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Mixed Reality Training Brainstorm and Breakdown

Project Introduction

As modern warfare increasingly blends live forces with simulated environments, there is a growing gap between traditional field training and high-fidelity digital simulation. Live exercises provide realism but are expensive, logistically constrained, and difficult to instrument. Simulated exercises are flexible and data-rich, but often lack the physical grounding and stressors of real movement and terrain.

This project is an attempt to bridge that gap by creating a mixed reality training system that links real soldiers and real equipment in physical space with a shared, persistent Unity-based battlespace. Rather than replacing live training, the goal is to augment it — allowing real-world actions such as movement, aiming, marking targets, and firing to be mirrored in a simulated environment that commanders can observe, control, and modify in real time.

At its core, this project explores how real people, physical terrain, and digital entities can coexist inside a single training framework, enabling combined-arms style scenarios without the cost and risk of live-fire exercises.

Core Concept

The system consists of multiple interacting layers:

A real soldier equipped with a weapon-mounted screen and input controls

A location and orientation tracking system that maps the soldier’s real-world position into a Unity scene

A shared simulated battlefield representing terrain, friendly units, and enemy entities

Mixed / augmented reality glasses worn by a commander or instructor, allowing them to view and manipulate the battlefield in 3D

A central simulation controller that synchronizes all participants and enforces rules, effects, and outcomes

From the soldier’s perspective, the weapon-mounted screen acts as both a situational awareness display and an input device. The soldier can:

mark objects or locations they are aiming at (“enemy spotted”)

fire simulated rounds that propagate through the Unity environment

receive feedback such as hit confirmation, suppression effects, or mission updates

From the commander’s perspective, the AR interface provides a live 3D map of the battlefield, showing:

real soldier positions and orientation

simulated enemies and vehicles

marked points of interest

simulated fire and effects

the ability to inject new entities or modify the scenario dynamically

The result is a hybrid training environment where real movement and decision-making are preserved, while the battlefield itself remains flexible, observable, and safe.

This project is not intended as a production system, but as a proof-of-concept training and experimentation platform.

Project Goals

- Create a shared mixed-reality simulation anchored to real-world space
- Accurately map real human movement and orientation into Unity
- Allow real-world actions (aiming, marking, firing) to affect the simulated environment
- Provide commanders with an AR-based 3D view of the live battlefield
- Enable dynamic scenario control (spawning enemies, vehicles, objectives)
- Support multiple participants operating simultaneously
- Allow for extensibility into vehicle simulators and additional roles
- Enable data logging and after-action review

Scope Clarification and Non-Goals

This project intentionally abstracts or omits certain real-world complexities in order to remain feasible as a personal project and effective as a training prototype.

The system does not attempt to:

- replicate classified weapon ballistics or sensor systems
- provide real-world fire control or targeting capability
- replace live-fire or force-on-force training
- operate as a deployable military system

All kinetic effects are simulated, and all hardware integrations are treated as training interfaces, not operational equipment. The focus is on interaction, coordination, and spatial reasoning, not lethality.

Project Elements Breakdown and Planning

1. Create a Shared Simulated Battlefield

The foundation of the system is a Unity-based 3D battlefield that acts as the authoritative world state.

This environment will:

- represent terrain, structures, and navigable space
- maintain the positions and states of all entities (real and simulated)
- serve as the synchronization point between physical space and digital representation

Unity is used for its real-time rendering, physics system, and extensibility. Terrain can be authored manually or procedurally generated, with scale chosen to match real-world training areas.

2. Real-World Position and Orientation Tracking

Each real participant must be continuously tracked in position and orientation.

Planned implementation:

- GPS, UWB, or indoor tracking (abstracted for prototype)
- IMU-based orientation tracking for weapon and body direction
- Coordinate transformation layer mapping real-world coordinates into Unity space

The goal is not precision but consistent, low-latency spatial coherence. Small errors are acceptable as long as relative positioning remains believable.

3. Weapon-Mounted Interface and Input System

The weapon-mounted screen serves as the soldier's primary interface with the simulation.

Functions include:

- live aiming reticle aligned with weapon orientation
- button-based inputs:
    - "mark target / point of interest"
    - "fire simulated round"
- minimal feedback indicators (ammo state, hit confirmation, suppression)

When the soldier marks a target, a raycast is projected from the weapon orientation into the Unity scene, placing a persistent marker visible to all participants.

4. Simulated Ballistics and Effects

All firing is simulated within Unity.

This includes:

- Raycast bullet simulation
- hit detection against simulated entities

The emphasis is on training-relevant feedback, not perfect ballistics. Effects are exaggerated where useful for learning and understanding.

5. Commander Mixed Reality Interface

The commander or instructor uses mixed/augmented reality glasses to view the battlefield.

Capabilities include:

- a 3D holographic representation of the battlefield
- real-time visualization of soldier positions and facing
- viewing marked targets and engagement history

- zooming, rotating, and filtering the battlefield

This interface functions as a live command-and-control view, enabling real-time intervention, instruction, and observation.

6. Multi-Participant Synchronization

The system is designed to support multiple real participants and multiple observers.

A central controller:
- maintains authoritative game state
- synchronizes updates across devices
- resolves conflicts and enforces simulation rules

This allows infantry, vehicle simulators, and command elements to coexist within the same simulated battlespace.

7. Scenario Control and Injection

Instructors can dynamically modify the scenario.
Examples include:
- spawning enemy units mid-exercise
- disabling or enabling environmental elements
- changing mission objectives on the fly

This allows training to adapt to trainee behavior rather than following a fixed script.

8. Data Logging and After-Action Review

All actions are logged:
- movement paths
- firing events
- target markings
- timing and outcomes

This data can be replayed in Unity for after-action review, enabling instructors to:
- analyze decision-making
- review coordination and spacing
- highlight missed opportunities or errors

System Architecture Summary

- Unity: authoritative simulation and visualization
- Real-world tracking layer: position and orientation ingestion
- Weapon interface module: soldier input and feedback
- AR interface: commander visualization and control
- Central controller: synchronization and rules enforcement

Intended Extensions

- Vehicle simulators feeding into the same battlespace
- Role-specific AR views (JTAC, vehicle commander, squad leader)
- AI-controlled opposing forces
- Integration with pre-recorded terrain or satellite data
- Closing Perspective

This project is intended as a training and experimentation platform, not a finished product. Its value lies in demonstrating how mixed reality can combine the physical grounding of live training with the flexibility and observability of simulation.

As a personal career project, it serves as a way for me to explore:

- simulation architecture
- real-time systems integration
- human–machine interfaces
- and the future of combined-arms training environments