# L-CAS: Local-Frame Collision Avoidance System for Non-Line of Sight Autonomous Systems

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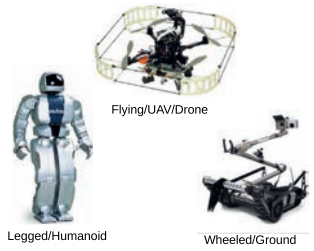
## High Level Vision

***Portable System for Formation Keeping and Increased Situational Awareness for Heterogeneous Non-Line of Sight Autonomous Systems***

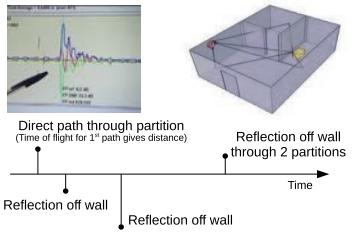
Solving the problem of not knowing where/what your co-robot is doing




Mounting Points for Various Robot Types

- Ultra-Wideband (IEEE802.15.4-2011)
- Two way ranging
- 5 hz position update rate (with 5 active robots)
- 20 m (~65 ft) Radius Localization range
- 20cm precision (indoor)
- 5 m/s (~11 MPH) Max Relative Velocity
- 200 g weight (less then the Pelican UAV max payload)
- Platform Independent (Socket/Ethernet Interface)

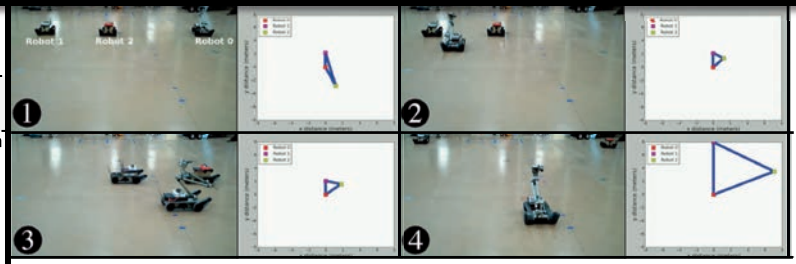
Ultra Wideband allows us to Distinguish between all the different paths between each Robot





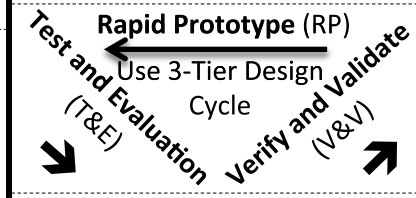
**L-CAS (βeta-2) with 9 axis Inertial Measurement Unit**


## Technical Approach and Risks

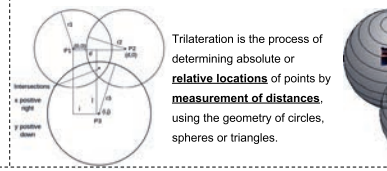



Video Link: http://lofarolabs.com/projects/lcas/

**Proof of Concept:** L-CAS local-frame localization test performed at the Laboratory for Autonomous Systems Research - NRL in Washington DC. Three iRobot PackBots were driven by human drivers in formation. Left shows external video feed of Robot 0, 1, and 2; Right shows the local-frame formation in reference to Robot 0. The frames are ordered left to right, top to bottom.

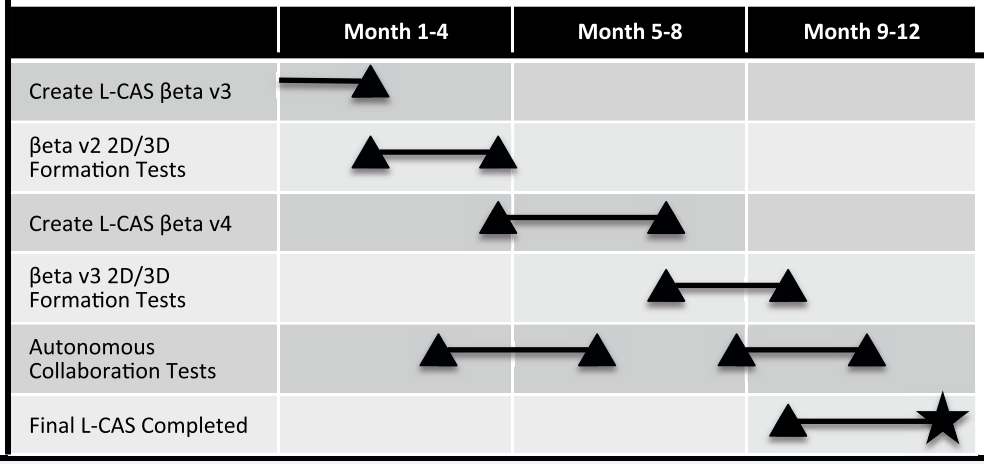



Localization using 2D and 3D Trilateration



Trilateration is the process of determining absolute or **relative locations** of points by **measurement of distances**, using the geometry of circles, spheres or triangles.

**Risks:** The primary risks are **1)** *achieving low formation update rate* and **2)** *unable to achieve relative orientation*. **Risk 1 is mitigated** by using multiple ranging sensors on different bands. **Risk 2 is mitigated** by adding inertial sensing units, as well as predictive controllers to the L-CAS unit's firmware. Overall idea is shown to work via the "Proof of Concept" work done by the Performer with the Naval Research Lab – LASR in 2015.




## Project Impact and Potential Application

L-CAS is a local-frame localization system that allows for **increased situational awareness** in homogeneous and heterogeneous mixtures of autonomous systems and humans. Each autonomous agent (robot and/or human) can carry an L-CAS unit. The relative distance between each L-CAS unit is determined using a multi-path resistant radio frequency ranging system. These distances are then shared between all L-CAS units. The relative formation of the group is determined by the using the distance from each L-CAS and implementing two and/or three-dimensional trilateration. Trilateration results in the location of each L-CAS unit in the local frame. The multi-path resistant nature of the ranging system means that this system can be **used in non-line-of-sight** circumstances (e.g. separated by walls, trees, etc.) while retaining formation information. This information increases situational awareness of all autonomous units.

**Applications:** Autonomous Formation Keeping for swarm and collaborative robots • Autonomous Collision Avoidance • Collaborative SLAM Map Building • Increase Situational Awareness for robot-robot, human-robot, and robot-robot teams • GPS Coverage Expansion • Autonomous Teaming • Multi-Agent Systems

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