The Wellcome Wolfson Institute for Experimental Medicine (WWIEM) is an innovative and pioneering bio-medical research and development facility. The laboratories are arranged around a central atrium which encourages collaborative working with transparency across the building between research spaces.

The concept maintains a clear adaptable floor plate, free from service risers by routing ductwork vertically on the building perimeter within an energy efficient double skin façade. The building celebrates the science that occurs within and is an exemplar of sustainable and carbon-limiting laboratory design. The building’s energy efficiency and forward looking low carbon design has made a positive contribution to the University’s target figures and sustainability commitments in managing its estate.

The building has a BMS system that links directly to a central estates energy monitoring system and the building will be monitored seasonally against energy performance targets.

The project has been at the cutting edge of BIM technology in Northern Ireland. BIM was successfully used as a tool for the design development, fabrication, installation and operation of the facility. It has broken new ground for QUB as the information stored in the BIM model will be used for facilities management.

BIM has been adopted across the project supply chain to enable better project outcomes to be realised. The use of BIM has been seen as a path finder for the whole team including the client in order to derive efficiencies and lessons learnt for WWIEM and future projects across the estate.
The Architect and Structural Engineer subsequently were required to deliver tender models to the Contractor’s Team. These models were to form the basis of which the M+E sub-contractor would coordinate their M+E model with.

BIM Objectives

Below are a number of BIM objectives identified for this pilot project:

- Standardise systems for geometric components and their parameters (metadata or attributes).
- Maximise the interoperability of the BIM data with the current Building Manual Procedure and Asset Register Procedure employed by Queens University Belfast.
- In anticipation of future requirements to provide FM data in COBie format, it is an objective to provide COBie outputs for Rooms and Components.
- Maximise feedback in design reviews with client team including end users through the use of 3D models.
- Use of BIM as a management tool for coordination of M+E services with Architectural fabric and structural componentry.

The processes, documentation and lessons learned on this project would be used to revisit the as-built federated model to align with current client asset information requirements (AIR) based on the developing Organisational Information Requirements (OIR).

International standards

A BIM Execution Plan (BEP) was developed on behalf of the client and was to be used by the Design Team and Contractor’s Team as a basis of how they produce, manage and share information. The standards adopted that were available at the time are as follows:

- BS 1192:2007
- PAS1192-2:2013
- BS8541 series

Roles and responsibilities were assigned to project team members aligned with PAS 1192-2:2013 of which they, amongst other responsibilities, would maintain the standards prescribed within the BEP.

The BEP was also an opportunity to highlight the processes that the team would abide by in order to facilitate the handover of an Asset Information Model (AIM) at project completion.
As BIM was a new way of working for the project team as a whole, there was a series of steps undertaken to upskill all members including the client team as well as procurement of the software to develop and coordinate the BIM models. The following are a number of areas addressed by the team:

**Hardware/software:** Since Autodesk Revit was each suppliers chosen platform for design information to be developed there was the need for the project teams to upgrade hardware, purchase licences for the software as well as receive formal training. The client team also began to procure hardware and software to enable them to receive and actively engage with the federated models post-handover. The client has also undertaken a pre-procurement exercise of FM Software providers which is explained further in the ‘Lessons Learnt’ section.

**Standards:** In order for the team to adopt the processes as specified within the BEP, there was a requirement for training in PAS1192-2:2013 and associated BS1192:2007. This training took the format of workshops and CPD’s. Ostick + Williams has undertaken a series of Knowledge Transfer Partnerships (KTP’s) with QUB in which a KTP Associate was employed to implement best practice BIM adoption aligned with BIM Level 2.

**COBie:** At the time of incorporating COBie within the project, the Client had an already established set of procedures for FM. These procedures dictated a set of data requirements which were at odds with some aspects of COBie. As a result the client has undergone a change programme to align their asset information requirements with COBie and industry best practice.

### Interoperability

Interoperability had a limited effect on the design development and construction generated information because the project team chose to adopt the same platform. Two key areas had been highlighted as potential issues:

**Fabrication:** The project team sought to overcome the known issues between design coordination software to fabrication. Unlike more recent releases of Autodesk Revit, the M+E functionality was limited to a small catalogue of componentry as well as a quality not suitable for fabrication. This challenge had been overcome by the advanced training in Revit componentry creation as well as an efficient workflow of services from the Revit model through to FABCAD MEP.

**Industry Foundation Class (IFC):** as the client and project team had been developing competencies in the prescribing of and generation of COBie data, there was also a requirement to interrogate IFC as a format for future integration with design software of other vendors but more importantly FM Software. Ostick + Williams have been undertaking research and developing workflows to optimise IFC extraction.

### Sustainability

Laboratory buildings are intensive energy users, typically requiring twice the energy of a similarly sized hospital. This provided a significant challenge to the client’s desire for a low carbon design; however the WWiEM has exceeded all targets. The 3Rs (reduce, recover, renewable) approach has been successfully applied after consideration of life cycle cost options for each.

Sustainability was placed at the forefront of the design approach to this new facility. The architects engaged with the M+E consultant early in order to test out conceptual massing models with Integrated Environmental Solutions (IES).

Energy demands are reduced by natural ventilation and light within the central atriums, enhanced thermal and air tightness values, solar control, double skin façade with preheat for AHUs, LED lighting and chilled beams.

Recovery takes the form of rain water harvesting, high efficiency air handling plant fitted with heat recovery, VRF installations including heat recovery, basement freezer rooms heat recovery to main atrium underfloor heating, heat dissipation from lab cold rooms and freezers are discharged into the double skin façade and recovered through the air handling system.

Renewable technologies include CHP, PV cells and bore well water supply. The building achieves performance figures such as BREEAM Excellent, EPC 31, air tightness 2.7 m3/hr/m2, and a BRUKL 12kgCO2/ m2 annum.

The double skin is a major feature of the building harmonising architecture and engineering. It maintains a clear adaptable floor plate free from service risers by routing ductwork to the perimeter within an energy efficient double skin façade. Key sustainable features of the double skin are:

- **Energy savings -** trapping a layer of air around the building increases the insulation level. The skin acts as a solar collector and the warm air in the void is used as a pre heat for the HVAC system. Computer modelling established 14% energy savings associated with these gains which translate into life cycle cost savings for the solution relative to base case.

- **Adaptability - HVAC ducts and other services are located within this zone with easy access and adaptability for future services installation. Solar gain / glare control -** The double skin creates an enclosed weather protected zone within which automated blinds are fitted to control solar gain and glare into the labs particularly on the south elevation.
Specialist software (IES) for the analysis of building performance was employed from the early stages of design to calculate the anticipated energy consumption and therefore facilitate informed design decisions to minimise the long-term environmental and operational costs. These computer-based simulations extracted geometry and materiality from the BIM model and enabled the design team to simulate the natural climate of the site, room by room energy loads and any proposed environmental strategies. The result of such extensive testing was the harmonisation of the site massing, internal loads and layout with the natural climate and site conditions. Design decisions which arose from this process included the addition of a double skin façade to regulate the internal environment and act as a pre-heat for HVAC systems, the inclusion of natural ventilation and the controlled positioning of natural lighting. In use these strategies have proven effective in delivering a design solution that takes account of the intense energy needs within a laboratory environment.

Soft Landings

The UK Government Soft Landings (GSL) process was adopted on this project to engage the building users during the design, construction, commissioning, handover and aftercare of the building. GSL is aligned with the NBS BIM Toolkit. The principal driver of the process is to deliver a problem free handover and occupation of the building. Many of the actions within the Government Soft Landings process were already being undertaken by Queen’s as part of its procurement procedures which included user consultations during the design process and work stage reporting. The normal process of user engagement was enhanced during construction when soft landings processes were followed including –

- Fortnightly BIM workshops of the MEP co-ordination by reviewing the model in Navisworks format on a large screen. Client side attendees included the PM, Clerk of Works, Architect, M+E Engineers and Estates maintenance representatives. The Contracts Manager and the M+E Co-ordinator, M+E sub-contractor design manager and BIM manager represented the contractor.
- A commissioning engineer was appointed to programme and manage the progressive inspection, testing and witnessing of the M+E systems. Training on the running and maintenance of the components and systems was also arranged for the maintenance team.
- Ostick + Williams prepared a Building User Guide (pocket guide) which was distributed to each of the building users at handover and occupation. The guide offers users an easy to follow explanation of the day to day operations and systems within the building.
- Leading up to handover weekly meetings were held with a selected group of Estates, Consultants, Contractor and building user representatives. These meetings continued at the same frequency for three months, fortnightly for the following 3 months and monthly for the reminder of the defects period. It is planned to maintain these meetings on a quarterly basis until 3 years post handover.
- The performance of the building is being monitored and fed back to the soft landings team who are responsible for communicating with the users, keeping an issues log and an action list for the contractor’s attention.

Innovative use of BIM

Both the architectural and structural Autodesk Revit models were created to technical design stage. These were delivered to the contractor as a basis to develop the M+E services model to ‘as-built’ status. The M+E sub-contractor (Harvey Group) received the M+E consultant engineering drawings as a starting point for the development of their Autodesk Revit Model. Spatial co-ordination was carried out within the federated model. The installation drawings were generated within Revit as shown in Fig 7. The model was also linked through to the software FABCAD MEP that then generated the fabrication drawings as demonstrated. This innovative process reduced the design-fabrication time from weeks to days.

Collaboration / Communication

Individual Organisation Co-ordination and Clash Detection process

Spatial co-ordination for this project was aligned with the principles of PAS 1192-2:2013, section 9.4. Each task team (organisation) had undertaken ownership of their WIP information and models and reviewed these with their design lead before issuing the information and model to the project team. This check had taken place at regular intervals and as was required prior to issuing.

If a clash had been detected which could not be resolved by the design lead then the lead consultant was involved in the discussion to reach agreement and make necessary changes to the model(s).

Project Team Coordination and Clash Detection meeting Process

As part of the project team’s risk management strategy, formal design co-ordination meetings would take place regularly through the construction period between all disciplines, the Contractor and the Client. It was conducted by Ostick + Williams pre-construction and Harvey Group thereafter. Models would be shared by each organisation, at least 24hrs prior to the meeting and converted to an Autodesk Navisworks File (.NWF). This would contain a linked path to each organisations live model.
To aid in the efficiencies of Design Review/Co-ordination meetings, especially those with the Client’s team, the Contractor would prepare the presentation of the model to focus on the key issues. This would take into consideration:

- Preparation of meaningful 3D views as per the meeting’s agenda to begin navigation.
- Have coloured filters established within Navisworks to distinguish M+E services to their system name.
- Search sets (component grouping) established in order to manage the models components easier.

Visual co-ordination/design issues that arise from the meeting would be documented via viewpoints and comments. At the end of the meeting a viewpoints report would be formally issued to the appropriate project members. Formal clash tests would not be conducted between ‘Model’ and ‘Model’ as the results could be unwieldy. A logical approach was adopted by the project team and the appropriate element search sets. E.g. ‘Ductwork’ against ‘Walls’ would have been used.

Particular attention was paid towards:

- Hard clashes and construction tolerances.
- Soft Clashes (for example, positioning of insulation around ductwork and pipework) and proximity checks (for example, the placement of oxygen and other gases).

A formal clash report would then be issued to the relevant parties for modification of each model and re-issued to the project team.

Health and Safety

Prevention through design was facilitated by visualising the spaces in 3D. The design team were able to discuss maintenance activities and gain a greater understanding of how the spaces would operate following completion.

BIM was also adopted by the Contractor’s team as a risk management tool as it very clearly communicated to site based staff the need to accurately install the building componentry. This allowed efficient phasing and installation of services taken from the soffit downwards. The federated 3D models would have also been used for toolbox talks and site inductions.

FIGURE 8. COORDINATION OF FEDERATED MODELS

BIM for FM

Queens Universities Estates Directorates overarching aim for this pilot project was to integrate the use of the federated BIM within their Operation and Maintenance (O+M) procedures. Although it was the Client’s first BIM project as well as the first BIM project for the project team as a whole, it was made clear that the project team should develop a strategy alongside the QUB FM team for integration of the extracted data into their existing FM procedures.

BIM Integration with the O+M Manual

As well as handing over the ‘as-built’ Revit models, the project team arranged for the handover of the O+M manual that had hyperlinks to the Navisworks version of the federated models. This took the form of a combined PDF that contained all 2D information as well as direct links to the 3D model so that the

FIGURE 9. COORDINATION OF FEDERATED MODELS

FIGURE 10. COORDINATION OF FEDERATED MODELS
Estates maintenance team could plan activities much more efficiently. The live PDF drawing format will act as the central repository for change control of models and extracted documentation.

The project team also proposed and executed a novel idea of combining the 3D Navisworks models with the extracted 2D DWFs of the sheets into a single Navisworks File. The Globally Unique ID’s (GUID) of each component links the 2D to the 3D therefore allowing the FM team to view 2D intelligent drawings and view the same component in 3D at a click of the button. Coloured filters were also established for the M+E services in both 2D and 3D which would give the FM team a mode to easily track systems when performing maintenance activities.

COBie requirements

Key to any change programme is communication of change and adequate support throughout. The client acknowledged that to truly implement COBie as a requirement for the pilot project and future projects there would need to be internal change of procedures and documentation. This will be discussed further under the section ‘lessons learnt’.

As the WWIEM was a pilot project for the integration of BIM, the BEP stipulated a hybrid of data requirements including the addition of custom shared parameters aligned to the project asset register. The custom parameters included room code; building code; asset type; asset description; asset code and asset number. These parameters where populated for all instances aligned with the asset register.

COBie was also prescribed as a requirement and as such, the project team sought to populate the models with COBie parameters and complete with relevant information in advance of handover. The project team, including the client acknowledged during this process that further direction would be fundamental to the success of COBie integration particularly as the client sought to investigate an FM software platform that would integrate with COBie and QUB requirements.

Key Project Outcomes

Time
The project was an extremely challenging exercise involving the pre-construction co-ordination of fabric, structure and complex M+E systems and construction on a very constrained site surrounded by sensitive activities. The new Institute needed to be ready by the summer of 2015 to allow 300+ research staff to transfer from existing facilities to continue to develop their ground breaking life sciences research. The project was completed on time and the adoption of level 2 BIM has been credited as one of the key reasons for staying on programme. Pre-construction co-ordination was done very well, the M+E Revit model was interoperable with the fabrication of ductwork, piping, cable trays and supports which increased speed and minimised waste which resulted in very few instances of delays. The process also allowed the contractor to adjust the installation sequence by maximising off-site fabrication which delivered the time benefits expected of lean construction.

Quality
The completed project has a very good appearance in terms of the internal and external finishes and this extends to the installation and systems that are mostly covered up where the standard of installation has benefited greatly from pre-construction clash detection and off site fabrication. The project was the overall winner in the NI Construction Excellence Awards 2015 and the use of BIM was cited by the judges as having made a major contribution to the high quality of the completed project.

Cost
The project has been delivered to the capital budget. Reporting has been thorough and consistent throughout the construction period and there were very few site changes or outstanding RFIs to throw the project cost management off track. Queen’s Estates Directorate is in no doubt that the BIM level 2 process has improved predictability of outcome and positively influenced the successful management of project costs.

Client Engagement
Queens have been proactively engaged in the application of BIM in the WWIEM project as a pathfinder to learn lessons with a view to realising the benefits across the entire campus the drive has started at Director level within the Estates Directorate which has been fundamental to the successful implementation of BIM. The regular BIM co-ordination meetings improved day-to-day construction management and acted as a means for the Contractor, designers and building users to work collaboratively for the betterment of the end result. Soft landings has extended the design team’s involvement in the project and as we work through the 3 year post occupation period during which time we are continuing to work on the use of COBie for FM.

Lessons Learnt
The Client, having adopted the fundamental BIM steps throughout the later stages of the project, subsequently sought to formalise their adoption and optimise the processes involved so as to build upon the derived benefits for future projects. Even as the project was drawing to a close, QUB Estates Directorate was actively establishing a ‘BIM Implementation Group’ tasked with sharing the knowledge gained and overseeing the wide scale implementation of BIM processes across the QUB Estates Directorate. Ostick + Williams have been invited to this group with other industry specialists to share their strong working knowledge of BIM. The group’s goal is for the implementation of BIM within the Estates Directorate and it also supports the principle that each of these specialists should also benefit from the shared knowledge and experience, hence driving the wider implementation of quality BIM techniques and workflows.
To address these a subgroup of the BIM Implementation group mentioned above was formed from members of the Estates Directorate and Ostick + Williams, the project architects for the Wellcome Wolfson Institute, who were tasked with refining the requirements for the delivery of project information and data in the form of IFC and COBie. Of particular interest to this subgroup was the timely exchange of data so as to support key client decisions throughout the design and construction therefore defining what data should be exchanged and when was critical. This focus began with the creation of a BIM authoring software to COBie workflow that would help suppliers provide data in a manner that aligned with the client’s needs and suitable for incorporating into a computerise FM management system. This workflow was supplemented by the creation of a ‘COBie Responsibility Matrix’ which simplified the responsibility for the creation/update of data prior to each data drop and an ‘Asset Register’ which defined in simple terms the information needed for each asset.

The work of this subgroup demonstrates the lessons learnt by the project team and client with regard to the retention of project data and management of the design process so that data is delivered in a sensible and as needed manner. These activities ensure that the ultimate goal for the exchange of data from the CAPEX to OPEX stages to support facilities management activities is now possible. These refinements to the required delivery of sensible data via the COBie and IFC format structure were subsequent additions to the client’s Asset Information Requirements. These in turn are incorporated within the Employer Information Requirements (EIR) for any future projects.

Having recognised the importance of retaining the data produced throughout the design and construction stages and having refined the process by which this information is exchanged via IFC and COBie, the client has initiated a review of their facilities management practices. This process is again facilitated through a subgroup of the main BIM implementation group, formed by the client themselves with the addition of Ostick + Williams and other organisations specialised within the field of BIM for FM.

This review both establishes a change to the culture within the client’s facilities management team as they transition to the digital management of assets and incorporates the selection of a FM management system that is capable of a bi-directional link with the BIM model and is a testimony to the impact of the implementation of BIM level 2 within the WWIEM project on the wider estate strategies.

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**LESSONS LEARNT**

**IFC & COBie Optimisation and Validation**

The project provided the client with their first experience of requesting ‘COBie’ for data exchange; albeit without full consideration as to the data content and with a reluctance to abandon their traditional data handover methods employed for non-BIM enable projects. From this the client and project team developed an understanding as to the importance of specifying the exact data required rather than an undefined ‘COBie’ approach. A related issue was that of the exchange of data via IFC. Whilst the project had been fortunate in that all stakeholders worked within the Autodesk Revit environment for the creation of BIM data, it became apparent that this would not always be the case.

![Figure 12 COBie Extraction Workflow](image-url)