High-Performance 64-bit HPSC Microprocessor (MPU) New Era of Autonomous Space Computing

Nicolas GANRY

Senior Product Marketing Manager

Microchip Technology Nantes

RISC-V in Space, Wednesday 2nd April 2025

SMART | CONNECTED | SECURE

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Microchip In A&D By The Numbers

60+ Years

of Space Innovation & Heritage

- **NASA:** Atlas ('57), ISS, Cassini, Rover
- **ESA:** ATV, Gaia
- **Commercial:** Globalstar 2, OneWeb, SpaceX
- **Mil:** F-35, F-16, AIM9X, Hellfire, Bradley
- **Aero:** Boeing, Airbus, Bombardier

>40,000

Space Flight Qualified Microchip Processors Shipped

#1

Market Share - A&D Semi

$839M Annual A&D Revenue (FY24)

>1000

A&D Customers WW

>71,000

Hi-Rel Products For A&D Market

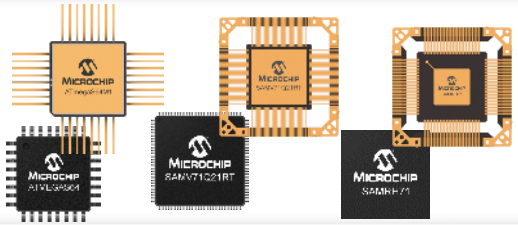
>100

Microchip components on NASA Perseverance Rover & Ingenuity Helicopter

Largest Space Semiconductors Portfolio

MPUs and MCUs

8-bit AVR®
32-bit SPARC V8 and Arm® M3 & M7
GNSS SoC

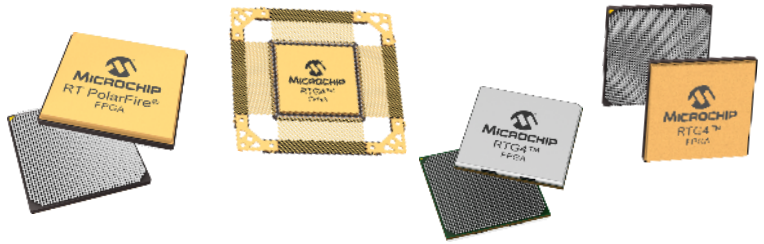


Communication Interface and Memory

SpaceWire, Ethernet, CAN
SRAM
NVM memories

FPGAs

RT PolarFire®
RTG4™
RT ProASIC3®
RTAX™, RTSX-SU

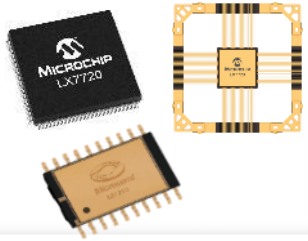


Power Solutions

Rad-hard JANS Diodes, Bi-Polar Small Signal Transistors
Rad-hard Isolated DC-DC Converter Modules
Custom Power Supplies 2W to > 5 kW
Point of Load Hybrid Solutions
Electromechanical Relays

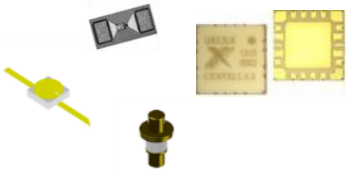
Mixed Signal Integrated Circuits

Telemetry and Motor Control Space System Managers
Power Supply Protection



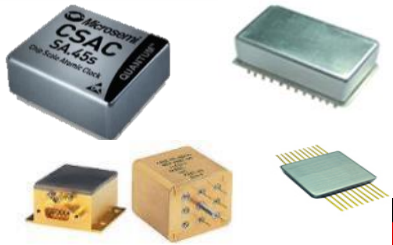
RF Products

Packaged and Chip Si and GaAs RF Diodes
SAW Filters
Packaged and Bare Die GaN and GaAs MMICs
GaN on SiC HEMT transistors



Timing Solutions and Oscillators

Ovenized Quartz Oscillators
Hybrid Voltage Controlled
Temperature Compensated Crystal Oscillators
Cesium Clocks
Chip-Scale Atomic Clock (CSAC)

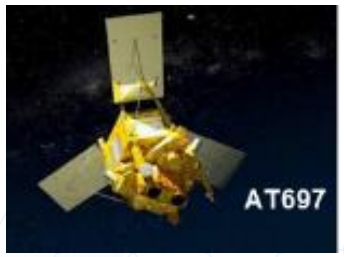


Processing: An Unrivalled Flight Heritage

Colombus
2008

Proba2
2009

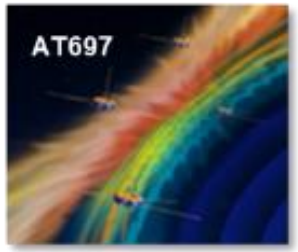
JUNO (Nasa)
2011



SPOT6
2012

Sentinels &
Alphasat
2013

SVOM/Eclair
2013



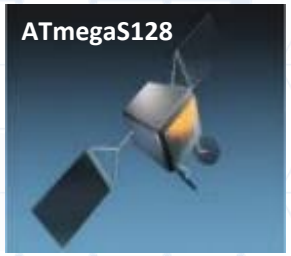
MMS (Nasa)
2014

Exomars
2016

Solar Obiter
2017

Bepi-Colombo
2018

Perseverance 2021



Mega Constellation
LEO Sat -2019

ASBM 2024

IRIDE 2025

Thousands of flight models
delivered worldwide

Capella Sequoia
Earth Obs 2020

ANGELS Nanosat
2020

MICROCHIP

Space Computing Demands a Gamechanger

Face to New Space Challenges

Space Agencies

Need for advanced computing

- Autonomous Missions
- Advanced Sensors
- Moon to Mars
- Growing Threat
- Faster Dev Cycles

More Compute & AI

More I/O Bandwidth & Efficient Data Transfer

Rad-Hard & Fault Tolerance

Cybersecurity

Adopt Industry Standards and Open Technology

Commercial Space

Follow the trend of terrestrial computing

- Intelligent Edge
- Secure Compute
- RISC-V® ISA

Microchip's Response To Delivering on the Enabling Capabilities: *PIC64-HPSC*

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HPSC: Game Changing Space Compute Solution

20th Century	2000s	2010s	2025
Pre VLSI	**32-bit Single-Core**	**32-bit Multi-Core**	**64-bit Multi-Core**
Custom ISAs	SPARC & PowerPC		**RISC-V**

Discrete TTL chips
"Building out gates of a CPU"
<<1 MIPS

Scalar Processors

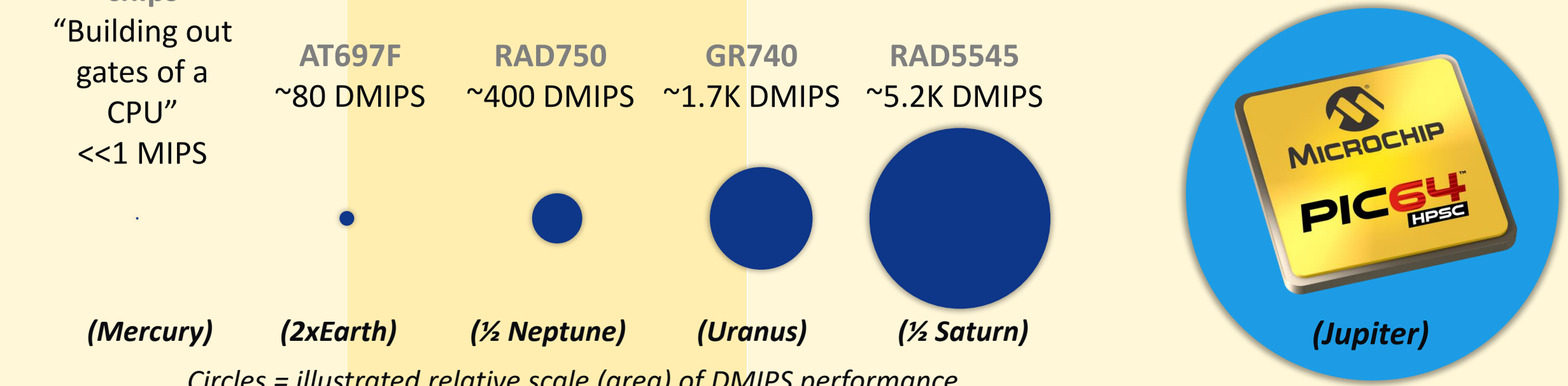
AT697F
~80 DMIPS

RAD750
~400 DMIPS

GR740
~1.7K DMIPS

RAD5545
~5.2K DMIPS

PIC64-HPSC
26K DMIPS, 2 TOP/s, 256 GFLOP/s



(Mercury) ***(2xEarth)*** ***(½ Neptune)*** ***(Uranus)*** ***(½ Saturn)*** ***(Jupiter)***

Circles = illustrated relative scale (area) of DMIPS performance

Sources: CPUshack.com, BAE, Frontgrade, ESA, University of Pittsburgh

MICROCHIP

HPSC – Enabling the Next-Generation of Spaceflight

Microchip was awarded a contract by **NASA JPL** to develop the next-generation **High-Performance Spaceflight Computing (HPSC)** processor

Canada
Architecture, Design, Test Management

France
Radiation, Qual, Manufacturing

USA
Foundry, IP, NASA/JPL Sponsorship

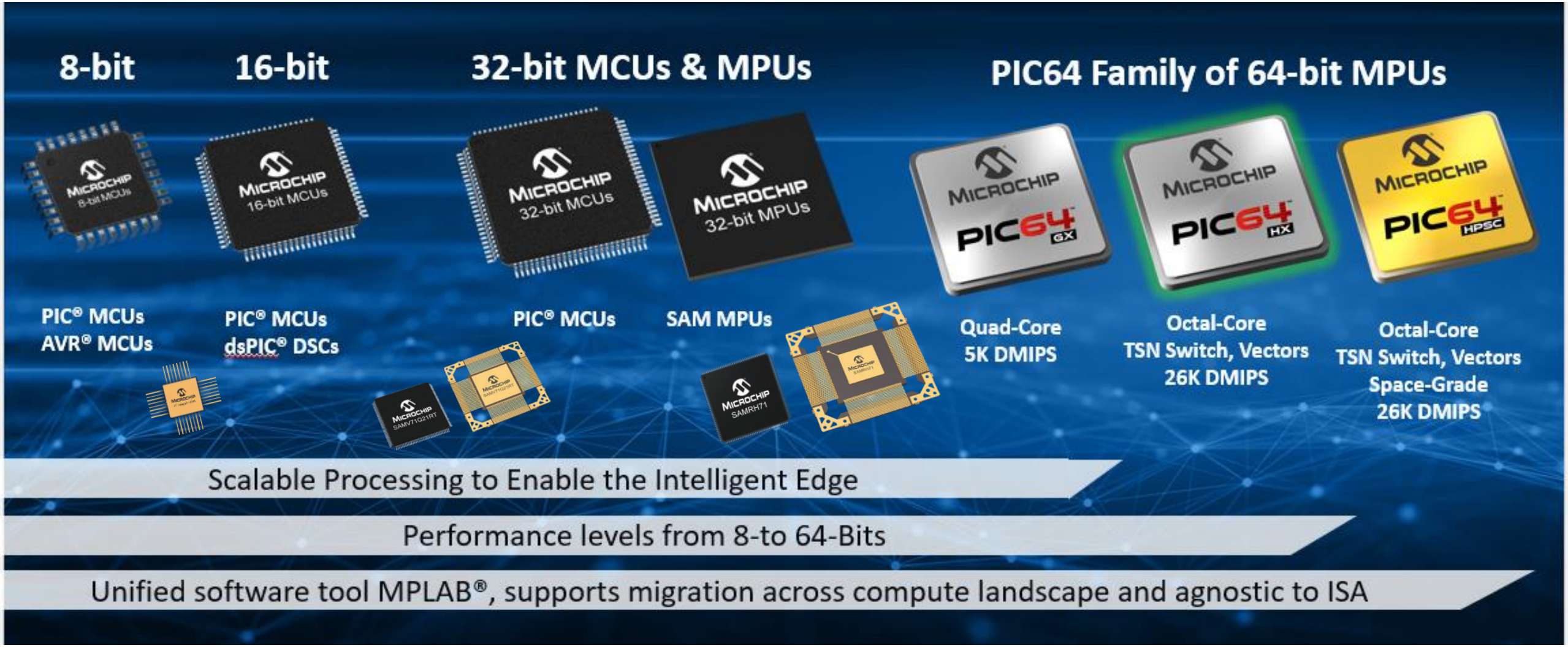
EU
IP

- **High Performance 64-bit Computing**
  - Up to 26k DMIPs
  - Virtualization
  - Artificial Intelligence
- **TSN Ethernet Integration**
  - 240G TSN Ethernet Switch
  - Comprehensive TSN Feature Set
  - Up to 20 ports with speeds from 10M to 10 Gbps
- **Exceptional Fault-Tolerance**
- **Defense-Grade Security**
- **Radiation-Hardened and Radiation-Tolerant**

Industry's Highest Performance Processor for Space → EM Devices Q3 2025

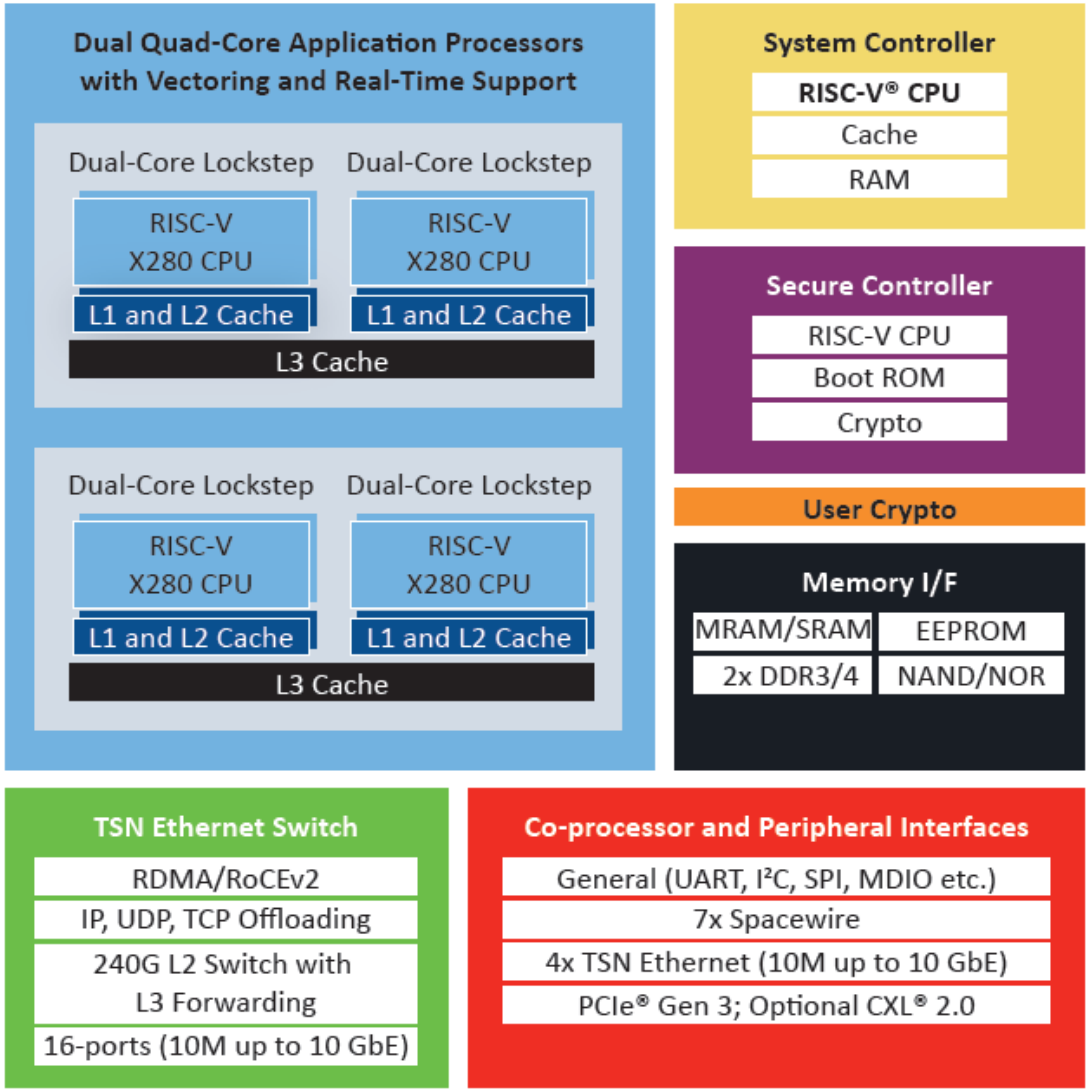
Microchip's Expanding Compute Portfolio

Scalable Computing at the Intelligent Edge



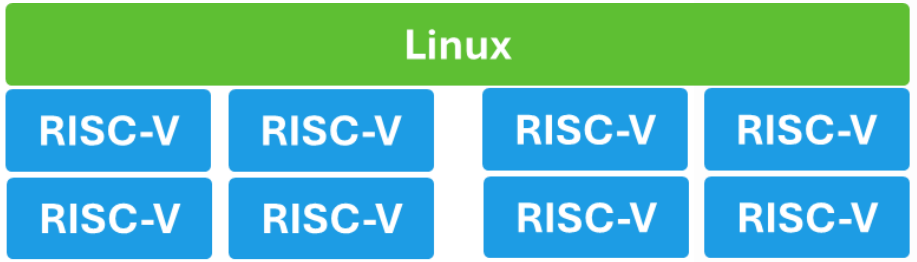
PIC64-HPSC Architecture Highlights

- **Groundbreaking 64-bit RISC-V® Scalar and Vector Compute Engines**
- **Integrated 240G TSN Ethernet Switch for Networking and Connectivity**
- **Advanced Defense Grade Security Enclave**
- **Unprecedented Fault-Tolerance for Mission Critical Applications**
- **Radiation-Hardened and Radiation-Tolerant versions enable any mission profile**



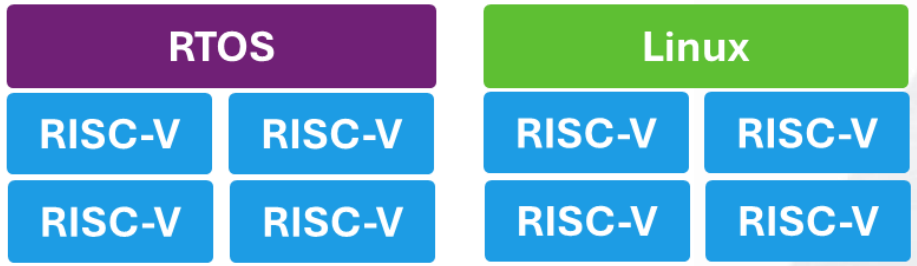
Multicore Flexibility for Mixed Criticality Systems

SMP



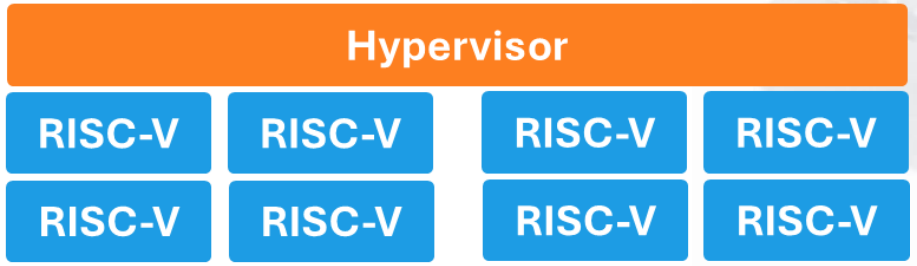
Symmetric Multiprocessing (SMP): All cores dedicated to a single OS for highest performance

AMP



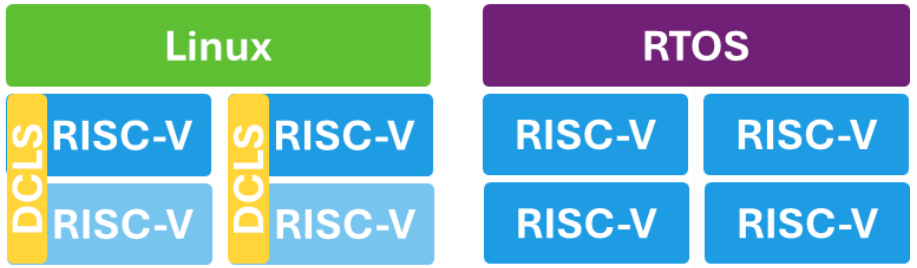
Asymmetric Multiprocessing (AMP): Enables mixed criticality: Real-Time and Non-Real Time

Hyper-visors



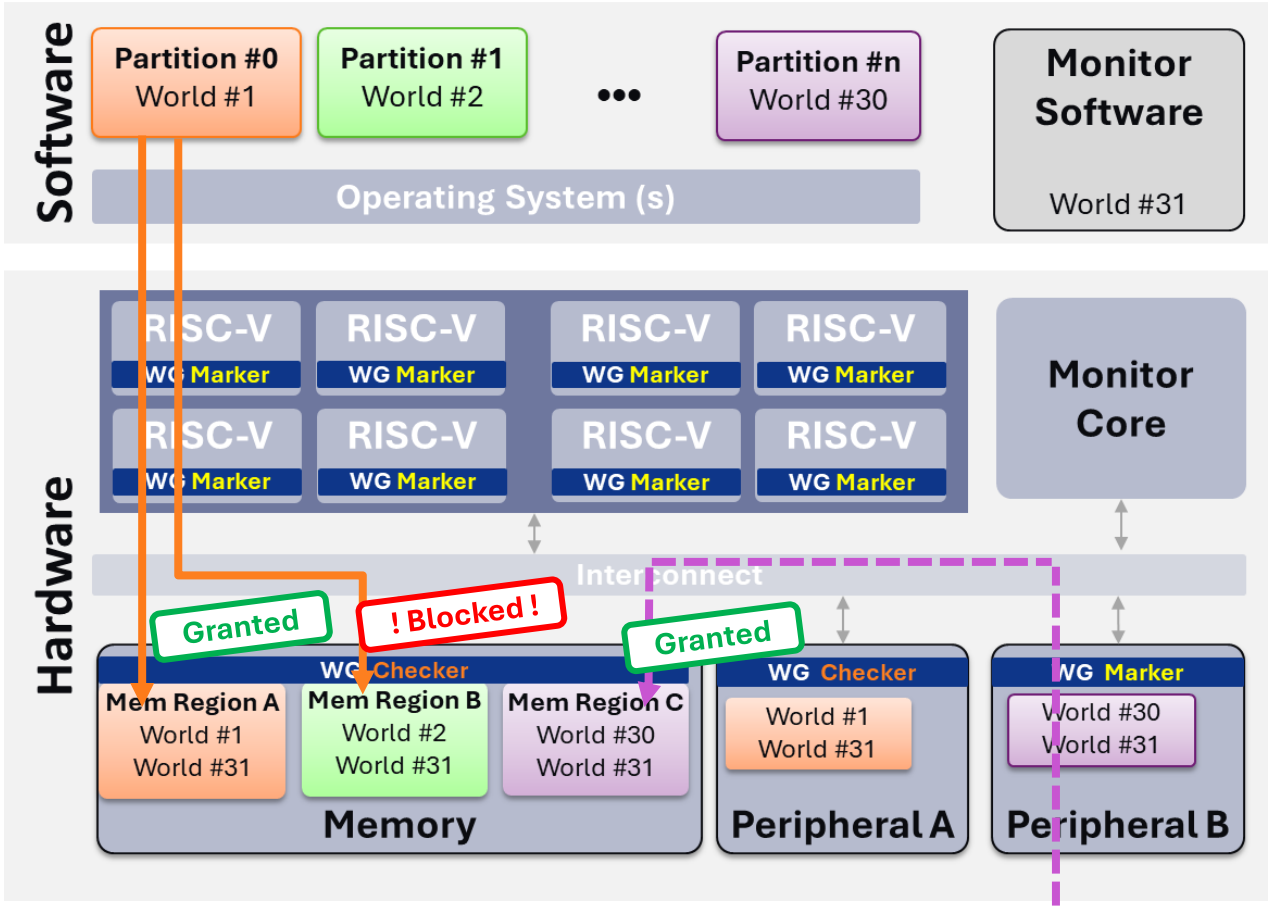
Hypervisors: Support for mixed criticality, time-and-space partitioning OS's, and virtual machines

AMP + DCLS



AMP + DCLS: Enables mixed-criticality + compute level fault-tolerance

WorldGuard for Isolation, Partitioning and Security



- Donated to RISC-V® by SiFive
- Groups resources into worlds
  - Up to 32 worlds vs. 2 for TrustZone®
  - Resources can be in 1 or more worlds
  - World 31 is most “trusted” world
- Hardware markers and checkers ensure isolation
- Worlds can be assigned to cores / VMs / privilege modes and/or DMAs
- Targets can be peripherals or memory regions

WorldGuard Enables

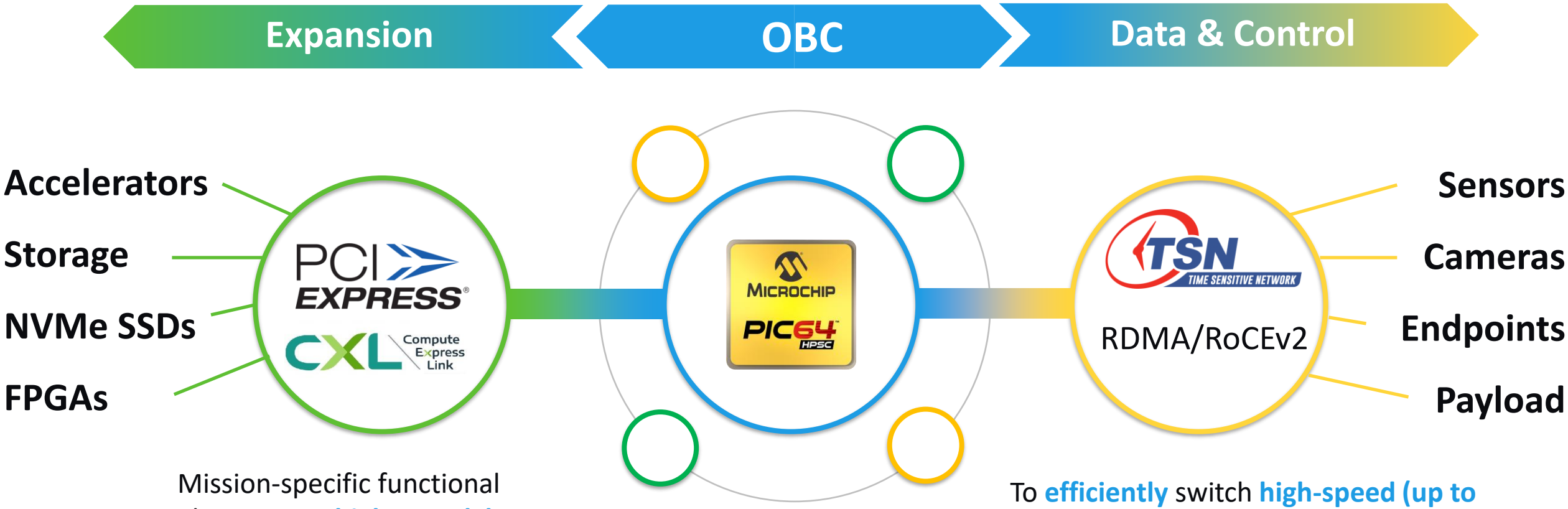
- Partitioning and Isolation
- Fault-Tolerance
- Time and Space Partitioning Operating Systems
- Security: Trusted Execution Environments

Data Ingestion: PIC64-HPSC Delivers TSN Ethernet

PIC64-HPSC: TSN Ethernet Benefits for Space

Supports IEEE TSN for Aerospace Onboard Ethernet Communications

Enables On-Board Computing (OBC) Extensibility

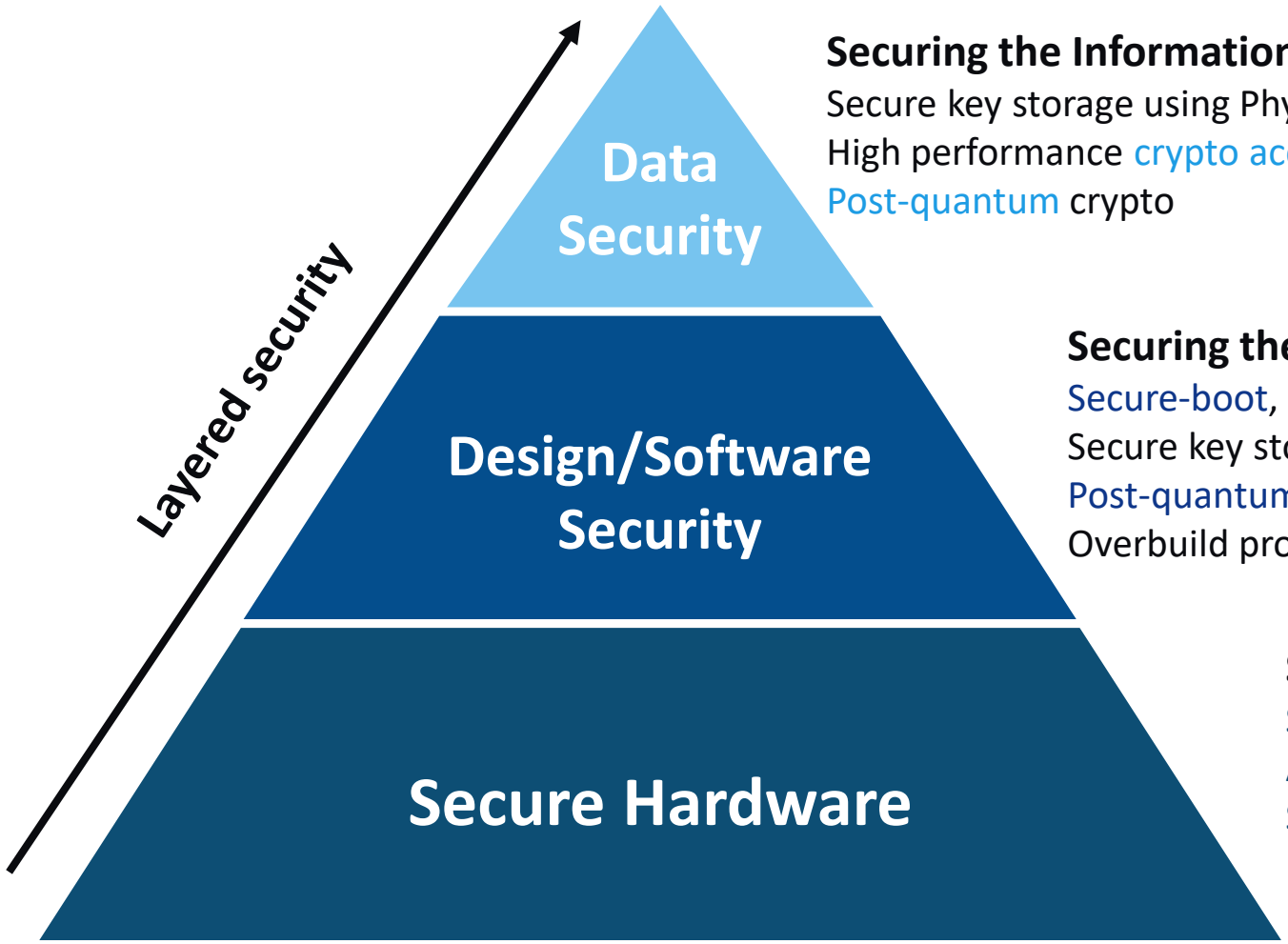


Mission-specific functional acceleration via **high-speed, low-latency**, **point-to-point** and **coherent memory sharing** buses

To **efficiently** switch **high-speed (up to 10 GbE)** data from remote endpoints to the processor and other processing nodes in **real-time, deterministically**

System Extensibility with Field Proven Industry Standard Connectivity

Layered Security Against Physical & Cyber Threats



Securing the Information
Secure key storage using Physically Unclonable Function (PUF)
High performance crypto accelerators
Post-quantum crypto

Securing the Application and Infrastructure
Secure-boot, secure provisioning
Secure key storage using Physically Unclonable Function (PUF)
Post-quantum crypto
Overbuild protection

Securing the Hardware
Secure manufacturing
Anti-tamper (detection and response)
Side channel countermeasures
NIST-certified accelerators

PIC64-HPSC Delivers Unparalleled Security for Critical Space Infrastructure

PIC64-HPSC Design Philosophies

Industry Standard & Proven Technologies

- Ethernet
- TSN
- RDMA, RoCEv2
- PCIe®
- Etc.

Art of Balancing

- Hardening
- Performance
- Power

Open-Standard Open-Source

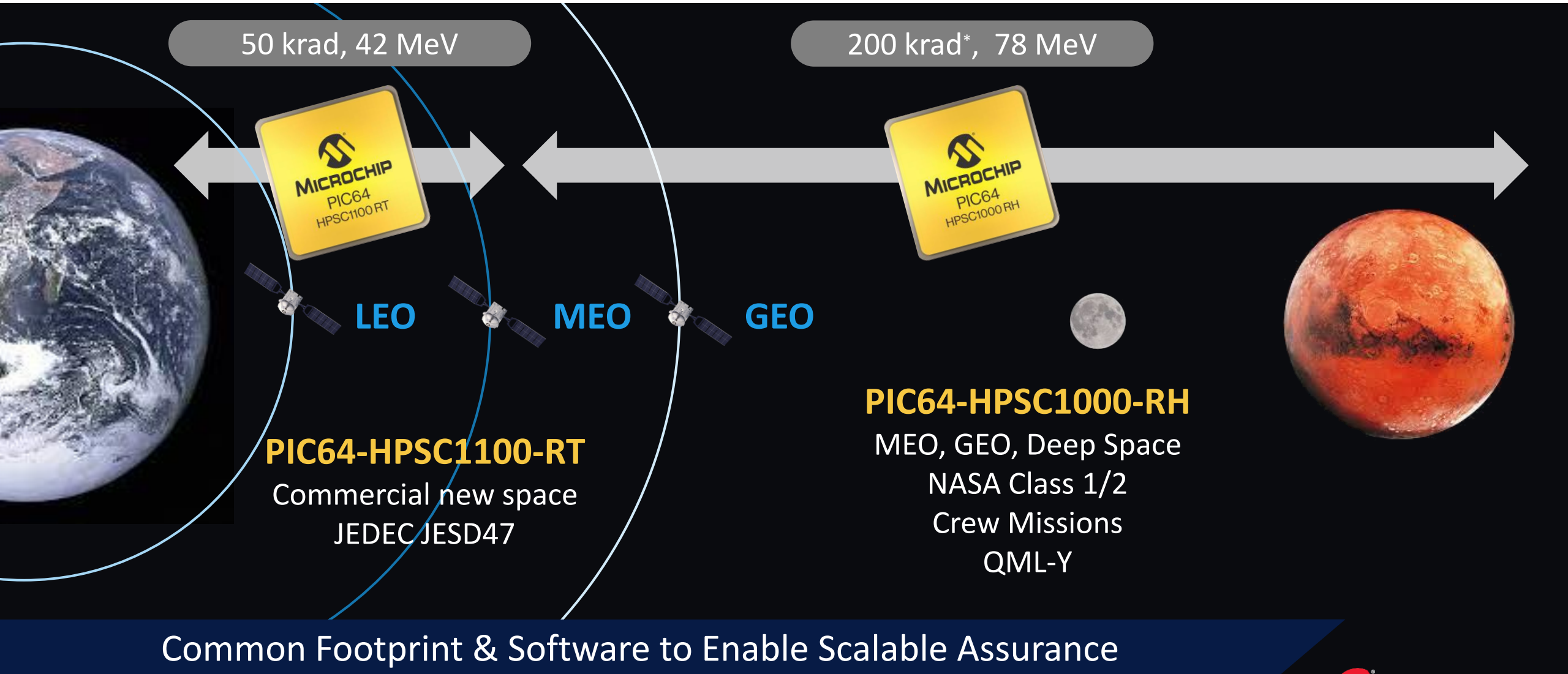
- RISC-V® ISA
- Hypervisor
- Software Tools and Libraries

Considerations when making tough choices

- **Radiation Tolerance:** critical yet least flexibility
- **Compute Performance:** *peak* performance is “baked in”
- **Power Consumption:** tunable against performance/features

HPSC – From Low-Earth Orbiting to Deep Space

PIC64-HPSC Series: Radiation-Hardened and Radiation-Tolerant Variants for Spectrum of Missions



Common Footprint & Software to Enable Scalable Assurance

*tested to 200 krad

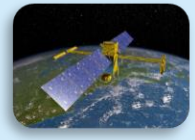
MICROCHIP

Supporting Open Source & Commercial Software

Extensive Development Tools, Libraries and Operating Systems for PIC64-HPSC Series

Applications

Satellites



Spacecraft

Rovers/Landers

Aviation

Defense

Industrial

Middleware

System Libraries: OpenSBI, OpenAMP, OpenMP, OpenSSL (Cryptography and SSL/TLS Toolkit)

Performance Libraries: FFTW, POCL, OpBL × enAS

AI Frameworks: PyTorch, TensorFlow, TensorFlow Lite

Operating Systems

Linux
Operating System, BSP and Drivers

Real-Time Operating System(s): RTEMS, WNDRVR, SYSGO EMBEDDING INNOVATIONS, Green Hills SOFTWARE

Hypervisors: Xen Project, KVM

Design Resources

Simulation Models

Velocity Switch S/W

Drivers

System Controller

Configuration Tool

Crypto Tool

Tools

Compilers: LLVM COMPILER INFRASTRUCTURE, OpenXLA, IREE, GCC

Development Tools: MPLAB EXT, LAUTERBACH DEVELOPMENT TOOLS, ENTRUST SECURING A WORLD IN MOTION

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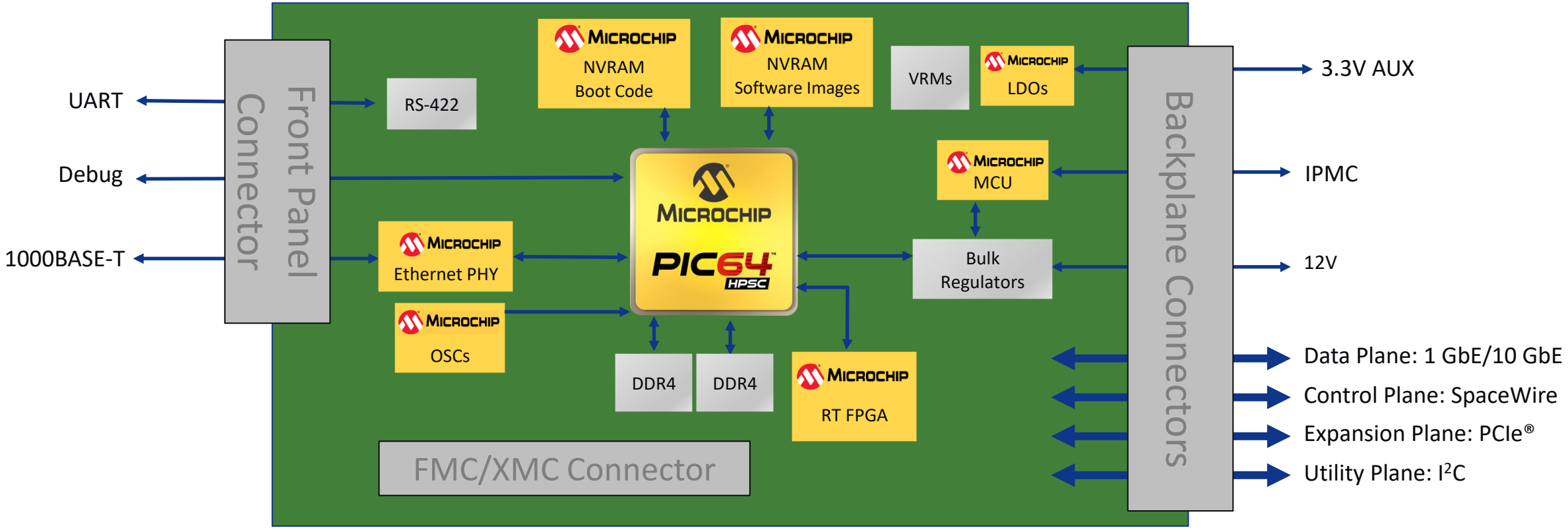
Microchip Uniquely Enables System Solution

Expansive Portfolio Provides Complete Validated Design to Accelerate Time to Market

Typical Single Board Computer (SBC) Reference Design



Memories

Transceivers

RDMA IP

Enabling the Space SBC Ecosystem

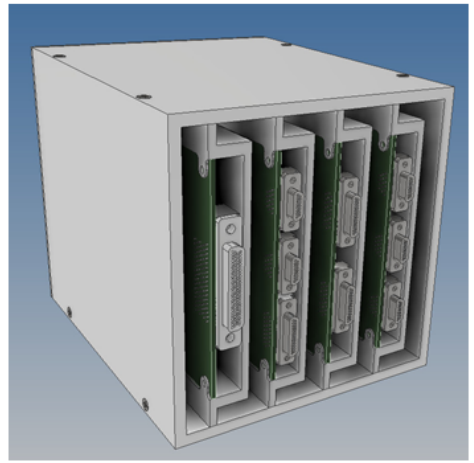
Single Board Computer (SBC) Partners To Fully Address Customer Development Needs

Innovative Computing Element "ICE"

- **ICE** program is currently under evaluation in **ESA** & **ASI**. No formal approval yet
- **ICE** is proposing to use Microchip's HPSC with Neat's **GeminiX-S** Operating System
- **ICE** will be used to implement Radiation Tolerant High Performances, High bandwidth class of computers to address autonomous **AI based applications**.

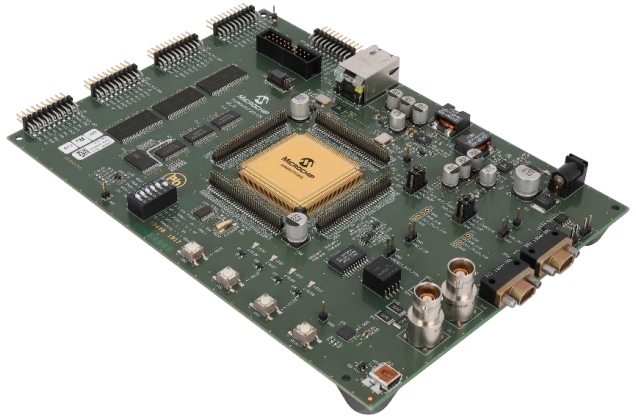
- GeminiX-S Operating System is a generic low-level SW that implements a real time OS-like environment. Main characteristics are:
  - 100% Neat's in-house development. MISRA C 2012, with coding rules
  - SW Defensive Programming (assertion, data check before use, …)
  - Controlled execution flow (token passing)
  - 64 bit code protection of firmware on Mass Memory (CBC-MAC) for each 1 Kbyte block of data.
  - Stand-alone self-booting executable
  - Configurable isochronous interrupt service (resolution depending on specific timer technology)
  - High coverage diagnostic routine for on-line testing of:
    - CPU (registers, ISA, stack, internal RAM if available)
    - Memories (RAM, Mass Memory)
    - Data path (HW assisted BUS test)

Concept view

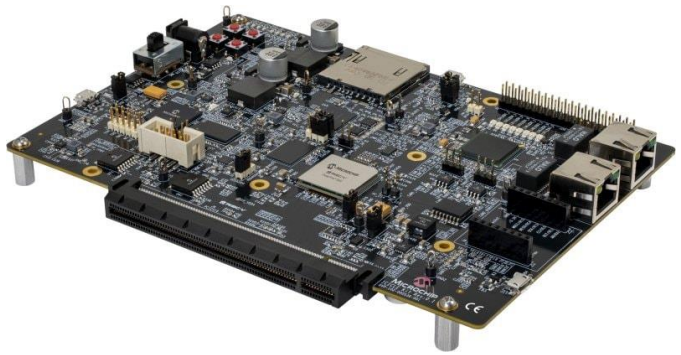


SAVOIR Bootloader – towards RISC-V

- SAVOIR Flight Computer Initialization Sequence
  - ECSS PUS-C telecommand & telemetry link
  - Existing ECSS criticality B pre-qualified version
  - Supported SAMV71Q21(RT), SAMRH71F20 and SAMRH707F18

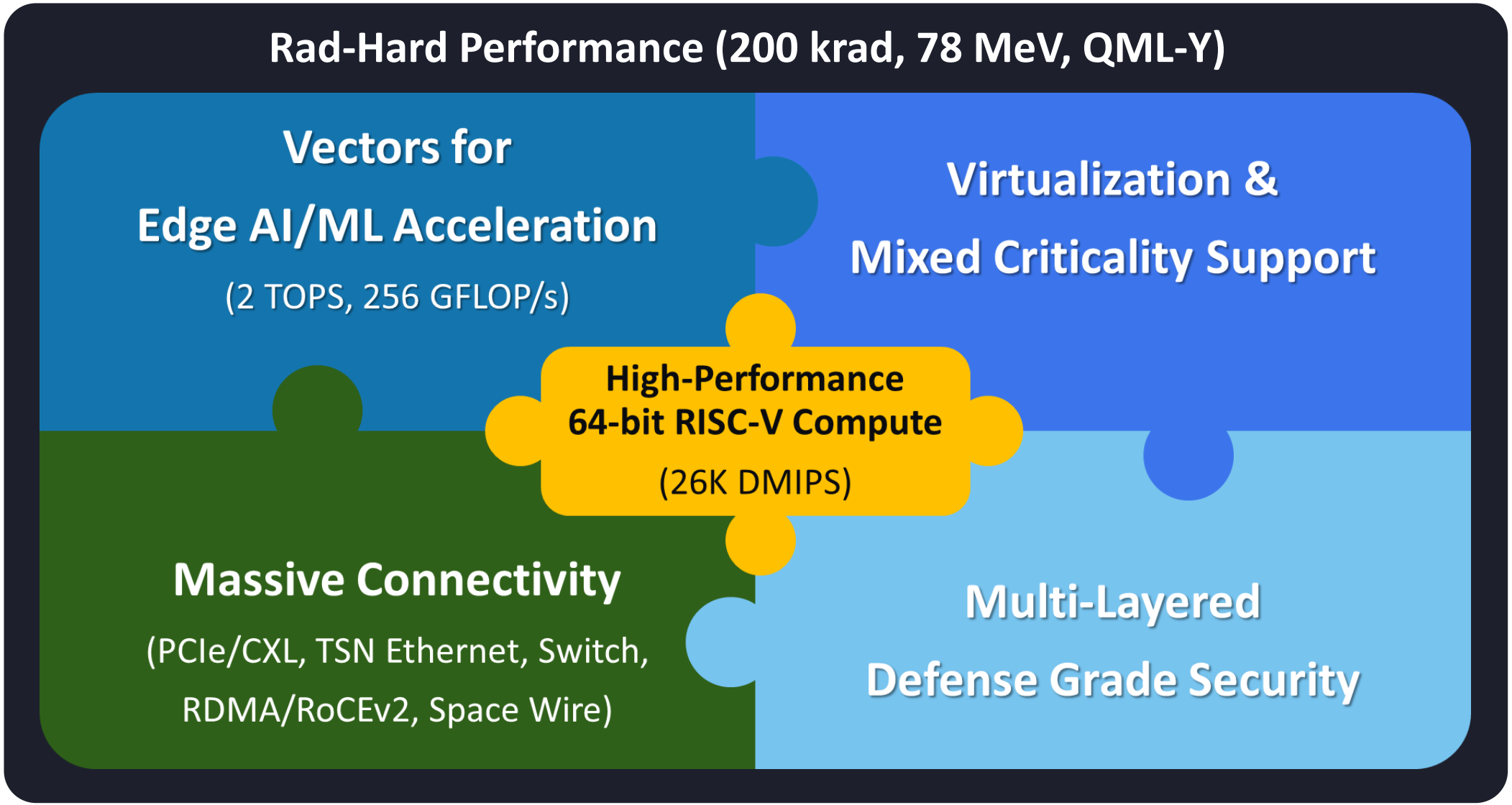


- Way forward RISC-V compatibility
  - Existing bootloader port for PolarFire MPFS250T
  - Supported non-volatile eNVM and eMMC memories
  - Application software execution from RAM



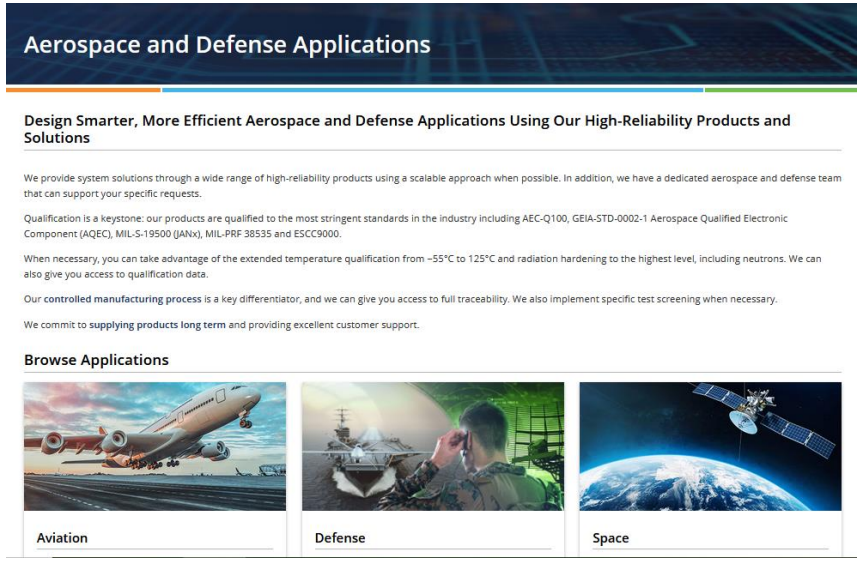
- Foreseen integration of SAVOIR boot functionalities with PIC64 HPSC in 2025

PIC64-HPSC: Arriving in 2025



Where to Learn More

- **Web pages to access Link**
  - Products, applications
  - Reference designs on product pages
  - Brochures
  - Newsletters
- **A&D BDM's, Sales teams**
- **nicolas.ganry@microchip.com**



PIC64-HPSC Product Website

NASA HPSC Whitepaper

TSN For Space Whitepaper (Microchip)

Securing Space Infrastructure Whitepaper (Microchip)

New Product Announcements

PIC64-HPSC

Microchip Unveils Industry's Highest Performance 64-bit HPSC Microprocessor (MPU) Family for a New Era of Autonomous Space Computing

JANxx Transistors

Microchip Adds Military-Standard Enhanced Low Dose Radiation Sensitivity (ELDRS) Qualification to Its Portfolio of Small-Signal Bipolar Junction Transistors to Ensure High Reliability for Critical Applications

SAMD21RT

Microchip Expands its Radiation-Tolerant Microcontroller Portfolio with the 32-bit SAMD21RT Arm® Cortex®-M0+ Based MCU for the Aerospace and Defense Market

LE50-28

Radiation-Tolerant DC-DC 50-Watt Power Converters Provide High-Reliability Solution for New Space Applications

RT PolarFire® system-on-chip (SoC) FPGA

Radiation-Tolerant PolarFire® SoC FPGAs Offer Low Power, Zero Configuration Upsets, RISC-V® Architecture for Space Applications

New integrated actuation power solution

Integrated Actuation Power Solution Aims to Simplify Aviation Industry's Transition to More Electric Aircraft

MICROCHIP

Aerospace and Defense Applications

Building secure, robust and reliable electronic systems for space, aviation and defense applications is critical. We have a long history and proven track record of providing innovative, reliable and high-quality solutions for these types of applications. In 1957, we supplied the electromechanical relays for the Atlas launch vehicle. Voyager 1, the furthest manmade object from Earth, has been utilizing our frequency control products to aid in the transmission of data from a distance of 13 billion miles. We have continuously expanded our product offerings to deliver the largest portfolio of aerospace and defense semiconductor solutions in the market to give you the freedom to innovate.

- Our high-reliability, radiation-tolerant and radiation-hardened products are designed and qualified for the harshest environments
- Many of our products are designed to fit small footprints, consume very little power and operate reliably in high-temperature and electromagnetic environments
- We offer a wide variety of packaging and quality screening options, including hermetically sealed and non-hermetic/plastic products screened to various qualification levels
- Our COTS-to-radiation-tolerant devices are tailored to withstand levels of Total Ionizing Dose (TID) and Single Event Effects (SEE) for lower earth orbits and new-space applications
- Our radiation-hardened devices are Rad-Hard By Design (RHBD), offering the highest levels of TID and SEE radiation performance for the most demanding applications

You can take advantage of our extensive expertise and technical support to reduce your integration risk and development time. Our development ecosystem includes IP licenses, a variety of demonstration and evaluation kits, reference designs, software, application notes and detailed documentation. Our team of engineering, sales, marketing, logistics and quality experts provide the specialized support that you need to solve your most difficult design challenges.

Explore These Application Areas

Aviation

Learn More

Defense

Learn More

Space

Learn More

Explore our Portfolio of Products

ASICs	Communication Interfaces	Discretes	Electromechanical Relays
FPGAs	Frequency and Timing	MCUs and MPUs	Memory
Mixed-Signal ICs	Power Management	RF, Microwave, Millimeter Wave	Synchronization Systems

Thank You

https://www.microchip.com/en-us/solutions/aerospace-and-defense

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