Faculty Panel Presentation

Date: 05/4/2026

Team: sddec26-11

OUR TEAM

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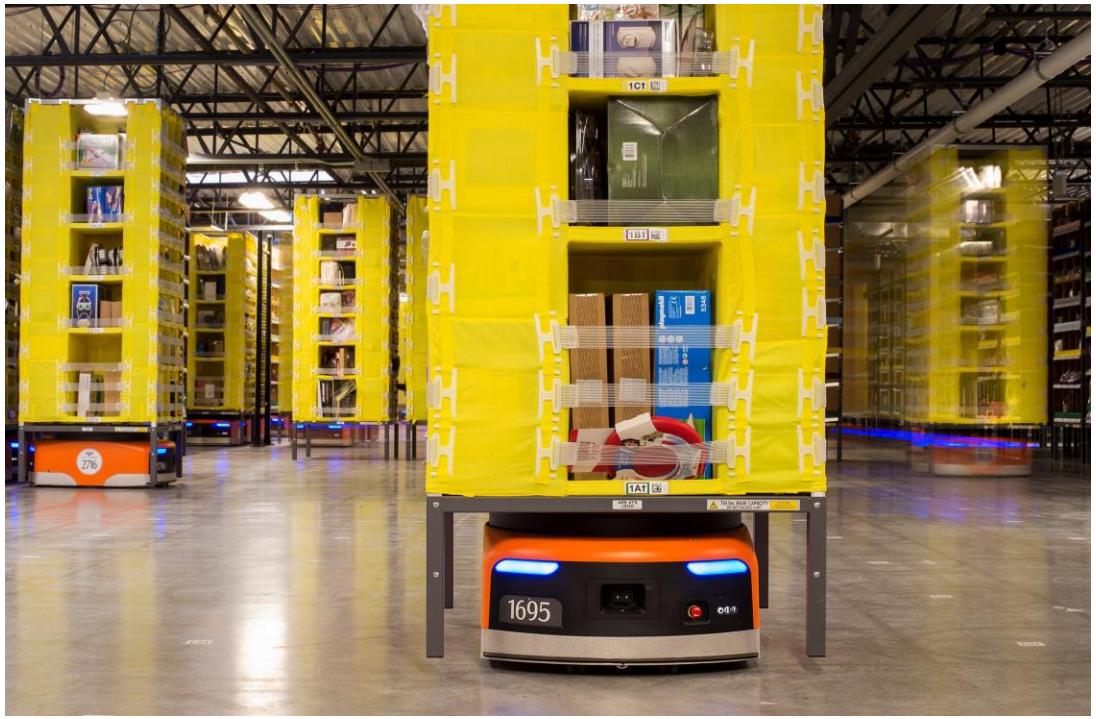
PROBLEM CONTEXT

Problem:
- Inventory Management
- Safety

The need:
- Faster Accurate Tracking
- Automated System

The User:
- Warehouse Workers

CURRENT SOLUTIONS - AUTOMATION



Amazon warehouses "Kiva" robots

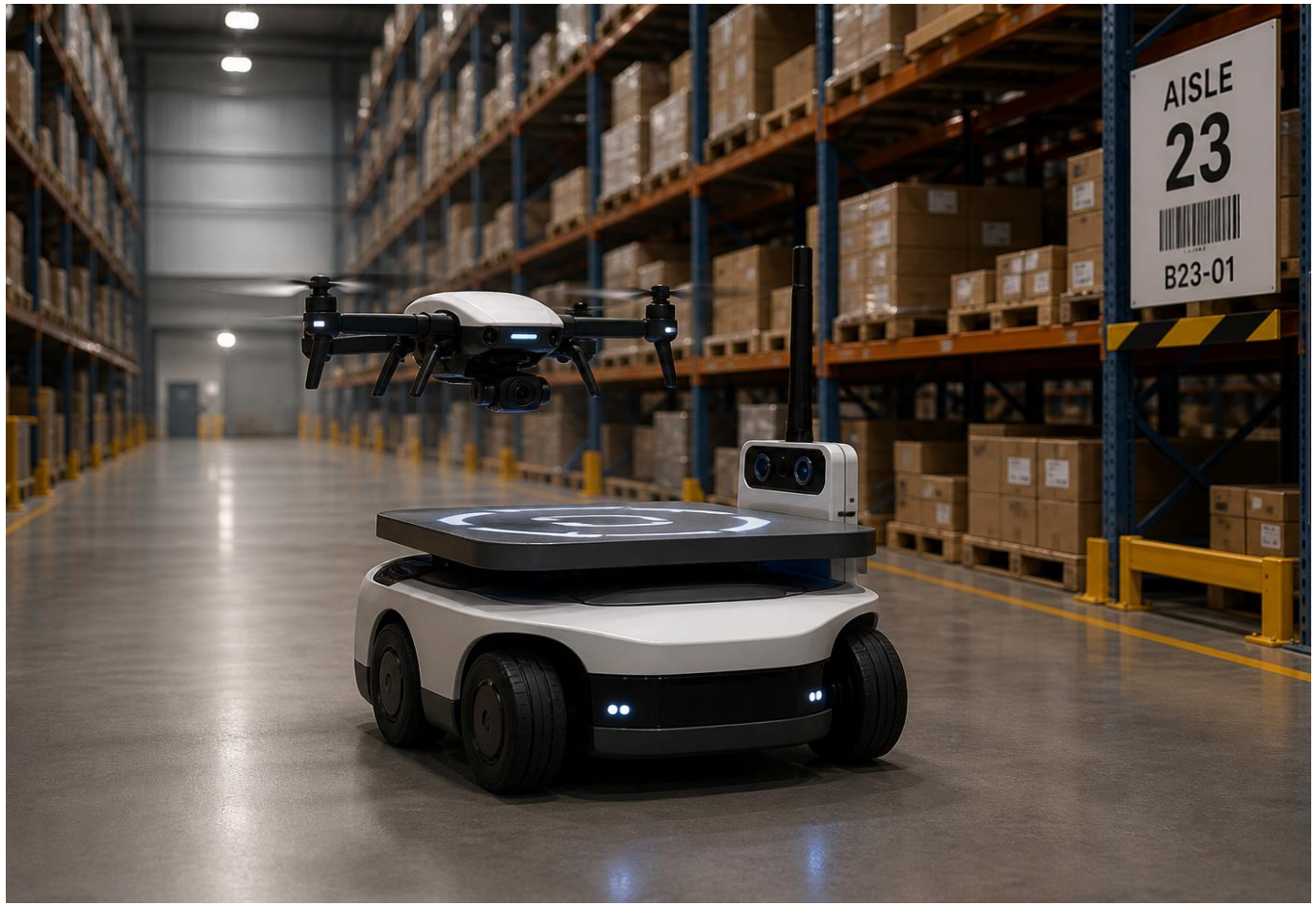
Ocado warehouses using "The Hive"

PROS	CONS
Highly Accurate	Requires New Infrastructure
Improves Efficiency	Expensive

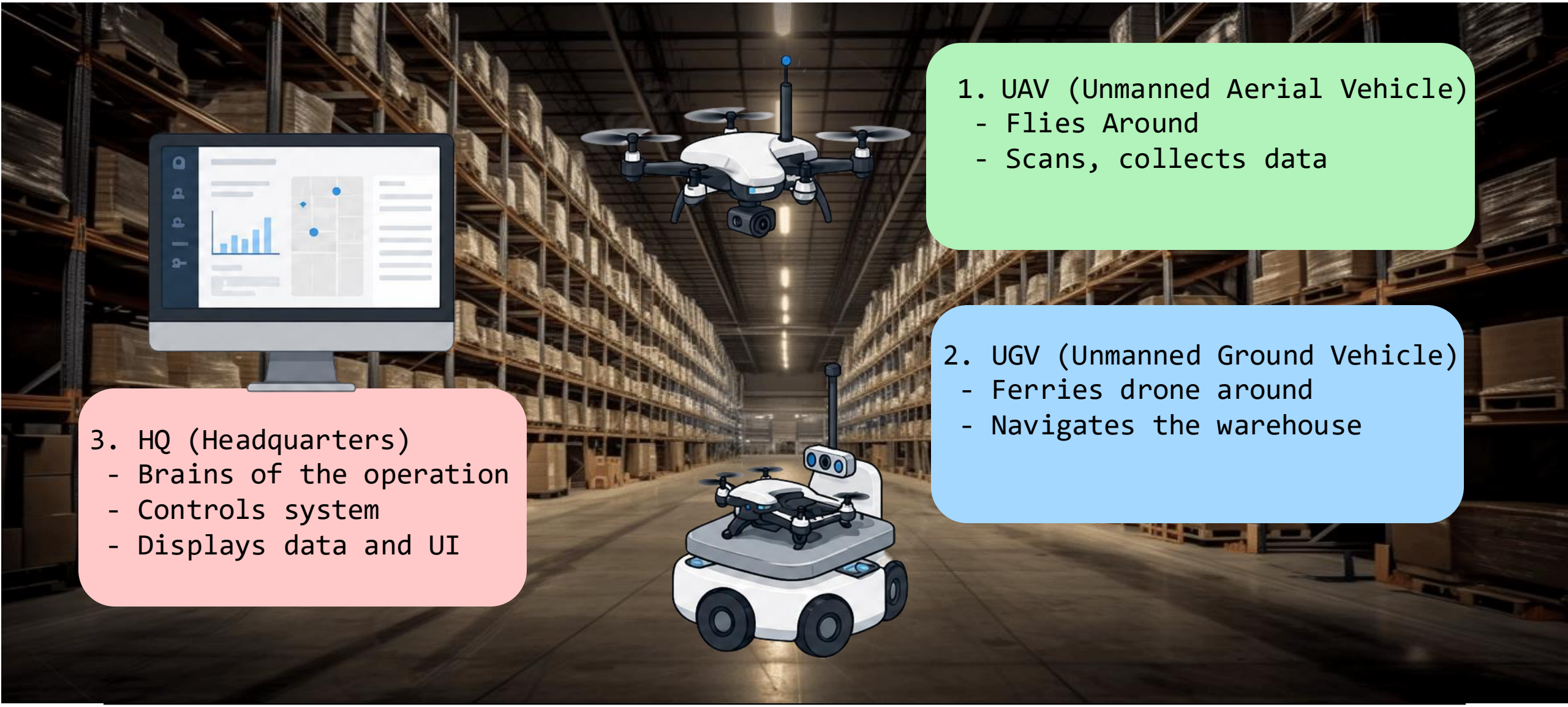
OUR SOLUTION

Coordinated aerial-ground robotic system for warehouse inventory management

- Lower Cost
- Scalable
- Verticality
- Existing Infrastructure



DESIGN - OVERVIEW



1. UAV (Unmanned Aerial Vehicle)
   - Flies Around
   - Scans, collects data

2. UGV (Unmanned Ground Vehicle)
   - Ferries drone around
   - Navigates the warehouse

3. HQ (Headquarters)
   - Brains of the operation
   - Controls system
   - Displays data and UI

DESIGN - BEHAVIOR

1 UAV Scans

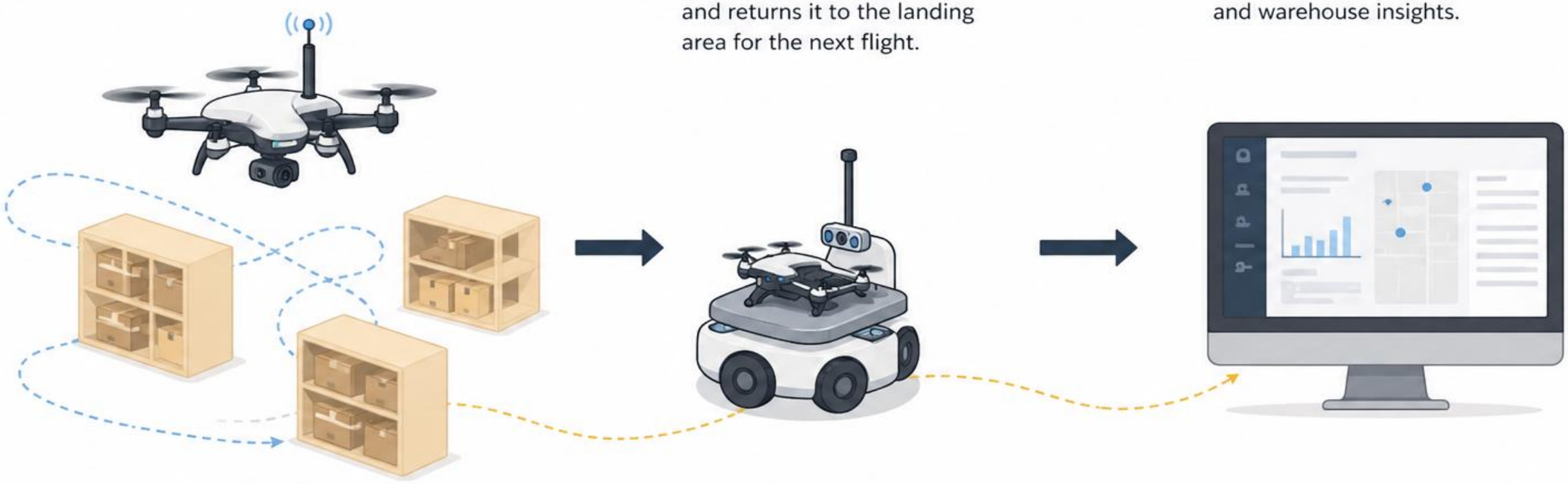
The UAV flies through the warehouse to capture images and inventory data.

2 UGV Transports

The UGV picks up the UAV, moves it between locations, and returns it to the landing area for the next flight.

3 Data & Insights

All data is sent to the computer, providing up-to-date inventory and warehouse insights.



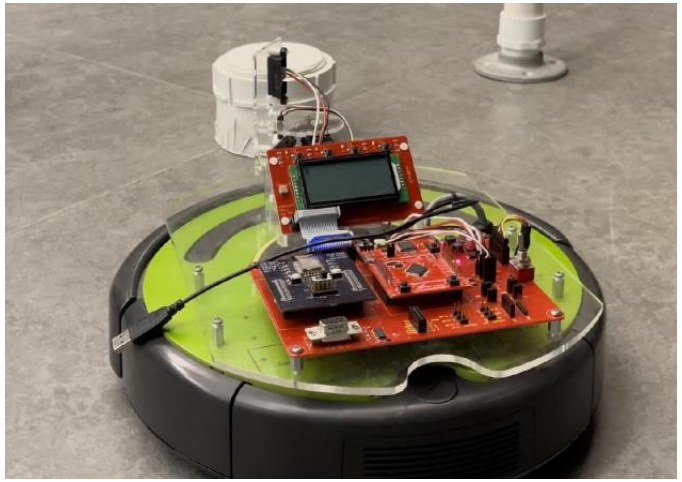
DESIGN - UGV

Functions
Scan Warehouse
Avoid Obstacles
Landing Pad

Challenges
Environment Sensing
Stability

Smart Robot Car V4
Open Sourced Highly Customizable Controlled via WiFi

Elegoo/CyNot



CyBot

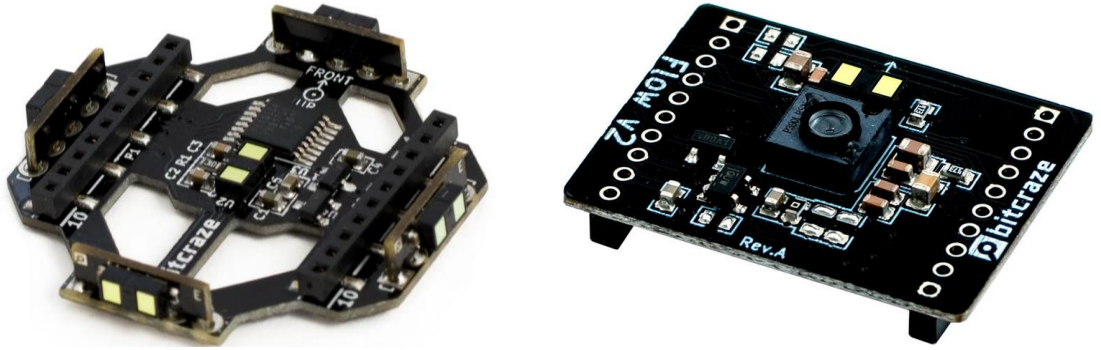
DESIGN - UAV

Functions
Navigate Warehouse
Avoid Obstacles
Scan Inventory

Challenges
Power
Localization

Crazyflie 2.1
Open-Sourced Expandable with "decks" Palm-sized 10 minutes of flight Controlled via radio

CrazyFlie 2.1 Brushless

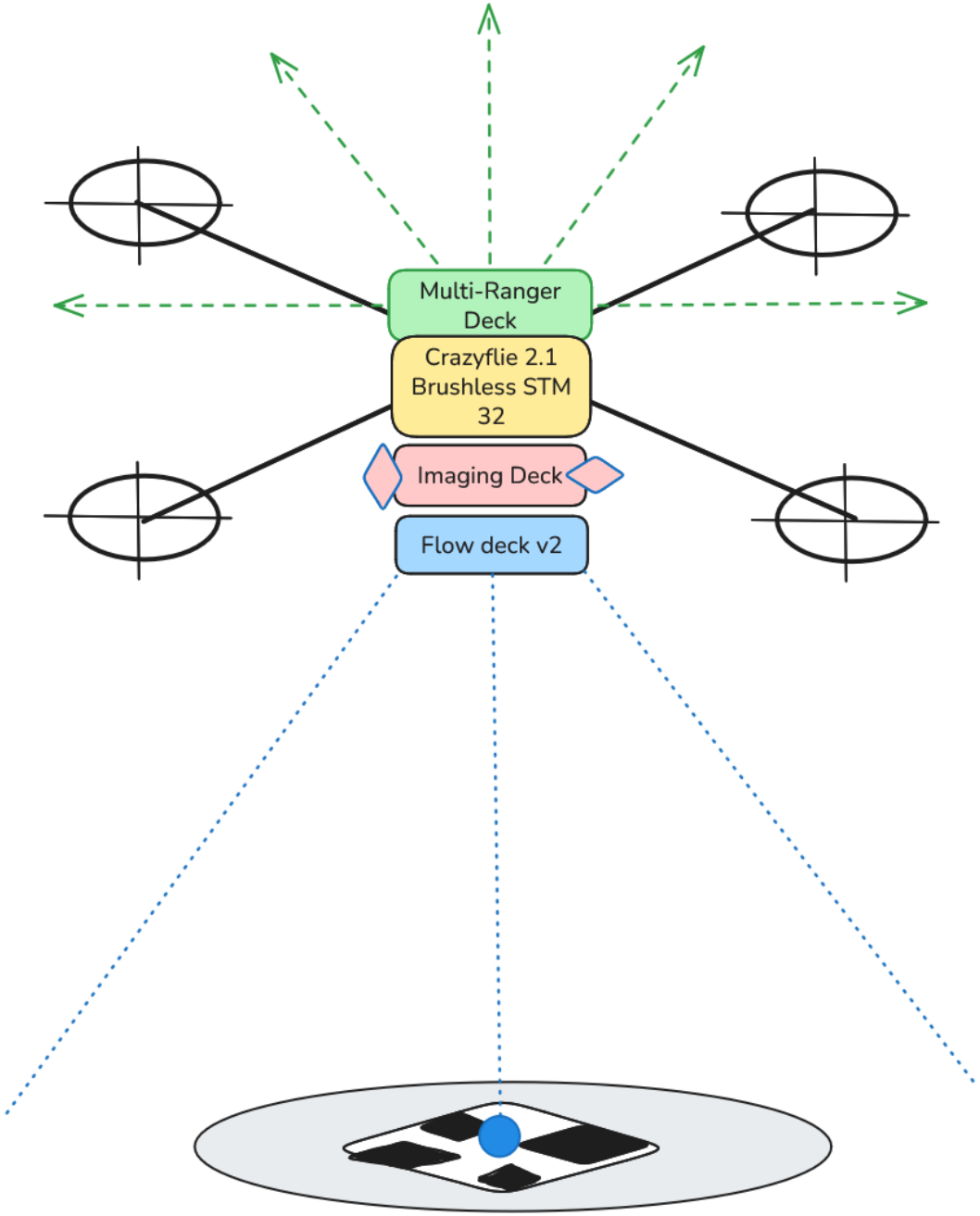


Available "expansion decks"

DESIGN - UAV

1. Multi-Ranger Deck
- 5 ToF lasers
- Object detection

2. Imaging Deck
- Forward / Downward facing cameras
- Streams image data



3. Flow Deck v2
- Monitors ground
- Improved stability
- Altitude/Velocity

4. Landing Pad
- On top of UGV
- ArUco markers assist in landing

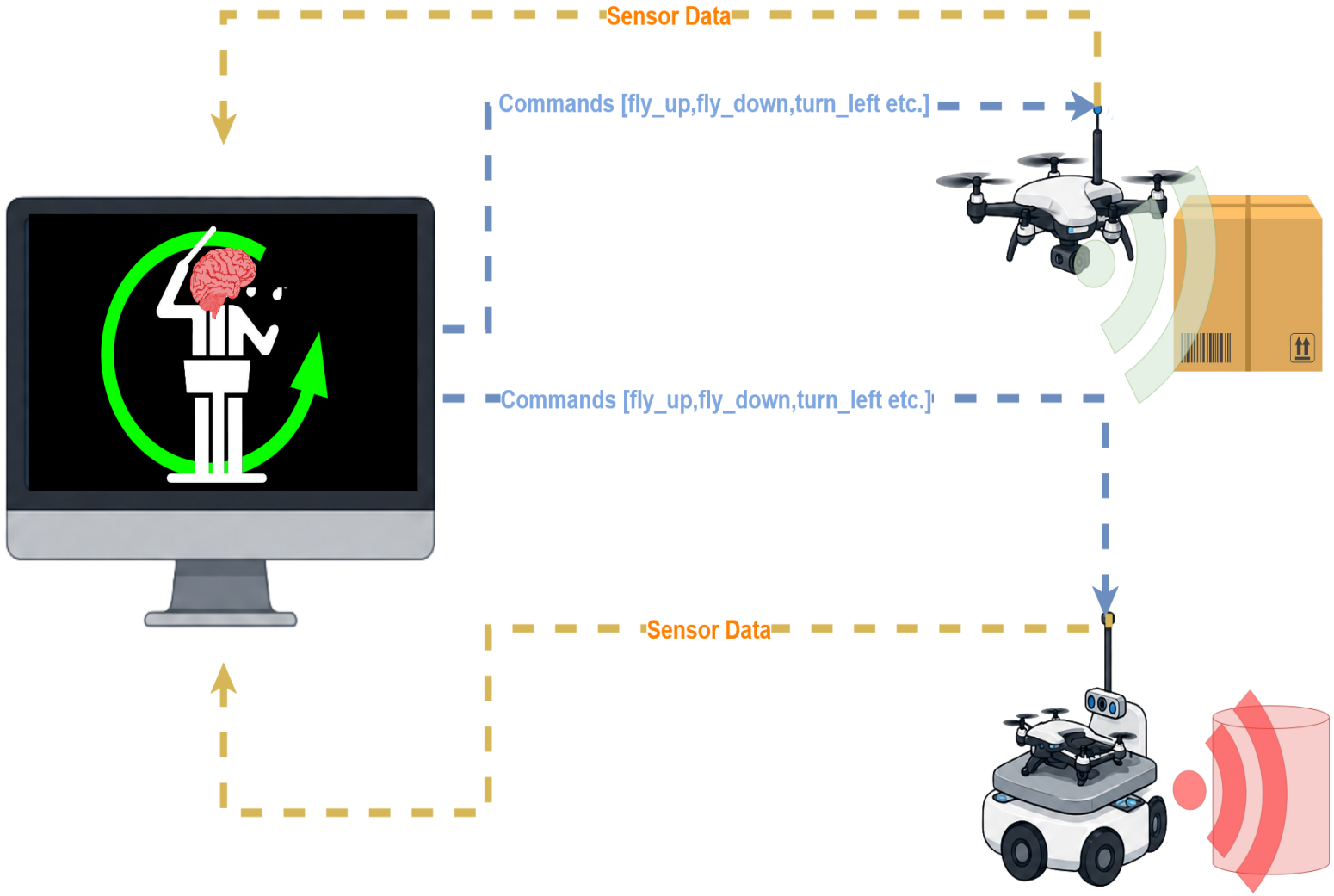
Result
X/Y/Z position estimate
- Indoors
- No GPS
- No external infrastructure

DESIGN - HQ

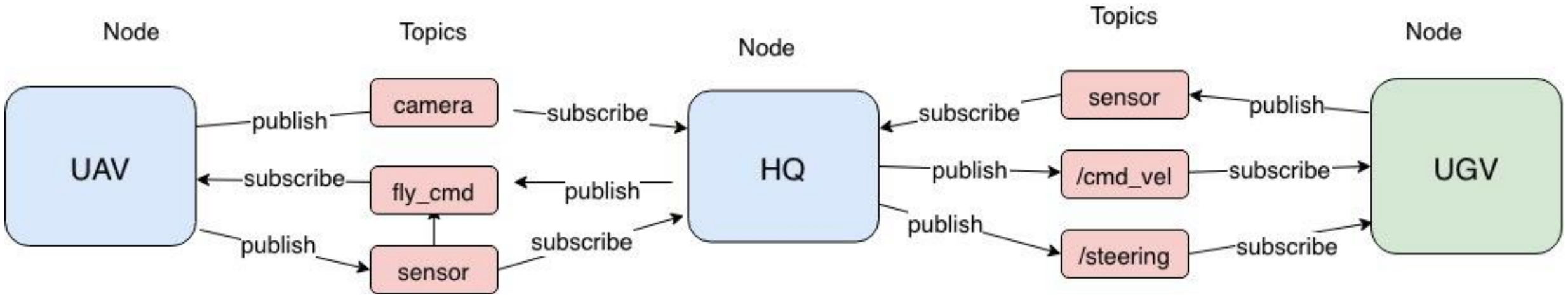
Functions
Conductor
Processes Data
User Interface

Challenges
Time Constraints
Coordination

Software
Ros2
Python
OpenCV



DESIGN – ROS 2



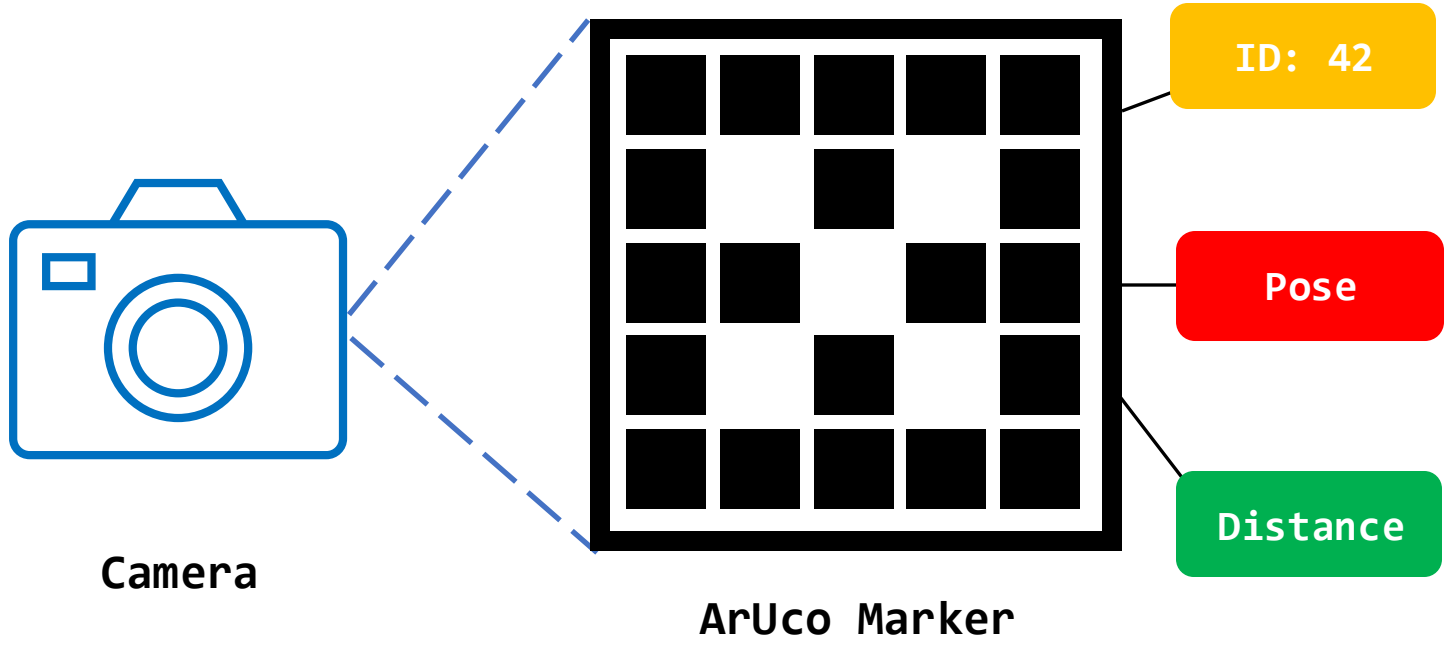
Functions	Challenges	Solution
Robot Centered Framework	Coordination	ROS 2
Control / Communication	Maintainability	

DESIGN - IMAGE RECOGNITION

Functions
Recognize items in frame
Estimate pose & distance

Challenges
Variety
Low-Light Conditions

Solution
ArUco Markers

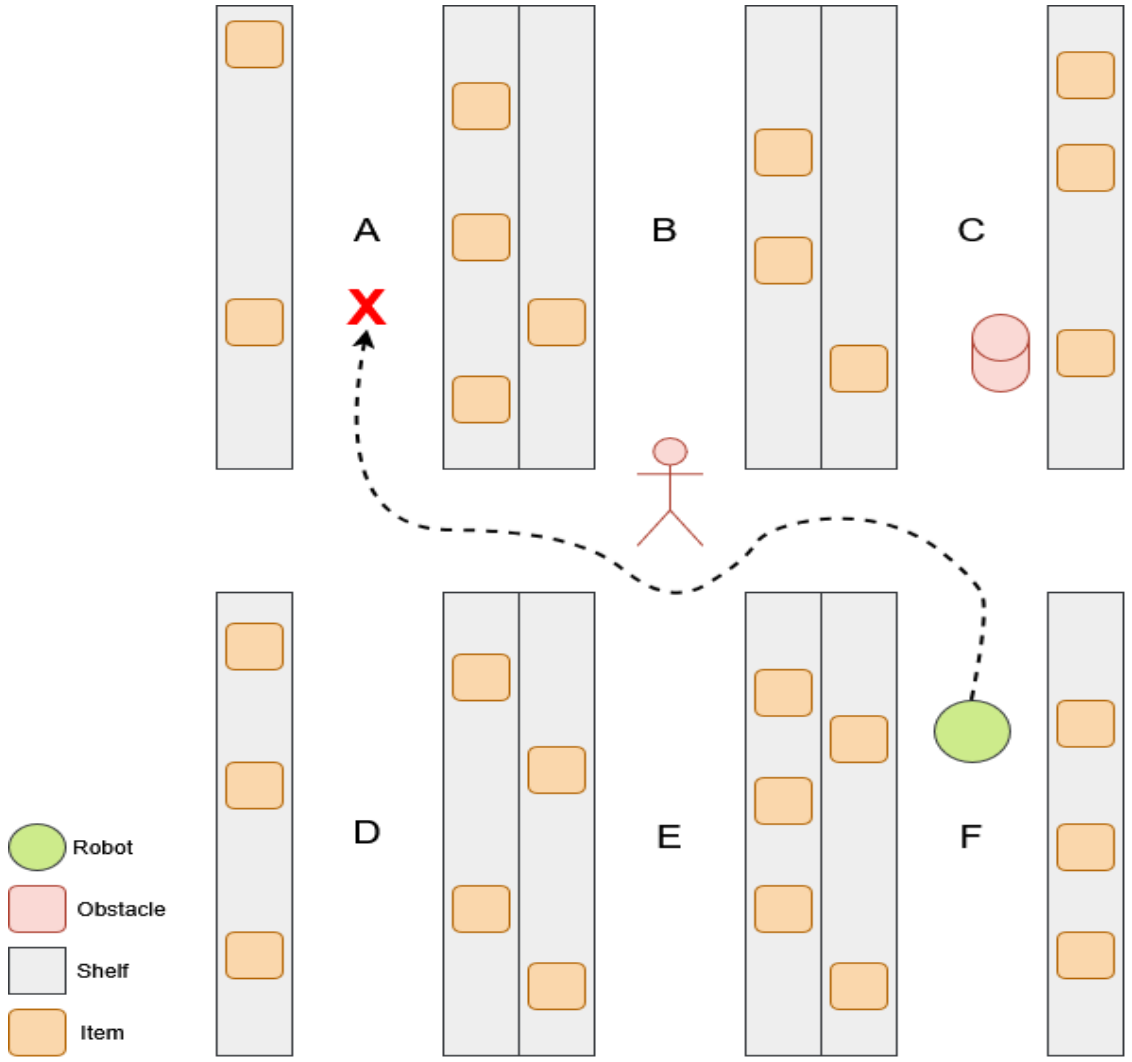


DESIGN - MAPPING

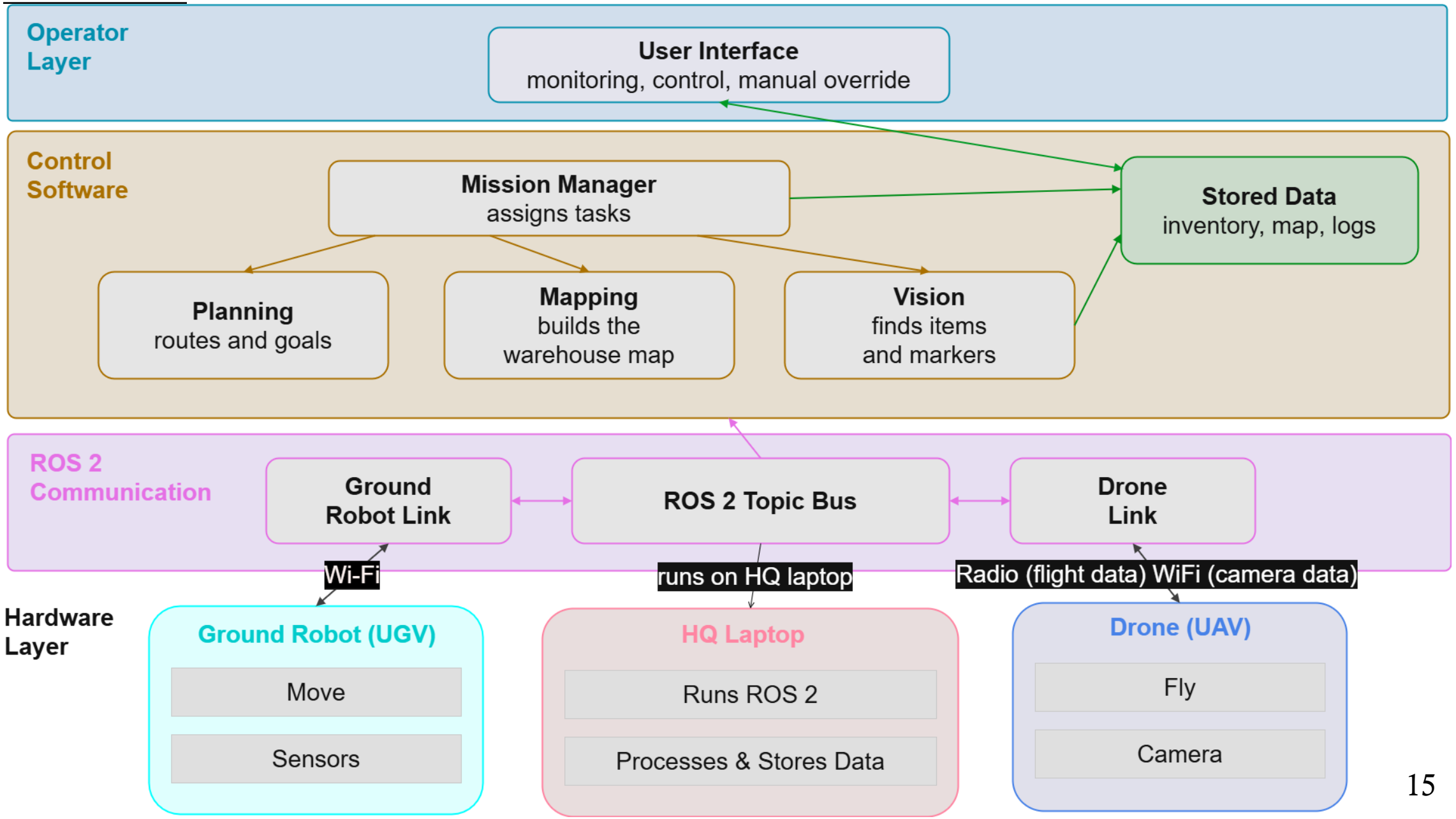
Functions
Navigate Warehouse

Challenges
Unknown Obstacles Efficiency

Solution
Slam_toolbox Nav2

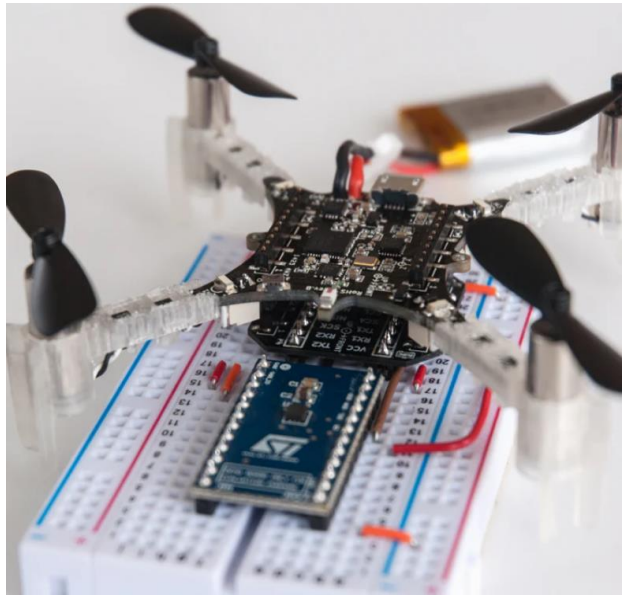


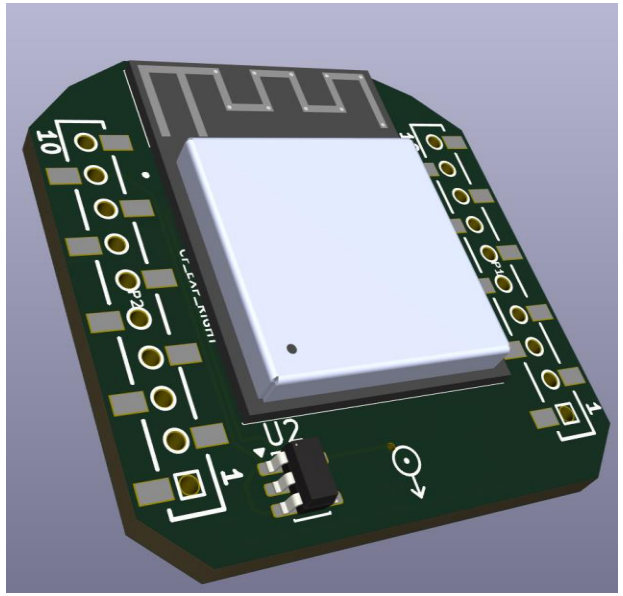
DESIGN - HIGH LEVEL



PROTOTYPE TESTING - HARDWARE

Hardware

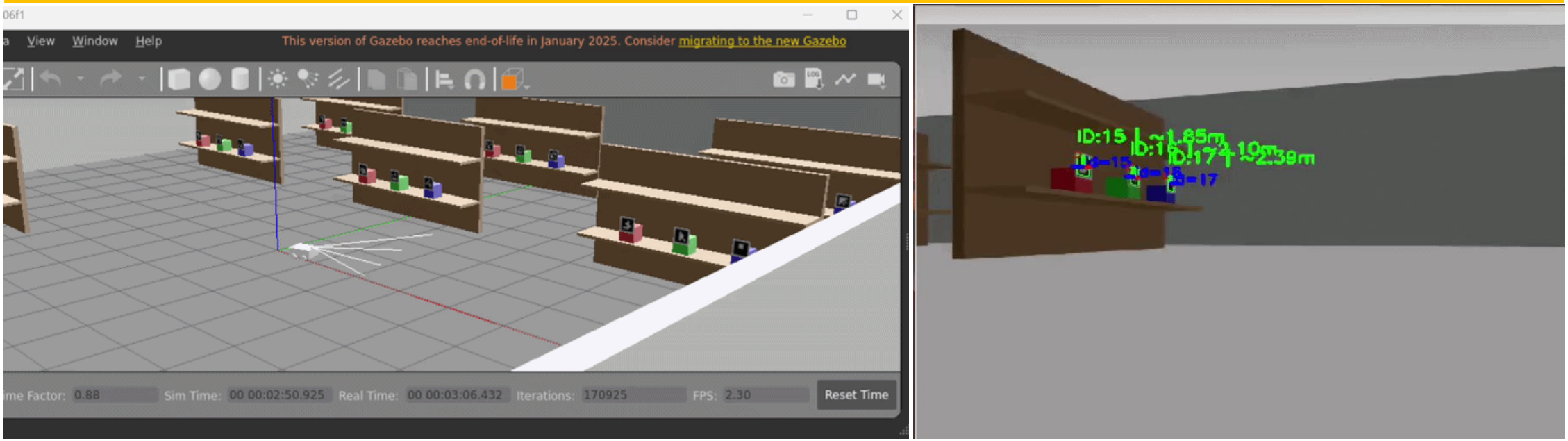




Hands On Approach
Designing Hardware
Validating Performance

PROTOTYPE TESTING - SOFTWARE

Software



Simulations of system within Gazebo

Isolated Environment
Testing Code
Finding Bugs

PLAN MOVING FORWARD & GOALS

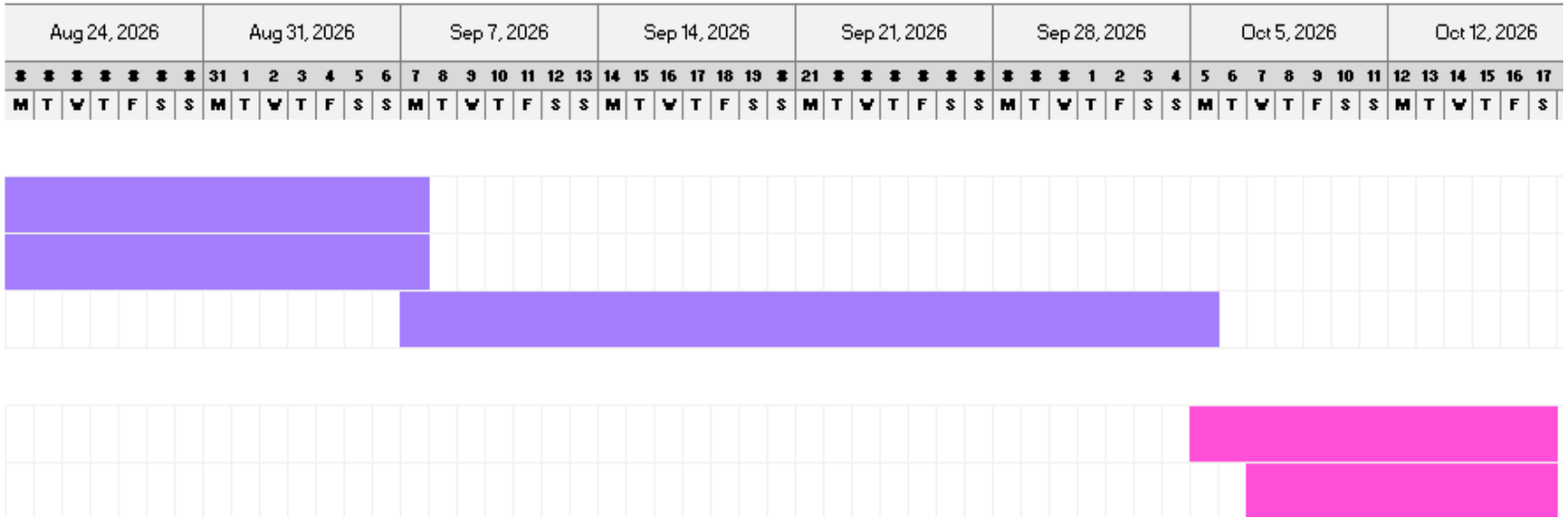
Goals	Stretch Goals
- Finalize design of UAV, Imaging deck, and UGV - Merge software and hardware beyond just simulations - Complete bill materials - Working UI - Working demonstration by October 1st - Finish Testing and Refinement Plan by November 15th	- Real-time object detection - UGV wireless recharging station - Smartphone app - Test in a variety of real warehouses

PLAN MOVING FORWARD & GOALS

Team sddec26-1 Project lead

Display week: 1

TASK	ASSIGNED TO	PROGRESS	START	END
Production				
Finish Integrating Code	Hardware	0%	8/24/26	9/7/26
Finish Simulations	Software	0%	8/24/26	9/7/26
Unity	Hardware+Software	0%	9/7/26	10/5/26
Testing and validation				
Demo Enivronmentment	Hardware	0%	10/5/26	10/19/26
Stress Test	Hardware+Software	0%	10/7/26	11/4/26



FINAL WORDS - LESSONS LEARNED

So many choices

Some planning

Now we're rollin'

SUMMARY & Q / A

Goals	Stretch Goals
- Finalize design of UAV, Imaging deck, and UGV - Merge software and hardware beyond just simulations - Complete bill materials - Working UI - Working demonstration by October 1st - Finish Testing and Refinement Plan by November 15th	- Real-time object detection - UGV wireless recharging station - Smartphone app - Test in a variety of real warehouses

EXTRA DESIGN - IMAGING DECK *(PROTOTYPE)*

Functions

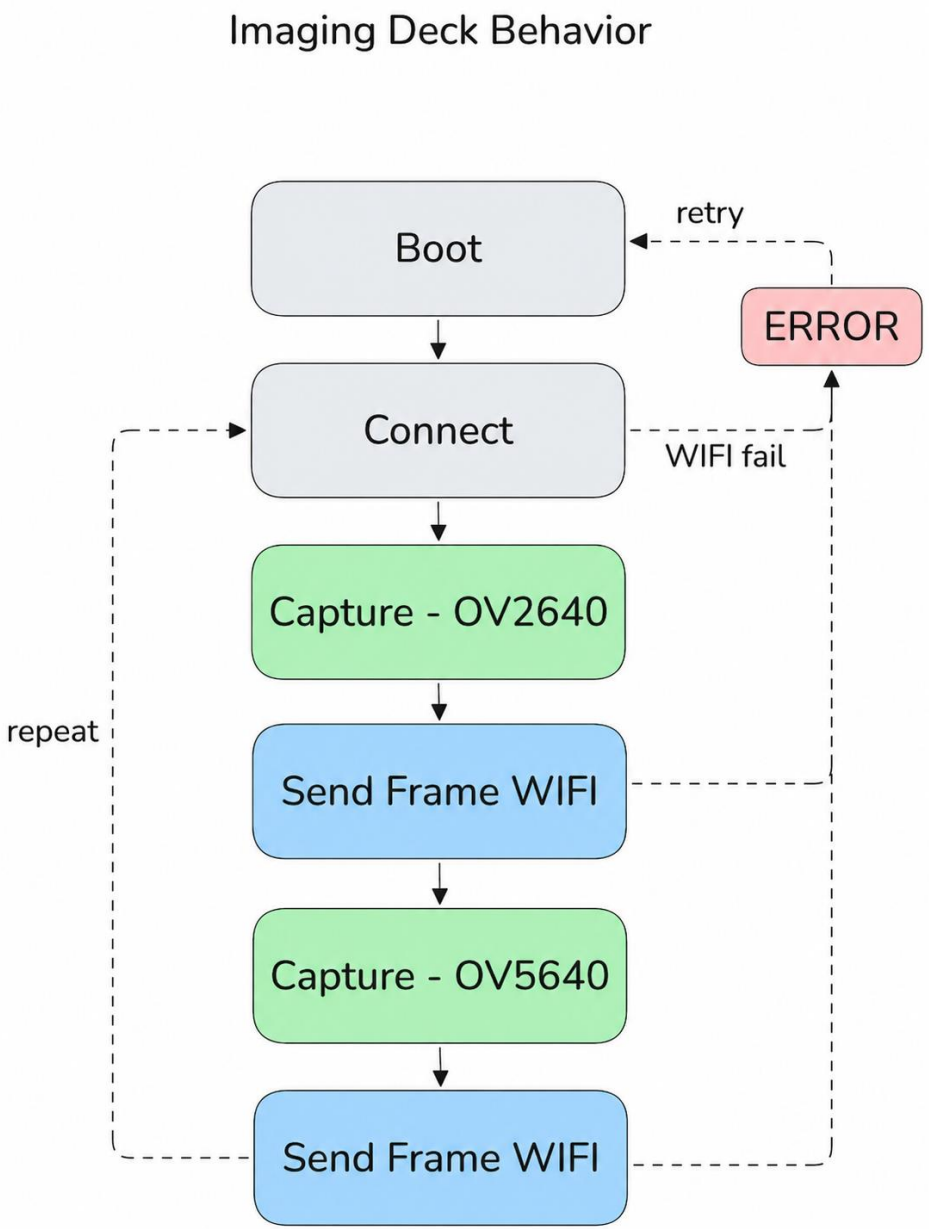
Operate two cameras
Transmit images

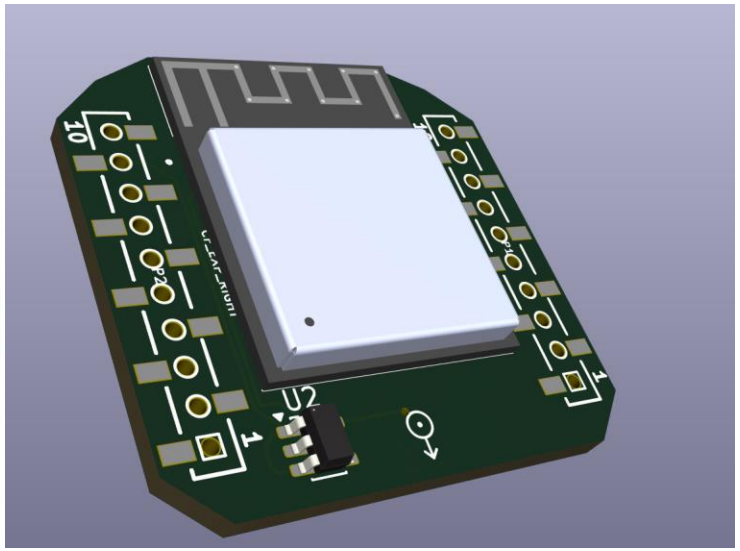
Challenges

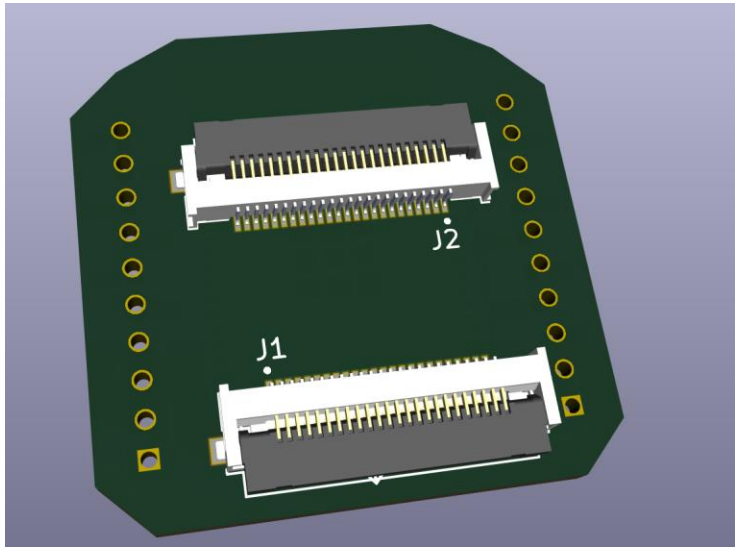
Space
Must fit on CrazyFlie
Two cameras one microcontroller?
Speed

Components

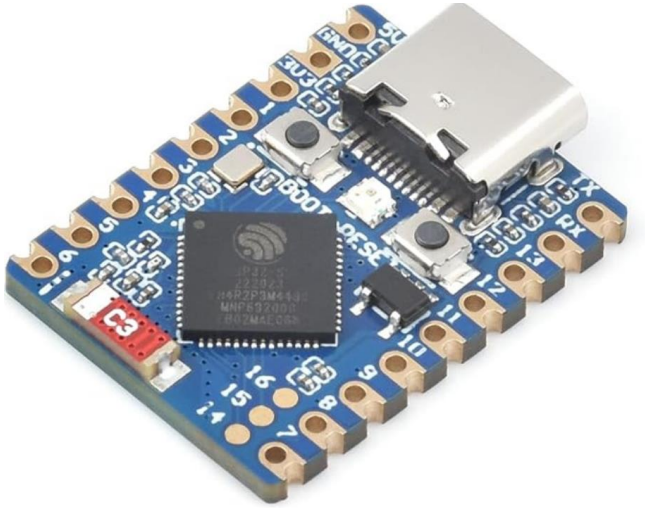
ESP 32 Microcontroller
OV 2640 Camera
OV 5640 Camera







EXTRA DESIGN - IMAGING DECK COMPONENTS



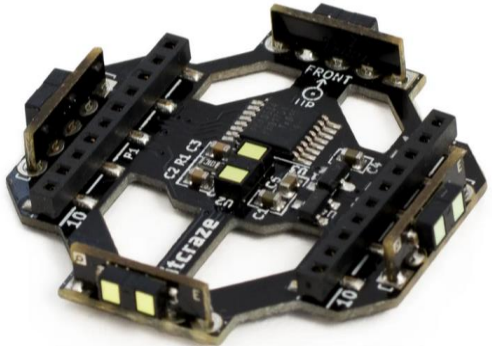
ESP32-S3-MINI
Dual-Core 240MHz
2.4GHz WIFI
Classic and tested
22.5 x 18 mm (tiny)

OV5640
5MP
~10fps@720p Streamed (un-tested)
DVP
Auto-focus, detailed

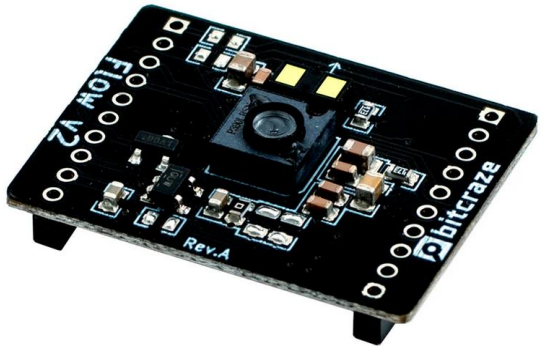
OV2640
2MP
30fps@SVGA Streamed (Tested)
DVP
Hardware Compression!

EXTRA DESIGN - UAV DETAILED..ISH

CrazyFlie 2.1 Brushless



Multi-Ranger Deck



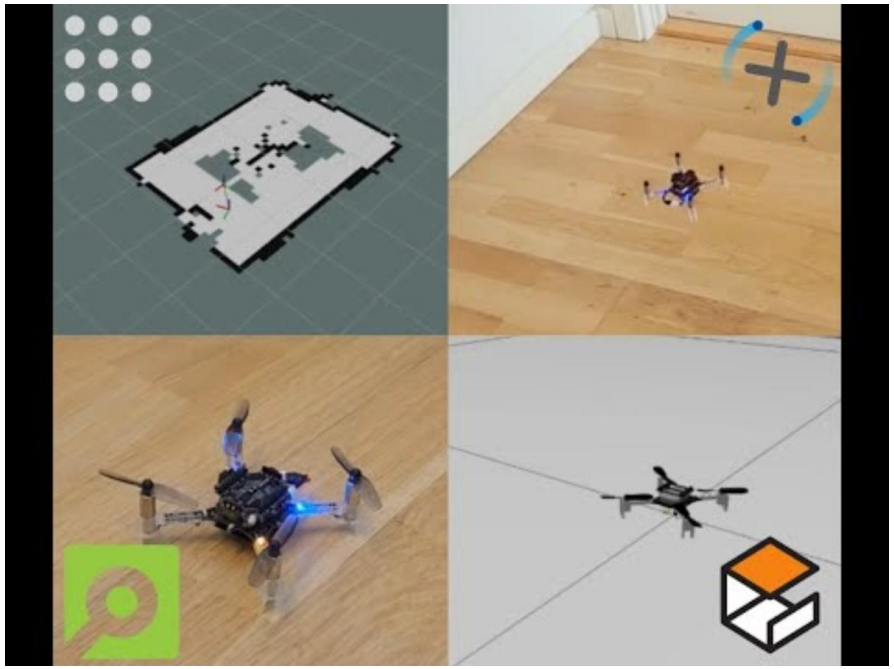
Flowdeck v2

350mAh Lipo battery

Maybe a larger battery?

	CrazyFlie 2.1	Multi-Ranger Deck	Flowdeck v2	Image-Deck(est)	4x Motors	Battery 350mAh	Total
Weight	34g	2.3g	1.6g	~5-7g	30g x 4 = 120g thrust	9.1g	**~68g thrust**
Power (simple)	VCC 3V (100mA) VCOM (max 1A)	~50mA	~30mA	~160-190mA	2A hover	350mAh 3.7V 15C-30C	**~2.37A**
Flight Time(est)	~10min						**~8.9min**

EXTRA PROOF - BITCRAZE



Example of CrazyFlie using ROS2 and Gazebo

Example of CrazyFlie Multi-Ranger Deck point cloud

Both examples use the same deck configuration we chose

EXTRA PROOF - SIMILAR PROJECTS

drones

MDPI

Article

Collaborative Infrastructure-Free Aerial–Ground Robotic System for Warehouse Inventory Data Capture

Rafaela Chaffilla [1], Paulo Alvito [2] and Meysam Basiri [1,*]

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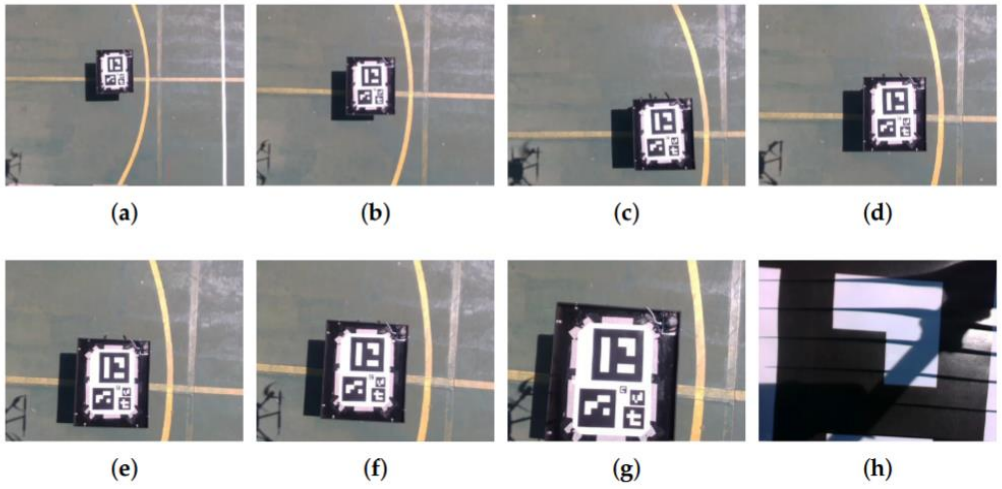
Our takeaways:

1. The problem is real
2. The timing is right (2025)
3. Validates our design
4. We can iterate.. Cheaper, better?
5. What can we learn from this?
   - Optimal strategies
   - Risks
6. Similar, but differs in scale & cost
7. Less 'user-focused' more proof of concept

(a) (b)

UGV *UAV*



(a) (b) (c) (d)

(e) (f) (g) (h)

UAV Landing with ArUco markers

EXTRA DESIGN - DECK COMPATIBILITY

	LED-ring deck	Qi 1.2 wireless charging deck	Micro SD card deck	Loco Positioning deck	BigQuad deck	Buzzer deck	Z-ranger deck V2, Z-ranger V1	Flow deck V2, Flow deck V1	Multi-ranger deck	Motion capture marker deck	Lighthouse positioning deck	Active marker deck	AI deck	Color LED deck
LED-ring deck	-		yes	yes		yes			yes	yes	yes	yes	yes	yes
Qi 1.2 wireless charging deck		-	yes	yes	yes	yes			yes	yes	yes	yes	yes	yes[1]
Micro SD card deck	yes	yes	-	yes[2]	yes	yes	yes	yes[2]	yes	yes	yes	yes	5	yes
Loco Positioning deck	yes	yes	yes[2]	-	yes	yes	yes	yes	yes	yes	3	yes	6	yes
BigQuad deck		yes	yes	yes	-		yes		yes	yes	3	yes	7	yes
Buzzer deck	yes	yes	yes	yes		-	yes	yes	yes	yes	yes	yes	7	yes
Z-ranger deck V2, Z-ranger V1			yes	yes	yes	yes	-		yes	yes	yes	yes	yes	yes
Flow deck V2, Flow deck V1			yes[2]	yes		yes		-	yes	yes	yes	yes	yes	yes
Multi-ranger deck	yes	yes	yes	yes	yes	yes	yes	yes	-	yes	yes	yes	yes	yes
Motion capture marker deck	yes	yes	yes	yes	yes	yes	yes	yes	yes	-	yes		yes	yes
Lighthouse positioning deck	yes	yes	yes	3	3	yes	yes	yes	yes	yes	-		4	yes
Active marker deck	yes	yes	yes	yes	yes	yes	yes	yes	yes			-	yes	yes
AI deck	yes	yes	5	6	7	7	yes	yes	yes	yes	4	yes	-	yes
Color LED deck	yes	yes[1]	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	-

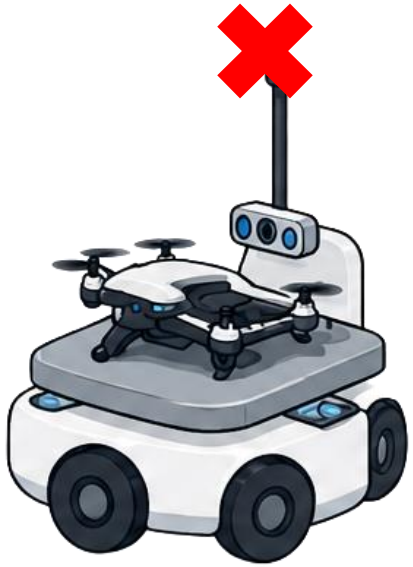
Bitcraze Compatibility Matrix

EXTRA DESIGN - FAILSAFES & FALLBACKS

1. STOPS -> hovers
Retries connection

1. Retries connection
2. Reports ERR and logs

Notifies operator
-Last-known location
-Time etc.



STOPS -> Retries connection

2. No comm after max retries

Performs auto-land procedure

Waits on low-power