



Towards a Radiation-Tolerant Display System

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Acronyms

COTS: Commercial-Off-The-Shelf

CPU: Central Processing Unit

FPGA: Field-Programmable Gate Array

GPU: Graphics Processing Unit

LCD: Liquid Crystal Display

OLED: Organic Light-Emitting Diode

Rad-Hard: Radiation-Hardened

Rad-Tol: Radiation-Tolerant

SEE: Single-Event Effect

SEFI: Single-Event Functional Interrupt

SEL: Single-Event Latchup

SoC: System-on-Chip

STAR: Space Technology Application Renderer

TID: Total Ionizing Dose



Acknowledgements

Thank you to Landen Ryder and Justin Bautista for frontrunning the previous work which led to design decisions for this project

Thank you to the NASA Electronic Parts and Packaging (NEPP) Group at NASA Goddard Space Flight Center for supporting the radiation testing within these and previous works

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Mission-Critical Computing
NSF CENTER FOR SPACE, HIGH-PERFORMANCE,
AND RESILIENT COMPUTING (SHREC)

Displays are everywhere!



In the stations

In pressurized rovers

In the suits

In unpressurized rovers

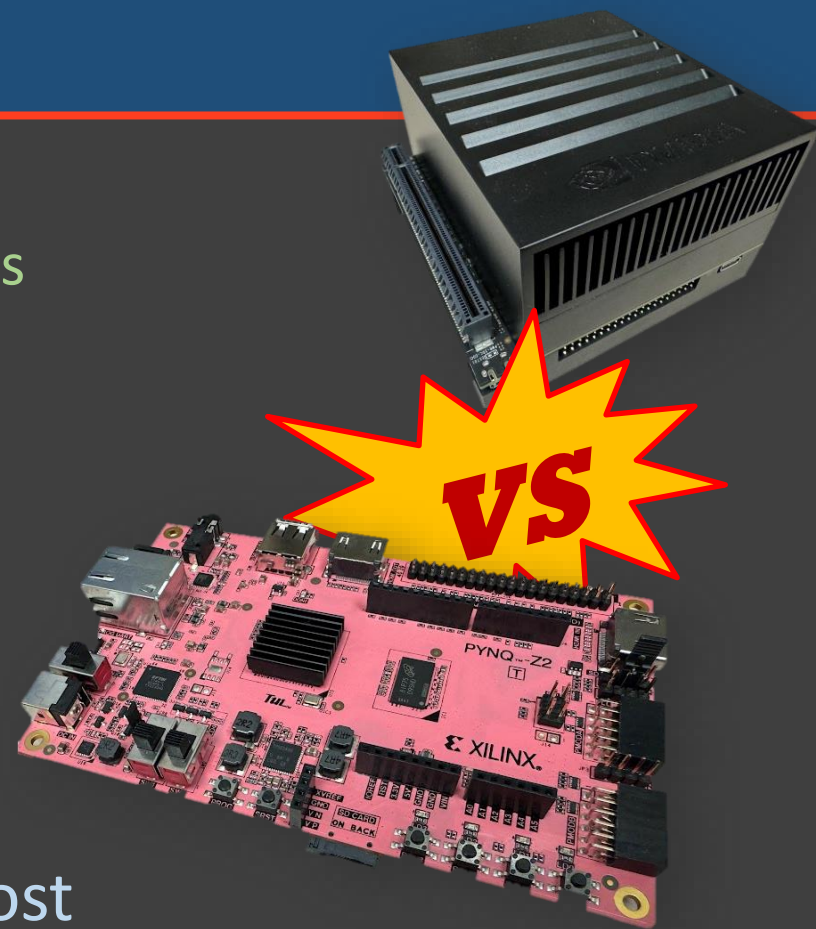
In extravehicular equipment

How should we make them?

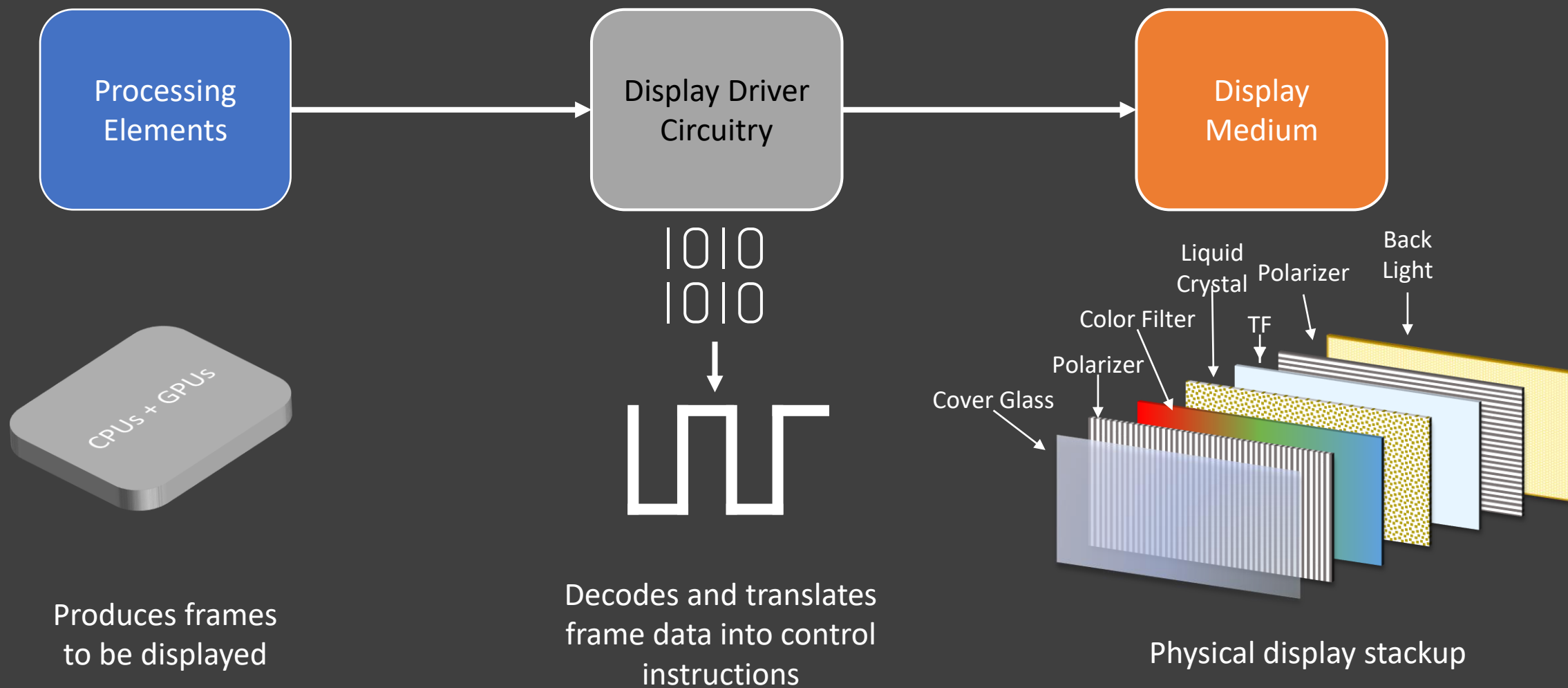


Problem Statement

- Inspired from NASA 2020 Taxonomy
 - Crew and display systems are essential for NASA functions
- Need scalable architecture to drive display systems
 - Current rad-hard processors do not have the processing capabilities for graphics rendering
 - COTS processors more performant, less reliable
 - Rad-hard GPUs unavailable
- Need to understand interoperability of the system
- Engineering trades of reliability, performance, and cost
 - Reliable system architecture using COTS and rad-hard parts

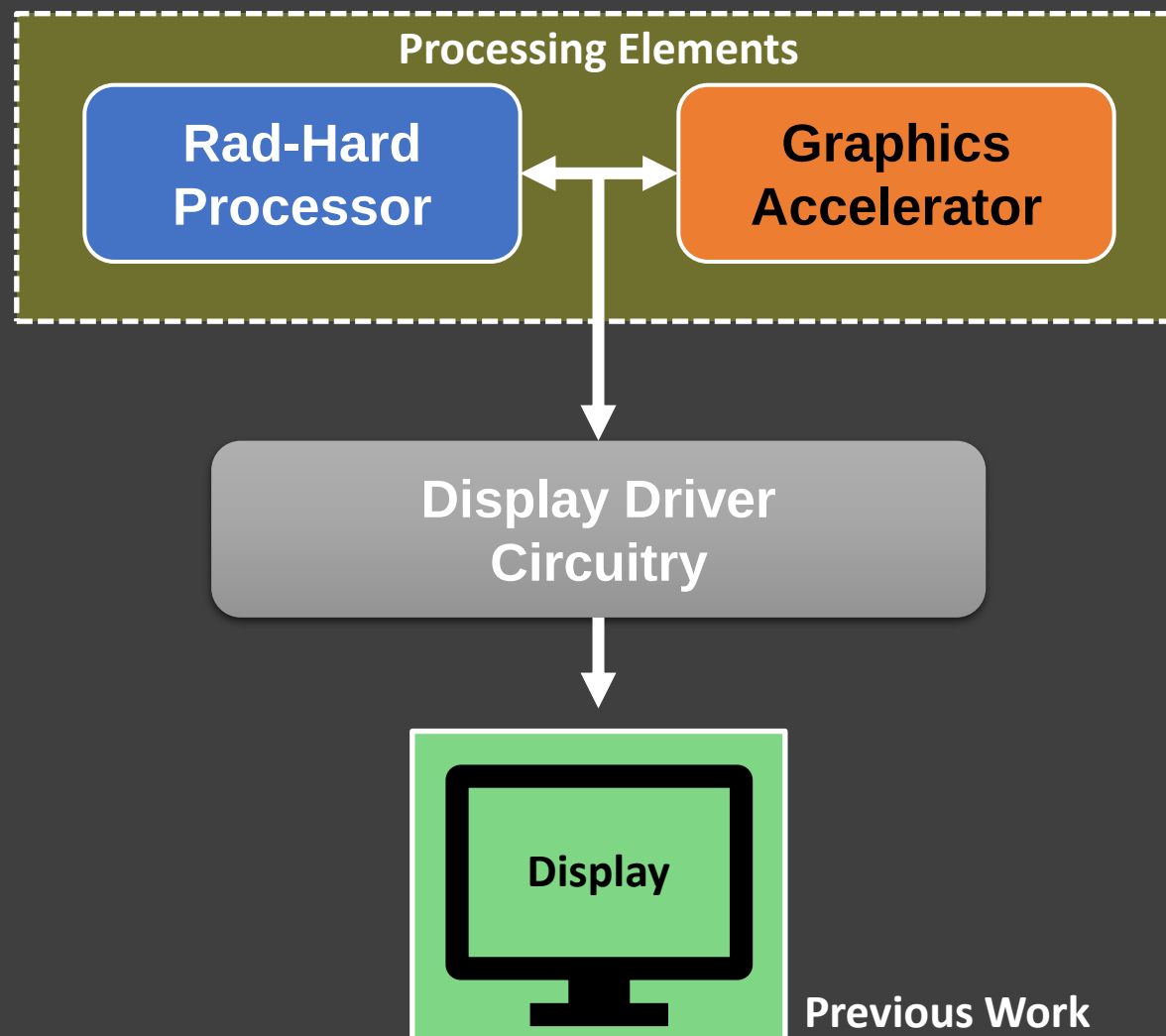


Display Pipeline



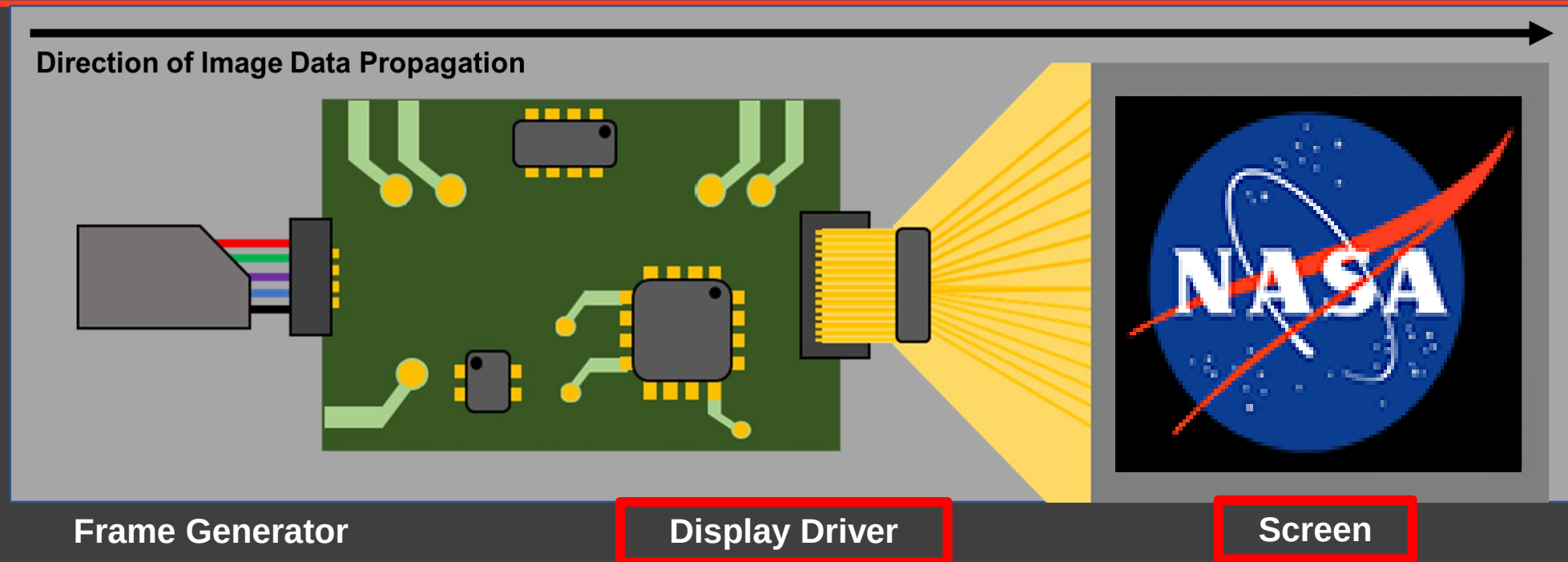


Previous Project Scope





Previous Work - Rad. Resistant Displays

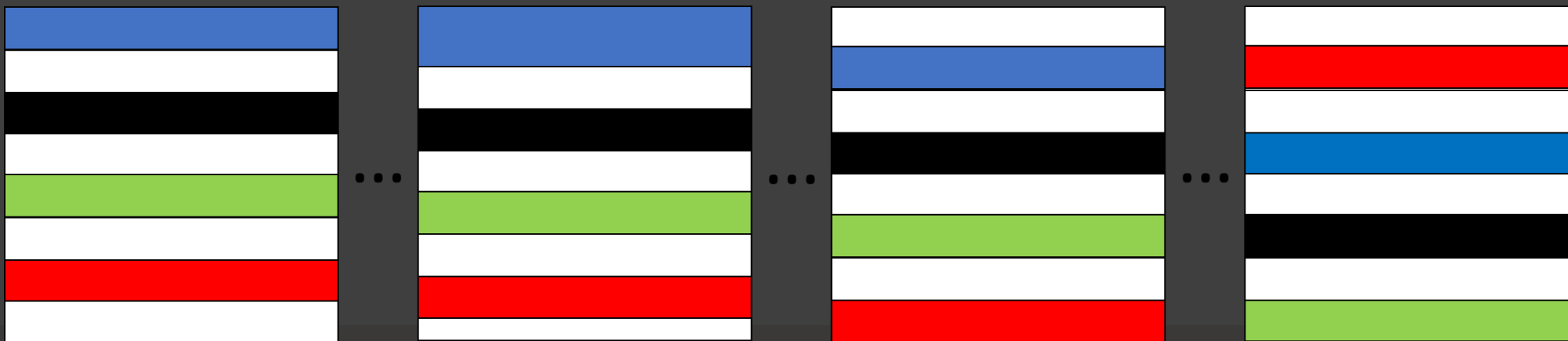
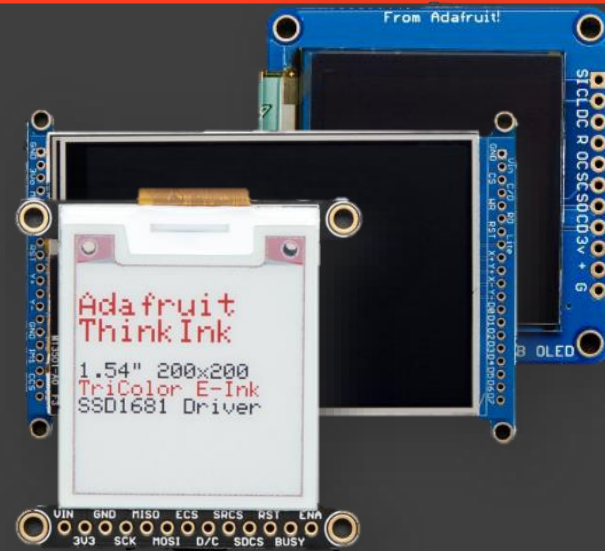


- Focused on exploration of components unique to electronic display systems
 - Display Drivers – convert image data into temporal drive signals to drive screens
 - Electronic Screens – addressable arrays of optical emission/modulation pixels
- Developed test methodologies and metrics for characterizing future displays needs
- SEFIs in configuration registers main driver of availability requirements



Previously, On Resilient Displays...

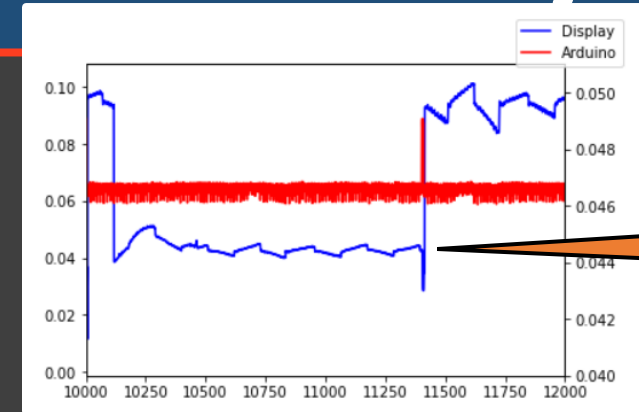
- Lawrence Berkeley National Labs
 - 16 MeV/n tune
 - Moving color patterns
 - OLED, LCD, eInk
- Scrolling color pattern
- Looking for single-event effects



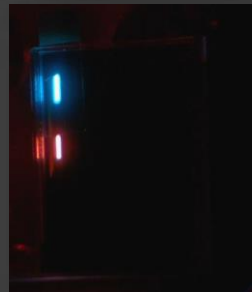
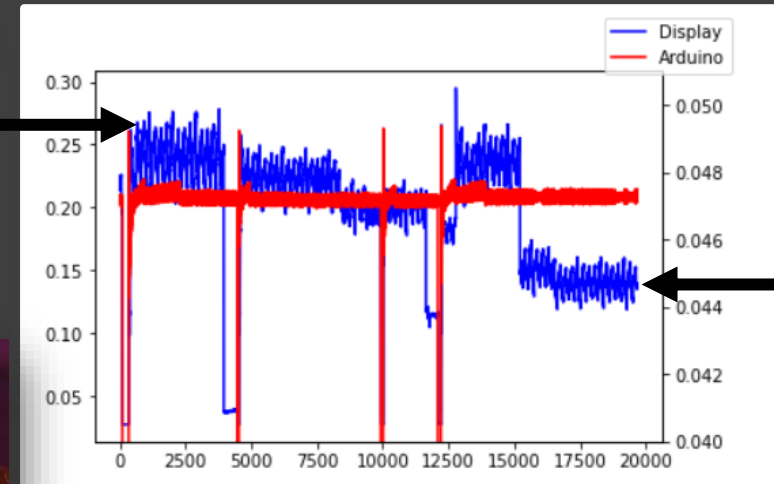


Heavy Ion Results Summary

- Black screen occasionally with OLED
- Elevated Brightness on one OLED
- Destructive effects @ highest LET on OLED
- No upsets in elnk observed
- LCD upsets cleared when LCD memory rewritten
- **Moving forward with LCDs**



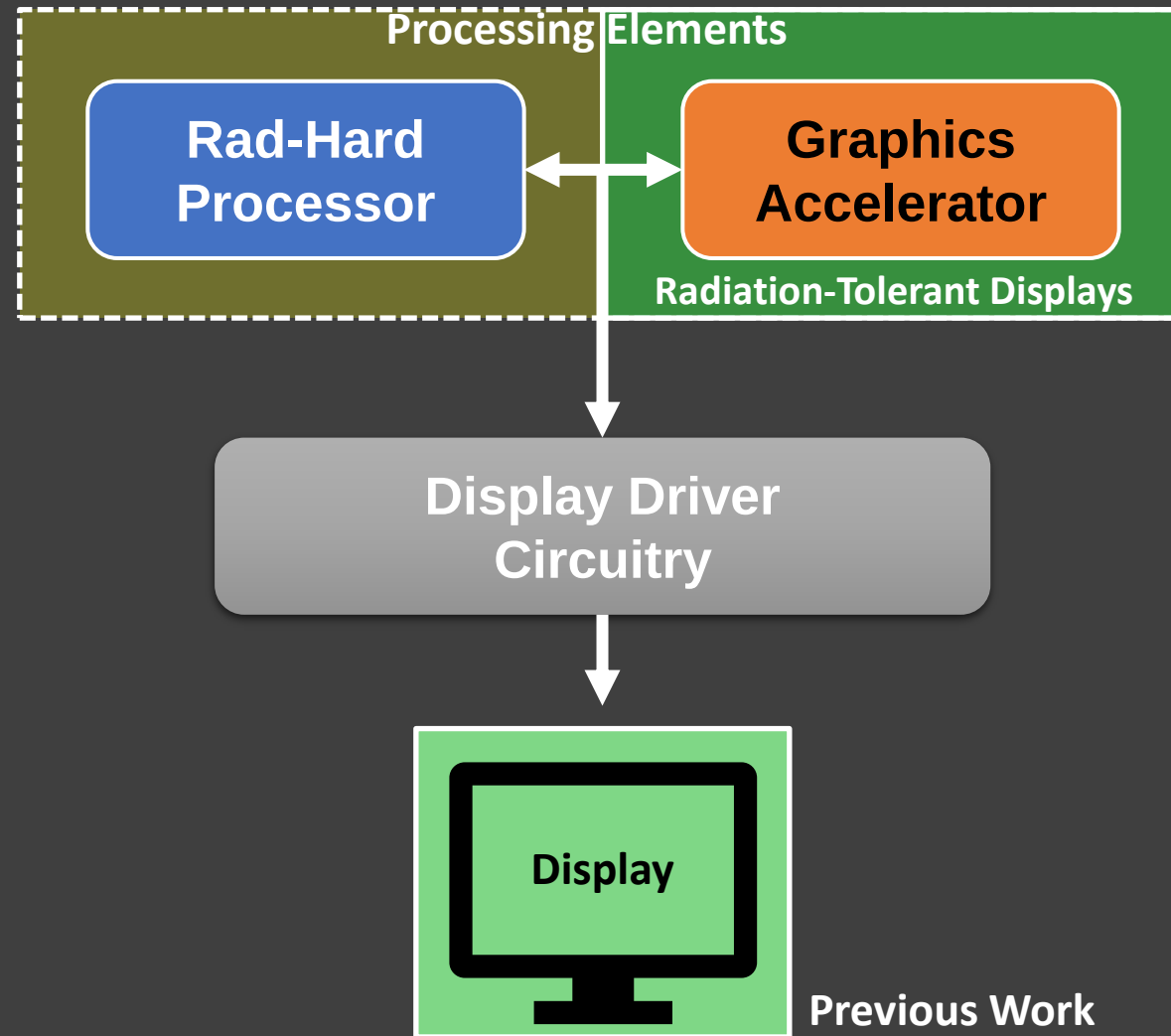
Pattern during black screen



OLED: Organic Light-Emitting Diode
LCD: Liquid Crystal Display



Project Scope – Now Avionics

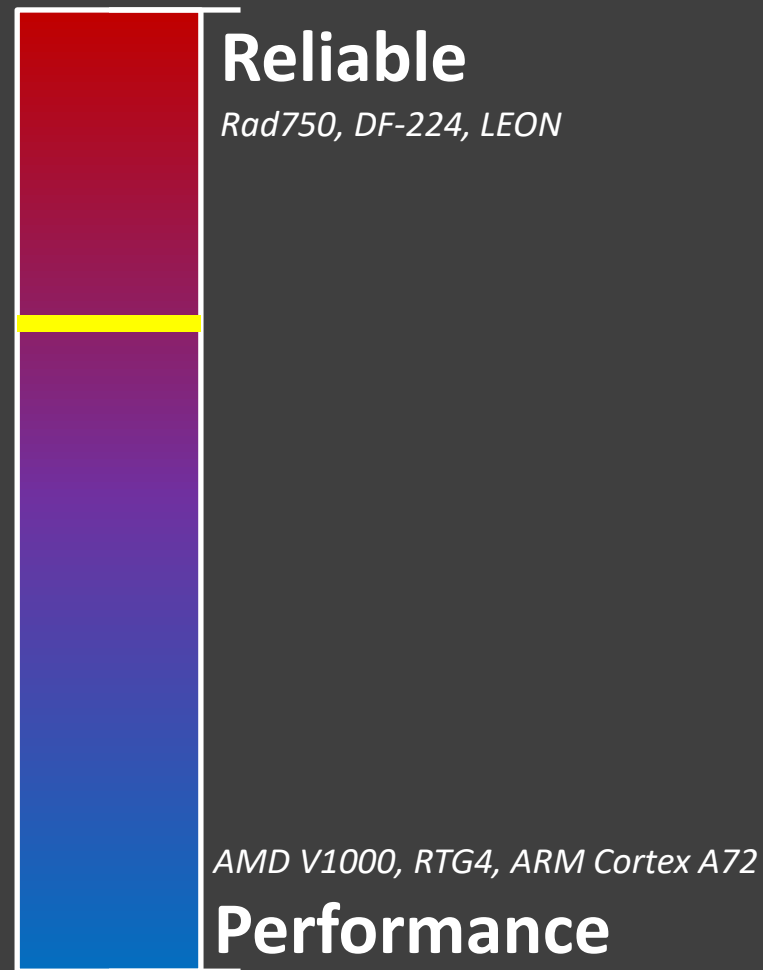


Rad-hard: Radiation-Hardened



Tradeoffs

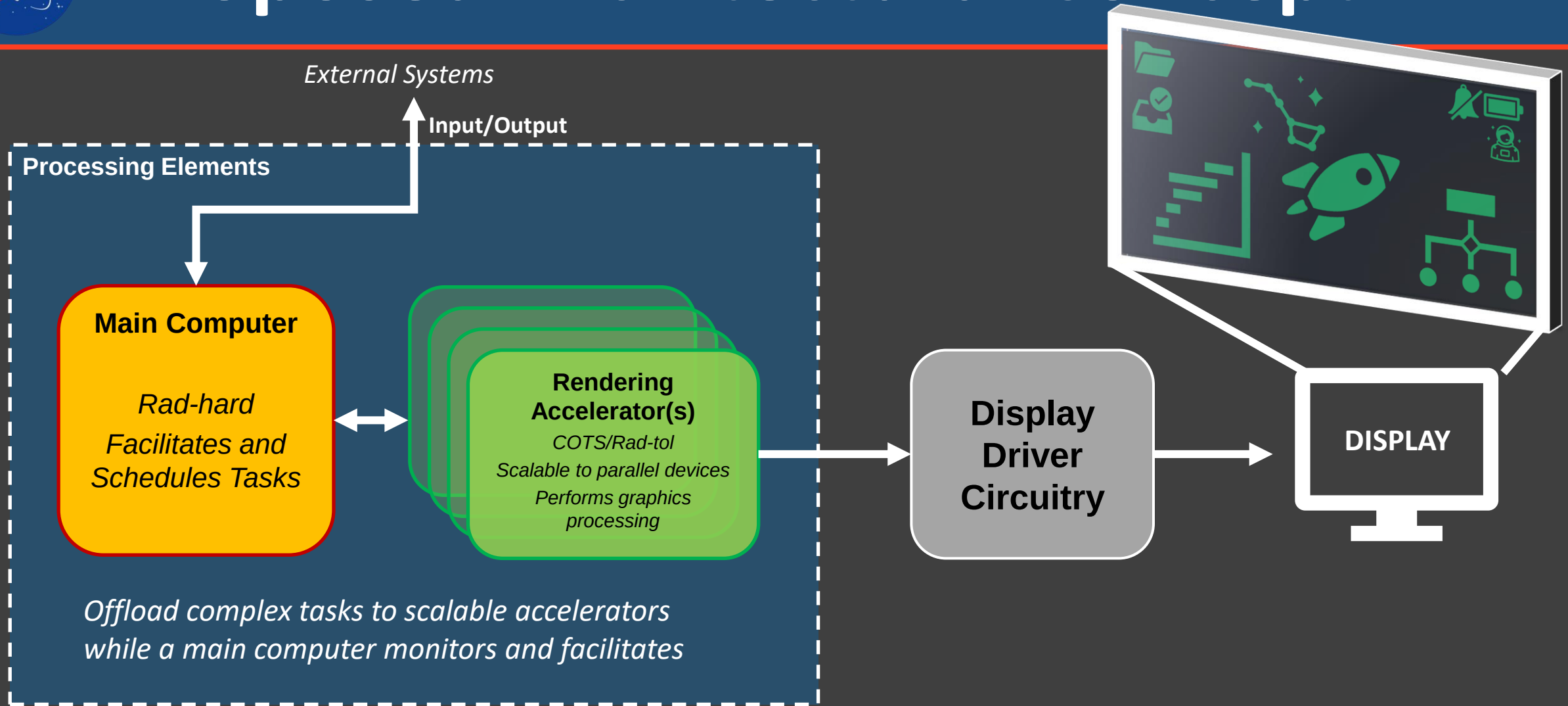
- Computational Performance
 - Need to be able to perform application needs
- Radiation Reliability
 - **Minimize** TID and SEE effects
 - **Maximize** availability
- Scalability
 - Scalable to fit various requirements
 - Size/power/form factor/etc.
 - Allow for replacements with minimal work



TID: Total Ionizing Dose
SEE: Single-Event Effect



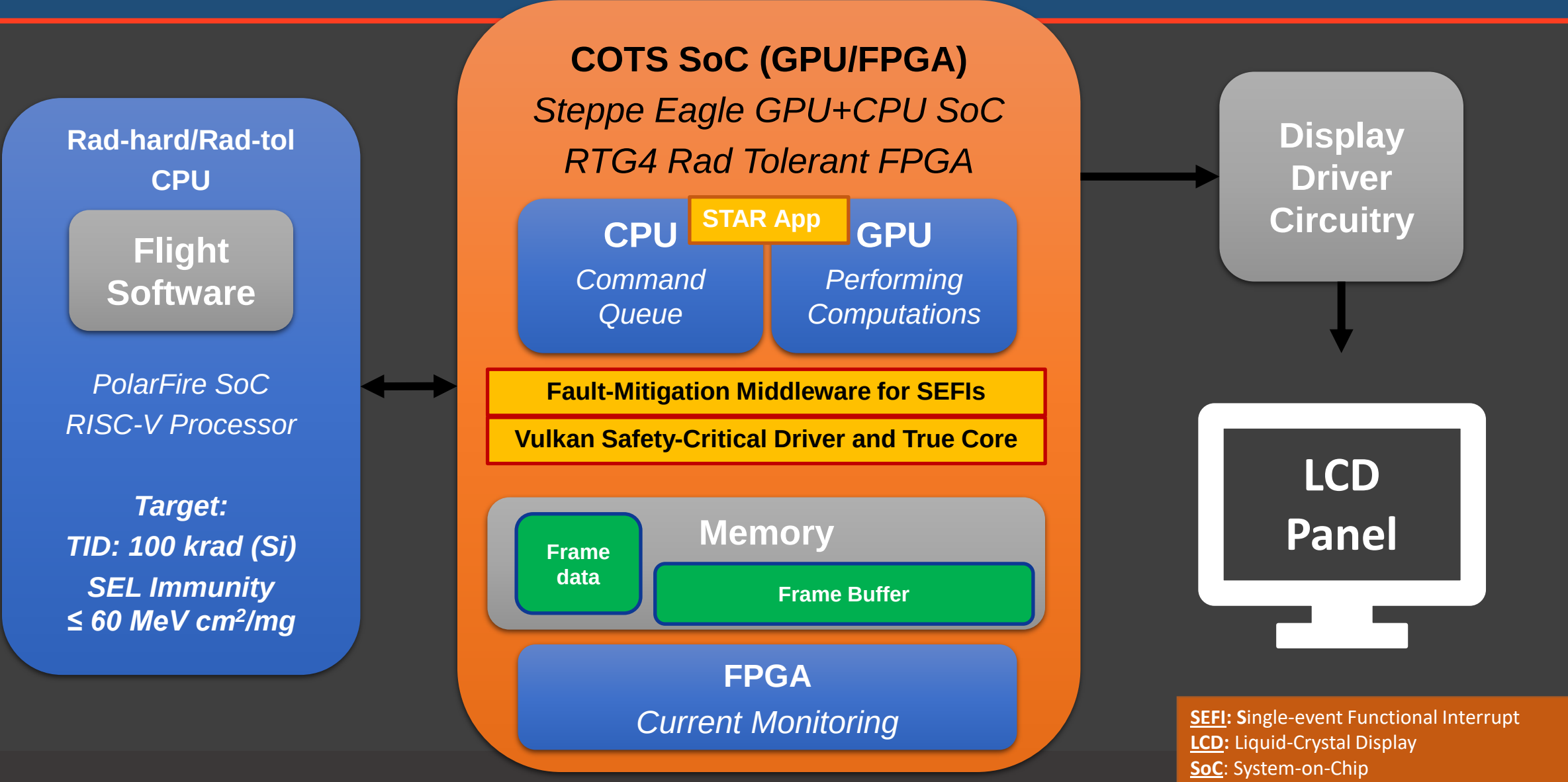
Proposed Architectural Concept



Rad-hard: Radiation Hardened
Rad-tol: Radiation Tolerant



Let's Get More Specific - Architecture Demo





Current Demo

- Main Computer
 - Planned: PolarFire SoC RISC-V processor
- Hardware accelerator (Moog Sierra)
 - AMD Steppe Eagle GPU SoC
 - x86 processor
 - RTG4 Radiation-tolerant FPGA
- STAR application running on devkit



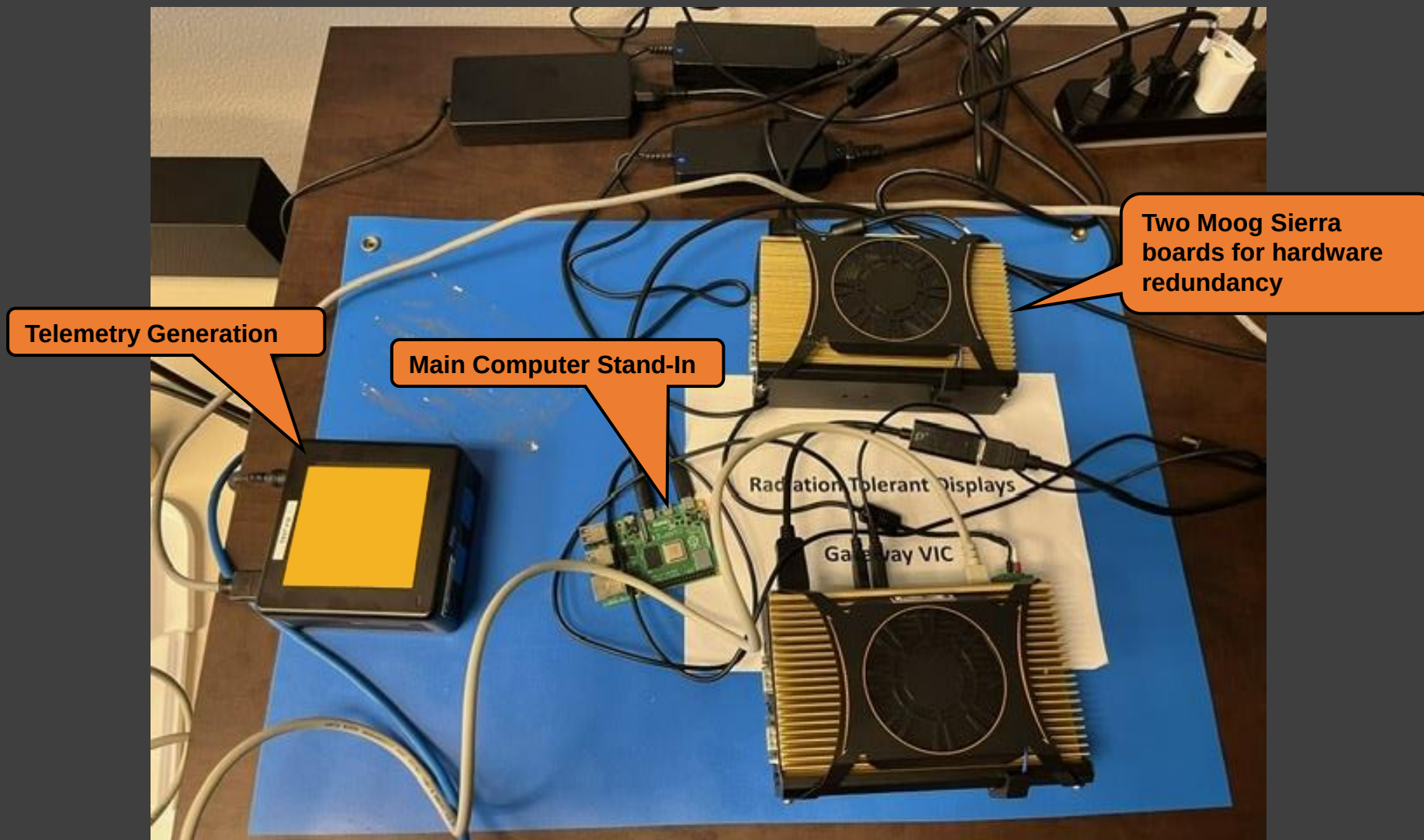
*Moog Sierra GPU
Single-Board Computer*

SoC: System-on-Chip

STAR: Space Technology Application Renderer



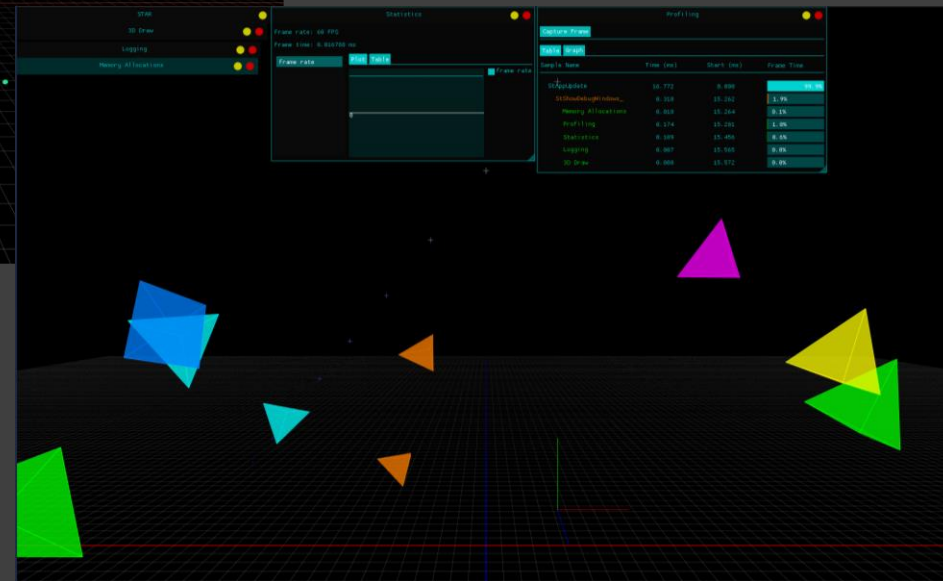
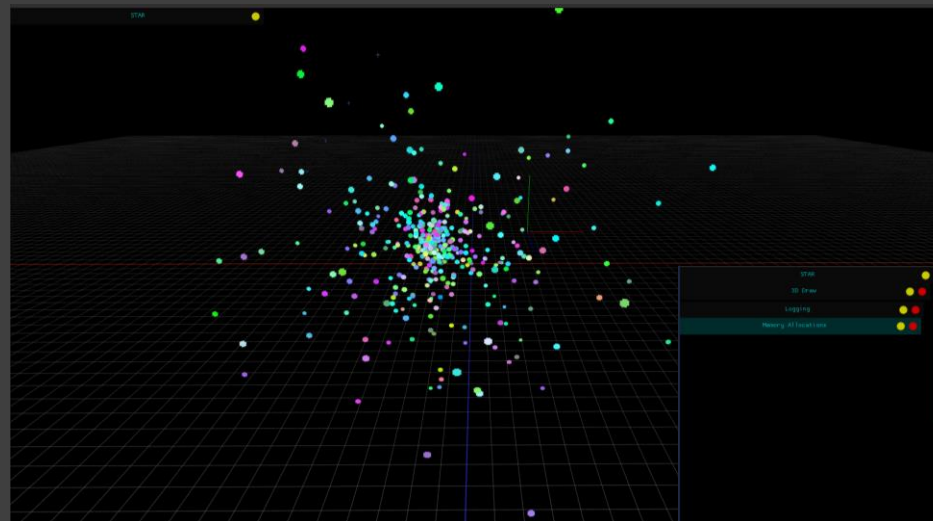
Demo Setup



Use-Case Examples of STAR Apps



Low End: Text-based GUI
Depicted on MSP430



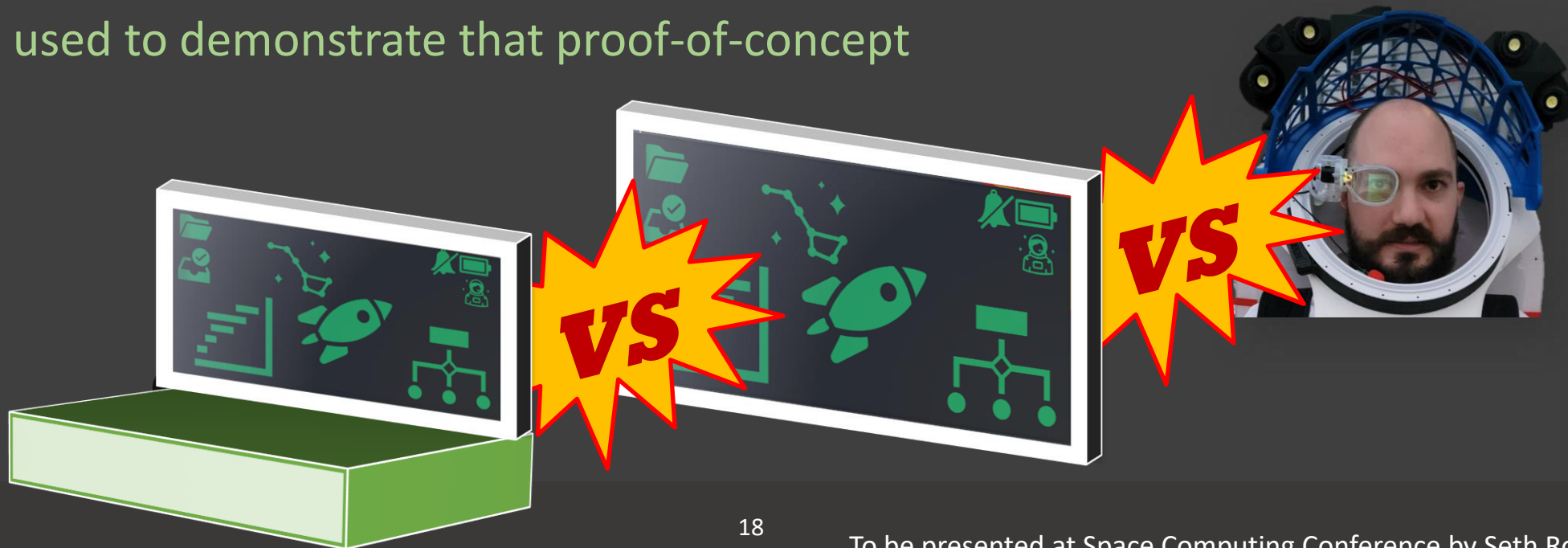
High End: 3d rendering

STAR: Space Technology Application Renderer



⚠ Hold on one second! ⚠

- Proposal not an off the shelf solution
 - It is to understand architectural feasibility
- The idea is to be as **scalable as possible**
- Choice of processor(s) or display system entirely dependent on missions
- Proof-of-concept of augmenting rad-hard processing with COTS accelerators
 - Demo used to demonstrate that proof-of-concept





Where Do We Go From Here?

- Receiving LCD panels from selected vendor
- Heavy ion testing panels in the Fall
- Develop and demo use cases for different mission concepts



LCD: Liquid-Crystal Display



Conclusions

- Design a proof-of-concept of reliable, scalable display system architecture
- Previously irradiated display panels
 - Current work is on avionics
 - Using a radiation-hardened processor alongside a COTS accelerator
 - Working with industry for new use cases and design needs
- Demo using AMD Steppe Eagle GPU SoC with RISC-V processor
 - But the choice is yours!

SoC: System-on-Chip
COTS: Commercial Off The Shelf