Opportunity Title: Ultra-Narrowband Transceiver Design for Long Range Low Power and Low Profile Communications
Opportunity Reference Code: ICPD-2019-28

Organization Office of the Director of National Intelligence (ODNI)

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If you have questions, send an email to ICPostdoc@orau.org. Please include the reference code for this opportunity in your email.

Application Deadline 3/1/2019 6:00:00 PM Eastern Time Zone

Description **Research Topic Description, including Problem Statement:**

- With the advent of the Internet-of-Things (IoT) and machine-to-machine (M2M) applications, wireless network operators are diversifying their traditional human-centric, high rate, always-on access paradigm to suit a new age of connected objects with vastly different traffic patterns and usage demands. Such applications typically require cheap, low frequency radio interfaces with greater than 10km range and 10-year battery life for the transferal of infrequent short length frames. This has heralded new communication standards for so-called low power wide area (LPWA) networks designed to minimize power consumption and increase range. Ultra-Narrowband (UNB) is a promising technique in this field.
- UNB uses advanced signal processing techniques and exploits the low noise floor of low bandwidth communications (typically less than 100Hz) to enhance the signal to noise ratio (SNR) of an UNB receiver providing superior sensitivity over traditional wideband systems, hence improved range of operation. Low bandwidths (therefore low data rate) combined with short frame durations allow for extended battery durations at ranges of 30km or more in small form factor embedded devices. This type of technology is particularly suited for command and control applications, long range infrastructure-less text messaging or location tracking applications.
- An additional and infrequently considered aspect of UNB communication is the difficulty of observation and interception by unintended recipients. An observer must have narrowband equipment with a noise performance similar to the UNB system in order to firstly detect the signal and secondly must tune to the precise 100Hz channel at the correct time for a short burst. This is further complicated by the effects of clock jitter since traditional UNB devices typically utilize cheap hardware with poor frequency stability. These attributes if combined with additional encryption strategies make UNB favorable for low rate, low observable communications which may defeat an opportunistic hacker.
- There are still aspects of practical UNB implementation that require further research. The application of more advanced modulation and encoding schemes hold the potential to increase range further, however this will require additional signal processing which is only now

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becoming possible to perform within an acceptable power budget. Similarly, encryption methods such as transport layer security (TLS) become difficult when one is trying to preserve low power consumption and short data frames. The challenge is to devise methods that provide acceptable security without compromising the low power aspects of the communications device.

- Taking these issues into account, this project aims to facilitate long range, low data rate communications utilizing UNB technology to enhance battery life and reduce power consumption for low observable applications.

Example Approaches:

- In order to release practical UNB communications, it is important to thoroughly understand the requirements of a potential system and expected performance of UNB technology. There is little literature surrounding this relatively novel technology so firstly a thorough analysis of UNB must take place. This will consist of three parts
  - Literature review – Survey the field for recent advances.
  - Simulation of typical UNB deployments to establish the performance bounds and realize potential issues.
  - A more thorough analysis of currently available UNB implementations.
- Quantify the possibilities of unintended reception by a third party with regard to:
  - The inherently undetectable nature of UNB communications.
  - The expected performance of a third party's reception equipment.
  - Enhancements in achievable range through advanced modulation and encoding schemes (these have been the subject of previously funded research).
  - The potential for enhanced integrity of transmitted data via encryption given the overarching requirements for low power and cost.
- This initial research will culminate in the primary goal of this study to design and prototype UNB communications equipment specifically for low rate, low probability of detection/interception communications. Key aspects of consideration will include:
  - Long range transceiver architecture whilst maintaining low power consumption.
  - Signaling and setup procedures for reliable/acknowledged data delivery
  - Frame formats for maximum utilization of available capacity
  - Battery design and provisioning

Key Words:

Ultra-Narrowband; Low power wide area (LPWA); Long range communications; Low profile communications

Qualifications

Postdoc Eligibility

- U.S. citizens only
- Ph.D. in a relevant field must be completed before beginning the appointment and within five years of the application deadline
- Proposal must be associated with an accredited U.S. university, college, or U.S. government laboratory

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- Eligible candidates may only receive one award from the IC Postdoctoral Research Fellowship Program.

Research Advisor Eligibility

- Must be an employee of an accredited U.S. university, college or U.S. government laboratory
- Are not required to be U.S. citizens

Eligibility Requirements

- **Citizenship:** U.S. Citizen Only
- **Degree:** Doctoral Degree.
- **Discipline(s):**
  - **Chemistry and Materials Sciences** (12 👁)
  - **Communications and Graphics Design** (6 👁)
  - **Computer, Information, and Data Sciences** (16 👁)
  - **Earth and Geosciences** (21 👁)
  - **Engineering** (27 👁)
  - **Environmental and Marine Sciences** (14 👁)
  - **Life Health and Medical Sciences** (45 👁)
  - **Mathematics and Statistics** (10 👁)
  - **Other Non-Science & Engineering** (5 👁)
  - **Physics** (16 👁)
  - **Science & Engineering-related** (1 👁)
  - **Social and Behavioral Sciences** (28 👁)