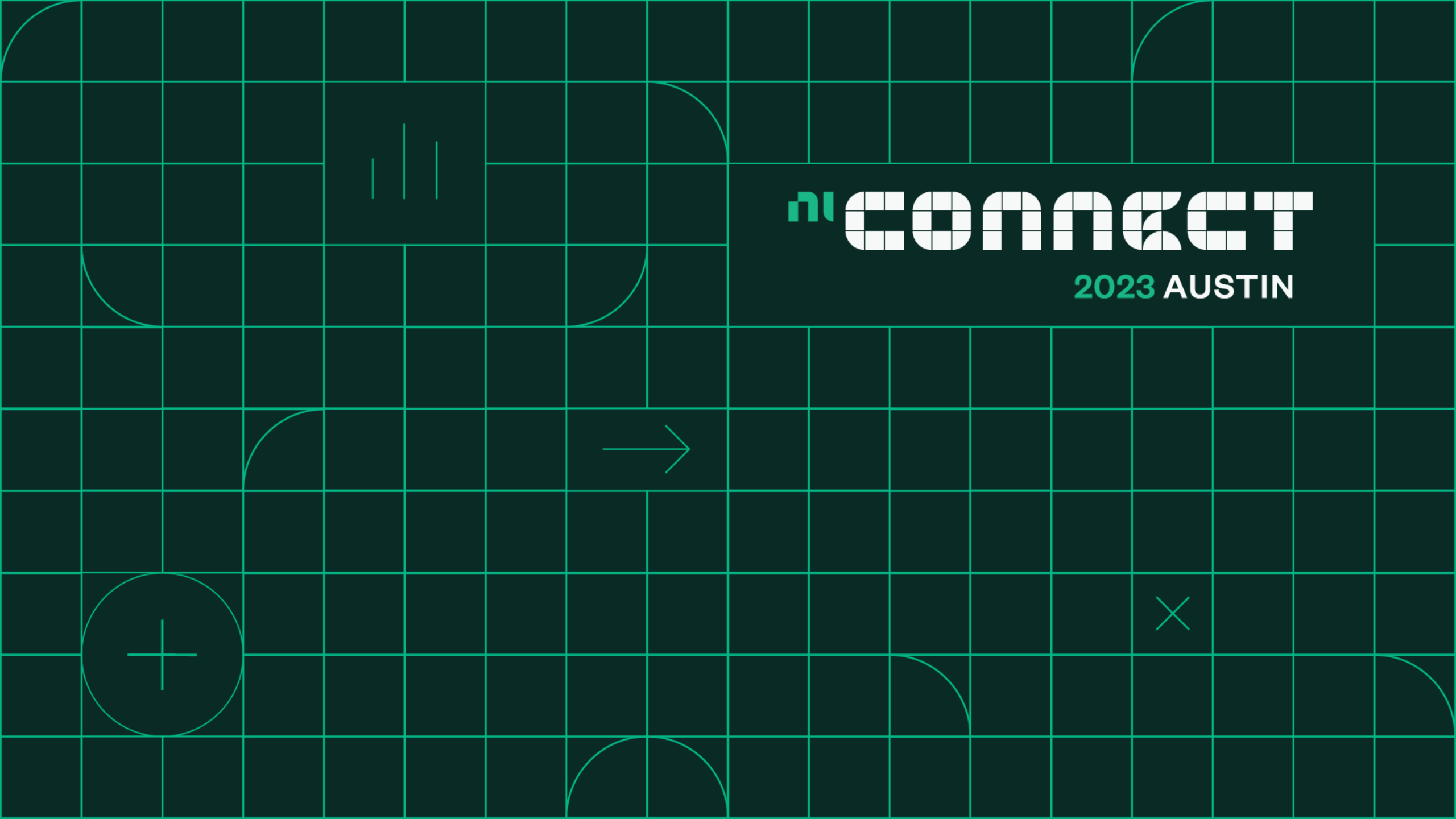

CONNECT
2023 AUSTIN

USRP X440

Markus Unger
Javier Valenzuela

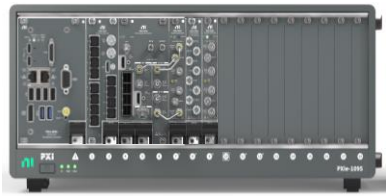
Game Changing Bandwidth and Channel Density in Software Defined Radio

Two Platforms for RF Prototyping and Deployment

Low SWaP-C Prototyping with USRP

Differentiators:

- Broad portfolio of low-cost <$30k COTS SDRs
- Integration of RF with baseband and digital
- Open-source Software, wide toolchain adoption
- Enables software migration to tactical hardware



High-performance Prototyping and Validation with PXI RF

Differentiators:

- One instrument for all FR1, FR2, and FR3 frequency ranges up to 54GHz
- Instrument-quality SDRs with latest ADC/DAC and RF Technologies
- Native mixed-signal capability (Digital, RF, Analog, etc.)
- Modularity and scalability supporting high channel counts
- Automated Sync Routines for Repeatable Phase Coherence
- Hardened Infrastructure for data streaming, real-time processing, and storage
- Future Real-Time 4 GHz BW with Co-Processor

Product Introduction

Markus Unger – Product Manager USRP

What do customers expect from a game changing SDR?

Simply MORE!

- More Instantaneous Bandwidth
- More Channels
- More Phase Coherency
- More Streaming Rate
- More Flexibility
- And much much more…

Q3 2023

NI Ettus USRP X440 Product Overview

IF Capabilities

Front-End Conn:	Balun coupled, MMPX
IF Range:	30 MHz – 4 GHz*
Bandwidth:	Up to 1.6 GHz* / channel, 3.2 GHz / total
Direct Sampling:	Flexible, up to 4 GSps
Number Channels:	8 (TX/RX or TRX)
Phase Coherency:	Yes (sample based)
TX output level:	< 0 dBm full scale
RX input level:	10 dBm full scale

** IF-Bandwidth combination limitations apply due to Nyquist zones and gaps*

Digital Capabilities

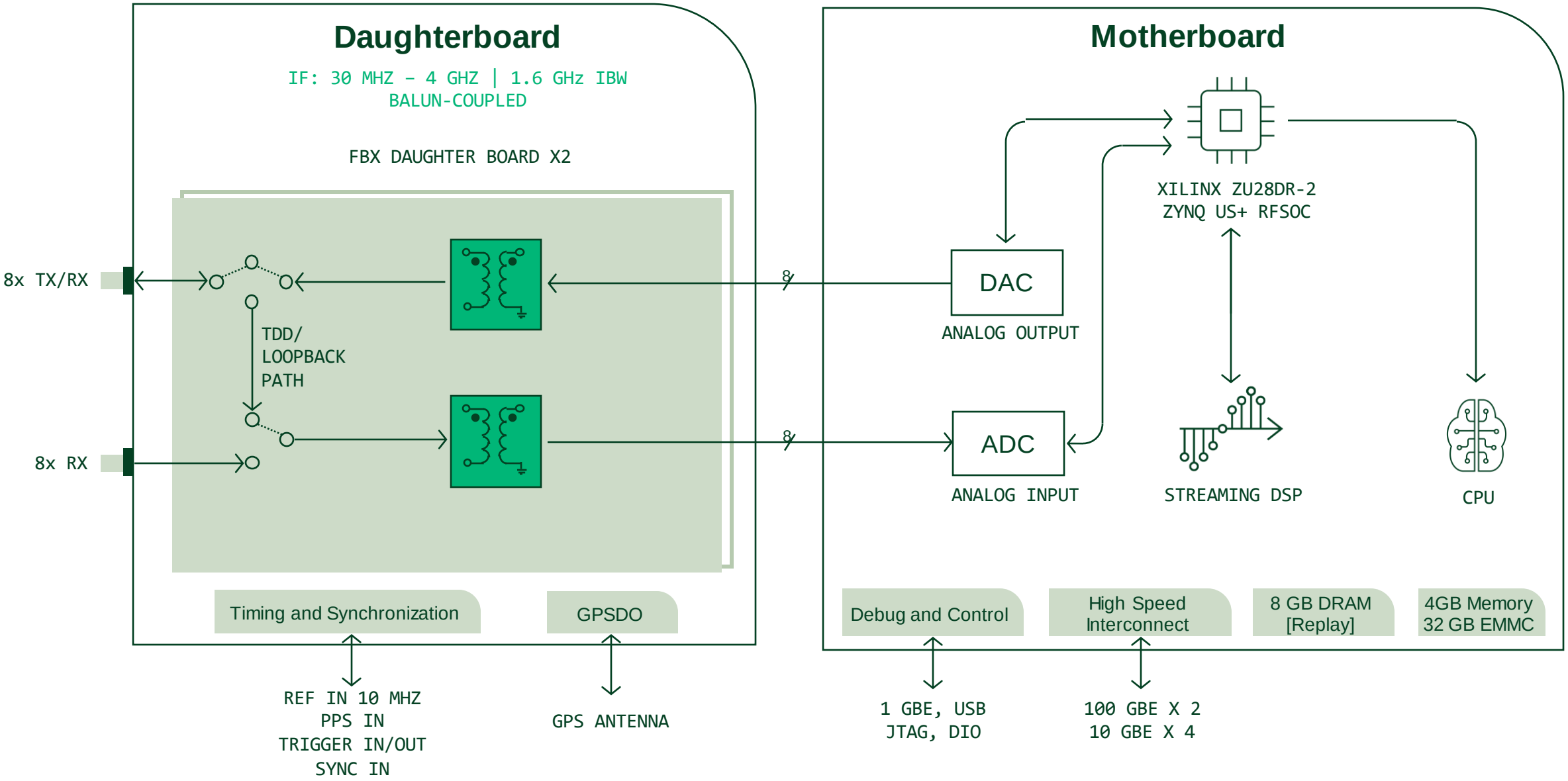
Xilinx Zynq Ultrascale+ RFSOC ZU28DR-2
Built-in quad core ARM processor
Streaming Interface: Dual 100GEth via QSFP28
Synchronization: 10 MHz / PPS, GPSDO, IF
Software: Open source (GNU Radio, RFNoC, UHD)
GPIO for Front-End control via UHD API or FPGA
2x 12 lanes via HDMI with SPI protocol support

USRP X440 is covered by Export Administration Regulations (EAR) NS2. Refer to US Department of Commerce for details and country chart.

USRP X440 Comparison to X410

	NI Ettus USRP X410	NI Ettus USRP X440
Frequency	1 MHz – 7.2 GHz	30 MHz – 4 GHz
Bandwidth	400 MHz	Up to 1.6 GHz
Channels	4 Tx, 4 Rx	8 Tx, 8 Rx
I/O Type	RF	IF
Architecture	Integrated	Integrated
Communication	100/10/1 GbE or PCIe	Dual 100 GbE, 10/1 GbE
Synchronization	10 MHz, PPS, GPSDO	10 MHz, PPS, GPSDO, IF
Software Support	GNU Radio, C++, Python, RFNoC, LabVIEW, LabVIEW FPGA	GNU Radio, C++, Python, RFNoC
Key Applications	Communications, 5G, Wireless Research	Radar, Electronic Warfare, Direction Finding, SIGINT. SATCOM Ground Stations, mmWave

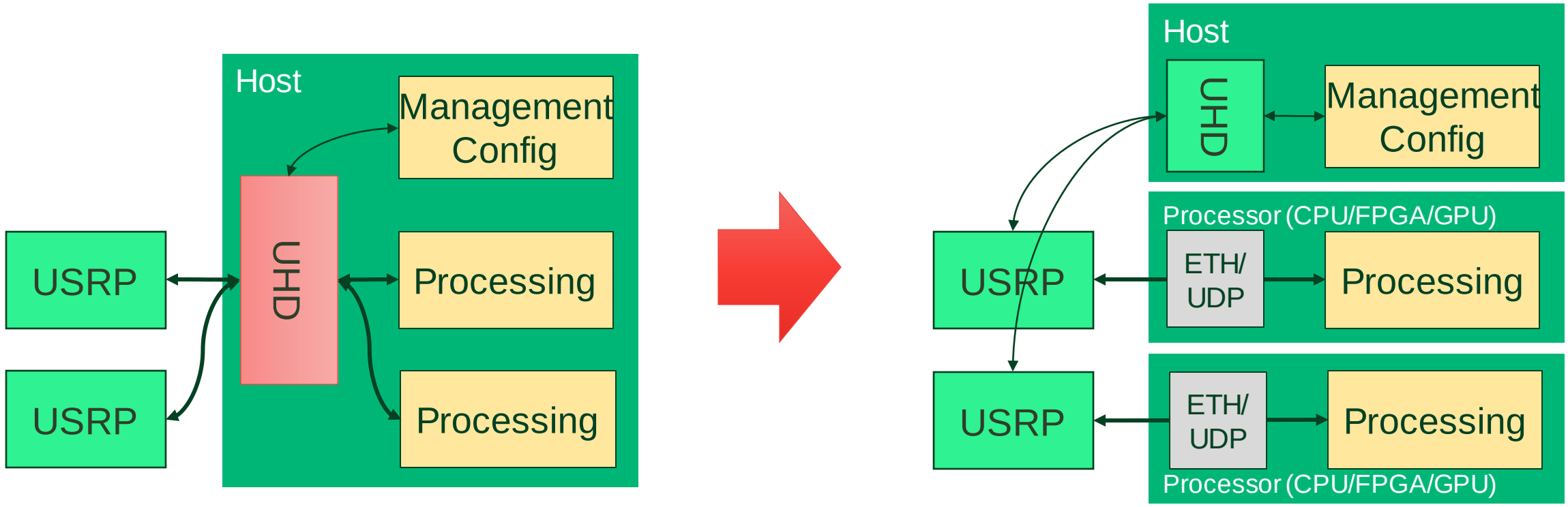
NI Ettus USRP X440 High Level Block Diagram



Raw UDP Traffic to Remote Destination

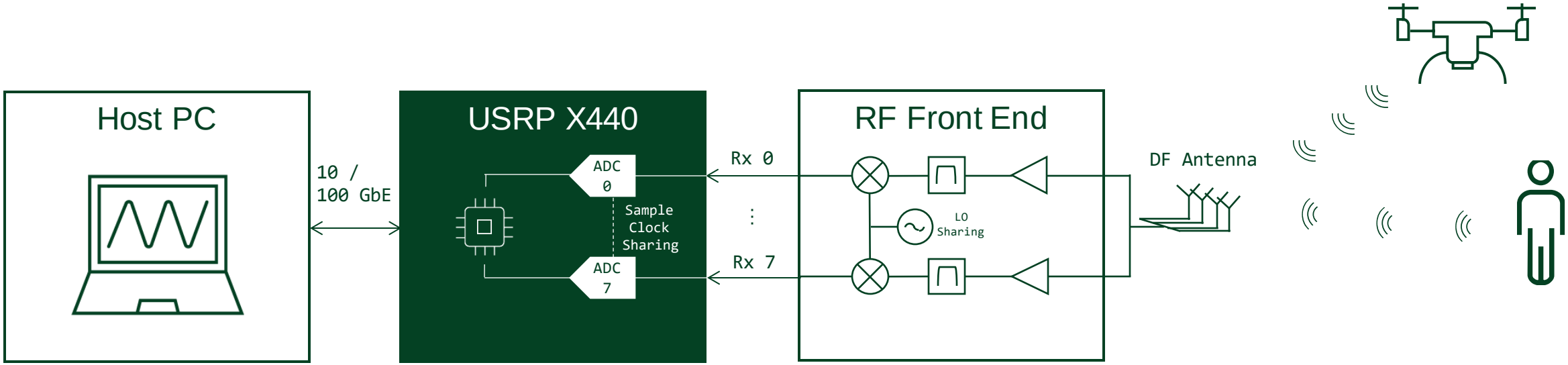
More **streaming flexibility**:

- RX Stream to any network destination working, TX in preparation
- Stream data with or without CHDR metadata, prepared for VITA49 framing
- Seamless integration into RFNoC



Applications for USRP X440

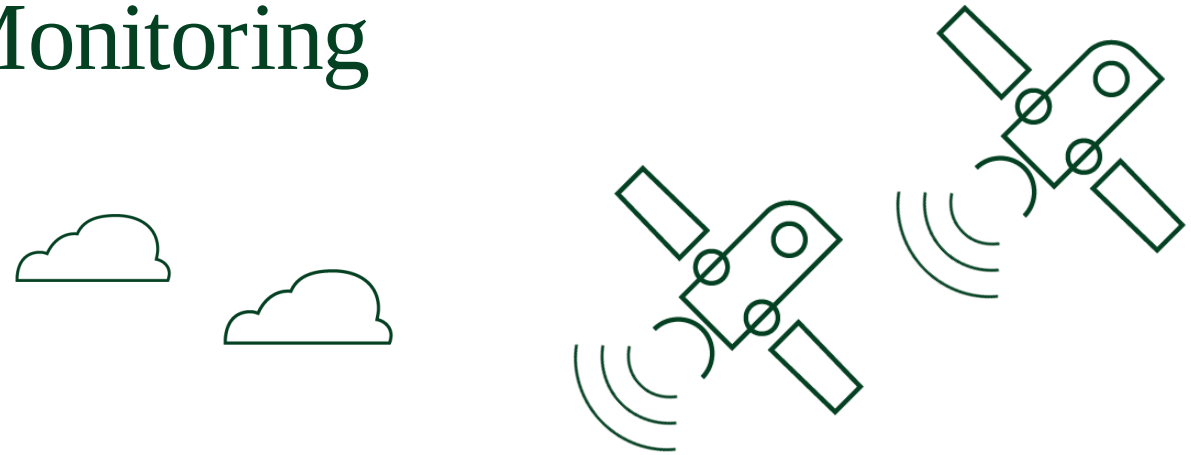
Direction Finding

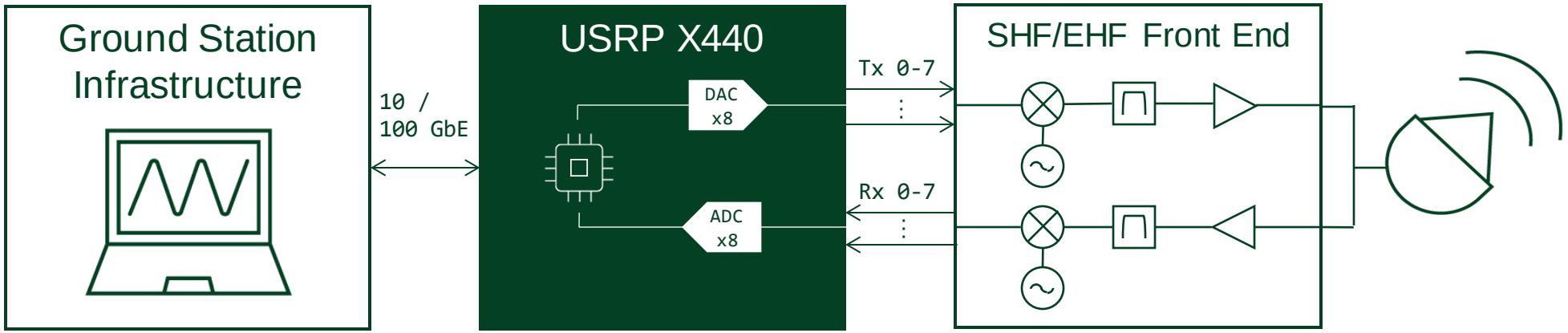


Phase coherent sampling for Angle of Arrival estimation

Key NI Third Party

SATCOM Ground Station Monitoring

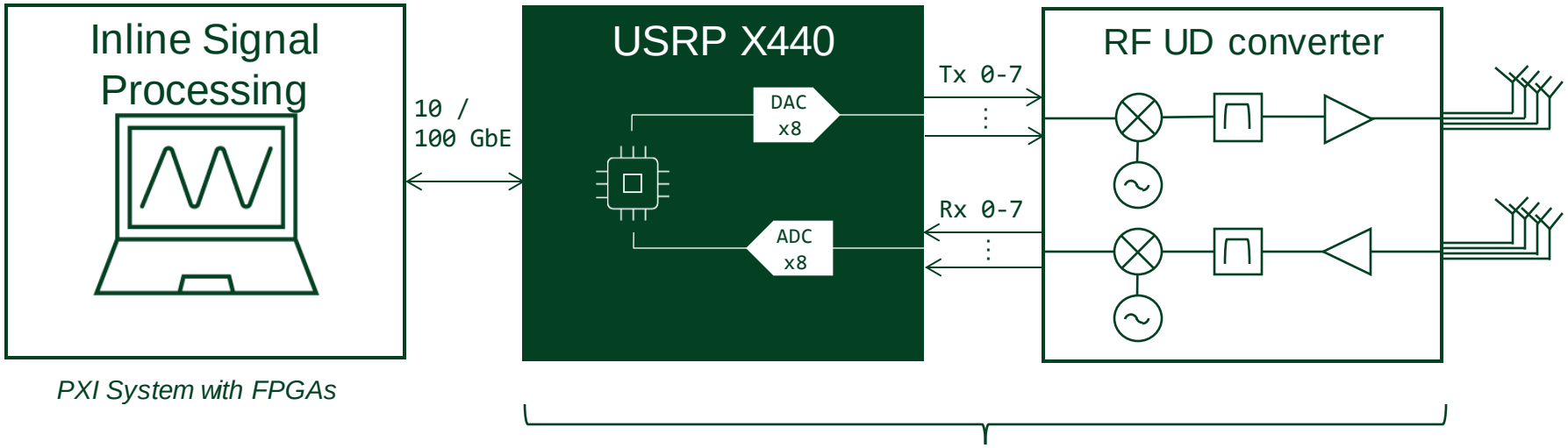




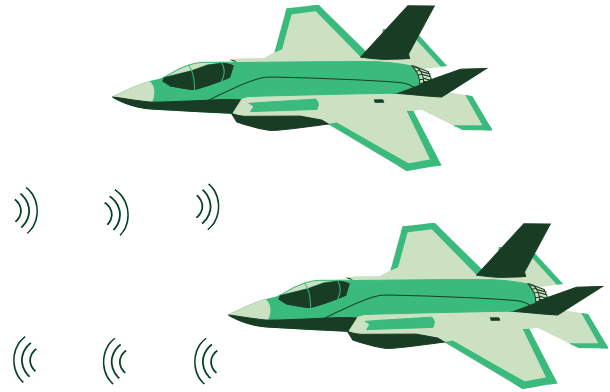
Raw, unimpaired wideband IF signal for clean up- and downconversion

Key NI Third Party

Radar Prototyping



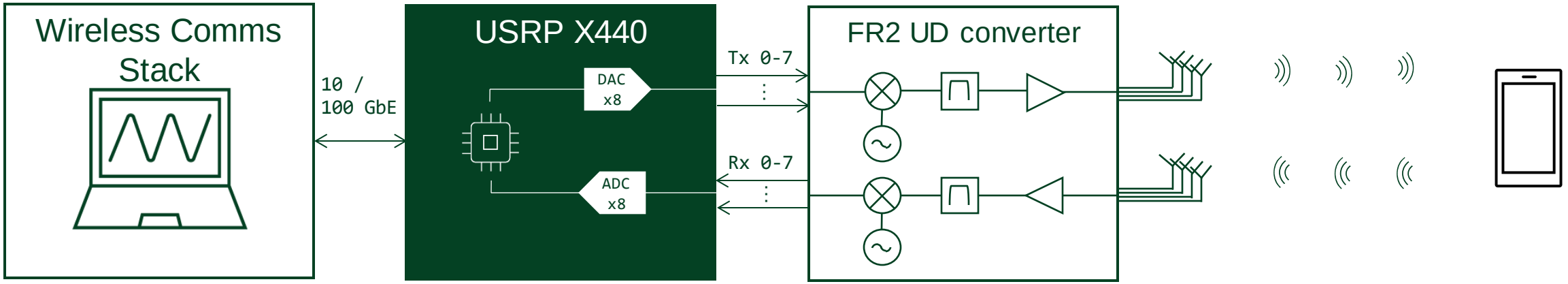
PXI System with FPGAs



X440's channel density and wide Bandwidth makes it an ideal platform for Radar Prototyping. 100GbE data links and onboard FPGA provides streaming and data compression capabilities provides an ideal mix of centralized verses edge compute for effective prototyping techniques

Key NI Third Party

mmWave Comms Research



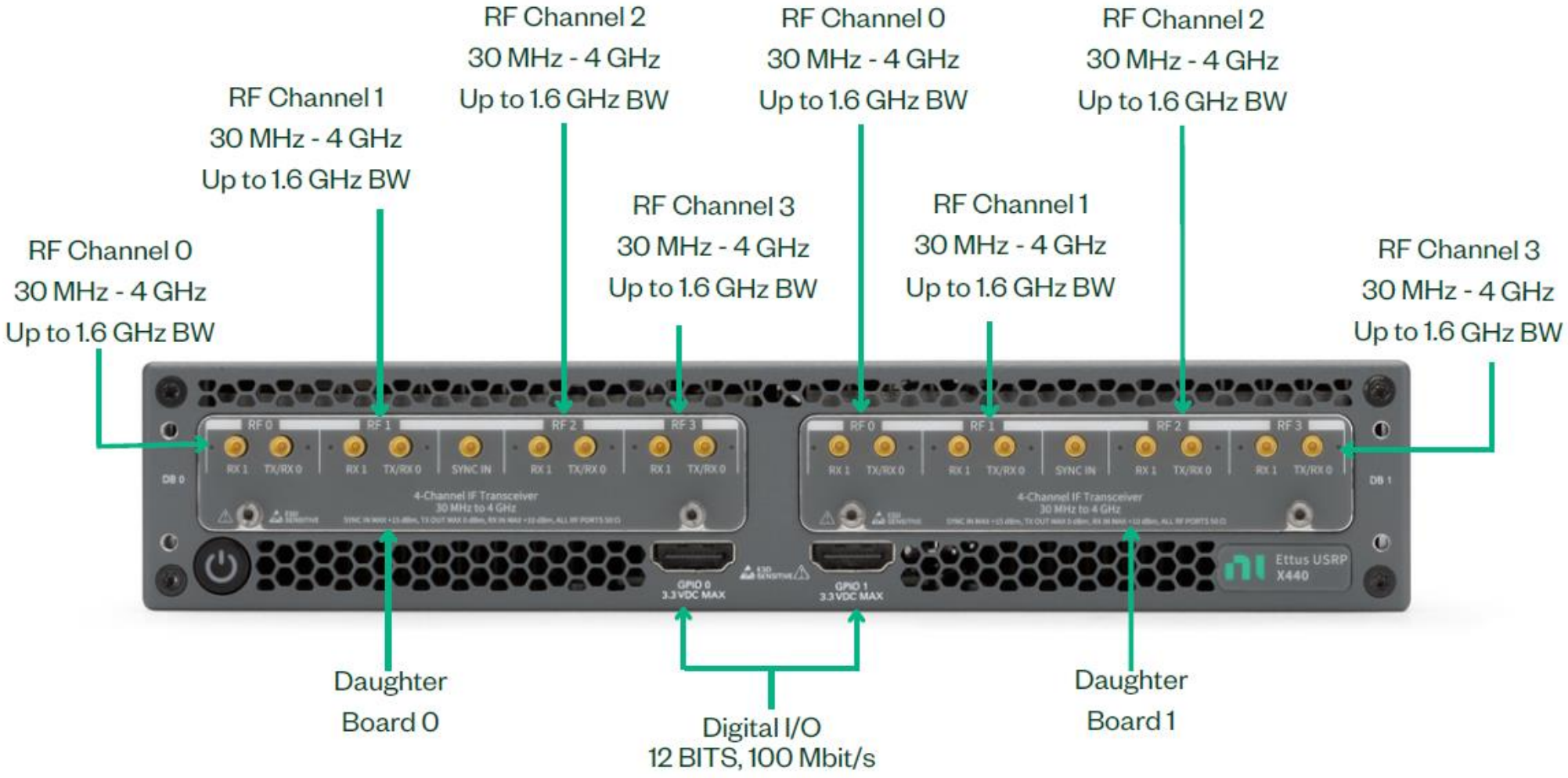
For example, running a wireless communications stack like OpenAirInterface in FR2 mode

For example, 5G NR FR2 Up/downconverters and/or antenna arrays like the TMYTEK UD Box.

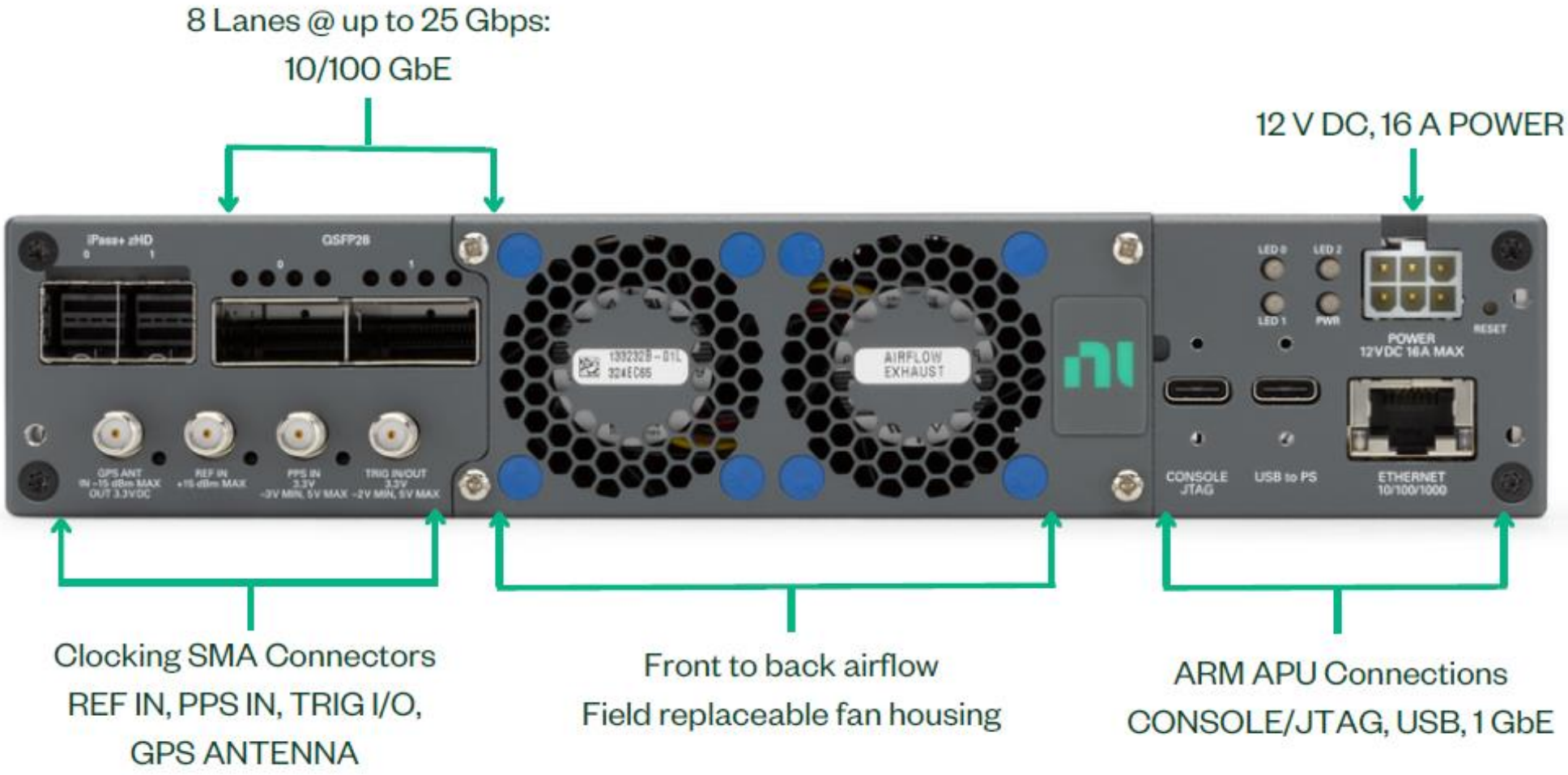
The X440 is NOT a successor or replacement of the X410. Depending on the requirements the X410 might still be the more suitable solution for FR1 research as it combines the digitizer and RF Front End for that Frequency Range in a single device.

Key NI Third Party

USRP X440 Front Panel



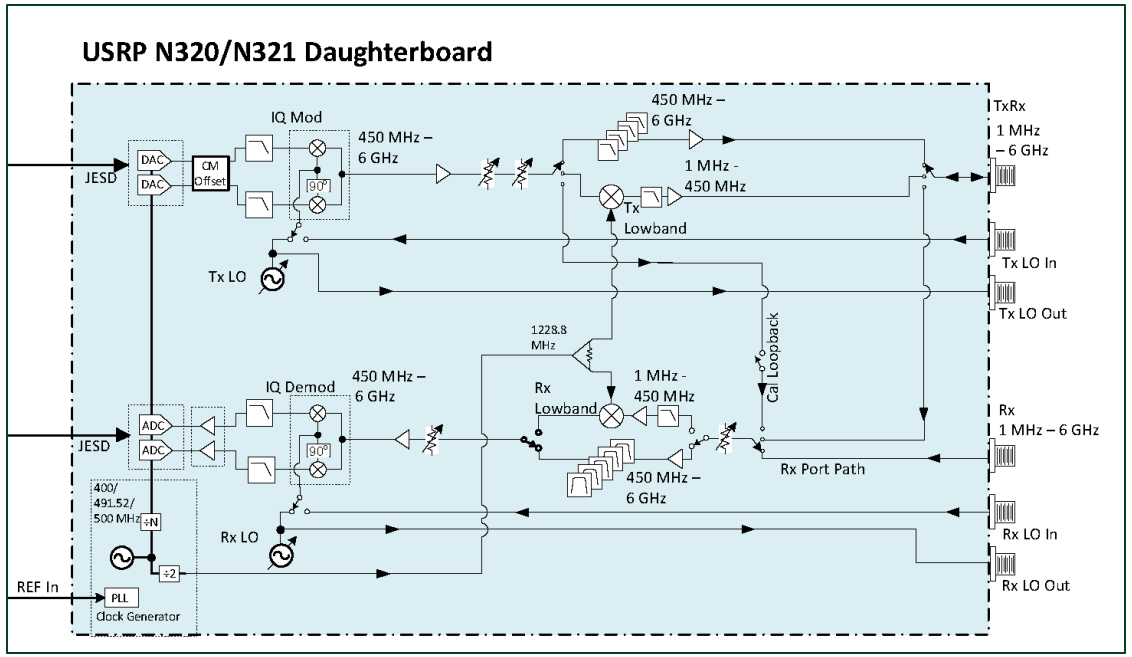
USRP X440 Back Panel



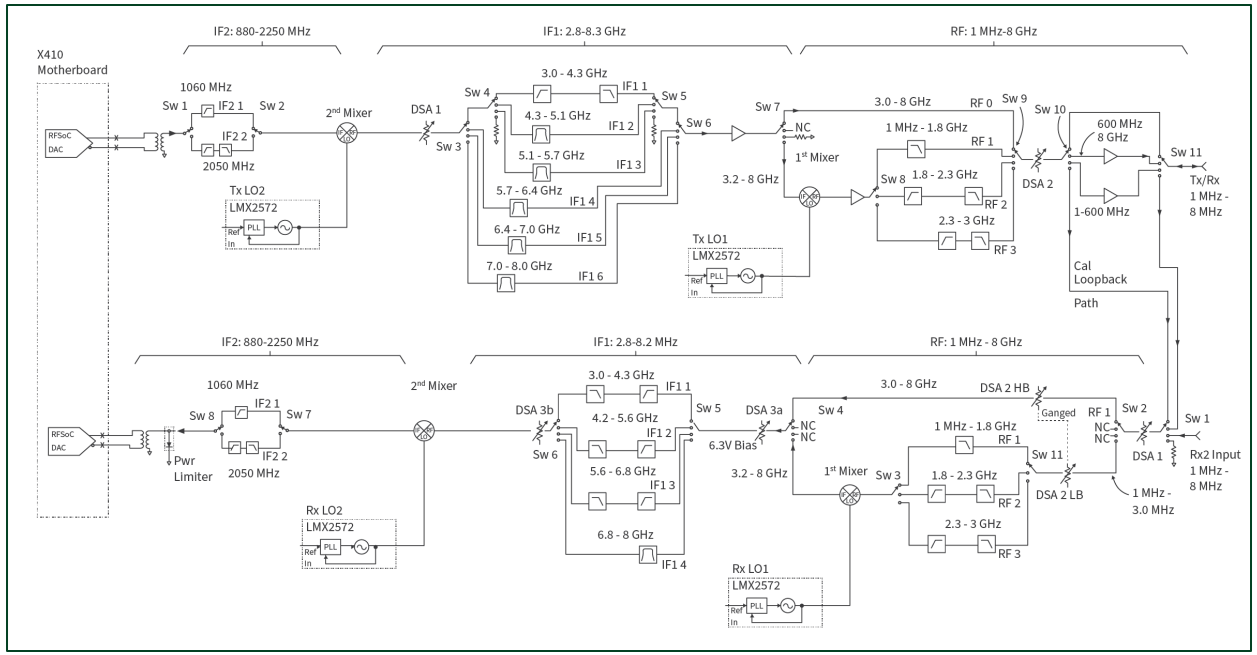
Technical Deep Dive

Javier Valenzuela – Senior Digital HW Expert

Classic NI Ettus USRP RF Front-Ends

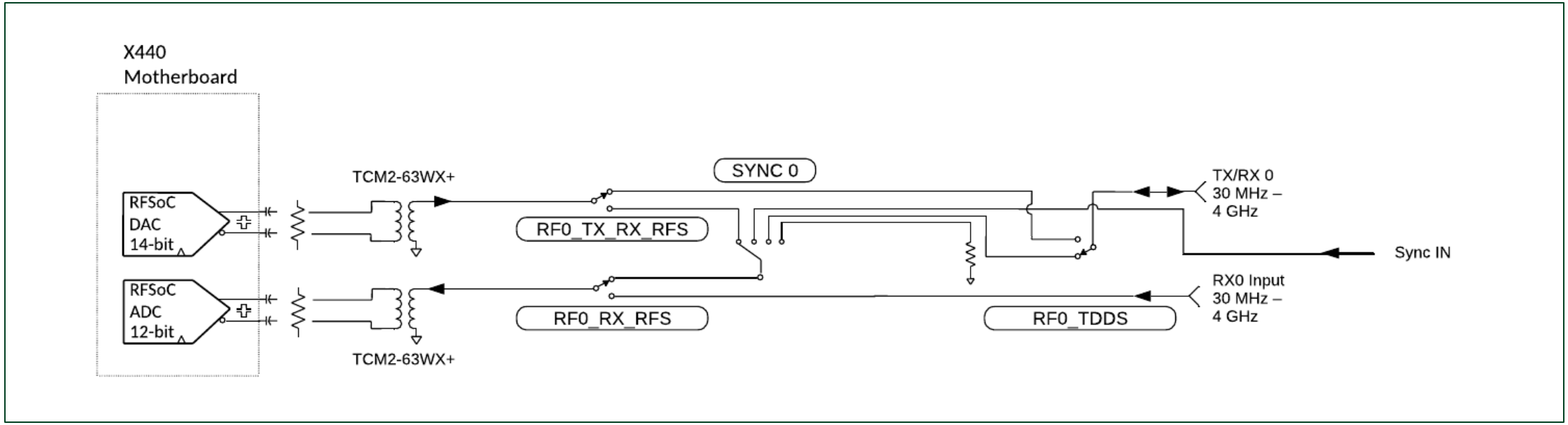


Direct Conversion



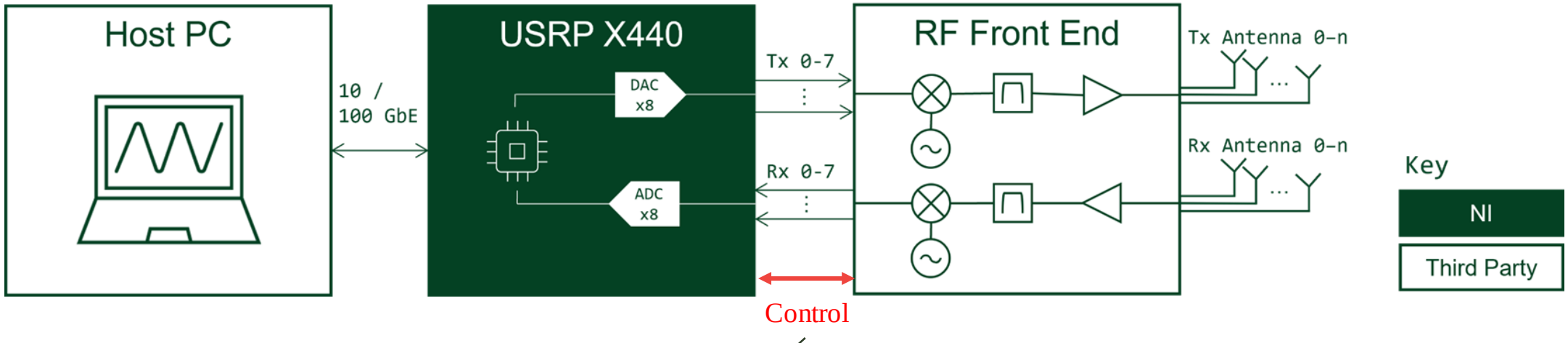
Super-Heterodyne

X440 Direct IF Sampling



- ➕ Flexibility of RF (spurs, frequency planning, bandwidth, …)
- ➖ Integration of third party RF Front ends or design own RF Front End

X4xx Extension Framework



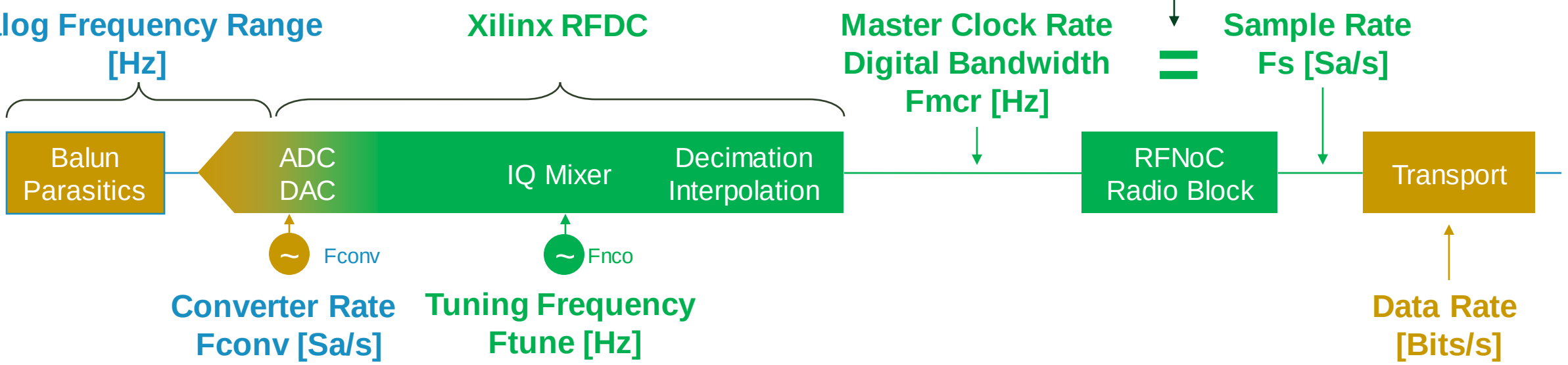
Getting Started with Front-Ends

https://files.ettus.com/manual/page_extension.html

- GRCon 2022 - GPIOs on USRPs by Martin Braun (Slides)
- GRCon 2022 - GPIOs on USRPS by Martin Braun (Recording)

X440 Sampling Rates

! X440 works without RFNoC DDC/DUC



X440 Master Clock Rate

Example: Opening a Session with a Master Clock Rate

```
usrp = uhd.usrp.MultiUSRP('addr=localhost,master_clock_rate=125e6')
```

This will generate a Converter Rate of 1GSps and a signal chain which supports an analog bandwidth of 100MHz

MPM determines the appropriate settings when configuring a new Master Clock Rate:

```
Clock Config: {
'spll_config': SpllConfig(ref_freq=10000000.0, output_freq=500000000.0, output_divider=6, prc_divider=48,
vcxo_freq=<Spll1Vco.VCO100MHz: 0>, sysref_div=1200, sysref_delay=24, clkin0_r_div=200, pll1_n_div=50,
pll2_prescaler=2, pll2_n_cal_div=15, pll2_n_div=15),
'mmcm_feedback_divider': 13, 'mmcm_input_divider': 1, 'mmcm_output_div_map': {'r0_clk': 13, 'prc': 13},
'rfdc_configs': RfdcConfig(conv_rate=4000000000.0, resampling=8)}
```

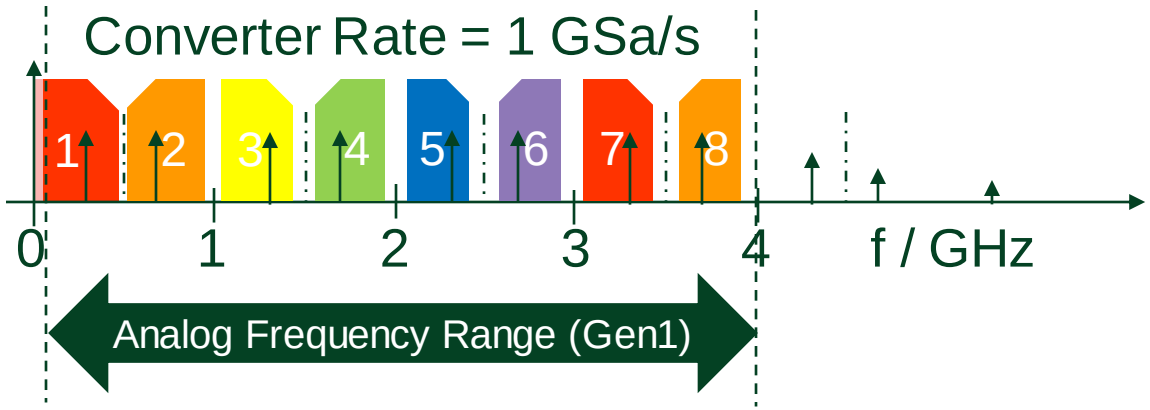
MCR	Converter Rate	Resampling
125 MHz	1 GHz	8
500 MHz	4 GHz	8
2000 MHz	4 GHz	2

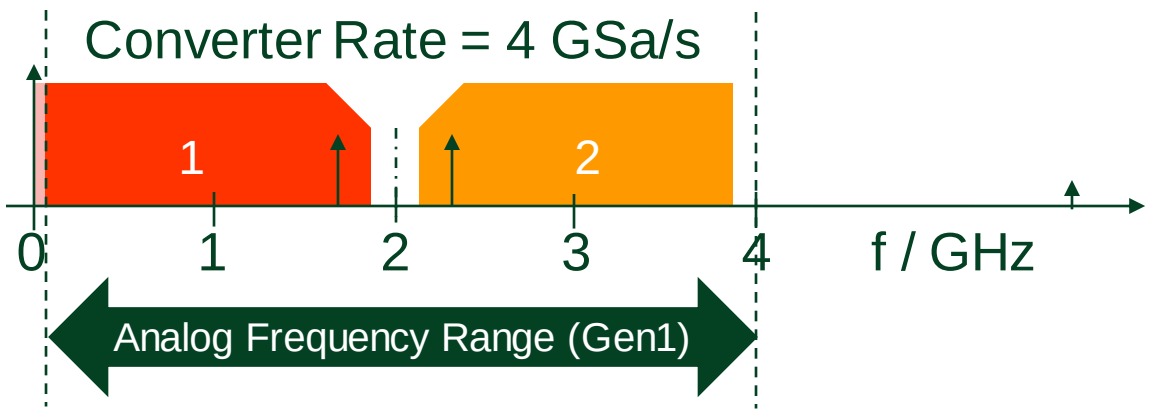
*Per Default, UHD will calculate the highest possible converter rate (MCR x Resampler = Fconv).

X440 Nyquist Zones

```
usrp = uhd.usrp.MultiUSRP('addr=localhost,master_clock_rate=125e6')
```

```
usrp = uhd.usrp.MultiUSRP('addr=localhost,master_clock_rate=500e6')
```





Without external Filtering:
DAC: sends out all frequencies at once
ADC: cannot distinguish tones at the named frequencies

Tones

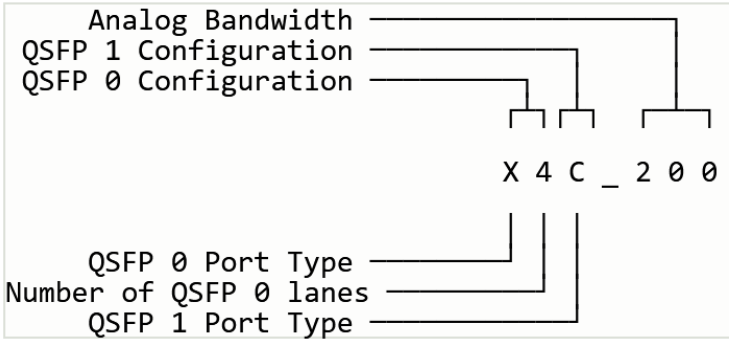
Nyquist Zones

X440 Default Personalities and Bitfiles

Capabilities	CG_1600	CG_400	X4_1600	X4_400
Channels	2	8	2	8
Bandwidth	1600	400	1600	400
Dual 100GbE	yes	yes	no	no
Replay	no	no	yes	yes

Channel vs Bandwidth

Streaming vs Burst



X: 10GbE
C: 100GbE
G: Gigabit

If the QSFP 1 configuration is not specified, then that port is unused. XG and CG indicate that each QSFP port has a single 10 GbE or 100 GbE, respectively (same as previous USRPs)

Thank you!

Visit the X440 demo in the Defense section of the expo floor

At NI, we're revolutionizing how enterprises use test insights to drive product and business performance.

Reduce time to market by accelerating product development

Deliver customer satisfaction by improving functionality and reliability

Improve the bottom line by reducing operational cost

Prepare for the future by adapting to evolving test needs

Make Test Strategy a Differentiator for Your Business

AUTOMATION

Increase test coverage with software-connected and model-based test methodologies.

STANDARDIZATION

Drive organizational consistency in test processes, systems, software, and data.

DIGITAL TRANSFORMATION

Deploy and connect enterprise-wide tools for asset and data management and analytics.

BUSINESS PERFORMANCE

Realize the benefits of an intentional test strategy.

- Reduce time to market
- Deliver customer satisfaction
- Improve the bottom line
- Prepare for the future