Project Pegasus

UAV Package Delivery System

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What we're doing

Problem

- Labor-intensive package delivery process

Solution

- Use UAVs to expedite delivery process

Project Description

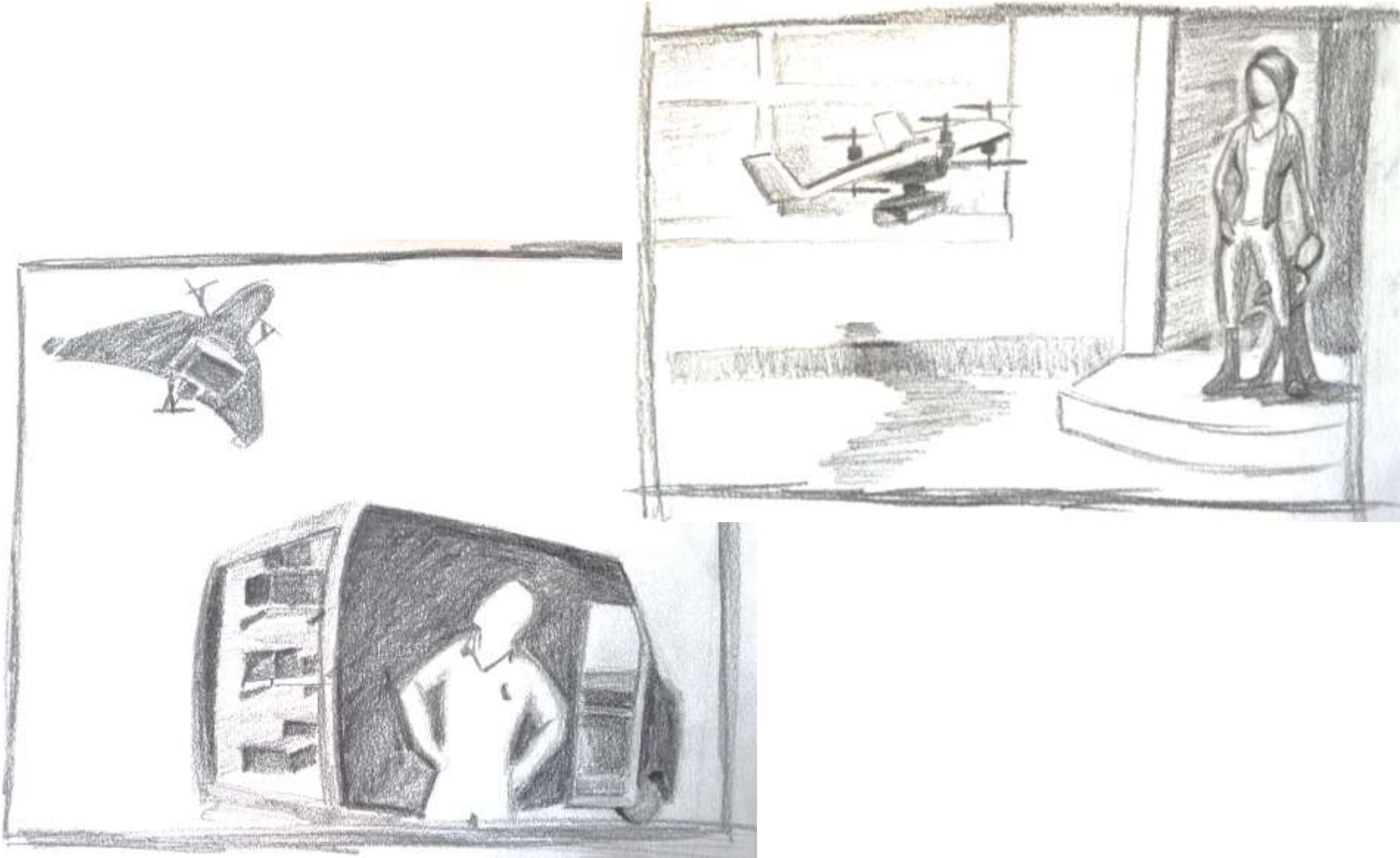
- Given the coordinates of the house, a UAV with a package takes off from point A
- Autonomously reaches close to the house
- Scans the outside of the house for a visually marked drop point, lands, drops off the package,
- Takes off again to land on another platform at point B.

Where we're at

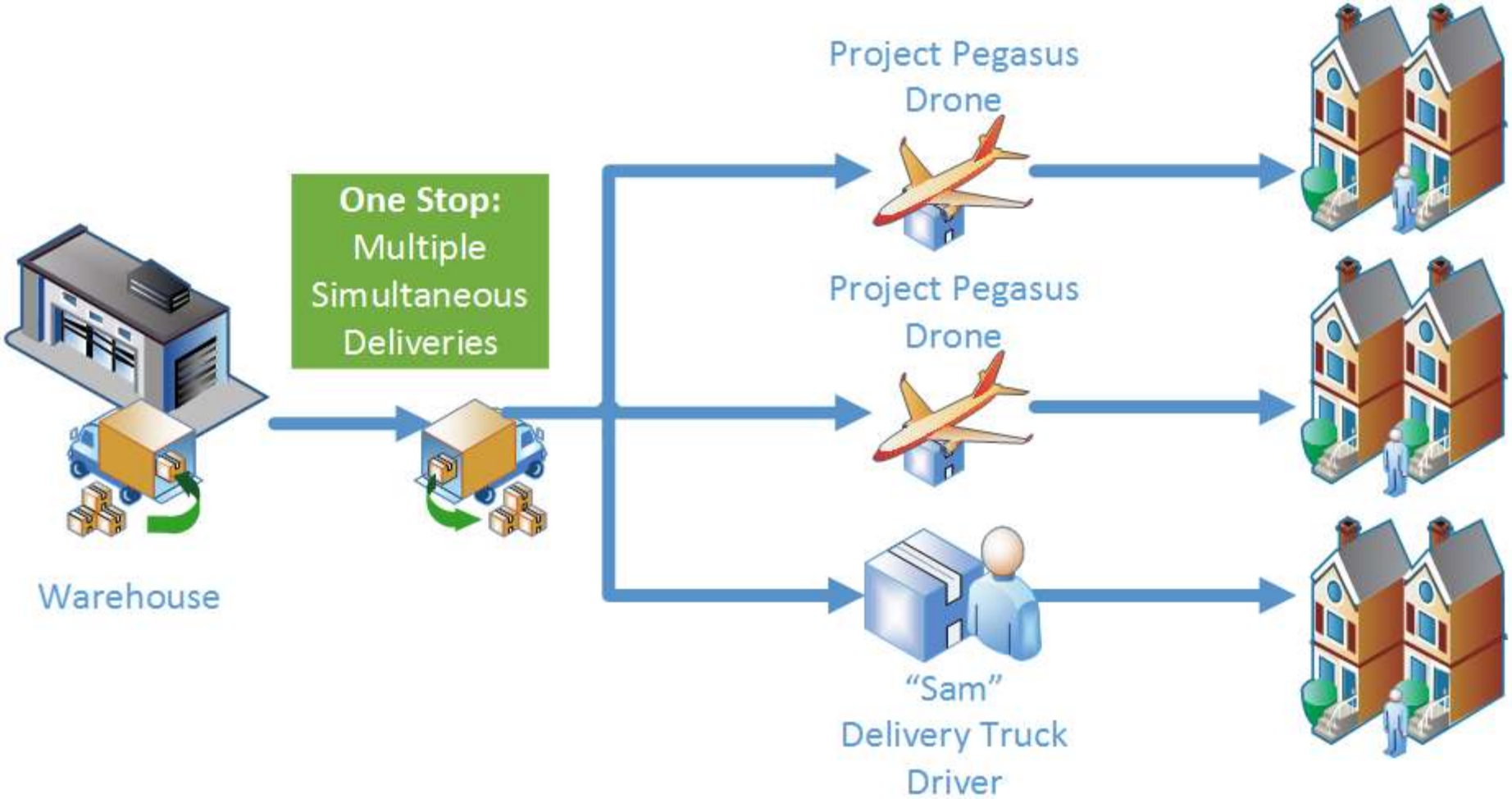
We are currently **under** budget ($3,311 spent)

We are **on track** with our *revised* schedule

Use Case



Use Case


Project Pegasus
Drone
One Stop:
Multiple
Simultaneous
Deliveries
Project Pegasus
Drone
Warehouse
"Sam"
Delivery Truck
Driver

Requirements Modification

Mandatory Functional Requirements moved to Desired

- M.F.8 Takes coordinates as input from the user. **-> D.F.6**
- M.F.9 Communicates with platform to receive GPS updates (intermittently). **-> D.F.7**

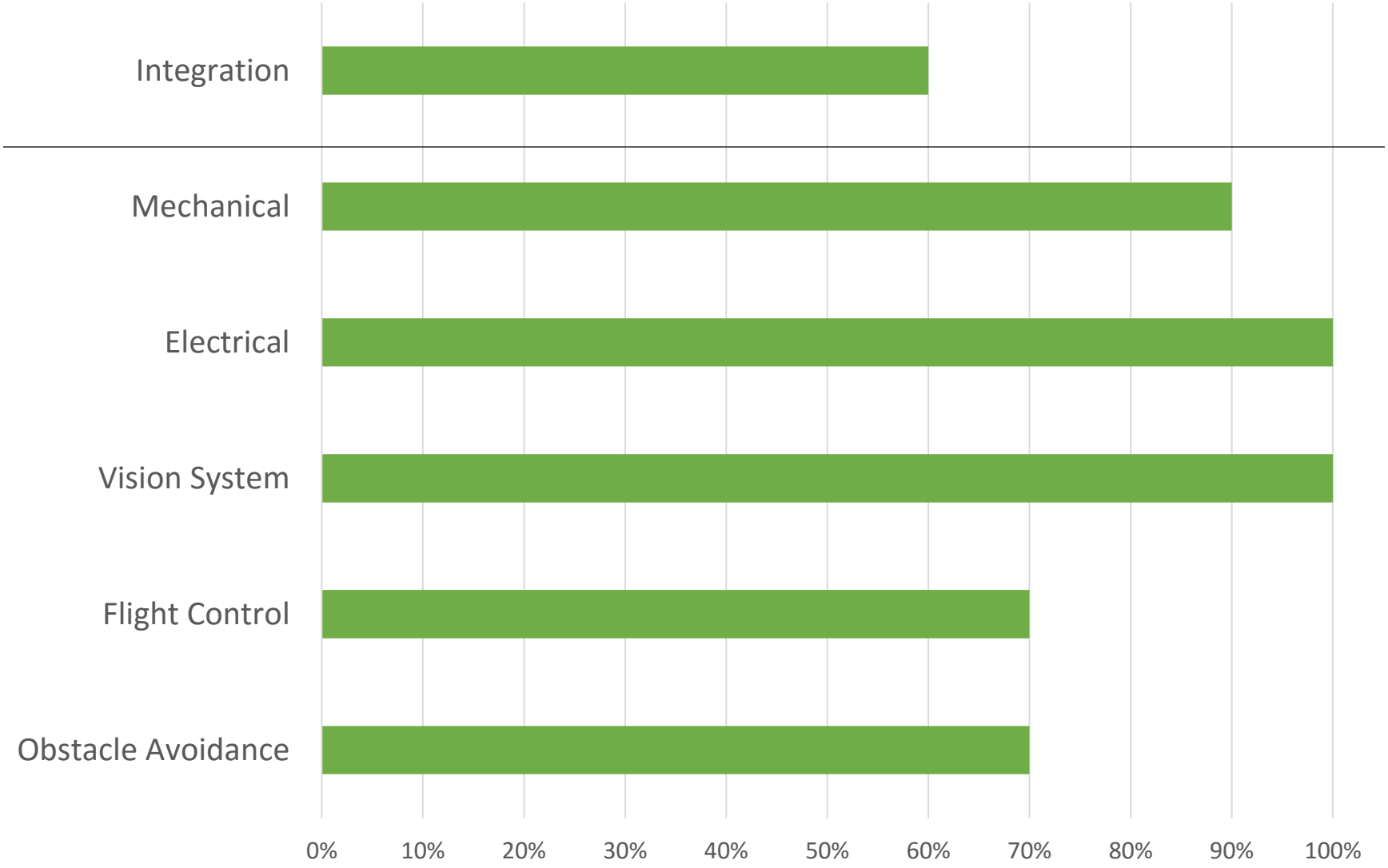
Mandatory Non-Functional Requirement moved to Desired

- M.N.4 Not reliant on GPS. Uses GPS to navigate close to the house. Does not rely on GPS to detect the visual marker at the drop point. **-> D.N.6**

Refined Requirement

- M.N.6 Package should weigh at most 100g and fit in a cuboid of dimensions 9.5” x 6.5” x 2.2”.

Current System Status

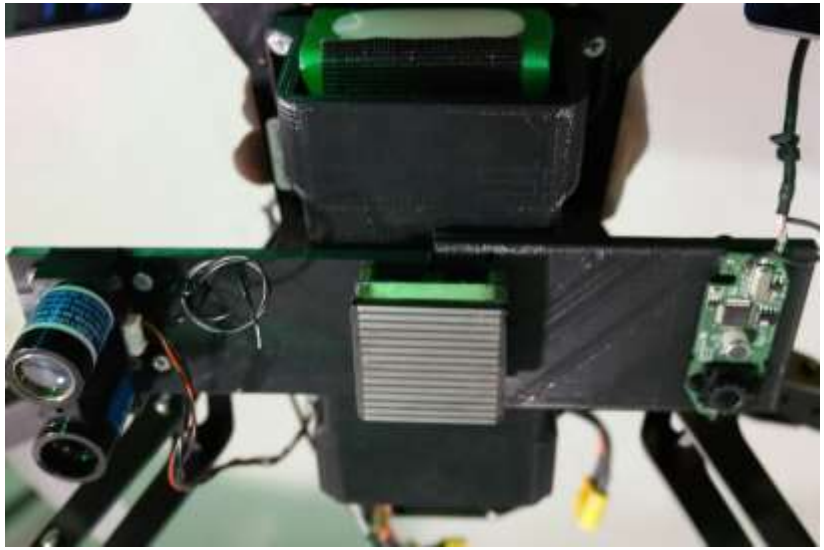


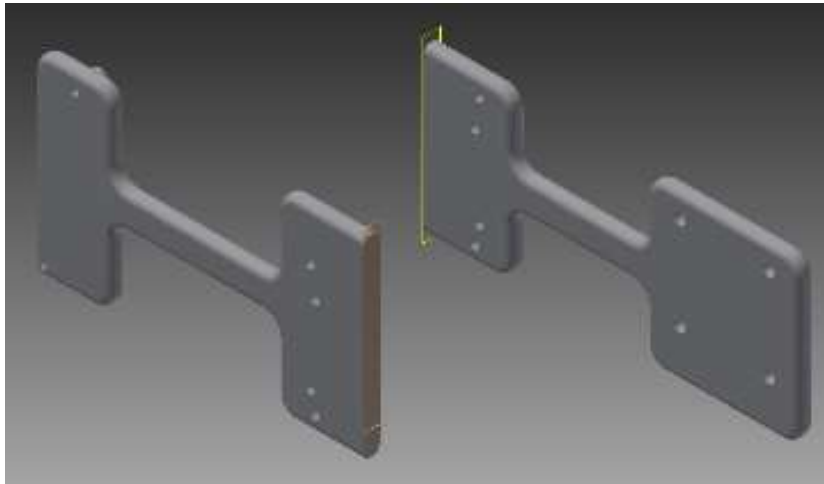
Mechanical and Electrical

Status:
Completed and integrated with drone

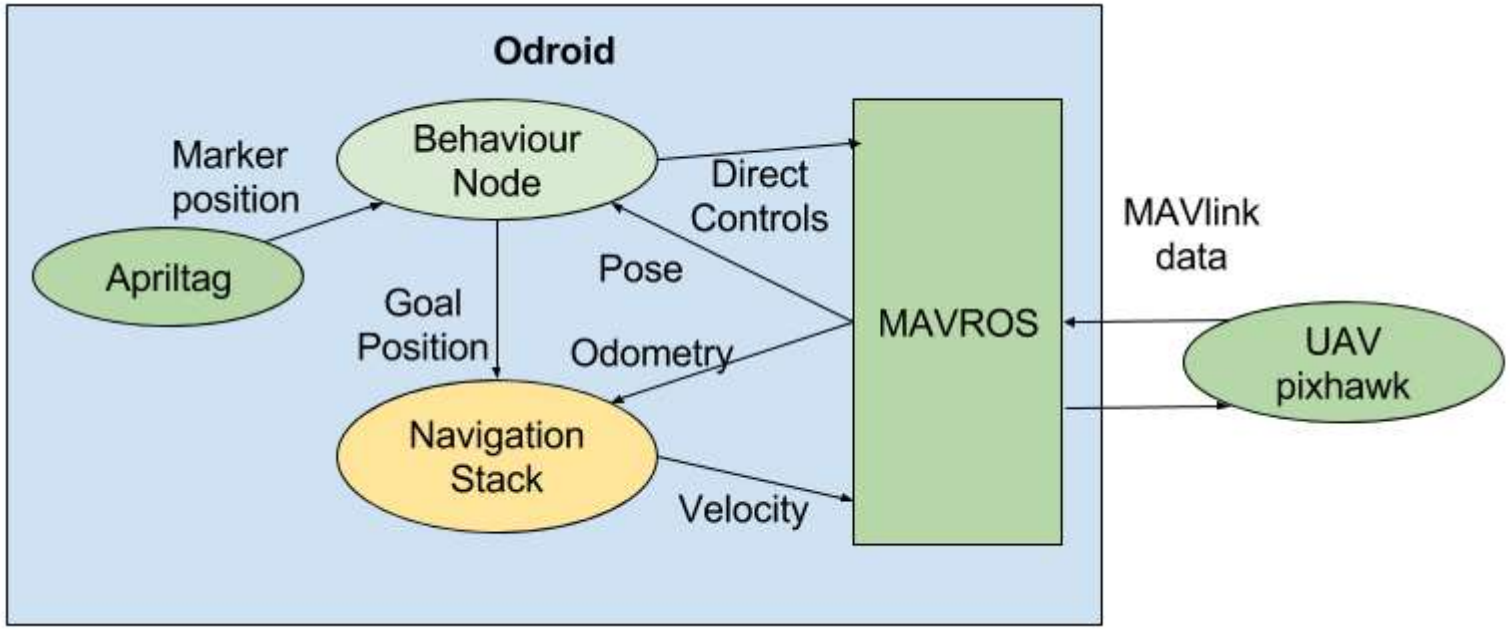
Results:
Drone 100% ready for Software Integration and Testing

Possible Areas for Improvement
- Weight Reduction
- Ease of Modification





Software Architecture



Status

- Flight Control: Autonomous marker following
- Obstacle Avoidance: Primary integration of Navigation Stack completed

Flight Control and Vision Subsystem

Position over marker held with 50cm accuracy

Flight Control and Vision System

Challenges faced

- Coordinate frame conversions. Keep it simple

Remaining targets/challenges

- Autonomous take-off and landing
- Integrating flight control with the navigation stack

Obstacle Avoidance

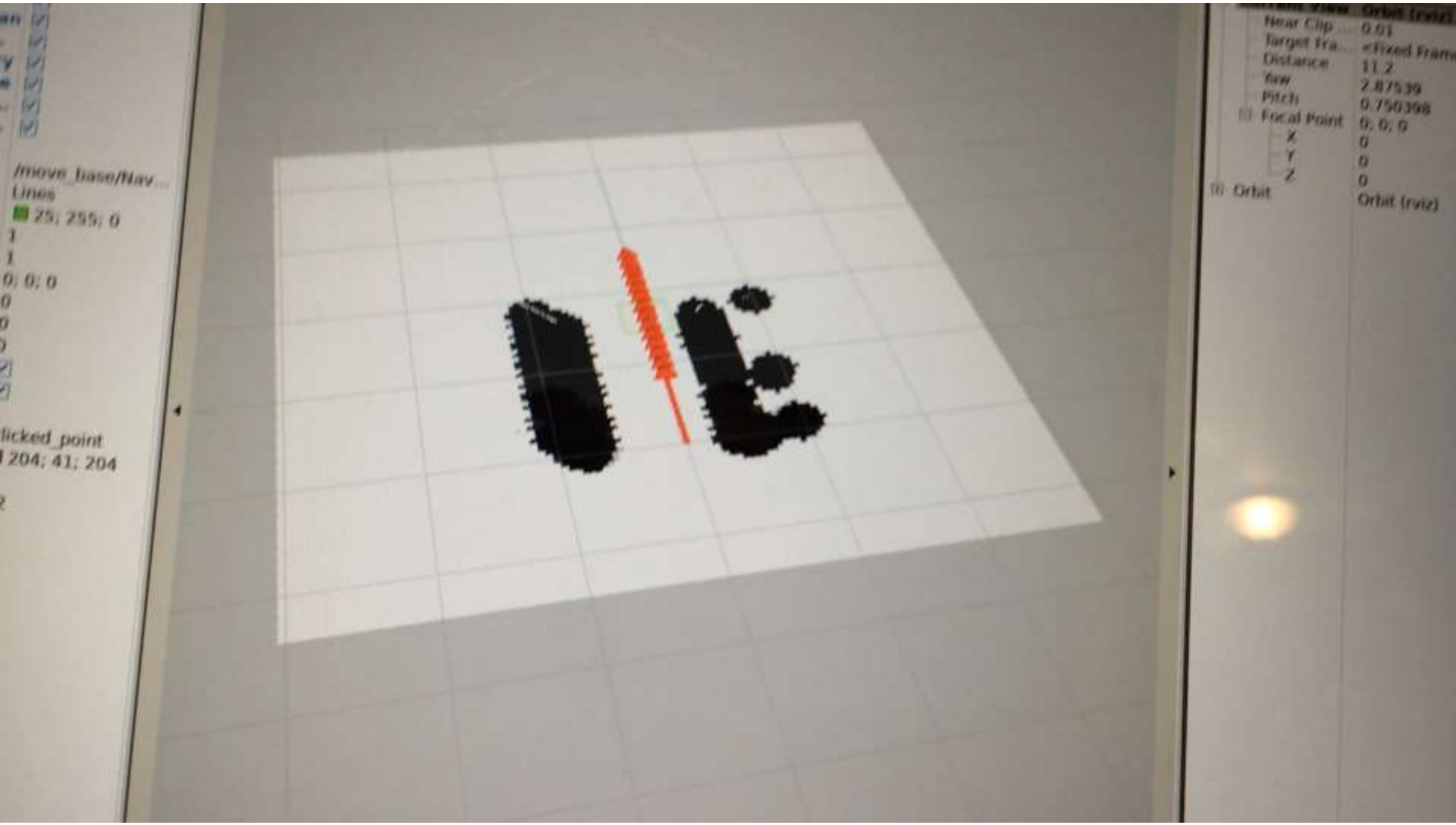
Functional Components:

- Path Planning
- Collect Sensor Information – 2D LIDAR data
- Avoid static obstacles

Current Status: Completed:

- Obstacle Avoidance in Simulation
- Communication between navigation stack and pixhawk achieved

Obstacle Avoidance Functionality & Testing



Obstacle Avoidance

Challenges Faced:

- Tune Navigation Stack parameters
- Realize to change Global map configuration from static to rolling map

Major remaining target/challenges:

- Fix ROS Topic compatibility issues between Navigation Stack and Mavros
- Complete integration on Navigation stack with flight control

Schedule Status: On Track

#7 End January

- Setup Mechanical and Electrical subsystems on new drone

#8 Mid February

- Obstacle Avoidance in Simulation
- Autonomous A-to-B Navigation on Drone

#9 End February

- Initial Obstacle Avoidance Integration
- Autonomous Marker Tracking

#10 Mid March

- Autonomous A-to-B Navigation with Obstacle Avoidance

#11 End March

- Autonomous Marker Search while Avoiding Obstacles
- Autonomous Package Delivery to Known Drop Point

#12 & SVE

- Autonomous Package Delivery

Spring Validation Experiment

Test ID	**E - Obstacle-less package delivery test**	
Detais	Validates that packages can be delivered to a house without any obstacles in the path	
Required	Platform, Open space (outdoor environment), Fully equipped system.	
Step	**Step Description**	**Success condition**
E.1	Place UAV with package at platform	
E.2	Initiate system with GPS coordinates for the house and return point	
E.3	UAV takes off autonomously towards the house	Autonomously navigates using GPS to reach near given GPS coordinates
E.4	Reaches waypoint near the house using GPS	
E.5	Identifies and navigates to the visually marked drop off point (with no obstacles in the path)	Identifies the visual marker and navigates to it
E.6	Lands and drops the package	Placed within 2m from marker
E.7	Autonomously takes off and navigates to the GPS of the return point	Package dropped. UAV departs
E.8	Detects, navigates and lands at the platform with the visual marker	Lands within 2m from the marker

Spring Validation Experiment

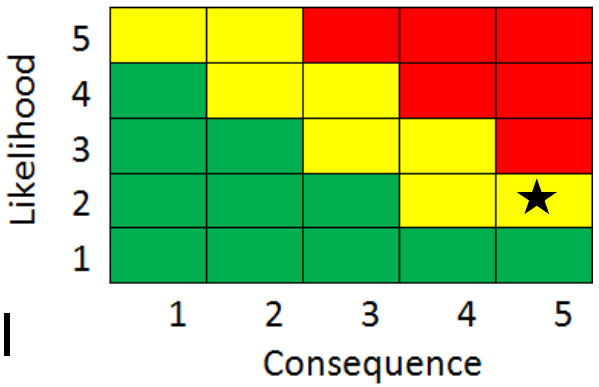
Test ID	**F (uses E) - Package delivery test with obstacles**	
Description	Validates that packages can be delivered to a house even with static obstacles in the path	
Required	Platform, Outdoor environment, Obstacles (cross section: 1.5m x 0.5m, 2m x 2m).	
Step	**Step Description**	**Success condition**
E1-E4	Repeated	
F.1	Searches for the marker or Identifies the marker and plans path to navigate to it	Identifies the visual marker near GPS destination.
F.2	Place an obstacle (2mx2m) in the path of the UAV	Avoids the obstacle
F.3	Place an obstacle (2mx2m) on the side of the UAVs path	
F.4	Repeat with 1.5m x 0.5m obstacles	
F.5	Repeat with both obstacles, placed in 240 degree cone around vehicle	
E.6-E8	Repeated	

Budget

Item	Projected budget
Spent	$ 3,311
Balance	$ 689
Projected Expenses • Test Environment	$ 200

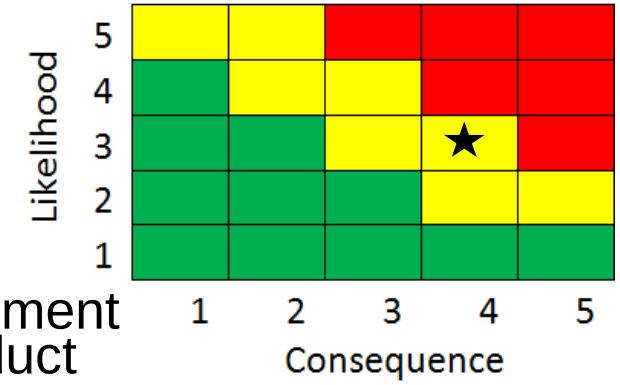
- Used 83% of allocated $4,000
- Multiple spares bought and set up
- Remaining balance for emergencies

Risk 1: Marker Search Algorithm not robust



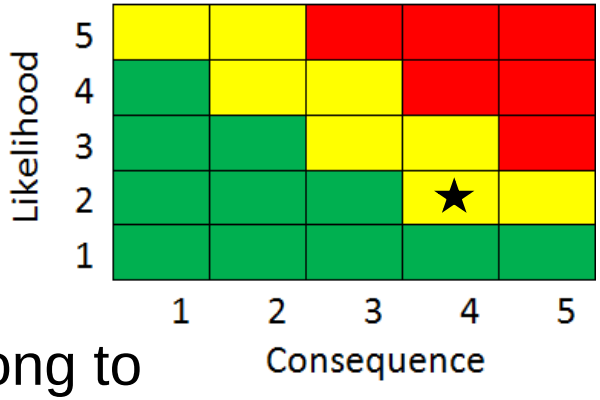
- Type: Technical
- Description:
  - There is a possibility that the UAV will not find the marker
- Consequence:
  - Drone will fail to deliver the package
- Mitigation:
  - Experiment with different search patterns (e.g. increase granularity)

Risk 2: Weather limiting testing opportunities



- Type: Operational
- Description:
  - UAV must be tested outdoors and inclement weather may limit opportunities to conduct tests
- Consequence:
  - Delayed integration of subsystems
- Mitigation:
  - Integrate software subsystems on simulation
  - Review weather forecasts ahead of schedule

Risk 3: Integration of Navigation Stack with Pixhawk



- Type: Technical
- Description:
  - The navigation stack may take too long to integrate with the flight control.
- Consequence:
  - Delayed integration of subsystems
- Mitigation:
  - Integrate early. Start integration on simulation
  - Have backup delivery without obstacles prepared

Conclusion

Completed

- Electrical/physical assembly
- Integrated subsystems:
  - Vision
  - Sensors
  - Gripper

Pending

- Integrate Navigation Stack
- Testing

On track for SVE

Questions?