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114 – HOW TO FIND YOUR WAY AROUND

A Practical Guide to Coordinates in Revit

INTRODUCTION

SPEAKER BIO

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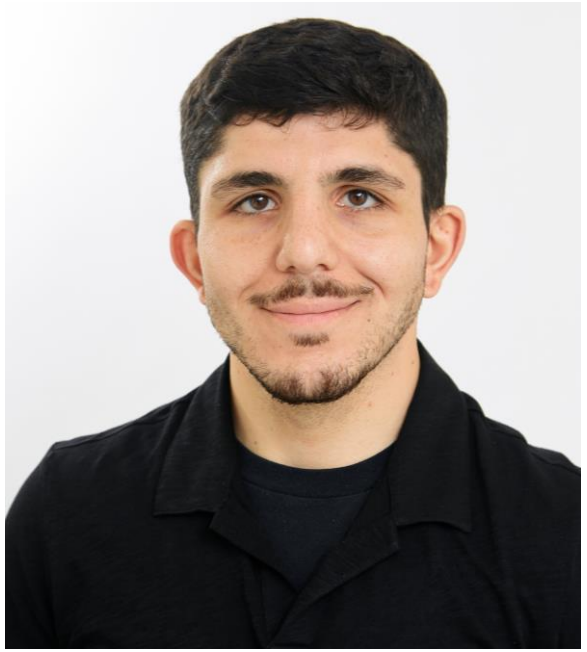
- BIM Coordinator and Job Captain at HKS
- Eight years of experience in AEC industry with focus on Design Technologies
- Architectural Design
- Estimating and Planning
- Concept design
- Construction Documents
- Field Operations
- Research and Staff Training



GOALS

- Learn the basics of how coordinate systems function in Revit – Shared and Internal
- Future proof your projects with templates aligning your models with survey files
- How you can troubleshoot your coordinate alignment including verification techniques
- Come away with a better realization of how you can best use coordinate and positioning in Revit for your project

NOTES

- This guide is based on my experience
- It is not an exhaustive list of every kind coordinate definition in Revit
- The presentation will be an overview to get you oriented to the coordinates in Revit and how you can best proceed on your projects

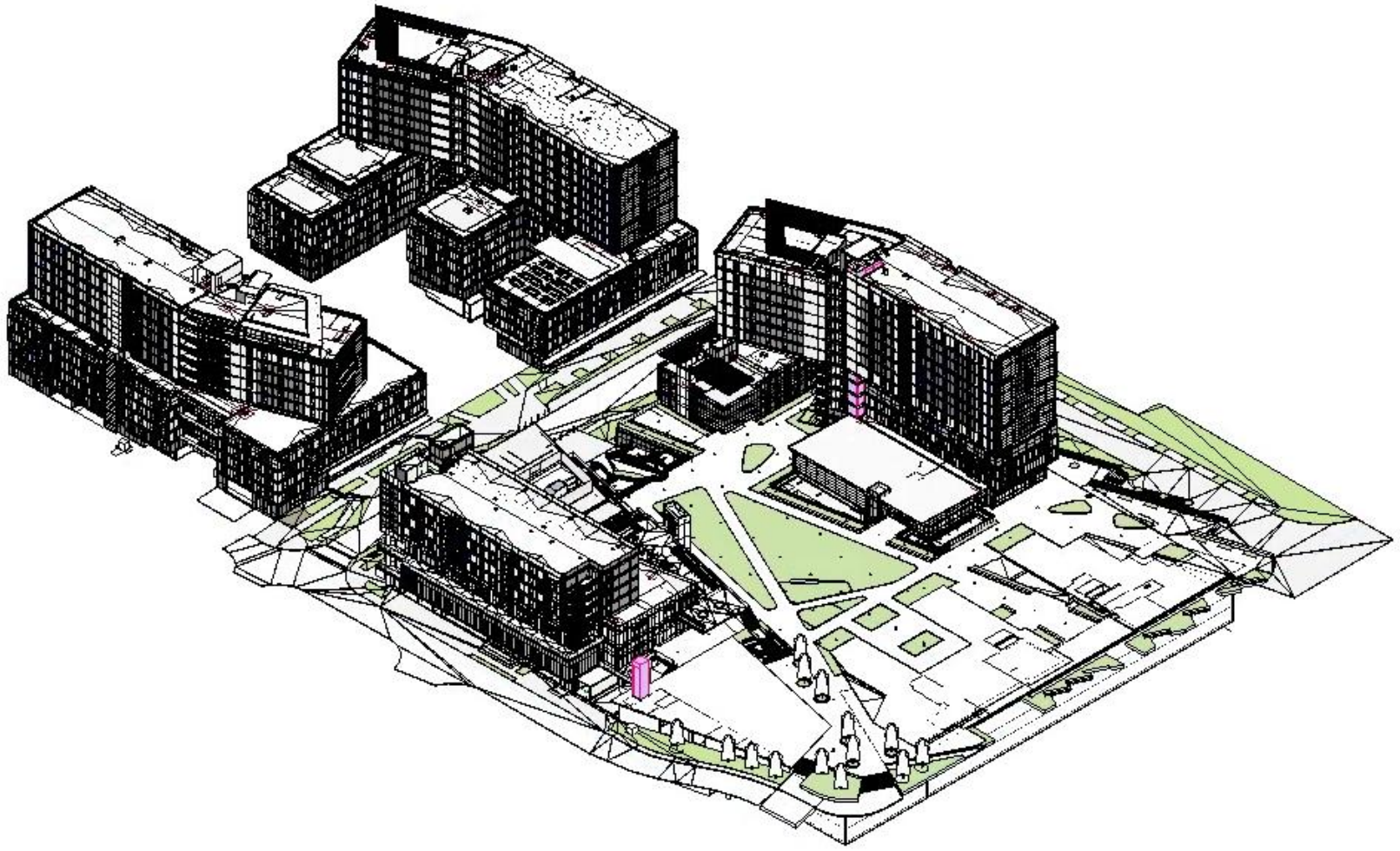
CASE STUDY

CASE STUDY

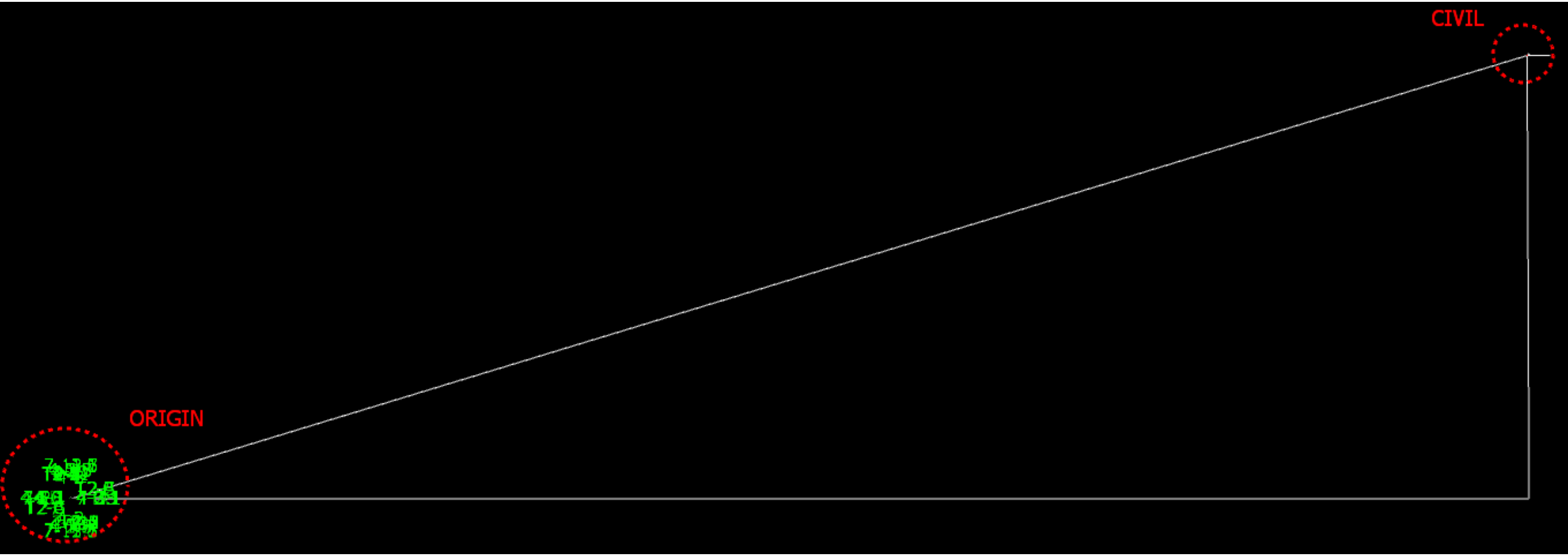
- UCSD North Torrey Pines Living and Learning Center
- 2000 Student beds, Academic buildings, offices, open space and shared spaces
- 6 Buildings and a Parking Structure
- Takes the spot of a parking lot
- Design Build Project with Architect and GC working together from the start

CASE STUDY

- Project Hosted on BIM 360
- 14 Architecture models
- 55 Models in Total
- Shared Coordinates used to align all the Revit models

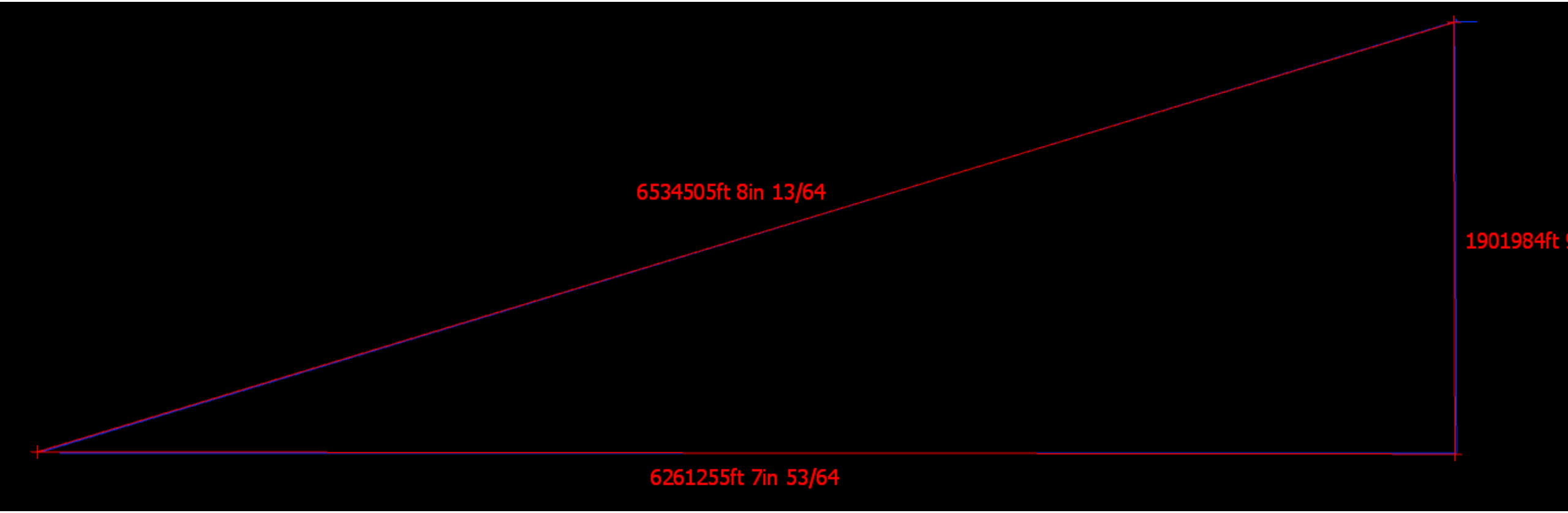


CASE STUDY



- We didn’t align the CAD model from Civil
- Our Revit models started from one set of backgrounds and Civil had a different background

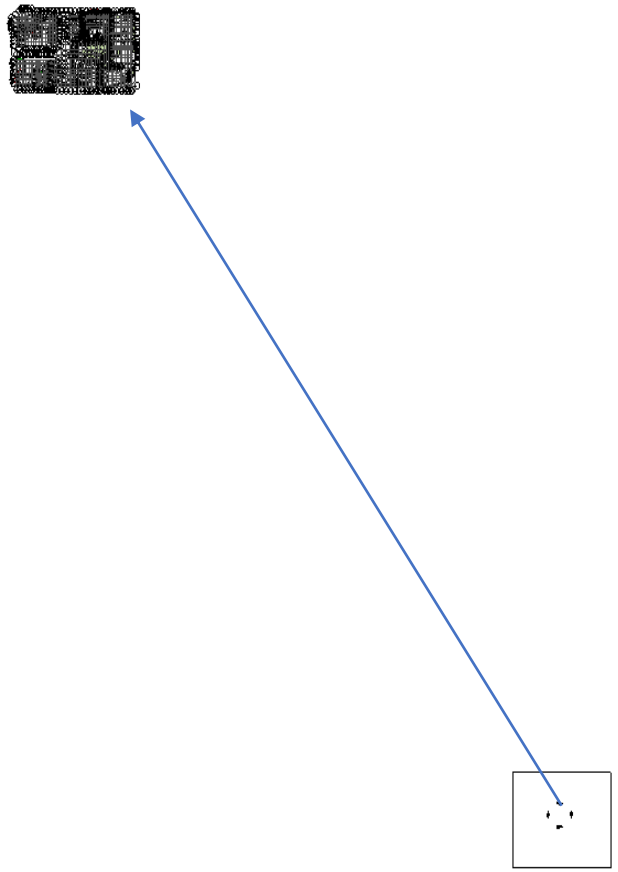
CASE STUDY

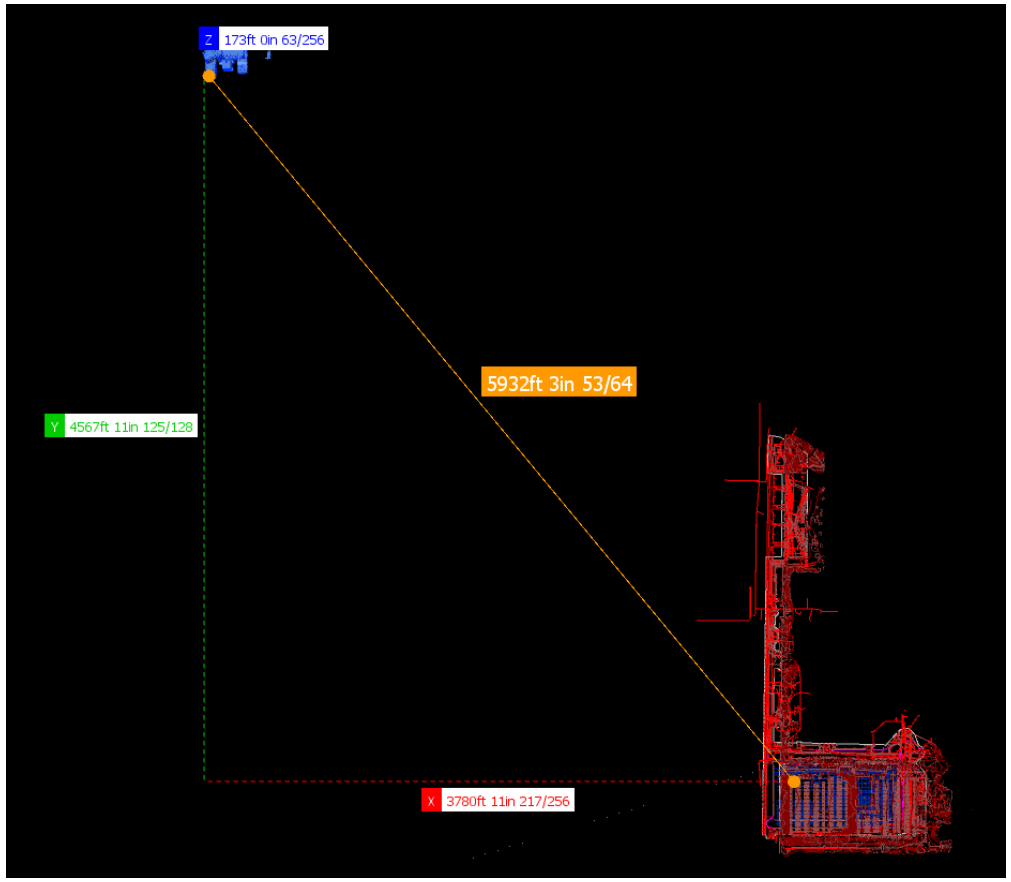


- The difference between those two points was about 1200 miles North East

CASE STUDY

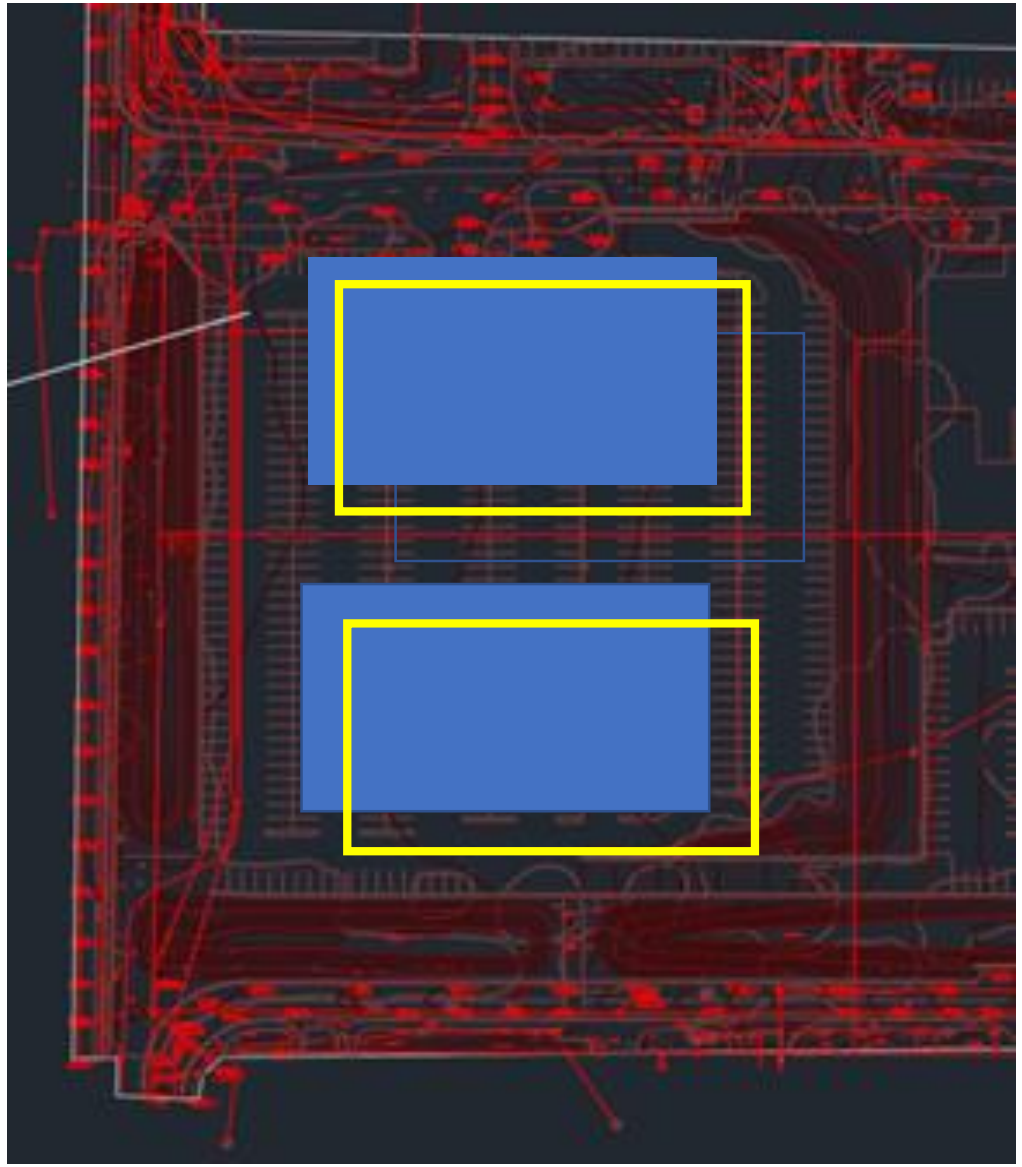
- Turns out our backgrounds were different we had been manually placing links into each other’s views
- That difference was reflected in the Revit model relative to the Origin.





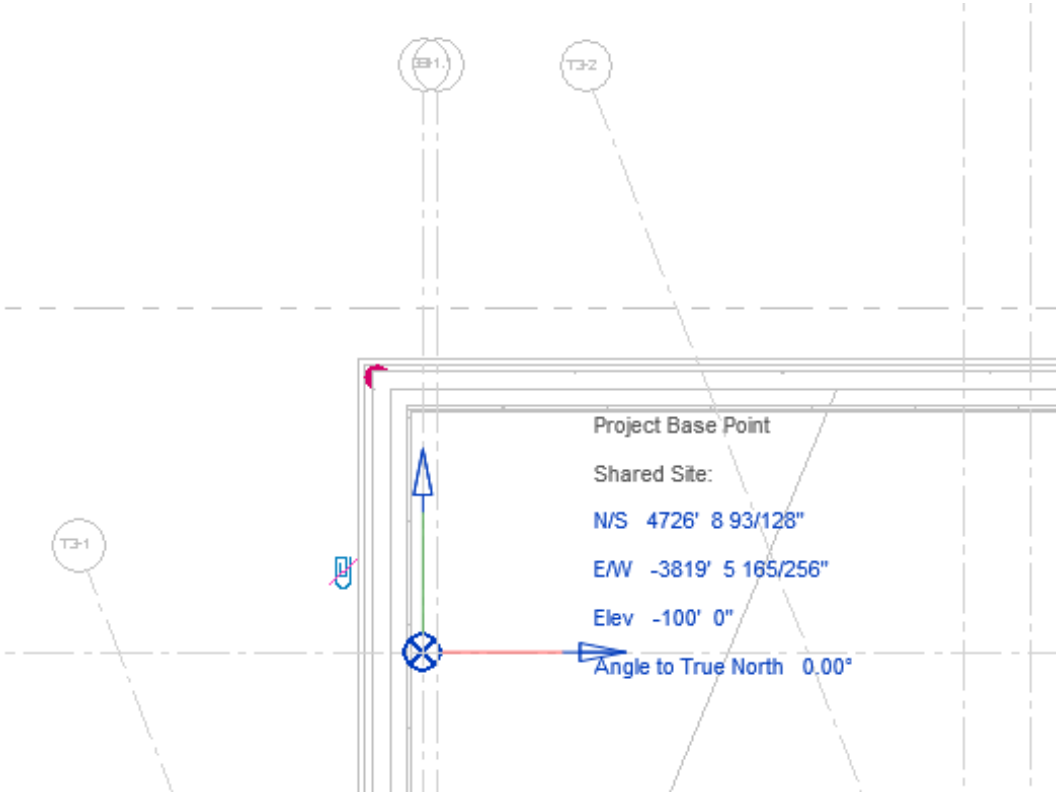
CASE STUDY

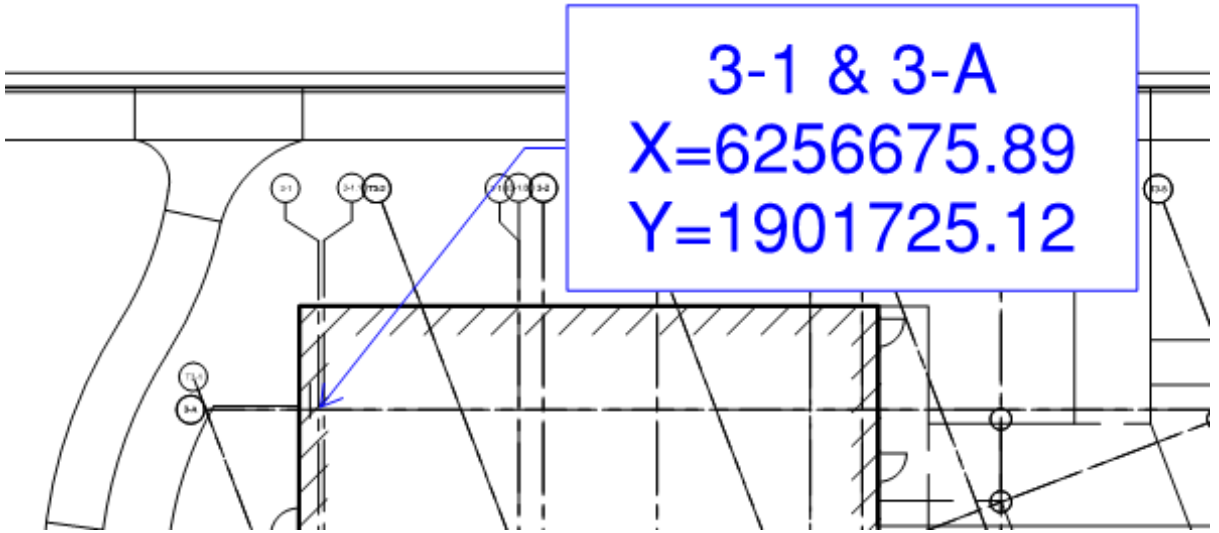
- Bonus points
- The building footprint on topography was different from the Architecture plan
- A miscommunication between the Architect and Civil about a grid shift a year earlier started the discrepancy
- Architect moved the grids to move columns not the building itself
- Civil thought the Grid movement meant a building shift
- The Civil engineer was also in charge of the Topography design for the site
- Therefore the topography didn’t match the building position and the Architect had to move the buildings affected which changed the utility point of connection between the buildings.



CASE STUDY

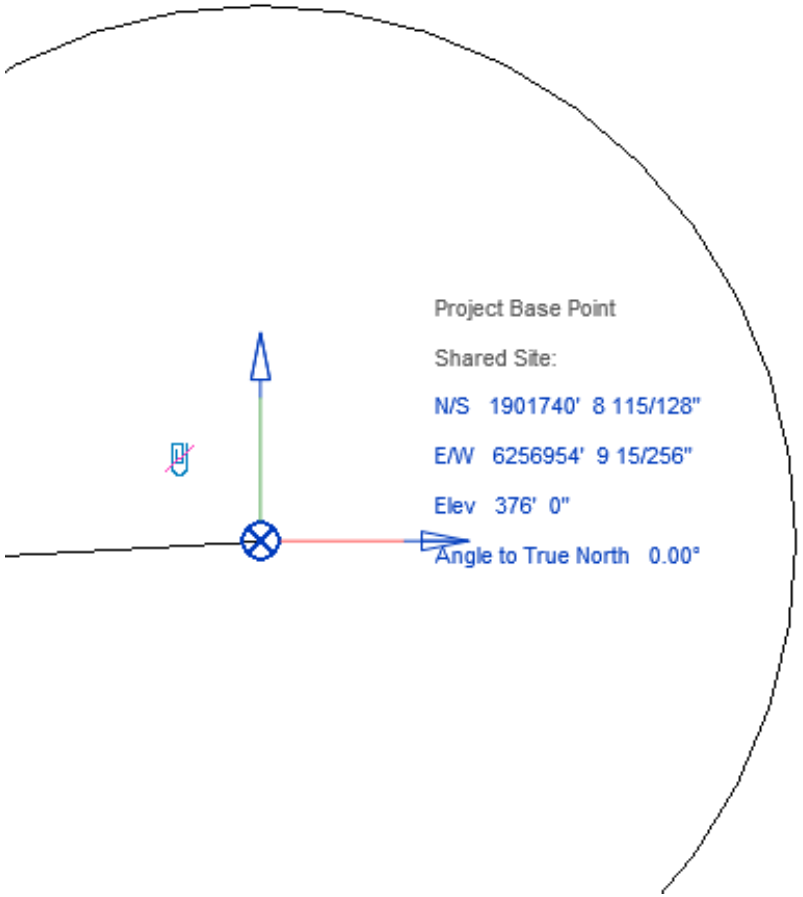
- Our Project Base point was completely different from the Civil coordinates and Civil didn’t match our building position

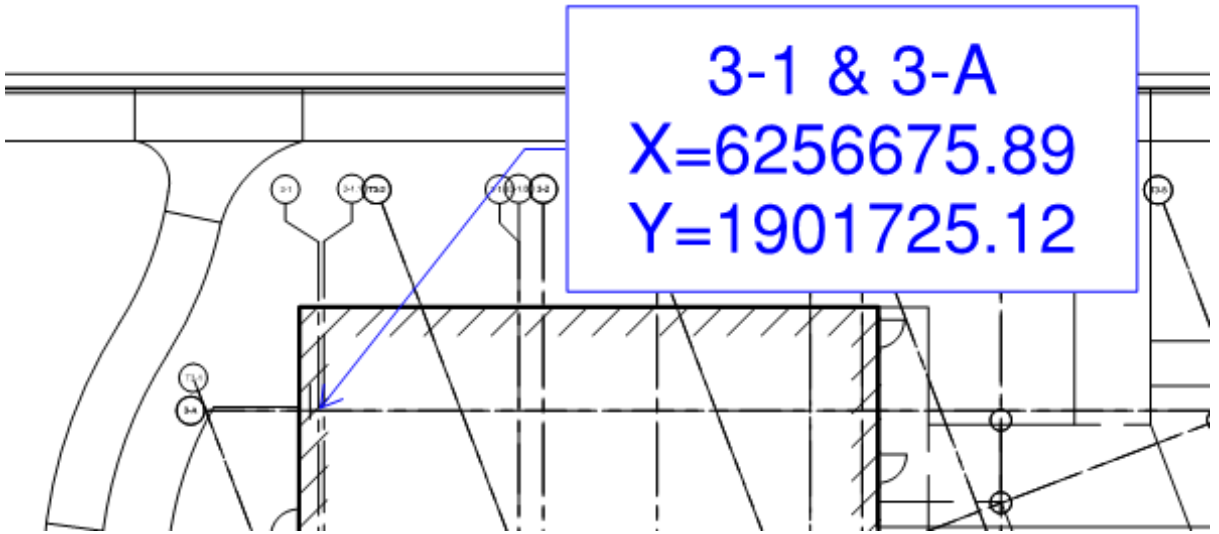




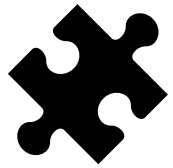
CASE STUDY

- Long Story Short We moved the models so we are all aligned weeks before submitting 100% CD set.





- Why did this happen now where as before BIM 360 it seemed so easy?
- Projects are big, complex and have more stake holders than ever leading to many models and data being exchanged requiring common standards and references to avoid ‘drift’
- We are now integrating each other’s models and referencing content more than ever with Cloud services like BIM 360
- On-site hardware equipment require model information that is coordinated in the first place or you can’t realize on-site efficiencies
- The accessibility of more precise tools leads users to rely on BIM models in projects which reduces tolerances for errors while modeling
- Revit and BIM tools started off as a way to get Sheet sets completed faster with a 3D model is now part of a full cycle design, construction and operations process and needs to be prepared more diligently with every new project.



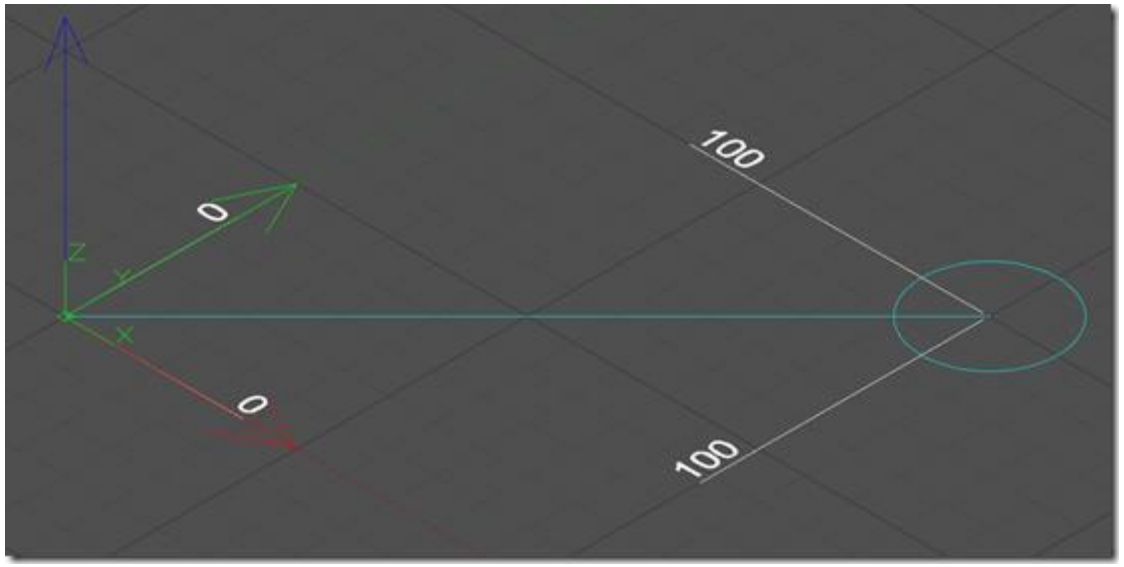
SURVEY BASICS

SURVEY BASICS

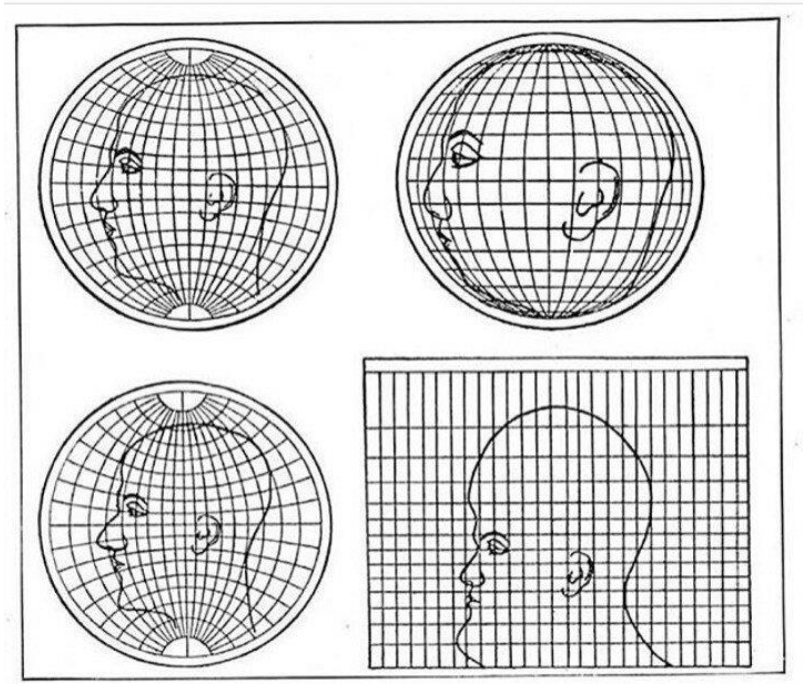
- Before we dive into Revit let’s consider the source material
- Surveys and Cartography create the link between the real world and our designs
- When we refer to coordinates we’re talking about these positions

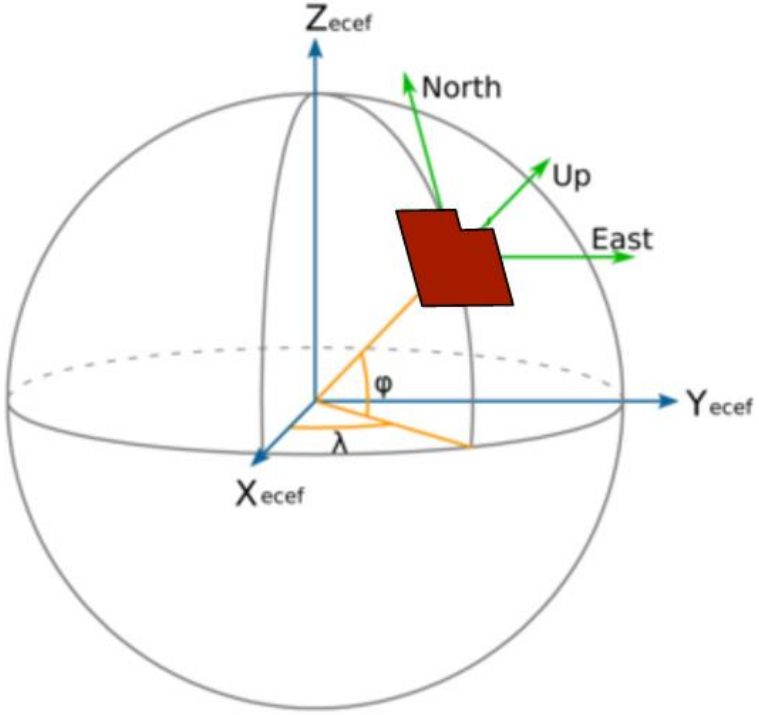
SURVEY BASICS

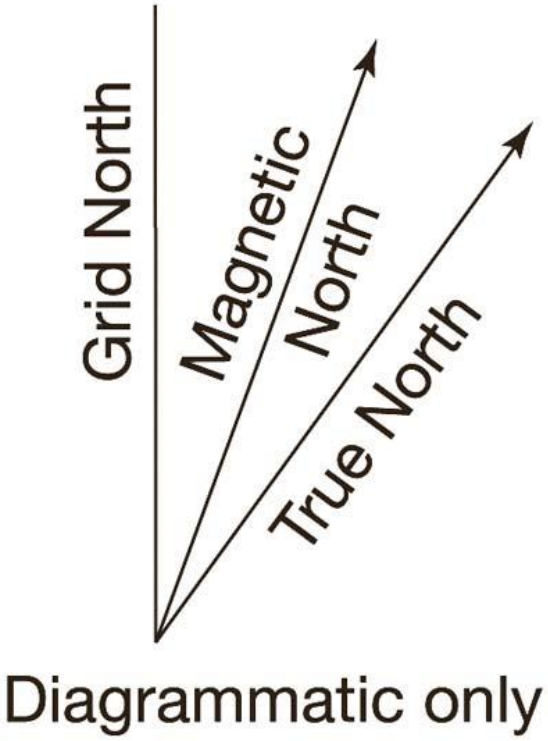
- When we think of coordinates we think of grids and Cartesian graphs
- There’s points in space that you can connect to define shapes
- In a 3D world you have XYZ coordinates to define space and objects in space
- Therefore you expect a survey of these points to spell out where you are designing into



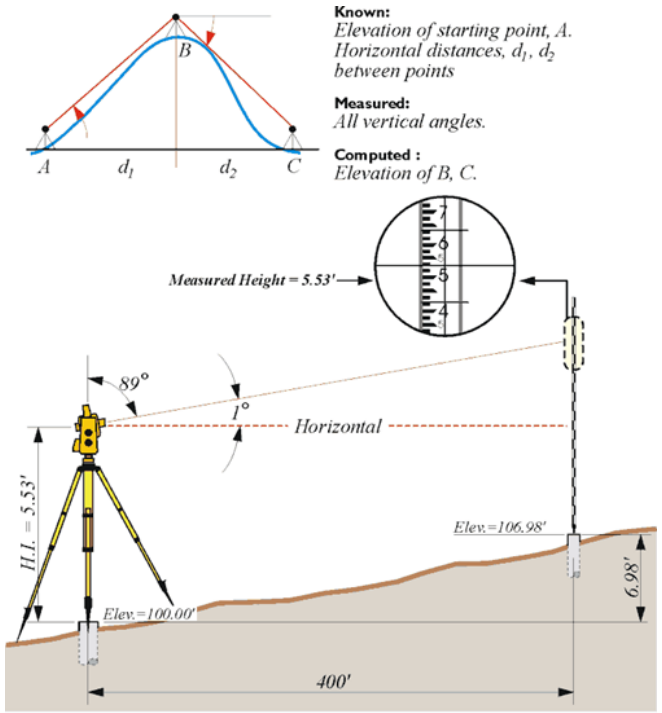
- The reality is different - Surveying can be tricky
- It often takes more modifications then you expect to get an imperfect shape to show as an easy to read flat surface for drawing your building on
- What does it take to understand the Surveyor's craft of changing 3D to 2D?

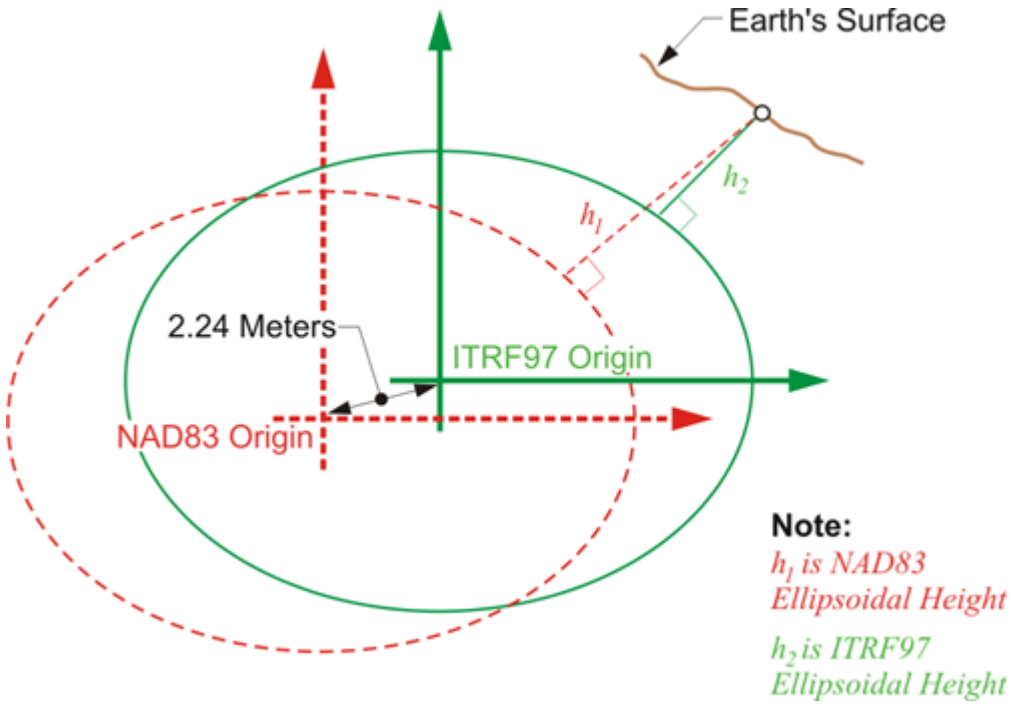






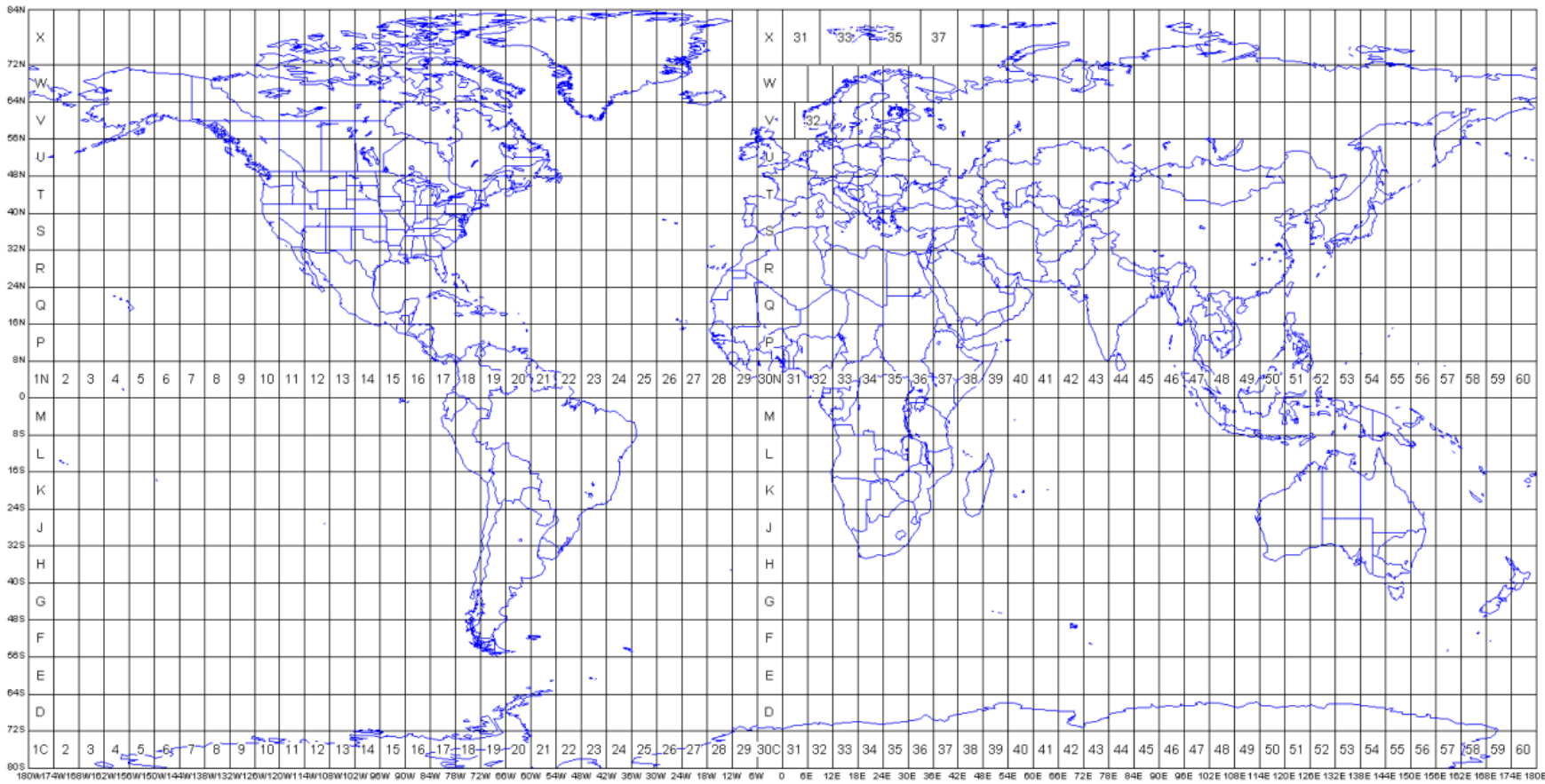
- Surveys are done on uneven terrain
- The Earth is not a perfect sphere but an ellipse shape
- That means local variations exist over large areas that have to be accounted for with Datums



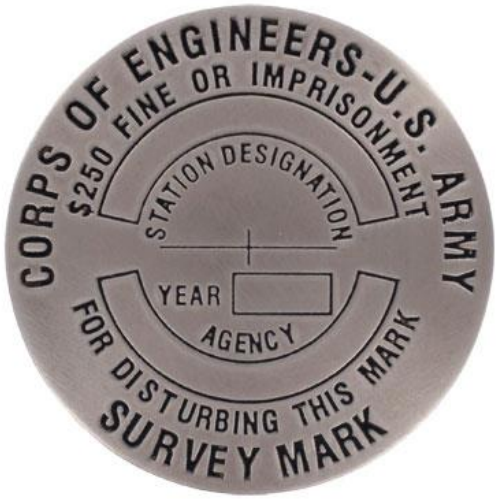


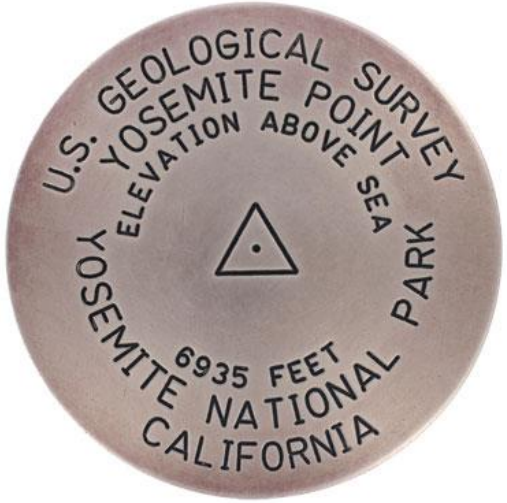
SURVEY BASICS

- The Datum system is accounted for regionally with a UTM system which references distances between Longitude and Latitude
- Those points are referred to as Northing and Easting



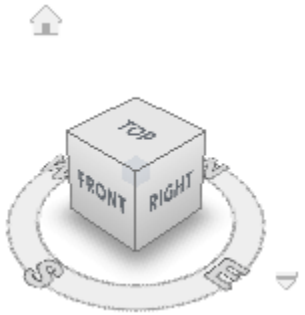
- What does this have to do with Revit?
- The essentials of Surveys is what Revit basis its positioning systems
- Knowing the survey methods helps you keep track of the Revit coordinates

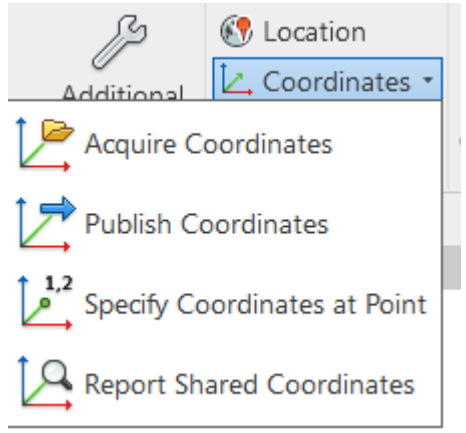


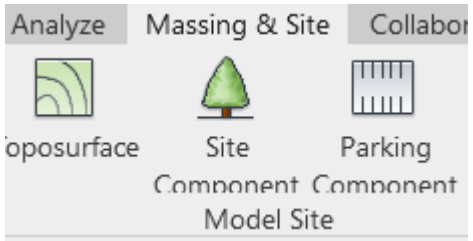


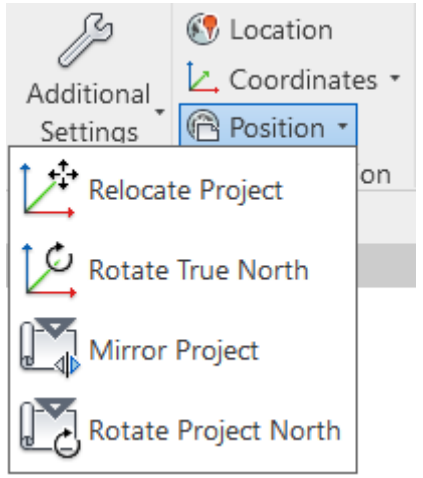
REVIT COORDINATES

- **OPTIONS IN REVIT**
- Revit has a lot of ways to set site information and model positions
- There is no obvious method to create the site conditions in Revit so you have to know your options and where to starts
- Location, Coordinates, Position and Model Site have options to choose from

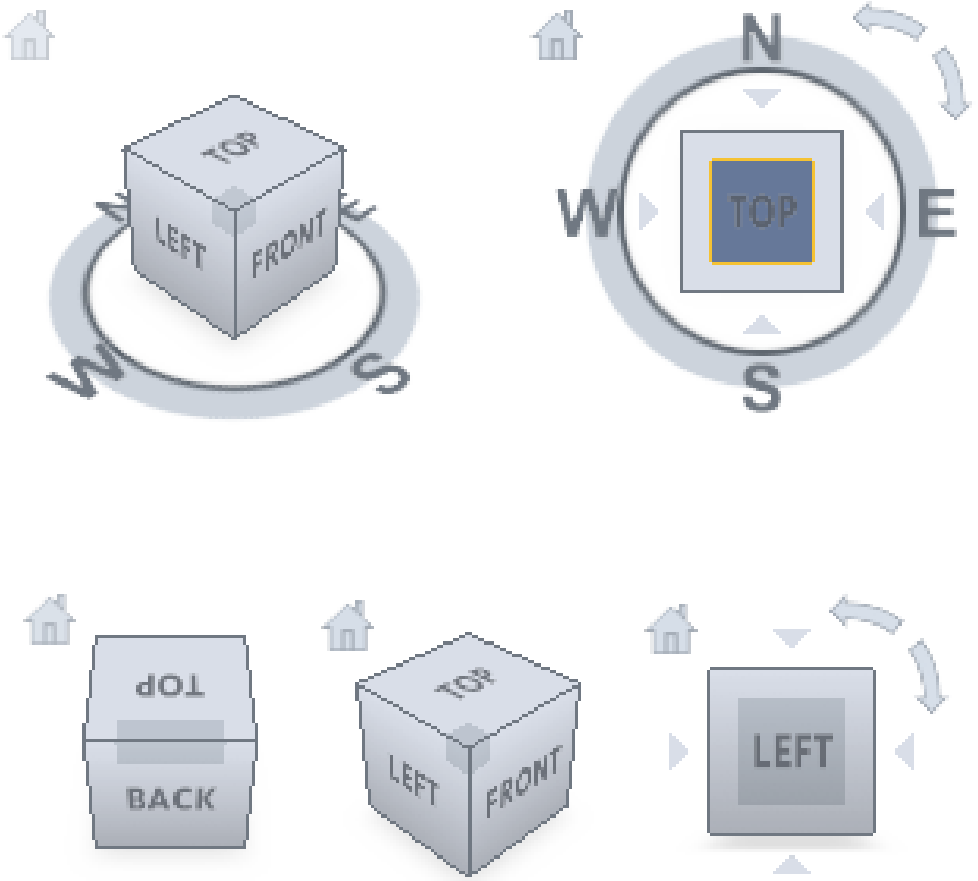




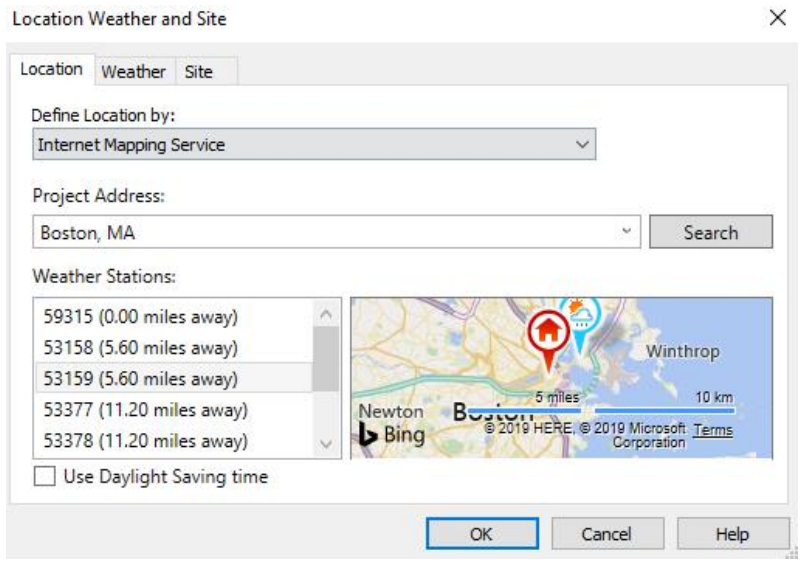


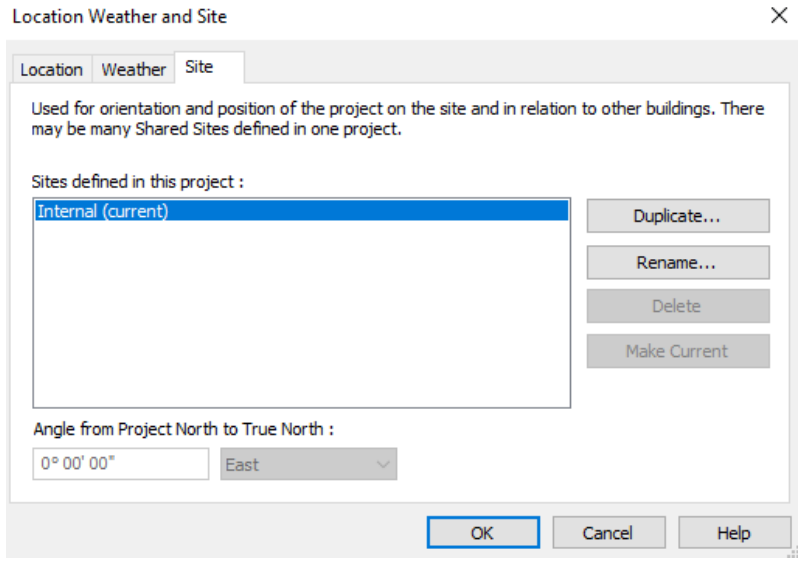


- **View Cube**
- Useful for navigating and setting views
- Can orient you in Cardinal directions
- Has no function to set any coordinates

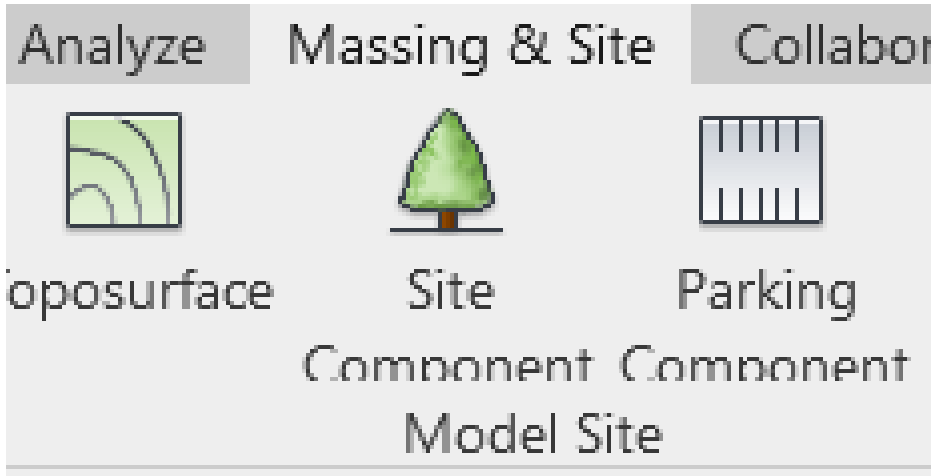


- **LOCATION AND SITE**
- The location of Revit is not set by location
- This option is only for information relating to sun shade and some analysis tools
- The Site tab in the same setting is a different purpose
- It is used to record different internal and shared sites for different model positions and can be useful for a multi-building project
- Sites which are already recorded can be modified here but not created in this setting

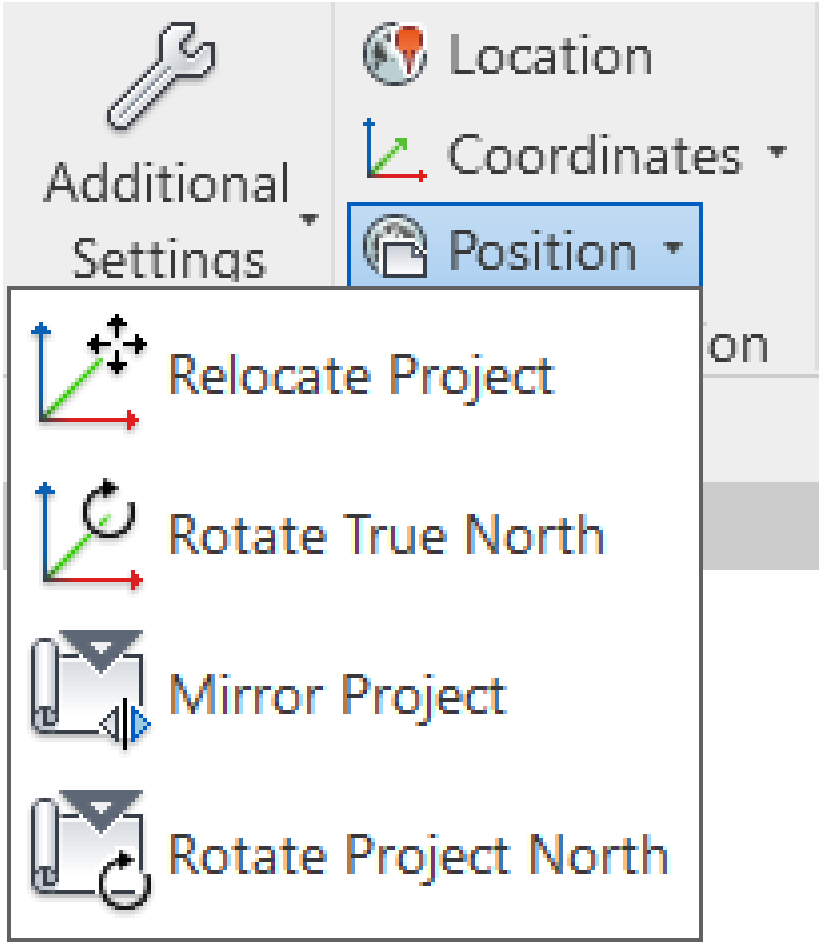




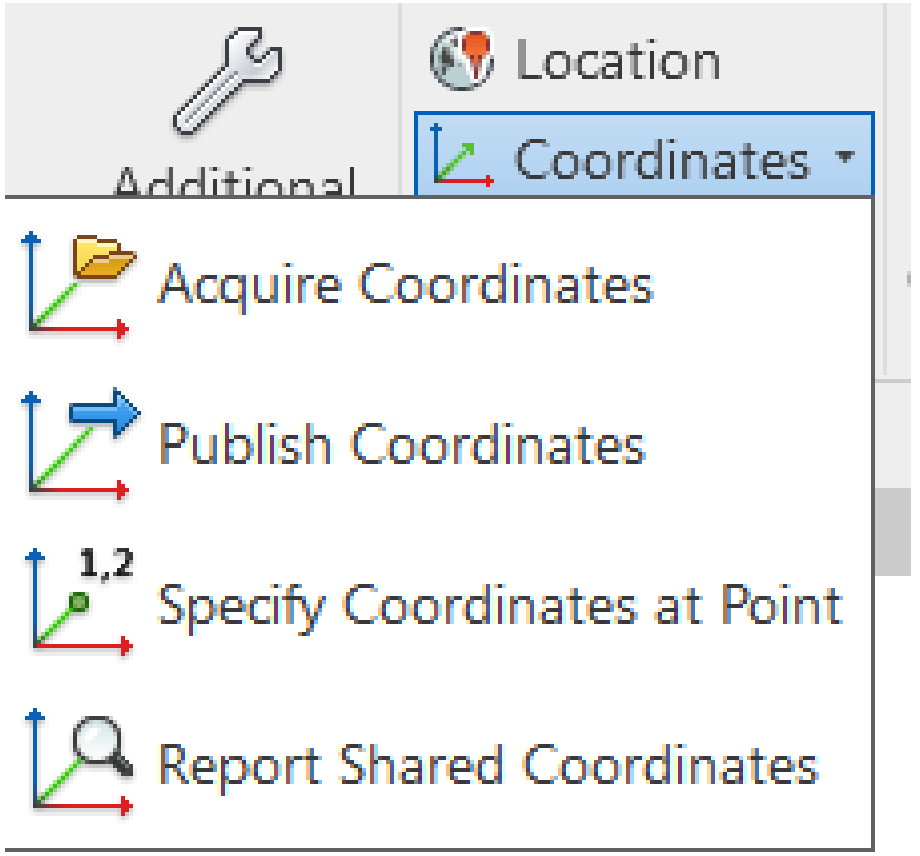
- **Model Site**
- These are modeling tools that relate to the position of your project
- For example the Toposurface follows the Origin point so you need to be aware of where your modeling positioning system is when drawing these elements
- Otherwise they do not modify the coordinates



- **POSITION**
- This tools lets you orient the building
- 360 rotation

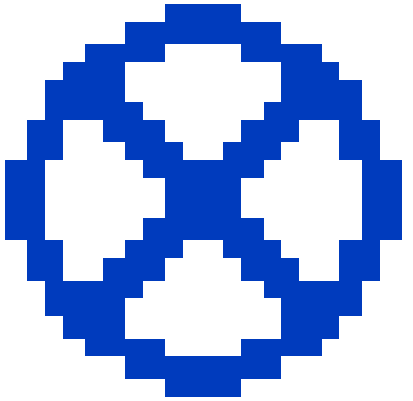


- **COORDINATES**
- This tool lets you set and export the model coordinates
- XYZ in orientation

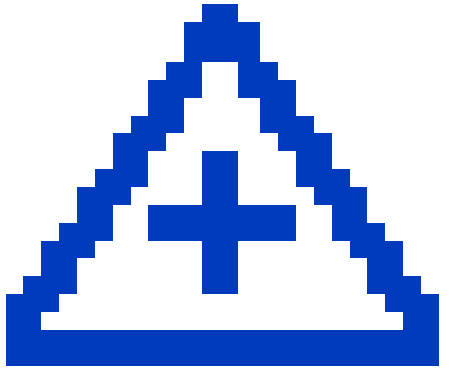


- **Project Base Point (PBP) does not equal origin**
- The project base point defines the origin (0,0,0) of the project coordinate system.
- It also can be used to position the building on the site and for locating the design elements of a building during construction.
- Spot coordinates and spot elevations that reference the project coordinate system are displayed relative to this point.

- **Survey Point (SP) can move around but you can't tell how it transformed**
- The survey point represents a known point in the physical world, such as a geodetic survey marker.
- The survey point is used to correctly orient the building geometry in another coordinate system, such as the coordinate system used in a civil engineering application.



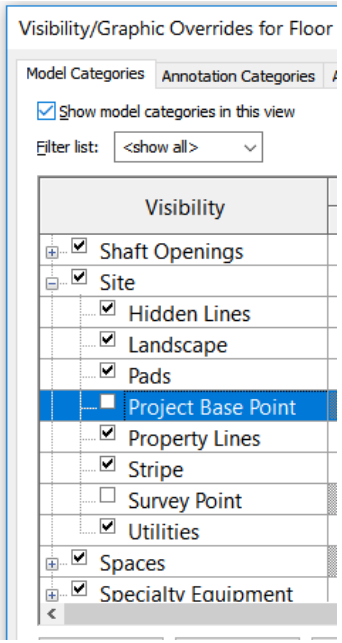
PROJECT BASE POINT



SURVEY POINT

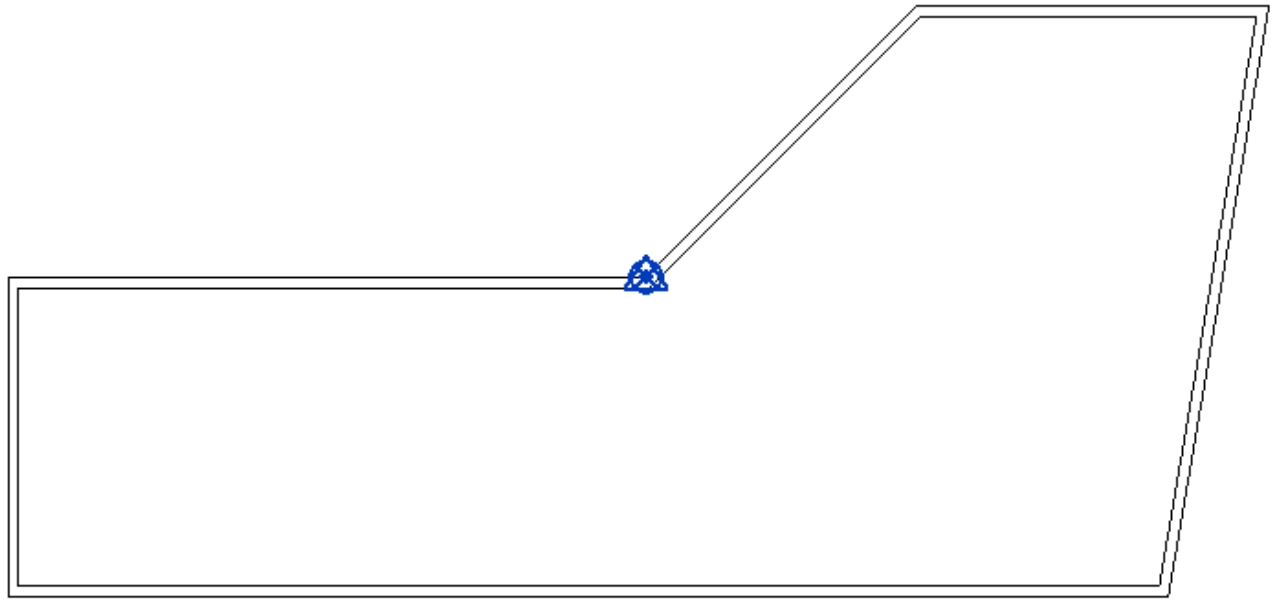
- **Getting Started**
- A new blank project level view doesn’t give you anything to see

- **Turn on the SP and PBP with Visibility settings**
- Revit templates have them turned off by default so you don’t modify them unless you want to



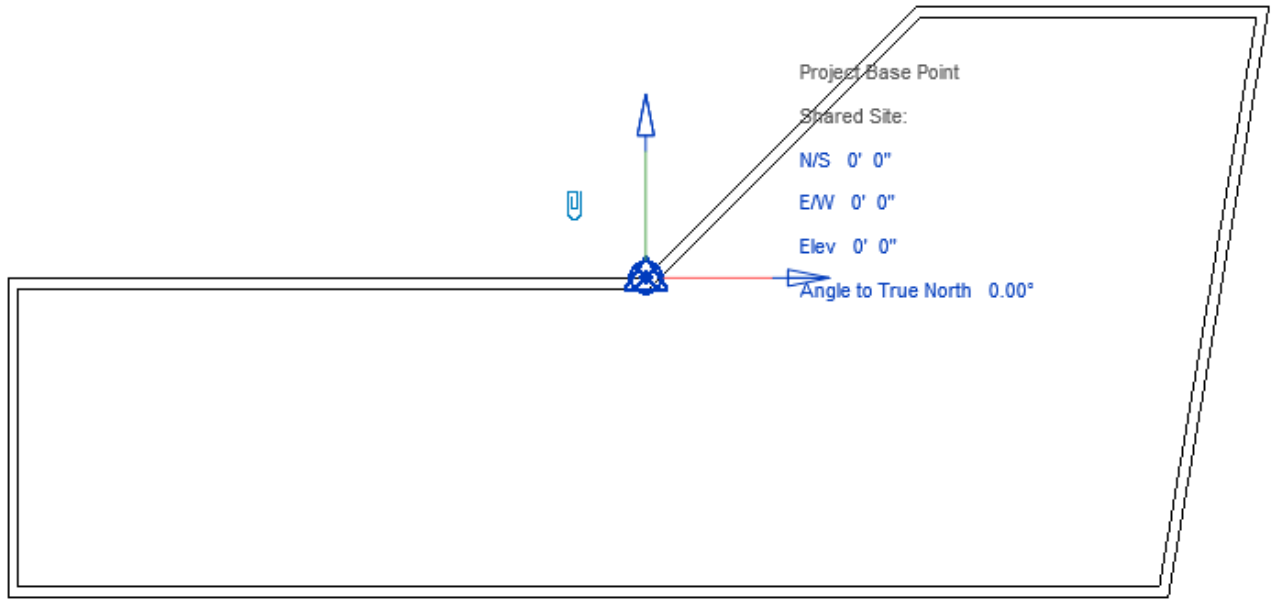
- **Elevations**
- You can also see the points in an elevation view since they orient in 3 dimensions
- Your elevations can reference either the SP or PBP position depending on your elevation family settings

- **Coordinates in relation to a building**
- You can draw your model around these points or however you want to orient them
- Every element will have an orientation (XYZ) to these points

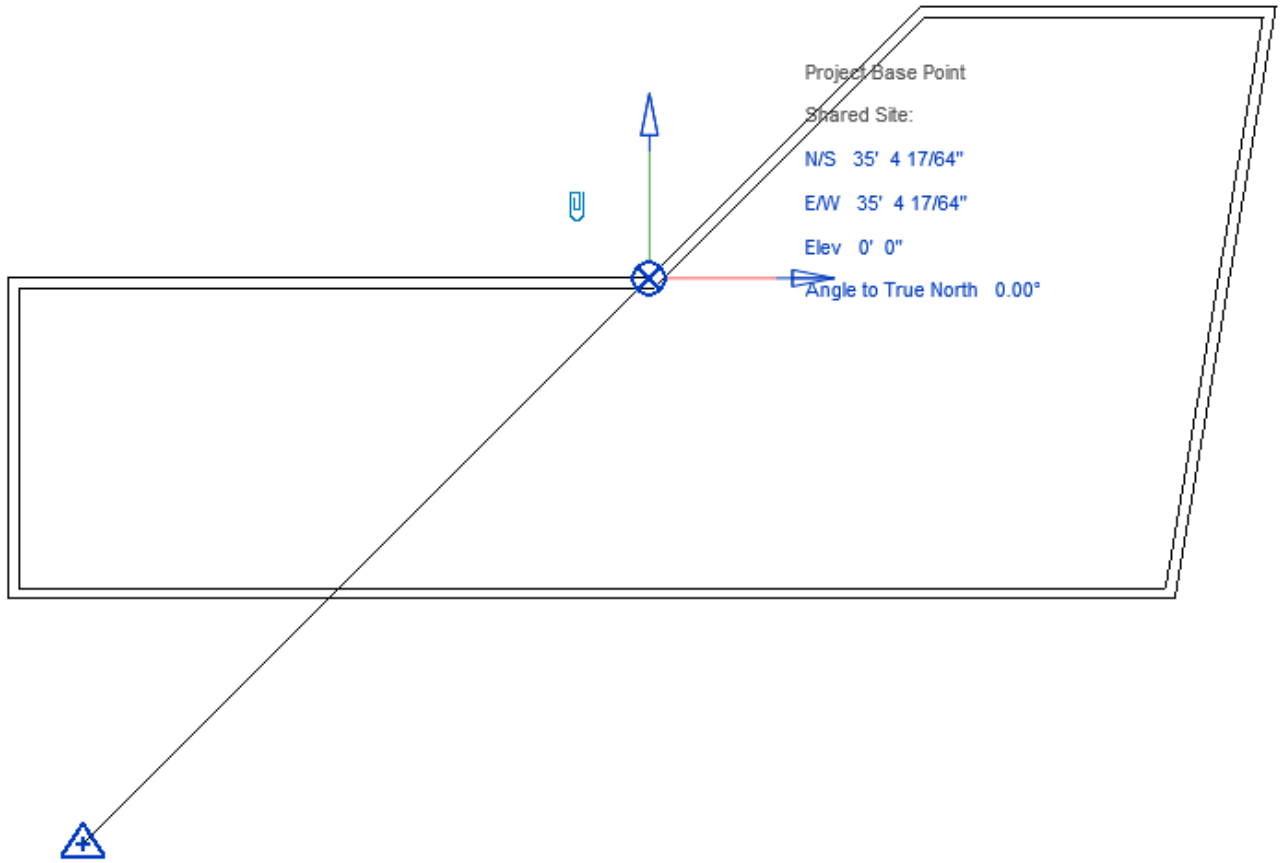


REVIT COORDINATES

- **Reporting coordinates**
- Default template has 0,0,0 position for all points in Revit

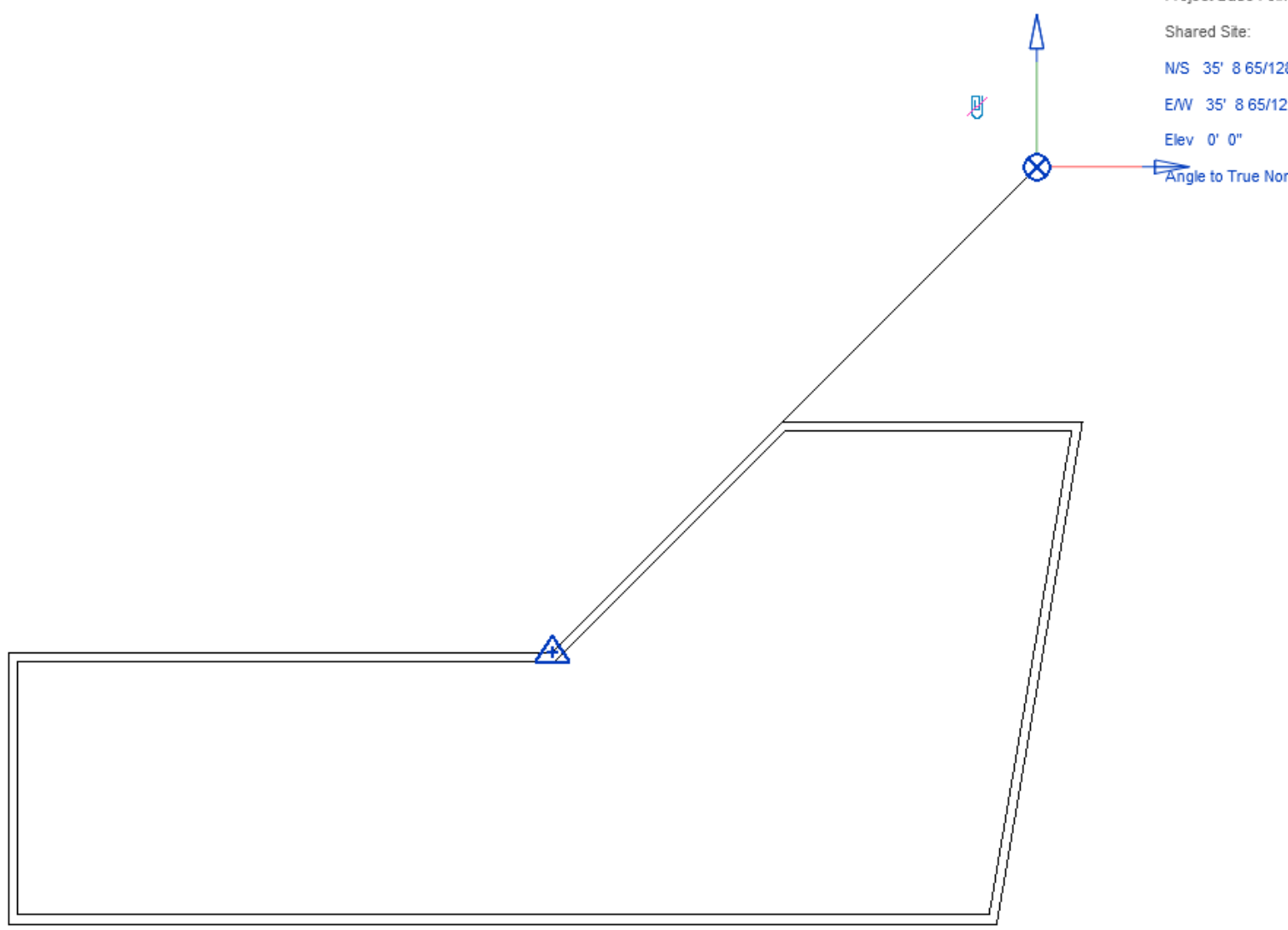


- **Moving the Project Base Point (clipped)**
- If you move the clipped PBP then all the elements move along with it
- In effect your model goes wherever the base point goes

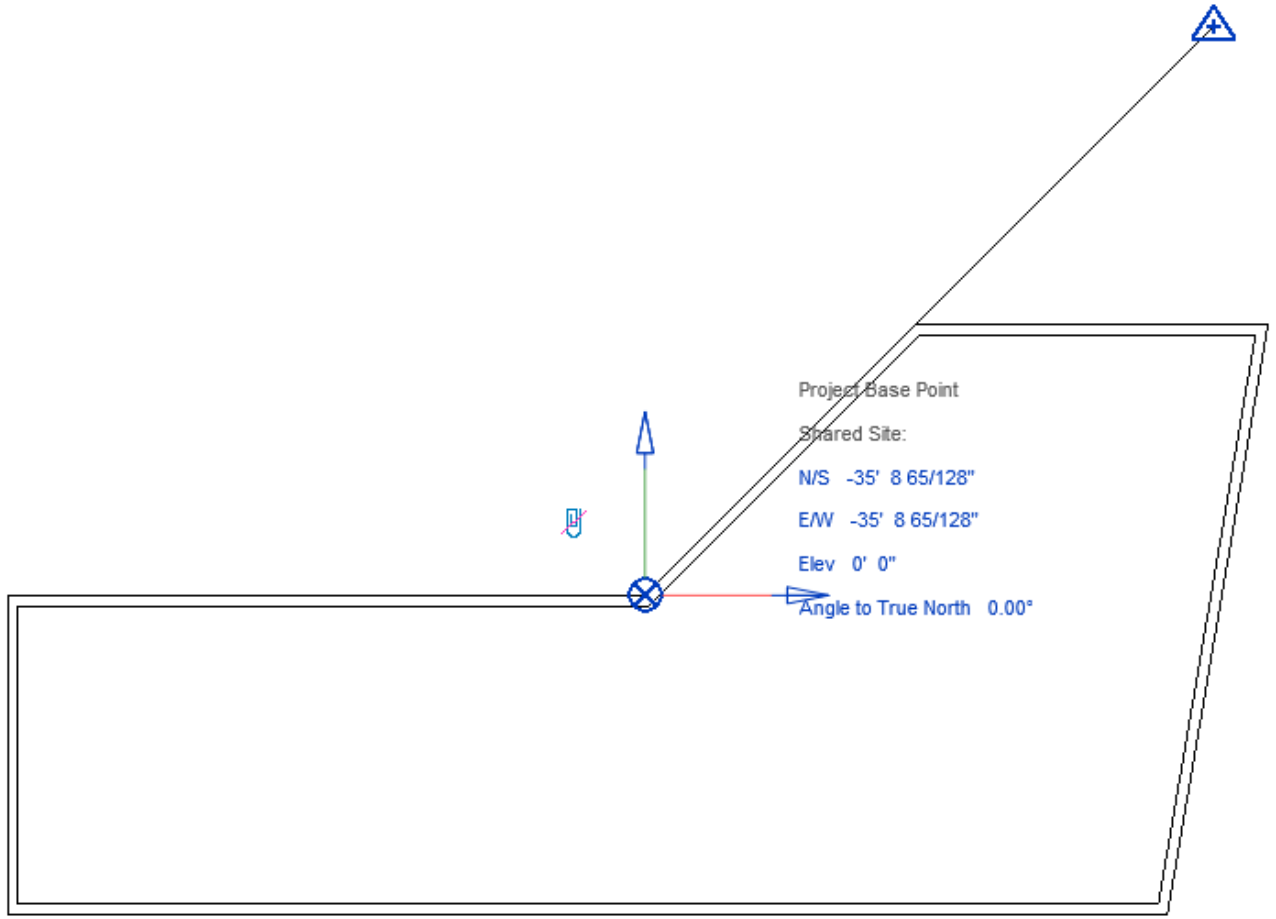


REVIT COORDINATES

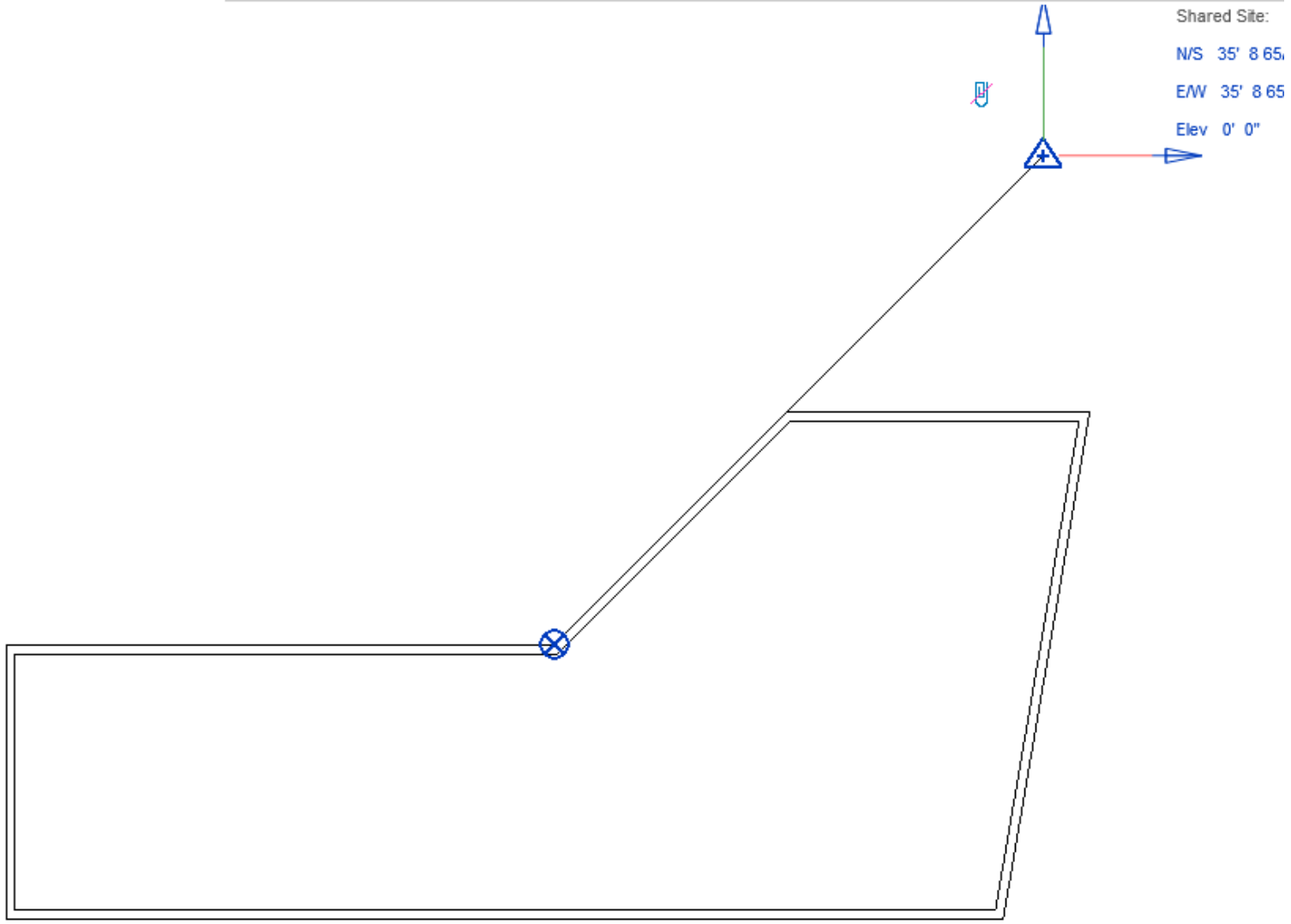
- **Moving the Project Base Point (unclipped)**
- If you move the unclipped PBP then your elements stay in place and the base point coordinates update
- It’s like your base point becomes a spot coordinate



- **Moving the Survey Point (clipped)**
- If you move the clipped SP then all the PBP moves in relation with it
- The model elements stay in place but their position in space (shared) changes

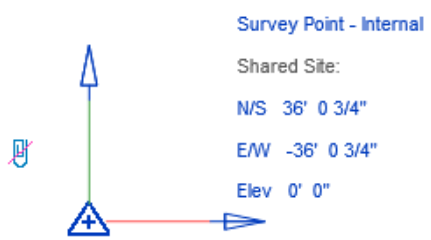


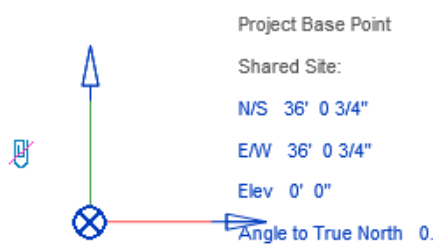
- **Moving the Survey Point (unclipped)**
- If you move the unclipped SP then its position changes but everything else stays the same
- Not advised since you can easily lose track of where all the points in the model end up

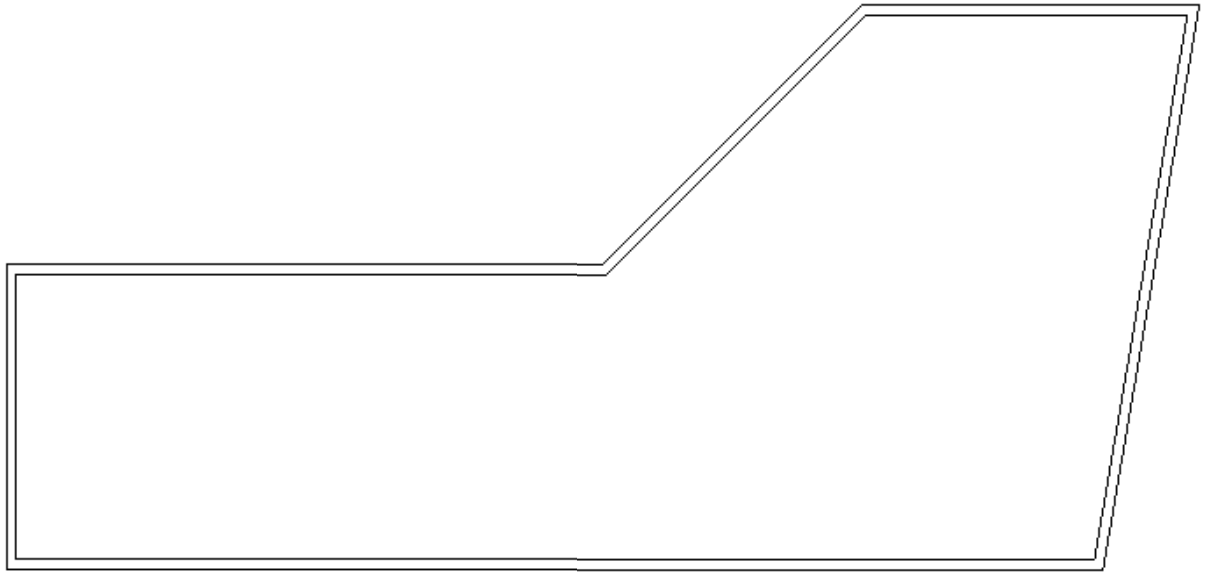


REVIT COORDINATES

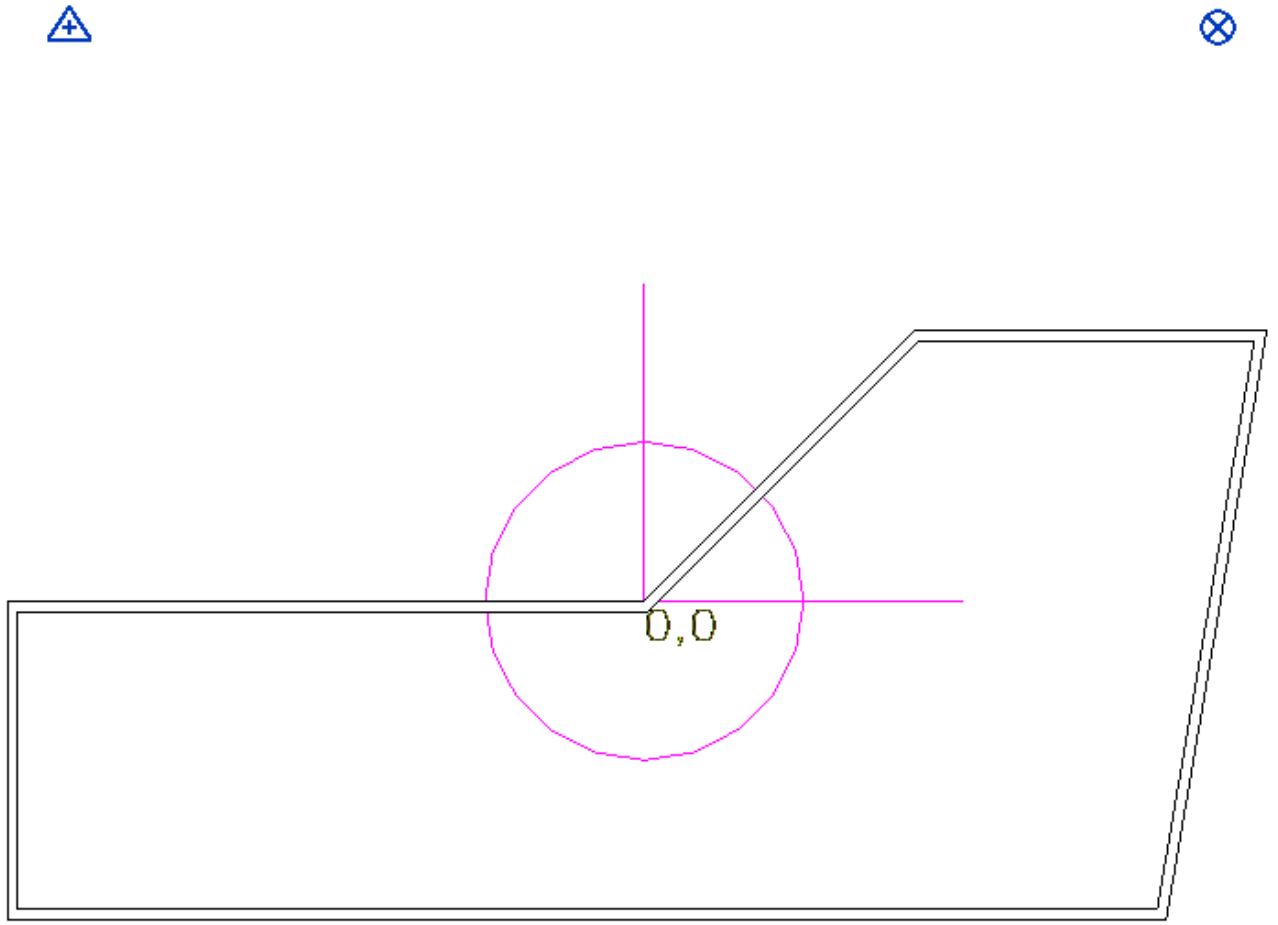
- **Moving both points (unclipped)**
- The SP and PBP both report positions relative to their original position
- Since they both moved what is defining these values?



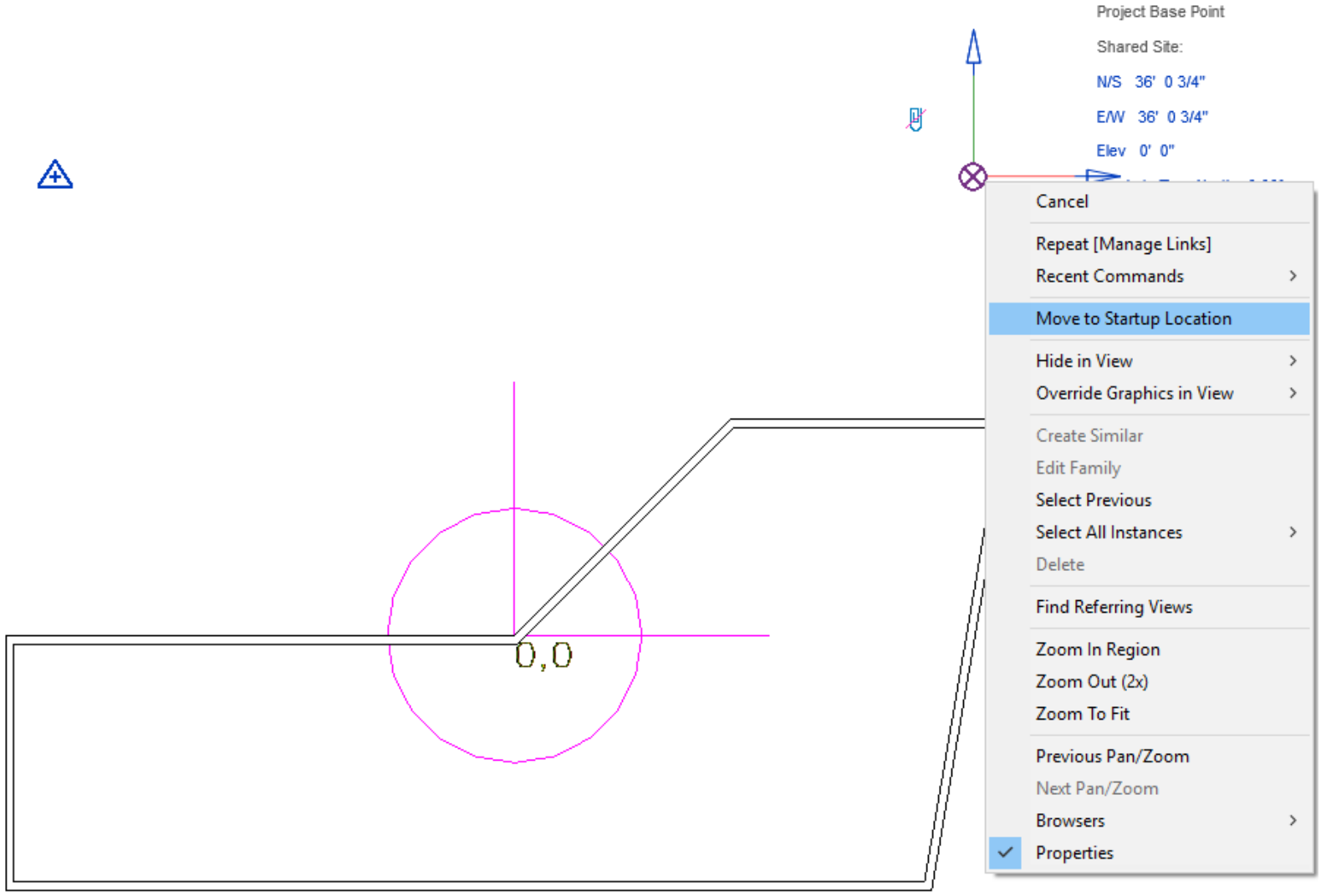




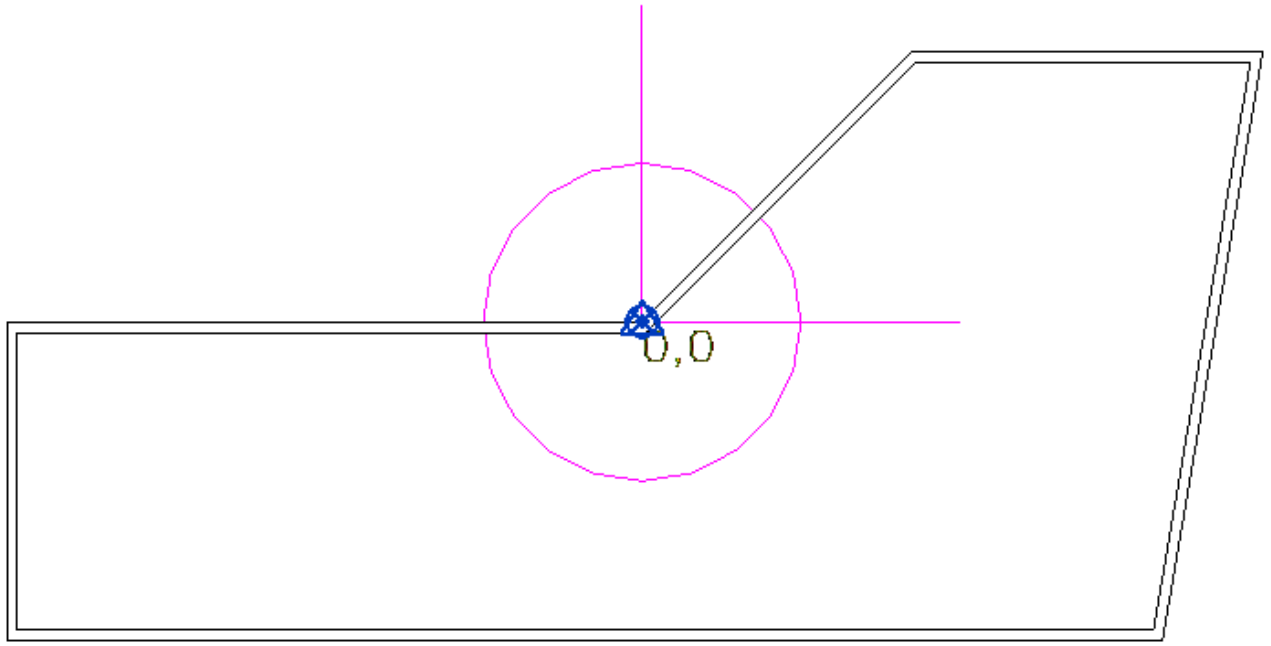
- **Project Origin**
- It’s the project Origin
- The invisible 3rd point that governs everything in reality
- It is the system you actually model in
- PBP and SP are references you use for linking and exporting models with Revit



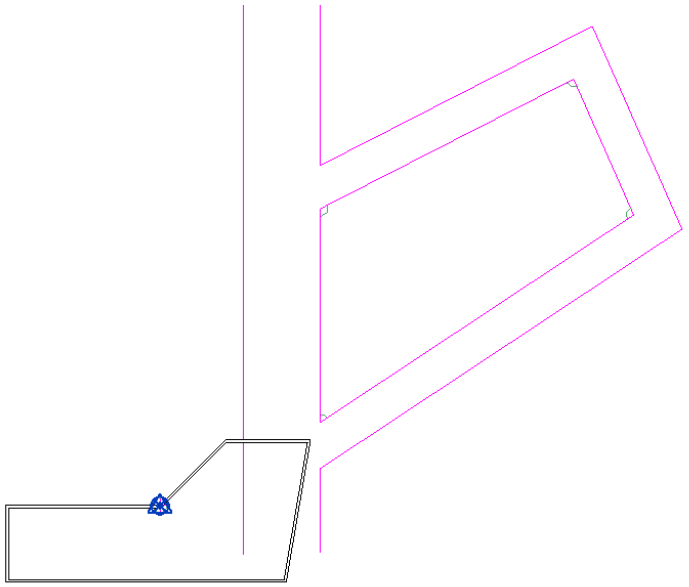
- **Showing Project Origin**
- Revit has no symbol or way of showing project origin
- You can right click on the PBP and tell it to move to startup location as one way of displaying the origin
- Depending on the SP relative position the PBP may return to 0,0,0 or another coordinate but will be at the origin regardless
- You can also insert a CAD link marking the origin
- A Revit family loaded to the origin can also display its position

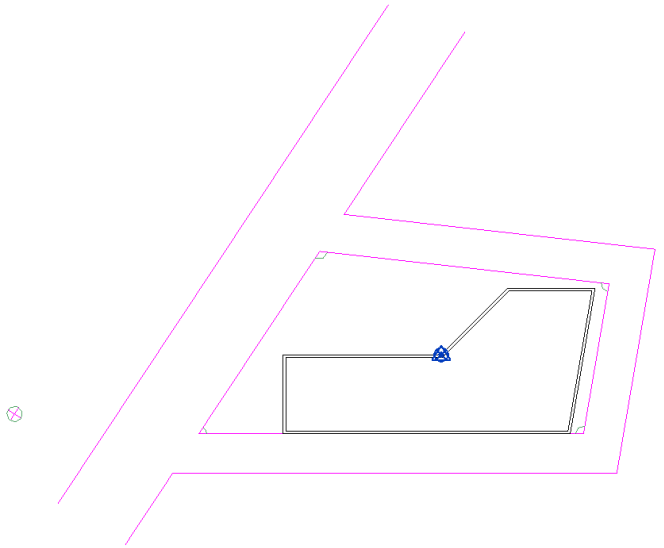


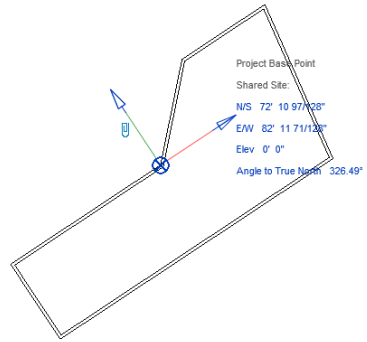
- **Referencing 3 points**
- We marked and established all three points: Origin, Survey and Base point
- Ultimately all your modeling is around the Origin with the SP and PBP used for alignment
- If you are never going to export or link other models then you won’t have to worry about these anymore
- You will probably have to use other models at some point so we need to see coordinates in action



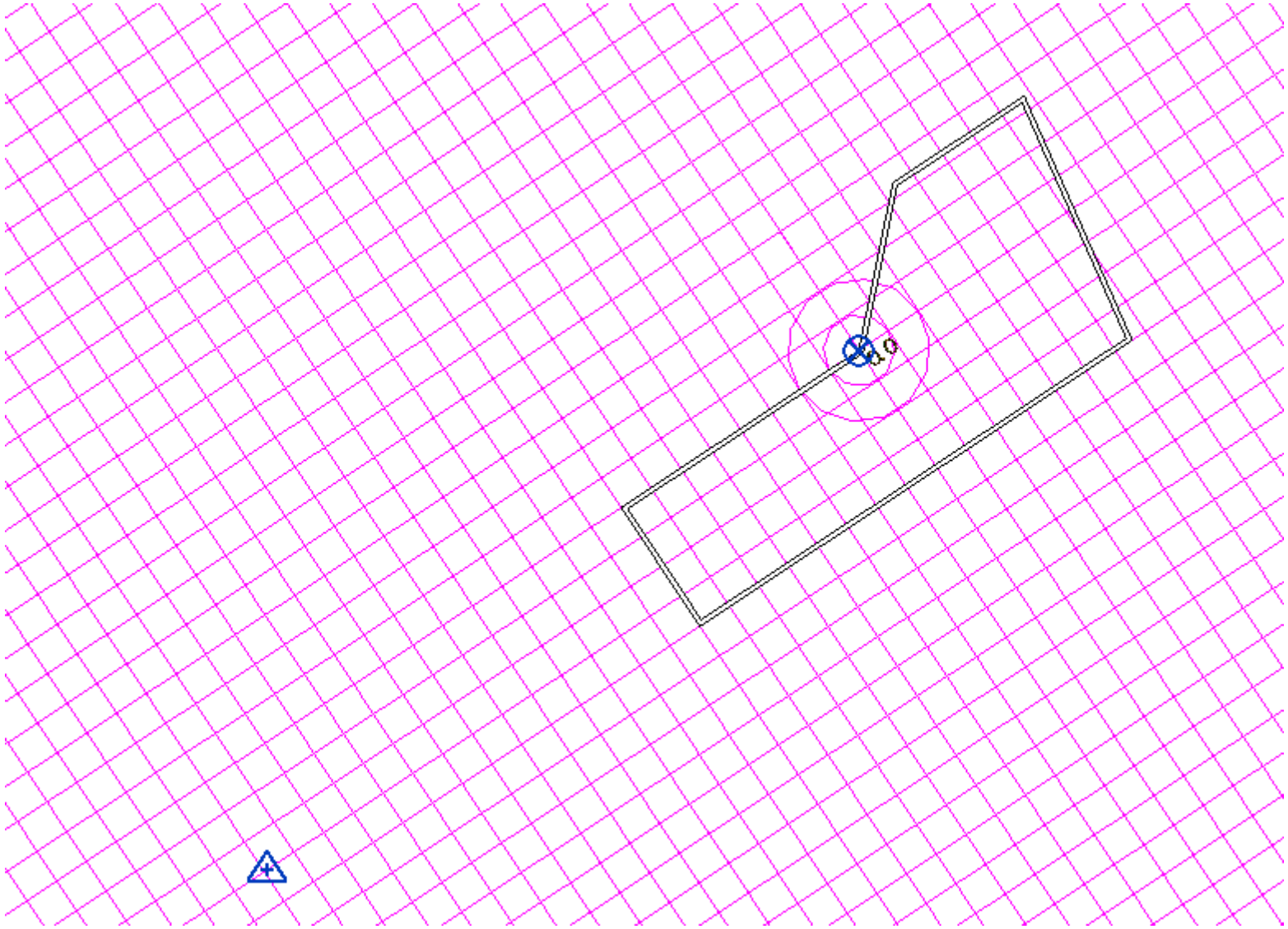
- **Creating Shared Coordinates**
- Shared Coordinates is useful for aligning site content to your Revit model
- Link in a CAD file or Datum model and orient it around your building
- Once you rotated the model use the acquire tool to gain its position
- In a **True North** view you can see the building has rotated



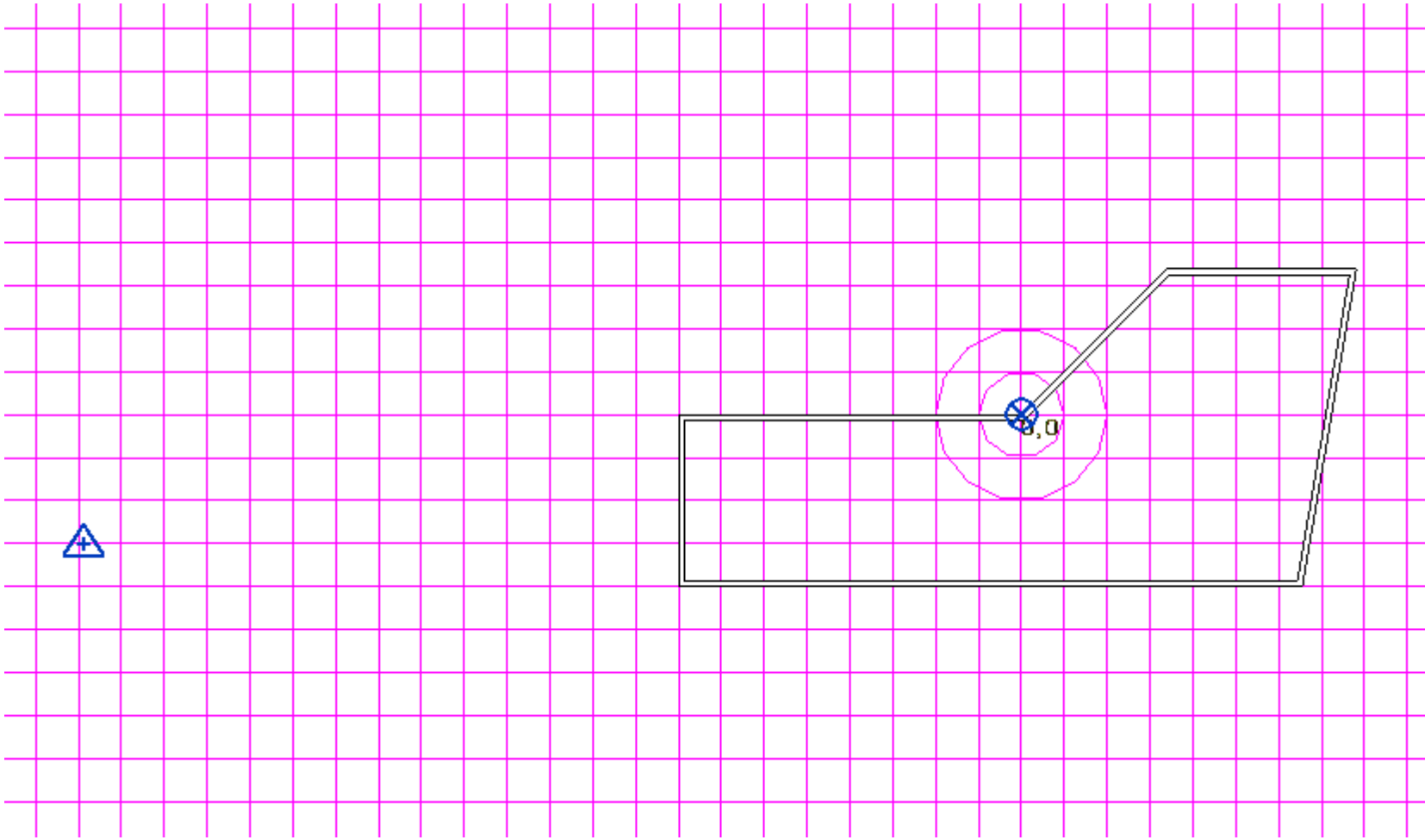




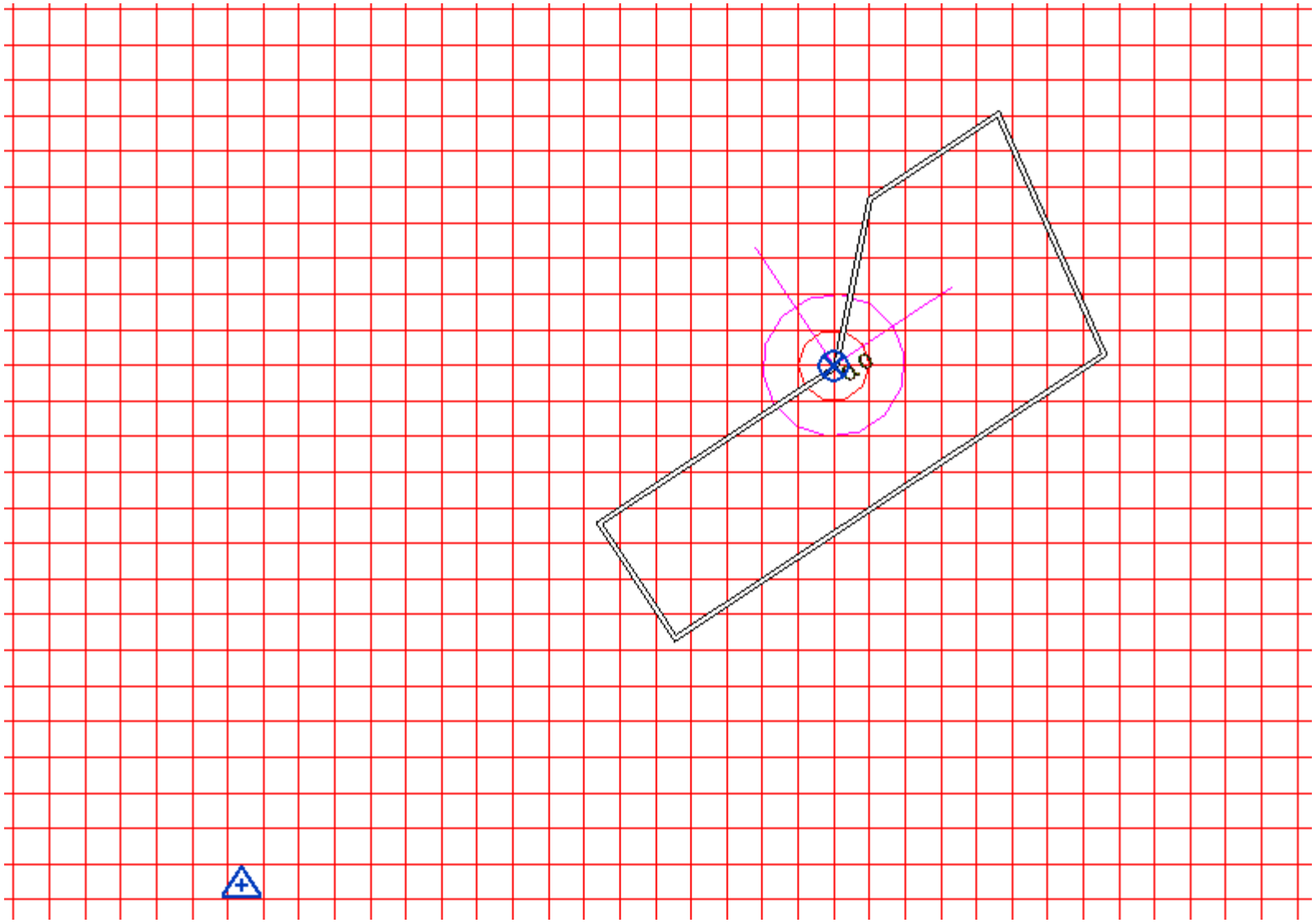
- **True North views**
- Revit lets you change the view settings from Project and True Norths which orient the views differently
- True North displays the rotation of the site per your Shared Coordinates



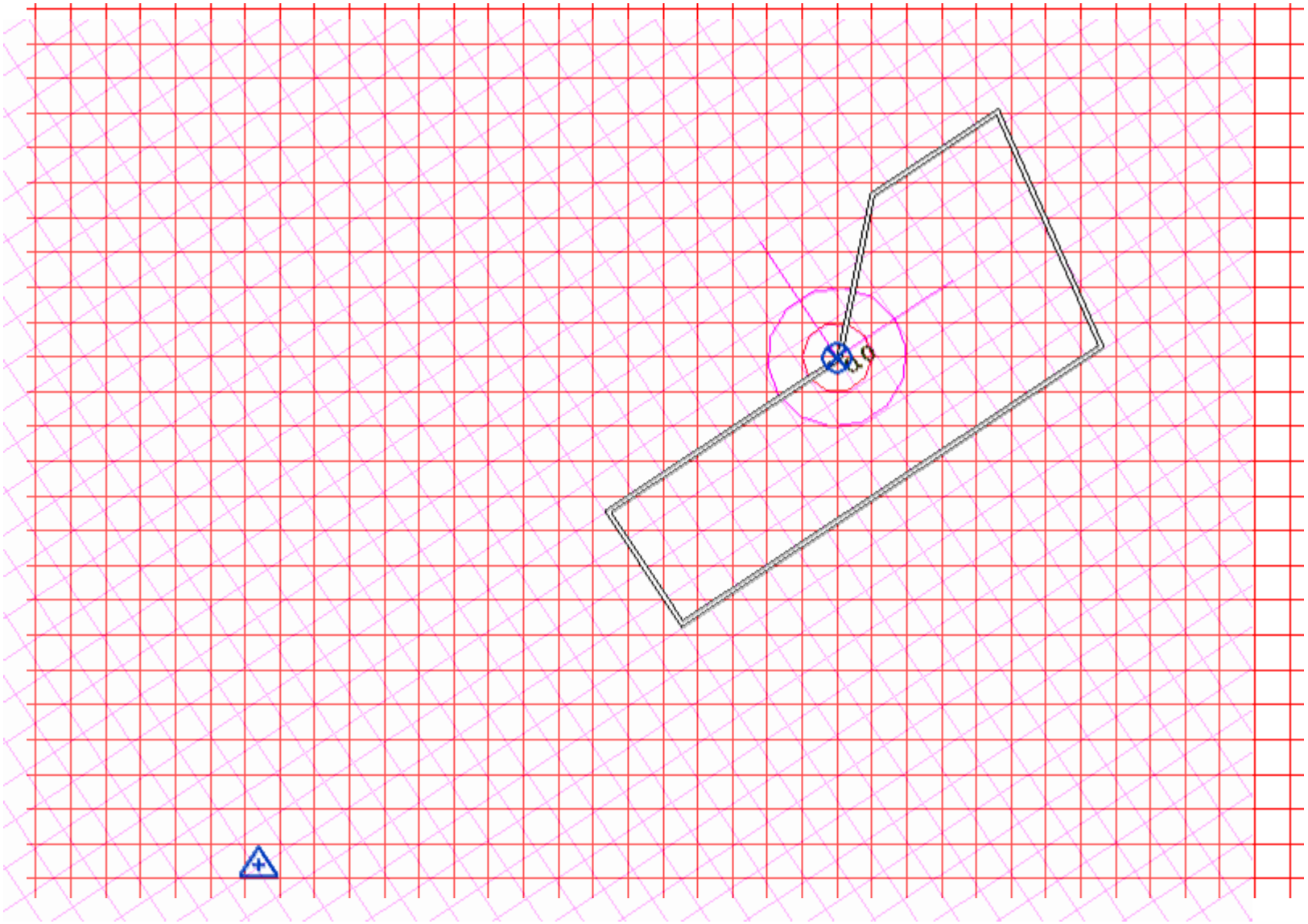
- **Project North views**
- Project North view orients to a horizontal sheet friendly view of the building model



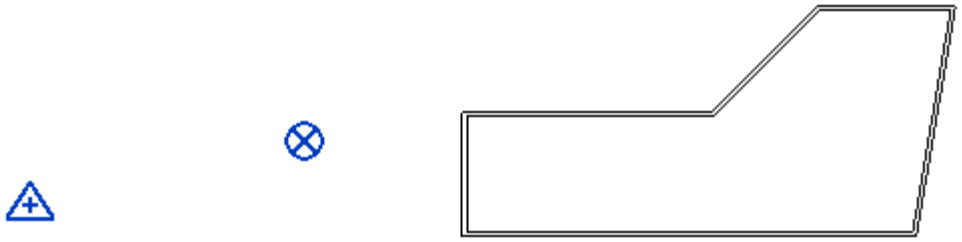
- **Model Position**
- However even in True North the ‘orientation’ never changed
- This is another ‘secret’ of the model coordinates and position
- Revit never actually changed the location or rotation of your model
- The view changed but the model stayed in the exact same place
- Same for the Origin



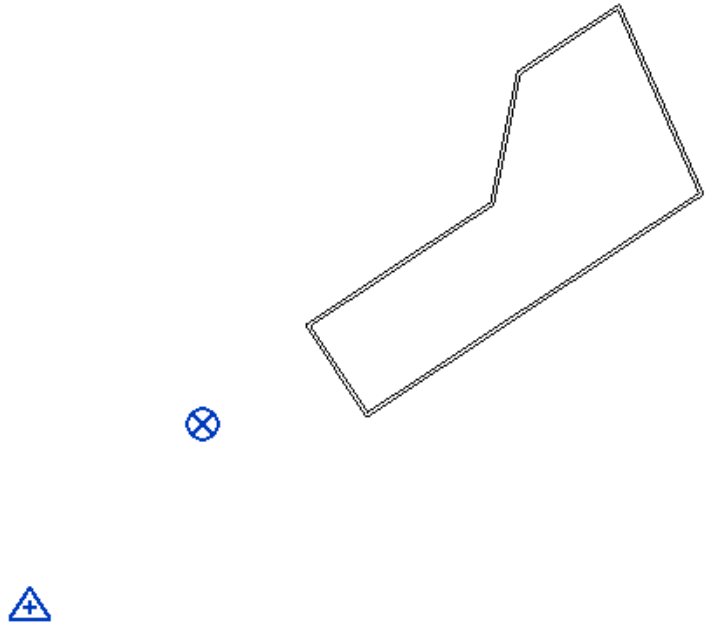
- **Orientation**
- In effect wherever you drew the model is where it stays
- To actually change the position of the model you would have to copy the elements somewhere else or move the whole building
- Revit's coordinates system works by actually moving your model but to provide references with the SP and PBP to orient with other models
- The position system can create a rotated view from the normal like the WCS and UCS in AutoCAD



- **Orientation**
- These functions aren’t obvious in Revit because there are few visual cues to make it clear
- Keeping track of where your coordinate points are is a good start
- Match definitions to make it easy to remember.
- Project North is Internal Coordinates
- True North is Shared Coordinates

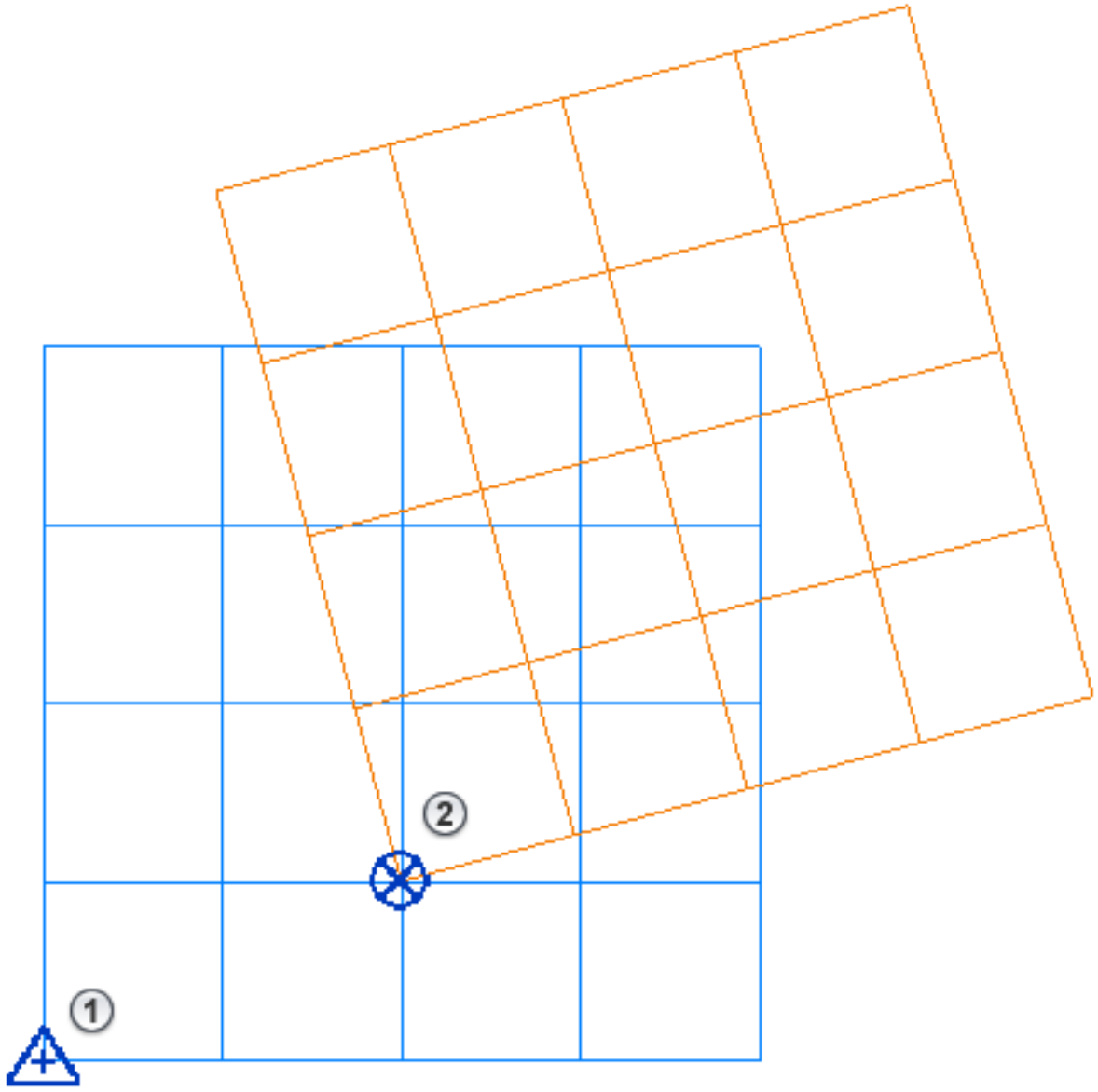


PROJECT NORTH = INTERNAL COORDINATES

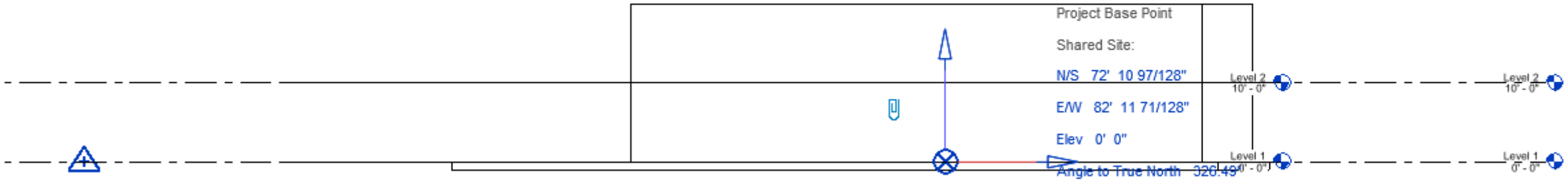


TRUE NORTH = SHARED COORDINATES

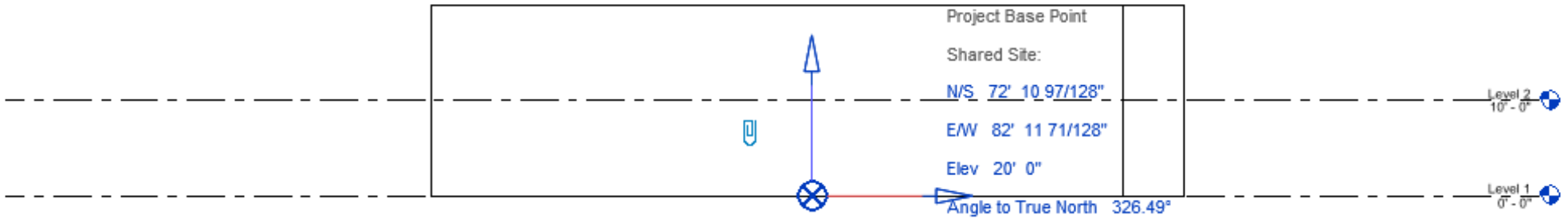
- **Orientation**
- Understanding the relationship between model location and the coordinates in Revit is a big step in understanding where you are in the project
- SP and PBP are only meant to align your model to other models
- The position is the rotation
- Being aware of these settings can make managing your location a lot easier



- **Elevation**
- Note on the Z axis
- The SP and PBP orientation displayed in plan works the same in elevation views
- Your levels can be set with either the PBP or the SP as the reference height



- **Elevation**
- Keep in mind that the SP can be moved down clipped (without the SP points changing numbers)
- The PBP elevation can be changed this way
- Be careful of how you move the SP clipped because without a reference point marked and no coordinates reporting you can easily lose track of where you started

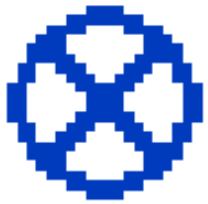


SUMMARY

- The coordinate system in Revit is two systems.
- The first is the internal system in Revit based around it's internal origin.
- Everything in Revit is modeled in relation to this point.
- Every model element has an X, Y & Z coordinate in relation to this point.

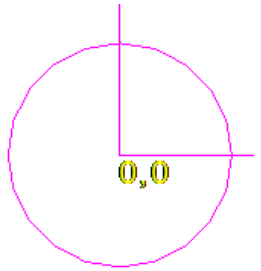
- The shared coordinates system maintains that everything sits in the same place and you move the world (or coordinates) around it.
- Not the model moving around in the world
- In Revit you model a building at project north then use the coordinates to tell it the relation to true north.

- Revit will display the model in true north, but it's an illusion.
- The model never rotates, it's just the graphical view that makes the model appear at true north.
- It is still set out in Revit's internal coordinates and project north.



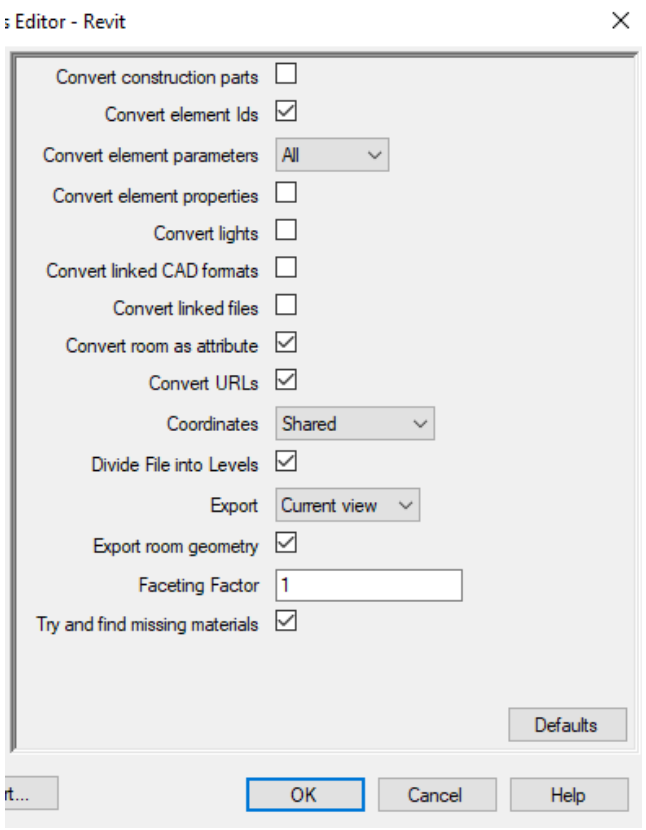
PROJECT BASE POINT

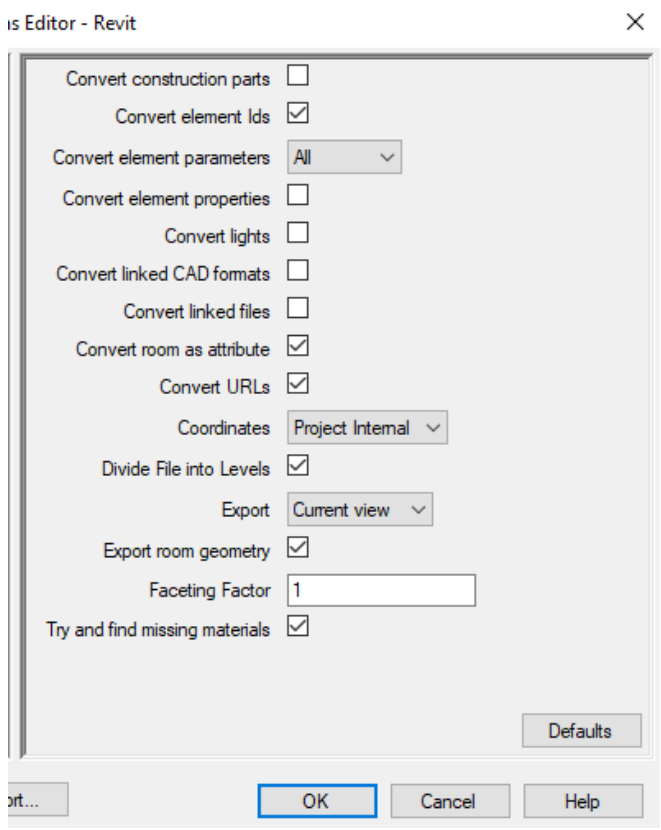
SURVEY POINT



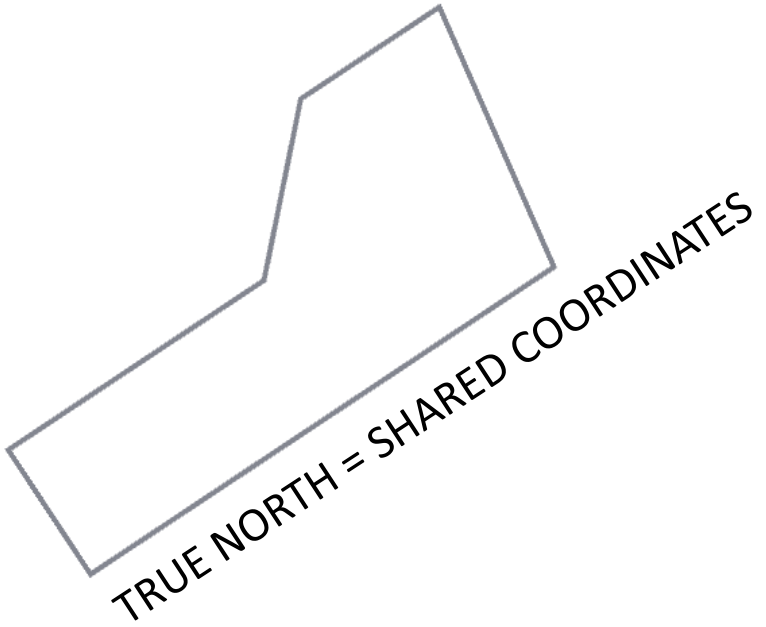
CHECKING YOUR WORK

- **Exports**
- My preferred way to figure out where my projects are outside of Revit is a Navisworks export
- You can export shared (PBP) or Internal (Origin) in the options menu



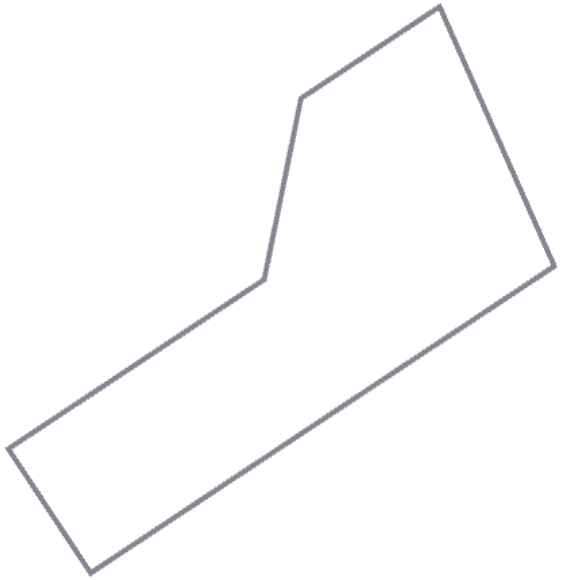


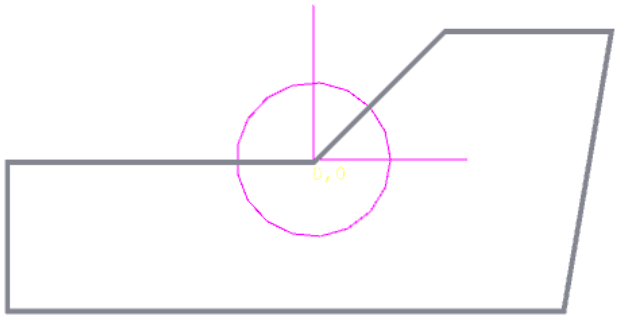
- **Navisworks**
- Within the Navisworks project you can add both versions of your project to see where they line up
- Navisworks represents the ‘truth’ about your model position
- If they match your Revit positions the way you expect then everything should check out
- If the exports are in different places then you may have to modify the Revit model to correct the alignment



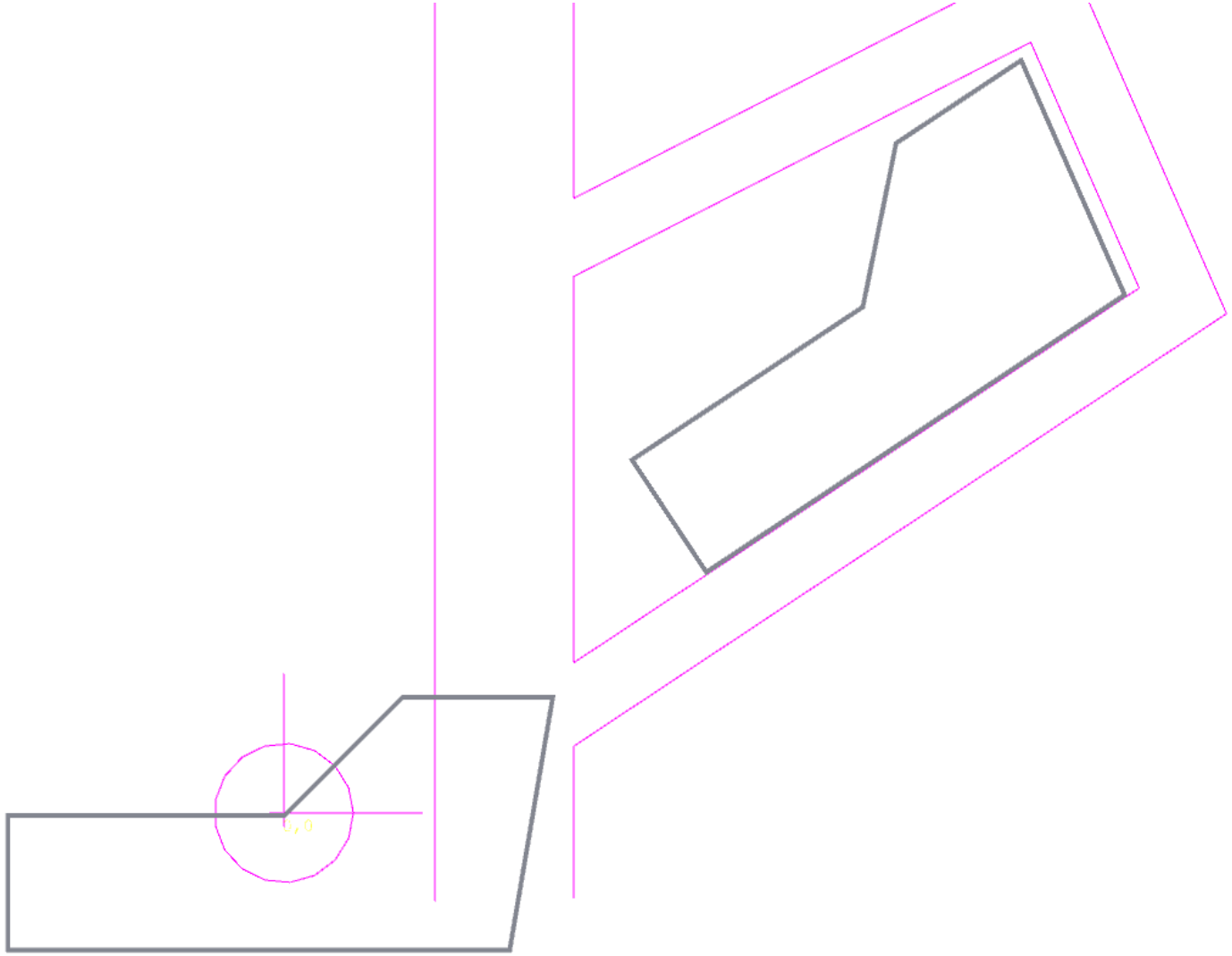
PROJECT NORTH = INTERNAL COORDINATES

- **Navisworks**
- You can bring in the Origin marker to see where 0,0 points sets compared to your models



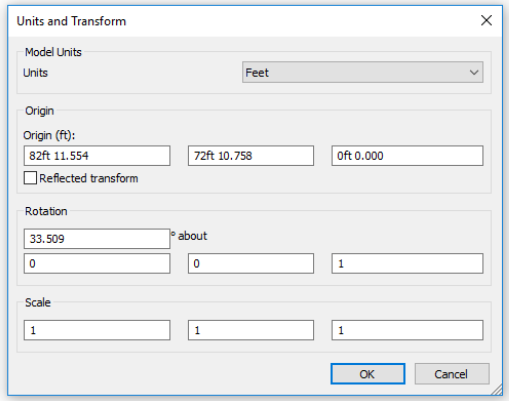


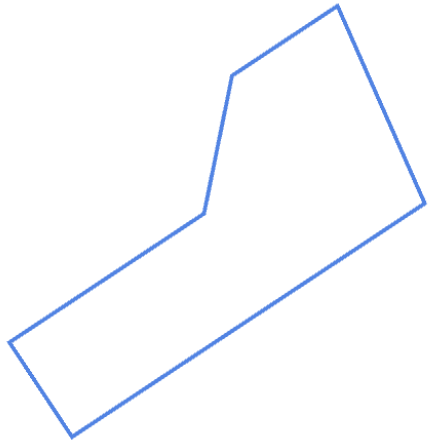
- **Navisworks**
- The Survey or Datum can also be brought in to compare the models to the expected orientation

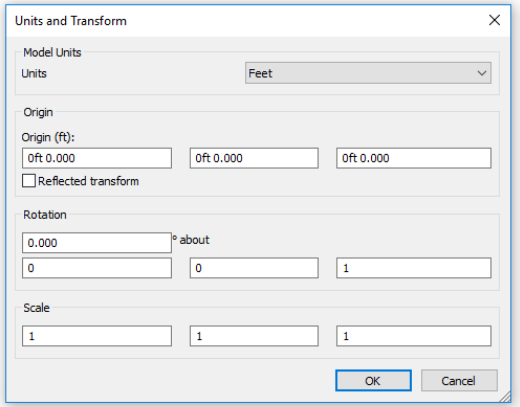


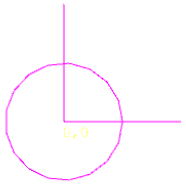
CHECKING YOUR WORK

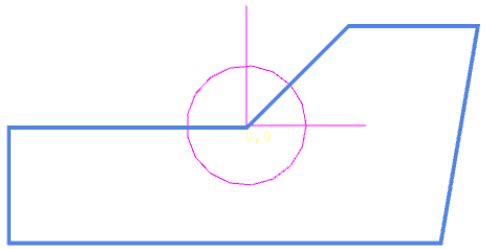
- **Navisworks**
- You can also look up the model offset relative to the 0,0 in Navis and from the export
- Internal exports should be 0,0,0
- Shared Exports will report whatever number the PBP reports in Revit



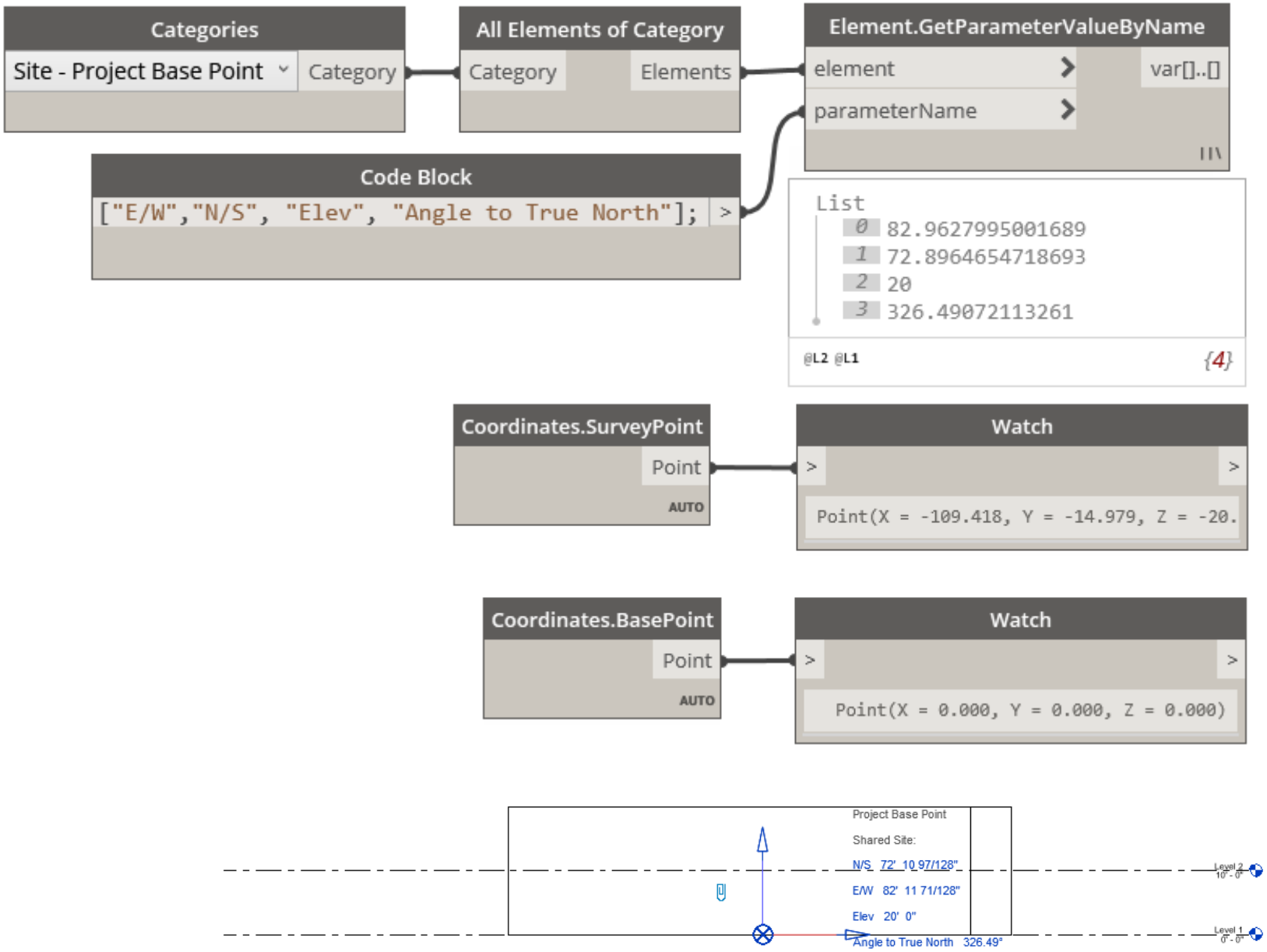




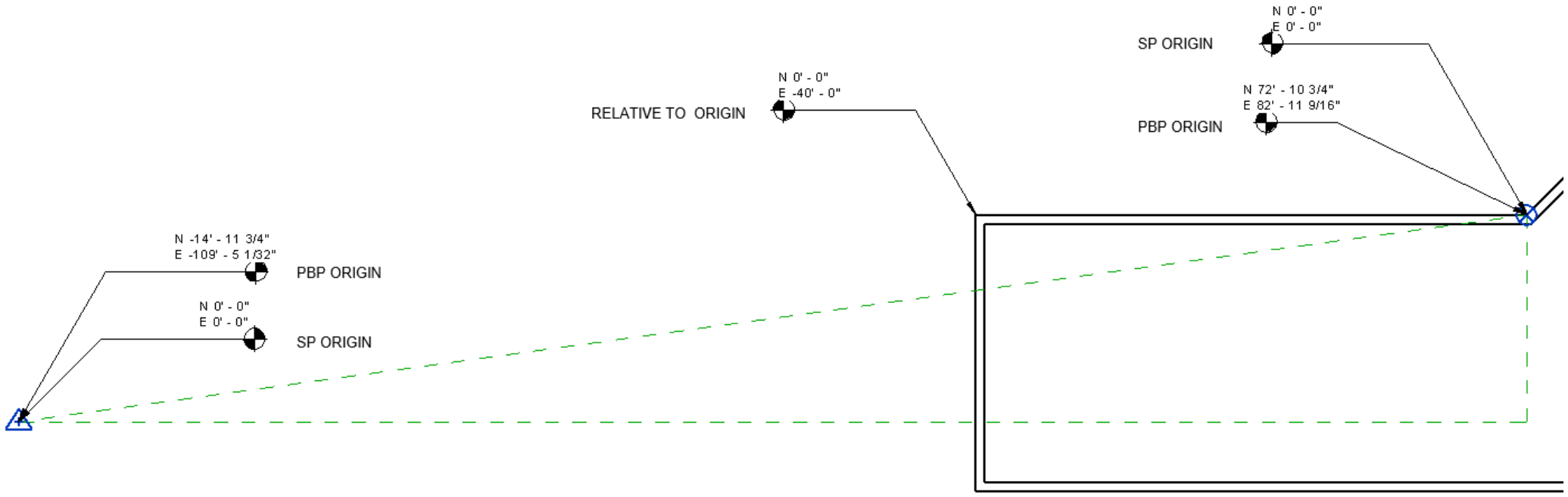




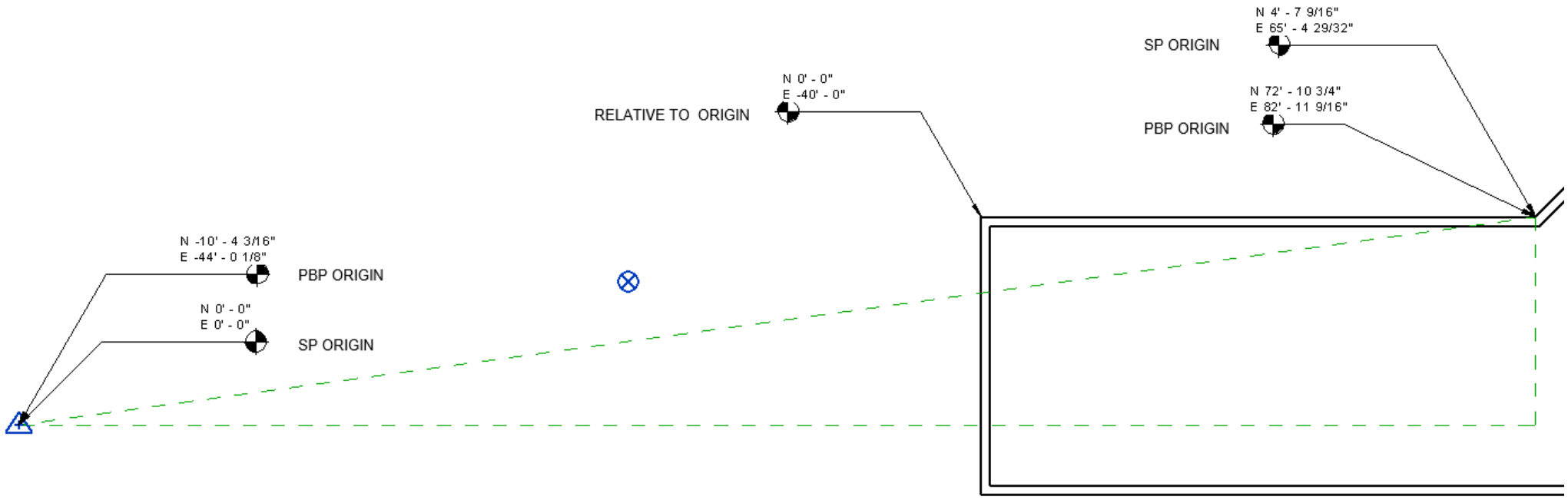
- **Dynamo**
- If you have the Dynamo add in then you can report positions with a few nodes
- The ‘Coordinates.SurveyPoint node will tell you the offset from SP or the PBP location in other words
- The ‘Coordinates.BasePoint’ node will report the PBP location which if it is on the Origin itself will be 0,0,0
- One of the easiest paths to find coordinates without going through view settings



- **Spot Coordinates**
- You can also create spot coordinates to check your position
- 3 types – relative to Survey Point, relative to Project Base Point and Relative to Origin
- Having these annotations in a reference view or start up view can keep tabs on all the model coordinates



- **Spot Coordinates**
- Changing the PBP or SP position will update these points making it easy to check if anything has moved

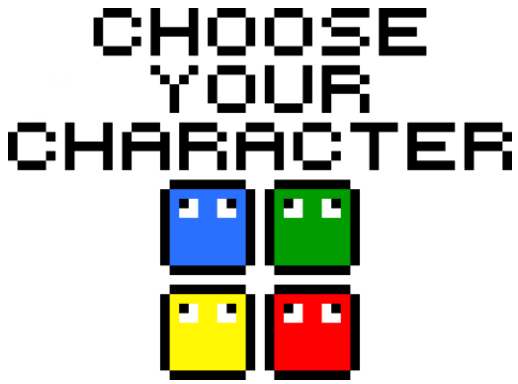


STARTING A NEW PROJECT

STARTING A NEW PROJECT

- How Can your project start off the right way?
- Refer to the real world – get a documented survey file
- Decide how you will orient your project on the site with the survey file
- From there decide your model strategy

- **Linking methods**
- Origin to Origin – For small projects where all models can be aligned from the get go
- Center to Center – Limited use, probably not a good starting point
- Project Base Point to Project Base Point – Useful for single building projects that can be aligned with one set of grids
- Shared Coordinates – Multiple buildings and large sites like a campus project can make the most use of Shared Coordinates since you can align to a datum reference file with all the building positions loaded within
- Manual Position – Not a strategy



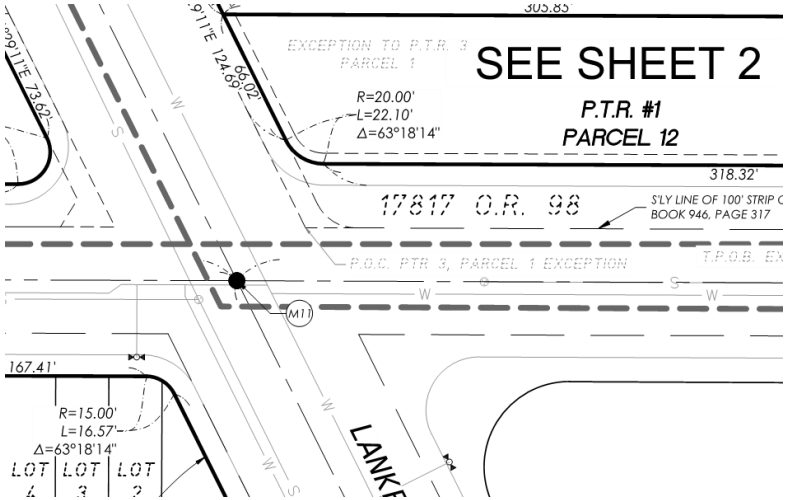
STARTING A NEW PROJECT

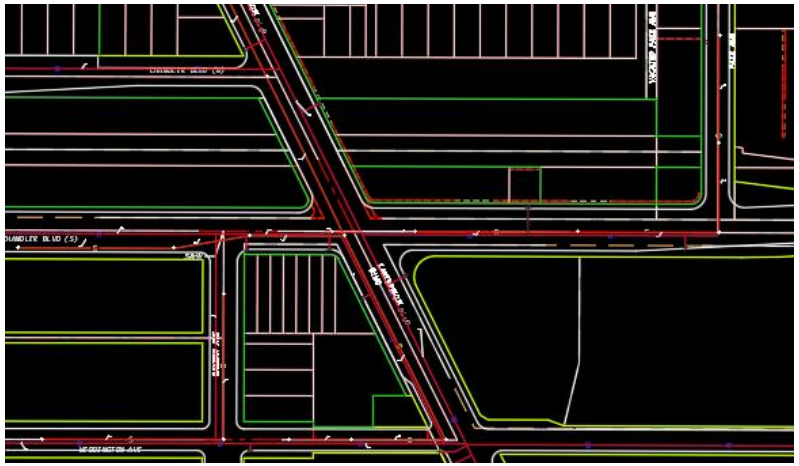
- Multiple building Coordination model method
- Works well with projects over a large site or multiple buildings
- Requires upfront coordination to work properly
- Most of your time will be spent working with Surveyor and Project team to set things up
- The keystrokes and model updates aren’t complicated as long as you remember the coordinate relationships

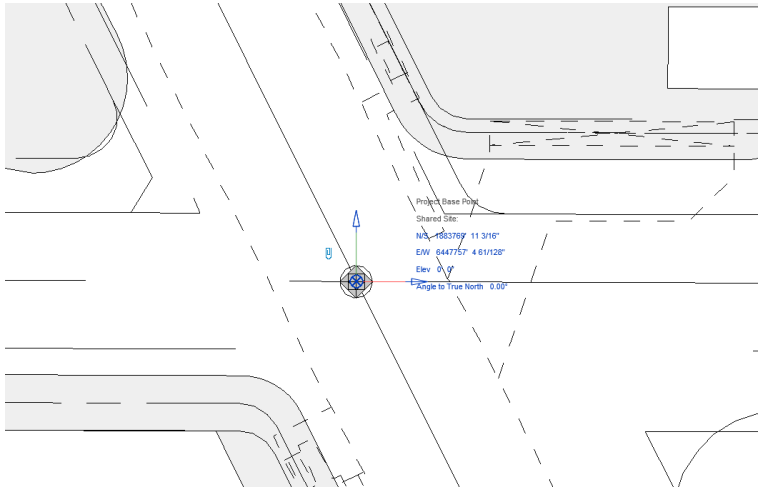
- **Site Survey** information to ask for.
- State Plane Coordinates
  - NAD83 alignment of the project site which is the Northing and Easting (X and Y coordinates)
  - Basis of Orientation
- Elevations
  - Sea Level elevations for site conditions
  - Elevation information Modeled into the topo lines (Z coordinates)
  - The topography lines in the Survey model should have the elevation information embedded into it for our coordination efforts
- True North
  - Survey file must align to the true north
  - North arrow symbol pointing to True north isn't a substitute – the survey model plan should be aligned to true north
  - Provide reference of angle between true north orientation and 0 degrees horizontal relative to the survey file (provide angle of rotation)
- Tree placement
  - Accurate location of the site trees
  - Can Survey provide tree heights?
  - Can survey provide canopy diameters?
- Street Centerlines
  - Centerlines of nearby roads
    - Boulevards
    - Access Lanes
- Control Points
  - Provide Control points at intersections - where possible
  - In addition if there are other notable site monuments or control points to Tie in the building to the site then list those into the Survey plans
- Building Tie in
  - Record position of project building footings
  - Record position of project building walls on the footings

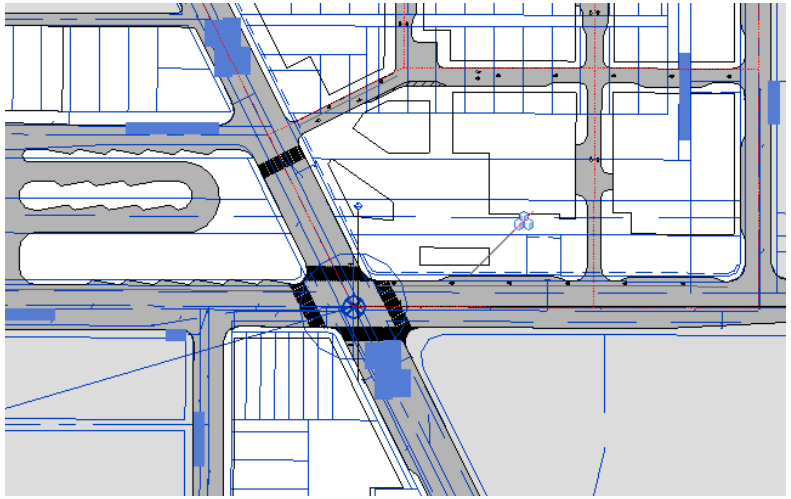
STARTING A NEW PROJECT

- Get a Survey with bearing and relevant Geographic Coordinate System
- Specify a point on that survey you will align the project like a monument or centerline intersection
- Create a datum model to what is modeled after the Survey layout
- Use the Datum model to acquire its coordinates in your own Revit project
- Confirm your PBP matches that of Datum which itself orients to the survey point



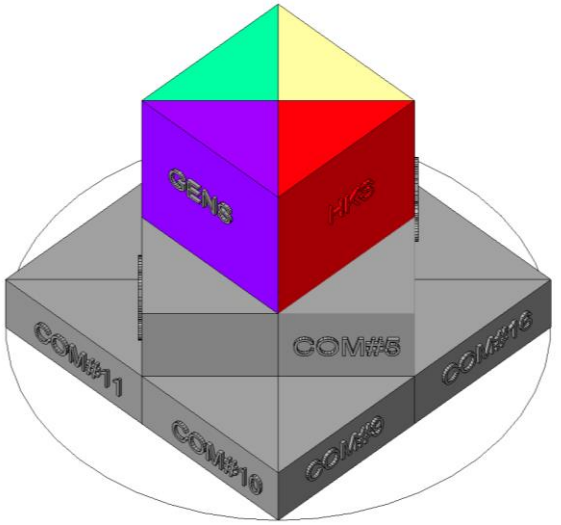


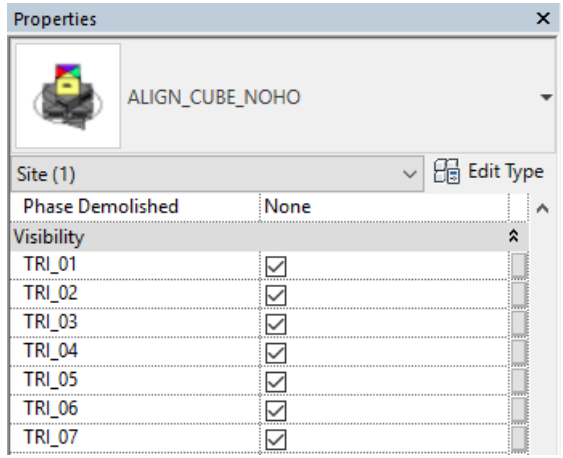


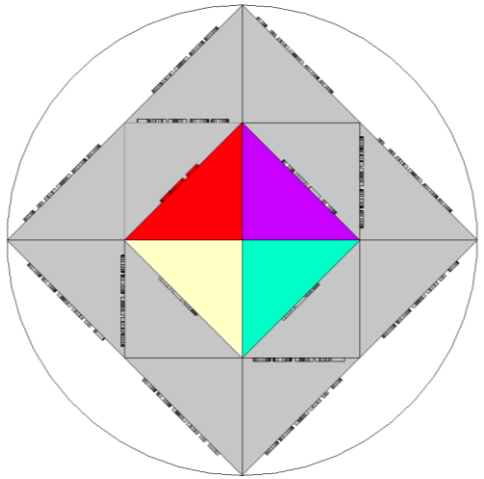


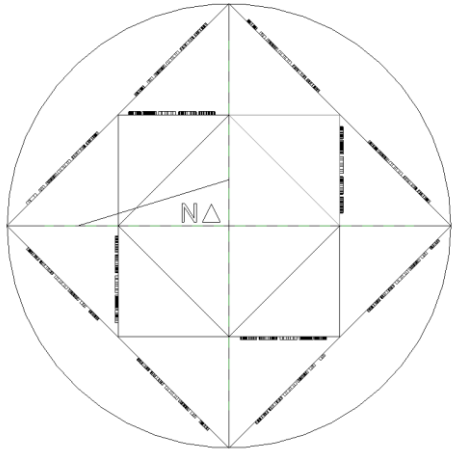
STARTING A NEW PROJECT

- At the Survey control point you set your intersection place a marker
- Using a Family that can be loaded at the PBP can document the alignment between multiple disciplines
- Architect, Engineers, Contractors, etc can be listed on a subdivision of the cube and keep the common North marker to orient the models
- With this family you can quickly check if a shared Coordinates model is linked up in the right place if the cubes join correctly









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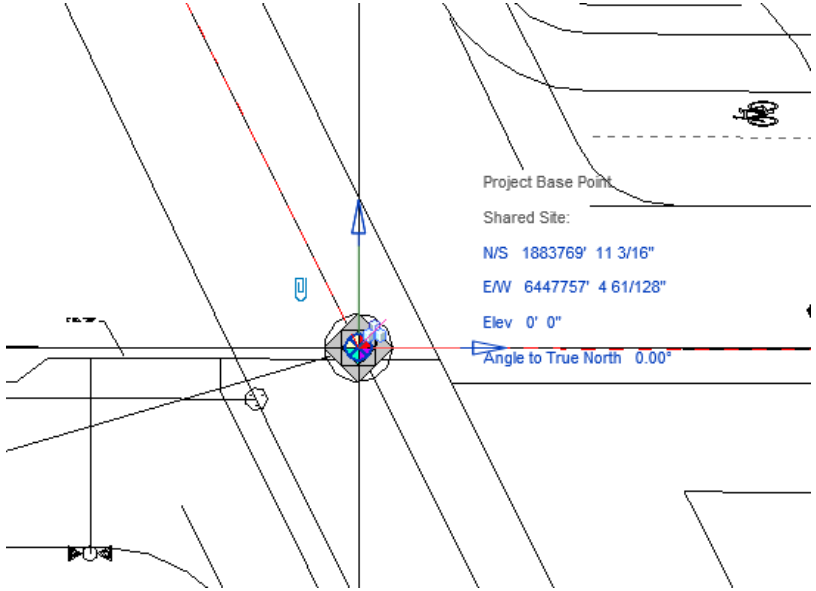
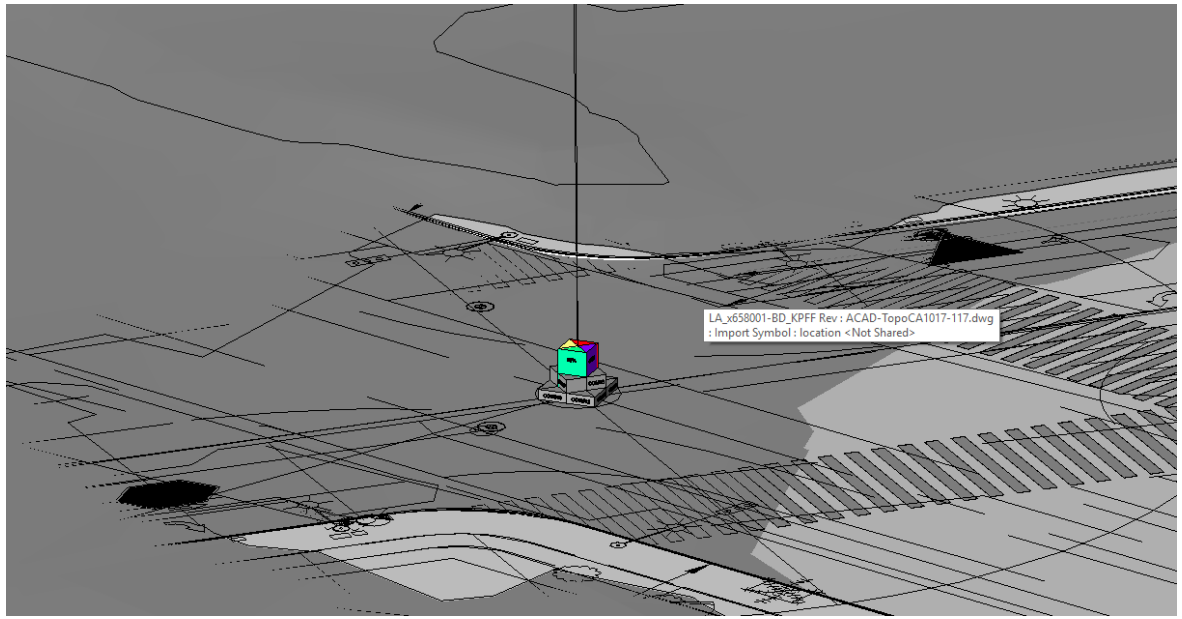
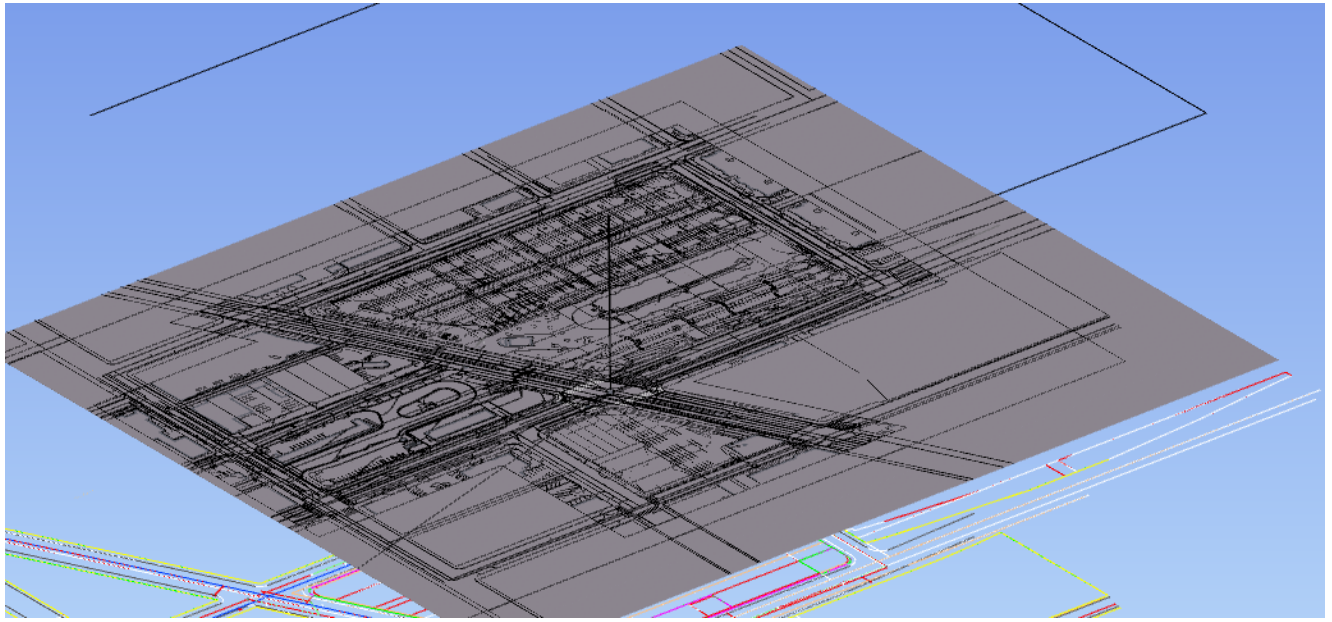
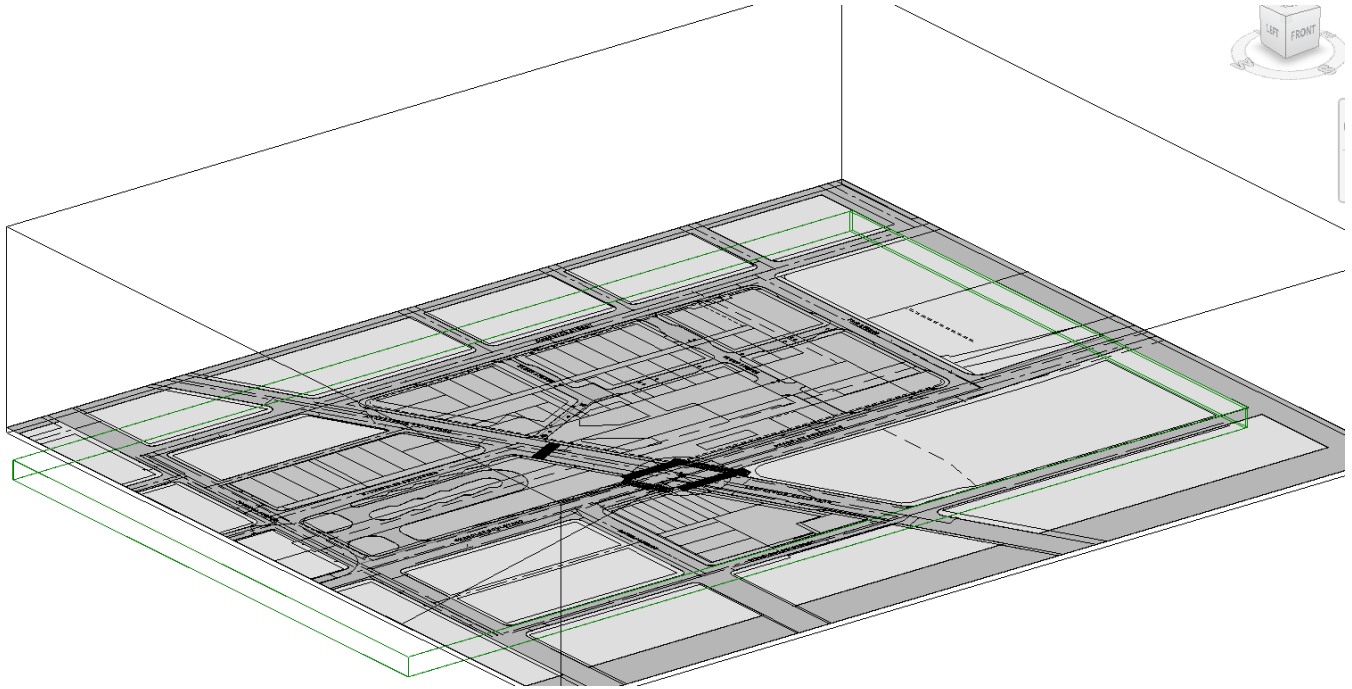




STARTING A NEW PROJECT

- Last check is to export your 3D model into Navisworks with Shared settings
- Compare the Revit and Survey CAD exports
- If they line up then you have a correctly orient Shared position
- Make sure each building you have within the site goes through the same check before releasing the model to consultants or back to the Architect to link with





STARTING A NEW PROJECT

- Document all of this
- Add the project position information into your BIM execution plan
- List it in your dashboard
- Have a webinar with the project team to explain all your steps so everyone understands these requirements

Don’t make people guess, say it and write it!

RECAP

RECAP

- Lessons Learned
- Don’t take your model position for granted or it can be a lot of time and effort to correct it
- There are many ways to set the model in Revit so pick the method and tools which work best for your project
- Double check your work in software outside of Revit
- Document the position and share it with the project team

RESOURCES

- Sources used for this presentation
  - Kbachman - http://www.dialogdesign.ca/wp-content/uploads/S3_2_Hand_SharedCoordinates_-KBachmann.pdf
  - Revit Pure - https://revitpure.com/blog/13-tips-to-understand-revit-base-points-and-coordinate-system
  - Modelical - https://www.modelical.com/en/gdocs/coordinates-in-revit/
  - The Revit Kid - http://therevitkid.blogspot.com/2015/05/revit-tip-controlling-your-levels.html
  - The Revit Kid - http://therevitkid.blogspot.com/2015/08/revit-tip-project-base-point-and-survey.html
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