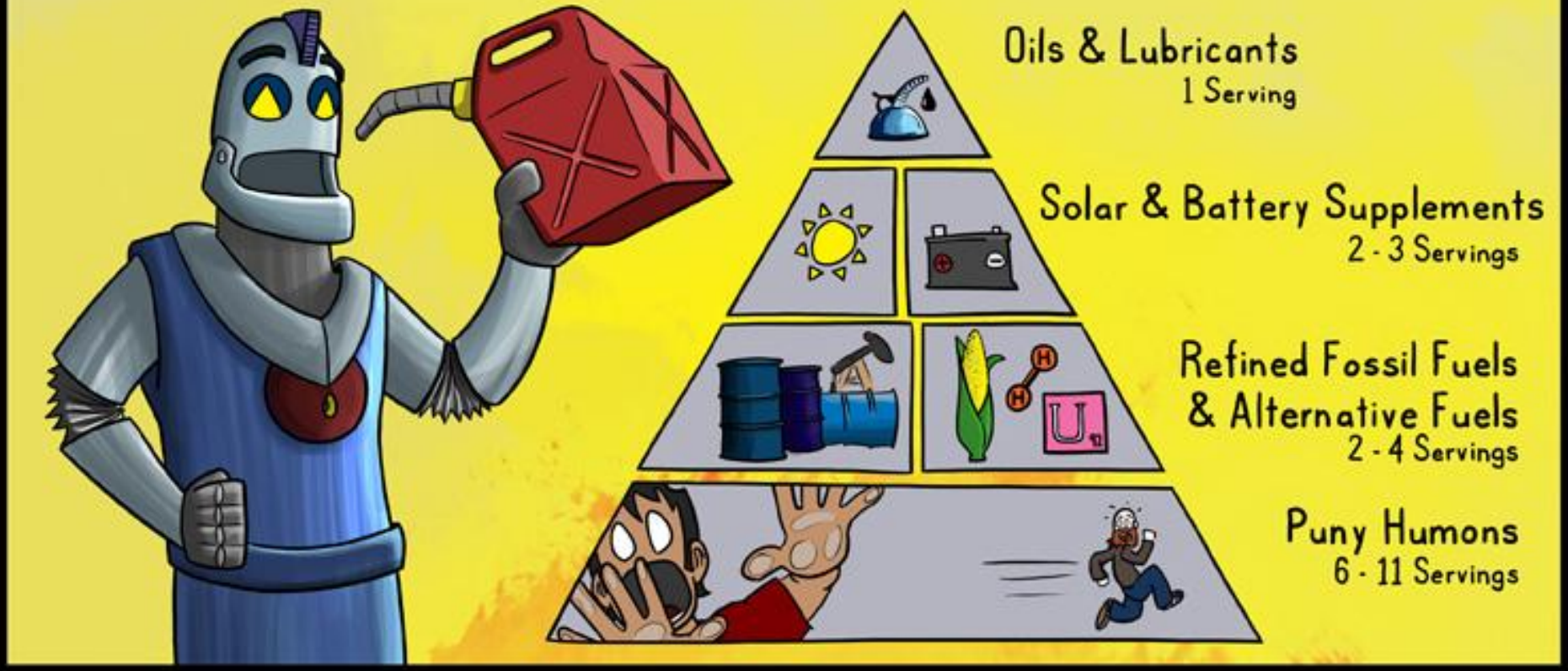
Alaska Robotics

Robot Food Pyramid



I-Guide

Intelligent Guide Robot

Joe Buckner & Nir Chezrony

Advisors:
Dr. Joel Schipper & Dr. James Irwin, Jr.

Sponsored By:
Northrop Grumman

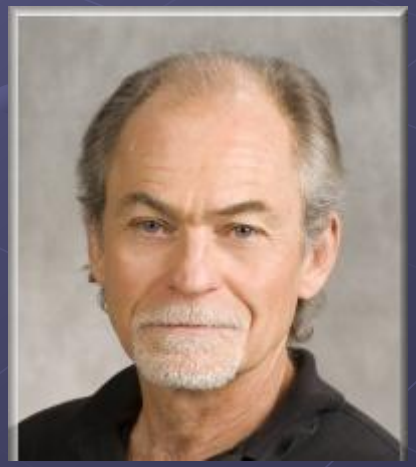
BRADLEY UNIVERSITY

Presentation Overview

- Project Summary
- Topological Decomposition
- Goals & Requirements
- System Block Diagram
- Hardware Overview
- Software Suites
- Software Flowcharts
- FCRAR

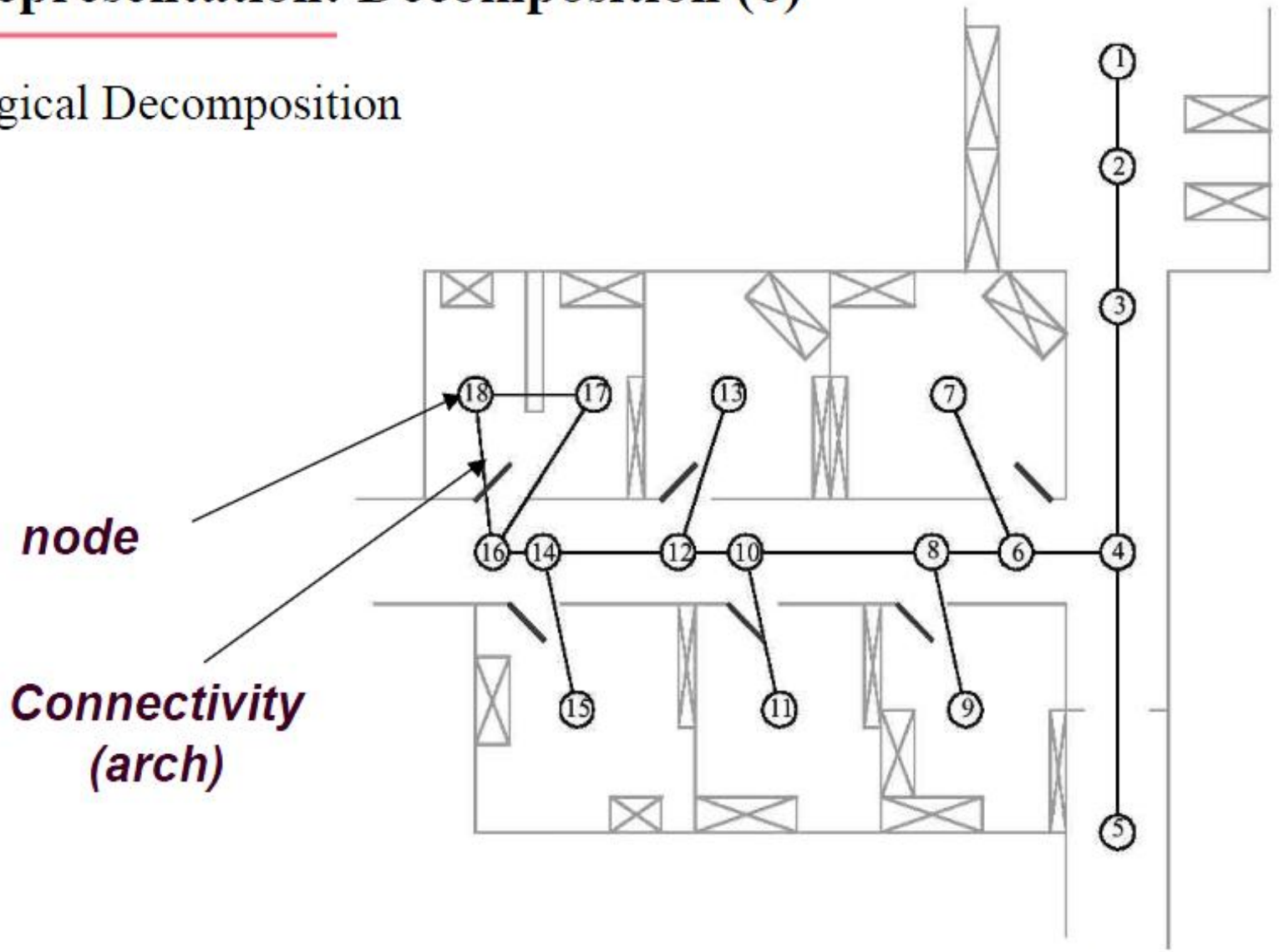
Project Summary

- Autonomous Tour Robot – Pioneer 3
- 2nd and 3rd floor of ECE Department
- Utilize Elevator
- Localization - Barcodes
- Navigation – Topological Decomposition



Map Representation: Decomposition (6)

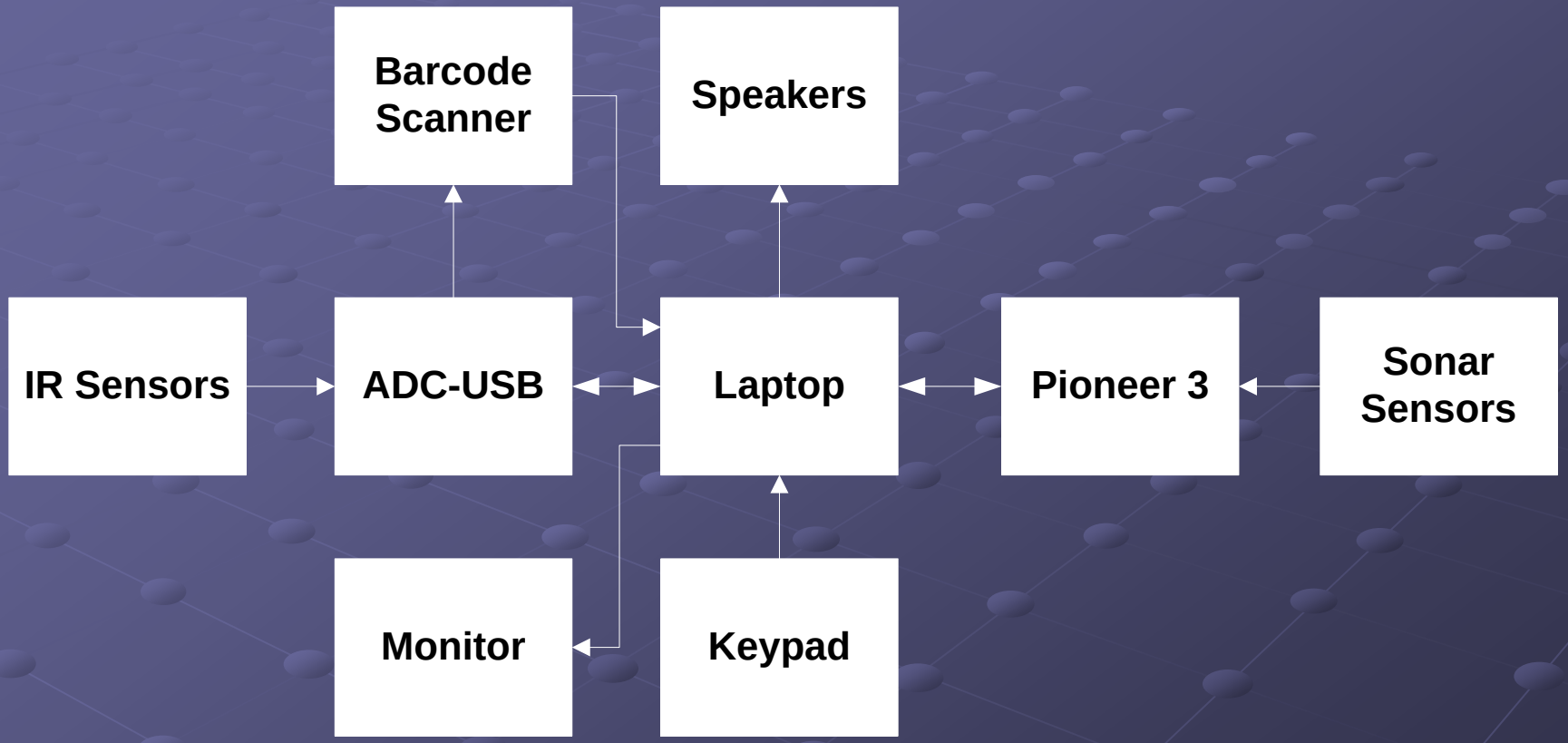
- Topological Decomposition



Project Goals Drive Functional Requirements

- Successfully Navigate ECE Department
  - 3 floor tour options or 28 locations
  - Locate waypoints within a 4’ radius
- React in a ‘Human-like’ Manner
  - Avoid all obstacles → humans avoid obstacles
  - Software loop time → human reaction time
  - Transit speed → human walking speed

System Block Diagram

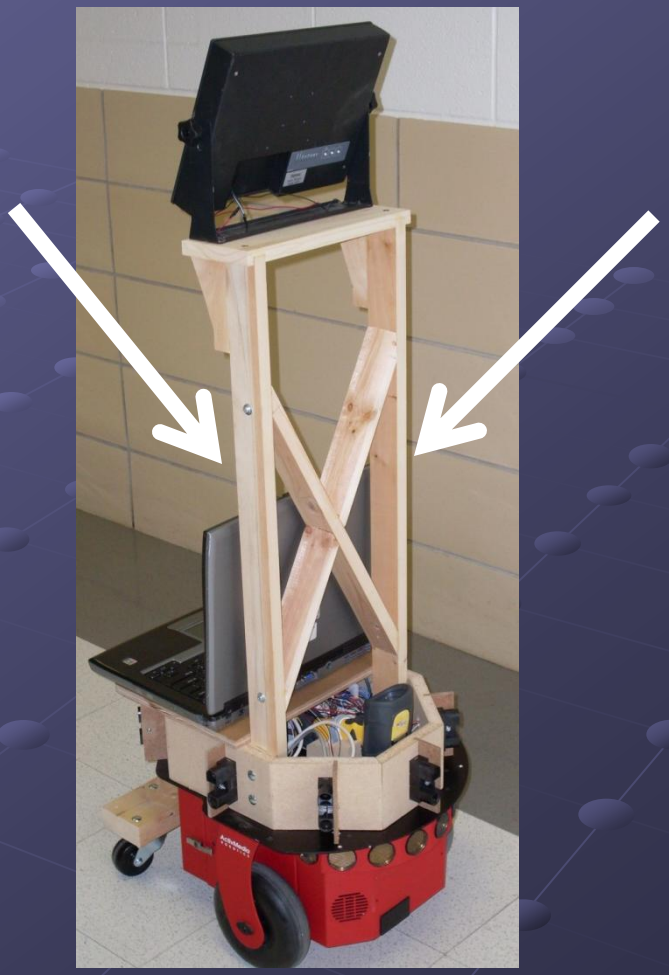


Pioneer 3

Laptop

Keypad*

Speakers*



Bump Sensors*

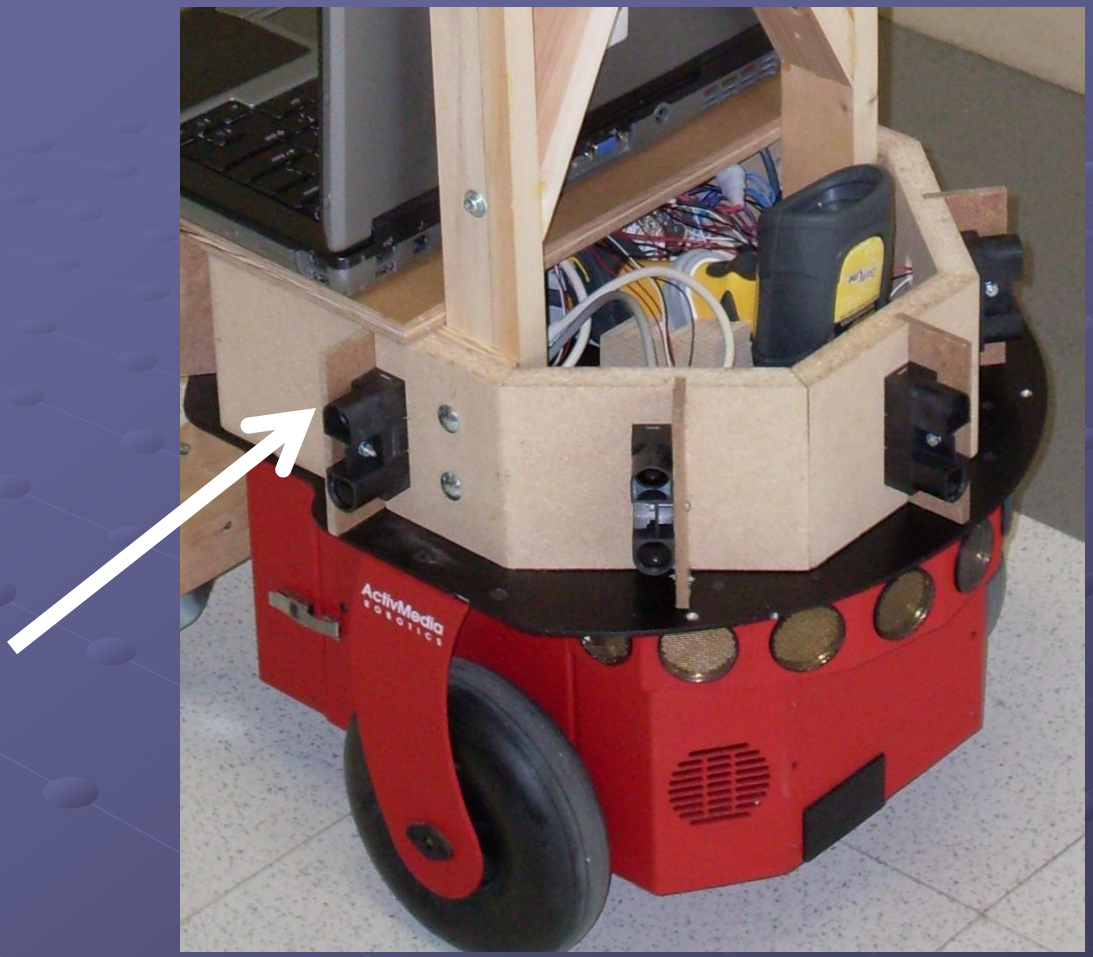
Monitor

Barcode Scanner

ADC-USB

Ultrasonic Sensors

Infrared Sensors



Pioneer 3

- Basic Platform
- Serial Port Communication
- Sonar Sensor Bank
- Dead Reckoning

Barcode Scanner

- Triggered via USB to ADC
- Reads Barcodes from the Ceiling
- Read Range up to 17 feet
- Powered via Laptop

Barcode

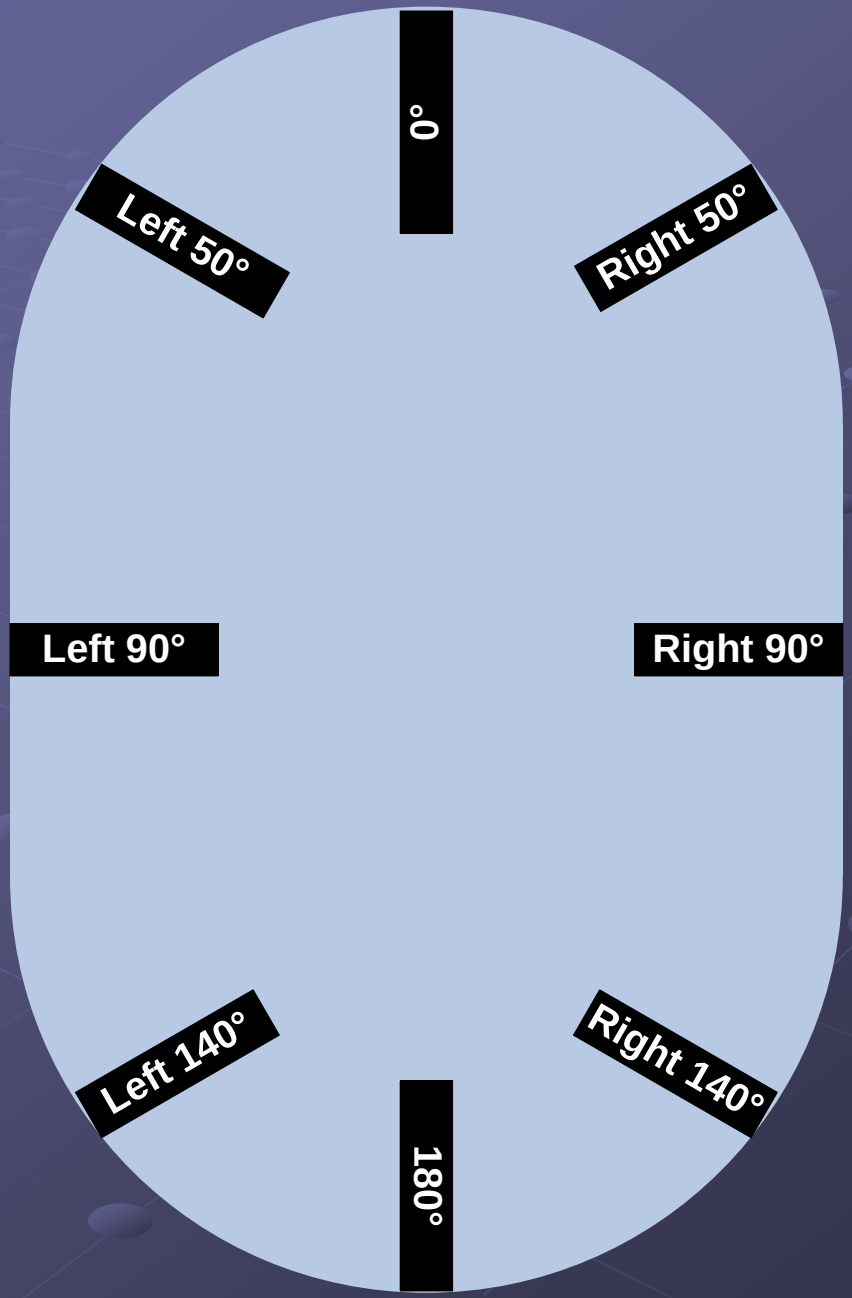
ADC to USB

- 11 Analog Inputs – 10 bit resolution
- 1 Digital Output
- Driver in C
- Powered via Laptop

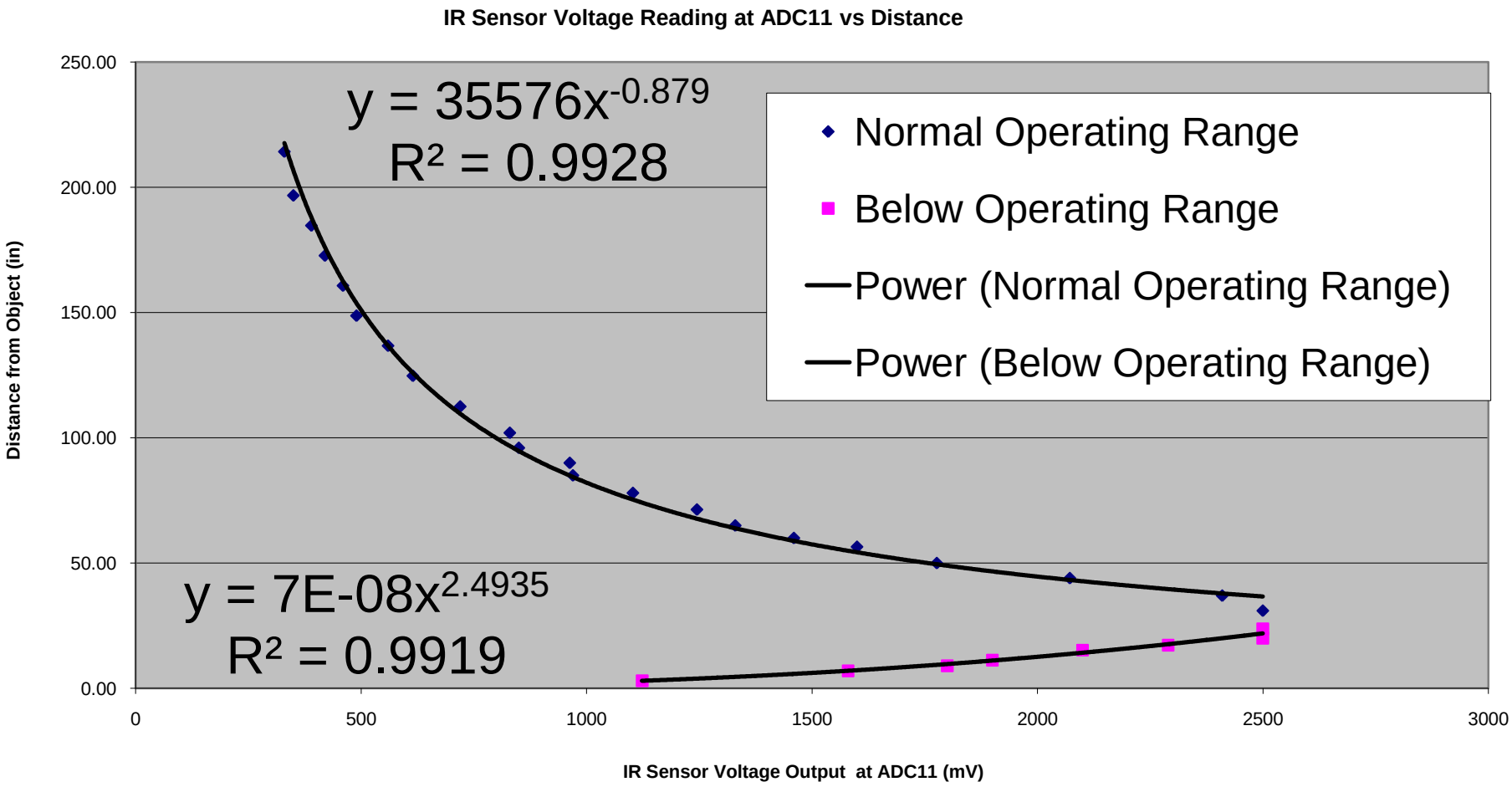
IR Sensors

- Range: 3.2ft – 18ft
- Works in ambient light
- Powered by Pioneer 3 Batteries
- Analog Voltage Output

FRONT



Voltage to Millimeter Conversion

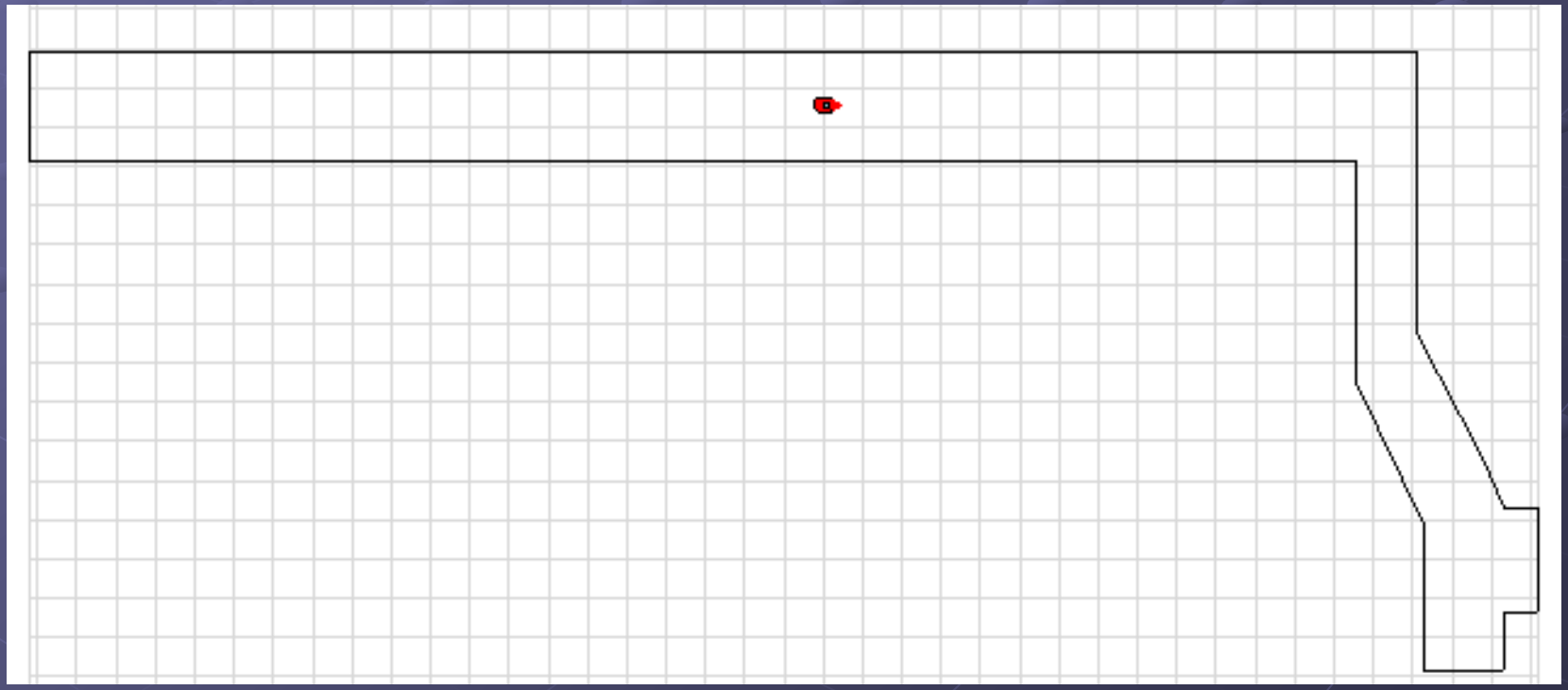


Kiosk Monitor

- Overvoltage Protection Circuitry
- Operating Range 8 – 13.2 VDC
- Powered via Pioneer 3 Batteries

Software Suites

- Microsoft Visual Studio
- Aria MobileSim



Initialization

- Robot Initialization
- ADC-USB Initialization
- Software Logging
- Calibration Module

Calibration

$$Law\ of\ cosines: C^2 = A^2 + B^2 - 2AB\cos(\alpha)$$

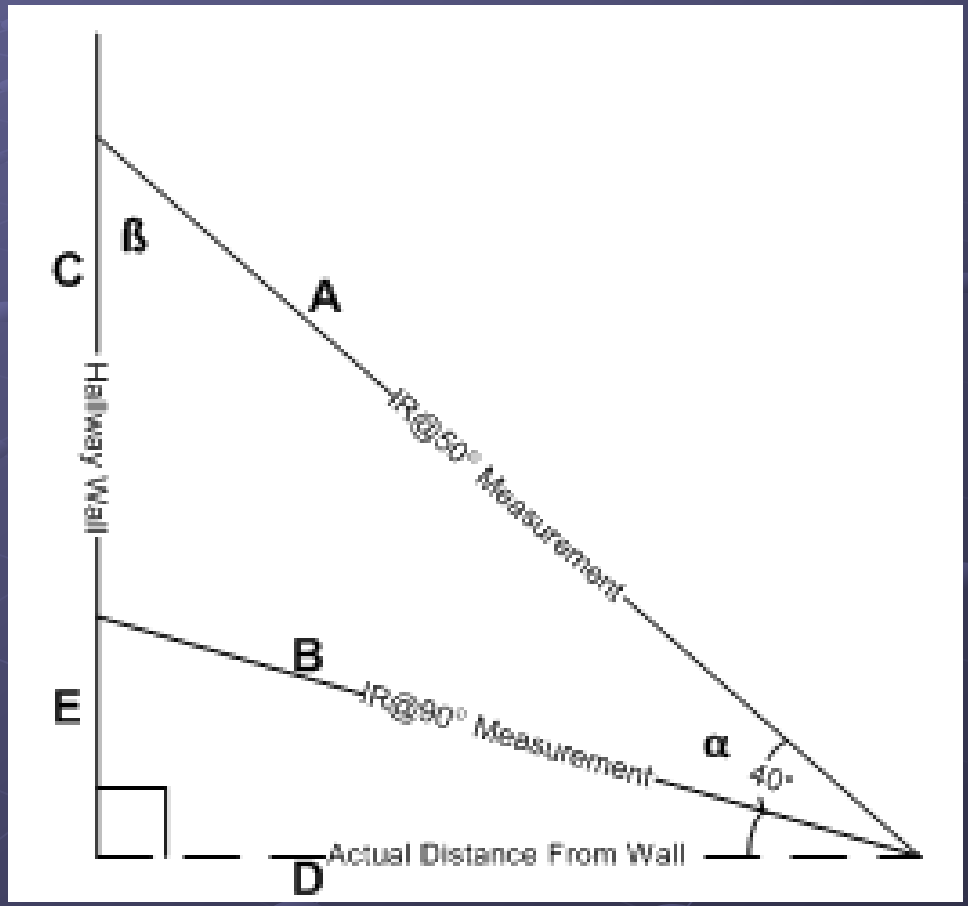
$$Law\ of\ cosines: \cos(\beta) = \frac{A^2 + C^2 - B^2}{2AC}$$

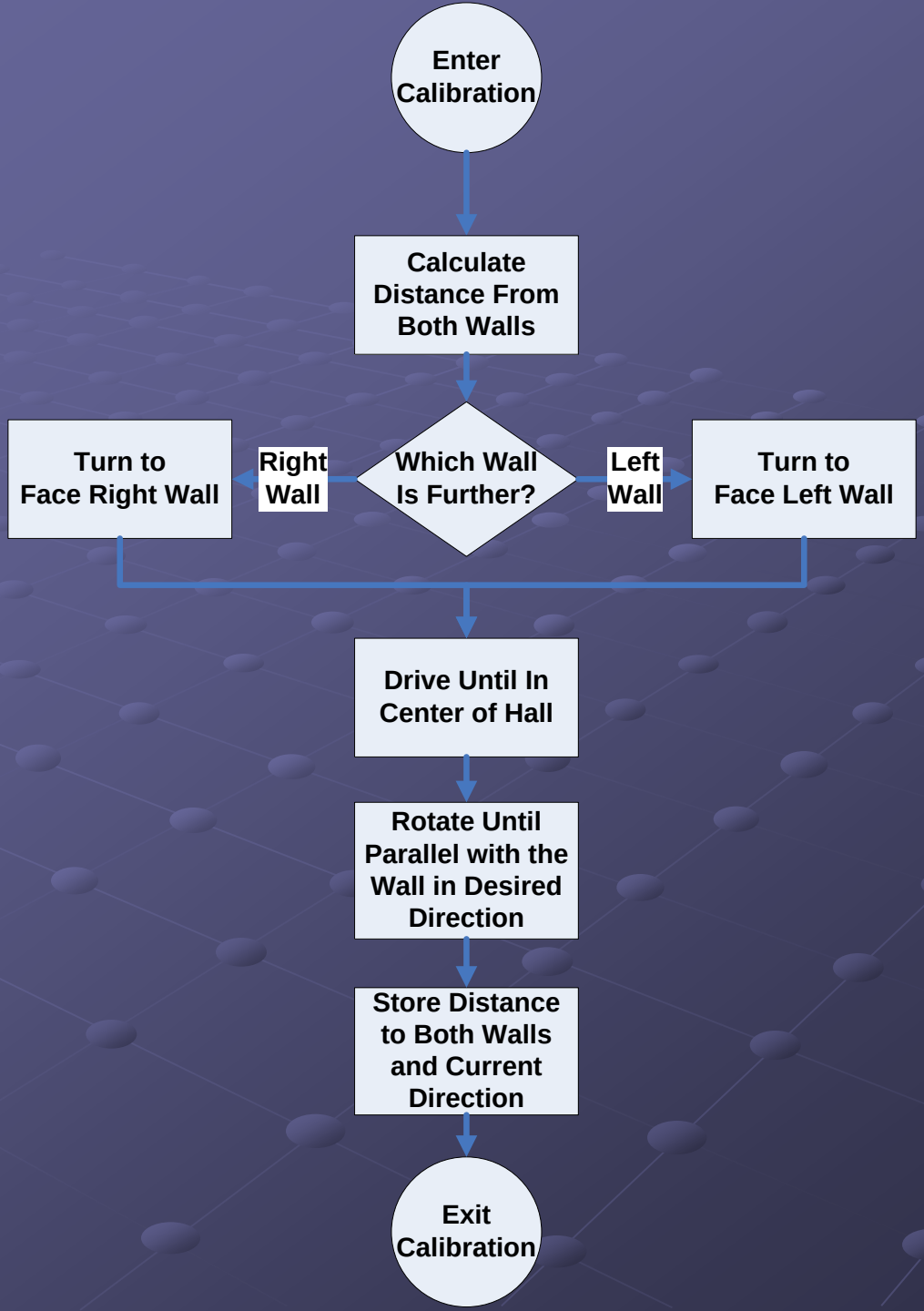
$$Law\ of\ sines: \frac{\sin(\beta)}{D} = \frac{\sin(90°)}{A}$$

$$A\sin\left(\cos^{-1}\left(\frac{A^2 + C^2 - B^2}{2AC}\right)\right) = D$$

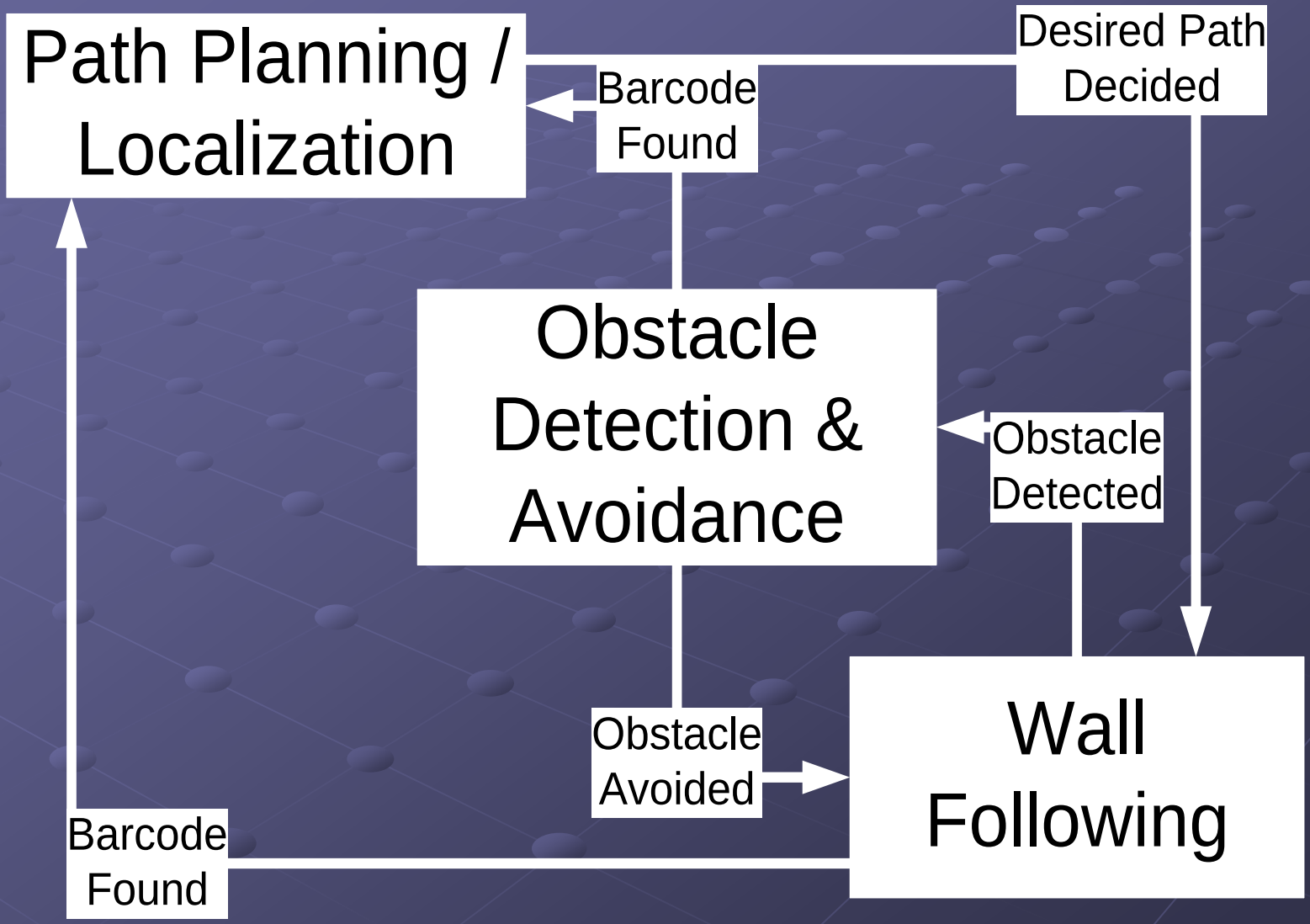
$$Reduced\ Form: A\left(\sqrt{1 - \left(\frac{A^2 + C^2 - B^2}{2AC}\right)^2}\right) = D$$

$$Angle\ from\ Parallel: \cos^{-1}\left(\frac{A}{D}\right)\ (in\ radians)$$



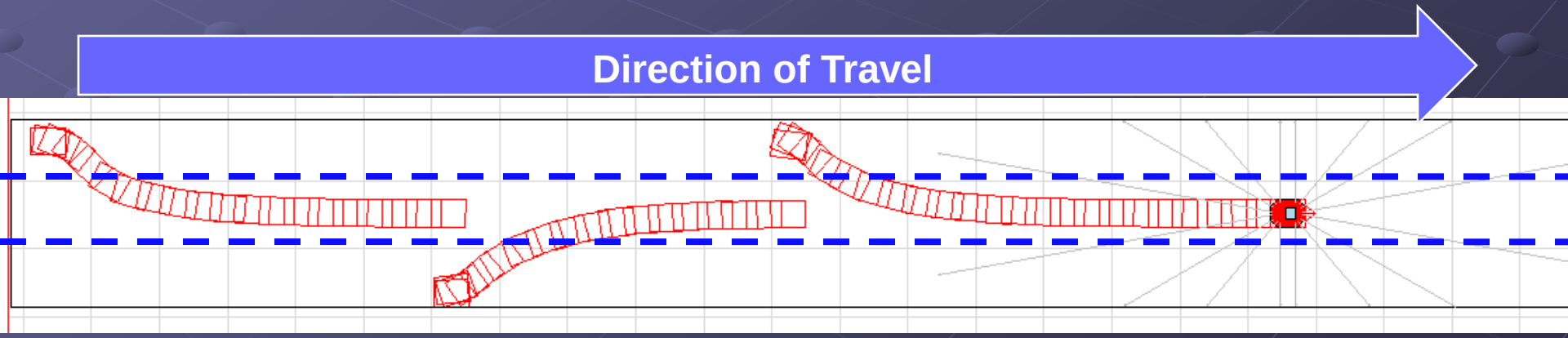

Enter Calibration
Calculate Distance From Both Walls
Which Wall Is Further?
Right Wall
Turn to Face Right Wall
Left Wall
Turn to Face Left Wall
Drive Until In Center of Hall
Rotate Until Parallel with the Wall in Desired Direction
Store Distance to Both Walls and Current Direction
Exit Calibration

Software Flowchart



Wall Following

- Save Distance from Each Wall
- ‘Center of Hall’ Threshold
- Proportional Turning Rate
- Rate Limit Turning Rate



Obstacle Detection & Avoidance

- Obstacle Approaching
  - 80cm < obstacle distance < 120cm
  - Rotate to open pathway
  - Rotation speed dependent which sensor locates obstacle

Obstacle Detection & Avoidance

- Obstacle Detected
  - Obstacle distance < 80cm
  - Slow down
  - Rotate towards open pathway
- Backup
  - Obstacle distance < 80cm
  - Backup if clear
  - Rotates if not

Path Planning & Localization

- Barcode Provides Location Only
- Two Barcodes Determines Direction
- Adjust Direction if Necessary
- Nodal Connectivity Paired with Barcodes

Wall Following Demo

Path Planning & Localization Demo

Future Work

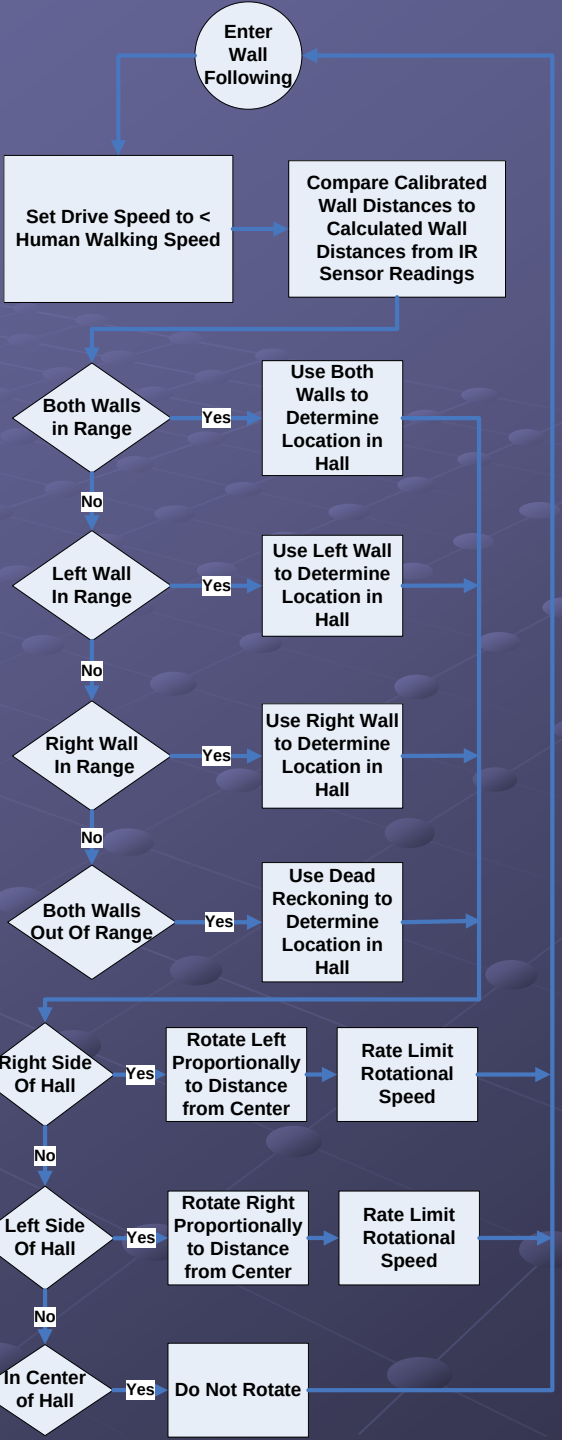
- Utilizing the Elevator
- 1st and 3rd Floor Navigation
- Program GUI including Tour Information
- Bump Sensors, Keypad, Monitor, and Speakers Integration
- Docking Station
- Fix ADC – USB Close

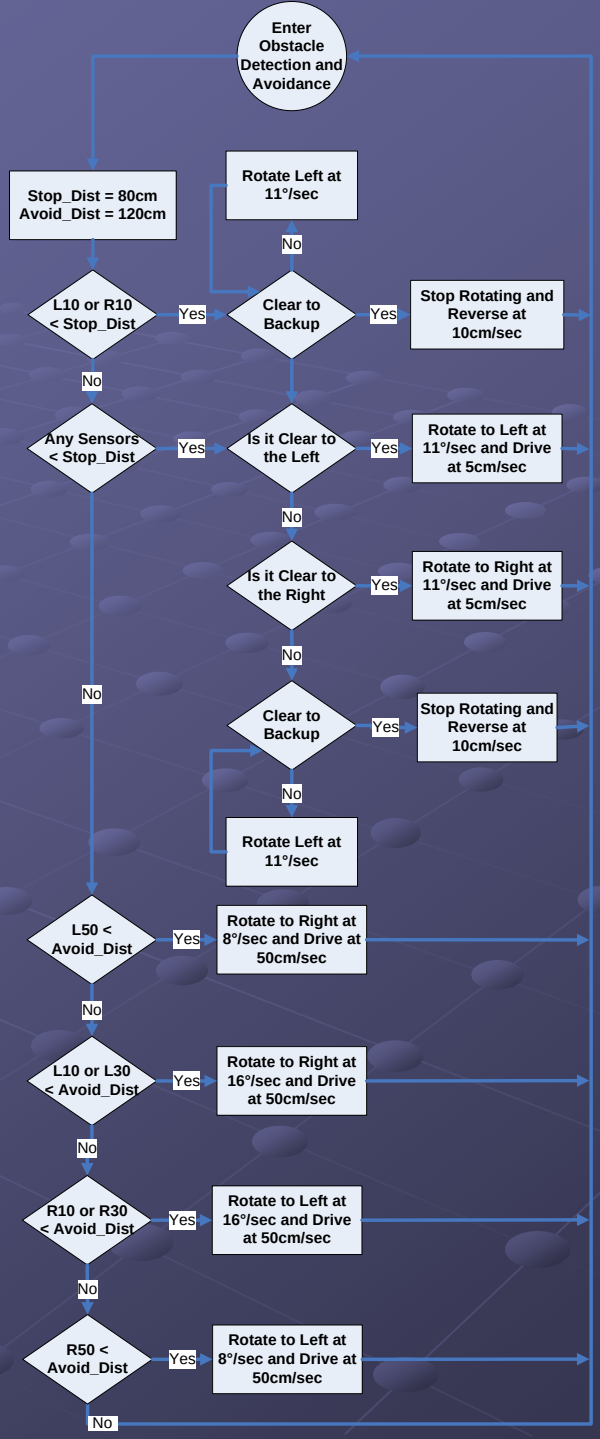
Florida Conference on Recent Advances in Robotics

- Florida Atlantic University
- May 21st & 22nd
- Publication

Acknowledgments and Questions

- Dr. Joel Schipper
- Mr. Chris Mattus
- Mr. Nick Schmidt
- Mr. Steve Gutschlag
- Dr. James Irwin, Jr.
- Dr. Aleksander Malinowski
- Dr. Gary Dempsey


Enter Wall Following
Set Drive Speed to < Human Walking Speed
Compare Calibrated Wall Distances to Calculated Wall Distances from IR Sensor Readings
Both Walls in Range
Yes
Use Both Walls to Determine Location in Hall
No
Left Wall In Range
Yes
Use Left Wall to Determine Location in Hall
No
Right Wall In Range
Yes
Use Right Wall to Determine Location in Hall
No
Both Walls Out Of Range
Yes
Use Dead Reckoning to Determine Location in Hall
Right Side Of Hall
Yes
Rotate Left Proportionally to Distance from Center
Rate Limit Rotational Speed
No
Left Side Of Hall
Yes
Rotate Right Proportionally to Distance from Center
Rate Limit Rotational Speed
No
In Center of Hall
Yes
Do Not Rotate

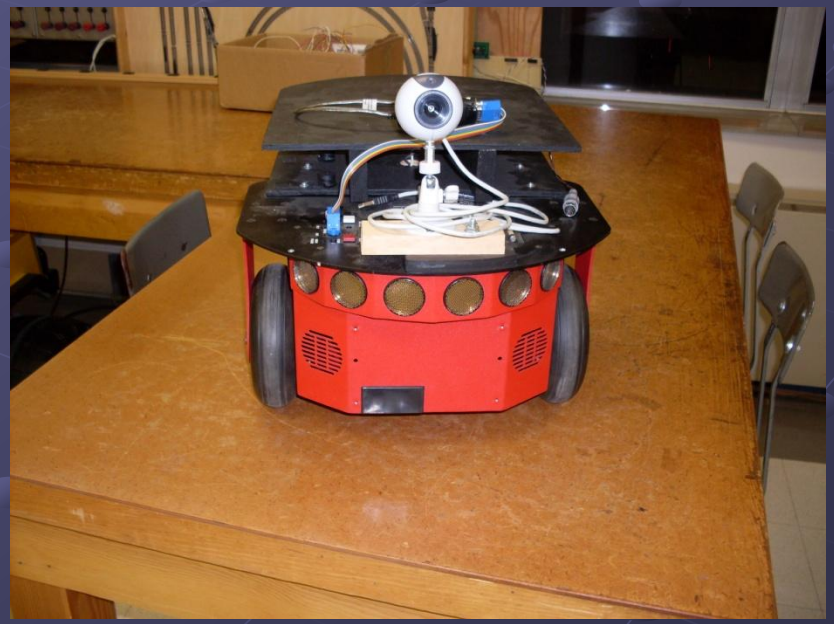

Enter Obstacle Detection and Avoidance
Stop_Dist = 80cm
Avoid_Dist = 120cm
Rotate Left at 11°/sec
No
L10 or R10 < Stop_Dist
Yes
Clear to Backup
Yes
Stop Rotating and Reverse at 10cm/sec
No
Any Sensors < Stop_Dist
Yes
Is it Clear to the Left
Yes
Rotate to Left at 11°/sec and Drive at 5cm/sec
No
Is it Clear to the Right
Yes
Rotate to Right at 11°/sec and Drive at 5cm/sec
No
Clear to Backup
Yes
Stop Rotating and Reverse at 10cm/sec
No
Rotate Left at 11°/sec
No
L50 < Avoid_Dist
Yes
Rotate to Right at 8°/sec and Drive at 50cm/sec
No
L10 or L30 < Avoid_Dist
Yes
Rotate to Right at 16°/sec and Drive at 50cm/sec
No
R10 or R30 < Avoid_Dist
Yes
Rotate to Left at 16°/sec and Drive at 50cm/sec
No
R50 < Avoid_Dist
Yes
Rotate to Left at 8°/sec and Drive at 50cm/sec
No

Parts List

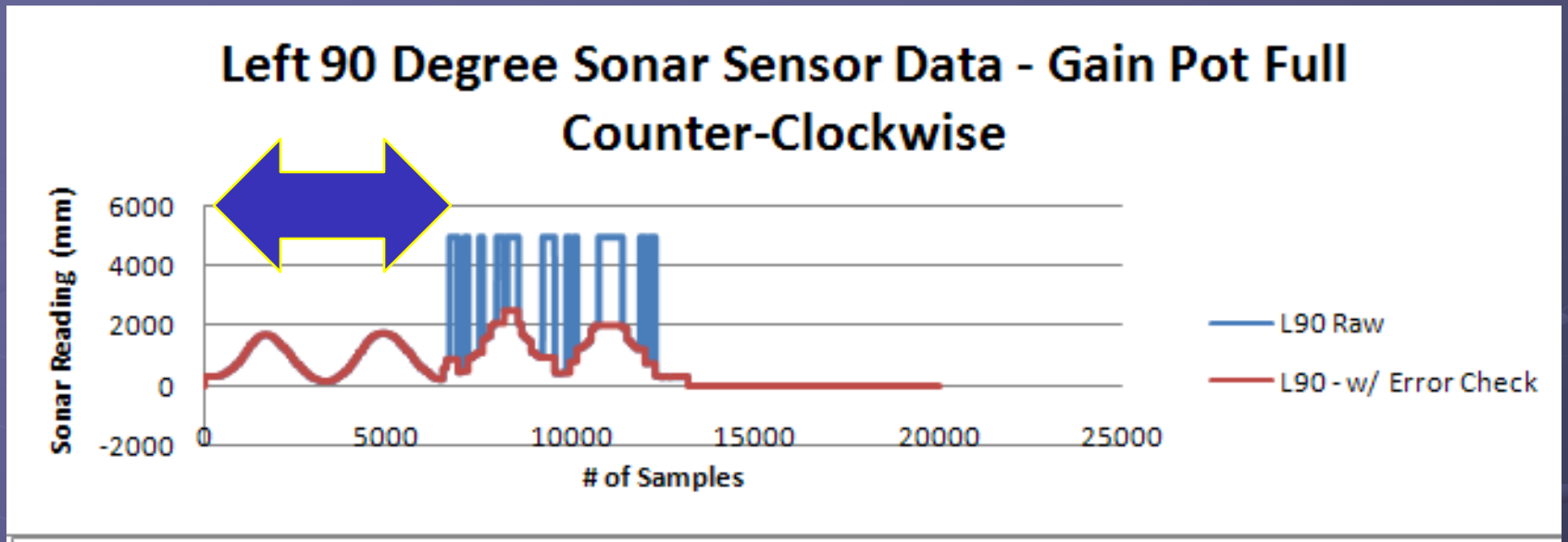
Component	Vendor	Part Number	Quantity	Ordering Cost
Touchscreen	3M	11-81375-225	1	
Speakers	Cyber Acoustics	CA-2908	1	$ 40.00
IR Sensors	Sharp	GP2Y0A700K	8	$ 100.00
Barcode Reader	Wasp	WLS8400ER	1	$ 600.00
Rear Sonar Sensors	ActivMedia	ACAX032	1	$ 470.00
Compass	ActivMedia	ACT012	1	$ 1,395.00
DC-DC Converter	Recom	RP30-1212SF	1	$ 110.00
Bumper	ActivMedia	ACAX013	1	$ 945.00
ADC to USB with Terminal Board	Pico Technology	PP241	1	$ 189.00
Voltage Regulator	National Semiconductor	LM317T	1	$ 1.86
Pioneer	ActivMedia	P3X0001	1	
Grand Total				$ 3,850.86

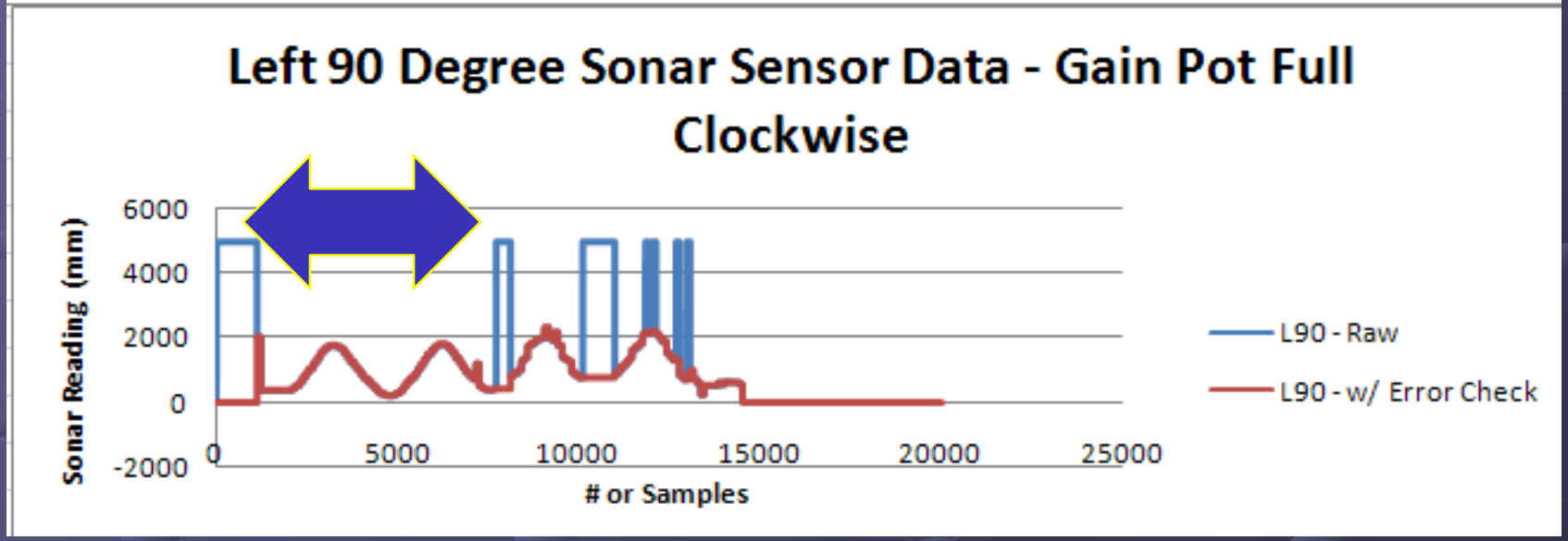
Sonar Sensor Failure

- Firing Order & Firing Rate
- Gain Potentiometer
- Simple Software Fix
- Complex Algorithm

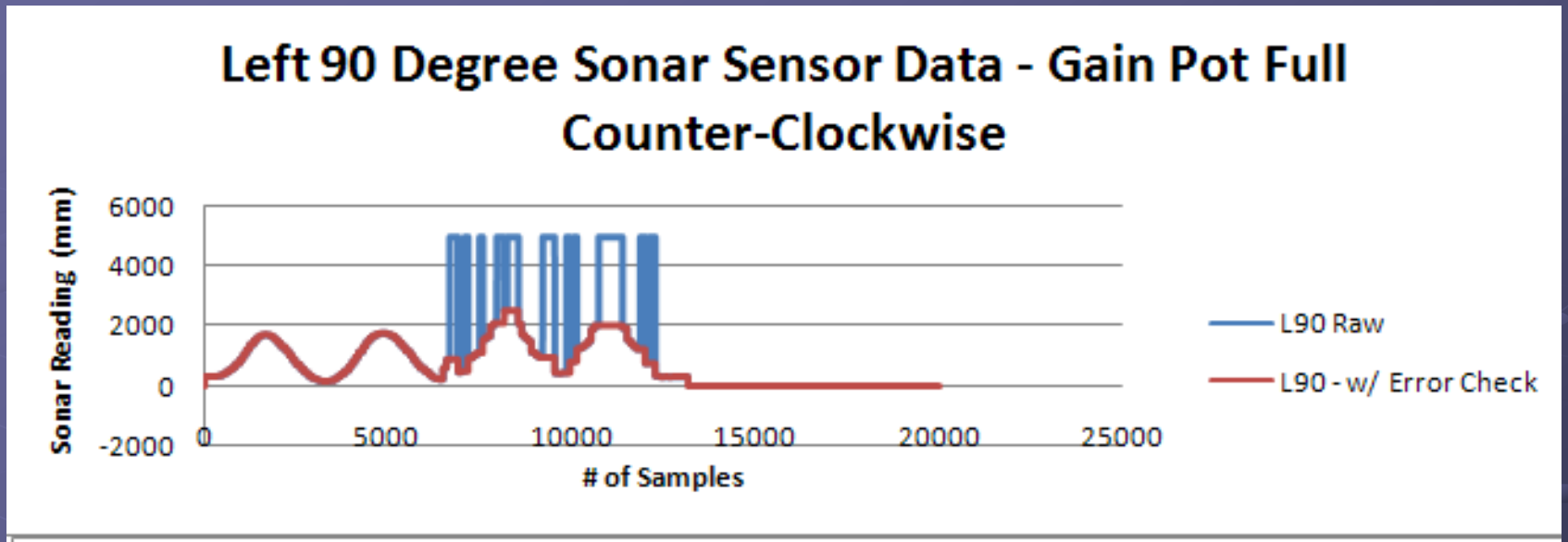


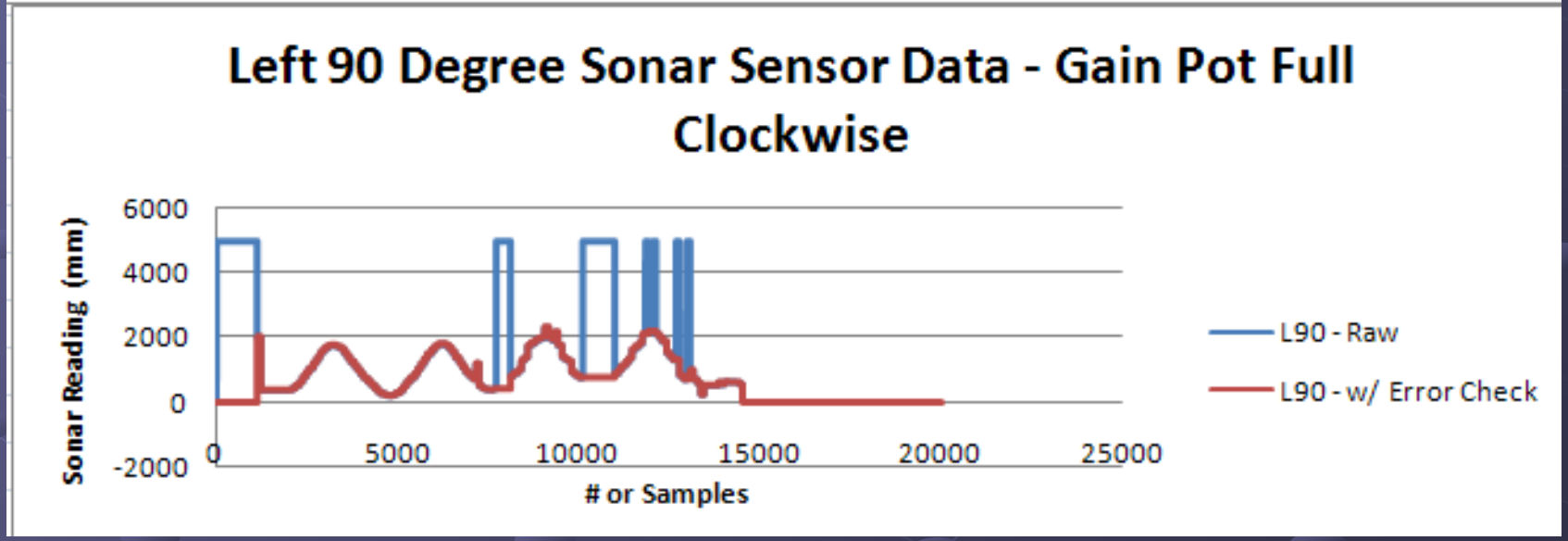
Sonar Sensor Fix Data



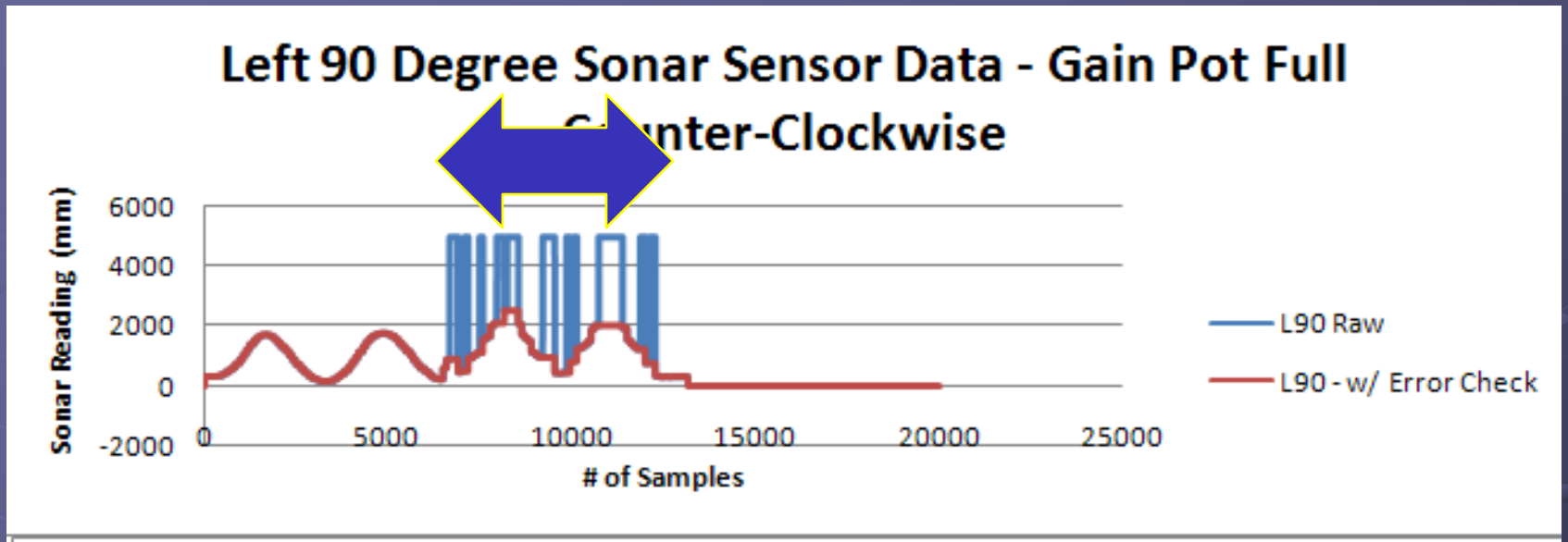


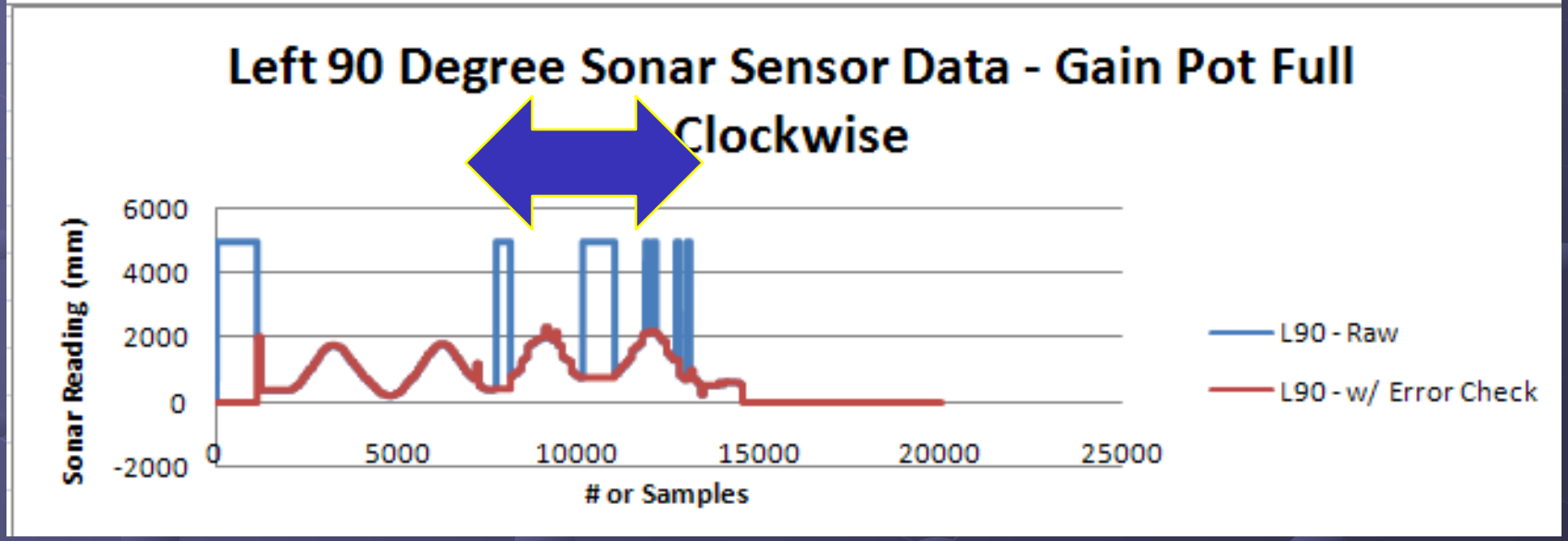
Sonar Sensor Fix Data



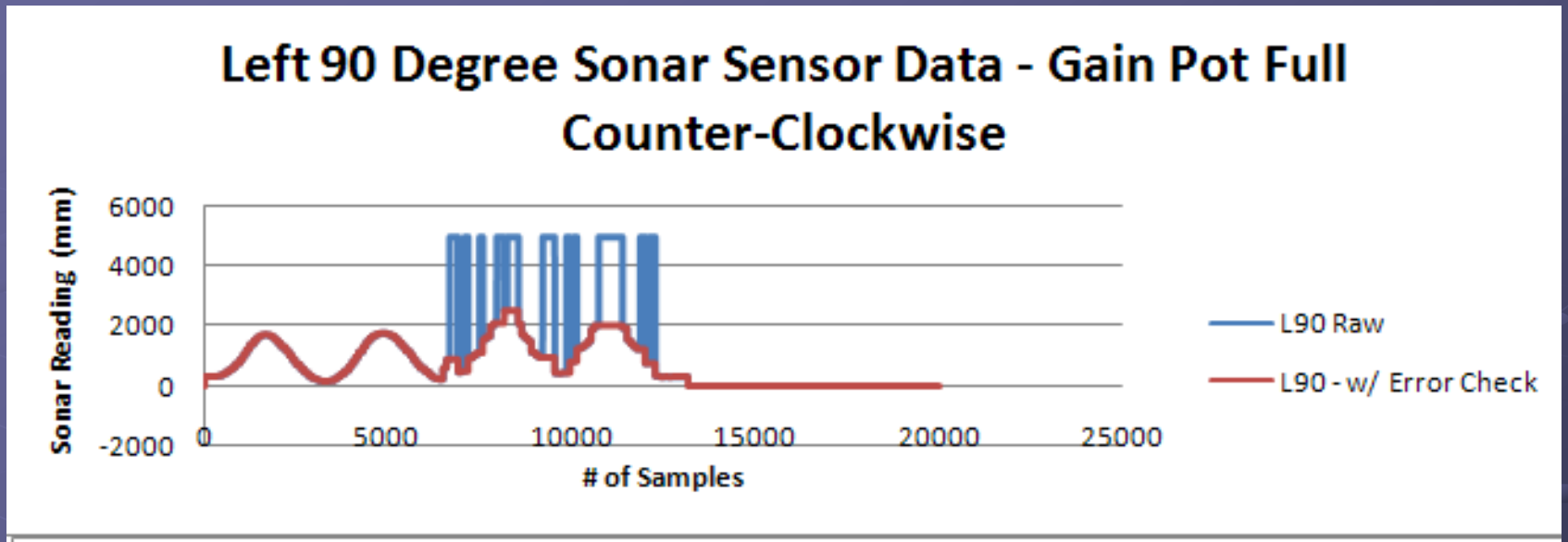


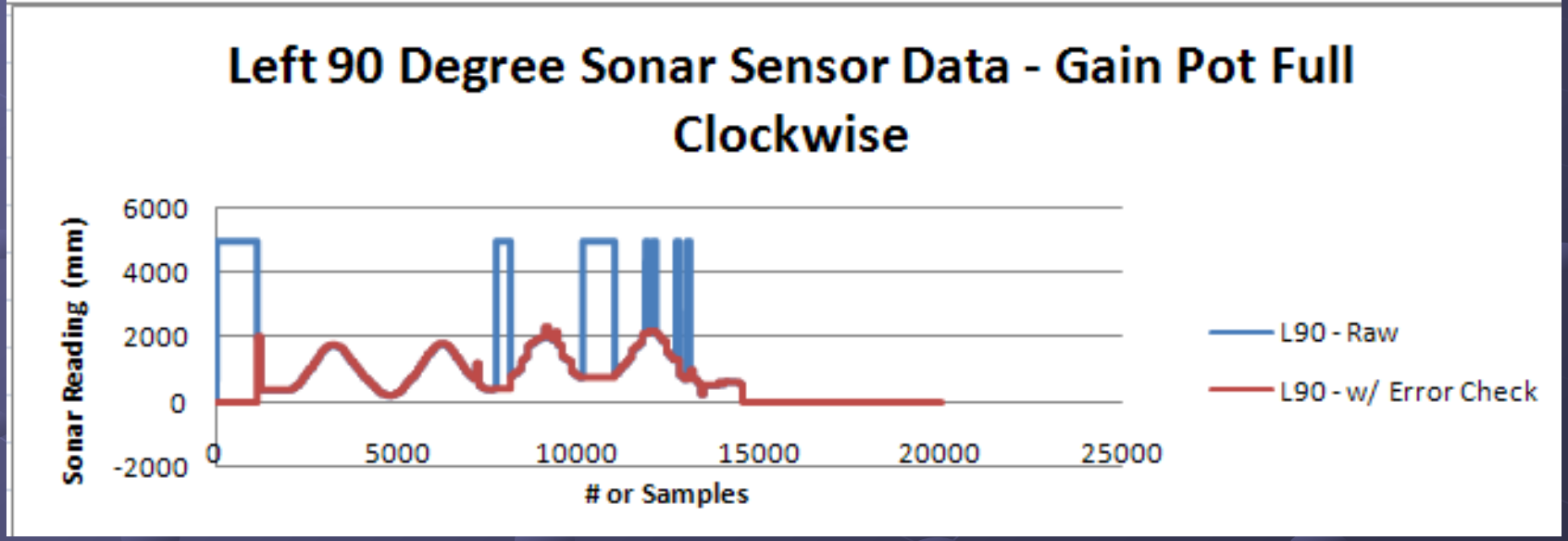
Sonar Sensor Fix Data





Sonar Sensor Fix Data



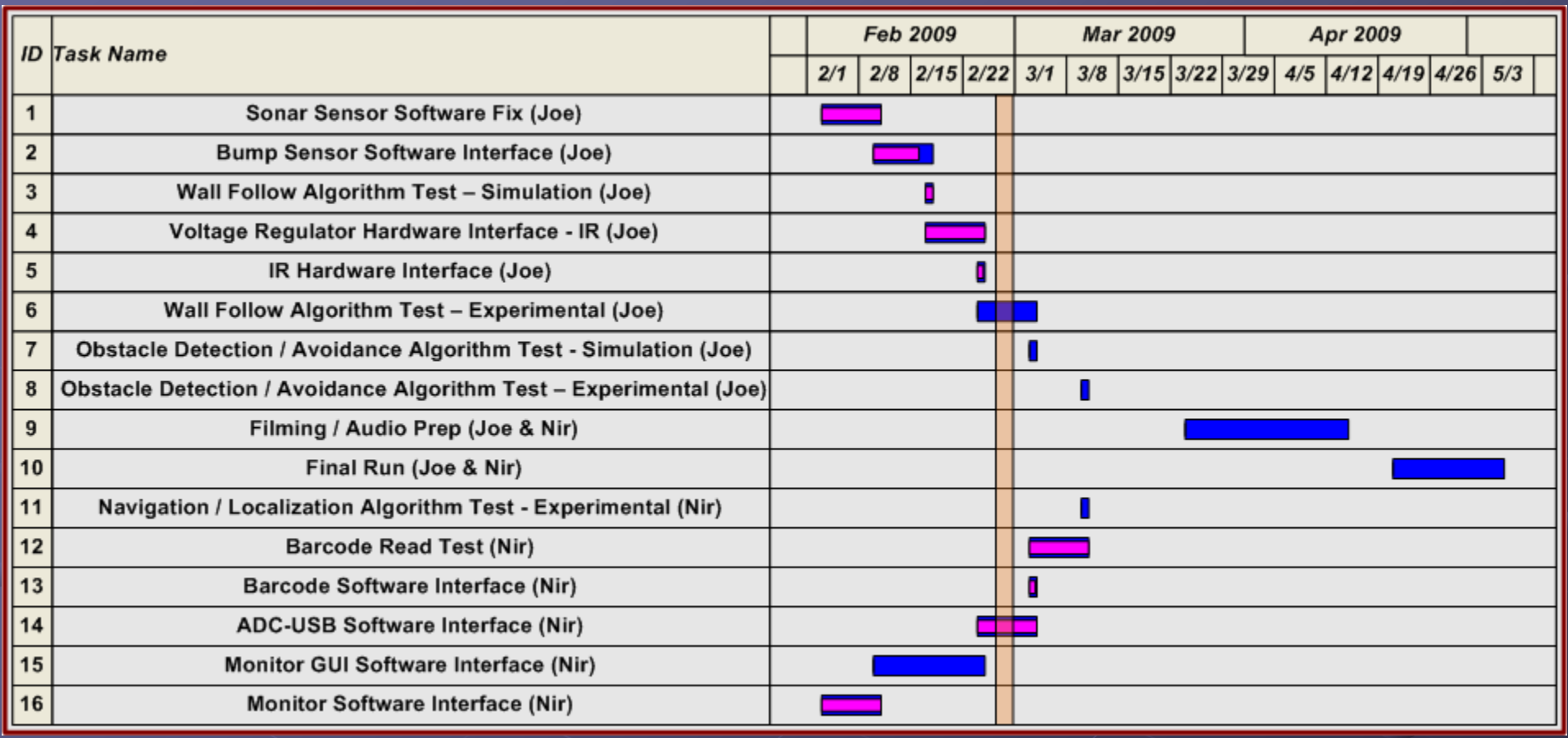


Current Work

- Barcode Scanner – Hands-Free Operation
- Monitor Overvoltage Protection
- IR Sensor Functionality
- Obstacle Detection / Avoidance Algorithm

Future Work

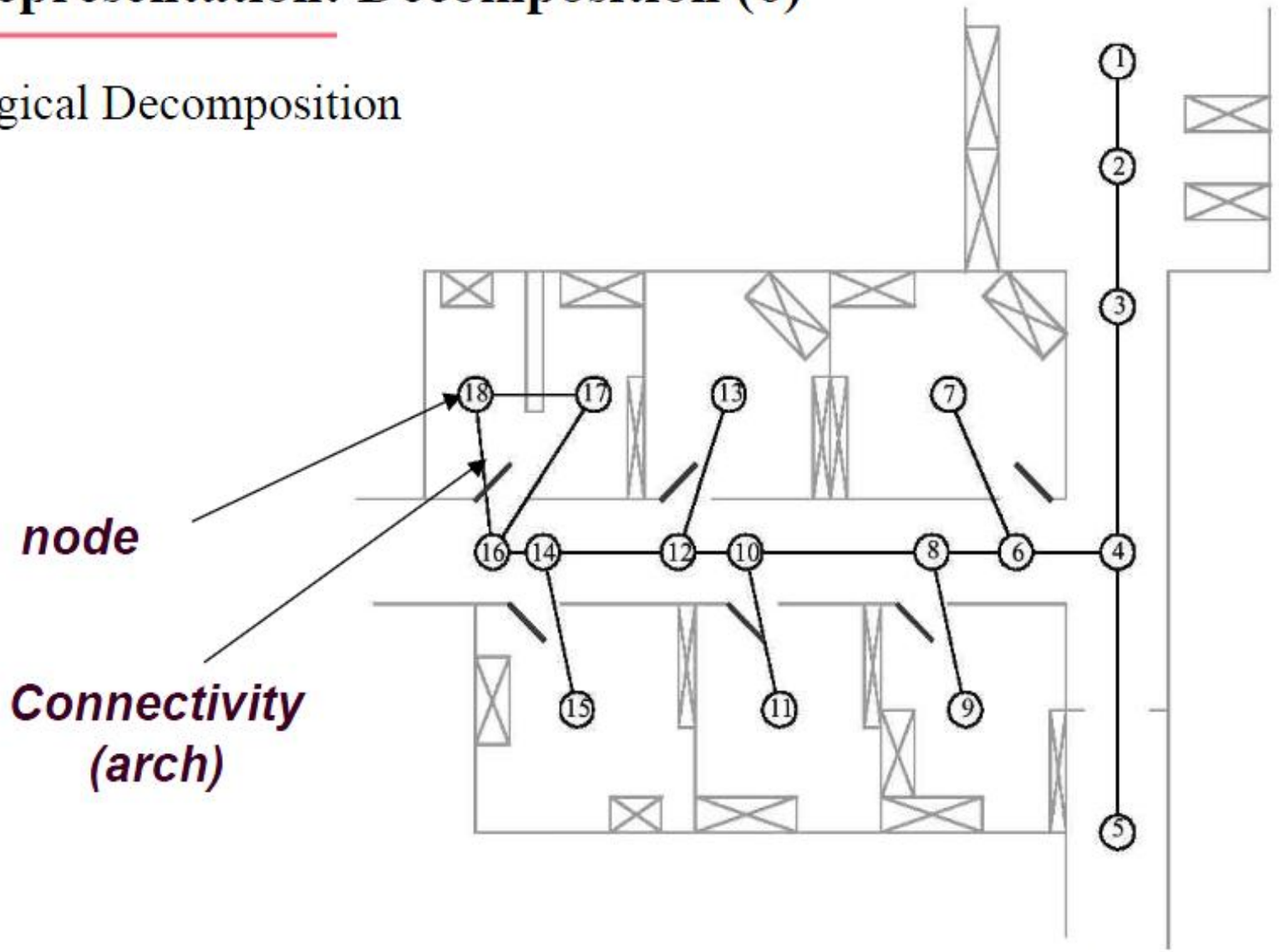
- Mounting Components
- Bump Sensors
- Navigation / Localization Algorithm
- Video Recording
- GUI
- Video Playback


ID
Task Name
Feb 2009
Mar 2009
Apr 2009
2/1
2/8
2/15
2/22
3/1
3/8
3/15
3/22
3/29
4/5
4/12
4/19
4/26
5/3
1 Sonar Sensor Software Fix (Joe)
2 Bump Sensor Software Interface (Joe)
3 Wall Follow Algorithm Test – Simulation (Joe)
4 Voltage Regulator Hardware Interface - IR (Joe)
5 IR Hardware Interface (Joe)
6 Wall Follow Algorithm Test – Experimental (Joe)
7 Obstacle Detection / Avoidance Algorithm Test - Simulation (Joe)
8 Obstacle Detection / Avoidance Algorithm Test – Experimental (Joe)
9 Filming / Audio Prep (Joe & Nir)
10 Final Run (Joe & Nir)
11 Navigation / Localization Algorithm Test - Experimental (Nir)
12 Barcode Read Test (Nir)
13 Barcode Software Interface (Nir)
14 ADC-USB Software Interface (Nir)
15 Monitor GUI Software Interface (Nir)
16 Monitor Software Interface (Nir)

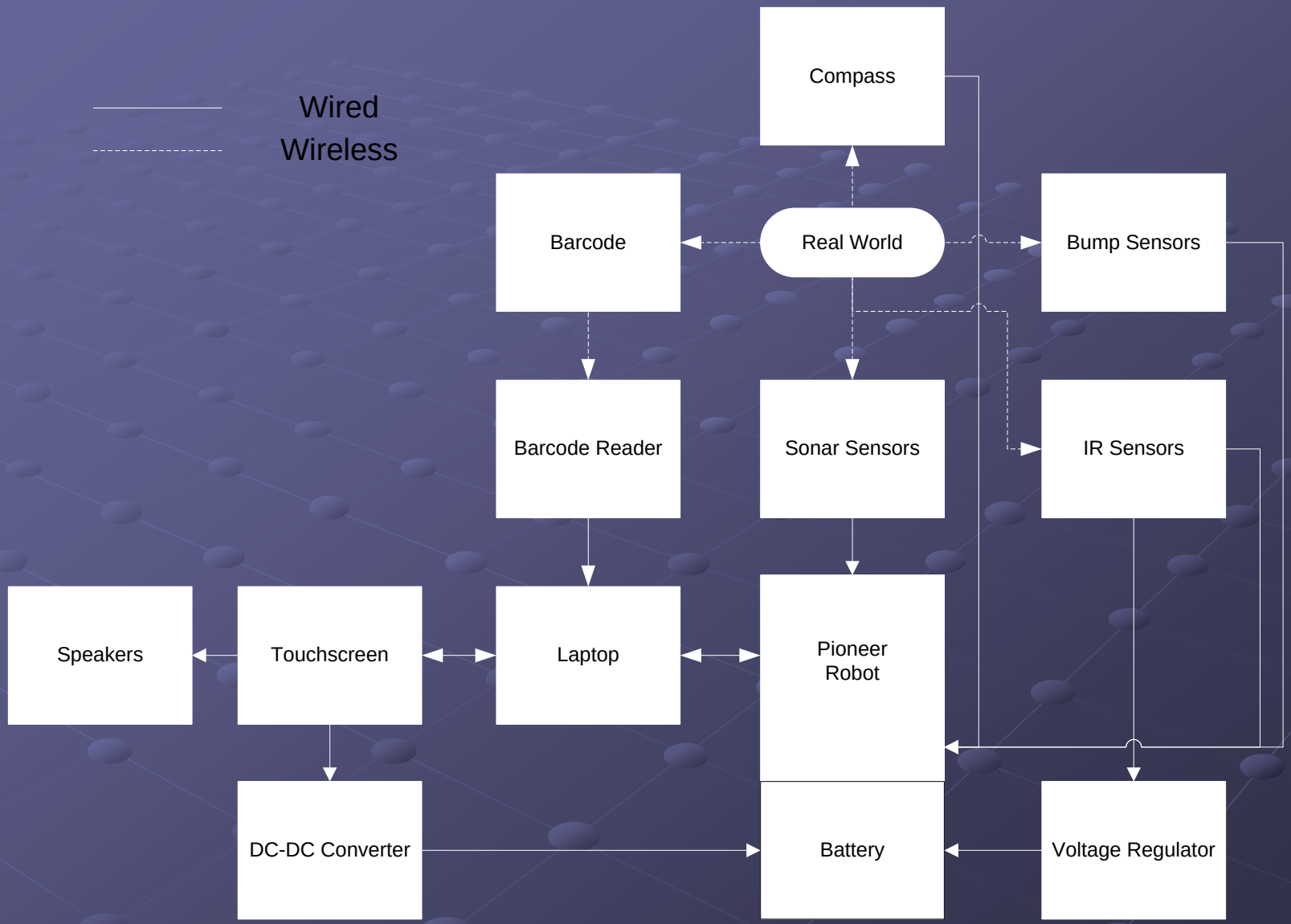
End of Presentation: Supplemental Slides Follow

Map Representation: Decomposition (6)

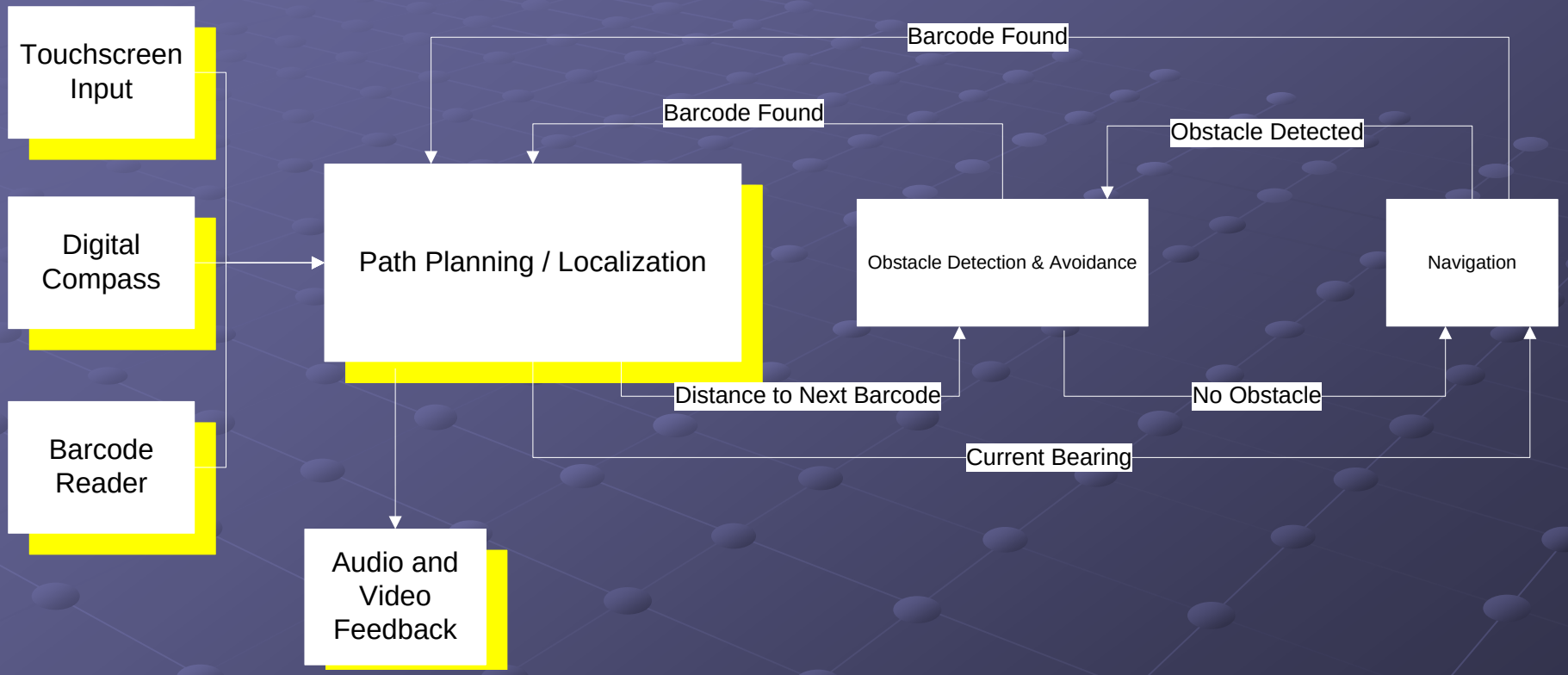
- Topological Decomposition



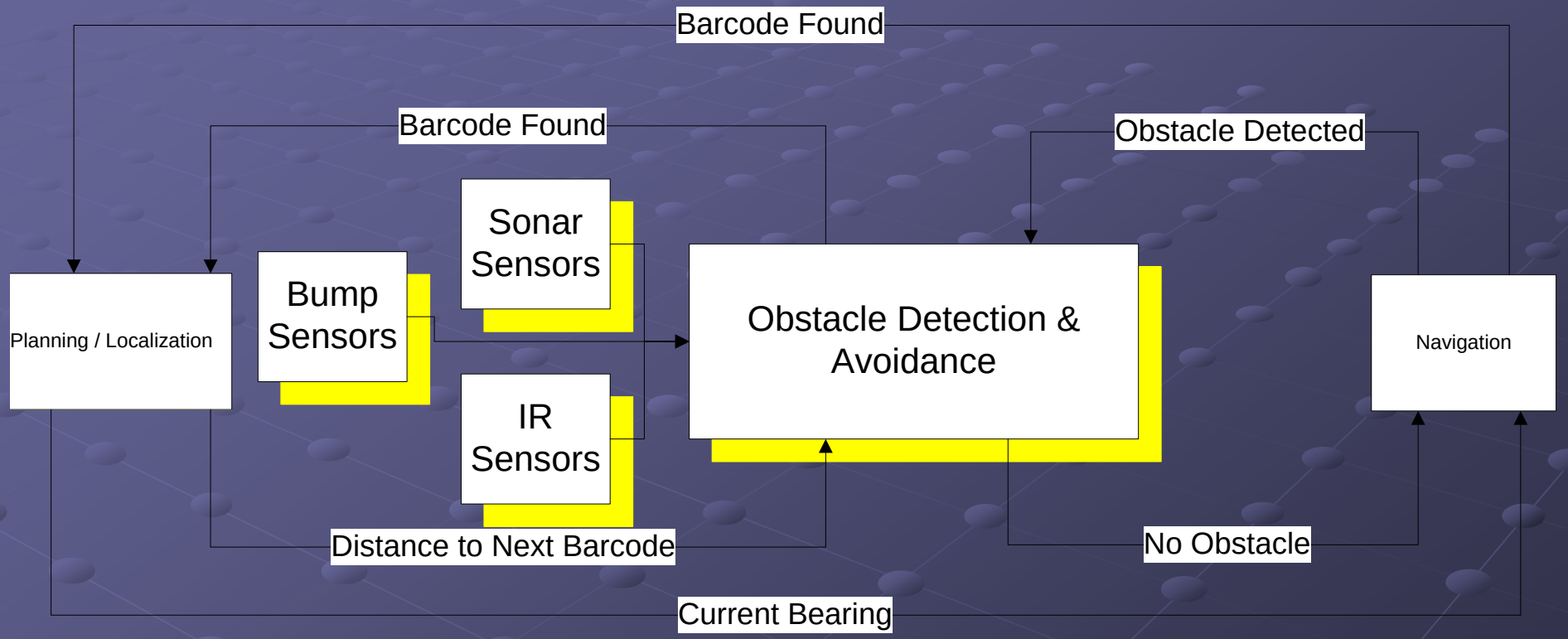
System Block Diagram



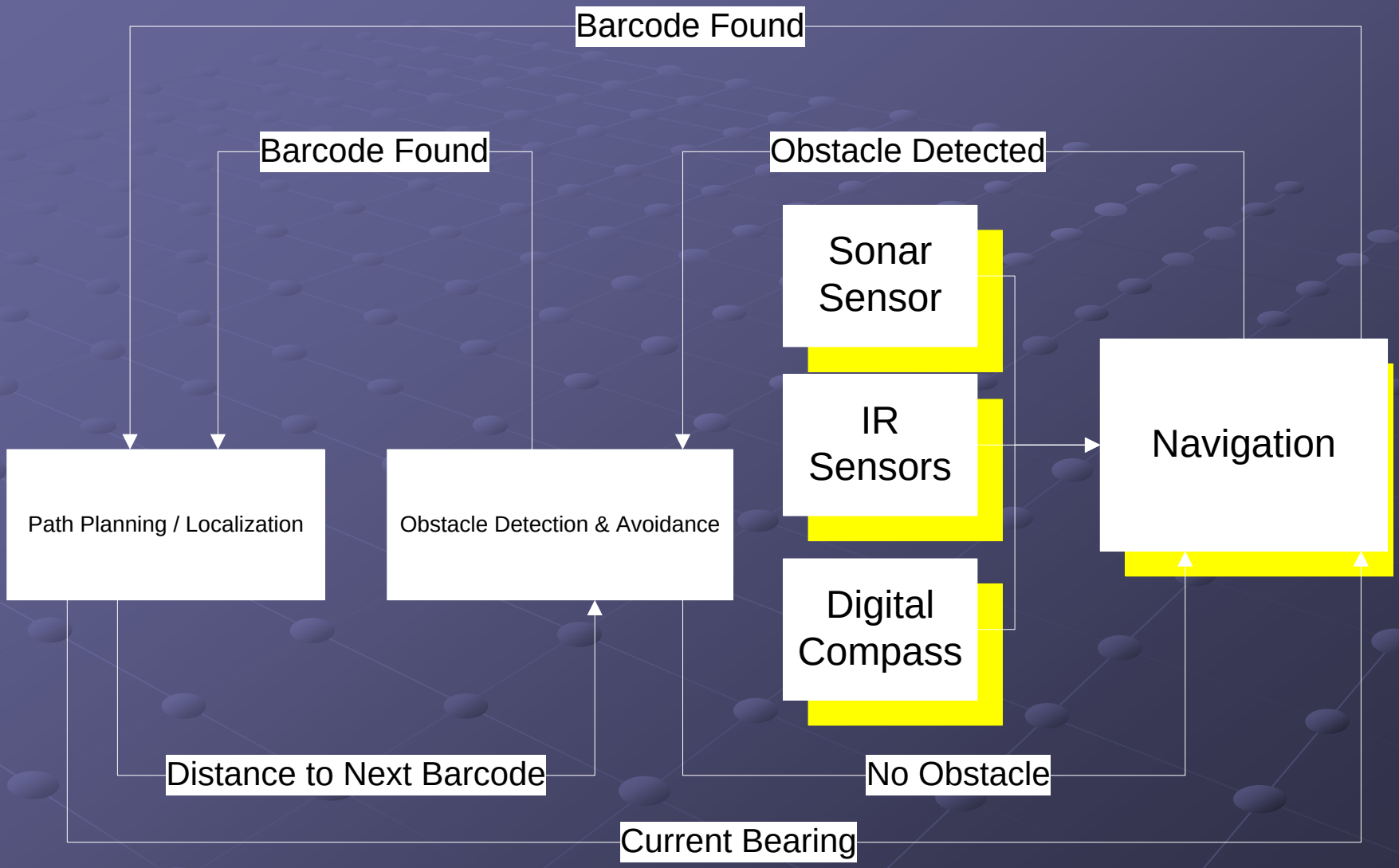
Software Flowchart



Software Flowchart

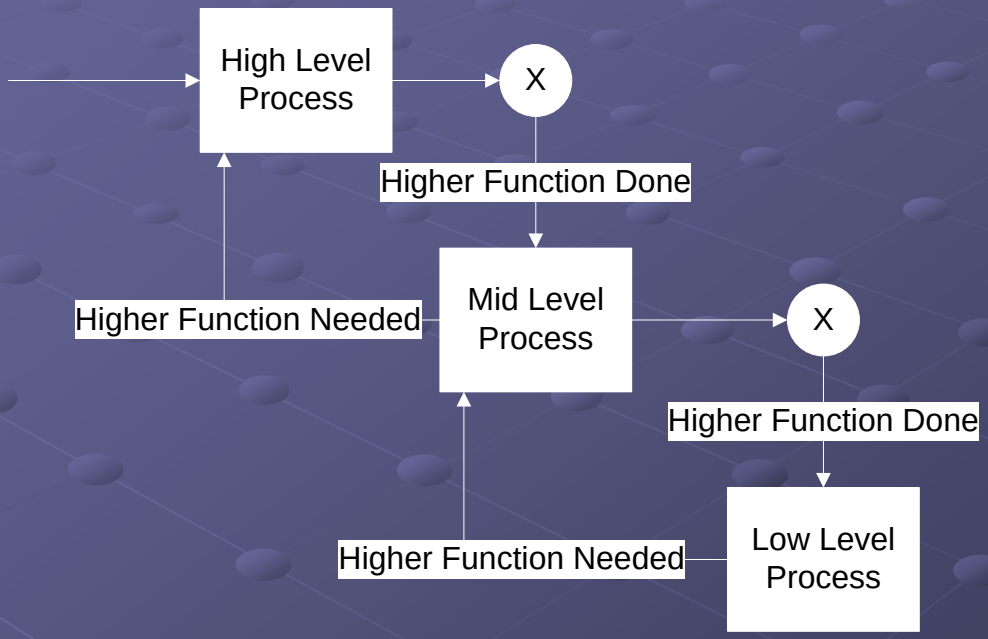


Software Flowchart

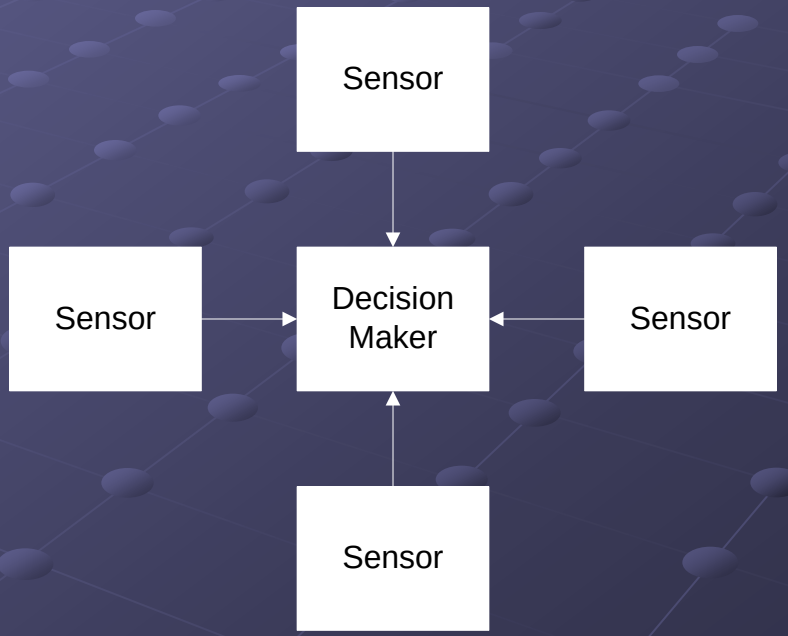


Subsumption vs. Blackboard Architecture

- Subsumption



- Blackboard



High Level Goals

- Successfully navigate the ECE Department
- Identify key points throughout a tour
- Provide accurate information to the user
- Provide a means for user input

Full Requirements (1)

- Must reach intended goal within a 4’ radius
- Avoid all obstacles, moving or stationary
- Must detect when battery is at 10% of max charge
- Additional range sensors added to the Pioneer 3 must have a minimum range from 6” to 10’

Full Requirements (2)

- Additional range sensors added to the Pioneer 3 must have a measurement accuracy of 5”
- Must allow user to select one of 28 locations or one of 3 complete floor tours
- Additional compass sensor added to the Pioneer 3 must provide an accurate magnetic bearing within 10°
- Must have a complete software loop faster than 180 ms

Full Requirements (3)

- Must have a complete software loop faster than 180 ms
- Must maintain an average speed of 31.5 in/sec during transit