Ensuring that the Needs of the End User are Effectively Communicated through BIM during the Building Design Stage

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Ensuring that the Needs of the End User are Effectively Communicated through BIM during the Building Design Stage

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Abstract–The Grangegorman Development Project is the largest single development of 3rd level education accommodation in the history of the Irish State. Planned for completion in 2023, it will relocate all of Dublin Institute of Technology’s (DIT) activities from their current 39 locations to a single campus. This is a once-off opportunity for DIT and it is therefore critical that the campus is designed to meet end-users’ needs. As part of the strategy to achieve this, it has been specified that all work packages within the campus must use Building Information Modelling (BIM) in the design, construction and the planning of the operation of the buildings. This approach has highlighted the growing importance of BIM in Irish Public Sector projects. To maximize the benefits of BIM, it is vital that the end-users of the campus are fully engaged in the design process and that their needs are fully appreciated. This paper will detail a new process, in which the end-user will operate as an integral part of the design process, as witnessed in the most recent procurement phase of the campus. The data collation methodology will involve the review of existing procedures in place to communicate the needs of the end-users. This will be achieved through interviews and analysis of existing Facilities Management (FM) documents. The findings from this case study suggest that the application of BIM can serve as an enhanced communication tool to improve relations between the design team and the end-user.

Keywords–Building Information Modelling, Facilities Management, End-Users, Grangegorman, Public Works, Ireland

I BACKGROUND

The Irish Architecture Engineering and Construction (AEC) sector has shown a strong increase in construction output to €11bn in 2014. This is expected to rise to €12.5bn in 2015 and €15.3bn in 2016 [1]. A warning comes with this increase in that there are still a number of challenges for the sector to overcome. These challenges will need to be addressed to ensure the construction sector can meet the demands made on it over the coming years. Some of these challenges include access to finance, resolution of the mortgage arrears issues, existing planning regulations and ensuring the industry has the skilled workforce to undertake the expected pipeline of work to the highest standards. [2]. A solution to some of these problems as advocated in recent reports such as the Forfás Report 2013, is to promote the use of BIM and develop the associated technical skills amongst Irish construction firms, so that they can successfully compete in markets where BIM is widely adopted or a regulatory requirement [3]. The Construction 2020 report, which is a strategy for a renewed construction sector prepared by the Irish Government echoes this sentiment. It is suggested that adoption of BIM can increase the attractiveness for the sector for young professionals. The strategy champions BIM as a tool that can drive efficiencies and increased productivity in construction [4]. In 2014 Deeney et al. suggested that despite the fact that BIM could be the catalyst for Irish construction, the
Government would not agree to a BIM mandate while the country was being funded by Europe [5]. The Irish Government at present still remains sceptical about BIM, as evidenced by recent announcements made by the Irish Government Chief Procurement Officer for the Public Service. The Public Service is not proposing that BIM be a requirement to qualify for Irish public works contracts, unlike the situation that pertains in the UK. They are reluctant to impose BIM as a requirement on the lower end of the market place, as there is a nervousness in small businesses about the need to invest in the software and expertise [6].

Recently there have been encouraging signs of BIM being used on elements of public works projects. These include the Grangegorman Development Project and the proposed new Children’s Hospital which is to be primarily located on the city centre site of the existing St James Hospital.

The Grangegorman Development Project represents the largest single development of 3rd level education accommodation in the history of the State. Planned for completion in 2023, it will relocate all of Dublin Institute of Technology’s (DIT) activities from their current 39 locations to a single campus. Figure 1 illustrates the current geographic disparity of the nine separate major buildings that as a collective make up DIT.

With the development of such a campus it is critical that it is designed to meet end-users’ needs. The Grangegorman project represented an opportunity to review existing procedures to communicate the needs of the end-users and observe how BIM is been applied to enhance this process.

The first tranche of 1000 students arrived on campus in September 2014 occupying refurbished listed buildings on site. They will be joined in 2017/18 by a further 9000 students from thirteen of DIT’s Schools who will relocate from existing locations at Kevin Street, Cathal Brugha Street, Rathmines and Chatham Row.

In July 2012, the Irish Government announced a €2.25bn Stimulus Package to promote employment and economic activity in the Irish Economy. Using Public Private Partnership (PPP) as a primary procurement vehicle, a series of projects were to be

**II AIM AND METHODOLOGY**

The aim of this paper is to examine the issues involved in communicating the needs of end-user to the design team. The paper will also suggest how BIM can be used as a medium for more effective communication. The methodology employed was twofold. Firstly, the extensive documentation available on the project was reviewed to gain an understanding of the nature, scale and history to date of the delivery of the project. This review is documented in section III of the paper. The second aspect of the methodology involved collection of data on the management of the delivery of the project to date. To achieve this a total of five interviews were conducted, four with members of the DIT Campus Planning Team (DITCP) with the purpose of documenting current practices. These interviewees included the Head of Campus Planning and the Team Leaders for the College of Arts and Tourism, Engineering and Built Environment and Sciences and Health. The interviewees where all involved in the end-user consultation with the design team. The fifth interview was conducted with a senior member of the Grangegorman Development Agency (GDA) to validate the findings from DITCP. The findings, presented in the following sections of the paper, conclude that the proper application of BIM can be used in the future to better communicate the end-user needs. The results are presented as a process map later in the paper.
delivered over the following years. Since the Grangegorman Strategic Plan had a number of “jobs rich and shovel ready” projects available – all of which were approved under the Grangegorman Strategic Development Zone planning permission of 2011. €200 million was allocated to Grangegorman to deliver 50,000m² of floor space procured via a PPP [8].

The buildings identified for development of this element of the project are designated as Central and East Quads. The Central Quad will provide the primary facilities for students and staff in technical and scientific disciplines in the Sciences, Health, Tourism, Food, Computing, and some Engineering disciplines. The East Quad is to be a centre of excellence for Creative Arts, Music and Drama, Social Sciences, and Languages. The East Quad forms part of the wider ‘Social and Cultural Heart’ of the campus.

A distinctive feature of DIT education is a particular emphasis on practical and discipline specific skills. To provide this type of educational experience both Quads comprise of diverse specialist spaces such as laboratories, workshops, kitchens, performance spaces, Information Technology (IT) rich classrooms and variety of distributed learning spaces.

The DIT Grangegorman campus represents a unique design approach in which the Client team has played an active hands-on role throughout the planning, design and construction processes with the specific purpose of ensuring the needs of the end-user are realised. Though BIM is still at an early stage of deployment in Ireland, there is an established view that it can enhance end user understanding of the building process. The development of the campus provided an opportunity to test this.

IV PROJECT MANAGEMENT AND HIERARCHY

National Development Finance Agency

Before 2002 project management expertise devoted to PPP projects available to the Government was spread across several government departments. As each PPP project was completed, the related project team disbanded. As a result valuable PPP project expertise was consistently lost to the State. The National Development Finance Agency (NDFA) was established in January 2003 in accordance with the National Development Finance Agency Act 2002 [9] and in 2006 it was given full responsibility for the procurement and delivery of PPP projects in all sectors other than in transport and water/waste water. The NDFA performs its functions through the National Treasury Management Agency (NTMA) [10]. Non-PPP works packages on the Grangegorman project are procured by the GDA on behalf of the Minister for Education and Skills whilst the NDFA has the dual role of procuring the PPP elements and acting for and on behalf of the Minister for Education and Skills as the financial adviser for all work packages valued above €20 million. The PPP project is managed through the NDFA by a project board and a project team, which included representation from DIT and the GDA. All decisions for the project are reviewed by the project team and major issues are referred to the board.

Grangegorman Development Agency

The GDA is a statutory agency established in 2006 by the Irish Government under the Grangegorman Development Agency Act 2005 to redevelop the former St. Brendan’s Hospital grounds in Grangegorman near Dublin City Centre [11]. Its function is to accept the site, consult with stakeholders, prepare all necessary plans and strategies documentation and to procure and manage all developments. In addition the GDA will dispose of DIT properties and return new facilities to DIT, HSE or other bodies as appropriate. The GDA acts as a project manager with full responsibility for the planning and delivery of the construction projects [12].

The GDA representative stated that they worked in parallel with the NDFA in delivering the PPP project. They noted that at the earliest stages the GDA had the lead on the delivery of the two buildings that comprise the projects. The NDFA took over a leading role once the Technical Advisors (TAs) had been procured for the project.

DIT Campus Planning

The DIT Campus Planning Team (DITCP) is a group of DIT staff, seconded to the project from a cross-section of areas in DIT. The role of the Team is to liaise between end-users, agencies involved in procurement and TA teams. A significant aspect of this role involved setting up and managing end-user consultation in the planning delivery of the new campus. In the earlier stages of the project the team was required to develop, refine and test strategic briefs for each element of the new campus and present these to the senior leadership team for approval. The team engaged with designers/consultants/GDA to ensure that the needs of DIT were met and that fitness of purpose of the campus is achieved. Thus, it was the role of the DITCP to address the functional risk aspect of the development.
An appreciation of the interaction between NDFA/GDA/DITCP was formed during the interviews described below. The text presented in italics in the following sections are direct quotations from the interviewees and are credited accordingly.

It was necessary for DITCP to “work very closely with the GDA to avoid an extra layer of removal because the PPP project by its nature places the NDFA between you and the tendering bodies” (DITCP). DITCP became “the interface who provided information to the GDA who give that information to the NDFA, who give that information to the preferred tenderer, who passes it down to his sub-contractor, etc.” (DITCP).

To better understand and communicate the end-user requirements a number of building groups where established in each of the 13 schools that would occupy the new facilities. This approach was based on advice received from consultation with equivalent bodies in the University of Limerick and elsewhere from whom advice had been sought at the outset of the project. “The Building Groups were further simplified by having a single point of contact within a school that conveyed the needs of the end-users for that school” (DITCP). Once details are agreed with individual schools the overall proposals were presented and ratified by the DIT Senior Leadership team and the DIT Governing Body. All final decisions involved a collaborative process with the project team and board with advice from the TAs.

a) Technical Advisors

A team of TAs were appointed by the GDA and the NDFA to prepare for the PPP bidding process following an international procurement competition. The team of TAs acted as the NDFA’s Architects, Engineers and other professional consultants, led by a specialist project management company. Their role was to work alongside the NDFA in preparing the specifications for the Central and East Quads, to be developed through the PPP.

DITCP worked alongside the TA teams who fed back design concerns to the NDFA. This ultimately resulted in the “technical advisors becoming a middleman” (DITCP). Figure 2 details the hierarchy of the project in where DIT worked with the GDA, TAs and school building groups to realise the best design for the end-user before final sign-off by the NDFA.

In order for the end-users’ needs to be translated there was a need to create and document an FM strategy that would encompass their requirements. The key objective of producing an FM strategy was the identification and implementation of the most appropriate FM service delivery model which maximises value for money for DIT in the context of the Grangegorman PPP. Ongoing negotiations took place between all parties to establish clearly defined and well understood service boundaries and interfaces between the PPP and non-PPP elements of the campus. This involved establishing where written procedures were in place and refinement of these in terms of what was required in a PPP contract. “Where written procedures did not exist, DIT was required to develop such procedures and to produce a written description of the procedure in a format required for a PPP contract” (DITCP).

The FM strategy was divided into soft and hard FM. Hard FM involved Building and Asset Maintenance, Lifecycle Replacement, Security, Health and Safety Management, and Energy and Utilities Management. Soft FM services consisted of Cleaning, Waste Management, Pest Control and Caretaking. Three selected areas consisting of hard and soft FM requirements are detailed below to demonstrate the high level of communication required between the DITCP, GDA, NDFA and the TAs:

- Information Technology: After careful analysis and previous experience it was decided that it would be best to keep the IT in house, as it was too difficult to confidently price a state of the art system over the lifecycle of the project. Since the infrastructure required to support this equipment had to be hard wired into the building, the PPP Company (PPP Co) were required to provide and install all of the ducting to facilitate a DIT fit out of the cabling. In respect of the Audio Visual (AV) facilities, it was decided that DIT would specify the AV system which the PPP Co would purchase, install and commission. DIT would then take ownership of the system and be responsible for
its operation for the duration of the PPP contract. The handover would include a demonstration of the AV system in full working mode.

- **Cleaning**: It was decided the most practical solution was to include cleaning services within the scope of the PPP scheme. However some issues still had to be negotiated, such as the cleaning in particular areas i.e. the cleaning of food surfaces and food preparation was very specific. To ameliorate risk, it was agreed that the selected PPP Co clean the floors and the walls, but DIT staff would clean the pots, the pans and the surfaces that food is cooked in.

- **Caretaking**: The responsibility for the building and asset maintenance is with the PPP Co. There is an agreed predetermined level of risk and contractual responsibility. Some elements would remain the responsibility of DIT e.g. grounds maintenance, as there would be a potential for dispute of the boundaries at which the responsibilities transferred. DIT also have technical staff who are responsible for items such as gas and chemical deliveries. It was decided to continue to do this, as it made no sense to outsource.

## VI DIFFICULTIES

The DITCP encountered a number of difficulties in communicating the needs of the end-users. These were in part due to issues with presentation of technical information to non-specialists. Such presentations occurred at scheduled times and often did not allow for sufficient scope to tease out issues of concern to end-users. The chosen medium of 2D based drawings was also difficult. The problems encountered are outlined below.

### a) Technical Advisor Interaction

It was difficult in some instances in documenting the key criteria covered in some of the meetings. “This was a complex process and in some instances resulted in a loop of communication between all parties without progress been made. This happened as the TAs were working within a very tight timeframe and the short turnaround in time for production of drawings resulted in many cases in which drawings where being presented during the meeting rather than being reviewed. The meetings were actually being used for feedback, as well as for design”. (DITCP).

The extensive list of over 66,000 items of furniture, fittings and equipment (FFE) also caused difficulty. Again, the review of this list went through several iterations. “Before the technical advisors took responsibility for this, the GDA hired external architects to produce a FFE schedule” (GDA). This process produced a database that was refined using Excel, from which spreadsheets were used to populate a specialist software programme to produce room datasheets. A data input problem arose in this process, resulting in confusion when end users set about verifying the information provided to them on the room data sheets. Confusion turned to frustration with some end users as it took several iterations to correct.

It was also difficult to demonstrate the FFE needs and limitations to the end-users through the use of 2D drawings and other non 3D based formats. There was a fear amongst the end-users of under-resourcing and as a result end-user FFE requirements in some cases became over specified and ultimately could not fit into the allocated space provided.

The Strategic Plan for the development of the campus provided information for the production of several strategic building briefs, including briefs for the Central and East Quads. In these documents the schedule of accommodation was provided for the entire building based on the specialist space need of each of the schools. Exemplar designs were used to illustrate this in which were eventually fully worked up to architectural drawings. “To achieve this, the design team had a lot of interface with the individual schools and their users. They discussed and documented the needs of each room. This enabled the room data sheets to be worked through in detail and a shared understanding of the spaces to be realised” (DITCP). Having a strategic plan in place enabled the DITCP to negotiate with the end-users as “it is essential to have an agreed starting point for spatial requirements if you need to seek compromise. Without this, it’s very hard to argue in favour or against any suggestion for amendment” (DITCP). The end-users are the specialists in their own area and have a set requirements of what space is required to efficiently run their school. "Communicating these spatial requirements involved using concepts about how the building would work. This would establish the adjacencies of the spaces required for the building to function, thereby addressing the Functionality Risk that was being borne by DIT” (DITCP).

The funding provided in the stimulus package for 2012 was not sufficient to build both of the quads to the extent defined in the strategic brief for each building. Following cost estimation exercises it was established that consequently, the space originally allocated to each school had to be reduced. This resulted in a rationalising of space through the production of a revised schedule of accommodation. This was a lengthy and difficult
process that involved extensive negotiation between DITCP and the end-users. The TAs had to find out how these spaces relate to each other and how these spaces inter connected on a school by school basis e.g. keep all of the heavy labs together, because they would require a certain type of ventilation. The TA architects began the process by using massing diagrams to lay out how all of this would work. After a number of iterations they eventually began to develop floor plans. Issues arose from this exercise as a result of trying to fit the maximum amount of functional space into a tight envelope. “This exercise was difficult as the TAs had to rely on non-design specialists to provide them with an understanding of the functionality of the space. For example, a room that is long and narrow might function perfectly for one school, much better than a square one, whereas for another one the square room is optimal (DITCP).

DITCP is comprised of a mix of people, some whom were academic members that were not all based in construction related disciplines. This meant that some of the team were new to the construction process. One such DITCP member, felt that “as a non-specialist, it was sometimes difficult to understand the construction process and I was at a disadvantage during the technical meetings. This was often due to the use of 2D drawings as a means to communicating 3D concepts and trying to visualise the details of these concepts” He further commented that it takes some time as a non-specialist to reach the required level of those who have been professionally operating with the sector. “The translation effect between a non-specialist and the specialist people, takes a while to get up to speed with the language, the programming style, the legislation, all of those things take some time” (DITCP). Despite some of these problems, he found that his involvement was absolutely essential, as the TAs would find it too difficult to try to accommodate input for a number of different schools without a structured focal point.

b) N DFA and G DA Interaction

The NDFA is responsible for ensuring that the best possible deal for the State in relation to value. Control of costs is part of this responsibility. As a result, the NDFA sought to ensure that cost was controlled within the affordability cap of the project. “The PPP market in Ireland has been fairly fraught over the last number of years, where there were a lot of cancellation of competitions e.g. Prison Service. The NDFA had to ensure that the preferred bidder could deliver the project and meet the requirements and so therefore were mindful that the stated deliverables were realistic. This required an intimate working arrangement with the GDA in order to ensure this” (GDA).

c) DIT and End User Interaction

DITCP found it difficult in some instances to use 2D drawings to illustrate spatial needs to the different building groups using the chosen medium. There is a healthy competition between schools that serves in incentivising the different departments. With each school there is a need to justify why one department is assigned more space that the other. This takes very careful negotiation and can be a problem. The inclusion of the DITCP in negotiating this aspect was crucial, as they are familiar with the end processes and therefore can confidently interact with the Building Group” (DITCP.) It was found that unless drawings where presented with full annotations with room areas, scales, gridlines or colour coding to show one school from another, it would result in a lack of clarity of which school occupies what.

There was also a lack of appreciation of the difficulty that specific non-technical people had understanding technical information. “In one case a musician looked at a set of plans and stated that his lack of ability to make sense of them would probably be similar to my lack of ability to hear the tune when looking at a page of musical notations” (DITCP).

As stated DITCP performed an internal space planning exercise prior to the outset of the project. School members visited similar facilities in order to help them visualise the various options for the layout of their designated spaces. This provided an understanding of shared spaces where adjoining rooms could be designed to serve a number of departments to cater for peak and low demand as dictated by the CAO offering. As different departments will require larger spaces at different times it was important that these space were designed to be flexible. Despite these exercises it was still a difficult process for the end-user. In some instances “the end-users where basing their brief on how they operate currently with no understanding that they have a clean slate and they have an “opportunity to design this from scratch” (GDA). The end users to this effect tried to contribute to spaces to ensure they were being designed to be flexible. The medium of 2D drawings made this process difficult. A 3D representation would be much more useful.

Figure 3 illustrates the core difficulties detailed within the original process, as explained throughout this section. This included the face-to-face meetings with the TAs in which it was difficult on occasion to translate the requirements of the end-user through current practices alone. Other difficulties mapped in the figure include data input problems to the specialist software. This led
to frustration from the end users who already had difficulties in visualising the FFE limitations through the format used. Further difficulties are acknowledged in this process through the application of 2D drawings to explain the functionality of spaces. The next section will advocate BIM as a solution in offering a more rewarding methodology in regards to the detailed difficulties in figure 3.

## VII BUILDING INFORMATION MODELLING

After all of the information was collected from the process detailed above, a set of tender documents were drafted by the TAs, with extensive input from GDA and DIT. Part of the tender requirements was the mandating of the development and presentation of a fully populated Building Information Model.

> Such a model had not been developed in the pre-tender stage and for future pre-tender stakeholder interaction it was acknowledged that it would be important for the TAs to produce a 3D model. “In addition, the NDFA were conscious of the growing need for BIM and were keen to incorporate the latest technology into this project in order to promote greater value through the use of BIM on publicly funded projects generally.” (GDA)

Despite a BIM model and its associated processes not been adopted before the tender stage, there is a strong awareness of its capabilities within Grangegorman. This was further validated by a number of the DITCP and GDA personnel taking the BIM Training modules offered by the DIT accredited MSc in Applied BIM and Management programme in the 2014/15 academic session.

One area noted by the majority of interviewees as being crucial to the stakeholder consultation process is the understanding of the dimension of spaces. A scaled model of the building was used

<table>
<thead>
<tr>
<th>Building Groups</th>
<th>DITCP</th>
<th>TA</th>
<th>GDA</th>
<th>NDFA</th>
</tr>
</thead>
<tbody>
<tr>
<td>13 Established building groups agreed on required end use needs, Senior Leadership team and the DIT Governing Body sign off</td>
<td>DITCP communicate the needs of the building groups to the TAs and GDA. This was achieved through scheduled meetings. TAs would then create designs based on the recorded requirements. Designs were reviewed and agreed by all parties.</td>
<td>Refined end user requirements agreed and included in tender package.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Communication Process

Non Specialists found 3D drawings frustrating to understand and difficult to visualise.

In some instances this process resulted in a loop of communication between parties without progress being made. The meetings were being used for feedback, as well as for design.

**Waste (Time and Money)** in the supply chain from repeated and lost information as a result of communications difficulties.

### Communication Difficulties

A total of 66,000 items of furniture, agreed and specified.

FFE database was refined using Excel, from which spreadsheets were used to populate a specialist software programme to produce room datasheets. 

Refined end user requirements agreed and included in tender package.

### FFE Process

Difficult to convey FFE through 3D drawings (Schools over specified due to fear of under rescouring / frustration with verifying FFE).

A data input problem arose in this process, resulting in confusion when end users set about verifying the information provided to them on the room data sheet.

**Waste (Time and Money)** in the supply chain as a result from the repeated FFE exercise.

### FFE Difficulties

Internal space planning exercise performed prior to the onset of the project to help visualise the various options for the layout of their designated spaces.

Exemplar designs were used to illustrate the specialist space need of each of the schools.

Missing diagrams were produced once in an understanding of how these spaces relate to each other was gained by the TAs. After a number of iterations floor plans were developed.

Refined end user requirements agreed and included in tender package.

### Functionality Process

Difficult to visualise the various possibilities for the layout of designated spaces /

Being their brief on how they operate currently operate.

Due to cost measures space originally allocated to each school had to be reduced. This resulted in a rationalising of space through the production of a revised schedule of accommodation. This was a lengthy and difficult process that involved extensive negotiation between DITCP and the end-users. This was difficult to convey to the end users.

Some spaces may not have achieved their full functionality potential. This may cause problems in the future.

### Functionality Difficulties

Figure 3: core difficulties
with different coloured pieces to indicate the sizes of the allocated spaces. This was useful, as it gave people an understanding of where they would be in the building. A virtual model would have significantly expedited this process. The model could be used to visualise the room sizes through a virtual walk through instead of explaining that “a particular space is five times bigger than another. By having a BIM model it would probably allay some fears. So it certainly would smooth the process, give more confidence in the process” (DITCP). Similar initiatives have been demonstrated, as seen at the CITA Technology Challenge Conference in 2014, where Waterford Institute of Technology used a combination of BIM and Oculus Rift to demonstrate to the end-users the proposed changes to an existing railway station [13].

A model could have helped the designer understand the area of functionality from an educational perspective more easily. “A room that is long and narrow might function perfectly for one school, much better than a square one, whereas for another one the square room is best. An example of this was in the case of a laboratory that required 80 sq. of space, a 20m long by 4m wide room was suggested. Despite the brief being realised this suggested laboratory was not practical due to the fact that such a lab is usually a square, so as to accommodate a combination of the students and large lab equipment (DITCP). The use of a BIM model would have reduced people’s fears and ultimately helped in the stakeholder consultation process. “It would make them feel more of a sense of engagement with the designers I think” (DITCP). A model if used from the start would have made things easier for everyone. It would have saved a lot of time on the overall scope of the project. There was a strong belief that the use of BIM technologies could have made interaction with all parties a more easier and rewarding process.

There was also a consensus that the use of BIM would have provided an understanding for the end-user in regards to the FFE. “As the FFE was presented in a spreadsheet that is hundreds of pages in length, it was difficult to work with. If a model was used to visually inspect the furniture within the room it would provide an instant understanding for the end-user” (GDA).

The option of Cloud BIM technology could have provided the real time monitoring of construction progress, clash detection and data sharing amongst the construction team [14]. This would have ensured that the end-users and TAs could interact on the same model to progress the suggested design changes. Mark ups could have been carried out online and design changes could be implemented faster and more effectively. Figure 4 illustrates how the previous process detailed in Figure 3 could have been enhanced through BIM.

**VII CONCLUSION**

The Grangegorman PPP is unique in that it has an end-user focused team involved from the beginning who are dedicated to executing and ensuring the best interests of the end-user. This team in order to keep focus on the end-user requirements have to operate through a number of channels in order to serve the best interests of the end-users. The GDA acknowledged that it is important to have the end-user involved and that they buy into the solution. Their involvement is helpful from the designer’s point of view, as they get to sit down with the end-users and ensure the design meets their needs. As the end-users are not trained as designers it is very difficult for them to actually picture the optimum solution. This results in the end-users going back to the way they were originally operating. Exemplar designs were shown to the end-user to help overcome this. This
still resulted in the insistence of impractical FFE requirements within the allocated spaces.

Though BIM will play a key part during construction there was no provision for it to be used at the pre-tender stage. This represented a lost opportunity and would have provided a tool that could have been used as a more rewarding and practical medium. A BIM model can offer the opportunity to visualise space easily, therefore improving an understanding of underutilised spaces, as well as performing exercises in space management that are not possible in traditional FM software packages. BIM can be used by the whole team to further collaboration techniques, as it helps offer an easier way of understanding the project requirements. Collaboration was key in the Grangegorman process and the use of 2D drawings created difficulties for those not familiar with them. BIM could be the tool that helps non specialised end-users in the construction process to contribute more effectively.

The stakeholder engagement process using BIM in Figure 4 suggests an enhanced method for space planning and for the planning of installation of FFE. The original process as detailed in Figure 3 was fraught with difficulties, as it was weak on collaboration and it did not maximise the opportunities for promoting an understanding of the developing design. The GDA, TAs and DITCP can work through a BIM medium in order to realise a more rewarding pre-ender process. The interactive capabilities offered by BIM can result in the design teams working from a synchronised model within a common data environment in the sharing and recording of information. This in turn should reduce the need for face-to-face to meetings and can offer a more efficient way to implement, record and track design changes. The model can be used with BIM room scheduling software to ensure that the FFE output is realised through the correct medium. The model can assist in ensuring the TAs and DITCP can work with the end-users to visualise spaces and their connection to each other. This can help in maximising the functionality of these spaces and ensuring they are flexible to meet future demands.

It is the aspiration of the DITCP, NDFA and GDA to use BIM within the pre-tender stage, although this is somewhat restricted by the costs associated with realising this ambition and technical barriers in the industry. It will be interesting to follow the progress of this project and to record the extent to which this aspiration will be achieved.

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