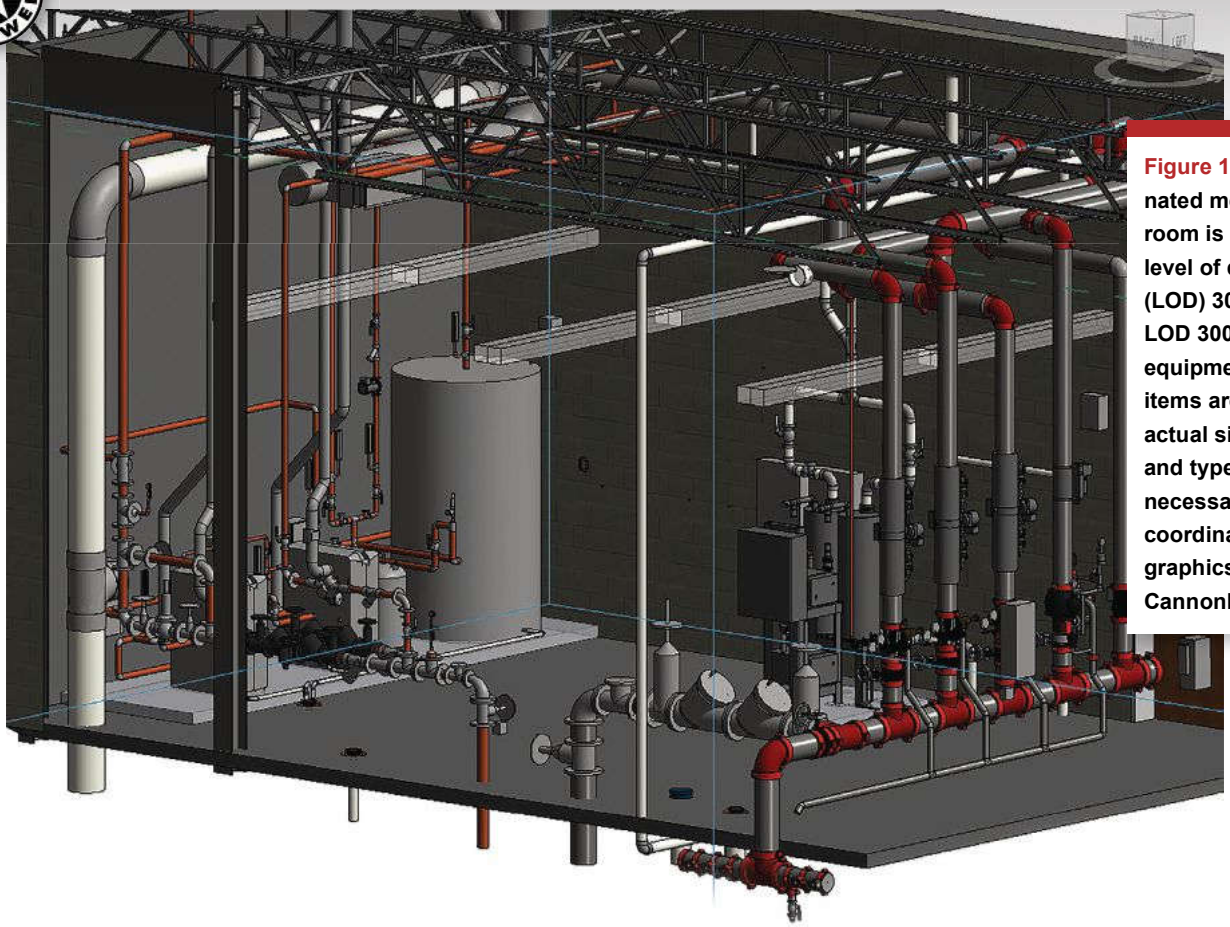

Figure 1: A coordinated mechanical room is modeled to a level of development (LOD) 300. At an LOD 300, all piping, equipment and other items are modeled at actual size, quantity and type, which is necessary for proper coordination. All graphics courtesy: CannonDesign

Using **BIM** for project coordination

BIM is used frequently when working across multiple disciplines, which can prevent clashes across mechanical, electrical, plumbing, and fire protection engineering and with other stakeholders.

BY DEREK MAIN, *CannonDesign, Buffalo, N.Y.*

Building information modeling (BIM), clash detection, clash prevention, level of development (LOD), 4-D, 5-D: These are terms heard or used regularly by those working in the architecture, engineering, construction (AEC) Industry. But at the rate these terms are thrown around, do we really understand what they are? Are we really doing what we say we're doing? If we aren't, why aren't we? Are we following best practices?

Many engineers assume that if they're using Revit, they're doing BIM. However, although Revit is one of the many tools to use for BIM, many individuals only use Revit for 3-D modeling—and they

Learning objectives

- Understand the basics of BIM for project coordination.
- Compare clash prevention and clash detection; identify where each is best used for BIM coordination.
- Illustrate how BIM can improve workflow and overall engineering design.

may or may not be coordinating among disciplines. Three-dimensional modeling is only considered BIM when information is tied to what is modeled; that is, when elements in the model have data in them that is scheduled on drawings or used for cost estimating, exported for other tasks in construction, or even used for facilities management.

Clash prevention versus clash detection

When it comes to using BIM coordination to determine where elements "fit," there are primarily two processes of coordination: clash prevention and clash detection.

Clash prevention provides assurance that the modeled geometry of all building components and systems will fit in their allocated space and that all items can maintain access and serviceability. This process is primarily done during the design phase when laying out the routing of all systems. While not every offset or adjustment is shown in the model for design documentation, the building can be constructed without issue, and any adjustments not requiring a request for information (RFI) are made by the contractor during the construction phase.

Most clash prevention tasks on a project can be performed simultaneously while developing the design, but require each individual on the project team to do due diligence of coordinating any congested areas of the building. While designers are working in a model, some critical areas may still require communication among team members, whether it be face-to-face, over the phone, via email, etc.

The clash-detection process is a review that ensures all building components, assemblies, and systems properly fit in their to-be-installed condition without interferences or encroachment with any other building assemblies. This process is occasionally done by the design team if required; however, this is often done on the contracting side. Several ways clash detection can be accomplished include, but are not limited to:

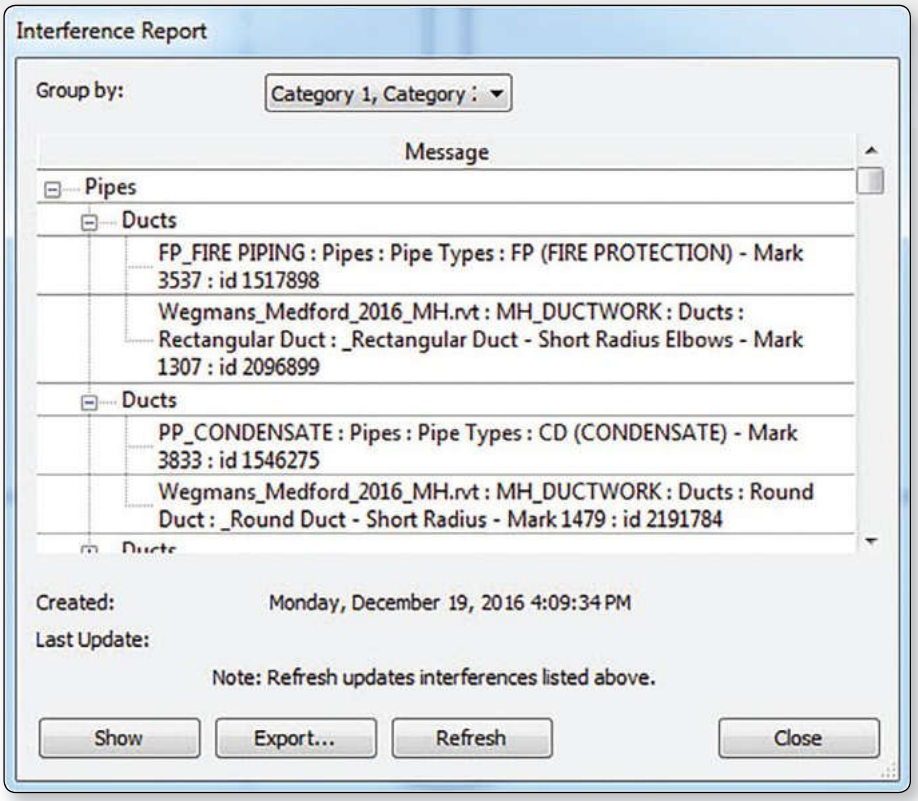

Figure 2: Using Revit's interference check tool allows an engineer to quickly find any invalid intersections that may have been missed through other coordination methods.

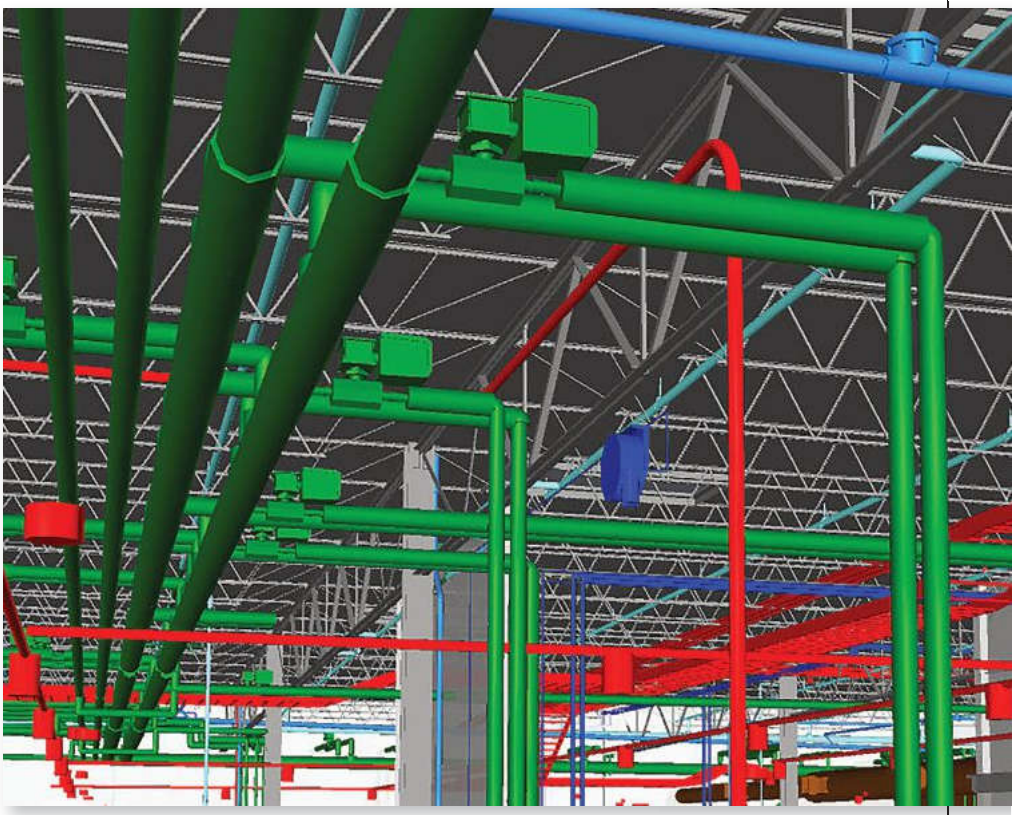

Figure 3: Navisworks is a popular software solution to use for model-coordination reviews and clash detection.

Using **BIM for project coordination**

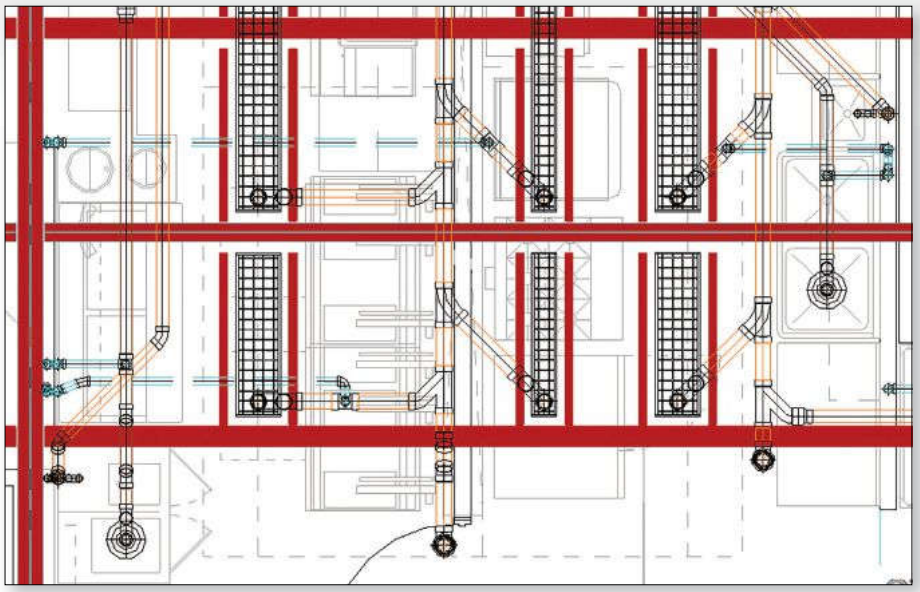

Figure 4: This project involved remodeling an existing building where the floor load doubled, requiring additional beams to be added with a spacing of 5 ft on center. Using structural plan views made it easy to coordinate drain and floor penetrations for the restaurant areas above.

- Interference check reports in Revit
- Clash detective in Navisworks Manage
- Model checks by visual inspection in 3-D coordination views.

The interference check tool in Revit has received some improvements recently, allowing for easier coordination checks. Within the tool, element categories are selected to compare against other elements in the model or with elements in other linked models, such as inspecting for clashes between structural steel and plumbing piping. After the report is run, elements that have an invalid intersection (collision) are listed, with both element ID number and a descriptive name ID. These can then be selected and shown in an available view to adjust. Using this method can be quicker than performing clash detection in a separate program, however, using a program like Navisworks for this may be better performance-wise for those using computers with less horsepower on larger projects.

Clash detection in Navisworks is probably the most well-known option when it comes to BIM coordination and is very popular on the contractor side. Navisworks can handle many different file types and is typically quicker to use than an equivalent Revit model. Search sets can be used for filtering or color-coding the various systems in a model, and clash detection is relatively easy as well. During the coordination process, clashes can be found in the Navisworks model and updated in the Revit model. These updates are done manually in the Revit model; however, Autodesk does have a tool called switchback, which allows users to quickly move back and forth between the Revit design and Navisworks review models.

Coordination views that are predefined in the Revit model are easy to use for both clash prevention and clash detection. These can include 3-D views, sections, and working views that are double-line (fine detail level of graphics) as well as color-coded with filters applied to the various systems. These views are regularly used throughout the design of a project and can be used in coordination meetings instead of the old "paper tacked to the wall" method, which usually still results in some coordination issues.

Another type of coordination or working view in Revit that is valuable during design is the structural plan view. These views are used to see where the beams or foundations are located that support the level being viewed. With these, it is easy to coordinate the location of floor drains, fixture drains, or any other floor penetrations.

LOD specification

The LOD, while sometimes referred to as the level of detail, is actually the level of development specification. This is a reference used in the AEC industry to standardize the level of quality and reliability of content in building information models at various stages of the design and construction process. This specification receives annual updates and review by BIMForum, the U.S. chapter of buildingSMART International. The LOD in a model has a direct connection with coordination in that model, and using the BIMForum LOD for your company's standard level of detail is best for collaboration with other firms or contractors on the same project. For clash detection or even clash prevention, a minimum of LOD 300 is required. At an LOD 300, all piping, equipment, and other items are modeled at actual size, quantity, and type, which is necessary for proper coordination.

When agreeing on the LOD for a project, it is better to think about what level the project is required to be at for completion, rather than what is desired at each phase. While an LOD 200 (in which most content is generic in size, shape, or type) may only be needed for an earlier phase of a project, sometimes it makes sense for some content to already be at an LOD 350 (where content is true to size, shape, and type and may have embedded information).

For example, at the design development phase of a project, the requirements may be to provide an LOD 200. However, the water heater may have already been selected, so an LOD 350 is used to place the water heater graphically in the model. Also included at a

LOD 350 is the parameter information that is automatically populated in the water heater or equipment schedule, which in turn is needed for the design development submission. For this reason, it is better to view the required LOD for each phase as a minimum rather than as a required "target."

Keep in mind, the LOD for a project is usually specified in a project's contract and BIM execution plan, where many firms have an LOD to which they typically design projects. However, some projects may have circumstances requiring a different LOD from the norm, so it is helpful for this information to be communicated to team members during a project's BIM kickoff meeting where all model-related information is shared with the project team.

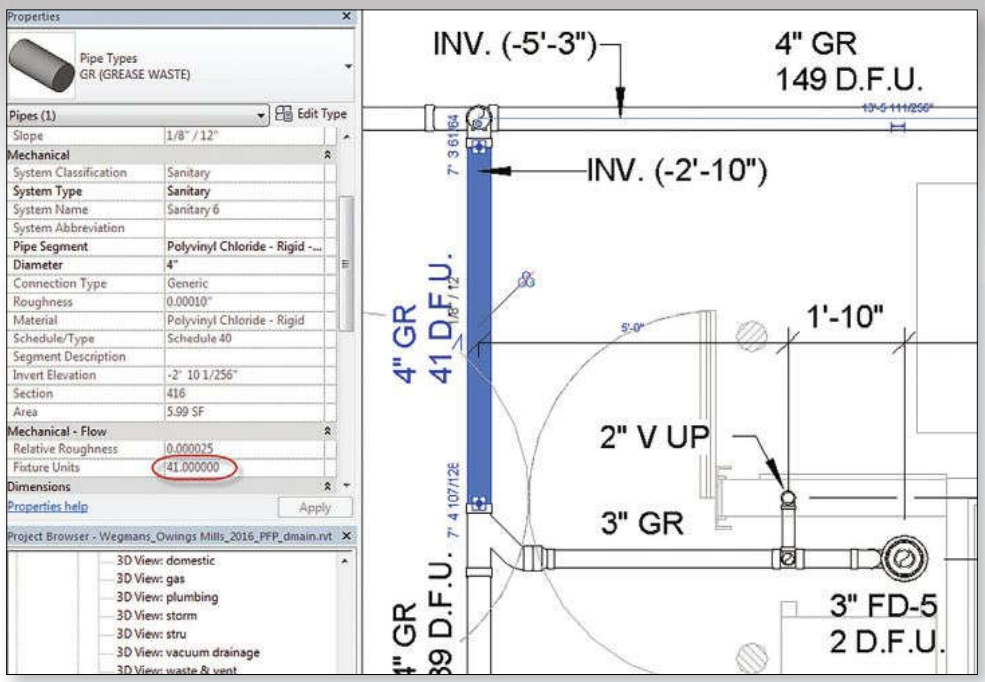

Figure 5: **Using the automation of piping systems in Revit allows for better coordination between sheets, in addition to improved quality and quicker design changes or revisions.**

Beyond 3-D

Outside of geometry coordination, there is another coordination process that can be happening with BIM. "Four-dimensional," or model-based scheduling, happens when we virtually communicate planned construction phases in a project by merging model data with project schedule milestones and duration. Being able to visually plan and simulate with time and space allows team members to review and improve trade coordination, phased construction, site logistics, and installation sequencing. For example, review of the model geometry shows that some mechanical, electrical, and plumbing (MEP) systems may need to be installed out of order to ensure proper fit or coordination during construction.

"Five-dimensional" is model-based cost estimating, where using the BIM model to quantify materials allows for better alignment between project budget and the design/construction process. To ensure accuracy, using BIM for cost estimating should be an item that is defined in the project's requirements. Elements in the model can be quantified in automated schedules and extracted for use in other cost-estimating software, such as Innovaya Visual and Sage Estimating.

CASE STUDY: **Robinson-Falconio Residence Hall**

A complete renovation was finished on this St. Bonaventure University (N.Y.) dormitory building of approximately 85,000 sq ft, including replacing a majority of the domestic water and waste systems as well as the addition of a sprinkler system conforming with NFPA 13R; Standard for the Installation of Sprinkler Systems in Low-Rise Residential Occupancies. For this project, the process of clash prevention was used for BIM coordination.

With a floor-to-floor elevation of 8 ft 8.5 in., the structural concrete building allowed for 7.5 in. of space above a 7 ft corridor ceiling height. In the adjacent rooms, a decreased slab thickness and an exposed ceiling allowed for a clear height of 8 ft 3 in. Soffits with sidewall sprinkler heads were used for protecting these rooms, while concealed pendent sprinkler heads were located in corridors and community spaces with ceilings.

With tight clearances and the need to maintain constructability, even a 1-in. sprinkler branch pipe needed to be routed where it would not cross over an electrical fixture or light mounted in the ceiling. Other areas of the building needed extra attention as well, such as the shower rooms where downlights in each stall needed to be offset to allow clearance for exhaust ductwork and the drain p-trap from the floor above.

Thorough clash prevention was performed throughout the design of the building, including holding coordination meetings, with all work and coordination accomplished in Autodesk Revit software. As a result, there was only one request for information during construction for the plumbing and fire protection design: An existing wall that was chosen to install a flush-mount fire department connection was not viable, so a free-standing fire department connection was used instead.

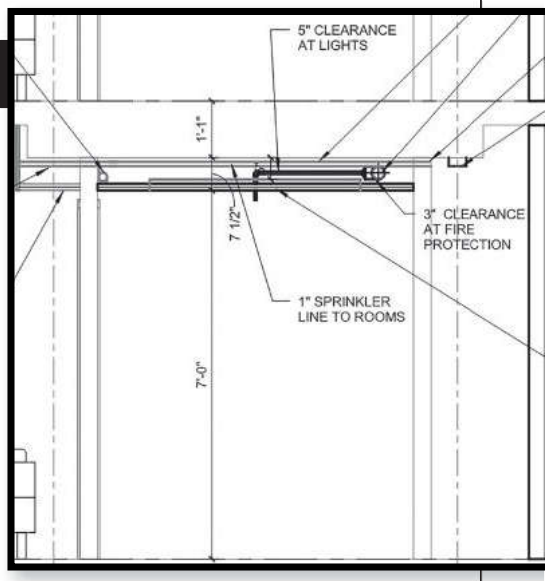

Figure 6: **Coordinated sections were placed on drawings to aid the contractor in locating the various mechanical, electrical, and plumbing (MEP) systems in tight, congested areas.**

Using **BIM for project coordination**

For instance, having the plumbing systems modeled accurately with equipment and fixture content, pipe sizes, and location allows for a significant reduction in time for the cost estimators. Instead of counting fixtures and measuring pipe runs on a set of drawing plans and entering that information into estimating software, the estimator can open the model and export data directly into the software, saving hours of time.

But wait, there's more

When thinking about BIM coordination, the terms clash prevention, clash detection, LOD, etc. are all obvious processes that come to mind. However, there is another type of coordination in BIM: automation.

When working in a Revit model, automation is another form of coordination. Taking advantage of Revit's piping systems allows for flow in piping to be automated, which can then be tagged. When these are automated and tagged, the information is consistent between drawing sheets; the values on floor plans match the values on riser diagrams. When a modification is made to the design, the changed values are automatically updated on all affected sheets.

In addition to the piping, automation of all schedules also improves the coordination between sheets and MEP disciplines on a project. Using content with true dimension and parameter information allows for fixture and equipment schedules to be populated with this information. The schedule sheets are coordinated with the floor plans, and any changes made in the model to these items related to quantity, type, etc., will automatically update in the schedules.

As the popularity of BIM increases, 2-D construction documents seem to evolve from being more schematic in nature. Complaints about this, expressed by project engineers, include drawings not looking the way they're used to seeing them, changes in workflow requiring designers to model in a third dimension, and hours shifting to performing different or unfamiliar tasks. While these are all true, and there are learning curves to some workflows, the improved coordination and efficiency of working in a 3-D world allow for quicker design completion.

CASE STUDY: **Wegmans Food Markets**

Wegmans Food Markets built a new store in Owings Mills, Md., of approximately 130,000 sq ft with a considerable amount of food prep/production/kitchen space and a burger bar. For the design deliverable, the engineers were required to produce an Autodesk Revit model and documents that had all mechanical, electrical, and plumbing (MEP) systems in their to-be-installed conditions, including dimensioning of some system mains and all floor penetrations.

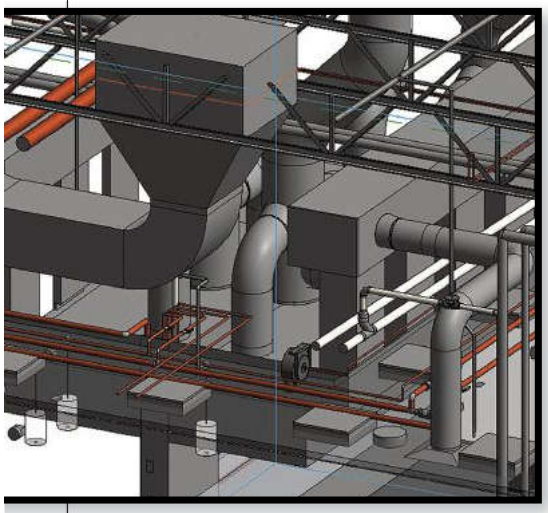

Figure 7: Weekly coordination meetings with prepopulated views in the model proved valuable for determining solutions to coordination issues that would appear in congested areas.

Other requirements included adequate spacing for constructability, such as offsets from walls for hanging drywall, proper spacing between hangers for decorative features, and ensuring any system penetrations through walls were above trim work. In addition, it was necessary to have all systems and mains located for maintaining serviceability and future modifications in renovation, such as being able to dig up a sanitary main for drain relocations in one area without having to tear into walls or go through other areas not receiving renovations.

It was also necessary to run clash-detection reports in Navisworks and provide "model walkthroughs" with the owner's design group. These model walkthroughs allowed the client to see how the building's MEP systems would look before construction, to ensure they maintain the required appearance as well as to locate any desired changes with the MEP systems. At the end of construction and after the store opened, any changes or adjustments in construction also needed to be incorporated into the Revit design model, which would then become the as-built model.

Over the course of the project's design, weekly coordination meetings lasting 1 to 2 hours were conducted to visually inspect the MEP systems throughout the building. These meetings were conducted while in the Revit model with predefined coordination views, using a meeting room with a PC and a large interactive display panel for everyone to see the model at once, in addition to having a video conference call session running for those that were working on the project from a different office.

While all team members were doing their due diligence for clash prevention when laying out their systems, these meetings proved valuable for determining solutions to coordination issues that would appear in congested areas. Toward the end of the design phase, clash detection also was performed by one team member from each discipline to ensure there were no interferences.

While there were many building layout and design changes that resulted in revisions, proper coordination and clash detection allowed for minimal revisions to the plumbing systems via requests for information due to conflicts. One was the adjustment of a sprinkler branch line that was clipping a duct, which was easy to correct. The other issue was an interference with a couple of drain p-traps and the structural footing, which was also easy to resolve. Unfortunately, this was missed when coordinating with the structural engineering team, as that portion was performed by another engineering firm that was not using Revit at the time.

For this project, an in-house structural engineer created and updated a model of the structure from design progress drawings, which worked out well. Having to recreate the model was extra effort, so it is beneficial for all external team members to use the same or compatible software.

The 2-D drawing is still the primary document to construct from; however, it is produced from a 3-D model. Areas, such as a toilet chase wall, may appear congested on a plan view, as piping is modeled as it would be installed instead of being spaced where it would be graphically pleasing, but a reference to an isometric view quickly clarifies the area. Not only are these 3-D isometric views significantly quicker to generate than a "flat" riser diagram would be, but they are typically clearer and easier to understand for contractors needing to install the system, resulting in fewer RFIs.

In some instances, more emphasis is put on the isometrics, rather than the plan views, to define the design system. In addition, while working in a 3-D world is an adjustment for more experienced engineers, it allows for younger designers to get up to speed quicker, as it is much easier to understand how these systems are put together in 3-D than in 2-D.

Automation of various processes in the plumbing design allows for a better coordinated drawing set, better coordination with other MEP disciplines, and cost estimation. It also allows better overall drawing quality. This automation, in combination with smarter model content, can then allow the owner to use the BIM for facilities management. When model elements are consistent with the manufacturer's data, such as make, model, product data, and other information, they can then be exported to Excel or used with other software products, such as BuildingOps in the BIM360 suite.

While this may require owners to adapt or use new software, the electronic information can enable better record-keeping, such as recording building conditions, than traditional paper drawings and equipment binders that are easily lost. If a piece of equipment fails, a facilities engineer can scan the equipment tag with their electronic device and view information, such as the install date or any possible warranty information, in one place. Using a model and its information for facilities management does require effort on the owner's side to keep information up-to-date, but for some owners, this effort can be worth it long-term.

So what does this all mean?

While the AEC industry as a whole has been a bit slower to improve processes as compared with other industries, there are significant advances happening right now. Not only is BIM here to stay, but the available software for use with BIM is continuously improving in capabilities and interoperability.

While some feel that various workflows in BIM take too much time, the reality is that many other workflows and tasks throughout a project see improved efficiency and a significant reduction in time as a result. With shorter design and construction time frames, tighter budgets, and higher expectations from clients, BIM is invaluable. Clash prevention and detection allow for better-coordinated projects, resulting in fewer RFIs.

BIMForum's LOD specification provides an industry standard for a minimum baseline that architects and engineers can follow for better alignment when collaborating with other project partners. Model-based scheduling (4-D) can improve timelines to meet shorter construction windows and 5-D model-based cost estimating allows for the design to better align with required project costs. At the end of construction, not only has the project team provided a better-quality project, the owner has more accurate data that can be retained and used for facilities management or future renovations. |cse|

Derek Main *is a plumbing engineer and BIM development leader at CannonDesign with 9 years of experience in educational, health care, and grocery markets. In addition, he is responsible for managing and advancing the digital practice/design processes for the firm's plumbing group.*