tear-down:	Wednesday, July 13	1:00 PM - 4:00 PM

## EXHIBITORS

Please check our web site ([www.nsrec.com](http://www.nsrec.com)) for a current listing of companies exhibiting at 2005 NSREC.

# Industrial Exhibits

## EXHIBITORS

NSREC Industrial Exhibits

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207	208	

### West Ballroom

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312		304
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### Grand Ballroom A

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Company	Internet Site	Booth(s) #
3D Plus - USA	<a href="http://www.3d-plus.com">www.3d-plus.com</a>	307
Actel Corporation	<a href="http://www.actel.com">www.actel.com</a>	117, 118
Aeroflex Colorado Springs	<a href="http://www.aeroflex.com/radhard">www.aeroflex.com/radhard</a>	114, 115
ATK Mission Research Microelectronics Division	<a href="http://www.mrcmicroe.com">www.mrcmicroe.com</a>	106
Atmel	<a href="http://www.atmel.com">www.atmel.com</a>	304, 305
BAE Systems	<a href="http://www.iewe.na.baesystems.com/business/sse.htm">www.iewe.na.baesystems.com/business/sse.htm</a>	101
Boeing - Phantom Works	<a href="http://www.boeing.com">www.boeing.com</a>	104
Boeing Solid State Electronics Development	<a href="http://www.boeing.com/ssed">www.boeing.com/ssed</a>	112
DPA Components International	<a href="http://www.dpaci.com">www.dpaci.com</a>	109
Honeywell Solid State Electronics Center	<a href="http://www.myspaceparts.com">www.myspaceparts.com</a>	206
ICS Radiation Technologies	<a href="http://www.icsrad.com">www.icsrad.com</a>	308
Idaho Accelerator Center	<a href="http://iac.isu.edu">http://iac.isu.edu</a>	210
International Rectifier	<a href="http://hirel.irf.com">http://hirel.irf.com</a>	113
Interpoint, a Crane Company	<a href="http://www.craneae.com">www.craneae.com</a>	107
Intersil Corporation	<a href="http://www.intersil.com">www.intersil.com</a>	309
J.L. Shepherd & Associates	<a href="http://www.jlshepherd.com">www.jlshepherd.com</a>	306
JD Instruments	<a href="http://www.jdinstruments.net">www.jdinstruments.net</a>	312
Lawrence Berkeley National Laboratory	<a href="http://www.lbl.gov">www.lbl.gov</a>	311
Maxwell Technologies	<a href="http://www.maxwell.com">www.maxwell.com</a>	103
Modular Devices Inc.	<a href="http://www.mdipower.com">www.mdipower.com</a>	116
NASA Goddard Space Flight Center	<a href="http://lws-set.gsfc.nasa.gov">http://lws-set.gsfc.nasa.gov</a>	201
NASA Marshall Space Flight Center	<a href="http://etdo.msfc.nasa.gov">http://etdo.msfc.nasa.gov</a>	207, 208
Northrop Grumman Electronics Systems	<a href="http://www.northropgrumman.com">www.northropgrumman.com</a>	302
Peregrine Semiconductor Corp.	<a href="http://www.psemi.com">www.psemi.com</a>	102
Prairie View A&M University - NASA Center for Applied Radiation Research	<a href="http://www.pvamu.edu/carr">www.pvamu.edu/carr</a>	209
Sandia National Laboratories	<a href="http://www.sandia.gov">www.sandia.gov</a>	105
Silvaco International	<a href="http://www.silvaco.com">www.silvaco.com</a>	301
Survivability, Vulnerability and Assessment / White Sands Missile Range	<a href="http://www.wsmr.army.mil/capabilities/datts/testing/lab_fac/nucleareffectsfac.html">www.wsmr.army.mil/capabilities/datts/testing/lab_fac/nucleareffectsfac.html</a>	111
Synopsys	<a href="http://www.synopsys.com">www.synopsys.com</a>	110
Synplicity, Inc.	<a href="http://www.synplicity.com">www.synplicity.com</a>	310
Texas A&M – Cyclotron Institute	<a href="http://cyclotron.tamu.edu/ref">http://cyclotron.tamu.edu/ref</a>	204
Texas Instruments	<a href="http://www.ti.com/space">www.ti.com/space</a>	108
US Semiconductor Corporation	<a href="http://www.us-semi.com">www.us-semi.com</a>	203
Vanderbilt University - Institute for Space and Defense Electronics	<a href="http://www.isde.vanderbilt.edu">www.isde.vanderbilt.edu</a>	202
VPT Inc.	<a href="http://www.vpt-inc.com">www.vpt-inc.com</a>	205
Xilinx	<a href="http://www.xilinx.com">www.xilinx.com</a>	303

# 2005 IEEE NSREC Technical Sessions 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.  
*Non-members must register at the non-member rate.*

## CANCELLATIONS

A \$25 processing fee will be withheld from all refunds. Due to advance financial commitments, refunds of registration fees requested after June 10, 2005 cannot be guaranteed. Consideration of requests for refunds will be processed after the conference.

Mail or Fax this form and your remittance  
(payable to 2005 IEEE NSREC) to:

**ETC Services, Inc.**  
**2254 Emerald Drive**  
**Castle Rock, CO 80104**

**720-733-2003 Fax: 720-733-2046**

## REGISTRATION FEES (in U.S. dollars)

Late fee REQUIRED if payment received after June 10, 2005.

	<u>Early</u>	<u>Late</u>	
<b>IEEE Member</b>			
Short Course	\$230	\$280	\$ _____
Technical Sessions	\$400	\$480	\$ _____
<b>Non-IEEE Member</b>			
Short Course	\$290	\$345	\$ _____
Technical Sessions	\$500	\$600	\$ _____
<b>Full-Time Students who are IEEE Members *</b>			
Short Course	\$115	\$280	\$ _____
Technical Sessions	\$115	\$480	\$ _____

**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: **2005 IEEE NSREC.**

☐ Charge registration fees to my credit card (U.S. dollars):

☐ American Express ☐ Master Card ☐ Visa

Card No. \_\_\_\_\_ Expiration Date \_\_\_\_\_

Printed Name \_\_\_\_\_

Address \_\_\_\_\_

Address \_\_\_\_\_

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. Only one form of payment is needed.**

\*To obtain the full-time student IEEE rate, you must provide your IEEE number on this form.



# 2005 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 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 this form is submitted and you would like to request a refund, you must notify ETC Services by email at [etcservices@qwest.net](mailto:etcservices@qwest.net) or FAX at 720-733-2046 no later than July 5 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 2005 IEEE NSREC) to:**

**ETC Services, Inc.  
2254 Emerald Drive  
Castle Rock, CO 80104**

**720-733-2003 Fax: 720-733-2046**

## ACTIVITY FEES (in U.S. dollars)

Late fee REQUIRED if payment received after June 10, 2005. **We strongly encourage early registration; note that the number of tickets available after pre-registration for each event is limited.** Children must be accompanied by an adult during all tours and social events.

	Early	Late	Number Attending	Total Cost
<b>Short Course Reception: Sunday, July 10</b>				
Adult/child	\$0	\$0	_____	
<b>Seattle City Tour: Tuesday, July 12</b>				
Adult	\$22	\$28	_____	\$ _____
Child (age 3-12)	\$15	\$20	_____	\$ _____
Child (age 0-2)	\$0	\$0	_____	
<b>Industrial Exhibits Reception: Tuesday, July 12</b>				
Adult/child	\$0	\$0	_____	
<b>Tillicum Village Cruise and Show: Wednesday, July 13</b>				
Adult	\$45	\$55	_____	\$ _____
Child (age 5-12)	\$20	\$25	_____	\$ _____
Child (age 0-4)	\$0	\$0	_____	
<b>Museum of Glass/Gig Harbor: Thursday, July 14</b>				
Adult	\$34	\$40	_____	\$ _____
Child (age 3-12)	\$28	\$33	_____	\$ _____
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: **2005 IEEE NSREC.**
- ☐ Charge registration fees to my credit card (U.S. dollars):
- ☐ American Express ☐ Master Card ☐ Visa
- Card No. \_\_\_\_\_ Expiration Date \_\_\_\_\_

Printed Name \_\_\_\_\_

Address \_\_\_\_\_

Address \_\_\_\_\_

Signature \_\_\_\_\_



# Social Program



*"Enjoy your stay while you visit one of the most beautiful cities in the world!"*

*Kay Jobe, Boeing Satellite Systems  
Local Arrangements Chairman*



*Boats move in and out of the Bell Harbor Marina, with the Seattle skyline as a backdrop. Photo: Tim Thompson, courtesy of Seattle's Convention and Visitors Bureau.*

## SEATTLE, WASHINGTON

The combination of water, hills and lush greenery, set against a backdrop of far-off mountains, including the breathtaking Mt. Rainier, makes Seattle one of the most beautiful urban areas in the U.S. Truly, the bluest skies are in Seattle, and the days are long and warm in July, where the amount of rainfall is less than Phoenix during that month. Everyone takes advantage of the outdoors! This easily accessible and user-friendly city has numerous fine restaurants, interesting museums, and a vigorous arts scene in the downtown area. Unique attractions, such as the Pike Place Market, draw many locals and visitors through displays of wearable art, fresh fruits, vegetables, and huge bouquets of fresh flowers that fill the senses with wonderful colors and delicious scents. Cycling and walking trails interlace the urban area, and local ferries interconnect nearby islands, providing yet another fun and unique way to tour the area. Seattle is also a major US port and boasts modern cruise ship facilities for trips to Alaska.

**Children must be accompanied by an adult during all tours and social events.**

**SUNDAY, JULY 10  
5:00 PM TO 7:00 PM  
SHORT COURSE  
RECEPTION**

Please join us for light refreshments in the Metropolitan Ballroom room from 5:00 PM to 7:00 PM. The registration desk will be open from 5:00 to 9:00 PM.

# Social Program

## **TUESDAY, JULY 12 9:30 AM TO 12:30 PM SEATTLE CITY TOUR**

The adventure begins as we head out of the downtown area, past Seattle's sports stadiums and to the colorful waterfront bustling with eateries, gift shops and attractions.

As we travel beside the glistening waters of Lake Union, you will view a kaleidoscope of floating homes and the University of Washington Campus. We will also pass through the eclectic neighborhood of Fremont, strewn with sculptures, before we stop and visit the Hiram Chittenden Locks, which separates Puget Sound from Lake Union. See boats pass through the locks and inspect the fish ladders where thousands of salmon travel upstream to spawn.



*Visitors watch as boats make the transition from the fresh water of Lake Washington and Lake Union to the salt water of Puget Sound through Hiram M. Chittenden Locks in Ballard, Seattle's Scandinavian neighborhood. Photo: Seattle's Convention and Visitors Bureau.*

We will continue on our way to a stunning viewpoint of the Seattle skyline and breathtaking Mt. Rainier. Great photo op!!

We then return to the streets of beautiful Seattle. View a maze of smart high-rises and Art Deco buildings. See the shopping district of Seattle and then drive through Seattle's 1852 birthplace - historic Pioneer Square. Cozy bookstores, nightclubs and restaurants are nestled in the Square's red brick buildings. And finally, visit the famous Pike Place Market, bounding with fresh fish, fruits, vegetables, flowers, and crafts.

Buses will depart promptly at 9:30 AM from the Sheraton for a bus tour of the area with an extended (45 minute) stop at the Hiram Chittendon Locks. Buses will return at 12:00 PM to Pike Place Market, where people can choose to stay at the Market and get lunch on their own, or ride the coach back at 12:15 PM to return to the Sheraton by 12:30 PM. The Sheraton is a short uphill walk on Pike Street if you choose to stay and enjoy the Market.

## **TUESDAY, JULY 12 6:00 PM TO 10:00 PM INDUSTRIAL EXHIBITS RECEPTION**

**6:00 PM COCKTAILS  
7:00 PM BUFFET**

A reception will be hosted by the NSREC exhibitors in Grand Ballroom A and East and West Ballrooms. Along with meeting representatives from leading companies in the radiation-hardening industry, enjoy complimentary food and drinks for NSREC attendees and their guests. Visit the exhibits and any registered technical attendee can participate in the Reception Raffle. **NOTE: Children under 16 must be accompanied by an adult in the Exhibits.**





# Social Program

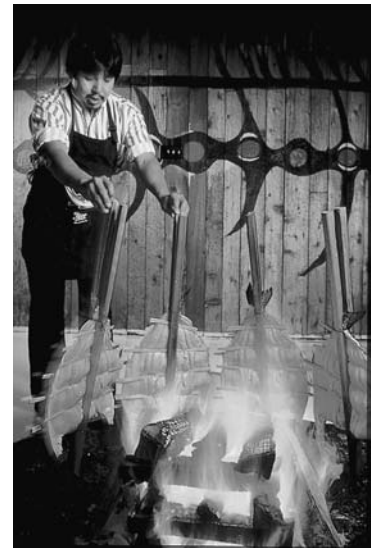
**WEDNESDAY, JULY 13  
4:30 PM – 10:15 PM  
TILlicum VILLAGE CRUISE  
AND SHOW**

The main social is planned for Tillicum Village on Blake Island State Park. The adventure begins at Pier 55 on Seattle's central waterfront. Relax and enjoy the magnificent scenery during the one-hour cruise on Elliott Bay on your exclusive NSREC charter. When you arrive at Tillicum Village, make your way up to the longhouse along the pathway strewn with clam shells bleached by the sun. Before you enter the longhouse, take a moment and enjoy an appetizer of clams and nectar. Be sure to crush those empty clam shells when you are finished. They're fun to smash and you will help preserve the path! Inside the longhouse, watch as whole Chinook salmon is cooked over an alder-wood fire on cedar stakes in the traditional Northwest Coast Indian style.

Your private NSREC meal is served buffet-style and includes traditional Indian-style Baked Salmon, Warm Tillicum Whole Grain Bread, New Red Potatoes, Long-Grain Wild Rice, Fresh Salad Bar, Boehm's Chocolate Salmon, and Beverages. NOTE: The menu is the same for Adults and Children. As you finish your meal, the lights dim while the myth and magic come to life in the spellbinding, 30-minute performance featuring the Tillicum Village dancers.



*"Dance On The Wind."*  
Photo: Courtesy of Tillicum Village.



*Salmon bake. Photo: Courtesy of Tillicum Village.*

Then feel free to watch the carvers....or browse through the gift gallery featuring artwork of local artisans....or we are fortunate to have fellow NSREC attendee, Mark Baze, a local expert, volunteer to lead a guided hiking excursion.

We then reboard the boat for a one-hour return trip where we can enjoy the night lights of Seattle.

Buses start leaving at 4:30 PM from the Sheraton, with the last bus leaving at 5:00 PM, for the short ride to Pier 55. There is plenty of seating for everyone on the charter and you can purchase refreshments. We arrive at Tillicum at 6:15 PM and the buffet starts at 6:30 PM. Please be back at the charter at 9:15 PM for the return cruise. NSREC buses will meet us at Pier 55 for the short ride back to the Sheraton.

Strollers can be taken on the bus and charter; however, the paths at Tillicum are not stroller friendly. Please wear comfortable shoes and clothing and bring a light jacket and sweater since it will be breezy and cool during the cruise. Don't forget your camera! Special dietary requests can be accommodated with advance notice.

**Attendance at this event is limited to immediate family members. Please sign up early to guarantee a spot since space is limited.**

# Social Program

**THURSDAY, JULY 14  
9:00 AM TO 4:00 PM  
MUSEUM OF GLASS TOUR  
AND GIG HARBOR  
SHOPPING**



*Blomma Vase  
Museum of Glass Limited Edition 2004  
Photo: Russell Johnson, courtesy of the Museum of Glass*

The Museum of Glass is an international center for contemporary art with a sustained focus on glass. Feel the heat as you watch a team of artists create masterpieces from molten glass in the Hot Shop Amphitheater. Tour the exhibitions and education studio or take in a performance or lecture in the theater. Explore the art on the outdoor plazas and cross the 500-foot long Chihuly Bridge of Glass. Docents will lead us on a 45 minute tour of the gallery

in groups of twenty and then we will have the opportunity for a little art therapy for adults and children where we can create our own masterpieces with the artist-in-residence. We will have about two hours to explore the museum. Please visit the Museum of Glass web site, [www.museumofglass.org](http://www.museumofglass.org), for more information. Buses will load at 11:45 AM for prompt departure at 12:00 PM (noon) for Gig Harbor.

The next stop is the quiet waterfront village of Gig Harbor, a community rich in maritime history, scenery, and quaint shops. Founded in 1946, Gig Harbor is one of the most picturesque small cities in America, located on Gig Harbor Bay in Puget Sound across the Narrows Bridge from Tacoma. You will have two hours to have lunch on your own, shop and stroll along the waterfront. Buses returning to the Sheraton will start loading at 2:30 PM for departure at 2:45 PM.



*©Steve Gibson/Terrell Publishing*

Buses depart the Sheraton promptly at 9:00 AM and return to the Sheraton at 4:00 PM. This is a casual event, and comfortable clothes and shoes are recommended. Strollers can be accommodated on the bus and are recommended for smaller children.

## **AEROBICS**

Get your day started with Dave Bushmire, our own certified aerobics instructor. These lively sessions will take place Tuesday, Wednesday and Thursday at 6:30 AM in the Cirrus Room on the 35th floor.

## **ACTIVITIES CANCELLATION POLICY**

To encourage advance registration for conference social activities, NSREC will refund all activity fees for conference attendees and companions who for any reason are unable to attend the conference. If your plans change after your activities registration form is submitted, request a refund by notifying ETC Services by fax at 720-733-2046 no later than July 5, 2005.

# Local Activities

## SEATTLE WATERFRONT

The aquarium may be the largest attraction on the waterfront, but the area is a mecca for tourists looking for boat trips, a bit of Seattle history and a kid-friendly museum.

## ODYSSEY, THE MARITIME DISCOVERY CENTER

An interactive museum exploring Seattle's working relationship with Puget Sound and the North Pacific, from commercial fishing and shipping to trade, recreation and marine protection. Exhibits include virtual kayak rides and simulated tugboat navigation. For more information contact [www.ody.org](http://www.ody.org).

## PIKE PLACE MARKET (PPM)

This authentic 96-year-old farmers market is a lively hodgepodge of stalls offering fresh flowers, fruits, vegetables, fish and meats.

A must do for anyone who wants to connect with the city's soul. PPM tends to get crowded in the summer so go early especially if you have a stroller. Lots of cool cafes in the area and the original Starbucks is right across the street. Savor the aromas of roasting coffee, fresh-baked bread, spices and cheeses as you wander the aisles and marvel at the artistic arrangements of produce. Some of the Market's restaurants offer views of Elliott Bay, along with traditional and ethnic foods to enjoy at a sit-down meal or to take away. The northern portion of the Market is home to craftspeople selling pottery, jewelry and clothing.



*Photo: Courtesy of Seattle's Convention and Visitors Bureau.*

The Market is officially open Monday - Saturday from 10:00 AM to 6:00 PM, Sunday 11:00 AM - 5:00 PM. Individual shop hours vary. Information: 206-682-7453, [www.pikeplacemarket.com](http://www.pikeplacemarket.com).

## PIONEER SQUARE

Seattle's historic district is filled with brick and sandstone buildings that house a vibrant neighborhood full of art galleries, clubs and restaurants.

Take in the popular Underground Tour ([www.undergroundtour.com](http://www.undergroundtour.com)) for a view of what was ground-level Pioneer Square before the Great Fire of 1889. This is a fascinating look at Seattle's colorful history from the bottom up.

**Klondike Gold Rush National Historic Park** is a small museum recalling the exciting days more than a century ago when rough-and-ready gold-seekers converged on Pioneer Square on their way to the Yukon (17 S. Main St. off Pioneer Square). It's filled with historical information about the Klondike Gold Rush, which started in 1897. Park rangers demonstrate gold-panning techniques and show movies about Seattle's role in the Gold Rush. Open 9:00 AM - 5:00 PM daily except some holidays; free. Contact [www.nps.gov/klse](http://www.nps.gov/klse) for more information.

# Local Activities

## SPACE NEEDLE

This is a must if you like panoramic vistas from Seattle's icon, but it is best to go on a clear day. Take the monorail (kids really like this, even big kids), which runs every 10 minutes from the station at Seattle Center, (across from the Space Needle) and from Westlake Center Mall, at Fifth Avenue and Pine Street. For more information contact [www.seattlemonorail.com](http://www.seattlemonorail.com). The 605-foot-tall Space Needle at Seattle Center is a great place to get an overview of the city. The Needle, a designated Seattle landmark, has two restaurants and an observation deck with a 360-degree view. Call 206-443-2111 or contact [www.spaceneedle.com](http://www.spaceneedle.com) for more details.

## EXPERIENCE MUSIC PROJECT

If you have children who like music and want hands on experience, or if you are really a rock star alter-ego, this is your museum. Not like any museum you have ever seen and it is right at the Space Needle. Since its opening in 2000, this Frank O. Gehry-designed landmark has welcomed almost 2 million visitors. EMP's 140,000-square-foot building houses a variety of venues where visitors can

watch films, hear an oral history, get guitar lessons or enjoy a concert. Its interactive exhibits and unique artifacts explore American popular music, from its roots in jazz, soul, gospel, country and the blues, to its influence on hip-hop, punk and other genres. Its motto is: "You don't need to be a rock star to appreciate EMP, but you might leave here feeling like one." EMP is situated at the foot of the Space Needle. Call 206-367-5483 to check on hours for specific venues, or check the Web site: [www.emplive.com](http://www.emplive.com).



*Photo: Tim Thompson, courtesy of Seattle's Convention and Visitors Bureau.*

## MUSEUM OF FLIGHT

In the steel-and-glass Great Gallery, visitors can explore the history of aviation with dozens of historic aircraft suspended six stories above. Experience a wild air show routine in the X-Pilot full-motion simulator; learn how airplanes fly in the hands-on Flight Zone; and journey through history aboard the first presidential jet Air Force One. Also, the museum now houses the only retired Concorde jetliner displayed on the West Coast. The complex is about 15 minutes south of downtown at 9404 E. Marginal Way S. Open daily 10:00 AM - 5:00 PM, till 9:00 PM on the first Thursday of the month. Contact 206-764-5720 or [www.museumofflight.org](http://www.museumofflight.org)

# Local Activities

## MOUNT RAINIER

At 14,411 feet, it's the fourth-highest mountain in the lower 48 states and still one big, mean active volcano, regardless of how serene it looks on a sunny day. It's about a two-hour drive from Seattle to reach the southwest slopes and the Nisqually entrance to Mount Rainier National Park, which leads to Longmire and Paradise, two of the most heavily used portions of the park during the summer. The Henry M. Jackson Memorial Visitor Center at Paradise, on the south flank of the mountain, is hard to miss because of its circular, space-station-like appearance. Cafeteria-style food service is available on a limited schedule. Lots of geologic volcano information is dished out to visitors by various displays and rangers. The indoor viewing platform at the top offers splendid views of the surrounding mountain ranges and Rainier itself. The center is open 10:00 AM - 7:00 PM daily.



*Photo: Tim Thompson, courtesy of Seattle's Convention and Visitors Bureau.*

## CHATEAU STE. MICHELLE WINERY

It takes about an hour from downtown Seattle to reach the picturesque Chateau Ste. Michelle Winery in Woodinville. It hosts more than 350,000 visitors a year who come for wine tasting and touring, classes, picnics and big-name summer concerts on the expansive grounds. 425-415-3300; 800-267-6793; [www.ste-michelle.com](http://www.ste-michelle.com)

Practically across the street is Columbia Winery, which is housed in a large Victorian-style house. 425-488-2776; 800-488-2347; [www.columbiawinery.com](http://www.columbiawinery.com)

## MOUNT ST. HELENS

This year marks the 25th anniversary of the Mount St. Helens eruption. Since it's about a 94-mile round trip from Seattle, allow a full day to visit the monument. That will allow you time to leisurely visit the centers and take in a few activities. Take along plenty of water if you plan to do any hiking. The Forest Service also recommends sturdy walking shoes, sunglasses and a hat. And most importantly – stay on the paths and keep your dog leashed. Information: [www.fs.fed.us/gpnmf/mshnvm/](http://www.fs.fed.us/gpnmf/mshnvm/)

## WEATHER AND CLOTHING

The average temperature during the day in July is 75 degrees but it cools off at night to an average of 56 degrees. Seattle in July experiences an average of five rainy days. Visitors should dress for mild weather. Light jackets and sweaters are advisable for the evening, especially when near the water. Remember, too, that conference rooms are usually cold, so attendees will want to dress a bit more warmly when in sessions.

# 2005 Conference Committee



General Chair  
Fred Sexton  
Sandia National  
Laboratories  
505-844-3927  
Fax: 505-844-2991  
sextonfw@sandia.gov



Technical Program  
Mike Xapsos  
NASA Goddard Space  
Flight Center  
301-286-2263  
Fax: 301-286-4699  
michael.a.xapsos@nasa.gov



Local Arrangements  
Kay Jobe  
Boeing Satellite Systems  
310-416-3705  
Fax: 310-364-5143  
kay-carol.m.jobe@  
boeing.com



Short Course  
Allan Johnston  
Jet Propulsion Laboratory  
818-354-6425  
Fax: 818-393-4559  
allan.h.johnston@  
jpl.nasa.gov



Publicity  
Teresa Farris  
Aeroflex Colorado Springs  
719-594-8035  
Fax: 719-594-8468  
teresa.farris@aeroflex.com



Finance  
Ron Lacoe  
Aerospace Corporation  
310-336-0118  
Fax: 310-336-5846  
ronald.c.lacoe@aero.org



Awards  
Jim Kinnison  
JHU/APL  
240-228-6169  
Fax: 240-228-6696  
jim.kinnison@jhuapl.edu



Industrial Exhibits  
Nazik Maloyan  
International Rectifier  
310-726-8412  
Fax: 310-726-8183  
nmaloyan@irf.com



Guest Editor  
John Cressler  
Georgia Tech  
404-894-5161  
Fax: 404-894-4641  
cressler@ece.gatech.edu



Associate Guest Editor  
Philippe Paillet  
CEA, France  
33 1 69 26 50 89  
Fax: 33 1 69 26 70 53  
philippe.paillet@cea.fr



Assistant Guest Editor  
Jim Felix  
Sandia National  
Laboratories  
505-844-6132  
Fax: 505-844-2991  
jafelix@sandia.gov

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# Radiation Effects Steering Group

## **Chairman**

Ronald D. Schrimpf  
Vanderbilt University  
Electrical Eng. and Comp. Science  
P.O. Box 1608, Station B  
Nashville, TN 37235  
615-343-0507 fax: 615-343-0601  
ron.schrimpf@vanderbilt.edu  
(Term expires: 7/06)

## **Past Chairman**

Dale G. Platteter  
NAVSEA Crane  
Code 605, Building 3334  
300 Highway 361  
Crane, IN 47522-5001  
812-854-1206 fax: 812-854-1751  
platt@ieee.org  
(Term expires: 7/06)

## **Junior Member-at-Large**

Véronique Ferlet-Cavrois  
CEA  
BP12 SEIM  
91680 Bruyeres-le-Chatel France  
33-169-26-4265 fax: 33-169-26-7053  
veronique.ferlet@cea.fr  
(Term expires: 7/07)

## **Special Publications Assignment**

Paul V. Dressendorfer  
Sandia National Laboratories  
MS 1413 / Department 1141  
P.O. Box 5800  
Albuquerque, NM 87185-1413  
505-844-5373 fax: 505-844-5470  
dressepv@sandia.gov

## **Vice-Chairman, 2007 Conference**

Lloyd W. Massengill  
Vanderbilt University  
Electrical Eng. & Comp. Science  
Box 1683, Station B  
Nashville, TN 37235  
615-343-6677 fax: 615-343-6614  
lloyd.w.massengill@vanderbilt.edu

## **NPSS AdCom Member**

Joseph M. Benedetto  
ATK Mission Research Corporation  
5017 North 30th Street  
Colorado Springs, CO 80919  
719-633-2344 x177 fax: 719-532-1926  
benedetto@mrcmicroe.com  
(Term expires: 12/06)

## **Executive Vice-Chairman**

Timothy R. Oldham  
NASA Goddard  
Code 561.4  
Building 22, Room 048  
Greenbelt, MD 20771  
301-286-5489 fax: 301-286-4699  
toldham@pop500.gsfc.nasa.gov  
(Term expires: 7/06)

## **Senior Member-at-Large**

Gary K. Lum  
Lockheed Martin  
Orgn. L4, Bldg. 157  
1111 Lockheed Martin Way  
Sunnyvale, CA 94088  
408-756-0120 fax: 408-734-2005  
gary.lum@lmco.com  
(Term expires: 7/05)

## **Vice-Chairman, Publications**

Marty Shaneyfelt  
Sandia National Laboratories  
P.O. Box 5800, MS-1083  
Albuquerque, NM 87185-1083  
505-844-6137 fax: 505-844-2991  
shaneymr@sandia.gov  
(Term expires: 7/06)

## **Vice-Chairman, 2005 Conference**

Fred W. Sexton  
Sandia National Laboratories  
MS 1081 / Department 1762  
P.O. Box 5800  
Albuquerque, NM 87185-1081  
505-844-3927 fax: 505-844-2991  
sextonfw@sandia.gov

## **Vice-Chairman, 2008 Conference**

Paul E. Dodd  
Sandia National Laboratories  
PO Box 5800  
MS 1083  
Albuquerque, NM 87185-1083  
505-844-1447 fax: 505-844-2991  
pedodd@sandia.gov

## **NPSS AdCom Member**

Allan H. Johnston  
Jet Propulsion Laboratory  
MS 303-220  
4800 Oak Grove Drive  
Pasadena, CA 91109  
818-354-6425 fax: 818-393-4559  
allan.h.johnston@jpl.nasa.gov  
(Term expires: 12/07)

## **Secretary**

Jeffrey D. Black  
Vanderbilt University/ISDE  
2014 Broadway, Suite 200  
Nashville, TN 37203  
615-322-3758 fax: 615-343-9550  
jeffrey.d.black@vanderbilt.edu  
(Term expires: 7/06)

## **Member-at-Large**

Steven L. Clark  
Air Force Research Lab  
3550 Aberdeen Ave., SE  
Kirtland AFB, NM 87117-7556  
505-846-6067 fax: 505-853-2205  
steven.clark@kirtland.af.mil  
(Term expires: 7/06)

## **Vice-Chairman, Publicity**

Teresa Farris  
Aeroflex Colorado Springs  
4350 Centennial Blvd.  
Colorado Springs, CO 80907-3486  
719-594-8035 fax: 719-594-8486  
teresa.farris@aeroflex.com  
(Term expires: 7/06)

## **Vice-Chairman, 2006 Conference**

Janet L. Barth  
NASA/GSFC  
Code 561.4  
Building 22, Room 046  
Greenbelt, MD 20771  
301-286-8046 fax: 301-286-4699  
janet.l.barth@nasa.gov

## **NPSS AdCom Member**

Dennis B. Brown  
National Reconnaissance Office  
AS&T Div.  
14675 Lee Rd.  
Chantilly, VA 20151  
703-808-5290 fax: 703-808-2646  
dbbrown@ccf.nrl.navy.mil  
(Term expires: 12/05)

## **RADECS Liaison**

Robert Ecoffet  
DTS/AQ/EQE/ER  
CNES - Toulouse Space Center  
18 Avenue Edouard Belin  
31401 Toulouse Cedex 4, France  
33.5.61.28.17.96 fax: 33.5.61.27.47.32  
robert.ecoffet@cnes.fr  
(Term expires: 7/06)



# ANNOUNCEMENT and FIRST CALL FOR PAPERS



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*Janet Barth  
NASA/GSFC  
301-286-8046*

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*Gary Lum  
Lockheed Martin  
408-756-0120*

Local Arrangements

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Consultant  
321-255-2791*

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## 2006 IEEE NUCLEAR AND SPACE RADIATION EFFECTS CONFERENCE Short Course and Radiation Effects Data Workshop

**July 17 - 21, 2006**

**Marriott Sawgrass Resort and Spa  
Ponte Vedra Beach, Florida**

The 2006 IEEE International Conference on Nuclear and Space Radiation Effects will be held July 17-21 in Ponte Vedra Beach, Florida at the Sawgrass Marriott Resort and Spa. 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 17, a Radiation Effects Data Workshop, and an Industrial Exhibit. The technical program includes oral and poster 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 Advanced Technologies
- Isolation Technologies, such as SOI and SOS
- Optoelectronic and Optical Devices and Systems
- Methods for Hardened Design and Manufacturing
- Modeling of Devices, Circuits and Systems
- Particle Detectors and Associated Electronics for High-Energy Accelerators
- Cryogenic or High Temperature Effects
- Single-Event Effects
- Novel Device Structures, such as MEMS and Nanotechnologies

### Space, Atmospheric, and Terrestrial Radiation Effects

- Characterization and Modeling of Radiation Environments
- Space Weather Events and Effects
- Spacecraft Charging

### Hardness Assurance Technology and Testing

- Testing Techniques, Guidelines and Hardness Assurance Methodology
- Radiation Exposure Facilities
- Dosimetry

### Commercial Space Systems

### New Developments of Interest to the Radiation Effects Community

**PAPER SUMMARY DEADLINE: FEBRUARY 3, 2006**

## PROCEDURE FOR SUBMITTING SUMMARIES

Authors must conform to the following requirements:

1. Prepare a single Adobe Acrobat file (maximum 5 pages) consisting of (a) an abstract no longer than 35 words on the first page, followed by (b) an informative **two to four page summary** describing results appropriate for 12-minute oral or a poster presentation. On the first page, please include title, name and company affiliation of the authors, and company address (city, state, country). Identify the author presenting the paper and provide telephone, fax, and email address.
2. The summary must include sufficient detail about the work to permit a meaningful technical review. In the summary, clearly indicate (a) the purpose of your work, (b) significant new results with supporting technical material, and (c) how your work advances the state of the art. Show key references to other related work. The summary must be **no less than two and no more than four pages** in length, including figures and tables (one additional page is allowed for the 35-word abstract). *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. Prepare your summary using 11 point or greater type on either U.S. Standard, 8.5 inch (21.6 cm) x 11 inch (27.9 cm), or A4, 21 cm x 29.7 cm, white paper, with 1 inch (2.5 cm) margins on all four sides, and single-column format.
4. Obtain all corporate, sponsor, and government approvals and releases necessary for presenting your paper at an open-attendance international meeting.
5. The submission process consists of two parts: (a) submit an Author Information Form on the **www.nsrec.com** website and (b) email your summary (PDF format) to the Technical Program Chairman as described on **www.nsrec.com**. *Authors are requested to state their preference for presentation (oral, poster, or data workshop) and for session.* 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.

**Summaries must be received by  
February 3, 2006**

**Detailed submission and  
formatting instructions  
will be available after  
January 2, 2006  
at [www.nsrec.com](http://www.nsrec.com)**

Papers accepted for oral or poster presentation at the technical program will be eligible for publication in the Conference issue of the *IEEE Transactions on Nuclear Science* (December 2006), 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 Record and are not candidates for publication in the Conference issue of the *IEEE Transactions on Nuclear Science*.

## PONTEVEDRA BEACH, FLORIDA

NSREC - 2006 will be held at the Marriott Sawgrass Resort and Spa in Ponte Vedra Beach, just south of Jacksonville. Jacksonville and the Beaches are fabulous Florida at its best with a dash of Southern charm added. From expansive beaches and endless saltwater marshes to a modern downtown, exciting shopping and championship golf courses, there are activities to please everyone. Jacksonville is a city adorned with fountains, parks and plazas, with neighborhoods lined with hundred-year old oak trees draped with Spanish moss. St. Augustine is just a short drive away, and offers many attractions including Fort San Marcos, built to defend this oldest city in the United States against would-be invaders. Guided tours on buses and trams and scenic boat tours are a great way to see the city. To the North of Jacksonville is Amelia Island, with downtown Fernandina Beach offering antique shopping and fine dining. The Jacksonville area features numerous Florida state parks, including Guana State Park, the Timucuan Preserve and the Fort George historical site. The parks offer opportunities for hiking, fishing, water sports and bird watching. Other Florida attractions such as the Kennedy Space Center and the Orlando attractions are a few hours' drive away.



*Photo: courtesy of the Marriott Sawgrass.*

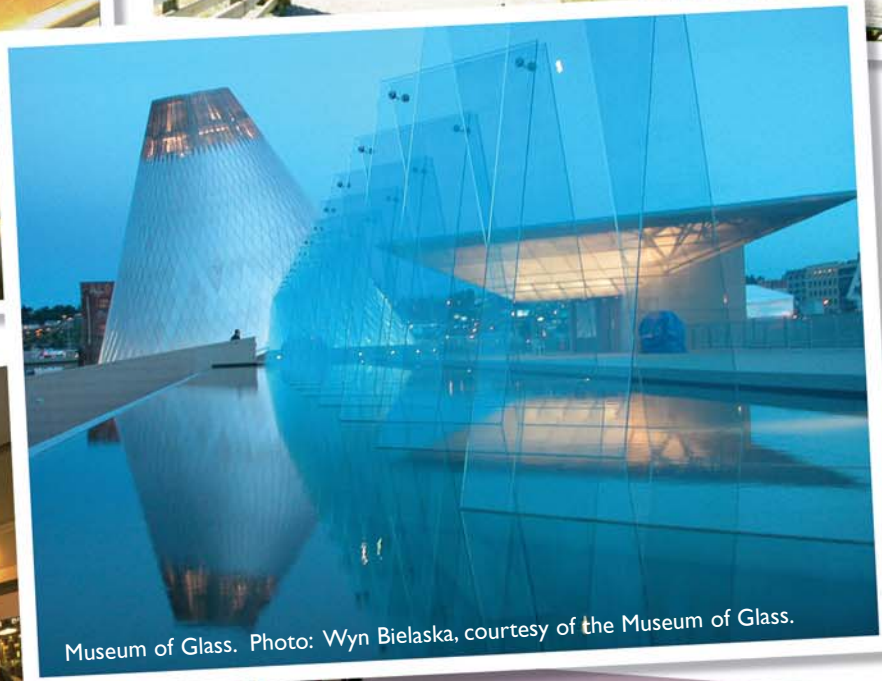
# Seattle, Washington

Photo: Tim Thompson, courtesy of Seattle's Convention and Visitors Bureau.

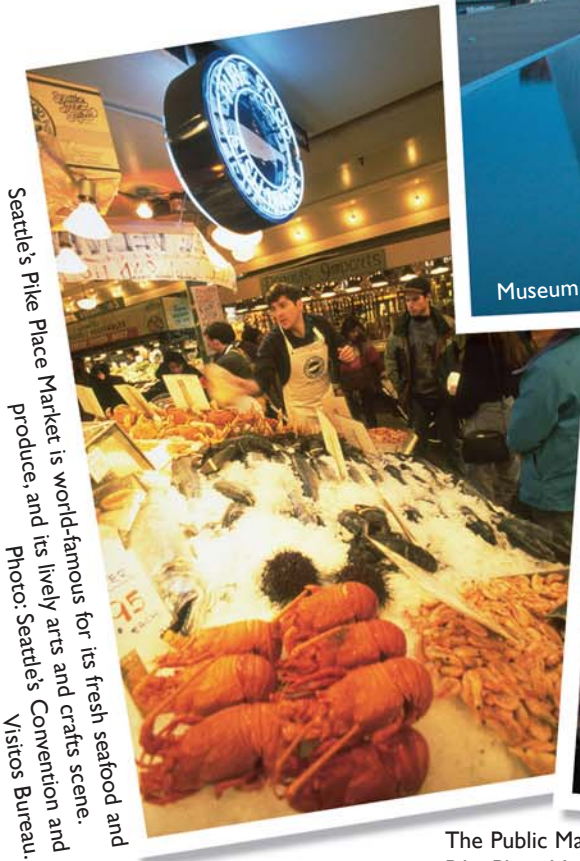


Experience Music Project and the Seattle Space Needle share acreage on the Seattle Center Grounds.

Photo courtesy of Tillicum Village.



Museum of Glass. Photo: Wyn Bielaska, courtesy of the Museum of Glass.



Seattle's Pike Place Market is world-famous for its fresh seafood and produce, and its lively arts and crafts scene. Photo: Seattle's Convention and Visitors Bureau.

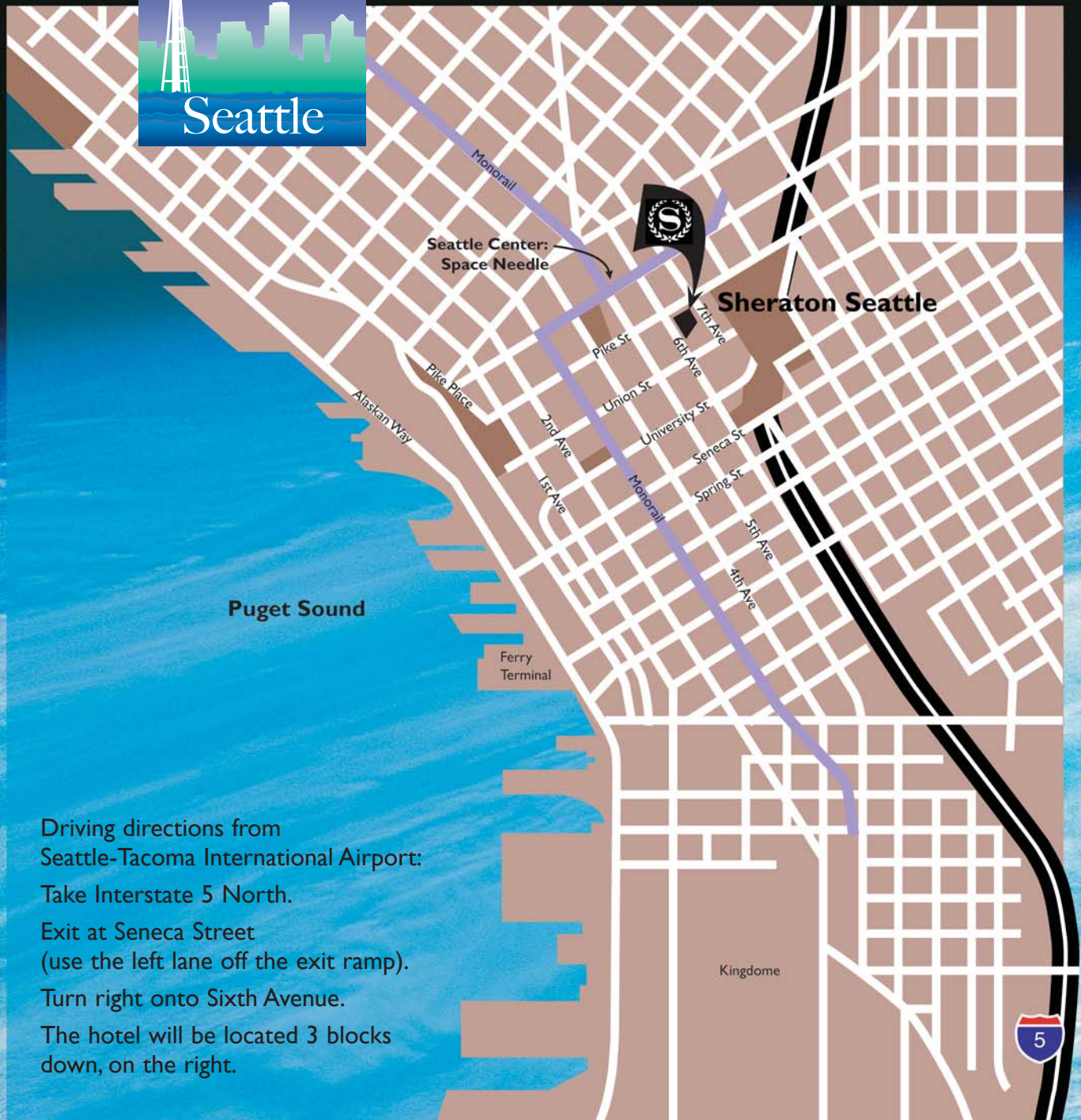


The Public Market sign hovers over Pike Place Market, with Elliott Bay, Puget Sound and West Seattle in the background. Photo: Tim Thompson, courtesy of Seattle's Convention and Visitors Bureau.





## DOWNTOWN SEATTLE



Driving directions from  
Seattle-Tacoma International Airport:  
Take Interstate 5 North.  
Exit at Seneca Street  
(use the left lane off the exit ramp).  
Turn right onto Sixth Avenue.  
The hotel will be located 3 blocks  
down, on the right.

15 miles to  
Seattle-Tacoma  
International Airport