**Company:** L3 Technologies

**Product:** Multi-Robot SLAM System for Navigating Ships (Work in Progress)

**Description:** With the growth of the internet of things, networks of robots have increasing potential to simultaneously complete and share information on a single overall task. This potential product will utilize a multi-robot system to map select areas of a ship with limited need for human resources. The system will be able to accurately map an environment using multiple robots, merge these various maps to a single consistent map, and locate items of interest within the environment to be noted on the map.

**Issues/Improvements/Needs:** Eventually it is desirable to have robots that can navigate the entire ship and enter over room thresholds. Currently, humans must survey ships. For a cargo hold navigating robot, it needs to be able to create a full 2D map of the environment. Also, it should be able to identify suspicious objects and notify a human operator of its nature and location making intelligent decisions based on machine learning. In addition, it would be nice if the human operator could override autonomous navigation and manually either operate the robot or setup points of interest for the robot to explore.

**Company:** General Electric

**Product:** FAST Platform

**Description:** This product is used to inspect tanks and pipes, typically in an oil and gas setting. It is compact to allow access to areas normally inaccessible to humans. The product also weighs approximately 30lbs. It uses some variety of scanning equipment to inspect and map the environment.

**Issues/Improvements/Needs:** This device is very specific to the oil and gas industry and cannot be used for both inspection and surveillance. In addition, the devices cannot work in a multi-robot system to reduce inspection time, and are approximately 30lbs each, making transporting multiple robots difficult.

**Company:** Pure Technologies

**Product:** Robotic Pipeline Inspection

**Description:** This product is capable of performing multi-sensor inspections in dewatered pipe or while submerged. It can travel a total of 1.8 miles from a single access point. This product is tethered by a high-strength, fiber cable and is completely open ended. The robot can be equipped with any tool or sensor necessary to carry out an inspection. Some tools used on these robots include: CCTV, SONAR, 3D LIDAR, electromagnetic sensors, and Inertial Measurement Units.

**Issues/Improvements/Needs:** These systems are designed specifically for pipelines where being either partially or fully submerged in water is likely. These robot systems do not work together, instead one is sent into the pipe to map the entirety of the pipe by itself. Additionally, the robots are quite large which would not be conducive to mapping a ship cargo hold where space is extremely limited.

**Company:** KnightScope

**Product:** K5

**Description:** The K5 monitors its surrounds with a variety of sensors (including video and thermal cameras) and using a proprietary filtering system determines anomalies and notifies relevant authorities about them. It also knows to return to a charging station automatically and has multiple defenses against vandals and minor disturbances.

**Issues/Improvements/Needs:** it only follows pre determined routes and isn't capable of mapping. Also its sensors occasionally malfunction leading to it taking nonoptimal routes and making improper choices.

**Company:** Amazon

**Product:** Inventory Robot

**Description:** 30,000+ robots working alongside 230,000 people. Amazon acquired Kiva Systems in 2012 (a robotics company). These robots work in warehouses to automate the picking and packing processes. The robots are 16 inches tall and around 145 kilograms. They run at about 5 mph and can move packages with a maximum weight of 317 kilograms. In addition to the Kiva robots, Amazon also uses robotic arms to move larger amount of inventory including large pallets. Amazon has also explored delivering packages using drones.

**Issues/Improvements/Needs:** Doesn’t appear that they communicate with each other. This could enable the company to take out another layer of needed human interaction if instructions could be given to one robot and communicated to other robots.

**Company:** Target/Simbe Robotics/Techstars(?)

**Product:** Talley-the autonomous robot by Simbe Robotics

**Description:** Robots are being tested at Target, a location in San Francisco, to stock shelves and monitor inventory. Talley, the robot created by Simbe Robotics (startup) is an autonomous robot that can move around and scan barcodes. This enables the robot to find misplaced items or low stock products.

**Issues/Improvements/Needs:** The robot is tall and skinny which could lead to being tipped over by a customer. This shape could be more effective and increase the speed of the robot.

\*\*Other companies with robots: Orchard Supply Hardware (subsidiary of Lowe’s in San Jose) & Best Buy in NYC

**Company:** Stevens Institute of Technology - Research

**Product:** LA3DM

**Description:** This library helps expand the reach of mapping software as it allows for extrapolation of data in a 3d mapping software such as octomap. By utilizing a moving platform with a 3D depth camera a robot can quickly scan its surroundings and identify the overall shape of objects around it, then utilizing different mathematical processes fill in any missing data points to allow a fuller, more accurate map.

**Issues/Improvements/Needs:** The work being done is still very much in the experimental stage, undergoing field tests. It is also not in a position to be commercialized, as it is currently an extension to free software and available without charge. It would need to be developed into a proprietary system and greatly expand the scope of work to include a hardware package and better gui support. As of right now there is a steep learning curve with regards to setting up the system, requiring a linux OS which removes a great many potential customers who would be using windows or Macintosh systems.

**Company:** Google

**Product:** Waymo

**Description:** Waymo is a self-driving car that was designed with the intention of developing safer roadways and increasing accessibility of transportation to everyone. The vehicle uses LiDAR to detect surroundings and map the environment. In addition, several cameras at various points on the vehicle allow for 360 degree vision to be interpreted by the vehicle computer.

**Issues/Improvements/Needs:** Waymo is designed for transportation alone and cannot be used for navigating small areas within ships. However, the technology that Waymo uses can be used as a basis for designing such a device. In addition to using LiDAR, cameras can be used, paired with image processing, to create more useful maps of the environment as well as to make better decisions while navigating.

**Company:** STRAHL LLC

**Product:** GECKO 9050 Pipe Inspection Robot

**Description:** This product was developed in order to navigate and inspect longer pipes with multiple bends and other obstacles. The system has a base unit with a large color display and control buttons, including a full keyboard for making notes or naming captured files and a sun shield. The product also includes an SD memory where files can be saved and stored which improves the data portability. The product includes a self-leveling pan as well as a tilt camera and a Kevlar water and acid proof cable.

**Issues/Improvements/Needs:** This product is designed specifically for pipe inspection and does not include a LiDAR system or similar mapping sensor. This would reduce the ability of the product to be able to detect objects of interest. While the product is able to navigate difficult channels, it cannot send information back to a remote user. Additionally, there is no depth camera reducing the information that someone can store.