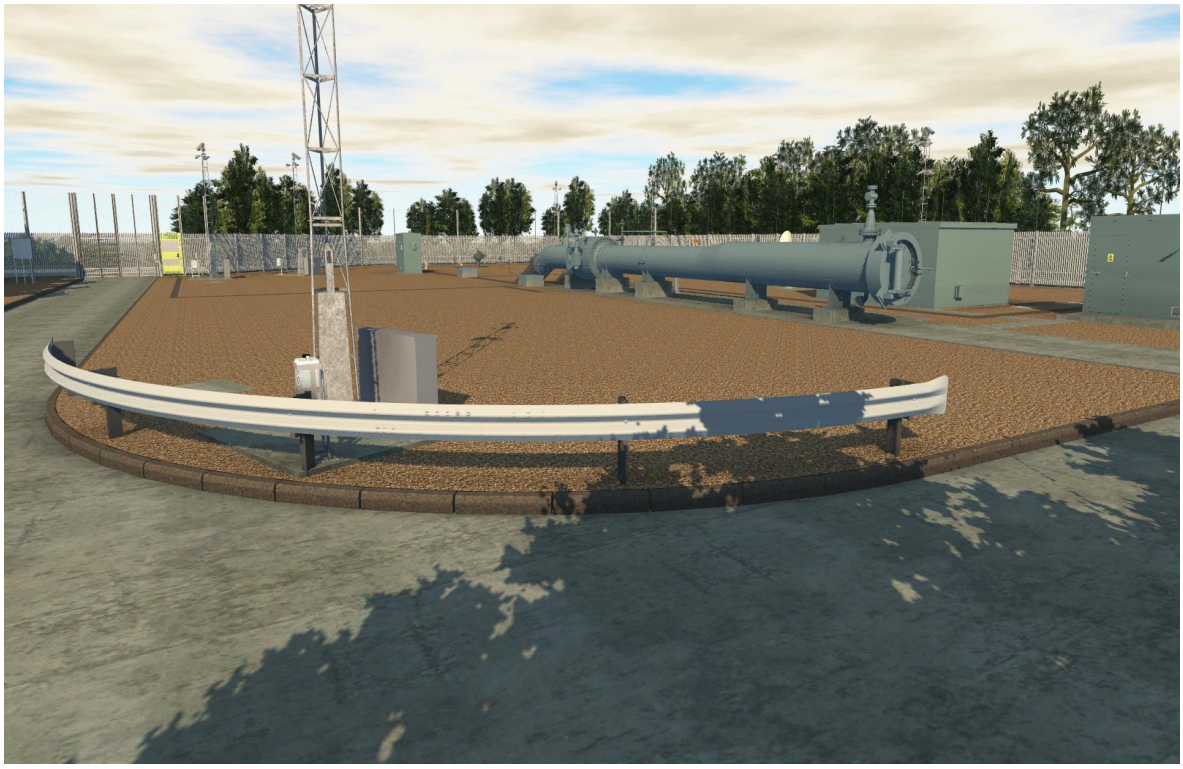
BUILDING INFORMATION MODELLING



BIM Trial - Recommendations

Report No. 13-2816-RPT-0004

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Contents

Executive Summary

RIIO[1] is driving initiatives across the energy industry, with companies such as National Grid and other infrastructure providers looking to provide more efficient capital projects and asset management processes to meet and exceed the RIIO targets.

This innovation project has focused on how Building Information Modelling (BIM) can enhance the delivery of projects for National Grid.

"what is BIM"

BIM is, *"A digital representation of physical and functional characteristics of a asset… and a shared knowledge resource for information forming a reliable basis for decisions during its life-cycle; defined as existing from earliest conception to demolition"*[2]

Essentially BIM is about pegging data to 3D models throughout the design, construction and maintenance of an asset, with the ability to store the models for reuse on future projects.

BIM is not a new concept, having been used successfully in some corners of the construction industry for over 10 years and expected to become UK industry standard, supported by the governments mandate to use collaborative 3D BIM on all its public sector centrally procured construction projects by 2016. The main aim of the government's initiative is to reduce capital expenditure, reduce delivery and reduce the carbon burden in line with the 2020 target of 20%.

BIM is a collaborative structured process (not a software solution) that is used to assist the strategic planning, design, construction, operation and maintenance of a building or infrastructure project. BIM software and technology facilitate the exchange and interoperability of the information gathered during the life of the project in a structured and intelligent manner. Often described as a "game changer", BIM is a major step change in the way construction projects are designed, constructed and how the asset is managed and maintained after handover.

This innovation project has focused on how BIM can improve the management and drive efficiency of infrastructure projects within the gas transmission industry, focusing initially on the design and construction phases of the project (the project information model) whilst also considering the requirements of the asset information model. The BIM process is also fully applicable to the electricity transmission business and other projects such as the integrated security and tunnels in the UK and US.

BIM has been complimented by more advanced spatial survey techniques such as laser scanning and photogrammetry which provide an accurate "as-is" visual representation of the site, allowing greater synergy between the real and virtual environments, enhancing integration with the model and the project workflow. This "true" representative survey removes ambiguity, such as conflicting historical records from the equation.

[1] Revenue=Incentives+ Innovation+Outputs
[2] National Institute of Building Sciences

The evaluation report will demonstrate by example the benefits and performance enhancements that can be achieved with the implementation of intelligent 3D modelling to supplement existing National Grid quality management systems and safety processes.

The evaluation report details the progress, lessons learnt and successes of implementing BIM in practice within the gas industry on a trial project. Based on comparable deliverables, the trial project demonstrated savings during design when compared with a previous tendered project. Overall pipeline Front End Engineering Design (FEED) costs are expected to realise a 4-11% reduction in cost due to implementation of BIM as the design moves from the current 2D focused process to an intelligent 3D process; a significant contribution from a single project phase towards the Government's 20% target.

The savings in design time should increase as National Grid's component and assembly library expand.

The main benefits identified during the trial were;

- Provides an accurate visual representation of design intent – better defines scope
- Avoids duplication of effort
- Provides a single source of truth – centralised data control
- More informed and transparent decision making
- Safer working, improved occupational and process safety
- Improved carbon performance and reduction in whole life cost
- Improved schedule certainty
- No loss of information through project phase to asset management
- Less "guesstimation"
- Tighter schedule and resultant cost control for construction

Implementing BIM benefits every participant of the project, although the owner and operator of the asset reap the most significant rewards of BIM. It is important to note that some of the benefits listed above are not necessarily in the interest of designers and constructors, although overall efficiency savings and reputational benefits would benefit all contributors. The implementation of BIM needs to be driven by National Grid as an asset owner and the main beneficiary of the process. National Grid can capitalise on the lessons learnt and strides made in the building industry, driving value in capital and operational costs, whilst embedding sustainability and improving safety.

A BIM library will also provide the most significant benefit to National Grid once implemented, reducing early design stage resource and streamlining project implementation.

Objectives of the BIM trial project

The objectives of the BIM trial were to identify where efficiency savings could be achieved and demonstrated on gas transmission projects in terms of cost, carbon burden, project schedule and operational expenditure. Other less quantifiable benefits such as improved decision making and earlier detection of potential commercial, occupational and process safety; and environmental risk were also objectives.

BIM Trial High Level Objectives

- Produce cost effective design, reduced programme
- Establish Rule based design processes to enhance safety by design and validation
- Establishing and improving carbon performance
- Embed sustainability, e.g. reduction in waste and transportation
- Establish procedures to allow monitoring / comparing equipment and construction costs
- Controlled learning from trial to aid development of BIM standard
- Establish interaction requirements with existing systems
- Reduce project risks

The BIM process complies with existing National Grid quality and health and safety management systems, such as T/PM/HAZ/9 and NGUK/CON/BP135/G to enhance and not replace proven process and management systems.

Recommendations

The BIM trial project has followed the Governments BIM Construction Strategy published May 2011 by exploring the potential benefits of BIM and capturing lessons learnt on a moderately complex and manageable project.

Applying the BIM trial project percentage cost savings across a number of example pipeline FEED tender returns equates to an estimated overall pipeline FEED cost reduction of between 4% and 11%; based on the saving on the engineering and design deliverables as a percentage of total FEED costs. Notably, savings of 4-11% during a tender event are typically sufficient to commercially differentiate between tenderers. The move from 2D design process towards intelligent 3D modelling allows streamlines the transition between project phases, minimising data loss and driving efficient production of deliverables.

The savings can be broadly attributed to;

- Standardisation and replication of components and assembles (the Lego™ box)
- Application of parametric modelling
- Capturing data once then enabling multiple applications

There are already a number of quick wins ready for embedding into projects, plus more substantial near term and medium term possibilities for National Grid to benefit business wide (UK and US, gas and electric) from BIM. It is recommended BIM continues to be deployed in a controlled and graduated manner across projects and the business. It is important to note the FEED percentage savings will vary depending on the standardisation and repeatability of a type of project. It is recommended projects of high repeatability in terms of components and frequency should be targeted first. For National Grid this should include security projects and minimum offtake connections and substations, where standard 3D models can be utilised to replace the current 2D based process.

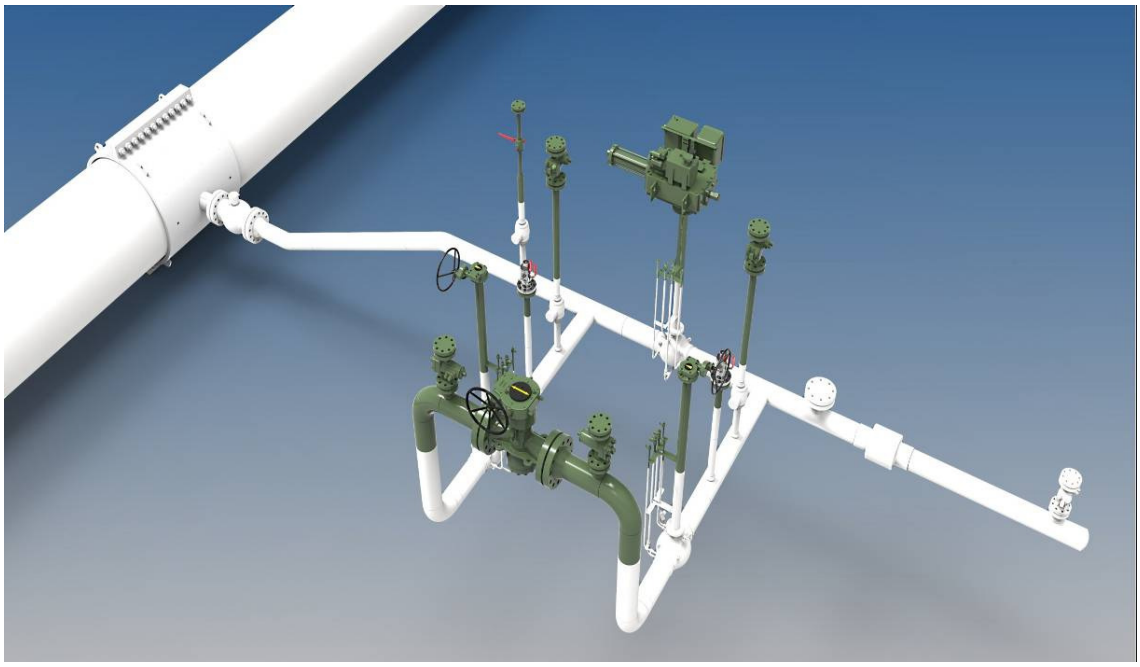

Figure 1 - Example Minimum Offtake Connection – Potential for BIM Application

Projects such as compressor stations which already use 3D modelling and contain bespoke equipment are unlikely to achieve the same level of savings in the FEED phase, however there are potential savings in the construction phase, particularly through the application of 4D modelling.

BIM literature often discusses the theoretical, economical cut off point for application of the BIM process; indeed the UK Government initially had a £50M then £5M threshold. The current stance from the UK Government is every public funded contract shall be let using a BIM process from 2016. The recommendation to National Grid from the trial is to focus on the high value contracts initially; then the organic development of assemblies and components from these projects will enable even minor works and modification to be delivered more efficiently by applying the BIM process.

The "Lego™ Box"

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The current design process typically starts with tens, if not hundreds of specifications being issued to the designer to read and ultimately translate into drawings and models. Too often designs commence with a blank "piece of paper". The final design is a functional and safe design, however, potentially not the optimum design in terms of cost and carbon; due to the time limited period and the traditional, sequential design process. Too often the engineering, economic and environmental disciplines operate in silos with costing and carbon addressed too late in the design phase to enable genuine alternative solutions to be evaluated and taken forward.

By tagging cost and carbon data to the components and assemblies enables the engineers, particularly the process, mechanical and civil, to make informed economic (capital and whole life cost) and environmental (carbon performance and Best Available Techniques) decisions from the outset of the design development process.

The Lego Box approach of standard and repeatable components and assemblies significantly reduces design time. For example, by producing a block valve arrangement mechanical 3D model ahead of the pig trap 3D model reduced the design time from a forecast 60 hours to 10 hours - noting it took as long to render the final imagery overnight as to develop the model.

Components and assemblies from previous projects become the benchmark, not only in terms of technical assurance (T/SP/HAZ/9 "The Application Of Formal Process Safety Assessments During Engineering Design Phases" Assessments and T/PM/G/35 "The Management Of Modifications and Repairs to National Grid Transmission & LNG Storage Sites including New Works or Temporary Modifications on Existing Operational Assets") but also cost and carbon as data has been tagged to the components and assemblies.

Figure 2 - Typical Block Valve Site – Consists of Standard Assemblies

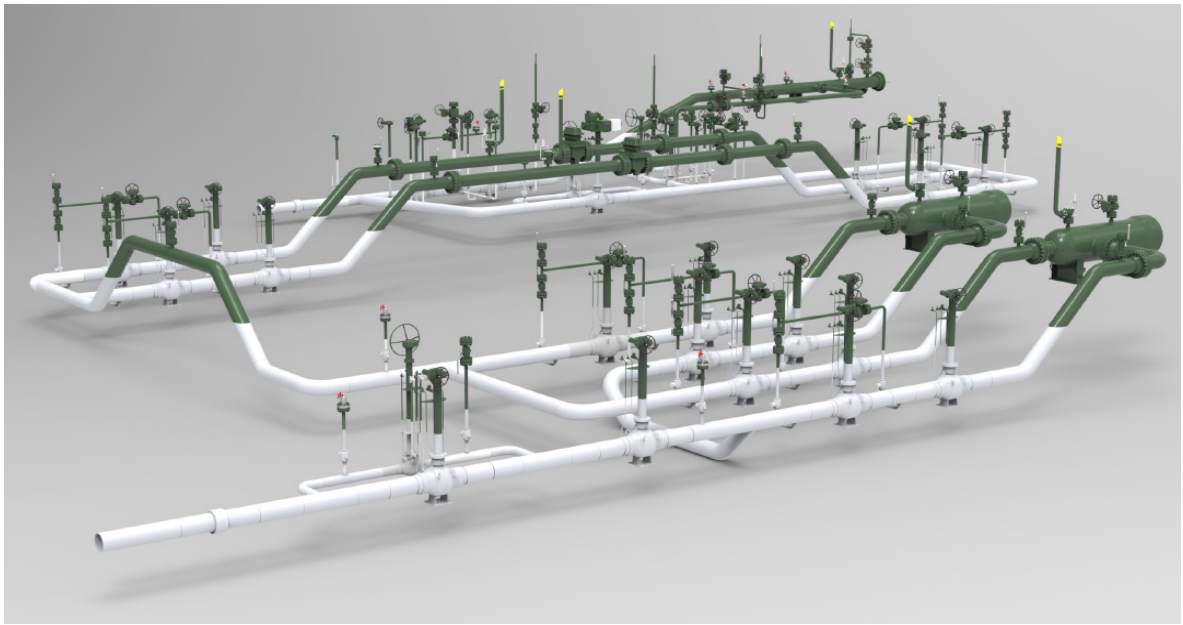

Figure 3 – Pig Trap Model >80% Reduction in Design Time using library Components

A criticism often levelled at standardisation is it hinders continuous improvement; however the designer should be incentivised through the contract (such as Key Performance Indicators) to improve on the benchmark designs where necessary rather than reproduce a variation to an existing design.

Subject to approval to proceed to the business ready BIM phase, the recommendation for maximising the potential efficiency savings from the Lego Box is to develop a single, central repository of components and assemblies covering the gas and electric business with free access to the supply chain using a Common Data Environment. The proposal includes

developing / obtaining those key components from our approved vendors covering typical equipment sizes prior to launch, followed by the organic development as further projects produce models for inclusion. Models would be controlled through the existing National Grid design assurance processes such as T/PM/G/35 and T/PM/G19. Intellectual property, rights to material, rights to use and rights to reuse will require further legal input to enable this to occur.

Parametric Modelling

Parametric modelling should be maximised throughout the design phase as a significant time and cost efficient process. Typically, non-critical but highly repeatable components such as fence panels, paths, kerbs, ducting and post and rail fences can be modelled very quickly, often in less than one minute by applying the parametric rules to the model. Example parametric modelling AVI files are provided in the BIM trial handover records. Parametric modelling should be added to all design scopes.

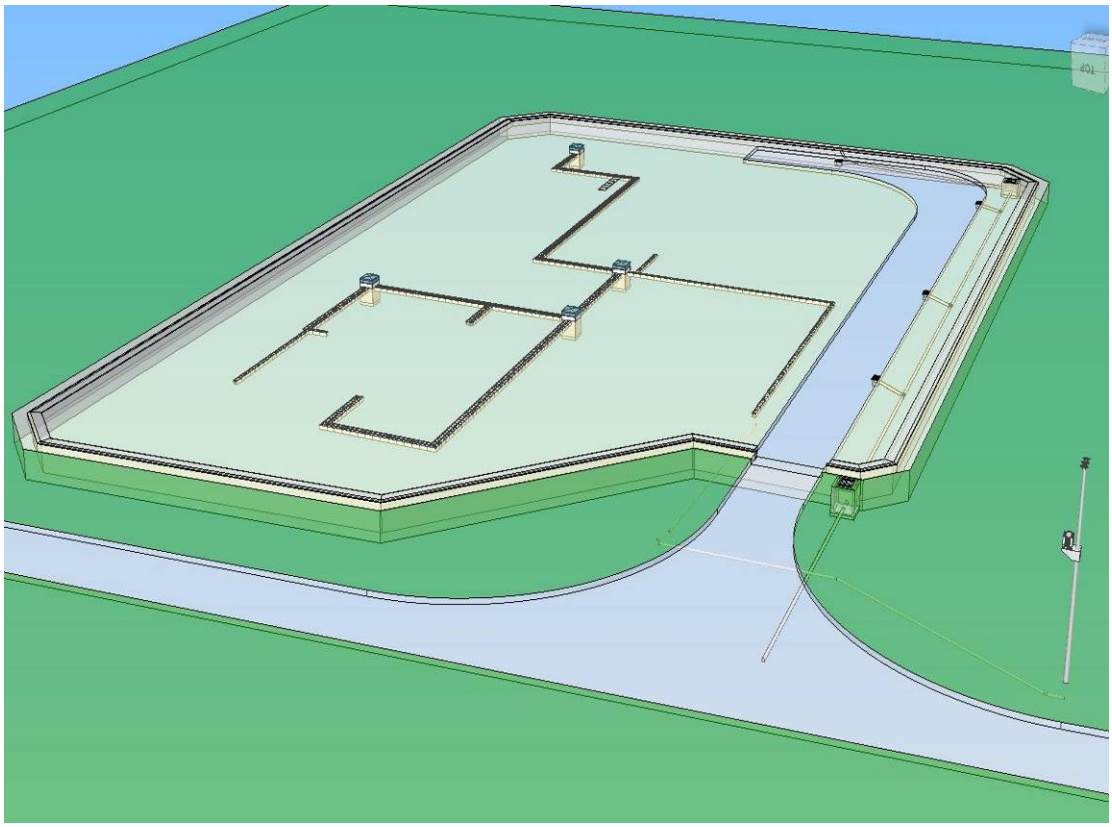

Figure 4 - Parametric Modelling of Fence and Ducting

Capturing and Tagging Data

Tagging data to models enables the automated production of design deliverables in considerably less time and cost efficient manner than the traditional manual activity. Pipeline and installation design deliverables produced direct from the model include;

- Material Take Off's
- Civil Material Take Off's / Bill of Quantities
- Bend Schedules
- Schedule of Planned Maintenance Requirements
- SIL Rated Equipment Registers
- Critical Equipment Register
- Cathodic Protection Schedules
- LOLER Register
- DSEAR Register

A recommendation is for each project is to review the handover records process between the project and the asset owner to define the deliverables which should be produced directly from the 3D model.

Tagging data to models enables the automated production of design deliverables such as Material Take Off's, LOLER registers, DSEAR registers and the like, which traditionally have been a manually driven process. A recommendation prior to full scale deployment of BIM is to review the handover records process between the project and the asset owner to determine and specify the deliverables which should be produced directly from the 3D model.

First Pipe Size (NB) mm	Second Pipe Size (NB) mm	Press Rating	Description	Qty / Length (m)	Datasheet	Supplier	Remarks
1050		CL600	VALVE, BALL, FULL BORE, WE/WE TO T/SP/V6, TO SUIT 17.5mm W/T REMOTE ELECTRIC ACTUATOR & GEARBOX.	3		CORT / ROTORK	Existing valves 190301,02 and 03
1050		CL600	VALVE, BALL, FULL BORE, WE/WE TO T/SP/V6, TO SUIT 17.5mm W/T LOCAL ELECTRIC ACTUATOR & GEARBOX.	1		CORT / ROTORK	existing valve 190304
100		CL600	VALVE, BALL, WE/ RF, TO T/SP/V6, TO SUIT 6mm W/T, L245	1			Vent Valve 190307
300		CL600	VALVE, BALL, WE/ WE, TO T/SP/V6, MANUAL GEARBOX, TO SUIT 6mm W/T, L245.	1			Valve 190305 (vent)
100		CL600	VALVE, PLUG VALVE, REG PATTERN, FLANGED RTJ/RTJ, T/SP/V/6	1		AUDCO	Valve 190308 (drain)
300		CL600	VALVE, PLUG VALVE, REG PATTERN, FLANGED RTJ/RTJ, T/SP/V/6	1		AUDCO	Valve 190306 (bridle
1050		CL600	UNIVERSAL PIG TRAP, C/W PIG ALERT, WE, R/H BRIDLE, T/SP/E/56	1		GD	
1050		CL600	INSULATION JOINT WE/WE TO T/SP/E/56 TO SUIT 17.5mm W/T	1			
1050	50	CL600	PIG ALERT, MODEL NO. VMWX , C/W PUP AND ISOLATION VALVE, STEM EXTENSION 2250mm	1		GD	BURIED PIG ALERT
1050	50	CL600	PIG ALERT, MODEL NO VMW	1		GD	ON PIG TRAP
50		CL600	VALVE, PLUG VALVE, RTJ/RTJ , WRENCH OPERATED, T/SP/V/6	12		AUDCO	
25		CL600	VALVE, PLUG VALVE, RTJ/RTJ , WRENCH OPERATED, T/SP/V/6	3		AUDCO	
50		CL600	VALVE, BALL, FLANGED RTJ/RTJ, TO T/SP/V6, WRENCH OPERATED	9			
1050			BEND, 22.5 DEG, 3D RADIUS TO SUIT 17.5mm W/T, PAINTED TO T./SP/PA/10	1			B7 EXISTING
1050			BEND, 22.5 DEG, 3D RADIUS TO SUIT 17.5mm W/T, L450,COATED TO T./SP/CW/6	1			B7 EXISTING
300			BEND, 90 DEG, 1.5D RADIUS, TO SUT 9.52mm W/T, L360, PAINTED TO T/SP/PA/10	3			B4 EXISTING
300	200		REDUCER, CONCENTRIC, TO SUIT 9.5mm x 8.2mm W/T, T/SP/B/12, BARE	1			F3 EXISITNG
200	100		REDUCER, CONCENTRIC, TO SUIT 8.2mm x 6mm W/T, T/SP/B/12, BARE				F3 EXISTING
300			BEND, 22.5 DEG, 1.5D RADIUS TO T/SP/B/12, TO SUIT 9.52mm W/T, L360, PAINTED TO T/SP/PA/10	1			B4 EXISTING
50			BEND, 90 DEG, 1.5D RADIUS, TO T/SP/B/12, TO SUIT 5.5m W/T, PAINTED TO T/SP/PA/10	3			B4 EXISTING
1050	1050		TEE, EQUAL, C/W GUIDE BARS, TO T/SP/B/12, C/W 250mm PUPS TO SUIT 17.5mm W/T	4			T1 EXISTING

Figure 5 - Material Schedule Output from the Model

Considering civil material take off's / bill of quantities these are typically left to the Mains Works Contractor to estimate. There is no driver with respect to programme as civil materials are typically short lead time items, which are not subjected to the same level of scrutiny as

mechanical components. The civil estimates typically result in overestimation and wastage. The recommendation is to mandate civil estimates within the design phase. Not only will site wastage be reduced but also with sustainability reviews undertaken sufficiently early enough in the design phase will again provide the opportunity to identify more sustainable alternatives. Civil estimates should form part of the prerequisite information for a sustainability review.

Quick Wins

There are a number of quick wins identified from the BIM Trial project. These are recommended for immediate application within all major projects.

Quick Win - Mandating 3D Modelling

The application of 3D modelling is not consistent across major projects. Compressor projects have been using 3D modelling for approximately 6 years, primarily for clash detection and coordination purposes; however substation, pipeline, tunnel and security projects are predominantly still 2D based. It is recommended 3D modelling is mandated across all major projects. 3D modelling has the capability to simply "drop out" any existing 2D requirements (planning requirements, legacy drawing records requirements etc), but with the added functionality of enabling analysis, such as lighting and hazardous areas; and parametric modelling. Using 3D and parametric modelling it can take longer to annotate the drawing template than to actually produce the drawings from the 3D model. The size of a 3D model is considerably smaller than the sum of the 2D record files, from a data storage perspective.

Figure 6 - 3D Imagery of Pigtrap Compound Using Infraworks

The implications on the supply chain for mandating 3D modelling are virtuous. From the BIM Request for Information all tier 1 designers within Gas Transmission have 3D modelling capability. There is evidence that designers have to take equipment package 3D models from

the supply chain and “dumb down” to 2D for inclusion on drawings to meet National Grid’s requirements; an unnecessary cost burden. An example includes weld fillet details being visible on 2D fabrication drawings. There is very little first principle CAD work required from our designers, with designs consisting of approved components integrated by the designer. The “Lego Box” is largely already publicly available with many suppliers actively publishing their models on their websites.

Change control time is also significantly reduced using intelligent 3D modelling when compared with the traditional 2D approach. Taking the parametric fence line example; if the scope changes from a standard fence to a high security fence the parametric modelling would again be repeated in seconds and not hours.

3D modelling and analysis is a developing market. Traditionally activities such as stress, noise and lighting analysis have been awarded to specialist consultants. Too often costs are borne to initially develop a model to then run the analysis software. For example, AGI stress analysis costs should drop by 50-70% as the input PCR file is produced directly from the model. As the 3D modelling packages develop with more and more plug ins being available, these specialist works areas can be brought back in under the mainstream designers remit. The BIM trial project has successfully produced a lighting study direct from the 3D modelling software. The developments of plug ins for noise, vibration, heating and ventilation are further investigated. The caution at this stage is whether the plug in’s have been successfully validated for engineering purposes.

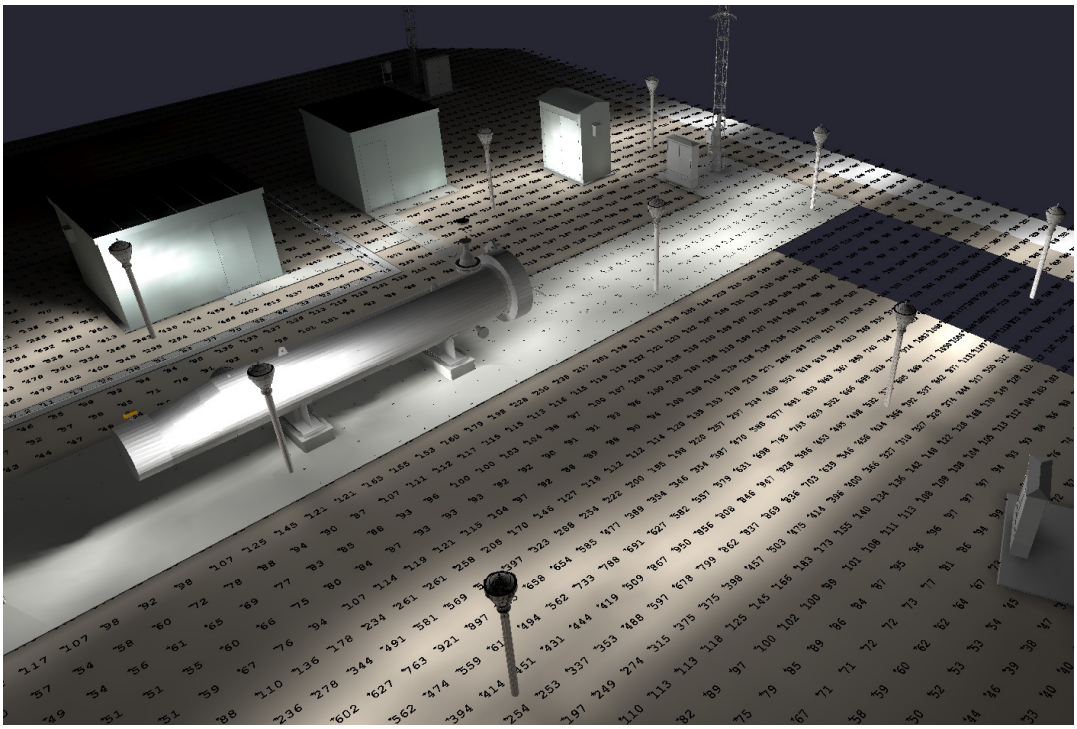

Figure 7 - Lighting Levels – Using Elumtools

Interoperability of 3D models still provides some challenges, however between reciprocating licence agreements (such as Bentley and Autodesk), universal file formats such as STEP and organic software developments; interoperability can be addressed. In the short term, National Grid would be required to stipulate the final files format type(s) for 3D models within new contracts.

Quick Win - Laser Scanning and Photogrammetry

Laser scanning and photogrammetry provides not only enhanced quality of the deliverable when compared to the more traditional topographical site survey methods but also at reduced cost and time; notably reducing repeat visits to hazardous areas. For a large above ground installation (1.5-2 hectares) took 1.5 days of site time and a further 3-4 to post process the data. To undertake a topographic survey using EDM technology to capture site above ground features (even to a basic level) would have taken around 8-10 days, usually requiring attendance from a National Grid representative to accept form of authority. The level of detail that is captured is only a fraction of that that can be captured by 3D laser scanning and far more prone to human error. Using laser scanning, block valves can be completed within 1 day on site. A lesson learnt from the BIM trial project was the variation in prices to complete the survey. As laser scanning technology has advanced significantly over the past decade it is recommended a number of quotes are obtained to ensure costs reflect current prices and not legacy prices for new technology.

Laser scanning and photogrammetry has subsequently been deployed on a live Capital Delivery project and has been approved as a Best Practice within Gas Transmission. This Best Practice status ensures its contractual presence on future projects. It is recommended a National Grid laser scanning and photogrammetry specification be produced to cover all types of installations (substations, pig trap compounds, compressors etc). The photogrammetry output file should always be provided in freeware format to minimise any software costs for the end users.

Figure 8 - Substation Example of Photogrammetry and Laser Scanning

Laser scanning should not only be deployed at the outset of the project, but mandated for the collection of as builts as part of the handover and asset records process as it reduces the time between physical completion and the records being captured on the pertinent asset

management systems. A further recommendation is to determine whether laser scanning can be used for maintenance, such as structural roof deflections; this could potentially eliminate the need to work at height on such surveys.

Quick Win - Application of 4D Modelling

The application of 4D modelling is more pertinent for National Grid than most current users of BIM. Considering the architectural and civil BIM pioneers where facilities management is relatively high cost, compared to build; the whole life operation cost of a pipeline and above ground installation is typically less than the capital expenditure to install the assets. Therefore the high risk, high cost focus project phase for National Grid pipelines should be the construction phase.

The BIM request for information confirmed all Tier 1 Gas Transmission designers have 4D modelling capability and software; but have not yet applied it to pipeline and plant projects.

The application of 4D modelling enables opportunities to be identified as well as hazards. National Grid has made good progress with off site civil fabrication; this should be extended to include the mechanical fabrications, reducing time on site, impact on local community due to transportation. It is recommended optimised fabrication be a guideword within the National Grid HAZCON.

4D modelling also enables the designer to address the build sequence (temporary works) as well as the permanent works; supporting the primary responsibilities of the designer as per the CDM Regulations. 4D modelling encourages “soft clash” detection, such as a clash between open excavations and plant movements. The current pre-requisites for a National Grid HAZCON study are 2D drawings of the permanent works and therefore the study relies upon the experience, interpretation and hindsight of the attendees rather than being able to visualise and interrogate the site specific build sequence.

The development of the 4D model when compared to the traditional prerequisites for a HAZCON study incurred an additional 30 hours of design time; however this increase in design phase cost is a small percentage of the benefits 4D modelling brings to the whole life costs. The 30 hours also reflects the “first of a kind” programme, once benchmarked build sequences are established and suitably defined this development time should reduce. Of note, a typical tendered programme for an above ground installation contains 12 -15 activities, whereas the output 4D model contained closer to 90, explaining the additional costs borne.

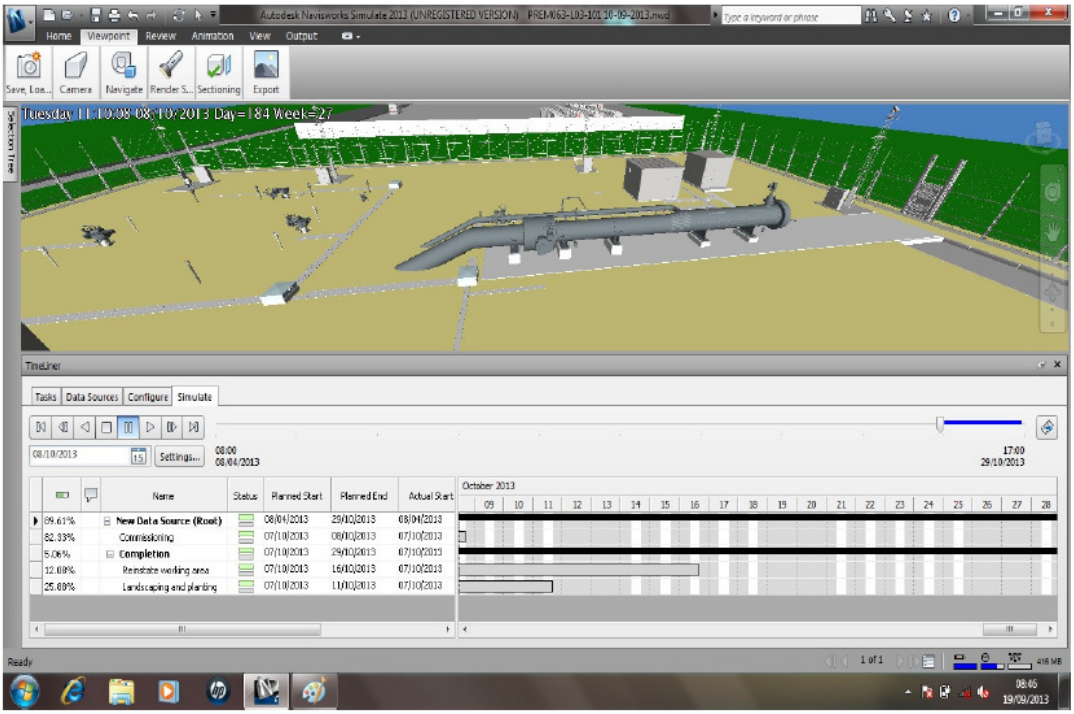

Figure 9 - Navisworks 4D Modelling – Example from BIM HAZCON Study

The most common 4D modelling / coordination tools come with a reduced freeware option. It is recommended all project managers, project engineers, development engineers and discipline engineers, as a minimum are provided with this freeware to review the 3D and 4D model as the design progresses. As a result the focus of design reviews becomes the high cost, high risk build sequence.

It is recommended 4D modelling becomes an integral part of the T/SP/HAZ/11 Specification for the Application for Construction Hazard Studies specification with immediate effect for all installations (gas and electric) and special crossings (pipe jacking, tunnels and horizontal directional drilling).

4D modelling has further potential benefits for National Grid, for example within procurement events. Construction procurement events should also focus upon the high risk, high cost project objectives, i.e. the build sequence rather than on the competence and capability of the tenderer and proposed individuals. In essence, 4D modelling would provide a combined project execution plan and programme, which traditionally have been separate deliverables.

4D modelling would facilitate cost tightening across the tenderers; the visualisation and sequencing would enable tender queries to be raised during the event; further defining scope prior to contract award. It is recommended the 4D model from the preceding design phase would act as a benchmark to tender against. During the BIM trial project a number of AGI build programmes were evaluated to develop the 4D model. There was an approximate 20% variation in build time and cost for analogous projects compared to the post constructability 4D model. Cost variation across tenderers should represent genuine competitive tensions as opposed to ambiguity in scope leading to variation. National Grid, particularly Global Procurement, would need to review the technical and commercial evaluation procedure to enable 4D modelling to be utilised.

4D modelling can be further utilised during the construction phase to aid schedule performance. Considering Earned Value Management principles cost performance is relatively straight forward with cost, time and resource information. Schedule performance has an element of subjectivity due to interpretation of progress. Using the 4D model and augmented reality on an ipad / tablet it is currently feasible to stand on site with the 4D model, move the build sequence forwards or backwards to reflect the visible progress on site to obtain a percentage completion against an activity. A minor amendment to construction contracts would be required to enable augmented reality to be utilised as the basis of schedule performance assessments.

Quick Win – Site Layout Studies (T/SP/G/37) and Safe Working Design Studies (T/SP/G/38)

The National Grid formal process safety assessment process can be further enhanced in terms of quality and cost reduction by utilising coordination tools such as Navisworks and Navigator. The current National Grid site layout study prerequisite is a 2D plan; resultantly horizontal separation distances are focussed upon. Utilising the inbuilt functions of coordination tools will systematically step through all potential clash and separation infringements in 3D. A report can be generated directly from the model capturing the clashes as well as the mitigation action or the documented acceptance of the clash. Site Layout Studies should no longer be a singular design review activity, but repeated by the designer from optioneering through to the detail design stage. The time to step through the design review is reduced to minutes rather than hours. Lessons learnt capturing this step change in the T/SP/G/37 specification have been registered within the National Grid Quality Management System NGUK/ConBP178G.

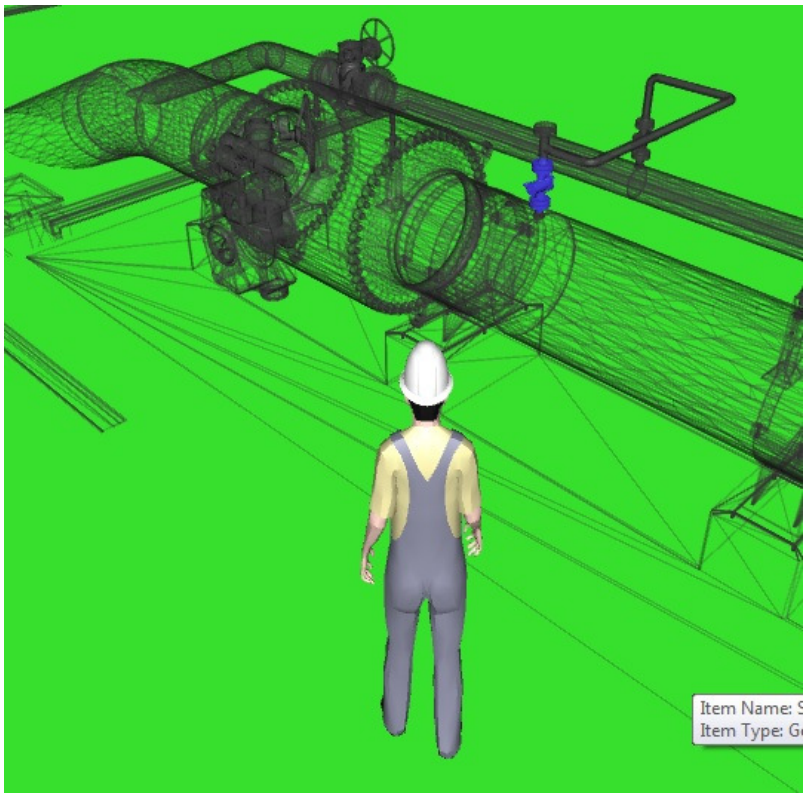

Figure 10 – G38 Safe Working Design Assessment

For human factors the same coordination tools and functions can be applied. Considering the ergonomics of maintenance staff and typical vehicles such as Hiabs, MEWP's and cranes; can all be utilised as avatars within the coordination tool. Again, lessons learnt on the improvement to the T/SP/G/38 specification have been registered. The ability to change avatars has been captured within the T/SP/G/38 report and lessons learnt register.

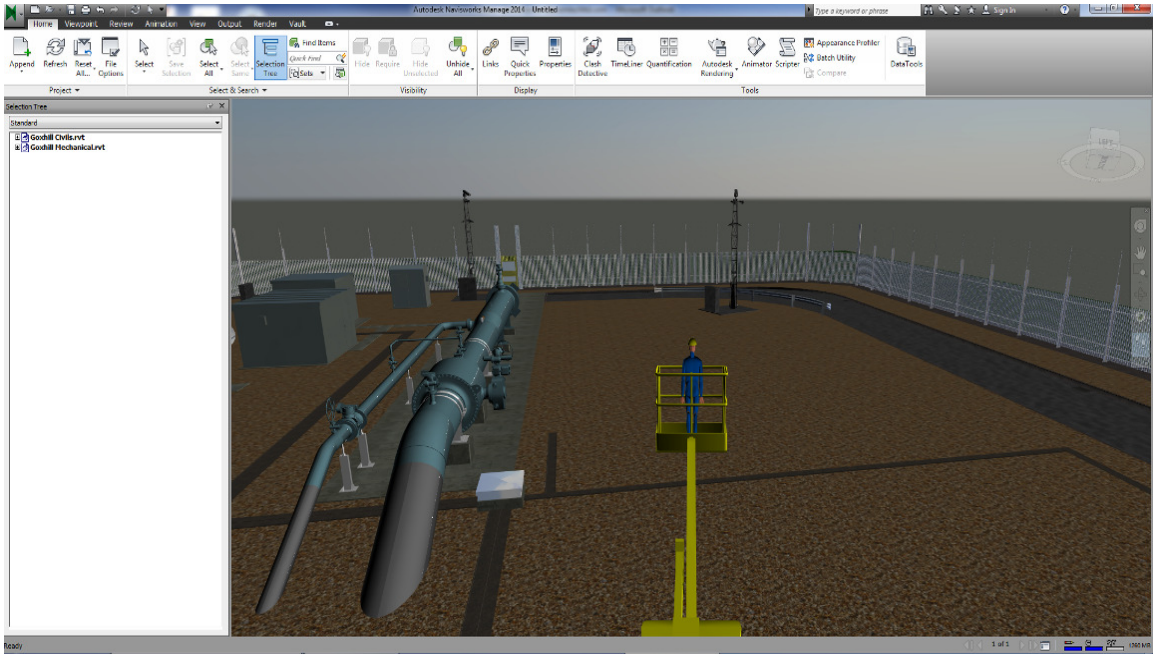

Figure 11 - MEWP Avatar Utilised for Collision Detection

Near and Medium Term Recommendations - Training

BIM training requirements will vary by role and by discipline. Recognising the general business need for 3D / 4D coordination training the BIM Trial project developed and delivered the first accredited Navisworks training package for the pipeline industry. The training package is part of the handover deliverables, ready for onward dissemination.

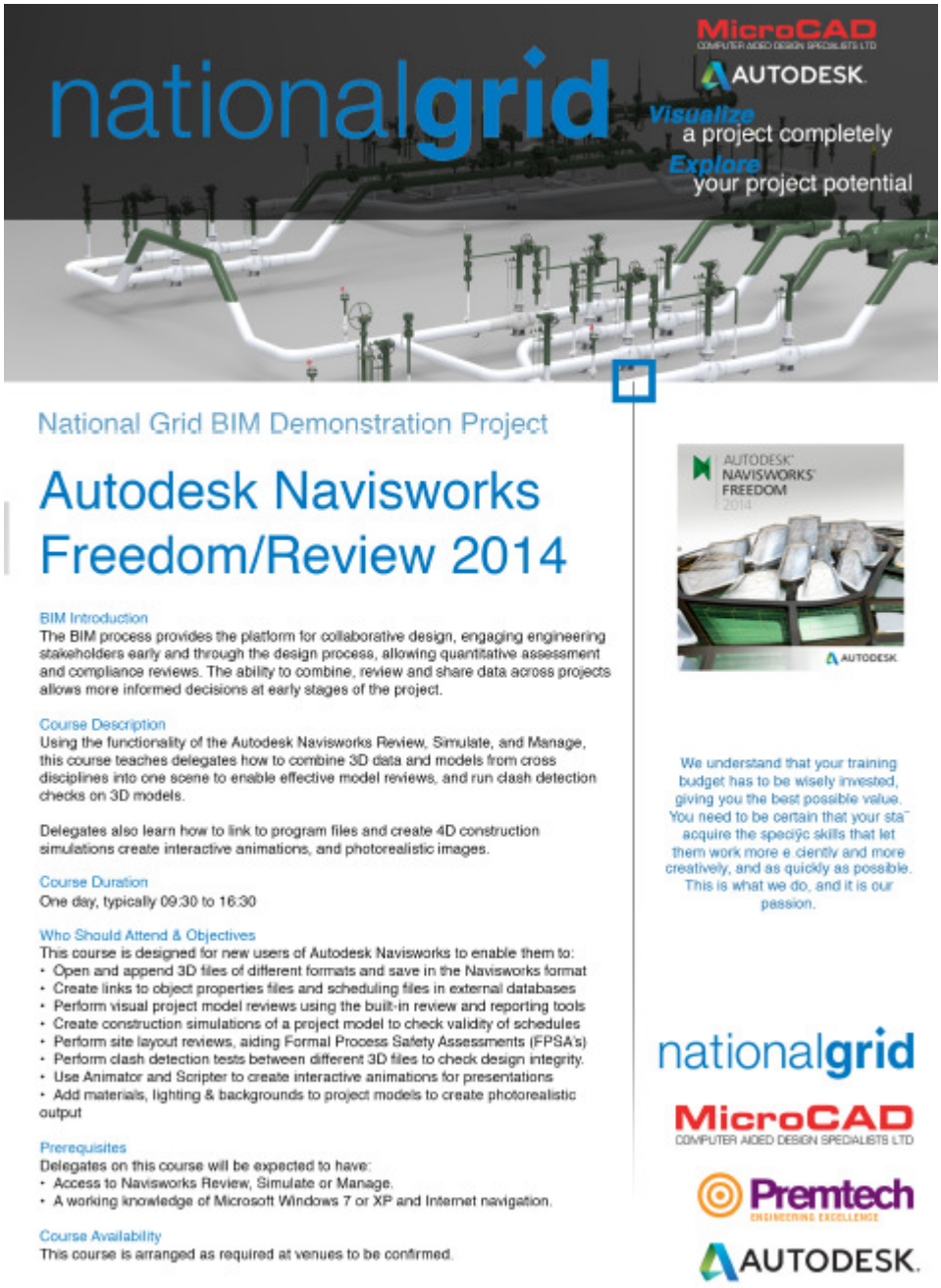

Figure 12 - Accredited Navisworks Training Package for the Pipeline Industry

The Navisworks training package typically meets the needs of the client role within a project, however for those business units of National Grid who undertake design activities in house, further training is required, from the manager awareness level through to detailed user level.

Training is not just a formal educational exercise. Over the course of the BIM trial project, 133 internal and external persons have accepted presentations and briefs on the BIM trial project, which will rise to nearly 200 persons upon completion of IGEM presentations during the Spring 2014. This must continue in the same open book manner to enhance the awareness and benefits of BIM industry-wide. Throughout the presentations it has been a lack of background knowledge of BIM which has generated the most apprehension and resistance to the BIM process. A simple 15 minute overview has proven very beneficial in establishing a basic awareness to then lead onto discussing the genuine and proven potential of BIM.

Near and Medium Term Recommendations – 5D Modelling

5D modelling has been demonstrated by the project, however to achieve the business efficiencies from tagging costs to components a more centralised approach is required. During the project, cost loaded material take off's have been delivered directly from the model, using the BIM codes to "look up" cost data. The process is proven, however the quality of the costing data could be questioned; too reliant on a small number of budget quotes and therefore of limited accuracy and resultant worth. It is recommended costing data should be maintained by a central team; this would enhance the statistical accuracy of the cost data. It is recommended the designer develops a cost estimate using activity schedules and BIM codes, enabling the centralised team to challenge and review, particularly on any variations from the centralised model.

To ensure the cost data from each project is consistent activity schedules for each type of project must be adhered to. Not only are consistent activity schedules required, the supporting information and assumptions such as material transportation liabilities and year of delivery must be provided by the designer to ensure like for like costs are being compared. To support this level of detail a capital cost and whole life cost scope has been developed by the BIM Trial project for wider National Grid review.

Near and Medium Term Recommendations – Carbon Modelling

Similarly to the 5D modelling, the linking of carbon data from a Sima Pro export has been successfully achieved using the BIM code as the "look up" tool. It is now a question of time and effort to develop the Sima Pro library with all common components for the industry. Progress is being made on the gas and electric front, however for the next 12 months it is suggested the current methodology of carbon calculators is followed until the library is more developed and ready for deployment.

Near and Medium Term Recommendations – 6D Modelling

Following the government's BIM strategy of a graduated approach to BIM an early decision was made to focus upon the design and build phases of the project with a conscious look across at the asset management systems. Discussions have been held with the potential alignment of asset systems such as Ellipse to the BIM project model. All data attributes required for Ellipse have been added to the project model. The recommendation is to focus initially on streamlining the interface between the BIM model and legacy asset systems as

opposed to handover the BIM model as the asset model. A working group has been established by Capital Delivery Electricity to evaluate the project to asset BIM model transition. Further work during the business ready phase would be to develop workflows through the project and asset model phase.

Near and Medium Term Recommendations – Learning and Development

An additional advantage of intelligent 3D modelling is the ability to link into not only the asset management systems but also handover to Learning and Development for training purposes. The geometric model utilised for engineering purposes can be transferred to a graphical interface model and training, an example of this being the Eakring AGI training package. Further advances in training aids which are recommended for evaluation are virtual reality headsets such as Oculus. This technology is driven by the gaming industry; however it is directly transferrable to the engineering industry. Headsets start from as little as £200. It is possible to connect remote users via headsets and avatars to a single training model. The benefits of this type of technology are the reduction in travel to complete training and the increased availability of specialist trainers to link in remotely.

Figure 13 - Virtual Reality Headsets for Training Purposes

Conclusions

The BIM trial project has provided a strong indication that BIM processes can provide financial, engineering, safety, environmental and quality benefits in both design and build phases for National Grid; with further opportunities in the operational phase.

The project has demonstrated cost savings of between 4 and 11% are achievable when moving from 2D based design to intelligent 3D modelling in the FEED phase alone; further possibilities exist in the construction and operational phases to exceed the government's 20% target primarily through the use of 4D, 5D and 6D modelling. As a result of this trial project all UK and US National Grid projects currently using a 2D process should be reviewed and moved across to intelligent 3D modelling. Standardisation and repeatability should be the two key metrics in this assessment. Whereby 2D design is completed in house a review of the investment costs (software licences and training predominantly) and rates of return should be undertaken.

The design houses have demonstrated BIM capability within their business, however not necessarily always in the utilities sector; a continued effort is required to ensure the BIM competence and capability is transferred into gas and electric from the architectural and civil business units. An open book approach to the development of BIM for National Grid has proved fruitful and should be maintained; gathering best practices from those designers leading in this field and ensuring the National Grid BIM scope is fit for purpose and to industry standard.

Intellectual property rights remains a risk for the deployment of BIM, however the architectural and civil industry have conquered this challenge. Dialogue is in place with National Grid Legal to progress and resolve this hurdle. A continuing review of BIM industry literature and forums should also assist in this challenge.

Recognising the gravitas and step change required for BIM, it is recommended the quick wins identified from the trial project are embedded using the appropriate pragmatic route such as Best Practices in a piece meal approach.

The project has successfully demonstrated the cost loading of material take offs. The availability of comparable cost data remains a challenge. Further dialogue is required with the e-Hub team to develop the 5D modelling aspect of BIM. Cost capture not only needs to align to activity schedules but have evidence of how these prices are compiled. The central repository of cost data shall enhance the robustness of cost estimates. Using the BIM coding system as a "look up" would enable a designer's cost loaded activity schedule to be directly compared to the in house cost estimate, by replacing the cost estimation relational database with the internal National Grid database, without compromising commercial sensitivities.

Dialogue is required with National Grid Policy to ensure the recommendations, particularly in the Formal Process Safety Assessments (T/SP/HAZ/11, T/SP/G/37 and T/SP/G/38), are captured and concreted into the relevant specifications.

Further dialogue is required with Global Procurement to put the procedures in place for 4D models to become the centrepiece of major project build tenders. The technical evaluation

should focus upon the high cost; high risk build sequence using 4D modelling as opposed to interrogation of the competence and capability of the tenderer; competence and capability can be directly assessed from the quality of the 4D model.

Whilst the trial project has achieved its objectives, the deployment of BIM needs to continue in a controlled and graduated manner. The recommendation is to put forward a joint gas and electric “business ready” phase; to include work flow planning and development of the BIM bank. This joint paper shall be completed in the spring of 2014, pending feedback and acceptance of the recommendations from this trial project.

Due to the high repeatability of certain replacement initiatives such as water bath heater replacements, minimum offtakes and the security enhancement projects, these projects would see the most significant benefit from an established approved BIM component library. For these types of projects the library would be well defined and could benefit greatly from the parametric capability.

There are also still hurdles to full deployment and the small steps that have been taken have provided focus, identifying areas where the most significant benefits have been achieved and where future concentration of effort could be applied.

To summarise the findings of the trial, BIM has provided

- A reduction in uncertainty in cost and carbon performance
- Streamlined visualisations required for the planning consent process
- Demonstrated consistent and accurate information can be carried forward for asset management
- Demonstrated the benefits of standardisation of typical infrastructure to avoid redesign
- Delivered enhanced safety processes
- Reduced risk

With Thanks

Here's to imagination, innovation and realisation;

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Thank you

Paul Lee

BIM Trial Project Manager

Glossary

AEC	Architecture, Engineering and Construction
BIM	Building Information Modelling
Clash Detection	Identification of physical interaction with model components (soft clash can be interaction of components in time)
CDE	Common Data Environment
COBIE	Construction-Operations Building Information Exchange, standard for structure of model handover data for O&M
IFC	Industry Foundation Class, data exchange format
LOD	Level of Detail – Level of geometric detail
LOI	Level of Information – Level of data detail
LODn	Level of Definition (level of model detail)
GIS	Geographic Information System
Objects	3D building components object
.	
Parametric model	Geometry constructed using rules and constraints.
Point cloud	3D laser scan, capturing high density survey points
Rendering	For development of the design, presentations and client sign-off, very detailed and life-like images of the model are created.
Uniclass	Uniform Classification System used to organise construction information into a standard order.
XML	Extensible Markup Language used for sharing structured data.
4D	Time / Schedule simulation
5D	Attaching cost data to model components and activities
6D	Application of O&M data to the model

AVI file list

2D Drawings	Generation of 2D drawing views from 3D Model
4D Modelling	Navisworks Timeliner Trial
Material Schedule	Generation of Materials Take off from 3D model
Carbon Performance	Linking of carbon Data to 3D model components
G37 Separation	Site layout Study – Separation Distance Check
Bend Radius	Enforcing rules, minimum bend radius
Fencing	Parametric Fencing Demonstration