Integrating Autonomous Agents into the OODA Loop for Optimized RAM Operations

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Introduction - RAM & HSI

- **Evolution of Warfare - Age of Information**
  - Artificial Intelligence (AI), Explainable AI (XAI)
  - Autonomous Agents (AA)
    - Drones, Quadrupeds, Bipeds
  - Big Data
- **Reliability, Availability, Maintainability (RAM) Complexity**
  - Increasingly complex systems
  - Decision-making tools
- **Human Systems Integration (HSI)**
  - Keep humans at the center of design
  - Usability and interactivity of tools

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Introduction - Problem

- **Problem:** As RAM systems become more complex, there is a growing need for better decision-support tools.
- **Thesis:** This research explores how autonomous agents (AA), integrated into the OODA loop via AR, can enhance RAM operations by delivering the right information density at the right time.
- **Objective:** Optimize human-machine interaction to reduce cognitive overload and improve operational accuracy.

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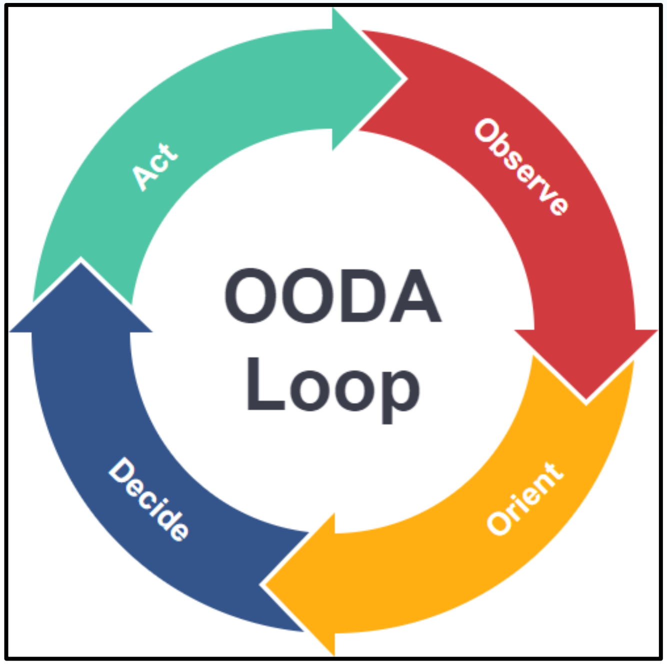
OODA Loop + SA Model



United States Air Force
Colonel John Boyd
[Observe, Orient, Decide, Act (OODA) Loop]

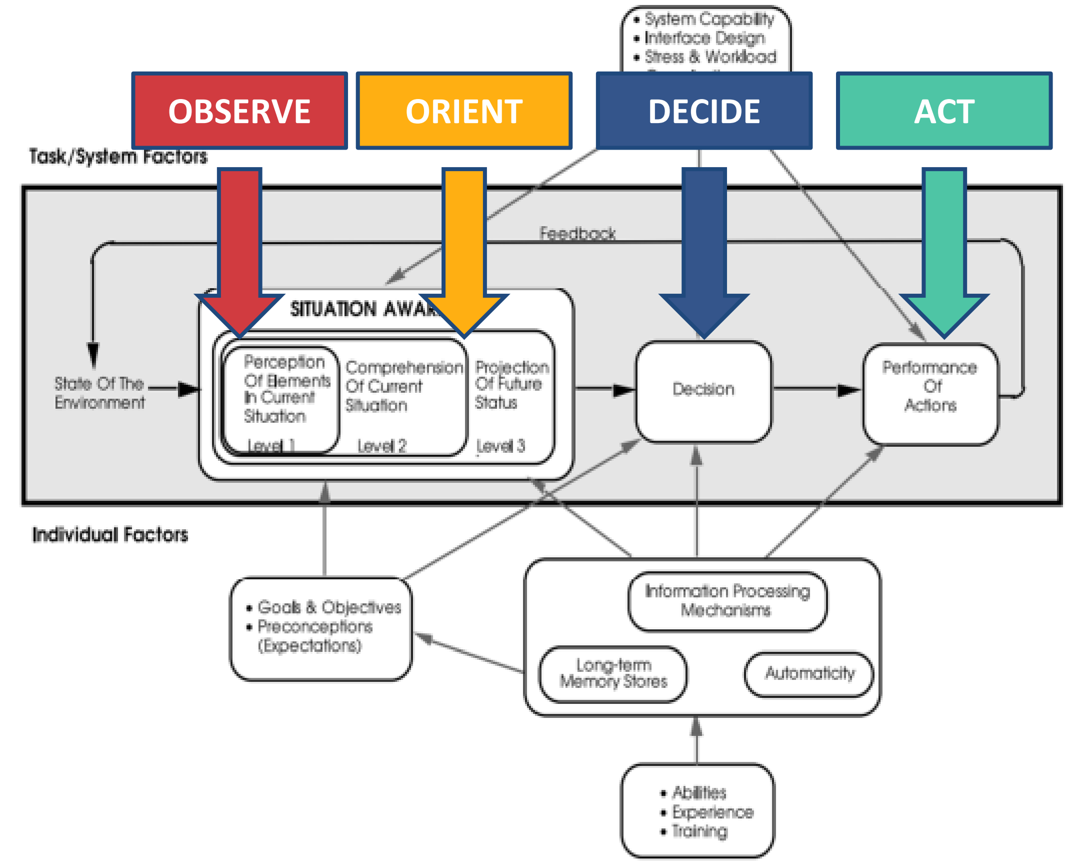
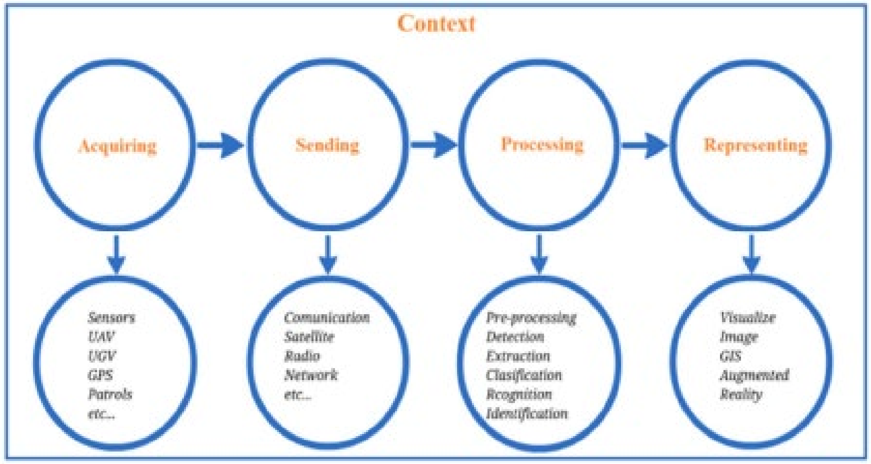


Figure 1 – Endsley's model of situation awareness (Endsley, 1995)

Solution - Information Density

- ❖ Takeaway: **Superior Awareness Wins**
- ❖ How much information is beneficial/harmful to Awareness?
  - ➢ Attention vs Distraction?
- ❖ Humans are very susceptible to Information **Overload** and **Underload** [x1] DLR WATT
  - ➢ Situational Awareness is the “bandwidth” of human information processing



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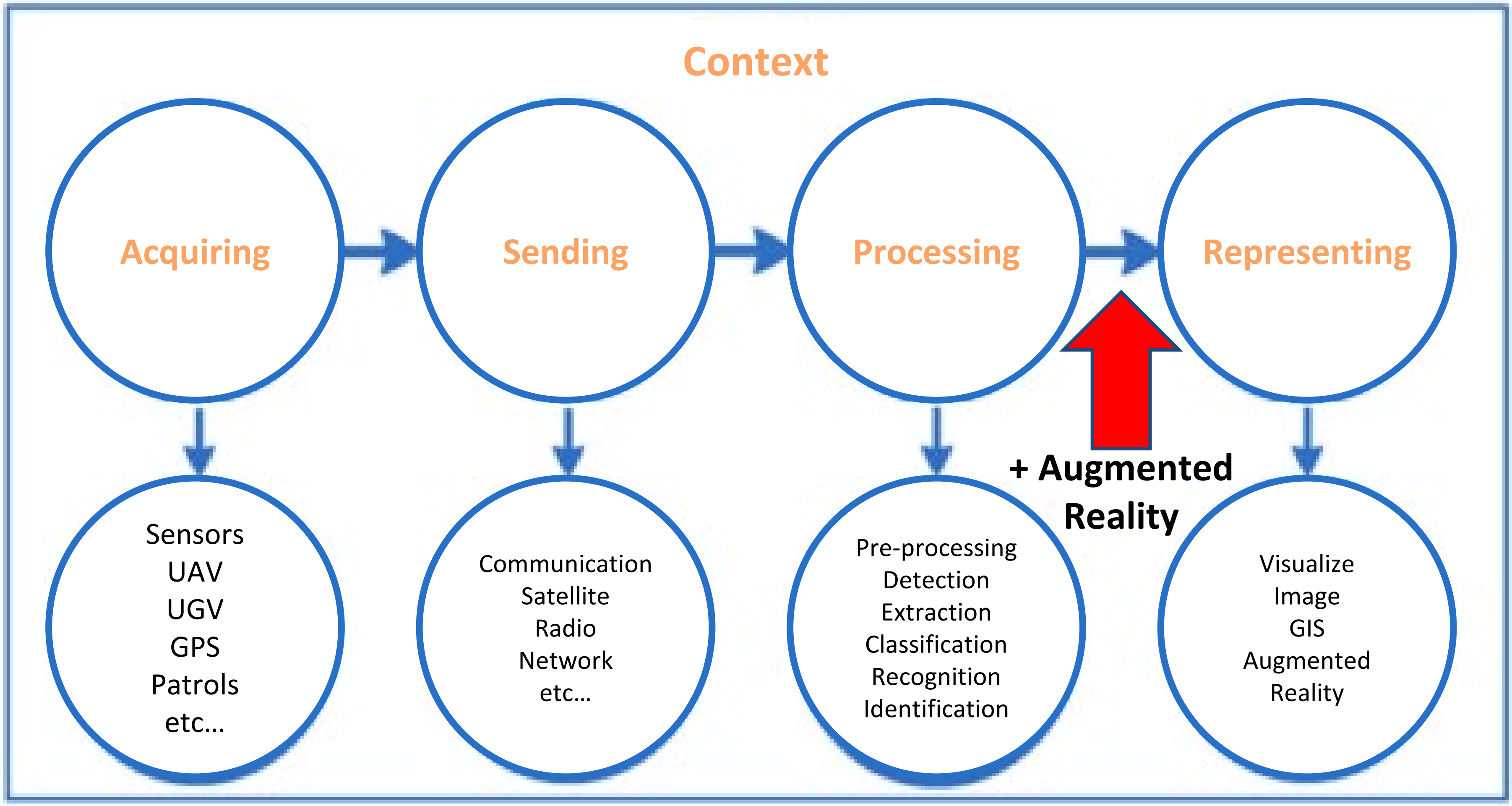
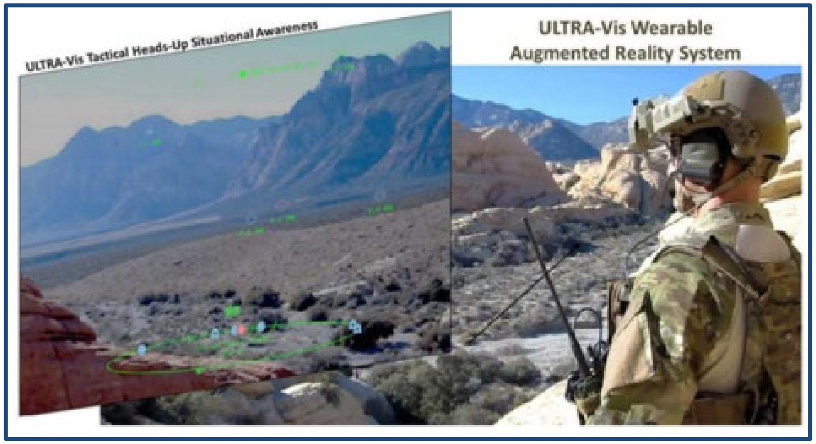
Information Model



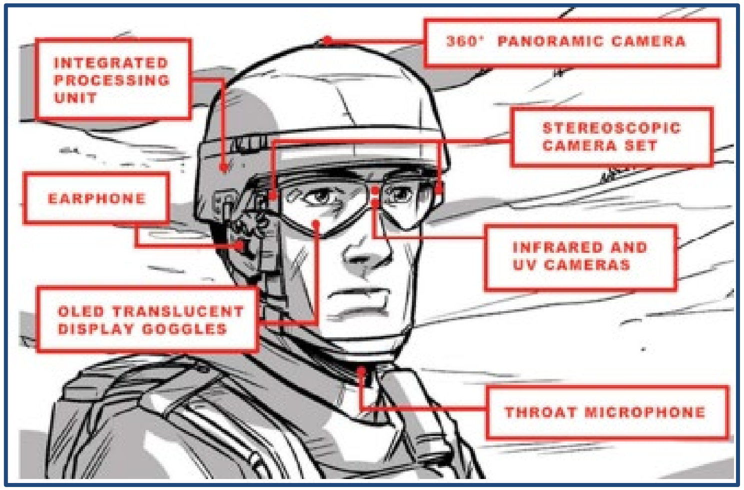
[3] Figure 2 – IM stages. The information transformation process

Review of Military Projects

- DoD
  - **Intelligent Augmented Reality Model (iARM)**
  - **Urban Leader Tactical Response, Awareness and Visualization (ULTRA-Vis)**



[3] ULTRA-Vis



[3] iARM

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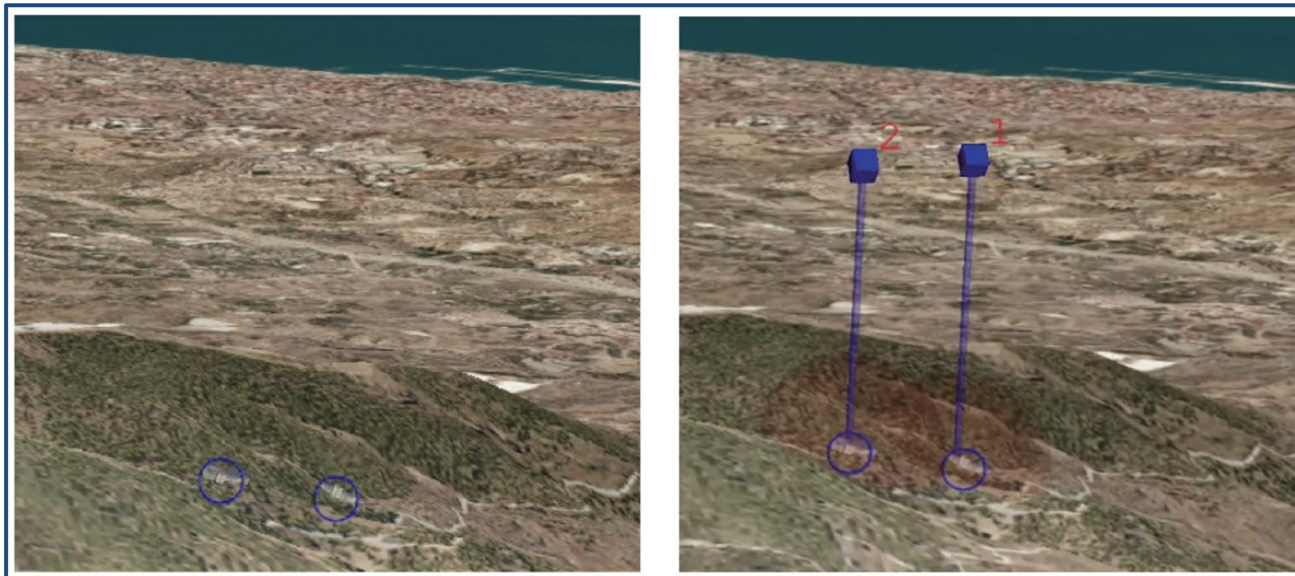
Review of Military Projects

- NRL
  - **Battlefield Augmented Reality System (BARS)**
- University of Zurich
  - AR tool for MALE **UAV ISTAR** missions



(a) Raw video stream (b) Augmented video

[5] UAV ISTAR missions

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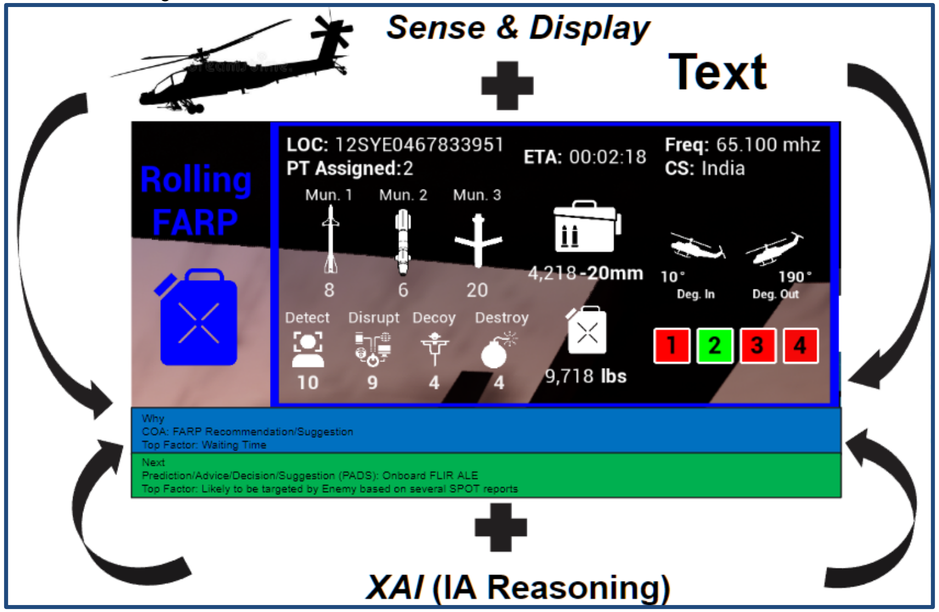
Inspiration - Dynamic InfoGraphics

- ❖ **Explainable Artificial Intelligence (XAI)** integrated displays
- ❖ **U.S. Army DEVCOM's Dynamic InfoGraphics (DIG)** [1]
  - ➢ Developed for FVL pilots in "Heads Up – Eyes Out" in Degraded Visual Environment (DVE) conditions
- ❖ Focused on assessing trust, situation awareness, and effective human-agent teaming
  - ➢ **"Information is only useful if it can be understood"**



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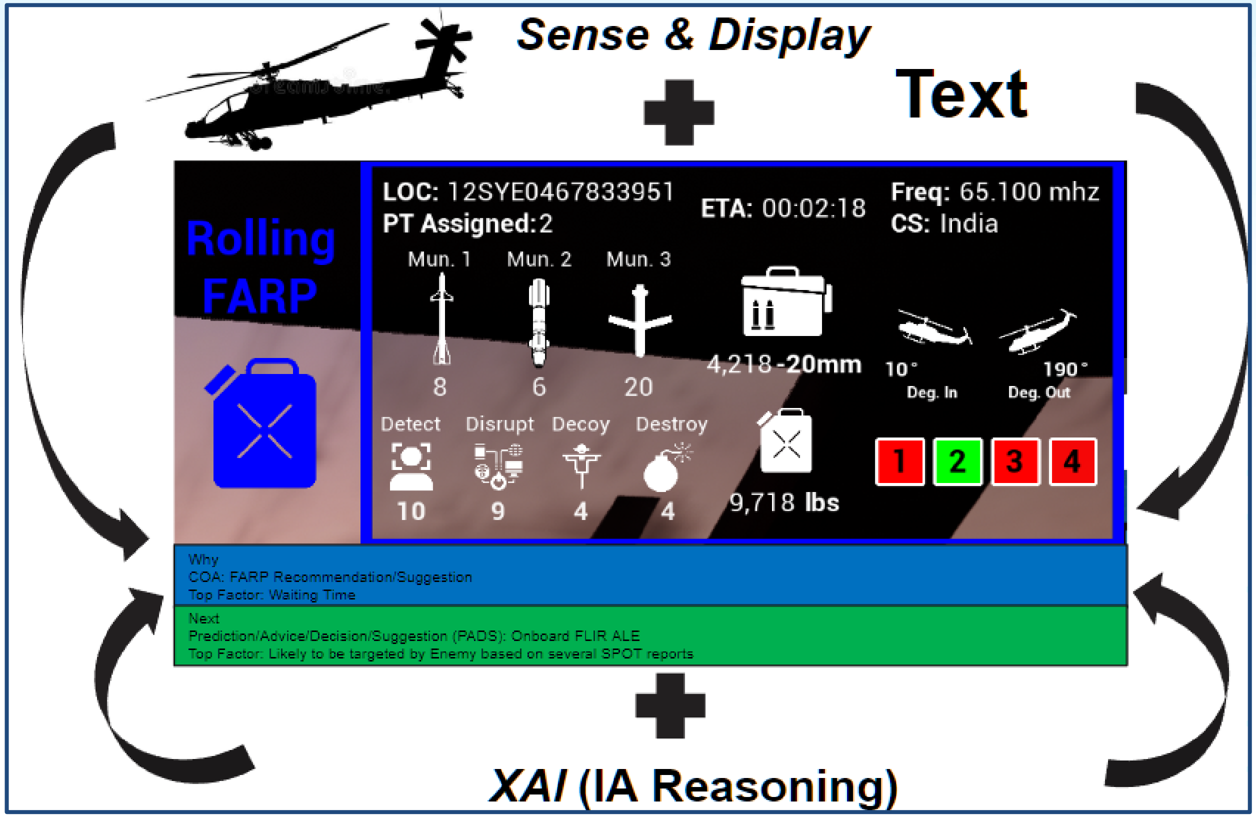
Dynamic InfoGraphics (DIG)



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[1]

Extending the Research

- New approach - **XAI** integrated into **AR:**
  - **Alleviate cognitive strain** by offering clear explanations
  - Enabling operators to **focus on the task at hand**
  - Granting users **intuitive understanding** of AI decision-making
  - **Increasing trust** in the technology → more confident user base
- How might Dynamic InfoGraphics be extended to **ground-based operations?**
  - Providing support in critical, high-stress situations
    - Search & Rescue
    - Disaster Response
    - Hostage Rescue

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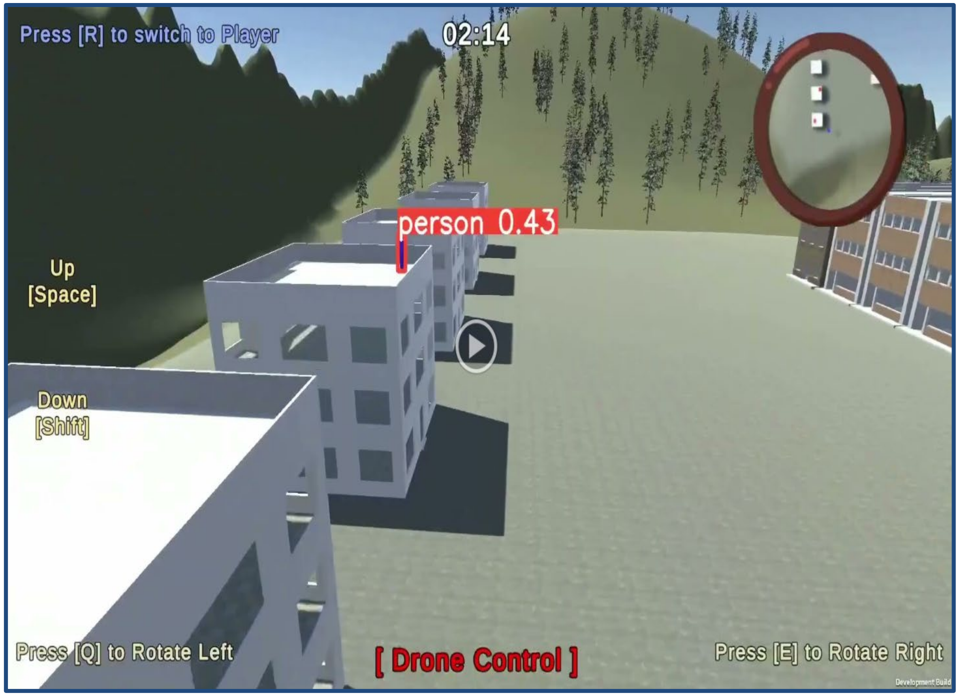
Existing Testbed

- Previous lab work tested a mouse & keyboard **Hostage Rescue:**
  - **Drone + Human** operator teaming
  - **AI/Machine Learning** algorithms
  - Object + person **image recognition**



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Augmented Reality

Unity

- **Unity** - Modeled after vibrant, densely populated Brazilian Favelas
- **Magic Leap 2** AR Headsets

Magic Leap 2 cameras and sensors

Performance Measures

- ❖ **Comparing Performance** across trials with/without Agent feedback
  - ➢ Collecting and Measuring **biometrics (eye data)** via Magic Leap 2

```
Timestamp,Gaze Position X,Gaze Position Y,Gaze Position Z,
Gaze Rotation X,Gaze Rotation Y, Gaze Rotation Z,Gaze Rotation W,
Left Pupil Diameter,Right Pupil Diameter,Left Eye Openness,Right Eye Openness,
Gaze Behavior Type,Behavior Duration,Behavior Amplitude,
Behavior Direction X,Behavior Direction Y,Behavior Direction Z,Behavior Velocity
```

```
.9717981,Fixation,4
773355,Saccade,1.66
70131,Saccade,3.332
70815,Saccade,5.000
3368,Unknown,9.2233
516,Pursuit,1.66626
52,Pursuit,3.334045
202,Pursuit,5.00030
```

- ARControllerData.csv
- CollectionLog.csv
- EyeData.csv
- HandData.csv
- HMDData.csv
- SensorData.csv
- UnityData.csv

```
private void CollectAndWriteHandData()
{
    // Collect data for left hand
    Vector3 leftHandPointerPosition = leftHar

    // Collect data for right hand
    Vector3 rightHandPointerPosition = rightH
```

[Magic Leap 2 Headset]

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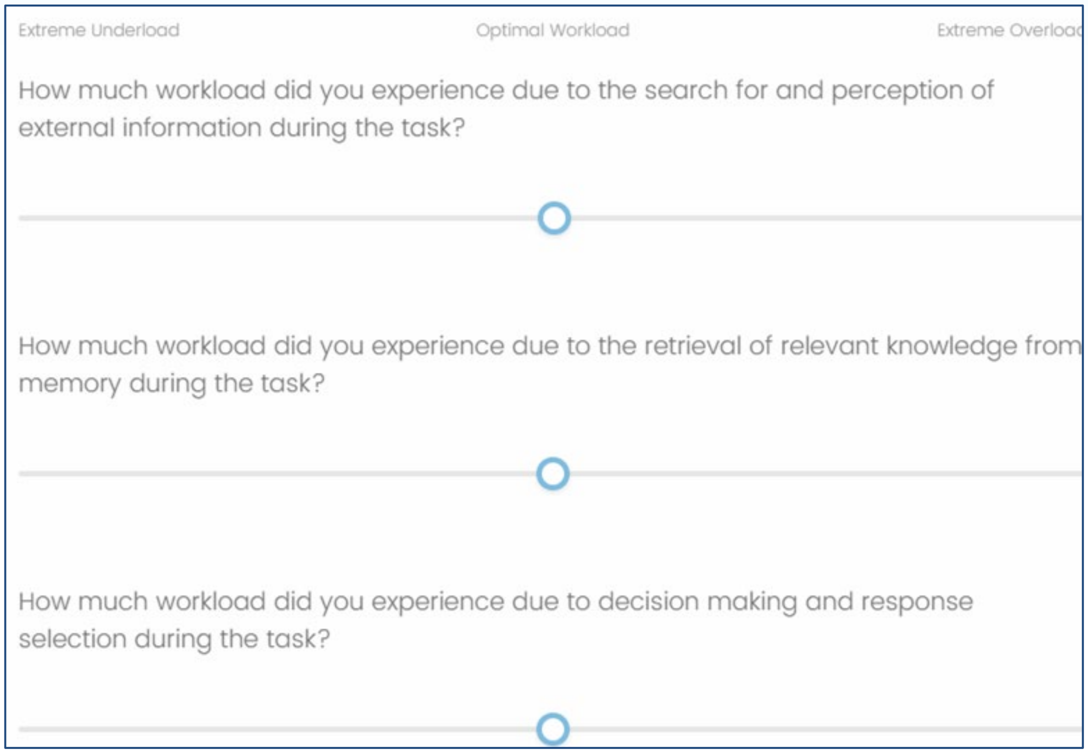
Survey

- ❖ **Methodology:**
  - ➢ Intro Survey → Simulation → Debriefing → Exit Survey

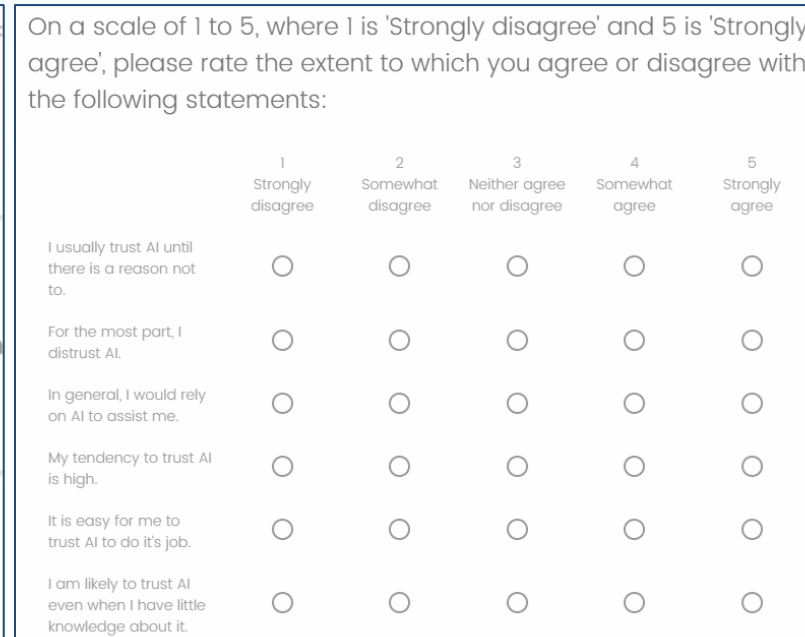

Extreme Underload | Optimal Workload | Extreme Overload

How much workload did you experience due to the search for and perception of external information during the task?

How much workload did you experience due to the retrieval of relevant knowledge from memory during the task?

How much workload did you experience due to decision making and response selection during the task?

[6] DLR Workload Assessment Tool


On a scale of 1 to 5, where 1 is 'Strongly disagree' and 5 is 'Strongly agree', please rate the extent to which you agree or disagree with the following statements:

	1 Strongly disagree	2 Somewhat disagree	3 Neither agree nor disagree	4 Somewhat agree	5 Strongly agree
I usually trust AI until there is a reason not to.	○	○	○	○	○
For the most part, I distrust AI.	○	○	○	○	○
In general, I would rely on AI to assist me.	○	○	○	○	○
My tendency to trust AI is high.	○	○	○	○	○
It is easy for me to trust AI to do it's job.	○	○	○	○	○
I am likely to trust AI even when I have little knowledge about it.	○	○	○	○	○

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Human Trials and Data Collection

- **Experiment Setup:** Testing **static** vs. **dynamic** Autonomous Agent information feedback in the simulation
- **Measuring Cognitive Load:** Assess how **different densities of information** lead to overload, underload, or optimal decision-making
- **User Surveys: Qualitative feedback** on human-system interaction, usability, and trust in AI-driven systems.
- **Data Collection**
  - Obtained IRB approval
  - Sample of 30-150 participants, primarily students, aged 18-25 years

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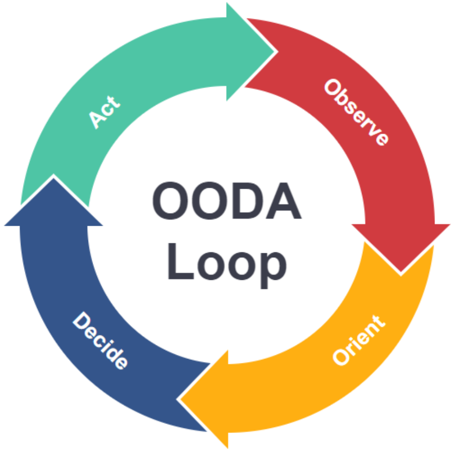
Implications

- Current AR applications **may fail** to meet expectations
  - For reasons that range from the "high-level" application soundness down to "low-level" issues of basic perception [4]
- Newly emerging AR technologies revolutionizing **Situational Awareness**
  - In an age of Warfare driven by **data and information**
- Maintaining the **Technological Edge** is vital
  - **Intelligence Integration** from multiple intelligence sources into a unified, coherent **AR interface**
  - OODA loop



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Future Work

- **Biometric** sensor data integration
  - Monitor and reduce operator stress levels throughout tasks
- Exploring and **capturing human-intent**
  - Bridging the gap between human and AI communication
- Seamless/tailored **AR interfaces**
  - Efficiently using space in, between, beyond physical reality

Conclusion

- **Purpose Recap:** Our goal was to enhance **RAM operations** by integrating **autonomous agents** into the **OODA loop** through **Augmented Reality**, supporting decision-making in high-pressure environments.
- **HSI and RAM:** By keeping **humans at the center** of design, we aim to ensure that AI-driven solutions augment human capabilities without causing overload (or underload).
- **Key Insight:** Optimizing **information density** with real-time **AI feedback** can significantly reduce cognitive strain, improving reliability and performance.
- **Future:** Continue exploring **AI-AR integration** for cross-disciplinary applications and further validate **Endsley's situational awareness theories** for modern, data-intensive environments.

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[1] Hartnett, Dr. Gina. (2023). DIG Overview for ISIC Lab Tours 2023. DEVCOM Analysis Center. PowerPoint Presentation.

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[3] Mitaritonna, A., & Abásolo, M. J. 2015. Improving Situational Awareness in Military Operations using Augmented Reality. *WSCG 2015 Conference on Computer Graphics, Visualization and Computer Vision.

[4] Pedersen, I. (2005). A Semiotics of Human Actions for Wearable Augmented Reality Interfaces. Semiotica, 2005(155-1/4), 183-201.

[5] Ruano, S., Cuevas, C., Gallego, G., & García, N. (2017). Augmented Reality Tool for the Situational Awareness Improvement of UAV Operators. *Sensors*, 17(2), 297. https://doi.org/10.3390/s17020297

[6] N. Brandenburger, A. Dressler, and J. Grippenkoven, "DLR Workload Assessment Tool (DLR-WAT) – Official English Version," German Aerospace Center, Institute of Transportation Systems, Berlin, Germany, 2023.

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Thank You!

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