Using **BIM** to transform MEP design

A WHITEPAPER BY PROGMAN

MagiCAD

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Introduction

In our last whitepaper we discussed **Understanding BIM in the Age of Digitisation**. The paper covered how digital models have become the accepted methodology of the construction industry, and why it's beneficial for all parties to adopt BIM.

We discussed the idea of Failing Fast as applied to construction. The only way to Fail Fast is not with bricks and mortar – it's with a digital twin of the building – only fully realised with a BIM model.

In this complementary whitepaper we'll delve further into how BIM defines the design, construction, and usage phases, specifically for the MEP (mechanical, electrical and plumbing) facets of the project.

Demands of BIM

While adopting BIM for the first time may involve a new capital expenditure, the promise of BIM is that, over time, it reduces the overall lifecycle cost of a building.

Furthermore after BIM is used for a first project, the necessary tools, procedures and know-how will be already in place for the next project. Good practices and co-operation with other stakeholders come as a standard in all projects. This is true even if they are not needed in all projects yet.

The basic demand is to have a building completed in a fast and cost-efficient way, on time. Luckily today, we are looking further into the future. Construction projects must now take into account sustainability and environmental impact. It is widely understood that a building's "cost" in terms of financial and environmental resources bound far into the future, beyond just the construction phase.

With this forward-looking approach, the end user's needs are taken into account sooner. Knowing what end result will satisfy all parties' needs is better understood nowadays. It also decreases the environmental impact of a project, when the number of changes is decreased.

With this complex web of demands weighing on the project stakeholders, adopting BIM is the simplest and most effective means to achieving a positive outcome for the lifecycle for the project.

With BIM we can reach an end result that will satisfy the needs of all parties and, over time, reduce overall lifecycle costs of a building

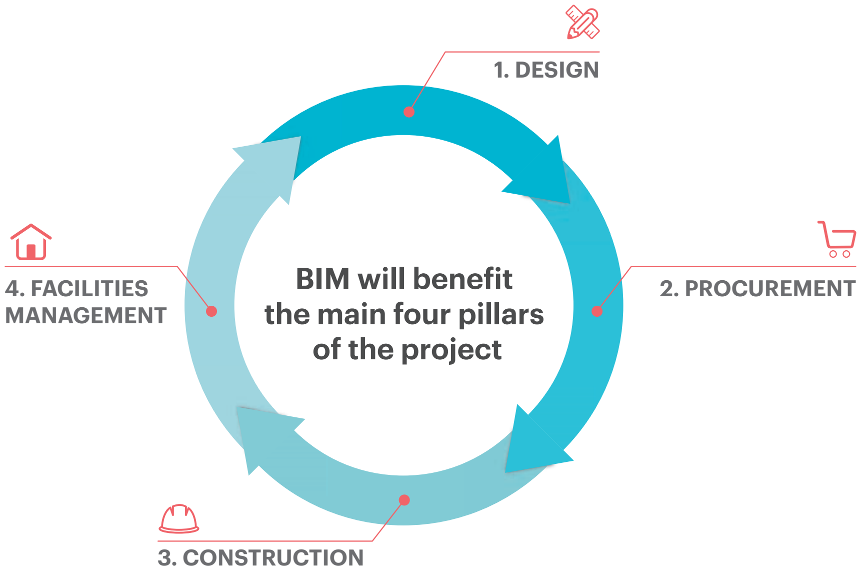
Adopting BIM means:

Reducing costs throughout the business processes
Via a rapid exchange of design information – different scenarios can be explored faster, allowing for more iterations. The outcome? A more robust design and a more efficient decision-making processes overall.

Saving time in documenting the decisions

- All drawings can be captured in one comprehensive model in 3D format, keeping them all together in a single environment, rather than relying upon individual 2D drawings
- The production of necessary engineering calculations can be done quickly and easily
- All geometric and spatial data required to perform energy calculations are produced directly from the model
- The demands of being able to demonstrate environmental compliance are eased; reducing the building's lifecycle costs
- Integration of cost (5D) and scheduling (4D) data enables online cost estimation and visualisation of the construction, over time
- Accurate Bills of Quantities are produced directly from the model. The data required to control procurement can be linked directly from the model, optimising the whole procurement process
- Integrating interoperability further into the BIM environment
- The detailed model contains all data and geometry required for installation of the MEP systems
- Once the building is completed, the next version of the model will inform all facilities management (FM) decision-making and systems, including linked data specifically for FM.

In summary
BIM enables the 3D model to develop during the lifecycle of the building. As the project progresses, the linked data in the model grows and the stakeholders can access to data that is relevant for each specific phase – design, procurement, construction, Facility Management. The end-goal is a building that meets the needs of the people using it. We will explore these four areas in detail in the following sections.



1. BIM in design

When completed, buildings need to offer an optimal space for their purpose.

Design is still a phase in the construction project, but this is changing. A good design adapts as it gathers input from all stakeholders. Financial targets, usage demands, engineering possibilities, costs, and other factors will impact the final design. Optimal design demands contribution from all stakeholders, a meaningful collaboration method, and willingness to reach common goals. BIM enables this.

Space requirements for MEP design
MEP designers are tasked with taking the digital model, and ensuring that space requirements are met for ducts, pipes, technical rooms, switchboards, and the large units such as air handling units. The main positions and sizes of shafts, technical rooms, and main units can be estimated and even optimised using the information in the model.

The model will enable the study of alternative designs. For example, the digital model of a hospital can be reviewed by a nurse, a surgeon, a doctor to ensure that the spaces are optimal for their purposes. Revisions can also be made if it is determined that a space is inadequate. Importantly, these revisions are made in the building's digital twin, during the design phase, rather than after the construction has begun, costing multiple times more.

As the design progresses and the model becomes more stable and accurate, more exact routes can be designed, using precise dimensions of ducts, pipes and cable trays. This avoids collisions and provides the needed builder's work openings for main routes.

Energy analyses

The digital BIM model also provides information for initial energy analyses. Predictions of the consumption of energy can be determined. The model can be revised to lower energy consumption or to determine where fixes are needed. Later on, estimated energy analysis can be validated against actual performance - or measured consumption.

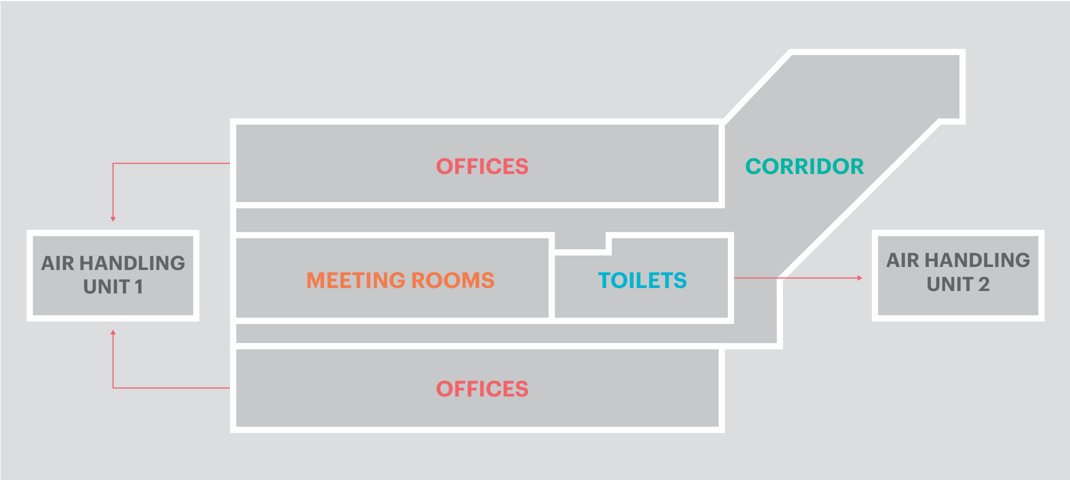
According to World Watch Institute data, buildings are responsible for the annual consumption of 40% of the world's energy[1].

Architectural decisions such as site selection and building orientation have huge impacts on the overall energy efficiency of a building, but the MEP design can impact energy consumption through the whole lifecycle of the building. It's not just heating and cooling systems that determine a building's energy usage; for example, well-designed duct and pipe systems have lower pressure loss, equating to lower energy consumption. Also MEP systems that work only on-demand have the same affect. Well-designed electrical systems will have lower loss, and use less energy.

The internal layout of a building's rooms can have great impact on areas that need to be heated or cooled. Noise level, lighting level, and motion of airflow through the building are all factors that the BIM model can determine. The switchboards can be modelled as close as possible to the rooms that will use the most electricity. This reduces the load on electrical networks.

Different network solutions, dimensions and routes can be calculated for finding the optimised solution by space and energy (including pressure loss, voltage drop causing energy consumption, etc.).

The latest energy efficient systems can be accounted for in the BIM model: passive solar heating systems, photovoltaic elements, geothermal heating or daylighting systems.



[1] Source: Energy-Efficient Building Design in the Context of Building Life Cycle, by Izzet Yüksek and Tülay Tikansak Karadayi

Optimising of space and network design
One example of how MagiCAD cooperates with selection tools that are provided by a third party includes DIALUX.

With this free software you can design, calculate and visualize the lighting professionally for single rooms, whole floors, buildings and outdoor scenes. DIALux is used as a planning tool by more than 680,000 lighting designers worldwide. DIALux constantly undergoes further development and meets the requirements of modern lighting design and lighting calculation. It enables planning and design, using the electronic luminaire catalogues of the world's leading luminaire manufacturers. Models can be superimposed on MagiCAD data of other architectural programmes to create customised lighting design.

MagiCAD enables exporting from Revit to DIALux. After the lighting design is made in DIALux and the luminaires have been selected, they can be imported back into the correct space and position in the MagiCAD for Revit model, with all the technical information available. At the same time, a 2D symbol can be added to a luminaire from one of the localised symbol libraries inside MagiCAD.

Selection of products
Products can be entered into the BIM model complete with the manufacturer's technical data. Not only downloadable BIM objects, the products may be selected from among hundreds or thousands of variants. MagiCAD's own selection tools or third party selection tools may be a big help in this process. The products that require configuration can be done so, to meet all demands, for example, AHU configurators.

Calculations
Using the BIM model, calculations can be run using true objects and their manufacturer's technical specification data. The data-rich model can ensure the completion of exact network dimensioning, ventilation system balancing simulations, and exact sound calculations. It's critical that these calculations can be run in a digital model, where tweaks and revisions can easily be made, based upon robust data inputs.

The local area standards offered by MagiCAD (UK, EU, German, etc) ensures that these calculations are relevant to the project's region. These local standards are only available for the MEP design module in MagiCAD, not in the basic Revit or AutoCAD software.

"If calculations aren't based on real products, then they are just estimations," said Pauli Keinonen, Technical Director for MagiCAD at Progman.

Cost estimation
The estimated cost of the building materials can be constantly assessed, using the BIM model populated with authentic manufacturer's information, for every element of the MEP design. The total cost of installation can be estimated, when objects are also linked to local work costs.

Importantly the BIM model can inform changes to cost estimation. If certain changes are made to the design, how does it impact the current overall cost of the project?

Coordination and Collaboration
By enabling the various stakeholders to communicate more effectively, the BIM model means that changes to the model become proactive rather than reactive – solving problems before they happen.

One example would be whether openings are in the right place. The MEP designer will require placement of openings for pipework and so on. This information can be instantly sent to the structural engineer using the BIM model, to ask whether it's ok to have holes in a particular slab, or whether that structure needs to remain intact because there are necessary steel supports there.

2. BIM in Procurement

After many iterations and revisions the design phase can be completed, moving onto the necessary procurement of building materials.

It's important to understand that the construction industry is a huge source of landfill waste. Up to 40% of all solid waste in the US, for example, comes from building projects.[2]

BIM can have a dramatic impact on reducing material waste. Quantity take-off or, how much material is needed to construct the building, can be based upon the 3D BIM model – a far more accurate interpretation than a 2D drawing.

By establishing an accurate procurement process, the building's sustainability can be dramatically improved. It can result in less wastage of energy, resources, and travel time to obtain all the building materials, resulting in significantly lowered carbon emissions.

[2] "4 BIG ways the IoT is impacting design and construction," by Jacqi Levy, IBM IoT blog https://www.ibm.com/blogs/internet-of-things/4-big-ways-the-iot-is-impacting-design-and-construction/

3. BIM in Construction

During construction phase, the first fruits of BIM collaboration are ripe to be picked.

BIM collaboration during design and procurement phases, enables the contractor to find the most cost-efficient way to build and the MEP designer the most optimal ventilation, heating, plumbing and electrical networks. Combining these viewpoints is critical for completing a building successfully.

Scheduling

Planning and scheduling of construction activities helps engineers to complete the project in time and within budget. Errors or delays in scheduling can result in high costs. For example, a bad scheduling of people and material delivery can cause highly-paid specialist workers to remain idle on-site while waiting for material to arrive, unable to complete their tasks. Space is a consideration as well. Many sites have a limited space for storing construction materials and therefore careful planning of timing, order and amounts delivered is needed. BIM software using information in the BIM model will inform the construction managers about each step of the construction project.

Explaining the four pillars of the BIM project

BUILDING PROJECT

- Project team gathered
- Collaboration on conceptual design with input from all parties
- BIM model ready
- Detailed architectual, structrual and MEP design

- Cost estimate
- Tender and supplier selection
- Time-table
- Purchase schedules

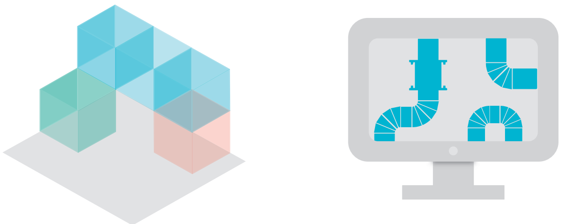
- Scheduling
- Prefabrication
- Logistics
- Built

- Complete virtual building provided to owner
- Operation and maintenance
- Renovation

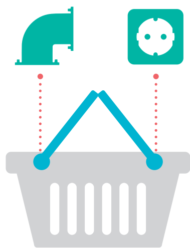
1. DESIGN → **2. PROCUREMENT** → **3. CONSTRUCTION** → **4. FACILITIES MANAGEMENT**

MEP DELIVERABLES

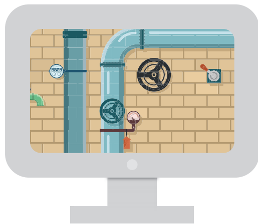
- Engineering system concept
- Requirements of spaces of MEP systems
- Space requirements of tech rooms and main routes
- Energy analysis
- MEP calculations and simulations based on intelligent product information
- Requirements for builders' work openings
- VR for design coordination and feedback
- Detailed 3D MEP network models



- Quantity take-off MEP components from the 3D model
- Requirements of main units and other components



- MEP model used in prefabrication
- VR MEP model used for coordination and accurate installations on site
- VR used for tenant feedback



- MEP systems optimised based on actual usage
- Energy savings by using MEP systems on demand
- Maintenance needs
- Information for better design in coming projects

Prefabrication
A huge trend in construction is emerging in pre-fabrication of entire buildings or elements of buildings. In a factory, elements can be constructed using tried-and-test methods of lean manufacturing – this would be far more challenging to achieve on a building site.

MEP systems are no different; tailor-made products and networks of products are seen more regularly. Pre-connecting some MEP elements and installing them as packages is now a mainstay of a build. It all helps the build meet strict time-sensitive deadlines.

Furthermore, products can be pre-adjusted before coming onsite. All of these decisions can be informed by the data-rich BIM model.

Using pre-fabricated elements, the materials can be brought to site on the day they are needed. The project can, in a way, be put together like modular building blocks.

Examining Virtual Reality applications to BIM
Augmented or virtual reality elements can be drawn into a BIM model, enabling 'next-generation' techniques that deliver whole new levels of efficiency. Virtual meetings can be held between various players in the build (architect, contractor, MEP designer).

"With our BIM software MagiCAD for Revit, it is possible to design the building's ventilation, piping, electrical and sprinkler systems using real MEP products and components from over 250 international manufacturers, with each product including full technical product data. This means that, for example, each duct, air terminal and air handling unit in a ventilation system designed with MagiCAD automatically integrates the accurate and manufacturer-verified geometry and product data based on the actual, real-life products. Nowadays also the users of native Autodesk Revit can access and download many of these products to their projects using our online BIM object library MagiCloud", comments Pauli Keinonen, Technical Director for MagiCAD at Progman.

Once the MEP design is completed using MagiCAD, the data will all be contained with the Revit project. At this point, various VR rendering plugins for Revit can be utilised, such as Enscape.

"When the model has been rendered into a format suitable for VR, VR technologies can be utilised as part of project coordination meetings, allowing the participants to see in practice how the MEP systems have been routed inside the building, how the routing fits to the available spaces and also to examine alternative approaches to solving specific problem spots in the system's design," said Keinonen.

VR opens the possibility of gaining real feedback from a building by its end-users, before the building exists. Using VR headsets, in the case of a hospital, a doctor or nurse can "walk-through" their space, flagging up problems where spaces aren't suited to purpose.

VR also opens up the potential of time-flagging in construction. The processing power of VR is moving so swiftly forward, by the time of publication of this whitepaper advances will be made. Once it's possible to reliably match the building's MEP elements against actual coordinates of the space, it will also be possible to do a VR walk-through of installed elements. Not only can it be seen how to install an MEP element correctly, but it can also be seen when in the schedule the install needs to happen, to relate to the spaces and objects being installed around it.

In one quick glance a building's installed elements could be viewed in VR, and matched against the scheduling timeline, to see if the installation is happening on-time.

"This would mean a leap forward in terms of utilising the time dimension of BIM," said Keinonen.

4. BIM in Facilities Management

FM covers 70% of the cost of a building over its entire lifecycle. Thus, the true cost-savings potential of BIM is unlocked once the building has breathed life – when people are living and working inside the space.

No building is a finished product at the end of construction – buildings are constantly changing, being updated, as they're used through the years. By their very nature buildings are in place to serve people's needs for as long as possible – maybe for centuries - but people's needs never remain stagnant. Our needs are always changing with time, and so facilities management needs to be informed by the most robust data and the most accurate 3D models.

The smart buildings of today are fitted with intelligent sensors. MEP systems can always be optimised based on actual usage once the construction is finished. Energy saving can be achieved using the system on demand.

For example, lights in a bathroom will go on automatically, only when a person walks in. Ventilation sensors can be fitted in large open spaces, like an auditorium or concert hall. The ventilation will increase as people walk in, and turn down when people are leaving. Sensors can pick up changes in lighting so if the lights go dim, the bulbs can be changed before they blow.

The full promise of VR can be achieved when these sensors are connected via IoT (Internet of Things).

"At the same time, VR can make it easier for the maintenance personnel to find the device in need of maintenance by showing directions to the device. Also, for example with a control valve in a piping system, VR can provide them with all the needed product-specific specifications, real-time data on the current operation of the valve based on the sensors, and even advise on the optimal settings for the valve. This can all be linked in the smart buildings of today." concludes Keinonen.

24-HOURS IN A SMART BUILDING

5 AM

Manager arrives for a global call

Sensors detect car and exterior lights go on

Security system grants access

Lights on

HVAC system adjust airflow + temperature

10 AM

Meeting in the conference room

Lights on when people arrive

Temperature adjust, depending on the number of people

1 PM

Sun pours in through south-facing windows

Daylight harvesting dims lighting

6 PM

Most of the building is empty

Following a schedule, lights off, except where occupancy is detected

OVERNIGHT

Zzz

When nobody is in the building

HVAC, lights + security all setback

Soruce: Based on Honeywell, 24-hours in a smart building by Sara Glassman

The end product

When a building is completed, everyone in the build should be happy – the owner, the users, the service and facilities managers. The designers and contractors should know they have delivered a project on-time and on-budget.

"If the end-result isn't good, it doesn't matter if a project saved time and cost. MagiCAD is about helping to build better buildings. Quality is paramount and standards are purposely set high. "

Pauli Keinonen,
Technical Director for MagiCAD

ABOUT PROGMAN | Progman specialises in software and services for the building industry. Our popular Building Information Modelling (BIM) software, MagiCAD, offers powerful Mechanical, Electrical and Piping design functions and integrated engineering calculations for Revit and AutoCAD. It is used by more than 3 800 companies in over 80 countries around the world. In addition, our online BIM library, MagiCloud enables access to over 1,000,000 manufacturer-verified products from 250 globally renowned manufacturers. Each product is complete with accurate dimensions and comprehensive technical data.

With more than 35 years of experience in the industry, our team of passionate software professionals continues to provide our customers with intelligent solutions that make daily engineering and design easier, faster and more profitable. Progman is a Glodon Group company.

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