System Readiness Review

Friction Force Explorers

Neil Jassal
Rachel Holladay
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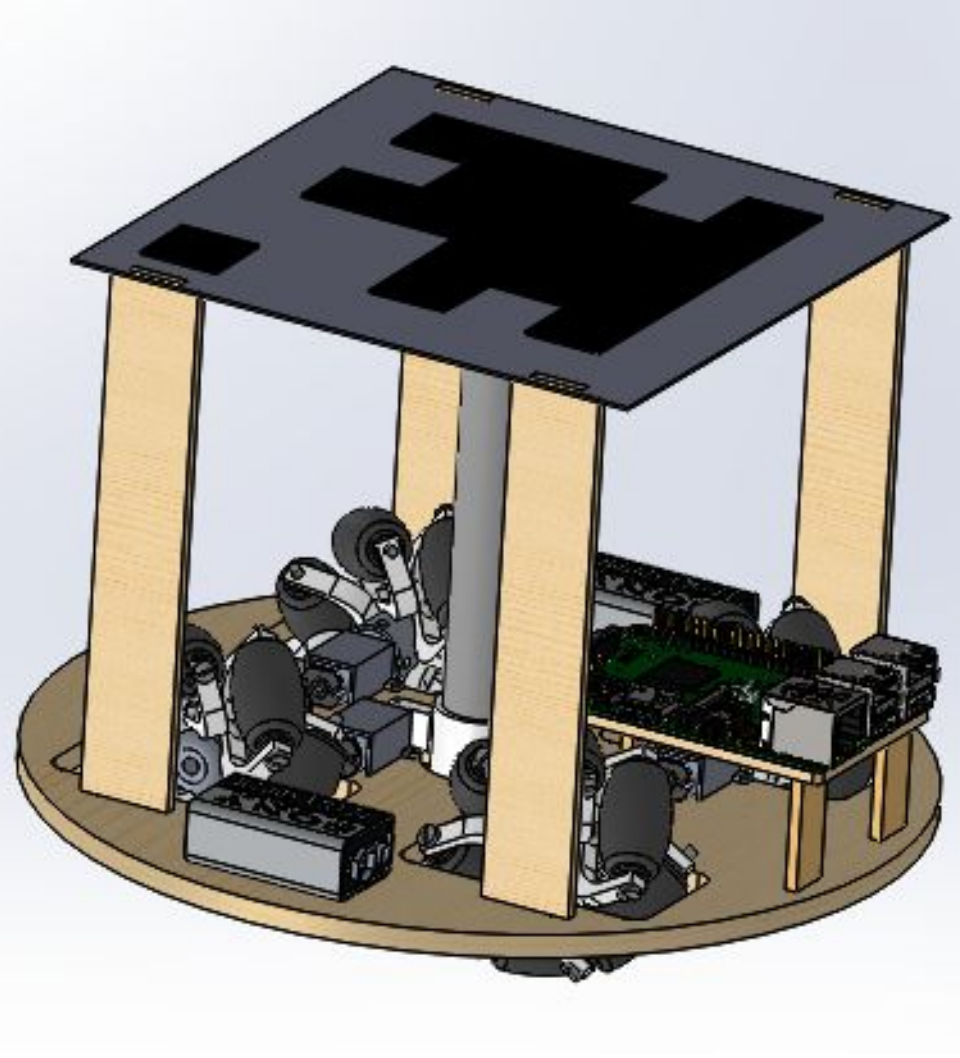
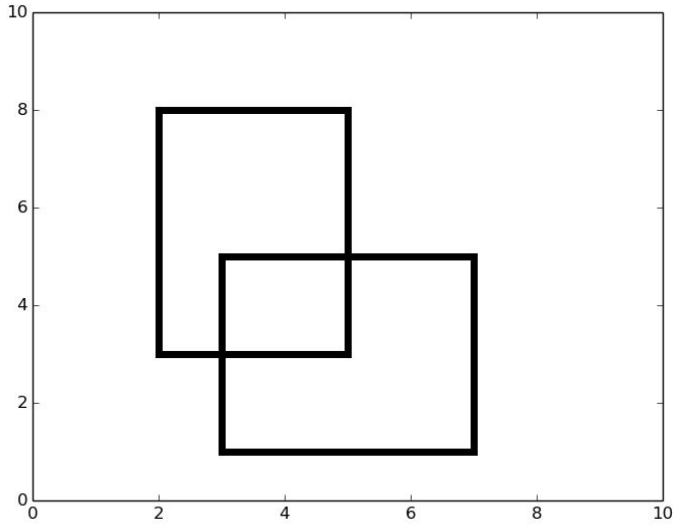
Objective:

To develop a multi-agent system that collaboratively and efficiently draws inputted images at variable scale.

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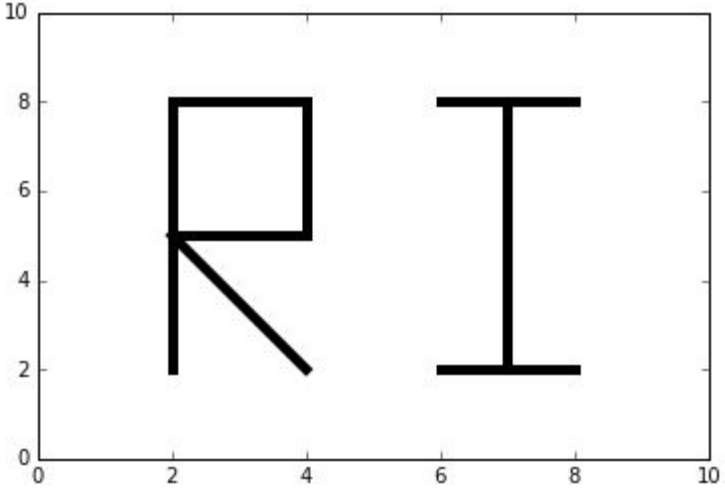
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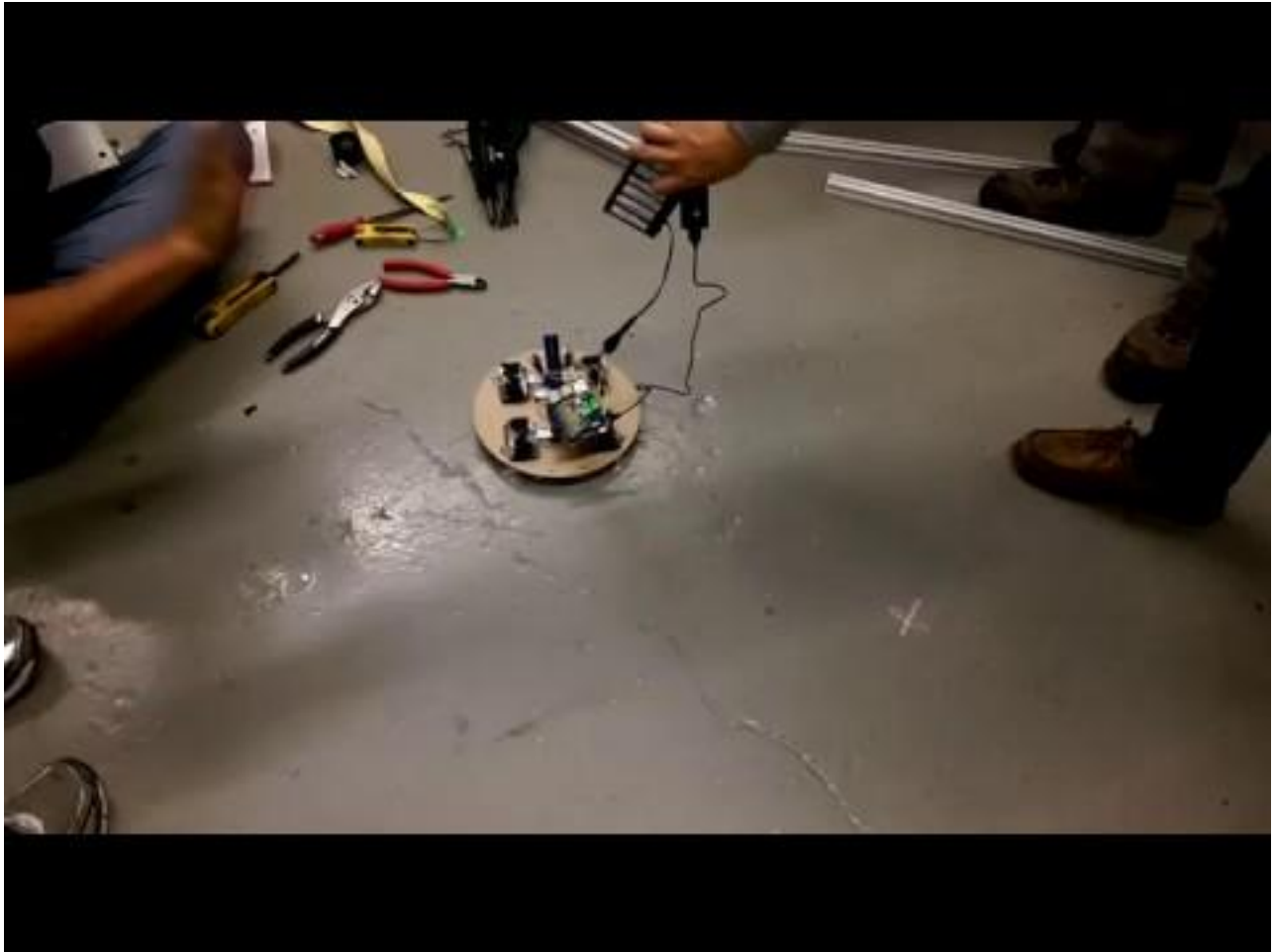
Build Updates

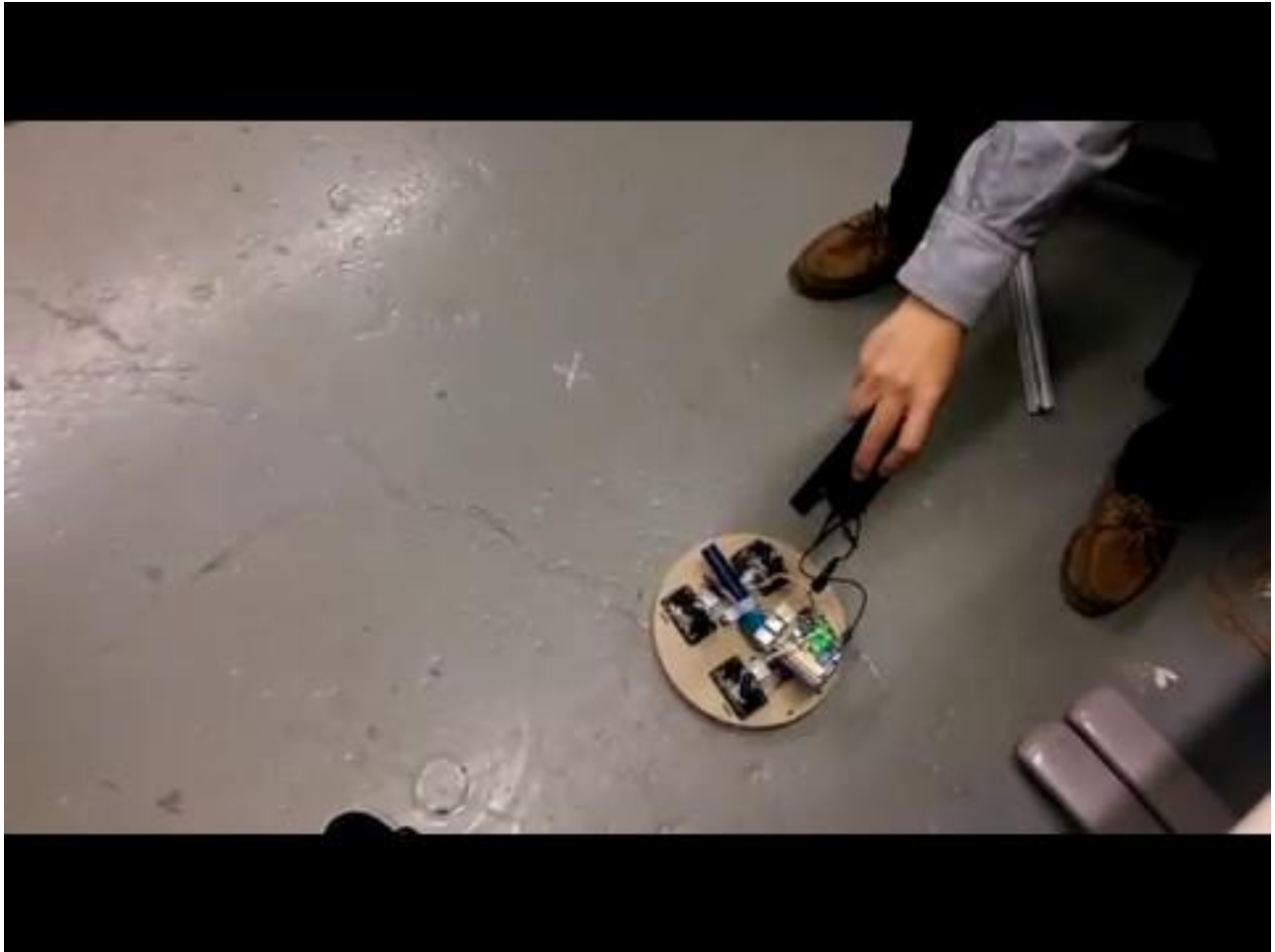
Mechanical Updates - Birth Of Blue

[See Physical Robot]

System Updates - Driving Test

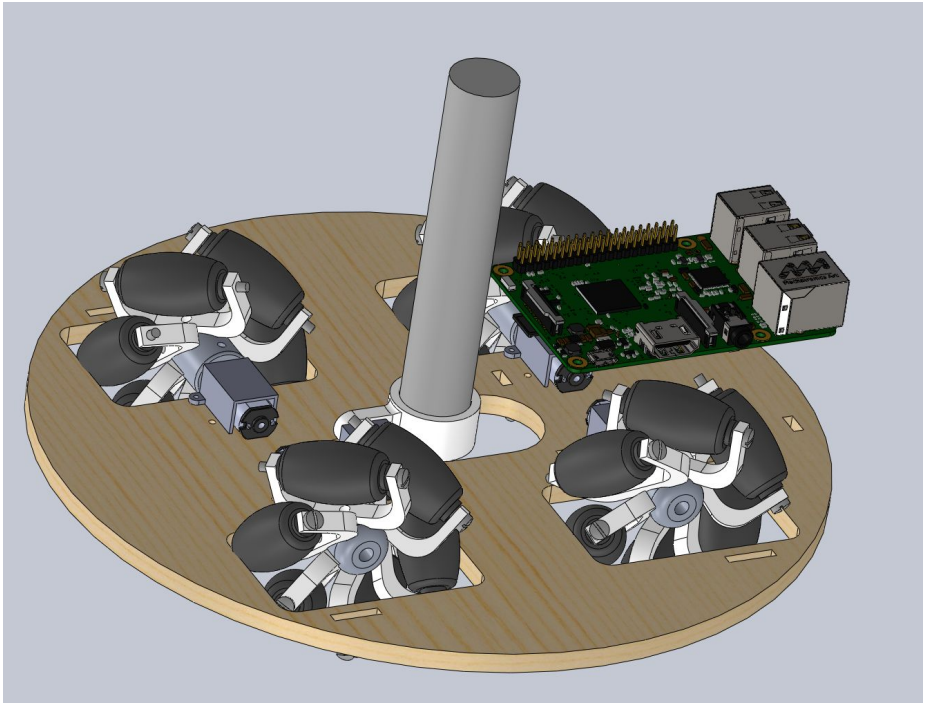


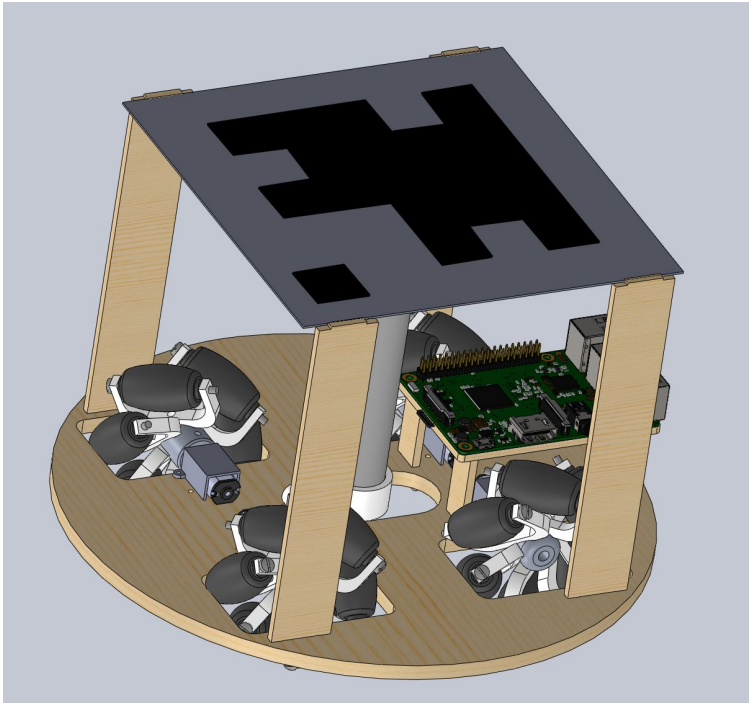
System Updates - Driving Test



System Updates - Driving Test

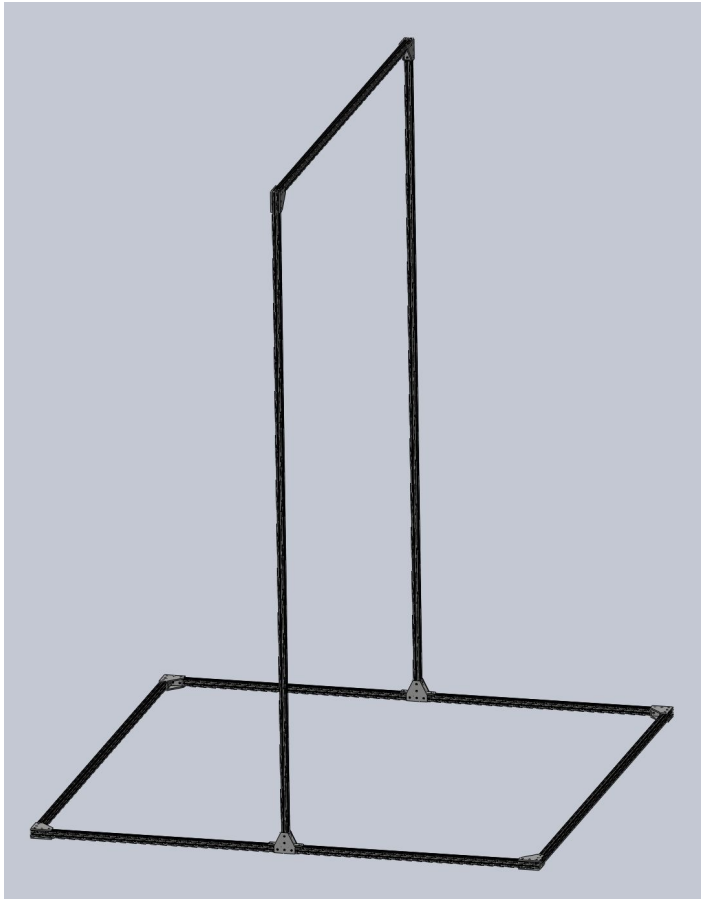
Mechanical Updates - April Tag and Electronics Mount

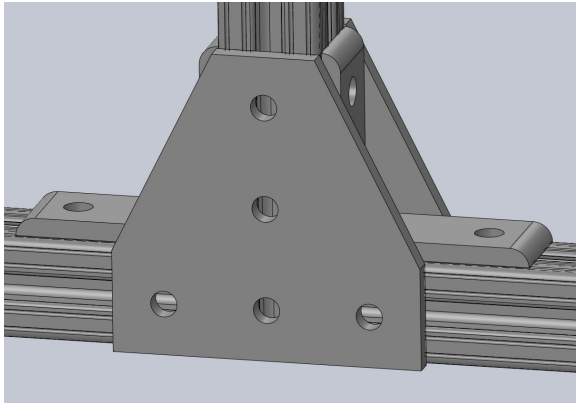


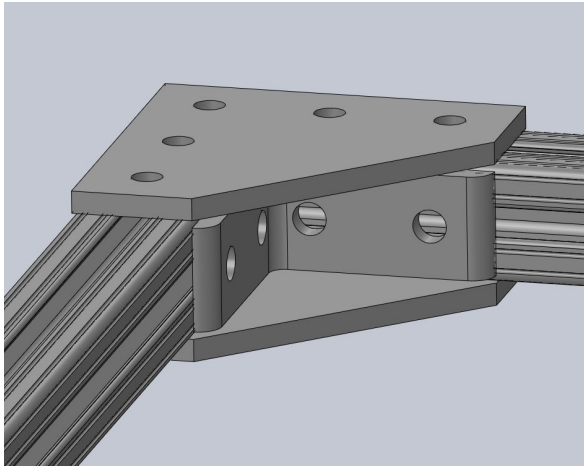


- Current prototype demonstrated the functionalities of 3D printed parts.
- Next steps: install April Tag holder and Raspberry Pi holder; clean up wiring.
- Attach the batteries to the bottom of April Tag holder using velcro.

Mechanical Updates - Camera Mount







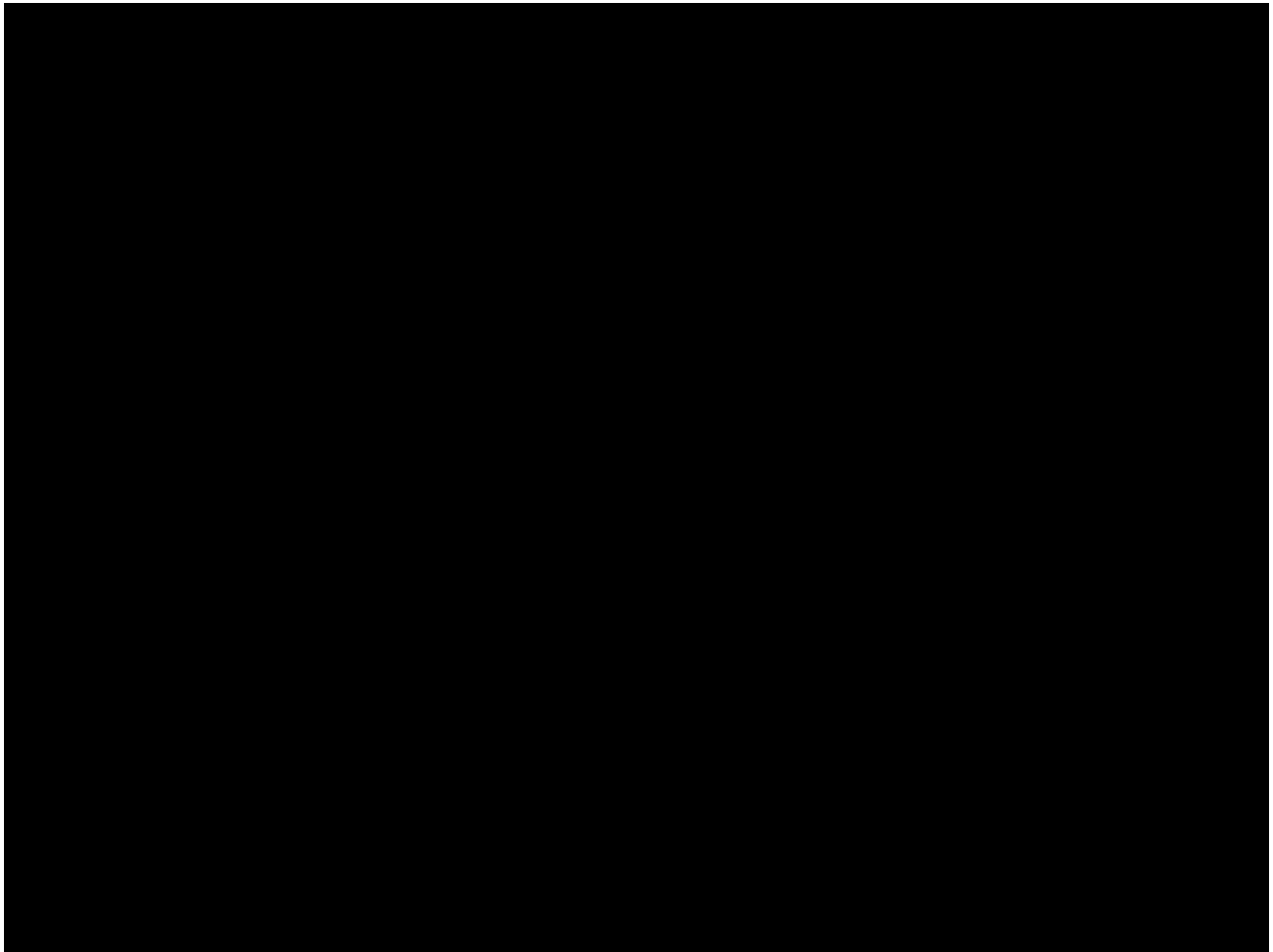
- 8020 Aluminum
- Base: 6 ft. by 6 ft.
- Height: 8 ft.
- Can easily be disassembled into two parts for transportation.
- Camera mounted in the middle using velcro.

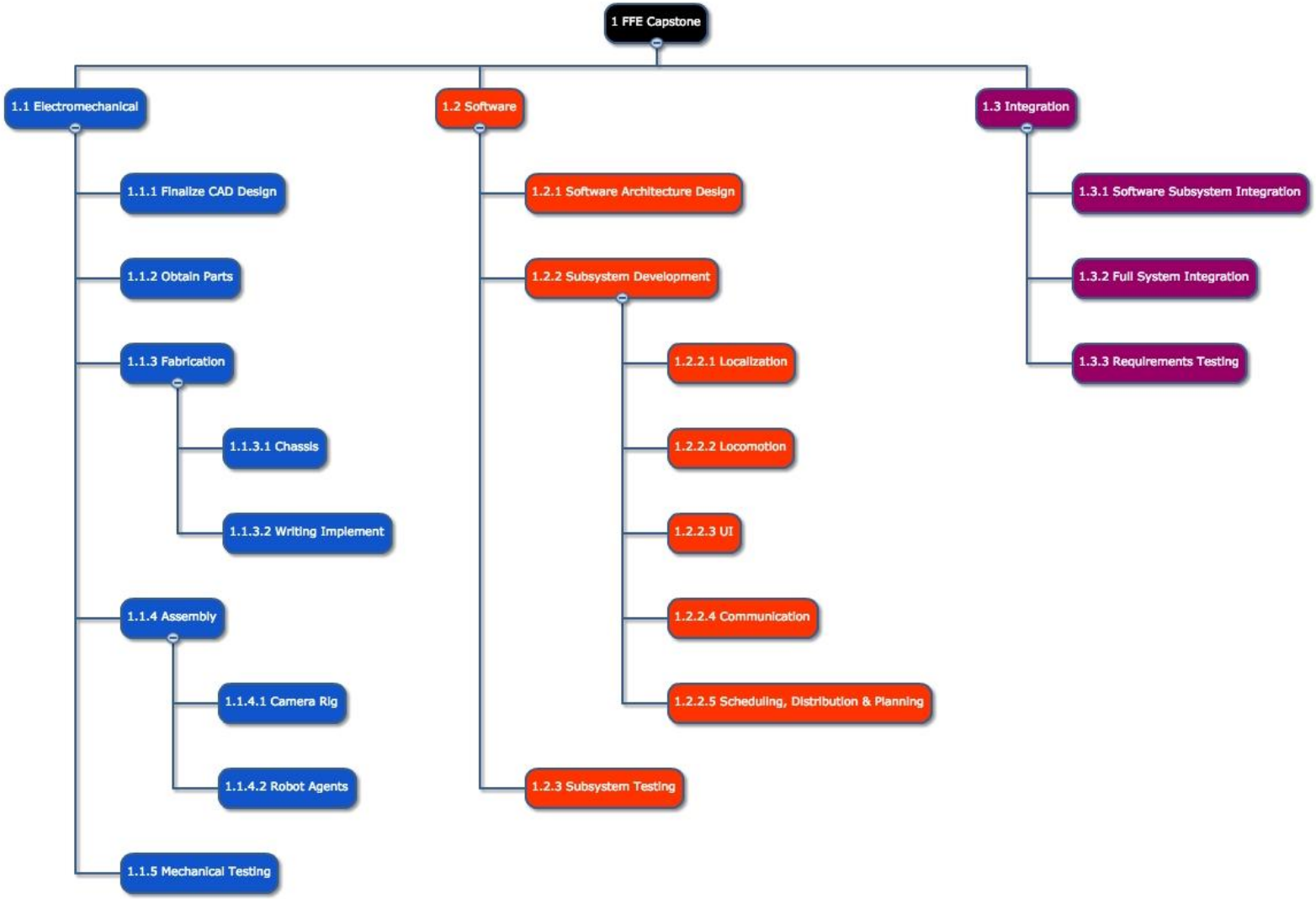
Mechanical Updates - Birth Of Bad

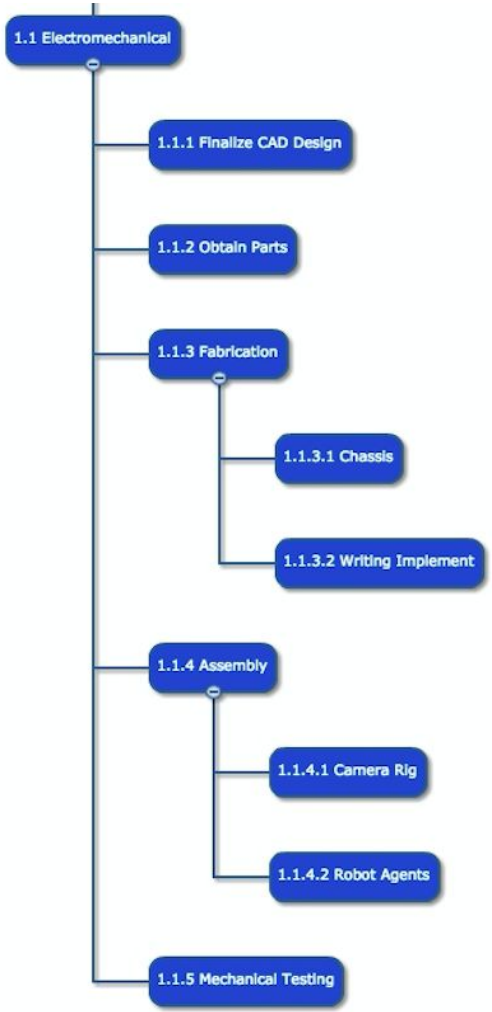
Coming Soon!

Software Updates - April Tag Tracking

Software Updates - UI




1 FFE Capstone
1.1 Electromechanical
1.1.1 Finalize CAD Design
1.1.2 Obtain Parts
1.1.3 Fabrication
1.1.3.1 Chassis
1.1.3.2 Writing Implement
1.1.4 Assembly
1.1.4.1 Camera Rig
1.1.4.2 Robot Agents
1.1.5 Mechanical Testing
1.2 Software
1.2.1 Software Architecture Design
1.2.2 Subsystem Development
1.2.2.1 Localization
1.2.2.2 Locomotion
1.2.2.3 UI
1.2.2.4 Communication
1.2.2.5 Scheduling, Distribution & Planning
1.2.3 Subsystem Testing
1.3 Integration
1.3.1 Software Subsystem Integration
1.3.2 Full System Integration
1.3.3 Requirements Testing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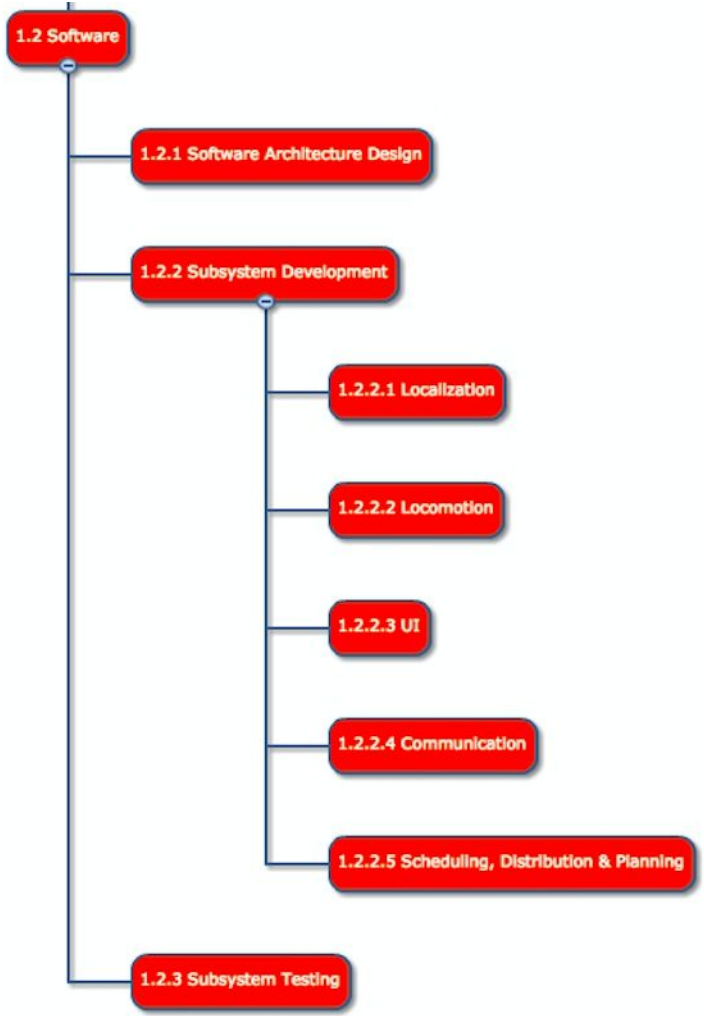
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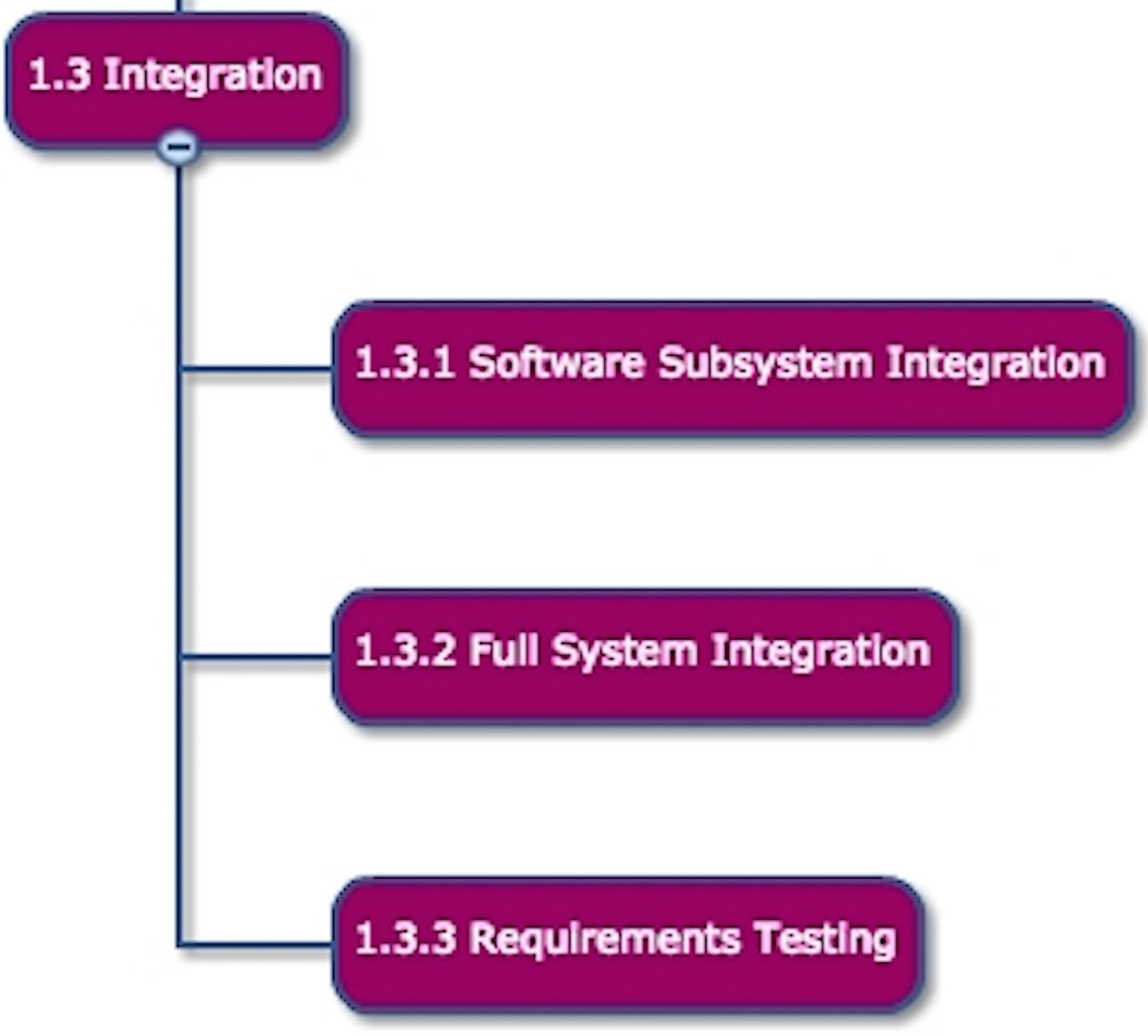
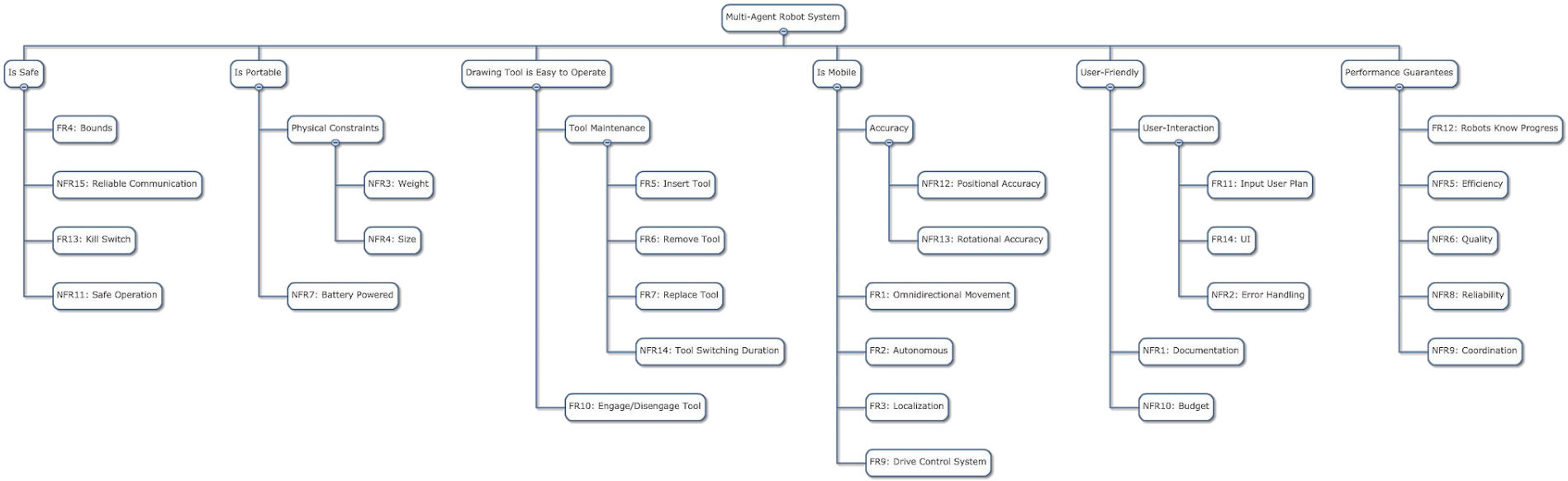
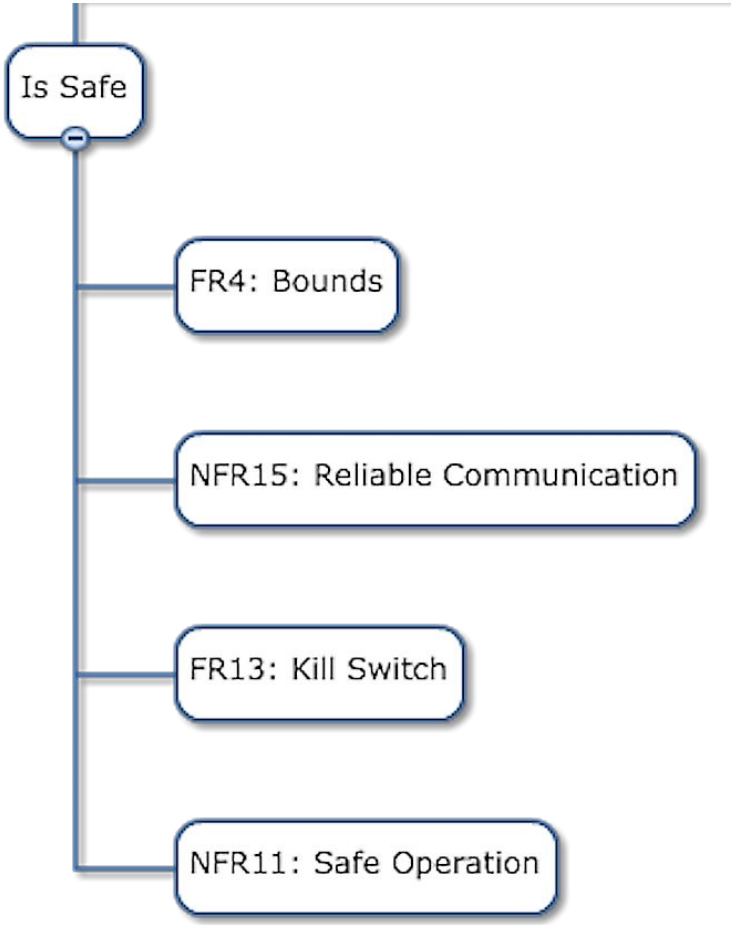

1.3 Integration
1.3.1 Software Subsystem Integration
1.3.2 Full System Integration
1.3.3 Requirements Testing

Project Management & Schedule

	Week Number	1	2	3	4	5	6	7	8	9	10	11	12	13
WBS	Task	1/30	2/6	2/13	2/20	2/27	3/6	3/20	3/27	**4/3**	4/10	4/16	4/24	5/1
1.1	Electromechanical													
1.1.1	Finalize CAD Design													
1.1.2	Obtain Parts													
1.1.3.1	Chassis Fabrication													
1.1.3.2	Writing Implement Fabrication													
1.1.4.1	Camera Rig Assembly													
1.1.4.2	Robot Agent Assembly													
1.1.5	Mechanical Testing													
1.2	Software Implementation													
1.2.1	Softare Architecture Design													
1.2.2.1	Localization Subsystem Development													
1.2.2.2	Locomotion Subsystem Development													
1.2.2.3	UI Subsystem Development													
1.2.2.4	Communication Subsystem Development													
1.2.2.5	SDP Subsystem Development													
1.2.3	Software Subsystem Testing													
1.3	Integration													
1.3.1	Software Subsystem Integration													
1.3.2	Full System Integration													
1.3.3	Requirements Testing													
	Demo Preparation													

Objectives Tree


Multi-Agent Robot System
Is Safe
FR4: Bounds
NFR15: Reliable Communication
FR13: Kill Switch
NFR11: Safe Operation
Is Portable
Physical Constraints
NFR3: Weight
NFR4: Size
NFR7: Battery Powered
Drawing Tool is Easy to Operate
Tool Maintenance
FR5: Insert Tool
FR6: Remove Tool
FR7: Replace Tool
NFR14: Tool Switching Duration
FR10: Engage/Disengage Tool
Is Mobile
Accuracy
NFR12: Positional Accuracy
NFR13: Rotational Accuracy
FR1: Omnidirectional Movement
FR2: Autonomous
FR3: Localization
FR9: Drive Control System
User-Friendly
User-Interaction
FR11: Input User Plan
FR14: UI
NFR2: Error Handling
NFR1: Documentation
NFR10: Budget
Performance Guarantees
FR12: Robots Know Progress
NFR5: Efficiency
NFR6: Quality
NFR8: Reliability
NFR9: Coordination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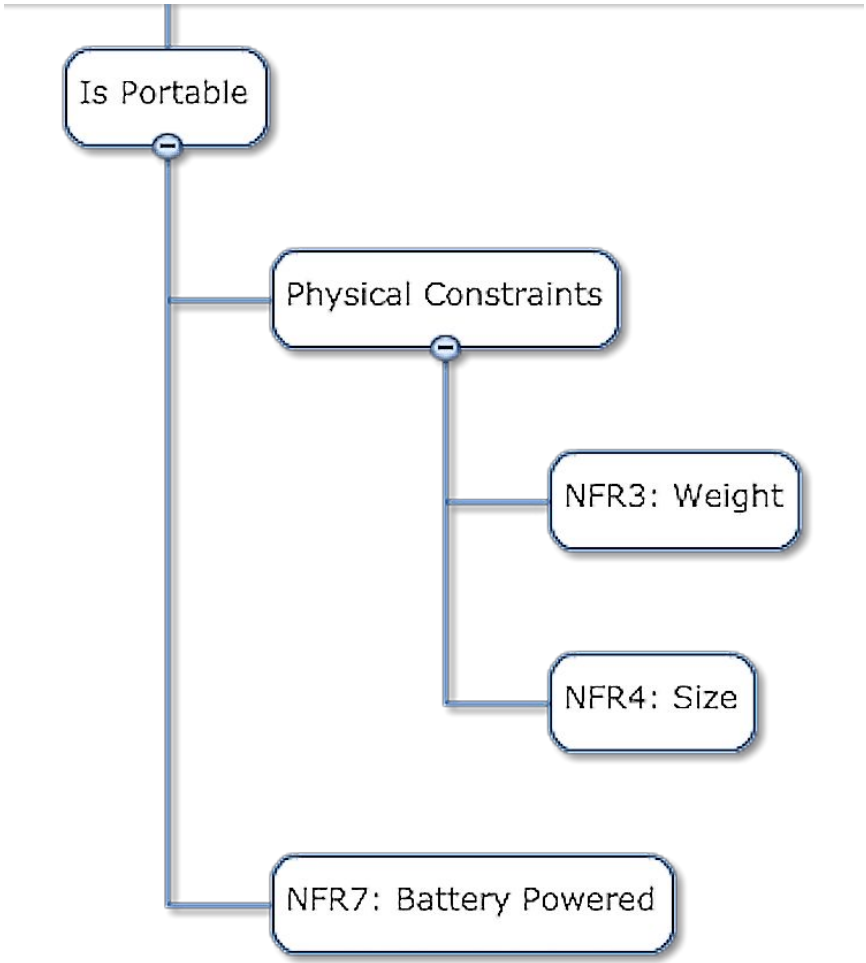
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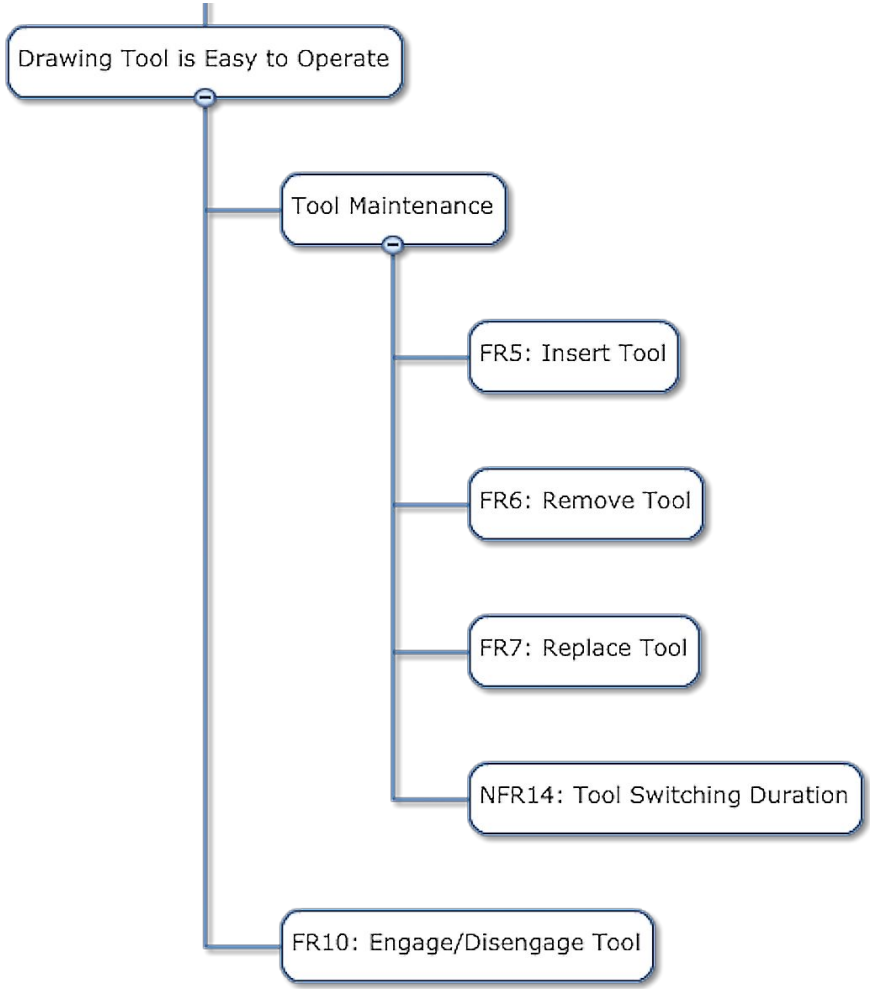
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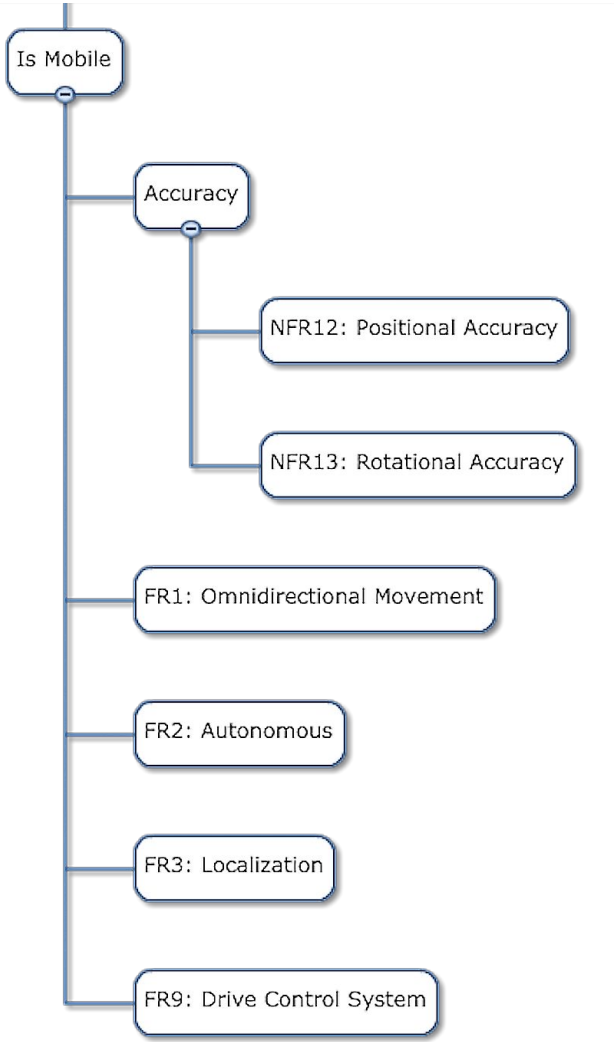
FR10: Engage/Disengage Tool


Is Mobile
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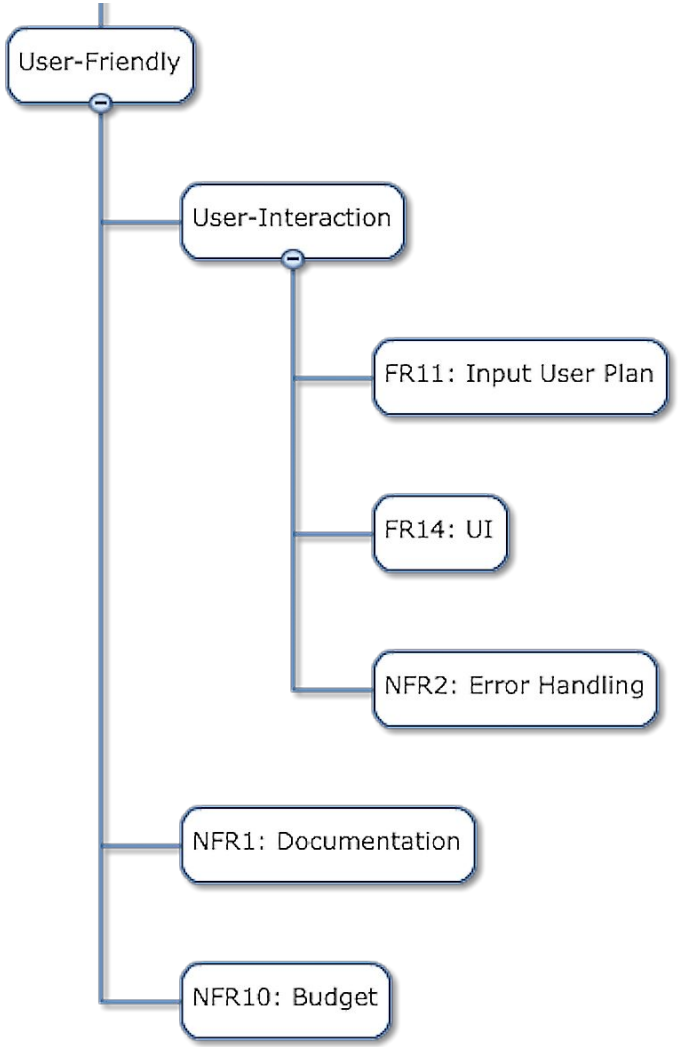
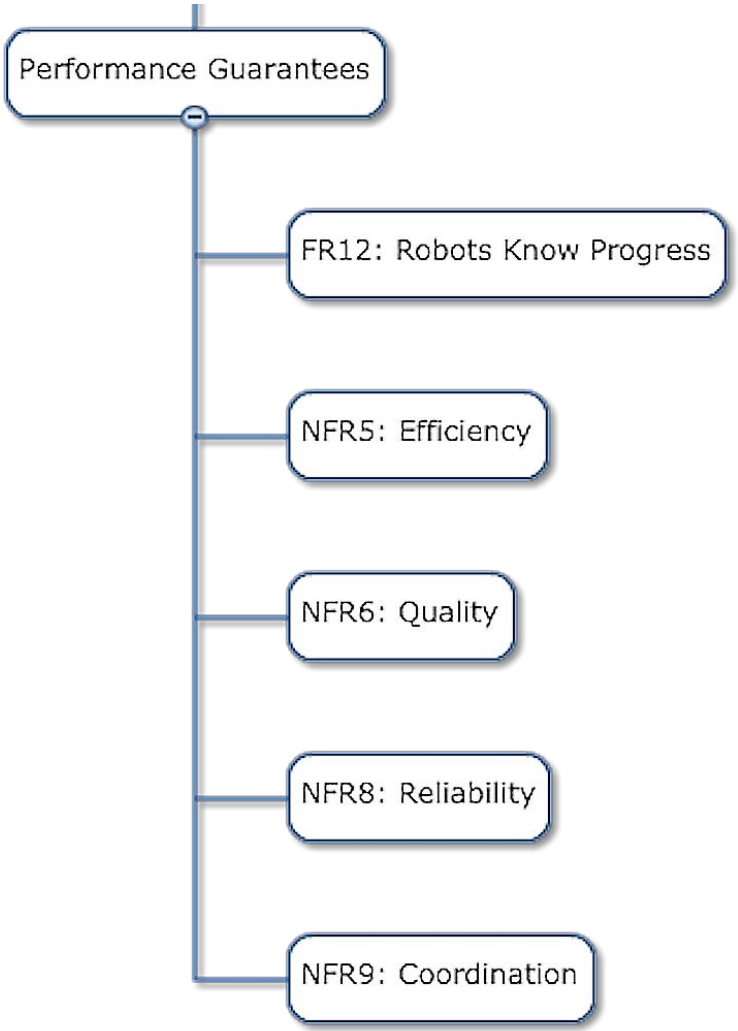
FR2: Autonomous
FR3: Localization
FR9: Drive Control System


User-Friendly
User-Interaction
FR11: Input User Plan
FR14: UI
NFR2: Error Handling
NFR1: Documentation
NFR10: Budget


Performance Guarantees
FR12: Robots Know Progress
NFR5: Efficiency
NFR6: Quality
NFR8: Reliability
NFR9: Coordination

Requirements Traceability Matrix

	Subsystems	Writing	Communication	Locomotion	Localization	SDP	Mechanical Structure
Functional Requirements	FR1: Omnidirectional Motion			X			
	FR2: Autonomous			X	X	X	
	FR3: Localize Globally + Locally				X		
	FR4: Within Bounds			X	X		
	FR5: Insert Tool	X					
	FR6: Remove Tool	X					
	FR7: Replace Tool	X					
	FR8: Coordination					X	
	FR9: Drive Control			X			
	FR10: Turn on/off Tool	X					
	FR11: Input Plan		X			X	
	FR12: Know Progress		X		X	X	
	FR13: Kill Switch	X	X	X			
	FR14: User Interface		X			X	

	Subsystems	Writing	Communication	Locomotion	Localization	SDP	Mechanical Structure
Nonfunctional Requirements	NFR1: Documentation	X	X	X	X	X	X
	NFR2: Error Handling	X	X	X	X	X	X
	NFR3: Weight Restriction						X
	NFR4: Size Restriction						X
	NFR5: Efficiency					X	
	NFR6: Quality	X		X	X		
	NFR7: Battery Power	X		X			
	NFR8: Reliability	X	X	X	X	X	X
	NFR9: Reliable Communication		X				
	NFR10: Budget						X
	NFR11: Safe			X	X	X	X
	NFR12: Positional Accuracy			X	X		
	NFR13: Rotational Accuracy			X	X		
	NFR14: Tool Switching Duration	X					X

Risk Management

Risk ID:	Risk Title:	Risk Owner:
1	Defective Parts	Don

Description:
Parts that we ordered arrived defective or do not perform to specifications

Consequences:	Risk Type:
We need to reorder parts, expending extra time and budget	Parts

Risk Reduction Plan:	Expected Outcome
We will order only parts that have been extensively reviewed, or we have experience with, and order extra parts	We will be able to properly deal with any parts that break during the development process

Likelihood \ Consequence	1	2	3	4	5
5					
4					
3					
2		X			
1					

Actions taken:

- Reliable parts only
- No problems so far

Risk ID:	Risk Title:	Risk Owner:
2	Unvavailable Group Member	All

Description:
A group member becomes unavailable for work due to travel, sickness, or other emergencies

Consequences:	Risk Type:
Work that would have been distributed to that group member needs to be reassigned	Logistical

Risk Reduction Plan:	Expected Outcome
We will ensure that every group member is always on the same page about progress so we don't lose too much progress	If a member becomes unavailable, it will only be for a short time and can be easily dealt with

Consequence						
1	2	3	4	5		
					5	
					4	
			X		3	
					2	
					1	Likelihood

Actions taken:

- Regular updates/check-ins
- No incapacitations so far

Risk ID:	Risk Title:	Risk Owner:
3	Breaking parts	Eric

Description:
Parts unexpectedly break as a result of accidents or improper use

Consequences:	Risk Type:
We need to reorder parts, expending extra time and budget	Parts

Risk Reduction Plan:	Expected Outcome
We will practice safe procedures when working with parts and order extras in case	Few parts will break, and even if they do we will have extras on hand

Likelihood	Consequence					
	1	2	3	4	5	
5						
4						
3						
2				X		
1						

Actions taken:

- Motor shaft broken
  - Reprinting
- Motor encoder magnets stuck on motors

Risk ID:	Risk Title:	Risk Owner:
4	Mecanum Drive Too Unstable	Eric

Description:

The drive mechanism for the robot proves too be too unstable or unreliable for our purposes

Consequences:	Risk Type:
We will need to redesign the drive mechanism, expending considerable time and effort	Design flaw

Risk Reduction Plan:	Expected Outcome
We will build enough time in our schedule to deal with it if necessary, and will use suspension	The instability resulting from the wheels will be manageable

Consequence						
	1	2	3	4	5	
						5
						4
				X		3
						2
						1 Likelihood

Actions taken:

- Tested mecanum drive
  - No rocking or vibrating

Risk ID:	Risk Title:	Risk Owner:
5	Localization not precise enough	Neil

Description:
Our localization system is not precise enough to ensure that the drawings are accurate representations of input

Consequences:	Risk Type:
We will need to redesign the localization system or redefine drawing requirements	Design flaw

Risk Reduction Plan:	Expected Outcome
We will test the localization system early on in order to catch any design flaws within the system	Localization will work well enough for our purposes

Likelihood	Consequence					
	1	2	3	4	5	
5						
4						
3						
2			X			
1						

Actions taken:

- Have not reached that point yet
- Testing localization as soon as April tag mount is made

Risk ID:	Risk Title:	Risk Owner:
6	Unexpected Budget Overruns	Rachel

Description:
We unexpectedly run out of budget, because parts cost more than expected or other parties reduce our budget

Consequences:	Risk Type:
We need to scale down our project, or possibly even acquire funds through other means	Logicstical

Risk Reduction Plan:	Expected Outcome
We will leave a significant buffer in our budget in case unexpected situations occur	We will have a large enough buffer that essential components will be acquired

Actions taken:

- Still well within budget
- Need to order second robot and computing platform

Testing and Evaluation Plan

Performance Test: Locomotion Accuracy	
Test Question	Is the robot able to drive with positional and rotational accuracy?
Operational Procedure	The robot drives along a predetermined testing route consisting of at least 3 feet of linear distance and 90 degrees of turn.
Metric	The difference of the robot's final position and orientation from the intended position and orientation.
Acceptance Criteria	The robot's position must be less than 1 inch away from the intended position and its orientation must be within 10 degrees of the intended orientation. This result must be achieved 90 percent of the time.
Requirement	NFR 12: Positional Accuracy
Logistics	Time: after locomotion system is installed; Location: on any smooth surface; Equipment: rule; Test personnel: Don

Performance Test: Painting Accuracy	
Test Question	How closely does the drawn image resemble the original image?
Operational Procedure	Using the an input set, input each for the system to complete. After completion, overlap the original image with the image of final drawing captured from overhead camera. Rescale the two images so that they are in the same size. Evaluate the coherence of the two images.
Metric	The percentage of drawn lines that were within 3 pixels of difference compared to those of the original image.
Acceptance Criteria	The system must successfully and accurately draw 95% of the lines in the original image.
Requirement	NFR 6: Quality
Logistics	Time: after fully system constructed; Location: on any smooth surface; Equipments: image processing software; Test personnel: Rachel

Functional Test: Simultaneous Driving and Writing	
Test Question	Can the writing tool make a mark while driving?
Operational Procedure	With a fully loaded writing implement, the robot will mark a 1 ft. line on the writing surface.
Metric	Whether or not any discernible mark is made and the full distance is covered.
Acceptance Criteria	A discernible mark must be made and the full distance must be travelled without the robot becoming stuck or breaking.
Requirement	NFR 6: Quality
Logistics	Time: after drawing and locomotion systems are installed; Location: on any smooth surface; Equipments: chalk paper; Test personnel: Eric

Performance Test: Localization Robot Position Accuracy	
Test Question	Is the localization system able to accurately determine the position of each robot?
Operational Procedure	Both robots sit stationary within the working bounds. The localization system then attempts to determine their locations.
Metric	The difference of the robot's actual position from the position reported by the localization system.
Acceptance Criteria	The reported position must be within 1/10 in. of the actual position.
Requirement	NFR 6: Quality, FR 4: Within bound
Logistics	Time: after camera jig is installed and robot is fully completed; Location: on any smooth surface; Equipments: rule; Test personnel: Neil

Functional Test: Budget	
Test Question	Does the cost for developing this robotic system exceed our budget?
Operational Procedure	Document total amount of money spent for designing and constructing this robot system. This includes machining expense, part cost, and etc.
Metric	Total amount of money spent.
Acceptance Criteria	Total developing expense has to be less than $2500.
Requirement	NFR 10: Budget
Logistics	Time: after the project is completed; Location: NA; Equipment: calculator; Test personnel: Neil

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