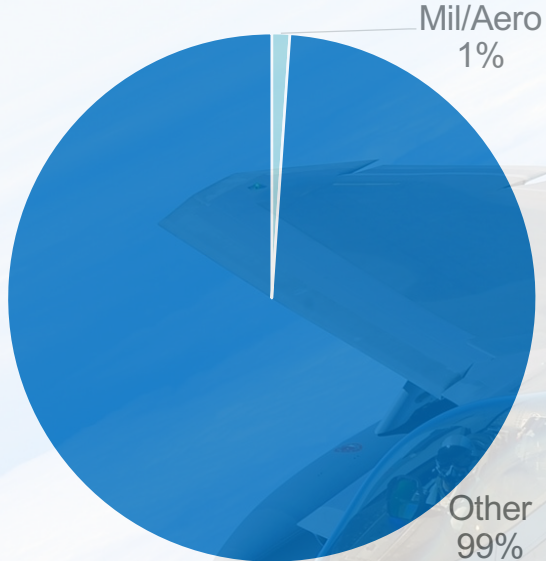# VORAGO TECHNOLOGIES
8th Interplanetary CubeSat Workshop, June 2019

Leveraging mainstream commercial technology – IP and wafer foundries

Semiconductor Market Share

Mil/Aero 1%

Other 99%

- Space is a small fraction of mainstream semiconductor market
- Mainstream applications are what are driving semiconductor investments
- Semiconductor business going through consolidation phase which increases focus on big markets
- Efforts underway in space market to leverage COTS parts but there are some fundamental issues
- VORAGO leverages mainstream CMOS technology & infrastructure
  - o Harden standard CMOS technology
  - o Capability to run through any CMOS fab
  - o Adopt industry standard IP like ARM™ cores
  - o Reuse IP modules and software to turn around designs faster

VoragoTech.com

VORAGO Technologies

- Privately held fabless semiconductor company headquartered in Austin, TX
- Patented HARDSIL® foundation technology
- Focused on space technology since 2004. Commercializing technology since 2015

VORAGO Technologies, Austin, Texas.
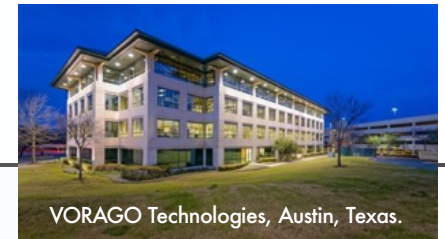
HARDSIL® – Technology

- Patented semiconductor technology (14 patents to date)
- Licensed to LSI, TI and Global Foundries
- Embedded into standard CMOS manufacturing process
  - Standard manufacturing equipment
  - Fully design agnostic
  - Eliminates latch-up
  - Enables high temperature performance beyond 200°C
  - No impact on transistor performance or yield
- Hardens silicon against radiation, temperature and electrical stress

HARDSIL® – Products

- Radiation hardened portfolio up to 300 krad(Si)
  - 8M & 16M SRAMs
  - ARM® Cortex®-M0 MCU
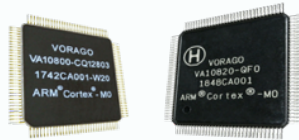- High temperature portfolio 200°C
  - ARM® Cortex®-M0 MCU

Technology Capabilities

| Technology Implementation	Integrated Circuit Design	Multi Die Package Design	Board Design
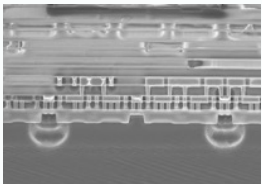
- Technology scalable to FinFET
- Implemented in 4 foundries
- Uses standard commercial processes and equipment
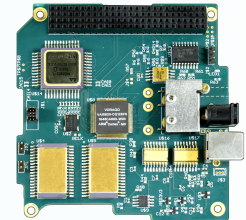- Runs in any factory:
  - 3-4 months time to implement

- Products qualified to QML level
- Strong flight heritage
- 5 products in production
- 3 products in development
- Radiation tested
- 10 products converted to HARDSIL
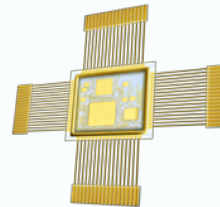
- Custom package and custom substrate development
- 2D, 3D packaging
- High reliability ceramic and plastic material
- QML in progress

- Custom design (Altium)
- Custom firmware
- 3D model for assembly and easy mating
- Turnkey component purchase
- Custom test fixtures
- Automated testing and static
- Radiation testing

Released Products

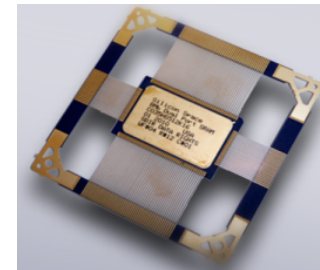| PA32KAS Microcontroller	VA10820 Microcontroller	VA10800 Microcontroller	HS512K16 Dual-port SRAM	SMV512K32 SRAM

- 1st Gen MCU
- Operational on ISS and sun-synch orbit

- 2nd Gen MCU
- Operational on commercial and US Government CubeSats

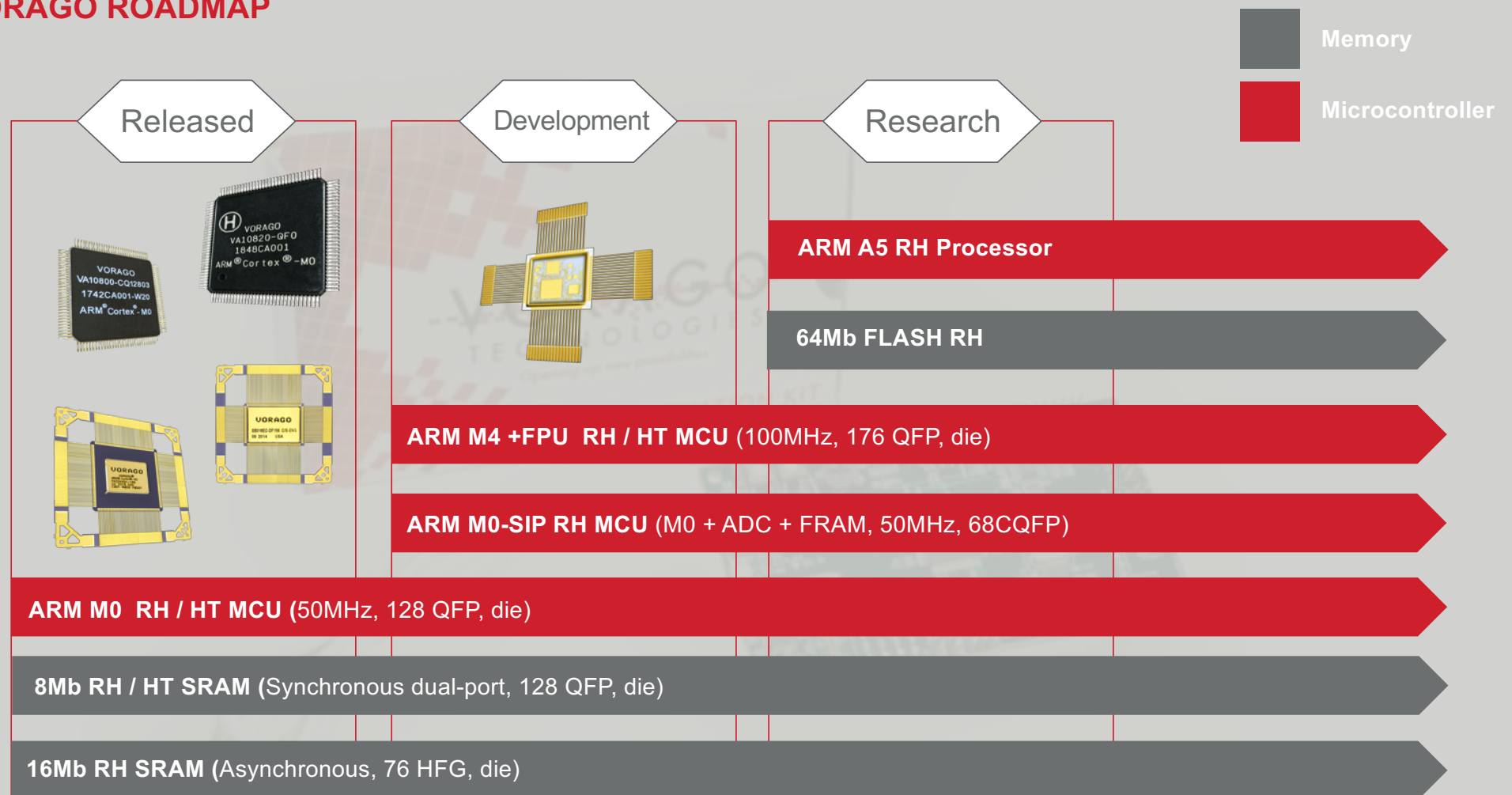- 200°C operation Aerospace distributed engine controls
- Downhole drilling

- Developed for MDA for missile interceptors

- Packaged version QML-V qualified
- Operational on ISS and prime aerospace satellites

VORAGO ROADMAP

Released

Development

Research

ARM A5 RH Processor

64Mb FLASH RH

ARM M4 +FPU RH / HT MCU (100MHz, 176 QFP, die)

ARM M0-SIP RH MCU (M0 + ADC + FRAM, 50MHz, 68CQFP)

ARM M0 RH / HT MCU (50MHz, 128 QFP, die)

8Mb RH / HT SRAM (Synchronous dual-port, 128 QFP, die)

16Mb RH SRAM (Asynchronous, 76 HFG, die)

VORAGO MCU Use Case Configurations
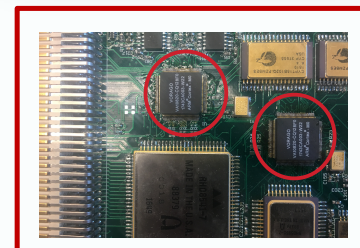
Main Processor
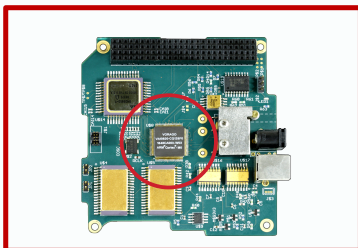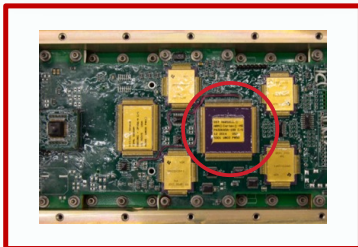
- MCU executes main control algorithm
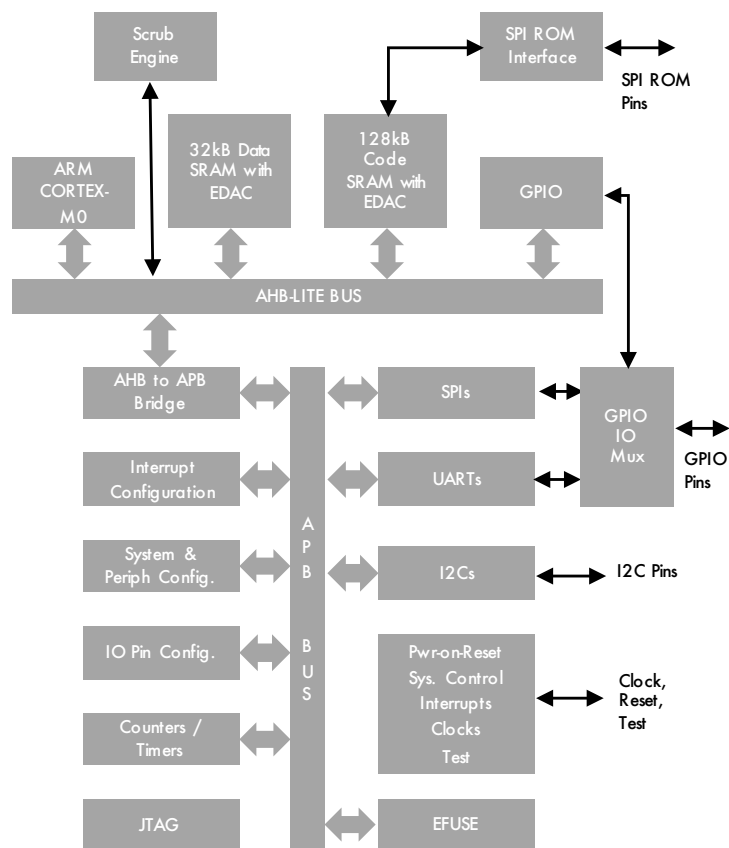
Watchdog Processor
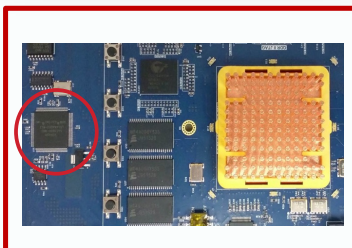
- MCU watchdog for FPGA

Multi Processor Configuration

- Distributed processing system using multiple MCUs

VA10820

Radiation-hardened ARM® Cortex®-M0 Microcontroller

Key Features and Advantages

- Latch up Immune with *HARDSIL*® Hardened by Process Technology
- Power Gating and Hardware Debugger
- 32KB Data and 128KB Program Memory
- 1Kb One Time Programmable Configuration Memory (OTP)
- 24 Counter/Timers with Extensive Hardware/Software Triggering
- 3 SPI (one SPI is master only), 2 I2C, and 2 UART External Interfaces
- 56 Multiplexed General Purpose 3.3V I/O (GPIO)

Specifications

- Total Ionizing Dose (TID) – 300K rad(Si)
- Soft Error Rate (SER) with EDAC enabled – 1e-15 errors/bit-day
- Linear Energy Transfer (LET) – 110 MeV-cm2/mg (at T=125C)

Description	Part number	Environment	Temperature Range	Package
Radiation-hardened microcontroller	VA10820-D0000F0PCA	Rad-hard 300K rad (Si)	-55 to 125°C	Die
Radiation-hardened microcontroller	VA10820-CQ128F0ECA	Rad-hard 300K rad (Si)	-55 to 125°C	Ceramic 128 LQFP
Radiation-hardened microcontroller	VA10820-PQ128F0PCA	Rad-hard 300K rad (Si)	-55 to 125°C	Plastic 128 LQFP

VA41630
Radiation-hardened Arm® Cortex®-M4 Microcontroller
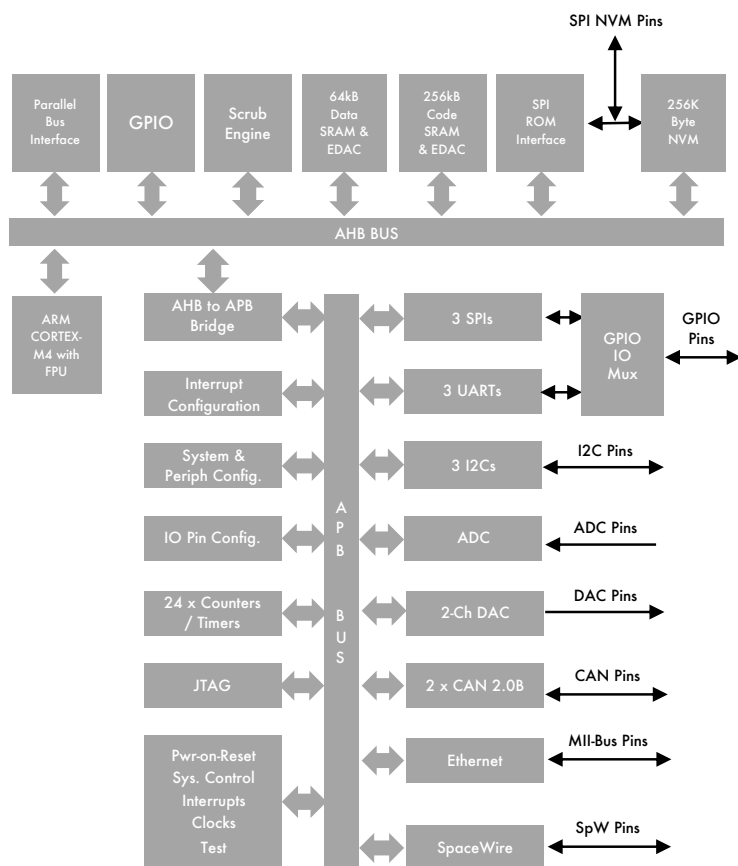

Specifications

- **CPU:**   100MHz Arm® Cortex®-M4 with Floating-Point Unit (FPU)
- **Process:**   *HARDSIL®*
- **Voltage:**   3.3V
- **Package:**   176 C/PQFP, die
- **Temperature:**   - 55°C to 125°C

Key Features and Advantages*

- Latch up Immune with *HARDSIL®* Hardened by Process Technology
- SWD debug interface
- 64KB SRAM Data and 256KB EDAC Program Memory
- 256KB NVM
- 24-Ch, 32-bit Timers with Extensive Hardware/Software Triggering
- 3 SPI, 3 I²C, 3 UART, 2 CAN, Ethernet
- 8-Ch, 12-bit, 600Ksps ADC
- 2-Ch, 12-bit, 1MHz DAC
- Full-duplex 100MHz SpaceWire Interface
- DMA controller
- 104 Multiplexed General Purpose 3.3V I/O (GPIO)
- Memory configuration options
  - Internal NVM
  - External SPI NVM
  - External parallel NVM / SRAM

SWaP reduction using the VA41630

- The VORAGO radiation-hardened ARM® Cortex®-M4 based microcontroller integrates up to eight discrete IC functions into a single device.

  - Enables reductions in **size, weight and power consumption**. The integration also greatly simplifies design and logistics as well as improving reliability of electronic circuits
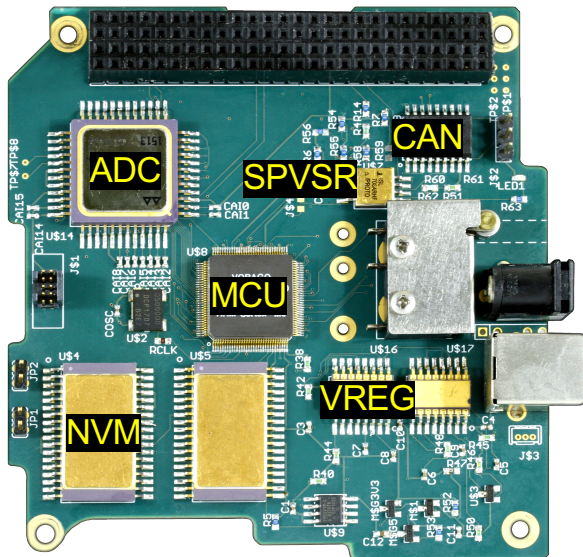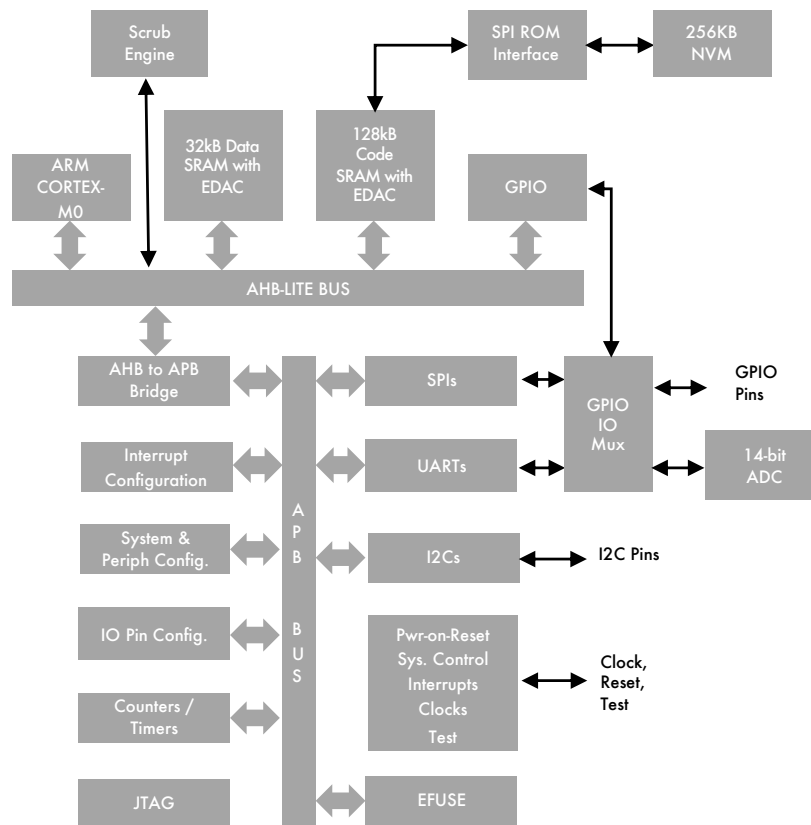

RH-OBC-1

Chip-count reduction example

- The CubeSat on-board computer design can be optimized by replacing six devices with a single higher performance VA41630 MCU.

VA10820-SIP
Radiation-hardened ARM® Cortex®-M0 Microcontroller with NVM, ADC


SIP

- VA10820 MCU
- Cobham RHD5950 ADC
- Cypress CYRS15B102 2 Mbit FRAM
- Six capacitors, two resistors
- Smallest possible package (23mm x 23mm)
- Approx. 5X smaller PCB area than using discrete ICs
- MIL-PRF-38534 Class K qualification
- Development kit and BSP

SIP Operation

- VA10820 boots from FRAM over SPI on power-up
- FRAM has 2X SRAM storage
- CPU executes from internal (protected) SRAM
- ADC connected on parallel ports (16-channels)
- 5V inputs on ADC, 3.3V I/O

RH Embedded Processing System-In-Package
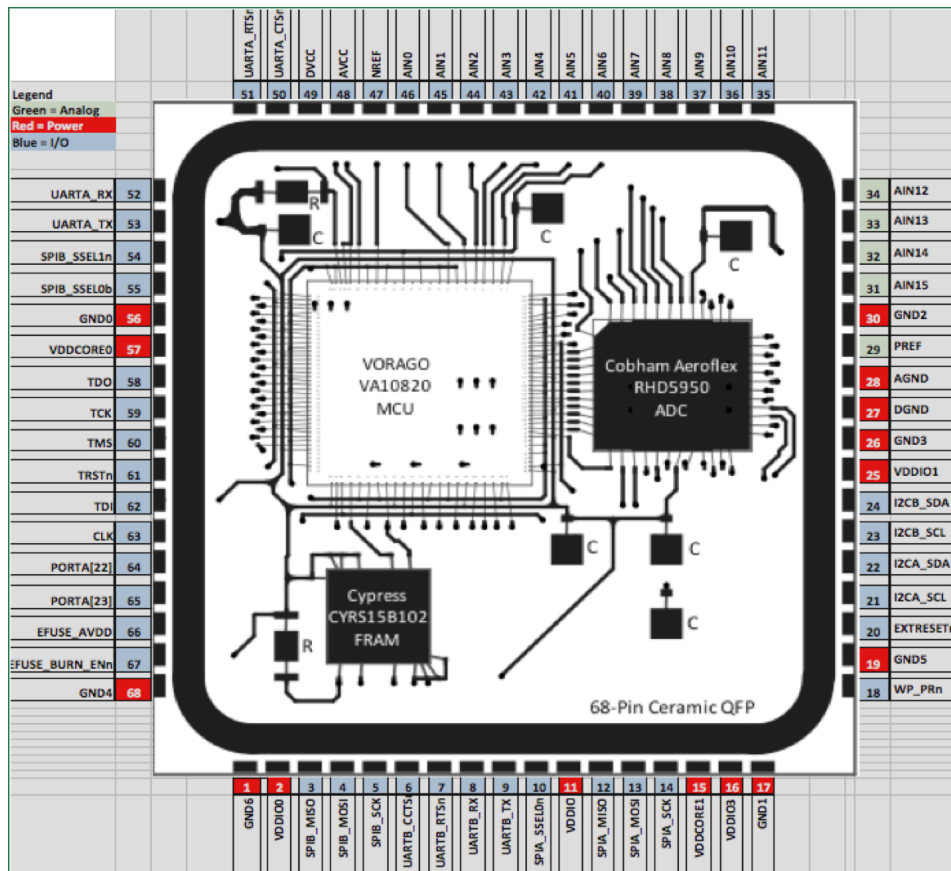
- 68-pin ceramic package

- VORAGO VA10820 MCU

- RH Aeroflex 16-Ch ADC

- Cypress FRAM

- Qualification MIL-PRF-38534 Class K
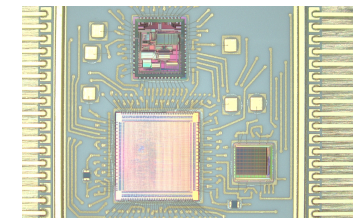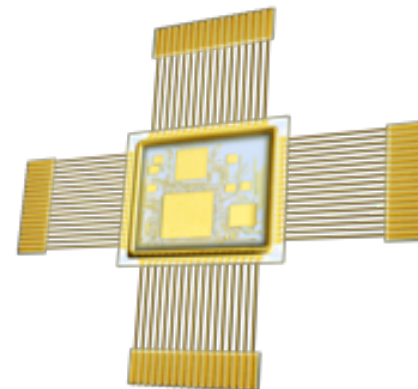
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Opening up new possibilities