Navigating Through the Storm Using Coordinate Systems in Autodesk® Revit®

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AB1412 One cannot sail happily and safely without mastery of navigation coordinates, and the same holds true for any Autodesk Revit-based software user who works on projects with a multitude of linked models. This class "blows away the fog" covering coordinate systems in Revit and offers clarity so you can sail your way through the roughest of seas. We drill through all the means of controlling shared coordinates and lift the curtain of abstraction through rich, visual aids. Learn to properly rig your projects and linked files for perfect shared positioning and master the concepts behind survey and project base points. Following this class you will no longer have to rely on the Coast Guard for rescue and assistance and will garner the bravado of a true captain of the seas!

Learning Objectives
At the end of this class, you will be able to:

- Explain the coordinate systems in Revit projects and families
- Use the project base point and survey point
- Successfully link multiple project files/models with predictable results
- Exercise total control over the shared coordinate system instead of letting it control you

About the Speaker

David has practiced Architecture for 12+ years and draws his experience from exposure to projects of all shapes and sizes, new or renovated, mainly in the Educational and Healthcare sectors. He was the team leader on several Revit pilot projects prior to joining HOK in late 2012 as Regional buildingSMART Manager, where he is still very passionate about mentoring his peers in the office and across the globe through his blog “Do U Revit?” and as an author on “HOK BIM Solutions”. His current role is focused around leading project teams with all aspects of BIM and inter-related technologies across the disciplines of Architecture, Interiors, Landscape/Planning, Structural and MEP, all the while championing HOK’s firm-wide processes. David graduated with a Masters of Architecture (Texas A&M - 2001), a Bachelor of Engineering & Architecture (University of Malta - 1999) and in his spare time is always desperately trying to keep up with reading and contributing to the BIM and Revit communities.

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Introduction

We have all been there: Every time you are faced with positioning of linked files or trying to deal with anything related to coordinates, it feels like battling a major storm: you know the end goal, but have no confidence in knowing if you are navigating the safest path. This class will help you visualize the outcome when using some of the most abstract tools in Revit, so you can reach any port, on any vessel, in any weather condition!

Charting the Course

1. The Revit Coordinate System(s)
   1.1. Common Terminology
   1.2. Getting Oriented
   1.3. The Survey Point
   1.4. The Project Base Point
   1.5. Reporting Distances and Elevations
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   6.4. Rotating Project North
   6.5. Finding a Link’s World/Internal Coordinate System Origin
   6.6. The Origin in Families
7. Conclusion
1. The Revit Coordinate System(s)

What makes Revit’s coordinate systems(s) and associated tools so difficult to understand is the lack of visual feedback we receive when interacting with related features. Most of us are used to having some point of reference that helps our brain orient itself in digital space. It is no surprise that we feel frustrated and lost when dealing with these seemingly invisible coordinates.

To make things worse, we also think that this topic is a lot more complex than it really is. Thanks to that perception we often ‘abandon ship’ and never truly try to understand what is happening behind the scenes!

Similar to most CAD software, any point in Revit’s Euclidean space is defined by three Cartesian coordinates on fixed X, Y and Z axes that meet at the Origin (0,0,0). Whilst these are typically exposed to the user through visual means, in Revit they are not as “in your face” as other CAD packages, but make no mistake: they are still there! This fixed system is essential to position elements in space such as points, lines, planes, surfaces, solids and other user-defined coordinate systems.

To help with positioning of linked files and to work at convenient orientations, we also get to define any number of secondary coordinate systems using similar X, Y and Z axes, rigged off the fixed coordinate system.
Elements in digital space are all positioned relative to the fixed coordinate system. However we can use secondary coordinate systems to aid in more convenient reporting of their location in 3D space.

For predictable positioning of linked files, we typically pick any one of these known coordinate systems and align our files by matching up the coordinate system’s Origin and XYZ orientation. We don’t necessarily have to do this, but it is definitely the smart thing to do. You can manually move and rotate files around until they are in the desired positions, but what if you need to redo this again, perhaps in other software applications? If you were to do this, you would need to record all the rotations and translations leading up to the final placement of your files and repeat these exact steps each time. Other BIM authors would need to do the same thing, but reverse the rotations and translations when placing your file in theirs. Sounds complicated? Not only is it complicated, but it is inefficient, prone to the loss of these essential rotation and translation values, and can easily result in serious errors.

If all geometry in multiple linked files is in the same relative position from the fixed coordinate system, we would use this system to align the files. Unfortunately this is often not the case due to a lack of understanding of these basic principles. As we’ll see later on though, Revit gives us the ability to not only define a secondary coordinate system in a project, but to also drive it into other linked files. Think of it as forcing a pin in 3D space to mark the location of this secondary coordinate system in multiple linked files at once. We can then position them relative to each other as many times as required by matching up these secondary coordinate systems’ Origin and XYZ orientation.

Proper understanding of these fundamental concepts will result in a solid foundation upon which to build confidence in mastering the associated tools in Revit and beyond. Unfortunately not all applications speak the same language, so let’s take a look at some familiar terms used in the AutoCAD world and see how these map to Revit’s jargon.
1.1. Common Terminology

<table>
<thead>
<tr>
<th>Fixed Coordinate System</th>
<th>AutoCAD</th>
<th>Revit</th>
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<tbody>
<tr>
<td>World Coordinate System (WCS)</td>
<td>Internal Coordinates</td>
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<tr>
<td>Secondary Coordinate System</td>
<td>User Coordinate System (UCS)</td>
<td>Shared Coordinates</td>
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<tr>
<td>Named UCS’s</td>
<td>Sites</td>
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</tbody>
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A lot of users are familiar with AutoCAD’s terms and associated graphic cues that help us see the coordinate systems’ axes. In contrast, Revit greets us with a blank canvas that leaves most scratching their heads, wondering where any of these are located.

1.2. Getting Oriented

Some indirect graphical means to display the location of the **Internal Coordinates** and the **Shared Coordinate** system is available through the Project Base Point and Survey Point respectively, which are subcategories of Site.

**To find the Internal Coordinate System’s Origin:**
- Set the icon to ![icon](image)
- Right-Click on the icon and pick Move to Startup Location

The center of the relocated Project Base Point will mark the Origin (equivalent to the WCS Origin).

**To find the Shared Coordinate System’s Origin:**
- Set the icon to ![icon](image)
- Set all values to zero

The center of the relocated Survey Point will mark the origin (equivalent to the UCS origin).

You can also use the unclipped Project Base Point and zero-out all distances to find the origin of the Shared Coordinate System. Be extra careful not to do this when clipped, as this will move the Shared Coordinate System instead!

Assuming that the subcategory visibility is enabled for the Project Base Point and Survey Point, the icons will only display based on the following criteria:

- **Plan Views:** Icon is anywhere below the cut plane
- **Ceiling Plan Views:** Icon is anywhere above the cut plane
- **Sections/Elevations:** Icon is anywhere in front of the cut plane
- **3D Views:** Icon is anywhere within the section box

*To make sure you can see the Survey and Project Base Points, set a plan view with a very high cut plane or a 3D view with no section box.*
Note that both the Project Base Point and the Survey Point report the \textbf{N/S}, \textbf{E/W} and \textbf{Elev} distances relative to the Shared Coordinate System as defined by the current Site.

\textbf{1.3. The Survey Point}

The Survey Point represents a known location in the surveyor’s world, equivalent to a station pin or geodetic survey marker in a civil engineer’s site drawing. Think of it as a stake driven into the ground at a convenient location, perhaps at the intersection of two property lines. This point will have a shared coordinate value relative to the surveyor’s origin, or it could serve to mark the origin itself. In the image below, the Survey Point on the left is placed at the origin (note how everything reads 0'-0''), while the one on the right is at a distance from the Shared Coordinate origin.

\textbf{1.4. The Project Base Point}

The Project Base Point represents a convenient spot on the project site and is analogous to driving a stake into the ground to mark a work-point. It is used to locate project geometry/datums in 3D space through convenient, simplified and rational measured distances and elevations. You can think of it as the origin of a “local coordinate system” for the building: if the building needs to be relocated and/or rotated, you simply re-define the position of the clipped Project Base Point on the site. In this case, its relative position to project geometry stays the same, so existing distances measured from this point do not change. Moving the unclipped Project Base Point is equivalent to marking a different work-point relative to the building.

You can use any logical point for the Project Base Point, such as the intersection of grid lines, or a prominent building corner or geometrical feature. Revit’s Project North (Project Base Point’s green axis) always points to the top of the screen in plan views whose Orientation is set to Project North. Note that you could arbitrarily locate a Shared Coordinate System in a project and proceed with modeling and final
documentation of the entire project through a carefully located Project Base Point (we’ll refer to this as the **Project Coordinate System** from now on). The final position of the Shared Coordinate System can then be determined just before you need to mark the work-point on the site so the surveyor can drive that stake into the ground, from which building elements can then be located in real space.

*The Drawings’ Project North is typically defined as the orthogonal axis that most closely aligns with True North. In this class, we are simply talking about Revit’s Project North, which is fixed to only one of four typical positions (top, bottom, left or right).*

Note that if you are sharing model data throughout the design life of a project, it is recommended that you set and fix the Shared Coordinate system location as early as possible and avoid changing it!

### 1.5. Reporting Distances and Elevations

When documenting the design of a building, it is very important to report the heights of major building components such as structural and finish floor heights, top of parapet walls, etc. This can obviously be done through dimension strings starting from a common location, such as the finish floor line on the first floor, but in most cases we prefer to use some kind of annotation on “vertical drawings” to communicate height relative to a chosen point other than using typical dimension strings. Levels, Spot Elevations and Spot Coordinates give us this capability and can be customized quite easily.

### 2. Quick Facts

When using any of the tools that affect the Shared Coordinate System, the resulting behavior does not always readily make sense. It almost seems as if Revit is playing some devious slight of hand, a magic trick of sorts! The following tables are great troubleshooting aids to quickly visualize what is happening, even if the operations are somewhat abstract or the visual feedback is contrary to your perceptions.
### Facts

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<table>
<thead>
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<tbody>
<tr>
<td>a.</td>
<td>Moving the clipped <strong>Survey Point</strong> = Moving the clipped <strong>Project Base Point</strong> by the same distance in the opposite direction</td>
</tr>
<tr>
<td>b.</td>
<td>Changing Angle to <strong>True North</strong> to a larger number (clockwise) = Rotates Shared Coordinate System around the <strong>Project Base Point</strong> in an <em>anticlockwise</em> direction</td>
</tr>
<tr>
<td>c.</td>
<td>Before you're able to use shared positioning, you have to:</td>
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<td>c.</td>
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<td>c.</td>
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<tr>
<td>d.</td>
<td>Survey and Project Base Points from linked files do not show up in the host file (they are not even available in the V/G settings for the linked file)</td>
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<tr>
<td>e.</td>
<td>When shared coordinates are published from Revit to a DWG, the Shared Coordinate System defined in the current site will be recorded as a named UCS in the DWG file called <strong>REVIT60-DefaultLocation</strong>. It is recommended to change the suffix before publishing coordinates to something more meaningful</td>
</tr>
<tr>
<td>f.</td>
<td>Revit cannot acquire shared coordinates from a model with multiple Site definitions when using the <strong>Acquire Coordinates</strong> tool</td>
</tr>
<tr>
<td>g.</td>
<td>The <strong>Survey Point</strong> and <strong>Project Base Point</strong> both read their position relative to the Shared Coordinate system origin and axes</td>
</tr>
</tbody>
</table>

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**Revit**

[Image of Revit interface]

**Click here to pick which site to acquire from**

**Select Site**

*Select Shared coordinates of the current project and By Shared Sites Link...* You can acquire coordinates from links with multiple named locations by clicking on the **Shared Site button** in the link's instance properties.

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The proof is simple: when on top of each other, these icons will always report the same distances. Note that we can set Levels, Spot Coordinates and Spot Elevations to read relative to the **Project Base Point** as if it were another coordinate system.
In various blogs and forum posts, you will find discussions about "Project Coordinates" which reference the fixed, internal Revit coordinates. This is not to be confused with the Project Base Point, which appeared in Revit 2010 together with the Survey Point and the Ribbon UI.

If you type in distances that place the Project Base Point outside of a 10 mile radius boundary from the Startup Location (Project Internal 0,0,0) or drag it outside of this boundary, Revit will prompt you with the following:

However if you drag the Project Base Point around using the arrow controls, Revit will not complain!

It is also interesting to note that Revit imposes a length limitation of 30,000' when input in the drawing area through a dimension or temporary dimension. You can drag to resize objects, or use the re-size tool to get the desired dimension.

Revit does not expose the Internal Coordinates for reporting purposes in Levels, Spot Elevations and Spot Coordinates.

When you link a file with the Auto – Origin to Origin option, there is no direct way to verify if it has been moved from its initial position.

When you Transfer Project Standards and keep Project Info checked, any Location and Shared Site data will also be transferred. If the names of your Shared Sites in the file you’re transferring from are the same as in the file/s you’re transferring to, these will be updated. Changing Shared Coordinates in this manner is not usually desirable behavior, so be extra careful when doing this or skip Project Info.

Per David Conant from an AUGI Forums post in 2007-06-18:

“Revit’s internal calculations do not like very large coordinate numbers. There are many number systems used in an app like Revit, some for calculating values, some for driving the display, etc. In some cases these systems differ in the precision of the numbers they can use. When numeric values are small, these differences in precision are insignificant. When numbers get large, the differences while still small on a percentage basis become large enough to affect the results of display and operations. Thus, it is important to keep your Revit project near Revit’s origin....”

Back then the limitation was a 1 mile radius boundary, which has since been raised to a 10 mile radius. Even though you can move the Project Base Point outside this boundary, be very careful! Once geometry is 10 miles away from the Project Internal Origin, geometry will start displaying incorrectly on the computer screen. Note that the Shared Coordinate Origin can be moved outside this boundary with no issues.

We can still achieve this goal indirectly by moving the Shared Coordinate System to the Startup Location (where the Survey Point reports all zero distances). Annotation set to read by Survey Point will then report the same values as the Internal Coordinate System would if it were an available option.

Unless you place some kind of visual marker within the file at the WCS or Internal Origin, it is impossible to reset its position, short of removing the link and re-linking. If the host and linked file use shared positioning, there is an indirect way to find where the Internal/World Coordinate System Origin of the link is (see Section 6).

When you look at a project started from the default template, you will notice that the current site is called "Internal". This means that the Shared Coordinate System of the current site matches Project Internal. It is recommended practice to create a new Shared Site with a unique name and set it as current. This leaves the default site “Internal” available just in case you need to position that project by its fixed origin.
3. “Rigging” Shared Coordinates

Proper rigging of sails on a boat is crucial to navigating the ocean safely and efficiently. The same holds true when working on projects with multiple linked files. You will not be using ropes to hold everything together, but the invisible connections between them have to be in place nonetheless. Too often, teams assume that shared coordinates should “just work” and don’t understand that there is no such thing without proper rigging! This is the single most popular myth when it comes to this subject.

Why should we bother with setting things the right way? Can’t we just move the links around manually and call it a day? Sure you can, but do you have any guarantee that the links won’t be accidentally moved, or in need of re-assembly by other team members in the same application or another one after exporting to a new file format?

Since the use of IFCs is gaining traction and these rely on Shared Coordinates, let’s focus on this instead of using Auto – Origin to Origin for the time being. In order to link using the Auto – By Shared Coordinates option, you first need to ensure coordinates are “shared” (see Fact 2.c). This is achieved through publishing or acquiring coordinates and I prefer using the link’s Shared Site instance parameter button to do this. When sharing coordinates, two things will happen:

1. A bond is established between all files, which Revit will always recognize;
2. The position of the Shared Coordinate System updates as follows:

When acquiring coordinates, the Shared Coordinate System of the host’s current Site will adjust and nothing else needs to be done. On the other hand when publishing coordinates, location changes in the link are temporary until these are saved back. For this reason, publishing coordinates is only
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recommended if the files are linked from the same network location where authored (typical of multi-discipline firms). If you are dealing with external consultants or copying of links between offices, you would lose these changes when updated files are received and reloaded. We will look at other techniques in Section 4 to deal with this workflow, where each author will manually synchronize the Shared Coordinates in their file through the Specify Coordinates at Point tool, arguably the most useful tool in the pack.

Once coordinates have been shared between files, they can all be linked together with the Auto – By Shared Coordinates option and will be properly placed in relation to each other.

There are cases when the current position of a link will be modified. Here are the scenarios:

   a) When you publish Shared Coordinates to a link;
   b) When link ‘A’ is already positioned by Shared Coordinates and you acquire again from link ‘B’, the Shared Coordinates of ‘A’ will update temporarily;

When this happens, Revit will want to save these changes to the linked file/s, and does not need to open them to do so. This can give rise to problems with workshared projects, where the Project Info workset gets owned and is not relinquished if changed positions are not saved back. So you can end with a model of a certain discipline having this workset checked out by a user of an unrelated discipline (ex: Interiors user owning this workset in a Mechanical model). It is always best to avoid modifying locations in this manner to reduce team confusion! This is especially problematic in multi-disciplinary environments where all or most discipline models are authored and saved on the same network.

To avoid owning Project Info, disable shared positioning once all links are in place. Now the link’s Shared Coordinates cannot be updated inadvertently. Note that if the host model’s Shared Coordinates update, link positions will not change automatically. To resolve, simply pick each link and change the Shared Site settings, and then stop sharing soon after. Also when re-acquiring Shared Coordinates from another link, it is recommended to disable shared positioning of any links before doing so to avoid pushing changes back to them.

When saving the host file, you are prompted to decide what to do with the link.

Note: You have to be careful with this dialog. There are cases where the location is marked as changed, even though it has not. This tends to happen when moving a link instance to a new positioning in the Choose Site dialog. In that case, pick the option Do not save, close the host file and re-open.
When a link’s Shared Coordinates are changed as a consequence of shifting it, this dialog will warn you of this fact and gives you the option to save changes right away, or offers you other options to do so later.

If you don’t save these changes right away, the read-only checkbox under Positions Not Saved (in the Manage Links dialog) is automatically enabled. You can choose to save these positions from here without saving the host model. Unfortunately if you want to discard changes, you have to be very careful and not save positions as discussed on the previous page. It would be very nice if we could discard changes from here without requiring us to close the host model!

When coordinates have been shared (the "bond" is established), you can move a link instance to a new “Site” or record the current position as a new or existing site. The latter modifies the Shared Coordinates of the link instance and saving the position is required.

This option is very important! Use when you need to re-acquire coordinates from another link or after positioning links in workshared projects, to avoid ownership issues with Project Info.

Beware of this option! It does exactly as it states, but I think it is a bit misleading since it will still write the modified shared coordinate location to the link. If you don’t want that to happen, pick the Do not save option.
4. Linking Scenarios

The first decision to be taken is whether or not to bother with setting up Shared Coordinates between links, or if to simply use Origin to Origin linking. Either way, you need known, predictable origins when lining things up. Without this, proper positioning will turn into a dangerous guessing game. If you fully understand what we have covered so far, you are already in a better position to decide which strategy to adopt.

Regardless, you should always default to Auto – Origin to Origin linking when possible. This was a best practice in the CAD days and in my opinion is still applicable today. Shared Coordinates offer us more flexibility, but they are a little bit difficult for most users to comprehend, especially due to the low frequency of use over the life of a project. You can always implement and tweak Shared Coordinates at any time, but if you start with Origin to Origin linking, you will find that managing Shared Coordinates will be a bit easier since their relative position to the Internal Origin will be consistent across all links. As with all rules of thumb, there are exceptions as you can see in Section 5.

Unfortunately in most cases Shared Coordinates become the solution to correct sloppy start-up processes, where models are linked using the default (and highly random!) Auto – Center to Center. The tell-tale sign that Origin to Origin linking was not used is that Discipline A starts working with no complaints when using Discipline B’s model, but when B tries to link A’s model Origin to Origin, things don’t line up. Short of moving geometry, the (apparent) easiest solution is to use shared positioning. However if it is early in the process, I still recommend making geometry adjustments instead. For more information on how to accomplish this without disturbing existing sheets and viewports, please refer to Sub-Section 6.1.

Let’s take a look at some of the most common linking scenarios and recommended strategies.

4.1. CAD Site Survey in Building model

This is possibly the most common situation of all. It is very common for site survey geometry to be modeled very far from the World Coordinate System (WCS) Origin since all the point data collected is with respect to a known datum. For this reason, linking Origin to Origin might not work as Revit imposes a 10 mile radius boundary around the Internal Origin. Behavior when linking CAD files with large geometry extents or geometry located a large distance from the WCS Origin varies and is documented in depth in Section 5.

In most cases Revit will default to Center to Center linking. Either way, you need to make sure the site geometry is roughly centered on the Internal Origin, so move it accordingly. The geometry is also typically modeled at real elevation values, so you might need to adjust it vertically as well in a section or elevation view, or by orienting a 3D view to a vertical plane (the View Cube comes in handy for these tasks). Note that if you adjust the orientation of True North after linking, you will need to rotate the link by the same amount in the opposite direction. If you acquire coordinates from the link first and then rotate True North, the link will not need to be rotated as it will stay aligned to True North. As you can see in the following image, if you have multiple Sites defined in your host model, all of them will adjust. The Current Site behaves as expected, but the others receive translations that are completely unexpected. Only acquire coordinates if you anticipate the need to report real site coordinates.
Note that if you need to link other models and share coordinates with them, you don’t necessarily need to sync with the CAD survey first by acquiring. You can always use the Specify Coordinates at a Point tool instead, which will only modify the Current Site and avoid the problem described above.

4.2. Multiple Discipline Models in Architectural

Small to medium sized projects tend to be split in multiple models. Most commonly you’ll have an Architectural, Structural and MEP model. As project size increases, you will find that the quantity of models increases, where each discipline will have its own. At times these are further subdivided to control file size and also to deal with manpower issues such as when splitting work between geographically distributed teams or when trying to ensure that no more than 6 to 8 users will need concurrent access to each model (due to performance issues).

Luckily the solution is scalable and can be applied to any number of models. However implementation varies based on whether the models are authored on the same network or shared through file-transfer utilities. When linking other models, you will do yourself and your team a huge favor by using the Auto-Origin to Origin option. If the team fails to do this and moving geometry is out of the question, you can implement Shared Coordinates so any model can be properly positioned in relation to any other, which is the same thing that you can accomplish through Origin to Origin linking.

Models authored on the same network

First you have to decide which model you will be publishing or acquiring from. This can be the main Architectural model or, more commonly, a site model. Once all links have been properly placed in
relation to one another in the host model, you can publish coordinates to all links. It is highly recommended that each model have a unique Site name and that you leave the default site “Internal” as is. You can create new sites within the linked files during the publishing process. Please note that these new positions need to be saved to each link and can cause some Workset issues if saving is interrupted. Once this is accomplished successfully, you can open each link and position any other related link by Shared Coordinates.

**Models shared from external sources**

If you “push” coordinates to all links, your work would need to be repeated since the links will be refreshed on a regular basis through frequent file transfers. Other team members would also not be able to use shared positioning unless everything is set up properly. In this case you need to have each model author acquire coordinates from the host (ex: the site model). This requires manual positioning and is inherently prone to error (I hope you can see why I keep suggesting starting off right by linking Origin to Origin!). The acquiring process is necessary to establish the “bond” between files, but a process to ensure that everything is correctly positioned needs to be followed.

Start by establishing a common work-point, say at the intersection of a set of grids or a prominent corner of the building. This needs to be clearly identified in each model by moving the unclipped Project Base Point to this common location. In the host model, use the Specify Coordinates at Point tool to report the coordinates, elevation and True North orientation. Then simply distribute a screenshot of this information so all model authors can repeat this process and enter this data if it differs in their model. Now when updated files are shared, links will land properly in relation to each other when Shared Positioning is used.

**4.3. Multiple Buildings on a Campus**

With these kinds of projects, you need to ask yourself whether linking together every single model of every building is ever going to be needed. If the answer is yes, then you simply need to follow the same process discussed in 4.2. However the question is more subtle: if you are going to do collision detection between the structural foundation, under-floor plumbing and a site model that contains existing underground utilities, then the answer is a definite yes. This is seldom required though, so you have to be slightly more careful in answering as it can help you avoid a lot of unnecessary coordination between models. If all you need is to link the Architectural models in the Site model and use shared positioning, then you only need to worry about Shared Coordinates between these models only. Origin to Origin linking could be used between Architectural and all other discipline models, which will still enable you to assemble them in applications such as Navisworks. If you're exporting to IFC, you will need to use shared coordinates but at this point, you simply need to ensure that the Shared Coordinate Origin is in the same position in all links (ex: aligned to the Internal Origin, such as in the default Site “Internal”).

**5. Issues with Large Coordinates in Links**

When linking files that contain geometry and an origin that do not fit within a 10 mile radius imaginary boundary, or files that change in subsequent updates to this state, unexpected link movement and possible display issues may occur. Following is documentation of known CAD link behaviors (unexpected results marked with a red “?“), followed by a recommended workaround utilizing container files.
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Auto - Origin to Origin
1. CAD Link’s Center of Geometry is positioned on the Revit file’s Internal Origin; typically no warning is issued but sometimes this is incorrectly displayed.
2. CAD Link changes to B & is reloaded: Link shifts so its Origin is positioned on the Link’s Center of Geometry as it existed before the reload (no warning). A warning about geometry extents being larger than 20 miles is issued.
3. CAD Link changes to C & is reloaded: Link updates, no shifting, no warnings.
4. CAD Link changes to D & is reloaded: Link updates, no shifting. A warning about geometry extents being larger than 20 miles is issued.

Auto - Center to Center
1. CAD Link’s Center of Geometry is positioned on the Revit file’s Center of Geometry.
2. CAD Link changes to B & is reloaded: Link shifts so its Origin is positioned on the Link’s Center of Geometry as it existed before the reload (no warning). A warning about geometry extents being larger than 20 miles is issued.
3. CAD Link changes to C & is reloaded: Link shifts so its Origin is positioned on the Link’s Center of Geometry as it existed before the reload (no warning).
4. CAD Link changes to D & is reloaded: Link shifts so its Origin is positioned on the Link’s Center of Geometry as it existed before the reload (no warning).

Manual options
1. When using Manual - Origin or Manual - Base point, the following dialog is displayed (cursor will not be at origin of link). This is not displayed when using Manual - Center, which is as expected.
2. Once placed, if CAD Link changes to B & is reloaded: Link updates, no shifting. A warning about geometry extents being larger than 20 miles is issued. If CAD Link changes again back to A and is reloaded: Link shifts so its Center of Geometry is positioned on the Link’s Origin as it existed before the reload (no warning).
3. Once placed, if CAD Link changes to C & is reloaded: Link updates, no shifting. If CAD Link changes again back to A and is reloaded: Link shifts so its Center of Geometry is positioned on the Link’s Origin as it existed before the reload (no warning).
4. Once placed, if CAD Link changes to D & is reloaded: Link updates, no shifting. A warning about geometry extents being larger than 20 miles is issued. If CAD Link changes again back to A and is reloaded: Link shifts so its Center of Geometry is positioned on the Link’s Origin as it existed before the reload (no warning).

Manual options
1. When using Manual - Origin or Manual - Base point, the following dialog is displayed (cursor will not be at origin of link). This is not displayed when using Manual - Center, which is as expected. A warning about geometry extents being larger than 20 miles is issued.
2. Once placed, if CAD Link changes to A & is reloaded: Link shifts so its Center of Geometry is positioned on the Link’s Origin as it existed before the reload (no warning).
3. Once placed, if CAD Link changes to C & is reloaded: Link updates, no shifting, no warnings. If CAD Link changes again back to B and is reloaded: Link updates, no shifting. A warning about geometry extents being larger than 20 miles is issued.
4. Once placed, if CAD Link changes to D & is reloaded: Link updates, no shifting. A warning about geometry extents being larger than 20 miles is issued.
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Auto - Origin to Origin
1. CAD link's Origin is positioned on the Revit file's Internal Origin; typically no warning is issued but sometimes this is incorrectly displayed.
2. CAD link changes to A & is reloaded: Link shifts so its Center of Geometry is positioned on the Link's Origin as it existed before the reload (no warning).
3. CAD link changes to B & is reloaded: Link updates, no shifting. A warning about geometry extents being larger than 20 miles is issued.
4. CAD link changes to D & is reloaded: Link updates, no shifting. A warning about geometry extents being larger than 20 miles is issued.

Auto - Center to Center
1. CAD link's Center of Geometry is positioned on the Revit file's Center of Geometry.
2. CAD link changes to A & is reloaded: Link shifts so its Center of Geometry is positioned on the Link's Origin as it existed before the reload (no warning).
3. CAD link changes to B & is reloaded: Link updates, no shifting. A warning about geometry extents being larger than 20 miles is issued.
4. CAD link changes to D & is reloaded: Link updates, no shifting. A warning about geometry extents being larger than 20 miles is issued.

Manual options
1. When using Manual - Origin, Manual - Base point, or Manual - Center, each option works as expected, no dialog is displayed.
2. Once placed, if CAD link changes to A & is reloaded: Link shifts so its Center of Geometry is positioned on the Link's Origin as it existed before the reload (no warning).
3. Once placed, if CAD link changes to B & is reloaded: Link updates, no shifting. A warning about geometry extents being larger than 20 miles is issued.
4. Once placed, if CAD link changes to D & is reloaded: Link updates, no shifting. A warning about geometry extents being larger than 20 miles is issued.

NOTE: Manual placement options don't offer snapping capabilities. Even though these do give the illusion of snapping to an edge, the process is akin to "eyeballing". You need to adjust the location of the CAD link after placement, which is unfortunate.
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RECOMMENDED WORKAROUND
Start a new CAD file (host) and Xref the CAD background into it so the geometry is roughly centered around the host's Origin. The host file is what you will link into Revit. If the CAD background changes, open the host file, reload the Xref & re-save, then reload the CAD link in Revit.

Auto - Origin to Origin
1. CAD link's Origin is positioned on the Revit file's Internal Origin; typically no warning is issued but sometimes this is incorrectly displayed.
2. CAD link changes to B & is reloaded: Link updates, no shifting, no warnings.
3. CAD link changes to C & is reloaded: Link updates, no shifting, no warnings.
4. CAD link changes to D & is reloaded: Link updates, no shifting, no warnings.

Auto - Center to Center
1. CAD link's Center of Geometry is positioned on the Revit file's Center of Geometry.
2. CAD link changes to B & is reloaded: Link updates, no shifting, no warnings.
3. CAD link changes to C & is reloaded: Link updates, no shifting, no warnings.
4. CAD link changes to D & is reloaded: Link updates, no shifting, no warnings.

Manual options
1. When using Manual - Origin, Manual - Base point, or Manual - Center, each option works as expected, no dialog is displayed.
2. Once placed, if CAD link changes to B & is reloaded: Link updates, no shifting, no warnings.
3. CAD link changes to C & is reloaded: Link updates, no shifting, no warnings.
4. CAD link changes to D & is reloaded: Link updates, no shifting, no warnings.

NOTE: Manual placement options don't offer snapping capabilities. Even though these do give the illusion of snapping to an edge, the process is akin to “eyeballing.” You need to adjust the location of the CAD link after placement, which is unfortunate.
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**Auto - Origin to Origin**
1. CAD link's Origin is positioned on the Revit file’s Internal Origin and the following incorrect warning is displayed (Center to Center is not used).
2. CAD link changes to A & is reloaded: Link updates, no shifting, no warnings.
3. CAD link changes to B & is reloaded: Link updates, no shifting, no warnings.
4. CAD link changes to D & is reloaded: Link updates, no shifting, no warnings.

**Auto - Center to Center**
1. CAD link's Center of Geometry is positioned on the Revit file’s Center of Geometry.
2. CAD link changes to A & is reloaded: Link updates, no shifting, no warnings.
3. CAD link changes to B & is reloaded: Link updates, no shifting, no warnings.
4. CAD link changes to D & is reloaded: Link updates, no shifting, no warnings.

**Recommended Workaround**
Start a new CAD file (host) and Xref the CAD background into it so the geometry is roughly centered around the host's Origin. The host file is what you will link into Revit. If the CAD background changes, open the host file, reload the Xref & re-save, then reload the CAD link in Revit.

**Auto - Origin to Origin**
1. CAD link's Origin is positioned on the Revit file’s Internal Origin; typically no warning is issued but sometimes this is incorrectly displayed.
2. CAD link changes to A & is reloaded: Link updates, no shifting, no warnings.
3. CAD link changes to B & is reloaded: Link updates, no shifting, no warnings.
4. CAD link changes to C & is reloaded: Link updates, no shifting, no warnings.

**Auto - Center to Center**
1. CAD link's Center of Geometry is positioned on the Revit file’s Center of Geometry.
2. CAD link changes to A & is reloaded: Link updates, no shifting, no warnings.
3. CAD link changes to B & is reloaded: Link updates, no shifting, no warnings.
4. CAD link changes to C & is reloaded: Link updates, no shifting, no warnings.

**Manual options**
1. When using Manual - Origin, Manual - Base point, or Manual - Center, each option works as expected, no dialog is displayed.
2. Once placed, if CAD link changes to A & is reloaded: Link updates, no shifting, no warnings.
3. CAD link changes to B & is reloaded: Link updates, no shifting, no warnings.
4. CAD link changes to D & is reloaded: Link updates, no shifting, no warnings.

**Manual options**
1. When using Manual - Origin, Manual - Base point, or Manual - Center, each option works as expected, no dialog is displayed.
2. Once placed, if CAD link changes to A & is reloaded: Link updates, no shifting, no warnings.
3. CAD link changes to B & is reloaded: Link updates, no shifting, no warnings.
4. CAD link changes to C & is reloaded: Link updates, no shifting, no warnings.

**NOTE:** Manual placement options don't offer snapping capabilities. Even though these do give the illusion of snapping to an edge, the process is akin to "eyeballing"! You need to adjust the location of the CAD link after placement, which is unfortunate.
6. Advanced Topics and Troubleshooting

The following sub-sections outline various techniques to troubleshoot and resolve common problems.

6.1. Moving Geometry without Disturbing Viewports on Sheets

If you already have sheets set up, you can still move geometry and avoid having to adjust your viewports and sheet layouts. As long as you pick the views’ crop regions and move them using the move tool, viewports on sheets will maintain their position. This operation will behave as if panning the view, leaving sheet layouts intact. Please note that dragging or moving scope boxes that are assigned to views will not have the same desired outcome.

If you have multiple views already placed on several sheets, make sure to draw a detail line in one of the plan views that represents the start and end point of the move. This will allow you to repeat the exact same move with multiple crop regions as many times as you need. Simply pick the crop regions, switch to the view containing the detail line, then move by picking one end of the line as the start point and the other as the end point. Make sure to move other annotation as well and not just geometry, such as callouts, sections and elevation tags. This will also preserve the position of these viewports on sheets. Most users avoid moving geometry as they think this will result in lots of lost work hours re-setting sheets, but as you can see the work is minimal and the benefits are well worth it. It goes without saying that nothing beats doing it right the first time!

6.2. Resetting the Shared Coordinate System

Once coordinates are acquired from a link, you cannot re-acquire from that same link. Revit will not see the point in re-acquiring once the “bond” between files is established, even though you might have a legitimate reason for doing so, such as when the position of the shared coordinate system has changed in the link. The rule is simple: You cannot re-acquire from the link that has been acquired from last. So the solution is to acquire from another link, and then re-acquire from the desired one.

When following this procedure, it is very important that you disable shared positioning of any other link first. If you omit this step, there is a big chance that the shared coordinate system you acquire from the desired link will be pushed to others. If this happens, you will then be unable to acquire from those independent links since Revit will see them as one and the same (the “bond” will be the same for all of them). You can also reset Shared Coordinates in those links by following the process outlined below.

It is always best to be very systematic in your approach to this:

a) Start a new project from no template and place some simple geometry so you can see it when you link this file. You can use a reference plane, model line or a wall for example;
b) Save this temporary file and close out of it;
c) Open the model whose Shared Coordinates you want to re-set;
d) Disable shared positioning of all links (click here for more info.);
e) Link the temporary file and use Auto – Origin to Origin;
f) Acquire coordinates from this temporary link and pick the corresponding site in the host model, assuming you have more than one (it is best practice to leave the default “Internal” untouched and not set as the current site);
g) Remove the temporary link and delete the file;
h) Save your host file. Now you can acquire coordinates from any link.
i) Step g) is very important! You do not want to re-use this temporary file to re-set Shared Coordinates. Revit is probably generating some sort of unique “handshake code” when a new file is started, and then uses it to establish a bond between links. Re-setting Shared Coordinates in multiple hosts by acquiring from the same file will result in the undesirable consequence of establishing the same “bond” between them all!

6.3. Property Lines

The behavior of property lines with respect to rotating True North differs based on how these were created. This issue has been logged with Autodesk for future resolution. In the meantime, it is important to understand the two distinct behaviors so you are not unpleasantly surprised by their modified position following an adjustment to True North!
6.4. Rotating Project North

If you model a project using a certain orientation and later decide that aligning Revit’s Project North to another side of the building is more convenient for sheet layout, we can use a dedicated tool to achieve this goal.

If you do this in a workshared project, make sure no one is working in a local file. View-specific elements will also be rotated, however some cleanup time is to be expected and accounted for.

You can pick from one of the pre-defined options or pick an edge whose orientation you would like to match. **Rotation will occur around the Project base Point.** Note that the direction of True North in relation to the building will not change. As a result, the Shared Coordinate Origin will also rotate around Project North with the building geometry, which means that Spot Coordinates reporting by Shared Coordinates will stay constant, but those reporting by Project Base Point will adjust accordingly.
6.5. Finding a Link’s World/Internal Coordinate System Origin from the Host

Revit does not expose the Internal Coordinates for reporting purposes, however we can still achieve this goal indirectly if needed. All we need to do is align the Shared Coordinate System with the Internal Origin. This is easily achieved by making sure the Survey Point is reading all zero distances (unclip and zero out all distances), and then move it in a clipped state to the Startup Location (refer to Sub-Section 1.2 for more about the Startup Location). Alternatively if you have not modified the default Site “Internal”, you can set this as the current site, which will achieve the same goal. Any Levels, Spot Coordinates or Spot Elevations set to read by Survey Point will now effectively report relative to the Internal Coordinates.

If you have links that use shared positioning and you want to find their Internal Origin without opening them, you can move these linked instances to Site “Internal”. The Survey Point in the host model will then mark the Internal Origin of the links. Since you cannot have 100% certainty that the sites “Internal” have not been altered, it is recommended you open the linked models to verify and/or drop some type of marker at the Startup Location, which can then be seen in the host model.

6.6. The Origin in Families

Families have Origins as well, which is required for proper insertion in the project environment. This is defined through the intersection of two orthogonal planes by checking the Defines Origin parameter.

There are rare instances where this setting is not respected and the actual Origin is used instead. These are typically bugs in the family templates, something that has been around for as long as I remember. Keep in mind that you can always temporarily insert a CAD file in the family with some linework at the World Coordinate Origin using the Auto – Origin to Origin option to mark the Origin location.
7. Conclusion

We have made it safely to the harbor! This topic is not very complex in and of itself, but it is very difficult to comprehend and apply. Some of the operations seem abstract and things move contrary to our perception. I hope that this class and handout will help you in thoroughly understanding Coordinate Systems in Revit and may you experience success in all your linking adventures.

References and Resources:

http://revitoped.blogspot.com/2012/05/shared-coordinate-post-summary.html


Autodesk Skill Builder: Transferring Site Data Between Revit Architecture and AutoCAD Civil 3D

http://do-u-revit.blogspot.com/search/label/Shared%20Coordinates