Advancing Spectrum Science: Rely on Domain Knowledge or Handoff to Machine Learning Models?

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National Radio Dynamic Zones (NRDZ) Phase 2 EEL

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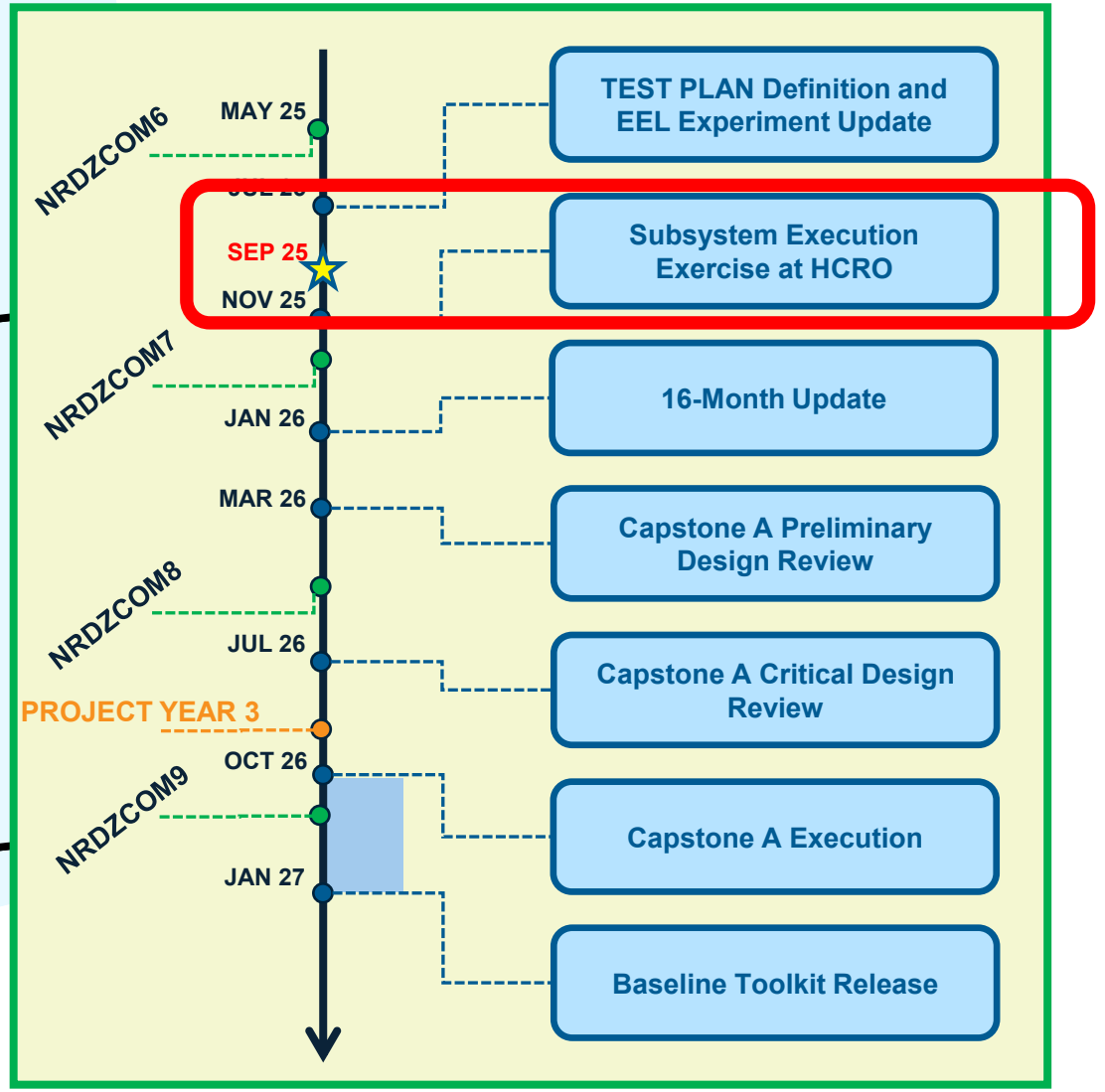

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NRDZ-as-a-Service Ecosystem for Field Deployment

RDZ: Radio dynamic zone is multidimensional volume (time, space, spectrum, etc.).

RDZ Volume contains the experiment with expectation to prevent harmful interference external of the RDZ Boundary.

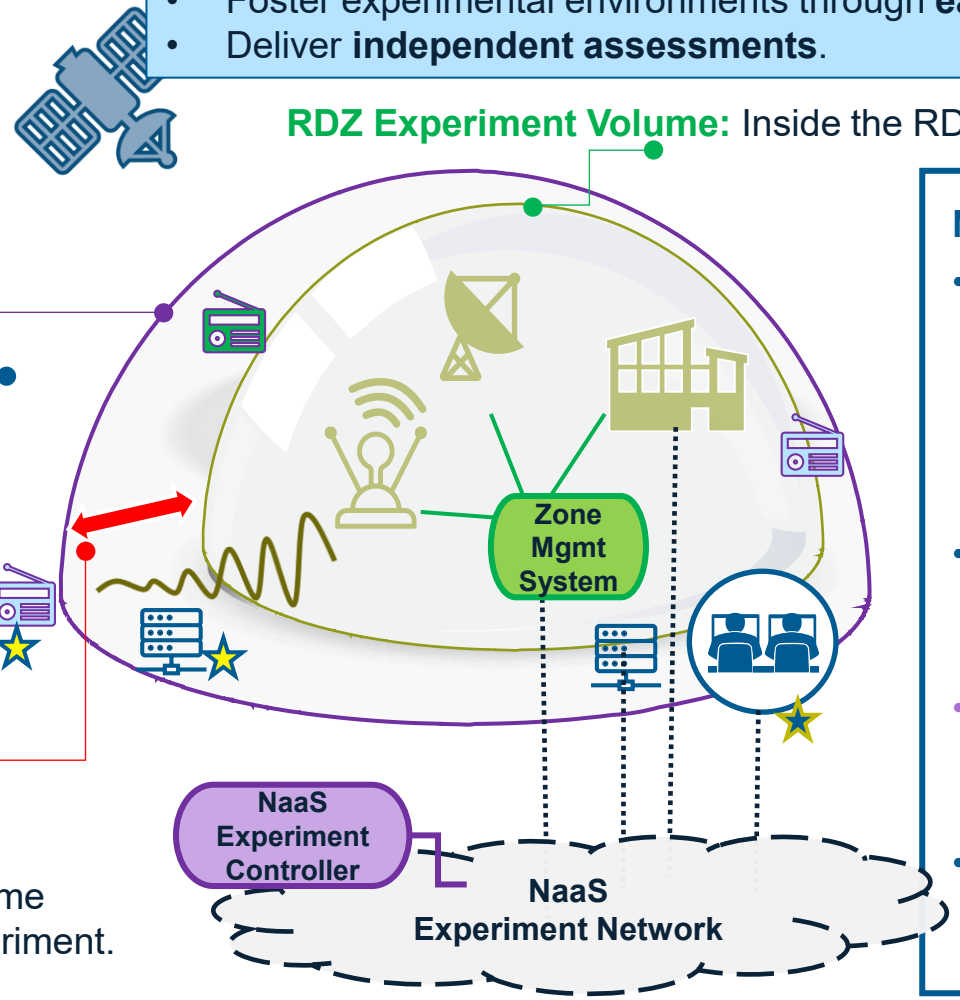
EME: Existing electromagnetic environment which consists of spectrum incumbents, equipment and infrastructure.

RDZ Integrity Region: The shell within the RDZ volume and external to the inner experiment.

NaaS Functions for successful experiment execution

- **Safeguards** spectrum incumbents from NRDZ experiments by upholding **RDZ boundary integrity**,
- Foster experimental environments through **easy-to-integrate** components,
- Deliver **independent assessments**.

RDZ Experiment Volume: Inside the RDZ Volume and contained by the Experiment Boundary.



NRDZ-as-a-Service Components:

- **RDZ Monitoring Network** maintains RDZ boundary
  - spectrum sensing devices ★
  - additional information-bearing sensors, ★ such as interference reports or weather measurements.
- **NaaS Experiment Network** is an IP-based means to insert spectrum access hardware devices, spectrum dependent software
- **NaaS Experiment Controller** orchestrates the experiment, maintains RDZ functions and prevents harmful interference
- **Monitoring and Management for** Local interaction and experiment observations at the field trial ★

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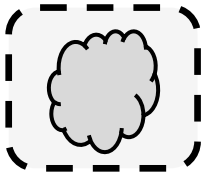
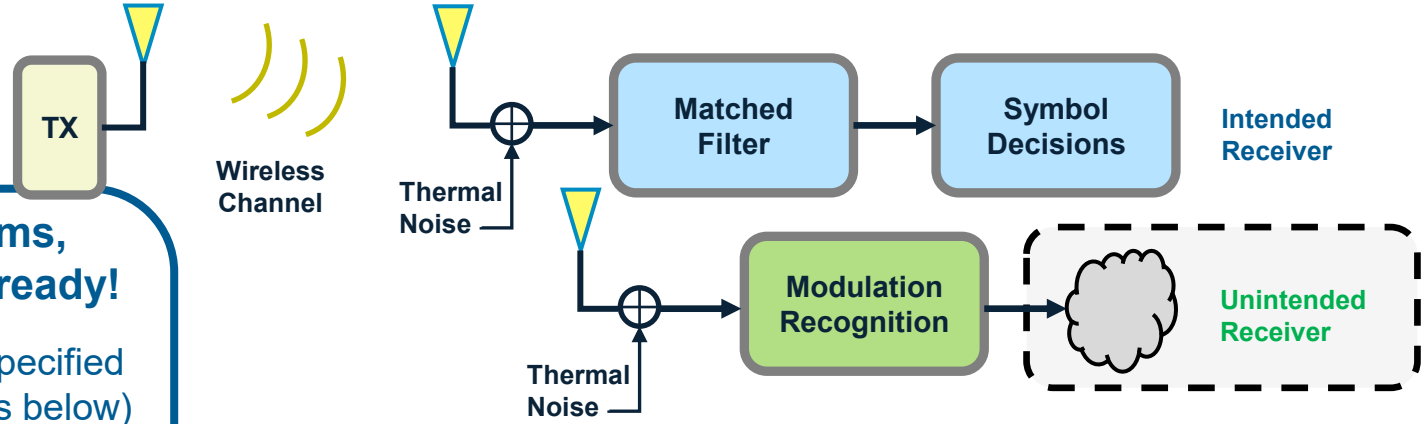
The Need for Classification Performance Requirements

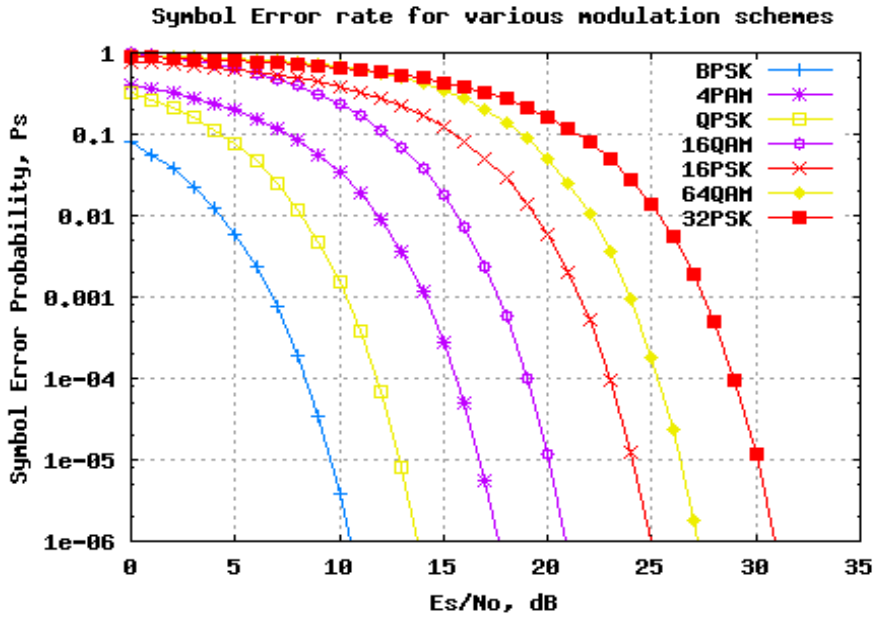


Downstream Processing sets the desired performance requirements



In other aspects of receiver systems, designers set these requirements already!

Error Correction as Downstream Processing specified the amount of bit or symbol error rates (such as below)



https://www.embedded.com/print/4017668

Unintended Receiver downstream decision making processes stagnate or operate unreliably due to unknown performance.

NEED FOR STATEMENT LIKE:

1% Error at 1.3 dB SNR by observing 32 symbols

Error	Symbol Length 1	2	4	8	16	32	64
10^{-1}	8.625	6.299	4.061	1.925	-0.106	-2.039	-3.883
10^{-2}	13.119	10.493	8.022	5.679	3.453	1.342	-0.661
10^{-3}	15.41	12.653	10.051	7.597	5.27	3.062	0.969
10^{-4}	16.939	14.115	11.428	8.894	6.497	4.225	2.072

← Better performance

Increase Observation Time →

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Example: Performance Bounds for BPSK versus QPSK

Modulation Set
- BPSK, QPSK

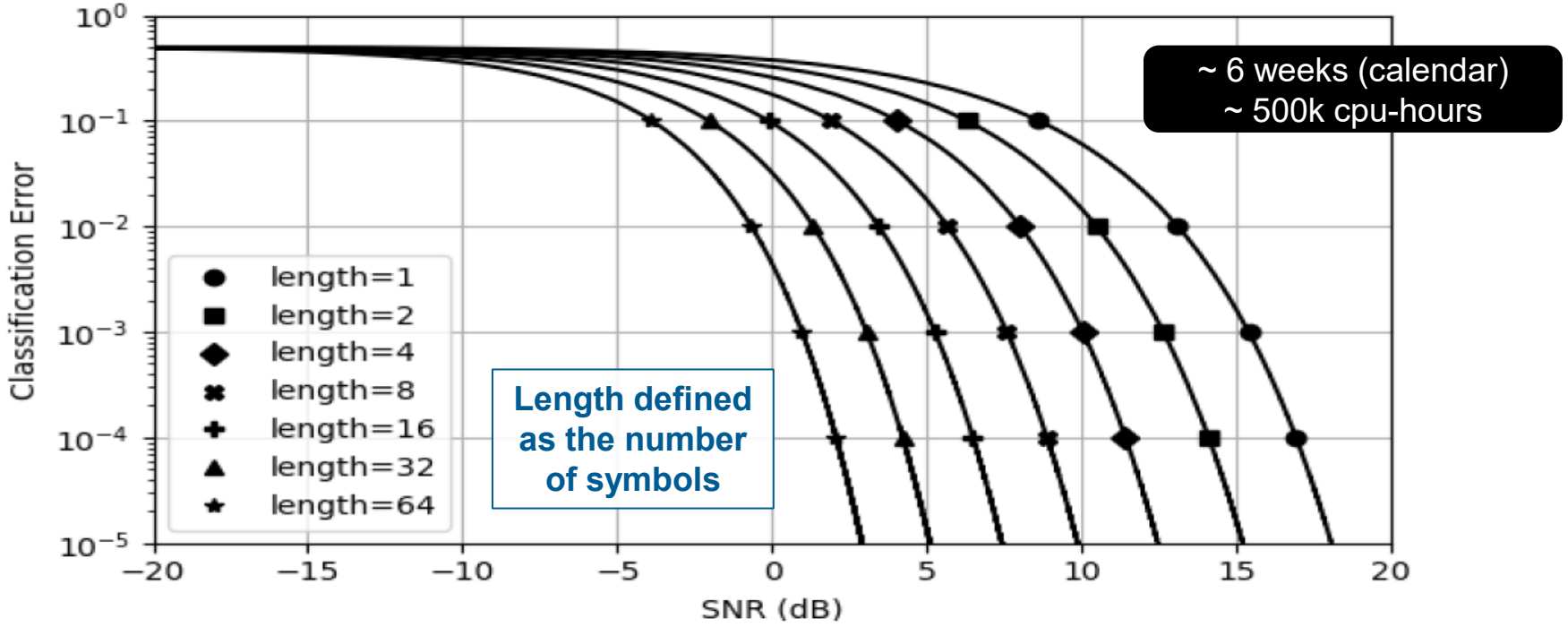
Observation Length
- 2^k for k = 0, 1, …, 6

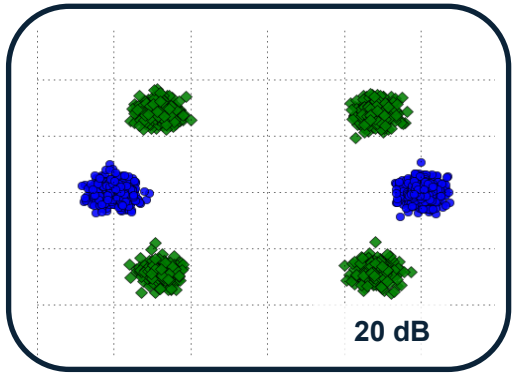
SNR Values
- -20 dB to +20 dB at 0.001 dB steps

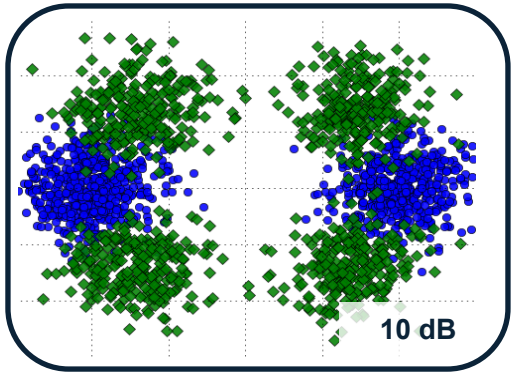
Need to Ensure Significant Number of Error Events
- 10^{-3} is 1 per thousand
- 10^{-6} is 1 per million

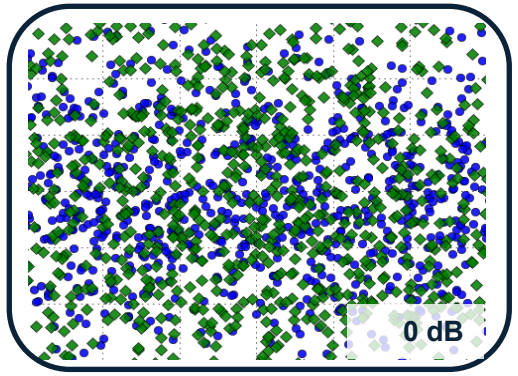
Number of Total Events
- ~150 million/(SNR,length)
- Yields confidence when there are “no errors”

IMPACT: Requirements can be set for systems with modulation classification









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Radio Telescopes Are Sensitive to Interference

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