Mission Adaptable Software Define Radio (MASDR) Ground Station to the WInnComm 2018

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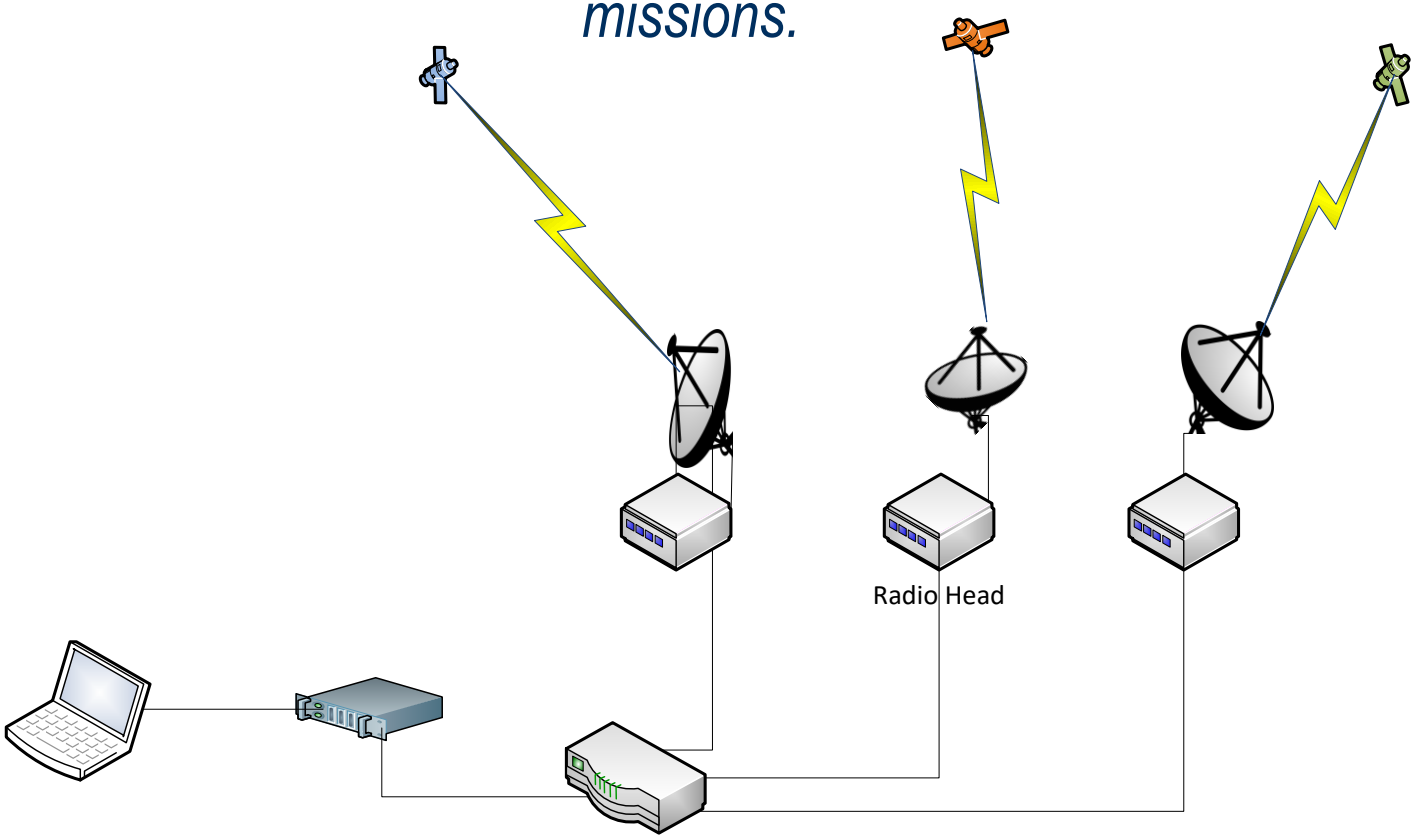
MASDR Vision

The MASDR Ground Station shall deliver an optimized SWaP-C ground systems solution that is highly mobile, reconfigurable, and easily integrated into existing satellite systems to support both new and current space missions.



Approach

Ettus E310 SDR

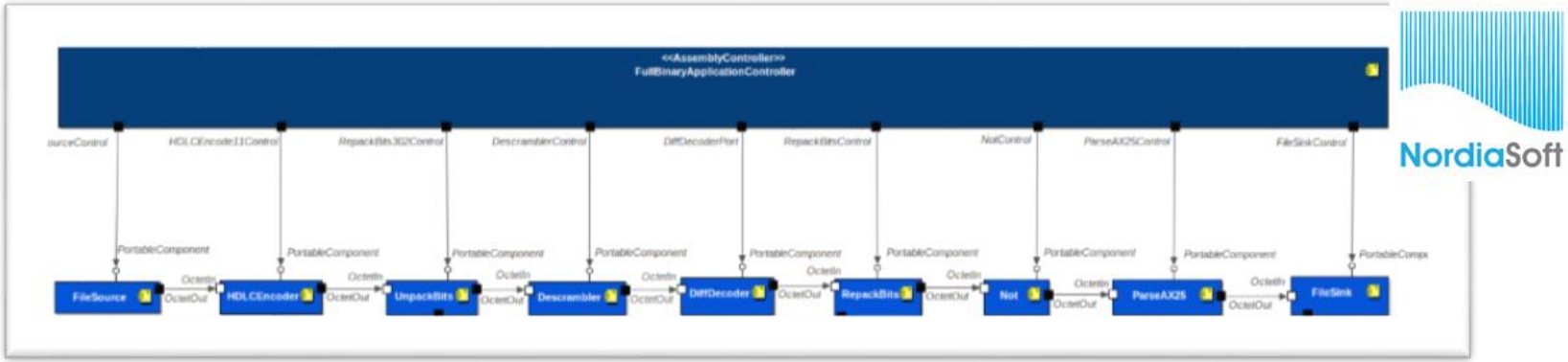
MASDR FY18 Accomplishments

Completed NordiaSoft eCo Software Training

Development Team attended a four-day NordiaSoft Training Workshop (2/20 – 2/23) to learn how to utilize new software tools for waveform development.

MASDR FY18 Accomplishments

- 1. Successfully performed Hardware-In-Loop testing using E310 and PropCube GnuRadio Flowgraphs
- 2. Decoded packets with Ettus E310 during PropCube satellite passes
  - Used ground station and E310 SDR to successfully receive PropCube transmissions during live satellite passes.
- 3. Verified partial PropCube SCA 4.1 waveform using NordiaSoft's eCoSuite
  - Successfully created several digital processing SCA components and validated functionality using PropCube data packets.



MASDR Project Milestones

FY18	FY19	FY20
Phase 1. (Q1) - Define system requirements - Finalize architecture **Phase 2 (Q2-Q4)** - Verify E310 compatibility with existing ground station - Develop SCA 4.1 waveform applications .	**Phase 3 (Q1-Q2)** - Complete SCA waveform applications and test cross compatibility with multiple USRP radios **Phase 4. (Q2-Q3)** - Integrate SDR into existing Ground Station - Demonstrate modified Ground Station communications functionality with multiple on-orbit satellites **Phase 5 (Q4)** - Hold technology demonstration to potential sponsors. - Obtain signed Technology Transition Agreement	Follow-on Tasks: T1: Assemble ground station and verify SCA waveform functionality. T2: Develop front-end user software application T3: Develop CONOPS for ground station network to work with existing and future satellites. T4: Deploy additional terminals at key locations T5. Conduct technical demo, assessment, and training to 76. Evolve to transitional user requirements

FY19 Q1 Goals

Obtain Site Approval for Frequency Transmission (Dec 2018)

- PropCube (In-Orbit Satellite Waveform)
- HiakaSat (Development Satellite Waveform)

Complete end-to-end PropCube Waveform Application Development (Dec 2018)

- **Complete SCA Application in eCoSuite**
  - Use open-source DSP library (liquid-dsp) to complete complex baseband SCA components
  - Use developed SCA components to create waveform applications and confirm end-to-end functionality for both PropCube and HiakaSat

Deploy and Test SCA Waveform Application. (Dec 2018)

- **Use SDRs to test SCA Waveforms in Lab Environment**
  - Transmit and receive decoded packets between two E310 SDRs in the lab
  - Demonstrate cross compatibility and software portability with the N300 USRP

FY19 Q2 Goals

Integrate SDR into Ground Station (Mar 2019)

- **SDR + MC3 Ground Station to support live operations and end-of-year demonstration**
  - Integrate SDR into MC3 UHF transmit and receive chain
  - Identify and procure new hardware and software required for SDR integration.

Software Solution for Ground Station Operator (Mar 2019)

- **Develop End User Interface**
  - Leverage existing software (COSMOS?) to provide interface for SDR control and configuration

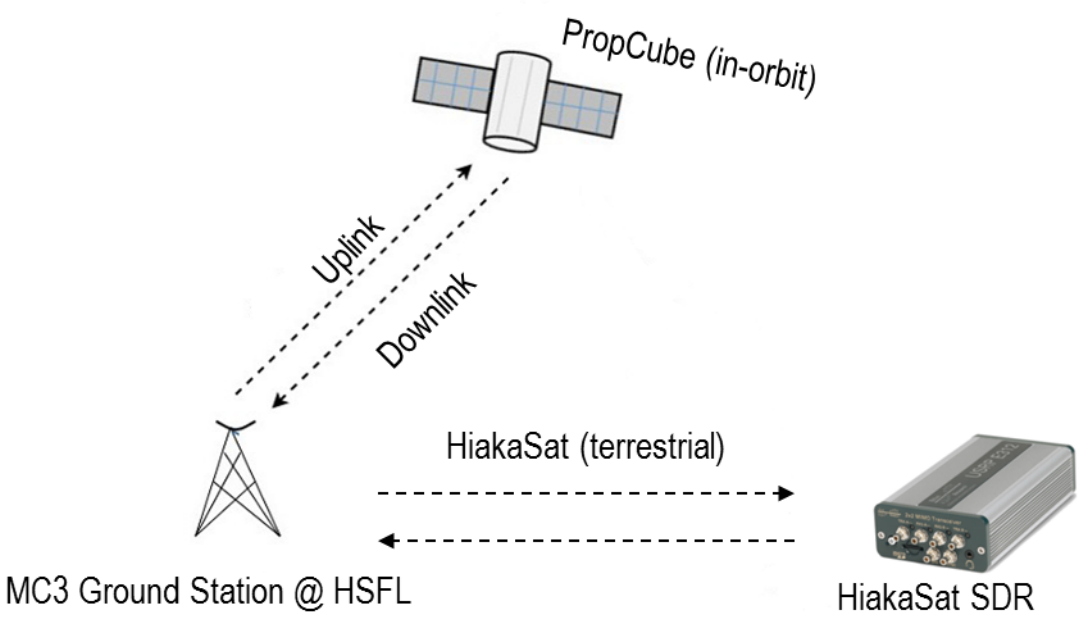
Validate Modified Ground Station functionality (Jul 2019)

- **Verify SCA waveforms applications using modified Ground Station**
- **Perform over-the-air testing with PropCube satellites (in-orbit) and HiakaSat radios (terrestrial)**

FY19 Q4 Goals

Coordinate Operational Demonstration (Aug 2019)

- **Ground Station Communications using PropCube and HiakaSat waveforms**
  - FY19 end-of-year demonstration will be the transmission and reception of two different waveforms; PropCube and HiakaSat
  - Showcase SCA v4.1 benefits by using two different radio platforms during demo



FY19 Q4 Goals

Project Transition

- **Obtain technology Agreement with Sponsor(s) – In process**
  - Seek transition partner(s) for MASDR beyond FY19
  - Determine evolutional goals from transition sponsor
  - Pursuing project collaboration opportunities through the Responsive Space Capabilities Memorandum of Agreement (RSC MOU) (USA) SAF/IAPC, involving participants from 11 nations

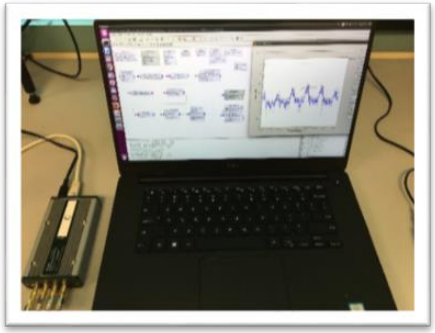
SAF/IAPC: Secretary of the Air Force / International Armaments Cooperation Division

Highlights - Verified E310 Compatibility with Ground Station

- **Findings:** Observed receive frequency offset by operators during satellite with E310.
- **Troubleshooting:**
  - Characterize frequency reference difference between USRP 2922 vs. E310. Measured offset as high as 36.5 kHz delta.

Image courtesy of Hawaii Space Flight Laboratory

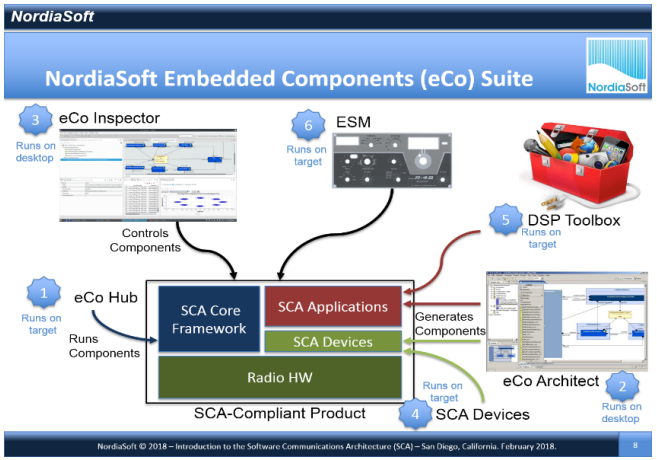
Tx SDR	Rx SDR	Successful Packet Reception Frequency range
E310-B	E310-A	913.972 MHz +/-1.5 kHz
E310-B	NI-USRP 2922	913.9725 MHz +/-1.5 kHz
E310-B	NI-USRP 2922 (w/ 10MHz Sig Gen Ref)	913.9355 MHz +/-1.0kHz
E310-B	NI-USRP 2922 (w/ 10MHz MC3 Ref)	913.97225 MHz +/-1.25kHz



- Develop recording capability to capture the receive signal of a real-time Propcube satellite pass. (in process)
- Use Propcube recording to perform bench level troubleshooting and find root cause.

Highlights - Developed reconfigurable SCA 4.1 compliant SDR

- **Setup Development Environment.**
  - Install Ubuntu, GNURadio, drivers, configure SDRs,
  - NordiaSoft eCoSuite Install. Initial install incompatibility with OS environment, Ubuntu 16.04 kernel 4.4.
  - SDR Testbed simulation in lab controlled environment
- **Completed eCoSuite Examples**
  - Demonstration Guide and preinstalled libraries to successfully build, compile, and run example applications
  - Build SCA Components to recreate example AudioEffect application.



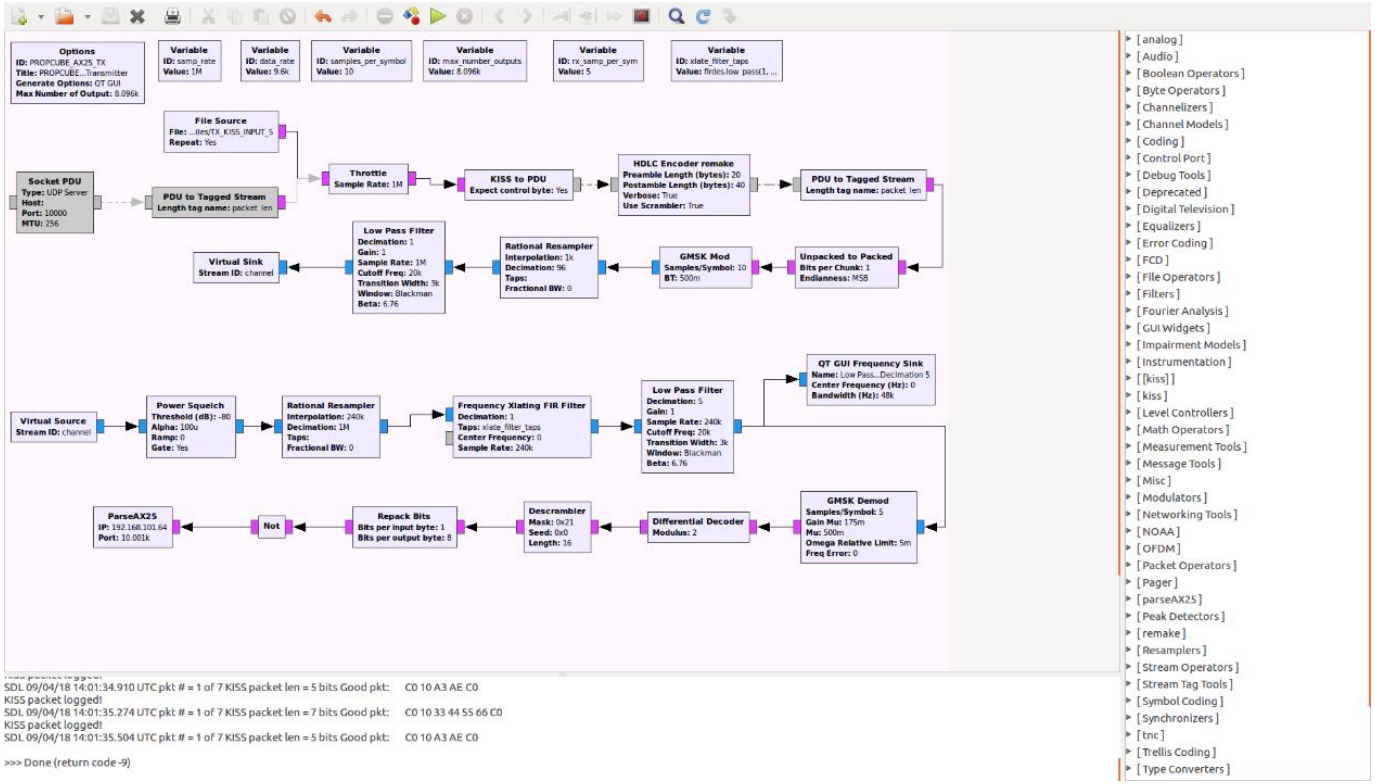
Highlights - Developed reconfigurable SCA4.1 compliant SDR

- Develop GNU Radio waveform models for HiakaSat and PropCube. Leverage GNU Radio models to support SCA software development.

Figure. GNURadio PropCube receiver flowgraph using FlatSat recording

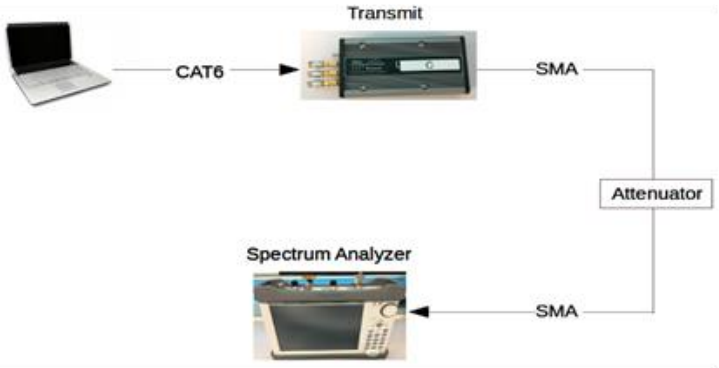
Highlights - Developed reconfigurable SCA 4.1 compliant SDR

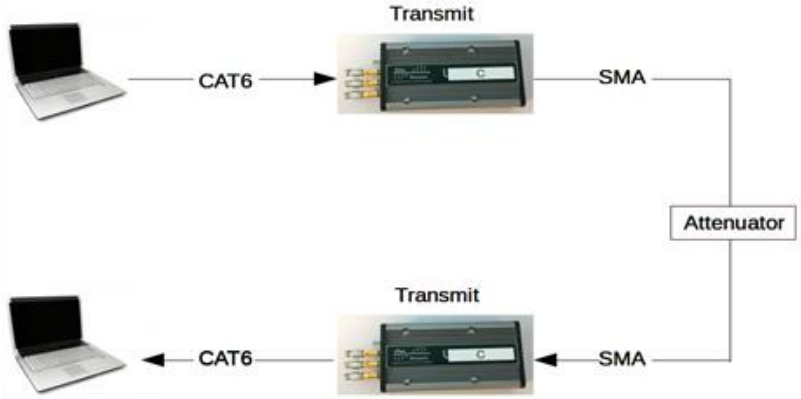
- Develop GNU Radio waveform models for HiakaSat and PropCube. Leverage GNU Radio models to support SCA software development.

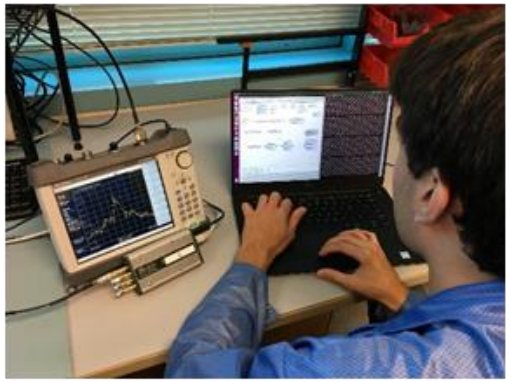


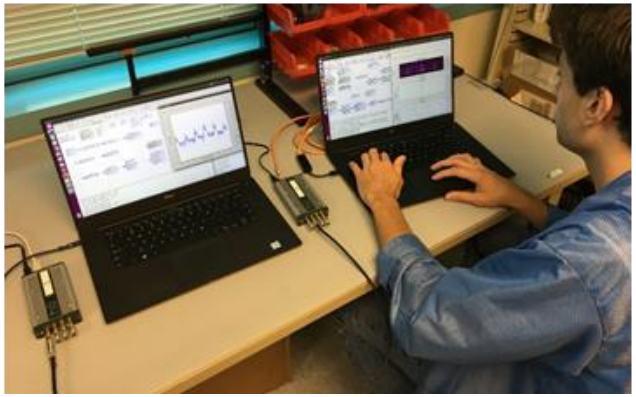
Highlights - Developed reconfigurable SCA 4.1 compliant SDR

- Validated GNURadio models with hardware-in-the-loop testing.









Highlights - Developed reconfigurable SCA 4.1 compliant SDR

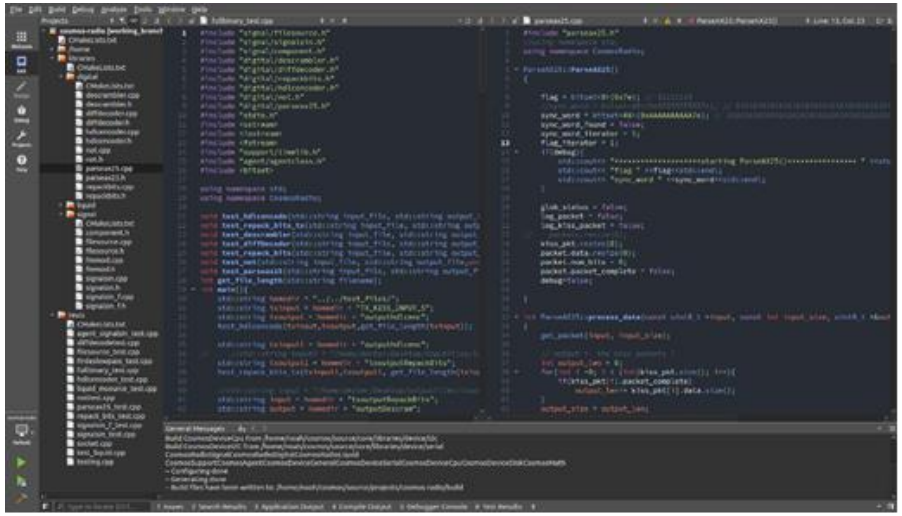
- Break down major, complex milestone into 7 sub-tasks
- Leverage SCA component re-use for subsequent sub-tasks and milestone objective

#	Sub Task	Duration	ECD
1.	Develop SCA Component using eCo Suite IDE	2 weeks	06/15/18
2.	Develop SCA Transmit Application (Single Tone)	2 weeks	06/29/18
3.	Develop SCA Receive Application (Single Tone)	2 weeks	07/13/18
4.	Validate Waveform Application End-to-End with HIL test bed	1 week	07/20/18
5.	Develop PropCube Transmit Application (GFSK)	2 weeks	08/03/18
6.	Develop PropCube Receive Application (GFSK)	2 weeks	08/17/18
7.	Develop HiakaSat Waveform Application	2 weeks	08/31/17

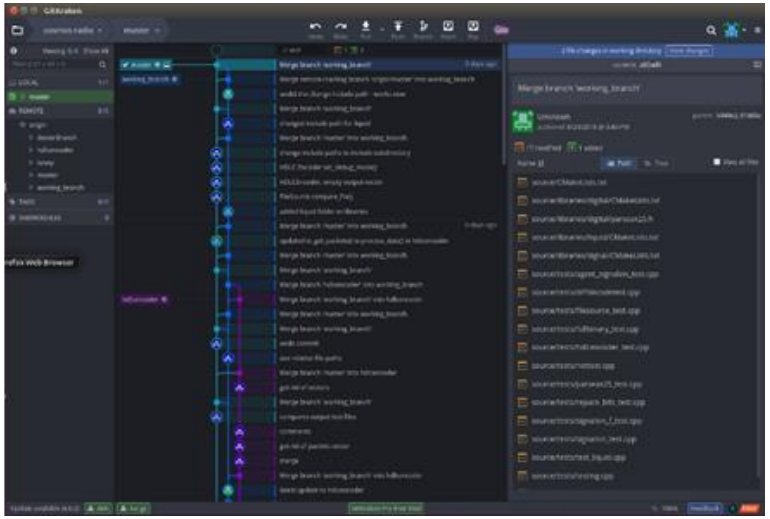
Highlights - Developed reconfigurable SCA 4.1 compliant SDR

▼ Used eCo Suite IDE

- Created external source code libraries for C++ Implementation
- Utilized QTCreator and GitKraken software tools for testing and team development



QTCreator



GitKraken

Highlights - Developed reconfigurable SCA 4.1 compliant SDR

▼ Used NordiaSoft eCo Suite IDE