Securing Compartmented Information with Smart Radio Systems (SCISRS)

Paul Kolb, Program Manager, Proposers’ Day, August 20, 2020
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
What is the airspeed velocity of an unladen swallow?
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.*
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

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<thead>
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<th>BAA Term</th>
<th>SCISRS Definitions</th>
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<tr>
<td><strong>Anomaly</strong></td>
<td>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.</td>
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<tr>
<td><strong>Background</strong></td>
<td>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.)</td>
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IARPA Overview
Dr. Catherine Cotell, IARPA Deputy Director (Emeritus)
Intelligence Advanced Research Projects Activity
Office of the Director of National Intelligence
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, measurable, 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?

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.

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:

iarpa.gov  |  301-243-1995
info@iarpa.gov
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Securing Compartmented Information with Smart Radio Systems (SCISRS)

Paul Kolb, Program Manager, Proposers’ Day, August 20, 2020
The IC & DoD need sensitive information to be secure \textit{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

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):

\[ \frac{1}{2} T_D \]

\[ B_D = \frac{1}{2} T_D \]

\[ B_C = \frac{1}{2} T_C \]
A Signal Below the Noise Floor

Noise Floor = 10 Log($kBT/mW$) + Noise Figure + 10 Log($BW/Hz$)

-174 dBm  NF > 0  2 MHz

= - 111 dBm for GPS

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

Mimics:

Hey …  … let’s talk, I’m  … ignore me, I’m
- a GPS satellite
- a cell tower
- your WiFi router
- 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

Simulated LTE Transmitter Harmonics

Raw data
Max hold
Max hold with averaging

![Simulated LTE Transmitter Harmonics Graph](image-url)
Unintended Emissions (BAA: RF Emanations)

- Screens

Simulated LTE Transmitter Harmonics

- Raw data
- Max hold
- Max hold with averaging
Unintended Emissions (BAA: RF Emanations)

- KVM* switches

*keyboard, video monitors, and mice

Simulated LTE Transmitter Harmonics

Raw data
Max hold
Max hold with averaging
Unintended Emissions (BAA: RF Emanations)

- transmitter harmonics
- screens
- KVM
- “Anything with a microprocessor”*

*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)
NOTIONAL RF EMISSION TYPES BY SOURCE:

RF EMISSION:

SIGNAL:

COMMUNICATION SIGNAL:
- NEW WiFi
- NEW cell
- ZigBee
- comms. jammers
- broad band jammers

RF ANOMALY:
- LPI Signals
- Altered Signals
- Mimic

EMANATION:
- bad cables
- failing electronics
- cables
- screens
- electronics

NATURAL:
- black bodies
- cosmic sources
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)
Optimization/Speed

Sliding Correlator: (slow)

You Only Look Once (YOLO): ~ 100 frames/s
bounding box + confidence

7x7 grid
classification probability map
final detections

Over-the-air ISM band emissions

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

3rd D for RF: PHASE
Visible vs. RF Images

Too Much Data

High-def video:
~ Mb/s

RF nodes:
~ Tb/s

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

Add noise to the input image

Feed corrupted input into autoencoder

compressed image

Measure reconstruction loss against original image

www.jeremyjordan.me/autoencoders (used with permission of the author)
RF Anomalies & RFML

Autoencoding

SDRs & Datasets

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

ARRL Heritage Museum (used with permission)

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

# Publications

*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)
Open Questions?

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

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<th><strong>CLASSICAL SIGNAL PROCESSING</strong></th>
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<td><strong>ENSEMBLE METHODS</strong></td>
<td><strong>CYCLOSTATIONARY</strong></td>
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<td>Kurtosis/Skew</td>
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<td>Stacking</td>
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<td>Bagging</td>
<td>Integration</td>
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<td><strong>NEURAL NETS &amp; DEEP LEARNING</strong></td>
<td><strong>X^2, X^4, X^8</strong></td>
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<td>Convolutional Neural Networks</td>
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<td>Generative Adversarial Networks</td>
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<td><strong>FAST FOURIER TRANSFORM</strong></td>
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<td><strong>FREQUENCY TRANSLATION</strong></td>
<td>Base Banding</td>
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<td>Up/down Conversion</td>
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<td><strong>WINDOWING</strong></td>
<td>Blackman</td>
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<td>Hamming/Hanning</td>
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<td><strong>SAMPLING</strong></td>
<td>Decimate</td>
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<td>Down-sampling Multirate</td>
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</table>
Test & Evaluation Plan
High Level Overview

Signals:
- IoT
- LPI

Hardware:
- SDR

Data:
- time
- frequency

Analysis:
- normal Baseline
- ... BIN 1
  - power
  - duration
  - frequency
  - bandwidth
  - modulation
- BIN 2
  - $P_j(t)$
- BIN $x$
  - $P_k(t)$

Anomalies:
- IoT
- WiFi
- medical
- threat
T&E:
1) supply RF quiet test bed: 1000 – 5000 ft\(^2\)
   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

space: 1000-5000 ft\(^2\)
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:

- **OVERT BASELINE:**
  - testbed WiFi
  - cell in testbed
  - ZigBee in testbed

- **EMANATION BASELINE:**
  - cables
  - screens
  - electronics

- **RF BACKGROUND:**
  - **NATURAL:**
    - black bodies
    - cosmic sources
    - neighbor’s WiFi
    - powerline Emanations
    - Signals from passing airplane

**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
## Metrics

### Tasks per Phase:

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<tr>
<th>Signal/Transmission Type</th>
<th>True Positive Rate, False Positive Rate</th>
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<tr>
<td></td>
<td>Phase 1</td>
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<tr>
<td>Overt Communication</td>
<td>90%, 5%</td>
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<tr>
<td>LPI</td>
<td>50%, 10%</td>
</tr>
<tr>
<td>Altered/Mimicked</td>
<td>-</td>
</tr>
<tr>
<td>Metadata for Comm. Signals*</td>
<td>80%, 10%</td>
</tr>
<tr>
<td>Emanations**</td>
<td>must report #</td>
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<tr>
<td>Anomalous Emanations***</td>
<td>80%, 10%</td>
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**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.
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
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
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](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
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.
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 Offeror’s 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.


- 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
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.
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<th>Time (EDT)</th>
<th>Topic</th>
<th>Speaker</th>
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| 1:00 PM – 1:15 PM | Welcome, Logistics, Proposer’s Day Goals | Dr. Paul Kolb  
Program Manager, IARPA |
SCISRS Proposers’ Day

We’ll be back shortly

- Submit your questions via the Q&A Tool