Proven Robotics

Purdue University | West Lafayette, Indiana, USA

"In Depth Engineering"

Mission Theme

The farthest reaches of space and the deepest depths of the ocean have more in common than meets the eye. Both are environments that are dangerous for human beings to explore, and as such, both remain relatively unknown. To aid in these explorations, humanity has developed and deployed both ROVs and satellites to go where no man has gone before. Whether it's under thousands of pounds of pressure, or traveling millions of miles across the cosmos, these ROVs help understand the environment of these dark, dangerous, and foreboding worlds.

Just as the space race in the 1960s brought many technological marvels to the general public, current space and underwater based ROV needs do the same. As underwater sonar helps ROVs map the seafloor, it also help satellites map the surface of planets. By utilizing the innovation of both underwater and space industries, both are able to be explored and promoted more efficiently and safely.

The innovation of these exploration systems eventually make its way directly to industry. ROVs are most widely used in the oil industry by assisting with oil platform inspection, maintenance, and repair. Furthermore, they regularly see use with assisting in recovery of various items such as shipwrecks.

1. http://oceanexplorer.noaa.gov/technology/tools/sonar/sonar.html
2. https://www.onepetro.org/conference-paper/OTC-13158-MS

Safety

- Safety training for all employees
- Proper safety equipment provided for all employees such as safety glasses, first aid kits, gloves and emergency wash stations
- Diagnostics sent from ROV to pilots throughout mission to ensure continuous proper functionality
- Fused power system, no sharp edges, and thruster shrouds

Careful focus and precision was used in all aspects of design and manufacturing for the safest vehicle

Each component was tested to its limits for high factors of safety

Acknowledgments

PESC
Purdue University Office of the Provost
IEEE
Purdue Engineering
SolidWorks
CS Eagle
RSS Grinders & Automation, Inc.
Indiana Space Grant Consortium INSGC
MATE
So Cal Machine Tools

Bechtel
Black & Veatch
Eastman Chemical
Digi-Key
IEEE

Binder
Netgear
Northrop Grumman
Wabash Power Equipment
Company

Logos supplied by company website

Abstract

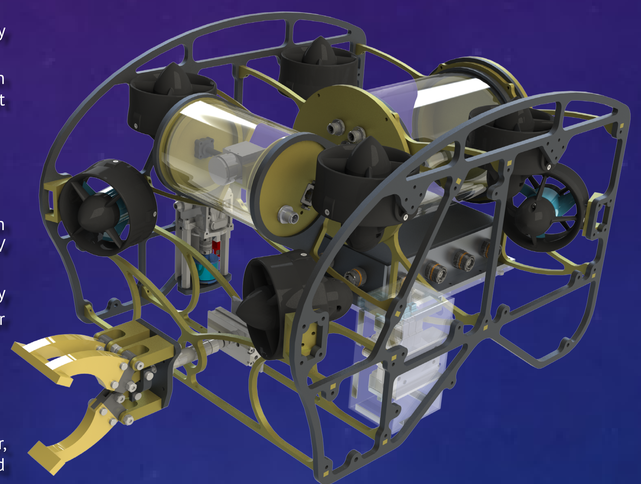
Proven Robotics worked to design ROV *Maelstrom*, the first Remotely Operated underwater Vehicle (ROV) capable of conducting reconnaissance, recovery, and maintenance under extreme oceanic environments on Earth and in outer space. *Maelstrom* is capable of delving into any environment, from the depths of Europa to the bottom of the Mariana Trench. This unrivaled versatility will push human exploration onwards.

ROV *Maelstrom's* design utilizes open-loop hydraulics and optimizes weight and volume, allowing for more electronics and tools. The company also features a tri-camera system and a sonar positioning system on ROV *Maelstrom*. In order to facilitate rapid and reliable development, the company is split into Mechanical, Software, and Electrical departments, which are responsible for their respective ROV components overseen by an Administrative department. The departments were in constant communication throughout production in order to ensure continued progress and success.

This multipurpose ROV meets mission requirements to complete the Outer Space and Inner Space simulations at MATE's 2016 international competition. This includes seafloor exploration and discovery, maintenance and recovery of items of interest, and determination of sample origin. It is the product of methodical planning and iterative design. ROV *Maelstrom's* ability has been tested in mock simulations and Proven Robotics is proud to exhibit its performance.

Design Rationale

ROV *Maelstrom*



** Buoyancy and ballast omitted for clarity*

Camera Tube

- Main full HD camera mounted to servo to provide a full 180 degree tilt view.
- External connectors allow for easy attachment and removal.
- Two secondary camera boxes on both left and right sides support pilot to direct ROV.

Power Distribution Board

- 48 V to 12 V DC-DC conversion to power motors and other ROV applications
- 2400 W total output power capacity
- I^2C communication for thruster speed and direction control

Open Loop Hydraulics

- A pump pressurizes pool water, which is used as the working fluid for a hydraulic system
- No dynamic seals needed for hydraulics, compared to standard electric motors

Thrusters

- Blue Robotics T200 brushless motors with external ESC
- Four vertical and four horizontal set at 20 degree offset to improve balance and forward thrust

Electronic Tube

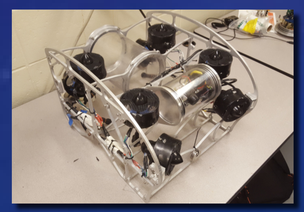
- Fixed tube couplings keep polycarbonate tube from flexing and provides a constant sealing surface.
- Multiple o-rings provide several redundancies in case any single seal fails.

BattleStation

- Interface update to provide pilot statistics of ROV depth, water temperature and configurations of Joysticks to promote usability
- Cameras View Application on other monitor provides full view of underwater scene.
- Mission tracking with timer, task list and point calculator

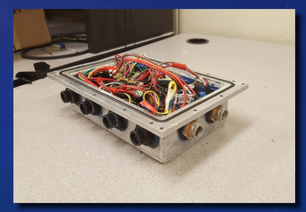
Manipulator

- Can easily grasp large cylindrical objects, due to wide opening
- Powered by single hydraulic piston for grasping, and secondary actuator for rotation of 90 degrees
- Interchangeable tips allow for specific use cases in future designs



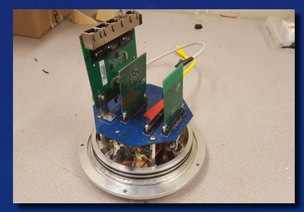
Frame

- Consists of multiple custom plates joined together using hybrid mortise and tenon joints for easy assembly
- Made from high strength aluminum that allows for considerable material removal resulting in a very low weight structure.



Power Distribution Box

- Aluminum box used for strength and use as a heat sink
- Clear Polycarbonate lid for easy inspection of internal electronics
- Dive bell geometry used to save electronics in case of a leak
- Isolates noisy power conversion from more sensitive electronics



Main Electronics

- Contains a backplane for easy board to board connection
- Custom designed microcontroller to function as the brains of the ROV
- Application board provides additional board for expansion to more tools and controls

Company Evaluation

This is Proven Robotics' seventh time in the MATE ROV International competition. ROV *Maelstrom* is the most technologically advanced ROV in company history. This ROV contains a never before seen sonar system to pinpoint the location of the ROV with great accuracy and an innovative frame design, one of the lightest in company history. Combined with a variety of tools, and the the most powerful thrusters the company has used, ROV *Maelstrom* has met company standards, qualified for the international competition, and is ready to perform.

Much of the ROV's successes are due to the strength of Proven Robotics' administrative structure, networking with alumni, and effective training program. The company is divided into simple yet effective mechanical, electrical, and software divisions overseen by an administrative team. Additionally, the company runs an intensive training program and networks with its alumni to turn employees into highly qualified members of Proven Robotics.

Despite many successes, the company was not without its challenges, the biggest of which was time management. While deadlines were met during the training and design phase, building and testing the ROV encountered various delays. However, the company delivered an on-time and on-budget product through coordinated employee efforts and resourcefulness.

Throughout the year, Proven Robotics has identified key areas in which to improve the company. In order to more efficiently utilize employees time, tasks will be clearly prioritized, continuously reevaluated as needed, and displayed to all members. Additionally, an increased focus on the building and testing phases of the ROV will be emphasized in order to ensure all phases receive the appropriate attention.

Throughout all ROV phases, the student employees were able to complement their college education with real hands-on experiences. The most rewarding part of the process was when ROV Maelstrom finally qualified for internationals after many trial runs. While frustrating, each failed run taught the company lessons on the way to success.

Employees researching and working in our lab space

Company Information

Photo credit: John Lee

Kyle Rakos	Chief Executive Officer	Computer Engineering
Sanay Shah	Chief Operating Officer / Mech. Team	Industrial Engineering
Joshua Berg	Mechanical Team Lead	Mechanical Engineering
Matt Molo	Software Team Lead / Pilot	Computer Science
Luke McBee	Electrical Team Lead	Computer Engineering
Ryan McBee	Embedded Software Subteam Lead	Computer Engineering
Carolyn Lewelling	Lead Sponsorship Coord / Electrical Team	Electrical Engineering
Alex Ruffino	Sponsorship Coord / Mechanical Team	Mechanical Engineering
Henry Shi	Technical Writer	Industrial Engineering
Ashiq Kurian	Computer Graphics	Industrial Engineering
Joseph Pejril	Mechanical Team / Co-pilot	Mechanical Engineering
Jared Borg	Mechanical Team	Mechanical Engineering
Teal Dowd	Mechanical Team	Mechanical Engineering
Dan Schillizzi	Mechanical Team	Mechanical Engineering
Alex Gebhardt	Mechanical Team	Mechanical Engineering
Scott Giammatteo	Mechanical Team	Aerospace Engineering
Amandeep Singh	Mechanical Team	Mechanical Engineering
McKenzie White	Mechanical Team	Environmental Engineering
Katie Lothrop	Mechanical Team	Mechanical Engineering
Rohit Srivastava	Mechanical Team	Biomedical Engineering
Tom Lorenc	Mechanical Team	Mechanical Engineering
Jakob Andren	Electrical / Software Team	Engineering Physics
Xinyi Jiang	Electrical Team	Electrical Engineering
Rodolfo E. Leiva	Electrical Team	Electrical Engineering
Nicholas Loffredo	Electrical Team	Electrical Engineering
Samuel Deghuee	Electrical Team	Electrical Engineering
Bayley Clausen	Electrical Team	Mechanical Engineering
Alan Han	Electrical Team	Electrical Engineering
Charles Li	Electrical Team	Electrical Engineering
Wen Shen Mow	Electrical Team	Electrical Engineering
John Lee	Software Team / Pilot	Computer Engineering
Yuqin Duan	Software / Mechanical Team	Computer Engineering
Brandon Stewart	Software Team	Computer Science
Ben Maxfield	Software Team	Computer Science
Charlie Su	Software Team	Computer Science/Physics
Oksana Makarova	Software Team	Electrical Eng./Physics
Ajay Gopakumar	Software Team	Computer Engineering
Joel Copi	Software Team	Computer Engineering
Jason King	Software Team	Computer Engineering
Mimansa Verma	Software Team	Computer Engineering
Michael Reeves	Software Team	Computer Science/Physics
Nathan Glotzbach	Software Team	Physics
Mentors: None		