Integrating Real-Time Vehicle and Watercraft Modeling and Simulation Tools for Analysis of Amphibious Operations

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Introduction

Amphibious operations are complex, multi-domain problems that occur in an unpredictable environment. As such, they require knowledge and understanding of the battlespace to be successful.

The present work was undertaken to develop and demonstrate a proof-of-concept tool that combines existing ERDC simulation capabilities for watercraft and ground vehicles. The new multi-domain co-simulation environment allows for the modeling and simulation of amphibious operations.

Existing Simulation Tool: Ship/Tow Simulator (STS)

Since the 1980s, the ERDC STS has served as a vital engineering tool to evaluate designs or modifications of ports, harbors, inland waterways, etc. for the U.S. Army Corps of Engineers (USACE). The ERDC STS consists of three full mission ship bridges that feature hardware to replicate an actual ship bridge. Simulations occur in real-time, and the bridges can operate independently or be connected to capture ship-to-ship interaction.

A 2015 pilot study explored using the STS to support amphibious operations planning. During this study, the operational parameters of axes of assault, timing, and lighting were examined. The resulting data were used by U.S. Marine Corps (USMC) subject matter experts (SMEs) to develop an operational landing plan successfully.

Craftmaster piloting LCU toward the shore in one of the STS bridges

Existing Simulation Tool: Autonomous Navigation Environment Laboratory (ANVEL)

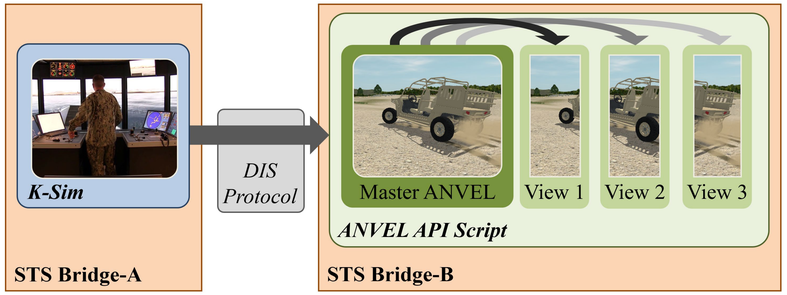
For over a decade, ERDC has been developing and using a suite of government-owned modeling and simulation (M&S) tools to assist in unmanned ground vehicle (UGV) autonomy development. These tools comprise the Virtual Autonomous Navigation Environment (VANE) and include vehicle-terrain and sensor-environment simulation capabilities. The VANE tools can be configured to operate independently or in a co-simulation.

The VANE tool ANVEL was used for ground vehicle simulations in the present study. ANVEL enables users to build models of a UGV system (including the sensors) and perform interactive testing in a virtual environment. Several U.S. Army robotics programs have made extensive use of VANE::ANVEL to perform early autonomous algorithm development before physical systems were available for testing.

Co-simulation Approach

In the Ship-to-Shore (S2S) simulation environment, each constituent M&S tool retains supremacy over its own traditional domain. Thus, the primary new development required to enable the proof-of-concept co-simulation tool was the creation of a communication bridge between the STS and ANVEL to synchronize craft position in the two simulators. The DIS standard was implemented to facilitate this data transport.

The co-simulation took place in two stages. In the first stage, the ANVEL simulation was a passive mimic of the STS until the Landing Craft Utility (LCU) reached the shore. At that point, the second stage started, and ANVEL took control of the vehicle model as it was manually driven onto the beach and then inland. During the initial demonstration of the S2S tool, the vehicle was controlled manually. However, ANVEL retains the capability to integrate autonomy for software-in-the-loop simulations. Thus, an S2S co-simulation of UGVs disembarking from a landing craft would be possible should it be required.

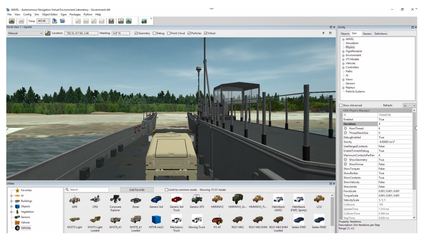


Amphibious co-simulation architecture.

Demonstration

A virtual representation of Mile Hammock Bay (MHB) in North Carolina, USA, was created to enable the demonstration of the S2S proof-of-concept. The geometry of both the STS and ANVEL virtual environment was based on off-the-shelf light detection and ranging (LIDAR) from the National Oceanic and Atmospheric Administration (NOAA), but the K-Sim scene required additional data to define typical wind and current conditions that would affect the LCU.

The combined capability provides a novel environment for ship-to-shore mission assessment. This will enable enhanced planning, rehearsal, and decision support prior to mission execution.



Vehicle being driven off LCU in ANVEL

Conclusion

The S2S technology developed in this study could potentially play a significant role in the preparation and rehearsal stages of a Multi-Domain Operation (MDO). S2S M&S incorporates hydrodynamics, ship motion, vehicle performance, and terrain parameters. This enables the analysis of a landing operation from its origination in the well-deck(s) of a ship(s) stationed below the horizon to the beach to the final upland objective. By combining both sea and land domains into a single co-simulation tool, planners can assess risk and determine the timing and logistics of littoral and upland operations in real-time. This analysis allows planners to develop operational plans based on potential weather, sea, and land conditions and gives operational commanders significantly more data than previously available to make go/no-go decisions.

ANVEL and the STS are both valuable tools in their respective domains. However, ERDC SMEs created a new Ship-to-Shore M&S capability by combining these existing tools into a co-simulation architecture. The S2S proof-of-concept represents one of the ways the ERDC M&S tools are evolving to engineer and win the future fight. Many possible improvements are being explored to transform the proof-of-concept into a robust simulation tool for MDO. These improvements include expanding the types of operations that can be simulated, increasing the size of operations simulated, and improving the technology itself through research and development (R&D) initiatives.

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