Autodesk Revit Systems: BIM for MEP Engineering

Autodesk® Revit® Systems is the purpose-built building information modeling (BIM) software for mechanical, electrical, and plumbing (MEP) engineering. This white paper explores how key concepts of BIM improve MEP design processes, both building mechanical and electrical, and how those processes are further enhanced when combined with Revit-based architectural and/or structural workflows.

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Using BIM to Improve MEP Design

Today's demanding business environment is driving a push towards more efficiency and integration in building industry supply chains. Owners are demanding better built buildings for less money in less time. Architects, engineers and contractors are under pressure to streamline their building design and delivery process - searching for ways to improve productivity, lower costs, and deliver better-quality products.

The success of BIM for building design - as evidenced by the rapid adoption of BIM solutions like Autodesk® Revit® Building software - is redefining clients' expectations of their MEP consultants. Like BIM for building and structural design, BIM for MEP is a design methodology characterized by the creation and use of coordinated, consistent computable information about a building's MEP design - information used for design decision-making, production of accurate documentation, predicting performance, cost-estimating and construction planning, and, eventually, for managing and operating the facility.

Several key concepts of Revit Systems are fundamental to understanding how BIM impacts the MEP design process: the use of a computable building model, holistic design, and parametric change management.

Computable Building Model

Revit Systems features a *computable* building model – that is, a model in software that can be operated on by a computer as a building

Using a conventional CAD system for design, MEP engineers and designers visualize the 3D design in their brain and transfer it to a 2D drafted representation. Some CAD systems fashioned specifically for MEP design allow the user to model the system geometry in 3D for the purposes of coordination and extracting drawings - making the model seem more intelligent than it really is. But because the model isn't computable, the elements and systems don't know how to interact with each other.

Whereas the Revit Systems building information model captures the functional relationships between building elements and systems. Walls, beams, ducts, pipes, distribution panels; they all "know" what they are, what they do and how to react to the rest of the building.

Holistic MEP Design

This computable Revit Systems building model enables a "holistic" design approach, i.e. MEP design done in the context of the whole building. For example, since the electrical and mechanical systems "know" about each other - an electrical engineer can track the power requirements of the mechanical equipment included in the design and have the software automatically configure electrical load requirements to dynamically change in mechanical equipment specifications.

This holistic approach unites not only the MEP disciplines, but the process as well - featuring an integrated digital environment for design, documentation and analysis. When used in conjunction with other team members using Revit-based design applications, this holistic approach expands to include the rest of the building as well.

Parametric Change Management

The majority of MEP engineering solutions today are based on CAD technology with a focus on the production of construction documentation rather than the engineering design itself. The drawings are either created directly, or extracted from a model. As the design evolves, a high level of effort is required to manage and coordinate the documentation and actionable building design data (such as schedule, cost, building performance, and so forth) of these CAD systems.

In contrast, Revit Systems is built upon a parametric change engine that provides immediate, comprehensive change propagation through the natural operation of the software. This results in the reliable, coordinated, and consistent design information and documentation that characterizes BIM.

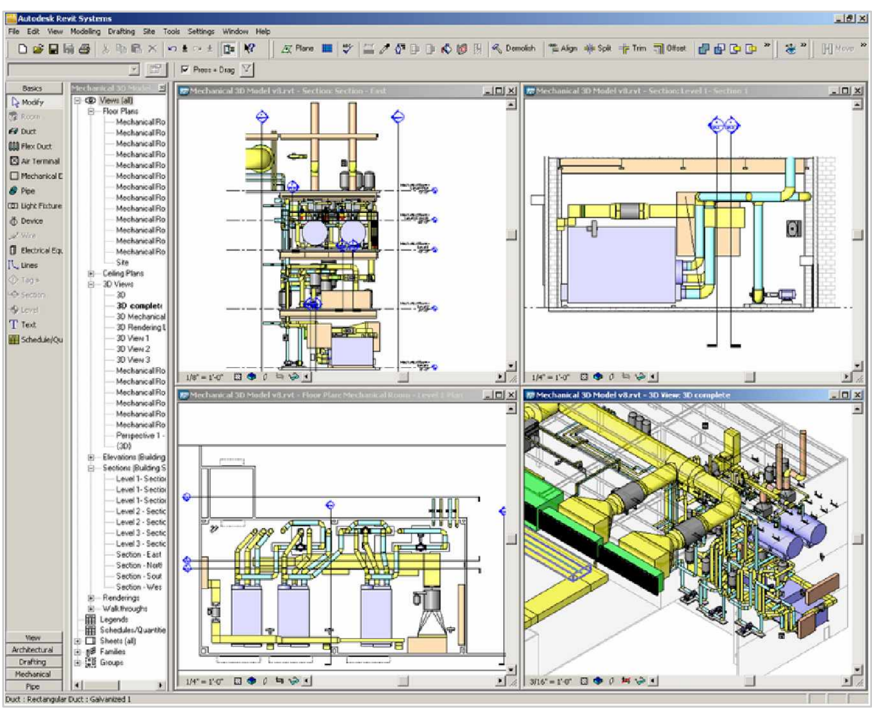

Figure 1

Autodesk Revit Systems expands the scope of the Revit family of products, delivering a BIM platform for collaborative multi-disciplinary building design. Image courtesy of Dal Pos Architects – Robson Woese Consulting Engineers.

MEP Design with Revit Systems

Design and Feedback

Revit Systems offers a unified environment for MEP design and engineering, analysis, and documentation. MEP engineers work directly in the model, and the drawings themselves are part of the building information model. Intuitive layout tools make system layout fast and easy. Engineers modify their design by dragging design elements to move or change them on the screen. The parametric change engine enables all model views and drawing sheets to update automatically whenever a change is made anywhere for accurate and coordinated designs and documents at all times.

Revit Systems features automatic sizing and systems layout tools, and provides engineers with immediate feedback on their design. For example, during the layout of a mechanical system, Revit Systems displays the critical flow of a mechanical system, allowing an engineer to modify the design for maximum performance and efficiency.

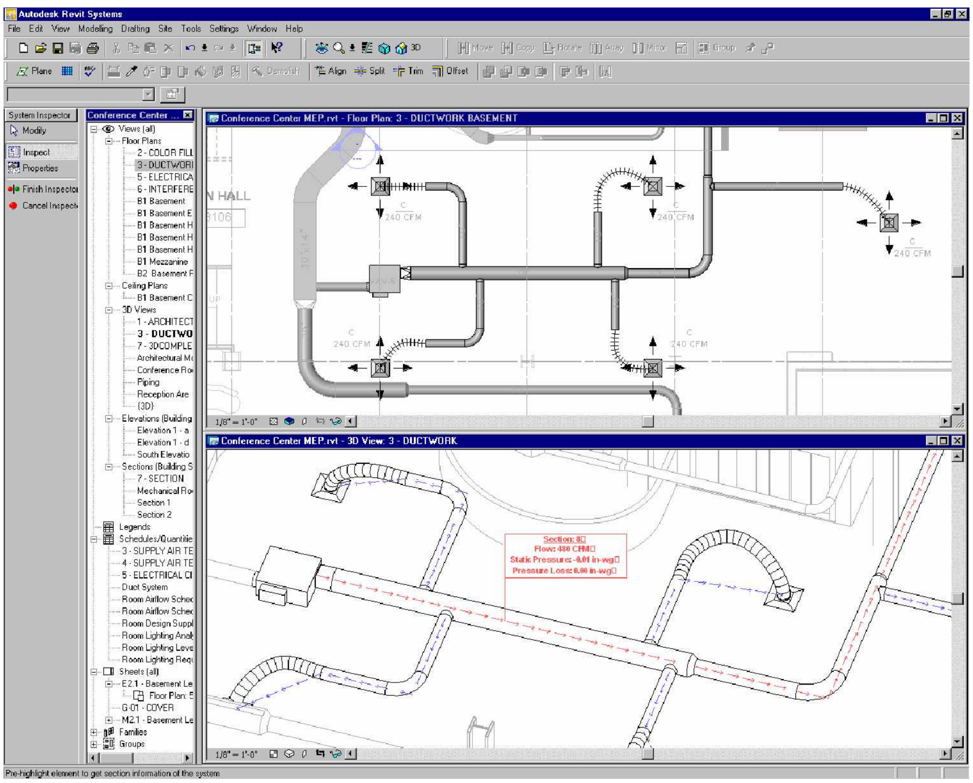

Figure 2

Revit Systems provides engineers with immediate feedback on their designs, such as displaying the critical flow path of a mechanical system (shown in the bottom view opposite).

Avoiding Interferences

Automatic interference checking during the design process is another valuable feature of Revit Systems. Typically, a building's architectural and structural systems are defined well in advance of its MEP systems, with only standard "rule of thumb" space allowances reserved for the latter. This sets the stage for inevitable conflicts between the area needed for those MEP systems and the overall cost of the building. In large building designs - such as hotels, high-rise apartment buildings, or intricate office complexes - squeezing the required MEP systems above the ceiling becomes particularly challenging.

The 3D modeling environment of Revit Systems helps the MEP designer overcome the challenges of fitting the required components into tight spaces, and then provides interference checking to detect collisions during the design process - reducing the risk of construction cost overruns.

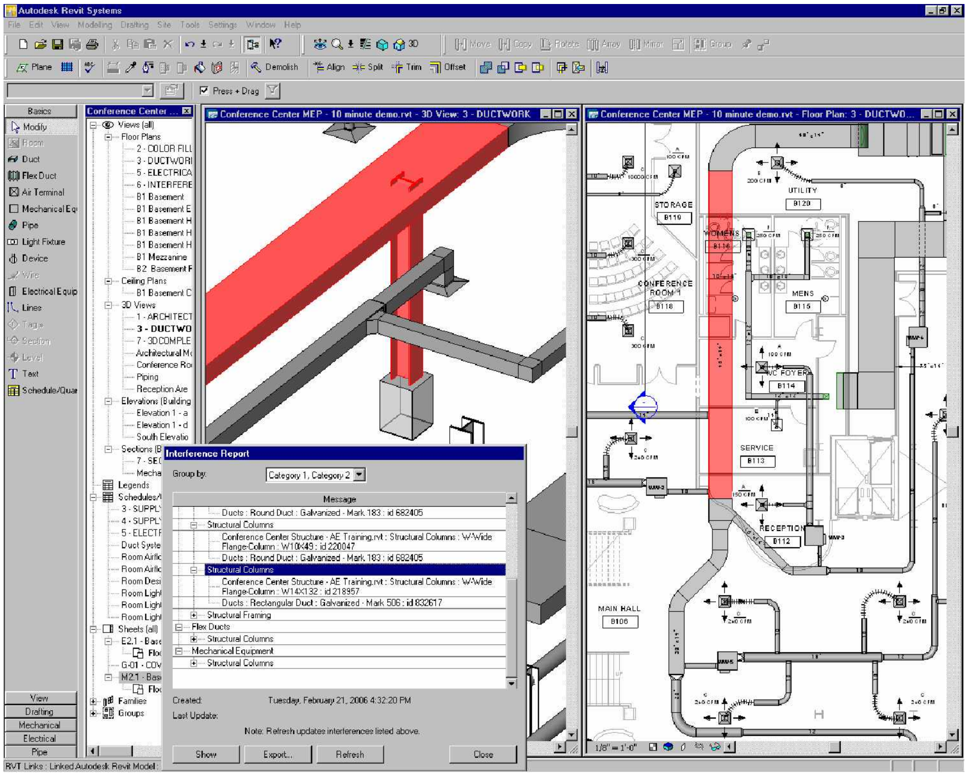

Figure 3

Revit Systems provides interference checking to detect collisions during the design process.

Green Design

Revit Systems also supports key aspects of sustainable design by facilitating complex processes and analyses. For example, Revit supports export to gbXML for use in third-party energy and heat load analysis applications. MEP engineers can use the information created in their computable Revit Systems building information model to test the performance of their design, eliminating the time-consuming task of transferring data manually.

BIM for Mechanical Design

Data-Centric Design

The data-rich, computable Revit Systems model is used to drive the MEP design process, with a host of tools to aid in the layout of mechanical ductwork and piping, and plumbing systems.

For example, Revit Systems enables users to perform many engineering calculations directly in the model; calculations like sizing mains, branches, or whole systems at a time, using industry-standard methods and specifications (such as the ASHRAE fitting loss database). System sizing tools are integrated with the layout tools and instantly update the size and design parameters of duct and pipe elements - without file exchanges or third-party applications.

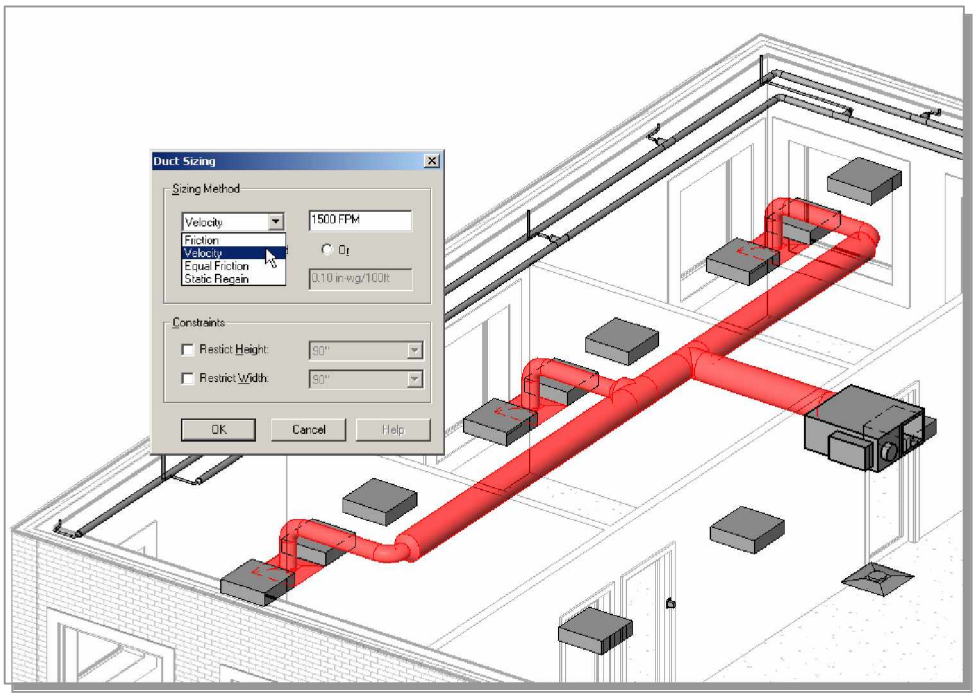

Figure 4

Revit Systems enables duct sizing directly in the model during layout.

Revit Systems automatically provides duct and pipe routing solutions between any two points. The routing path is constrained by the engineer, who selects fitting or connection preferences to meet specific design criteria. The software then finds and displays multiple routing paths - allowing the engineer to choose the option that works best for a design.

During the layout of the plumbing design, a user just defines the rise over run and the software automatically calculates invert elevations according to industry codes and tags them at the ends of pipe runs - minimizing the guesswork and manual calculation on sloped pipe. The software also automatically places all plumbing risers and drops - reducing the tedious aspects of system modeling.

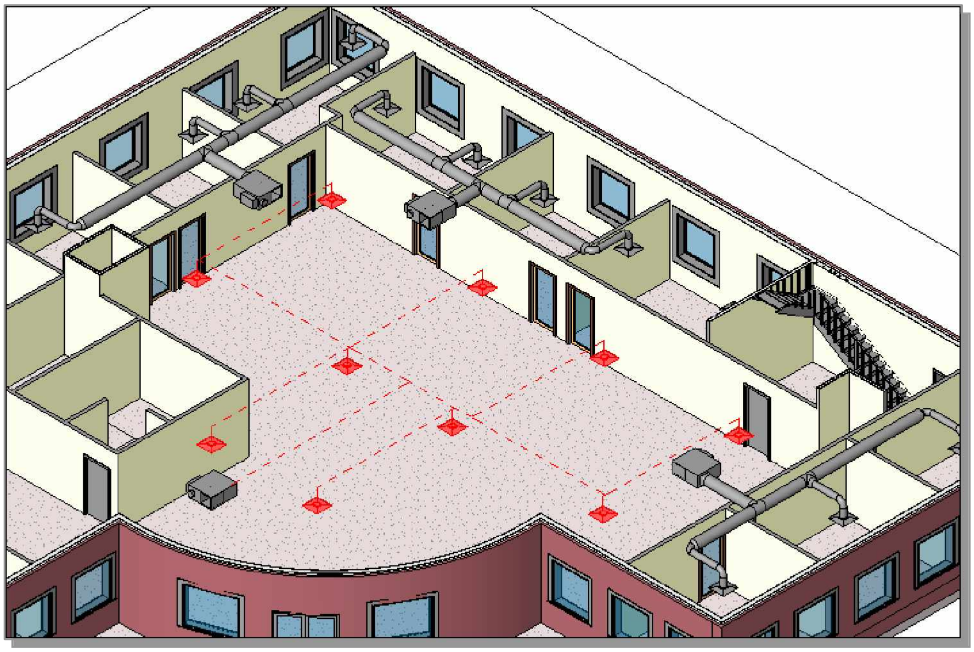

Figure 5

Revit Systems automatically provides routing solutions based on predefined duct preferences. To view routing solutions, the user selects any duct system component to identify the system and the software displays a series of temporary duct routing graphics (shown here in red).

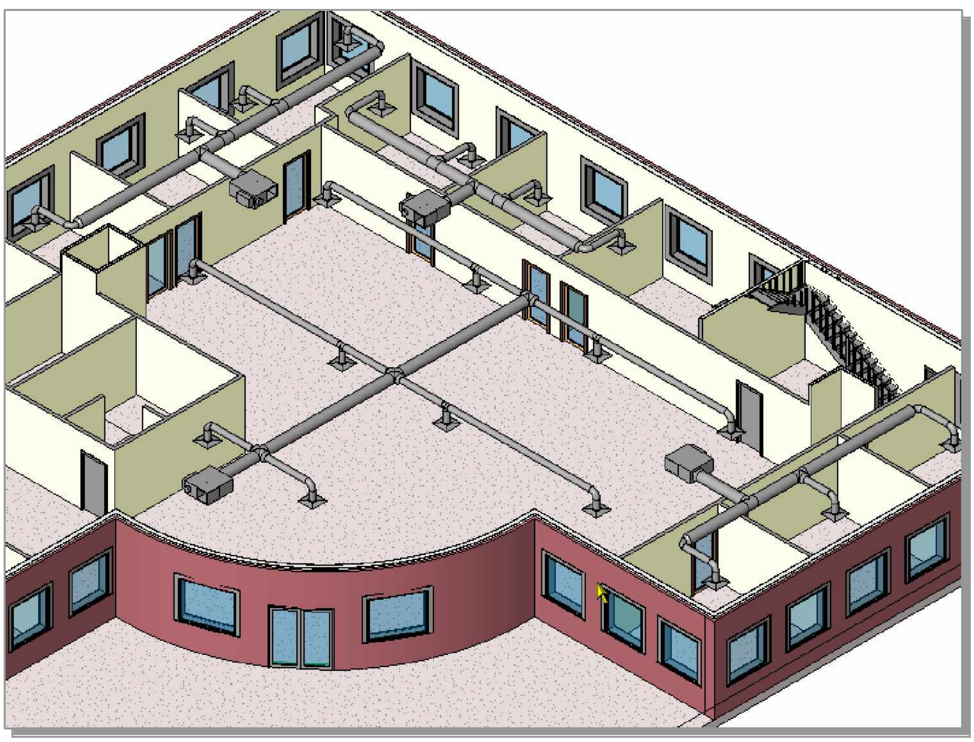

Figure 6

The user then views the various solutions for routing the ductwork, using arrow buttons to scroll back and forth through the solutions, and clicks Finish to select a specific solution.

Design Insight

The computable Revit Systems building information model is also used to give the MEP engineer feedback as the design progresses.

Ducting or piping can be color-coded by a design parameter (such as low or high pressure, fluid service, velocity range, flow rate, etc). This "live" visual representation of design data gives engineers instant insight into the design intent for a particular system.

The System Inspector displays the critical flow path for a duct run and provides a quick method for viewing the design specifications for each duct segment in a system. This feedback allows an engineer to quickly identify areas of the system with the highest pressure loss and then modify the design to optimize system performance.

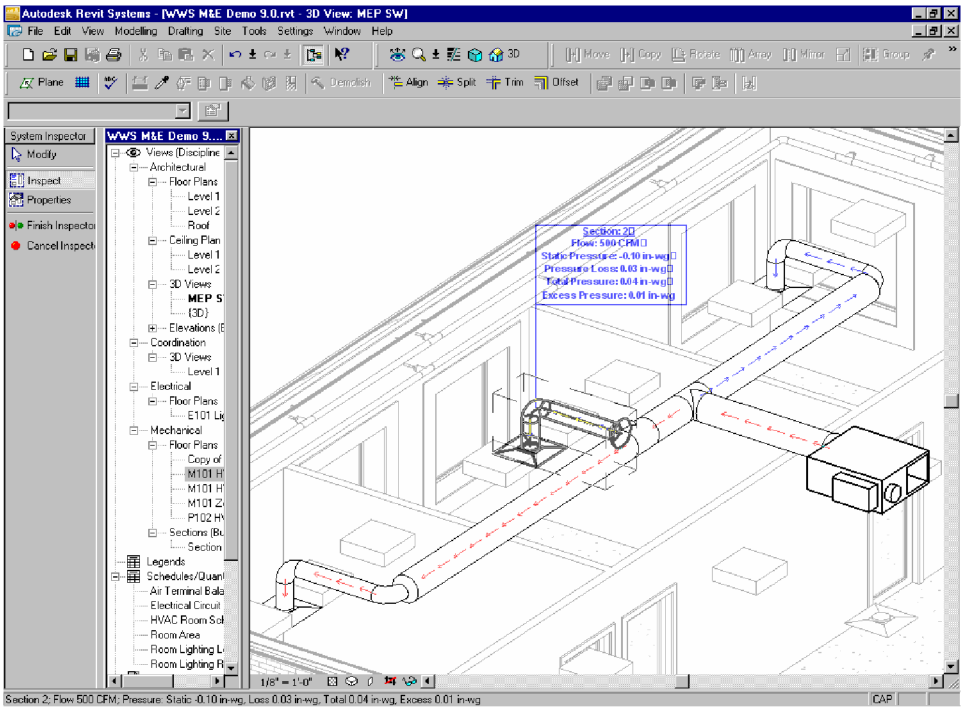

Figure 7

The System Inspector provides immediate design feedback.

As described earlier, Revit Systems detects clashes between any MEP system components (and when used in a Revit-based workflow, between architectural and structural elements from Revit Building and Revit Structure as well). Detection of interferences during the design process reduces costly field rework.

The computable model created by Revit Systems contains the necessary level of detail to enable direct engineering analysis. To facilitate that analysis, Revit Systems supports export via gbXML to industry leading gbXML third-party analysis applications, eliminating the manual transfer of data back and forth between modeling and analysis packages.

Increased Coordination

A major source of the mistakes and delays in building construction can be attributed to poorly coordinated design documents. In the Fifth Annual FMI/CMAA Survey of Owners - a 2004 survey conducted by FMI Corporation and the Construction Management Association of America (CMAA) - 70% of owners said they are seeing a decline in the quality of design documentation. For firms with slim profit margins, any rework costs exacerbate the bottom line - and MEP profit margins are notoriously slim (from 5% to 15% depending on the type of project).

A purpose-built BIM solution like Revit Systems automatically coordinates all design documentation - because views, drawings, schedules, reports and so forth are all "live" views of the same underlying database. The result is a dramatic reduction in documentation errors, producing an accurate design that requires less rework.

Revit Systems also allow the design and documentation of MEP systems to be done concurrently instead of serially, because project deliverables are created dynamically while the design work is being done. The production of design documentation requires less time and effort by the design team, increasing project throughput. In addition, a concurrent design and documentation effort tends to naturally increase project coordination, with team members working in real time on the execution of the design - minimizing the amount of information loss between participants.

Enhanced Communication

Revit Systems includes a variety of features that enhance project communication between team members, architects, clients, and contractors - including Revit Worksharing (described later in this paper), import/export features, and visual communication techniques.

During the design process, color-filled room plans can be used to visually communicate design intent. Rooms can be color-coded based on critical design parameters such as room types or airflow requirements. These color-filled plans are just another live view of the building information model and they update automatically whenever design changes are made.

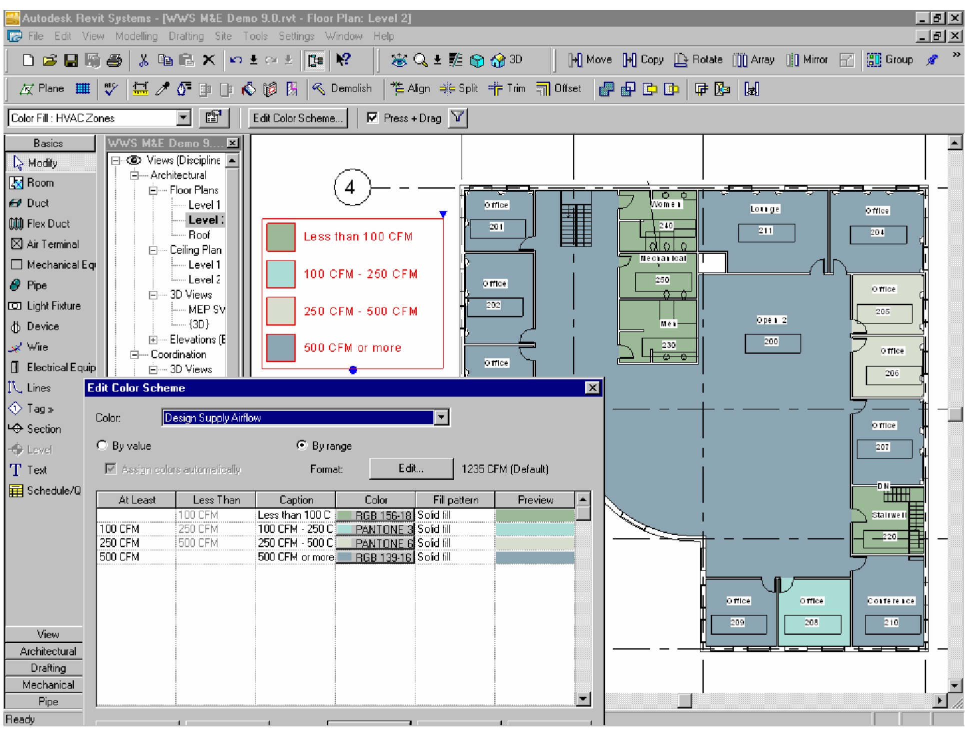

Figure 8

Color fill plans in Revit Systems are a visual representation of design intent.

Revit Systems can export to, import from, or link with a variety of CAD formats - including DWG™, DWF™, DXF™, and DGN. This assures compatible data exchange with software applications - as well as clients, architects and partners. For example, 3D DWG files output from Revit Systems can be used in Autodesk® VIZ or Autodesk® 3ds Max® software to create photorealistic renderings of a building's MEP engineering designs for enhanced communication with clients or team members. Similarly, DWF files output from Revit Systems can be used in Autodesk® Design Review software to facilitate the review process.

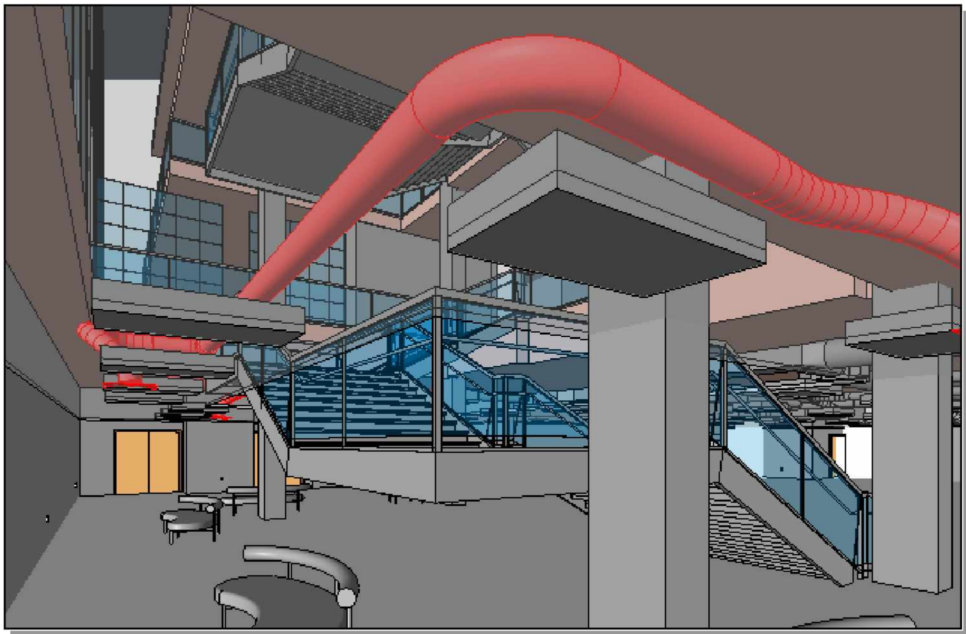

Figure 9

Revit Systems can quickly generate realistic rendered views of a building model.

Revit Systems can also read and write ACIS® solids, which gives users a way to import and export Revit Systems models to and from AutoCAD® or Autodesk® Architectural Desktop. This method can be used to cut sections and perform visual interference detection.

Finally, users can easily upload files from Revit Systems to an Autodesk® Buzzsaw® site for web-based collaborative project management. Added functionality even allows for automatic conversion of Revit Systems files to either DWG or DWF format.

BIM for Electrical Design

As explained earlier in this paper, a computable building model captures the functional relationships between building elements and systems. Architectural, structural and MEP elements all "know" what they are, how to interact with each other, and their role within a larger system. A computable building model is of particular importance for electrical design.

For the building mechanical design discipline, defining and understanding the physical relationships of building elements (i.e., the location, size and relationship between building components in 3D space) is as important as being able to model and get feedback on how the system functions (i.e., how much air flow should/can be delivered to a space and the pressure required to move that air through the ducts).

For the building electric design discipline, physical modeling takes a back seat to system modeling. Wires aren't actually routed in the model - that's left to the contractor on site. The only things physically modeled are electrical devices and equipment such as lighting fixtures, transformers, generators, panel boxes, etc., whereas system modeling is of the upmost importance. Are there any devices not assigned to a circuit? What is the number and types of circuits? Is there adequate power and light for the space to be used as intended?

These design considerations and calculations form the basis of the electrical engineer's challenge. The computable Revit Systems model is a perfect environment for this type of data-centric system modeling.

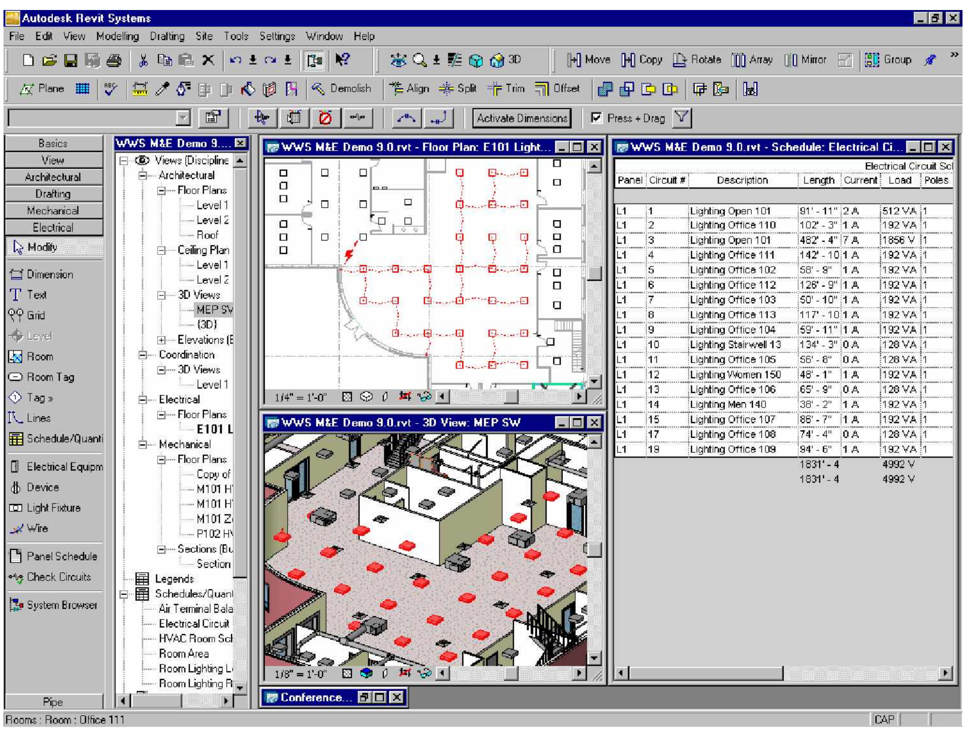

Figure 10

Revit Systems enables electrical system modeling within the context of the entire building model for optimized system design and to help ensure design coordination.

System Modeling

With Revit Systems, electrical engineers model the power and lighting circuitry of the building spaces. During system modeling, the user places light fixtures, power devices and equipment in the model, then creates a circuit connected to a distribution panel. The user defines wire types, voltage ranges, distribution systems, and demand factors to ensure the compatibility of electrical connections in the design and prevent overloads and mismatched voltages.

The resultant circuit model allows users to calculate the estimated demand loads on feeders and panels, and then use these loads to adequately size equipment in the design environment. Load balancing is made easy when managing circuits; with the click of a button users can balance electrical loads between the buses on their panels. Built-in circuiting tools also allow users to total loads and generate reports for accurate documentation.

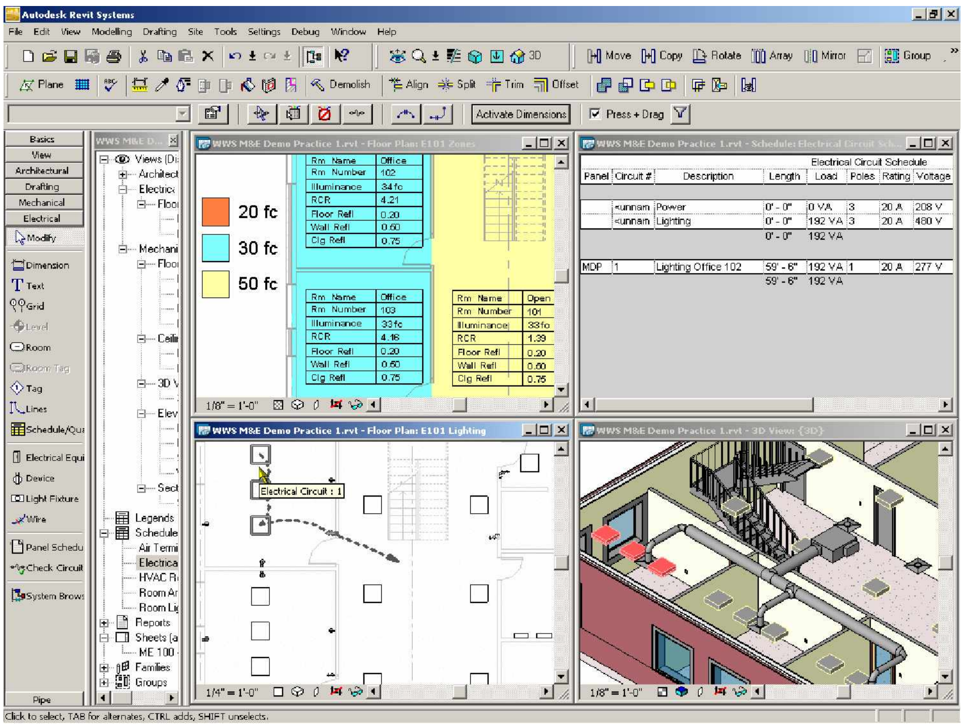

Figure 11

Revit Systems allows electrical engineers to model the power and lighting circuitry of the building spaces.

A System Browser lets a user check the continuity of an electrical model to identify orphaned elements that are not connected to any system, making sure that system elements are properly connected and contribute to system load requirements for optimized circuitry. Once the circuits are defined, Revit Systems automatically "wires" the electrical devices by placing annotation that includes the homerun to the panel assigned to the circuit.

Built-in electrical calculations enhance the system design with engineering data, providing design decision support from the building model and reducing the burden of manual calculations. For example, Revit Systems can automatically estimate lighting levels in rooms based on the lights placed in the space, excluding daylight. The user just defines the reflectivity values of the room surfaces, attaches industry-standard IES data files to lighting, defines the calculation workplane height and the system automatically calculates the average estimated illumination value for the room.

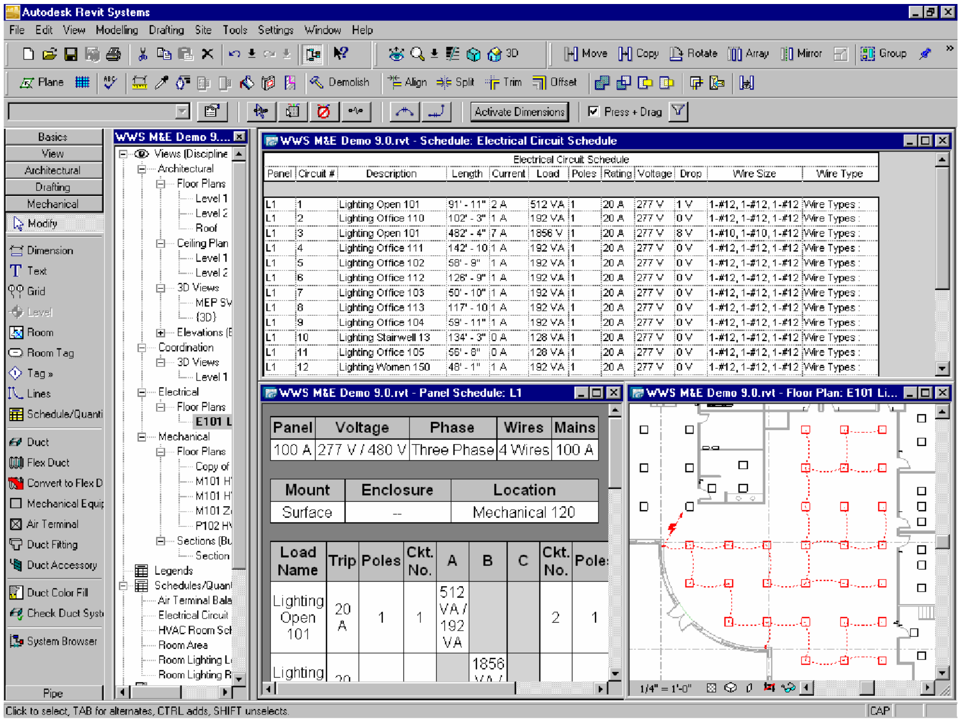

Figure 12

Revit Systems automatically places wire directly in the model as annotation during layout.

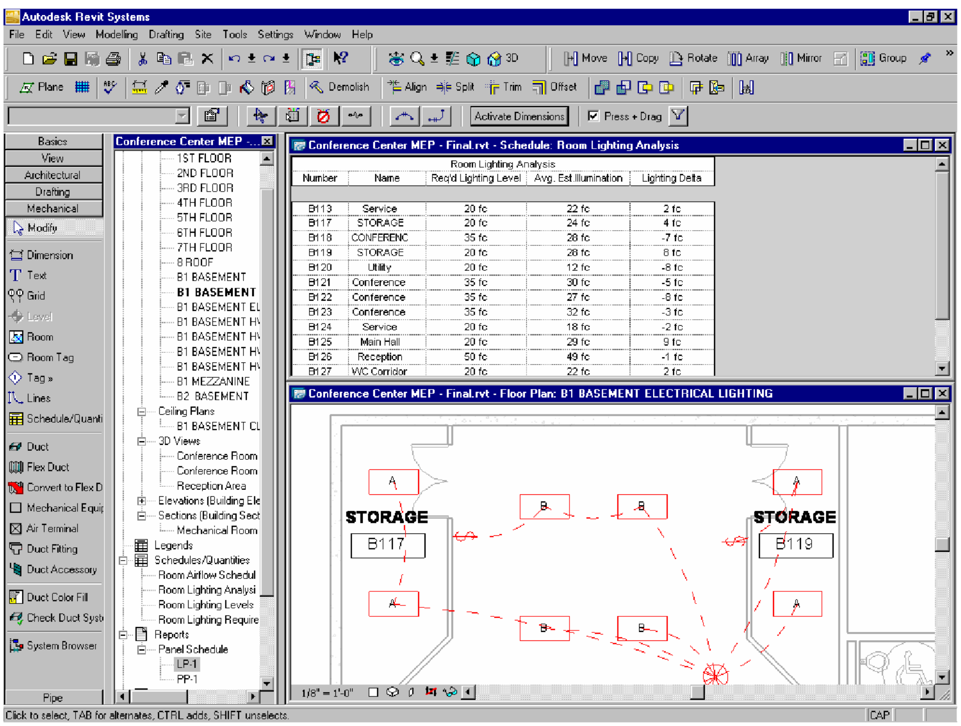

Figure 13

Revit Systems automatically calculates the average estimated illumination value for a room based on predefined electrical parameters. The calculated illumination values can be scheduled in a report for design documentation.

Increased Coordination

Coordination between a building's electrical and mechanical systems is critical, as one powers the other. The data-centric approach of Revit Systems provides engineers a holistic view of the building model and systems. For examples, a user can review the electrical requirements on mechanical equipment, and configure voltage and power load requirements to dynamically update in panel schedules.

In addition to building model and system coordination, a purpose-built BIM solution like Revit Systems automatically coordinates all design documentation as well. Like all Revit platform solutions, drawings, sheets, views, schedules, reports and so forth are all "live" views of the same underlying database. Therefore electrical documentation such as electrical plans and panel schedules are always consistent.

Panel	Voltage	Phase	Wires	Mains
100 A	277 V / 480 V	Three Phase	4 Wires	100 A

Mount	Enclosure	Location
Surface	--	Mechanical 120

Load Name	Trip	Poles	Ckt. No.	A	B	C	Ckt. No.	Poles	Trip	Load Name
Lighting Open 101	20 A	1	1	512 VA / 192 VA			2	1	20 A	Lighting Office 110
Lighting Open 101	20 A	1	3		1856 VA / 192 VA		4	1	20 A	Lighting Office 111
Lighting Office 102	20 A	1	5			192 VA / 192 VA	6	1	20 A	Lighting Office 112
Lighting Office 103	20 A	1	7	192 VA / 192 VA			8	1	20 A	Lighting Office 113
Lighting Office 104	20 A	1	9		192 VA / 128 VA		10	1	20 A	Lighting Stairwell 130
Lighting Office 105	20 A	1	11			128 VA / 192 VA	12	1	20 A	Lighting Women 150
Lighting Office 106	20 A	1	13	128 VA / 192 VA			14	1	20 A	Lighting Men 140
Lighting Office 107	20 A	1	15		192 VA / 0 VA		16			
Lighting Office 108	20 A	1	17			128 VA / 0 VA	18			

Phase A	Phase B	Phase C	Total VA
1408 VA	2560 VA	832 VA	4800 VA

Mfg. / Type	Modifications	Amps RMS. Sym.
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Figure 14

Revit Systems automatically creates panel schedules, such as the one shown opposite, and automatically coordinates all design documentation such as this.

Enhanced Communication

As described earlier in the building mechanical design section, Revit Systems includes a variety of features that enhance project communication: distributed building information modeling via Revit Worksharing, import/export features, visual communication techniques, etc. This is equally important for electrical designers and all the same Revit Systems features apply. For example, electrical designers can export their Revit Systems model to Autodesk VIZ to produce photorealistic lighting renderings or upload their files to an Autodesk Buzzsaw site or export their design to a CAD format to share with a client.

Figure 15

Electrical designers can use building information modeling to study lighting levels and design directly in Revit Systems, or export to Autodesk VIZ for realistic lighting visualizations such as the image shown here.

Inside a Revit-based Design Team Workflow

Since Revit Systems is built on the Revit platform, coordination between MEP team members using Revit Systems, architects using Revit Building, and structural engineers using Revit Structure is streamlined.

The architectural spaces created using Revit Building can be used by Revit Systems to support load calculations, track airflow in rooms and coordinate panel schedules. The architectural and structural elements created by (respectively) Revit Building and Revit Structure can be used to uncover potential conflicts with MEP system components early in the design process.

Well-established processes for worksharing amongst Revit users equally apply to MEP engineers using Revit Systems. Revit Worksharing distributes the power of the parametric modeling environment across a project team, providing a complete range of collaboration modes to suit the workflow and requirements of the parties involved, including the following alternatives:

1. On-the-fly, simultaneous access to a shared model between architects, structural engineers and MEP engineers.
2. The formal division of the project into discrete shared worksets that are reserved for editing by a single user at a time (such as "floor_1_architectural", "floor_1_structural", "floor_1_mechanical", "floor_1_plumbing" and so on).
3. A complete separation of project elements or systems into individually managed but linked building information models.

File linking works like the External Reference (xref) capability in AutoCAD software, with the added capability to monitor and update specific key elements that are shared in the design process. Worksharing offers the additional ability to propagate and coordinate changes between designers, documentation and disciplines.

A user works independently in a workset, periodically posting changes back into the master project file and refreshing the workset with changes from other users. Worksets can be displayed as needed, avoiding the memory-intensive display of parts of the building model that aren't necessary for a specific design activity. For example, an electrical engineer may want to constantly view the architectural workset, but toggle the visibility of the structural workset on or off to suit his design needs. Standard model-viewing mechanisms are supported for worksets, allowing the MEP engineer to create drawings that include any elements from the shared models.

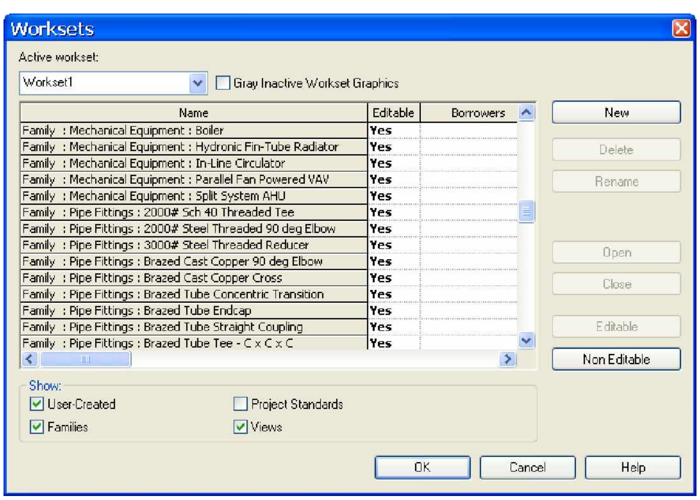

Figure 16

Revit Worksharing streamlines coordination between MEP team members using Revit Systems, architects using Revit Building, and structural engineers using Revit Structure.

Summary

Autodesk Revit Systems offers MEP engineers advanced functionality for building electrical and mechanical design. The computable Revit building model allows firms to create, manage and share design information more effectively - contributing to increased profitability, reduced risk and fewer inefficiencies in building design. Parametric change management helps eliminate coordination errors in documentation sets, and minimizes coordination errors between engineering design teams - as well as architects and structural engineers within Revit-based workflows.

Firms can finally transition from a workflow based on 2D drafting to the holistic approach of integrating whole systems in a 3D digital environment, facilitating digital information sharing for engineering analysis and digitally-driven design for buildings.

Consider these comments by Bob Gracilieri, President and CEO of SEi Companies, a mechanical, electrical, plumbing, and fire protection firm known for working in sophisticated environments on complex projects. "BIM brings a new dimension to the way MEP firms can do business," reports Gracilieri. "It allows us to get out of the commodity mode and offer a value proposition service to our clients. It will change the whole culture and image of our industry."

About Autodesk Revit

The Autodesk Revit platform is Autodesk's purpose-built solution for building information modeling. Applications such as Autodesk Revit Systems, Autodesk Revit Structure, and Autodesk Revit Building built on the Revit platform are complete, discipline-specific building design and documentation systems supporting all phases of design and documentation. From conceptual studies through to detailed documentation and scheduling, applications built on Revit help provide immediate competitive advantage, better coordination and quality, and can contribute to higher profitability for engineers and the rest of the building team.

At the heart of the Revit platform is the Revit parametric change engine, which automatically coordinates changes made anywhere — in model views or drawing sheets, schedules, sections, plans… you name it.

For more information about building information modeling please visit us at *http://www.autodesk.com/bim*. For more information about Autodesk Revit Systems and the other discipline-specific applications built on Revit please visit us at *http://www.autodesk.com*

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