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Navisworks: It's Not Just for Contractors

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Learning Objectives

- Understand the use cases and benefits of working in Navisworks during the design phases of projects.
- Understand the distinction between design coordination and construction coordination.
- Understand how to configure a Navisworks model for design coordination.
- Understand how to implement Navisworks standards and a standardized workflow for design coordination.

Description

Your teams are experienced with Revit and BIM. You have a BIM Deployment plan, exchange models with the team regularly, and have coordination meetings to review model progress. You share your coordinated, 'clash-free' models during construction only to be shocked at the first construction coordination meeting when the design models contain 53,724 clashes.

Every BIM Manager has nightmares about this scenario. Implementing Navisworks during the design phases of a project will allow the team to coordinate more efficiently and eliminate issues that typically may not be discovered until later in the project. Navisworks provides powerful tools that can be utilized during design to streamline workflows and add value to your BIM process.

Specific use cases for implementation during design will be presented and provide understanding of how to implement a refined coordination process. Strategies for establishing efficient standardized workflows for implementation will be presented.

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Speakers

Thomas J. Kemp

A Registered Architect and BIM Specialist, Tom pushes the practical boundaries of BIM technology in RATIO's architectural practice.

He is responsible for driving value through the application of technology by identifying project and client needs, specifying solutions, and establishing the business value of solutions. Focusing on Revit and Building Information Modeling since the beginning 2004, Tom has been involved with implementing and managing design technology at a number of firms.

RATIO's team of BIM Specialists are responsible for the adoption of BIM technology throughout the firm, defining and maintaining standards, seeking out innovative and efficient best practices, and training users. With more than 20 years of experience in architecture, Tom has spoken across the country at Autodesk University, BILT NA, and various Association of General Contractor events on issues related to BIM, innovation, and technological change in the AEC industry.

Sarah Causey

As a BIM Specialist with a passion for technology and its evolving impact on design, Sarah trains and supports RATIO professionals in the use of BIM software, while supporting project managers in the awareness and resolution of coordination issues throughout the construction documentation and construction administration phases.

Sarah leverages a unique, multi-disciplinary background in her work at RATIO, giving her a broad perspective on the construction industry. She earned a Bachelor of Arts, Interior Design and Master of Science, Building Construction Management from Purdue University, and a Master of Science, Sustainability, Technology, and Innovation from the Dublin Institute of Technology. Before her time at RATIO, Sarah was a BIM consultant with firms including Kohn Pedersen Fox and Robert A.M. Stern. She worked on large, complex projects such as the Hudson Yards development in Manhattan, the largest private real estate development in United States history.

The common thread throughout her experiences has been technology. Through transdisciplinary approaches, she seeks to interface design and technology to push the envelope for what we can accomplish in the future.

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Navisworks Overview

"Navisworks project review software lets architecture, engineering, and construction professionals holistically review integrated models and data with stakeholders to better control project outcomes"

https://www.autodesk.com/products/navisworks/overview

Navisworks includes tools and functionality for:

- Coordination
- Clash Detection
- Clash and Interference Management
- Model Review
- Data Aggregation
- 5D Project Scheduling
- Photorealistic Model Rendering
- Object Animation and Model Simulation
- Quantification
- Integrated 2D Quantification
- 3D Model Quantification

Our implementation at RATIO is focused on utilizing the Clash Detection functionality within Navisworks to implement a Clash Prevention process for design coordination.

Navisworks is available in three different versions:

Navisworks Freedom is a free viewer for native NWD files. Freedom provides functionality to view models, but does not provide any editing or mark-up capabilities. Consultants and team members that do not have access to Navisworks Manage can utilize Navisworks Simulate or Freedom to review models generated by the team.

Navisworks Simulate adds editing and mark-up functionality to the features available in Freedom.

Navisworks Manage includes these features and adds Clash Detection and Management functionality. These functions are essential to the Clash Prevention process and are only included with Navisworks Manage.

https://www.autodesk.com/products/navisworks/compare/compare-products

Native File Types

"Autodesk Navisworks has three native file formats: NWD, NWF, and NWC.

NWD File Format
An NWD file contains all model geometry together with Autodesk Navisworks-specific data, such as review markups. You can think of an NWD file as a snapshot of the current state of the model.

NWD files are very small, as they compress the CAD data by up to 80% of the original size.

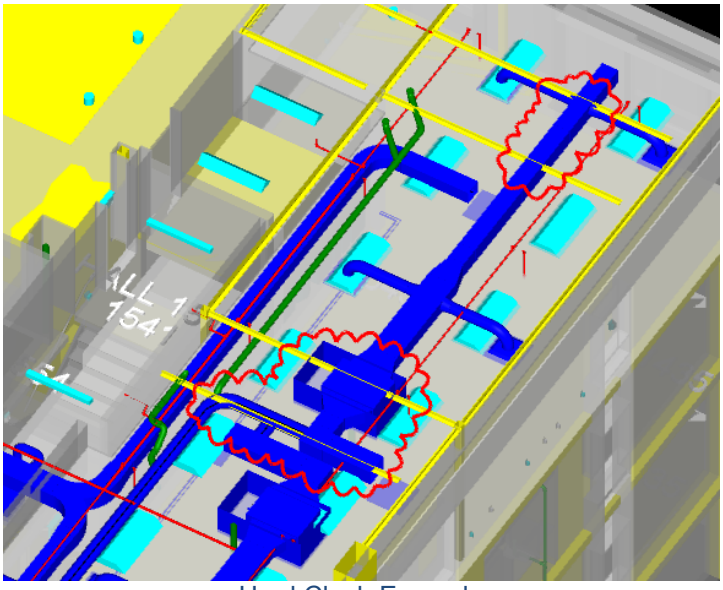
NWF File Format
An NWF file contains links to the original native files (as listed on the Selection Tree) together with Autodesk Navisworks-specific data, such as review markups. No model geometry is saved with this file format; this makes an NWF considerably smaller in size than an NWD.

NWC File Format (Cache Files)
By default, when you open or append any native CAD or laser scan files in Autodesk Navisworks, a cache file is created in the same directory and with the same name as the original file, but with an NWC file extension.

NWC files are smaller than the original files, and speed up your access to commonly used files. When you next open file or append file in Autodesk Navisworks, the data is read from the corresponding cache file if it is newer than the original file. If the cache file is older, which means the original file has changed, Autodesk Navisworks converts the updated file, and creates a new cache file for it."[1]

Types of clashes

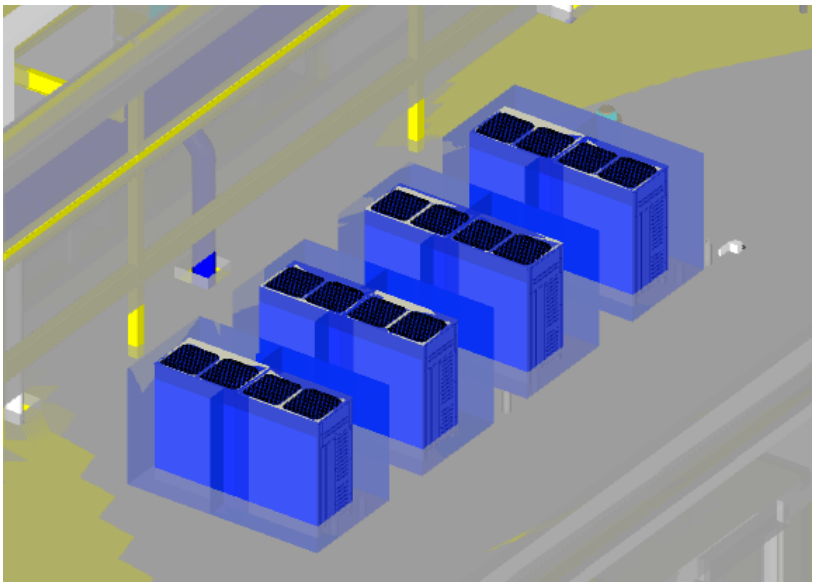
A **Hard Clash** is an instance where two components occupy the same physical space (for example, a section of duct or pipe that passes through a structural beam). If these types of clashes are first identified on the construction site, they can be costly and time consuming to resolve.



Hard Clash Example

[1] http://help.autodesk.com/view/NAV/2016/ENU/?guid=GUID-C6936A0B-1597-4880-83F9-7041894A4204

A **Soft Clash** is when an element does not have the geometric clearance required for installation, replacement, or maintenance. For example, minimum clearances must be provided to access and maintain a piece of mechanical equipment. Specific tolerances or modeled clearance elements can be used to automate soft clash detection.



Soft Clash Example – Mechanical Equipment with Clearances

A **Workflow** or **4D Clash** involves the sequence of delivery and installation of elements and components. These relate to the overall scheduling of contractors and management of the general project timeline and require the input and expertise of the construction team to identify and resolve.

Implementation Objectives

As a design firm, our implementation of a Navisworks Clash Prevention process during the design phase of a project is focused on two objectives:

1. Improving coordination between disciplines at the conclusion of the Construction Document Phase.
2. Improving the efficiency of the coordination process for the design team.

In addition, we are always conscious of our software budget and desire to utilize applications and tools that are part of our Autodesk subscription. We recognize that there may be additional third-party tools that could be used in addition to Navisworks for clash prevention.

Design Coordination and Construction Coordination

Architects, engineers, and designers did not start coordinating and collaborating on building designs with the advent of BIM technology. Those efforts are at the core of the modern profession. However, Revit and BIM technologies opened the potential for coordinating and collaborating more closely between firms and disciplines in all phases of a project in a virtual environment.

The first questions from most seasoned professionals when initially introduced to Revit are centered around coordination and collaboration. How can we work more closely with consulting engineers? Can our design partners access and work in the same model as our internal team? Designing and accurately modeling in a 3D environment with Revit allow for this type of coordination and collaboration to happen on even the smallest projects.

Clashes or conflicts are a natural part of the design process, even when teams are using the most up-to-date design tools. During the Design Phases of a project, this is standard collaboration/design process, and design differences can be reviewed for efficiency and resolved. But once a project moves into the Construction Administration phase, conflicts between disciplines are seen as errors in the design, often resulting in rework and additional cost or time.

Design Coordination – CAD and Revit

Typical Design Phase coordination utilizing CAD or Revit tools mirrors the process that Architects, engineers, and designers have been utilizing long before digital design tools existed. Drawings or models from each discipline are overlaid and reviewed by the project team for conflicts. These reviews are typically focused on hard clashes, although more experienced project teams may review soft clashes for some conditions. Ideally, this is a collaborative environment where each discipline provides input to potential solutions and the direction is guided by experienced judgement and a general opinion of the scale of the costs associated with design changes. Most of this effort is executed on paper (or PDF) and using the same tools used in the design process (Revit).

Clash Detection and Prevention as BIM Uses

Clash Detection and Clash Prevention are defined as discrete BIM Uses with specific BIM-enabled processes that utilize the project model data to meet design and performance objectives throughout the project lifecycle. Clash Detection and Clash Prevention are defined by documents widely accepted in the industry as 'standards' as follows:

Clash Detection

"During the design assist and/or construct phase, construct team members shall be expected to coordinate the building components, assemblies, and systems to properly fit in their to-be-installed condition without interferences or encroachment with any other building assemblies. This Clash Detection process will be based upon the Trade Coordination BIM components which have progressed to an LOD 350 (and potentially LOD 400) representing the final/actual fabricated geometry and unencumbered routing.

. . . Clash Detection should not be confused with . . . Clash Prevention BIM Use Case that is led by the Design Team during the design phase."[2]

Some BIM Deployment Plans and Standards will refer to this process as '3D Coordination'. Clash Detection is a BIM Use utilized during the construction phase of a project with the goal of eliminating conflicts between elements and systems prior to installation.

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[2] *Ohio-state_bim_pds* [PDF]. https://fod.osu.edu/sites/default/files/ohio-state_bim_pds.pdf, (2017, January 20). Columbus, Ohio: The Ohio State University.

Clash Prevention

"During the design phase, the Design Model Manager and discipline-specific Model Managers are required to coordinate their LOD 300 building components, assemblies, and systems. . . . They shall design to provide assurance that the occupiable space needed by these building systems is adequate and that the systems can be integrated without interfering with one another while maintaining accessibility and serviceability.

The Clash Prevention BIM Use Case should not be confused with . . . Clash Detection BIM Use Case that would be led by the construction team. The Clash Prevention process allows for the overall coordination of the spatial relationships of the model's components, assemblies and systems and their final progression . . ."[3]

BIM Deployment Plans and Standards may consider Clash Prevention (or Clash Avoidance) as part of a 'Design Review' BIM Use that is also used to evaluate other criteria in a virtual environment such as spatial aesthetics, sightlines, lighting, and security. Clash Prevention by definition is a BIM Use utilized by the design team during the design and construction document phases of a project. This Use is intended to coordinate the spatial and geometric requirements to install and service building elements and systems. It is not intended to isolate specific conflicts or dictate construction sequence, means, or methods.

Clash Prevention	Clash Detection
Design Phase BIM Use	Construction Phase BIM Use
Implemented by the Design Team	Implemented by the Construction Team
Design Intent (LOD 300) Models	Construction (LOD 350-400) Models
Design Geometric Requirements	Actual Fabricated Geometry
Design Intent	Installation Means and Methods
Increase Communication & Coordination	Avoid Conflicts
Effectiveness of Design	Schedule and Budget

Use Cases for Design Teams

Implementing a Navisworks clash prevention process during the design phases of a project can be beneficial to all projects and delivery methods. The clash prevention process can be adjusted based on the project delivery and the Design Team.

[3] *Ohio-state_bim_pds* [PDF]. https://fod.osu.edu/sites/default/files/ohio-state_bim_pds.pdf, (2017, January 20). Columbus, Ohio: The Ohio State University.

Delivery	Model Authors	Clash Prevention Lead (Participants)	Notes
Design-Bid-Build	Architect, Consulting Engineers (Structural, MEP, Other)	Architect of Record (Consulting Engineers)	
Design Assist	Architect, Consulting Engineers (Structural, MEP, Other), Select Sub-Contractors or Suppliers	Architect of Record (Construction Manager, Consulting Engineers, Select Sub-Contractors or Suppliers)	Clash Prevention Models may be handed off to the Construction Manager for Clash Detection during Construction.
Design Build	Architect, Consulting Engineers or Sub-Contractors	Architect of Record (Construction Manager/General Contractor, Consulting Engineers, Sub-Contractors)	Clash Prevention process may transition to Clash Detection

The benefits of implementing a Clash Prevention process include:

- More efficient coordination between disciplines.
- Improved coordination between disciplines leads to fewer substitutions and RFI's during the Construction phase.
- Improved constructability of final design intent documents and models.
- More accurate models that can be used for pre-fabrication.
- More accurate models that provide a basis for record documentation.

Clash Prevention Coordination Meeting

Project requirements and systems are becoming increasingly complex for every project. In addition, project timelines are continually compressed. As a result, the time allotted for coordination between disciplines is greatly reduced. Design teams often struggle to identify and resolve all areas of a project where the design of systems and elements interfere with one another and create construction conflicts. Too often, the result is a Construction Phase change to the design that has a negative impact on the aesthetics and effectiveness of the project. The intent of implementing a Navisworks Clash Prevention process is to improve the efficiency and effectiveness of coordination between Design Team disciplines.

Clash Prevention processes are integrated with standard coordination between disciplines during the Design Development and Construction Document phases of projects. These meetings are very similar to traditional coordination meetings, enhanced with some BIM. Many projects and teams may already be having similar types of meetings utilizing Revit during a coordination meeting to review conditions. Clash Prevention is an ongoing activity that should occur with every project coordination meeting. Clash Prevention utilizing Navisworks is not a substitute or replacement for traditional design coordination. While the technology will expedite locating and identifying issues, the critical eye and experience of the architect, engineer, and designer are required to evaluate design solutions.

It is important to understand that this is an ongoing process that involves the entire Design Team and aligns with traditional coordination efforts. We don't just 'do Navis' once on a project. We create the Navisworks model and update it with every coordination meeting, continually reducing tolerances, until all design intent issues have been identified and addressed. The repetition and refinement are the key to realizing the full ROI in the clash prevention process.

Integration with Clash Detection

Construction Managers or other construction professionals providing design assist or pre-construction services should always be included in Clash Prevention coordination meetings. A construction perspective on the Clash Prevention process can inform the Design Team on construction sequence, means, and methods issues that may not otherwise be considered. The knowledge gained by the Construction Team through this process feeds directly into the Construction Phase Clash Detection process and ensures that the design intent for the project is honored through fabrication and installation. All Navisworks models generated through the Clash Prevention process are provided to the Construction Team for use in transitioning to a Clash Detection BIM Use.

Clash Prevention Meeting Tools

Navisworks Manage
This is the primary tool used for model review during the Clash Prevention Meeting. Specific views aligning with the meeting agenda for the areas and issues to be reviewed should be created prior to the meeting.

Revit
Supplemental model review tool used to review detailed model conditions and to check dimensions during the Clash Prevention Meeting.

Bluebeam
Used to review and reference the most recently issued documents for the project.

Excel
Used to review the Action Tracker document to guide the meeting and document decisions and action items.

Clash Prevention Process

- As the Design Team lead, the Architect-of-Record (AOR) for the project leads the Clash Prevention process and is responsible for compiling Navisworks models.
- All consulting engineers and trades provide Navisworks NWC models generated from their current Revit design model a minimum of two business days prior to the coordination meeting. Each discipline is responsible for authoring an accurate design model per the Project BIM Deployment Plan and is also responsible for creating the model used for coordination. Navisworks Freedom can be used by firms to view models exported from Revit.
- The (AOR)'s Model Manager or BIM Specialist will also export a NWC file from the current architectural Revit model as well as updated collateral models.

- (AOR) compiles or updates a federated Navisworks NWF model from the individual NWC files provided by consultants.
- The Project Director and the Model Manager/BIM Specialist will review standard clash tests and identify the tests and conditions to be used for the project. Initially these will focus on larger systems and components with a higher tolerance. As the project progresses the tolerances may become higher as the focus looks at smaller, specific elements.
- Model Manager/BIM Specialist generates and updates the Excel Action Tracker spreadsheet. Issues are recorded in the Action Tracker and prioritized by the Project Manager for the coordination meeting agenda. Issues that had been identified previously will be reviewed and updated in the Action Tracker. If they have not been resolved they are included in the meeting agenda.
- Model Manager/BIM Specialist will publish a Navisworks NWD file and distribute it with the Action Tracker to the Design Team one day prior to the Coordination Meeting. Consultants can use Navisworks Freedom to review the NWD file.
- The Model Manager/BIM Specialist attends the Coordination Meeting with the Design Team and 'drives' the Navisworks model.
- The Action Tracker guides the review of Navisworks views during the Coordination meeting. It is often helpful to have the current Revit model and the most recently issued PDF documents available during the Coordination meeting.
- Any next steps or action items identified by the Design Team during the coordination meeting are recorded in the Action Tracker and distributed to the team post-meeting.
- Rinse and repeat!

Clash Prevention Workflow

The Clash Prevention process can be broken down into (4) discrete steps:

1. Revit Model Setup
2. Navisworks Model Setup
3. Clash Prevention
4. Coordination Meeting

This is a process that is typically started when a project moves into the Construction Document phase. Some projects will even begin clash prevention late in the Design Development phase.

1. Revit Model Setup

On projects where clash prevention is utilized, each consultant and member of the Design Team is held accountable for creating and transferring their Navisworks files to the Architect. We build on the regular routine of Revit model transfers, by adding the extra step of transmitting an NWC file. We believe that each NWC file should be created by the model author. This removes any liability issues caused by worksets or elements being turned on/off unintentionally. By placing this responsibility on each consultant, they can control what will be included in the coordination and clash prevention processes.

Setting Up Export View

Step one in exporting a NWC file from Revit is creating a customized 3D view. In your Revit file create a 3D view with the following settings:

TIP: Implementing a standard name for the Navisworks Export view makes it easy to search the project browser and locate the view when it is time to export an update.

View Name:	NAVISWORKS_EXPORT
View Settings:	
Detail Level:	Fine
Visual Style:	Shaded
Visibility/Graphics:	
Model Categories	
Areas	OFF
Lines	OFF
Mass	OFF
Parts	OFF
Raster Images	OFF
Annotation Categories	OFF
Analytical Model Categories	OFF
Imported Categories	OFF
Revit Links	OFF

Phase and Phase Filter

Phases vary per project, so ensure that the phase filter is set appropriately in this view. The entire design team should discuss this during the CD phase kickoff meeting, prior to the first NWC transmittal

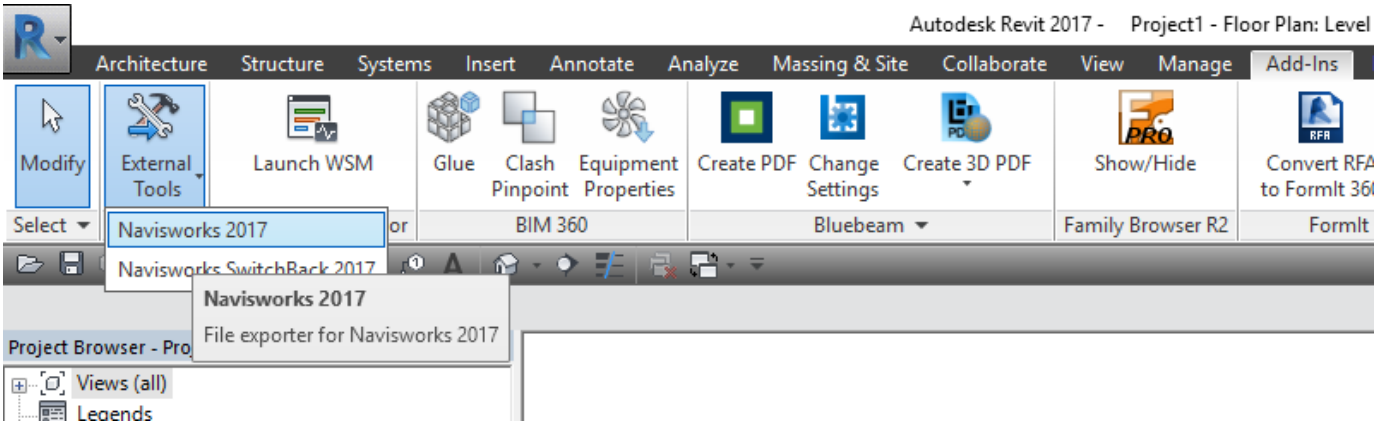
This export view should be maintained in each Revit model for the project and reviewed and updated prior to exporting an updated NWC file. The intent is to isolate the model components for each discipline in Revit and create a corresponding NWC file. Some consultants may find it preferable to create multiple export views within Revit and multiple NWC files. For example, an MEP Engineer may want to create individual NWC models for mechanical, electrical and plumbing.

Navisworks NWC Export - Revit

Download the Navisworks Export Utility: The most efficient way to quickly export Navisworks cache files from Revit is through the Navisworks NWC export utility. Depending on the version of Revit you are using, you will first need to download the appropriate add-in using the link below:
http://www.autodesk.com/products/navisworks/autodesk-navisworks-nwc-export-utility

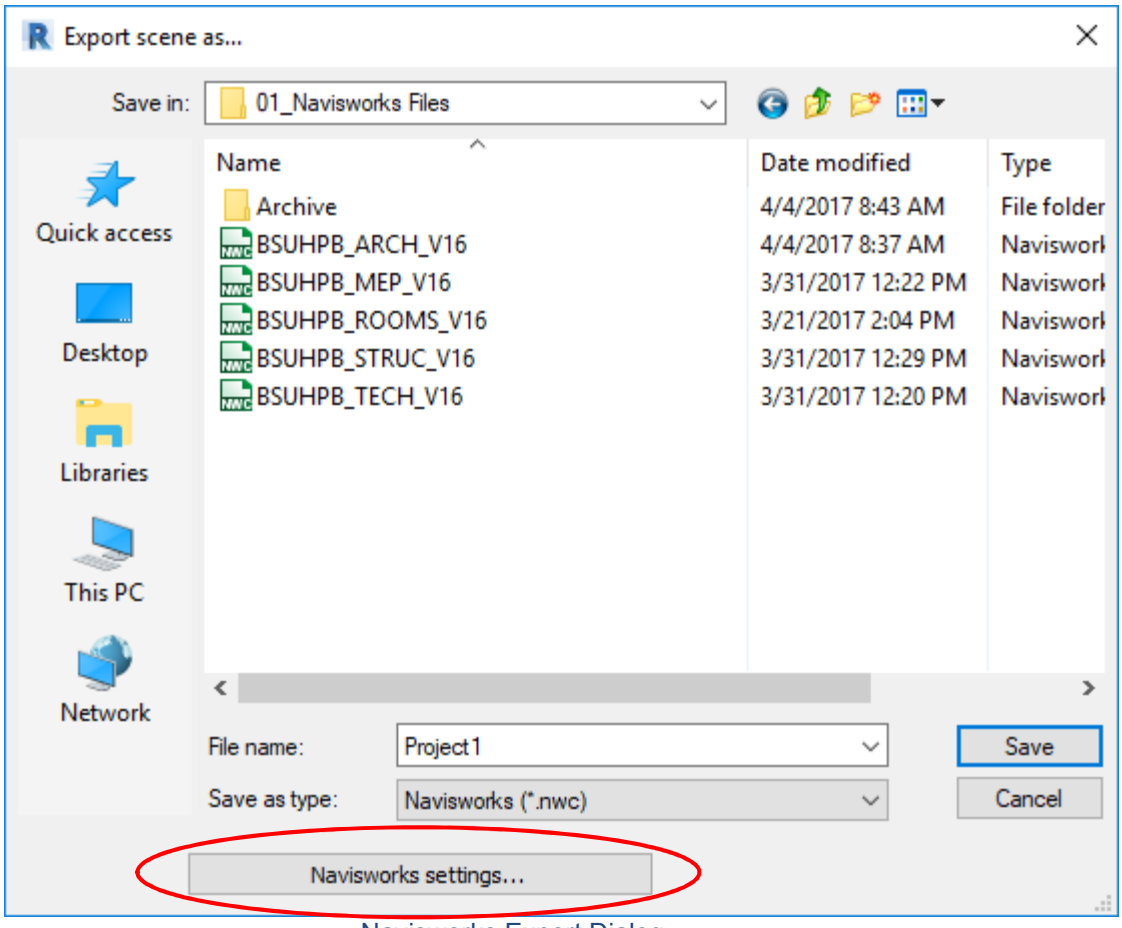
Revit Navisworks Export

With the export 3D view opened, select the Revit Navisworks exporter add-in. In Revit you will find the add-in located here:



Navisworks NWC Export Utility in Revit

When the window appears, browse for the location in which you wish to place the NWC, then select “Navisworks settings…”



Navisworks Export Dialog

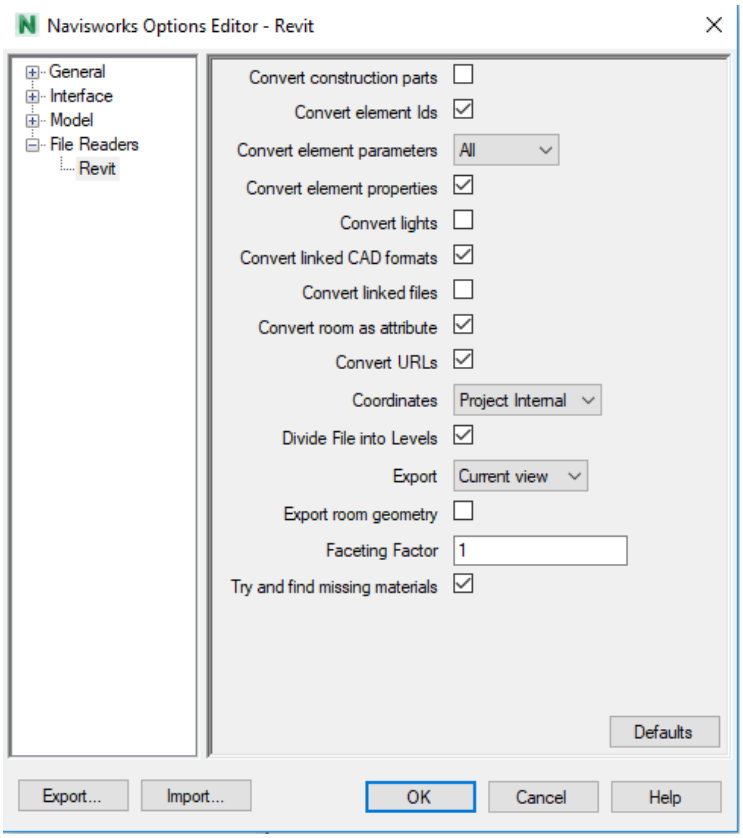
Navisworks Settings

Turn OFF:

- Convert element IDs
- Convert Linked Files
- Export Room Geometry

Turn ON:

- Convert element properties
- Coordinates: Project Internal
- Export: Current View



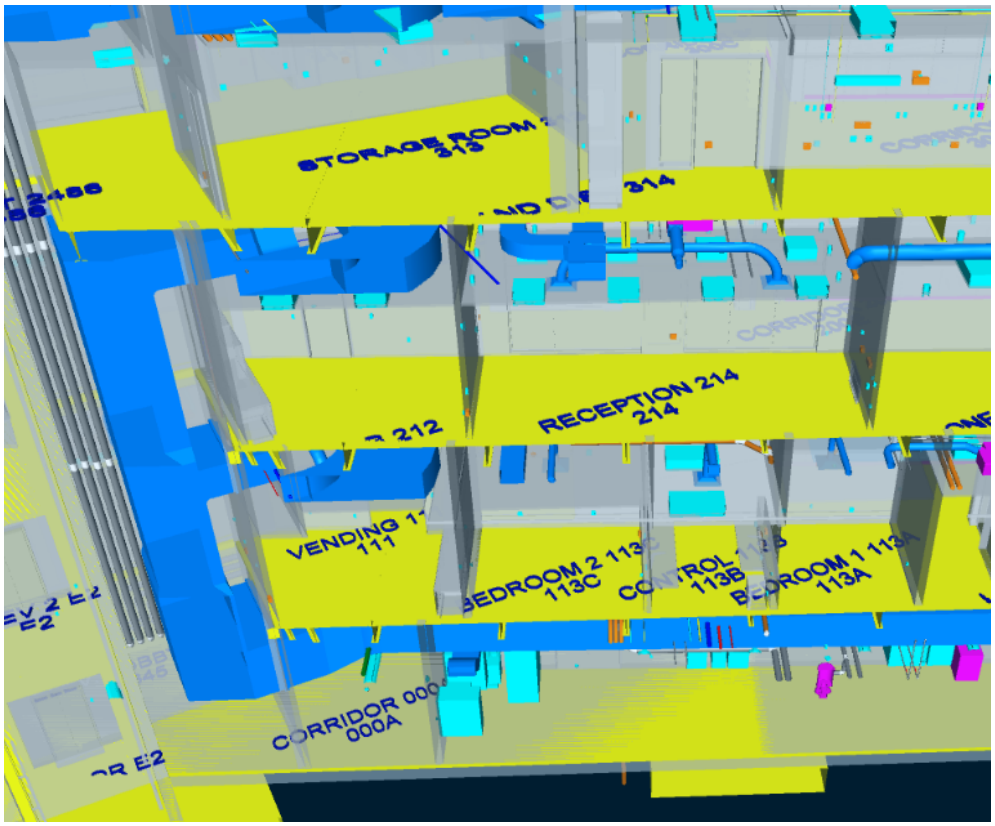
Navisworks Export Settings

3D Room Names and Grid Lines (Dynamo)

There are two embellishments to the process that we've found invaluable. Likely, the greatest challenge in introducing Navisworks into your design team coordination meetings will be the adjustment for attendees. Navisworks looks much different from Revit and you will be slicing/dicing the model into a multitude of views, zoomed in on coordination issues. In our early stages of use, a lot of time was wasted in meetings scrolling around in views making sure everyone was oriented correctly.

Our solution to this problem has been to incorporate two families and two Dynamo scripts to aid in orientation. The first is 3D Room Names, the second is 3D Grid Lines. The image below

shows our 3D room names. The Dynamo graph pulls room names/numbers, and places a 3D Text family in each room, at their appropriate level with a base offset of 6" to allow for finish floors. Although it isn't a perfect process (sometimes the text overlaps), it has greatly helped Teams understand where we are looking at any given moment.



3D Room Names and Grids

The Dynamo graph creates the 3D Room names and Grid elements in the Revit model. We manage these on a separate workset and create additional 3D export views within the Revit model to create individual NWC models of these elements. Having these as separate models in Navisworks provides flexibility on controlling the color and visibility of these elements in views.

2. Navisworks Model Setup

This section outlines ways to setup an initial Navisworks NWF model. All strategies presented in this section are reflective of the process used at RATIO as a case study. As with most software, there are a variety of options and ways to set up these steps.

Appending Files

As discussed in the previous section, all consultants transmit their own NWC files from Revit using the Navisworks NWC Export Utility. Although it is possible to append multiple file formats into Navisworks, at RATIO we are exclusively using NWC files for our process. In general, there is one NWC per consultant, however in larger projects we

have seen benefits to breaking out the mechanical, electrical, plumbing and fire protection models into separate NWC's. Once all files are appended, the NWF file serves as the main working model. A naming convention for all of these file types should be standardized in the BIM Execution Plan. As long as all newly transmitted files have the same name as their predecessor, content will be updated in the NWF allowing for a quick and efficient update process, as well as the ability to track clash test progress.

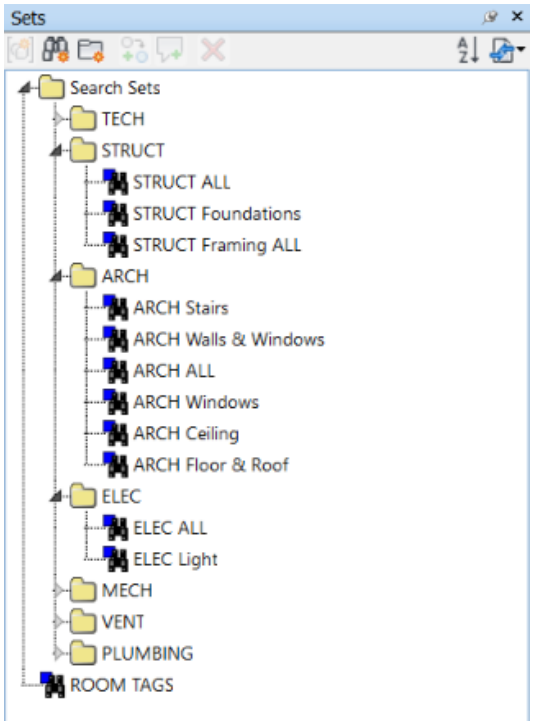
Sets

There are two types of sets in Navisworks: selection sets and search sets. These vary in their use as defined below:

Selection Set
A set of elements that have been selected either manually or through the selection tree then saved for later use.

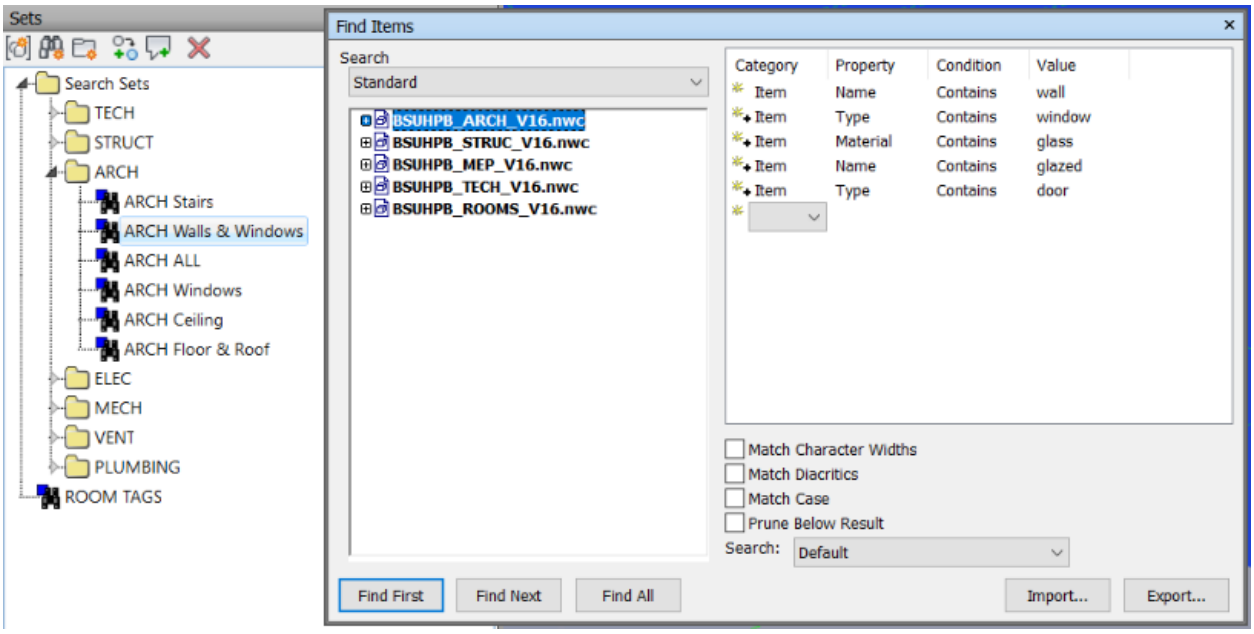
Search Set
A set of elements selected by defining search criteria through the Find Items window. Search sets are updating regularly to ensure that they include all elements that match the set criteria. Thus, if an element has been added or removed, the search set will update accordingly.

At RATIO, we utilize a standard set of search sets that can be imported into new models as a time saving measure. As you can see in the screenshot below, the search sets we use have been divided by discipline and may be expanded to further delineate specific element groups for the purposes of color coding and clash detection.



Standard Navisworks Search Sets

It is important when setting up search sets for your firm standard to make sure the criteria defining the search is clear. One strategy we have found useful is to isolate one NWC file at a time in Navisworks. Then through a process of trial and error, input conditions until you have selected the desired group of elements. Save that selection set, hide it, and move on until you have categorized all important sets pertaining to that NWC. Continue this process for all NWC files.



Defining Search Sets

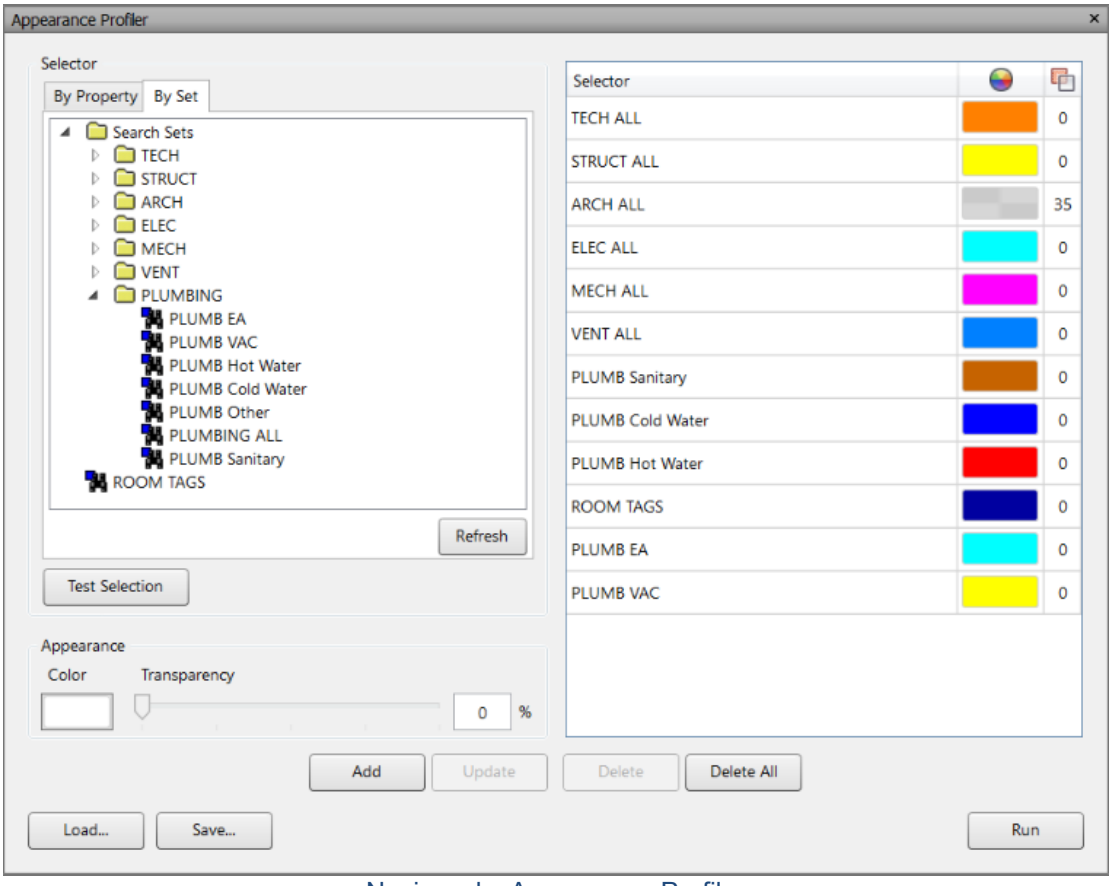
Once we developed a relatively good foundation of search sets, we exported them as an .XML file for use in the initial setup of our Navisworks models. It is important to note that although importing search sets does help begin the process of setting up a new model, each project is unique. As we all know, different firms model elements in different ways, with a variety of naming conventions, etc. With this in mind, the Model Manager setting up a new Navisworks model must test and edit all search sets for each project.

Appearance Profiler

Once we have search sets established, we use those same sets to apply a set of colors to our model. The Appearance Profiler in Navisworks enables us to utilize a standard set of colors to represent each discipline or system to be coordinated. It is our belief that Navisworks is best utilized as a coordination tool, and shouldn't be looked at as a rendering or animation tool. We use different software to accomplish those tasks. Although it often looks like a video game from the 1990s, applying consistent colors gives the team a clearer view of what is occurring in a crowded space.

For quickest results, utilize the search sets you've already spent time setting up by specifying the 'Selector By Set' tab. Next, simply add each of the search sets you want to be color coded to the Selector and apply a color and/or transparency. You can see in

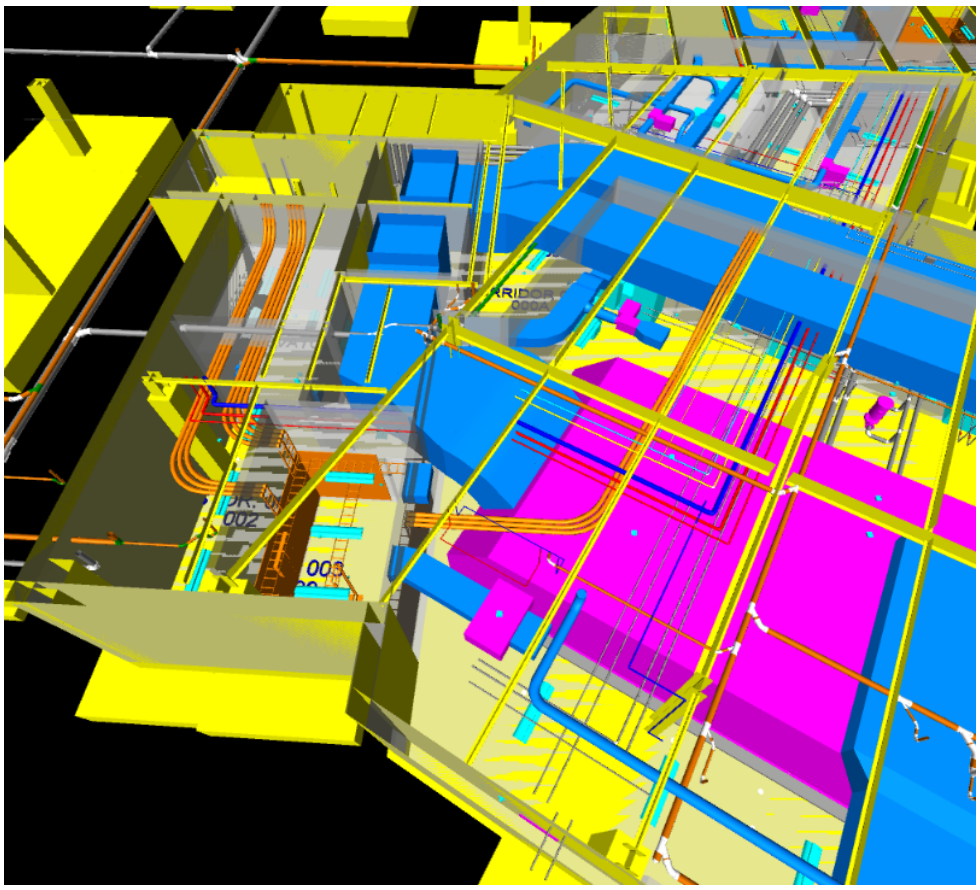
the screenshot below that we have chosen to delineate our plumbing systems by hot and cold water, sanitary, etc.



Navisworks Appearance Profiler

The Appearance Profiler is another item that can be standardized and loaded into models as a time saving measure. Simply save your initial appearance profiler setup as a .DAT file and load it into your next Navisworks model.

TIP: At RATIO we have found that when working on multiple projects, with a variety of consultants, it is effective to maintain similar colors across all projects in the firm. Over time, team members begin to memorize the colors, reducing time selecting elements to see what their properties are. For example, our Project Directors are used to structure always being yellow.

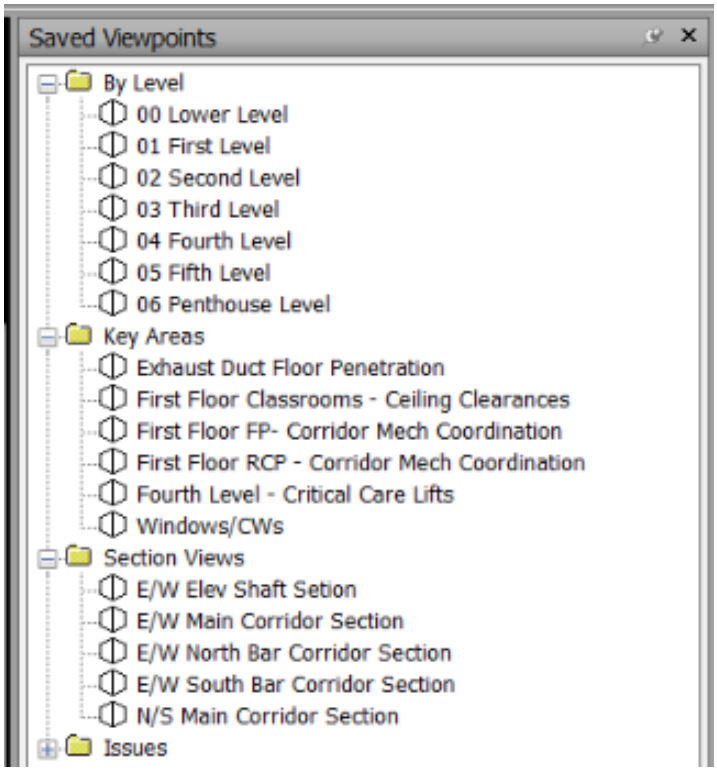


Navisworks Model with Appearance Profiler Colors

Creating Saved Viewpoints

Create saved viewpoints in the NWF model for use throughout the clash prevention process. We will group these pre-cut views into three sections under the Saved Viewpoints window: By Level, Key Areas, and Section Views.

For efficiency and organization during coordination meetings, we have found that setting up some pre-cut views that correspond to the Construction Document is useful. Naming and orienting views the same way as other project documents makes it easy to navigate during a meeting.



Navisworks Saved Viewpoints

By Level
An aerial view similar to a floor plan view created with an enabled sectioning box.

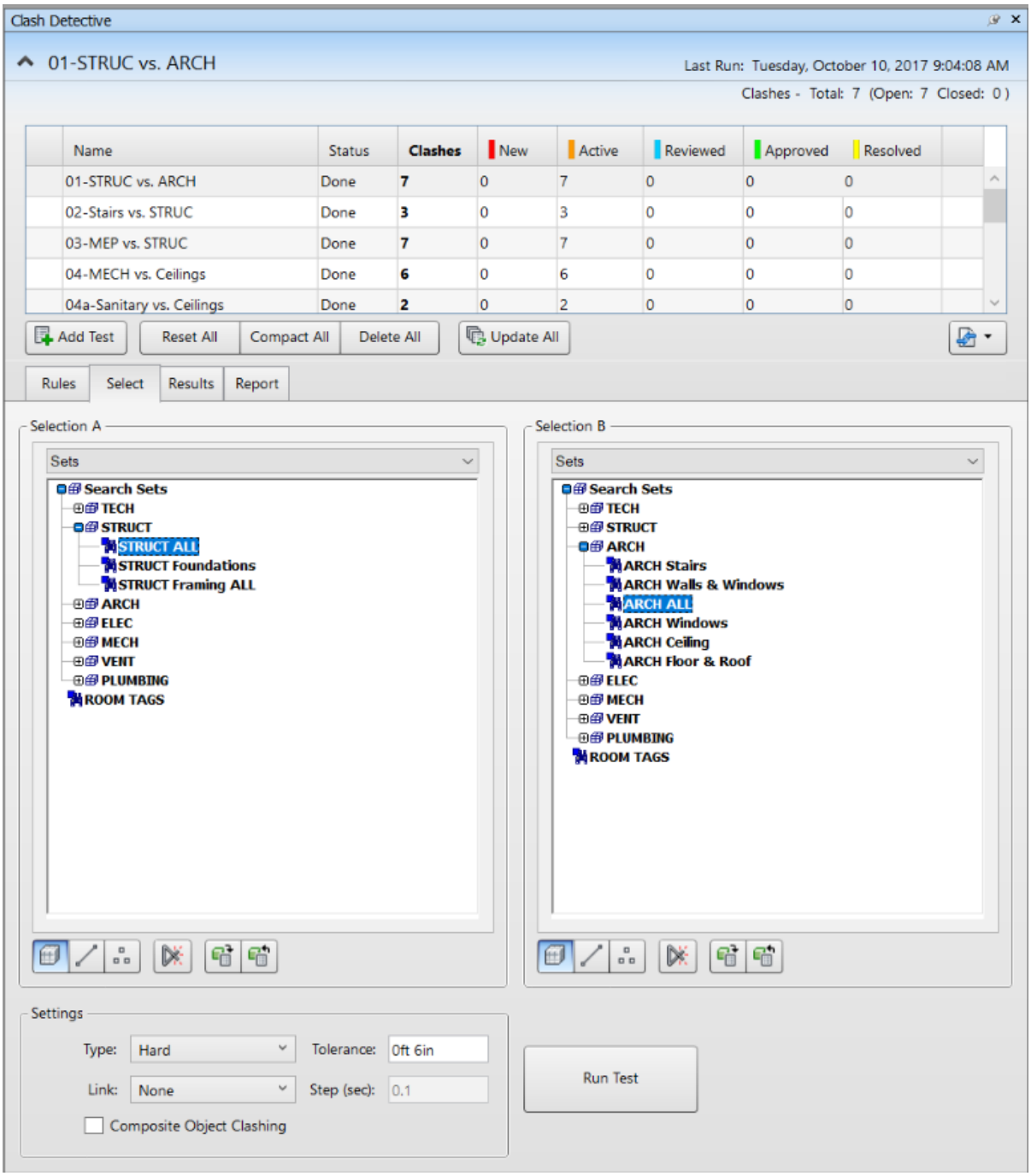
Key Areas
Axonometric view cut to highlight critical coordination spaces in the building.

Section Views
Multi-level, section cuts to show system integration and high traffic areas.

Issues
The issues folder hosts all clashes that correspond with issue numbers recorded in an Action Tracker. The next section describes how RATIO has been handling the clash process.

3. Clash Prevention

There are quite a lot of elements in the Clash Detective window. For the purposes of this handout, only select items will be touched on. However, there are a number of resources, including the Autodesk Knowledge Network, that contain in depth overviews of all parts of the Clash Detective dialog.



Navisworks Clash Tests

Developing Clash Tests

As stated previously, the incorporation of Navisworks in the design phase is to be viewed as a supplementary tool, rather than a replacement of typical coordination. As such, clash tests should be set up based on prioritization with the understanding that time may prevent all clashes from being caught, and therefor resolved. The clash prevention process is, by definition, based on design intent models (LOD 300), not installation or fabrication models (LOD 400+). It is advised to begin the clash prevention process with the items of most impact, whether that may be by cost or by re-design. For example, structural steel is usually at the top of the list at RATIO due to the fact that steel elements are prefabricated.

For sorting purposes, naming clash tests based on their priority helps to keep the team focused on resolving more important clashes first. For example, the first clash test in this example project is “01-STRUC vs. ARCH”.

Standard Clash Tests
01 - Struct vs. Ducts
02 - Ceilings vs. Ducts
03 - Struct vs. Ceilings
04 - Struct vs. Piping, Conduit, Cable Tray
05 - Duct vs. Piping, Conduit, Cable Tray
06 - Ceilings vs. Piping, Conduit, Cable Tray
07 – Struct vs. Lighting
08 – Struct vs. FP
09 – Ducts vs. FP

As a standard, we use Sets to organize selections for each clash test. As discussed above, search sets are used to grab elements based on criteria. We can use the Search Sets to test broad coordination issues (i.e. all structure versus all architectural elements) or more specific issues (i.e. sanitary lines vs. ceilings).

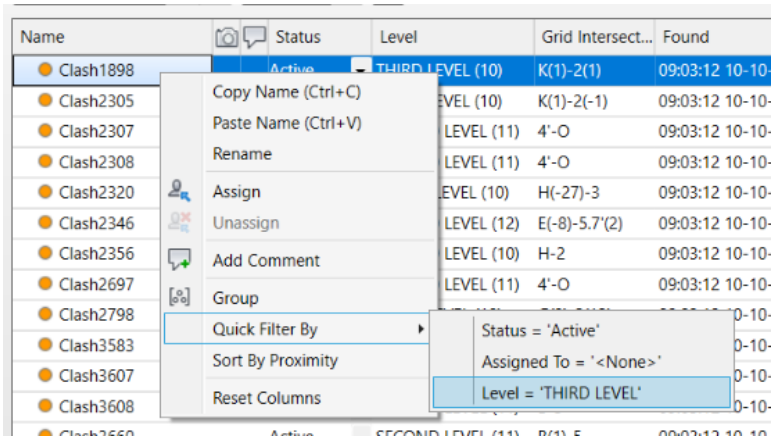
Settings for each clash test vary depending on the selections, as well as how far along into the CD phase clash prevention process you may be. At RATIO, we begin all clash tests set to a Type of Hard, and a Tolerance of 0ft 6in. As we progress in resolving issues, we will reset the Tolerance to 0ft 3in, and finally 0ft 1in. We will stop our clash prevention coordination with a tolerance of 1 inch, as it is not our goal to carry out full Clash Detection. Proceeding with a clash prevention process beyond a 1” tolerance is not practical with the design intent models produced by the Design Team.

The majority of our clash tests are set to the Hard type, but it is valuable to note that we have had instances where we have tested for soft clashes. For example, if the project is a steel building and we need to coordinate clearances in plenum spaces where the modeled steel does not show fire proofing, we may set up a clash test of the Clearance type set to a tolerance of 2 inches.

Managing Clash Results

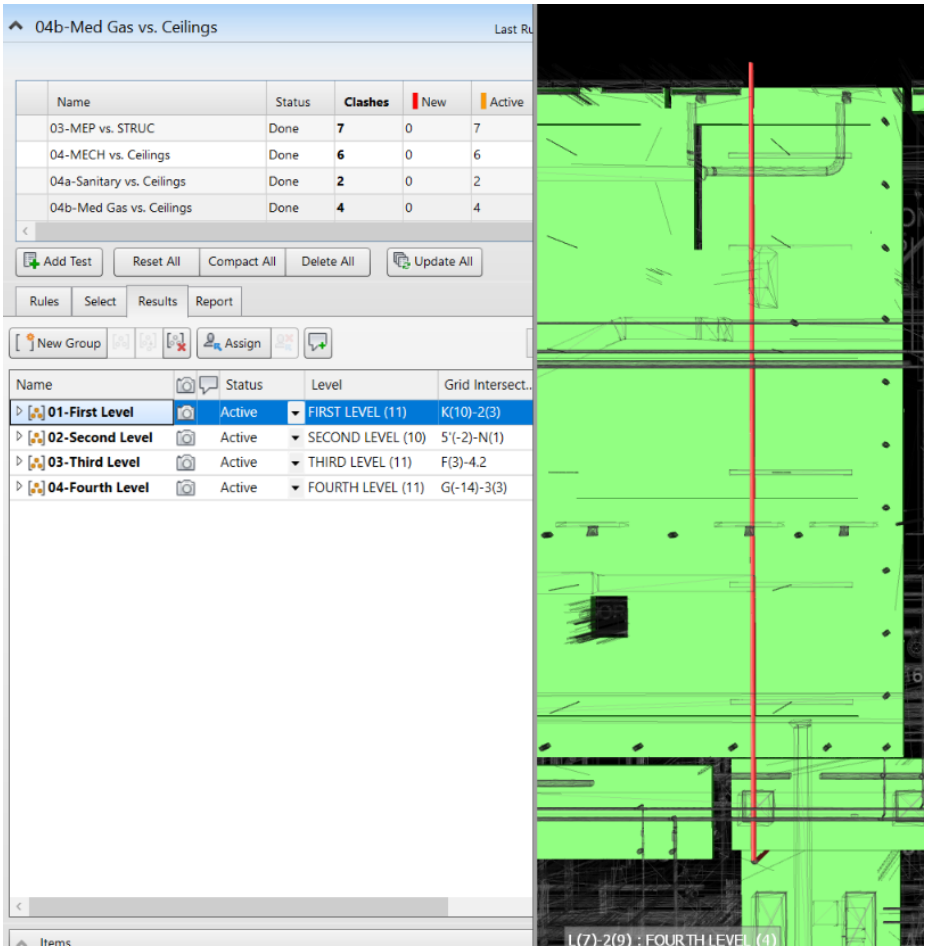
Managing the results of clash tests is yet another topic where you can go in many different directions. This can be the most time-consuming part of the clash prevention process if you do not have a strategy to manage issues. At RATIO we've determined that especially in the early stages of clash prevention, a more holistic view provide the most benefit. We view test results in groups by level.

The fastest way to sort clashes by level is through the "Quick Filter By" function. Right click on a clash, select 'Quick Filter By', and choose the Level. This will filter the clash list to only clashes on that level. You can select all clashes with the Shift key, right click and select Group. When finished with each level, remember to clear the quick filter.



Managing Clashes

Once completed, select a group, then use your Saved Viewpoints set up views to view all clashes at that level. In the screenshot below, you can see that all clashes on the First Level relate to a single med gas pipe run. By grouping, we were able to put each clash into context, thus realizing that by lowering that entire pipe run, we've resolved all Med Gas vs. Ceilings clashes on that level.



Grouped Clashes

Action Tracker

Although there are aspects of Navisworks Manage that are useful in tracking responsibilities alongside clash tests, we have developed an issue tracking process outside of Navisworks. This is primarily due to the fact that most of our consultants do not have the Navisworks Manage capabilities. The Clash Detective functionality that comes with the paid license of Navisworks Manage is excluded from Navisworks Freedom. In response to this reality, we are also utilizing an Excel 'Action Tracker' as a key for locating issue areas in the NWD file.

Navisworks Freedom is a free viewer for Navisworks models. With Freedom, design team members who do not own a license for Navisworks Manage are still able to receive and open published Navisworks files (NWD). Many of our consultants fall into this category. As part of our process, RATIO transmits a published NWD file along with the Action Tracker at least 24 hours prior to each coordination meeting, allowing team members to review clashes in advance.

RATIO

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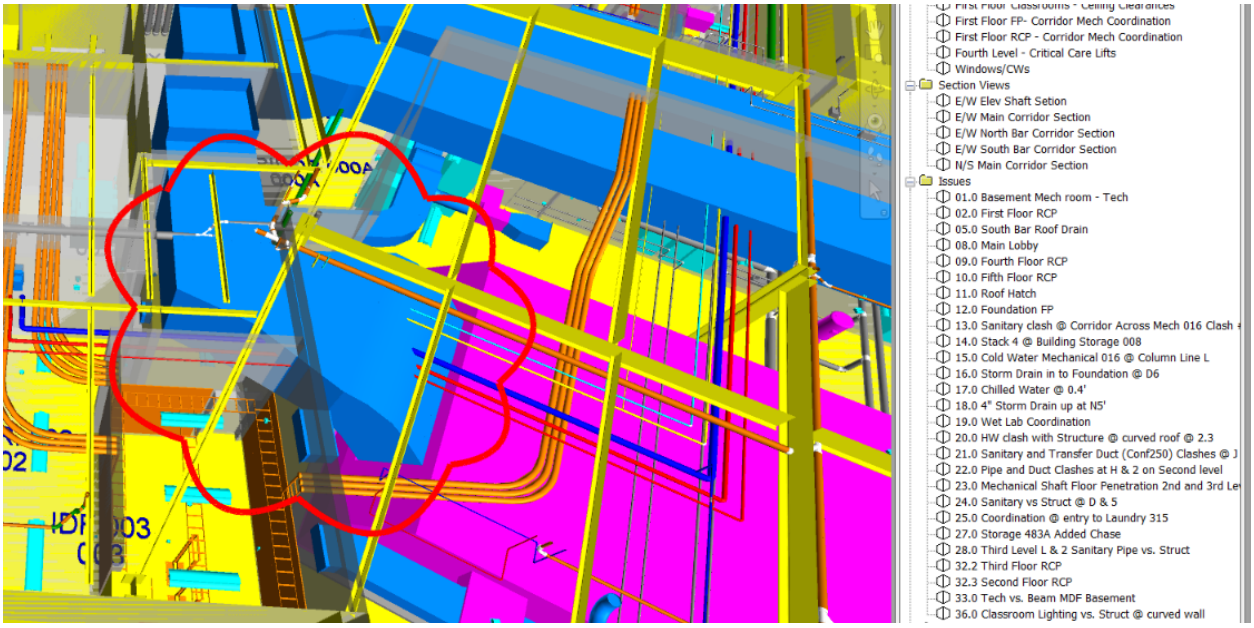
Status Legend
New Item for Discussion
Action Item
Change in Process
Important Update

Issue No.	Building Component: Action Item	Action By:	Area:	Navis Viewpoint(s):	Doc Reference:
1.0	Mechanical Room Ventilation vs. Tech Coordination	KJWW/Design27	Basement	Basement Mech room - Tech	M-300
2.0	First Floor RCP - Mech/Tech/Plumb Below Ceilings	ALL	First Floor	First Floor RCP	A-131A, M-301A,B
3.0	Height of Penthouse - Mech vs. Structural Coordinatio	KJWW/FRP	Penthouse	N/S Main Corridor Section	M-306, S-106-107
4.0	Basement Ceiling in Corridor vs. Mech Coordinatio	KJWW/RATIO	Basement	E/W Elev Shaft Section	M-300, A-130
5.0	Roof Drain Relocation - South Ba	KJWW/RATIO	Roof	South Bar Roof Drair	A-107A,B
6.0	Diffusers & Elec @ Main Lobby	KJWW/RATIO	First Floor	N/S Main Corridor Section	
7.0	Light Fixtures and Tech placement in Main Lobb	ALL	First Floor	N/S Main Corridor Section, First Floor RCF	A-131A, M-301A,B
8.0	Main Lobby Curtain Wall - Second Level Fin Tube	KJWW/RATIO	First/Second Floo	Main Lobby	
9.0	Fourth Floor RCP - Tech/Mech through Main Corridor & Outside of Shat	ALL	Fourth Level	Fourth Floor RCF	A-134A,B
10.0	Fifth Floor RCP - Tech through Main Corrido	Design27	Fifth Floor	Fifth Floor RCP	A-135A
11.0	Roof Hatch	RATIO	Roof	Roof Hatch	
12.0	Piping in Foundations	KJWW	Foundation	Foundation FP	
13.0	Sanitary Pipe Clash vs. Structure	KJWW	Lower Level	Sanitary clash @ Corridor Across Mech 01(	
14.0	Stack in Concrete Wal	KJWW	Lower Level	Stack 4 @ Building Storage 00(	
15.0	Cold Water Clash vs. Structure	KJWW	Lower Level	Cold Water Mechanical 016 @ Column Line I	
16.0	Storm Drain vs. Struct Foundatior	KJWW	Lower Level	Storm Drain in to Foundation @ D(	
17.0	Chilled Water vs. Struct	KJWW	Lower Level	Chilled Water @ 0.4'	
18.0	Storm Drain vs. Struct Clash as it turns up	KJWW	Lower Level	4" Storm Drain up at N5	
19.0	Multiple Clashes in Wet Lab Ceilings	KJWW	First Level	Wet Lab Coordination	
20.0	HW Supply/Return Clash wit hStruct at curved roo	KJWW	First Level	HW clash with Structure @ curved roof @ 2.:	
21.0	Sanitary Pipe Clash and Transfer Vent Duct Clash with Struct	KJWW	Second Level	Sanitary and Transfer Duct (Conf250) Clashes @ J and 2-:	
22.0	Area of Clash Focus	KJWW	Second Level	Pipe and Duct Clashes at H & 2 on Second leve	
23.0	Need Floor Opening in Slat	FRP	Second Level	Mechanical Shaft Floor Penetration 2nd and 3rd Leve	
24.0	Pipe vs. Struct Clash	KJWW	Second Level	Sanitary vs Struct @ D & 5	
25.0	Column Base Offset and Pipe vs. Struct Clast	KJWW	Third Level	Coordination @ entry to Laundry 31(	
26.0	Transfer Ducts vs. Struct	KJWW	Rooms A321, 425, 473, 477, 530, 518, 523, 521, 513, 511		
27.0	Needs Floor Penetrationat Levels 4 and !	FRP	Fourth Level	Storage 483A Added Chase	
28.0	Sanitary vs. Structure Clast	KJWW	Third Level	Third Level L & 2 Sanitary Pipe vs. Struct	
29.0	Sanitary Above Room 501	KJWW	Fifth Level		
30.0	Vent Pipe above 514	KJWW	Fifth Level		
31.0	Penthouse Columns	KJWW/RATIO	Penthouse	Penthouse Level	
32.1	Technology and MEP in Fourth Level Corridor Ceiling	Design27/KJWW	Fourth Level	Fourth Floor RCF	
32.2	Third Floor Main Corridor MEP & Tech below ceiling	KJWW/Design27	Third Level	Third Floor RCF	
32.3	MEP over Balcony	KJWW	Second Level	Second Floor RCF	
32.4	MEP under Ceiling at First Floor south end vestibul	KJWW	First Level	First Floor RCP	
32.5	Pipe in Clinic Waiting First Floor	KJWW	First Level	First Floor RCP	
32.6	Conduit in Main Lobby - First Floor	Design 27	First Level	First Floor RCP	
33.0	Tech vs. Struct Clash @ MDF Basemen	Design27/FRP	Lower Level	Tech vs. Beam MDF Basemen	
34.0	Conduit vs. MEP Issues	Design27/KJWW	Lower Level	Tech vs. MEP Clash Results - Lower Leve	
35.0	Tech vs. MEP Clashes	Design27/KJWW	First Level	Tech vs. MEP Clash Results - First Leve	
35.1	Tech vs. MEP Clashes	Design27/KJWW	Second Level	Tech vs. MEP Clash Results - Second Leve	
35.2	Tech vs. MEP Clashes	Design27/KJWW	Third Level	Tech vs. MEP Clash Results - Third Leve	
35.3	Tech vs. MEP Clashes	Design27/KJWW	Fourth Level	Tech vs. MEP Clash Results - Fourth Leve	
35.4	Tech vs. MEP Clashes	Design27/KJWW	Fifth Level	Tech vs. MEP Clash Results - Fifth Leve	
36.0	Lighting vs. Structure	KJWW/FRP	First Level	Classroom Lighting vs. Struct @ curved wal	
37.0	Med Gas vs. Ceilings	KJWW	All Floors	Clash Test: Med Gas vs. Ceilings	
38.1	Electrical on Glass and Mullions	KJWW	All Floors	ALL vs. Windows	
38.2	Fire Alarm Pulls on Glass and Mullions	KJWW	All Floors	ALL vs. Windows	
39.0	Lighting vs. Tech	KJWW/Design27	All Floors	Tech vs. MEP	
40.0	MEP vs. Tech	KJWW/Design27	All Floors	Tech vs. MEP	

Action Tracker

Each week (or biweekly depending on project timeline) consultants transmit their NWC files. One of the BIM Specialists at RATIO works with the Project Director to identify new, existing, or resolved action items in the Navisworks Clash Detective. These items are recorded in the Action Tracker color-coded Excel spreadsheet based on their status. Each week, this Action Tracker is updated to reflect clash prevention progress. The Action Tracker is also used when developing each coordination meeting's agenda.

One of the columns included in the Action Tracker is named "Navis Viewpoint(s)". This column provides reference for team members to locate the viewpoint in Navisworks that related to each issue. Navisworks viewpoints are named with the Issue No. as a prefix to reduce time cross referencing. In addition, redline tools in Navisworks allow the BIM Specialist to highlight areas in a viewpoint to further clarify clashes.

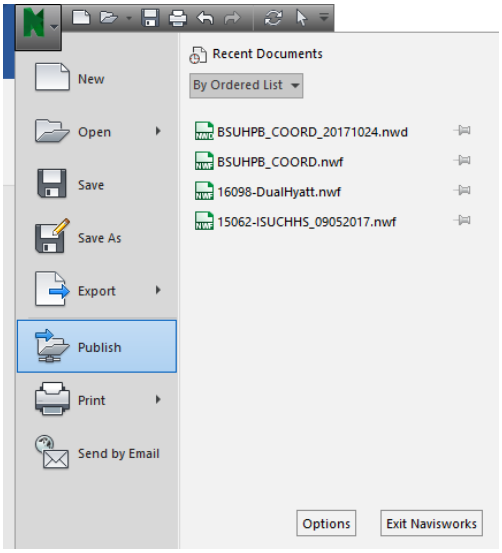


Navisworks Clash Issue Viewpoints

As Autodesk licensing moves towards Collections and away from Suites, it seems Navisworks Manage may become more widely used. In the future, we anticipate rethinking the Action Tracker if Navisworks Manage becomes a standard tool in practice.

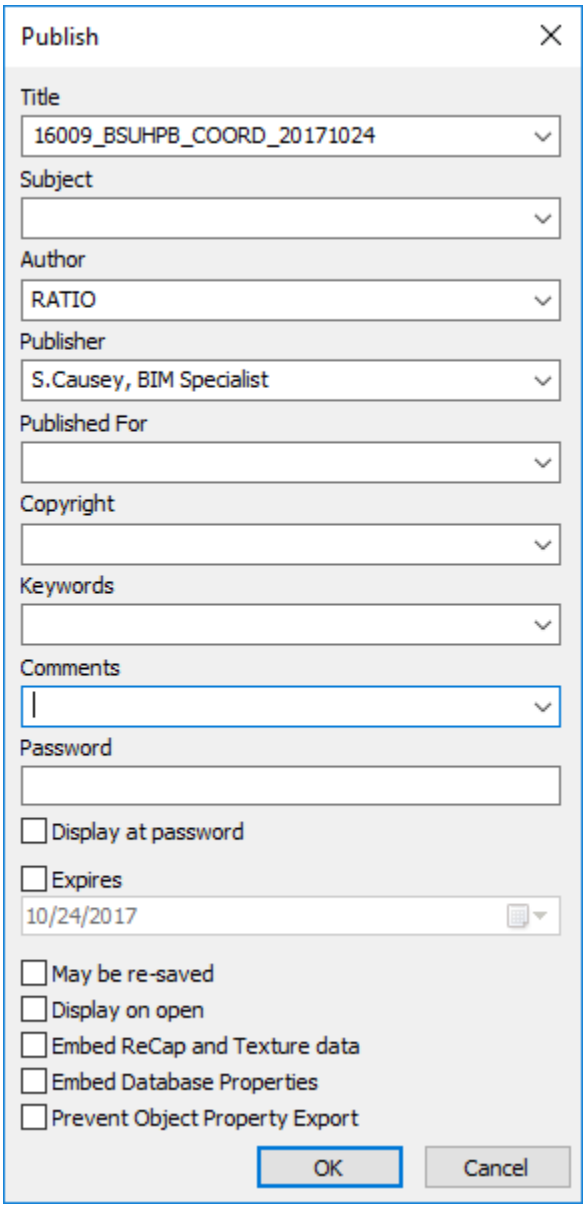
Publishing the NWD

As discussed in our clash prevention process timeline, we publish NWD files for all consultants prior to coordination meetings. The first step is to choose the Publish tool under the N at the top left-hand corner.



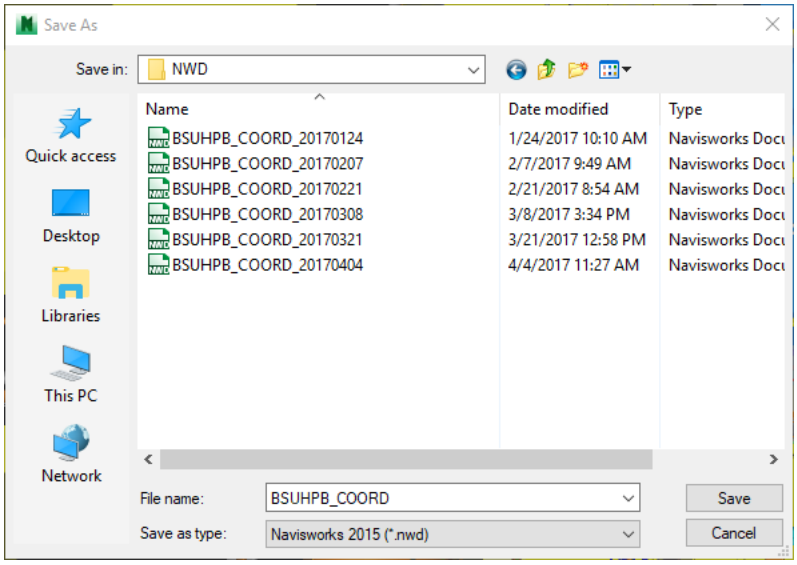
Publishing the NWD File

The following window will appear providing you with a variety of publish options. As seen in the screenshot below, typically we assign a Title, Author, and Publisher. If the file needs higher levels of security, you can password protect it, preventing users who are not in possession of the password from opening the model at all.



NWD Publish Options

As part of the Save As process to NWD, appending the date to the file name keeps models organized and easily referenced in the future.



NWD File Naming

Once these steps have been completed, you can transmit the model through your preferred file management system.

4. Coordination Meeting

With the Navisworks model, Action Tracker, and meeting agenda aligned, we prioritize the clash prevention portion of coordination meetings at RATIO to occur either at the beginning or end. Due to the fact that our BIM Specialists take part in these meetings to "drive" the model, reserving specific time for clash review has the least impact on the design team fee.

The clash review portion of the meeting consists simply of going down the action tracker list reviewing clashes that have been resolved, items that have yet to change, and new issues that were found since the previous meeting. The team uses the review time to resolve as many as possible.

Clashes to Revit

In future development of our process, we hope to incorporate some intriguing ideas we have found from others. BIM One Inc. developed a Clash Sphere Generator that will import clashes from Navisworks into your Revit model by placing spheres in the same location. Although we have yet to try this, we wanted to share with you that tools like this are out there.

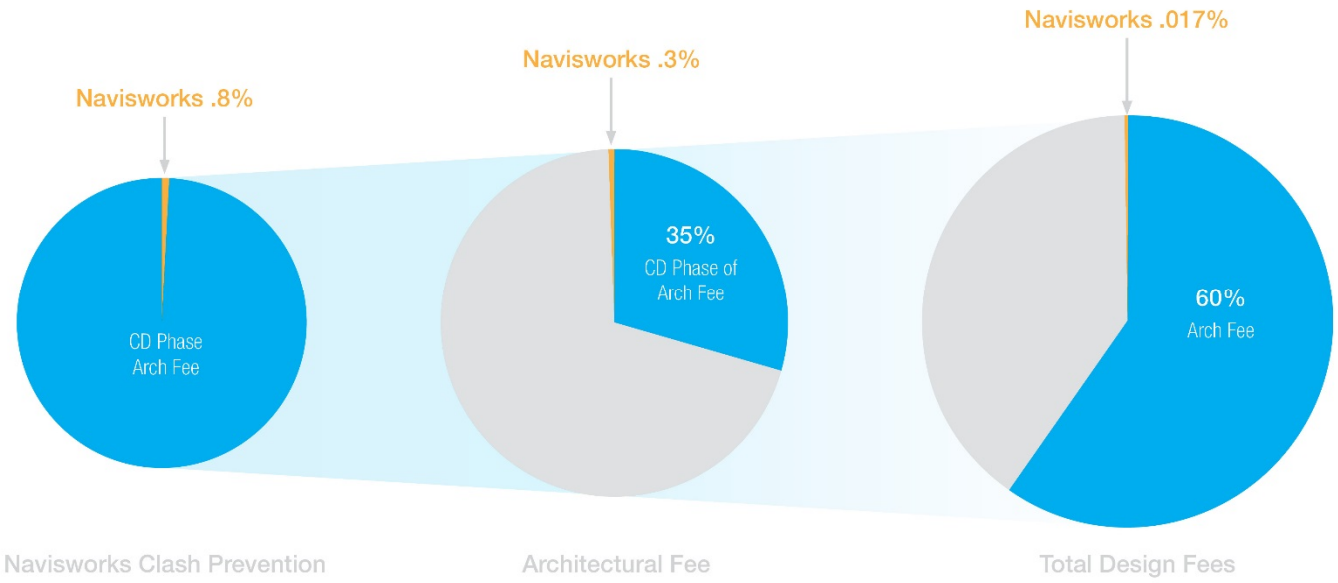
https://www.bimone.com/UserGuide/Clash%20Sphere%20Generator%20-%20User%20Guide.pdf

Conclusion

This process is not a replacement for traditional coordination, nor is it a fix for poorly designed and coordinated buildings. However, BIM processes that improve trade coordination, such as Clash Prevention, are often cited as having a significant positive impact on the outcome of projects. In the 2015 Dodge Data & Analytics SmartMarket Report "Measuring the Impact of BIM on Complex Buildings", Andy Reinach with Alexandria Real Estate Equities is quoted that "…he sees direct profit from BIM…" He continues to explain that BIM coordination functionality such as Clash Prevention gives design and construction teams "…the ability to find issues in real time and work them out so that you finish the design virtually before you hit the field gives you the best bang for your buck."[4]

The business case for incorporating Navisworks for Clash Prevention in the design phase is all about setting limitations. Being diligent about drawing the line between clash prevention and clash detection is critical to making this process efficient and economical for Design Teams. In addition, it is important to realize and accept that design intent models are utilized for the Clash Prevention process and not all construction and installation issues that can be identified. We still must produce well-coordinated designs before introducing Navisworks.

Although we do not have very specific data at this point, we extrapolated some information from our enterprise resource planning software to help illustrate how much time RATIO is spending on Clash Prevention on a typical project:



Clash Prevention Relative to Total Fees

[4] *Measuring the Impact of BIM on Complex Buildings*. Dodge Data & Analytics, *Measuring the Impact of BIM on Complex Buildings*, www.construction.com/toolkit/reports/measuring-impact-bim-complex-buildings.

A sample higher education classroom building project provided some sample statistics.

The project is currently under construction. During the Construction Document phase, RATIO BIM Specialists spent less than 40 hours to implement Clash Prevention. This represents approximately 0.8% of the fee for Architectural Construction Documents. Consider that the CD phase fee is 35% of the total Architectural fee, which is 60% of the total design fee for the project. To put this in perspective, on a project with a $1 million design fee, the effort associated with Navisworks Clash Prevention represents $1680 in fee.

Feedback from the Project Director, Project Architect, and the Consulting Engineering Team indicate that the Navisworks Clash Prevention process enabled the team to identify and resolve problem areas more efficiently than coordinating with PDF drawings and Revit models.