Cognitive and Fatigue Field Assessments

Ryan Couse, Mac Kortrey, Alex Nwogu, Natalie Weaver
Faculty Advisor: Dr. Charlie Klauer Client Contact: Bill Shepherd

Company Background

- The Systems Engineering Research Center (SERC) is a not-for-profit, University Affiliated Research Center that is sponsored by the Department of Defense.
- The SERC conducts research with the objective of having a positive impact on the national security of the United States

Client Background

- The SERC put us in contact with U.S. Navy SEAL Delivery Vehicle Team - 2 (SDVT-2), which operates under the United States Special Operations Command (USSOCOM).
- SDVT-2 is stationed at Joint Expeditionary Base in Little Creek, VA and are currently using a Dry Combat Submersible (DCS) to transport and deploy SEALS during missions.

Problem Description

The Dry Combat Submersible (DCS) is still in its prototype stage, so there has been little to no research done on the task demands of this specific work environment. As a result, the Pilots and Co-Pilots are conducting missions on unvalidated shift lengths. The crew also has no way to measure their levels of workload and/or cognitive fatigue during the mission, leaving optimum performance unknown.

DCS Overview

Crew Members
DCS can hold up to 10 crew members, 3 or 4 of whom are trained Pilots/Co-Pilots

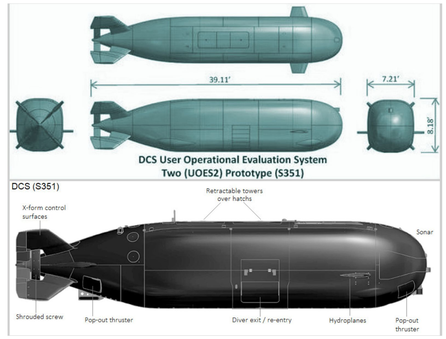
Mission
Future missions can be up to 72 hours with an additional 4 days of life support

Current Operations
The Pilots and Co-Pilots are currently operating on a 6 hour shift schedule

Task Demands
Pilots and Co-Pilots need to be responsive and track various data sets and systems

Confined Space
The ship is 9 ft wide, 40 ft long, and is separated into 3 compartments

Rest Conditions
The conditions for rest are very poor, as the entire interior of the ship is made of steel

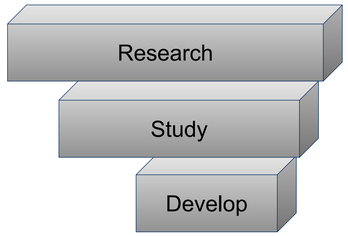


Project Approach

Phase I: Conduct literature review on task demands, shift lengths, and different fatigue measurement methods.

Phase II: Develop a human performance study to assess the sensitivity of different fatigue measurement methods as well as the impact of shift length for a 12-hour mission.

Phase III: Develop an optimum shift schedule guide for SDVT-2 12-hour missions and measurement tools to assess appropriateness of shift durations for longer missions.



Experimental Design

Objectives
- Simulate the DCS environment as effectively as possible
- Utilize a set of previously validated surveys and neuropsychological tests to assess fatigue and cognitive abilities over time

Measurements
- Cognitive Assessments
  - Arithmetic table
  - NASA-TLX workload assessment
  - Simon working memory span task
  - Repeatable episodic memory test
  - Reaction time task
  - Stroop Color and Word Test
  - Paced Auditory Serial Addition Test (PASAT)
  - Trail Making Test
- Physiological Assessments
  - Non-invasive continuous monitoring
  - Devices
    - Empatica E4
    - Actigraph
      - wGTX3
      - CenterPoint Insight
      - GT9x Link
    - HR Monitors - Polar H10, H9, OH1

Procedure
- Participants - recruit 12 total members from the Virginia Tech Naval ROTC in 4 groups of three
- Duration - 12 hour period on weekends
- IRB Approved

Tasks
- Pilot - Operation of a Digital Combat Simulator
- CoPilot - Perform a variety of logging tasks, track noticeable trends in the data, monitor Pilots performance
- Rest - Remain seated, may read hard copy materials

Polar OH1 Optical Heart Rate Sensor

Microsoft Flight Simulator

Expected Findings

Physiological Indicators of Fatigue
- Heart Rate Variation: Increased HRV indicates increased cognitive demand and increased cognitive fatigue
- Wrist Activity: Little to no wrist movement for 4-5 minutes indicates fatigue

Cognitive Indicators of Fatigue
- Performance on cognitive assessments will decline over time as fatigue increase
- Investigate which cognitive indicators are the most sensitive for this population and work environment

Shift Schedule Guide
- Identify the point during a 12-hour mission at which cognitive ability has significantly declined, indicating a job rotation is necessary
- Project findings to develop guides for 24-hour, 36-hour, and 48-hour mission lengths

Deliverables

Human performance study experimental design for future team and/or Navy use

Non-invasive fatigue measurement methods that can be used in the mission environment

Shift schedule guide to aid in determining shift lengths for various mission durations

Impact

Potential savings from avoiding fatigue-related failures
- Program Cost: $236 million for 3 Dry Combat Submersibles
- Personnel Cost: training a Navy SEAL is estimated to be $350,000 - $500,000

Potential benefits from increased cognitive performance
- Increased alertness, vigilance, and focus to ensure mission success

Time saved for future projects
- VT senior design: 4 months for research and IRB application
- DCS Simulator: Suggested tasks to mimic the Pilot and Co-Pilot demands
- SDVT-2: Methods to accurately measure fatigue during missions