PROJECT 3 DESIGN NOTEBOOK

TEAM 45

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MEETING AGENDAS AND MINUTES

January 31, 2016, 6pm
Agenda:
- C2 BNS
- Project 3 Gantt Chart

Meeting Minutes:
- Team worked on C2 Bonus Activities
- Discussed a basic meeting schedule for Project 3

Electronic Signatures:
- Kathryn Atherton
- Joshua Hahn
- Hannah Mackin Schenck

February 2, 2016, 8pm
Agenda:
- Kit Counting

Meeting Minutes:
- Team counted the parts of the kit and recorded the results
- Team submitted the part count

Electronic Signatures:
- Kathryn Atherton
- Joshua Hahn
- Hannah Mackin Schenck

February 3, 2016, 7:30pm
Agenda:
- Kit replenishing

Meeting Minutes:
- Joshua Hahn unable to attend -- excused absence
- Team checked into the Kit Replenish Session in the Engineering Classroom
- Team did a spot check of the parts
- Team received parts needed to replenish the kit

Electronic Signatures:
- Kathryn Atherton
- Hannah Mackin Schenck

February 7, 2016, 8pm
Agenda:
- C3 BNS

- Project 3 DSR

Meeting Minutes:

- Team finished C3 BNS and shared all documents
- Team created the DSR
- The 6 tasks were split between the three members, to be completed before the next meeting

Electronic Signatures:

- Kathryn Atherton
- Joshua Hahn
- Hannah Mackin Schenck

February 8, 2016, 8pm

Agenda:

- Review and edit DSR document

Meeting Minutes:

- Team reviewed each other's work and made edits to wording
- Team submitted document

Electronic Signatures:

- Kathryn Atherton
- Joshua Hahn
- Hannah Mackin Schenck

February 14, 2016, 4:15pm

Agenda:

- RFAI 1
- Brainstorming

Meeting Minutes:

- Team came up with various means to solve the problems posed by each subsystem
- Means were composed into a Morphological chart
- RFAI 1 Questions were composed
- RFAI 1 document was submitted
- Team began building a basic structure for the ALV

Electronic Signatures:

- Kathryn Atherton
- Joshua Hahn
- Hannah Mackin Schenck

February 16, 2016, 8pm

Agenda:

- C4 BNS, Statistics BNS
- Build body of ALV

Minutes:
- Completed C4 BNS
- Built a model of ALV with conveyor belt for boxes to be dropped off with
- Researched robot models with wheels

Electronic Signatures
- Kathryn Atherton
- Joshua Hahn
- Hannah Mackin Schenck

February 23, 2016, 7:30pm
Agenda:
- Finish wheel chain
- work on holding/unloading antenna
- Experiment with RobotC

Minutes:
- Kathryn Atherton absent -- excused
- Added a 3rd wheel on each side
- Added moter on back to power conveyor belt
- Downloaded RobotC
- We have a clicky brick. We need to get that fixed.

Electronic Signatures:
- Joshua Hahn
- Hannah Mackin Schenck

February 27, 2016, 3:30pm
Agenda:
- Continue building antenna holding/unloading mechanism
- Experiment with RobotC
- Determine when to test the magnetic sensors

Minutes:
- Conveyor belt building continued
- RobotC experimentation begun
- 3D Printed “Slide” Considered using CATIA
- House of Quality outline created

Electronic Signatures:
- Kathryn Atherton
- Joshua Hahn

- Hannah Mackin Schenck

March 1, 2016, 9pm
Agenda:
- Check measurements on 3D printed ramp
- Begin design of 3D printed 'cage' to hold antenna in place

Minutes:
- Kathryn Atherton absent -- excused
- Ramp dimensions checked
- Sketches of Cage begun
- Experimentation with RobotC

Electronic Signatures:
- Joshua Hahn
- Hannah Mackin Schenck

March 7, 2016, 7pm
Agenda:
- Code ALV to do as many tasks as possible for Wednesday's POC
- Minimum: Tasks 1 and 3
- Complete and Submit RFAI 2
- Improve POC Specifications and Re-Submit

Minutes:
- POC Specifications revised and re-submitted
- RFAI 2 completed and submitted
- Last wheel for ALV obtained

Electronic Signatures:
- Kathryn Atherton
- Joshua Hahn
- Hannah Mackin Schenck

March 8, 2016, 9:30pm
Agenda:
- Code ALV to do as many tasks as possible for Wednesday's POC
- Minimum: Tasks 1 and 3
- Build the robot to be able to hold antenna in POC

Minutes:
- RobotC used to code ALV to accomplish Tasks 1, 3, and 5
- Robot built with cage to hold at least 3 antenna at once

Electronic Signatures:

- Kathryn Atherton
- Joshua Hahn
- Hannah Mackin Schenck

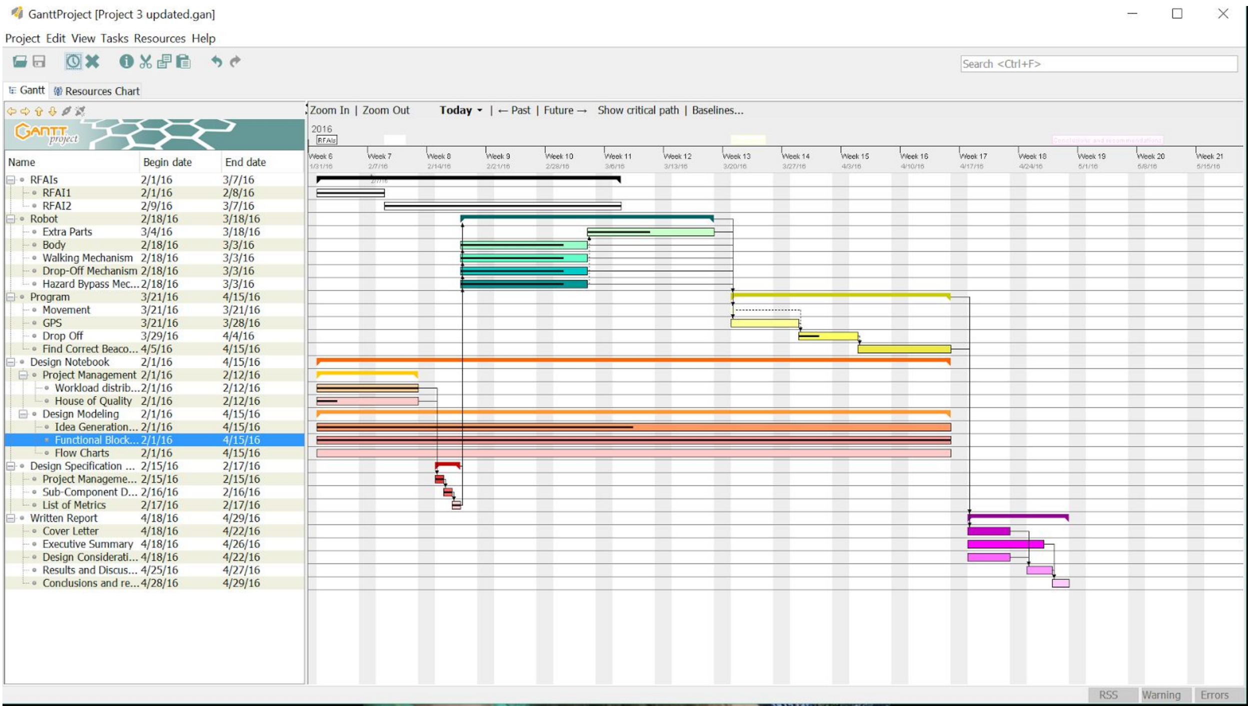
March 20, 2016, 7pm
Agenda:
- Build ALV to complete prototype
- Begin testing
- Begin RobotC GPS code

Minutes:
- GPS in RobotC research begun
- Robot built to Completion

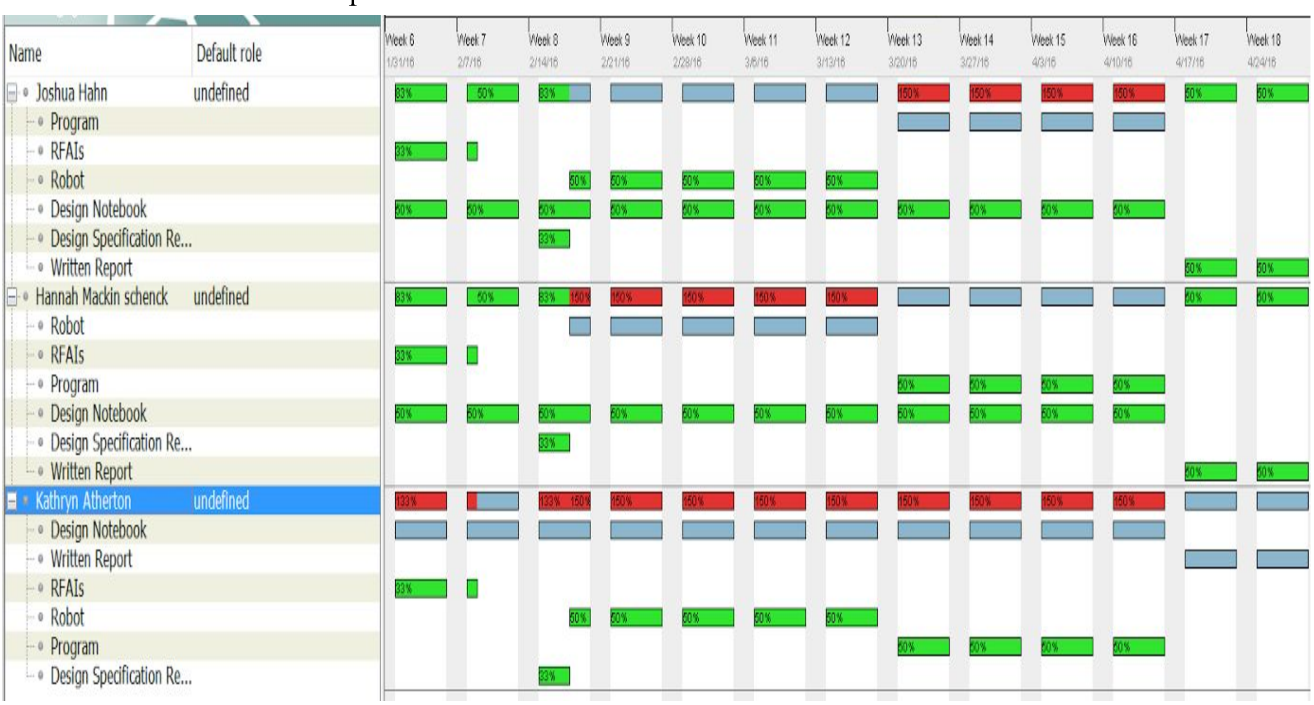
Electronic Signatures:
- Kathryn Atherton
- Joshua Hahn
- Hannah Mackin Schenck

PROJECT SCHEDULING/ MANAGEMENT

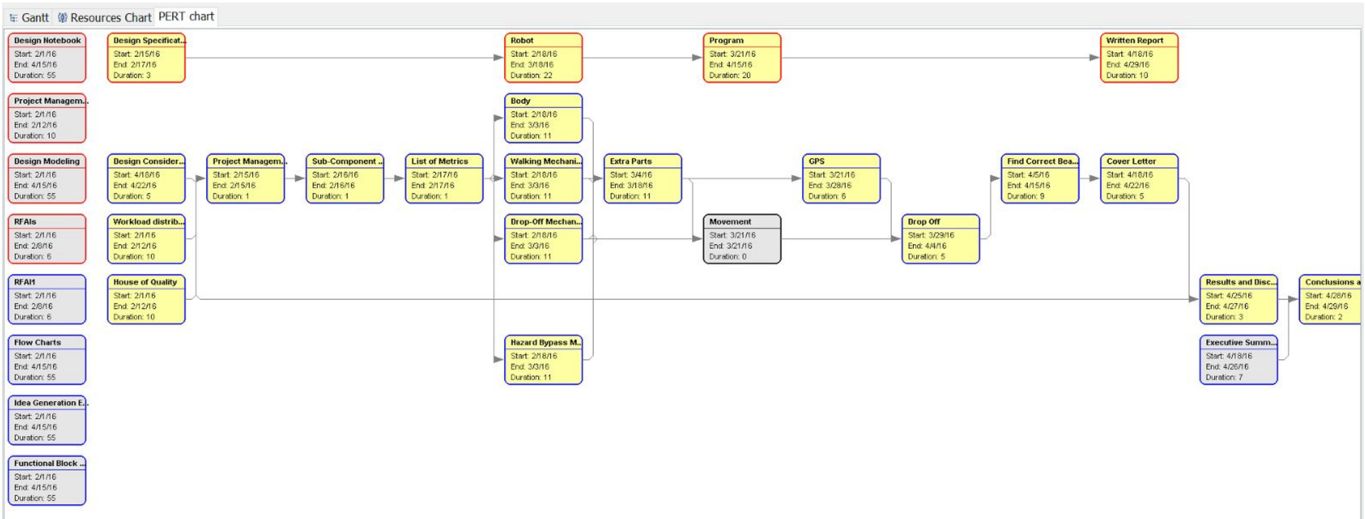
Gantt Chart -- Updated 2/15/2016



Workload Distribution -- Updated 2/15/2016



Work Breakdown Structure -- Updated 2/15/2016



BRAINSTORMING

Morphological Chart -- Updated 2/14/2016

System	Means		
Body	Tank	Multi-wheel design	
Wheels	treads	big wheels	small wheels
Drop-off system	bed with treads	separate container for each antenna	
Drop-off location w/ respect to robot	behind	to the side(s)	
Overcome obstacles	snow plow	drive over	

Design Specifications -- Updated March 13, 2016

Customer Need	**Technical Need**	**Technical Requirement**	**Target Value**	**Current Performance**
TASK 1: MOBILITY IN OBSTACLE-FREE AREA				
Move quickly	Time to travel 1 foot in a straight line	Travels 1 foot in < 1 second	Travels 1 foot in < 0.5 seconds	Travels 1 foot in 0.5 second
Move straight	Travel to a specified location via a straight line and stop with marker over a specified point	Marker < 2 inches from point	Marker < 0.5 inches from point	
Make tight turns	Turning radius -- radius of the smallest circular path the ALV can follow	Radius < 5 inches	Radius < 3 inches	

Can follow a path that turns	Travel to a specified location via a path with at least 1 turn immediately before the location and stop with marker over a specified point	Marker < 2 inches from point	Marker < 0.5 inches from point	
Move over a large distance	Minimum distance able to travel without breaking	Minimum distance > 20 feet	Minimum distance > 25 feet	Minimum distance > 6 feet
TASK 2: NAVIGATE USING GPS SIGNAL/ SURROUNDING OBSTACLES				
Stops at a given destination	The ALV stops within a small distance of given location	Distance < 3 inches	Distance < 1 inch	
Navigate around surrounding obstacles	Distance from edge of obstacle to edge of ALV while maneuvering around obstacle	Distance < 5 inches	Distance < 2 inches	
Can navigate along a straight path	Distance offset from a straight path 5 feet long	Distance < 5 inches	Distance < 2 inches	

Can navigate around corners	Distance offset from a circular path of radius 3 feet	Distance < 5 inches	Distance < 2 inches	
Can turn to face next checkpoint	Difference in angle between a randomly selected checkpoint and where the robot is facing after orienting itself	Angle < 10 degrees	Angle < 5 degrees	
Troubleshoots if ALV runs into an obstacle it cannot overcome	Time to re-route around obstacles ALV cannot overcome	Time < 5 seconds	Time < 2 seconds	
TASK 3: ABILITY TO TRAVERSE SMALL OBSTACLES				
Overcome small hazards	Height of obstacle AVL able to overcome	Able to overcome obstacles of height > 10 mm	Able to overcome obstacles of height > 20 mm	Able to overcome obstacles of height > 6 mm
Move quickly to overcome hazards	Time to travel 1 foot while overcoming obstacle with maximum height 10 mm	Travels 1 foot < 2 seconds	Travels 1 foot < 1 second	Travels 1 foot in 0.5 seconds
Traverse a variety of obstacles and terrain	Time to travel 1 foot while traversing	Travels 1 foot < 2 seconds	Travels 1 foot < 1 second	Travels 1 foot in 0.5 seconds

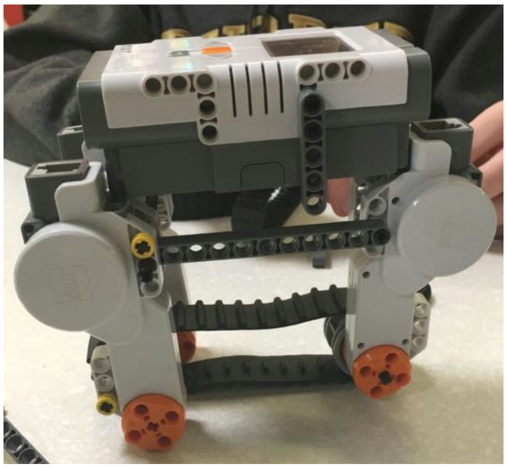
	irregular terrain (squishy, slippery, rough, uphill, downhill, uneven, etc.)			
TASK 4: LOCATE BEACON AND STOP AT IT				
Locate and stop at beacon	Distance from the center of where antenna would be placed to the center of the beacon	Distance < 1 foot	Distance < 6 inches	
Make known that a beacon location has been identified	Time to beep 3 times after correctly identifying (i.e. stopping at) a beacon	Time < 1 second	Time < 0.5 seconds	
TASK 5: TRANSPORT AND DROP ANTENNA IN PROPER ORIENTATION				
Can carry multiple antenna	Distance can walk fully loaded	Can walk at least 10 feet with 600 grams loaded onto the robot without falling over	Can walk at least 20 feet with 800 grams loaded onto the robot without falling over	
Can place antenna close to drop point	Distance from a drop off point to the closest part of the box to	Can drop antenna off 0 inches away from the drop off point	Can drop antenna off 0 inches away from the drop off point	

	drop off location			
Can place antenna in proper orientation	Number of antenna that are placed with the correct side facing up	Can drop all 3 antenna in the correct orientation	Can drop all 3 antenna in the correct orientation	Drops 0 / 3 antenna in correct orientation
Can disengage	Distance the robot can move away from a drop off point after unloading an antenna package within 30 seconds	Can move 2 cm away from the antenna after unloading it	Can move 3 cm away from the antenna after unloading it	Can move 50 cm away from the antenna after unloading it
Does not drop antenna en route to destinations	Distance the ALV can travel without losing any antenna	Can travel at least 10 feet fully loaded without losing any antenna	Can travel at least 20 feet fully loaded without losing any antenna	
TASK 6: UTILIZE GPS TRACKING SOFTWARE				
Can display its current coordinates	Distance from where the robot is to where it thinks it is	Distance is less than 10 cm	Distance is less than 5 cm	
Can recognize invalid coordinates	Time to recognize invalid coordinates	Time < 10 seconds	Time < 5 seconds	
Can determine its direction	Difference in degrees of	Degree difference is	Degree difference is	

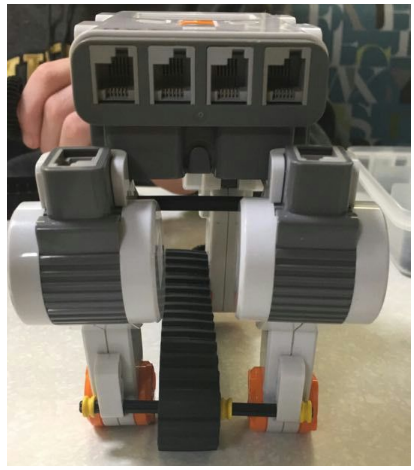
	where the robot is facing versus where it thinks it is facing	less than 30 degrees	less than 10 degrees	
Can receive GPS coordinates	Time to receive and display GPS coordinates	Takes less than 10 seconds to receive and display the correct GPS coordinates	Takes less than 5 seconds to receive and display the correct GPS coordinates	

PROTOTYPES

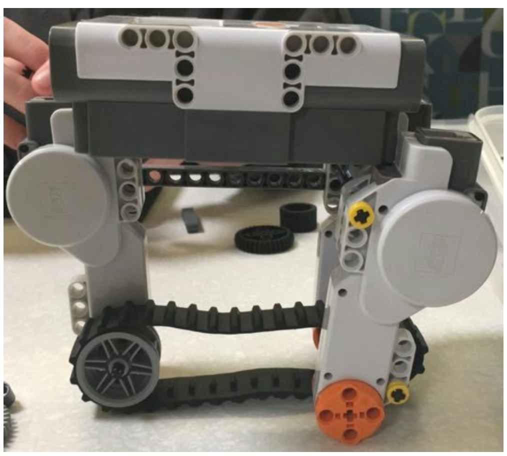
PROTOTYPE I -- Created Feb. 16, 2016; Rejected February 16, 2016



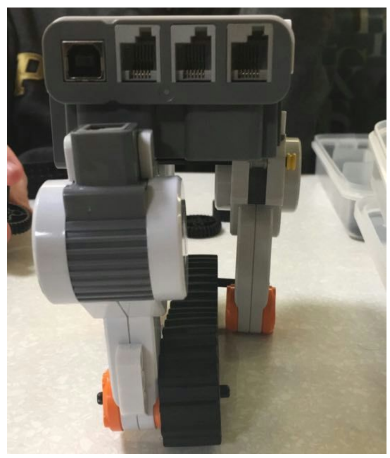
(left side view)



(back view)



(right side view)

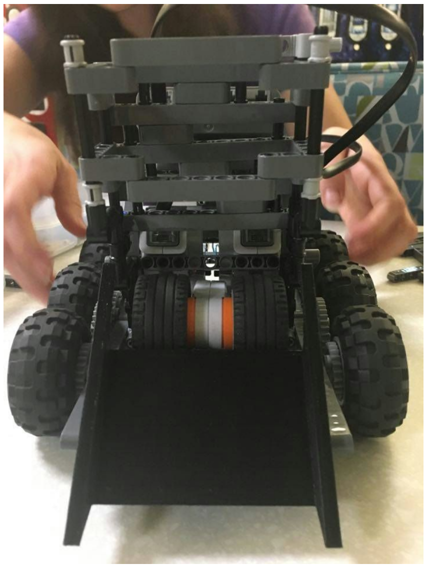


(front view)

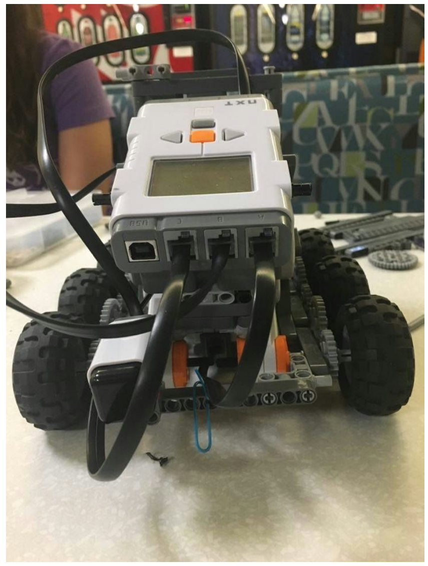
Explanation of Design:

This design was meant to incorporate the multi-wheel design with small wheels, a conveyor belt-style drop-off system, with the antenna being dropped off behind the ALV. The rationale behind the design was that the boxes would be protected within the body of the robot to prevent them from spilling out or getting damaged during landing and travel. This design was ultimately rejected, as the space above the conveyor belt just barely had enough space for the three antenna boxes, thus making the boxes prone to becoming stuck in the space when it was time to drop one off.

PROTOTYPE II -- Created February 16, 2016; Rejected --

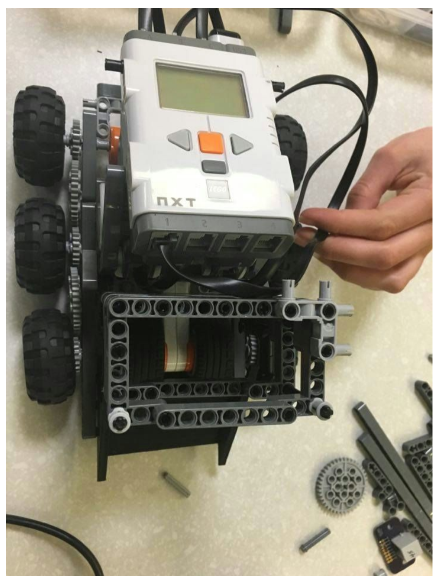


(back view)

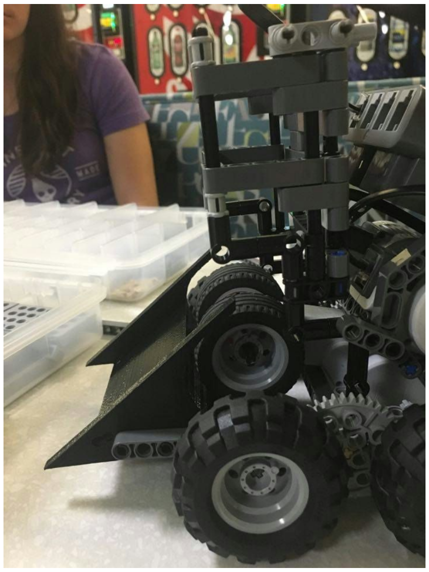


(front view)

(side view)



(top view)

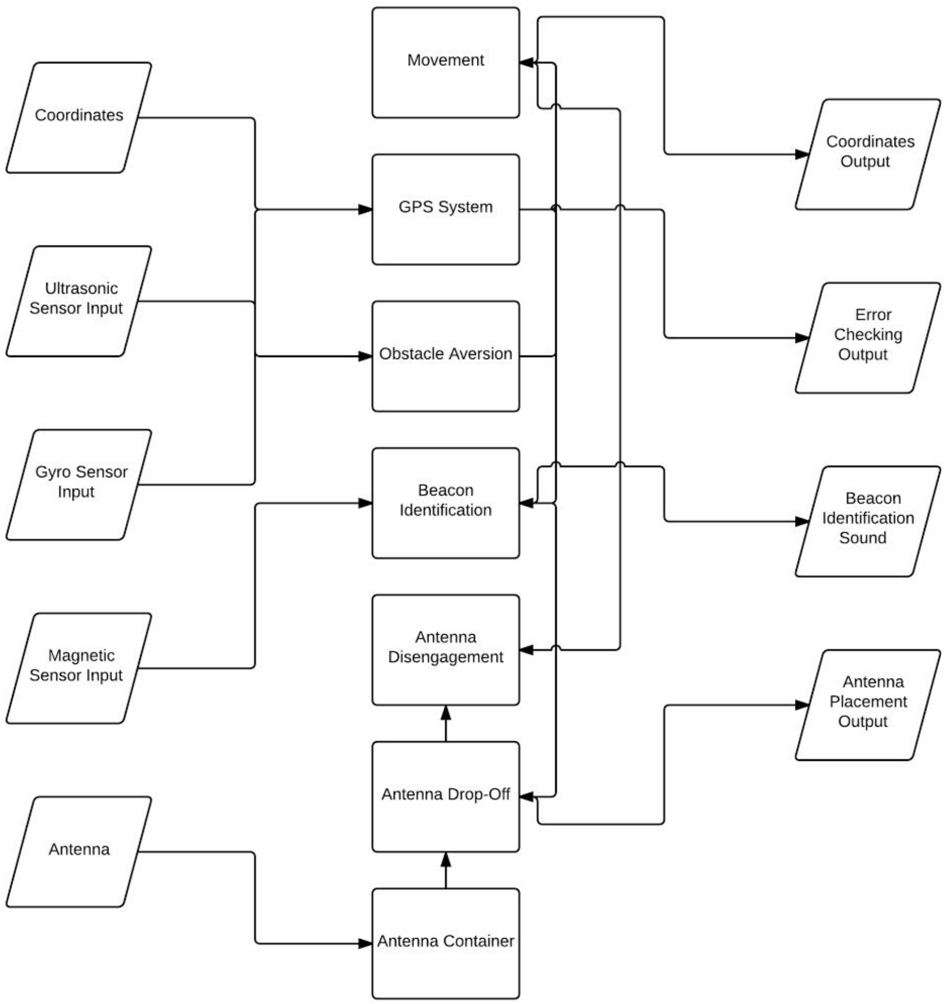


(side view of slide)

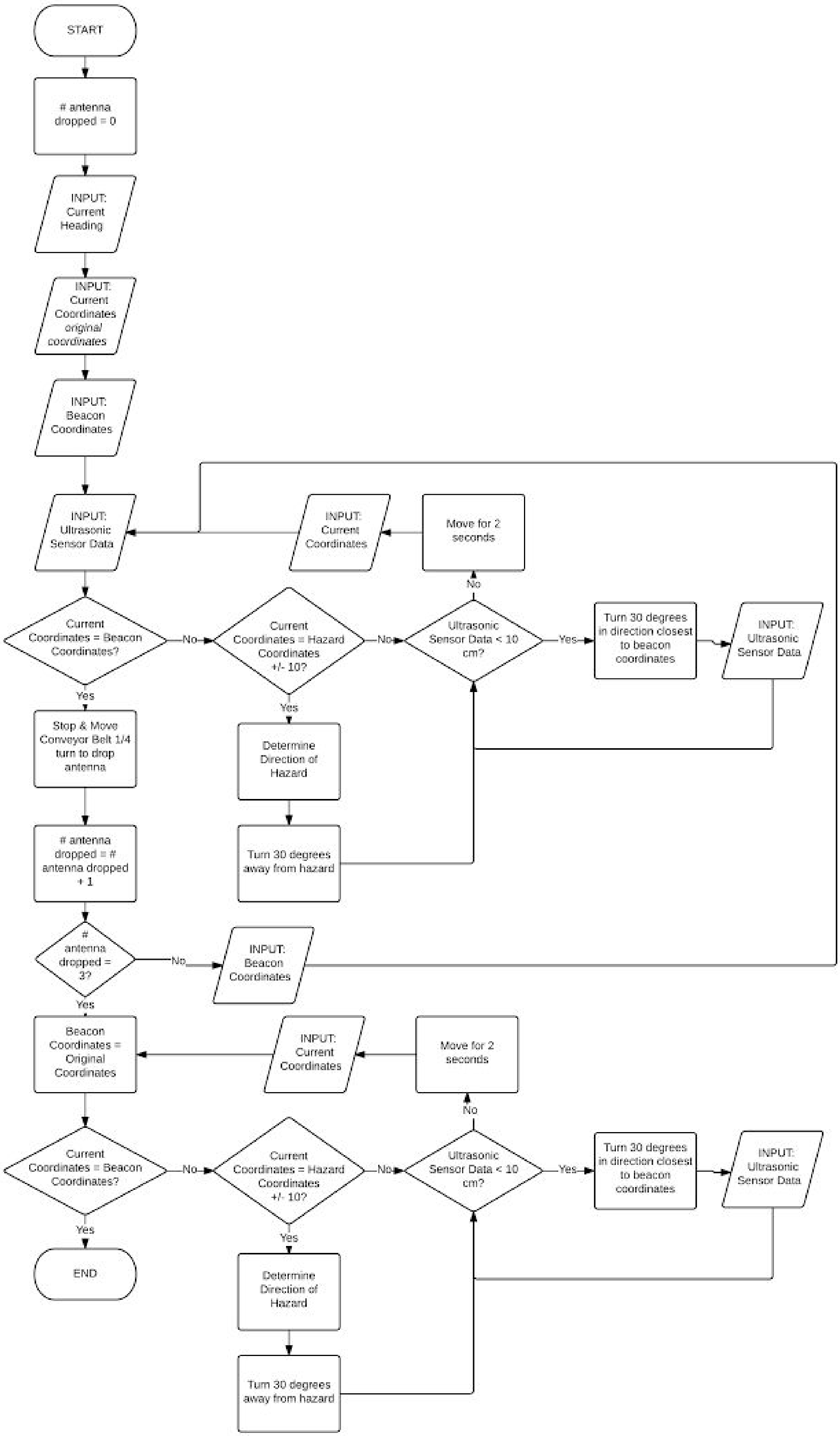
Explanation of Design:
After the first design was rejected, a basic framework for an NXT robot was created based on the research done by the team. February 27, 2016, the team added a conveyor belt to the back in order to hold and drop off the antenna. March 8, 2016, the team added a cage to the back over the conveyor belt to hold and drop antenna. March 10, 2016, the team added a slide to the back behind the conveyor belt to control the dropping of the antenna.

FLOWCHARTS AND QFDs

Functional Block Diagram -- Updated March 13, 2016



Code Logic Flowchart 1 -- Updated March 21, 2016



START
antenna dropped = 0
INPUT: Current Heading
INPUT: Current Coordinates original coordinates
INPUT: Beacon Coordinates
INPUT: Ultrasonic Sensor Data
INPUT: Current Coordinates
Move for 2 seconds
Current Coordinates = Beacon Coordinates?
No
Current Coordinates = Hazard Coordinates +/- 10?
No
Ultrasonic Sensor Data < 10 cm?
Yes
Turn 30 degrees in direction closest to beacon coordinates
INPUT: Ultrasonic Sensor Data
No
Yes
Yes
Stop & Move Conveyor Belt 1/4 turn to drop antenna
Determine Direction of Hazard
antenna dropped = # antenna dropped + 1
Turn 30 degrees away from hazard
antenna dropped = 3?
No
INPUT: Beacon Coordinates
Yes
Beacon Coordinates = Original Coordinates
INPUT: Current Coordinates
Move for 2 seconds
No
Current Coordinates = Beacon Coordinates?
No
Current Coordinates = Hazard Coordinates +/- 10?
No
Ultrasonic Sensor Data < 10 cm?
Yes
Turn 30 degrees in direction closest to beacon coordinates
INPUT: Ultrasonic Sensor Data
Yes
Yes
END
Determine Direction of Hazard
Turn 30 degrees away from hazard

EXPERIMENTS AND RESULTS

POC 1 Testing -- Updated March 9, 2015

TASK	DESCRIPTION	PASS/FAIL?	OBSERVATIONS
1	Move in an obstacle-free area after turning 30 degrees toward the intended path	PASS -- INTEGRATED WITH TASK 3	The ALV turned and passed smoothly through the course
2	Navigate using GPS signal or surrounding obstacles	UNABLE TO ATTEMPT	N/A
3	Avoid/Traverse small obstacles	PASS -- INTEGRATED WITH TASK 1	The ALV turned and passed smoothly over the obstacles
4	Locate a beacon and stop at it. Beep three times after stopping with the paperclip over the beacon	NOT ATTEMPTED	N/A
5	Transport and drop an antenna in proper orientation	FAIL	No matter the orientation of the block inside the ALV's cage, it would never fall in the correct orientation --> need a way to control its fall
6	Utilize GPS tracking software	UNABLE TO ATTEMPT	N/A

Total Score: 8 / 24

DECISION MATRICES

House of Quality (How vs. How) -- Updated March 14, 2016

Criteria/Specifications																									
Time to travle 1 foot in a straight line																									
Travel to a specified loction via straight line and stop with marker over a specified point																									
Turning radius -- radius of the smallest circular path the ALV can follow																									
Travel to a specified location via path with at least 1 turn immediately before the location and stop with marke		‡	‡																						
Minimum distance able to travel without breaking																									
ALV stops within a small distance of given location		‡																							
Distance from edge of obstacle to edge of ALV while maneuvering around obstacle			‡	‡																					
Distance offset from a straight path 5 feet long		‡																							
Distance offset from a circular path of radius 3 feet		‡	‡	‡			‡	‡																	
Difference in angle between a randomly selected checkpoint and where the robot is facing after orienting itself																									
Time to re-route around obstacles ALV cannot overcome																									
Height of Obstacle ALV able to overcome																									
Time to travel 1 foot while bypassing obstacle with maximum height 10 mm	‡											- -													
Time to travel while traversing irregular terrain	‡											- -	‡												
Distance from the center of where antenna would be placed to the center of the beacon		‡				‡																			
Time to beep after correctly identifying a beacon																									
Distance can walk fully loaded	-				‡																				
Distance from drop off point to the closest part of the box to the drop off location		‡				‡		‡	‡						‡										
Number of antenna that are placed with the correct side facing up																									
Distance the robot can move away from a drop off point after unloading an antenna package within 30	- -				‡								- -	- -			‡								
Distance the ALV can travel without losing any antenna	-				‡												‡								
Distance from where the robot is to where it thinks it is		‡				‡		‡	‡	‡					‡			‡							
Time to recognize invalid coordinates																									
Difference in degrees of where the robot is facing to where it thinks it is facing		+	+			+		‡	‡	‡					+							+	‡		
Time to receive and display GPS coordinates											‡														
Direction of improvement	▼	▼	▼	▼	▲	▼	▼	▼	▼	▼	▼	▲	▼	▼	▼	▼	▲	▼	▼	▲	▲	▼	▼	▼	▼
How - (Criteria/Specifications)	Time to travel 1 foot in a straight line	Travel to a specified loction via straight line and stop with marker over a speci	Turning radius -- radius of the smallest circular path the ALV can follow	Travel to a specified location via path with at least 1 turn immediately before t	Minimum distance able to travel without breaking	ALV stops within a small distance of given location	Distance from edge of obstacle to edge of ALV while maneuvering around obs	Distance offset from a straight path 5 feet long	Distance offset from a circular path of radius 3 feet	Difference in angle between a randomly selected checkpoint and where the ro	Time to re-route around obstacles ALV cannot overcome	Height of obstacle ALV able to overcome	Time to travel 1 foot while bypassing obstacle with maximum height 10 mm	Time to travel while traversing irregular terrain	Distance from center of where antenna would be placed to the center of the b	Time to beep after correctly identifying a beacon	Distance can walk fully loaded	Distance from a drop off point to the closest part of the box to drop off locatio	Number of antenna that are placed with the correct side facing up	Distance the robot can move away from a drop off point after unloading an an	Distance the ALV can travel without losing any antenna	Distance from where robot is to where it thinks it is	Time to recognize invalid coordinates	Difference in degrees of where the robot is facing to where it thinks it is facing	Time to receive and display GPS coordinates

House of Quality (What vs. How (above)) -- Updated March 14, 2016

What-Customer Needs																									
Move quickly	■	○	▲	○	■	○	○	▲	▲	▲	▲	▲	■	▲	▲	▲	▲	▲	▲	■	▲	▲	▲	▲	▲
Move straight	○	■	○	▲	○	■	○	■	▲	▲	▲	▲	○	▲	■	▲	▲	■	▲	▲	▲	○	○	○	○
Make tight turns	▲	○	■	○	▲	■	■	▲	■	○	○	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	○	○	○	○
Can follow a path that turns	▲	○	■	■	▲	■	■	▲	■	○	○	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	○	○	○	○
Move over a large distance	○	▲	▲	▲	■	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	○	○	○	○
Stop at a given destination	▲	■	▲	○	▲	■	▲	▲	▲	▲	▲	▲	▲	▲	■	▲	○	▲	▲	▲	▲	■	○	○	○
Navigate around surrounding obstacles	▲	■	■	■	▲	▲	■	▲	○	○	■	○	○	○	▲	▲	▲	▲	▲	○	▲	○	○	○	○
Navigate along a straight path	▲	■	○	▲	○	▲	▲	■	▲	▲	▲	▲	▲	▲	○	▲	▲	▲	▲	▲	▲	○	○	○	○
Navigate around corners	▲	▲	■	■	▲	▲	■	▲	■	○	▲	▲	▲	▲	○	▲	▲	▲	▲	▲	▲	○	○	○	○
Troubleshoots if ALV runs into an obstacle it cannot overcome	▲	▲	▲	▲	▲	▲	○	▲	○	▲	■	○	○	○	▲	▲	▲	▲	▲	▲	▲	○	○	○	○
Can turn to face next checkpoint	▲	▲	○	○	▲	▲	▲	▲	○	■	○	▲	▲	▲	▲	▲	▲	▲	▲	○	▲	○	○	■	○
Overcome small hazards	▲	▲	▲	▲	○	▲	○	▲	▲	▲	○	■	■	■	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Move quickly to overcome hazards	■	▲	▲	▲	○	▲	○	▲	▲	▲	○	■	■	■	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Traverse a variety of obstacles and terrain	▲	▲	▲	▲	○	▲	○	▲	▲	▲	○	■	■	■	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Locate beacon and stop at beacon	○	■	▲	■	▲	■	▲	▲	▲	▲	▲	▲	▲	▲	■	■	▲	■	▲	▲	▲	■	▲	■	▲
Make known that a beacon location has been identified	▲	○	▲	▲	▲	○	▲	▲	▲	▲	▲	▲	▲	▲	○	■	▲	○	▲	▲	▲	▲	▲	▲	▲
Place antenna close to drop point	▲	■	▲	■	▲	■	▲	▲	▲	▲	▲	▲	▲	▲	■	▲	■	■	▲	○	○	○	○	○	○
Carry multiple antenna	▲	▲	▲	▲	■	▲	▲	▲	▲	▲	▲	▲	▲	▲	■	▲	■	■	▲	▲	■	▲	▲	▲	▲
Drop antenna in proper orientation	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	■	▲	▲	■	■	▲	▲	▲	▲	▲	▲
Disengage	■	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	■	▲	▲	▲	▲	▲	▲	■	▲	▲	▲	▲	▲
Does not drop antenna en route to destinations	▲	▲	▲	▲	■	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	■	○	▲	○	■	▲	▲	▲	▲
Display current coordinates	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	■	▲	▲	▲	▲	▲	▲	■	■	■	■
Recognize invalid coordinates	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	■	■	▲	■
Determine its direction	▲	▲	▲	▲	▲	▲	▲	▲	○	■	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	■	▲	■	○
Can receive GPS Coordinates	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	■	▲	▲	▲	■	▲	○	▲	▲	▲	▲	■	▲	▲	■
How Much (targets)	0.5	0.5	3	0.5	25	1	2	2	2	5	2	20	1	1	6	0.5	20	0	3	3	20	5	5	10	5
Units	s	in	in	in	ft	in	in	in	in	degre	s	mm	s	s	in	s	ft	in	/3	cm	ft	cm	s	degrees	s

House of Quality (What vs. Now/Weighted Decision) -- Updated March 22, 2016

Harris Corp.	W	**What**-Customer Needs
5	5	Move quickly
5	5	Move straight
3	3	Make tight turns
3	3	Can follow a path that turns
5	5	Move over a large distance
5	5	Stop at a given destination
3	3	Navigate around surrounding obstacles
3	3	Navigate along a straight path
3	3	Navigate around corners
5	5	Troubleshoots if ALV runs into an obstacle it cannot overcome
3	3	Can turn to face next checkpoint
2	2	Overcome small hazards
2	2	Move quickly to overcome hazards
5	5	Traverse a variety of obstacles and terrain
5	5	Locate beacon and stop at beacon
1	1	Make known that a beacon location has been identified
5	5	Place antenna close to drop point
5	5	Carry multiple antenna
5	5	Drop antenna in proper orientation
2	2	Disengage
5	5	Does not drop antenna en route to destinations
1	1	Display current coordinates
5	5	Recognize invalid coordinates
5	5	Determine its direction
5	5	Can receive GPS Coordinates

Prototype 1	Prototype 2		Prototype 1	Prototype 2
0	5		0	25
0	4		0	20
0	0		0	0
0	0		0	0