

EML4552: SENIOR DESIGN II
OPERATION MANUAL

Project Overview:

This project focused on creating a working boat system for the RoboBoat competition sponsored by Robonation, and held at Reed Park, in Daytona FL, annually. During this international competition, teams must develop an autonomous boat to tackle several assigned tasks. Figure 1 below shows the outline of a typical course.

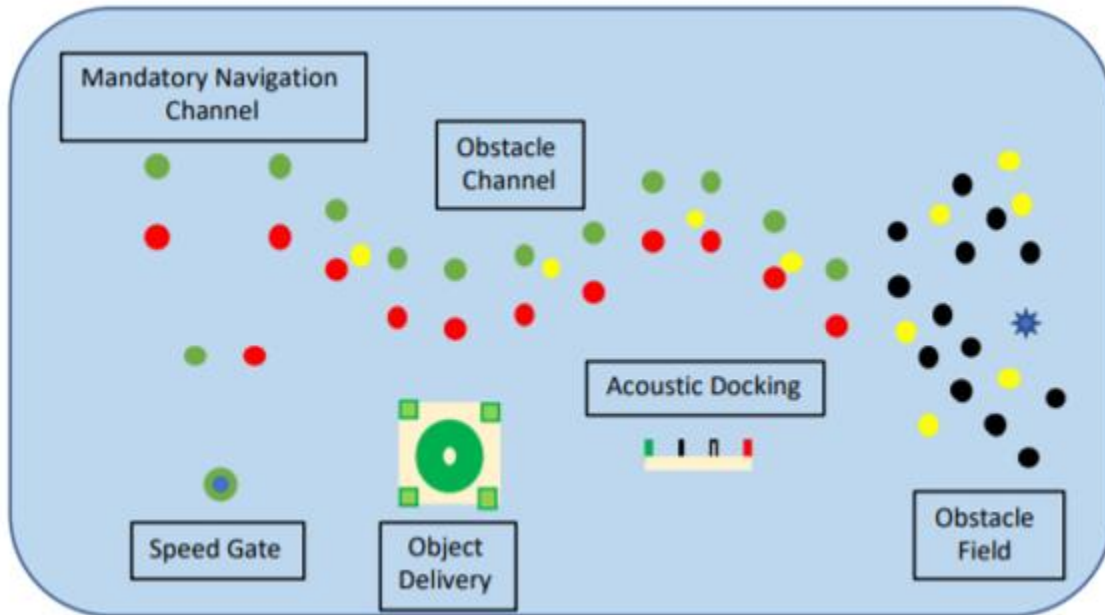


Figure 1 - A diagram depicting the tasks and challenges that the boat needs to complete.

In 2019, a team of FSU students attended the competition. Although they received high marks in the static portion of the competition, the boat failed in the performance portion of the competition. This project focuses on designing and creating a new boat in order to perform better in the competition next year.

1) Component Module Description

a) Boat Hull

- i) The hull is constructed of a fiberglass/resin composite and if used in fresh water should remain pristine, but if used in saltwater will require a fresh water rinse after usage.
- ii) While normal usage is common, the hull should not be subjected to harsh treatment such as sliding along rough terrain.
- iii) It might be necessary in the future to add bulkheads in the interior to increase the stability of the vessel

iv) Weight Limits

- (1) So far, the hull has been tested carrying 24 pounds. Image 1 shows the weight distribution with 6 pounds in each pontoon and 12 pounds in the central section of the hull. Please note each dive weight weighs 3 pounds each. With this weight distribution the waterline was consistently at 3 inches all the way around the hull.

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Image 1- 24 lb weight evenly distributed

- v) **Deflection limits etc**
 - 24 pounds was placed at the stern and no deflection was recorded, it has not been tested for heavier weights and it is unknown what the fracture load would be.
- b) **Mounts**
 - i) 8020 Rail Mounts
 - ii) Mount Base (STL)
 - iii) Lidar Mount (STL)
 - iv) Visual Feedback Mount (STL)
- c) **Electrical**
 - i) **Wiring/Power**
 - (1) Power Box
 - (2) Blue Robotics T200 thrusters (X2)
 - (3) Blue Robotics Basic ESCs (x2)
 - (4) Turnigy High Capacity 10000mAh 4S LiPo Batteries (x4)
 - (5) KNACRO DC 12V to 19V Power Converters (x2)
 - (6) 12 Gauge Wire
 - (7) 20 Gauge Wire
 - (8) Barrel Connectors
 - (9) Screw Terminals (DZS Elec 30 pcs Screw Connectors)
 - (10) XT60 Connectors
 - ii) **Sensors Used**
 - (1) Ouster OS1 LiDAR
 - (2) VectorNav rugged 300
 - (3) Simply Nuc (x2)
 - (4) Arduino Mega 2560
 - (5) Netgear N900 Router
 - (6) FrSKY Taranis 9xd plus
 - (7) FrSKY x8 Receiver

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- (8) LED Light Stack
- (9) Emergency Stop E-Kill Switch

2) **Hardware/Software Integration**

a) **Wiring**

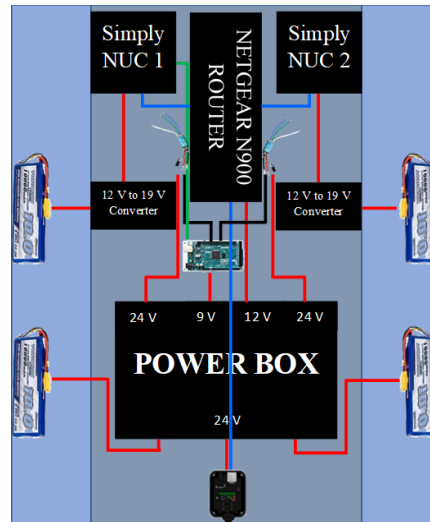


Figure 2 - An illustration of the power box setup and component layout on the test boat. The red lines show power connections, the blue lines show Ethernet connections, the green lines show USB connections, and the black lines show data-out connections.

The four (or five) batteries used to power the whole system are placed inside the pontoons of the boat when testing, while most components will sit inside the plastic bin portion in the middle of the boat (exception is the LiDAR). Looking at the boat from the back (LiDAR is in the front and thrusters are in the back), three sets (a set consisting of one red and one black wire) of wires go from the left side of the bin into the left pontoon. Each set connects to a battery in the left pontoon, but two connect to an input for the power box and one connects to a 12V to 19V converter in the bin. Still looking at the boat from the back, two sets of wires go from the right side of the bin into the right pontoon. Each set connects to a battery in the right pontoon, but one set is meant to connect to an input for the power box and the other connects to a 12V to 19V converter in the bin.

XT60 connectors were soldered, and covered in heat shrink tubing, to the three sets of wires serving as the power inputs from the batteries to the power box. Wire ends from the two 24V outputs on the front of the box (labelled as T2 and T2) were soldered to XT60 connectors and covered in heat shrink tubing. Two more XT60 connectors each had a set of wires soldered to it and covered in heat shrink tubing. These connectors were plugged into the XT60 connectors from the two 24V outputs mentioned previously. The other ends of these wires will go into screw terminals to provide power for the two Basic ESCs. The wires coming from the last 24V output on the power box were tinned and screwed into a barrel connector. This connection is meant for the LiDAR data box. The wires for the 9V and 12V outputs on the box were also tinned and each screwed into their own barrel connector. The 9V connection is for the Arduino Mega and the 12V connection is for the router; these are labelled as such on the box itself.

Screw terminals were used to connect the ESCs to wires connected to the two XT60 connectors. The red and black wires of the ESCs went into one side of the terminals while the red and black from the XT60 connectors went into the opposite of the terminal (matching red to red and black to black).

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Once again screw terminals were used to connect the white, green and blue wires of the ESCs to the white, green and blue wires of the thrusters. Again, the wires of the ESCs went into one side of the terminals while the wires of the thrusters went into the other side (matching the colors to each other). Input wires on two 12V to 19V converters were soldered to extra wire to extend the length. This connection was covered with heat shrink tubing. The input and output wire ends of both converters were then tinned and screwed into barrel connectors. The input connection for each converter will be connected to a battery and the output for each will be for a Simply NUC computer.

3) **Operation**

a) **Wiring**

i) **Voltage Check (carry this out before components are connected)**

- (1) Ensure that no components are plugged in and that the kill switch is in the “OFF” position (OFF means no power to ESCs and thrusters) by pushing in the switch button.
- (2) Place two 4S LiPo batteries into each pontoon (four batteries total).
- (3) Connect the XT60 connectors from the four batteries into two power box inputs and the two computer inputs (the two sets of wires that lead from the pontoon to the 12V to 19V converters in the bin). Note that each pontoon has one computer connection, while the left pontoon (when facing the back of the boat) has two power box connections and the right pontoon only has one power box connection. A fifth battery is optional to plug into the third power box input.
- (4) Put the kill switch in the “ON” position (ON means power to ESCs and thrusters) by turning the switch button clockwise. Using a multimeter, measure the voltage output from each output on the power box and from the output of both 12V to 19V converters. Listed below are the voltages each output should read; in parentheses is the voltage range rated for each specific device.
 - (a) Output to the LiDAR data box from the power box: 24V (22-26V)
 - (b) Output to the Arduino Mega from the power box: 9V (7-12V)
 - (c) Output to the NETGEAR router from the power box: 12V (12-19V)
 - (d) Output to the Basic ESCs(x2) from the power box: 24V (7-26V)
 - (e) Output to the Simply Nuc(x2) from the 12V to 19V converter: 19V
- (5) Once it is verified that all voltage outputs are correct, put the kill switch in the “OFF” position by pushing in the switch button.

ii) **Voltage/Current Check - Sensors Connected (perform this after the above steps)**

- (1) Plug each device into their appropriate connection.
- (2) Plug the power cord from the LiDAR data box into the barrel connector of the 24V output from the power box. A green light will emit from the LiDAR data box.
 - (a) Plug the barrel connector from the 9V output of the power box (labelled Arduino) into the Arduino Mega board. A green light will emit from the board.
 - (b) Plug a USB cable into the Arduino board and the Simply NUC on the right (when facing the back of the boat).
 - (c) Plug the power cord from the NETGEAR router into the barrel connector of the 12V output from the power box (labelled networking). Press the power button on the router; green and blue lights will emit from the side of the router.
 - (d) Plug both ESCs into the XT60 connectors of the two 24V outputs (both labelled as T2 on the box).
 - (e) Plug the GPIO wires from the ESCs into the Arduino.

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- (f) Plug the power cord from the two Simply NUC computers into the barrel connectors of the 12V to 19V converters. Press the power button on the front of both computers and a white light will emit from the power button.
 - (g) Plug an Ethernet cord from the router into each computer and the LiDAR.
 - (h) Put the kill switch in the “ON” position by turning the switch button clockwise
 - (i) Using a multimeter, measure the voltage output and current draw from each output.
 - (j) Listed below are the voltages each output should be and currents each output should not exceed; in parentheses is the voltage range rated for each specific device.
 - (i) Output to the LiDAR data box from the power box: 24V (22-26V) and 0.6-0.8A
 - (ii) Output to the Arduino Mega from the power box: 9V (7-12V) and (max) 1A
 - (iii) Output to the NETGEAR router from the power box: 12V (12-19V) and (max) 2.5A
 - (iv) Output to the Basic ESCs(x2) from the power box: 24V (7-26V) and (max constant current) 30A
 - (v) Output to the Simply Nuc(x2) from the 12V to 19V converter: 19V and (max) 3A
 - (k) Once it is verified that all voltage and current outputs are correct, put the kill switch in the “OFF” position by pushing in the switch button, until ready to use the boat.
- (3) **Arduino Pin out**
- (a) **Rc receiver channels**
 - (i) Channel 1 = pin 3
 - (ii) Channel 2 = pin 4
 - (iii) Channel 5 = pin 5
 - (b) **ESCs (White = signal & Black = ground)**
 - (i) Left Esc = pin 9
 - (ii) Right Esc = pin 11
- iii) **Software**
- (1) **Calibration of sensors**
 - (a) **Lidar:**
 - (i) Ouster makes a windows calibration system.
 - (ii) Firmware can be updated using the administration page accessed through the webpage.
 - (2) **Vectornav**
 - (a) Vectornav VN-300 can be calibrated using the quickstart documentation provided by the manufacturer (Vectornav).
 - (b) Vectornav’s website has a windows program to calibrate.
 - (3) **Launch files etc**
 - (a) The Master nuc should launch master. Launch
 - (i) This is found in the launcher file under the ROS workspace
 - (b) The secondary nuc should launch os1.launch
 - (i) This is found in the launcher file under the boat workspace.
 - (4) **Remote Control Software**
 - (a) Turn on Remote control and clear any warnings from the system

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- (b) Ensure that the “killed” switch (channel 5) is flipped forward, or on
- (c) Place vehicle in correct mode (channel 6)
- (d) Away from operator = manual
- (e) Towards operator = autonomous mode

4) **Troubleshooting**

a) **Power Box**

i) **If the power box does not start (indicated by the sound of the DC fan turning on)**

- (1) Check that the batteries are outputting at least 14.8 V, and up to 16.8 V
- (2) Check that there is continuity on all of the connections going into the box
- (3) Check that all of the connections going in and out of the bus bar are secure

b) **OS1-LiDAR**

i) **If the OS1-LiDAR does not start (indicated by the green light on the data box)**

- (1) Check that the batteries are outputting at least 14.8 V, and up to 16.8 V
- (2) Check that there is continuity on all of the connections going into the box
- (3) Check that all of the connections going in and out of the bus bar are secure

ii) **If the OS1-LiDAR does not connect to the network**

- (1) Make sure the network cable is plugged in and the router is working correctly
- (2) Make sure the IP address listed in the launch files matches the IP address logged into the router
- (3) Double check the firmware of the lidar by accessing the homepage using the ip address of the lidar

c) **Arduino Mega**

i) **If the Arduino Mega does not start (indicated by the green light on the board)**

- (1) Disconnect the Arduino and check the output from the box for the Arduino is 9 V
- (2) Check that the wires are connected to the barrel connector securely; if 9 V is read on the wires but not on the securely connected barrel connector, the barrel connector may need to be replaced
- (3) Check that the appropriate wires go to the appropriate pins
- (4) Check that there is continuity on the hot and ground wires coming out of the power box; if this fails, the wires may need to be replaced
- (5) Check that the connection from the Arduino’s 9 V converter is securely connected to the bus bar inside the power box
- (6) Check the Arduino’s 9 V converter is not dead by supplying the input with a voltage within the range of 12 V to 24 V, and checking the output for 9 V; if this fails, the converter may need to be replaced

d) **N900 NETGEAR Router**

i) **If the N900 NETGEAR router does not start once the power button is pressed (indicated by the green and blue lights on the side of the router)**

- (1) Disconnect the router and check the output from the box for the Arduino is 12 V
- (2) Check that the wires are connected to the barrel connector securely; if 12 V is read on the wires but not on the securely connected barrel connector, the barrel connector may need to be replaced

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- (3) Check that there is continuity on the hot and ground wires coming out of the power box; if this fails, the wires may need to be replaced
 - (4) Check that the connection from the router's 12 V converter is securely connected to the bus bar inside the power box
 - (5) Check the router's 12 V converter is not dead by supplying the input with a voltage within the range of 15 V to 24 V, and checking the output for 12 V; if this fails, the converter may need to be replaced
- e) **ESCs/Thrusters**
- i) **If the ESCs/thrusters do not start once the power button is pressed (indicated by the green and blue lights on the side of the router)**
 - (1) Disconnect the ESCs and check the output from the box for the ESCs is 24 V
 - (2) Check that the wires are connected to the barrel connector securely; if 24 V is read on the wires but not on the securely connected barrel connector, the barrel connector may need to be replaced
 - (3) Check that there is continuity on the hot and ground wires coming out of the power box; if this fails, the wires may need to be replaced
 - (4) Check that the connection from the ESC's 24 V converter is securely connected to the bus bar inside the power box
 - (5) Check the ESC's 24 V converter is not dead by supplying the input with a voltage within the range of 10 V to 17 V, and checking the output for 24 V; if this fails, the converter may need to be replaced
 - ii) **If the thrusters do not turn on or are not controlling the boat properly**
 - (1) Make sure the Arduino is powered up correctly.(the powered light should be on)
 - (2) Make sure the RC Receiver LED green light is on.
 - (3) Make sure the RC software safety lock is not on.
 - (4) Make sure the hardware safety lock is not on.
 - (5) Make sure the escs are connected properly
 - (6) Check the pins on the Arduino against the code to make sure there is not a pin in the wrong place.
 - (7) The ESCs Blue/Green/White may need to be flipped (flip any two to work)
 - (a) Do not flip white and black wires.
 - (8) Check to make sure the thruster pins 9 and 11 are not flipped on the Arduino.
- f) **SNUCs**
- i) **If the SNUCs do not start once the power button is pressed (indicated by the light coming on on the button), applies for both SNUCs**
 - (1) Check that the batteries are supplying the correct voltages, in the range of 15.0 V to 16.7 V
 - (2) Disconnect the SNUC(s) from the circuit and test that the output voltages coming out of of the converter are 19 V;
 - (3) Check that the wires are connected to the barrel connector securely; if 19 V is read on the wires (without being attached to the barrel connected) but not on the securely connected barrel connector (when the wires are connected), the barrel connector may need to be replaced
 - (4) Check the voltages at each connection starting at the battery all the way to the SNUC; it is possible a barrel connector is bad or a connection is loose

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- (5) Check the SNUC's 12 V to 19 V converter is not dead by supplying the input with a voltage within the range of 10 V to 17 V, and checking the output for 19 V; if this fails, the converter may need to be replaced
 - (6) Check that there is continuity on the hot and ground wires coming out of the converter and into the power cord; if this fails, the converter could be bad or the SNUC power cord may need to be replaced
- ii) **If the SNUCs are not connected to the network**
- (1) Check to make sure the network is on.
 - (2) Make sure that the laptop bagging data is on the proper network.
 - (3) Make sure the ip address of the nuc is correct according to the router
 - (4) Make sure the wireless network is not masking the lan network (using a monitor and keyboard).
 - (5) Make sure the connected network is enabled (using a monitor and keyboard).
- g) **VN-300 VectorNav**
- i) **If the vectornav is not working correctly**
 - (1) Make sure the system is calibrated correctly.
 - (2) Make sure the system is physically placed in the correct orientation.
 - (3) Make sure the gps modules are at least 1 meter apart.
 - (a) The error on the vectornav is the inverse of the distance the nodals are from each other.