Opportunity Title: Conceptualization of Swarm or Team Robots for Autonomous Tunneling
Opportunity Reference Code: ICPD-2022-02

Organization Office of the Director of National Intelligence (ODNI)

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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:**

Subterranean excavation is a dangerous, labor intensive, and time consuming task. We want to develop ways of mitigating these issues by replacing humans with a multi-unit system of robots that improves reliability and efficiency through redundancy. This system can be a swarm of identical robots, majority identical with several “leaders”, or groups of task specific ones. The system may consist of a true swarm of autonomous agent robots or semi-autonomous agents that are directed by a few leaders or a centralized computer. At the end of this effort the Postdoc will submit a report detailing one or more potential robotic excavation systems

The study will need to address three primary phases of operation. The system will need to excavate soil, transport the soil down the length of the tunnel, and then install some structure to shore (strengthen with some rigid liner/structural element) to make the tunnel stable for use. This theoretical system should meet the following requirements with the assumption that the excavation will be only horizontal and in ideal soil with good standup:

- Capable of excavating >50 feet
- Autonomous or semi-autonomous operation with all user interface outside the tunnel
- Individual robots be portable (<50 pounds each)
- Robots able to maintain tunnel axis within 9” at 50’
- Minimal on site servicing
- Excavate at least 1 foot per hour of smallest cross sectional area achievable
- Simple and rugged controls
- Persistent power without umbilicals if possible

Several key challenges will need to be addressed. The robots will need sufficient bracing force to be able to dig into naturally compacted soil,

though it does not need to account for solid rock, gravel, or flowing sand. The robots must remain portable but be capable of transiting the tunnel multiple times and/or excavate significant amounts of soil without stopping the excavation process via coordinated recharging, swappable batteries, or some other method. Their design should be simplified enough that non-expert users could affect repairs and maintenance.

Example Approaches:

Example approaches will depend on the maturity of the quantum sensor and its intended application environment. Some interesting directions include (but are not limited to) using machine learning techniques to simplify the user experience, using quantum and/or classical control techniques to increase robustness against noise, employing digital signal processing algorithms to increase sensor speed or improve accuracy, and applying advanced packaging techniques to reduce sensor size. These techniques may also be used to improve the performance of enabling technologies for the quantum sensor, such as lasers, photonic integrated circuits (PICs) or photon detectors, but the proposal should then include the use of these enabling technologies in an actual quantum sensor. Proposals may include work on theory, modeling or algorithms, but must apply these to a quantum sensor in the lab during the first year of the effort.

The investigator may take one of three potential avenues:

- Utilize market surveys, subject matter expert input, and/or simulated robotic systems to conceptualize a swarm excavation system.
- Alternatively, robots (at scale or nominal size) could be constructed to empirically demonstrate a viable system. These robots need only demonstrate the mechanical functions, they could be manually controlled via wires – swarm communications are not required for an initial demonstration.
- Another method of the investigator's design that they believe will meet the needs of the proposal.

Relevance to the Intelligence Community:

The Intelligence Community has a need to investigate areas for adversarial/criminal tunneling and the emplacement of objects of concern that cannot be readily or safely reached through surface excavation. Current methods are dangerous and strenuous to human workers so increased autonomy in these situations can expedite the process and better protect our people.

Key Words: Swarm, Robotics, Autonomy, Tunneling, Excavation, Mining, AI, Underground, Subterranean, Coordination, Navigation, GPS Denied, Simulated Robotics, Small Scale Robotics, Transport, Task Optimization

Qualifications

Postdoc Eligibility

- U.S. citizens only
- Ph.D. in a relevant field must be completed before beginning the appointment and within five

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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.
- **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 👁)