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Hydrogen Fuel in Support of Unmanned Operations in an EABO Environment

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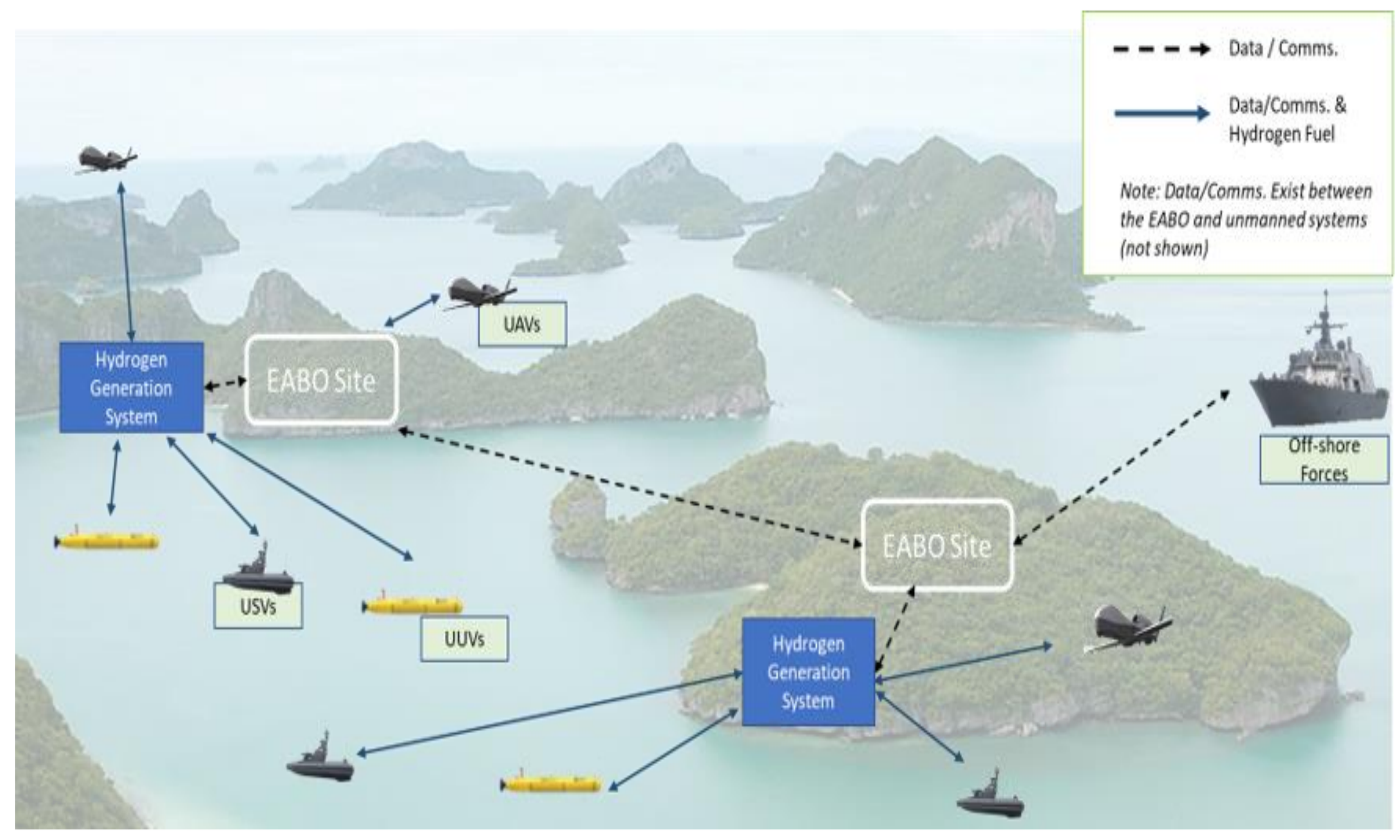
Hydrogen Fuel Enabling Unmanned Capabilities

Naval Postgraduate School

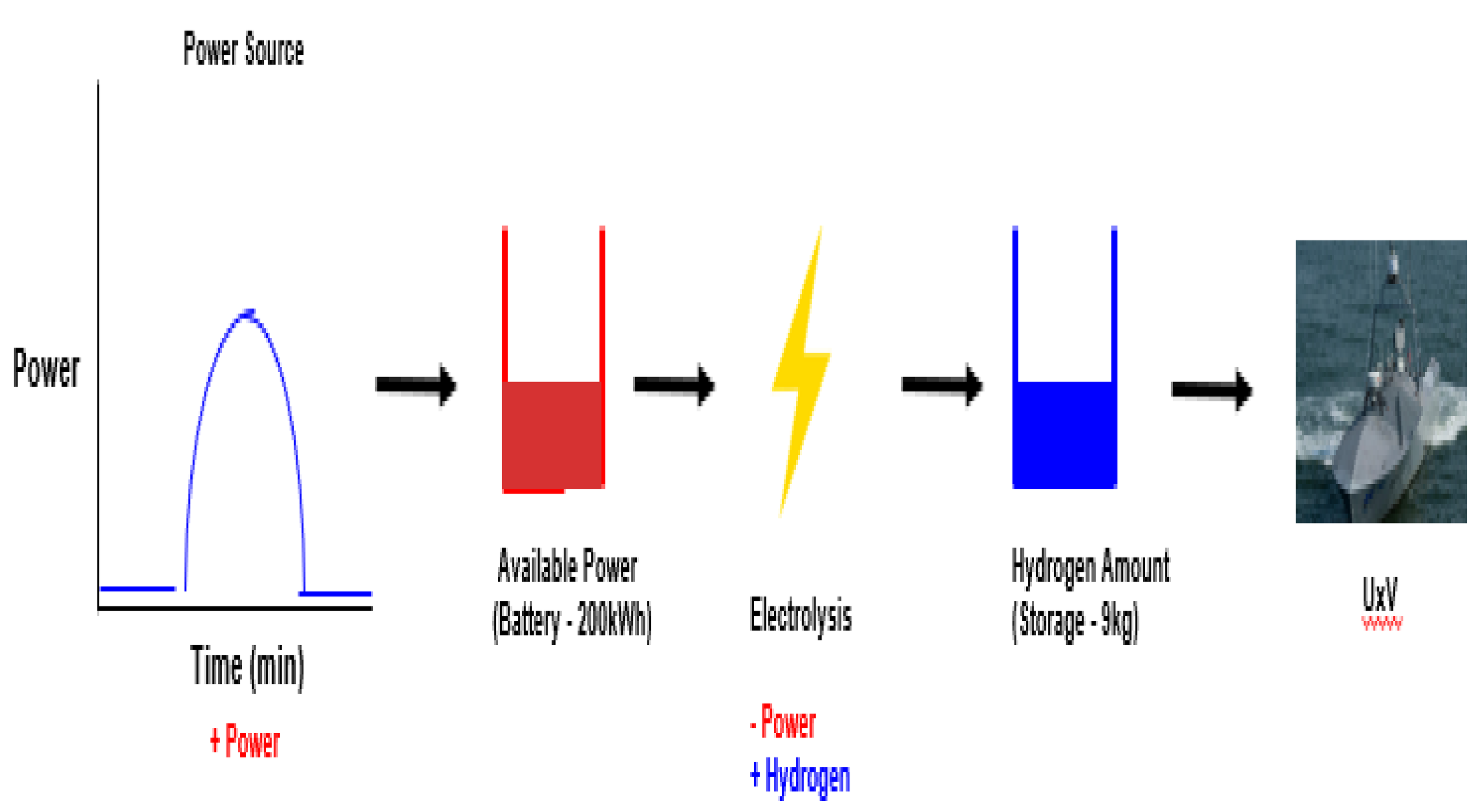
Motivation

Navy and Marine Corps planners developed the Expeditionary Advanced Base Operations (EABO) concept of operations to provide maritime commanders with more options for future sea control operations. EABO is envisioned as complementary to Littoral Operations in a Contested Environment (LOCE), which provides specificity regarding the concept for logistical support to multiple EABO sites. Those concepts and directions define a future combat environment that demands risk-worthy platforms to perform sea denial as a low-signature "inside force" that is untethered from a large petroleum supply chain. This study is motivated by that guidance and conducts an operational assessment of hydrogen requirements for use as a fuel in an EABO environment.



Distribution of hydrogen fueling sites to support Expeditionary Advance Base Operations (EABO)

Approach

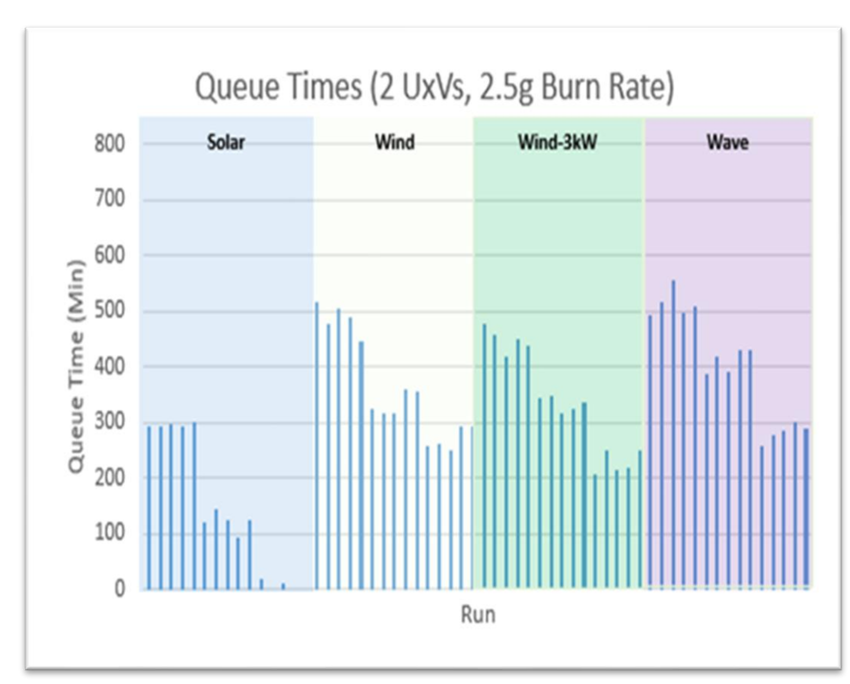


Implementation of Solar as a power source for electricity generation to enable electrolysis to utilize hydrogen fuel harvested from seawater

To assess the viability of hydrogen fuel this project utilized a discrete-event simulation in a software program called ExtendSim. The ExtendSim model simulates multiple EABO operational sites distributed across an island chain. Each site utilizes a combination of unmanned surface vehicles (USVs), unmanned undersea vehicles (UUVs), and unmanned aerial vehicles (UAVs). The model assumes that, since the EABO and LOCE concepts emphasize distributed operations, that each hydrogen generation system can operate without demand for external resources. This means that each hydrogen generation system has the capability of generate electricity and subsequently power the electrolysis of seawater into fuel. Additionally, there is an assumed constraint on the size of the hydrogen generation system. The model assumes that the system is transported to the site by a CH-53 helicopter, which dictates limitations for both size and weight.

Results

The model assessed the viability of alternative electricity generation strategies to support hydrogen generation that is decoupled from traditional fuel chains via harvesting of hydrogen from seawater. The model was exercised for a 7-day timeframe (10,080 minutes) and systematically varied the following as part of a designed experiment: quantity of unmanned systems (UxVs), UxV tank size, UxV hydrogen burn rate, UxV travel time to mission area, UxV operational deployment duration, hydrogen refuel rate, electricity generation type, and number of electricity generation systems. The analysis showed the use of solar electricity generation, rather than wind or wave approaches, has the largest impact on operational performance. Notably, approximately 10 solar devices are able to keep 30 UxVs refueled over a one-week timeframe. As comparison, the next highest performing alternative, a 3kW rated wind turbine, requires approximately 20 systems to refuel 20 UxVs. The other electricity generation types considered (a 1kW rated wind turbine and a wave generator) are only able to support an average of 14 UxVs.



Simulation results showing unmanned system refueling capacity using different electricity generation techniques

Future Work

Direct follow-on research can be dedicated to a comparison of the preferred solution from this project to other alternatives that were beyond the scope of this research. Solar appears to be a more promising technology in the near term than either wind or wave for hydrogen generation and may warrant additional emphasis. The results suggest investigation that compares hydrogen fuel to other potential fuel types, especially nuclear, may be worthwhile using a similar approach.

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