Misbehavior Detection System for Cellular Vehicle-to-Everything Networks

Final Critical Design Review

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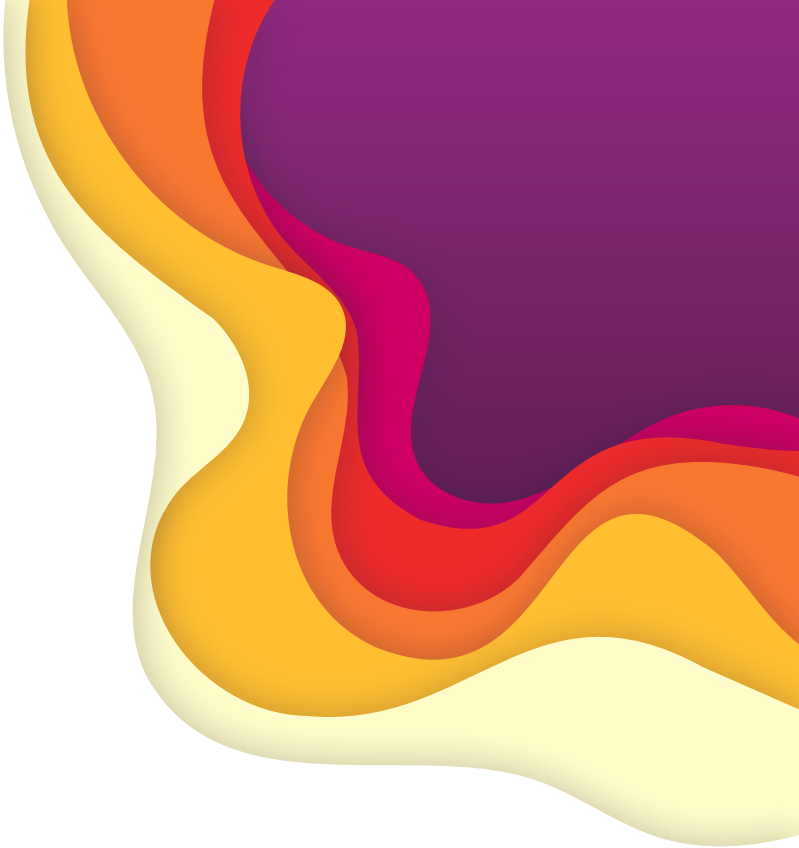
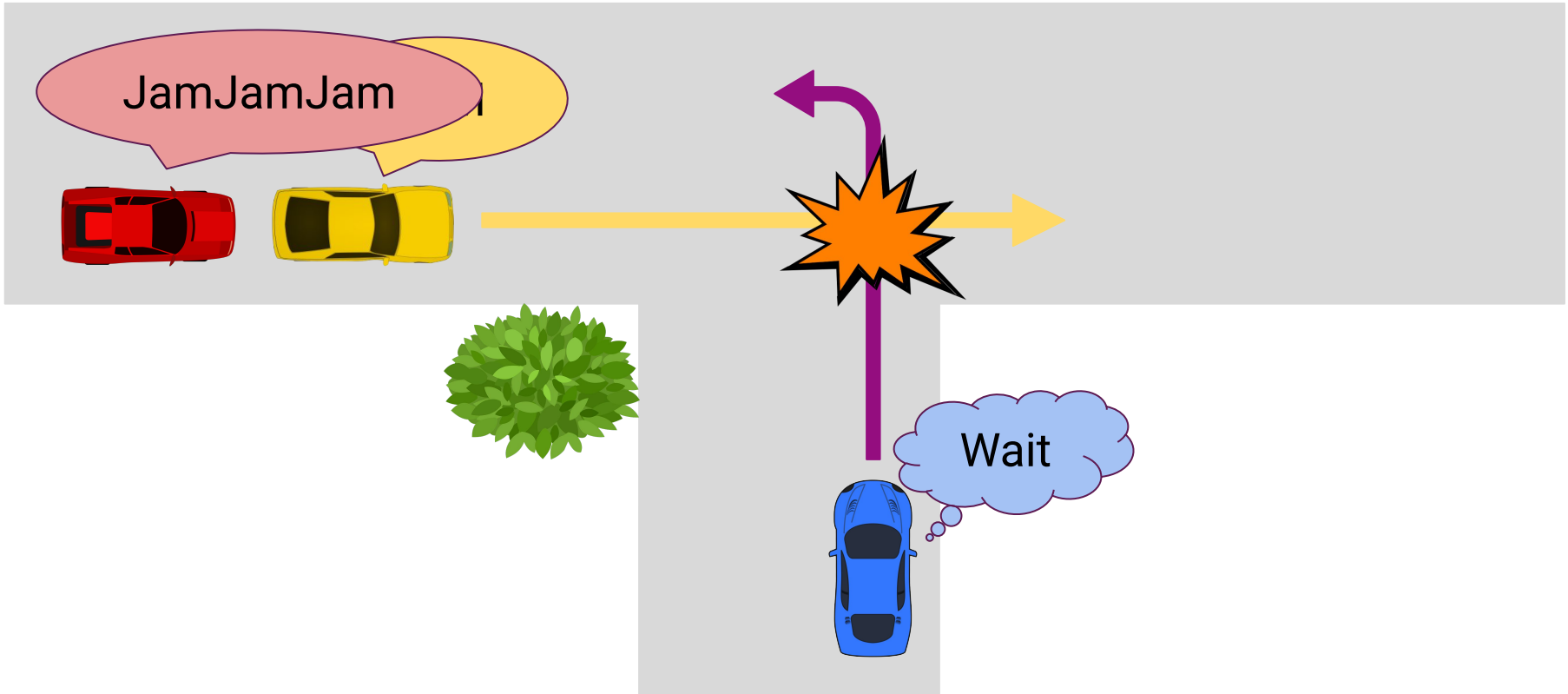
Overview

- Problem Statement
- Requirements
- C-V2X Protocol
- Experimental Setup
- Software Libraries
- Demo:
  - Cellular Bitrate Tests
  - C-V2X Transmit
- Signal Analysis
- Progress
- Gantt Chart



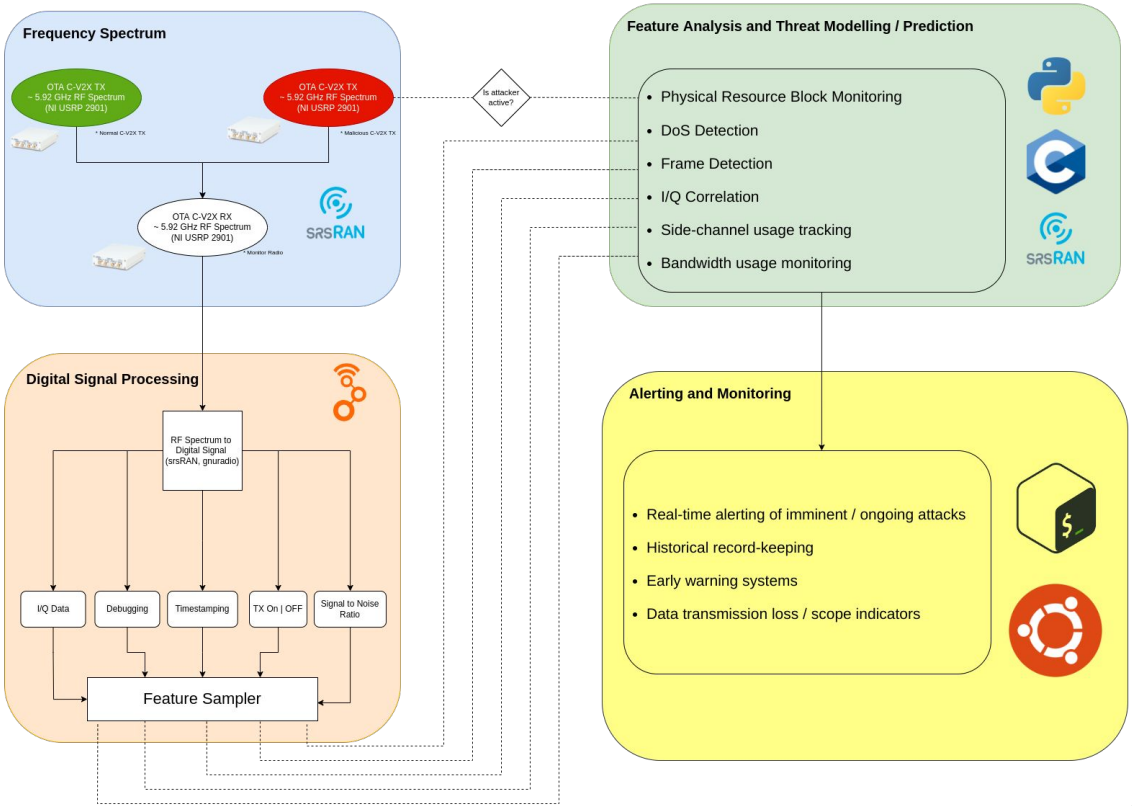
A Quick Visual



Problem Statement

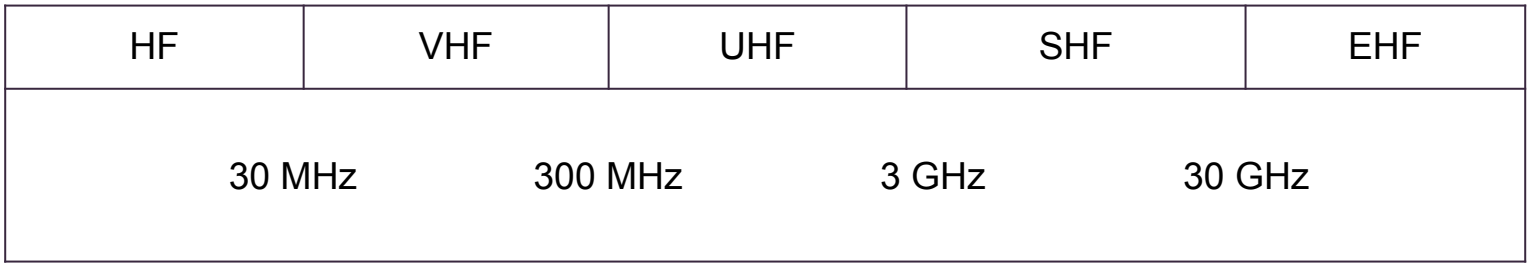
To thoroughly understand the effectiveness of the C-V2X standard, we must analyze physical layer attacks on nodes in the network.

Project Components



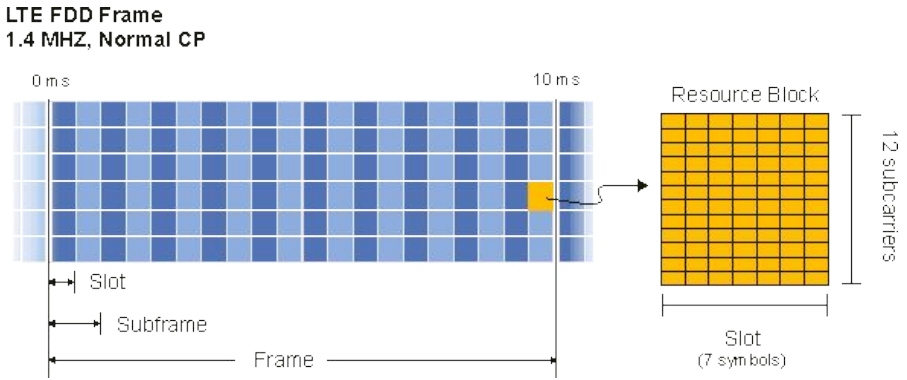
C-V2X Protocol

- A cellular network protocol that uses sidelink communication, a.k.a direct, peer-to-peer communication
- Based on LTE and operates in the 5.9 GHz ITS band
- Vehicles communicate via periodic Basic Safety Messages (BSM)
- Bandwidth is divided into subchannels which is a group of multiple resource blocks
- Mode 4: autonomous resource selection
- Sensing-Base Semi-Persistent Scheduling (SB-SPS)
    - Frequency hop after some number of transmissions
    - Sensing: energy, PSCCH decoding, priority information

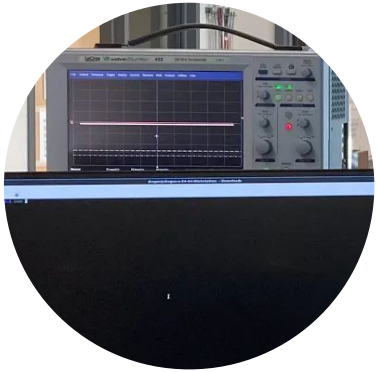


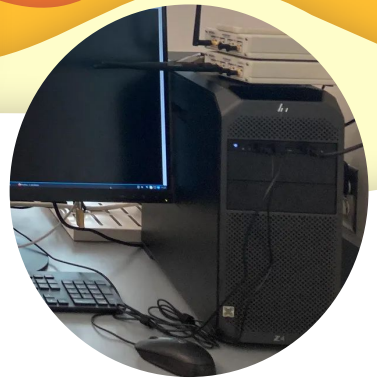
Resource Blocks

- The LTE physical layer frequency allocation can be visualized with resource blocks.
- Each frame spans 10 ms and is subdivided into 1 ms subframes each of which is capable of carrying at most one transmission.
- A transmission can use one or more resource blocks within a subframe.



Experimental Setup



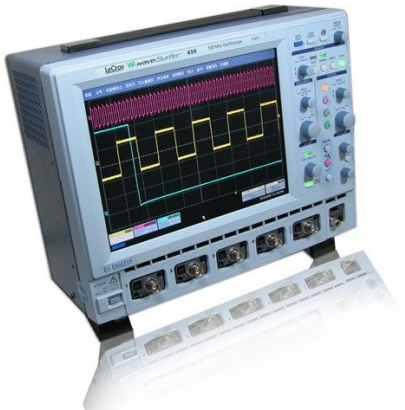


Experimental Setup

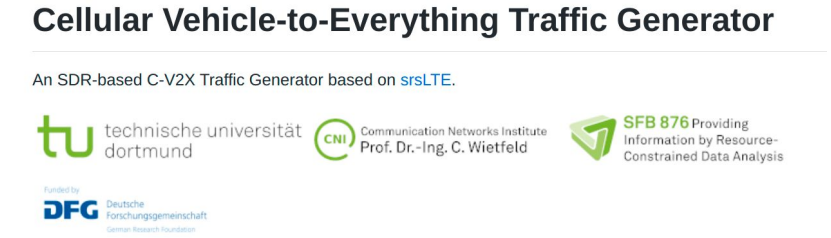
- National Instruments Universal Software Radio Peripheral 2901
  - (NI USRP 2901)
- 70 MHz to 6 GHz
- 56 MHz Bandwidth

Experimental Setup

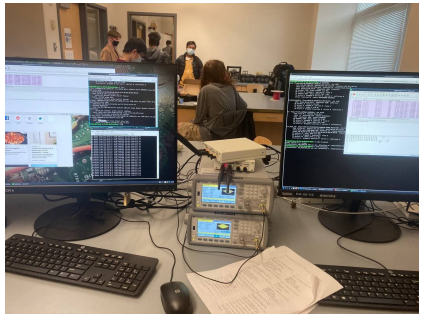
- Keysight 33550B Waveform Generator
  - 10 MHz sine, 10 dBm
  - 1 Hz sine, 10 dBm
- LeCroy Wavesurfer 442 Oscilloscope
  - Verification

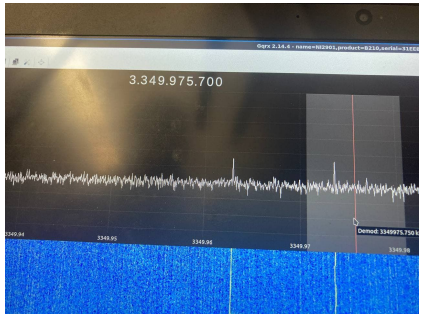


Software Libraries

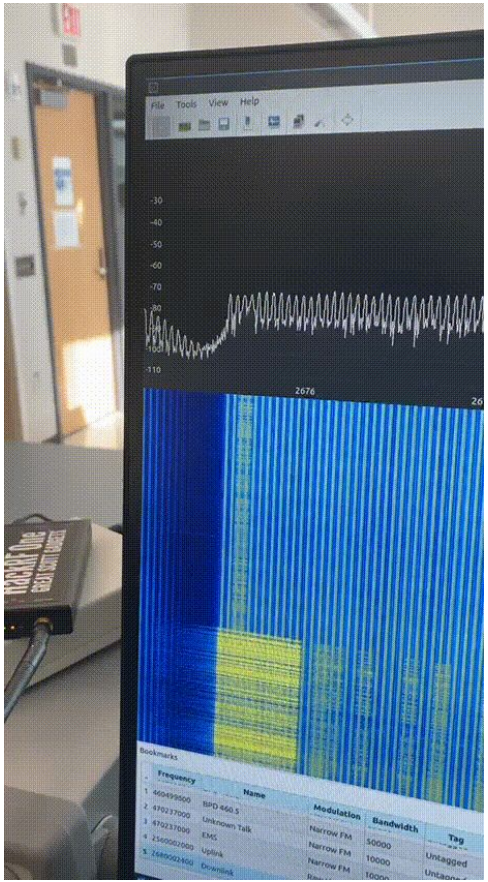


Demo: Cellular Bitrate Test

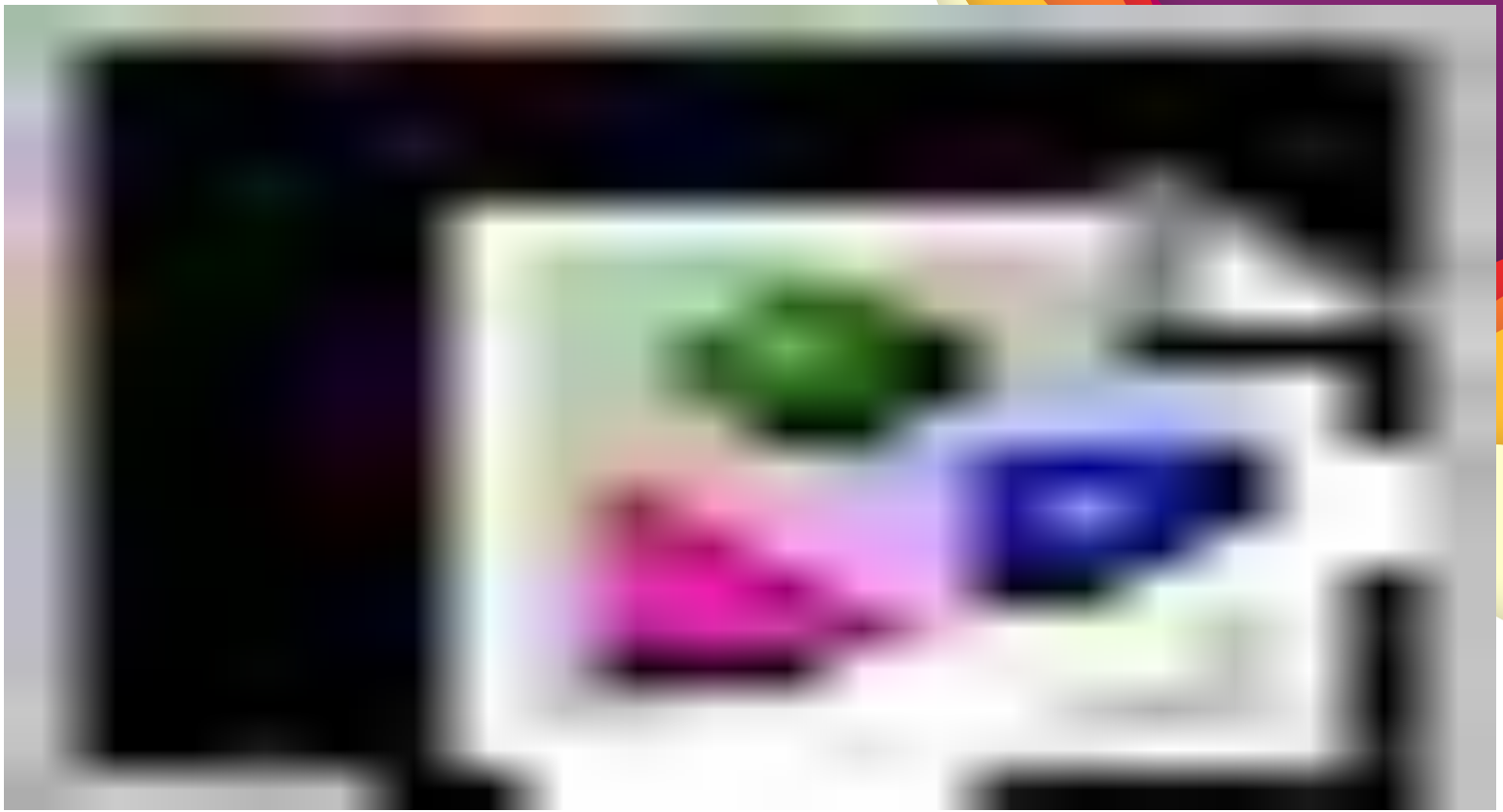





```
dragon@dragon-a-Z4-G4-Workstation:~$ iperf -c 172.16.0.1 -w 2m -t 30s
Invalid value of '1s' for -i interval
------------------------------------------------------------
Client connecting to 172.16.0.1, TCP port 5001
TCP window size: 2.00 MByte (WARNING: requested 1.91 MByte)
------------------------------------------------------------
[  3] local 172.16.0.5 port 37700 connected with 172.16.0.1 port 5001
[ ID] Interval       Transfer     Bandwidth
[  3]  0.0- 1.0 sec  4.12 MBytes  34.6 Mbits/sec
[  3]  1.0- 2.0 sec  2.62 MBytes  22.0 Mbits/sec
[  3]  2.0- 3.0 sec  2.75 MBytes  23.1 Mbits/sec
[  3]  3.0- 4.0 sec  2.12 MBytes  17.8 Mbits/sec
[  3]  4.0- 5.0 sec  2.75 MBytes  23.1 Mbits/sec
[  3]  5.0- 6.0 sec  2.62 MBytes  22.0 Mbits/sec
[  3]  6.0- 7.0 sec  1.18 MBytes  9.89 Mbits/sec
```

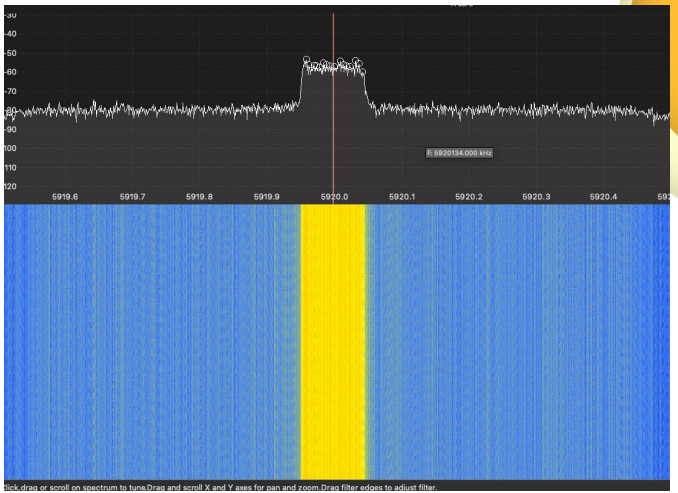


Demo: C-V2X Capture



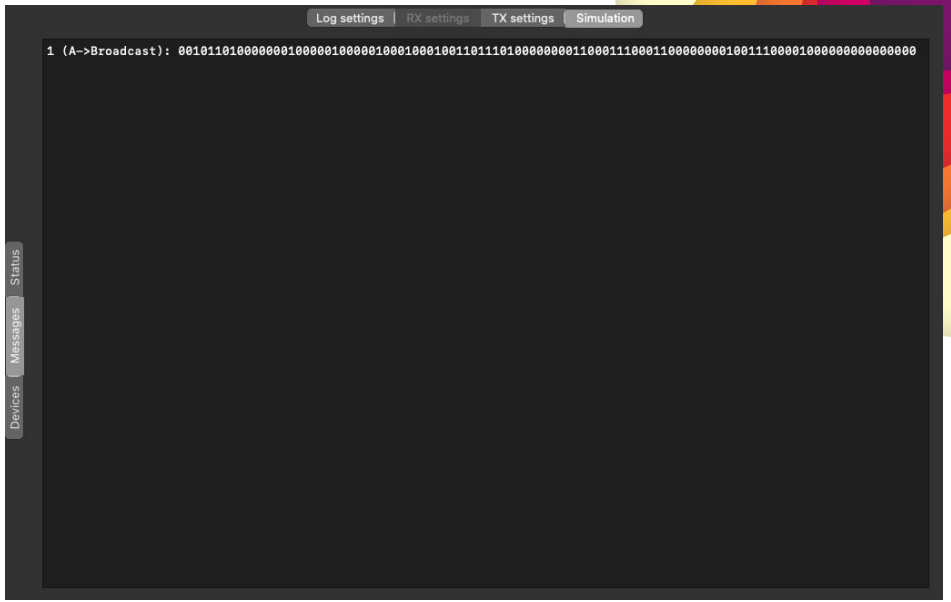
Signal Analysis

gqrx: big-picture analysis of frequency



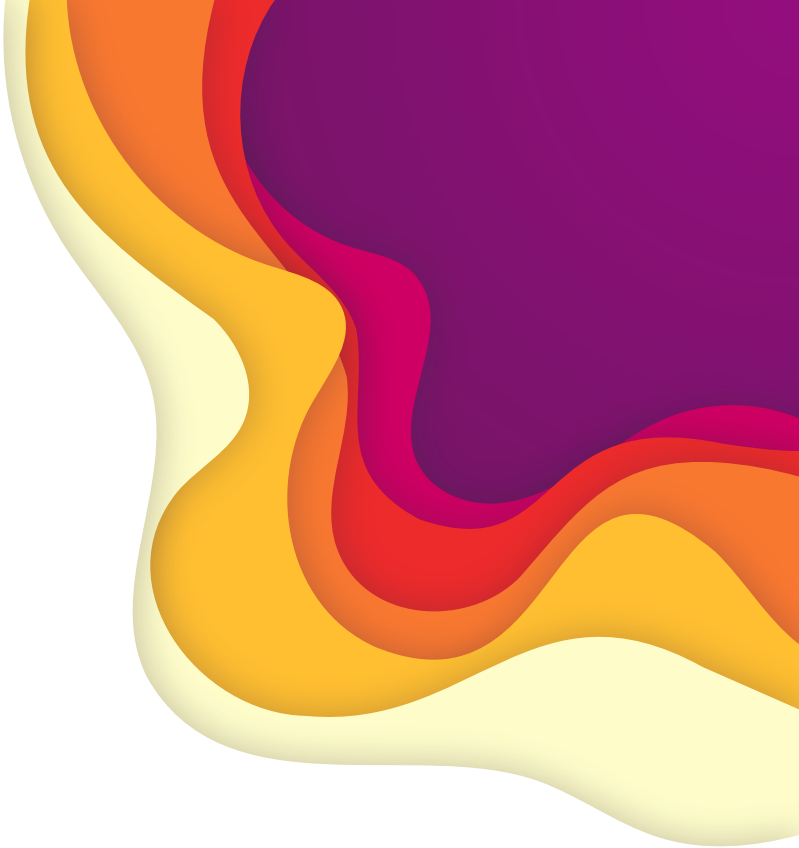
Signal Analysis

Universal Radio Hacker: granular analysis



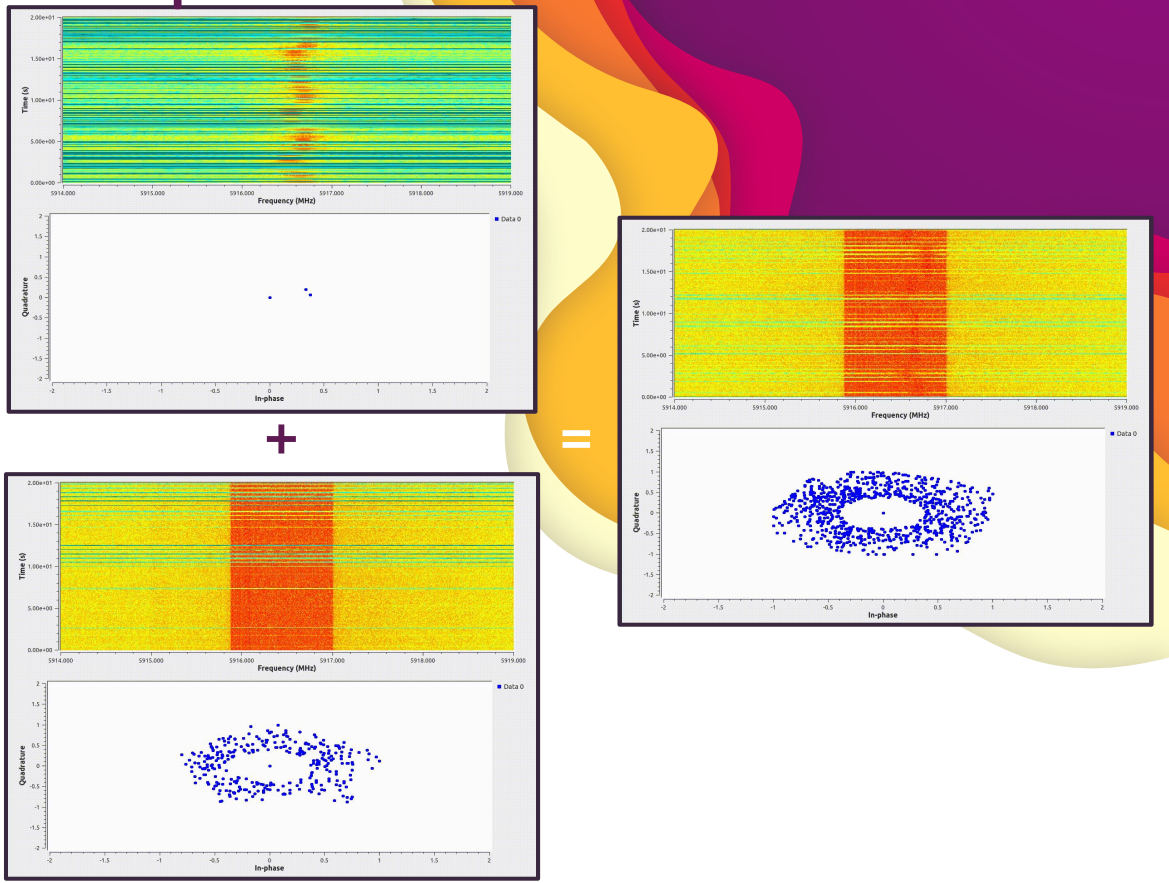
Teams

- Hardware Team
  - Radio setup
  - Jammer design
- Data Team
  - Data extraction
- Machine Learning
  - Algorithmic jammer detection
- Cross-Team
  - Written deliverables



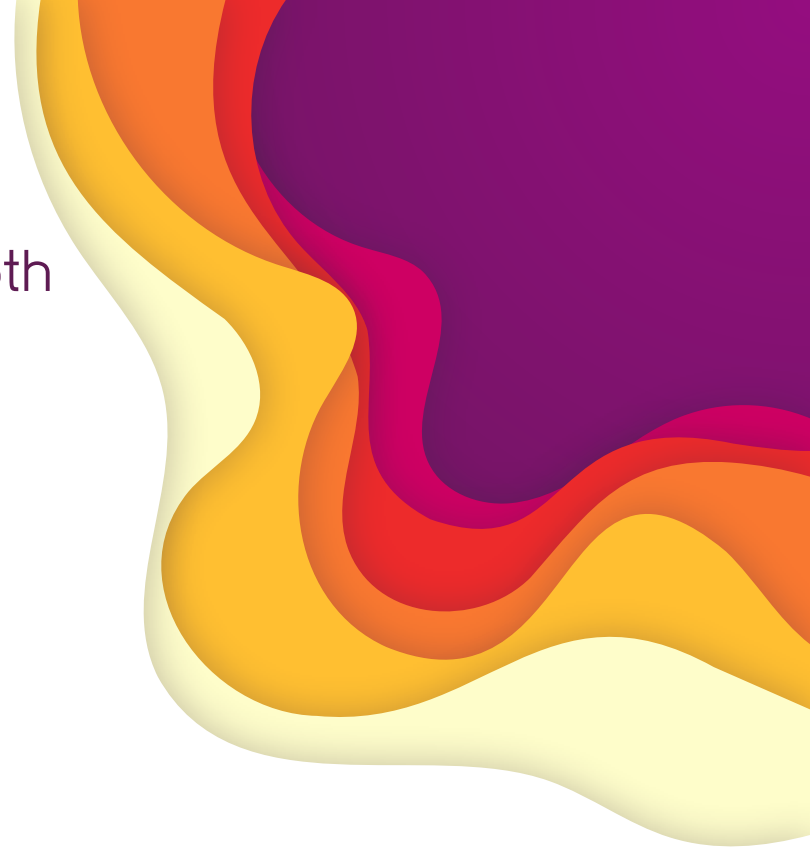
Hardware Team: Complete

- Set up radio infrastructure
- Sync USRPs with signal generators
- Verify OTA communication through ping tests
- Generation of V2X signal
- Modification of jammer code
- Creation of combined-receiver for jammer and V2X-TX



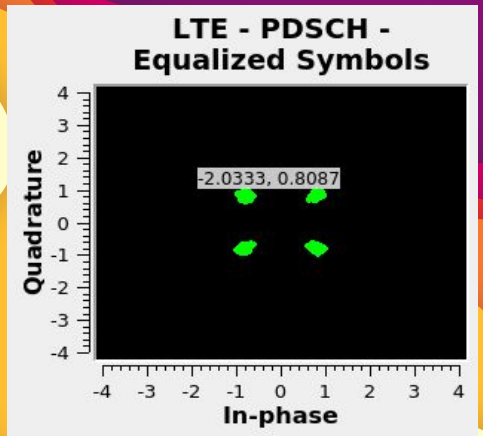
Hardware Team: Todo

- Create GNURadio file to transmit both signals to modified srsRAN receiver created by data team
- Iterate on jammer code/possibly transition to pattern matching



Data Team: Complete

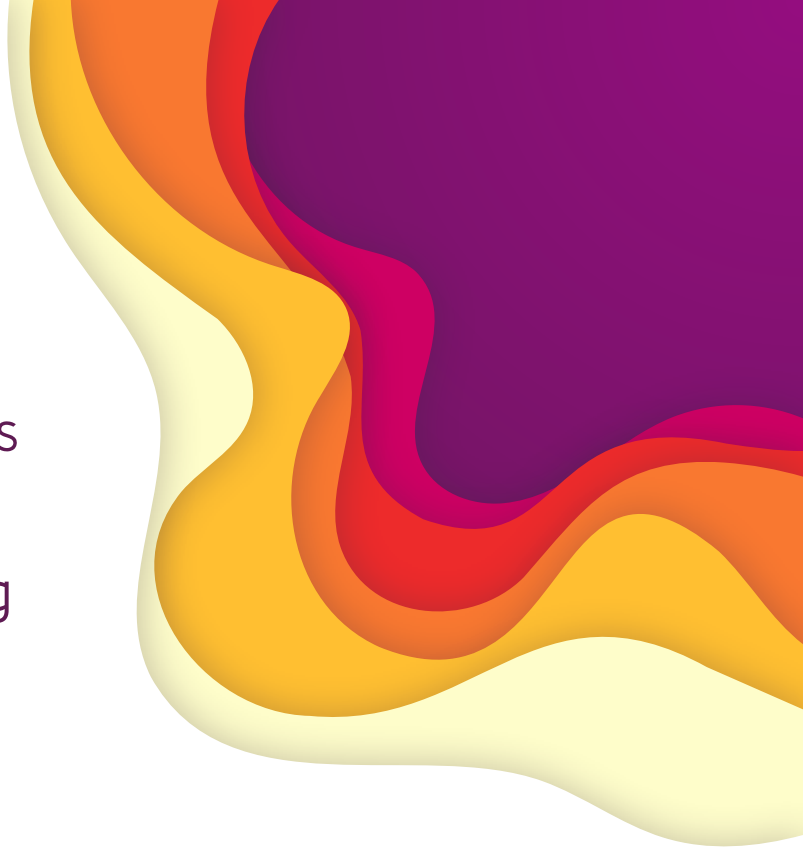
- Identify classes in SrsRAN containing IQ data and resource block information
- Design probing function to circumvent config disabling print statements
- Extract time-stamped IQ data from SrsRAN
- Extract resource block group allocation array from SrsRAN




```
enb_pusch: 0 + 0i
enb_pusch: -0.682389 + -0.72735i
enb_pusch: 0.744513 + -0.673355i
enb_pusch: 0.724487 + -0.676256i
enb_pusch: -0.680058 + -0.712481i
```

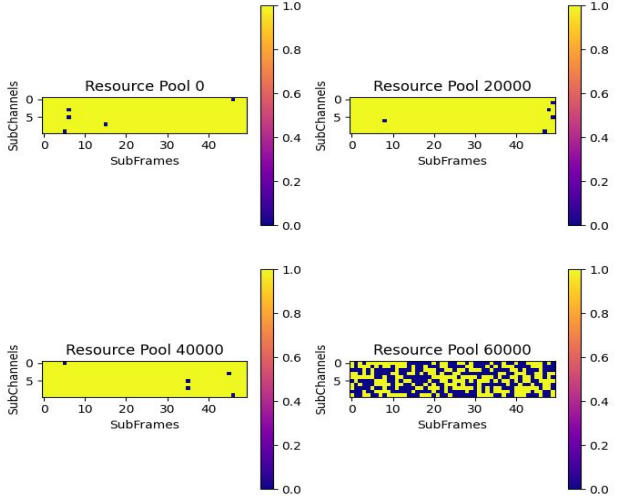
Data Team: Todo

- Data collection IQ data using GNURadio and the WPI jammer for the non-jammed and jammed states
- Labelling and pre-processing of the data for use in the machine learning model
- SrsRAN C-V2X reception



Machine Learning: Complete

- Prototype CNN Model for testing jammed RBGs detection
- Deep learning model with 3 methods
  - CNN with more tunded layers
  - ResNet (Residual Network)
  - CLDNN (Convolutional Long-Short Term Deep Neural Network)

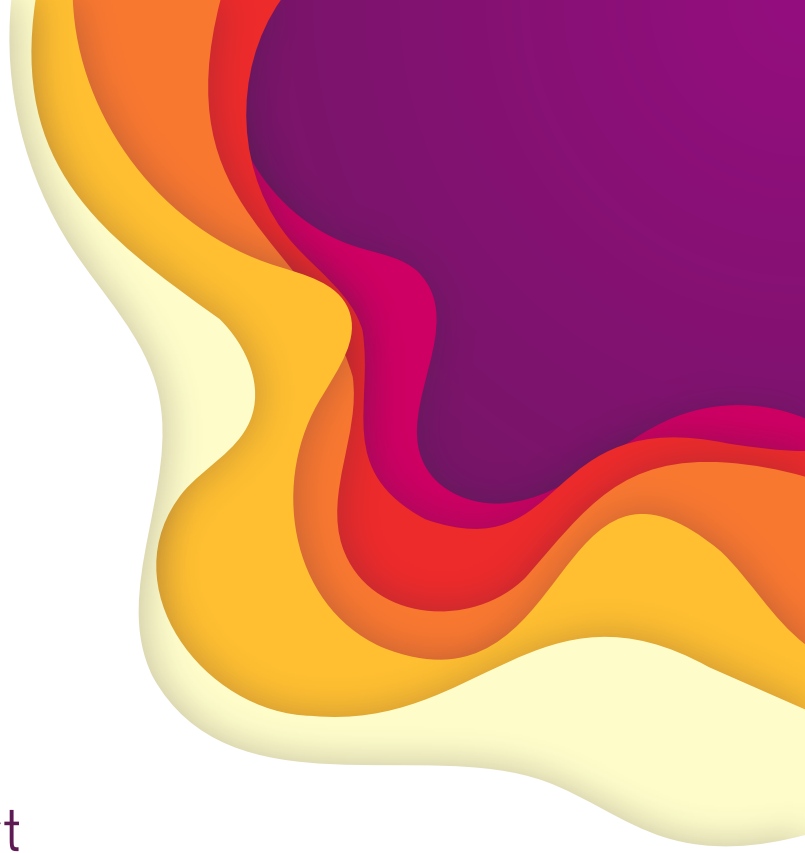


Machine Learning: Todo

- Final model selection and evaluation (do the validation and testing based on our own GNU generated datasets)
- Further feature engineering for better jammed block recognition.

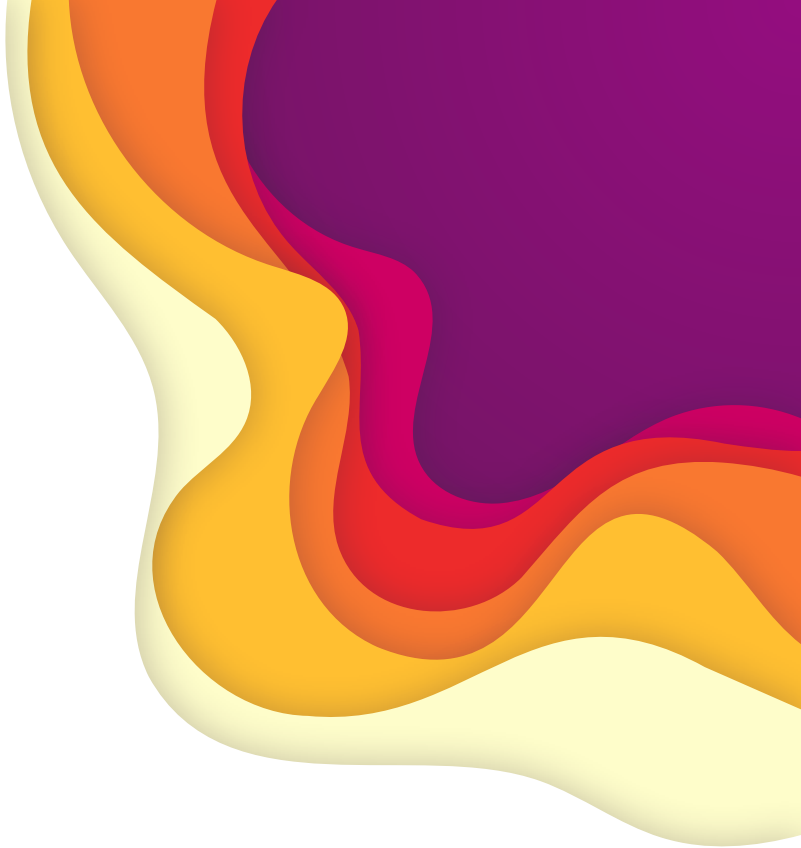
Cross-Team: Complete

- Preliminary Design
- PDRR slides and report
- First prototype test plan and report
- Second prototype test plan
- CDR slides
- Air Force Research Lab reports
  - Interim progress report
  - Final design showcase and report

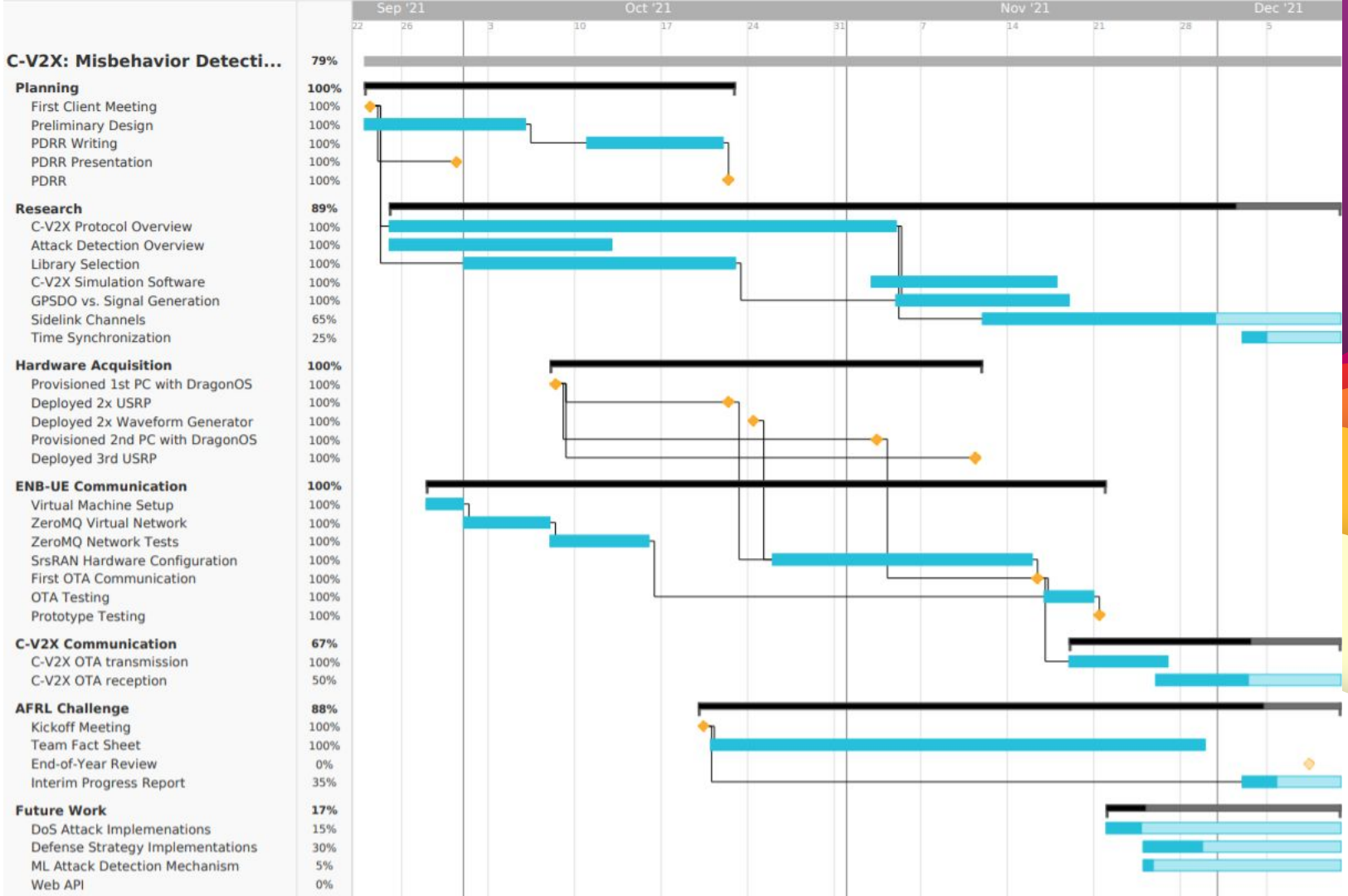


Cross-Team: Todo

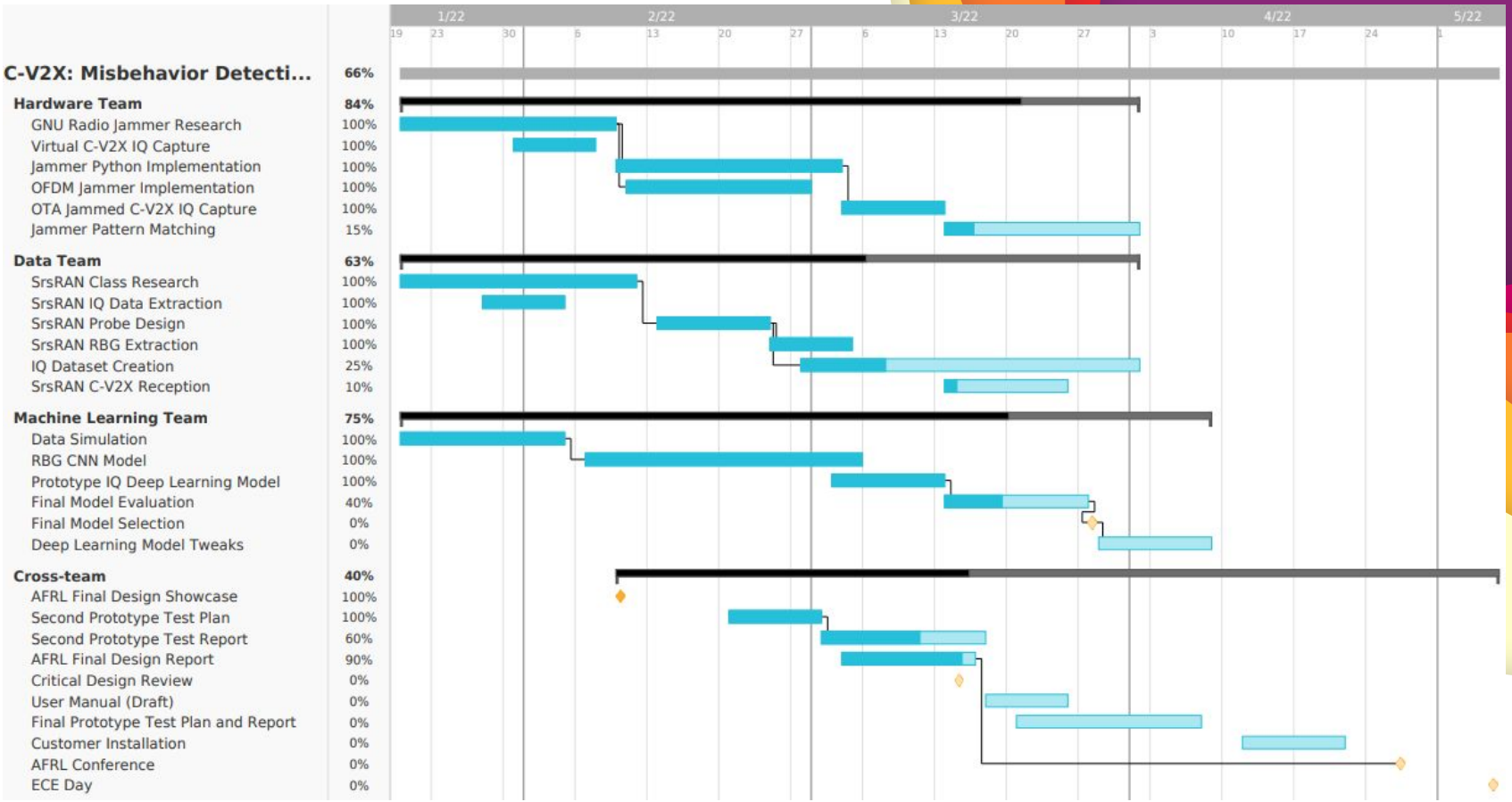
- Second prototype test report
- Final prototype test plan and report
- User Manual draft and final
- Customer installation
- AFRL Conference?
- ECE Day poster



Gantt Chart (2021)



Gantt Chart (2022)



Thank you!

Questions?