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**Assignment Title - BIM as a whole life process and a
Building Management Tool**

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BIM as a Whole Life Process and a Building Management Tool.

Technical Case Study Report.

Introduction

In this case study we will be looking at how the UWTSD SA1 Campus Building Information Modelling (BIM) has been adopted, and critically analyse and assess the process that has been followed. This will be broken down into three key areas of discussion. Firstly, we will look at the 'As Designed' versus the 'As Built' models provided by the main contractor. Secondly, we will evaluate how the Facilities Management (FM) team have utilised the BIM output from the main contractor to highlight opportunities and the challenges that will be associated with the maintenance and management of the estate. Finally, we will look at how the use of BIM technologies can be integrated into BMS to increase the energy efficiency of the estate, suggest improvements through examination over time and help manage these improvements for the whole lifecycle of the property / asset.

“One of the problems in the architectural engineering and construction (AEC) sector is that there are so many different professionals working on different parts of the project (structure, services, design, distribution ... etc.) following a fragmented method of management. Each of these parts must be based on a common “idea” and follow the same criteria of others, they are the key part of information that, all together, allow the possibility to create the project. If information is not accurate and exactly enough, the next stages will be affected by it.” (Abd & Abd, 2014; Tauriainen, Puttonen, & Saari, 2015). Therefore, the lack of appropriate documents, change orders and as a built drawing for existing buildings is very common.

“The fundamental hypothesis of BIM is collaboration by different stakeholders at different phases of the life cycle of a facility to insert, extract, update or amend information within BIM to support and express the roles of that stakeholder.” (Smith, 2009).

'As Designed' versus the 'As Built' models.

Here we will look at how Building Information Modelling (BIM) methodologies and digital technologies have been used for 'As Designed' and 'As Built' information where we will critically analyse how the data compares between the two.

Looking at the UWTSD SA1 Campus project we can see in the 'BIM Execution Plan' (BEP) starting with the 'Plan of Work' stages as agreed by all parties concerned in Fig. 1.

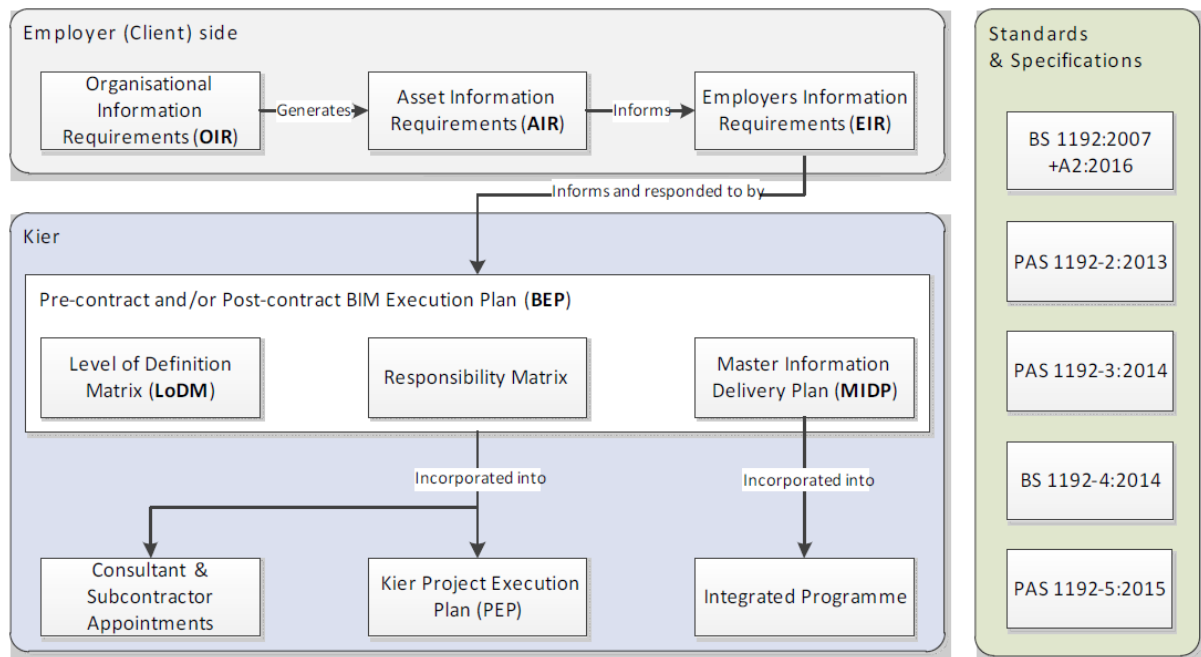


Fig. 1. - Information Management Documentation (BIM Execution Plan)

As we can see from Fig. 1 the Employer (Client) will have the Organisational Information Requirements (OIR) to generate the required Asset Information Requirements (AIR) which will provide the Employers Information Requirements (EIR) for the contractor to produce its BEP to all current standards and specifications.

As specified within the BEP all project disciplines would be working within a Common Data Environment (CDE) and the working platform would be BIMXtra to facilitate level 2 BIM maturity as defined by PAS 1192-2:2013.

BIMXtra would be used to share and publish information with Revit models to be uploaded to the platform. From here the information would be made available to the entire project team to collectively enhance and utilise. Fig. 2.

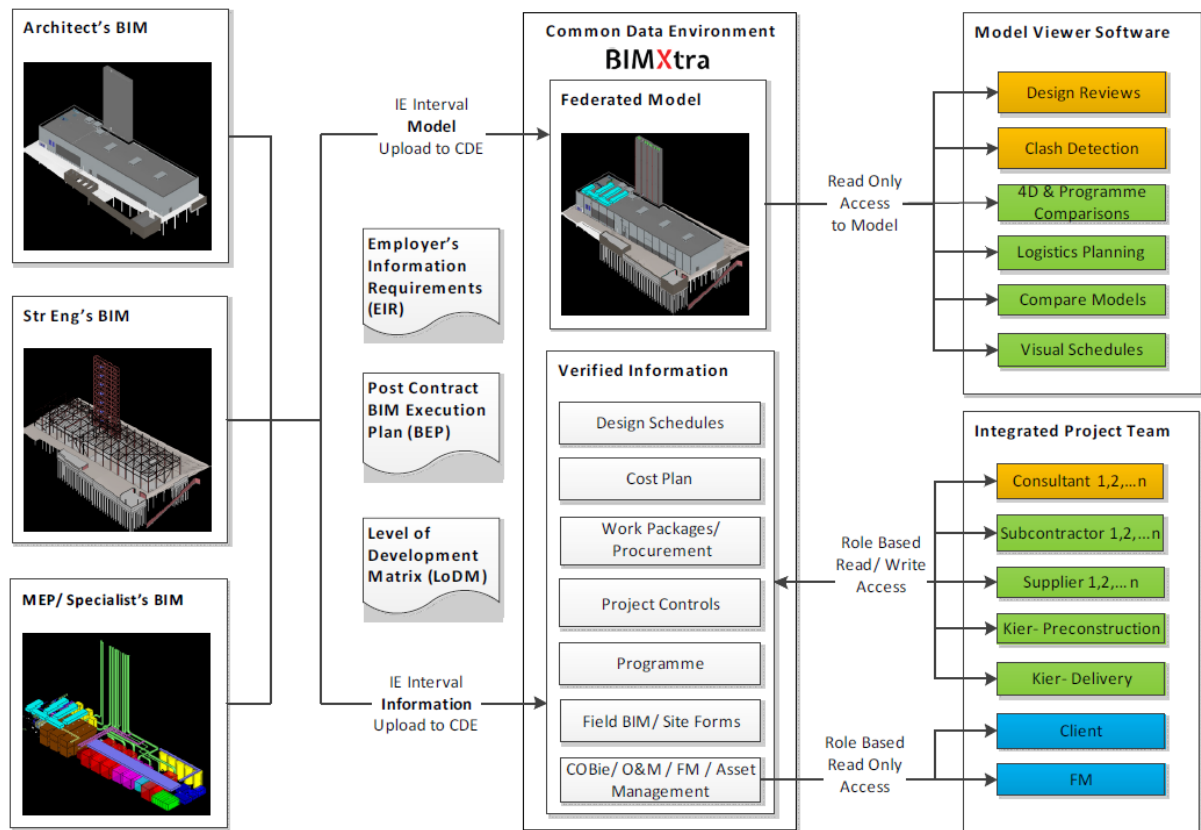


Fig. 2 – Project BIM Workflow (BIM Execution Plan)

At this stage, an EIR had not been produced by the client (UWTSD)

Detailed information would be required which would be held in the Project Information Model (PIM) collaboratively developed and maintained within the CDE. This would be agreed with a set of deliverables identified within the project BIM scope as 'P) Planned, (R) Required or (N) Not Required' and would be set out at various stages 'Pre-Contract, Construction and Handover' as defined in the BEP.

Within the project BIM menu there are several key items to look at when we critical analyse and compare the data.

BIM Ref No: -

KB 102 - Training strategy in place. (R)

Training required at all stages of the project.

KB 301 - Design reviews conducted in a 3D environment. (R)

Reviews required at both Pre-Construction and Construction

KB 306 - Clash resolution and detection. (R)

Reviews required at both Pre-Construction and Construction

KB 605 - Site forms and reports (Field BIM) (P)

These were planned for all stages of the project.

KB 701 - AIM – Asset Information Model required. (R)

Required at all stages of the project.

KB 702 - COBie data (R)
Required at all stages of the project.

KB 801 - BIM project performance Reporting. (R)
Required at all stages of the project.

KB 802 - BIM case study authoring. (R)
Required at all stages of the project.

Kier fundamental requirement for Level 2 implementation

As said within the BEP “The success of BIM is reliant on each collaborating stakeholder performing their roles and responsibilities” if one link fails then the chain will be broken.

Has / Was the EIR ever completed and submitted to achieve and support BIM objectives?

As a Main Contractor has Kier successfully carried out its role of Project Information Manager and Project Delivery Manager?

The Level of Definition Matrix (LoDM) is collaborated and held within the BIMXtra model in response to the EIR and AIR. This information is held in Appendix 2 of the BEP to which no access was provided but without the submission of the EIR as suggested previously, could not have been completed.

As discussed previously Coordination Software was used by all stakeholders to review the PIM. Alternative software from BIMXtra i.e. Autodesk Navisworks may also have been used to look at things like clash detection etc. for the stakeholders not conversant with the BIMXtra software and on completion uploaded to the CDE.

As we are aware, there will be various stakeholders working on this project and a common project coordinate system has been established to form the basis of model integration. Fig. 3 & 4.

Model Reference	Grid	Easting	Northing	Angle to True North
Project grid	A/1	000,000.000	000,000.000	0.00
1x1x1 Cube (North West Corner)	N/A	000,000.000	000,000.000	0.00

Base level of cube is 00000 (top of foundations)

Fig. 3 - Northings and Eastings (BIM Execution Plan)

Building Reference	Level Name	Site FFL	Building FFL
01	FN	00000	-0000
	GF	00000	0000
	01	00000	0000
	02	00000	0000
	RF	00000	00000

Fig. 4 - Levels / Chainage (BIM Execution Plan)

Within the BEP a BIM Meeting calendar is provided with Four specific “Meeting / Milestone” “Purpose / Notes” and “Meeting Attended by” agenda sections that is drawn to my attention: -

Meeting / Milestone	Purpose / Notes	Meeting Attended by
BIM for FM scope meeting (if required)	The purpose of this meeting is to discuss and agree the scope of FM related BIM requirements and explore the possibilities of BIM/FM integration	K – Client (UWTSD) J - Client's Rep. (UWTSD) F - Facilities (Asset) Manager (UWTSD) W - Main Contractor (Kier Construction Western) Y1 - Kier FM (Kier Facilities Management)
BIM progress reviews	The purpose of the workshop will be to evaluate progress on BIM and BIMXtra.	W - Main Contractor (Kier Construction Western) A – Architect (Stride Treglown Architects) S - Structural Engineer (Jubb Consultants) M - Mechanical Engineer (Troup Bywaters + Anders) E - Electrical Engineer (Troup Bywaters + Anders) P - Public Health Engineer (Troup Bywaters + Anders) X1 - Subcontractor 1 – M&E (Whitehead Buildings Services)
Clash avoidance / detection workshops	The purpose of the workshop will be to conduct select clash detection scenarios using the chosen software. This could be combined with the BIM Progress Reviews	W - Main Contractor (Kier Construction Western) A – Architect (Stride Treglown Architects) S - Structural Engineer (Jubb Consultants) M - Mechanical Engineer (Troup Bywaters + Anders) E - Electrical Engineer (Troup Bywaters + Anders) P - Public Health Engineer (Troup Bywaters + Anders) X1 - Subcontractor 1 – M&E (Whitehead Buildings Services)
BIM hand over meeting	To confirm the acceptance of BIM deliverables as per this BEP	K – Client (UWTSD) J - Client's Rep. (UWTSD) F - Facilities (Asset) Manager Y1 - Kier FM (Kier Facilities Management)

With BIMXtra Protocols the project is based on EIR found in the LoDM which is the basis on which the BIMXtra platform is structured and built around, the use of BIM as a Construction Model tool can be used to advantageous effect as shown in Fig. 5.

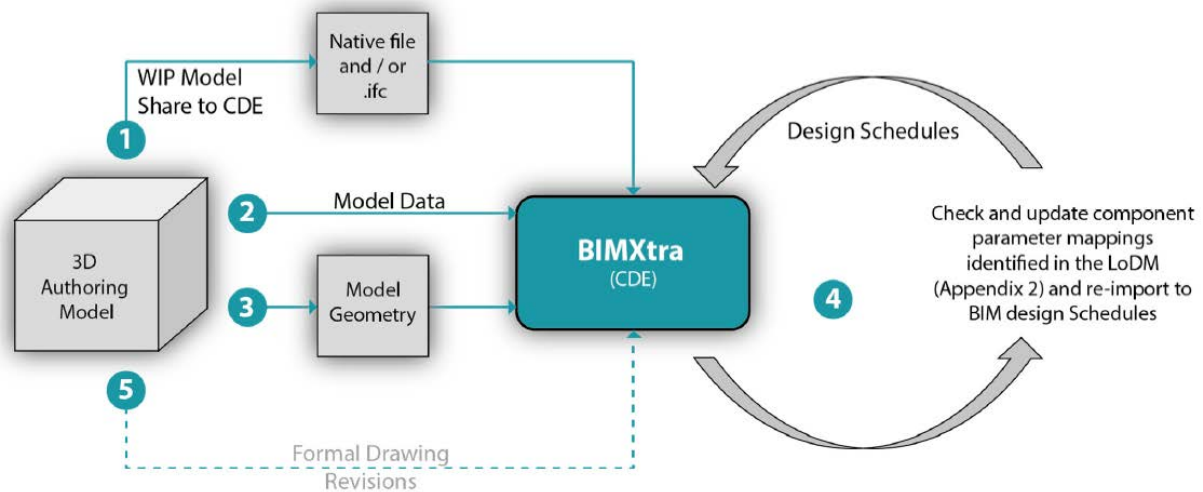


Fig. 5 - BIMXtra MIE Process (BIM Execution Plan)

Data / Models Provided for Critical Analyse

Using the BIM Models provided we have been able to conduct our own critical analysis of the BEP for ourselves. The files were in ifc file format and have been uploaded into our Revizto 5 software to be analysed. I have also used Navisworks to check for similarities or anomalies to the BIM modelling as we do not have access to the BIMXtra programme.

We also carried out laser scanning using a Leica RTC360 to check for differences between the Design Model and the finished product at handover.

As we imported the given ifc files for the Mechanical and Electrical (M&E) into Revizto 5 software using data from Fig. 3 we could see that Co-ordination issues were a problem to start as seen in Fig. 6 and 7. Where both models show components below finished ground level and Fig. 8 showing components between levels.

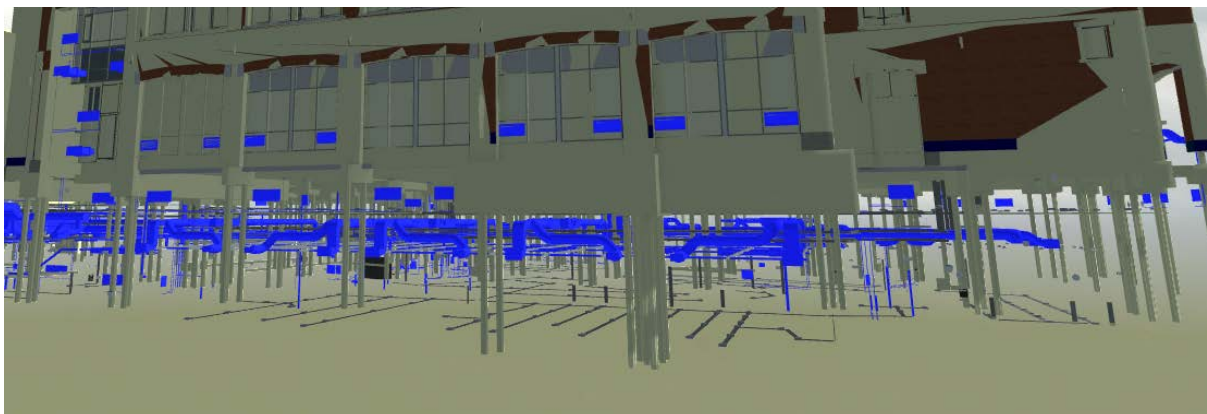


Fig. 6 – Original Mechanical Model (Revizto 5 - UWTSD-WBS-01-XX-M3-M-001.ifc)

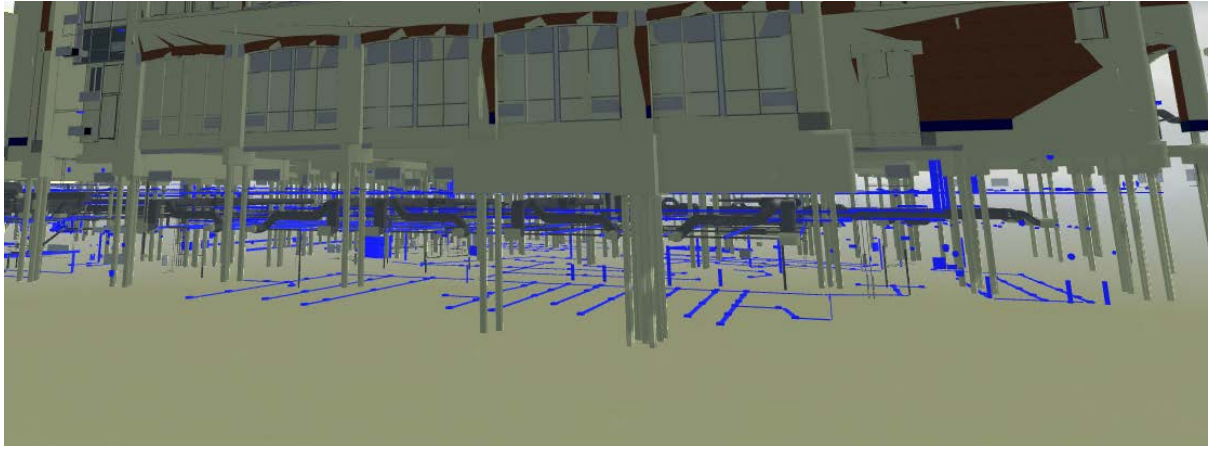


Fig. 7 – Original Electrical Model (Revitzo 5 - UWTSD-WBS-01-XX-M3-E-001.icf)

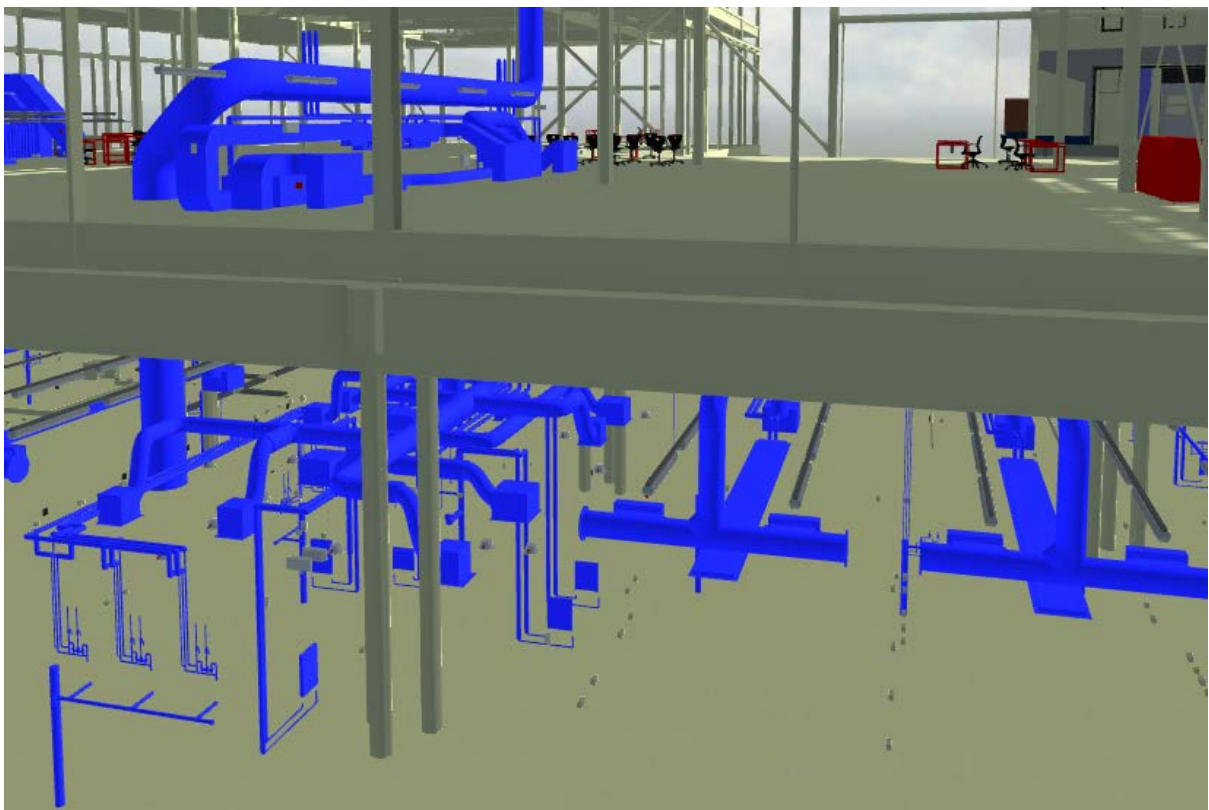
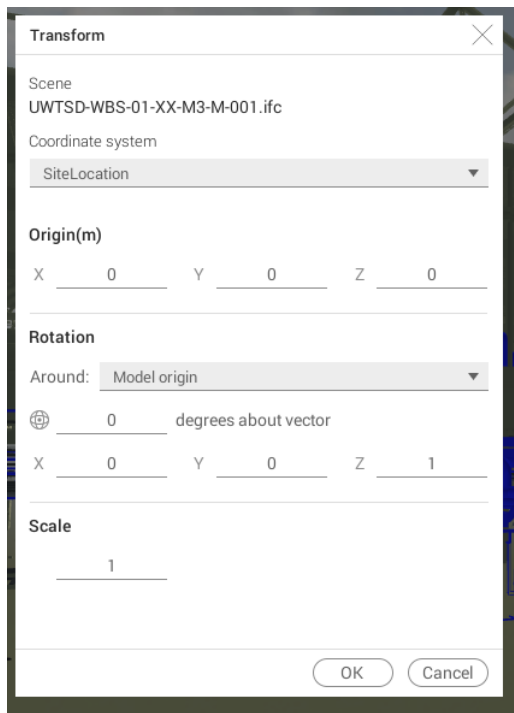


Fig. 8 - Original Mechanical Model (Revitzo 5 - UWTSD-WBS-01-XX-M3-M-001.icf)

With some adjustments using the measure tool in the programme we were able to realign the models as seen in Fig. 9 and 10 so we could check for discrepancies which could not have been done accurately using the clash detection / avoidance workshops with the models in their original position therefore leading to the questioning of appropriate training also the acceptance of BIM deliverables as per the BEP at handover.



Transform

Scene
UWTSD-WBS-01-XX-M3-M-001.ifc

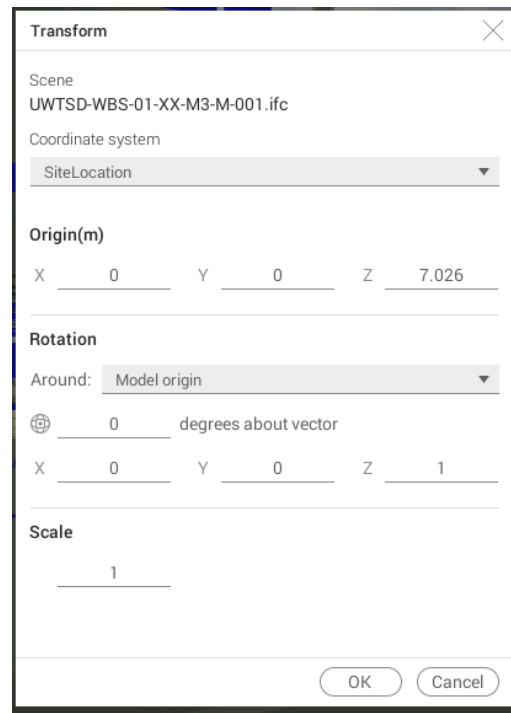
Coordinate system
SiteLocation

Origin(m)
X 0 Y 0 Z 0

Rotation
Around: Model origin
0 degrees about vector
X 0 Y 0 Z 1

Scale
1

OK Cancel



Transform

Scene
UWTSD-WBS-01-XX-M3-M-001.ifc

Coordinate system
SiteLocation

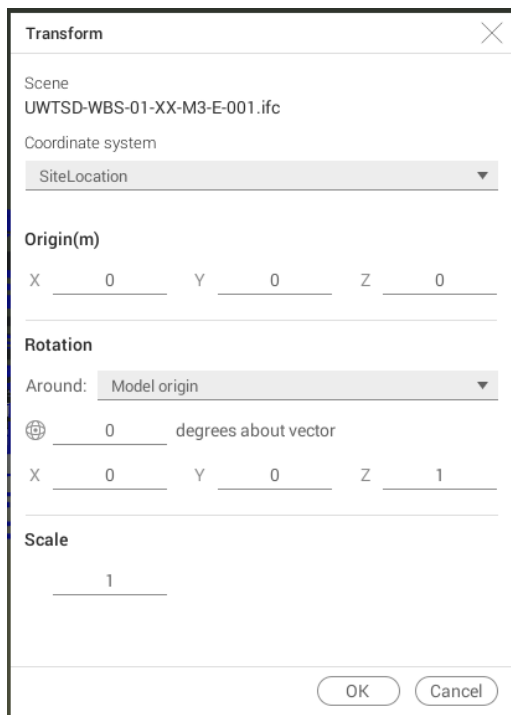
Origin(m)
X 0 Y 0 Z 7.026

Rotation
Around: Model origin
0 degrees about vector
X 0 Y 0 Z 1

Scale
1

OK Cancel

Fig. 9 – Amended Mechanical Model on ‘Z’ axile (Revitzo 5 - UWTSD-WBS-01-XX-M3-M-001.icf)



Transform

Scene
UWTSD-WBS-01-XX-M3-E-001.ifc

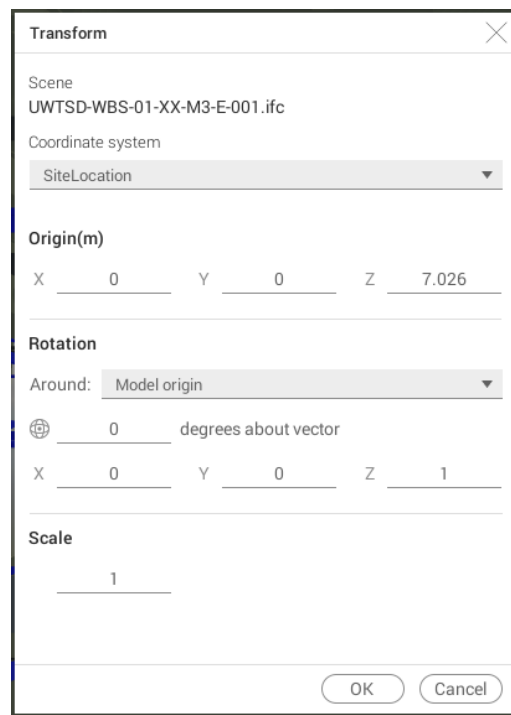
Coordinate system
SiteLocation

Origin(m)
X 0 Y 0 Z 0

Rotation
Around: Model origin
0 degrees about vector
X 0 Y 0 Z 1

Scale
1

OK Cancel



Transform

Scene
UWTSD-WBS-01-XX-M3-E-001.ifc

Coordinate system
SiteLocation

Origin(m)
X 0 Y 0 Z 7.026

Rotation
Around: Model origin
0 degrees about vector
X 0 Y 0 Z 1

Scale
1

OK Cancel

Fig. 10 - Amended Electrical Model on ‘Z’ axile (Revitzo 5 - UWTSD-WBS-01-XX-M3-E-001.icf)

Sectional views of the M&E models Fig. 11 and 12 have been used and visual inspections of various other areas around the model to identify any clashes. The laser scanning Fig. 13 has been overlayed in the model to carry out a further visual inspection to the handover models provided.

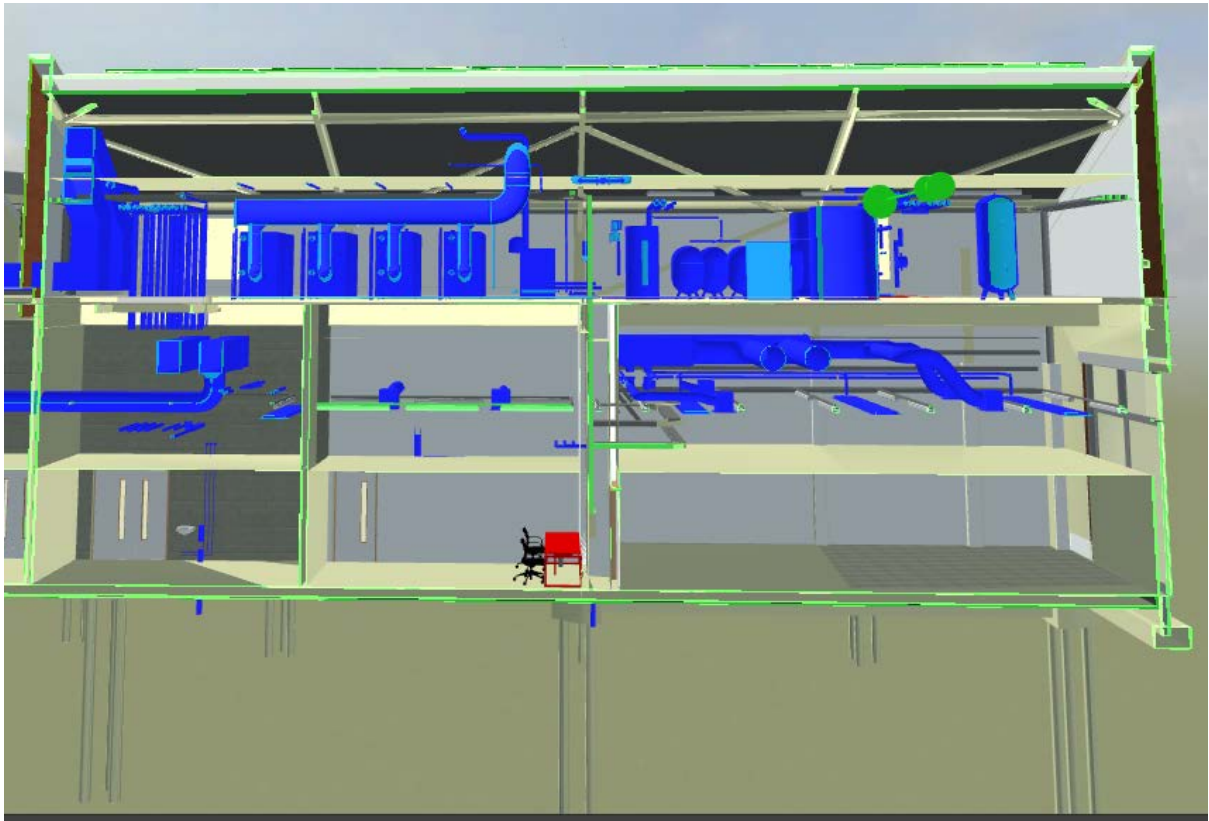


Fig. 11 – Mechanical Section view (Revitzo 5 - UWTSD-WBS-01-XX-M3-M-001.icf)

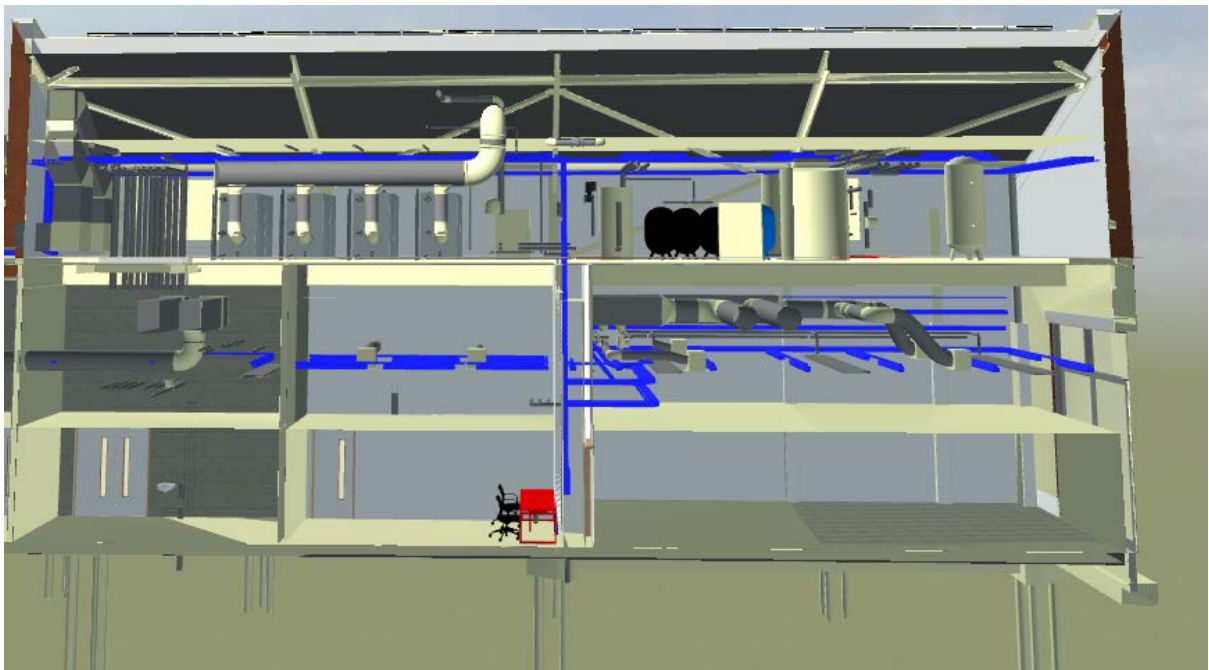


Fig. 12 – Electrical Section view (Revitzo 5 - UWTSD-WBS-01-XX-M3-E-001.icf)

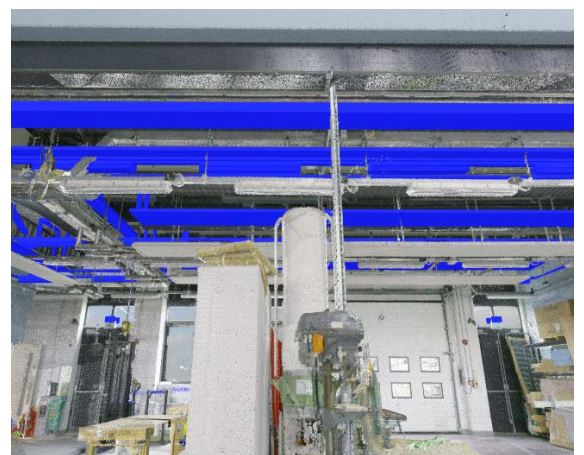
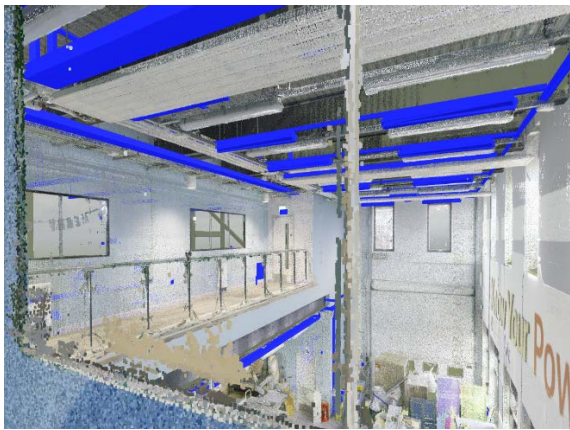
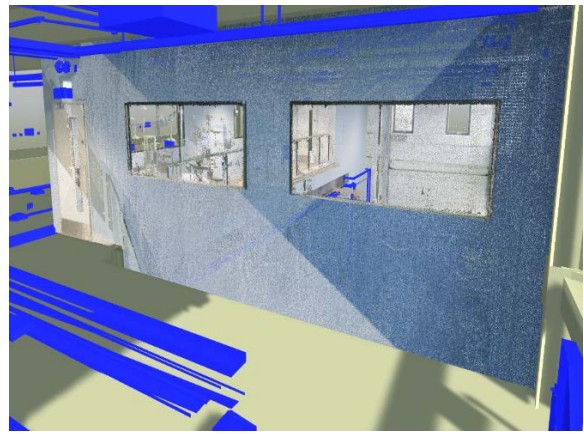
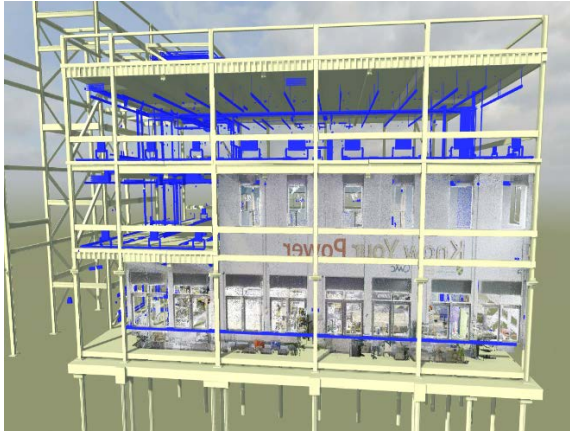


Fig. 13 – Laser scan using a Leica RTC360 (Revitzo 5 – ACBA 7002 Con. Tech.)

From the above images we can see there are some issues in the Revit 5 modelling but following onto the laser scanning we can get a good perspective of where there are some issues within the handover model.

Further clash detections carried out with the Navisworks software has brought on further issues as we can see Fig. 14 below, although many of these anomalies can be attributed to for example pipework running through the floor with no architectural holes provided, again this should have been addressed during BIM progress and clash detection meetings as set out in the BEP programme.

Clash Detective

Test 1 ⚠️ Last Run: 05 January 2023 17:19:1

Clashes - Total: 2282 (Open: 2282 Closed: 0)

Name	Status	Clashes	New	Active	Reviewed	Approved	Resolved
Test 1	Old	2282	2282	0	0	0	0
Test 2	Old	1378	1378	0	0	0	0
Test 3	Old	62	62	0	0	0	0
Test 4	Old	614	614	0	0	0	0
Test 5	Old	6	6	0	0	0	0

Buttons: Add Test, Reset All, Compact All, Delete All, Update All

Rules Select Results Report

Selection A

Standard

- UWTSO-WBS-01-XX-M3-E-001.ifc
- UWTSO-WBS-01-XX-M3-M-001.ifc
- UWTSO-WBS-04-XX-M3-ME-001.ifc
- UWTSO-WBS-06-XX-M3-S-0004.ifc
- UWTSO-JUB-01-XX-M3-S-0003.ifc
- UWTSO-JUB-04-XX-M3-S-0003.ifc
- UWTSO-JUB-06-XX-M3-S-0003.ifc
- UWTSO-STL-01-ZZ-M3-A-ZZZZ-00001_P
- UWTSO-STL-06-ZZ-M3-A-ZZZZ-00001_C
- UWTSO-STL-04-ZZ-M3-A-ZZZZ-00001_Li

Selection B

Standard

- UWTSO-WBS-01-XX-M3-E-001.ifc
- UWTSO-WBS-01-XX-M3-M-001.ifc
- UWTSO-WBS-04-XX-M3-ME-001.ifc
- UWTSO-WBS-06-XX-M3-S-0004.ifc
- UWTSO-JUB-01-XX-M3-S-0003.ifc
- UWTSO-JUB-04-XX-M3-S-0003.ifc
- UWTSO-JUB-06-XX-M3-S-0003.ifc
- UWTSO-STL-01-ZZ-M3-A-ZZZZ-00001_P
- UWTSO-STL-06-ZZ-M3-A-ZZZZ-00001_C
- UWTSO-STL-04-ZZ-M3-A-ZZZZ-00001_Li

Clash Detective

Test 1 ⚠️ Last Run: 05 January 2023 17:19:1

Clashes - Total: 2282 (Open: 2282 Closed: 0)

Name	Status	Clashes	New	Active	Reviewed	Approved	Resolved
Test 1	Old	2282	2282	0	0	0	0
Test 2	Old	1378	1378	0	0	0	0
Test 3	Old	62	62	0	0	0	0
Test 4	Old	614	614	0	0	0	0
Test 5	Old	6	6	0	0	0	0

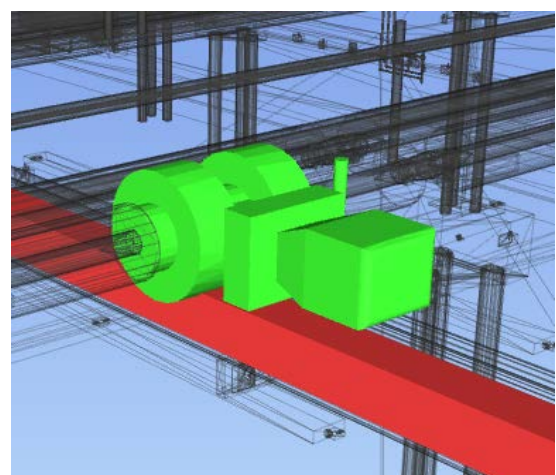
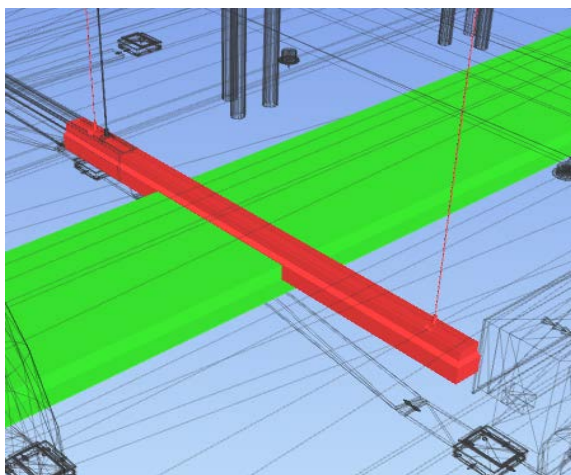
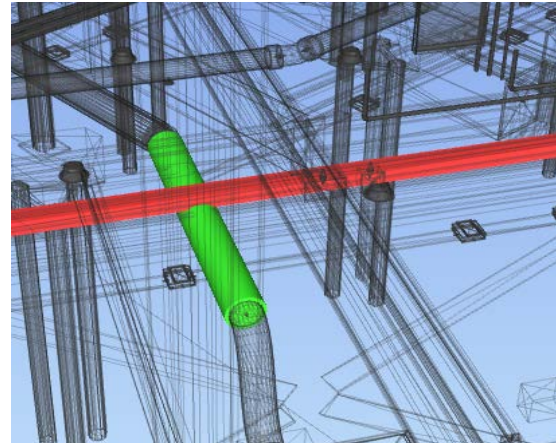
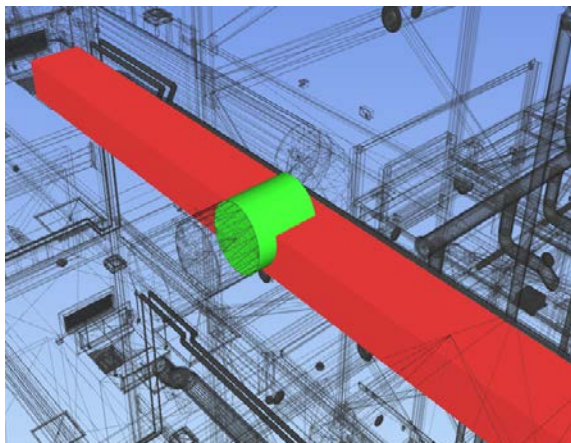
Buttons: Add Test, Reset All, Compact All, Delete All, Update All

Rules Select Results Report

New Group Assign

Name Status Found Approved... Approved Descriptio...

Clash1	New	17:19:10 05-01-2023		Hand
Clash2	New	17:19:10 05-01-2023		Hand
Clash3	New	17:19:10 05-01-2023		Hand
Clash4	New	17:19:10 05-01-2023		Hand
Clash5	New	17:19:10 05-01-2023		Hand
Clash6	New	17:19:10 05-01-2023		Hand
Clash7	New	17:19:10 05-01-2023		Hand
Clash8	New	17:19:10 05-01-2023		Hand
Clash9	New	17:19:10 05-01-2023		Hand
Clash10	New	17:19:10 05-01-2023		Hand
Clash11	New	17:19:10 05-01-2023		Hand
Clash12	New	17:19:10 05-01-2023		Hand
Clash13	New	17:19:10 05-01-2023		Hand
Clash14	New	17:19:10 05-01-2023		Hand
Clash15	New	17:19:10 05-01-2023		Hand
Clash16	New	17:19:10 05-01-2023		Hand
Clash17	New	17:19:10 05-01-2023		Hand
Clash18	New	17:19:10 05-01-2023		Hand



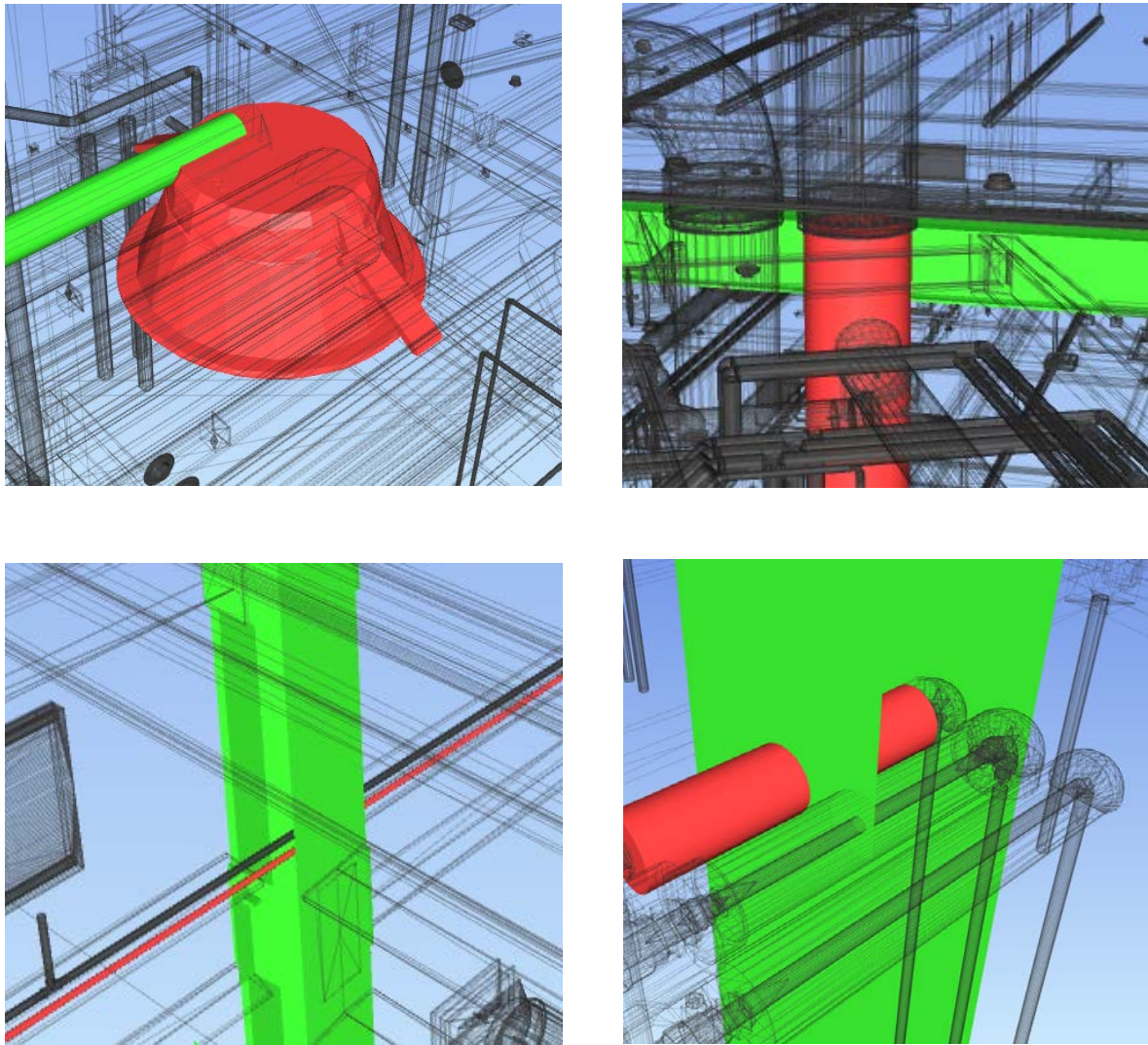


Fig. 14 – Clash detection Images taken from Autodesk Navisworks (UWTSD ifc files)

Conclusion

Considering the “As Designed / As Built” scenario there have been several factors that need to be considered. Firstly, has the client (UWTSD) been involved enough and was there an EIR produced for the BEP to be collated to its full potential. Looking at the resources we have available it would suggest that was not the case. Detailed information required for the PIM, which is required for level 2 BIM implementation would appear to be missing or incomplete. We could also say that training has not been adequately provided for all stakeholders as models have been imported to the wrong location and had to be adjusted accordingly. Therefore, how can Clash Detection simulations be accurately completed if co-ordination figures are inaccurate. Finally there are four specific meetings / milestones within the BEP BIM calendar that highlighted downfalls within the project, the lack of commitment to explore BIM / FM integration, BIM progress reviews and Clash Detection shows a failure to pick up inaccuracies within the models that have been explored and lastly the BIM handover meeting, it would seem that that BIM deliverables have been accepted as per the BEP but when we look at the data / models examined they would appear to be unacceptable after the critical analysis we have carried out using said software against the BEP brief.

Facilities Management Integration of BIM

The British Standard for Facility Management (FM) (BS EN 15221-1:2006 Facility Management-Part 1) describes FM as the integration of processes within an organisation to support and develop the agreed services which support and improve the effectiveness of its primary activities (Codinhoto & Kiviniemi, 2016), (Baker 2017). According to The International Facility Managers' Association (IFMA), the major functional responsibilities of FM can be divided into four categories: operational services, maintenance services, administrative services, and facility development services.

Operational services involve the day-to-day management and operation of the facility, such as ensuring the facility is clean and safe, and that all services within the facility are running smoothly. Maintenance services involve the regular maintenance of the facility and its equipment, including repairs, inspections, and replacements. Administrative services involve the management of personnel, including hiring and training inexperienced staff, as well as record-keeping and budgeting. Finally, facility development services involve the planning, design, and construction of new facilities and the renovation of existing ones.

There are two main types of computer-based FM systems which support FM functions. These are Computer Maintenance Management Systems (CMMS) and Computer Aided FM (CAFM) systems.

CMMS systems are designed to help manage planned and reactive maintenance activities. They provide tools for tracking and recording work orders, scheduling maintenance activities, and monitoring equipment performance.

CAFM systems are designed to provide a comprehensive set of tools for managing the entire lifecycle of a facility, from design and construction through operations and maintenance. They provide tools for space management, asset tracking, resource scheduling, and cost analysis. They also provide tools for reporting and visualising data, as well as for forecasting and planning.

Overall, CMMS and CAFM systems have contrasting functions, yet both are intended to support the total FM processes. However, there are still challenges in supporting the FM processes with these existing tools and technologies. For example, existing systems do not always provide the data required to make informed decisions and may not be able to handle the complexity of some FM processes. Additionally, there may be difficulties in integrating the systems with other software, such as BIM or BMS. As such further research in this area would be needed to support and facilitate the FM integration processes.

Utilising these within FM systems would also provide one source of data that all stakeholders agree is the definitive and reliable source of information called the Single Source of Truth (SSoT). This would be particularly important, where having a single source of all information such as, design documents, images, snag lists and correspondences in one single shared location can help to streamline processes, reduce complexity, and increase efficiency. Additionally, the use of a SSoT can help to reduce the risk of errors and omissions in data, as well as improve project collaboration by providing all stakeholders with real-time access to the same data.

Unfortunately looking at the handover package it would suggest there are still three sources of information, models from BIMXtra, Navisworks and Native files from Revit. Using the collected data, it would suggest a breakdown in communication and collaboration whilst creating the models and thus the issues we have seen have arisen.

As shown in Fig. 15 below, the holistic view of BIM gives a visual explanation of how BIM and its various levels can be integrated into the FM system with a SSoT supporting the whole lifecycle process of an asset.

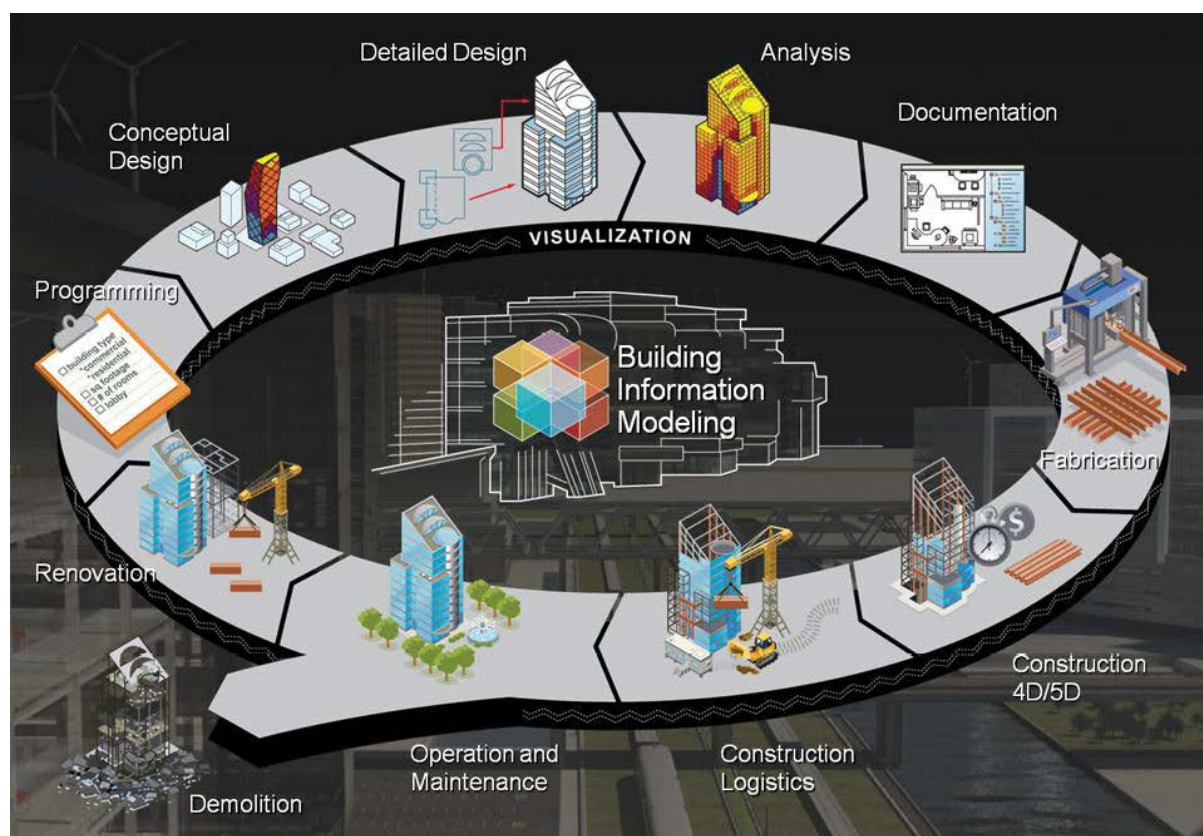


Fig. 15 – Holistic view of BIM (www.buildipedia.com)

As discussed in the previous section ‘As Designed’ versus the ‘As Built’ models when we looked at the BEP process several issues came to light, firstly the EIR, has the client (UWTSD) provided this information to be implemented into the BEP enabling the asset to be handed over to the client on completion with all “design, construction, operation and maintenance information captured and associated to all model components” hosted digitally in the CDE as described within the BEP for the clients use in operation.

It would appear that BIM and FM integration was available to the client within the Meetings / Milestone calendar to discuss and agree the scope and requirements but looking at the models that have been supplied to the FM team there is very limited information and even less automation within the software provided, suggesting the client gave very limited input to the assets BEP programme.

As we have seen in the modelling previously, BIM software could be used to improve the construction process bringing to light issues that can be solved in the planning stage, if used correctly with adequate training. Using BIM software could be an excellent tool for the FM to run its Operations and Maintenance (O&M) schedules bringing together the information collated within the CDE to the day to day running of the asset as well as any future developments and upgrades as seen in Fig. 15.

The FM team are using the CAFM system which as discussed earlier can provide benefits to the entire life cycle of an asset. The software that is being used for the Building Management Systems (BMS) is BSC (Building Management Controls), research into this system has shown it has the capability to provide the FM team with the required information to run the day-to-day O & M also they can provide tools for space management, asset tracking, resource scheduling, and cost analysis. Unfortunately, closer inspection of the said software on-site has revealed this is not the case, as many of the functions of the software have not been utilised as they can be. This could be down to the lack of knowledge and training by the client working with the Asset supplier (KIER's) when producing the EIR and not knowing or overlooking the final handover package to the client (UWTSD).

Using the figures below we can see one example of how the BEP has not been utilised to its full potential and issues have arisen from them. Firstly Fig. 16 shows the building in its entirety and how its finished product should look. The second image Fig. 17 shows the buildings room volume to which the HVCA system has been calculated, showing a vastly oversized volume this has led to the mechanical air supply systems to be vastly oversized, having a knock-on effect to the pricing of the installation and the energy efficiency of the building. Fig. 18 illustrates how using the analysis report in Revit could have highlighted this issue. This intern could have led to upgrading / downgrading of the system to make this run more cost effectively and to reduce the carbon emissions of the Asset.

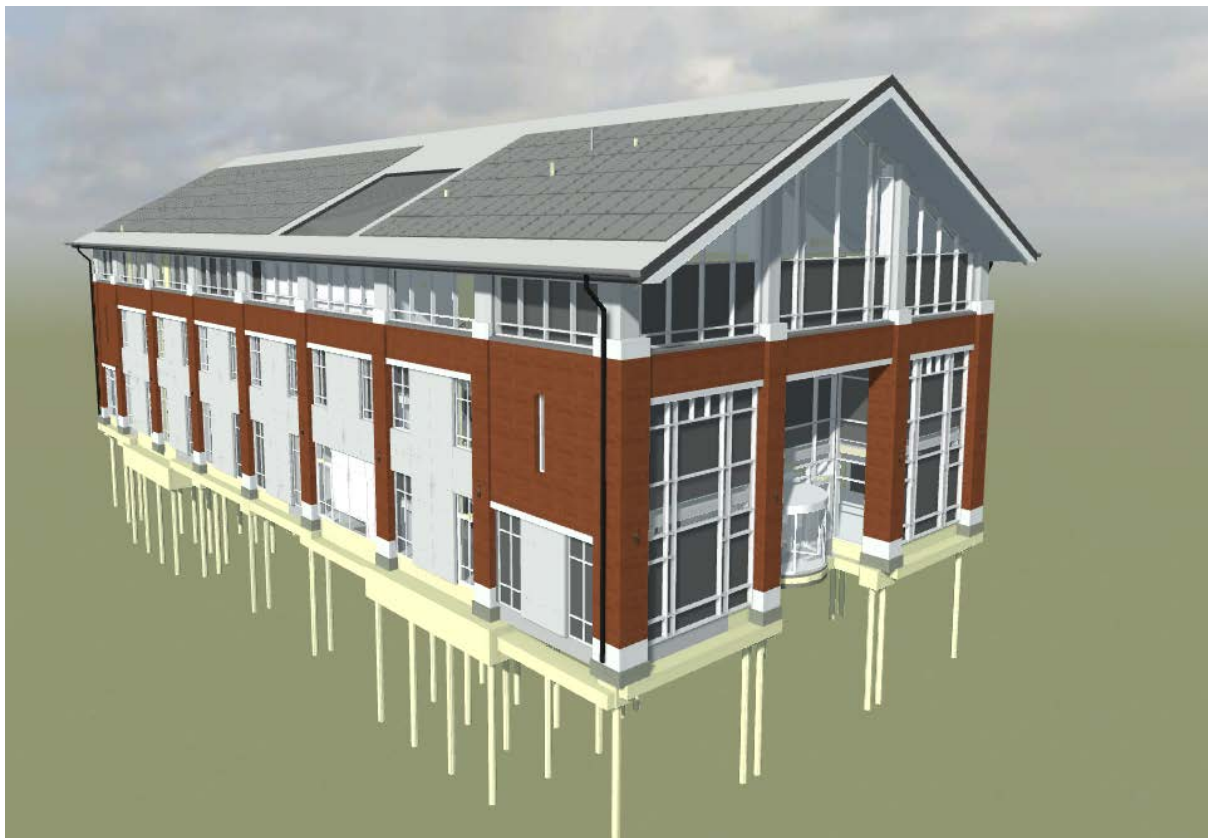


Fig. 16 - UWTSD SA1 Library



Fig. 17 - UWTSD SA1 Library (Room Volume)

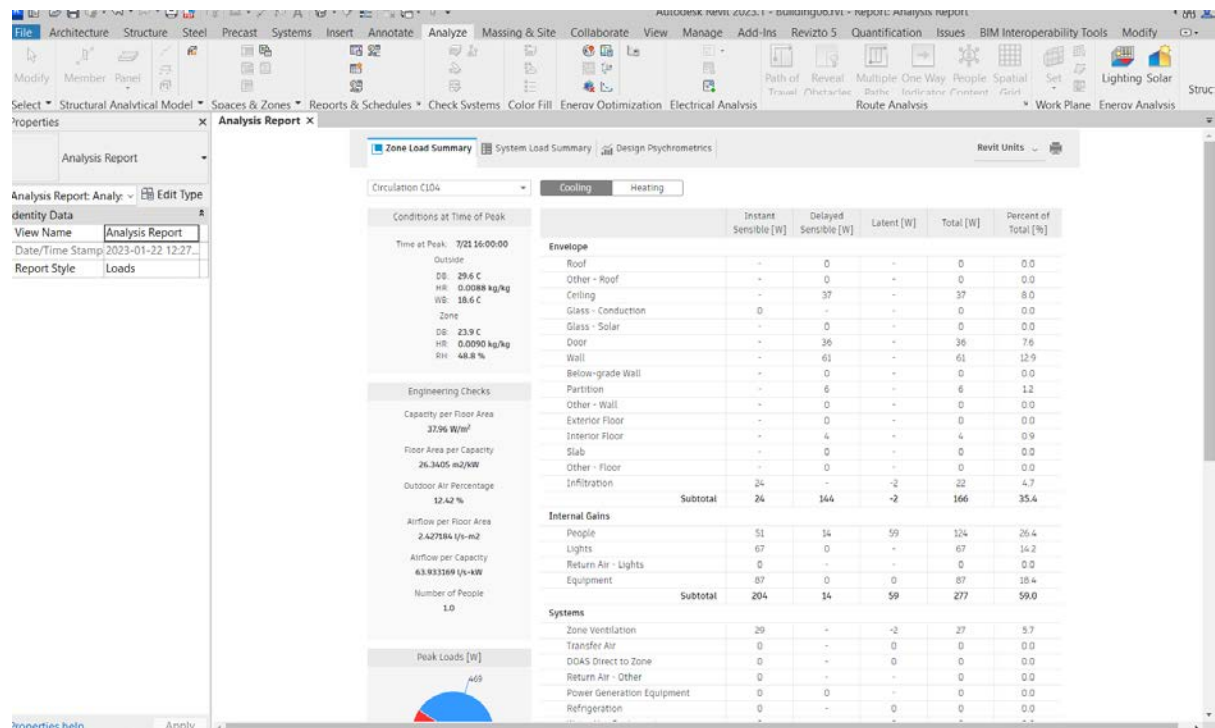


Fig. 18 – Screenshot of Analysis Report from Revit (UWTSD SA1 Library)

Guidance from Welsh Governments “Planning for Sustainable Buildings” 2014 states

“It is an endemic problem that building users are given insufficient training and support to enable them to operate sustainable buildings effectively and efficiently.

Adopting a full programme of ‘Soft Landings’ can resolve this problem cost effectively and by adopting this approach at the outset of a project, it can involve users and building managers in discussion about building performance and operation, afford particular attention to the proper commissioning of systems, and then provide specific support to building users over the first 12-24 months of occupation.” (Wales, G. (2018).

They also suggest a ‘Soft Landings’ approach is more cost effective than the maintenance of poorly understood and poorly used systems.

Conclusion

As we can see, the way in which the project was run from start to finish, there have been issues with the BEP. This intern has led to the FM team having reduced control over the asset and inheriting problems within the systems in future years. These issues could have been addressed if an EIR was produced with accurate requirements supplied for the FM team to Manage, Plan and Maintain the Asset to high standards when creating the BEP, to the handover stage of the project. If a SSoT was put in place correctly, then many of the problems / issues could have been averted enabling a smoother transition at handover and reducing cost on the project.

The CAFM system that has been put in place has very limited functionalities and provides inaccurate data to the user. Remote sensory and control systems are at a minimum, requiring manual inspection and manual resetting of machinery lockouts. Monitoring building performance using metering systems and conducting post occupancy evaluations could provide an insight into the actual functioning of the asset. These systems could measure primary energy sources as well as specific end-use consumption, allowing for detailed analysis of the asset. This could have been established and overseen as part of a ‘Soft Landing’ approach under the BEP.

Combining BIM with BMS Technologies for Energy Efficiency Performance.

Research would suggest that BIM can be a powerful tool that can be used to improve the energy efficiency and comfort of a building / assets, as well as its overall performance. By combining BIM with building simulation and optimisation tools, it is possible to explore a range of different approaches to improve energy efficiency and comfort conditions.

Additionally, by integrating data from multiple sources, it is possible to create a comprehensive overview of the building and its systems, allowing for more efficient and exact analysis. BIM can facilitate the review of results and provide insights into potential methods for improving building performance, such as improved energy efficiency, improved indoor environmental quality, and reduced operational costs as previously discussed.

As we have seen, we have used various different software to collate information and gather information from our models. We could now use this information to improve the buildings / assets energy performance and make upgrades to the said buildings / assets. As we explored in 'FM integration of BIM' there are various other forms of software that have become available in recent years to conduct the day-to-day management and operation of the facility and throughout its whole life cycle.

Throughout this study, we have observed the use of a CAFM system BMS by the FM team. We propose that, with upgrades in sensory equipment and training, this system could facilitate a more efficient and cost-effective program for the asset. Additional research has revealed the successful integration of this said system in other educational institutions within South Wales to be a success.

Research into one of these establishments has shown the BMS system utilises KNX functionality, this provides field and room control of the lighting, space heating / cooling, ventilation and emergency lighting, self-testing, and reporting. This system can also provide comprehensive control of both the Mechanical & Electrical elements, together with the flexibility of local override control & monitoring to the site staff. (BSC Ltd. (n.d.).

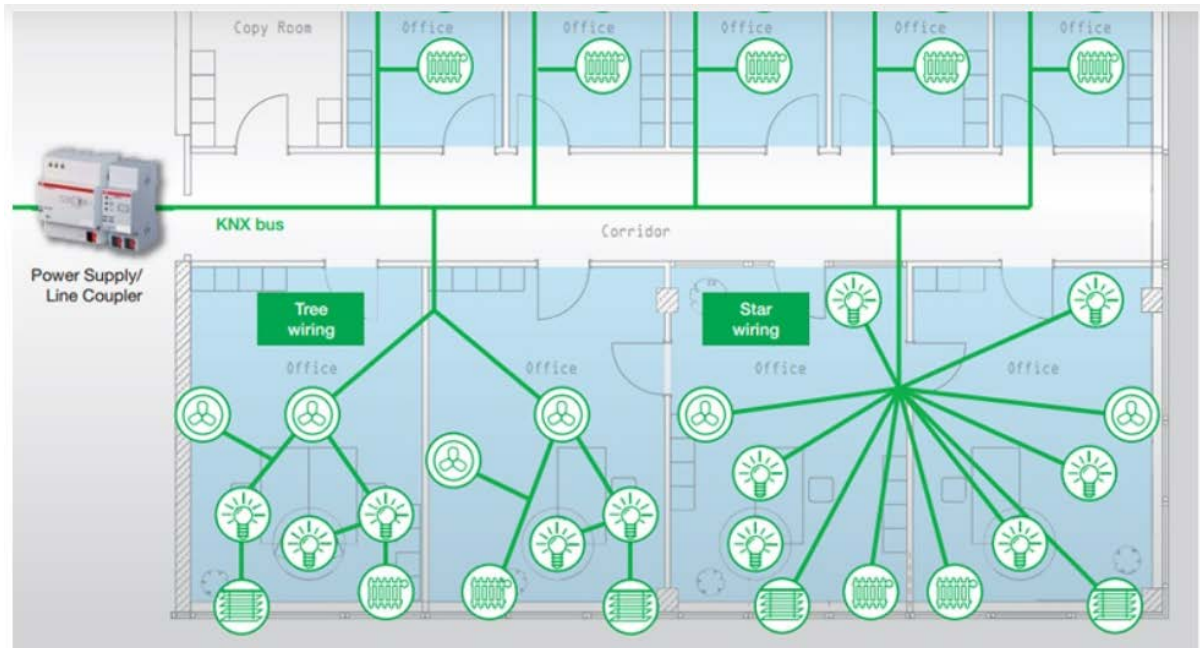


Fig. 19 - BSC with KNX integration. (<https://www.bemi.fi/key-benefits-of-knx-automation-for-commercial-and-industrial-buildings/>)

The system in Fig.19 shows how the UWTSD SA1 Campus Buildings could be upgraded to make a difference, bringing together every room, every employee, and every student into an automated operation of integral building functions. The automation could manage the security, lighting, heating, energy efficiency, sensors, dimmers, valves, blinds, shutters, audio, video, displays and more.

The advantages of this smarter operational BMS system can improve building operational efficiency, lower energy consumption / costs and optimise the working conditions of all building occupants if operated correctly. Fig. 20



Fig. 20 – KNX Operational features. (<https://www.bemi.fi/key-benefits-of-knx-automation-for-commercial-and-industrial-buildings/>)

Intelligent capture of consumption data ([Smart Metering](#)) as well as coupling with other intelligent networks ([Smart Grid](#)) would up new possibilities for further optimisation and increased energy efficiency for the future and can also provide huge financial savings for the asset through efficient energy management, usage and consumption. Fig. 21 (Bendtsen. M, (2019).

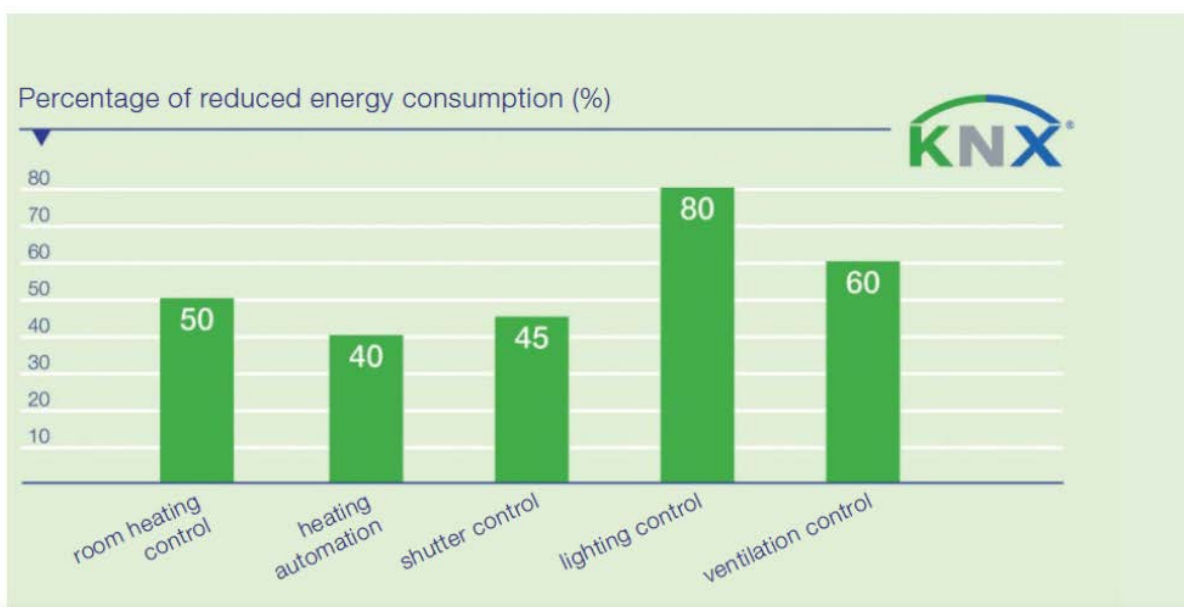


Fig. 21 – Example of Cost Savings using KNX Energy Management. (<https://www.bemi.fi/key-benefits-of-knx-automation-for-commercial-and-industrial-buildings/>)

The KNX system is said to be future-proof therefore adding value to the installation / upgrade to achieve the highest standards for the entirety of the Asset. Combining these technologies will give the FM team the knowledge and understanding of how the building can become more energy efficient over time.

“KNX is a future-proof technology that has over 400 manufacturer compatible devices that are backwards compatible enabling upgrades to the system without the need to upgrade all the devices already installed”. (Bendtsen, M. (2019, June 26).

Conclusion

The study found that there were communication breakdowns between the client (UWTSD) and the supplier (KIER) during the BIM Execution Plan (BEP) process, which led to various issues related to the modelling of the Asset and the Handover on completion. These issues have had a significant impact on the daily operations of the Facility Management (FM) team and their ability to optimise the effectiveness of the Asset.

To address these issues, I propose that upgrading the currently installed Building Management System (BMS) would greatly impact the overall running costs of the Asset. An upgraded BMS would provide vital information and feedback on the system's performance, enabling mechanical and electrical upgrades. This would also highlight any oversized heating, ventilation, and air conditioning (HVAC) installations, providing the data and proof for changes to be made to improve energy efficiency and reduce the Carbon Footprint of the Building / Asset.

Furthermore, the integration of Building Information Modelling (BIM) with BMS is crucial in capturing and analysing accurate information, including data related to the scale, flow rates, and other essential parameters of the Building / Asset. To ensure this integration is done correctly, the BIM models need to be carefully examined and adjusted to match the specific requirements of the BMS. This would ultimately result in improved operating costs and energy efficiency of the Buildings / Assets in question.

In addition, the integration of BMS and KNX systems would enhance the Asset's components (Mechanical / Electrical) lifespan and future-proof the system for its whole life cycle. Although there will be additional costs for training staff to achieve this, the advantages gained would far outweigh these costs. The integration of BMS and KNX systems would allow for more efficient communication between the Asset's components, leading to improved performance and longevity of the Asset.

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