Irish BIM Innovation Awards 2016

Mercury Engineering Submission
Mylan Dublin Respiratory Project, Phase 2
# Table of Contents

Introduction ........................................................................................................................................ 2
Mylan Dublin Respiratory Project, Phase 2 Project Details ................................................................. 3
Mercury Engineering MDRP Phase 2 Project Team ........................................................................... 4
Mercury Engineering’s Innovative Use of BIM on MDRP Phase 2 .................................................. 5
  BIM Enabled Off-site Fabrication ........................................................................................................ 6
  Geospatial Engineering for digital Construction .................................................................................. 8
  BIM Assisted On-Site Construction .................................................................................................... 10
  Open Standard Data Transfer ............................................................................................................ 11
Interoperability ................................................................................................................................... 12
  Evaluation ........................................................................................................................................... 12
  Authoring Software ............................................................................................................................. 12
  Collaboration Software ......................................................................................................................... 13
Collaboration & Communication .......................................................................................................... 14
Use of International Standards ............................................................................................................ 16
Education & Training ............................................................................................................................. 18
  BIM for Foremen ............................................................................................................................... 19
  Navisworks Site Training ...................................................................................................................... 19
  Survey Data Handling ......................................................................................................................... 20
Risk Management ................................................................................................................................. 21
Key Project Outcomes ........................................................................................................................... 23
BIM Lessons Learnt ............................................................................................................................... 23
Introduction

The Mylan Dublin Respiratory Project, Phase 2 consisted of ten separate project areas assigned to seven different contractor companies under the management of the main contractor, M+W Group. Owing to the number of sub-contractors responsible for these separate project areas it was necessary to implement a system to properly and effectively coordinate the site works. The issuing of up-to-date drawing packs, equipment models and the capture and development of as-built documentation also need to be managed. In light of these project requirements and the associated risks, the use of innovative digital construction technologies, including building information modelling, electronic procurement, prefabrication techniques and high definition surveying, were, in effect, mandated for the project.

The BIM Execution Plan (BEP) developed by the main contractor recognised the consequences of the delivery of poor quality mechanical and electrical production information. The successful delivery of the project to the client’s requirements was predicated on the elimination of delays, disputes and extra costs inherent in a traditional, non-coordinated, site fabricated project. This was achieved through the development of an LOD400 construction model with regular uploads of contractor details in an agreed, interoperable format in conjunction with weekly coordination meetings. All data, produced to recognised international standards, was shared through a designated common data environment and administered with an intelligent project management platform allowing all personnel to work to a defined process using real-time data.

With a company goal of ‘Right First Time’ Mercury Engineering sought to fully embrace the use of these digital construction technologies to drive the coordination, prefabrication and installation process. Through the better information management made possible by a collaborative dataset, it was possible to successfully manage the scope of works internally and to the client’s satisfaction. Iterative 3D laser scanning was used to capture as-built conditions to allow the modelling team to effectively coordinate the detailing of all systems. These modelled elements were passed to our prefabrication workshop, co-located with our BIM Hub, for production, delivered to site and installed by site teams trained in the use of coordination software to assist field work. The authoring software utilised for the project allowed for the generation of bills of material which provided accurate take-off information to assist both costing and procurement and isometrics for production and installation detail. Once the project had reached construction completion, a final set of 3D laser scans were conducted to allow for the completion of a redlined handover model which was delivered to the client, as requested, in an open standard format to aid operation and maintenance and provide historical context to any future expansion.
Mylan Dublin Respiratory Project, Phase 2 Project Details

Overview

Mylan is one of the world’s leading specialty and generic pharmaceutical companies who manufacture and market over 1,400 different medicines to retail, wholesale, government and institutional organisations covering virtually every dosage, form and therapeutic category. After three decades in Ireland, the MDRP project represented an expansion of the local footprint for Mylan Respiratory, including R&D facilities. With Mercury Engineering contracted to complete the M&E scope for the project, representing a €15million value with a project duration of six months, 260 people were employed by Mercury at peak to construct the facility using BIM and off-site fabrication methods.

Mercury Engineering Scope

<table>
<thead>
<tr>
<th>Clean production areas</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tech Spaces</td>
</tr>
<tr>
<td>Plant Rooms</td>
</tr>
<tr>
<td>2 No. Warehouses</td>
</tr>
<tr>
<td>1 No. Canteen/ Dining area</td>
</tr>
<tr>
<td>1 Large office and reception area</td>
</tr>
<tr>
<td>Engineering Rooms</td>
</tr>
<tr>
<td>Chemical Labs</td>
</tr>
<tr>
<td>UPS Room</td>
</tr>
<tr>
<td>2 No. Water tanks</td>
</tr>
<tr>
<td>CUB</td>
</tr>
<tr>
<td>BMS/ EMS</td>
</tr>
<tr>
<td>Loading Dock</td>
</tr>
<tr>
<td>Boiler Room</td>
</tr>
<tr>
<td>Goods Outwards &amp; Waste Outwards</td>
</tr>
<tr>
<td>External Areas - lighting, security huts etc</td>
</tr>
</tbody>
</table>

Project Metrics

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of AHUs</td>
<td>13</td>
</tr>
<tr>
<td>No. of Boilers</td>
<td>4</td>
</tr>
<tr>
<td>Metres of pipe installed</td>
<td>20,250</td>
</tr>
<tr>
<td>No. of Field Welds</td>
<td>250</td>
</tr>
<tr>
<td>No. of FAB Welds</td>
<td>200</td>
</tr>
<tr>
<td>Metres of Duct Installed</td>
<td>11,000</td>
</tr>
<tr>
<td>No. of test packs</td>
<td>106</td>
</tr>
<tr>
<td>Equipment installed (tonnage)</td>
<td>140</td>
</tr>
<tr>
<td>Metres of cable installed</td>
<td>764,000</td>
</tr>
<tr>
<td>Metres of Tray Installed</td>
<td>19,000</td>
</tr>
<tr>
<td>No. of electrical boards</td>
<td>15</td>
</tr>
<tr>
<td>No. of MCC's</td>
<td>16</td>
</tr>
<tr>
<td>Client Process Equipment Installed</td>
<td>P4 Chiller and associated equipment</td>
</tr>
<tr>
<td>No. of Isometrics</td>
<td>4,044</td>
</tr>
</tbody>
</table>
Mercury Engineering MDRP Phase 2 Project Team

Shannon Brown – BIM Project lead

Management of modelling process and coordination with all stakeholders

Alessandra Benedettelli – BIM Modeller

Output of IFC documents, drawings and creating general arrangements and structural details

Cathal King – BIM Modeller

Design and coordination of LPHW, CHW & domestic services models using Cadworx & Revit

Keith Walsh – BIM Modeller

Design and coordination of LPHW, CHW & domestic services models using Cadworx & Revit

Ciarán McManus – BIM Surveyor

Site survey work and production of processed 3D scan files
Mercury Engineering’s Innovative Use of BIM on MDRP Phase 2

The MDRP Phase2 project scope gave us the opportunity to further develop and enhance methods of construction previously developed on earlier BIM focused projects. These advances were used to drive efficiency, ensure quality and improve the knowledge base within the project team, and subsequently across the group as a whole. With over 20km of pipe, 11km of duct and 140t of equipment to install in a six month period in a new build facility, it was vital to the success of the project that our organisations “Right First Time” goals were achieved through the deployment of innovative technologies and workflows by dedicated, engaged team members. A broad overview of these methods used on MDRP are as follows:

- BIM enabled Off-site Fabrication
- Geospatial Engineering for Digital Construction
- BIM Assisted On-site Construction
- Open standard data transfer

The use of the chosen approach to construction looked to leverage data generated through the modelling process across all subsequent work areas and this multi-use tactic required stringent management of the modelling aspect to ensure data integrity.

Figure 1, MDRP Phase 2 Project Workflow
BIM Enabled Off-site Fabrication

Given the increased complexities of new build facilities, the ability of mechanical and electrical trade contractors to fabricate and install piping, ductwork and electrical containment on-site in an efficient and timely manner has led to an increase in the need for prefabrication. However, the prefabrication of complex building elements without proper coordination, detailing and procurement can lead to significant amounts of rework on site which defeats the intended purpose of prefabrication and imposes unnecessary time and financial costs to a project. The use of digital construction technologies, if applied correctly, will go some way to assuage these difficulties. On the MDRP project the Mercury Engineering prefabrication facility in Newbridge, Co. Kildare was utilised to take input from the co-located BIM Hub and produce the necessary spool pieces for completion of the mechanical element of the project. Operating to best in class quality and safety standards, the prefabrication facility comprises a Class 10 cleanroom including welding area for high purity pipework along with low purity facilities for carbon steel, PVC, stainless steel and modular construction.

![Figure 2, Class 10 Cleanroom, Newbridge](image)

A number of software solutions were used for the prefabrication from both a management and fabrication perspective. The data flow described in Figure 3 illustrates how the prefabrication process is managed from modelling through to installation with constant monitoring and interaction by the engineering staff.
Using the *EIDA* management system, the following details are shared following generation from the BIM model:

- Piping isometrics
- P&ID’s
- Ductwork & support details
- Specifications

Using data transferred directly to this application and manually entered need dates, the system will track the necessary production metrics:

- % fabricated
- Material reserved
- Line available
- Line picked
- Fab start
- Fab & QA complete
Once fabrication has been completed the site based engineers can request a required spool through the system and have full traceability of despatch and delivery updates. Once landed, the installation process can be tracked through to upload of punch lists and finally test pack completion. This continuity of data across all activities allows for full quality accountability from spool detailing to construction completion.

The chosen modelling software for pipework detailing, *Cadworx Plant Professional*, allows for the generation of a bill of materials (BOMs) per spool complete with custom component data embedded through the *Cadworx* component library. With an integrated linkage between the authoring software and the procurement element of *SAP*, using *SAP* coded BOMs, allowed for ‘*Just In Time*’ ordering and delivery of components.

**Geospatial Engineering for digital Construction**

With the development of skillsets around the field capture and use of various forms of geospatial content within the project team this knowledge was implemented on the MDRP project to assist in the coordination process. Those techniques employed consisted of:

- Iterative 3D laser scans
- Connection point verification
- Redline scans

From experience of previous projects, the coordination of works based purely on a federated model can create difficulty due to misalignment issues from construction. In order to alleviate this problem, a series of iterative 3D laser scans were programmed at key schedule milestones to capture constructed elements.

![BIM Modeller using 3D Scans as background condition](image)

*Figure 4, BIM Modeller using 3D Scans as background condition*
These iterative scans were used as a background conditions model by the modellers and gave confidence in coordination of newly detailed elements. This enabled accurate clash detection of work in progress (WIP) models against both planned works illustrated in the federated model, WIP from other stakeholders, and accurately, field verified constructed content. Along with the ability to clash detect against as-built conditions, the 3D lasers scans also permitted accurate point verification and connection detailing.

Figure 5, Iterative 3D Laser Scan for Coordination

This information was captured on site using high definition laser scanning tools and total stations and presented to the modellers in a number of different formats to allow for flexibility of usage. Laser scans were delivered using two distinct methods:

- Integration of registered and referenced point cloud database with authoring software – using this method modellers were able to model directly through the point cloud and avoid any potential conflict eliminating the need to model, check and readjust thus reducing the time taken to produce conflict free content
- Creation of native Navisworks files to allow for interrogation of as-built content against federated model
- Bespoke routine for import of connection point surveys which included location, type and size of POC to authoring software

Once construction was complete, a redline scan was carried out to capture the final as-built condition. Combined with detail from the iterative scans carried out through the course of the project, an as-constructed model was generated to satisfy the handover to the client.
BIM Assisted On-Site Construction

The generation of a 3D model, inherent in the BIM process, provides a powerful tool for assisting the construction process for site based workers. With traditional methods of issuing general arrangement drawings fast becoming obsolete, the use of a 3D BIM model was used on the MDRP project to improve site coordination and enhance productivity. The provision of dedicated ‘BIM Boxes’ allowed upskilled site staff to interrogate the most up-to-date model and determine installation information not previously obtainable for 2D drawings.

![Mercury Mobile BIM Box](image)

**Figure 6. Mercury Mobile BIM Box**

The provision of this equipment in conjunction with the delivery of relevant training modules empowered site staff to reap the benefits of the data and model developed as part of the BIM process.

Engineering review

Using the data sharing and collaboration systems available to the project team, it was possible to share modelled content with site to carry out engineering and constructability reviews. These reviews assisted in improving the quality of the end product and the use of collaboration technology already in place meant a streamlined and lean approach could be taken to this necessary step both in terms of team members and time taken.
Site Materials

Using the SAP encoded information produced with the bill of materials and the availability matrix from fabrication simplified the ordering of materials and calling down fabricated spools. The adoption of the EIDA data management system across the project made the reuse of this information, produced by the modelling process, a valuable asset in managing this ‘Just In Time’ activity.

Open Standard Data Transfer

As per the client’s request, the as-built model was delivered as an IFC file. The generation of the required file type from the redlined, final model was achieved by exporting the federated model using i-Construct for Autodesk Navisworks. This bolt on application to Navisworks allowed for the creation of the necessary data from the property sets inherent in the model.

Figure 7, i-Construct for Autodesk Navisworks
Interoperability

Evaluation

Prior to engagement in any BIM authoring on a project, Mercury carry out a software evaluation to ensure the right tools are used to produce the necessary content, Figure 8 illustrates the criteria for the MDRP project.

<table>
<thead>
<tr>
<th>Mercury Software</th>
<th>For</th>
<th>Against</th>
<th>Advise to project team</th>
</tr>
</thead>
<tbody>
<tr>
<td>CADWorx Plant Professional</td>
<td>Excellent for isometric and detail detailing, suits the Mercury shop</td>
<td>Weak on documentation and electrical</td>
<td>Advice using on all piping, electrical and support. Will require purchase of additional 2 No. licences w/</td>
</tr>
<tr>
<td></td>
<td>fabrication norms. Have and can build specification / library ready</td>
<td>electrical plans that are already created.</td>
<td>interoperated also 1 fieldbus control should be used on point to point electrical.</td>
</tr>
<tr>
<td></td>
<td>and data.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>AutoCAD Fabrication</td>
<td>Good for electrical and detail detailing suits the fabrication shop in</td>
<td>Not traditional isometric outputs. Complicated to build library.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Navisworks, MEP</td>
<td></td>
<td></td>
</tr>
<tr>
<td>AutoCAD-Sew MEP</td>
<td>Good for complete project team aligned to same.</td>
<td>Poor for Mercury shop deliverables</td>
<td>Only as a reference tool for the supplied (removal cost existing software)</td>
</tr>
</tbody>
</table>

Figure 8, MDRP Software Evaluation

Intergraph CADWorx Plant Professional 2015

Mercury used *CADWorx Plant Professional* for both process and mechanical piping system as well as support detailing and electrical containment. *CADWorx* allows for quick and easy creation of fully intelligent 3D plant models. Because *CADWorx* models are *AutoCAD* based, they offer unparalleled flexibility and collaboration. Automatic isometrics can be produced...
from piping layouts or project databases. *CADWorx Plant Professional* includes *ISOGEN* for automatic isometric production as well as *Orthogen* for automatic general arrangement drawing production.

**AutoCAD Fabrication 2015**

Mercury used *AutoCAD Fabrication 2016* for production of all ductwork detailing, this software uses manufacturer-specific content to help generate better estimates, create more accurate detailed models, and directly drive MEP fabrication. Our ductwork fabricator has integrated outputs from the software directly into their fabrication shop.

**Collaboration Software**

**Navisworks 2015**

*Navisworks* allowed Mercury to combine 3D models and run clash detection on multiple model sources. Generating clash reports of interferences between MEP elements and other building which were adjudicated upon and corrected before fabrication.

**i-Construct**

*i-Construct* is a ‘plugin’ application for *Navisworks*. It extends the capabilities of *Navisworks*. On the Mylan project this was primarily used for amalgamation and integration of data sources into the model i.e. ‘as built tagging data as well as the conversion of the ‘as built’ nwd to IFC2x3 as required by the client.
Collaboration & Communication

With a large number of stakeholders involved in the project, an effective set of support strategies and applicable tools for collaboration, data sharing and communication between all stakeholders were vital to fulfilling this aspect of the project. The aim of these strategies was to “generate the maximum benefit of collaborative arrangements increasing efficiency and effectiveness”. In Mercury’s case this meant collaboration between both internal and external project partners. The enabling tools used to accomplish crucial collaboration and communication included:

- M+W Link – CDE
- EIDA – data management platform
- BIM Hub/ Fab Shop co-location
- Regular stakeholder coordination workshops

The BIM Execution Plan (BEP) devised by the main contractor stipulated that all modelled information should be shared for collaborative coordination purposes through their Common Data Environment (CDE), M+W Link. The BEP stipulated the frequency and timing for the upload of clash detected content to the CDE along with the required format for each discipline.

<table>
<thead>
<tr>
<th>Discipline</th>
<th>Format</th>
</tr>
</thead>
<tbody>
<tr>
<td>Architectural</td>
<td>*.rvt</td>
</tr>
<tr>
<td>MEP</td>
<td>*.dwg</td>
</tr>
<tr>
<td>Structural</td>
<td>*.rvt</td>
</tr>
<tr>
<td>Process</td>
<td>*.dwg</td>
</tr>
<tr>
<td>Clean Room</td>
<td>*.rvt</td>
</tr>
<tr>
<td>Coordination</td>
<td>*.nwd</td>
</tr>
</tbody>
</table>

Table 1, Model content delivery format

“The collaboration between trades on the Mylan Phase 2 Project using the federated model help us to achieve a high rate of Right First Time with our electrical installation works and avoid costly rework. Using the model to communicate intent with the site crews also helped enormously” – Stephen O’Sullivan, Electrical Supervisor
In conjunction with the sharing of modelled content through the CDE, coordination workshops, managed by the main contractor, were an important part of the process to assist the collaboration process and deliver a functional, realistic digital twin of the expected completed facility.

The use of the EIDA system to allow collaboration and data sharing between all Mercury Engineering project stakeholders provided an intelligent project management platform allowing all personnel to work to a defined process using real-time data.

"The communication strategies implemented on MDRP Phase 2, through the use of the EIDA data management system and the co-location of the Mercury BIM Hub with our facility meant that information was delivered as expected and any issues could easily be resolved" – Seán McCarthy, Prefabrication Project Manager

The EIDA system was used for transmittal of BIM produced documentation to all internal stakeholders including:

- Piping isometrics
- P&ID’s
- Ductwork & support details
- Specifications
- SAP encoded BOMs

Along with the sharing of this content from the BIM Hub, the system could also be used as a document control application and to share information on:

- Material availability
- Fabrication progress
- QA/QC
- Site Progress logs
- RFI’s
- Permit requests

A secure, networked server was used to disseminate all required modelled content and federated models to both our prefabrication facility and to our site based team.
Use of International Standards

As the construction sector can be viewed as a highly fragmented industry serving the needs of multiple stakeholders across all sectors and industries, both public and private, the need for best practice guidelines to enable meaningful collaboration is a must. The use of building information modelling to realise the project goals of the MDRP Phase 2 project necessitated an adherence by all stakeholders to applicable BIM standards. The application of these standards provided control over the following aspects of the model generation:

- Central and project resources
- Model naming
- Object naming
- Spatial co-ordination
- Component modelling
- Data exchange

<table>
<thead>
<tr>
<th>BIM Standard</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>PAS1192:2</td>
<td>Process management, model development</td>
</tr>
<tr>
<td>BS 1192:4 2014</td>
<td>Collaborative production of information</td>
</tr>
<tr>
<td>ISO 12006:2</td>
<td>Use of Uniclass framework for categorising components</td>
</tr>
<tr>
<td>BS8451:1 2012</td>
<td>Development of component library</td>
</tr>
<tr>
<td>BS8451:2 2011</td>
<td>2D symbols for BIM</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Protocols/ Guides</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>AEC (UK) BIM Protocol</td>
<td>Implementation of standard recommendations</td>
</tr>
</tbody>
</table>

In conjunction with these standards for model development, process management and content delivery, both the off-site fabrication process and on-site installation works were carried out to internationally recognised quality and safety standards. Likewise, all appropriate and relevant engineering standards were used to ensure the engineering veracity of the modelled content.
Figure 10. Fabrication Quality and Safety Certification
Education & Training

Mercury Engineering’s vision is “to be the best and most successful multidisciplinary contractor in every sector and geographical area in which we operate”. We believe that the success and continued growth of the company depends on the knowledge, skill and competence of our employees to drive group performance to our goal of Right First Time installations. Mercury considers our people to be our greatest strategic asset and hence is committed to providing training and development opportunities to all employees. We do this by utilising the talents, skill and experience of our workforce and encourage employees to seek out development opportunities in partnership with front line management. We implement this policy through:

- Appropriate training and development activities to ensure the competence levels of employees are developed and maintained to the highest possible standards;
- Identification of training needs and the provision of training programmes to meet these needs;
- Encouraging our employees to fully consider their own training and development needs in conjunction with their direct line manager;
- A review process of training and development interventions both formally and informally to ensure on-going improvement of our training;
- Internally delivered courses are continually evaluated and benchmarked against industry best practice and are regularly reviewed and updated in line with legislative amendments.

In the context of the Mylan P2 project the education and training delivered to project team members included BIM focused training across the full site team and upskilling of BIM staff in new areas of technology application specific to the project. This comprised of:

- BIM for Foremen – an overview of the BIM process focusing on application to site based teams
- Navisworks site training – training in the use of Navisworks for site base employees as required
- Survey data handling – upskilling of BIM modellers in the use of Leica Cloudworx
BIM for Foremen

Given the chosen method of working on the Mylan project, a skills gap was identified with some of the foremen who would not have previously been involved with this way of working. To this end, a training document was developed to explain the fundamentals of BIM to site based foremen. The training approached the subject by posing a number of questions:

- What is BIM? – while people may have heard of the technology, the communication of a succinct definition of the technology was deemed important to dispel any misconceived ideas about what BIM could and couldn’t do;
- How does it work? – a brief outline of the fundamental capabilities of BIM, the importance of data and collaboration, required inputs and possible outputs;
- What tools are used? – how data is captured, input and generated from the system. Data sharing, model viewing and construction applications;
- What does it mean for Mercury? – how BIM enables Mercury to achieve closer control of projects through the controlling the quality of product information, generating and using process information and improving the flow of product and process information;
- What does it mean to you? – detailing of the deliverables to construction from the BIM process, potential issues which may arise and how to resolve these issues.
- BIM next steps – how the process continues once construction is complete and what the final deliverable to the client is.

Navisworks Site Training

A fundamental step in the construction and installation process for the Mylan P2 project was the upskilling of relevant team members in the use of the Navisworks platform to view and interrogate the model as necessary. This training covered the basics to enable team members to better achieve the necessary coordination of installation under the following headings:

- Supported File Types – what files can be used and how
- Navigation Tools – how to move through the model
- Measure Tools – how to measure between elements as required
- Redlines – how to mark up the model to communicate changes or query
- Properties – how to view component properties, including how to setup the Quick Properties tool
Survey Data Handling

In order to assist the coordination process on the project, a series of iterative 3D laser scans were carried out at key milestone intersections to capture relevant constructed elements. Where this information would previously have been used to clash detect WIP content against, the point clouds were to be used as a background conditions model in this case and required the BIM modellers to ‘model through’ the scan. In practice this method of working employed the use of the Leica Cloudworx application which allowed the modeller to import the point cloud database directly into the authoring software. As this was a new approach, one-to-one tutorials were carried out with the modellers to demonstrate the functionality of the software and provide the necessary training to allow them to use this application. These tutorials focused on:

- Importing databases from Leica Cyclone including relevant preference settings
- Clipping of point cloud
- Rendering of point clouds and limitations
- Use of TruSpace to both view and model content
- Automatic generation of components using the software’s fitting tools

These tutorials were backed-up by ongoing support from the project BIM surveyor and suggestions from the modellers were integrated into the survey process to make the delivered survey data both easier to use and focused on specific BIM requirements.
Risk Management

The most effective method of controlling risk in construction is through the application of considered system processes. These processes must be robust, easy to follow and provide accurate, up-to-date data to support decision making and the execution of preventative and corrective actions. For the MDRP project, the definition of the project BIM goals by the main contractor at the outset of the project; namely:

- Better outcomes through collaboration
- Use BIM to convey safety
- Improve coordination between all disciplines
- Drive design using 3D Visualisation

were based on the perceived risks to the successful completion of the project.

<table>
<thead>
<tr>
<th>BIM project goal</th>
<th>Objective</th>
<th>Associated Risk</th>
<th>Timeframe</th>
</tr>
</thead>
<tbody>
<tr>
<td>Better outcomes through collaboration</td>
<td>All project partners – different design disciplines, the customer, contractor, specialists and suppliers – use a single, shared 3D model, cultivating collaborative working relationships. This ensures everyone is focused on achieving best value, from project inception to eventual decommissioning.</td>
<td>Project outcomes compromised due to silo mentality</td>
<td>Whole Life cycle.</td>
</tr>
<tr>
<td>Utilise BIM to convey safety in design</td>
<td>Use the 3D model to enhance operational safety. Contractors can minimise construction risks by reviewing complex details or procedures before going on site.</td>
<td>Potential for construction and operating accidents</td>
<td>Whole Life cycle.</td>
</tr>
<tr>
<td>Improve coordination between all disciplines</td>
<td>Integrating multidisciplinary design inputs using a single 3D model allows interface issues to be identified and resolved in advance of construction. The model also enables new and existing assets to be integrated seamlessly.</td>
<td>Potential for cost and time impacts of redesign.</td>
<td>Handover</td>
</tr>
<tr>
<td>Drive design using 3D visualisation.</td>
<td>BIM makes possible swift and accurate comparisons of different design options</td>
<td>Cost-effective and sustainable solution not achieved.</td>
<td>Whole Life cycle.</td>
</tr>
</tbody>
</table>

Table 3, Project goals and associated risk
The identification of potential hazards to the successful delivery of the project enabled control measures to be put in place to counteract these risks.

<table>
<thead>
<tr>
<th>Risk</th>
<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project outcomes compromised due to silo mentality</td>
<td>CDE used by all stakeholders for sharing of modelled content. Coordination workshops</td>
</tr>
<tr>
<td>Potential for construction and operating accidents</td>
<td>Model used to determine access routes to work areas based on location of high activity, design of system location reviewed to ensure safety of operation, prefabrication – move to workshop environment reduces risk of construction accidents, using model to carry out day-to-day inspections</td>
</tr>
<tr>
<td>Potential for cost and time impacts of redesign.</td>
<td>Quality control checks of modelled content specified in BEP. Sub-contractor QA/QC procedures – constructability, engineering review, digital transfer of data between systems, accurate as-built information captured,</td>
</tr>
<tr>
<td>Cost-effective and sustainable solution not achieved.</td>
<td>Cost engineering and comparison of options made easier through use of interoperable digital content, integrated model analysis tools to help bring predictability to the building life cycle</td>
</tr>
</tbody>
</table>

Table 4. Risk Control Measures
Key Project Outcomes

- Successful delivery of client’s facility – to be substantiate by clients Letter of Support
- Mitigation of risk as identified by main contractor – to be substantiated by main contractors Letter of Support
- Large number of site based staff trained in the use of BIM tools
- Illustration to construction supervisors of effectiveness of digital construction technologies
- Development of enhanced methods of delivering clash free model content using high definition scanning
- Workflows put in place to enhance interoperability through use of IFC format.
- Further integration of core team members across site, fab shop and BIM department

BIM Lessons Learnt

- Early integration and alignment of 3d coordination against construction milestones.

  *Noted: Late award and not having a MEP BIM model from design to develop meant that development of the BIM model and construction happened in parallel. Deviation from construction needed to be captured immediately so as avoid any abortive works by 3d detailing team.*

- 3d library creation time scale and availability of components in 3d.

  *Noted: Many vendors could not supply specific model elements and hence a volume of time was spent creating this content.*

- Training of subcontracting site staff in simple navigation skills in Navisworks.

  *Noted: Subcontracting constructing team did not have exposure to a BIM project prior to the MYLAN and as such training was required.*

- Communication with the site installation team

  *Noted: Communication with the site installation team and having them responsible for field installation by involving each trade contractor in BIM coordination process by allotting time in the daily meeting to BIM issues.*