n' CONNECT

Rapidly Prototyping Cognitive RF Systems

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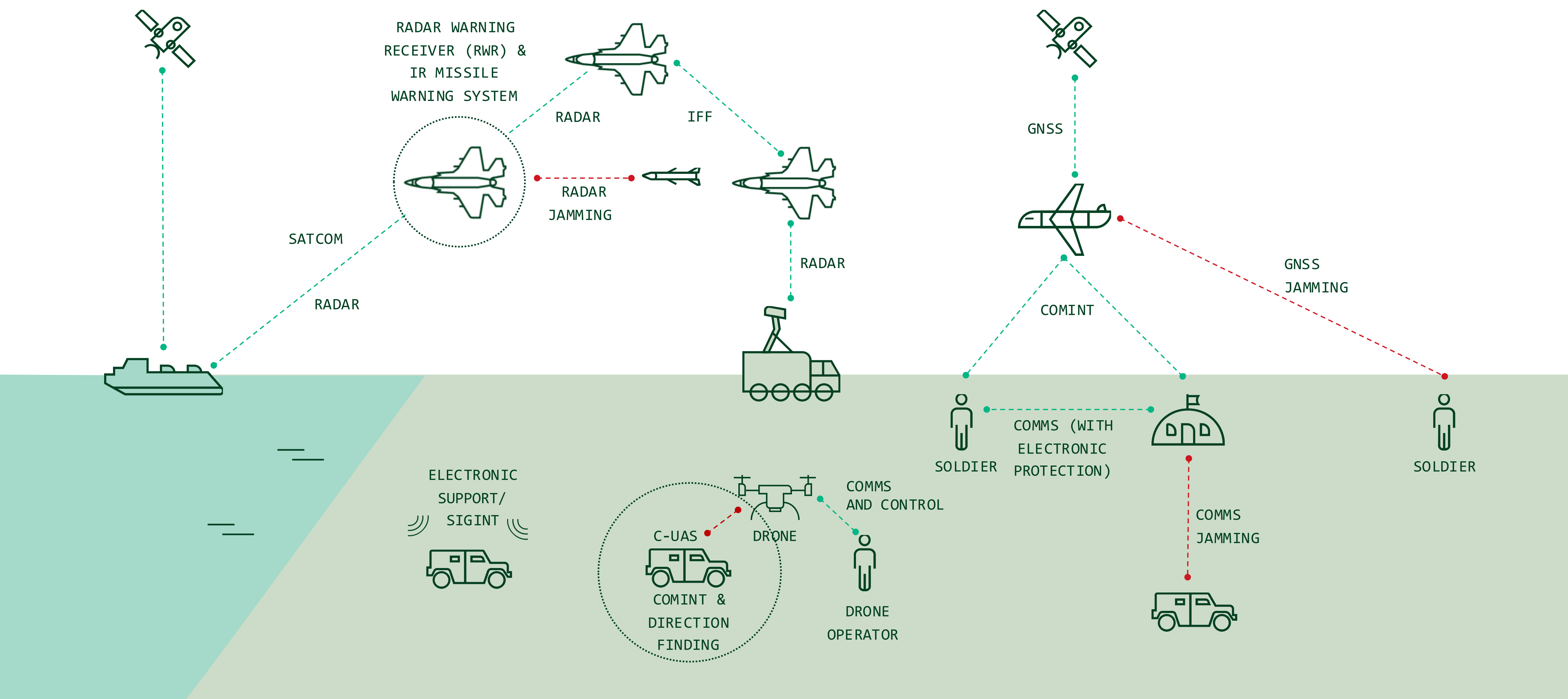
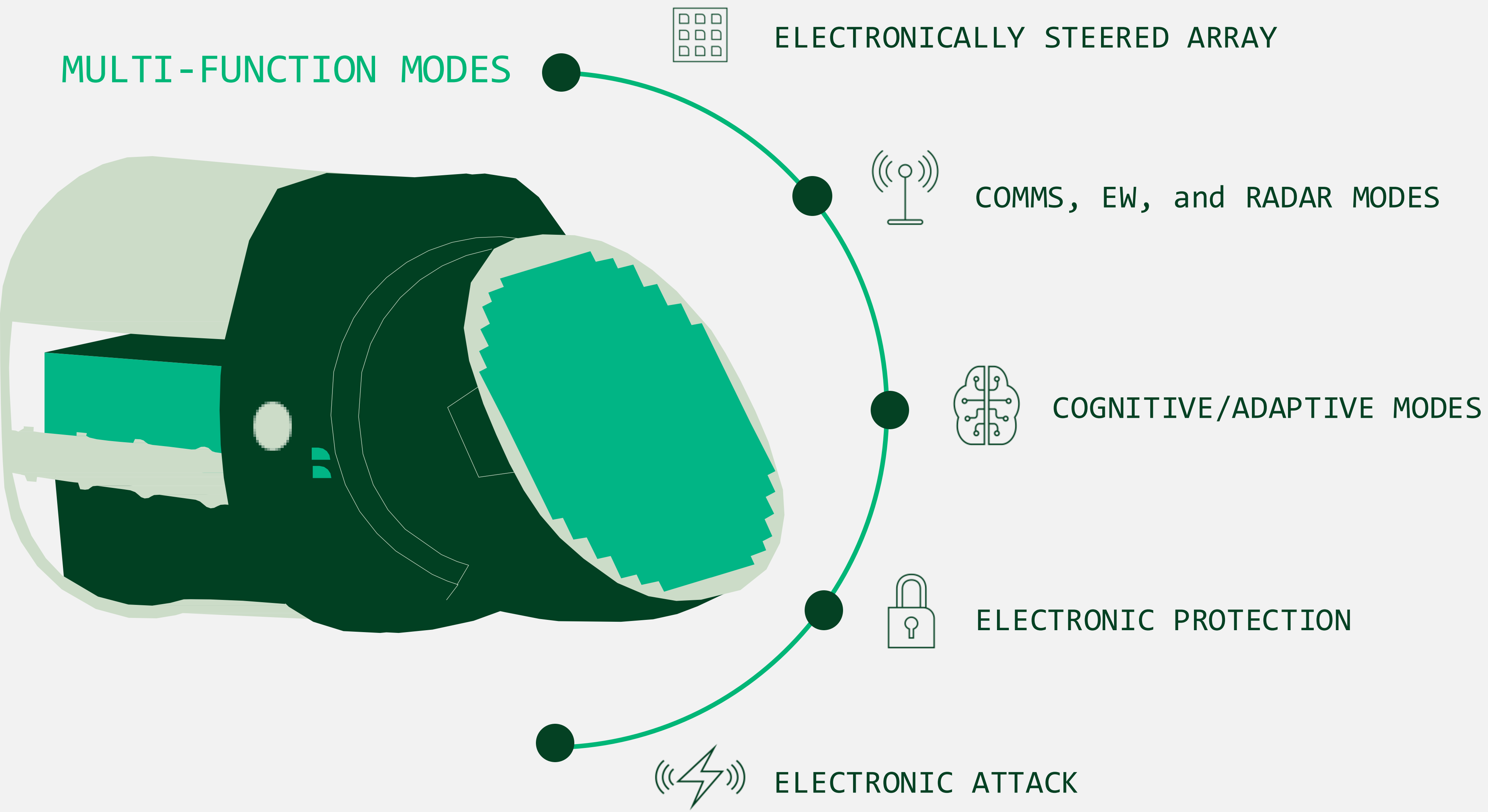
Agenda

- The Contested and Congested Electromagnetic Battlefield
- Moving from the Whiteboard to Proven Concept
- Open Architectures
  - Radar and EW Research
  - Communications Research
- Reference Architecture Overview
- How to Recreate the Architecture

The Contested & Congested Electromagnetic Battlefield

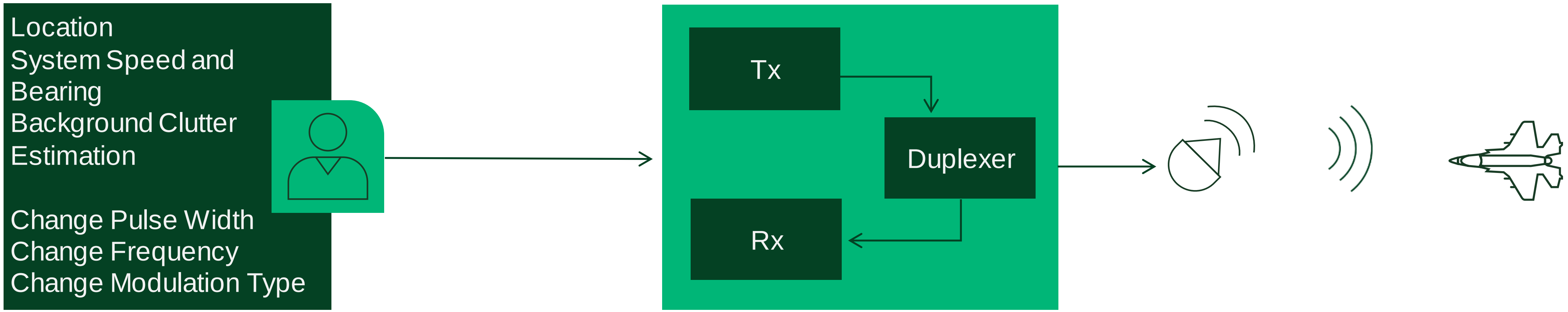


Radar, EW and Communication Design Challenges

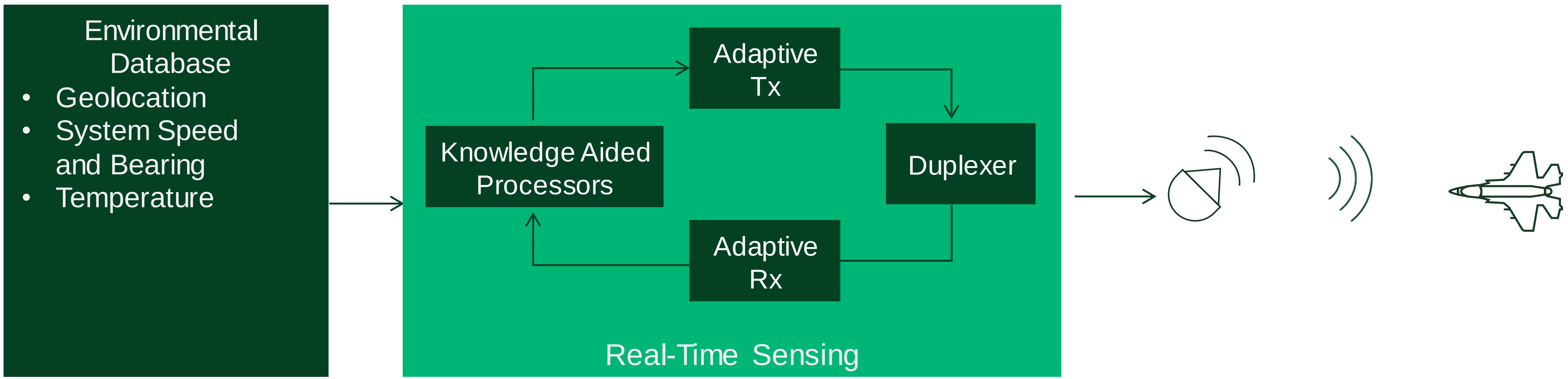


Cognition in RADAR

Standard RADAR System

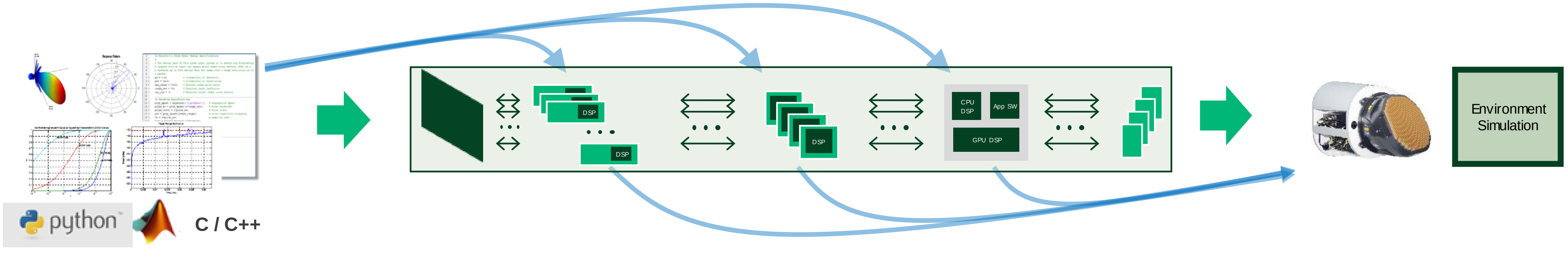


Cognitive RADAR System



Getting from the Whiteboard to Proven Concept

Software Simulation *Hardware Test Bed* *Tactical System*



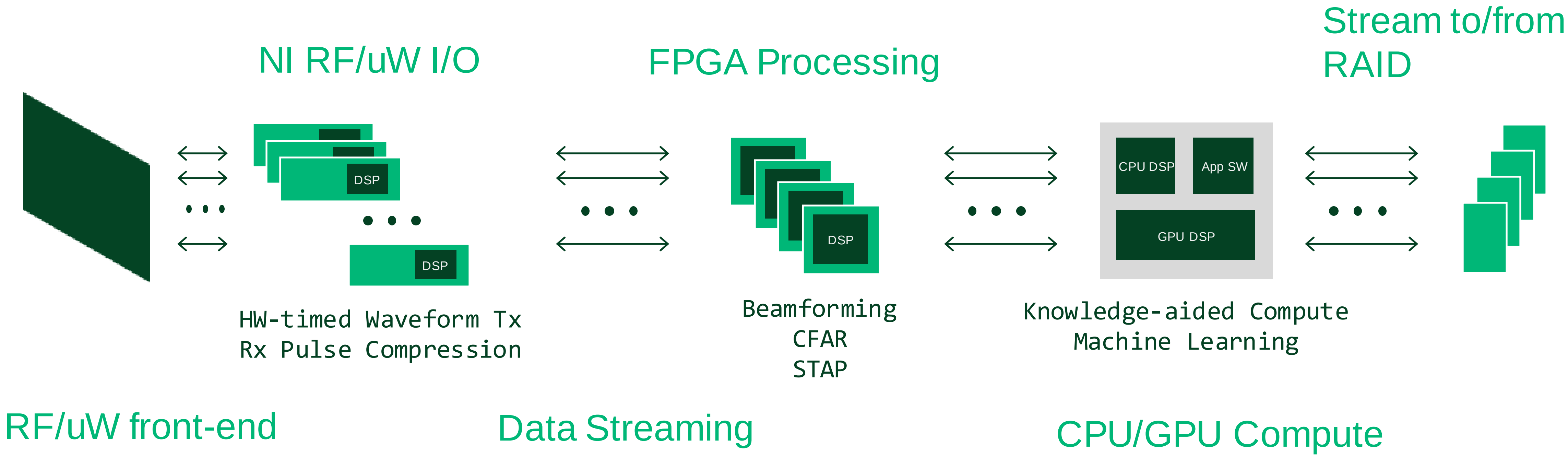
Develop and simulate algorithms and system in software

Develop hardware test bed, iterate with offline processing, migrate processing to hardware

Validate algorithms against simulator and real-world scenarios, iterating as necessary

Migrate validated algorithms to mission hardware, perform integration testing/validation

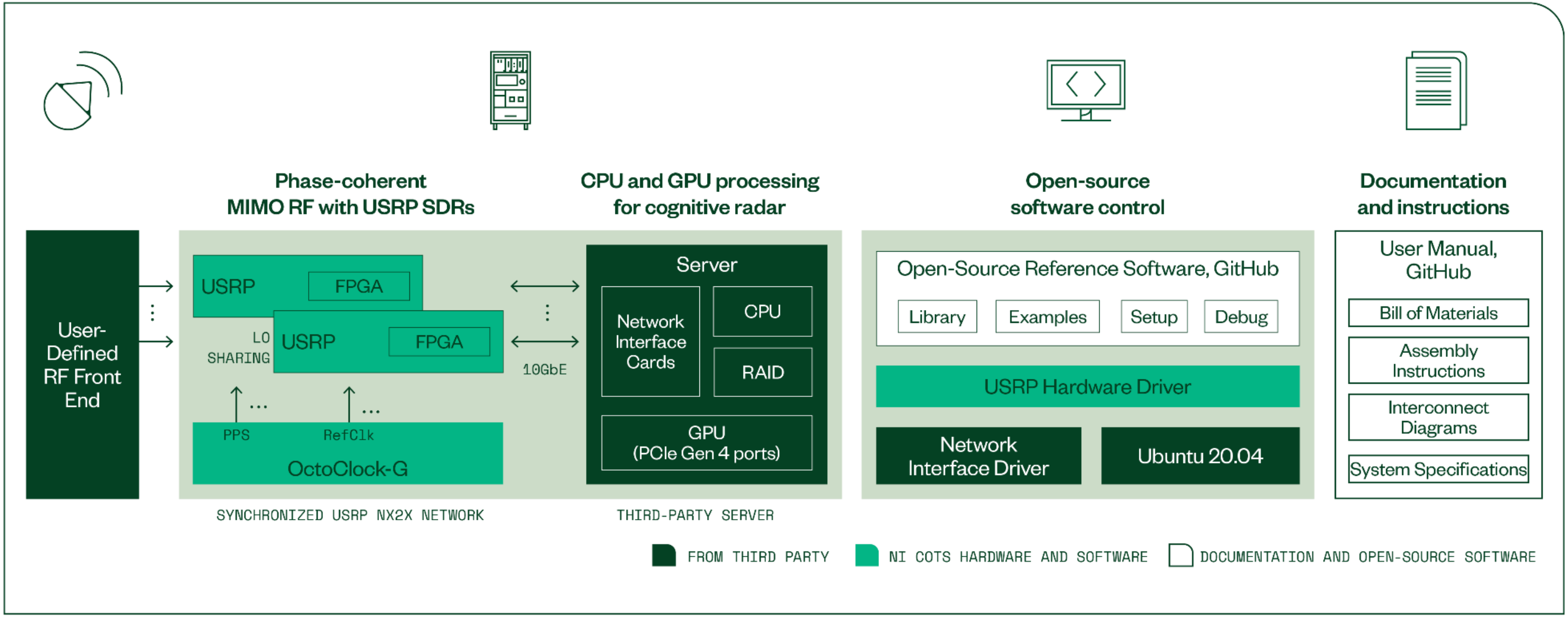
Architecting Cognitive RF Sensors with NI Technologies



NI Technology   Customer Focus

Open Architecture for Radar & EW Research (OARER)

Validated design pattern enables radar/EW researchers struggling to rapidly prototype new concepts to move **quickly** from software simulation to hardware demonstration, ultimately turning novel concepts into fielded capability faster

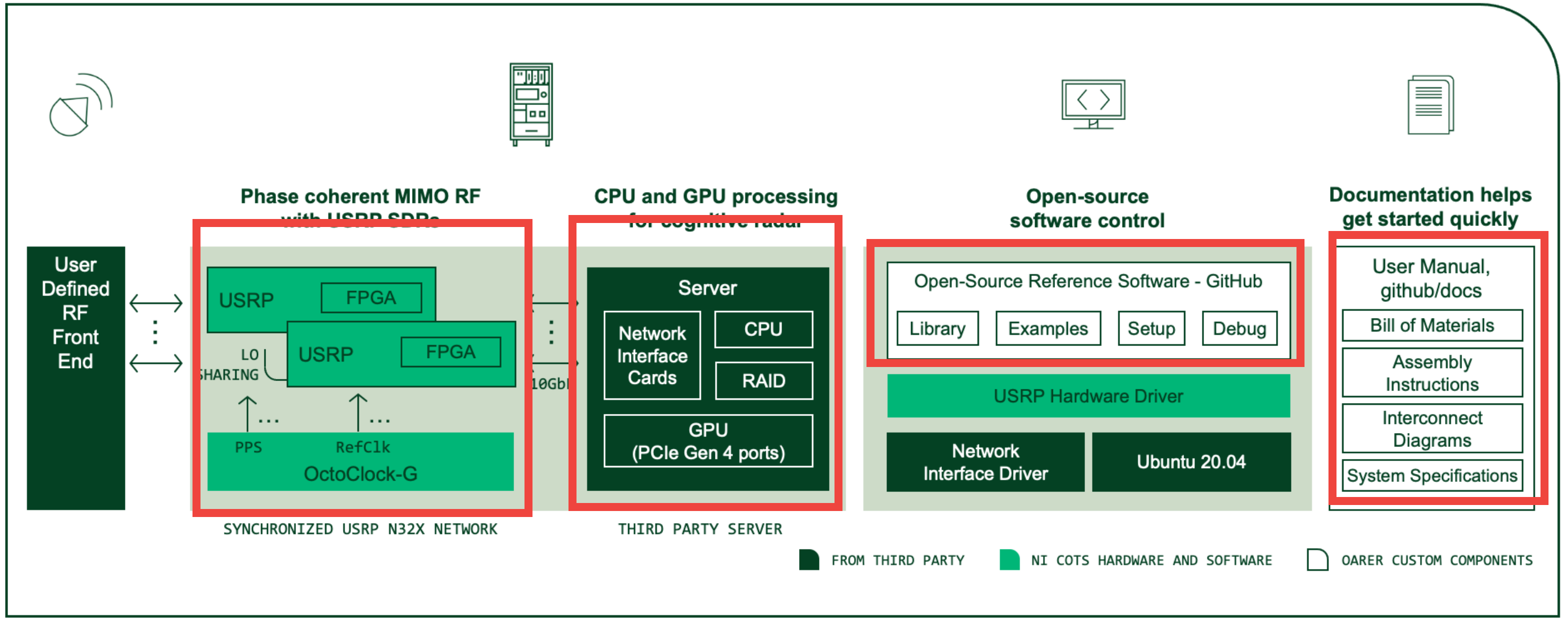


Multichannel RF Reference Architecture

System Overview

Components

- Built from N320, N321, and OctoClocks
- A Server to communicate with all USRPs
- Software on the server
- User Manual has all documentation



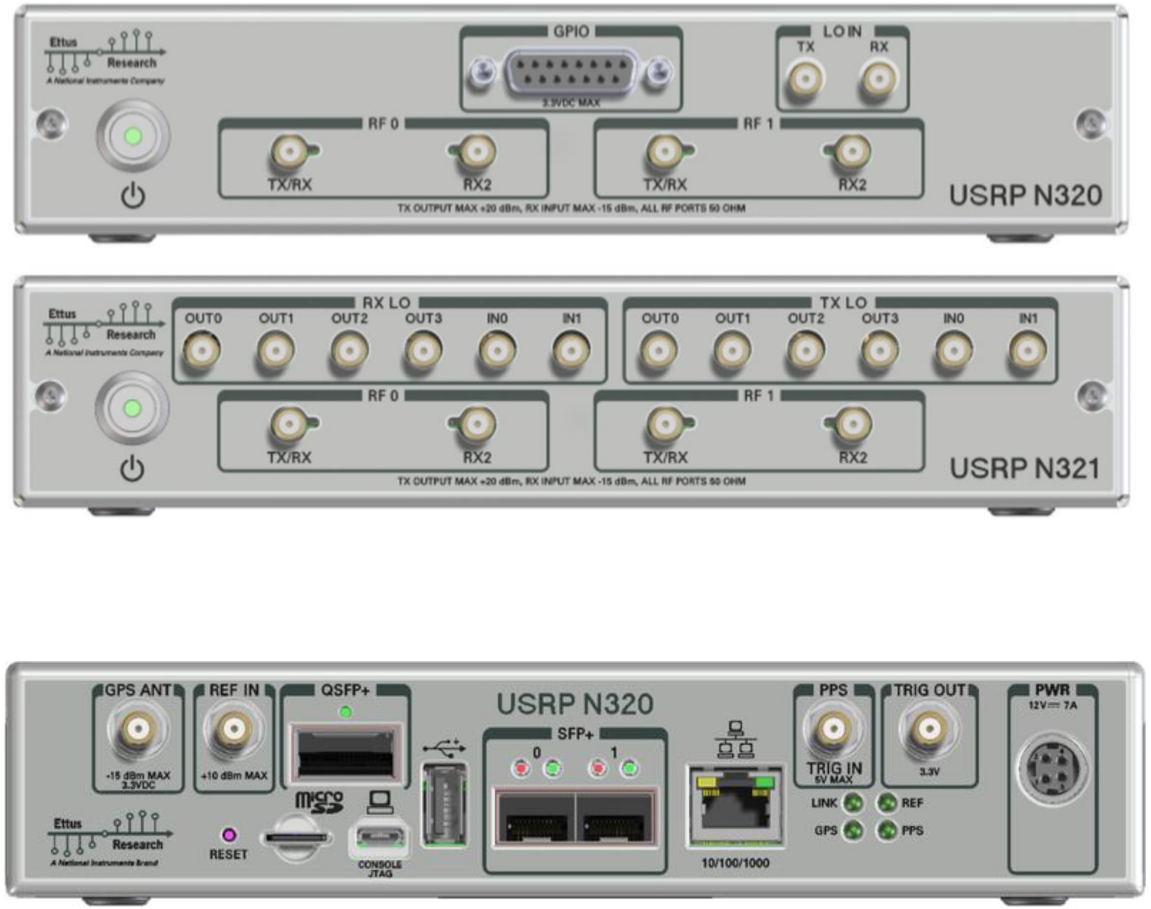
FEATURE HIGHLIGHTS

USRP N320/N321

3 MHz – 6 GHz range
200-MHz BW per channel
2X2 MIMO
200/245.76/250-MHz sample rates
Preselection filters
Dual SFP+ ports (1 GbE, 10 GbE, Aurora)
QSFP+, RJ45
GPSDO
Ethernet-based sync (White Rabbit)
Stand-alone operation

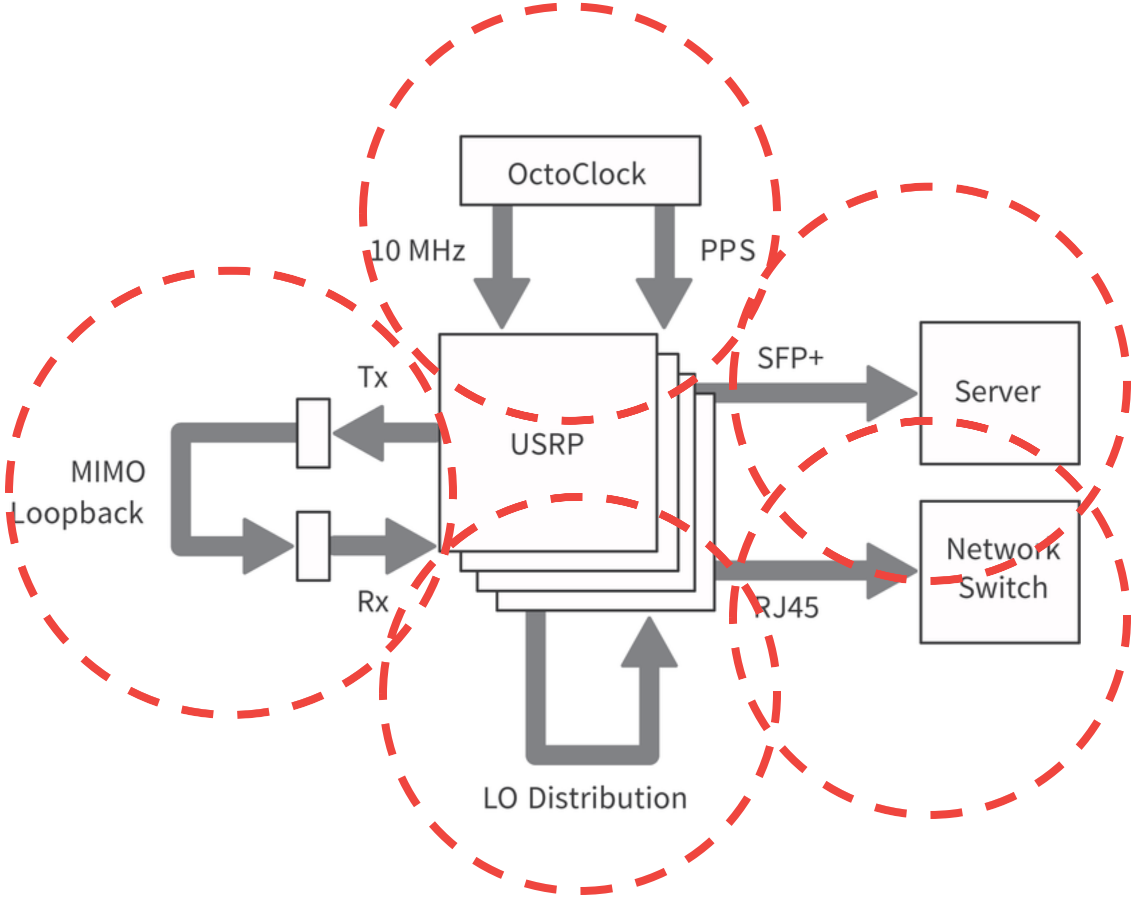
N320:
Zynq XC7Z100-2FFG900I
External LO input ports

N321:
LO Distribution for up to 128x128 MIMO



Connection Overview

- OctoClock
- MIMO Loopback
- LO Distribution
- Control Port Connection
- Data Connection

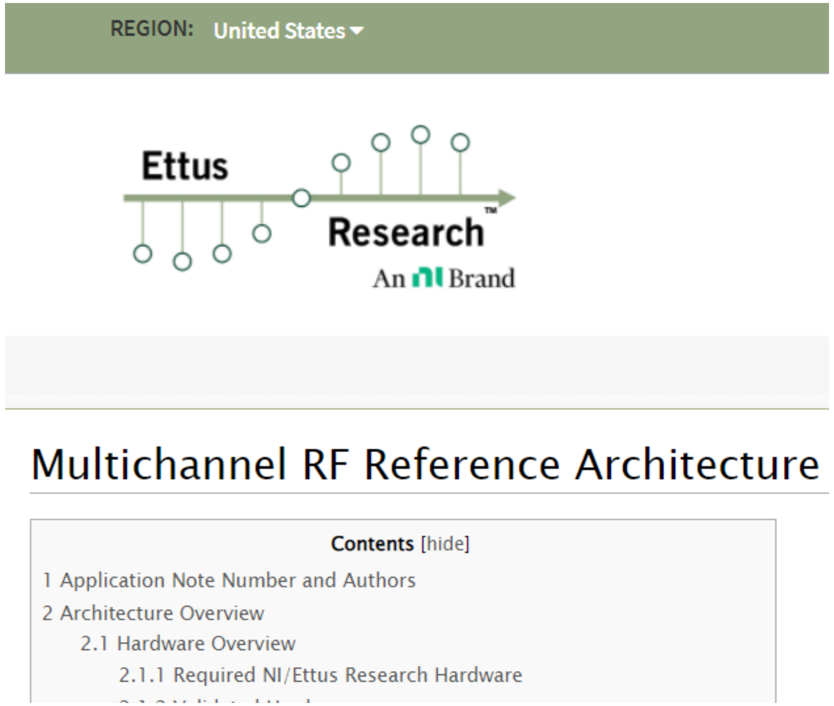


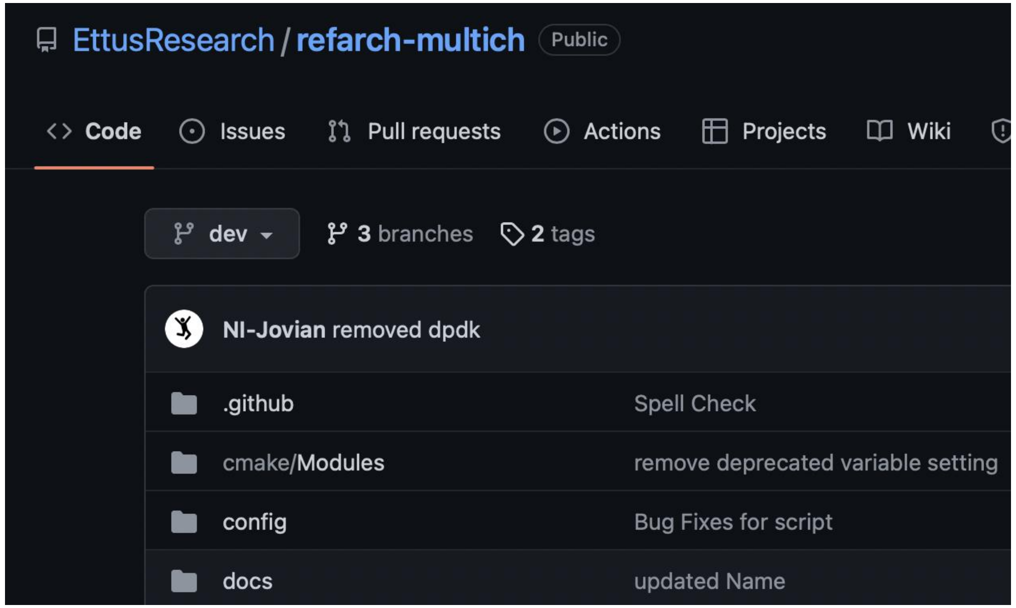
Software

Location & Documentation

https://kb.ettus.com/Multichannel_RF_Reference_Architecture

https://github.com/EttusResearch/refarch-multich





Using the Software

Example Source Code

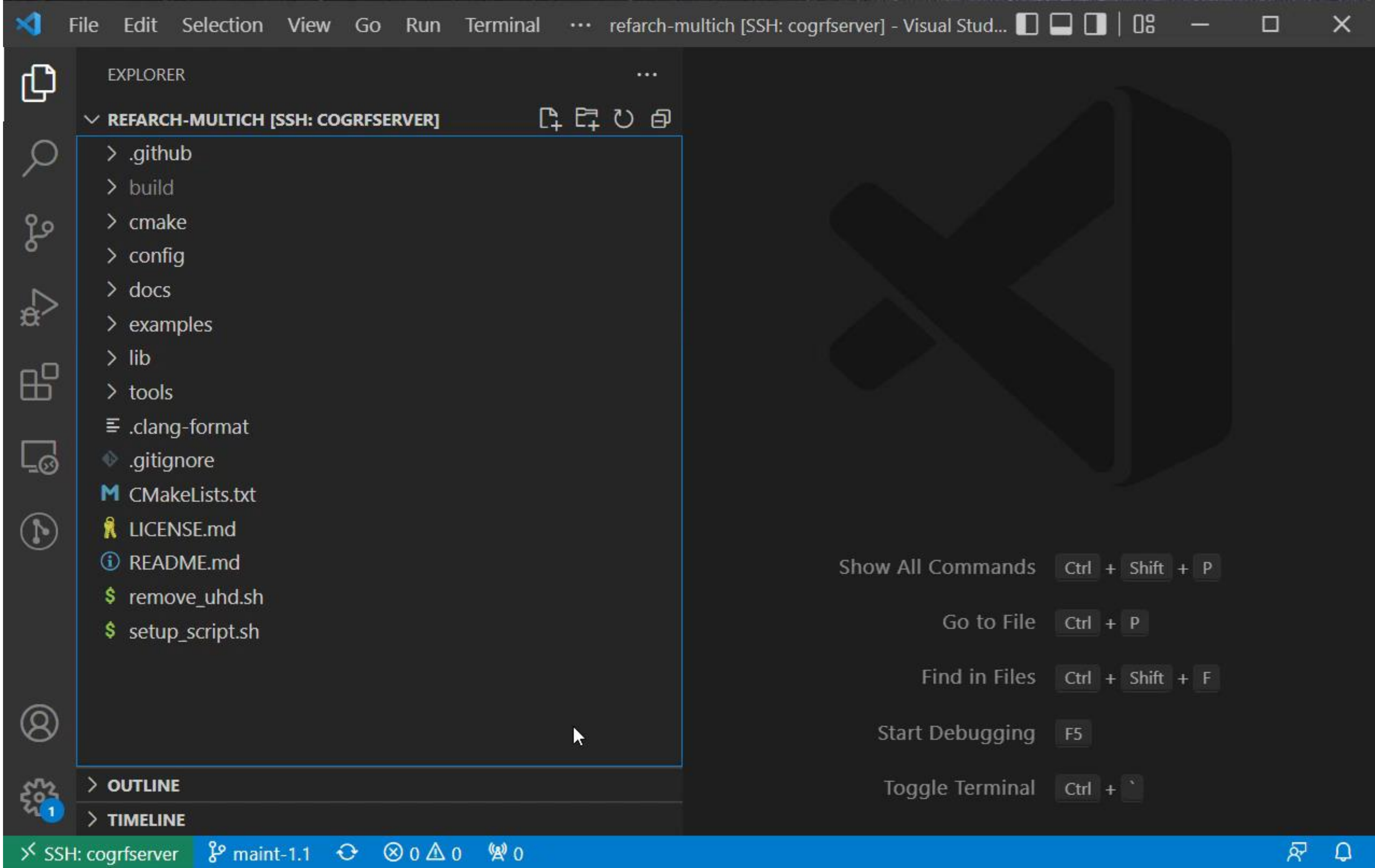
Multichannel RF Reference Architecture is built us

- **UHD RFNoC Example Source Code**— NI reco following UHD RFNoC examples, located in th
  - o `rfnoc_radio_loopback.cpp` —This examp
  - o `rfnoc_replay_samples_from_file.cpp` -
  - o `rfnoc_rx_to_file.cpp` — This example u
- **Reference Architecture Example Source Coc** demonstrate synchronized Tx–Rx operation s
  - o `Arch_iterative_loopback.cpp` —This ex
  - o `Arch_multifreq_loopback.cpp` —This ex `rfnoc_txrx_loopback.cpp`.
  - o `Arch_rfnoc_txrx_loopback.cpp` —This e implementation.
  - o `Arch_rfnoc_txrx_loopback_mem.cpp` —T multithreaded implementation.
  - o `Arch_rx_to_mem.cpp` —This example dem
  - o `Arch_txrx_fullduplex.cpp` —This examp
  - o `Arch_dynamic_tx.cpp` —This example is v files and/or have different logic in each transr USRP channel. Each thread can be customized

Documentation

Overview

- BOM
- How to wire the system
- Setup of USRP
- Setup of server
- Performance measurements
- Running the system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.clang-format
.gitignore
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README.md
remove_uhd.sh
setup_script.sh
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Go to File Ctrl + P
Find in Files Ctrl + Shift + F
Start Debugging F5
Toggle Terminal Ctrl + `
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The Setup Script

Moving to a one click install

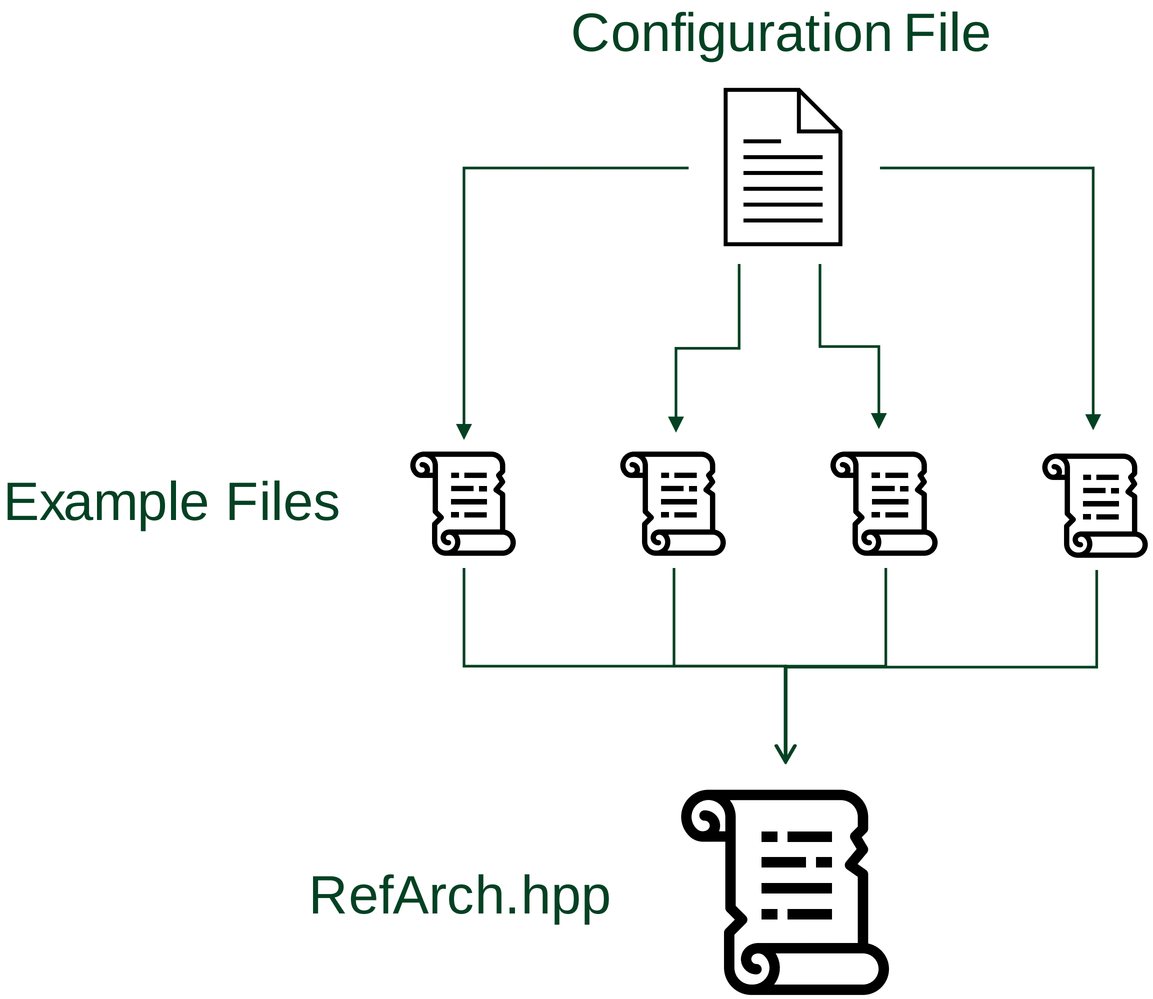
Before

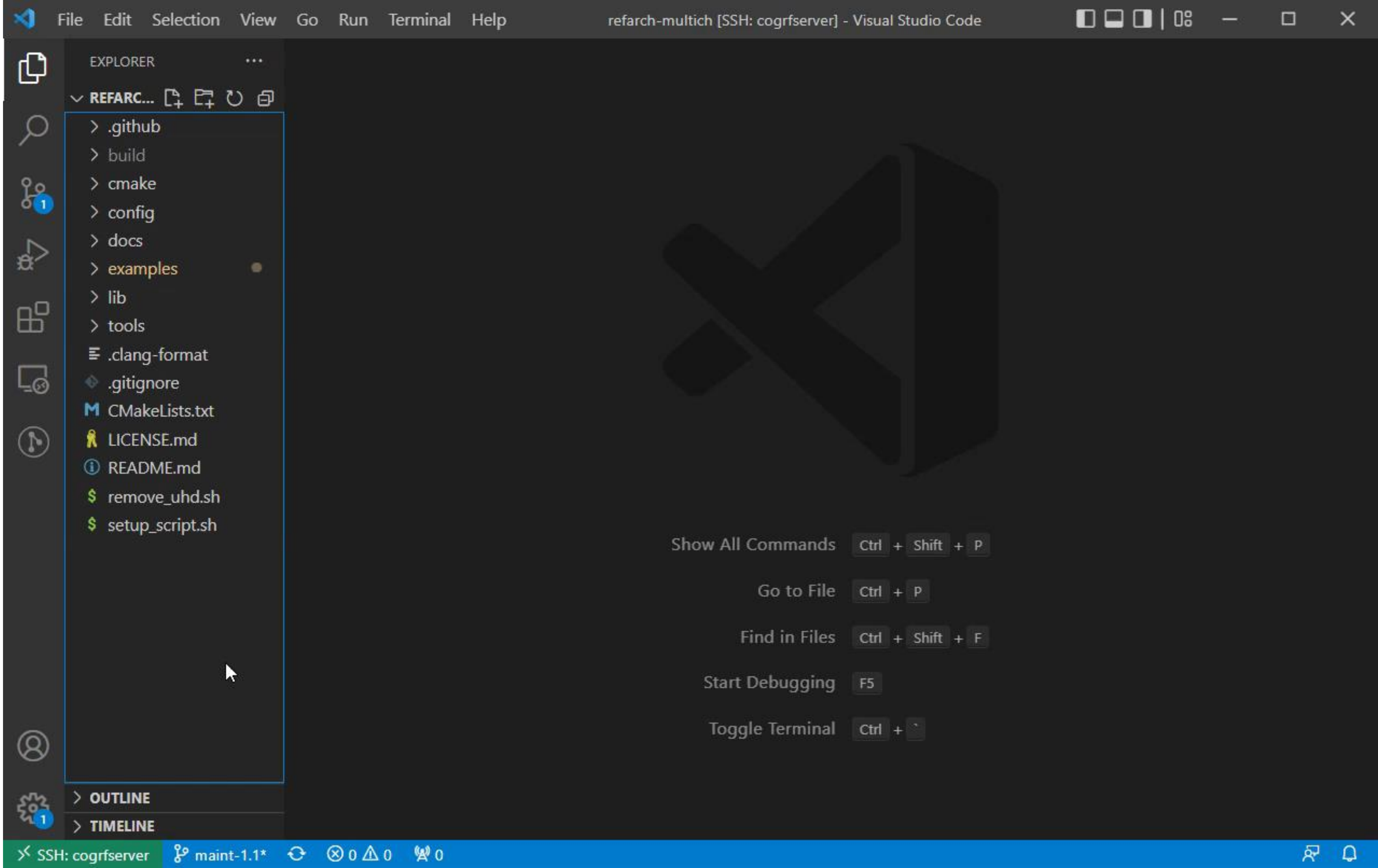
- Dependencies
- Cloning repository
- Finding more Dependencies
- Using Cmake
- Building UHD
- Adding UHD Library
- Enable CPU Performance
- Thread Priority
- Network buffers

After

- Run Script

Software Overview




File Edit Selection View Go Run Terminal Help
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cmake
config
docs
examples
lib
tools
.clang-format
.gitignore
CMakeLists.txt
LICENSE.md
README.md
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setup_script.sh
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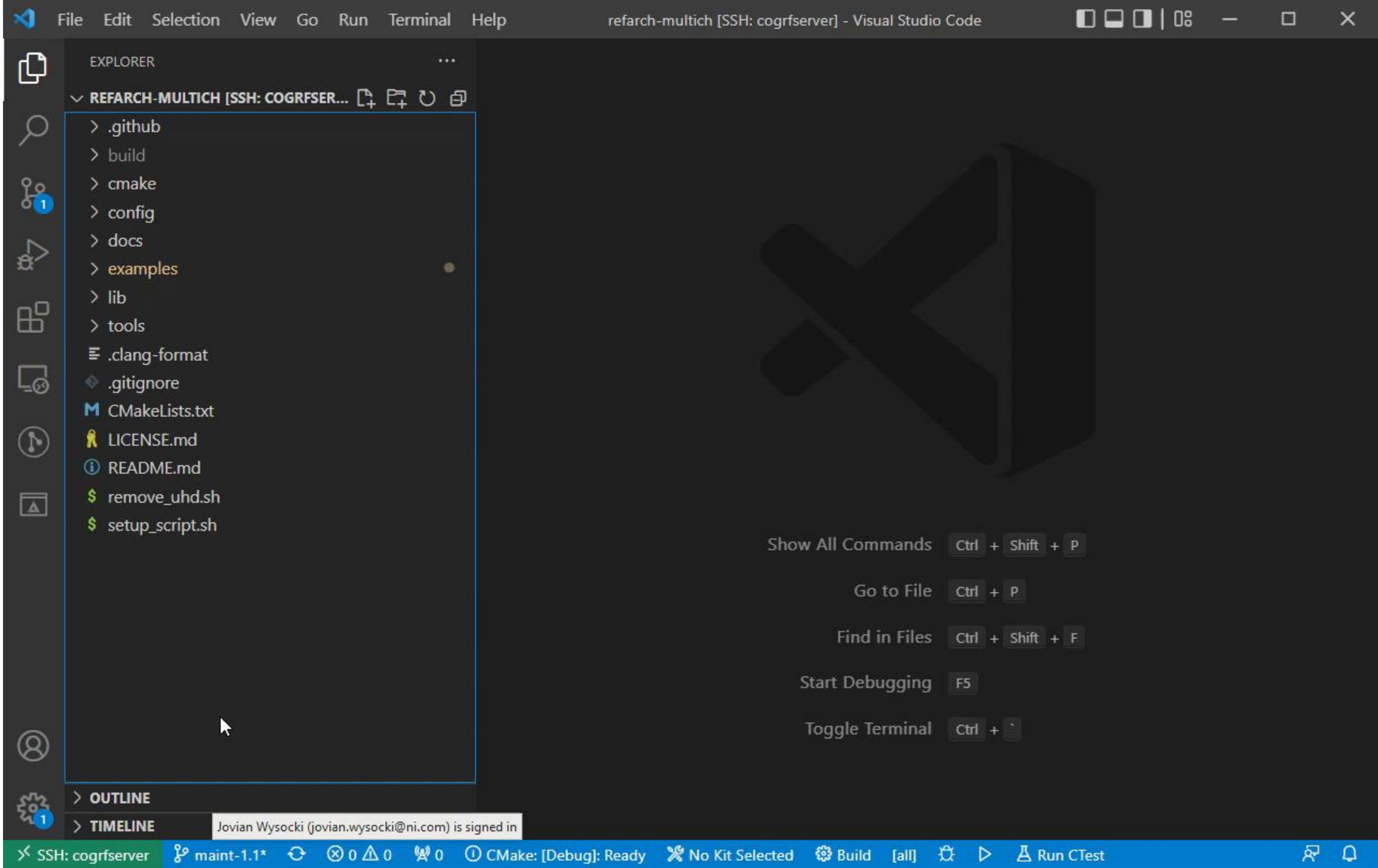
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.gitignore
CMakeLists.txt
LICENSE.md
README.md
remove_uhd.sh
setup_script.sh
OUTLINE
TIMELINE
Jovian Wysocki (jovian.wysocki@ni.com) is signed in
Show All Commands Ctrl + Shift + P
Go to File Ctrl + P
Find in Files Ctrl + Shift + F
Start Debugging F5
Toggle Terminal Ctrl + `
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Build
[all]
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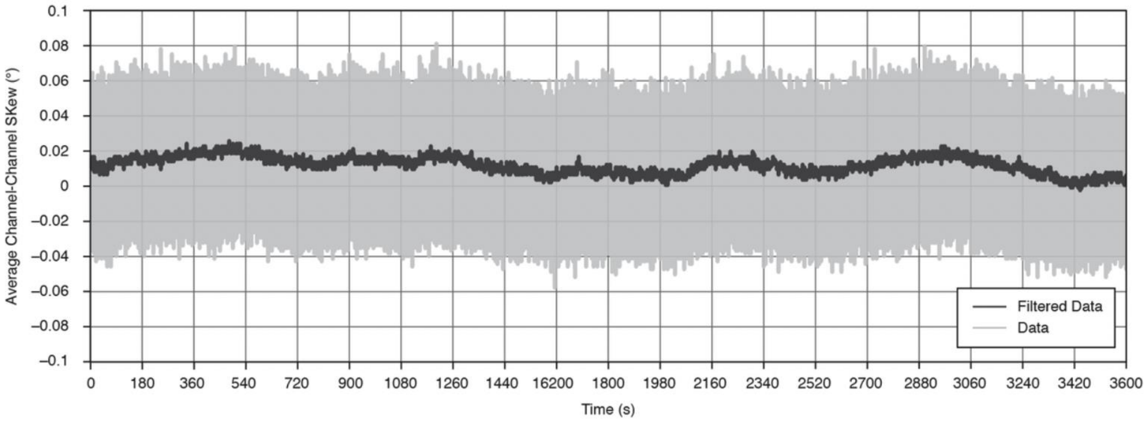
Performance

RX Phase Coherency

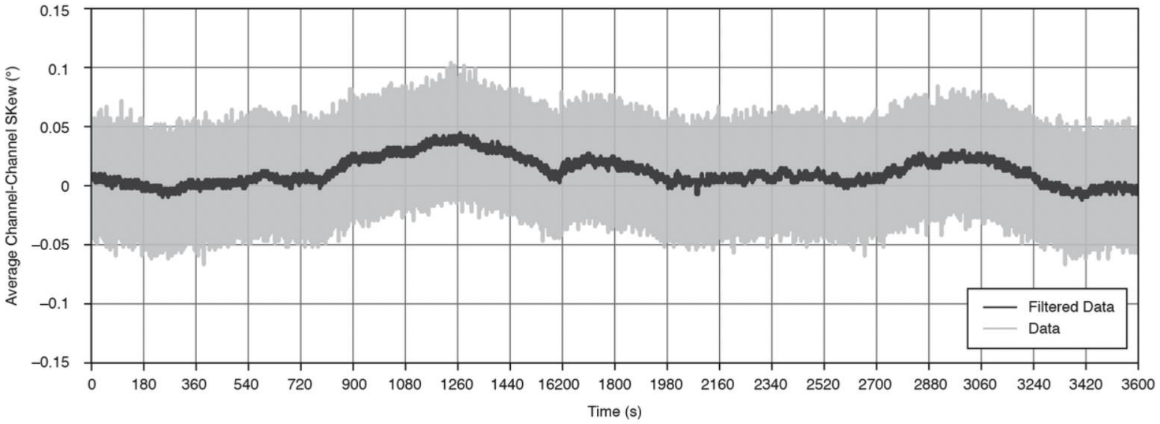
- 2 GHz
- < 1° Resetting the USRPs

Figure 23. Average Channel-to-Channel Phase Skew between Two Rx Channels on the Same Device over One Hour, Relative to t_0



Range, single device	0.139°

Figure 24. Average Channel-to-Channel Phase Skew between Two Rx Channels on Separate Devices over One Hour, Relative to t_0



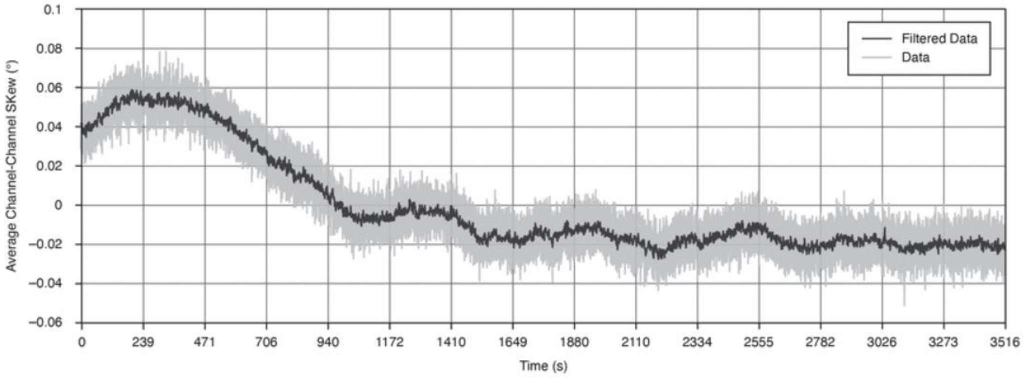
Range, system	0.167°

Performance

TX Phase Coherency

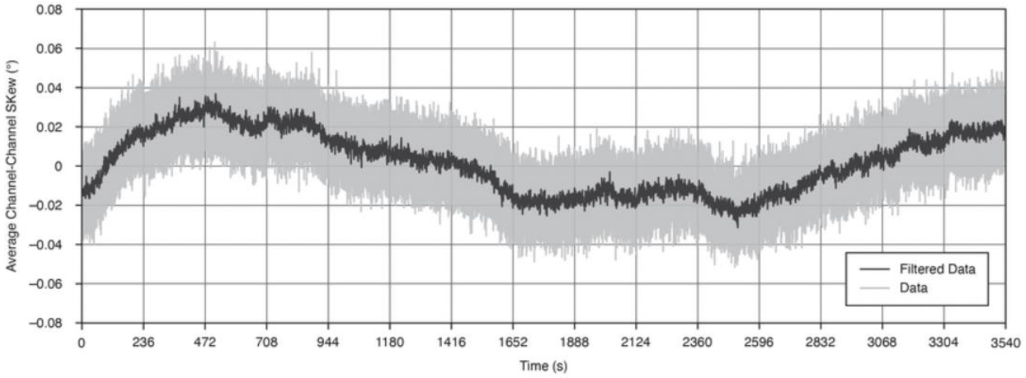
- 1 GHz
- < 0.1° Resetting the USRPs

Figure 26. Average Channel-to-Channel Phase Skew between Two Tx Channels on the Same Device over One Hour, Relative to t_0



Range, single device	0.128°

Figure 27. Average Channel-to-Channel Phase Skew between Two Tx Channels on Separate Devices over One Hour, Relative to t_0



Range, system	0.115°

Performance

RX/TX Streaming

- Actively working to improve performance with DPDK

Table 5. Streaming to Memory Data Transfer Rate

Streaming Rate (MSample/s per Channel)	Number of Channels	Measurement Time (s)
33.33	32	10
50	16	10
122.88	8	10

Table 7. Streaming Simultaneously to/from Disk Rate

Streaming Rate (MSample/s per Channel)	Number of Channels	Measurement Time (s)
11.11	32	10
25	16	10
62.5	8	10
62.5	4	10

See the demo on the Defense Technology Pavilion at NI Connect

More Information

- Ettus KB Multichannel RF Reference Architecture

- Contact us on the Ettus mailing list. Use MRFRA as the subject line! https://lists.ettus.com/list/usrp-users.lists.ettus.com

- Hardware List on GitHub page in the docs/ folder