

# AUTONOMOUS SAILBOAT

ECE 445 FINAL PRESENTATION

Team 2

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# OBJECTIVE

World Robotic Sailing  
Championship

Autonomous Sailboat  
with limited capability

# AUTONOMOUS

Desired Heading:  $105.11^{\circ}$

Heading:  $98.28^{\circ}$

$40.113987^{\circ}$  N  $88.290237^{\circ}$  W

Speed: 0.16 Knots

Relative Wind:  $270^{\circ}$

Heeling:  $1.25^{\circ}$

Rudder:  $-7^{\circ}$

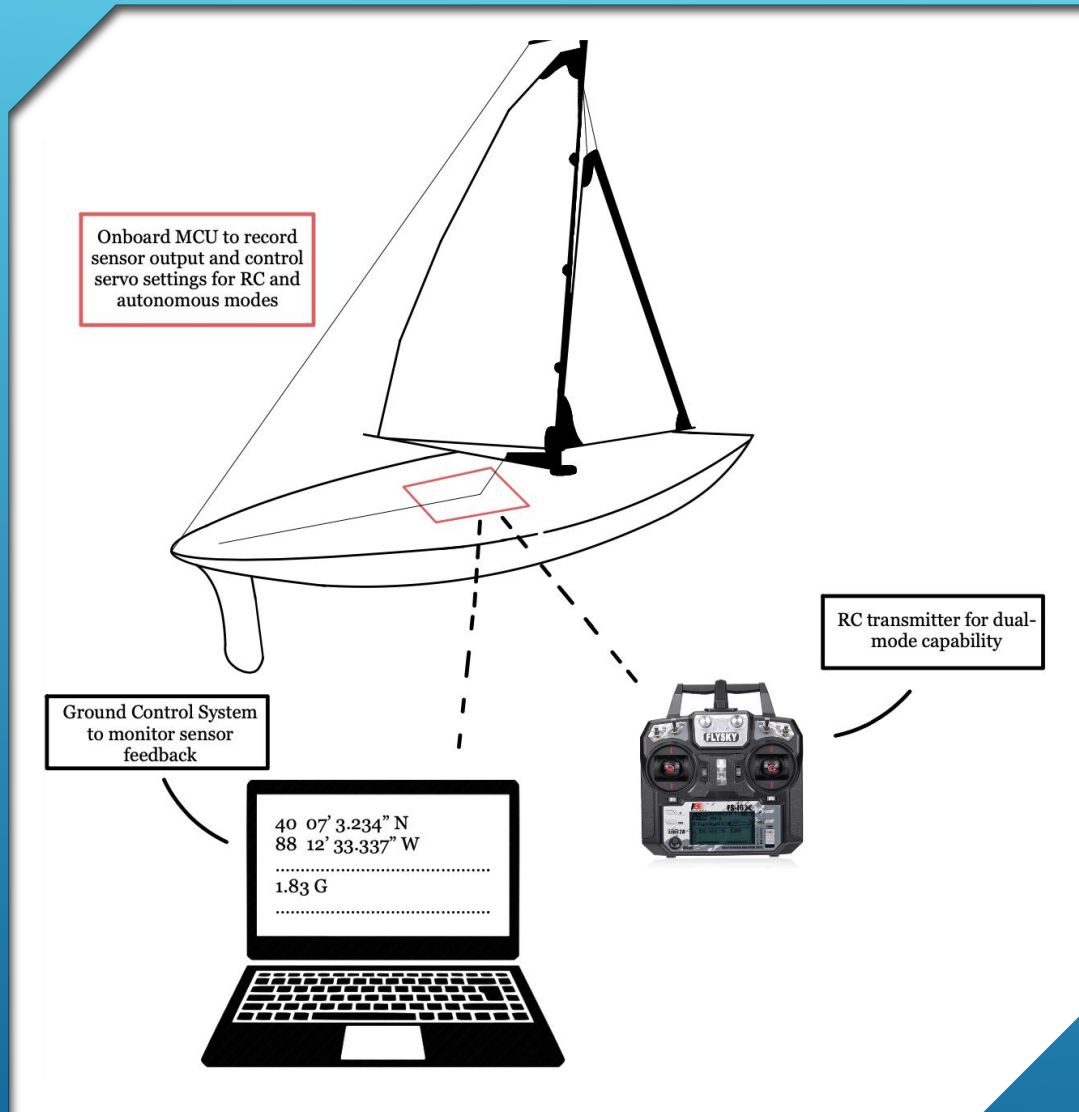
Sail:  $45^{\circ}$

Base

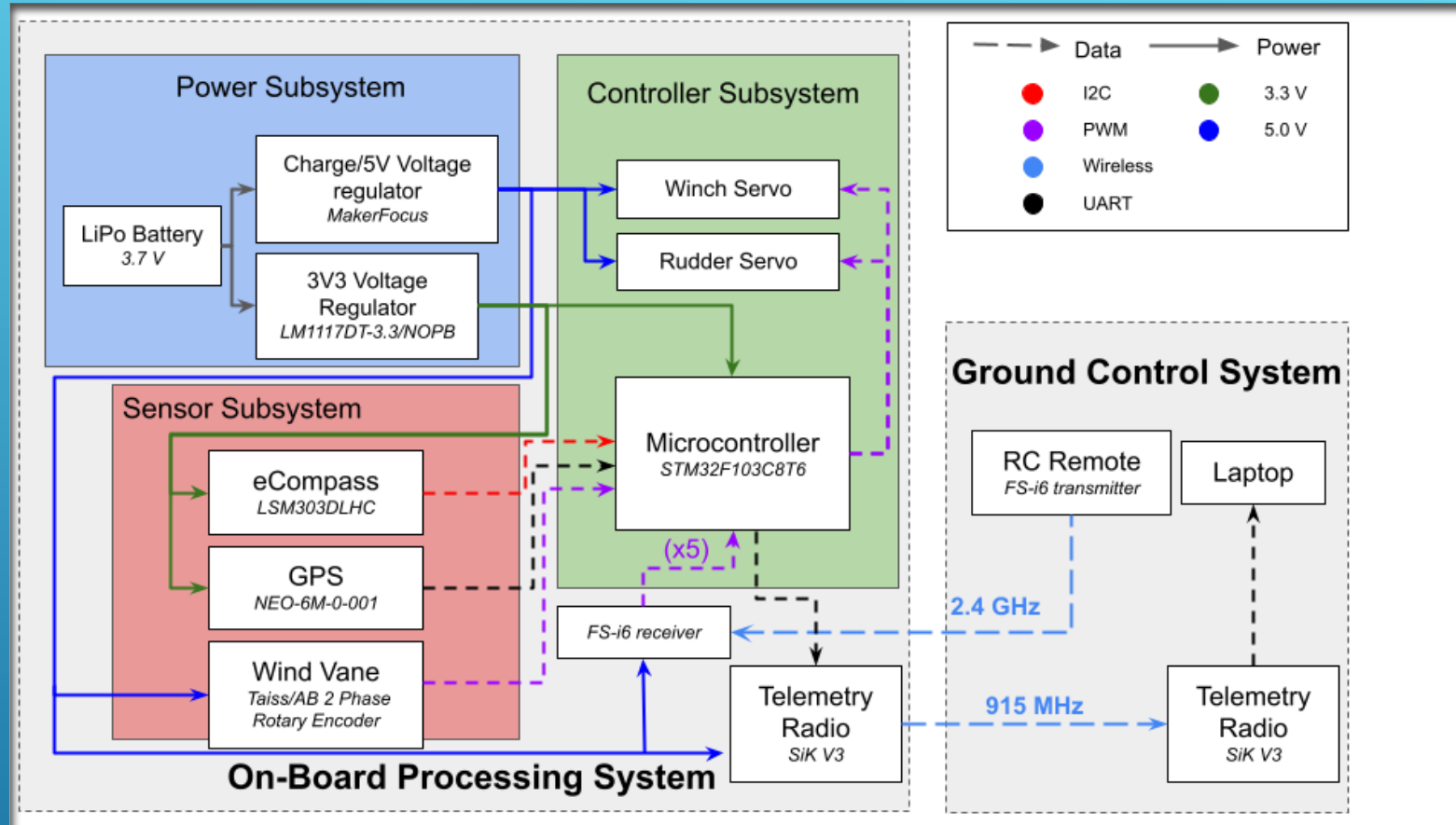
$40.114178^{\circ}$  N  $88.290027^{\circ}$  W

Distance to Base: 27.73 m

# ORIGINAL DESIGN







# BLOCK DIAGRAM





Set Mode

Set Base

# RC COMMUNICATION



# TELEMETRY



# GROUND CONTROL SYSTEM: LABVIEW

The interface is titled "Sailboat Data" and is set against a grid background. It features several data display areas:

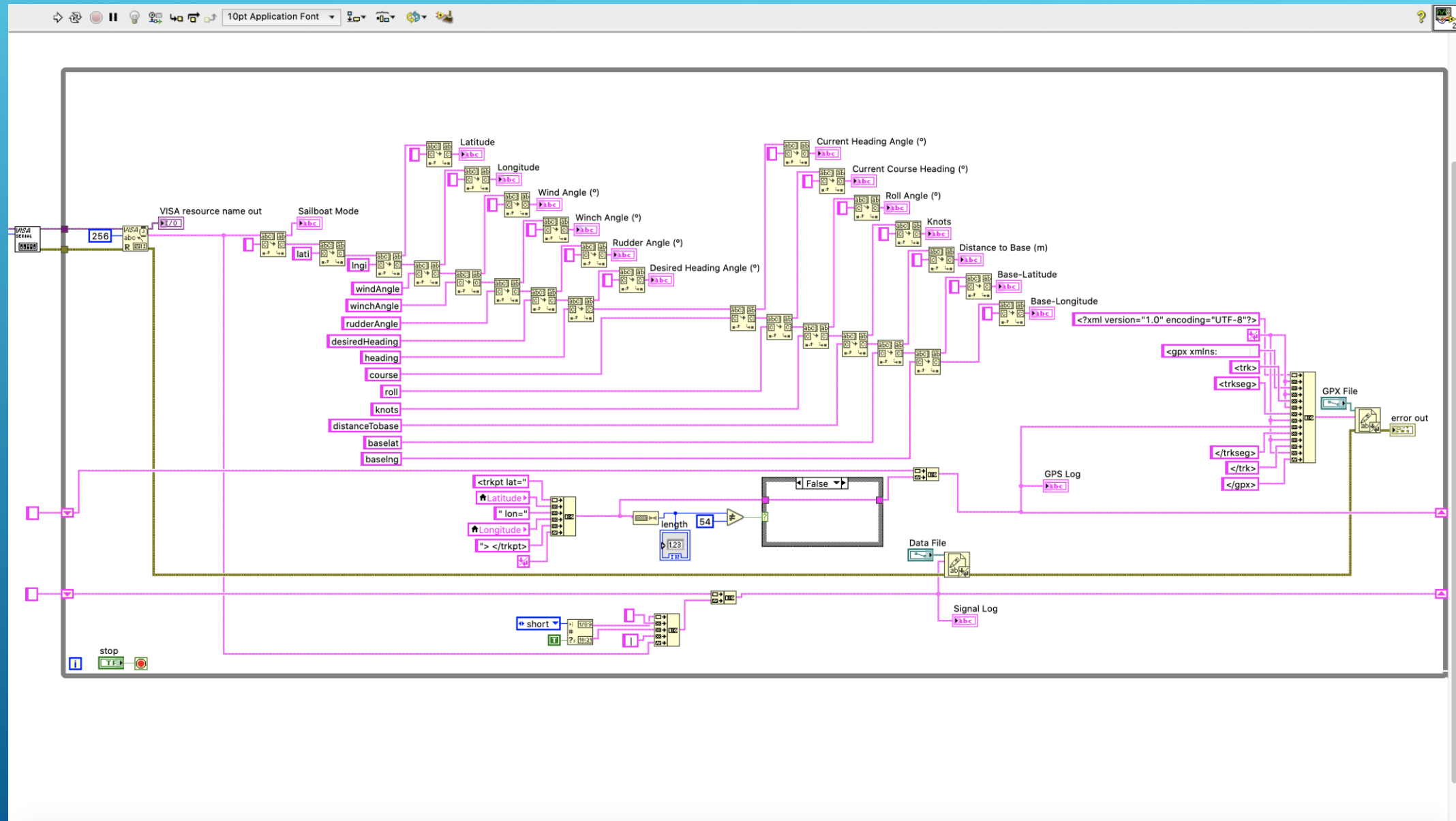
- Signal Log:** A text area on the left showing log entries. The first entry is: "2022/5/1 5:20:05 PM | MANUAL lati 40.115042 lngi -88.227654 windAngle 167.00 winchAngle 90.00 rudd".
- Sailboat Mode:** A dropdown menu currently set to "MANUAL".
- Latitude and Longitude:** Two input fields showing "40.115042" and "-88.227654" respectively.
- Wind Angle (°):** An input field showing "167.00".
- Desired Heading Angle (°):** An input field showing "0.00".
- Winch Angle (°):** An input field showing "90.00".
- Rudder Angle (°):** An input field showing "119.00".
- Return-to-Base Data:** A sub-panel containing:
  - Distance to Base (m):** An input field showing "0.00".
  - Base-Latitude:** An input field showing "40.115042".
  - Base-Longitude:** An input field showing "-88.227654".
- Current Heading Angle (°):** An input field showing "197.89".
- Current Course Heading (°):** An input field showing "48.47".
- Roll Angle (°):** An input field showing "-174.82".
- Knots:** An input field showing "4.50".

At the bottom, there are three main sections:

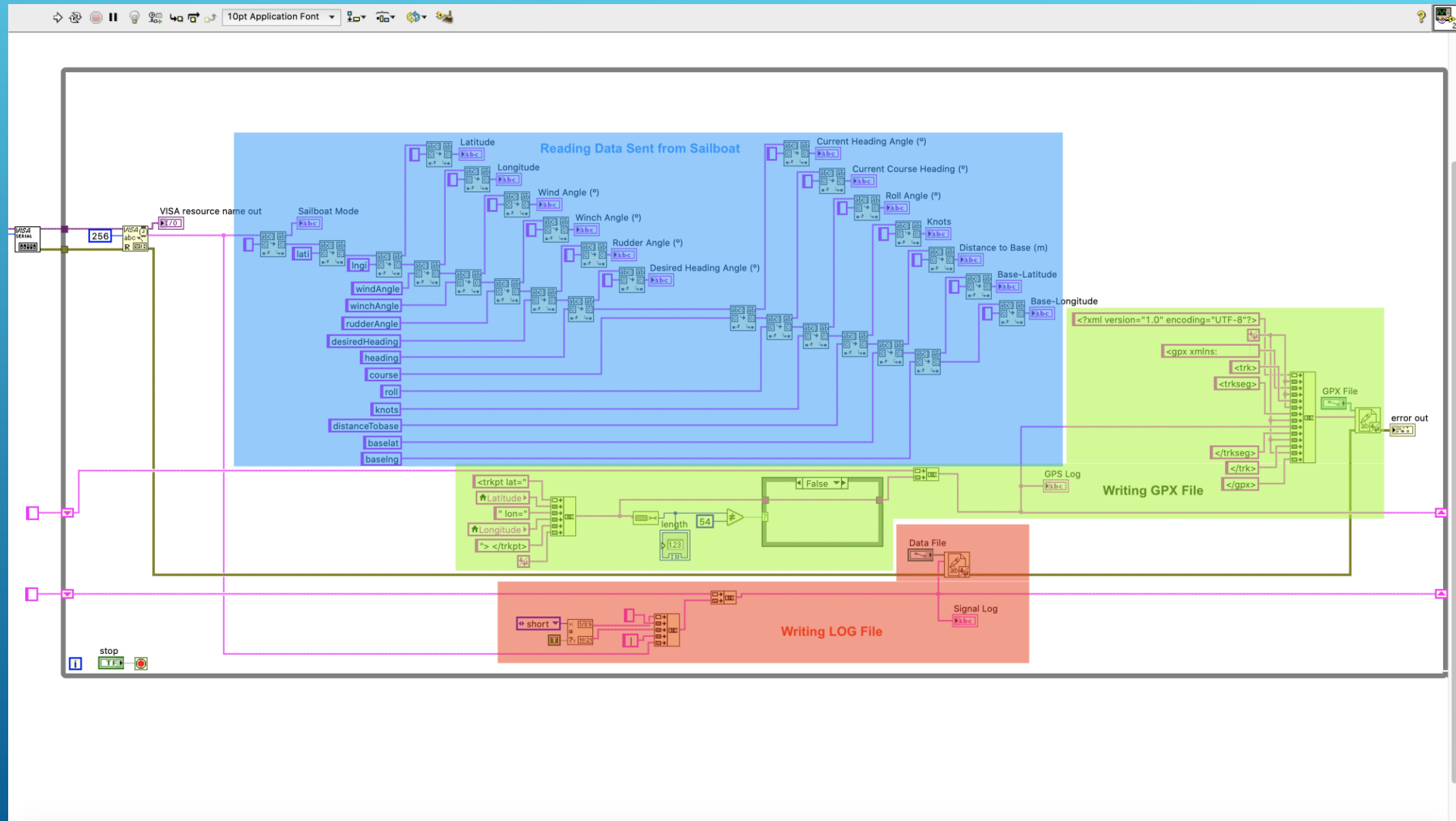
- Data File:** A file path "/Users/ArthurLiang/Desktop/Sailboat\_Log.txt" with a "length" of "54".
- VISA Resource:** A section showing "error out" status with a red "X" icon, "status code" "-1073807343", and "source" "Property Node (arg 1) in VISA Configure Serial Port (Instr).vi-". A red "STOP" button is located below this section.
- GPX File:** A file path "/Users/ArthurLiang/Desktop/GPS\_Map\_Display.gpx".

The top of the window has a standard LabVIEW toolbar with icons for file operations, execution, and help.

# GROUND CONTROL SYSTEM: LABVIEW



# GROUND CONTROL SYSTEM: LABVIEW



# GROUND CONTROL SYSTEM: LOG

2022/4/27 2:37:29 PM	MANUAL	lati	40.114868	lngi	-88.227688	windAngle	329.00	winchAngle	72.00	rudderAngle	62.00	desiredHeading	57.32	heading	53.15	course	0.00	roll	179.35	knots	0.06	distanceTobase	16.29	baselat	40.114921	baselng	-88.227866
2022/4/27 2:37:30 PM	MANUAL	lati	40.114866	lngi	-88.227684	windAngle	329.00	winchAngle	72.00	rudderAngle	73.00	desiredHeading	57.32	heading	54.30	course	0.00	roll	178.80	knots	0.13	distanceTobase	16.60	baselat	40.114921	baselng	-88.227866
2022/4/27 2:37:31 PM	MANUAL	lati	40.114866	lngi	-88.227682	windAngle	329.00	winchAngle	76.37	rudderAngle	73.00	desiredHeading	57.32	heading	55.55	course	0.00	roll	178.94	knots	0.08	distanceTobase	16.80	baselat	40.114921	baselng	-88.227866
2022/4/27 2:37:32 PM	MANUAL	lati	40.114864	lngi	-88.227677	windAngle	329.00	winchAngle	80.78	rudderAngle	73.00	desiredHeading	57.32	heading	53.64	course	0.00	roll	178.89	knots	0.10	distanceTobase	17.27	baselat	40.114921	baselng	-88.227866
2022/4/27 2:37:33 PM	MANUAL	lati	40.114862	lngi	-88.227672	windAngle	329.00	winchAngle	85.28	rudderAngle	62.00	desiredHeading	57.32	heading	57.63	course	0.00	roll	178.69	knots	0.10	distanceTobase	17.79	baselat	40.114921	baselng	-88.227866
2022/4/27 2:37:34 PM	MANUAL	lati	40.114861	lngi	-88.227667	windAngle	329.00	winchAngle	86.61	rudderAngle	53.00	desiredHeading	57.32	heading	53.11	course	0.00	roll	178.89	knots	0.21	distanceTobase	19.08	baselat	40.114921	baselng	-88.227866
2022/4/27 2:37:35 PM	MANUAL	lati	40.114858	lngi	-88.227657	windAngle	329.00	winchAngle	86.61	rudderAngle	87.00	desiredHeading	57.32	heading	53.28	course	0.00	roll	178.89	knots	0.21	distanceTobase	19.08	baselat	40.114921	baselng	-88.227866
2022/4/27 2:37:36 PM	MANUAL	lati	40.114858	lngi	-88.227654	windAngle	329.00	winchAngle	86.61	rudderAngle	87.00	desiredHeading	57.32	heading	53.41	course	0.00	roll	178.90	knots	0.01	distanceTobase	19.29	baselat	40.114921	baselng	-88.227866
2022/4/27 2:37:38 PM	MANUAL	lati	40.114858	lngi	-88.227650	windAngle	329.00	winchAngle	86.61	rudderAngle	87.00	desiredHeading	57.32	heading	53.58	course	84.00	roll	178.95	knots	0.18	distanceTobase	19.68	baselat	40.114921	baselng	-88.227866
2022/4/27 2:37:39 PM	AUTONOMOUS	lati	40.114858	lngi	-88.227650	windAngle	329.00	winchAngle	72.00	rudderAngle	102.00	desiredHeading	53.25	heading	53.25	course	84.00	roll	178.74	knots	0.18	distanceTobase	19.68	baselat	40.114921	baselng	-88.227866
2022/4/27 2:37:40 PM	AUTONOMOUS	lati	40.114857	lngi	-88.227645	windAngle	329.00	winchAngle	72.00	rudderAngle	91.00	desiredHeading	53.25	heading	55.04	course	0.00	roll	179.20	knots	0.24	distanceTobase	20.09	baselat	40.114921	baselng	-88.227866
2022/4/27 2:37:41 PM	AUTONOMOUS	lati	40.114856	lngi	-88.227641	windAngle	329.00	winchAngle	72.00	rudderAngle	88.00	desiredHeading	53.25	heading	54.77	course	0.00	roll	178.94	knots	0.20	distanceTobase	20.47	baselat	40.114921	baselng	-88.227866
2022/4/27 2:37:42 PM	AUTONOMOUS	lati	40.114855	lngi	-88.227638	windAngle	329.00	winchAngle	72.00	rudderAngle	96.00	desiredHeading	53.25	heading	52.74	course	11.00	roll	179.10	knots	0.20	distanceTobase	20.75	baselat	40.114921	baselng	-88.227866
2022/4/27 2:37:43 PM	AUTONOMOUS	lati	40.114854	lngi	-88.227636	windAngle	329.00	winchAngle	72.00	rudderAngle	91.00	desiredHeading	53.25	heading	53.60	course	2133.00	roll	178.84	knots	0.15	distanceTobase	20.90	baselat	40.114921	baselng	-88.227866
2022/4/27 2:37:44 PM	AUTONOMOUS	lati	40.114853	lngi	-88.227635	windAngle	7.00	winchAngle	72.00	rudderAngle	121.00	desiredHeading	53.25	heading	46.32	course	85.00	roll	179.65	knots	0.32	distanceTobase	21.06	baselat	40.114921	baselng	-88.227866
2022/4/27 2:37:45 PM	AUTONOMOUS	lati	40.114852	lngi	-88.227634	windAngle	0.00	winchAngle	72.00	rudderAngle	165.00	desiredHeading	53.25	heading	34.66	course	85.00	roll	178.55	knots	0.34	distanceTobase	21.12	baselat	40.114921	baselng	-88.227866
2022/4/27 2:37:46 PM	AUTONOMOUS	lati	40.114852	lngi	-88.227633	windAngle	346.00	winchAngle	72.00	rudderAngle	165.00	desiredHeading	53.25	heading	39.99	course	85.00	roll	178.89	knots	0.33	distanceTobase	21.23	baselat	40.114921	baselng	-88.227866
2022/4/27 2:37:47 PM	AUTONOMOUS	lati	40.114849	lngi	-88.227634	windAngle	347.00	winchAngle	72.00	rudderAngle	165.00	desiredHeading	53.25	heading	38.89	course	85.00	roll	178.24	knots	0.31	distanceTobase	21.29	baselat	40.114921	baselng	-88.227866
2022/4/27 2:37:48 PM	9	distanceTobase	21.30	baselat	40.114921	baselng	-88.227866																				
2022/4/27 2:37:49 PM	AUTONOMOUS	lati	40.114844	lngi	-88.227636	windAngle	337.00	winchAngle	72.00	rudderAngle	155.00	desiredHeading	53.25	heading	44.22	course	85.00	roll	178.80	knots	0.47	distanceTobase	21.36	baselat	40.114921	baselng	-88.227866
2022/4/27 2:37:50 PM	AUTONOMOUS	lati	40.114847	lngi	-88.227637	windAngle	333.00	winchAngle	72.00	rudderAngle	49.00	desiredHeading	53.25	heading	69.28	course	85.00	roll	179.40	knots	0.23	distanceTobase	21.14	baselat	40.114921	baselng	-88.227866
2022/4/27 2:37:51 PM	AUTONOMOUS	lati	40.114844	lngi	-88.227637	windAngle	18.00	winchAngle	72.00	rudderAngle	41.00	desiredHeading	53.25	heading	69.66	course	85.00	roll	-179.59	knots	0.02	distanceTobase	21.24	baselat	40.114921	baselng	-88.227866
2022/4/27 2:37:52 PM	AUTONOMOUS	lati	40.114839	lngi	-88.227640	windAngle	7.00	winchAngle	72.00	rudderAngle	40.00	desiredHeading	53.25	heading	71.02	course	85.00	roll	178.65	knots	0.39	distanceTobase	21.26	baselat	40.114921	baselng	-88.227866
2022/4/27 2:37:53 PM	AUTONOMOUS	lati	40.114837	lngi	-88.227639	windAngle	5.00	winchAngle	72.00	rudderAngle	40.00	desiredHeading	53.25	heading	71.22	course	85.00	roll	178.85	knots	0.48	distanceTobase	21.42	baselat	40.114921	baselng	-88.227866
2022/4/27 2:37:54 PM	AUTONOMOUS	lati	40.114836	lngi	-88.227641	windAngle	4.00	winchAngle	72.00	rudderAngle	40.00	desiredHeading	53.25	heading	71.50	course	85.00	roll	179.00	knots	0.17	distanceTobase	21.33	baselat	40.114921	baselng	-88.227866
2022/4/27 2:37:55 PM	AUTONOMOUS	lati	40.114835	lngi	-88.227642	windAngle	354.00	winchAngle	72.00	rudderAngle	40.00	desiredHeading	53.25	heading	71.00	course	85.00	roll	179.20	knots	0.12	distanceTobase	21.35	baselat	40.114921	baselng	-88.227866
2022/4/27 2:37:56 PM	AUTONOMOUS	lati	40.114834	lngi	-88.227640	windAngle	20.00	winchAngle	72.00	rudderAngle	85.00	desiredHeading	53.25	heading	54.97	course	85.00	roll	178.79	knots	0.18	distanceTobase	21.50	baselat	40.114921	baselng	-88.227866
2022/4/27 2:37:57 PM	AUTONOMOUS	lati	40.114831	lngi	-88.227641	windAngle	9.00	winchAngle	72.00	rudderAngle	71.00	desiredHeading	53.25	heading	56.81	course	85.00	roll	177.86	knots	0.18	distanceTobase	21.56	baselat	40.114921	baselng	-88.227866
2022/4/27 2:37:58 PM	AUTONOMOUS	lati	40.114830	lngi	-88.227642	windAngle	10.00	winchAngle	72.00	rudderAngle	69.00	desiredHeading	53.25	heading	56.14	course	85.00	roll	178.34	knots	0.28	distanceTobase	21.60	baselat	40.114921	baselng	-88.227866
2022/4/27 2:37:59 PM	AUTONOMOUS	lati	40.114828	lngi	-88.227642	windAngle	18.00	winchAngle	72.00	rudderAngle	65.00	desiredHeading	53.25	heading	56.01	course	85.00	roll	178.29	knots	0.21	distanceTobase	21.64	baselat	40.114921	baselng	-88.227866
2022/4/27 2:38:00 PM	AUTONOMOUS	lati	40.114826	lngi	-88.227642	windAngle	26.00	winchAngle	72.00	rudderAngle	53.00	desiredHeading	53.25	heading	57.13	course	85.00	roll	178.29	knots	0.21	distanceTobase	21.75	baselat	40.114921	baselng	-88.227866
2022/4/27 2:38:01 PM	AUTONOMOUS	lati	40.114826	lngi	-88.227645	windAngle	38.00	winchAngle	72.00	rudderAngle	45.00	desiredHeading	53.25	heading	57.18	course	85.00	roll	178.44	knots	0.17	distanceTobase	21.53	baselat	40.114921	baselng	-88.227866
2022/4/27 2:38:02 PM	AUTONOMOUS	lati	40.114826	lngi	-88.227649	windAngle	66.00	winchAngle	72.00	rudderAngle	40.00	desiredHeading	53.25	heading	57.64	course	85.00	roll	178.24	knots	0.15	distanceTobase	21.24	baselat	40.114921	baselng	-88.227866



# GROUND CONTROL SYSTEM: GPX FILE

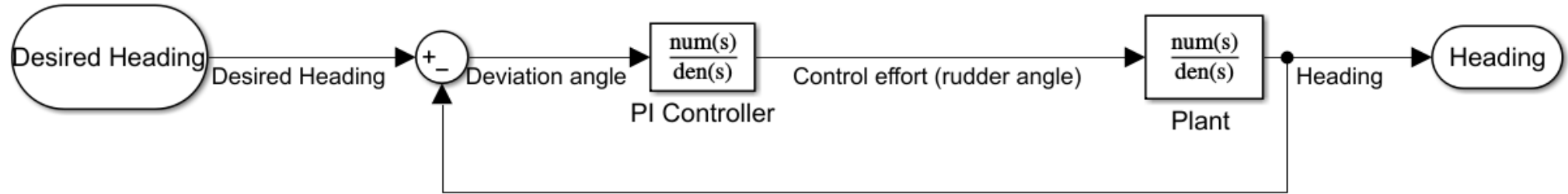
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www.topografix.com/GPX/1/1 http://www.topografix.com/GPX/1/1/gpx.xsd http://www.garmin.com/xmlschemas/GpxExtensions/v3 http://
www.garmin.com/xmlschemas/GpxExtensionsv3.xsd http://www.garmin.com/xmlschemas/TrackPointExtension/v1 http://www.garmin.com/xmlschemas/
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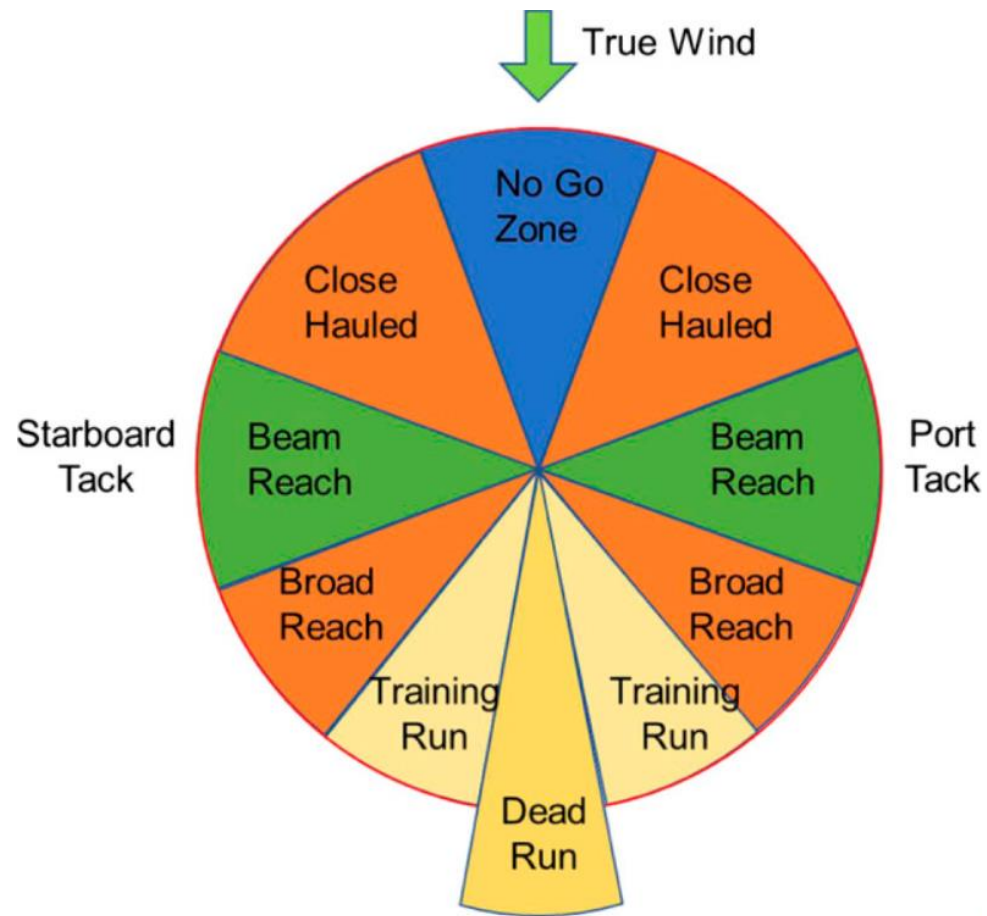
# EXPERIMENTAL RESULTS



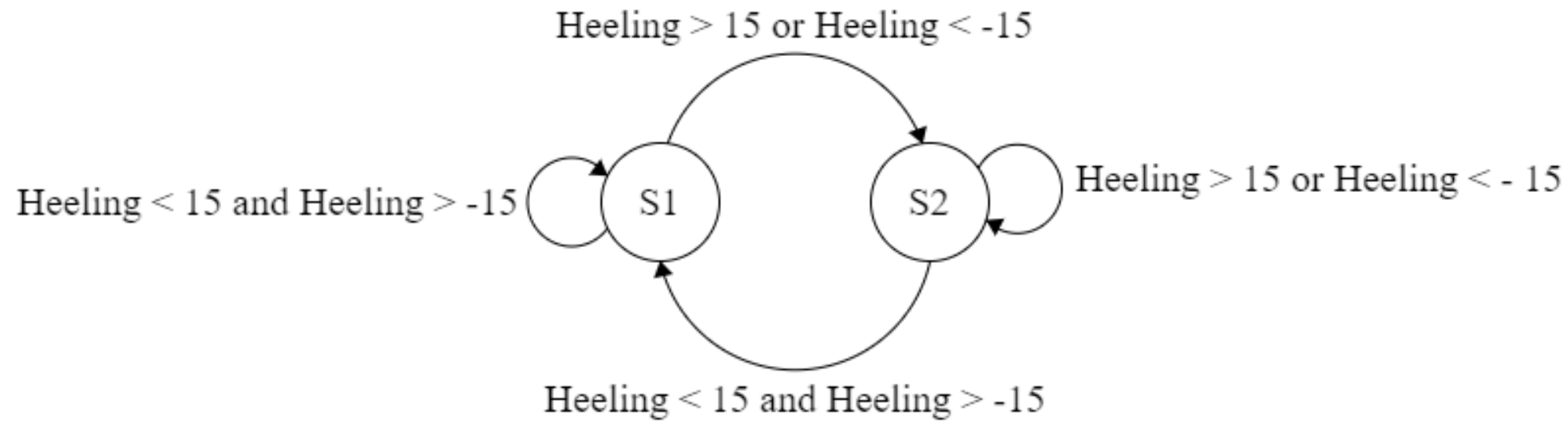
<https://gpx.studio/>



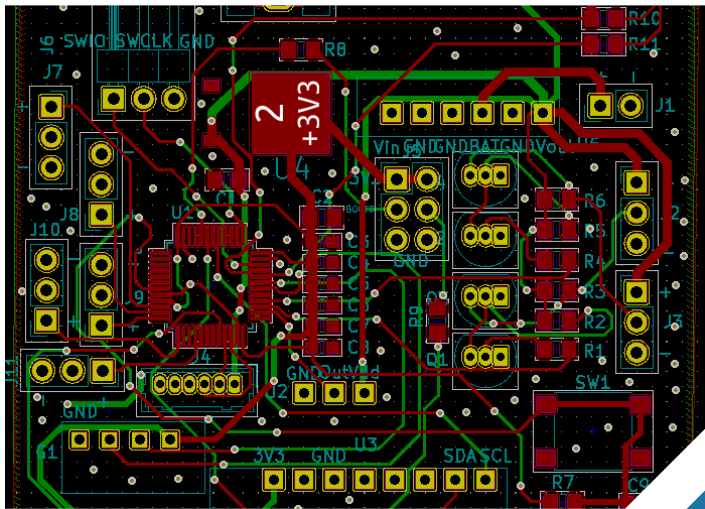
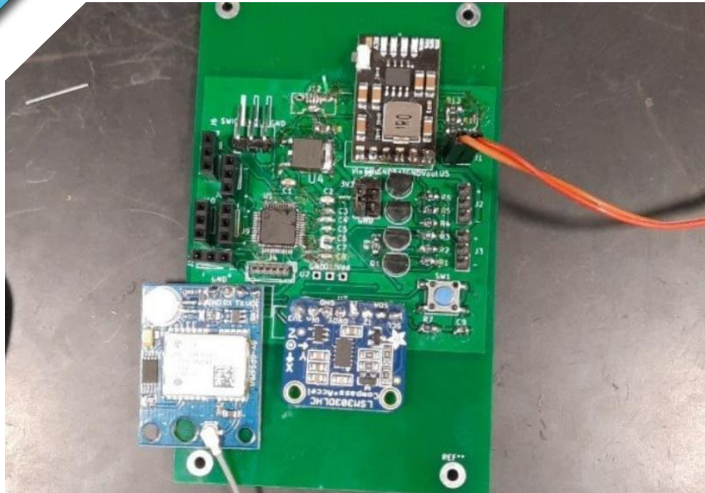
# RUDDER CONTROL



# SAIL CONTROL



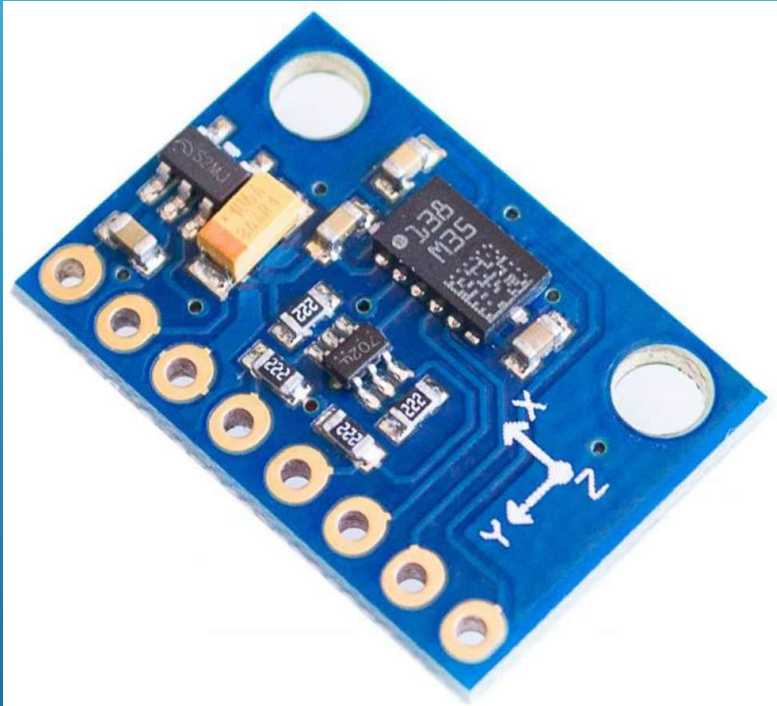
# SAIL CONTROL



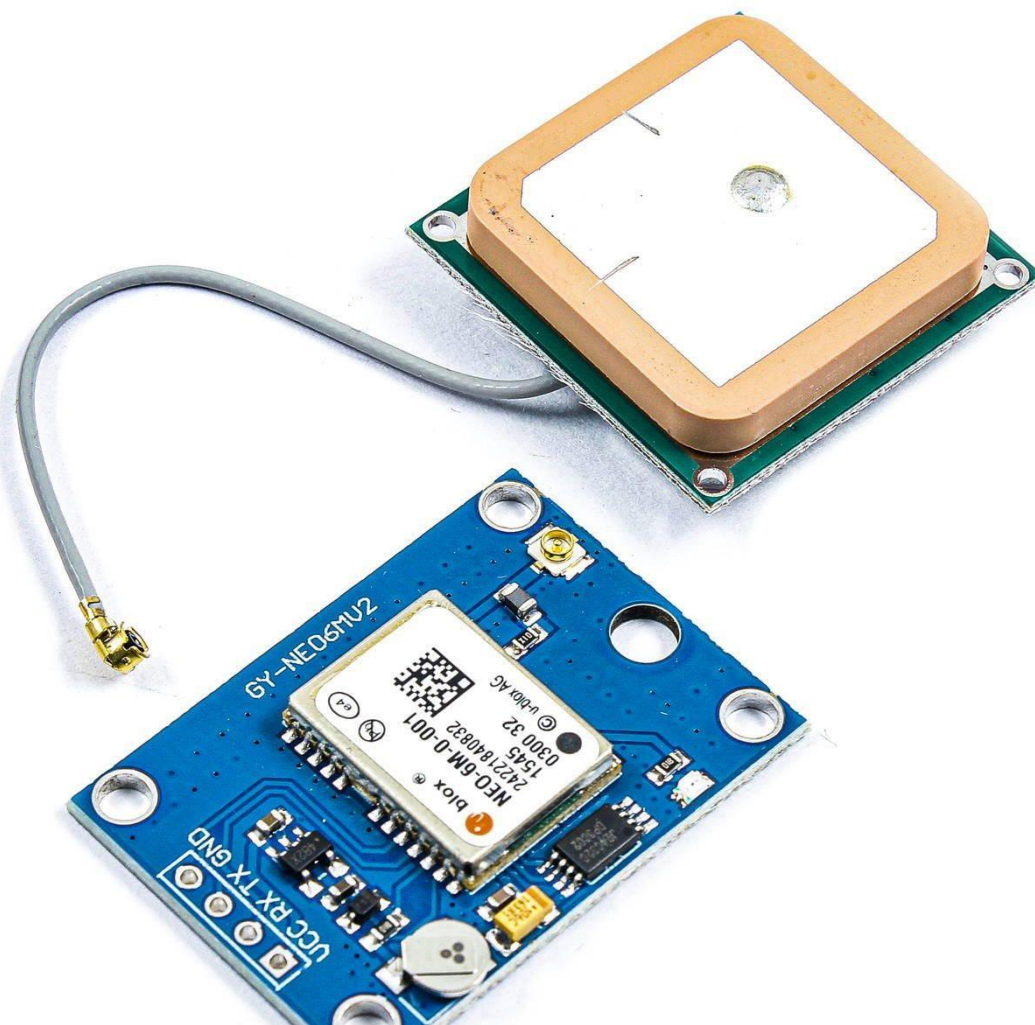
# E-COMPASS



# ECOMPASS - LSM303



- Hard Iron Calibration
  - $\text{Offset} = (\text{AccelMin} + \text{AccelMax}) / 2$
- Heeling Angle ~ Roll
  - $\text{Roll} = \text{atan2}(\text{AccelY}, \text{AccelZ})$

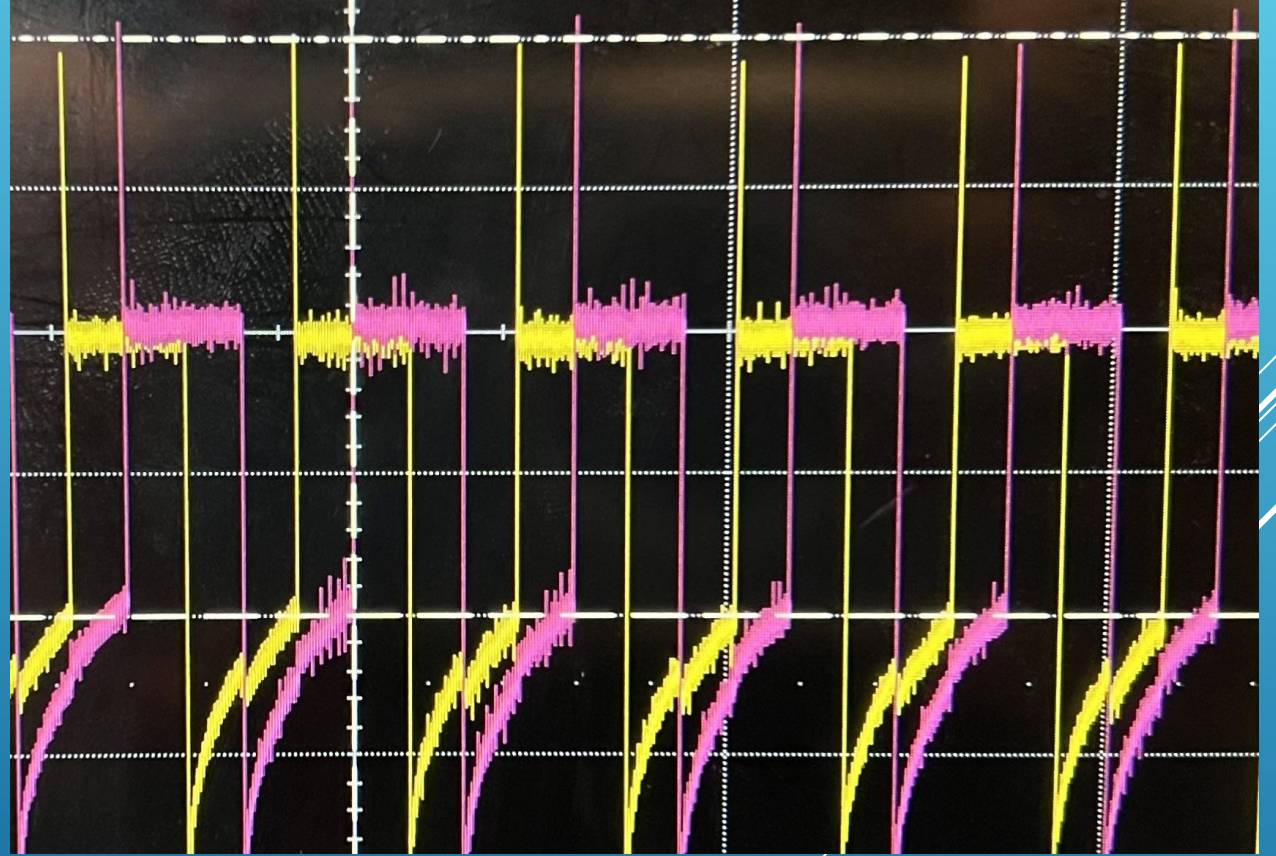


GPS –  
TINYGPS+

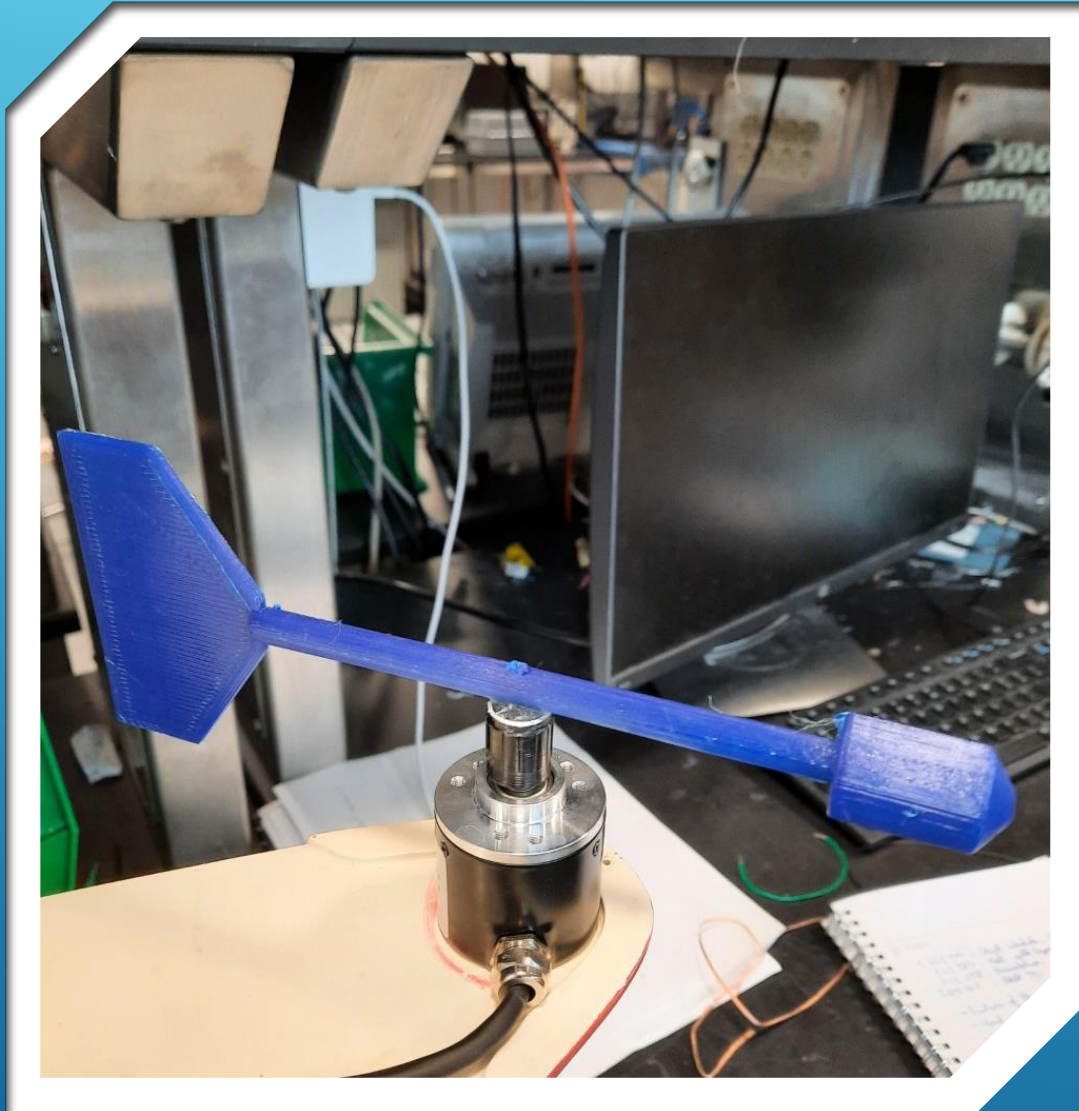


ENCODER

# ENCODER







# WIND VANE



# PROJECT SUCCESS

## ON-BOARD PROCESSING SYSTEM

- Rudder Control
- Sail Control

## GROUND CONTROL SYSTEM

- Telemetry sends data back to base

# CONCLUSIONS AND REDESIGN

- ▶ Differential Control
- ▶ PID Tuning (Ziegler-Nichols Method)
- ▶ Return to Base