Technology Trends in Modeling and Simulation

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Specific topics

AI and Machine Learning

Multi-resolution modeling

Procedural terrain generation

Scalability and cloud deployment

Exercising Digital Twins and MBSE models in the context of global multi-domain scenarios

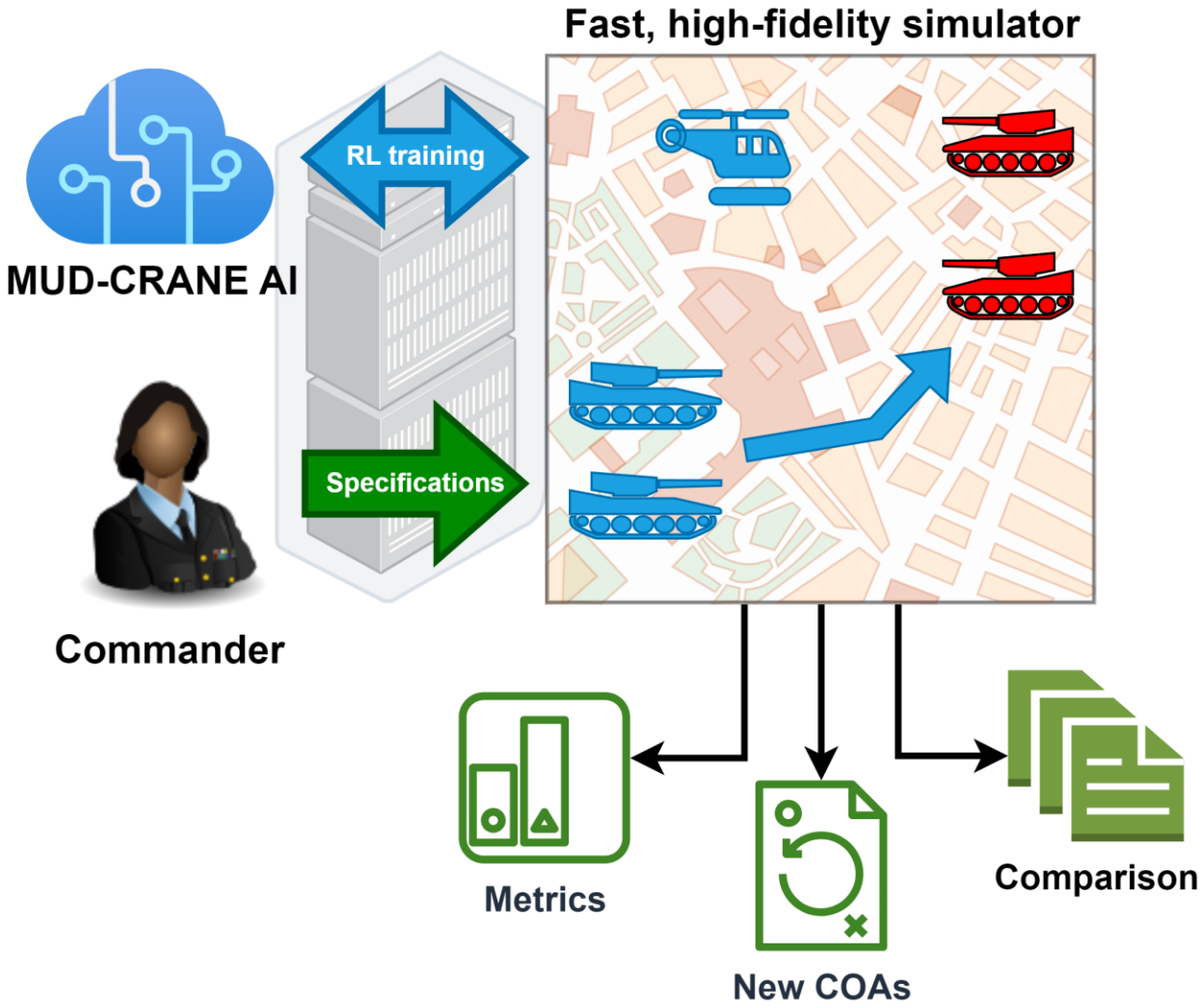
Our core AI message

VR-Forces is an ideal platform for developing, testing, and deploying AI and machine-learning solutions for M&S use cases

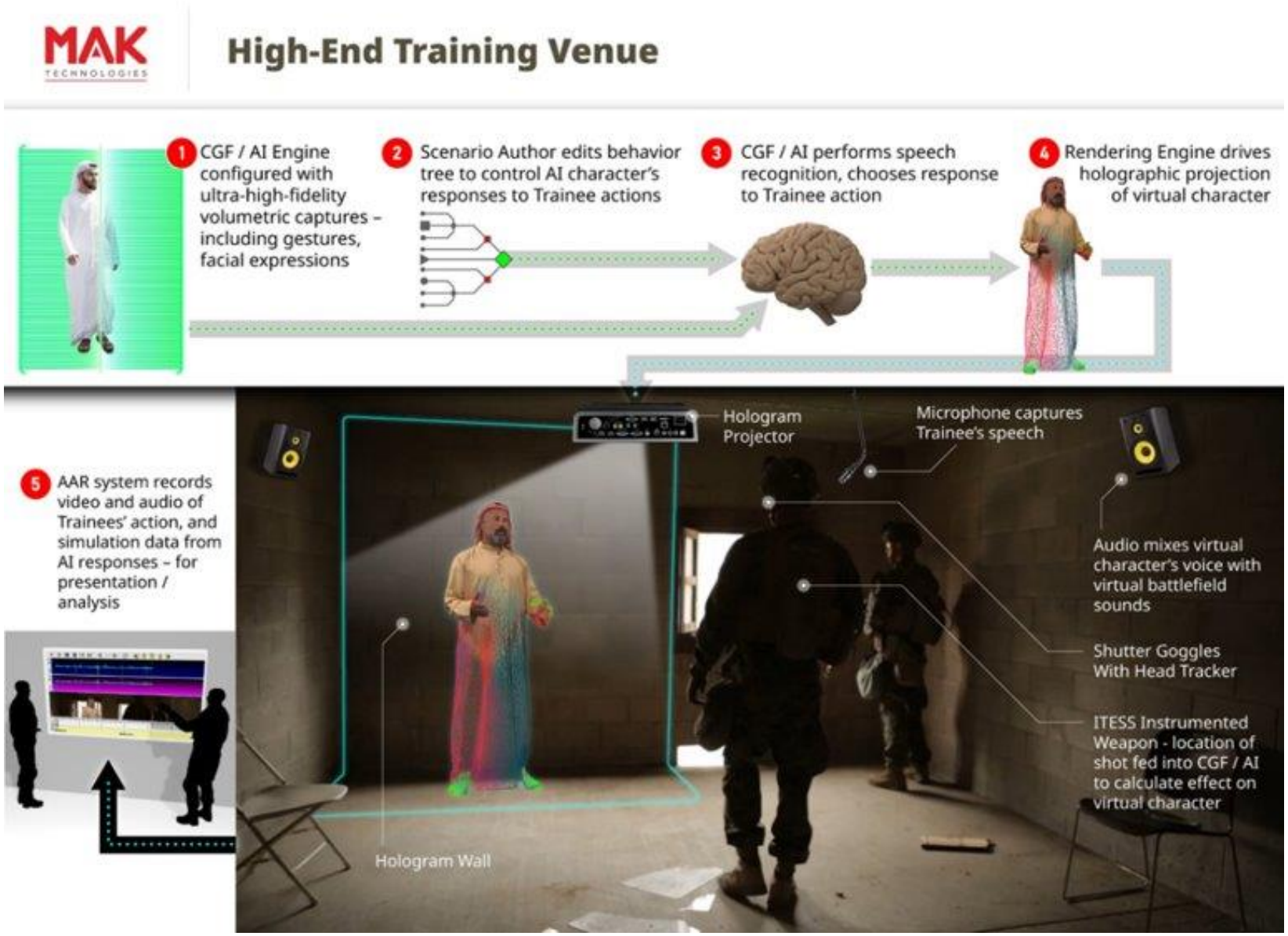
VR-Forces' architecture allows developers to build plug-ins that can make decisions, choose courses of action, and analyze results using neural networks, reinforcement learning, other emerging techniques

Boston Fusion's MUD-CRANE: Project Overview

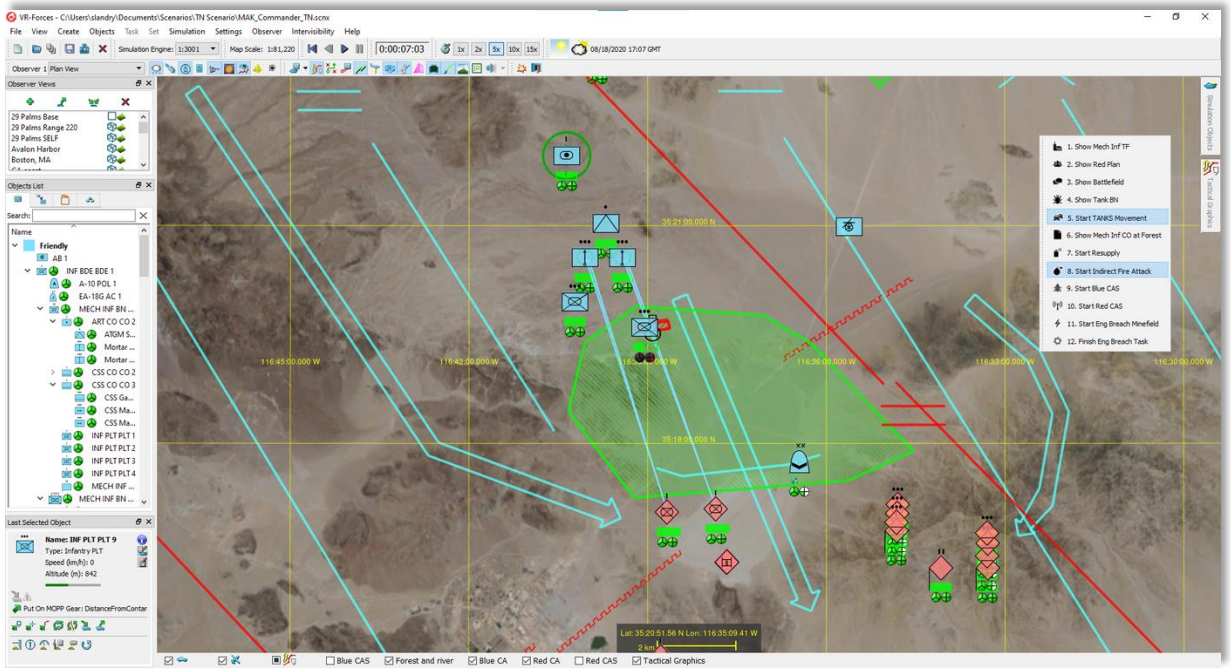
- Objective: COA Analysis using deep reinforcement learning in a simulation environment that is:
  - ✓ Fast
  - ✓ Customizable
  - ✓ High-fidelity
  - ✓ Scalable
- Integrating BFC's cutting-edge multi-agent RL with MAK's proven multi-domain operations (MDO) simulation
- 1000x speed-up over real time in realistic, large-scale, aggregate-level scenario with RL agents in control



Intelligent Avatars



Multi-resolution Modeling



Goal: Simulate at Aggregate Level, but add entity-level fidelity where appropriate

Add attributes to Aggregate simulation to make it more "Entity-Level"

- E.g. track state of ammo and fuel for each subordinate entity
- Model gets complex, without benefits of actual Entity-Level simulation

Integrate two engines (one Aggregate Level, and one Entity Level)

- Leads to correlation issues, developing content/configuration twice, and two distinct user experiences rather than unified system design

Use an engine that supports Multi-Resolution Modeling

Multi-resolution Modeling in VR-Forces

VR-Forces supports both true aggregate-level (constructive) simulation model, and entity-level (virtual) simulation models in the same engine

- But currently requires choosing between separate Simulation Model Sets (SMS)

Recent project prototyped multi-resolution modeling

- Combined Entity- and Aggregate-Level models into a single hybrid SMS
- Sensors that can detect objects modeled at either level (incl. sending spot reports)
- Fly out missile at entity-level, and calculate damage on aggregate-level unit
- Switch representation of a unit between entity/aggregate at run-time
  - Not just visual switch, but underlying back-end model
  - Switch to an entity-level model when a UAV flies over to generate sensor picture
  - Switch both red and blue companies to an entity-level model to fight a battle, and flow results into aggregate-level model at run-time

All communicated through HLA

Multi-resolution Modeling - Status

Proved the concept, but not yet a productized capability

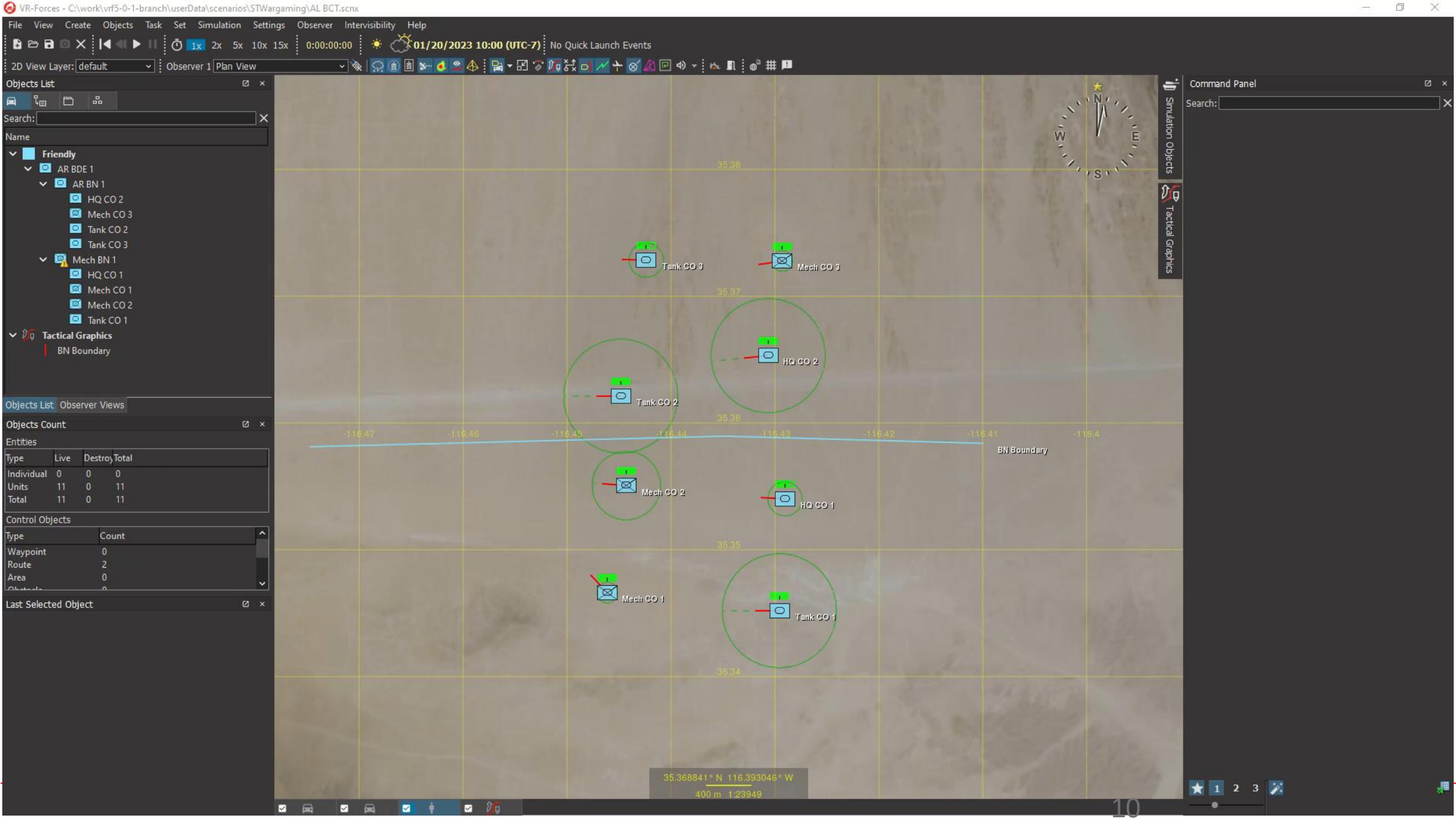
Much work required to develop and implement business logic

- The easy part is getting Entity and Aggregate models to exist in the same scenario
- Hard part is determining what kinds of interactions between them might actually make sense; and implementing the logic required to achieve those interactions

Development and scripting needed to implement the aggregate unit behaviors, scripts, and doctrine required for various use cases

MAK VR-Forces is an ideal foundation for projects that seek to employ multi-resolution modeling techniques

- MAK stands ready to build on the prototyping work we've done, and to work with integrators or end-users on a custom basis to meet project-specific requirements


VR-Forces - C:\work\vrf5-0-1-branch\userData\scenarios\STWargaming\AL BCT.scnx
File View Create Objects Task Set Simulation Settings Observer Intervisibility Help
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Tactical Graphics
BN Boundary
Objects List
Observer Views
Objects Count
Entities
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Individual 0 0 0
Units 11 0 11
Total 11 0 11
Control Objects
Type Count
Waypoint 0
Route 2
Area 0
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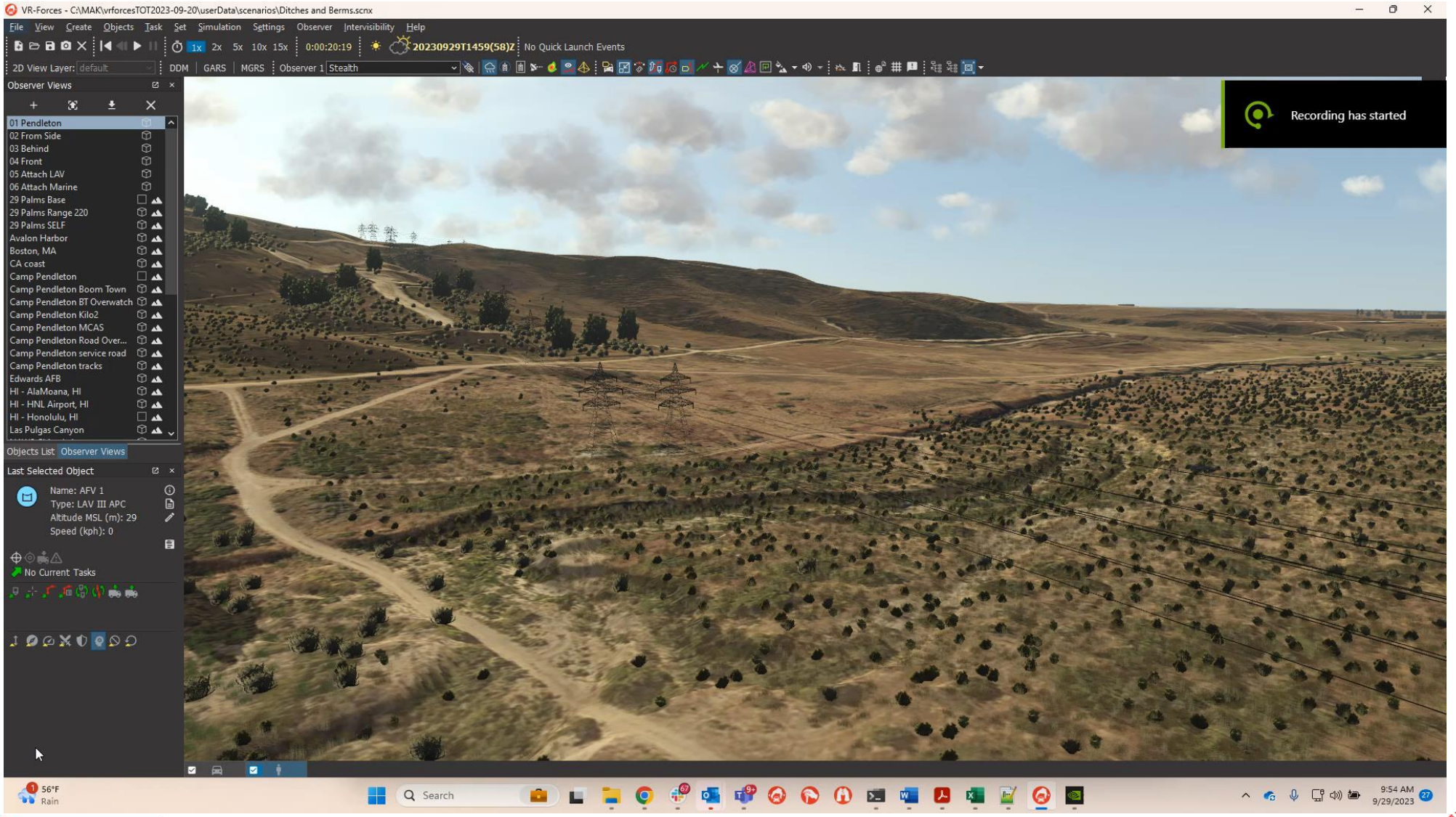
Procedural Terrain Generation

“Procedural Earth 2” Engine

Coming in VR-Forces 5.1
Q1 2024

Create Ditches and Berms in VR-Forces



No Artist Intervention was Required to Generate these Scenes of Ukraine

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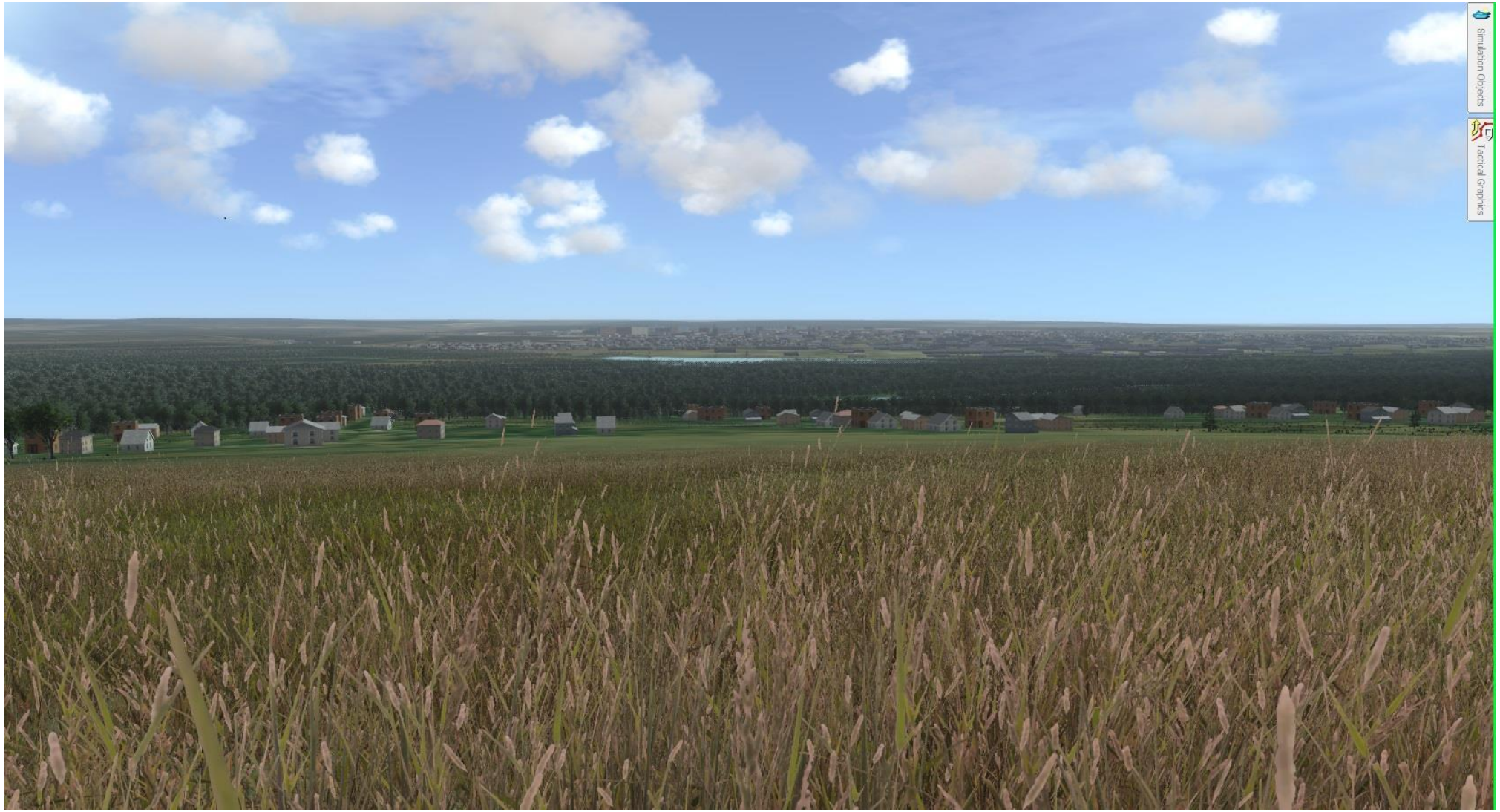

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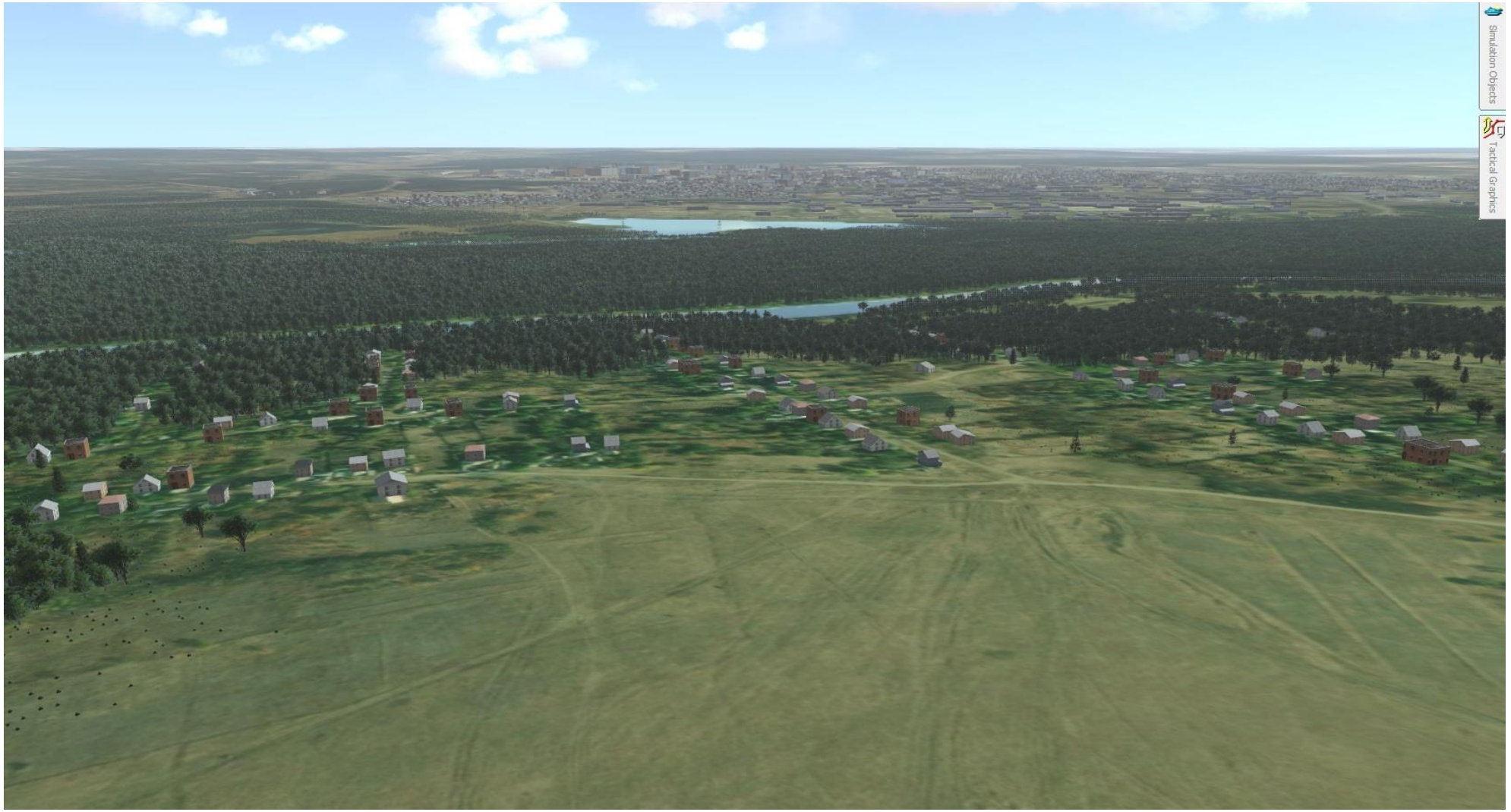
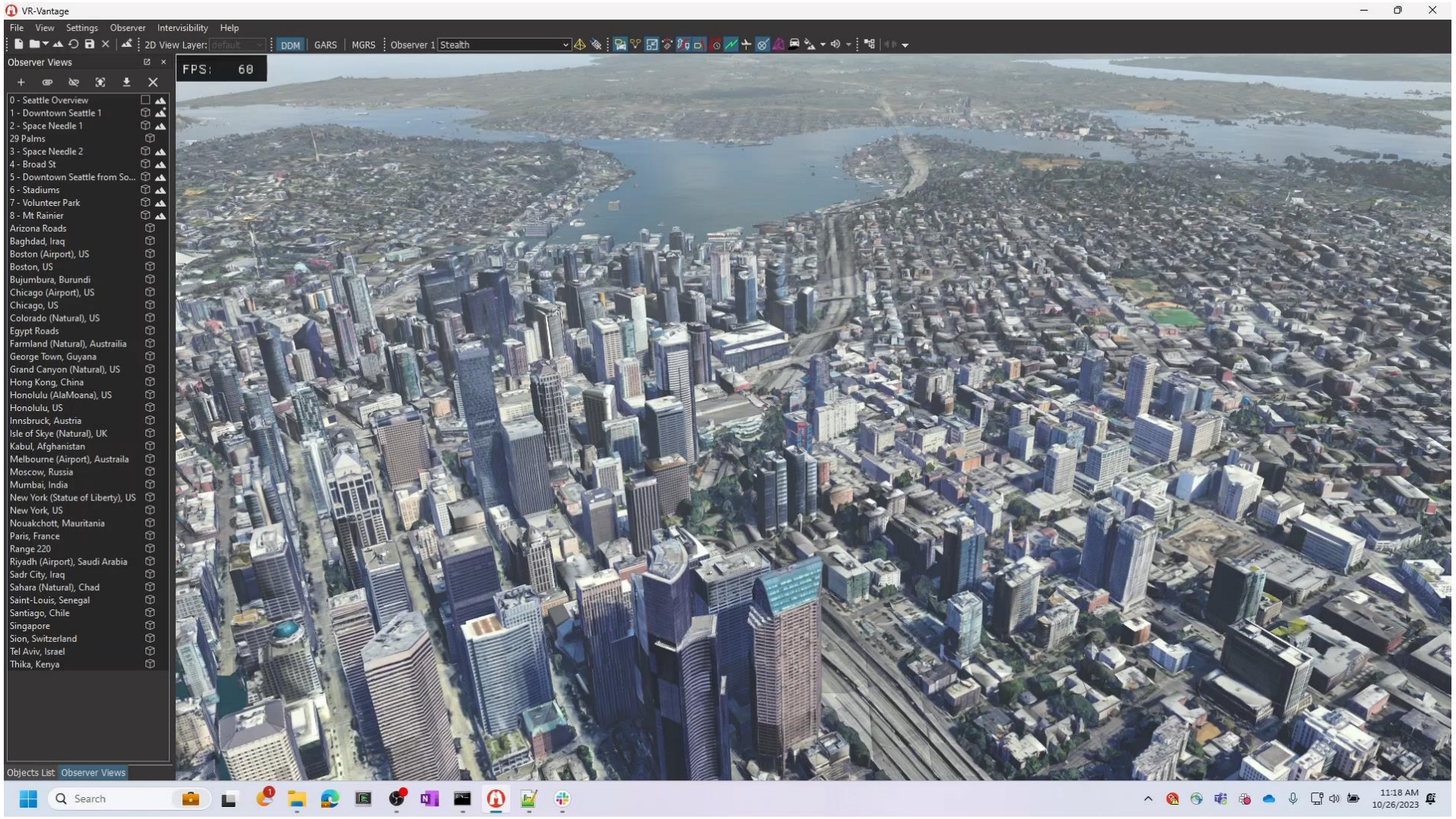
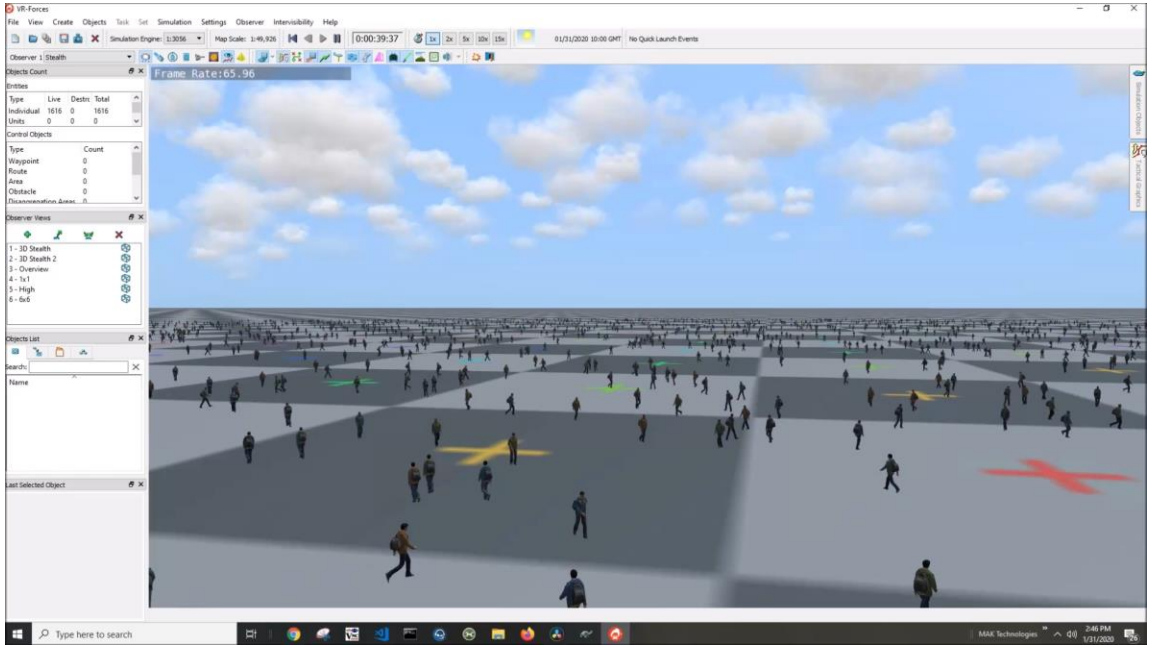


Started Prototyping Google Photorealistic 3D Tiles (Will **NOT** be supported in the Q1 2024 releases)



Scalability and Cloud Deployment



Scalability Requires System-wide Design

Simulate

A Simulation Engine that can efficiently **simulate** millions of entities

Scalable "Power Plant"

Communicate

A Data Storage and Transmission Infrastructure that can **communicate** data about millions of entities

Scalable "Power Grid"

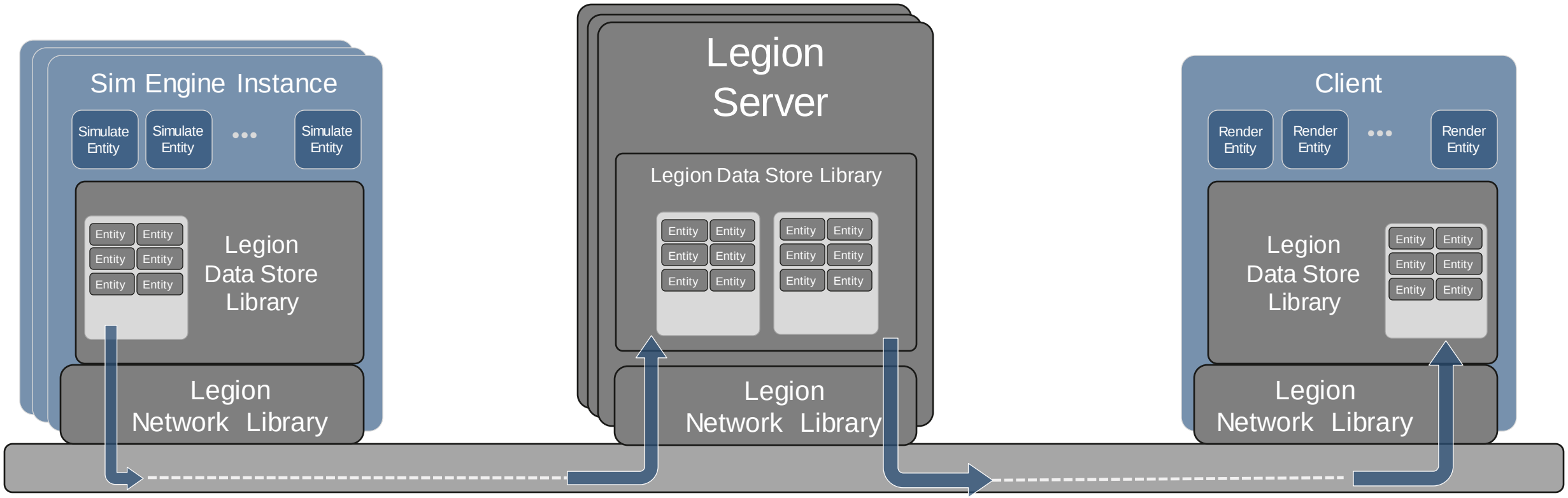
Visualize

Virtual Simulators that can connect to million-entity simulations, and efficiently **visualize** thousands of entities that are most relevant to the player

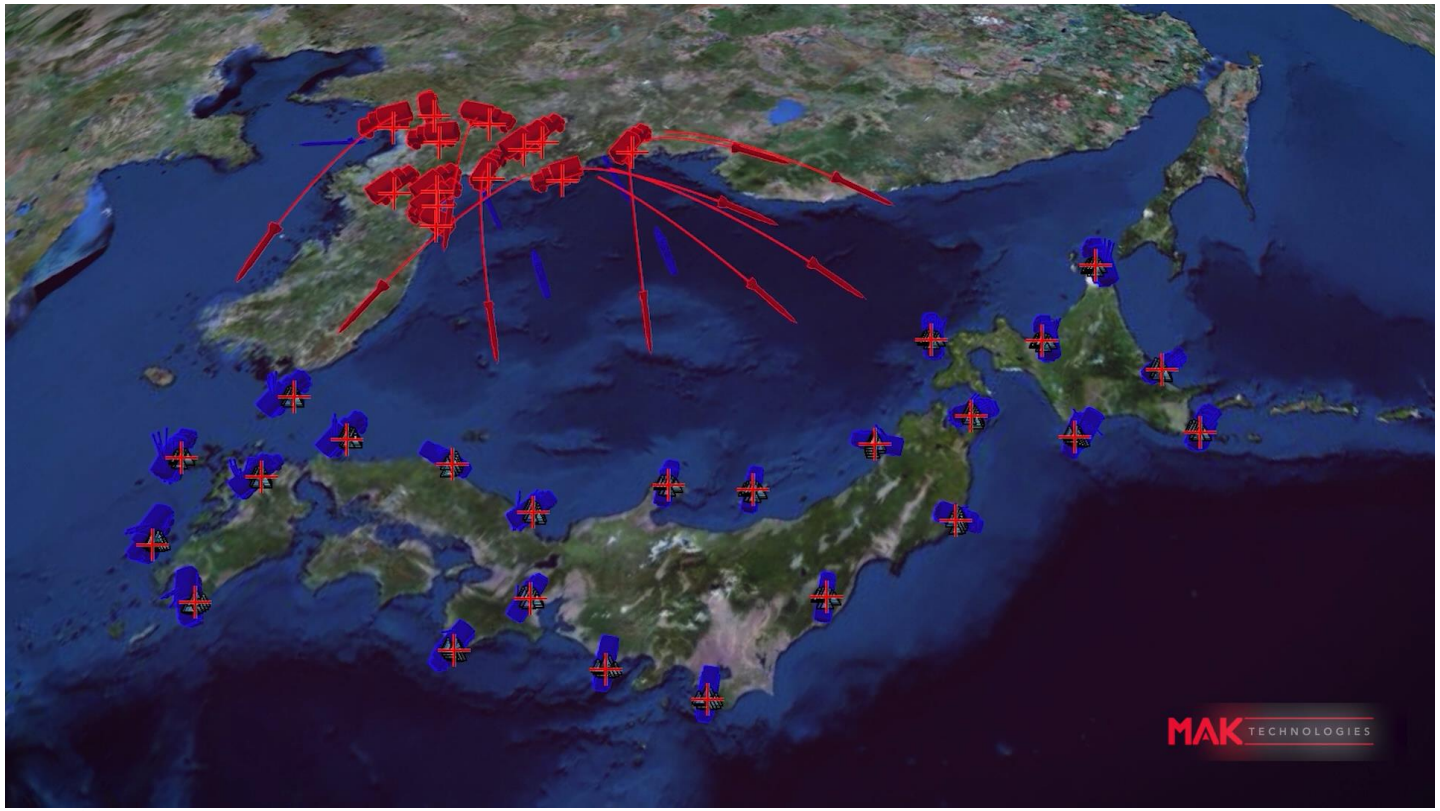
Smart and Efficient "Appliances"

MAK Legion Overview

- **Data Store Library -** enables efficient multi-threaded simulation applications
- **Network Library -** efficiently passes state updates and events between applications
- **Entity Server -** maintains and serves authoritative state based on client interest

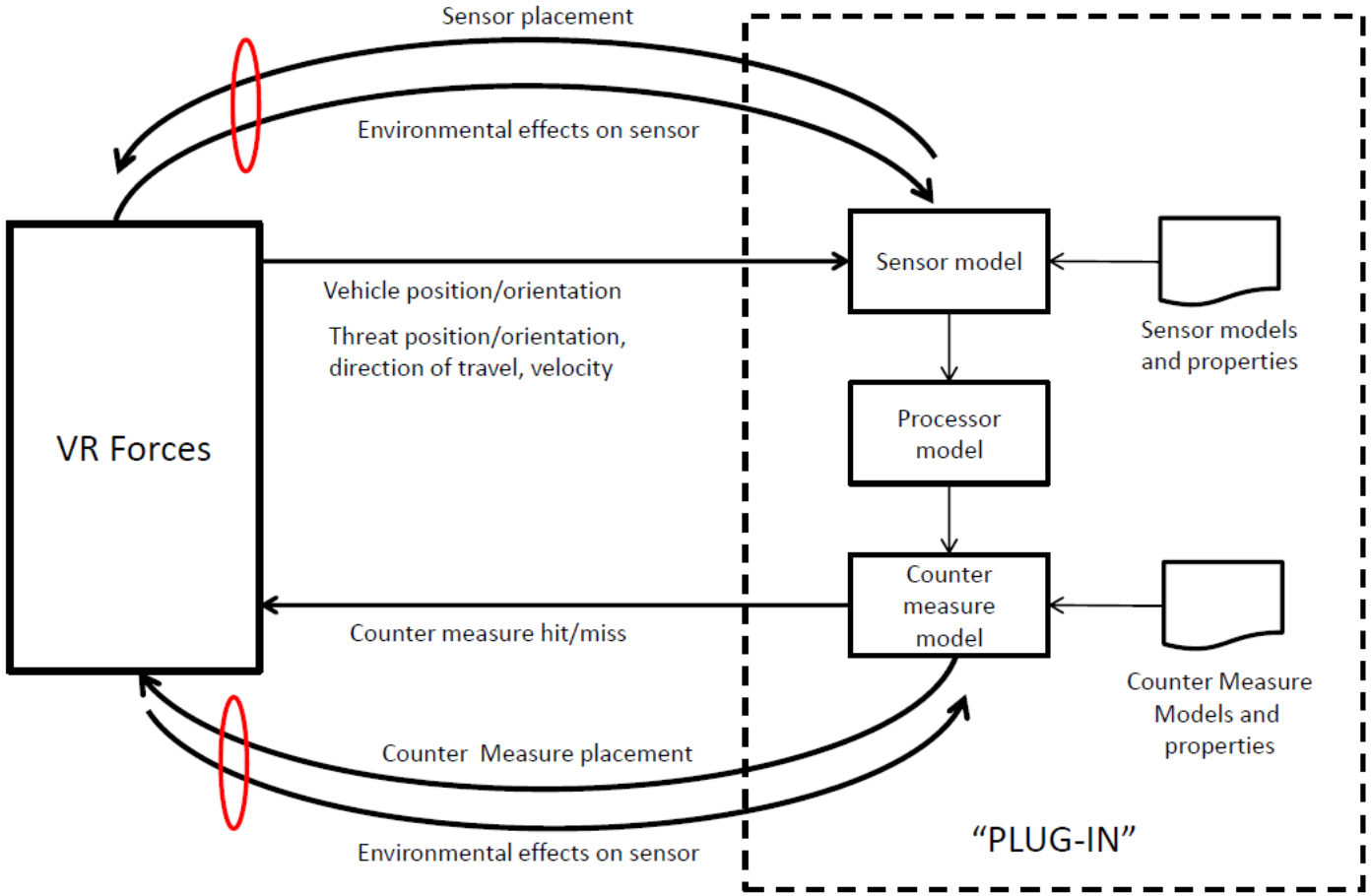


Exercising Digital Twins and MBSE Models in the Context of Multi-Domain Synthetic Environment

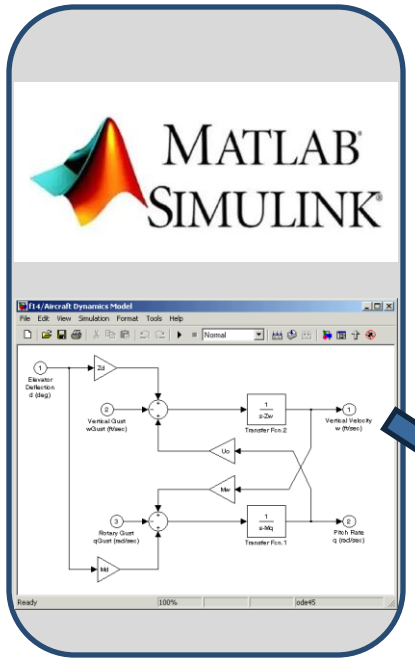


Example: TARDEC Experiment (2015) with Reactive Armor

High-fidelity model of a sensor and counter-measure, plugged into VR-Forces through the API, run at 1,000 frames per second of simulation time, with slow-motion replay in VR-Vantage Stealth 3D viewer



Plugging in Engineering-level Models from MATLAB and Simulink into VR-Forces



Export C++ code from a MATLAB or Simulink Model

C++
CPP

VR-Forces Plug-in

VR-Forces GUI

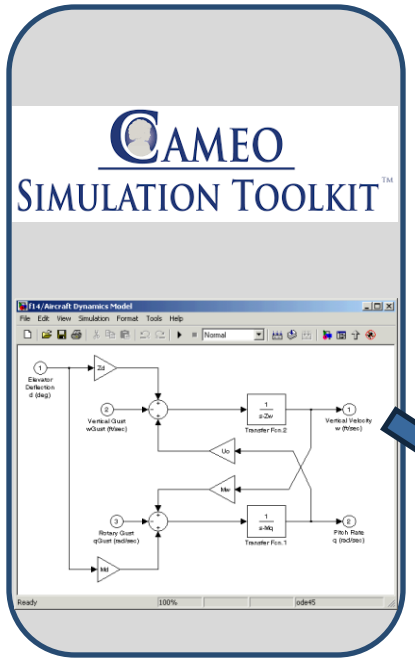
HLA

VR-Forces Sim Engine

Model executing within a VR-Forces synthetic environment, interacting with terrain, weather, and other entities

Custom plug-in adapts *each* external model to VR-Forces by creating and registering custom VR-Forces actuators, sensors and controllers that call the model code that was exported from MATLAB

Desire for a more Data-Driven, Standards-based Approach to Allow a Standard Plug-in to Import Arbitrary Models



Export Models in SysML Standard Format

VR-Forces Plug-in

VR-Forces GUI

HLA

VR-Forces Sim Engine

Holy Grail: A single VR-Forces plug-in (or built-in capability) allows VR-Forces to read any compliant SysML model and execute it in the context of a realistic multi-domain military scenario

Model executing within a VR-Forces synthetic environment, interacting with terrain, weather, and other entities

Can a Standard Plug-in Import Arbitrary SysML Models?

A classic example of “PowerPoint Engineering”!

While SysML provides standard syntax, it doesn’t define standard model semantics (much like UML, XML, or even HLA)

Perhaps it’s possible for a simulation tool (like VR-Forces) to define a set of semantics conventions for use with SysML…

- Standard names and types for various inputs, outputs, function signatures, etc.
- Levies constraints and responsibilities on the model developer
- Modeler needs to build their Digital Twin specifically so that it can run in VR-Forces

VR-Forces could load / execute SysML models specifically built for VR-Forces

- This is what usually is happening in demos by other vendors
- MAK currently supporting a small pilot project with L3Harris

Standardization of Conventions Across Vendors' Tools?

In theory, various synthetic environment vendors could define standard semantics conventions on top of SysML that they all agree to implement

Could allow reuse and interoperability – the import of Digital Twin models built to these standards into any compliant simulation tool

This is an area that MAK is interested in exploring

- We have much experience developing open interoperability standards – RPR FOM, WebLVC, DIS, HLA, C2SIM, Simulation Scalability Study Group, etc.
- Let us know if you have funded projects in this area!

There may be limits to what's feasible, given the breadth of mutually incompatible design choices made by different vendors

- Same issue that has made it elusive to have standard scenario/behavior content that can be executed by multiple vendors' engines

Final Word…

Whether by explicitly adapting Digital Twin models to run in VR-Forces, or in the future by building such models to a data-driven Standard…

…VR-Forces provides an excellent, flexible, multi-domain environment in which to exercise models of all kinds of systems in a battlefield scenario

VR-Forces provides the terrain, weather, targets, CGF entities and behaviors, scenario events, tactical graphics, moving map display, 3D viewer, scenario authoring GUI, AAR tools, HLA/DIS interoperability, global scale, flexible APIs and other infrastructure required for concept development, testing, and experimentation during all phases of the MBSE process

Thank you

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