ACHIEVING LEVEL 2 BIM
SCHOOLS BUNDLE 4

BAM IRELAND CMG BIM
INITIATIVE OF THE YEAR 2016
1. INTRODUCTION

On 17 July 2012 the Minister for Public Expenditure and Reform announced details of a new Stimulus Package including two further bundles of schools to be delivered through Public Private Partnership. The fourth bundle of schools consists of four schools on four sites, in counties Clare, Cork, Louth and Tipperary. The four schools are to provide accommodation for approximately 2,950 students.

Planning, specimen design and the procurement of this Project was undertaken by the Department of Education & Skills and the National Development Finance Agency. BAM PPP was appointed as Preferred Tenderer in Q3 2014.

Financial close on the project was achieved on 22nd December 2014. The SB4 project consists of the design, construction, financing and maintenance of the four schools as detailed above. Construction started on site in early January 2015 and the first School, Comeragh College, Carrick on Suir, is on programme to open on Monday 14th March 2016.

2. SUMMARY

The Schools Bundle 4 PPP tender was the first public tender competition held in the Irish state which had a BIM level 2 mandate as part of its ITN (Invitation to Negotiate). BAM Ireland are market leaders in the deliver if BIM across all contract types and naturally we were keen to be involved in a PPP contract that requested this form of delivery.

BAM Ireland is a whole life-cycle organisation that should benefit from the advantages that a full level 2 delivery brings given that our company structure includes the PPP Co. (BAM PPP), the Works Co. (BAM Building) & the Ops Co. (BAM FM). The challenge we faced was to bring to bear the benefits that a successful level 2 delivery can bring to both the capital and operational stages of an asset.

Many challenges were faced and overcome along the way particularly given that the current Irish market is not fully mature in its ability to delivery BIM level 2. BAM has pioneered the technology and processes which are necessary to glean the benefits of the digitisation of a building asset and at all times a strong focus was placed on adding value to the construction works or in fact the facilities management delivery. We hope to demonstrate throughout this submission how a well thought out level 2 delivery can benefit all stakeholders from sub-contractors to designers and beyond.

3. PPP SCHOOLS BUNDLE 4, THE ITN REQUIREMENT

(The BIM model shall be completed by the PPP Co. to a level of detail required for 7D facilities management which refers to the intelligent linking of individual 3D components or assemblies with all aspects of project life-cycle management information. The BIM file shall include for information in relation to the FM and operation and maintenance (O and M) functions including – space and asset management, and maintenance management.)

The above statement like with most project requirements is where you would have expected this journey to begin, however; BAM had already made a decision to proceed using a BIM Level 2 methodology on the SB4 project prior to the receipt of the ITN. Most interestingly, the procuring authority (NDFA) had advised that in an effort to ensure reduced bid costs and to maintain an open and accessible bidding process, there was no need for bidders to produce their work through BIM during the bid submission phase of the competition. It was considered that this was a pragmatic approach to take given the level of BIM maturity in the Irish AEC market at the time of tendering.

The NDFA are leading the Irish market in the promotion of the use of Level 2 BIM in publicly procured projects and have been clearly demonstrating this in recent procurement competitions by including a requirement for BIM for Facilities Management in their Invitation to negotiate tender requirements. NDFA believe that the PPP model is uniquely placed to demonstrate how BIM technologies can facilitate and drive efficiencies throughout...
the delivery and operational phases of public capital projects. The Authority (NDFA) have clearly bought into the process and believe that implementing such workflows would deliver better value for the Irish tax payer. So what is full BIM Level 2 delivery?

3.1 - Level 2 BIM

This is distinguished by collaborative working – all parties use their own building information models, but not necessarily working on a shared, model. The collaboration comes in the form of how the information is exchanged between different parties – and is the crucial aspect of this level. Design information is shared through a common file format, which enables any organisation to be able to combine that data with their own in order to make a federated building information model and to carry out interrogative checks on it. Hence any software that each party used must be capable of exporting to one of the common file formats such as IFC (Industry Foundation Class) or COBie (Construction Operations Building Information Exchange). This is the method of working that has been set as a minimum target by the UK government for all work on public-sector work, by 2016.

The standard PAS 1192-2:2013 frameworks the processes and standards required to achieve BIM level 2 and is currently set as the accepted industry standard for such a form of project delivery. Standards such as:

- BS1192:2007: (Collaborative production of architectural, engineering and construction information Code of practice)
- PAS 1192-2:2013: (Specification for information management for the capital/delivery phase of construction projects using building information modelling)
- PAS 1192-3:2014: (Specification for information management for the operational phase of assets using building information modelling)
- BS8541-1, 3 & 4: (Library objects guidance on classification, measurement and specification for Architecture, Engineering and Construction elements)
- BS 7000-4:2013: (Design management systems. Guide to managing design in construction)

PAS 1192-2:2013 also outlines the requirements for the Information Delivery Cycle (Ref. Figure 1 above). This illustrates when information is to be exchanged and provides a high level overview of the various RIBA Work stages employed within the standard.

4. PROJECT DELIVERY

4.1 - Bid Stage BIM

BAM made a decision to use BIM through the bidding stage believing this would add value and reduce risk during this critical point of the competition. Many challenges existed during the bid phase namely the inexperience of the design team in such a level of BIM delivery. BAM conducted capability assessments to establish where assistance would be required and duly formulated a training and support programme for the project. All designers engaged and as the bid phase progressed the ability of the BAM team increased significantly. BAM has a dedicated VDC (Virtual Design & Construction) department which managed this process. The use of BIM during the bidding stage of the competition had many benefits all resulting in a more robust bid submission. We have outlined some of these benefits below.

- **4.1a Rapid exemplar design assessment**
  - The SB4 project came to market with 4 No. Exemplar design produced in a traditional 2D format. BAM generated our initial project information model immediately upon receipt and set about assessing the regulatory compliance of the design through this medium.
  - Issues were identified where the planning drawings were not coordinated, this was of particular concern on all external facades and roofs, the use of BIM allowed the early identification of these issues within the consultation process thereby reducing risk for BAM.
  - BAM was able to rapidly bring proposals before the Technical Advisory team and adequately demonstrate the impact of various design proposals through virtual tours of the model leading to a number of successful modifications to the original exemplar design.

- **4.1b Visualisation**
  - BAM were able to rapidly produce high quality visualisations directly from our Building Information Models, this generated significant reductions in cost as there was no longer a need to employ expensive third party specialists to produce this work. (Ref. Figure 2)
Extensive consultation both internally and externally took place with the models to look at various strategies for colour schemes and finishes, the models proved invaluable to allow us to rapidly assess and modify our design intent on an ad-hoc basis.

- **4.1c Rapid quantification**
  - Our internal use of specialist BIM quantity take off software (CostX) meant BAM could engage in an iterative costing methodology as the design developed. This ensured that there was no need for significant late modifications nearing bid completion again reducing time output for all involved in the project.
  - The quantification was also coupled with regular virtual tours of the developing design to ensure the quantity surveyors fully appreciated the designer's intent and to allow for early intervention where necessary.

- **4.1d Robust project programme**
  - BAM produced a full 4D programme for all four schools. This process assisted our senior planners in better assessing their programme. Each school had at least four programme iterations which significantly impacted on the programme proposal.
  - The production of a 4D programme also allowed BAM to better assess our projects accommodation, access routes, crane locations etc. through the use of 4D clash detection (this is the process whereby the projects programme is present during a clash detection and therefore allows the assessment of an objects presence at any given time).

- **4.1e Reduced risk**
  - All of the above factors culminate in reduced risk for BAM. BAM could confidently stand over its price, programme and design intent having robustly assessed all of these factors virtually.
  - BAM reduced its risk contingency by nearly 2% as a result of processes employed at bid stage.

4.2 - The Common Data Environment (CDE)
From bid stage BAM implemented a compliant CDE (Common Data Environment) on the project (single source of information for any given project, used to collect, manage and disseminate all relevant approved project documents for multidisciplinary team in a managed process) Ref. section 3.13 PAS 1192-2:2013. BAM's CDE fully leveraged all standards compliant meta-data such as correct nomenclature which allowed for the automated registration of all project documents be they reports, drawings or models. Both the structured information, a compliant CDE and use of the above standards leads to a consistent level of information delivery including documentation, non-graphical data and of course graphical model information across the project which in turn reduced time spent in locating information on the project. This is a practical example of how the application of a level 2 process improved workflows and was not a model centric process. This is a common miss-conception often displayed within the Irish & UK market and when fully understood, understandably improves outcomes from an information aggregation perspective. BAM estimate that over the course of the SB4 project from bidding through to handover the below percentage reduction can be attributed to the compliant CDE.

**Stakeholder engagement:** Engagement with CDE at 95% across all four schools (previously at approx. 50% with many stakeholders using e-mail or Dropbox for information transfer)*

*Survey conducted (Jan 2016 across BAM operatives and extended supply chain) and compared to actual performance metrics from BAM's delivery of SB3.

All of the above has resulted in a reduced overhead for BAM and our extended supply chain as well as improving targeted deliverables.
4.3 – Construction stage BIM

The benefits of having developed our designs through BIM at bid stage had an immediate positive effect on the construction deployment. All involved in the projects during the bid we far better placed to pass information across to BAM Building for delivery. All the documentation including drawings, reports models etc. was easily identifiable and of course the models were useful as a project overview tool to better inform those who had not been involved in the project to that point.

The use of BIM meant the realignment of traditional procurement methodologies to a less used; early contractor engagement approach. All of BAM’s principal Sub-Contractors were engaged under the CIC BIM Protocol Contract and set about developing the approaches within a BIM environment. The above early engagement brought about a 91% reduction in on site precast cores when compared with BAM’s PPP Schools Bundle 3. BAM also achieved a reduction in the order of 78% with site corrective actions as a result of better coordinated designs. The use of mobile technology has fostered a culture of observations on BAM’s BIM enabled jobs, having all the current and relevant construction information available on site means that the likelihood of the incorrect information being used is significantly reduced.

BIM has also had a positive impact on the amount of resources required to manage various processes. As a result of better coordinated information, BAM and our Professional Services have had to spend less time on site and or dealing with design related issues. More time can be afforded to managing better health and safety as well as a quality on site.

BAM employed a full suite of cloud based information management products all with the capability of leveraging the emerging and developing BIM information. These products had many value-added benefits which; when combined brought significant time savings to the project. Below is a list of some of these benefits.

- **4.3a Instant access to current information via mobile devices.**
  - Operatives had instant access to all current design information reducing the need to spend unproductive time travelling to and from a site office. This was facilitated through the use of QR coding on site. (Ref. Figure 3)
  - Reduced errors in construction as all information was being taken from the CDE.

- **4.3b Improved health and safety performance.**
  - Operatives could spend more time on site as office based administrative workload was reduced. Initial surveys suggest that site based operatives could spend at least 40% more time on site. (Ref. Figure 4)
  - The mobile devices meant that BAM could implement a culture of observations and better assist our sub-contractors with all health and safety requirements.

- **4.3c Improved efficiency with Quality**
  - Automated reports generated off the BAM system mean more time was spent on site dealing with issues increasing sub-contractor quality and ensuring construction was delivered as prescribed.

- **4.3d Real-time access to federated Building Information Model.**
  - All project cloud tools were made freely available to all project stakeholders therefore increasing process engagement and reducing the cost of process engagement significantly for all of BAM’s stakeholders.

- **4.3e Verification with High Definition Scanning (HDS).**
  - BAM realised the weaknesses of our specialist supply chain to capture as installed information, both graphical and non-graphical in a time frame that would efficiently support the creation of the required asset information model. The accuracy of the as installed graphical information is key to the creation of the Asset Information Model. BAM self-delivered High Definition Scans prior to wall and ceiling closure to ensure that an accurate as installed data was captured which did not impact on programme delivery. (Ref. Figure 8)
  - BAM registered and processed the scan data internally and made it available to the extend specialist sub-contractors to allow them to accurately create their as-installed models.

- **4.3f Web based model coordination meetings.**
  - BAM provided the infrastructure to enable regular web conference meetings as many of the stakeholders were widely dispersed across Ireland therefore reducing the requirement to travel long distances.
  - BAM’s BIM 360 Glue product ensured seamless collaboration amongst BAM stakeholders. This cloud based BIM coordination tool has a built in issue management system which allows the automatic notification of all design related issues to the relevant parties involved.

- **4.3g Improved Project Management**
  - Real-time access to project performance metrics through our cloud based dashboard system. (Ref. Figure 5)
  - More transparent project management through our cloud based issues management system.
  - Better focused supplier management through automated focused reporting.
All of the above benefits have been enabled and are fully related through BAM’s BIM 360 suite of cloud products. The cloud based products are fully interlinked with the current Building Information Models; meaning that all data captured, be it quality, health and safety or design is fundamentally related to an object within the model environment e.g. space, location, status or additional embedded meta-data (photographs, mark-up’s, reports, checklists, object status (delivered, installed, commissioned, etc.)).

This supports the progressive growth of information throughout the project as all information is secured and available for the next critical stage of delivery; FM handover.

BAM’s project delivery has been significantly improved as a direct result of the available BIM related technologies and workflows. The technology has provided a fully transparent and auditable process which in turn means BAM have had better visibility on the performance and engagement of all project team members such as Architects, Engineers and of course Specialist Contractors. BIM has allowed BAM to have a single source of digital truth for the project delivery.

4.4 – Facilities Management BIM

For many within the Irish and UK construction industry, full Level 2 BIM delivery all the way through to FM is the Holy Grail. No company has yet achieved this and it is believed to be the point at which the newly digitised processes really accrues most value. BAM have been pioneering the use of BIM within FM for the last four years. This process has seen many engagements and failures and it was with this in mind that BAM knew a high level engagement with our strategic partner Autodesk was necessary.

BAM Ireland has exclusive access to the development team for Autodesk’s new CAFM (Computer Aided Facilities Management) System known as Building Ops. BAM & Autodesk have worked on this for the last twelve months on the development of this new CAFM system to satisfy BAM FM’s contractual obligations under the SB4 PPP PA (Project Agreement); and BAM Buildings BIM2FM delivery, as per ITN requirement referenced above.

• 4.4a Data Management

It is vital to realise the importance of the capture and development of the required project asset information data throughout the procurement & construction phase of delivery. Populating this data late within the project delivery would rain against the lean principals prescribed by PAS 1192-2:2013 for CAPEX delivery. To be clear, adopting the late population approach as described above is almost certainly creating duplication of effort on a number of levels and was identified by BAM as an area that improvements could be made.

BAM executed this aspect of work through the Autodesk BIM 360 Field and Glue products. These products are cloud based interlinked BIM tools. All relevant asset information (including data sheets and commissioning information) could be captured on mobile devices by the right people at the right time. COBie (Construction Operations Building Information Exchange) is a data format for the publication of a subset of building model information focused on delivering building information not geometric modelling. It is closely associated with building information modelling (BIM) approaches to design, construction and management of built assets, and was devised by Bill East of the United States Army Corps of Engineers, who authored a pilot standard in June 2007 (Ref. Wikipedia) was used throughout this process as a way of creating clean, compliant and standardised data.

The COBie data-set was progressively enhanced throughout the construction delivery phase. This data-set is associated with BIM objects and coupled with all other data capture through BIM 360 Field means that BAM has a complete data-set at project completion stage which has been added to by many individuals and organisations. Therefore, there was no need for BAM to resource the production of this information as an additional process to the traditional project delivery.

BAM FM engaged with the BAM VDC team early during the construction stage to ensure that their digital needs were going to be met. BAM FM identified their asset requirement through both an OIR (Organisational Information Requirement) and an AIR (Asset Information Requirement) Ref. PAS 1192-3:2014 4.4 & 4.5. This provided clear guidance as to their asset information needs and ensured no time was wasted in the production of irrelevant assets.

The link formed between Autodesk Building Ops and BIM 360 Field is bi-directional and seamless. At 14.20 on the 11th February 2016 (Ref. Figure 6), the first full commercial transition of a progressively developed building information model data-set took place for the Schools Bundle 4 Carrick on Suir school making it the first Level 2 BIM project to transfer such data into a bi-directional CAFM system, saving BAM FM €15,000 (set-up fee) and one full time resource for one month (for one school only when compared with Schools Bundle 3).

These savings are also being achieved across the other three SBA schools and represent a major win for BAM. The Autodesk Building Ops system that BAM FM are now employing has been built from the ground up in conjunction with BAM and has a major focus on the user experience. The previous BAM CAFM system was not user friendly, complex and inaccessible. Building Ops will allow multiple end users access to the CAFM system through an intelligent HTML5 interface (Ref. Figure 7) (smartphone, web, mobile devices). This system is simplistic in its design and will encourage end-user engagement which is critical for BAM FM as engagement with the system will assist in the analytics required for lifecycle decision making.

The now fully developed Asset Information Model (AIM) is central to the Building Ops CAFM system. All reactive and preventative actions on all items are linked through the AIM. The asset contained within the CAFM system is bi-directionally linked to the AIM at all times i.e. the data sitting behind the assets within the AIM is automatically updated through the CAFM system.

All of this means the developed models have been fully leveraged for planning, bidding, design, procurement, construction and finally, operations. This represents a significant advancement in how data is enhanced while it transitions and from one RIBA work stage to another. In delivering Schools bundle 4, BAM can confirm; that adopting the principals outlined in PAS 1192-2:2013 that projects are delivered with more certainty, less waste and improved efficiencies across the board.

Therefore, achieving BIM Level 2 on a project greatly improves chances of commercial success for all stakeholders. The decision as to where these savings are realised by each stakeholder is their own to make and will provide commercial and competition advantages going forward.
5. CONCLUSION & PROJECT BENEFITS

(In addition to the extensive list of benefits outlined above, please see below additional project benefits).

*NB Item listed as short term benefits (in the context of the SB4 project) can been translated to longer term benefits if replicated on future projects.

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<thead>
<tr>
<th>WHO BENEFITED</th>
<th>HOW</th>
<th>TERM BENEFITS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Client (NDFA)</td>
<td>Enhanced competitive bid price due to certainty gained through BIM</td>
<td>Long</td>
</tr>
<tr>
<td>Designers*</td>
<td>Reduced time on delivering stage 4 design (benchmarked from SB3)</td>
<td>Short</td>
</tr>
<tr>
<td>Designers*</td>
<td>Significant reduction in technical queries from construction team</td>
<td>Short</td>
</tr>
<tr>
<td>BAM Building*</td>
<td>Reduced waste, time, people and materials (benchmarked from SB3)</td>
<td>Short</td>
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<tr>
<td>BAM Building*</td>
<td>Efficiencies gained in dealing with specialist contractors etc.</td>
<td>Short</td>
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<tr>
<td>BAM FM*</td>
<td>No CAFM system set-up fees</td>
<td>Short</td>
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<tr>
<td>BAM FM*</td>
<td>No requirement to manually populate CAFM system</td>
<td>Short</td>
</tr>
<tr>
<td>BAM FM*</td>
<td>Improved purpose built CAFM system</td>
<td>Long</td>
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5.1 – Client Handback following 25 Years of Operation

On conclusion of the 25 year operational period for the SB4 project, the Schools and grounds are handed back to the Sponsoring Department - in this case, Department of Education & Skills. Schedule 2 of the PPP contract sets out the lifecycle requirements for all building elements in terms of residual life required at the end of this 25 year operational period. The use of BIM on this project will provide certainty on the quality of the asset information and the condition of the Schools for the future use of the Client.