NASA EEE Parts

and

Advanced Interconnect Program (AIP)

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(JPL) (GSFC)

(Co-program Managers)

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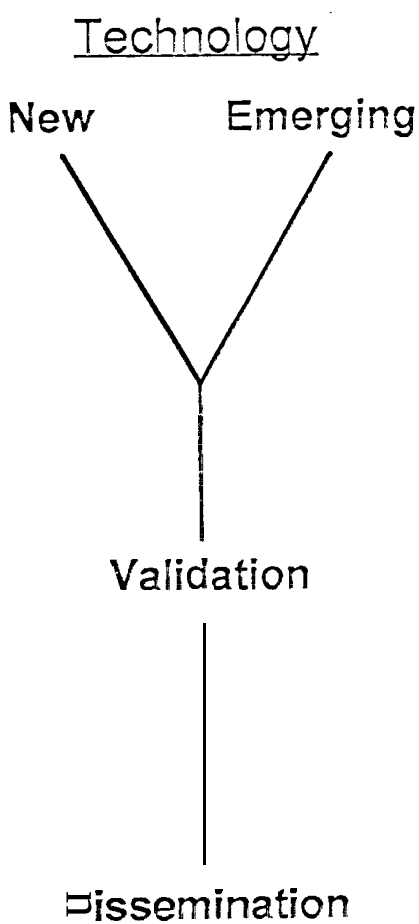
NASA EEE Parts & Advanced Interconnect Program

Topics

- Program Overview Description — T. Gindorf
- EEE Parts
  - Information Dissemination — T. Gindorf, A. Garrison
  - Electronic Part Reliability — T. Gindorf
  - Microelectronic Space Radiation Effects Program — T. Gindorf
- Advanced Interconnects
  - Area Array Packaging — T. Gindorf
  - Surface Mount Technology — T. Gindorf
  - Chip on Board Technology — A. Garrison
  - Technology Validation Assessment — A. Garrison
  - Concluding Remarks — A. Garrison

EEE Parts

NASA EEE PARTS AND ADVANCED NTERCONNECT PROGRAM



Program Objectives

I. Accelerate the readiness of new technologies through development of validation, assessment and test method/too's.

- Provide NASA Projects 'nfusion paths or emerging technologies

I . Provide NASA Projects technology selection, application and validation guidelines for hardware and processes

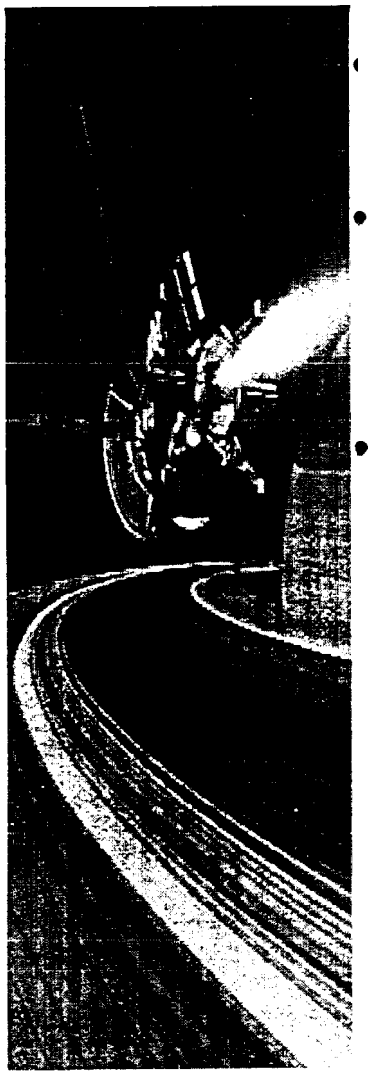
IV. Dissem'nate quality assurance, reliability, validation, tools and availab:lity information to the NASA community

Policy Statement

- The NASA EEE Parts Program and Advanced Interconnect Program will be coupled to existing or future NASA Project needs
- Tasks with a Project's endorsement and co-funding will be given priority
- Leveraging with industry, academia and government agencies, to multiply the effectiveness of the programs, will be actively pursued

NASA GEE PARTS PROGRAM

PROGRAM THRUSTS



- **Information Dissemination**
  - Part availability, reliability, and radiation data
- **Electronic Part Reliability**
  - Evaluation of advanced technology failure modes
  - Evaluation and development partnerships
- **Microelectronic Space Radiation Effects Program**
  - Piece part radiation testing and evaluation
  - Research into new radiation effects
  - Radiation data dissemination

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Information Dissemination

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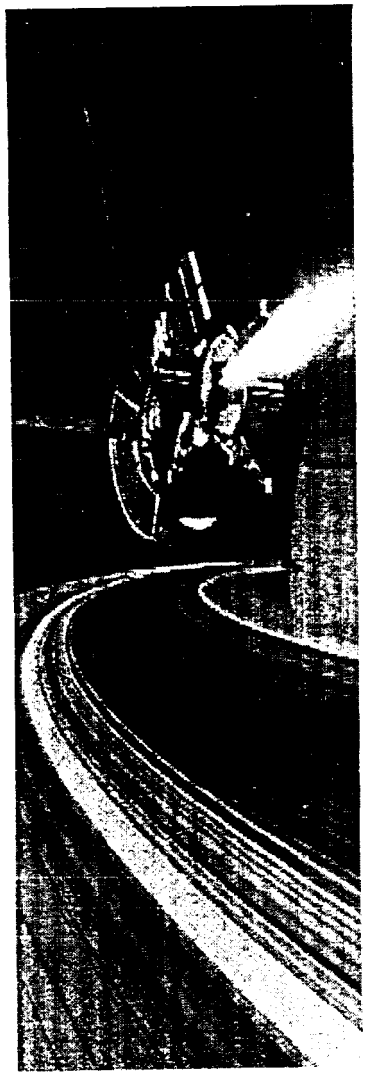
INFORMATION DISSEMINATION



- The NASA Parts & Packaging Home Page Contains In-House Parts Availability and Pricing Data, Failure Analysis Reports, DPA Results, GIDEP Alerts, and Radiation Data (RADATA)
- Partnerships with the Aerospace and Semiconductor Industries will Provide Rapid On-Line Parts Search Capabilities
- Links to University Research is also planned

PSAP, ASAP, CORE

1 or 2 pages

TO BE SUPPLIED BY MIN GARRISON (GSFC)

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EEE Parts

Electronic Part Reliability

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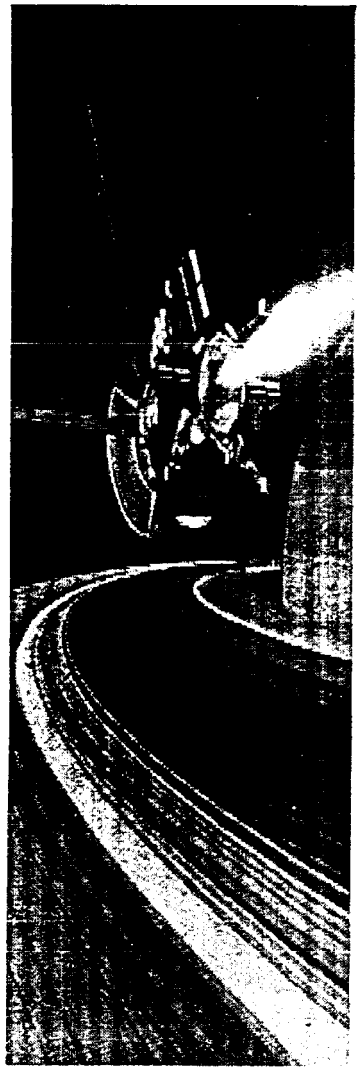
ELECTRONIC PART RELIABILITY



- **Flight** Readiness **Technology** Assessment
  - Perform quality and reliability assessments on COTS (commercial off the shelf) technologies
  - Determine relationship between manufacturing quality (via parts construction analysis) and reliability (via environmental stress tests)
  - Determine stress vs. fai ure mode and mechanism relationships
  - Publish evaluation resu ts and space flight qualification guidelines

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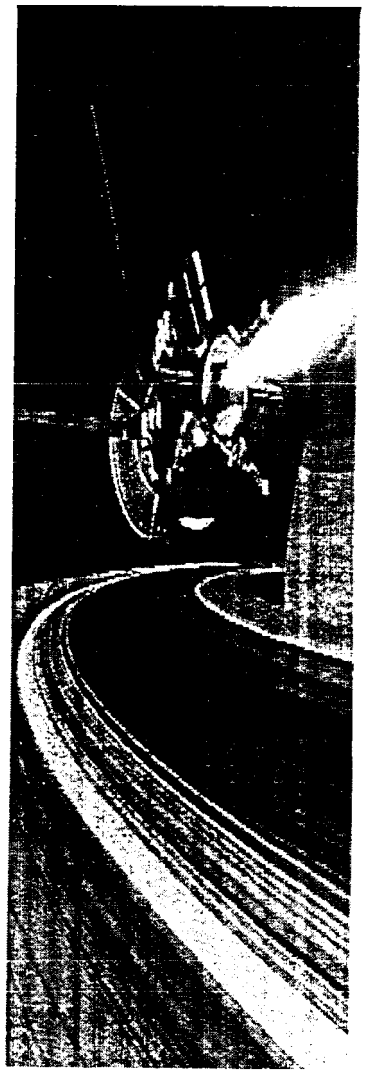
ELECTRONIC PART RELIABILITY



- **MEMS Reliability Assurance**
  - Evaluate both MDLs and commercial devices for reliability
  - Currently evaluating MDL's tunneling accelerometer
    - Assisted in wafer screening techniques and performed mechanical (vibration) qualification
  - Construction analysis of commercial accelerometers
  - Reliability evaluations of tunneling IR sensor (Golay cell) and micro-gyro
  - Evaluation of between fabrication processes and reliability
  - Stress vs. failure mode and mechanism evaluations
  - Publish results and space flight qualification guidelines

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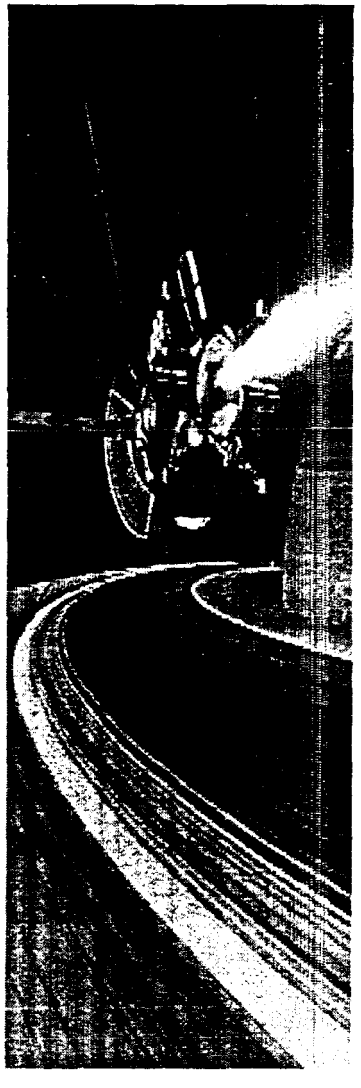
ELECTRONIC PART RELIABILITY



- **High Performance, High Reliability A/D Converter**
  - Evaluate currently available 14 & 16 bit, low power, 100ksamp e/s A/D converters for construction quality and reliability
  - Partner with industry to develop 16 bit, low power, high sample rate (1 MS/s), rad hard A/D converter
  - Publish evaluation. results

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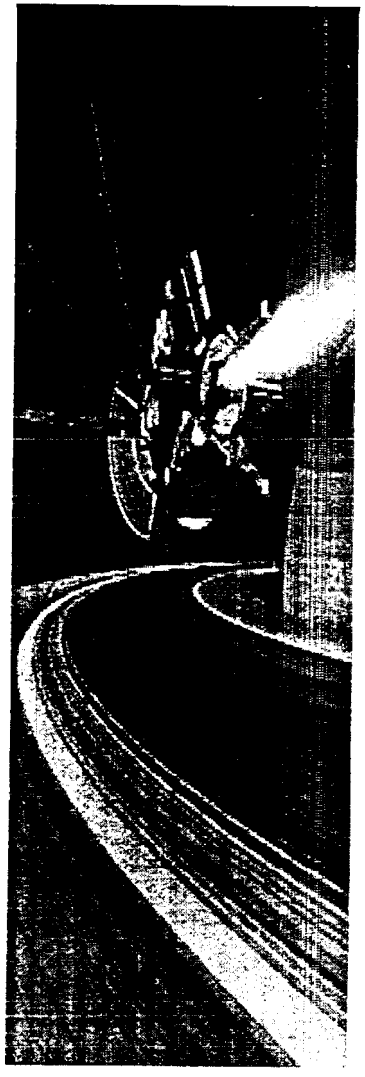
ELECTRONIC PART RELIABILITY



- Active **Pixel Sensor**
  - Assist in the transfer of commercial CMOS design to radiation hard design
  - Assist in the development of radiation hard design rides
  - Perform radiation characterization, on. existing CMOS designs
  - Perform radiation characterization on rad hard design
  - Perform reliability evaluations on rad hard design.
  - Publish radiation and reliability results

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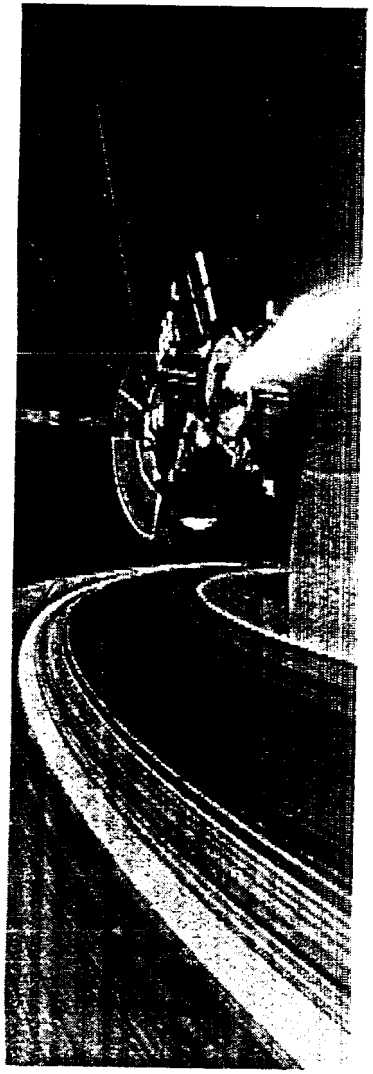
ELECTRONIC PART RELIABILITY



- **MMIC Reliability Assurance**
  - Publish GaAs MMIC space flight qualification guidelines
    - Contains practices applicable to both users and manufacturers
- **Compound Semiconductor Reliability Assurance**
  - Hydrogen effects risk mitigation
    - Develop failure model
    - Determine solution set
    - Partner with industry to develop TaSiN gate structure
  - Non-Destructive channel temperature measurement
    - Operational channel temperature change relates to reliability
    - Technique can be used as reliability screen

EEE Parts

Microelectronics Space Radiation

Effects Program

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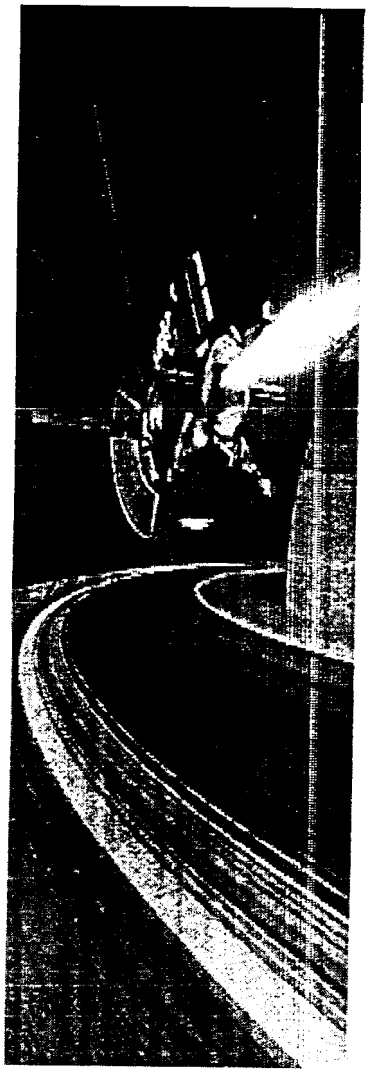
MICROELECTRONICS SPACE RADIATION EFFECTS PROGRAM



- MSREP includes TID (total ionizing dose) and SEE (single event effects) tests and evaluations
- MSREP supports projects and radiation research
- Project Support

  Consultations on potential radiation problems in photonics, high density RAMS, microprocessors, and low voltage electronics

  Ongoing effort to perform TID and SEE tests of Motorola 604 powerPC in cooperation with NMP and Motorola

  Perform radiation tests on low voltage, low power microelectronic devices from MIT and Loral

  Provide radiation test and evaluation support to MDL for products to be flown on NMP (e.g., TDL, microgyro)

  Disseminate radiation. test data via RADATA data base (available in NASA Parts & Packaging home page)

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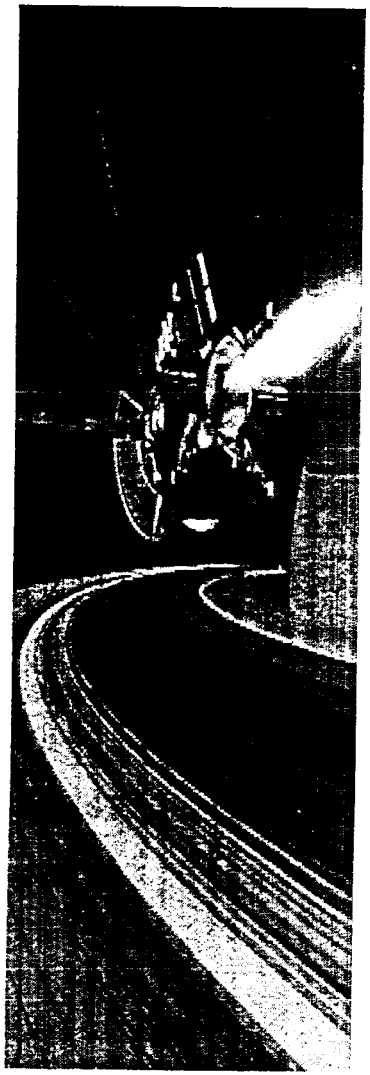
MICROELECTRONICS SPACE RADIATION EFFECTS PROGRAM



- EEE Parts Program Support
  - Radiation tests on high performance A/D converters
  - Radiation tests on commercial MEMS devices (e.g., ADXL50 accelerometer)
  - Radiation tests on COTS devices
  - Continued. evaluations of FPGA's (field programmable gate arrays)

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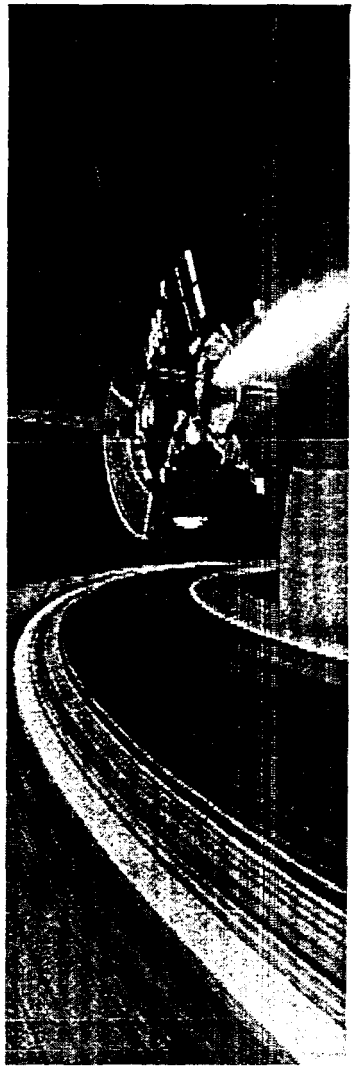
MICROELECTRONICS SPACE RADIATION EFFECTS PROGRAM



- **Enhanced** Low Dose **Rate** Effects
  - Bipolar and BiCMOS devices can be susceptible to low dose rate effects
  - Significant parametric degradation at low dose rates (i.e., mission dose rates) as compared with traditional moderate to high dose rate tests
  - Goal is to provide effective moderate dose rate test methodology, using temperature acceleration to approximate low dose rate response

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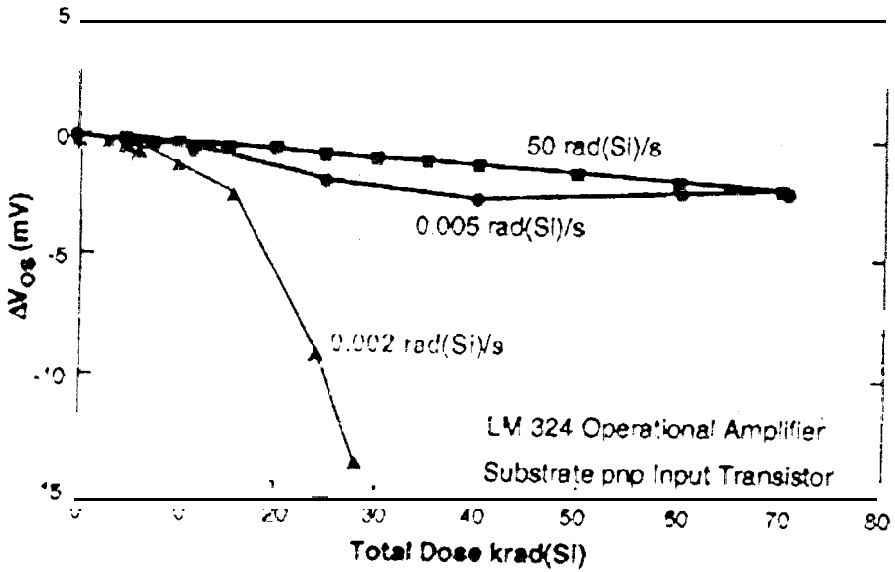
MICROELECTRON CS SPACE RADIATION EFFECTS PROGRAM



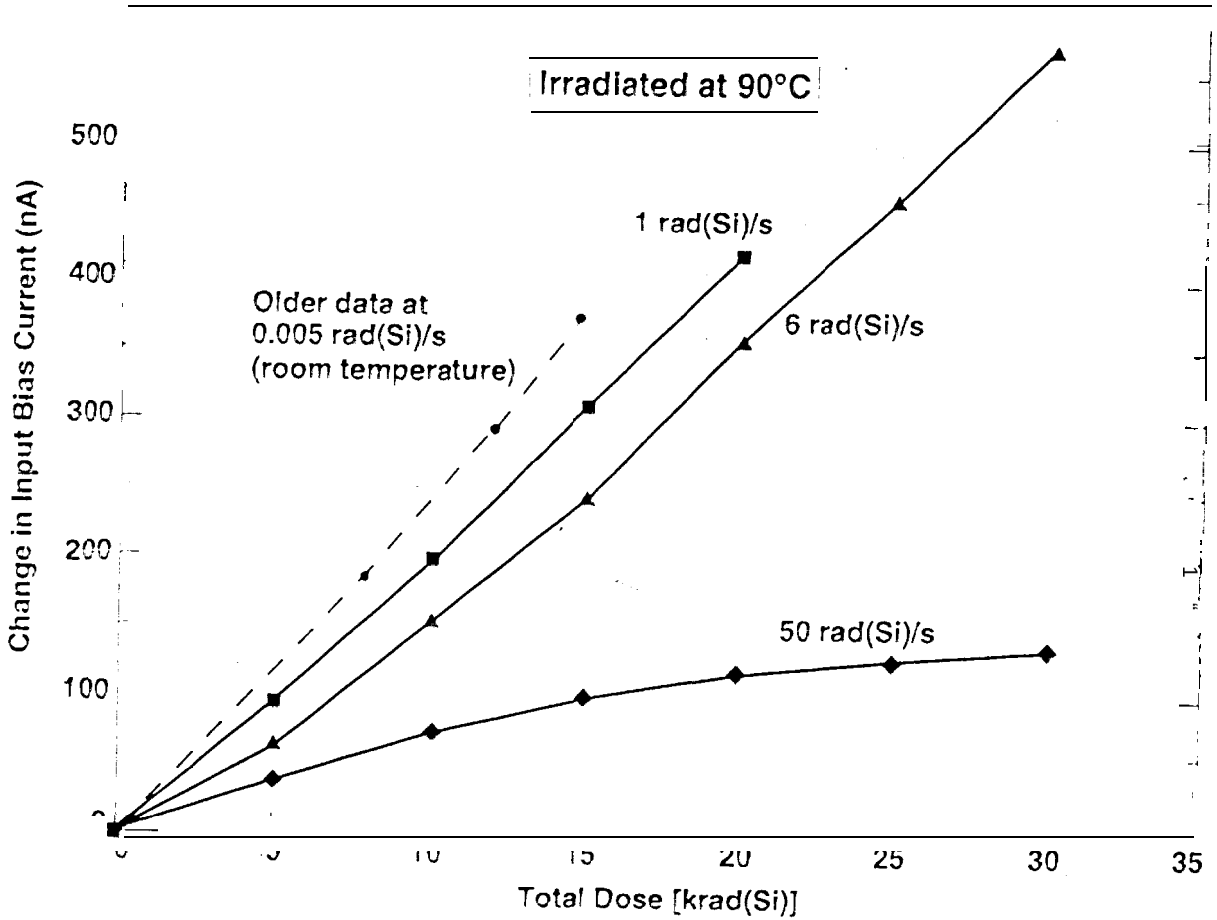
Laboratory radiation test at high dose rate is no longer conservative.

Saturation of enhanced low dose rate effect may not occur until very low dose rates.

A similar op-amp was eliminated from Cassini because of this problem.

Hardness assurance test recommendation will probably be a combination of reduced, but moderate dose rate, and elevated temperature.

ect of Dose Rate on Elevated Temp Irradiations of LM111



Hardness assurance test recommendation will probably be a combination of reduced, but moderate dose rate, and elevated temperature.

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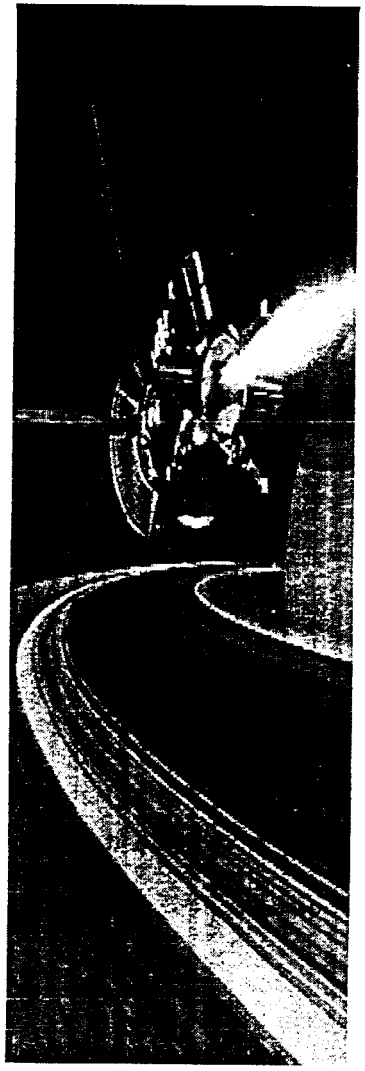
MICROELECTRONICS SPACE RA)IATION EFFECTS PROGRAM



- Effect of **Scaling on TID and** Hard Errors
  - As device feature sizes shrink to achieve densities, device oxides become thinner.
  - Decreased oxide thickness leads to increased electric fields across the oxide,increasing the vulnerability to oxide damage.
  - Work has already been performed on DRAMs and FPGAs
  - Task offers "glimpse into the future" to further define the mechanisms involved in *microdose* induced failures and *single event dielectric rupture* (SEDR)

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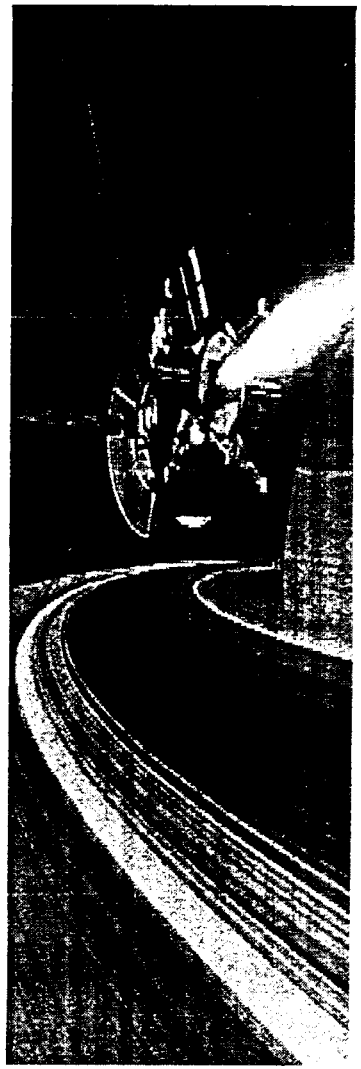
MICROELECTRONICS SPACE RADIATION EFFECTS PROGRAM



- **Latchup Mitigation**
  - High latchup LET requirements severely constrain a projects microcircuit selection
  - Many FBC projects are considering the use of parts that have lower latchup LET's as long as they can power down and reset the device every time a latchup occurs
  - This task will investigate the efficacy of de-latch circuitry and the reliability impact on devices under latchup-powerdown-powerup sequencing
  - Determine effect of neutron irradiation on COTS and SEE susceptibility

Advanced Interconnects

Area Array Packaging

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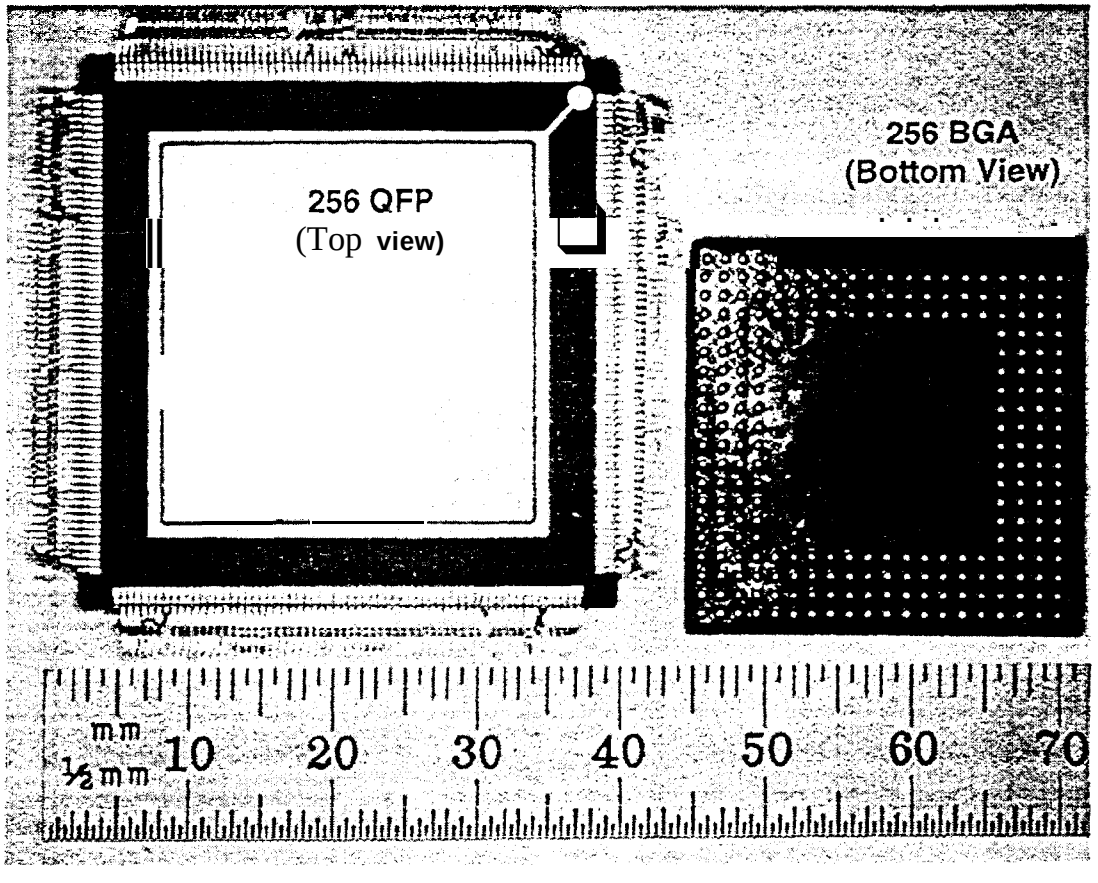
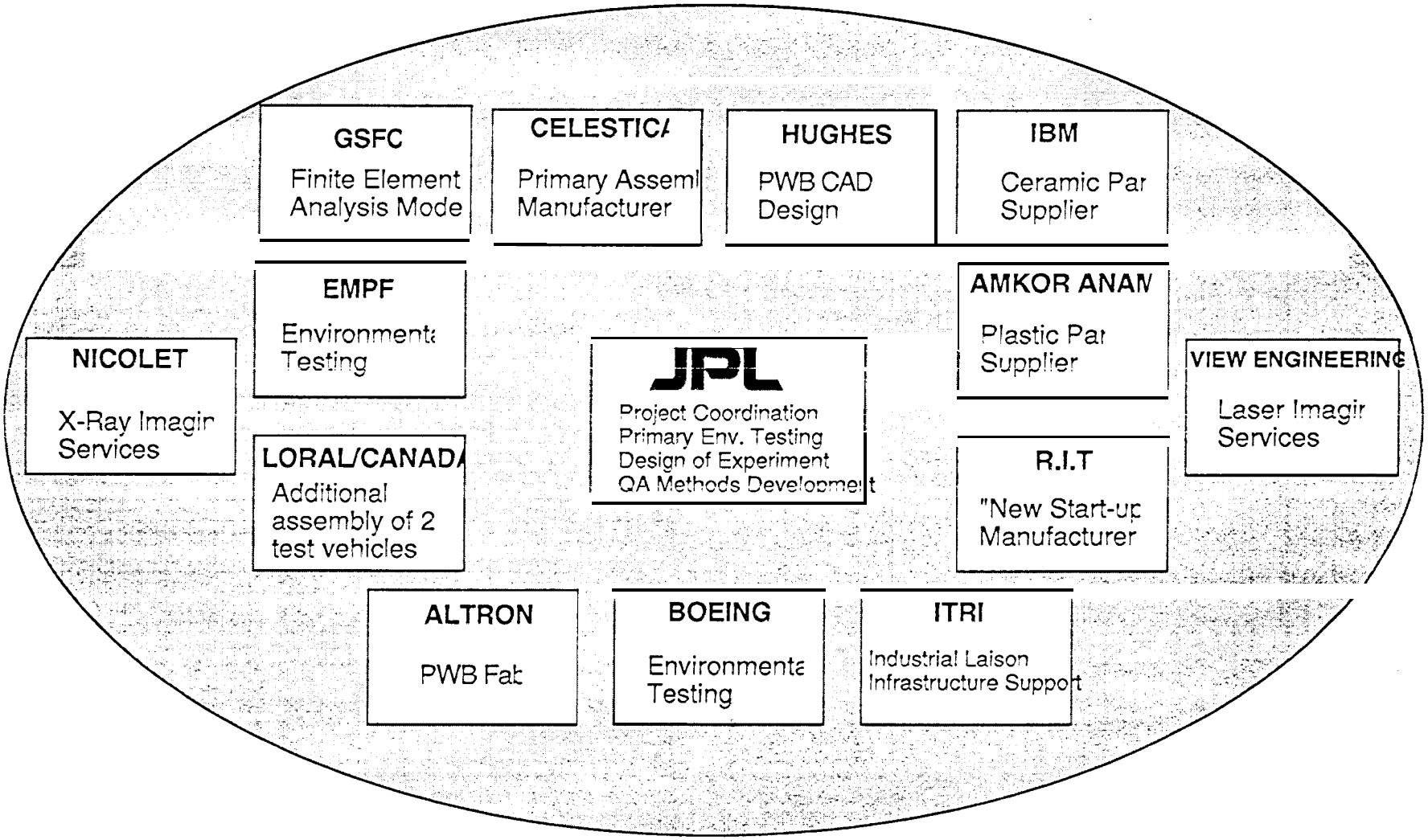
Area Array Packaging-Ball Grid Array

- Why BGA's?
  - » Area reduction of 2.5:1 over QFPs
  - » Primary challenge is the inspection of the interconnects

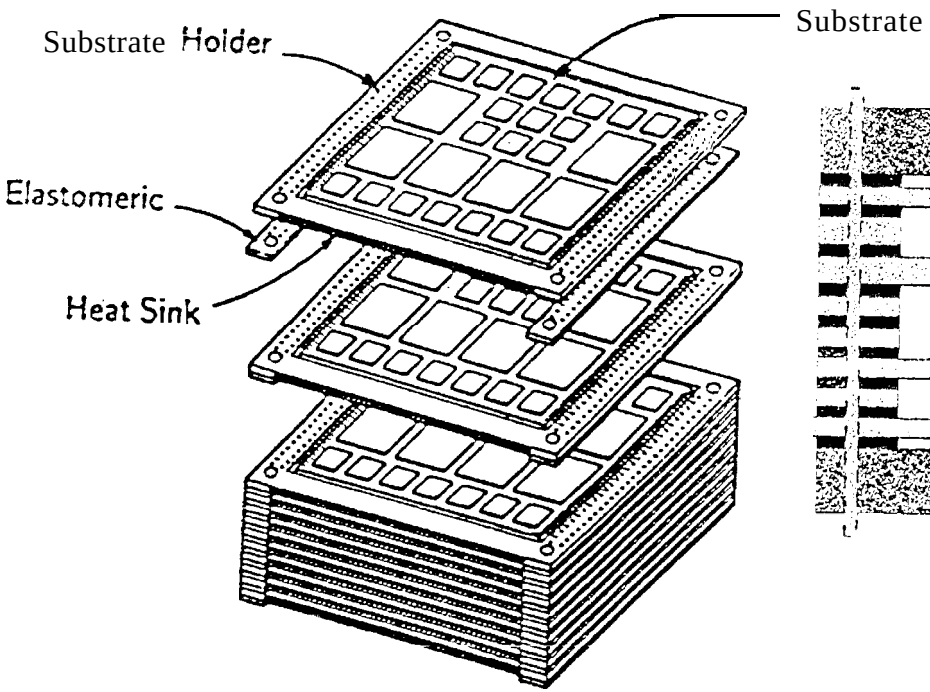


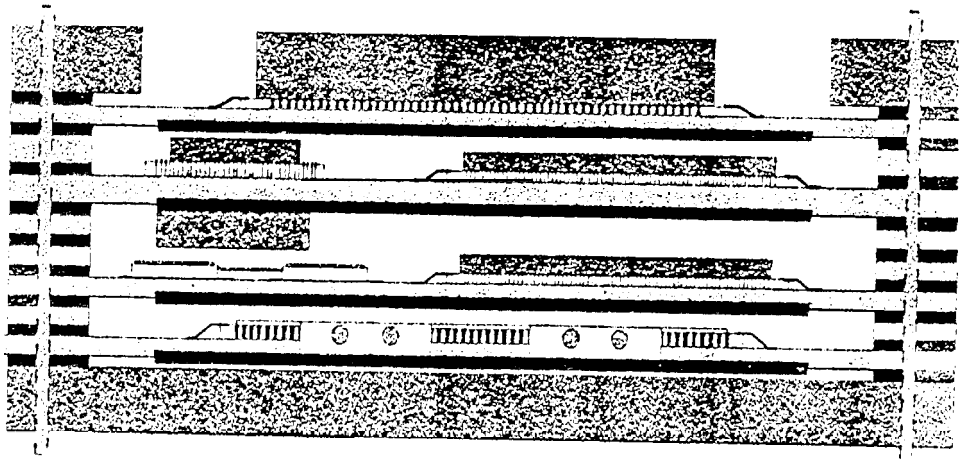
AAP Consortium



NMI' Application

- Area Array, elastomeric interconnections are being assessed for the **NMP DS-1** Advanced Avionics Block
  - » Includes Advanced Flight Computer, solid state memory, power, etc.
- Low-cost **MCM-D** technology





Advanced Interconnects

Surface Mount Technology

Surface Mount Technology (SMT)

Objectives

- Determine critical S-MT manufacturing parameters
  - Inspect and correlate solder-joint quality to manufacturing variables
- Correlate reliability to quality and bound critical. parameters
- Establish standards and inspection criteria using literature search. and test results
- Evaluate alternative inspection techniques (to manual, visual inspection)
- Develop packaging qualification thermal test methodology
  - Identify reliability dependency on mean temperature and Δt
- Develop experimental design and testing approach
- Verify test requirements
- Understand solder failure physics and establish failure sensitivities to solder properties, soldering processes, storage aging, and design con figurations
- Understand crack propagation
- Establish solder-joint life prediction methods
- Develop SMT solder-joint design and life-prediction guidelines

Deliverables to Date

SMT RTOPs

Deliverables	Completed Date
• "Solder Creep-Fatigue Interactions With Flexible Leaded Surface Mount Components", Book Chapter in *Thermal Stress in Microelectronic Packaging*, Von Nostrand Reinhold	December 1993
• Twelve *Technical Quarterly Reports* summarizing experience gained on SMT technology	1993-94
• Three draft copies of *SMT Engineering Guidelines* document that were reviewed and critiqued by industry experts	1994-95
• *Summary of NASA's Surface Mount Technology Survey, JPL D-11440*	January 1994
• Design of Phase 2 test vehicles	April 1994
• Valuable information gained in teaming with GORE and PAVE technology to qualify commercial connector technology	May 1994
• *Crack Propagation in Solder Joints During Thermal Mechanical Cycling J. of Electronic Packaging*	June 1994
• *Technical Summary Reports* on *Evaluation of Stereo, Z-axis, and Laser Scanner as Alternate Inspection Tools*	July 1994
• *Reliability Assessment of Solder-Joint S on LCCC Packages, JPL D-1192*	July 1994
• *Statistical Considerations in an Interconnect Qualification Program, Appendix C, 3rd Quarter FY94 Quarterly Report*	August 1994

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DELIVERABLES TO DATE -con't

SMT RTOPs

DELIVERABLES	COMPLETED DATE
• Valuable information gained in teaming with MISR project to qualify Kevlar PCBS	Jan 95
• Round robin workshop report	Jan 95
• Fabricated phase 2 test vehicles	Apr 95
• "Comparison of LCC Solder Joint Life Predictions With Experimental Results," *Journal of Electronic Packaging*	Jun 95
• Design of Experiments for the JPL SMT RTOP: Phase 2 Test, *RISR 16701/20103-1*	Jul 95
• Test Plan for Phase 2 SMT Assembly Reliability Testing , D-11470	Aug 95
• 3D Plots of Mfg Solder Defects Correlation to Package Types and Locationon	Sep 95
• "SMT Solder Joint Reliability and Quality Assurance Methodologies" *EEE Links, Vol. 1, No.4, October '95*	Ott 95
• "GuideFines for Solder Joint Reliability Determination", *Draft, JPL D-13412*	Jan 96
• "SMT Solder Joint Reliability/Workmanship Environmental Test Results Correlation For LCC Assemblies," *20th Annual Electronic Manufacturing proceeding*	Mar 96
• "The Interplay of Surface Mount Solder Joint Quallity and Reliability of Low Volume SMAS," *NEPCON WEst '96 proceeding*	Mar 96
• "Solderability Test and Correlation to SMT Joint Quality" *EEE Links, Vol.2, No. 1, March '96*	Mar 96
• SMT guideline document, Rev. E	Apr 96

Advanced Interconnects

Technology Validation Assessment

TO BE SUPPLIED BY MR. GARRISON (GSFC)

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Advanced Interconnects

Chip-on-Board Technology

TO BE SUPPLIED BY ANN GARRISON (GSFC

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Concluding Remarks

TO BE SUPPLIED
BY ANN GARRISON (GSFC)

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