Progress Review 1

Team A: Mind The Gap

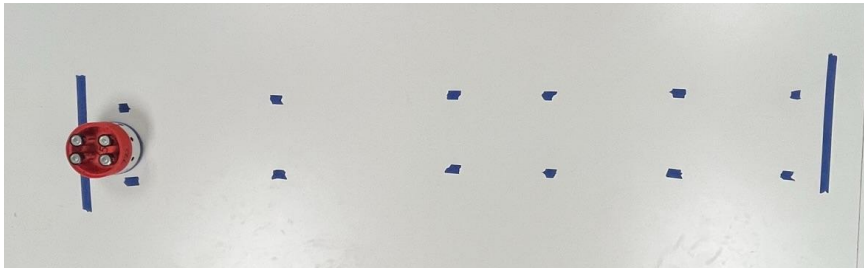
Agenda

1. Mechanism Design and Payload Tests - Sankalp
2. Localization using VICON - Sudhansh
3. Server-Agent communications - Hari
4. Task Allocator based on Hungarian Algorithm - Sandhya
5. Collision free MAPF planner - Dhanvi

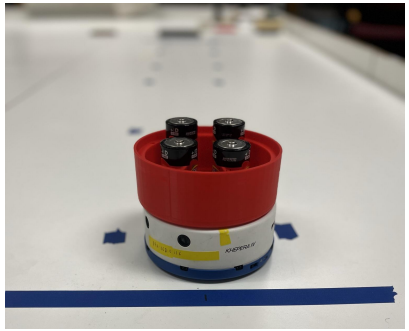
Coupling Mechanism

Work done for PR1:

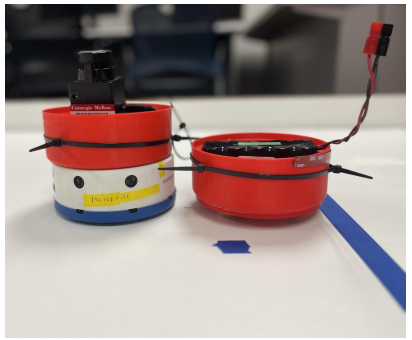
1. Khepera Payload Test



Test Track

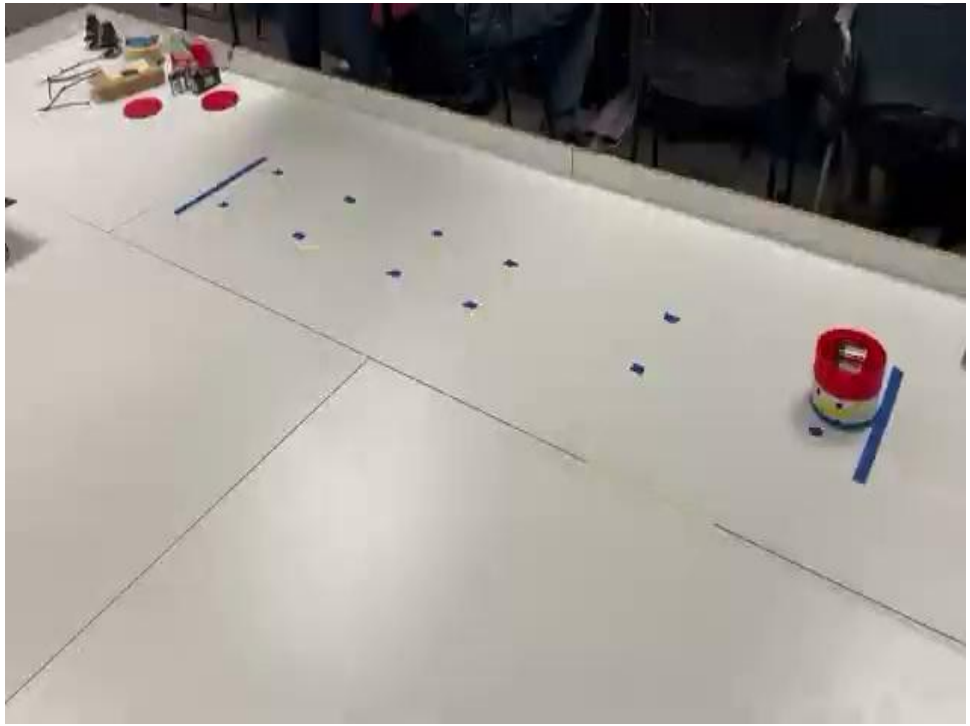


Individual Agent



Coupled Test

Coupling Mechanism

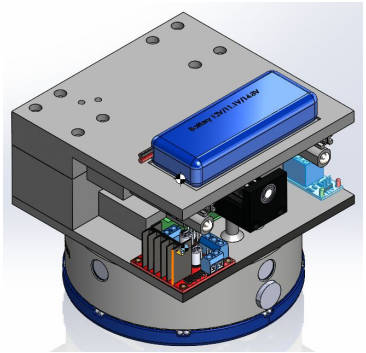


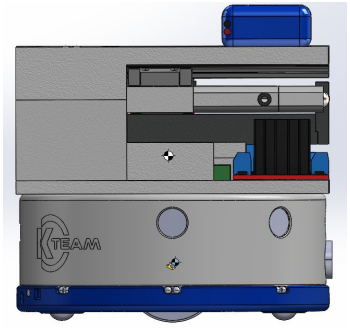
Test Run Video

Test No.	Weight (g)	Time Readings (LR1, RR, LR2)
1	784	3.98, 3.26, 4.12
6	1005	4.13, 3.23, 4.38
12	1588	3.66, 3.01, 3.78
22	2468	Failed attempt
24		4.33, 3.9, 4.62
30	3009	4.38, 4.02, 4.57
38	3566	4.44, 3.98, 4.69

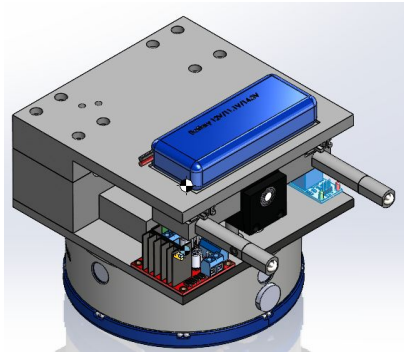
Coupling Mechanism

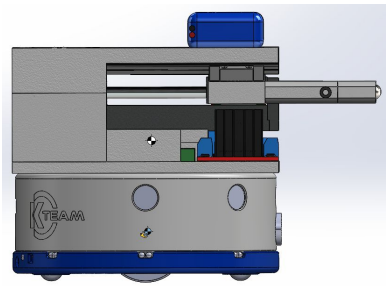
2. Coupling Mechanism Version 1- CAD



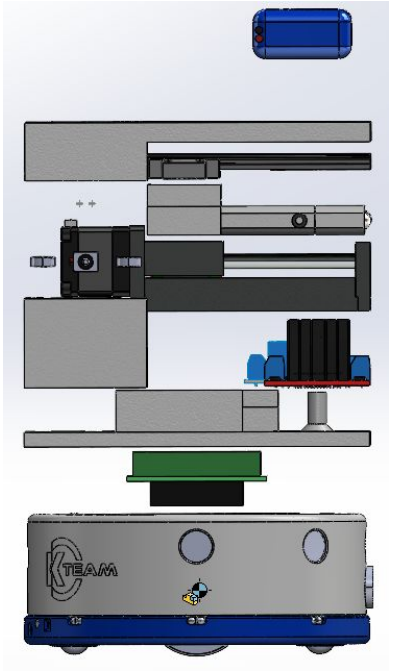


Pin Retracted



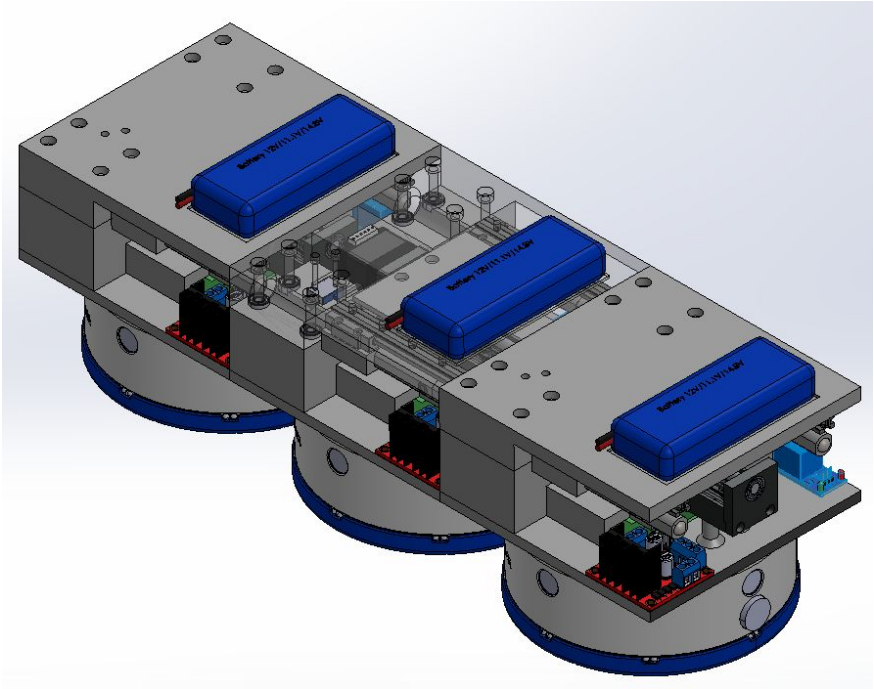


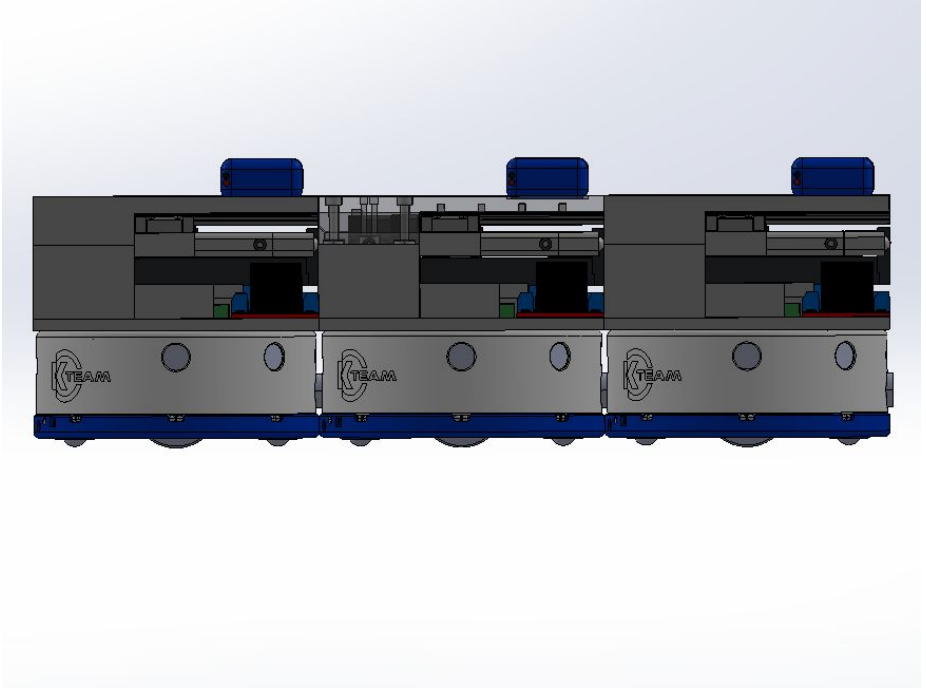
Pin Extended



Exploded View

Coupling Mechanism





Coupled State

Coupling Mechanism

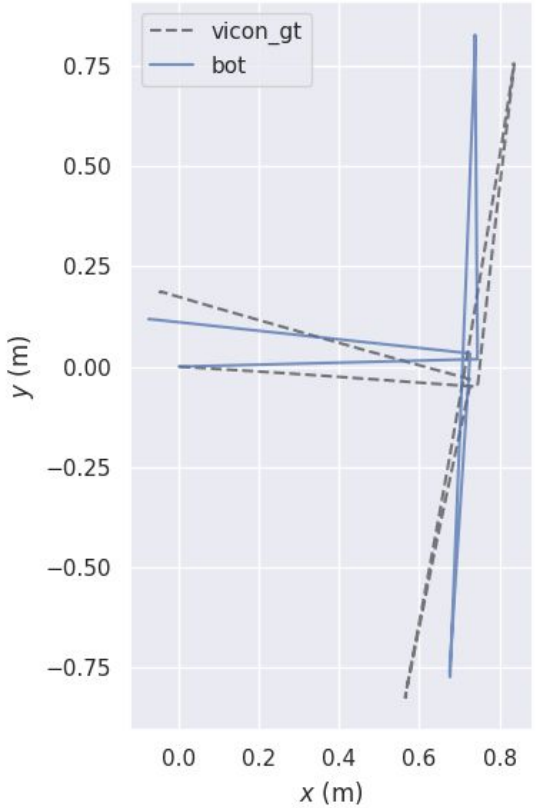
Goals for PR2:

1. 3D Prints
2. Procure Components
3. Initiate Assembly

Localization

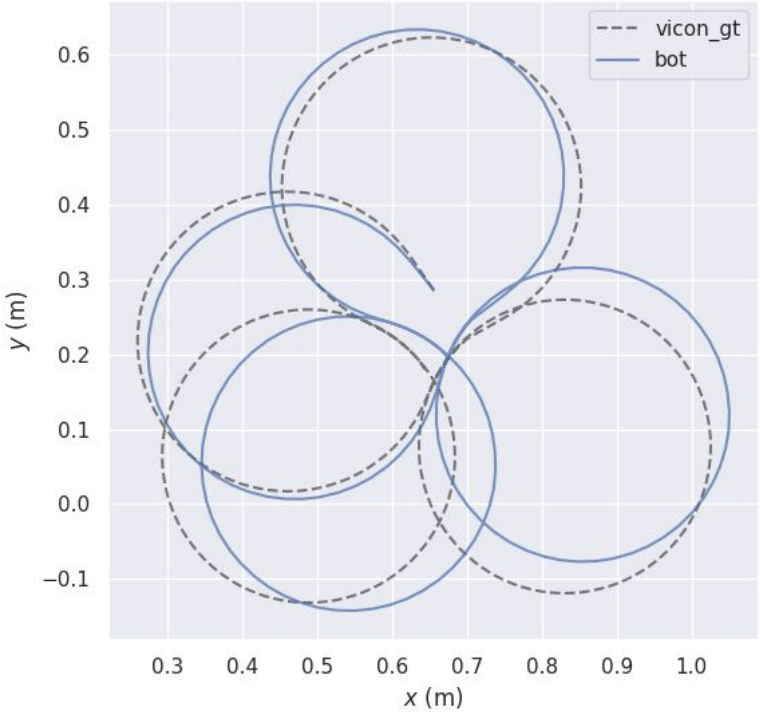
- Evaluated wheel odometry of the robots by comparing with trajectory from the VICON tracker
- Collected data from live runs using ROS
- Computed the Absolute Pose Error (APE) and Relative Pose Error (RPE) used as standard metrics for odometry evaluation
- Tried on random trajectories with enough straight lines and curves
    - Settled on 2 candidate trajectories to compare robot performances throughout
        - T-shape: Straight lines and in-place rotations
        - 8-shape: Curves in the trajectory; more relevant to pure pursuit types of control

Localization: T-shape Trajectory



Metric	Absolute Pose Error (m)	Relative Pose Error (m)
Mean	0.033763	0.002546
RMS	0.048392	0.004497

Localization: 8-shape Trajectory



Metric	APE (m)	RPE (m)
Mean	0.146804	0.007857
RMS	0.158103	0.009737

Localization: Challenges

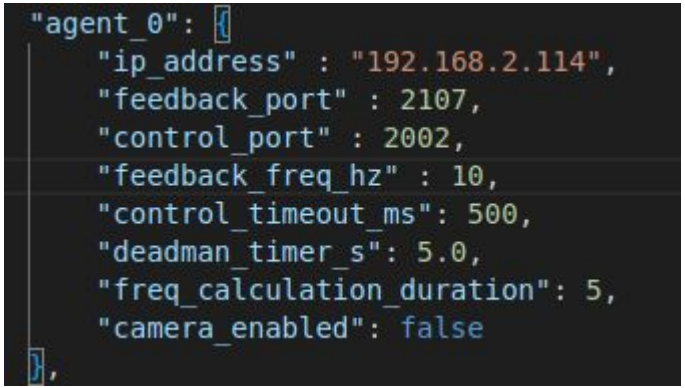
- Miscalibration of the VICON tracker accumulates large errors over time
  - VICON cameras pretty sensitive to disturbances in the environment
- Odometry thrown off if wheels aren't cleaned
- Ground clearance is very small; robots get stuck
  - Encoders keep ticking, odometry gets thrown off

Localization: Future Work

- Integrating SLAM Toolbox and using the Khepera's LRF Module
- Integrating the VICON's tracked odometry with SLAM Toolbox for map building
- Evaluating odometry from SLAM Toolbox
  - Using LRF scans and wheel odometry together
- Increasing payload improves localization accuracy
  - RoboSAR suggested we try this out and was validated

Communications

- Setup ROBOSAR FMS repository and tested the communications
  - UDP, Protobuf based



- Checked the maximum frequency for sensor data transmission - 10 Hz

Communications

- Checked the quality of data transmission by checking losses in sequence IDs
  - Tested for individual agents
  - Tested for multiple agents together - 3
- Debugged an issue where robot was not responding because of a missing LRF

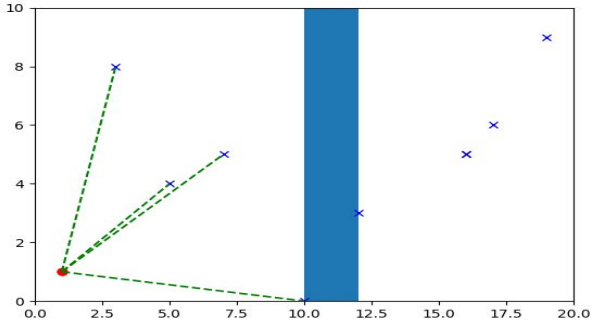
Future work

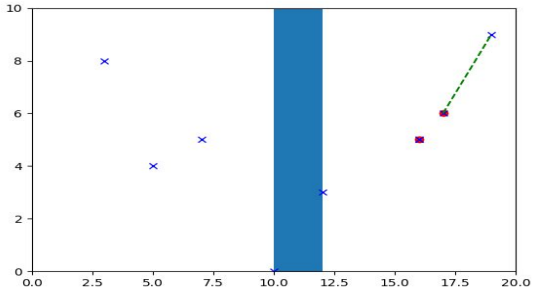
- Work on Pure pursuit controller and implement waypoint navigation in simulation and hardware
- Check Velocity obstacles method implemented by ROBOSAR team for centralized controller

Task Allocation

<u>Work done for PR1:</u>

- Literature Review of task allocation approaches
  - Focus on small robot swarms
  - Greedy algorithm - relatively naive, good starting point
  - Hungarian algorithm is good for one to one task allocation.
- Python program (Greedy POI Allocation)
  - Allocates POIs to robots on one side of a gap.
  - Uses A* to calculate cost per robot to reach a given POI, considering obstacles.
  - Uses the Hungarian algorithm to efficiently allocate POIs to the robots
  - Ensures that all POIs are allocated to robots





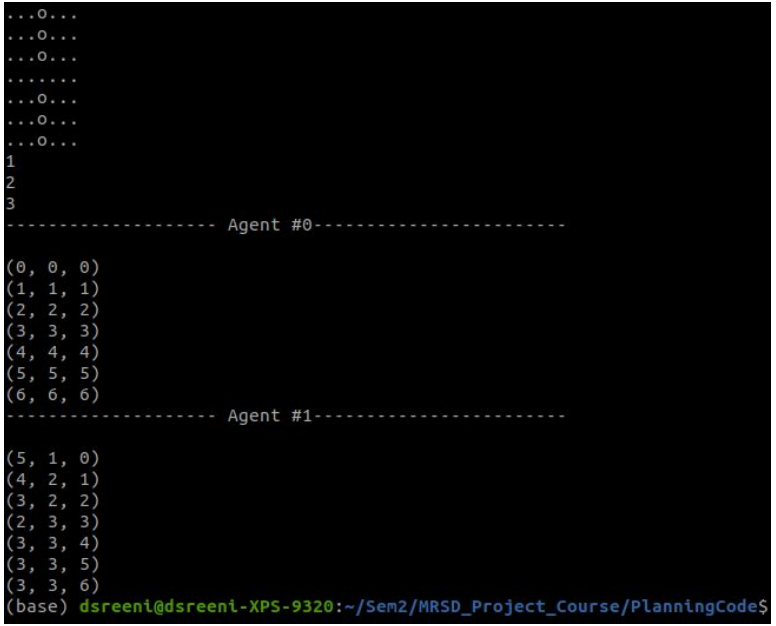
<u>Goals for PR 2:</u>

- Integrate greedy algorithm with planner and ROS
- Create reasonably optimised gap crossing task allocator, implement in simulatio..

Planning

Work done for PR1:

- Lit review of MAPF approaches
  - Multi-agent A* (very expensive)
  - Prioritized Planning (Quick but no guarantees)
  - Conflict based search (Optimal with good speed)
- C++ program
  - Takes input map and tasks as txt files (discretized 8-connected grids)
  - Outputs collision free paths for each agent
- ROS
  - Familiarization tasks (chatbot_node)
  - RoboSAR OccupancyGrid and map_server implementation



Goals for PR 2:

- Implement CCBS (plans for a fixed time horizon)
- Create a Planner ROS Node and integrate with OccupancyGrid
- Test in simulator

Risk Management

Key Risks Mitigated:

1. Identifying and ordering of parts (both final and local options for backup)
2. Payload tests suggest Khepera will be suitable for the task
3. Robosar FMS has been tested thoroughly with all agents and will be suitable

Key Risks Yet to Be Mitigated:

1. Sensor interference with enclosure
2. Enclosure breaking during testing

New risks:

1. Discretized planning approach might not be suitable
    - Need to perform unit test on actual hardware ASAP (By PR2)
2. Integration risk with Khepera extension boards
    - Use existing Khepera extension boards in lab to perform quick tests (By PR2)

Risk summary

Risk Title: High Lead time for coupling actuators

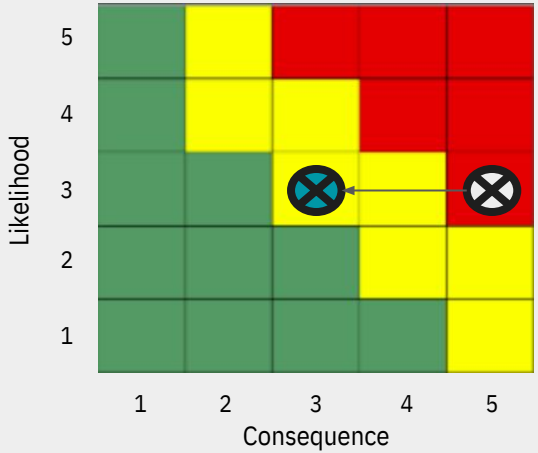
Risk Owner: Sandhya

Description:

Actuator does not arrive on time to develop mechanism for testing and integration

Consequences:

Delays design timelines, impacting mechanical system timelines for testing and integration



Mitigation Plan:

1. Order parts early (by second week of Feb 2023) to give sufficient buffer time
2. Identify local suppliers and backup designs to pivot in case of delays

Risk summary

Risk Title: Unexpected interference of mechanism or enclosure with Khepera sensors (cameras/IR)

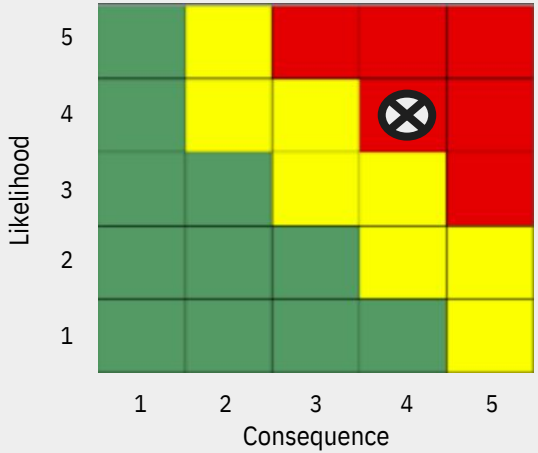
Risk Owner: Hari

Description:

The enclosure design causes unexpected interference in sensor readings during testing

Consequences:

Sensor readings will be unreliable affecting tracking behaviour, localization and planning performance



Mitigation Plan:

1. Alternate material enclosure design to account for emf interference
2. Multiple sub-tests in design phase to catch conflicts earlier

Risk summary

Risk Title: Enclosure breaks during testing

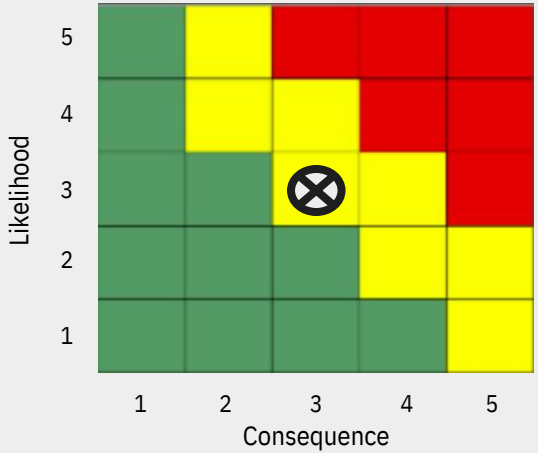
Risk Owner: Sankalp

Description:

Enclosure fails and weakens during vertical loading testing or integration

Consequences:

Mechanism might fail during the demo impacting timelines and SVD demo performance



Mitigation Plan:

1. Manufacture spare enclosures to keep on hand in case of failure
2. Create enclosure attachment SOP to standardise the process and speed it up

21

Risk summary

Risk Title: RoboSAR FMS unsuitable or requires more time than budgeted to implement

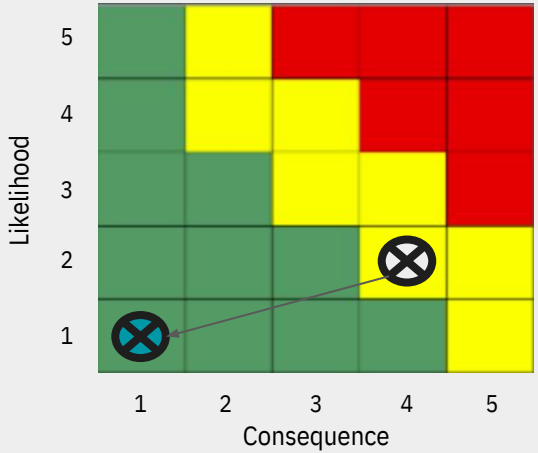
Risk Owner: Sudhansh

Description:

Since we are building on RoboSAR FMS, the time budgeted to learn, implement and test with our system is assumed to be small

Consequences:

Impact on timelines, and potential reworking of work plans to incorporate using a different FMS compliant with Khepera



Mitigation Plan:

1. Start early with reviewing code and identifying points of failure
2. Identify and perform trade studies for other options for communication

22

Risk summary

Risk Title: Team member(s) fall sick

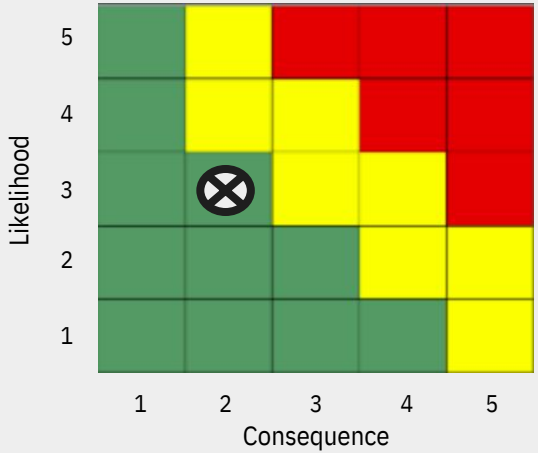
Risk Owner: Dhanvi

Description:

With the cold increasing, team members may fall sick for a few days at a time

Consequences:

Impact on timelines, work scheduling and hitting deadlines for milestones



Mitigation Plan:

1. Up-to-date documentation of each team member's work
2. Distribute work in a way that has at least two teammates involved in each stream
3. Rest days to prevent burnout and stressing

23