OCRobotx Team

Olympic College and Washington State University

WAM-V Application

for RobotX 2022 Competition

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Technical Approach and Justification

2022 will be the first OCRobotX Team event, and will present significant challenges. Primarily, raising the money to purchase the material items required, and travel costs associated with the competition in Australia. Moreover, the basic task of putting together a complete engineering group, and designing from startup the primary WAM-V Subsystems, coupled with the AI development, will likely force the team to confine itself to the Maritime Platform only and forego the UAV component of the competition. The WAM-V focus only, should not be considered an under-achievement by any means, considering the short ramp-up.

There are four major essential areas that must be designed, integrated, and proven, prior to any major sensor package development. Namely, the Ground Control Station (GCS), Onboard Mission Manager (MM), and the radio inter-connectivity frameworks—long range WIFI—the GCS and MM require the greatest amount of planning, design and testing. This design and testing should include forward thinking analysis of sensor capability and expansion. Secondarily, propulsion, power distribution and power management systems have almost equal importance to the overall success of the project mission rounding out the four areas. The goal is to develop a robust operating system design, scalable to handle the addition of sensors such as LIDAR, SONAR, RADAR, GPS/IMU, HD Vision and perception, as well as environmental weather, set and drift indicators/detectors, and propulsion control and feedback. The lack of rock-solid navigation, and positional uncertainty problems have plagued many of the RobotX competitors in the past. While the EE/CS team focuses on the computing infrastructure being constructed and tested. The ME teams will focus on the propulsion design and testing with two major goals: designing the propulsion control system to function under direct remote control—essential for initial deployment and placement of the platform—and secondly, semi-autonomous control via the GCS and MM, using waypoint concepts integrated with GPS and platform drift. Every attempt will be made to prove algorithm by algorithm performance, first with simulation, then a technique called ‘hardware-in-the-loop’. Hardware-in-the-loop consists of systematically replacing simulated sections, piece by piece, with real hardware proving the stimulus processing is reliable. Designing the MM this way allows for Sim-to-Hardware swap if a Subsystem fails and trouble-shooting in the field needs to take place. This technique also allows a complete system and pseudo-mission rehearsal prior to each in-water event.

Several of the RobotX team members in late 2019, designed and constructed a CrawlerBot (*see http://ocrobotx.org/mediawiki/index.php/Holonomic_Robotic_Platform#Project_Purpose*) using holonomic drive techniques in anticipation of using that experiential knowledge as an approach vector to design a more complex WAM-V propulsion system. It is apparent to the experienced team members that a combination of straightforward linear propulsion systems that can be mechanically articulated into a holonomic drive system presents the best of both options: speed when needed, and fine-grained maneuverability required to complete complex navigation maneuvers.

Power management presents a large opportunity for design consideration with respect to the computing network and infrastructure for sensor data processing, and AI backbone. Raspberry PI 4 computing has proven itself to be a very capable processing platform, hosting Python, MATLAB APIs, and other AI plugins. Distributed computing of multiple PIs can provide cluster computing performance, at literally a fraction of the super-computer cost, and using a miniscule amount of the power consumption. Linux, ROS, Python, and MATLAB are the primary software staples of the processing infrastructure required to complete the project, as well as embedded microcontroller devices similar to Arduinos.

Three primary sensor inputs, as well as advanced processing must be achieved to meet minimum competition status, namely: LIDAR, Vision and perception, and GPS/IMU. The EE/CS teams will divide the tasks among smaller working groups with articulated development and test events, as well as key subsystem integration milestones. LIDAR processing, vision mapping and AI perception, as well as occupancy grid development becomes critical as the project timeline progresses, since all of the competition tasks rely on mapping the field and interacting appropriately with the objects located in the range. The team has allocated funds to construct training aids to be deployed along with the WAM-V test phases, providing a competition range facsimile for training.

Secondary sensor development involves depth sounding/echo sounding sensors for bottom contour mapping which facilitates ground collision avoidance. Finally, SONAR ping detection, discrimination, ranging, and localization is also required to negotiate several of the competition challenges.

The ME teams' secondary task is to develop the projectile launcher required for the 'Dock and Deliver Challenge'. The in-water testing phase will primarily occur after the Vision-Perception algorithms and hardware have been range tested.

All design, development and test phases will be documented scrupulously as part of the team academic rigor. The OCRobotX team will employ the concept of 'The Digital Ecosystem'. The digital ecosystem (DE) goes hand-in-hand with the concept of Subsystem Integration plan. All team members will be trained to understand the significance of digital artifacts and how these products support the project.

Digital artifacts are defined as: project specifications, technical drawings, design documents, interface management documents, analytical results, bills of material (BOM), work breakdown structures (WBS), machining instructions, test procedures and test results and lastly schedules to include development, design, building, test, and integration. The project leadership is responsible for communicating the requirements as well as the appropriate artifacts and their purpose. The primary importance of digital artifacts becomes apparent during system integration, and producing the engineering paper required for the RobotX presentation. One critical function the DE fills, is to produce Objective Quality Evidence (OQE) to relevant stake holders, proving the engineering team has reached specific milestones in the development project, e,g. satisfying a progress audit by ONR, or WSU and OC staff. Since all of the DE is considered non-proprietary by RoboNation Standards, the OCRobotX team has opted to make all of the DE available at any time to the public via the OCRobotX Wiki located at: http://ocrobotx.org/mediawiki/index.php/Main_Page. The OC engineering club has most of the minutes published online since the first club meeting where the decision was made to participate in the competition (*see http://ocrobotx.org/mediawiki/index.php/OC_Engineering_Club org)*.

Design efficiency in learning heuristics will leverage work by previous team publications. The team will work to design an AI that is capable of determining the efficacy of its own decision making, i.e., the probability of mission success. This feedback can help the designers shape the machine and deep learning algorithms to maximize mission performance. One particular example would be an AI that monitors the power system to determine if the platform has the energy required to complete a range of tasks.

The master timeline for fundraising and development will take all of the time between the summer of 2021 through to November of 2022. A detailed Work Breakdown Schedule is embedded as two Gantt charts weekly and monthly. It is expected that momentum for the project will grow past the twenty students listed if ONR awards the platform to the OC-WSU Team.

Team Qualifications

Team Members	Academic Level	Major	Work Experience and Capabilities	Robotics Experience
C Zimmerman	Alchemy Code Lab	SWE	Junior Development SWE, Sales and Management	Raspberry PI
G Miller	OC Freshman	Finance	Business Owner, Accounting	
C Miller	OC Freshman	Finance	Business Owner, Accounting, AA Graphic Design	
J Martin	OC Sophomore	EE-CS	Naval Officer and Instructor, SWE, Navy Keyport Tech, IPC Mfr. Master Instructor, Surface Mount Electronics Master Craftsman, 3D Printing, Certified Solidworks ME DA	UUV, RobotX, SeaPerch, CrawlerBot, SMT Mfr.
N Zimmerman	OC Sophomore	EE-CS	Technical Writing, Business Writing	
D Rancap	OC Sophomore	ME		
K Richardson	OC Sophomore	ME		
Y Martin	WSU Junior	EE	Keyport Outreach Mentor (SeaPerch, RoboSub, Camp Create), IPC Mfr.	SeaPerch, CrawlerBot, Other
D Jensen	WSU Junior	ME	3D Printing, Plasma Cutting and Powder Coating Contractor	CrawlerBot
R Simpson	WSU Junior	ME	College Math Tutor	CrawlerBot
E Ma	WSU Junior	ME	Business Owner, Maritime Boat Handler	CrawlerBot
J Macinko	WSU Junior	EE	College Math & Physics Tutor, Certified Solidworks ME DA, SWE, Brand Ambassador	
J Pipkins	WSU Junior	ME	COSTCO Logistics Support	CrawlerBot
W Tablan	WSU Junior	EE		
Z Chausee	WSU Junior	EE	US Airforce Vet (Electronic Tech), Business Owner, Computer Repair	
B Otto	WSU Junior	EE	Service Industry Manager	
E Nolting	WSU Junior	EE	Logistics Manager	SeaPerch
G Legister	WSU Junior	ME	US Marine Corp Vet (Logistics), College Mathematics Tutor and Support Technician, NASA Aerospace Scholar, Professional Driver	
I Tran	WSU Junior	ME		
P Wolczko	WSU Junior	EE	ME Degree, Manufacturing Design, Cad ,CNC Machining, Eagle Scout, SWE	
J Guerreo	PhD	EE	Professor, Faculty Advisor	
M Kejariwal	PhD	EE	Program Coordinator EE,Professor, Faculty Advisor	
M Pitts	PhD	ME	WSU Program Coordinator MME, Faculty Advisor	Mechatronics
G Tuncol	PhD	ME,EE	Professor, Faculty Advisor	
P Dodge	BS	ME,EE	Lab Tech, Grad Student Participant	
B Asgharian	PhD	ME	Professor, Faculty Advisor	
J Stoch	BS	ME, EE	Keyport Advisor and Mentor	UUV, USV
D Bevans	PhD, Scientist	OCE	AI Keyport Team Advisor, Sonar Acoustics, Autonomy T&E, Small Boat Handling Advisor	UAV, USV, RoboBoat
M Renken	PhD, Scientist	EE	Keyport Team Advisor	UAV, USV, ASV, RobotX
J Stark-Dykema	BS	ME	Keyport Advisor and Mentor	
S Naranjo	MA	Education	Navy Senior Enlisted, Mentor, Teacher	
B Henry	BS	CS, SWE	Naval Officer, SWE, Software Advisor	
A Darnton	PhD	ME	Keyport Team Advisor	

(Table 1: Team Members and Advisors)

Facilities

Olympic College and Washington State University-Bremerton share an expansive campus, with an adequate project space and secure storage yard for large maritime vessels. The Kitsap peninsula is surrounded by water on all sides, and has eight public boat launches within 8.5 miles, the closest being less than three blocks from the shared OC/WSU buildings. Some of the team members have access to Keyport Naval Base 3d Printing innovation lab resources available for use, as well as OC having additive manufacturing capabilities. Olympic College specializes in training the Puget Sound Naval Shipyard workforce of tomorrow, consequently the campus has a robust Welding and Machine Shop capable of precision machining.

With a rigorous test schedule, and clearly defined test milestones (*see the project Gantt in the summary section*), the OCRobotX team will utilize Social Media, the local press, and Navy Region Support, to leverage every Maritime Test and Evaluation (MT&E) evolution as a public fundraising/awareness event, as well as a continuous recruitment tool for College Sophomores, Freshmen, and Highschool-College Running-Start Juniors and Seniors.

Test, Evaluation and Performance considerations are managed by a dedicated senior team position titled 'Marine Science: Subsystems Integrator' *('Systems Integrator' embedded document in summary for more detail*), This position will be filled by one of the most experienced and motivated students, relying on expert mentorship and advice from Naval Scientists, Engineers, and University Advisors. This individual is held accountable for the 'Integrated Design, Build and Test Plan'. Industry best practice shows that projects with an integration plan have a higher degree of success. This type of plan defines the stages of integration, during which system elements are successively integrated to form higher level elements, and eventually the finished RobotX platform. The integration plan includes descriptions of the required teams, test standards, testing methods, and integration schedule.

Sponsorship and Partnerships

Industry Partner/Sponsor		
Corporation	**Requested Product Support**	**Website Contact Location**
Tacoma Screw	Fasteners and Tools	http://www.tacomascrew.com/
Teledyne	sensors, cameras and image processing APIs	https://www.teledyneimaging.com/
Banner Engineering	Radar Sensor, LED Indicators	https://www.bannerengineering.com/us/en.html
Christina Foundation	Recycled Computer Systems, Displays	https://www.cristina.org/become-partner/
Glenair	Marine Grade Connectors, cables	https://www.glenair.com/
Copenhagen Subsea	Thrusters, Propulsion Hardware	https://www.copenhagensubsea.com/
Blue Robotics	Sonar, Depth Sounder, Thrusters	https://bluerobotics.com/
Mathworks	MATLIB Linux API Libraries	https://www.mathworks.com/
NVIDIA	Display Hardware, Vision AI, TX2 Kit	https://www.nvidia.com/en-us/research/academic/
Velodyne LiDar	LIDAR Module	https://velodynelidar.com/
SilverNet	long distance WIFI equipment	https://silvernet.com/contact-us/
Raspberry PI	Computing Hardware	https://www.raspberrypi.org/
Linak	Linear Actuator Modules	https://www.linak.com/about-linak/csr/sponsorships/
Volz	Servo Actuators, and support Hardware	https://www.volz-servos.com/
Torc Robotics	Remote Task Control System	https://torc.ai/
Theia Technologies	Linear Optical Lenses and Technology	https://www.theiatech.com/
Boston Whaler	Grants	https://www.bostonwhaler.com/
Parker Lord	Microstrain GPS/IMU Sensors	https://www.microstrain.com/inertial-sensors/all-sensors
Aptiv	Connectors, Cable, Tools, Grants	https://www.aptiv.com/
Costco Wholesale	Marine Batteries, Chargers, Fire Extinguishers, High Volume Inflater/Deflator, Folding Chairs, Portable Canopy, Portable Table	https://www.costco.com/charitable-giving.html
Private Industry Financial Support		
Corporation	**Requested Support**	**Website Contact Location**
Lockheed Martin	Grants, Monetary Sponsorship	https://www.lockheedmartin.com/
Northrup Grumman	Grants, Monetary Sponsorship	http://www.boeing.com/principles/community-engagement.page#/education
Boeing	Grants, Monetary Sponsorship	https://www.rtx.com/
General Dynamics	Grants, Monetary Sponsorship	https://www.gd.com/
Raytheon	Grants, Monetary Sponsorship	https://www.rtx.com/contacts
International Society for Optics and Photonics	Grants, Monetary Sponsorship	https://spie.org/education/education-outreach-resources/education-outreach-grants?SSO=1
Captain Planet Foundation-ecoTech	Grants, Monetary Sponsorship	https://captainplanetfoundation.org/grants/ecotech/
AMGEN Foundation	Grants, Monetary Sponsorship	https://www.amgen.com/responsibility/amgen-foundation/amgen-foundation-grants
SC Johnson	Grants, Monetary Sponsorship	https://www.scjohnson.com/en/interacting-with-sc-johnson/grants/
DiscoverE Engineers	Grants, Monetary Sponsorship	http://www.discovere.org/about-us/outreach-grants
Michael & Susan Dell	Grants, Monetary Sponsorship	https://www.dell.org/how-we-fund/grants/?tab=partnerships-content
Aflac	Grants, Monetary Sponsorship	https://www.aflac.com/about-aflac/corporate-citizenship/default.aspx
Bruce J. Heim Foundation	Grants, Monetary Sponsorship	https://brucejheimfoundation.org/grant-applications/Applications
Halliburton	Grants, Monetary Sponsorship	https://www.halliburton.com/en/about-us/serving-communities/halliburton-foundation-granting-programs
Shell Corporation	Grants, Monetary Sponsorship	https://www.shell.us/sustainability/request-for-a-grant-from-shell.html
Sony	Grants, Monetary Sponsorship	https://www.sony.com/en_us/SCA/social-responsibility/giving-guidelines.html
PPG Foundation	Grants, Monetary Sponsorship	https://communities.ppg.com/who-we-are

(Table 2: Anticipated Support and Partnership)

Management Approach

The OCRobotX team primarily consists of high school students, freshmen and sophomores pulled from Olympic College—serving as apprentice support staff to a more mature engineering team of 3rd year OC sophomores, and Juniors, Seniors and Grad students from Washington State University (WSU). Recruitment is ongoing primarily one on one. The OC recruitment slogan is "Each one Win one".

Team management occurs at three layers: Technical Project Management (TPM), Department Level, and Team Level. Leadership positions are voluntary and rotational. Top leadership is expected from more senior students. WSU has discussed integrating the RobotX project into one of it's Senior-Design options. There is consideration to grade holistically based on management success regardless of product deliverable efficacy. The TPM oversees the Subsystems Integrator (SI), the Engineering Team Manager (TM), the Public Relations Manager (PAO), and the Financial Manager (FiMa). Fundraising, Finances, Property Management, and Public Affairs are handled primarily by OC students majoring in finance, accounting, and multi-media degrees. The TM oversees respective engineering teams EE, ME, CS, Mathematics via the Team Leads. Teams are dynamically fluid and can be mixed disciplines based on the development and testing tasks and milestones (*see Gantt in summary section*). A complete laydown of team member core competencies and broad project responsibilities can be seen in the document embedded in the summary section below (OC*RobotX Team Member Duties*). Team working and planning groups determine team direction, and managers lead by example.

The OCRobotX team continually refines its management principles and documents requirements through the OCRobotX Wiki located at http://ocrobotx.org/mediawiki/index.php/Main_Page . The Technical Project Management documents and Gantt Production schedule are hosted by the software 'Projeqtor' with a team project instantiation located at http://ocrobotx.org/projeqtor/view/main.php, Login: Guest, Password: Guest.

Rough Order of Magnitude Cost

An estimate of expenditure totals can be found in the table (*Table 3: Total Costs by Category)*, for a detailed line-item breakdown see the embed table in the Summary Section. Social Media Platforms such as GoFundMe, as well as corporate sponsorship and grants will be heavily leveraged to provide financial resources to insure successful completion of the project.

Note: The Budget Estimation is a living document.

			Funding Source					
Categories		**Totals**	ONR	Keyport	OC/WSU	Industry Sponsors	Grants	Social Media Fundraising
Competition Travel Expenses	**(includes Travel Stipends)**	**$50,960.00**						
Material Cost	**(includes WAM-V)**	**$72,310.00**						
Maritime Platform Components		**$17,207.00**						
Constructed Items		**$7,200.00**						
Team Tools	**Totals**	**$4,105.00**						
Hazmat	**Totals**	**$305.00**						
Project Cost	**Total Financial Commitment**	**$152,087.00**						

(Table 3: Total Costs by Category)

Summary

The OCRobotX team has presented the University and College Staff, including the OC Dean with several briefs indicating the willingness of engineering students to participate fully in the competition. Enthusiasm has been expressed by students as early as the freshman class which includes high school Running Start participants. Recruitment strategy has purposefully focused on 2nd and 3rd year sophomores who pivoted into the Junior Class and make the core of this year's participants leveraging the RobotX competition as their Senior Project next fall. Encouraging non-engineering students to participate, leverages human capital for the area of public relations and finance, relieving engineering students of the burden of raising capital and engineering. Some of the team members have several years of professional logistics experience stemming from the military and private industry. Utilizing non engineering student participants as resources for solving financial and logistics issues in-tandem with the develop team ensures a high rate of success in meeting the goal of sending students to the Australian competition.

The Kitsap Peninsula has a robust mentorship program of RoboNation Initiatives—SeaPerch, Robosub—sponsored by Keyport and PSNS. Every opportunity to exploit the home team advantage to inspire STEM competition at a K-12 level will be afforded the program facilitators. The OC team has demonstrated that several students who have been previous RoboNation participants were inspired to join the OCRobotX team, and that the RobotX competition can become the RoboNation Capstone event.

The principal authors felt it was necessary to include additional information as embedded documents to illustrate the long-term commitment that members of the team have despite the debilitating social and physical separation from the College and University campus that the current pandemic has caused. They are offered as addendums to the provided information to assure the ONR application adjudicators that every effort will be made to follow through with the project commitment.

The following embedded items can be opened to provide extensive detail concerning the OCRobotx team proposal and referenced throughout this application.

OCRobotX_Budget_Estimate.xlsm *Detailed Line-item Budget Estimate*	ProjeQtOr_Weekly.mhtml *Detailed Project Gantt-Weekly*	ProjeQtOr_Month.mhtml *Detailed Project Gantt-Monthly*
Subsystems Integrator - RobotX.pdf *Marine Science System Integrator*	RobotX Team - responsibilities.pdf *OCRobotX Team Member Duties*	Project Management - RobotX.pdf *Basic PM Guidelines*

These items are bundled as attachments to the PDF file.