An Open Architecture, Server-Based Solution for Next Generation Electronic Warfare System

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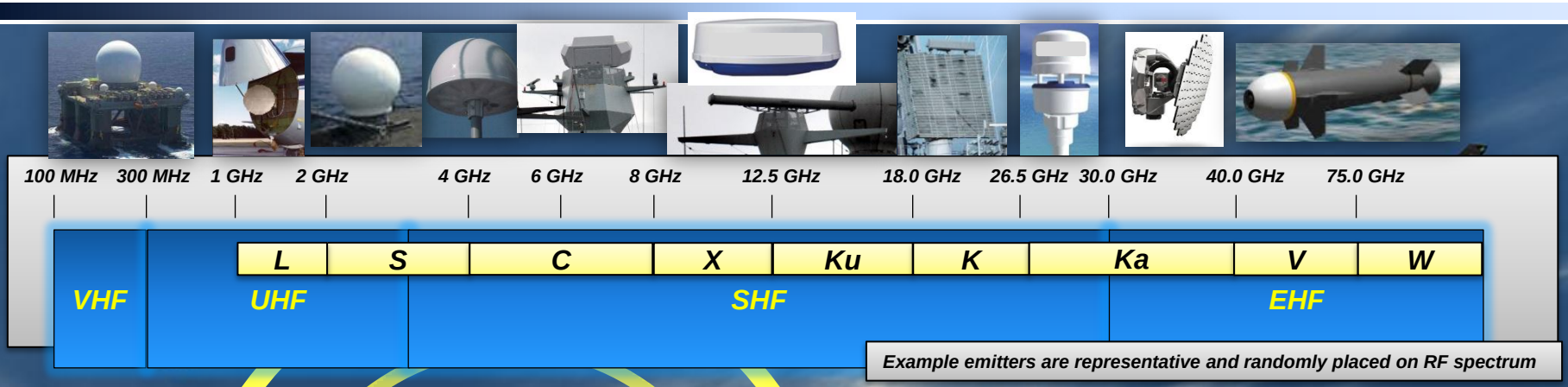
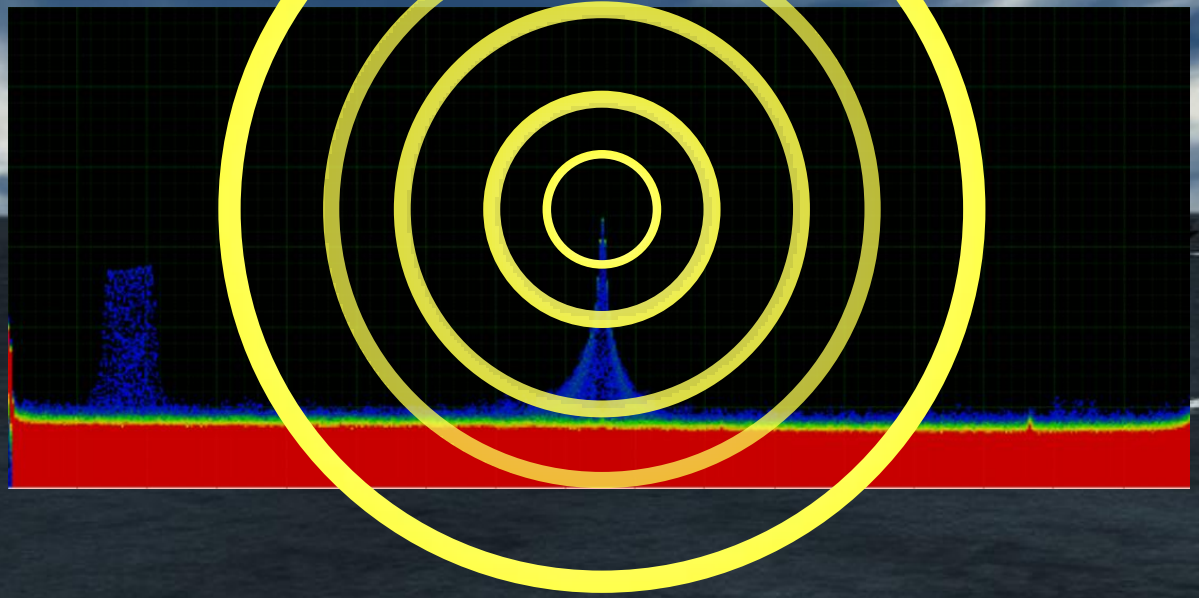
LOCKHEED MARTIN

Outline

- Electronic Warfare Overview
- IR&D Backstory
- System Architecture
- Network and GPU Performance

The EW Battlespace & RF Spectrum Challenge

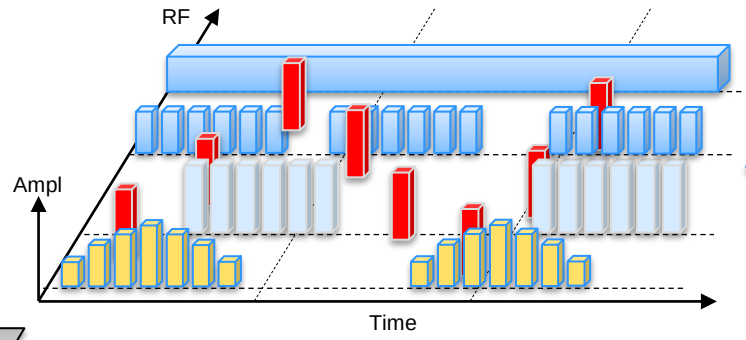


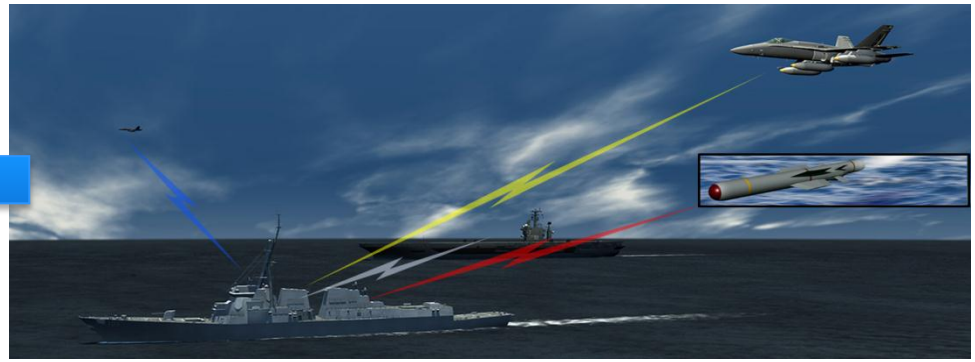


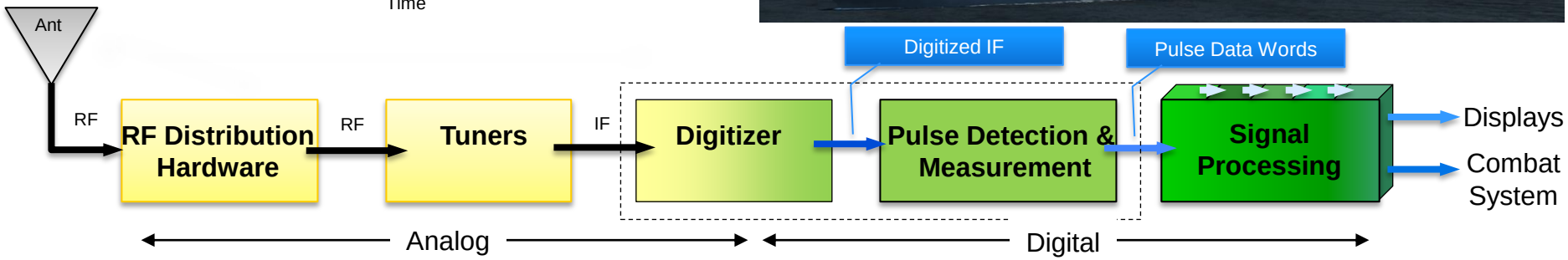
- Our Customers Need The Ability to Detect, Analyze, and React to Emitters in the Battlefield
- Modern EW Systems need to measure and report the **entire** RF Spectrum
- The RF spectrum is both wide and dense
- The emitters are diverse : commercial and military
- Emitters are becoming more agile with the landscape constantly changing

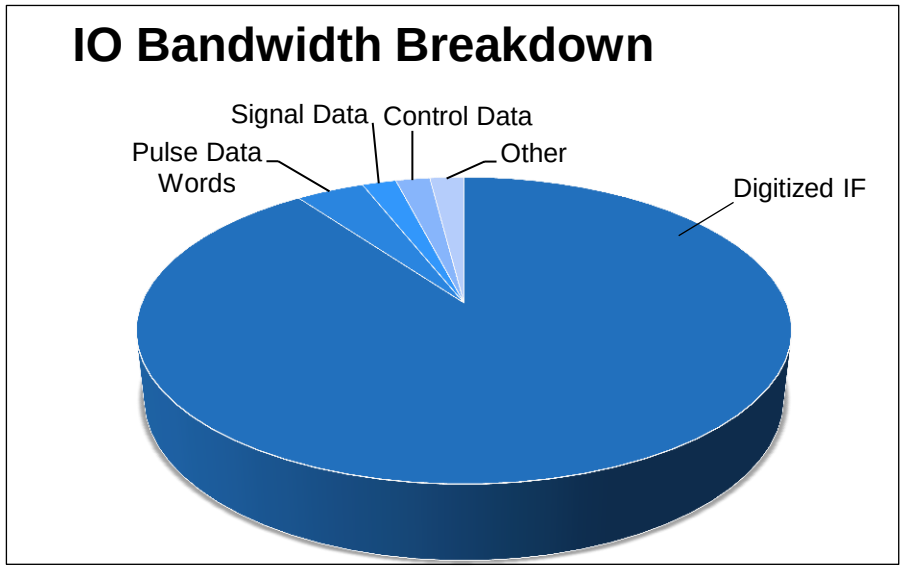
Previous approaches of selective listening on known emitters are not adequate

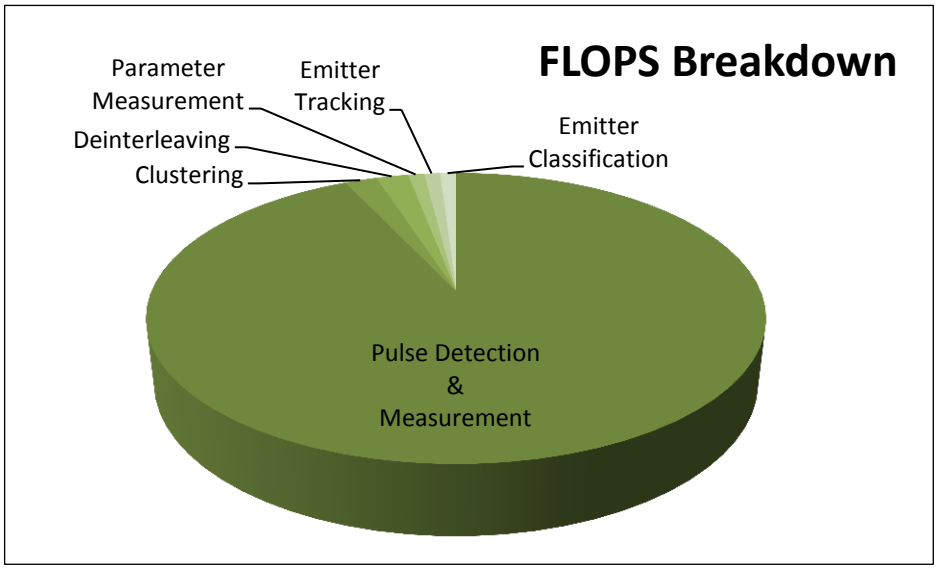
EW System Architecture - Basic



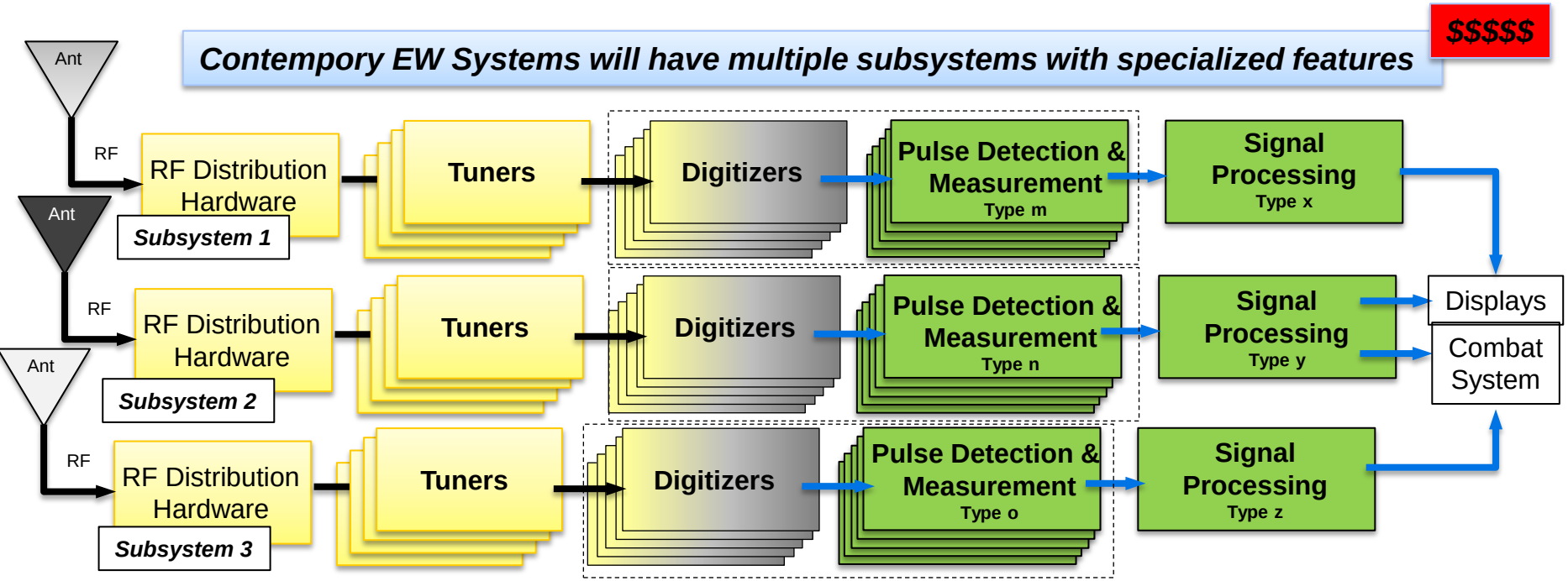


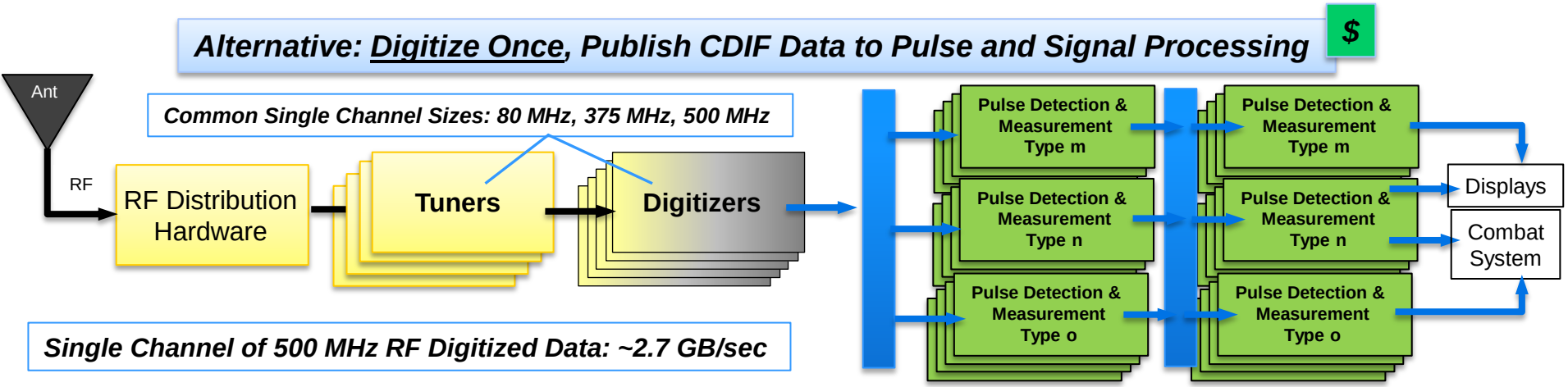






EW System Architecture – Scaled





I&RD Project Objectives

Key Tenants Envisioned for Next Generation EW System Architectures

- Digitize the Spectrum and Distribute CDIF via a Flexible Digital Backbone
- Deliver new capability via mission and target-specific software applications hosted on a common hardware solution
- Replace custom, proprietary interfaces with open, standardized interfaces to facilitate rapid and affordable capability insertion

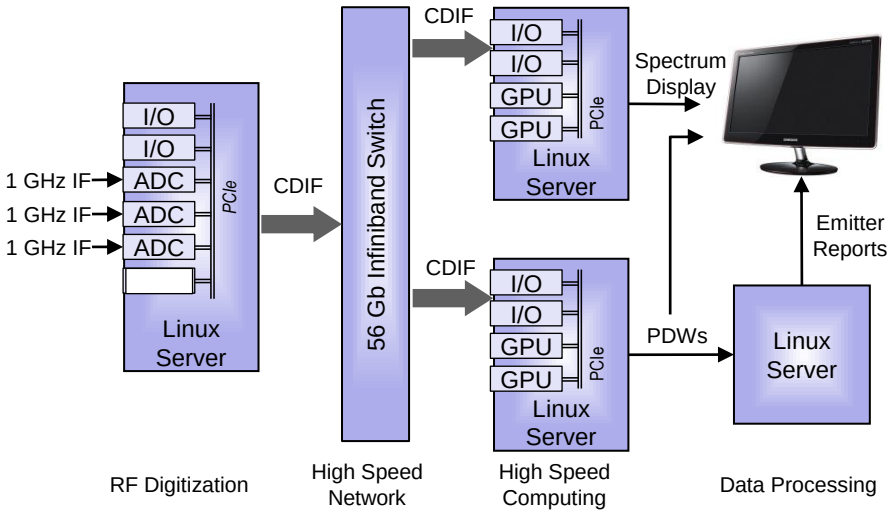
Server-Based Electronic Warfare Engineering Development Model

- Objective: To evaluate the ability of current & projected COTS technologies to realize Next Gen EW Architecture Vision

Server-Based Electronic Warfare Demonstrator

Advanced Development Model Overview

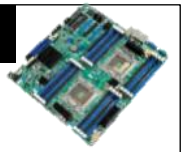
Architecture



Objectives

- ✓ Validate key COTS technologies: RF digitization, high-speed networks and high-speed computing environment
- ✓ Migrate pre-existing FPGA and PowerPC based receiver processing to Linux Servers and Intel & NVIDIA accelerators
- ✓ Demonstrate scalability of architecture to greater bandwidths (wideband feasibility)
- ✓ Validate Open Interface Data Distribution Services (DDS) publish / subscriber services
- ✓ Verify key TPMs: CDIF throughput, Processing Bandwidth, Measurement Accuracy, Dynamic Range

Enabling Technologies

COTS A/Ds Digitizers	PCIe Gen 3.0	High Speed Network	General Purpose GPUs	Intel Xeon Multicore CPUs
				
• Easily scaled across general purpose HW hosts • Flexibility in configurations • Publish source I&Q data • **Today**: 12 bit @ 500 MHz • **Next Gen**: 16 bit @ 500 MHz	• Open standard with accelerated performance road map • More configurable, higher bandwidth than VME • **Today**: 7.88 GB/sec (8xGen 3) • **Next Gen**: 15.7 GB/sec (8xGen 4)	• Widely used open standard provides most bandwidth solution • User level multicast • Near term (2015) projection of >100 Gbps • **Today**: 7GBps per channel • **Next Gen**: 12.5 GBps per channel	• Excellent GFLOP/watt ratio • Cost benefit over FPGA • High-order SW language • Vast CUDA libraries • **Today**: Kepler GPUs with ~5 GFLOPS per watt • **Next Gen**: Maxwell GPUs with ~12 GFLOPS per watt	• Excellent GFLOP/watt ratio • Supports numerous High-order programming languages • Most mainstream target processing environment • **Today**: 2600 Xeons • **Next Gen**: Xeons with Phi Accelerator

100% COTS Architecture Provides an Open, Scalable, Upgradable and Affordable Solution

EW Advanced Development Model – First Generation

Next Generation EW System – *Tactically Relevant, Multi-Channel, Open Architecture EW Solution*

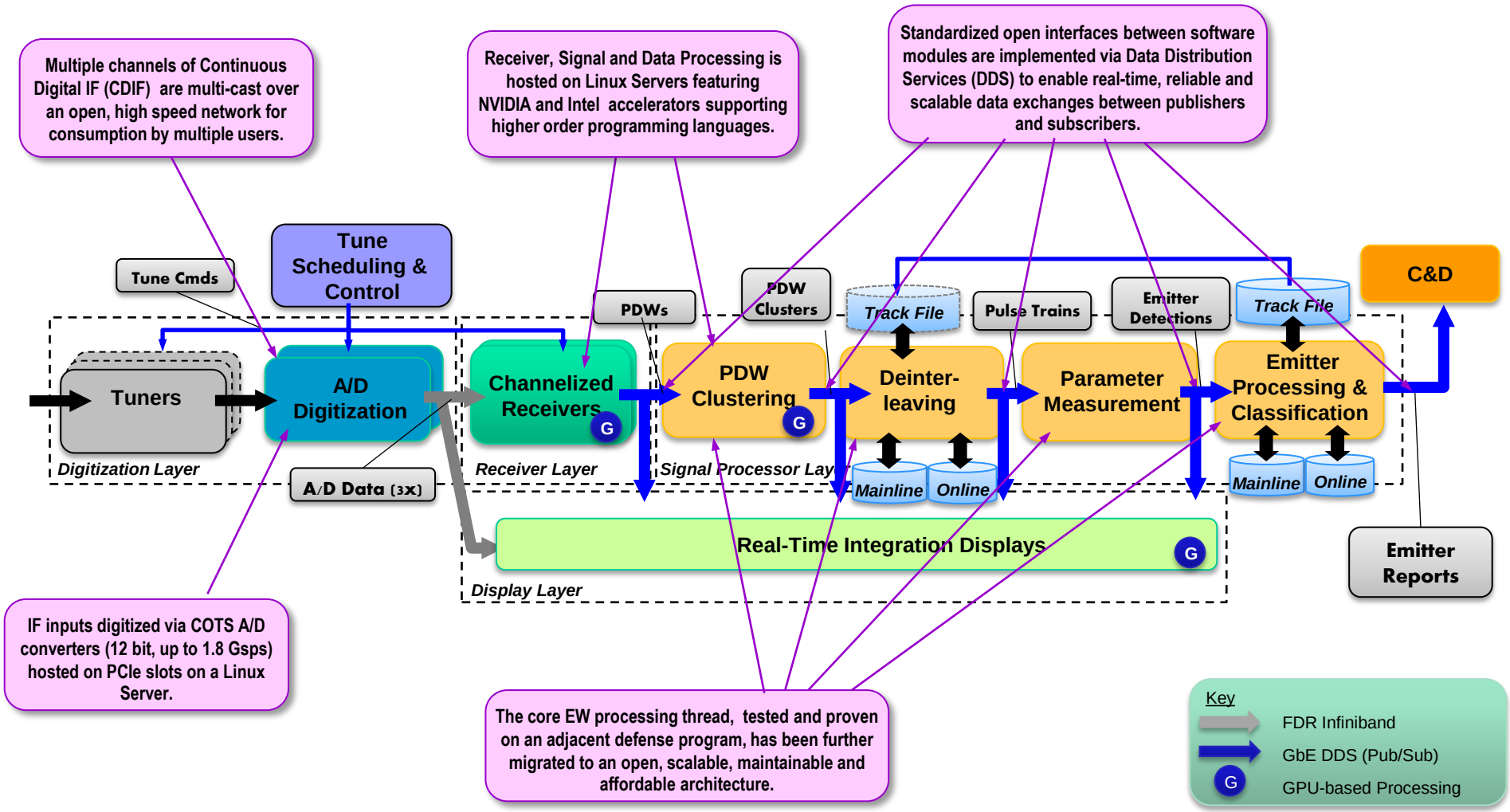
Digitization Layer– *COTS A/D Solution Digitizes and Multicasts all CDIF Data to a Scalable Number of Processing Nodes*

Processing Layer – *COTS GPGPUs Perform Bulk of Real-Time Signal Processing with Multi-Core CPU's Completing the Balance*

High Speed Network– *56 Gbps per channel Infiniband Network*

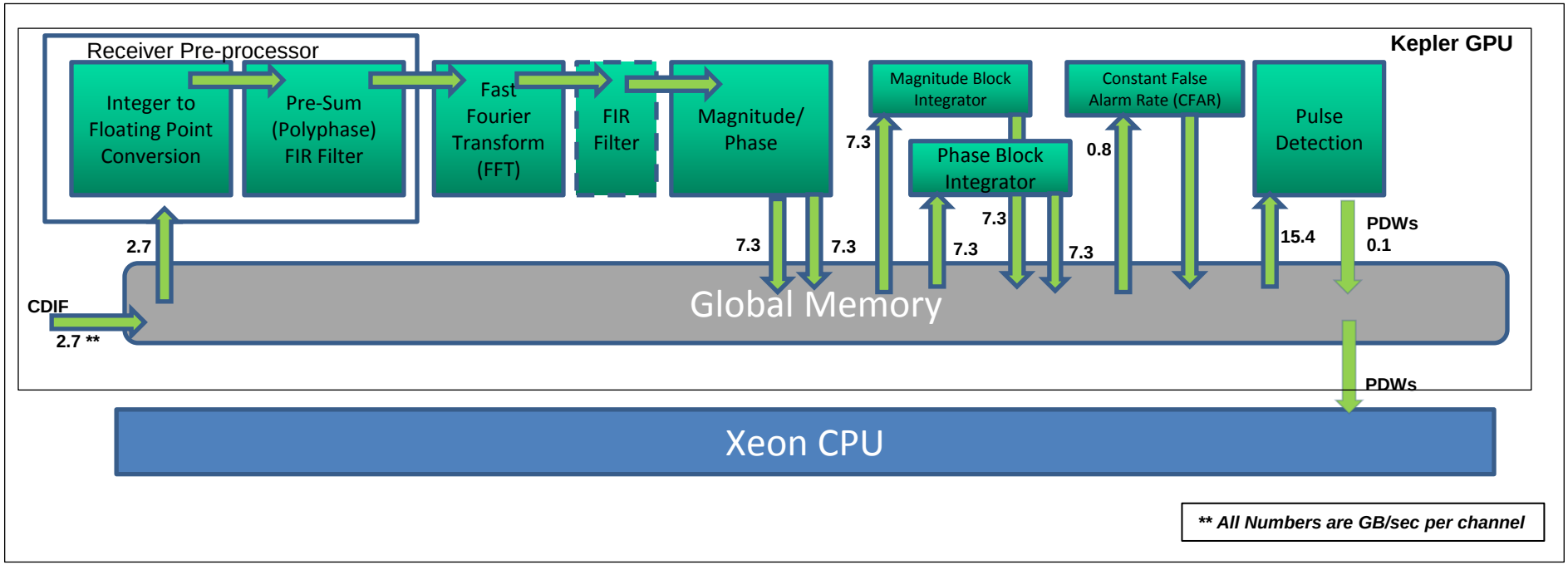
Server-Based Electronic Warfare ADM

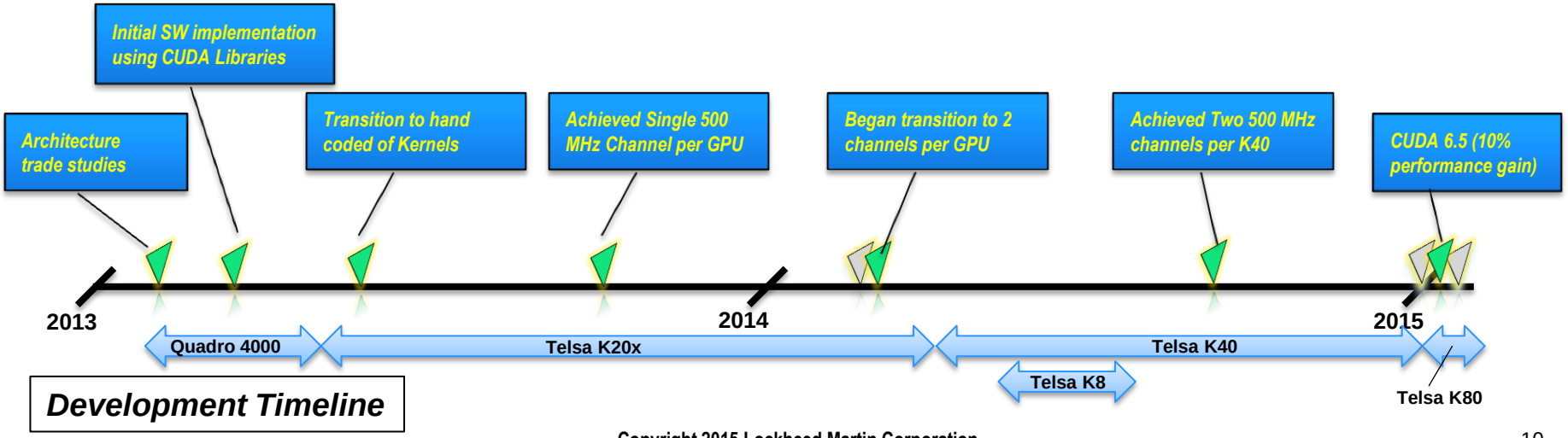
Software Overview



Open Architecture and Modular, Software-Based Solution Facilitates Rapid Capability Insertion in Response to New and Evolving Threats

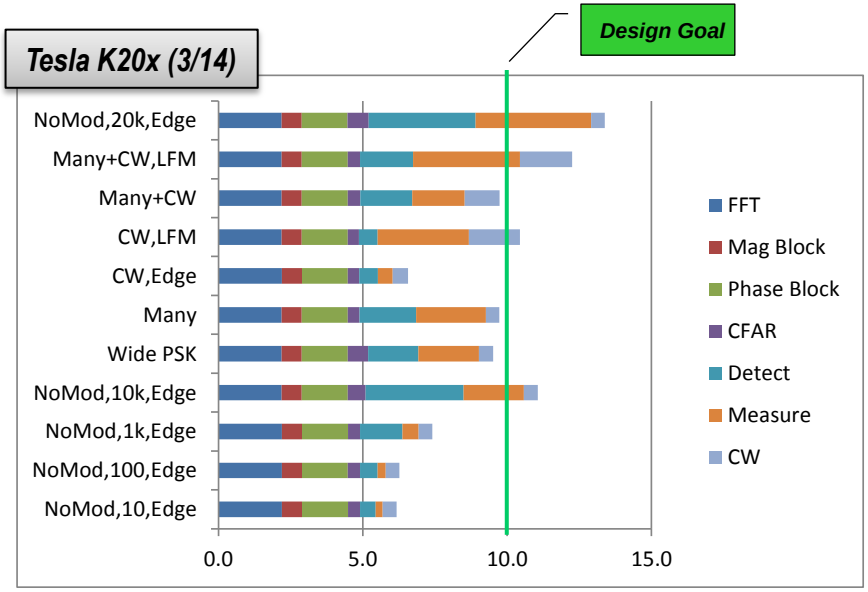
Channelized Receiver GPU Implementation & Timeline



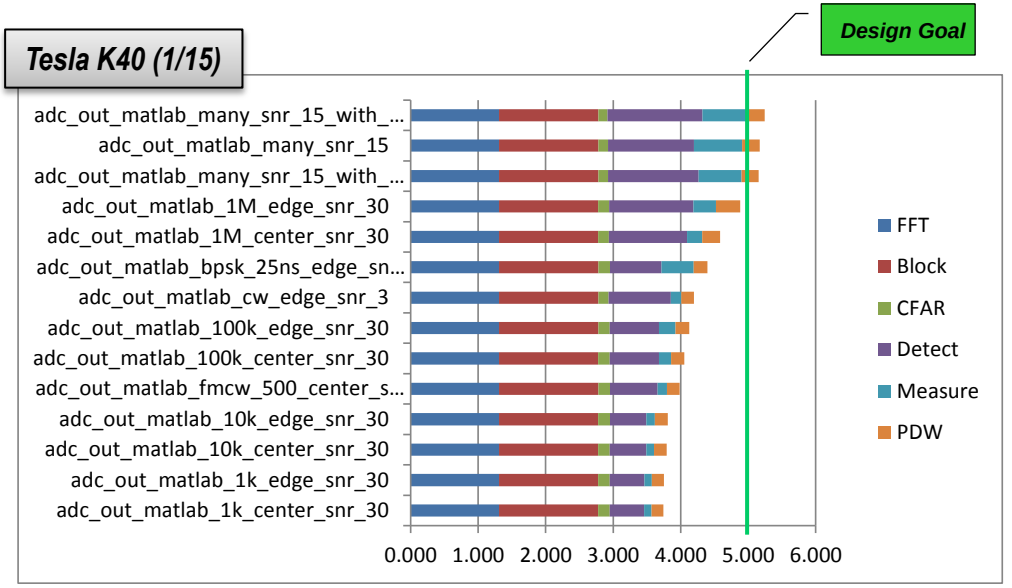


Benchmarks – 3 Generations of GPGPUs

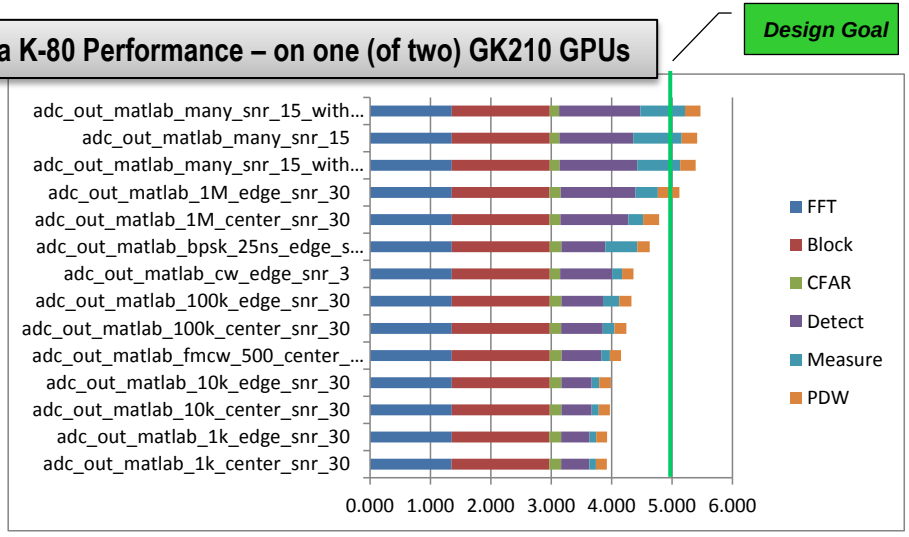
Tesla K20x (3/14)



Tesla K40 (1/15)



Tesla K-80 Performance – on one (of two) GK210 GPUs



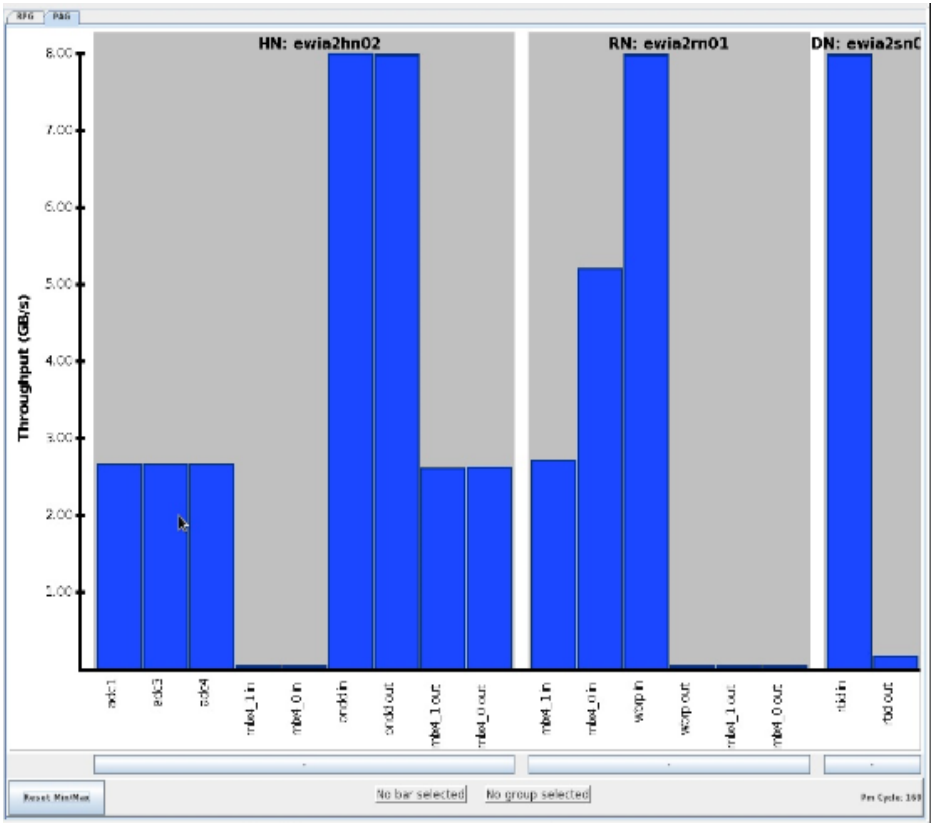
Tesla K-80 Single Precision Performance (Constant Data Stream)

Kernel	K40	K80 (per GPU)	
Samples	13330000	13330000	
Threads	1666250	1666250	
Ops	1.14638	1.14638	Gflops
Time	1.058	1.185	ms
Ops/s	**1084**	**967**	Gflops

700 GLOPS typically advertised for Single Precision cuFFT processing (FFT length of 4096)

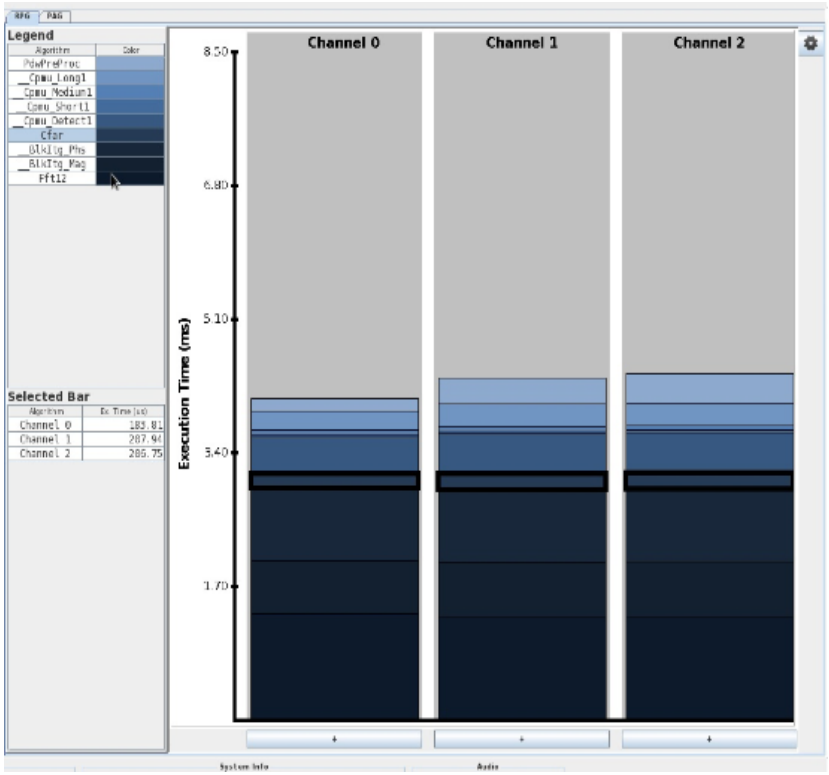
cuFFT 6.0 on K40c, ECC ON, 32M elements, input and output data on device

Real-time Instrumentation

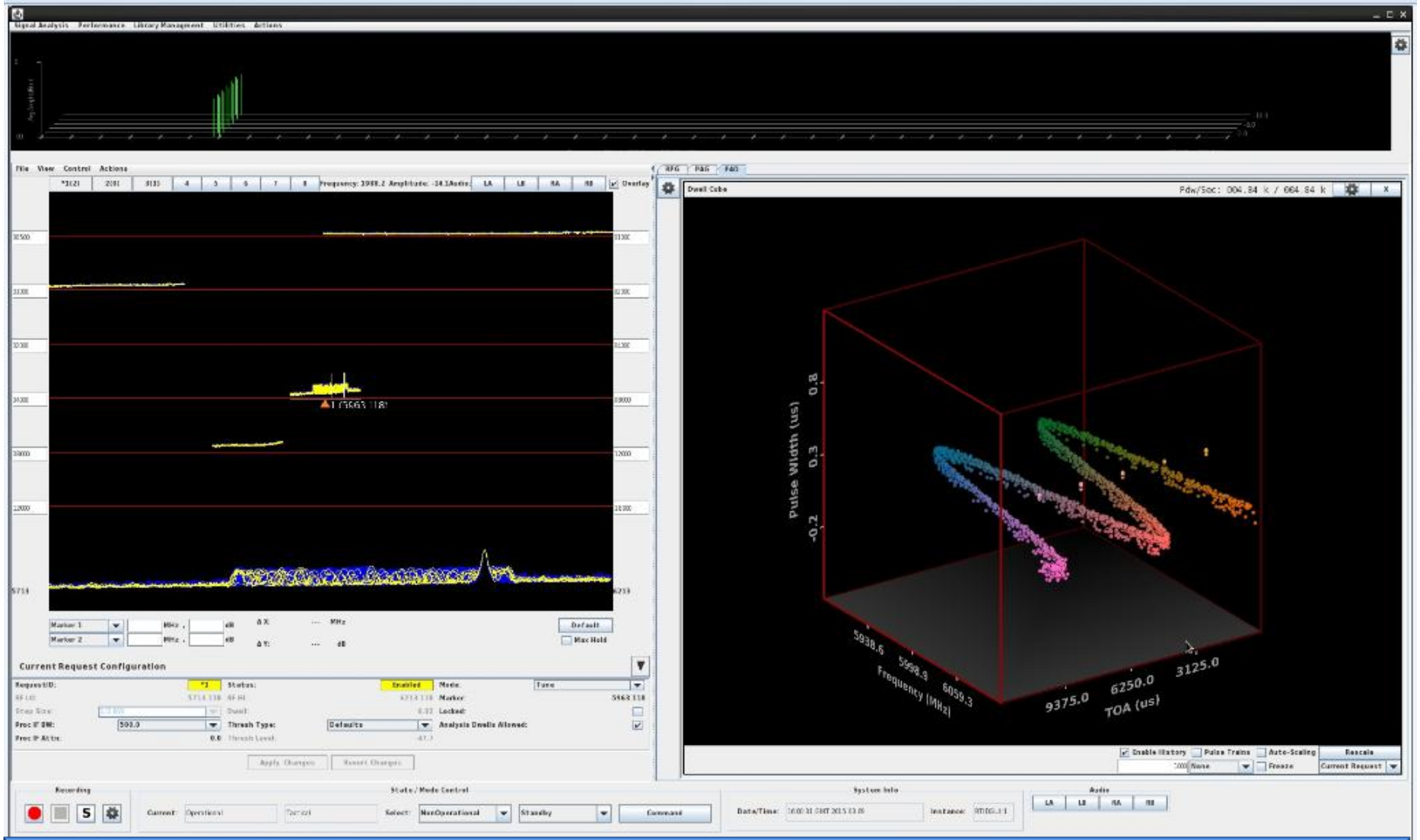


- Software monitors utilization of GPU resources
- Color-codes various stages of the Channelized Receiver processing over time

- Software monitors all network related resources and provides real-time feedback on current throughput
- Screen capture confirms Multicast Infiniband of high bandwidth Digitization Data



Signal Processing Displays



Both Core Signal Processing Software and Real-time Signal Processing displays hosted on GPU processors

Summary

- **Conclusions**
  - The Enabling Technologies are moving fast driven by wide commercial / non-defense markets
  - We continue to be encouraged by results to date and anticipate continued performance gains due to ongoing COTS evolution
- **Next Steps**
  - The transition of this server-based architecture to a tactical system is underway
  - Extend architecture to additional applications across the RF/EW enterprise
    - Through integration of mission and target-specific SW applications
    - Through continual integration of next generation COTS HW technologies

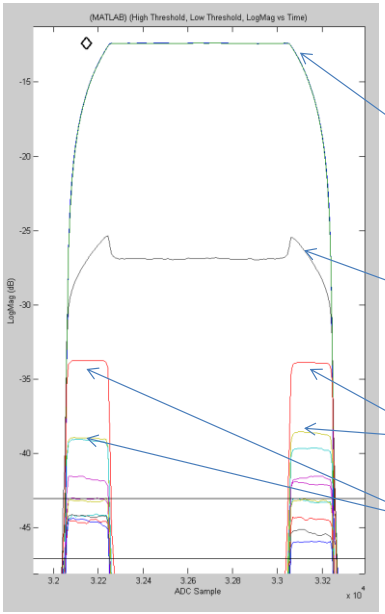
As the Technology Matures, More Systems will Adopt, Accelerating Development

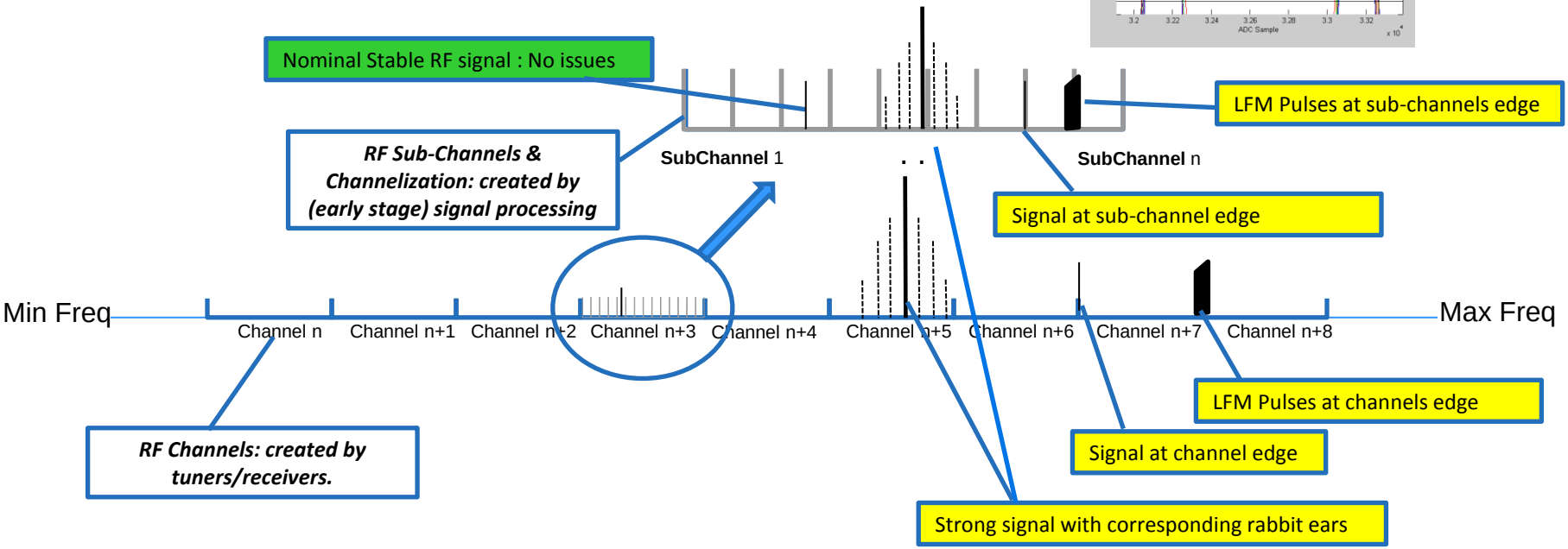
1.0 – Complex Pulse Measurement - Background

Pulse Filtering and Channelizer Compensation

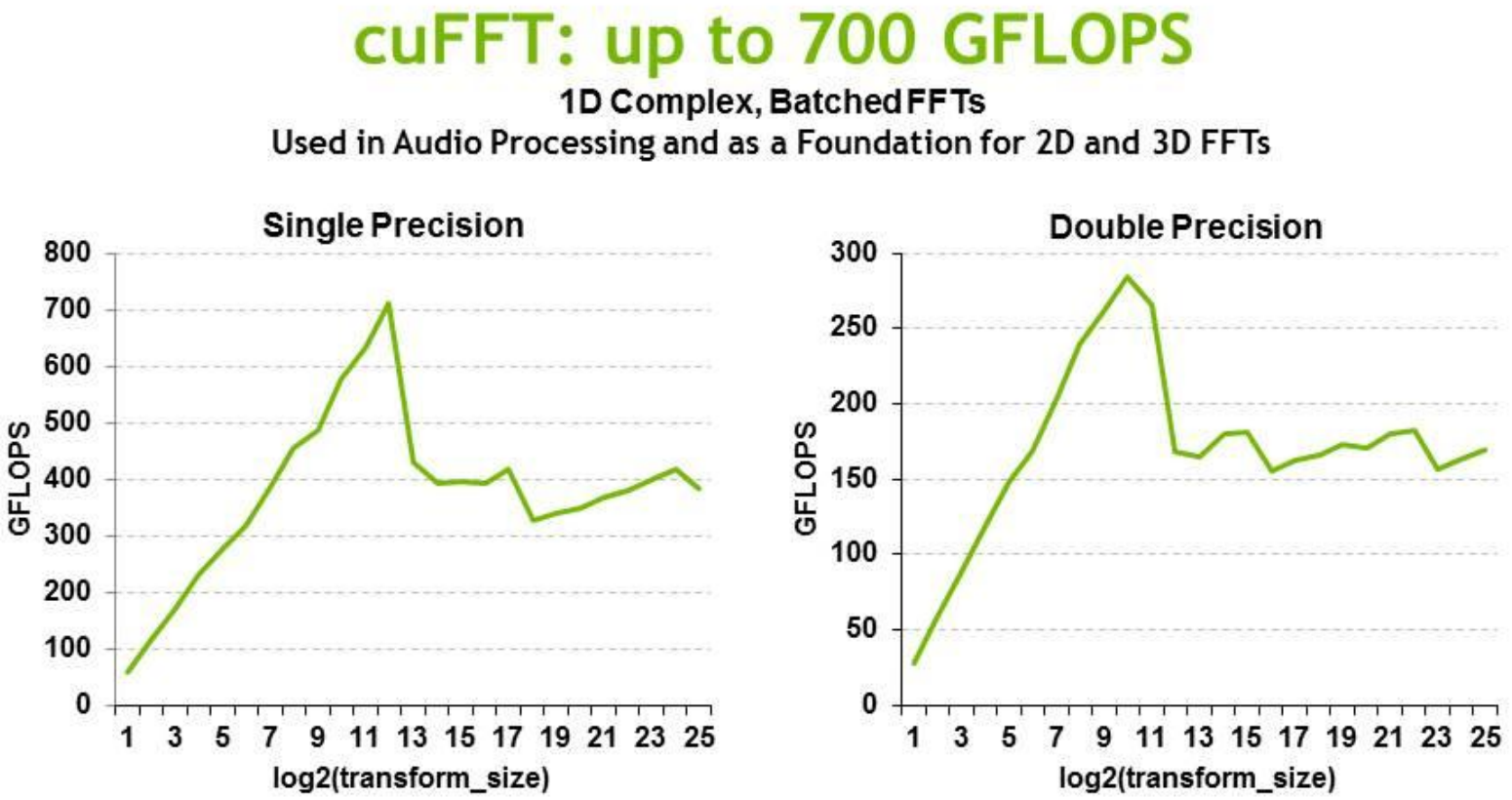
Summary:

- **To achieve wideband coverage, the RF spectrum is divided into channels and further sub-divided into sub-channels**
- **The division/sub-division of the RF spectrum creates conditions that have to be accounted for various signal types in order to accurately measure/characterize the RF environment**





FFT Performance



Performance may vary based on OS version and motherboard configuration

• cuFFT 6.0 on K40c, ECC ON, 32M elements, input and output data on device