CISCOR

CENTER FOR INTELLIGENT SYSTEMS, CONTROL, AND ROBOTICS

Team 10
GOLIATH Autonomous ATV

Group Members:

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Background

- CISCOR focuses on mobile robotic path-planning
- Requires a more robust autonomous off-road platform
- Previous work included remote control
- Actuators installed

Objectives

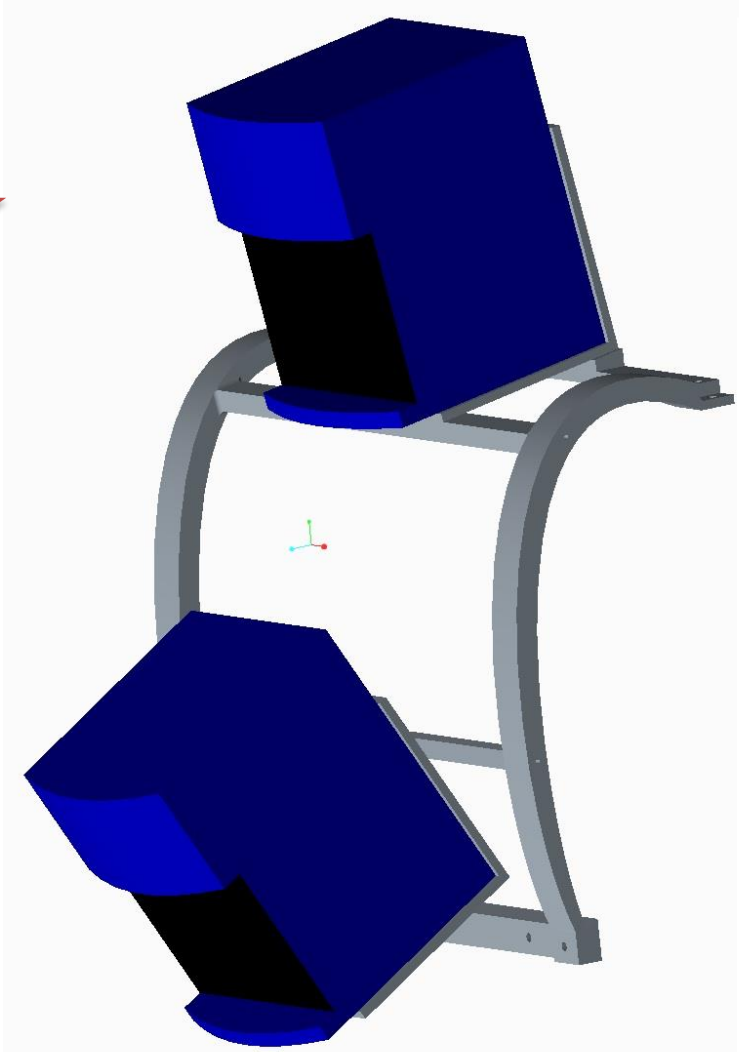
- To integrate a sensory system that will scan the surrounding environment
- Use data to compute a trajectory to perform waypoint navigation and road following autonomously
- Will be used as a future research platform for CISCOR

Concept Selection

- Decision matrix design parameters
  - Functionality
  - Simplicity (# of parts)
  - Ease of manufacture
  - Low cost
  - Low time to manufacture
  - Small amount of interference (parts/human)
  - Low susceptibility to damage(environment impact or rust etc..)
  - Ease of data calculation
  - Ease of adjustment
  - Low energy consumption
  - Lightweight

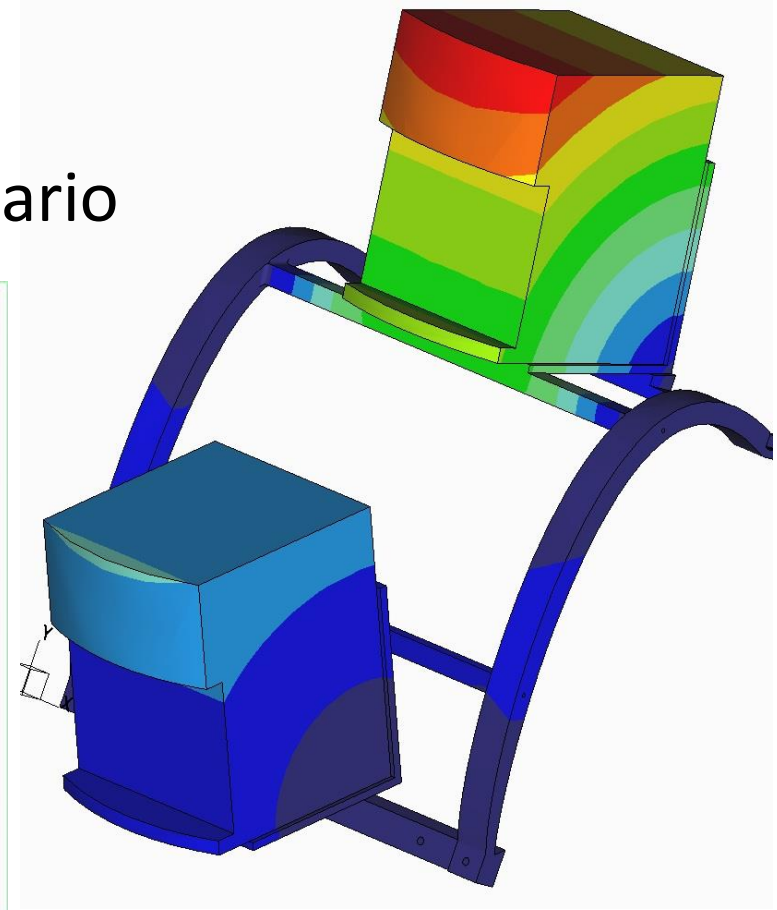
Laser Selection and Analysis

- Concept 1 score: 492.5
- Concept 2 score: 527.25
- Concept 3 score: 412.25
- Concept 2 selected
  - Functionality
  - Ease of Calculation



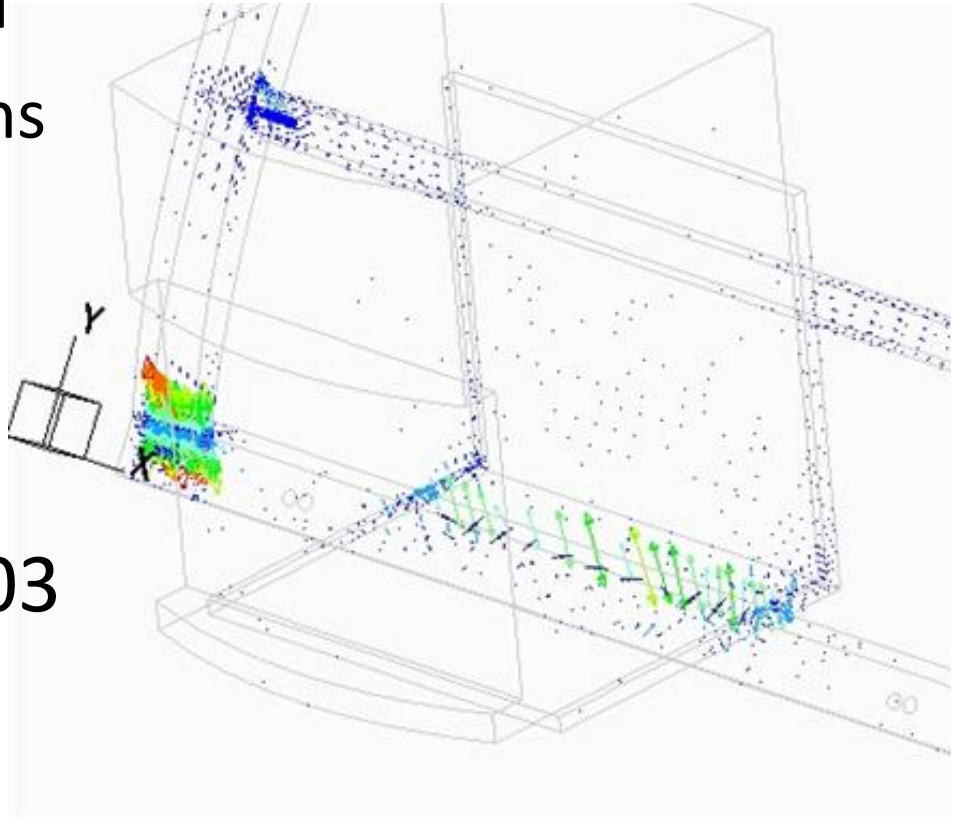
Laser Selection and Analysis

- Simulate 20 mph collision
  - Assumed as worst case scenario



Laser Selection and Analysis

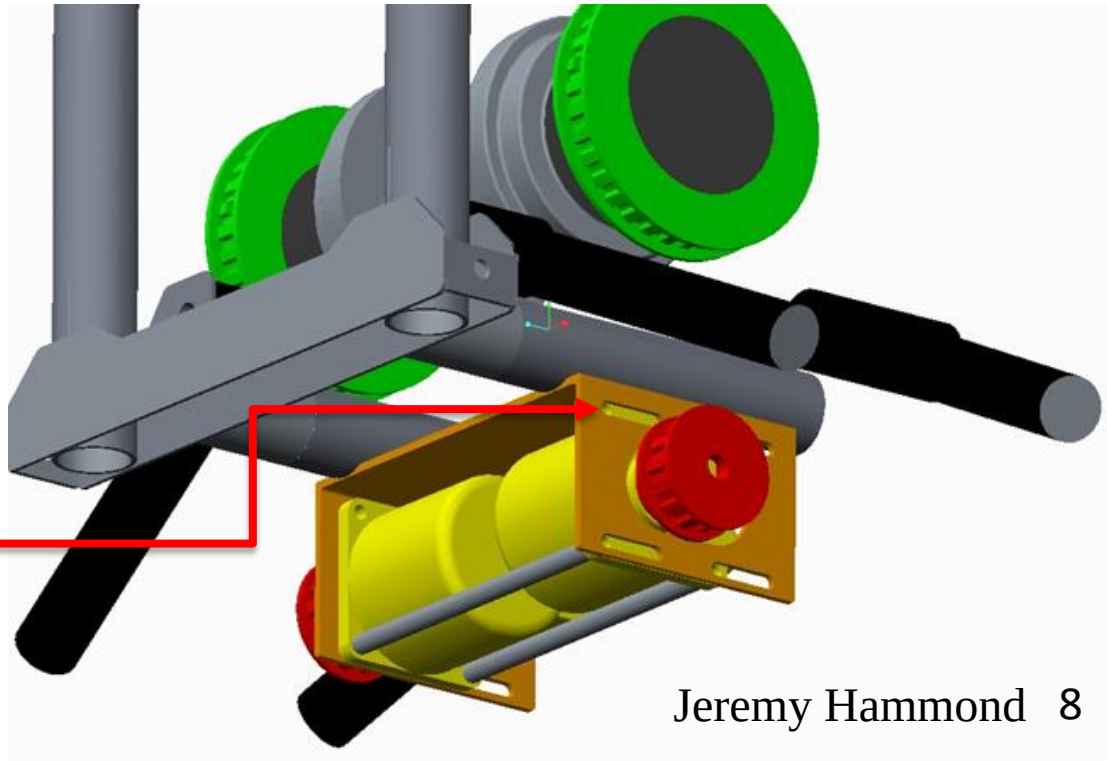
- 6061 AL yield strength 241 Mpa
- Max stress 105 Mpa
  - Stress concentrations located at joints



- Factor of safety 2.303

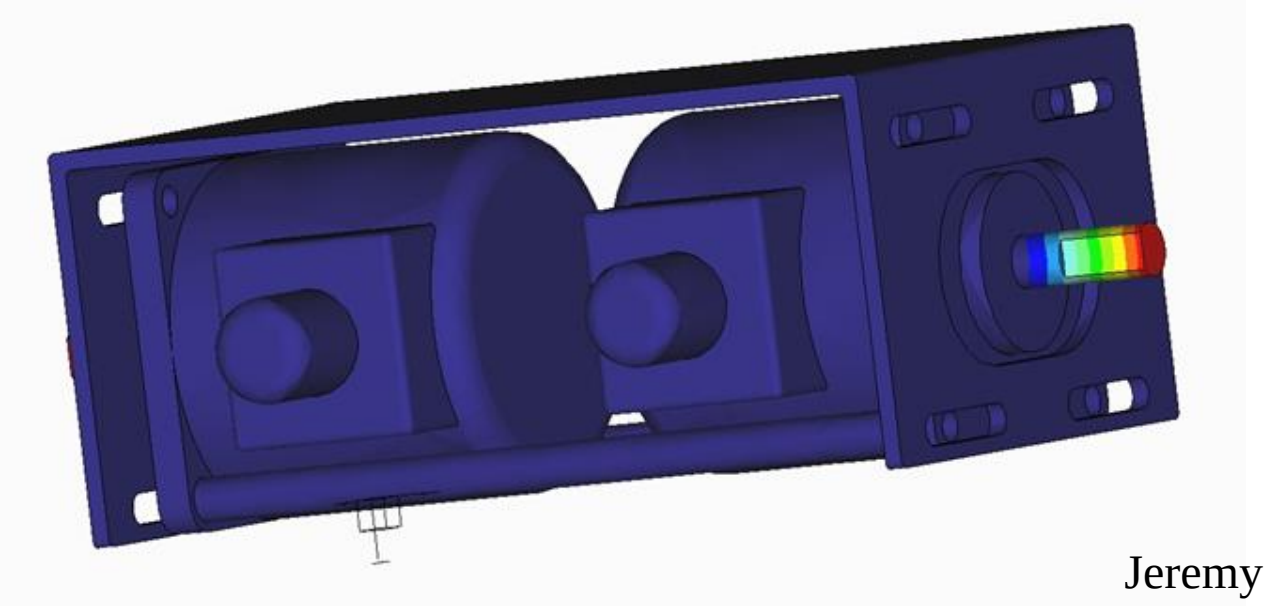
Front Encoder Selection and Analysis

- Concept 1 score: 550.75
- Concept 2 score: 582.75
- Concept 2 selected
  - Small Interference with Parts
  - Functionality
- Belt tension option added



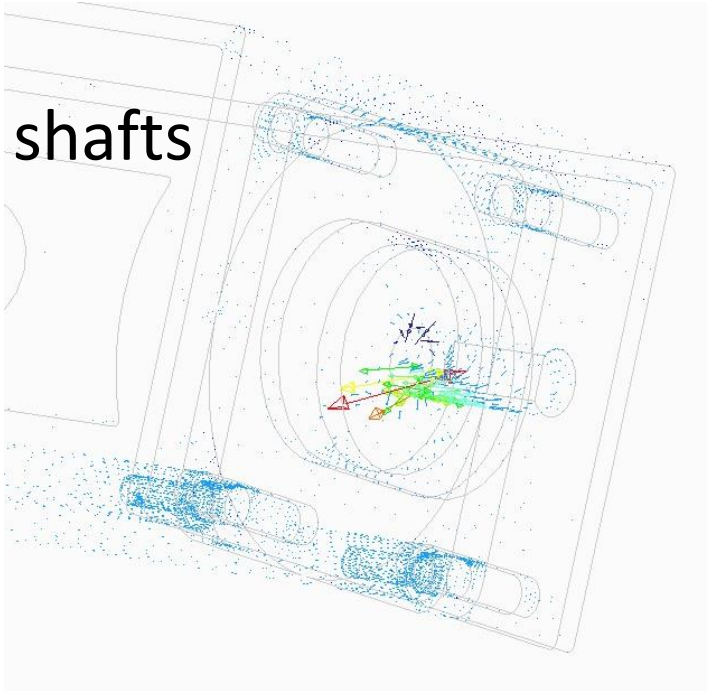
Front Encoder Selection and Analysis

- Applied 80 lbf to encoder shafts
  - Maximum allowable load rating
  - Shafts made from 303 stainless steel
  - Support structure made from low carbon steel



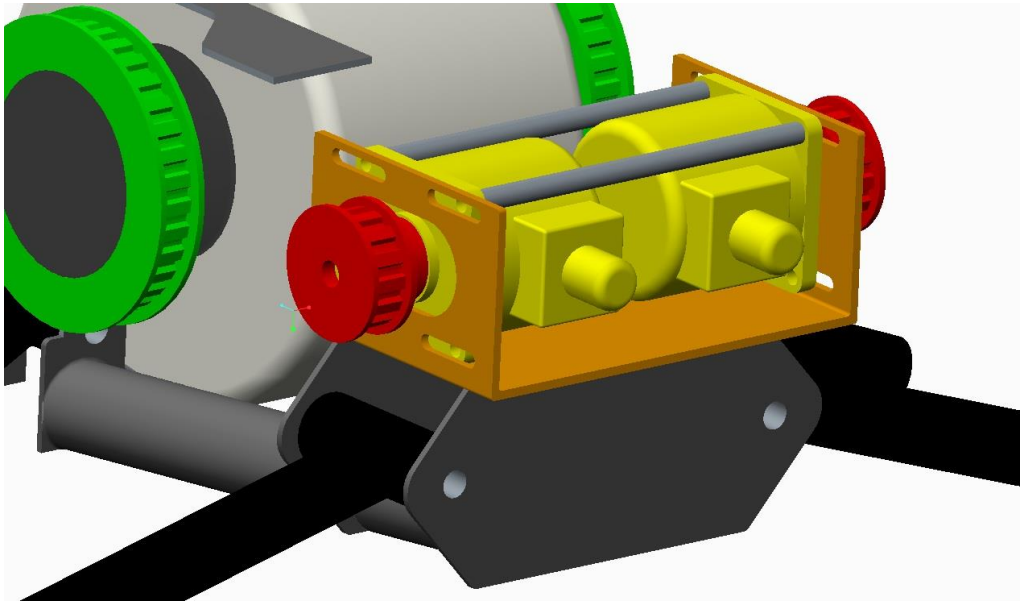
Front Encoder Selection and Analysis

- Max radial load 80 lbf
- Stainless steel yield strength 200 Mpa
- Max stress 80 Mpa
  - Located at base of encoder shafts
- Factor of safety 2.49



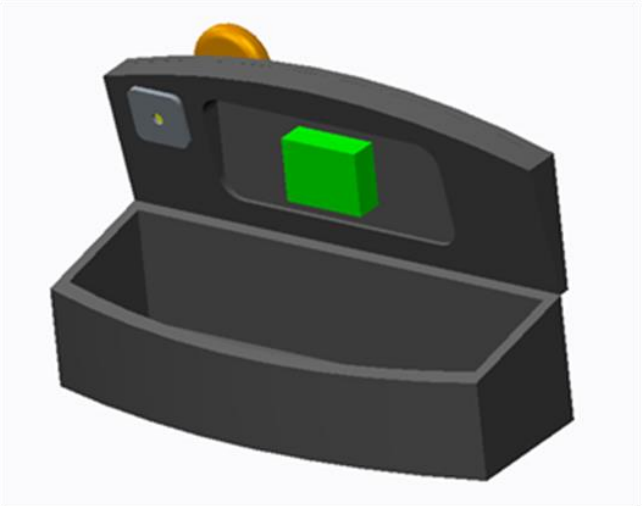
Rear Encoder Analysis

- Same design as front encoder mount
  - Ease of manufacture
- Analysis already done



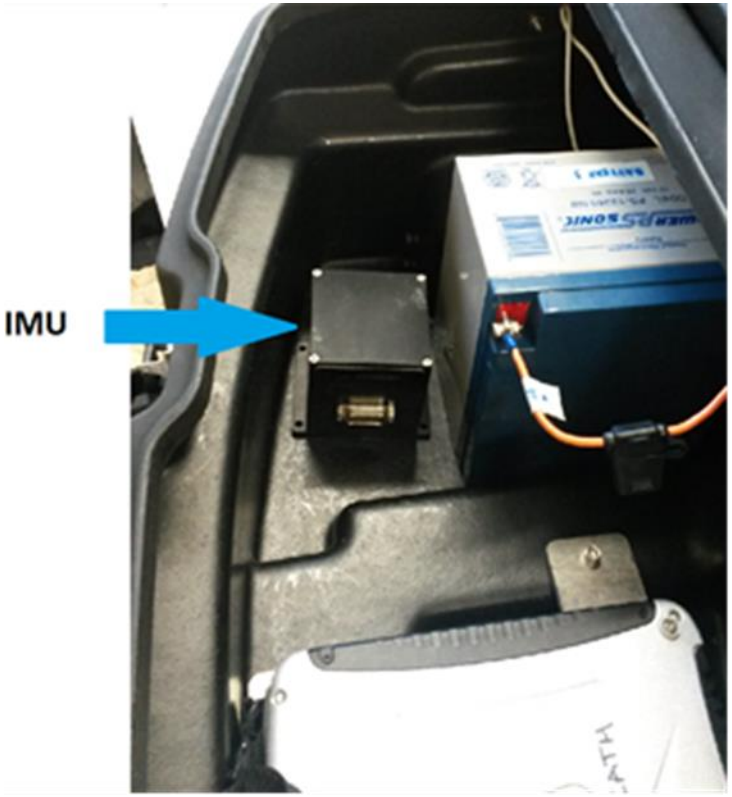
GPS Selection and Design

- Concept 1 score: 600.75
- Concept 2 score: 603.25
- Concept 2 selected
  - Small Interference with parts
  - Low Susceptibility to Damage
- No stress analysis



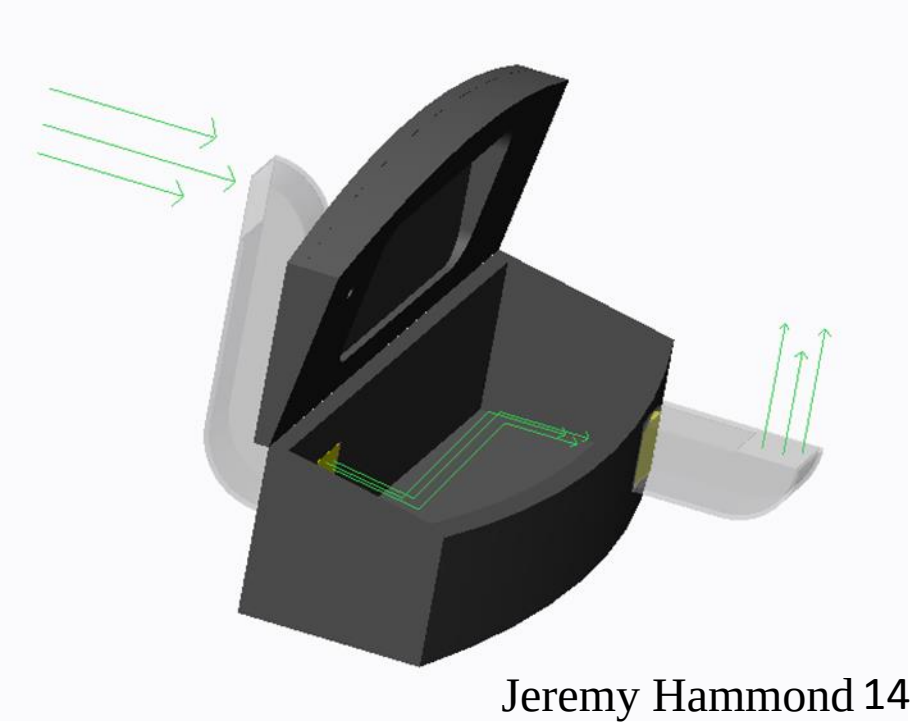
IMU Selection and Design

- Concept 1 score: 641.25
- Concept 2 score: 586.5
- Concept 3 score: 616.2
- Concept 1 selected
  - Low Susceptibility to Damage
- No stress analysis



Heat Selection and Analysis

- Concept 1 score: 496.75
- Concept 2 score: 535.0
- Concept 3 score: 397.5
- Concept 2 selected
  - Functionality
  - Low Energy Consumption

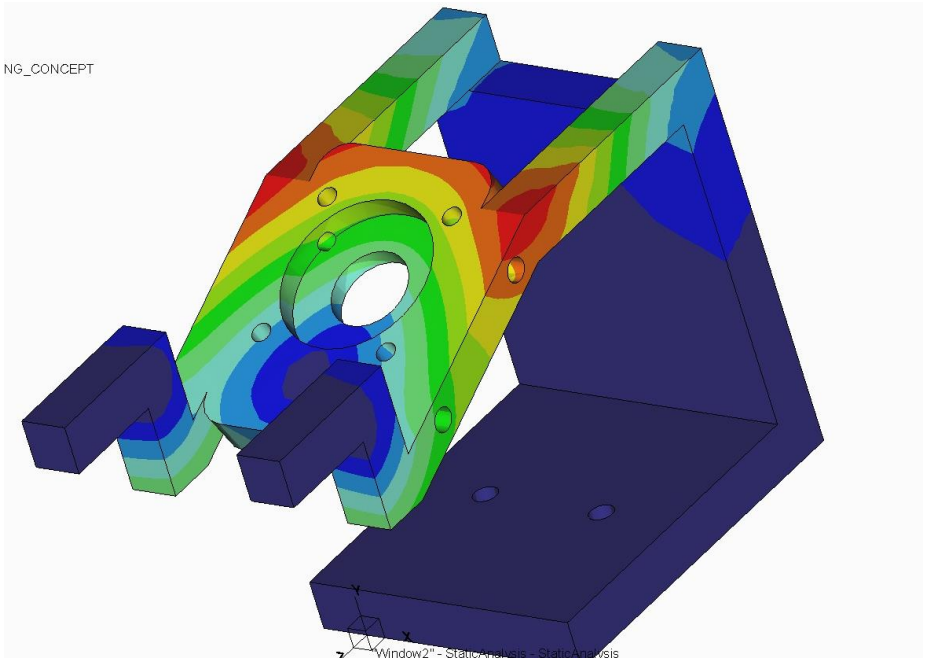


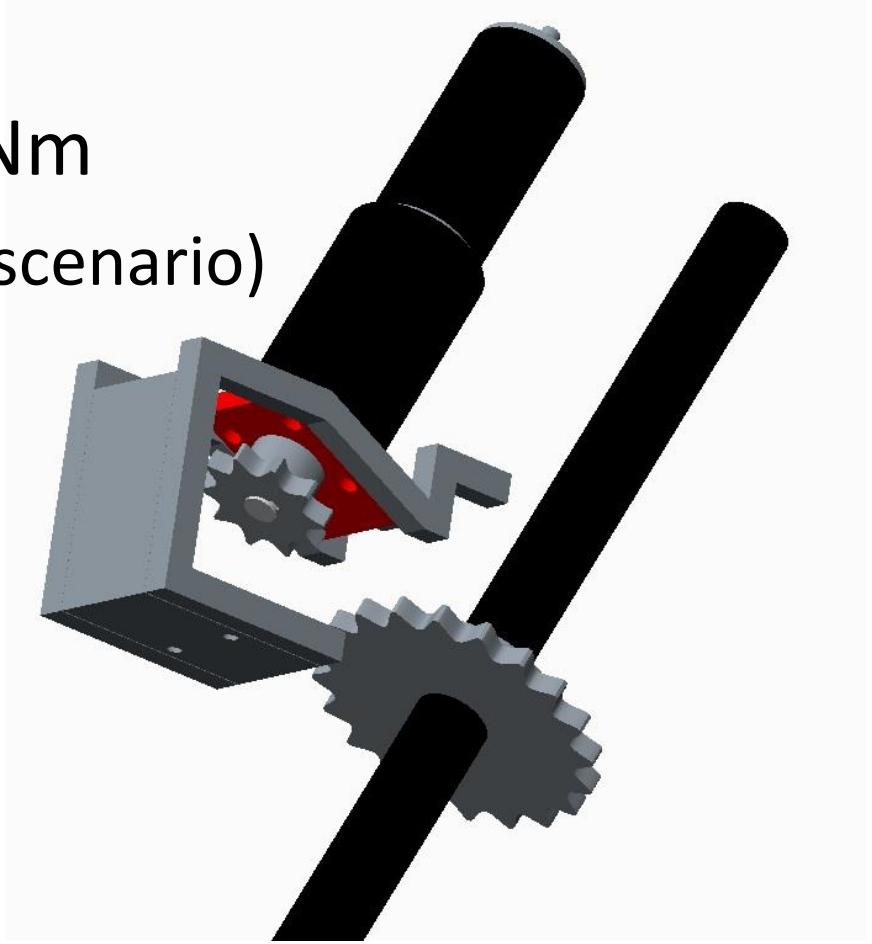
Heat Selection and Analysis

- Analysis assumptions (worst case scenario)
  - Outside air temp 90 deg F
  - Isothermal internal surfaces 130 deg F max
  - Prandalt number [Pr], thermal conductivity [k], viscosity [u], density[p] of air taken at film temperature
  - Modeled as forced convection over flat plate
- Refined power dissipation needs ~(64.4W)
- 250 ft^3/min fan X2
  - 64.69 W theoretical heat dissipation

Steering Motor Mount Analysis

- No decision needed
- Max motor torque 892 Nm
  - Stall torque (worst case scenario)

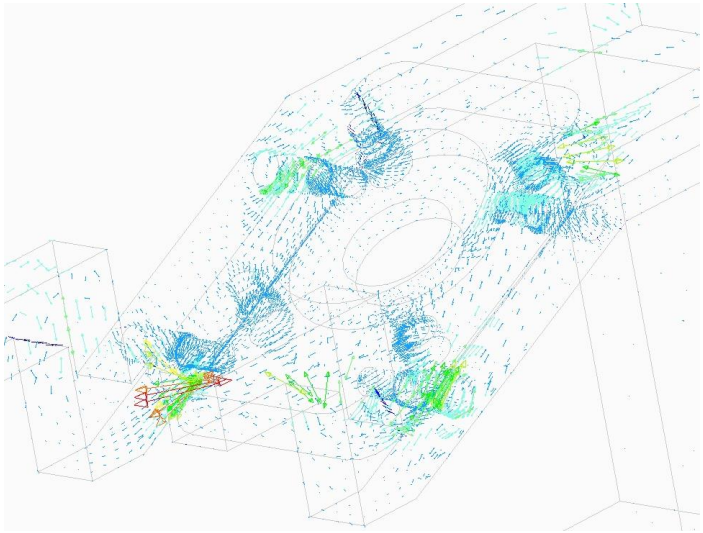




Steering Motor Mount Analysis

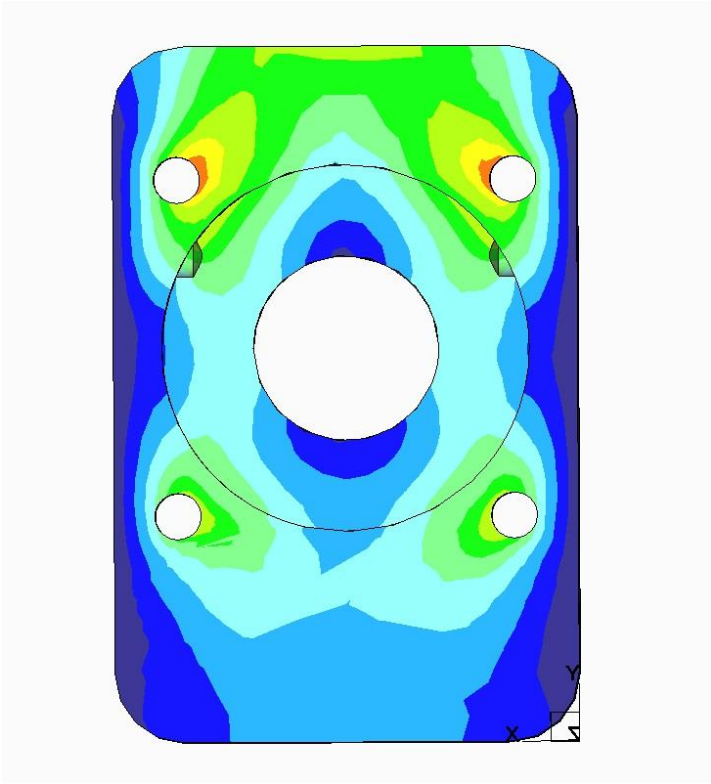
- 6061 AL yield strength 240 Mpa
- Max stress 95 Mpa
- Factor of safety 2.55
- Stress concentrations

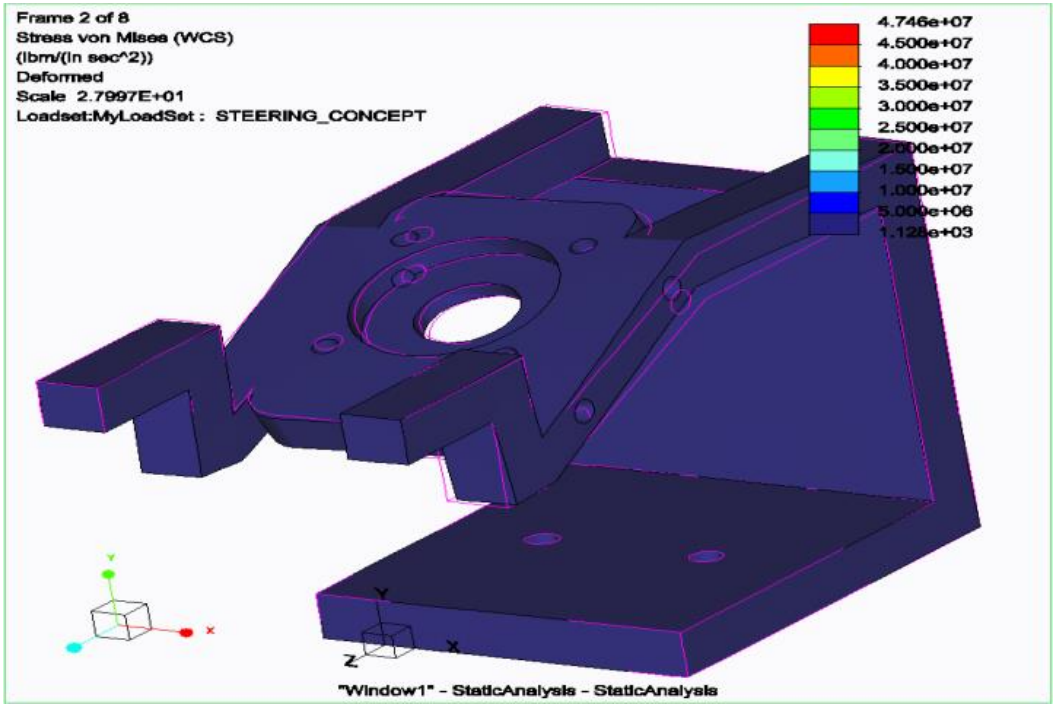
  at bolt holes



Steering Motor Mount Analysis

- Mount displacement

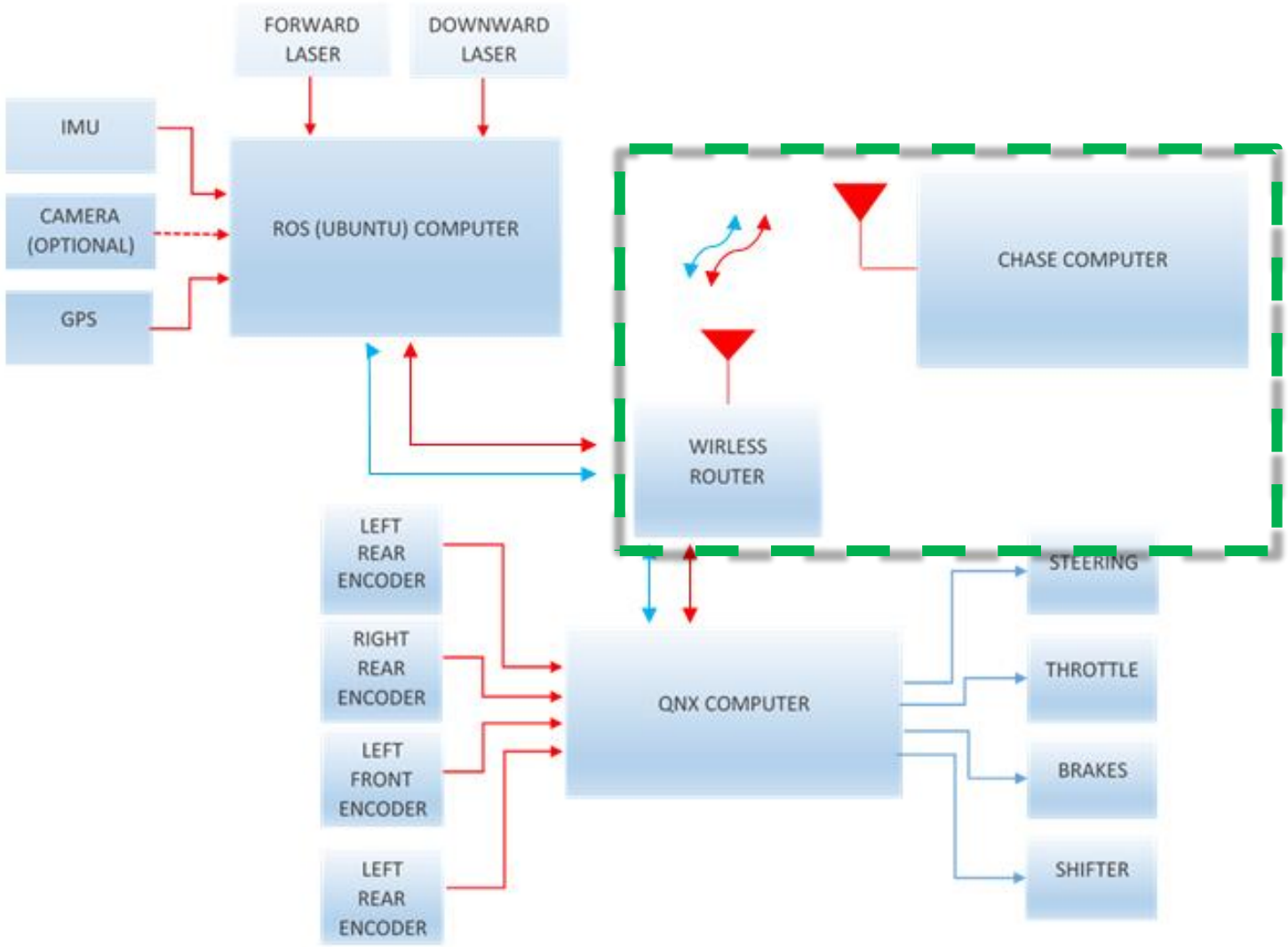




Materials / Manufacturing

- Mounting Brackets (all water jet cut) for:
  - Encoders – aluminum 6061
  - GPS – aluminum 6061
  - Lasers – aluminum 6061
  - IMU – aluminum 6061
- Tubing (laser cut) for:
  - ATV trunk fans – abs plastic
- Screws, Bolts, Nuts, etc:
  - Purchased from McMaster Carr if not readily available

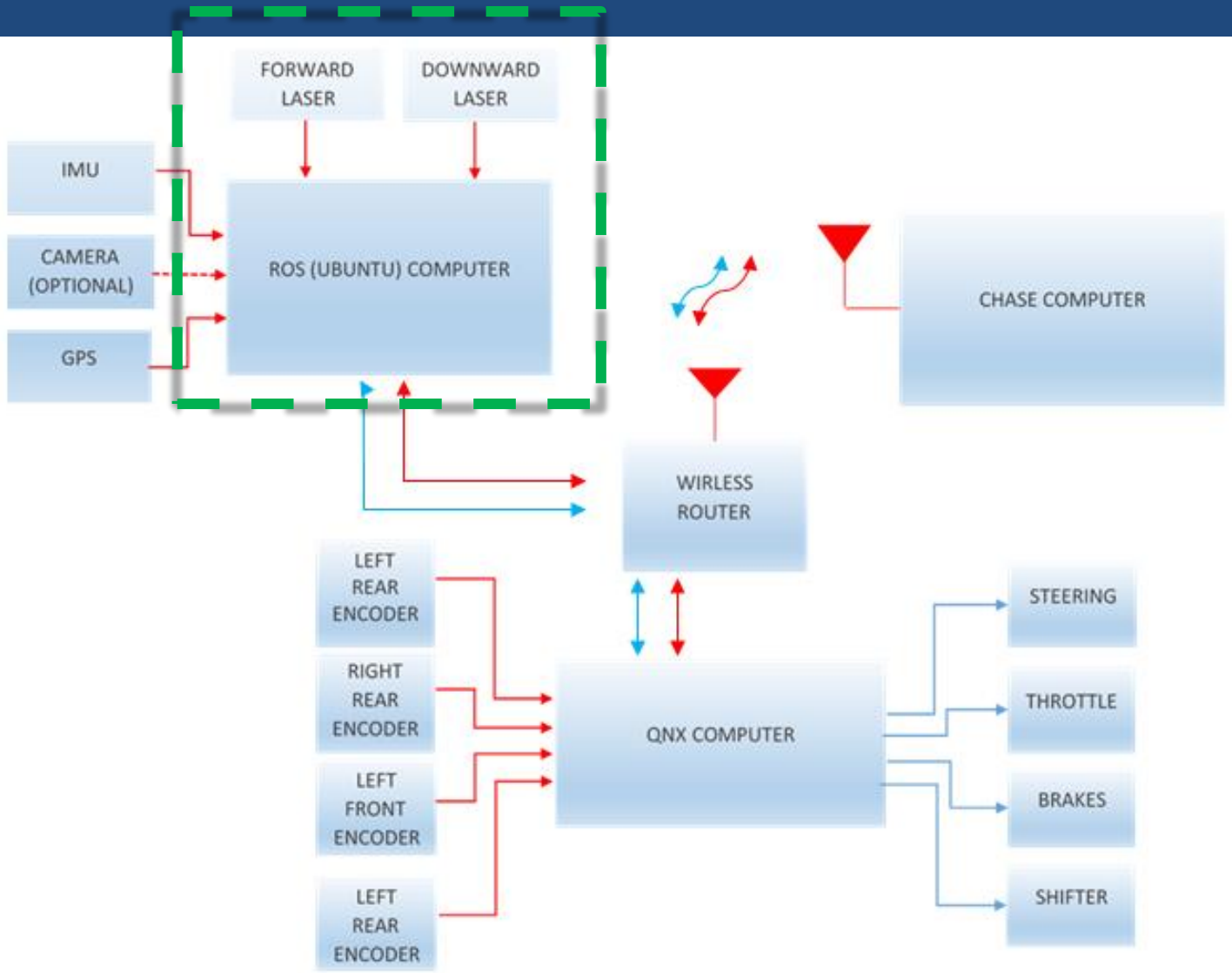
Computer Needs and Control



Router / Chase Computer

- Laptop running Windows 7
  - Remotely connect to ROS Toughbook
- TP-Link Router
- Connections:
  - IEEE 802.11g standard
  - Range: 30 miles
- Power Requirements:
  - +12V DC
  - 1 A max

Computer Needs and Control

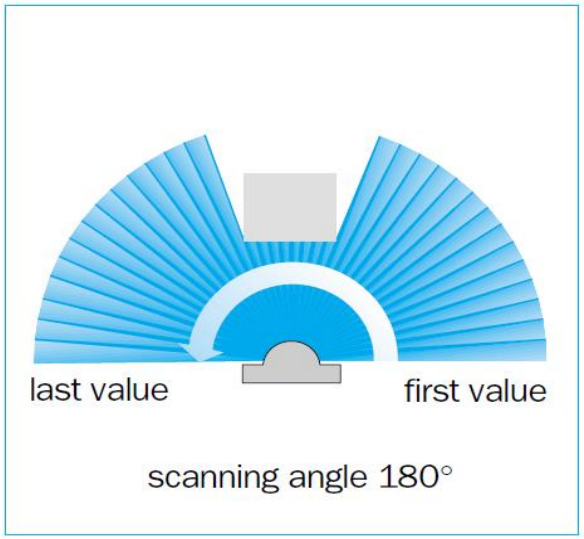


SICK Laser

- SICK LMS-200 Laser Measurement System
- 180 degree scan profile
- Angular resolution

  = 0.25^{o}
- Two lasers
- Power Supply needed

  24V DC / 2.5A
- RS-232 to USB converter



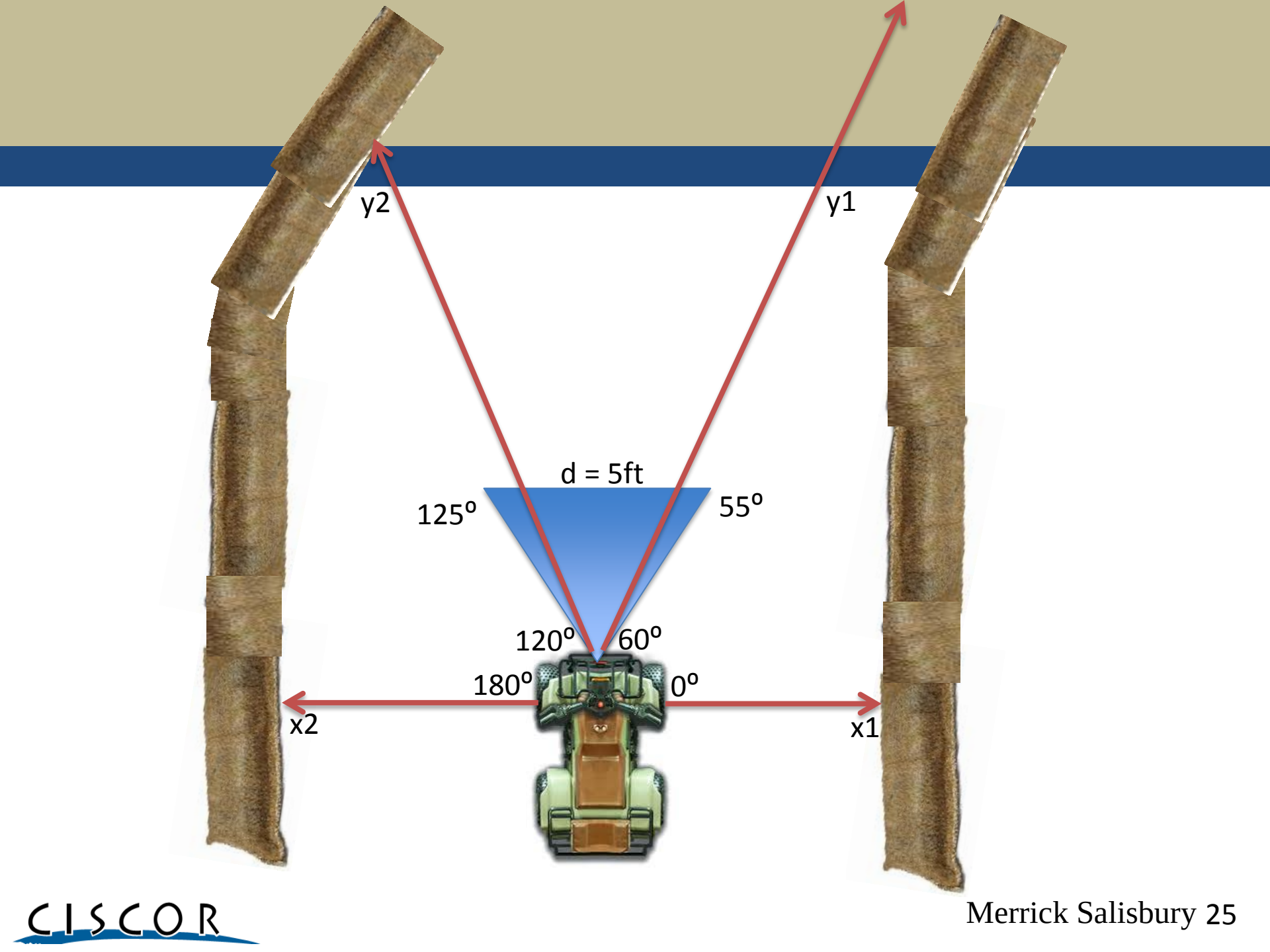
Road Following Pseudo Code

```
function firstsensor(s,d){
        int x1,x2,d,s
        IF (d<4.5feet) THEN
                Full brake to stop immediately
                    Spin
        ELSE
                Do nothing
        END IF
        IF (x1=x2) THEN
                IF (s>5) THEN
                        s = s
                ELSE
                        s = s + 1 //increment speed
                END IF
        ELSE IF (x1<x2) THEN
                d = -2      //turn left
        ELSE IF (x1>x2) THEN
                d = 2       //turn right
        ELSE IF (x1<<x2) THEN
                d = -4
                IF (s >1) THEN
                        s = s - 1
                ELSE
                        s=s
                END IF
        ELSE IF (x1>>x2) THEN
                d = 4
                IF (s >1) THEN
                        s = s - 1
                ELSE
                        s=s
                END IF
        ELSE
        END IF
        return(s,d)
}
```

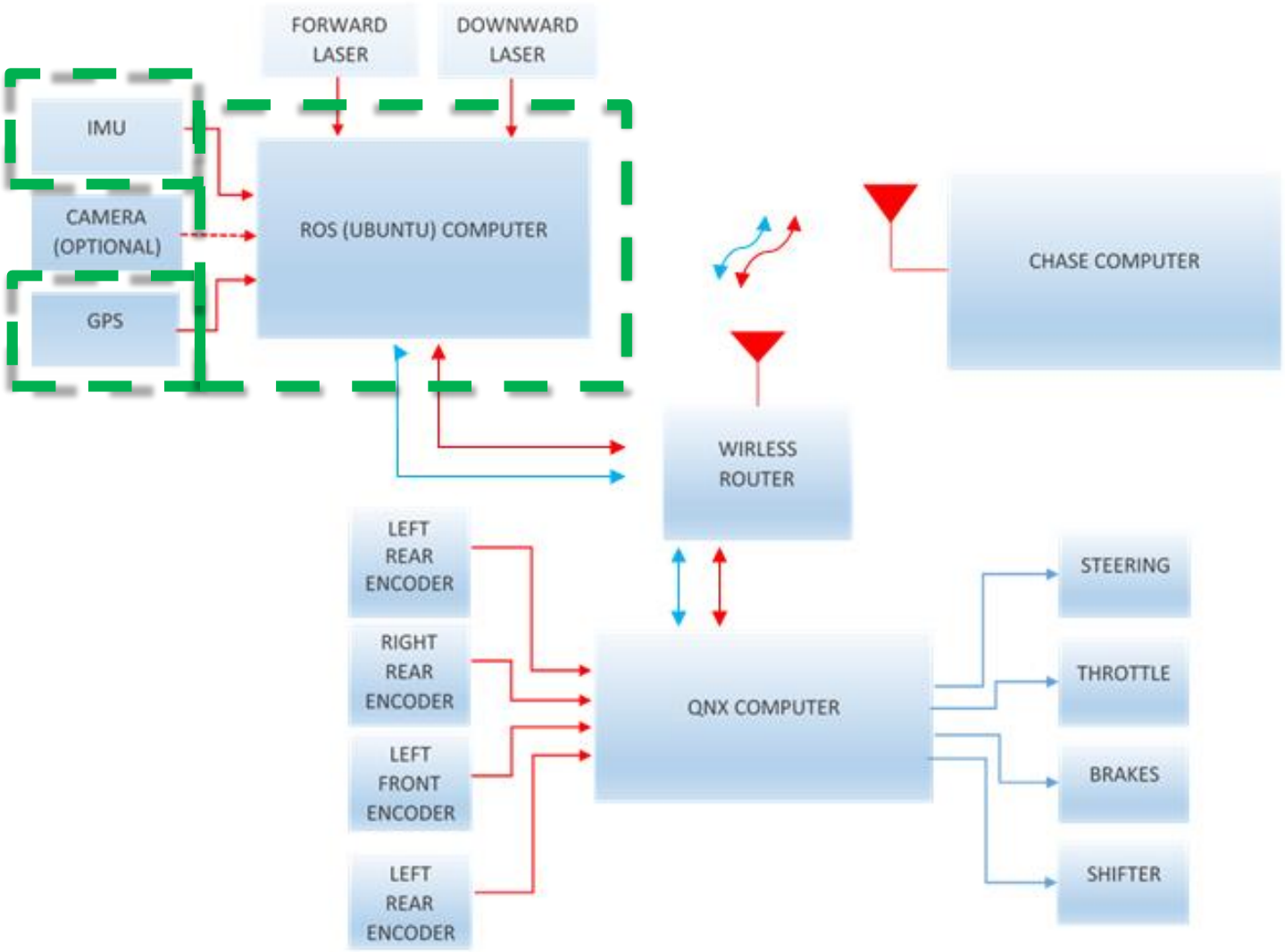
```
function secondsensor(s,d){
        int y1,y2
        IF (y1=y2) THEN
                s = s
        ELSE
                IF s < 3 THEN
                        s = s
                ELSE
                        s = s-1
                END IF
        END IF
}

main(){
        function firstsensor(s,d);
        function secondsensor(s,d);
}
```

Speed = s; Direction = d; Brake = stop flag; Shifter = forward;
//First sensors scans 3-5feet in front of the ATV
//Second sensors scans 15-20ft in front of the ATV
//x1 is the distance from road edge at 0 degrees(right side)
//x2 is the distance from road edge at 180 degrees (left side)
//d is the distance from an obstacle immediately in front of atv (ranged 55-125 degrees)
//y1 is the distance from the road at 60 degrees (right side)
//y2 is the distance from the road at 120 degrees (left side)

CISCOR


y2
y1
d = 5ft
125°
55°
120°
60°
180°
0°
x2
x1

Computer needs and control

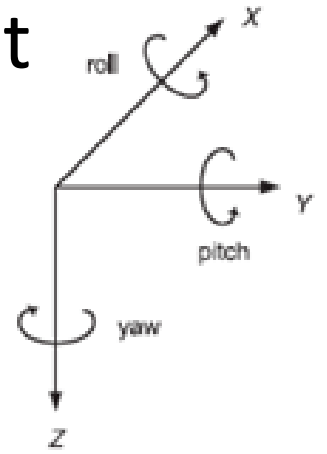


GPS

- Pro-Pack G2 plus GPS
- Connections:
  - RS 232 to USB Converter (CPU)
  - RS 232 (IMU)
  - Antenna Cable (GPS Antenna)
- Power Requirements:
  - +9V to +18V DC
    - 2.5W Power

IMU

- Crossbow Inertial Measurement Unit
- Connections:
  - RS 232 (GPS)
- Power Requirements
  - +9V to +30V
    - < 250 mA (< 3W @ 12V)

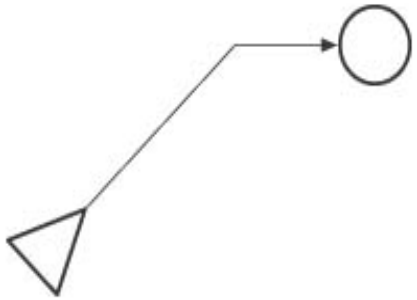


Waypoint Navigation

- Basic Path Finding Algorithm
  - Demonstration of system functionality

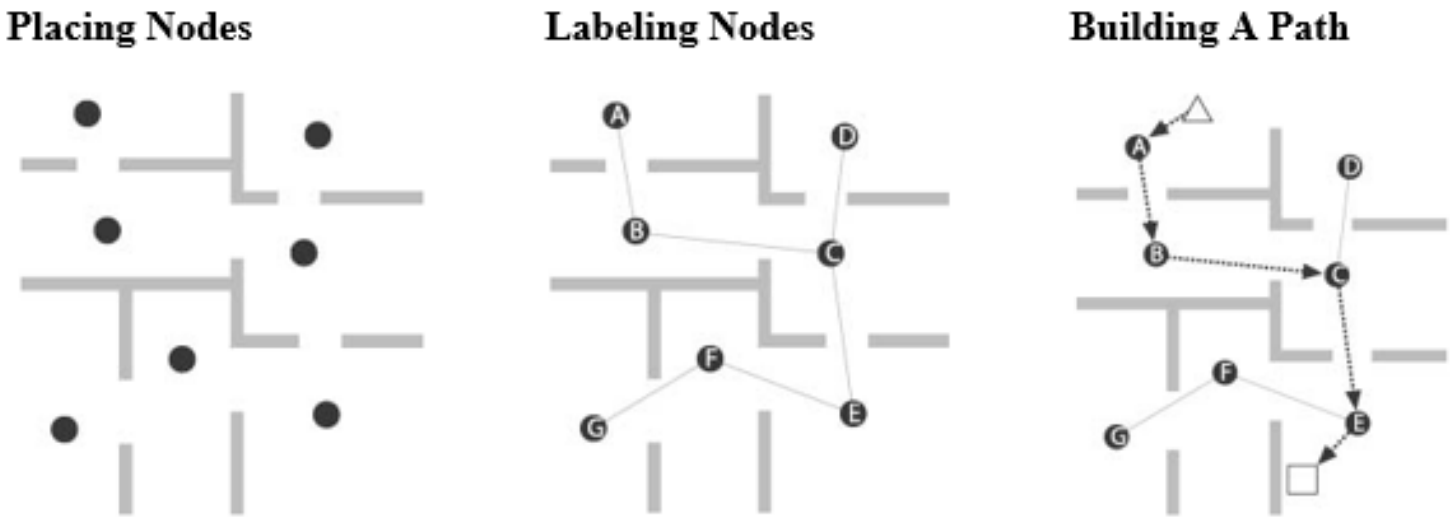
Basic Path Finding Algorithm:

```
Given a destination (x2,y2)
Record current position (x1,y1)
If x2 > x1
        Orient in Eastern direction
Else if x1>x2
        Orient in Western direction
While ( current position != destination)
        If x1 < x2
                x1← x1++    ; using the encoders to determine the necessary trajectory to
        else if  x1 > x2
                x1 ← x1 - -
        If y1 < y2
                y1← y1++
        else if  y1 > y2
                y1 ← y1 - -
```



Waypoint Navigation

- Navigation using multiple waypoints(or nodes)
  - Extension of Basic Path Finding Algorithm
  - Uses node table to determine best path of navigation



Waypoint Navigation

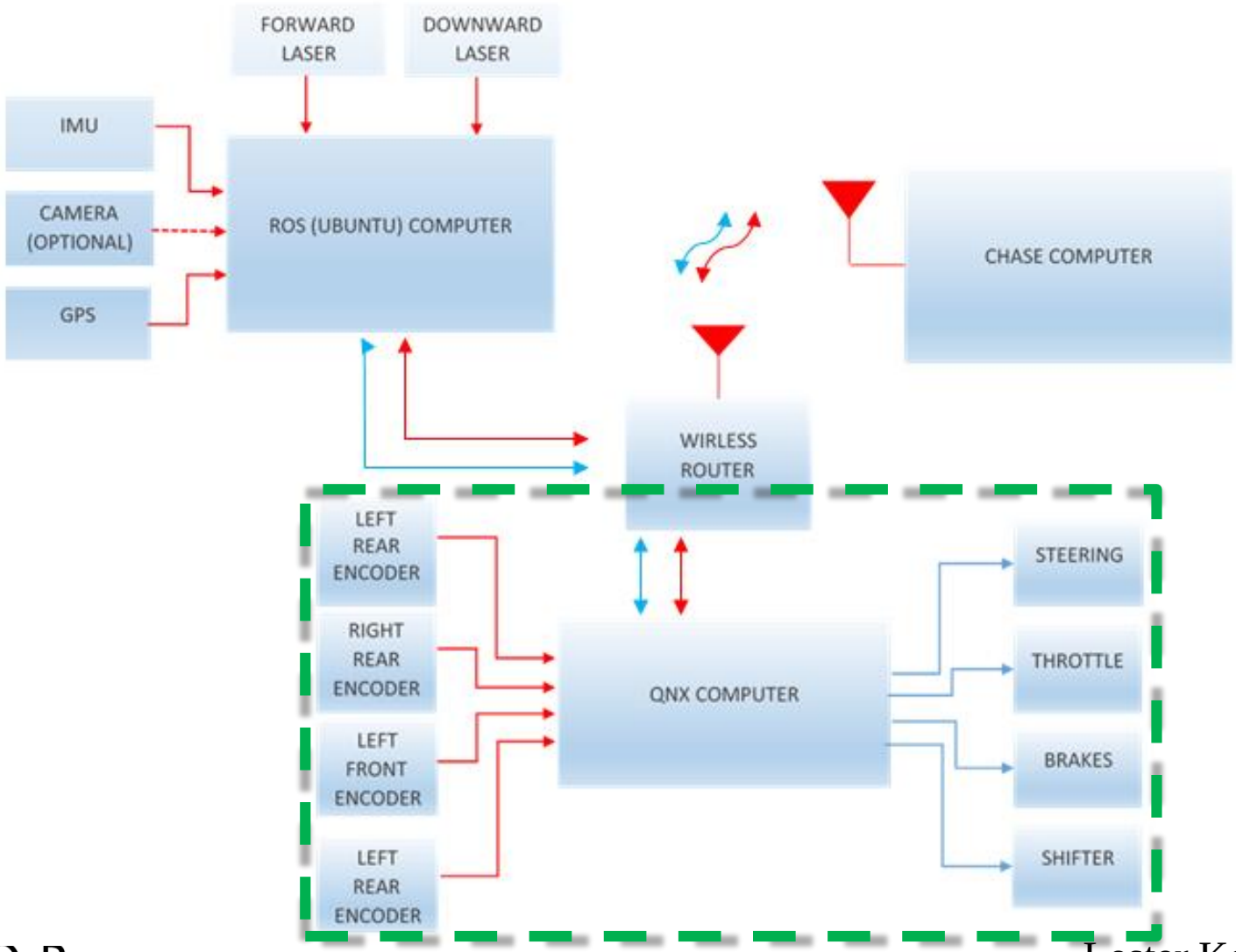
Functionality

1. User places nodes on a map of the testing terrain
2. Nodes will be labeled in order of nodes that are most accessible
3. Node table is used to determine best path to destination

Node Table

Start \ End	A	B	C	D	E	F	G
A	—	B	B	B	B	B	B
B	A	—	C	C	C	C	C
C	B	B	—	D	E	E	E
D	C	C	C	—	C	C	C
E	C	C	C	C	—	F	F
F	E	E	E	E	E	—	G
G	F	F	F	F	F	F	—

Computer needs and control



Conclusion / Future Plans

- Mechanical designs have been finalized
- Structural and thermal analysis proves functionality of designs
- Communication with sensors still in progress
- Autonomous algorithms not fully developed
  - Pending collaboration with CISCOR researchers

Sources

http://sicktoolbox.sourceforge.net/docs/sick-lms-technical-description.pdf

http://www.novatel.com/assets/Documents/Papers/ProPakG2plus.pdf

http://saba.kntu.ac.ir/eecd/ecourses/instrumentation/projects/reports/Poly%20Gyroscope/Producers/Crossbow/IMU/6020-0019-01_B_IMU300CC.pdf

http://www.ctiautomation.net/PDF/Accu-Coder/Accu-Coder-725-Shaft-Encoders.pdf

http://www.maxonmotorusa.com/medias/sys_master/8807014760478/13_106_EN.pdf

Fin

Questions?

Comments?