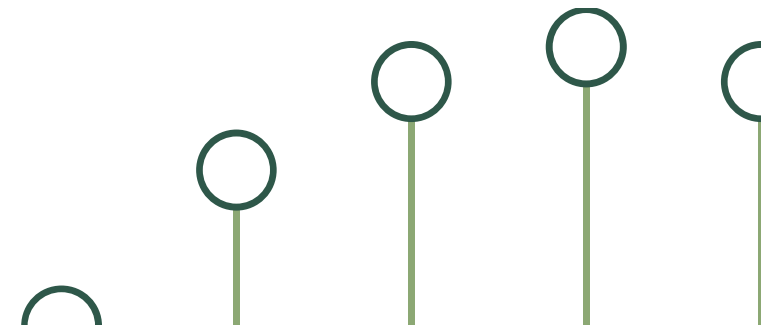




# Ettus Research Future Directions

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4<sup>th</sup> OAI Workshop  
Paris, France  
November 8, 2017



# Company Overview



- USRP family of software-define radio (SDR) products
- A National Instruments (NI) company since 2010
- Located in Silicon Valley, California
- Multiple operating areas include satellite, cellular, vehicular, and radar
- Open source focused - GNU Radio, OpenAirInterface, Osmocom, and other software ecosystems



# NI Platform for Radio Prototyping

## APPLICATIONS

Mobile Broadband

5G Research

Spectrum  
Monitoring

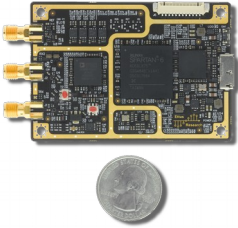
Industrial Internet of  
Things (Wireless)

Radar

V2V, V2I, V2X



# Ettus Research Product Line



B-Series  
USB  
12 bit ADC/DAC  
Up to 56 MHz bandwidth



N-Series  
1 GigE Ethernet  
14/16 bit ADC/DAC  
Up to 40 MHz bandwidth



X-Series  
Dual 10 GigE Ethernet  
14/16 bit ADC/DAC  
Up to 160 MHz bandwidth



E-Series  
Embedded ARM processor  
12 bit ADC/DAC  
Up to 56 MHz bandwidth



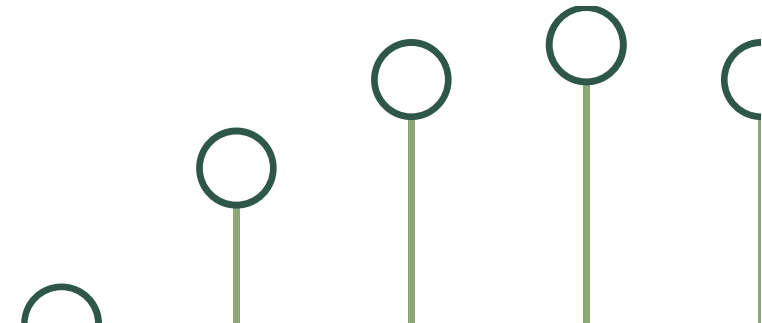
# Contents

- USRP N300/N310
- USRP E320
- Future Directions for 5G





USRP N300/N310



# N300/N310 Specifications

- Channels: up to 4x4 per device
- 100 MHz bandwidth/channel
- 10 MHz – 6 GHz
- Embedded ARM processor for stand-alone operation
- Large user-programmable FPGA
  - Zynq 7100 or Zynq 7035
- 2 x 10 GbE streaming support
- Remote management support
- Rack mountable, half wide, 1U
- Support for UHD/RFNoC, GNU Radio, LabVIEW Communications (post release) & MATLAB (post release)

**Available: Q1 2018**

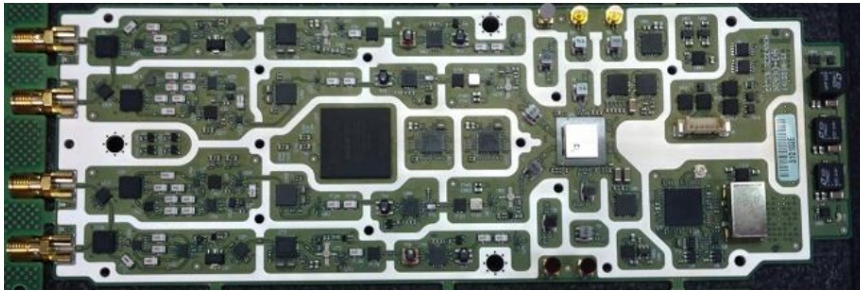


## Applications:

- Communications System Design/Prototyping
  - 5G NR, LTE, 802.11
  - UE emulation
  - massive MIMO
- SIGINT/EW
- Spectrum Monitoring
- Navigation
- Record & Playback

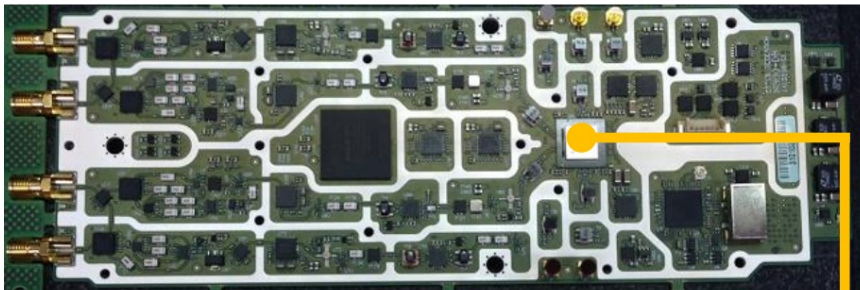


# N300/N310 Internal Design

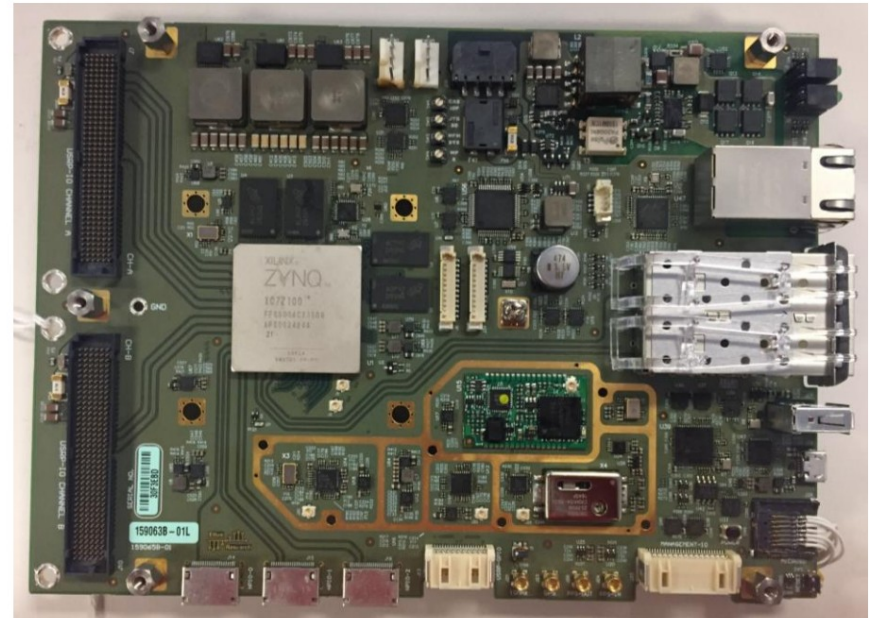


Front

ADI 9371 (“Mykonos”) based daughtercard



ADI 9371 “Mykonos”



N3x0 Motherboard

Rear

# N300/N310 Motherboard Components

2 GB FPGA DRAM  
(DDR3)

2 GB ARM DRAM  
(DDR3)

RJ45 (Ethernet) connector

Daughterboard  
connectors

2 SFP+ Ports  
(10 GbE)

USB 2.0 Port

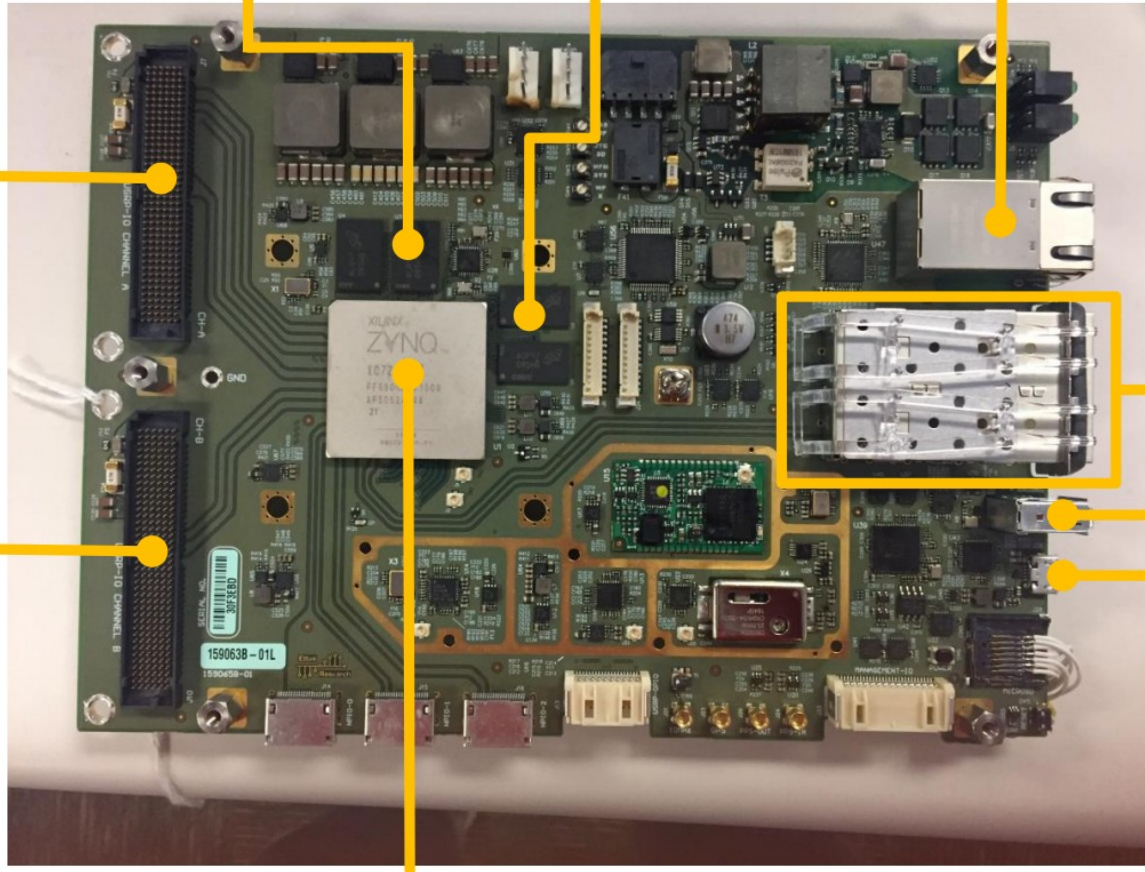
JTAG Port

Front

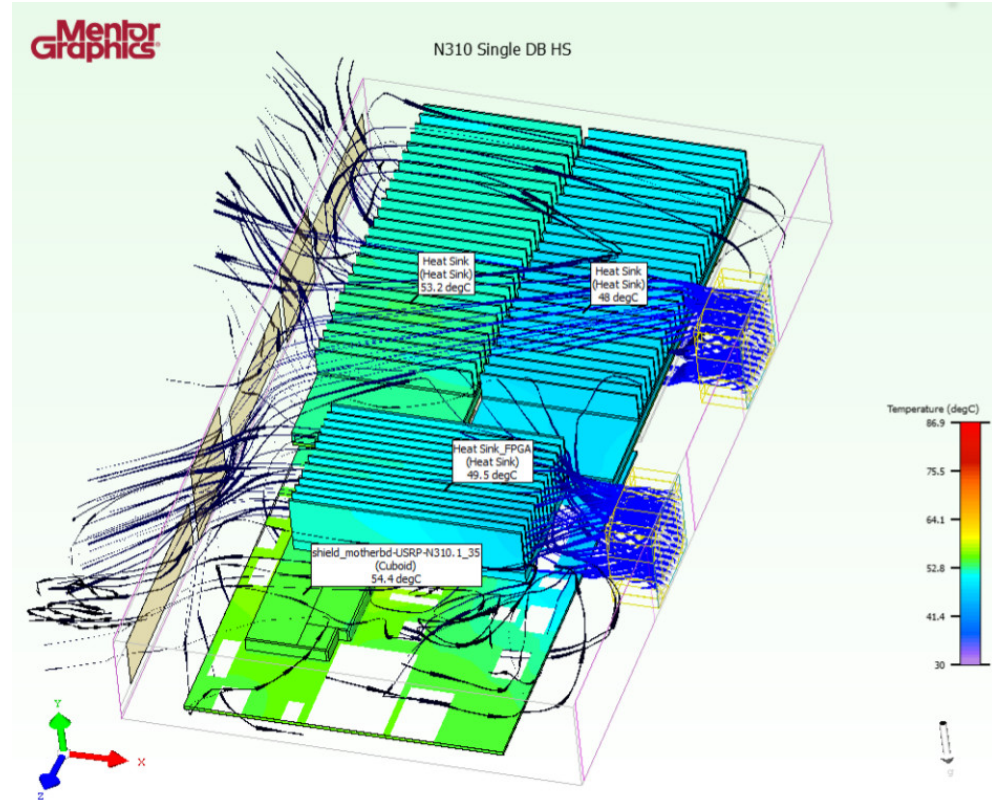
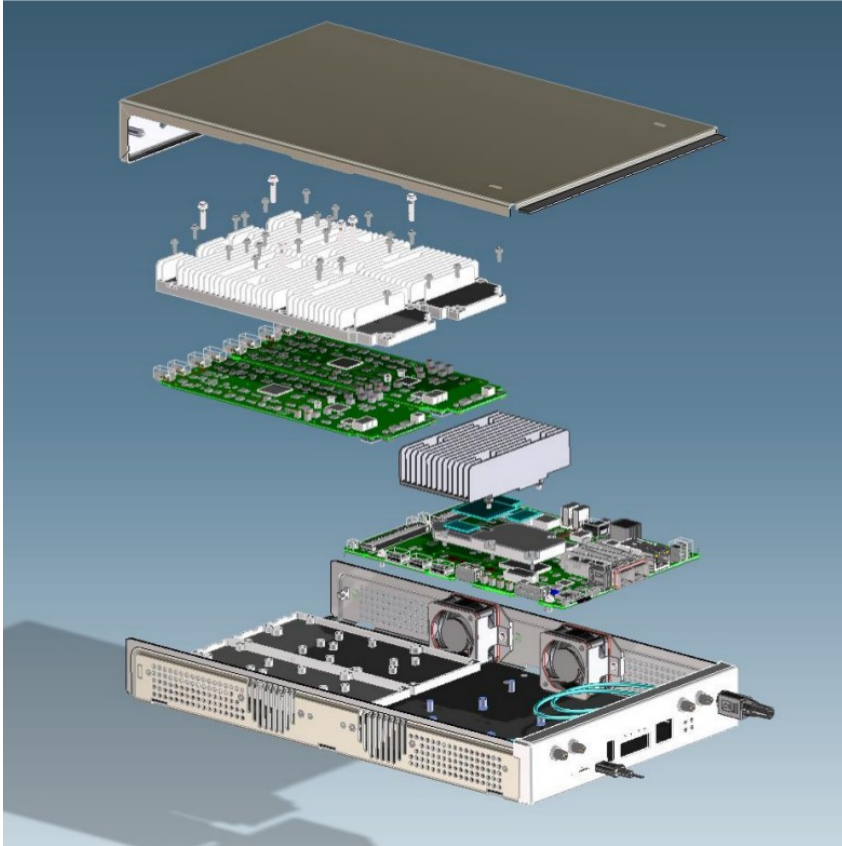
Rear

Xilinx Zynq Chip

Embedded ARM processor + user-programmable FPGA



# N300/N310 Mechanical Design

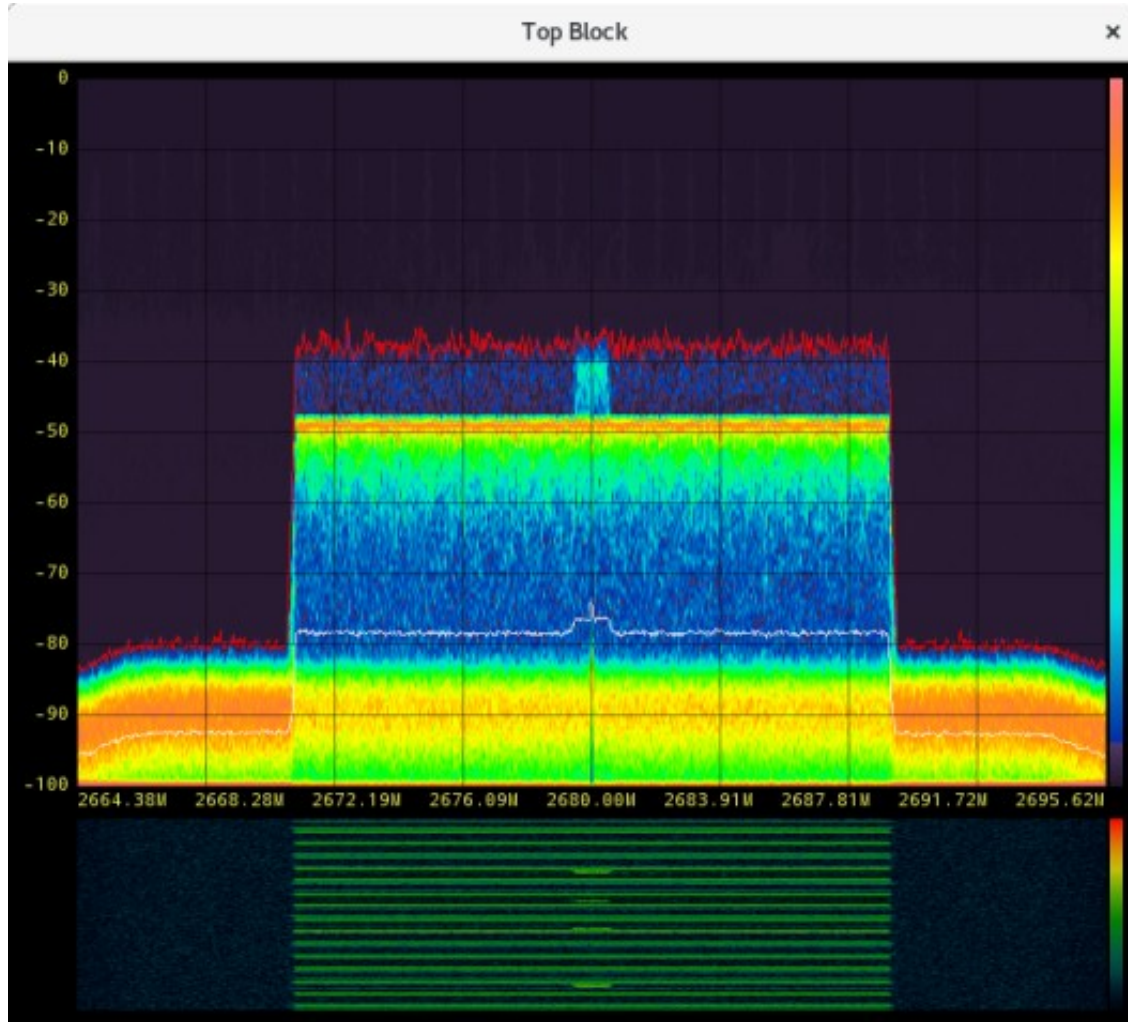


## Key RF Performance Specifications:

- Up to 4 Tx channels, 4 Rx channels
- RF daughtercard based on the new Analog Devices 9371 RFIC
- 16-bit resolution, 100MHz Instantaneous Rx RF bandwidth/channel
- 14-bit resolution, 100 MHz Instantaneous Tx RF bandwidth/channel
- Phase Coherent
- 10 MHz – 6 GHz Frequency Coverage
- IQ impairment corrections: IQ Sampling with IQ imbalance, DC offset calibration
- Programmable 128 tap Tx FIR filter
- Programmable 96 tap Rx FIR filter

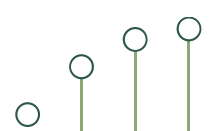


# N310 Spectrum and Dynamic Range



Source:  
Windowed 20 MHz LTE  
Rohde & Schwartz SMU

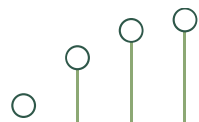
Receive:  
N310 – AD9371 RFIC



# N300/N310 Clocking and Sample Rates

- Sample Clocks
  - 125 MHz, 122.88 MHz, 153.6 MHz
  - 3GPP rates: 30.72 x 4 and 30.72 x 5 MHz
  - Additional rates may be available after launch
- Available Sample Rates
  - Existing FPGA based sample rate conversion carries over from existing devices
  - Integer decimation with two halfband FIR filters and CIC filter per channel
- LTE Sample Rates

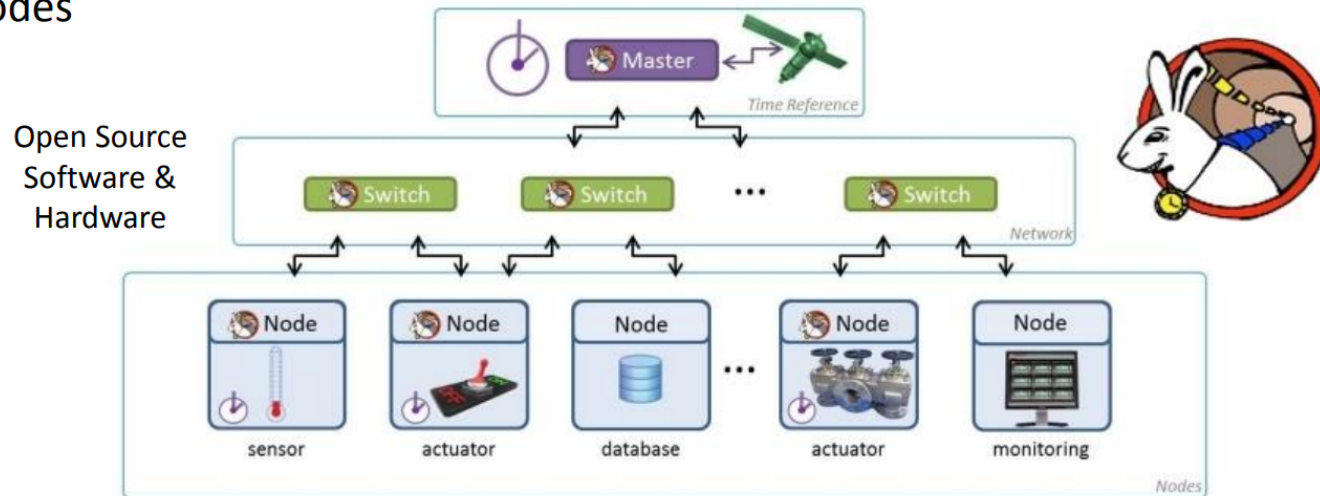
Bandwidth (MHz)	20	15	10	5	3	1.4
Sample Rate (Msps)	30.72	15.36	15.36	7.68	3.84	1.92



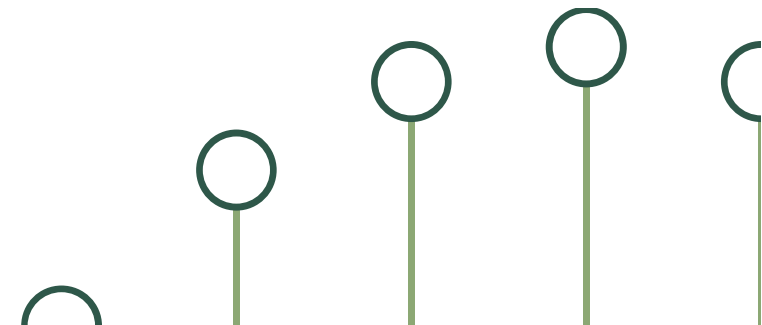
# N300/N310 Timing over Ethernet

## White Rabbit: sub-ns ethernet-based synchronization based on IEEE 1588 and SyncE

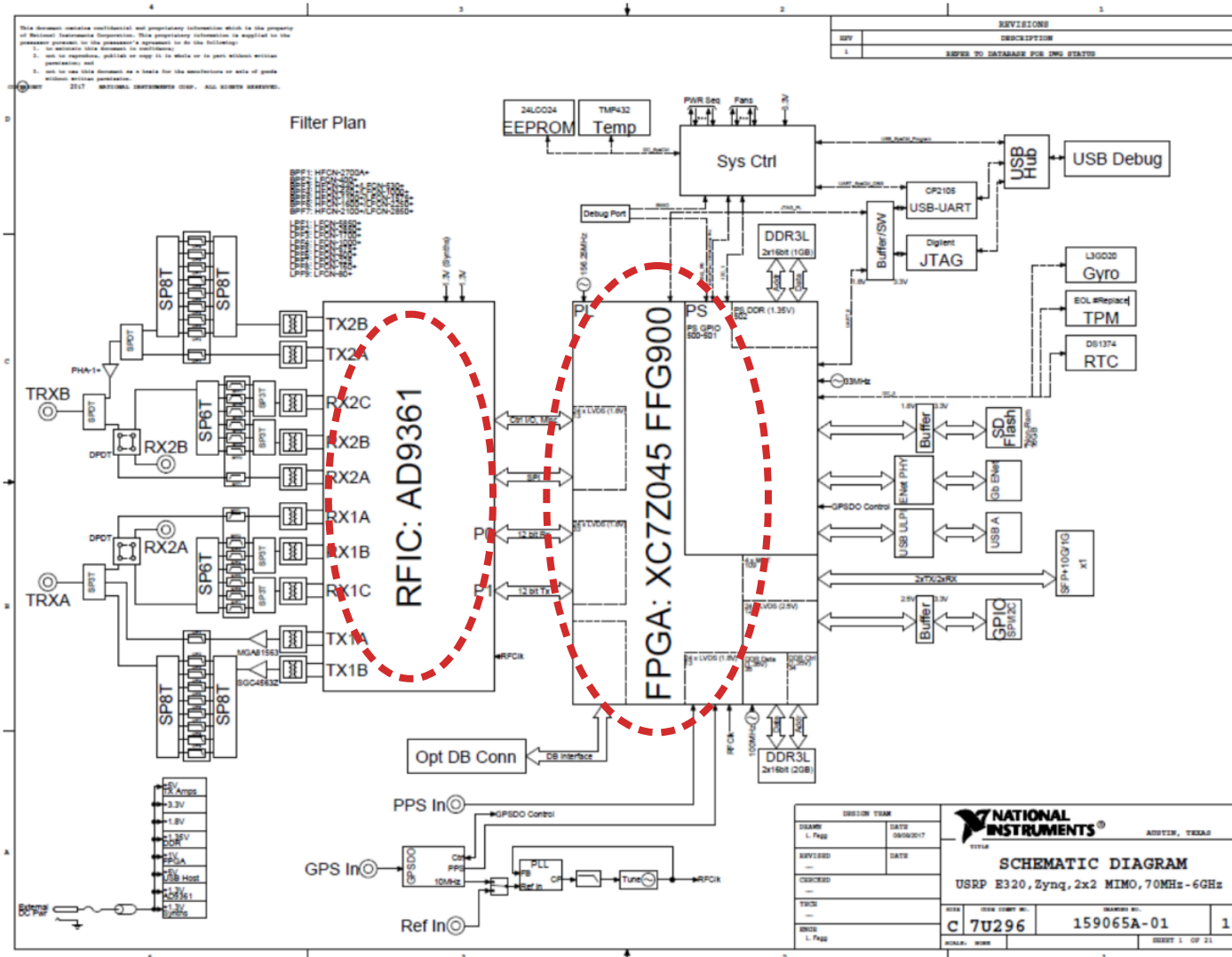
- Accuracy: < 1 ns skew, < 100 ps jitter
- Distance: > 10 km
- > 2,000 nodes



USRP E320



# E320 Zynq 7045 FPGA and AD9361 RFIC



# FPGA Comparison

**E310**

**N300**

**E320**

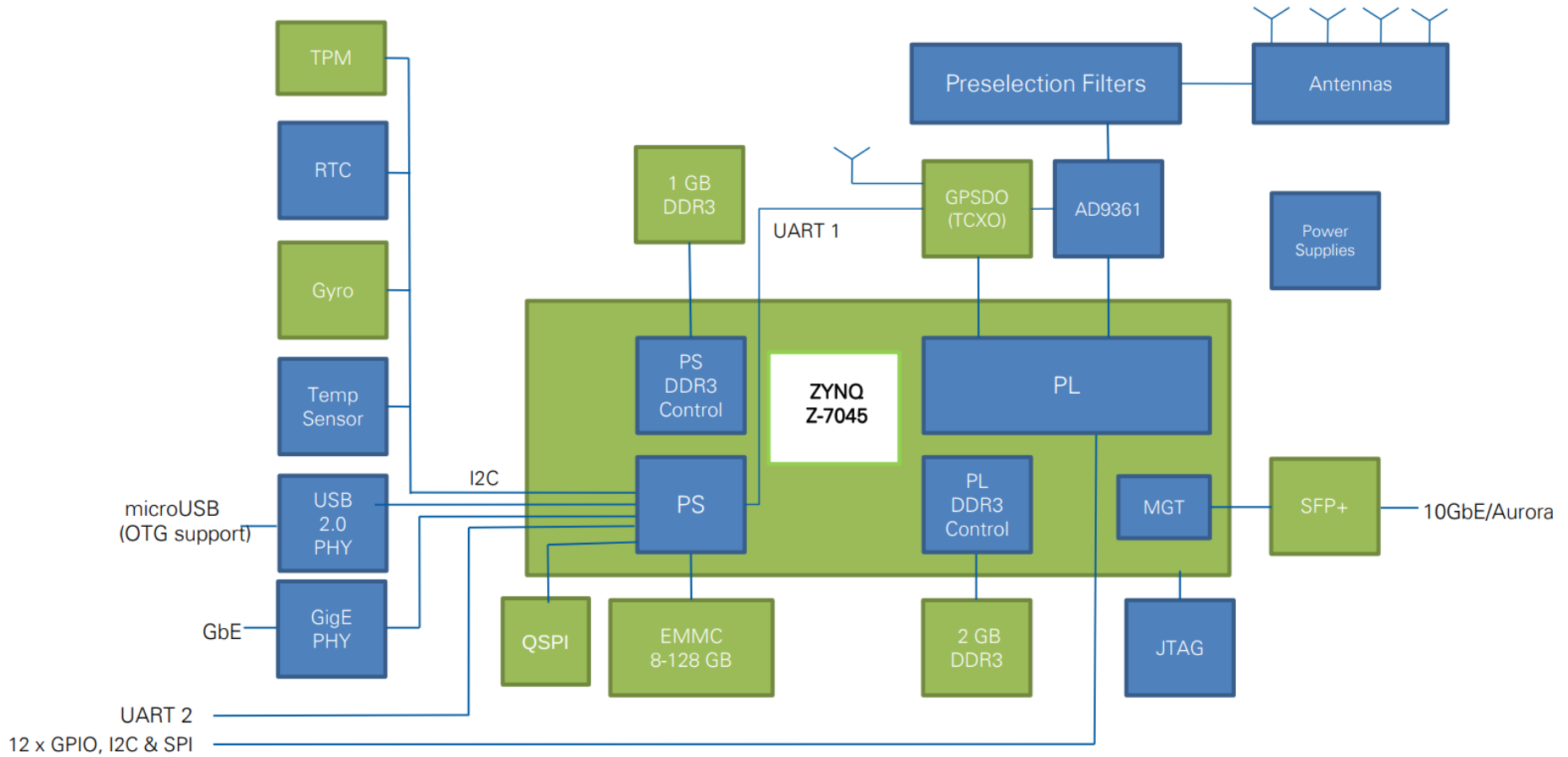
**X310**

**N310**

	Zynq 7020	Zynq 7035	Zynq 7045	Kintex 7 410T	Zynq 7100
Logic Cells	85K	275K	350K	406K	444K
BRAM (MB)	4.9	17.6	19.1	28.6	26.5
DSP Slices	220	900	900	1540	2020
Flip-flops	106K	343K	437K	508K	554K
LUT's	53K	171K	218K	254K	277K
GMACS	276	1334	1334	2289	2622



# E320 Block Diagram

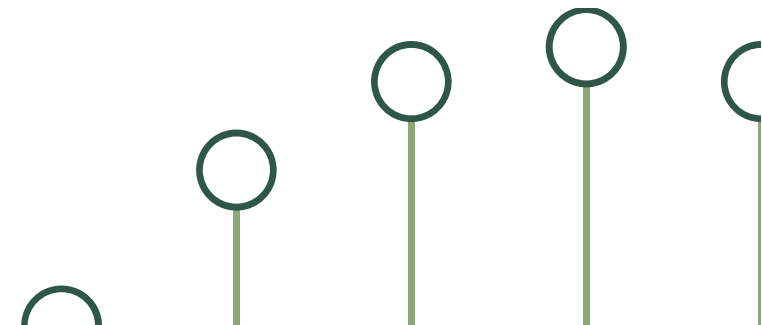


# E320 Features

- Bandwidth: SFP+ to MGTs on FPGA to support a single 10GbE or 12.5Gb Aurora streaming interface
- Security: Trusted Platform Module
- Ruggedness: Enclosure which also acts as a passive heatsink, fan header and attach points for Zynq (for convection cooled apps), single PCB to make OEM integration easier
- Reliability: Temperature sensors on AD9361 and Zynq
- Portability: Battery connector
- SWaP: 3U Eurocard size
- Jackson Labs LTE-Lite GPSDO
- MEMS gyroscope



# Future Directions for 5G



# 5G mmWave RF and Bandwidth

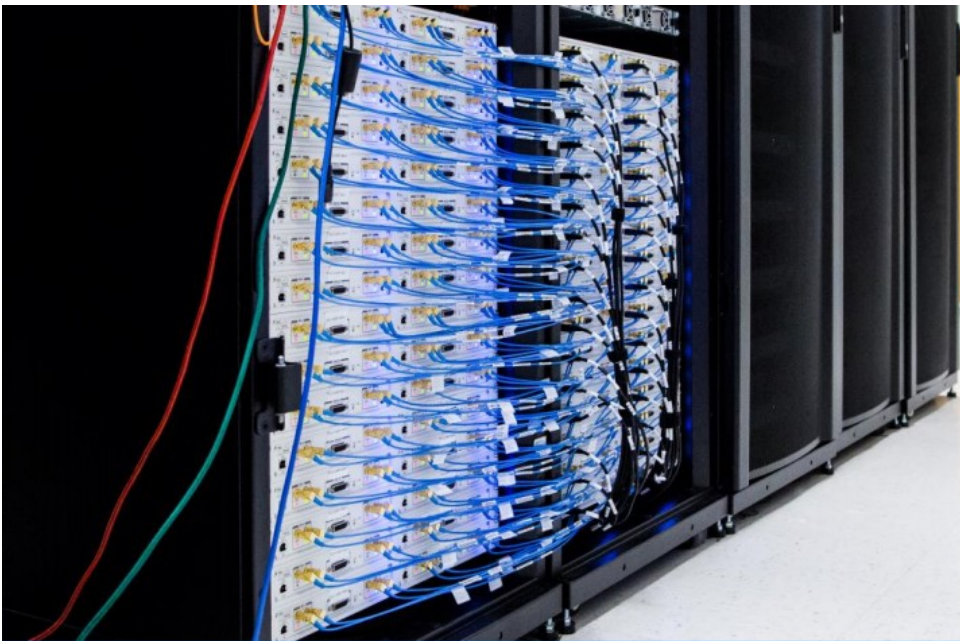
## United States FCC identified bands for licensed or hybrid use

- 24 GHz
- 28 GHz
- 37 GHz
- 39 GHz
- 47 GHz

*Use of Spectrum Bands Above 24 GHz for Mobile Radio Services, Second Report and Order, Second Further Notice of Proposed Rulemaking, Order on Reconsideration, and Memorandum Opinion and Order, GN Docket No. 14-177, Oct 26, 2017*



# Scalability



## NI Provides SDR Technology for DARPA Spectrum Collaboration Challenge

- 256 x 256 Channel Emulator
- 56,000+ Simultaneous Channel Interactions
- 52+ TB/s System Throughput



Thank You

