Enabling the Orbital Internet: Scalable Hi-Rel Solutions for Boot, Storage and AI Processing

Paul Chopelas, General Manager, Aerospace & Defense
Avalanche Technology

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Space Computing Conference
Mountain View, CA

avalanche technology

Agenda

Roadmap Update

Qualification and Ecosystem Update

Boot Solutions – Device Level

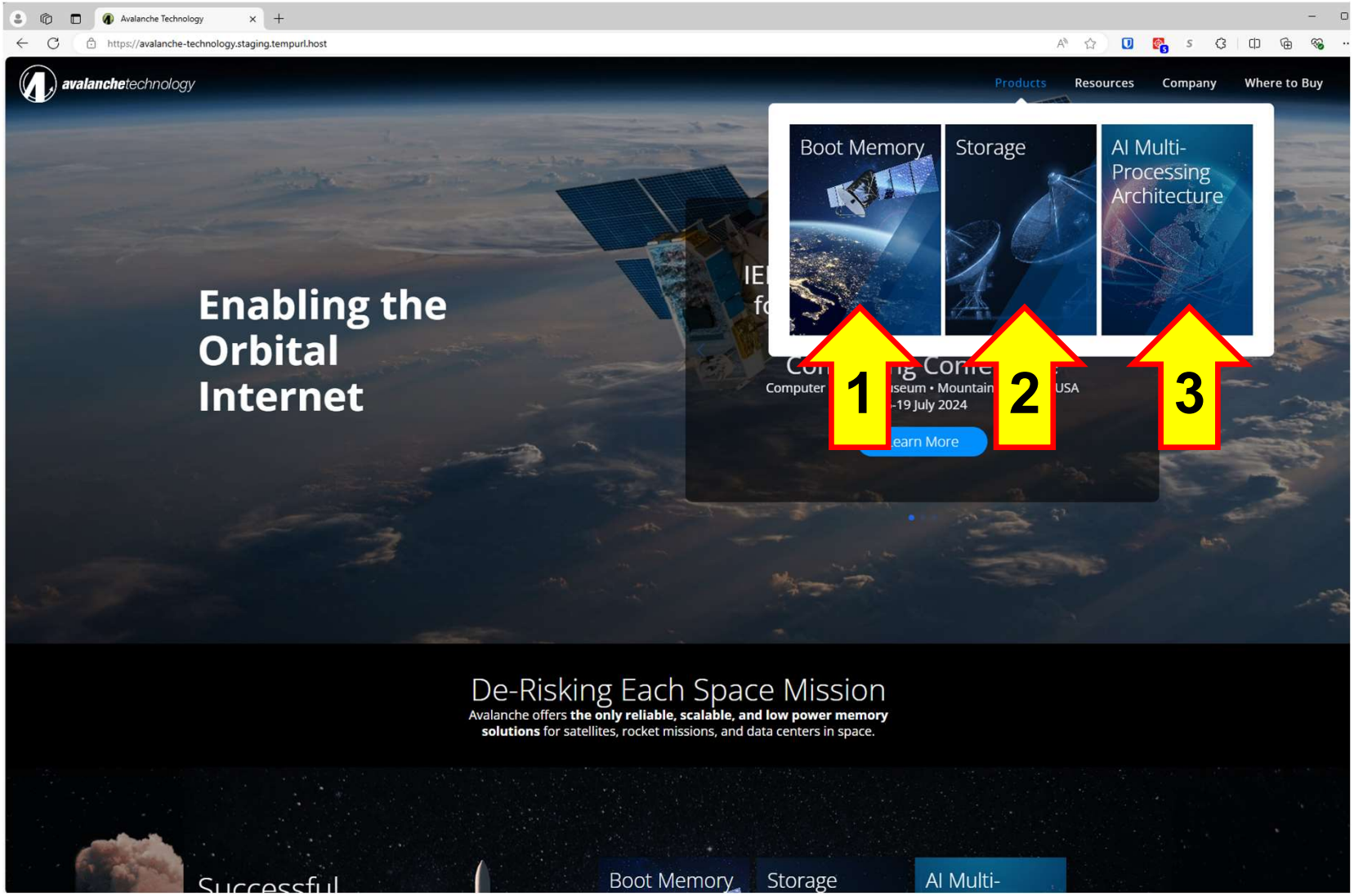
Enabled Platforms – Storage

Enabled Platforms – Board & Device

Enabled Platforms – AI/Processing in Space

Resources and Support

Roadmap Update


Avalanche Technology
https://avalanche-technology.staging.tempurl.host
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Products
Resources
Company
Where to Buy
Boot Memory
Storage
AI Multi-Processing Architecture
1
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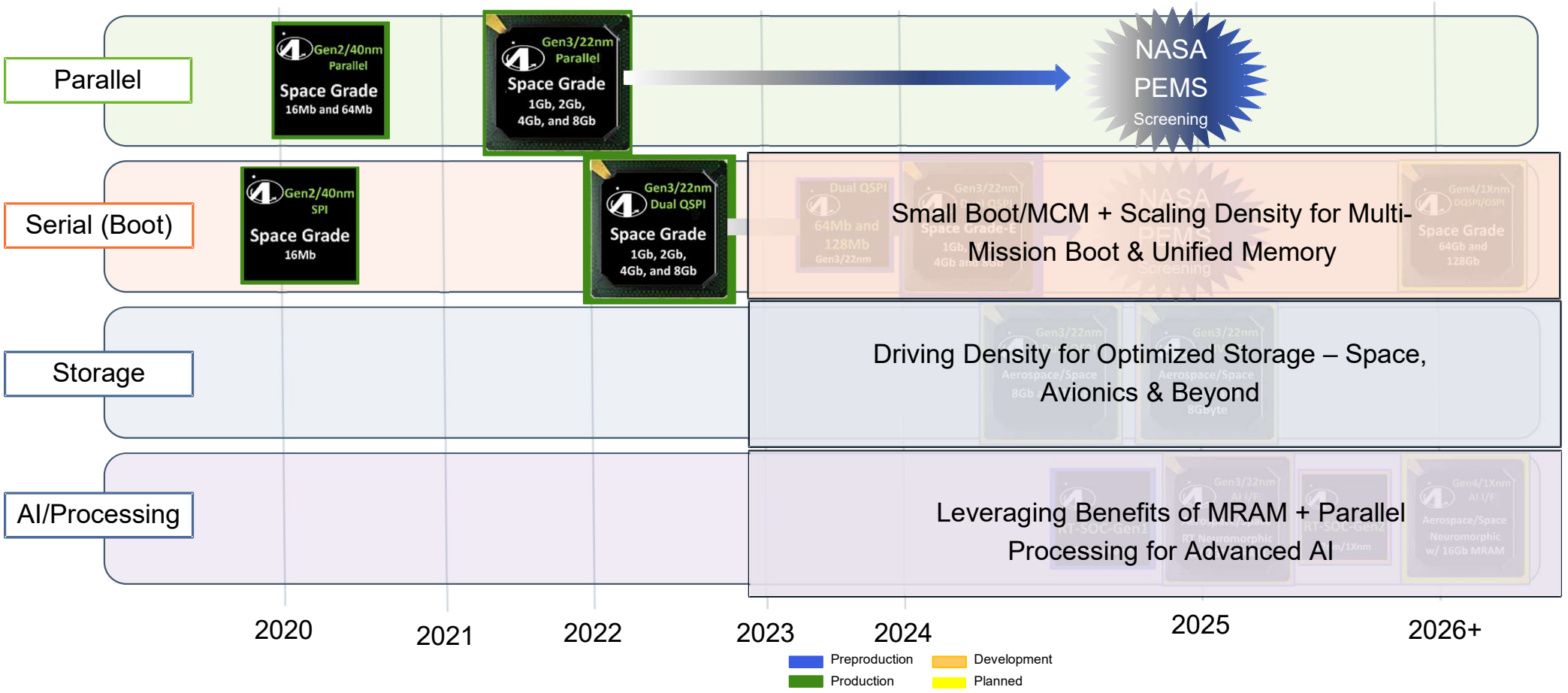
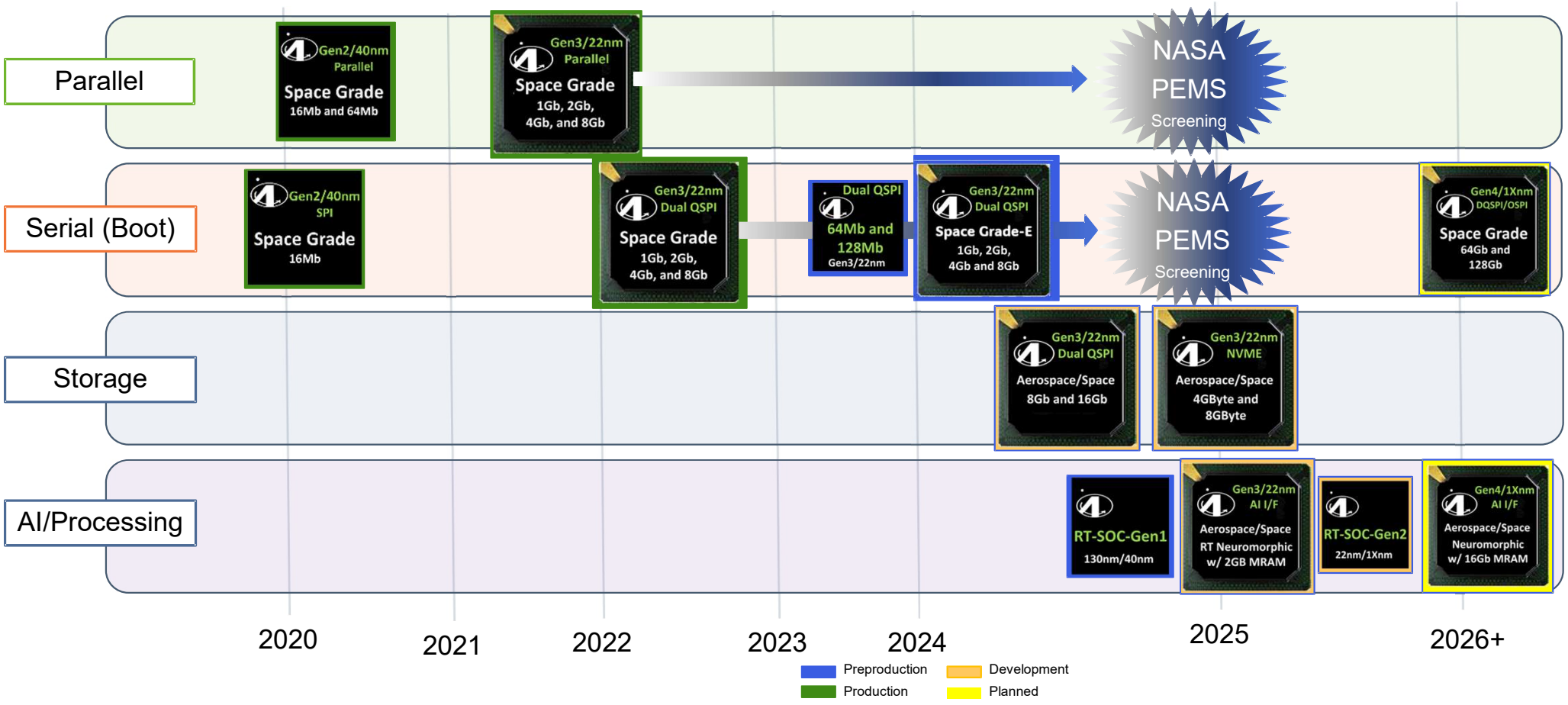
Enabling the Orbital Internet
Learn More
De-Risking Each Space Mission
Avalanche offers the only reliable, scalable, and low power memory solutions for satellites, rocket missions, and data centers in space.
Boot Memory
Storage
AI Multi-

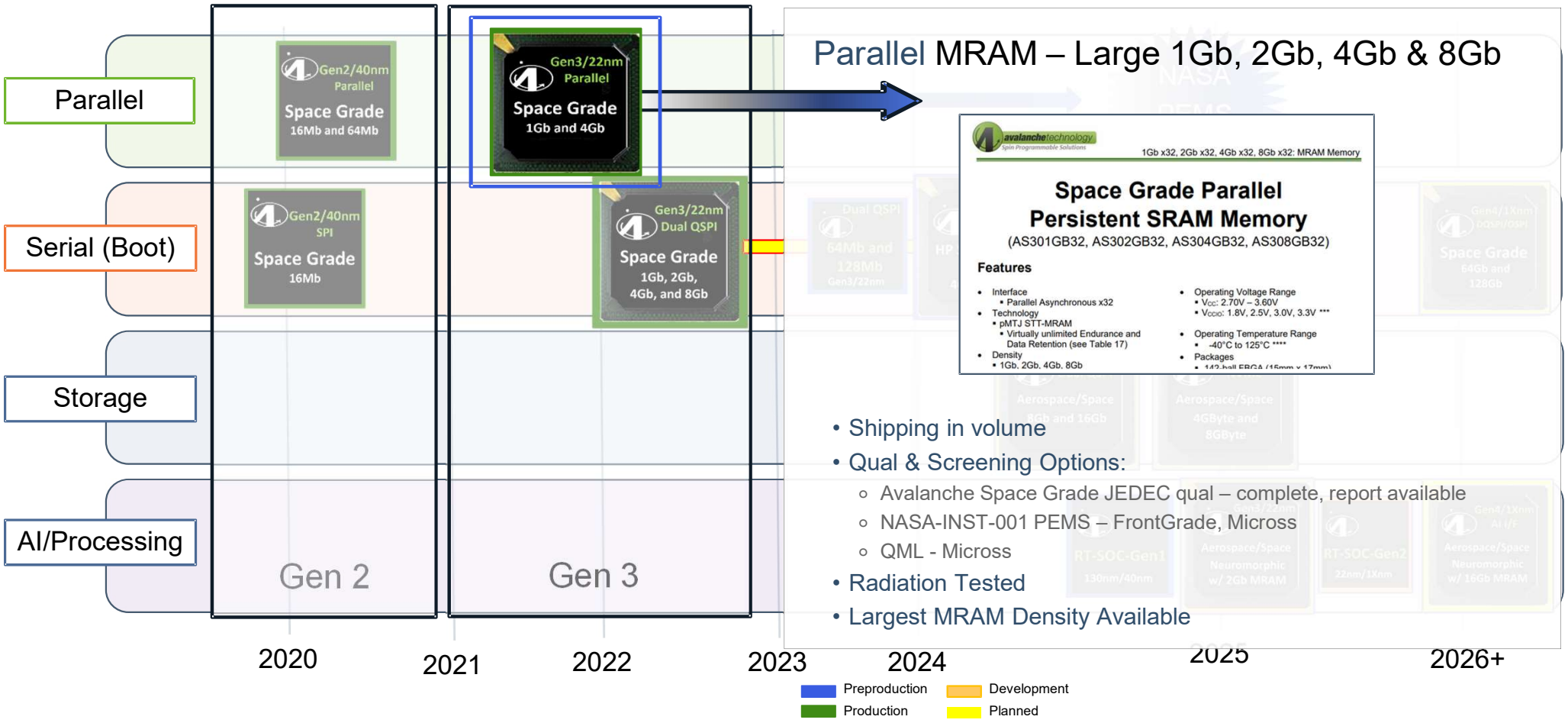
Avalanche MRAM/Processing Product Roadmap



Avalanche MRAM/Processing Product Roadmap



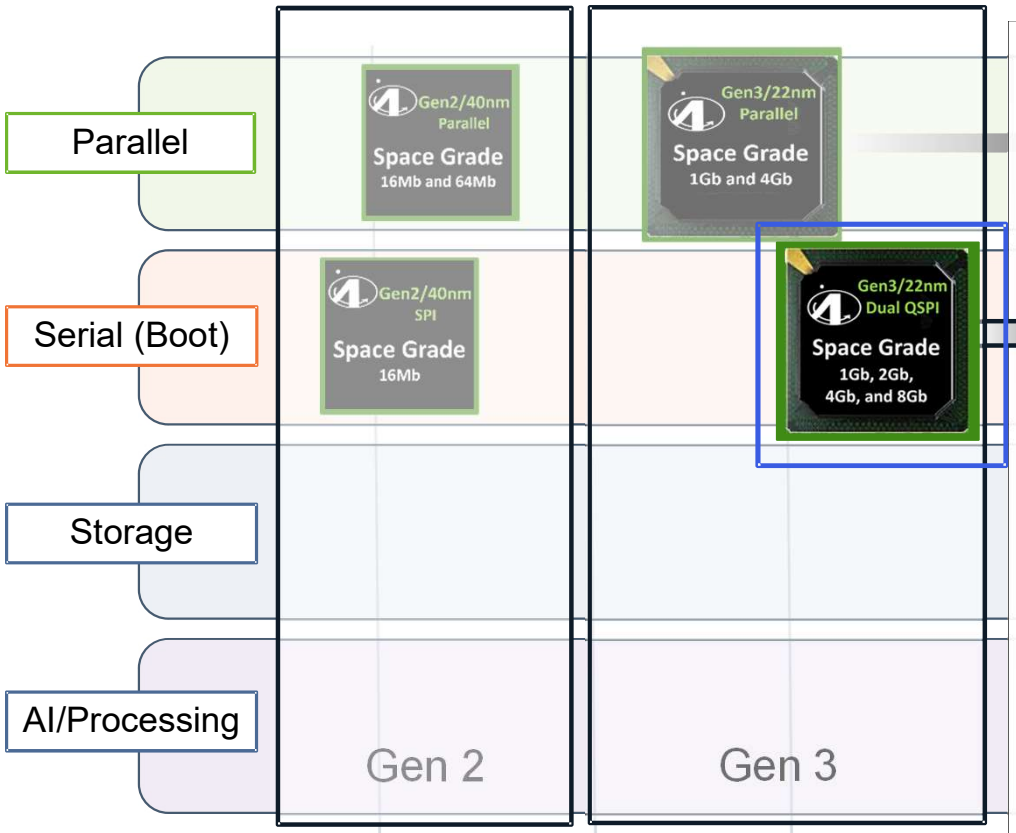
Avalanche MRAM Solutions Available Today



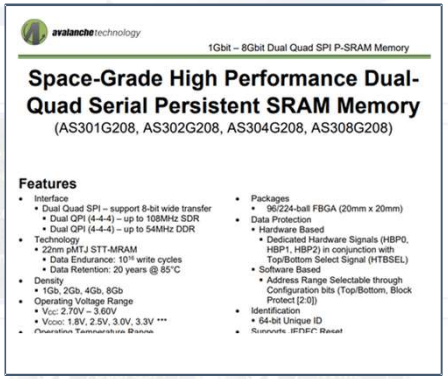
Parallel MRAM – Large 1Gb, 2Gb, 4Gb & 8Gb

- Shipping in volume
- Qual & Screening Options:
  - Avalanche Space Grade JEDEC qual – complete, report available
  - NASA-INST-001 PEMS – FrontGrade, Micross
  - QML - Micross
- Radiation Tested
- Largest MRAM Density Available

Avalanche MRAM Solutions Available Today – Ideal for Configuration



Serial MRAM (Dual QSPI) -1Gb, 2Gb, 4Gb & 8Gb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1Gbit – 8Gbit Dual Quad SPI P-SRAM Memory

Space-Grade High Performance Dual-Quad Serial Persistent SRAM Memory

(AS301G208, AS302G208, AS304G208, AS308G208)

Features

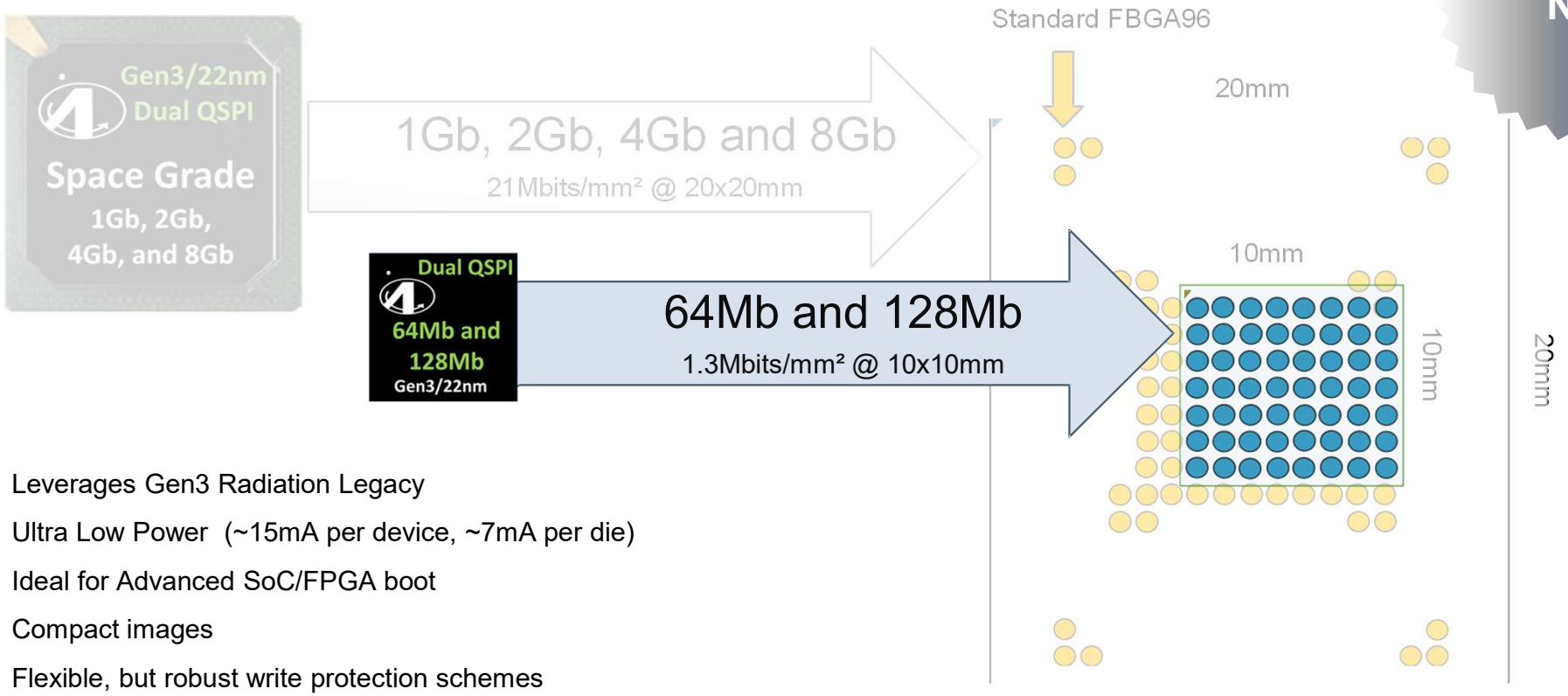
- Interface
  - Dual Quad SPI – support 8-bit wide transfer
  - Dual QPI (4-4-4) – up to 108MHz SDR
  - Dual QPI (4-4-4) – up to 54MHz DDR
- Technology
  - 22nm pMTJ STT-MRAM
  - Data Endurance: 10^{16} write cycles
  - Data Retention: 20 years @ 85°C
- Density
  - 1Gb, 2Gb, 4Gb, 8Gb
- Operating Voltage Range
  - V_{CC}: 2.70V – 3.60V
  - V_{CCIO}: 1.8V, 2.5V, 3.0V, 3.3V ***
- Packages
  - 96/224-ball FBGA (20mm x 20mm)
- Data Protection
  - Hardware Based
    - Dedicated Hardware Signals (HBP0, HBP1, HBP2) in conjunction with Top/Bottom Select Signal (HTBSEL)
  - Software Based
    - Address Range Selectable through Configuration bits (Top/Bottom, Block Protect (2:0))
- Identification
  - 64-bit Unique ID

- Shipping in volume
- Qual & Screening Options:
  - Avalanche Space Grade JEDEC qual in progress
  - NASA-INST-001 PEMS – FrontGrade, Micross and Avalanche
  - QML - Micross
- Radiation Tested
- Largest MRAM Density Available
  - Petalinux Drivers available for AMD/Xilinx FPGA

Preproduction
Production
Development
Planned

Low Density Serial (Dual QSPI) – 64Mb and 128Mb Gen3

Sampling Now



Leverages Gen3 Radiation Legacy

Ultra Low Power (~15mA per device, ~7mA per die)

Ideal for Advanced SoC/FPGA boot

Compact images

Flexible, but robust write protection schemes

Single or Dual QSPI Interface

Qualification and Ecosystem

Powered by Avalanche – MRAM Device Ecosystem

Industrial Grade
Space Grade
PEMS (with DPACI)

Space Grade
QED, PEMS, and RadHard
30-year Hi-Rel Qual Heritage
Plastic, Die, Hermetic, and MCM

Space Grade
QED, PEMS, and RadHard
Standard and Custom
30-year Qual Heritage

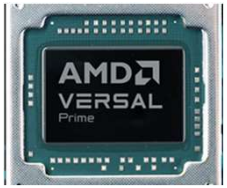
Powered by Avalanche - Qual & Screening Ecosystem Options

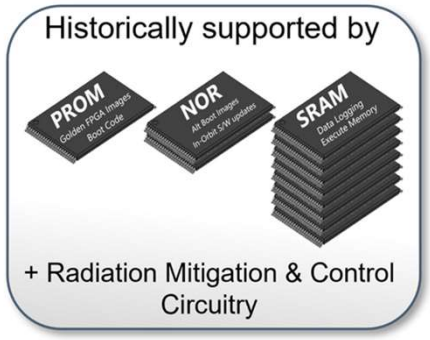
Packaging		Plastic Encapsulated				Hermetic, Ceramic, MCM
Qual Level		JESD-471	NASA PEMS			QML
Vendor		avalanche technology	avalanche technology	FRONTGRADE	micross	micross
Product Family		Space Grade	QED Series	UT8MRQ Series	QED Series	Multiple
Avalanche MRAM Generation		Gen3	Gen3	Gen3	Gen2 & Gen3	Gen2 & Gen3
Comments		Representative radiation reports only.	The exact same packaged device, custom marked to vendor; each responsible for their own Qual & Screening flow. Datasheet of origin is Avalanche.			Multiple package, screening & radiation options for each
Space Grade-E Parallel & DQSPI	TID	100kRad	100kRad	100kRad	300kRad	300kRad
	SEE	75MeV	75MeV	75MeV	75MeV	75MeV
Space Grade Parallel & DQSPI	TID	75kRad	75kRad	75kRad	75kRad	75kRad
	SEE	≤37MeV	≤37MeV	37MeV	37MeV	37MeV
ITAR		No	No	Yes	Yes	Yes

Boot Solutions - Device Level

Enabled Booting and nvStorage for AMD/Xilinx Devices

SW-Defined Platforms for Space – Respond to Threats in Real Time





Now

No redundancy, mitigation or control needed

Dramatically simplified hw & sw architecture, rapid boot

In Orbit FOTA support: multi-mission adaptability ENABLED

Support Resources Available

Family	Petalinux Support				Fabric Only
	23.2	23.1	22.2	22.1	No O/S
Versal	✓	✓	✓	✓	✓
Ultrascale+	✓	✓	✓	✓	✓
Ultrascale	✓	✓	✓	✓	✓

https://www.avalanche-technology.com/support/development-kits/

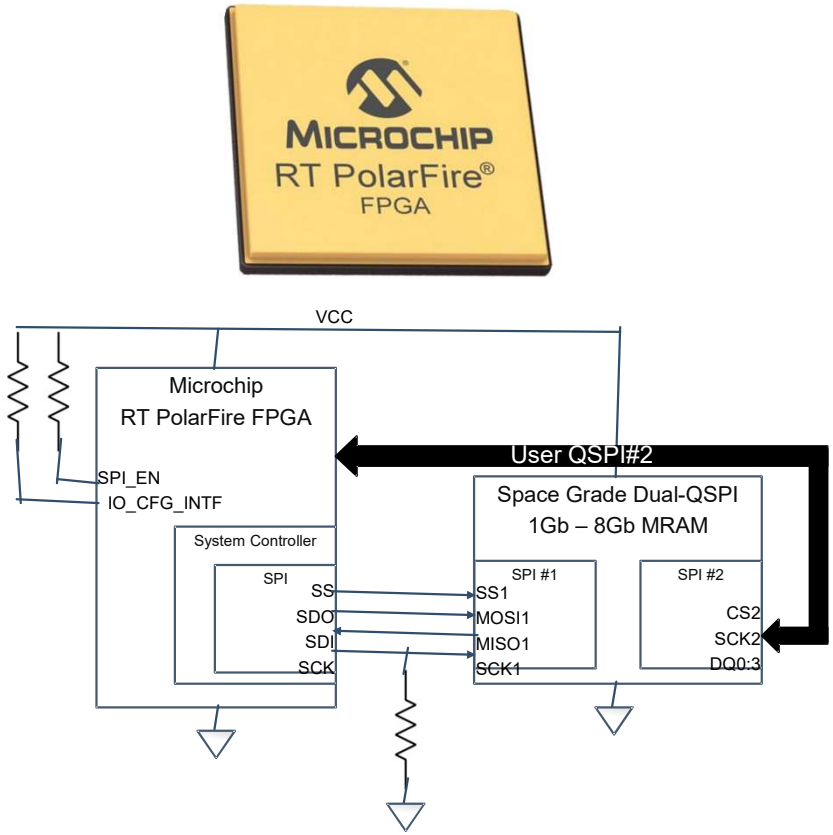
Gen 3 Space Grade Dual QSPI P-SRAM™ Kit for Xilinx

Development Kit:
Download the User Guide
Download the Sample Code
Xilinx/AMD Versal Boot Linux Drivers

Reference Design:
Download the Schematic, Board Layout, Gerber, BOMs

Orderable Part Numbers:
Kit: AK30X208XILCCSOC
Socket: ABGA96-1-20×20

Enabled auto-updating RT PolarFire's on-board Flash



Auto-updating RT PolarFire FPGAs w/MRAM

RT PolarFire use SFDP [Serial Flash Discoverable Parameters]. Part of the JESD216 standard.

Avalanche DQSPI MRAMs do not support SFDP.

However, Avalanche DQSPI MRAMs have successfully auto-updated the RT PolarFire's on-board flash using its extended address register.

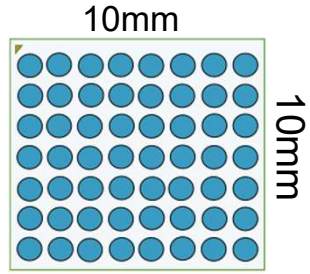
App note will be available in July 2024

Mini-Boot: Low Density Serial (Dual QSPI) – 64Mb and 128Mb Gen3

Dual QSPI
64Mb and 128Mb
Gen3/22nm

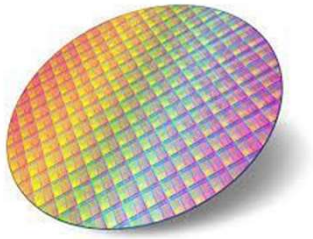
Gen 3 Devices
Sampling 2Q24

64Mb and 128Mb
1.3Mbits/mm² @ 10x10mm



Gen 3 Die Form
Sampling 3Q24

	AV64M	
	X (um)	Y (um)
Die Size (W/O Scribe)	5118.03	3974.04
Scribe (80um)	80	80
Die Size (W/ 80u Scribe)	5198.03	4054.04



Leverages Gen3 Radiation Legacy

Ultra Low Power (~15mA per device, ~7mA per die)

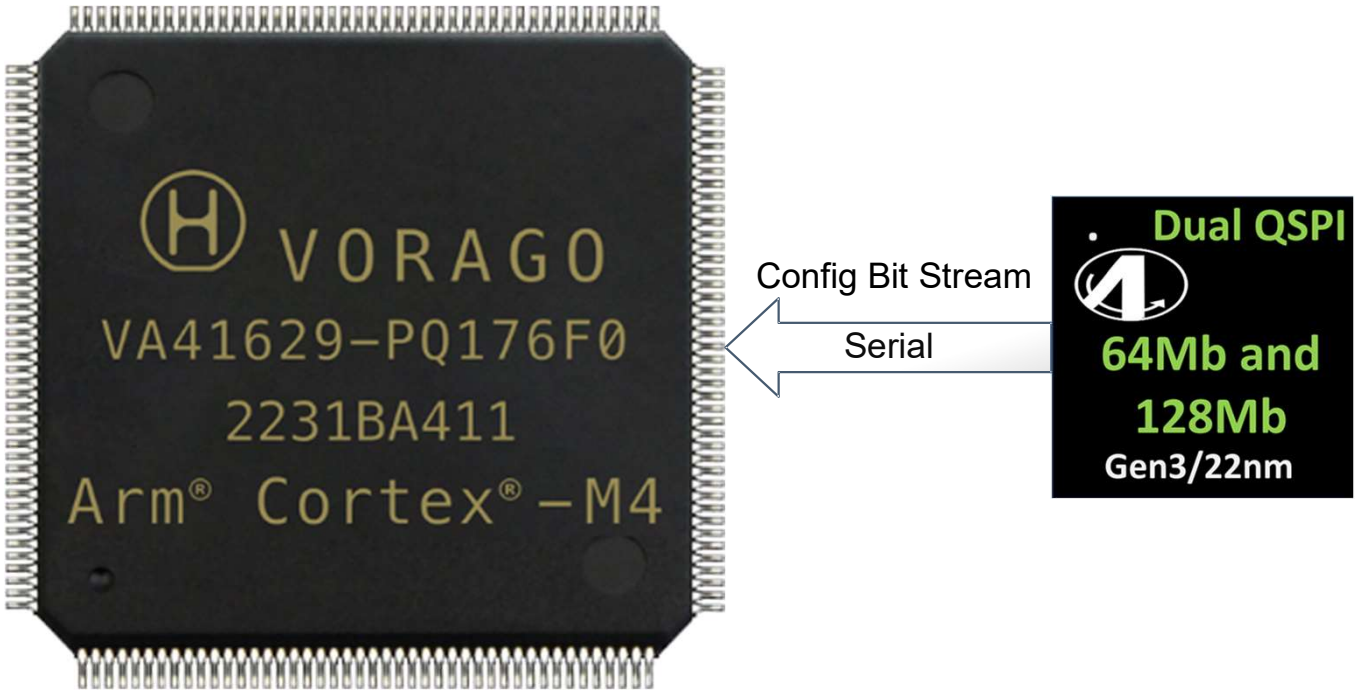
Ideal for Advanced SoC/FPGA boot

Compact images

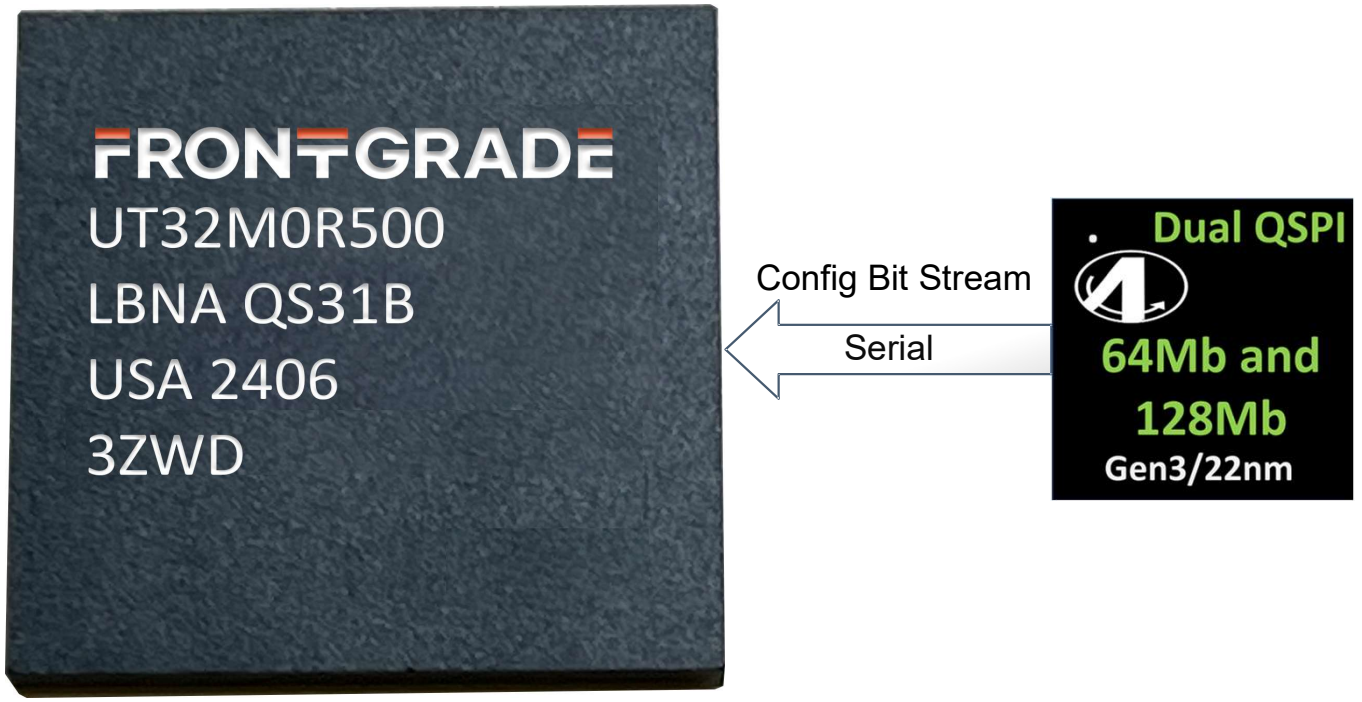
Flexible, but robust write protection schemes

Single or Dual QSPI Interface

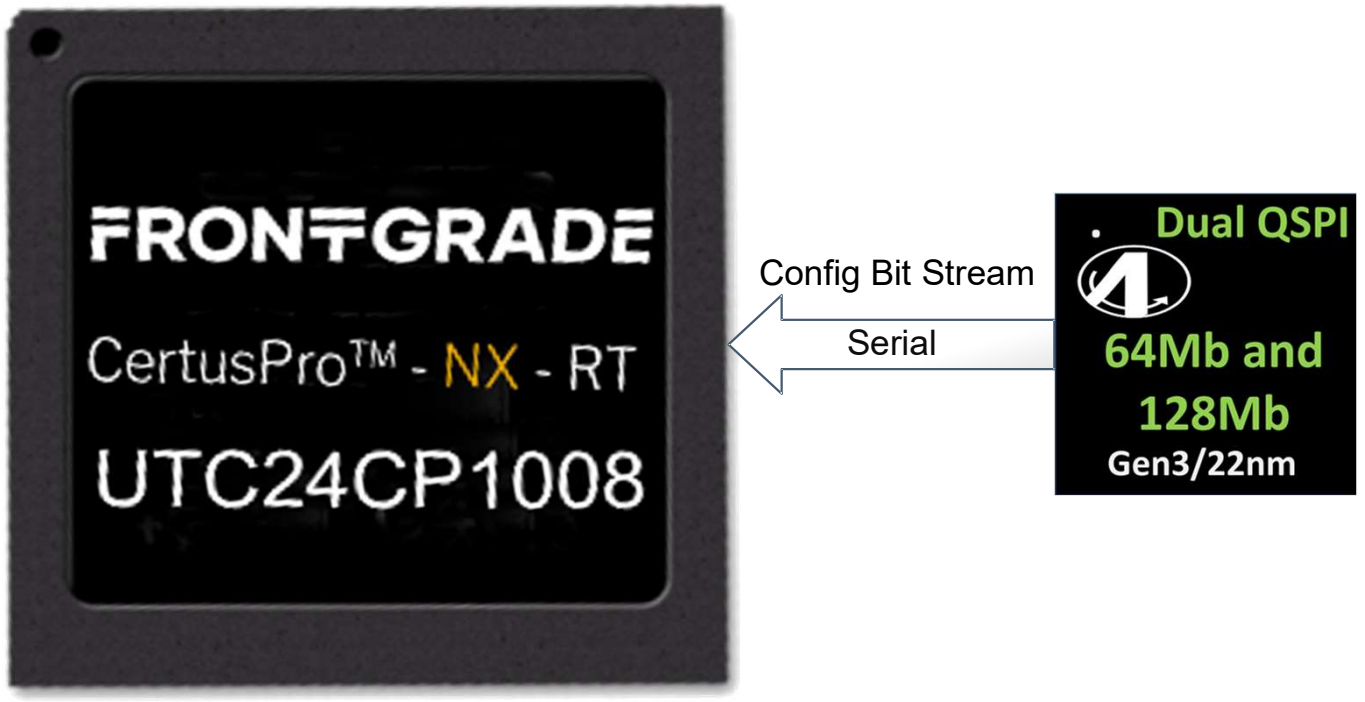
Enabling Booting for Vorago ARM-M4 Series Family SoCs



Enabling Booting for Frontgrade UT32M0R500 SoC



Enabling Booting for Frontgrade/Lattice CertusPro FPGAs



Enabling Booting & Working Memory for Gaisler GR716 LEON3FT Processor

Config Bit Stream

Serial

Dual QSPI

64Mb and 128Mb

Gen3/22nm

OR

Config Data

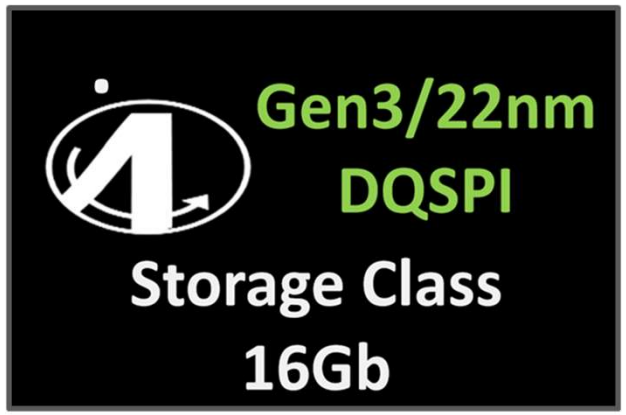
Config & Mem Interface

& Working Mem

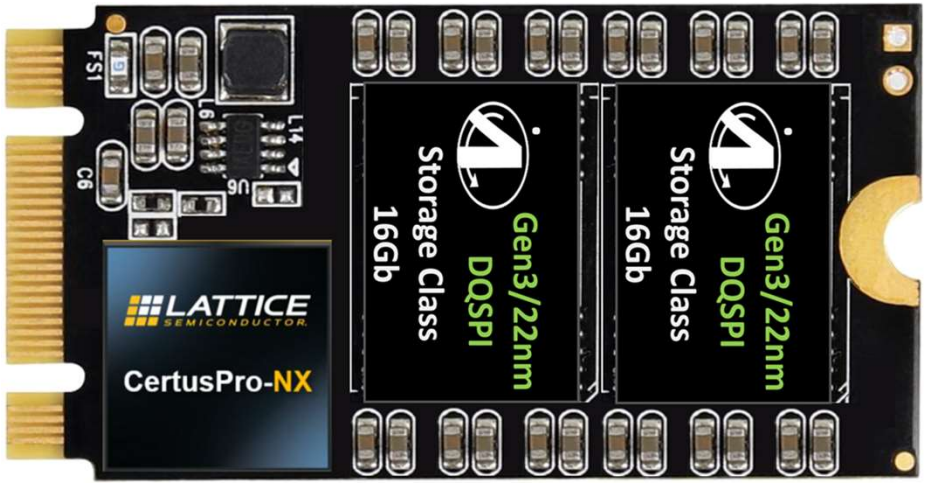
64Mb Die

Enabled Platforms - Storage

Avionics and Space Grade Storage Class Products

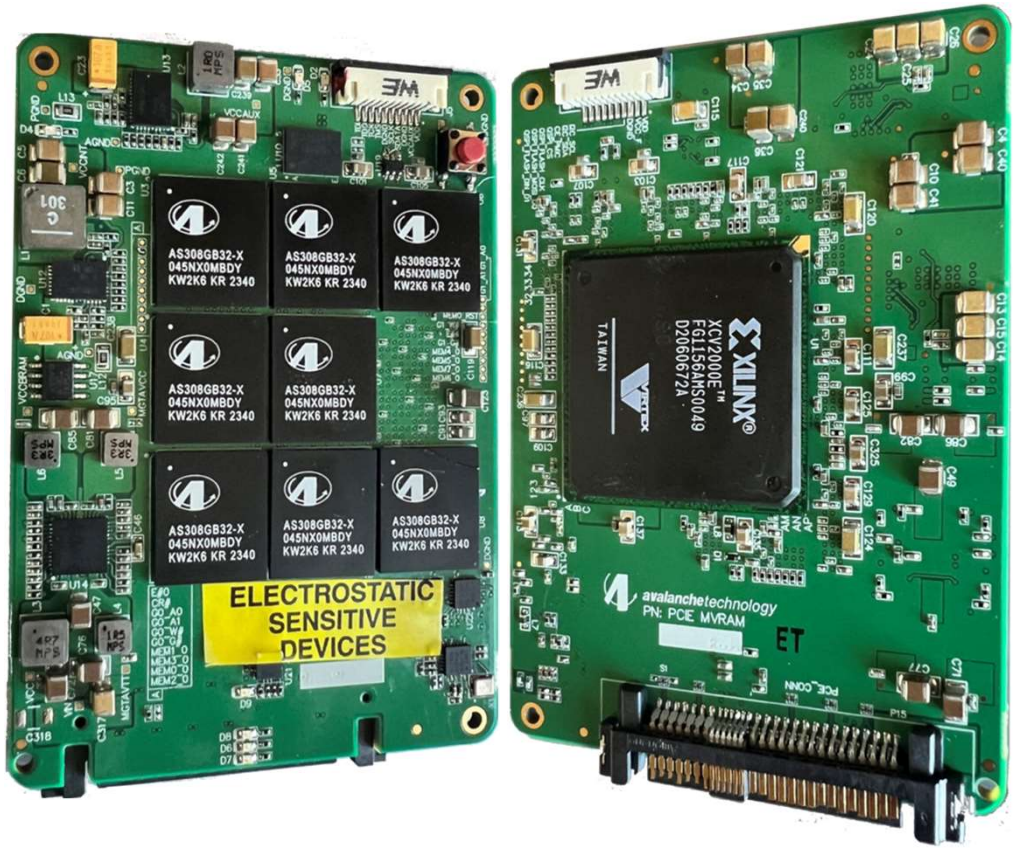


16Gb MRAM Single Chip

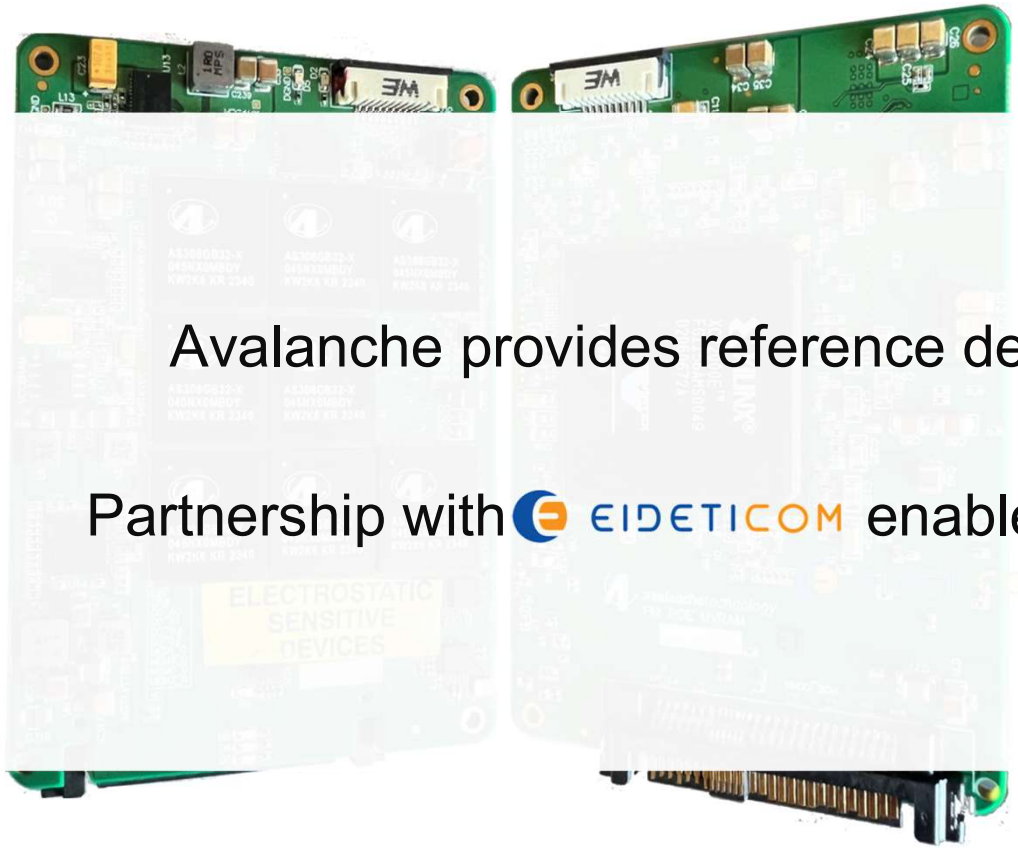


M.2 64Gb (8Gbyte) MRAM Module
EM configuration uses standard M.2 connector
Ruggedized modules use BGA mounting style

Enabling the driver for Storage Solutions in Space



Enabling the driver for Storage Solutions in Space



Avalanche provides reference design with low level drivers

Partnership with EIDETICOM enabled plug and play NVMe stack

BLUEHALO® enabled 8Gbyte MRAM Data Buffer

8GByte All MRAM Data Buffer

Licensed NMVe stack from EIDETICOM

AI Memory: Xilinx KU060 FPGA supports data operations:

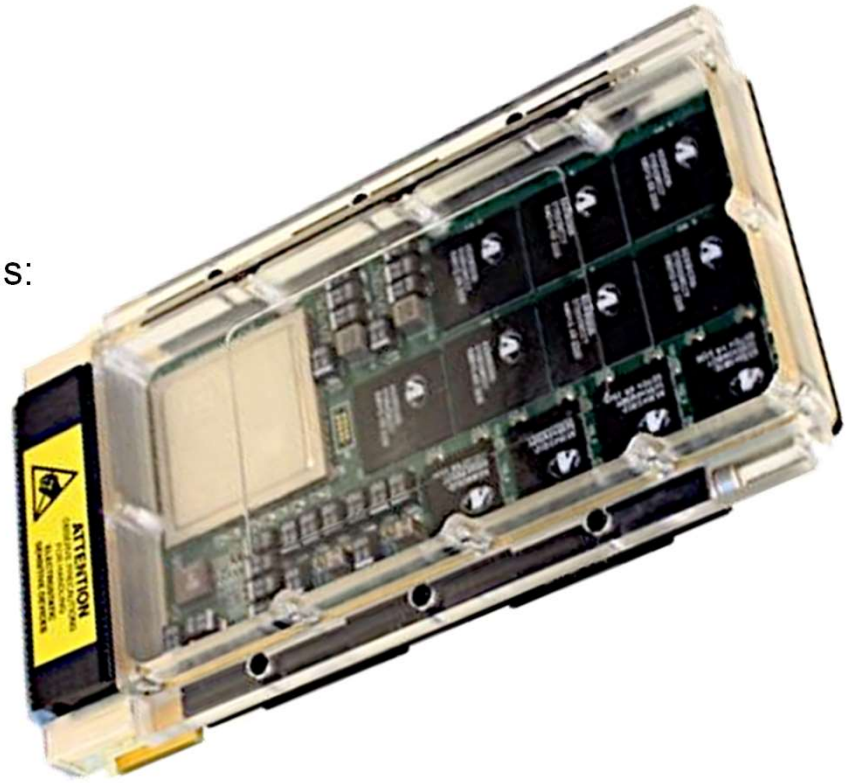
- Compression, Cyber Security, Parameter Extraction, etc.

High performance SSD

10^{16} Write Cycle Endurance

Low power

3U VPX

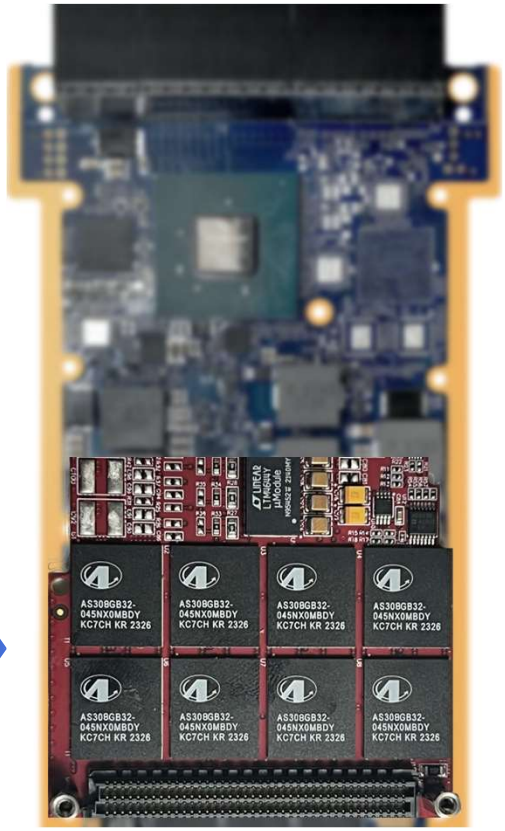


TRUSTED Semiconductor Solutions™

enabled 8Gbyte Customizable Mezzanine Card

3U SpaceVPX Processor Board

MRAM Data Buffer on mezzanine card



MRAM 8GByte Cache daughter card

- Utilizes existing Xilinx Zynq board

Hi-Rel 3U VPX board based on Agilex-5

- Plan to make FMC compatible with MRAM Cache card

Radiation Circumvented 3U VPX board

- TSS developing PDDIC that detects, circumvents, and recovers from a radiation event
- Uses the Agilex-5

mercury enabled Hybrid (MRAM+NAND) SpaceDrives

DATASHEET

In Development

Quadrium 3U VPX Rad-Tolerant, Mini-SpaceDrive
Multi-Host, 350 GBytes NAND, 120 M
3.2 Gbit/s, Parallel, Octal SPI, SpaceF

Models: RH3350NM6S-000I01-01

- Rad-Tolerant non-volatile storage: 350 GBytes NAND plus 12
- Triple-Redundancy for host Data and internal ECC bytes. Four, 8
- Lesser screened, plastic RTG4 FPGA to enable cost sensitive New
- Rad-Tolerant, by design. All components except NAND.
- SpaceVPX compatible, 3U VPX form-factor, single 5V supply
- Lower cost, lower speed, implementation of Mercury's popular
- Multi-Host operation. Up to 6 hosts using Parallel, Octal SPI and

The RMS350 is the first in a series of lower cost, radiation tolerant, NAND storage devices based on Mercury's popular SpaceDrive product. Using the latest generation of TLC NAND in SLC mode, the RH3350 is ideal for implementing high-reliability non-volatile storage in lower-cost applications requiring radiation tolerance.

Space grade reliability is accomplished using Rad-Tolerant, by-design components (except NAND), 3 copies of host and Reed Solomon data. To better enable lower cost NewSpace applications, lesser screened versions of true RT-by-design components are utilized. A full screened ***Premium*** version is available by special order.

The RMS350 replaces the cumbersome NAND flash command set and interface with flexible Parallel, SPI and SpaceFibre interfaces. Interfaces can be used together allowing multi-host operation. The full storage capacity is accessible by up to 6 hosts. Commands issued by interfaces are serviced based on bus ownership. Numerous status registers allow monitoring product health including PE counts, Retired Blocks, Spare Blocks, ECC errors and

mercury

DATASHEET

In Development

Quadrium Rad-Tolerant, Triple Redundant, Mini-S
Multi-host, 350 GBytes NAND, 120 MBytes MRAM
3.2 Gbit/s, 120 pin Quad Plastic Package

Models: RMS350NM6S-000I01-01

- Rad-Tolerant non-volatile storage: 350 GBytes NAND plus 120 MBytes of MRAM
- Triple-Redundancy for Data and ECC bytes. Four, 8-bit, ECC corrections every 16 bytes of
- Lesser screened RTG4 FPGA to better enable cost sensitive NewSpace applications
- Rad-Tolerant, by design. All components except NAND.
- Compact solder down form-factor, single 5V supply
- Lower cost implementation of Mercury's popular SpaceDrive product
- Multi-Host operation. Up to 6 hosts using Parallel, Octal SPI, SpaceFibre interfaces

The RMS350 is the first in a series of small form-factor radiation tolerant NAND storage devices based on Mercury's popular SpaceDrive (SSDR) product and packaged in a solder-down form-factor. Using the Micron B27C TLC NAND device in SLC mode, the RMS350 is ideal for implementing high-reliability non-volatile storage in lower-cost applications that require radiation tolerance.

Space grade reliability is accomplished using Rad-Tolerant, by-design, components (except NAND), and 3 copies of host and Reed Solomon data. To better enable lower cost NewSpace applications, lesser screened versions of true RT-by-design components are utilized. A full screened Premium version is available by special order.

The RMS350 replaces the cumbersome NAND command set and interface with flexible Parallel, Octal SPI, and SpaceFibre interfaces. Interfaces can be used together allowing multi-host operation. The full storage capacity is accessible by up to 6 hosts. Commands issued by interfaces are serviced based by bus ownership and order received. Numerous status registers allow monitoring product health including PE counts, Retired Blocks, Spare Blocks, ECC errors and more. The RMS350 implements a deterministic, corruption-free shutdown process with an optional external capacitor to supply a

- NAND/MRAM SEE mitiga
  - Optional power cycle p
  - Physical X,Y placemer
- Data reliability:
  - Triple redundant Host
  - Four 8-bit corrections
  - Automatic retirement
  - PE cycle tracking for a
- Performance (up to 400
  - One 32-bit parallel in
  - Two 16-bit parallel in
  - Four 8-bit parallel int
  - Octal SPI interface
  - SpaceFiber interface:
- NAND endurance:
  - Minimum 60,000 dri
  - Total Bytes Written
  - Up to 32 full drive ov
  - 1-month retention at
  - Host capacity is cons

mercury

DATASHEET

CONCEPT

Rad-Tolerant 6U VPX 100 Gbit/s Quad-Host SpaceDrive
Host Capacity of 22 TB NAND plus 400 MBytes MRAM
PCIe and mFAST interface options

Models:
RH622TNM6S-000I22-01 (22 TB EDU), RH622TNM6S-000I22-02 (22 TB Flight unit)

- Radiation-tolerant storage for space and commercial applications with potential for radiation exposure
- 22 TB using 3D TLC NAND in SLC mode (60K PE cycles)
- 400 Mbytes of general purpose MRAM (100 MB/s)
- 6U VITA 78, 220mm (SpaceVPX compatible) form-factor
- Rad-Tolerant components
- Single 5V supply

The RH622T is the second product in the Mercury's ***SpaceMax*** series of radiation tolerant SpaceDrives. Designed to maximize both performance and capacity, the RH622T supports a raw data rate of 160 Gbps and a sustained host data throughput of 100 Gbits/s. This represents a 5.5X improvement in performance and a 4.8X increase in capacity compared to the Boron 4.5TB SpaceDrive.

Like all members of the ***SpaceMax*** series, the RH622T utilizes the latest generation of 3D TLC NAND running in SLC mode. Host capacity remains constant across the entire life through use of very strong error correction and more than 16% of additional capacity dedicated to spare blocks.

To keep power consumption low, the RH622T utilizes multiple low power PolarFire FPGAs operating in parallel. Each PolarFire manages 25% of the capacity using four 10-Gbps SERDES Lanes per PolarFire. A single host can control the entire capacity, or four hosts can each control 25% of the capacity independent from the other 75% of the capacity.

Designed for fault-tolerance with multiple failed NAND devices, the RH622T SpaceDrive is the world's fastest and most reliable nonvolatile VPX storage device and is ideal for applications where full-time availability and high reliability are requirements.

- Radiation-tolerant design details:
  - NAND: Micron B27C die, PEM. TID >30 krad. Screened to EEE-INST-002
  - MRAM: Avalanche Gen3. 100 krad TID, SEE > LET 45 MeV.cm2/mg
  - PolarFire NAND Controller
    - TMR of critical logic. 1.2V IOs for best SEL tolerance.
    - Total ionizing dose (TID) > 100 krad
    - Configuration upsets immunity to LET > 80 MeV.cm2/mg
    - Single-event latch-up (SEL) immunity to LET > 80 MeV.cm²/mg
    - Registers SEU rate <10-12 errors/bit-day (GEO Solar Min)
    - SET upset rate < 10-8 errors/bit-day (GEO Solar Min)
  - All other devices: Radiation Tolerant, by design, to >100K rad
- VPX connectors:
  - Guide block key is adjustable and ships in the 0° position
  - Smith's KVPX Series: 500 mate/unmated cycles
  - TE connectivity MultiGig RT 2-R Series: 500 mate/unmated cycles
- Operating modes: Linear and Host Addressable
  - Linear Mode: Sequential data recording (Data recorder mode)
  - Host Addressable mode: operations on individual NAND blocks
  - Random SuperPage read operations: Both modes.
  - SuperPage size: 294,912 (per Port), 1,179,648 (4-Port mode)
  - SuperBlock size: 339,738,624 (per Port), 1,358,954,496 (4-Port mode)
  - UltraBlock size: 5,435,817,984 (per Port), 21,743,271,936 (4-Port mode). 1024 UltraBlocks

Enabled Platforms - Board & Device

Advanced Boot Solutions Enabling SW-Defined Platforms

Avalanche Technology Announces Support for NASA PEMS Qualification and Screening

In response to unprecedented demand for extended quali
compatible NASA PEMS options for enabling Dual QSPI M

FREMONT, CA, April 8, 2024 — Avalanche Technology, the leader in next generation MRAM technology, announced today the launch of a new product derivative to address the growing demand from the aerospace and defense community for extended qualification and screening solutions, particularly NASA PEMS INST-0001.

Leveraging Avalanche's Gen 3 Space Grade MRAM products being broadly adopted by the defense industrial base and commercial space customers, the new pin compatible PEMS qualified and screened versions of the popular Dual QSPI MRAMs will roll out mid-year.

Avalanche Technology Selected to Support Mercury's First Space-Qu
Processing Board Using AMD's Xilinx Versal AI Core

mercury systems™

oducts to build the next family of SWaP optimize

FREMONT, Calif., Nov. 8, 2023 /PRNewswire-PRWeb/ — Avalanche Technology, the leader in next generation MRAM technology, announced today that its Persistent-SRAM (P-SRAM) products were by Mercury Systems for the new SCFE6933, a next-generation processor board that will enable fa processing of data in orbit. The high-density 8Gb DQSPI Space Grade Persistent SRAM with furthe scalability is the ideal companion to the AMD (Xilinx) Versal Adaptive SoC platform that is feature platform.

Enabled Platforms – AI/Processing in Space

BLUEHALO® enabled 8Gbyte MRAM Data Buffer

8GByte All MRAM Data Buffer

Licensed NMVe stack from EIDETICOM

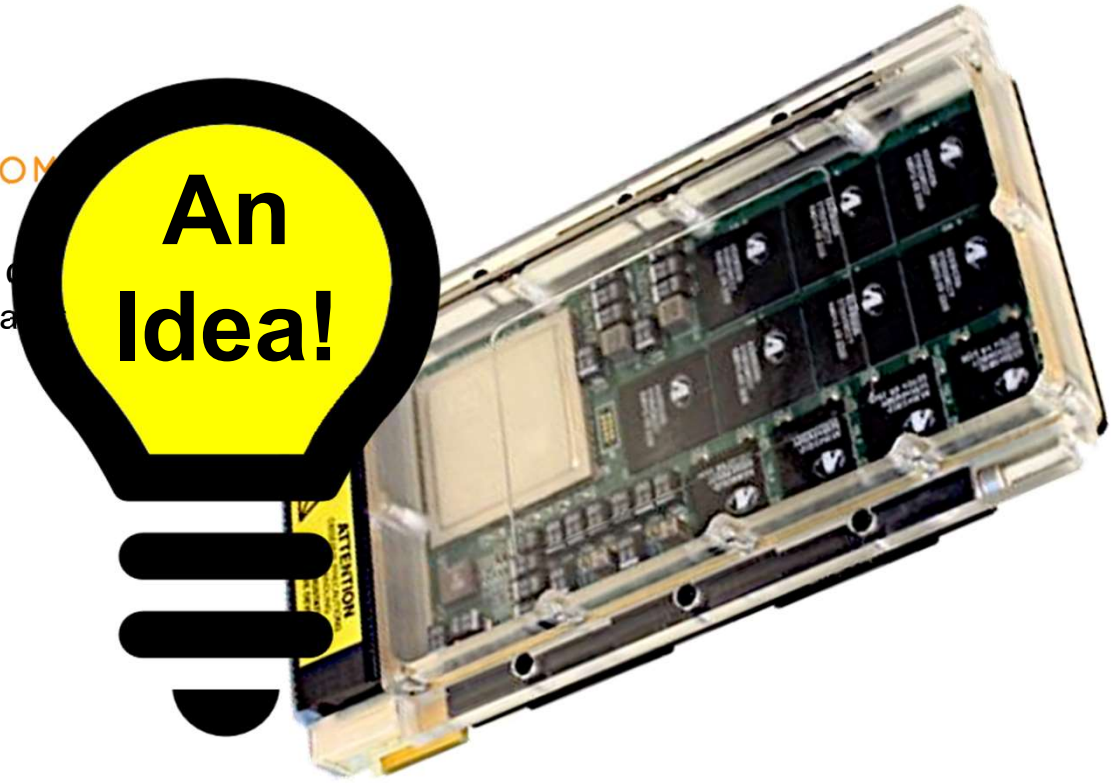
AI Memory: Xilinx KU060 FPGA supports c
- Compression, Cyber Security, Parameter Extra

High performance SSD

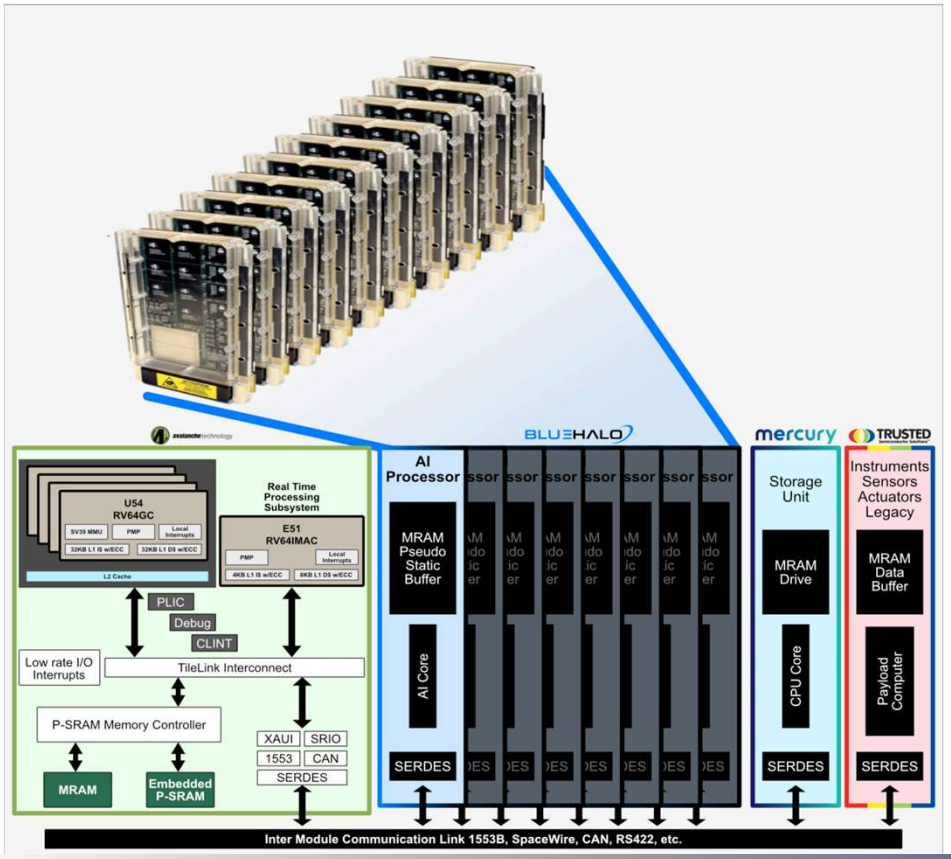
10^{16} Write Cycle Endurance

Low power

3U VPX



BLUEHALO® enabled Big Data Processing in Space



- Infinite write endurance allows in-place processing
- Data is pseudo-static
- Program algorithm cyclically changes to perform different stages of processing
- Move the program, not the data

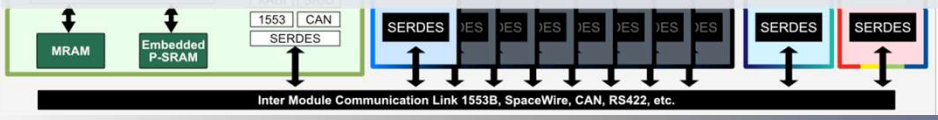
BLUEHALO® enabled Big Data Processing in Space

By utilizing a KU060 FPGA and MRAM

Processing Node can be deployed within *months* to

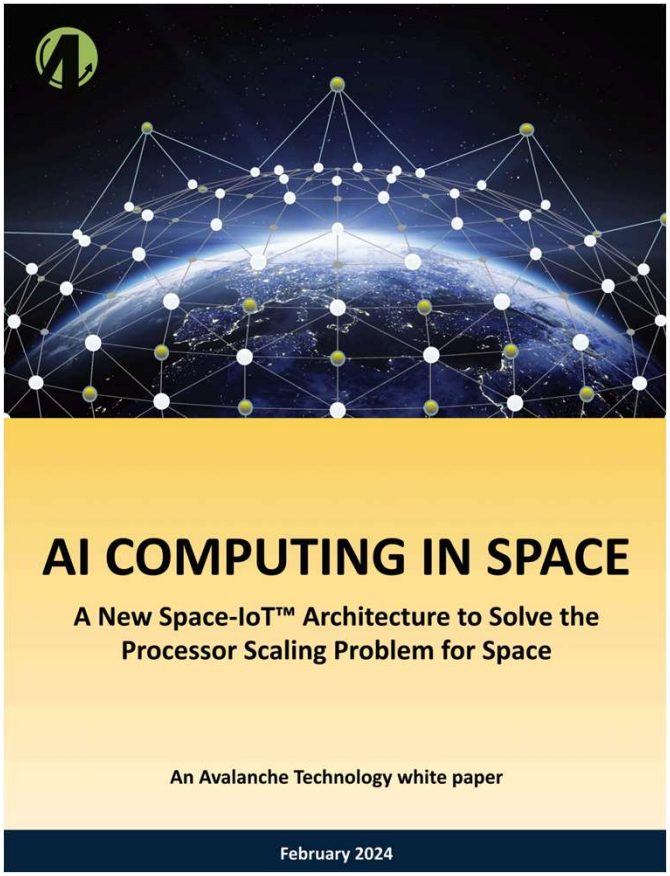
gather multiple cycles of learning

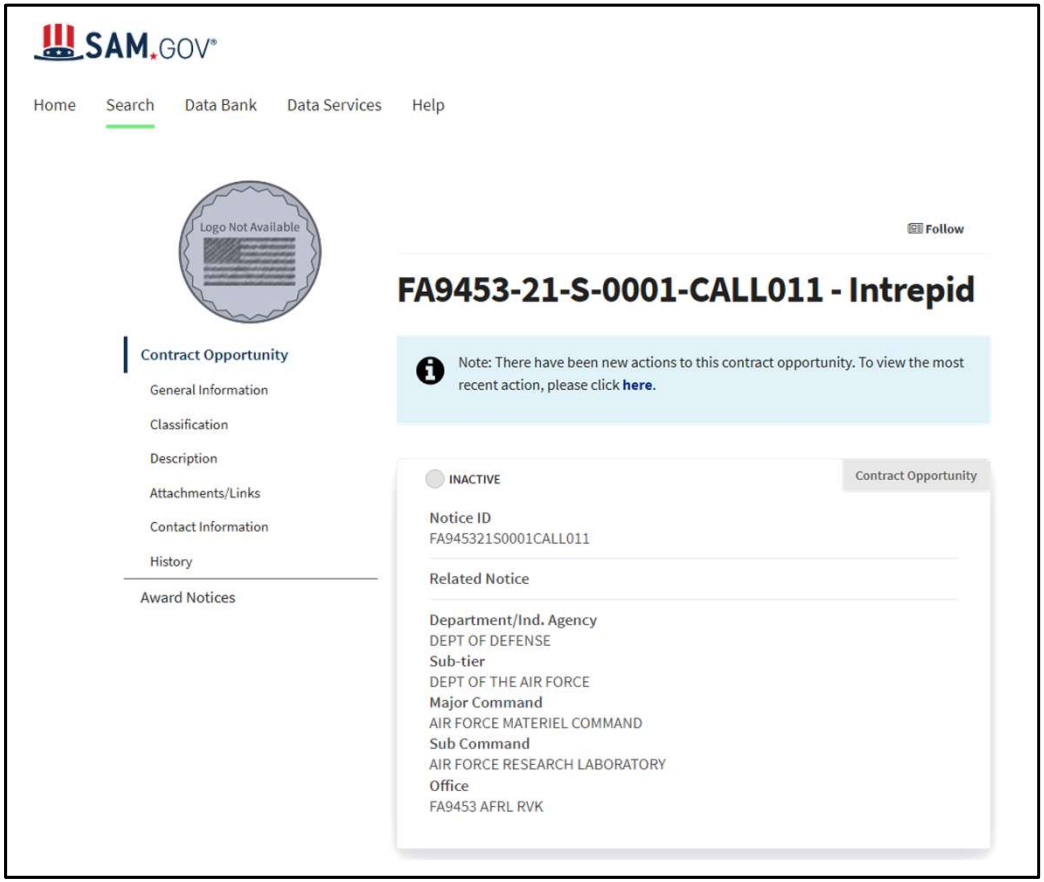
without waiting for final ASIC development



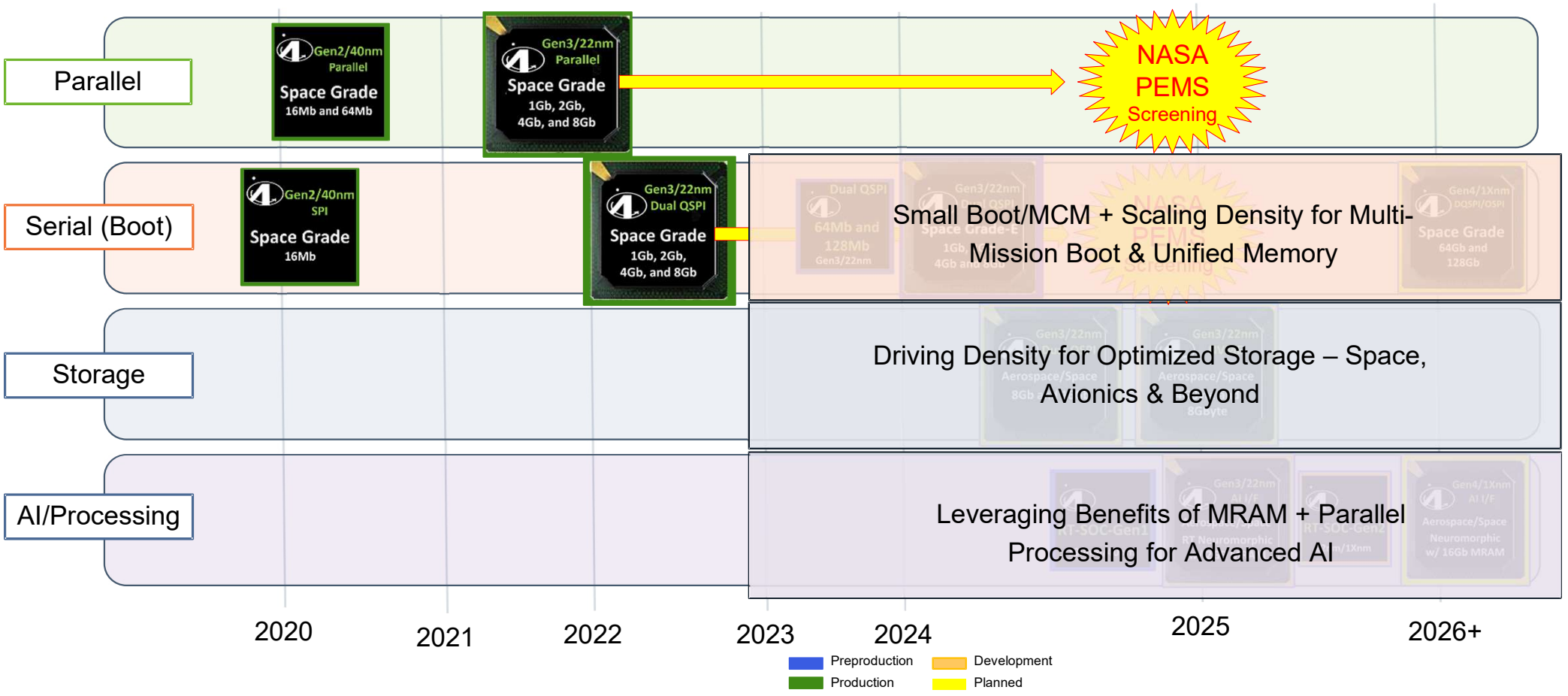
- Move the program, not the data

“AI white paper” + “AFRL – Intrepid Call” ➔ New Roadmap Vector

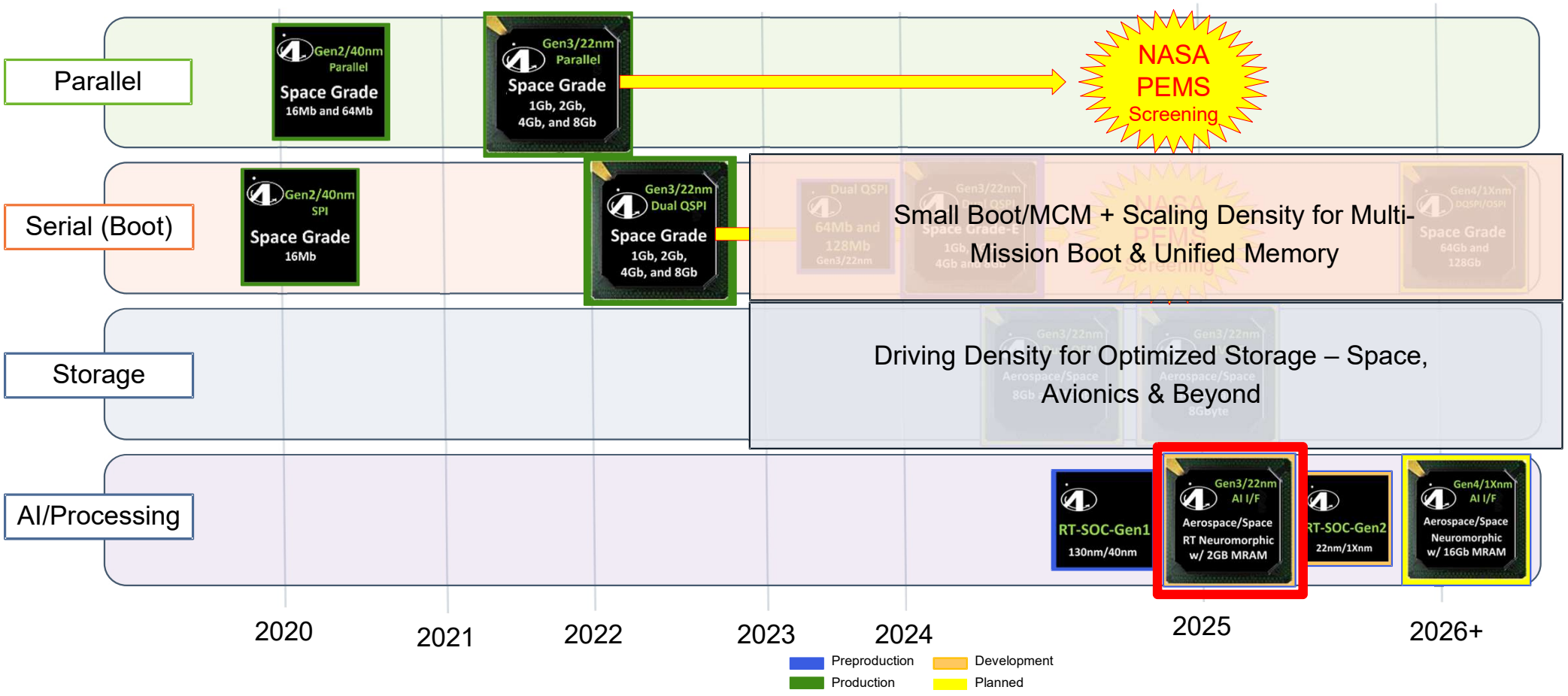




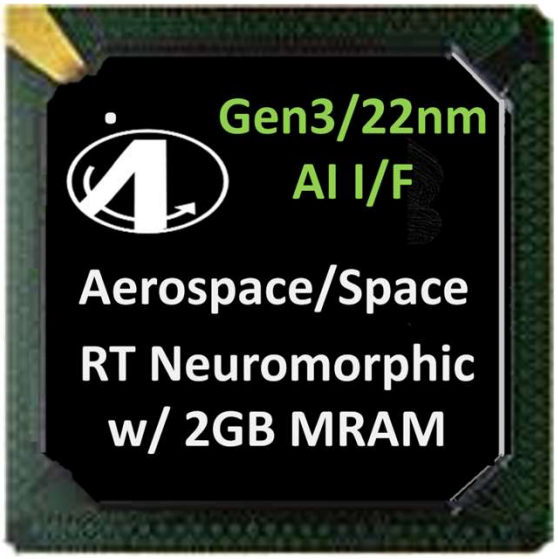
Avalanche MRAM/Processing Product Roadmap

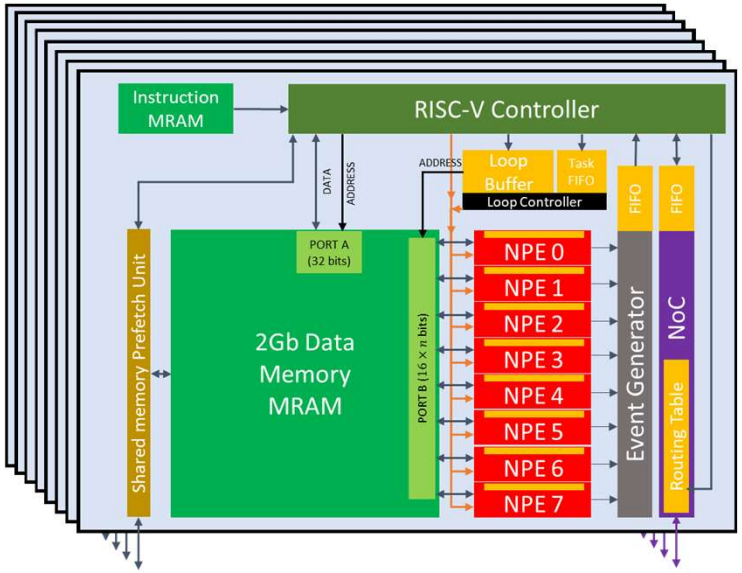


Avalanche MRAM/Processing Product Roadmap



Introducing the Avalanche Rad Tolerant Neuromorphic AI processor w/ MRAM





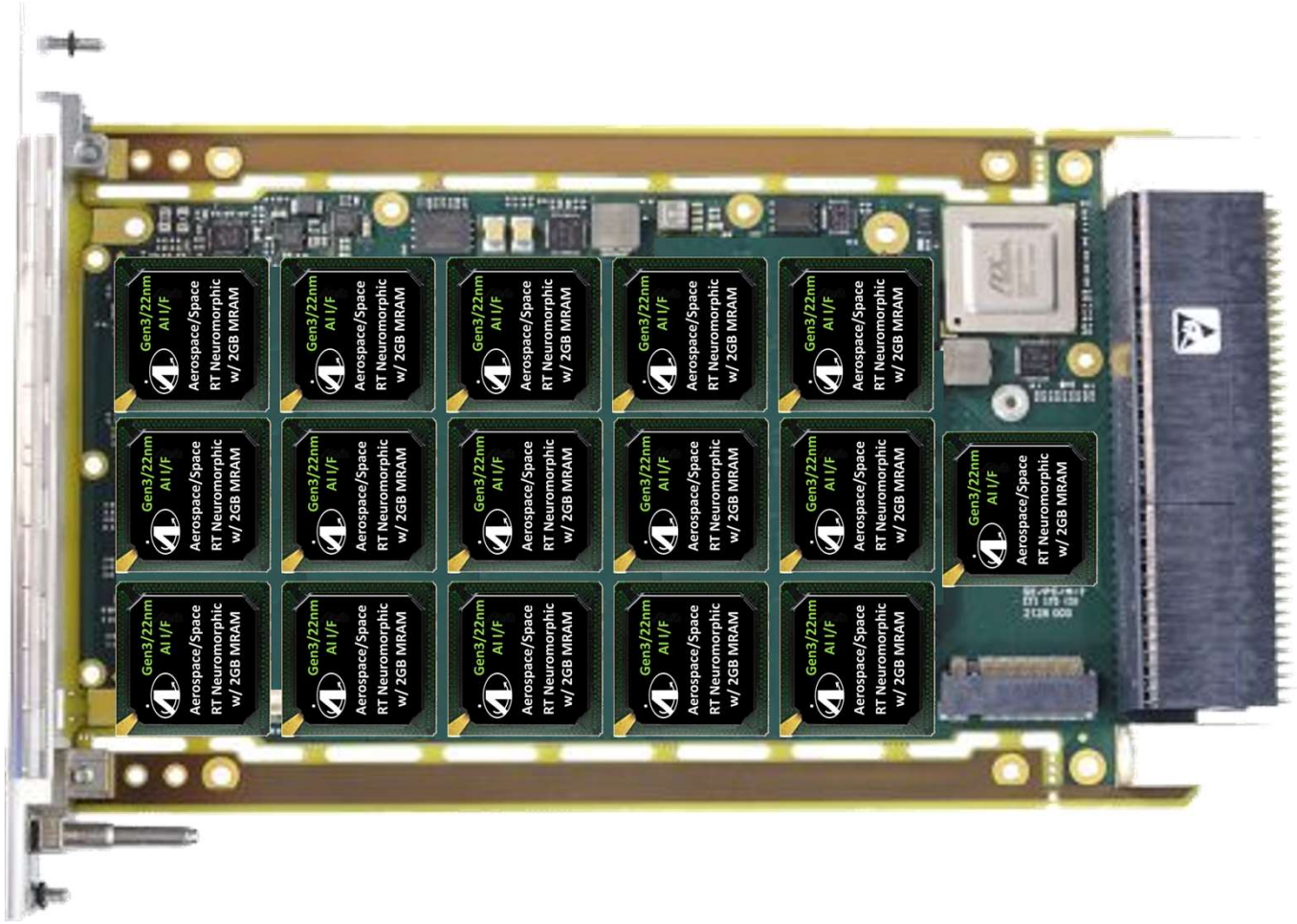
8 Dies/Package

Lowest Power Radiation-Tolerant AI/MRAM Device

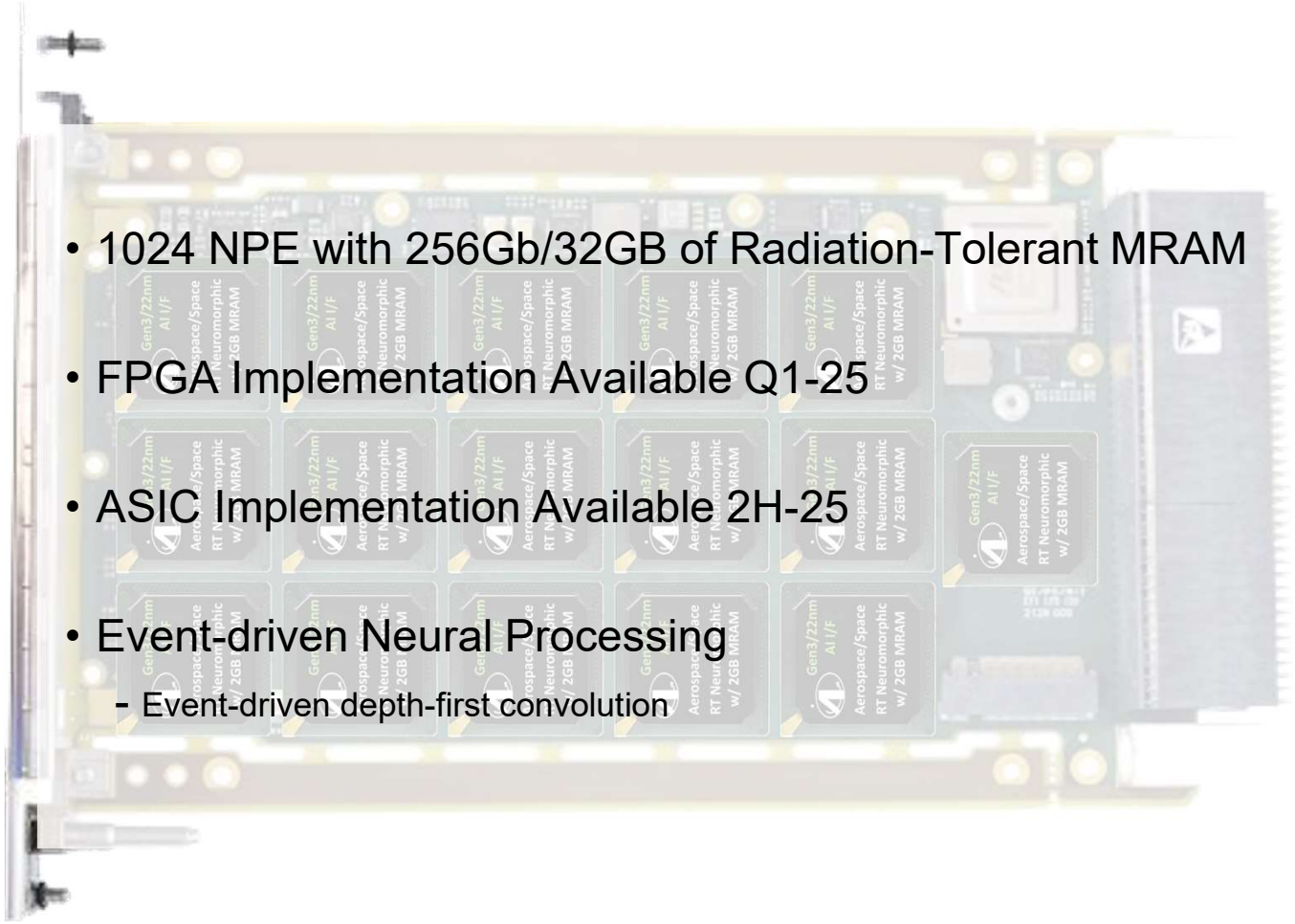
64 NPE and 16 Gb Radiation-Tolerant MRAM per Device

Uses Open-Source Software Tool Chain

Avalanche Neuromorphic MRAM processor Reference Design

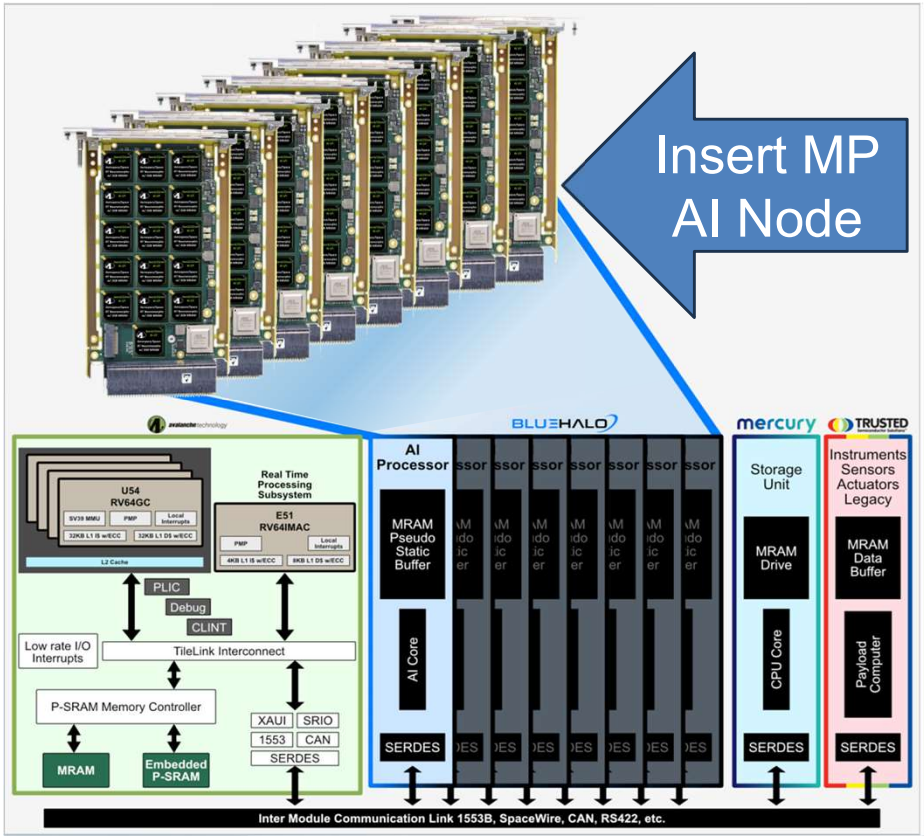


Avalanche Neuromorphic MRAM processor Reference Design



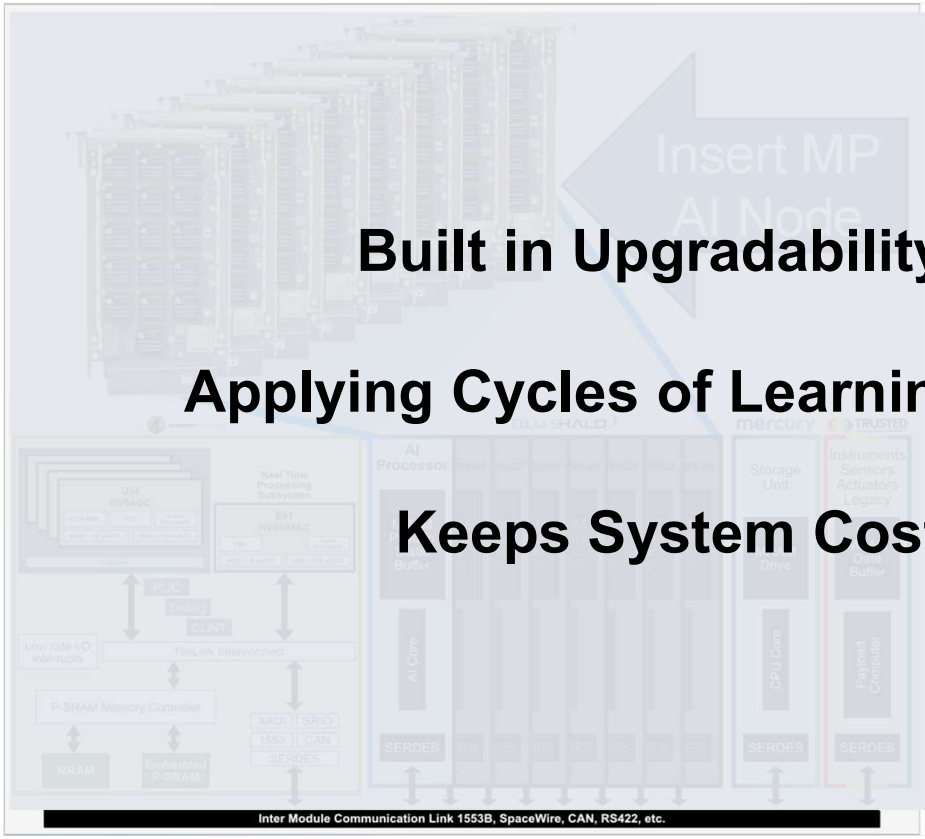
- 1024 NPE with 256Gb/32GB of Radiation-Tolerant MRAM
- FPGA Implementation Available Q1-25
- ASIC Implementation Available 2H-25
- Event-driven Neural Processing
  - Event-driven depth-first convolution

BLUEHALO® 's Modular Architecture Enables Rapid Tech Refresh



- Increased Processing Bandwidth
- Improved TOPS/Watt
- Inherent System Reusability
- Cost Effective Deployments

BLUEHALO® 's Modular Architecture Enables Rapid Tech Refresh



Built in Upgradability for Rapid Tech Refresh,

Applying Cycles of Learning & Technology Improvements

Keeps System Cost Effective and Relevant

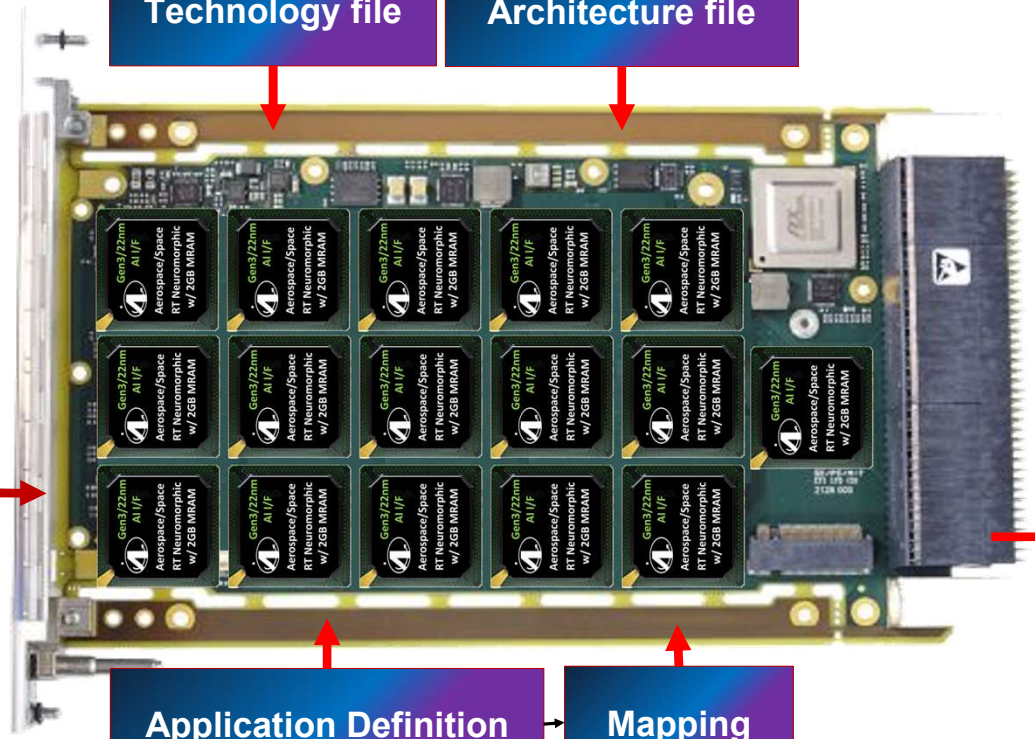
- Increased Processing Bandwidth
- Improved TOPS/Watt
- Inherent System Reusability
- Cost Effective Deployments

Avalanche Neuromorphic MRAM Processor Application Example

Temporal Input events

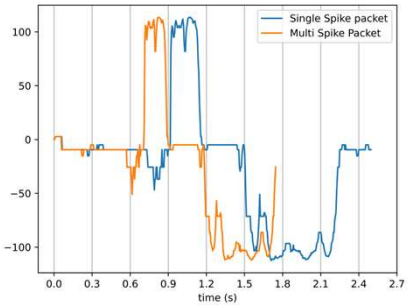
Technology file

Architecture file



Application Definition

Mapping



Temporal Output events

Resources

Support Resources @ www.avalanche-technology.com

1 - Datasheets, models, reference designs
- Boot module: Petalinux drivers, User Guide (Versal boot)
- Gen 3 reference designs
- IBIS & Verilog models

2 - Radiation test reports
- Gen 2 test report accessed via website (NASA)
- Gen 3 reports available by request

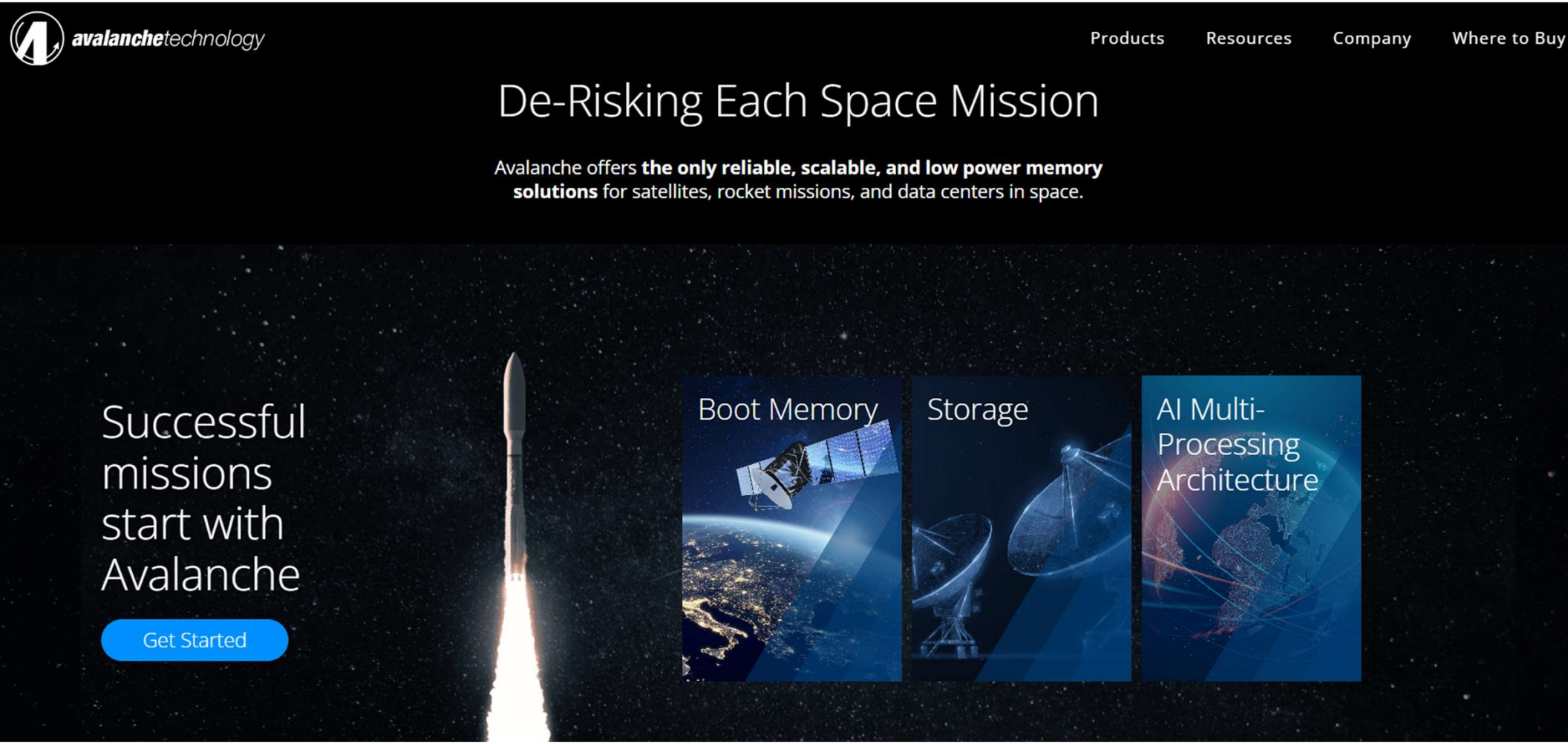
3 - Visionary White Papers
- Innovation enabled by Avalanche
- Data Centers in Space…
- …why the key to satellite scalability and resilience
- NEW: AI Computing in Space

6 - Newsletters
- Quarterly, register on main page

5 - Brochures
- Overall MRAM tech for hi-rel apps
- Space Grade products

4 - Space-centric Blogs
- Datacenter in Space series
- Why our MRAM is ideal for space

Avalanche – Enabling the Orbital Internet



Thank You!

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