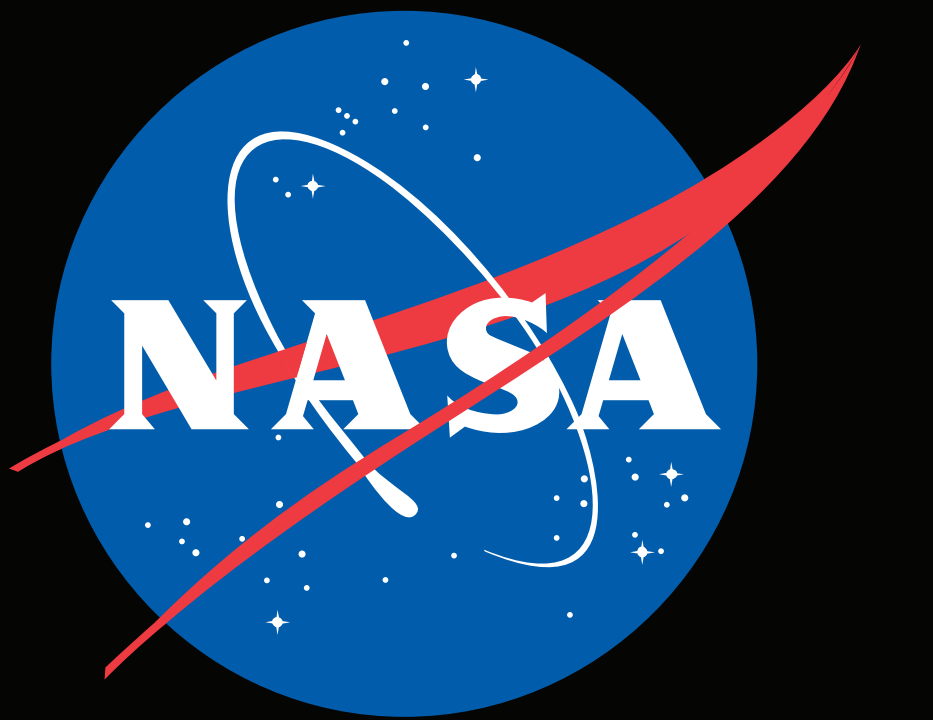# Modular Architecture for a Resilient Extensible SmallSat (MARES)

National Aeronautics and
Space Administration

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Acknowledgements: Colby Goodloe, Wei-Chung Huang, Munther Hassouneh, Steven West, Michael Johnson (NASA Goddard)

CubeSats and SmallSats have seen increasing success in Low Earth Orbit (LEO). However, there is a desire to send small, low cost missions beyond LEO into harsher environments. Additionally, most bus architectures do not currently have the on-board processing capabilities to handle high-speed science data and autonomous operations. MARES, currently under development at NASA's Goddard Space Flight Center, is a capabilities driven design and architecture with an emphasis on reliability, scalability, and high performance processing. Its applicability is broad including SmallSat missions, CubeSat missions, and high performance instrument processors. The highly integrated architecture reduces mass, volume, and power but still provides the flexibility of a modular system. Mission critical functions are handled by the Command and Data Handling (C&DH) Processor and Auxiliary cards, which are radiation hardened up to 100krad. SpaceCube™ Mini 3 processor card is primarily used for instrument data processing but its versatility and processing power provides a digital platform to reduce the SWaP of components and applications such as above-the-constellation GPS, software defined radio and LIDAR. This can be achieved by utilizing the same Mini card for various applications but multiple units can be utilized on the same bus if needed via a backplane design for the bus avionics. The catalog of new cards and features for MARES continues to grow, and the architecture can be expanded further with the design of mission-specific cards that plug into the same backplane as the rest of the bus. Standardized backplane configurations will reduce resources spent on customization and ensure a robust and compatible system.

Reliability

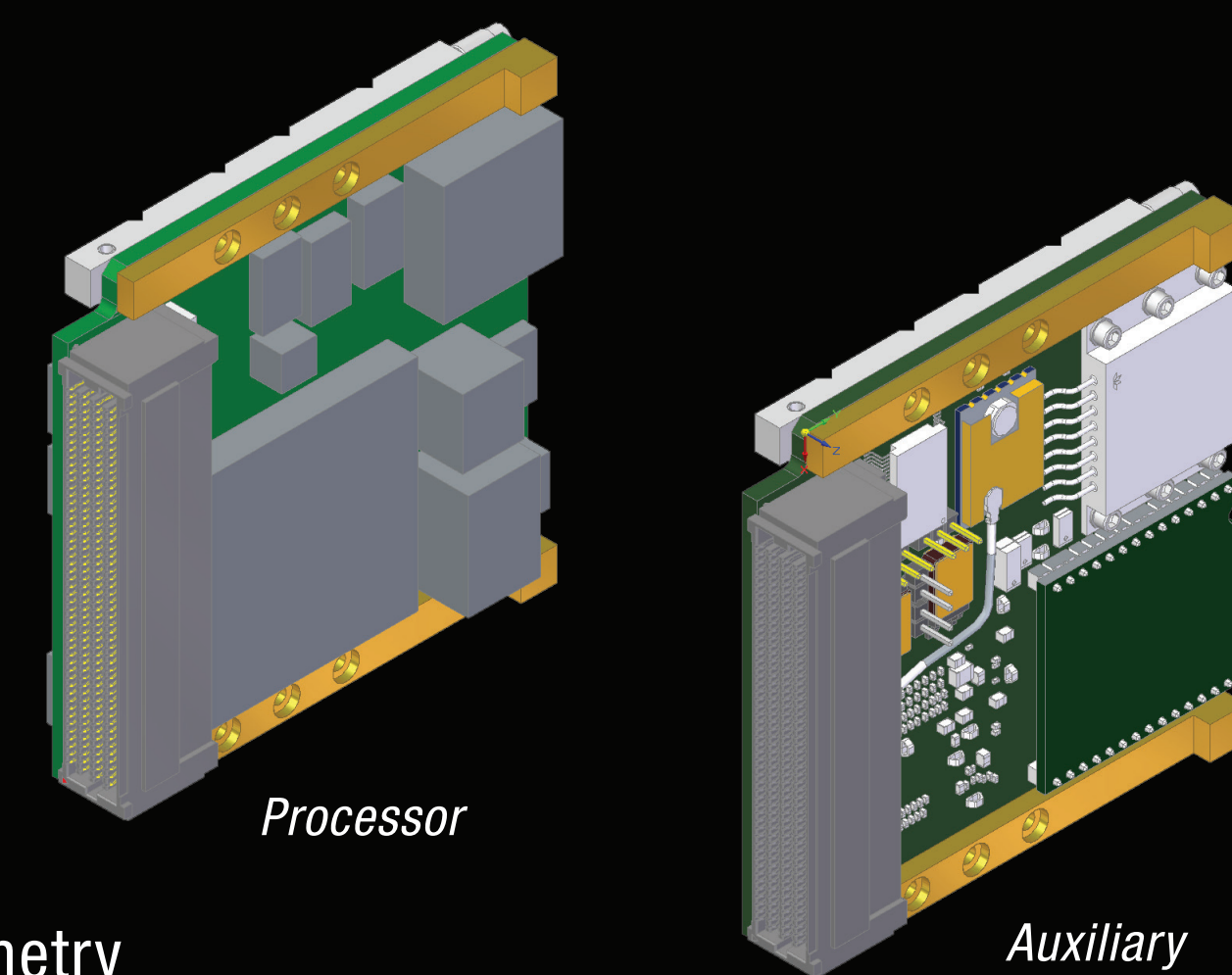### Reliable Systems for Critical Operations and Longevity

Features
- 100krad RTG4
- Reset Supervisory Chip
- On-board dosimeter

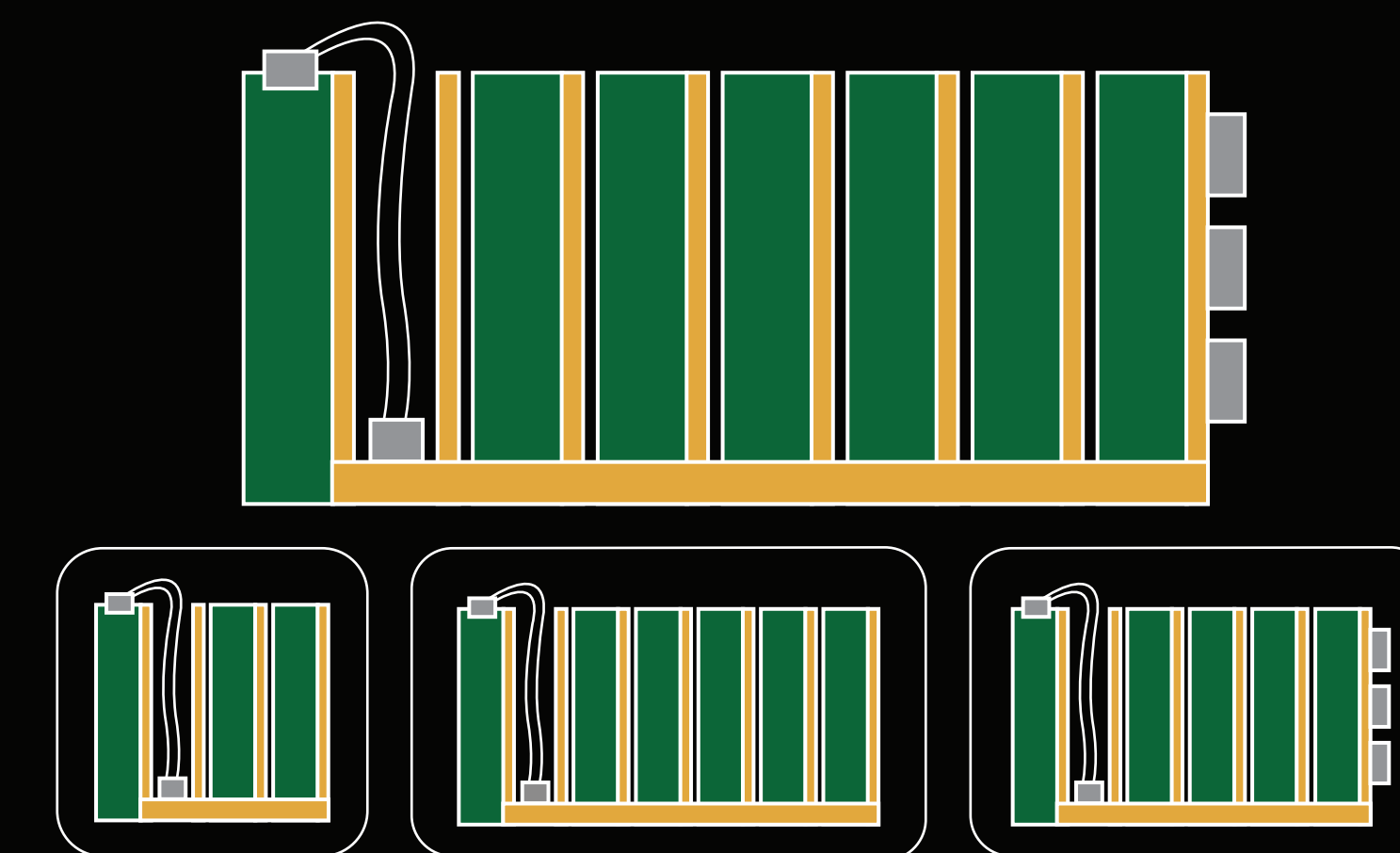**Memory**
- 16 MB SRAM
- 16 GB NAND Flash
- 1 MB EEPROM

Interfaces
- 8xRS-422
- 2 Heater Services
- 47 channels ADC for telemetry

Processor

Auxiliary

Scalability

Modular and Scalable Avionics from CubeSats to ESPA-Class
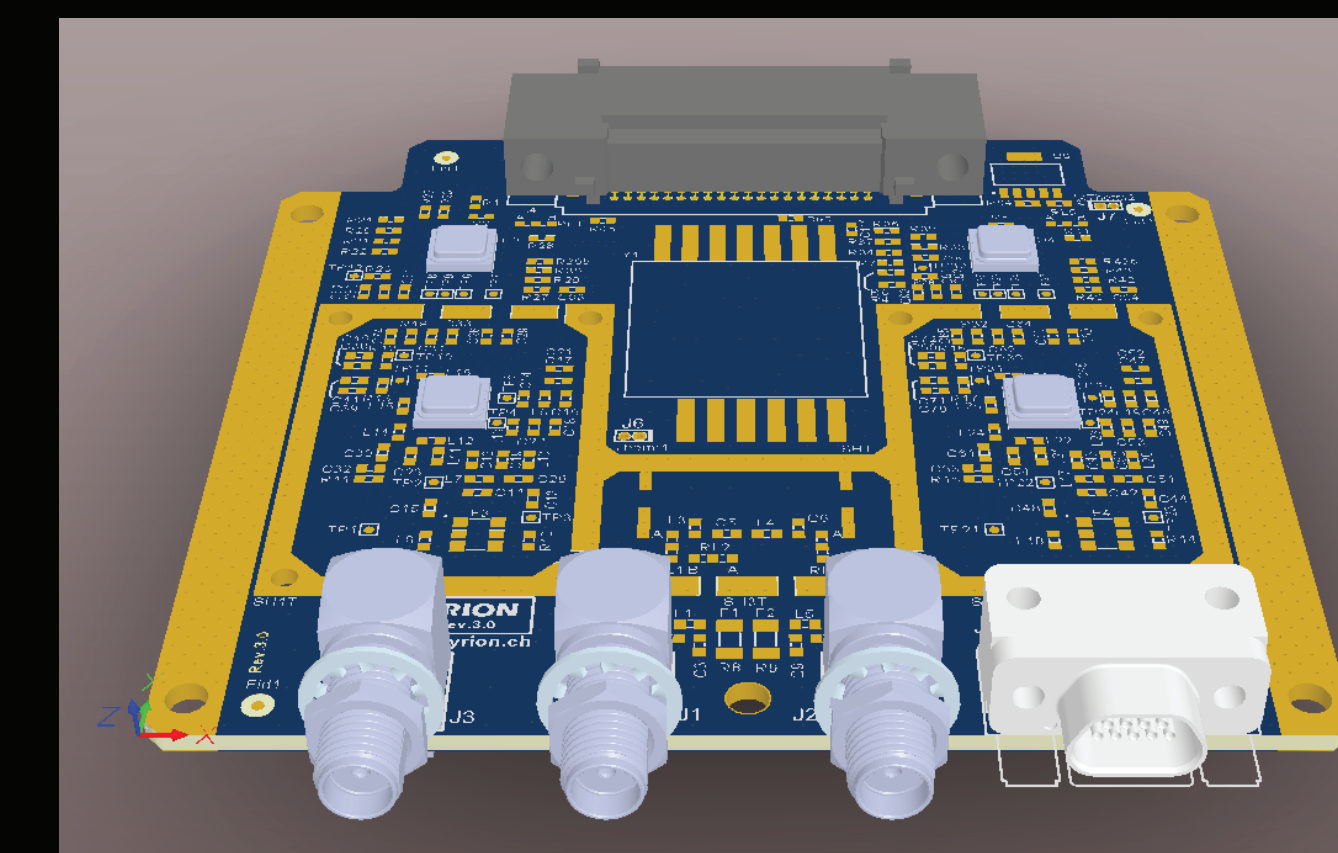- Backplane design allows for different tailored configurations

Integrated Global Positioning System (GPS)

Above-the-Constellation GPS
- Wide-band, dual frequency, multi-GNSS capable of receiving GPS L1/Galileo E1, and GPS L2 (or GPS L5)
- Low power < 0.5W
- Small size ~ 3.5" x 3.25"
- Rad-hard design

Above the Constellation Global Positioning System (GPS)

Performance

Orders of Magnitude More Processing Performance than State-of-the-art Radiation Hardened Systems

High-Performance Processor – SpaceCube™ 3.0 Mini

Features
- Xilinx Kintex KU060
- Embedded softcore Microblaze(s)
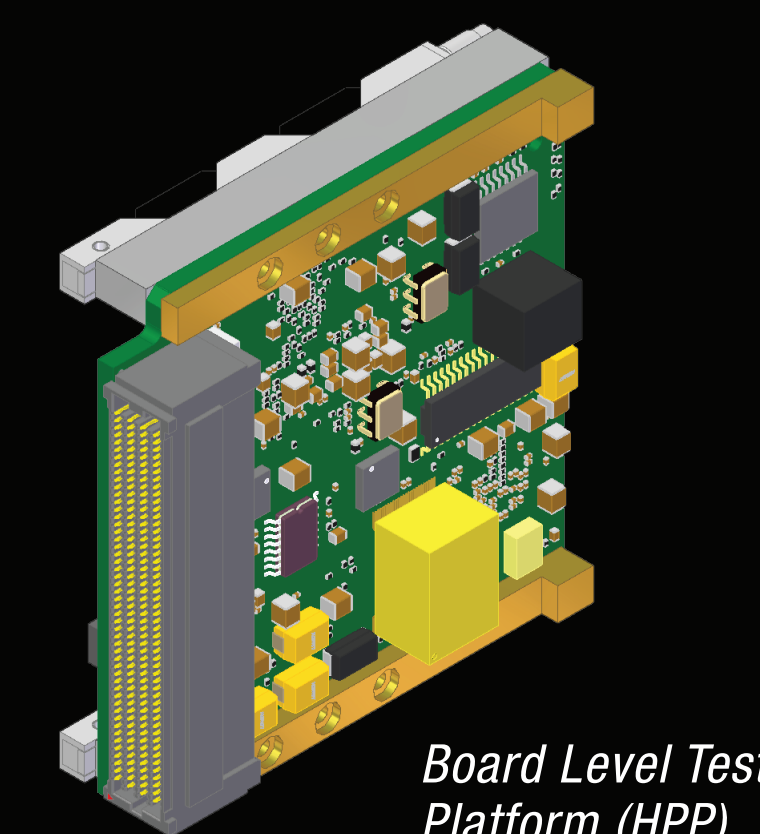- HPP (the SpaceCube™ 3.0 Mini) is rated to 60krad

Memory
- 2x 16 GB NAND Flash
- 2GB DDR3 SDRAM

Interfaces - Backplane
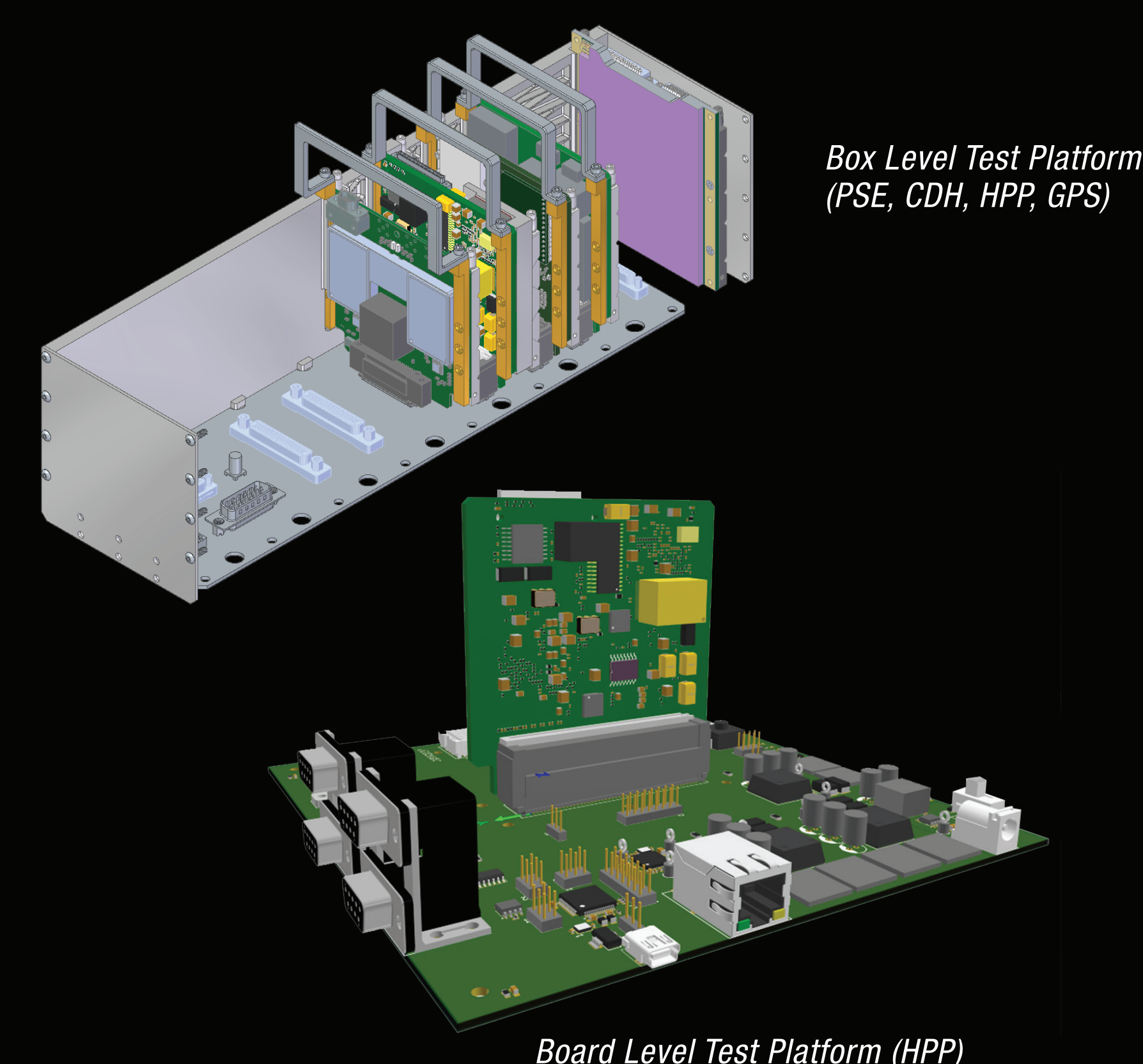- 48x LVDS Pairs or 96x 1.8 single ended I/O
- 30x 3.3 V GPIO
- 2x RS-422/LVDS

Interfaces – Front Panel (optional)
- 24x LVDS Pairs or 48x 1.8 V single-ended I/O
- 8x 3.3V single-ended I/O

Board Level Test Platform (HPP)

Develop and Test

Box Level Test Platform (PSE, CDH, HPP, GPS)

Board Level Test Platform (HPP)

## Integrated Software Defined Radio (SDR)
- 4 × 4 Multi-Input Multi-Output (MIMO) Architecture dual phase-synchronized Analog Devices AD9361s
- Frequency range from 70 MHz to 6 GHz with channel bandwidths up to 56 MHz and 12-bit ADC/DAC resolution
- On-board Radiation-Hardened Wideband Synthesizer with Phase Synchronization
- Noise optimized power system with low peak power consumption (> 11W)
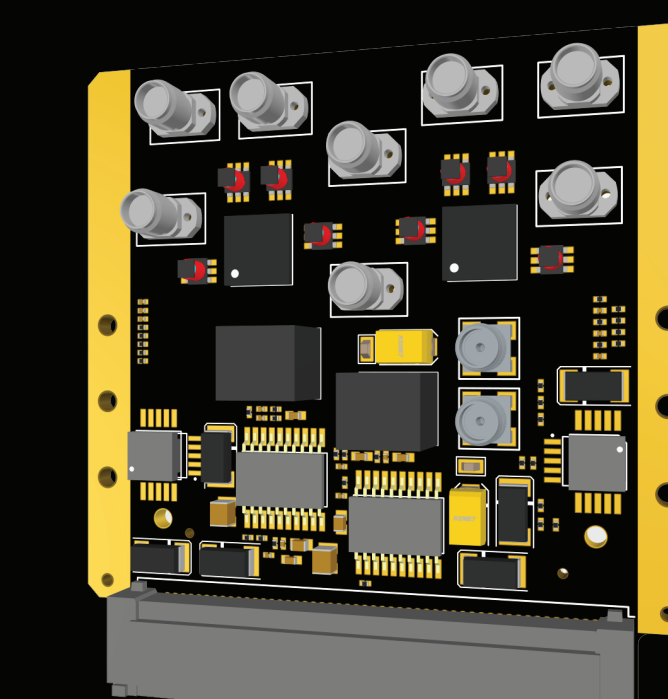
Software Defined Radio (SDR)

Integrated Radio Frequency (RF)
- Broadband RF amplifier design
- Compact RF/mechanical packaging
- Compatibility with NASA network
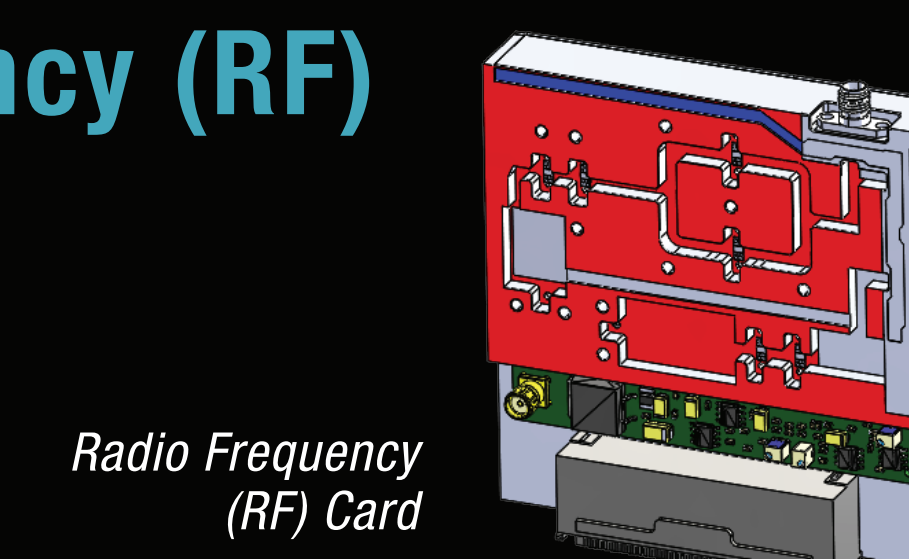
Radio Frequency (RF) Card

A SEA OF POSSIBILITIES

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