

# **Test Standard Revision Update: JESD57, “Procedures for the Measurement of Single-Event Effects in Semiconductor Devices from Heavy-Ion Irradiation”**

**Jean-Marie Lauenstein  
Code 561, NASA Goddard Space Flight Center**



# List of Acronyms

**ETW** – Electronic Technology  
Workshop

**FY** – Fiscal Year

**GSFC** – Goddard Space Flight Center

**JEDEC** – (not an acronym)

**JESD** – JEDEC Standard

**JPL** – Jet Propulsion Laboratory

**LET** – Linear Energy Transfer

**MBU** – Multiple Bit Upset

**MCU** – Multiple Cell Upset

**MOSFET** – Metal Oxide  
Semiconductor Field Effect  
Transistor

**NEPP** – NASA Electronic Parts and  
Packaging program

**SBU** – Single Bit Upset

**SEB** – Single-Event Burnout

**SEE** – Single-Event Effect

**SEFI** – Single-Event Functional  
Interrupt

**SEGR** – Single-Event Gate Rupture

**SEU** – Single-Event Upset

**SET** – Single-Event Transient



# Standard Rationale

- **Standards & Guidelines are developed/ revised to:**
  - Ensure tests follow best practices
  - Ensure results from different vendors/testers are comparable
  - Minimize and bound systematic and random errors

***Data must be meaningful and must facilitate  
part selection and risk analysis***

***Best practices must be disseminated to  
new members of the test community***

# Key Space Radiation Test Standards



Standard	Title	Date
JEDEC JESD57	Test Procedures for the Measurement of SEE in Semiconductor Devices from Heavy-Ion Irradiation	1996
JEDEC JESD234	Test Standard for the Measurement of Proton Radiation SEE in Electronic Devices	2013
MIL-STD-750-1	Environmental Test Methods for Semiconductor Devices TM 1017: Neutron irradiation TM 1019: Steady-state total dose irradiation procedure TM 1080: SEB and SEGR	2014
MIL-STD-883	Microcircuits TM 1017: Neutron irradiation TM 1019: Ionizing radiation (total dose) test procedure	2014
ESA-ESCC-25100	SEE Test Method and Guidelines	2014
ESA-ESCC-22900	Total Dose Steady-state Irradiation Test Method	2010

*(Prompt dose and terrestrial radiation standards not included)*

*\*TM = Test Method*

# Key Space Radiation Test Standards



Standard	Title	Date
JEDEC JESD57	Test Procedures for the Measurement of SEE in Semiconductor Devices from Heavy-Ion Irradiation	1996
JEDEC JESD234	Test Standard for the Measurement of Proton Radiation SEE in Electronic Devices	2013
MIL-STD-750-1	Environmental Test Methods for Semiconductor Devices TM 1017: Neutron irradiation TM 1019: Steady-state total dose irradiation procedure TM 1080: SEB and SEGR	2014
MIL-STD-883	Microcircuits TM 1017: Neutron irradiation TM 1019: Ionizing radiation (total dose) test procedure	2014
ESA-ESCC-25100	SEE Test Method and Guidelines	2014
ESA-ESCC-22900	Total Dose Steady-state Irradiation Test Method	2010

*(Prompt dose and terrestrial radiation standards not included)*

*\*TM = Test Method*



# JESD57 Update: The “Who”

- **JESD57 ownership: JEDEC JC-13.4 Government Liaison Subcommittee on Radiation Hardness Assurance**
- **Committee meetings 3 times/year:**
  - Both JC13.4 and G12 Radiation Hardness Assurance subcommittees provide a platform to work with relevant industry and user communities to:
    - Review major changes in content and format
    - Work toward consensus on more controversial or less established definitions, concepts, or methods



# JESD57 Update: The “Who”

- **JESD57 ownership: JEDEC JC-13.4 Government Liaison Subcommittee on Radiation Hardness Assurance**
- **Committee meetings 3 times/year:**
  - Both JC13.4 and G12 Radiation Hardness Assurance subcommittees provide a platform to work with relevant industry and user communities to:
    - Review major changes in content and format
    - Work toward consensus on more controversial or less established definitions, concepts, or methods
- **Web conferences twice a month:**
  - Review paragraph by paragraph
  - Achieve consensus within a small group prior to bringing content forward for subcommittee discussion and review



# JESD57 Update: The “Who”

- **JESD57 ownership: JEDEC JC-13.4 Government Liaison Subcommittee on Radiation Hardness Assurance**
- **Committee meetings 3 times/year:**
  - Both JC13.4 and G12 Radiation Hardness Assurance subcommittees provide a platform to work with relevant industry and user communities to:
    - Review major changes in content and format
    - Work toward consensus on more controversial or less established definitions, concepts, or methods
- **Web conferences twice a month:**
  - Review paragraph by paragraph
  - Achieve consensus within a small group prior to bringing content forward for subcommittee discussion and review
- **Draft rewrites between web conferences:**
  - Provide initial changes as a starting point
  - Incorporate suggestions and reorganize content for better flow





# Web Conference Participants

- **Aerospace Corp.**
- **BAE Systems**
- **Boeing**
- **Defense Logistics Agency**
- **Intersil**
- **Linear Technology**
- **Microsemi**
- **NASA GSFC**
- **NASA JPL**
- **NAVSEA Crane**
- **Semicoa**
- **Texas Instruments**

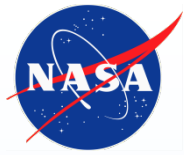
*Many more participants are involved via a mailing list*



# Key Updates in FY15

- **Streamlining into test standard format: guideline material to be captured in an “informative” annex**
- **Single-event transient (SET) test procedure added**
  - Contribution from Nick VanVonno, Intersil
- **Much effort spent on Terms & Definitions...**

# Terms & Definitions Highlights: Single-Event Upset (SEU)



- **1996:**

**single-event upset (SEU):** A single latched logic state from one to zero, or vice versa.

NOTE The SEU is “soft” because the latch can be rewritten and behave normally thereafter.

- **Proposed:**

**single-event upset (SEU):** The change of a bi-stable node state from one to zero, or vice versa, due to the passage of a single energetic particle.

NOTE 1 SEU, including SBU, MBU, and MCU, is typically "soft" because the affected nodes can be rewritten and behave normally thereafter.

NOTE 2 An SEU that results in a change in device functionality requiring intervention is defined instead as a SEFI.

# Terms & Definitions Highlights: Single-Event Upset (SEFI)



- **1996:**

**single-event functional interrupt (SEFI):** The loss of functionality of the device that does not require cycling of the device's power to restore operability unlike SEL and does not result in permanent damage as in SEB.

NOTE SEFI is typically caused by a device being cycled to a nongenerational test mode due to a heavy ion strike.

- **Proposed:**

**single-event functional interrupt (SEFI):** A non-destructive interruption resulting from a single ion strike that causes the component to reset, hang, or enter a different operating condition or test mode.

NOTE 1 A SEFI is often associated with an SBU/MBU in a control bit or register.

NOTE 2 Changes in functionality may require a soft or hard reset of the device, reprogramming of the control registers, or power cycling.

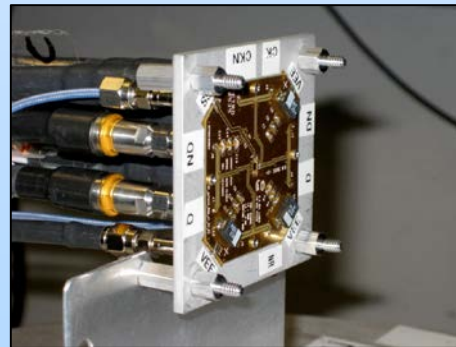
NOTE 3 A SEFI can introduce a latent reliability issue due to a period of high current. SEFIs that result in permanent damage are designated as single-event hard errors.

# JESD57 Challenge: Advanced Electronics



- How do we incorporate advanced electronics SEE testing into SEE test standards?
  - Revision of JESD57 is an opportunity for inclusion of more established methods for testing advanced electronics
  - Highly complex technologies will benefit from specific guidelines
    - ex/ NASA FPGA test guideline
  - Complex devices incorporate many modes and functions
    - Test results depend on how we test the device
    - The bleeding edge of testing is generalizing application specific test results to bound flight performance at all stages of the mission

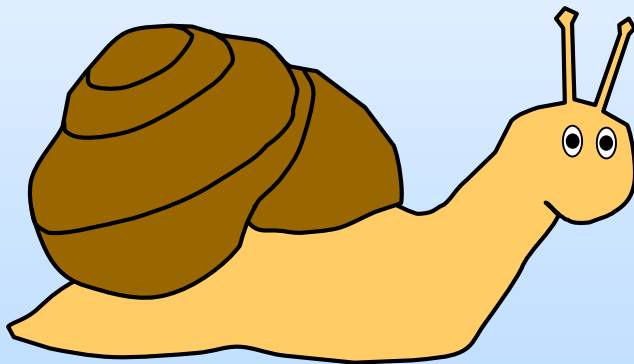
## *High-Speed Test Fixture*



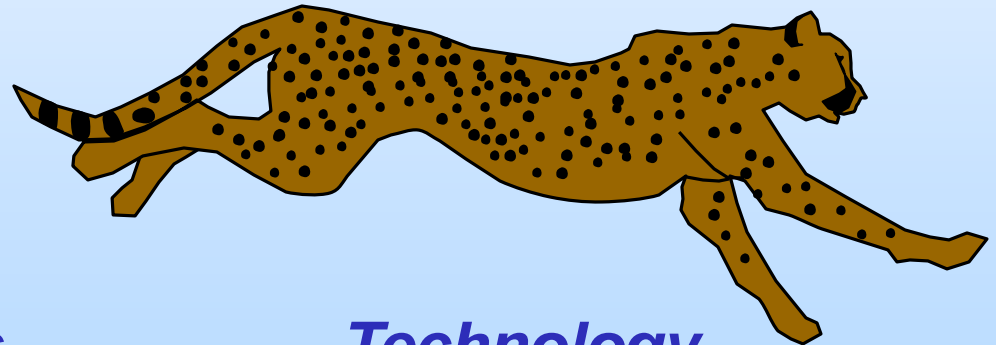
*Photo credit: J. A. Pellish, 2013*

# The Time Lag

- **Test standards & guidelines can (and often do) take years to develop or revise**
  - Widespread compliance can take additional years
- **Technology & research continuously evolve**



– *Test Standards*



– *Technology*

***The time lag is both useful and problematic***



# Summary

- **JESD57 is the only U.S. test standard covering many of the heavy-ion induced single-event effects**
  - ASTM F1192 guideline for measuring single-event phenomena induced by heavy ions
  - ESA-ESCC-25100 Single-event effect test method and guidelines
- **JESD57 is undergoing a long-overdue revision**
  - Broad participation by government, industry, and end users
- **Test standards such as JESD57 are a compromise between technical rigor and economic realities**
  - The goal is to be good enough to ensure success and cheap enough that the standards & guidelines will actually be used