C2VE: A Software Platform for Evaluating the Use of 3D Vision Technology for C2 Operations

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Motivation

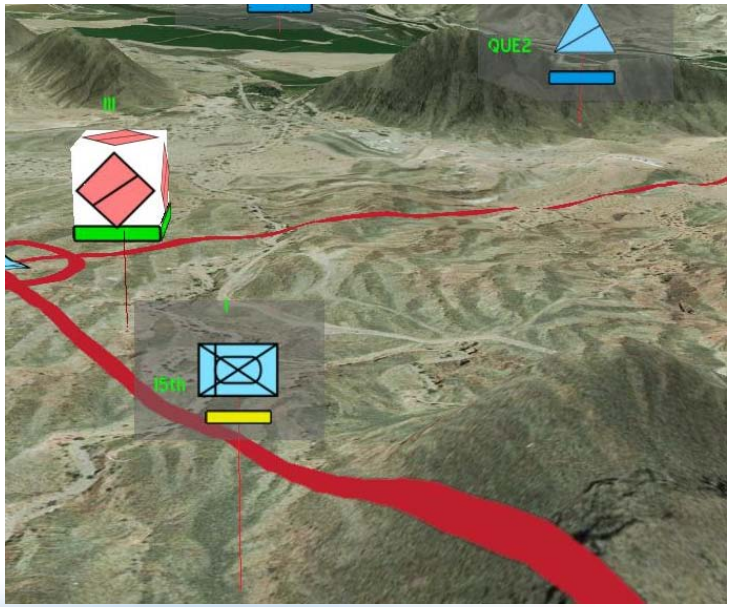
- Command and control (C2) environments are complex
  - High volume of data
  - Different sources
  - Complex relationships
- C2 systems should support effective decision making
- Important factor: how the data is displayed

Project Goals

- **Overall:** Study visualization options for C2
- **Phase 1**: Develop a **software platform** for analyzing information visualization options for C2
- **Phase 2** (upcoming): Study which options help the users complete their tasks most effectively
  - 3D or 2.5D
  - Symbol rendering methods
  - Use of annotations

2.5D vs. 3D

- 3D virtual environment projected into 2D
- Standard computer monitor or projector



- User perceives depth
- Our software supports several devices
  - Head-mounted displays

  - Several screen sizes

3D in Many Sizes

Rear projection
13 by 7.5 feet

Desktop with
3D monitor

small,
inexpensive,
portable

large,
multi-user

3D laptop

Front projection

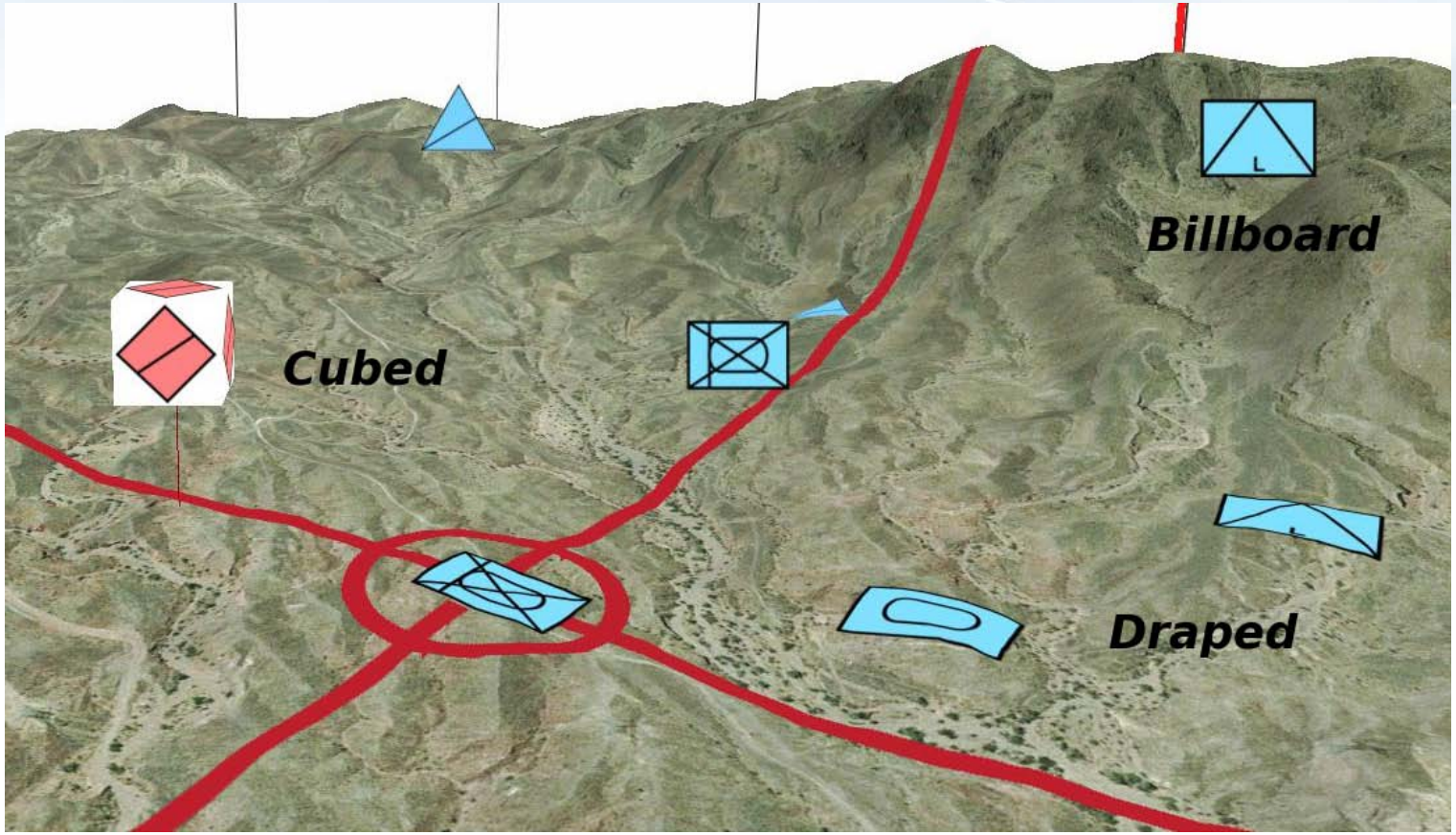
2.5D or 3D: Which is Better for C2?

- 3D: user perceives depth
  - Not available in 2.5D
  - Depth perception is not always accurate
- Existing studies with other applications: mixed results about which is better
- Software lets us systematically study this question for C2
  - Supports both 2.5D and 3D devices
  - Next phase of our project

Potential 3D Benefits

- Determine steepness of terrain
  - Is it passable or not?
- Line of sight information
  - Check visibility from candidate observation posts
  - Determine if enemy posts can observe route
  - Technically possible in 2.5D, but lack of depth perception is expected to be an issue
- Pinpointing aircraft location
  - Depth of airborne objects is difficult to determine in 2.5D
- ...

Symbol Rendering Options



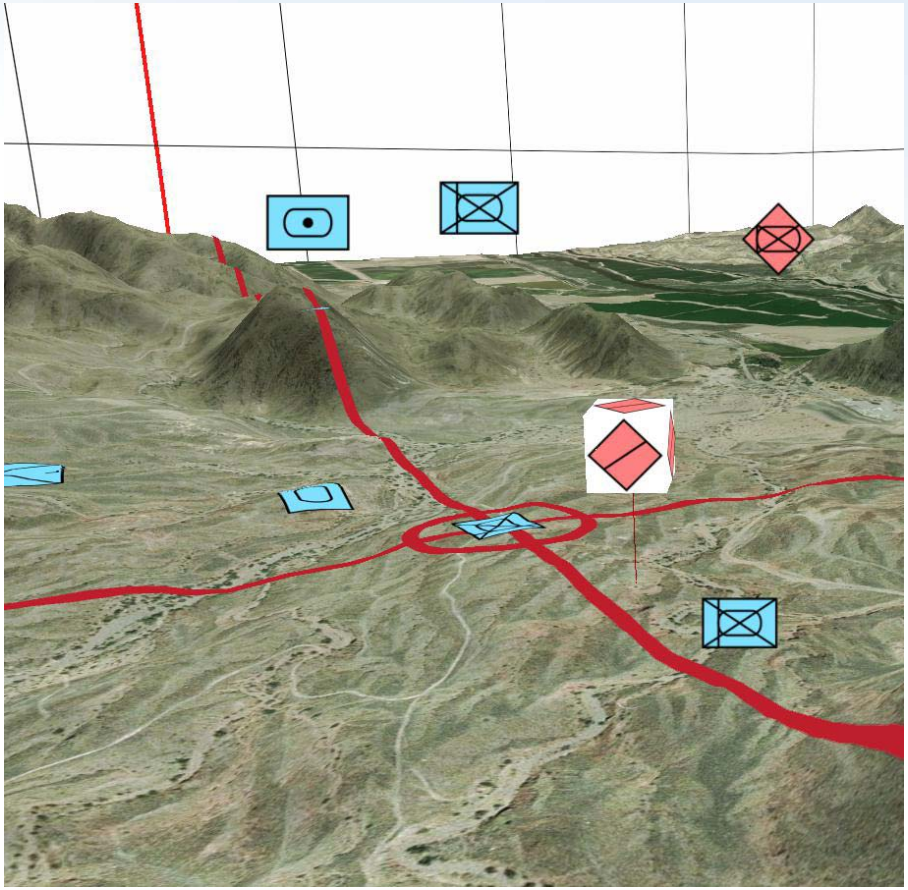
Phase 2: Which option is best?

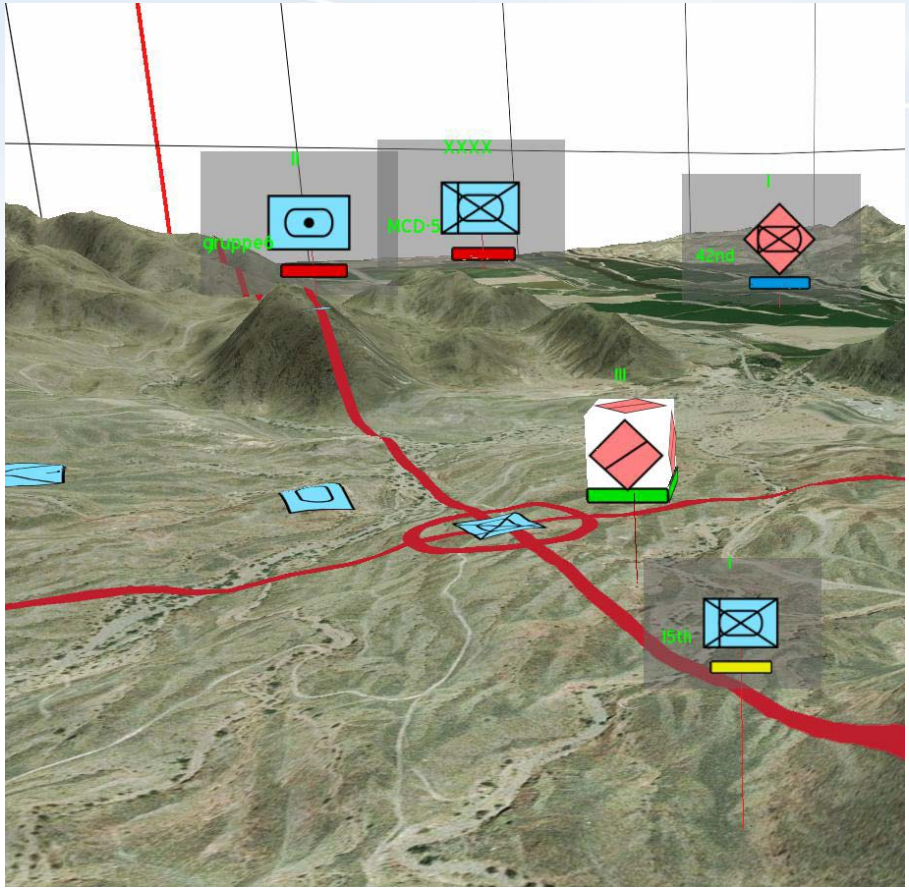
Symbol Rendering Options

- Billboards and cubes always face the camera
  - Rotate when the camera moves
- Draped symbols have fixed orientation

- Supports different types at once
- Can use rendering method to indicate features of units
  - Draped symbols for geographically fixed
  - Billboards for others

Optional Annotations





Optional Annotations

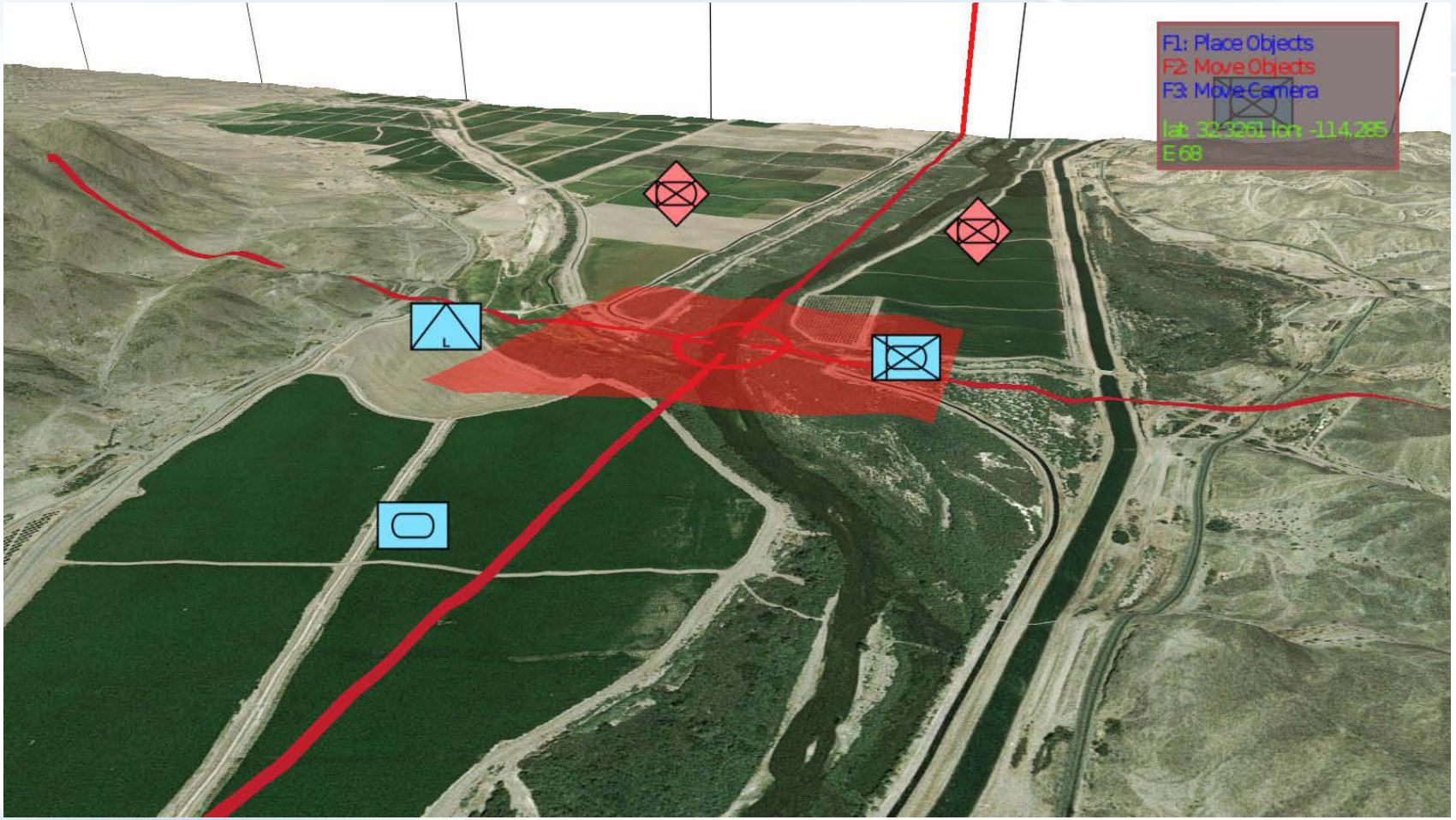
- Advantage: more information
- Disadvantage: risk of information overload with many symbols

- Current software: user can toggle on/off
  - Phase 2: Study when users toggle the annotations
- Possible future research: selective annotations based on context

Outline

- Goal: study visualization techniques for C2
- Our software: test bed for visualization techniques
  - 3D and 2.5D
  - Symbol rendering methods
  - Toggling annotations
- **Additional software features**
  - Rendering the landscape
  - Interacting with the system

Rendering the Landscape



Rendering the Landscape

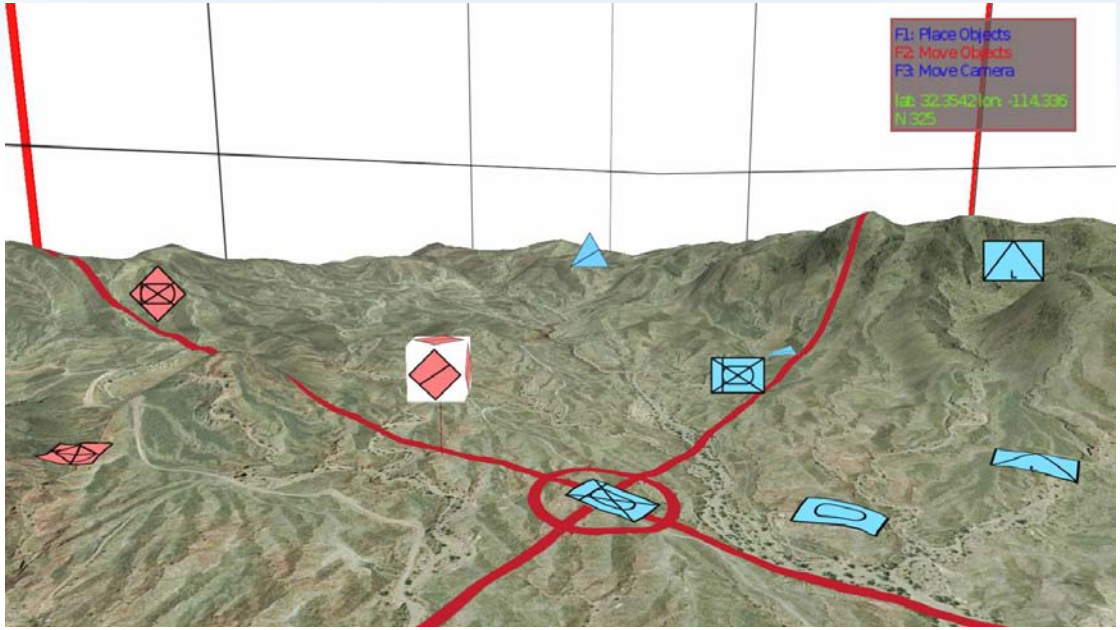
- Uses open-source 3D graphics engine
  - Object-oriented Graphics Rendering Engine (OGRE)
  - Supports terrain and texturing
  - Supports 3D models (buildings, vehicles, etc.)
- Visible landscape combines two data sources
  - Elevation data
    - From NASA's Shuttle Radar Topography Mission (SRTM) via USGS databases
    - Digital Terrain Elevation Data (DTED) format processed using MICRODEM mapping software
    - Generates height map image file for OGRE
  - Aerial images
    - From USGS Seamless Data Warehouse
    - Resolution: approximately 1 pixel per square meter
    - Can handle 7km by 7km area at this resolution
- OGRE applies image as a texture on the terrain

Interacting with the System

- Three modes of interaction
  - Move camera
  - Place symbols
  - Move/delete symbols
- Supports different input devices
  - Keyboard and mouse
  - 3D SpaceNavigator
  - 3D wand

Cursor Features

- Crosshairs for easy location
- Projected on skybox
  - Helps user with accurate perception of cursor depth

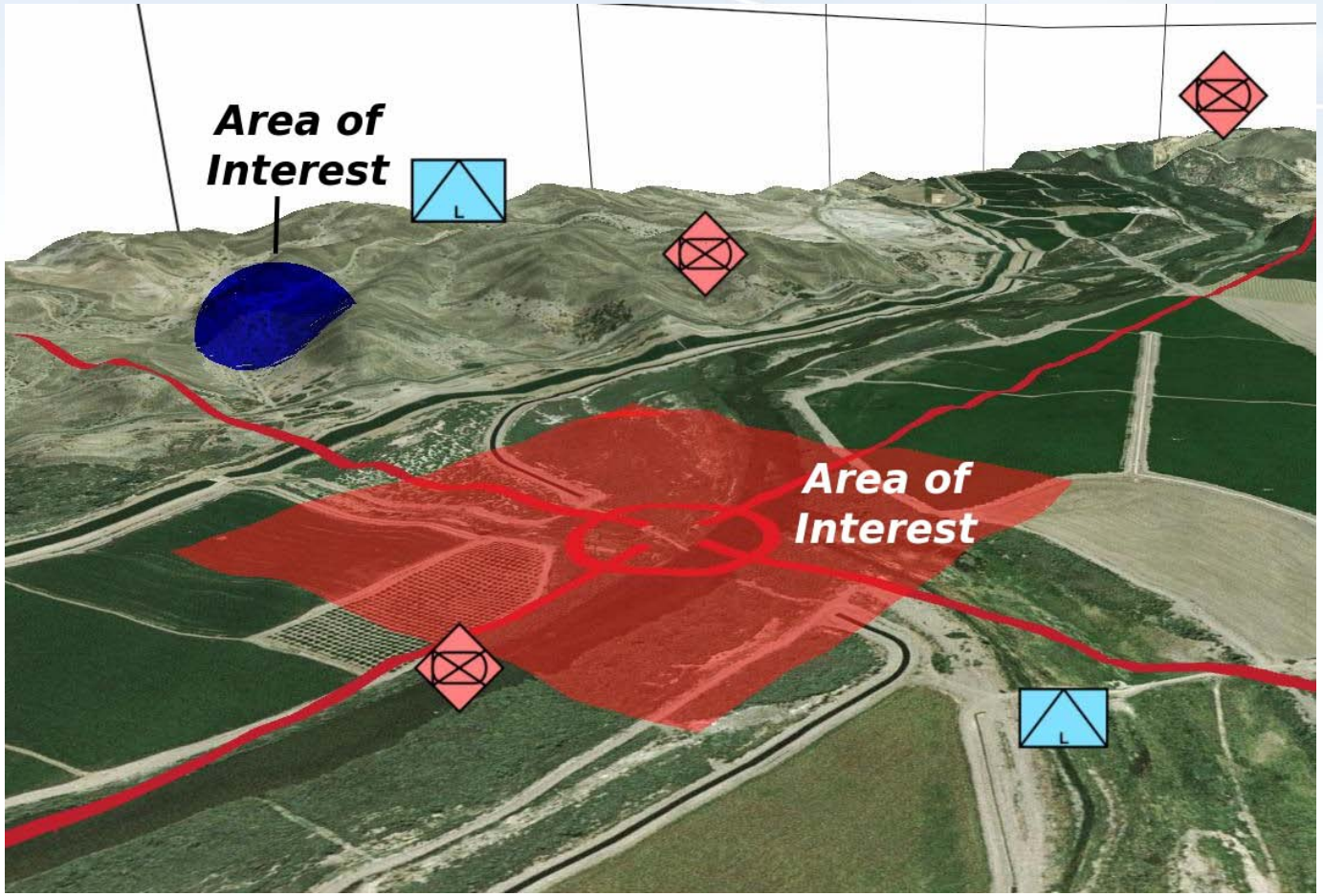


Symbol Manipulation

- Symbols from MIL-STD-2525C
- Toggle between modes via the keyboard
  - Delete symbol
  - Move symbol
  - Place a new symbol
    - Click at desired location
    - Graphical menu organizes symbols by category
    - User selects rendering mode (e.g., billboard)
    - User clicks on desired symbol
- Current symbol locations can be saved to file and reloaded later

Areas of Interest

- Drawn with the cursor
- Arbitrary polygons
- Domes



Summary

- Built a software platform for evaluating C2 visualization options

- 2.5D and 3D displays
- 3 types of symbol rendering
- Annotations can be toggled

Next Steps

- Conduct user studies to determine which visualization options are best

- Measuring "best"
  - Performance on tasks
    - Time to complete
    - Quality of decisions
  - User surveys

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Questions or Comments?