UCF
COMPUTER SCIENCE

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Project ARES

An Autonomous Drone System

Group L06

Impact a better future

(Aerial Reconnaissance Exploration System)

Meet The Team

Rayyan Jamil

Project Manager

Agentic AI

Hardware Integration

Modeling & Simulation

Abraham Ng

Logistics and Administration

React Dashboard

Agentic AI

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Hardware Integration

React Dashboard

Modeling & Simulation

Connor Hallman

Modeling & Simulation

Agentic AI

React Dashboard

Meet The Sponsor

Points of Contact

- **Christopher Griffith**
  - Scrum Coordinator
  - Weekly Agile Meetings
- **Madalyn Braganca**
  - Project Manager
  - Coordinator between UCF & Serco

Project Specifications & Requirements

Software Components

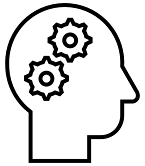
- ✓ **React Dashboard** – provides a central interface for mission planning, status visualization, and human-in-the-loop oversight with real-time data updates
- ✓ **Agentic AI** – implements a robust agent with access to tools that can effect change in the real world
- ✓ **Localized Large Language Models** – provides offline access and data security for queries and commands

System Requirements

- ✓ **Human-in-the-loop**– enables mission planning, live monitoring, and natural-language instruction parsing
- ✓ **Distinct drone agent** –operating independently and sharing data for missions
- ✓ **Real-time data integration** – ingest camera, GPS, and other sensor data for mission planning

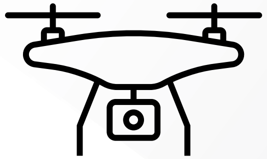
Can drones understand and carry out everyday conversational instructions without needing constant supervision or technical operators?

The Problem



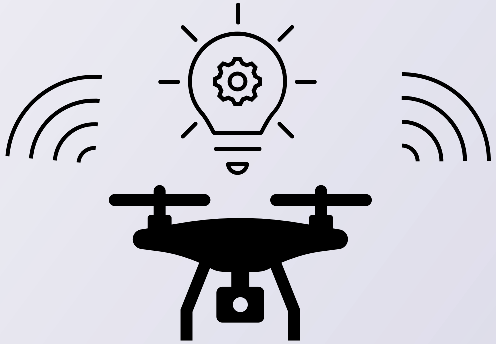
Drones currently...

- Require technical experience
- Support only basic commands
- Perform pre-written missions
- Incur high operational costs



What if we could...

- Translate from high-level commands automatically
- Enable drones to perceive and understand their environment
- Allow drones to adapt to changing conditions
- Equip drones with tools to execute complex missions independently



The Solution

Our agentic AI drone system...

- Operates without technical expertise
- Accepts commands in everyday English
- Is equipped with tools to execute tasks
- Incorporates a centralized dashboard
- Allows for manual control if needed

With our system, businesses can...

- Expand the range of drone applications, such as...
  - Performing agricultural tasks such as planting seeds, monitoring crop health, and applying fertilizer
  - Conducting construction inspections for leaks, roof damage, and structural issues
- Reduce operational costs when deploying drones at scale

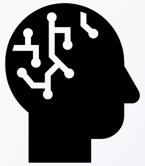
Agentic AI

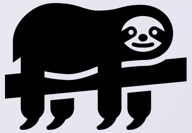
Agentic AI is artificial intelligence acting as an **agent** with independence and autonomy.

Our implementation features a LangGraph framework that...

1. Interprets human prompts into objectives
2. Makes decisions on how to pursue them
3. Takes actions that interact with physical environments
4. Adapts and reacts to changing conditions

Agentic	Non-agentic
Acts autonomously toward goals	Requires constant, predefined inputs
Interacts with its environment via tools	Limited to specific outputs





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Design Considerations

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Design Approach

On-Drone Processing

- ZED 2i stereo camera captures RGB-D data in real time.
- Jetson Nano on the drone runs ROS2 nodes to pre-process depth and image streams.

Ground Station Processing

- Processed data is transmitted to the ground control station.
- Additional computation is performed for AI inference and visualization preparation.

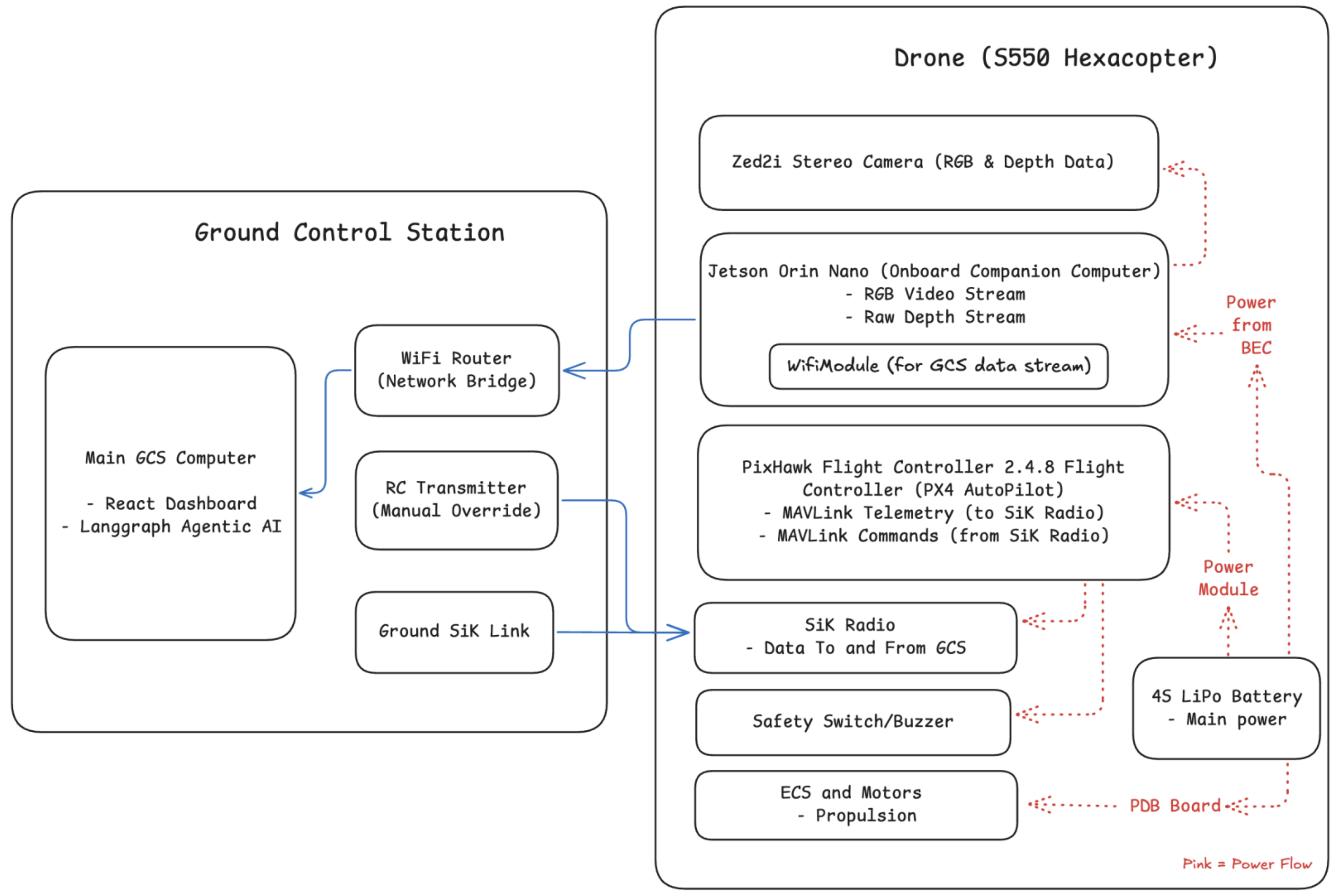
Visualization & Dashboard

- Data is sent to a React-based dashboard for live 3D rendering and video streaming.
- Operators can monitor the environment, visualize the digital twin, and make decisions in real time.

System Architecture

We decided to divide our system architecture into two key subsystems:

- The S550 Hexacopter
- The Ground Control Station



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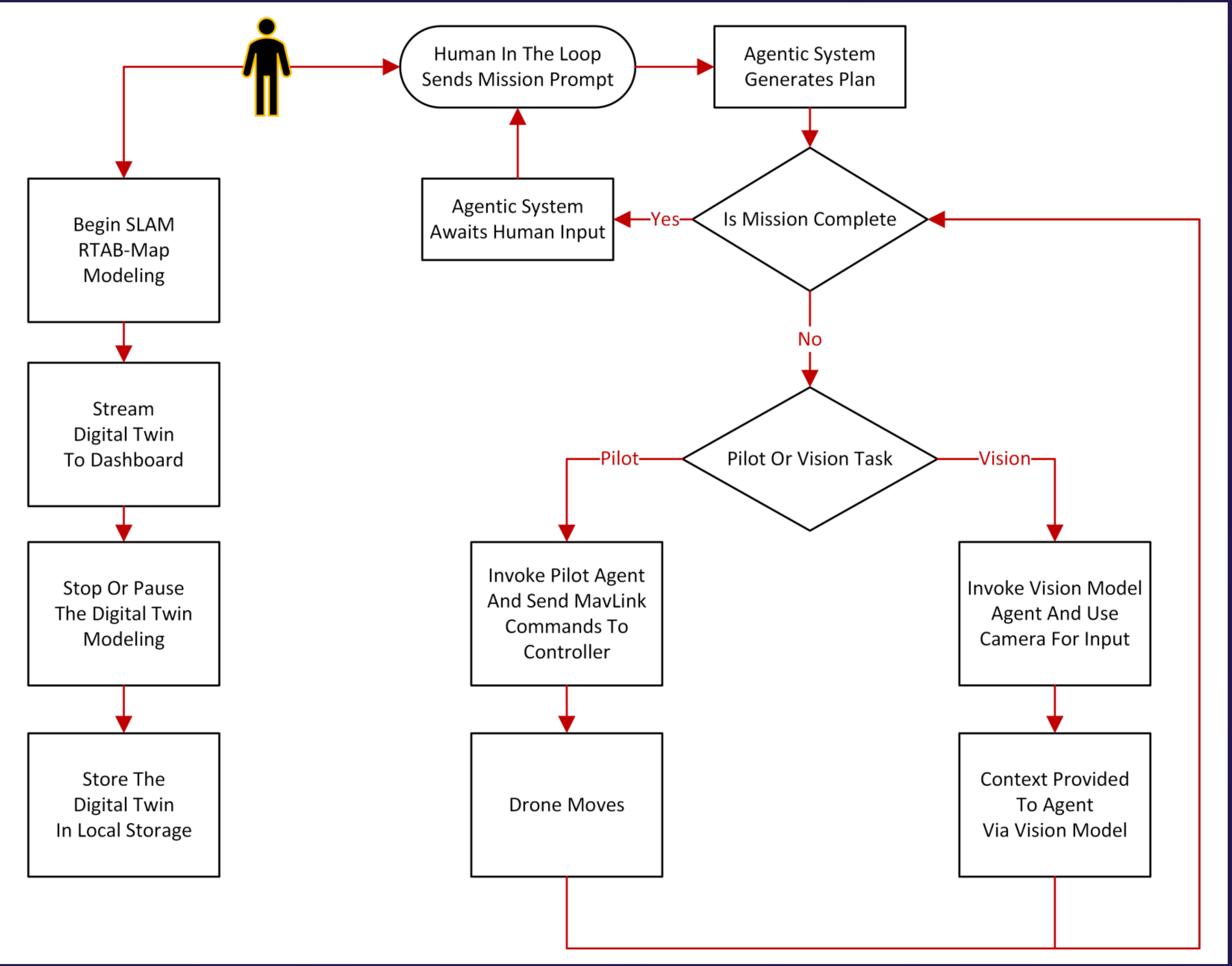


Event Diagram

- Users kick off the system with a single mission prompt.
- Digital twin construction can run simultaneously and in parallel with drone movement.

Significant Design & Component Decisions

Drone Kit Swap

- Switched from the Holybro X500 kit to the S550 kit

NIM Microservice to Ollama Server

- Ollama server more computationally efficient and already set up for prototyping

Hardware Upgrade

- Replaced Raspberry Pi with Jetson Orin Nano for real-time depth perception capabilities and enhanced processing power

Network Implementation

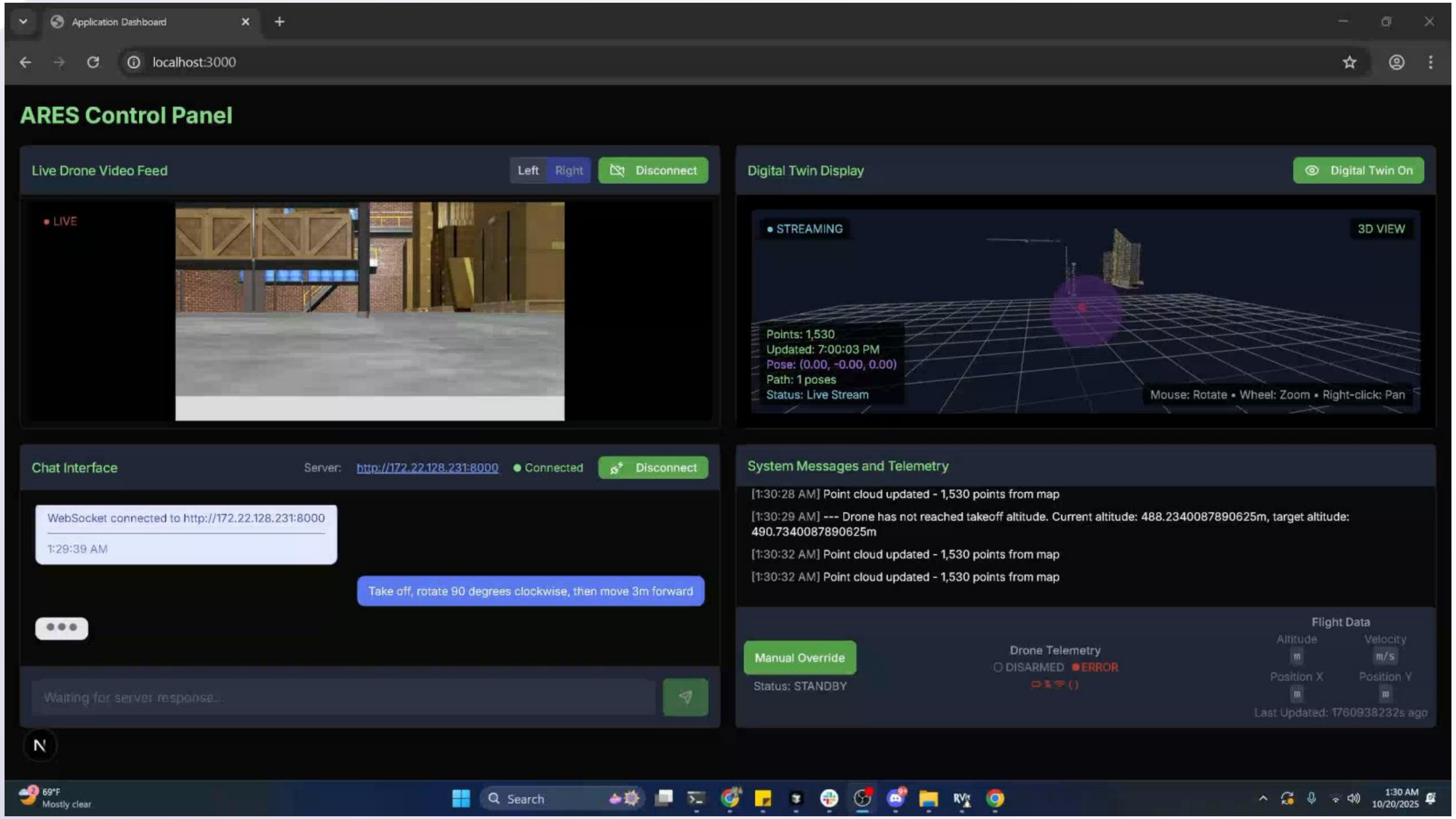
- Router and extender increased the potential connectivity range between the Jetson and the ground control station

Hardware and Software Details

Dashboard Components

React-based Dashboard built using **Next.js** with a four-quadrant layout featuring:

- Live Drone Feed
- Digital Twin Display
- Agentic AI Chat Interface
- System Messages and Telemetry



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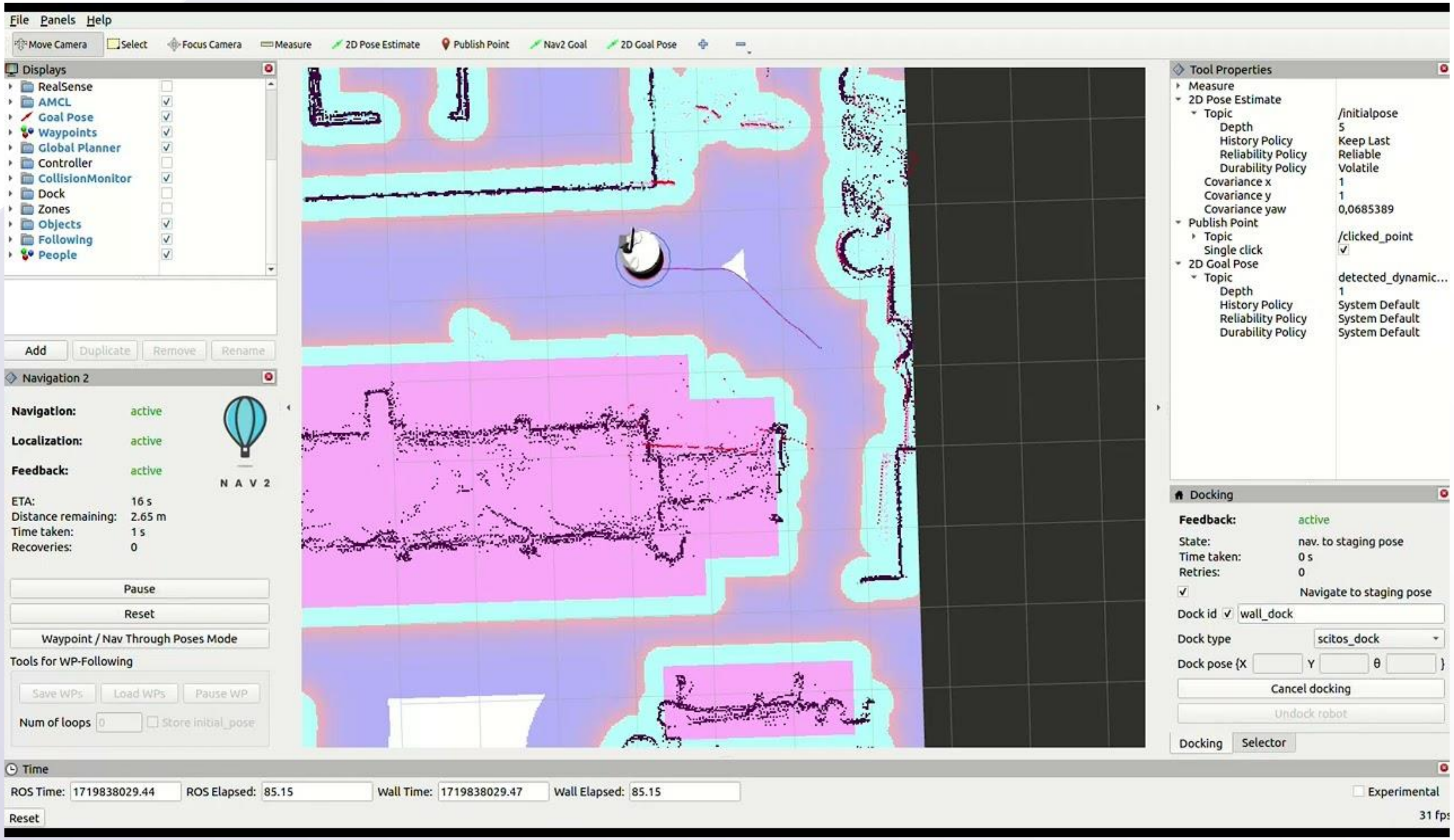
Navigation

Nav2 generates **Costmaps** which indicates how safe or dangerous a region is to travel through

- Pink regions are lethal
- Gray regions are safe
- Nav2 uses the costmaps to generate safe paths through an environment



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Hardware Components

S550 Drone

- Drone development kit
- Hexacopter with a 1 kg payload
- Originally ordered a quadcopter, but due to UCF lead time it went out of stock
- New drone (S550) has higher payload, and we learned more due to a more involved construction process

Jetson Orin Nano

- Uses CUDA cores to support real-time processing of depth data from the ZED 2i camera
- Effective platform for running large-language models in a small form factor

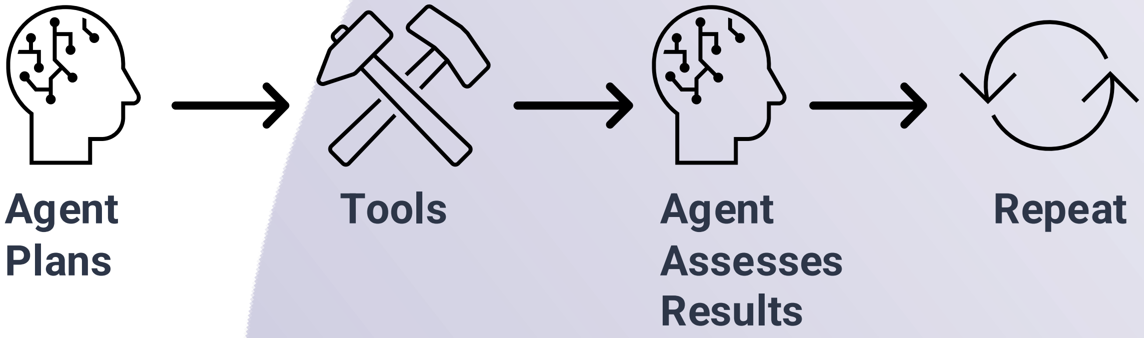
Communications and Network

- Transmitter for manual override of drone
- Router and extender for long range connections
- Radio for drone telemetry

Agentic AI Components

LangGraph and Langchain

- Framework for applications involving LLMs
- Well-suited for building stateful, multi-step AI workflows
- Uses a graph-based structure for more advanced systems (in comparison to LangChain)



Ollama

- Open-source tool to enable execution of LLMs and other generative AI models locally on your own machine
- **Llama 3.1:8B** for the LLM that handles commands and mission planning

Drone Simulation Components

Gazebo

- Drone Simulation Environment
    - Sensors, Physics, Environment
- Integrates seamlessly with ROS2
    - Publishes gazebo topics
    - ros_gz_bridge
- Rich tooling system
    - rviz, px4

PX4

- Flight control & navigation
- Safety features
    - Geo fencing
- Simulate the exact drone we purchased
- Implements MAVLink SDK
- Integrates with Gazebo & PixHawk

ROS2 (Robot Operating System)

- Handles communication between services as middleware
- Enables custom nodes
    - YOLO_perception_node
- Functions as a bridge
- Robust package system
    - rtab_map, px4, ros_gz_bridge, image compression, web sockets

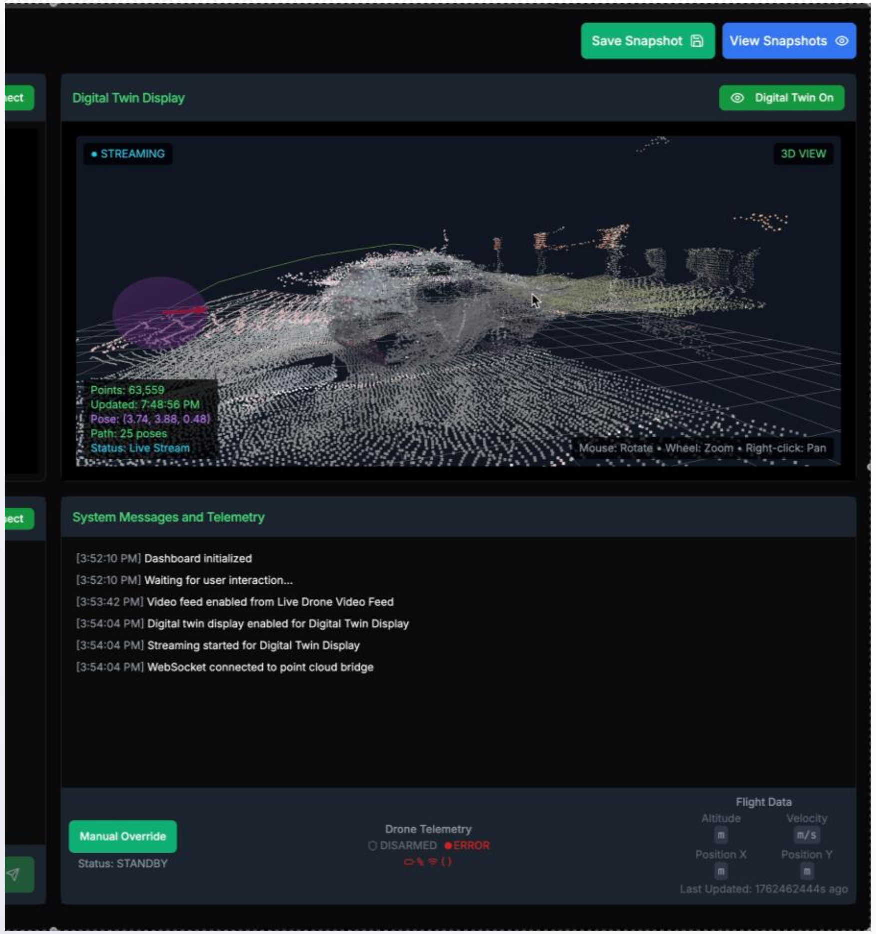
Video Components

ZED 2i Camera

- **Usage**
  - Integration with the Jetson
  - Low-latency streaming to the Dashboard
- **Challenges**
  - Handling high-bandwidth RGB and depth data in real time
  - Optimizing compression

RTAB-Map (SLAM Algorithm)

- **Usage**
  - Exploration
  - Real-time decision making
  - World comprehension
  - Geometric localization
- **Challenges**
  - Operation within Gazebo
  - Computationally intensive
  - Integration with the dashboard



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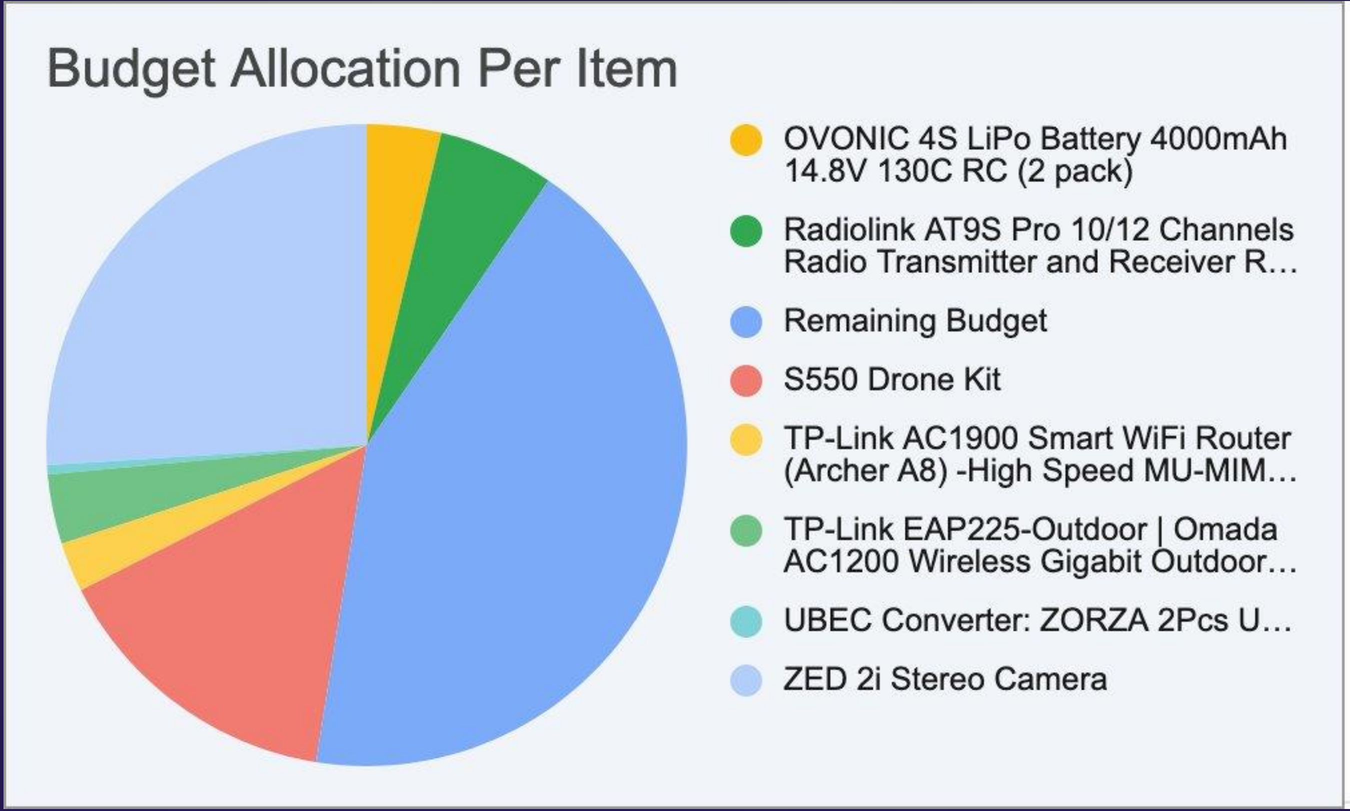
Logistics

Budget Summary

Serco sponsored us with a $2000 budget.

The drone kit and the camera constituted the majority of our costs.

Other costs include communication and electrical equipment.



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Jira Summary

Drone Navigation & Simulation

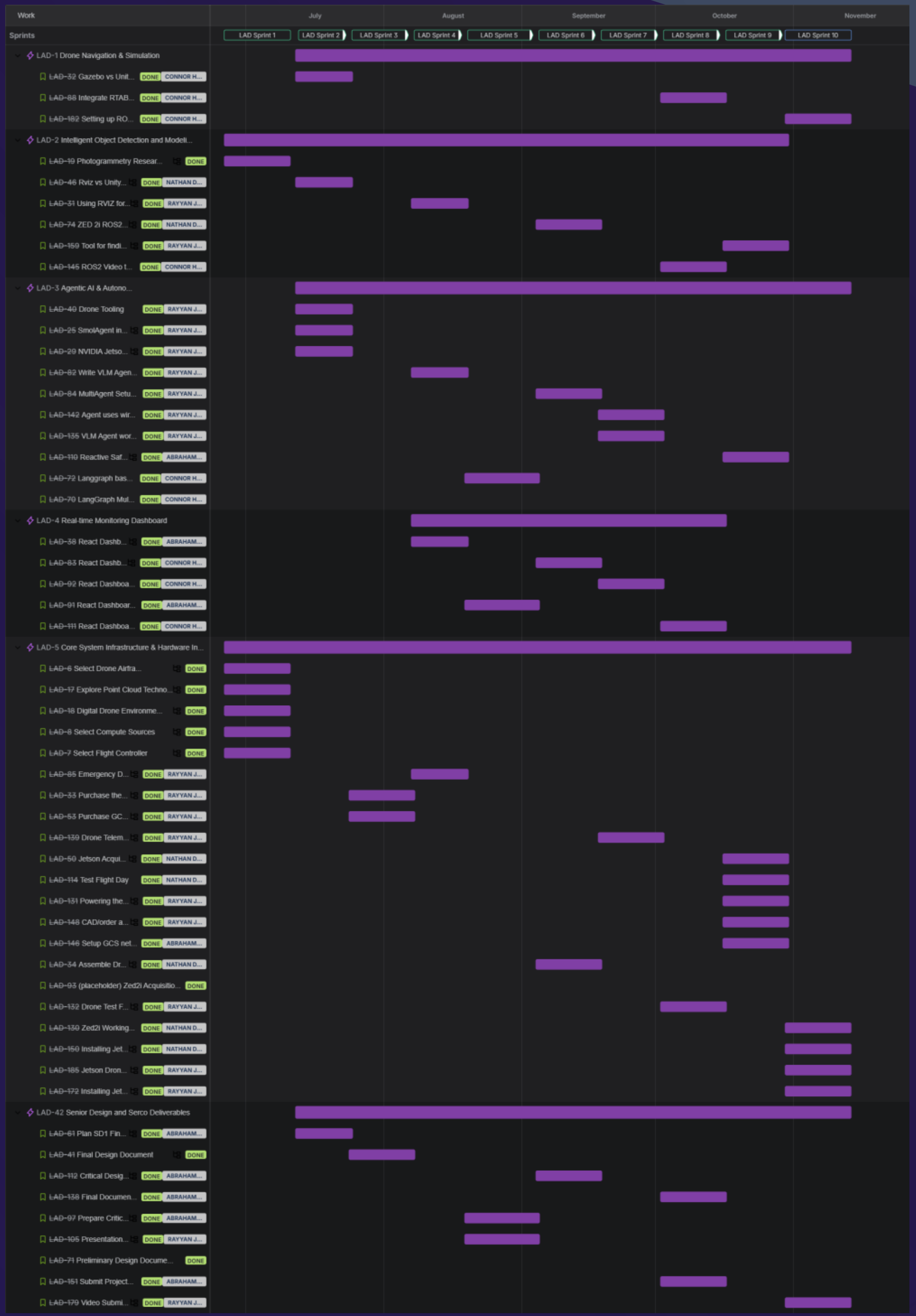
Intelligent Object Detection & Modeling

Agentic AI & Autonomy

Real-Time Monitoring Dashboard

System Infrastructure & Hardware Integration

Deliverables and Documents



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Challenges & Reflections

- Standardizing Development Environments
  - Time-consuming
  - Loss of progress
- Simulation Speed using VirtualBox
  - Impeded development
  - Prevented SLAM from working
- Hardware Order Delays
- Simulation vs. Reality
  - Test flights crashes and safety
  - Damages to ZED 2i

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Project ARES

Key Engineering Milestones

- Custom ROS2 Yolo_Perception_Node to fuse SLAM and YOLO to get x,y,z coordinates
- Unique power delivery system and hardware architecture to support a Jetson, six motors, a flight controller, and the ZED 2i camera
- React dashboard to provide a single intuitive interface for mission oversight, allowing the human operator to view all components in action, including the SLAM depth map, ZED 2i camera, and agentic AI dialogue, and system logs
- Specialized agent tools for vision tasks and trigger-based movement, enabling our agentic intelligence to understand human intent and execute multistep missions autonomously

Human Intent. Autonomous Flight. ARES.

Thank you!