

Construction Marking Robot

Team 19

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Presentation Outline

- Project Background
- Concept Generation
- Operation
- Where are we going?
- Questions





Project Background



Project Scope

- Robot to aid in the construction process
- Replicate floor plans from CAD file
- Develop marking arm
- Half inch accuracy
- Avoid obstacles
- Create error report
- Semi-Autonomous



Current Problem

- Construction Industry
 - Production is low
 - Lack of technology
- Current Method
 - Manual
 - Human Error
 - Time Consuming
 - Dangerous



Need and Goal Statements

Need Statement

“Since the recession, productivity in the construction industry is low”

Goal Statement

“Design a ‘proof of concept’ high precision marking robot that will lay out the preliminary floor plan of a construction site”



Project Parameters

- Must be able to obtain its precise position in the environment
- Must be able self-navigate and avoid obstacles
- Must be able to mark on concrete
- Cost must not exceed \$8,000
- Lightweight and easily portable



Pioneer 2-DX

- Two main boards: microcontroller and motor controller
- Robot total weight = 13.5 kg (4.5 kg for Sick LMS-200)
- Approximately 13" W x 17" L x 9" H
- Supports 16 sonars and equipped with bumper switches
- Up to three 12 V_{DC}, 7 Ah batteries
- Onboard Ethernet for wireless communication
- Runs on real-time operating system (QnX Neutrino RTOS)

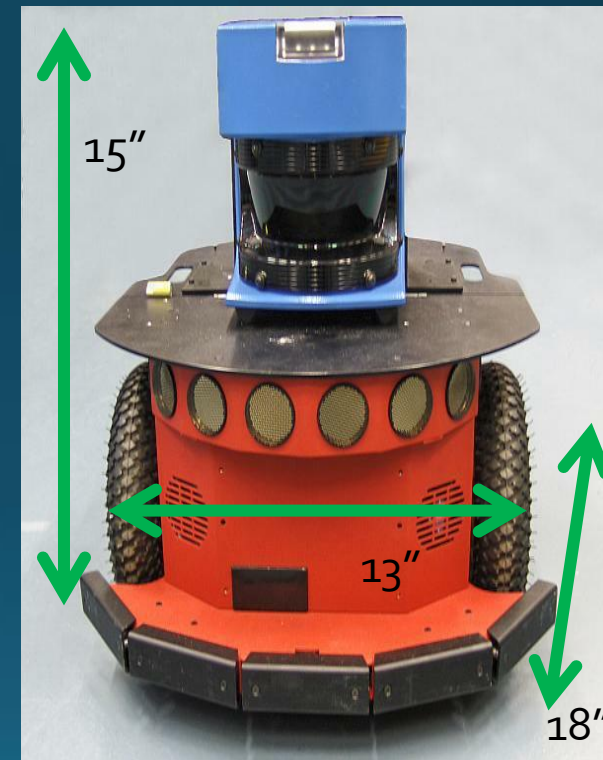


Figure 1 – Pioneer 2-DX



Robotic Totaling Station

- Provides increased efficiency
- Continuously measures exact location
- Provides vertical, horizontal angles, and distance of prism
- Has known coordinate location in CAD file as reference

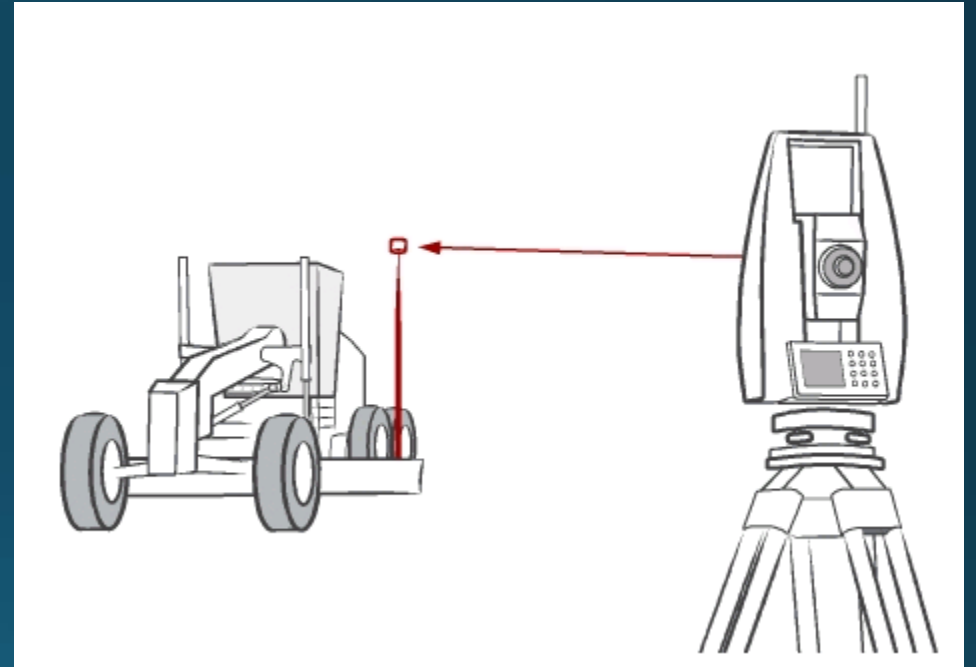


Figure 2 – Robotic Totaling Station

2D CAD

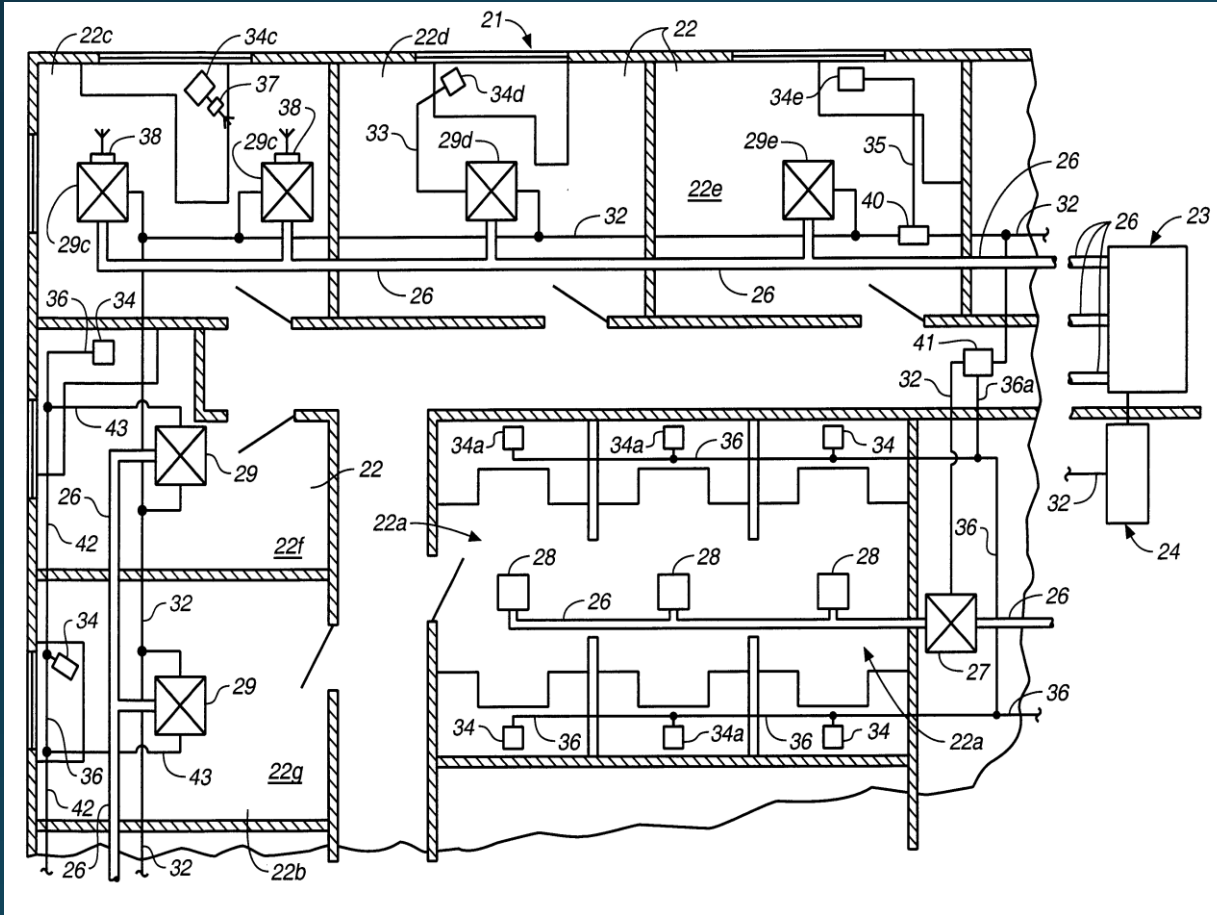


Figure 3 – CAD of Layout

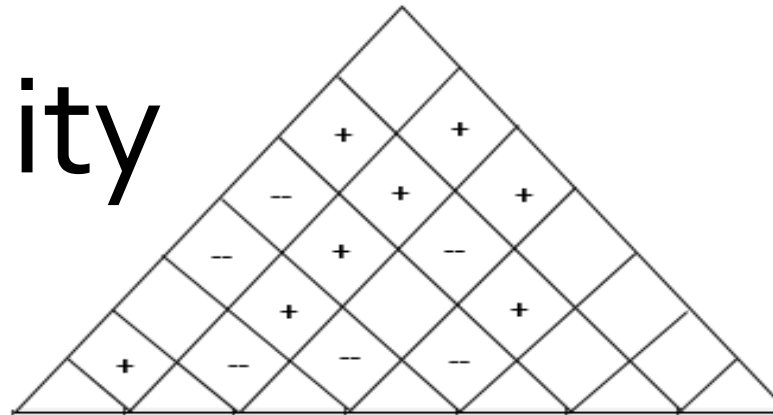
- Provided by the architects to the contractors
- Provides locations of:
 - Walls
 - HVAC
 - Electrical
 - Sprinkler Systems
 - Plumbing



Concept Generation



House of Quality



Legend of Roof

- + direct correlation
- inverse correlation

Legend of Competitor Comparison

- + maximize
- minimize
- o target value

Engineering Characteristics →		Rate of Coverage	Cost	Weight of Device	Battery life	Precision	Total Area Coverage	# of Colors	Selling Points	Competitor A	Competitor B	Target Values
Customer requirements	Importance to Customer											
Functionality	5	10	5	2	8	10	10	10	275	4	4	5
Easy to Operate	3		5			2		2	27	4	4	4
Light Weight	4	7	8	10	10		7	4	184	4	5	5
Safety	5			7		5			60	3	5	5
Portability	4	3	5	10				2	80	4	3	4
Price	1	3	10	7	8	5	2	5	40	3	4	4
Durability	4		5	3					32	3	3	4
Aesthetically pleasing	1							5	5	3	4	4
Serviceability	3		3		7			5	45	3	4	4
Other specific needs ↓	Importance Weighting →	93	131	144	109	86	80	105				
Competitor Comparison												
Direction of Improvement		+	o	-	+	+	+	o				
Laybot		?	?	75 lb	???	???	?	1				
Markbot		?	?	?	???	???	?	1				
Target Values		105QFT /min	<\$8000	<100lb	>4hr	???	100 FT^2	>1				

Figure 4 – House of Quality



Concept Generation

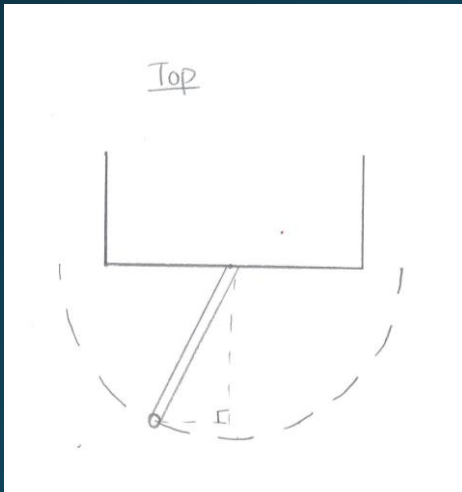
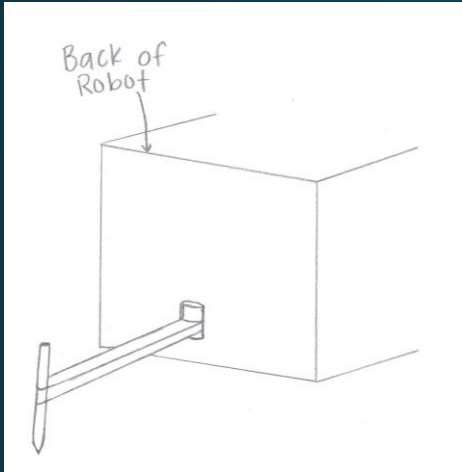


Figure 5 – Concept A

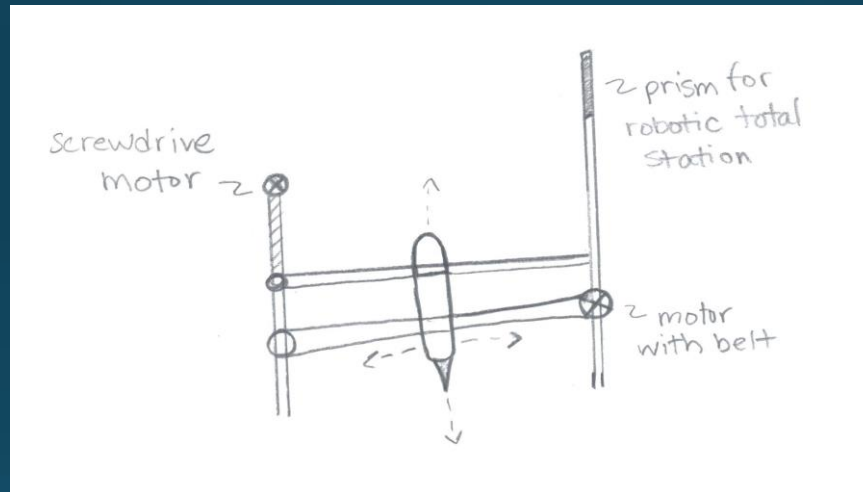


Figure 6 – Concept B

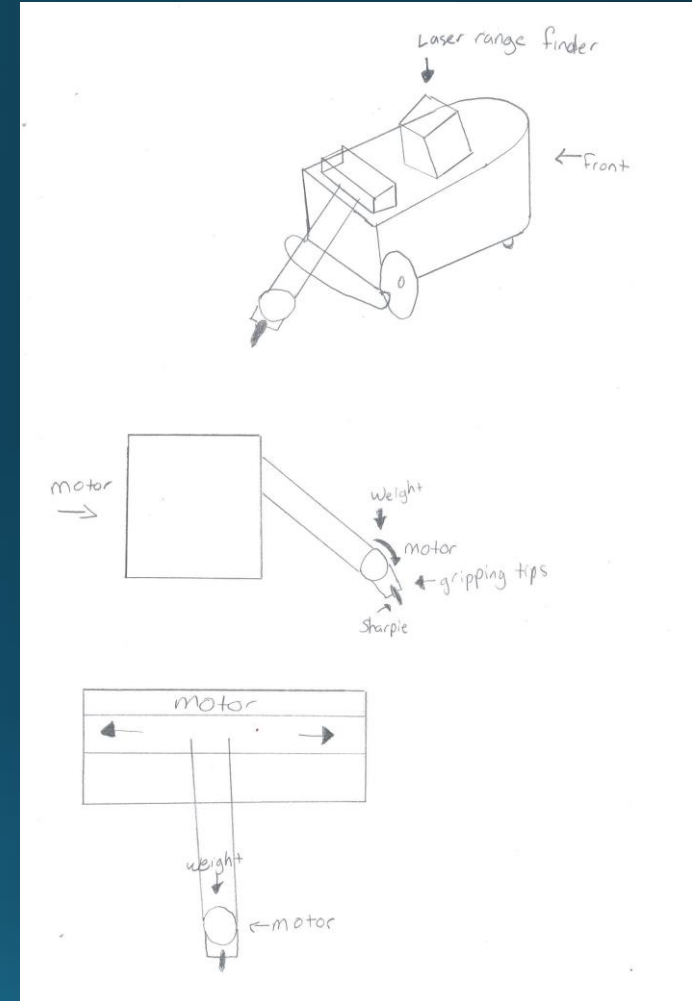


Figure 7 – Concept C



Morphological Chart

Requirements	Functional Parameters	Concepts Solution			
Functionality	Marking Reach	Inside of Robots Tires		Outside of Robots Tires	
	Marking Mechanism	Belt Driven	Manipulator Arm	Rack & Pinion	
Ease of Operation	Degrees of Freedom	1	2	3	7
	# of Motors	1	2	3	4
Lightweight	Material Selection	Aluminum	Wood	ABS Plastic	

Figure 8 – Morphological Chart



Pugh Diagram

Customer Requirements	Customer Importance	Target Values	Concept A	Concept B	Concept C	Selected Concept
Functionality	5	5	3	4	5	5
Easy to Operate	3	4	5	3	3	4
Light Weight	4	5	5	3	4	5
Safety	5	5	4	5	4	5
Price	1	4	5	2	4	4
Durability	4	4	3	4	4	4

Figure 9 – Pugh Diagram



Concept Selected

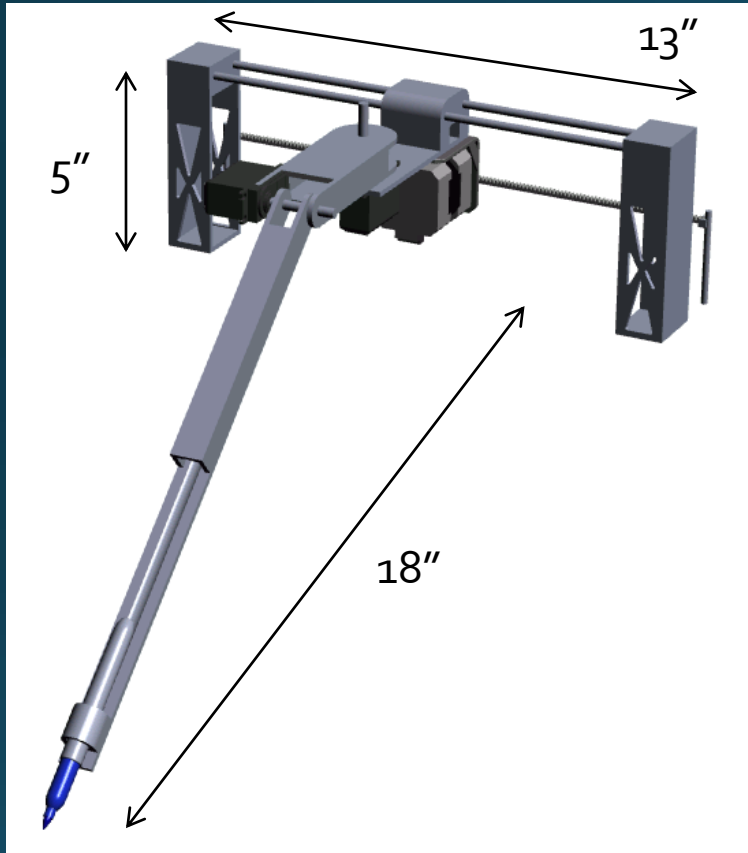


Figure 10 – Final Conceptual Design

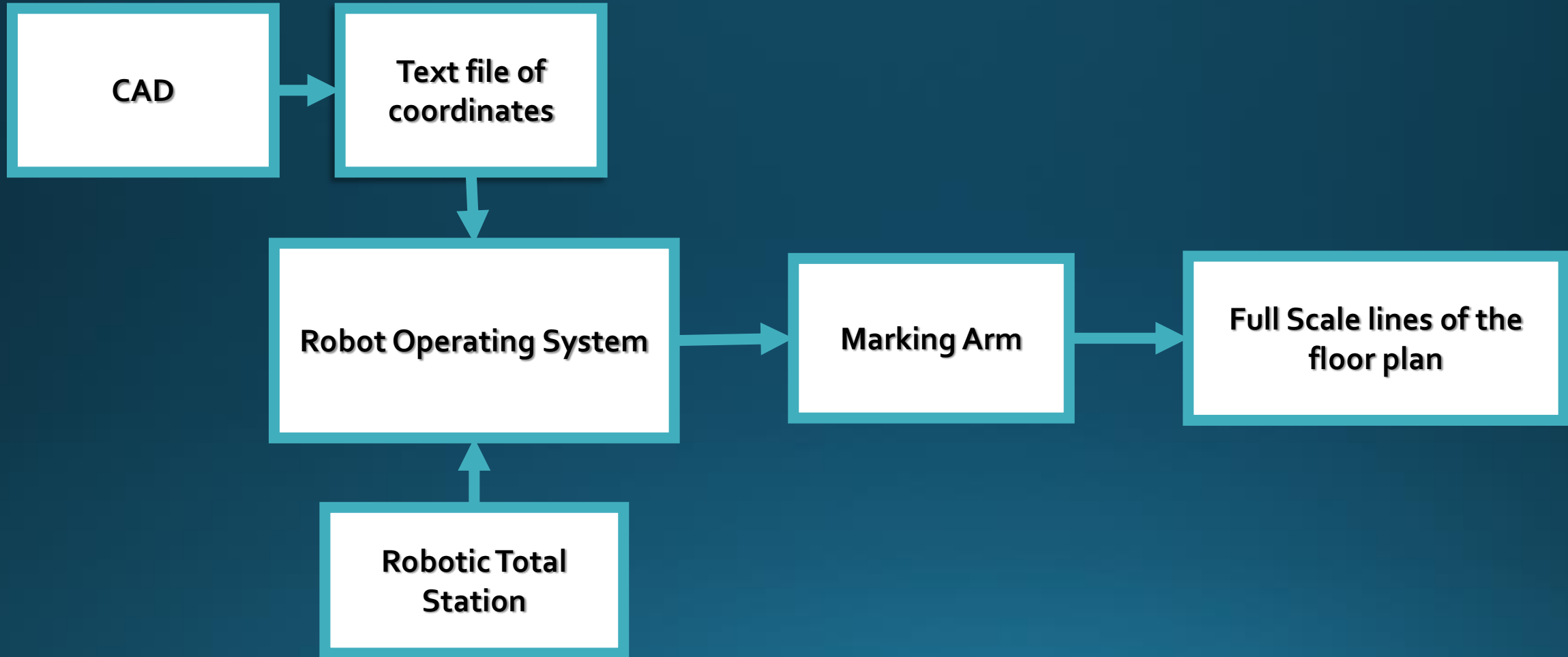
- Combination of previous designs
- 2 servo motors
- Provides greater reach
 - Movement in 2 directions
 - Marks outside of tread
- Stepper motor attached to rack and pinion



Operation



Block Diagram



Extracting CAD data





Where are we going?



Hurdles to Overcome

- Robot, CAD file, and total station all have their own coordinate system
- Metric system and English system (precision)
- Robot must adjust to the total station in real time
- Limited knowledge on total station (API)
- Error checking (obstacles)



Near Future

- Meeting with Sponsors and Advisors
- Finalize Design
 - Exact Dimensioning
 - FMEA
 - Bill of Materials
- Gather API
- Prototype
- Troubleshooting



Gantt Chart

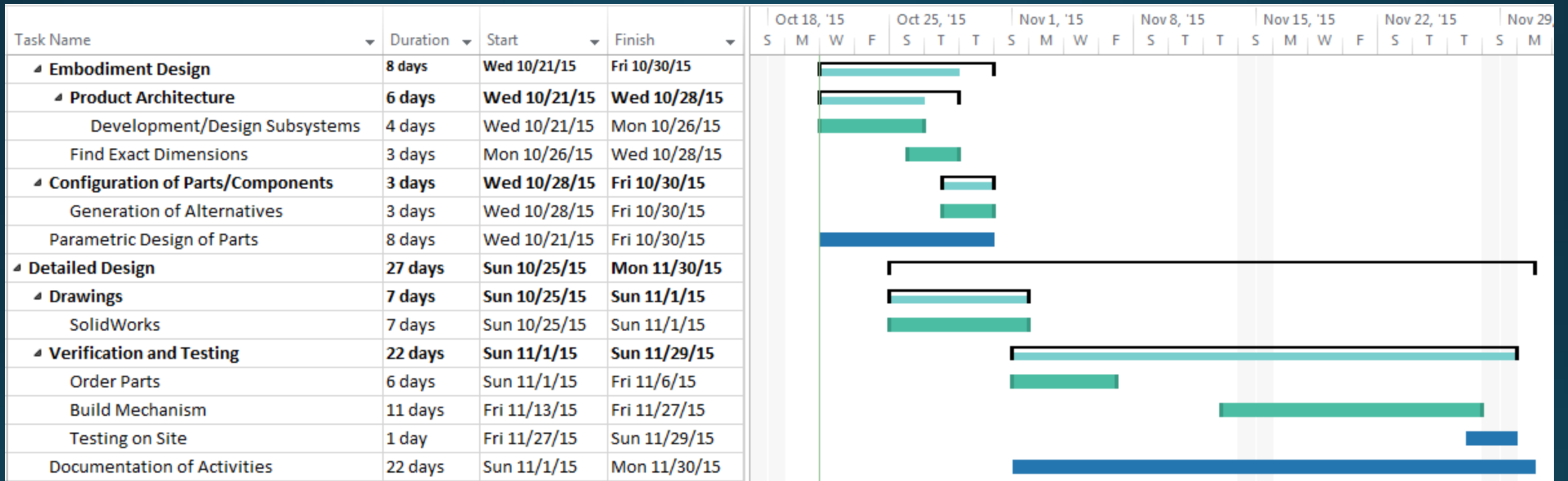


Figure 13 – Gantt Chart



References

- "Specifications & Controls." *ActivMedia Robotics Pioneer 2/PeopleBot Operations Manual V10*. N.p.: n.p., July 2002. 10-18. Print.
- Dieter, George E., and Linda C. Schmidt. *Engineering Design*. New York: McGraw-Hill, 2013. Print.





Questions?

