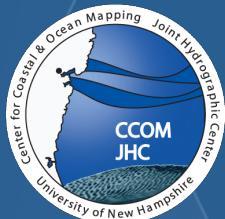


A Flexible, Low-Cost MOOS-IvP Based Platform for Marine Autonomy Research

Damian Manda

Andrew D'Amore, May-Win Thein, Andy Armstrong
University of New Hampshire Ocean Engineering
NOAA/UNH Joint Hydrographic Center



University of
New Hampshire



Design Goals

- Minimize Total System Cost
- Interface Flexibility
 - Existing vessels
 - Data collection systems
- Accessible software
 - Customizable path planning
 - Coordinated multi-vessel operations
- Robust Operation



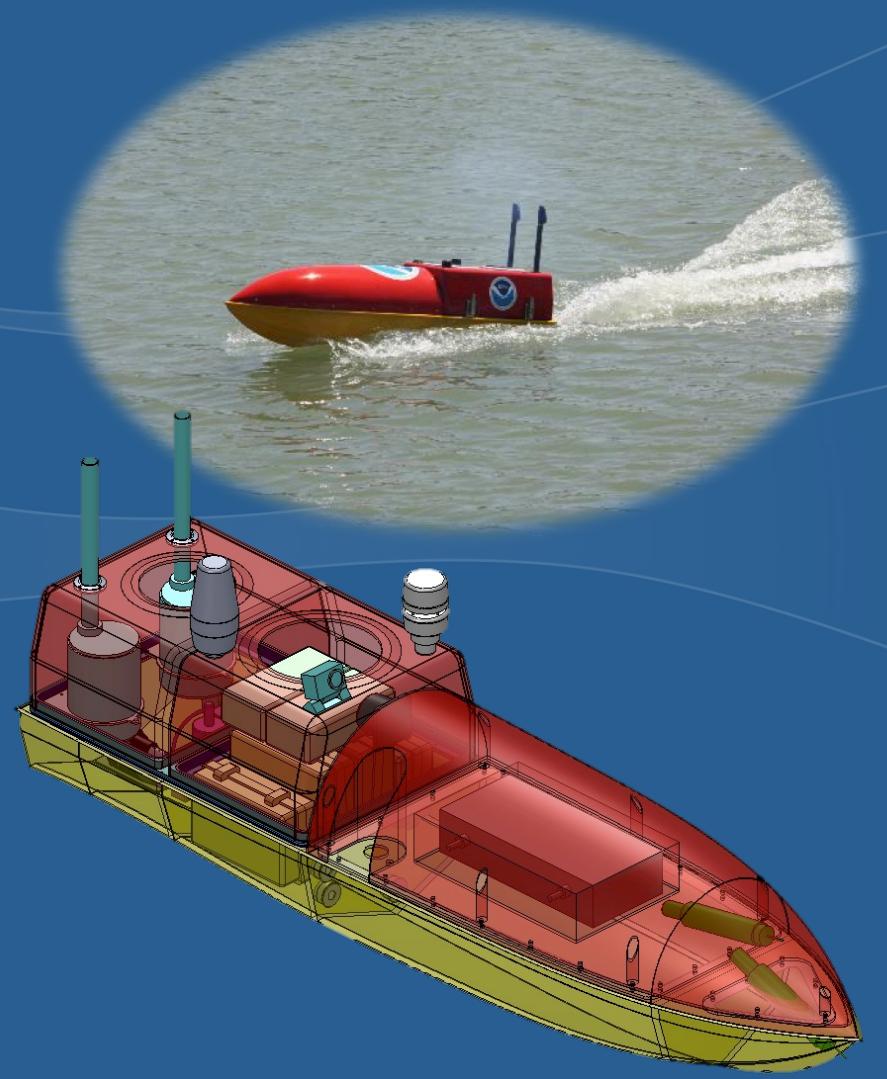
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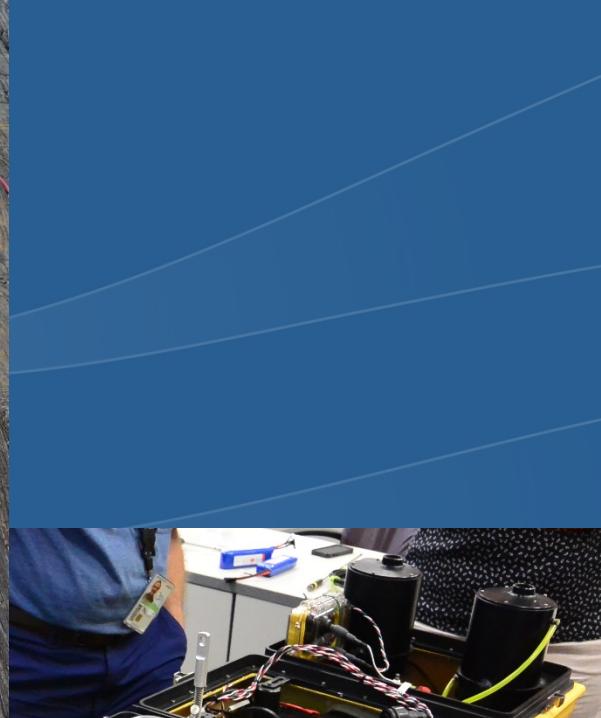


PLATFORMS

NOAA EMILY

- 65" Long
- 77 lbs No-Fuel Weight
- Max Speed 15 kts
- Endurance 2-5 days
- 4 Independently Sealed Compartments
- Local RF & Satellite Communications



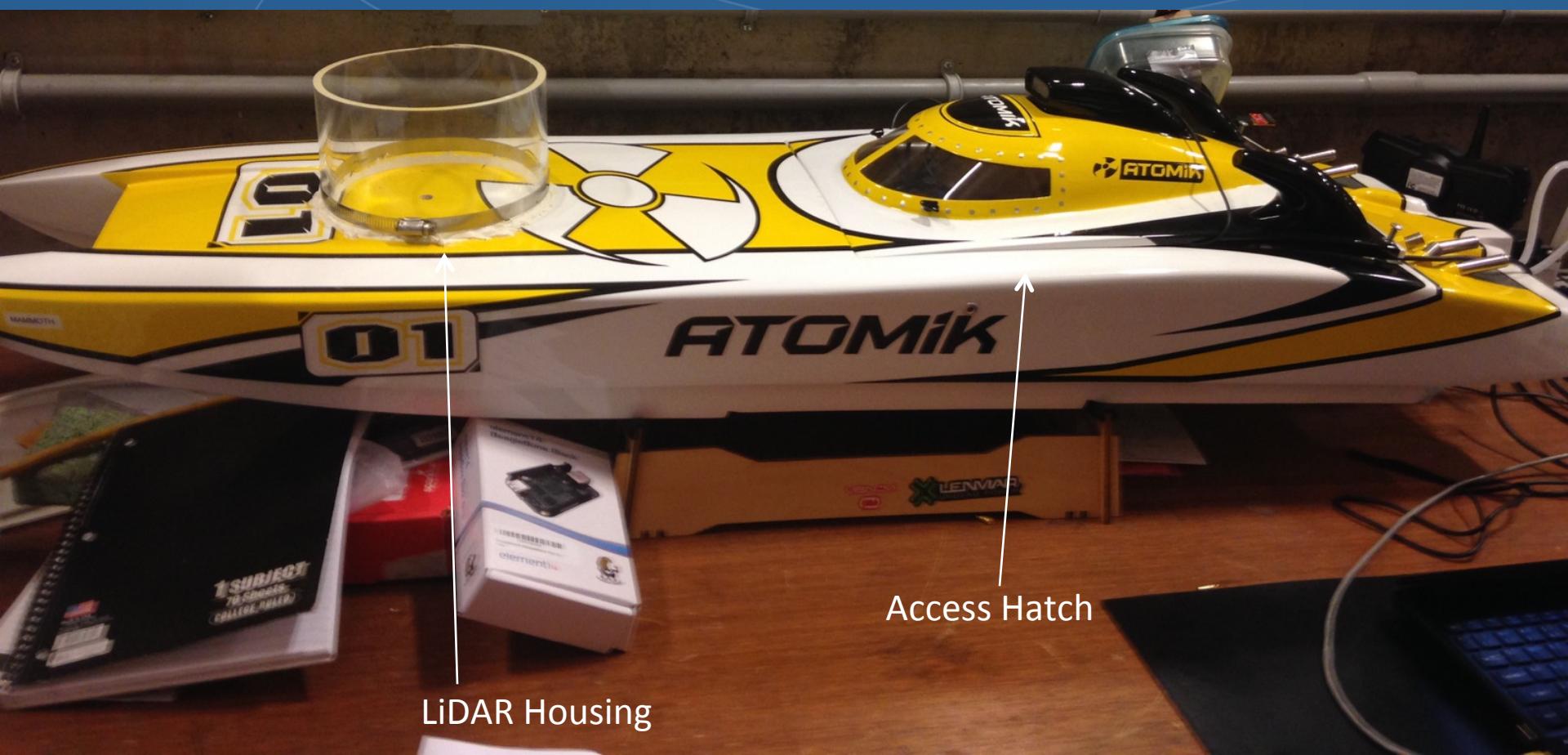


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UNH Undergraduate ASV 2

- Length: 4'
- Drive: Electric motor driven propeller
- Steering: Rudder Control
- Power Supply: Two 11.1V Venom RC Batteries, One 25.9 Wh Phone Charger Power Pack



Design Choices

- Purchased pre-built platform for reduced cost and time consumption
- Platform model was chosen for its size and simple design
- Single DC motor / single rudder for simpler modeling
- Lidar chosen for its short range accuracy and cost efficiency



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HARDWARE COMPONENTS

Hardware Design Philosophy

Simplicity

Low Cost

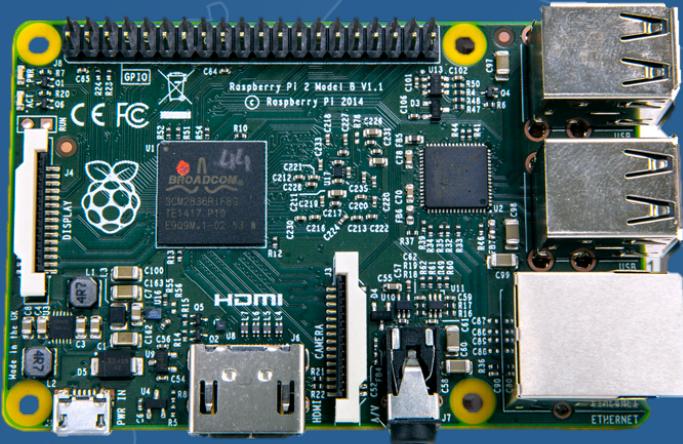
- Simplify wiring and number of interfaces
- Common operating voltages
- Minimize number of battery packs and necessary capacity



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Autonomy & Control



Raspberry Pi 2 Model B

900 MHz Quad Core ARM
1GB RAM
GPIO Headers
4 USB Ports
3.3 V Native



Arduino Mega2560

15 PWM
Analog, Digital In
Dedicated Interrupts
4 UART
5 V Native

Communication & Human Control



Futaba Hobby RC
6 Channels



Stock RC Control
3 Channels



Long Distance Wi-Fi
USB Powered
1 W



Ubiquiti Bullet Wi-Fi
POE
600 mW

Positioning



CHRobotics GP9

GPS

3 Axis Accelerometer

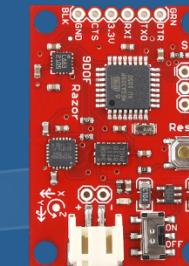
3 Axis Gyroscopes

3 Axis Magnetometer

Barometer

Temperature Calibrated

Orientation Kalman Filter



Adafruit Ultimate GPS

66 Channel GPS, 10 Hz Updates

Razor IMU

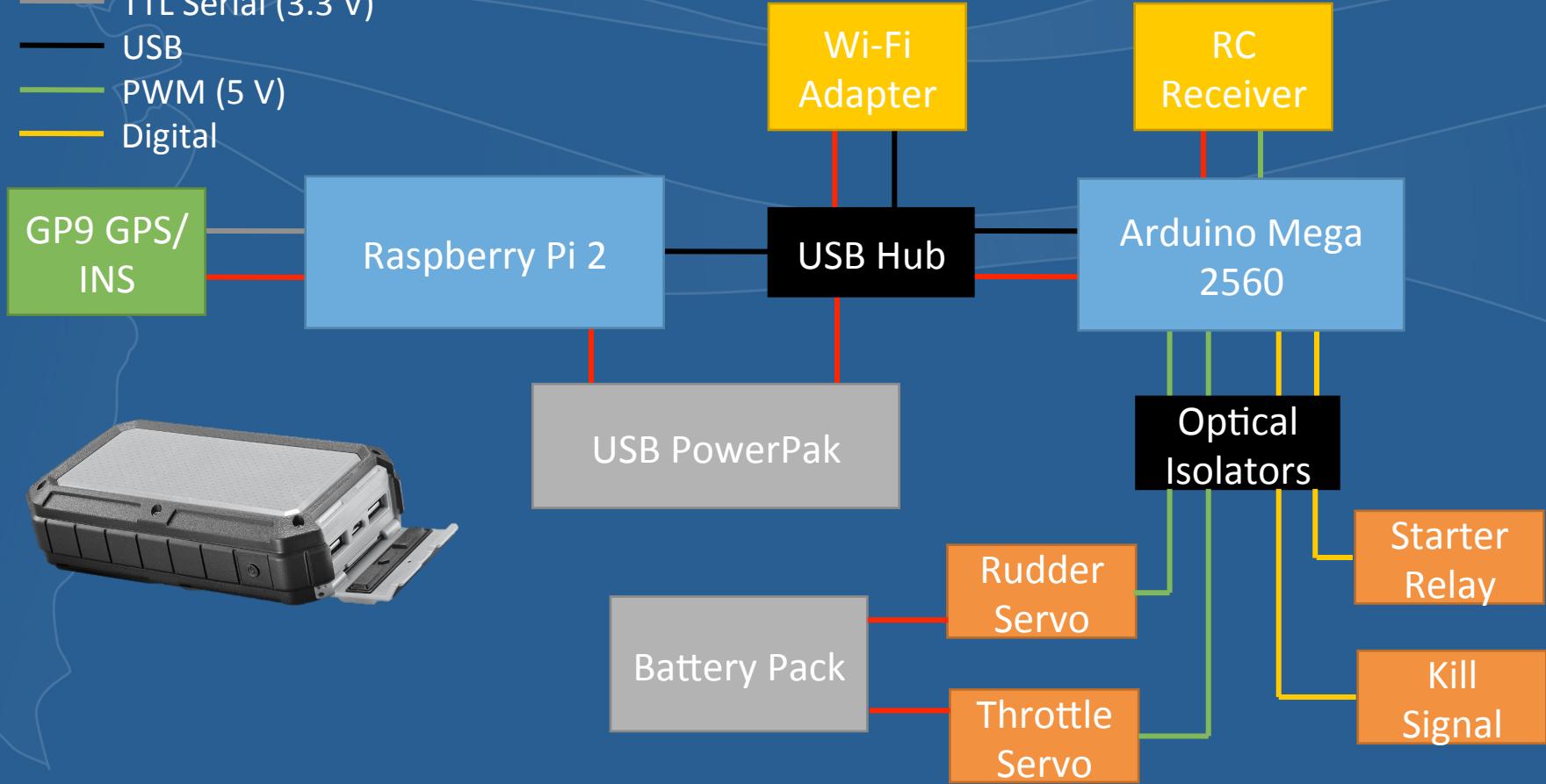
3 Axis Accelerometer

3 Axis Gyroscopes

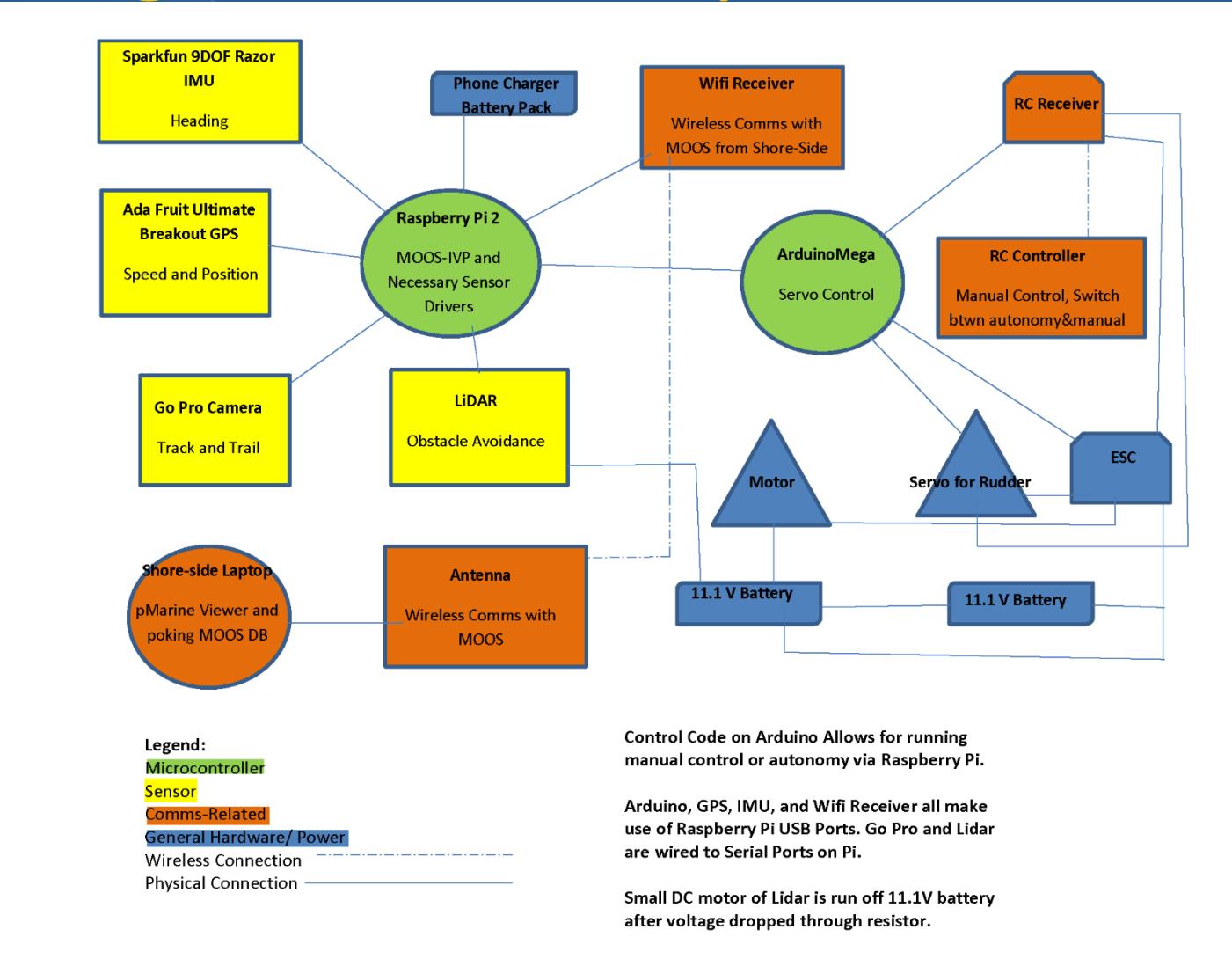
3 Axis Magnetometer

EMILY System Overview

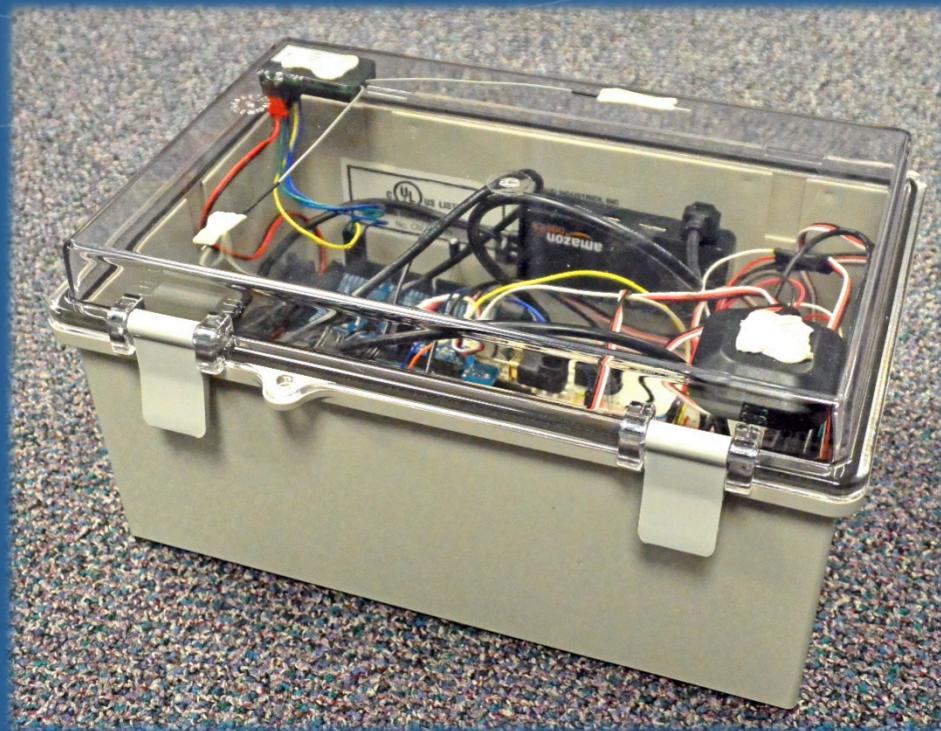
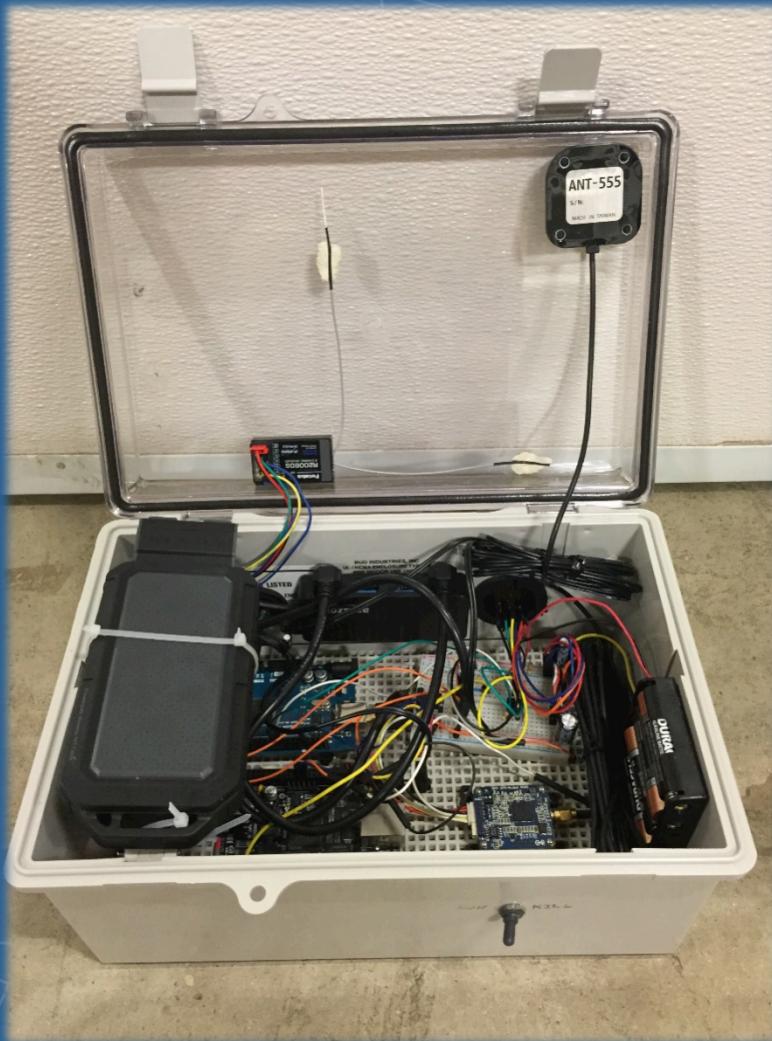
- Power
- TTL Serial (3.3 V)
- USB
- PWM (5 V)
- Digital



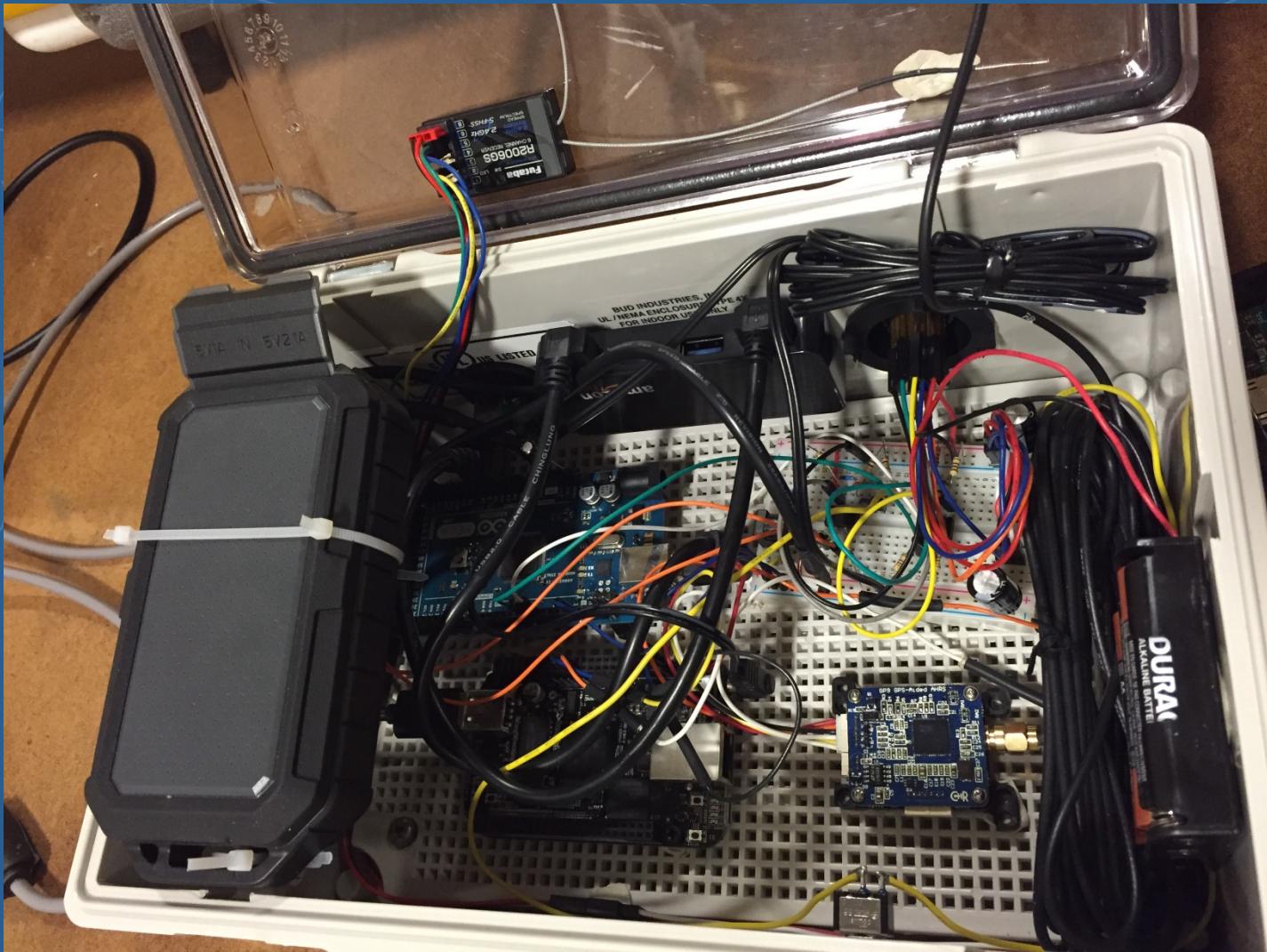
Undergraduate ASV System



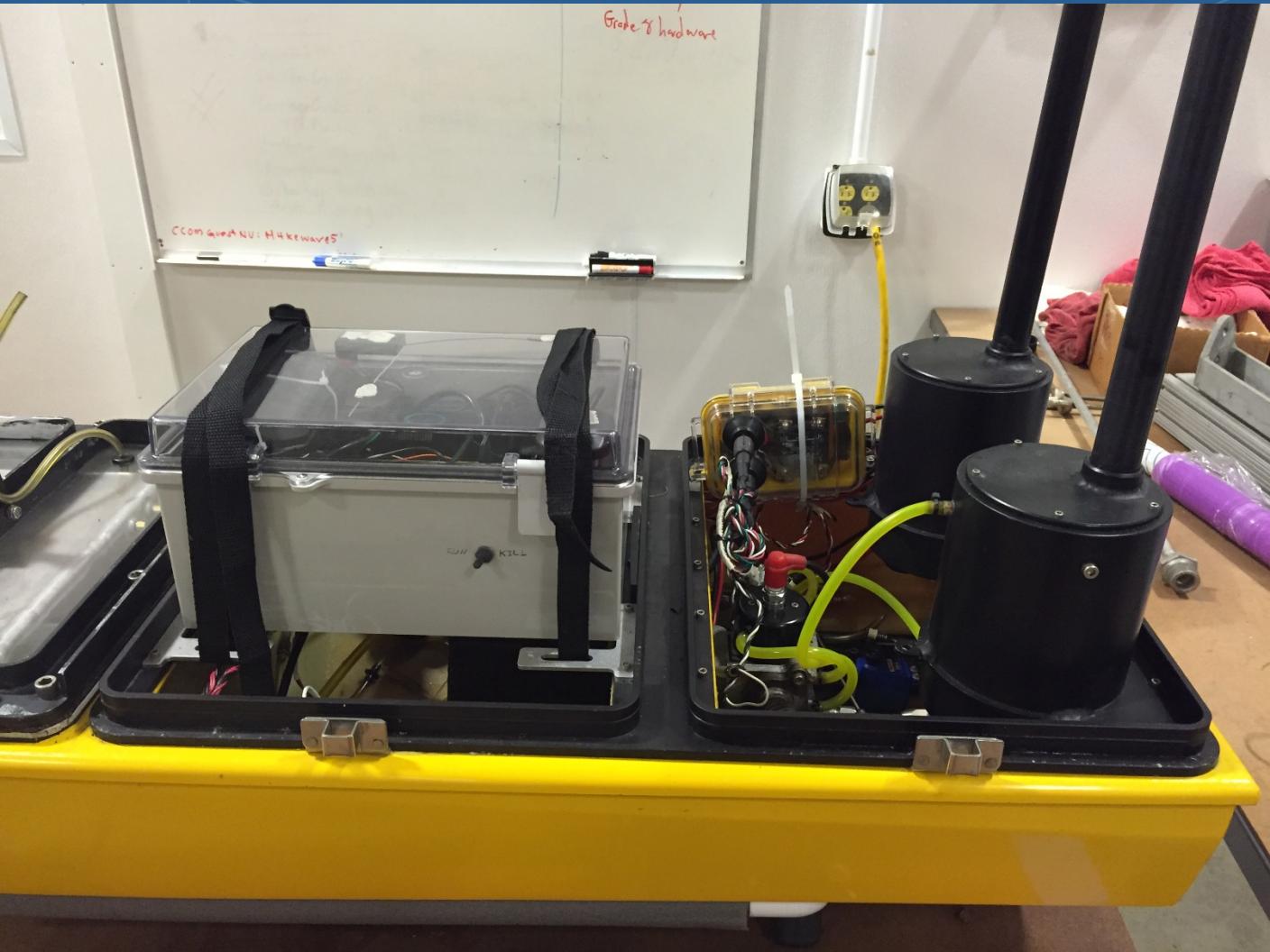
Assembled Autonomy Hardware



Electronics Detail



Control Module Installed



Space for Raspberry Pi
within Tupperware
Shielding

Arduino Within
Tupperware Shielding

RC Receiver

Electric Motor
and ESC

Rudder Servo

Power Consumption

Component	Maximum [mA]	Normal Operation [mA]
BeagleBone Black	803	542
Arduino	153	144
GP9	135	97
RC Reciever	30	21
Servo (2 Total)	600	5
Tube-U(n)	183	179
USB Hub	44	44
Total	2548	1037

11 hours run time under normal operation

EMILY Autonomy System Cost

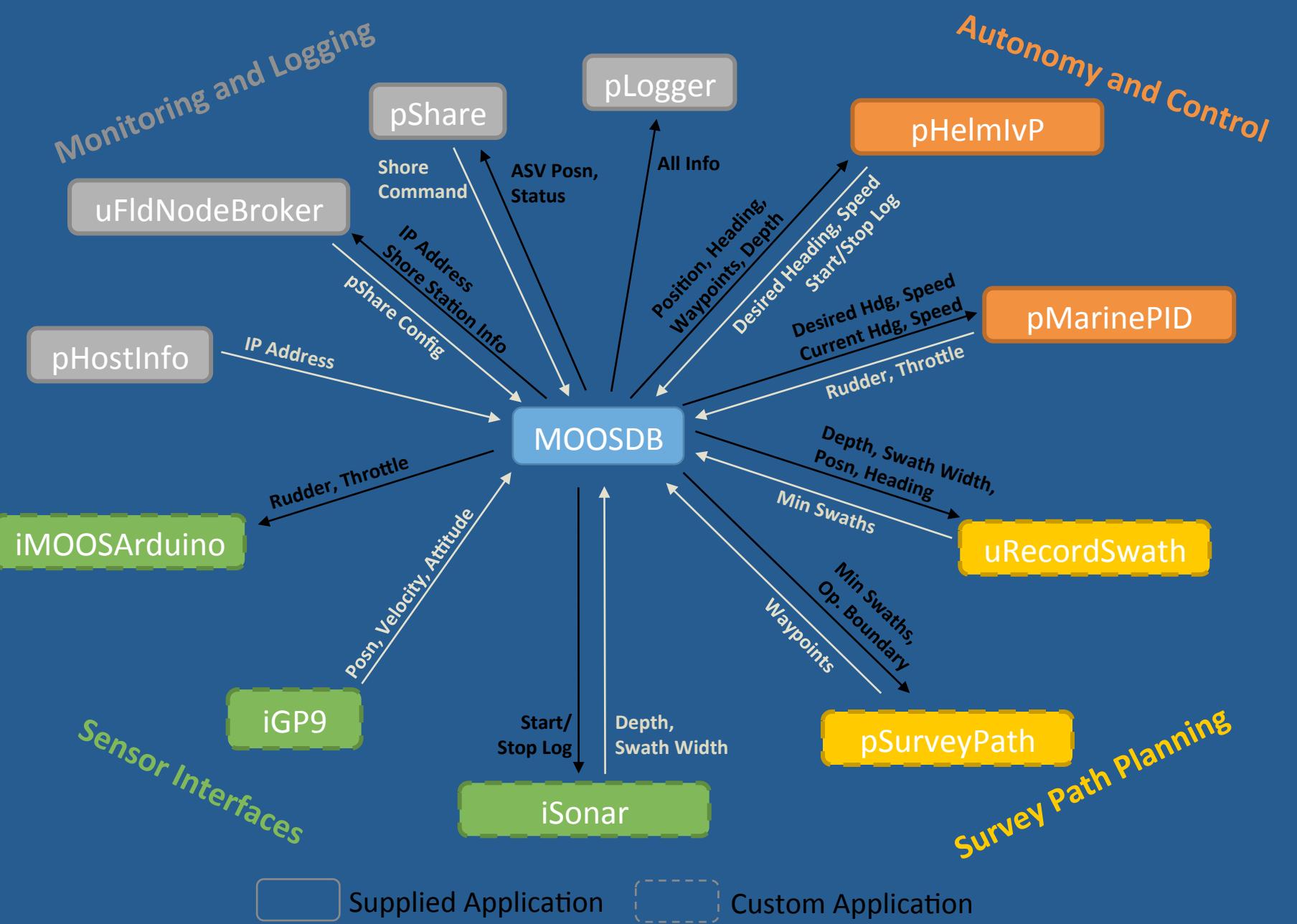
	Device	Cost
ASV System		
Autonomy Computer	Raspberry Pi 2	\$35
Microcontroller	Arduino Mega 2560	\$46
GPS/INS	CHRobotics GP9	\$399
Hobby RC System	Futaba 6J	\$180
Long Distance Wi-Fi + Antenna	Alfa Tube-U(N)	\$50
USB Hub	AmazonBasics 4 Port Powered	\$19
System Power	NewTrent PowerPak Xtreme	\$24
Enclosure and Cabling	Various	\$155
	<i>Subtotal</i>	\$908
Shore Monitoring System		
Long Distance Wi-Fi + Antenna	Alfa Tube-U(N)	\$55
Antenna Stand	Impact 9.6' Studio Light Stand	\$36
	<i>Total</i>	\$999

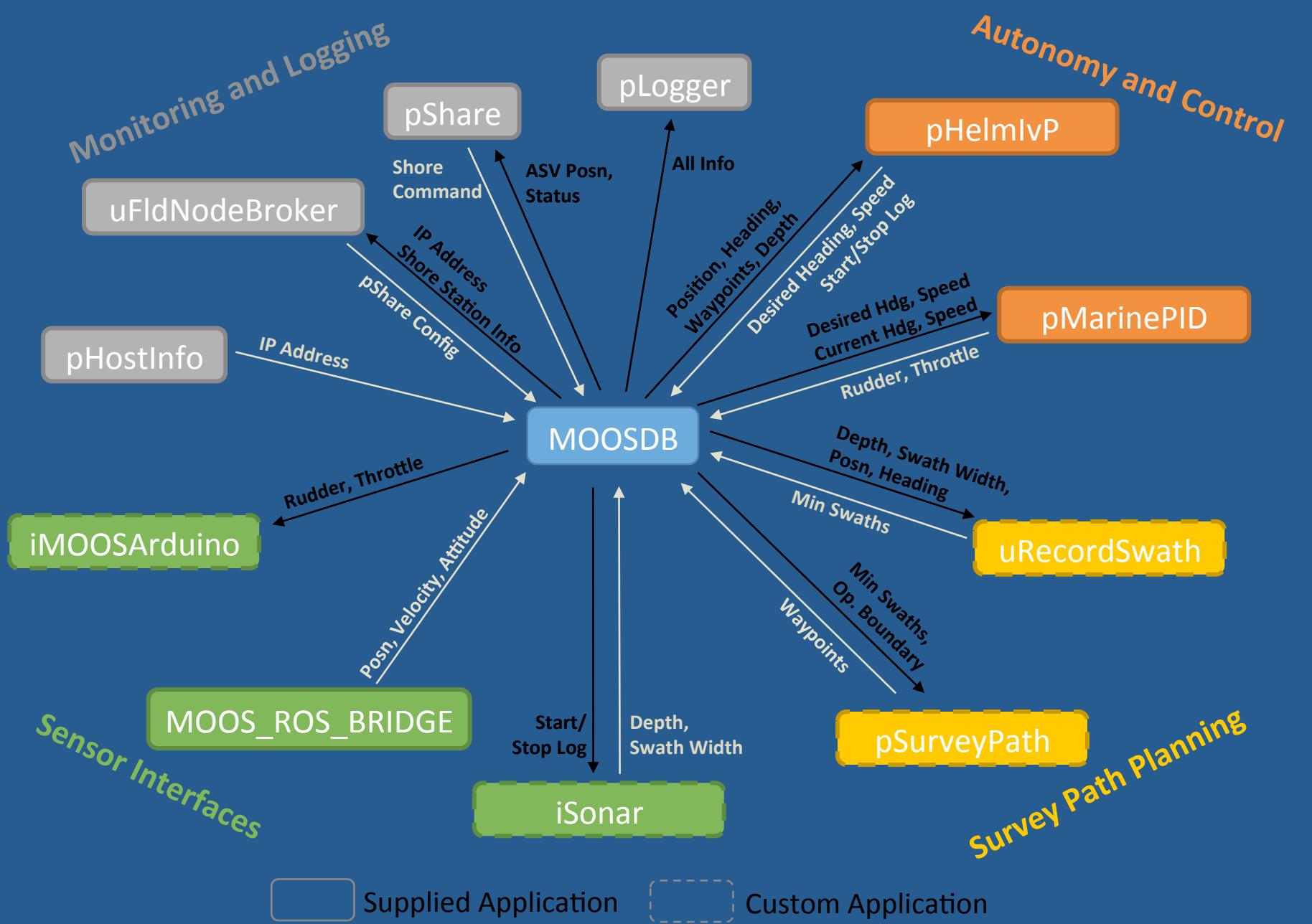
Undergrad Full Platform Cost

- Sensors: \$400
- Microcontrollers: \$80
- Physical Platform: \$1000
- Miscellaneous Wires & Connectors: \$250
- Wifi Communication: \$200
- Approximate total for fully functional ASV:
\$1900

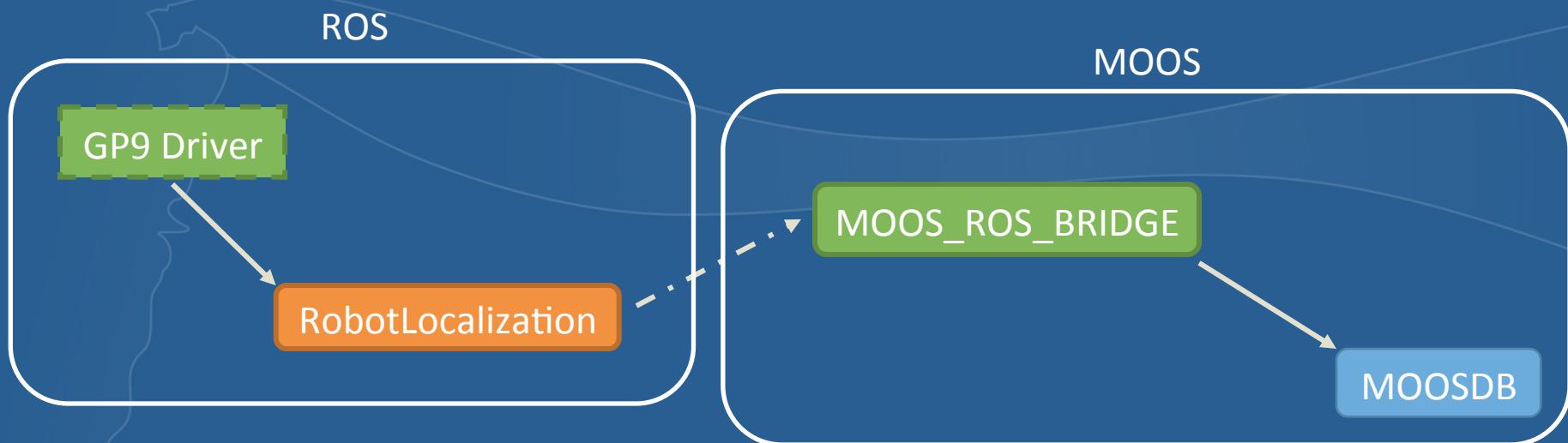
SOFTWARE





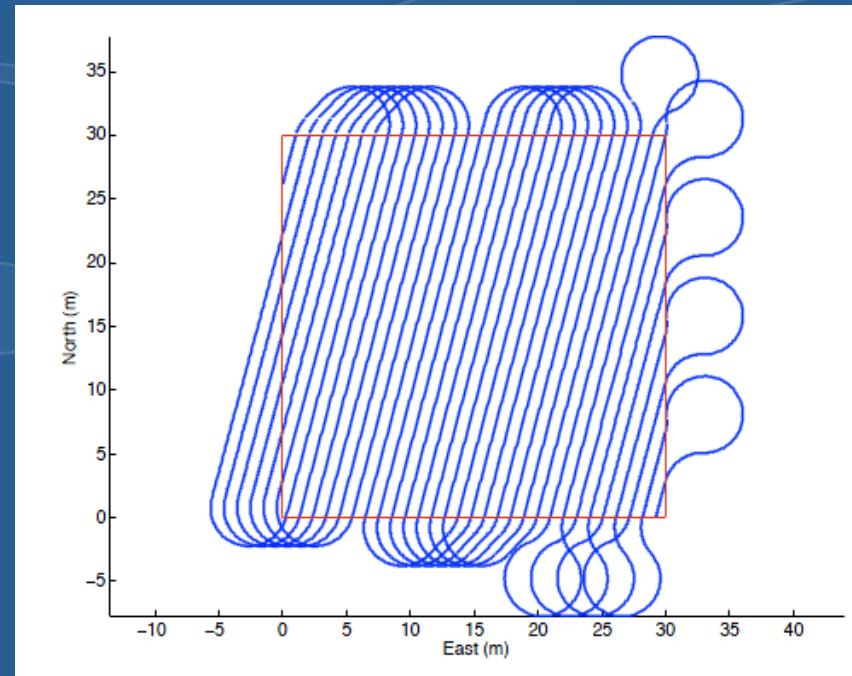


ROS Integration for Sensors



Hydrographic Survey Mission

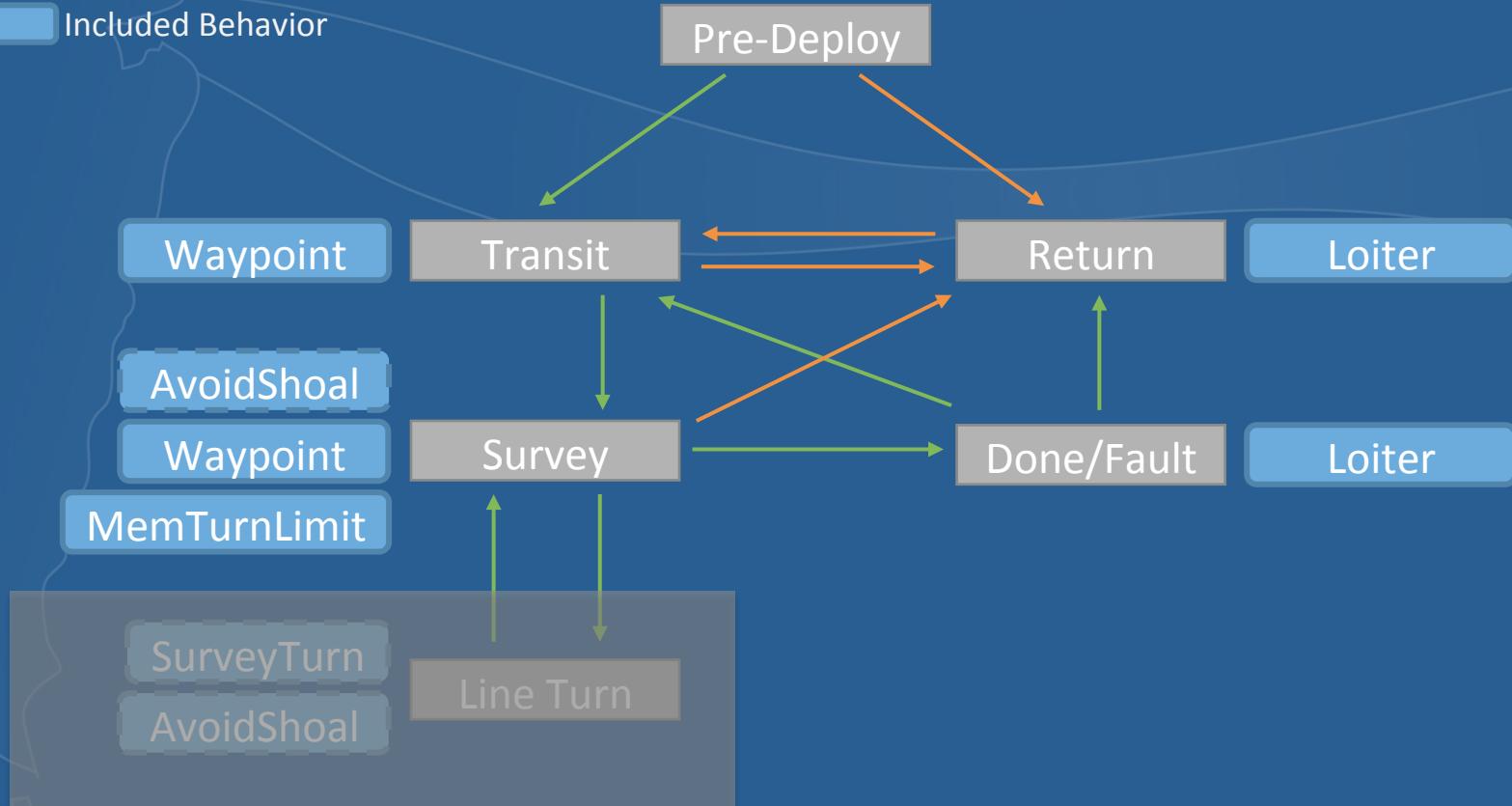
- Survey a designated polygon area
- Manage detected shallow areas
- Optimize survey pattern for depths
- Completion actions



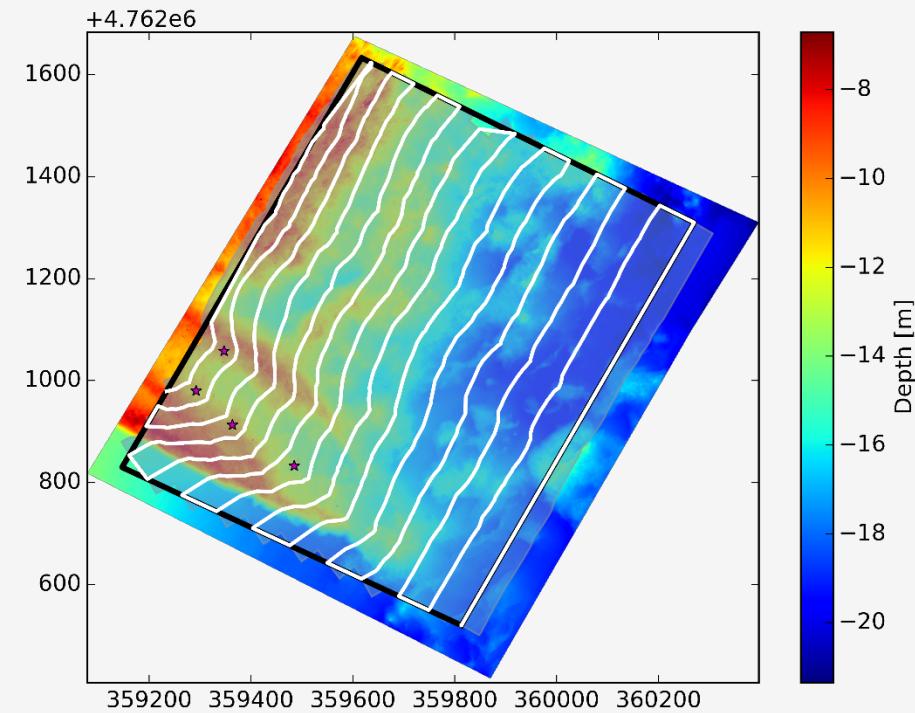
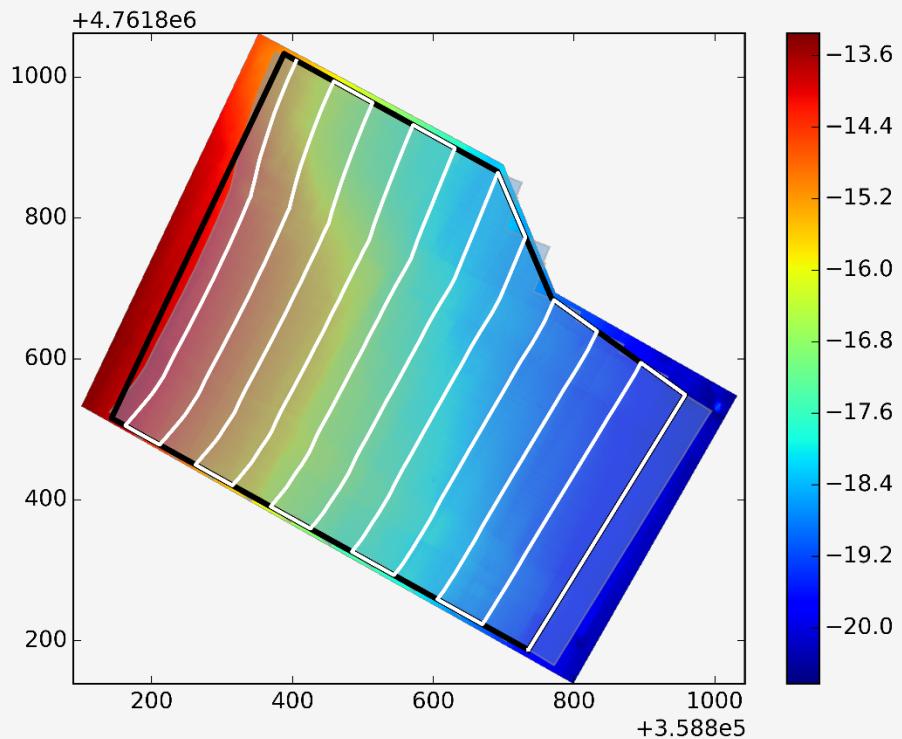
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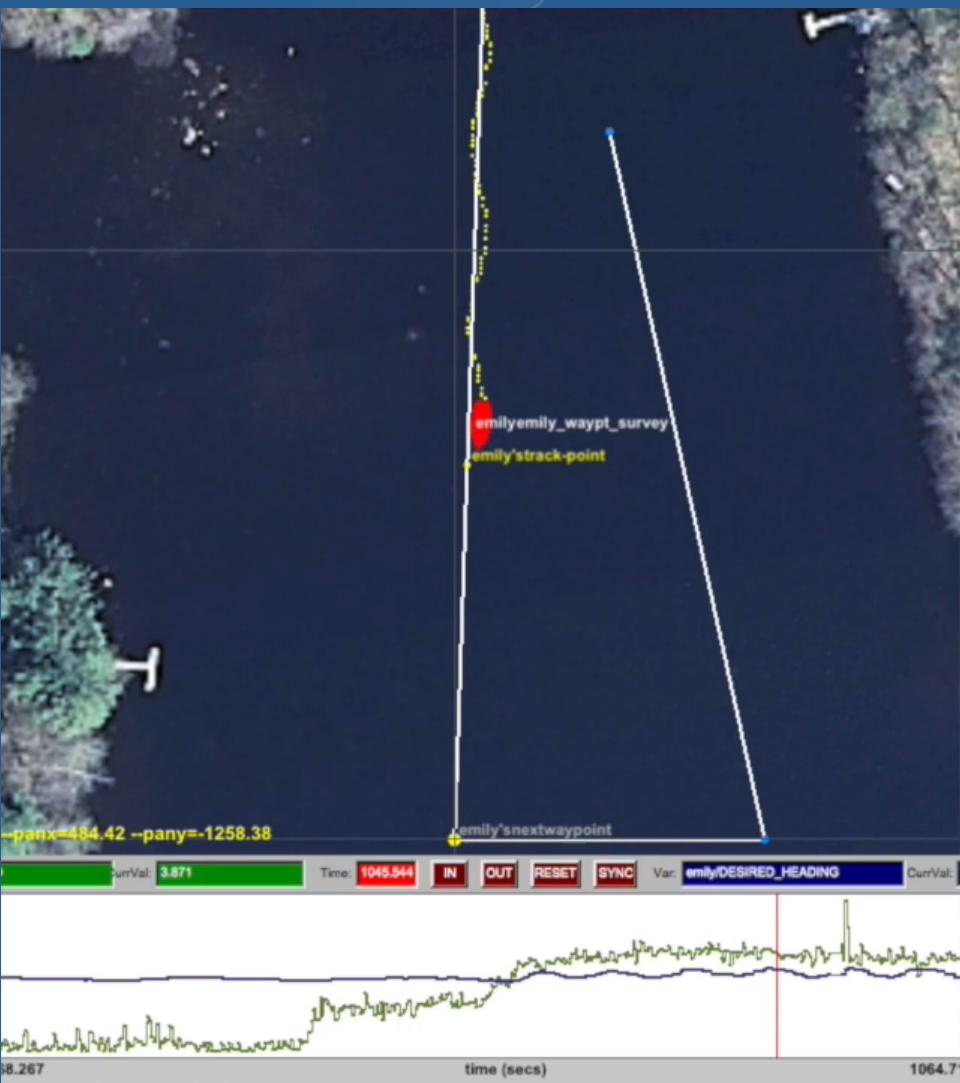


Autonomy Behaviors



Example Hydrography Path Planning





► YouTube: UNH ASV Test



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TOOLS

MOOS Config GUI

The image shows the MOOS Config GUI interface. On the left, a modal window titled "Available MOOS Apps" lists several application names: pMarinePID, pLogger, uSimMarine, pHelmIVP, iGP9, and iMOOSArduino. At the bottom of this window are "Cancel" and "OK" buttons. On the right, the main "MOOS Mission Configuration" window displays a configuration file with syntax highlighting for MOOS variables and values. Below the code editor, there is a configuration panel for the "iGP9" process, which includes fields for AppTick, CommsTick, SerialPort, and BaudRate. At the bottom right of the main window are "Save .moos" and "Close" buttons.

```
ServerHost = localhost
ServerPort = 9000
Community = emily

MOOSTimeWarp = 1
TERM_REPORTING = true

// [TODO] Please Set These
LatOrigin =
LongOrigin =

ProcessConfig = ANTLER
{
    MSBetweenLaunches = 400
    Run = MOOSDB      @ NewConsole = false
    Run = iGP9        @ NewConsole = false
    Run = pMarinePID  @ NewConsole = false
}

ProcessConfig = iGP9
{
    AppTick = 20
    CommsTick = 5
    SerialPort = /dev/tty01
    BaudRate = 115200
    Covariance = "0 0 0 0 0 0 0 0 0 0"
}

ProcessConfig = pMarinePID
{
    AppTick = 4
    CommsTick = 4
    speed_factor = 20
    sim_instability = 0
    tardy_helm_threshold = 2.0
    tardy_nav_threshold = 2.0
    active_start = false
    verbose = 1
    yaw_pid_kp = 0.5
    yaw_pid_kd = 0.1
    yaw_pid_ki = 0.012
    yaw_pid_integral_limit = 0.07
    yaw_pid_ki_limit = 0.2
    maxrudder = 100
    speed_pid_kp = 0.8
    speed_pid_kd = 0.1
    speed_pid_ki = 0.11
    speed_pid_ki_limit = 0.07
    maxthrust = 100
}
```



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MOOS Config GUI

XML config file



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Summary

- Total autonomy system cost ~\$1000, full platform for ~\$2000
 - Software platform with module architecture facilitates flexibility
 - Use of ROS for sensor integration and GUI to speed new user teaching.
 - Path planning algorithms for depth adaptive survey coverage
 - Installing on 3 small ASVs UNH



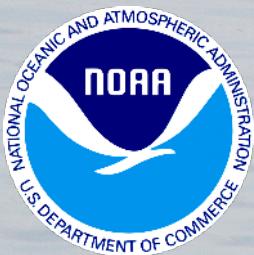
THANKS

NOAA Office of Coast Survey

NOAA Unmanned Aircraft Systems Office

Naval Engineering Education Center

QUESTIONS?



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