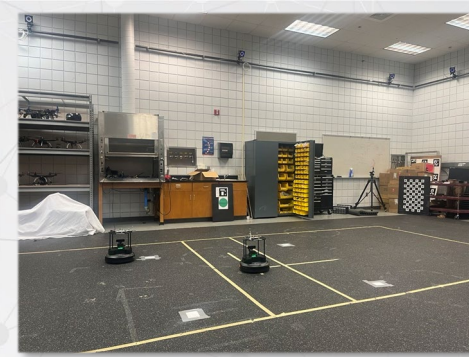


C1Cs Alexander Pasqualina & Alison Peckham; C2Cs Caleb Craddock, Sneha Laxminarayan, & Katelyn Winkleblech

AI-Informed Collaborative Navigation for GPS-Denied Environments

AFRL Munitions Directorate & University of Florida Autonomous Vehicles Laboratory

USAFA Department of Mechanical Engineering



INTRODUCTION / BACKGROUND

How will collaborative combat aircraft (CCAs) operate in GPS-denied environments?

- 1. MagNav:** Determine global position and orientation with only a magnetometer
- 2. Lead/Follow:** Determine relative position and orientation between two vehicles
- 3. NLGNC:** Enable natural-language communication for guidance, navigation, and control (GNC) of autonomous systems

PROCESS / METHODS

Week 1 – Intro: Learned Robot Operating System 2 (ROS2) via online tutorials and application demos provided by our sponsors; introduced to C++

Week 2 – Planning: Determined deliverables and started projects; split into package teams:

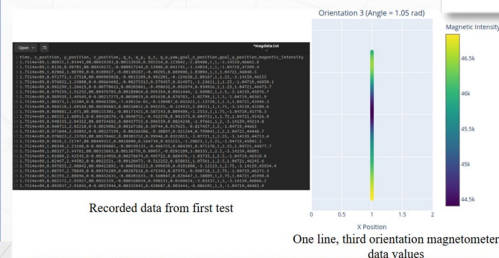
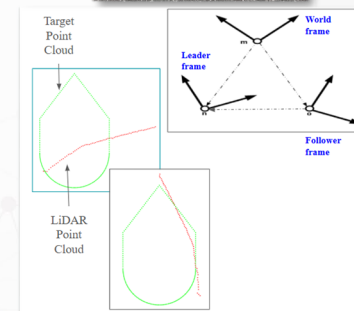
Alex & Alison, **MagNav**; Sneha & Katelyn, **Lead/follow**; Caleb, **NLGNC**

Week 3-4 – Coding: Implemented ROS2, converted from ROS1 -> ROS2, integrated AI, tested & debugged code

Week 5-6 – Application: Integrated hardware (magnetometer, relays, LiDAR, cameras, etc.); collected and analyzed data; debugged further; crafted visualizations; showcased final demos to the sponsor, Dr. Kevin Brink—AFRL lead at Eglin, AFB

DEMOS / ACCOMPLISHMENTS

- **MagNav Demo:** Turtlebot4 collects a map of magnetometer readings for 24 different orientations in an area of known coordinates with microcontroller and relay switches onboard to simulate magnetic interference.
- **Lead/follow Demo:** The leader bot navigates to known coordinates while the follower bot orients itself to the leader using Light Detection and Ranging (LiDAR) analysis.
- **NLGNC Demo:** In a room full of obstacles, we demonstrated human-like and intent-based GNC of a Turtlebot4 through a vision-language model (VLM). The user gave commands/intent (ChatGPT prompts) with their voice, and the robot interpreted, responded, and acted using an overhead camera, on-board speaker, and ROS2 programming architecture.



FUTURE PLANS

- Our research was accepted for presentation into the IEEE Aerospace Conference—one of the world’s most prestigious gatherings of scientists, engineers, and innovators.
- Research will continue via 499 at USAFA as we integrate machine learning into the **MagNav** package to filter magnetic interference from the relays, enhance the **Lead/Follow** package to perform on-board vectoring, and update the architecture of the **NLGNC** package to better align with modern AI agent system practices.
- Practical testing will continue through our mentors at the lab, providing us real-world data to train and refine our processes from.

CONCLUSION

- Robust navigation in GPS-denied environments is a key focus across the Joint Force.
- Magnetometer-based positioning methods offer reliable, jam-resistant navigation for aircraft.
- Leader/follower frameworks enable autonomous systems to combine various sensor data to effectively navigate around obstacles and terrain.
- AI-powered interfaces deliver intuitive command and control for operators to integrate autonomous systems into their battle rhythms.

