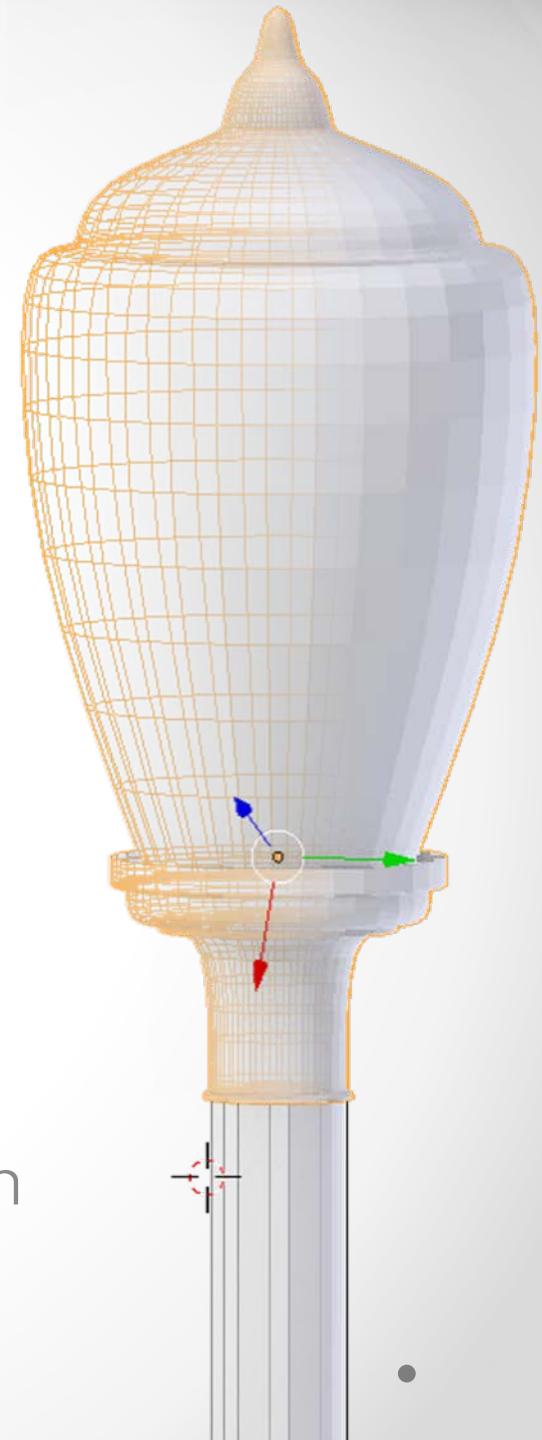


Designing Highways with 3D CAD

Joel Graff, P.E.
Illinois Department of Transportation



Contact information

Joel Graff, PE

Illinois Department of Transportation, District 2
819 Depot Ave,
Dixon, IL 61021

Ph: 815-284-5383 (work)

Email: joel.graff@illinois.gov

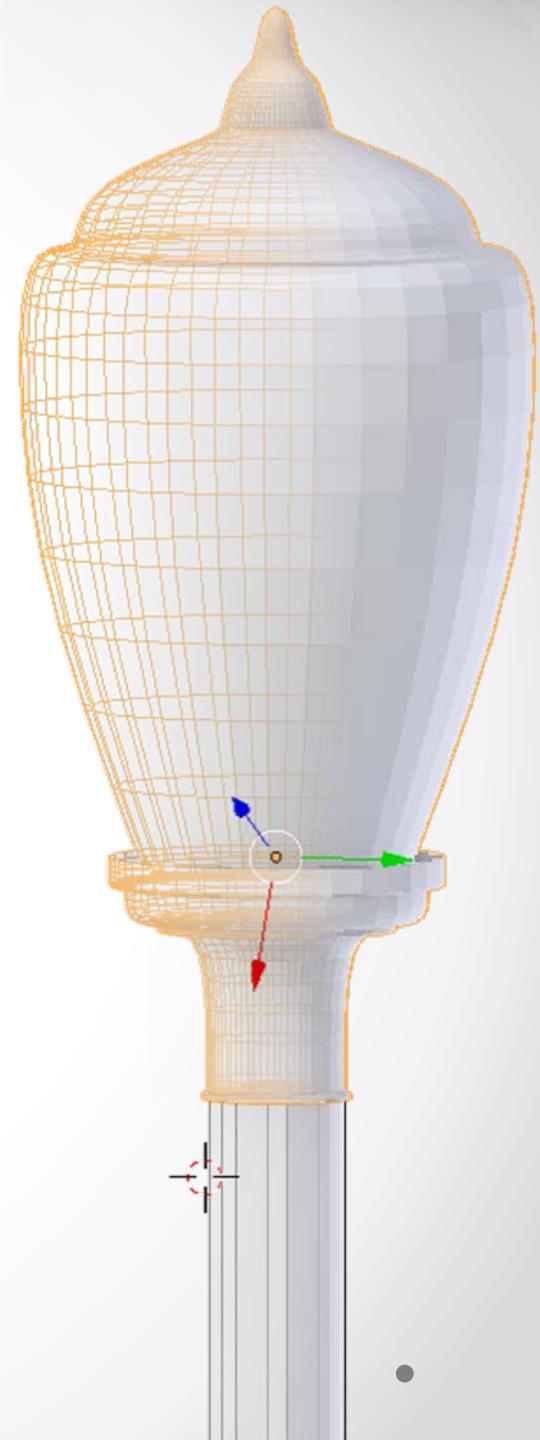
LinkedIn: www.linkedin.com/in/joelcgraff

IDOT is Hiring!

- Highway maintenance, technical / non-technical staff, and civil engineers
- No permanent postings
- Watch www.idot.gov (Employment tab)

Key Questions

- Why are we doing this?
- How does it work?
 - Construction
 - Visualization
 - Design
- What will it take to get there?

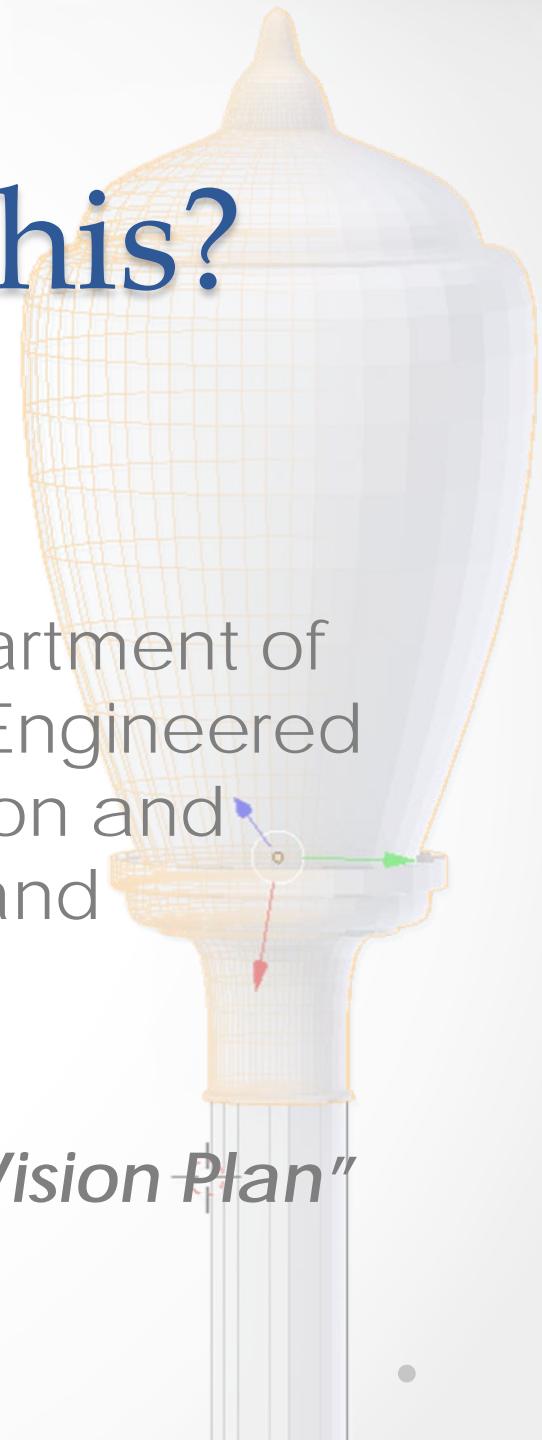


Why are we doing this?

Executive Leadership Commitment

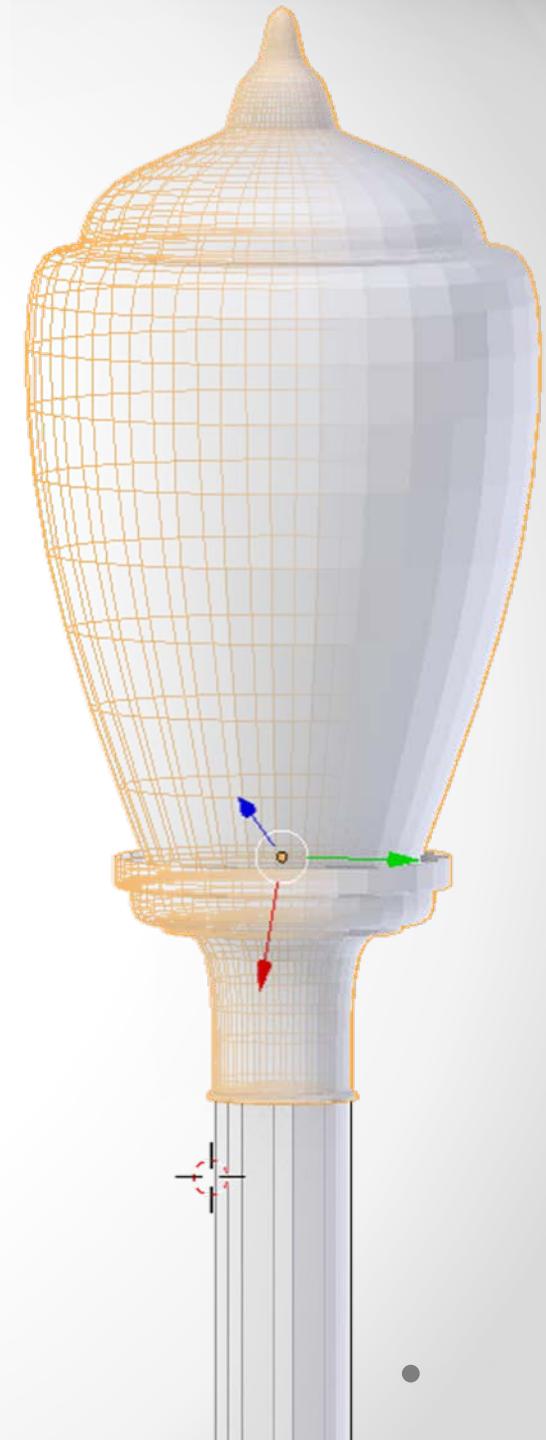
"It is the desire of the Illinois Department of Transportation to implement 3D Engineered Modeling from project conception and initiation through maintenance and operations."

- *"Building a Better IDOT: IDOT's Vision Plan"*



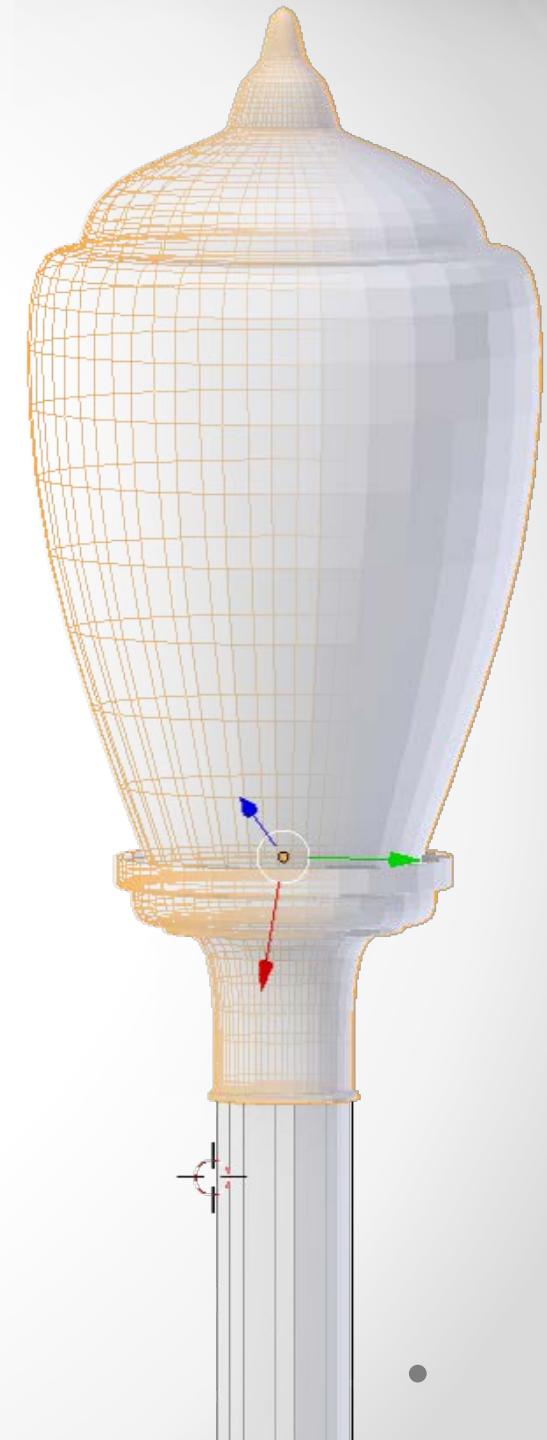
How does it work?

- 2D CAD creates *three models*
 - Top (plan)
 - Side (profile)
 - Front (cross-section)
- 3D CAD builds *only one model*
 - Parametric and volumetric
 - Everyone uses it
 - 2D views generated arbitrarily



How does it work?

- *Parametric modeling* is not 3D modeling (“meshing”).
- A parametric model is controlled by engineering parameters and constraints.
- Traditional 3D model “mesh” is generated automatically



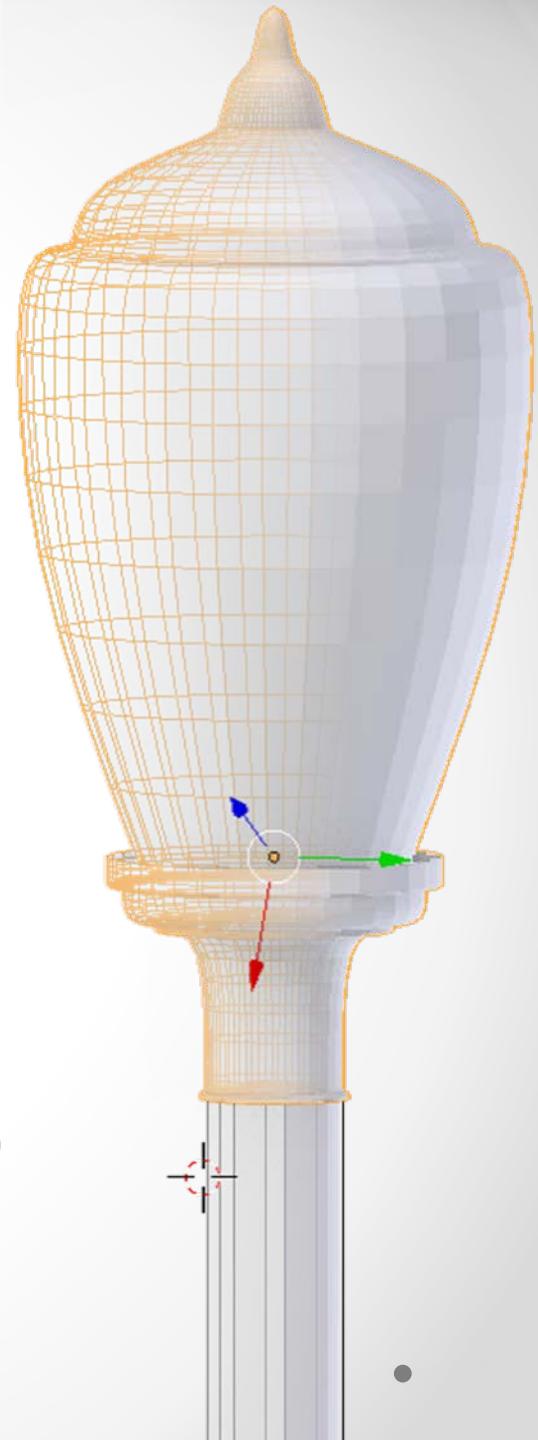
Applications

Ideal for

- New construction / reconstruction
- Major profile / cross-slope changes

Little or no benefit for

- Narrow surface widening
- Mill-and-fill / overlays
(minor profile/ cross slope changes)
- Locations with poor GPS signal
- Locations with no existing survey

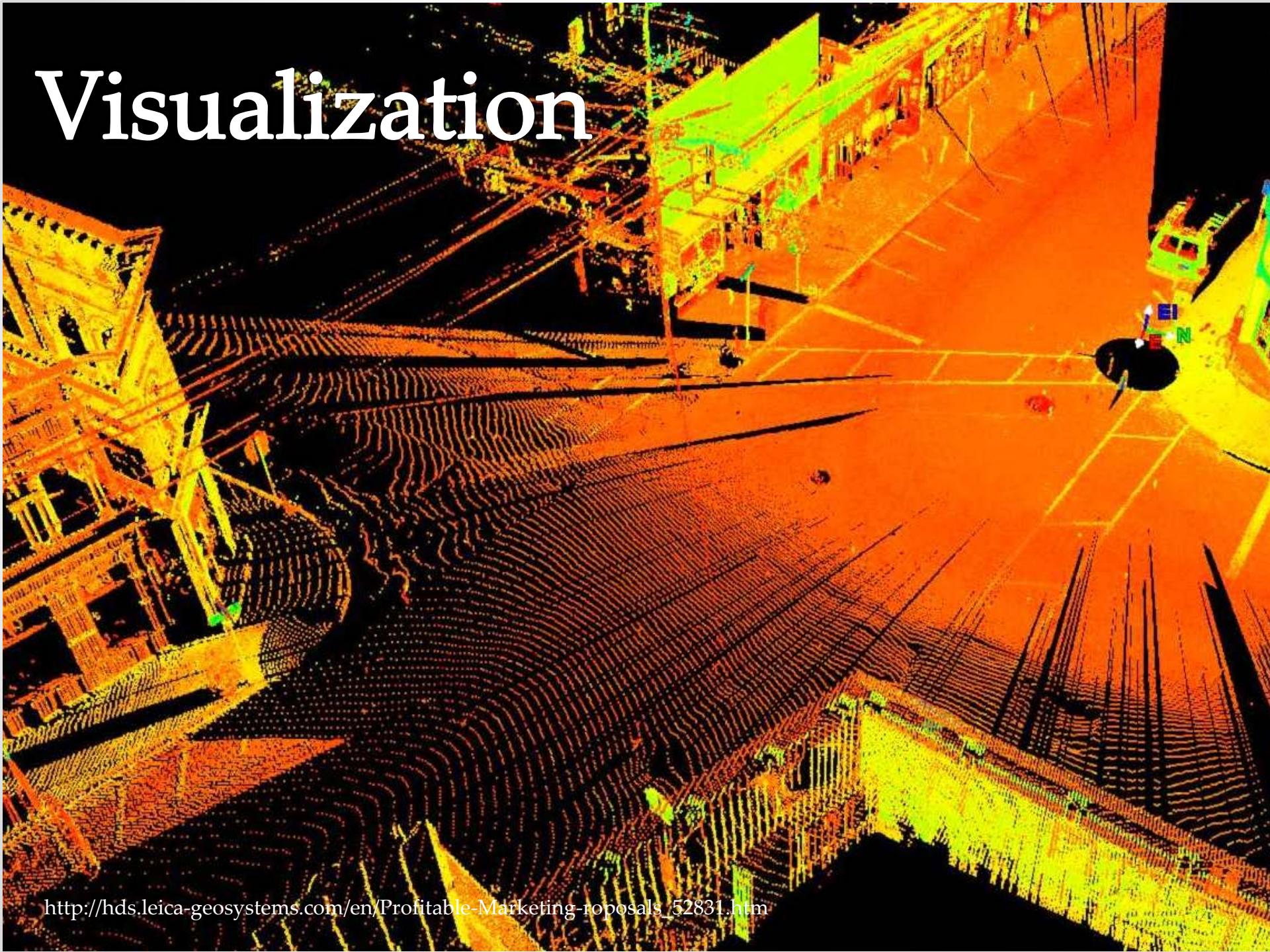


Construction Benefits

- Fully constructible
- Stake anywhere in project limits
- Improved accuracy in transitions, intersections, and earth work
- Utility / conflict identification
garbage in / garbage out caveat!
- Changes propagated to everyone
- Faster staking (~50% increase)



Visualization



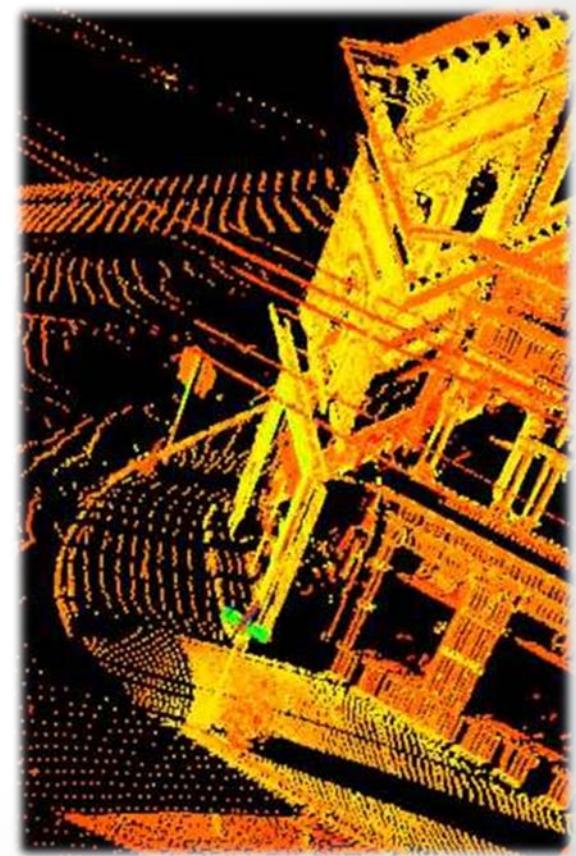
Visualization Benefits

- Information content increases 50x – 100x
- Interactive
- Rapid prototyping



Prototyping

- Reproduce existing infrastructure
 - Lidar
 - Laser scanners
 - Photogrammetry
- Integrate 3D prototypes with existing 3D (no pasting / superimposing)
- Deliverable on several platforms
 - 3D printing
 - Simulation (desktop / mobile)
 - Virtual Reality
 - Web

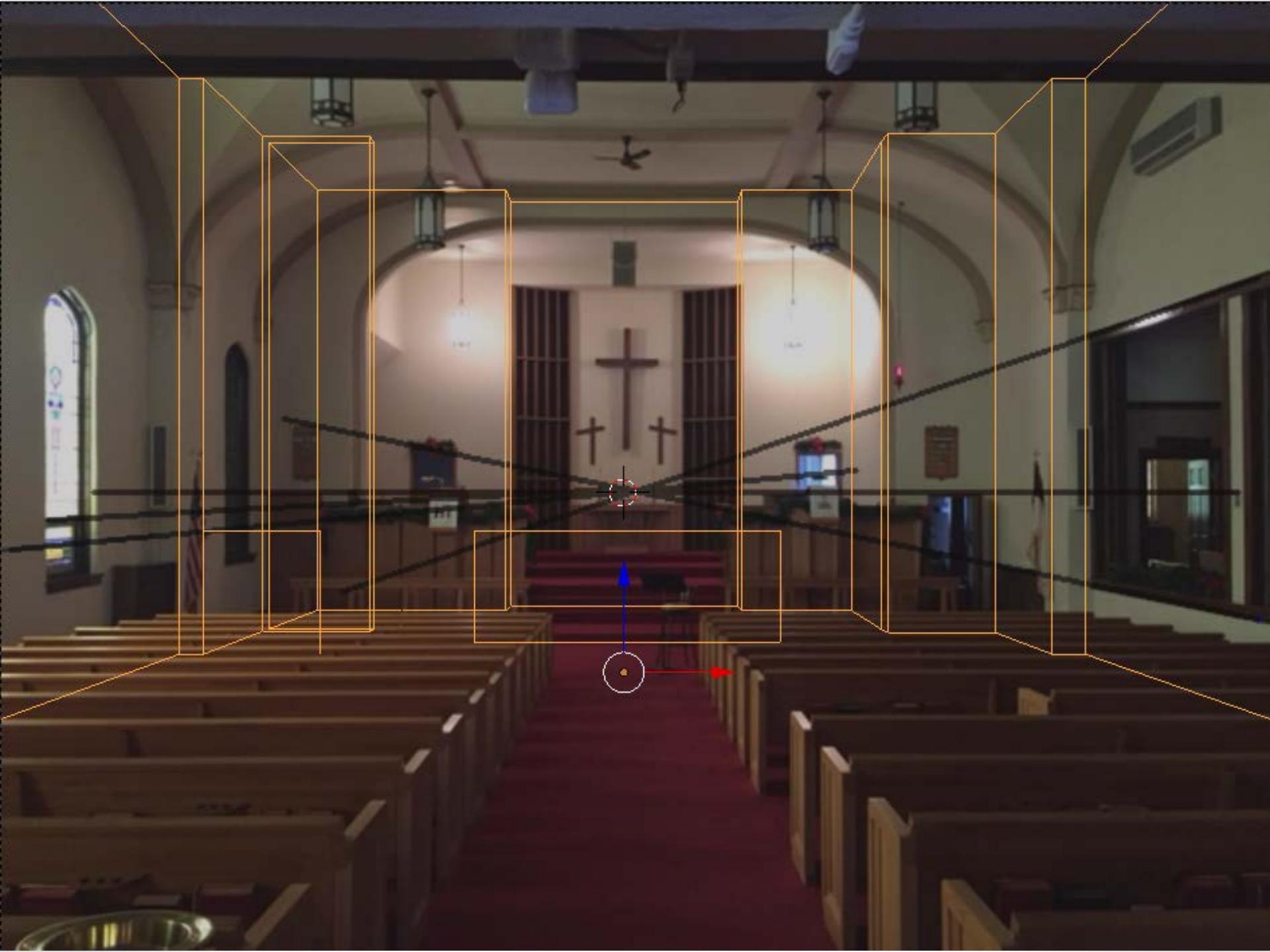


Photogrammetry Examples

- The following slides demonstrate producing actual 3D models strictly from a single, or a series of photographs.
- The technique does not require actual measurements and can produce reasonably accurate reproductions, given good photography and sufficient information about the camera lens used to take the images
- Commercial and open source packages exist which can produce 3D point clouds algorithmically from a series of images, like Bentley's Context Capture





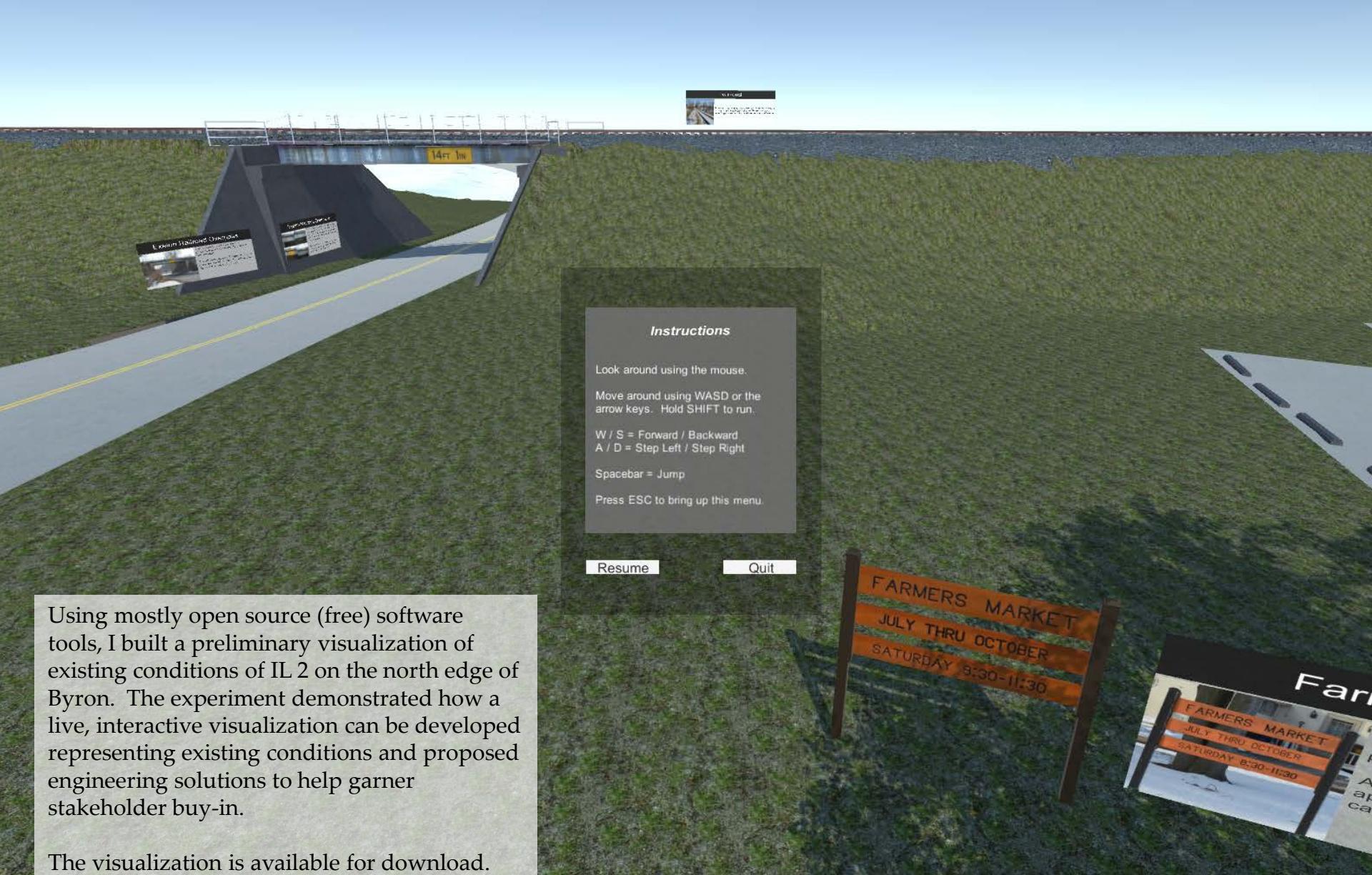






IL 2 Visualization





Using mostly open source (free) software tools, I built a preliminary visualization of existing conditions of IL 2 on the north edge of Byron. The experiment demonstrated how a live, interactive visualization can be developed representing existing conditions and proposed engineering solutions to help garner stakeholder buy-in.

The visualization is available for download.

Contact Joel Graff for details.

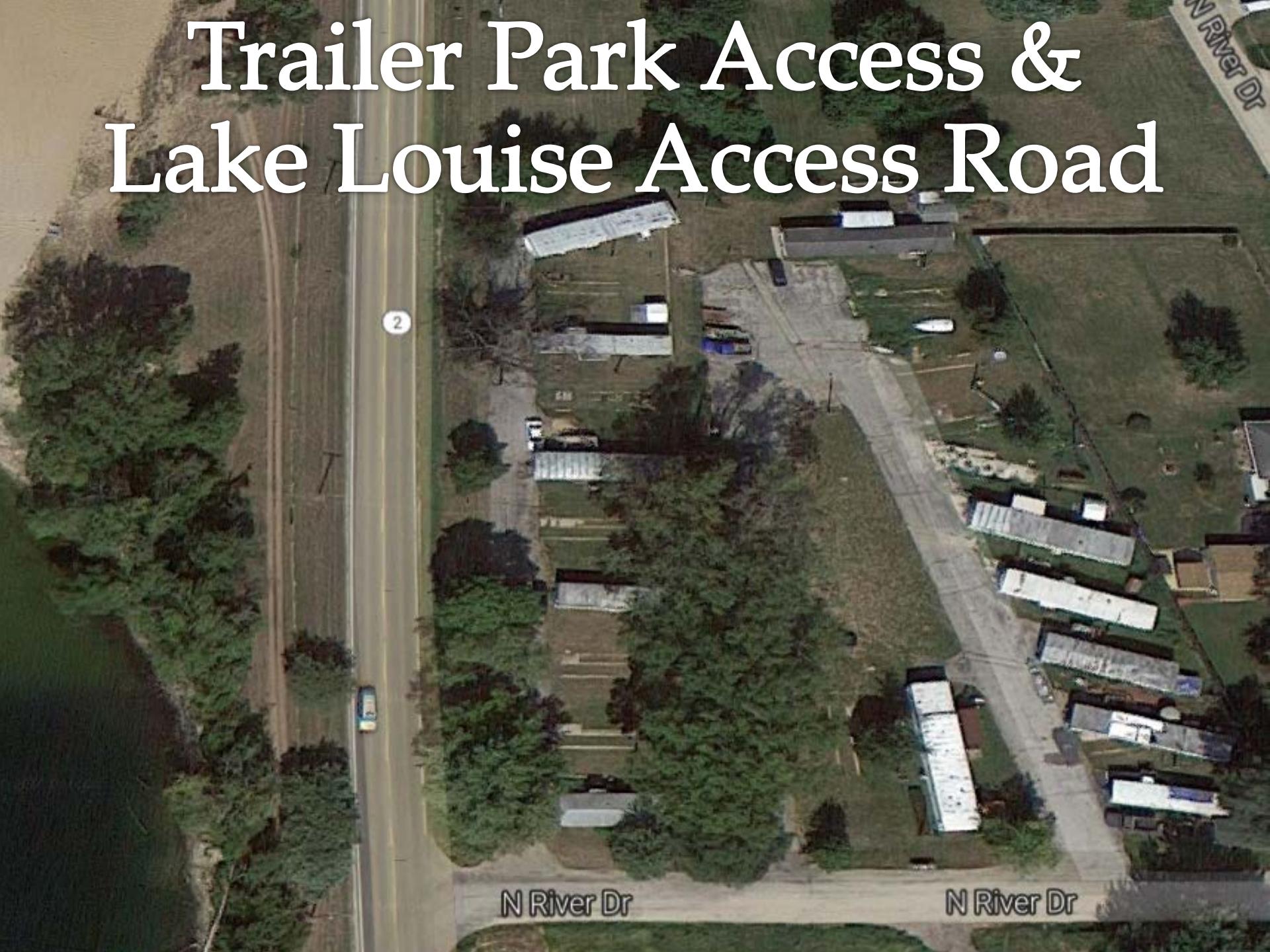
joel.graff@illinois.gov

LumenRT

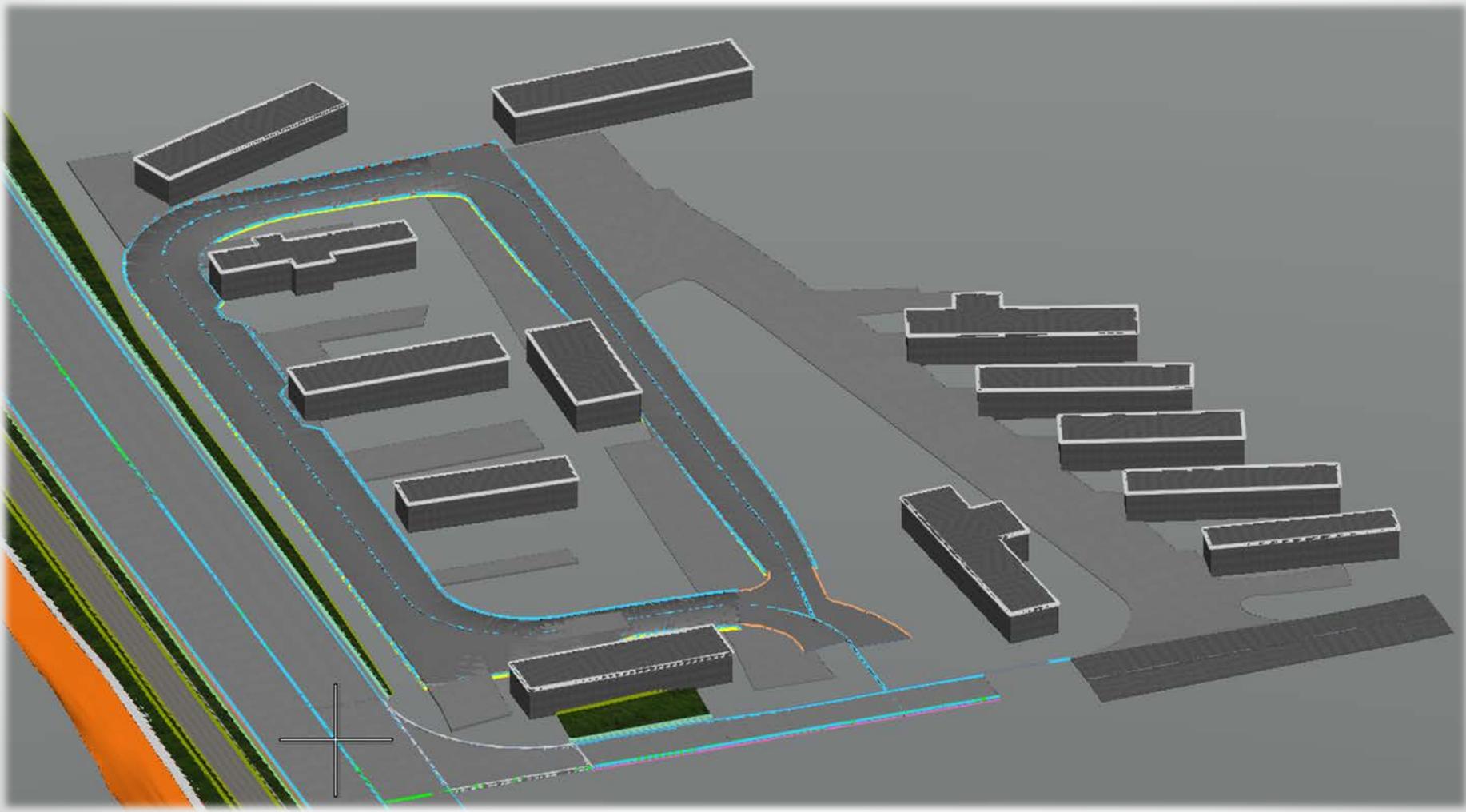


Integrated visualization with transportation-specific features including traffic and walking pedestrians

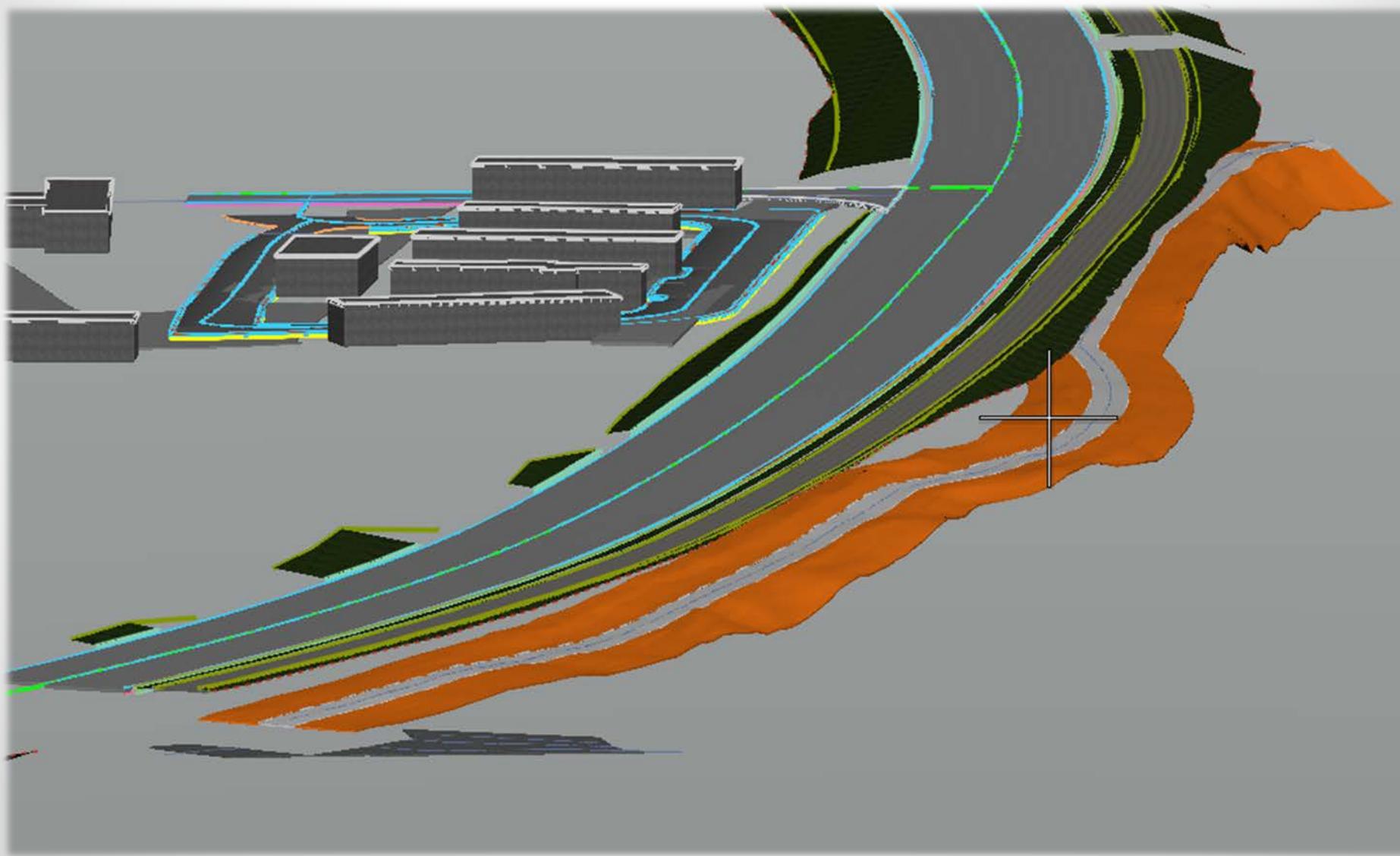
Trailer Park Access & Lake Louise Access Road



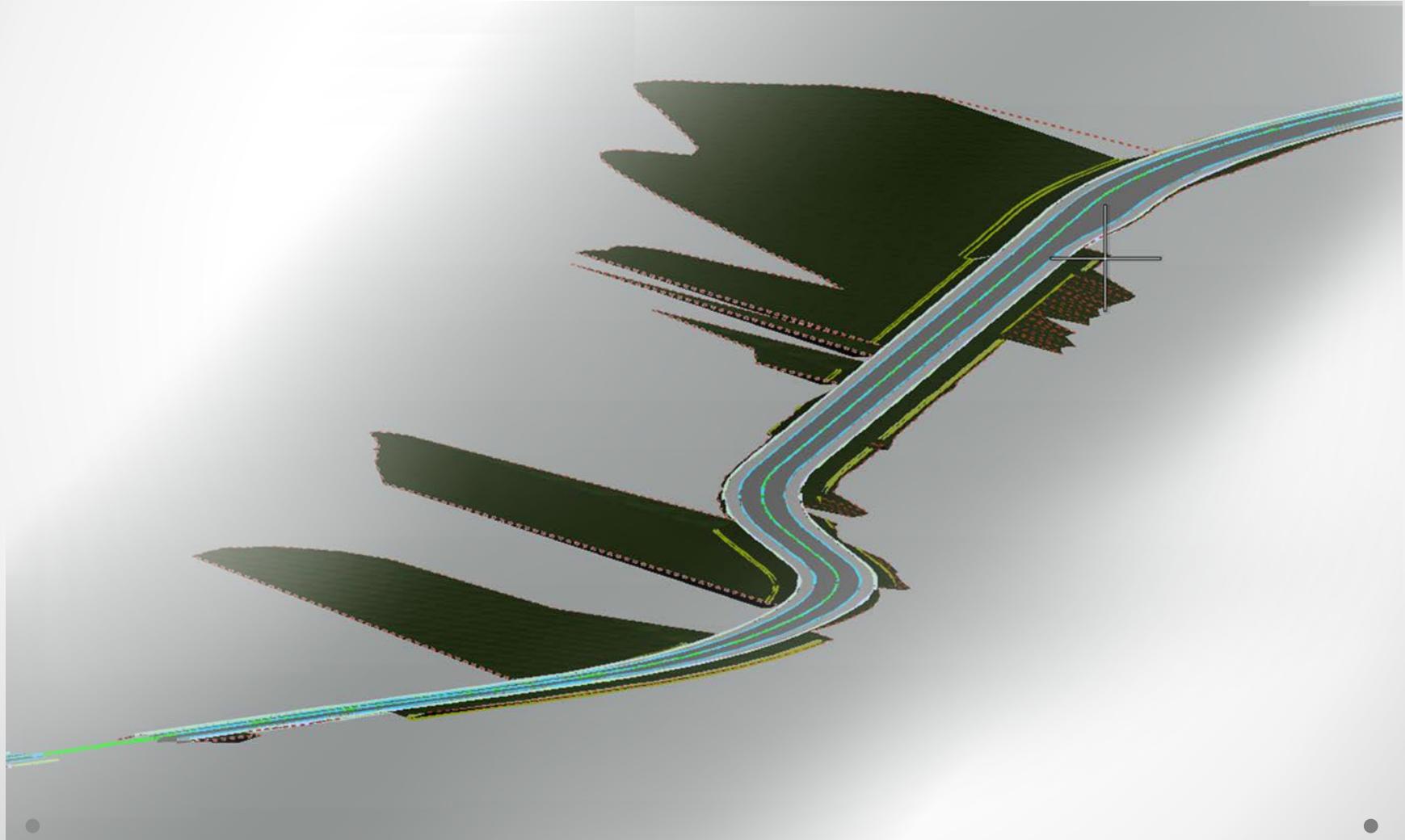
Trailer Park



Lake Louise Access Road



Design Modeling



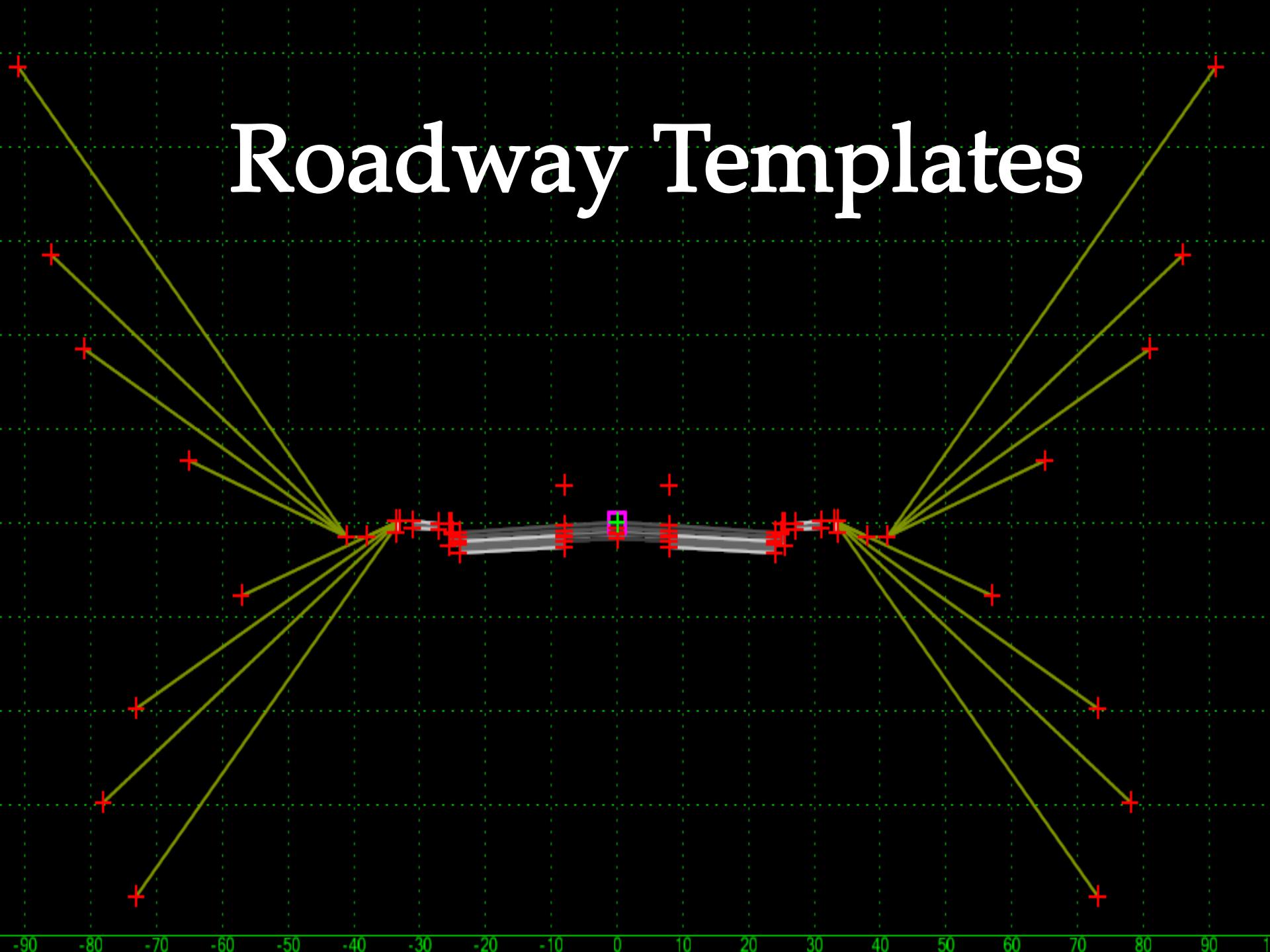
Design Modeling

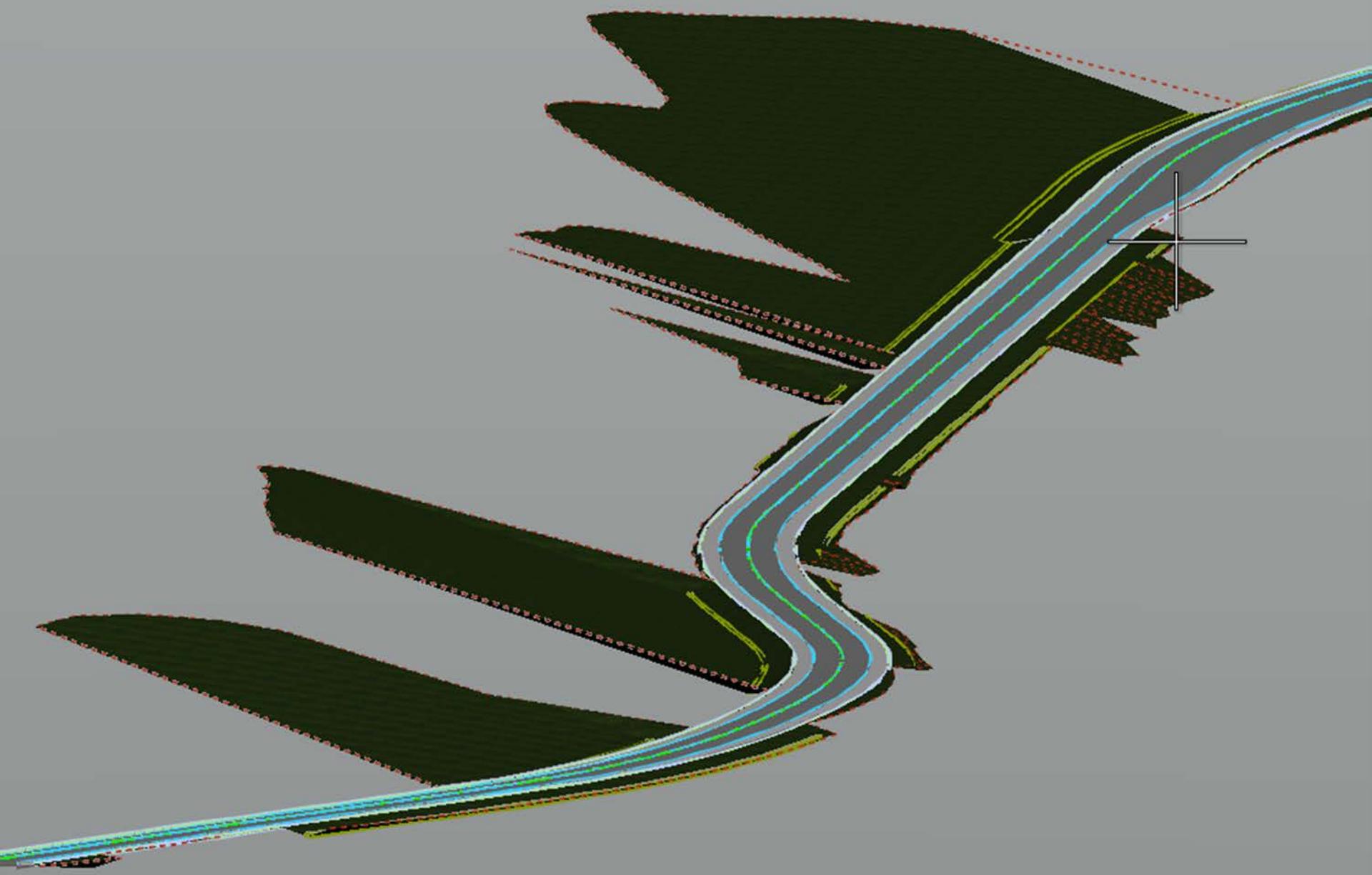
- ***Realtime*** - Visualize alignment / profile changes
- ***Volumetric*** - Direct quantities estimates
- ***Parametric*** - Incorporates existing engineering practices

Design Modeling

- Generate existing terrain model from survey data
- Create alignments
 - DGN file becomes sole source for all model data
 - New vertical geometry tools
 - GEOPAK goes away
- Construct model with roadway templates and civil cells
- Model is generated with “feature definitions”

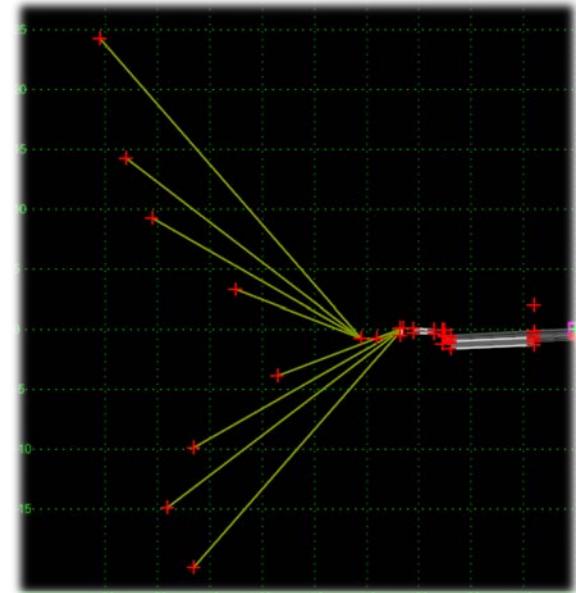
Roadway Templates





Roadway Templates

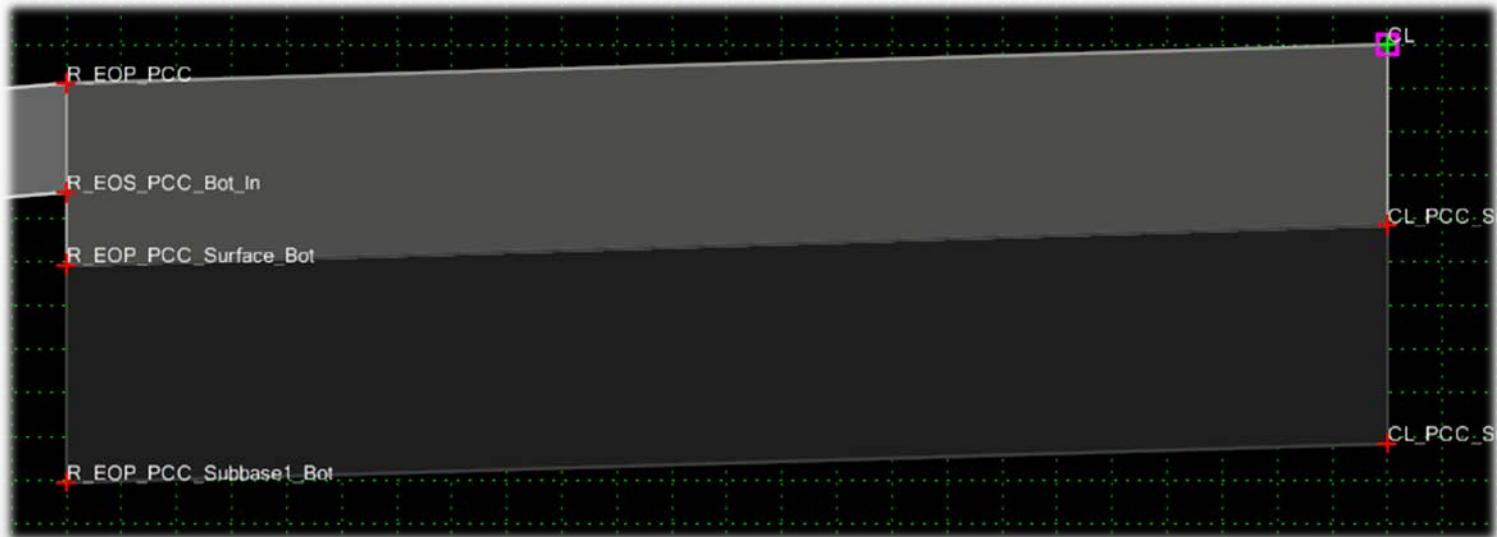
- Analogous to a typical section
- Applied to a “corridor” defined by an alignment.
- Multiple end conditions allow matching to existing terrain



Intermittent design elements like curb, shoulder, sidewalk, depressed gutter, gutter flags, etc. can be incorporated using display rules

Roadway Templates

- Points and edges that define the roadway structure
- Workhorse of the 3D model



Roadway Templates

Fixed Constraints

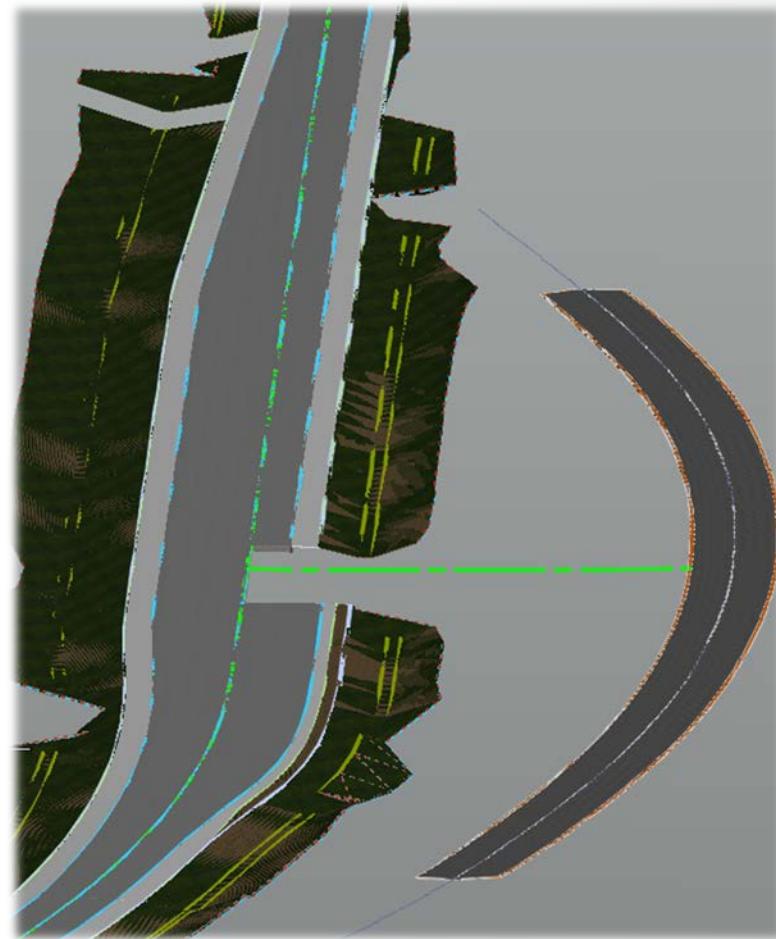
Linear transitions between templates

Parametric Constraints

Linear transitions within or across templates

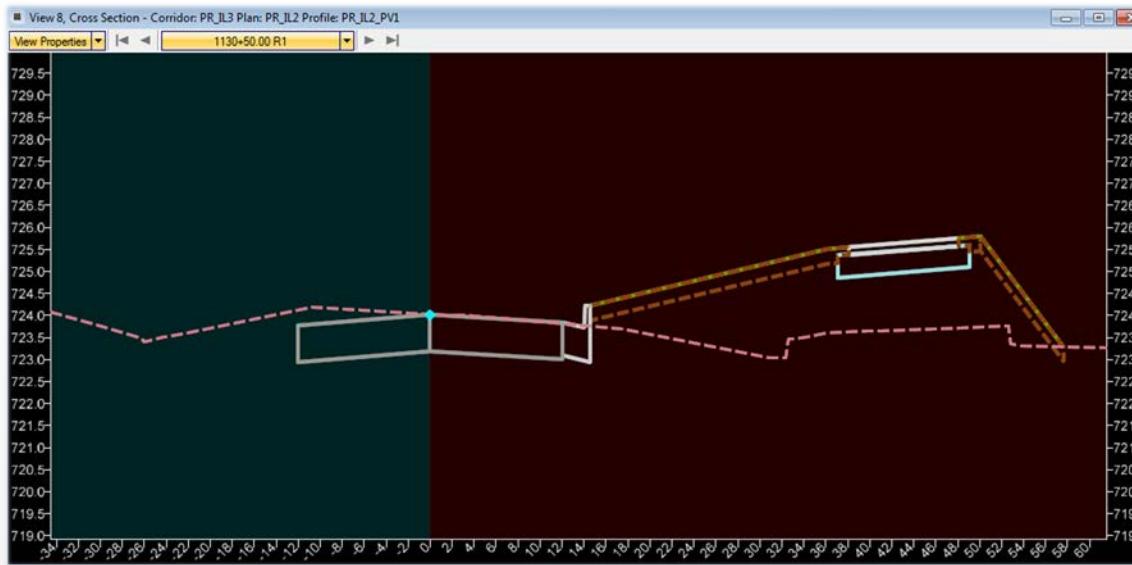
Horizontal Feature Constraints / Point Controls

Non-linear transitions



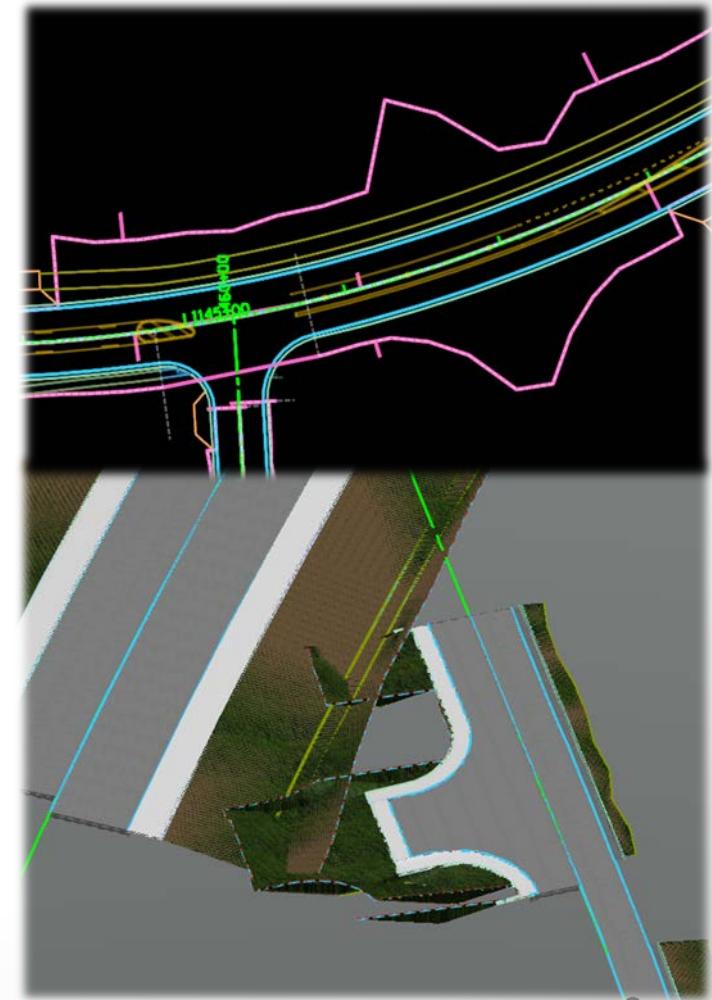
Template Cross Sections

- Generated immediately from template
- Shows all roadway elements in the template
- Cannot be used for final sheet cross-sections



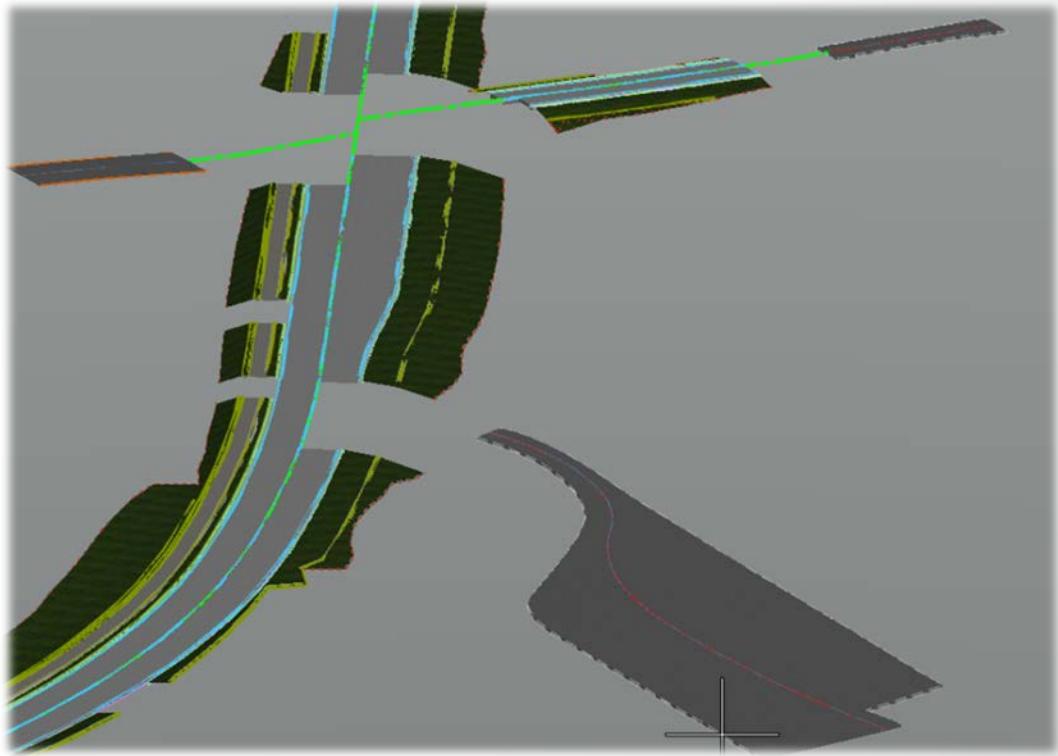
Corridors / Template Drops

- A corridor will usually have multiple templates
- Enables constraint application across templates
- Template drops occur at fixed intervals (25' = rough; 1' = fine)
- Multiple corridors can overlap and “clip” each other

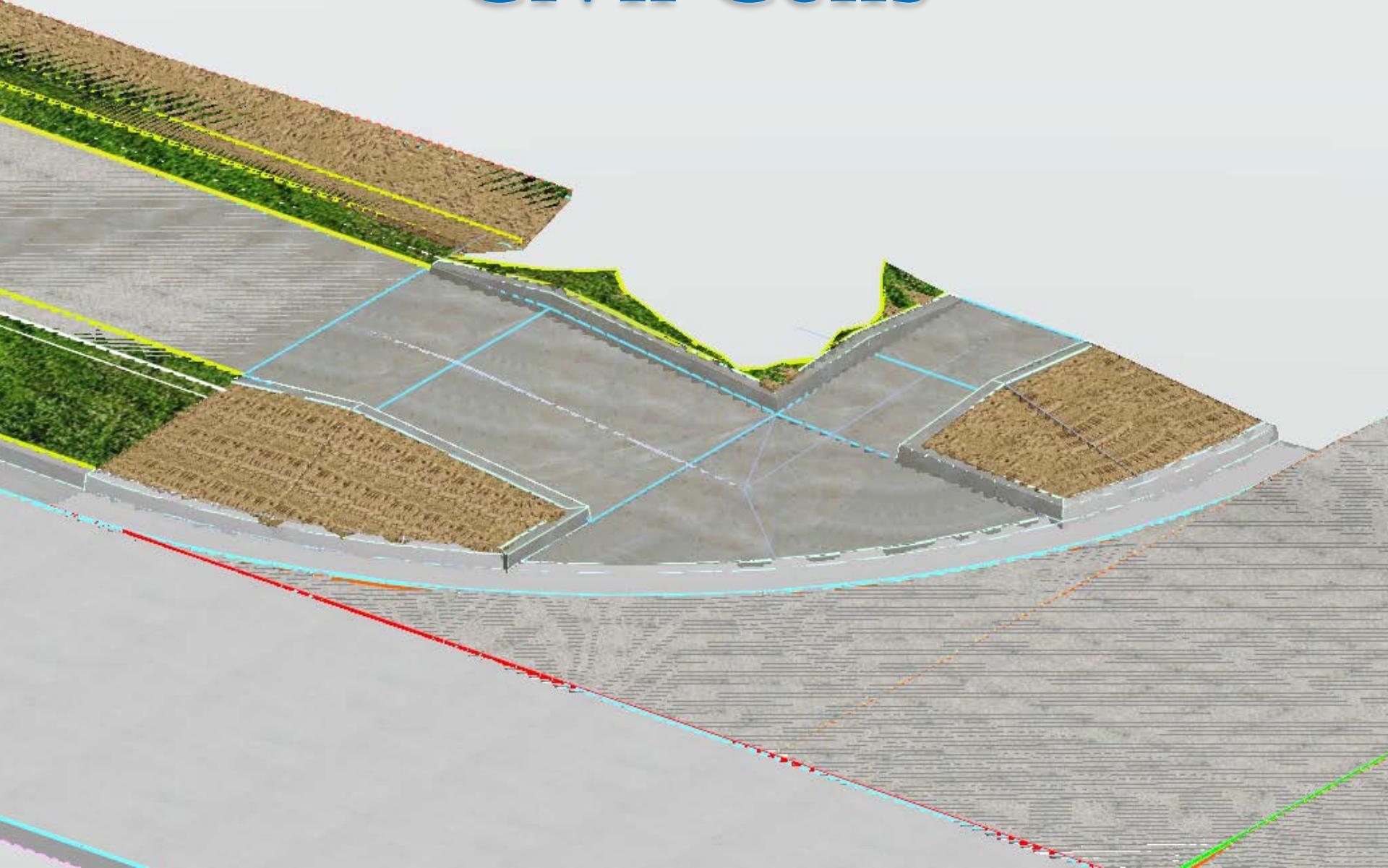


Existing Templates

- Generated from survey data
- Recreate:
 - pavement
 - curb and gutter
 - Sidewalk
 - turf
- Can be merged with proposed 3D geometry



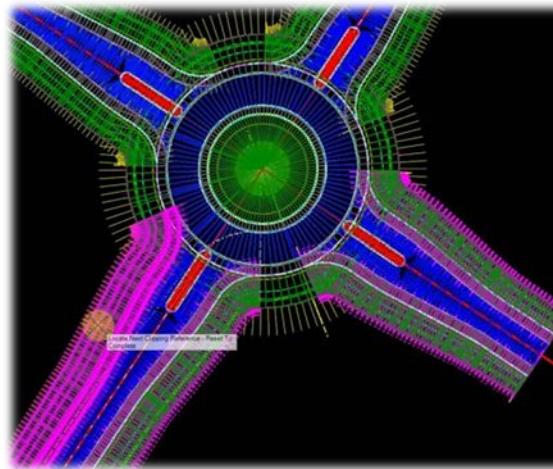
Civil Cells



Civil Cells

➤ Modular

- curb ramps
- intersections
- median islands
- interstate ramps
- roundabouts



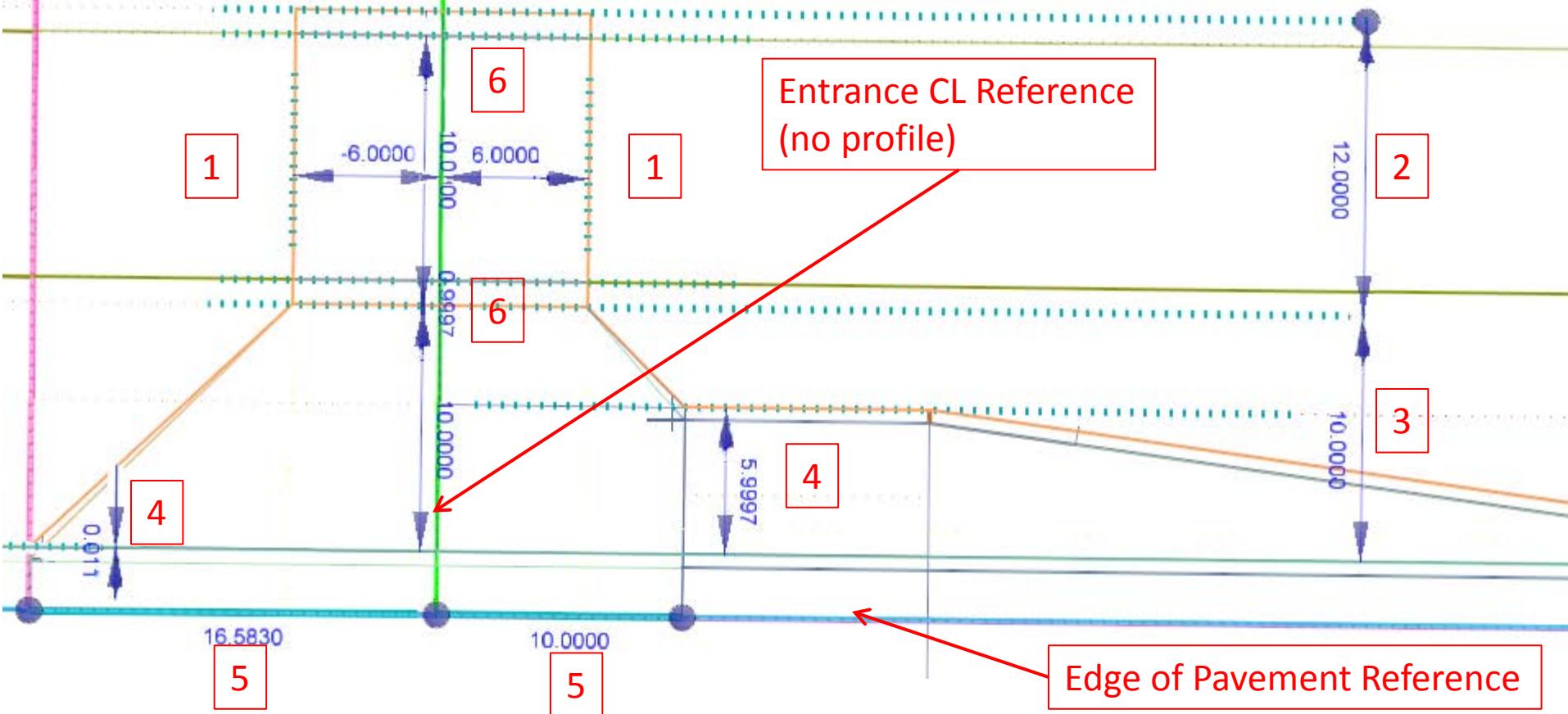
➤ Parametric

Existing lines determine cell dimensions

➤ Customizable

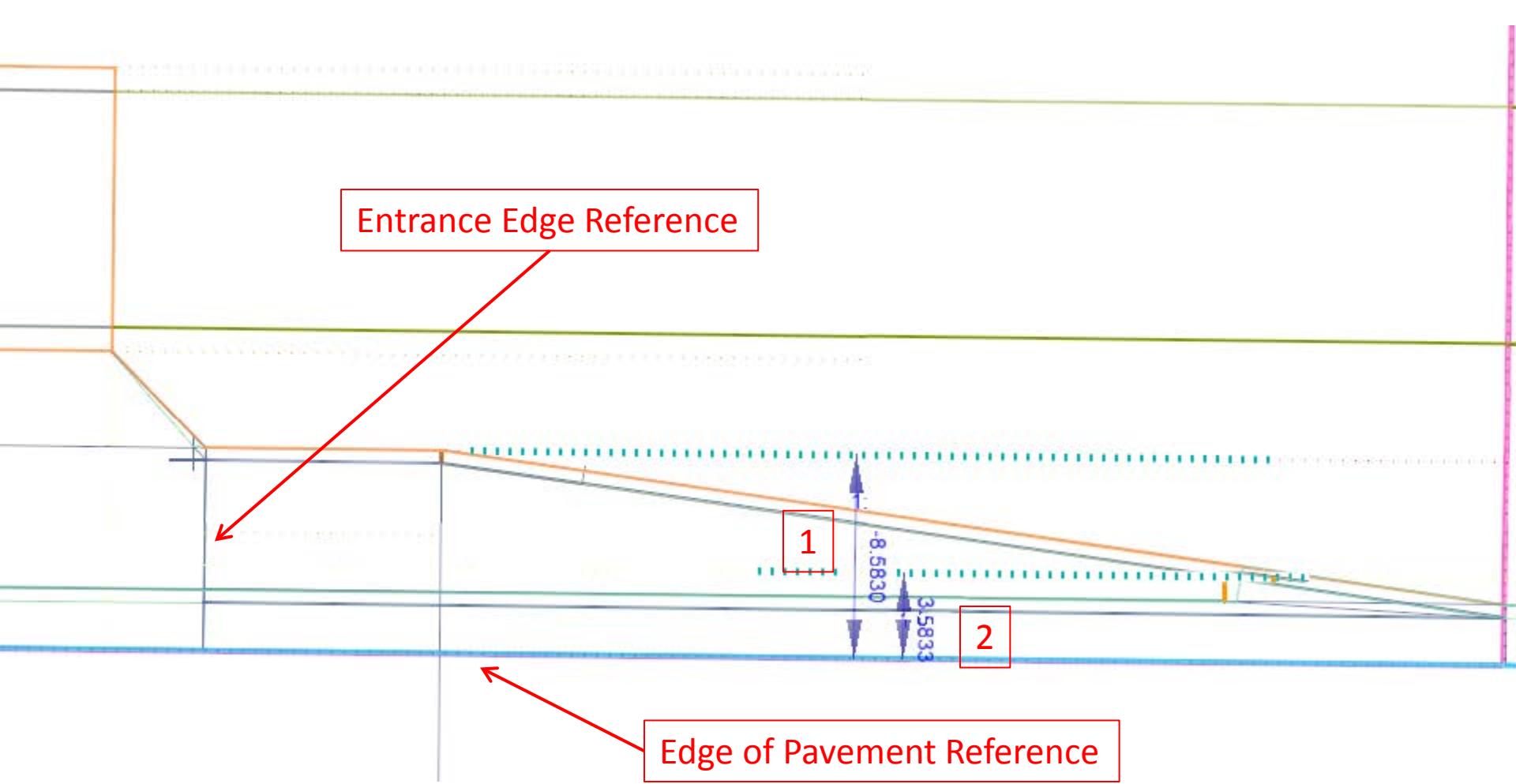
Create unique design elements





Urban Entrance Controls

1. Throat width (LT / RT)
2. Apron back
3. Back of curb (LT / RT)
4. Entrance widths (LT / RT)
5. Throat back
6. Sidewalk (Front / Back)

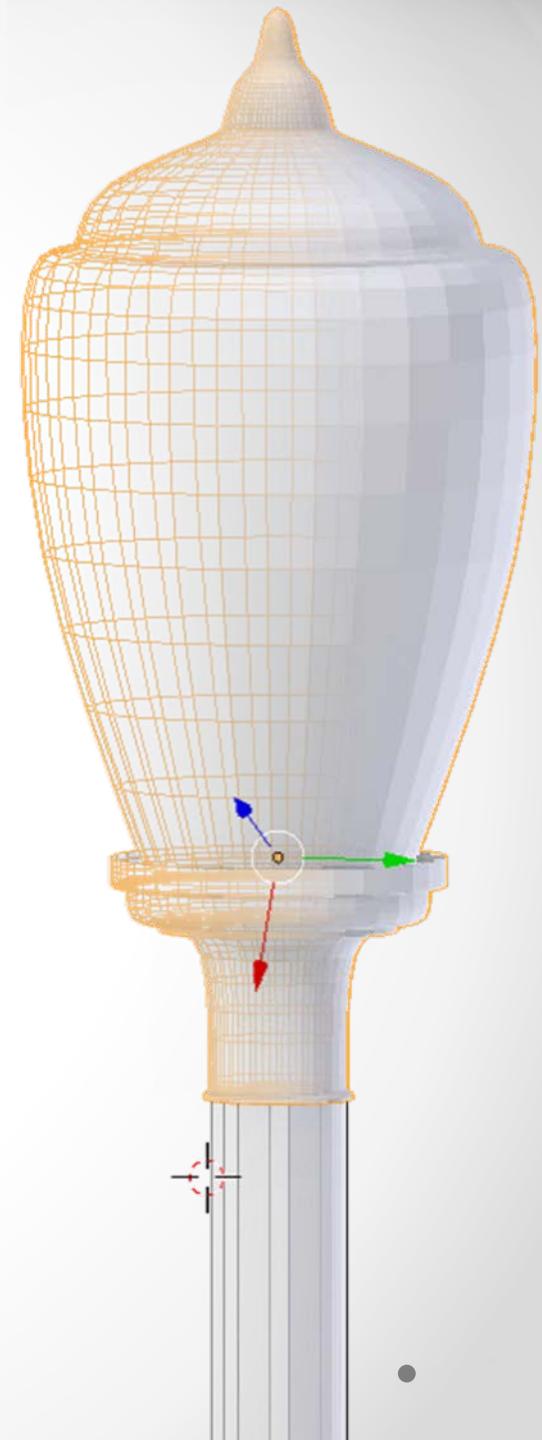


Urban Mailbox Return Controls

1. Return Cross-slope
2. Stub Width

Barriers

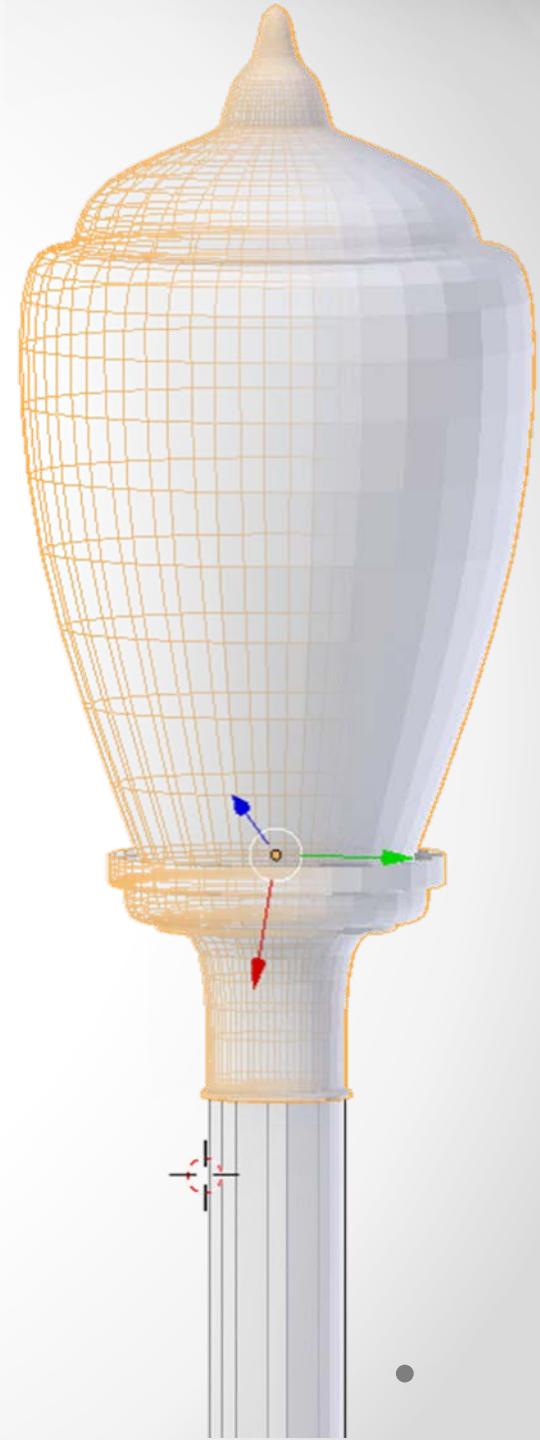
- Software isn't perfect
 - Old hardware
 - Letting schedules
 - Staffing
 - Training
 - Incomplete Civil Cell libraries
-



The Bottom Line

Integrating 3D CAD means...

- Everyone uses it
- Experts are everywhere
- Engineering gets done in 3D,
not alongside it



Questions?

