

Marker-Based Robotic Guidance System



MECA/MECH 440A-Senior Project

California State University, Chico

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Facility Need

The Lawrence Livermore Laboratory needs a closed-loop guidance system to navigate a robot through their secure storage facility.

Our Goal

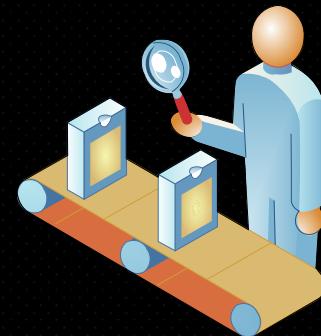
Design, build and test a closed-loop marker-based guidance system to accurately navigate a robot through a warehouse in a predetermined path.



Design



Build



Test

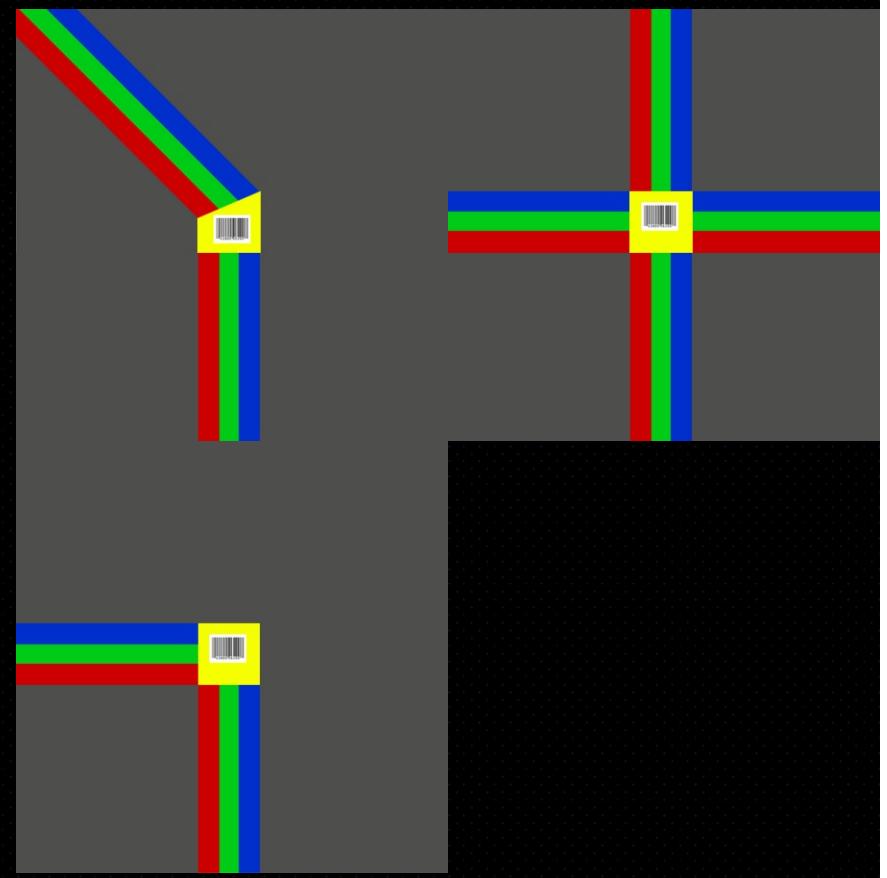
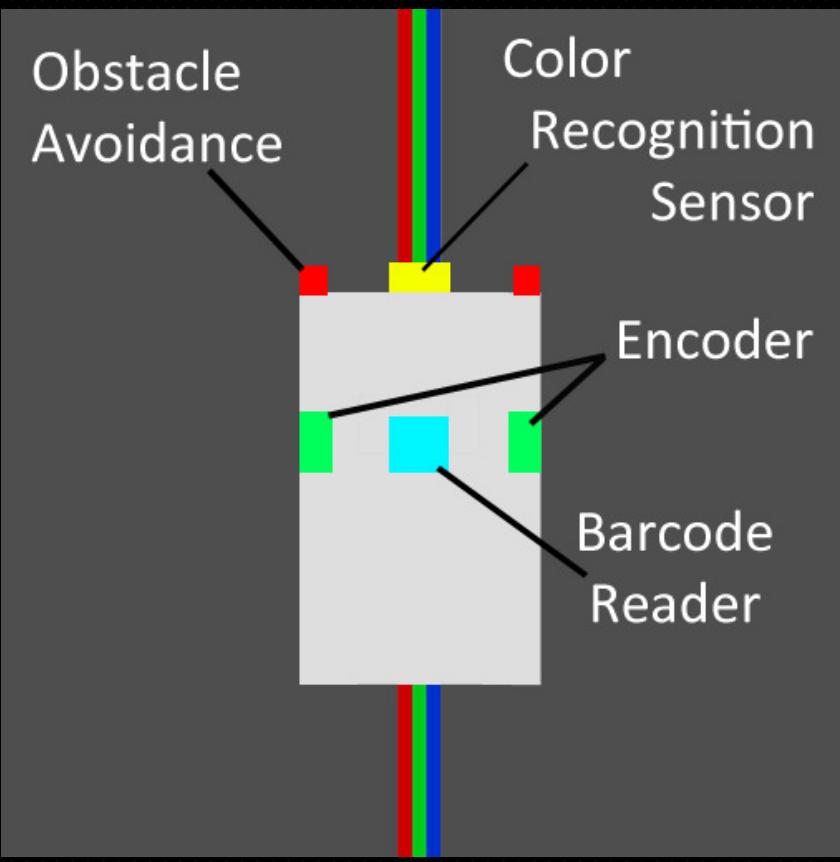
Engineering Specifications

Must Do:	Measurement Method/Device	Tolerance	Conditions	Result
Navigate a robot to a point via a predetermined path	Observation	-	Any angle turns Max speed 3 ft/s	
Provide location data at any given time	Encoders	+ 0.5 ms	At least every 2 ms	
Provide accurate location data	Surveyor's Tape	± 1 inches	-	
Tracking markers must be unobtrusive	Observation	-	-	
Tracking markers must be easy to apply	Observation	-	Applied at about 3 ft/min	
Tracking markers must be semi permanent	Observation	-	-	
Have an emergency stop.	Observation	-	-	
Have a collision avoidance system	Tape Measure	± 1 inches	Must stop if object is within 1 foot of robot	

Should Do:	Measurement Method/Device	Tolerance	Conditions	Result
System must mount and un-mount without significant modifications to the robot	Observation	-	-	

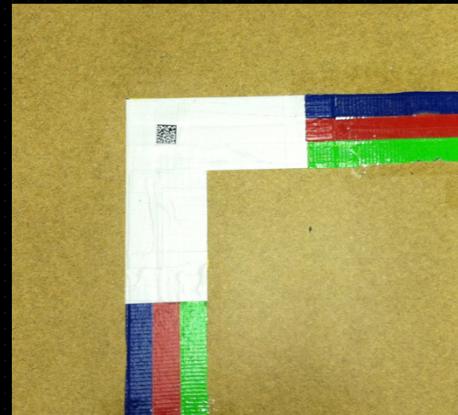
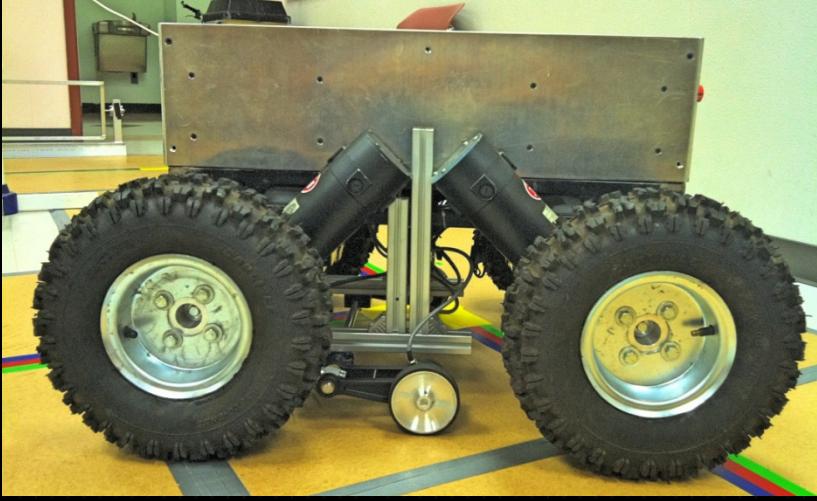
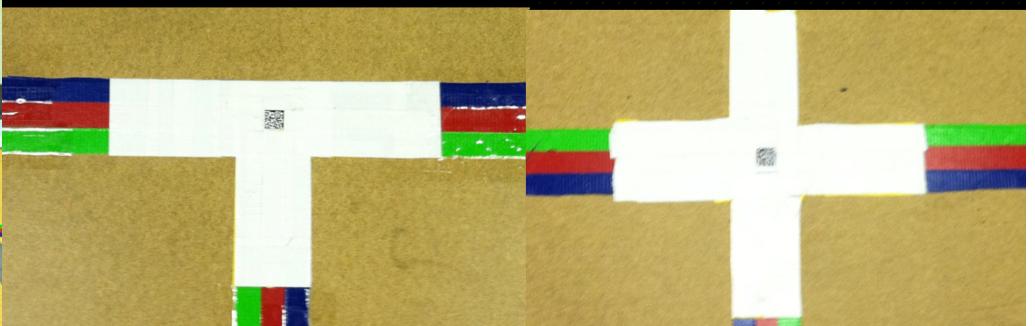
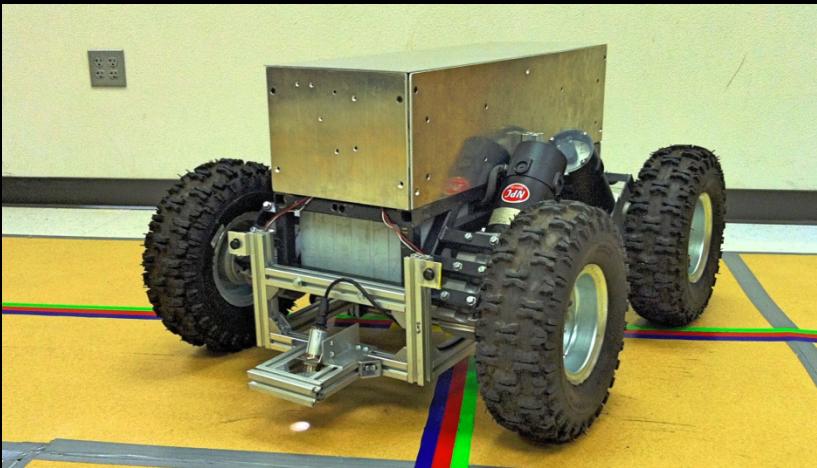
Design Solution

Marker Type	Line Following Method	Absolute Positioning Method	Relative Position	Obstacle Avoidance
Solid color floor tape with barcode markings at intersection	Color Sensor Module	Barcode at intersections.	Encoder with an idler wheel.	Ultrasonic Sensors (4)

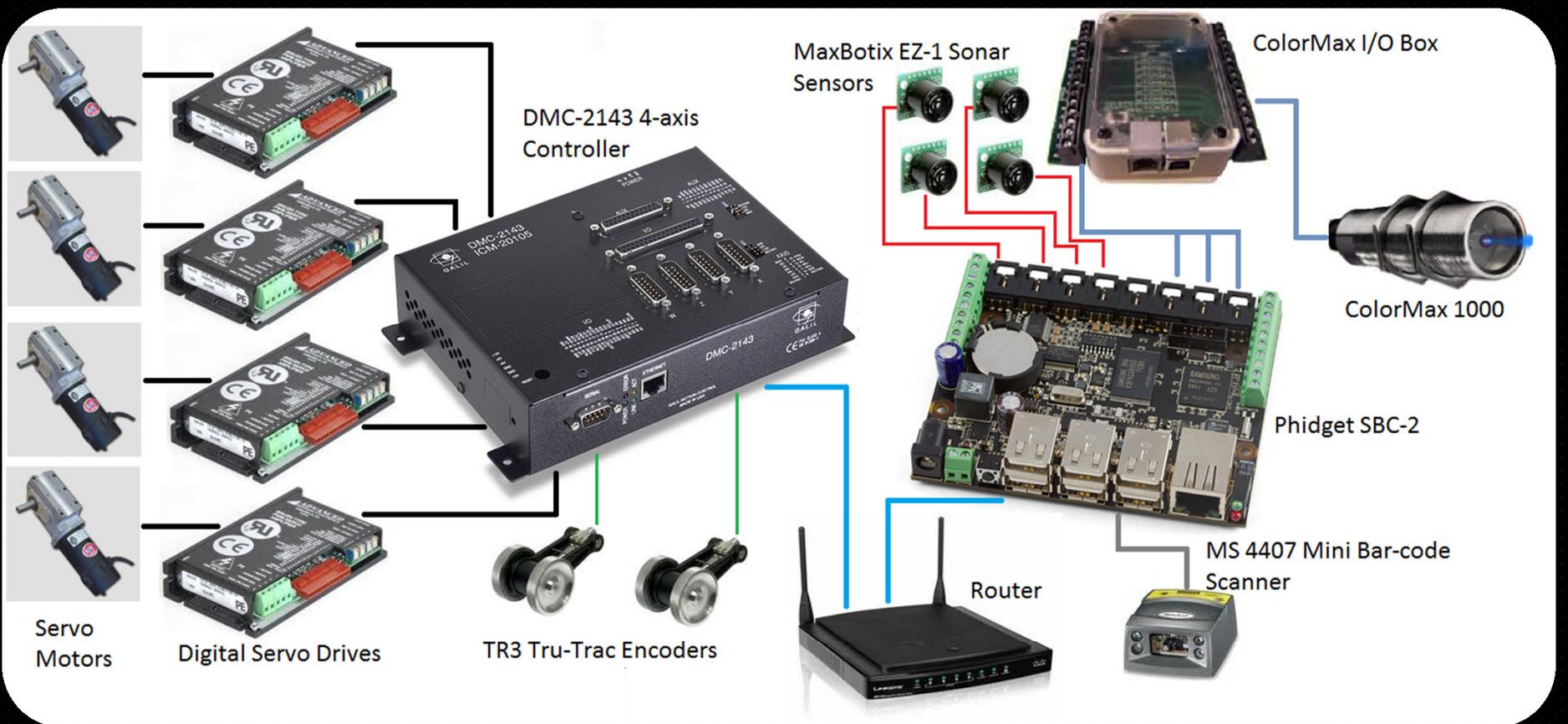


Design Solution

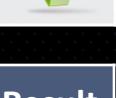
Marker Type	Line Following Method	Absolute Positioning Method	Relative Position	Obstacle Avoidance
Solid color floor tape with barcode markings at intersection	Color Sensor Module	Barcode at intersections.	Encoder with an idler wheel.	Ultrasonic Sensors (4)



Schematic



Engineering Tests

Must Do:	Test	Result
Navigate a robot to a point via a predetermined path	Used preset course to navigate from point to point. Used long straight path to show robot max speed = 3 ft/s	
Provide location data at any given time	Galil monitors encoder counts. 400 counts/in.	
Provide accurate location data	Compare distance returned by the Galil with actual distance of the move over various lengths of travel.	
Tracking markers must be unobtrusive	Tested ability to walk over tape without causing a tripping hazard.	
Tracking markers must be easy to apply	Applied tape at 3 ft/min when creating testing course.	
Tracking markers must be semi permanent	Used robot wheels to determine that the tape will withstand normal wear and tear. Tape can be removed.	
Have an emergency stop.	Ran robot and stopped its motion using a remote kill switch.	
Have a collision avoidance system	Ran robot towards a box. Will stop and avoid a collision when the robot comes within one foot of the box.	

Should Do:	Test	Result
System must mount and un-mount without significant modifications to the robot	System used only mounting features that were already on the robot.	

Budget

Bill of Materials

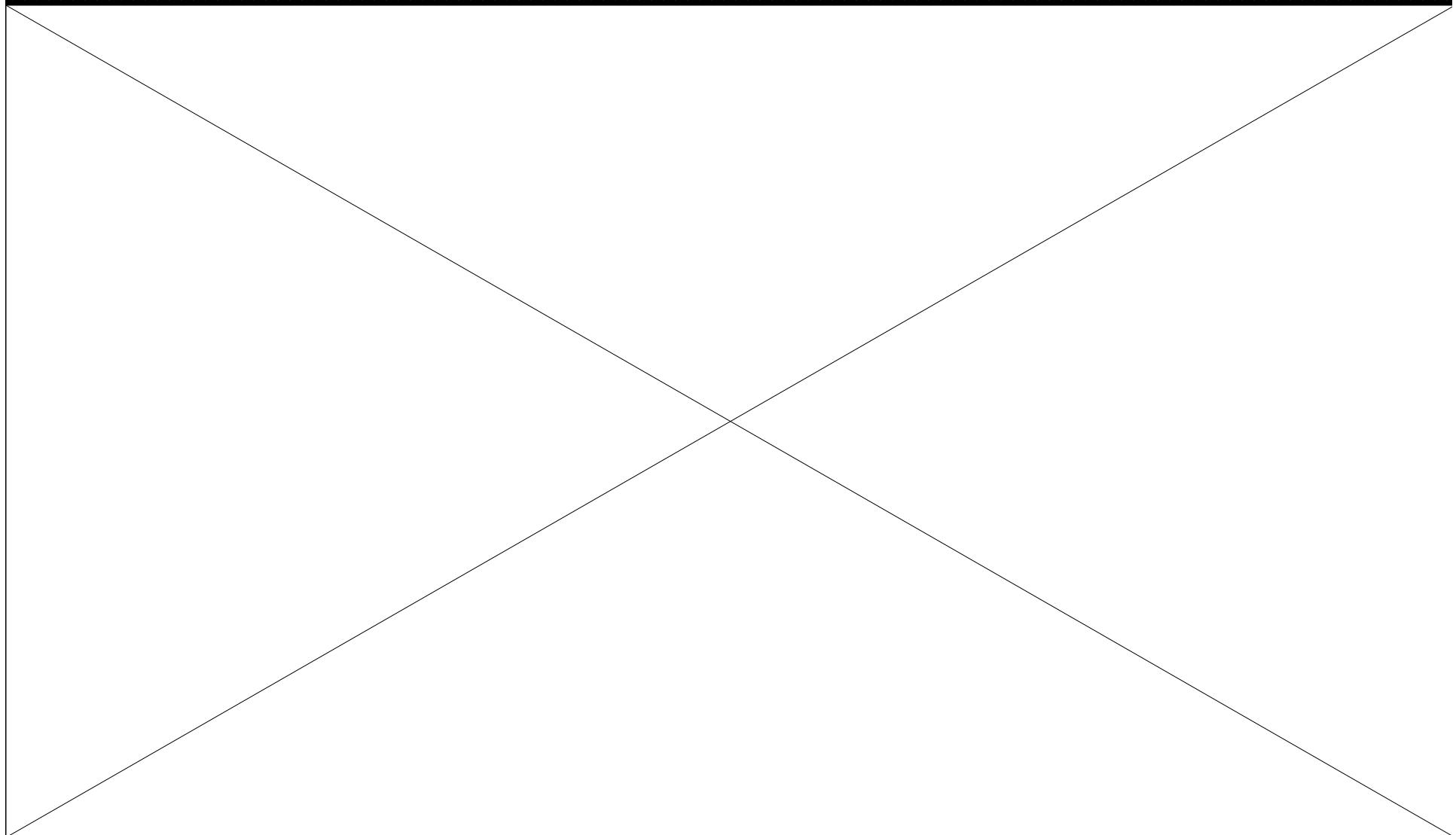
QTY	Manufacturer	Description	Unit Cost	Final Cost (w/ S&H)	Suggested Vendor
1	EMX Industries, Inc	ColorMax-1000 Color Recognition Sensor (CM100-4FLEX), I/O box, cables, mounting bracket, power supply, DB9 adaptor, and jamb nuts (CM100- Kit2)	\$1,215.28	\$1,381.00	http://www.emxinc.com/
1	Duck	Duct Tape	\$33.47	\$36.48	http://www.durastrip.com/
10	Home Depot	Tempered Hardboard	\$7.98	\$86.38	
3	Bi-Rite Steel & Fabrication Co., Inc.	3' Stainless Steel Solid Round	\$8.34	\$27.09	
2	Encoder Products	Heavy Duty Tru-Trac Encoder (TR3)	\$520.00	\$1,125.80	www.encoder.com
4	MaxBotix	EZ1	\$25.95	\$112.36	www.parallax.com
1	ASG Services	Plastic Floor Location Labels (Pack of	\$75.00	\$81.19	www.asgservices.com
1	Motorola	MS4407	\$337.00	\$364.80	www.keyence.com
1	TAOS	Linear Sensor Photodiode Array - 640x1	\$31.24	\$40.24	http://www.futureelectronics
5	Parallax	Infrared Emitter/Receiver (QTI)	\$5.99	\$36.23	www.parallax.com
1	Phidgets	Phidget SBC2	\$245.95	\$266.24	www.sparkfun.com
1		Poster	\$28.80	\$31.39	
			Total	\$3,589.21	

Budget

Budget Summary

Materials	\$3,589.21
Labor	\$182,832.79
Total	\$186,422.00

Demo



Questions?



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