SubjuGator 2007

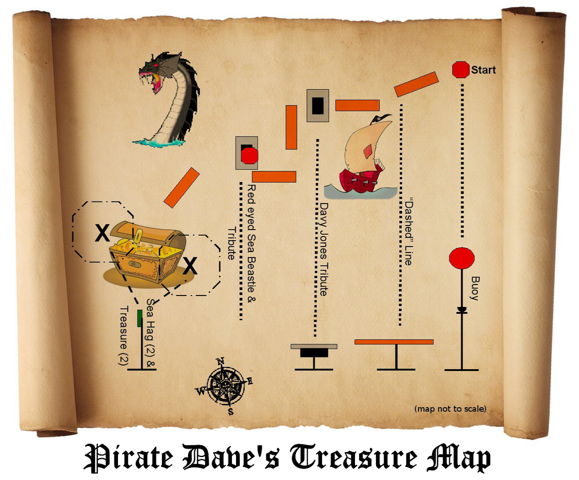
UF UNIVERSITY of FLORIDA
The Foundation for The Gator Nation

Machine Intelligence Laboratory

Mission

In order to accomplish the full mission, our autonomous submarine is expected to complete four tasks:

1. Demonstrate autonomous control by passing through a validation gate.
2. Free a flashing start buoy that is anchored by a mooring.
3. Track a segmented line along the seafloor to find a target bin. The robot must engage the second buoy to reveal the bonus target bin and must drop a marker inside this bin.
4. Activate its passive sonar in order to traverse to the proper surfacing zone. Within this surface zone, the AUV must identify the "treasure," capture it, and surface inside the zone boundaries.


Pirate Dave's Treasure Map

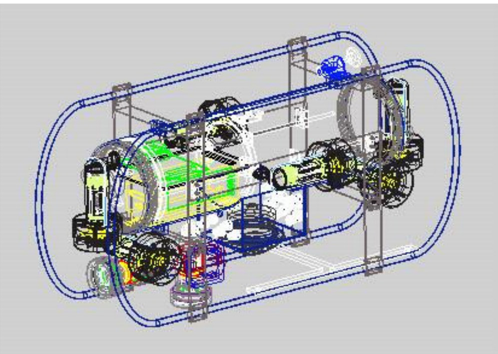
Design

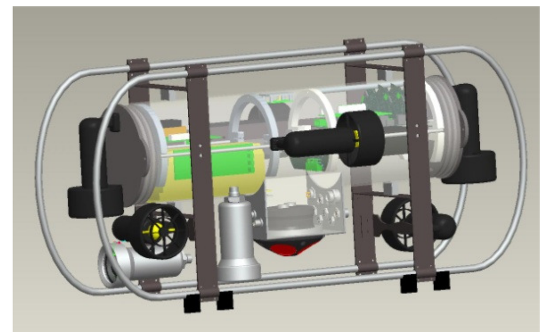
Every aspect of the SubjuGator's design has been revamped for our sixth generation vehicle. The electronics, software, and mechanical platform have all been completely redesigned. In order to visualize the new design, detailed models of nearly every component were created using multiple CAD software programs. Our design was intended for easy expansion with new sensor packages.

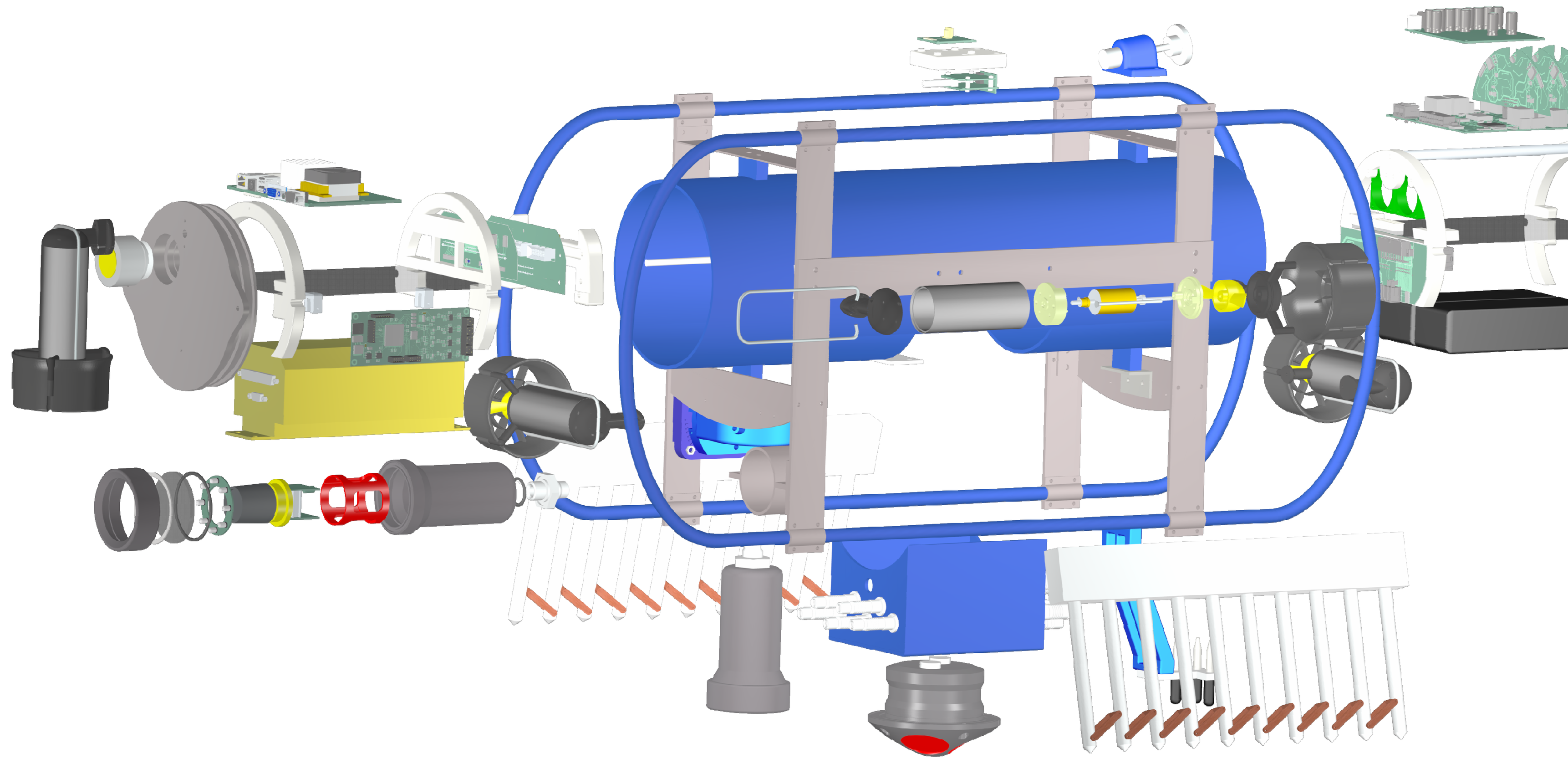
One of the biggest driving forces behind our design was the acquisition of our Teledyne DVL. This sensor serves as the centerpiece of our AUV. The DVL is a relatively heavy sensor, therefore we chose to center this sensor to aid in the balance and control of our platform.

The next major design choice in our implementation was thruster configuration. Six Seabotix SBT150 thrusters are arranged to provide full translational motion and both pitch and yaw rotational motions.

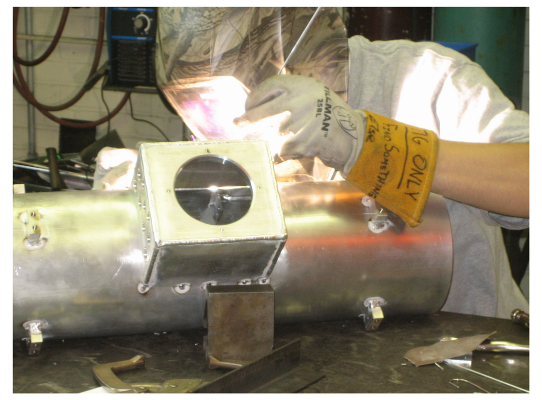
Finally, our team attributes a great deal of our success to the ease of access to the internal electronics. To accommodate this feature, internal rails were implemented on either side of the DVL to allow sliding tray systems with blind mate connectors on two backplanes.


Early Wire Frame Model


Intermediate CAD Render

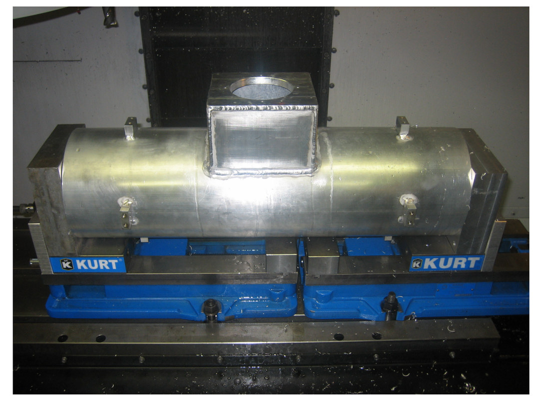

Exploded View of the SubjuGator Design Rendered with Pro Engineer CAD Software

Fabrication


Welding the DVL Housing

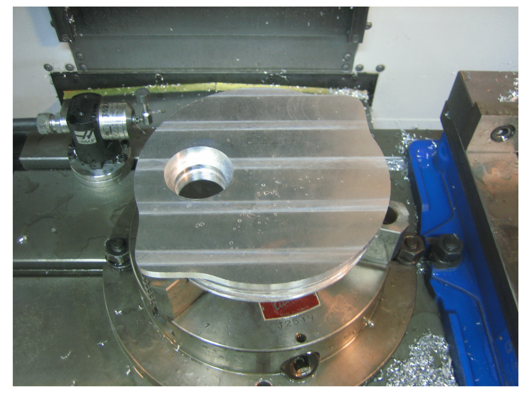
Subjugator's Hull is fabricated from a 7" OD aluminum tube. In order to accommodate our DVL, an additional compartment was added. The DVL housing was fabricated by first cutting a square out of the tube using a CNC Milling Machine. The remainder of the housing consists of 1/8" aluminum plate welded together to form a box. Hard points and internal mounts were also welded onto the hull for mounting thrusters and the external superstructure.


Freshly Anodized SubjuGator


SubjuGator in the CNC

Next, the end caps were fabricated from 1-1/4" thick aluminum plate using the CNC Mill. The end caps use a double o-ring seal to enhance fault tolerance at extended depths. After the hull and end caps were complete, we conducted an overnight leak test.

With the hull complete, the next step in fabrication was to create an external superstructure that was capable of supporting the thrusters and external sensors. Carbon Fiber composite materials were chosen because of the high strength to weight ratio. The composite materials were also used to support the protective cage that prevents accidental damage during testing and debugging.


End Cap Fabrication

At this point, our AUV was ready for external components such as cameras, hydrophones, and kill switch. We used a Stratasys Rapid Prototype machine to construct the mounts for these parts. Rapid prototype parts are created directly from CAD models that are re-sampled by the machine and then printed in small layers from bottom to top using ABS plastic.

Upon completion of the mechanical platform, our team decided to invest in a hard anodization process to protect the metal from corrosion and oxidation, common side effects of operating in chlorinated or salt water.

Team

Kevin Claycomb—Project Leader, Embedded Architecture, Electronic Hardware
Sean Cohen—Project Co-Leader, Embedded Computing & Communication, Public Relations
Jacob Collums—Project Co-Leader, Mechanical Platform Design and Fabrication
Carlo Francis—Power Systems Design, Composites Fabrication
Grzegorz Cieslewski—Acoustic Systems Design, Vision Systems Programmer
Don Burnette—Software Architect, Framework Manager, Controls System Design
Tom Feeney—Mechanical Visualization, Sensor Interfaces
Gene Shokes—Camera Housings, Marker System
David Conrad—Mechanical Support
Hector Martinez—Mechanical Visualization and Support
Michael Franks—Sensor Interfaces
Dr. Eric Schwartz—Faculty Coordinator, Advisor, Consultant

AUVSI ONR's Autonomous Underwater Vehicle Competition

- International Champions 2005
- International Champions 2006

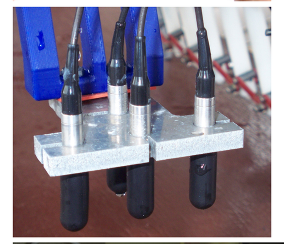
Sponsors

Sensors

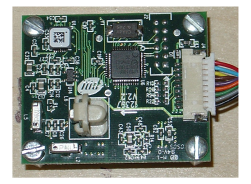
Navigational Sensors:

The SubjuGator makes use of four discrete sensor packages to provide feedback about the motion of the vehicle.

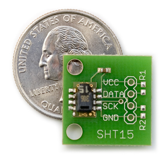
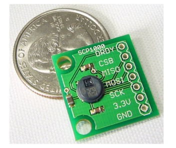





- The Teledyne Explorer Doppler Velocity Log (DVL) emits an acoustic signal that is reflected from the seafloor to give the controls system accurate positional feedback information.
- The DVL is directly interfaced with a Desert Star SSP-1 pressure sensor which provides depth and temperature information.
- The hydrophone array is used to triangulate the location of the acoustic pinger. This calculation is performed using time-of-arrival or phase difference techniques.
- The SubjuGator uses two Blue Fox cameras from Matrix Vision. Each camera is enclosed in a custom designed housing that includes white LEDs for extra illumination.




- For heading information, the SubjuGator uses the TCM5 3-axis compass module. In addition to directional information, the TCM5 also provides pitch and roll feedback.
- SubjuGator also makes use of a 3DMG Inertial Measurement Unit (IMU). This sensor uses 3-axis accelerometers, magnetometers, and an internal gyroscope to provide pitch, roll, and yaw feedback information.

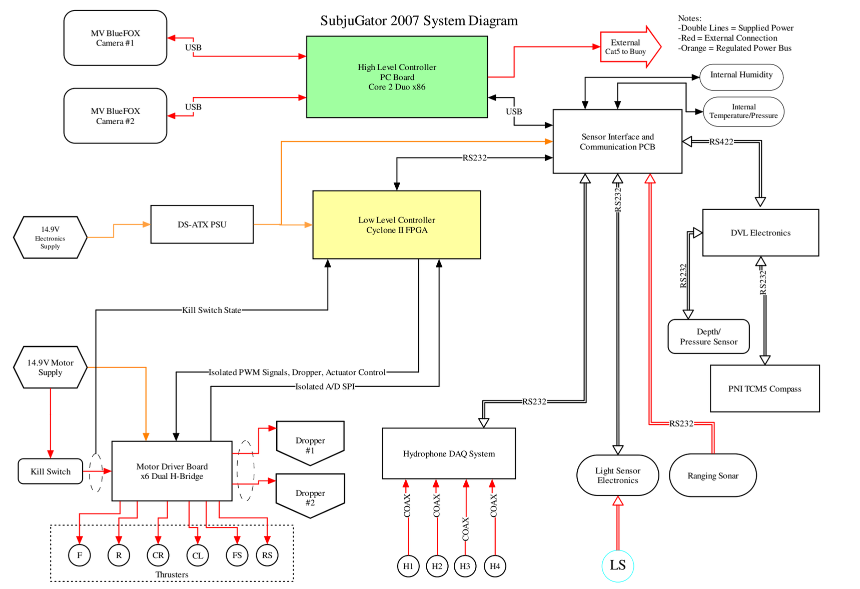



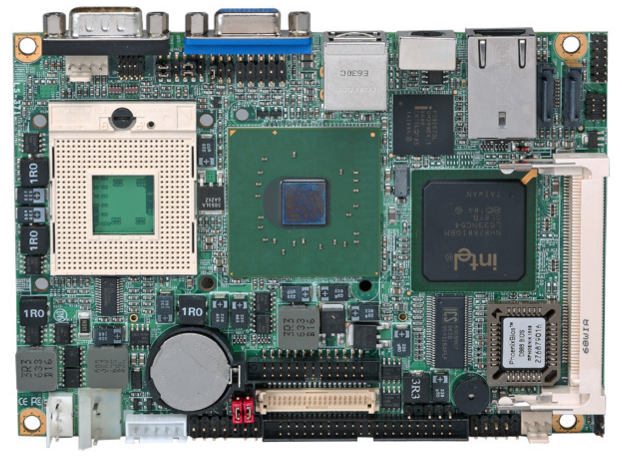
- Several environmental characteristics are monitored inside of the hull. Humidity and temperature are monitored with the SHT15 breakout board. Internal pressure is monitored with the SCP1000 MEMs barometric sensor board. Both of these products are inexpensive solutions available from SparkFun.

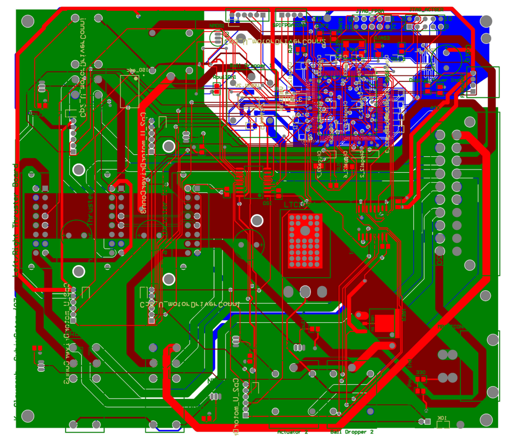
Electronics

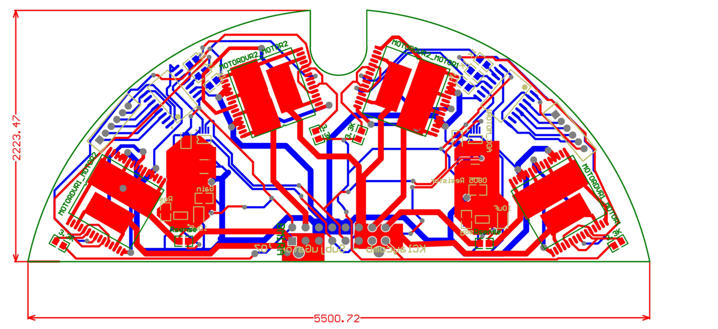
The heart of the SubjuGator is it's custom embedded electronics. Motor drivers, drive control circuitry, interconnect boards, the hydrophone data acquisition board, and sensor interfaces are all designed by our team to best suit the needs of our project.

In addition to our custom circuit boards, the SubjuGator also makes use of a few commercial off-the-shelf boards. These systems include the 3.5" Single Board Computer, the ATX power supply, and sensor electronics.


High Level System Diagram

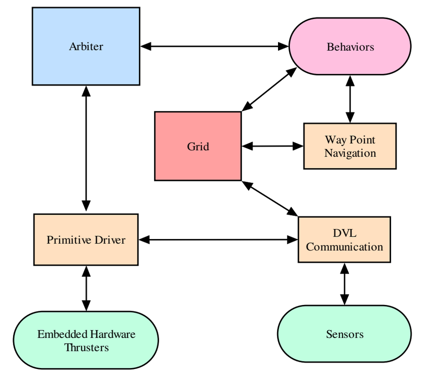

Commell LS-371 3.5" SBC


Motor Driver Motherboard

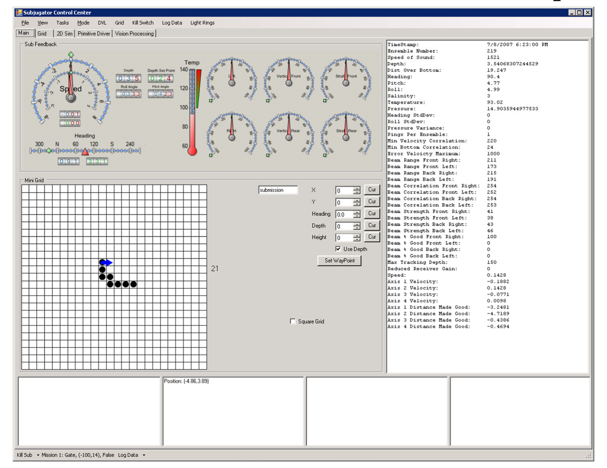

A Custom Motor Driver Board

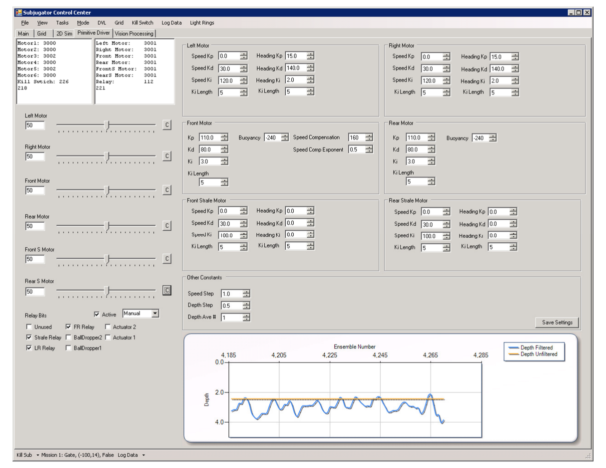
Software

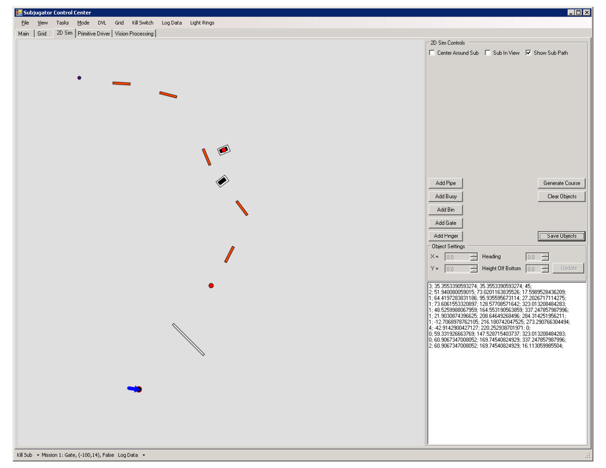
One of the most unique features of the SubjuGator is our software framework. Building upon our success in previous years using Microsoft products, our team decided to implement the Microsoft Robotics Studio (MSRS). MSRS is a service oriented architecture based on Microsoft's Coordination and Concurrency Runtime (CCR) and the Decentralized Software Services Protocol (DSSP). MSRS operates as a collection of custom services (independent programs running concurrently), each with a set of predefined input/output messages. This service based architecture allows for highly modular and configurable independent software components. At present, our architecture consists of a collection of over 15 independent services including the arbiter, the grid service, communication services, and various specialized behavior services.



High Level Architecture


SubjuGator Control Center


Primitive Driver Interface


2D Simulation Interface