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WBS# 24.1.3.2 – Project Title: **GPS-Free Navigation in Buildings**

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Summary Statement of Work This is an evaluation of candidate navigation solutions for GPS free inspection tools that can be used in tours of large building interiors. In principle, COTS portable inertial motion unit (IMU) sensors with satisfactory accuracy, SWAP (size, weight, power), low error, and bias drift can provide sufficiently accurate dead reckoning navigation in a large building in the absence of GPS. To explore this assumption, the capabilities of representative IMU navigation sensors to meet these requirements will be evaluated, starting with a market survey, and then carrying out a basic analysis of these sensors using LLNL's navigation codes.

Major Highlights: We started our analysis of potential COTS navigation sensors with a teleconference that covered the IAEA needs for a more accurate non-GPS sensor. We will soon have data on the performance of their current sensors that will inform our trade study.

Progress (by task)

Task 1 – Conduct Market Survey

Kicking off the project, we held a valuable teleconference on December 13, 2017 with the IAEA and DOE principals on the IAEA inspection needs for GPS-free interior building navigation. The participants included Dimitri Finker and Andrey Sokolov from the IAEA, Dan Decman, Steve Libby, and Dave Chambers from LLNL, Josh Tackentien from the US Mission, and Arden Dougan and Barbara Hoffheins of DOE/NA-241.

The IAEA leads outlined their needs for an accurate, non-GPS sensor system worn by inspectors that give a time stamped position history of the inspection. The current gyro/accelerometer 'dead-reckoning' system, as described, is apparently unsatisfactory in that it has significant drift after as little as 20 min. (particularly on its data on the direction of motion) that can't be adequately compensated for by their current navigation code/routine. Based on our recent analogous experience evaluating and improving atom interferometer sensors vis a vis ground corrected GPS we (the LLNL team) asked about which types of trajectories were most problematic (e.g. large, slow turning loops vs. abrupt back and forth motion), the extent to which their navigation solution made use of intermediate 'way point' information, and general knowledge of the building/facility layout.

Other sensor issues we will likely have to address included contamination, electronic noise, and the optimal way for the inspectors to wear the sensor (e.g. shoe, ankle or waist belt).

The IAEA scientists offered to share specifics on their navigation routine and its performance on explicit trajectories.

Action items going forward include: 1 – IAEA will send us data on their IMU (gyro/accelerometer), and navigation code, and its performance on varying tracks, and 2 – a January 2018 follow up web discussion on their sensor's current performance.

Having begun with this information, we are better prepared as we do our market survey of possible COTS solutions with varying 'SWAP' and also writing code with an improved navigation algorithm.

Publications: None

Issues: None

Project Performance:

- **Change Management:** None – the project is on track.
- **Budget Performance:** The current budget remains adequate for our trade study.
- **Schedule Performance:** Our project is on schedule. Assuming we receive the relevant data from IAEA, we should be able to complete the sensor trade study by the end of the second quarter of 2018.
- **Milestone and Deliverable Performance:** We met our main goal of connecting with the IAEA navigation sensor principals and have now begun the trade study.
- **Disposition and Transfer:** We don't anticipate a hardware transfer. This project is focused on producing a trade study of potential high accuracy 'dead reckoning' navigation sensors.

Carryover: None- this is a FY '18 project.