

Securing Compartmented Information with Smart Radio Systems (SCISRS)

Paul Kolb, Program Manager, Proposers' Day, August 20, 2020



Office of the Director of National Intelligence

I A R P A

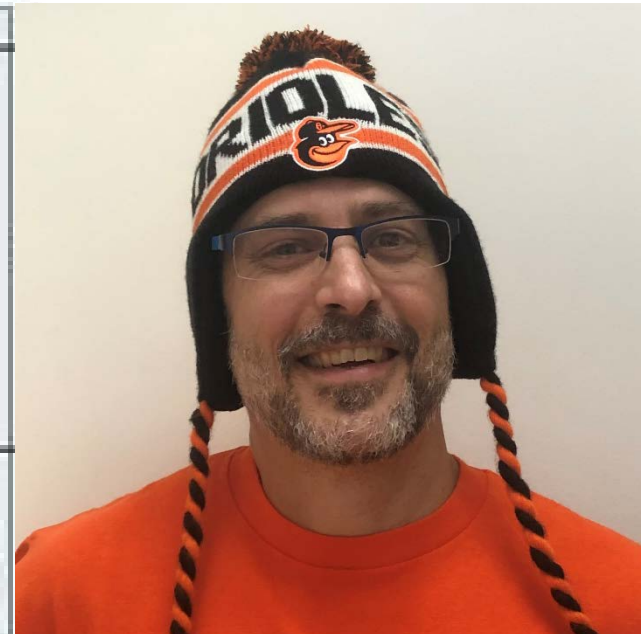
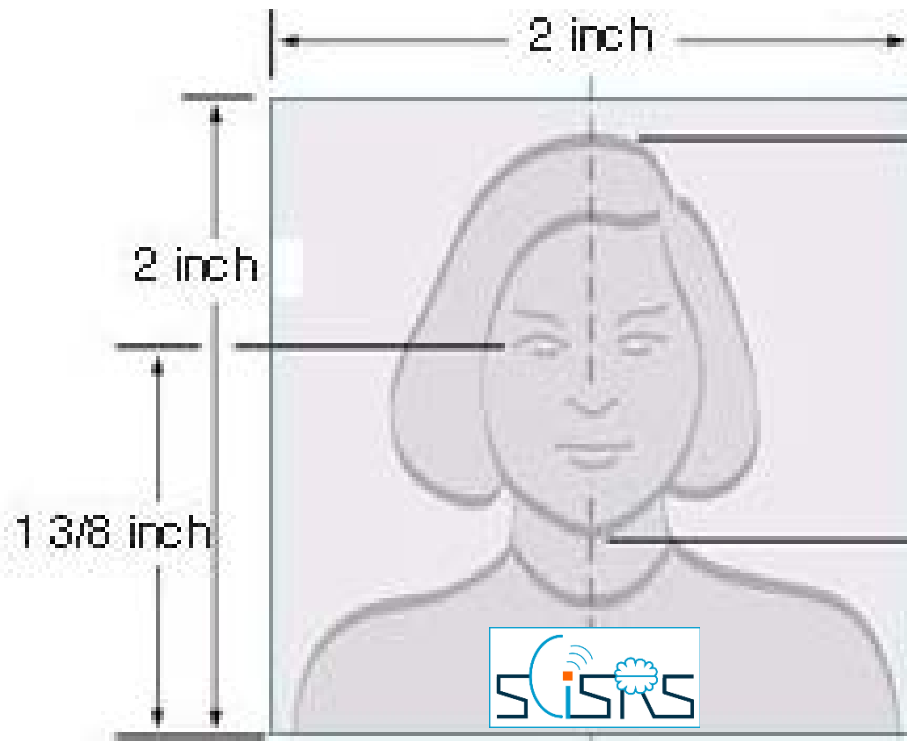
BE THE FUTURE





Welcome to the SCISRS Proposers' Day!

- Thank you for your interest in this virtual event





Welcome to the SCISRS Proposers' Day!

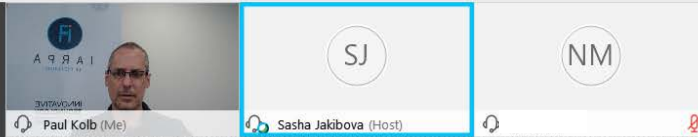
- Thank you for your interest in this virtual event
- A recording of the entire Proposers' Day may be posted on the SCISRS website
- To assure a clear broadcast stream, audio and video are disabled for meeting participants
- Please send us questions and comments at any time during any presentation through the WebEx "Q&A" tool
- Questions may relate to this presentation or the draft BAA Technical Volume posted on beta.sam.gov



Cisco Webex Events | Hide menu bar ^

Connected

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Q&A

All (0)

What is the airspeed velocity of an unladen swallow?

Send Send Privately...



Disclaimers



- This presentation is provided solely for information and planning purposes
- The Proposers' Day does not constitute a formal solicitation for proposals or proposal abstracts
- Nothing said at Proposers' Day changes the requirements set forth in a BAA
- The BAA language supersedes anything presented or said by IARPA at the Proposers' Day



Goals

- Familiarize participants with IARPA's interest in the SCISRS program
- Foster discussion of complementary capabilities among potential program participants, i.e., TEAMING
 - An attendance list may be provided to all attendees, please reach out to your fellow participants
 - Someone might have a missing piece of your puzzle

*Please ask questions and provide feedback.
This is your chance to alter the course of events.*



Q & A



- There will be a 15-minute break after the technical presentation and a 30-minute break after the contracting presentation
- Responses to selected questions will be broadcast at 3:15 PM EDT, so please don't log out or close your WebEx connection
- Feedback (but not Qs) about the draft BAA may be submitted to the program email at dni-iarpa-baa-20-03@iarpa.gov
- After this Proposers' Day, IARPA will review all the feedback received for a final BAA to be posted on beta.SAM.gov
- Responses to selected questions may be posted on the SCISRS website.



Questions & Definitions

BAA Term	SCISRS Definitions
Anomaly	An Anomaly (or “RF Anomaly”) is a Signal that differs from the RF Baseline or that is intended to hide in the ambient RF Baseline.
Background	The Background (or “RF Background”) is the superposition of all Emissions from (non-negligible) natural and manmade RF sources (and their interactions with the local physical environment) particular to a specific geographic location and time. To the extent that RF Emissions are directional, the RF Background is subject to the direction of RF Emission propagation at the location where background is measured. The RF Background is independent of the RF sources that will be installed inside each testbed. (Suggested Reference: International Telecommunications Union (ITU) Recommendation ITU-R P.372-13.)



Agenda



Time (EDT)	Topic	Speaker
1:00 PM – 1:15 PM	Welcome, Logistics, Proposer's Day Goals	Dr. Paul Kolb Program Manager, IARPA
1:15 PM – 1:25 PM	IARPA Overview	Dr. Catherine Cotell, Deputy Director (Emeritus), IARPA
1:25 PM – 2:10 PM	SCISRS Program Overview	Dr. Paul Kolb
2:10 PM – 2:25 PM	Break (Proposers formulate Qs)	
2:25 PM – 2:45 PM	Doing Business with IARPA	Linda Rodrock, IARPA Contracting Officer
1:00 PM – 3:00 PM	SCISRS Question Submissions	submit via Q&A
2:45 PM – 3:15 PM	Break (IARPA formulates As)	
3:15 PM – 4:15 PM	SCISRS Questions & Answers	Dr. Paul Kolb

IARPA Overview

**Dr. Catherine Cotell, IARPA Deputy Director (Emeritus)
Intelligence Advanced Research Projects Activity**



Office of the Director of National Intelligence

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IARPA Mission

IARPA envisions and leads *high-risk, high-payoff research* that delivers innovative technology for future overwhelming intelligence advantage

- Our problems are **complex** and **multidisciplinary**
- We emphasize **technical excellence** and **technical truth**



IARPA Method

Bring the best minds to bear on our problems

- Full and open competition to the greatest possible extent
- World-class, rotational Program Managers

Define and execute research programs that:

- Have goals that are clear, measureable, ambitious and credible
- Employ independent and rigorous Test & Evaluation
- Involve IC partners from start to finish
- Run from three to five years
- Publish peer-reviewed results and data, to the greatest possible extent
- Transition new capabilities to intelligence community partners



IARPA Snapshot

IARPA's research portfolio is diverse, including math, physics, chemistry, biology, neuroscience, linguistics, political science, cognitive psychology and more.

- **70% of completed research transitions** to U.S. Government partners
- **3,000+ journal articles** published
- IARPA funded researchers have been awarded the **Nobel Prize in Physics** for quantum computing research, a **MacArthur Fellowship**, a **Bell prize**
- IARPA is a member of the National Science and Technology Council (NSTC) and actively engages with the White House BRAIN Initiative, National Strategic Computing Initiative, and the NSTC Select Committee on Artificial Intelligence, the NSTC Subcommittee on Quantum Information Science (SCQIS), and NSTC Subcommittee on Economic and Security Implications of Quantum Science (ESIX)



How to Engage with IARPA

Getting Started with IARPA

At IARPA, we take real risks, solve hard problems, and invest in high-risk/high-payoff research that has the potential to provide our nation with an overwhelming intelligence advantage.

Are you interested in partnering with us to advance the state-of-the-art in research and development?

[Read More](#)

iarpa.gov | 301-243-1995

info@iarpa.gov

Reach out to our Program Managers.

Schedule a visit if you are in the DC area or invite us to visit you

Opportunities to Engage:

RFIS AND WORKSHOPS

Opportunities to learn what is coming, and to influence programs.

“SEEDLINGS”

Typically a 9-12 month study; you can submit your research proposal at any time. We strongly encourage informal discussion with a PM before proposal submission.

PRIZE CHALLENGES

No proposals required. Submit solutions to our problems – if your solutions are the best, you receive a cash prize and bragging rights.

RESEARCH PROGRAMS

Multi-year research funding opportunities on specific topics.



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The IC & DoD need sensitive information to be secure *anywhere* it is stored, used, generated, transmitted or received





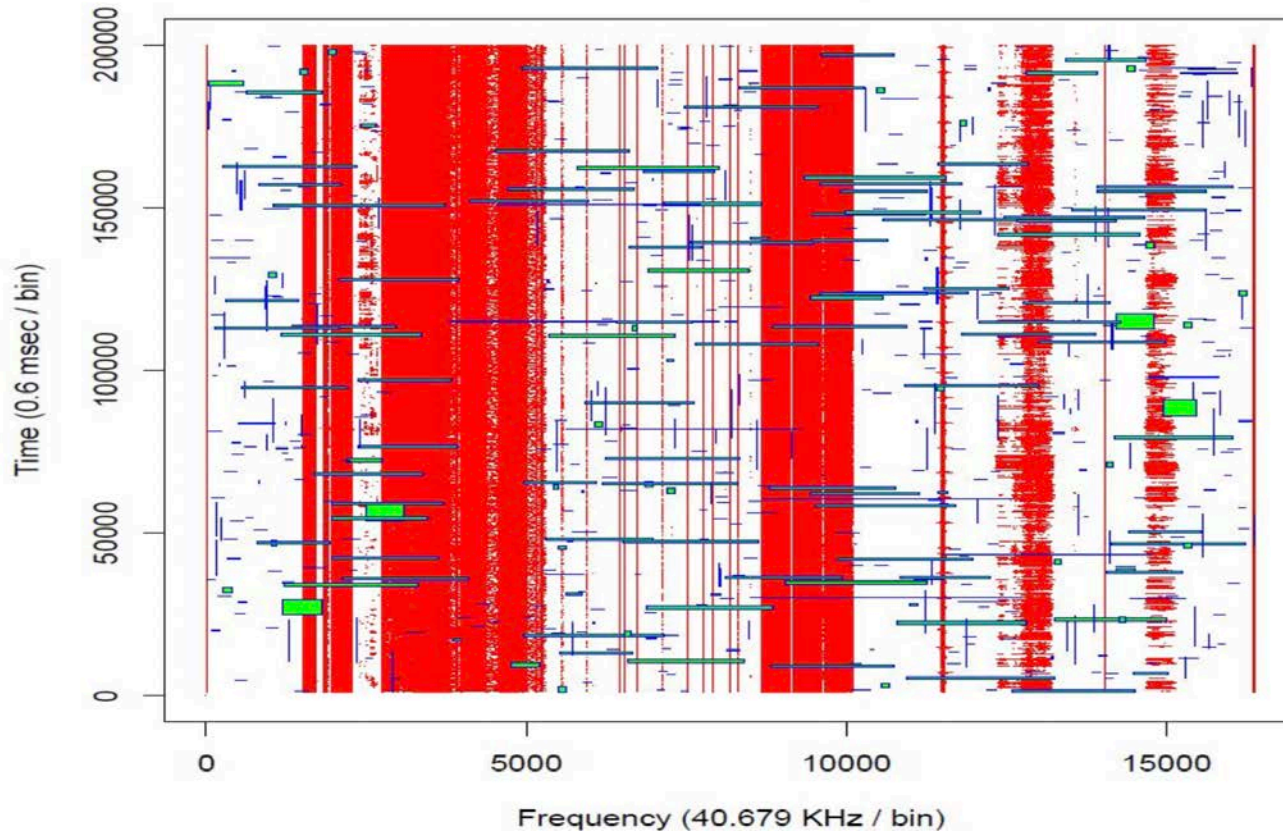
Securing Compartmented Information with Smart Radio Systems (SCISRS)

- ***One Solution:*** use advanced smart radio techniques to automatically detect and ***characterize RF anomalies:***
 - 1) *Low probability of intercept (LPI) signals (e.g., burst, spread spectrum, frequency hopping, hide-in-plain sight)*
 - 2) *Altered and mimicked (otherwise legitimate) RF signals*
 - 3) *Unintended emanations (for security and awareness)*



RF Environments Can Be Complex

Uniform Random Time-Freq Distribution of 600 Example Signals



“DARPA RF Machine Learning Systems (RFMLS) Program,” Paul Tilghman, MILCON 2019

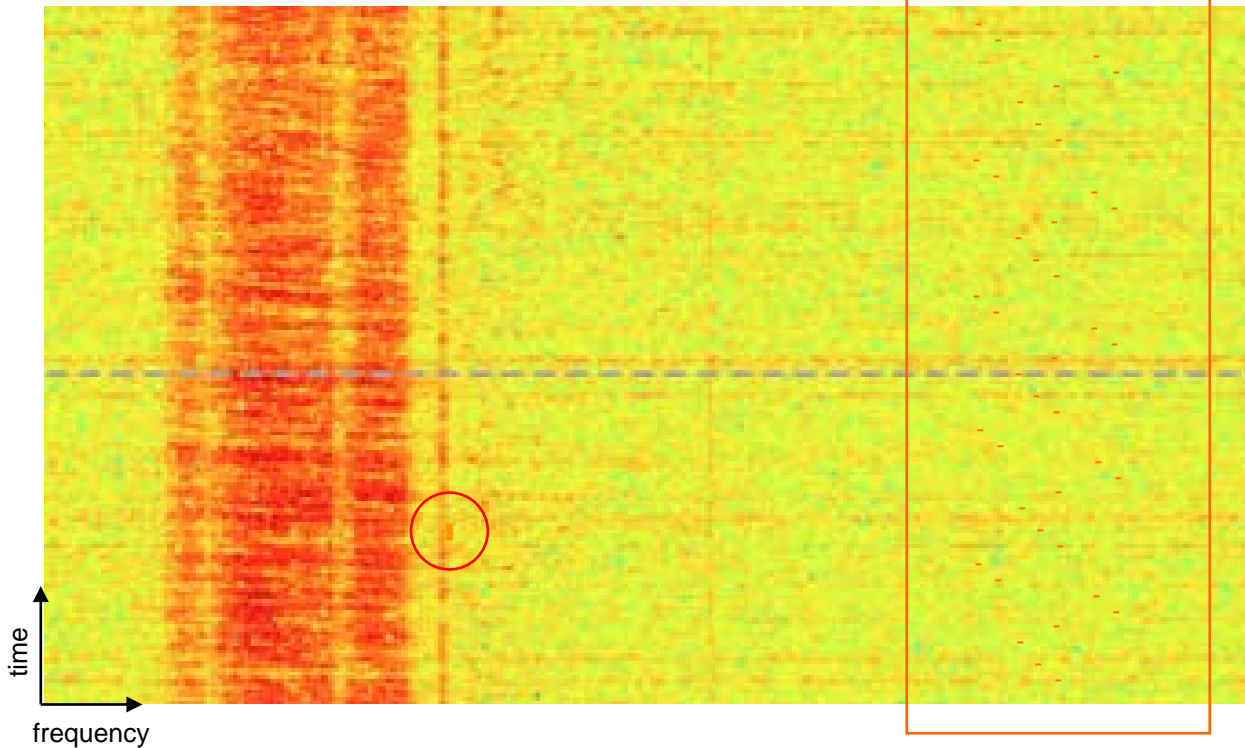


Low Probability of Intercept (LPI)



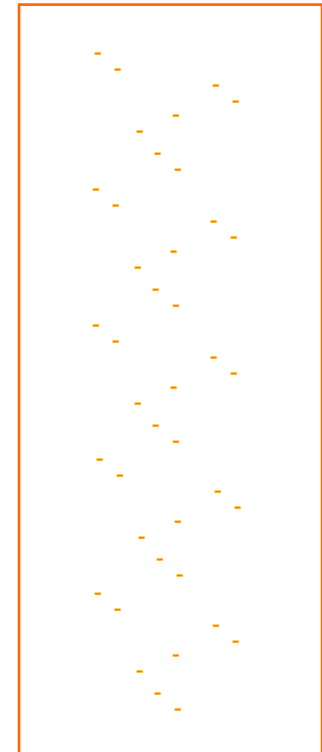
snuggled
burst:

frequency hopping spread
spectrum (FHSS):



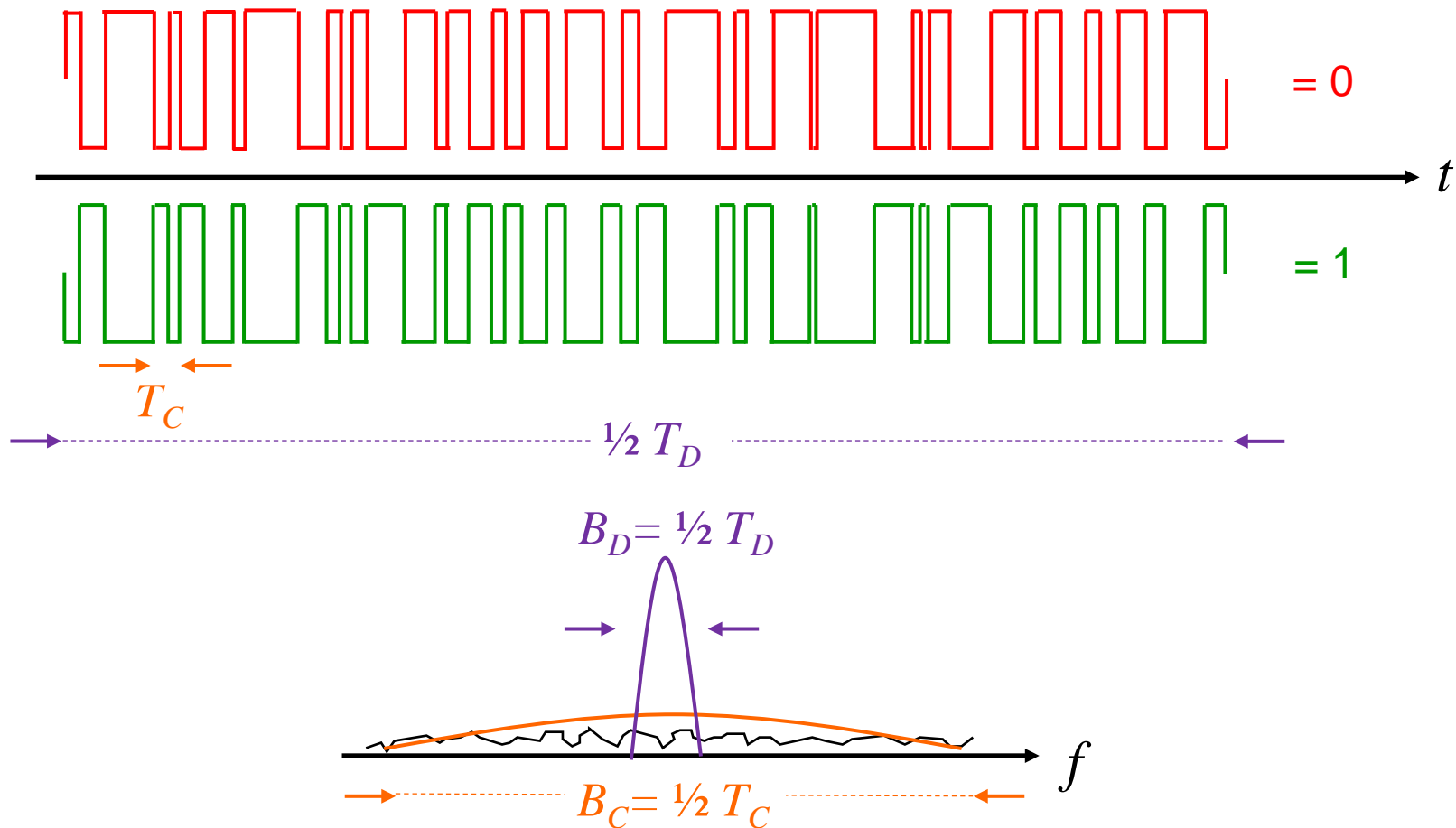
hide in
plain sight

hopping sequence
is pseudorandom





Direct Sequence Spread Spectrum (DSSS):





A Signal Below the Noise Floor

$$\text{Noise Floor} = 10 \text{ Log}(kBT/mW) + \text{Noise Figure} + 10 \text{ Log}(BW/Hz)$$

-174 dBm

NF > 0

2 MHz

= - 111 dBm for GPS

GPS signal intensity at Earth's surface: -130* to -122 dBm**

*receive antenna gain not specified: *GPS Standard Positioning Service Signal Specification*, U.S. Government, 2nd Ed., 1995

**receive antenna gain = 3 dBi: *Determination of GPS RF Signal Strengths*, IEEE, G. Rosenbaum, 2008



Mimics:

Hey ...



... let's talk, I'm

- a GPS satellite
- a cell tower
- your WiFi router

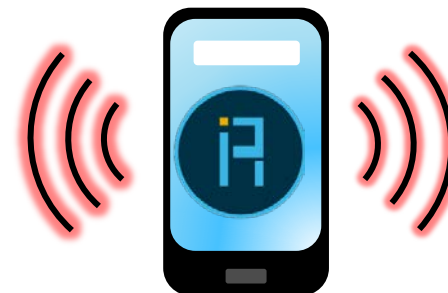
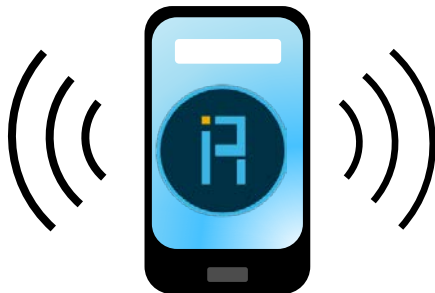
... ignore me, I'm

- just another LTE*
- just another IoT**
- neighbor's WiFi

* Long-term Evolution (LTE) protocol

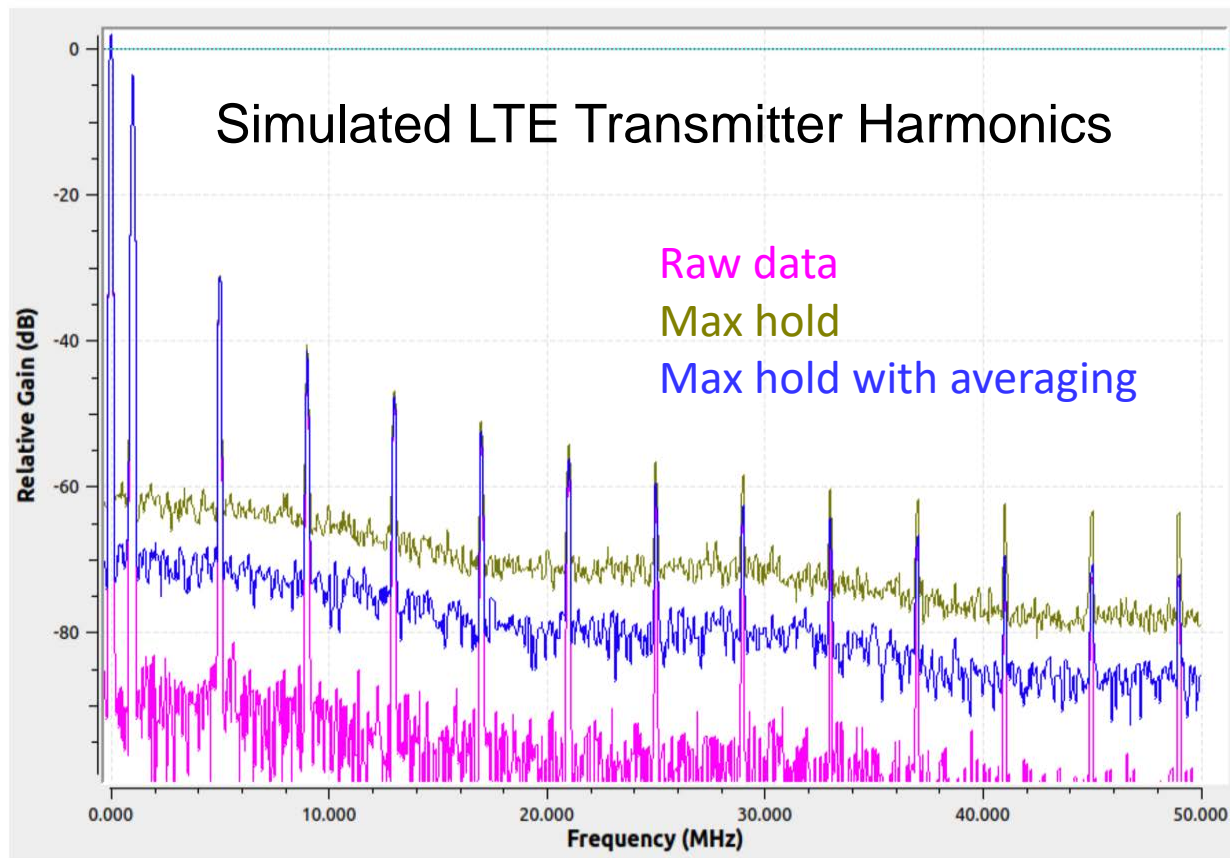
** Internet of Things (IoT) device

Altered Signal: Additional Modulation



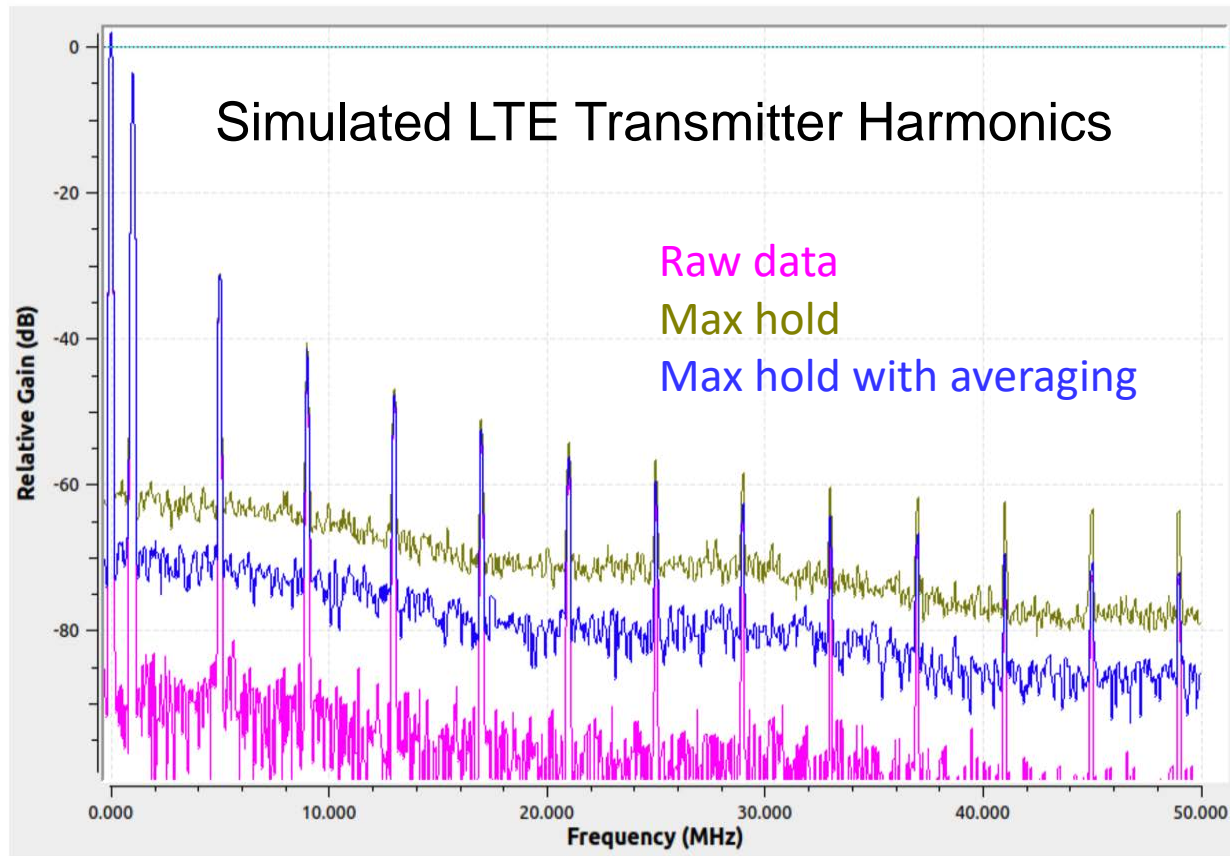
Unintended Emissions (BAA: RF Emanations)

- transmitter harmonics



Unintended Emissions (BAA: RF Emanations)

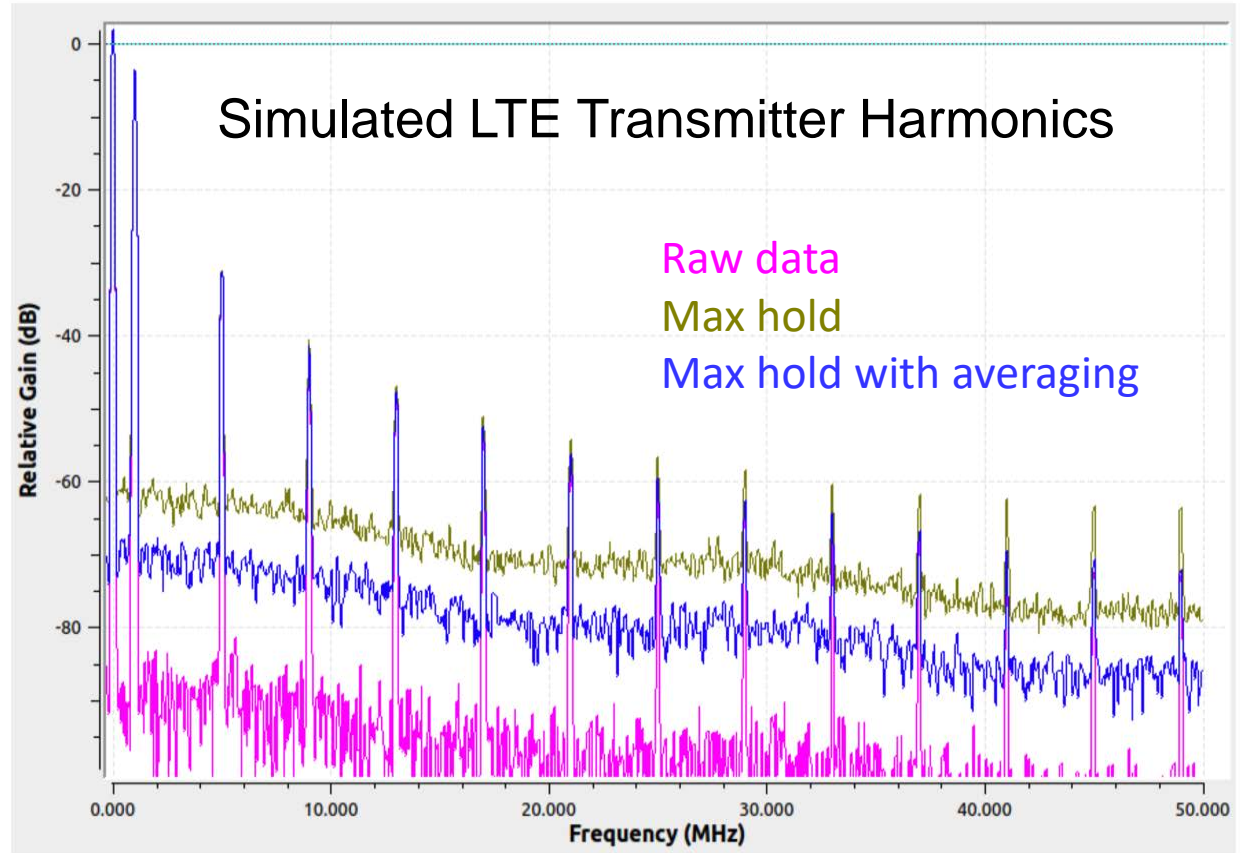
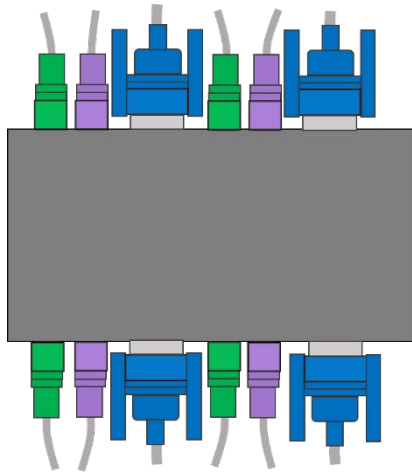
■ screens





Unintended Emissions (BAA: RF Emanations)

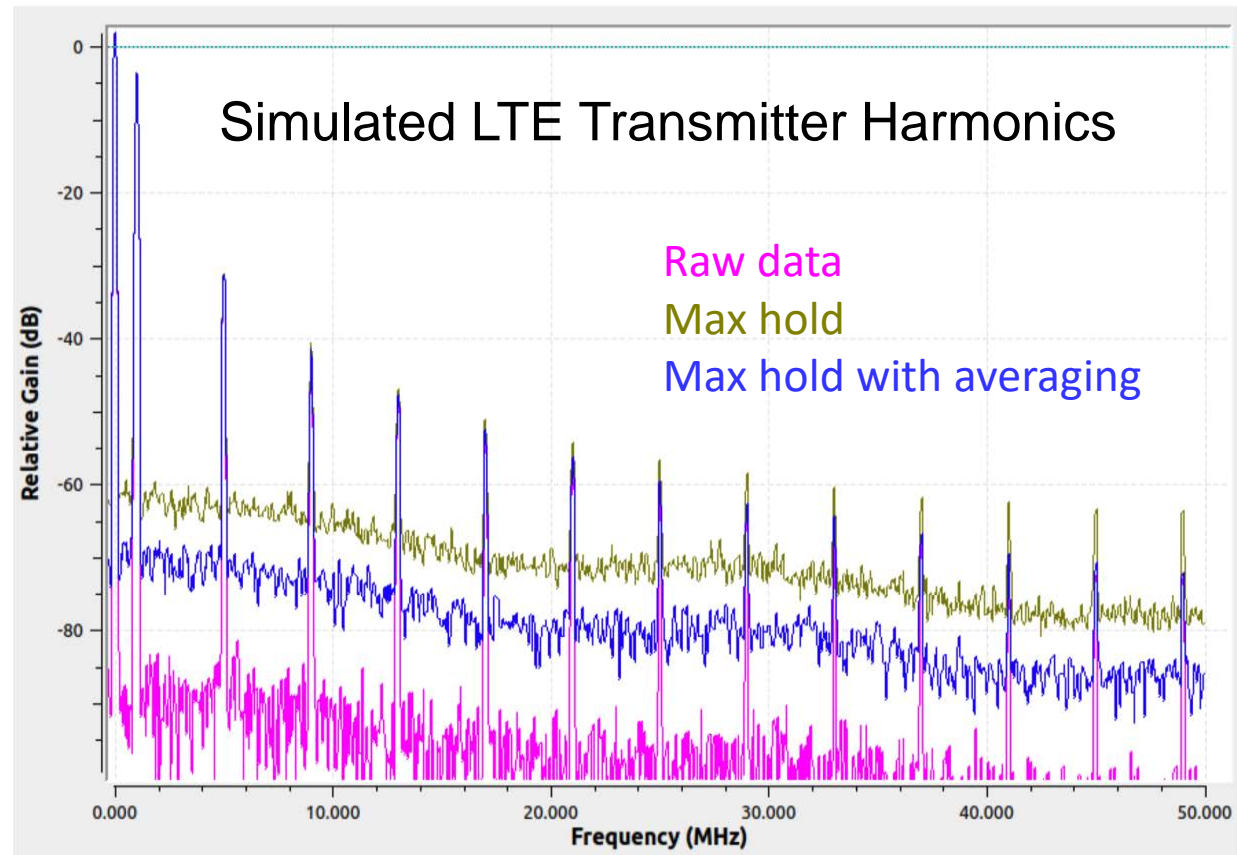
- KVM* switches



*keyboard, video monitors, and mice

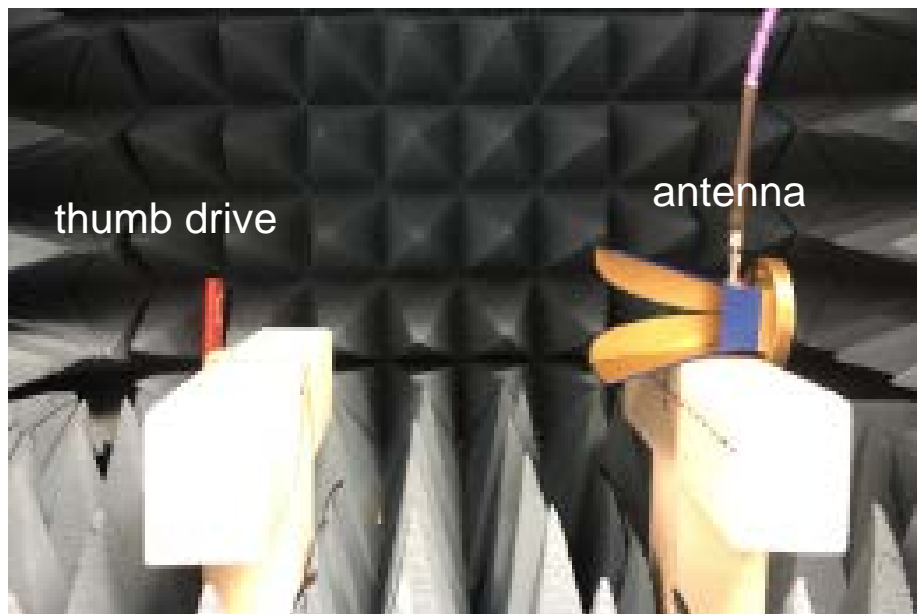
Unintended Emissions (BAA: RF Emanations)

- transmitter harmonics
- screens
- KVM
- “Anything with a micro-processor”*

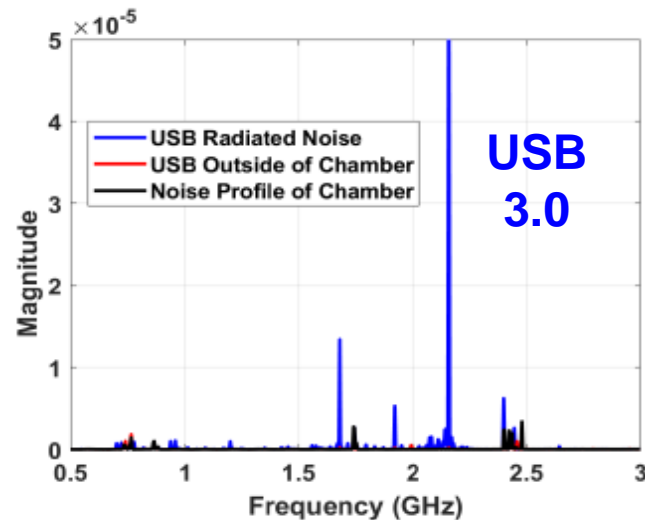
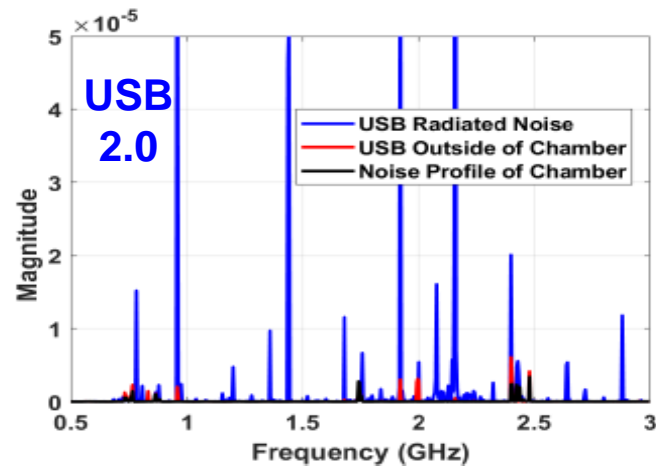


*PM for DARPA’s Leveraging Analog Domain for Security (LADS) program

Other Devices with RF Emanations



Dr. Jessica Ruyle, University of Oklahoma,
 2018 (used with permission of the author)

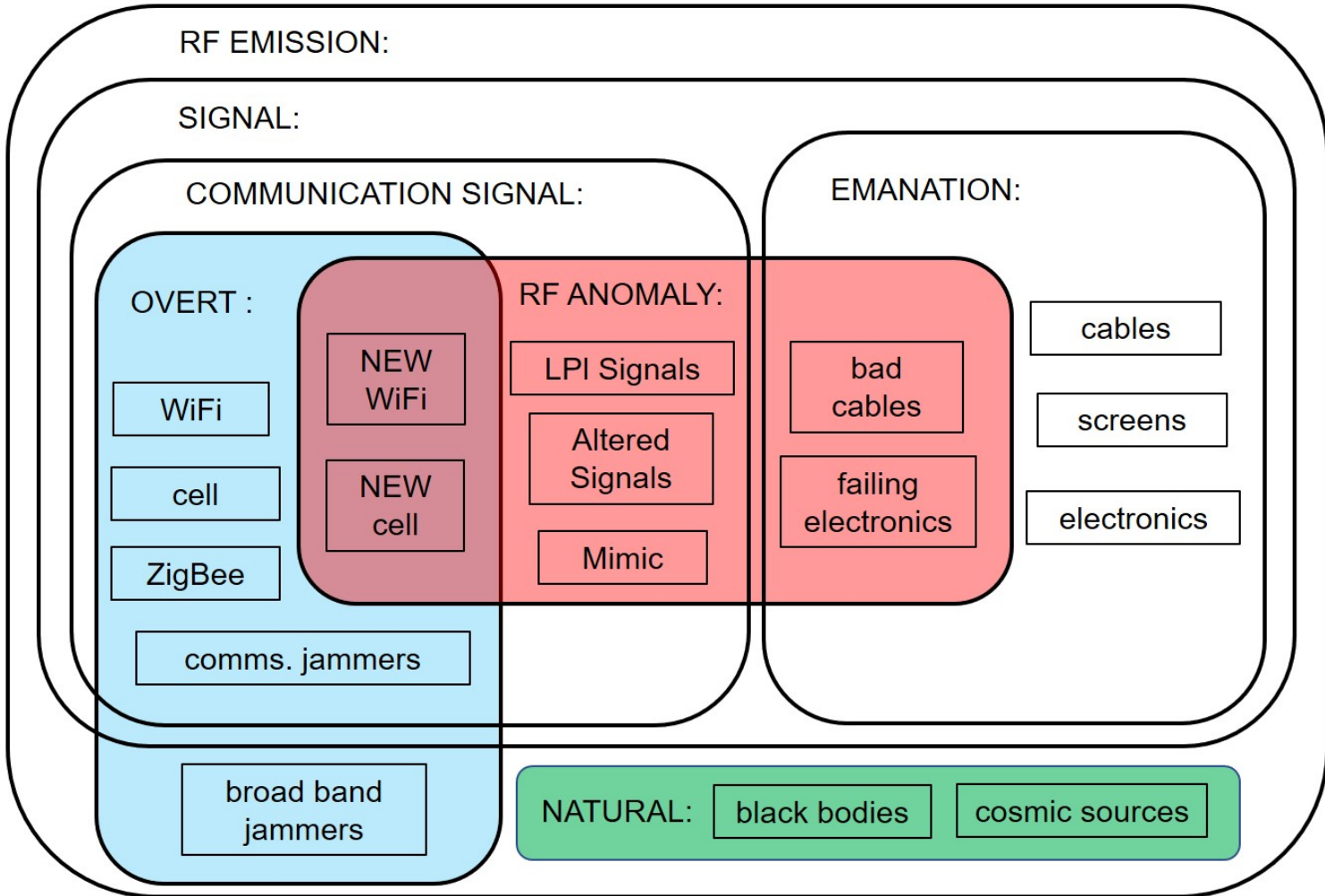




SIGNALS SUMMARY:



NOTIONAL RF EMISSION TYPES BY SOURCE:



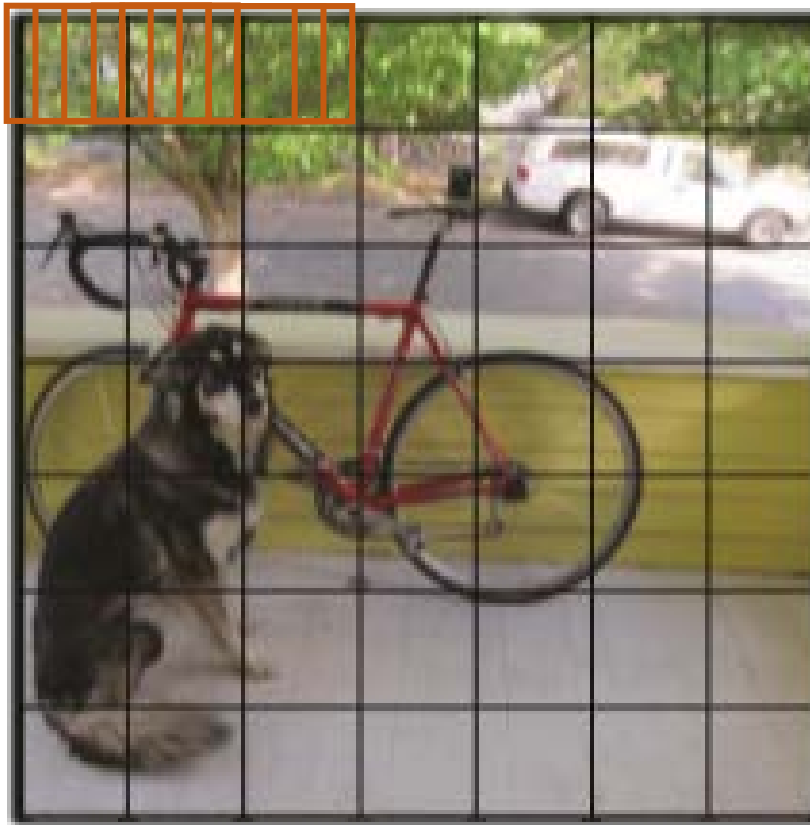


How we might get there

or what is new in the approach and why it can be successful?

- Radio Frequency Machine Learning (RFML)
- Classical Signals Analysis
- Software Defined Radios (SDRs)
- Graphics/Central Processing Units (GPUs/CPUs)

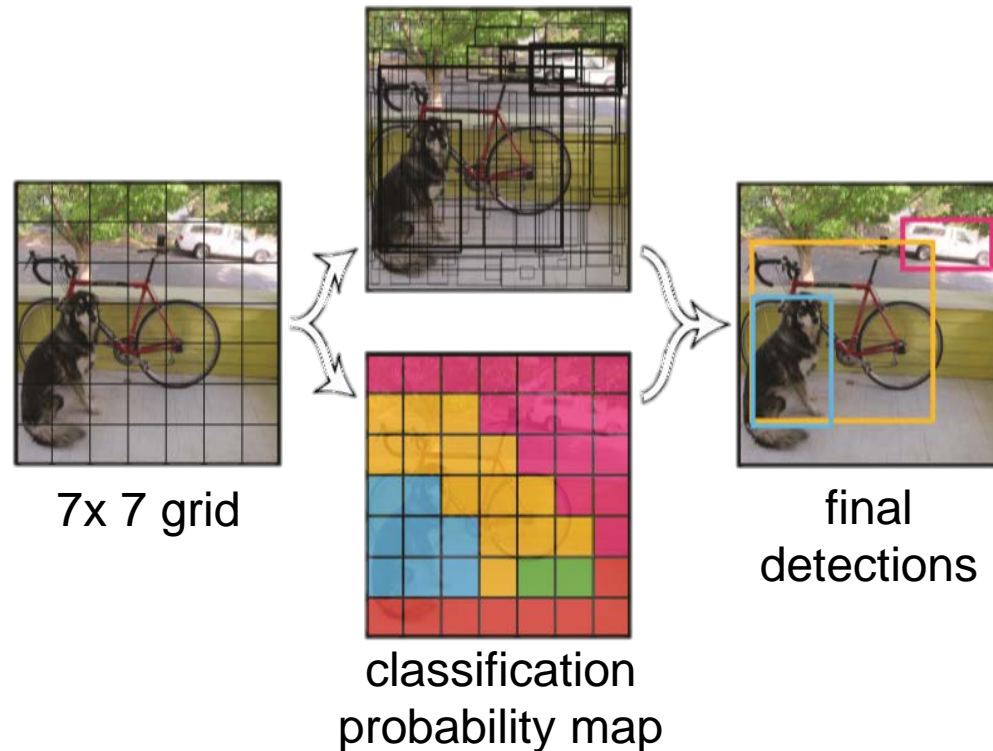
Sliding Correlator: (slow)



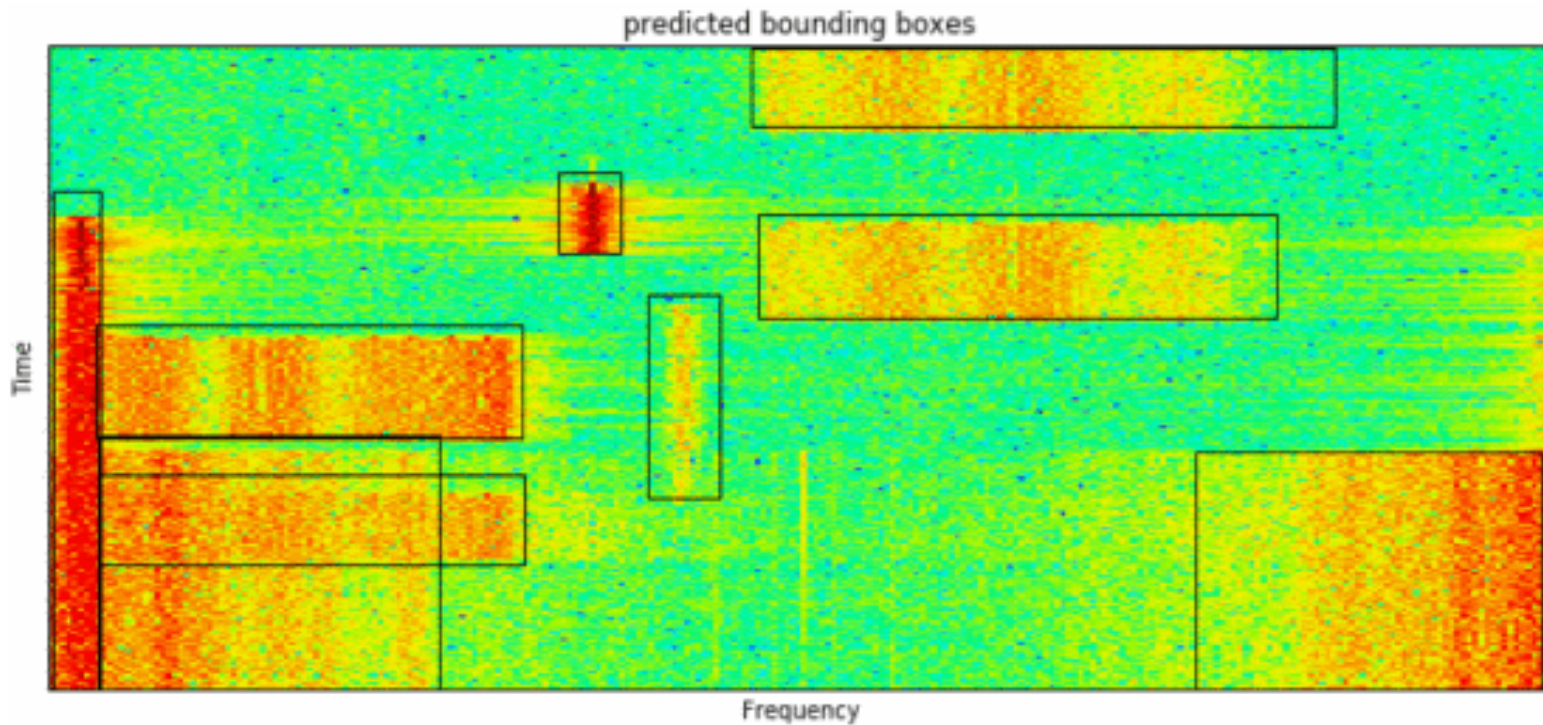
You Only Look Once (YOLO):

~ 100 frames/s

bounding box +
confidence



(J. Redmon, et al. "You only look once: Unified, real-time object detection" University of Washington. May 2016. [Online] Available: <https://arxiv.org/abs/1506.02640> (used with permission of the author(s))



Over-the-air ISM band emissions

T. O'Shea, et al. "Learning Robust General Radio Signal Detection Using Computer Vision Methods," IEEE (used with permission of the author(s))



Visible vs. RF Images



Image Obstruction



Image Superposition





Visible vs. RF Images



Image Obstruction



Image Superposition





Visible vs. RF Images



Image Obstruction



Image Superposition





Visible vs. RF Images



Image Obstruction



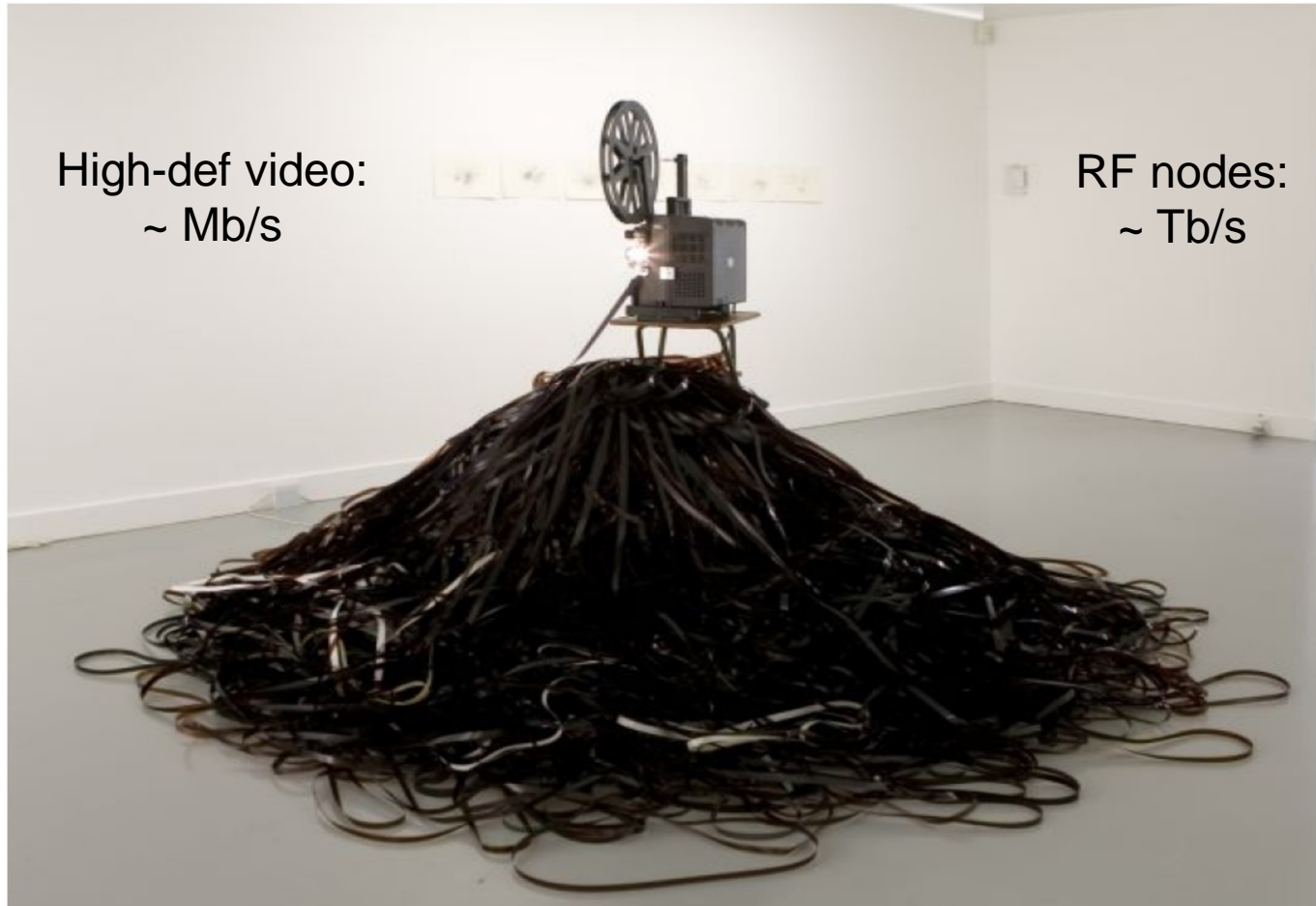
Image Superposition





Visible vs. RF Images

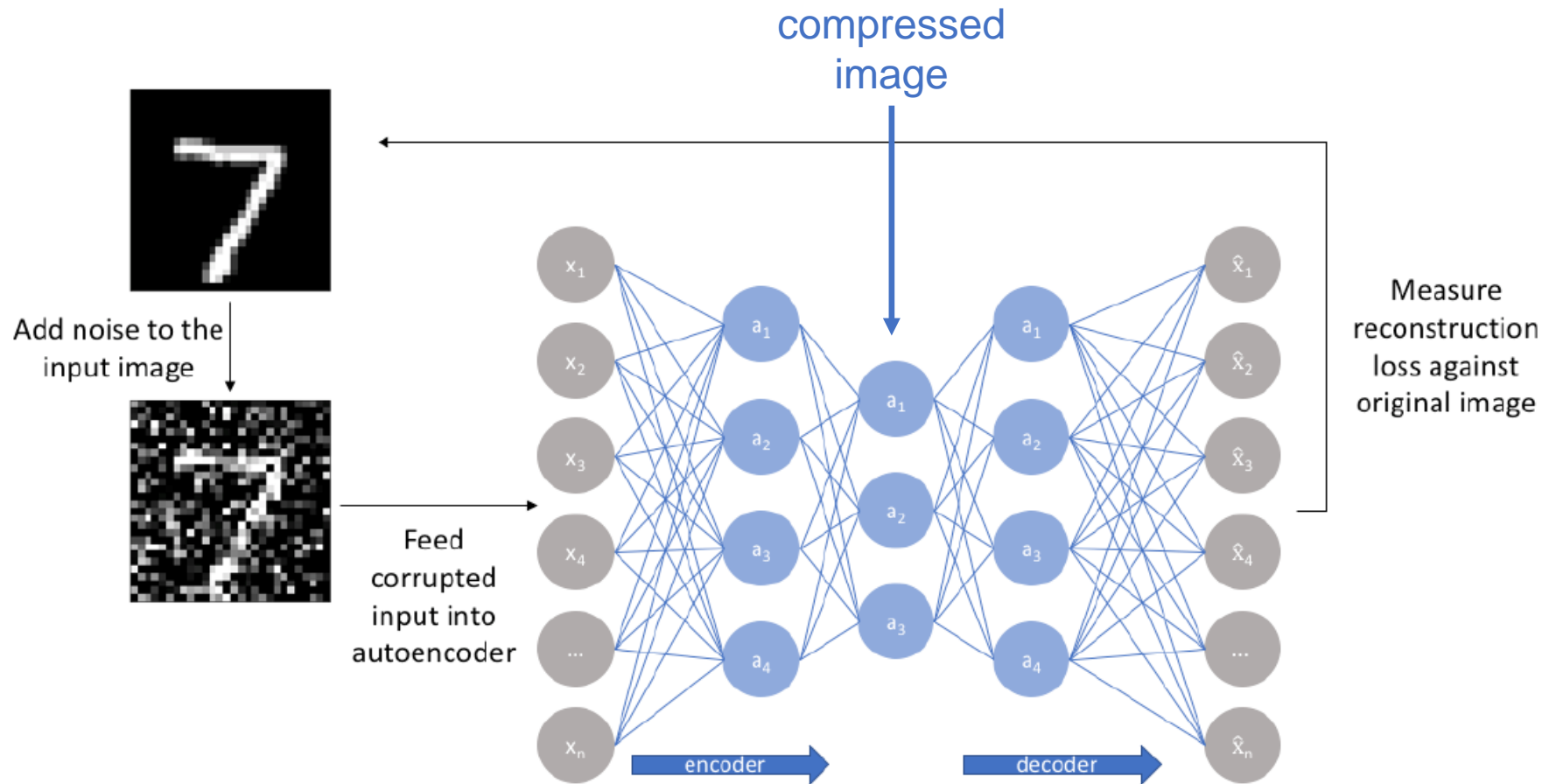
Too Much Data



Light Spill (2005) by Gibson + Recoder. Photo: Courtesy of M HKA and the artists



Autoencoders



www.jeremyjordan.me/autoencoders (used with permission of the author)

Autoencoding

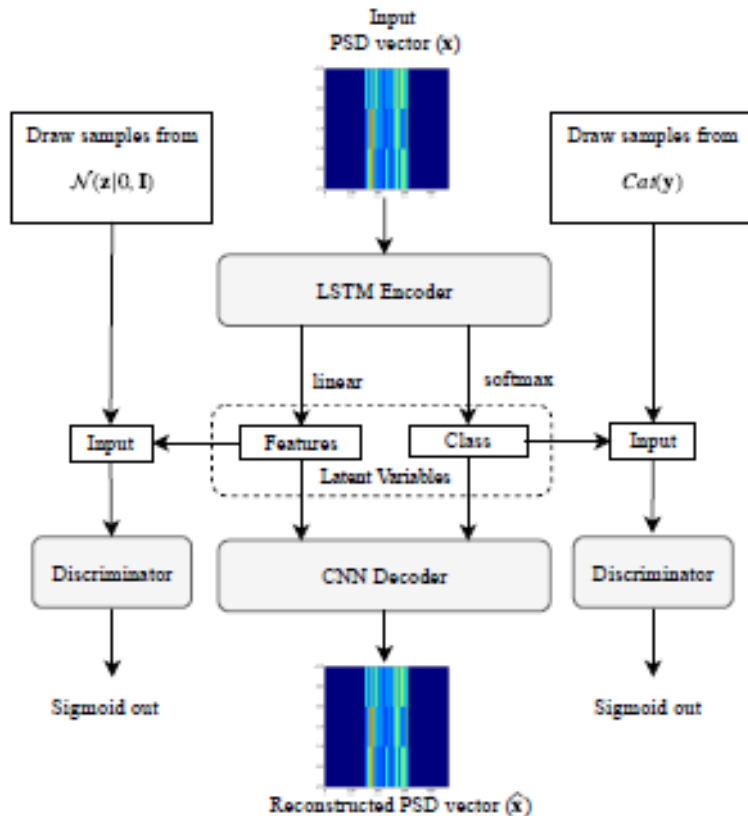
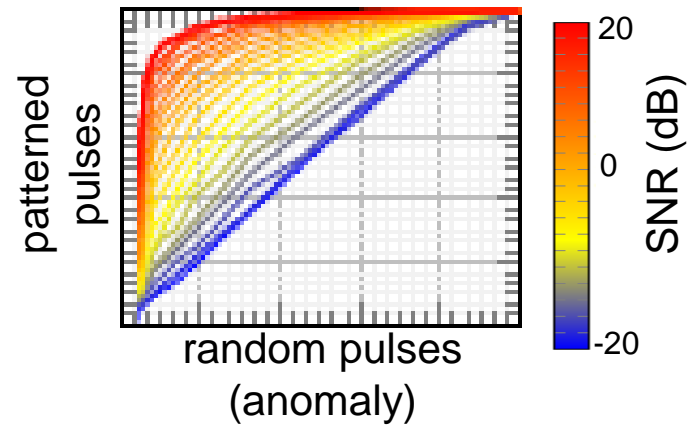
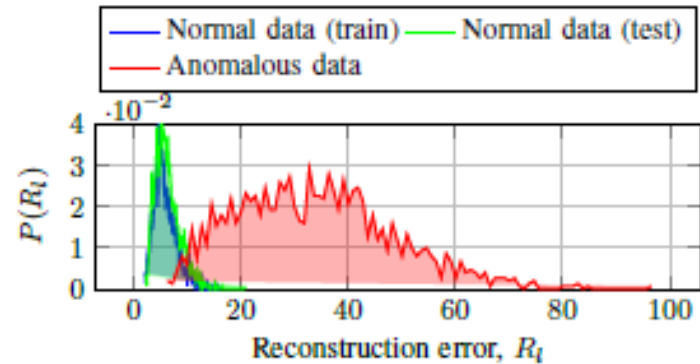


Fig. 2 Model architecture for anomaly detection.

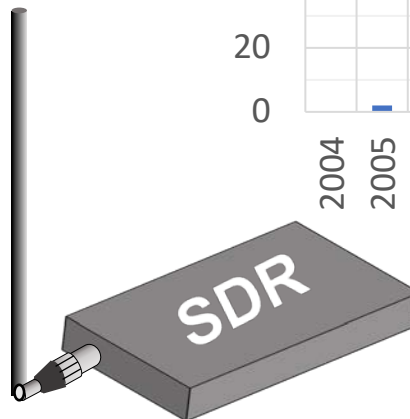


SAIFE: Unsupervised Wireless Spectrum Anomaly Detection with Interpretable Features, S. Rajendran, et al., CoFF vol. abs.1807.0831v1, 2018 (and references therein)

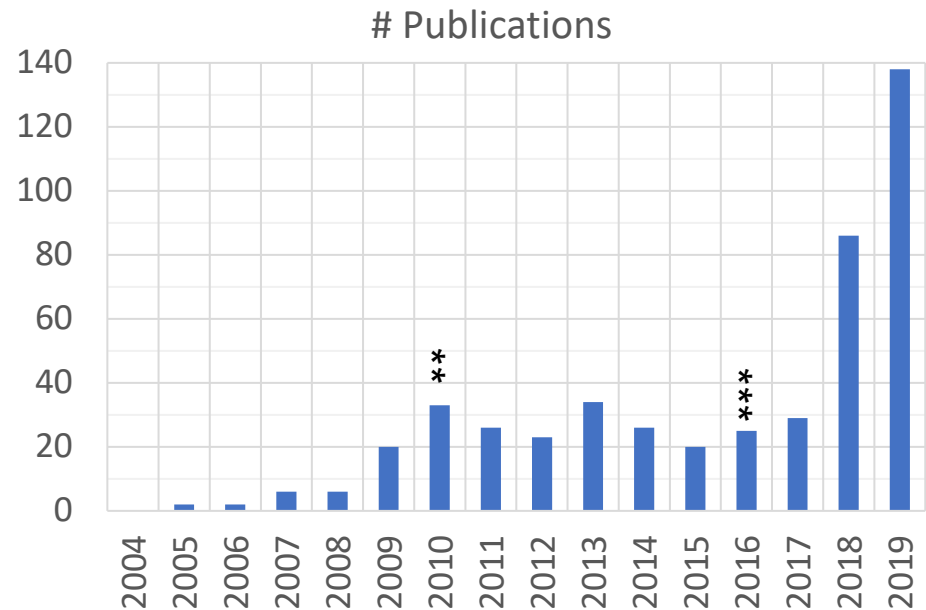
- What once took expensive, specialized equipment can now be done with an SDR and a laptop
- Published data sets have opened RFML research to a researchers without an RF lab
- DARPA's RFMLS program



ARRL Heritage Museum
 (used with permission)



“RF” or “radio” and “learning” in title (IEEE Xplore®)*



*educational learning removed
 **Ettus Research (SDRs) founded
 ***O'Shea RFML dataset published; T. J. O'Shea, et al., CoFF vol. abs. 1602.04105v3, 2016 (200+ citations)

Which combo of approaches is best for *hard* signals?

MACHINE LEARNING

CLASSICAL LEARNING

Unsupervised
clustering
pattern search
dimension reduction

Supervised
classification
regression

REINFORCEMENT LEARNING

Genetic Algorithms
Q-Learning
SARSA

ENSEMBLE METHODS

Boosting
Stacking
Bagging

NEURAL NETS & DEEP LEARNING

Convolutional Neural Networks
Recurrent Neural Networks
Autoencoders
Generative Adversarial Networks
Perceptrons

CLASSICAL SIGNAL PROCESSING

SIGNAL RECOVERY

Matched Filter
Carrier Recovery
Phase Locking
Timing Recovery

FILTERING

Impulse Response
Polyphase
Low/High Band Pass

CYCLOSTATIONARY

Kurtosis/Skew
Max Hold
Integration

WINDOWING

Blackman
Hamming/Hanning

X^2, X^4, X^8

SAMPLING

Decimate
Down-sampling
Multirate

FAST FOURIER TRANSFORM

FREQUENCY TRANSLATION

Base Banding
Up/down Conversion



Test & Evaluation Plan

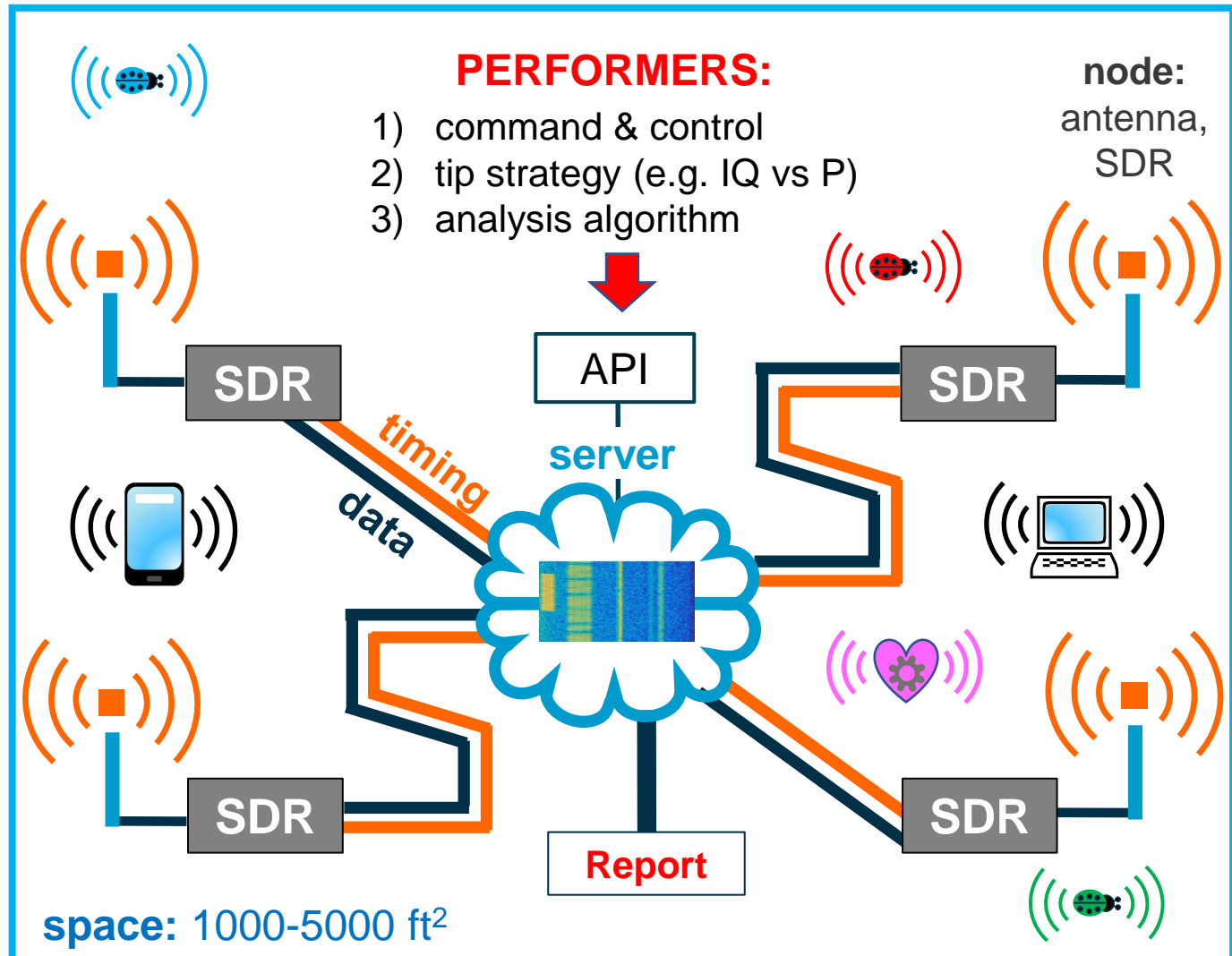
T&E:

- 1) supply RF quiet test bed: 1000 – 5000 ft²
RF noise can be added if needed
- 2) supply hardware: multi-node system
- 3) supply server with fixed compute power
- 4) supply application programming interface (API)
- 5) host visits for initial survey and test runs
- 6) provide performers with requested data
- 7) control and catalog RF emitters and LPI
- 8) evaluate test results against metrics

PERFORMERS:

- 1) command & control
- 2) tip strategy (e.g. IQ vs P)
- 3) analysis algorithm

node:
antenna,
SDR

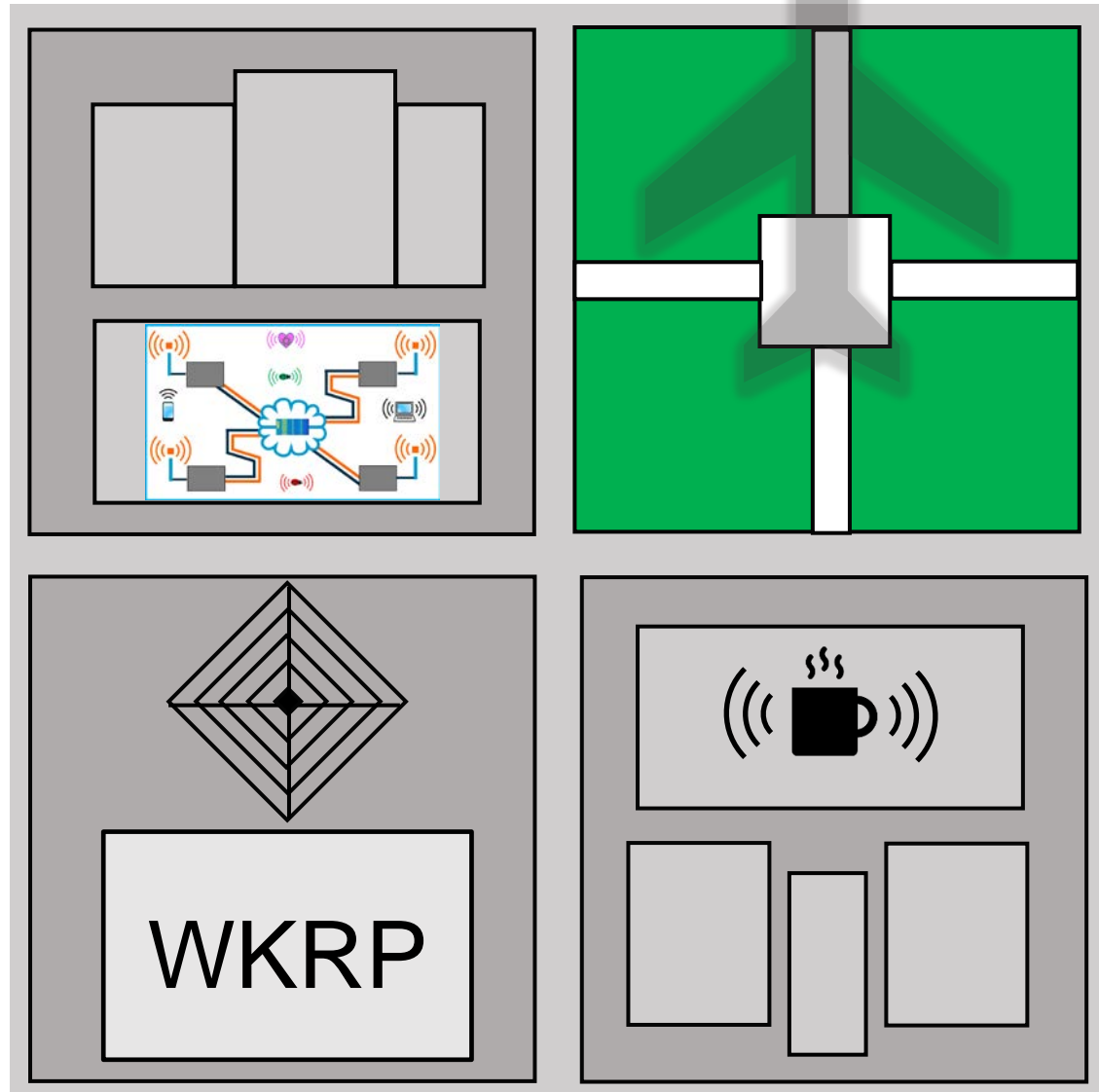




RF Background



- originates from sources external to and independent from the testbed
- depends on geographic location
- varies with time
- has spatial dependence
- adds to the testbed Baseline
- T&E will target about 40 to 50 dB of attenuation at 10 GHz

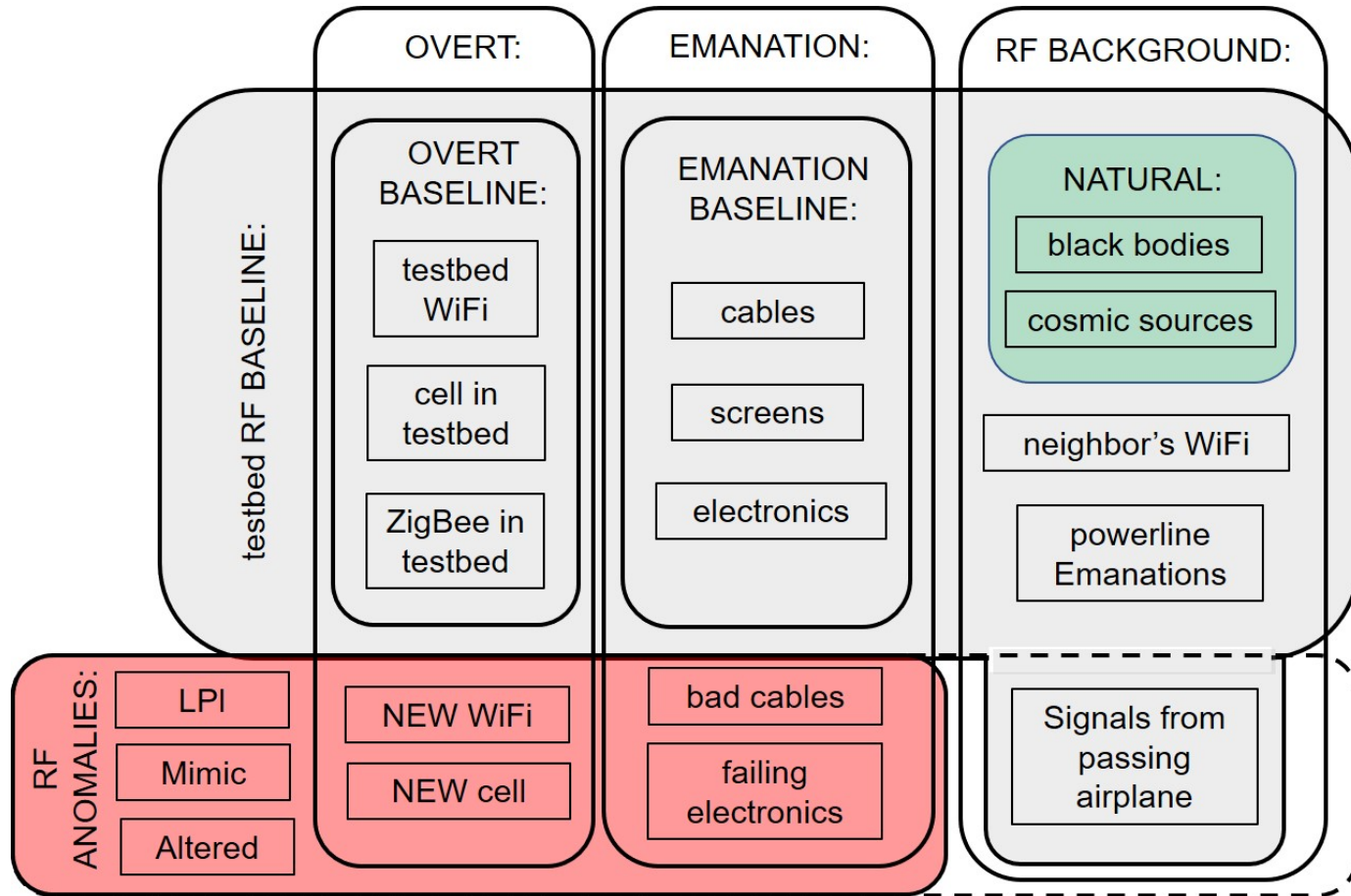




SOURCE LOCATIONS:



NOTIONAL RF BASELINE CONTRIBUTORS:



RF Background Reference: International Telecommunications Union (ITU)
Recommendation ITU-R P.372-13



Plan by Phase



Phase 1: Start with DSSS, Burst, Hoppers, Snugglers

- 1) T&E Teams build RF testbeds of cataloged (40+) RF sources
- 2) T&E Team installs RF hardware array, fixed server, supplies API
- 3) Performers visits each testbed site
- 4) Performers request RF data from T&E
- 5) T&E add RF devices emitting LPI and other Anomalous Signals
- 6) Test run: Performers command and run hardware, collect data, analyze, adjudicate, and report; “surprise” hardware may be introduced
- 7) T&E Team report test results against metrics
- 8) Performers recommend hardware changes

Phase 2: Add Altered and Mimicked Signals

- 1) New radio introduced late in phase 1: performer’s algorithms must be adaptable
- 2) Altered/mimicked signals added & LPI made harder

Phase 3: Add Anomalous Emanations

- 1) New radios or hardware possibly introduced
- 2) Performers must characterize Emanations, previous anomalies made harder





Tasks per Phase:

easy ←  → hard

Signal/Transmission Type	True Positive Rate, False Positive Rate		
	Phase 1	Phase 2	Phase 3
Overt Communication	90%, 5%	94%, 2%	98%, 1%
LPI	50% , 10%	50% (80% old) , 10%	50% (80% old) , 10%
Altered/Mimicked	-	50% , 10%	50% (80% old) , 10%
Metadata for Comm. Signals*	80%, 10%	88%, 5%	95%, 2%
Emanations**	must report #	125% x phase 1 best #	200% x phase 1 best #
Anomalous Emanations***	80%, 10%	80%, 10%	50% , 10%

Red/Blue tests designed with easy to hard signals targeting 50% success rates;

“old” rates refer to signals previously encountered

*Frequency, bandwidth, power level, signal duration, modulation type, baud rate, device type (e.g., WiFi, cell), other statistics; **signals must be “localized” with interpretable features**

**Controlling the number of detectable signals will be exceedingly challenging, but performers must report as many as possible in Phase 1. The largest reported (best) number will be taken as the benchmark for subsequent Phases.

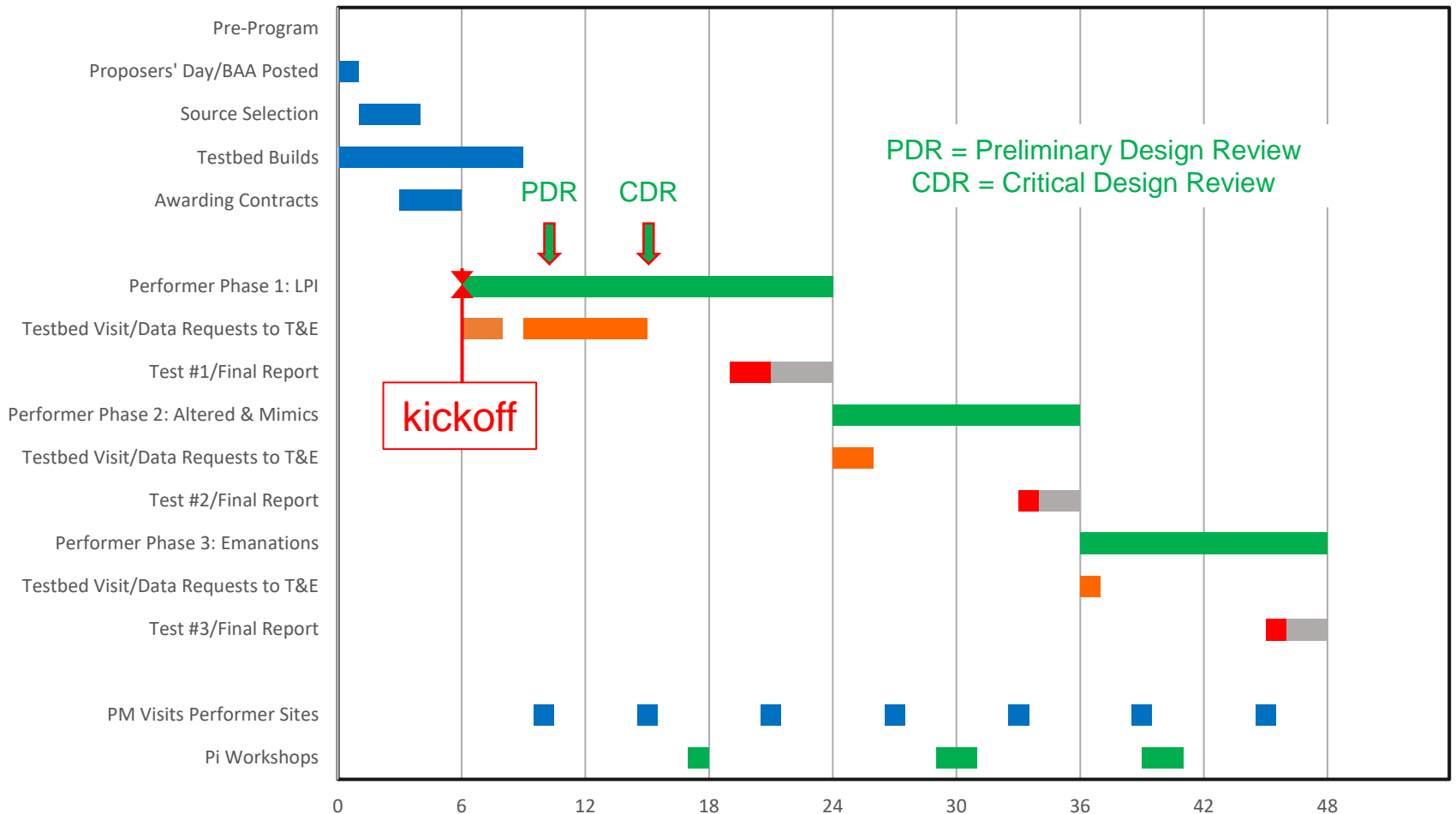
*** Includes increased power of the fundamental or harmonics, spurs, and frequency shifts; in Phase 3, software could be used to generate these anomalies.



Program Schedule



Program Timeline



Final Thoughts



Point of Contact

Dr. Paul Kolb

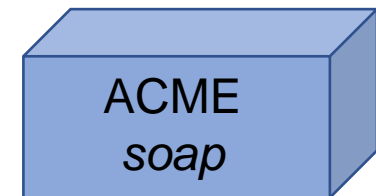
Program Manager

Office of the Director of National Intelligence

Intelligence Advanced Research Projects Activity (IARPA)

Washington, DC 20511

Phone: (301) 243-2082



- Electronic mail: dni-iarpa-BAA-20-03@iarpa.gov
include IARPA-BAA-20-03 in the Subject Line
- Website: <https://www.iarpa.gov/index.php/research-programs/scisrs>



SCISRS Proposers' Day

We'll be back shortly

- Submit your questions via the Q&A Tool



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Doing Business with IARPA

Acquisition Team



Office of the Director of National Intelligence

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Doing Business with IARPA



- Eligibility Information
- Preparing the Proposal - Broad Agency Announcement (BAA)
 - Electronic Proposal Delivery (<https://iarpa-ideas.gov>)
- Organizational Conflicts of Interest (OCI)
- Intellectual Property
- Streamlining the Award Process
- Questions and Answers (<http://www.iarpa.gov/index.php/faqs>)
- Pre-Publication Review
- IARPA Funds High Risk - High Payoff Research for the Intelligence Community
- **RECOMMENDATION: Please read the entire BAA as the information in this briefing may be updated. The BAA overrides this briefing.**



Eligible Applicants

- IARPA is seeking state of the art solutions
 - Content, communications, networking, and team formation are the responsibility of Proposers
- Foreign organizations and/or individuals may only participate as part of a U.S. based team
 - Prime Contractor must be a U.S. entity
 - All foreign participation must comply with any necessary Non-Disclosure Agreements, Security Regulations, Export Control Laws, and other governing statutes
 - Any other requirements identified in the BAA



Ineligible Organizations

- The following are generally **not** eligible to submit proposals under this BAA or participate as team members under proposals submitted by eligible entities:
 - Other Government Agencies,
 - Federally Funded Research and Development Centers (FFRDCs),
 - University Affiliated Research Centers (UARCs),
 - ❖ An entity of which only a portion has been designated as an UARC may be eligible subject to an OCI review.
 - Any organizations that have a special relationship with the Government; e.g., that would give them
 - ❖ access to privileged and/or proprietary information,
 - ❖ access to Government equipment or real property.



Preparing the Proposal

- Note BAA restrictions on proposal submissions
 - ❑ Interested Offerors must register electronically IAW instructions on: <https://iarpa-ideas.gov>
 - ❑ Interested Offerors are strongly encouraged to register in IDEAS at least one week prior to proposal “Due Date”
 - ❑ Offerors may only submit the “Final Version” of their proposal in IDEAS
 - ❑ Classified proposals are not anticipated for this program.
- Ensure you are registered in Beta.Sam.gov
- BAA Amendments and Q&As posted to Beta.Sam.gov
- Read BAA Evaluation Criteria carefully
 - ❑ e.g., “The technical approach is credible and includes a clear assessment of primary risks and a means to address them”



Preparing the Proposal

- Read and comply with the instructions on Organizational Conflict of Interest (OCI)
- Note eligibility restrictions on use of FFRDCs, UARCs, and other similar organizations that have a special relationship with the Government
 - Focus on possible OCIs of your institution as well as the personnel and subcontractors on your team
 - The BAA specifies the non-Government (e.g., SETA, FFRDC, UARC) support we will be using. If you have a potential or perceived conflict, bring it to IARPA's attention as soon as possible



Organizational Conflict of Interest (OCI)

- A potential conflict of interest includes but is not limited to any instance where an offeror, or any of its proposed subcontractor teammates, is providing either scientific, engineering and technical assistance (SETA), or technical consultation to IARPA. In all cases, the Offeror shall identify the contract under which the SETA or consultant support is being provided.



Intellectual Property (IP)

- IARPA applies FAR based clauses and procedures. The Offeror will be requested to identify any IP restrictions in its proposal.
- **Government Purpose Rights (GPR)** are a Department of Defense requirement, and IARPA applies FAR based contracting procedures.
 - State in the proposal any restrictions on deliverables relating to existing materials (e.g., data, software, tools)



Streamlining the Award Process



- Cost Proposal – IARPA will request the full cost proposal only after selection. The BAA will provide specific instructions.
- Statements of Work – will be submitted as part of the Offerors proposal.
- Key Personnel
 - Expected percentage of effort/hours that will be worked, note the Evaluation Criteria requiring relevant experience and expertise
- If selected for negotiations, the Contracting Officer may request your review of subcontractor proposals.



Questions and Answers

- Q&As today at Proposers' Day are informal information and do not override the BAA. ***The BAA is the authoritative document.***
- Please read entire BAA before submitting questions and conduct a Ctrl+F word search.
- Pay attention to Proposal & Submission Information.
- Read Frequently Asked Questions on the IARPA website @ <http://www.iarpa.gov/index.php/faqs>
- After BAA release, send your questions to:
 - ❑ SCISRS BAA: dni-iarpa-baa-20-03@iarpa.gov
 - ❑ Write questions as clearly as possible
 - ❑ Do NOT include proprietary information



Pre-Publication Review



- We encourage publication of **UNCLASSIFIED** IARPA-funded research in peer-reviewed journals, presentation at conferences, and publication in conference proceedings.
- Prior to public release of any work submitted for publication, the Performer will:
 - ❑ Communicate results to be publicly released with the IARPA Program Manager to discuss any sensitivities (e.g., security, speculation on IC use cases)
 - ❑ Provide advance courtesy copies to the IARPA PM and Contracting Officer Representative (COR/COTR)

IARPA Funding

- IARPA funds **High Risk – High Payoff Research** for the Intelligence Community
 - IARPA cannot waive the requirements of:
 - ❖ Export Administrative Regulation (EAR) or
 - ❖ International Traffic in Arms Regulation (ITAR)
 - Not subject to DoD funding restrictions for R&D related to overhead rates

- IARPA is not DoD



Disclaimer



- This is Research for the Intelligence Community
- Content of the Final BAA will be specific to this program
 - The Final BAA is being developed
 - Following issuance, look for Amendments and Q&As
 - There will likely be changes
- The information conveyed in this brief and discussion is for planning purposes and is subject to change prior to the release of the **Final BAA**.



Agenda



Time (EDT)	Topic	Speaker
1:00 PM – 1:15 PM	Welcome, Logistics, Proposer's Day Goals	Dr. Paul Kolb Program Manager, IARPA
1:15 PM – 1:25 PM	IARPA Overview	Dr. Catherine Cotell, Deputy Director (Emeritus), IARPA
1:25 PM – 2:10 PM	SCISRS Program Overview	Dr. Paul Kolb
2:10 PM – 2:25 PM	Break (Proposers formulate Qs)	
2:25 PM – 2:45 PM	Doing Business with IARPA	Linda Rodrock, IARPA Contracting Officer
1:00 PM – 3:00 PM	SCISRS Question Submissions	submit via Q&A
2:45 PM – 3:15 PM	Break (IARPA formulates As)	
3:15 PM – 4:15 PM	SCISRS Questions & Answers	Dr. Paul Kolb



SCISRS Proposers' Day

We'll be back shortly

- Submit your questions via the Q&A Tool