Update to Single Event Metadata Analysis Activities at JPL

Gregory R. Allen
grallen@jpl.nasa.gov
818 393-7558

Mark Hoffmann
mark.k.hoffmann@jpl.nasa.gov
626 240-8521

Wilson Parker
wilson.p.parker@jpl.nasa.gov
818 354-2525

Jet Propulsion Laboratory, California Institute of Technology

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The NASA Electronic Parts and Packaging Program (NEPP)

NEPP - Charter

Agency Priorities – Independent Support
- Commercial Crew
- Small Mission Reliability
- Coordination with NASA Consolidation, CLTs, NESC, STMD, SAPP, and radiation block buy
- Collaborate with DoD/DOE on space radiation test infrastructure

Technology Evaluation
- Advanced /new EEE parts/technologies
  - Ex. Advanced CMOS, GaN, SiC
- Working Groups (NASA , government, aerospace)
- Screening/qualification/ test/usage guidelines
- Partnering: NASA, Government Agencies, Industry, University, International

EEE Parts Infrastructure
- NEPAG Telecons and Working Groups
- SME Capabilities
- Communication and Outreach within NASA and to the greater aerospace community

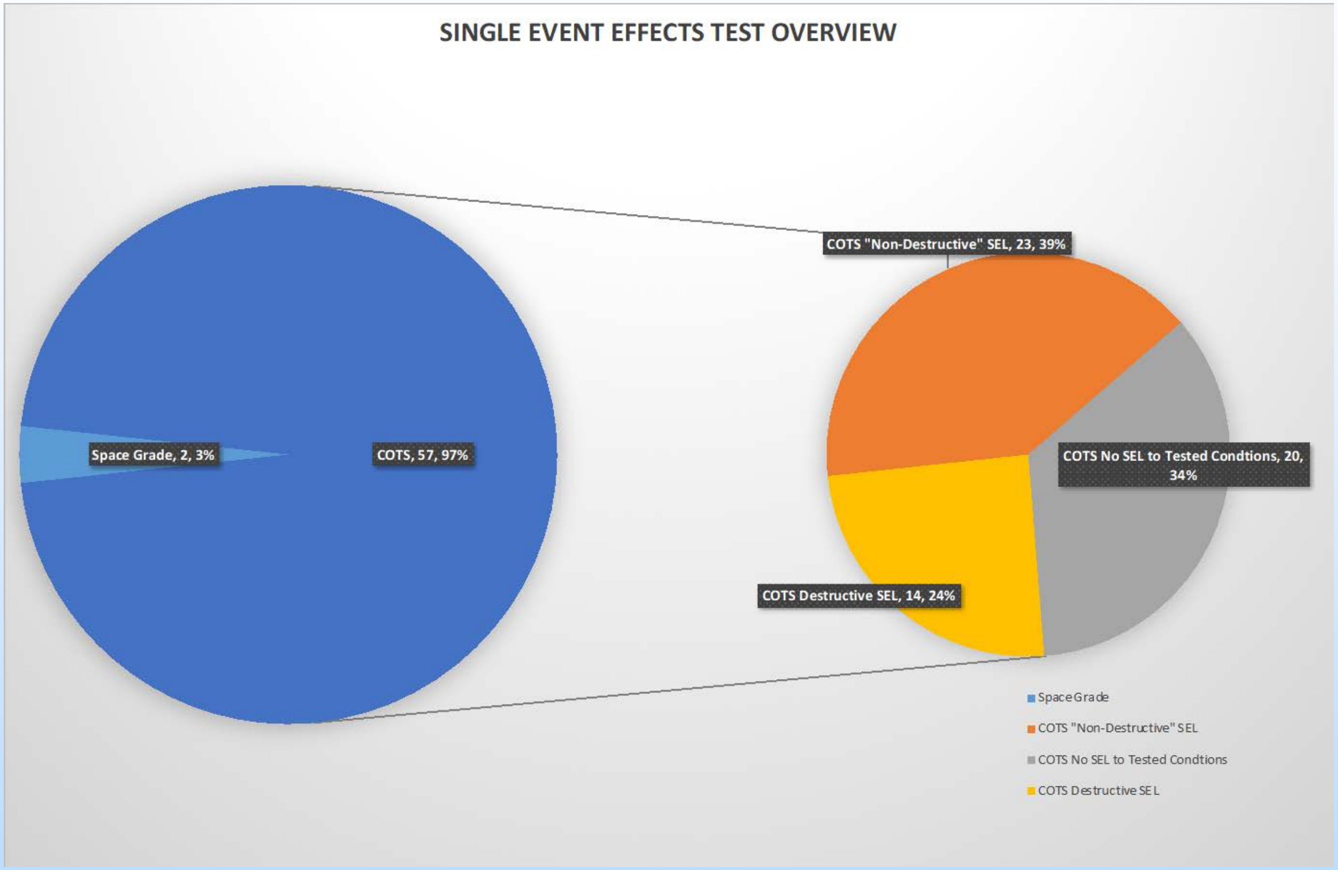
Trusted and RH Electronics
- Collaboration with NASA and other Agency Supply Chain and Trust organization Counterfeit Electronics
- Support DoD efforts on Trusted Foundries and FPGAs (w/NASA STMD and OCE/Space Asset Protection)
- Support DoD RH efforts

Agency Leadership
- NASA Policies and Procedures
- Agency Guidelines, Body of Knowledge (BOK) documents, and Best Practices
- Coordination of Government and Industry Standards
- Audit Coordination with AF, NRO, DLA
- Partnering within NASA and other Agencies, Industry, University, and International

Mission Assurance

EEE Parts Problem Investigations
- Agency/Industry-wide problems
- GIDEP and NASA Alert development

Background



SINGLE EVENT EFFECTS TEST OVERVIEW
Space Grade, 2, 3%
COTS, 57, 97%
COTS "Non-Destructive" SEL, 23, 39%
COTS No SEL to Tested Condtions, 20, 34%
COTS Destructive SEL, 14, 24%
Space Grade
COTS "Non-Destructive" SEL
COTS No SEL to Tested Condtions
COTS Destructive SEL

Task Objectives

- Due to the paradigm shift in spacecraft technology utilization, and the shift towards COTS technology, a plethora of COTS-based devices have been tested in recent years in addition to the decades of radiation data available in literature and online databases.
- We are developing an agency-level available database that attempts to expose radiation trends in the metadata.
- Our original focus will be on destructive effects (SEL, SEGR, etc.), but we will look beyond the standard voltage and temperature trends to manufacturer, technology process (not just node), device variables (e.g. for ADCs: number of bits, speed, architecture, etc).
- End goal is to expose buried trends to aid in part selection and MBSE analysis and guide bounding methodologies

Approach

- **Assemble database of radiation results for a single part type**
- **Focus on one radiation effect (SEL screening)**
- **Use data scraping to automate database population of device parameters**
- **Employ predictive model for untested parts**
- **Employ machine learning to discover hidden trends**

Previous Work - Example of Output from Model V.2.0

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California Institute of Technology

Radiation Metadata Tool

This tool is for the collection of testing data related to CMOS electrical components as well as assessing the risk associated with components for Single Event Latchup (SEL).

Risk Profiling | Data Collection

Risk Profiling

Input a part number to see the risk associated with a SEL at different LETs. If we do not currently have the part number, in our records, we will go out and scrape the internet for the metadata, save it for future use, then make our predictions based on what we found.

Clear

IEEE Part Info

Mfr Package Description	0.209 INCH, PLASTIC, SSOP-28
REACH Compliant	Yes
Status	Active
Converter Type	ADC, SUCCESSIVE APPROXIMATION
Analog Input Voltage-Min	-2.5 V
Analog Input Voltage-Max	2.5 V
Conversion Time-Max	1.15 Åµs
JESD-30 Code	R-PDSO-G28
JESD-609 Code	e0
Linearity Error-Max (EL)	0.0122 %
Moisture Sensitivity Level	1
Negative Supply Voltage-Nom	-5.0 V
Number of Analog In Channels	1
Number of Bits	14
Number of Functions	1
Number of Terminals	28
Operating Temperature-Min	0.0 Cel
Operating Temperature-Max	70.0 Cel
Output Bit Code	2'S COMPLEMENT BINARY
Output Format	PARALLEL, WORD
Package Body Material	PLASTIC/EPOXY
Package Code	SSOP
Package Equivalence Code	SSOP28,.3
Package Shape	RECTANGULAR
Package Style	SMALL OUTLINE, SHRINK PITCH
Peak Reflow Temperature (Cel)	235
Power Supplies (V)	+-5
Qualification Status	Not Qualified
Sample-and-Hold/Track-and-Hold	SAMPLE
Sample Rate	0.8 MHz

Temperature

25

Voltage

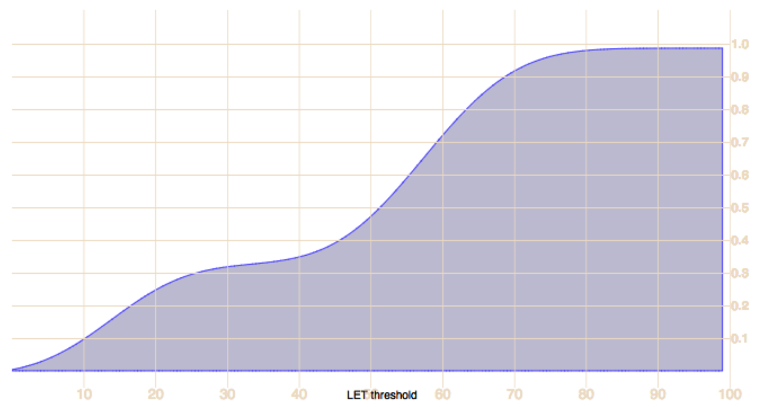
3

Update

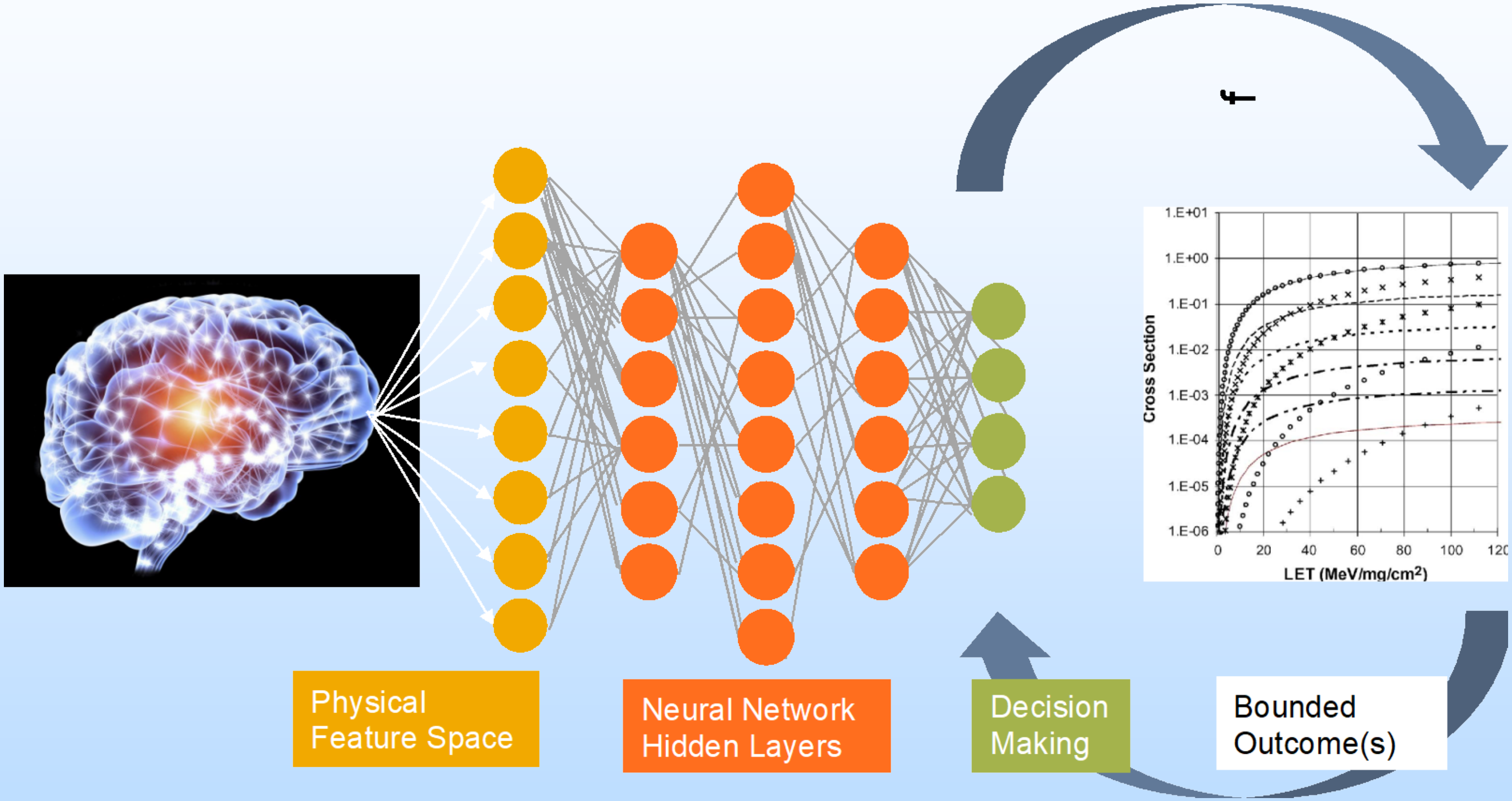
Test Info

Part	Temperature	Voltage	Details
LTC1419			64.0 < SEL < 68.3

Risk Threshold



Metadata Analysis

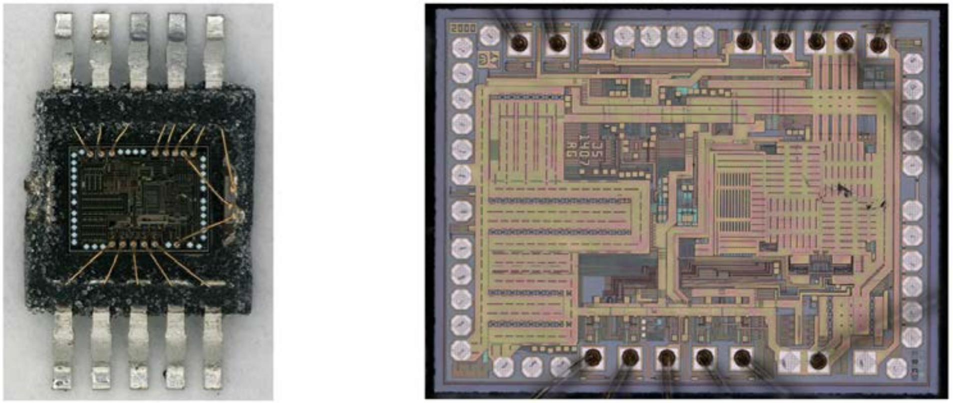


Automatic Semantic Segmentation of Radiation Susceptible Electronics

- **We attempt to built an automated system that can take the input of electronic die data and output the amount of susceptible area.**
- **The idea is that the greater the area of underlying components such as those that are CMOS is nature, is proportional to the susceptibility of the component undergoing various radiation effects**

Plasma Etch of Linear Tech LTC1272-8CCSW#PBF

Post Wet Etch | Post Wet Etch



Optical image showing the complete exposed die.

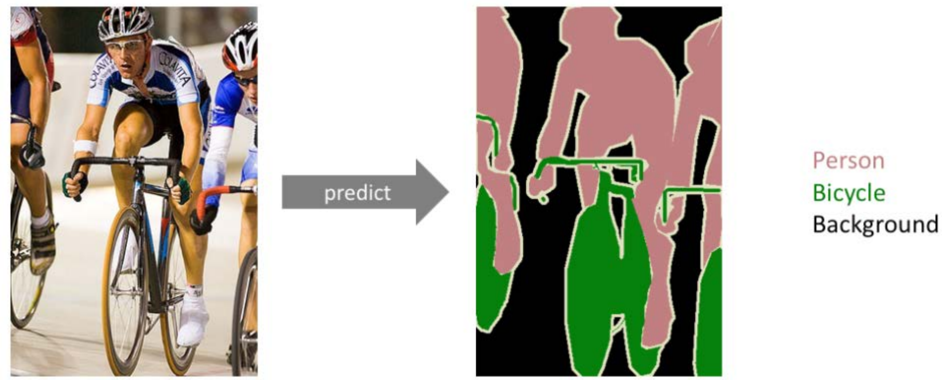
Optical image showing a detailed view of the die. Scratch in the die is an artifact from handling.

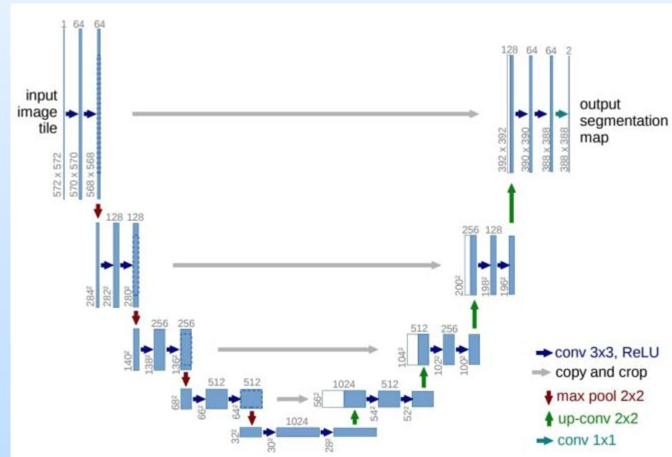
Methodology

- **Data Collection**
  - **Electronic dies are consistently being made**
- **Labeling**
  - **Labeling of the the electronic dies with the radiation susceptible areas vs. non radiation susceptible areas is a time consuming process. We label these images by drawing multiple bounding boxes on top of the die images so that we can generate 'masks' of areas of prediction**
- **Semantic Segmentation**
  - **We then build computer vision models that attempt to predict the class of every pixel on the die image one by one to determine total susceptibility of an electronic part**

Semantic Segmentation

- Goal is to take raw pixels + pixel labels to predict the classes of the pixels
- There are many popular methods for accomplishing this task, some of which include
  - Fully Convolutional Models
  - Encoder – Decoder Models
  - Pyramid Based Network Models
  - R-CNN Based Models
  - DeepLab Based Models
  - Etc.



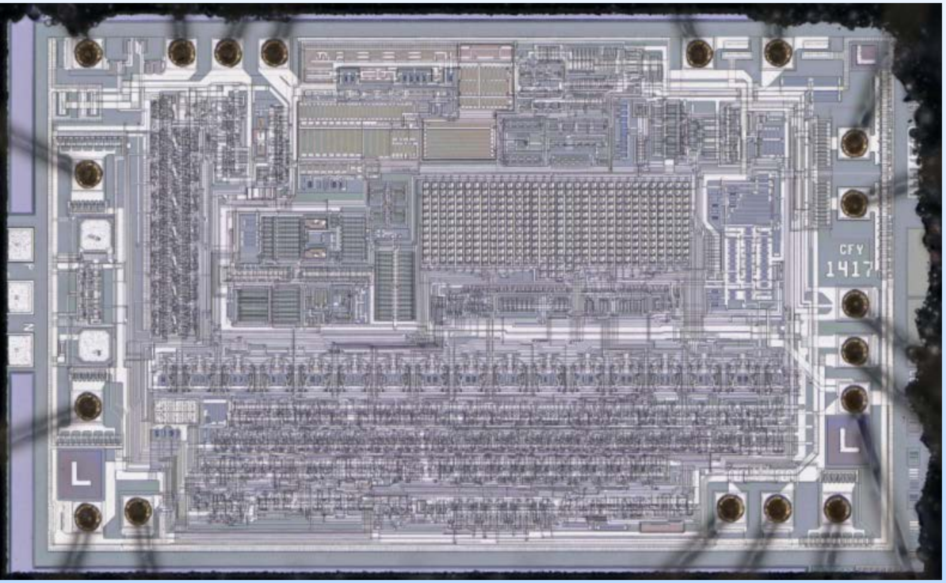


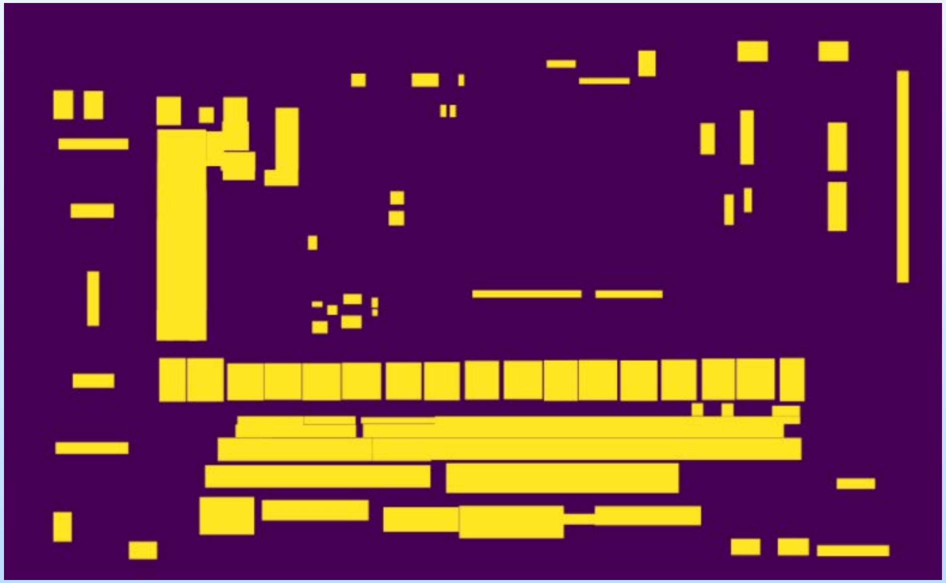
–Example U-Net architecture that falls into the ‘Encoder-Decoder Models’ family

High Image Resolution

Example Die Image and Mask (LTC1417)

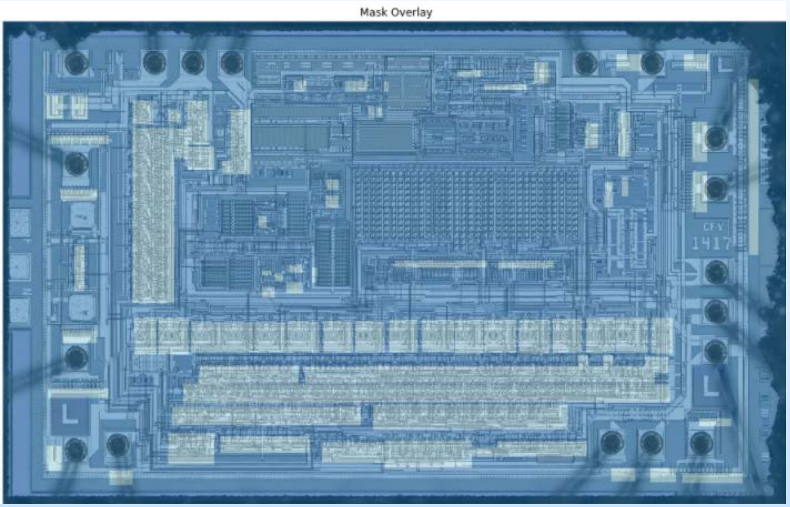
– **Challenge of needing to properly splice the high resolution images into appropriate tiles to train, and then assemble back together**





Showing the Mask Overlay

Into Tile Transformation



Conclusions & Future Work

- **Continue to develop machine learning methodologies**
- **Repeat with spatially correlated SEL data from pulse laser**
- **Repeat with “fuller” database**