# Modulation Recognition Using Machine Learning Approaches in CubeSat Signals

Vidushi Jain, PhD candidate[1]; Regina Lee, PhD[1]; Franz Newland, PhD[2]
[1]York University, [2]University of Ottawa

## Abstract


- CubeSats make up a large subset of the small satellite industry.
- Many CubeSat failure occur along the communication chain and failure to establish contact with the satellite
- GNU radio is a platform commonly used for processing signal, with the help of GR-satellite
- Establishing such decoding chains are a time-consuming task
- Machine learning can be used as a tool to decode signal coming from spacecrafts
- The focus is to target different layers of the OSI stack, and this poster demonstrates modulation detection layer

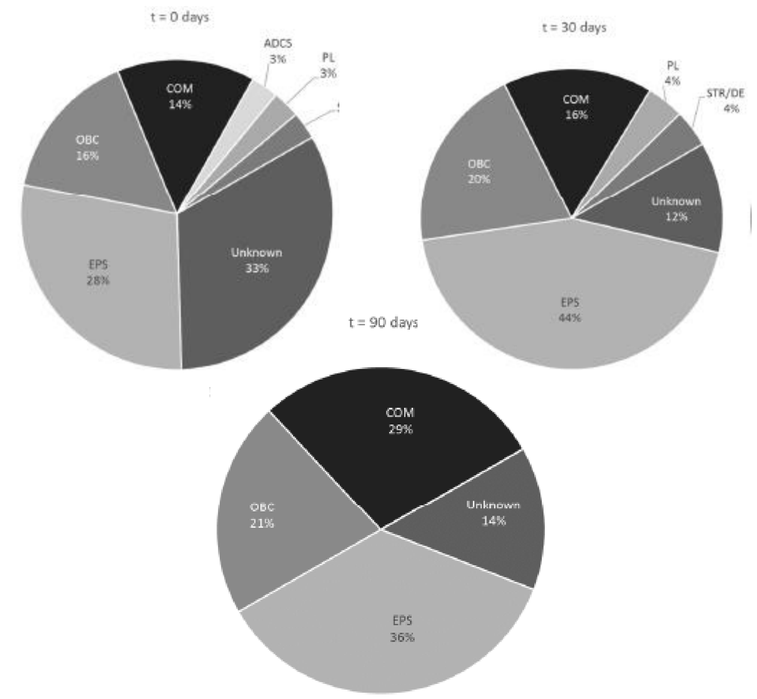




**Figure 1.** Subsystem contribution to CubeSat failure 0, 30 and 90 days after ejection .

## Problem

- New technology can aid in overcoming or reducing CubeSat failure rate
- Development of software tools to automate the signal processing from CubeSat signals will help in the success rate of CubeSats
- Using already existing GNU radio software an RF dataset can be synthesized to replicate CubeSat signal.
- Machine learning algorithm can be used to detect modulation sequences in CubeSat signals
- Different methods and algorithms can be used to compare the efficiency of modulation detection within space-based signals

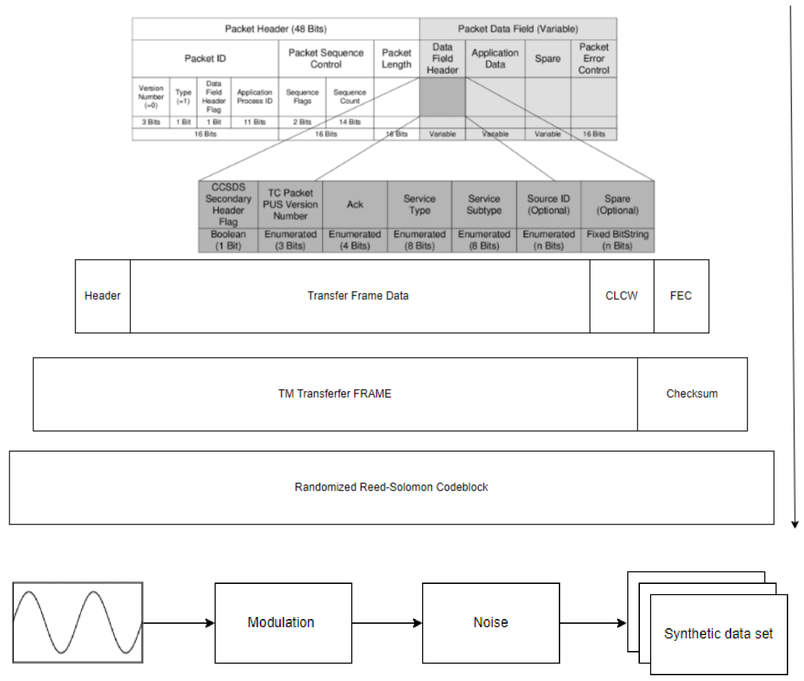






**Figure 2.** Illustration of CubeSat OSI stack and noise insertion for synthetic Dataset generation

## Methodology

- Simulated CubeSat telemetry packetized and inserted into frames
- Randomized code blocks modulated according to several standard CubeSat transponder modulation schemes; noise added to generate a simulated noisy space dataset relevant to most space missions
- Simulated dataset used to train neural networks to detect the modulation scheme used, with a bootstrap method
- To test the usability of the algorithm a ConvLSTM algorithm was used on a gaussian and phase noise synthesized signal

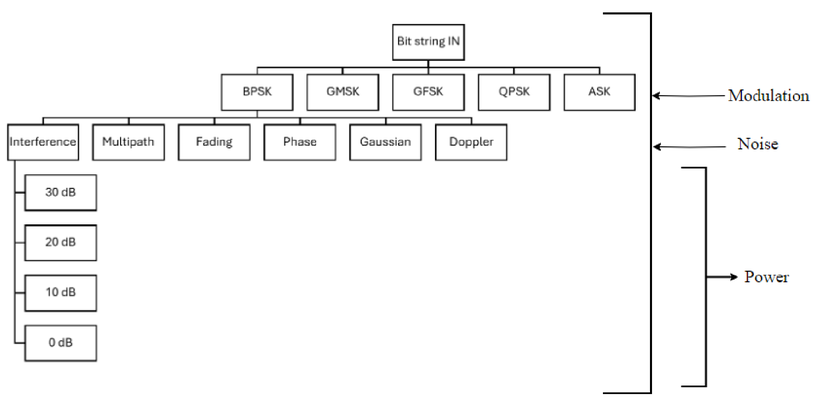
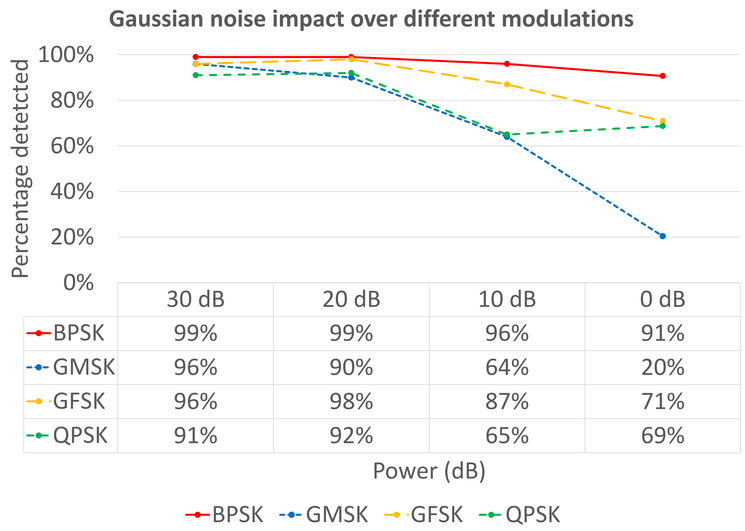
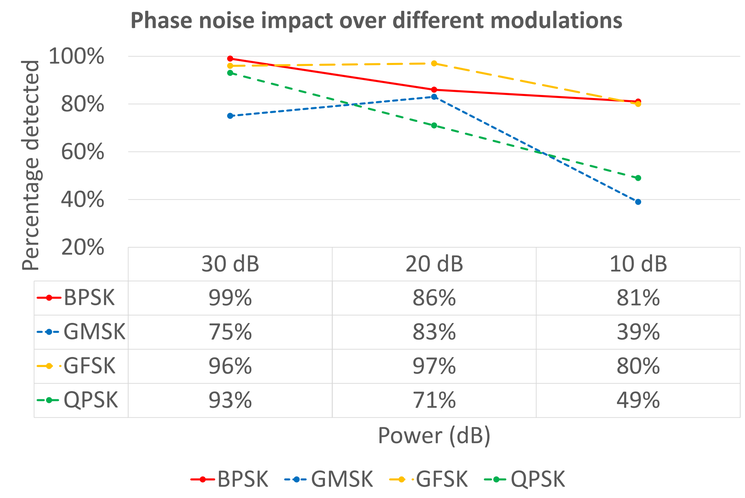



**Figure 3.** Modulation schemes and noise types used in simulated dataset




| | 30 dB | 20 dB | 10 dB | 0 dB |
|---|---|---|---|---|
| BPSK | 99% | 99% | 96% | 91% |
| GMSK | 96% | 90% | 64% | 20% |
| GFSK | 96% | 98% | 87% | 71% |
| QPSK | 91% | 92% | 65% | 69% |




| | 30 dB | 20 dB | 10 dB |
|---|---|---|---|
| BPSK | 99% | 86% | 81% |
| GMSK | 75% | 83% | 39% |
| GFSK | 96% | 97% | 80% |
| QPSK | 93% | 71% | 49% |

**Chart 1.** Modulation detection performance for preliminary simulated data

## Discussion

- From both noise it is evident that BPSK was detected more accurately than other modulation schemes
- GMSK had the worst performance, and detection did get more difficult as the signal to noise ratio decreased.
- Analysis chain has been proven, ready for full simulated dataset and subsequent testing on actual flight data.

## Future Work

- Further generation of signals using different modulation schemes and noise sources
- Testing the algorithm with a random distribution of the synthesised signal
- Checking the feasibility of the algorithm using SATNOGs received signal on an operating CubeSat
- Comparing the efficiency of different algorithms

## Contact

Vidushi Jain
York University
Email: Vidushi.jain.jv@gmail.com
Phone: 6476331956
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## References

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