

NPE SOUNDSDS Initiative

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Acronyms



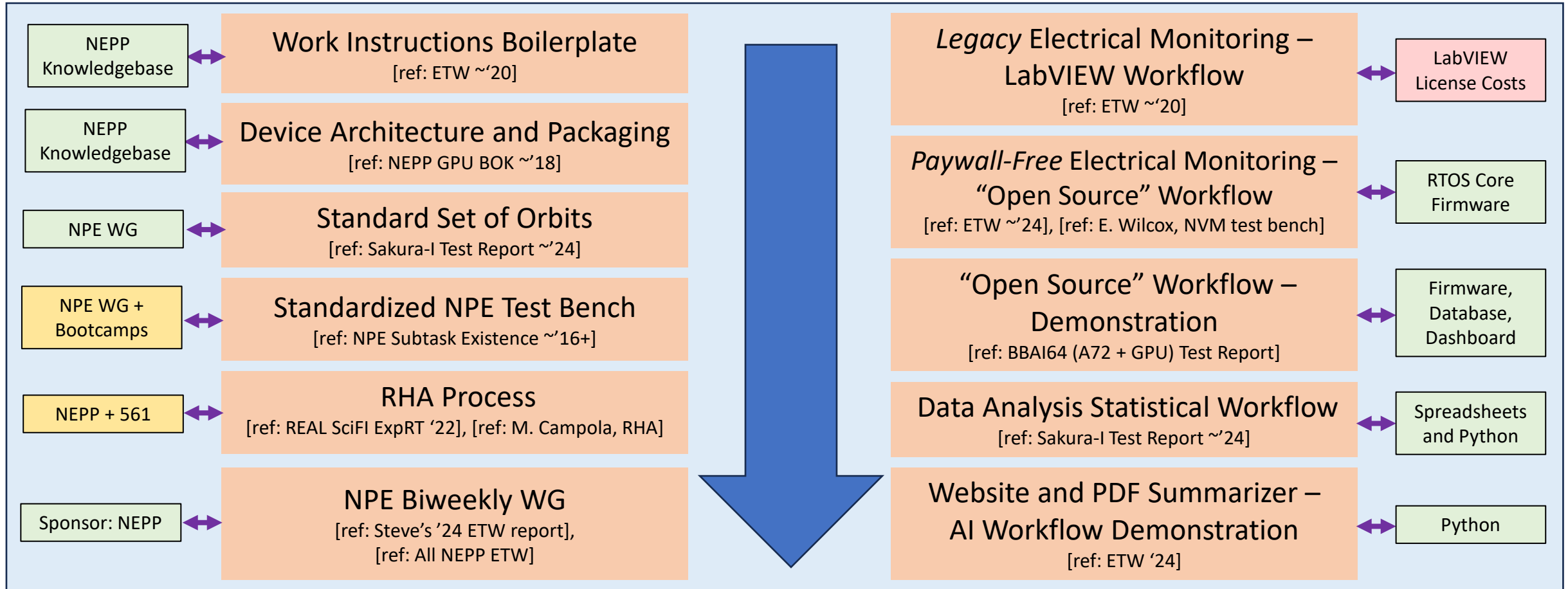
- Automotive Electronics Council Qualification (AECQ)
- Ames Research Center (ARC)
- Artificial Intelligence Machine Learning (AI/ML)
- Application Specific Integrated Circuit (ASIC)
- Ambient Temperature (AT)
- Commercial Off the Shelf (COTS)
- Comma Separated Values (CSV)
- Computer Vision (CV)
- Database (DB)
- Devices Under Test (DUT)
- Error Code Correction (ECC)
- Extravehicular Mobility Unit (EMU)
- Electronics Technology Workshop (ETW)
- Field Programmable Gate Array (FPGA)
- Fiscal Year (FY)
- General Purpose Input Output (GPIO)
- Graphics Processing Unit (GPU)
- Goddard Space Flight Center (GSFC)
- Graphical User Interface (GUI)
- Intellectual Property (IP)
- California Institute of Technology Jet Propulsion Laboratory (JPL)
- Johnson Space Center (JSC)
- Key Performance Parameters (KPP)
- Local Area Network (LAN)
- Linear Energy Transfer (LET)
- Low Voltage (LV)
- Mean Time Between Failures (MTBF)
- NASA Electronic Part and Packaging Program (NEPP)
- Natural Language Processor (NLP)
- NEPP Processor Enclave (NPE)
- Non-Volatile Memory (NVM)
- Operating System (OS)
- Printed Circuit Board Assembly (PCBA)
- Portable Document Format (PDF)
- Power Supply Unit (PSU)
- Pulse Width Modulation (PWM)
- Radiation Hardness Assurance (RHA)
- Radiation Effects and Analysis Group (REAG)
- Relative Humidity (%RH)
- Single Board Computer (SBC)
- Single Event Effects (SEE)
- Single Event Functional Interrupt (SEFI)
- Single Event Latchup (SEL)
- Single Event Upset (SEU)
- System on Chip (SOC)
- State of the Art (SOTA)
- NASA Electronic Part and Packaging program's Processor Enclave's Initiative on Sharing Our Underlying Non-Database Data Source (SOUNDDES)
- SPace ENVironment Information System (SPENVIS)
- Solid State Drive (SSD)
- Secure Shell (SSH)
- Exploration Extravehicular Activity Services (XEVAS)

Agenda



- Board Level Testing Workflow
- Texas Instruments TDA4VM – Workflow Example
- NPE SOUNDDES Initiative
- Summary

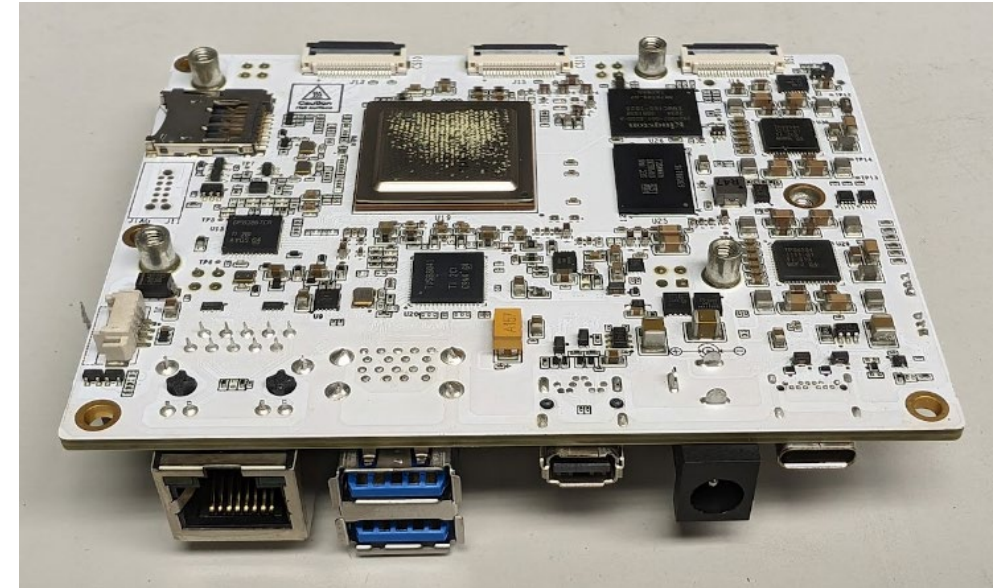
Board Level Testing Workflow



- Actionable workflow to perform mostly automated high-level data analysis quickly allowing the radiation effects engineer to produce a report with limited budget.
- Data gathered in this methodology is considered *structured*.

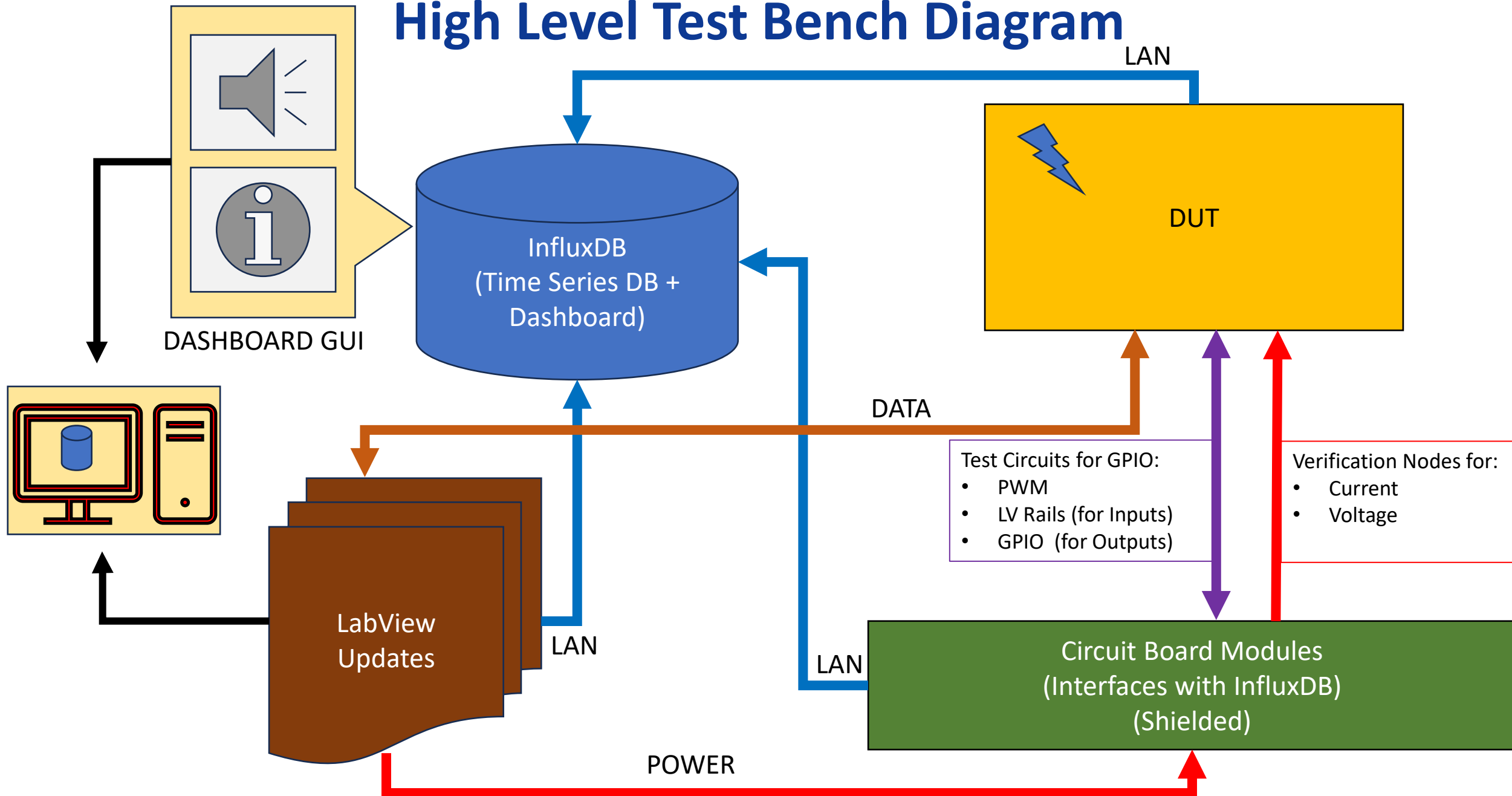
FY24 DUT – Workflow Example

- Texas Instruments TDA4VM (Dual ARM 64-bit Cortex A72)
 - High reliability, Automotive grade
- Rapid Test Plan
 - Reuse NEPP and JPL test bench software for GPU and ARM CPU
 - Explore OS loaded-driver dependencies by using two (2) OS variants
 - Create 3D-printed fixtures for easy PCBA swap
 - Use a COTS Test Vehicle with standard footprint headers for easy integration of peripherals
 - It's a bonus if the Test Vehicle has networking support

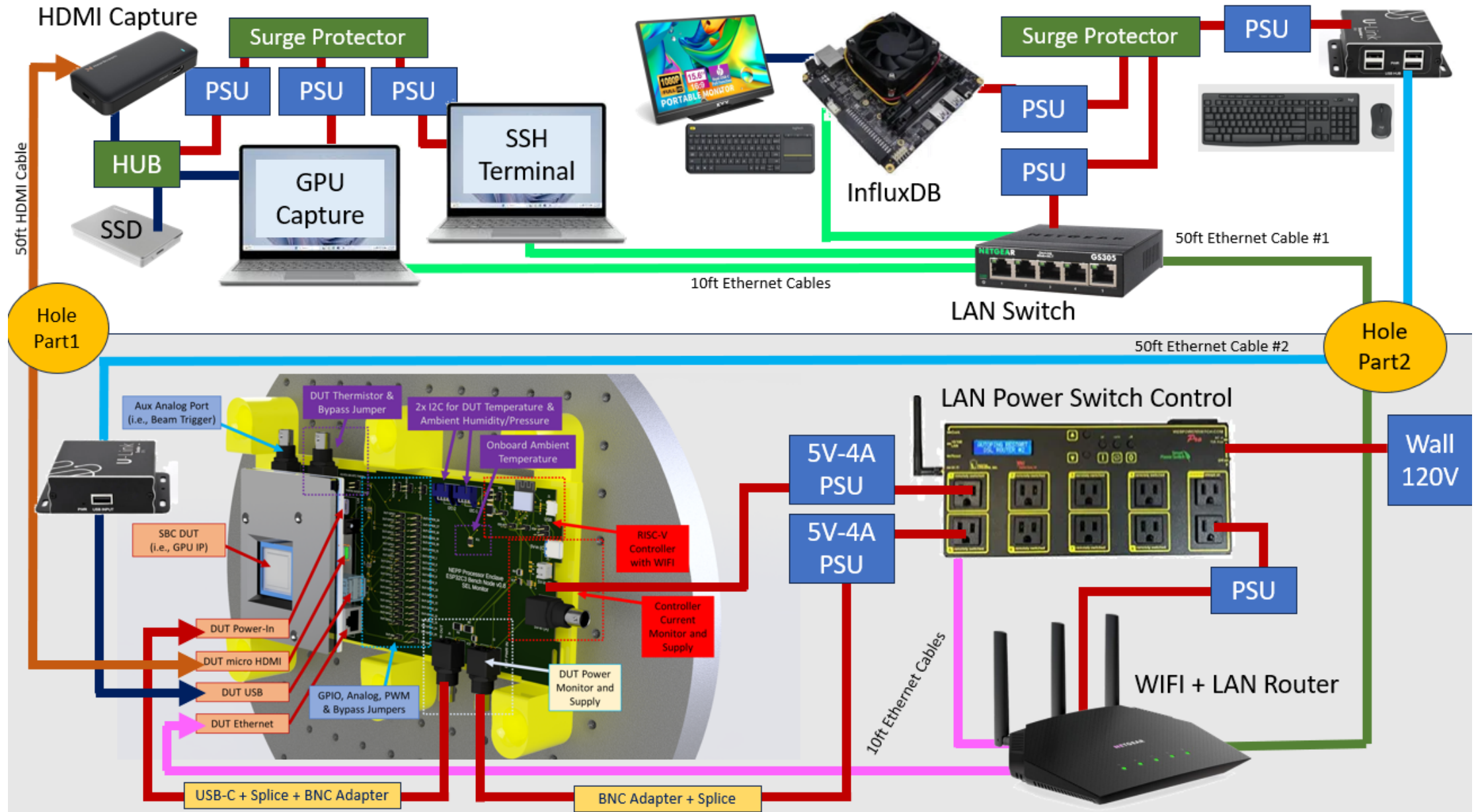


BeagleBone AI-64 Single Board Computer

High Level Test Bench Diagram

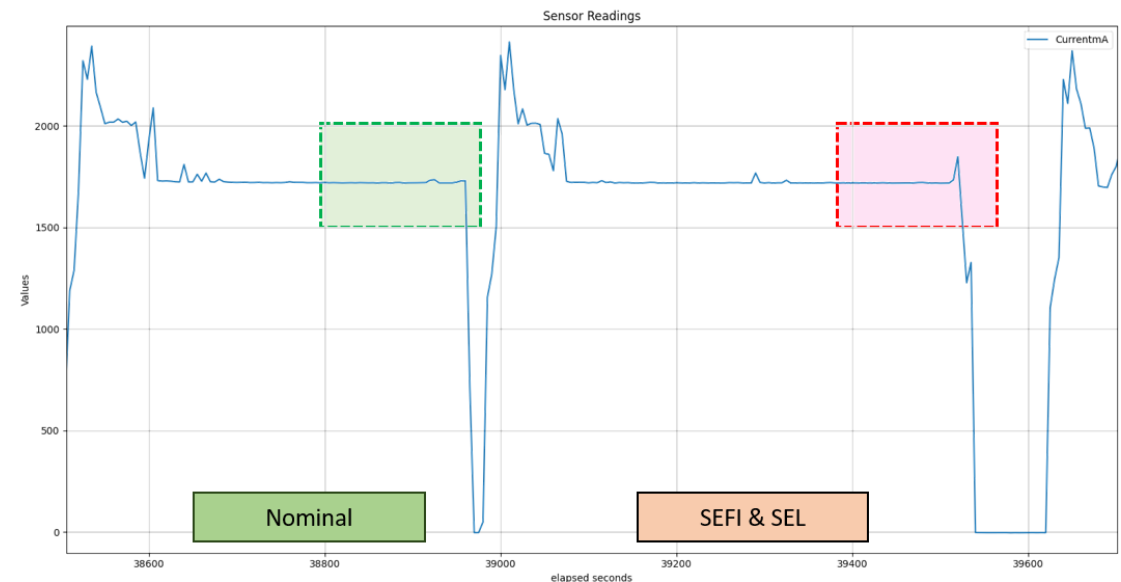
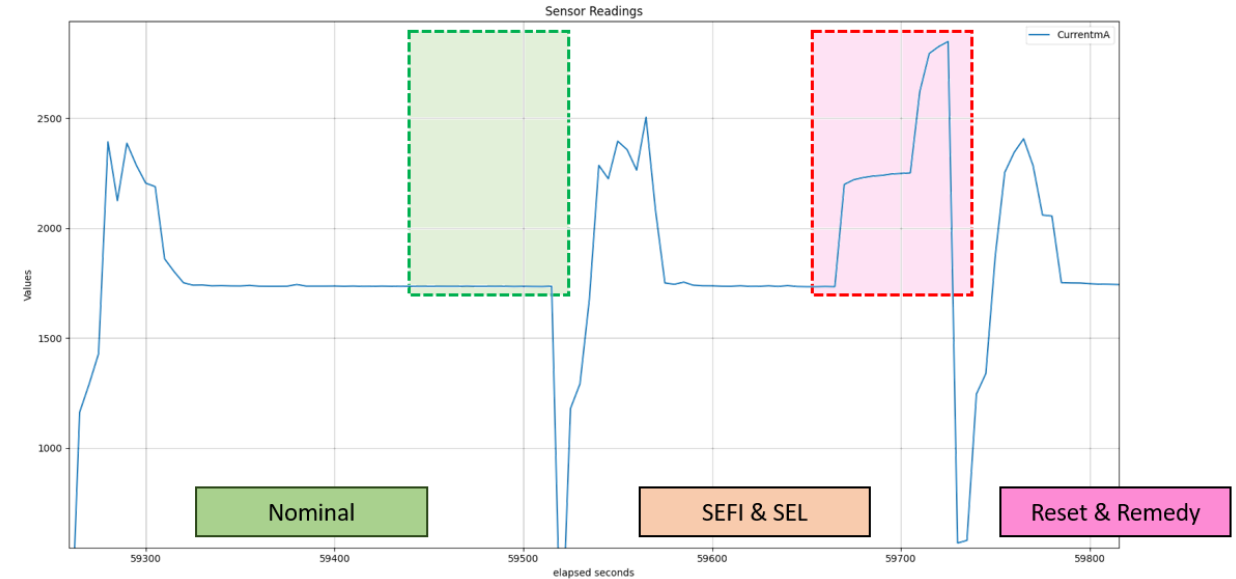


Detailed Test Bench Diagram



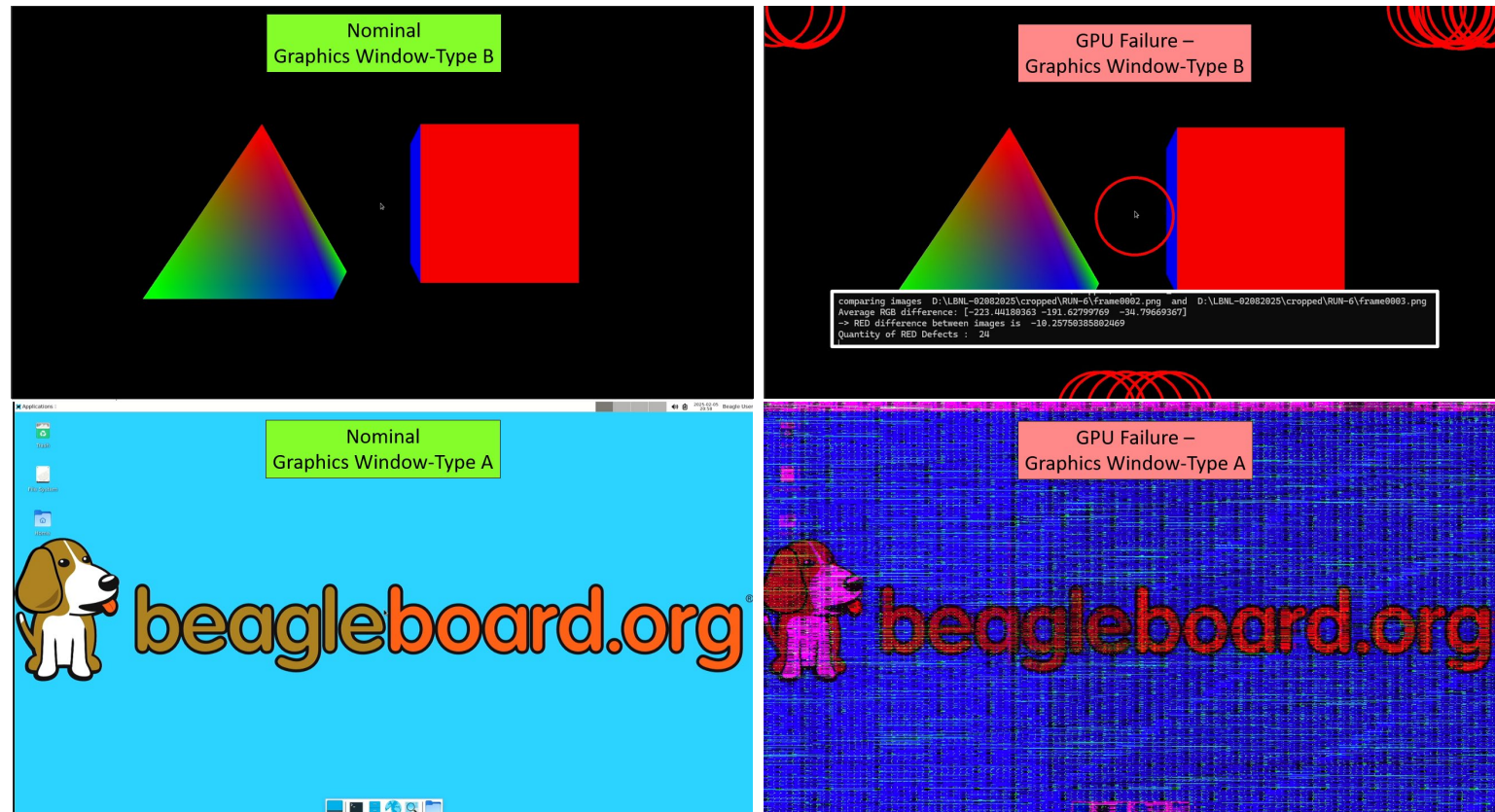
Rapid Electrical Analysis

- InfluxDB data is viewed in real time using a Grafana interface (within a web browser)
- The data from the csv file from an InfluxDB query is visualized using Python scripts and plots
- The plots are interactive for quick and easy zoom and pan (which Excel doesn't permit without changing either axis)
- In FY26, an Ai model will be trained to recognize anomalous signal patterns permitting real time response



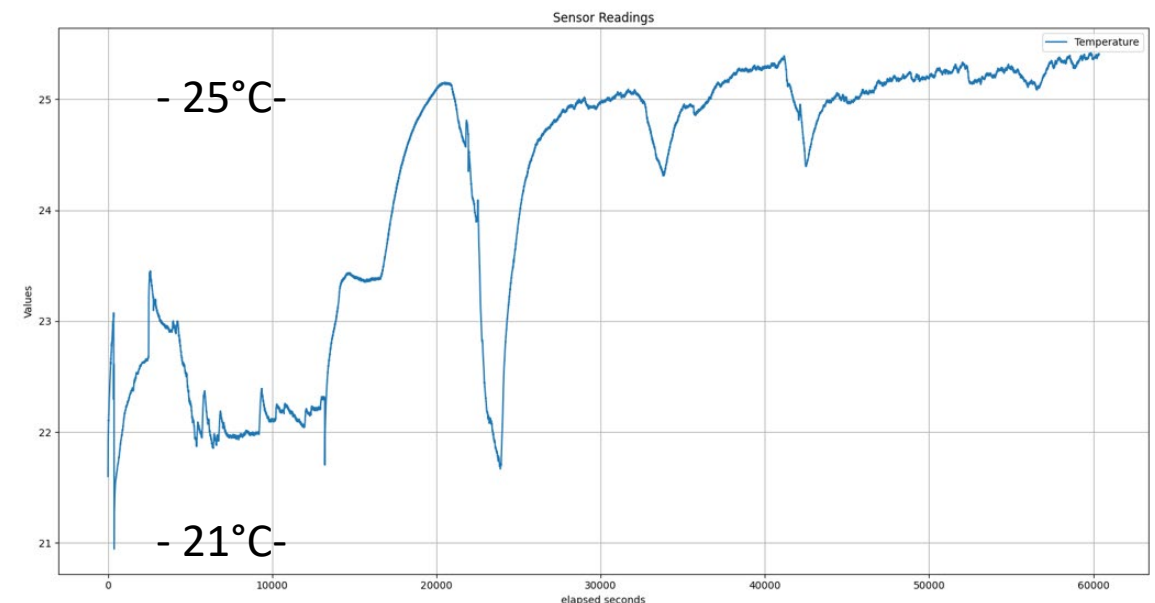
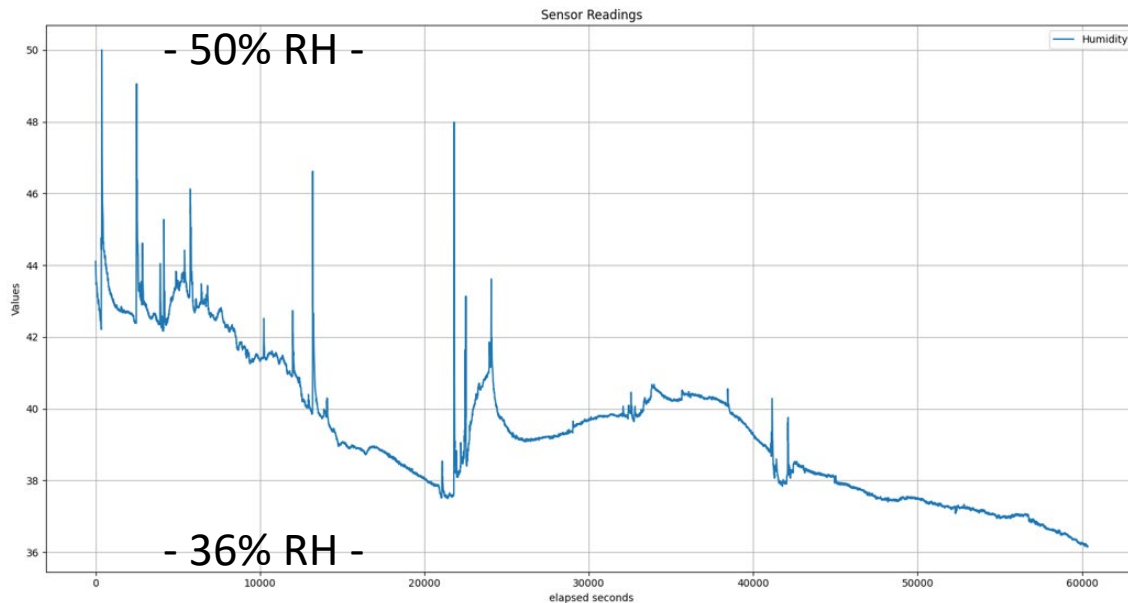
Graphics Based Assessment

- Automation permits us to:
 1. Compare sequential frames in a captured video stream
 2. Compare the video stream to a golden copy
- We can then use Python and OpenCV to identify pixel state defects by red, blue and green channels.
- Computers can see things that are hidden to the naked eye. Other times, the defects are obvious.



Are there Other Environmental Stressor at Play?

- What is the Ambient Temperature and Humidity?
 - Did these change over the course of the test?
- What can these affect, and can we record these throughout the day?
 - WIFI Access Point Strength (which has a persistent placement)
 - DUT Performance (which degrades with fluence)



Relative Humidity (%RH) and Ambient Temperature (AT) in the Cave Throughout the Test Campaign
(%RH – Dynamic, AT – Consistent)

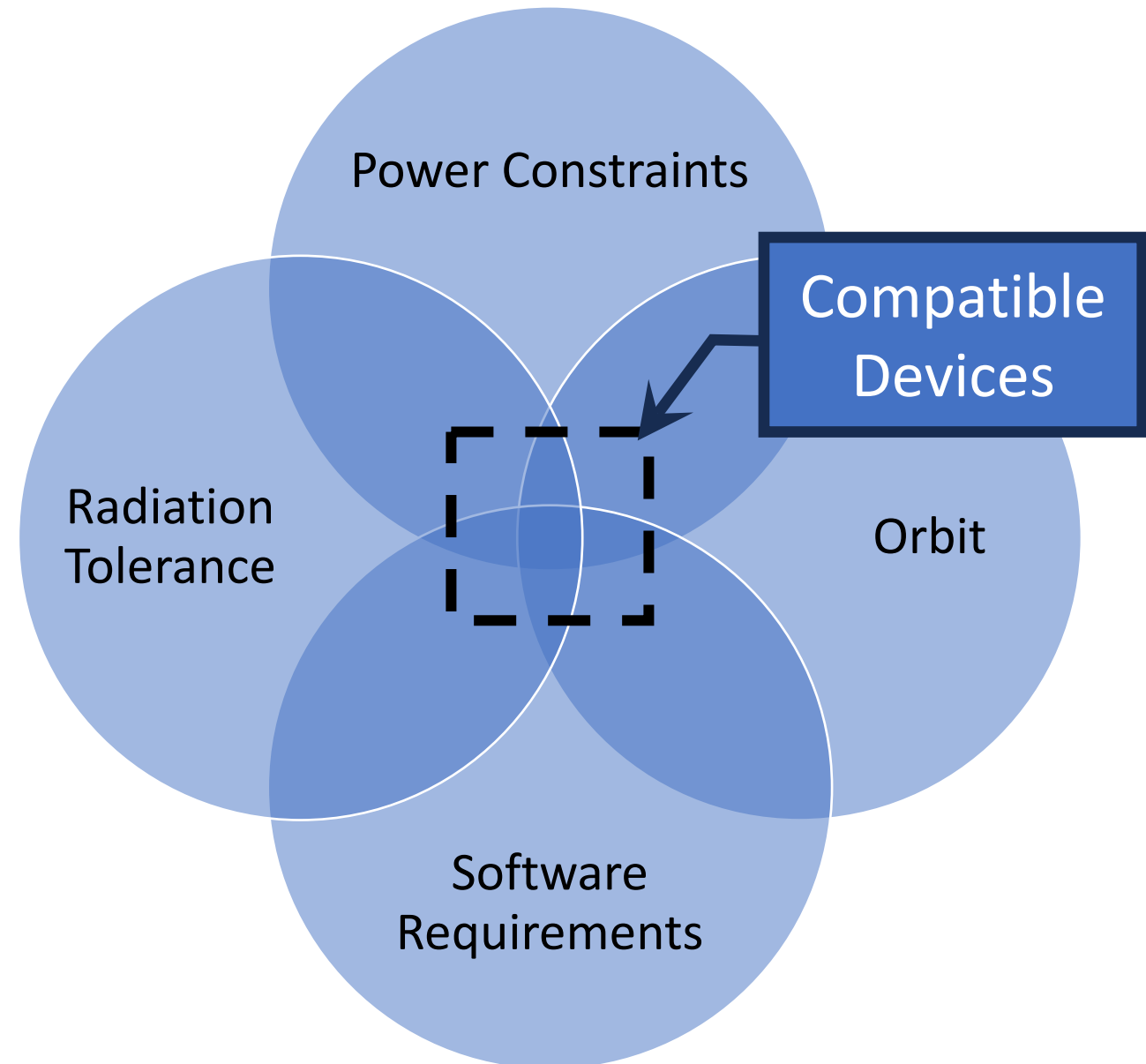
Why NASA Should Care

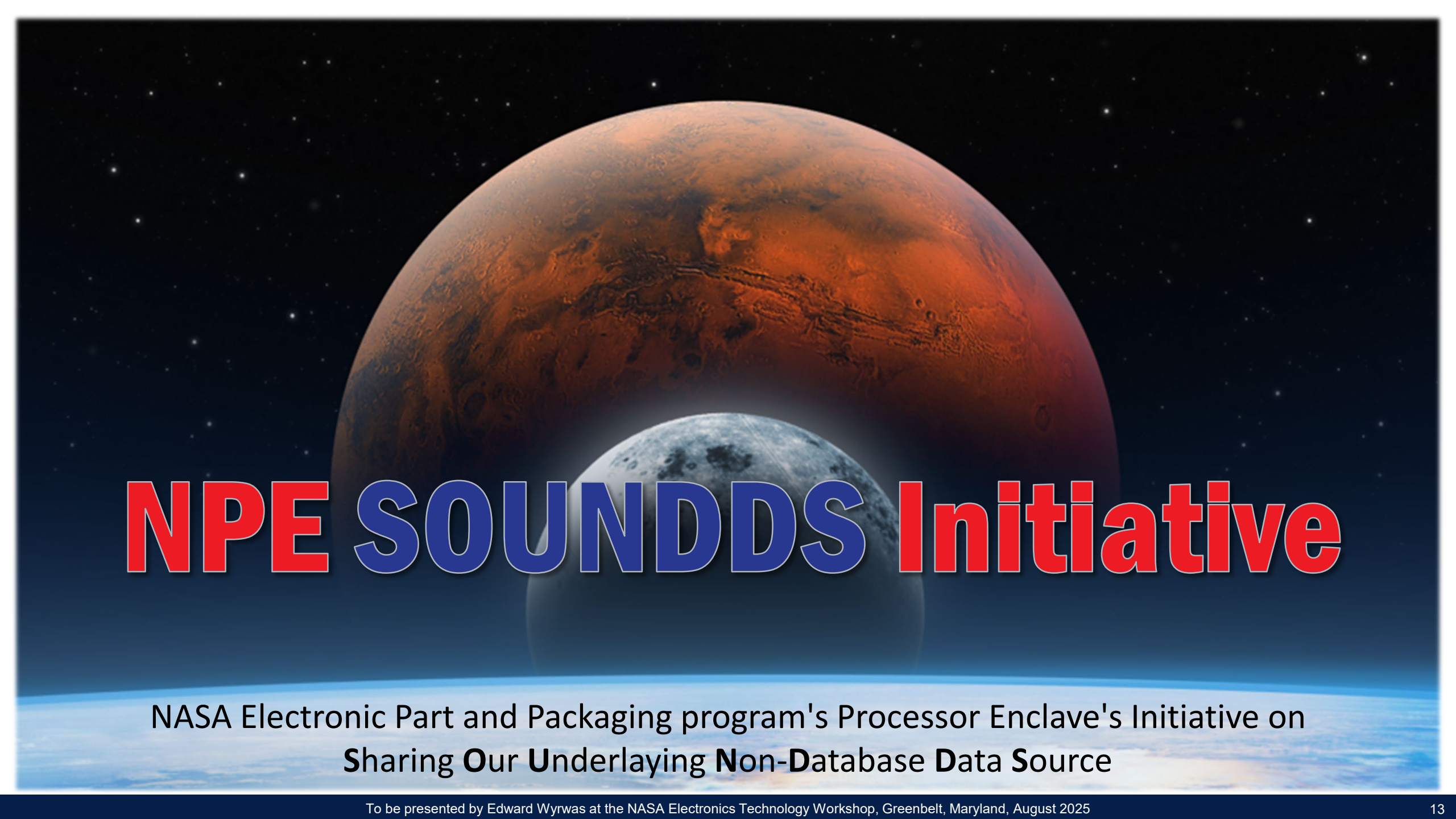


- Missions have been told to prioritize and optimize mass and volume allocations
 - Artemis discussions have indicated
 - there will be reduced thermal dissipation and requires low power, low thermal load on subsystems
 - low power, high compute capability requirements
 - EMU/XEVAS have substantial constraints in power, mass, and form factor which is driving unique form factors for displays, which require graphics processor devices of the same constraints
 - Lunar Surface Habitats' and Mars Vehicles' electronics requirements have severe mass limitations and very long radiation exposure, but will require more complex devices to meet mission parameters
- SEE testing of SOTA devices is necessary, but funding and timelines will never permit comprehensive test campaigns. Therefore, to achieve *good assurance* we must combine data sets (as described at FY24 ETW).

How Could We Try to Answer the “Which Device” Question

- Structured Data provides a method to compare Data Series
- Processing Test Run Logs through the same automation workflow achieves consistency
- Knowing the constraints helps narrow down the list of devices





NPE SOUNDSDS Initiative

NASA Electronic Part and Packaging program's Processor Enclave's Initiative on
Sharing **Our Underlying Non-Database Data Source**

Sample Inputs and Outputs

- A scrubbed test run log is the only requirement to produce an analysis data package
- A boilerplate spreadsheet is available to paste the minimally necessary data
- All test configuration context can be stripped out or swapped to arbitrary values. Any configuration options provided will be plotted according to that organization.
- Some public information displayed by the automation tool is fetched from offline files that were created using online tools and Ai models.
- The Weibull parameters produced by the tool become inputs into SPENVIS, which is accessed via its website.
- The Orbit Rates from SPENVIS are then used by the tool to calculate survivability.

					(MeV cm ² /mg)					(cm ²)
Run #	DUT #	Ion #	OS	Test Condition	LET	Flux	Fluence	Runtime	Dose	Cross Section SEFI
1	1	Ar	0	7	7.27	1.10E+03	2.35E+04	21.32	2.73E+00	7.06E-03

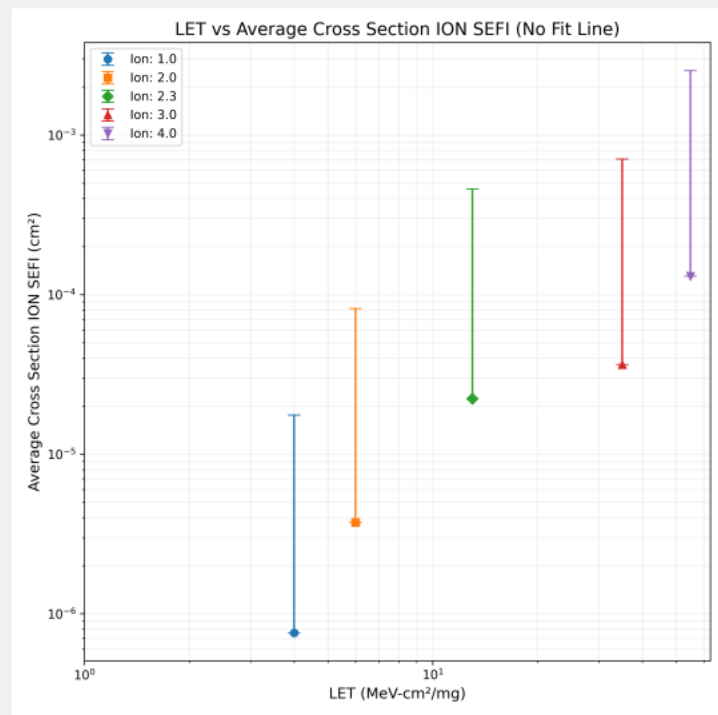
Select Device: BBAI64 Select Folder: LBNL_Feb2025_BBAI64_20250603_134620 Refresh Folders

Search: Enter search text Search

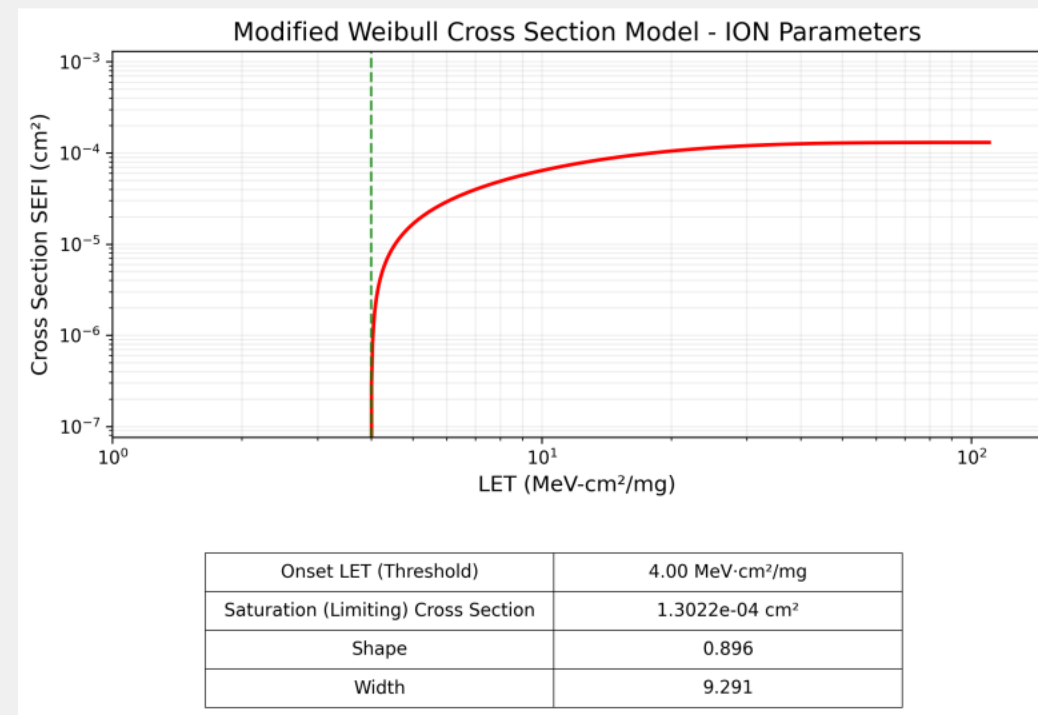
Autofit Columns Autofit Rows Autofit All View Weibull Parameters View Statistics Open Orbit Rates Application

Attribute		Details
1	Processor Cores	Dual-core 64-bit Arm Cortex-A72 at up to 2.0 GHz. Includes Arm Cortex-R5F MCUs, a C7x floating-point, vector DSP, and two C66x floating-point DSPs. Also features vision processing accelerators (VPAC) and deep-learning matrix multiply accelerators (MMA).
2	Processor Architectures	Arm Cortex-A72, Arm Cortex-R5F, C7x DSP, C66x DSP.
3	Cache Size	- Cortex-A72: 1MB shared L2 cache per dual-core cluster, 32KB L1 Data Cache and 48KB L1 Instruction Cache per core.
4	ECC Support	- DDR Subsystem: Supports Error Correcting Code (ECC) for LPDDR4 memory.
5	Graphics Cores and Standards	3D GPU PowerVR Rogue 8XE GE8430, up to 750 MHz. The provided information does not specify support for OpenGL, OpenCL, or Vulkan. However, the GE8430 is a capable GPU commonly used in embedded systems.
6	System Memory Type & Capacity	4GB LPDDR4 memory.
7	Supply Chain Status & Obsolete	The BeagleBone AI-64 is designed to use readily available parts to ensure supply. It is not obsolete and is being actively built. Note that the original BeagleBone AI may have some supply constraints.
8	Supply Voltage	Requires a 5V ≥ 3A (15W) supply via USB Type-C or barrel jack. A 5V > 3A laptop/mobile adapter is recommended.
9	Power Consumption	Approximately 5W when idle. Requires a 5V @ 3A (15W) power supply. The power consumption is described as "quite power hungry".
10	Process Node	16nm FF

Ion No Fit



Weibull Ion Plot



Device: BBAI64 | ENVRT: Lunar_001 | ENVR File: Lunar_001-ENVR.xlsx | Custodian File: BBAI64-Custodian.xlsx

Orbit Data:

	Attribute	Value
1	Approximate Sensitive Volume Thickness (um)	0.052
2	Trapped Radiation Models	AP-8, AE-8
3	Trapped proton anisotropy Model	Badhwar & Konradi 1990 MAX
4	Solar particle fluxes Model	CREME-96
5	Solar particle fluences Model	ESP-PSYCHIC
6	Galactic Cosmic Rays Spectra Model	ISO-15390
7	Shielded Flux Model	MFLUX
8	Unit for Rates	SEFI/Second
9	Worst Week - Solar Max	3.5981e-08
10	Worst Day - Solar Max	1.0599e-07
11	Worst 5 minutes - Solar Max	3.8295e-07
12	Worst Week - Solar Min	3.5981e-08
13	Worst Day - Solar Min	1.0599e-07
14	Worst 5 minutes - Solar Min	3.8295e-07
15	Total Direct Ionization Events - Solar Minimum	0.036104
16	Total Direct Ionization Events - Solar Maximum	0.036104
17	Unit for Rates	SEFI/min
18	Worst Week - Solar Max	2.1588600000000004e-06
19	Worst Day - Solar Max	6.3594e-06
20	Worst 5 minutes - Solar Max	2.2976999999999997e-05
21	Worst Week - Solar Min	2.1588600000000004e-06
22	Worst Day - Solar Min	6.3594e-06

Environment Data:

	Attribute	Value
1	Name	Lunar
2	Description	This environment is defined as a 385K km near-earth interplanetary orbit and referred to as Lunar Cruise. Guidance from NASA Ames Research Center's avionics trade study regarding Mission Radiation Environment Modeling and Analysis for their GCD Rad-Neuro Project (NASA/TM-20220011775, pages 10 and 11) was utilized to identify the orbital parameters. "The Moon has no atmosphere nor magnetosphere. At this distance from Earth, only the long tail of the magnetosphere proves any protection. Therefore, the Lunar mission environment is the same as the Cruise Phase radiation environment with one notable exception." The notable exception is the aggregation of shielding from the spacecraft, the Lunar body, and the Earth. The calculations are for worst case and do not include any consideration for shielding from these larger bodies. The critical time windows identified for this analysis were 2-hours and 15 days. The mission duration is 1 year.
3	Altitude Specification	Circular
4	Altitude (km)	385000
5	Inclination (deg)	0
6	Mission Duration (Days)	365
7	Critical Time A (Hours)	2
8	Critical Time B (Hours)	360
9	Critical Time C (Hours)	8760

Data Custodian(s):

	Attribute	Value
1	Document_001	Single-Event Effects Test Report Texas Instruments TDA4VM System on Chip
2	Website_001	https://ntrs.nasa.gov/citations/20250002872
3	Author_001	Edward Wyrwas
4	Institution_001	NASA (Ctr)
5	Email_001	edward.j.wyrwas@nasa.gov

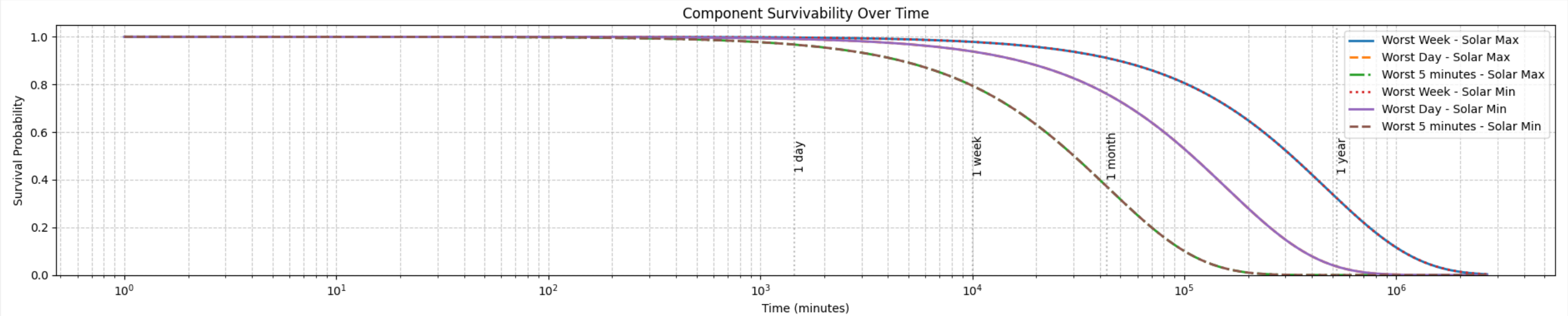
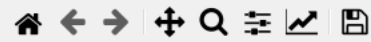
Survivability Plot:

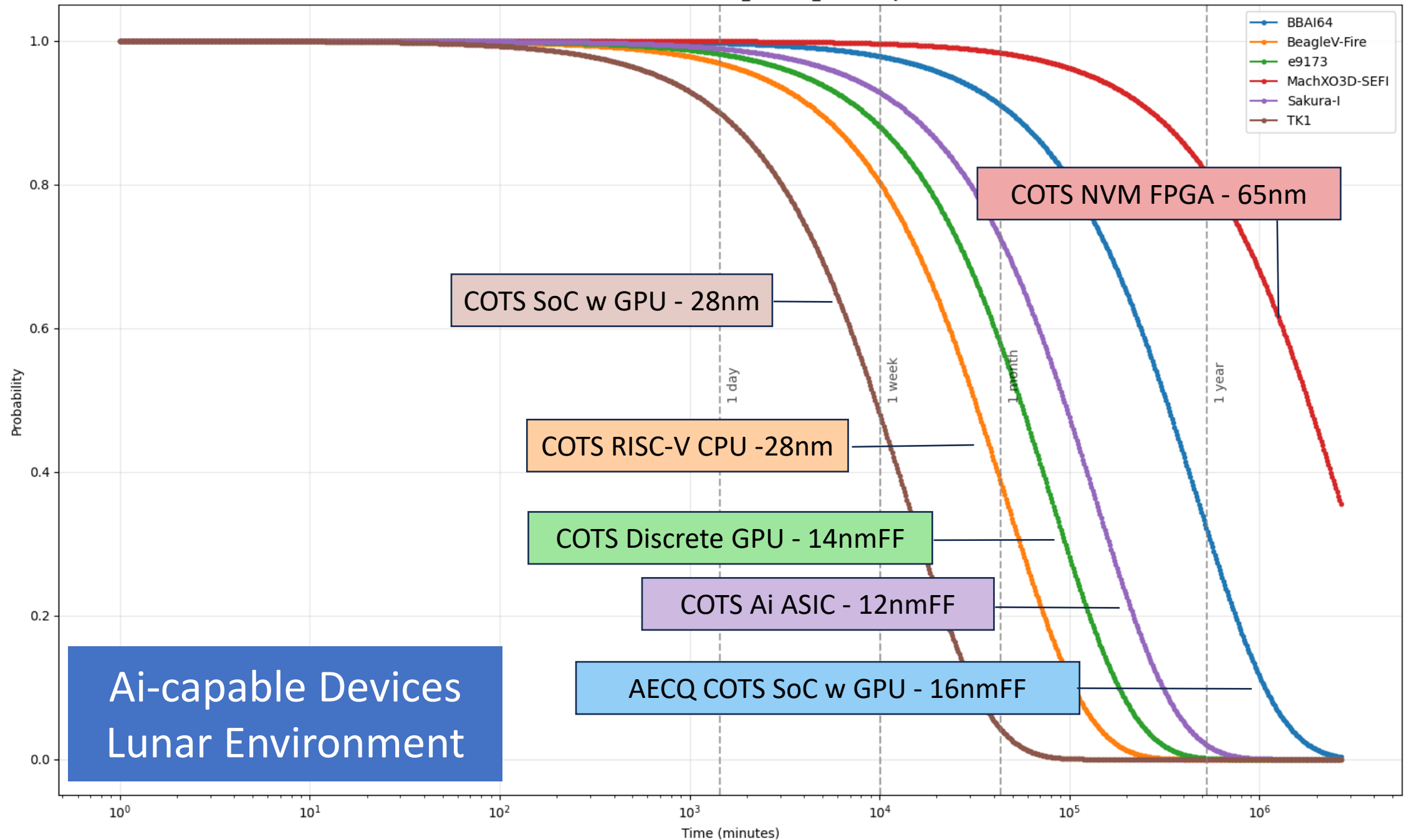
Save Data

Advanced Survival Plotter

Exit Full Screen

MTBF







Collaborations

- Aerospace Corporation
- Edge Cortex
- DIU
- Johns Hopkins University Applied Physics Laboratory
- Kupros Inc
- NASA ARC, GSFC, JSC
- AFRL and Space Force
- Troxel Aerospace

Processor Enclave telecon

- 1st and 3rd Fridays each month @ 1100 eastern
- Contact edward.j.wyrwas@nasa.gov

Summary



- With a reduction of funding and other resources, data sharing has become prominent across institutions to reduce gaps. However, the integrity and structure of that data is paramount to make it usable across different radiation test campaigns.
- The NEPP Processor Enclave has established a standardized workflow with automation that allows us to leverage everyone's data to complement or supplement our own tests, reducing or eliminating duplication altogether, and permitting comprehensive testing to take place.
 - It takes approximately 1-hour to on-board a tested device and its test run log
 - This data can be shared, without mission context or propriety (or hosted IT resources such as a database), through the NPE SOUNDDES Initiative.
 - This ultimately allows test campaigns to bridge institutions and eliminate double-spend.



Acknowledgements

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- NASA Electronic Parts and Packaging (NEPP) Program
- NASA Office of Safety & Mission Assurance

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