FlySense

Augmented Reality FPV assisted navigation (applied to a helicopter)

Design Review
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Shivang Baveja
Nick Crispie
Joao Fonseca Reis
Harikrishnan Suresh
Sai Nihar Tadichetty

Enhanced situation awareness using Augmented Reality to assist in aerial navigation

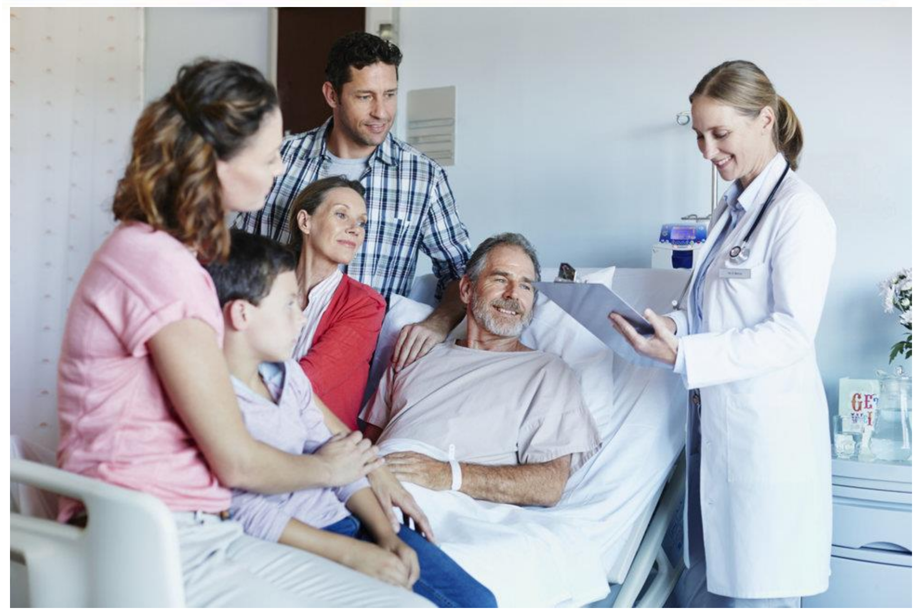
Solution

Commander Dolan
with FlySense

Pilot assistance system which keeps pilot close to the reality by giving all the necessary information right in front of their eyes

- Display surrounding obstacles
- Warn pilots about possibility of collision (escalating warning)


POLICE
911

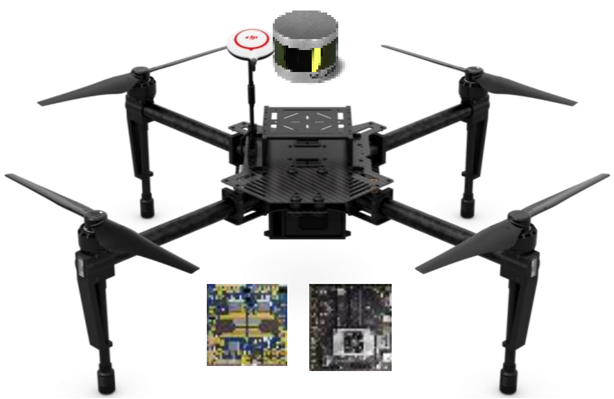


We have tailored our requirements to align with feedback from NEA pilots

Feature	Target Performance
Bird's Eye View coloring	• Clearly communicate forward direction (e.g. an arrow, a triangle) • Ensure surrounding images move smooth across time • Include a "ghost ring" indicating where it is really dangerous (addition to coloring obstacles) • Show no more than THREE levels of coloring on the obstacles (with crisp colors) • Most dangerous object should be blinking and have a bigger dot in the screen
Bird's Eye View sound	• Sound warnings should have current pilot input into account (not potential inputs) • Sound warnings should be consistent with the coloring regions (<THREE levels of warning) • Either do 360 degrees warnings or simply do flat sound (e.g. do not distinguish left or right) • Audio warnings should always be done at the same pitch to clearly identify its relation to obstacles
Pilot input override	• Pilot should clearly understand the dimension being constrained: speed or attitude – The dimension being constraint should be colored accordingly in the HUD with YELLOW or RED – Show message at the bottom of the HUD with the dimension being overridden

The final SVE system will have three major components: Aerial, Communications & User System

Aerial System



- DJI Matrice 100 (mounted with Jetson TX-2, Velodyne VLP16 Puck, PDB) and FPV Camera

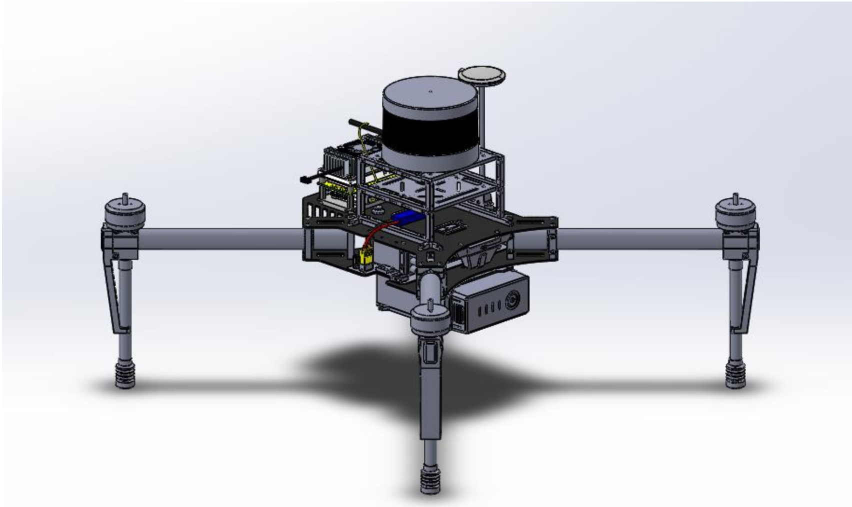
Communications

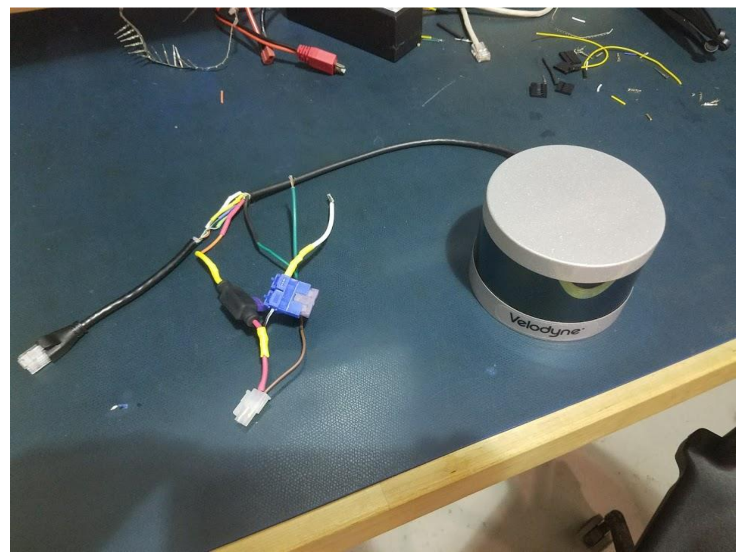
- 5 GHz Dual Radio Base Station with a 14dbi directional antenna

User System

- Epson BT 300 Augmented Reality headset
- Headset for audio warnings & voice command recognition

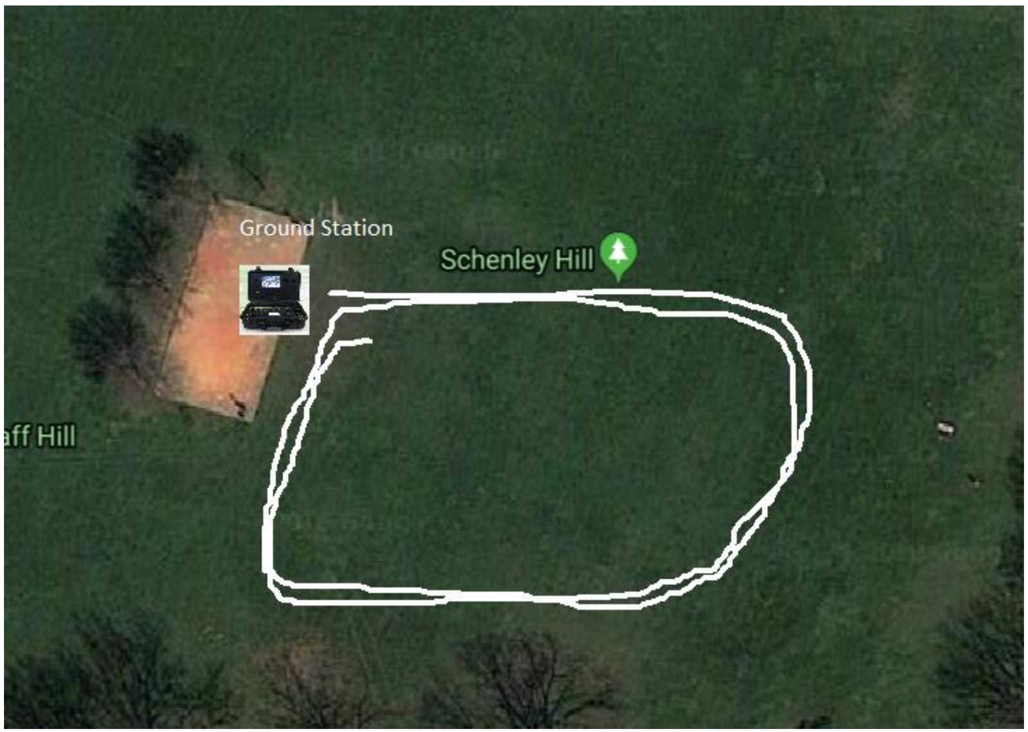
AERIAL SYSTEM: FLIGHT HARDWARE





Flight test at Schenley to test for latency

- Image stream published onboard the quadcopter and the received image stream was recorded.
- Test Parameters: Distance, Yaw, Altitude

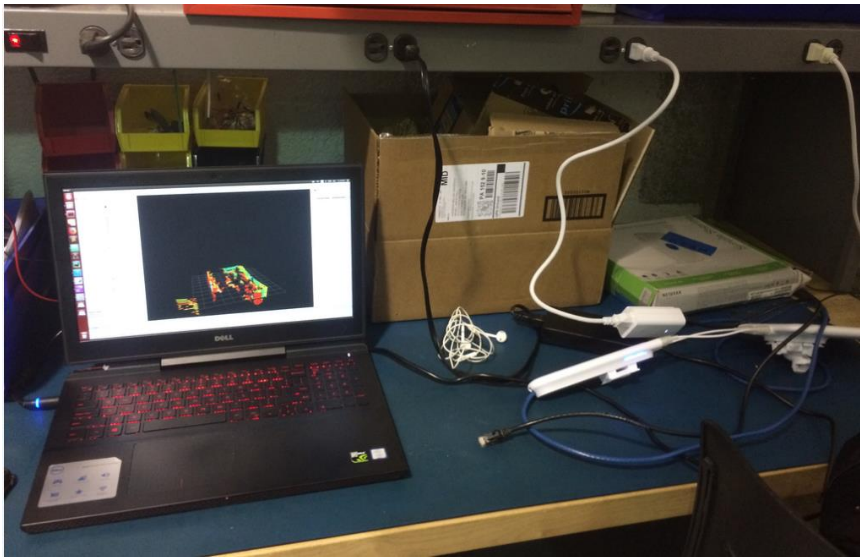


Results:

- No latency seen when flying at altitude less than 30m
- No latency seen when flying upto a distance of 60m, haven't tested beyond that.

Infrastructure ready to deploy the new software packages being developed

- Power module configured to output 12V and tested to ensure it can give sufficient current
- Velodyne modification: removing the box, shorten the cable
- Mounting Velodyne
- Quadcopter Wiring: Multiple fuse were placed to prevent damage to components
- DJI and Velodyne data coming perfectly in lab without any issue



Aerial platform was tested in steps to ensure safety

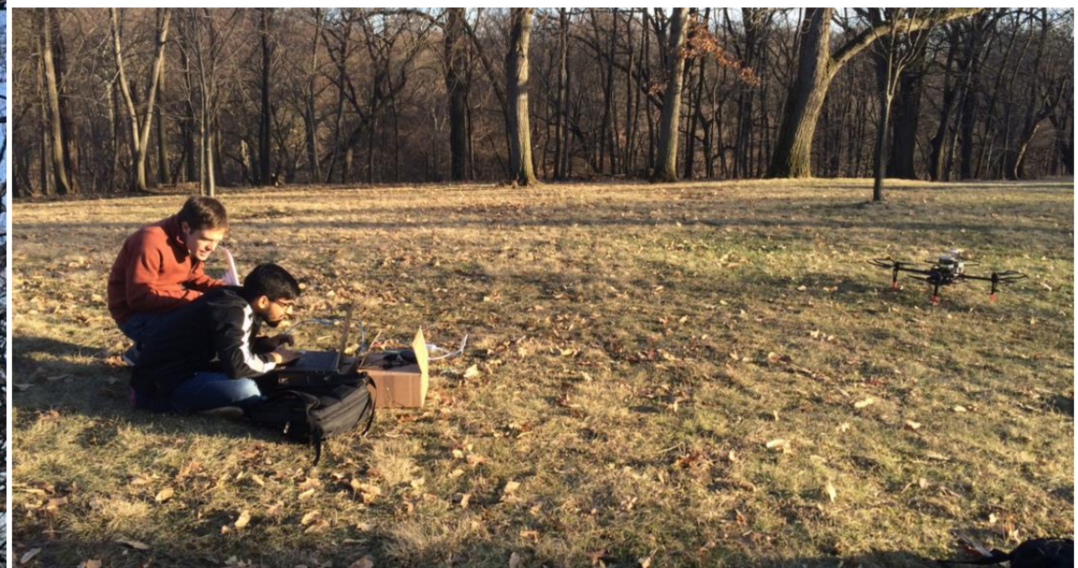
S.No.	Flight Test	Number of flights	Flight Time(min)
1	Flight without payload	2	10
2	Flight with dummy weight (400g)	1	9
3	Flight with dummy weight (800g)	1	13
4	Flight with dummy weight (1050g)	2	12
5	Flight with Jetson TX2	3	20
6	Flight with Jetson TX2 + dummy weight	2	18
7	Flight with Velodyne + Jetson TX2	2	13
	Total:	**13**	**95**

Flight System works reliably, next step is to add FPV camera

Collect data in SVE mission environment

Flight Test at Schenley Park

DJI M100 with Velodyne and Jetson TX2



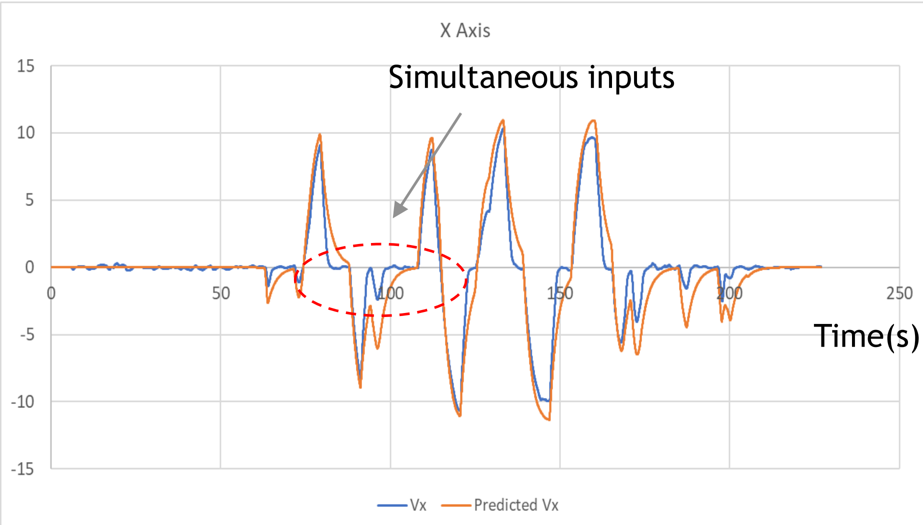
Starring Hari, Nick and Shivang in the background

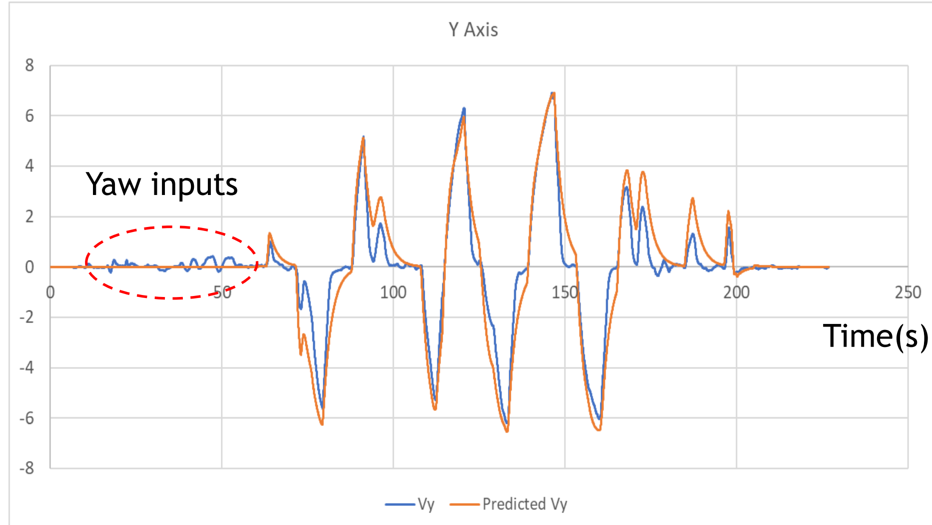
AERIAL PLATFORM: VIDEO OF SYSTEM TEST

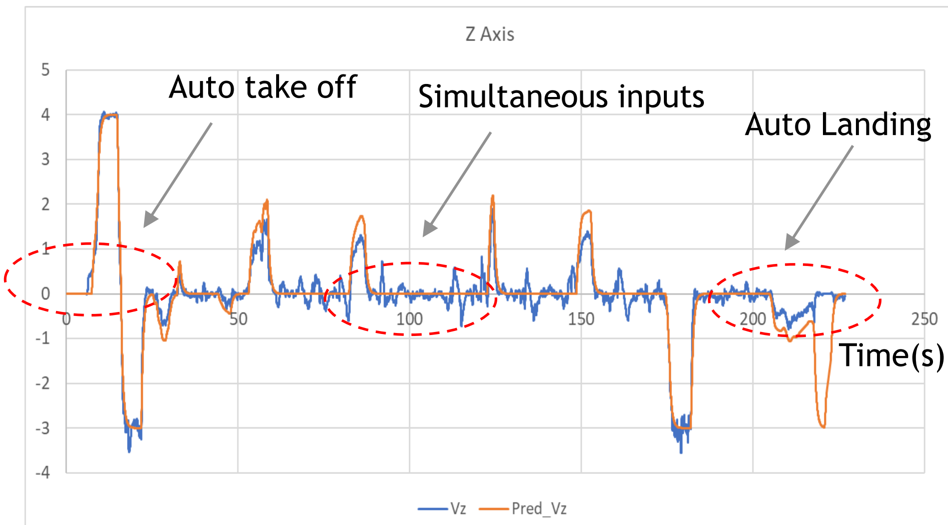
ProjectFolder-AreaFolder-Name-Date-DesktopPublishing-Author

The data from the second flight made on 18th February was successfully fitted to the dynamic model as we were able to successfully process all pilot inputs

… and accurately predict the speed across time using our approximate closed form dynamics model (projecting from the beginning of simulation, not from latest measurement)



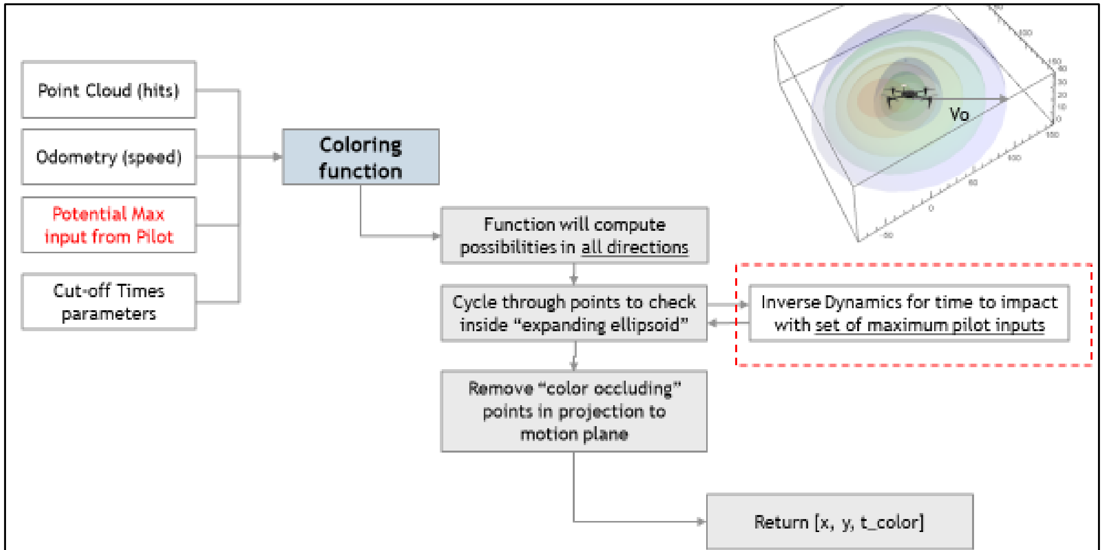


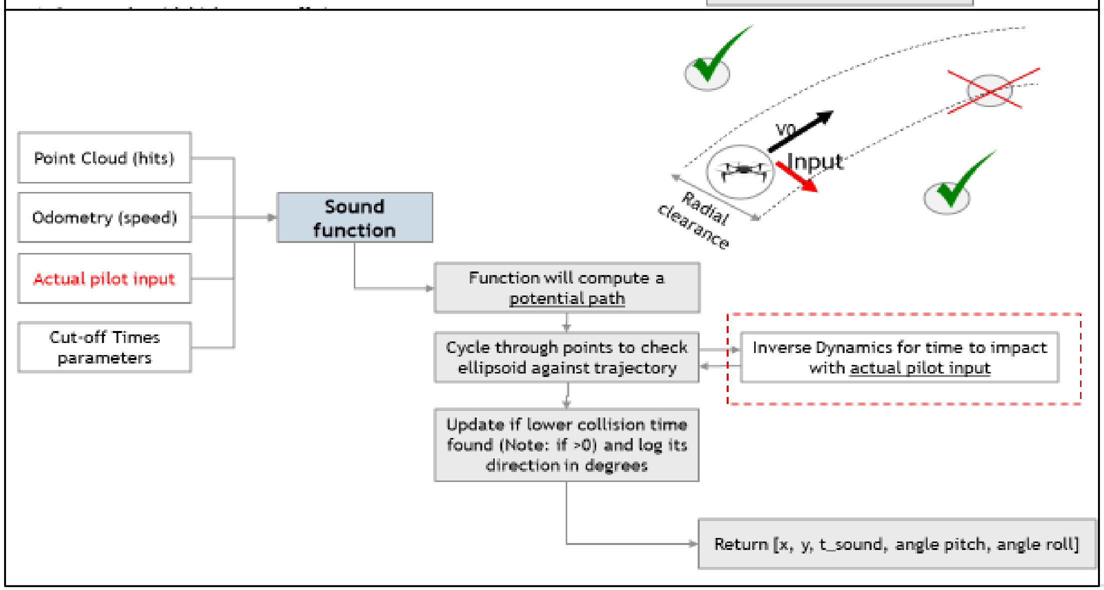


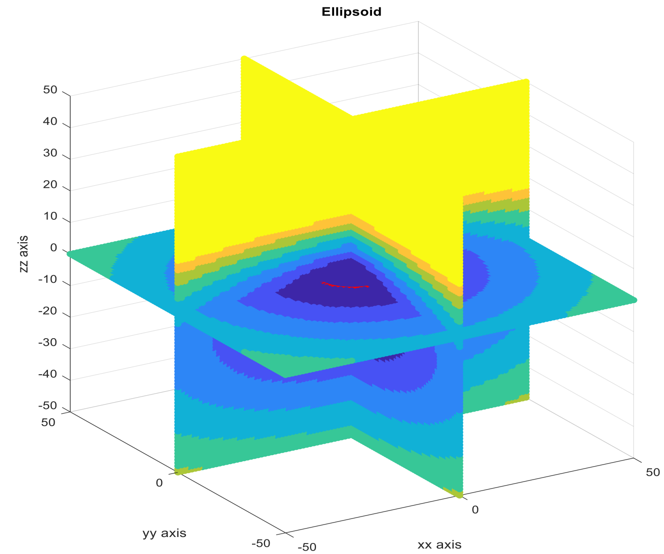
Sources of divergence:

- Flight phases with no pilot input
  - We used Autopilot to take-off
  - We used Autopilot to land
- Pilot introduces SIMULTANEOUSLY a pitch/roll and a throttle command, the DJI software cannot decouple the XY projection present in the "Throttle component"
- Yaw (rotation) inputs were ignored in this simplified translation motion model

Code for new dynamic window, new sound function, coloring function and "circle of doom" in line with NEA pilot workshop feedback being optimized and integrated with FlySense







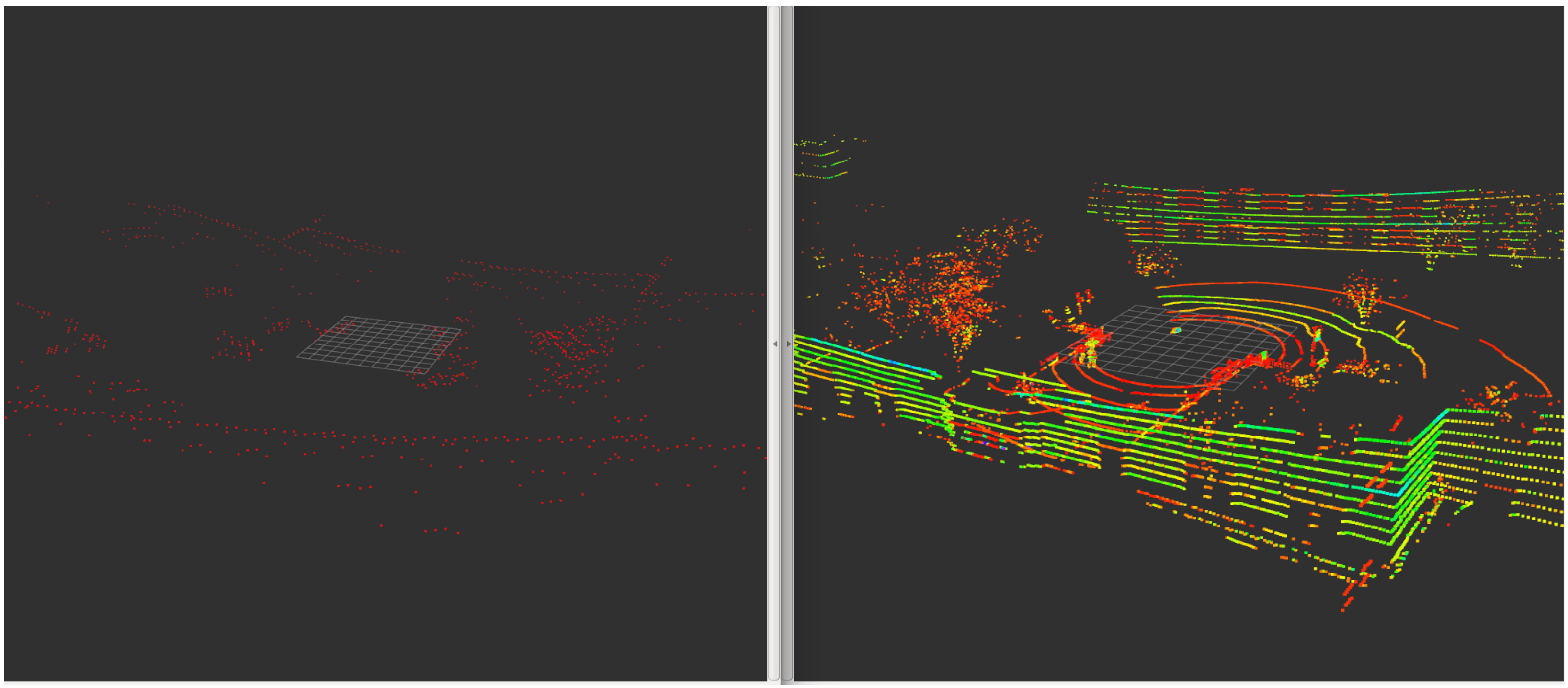
- Algorithm tested successfully in MATLAB with dummy data
- ROS node tested with dummy data and compared with MATLAB results
- ROS node integrated with FlySense software stack

Sound warnings in 3D

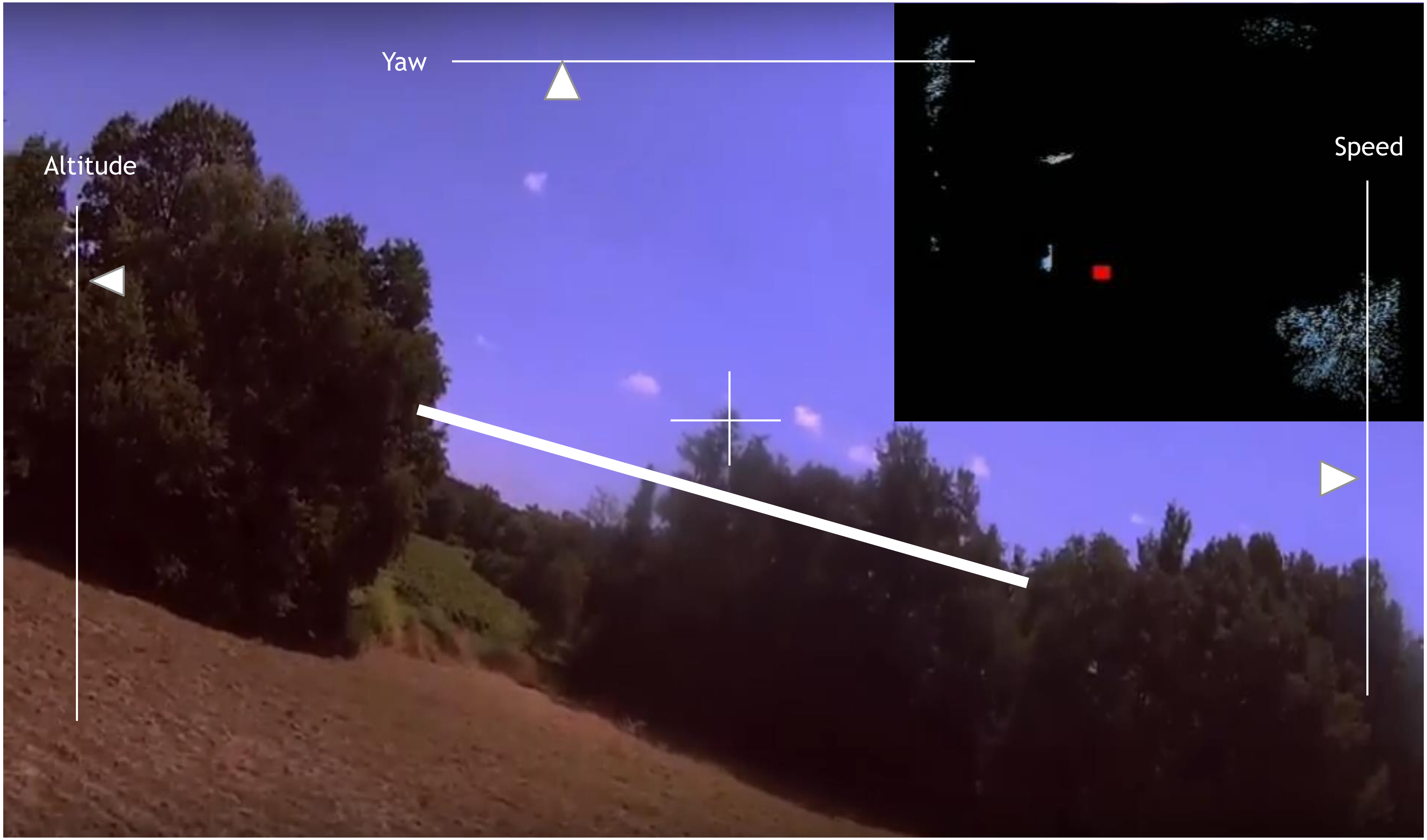
- Velodyne_height_map code modified to give obstacles in 3D
- Grid based approach – height of $cell_i$ = max(height of all points in $cell_i$)

Next steps:

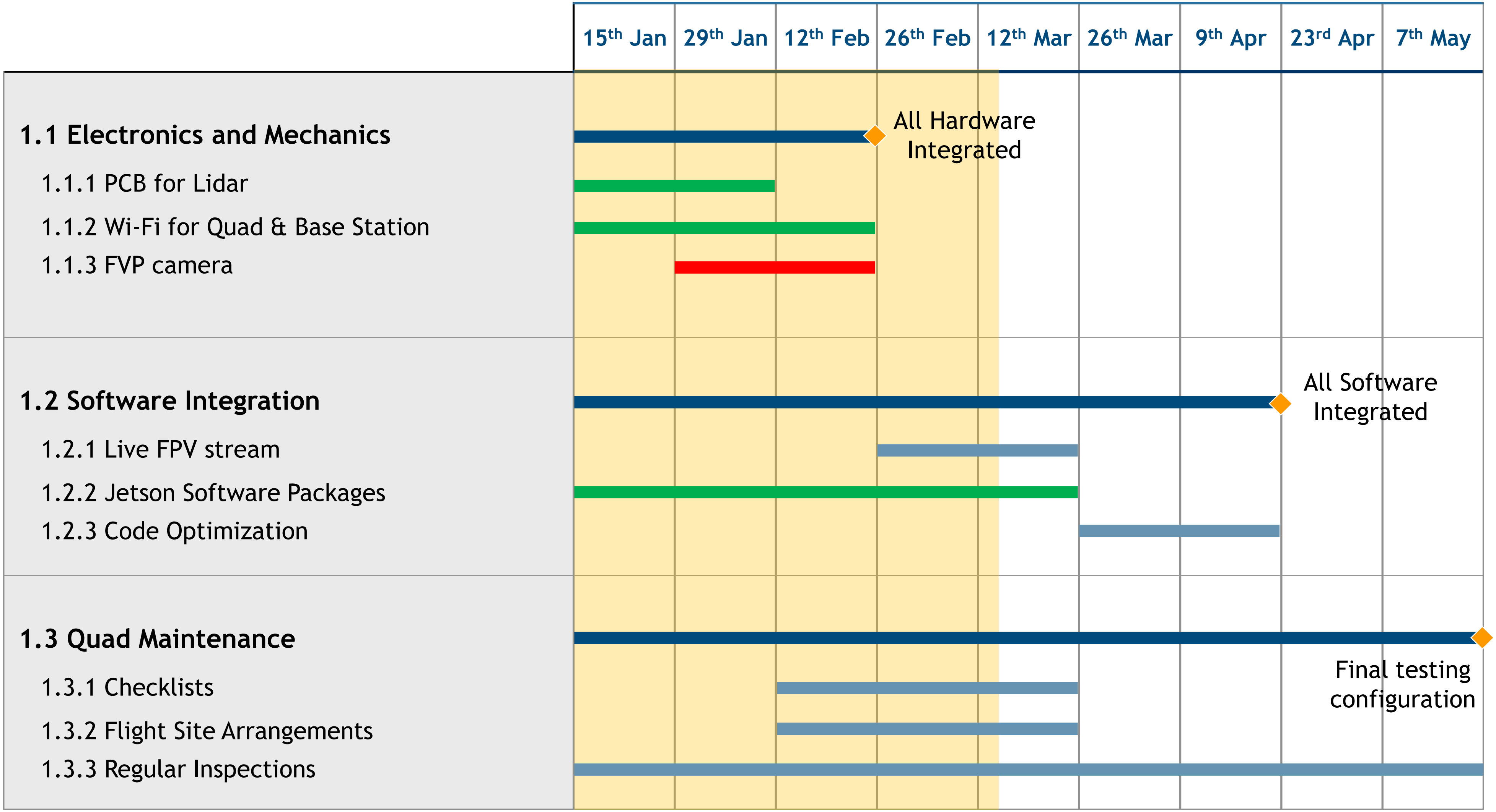
- To be merged with new dynamic window code
- Dynamically change parameters of grid based on flight dynamics
- Apply correction to height values based on flight tests



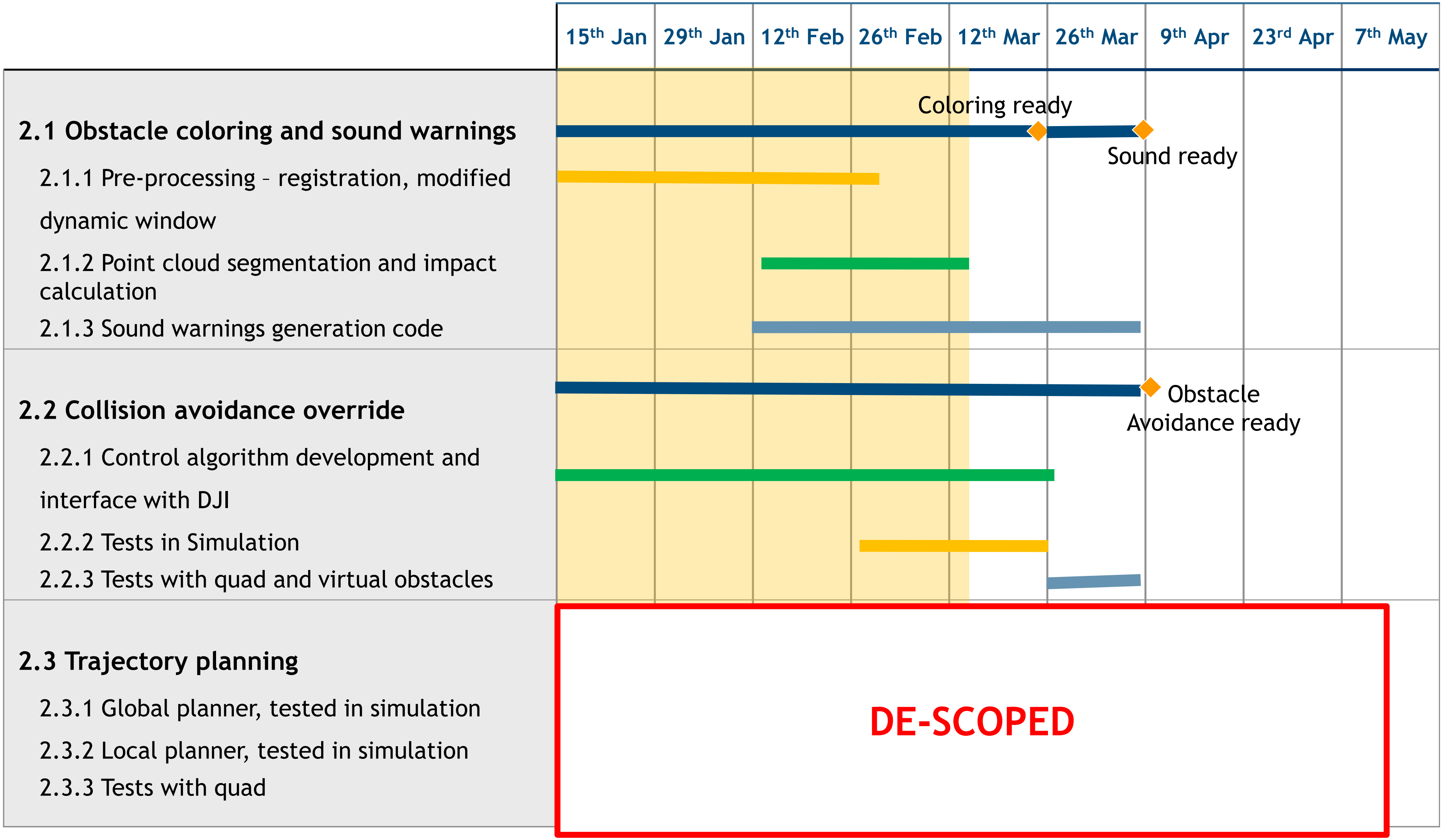
New integrated screen with two areas overlaid over FVP video being streamed from the quadcopter



PROJECT SCHEDULE: FLYING PLATFORM



CURRENT SYSTEM STATUS: PILOT ASSIST FEATURES



We have initiated testing at sub-system level in a flying quadcopter

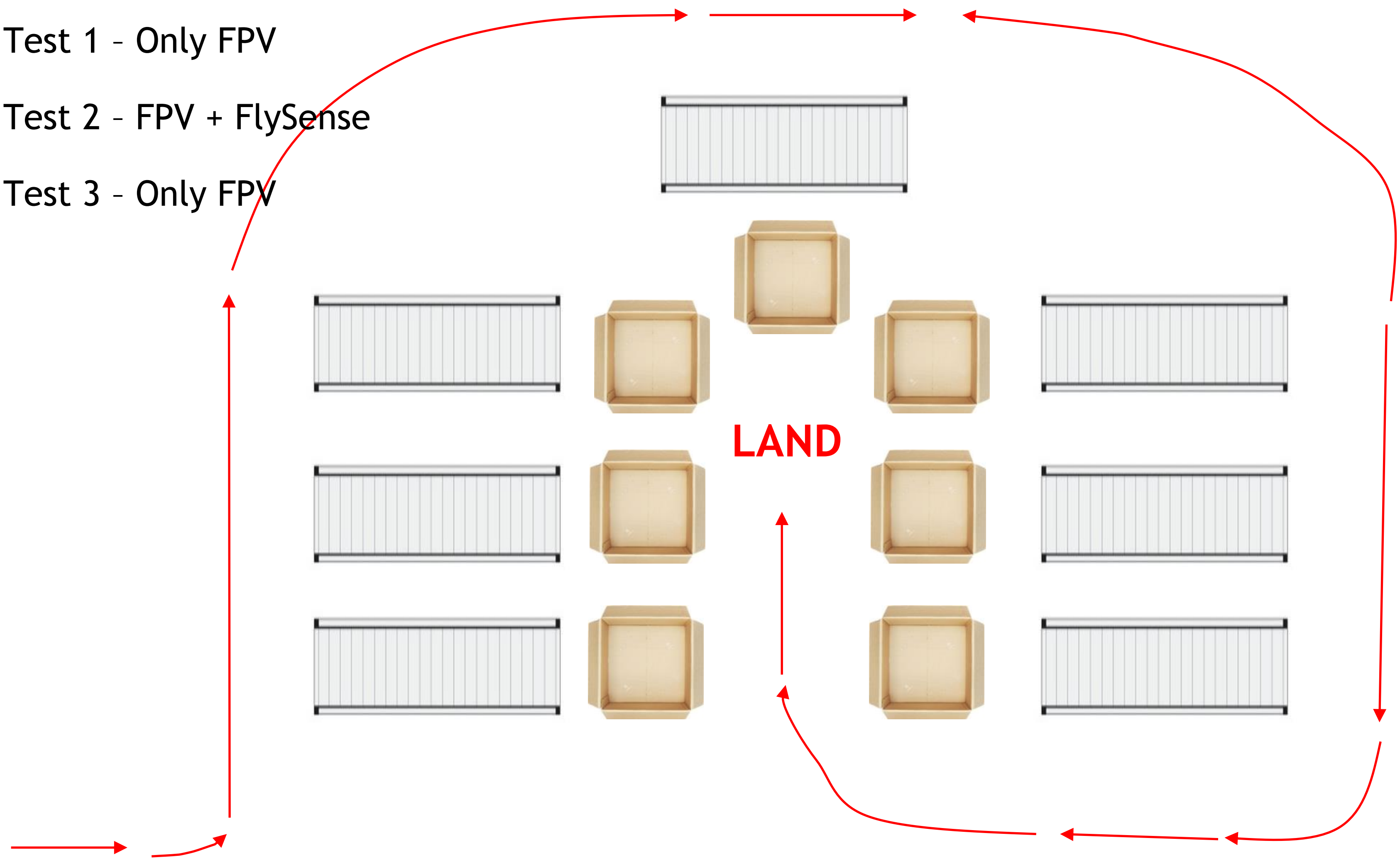
Test	ID	Architecture	Date	Status
T01	Sub-system	Quad Flights with Weights	10-Feb	OK
T02	Component	Power Module Test	12-Feb	OK
T03	Component	Communications Test	10-Feb	OK
T04	Sub-system	Log flight data to tune flight dynamics	13-Feb	OK
T05	Sub-system	Flight with Velodyne and Jetson onboard	20-Feb	OK
T06	Component	Test FPV Camera	14-Feb	OK
T07	Sub-system	Flight with Velodyne, Jetson and FPV camera	~~28-Feb~~	10-Mar
T08	Sub-system	Flight to Evaluate Birds Eye View, sound warnings	~~7-Mar~~	15-Mar
T09	Sub-system	Flight to evaluate “Stop” functionality	21-Mar	
T10	Sub-system	Flight with new video feed merging FPV and user widgets	14-Mar	
T11	System	SVE Dry run 1 (NREC)	4-Apr	
T12	System	SVE Dry Run 2 (Nardo)	11-Apr	
T13	System	Mini SVE (near campus)	25-Apr	

The maze test at NEA testing field will be done both with and without the FlySense system

Test 1 – Only FPV

Test 2 – FPV + FlySense

Test 3 – Only FPV



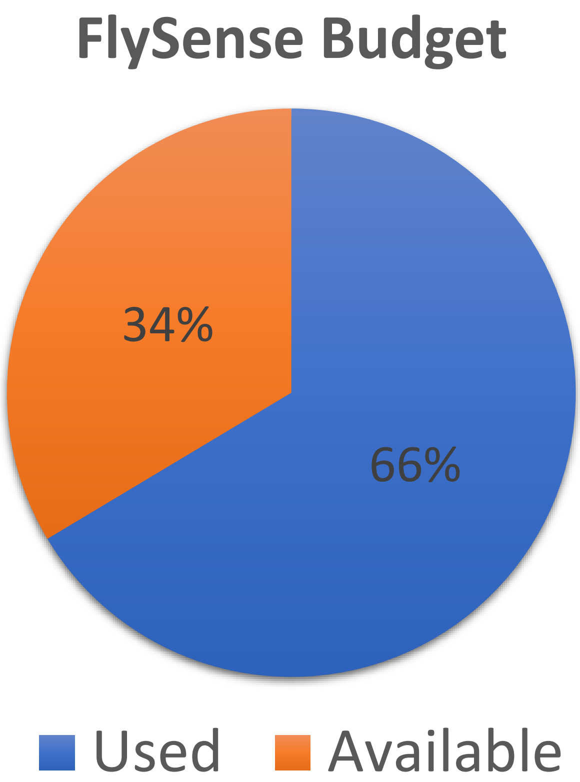
The first virtual obstacle test will be done in open field

Virtual Wall

1. Quad flying at 5 meters altitude

2. Pilot tries to crash into the virtual wall added in the LIDAR data

3. Algorithm will limit the “dangerous direction” but allow free movement in all the other directions



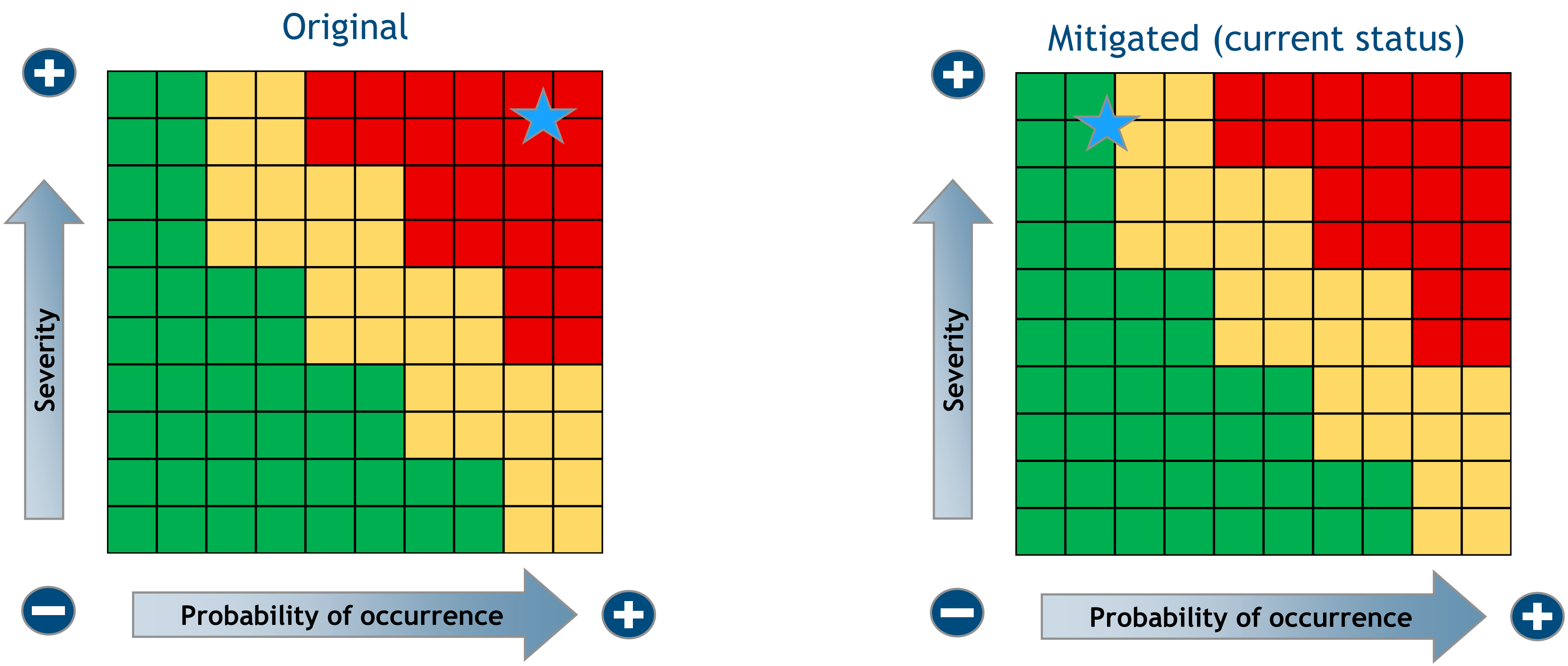
Recent Purchases

- WiFi Antennas
- Battery for powering Base-station
- Nvidia Jetson TX2
- FPV Camera

Future Purchases/Earmarks

- Additional M100 Battery(s) (~$200)
- Equipment for ease of testing/setting up Base Station (<$150)
- Leaving some reserve funds (~$500-$1000) for spare parts in case of crashes

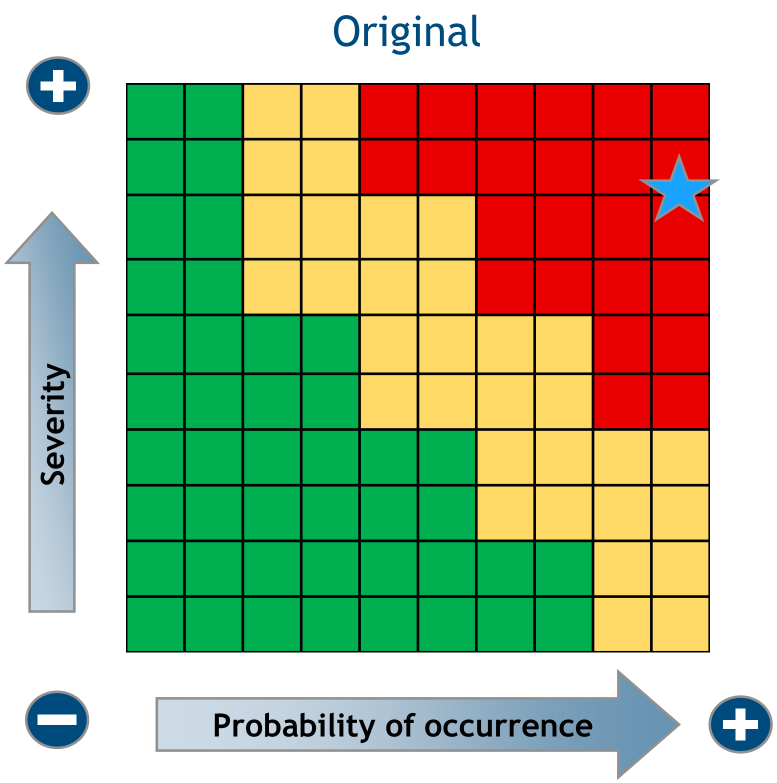
Quadcopter Connectivity Risk Mitigation

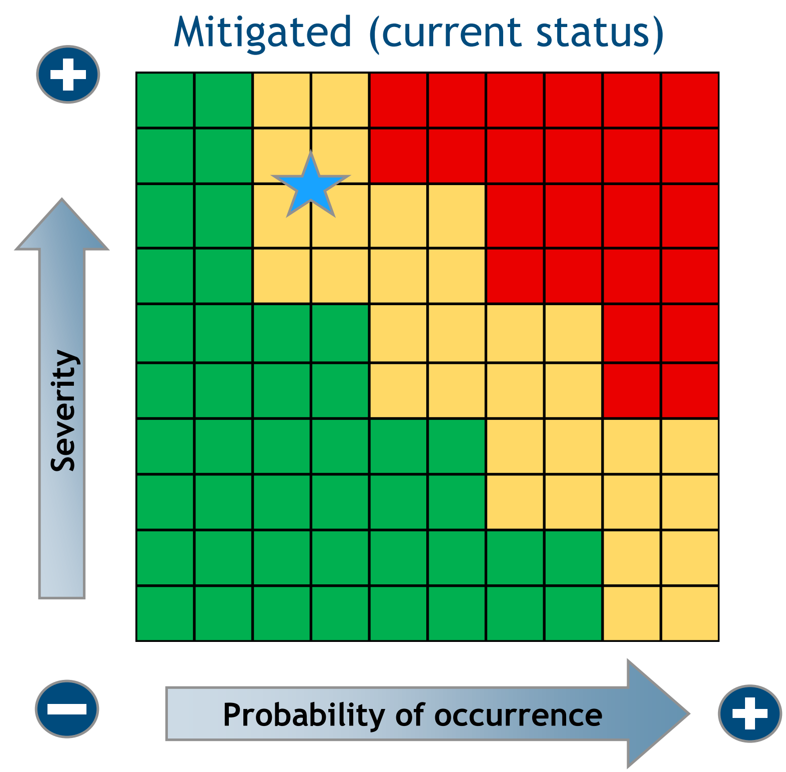


Risk Mitigation Strategies

- Switched to Jetson TX2 with better connection built in and online support
- Purchased powerful 2.4GHz directional antenna
  - Tested extensively over 100m range

Quadcopter Overweight Risk Mitigation



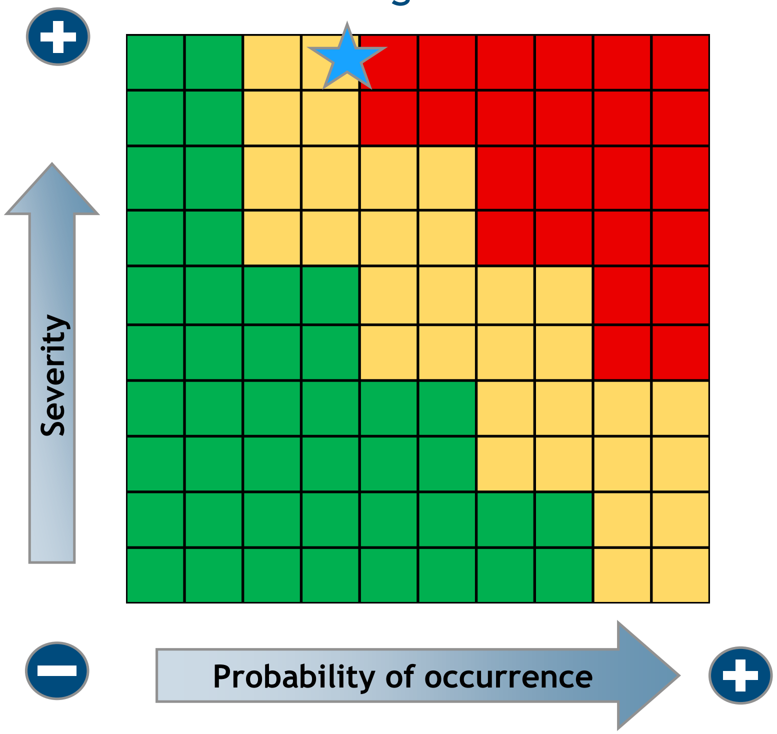


Risk Mitigation Strategies

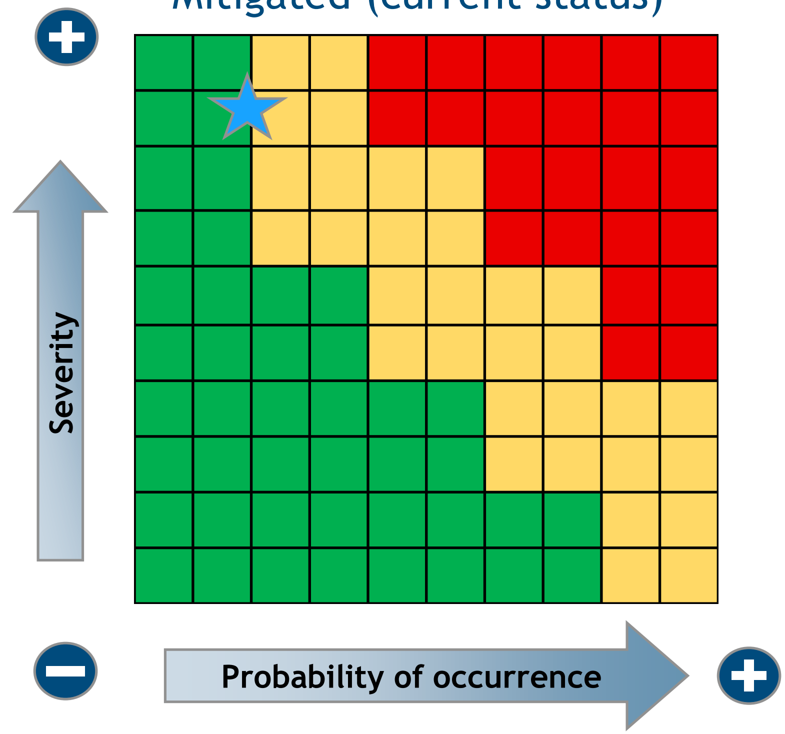
- Removed 150g of cable and 200g interface box from Velodyne
- Switched to lighter 24V-12V DC-DC regulator (saved 100g)
- Limited use of heavier connectors and extra wires
- Lighter mounting method for Velodyne (saved 80 g)

Quadcopter Crash during Flight Risk Mitigation

Original



Mitigated (current status)



Risk Mitigation Strategies

- Detailed flight hands approved by 2 people beforehand
- Pre-Flight checklists
- Lightened quad
- Robust hardware-won’t catch in propellers and greater chance of survival in minor crashes

Thank You!