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Tailored Tactical Surveillance

At our last DARPATech, the Special Projects Office (SPO) discussed the need for persistent global and theater surveillance and how, by advancing the state of the art in radar aperture technology, we are enabling tactical engagement across a wide range of battlefield scenarios. SPO is well on the way to achieving these radar enhancing technologies through the Integrated Sensor is Structure (ISIS) and Innovative Space-Based Radar Antenna Technology (ISAT) programs.

The past few years have highlighted that the narrow streets and the endlessly moving parts of a city create a complexity that is a dramatically different sensing environment, urban warfare requires new sensor concepts and new technologies, all of which stem from innovative individuals like you.

Countering Mortars in Urban Terrain

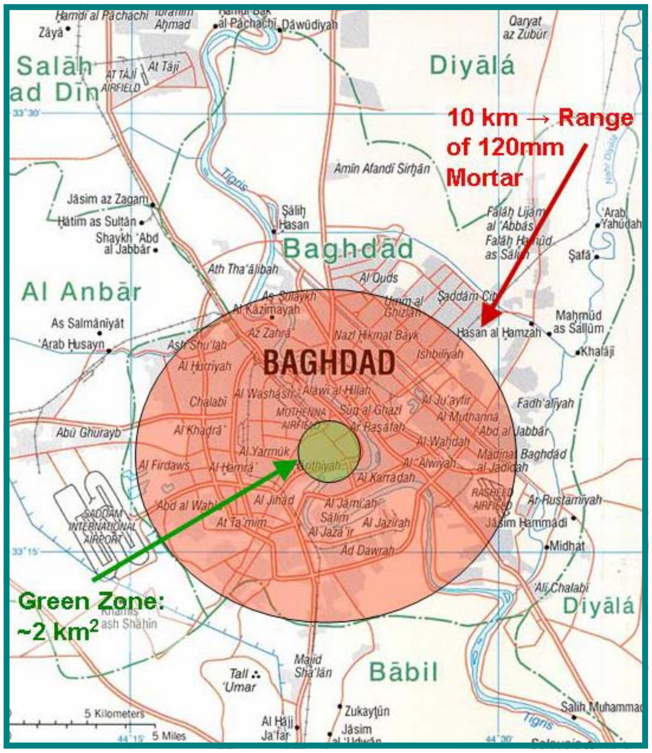
Emerging threats are not always next-generation weapons from the brightest technical minds an enemy has to offer. Increasingly, we are facing creative uses of old weapons in a new environment.

One example is the urban mortar problem. The Army's Firefinder Radar System provides an excellent point-defense for inbound mortars attacking semi-permanent US troop positions. On an urban terrain, the mortar has the advantage. The radar direct line of sight is muddled with buildings. These buildings and nearby movers create a thick haze of clutter for the Firefinder to sort through. Combined with limited viewing times, this clutter makes it extremely difficult to determine a mortar's launch position with enough certainty for safe and effective automatic counter fire. And, our enemies are fully aware of our reluctance to put noncombatants at risk.

SPO is looking to solve the urban mortar problem through innovative solutions, enabling continuous target visibility in urban environments. Mobile launchers are designed to "shoot and scoot." The only effective deterrent is an accurate counter fire response within seconds of the initial mortar volley. To enable an automatic counter fire system, the sensor system must determine the launch location within a meter and within the first 1-2 seconds after the attack.

To achieve this speed and accuracy, the sensor solution must start the mortar track at the earliest possible moment. Our initial studies indicate the mortar should be detected and under track before reaching 100 meters in altitude. This requires a good line of sight, well below 100 meters in every direction. While not a technical requirement, we need a solution that is affordable.

An area like the Green Zone, roughly 2 kilometers across, requires sensor coverage within a 10 kilometer radius. Two possible concepts come to



mind: a network of distributed, lightweight, low-power infrared sensors; and a light detection and ranging (LIDAR) system, slaved to a single 360° infrared sensor. Placed on the tops of buildings or other tall structures overlooking the defended area, either sensor approach could determine the mortar's trajectory accurately enough for a counter-fire solution. With precise impact locations, emergency services could be quickly dispatched. It's not the ultimate high ground, but rooftops and other tall structures are sufficient and save the logistics and expense of either air or space constellations.

We can increase the accuracy and speed of our response by increasing the number of samples while the target is at the lowest elevations. This means deploying a large number of inexpensive, but high quality sensors. Significant technologies are needed to make this concept a reality. For example, the sensors may be mounted on masts to achieve the optimal viewing angles. Because masts will sway and twist, system accuracy depends on knowing the sensor position and orientation. Propagating errors are a serious issue with any automatic response.

Another example is the detection of small IR signatures against the urban background clutter. Urban areas generate infrared clutter across all the spectral bands. This clutter competes with the mortar signature at the lowest altitudes, where detection and tracking are the most critical.

Other challenges include developing good resolution, wide-area staring sensors, and the tracking algorithms necessary for fixing a 1-meter launch position with 1 second of flight observation. This also needs to be cheap. As you can see, the technology needs for the counter-mortar mission in urban areas is a daunting challenge, and we are interested in hearing any sensor or system concepts that could solve this problem.

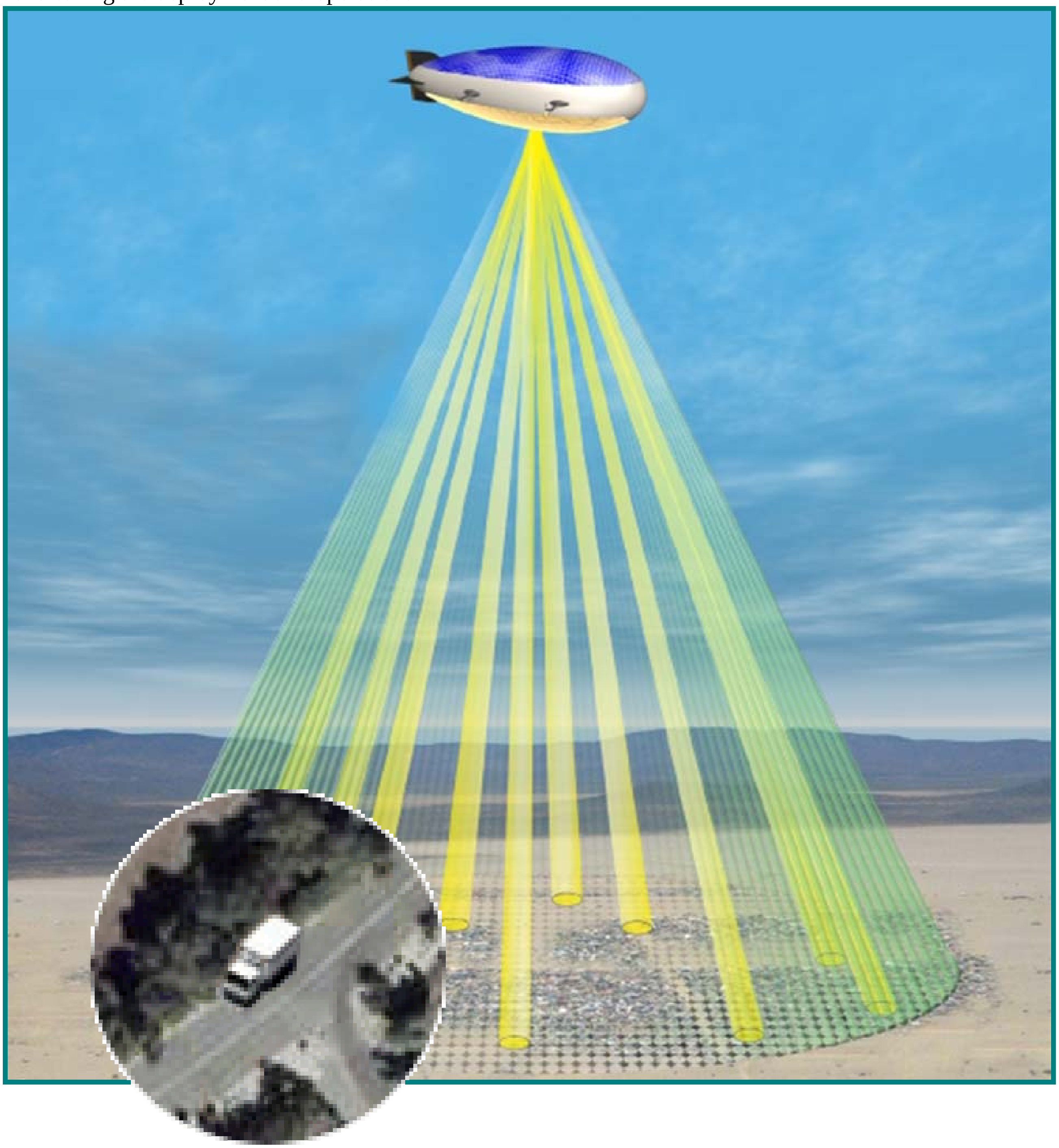
Responsive Near-Space

Not all urban targets are as accommodating as high-flying ballistic mortar rounds. A mortar's flight path is constrained by physics. Once the mortar pops up above the buildings, our ability to predict the mortar impact and launch locations is limited only by the sensor accuracy. The problem is much more challenging for targets operating at ground level.

Tactical tracking of urban ground targets requires nearly continuous direct line of sight between the sensor and target. Near-space provides that line of sight. Near-space is about 20 to 100 kilometers, or for the metric challenged, it's about 65,000 to 325,000 feet. Imagine a geostationary satellite parked 21 kilometers above the targeted area. The surface area directly in the sensor line of sight approaches that of a low Earth orbit satellite, but without Kepler's constraints.

In the last year, SPO's ISIS program began leveraging the characteristics of near-space to achieve persistent wide-area surveillance of air and ground targets using radar. This program is developing technologies to transform a stratospheric airship into a fully integrated radar system. The ISIS system is designed with over a year of on-station operational capability. Let me repeat, ISIS will operate *on-station* for at least 1 full year. To achieve this, ISIS focuses on developing and integrating component technologies, such as extremely lightweight regenerative power and radar electronics, into the airship structure. We are well on the way to reaching our goals.

We need to dramatically expand our thinking by shortening the deployment and operational timelines. Space assets bring a surge capability to the urban warfighter. Within hours, space systems can be retasked to focus on practically any global location. The level of persistence achieved depends on the number of satellites in the constellation, orbital parameters, and type of sensor. Today, we look to our existing space systems to ensure some level of latent surge capability, because we don't have a better solution.



SPO is looking for that better solution through responsive near-space systems. Specifically, SPO is exploring technologies allowing us to pack a persistent, station-keeping airship with a tactically meaningful sensor into the payload compartment of a missile. By achieving an extremely high compaction ratio, the persistent surveillance starts in hours versus days.

Let me set the picture. The US receives a warning that an attack on US assets abroad is imminent. A nearby carrier group launches two responsive near-space assets aboard modified standard missiles.

The first launch contains a signals intelligence system and a high-speed communications node. The second launch contains an electro-optic and infrared sensor suite specifically designed for tracking and identifying vehicles in urban terrain. As the missiles reach their release altitude, the payloads are decelerated to a precise location and speed conducive to inflation. The near-space platforms are inflated, and the payloads are unfurled. For sensitivity and wide frequency coverage, the signals intelligence system consists of an extremely large reflector antenna and a compact steerable feed array. The “origami-ed” optical payload is deployed and calibrated. The onboard power system unfolds during the deployment, and the station-keeping propulsion system is engaged. The whole process takes less than 2 hours and the deployed systems will provide persistent support to the inbound warfighters for 30 days.

This scenario describes the three core technical issues facing responsive near-space. The first is placing the sensor in near-space without destroying the near-space platform. Whether launched from a missile, carried by a hypersonic vehicle, or dropped from a low Earth orbiting satellite, a responsive near-space platform needs to decelerate from a significant velocity to near zero, and safely inflate at the proper altitude.

The second issue is achieving lightweight, high-compaction ratio sensor systems. The platform and sensor must collapse into a very small missile payload space, and then expand into a tactically useful payload. Finally, to achieve persistence in near-space, the platform must have a station-keeping capability. This requires power generation and propulsion systems, which must also fit into the same payload bay and deploy on station. SPO is funding an SBIR study of high-density, lightweight solar regenerative power systems. This is a good first step to understanding the possibilities, but there is much more to do. SPO is looking to fund the technical ideas that will make responsive near-space a reality.

In the earlier scenario, an electro-optic and infrared sensor suite specifically designed for tracking and identifying targets in urban terrain was described. This is a shift in philosophy from how we perform moving target detection and tracking today. Existing moving target sensors, such as the JSTARS and Global Hawk, use radar to detect a moving target’s velocity. At steeper depression angles, target velocity projected to the sensor is multiplied by the cosine of the depression angle. To achieve persistent surveillance in urban areas, the traditional sensor must operate predominantly at high depression angles, leaving the radar very little target signature to detect. But radar isn’t the only option. SPO is currently accepting proposals for one such option we call Large-Area Coverage Optical Search (LACOSTE).

LACOSTE

The objective of LACOSTE is detecting, tracking, and identifying moving targets across a large urban area. Electro-optic (EO) and infrared (IR) phenomenology, is well-suited to this problem. EO/IR works well at high-depression angles, doesn’t have multipath issues, and can resolve the target for identification.

However, current EO/IR systems aren’t capable of wide-area, high-update rate target searches, high-revisit target tracking, and target identification. The large optic required for target resolution is too big and bulky for high-speed, noncontiguous area search-while-track. Likewise, the small optic capable of extremely fast slewing isn't able to resolve targets for identification. The solution is a new breed of optical sensors capable of electronically steering within microseconds a narrow field of view anywhere inside a 90° cone angle. This optical sensor must also be capable of resolving moving targets for identification while operating in near-space.

SPO will be releasing a broad agency announcement (BAA) through the Air Force Research Labs Sensors Directorate in the near future. The BAA will contain a specific list of system performance parameters for solving the urban moving target detection, tracking, and identification problem from near-space. If you have concepts for solving this problem, please consider submitting a proposal.

In closing, let me stress again that there is significant DARPA-hard work to achieving tactical surveillance in urban environments. Specifically, we are looking to fund bright ideas in three areas:

- Counter-mortars concepts providing low-altitude target sensing for a fast and accurate threat geolocation
- Quickly deployable, responsive near-space system concepts addressing placement in near-space and high-efficiency subsystems with high-compaction ratios for launch
- Development of wide-area urban detection, tracking, and identification of moving targets using advanced EO/IR sensor concepts