IMMERSIVE VISUALIZATION EXPLORATION OF CREW STATION DESIGN FOR ACQUISITION PROGRAMS

Rachel S. Agusti[1], David Brown[1], David Hess[2], Kyle Kovacin[1], Michael Kvicala[2], Caleb Simmons[2], Aaron Smith[1], Colin Stewart[2]

1U.S. Army Combat Capabilities Development Command
Ground Vehicle Systems Center,
Detroit Arsenal, MI

2Torch Technologies, Sterling Heights, MI

Introduction - Abstract

Crew Station design *in the physical realm is complex and expensive due to the cost of fabrication and time required to reconfigure hardware necessary to conduct studies for human factors and optimization of space claim, but recent advances in* ***Virtual Reality*** *(VR) and* ***hand tracking*** *technologies have enabled a* ***paradigm shift*** *in this process. The Ground Vehicle System Center has developed an innovative approach using VR technologies to enable a* ***trade space exploration*** *capability which provides crews the ability to place* ***touchscreens*** *and* ***switch panels*** *as desired, then lock them into place to* ***perform a fully recorded simulation*** *of operating the vehicle through a virtual terrain,* ***maneuvering through firing points*** *and engaging moving and static targets during virtual night and day missions with simulated sensor effects for infrared and night vision.* ***Human factors*** *are explored and studied using hand tracking which enables operators to check reach by interacting with virtual components like flipping switches and with virtual touchscreens. This activity* ***supports acquisition*** *because it enables* ***technology assessments*** *and optimizations for human factors in a* ***cost effective and time efficient manner****.*

Supporting Acquisition

Soldier Touch Points (STP)

- Facilitates relevant feedback through an immersed 3D simulation.
- Early in the design and development process.
- Lowers program risk and cost by ensuring the optimized solution.
- Multiple STPs drove the agile development of the simulation.

Program Executive Office (PEO) & Cross Functional Team (CFT)

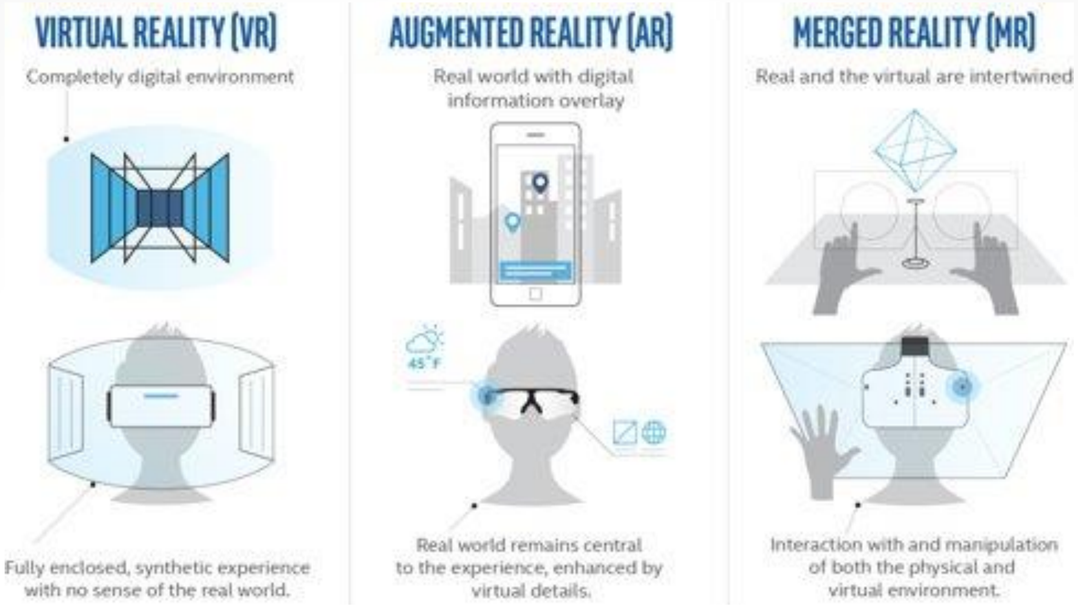
- Experienced the simulation firsthand to enhance understanding.
- Received deliverables with soldier feedback and reports.
  - Execution Report
  - Soldier Surveys
  - Objective Analysis Report

Soldier Touch Point

Value AR/VR Approach

Value of AR/VR/MR Approach

- When a participant hears information, it is easily forgotten.
- When a participant sees information, they are more likely to remember.
- When a participant physically performs the task and moves about the environment with engaging detail that is believable, interactive, and explorable the participant will be immersed and more likely to fully understand the experience.



Utilizing these technologies produces the most accurate and relevant feedback.

VR Technologies

Head Mounted Display (HMD) - Varjo XR-3.

- Resolution and peripheral vision reduced simulation sickness.
- Built-in hand and eye tracking.
- Compatibility with Steam and Unreal Engine.

Hand Tracking - Varjo XR-3 and future Manus

- Enables interaction with physical and virtual interfaces for operating the CS.
- Accuracy necessary to capture data from simulation.
- Tracking the correct participant.

Spatially Tracked Controllers – Valve Index Controllers

- Facilitates a simplified interface for designing the virtual CS.

Simulation Framework – Unreal Engine

- Immersive Simulation chosen foundation for simulation development

Varjo XR-3

Tracking Glove

Learning Objectives

1.Can the crew effectively conduct a simulated mission while completely under armor in VR?
   - Can a set of virtual touchscreens provide sufficient situational awareness?
   - Can the crew effectively collaborate on mission execution in VR?

2.How does different configurations impact mission performance?
   - Impacts of varying screen position, orientation, and count?
   - Impacts of varying control switch panels position and orientation?
   - Impacts of allowing the crew to custom position screens and control panels?
   - Capture sufficient data from the simulation to make recommendations for configuration.

Learning Objectives Continued

3.Is VR technology suitable for a physics-based CS simulation?

4.Is VR tracking suitable for required virtual interactions?

- Is VR tracking suitable for virtual touchscreen interaction?
- Is VR tracking suitable for virtual control panel interaction?

5.Is VR technology suitable for a 3-person crew to collaboratively reconfigure the layout?

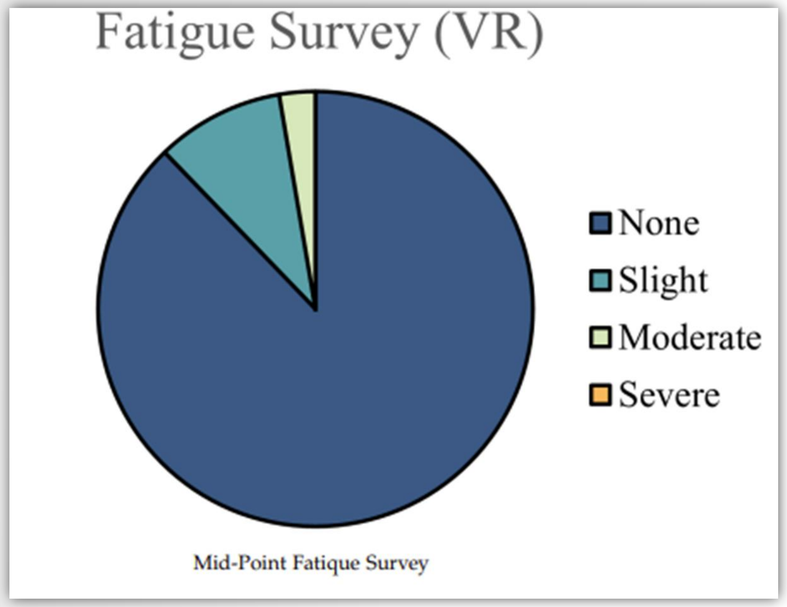
6.Is VR technology suitable for recording the information necessary to quantify performance?

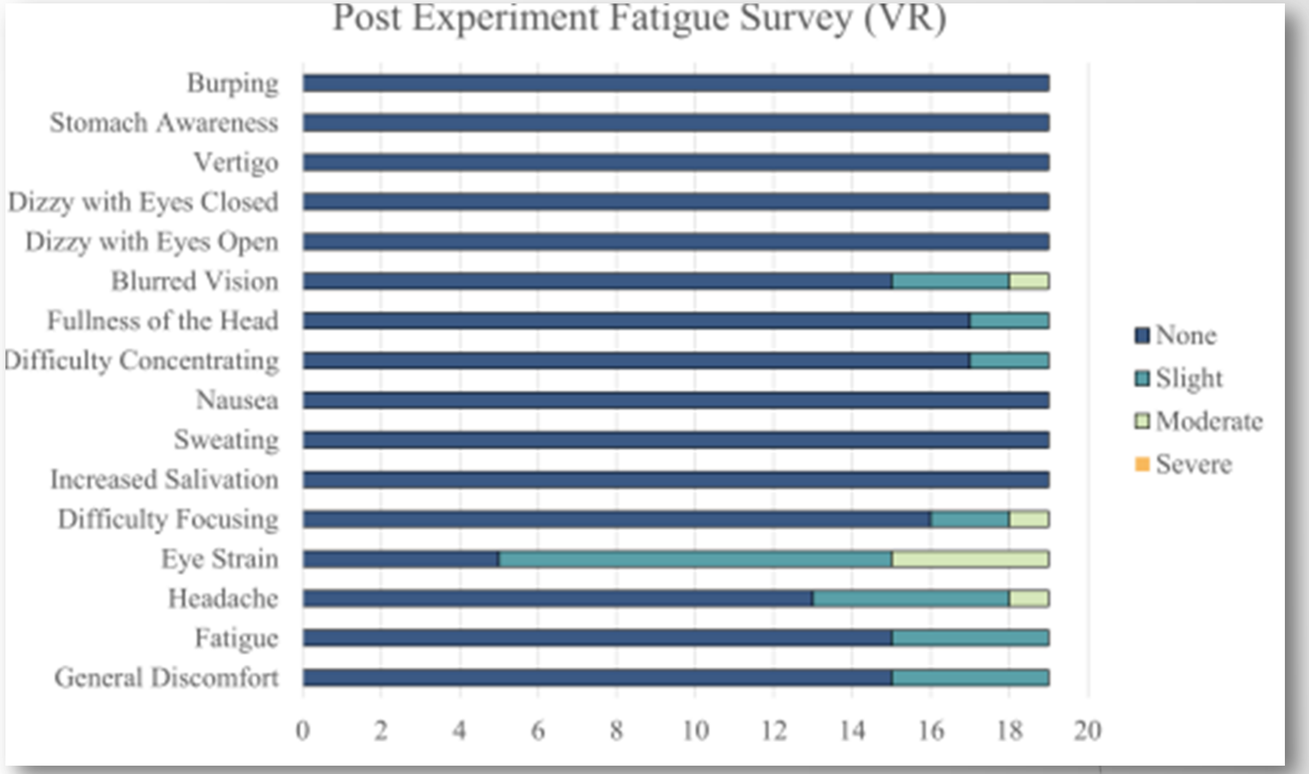
7.Can people operate in the required proximity while wearing the VR HMDs?

Managing VR Simulator Sickness

Simulator Sickness Mitigators

- Stable immediate environment.
- Situational awareness through virtual screens.
- Physically sitting.
- Physically stationary.
- Field of view and resolution.





VARICS Overview

Virtual & Augmented Reality Immersive Crew Station (VARICS):
GVSC Immersive Simulation Trade space exploration capability by enabling crews to reconfigure their CS in the **virtual environment** and then perform a **simulated objective** using the CS configuration.

Capabilities:

- Multi-User Crew Simulation
  - Vehicle physics, fire control, vehicle operations.
- Virtual Environment
  - Terrain, weather – night / day, targets.
- Simulated Objectives
  - Configure required targets, firing points, and timeouts.
- CS Design Mode
  - Configure virtual vehicle components position, orientation, count.
- Data Recording – Full Playback

Touchpoints

Virtual Touchpoints
- Touchscreens
- Switch Panels
- Virtual Space Claim

Physical Touchpoints
- Yoke
- Pedals
- Physical Space Claim

- Plug-n-Play Physical Touchpoints

Virtual Touch Points

Physical Touch Points

Virtual Switch Panel Interactions

There are Five Types of Switch Panel Interactions.

Virtual Dial
- Touch for direction indicator & touch again to trigger next state

Virtual Covered Switch
- State 1: Off & Covered
- State 2: Off & Uncovered
- State 3: On & Uncovered
- Reverts to State 1

Single touch to trigger and/set state:
- Open Switch
- Push Button
- Toggle Button

Virtual Dial Interface

Virtual Covered Switch

Single Touch Switch/Buttons

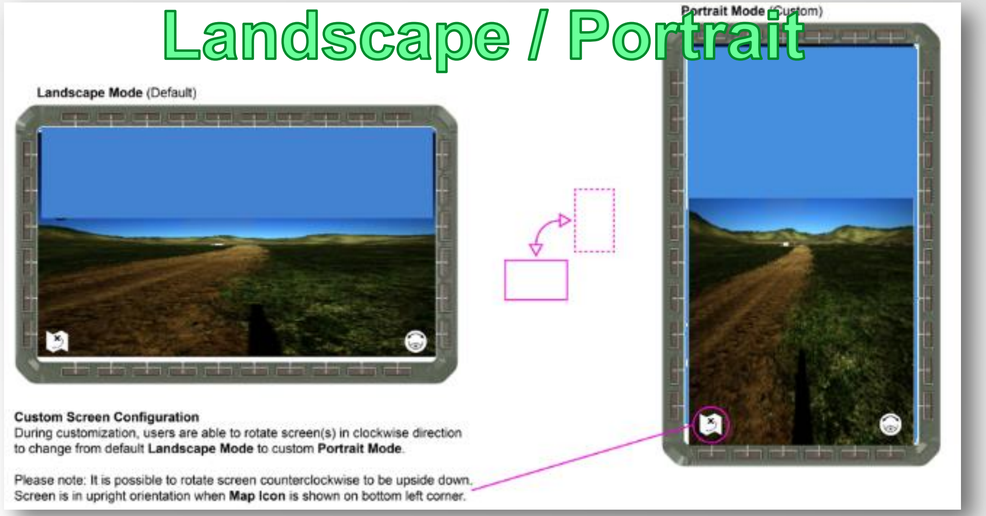
Human Machine Interface (HMI)

Virtual Displays

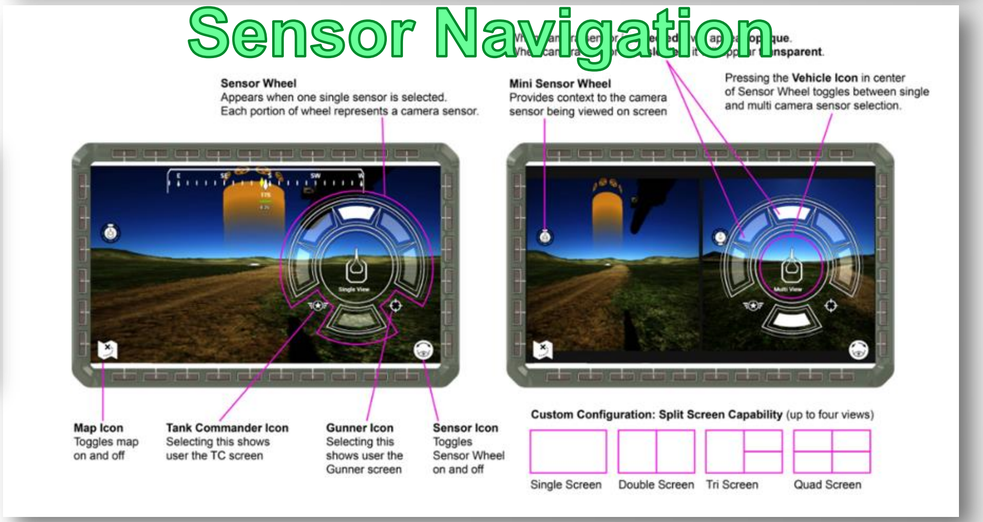
- Landscape / Portrait
- Sensor Navigation
- Compass
- Map
- Turret Orientation
- Sensor Mode – Visual, IR Black/White, & Night

Virtual Sensor Effects

Landscape / Portrait



Sensor Navigation



CS Reconfiguration

Virtual laser pointer

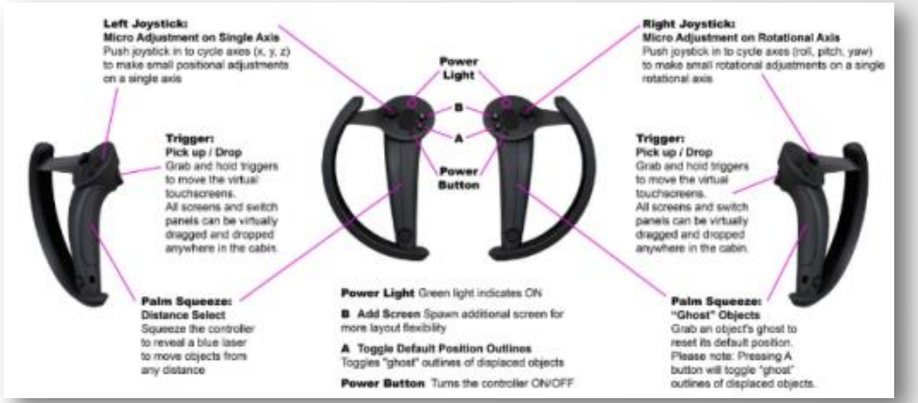
Distance & touch selection

Intersection color
- Orange – Intersecting movable component
- Red – Intersecting Non-movable component

Outlined component – indicates default position

Position Drag & Drop or Controller Joystick

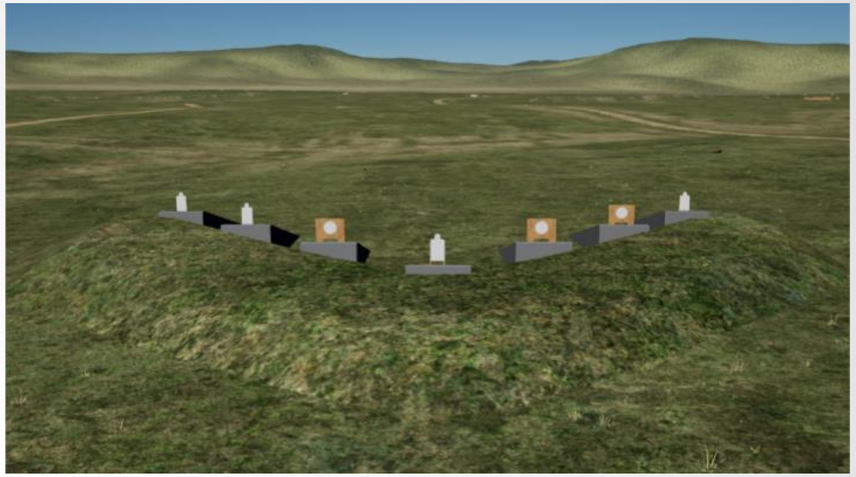
Reconfiguration Interface



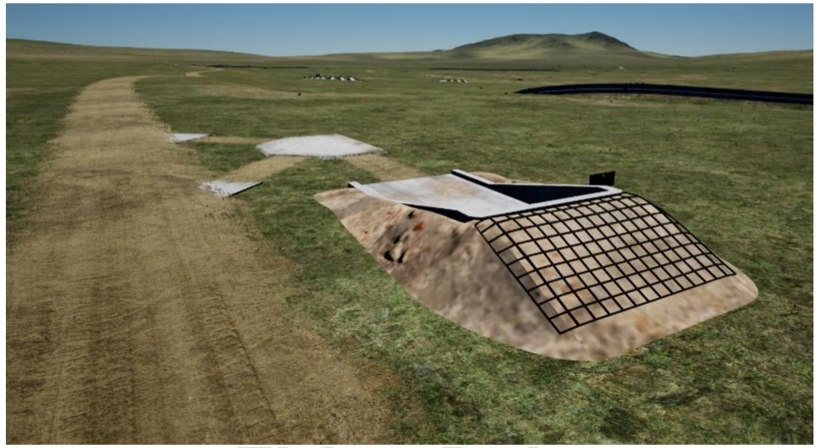
Valve Index Controls

Configurable Missions

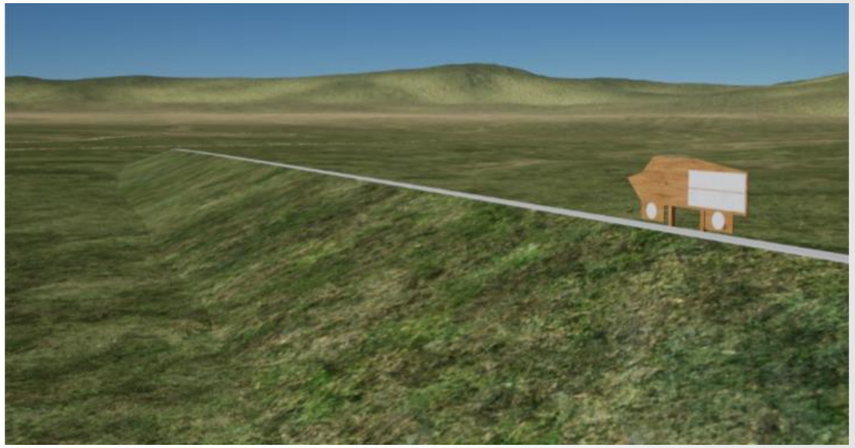
- Target Groupings
- Target Timeouts
- Target Armored
- Target Armored Moving
- Firing Point
- Firing Zone
- Weather Conditions



Target Grouping



Firing Point



Moving Target

Objective Analysis

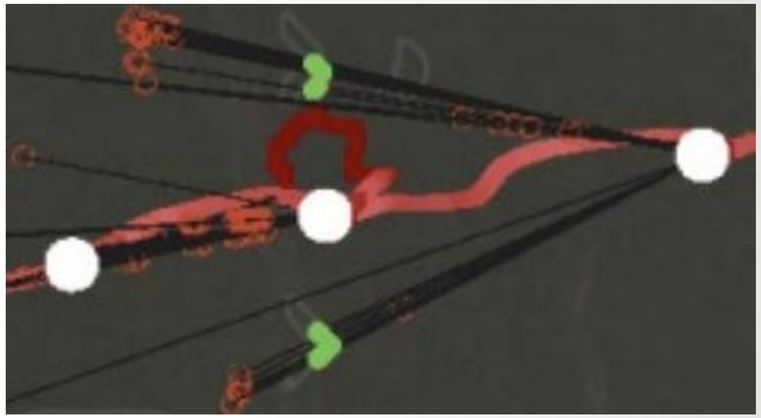
Interaction Timeline
- Indicates total time operator spent viewing each component

Mission Action Timeline
- Blue & teal bars indicate time searching for targets
- White bars indicate shots fired

Maneuver Map Timeline
- Path of vehicle as it maneuvers through terrain
- Black line is a shot trajectory
- White circle is a firing point
- Green circle is shot hit
- Red circle is shot miss

Seconds Observed

Event Timeline


Map Timeline

Future Development & Conclusion

Consider Impacts of the following:

- Varying the seating position for the roles.
- Having to assume multiple roles for a single position such as a scenario where the driver is unable to perform for a period.
- Improving the virtual terrain to be more accurate such as for target positions and types.
- Improve the infrared effect and having targets with dynamic infrared signatures.
- Improve hand tracking gloves and other haptic feedback.
- Develop capability for plug-in-play touchscreen UI.
- Having vehicle physics be more accurate.