VICTORIA Class Submarine Human-in-the-Loop Experimentation Plan and Preliminary Results

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Concept Development Design Framework

Knowledge Sources
(doctrine, SMEs)

Knowledge Acquisition

Requirements Generation

Refinement and Implementation

Domain Knowledge
Work demands

Design Requirements
Conceptual Artifacts

Physical Artifacts

Work Analysis

Identification of Design Concepts

Test/ Experiment (in vVICTORIA)

Problem Space = Work Environment

Solution Space = Artifact Space

Feedback

Evaluated Design Concept

Test result

Design hypothesis

Ref: Chalmers
VICTORIA C2 Design Concepts

- Top Rated Concepts by SMEs
  - C2 Information Integration & Tactical Display
  - Automated Record Keeping
  - Integrated Planning Tool
    - Navigation, tactical planning, signature management, platform systems management, comms
  - Emergency Management Tool
  - Reliable & Flexible Internal Comms System
  - Platform Systems Display
  - Signature Management Display
  - Improved Collaboration Between Command Team and EW - various design options
Information Integration Display
IID HIL Experimentation

- IID Placement in VCEL
  - Between Sonar and Fire Control.
  - Based on visual angle, and optimal viewing from various areas in the control room.
VICTORIA Capability Evaluation Laboratory (VCEL)

- Full Scale Plywood Mockup of VCS Control Room
- Simulation + Real Systems
- Audio, Video, Motion, Eye Tracking

Paper 075 for more details
Experiment

Participants

- Two Separate Teams
  - Watch Leader
  - 2\textsuperscript{nd} Officer of the Watch (OOW)
  - Sonar Supervisor
  - Sonar
  - TMA
  - ECM*
  - Helm*

- Team 1 had a more experienced WL (4.5 years) vs. Team 2 (.25 years) but overall team experience was similar (11 years vs. 10 years)

Scenarios

- Four Separate Scenarios
  - Same Operational Environment
  - Same Number of Contacts
  - Similar Mission (ISR)

- Communication Analysis
  - Assessed the scenarios for similarity
    - SMEs rated communication trends and workload as being the same.

- The majority of participants assessed their workload as average across all scenarios.
Procedure

- **Day 1: Training Day**
  - Both teams received training
  - Crew received Dangerous Waters training
  - Watch Leader received IID training

- **Day 2: Team #1**
  - Completed Four Runs
    - 2 Experimental Condition (IID)
    - 2 Control Condition (No IID)
    - 1.5 hours each
    - Debriefing session and questionnaire after each run.

- **Day 3: Team #2**
  - Same procedure as Day 2
    - Conditions and scenarios were counterbalanced.
Data Collection 1/2

- Watch Leader was equipped with SMI Eye Tracking Glasses
- Data was used to evaluate where the WL was looking on the IID.
Data Collection 2/2

- **Audio, Video, Motion**
  - Four wall-mounted video cameras + single mike
  - MP3 to record audio
    - Each team member
  - Microsoft Kinect
    - Measure movement in and around the control room.
    - Secondary Video Source

- **Screen Capture**

- **Debriefing Questionnaires**
  - Completed by each crew member after each run
  - 5 pt. Likert Scale

- **Simulation data**
  - Actual scenario state
  - Combat system data
Analysis Plan

- SME Evaluation for Performance and Situational Awareness
- Scenario based Warfighting performance metrics
- Behavioural Changes
  - Heat maps of OOW/2OOW movement
- IID Specific Assessment
  - Eye tracking data for actual usage
  - Correlation with tactical decision making by SME
  - Participant evaluations
SME Evaluation

- Former RCN Submarine Commander and Current Submarine Tactics Instructor
  - Took notes and evaluated behaviour during experimentation
  - Completed SME evaluation questionnaires every 30 minutes.
    - Ex. How would you rate the watch leaders situation awareness?
    - Ex. How would you rate the watch leaders workload?
    - Ex. How would you rate the assignment of priority to contacts?

- Reviewing audio/video to reconstruct WL/2OOW situational awareness.
Scenario Based Metrics: Mission, Safety, Covertness

- **Covertness metrics**
  - Time spent at periscope depth (PD), number of counter detections, and frequency of cavitation.

- **Contact management metrics**
  - Number of lost contact incidences, number of contacts detected vs. number in scenario, number of contact re-classifications, false alarms, or repeated contacts etc ...

- **Planning metrics**
  - Duration of the mission vs. the planned mission.

- **Safety metrics**
  - Collisions with vessels or land, accuracy of closest point of approach, look interval duration, frequency of going deep, and accuracy of pilotage.
Preliminary IID Eye Tracking Results

**Watch List**
- Dwell time: 1165 ms (0%)
- Average fixation: 333 ms
- First fixation: 333 ms
- Fixation count: 5.0

**Rel Brs**
- Dwell time: 66648 ms (1%)
- Average fixation: 196 ms
- First fixation: 333 ms
- Fixation count: 238.0

**SVP**
- Dwell time: 100 ms (0%)
- Average fixation: 100 ms
- First fixation: 100 ms
- Fixation count: 1.0

**Tote**
- Dwell time: 4359 ms (0%)
- Average fixation: 181 ms
- First fixation: 399 ms
- Fixation count: 18.0

**Schedule**
- Dwell time: 998 ms (0%)
- Average fixation: 150 ms
- First fixation: 100 ms
- Fixation count: 6.0

**Tactical Picture**
- Dwell time: 25621 ms (1%)
- Average fixation: 184 ms
- First fixation: 166 ms
- Fixation count: 105.0

**Depth, Telegraph, Lat/Long**
- Dwell time: 1065 ms (0%)
- Average fixation: 155 ms
- First fixation: 133 ms
- Fixation count: 6.0

**Ownship, Battery, Position**
- Dwell time: 31309 ms (1%)
- Average fixation: 205 ms
- First fixation: 100 ms
- Fixation count: 122.0

**Weather, Sunrise/set**
- Dwell time: 13177 ms (0%)
- Average fixation: 261 ms
- First fixation: 433 ms
- Fixation count: 42.0

**Alerts**
- Dwell time: 1231 ms (0%)
- Average fixation: 291 ms
- First fixation: 366 ms
- Fixation count: 4.0
Preliminary IID Results 2/2
Conclusions

- Developed and executed small sample HiTL experiment
- Investigated the utility of the Information Integration Display concept.
- Demonstrated a full development cycle of the C2 capability development framework.
- Demonstrated use of Mobile Eye tracking for C2 assessment.