CCAT First Responders Testing Scenario: Jan 2011

{OPENING INTRO}

CCAT, the Center for the Commercialization of Advanced Technology, with funding from the Department of Defense Domestic Preparedness Support Initiative, identifies innovative and mature technologies developed through DoD funding and promotes the advancement, commercialization, and transition of projects that can result in first responder capability improvements.

The ability to locate firefighters lost or trapped in a burning structure, where GPS is typically not available, would address one of the most important problems in firefighter's safety. Recent advances in sophisticated motion sensors have encouraged numerous companies and agencies to develop position-tracking systems for these types of GPS denied environments. The sensors are called Inertial Measurement Units, or IMUs.

CCAT and DoD's Domestic Preparedness Support Initiative have been investing in the development of several such systems for the past 3 years. They recently tested the University of Michigan's Personal Dead Reckoning system, or PDR. Working with the 1st responder community in the San Diego region, a series of demonstrations were conducted simulating real emergency scenarios and the kind of complex movements and gaits typical of firefighters working in these conditions. The tests were conducted at a downtown 25 story condominium complex, a suburban, horizontal-high rise community, and a rural, high-risk wildfire area.

The University of Michigan's PDR system consist of a heel-mounted IMU in a firefighter boot which tracks the foot's acceleration. It sends this information by wire to a small computer worn by the firefighter which converts the raw data into changes in the firefighter's position. The position information is communicated by radio to a base station running custom software which displays the information to the incident commander. In a finished system, the computer will be substantially smaller and lighter and the radio will be integrated with the firefighter's communications system.

The incident commander's software displays the position information superimposed on a floor plan, or if floor plans are not available, on an external outline of the building derived from satellite imagery. The software consists of complex algorithms which take advantage of unique characteristics of human motion. They also make use of the fact that most buildings have hallways that are parallel or at right angles to each other. The equipment is initialized before beginning an operation, a process which currently takes about 30 seconds but which the developer hopes to reduce to under 10 seconds.

{EXERCISE 1}

The first exercise location was the 25-story Vantage Point Condominium Complex and was conducted by the San Diego Fire Department. The scenario consists of a firefighter leaving the staging area, walking outside to the building entrance, proceeding by stairs to the 9th floor and crawling into the corner of an office. A search and rescue team is then tasked with locating that firefighter, using only information provided by PDR on both the first firefighter's location and their own path through the burning building.

In this segment we can see that as the firefighter climbs 9 floors of an enclosed staircase - an extremely challenging test for any IMU based system - the position is accurate to within 1.5 meters up the entire staircase. The rescue team was able to locate the firefighter and the system maintained an accuracy of better than 3 meters for the entire mission.

Additional testing included trials around the outside perimeter of the complex and in the underground parking structure. The PDR system continued to perform with a better than 3 meter accuracy.

{EXERCISE 2}
The second exercise was at the La Vida Real retirement community, a structure considered a horizontal high-rise, and conducted by crews from the San Miguel Consolidated Fire Protection District. As was the case at the downtown high-rise, the scenario has one firefighter taking a long and winding path until he becomes incapacitated, followed by a search and rescue team sent in to locate him, guided only by position information provided by the PDR system and communicated from the base commander viewing the display at his base station.

In this test the system was challenged by a building which had numerous turns that were not 90 degrees, and open or circular walkways, and by an even wider variety of firefighter movements including, amongst others, running, crawling backwards, moving furniture, dragging victims, and belly crawling.

On this display the incident commander sees the track of the original firefighter in red, and views in real-time the path of the search and rescue team in blue, and directs them to the incapacitated first firefighter. As in the high-rise scenario, the rescue team was able to locate the downed firefighter within less than 3 meters.

{EXERCISE 3}
The final exercise was a Wildfire scenario coordinated near the Cuyamaca fire station by CALFIRE firefighters. The circumstances for this outdoor scenario differed from earlier tests in that it is generally not a GPS denied environment.

The exercise involved a team of firefighters who first hiked to the highest point of a forest trail, then performed a hose lay at the base of the trail. The teams demonstrated many physical movements involved in a wildfire situation including deployment of an emergency fire protection shelter. All activity is again monitored from a nearby mobile base station. The Michigan system was tested without GPS to test accuracy using only accelerometers and magnetometers. While it performed well, it drifted farther than a GPS-only system that was tested at the same time.

{CONCLUSION}
Numerous programs - government and private, military and civilian - have devoted significant resources to the problem of personnel location in a GPS denied environment.

In two challenging scenarios and through a wide variety of realistic and challenging fire fighter movements and activities the system demonstrated better than 3 meter accuracy in an indoor, GPS-denied environment, regardless of mission length and duration.

In the outdoor wildfire scenario, where GPS is generally available, PDR performed better than any known GPS denied system, yet it was not as accurate as GPS on the kinds of long excursions typical of wildfire crews. CCAT also tested a GPS system with Cal Fire and it was their conclusion that modern GPS systems would provide most of the functionality they require and therefore the added cost and complexity of an IMU based system was not likely to be worth the effort in an outdoor wildfire environment.

For fighting fires indoors, PDR solves the critical problem of firefighter location. However, it is not yet in a form that is ready to be used by firefighters. One challenge is the requirement that the IMU be on the firefighter's boot. While sensors have improved significantly, they still accumulate errors, referred to as drift. By mounting the sensor in the boot, the University of Michigan's PDR system takes advantage of the fact that with each step the foot is momentarily stationary on the ground, and during this moment the system's sophisticated software is able to correct for most of the drift. While this is key to the system’s high degree of accuracy, it requires that the IMU be integrated in the firefighter boot and able to withstand heat, water and other environmental insults. Second, the IMU must communicate to a computer pack, which necessitates either a wire running up the pants leg or a radio system such as Bluetooth. Bluetooth would require its own battery, which would need to be kept charged. The system will also need to be merged with the firefighter's

radio. Finally, the 30 second initialization procedure needs to be shortened to about 10 seconds.

In summary, the University of Michigan's PDR has matured to the point where it solves the GPS denied location problem, and it now needs to be licensed to a system integrator who can implement the changes necessary to convert PDR into a commercial product that can be offered to the firefighting community.