Counter Underground Facilities
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The threat posed by Underground facilities is a serious and growing concern for United States' national security.
The number of underground facilities worldwide has increased dramatically over the past few years, especially in adversarial nations.
A recent, but trivial example is the simple "spider hole" that Saddam Hussein was found hiding in late last year.

Most, however, are more ominous and threatening- deeply bored tunnels, cut and cover facilities the size of buried Wal-Marts, deep urban bunkers with interconnecting tunnels, and natural caves like those that challenged us in Afghanistan.
They are used for command and control functions, production and storage of weapons of mass destruction, ballistic missile and artillery basing, and leadership protection, to name but a few of their potential applications.
In order to attempt to preclude detection and characterization by sensors, and to make them difficult to damage with conventional weapons, many of these facilities are deeply buried or significantly hardened.
To conquer the challenges and asymmetric threat they present, DARPA is continuing to support and evolve the Counter Underground Facilities program -- CUGF.

Today, I will be giving you more details about this program, including DARPA's continuing efforts in CUGF ground sensors, our new challenges in airborne sensing, and other specific technical and mission challenges for which we need new ideas.
I am convinced that we can continue to vastly improve our nation's capability to not only detect underground facilities, but also to effectively characterize underground activities, localize vulnerabilities, and remotely and reliably assess post-strike damage.

DARPA CUGF activities to date have focused on Passive Acoustic, Seismic, and Electro-Magnetic Monitoring (PASEM) by ground sensors.
Through our PASEM science studies, DARPA has proven that signals from underground facilities can be exploited to provide key information regarding function and activity level.
We have continued our work in the PASEM area by developing, and soon demonstrating, a prototype ground sensor system for monitoring critical activities and determining vulnerabilities.

This UGF-specific ground sensor prototype will be demonstrated at surrogate underground facilities in two challenging environments later this year.
The design incorporates innovative PASEM sensors, and advanced algorithms and signal processing techniques to provide a networked array of nodes to monitor and characterize signatures.
For the demonstration system, all sensor and communication nodes are hand-emplaced and the system is not form-factored, but the high-performance sensors are limited by true environmental clutter, not sensor self-noise or wind.

We are also investigating promising concepts in the areas of robust geophone-coupling, extremely sensitive EM sensors and sensor noise treatments, large-baseline coherent signal processing, and non-line of sight communications -- some have even been integrated into the system design.
The results of this demonstration will be both specific technologies for transition, and analytical results.

The latter will provide detailed knowledge of the right balance to strike in the transition system among sensor performance, in-node signal processing, and inter-node and exfiltration communications.
We will know how to provide the greatest counter-UGF ground sensor bang for the buck, or kilogram, or cubic centimeter- or any other metric of your choice.

This current prototype CUGF ground sensor system is in the camp of "small N" systems, which use a small number of sophisticated high performance nodes.

We want to extend our program scope to include your conceptual and technical ideas for simpler micro-sensor concepts that may be easier to deploy, but will use larger node counts.

For both these cases, DARPA challenges you to address the key technical gaps in system deployment, communications, and node energy efficiency and storage.
We have specific interest in affordable and robust sensor node geolocation technologies, and efficient long-haul communications concepts.

Our PASEM work has told us how to design deployable, autonomous, and very high gain ground sensor systems.
It has also given us enough information on signal and noise characteristics to point the way to an airborne implementation- specifically on a small, low-altitude UAV.

As a result, we are taking the program to the next level with LAASS, the Low-Altitude Airborne Sensor System, which will introduce the ability to find underground facilities on tactical time scales.
The mobility and aperture of LAASS provide a capability very complementary to the ground sensors.
These characteristics will enable it to find unknown facilities upon entry into hostile territory.
It also provides the additional spatial degrees of freedom needed to "image" the layout and connectivity of facilities.

To do this, the initial challenge is to isolate or remove the platform airframe and propulsor vibration noise from the potential sensors, for example extremely sensitive EM, RF gradiometric, acoustic - and potentially even gravity sensors.
The goal is to allow for rapid wide-area search and imaging in both quiet rural and highly cluttered urban environments.

The second challenge is to find a way to use the output of these magically quieted sensors to solve the EM inversion problem for source parameters like the electrical components of the facility.
This is a non-trivial estimation problem, challenged by both signal to noise ratio and model-mismatch issues.
Can you think of a way to obtain a low-bias estimate of the physical centroid of a tunnel using a fairly simple, and observable, parametric model of its wiring components- when in actuality it is a hairy mess of equipment and tangled runs and drops????

The LAASS concepts are currently in the data collection and proof-of-principle phase.
Beginning next month, test flights using sensors in a quiet tow-body below a manned aircraft will be conducted.
Sensors will be flown over underground facilities in a rural, mountainous environment and over a controlled urban area in various power configurations.

Data will be collected at various altitudes on both high-performance and prototype vector and total-field magnetic sensors, along with E-field, acoustic, and airframe vibration data.

Concurrently, an Operational Evaluation Team will work with potential operators of the LAASS UAV Platform, and consumers of the LAASS output products, to determine if desired performance is feasible within acceptable UAV operational envelopes on missions of interest.
Presuming success in the proof-of-principle testing, a BAA will be released approximately 6-8 months from now.

Under the BAA, teams will be selected to develop integrated sensor payload and platform designs using an existing or modified UAV that can achieve the desired end-to-end system performance within operational constraints.
The teams will be required to show how they can achieve low-noise sensor outputs and provide detection and location of an underground facility's layout and vulnerabilities.
We will be distributing the tow-body sensor data to qualified bidders to use in their proposal preparation.
Your immediate input on specific unique measurement requirements for the ongoing data collection is welcomed.

In addition to PASEM and LAASS, DARPA is interested in exploring other CUGF-enabling sensor modalities and supporting subsystems for deployment, mobility, communications, and geolocation.
We want to expand from our current focus on finding active, occupied facilities using passive sensing means.
Imagine the advantages of being able to strategically and tactically detect and localize dormant underground facilities and buried WMD caches.

What if we knew whether urban buildings were interconnected underground?
What if we could use that information to stop free movement of critical leadership or re-supply of command and control facilities?
The same information could prevent the re-occupation of buildings cleared and secured by our advancing urban forces.
To this end, can you think of ways to use tracer gases or spatial and temporal correlation processing of passive signatures, such as barometric pressure or portal "breathing" to reveal underground interconnects between buildings or facilities? The sensing architecture is very open-local point sensors, stand-off ground-based, and remote sensing are all of interest.

Finally, we really need to address the classification problem.
Can we separate hospital from hostile bunker when both are on emergency power, or the shepherd's comfy cave vs. the terrorist hideout when both enjoy the BBC thanks to their Honda generator? For this, we will clearly require inter-comparison of multiple measurement types.
The question is where and how to put it in the sensor and analysis chain-recognizing that both exfiltration comms and the number of operators and analysts available to address the information are at a premium.
We invite you to come to talk to us about your technical ideas and approaches to these challenging problems.

Again, the threat posed by underground facilities is serious, and certainly a growing concern for national security.
Our adversaries continue to employ innovative counter-measures, and are making the CUGF challenge even more difficult by developing better technologies in underground construction.

The Special Projects Office at DARPA wants to develop the technologies to effectively assess, counter, and ultimately eliminate this threat.

Maj. Monte Turner and I look forward to talking with you about approaches and innovative ideas you might have to solve this difficult, and important, problem.

I thank you for your attention.