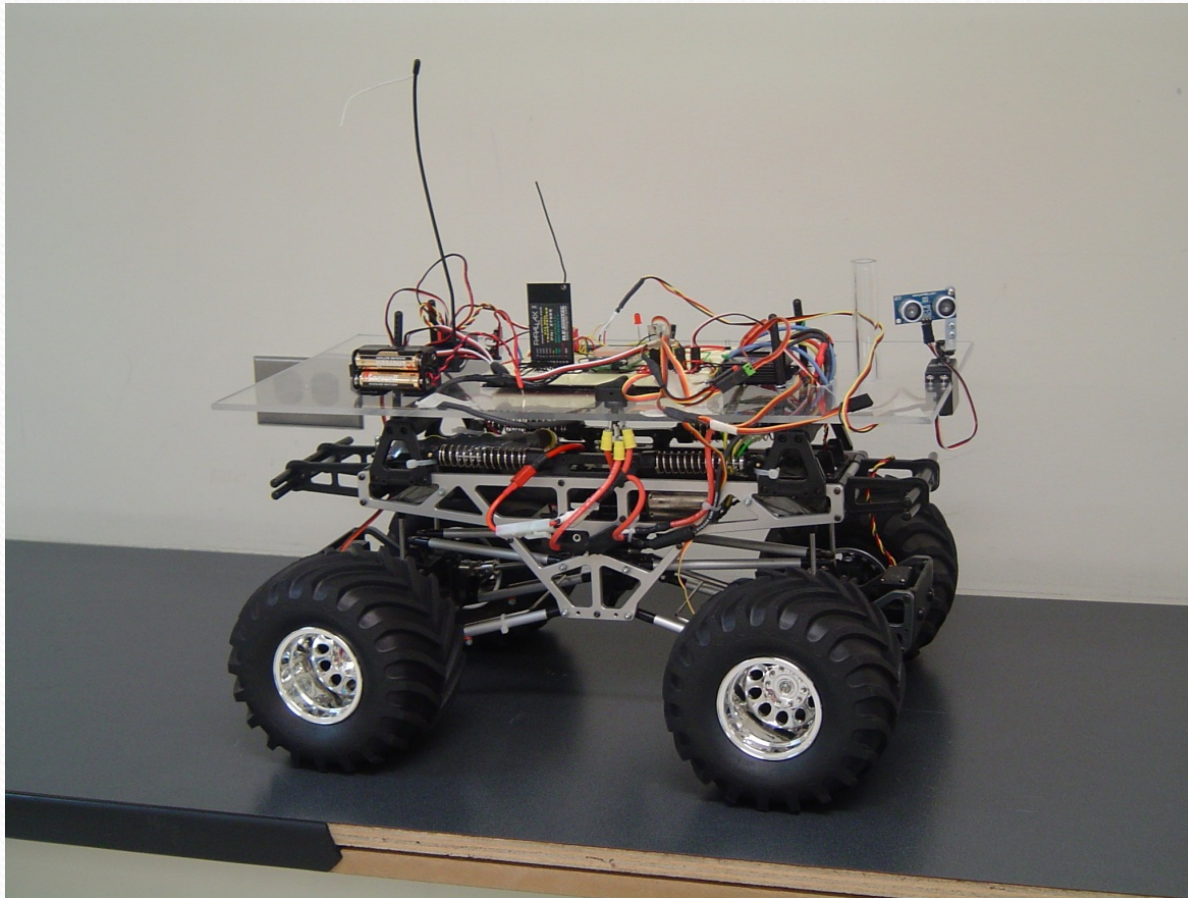# Autonomous Ground Vehicle

ME5643 Term Project

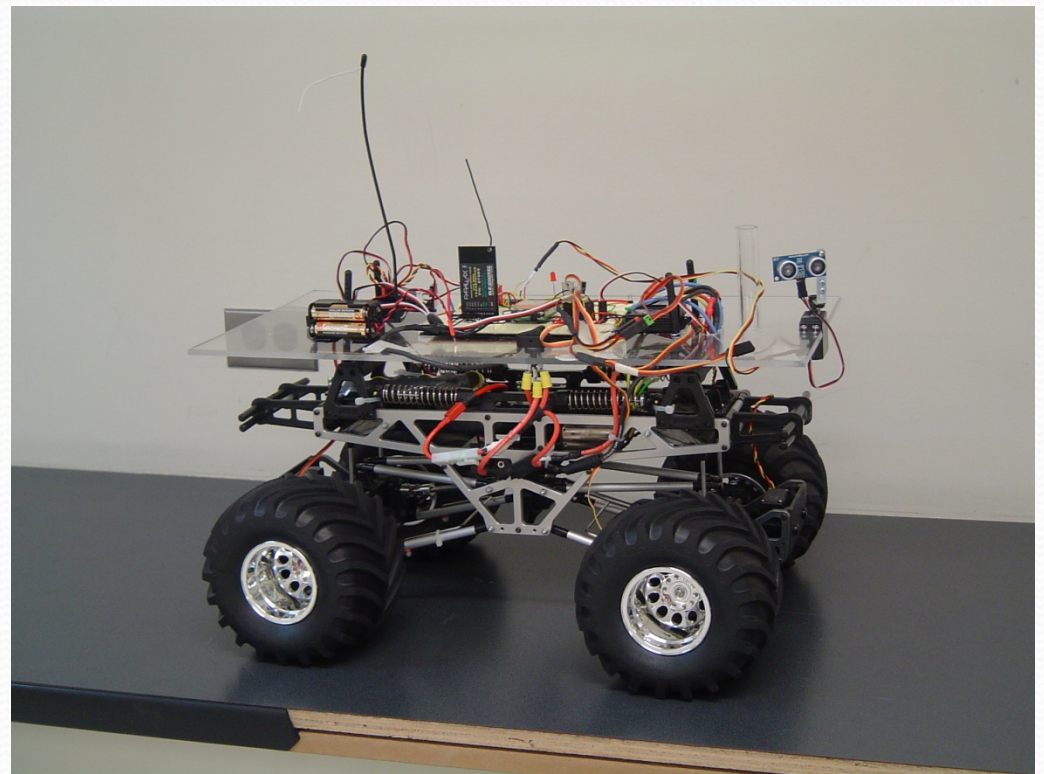<u>Group C</u>
Vito Guardi
Joseph Ferrari
Vlad Kopman

Outline

- **Introduction**
- **Specifications**
- **Limitations**
- **AGV System**
- **How It Works**
- **Safety Features**
- **Error Checking**
- **MATLAB Interface**
- **Cost Analysis**
- **Acknowledgements**
- **Future Tasks**

Introduction

Objectives
- Search a given area for a target
- Find a target using sensors
- Stop moving when a target is found
- Report the targets GPS coordinate back to the base
- Calculate the Distance and Bearing to the target from the base
- Point turret on base at target

Possible Uses
- Real-Time protection of a temporary battalion rest camp
- Autonomous patrol of areas adjacent to a stationary turret installation

Specifications

- Maximum Speed....................15 mph
- Minimum Turning radius.......5 feet
- Runtime...............................20 minutes
- GPS accuracy..........................16.5 ft
- GPS refresh rate......................1 second
- 912 MHz RF modem range.....800ft
- Target detection range.............1 to 4 ft
- Maximum searching radius....25ft
- Processing power.....................1 Parallax Propeller microcontroller – approx 8BS2's

Limitations

The AGV should never be run with out the supervision of a trained operator

It is up to the operator to ensure that the 75.550MHz and 912MHz frequencies are not being used by other devices, as it will cause harmful interference in the operation of the AGV

The operator should also hold the manual override transmitter while the AGV is in any mode of operation

Due to the added weight of the circuitry on the AGV it is top heavy and while excessive maneuvering is possible at high speeds it runs the risk of flipping the AGV over

Why Use The Propeller ???

- Package Type = 40-pin DIP

- Processors (cogs) = Eight

- Architecture = 32-bits

- System Clock Speed = DC to 80 MHz

- Power Requirements 3.3 volts DC

- Global RAM/ROM = 64 K bytes; 32 K RAM / 32 K ROM

- Cog RAM = 512 x 32 bits each

- I/O Pins = 32 (simultaneously addressable by all eight cogs)

- Current Source/Sink per I/O = 50 mA

- Running tasks in multiple cogs allow the propeller to effectively do multiple tasks at the same time

- Cogs can indirectly communicate with each other via access to a common global memory / hub

- Eliminates the need for multiple microcontrollers
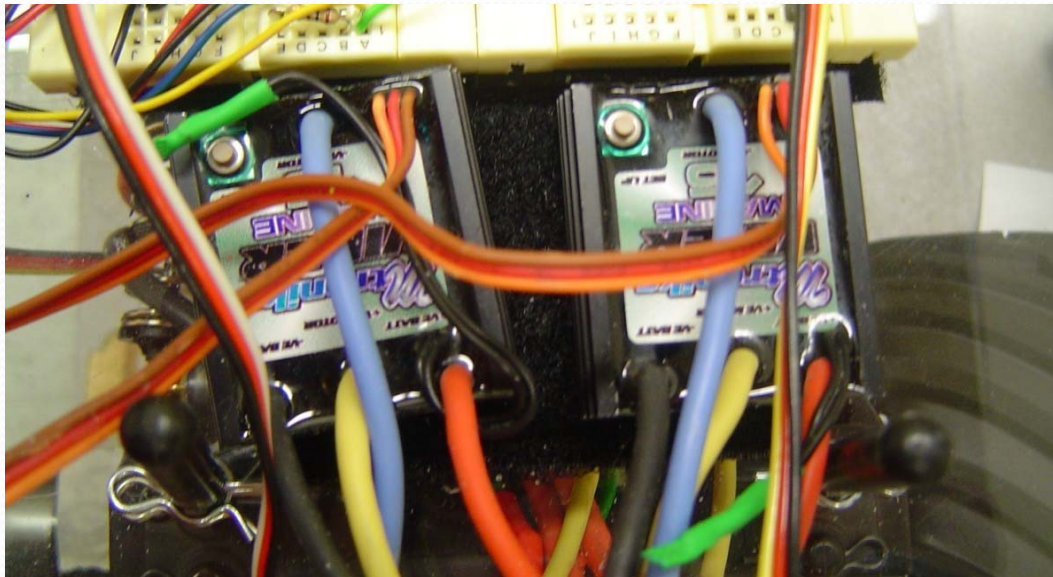
Platform

Tamiya TXT – 1 Chasse
Features
• Four Wheel Drive
• Durable Construction
• Twin 500 size motors
• Servo saver prevents damage to steering servo
• Off-road suspension
•Thermal and current overload protection

Disadvantages
• Old mechanical speed controller gives only crude inaccurate control of speed
• Inadequate turning radius
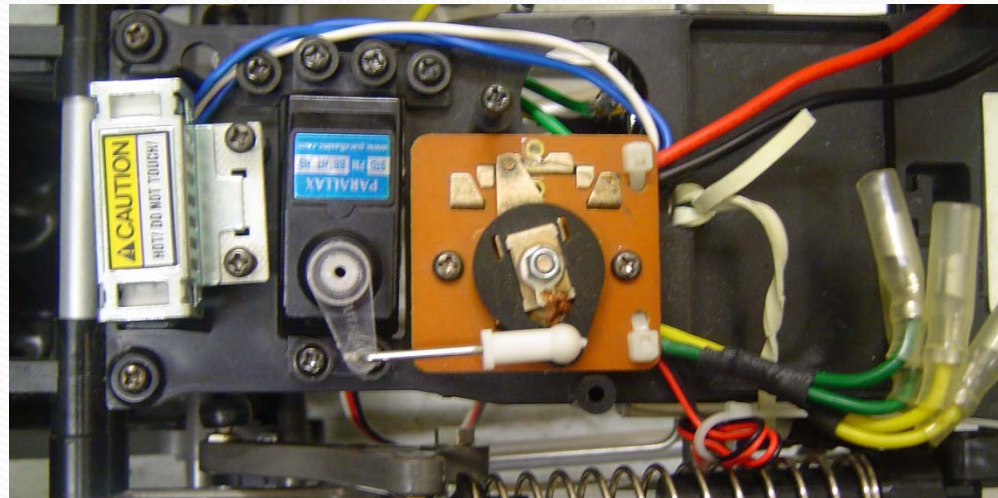
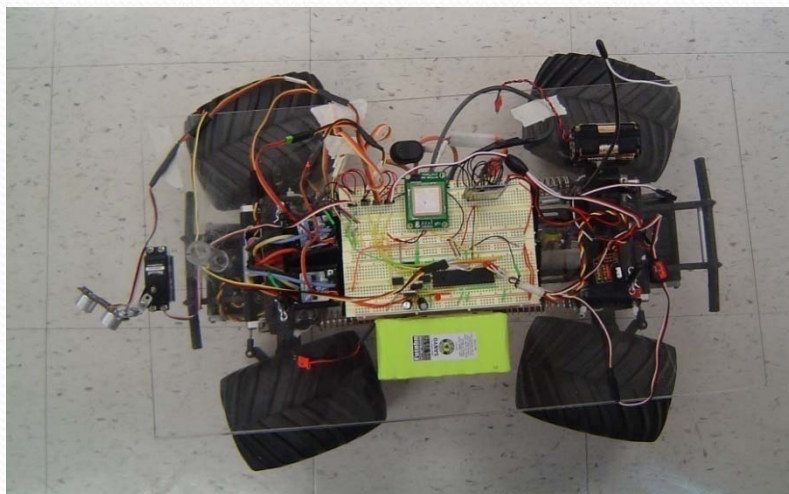# Platform Improvements

Electronic Speed Controllers
- Two Viper Marine 15 ESCs
  - High current (15Amp cont.)
  - Precision control of motor speed
  - Forward and Reverse
  - Built in safety features

Four Wheel Steering
- Two high torque servos
  - Greatly reduced turning radius

High Capacitance Batteries
- 4.2 AHr 7.2V Batteries
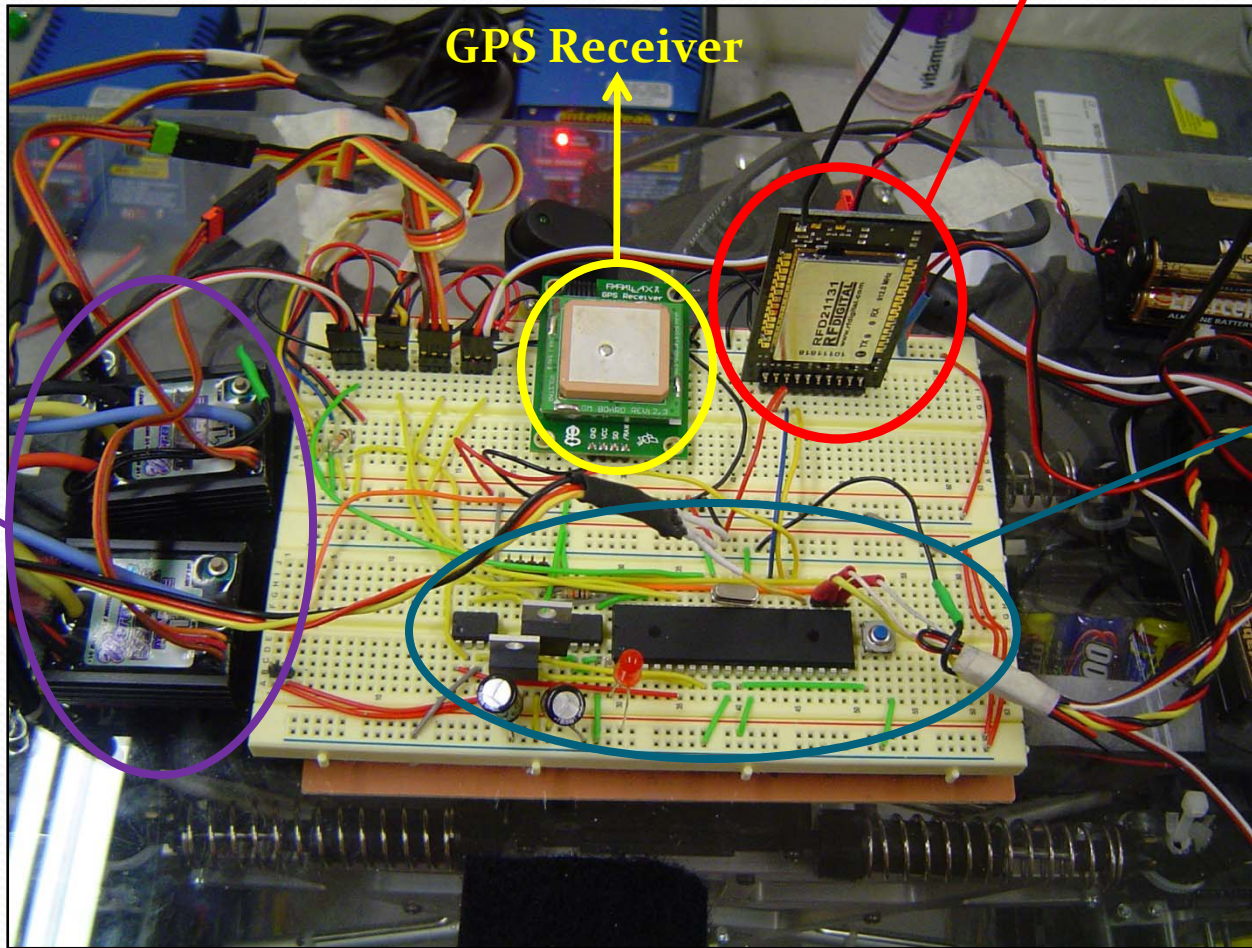 - Increased runtime by several minutes

Circuitry and Sensors

Wireless Transceiver

GPS Receiver

Viper Marine 15 ESC
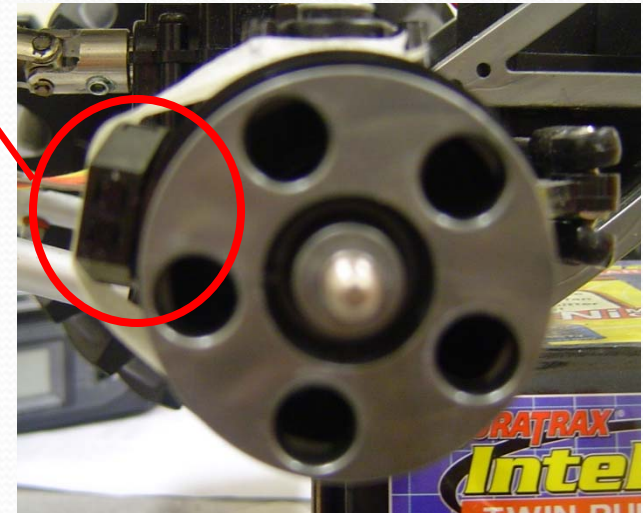
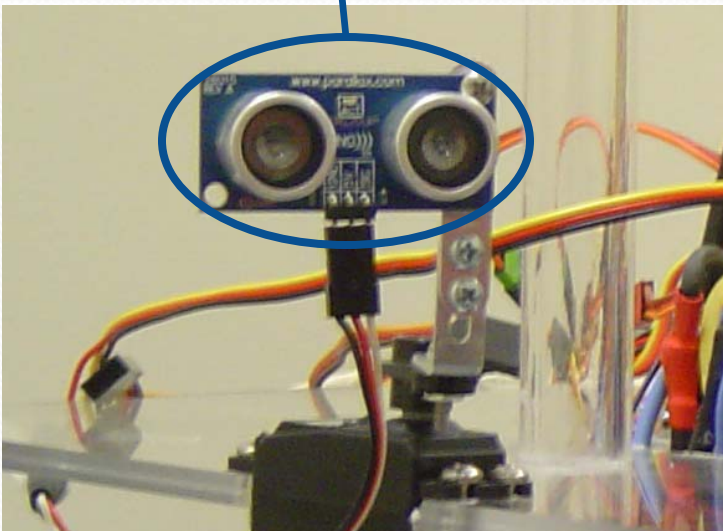Propeller and support circuitry

Circuitry and Sensors 2

Opto-Reflective Switch

Opto-Reflective switch used in conjunction with an ADC to make an optical encoder

Uses an IR Photo transistor and an IR LED which prevents sensitivity to ambient light
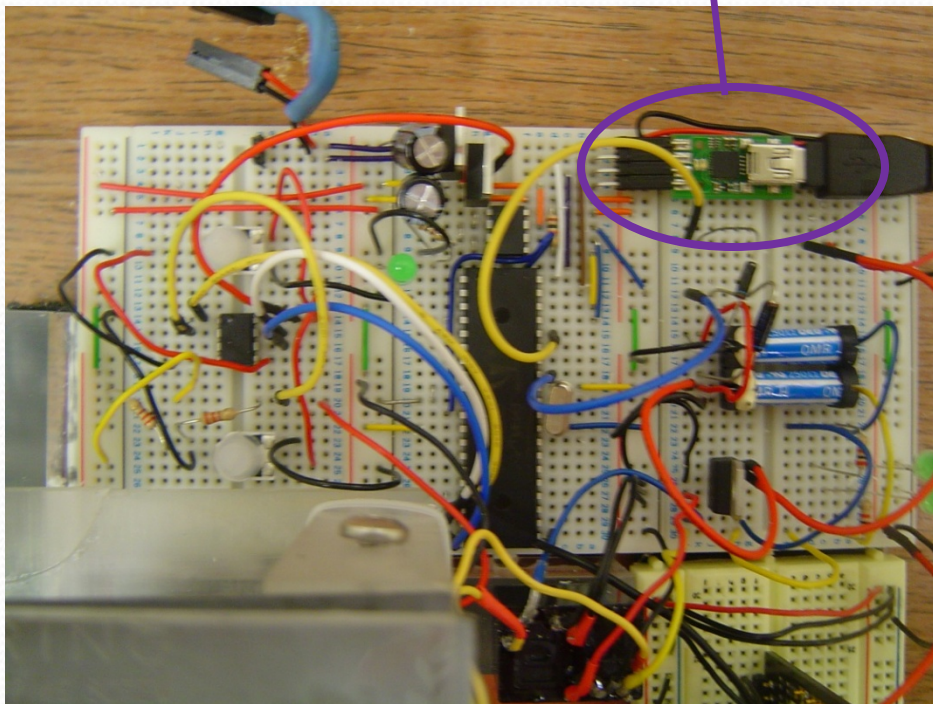
Ultra-Sonic (PING) Sensor

Circuitry and Sensors 3

Potentiometer

Comm. Port For MATLAB Interface

Wireless Transceiver

Circuit Diagrams – AGV Prop
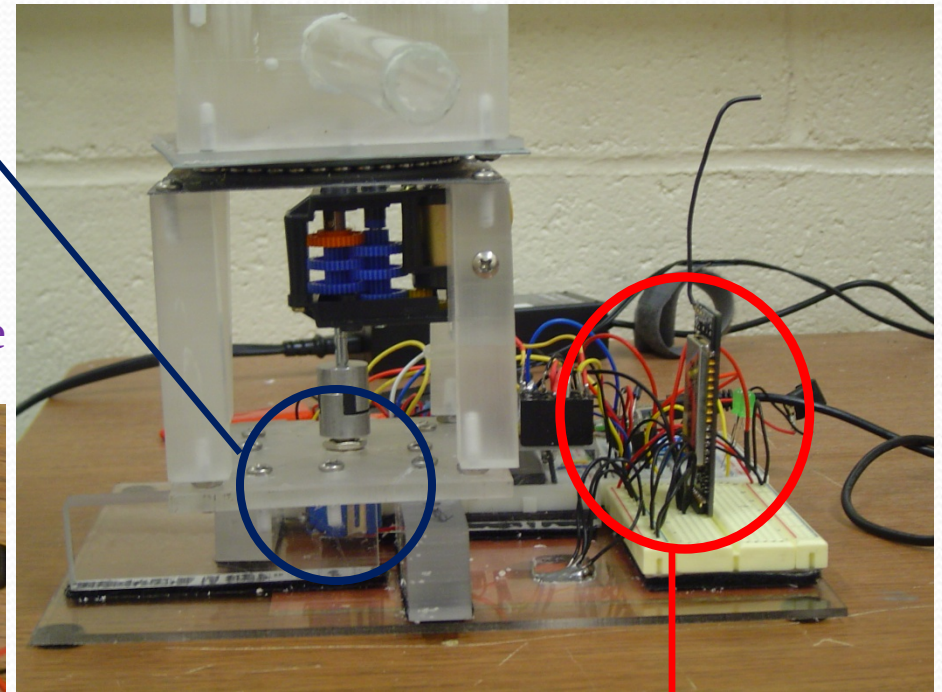
How it works – AGV Prop

How it works – Base

Wirelessly receive critical data from AGV

Check data for errors and store good data in global variables

Cog0

Serial Comm. channel with MATLAB

Cog1

Read from global memory

Control direction of base turret

Cog5

Propeller

Cog2

Read from and write to global memory

Send to MATLAB and receive data from MATLAB while checking for errors

Cog3

Check for time-out errors in serial comm. and restart comm. when necessary

Safety Features

Level 1 Safety Features - Active

•At any moment the operator can chose to take the AGV out of autonomous operation and take control of the robots main functions

Level 2 Safety Features – Passive

•If the operator takes the AGV out of the rage of the manual override transmitter it will automatically cut the throttle

•If the Propeller Microcontroller fails and control signals are no longer sent to the ESC, the Viper Marine 15's internal fail safe activates cutting the

Manual Override Switch

Programmable Fail-Safe Unit

Wireless Data Error Checking

When sending critical 32 bit data through an 8 bit radio modem error checking is a necessity

• 32 bit data is first broken down into 4 segments of 8 bit data

• Each segment is sent with a unique identifier character before it

• One segment is received at a time and the order of the data received is confirmed using the identifier character

• If one of the 4 segment is missing all of the data is rejected

```
elseif ( character == "&" )

  character := SERIN_CHAR ( 26, 9600, 1, 8 )
  if ( character == "N" )
    distance.byte[0] := SERIN_DEC ( 26, 9600, 1, 8 )
  else
    debug.str (string("badN",10,13))
    quit

  character := SERIN_CHAR ( 26, 9600, 1, 8 )
  if ( character == "O" )
    distance.byte[1] := SERIN_DEC ( 26, 9600, 1, 8 )
  else
    debug.str (string("badO",10,13))
    quit

  character := SERIN_CHAR ( 26, 9600, 1, 8 )
  if ( character == "P" )
    distance.byte[2] := SERIN_DEC ( 26, 9600, 1, 8 )
  else
    debug.str (string("badP",10,13))
    quit

  character := SERIN_CHAR ( 26, 9600, 1, 8 )
  if ( character == "Q" )
    distance.byte[3] := SERIN_DEC ( 26, 9600, 1, 8 )
    Debug.Str (string("Distance "))
    Debug.Str (Fstring.FloatToString(distance))
    Debug.Str (string(10,13))
    Debug.Str (string(10,13))
  else
    debug.str (string("badQ",10,13))
    quit
```
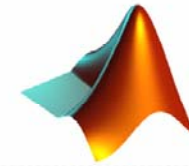
MATLAB Communication

- Distance and bearing calculations are too complex for the propeller

- Propeller is interfaced with MATLAB through simulink

- Create serial object

- Communicate with propeller through COM port

- Incorporate error checking to ensure both MATLAB and propeller are synced
  - Ensure erroneous data is not sent between MATLAB and propeller

- Simulink creates a user interface for displaying data

- Matlab creates GPS coordinates of different search patterns
  - To be used in future work

Calculate Distance and Bearing

•Distance and bearing calculations are too complex for the propeller
   •Propeller only can work with 7 significant figures

•Shortest distance is the great-circle distance between two points on the earth

•Bearing is the direction (degrees east of north) between two points
   •Calculated using ATAN2 function

•Bearing changes along a great-circle, so we can:
   •Constantly update bearing
   •Follow a rhumb line (line of constant bearing, but not shortest distance)
   •Assume constant bearing over short (< 100ft) distances   ← our solution
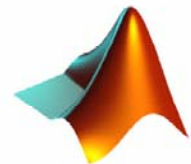
Simulink Interface
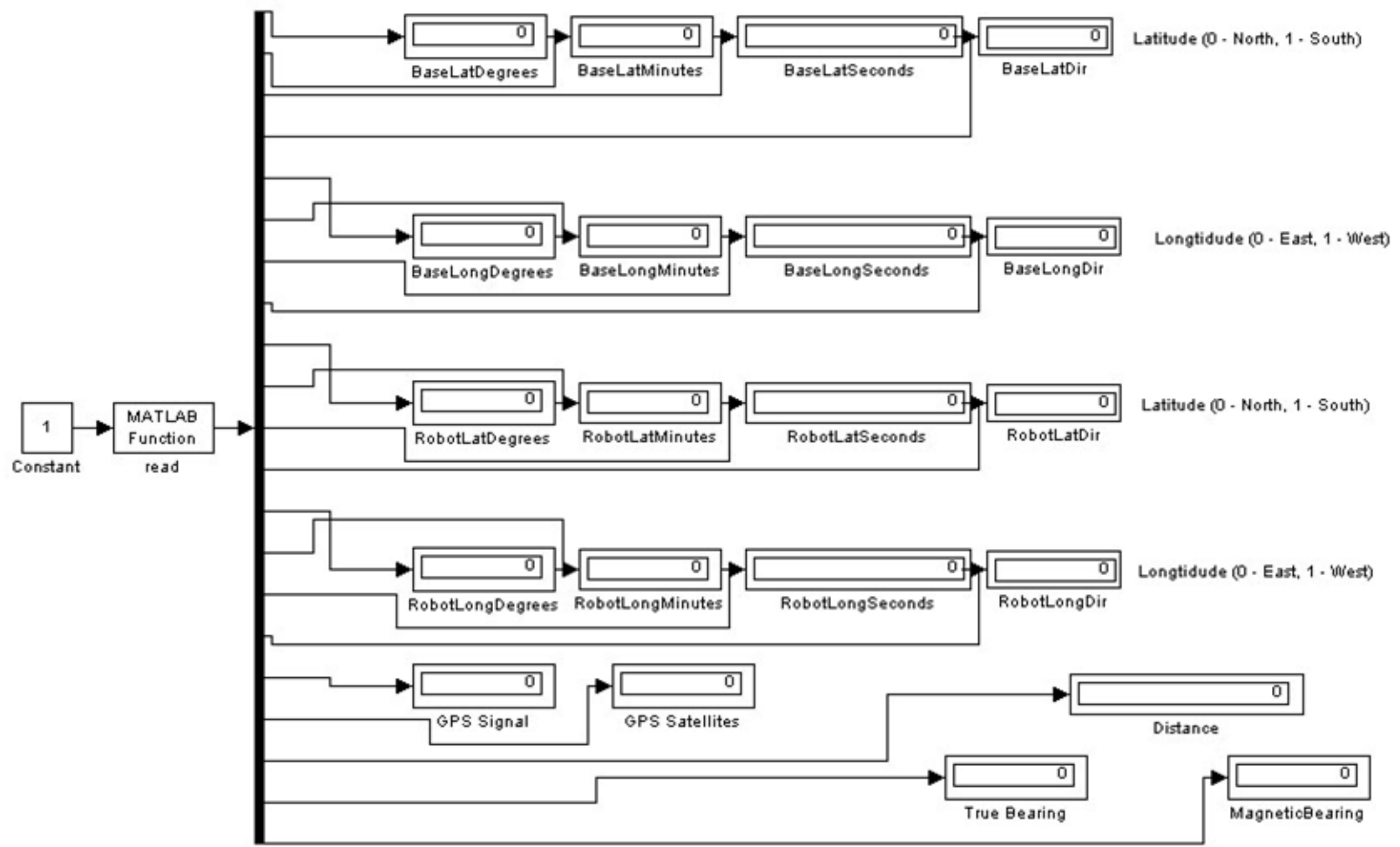
Cost Analysis

Part	Cost Per Unit	Units	Total Cost
ONFA Fail Safe	$26.99	1	$26.99
Viper Marine 15 ESC	$50.00	2	$100.00
Futaba 3Ch Remote	$109.99	1	$109.99
7.2V 4.2 Ahr Battery	$39.99	1	$39.99
9.6V .9Ahr Battery	$34.99	1	$34.99
Propeller Microcontroller	$12.95	2	$25.90
5V 1A Voltage Regulator	$1.95	2	$3.90
3.3V .5A Voltage Regulator	$1.95	2	$3.90
Various Capacitors	$3.00	1	$3.00
Various Resistors	$3.00	1	$3.00
Tamiya TXT-1 Kit	$369.99	1	$369.99
8 Bit Analog to Digital Converter	$6.00	1	$6.00
Opto-Reflective Switch	$15.00	1	$15.00
Wire	$10.00	1	$10.00
Solder	$10.00	1	$10.00
Plexiglass	$30.00	1	$30.00
Parallax Wireless Tranciever	$49.95	2	$99.90
Parallax GPS Reciever	$89.95	1	$89.95
6 Inch Breadboards	$15.00	2	$30.00
Parallax Ultrasonic Ping Sensor	$29.95	1	$29.95
Standard Servo	$12.95	1	$12.95
High Torque Servo	$32.99	2	$65.98
Reed Relays	$2.99	2	$5.98
H Bridge	$7.00	1	$7.00
Misalaneous Hardware	$20.00	1	$20.00
		Total	$1,154.36

Future Work

- Interface a digital compass with the AGV so that it knows its heading
    - Follow the heading calculated by MATLAB
    - Follow a series of waypoints that create a search pattern

- Create a more sophisticated target recognition system
    - Obtain a more accurate GPS location of target

- Integrate a digital compass into the base station
    - Improve accuracy
    - Remove need for calibration or orientation

- Increase scope of project
    - Multiple AGVs
    - Multiple turrets

Acknowledgements

- Sang-Hoon (Nathan) Lee

- Parallax Propeller Object Exchange
- http://obex.parallax.com/Parallax

- Propeller Web Forum
- http://forums.parallax.com/forums/default.aspx?f=25