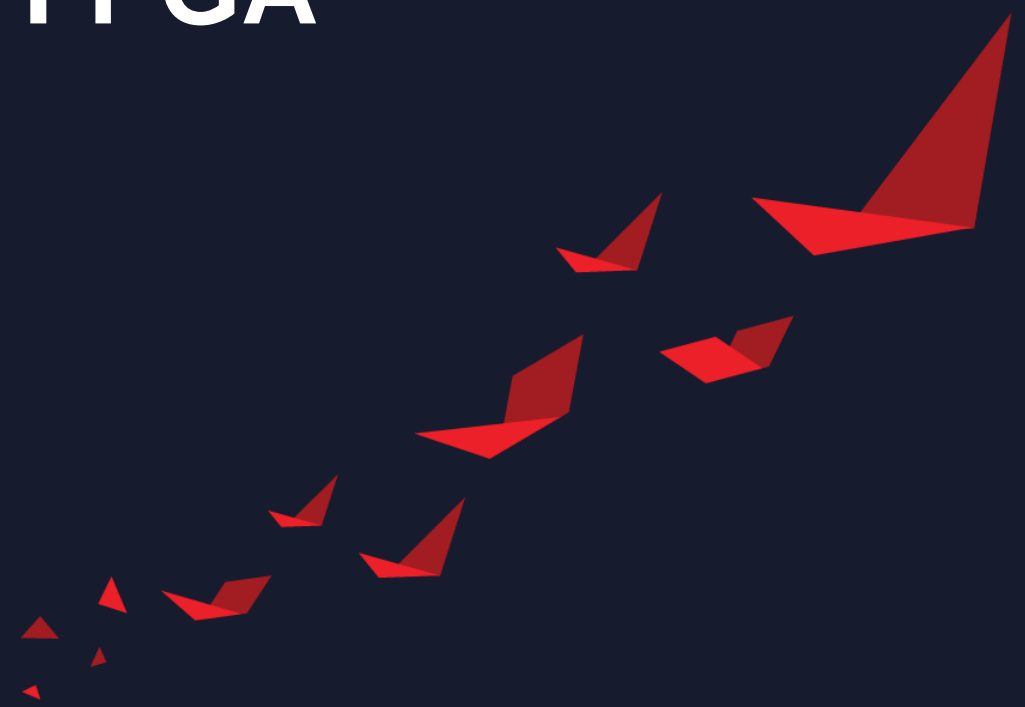




Launching Industry's First 20nm Radiation Tolerant FPGA for Space Applications

Minal Sawant
Space System Architect

May 19, 2020



Space Industry Market Challenges & Requirements



- ▶ Downlink Bandwidth is limited
- ▶ Fast time to market
 - Platform Concept for reuse on multiple missions



- ▶ Low Latency and High Bandwidth
 - E.g. Seamless and reliable connectivity for broadband communications



- ▶ Machine Learning in orbit



- ▶ Need for capability to process on board a satellite vs ground station
 - Reduce Development Time to launch (2-3 years Vs 5-6 years)
 - Process hundreds of Gbps data streams in real time



- ▶ Flexible System Architecture
 - Change algorithms “on the fly”
- ▶ Reliable components for long mission life, extreme environments
- ▶ SWaP (Size, Weight and Power) Tradeoffs

Key Target Markets and Applications

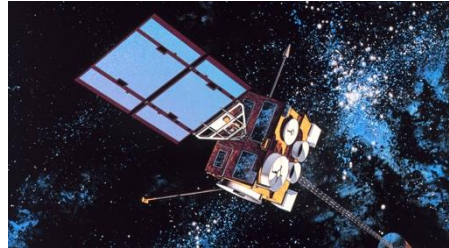
For Reconfigurable Payloads

Communication Payloads



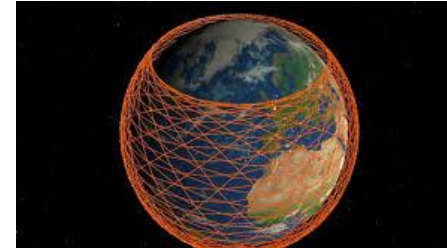
- ▶ Channelization
- ▶ Beamforming
- ▶ Phased Array Processing

Earth Observation Payloads



- ▶ Hyperspectral Cameras
- ▶ Synthetic Aperture Radar

Space 2.0 Constellations



- ▶ Broadband Internet
- ▶ High Speed Networks

Science Missions



- ▶ Display Modules
- ▶ Instruments
- ▶ Video Processing

Civil, Commercial & Defense Satellites

Signal Processing, HW/SW Reconfigurable, Robust Package, Space Grade Tested, On Orbit Flexible

Introducing the 20nm RT Kintex UltraScale FPGA

Building on 20+ Years of Heritage

Adaptive Computing for Ultra High Throughput,
High Bandwidth Satellite Applications

- ▶ True Unlimited On-Orbit Reconfigurable Solution
- ▶ >10X DSP Compute increase for Processing Intensive Algorithms & Analytics
- ▶ Full Radiation Tolerance across All Orbits
- ▶ Machine Learning Ecosystem enables High Performance Edge Inference in Space





Radiation Tolerant Kintex UltraScale XQRKU060

Process, Analyze & Reconfigure



RT Kintex UltraScale Platform

High Bandwidth Compute Capability

Features

- ▶ 2760 DSP Slices: Multi-precision fixed and floating point modes
- ▶ 32 High Speed SERDES (12.5Gbps): 400Gbps aggregate BW
- ▶ Radiation Tolerance across all orbits TID >100Krad/si, SEL >80MeV-cm²/mg
- ▶ Robust 40x40 mm Ceramic Column Grid Array Packaging

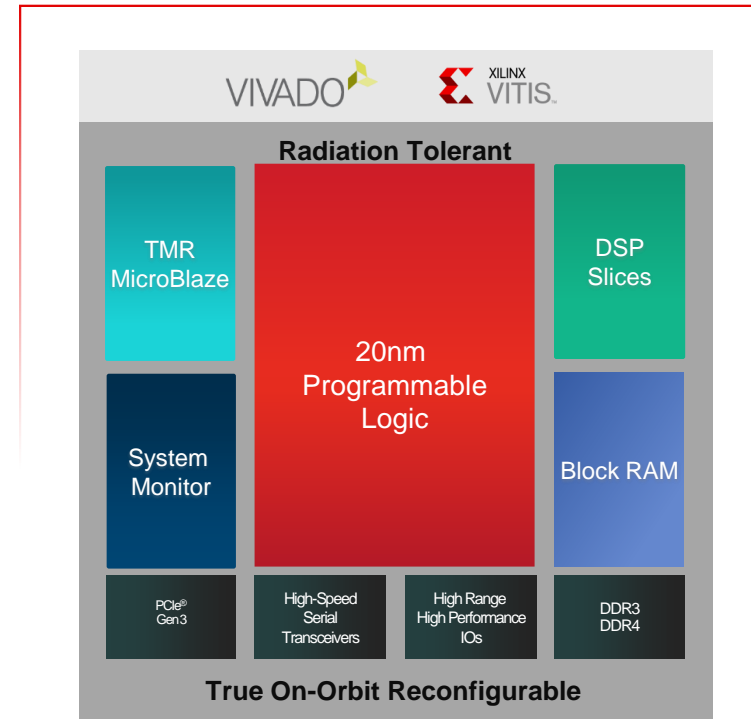
Meets Next Generation on Orbit Processing Needs

- ▶ Protos, Mechanical Samples: **NOW**
- ▶ Vivado SW, XPE*, Datasheet: **NOW**
- ▶ Production (Class B, Class Y): **Sept 2020**

*XPE Xilinx Power Estimator Tool
TID = Total Ionizing Dose
SEL = Single Event Latchup



MIL-PRF-38535



Simplified Development Environment

Vivado Design Suite



Next Gen Routing

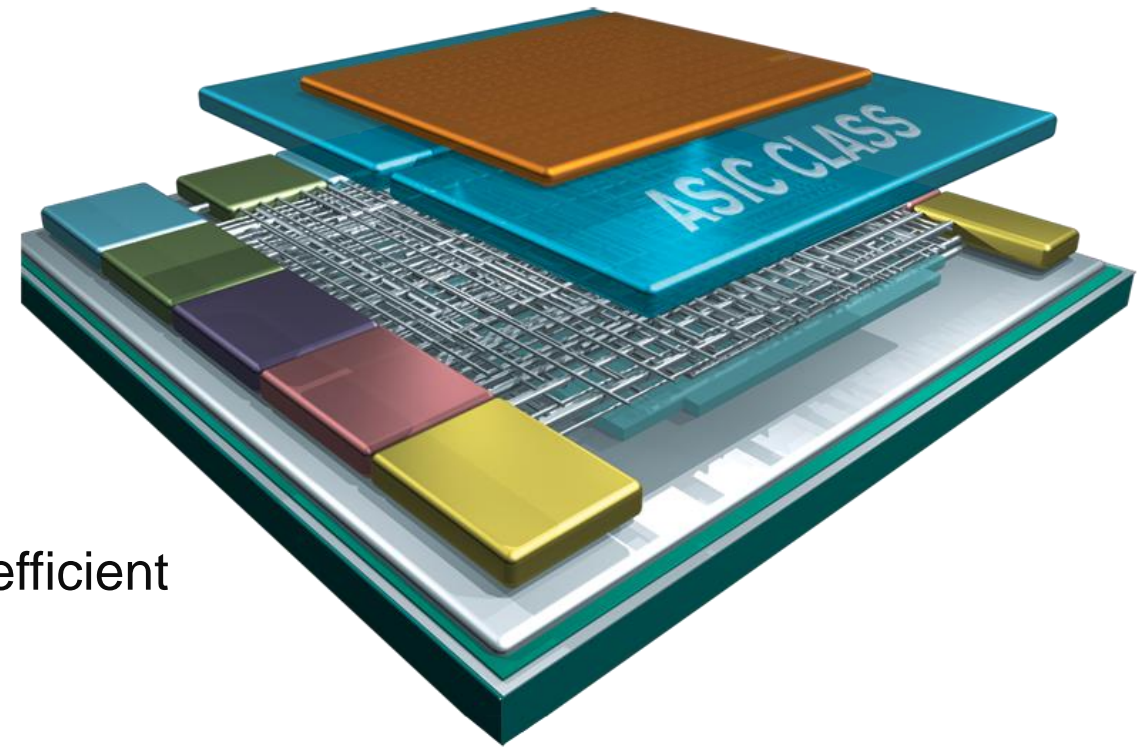
- ▶ Redesigned routing architecture
- ▶ **2X** routing resources, eliminates congestion

ASIC Like Clocking

- ▶ Flexibility for clock placement & balances skews

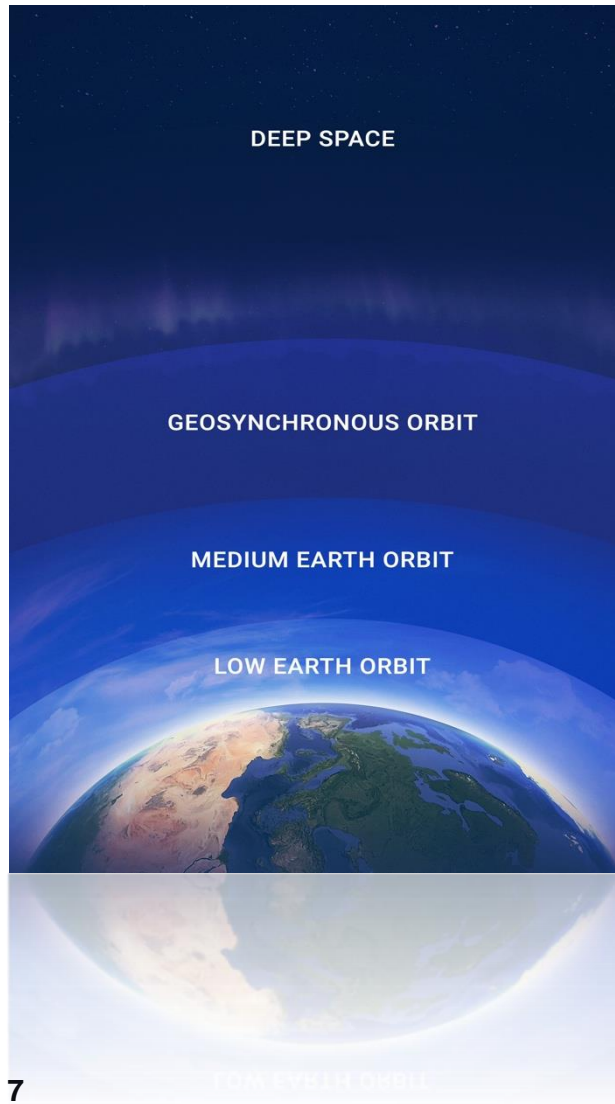
Intelligent 3D Analytical Placer

- ▶ Optimizes timing, congestion and wire length for efficient design placement



Space Resilient

Radiation Tolerance & Reliability Across All Orbits



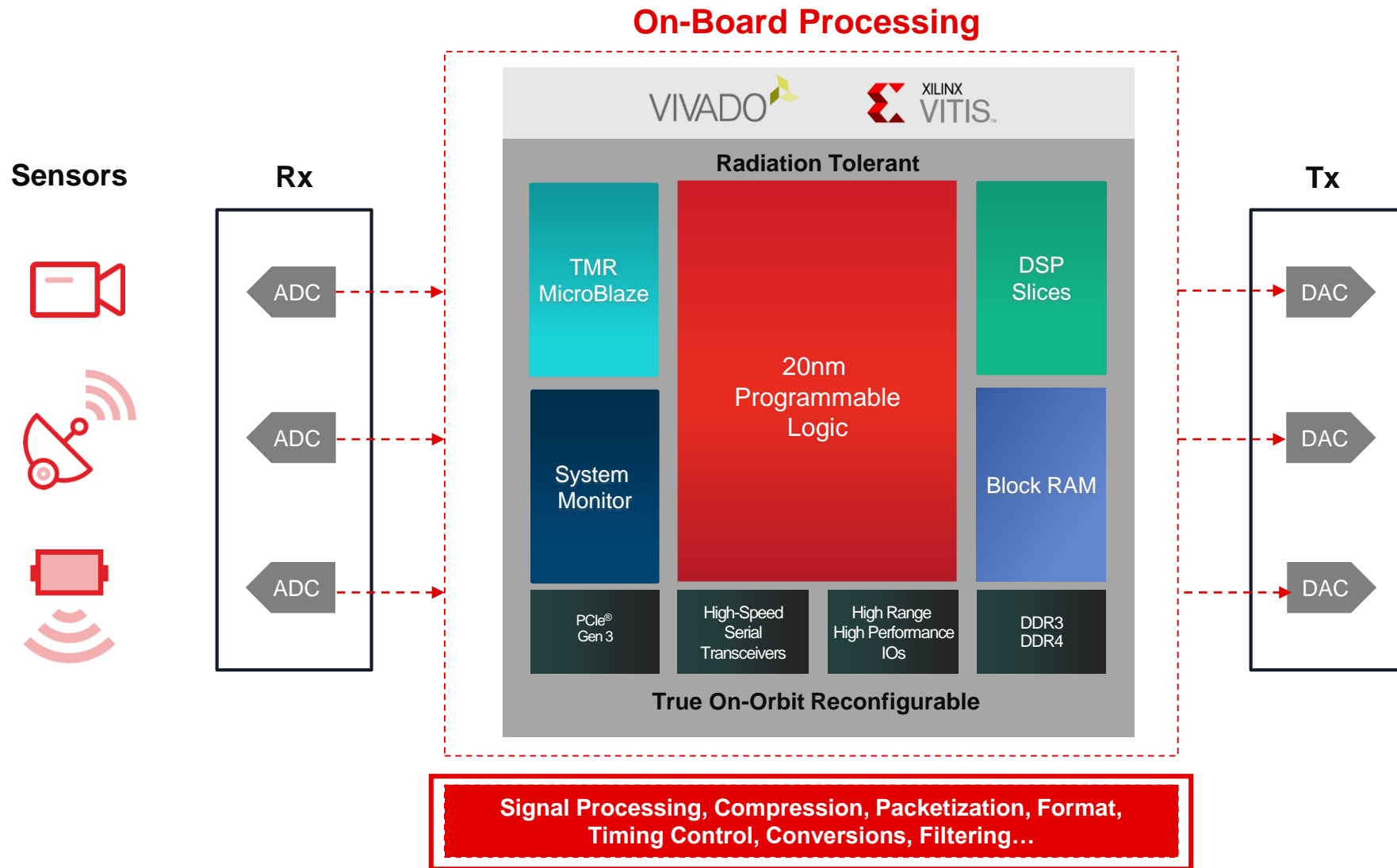
Radiation	Unit	LEO, MEO, GEO, Polar, Deep Space
Total Dose	>100 krad(si)	✓
Single Event Latchup	80 MeV-cm ² /mg @125°C	✓
SEU _{CRAM} SEU _{BRAM}	1 x 10⁻⁸ upset/bit/day 2.7 x 10⁻⁸ upset/bit/day	✓ (with Mitigation)

Silicon Reliability	Unit
20nm Family	<1.2 ppm
Kintex Family	3.8 FIT >3M Device Hours
XQRKU060	Passed 4000 Hours Class Y (QML-Y Equivalent) per MIL-PRF38535 in Progress

Package XQRKU060 Reliability	Package XQR5QV Reliability
CNA1509	CNA1752
Construction, Materials Similar	
Heritage in Space since 2009	

Unlimited On Orbit Reconfiguration

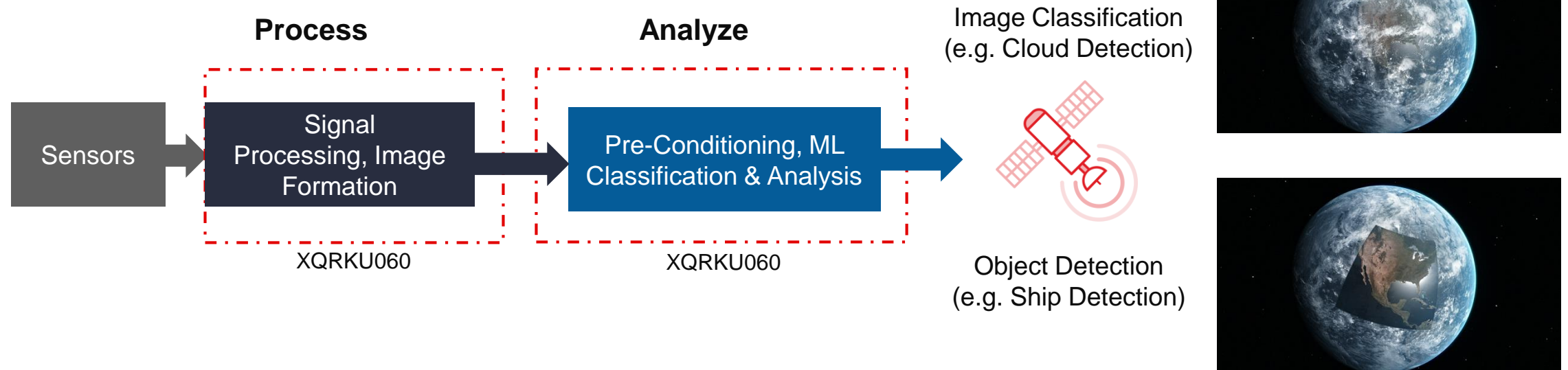
Change-on-the-Fly Capability



Bringing Machine Learning to Space

“Process and Analyze” with Real-Time On-Board Processing

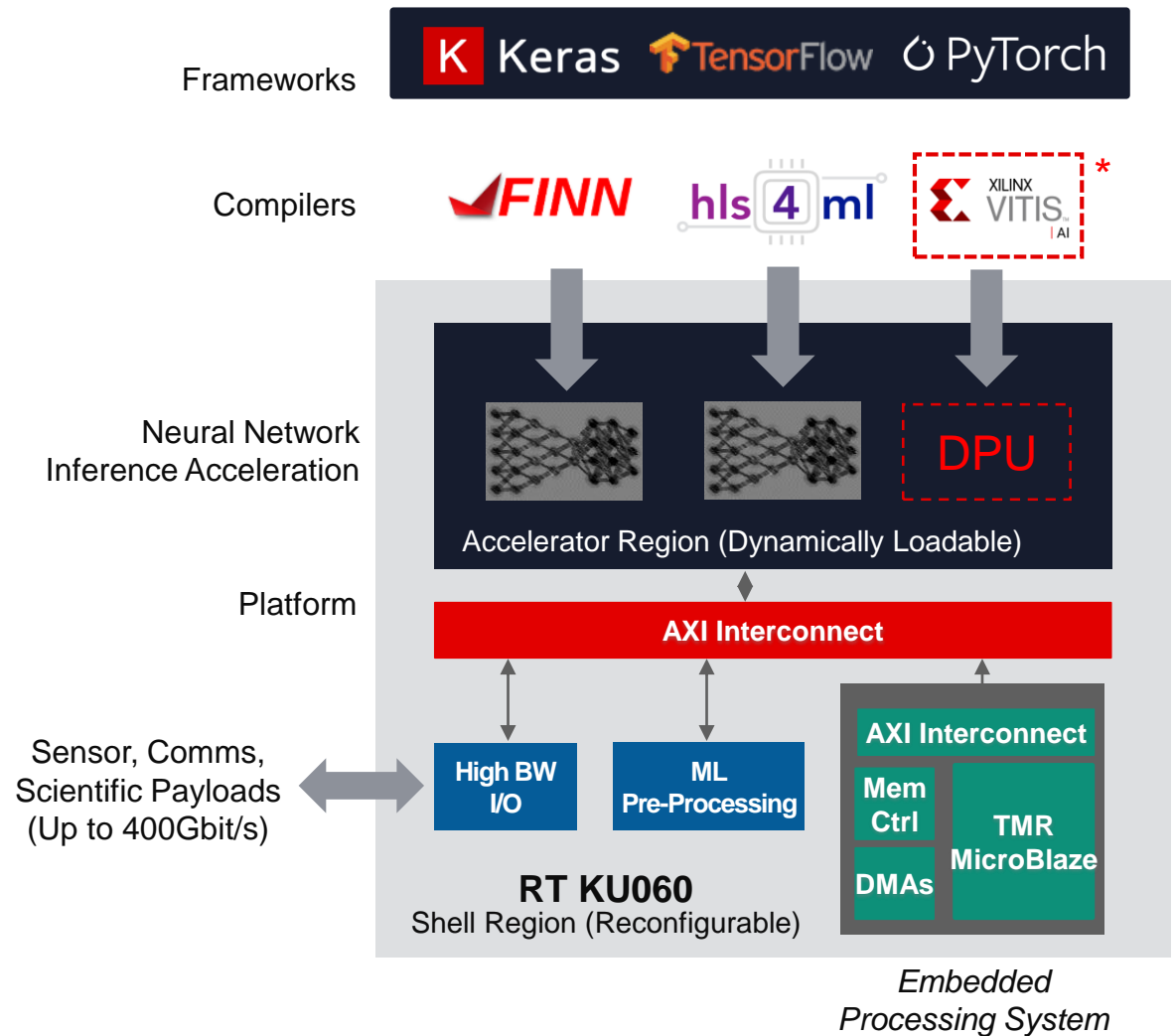
- ▶ Dense, power-efficient compute with scalable precision and large on-chip memory
- ▶ **5.7 TOPs** peak INT8 performance (nearly **25X** compared to prior generation space grade FPGAs)
- ▶ Triple Modular Redundant MicroBlaze™ supported by Xilinx Vitis™ Tools for ML-centric applications



Machine Learning on RT Kintex UltraScale

High Performance Neural Network Inference Acceleration

- ▶ Available flows today via open source compilers (FINN, HLS4ML)
- ▶ Low-latency, high-throughput performance with customizable pre/post-processing for CNNs & MLPs
- ▶ Supported ML frameworks include TensorFlow, Keras, PyTorch and others
- ▶ Multi-precision network support
 - Optimized for INT8 and below
- ▶ Future extensions to Vitis™ AI and Xilinx & Partner DPUs†

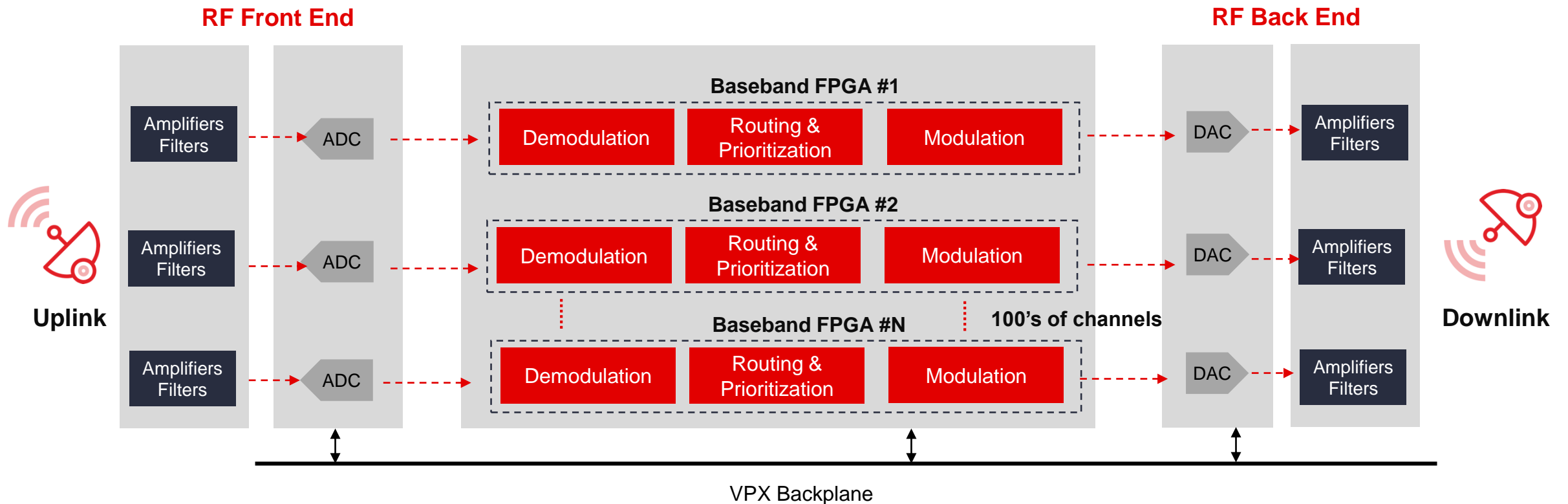


* Future Extension

† DPU = Deep Learning Processing Unit

Payload Use Case with RT Kintex UltraScale

Reconfigurable Telecommunication Satellite



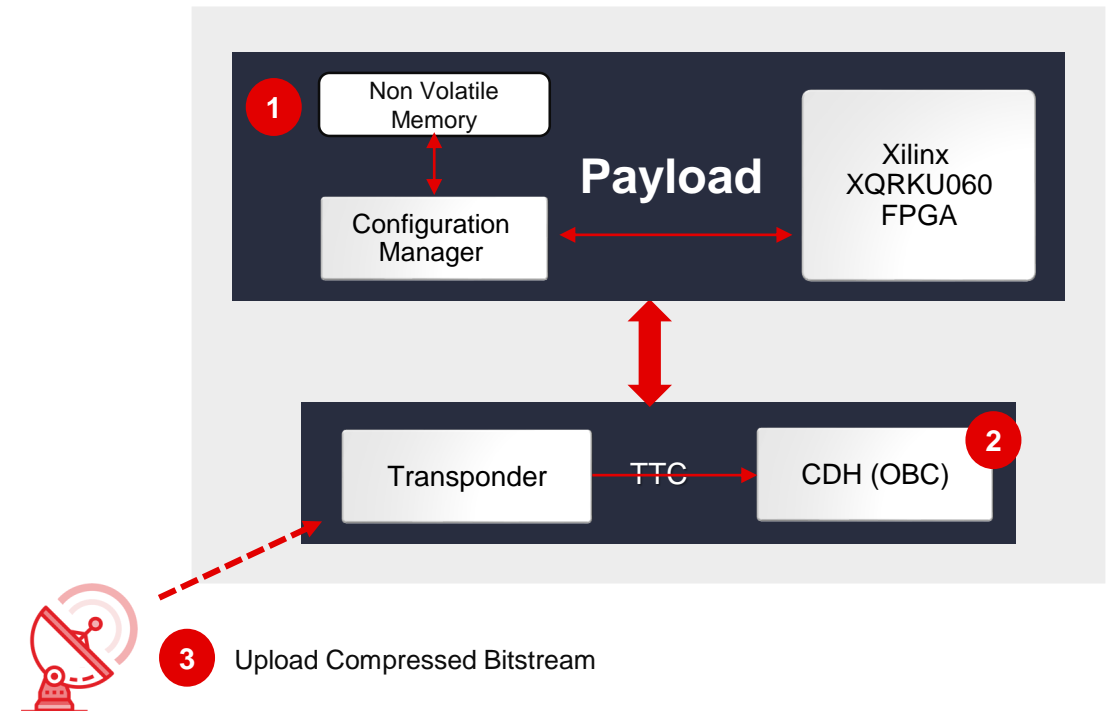
Allows Operators to Change and Adapt Frequency Plans, Channelization Bandwidths and Routing Uplinks to Specific Downlinks

Payload Use Case with Unlimited On-Orbit Reconfiguration



Reconfiguration Can Be Done by

1. Storage of multiple bitstreams in the Non Volatile memory
2. On-Board Computer (OBC)
3. Ground Station

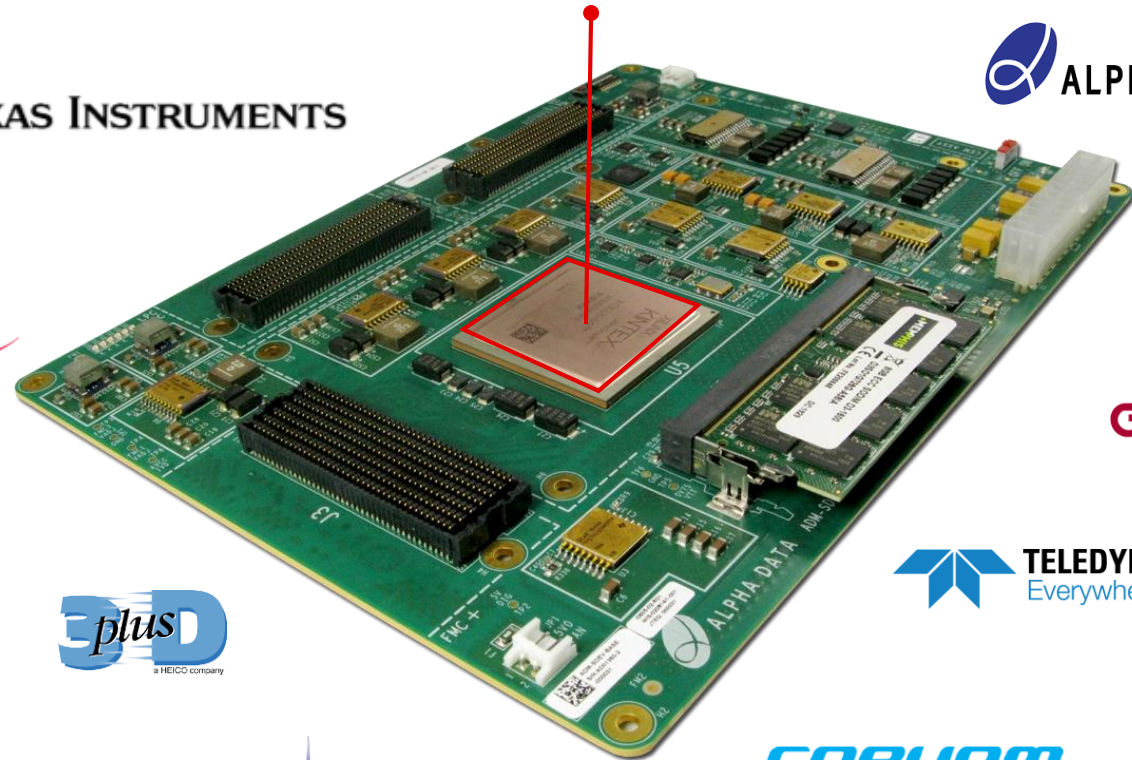


Ecosystem of Solutions

Available Today



Space Development Board	Alpha Data
SRAM	Infineon Technologies
NVM	Infineon, Cobham
DDR3	3DPlus
MCU	Cobham
TMR Synthesis Tool	Mentor Graphics
IP	Star Dundee
Power Solutions	Texas Instrument
High Speed ADC	Texas Instrument, Teledyne e2V

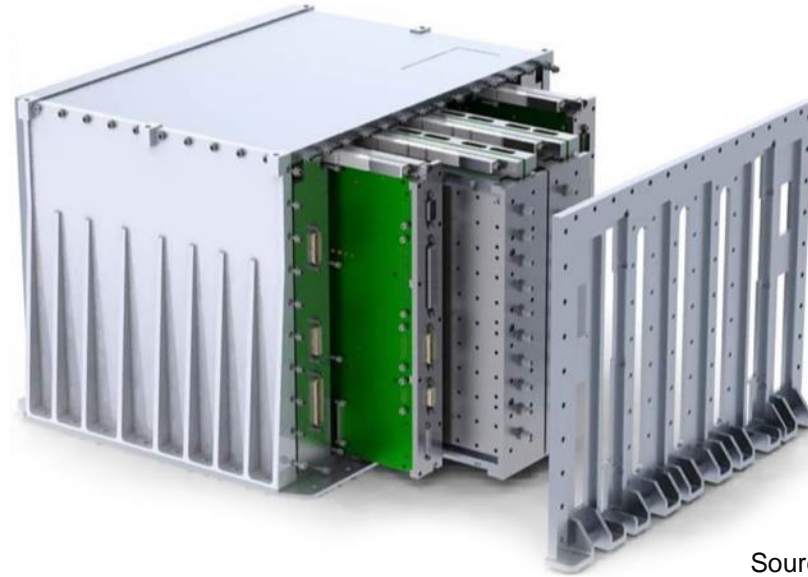


RT Kintex UltraScale Product Table

	XQRV4QV	XQRV5QV	XQRKU060	
Radiation Hardness	Tolerant	Hard	Tolerant	
Process (nm)	90	65	20	
Memory (Mb)	4.1 to 9.9	12.3	38	
System Logic Cells (K)	55 to 200	131	726	
CLB Flip-Flops (K)	49.1 to 178.1	81.9	663	10X
CLB LUTs (K)	49.1 to 178.1	81.9	331	
MGTs	None	18 at 3.125 Gbps	32 at 12.5 Gbps	5X
User I/O	640 to 960	836	620	
DSP Slices	32 to 192	320	2,760	8X
Radiation (TID (krad/si), SEL (MeV cm ² /mg))	300, >125	1,000, >125	100, >80	
Reliability (Package, Test)	CNA1509; V-Flow	CNA 1752; B-Flow & V-Flow	CNA 1509; B-Flow & Y-Flow	

20nm UltraScale in Reconfigurable Platform

Baselined in Application

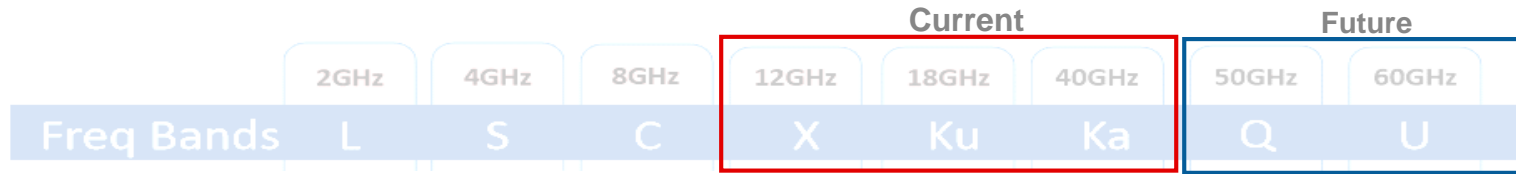


Source : SEAKR

- ▶ **Company:** SEAKR Engineering, Inc. Colorado
- ▶ **Product:** Reconfigurable Processor
- ▶ **FPGA:** 20nm UltraScale KU060
- ▶ **Function:** Interconnected with 12 Gbps SERDES links enabling high-throughput, flexible and reconfigurable modulation, demodulation, channelization and routing capability.
- ▶ **Application:** GEO SatCom

<https://www.seakr.com/seakr-announces-new-rf-reconfigurable-processor-for-space-platforms/>

Future Rollout for Space Applications



Directional Plan*
 SIP, Higher Density FPGAs,
 Next Gen Nodes
 XQ Ruggedized, Machine
 Learning, Vitis

Radiation Tolerant: **XQR**
 Defense Grade: **XQ**

Xilinx Class B, Class Y – **Sept 2020**
 Xilinx DPU Support – **Sept 2020**
 QML Class Y 2021-22



Shipping Today

Shipping Today



Virtex
XQR4QV

Virtex
XQR5QV

Kintex
XQRKU060

90nm

65nm

20nm

Next Gen Solution

Technology Nodes

* Xilinx evaluating these solutions

Strong Adoption and Heritage for 20+ Years



GRACE



MER



TerraSAR

PAST



OSIRIS REx



Iridium NEXT



Curiosity Rover

PRESENT



Perseverance MARS2020



ExoMARS



Next Gen Payloads

FUTURE

Key Takeaways

Industry's First 20nm Radiation Tolerant (RT) FPGA Targeted for Ultra High Throughput & High Bandwidth Satellite Applications

True Unlimited On-Orbit Reconfiguration to Enable “Change-on-the-Fly” Capability in All Orbits Across Space

Complete Solution to “Process and Analyze” for Real Time On-Board Processing including Machine Learning



Thank You

