U.S. ARMY COMBAT CAPABILITIES DEVELOPMENT COMMAND – C5ISR CENTER

Immersive Simulation of Infrared Sensor and Augmented Reality Technologies

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APPROVED FOR PUBLIC RELEASE

TRY IT BEFORE YOU BUY IT?

Which of these would you want to try before buying it?

- **A Sandwich?**

- **A TV, Laptop, or Cell Phone?**

- **An Automobile?**

- **End product of a multi-year research program?**
  - Very expensive!!!
  - Very large time and labor commitments!

- **Of course we would want to try the final product before investing:** ***the problem is it hasn't been built yet***

NVESD MODELING AND SIMULATION

- **Modeling, simulating, and evaluating sensor performance**
  - New sensor modalities (Passive, Active, Hyperspectral, Multi-Mode)
  - Advanced Signal Processing (Super-resolution, Fusion, Contrast Enhancement)
  - Increased Computational complexity (Compression, 3D, Computational Imaging)
  - Continually searching for improved tools and methods

- **Growing need for immersive testing of products and human performance with sensor imagery**

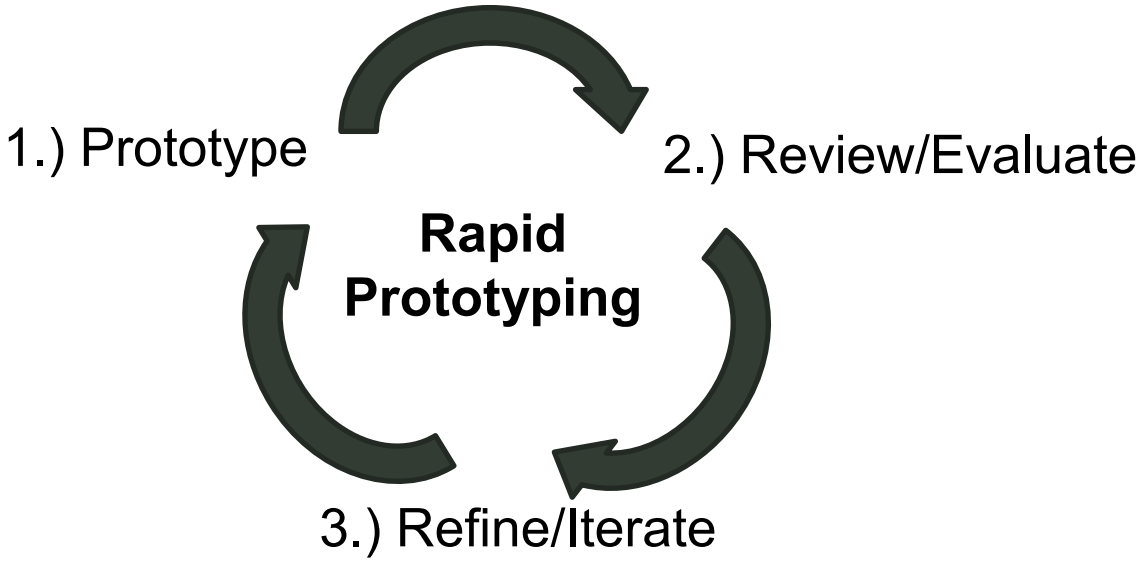
- **Purpose: present a new simulation tool NVESD acquired, intended use cases, and progress**

- **Wide range of applications**

VIRTUAL PROTOTYPING OF ADVANCED SENSORS

- **Virtual Prototyping – creation of a computer simulation of a product for presentation and/or evaluation**

- **Rapid, iterative prototyping is best practice for developing technology for human use**
  - Present early, progressive prototypes to users
  - Collect data from users as early in the process as possible (even prior to building 1st prototype)
  - Usability improves faster
  - Shorter development cycle
  - Ultimate cost savings



BROAD NEED FOR IMMERSIVE TESTING

- **Currently, NVESD evaluates human performance with sensors by showing imagery to human observers on a computer monitor**
  - Does this always represent the military task well?
  - Will results generalize from the laboratory to operational environments?
  - Unmanned aerial vehicle versus infantry weapon sensor system

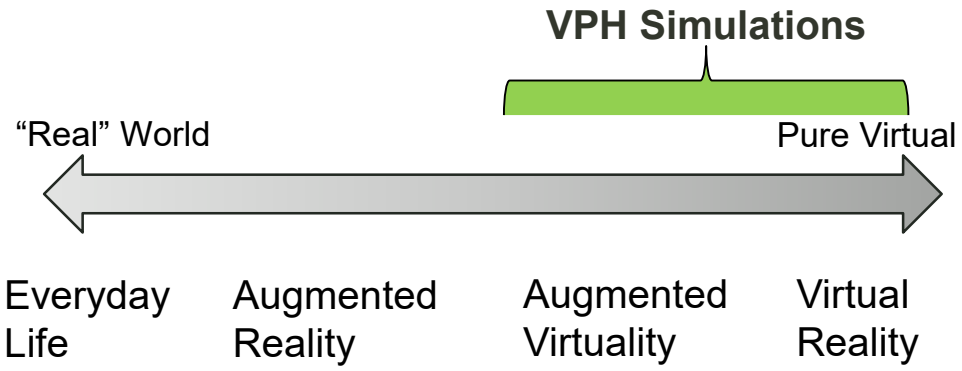
- **Displaying images on a computer monitor may ultimately ignore many aspects of human use of a sensor**

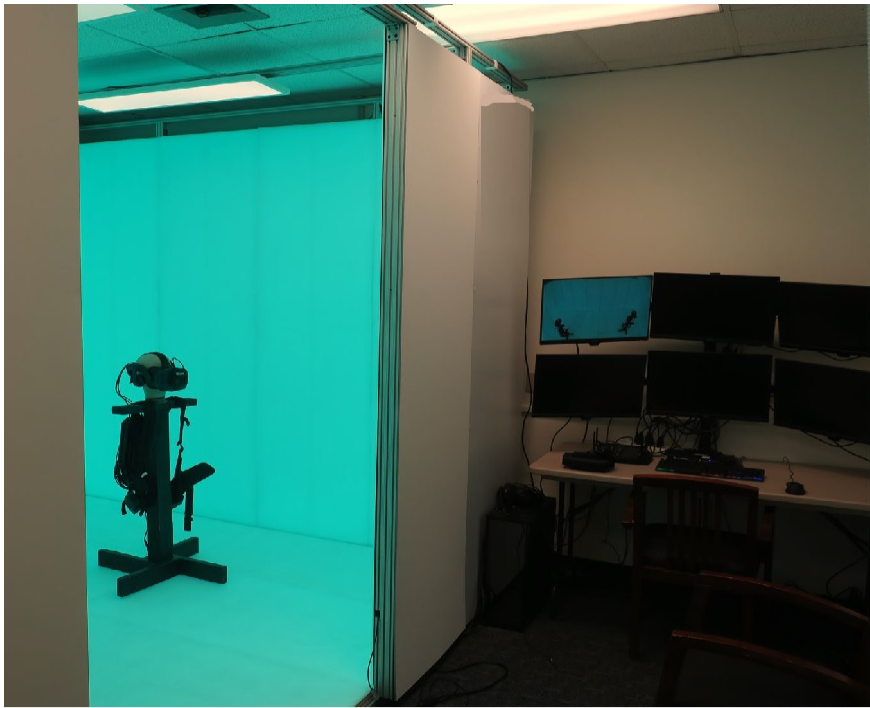
- **An immersive environment with realistic sensor use may lead to better estimates of performance**

VS.

DESIGN AND CONSTRUCTION

- **Immersive Simulation Chamber**
- **Designed for pure virtual reality and augmented virtual experiences**
  - Users are placed in a virtual environment, with or without the ability to see real objects placed in the chamber
- **Developed using commercial off-the-shelf hardware, customizable**
- **Image generator and display agnostic**





DESIGN AND CONSTRUCTION

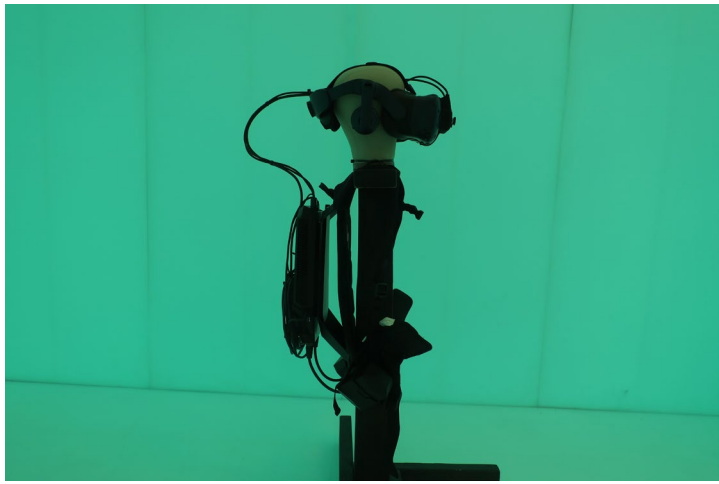
- **VR headset displays connected to lightweight backpack computers**
  Currently Vive (HTC Corporation), interchangeable

- **Enables users to walk around untethered in a virtual environment**

- **Vive displays are modified to include cameras**
  - Cameras capture and display anything within the chamber
  - Anywhere the camera sees open green space, it superimposes the virtual environment
  - Optional to combine VR with real objects

- **Chamber panels emit constant green light**
  - Electroluminescent tape behind sanded Plexiglas walls
  - No shadows
  - Configurable Intensity

- **Virtual ceiling and walls**



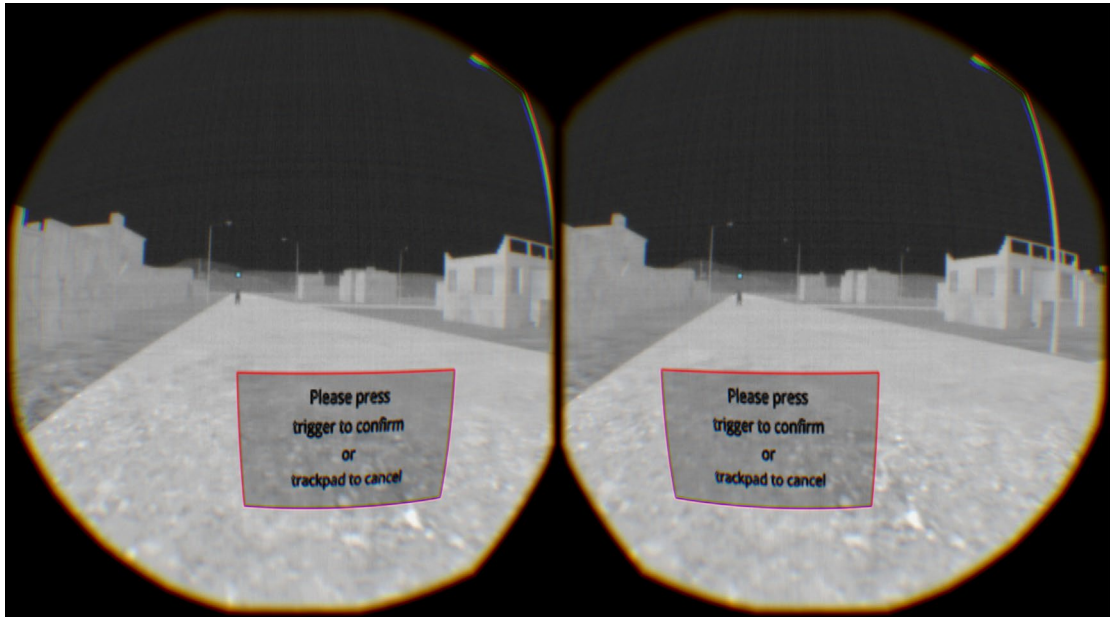
VIRTUAL PROTOTYPING HOLODECK (VPH)

A Soldier kneels in the VPH and gives a hand signal

A screenshot of how the Soldier appeared to another Soldier immersed in the VR chamber

INTEGRATION OF NIGHT VISION IMAGE GENERATOR (NVIG) SOFTWARE

- **Night Vision Image Generator (NVIG) – Sensor simulation software developed by NVESD (high priority)**
- **Modified NVIG for use with Steam VR Software Development Kit**
- **Configured NVIG to atypical nature of VR displays**
  - Two “viewports” in NVIG for two separate visual pathways (VR display is similar to binoculars)
  - Non-rectangular displays
  - Non-uniform pixel densities (pixel density is higher in the display’s center)
- **Two overlapping but unique images are generated**
  - Human eye perceives a single image with depth
- **Allowed us to leverage critical existing simulation capabilities in the VPH**



VIRTUAL PROTOTYPING

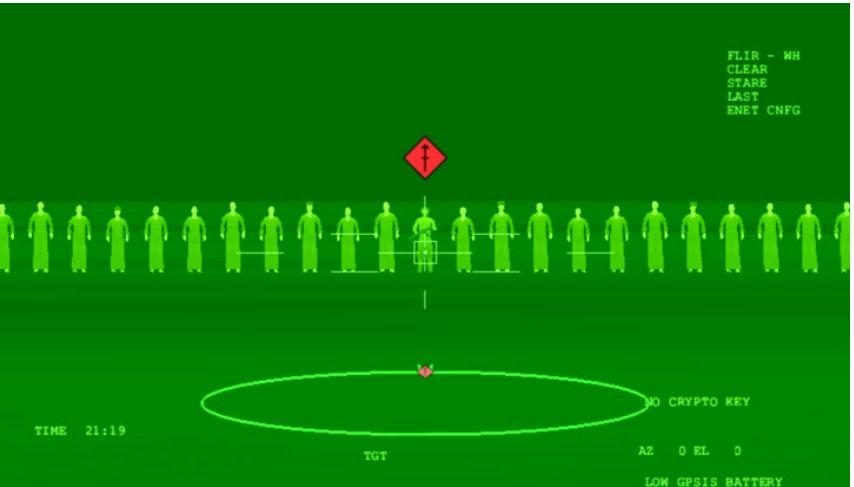
- Regularly use Night Vision Integrated Performance Model (NV-IPM) to estimated sensor performance of proposed designs
- NV-IPM: Performance Range Curves
- VPH: Visualize and use that sensor
- User research techniques: heuristic analyses, user tests, surveys, interviews and focus groups

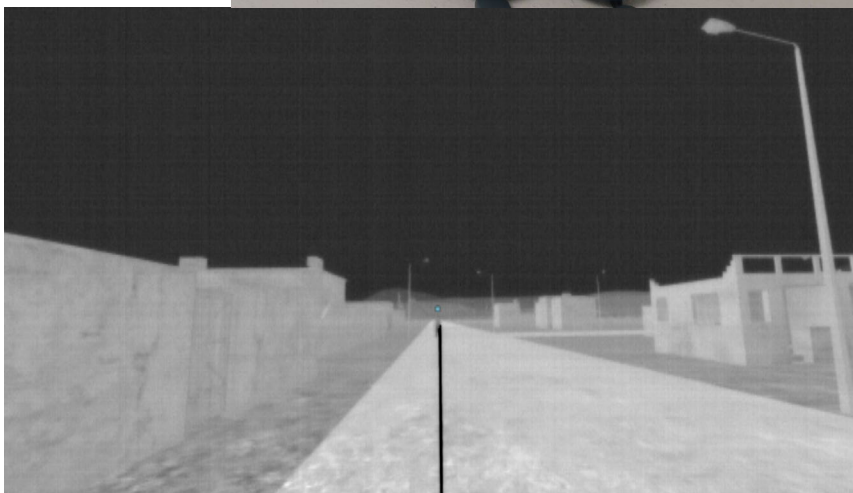
AUGMENTED REALITY SIMULATIONS

- **Experiments testing how operators perform when provided with additional information during a military task**
- **Evaluate specific instances of technology (ex. an AR HUD layout) or explore effects of AR in a broader context**
- **Compared to other applications, visual fidelity requirements are lower: most important aspect is cognitive fidelity of human's use of AR symbology for the task**
- **Eye tracking devices can be used to track gaze direction and dwell time**
  - Recently purchased eye-trackers to be integrated into the Vive displays

AUGMENTED REALITY SIMULATIONS

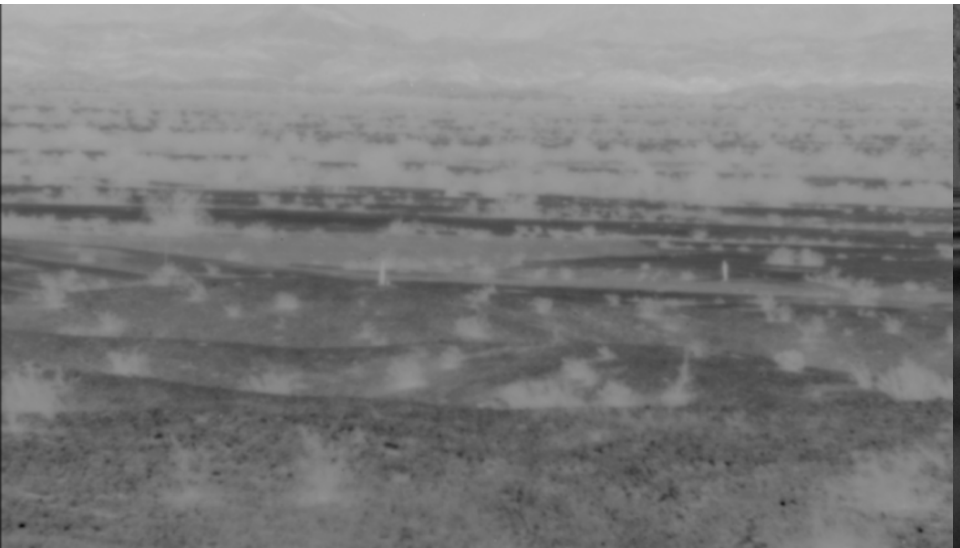
- **Currently: Explore target acquisition with AR in a 360 degree environment**
  - Last year: narrow field of view with sensor controls and a fixed monitor
  - Current: Wide field of view from 1st person perspective
- **More realistic use of sensor may lead to better performance estimates**
  - Both baseline and AR performance estimates

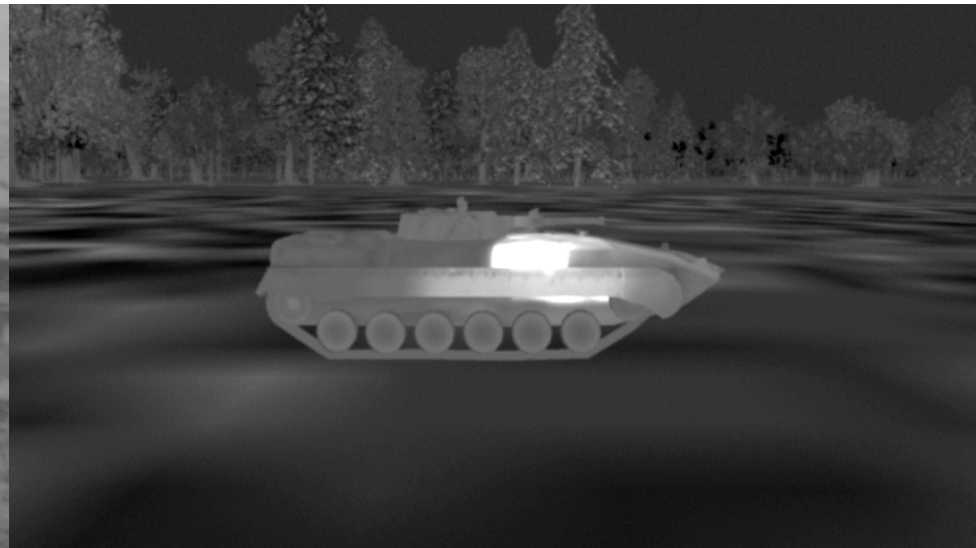




PERCEPTION TESTING

- **Detection Tasks – Perceive an event when it occurs**
- **Identification Tasks – Assign a label to a perceived object**
- **Typically, we show sensor imagery that ranges in quality to find limits of human performance**
- **Alternatively, we simply show imagery at varying ranges to estimate performance as a function of range**





PERCEPTION TESTING

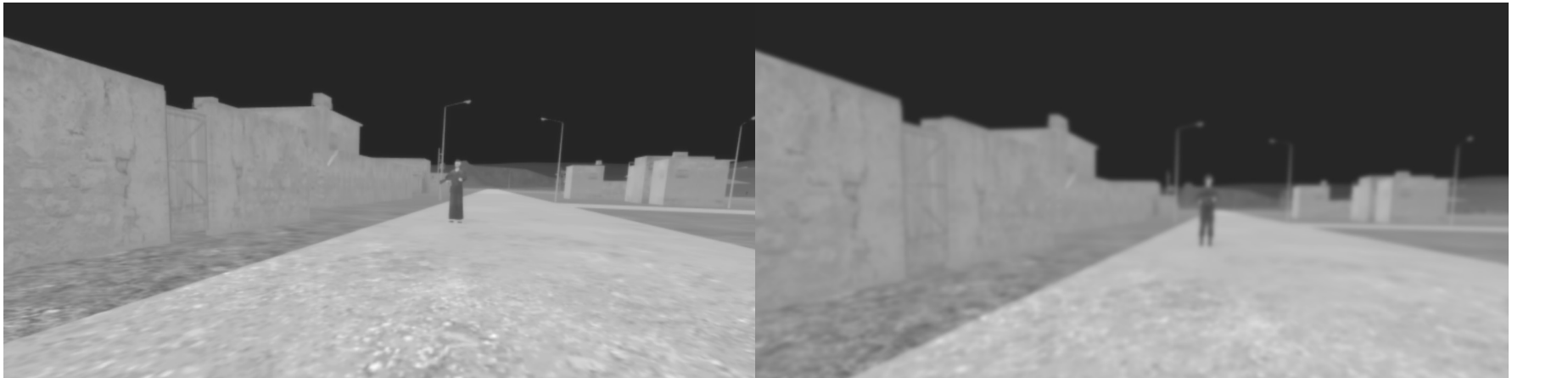
- **Perception tests may be more operationally representative if the user has control over the sensor and can use it in a realistic way**

- **Most challenging – strictest requirements for visual fidelity, most difficult goal to achieve**
  - Integration of NVIG software was an important step towards this goal

Challenges:

- **Correct display and modeling of images in atypical displays**
  - Pixel density is variable

- **Some experiments may be display limited (insufficient pixel density to accurately represent a target)**



CONCLUSION

- **VPH is a new NVESD simulation tool capable of supporting many experimental applications:**
  - Virtual prototyping
  - Augmented reality
  - Perception testing

- **Useful for evaluations of specific technologies throughout the design cycle, as well as a tool for answering broader research questions**

- **Goals: Improve usability, delivery timeline, quality of products, and overall program cost**

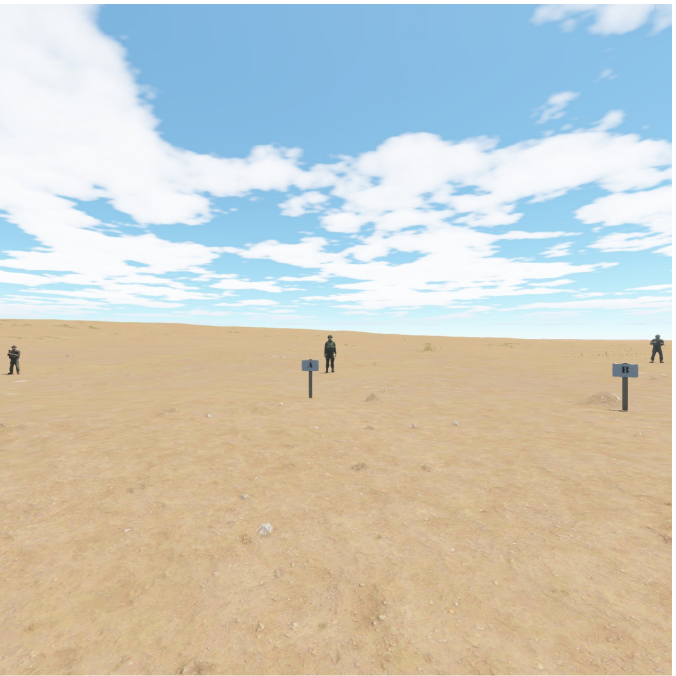
- **Use simulation to make evidence based decisions for sensors and AR technologies**

Appendix

EXPERIMENTS

- **“Alpha” Experiment**
  - Experiment designed to help us learn about the system and learn the process to creating one in the VPH
  - Weapon/No Weapon task using two image generators (Titan and NVIG)

- **Imagery Validation Study**
  - Replicate a v_{50} value for the same imagery displayed in two different environments
  - Verify that imagery simulations and degradations are being displayed and modeled properly in the VPH VR displays



EXPERIMENTS

- **Sensor Simulation and Tradeoff (Proof of Concept)**
  - Compare perception performance of a sensor in two configurations (narrow vs. wide field of view)
  - 2 tasks: Weapon/No weapon ID and weapon search at various ranges
  - Goal: observe pros/cons of the different sensor configurations (acquisition)

- **Augmented Reality Target Acquisition Study**
  - Measure target acquisition time as a function of AR guidance and angular error in target designations
  - Extend previous research with narrow field of view and a hand-controlled long range sensor
  - Wide field of view in 360 degree environment

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