Virtual Reality Bridge Trainer

Standalone Ship Bridge Trainer Using Virtual Reality

ELECOMP Capstone Design Project 2021-2022

Sponsoring Company:

Rite-Solutions, Inc.
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Company Overview:

Rite-Solutions is an award-winning Veteran-Owned Small Business (VOSB) headquartered in Middletown, Rhode Island, established since April 2000. We have a stable and deep corporate history in Rhode Island, with over 280 employees with core competencies including systems engineering, software development, information technology, and cyber engineering. The stability of our business is demonstrated by both our longevity and our business backlog – well over $200M in recent contract awards that will be executed over the next 5 years. We have achieved both state and national recognition; one of our founders, Joe Marino, is an active member of the RI Science and Technology Advisory Council, along with other trusted Rhode Island business and academic leaders.

Rite-Solutions is known for innovation and dedication to the information and decision support needs of our government and commercial customers, a commitment we have coined as a company slogan, *The Information Advantage™.* We have significant US Navy prime contracts in both warfare systems and business systems development and sustainment, as well as in Information Technology infrastructure support and cyber protection. In our research and development efforts, we demonstrate a proclivity for our own inventive solutions but also for finding and working with non-traditional partners, including academia and small commercial businesses, whose technologies we adapt to national research objectives in practical and meaningful ways that lead to productization.

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Our corporate culture is a major part of our drive to both attract and retain people who make a difference. We take pride in our ethos of the F.E.W. (Friends Enjoying Work). Our ownership and management team work to create an open, creative, and stimulating environment. Our founders embraced the servant-leader concept from company inception, and it continues to guide our management team and approach. We recognize great ideas can and do come from anyone, not just the C-suite. To facilitate ideation in an engaging format, we built and maintain a company-wide platform called Mutual Fun that promotes corporate giving, training, and innovation in technology and our culture in a stock game format. This approach to business nurtures the employer/employee relationship and moves our teams to a model where anyone who wants to can be part of the company's growth and contribute to our success. We have won numerous awards, including a recent award in 2021 as the **Providence Business News "best place to work"** among large organizations (> 150 employees), and received extensive media coverage and academic interest about our culture, including as the subject of case studies by Harvard University and Stanford University, in employee motivation and idea generation techniques.

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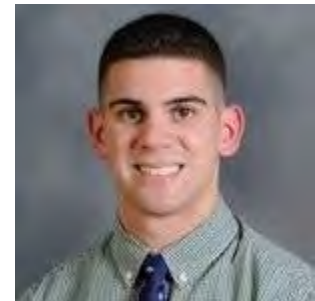
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Project Motivation:

For our commercial and DoD/Navy customers, a well-trained workforce is essential to their success. Unfortunately, training has lagged as the complexity and the nature of operational challenges continue to quickly grow and expand. Lack of adequate training has been identified as a key contributor to tragic accidents at sea for two major US Navy ship collisions (i.e., USS Fitzgerald and USS John McCain). Contributing to the training challenge is the lack of availability of training facilities and resources so that individuals can continually improve their skills while they are onshore or at sea.

Our project addresses this challenge by developing a standalone training system that utilizes new technologies such as Virtual Reality and gaming engines. VR devices coupled with a gaming engine that operates on a standalone laptop computer can provide low cost, individualized training to improve skill levels. Additionally, training can be made more compelling and interesting through gamification to appeal to a new generation of sailors. For this capstone project, we will focus our efforts on the development of a ship bridge trainer to improve the navigation skills of junior officers and navigation technicians by providing a simulated but realistic virtual environment. Moreover, this capability is relevant to both commercial and Navy vessels.

Anticipated Best Outcome:

The goal of this project is to design, develop, and implement a realistic and immersive Virtual Reality (VR) training program to train maritime operators how to handle and navigate their ship under various conditions to include abnormal weather, high contact density, and visual-only navigation. The application will be designed based on open system/industry standards and open software solutions to the greatest extent possible, will be able to support the use of a variety of commercial VR headsets (i.e., device agnostic), be modular to accommodate hardware/software, enhancements easily upgradeable to support multiple training scenarios, and operate on a standalone laptop.

Primary Objectives:

- Simulate the bridge or cockpit of a vessel to travel across an open body of water
- Develop realistic ship-handling physics (i.e., no sudden or sharp turns for large vessels)
- Accurately simulate the surrounding geography to include major land and port features
- Use Digital Nautical Charts to plot navigation buoys and navigation aids
- Include secondary contacts for the operator to interact with

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Secondary Objectives:

- Full range of weather options including, but not limited to, rain, fog, snow, hail, wind, etc.
- Fully adjustable set and drift to include speed and direction of current
- Adjustable sea state with rocking and swaying simulations
- Utilize the headset controllers to enable the operator to use simulated versions of:
    - Interactive radar with contact returns
    - A DNC chart viewer for simulated navigation
    - Automatic Identification System (AIS) display and user functionality
    - Ship's whistle
    - Throttle and steering
- Interactive sounds coming from the environment and other vessels (i.e., motor sounds, rushing water, ship's whistle)
- An option to record the training scenario to review lessons learned and mistakes made while conducting the approach

Project Details:

Overall system concept:

Driving a ship is a skill that requires lots of practice and experience to master the art. Many people never get the opportunity to pilot a vessel, and when they do, are often overwhelmed at the foresight and attention required to operate it. This becomes even more complicated when trying to pilot a massive commercial tanker or a naval warship with varying degrees of maneuverability. Today, much of this training comes with practical experience or word of mouth training. Where training facilities/resources do exist, there is limited availability and opportunity for individuals to learn and improve their skills. However, with advances in VR headsets, ship handlers can train in an immersive environment that eliminates danger while providing a rich, realistic training experience.

For a proof-of-concept demonstration, the proposed training system will provide immersive simulation of multiple port ingresses and egresses to train ship operators on various platforms. Specifically, our training scenarios will use Narragansett Bay as the proposed training environment where scenarios will simulate ingress/exit approaches from Providence/Bristol/Newport, RI to the Atlantic, and vice versa.

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Figure 1 is an example of an approach between Conanicut island and Newport. The simulation can start either just east of Gould Island or south of Newport approaching from the Atlantic. Major features of the route will include the buoy system guiding the approved transit lanes, Jamestown and Newport landscapes, and the Claiborne Pell Newport Bridge. The approach is approximately 8.5 nautical miles long. At an assumed speed of 10 knots the approach will take 51 minutes.
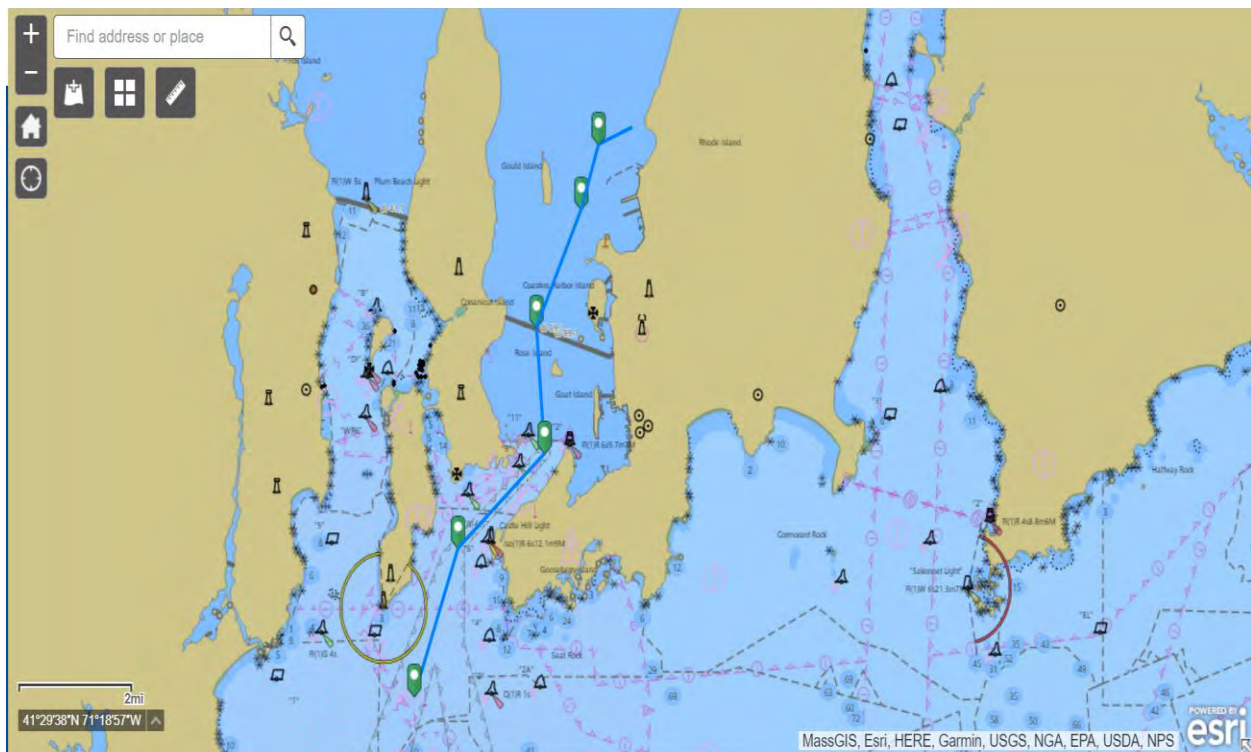
Figure 1 Example Newport Approach

Operation of the headset and the simulation software will be utilized as follows. The trainee will use the headset and be able to see the approach as if they are in the bridge or pilot house of a commercial or naval vessel. The trainee using the headset will be able to view radar for contact management, a Digital Nautical Cart (DNC) viewer for navigation and be able to operate the throttle and steering.

Another person (trainer) will be operating the training software running on a laptop. This person will be able to create secondary contacts so that the trainee using the headset will interact with and avoid these contacts. These contacts can be programmed to take a predetermined track or

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adjusted on the fly to test the trainee's spatial awareness. The trainer will also be able to set progressive weather and sea state conditions to challenge the trainee. In the absence of manual steering and throttle control, the trainee can issue verbal commands to the trainer to turn to a specific course and adjust speed.

The trainee should feel as if they are actually in the port they are operating in. This experience will be enhanced by accurately mapping the approach and building a realistic display of the surrounding terrain. Many experienced mariners use visual ques to mark their turns and line up their approaches, so the more detailed the terrain, the better the training product. Interactive sounds can also be developed to provide the trainee with a more immersive, realistic environment including the use of fog signals defined in the Nautical Rules of the Road.

This project will utilize a commercial VR product, the HTC Vive. However, it is important that the software design and development be modular and device agnostic so that future versions can accommodate other existing or new VR headsets. Similarly, open system standards, industry standards, open system solutions, and open/public datasets (e.g., maps, terrain, DNC, etc.) will be used to the greatest extent possible to mitigate risk and minimize development effort. Additionally, the VR headset will need to interface with the proposed gaming engine – Unity.

Software/Computer Tasks:

- Become familiar with HTC VIVE Virtual Reality Headset
- Become familiar with 3D game engine Unity
- Become familiar with C# and its development environment
- Develop Virtual reality 3D environment in Unity using Vive SDKs
- Create and or use API needed to construct scenario
- Get familiar with Blender and its 3d modeling software
- Find open source/public datasets needed for 3d environment (maps, terrain, satellite, DNC, etc.)
- Create 3d assets in blender that cannot be found and sourced
- Import 3d assets successfully into Unity from Blender
- Develop Virtual Reality user interface menu in Unity to select Scenario configuration and conditions
- Develop training scenarios in Unity

Composition of Team:

3 to 4 Computer Engineers

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Skills Required:

Computer Engineering Skills Required:
- Gaming Engines such as Unity or Unreal
- Game development
- Virtual Reality devices such as HTC Vive, Oculus Rift, etc.
- Software languages: C#, C++
- 3D Modeling and tools (e.g., Blender)

Anticipated Best Outcome's Impact on Company's Business, and Economic Impact

Rite-Solutions is continuing to expand our training system development capabilities for our DoD/Navy customers. We are currently a prime contractor for the AN/BYG-1 Onboard Team Trainer – Master Control (OBTT-MC) and the Electronic Warfare (EW) Trainer, and a subcontractor for other submarine based onshore and at sea training systems such as the Submarine Multi Mission Team Trainer (SMMTT). However, these resources and associated training opportunities are fixed in shore-based facilities and thus provide limited training opportunities. As a result, there is a growing demand for standalone trainers for use at sea as well as onshore to address immediate Navy needs to improve skillsets in numerous areas. The proposed trainer addresses a need identified by our staff who were recently active Navy service members. We view this capstone project as an opportunity to expand our training capabilities into a new and growing market as well as demonstrate the use of new and emerging technologies such as gaming engines and VR to provide training in new ways for a new generation of students.

Broader Implications of the Best Outcome on the Company's Industry:

Our immediate focus is on ship safety. As noted, the inadequacy of training has been a critical element in recent accidents at sea. Our proposed training system provides a relatively low cost solution to train students in ship handling. Rather than provide generic ship handling training to a student, we will be able to immerse the trainee in a simulated environment that is realistic to the one they will be operating in at sea. Moreover, we will be able to develop multiple levels of training to challenge all students to continuously improve their capabilities and skill level in a timely manner. As new operational challenges emerge, we will be able to rapidly develop and deploy new scenarios to address immediate training needs. Hopefully, this will aid in preventing future accidents.

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