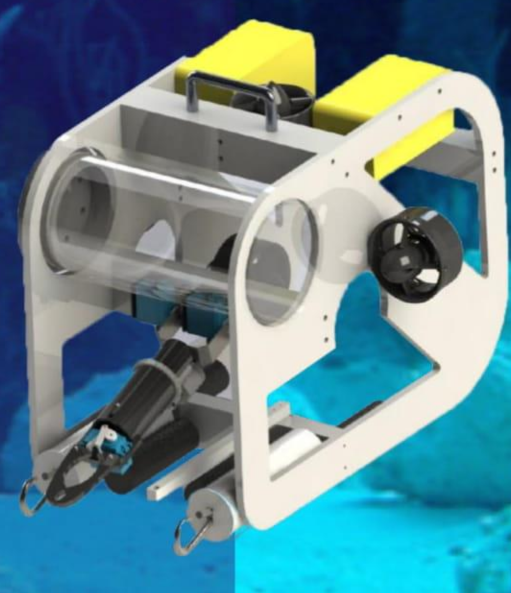
URI HYDROBOTICS

MATE COMPETITION 2018

TECHNICAL REPORT



Jordan Beason - Chief Technical Officer
Cole Boulanger - Chief Information Officer
Austin Clark - Chief Financial Officer
Hunter Claudio - Chief Operations Officer
Jackson Sugar - President

ABSTRACT

Figure 1: International Competition Team with ROV ICARUS

Our goal this year was to facilitate the building of a learning community. It is our hope that this new approach to team dynamics helps generate a close-knit group built to last. ROVs are not built in a day. Behind every ROV is a story of serious dedication to a seemingly endless task. Only the few who hold their ground and stick it out to the very end understand the feeling of accomplishment from that success. ICARUS is a tribute to those who keep their distance from the sun.

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INTRODUCTION

URI Hydrobotics is comprised of ambitious undergraduate students that strive to design, manufacture and build an explorer class ROV to compete in the MATE competition. As a company we strive to not only compete but also educate any new members to expand their knowledge and understanding of robotics systems. Every year poses new challenges and learning opportunities even for the most experienced veterans on the team, this allows everyone to further their own knowledge as well as to help one another learn in the process. We as a company project an atmosphere that allows any major to come and learn and put the time they want into educating themselves. We have a dedicated team of upperclassmen that work to keep the team in a functioning order and help direct students' endeavors. This year, we bring ROV ICARUS to Seattle, Washington.

DESIGN RATIONALE

ELECTRONIC SYSTEM

As the main goal of Hydrobotics is to teach, most design decisions are based solely with the intention to teach and learn by doing. In that light we spent a considerable amount of this year teaching important skills such as soldering, electronics, PCB fabrication and software. With the completion of the robot we certify that all those present for development have a well-rounded understanding of every component in action and how it was implemented.

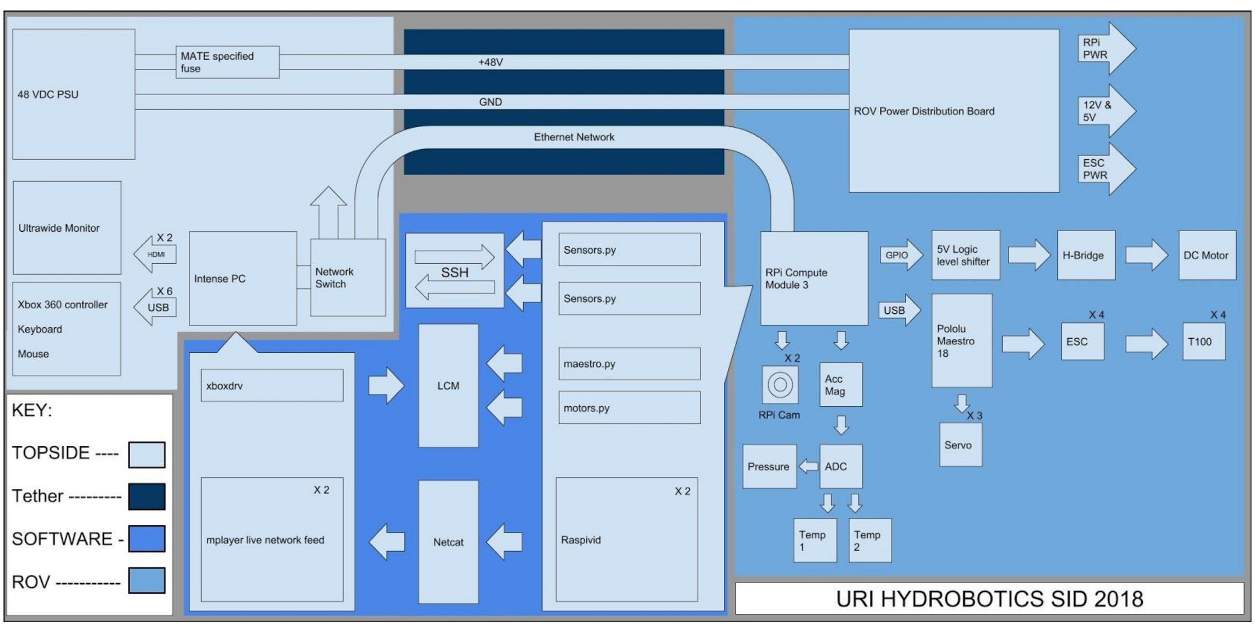


Figure 1: ICARUS SID

POWER DISTRIBUTION

To correctly power all of the subsystems on ICARUS, several different voltages were necessary. A 12V converter and two 5V converters were used to achieve power distribution. The 12V output is necessary for the operation of the ESCs and the T100 motors. The 5V output is necessary for the manipulator DC motor, the compute module power, the various sensors, and the servos. GPIO pins aboard the compute module provide power to the H-bridge circuit that controls the orientation of the rotations of the manipulator's DC motor. Also, a USB hub that is connected to the compute module acts as power for the Maestro and other peripheral devices.

CUSTOM POWER DISTRIBUTION BOARD

To conserve space within the bottle and promote efficiency, URI Hydrobotics has developed a PCB that consolidates all of the necessary power distribution. With safety also kept in mind, it was designed in a way such that the 48V input from the tether is separated from the output voltages. Opposite the input power, there are two connectors that output 12V. Two different 5V converters are used. One is solely for the power of the compute module. The other 5V converter is for all other auxiliary 5V power needs.

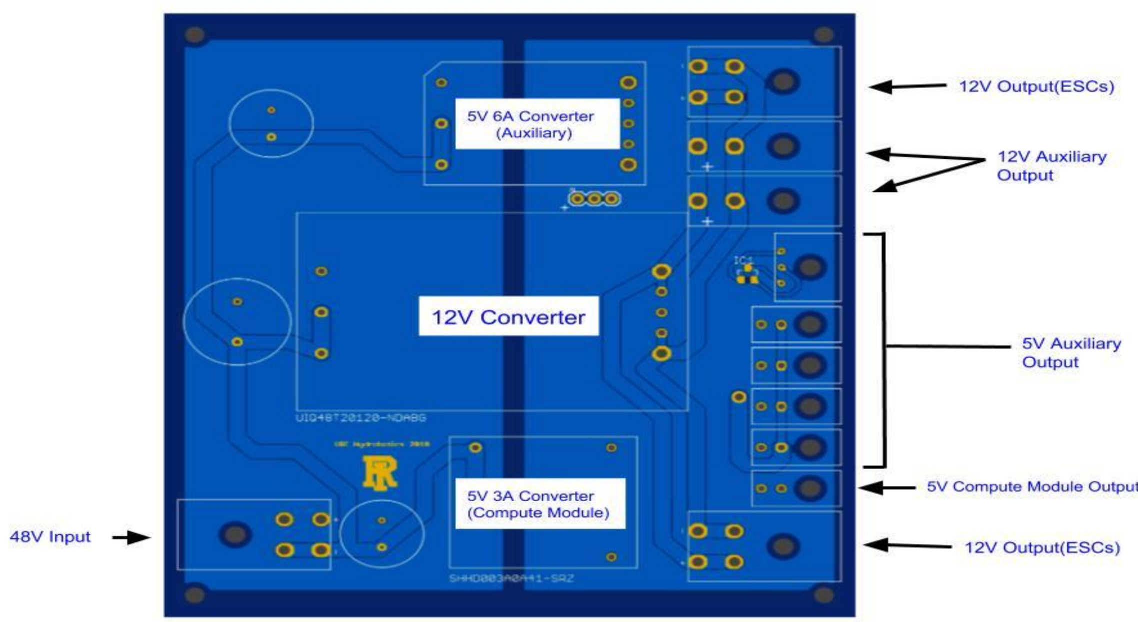


Figure 2: Labeled Power Distribution Board

CONTROL STACK

An in-house circuit board containing all other necessary wiring for the sensors, wifi module, and h-bridge is used to further promote efficiency and conserve space within the bottle. This board is connected to the compute module in a way such that the PCB rests directly above the compute module.

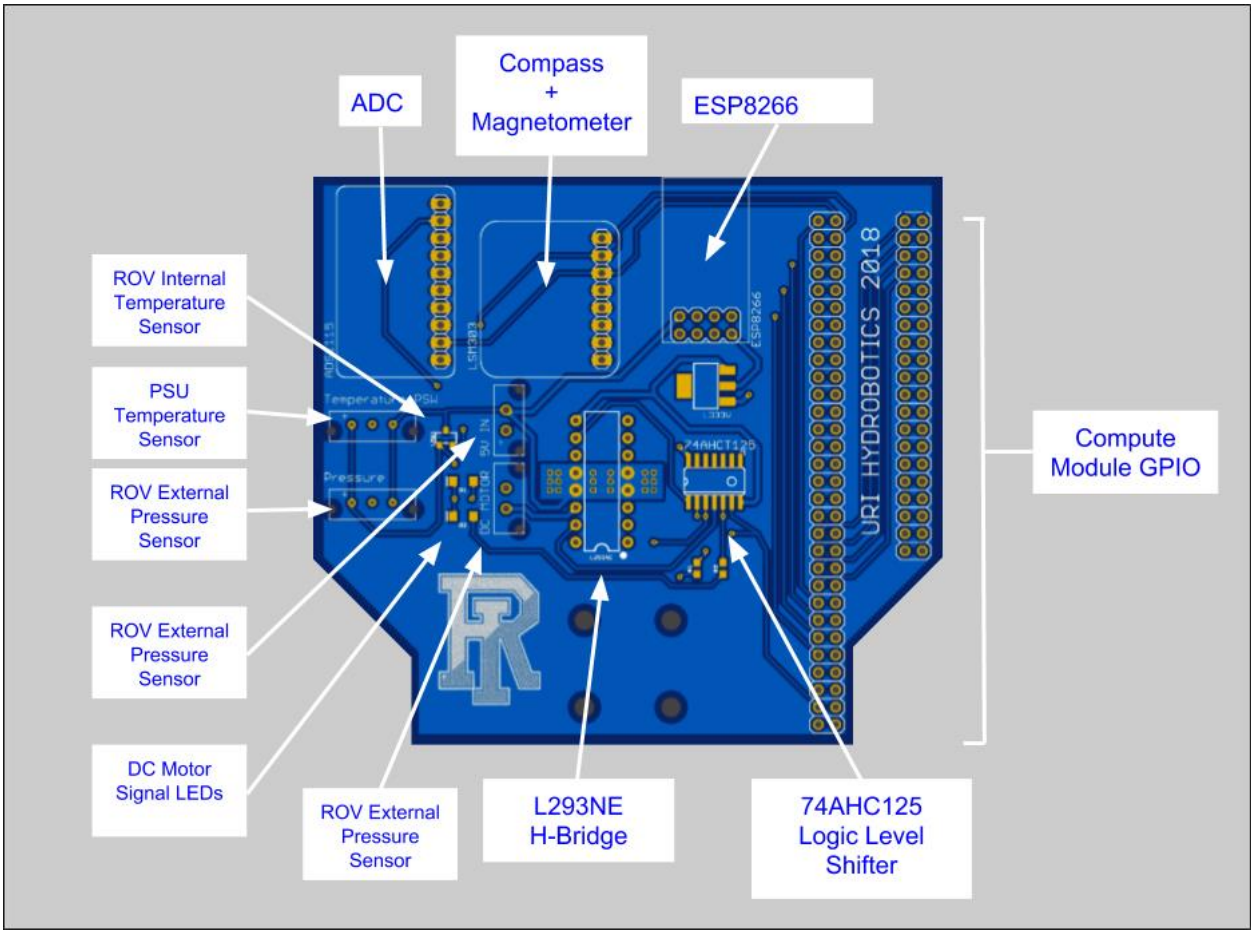
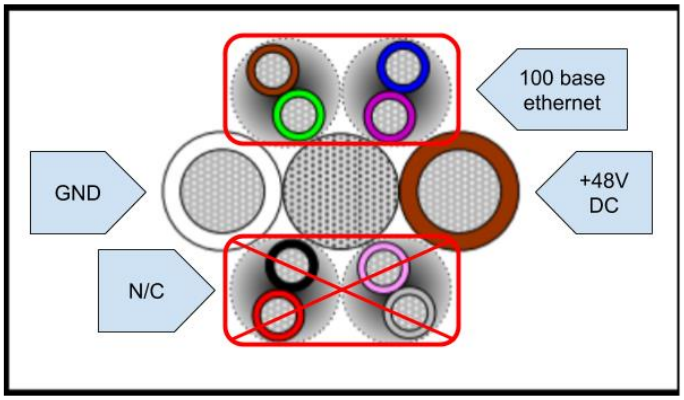


Figure 3: Pi-hat PCB

TETHER

The tether is an off the shelf Igus CF-211.010 chainflex cable of 15 meters in length. This cable was donated to us via the Igus YES program targeted at academic projects. The CF-211.010 is a continuous flex cable comprised of four 23 gauge twisted pairs for ethernet and two 17-gauge wires to deliver 48VDC to the robot. In this application, due to limited space in our bottle penetrators, we opt to use only two twisted pairs to send T100 ethernet, plenty of bandwidth to pass all data necessary for operation.

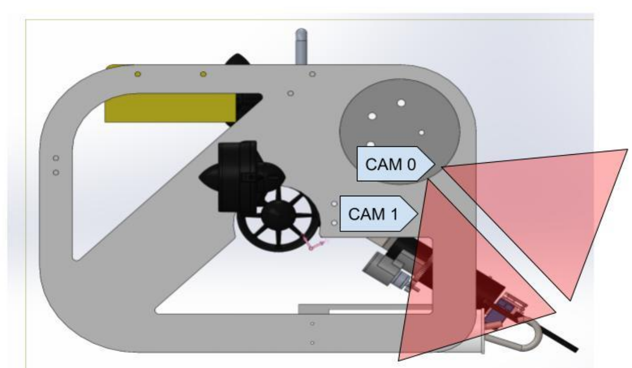
Figure 4: CF-211.101 Implementation



CAMERA

2 Raspberry Pi V2.1 Cameras are utilized by ICARUS. Both are connected directly to the Raspberry Pi 3 Compute Module. Looking at Figure X, the cameras are oriented in a way such that CAM1 focuses on the area underneath the bottle where most of the manipulation of objects will be taking place and is also the camera that is utilized by the video recognition software for identifying the plane wings. CAM0 provides a more general view of what is in the front of ICARUS. CAM0 can also show the manipulator when it is positioned completely horizontally, which can prove useful for some tasks such as connecting the ADV.

Figure 5: Orientation of Pi Cameras



TOPSIDE

The topside control system is comprised of an Intense PC recycled from URI Hydrobotic's 2016 MU-ROV that is running Debian and communicates with ICARUS through Ethernet via a Gigabit Ethernet Network Switch. The control system resides within a pelican case, where a 21" Ultrawide Monitor is mounted into the top of the case and serves as the main monitor, where most, if not all, software processes occur. The topside control system is also designed to allow for peripherals (such as a second monitor, USB connections, ethernet connections) to be connected to the system through the various pass throughs on the control panel. To supply power to both the electronics underneath the control panel and peripherals above the control panel, a server rack-mounted surge protector is used.

Figure 6: Topside Control System

SOFTWARE

The overall software architecture that comprises URI Hydrobotics' robot is an extension of the software architecture that was developed for the company's 2016 MU-ROV. The same method of using lightweight communications and marshalling(LCM) and a system link called Procman to communicate between topside and ICARUS. Many changes were made, however, to the pre-existing scripts such as the mapping of the motor and servo motions to the Xbox 360 Controller and implementing video streams for two cameras from the same compute module. New scripts were developed to complete the video recognition and the WIFI communications, as well as reading sensor data and determining the rotation of the manipulator arm.

VIDEO RECOGNITION

See Separate Image Recognition Document

WIFI

ICARUS uses WIFI communications not only for connecting to the OBS, but also uses WIFI communications for the release of the lift bag. For the release of the lift bag, an ESP-12V microcontroller is used to create an access point and a web page, similar to the OBS. A python script is then used to send serial AT commands from ICARUS and scrapes the web page that the ESP-12V hosts. When the web page is accessed, the solenoid holding the lift bag in place will then release.

MAPPING

Modifications have been made to the Hydrobotics' 2016 MU-ROV control mapping software to suit the needs of all electrical components for ICARUS. Additions were made to accommodate the motion of two different sets of servos. An executive decision was made to control the rotation of the DC motor manually through a script rather than to map it on the Xbox 360 Controller, to avoid accidentally rotating the motor by pressing a button.

MECHANICAL SYSTEM

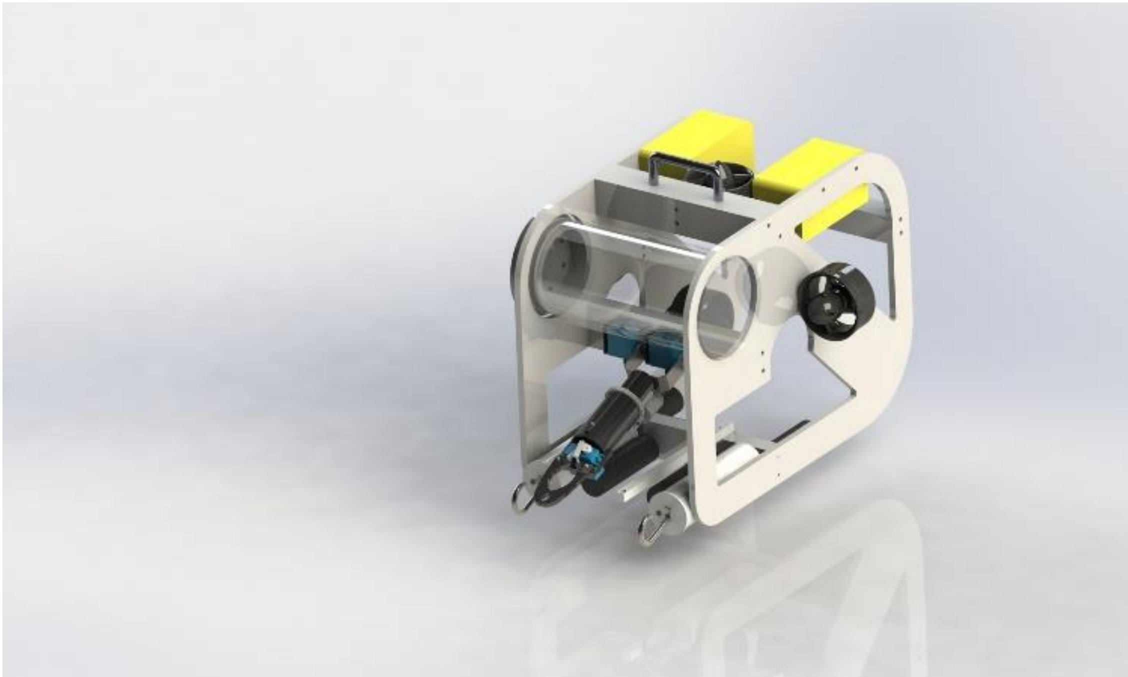


Figure 7: complete ROV design rendered on Solidworks

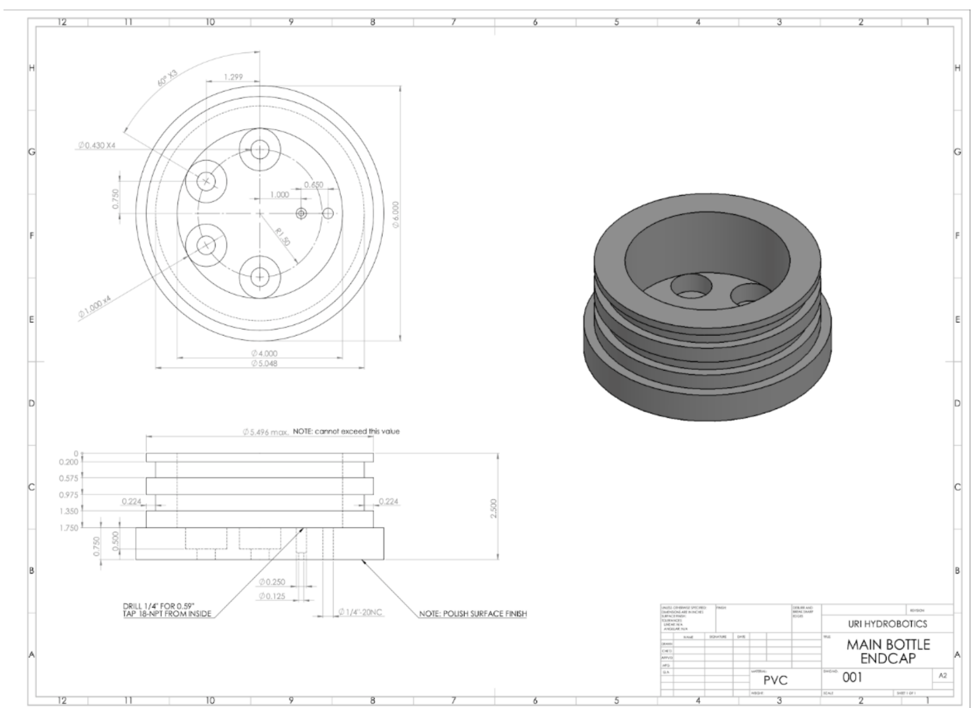
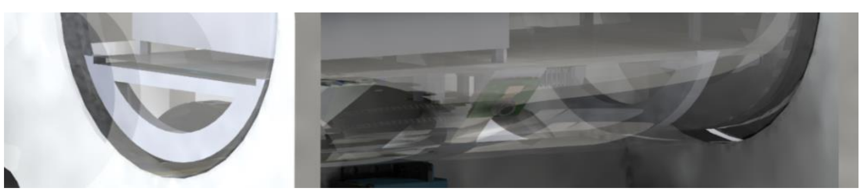


Figure 8: main bottle end cap design on Solidworks

FRAME

The frame for ICARUS is composed mostly of High Density Polyethylene. Considerations were in mind to keep this design as lightweight and sturdy as possible looking back at structural damage and warping of the Hydrobotics 2017 ROV for inspiration. The Frame design is composed of 2 hull panels and 4 lateral HDPE cross bars. The frame was laser cut from a ½ inch sheet of HDPE to provide 2 hull panels thick enough to not warp and to provide the manufacturing quality we couldn't otherwise provide. The 4 lateral cross bars were placed to prevent racking and torsion in the frame when the ROV is in use. Each lateral support was also placed in a key location to serve purposes for mounting necessary features. This included the mounting for the main manipulator, mounting for ballast, mounting for the vertical and lateral thrusters close to the center of mass, and in the rear mounting for a steel eye-ring used for tether stress relief.

Perhaps the most cautiously approached piece of the frame design was the bottle and end-cap as it would provide housing for all the electronics stack and would be catastrophic if this system were to fail. As well as housing the electronics the bottle would provide mounting for both Raspberry Pi cams used for observing the ROV's environment. To do this an acrylic mounting plate would hold the electronics centered in the bottle mounted on two discs 3D printed to match the inner diameter of the acrylic bottle. This in turn also made the system easy to service as the endcap could be removed and the electronics could slide out on an easy to access mounting board. Using the *Parker Handbook* for O-ring sizing and a dual O-ring design the mechanical team created a technical design to match (seen in figure 1B). It was decided this piece was to be manufactured out of PVC by a machinist based locally off the University of Rhode Island campus. This was to provide the specifications necessary for the seal to function properly which could not be provided by our team's equipment capabilities while also cutting down on lead shipping time.

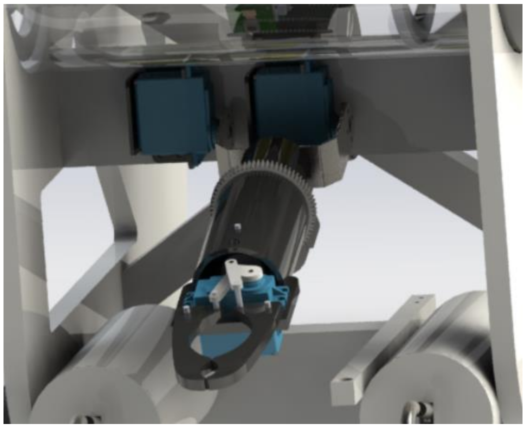


PROPULSION

For propulsion on the ICARUS, movement was provided by 4 Blue Robotics T100 Thrusters. T100 thrusters were chosen because of the excellent reliability of Blue Robotics products as well as the lower cost from previously purchased thrusters while still meeting necessary power requirements. Finger guards complying with safety standards IP20 were also manufactured for the 4 thrusters using premade 3D printed designs from thingiverse from a user name piercet.

The ROV has 4 practical degrees of freedom, 3 of which are linear; heave is provided by the single vertical thruster, sway is provided by the single central lateral thruster, and surge is provided by both side mounted forward thrusters. Also, a fourth practical degree of yaw is controlled by firing the two forward thrusters in opposite directions. In order to keep the ROV stable when strafing, elevating, or descending, the lateral and vertical thrusters were mounted as close to a point between center of buoyancy and mass as possible.

Figure 9: Main Manipulator Arm Location/Orientation



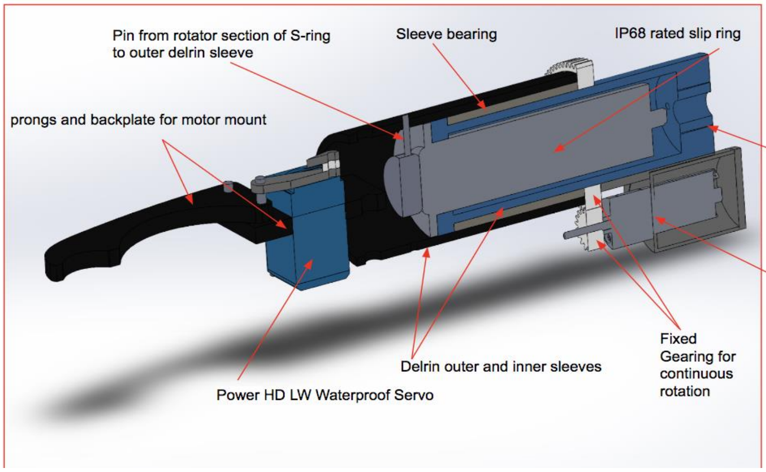


Figure 10: half section of manipulator design showing inner workings

The dynamic arm was designed with the mindset that it would need 3 effective axes of motions to complete the challenges proposed by tasks 2 and 3. These tasks would require an arm that could grasp variable circumference pieces of PVC, move objects on the ground to an upward position, and rotate objects positioned directly below the ROV continuously in 360 degrees of motion. These skills were essential for manipulating all manner of PVC, deploying the hydropower station task 3, and leveling the OBS for task 2.

In order to provide 90-degree pitch from a vertical downward position to a level horizontal position, the entire arm would be mounted on an aluminum c-bracket dual mounted to 2 servo motors (See Figure 2B for orientation of dynamic arm mount). For continuous rotation to level the OBS, a DC motor with a special gear mounted on an axle would rotate around the outer half of the manipulator along another fixed specially laser cut gear (See figure 2A for half section of manipulator). To prevent an electrical connection breaking during rotation, a special IP68 rated slip ring would host the electrical connection between the manipulators rotor and stator sections. The grasper on the manipulator was specially designed with 2 channels for ½ and 2-inch PVC and would be actuated by a 3rd servo motor. A majority of framing on the manipulator will be made of Delrin because it is low friction and easily machinable and 2 Delrin sleeves will have to be rotated about each other.

MANIPULATION (LIFT BAG SYSTEMS)

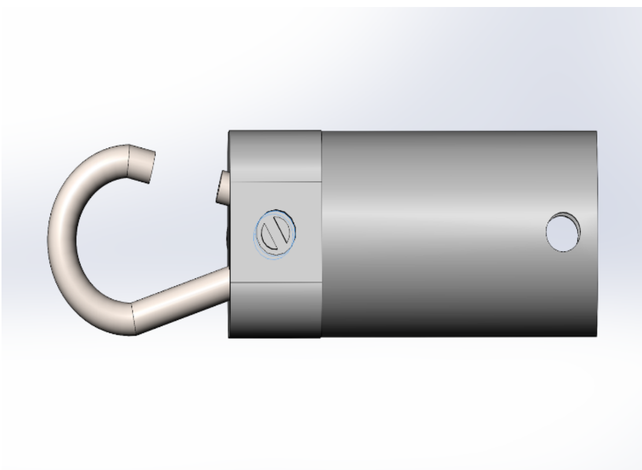


Figure 11: lift bag release device

Figure 12: lift bag (designed for 25lb payload)

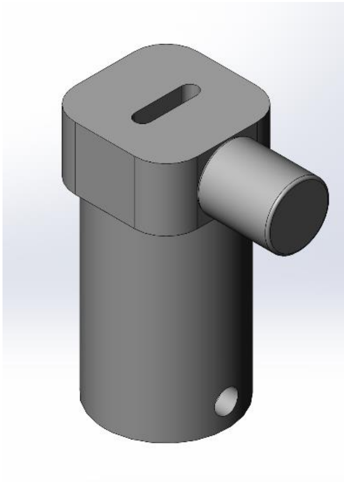


Figure 13: electronics and solenoid for remote release

Lift bags were a challenging part of the manipulation package as they would have to be precisely guided around the several U-bolts for the package to deploy. The lift bag package was designed to be reloaded after removing the debris. The lift bags are housed in a tube that protrudes from the front of the frame, in the cone of vision of the Raspberry Pi cameras. The navigator and pilot would need to slowly guide a carabiner around both U-bolts one after the other, which then the ROV would pull back, releasing the electronics package from the tube (Figure 13). The lift bag (Figure 12) will be deployed with attached buoyancy foam in order to right itself, where the ROV will hold stable as air from a static jig fills the lift bag from below (Air will be routed down with the tether and through a static jig seen in the bottom right of figure 2B).

The electronics package will receive a WIFI signal to release the lift bag from the debris package once the debris have been moved from the engine. This would happen when a transmitter on the side of the bottle came within approximately 10cm which would actuate a solenoid releasing the carabiner holding the lift bag to the object. The chute would also be reused later to hold the ADV and mount it on the mooring chain which would need to be navigated similarly to how the lift bag packages would need to be deployed.

BUOYANCY

Part Name	Material	Weight (lb)	(Taken up by water)	x	y	z
Bottle endcap	Delrin	0.58	14.1	-5.64	11.5	-3.49
Bottle	Acylic	2.46	318.08	-0.058	11.5	-3.5
Side Panel left	UHMW PE	3.21	93.46	-5.25	6.86	-9.9
side panel right	UHMW PE	3.21	93.46	5.25	6.86	-9.9
Lateral support bar Lift bags	UHMW PE	0.68	19.71	0	1	-7.5
Lateral support Bar manip.	UHMW PE	0.95	27.68	0	7.15	-6.5
Lateral support Bar back	UHMW PE	0.77	22.25	0	9.75	-19.25
Lateral cross bar front	UHMW PE	0.42	12.09	0	5.5	-12
Lateral cross bar back	UHMW PE	0.42	12.09	0	5.5	-13
Lateral support Bar bottle top	UHMW PE	1.36	39.41	0	14	-8
Carry Handle	Aluminium	0.13	1.33	0	16.27	-8
T-100 Thruster right	Various	0.65	10.37	7.41	9.13	-10.76
T-100 Thruster left	Various	0.65	10.37	-7.41	9.13	-10.76
T-100 Thruster top Vertical	Various	0.65	10.37	0	13.63	-10.91
T-100 Thruster mid lateral	Various	0.65	10.37	-0.36	7.15	-9.03
Lift bag chute left	PVC	0.27	5.84	-3.87	1.13	-3.25
Lift bag chute right	PVC	0.27	5.84	3.87	1.13	-3.25
Lift bag endcap left	PVC	0.06	1.25	-0.387	1.13	0.2
Lift bag endcap right	PVC	0.06	1.25	0.387	1.13	0.2
End cap carabine left	Stainless Steel	0.13	0.46	-3.87	0.93	1.62
End cap carabine right	Stainless Steel	0.13	0.46	3.87	0.93	1.62
Static jig	UHMW PE	0.08	2.43	2	2.25	-3.21
Servo Left	various	0.13	1.36	0	7.16	-5.29
Servo Right	various	0.13	1.36	-2.56	7.16	-5.29
Servo bracket Right	Plastic	0.06	0.36	-2.78	7.16	-5.59
Servo bracket Left	Plastic	0.06	0.36	-0.22	7.16	-5.59
Syntactic Foam left	Foam	0.24984	36	3.5	13.49	-14

Origin:	Bottom front center of robot frame		
Density of water:	0.036	lb/in^3	
Density of Foam:	0.00694	lb/in^3	
density of ballast:	0.284	lb/in^3 (iron)	
Balast weight:	5	lb	
Center of Mass			
x	y	z	
-0.1326112485	6.932168919	-7.272104844	
Center of Buoyancy			
x	y	z	
-0.1233566165	9.470322852	-7.27773585	
seperation of cb cx:	2.538153933	in	
Tipping Angle:	0.127112998	degrees	
(positive is forward)			
Mass:	25.81968	lb	
Bouyancy:	29.60192282	lb	
Acceleration upward:	0.14648682	in/s^2	
arm point of rotation:			
x	y	z	
0	6.5	-5.29	

Figure 14: trim table created using common mass properties and volumes of materials on the ROV provided by Solidworks

For calculations of buoyancy for the ICARUS, mass properties where heavily used from Solidworks 2017 to estimate where the center of mass and center of buoyancy were (shown in figure 4A). Here we wanted to have the center of buoyancy and center of mass directly above each other but as far away as we could have in order to increase the bot's stability. Solidworks gave relative XYZ coordinates which could be used to relate center and mass and center of buoyancy on the ICARUS frame and allowed us to center them towards the front of the frame. This is where the issue of the sideways acrylic bottle housing came into play; it added a large positive buoyant force to the front of the ROV and large weight to one side of the ROV because of the PVC end cap. Blue Robotics Subsea Buoyancy Foam R-3312 was used to move some buoyant force to the back of the bot (see figure 1A), then variable size pig iron housed in PVC pipe was used to ballast the ROV toward the front and off from the center due to the end cap. The trim table could only get us a close estimate to how the ROV would need ballast to be slightly positively buoyant (this is so if the ROV failed while in use it would slowly return to the surface of the water for retrieval: See figure 4A for acceleration upward data). The final trimming of the ROV ballast was compensated for when the ROV was tested in water for the first time.

SAFETY

Students' safety paramount to create a constructive work environment. As policy, we ensure all members adhere to safety protocols. Leaders equip new members with the necessary safety measures when working with power tools and electronic devices to prevent accidents before they happen.

ROV OPERATION

Here at URI Hydrobotics we have established key safety protocols when deploying and testing the ROV and all its systems. Before testing in water, the ROV is placed on the ground with all members standing a safe distance away. Then power is applied to the ROV and all thrusters are tested. Once the ROV is deemed safe to deploy, pilots take their hands off the controls and two members of the crew lower the ROV and tether into the water. The drivers are not allowed to touch any driving instrumentation until an all good signal is communicated from the crew lowering the ROV into the pool. Once the ROV has completed its mission it then returns to the surface where it is then received by the two members that lowered the ROV into the water previously. Like its deployment, when the ROV is being recaptured both drivers must put down any driving instruments and allow the pool side members to receive the robot. The ROV is then systematically powered down and a routine visual inspection of the robot is conducted to look for any visual damage or other abnormalities.

SHOP BEHAVIOR

During the inception of this year's team the prior members along with mentors give all the new students a safety rundown that gives members the necessary safety procedures that are needed to work in the shop environment. Once the mentors cleared the new members they are given access to the keycard locked lab to work. Once in the lab all company members are required to dawn the correct PPE (personal protective equipment), when working with plastic and heat or anything that produces a lot of dust a mask is required to be working to prevent inhalation of the particulates. In the lab members are required to work with the buddy system to prevent any manufacturing issues that may occur, but also to have each member peer to peer check one another with safety procedures. In the event of an emergency the buddy system allows for the injured member to immediately be cared for and given immediate attention, it also provides a speedy response time because one party can call for help as the situation occurs if it could not be prevented. Perhaps the biggest shop safety procedure that we as a company go through is the secured power system into the shop. After access is gained using the key card access a mentor must come to the shop and power the shop using a key which only mentors can obtain. This allows the mentors to log shop operation to keep a concise ledger of events during the shop hours.

Figure 15: Proper PPE being used in the work environment

ROBOT SAFETY FEATURES

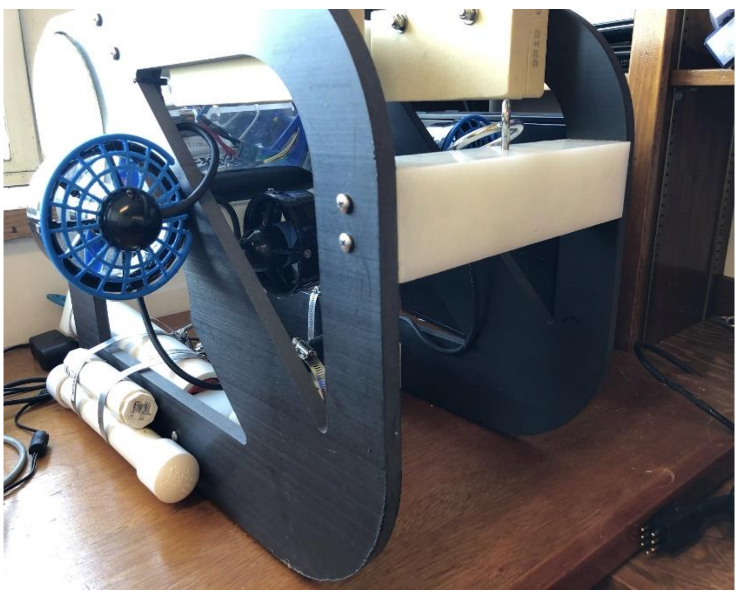


Figure 16: 3D Printed ROV thruster guards

Safety was the key feature when designing all the static and dynamic parts of ICARUS throughout its evolution. The mechanical team developed a structure absent of sharp corners and edges to prevent cutting or snagging, but also protects cables from being severed in the underwater environment; the department achieved this through rigorous deburring of all edges that were not machined with a bevel on ICARUS. The frame is also outfitted with a carry handle for the ease of transport and deployment, this allows the ROV to be handled in a safe and secure way when in transit. Also fitted onto the 4 thrusters are safety approved guards to prevent any injury that would occur if a finger were to become lodged into the thruster system. The robot also has approved tether security on both the ROV and topside control to provide stress relief for the tether. This allows for the strain of the tether to be relieved into the ROV and the topside control box to prevent tearing in the tether and allowing exposed wire into the water environment. Along with tether security the electronics team implemented a 15A fuse was attached to the tether that will sever power to the ROV from the main power supply in the event of a power spike or overheating. Inside the bottle of the ROV there are two temperature sensors that monitor the ambient temperature of the electronic systems to prevent overheating, in the event of an overheating incident the robot is shut down and returned to the surface using the innate positive buoyancy the ROV possesses.

COMPANY

The goal of the Hydrobotics team is to share experiences encompassing a variety of engineering and life skills. To encourage active participation this year, we proposed a new system to distribute funding and resources that rewards those who rise to the challenge. Every participant is capable of becoming a leader. In order to streamline the process of research and development we encouraged all work/projects for the ROV to be completed in a group setting. To disperse our limited resources, we established a standardized project proposal (P2) form to field ideas and promote collaboration. The P2 form is designed to aid the sharing of ideas, certifying that participants have put in the necessary thought and research for project completion. This form is not only good for basic documentation but also allows individuals to take ownership of their respective project only having to answer to the leaders of the club. A standard project proposal, at its core, is a free standing written document that could be consumed and understood without any prior knowledge of the system it outlines. Once the proposal is completed it is presented to the board for approval.

The board will consist of four experienced members (President, CFO, CTO, CIO, COO) , all with previous success on team projects, and one faculty advisor or graduate mentor. This board hears all project proposals before every weekly meeting and decides on funding/support accordingly. This allows for any participant to propose a unique idea, gain experience presenting technical subjects, and be rewarded with the opportunity to bring that goal to completion. The proposal writer is by default the project lead and is responsible for organizing, mentoring, and completing projects as a team.

Hydrobotics has received funding from long standing relationships with Raytheon and team members' supporting colleges as well as a tether donation from Igus. We are actively engaged in our school's engineering program's outreach events to boost enrollment in URI engineering. Active mentorship is the cornerstone of Hydrobotics outreach as our goal is to spread and expand on skills and knowledge attained in the engineering curriculum. ICARUS is the culmination of a year's long effort to educate and empower engineering students to push beyond their horizons and demonstrate their expertise.

Jordan Beason - CTO - Auxiliary Pilot
2nd Year Electrical Engineering and Chinese Language

Cole Boulanger - CIO - Co-Pilot
4th Year Computer Engineering

Hunter Claudio - COO - Tether Management
2nd Year Mechanical Engineering and German Language

Jackson Sugar - President – Pilot
5th Year Ocean Engineering and Chinese Language

Austin Clark - CFO - Pump Operator
2nd Year Mechanical Engineering and German Language

RESULTS/REFLECTION

This season provided a significant turning point for URI Hydrobotics. After a failed qualification attempt for the 2017 MATE Competition, mentors and captains alike took a large step back to discuss the true goals of the team, our motives, and what needs to happen in the future to be successful. The new season came with many challenges, on an intrapersonal and technological level. Only through teamwork, long hours, and a sense of responsibility between all members were we able to develop ICARUS to its full potential. The focus of our team is to educate; however, a time always comes every season where results are expected. It's during these times; the late team meetings, the all-nighters, and daily test sessions, that engineering and collaboration in its most perfect form occurs. It's during these times that students learn more about themselves, their capabilities, and their confidence as future engineers within society. During these times, the true goal of Hydrobotics is realized, and students learn just what it takes to be an engineer. ICARUS was built off these principles and will continue to be improved upon over the coming years as we improve our leadership and recruiting strategy.

ACKNOWLEDGEMENTS

Hydrobotics would like to extend their gratitude to these people and organizations that have made contributions and supported the team throughout the design process:

Robin Freeland, Dr. Brennan Phillips and Dr. Stephen Licht - our academic advisors, who provided insight during the design process

Gail Paolino- For performing all Hydrobotics purchasing

MATE Center- For organizing the competition, and providing a wonderful platform for education

Raytheon - For contributing monetary support

URI College of Engineering - For contributing monetary support

URI College of Ocean Engineering - For contributing monetary support

IGUS- For providing the tether for ICARUS

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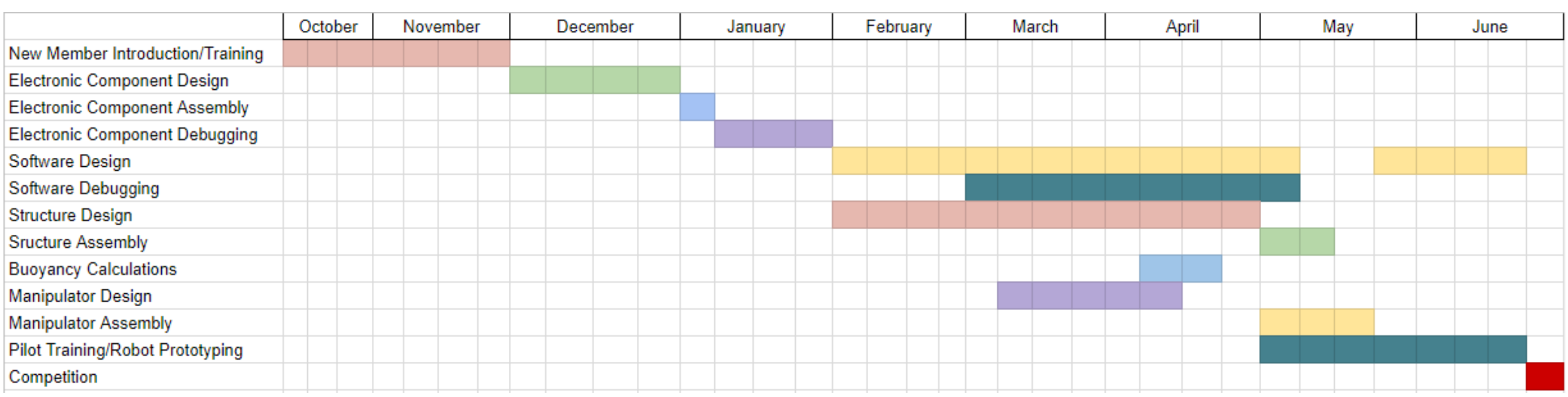
APPENDIX

GANTT CHART



BUDGET

2018 URI Hydrobotics Budget

		Reporting period	
School Name:	University of Rhode Island	From:	11/01/2017
Instructor/Sponsor:	Robin Freeland	To:	5/24/2018

Income				
Income at start of project (if any)				
Source				**Amount**
Raytheon Donation				$ 2,500.00
Deans office				$ 1,500.00
Ocean Engineering Department				$ 1,500.00
Team Donation Campaign				$ 800.00
Expenses				
Category	**Type***	**Description/Examples**	**Projected Cost**	**Budgeted Value**
ELECTRICAL COMPONENTS				
	Purchase	Custom Circuit Boards	$ 60.00	$ 60.00
	Purchase	Raspberry Pi	$ 150.00	$ 150.00
	Purchase	Wiring & Connectors	$ 20.00	$ 20.00
	Purchase	Speed Controllers	$ 100.00	$ 100.00
	Purchase	Sensors	$ 30.00	$ 30.00
	Donation	Tether	$ 154.00	$ -
	Donation	Waterproof Connectors	N/A	$ -
	Purchase	Thrusters	$ 520.00	$ 520.00
	Purchase	Cameras	$ 89.85	$ 89.85
	Purchase	Servo Motors	$ 94.17	$ 94.17
	Purchase	Slip Ring	$ 180.00	$ 180.00
	Purchase	Electronic Components	$ 720.00	$ 720.00
TOPSIDE CONTROL PANEL				
	Purchase	Pelican Case	$ 251.25	$ 251.25
	Purchase	Monitor	$ 156.99	$ 156.99
	Purchase	Wiring & Connectors	$ 300.00	$ 300.00
	Re-used	Keyboard / PC		$ -
	Purchase	Xbox Controller	$ 54.00	$ 54.00
	Re-used	Mouse	$ 10.00	$ -
	Purchase	Custom Panel	$ 162.00	$ 162.00
MECHANICAL				
	Purchase	Manipulator Parts	$ 336.20	$ 336.20
	Purchase	Custom Side Panels	$ 271.21	$ 271.21
	Purchase	3M Scotchcast	$ 75.38	$ 75.38
	Donation	Hot Glue	$ 15.00	$ -
	Re-used	Marine Epoxy	$ 20.00	$ -
	Purchase	PVC tubing	$ 100.00	$ 100.00
	Purchase	PVC material	$ 200.00	$ 200.00
	Purchase	HDPE Cross supports	$ 70.00	$ 70.00
	Re-used	Ballast	$ 30.00	$ -
	Purchase	Bouyancy Foam	$ 84.00	$ 84.00
	Purchase	Electronics Bottle	$ 60.98	$ 60.98
	Purchase	O-Rings	$ 10.00	$ 10.00
	Purchase	Tether Security	$ 30.00	$ 30.00
	Purchase	Nuts/Bolts	$ 250.00	$ 250.00
	Purchase	Lift Bags	$ 69.90	$ 69.90
MISC.				
	Purchase	Power Supply	$ 403.19	$ 403.19
	Purchase	Machining Costs	$ 200.00	$ 200.00
	Purchase	Outreach	$ 116.75	$ 116.75
	Purchase	T-Shirts	$ 611.00	$ 611.00
	Purchase	Register Fee	$ 300.00	$ 300.00

TRAVEL ESTIMATED COST	COST
6 People, Hotel, Airfare, Shipping	$5000 (based off previous years)

Total Income:	$ 6,300.00
Total Expenses:	$ 6,305.87
Total Expenses-Re-use/Donations:	$ 6,076.87
Remaining Funds:	$ 223.13