# BIOSwimmer™: Specifying Requirements and Interfacing Systems for an Autonomous Underwater Vehicle

A Major Qualifying Project Report respectfully submitted to the Faculty of Worcester Polytechnic Institute in partial fulfillment of the Degree of Bachelor of Science

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# Abstract

Sponsored by the Advanced Systems Group at Boston Engineering Corporation (BEC), this MQP aims to assist BEC with the Phase II development of the Biomimetic-In-Oil Swimmer (BIOSwimmer™). BIOSwimmer™ is an autonomous underwater vehicle designed to inspect the filled compartments of oil tankers for contraband. The project team verified the Phase I results and performed a detailed evaluation of potential sonar units with the cooperation of vendors. Test plans and flowcharts for software modules were created to help in the next phase of testing different sonar units and running integration tests. The project team explored how to interface between commercial-off-the-shelf object detection software and the inspection sonar system on the vehicle. In addition, the project team modified a BEC simulation from another project called GhostSwimmer™. These modifications consisted of alterating the simulation to demonstrate how a pencil-beam sonar will operate in high attenuation environments, including simplified multipathing.

## Acknowledgements

The project team would like to acknowledge as well as thank Mike Rufo and Boston Engineering for all of the guidance and sponsorship of this Major Qualifying Project. Even though the original intended MQP by the project team was to be much more hands on, this sponsored project proved to be a great experience and provided good insight into how a real life engineering firm operates. Although many road blocks dealing with outside vendors occurred during the project, Mike was always there to redirect the group onto the next task.

Many thanks also go out to Professor Padir and Professor Chernova for all their guidance, advice, and feedback during the project as advisors. The project team would also like to thank Matthew Sweetland and Paul Igo for their support in the project, in particular Paul for help with obtaining loaner sonar units and Matt for helping with the software tasks towards the end of the project.

# Contents

## List of Figures

## List of Tables



## List of Equations

## Executive Summary

Within the last decade the United States of America has focused extensively on strengthening and improving national security. Airports have stricter regulations and tightened security all around. Border control practices have been improved and there are more identification checks, even for United States citizens. The Department of Homeland Security (DHS) has taken not only these measures but has funded many other initiatives to improve our national security.

One of these areas to explore is the inspection of oil tankers docked at our national ports. Through SBIR grants, DHS is currently funding a project being ran by Boston Engineering Corporation (BEC) to develop an autonomous vehicle to perform in-liquid inspection and tackle these issues of identifying objects of interest (OOI) within the compartments of oil tankers. The platform for this project is called Biomimetic-In-Oil Swimmer, also known as BIOSwimmer™. BEC proved the feasibility of this vehicle in their Phase I period of the SBIR grant, and is currently developing a working prototype in the two-year Phase II period.

To help define the specifications and to better understand the issues associated with this project, the Advanced Systems Group at Boston Engineering Corporation pursued the aid of a student formed Major Qualifying Project (MQP) from Worcester Polytechnic Institute (WPI). This MQP has aimed to assist BEC with the Phase II development of BIOSwimmer™. The project team began their work with verifying the Phase I results and performed a detailed evaluation of potential sonar units with the cooperation of vendors. After narrowing down the potential candidates for inspection and object detection and obstacle avoidance (ODOA), the team worked to create test plans to collect data which would be useful in parameterizing imaging quality and specifying vehicle constraints.

The project team then created flowcharts for software modules which would be used to run tests from the test plans on the actual AUV. In addition to those, flowcharts were created to describe how the inspection software would operate with the vehicle and operator control unit (OCU) software. The project team then explored how to interface between commercial-off-the-shelf object detection software and the inspection sonar system on the vehicle. To learn about these interfaces, the project team worked with BEC to meet with Seebyte representatives. In addition, the project team modified a BEC simulation from another project called GhostSwimmer™. These modifications consisted of alternating the simulation to demonstrate how a pencil-beam sonar will operate in high attenuation environments, including a simplified multipathing. All of these deliverables consisted of an additional report which explained the findings and drew conclusions. Overall, the project team gained invaluable experience with systems engineering, and helped to drive the specifications and requirements of a real-world vehicle that will be improving national security.