Opportunity Title: The Internet of Space Things Using Commercial Grade Radios
Opportunity Reference Code: ICPD-2022-44

Organization	Office of the Director of National Intelligence (ODNI)
Reference Code	ICPD-2022-44
How to Apply	**Create and release your Profile on Zintellect** – Postdoctoral applicants must create an account and complete a profile in the on-line application system. **Please note: your resume/CV may not exceed 2 pages.** **Complete your application** – Enter the rest of the information required for the IC Postdoc Program Research Opportunity. The application itself contains detailed instructions for each one of these components: availability, citizenship, transcripts, dissertation abstract, publication and presentation plan, and information about your Research Advisor co-applicant. Additional information about the IC Postdoctoral Research Fellowship Program is available on the program website located at: https://orise.orau.gov/icpostdoc/index.html. If you have questions, send an email to ICPostdoc@orau.org. Please include the reference code for this opportunity in your email.
Application Deadline	2/28/2022 6:00:00 PM Eastern Time Zone
Description	**Research Topic Description, including Problem Statement:** Space is a new domain for the Internet of Things. Internet of Space Things systems integrate ground-based nodes with space-based infrastructure and terrestrial broadband backhaul. Several UK-based service providers are poised to launch services. However, the IC is interested in understanding the trade-offs needed to design Internet of Space Things (IoST) systems for distributed ground sensors including command and control in circumstances where the very best performance can be achieved with the least commitment of power both on the ground and in orbit. At the same time, development and operating costs need to be kept to a minimum. For this reason, the IC is interested in defining the design criteria for two-way LEO satellite communications using readily available radio chipsets where power, weight and size are all constrained. Aspects to be taken into account include: • On-air waveform efficiency and Ionospheric penetration (taking into account Total Electron Content (TEC) variations, angle of incidence, and space weather phenomena) • Coding schemes for power efficiency, range and operation at extremely low SNR assuming maximum achievable bandwidth is always wanted • Design implications for encryption schemes Some work has been done in this topic and is in the public domain on the space-ground down link, this project will explore

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the ground-space up link also and combine the paths two to show how efficient and effective two-way communications using short datagrams can be designed. Reciprocity over the paths is not assumed.

Key outcomes are:

- A parameter sensitivity analysis for waveform and coding schemes using suitable readily available radio chipsets that explores the compromise between link performance and power commitment.
- Link budget calculations and expected achievable bandwidths assuming a 500 - 2500km range to the satellite, maximum RF power levels <30dBm, and constrained antenna gains at both ends. A variety of ISM and allocated satellite bands should be included.
- Identification of performance limitations as a result of variations in Total Electron Content (TEC) in theIonsphere,
- Practical terrestrial experiments that confirm key aspects theoretical modelling.

Example Approaches:

Long Range (LoRa) is a popular choice for the one-way space-ground link with several choices of parameters and waveforms in use by operators (tinygs.com). The LoRa signal is tolerant of the magnitude of doppler shift encountered in LEO satellites. It is possible to use the cyclic redundancy check (CRC) to plot a Receiver Operating Characteristic (ROC) curve for LoRa datagrams received on the ground. However, this may be misleading as it relies on a linear relationship between SNR and decode success – this is clearly not the case as the signal processing is non-linear. Also, the uplink path (ground-space) is not taken into account, and there is no guarantee of reciprocity. So alternative performance criteria are needed.

Figure 1: ROC curve drawn for space-ground link for Norby satellite (LoRa SF=10, CR=5, BW=250kHz) on 436.703MHz

A variety of chipsets are available ranging from ultra-narrowband ultra-low data rate through to broadband burst transmissions. This repertoire needs to be systematically evaluated.

Relevance to the Intelligence Community:

Internet of Satellite Things is an important enabling technology for data transfer and command and control in the field, yet designs in use are ‘vernacular’ and have little published about them. Commercial services are not necessarily in the right form factor or with the right link performance. The aim is to know how to design suitable two-way LEO satellite communications that are both power efficient and secure.

Key Words: Cybersecurity, Cubesat, LEO, IoT, IoST, Waveform, Coding

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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
- 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.
- **Academic Level(s):** Postdoctoral.
- **Discipline(s):**
  - **Chemistry and Materials Sciences** (12 👁)
  - **Communications and Graphics Design** (2 👁)
  - **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** (2 👁)
  - **Physics** (16 👁)
  - **Science & Engineering-related** (1 👁)
  - **Social and Behavioral Sciences** (27 👁)