The buildingSMART Awards Yearbook

Winners, Finalists and Special Mentions 2020

Extraordinary winning projects from 2020 from the buildingSMART International Awards Program

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About buildingSMART

buildingSMART is the worldwide industry body driving the digital transformation of the built asset industry, committed to delivering improvement by the creation and adoption of open, international standards and solutions for infrastructure and buildings. buildingSMART is the community for visionaries working to transform the design, construction, operation and maintenance of built assets and is an open, neutral and international not-for-profit organization.

The buildingSMART Awards program was established in order to recognize exemplary projects that have used buildingSMART standards and solutions to effectively overcome interoperability challenges. The first awards were presented in Toronto in October 2014, and the program continues to grow year on year.

The 2020 Awards saw projects compete in 7 categories, with an additional 3 Awards being presented at the discretion of the buildingSMART management team, resulting in 10 project winners.

2020 Highlights

Categories

This program was divided into four broad categories: Project Delivery, Operations, Research and Technology. Each category has sub-categories and these provided the basis for the awards program.

Jurors

This awards program saw a record 111 jurors across 23 chapters. The role of the juror includes grading project submissions against a strict criteria designed to ensure the highest quality of submissions. This year there was also a new addition of a triage team to help reduce the amount of work on all jurors.

Submissions

There were a record 111 submissions across all the categories. The breakdown for those that passed triage is outlined below:

- Asset Management: 4
- Construction: 11
- Design: 15
- Handover: 2
- Integrated Project Delivery: 4
- Professional Research: 8
- Technology: 22
- Student Research: 8

Special Mentions

Due to the high quality of submissions, there were a number of projects deemed of a high enough standard to warrant a special mention. These projects scored exceedingly highly but fell slightly short of the required number to become a finalist. These projects therefore qualified as a "Special Mention" and were duly awarded this during the ceremony.

Contents








buildingSMART International

WINNER

Auckland Airport Maps its Future with openBIM

Auckland International Airport Ltd, New Zealand

About the Airport

Auckland Airport is an international airport that enables the safe carriage of passengers and users to and from New Zealand. The airport itself covers a land area of approx. 1700 hectares, onto which both its international and domestic terminals operate covering approx. 170,000m2 of space. Every year, 21 million passenger's pass through these terminals. The airport itself has full operational control of both the CAPEX and OPEX work. To ensure it could keep pace with growing demands and the need to ensure future capacity planning, the airport began to work on a project to deliver a smarter methodology for supporting these goals.

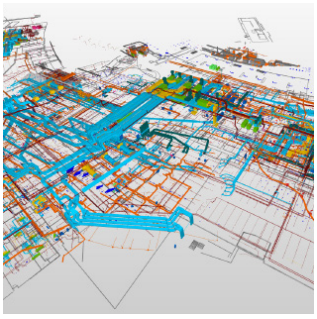
Core Objectives

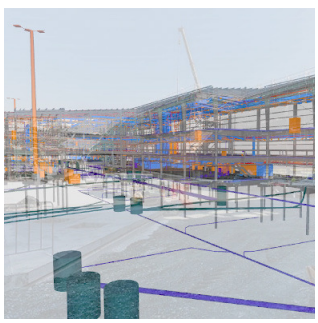
To enhance the use of IFC across multiple projects for enhancing the digital for the airport. The airport wanted to mandate the use of openBIM methodology to connect a variety of tools from their stakeholders.these goals.

About the Projects

Prior to the Covid-19 pandemic, the airport was undertaking its biggest capital works program and had committed to spending NZD $2 billion for a variety of projects. At the time the global pandemic started, there were 15 ongoing projects spread across the whole airport. All these projects were actively delivering models in IFC format. In the years prior, there had been numerous projects that were also delivering models in IFC format that fed into their federated terminal asset information model. The concept of digital delivery had been widely adopted by the airport since 2015 which was accelerated by the asset information model in place. There were a variety of different projects running concurrently, including:

Terminal Building Asset Information Models (AIM) – this project including continuous





development for more than 100 IFC models spanning a variety of design models, as-built construction models and Scan-to-BIM models, covering all disciplines.

IFC Model Sharing – this process was fully supported in accordance with their IDM (information delivery manual) requirements and were fully geocoordinated. The client did not restrict the use of authoring tool and utilized Oracle's Aconex platform as their common data environment. These models were used for a variety of use cases such as baggage handling, capacity planning, smoke simulation and new building design. Tools such as Sketchup, Revit, and Archicad were used extensively. Numerous projects were also utilizing BCF for issue resolution.

Capital Works Master Schedule (CWMS) – was a project that had a long-term view for their 2044 master plan. IFC was used for their 4D enabled plans, including better simulation and planning with Synchro, scale and geolocation with Archicad and overlaying project polygons with existing utilities data.

BIM to GIS – was a project that focused on delivering floor plans for better FME management. There was also a Proof of Concept alongside an external consultancy to convert existing 2D survey data into an IFC model (Using 12D) with a new property set that contained all the available utility data.

Highlights

- Over 100 disparate models successfully geo-loacted and exported to IFC
- 250,000+ elements modelled within the existing international terminal
- Client developed Asset Information Delivery Manual (AIDM), mandating OpenBIM delivery requirements for Native and IFC models for all new projects
- Developed a comprehensive 4D Capital Works Masterplan model utilizing IFC at its core

buildingSMART openBIM Solutions

IFC 2x3, IFC4, BCF

Software Used

Autodesk (Revit, Navisworks, Civil3D, AutoCAD, Recap pro, BIM360 Field and Glue), ArchiCAD, Solibri, SynchroPRO, Oracle Aconex, Oracle Primavera P6, Tekla, FME, Esri ArcGIS Pro, Renderlights,12D, Leica Cyclone Register 360, BIMCollab, Prosteel, Microsoft PowerBi, PyroSim

Other Standards

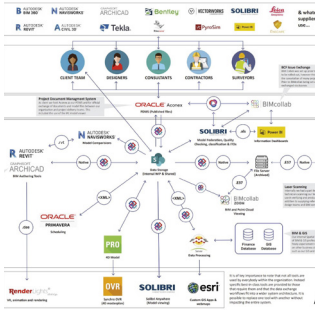
Omniclass, E57, XYZ, DWG, Collada, DWFx

Result

Jurors in the category of Asset Management were impressed with Auckland Airports innovative approach to openBIM. As the owner-operator, the jury felt the airport provided clear guidance to all those delivering work during this transformative time. It was clear that this projct adopted the best of both buildingSMART standards and solutions to deliver an effective outcome.

> "openBIM enabled us to do more with less by being free to work between multiple tools as needed, without having to work within the constraints of one software. It puts the output at the centre, which in the reality of a client organization is what matters most."

Karl Fitzpatrick, Auckland Airport



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WINNER

Machine Readable Norwegian Classification Manual for Bridge Inspections - V440

Norwegian Public Roads Administration, Norway

About the Project

The initiative to launch a machine-readable classification manual for bridge inspections originated from one of the larger infrastructure projects owned by the Norwegian Public Roads Administration (NPRA), the Bjørnafjorden fjord crossing, which aims to build a long floating bridge with an elevated section. As the Bjørnafjorden project needed a common classification system to align the incoming data streams, NPRA applied the classification defined in the existing bridge registration manual V440.

The V440 project lasted a year, reaching completion in August 2020, and involved four software vendors who actively participated through prototyping and the implementation of the published V440 ontologies in their software solutions.

Today, the resultant Norwegian bridge registration manual—V440—is issued by the Norwegian Public Roads Administration (NPRA) as a PDF document.

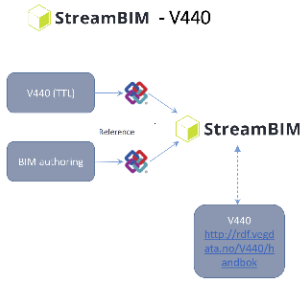
Core Objectives

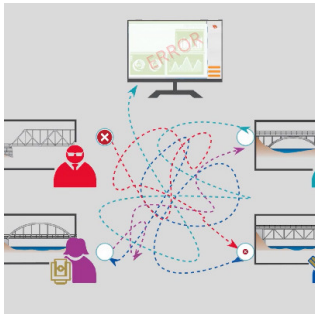
The project objective was to make the classification structure described in V440 available as an open, machine-readable format, to allow for automated and consistent classification of Norwegian bridges and structures in different software solutions.

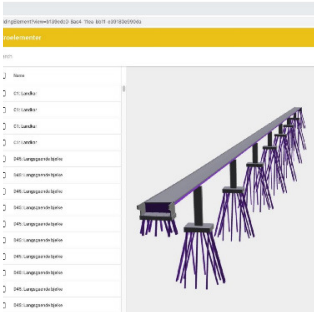
Project Description

Phase One

As the first step in Phase One, the domain experts in NPRA moved the information from the PDF-formatted V440 manual to a spreadsheet in a structure that easily could be imported into TopBraid Composer to define the ontology. The V440 classification ontology was developed using Linked Data and Semantic Web (LD/SW) technology, which employs open formats and are considered as openBIM in this project.







Phase Two
In phase two, NPRA and the project team conducted quality assurance revisions of the ontologies and published them at a server site.

In addition, a SPARQL endpoint was published, allowing the software vendors to use the querying language SPARQL to access the classification structure. GraphDB was used as the triplestore to provide the SPARQL endpoint.

A GitHub site was established, containing all the relevant information needed for the participants in Phase Three of the project, including ”getting started” material and the ability to ask questions.

Phase Three
In Phase Three, software vendors were invited to implement the use of the published ontologies.

This was followed by a prototyping process called openLAB adapted by buildingSMART Norway. This “workshop” lasted for several months where the participating software vendors could develop their solutions and exchange information and experiences.

The resulting classified BIM models were exported from the prototype editions of the software to the validation software as IFC 2x3 and/or IFC4 files.

Highlights

- Showed the benefit of moving “digital paper”-based (PDF format) classification systems to an open machine-readable format
- Showed how easy it is for software vendors to integrate well-documented ontologies into their software to produce valid IFC models
- Showed the benefit of using the LD/SW technology to link different ontologies together with linking rule sets
- Developed a lean and simple ontology modelling process using Excel spreadsheets for domain experts and Top Braid Composer for the LD/SW experts
- Made very good demo showcases for the use of LD/SW technology in four different software solutions
- Taught interested software vendors the basic concepts of LD/SW and how to implement this technology in existing software packages

buildingSMART openBIM Solutions

IFC 2x3, IFC4, ifcOWL

Software Used

Areo, Quadri, Tekla Structures, StreamBIM, Solibri, MS Excel, Protégé, TopBraid Composer, GraphDB

Other Standards

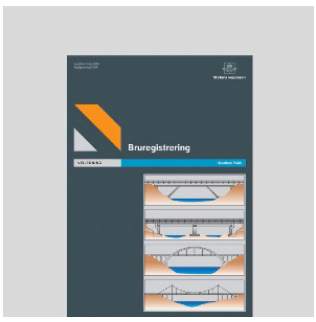
RDF, RDFS, SPARQL, OWL

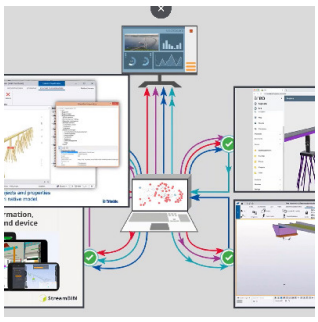
Result

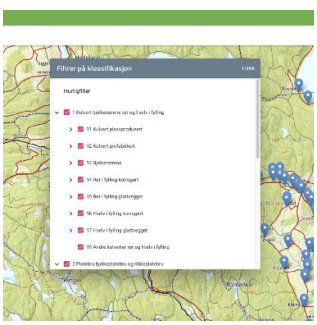
The use of openBIM and other open standards is the very essence of this project, with the main achievement being the V440 ontology. The project used only open formats when defining the ontologies and linking rule sets.

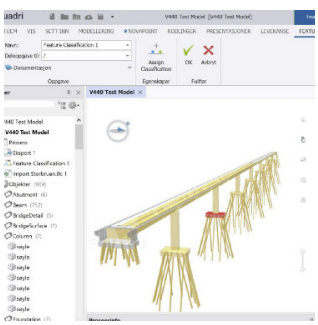
This project demonstrated how quickly software vendors can implement the use of Linked Data and Semantic Web (LD/SW) ontologies in their software when the ontologies are published in an open, standardized and well-documented format. By opening up LD/SW as the technology platform for openBIM, there are almost no limits to the possibilities that can achieved by linking and combining different ontologies.

The links to the V440 ontologies have now been published at the official NPRA site for manual V440 and the NPRA now expect the industry to use these ontologies in their daily work.









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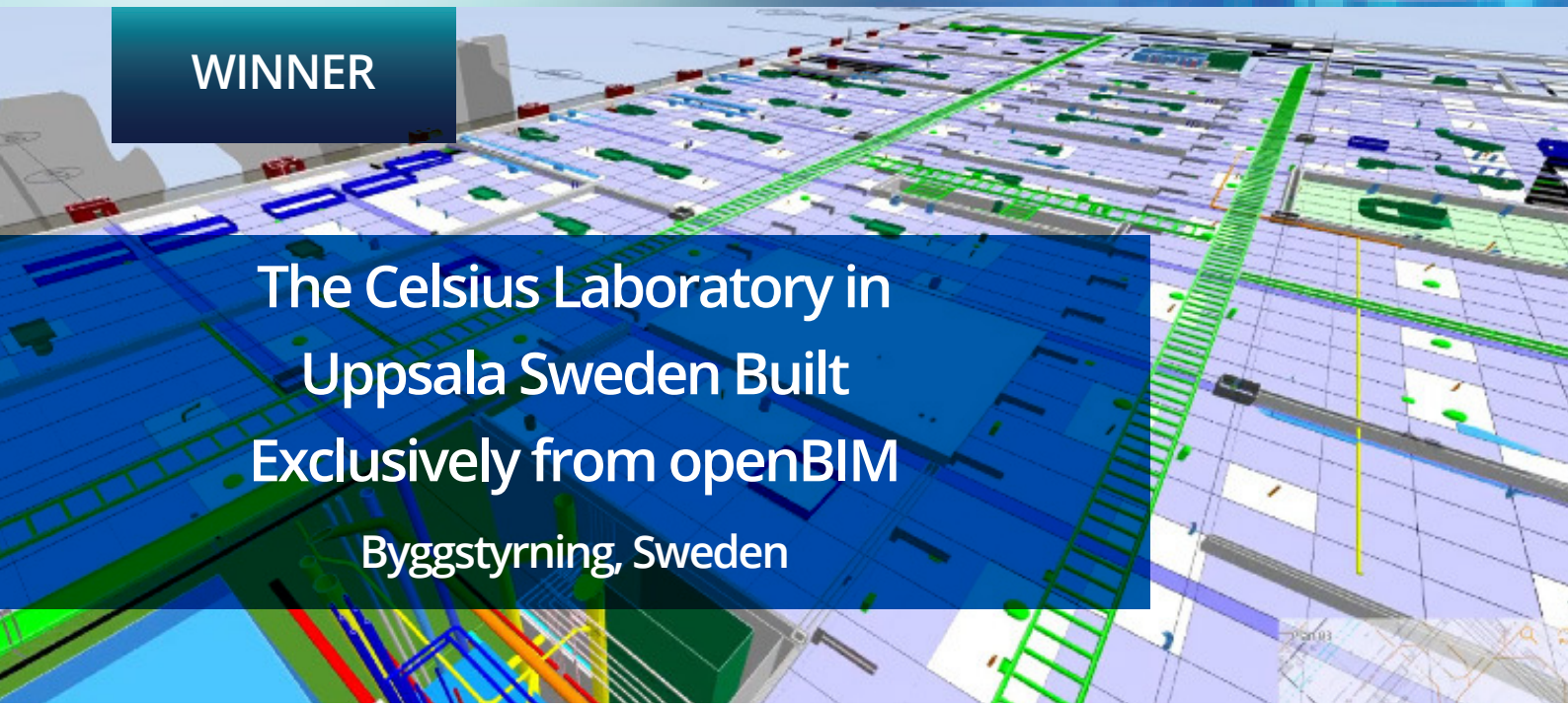
WINNER



The Celsius Laboratory in Uppsala Sweden Built Exclusively from openBIM

Byggstyrning, Sweden

About the Project

Project Celsius is a brand new 12,000m2 headquarters for the Swedish Food Agency, whose emphasis on using proven modern technology and solutions was a key factor in their initial brief to construction management firm Byggstyrning: "To dare to ask, to dare to try new solutions and not to do as we have always done. To be brave is to dare to make difficult decisions if they lead to a better whole. Celsius should be a role model and inspire visitors."

Core Objectives

From the outset, Project Celsius was driven by two clear goals: to work exclusively in openBIM—so as to create an unbroken and robust information chain—and to achieve industry-leading sustainability targets.

Project Description

To fulfil the vision of an unbroken information chain, an openBIM process was applied at all phases of the design and build of Celsius.

Design Phase: The design team focused on producing high-quality openBIM models with accurate and quality-checked information for participants downstream. Due to the ease of communication between stakeholders and designers through the BIM Collaboration Format (BCF), they were able to identify and solve more issues (over 1000) in the design than in previous projects.

Construction Phase: Project Celsius took the bold move to use the IFC model as the legal construction documents, knowing that they could rely on the format as an ISO standard. The 3D IFC models were to be viewed as a replacement for traditional construction drawings, this meant that throughout the whole construction phase there were no paper documents and all trades used mobile devices.

The gap between office and field was bridged by empowering all workers with an openBIM platform, which was agreed upon following direct consultation with the construction workers in order to implement the most functional and understandable application available to them. As a result, hardhat workers adopted openBIM and mobile technology in the field with ease, making the shift from drawings to 3D construction possible.

The openBIM application that was implemented, StreamBIM, offered several time-saving opportunities, such as through highly efficient communication of administration items, including quality inspections, safety issues, rework orders, as-built documentation, control checklists and design mark-ups. Additionally, an automated process was developed to keep the openBIM mobile application updated with the latest IFC models, thus saving hours each week in data management.

Highlights

- IFC models as legal construction document
- 90% built from IFC models in IFC tablet applications in the field (StreamBIM)
- 80% fewer rework orders
- All issues and communication related to locations in model by BCF
- Weekly automated export of IFC models from native application to aggregated IFC model in cloud (StreamBIM)
- No paper allowed on site (completely digitized jobsite)
- Workers ranked the project extremely high in communication

buildingSMART openBIM Solutions

IFC 2x3, BCF

Software Used

Revit, Navisworks, Autocad, Civil3D, Tekla Structures, ArchiCAD, Solibri, Rhino, SimpleBIM, StreamBIM, BIMcollab, BIMeye, BIM360 Design, Miro, Holobuilder, InsiteVR, Unity, Twinmotion

Other Standards

BIP, Building Information Properties (Swedish national open industry standard on naming IFC Property sets, attributes and values)

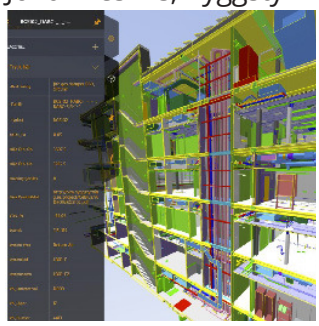
Result

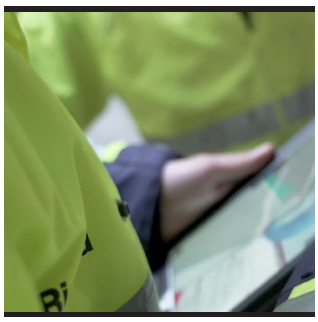
The benefits of the use of openBIM in the project are clear in some of the statistics: transport costs were reduced by 80% as a result of ordering materials from openBIM models, there were 80% less rework orders compared to projects not using openBIM models, the final costs are estimated to be as much as 10% below the initial budget, and the project has been ahead of schedule throughout its lifecycle.

The Construction award for Project Celsius is a recognition of the effort in challenging the status quo in the industry. The project is proof that the industry is now ready to move past the legacy of paper-based information exchange and move into a collaborative, data-driven construction process using openBIM as a solid foundation.

> "The award for Project Celsius is a recognition for our effort in challenging the status quo in the industry. Our project is proud to be a proof that the industry is now ready to move past legacy information paper-based exchange and move into a collaborative data driven construction process."

Johannes Ris, Byggstyrning





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FINALIST

BAB A7 - PPP Infrastructure Project Management Using openBIM

VIA IMC GmbH, Germany

About the Project

The Bundesautobahn 7 (BAB A7) motorway is the longest north-south transit motorway in Germany. This project comprises the six-lane expansion of a previously four-lane section over a total length of 29 kilometres, as well as the operation and maintenance of the project line spanning 30 years.

The infrastructure project also covers 170 structures including 44 bridge structures, 9 junctions, 12 parking and toilet facilities and 2 refuelling and rest areas, as well as around 40,000 m2 of noise barriers and walls. In addition, there are rainwater retention basins and drainage pipes as well as environmental protection and landscaping measures. The required earthworks cover 800,000 m³ of moved soil, which was determined using a digital terrain model.

Core Objectives

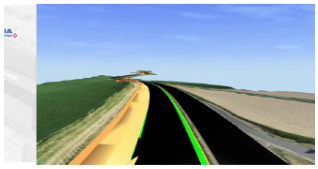
The objective is target-oriented, holistic project management with financial and time savings in the PPP project by using BIM.

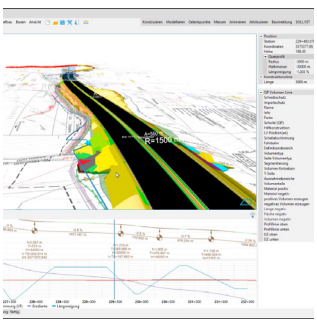
Project Description

openBIM methodology was implemented due to the project's complexity and the number of partners involved in the planning, construction and operation of the project. The development of the workflow took 1.5 years and successively replaced conventional project management.

Software processing of drone flights enabled all elements of the existing infrastructure to be modelled and attributized. This was an advantage for both project management and monitoring. In the pre-construction phase of the project, a digital meshed terrain model was created from the point cloud to calculate the necessary excavation and fill work for the project and then integrated into the BIM model for further use.

After the creation of a BIM-TARGET model, a two-stage model-based controlling process was introduced for the construction phase.





Category of Construction

In this process, site managers first reported their performance directly in the TARGET model. By providing data for an ACTUAL model and then comparing the TARGET versus ACTUAL models it was possible to react immediately to errors. With this new workflow, the project delivered an always-verifiable, cross-company project flow for future large projects.

In the second stage of the controlling process, the performance was independently checked by drone flight. By overlaying the drone flight and the point cloud with the 3D model and linking it to the estimation software, model-based construction performance reports were produced that could be compared to the site manager reports on the data management system (DMS).

The DMS enabled data exchange for all project participants, from design to construction phases, with data structured so that it can be used in the subsequent 30-year operation phase using openBIM methodology.

KorFin 5D coordination platform, which uses all common interfaces currently used in infrastructure, was used in the project and, after integrated modelling, the results were transferred to IFC with attributes in a clear, unambiguous and consistent database structure. This consistent, data-oriented format usage is a unique selling point and fully exploits the potential of openBIM since IFC is used directly for the transport of technical data.

Highlights

- Parametric, implicit planning volumes from standard interfaces
- Dispensing with segmented (split) volumes for process description
- Instead, innovating dynamic segmentation with process-specific time behaviour (and thus abandonment of processes for segmented construction processes)
- Schedule with 20,000 entries
- Implicit volumes from 5 million triangles (at runtime)
- Complete preservation of linkages during scheduling or construction changes or from external construction messages
- Complete referencing of components and specialist data (with exclusion of geometry or attribute copies)
- Complete, normed data scheme for all specialist data and components
- Linked 6D software evaluation

buildingSMART openBIM Solutions

IFC 2x3, IFC4, ifcXML, BCF

Software Used

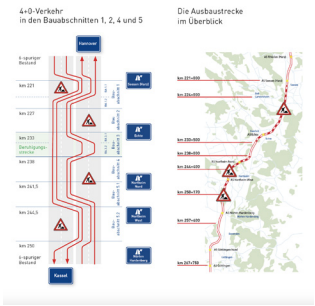
KorFin, iTWO 5D, iTWO 4.0, ArcGIS, Rhino with Grasshopper, Bentley – OpenRoads Connect Edition, iTWO Civil, Desite MD Pro, Autodesk Revit – Dynamo, MS Project, Powerproject, Thinkproject, Autodesk BIM360, ProjectWise, Oracle Aconex

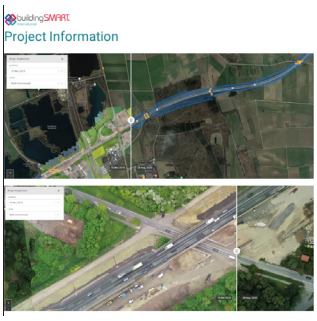
Other Standards

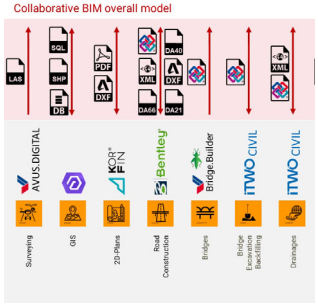
040, 021, REB, LandXML, D66, ISYBAU, TIF, ECW

Result

In this large-scale infrastructure construction project, a functioning control system could only be realized with an openBIM strategy that included all project participants. This was especially true during the construction phase, as it facilitated the coordination of three consortiums (and numerous subcontractors) and enabled costs and deadlines to be traceable and model based.







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FINALIST

The Eglantine Project: Building Differently, From a Participatory Approach to a 100% openBIM Neighborhood

Losinger Marazzi SA, Switzerland

About the Project

The Eglantine Project is a new, sustainable neighbourhood located in the heart of the Morges, close to Lake Geneva in Switzerland. The project, started in 2015, has been developed through a collaborative effort between the municipality, civil society, and Losinger Marazzi SA — the project lead and specialists in sustainable construction.

The project covers an area of 37,500 m2 and includes 13 buildings that house 450 apartments, underground parking, activity areas and a large public park. There will be no roads on the site and more than 1,200 bike parking places are planned.

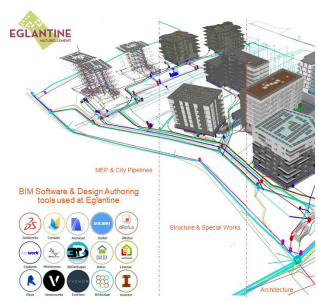
Core Objectives

The Eglantine Project aims to create a high-quality neighbourhood that adheres to the highest Swiss sustainable building standards "Minergie-ECO" and "Site 2000W". It also aims to integrate all stakeholders and inhabitants through a participatory approach at every step.

Project Description

More than 180 contractors (architects, engineers, landscapers, manufacturers, etc) from 20 partner firms comprised an Integrated Concurrent Engineering (ICE) Team, all focused on successful project delivery to a number of stakeholders and the neighbourhood's inhabitants.

Given the extensive collaboration required, the importance of using openBIM was recognized in the early stages of the project, when the team put together their BIM Execution Plan in order to achieve the Eglantine Project's objectives. More than 2,500 IFC files from 8 different design authoring software are now geo-located, with a neighbourhood coordination model containing 300 IFC files. The use of geo-location allowed high precision during the design phase and helps avoid potentially expensive problems on the construction site. Through the course of the



project, over 75,000 files have been shared in the project common data environment (CDE).

Three major benefits resulting from the use of openBIM can be seen as follows:

Collaboration: Collective work is essential to achieve the global objectives of the project. Flexible and dynamic sub-teams were formed and evolved during the project in response to unsolved issues on the project horizon.

Communication: Information needs to be exchanged easily and clearly; this is key to maintain the continuity of information and to achieve better quality planning and execution.

Sharing: At the core of teamwork, sharing gives the capacity to solve every upcoming problem, saving both time and money.

Throughout the project, use cases were developed in all the BIM dimensions, such as 3D printing from IFC models, online architectural choices for clients, or executing the concrete works without plans, directly from a geo-localized IFC.

Today, the Eglantine is in mid-construction phase and nearing the end of the design phase for the last four buildings. A BIMtoField tool is being used to gather all generated data, the updated IFC models and the layouts of every discipline available in the cloud. In parallel, more openBIM use cases continue to develop to digitalize site controls, manage security and safety, monitor the execution quality, and achieve higher efficiency.

Highlights

- More than 180 BIM users from 20 partner firms worked on the project
- More than 2,500 federated IFC files form the beginning of the project and a neighbourhood coordination model with 300 IFC files
- Over 75,000 files shared in the project Common Data Environment (CDE)
- Mechanical electrical plumbing (MEP) networks continuity in IFC from the city pipelines to the bathroom shower
- Two certification surveys, “Minergie ECO” & “Site 2000w”, on site with BIMtoField

buildingSMART openBIM Solutions

IFC 2x3, IFC4, BCF, MVDs

Software Used

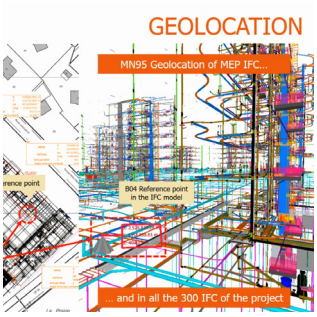
Archicad, Revit, Dynamo, Vectorworks, CADworks, SOLIDworks, Rhinoceros, Covadis, 3DShaper, BIMCollab, dRofus, Solibri Office, Solibri Anywhere, eDoc plans, simpleBIM, Dalux, EVOHOM, eDOCPlans, Lesosai, MS Project, Microsoft Sharepoint, Microsoft Teams

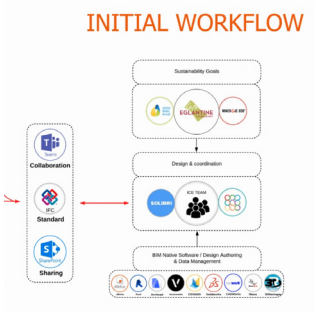
Other Standards

MN95

Result

The openBIM strategy and the ICE team organisation methodology have proved to be essential for this complex project. They allowed the project team to build a sustainable neighbourhood, optimizing every phase through efficient planning and collective problem solving. The Eglantine Project is a true openBIM neighbourhood, and soon its inhabitants will benefit from the outcomes of the project during the facility management phase.





buildingSMART International

WINNER

openBIM-OSIS Integrated Design of Panama Canal 4th Bridge

CCCC Highway Consultants Co.,Ltd, China

About the Project

Panama's Ministry of Public Works confirmed the CCCC-CHEC consortium won the bid for the project of the fourth bridge over the Panama Canal in 2018. The bridge is to be constructed just 0.5 kilometers north of the Bridge of the Americas and will have a design life of 100 years. The new bridge will connect the two ends of the Interoceanic Canal, boost transport links to Panama West and improve connectivity to inner Panama, benefiting at least 2 million local people.

Core Objectives

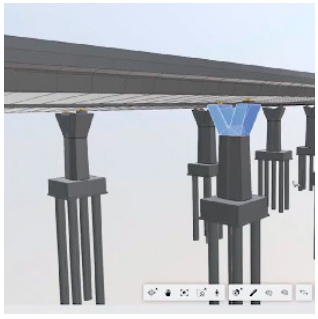
To utilize openBIM standards in the bridge design in order to increase interoperability and management efficiency.

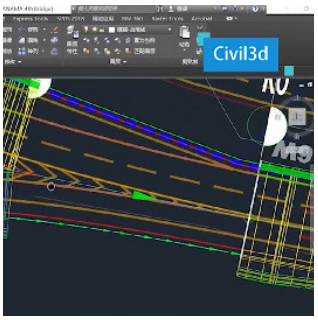
Project Description

The project comes with multiple and varied challenges, including but not limited to: satisfying numerous stakeholders, managing large scale cross-disciplines within the design team, overcoming difficult terrain and safety challenges, and undertaking specific studies and analysis due to the geographical location.

The client mandated in the Terms of Reference that the strategic objectives of the project were to create a seamless ecosystem of collaboration within project team, as well as to maximize BIM value by extending the usage from design to construction and asset management.

As well as full BIM usage throughout, also mandated in the project brief were BCF, COBie and IFC as the delivery formats. The openBIM standards, combined with ISO19650, were adopted in the project along the whole design phase, solving design challenges, improving cross-discipline collaborations and project interoperability, reducing coordination issues, and advancing project data qualities.





Category of Design

The detailed usage of openBIM is as follows:

IDM: In this infrastructure project, a tailored general cross-disciplinary IDM was created for the design phase.

IFC: IFC2x3 files hold structural information such as road structure modelling and bridge structure modelling, which are transformed to the service engineer for designing the transportation facilities and bridge accessories, as well as constituting the federated model for clash detection and coordination. An IFC schema database allows the data engineer to retrieve and operate according to the project needs. Further, using IFC has eliminated the barriers between different disciplines and software, of which there are more than 10 in use in this project.

BCF: BCF was used as the issue communication format. In both the modelling software (Revit) and coordination software (Navisworks), BCF-based issues were created and published onto the BIMTrack platform, which acts as the central server for hosting, tracking and interacting all the issues. By using BCF, all the issues can be maintained and tracked for the whole issue lifecycle until closed.

COBie: COBie standard was applied to the project from the design phase with the aim of extending the BIM use to the asset management phase, as well as making routine data validation. BIM models, together with COBie sheets, were uploaded to the FM platform YouBIM, to allow facility managers to view and check the data. By adopting COBie, potential mistakes were avoided, which saved on cost and provided a great return on investment.

LandXML: LandXML and IFC provides a readable protocol for the data exchange between stakeholders (e.g. topography data between the survey engineer and the bridge engineer) saving a large amount of time that would otherwise be spent in dealing with different format and files.

Highlights

- Client mandated native file formats and IFC, BCF, COBie
- Client required full BIM usage in design, construction and maintenance stages
- openBIM standards, combined with ISO19650, are adopted successfully in the project
- More than 10 different design software used in the project

buildingSMART openBIM Solutions

IFC 2x3, BCF, IDM

Software Used

BIM360, Navisworks, BIMTrack, BCFier, Revit, Dynamo, Civil3D, AutoCAD, Inventor, ANSYS

Other Standards

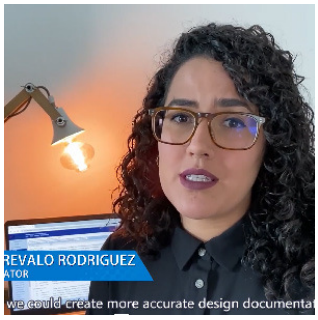
COBie, LandXML

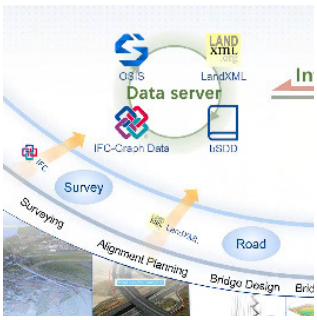
Result

By applying openBIM standards and philosophy, the project has thus far operated more efficiently and smoothly, by reducing data silos and enhancing interoperability. The project has been optimized in the design phase and moves towards a sustainable lifecycle.

> "openBIM systems create for us a bridge parametric design process and more accurate delivery, making the whole process more efficient. openBIM helps us achieve a connected digital environment, and keeps transforming the way we do design work."

Xi Liu, CCCC Highway Consultants Co Ltd





buildingSMART International

FINALIST

North East Link Early Works Utility Relocation Project: Challenging openBIM in a Highways Infrastructure Context

Cardno Victoria Pty Ltd, Australia

About the Project

North East Link is Victoria's biggest ever infrastructure project (A$10 billion build cost) and will fix the missing link in Melbourne's freeway network, connecting the M80 with an upgraded Eastern Freeway. Cardno were engaged as lead designers, utility coordinators and digital engineering leads for the planning phase of the project. Over 100 large and critical above and below ground utilities or services are to be moved as part of the Early Works Project (EWP), which will also include multiple interchanges, Victoria's longest road tunnel and Melbourne's first dedicated busway with express lanes.

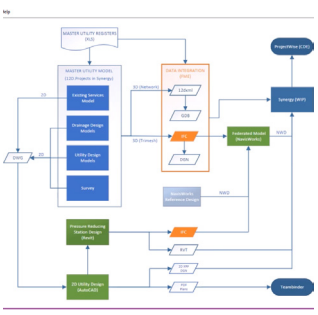
Core Objectives

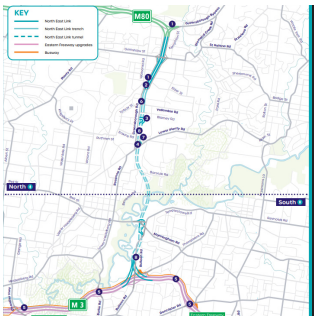
The Early Works Package objectives are the completion of critical enabling works to enable efficient and value-for-money delivery of the Primary and Secondary packages, whilst minimising critical interfaces and de-risking the North East Link.

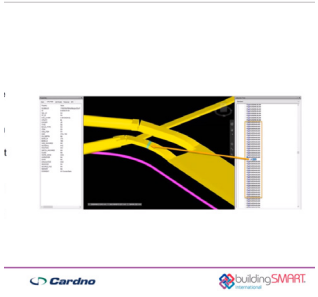
Project Description

North East Link is one of the first projects in Victoria to be guided by the principles and expectations of the new Victorian Digital Asset Strategy (VDAS). This strategy sets out the vital process for safeguarding the digital systems that will allow the state government to monitor and improve the creation and management of infrastructure assets in Victoria. The VDAS recommends that BIM collaboration occurs using openBIM formats, such as IFC.

Cardno were responsible for coordinating 3D design between multiple utility designers in highly congested and constrained sites across the three project zones. A rigorous approach to model federation and clash detection was required to meet the utility owner approval requirements. The project client also had comprehensive 3D model







file format and object metadata (attribution) requirements.

Once the project's BIM guidance and standards were defined, the EWP team set about identifying the BIM software ecosystem and developed detailed data workflows to meet these requirements. With IFC being defined as both a federal government recommendation and a project requirement, Cardno sought to pivot as much of the data workflows and 3D analytics as possible around this openBIM format.

Four separate technical elements used the openBIM IFC standard within the multiple BIM software applications of the project software ecosystem:

Clash Detection: Use of an openBIM standard allowed for rapid and consistent model federation in NavisWorks from different source applications without intermediate data transformation or reliance on proprietary file formats.

Attribution: IFC attribute families (trees) allowed for a flexible attribute management approach for utilities models using multiple different attribute sets (registers), linked by unique object ID.

Data Integration: The client required project models (3D & 2D) in several different file formats, many with full object-level attribution. Data integration platform FME was used to transform source files (including IFC files for trimesh models & 12dxml for network models) to the required formats with attributes and to client symbology standards.

Common Data Environment (CDE): Model federation using IFC sourced from the CDE with full version control and associations of sources.

Highlights

- Met client's IFC (2x3), DGN, geodatabase (ESRI) and 12dxml delivery format requirements, including strict LOI (attribution) requirements on 3D elements across all formats
- Utility coordination of full 3D design of new water, stormwater, sewer, gas, communications and power designs in a very constrained utility and site environment using strong BIM principles and approach
- Approved Issued for Construction designs for in-house and utility service provider (USP) designs delivered on time and to budget within a severely accelerated early works programme
- 600 different proposed utility objects, including 24 km of proposed new pipe or cable
- 36,000 different existing utility objects, including over 200 km of existing pipe or cable

buildingSMART openBIM Solutions

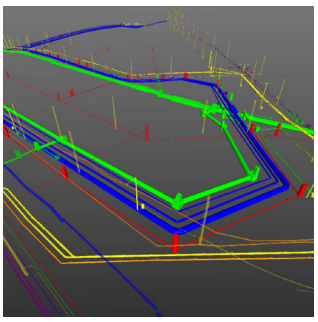
IFC 2x3

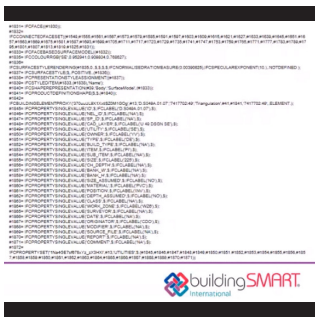
Software Used

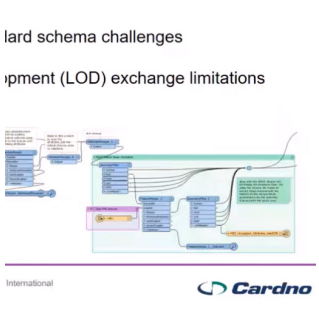
12d Model v14, Autodesk Revit 2019, Autodesk NavisWorks 2019, ProjectWise, 12d Synergy, Microstation V8i, Safe FME, ESRI ArcGIS

Result

The main benefits of using openBIM for this phase of the project were the ability to standardize project delivery requirements by clients, allow all stakeholders (including future ones) to plan for downstream data use, and the opportunity for users to develop new workflows and automations to both reduce time and improve quality assurance.







buildingSMART International

FINALIST

The Research of BIM Technology Applied in Intercity Projects in Shaanxi Province

China Railway First Survey and Design Institute Group Co., Ltd, China

About the Project

Located in China Shaanxi province, the Yanliang-Airport intercity railway, is an indispensable part of the intercity railway network of the central Shaanxi plain. The railway runs a length of 65.99 km with a design speed of 250 km/hour. This research project by China Railway First Survey & Design Institute Group (FSDI) examines the building information modelling (BIM) technology in the working drawings of the intercity railway using their independently developed "FSDI-BIM Design Series Software".

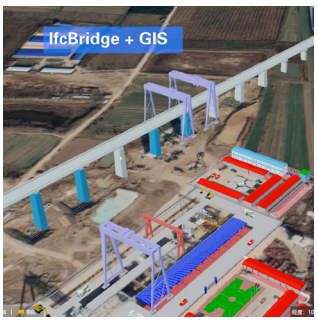
Core Objectives

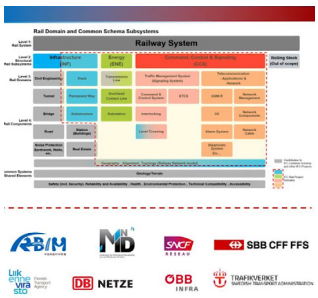
The FSDI-BIM platform was created to address the challenge of integrating railway engineering information, such as long strip and complex terrains, into a single model.

Project Description

The FSDI-BIM Design Series Software was independently developed using IFC standards to enable data exchange between various professional software, as used in planning, design, construction, operation, maintenance and management. Moreover, the platform enables speedy and accurate collision inspection and allows for efficient communication and exchange between project team members during review and annotation.

Through the IFC standard, FSDI-BIM can realize the 3D visual human-computer interaction design based on line, ground models and geology. The system includes the parametric, automatic and efficient creation of railway BIM models. It additionally enables the definition, addition and modification of property information of components and the automatic generation of construction drawings of railway and engineering quantity via BIM models.





Key applications of the FSDI-BIM platform include:

Parametric calculation simulation using various simulation calculation software, FSDI-BIM Design Series Software developed by linkage, importing the IFC 3D model, performing stress analysis, fluid calculation, illumination calculation, etc.

3D model construction using the FSDI-BIM platform to establish 3D railway models and convert and intercommunicate through the IFC format.

BIM-integrated application by converting to BIM+GIS space platform, real scene integration, cloud platform and other environments using the IFC format for design, construction, operation and maintenance management.

Through the application of the IFC standard, combined with the FSDI-BIM Series Design Software, the model and data of various disciplines were connected. This allowed geometric and semantic conversion of multi-source models, fusion of models and terrain, and establishment of a unified spatial reference. Additionally, the complete geometric and attribute information of the railway engineering model was retained.

Highlights

- The use of IFC modelling and the connection of different design software and self-developed design software to carry out design, modelling and simulation calculation
- More than 30 million professional models integrated and managed by IFC object models
- Reduced labour intensity and improved production management efficiency through design phase and construction site application

buildingSMART openBIM Solutions

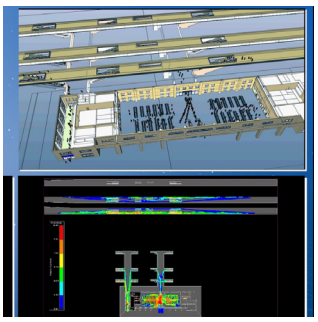
IFC 2x3, IFC4, ifcXML, IDM, MVDs, mvdXML

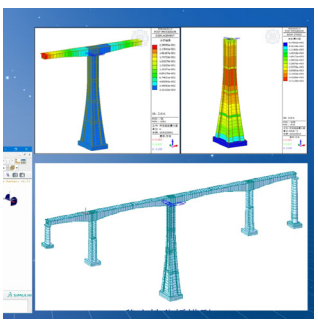
Software Used

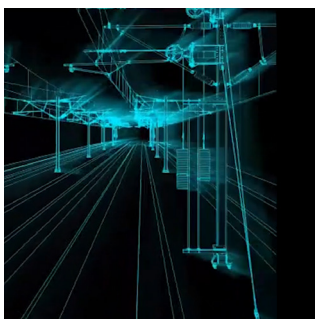
Revit, Navisworks, MicroStation, 3D Max, SketchUp, Inventor, ProjectWise, Tekla, DIALux, Ansys, Midas, PKPM

Result

A number of positive results were noted from the project. Through the application of the IFC standard, good interoperability and openness has been achieved between the digitalised railway and the construction asset industries, saving time in professional collaboration and money in software development costs. The IFC format has shown to be reliable for data exchange without the restriction of proprietary processes or data formats. It further provides a sustainable technical support foundation for the construction of smart cities, allows for continued development and improvement of FSDI-BIM series software, and saves costs for subsequent development.







buildingSMART International

WINNER

Vestfold Hospital
The Tønsberg Project
Vestfold Hospital, Norway

About the Project

The Tønsberg Project is the last stage of the Hospital Development Plan, initiated in1990, for the Vestfold County Hospital in Norway. The Tønsberg Project is divided in two parts—the Psychiatric building (delivered in May 2019) and the Somatic building (to be delivered in Q4 2021). The project was developed in two stages, as part of the old Psychiatric building fell within the footprint of the new Somatic building. The estimated value of the project is 3 Billion NOK (circa US $330 Million).

Core Objectives

To utilise existing and new digital tools and methodologies to achieve measurable results in design, construction and operation, specifically:

- functional and construction quality equal to or better than comparable hospitals;
- substantial reduction on project cost (10% reduction compared to a project finished in 2005 with corresponding regulatory technical standard);
- a complete handover in an openBIM FM documentation system;
- BREEAM Very Good certification.

Project Description

The implementation of openBIM has been a focus of South-Eastern Norway Regional Health Authority for over 10 years, with a goal to improve efficiency through digitalisation.

Using IFC4, the Tønsberg Project developed and deployed a Facilities Management (FM) software solution based on openBIM to ensure smooth handover, clear information ownership and data longevity.

The resulting Electronic Building Journal gives hospital building operational personnel more immediate and easy access to the model and all FM information, by directly connecting them to the

Category of Handover

This project established a new and efficient openBIM-based method to gather and deliver FM information, by automatically extracting information/documentation about objects and building systems from the contractors' supply chain and an external product database. BIM objects were directly connected to this extracted information. This method paves the way for an even smoother FM information handover delivery once all design group/contractors and building wholesalers start using Serialized Global Trade Item Numbers (SGTIN) as product identification—both in the model and the supply chain.

Notably, it is the first project in Norway to use the Integrated Project Delivery (IPD) model. This is a collaboration model with early involvement of the construction contractor and a shared risk-reward for all project participants, with a joint responsibility for mistakes and omissions during design and construction.

Highlights

- An Integrated Project Delivery (IPD) project
- Client demanded openBIM (IFC format) for file exchange and the delivery of both IFC files and native files for FM information delivery
- Established a novel method to connect information about building systems and objects from the supply chain to the FM information tool
- FM information is easily and quickly available to hospital operations team on a openBIM platform

buildingSMART openBIM Solutions

IFC 2x3, IFC4, BCF, mvdXML, MVDs, bSDD, ifcXML

Software Used

EDMmodelServer (including EDMweb, EDMissueDB, EDMcatalog, EBIMconnect) by Jotne EPM Technology AS, Solibri Model Checker, BIM Collab, ArchiCAD, Revit Structures, MagiCad, Tekla Structures, Novapoint, dRofus, CoBuilder, Map Portal from Norwegian Map Authority (Statens Kartverk), GLN database by GS1 Norway Primavera P6, Tekla, FME, ESRI ArcGIS Pro, Renderlights,12D, Leica Cyclone Register 360, BIMCollab, Prosteel, AutoCAD, Microsoft PowerBi, PyroSim

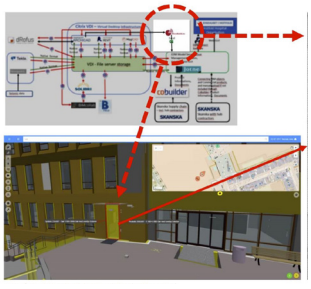
Other Standards

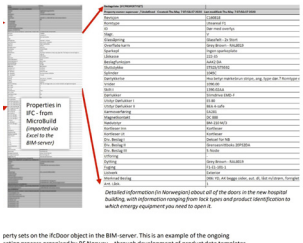
COBie, Serialized Global Trade Item Number (SGTIN) in unique asset identification

Result

buildingSMART International recognized the project's use of openBIM as the foundation of all its design work when it won in the Design category of the 2017 Awards program, and this has continued right through to the Handover phase, which is still underway as its second phase nears completion. The project is on schedule and on budget, including a near 10% cost reduction compared to a project that was completed in 2005. In line with the project objectives, BREEAM Very Good certification has been achieved for the Psychiatric building and the same is expected for the Somatic building.

One noted benefit of using openBIM is the reduced time to find relevant information in a maintenance situation. Traditionally, this would take from 0.5 to 3 hours, but with the hospital's new openBIM FM information tool, the time is reduced to only 5 to 15 minutes, depending on the complexity of the sought information. In many ways, the Tønsberg project is a pilot project, in which the handover process has been radically changed and may be considered as a model for the future.





perty sets on the ifcDoor object in the BIM-server. This is an example of the ongoing
sation process organised by BS Norway – through development of product data templates

buildingSMART International

WINNER

Smart openBIM Project Management on Novo Brdo Residential Complex with Bexel Manager

BEXEL Consulting, Slovenia

About the Project

The Novo Brdo neighbourhood is a new, publicly funded development by the House Fund of the Republic of Slovenia, and is comprised of 22 buildings housing 575 rental apartments. The 77,000m2 development focuses on the lifestyle needs of the young and old alike, and, as such, includes diverse public areas with shops, services, a library, playgrounds, extensive green areas and even a large, natural rainwater pond.

Core Objectives

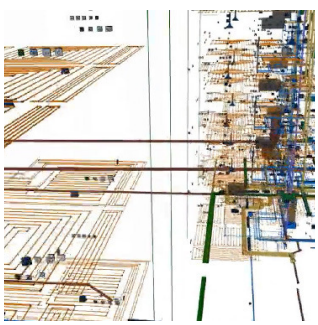
As a publicly funded project, transparency in project management processes has been defined as an important objective of the BIM implementation. Also, thorough mutual understanding and vast collaboration between project stakeholders are identified as the means for eliminating rework and lowering project risks and waste in effort, time and resources.

openBIM was identified as having a crucial role in the meeting of these project objectives and, as such, it was a mandatory requirement that all BIM results were delivered in open formats.

Project Description

Implementation of openBIM workflows and data exchange made the project goals achievable for stakeholders throughout the entire project lifecycle. Using BEXEL Manager (IFC-certified software), a large-scale federated BIM model was established as a single source of truth , with over 510,000 elements from 89 different IFC files. A Common Data Environment (CDE) was established to efficiently manage the project's communication, accessibility and updating challenges. An integrated Document Management System (DMS) allowed stakeholders to exchange documents with no format limits and to link directly to BIM model elements through fully supported openBIM standard workflows.

All project participants could access, at any time, insight into the planned quantities of work,



materials, specifications and changes that occurred over the course of the project. The central BIM model prevented any miscommunications and disputes typical for construction projects.

Timely detection of potential and actual collisions in the project, and efficient collaboration with project designers through information exchange, were enabled through the federated BIM model, CDE and adoption of openBIM standards. The elimination of shortcomings in the project resulted in significant savings in time and resources during the execution of works.

By maximizing the use of available data, technology and knowledge, it was possible to automate time-consuming tasks in planning, quality control, cost management, scheduling, value engineering, progress tracking and the certification process. This automation resulted in further savings in time and resources. For example, smart cost management introduced a variety of benefits through automation in cost database creation. This workflow, with IFC data as the basis of the process, allowed the project team to create a full cost database and bill of quantities with over 1,800 tasks in just 2 days. With traditional methods this type of task takes months to complete.

Highlights

- Large-scale federated BIM model with over 510,000 elements, from 89 different IFC files
- Using BEXEL Manager IFC Model Checker (IFC properties checking and validation) Add-in, more than 60,000 elements were identified with deficiencies in metadata (IFC properties missing or do not have adequate value)
- Automatically developed cost classification database with 1,872 cost items, and direct link to model elements through automatically created element queries based on model metadata (IFC properties)
- Implementing smart scheduling engine, based on defined spatial zones and construction sequence methodologies construction schedule with 4469 tasks and 6272 relations is generated, directly related with cost items and corresponding IFC model elements
- More than 3,000 spatial conflicts were detected and resolved
- Element-based monitoring of construction progress, planned vs actual comparison, earned value analysis, and regular advanced reporting

buildingSMART openBIM Solutions

IFC 2x3, IFC4, ifcXML, BCF, IDM, MVDs, mvdXML

Software Used

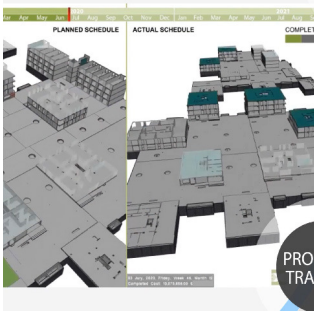
BEXEL Manager, BEXEL Manager CDE, BEXEL Manager FM, Autodesk Revit, Autodesk BIM 360, BIM Collab Cloud, Solibri model checker, Autodesk Navisworks, Autodesk 3DS MAX, Enscape

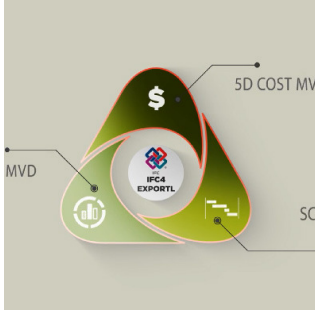
Other Standards

COBie, XLSX, XML

Result

Dedication to openBIM standards, as well as the export compatibility of the BEXEL Manager platform with standard traditional non-BIM file formats, allowed efficient exchange of information not bounded by technical limitations. This resulted in improved interoperability and collaboration, quality management, smart cost management and scheduling, progress tracking, reporting and facility maintenance.





buildingSMART International

WINNER

"Discovering Safety" - BIM Safety Risk Library for Built Environment

The University of Manchester, UK

About the Project

This research, by the University of Manchester, was undertaken as part of Phase 1 of the 'Discovering Safety' programme, which received funding from Lloyd's Register Foundation and data resource provided by HSE. It looked to provide a sematic alignment that could help address health and safety risks emanating from design in the preconstruction stage and lays the groundwork for the development of a safety ontology tool, that would mobilize UK Health and Safety Executive's (HSE) archive of construction health and safety risk data.

Core Objectives

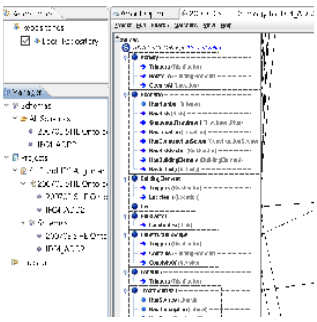
The project looked to improve access to knowledge and learning relating to how best to mitigate health and safety risks for key decision-makers on construction projects over the project lifecycle, starting with project planners and designers.

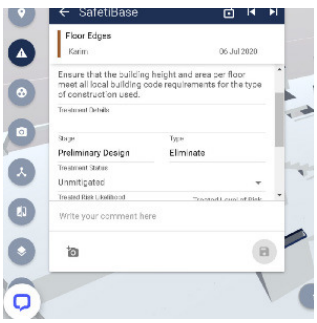
Project Description

As part of their research, several inter-related tasks were completed—an academic and industrial literature review, engagement with industry experts through steering committee workshops and focus groups with consultants, and collaboration with BIM software providers to develop the new platform.

openBIM provides solutions for improving software interoperability, thus ensuring accuracy of multi-party collaboration and improving the efficiency of the whole project. IFC schema was therefore considered in the project to achieve the required interoperability to store and exchange data related to construction safety management between different stakeholders.

A BIM prototype was developed—a new version of SafetiBase—where designers can identify potential risks and provide appropriate treatment prompts based on a web-based BIM platform (3D Repo). Another key output from the research was the





development of a safety and health exchange (SHE) ontology, where all the concepts and relationships are identified, and the ontology is mapped to relevant classes in IFC schema (ifcOWL ontology).

On the basis of the work done in Phase 1, future work could cover the following:

- Expanding the risk type covered in this phase (i.e. fall from open/edge) to include other prominent risks through establishing a community of practice of planners and designers who can extend the database and review more incidents in HSE and companies' archives.
- Evaluating the developed ontologies in real cases and aligning with other developed ontologies in the AECO domain such as ifcOwl.
- Developing a proof of concept for automatic rule-checking in 3D environment with some prominent risks.
- Developing a proof of concept for 4D modelling with some prominent risks. This would explore how the knowledge base can be utilised in the 4D environment to take into account the impact of design and construction sequencing on health and safety.
- Developing an IDM and a MVD for safety management to improve the integration between BIM data and safety databases for better earlier safer decisions.

Highlights

- A conceptual model for risk treatment prompts in the design and planning stages including seven concepts, their sub-concepts based on available guidelines and their relationships
- 165 RIDDORs and 31 press releases incidents were reviewed and annotated against the seven identified concepts
- A treatment prompt matrix based on the treatment prompt type and stage of implementation
- Nine scenarios and 162 treatment prompts related to fall from open/edge and in-situ concrete buildings
- Development of a safety and health exchange (SHE) ontology where all the concepts and relationships are identified, and the ontology is mapped to relevant classes in IFC schema (ifcOWL ontology)
- Development of a tool (SafetiBase) to identify, highlight and suggest a treatment for construction safety risks on a web-based BIM platform (3D Repo)

buildingSMART openBIM Solutions

IFC4, ifcOWL

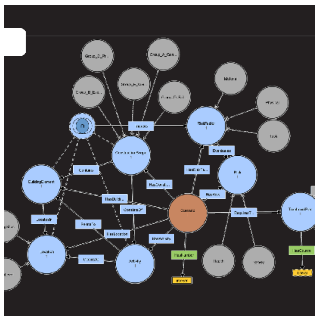
Software Used

Revit, Solibri Model Checker, BIMVision, 3D Repo

Result

By developing the semantic bridge between HSE archive (as represented in the SHE ontology) and ifcOWL classes, a knowledge database is available to designers and planners where they can easily access treatments to the eventuated risks in their design.

This helped to minimize occupational hazards early in the design, improve collaboration between stakeholders, enhance multidisciplinary data (related to safety, time and cost) and provided a roadmap for achieving interoperability between BIM and Agent Based Modelling (ABM) for safety in construction.



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FINALIST

Digitalized Cost Estimation in the Fv.547 Åkra sør – Veakrossen Road Project

COWI, Norway

About the Project

Åkrehamn is a local community centre with approximately 8,000 inhabitants on the island of Karmøy in Western Norway. As a result of growing traffic, it was resolved to create a bypass system that consisted of the bypass road (a 7 km single-lane highway), 3 km of local roads, four crossings (two of which to be level-free), 7 bridges and 12 underpasses.

The Norwegian Public Roads Administration (NPRA) appointed multinational design consultant COWI to produce both a zoning plan and a detailed design, including a specification of work. It was one of the first road projects by the NPRA to enable and enforce digital workflows between the stakeholders. The core requirements of these workflows were open standard models, a drastic reduction of the number of drawings and a mandatory BIM approach.

Core Objectives

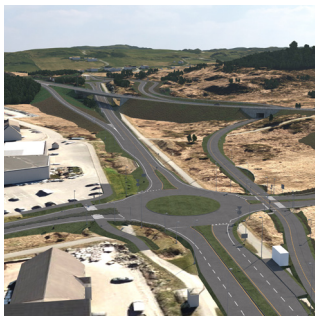
The project's main objective was to build a single-lane highway that bypasses the local community centre, with a secondary objective to enable and enforce digital workflows between the stakeholders in the project.

Project Description

The level of digitalisation required in the project meant a rethinking of traditional workflows. Conventional, drawing-based workflows for creating the specification of work and cost estimation became model-based using existing pre-BIM standards.

However, it was the ambition of the project team to not only digitalise traditional workflows but also to add value through automation. In cooperation with the Norwegian University of Science and Technology (NTNU), one workflow, namely cost estimation, was chosen for further investigation.

Cost estimation has traditionally been a manual and repetitive task prone to human error,



something which has reduced its reliability for the contractor. However, contractors need exact and reliable information about the planned assets in a project, especially for cost drivers like constructions and masses for road layers. Therefore, automation of cost estimation was deemed to be a promising solution.

Through collaborative workshops with discipline stakeholders, the project team identified 480 cost items that were suitable for automatic quantity take-offs. The corresponding entities were then identified in the discipline models and coded properties were added to a specific property set according to the NPRA's general specifications. These properties became a custom, user-defined property set when exported as IFC (2x3) files. An automated workflow, based on the IFC (2x3) schema, from four different design programs to a cost estimation software was established.

By using a custom-made property set instead of mapping the IFC entities, COWI were able to not only adapt the workflow to road entities but also collect all cost-relevant properties within a single information module. This helped estimators with low BIM knowledge to find the information needed for cost estimation faster.

In total, 50 models in IFC (2x3) for all disciplines (road, construction, water & sewer, electrical, landscape and earthworks) were created, consisting of 175,076 model entities.

Highlights

- Cooperation between a consulting company and a research institution.
- Paperless project in practice using model-based design to enable digital workflows.
- Client demanded a limited number of drawings.
- Specification of work and cost estimation were automated.
- Four design programs linked to a cost estimation software by a specifically coded property set based on IFC (2x3).
- Cost-relevant information was collected in one information module in a property set format.
- 70% of all cost items were mapped to model entities.
- 50% time reduction, especially at revisions.
- Manual errors reduced to zero.
- Workaround for not yet defined road entities in IFC (2x3).
- Estimators with low BIM knowledge could find the necessary information faster.

buildingSMART openBIM Solutions

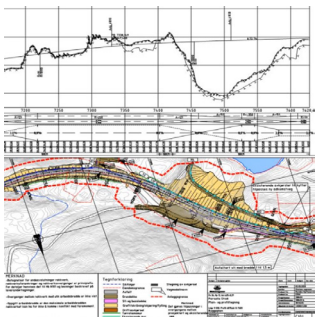
IFC 2x3

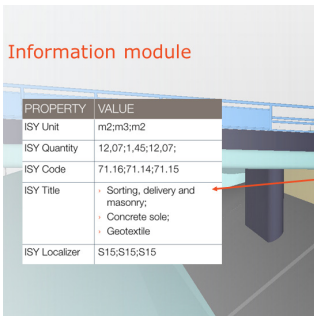
Software Used

Novapoint, Revit, Tekla structures, Civil 3D, Rhino with Grasshopper, Dynamo, SimpleBIM, ISY Beskrivelse

Result

In addition to digitalizing traditional workflows, COWI applied automation to add value downstream in the supply chain, to reduce redundancy of information and to improve productivity. Through this automation, the typically time-consuming and error-prone process of cost estimation took 50% less time and reduced manual errors to zero. Through the use of the IFC standard, the project team was able to create a robust and efficient platform fit for future developments.





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FINALIST

Structural Designing Supported by openBIM

Warbud SA, Poland

About the Project

Construction engineering company, Warbud SA, developed a standardised workflow for structural design that was tested on several large building models, all of which are due to be built in Warsaw, Poland. On average, the buildings consist of four underground levels, 35 overground storeys and 60,000 m2 of usable space.

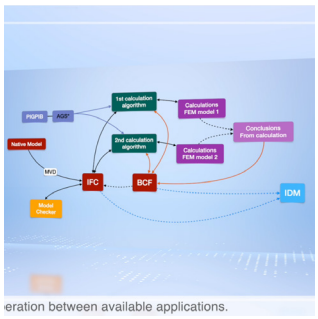
Core Objectives

The project's main objective was to create a standardised design process in order to design the structure of a building based on a federated BIM (IFC) model that is useful for all stakeholders. Currently, there is no software available that allows structural and geotechnical designers to create, modify and calculate structural elements and soil-structure interaction in one software package.

Project Description

Traditionally, cooperation between the structural and geotechnical teams has involved the creation of separate models in different discipline software. Feedback on the results of calculations was communicated between them through reports or via email and iterative calculations conducted until the results of the two teams converged. The Warbud SA team sought to overcome this time-consuming process by making use of an existing solution — thus avoiding the financial and time investment required to develop a new piece of software from scratch — to conduct a comprehensive analysis of the soil-structure cooperation during the design phase of the new buildings. The team identified the openBIM methodology, and the standards of IFC and BCF, as a means to enable more efficient collaboration between different disciplines in a foundation design process, as well as to optimise the cost of the design and safety of the building structure.

In this project, standardised information about soil conditions was used to generate a computational model in geotechnical BIM software. The



eration between available applications.

information, saved in this way, not only enabled the calculation of geotechnical problems, but also the export of the soil model to other BIM environment programs. In this way, a standardised flow of geological information was created, which could be used to visualise — in the openBIM environment — existing soil and water conditions at the investment site.

Two different algorithms were developed to enable interoperability in different stages of the design process. The first was used to perform iterative soil-structure interaction comparisons by performing simultaneous calculations in two different environments using a federated Finite Element Model (FEM) based on the IFC standard, thereby identifying the optimal and most accurate design solution.

The team used a second algorithm to create a parametric IFC model to find the optimal solution from many available design variants at the conceptual stage of the project. The developed workflows allowed for easy transfer of the model into different calculation software at any stage of the design process.

Through the application of an openBIM approach, Warbud SA was able to share the model between proprietary software that lack interoperability and coordinate projects in a consistent and standardised way. The time required in the design process was reduced as a result of being able to safely transfer all the data (model) between various calculation software.

Highlights

- Cooperation between structural and geotechnical designers
- Optimal structure design due to iterative calculation process and output data convergence
- One consistent federated FEM model based on the IFC model with the whole history of design
- Manual errors in model creation and calculation data transfer reduced to absolute minimum
- High-rise building models already transferred
- Model creation and calculation process semi-automated
- 40% time reduction in the construction design process
- Willingness to create a future Information Delivery Manual (IDM) for structural analysis

buildingSMART openBIM Solutions

IFC 2x3, BCF, IDM, MVDs

Software Used

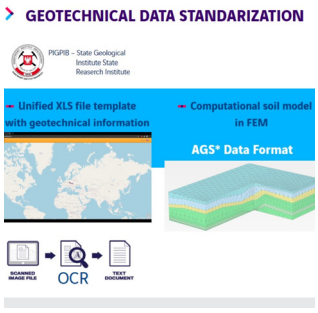
ARCHICAD, Rhino with Grasshopper, Revit, Dynamo, Solibri Model Checker, Dlubal, Robot, ZSoil, Plaxis, BimVision, BIMcollab, Navisworks

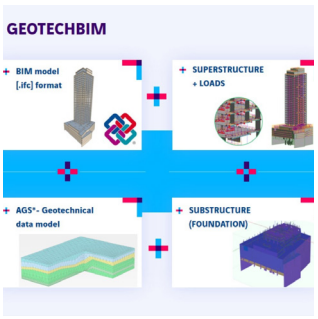
Other Standards

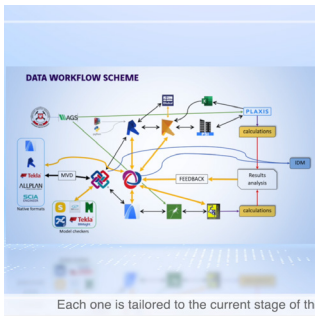
AGS, CSV, TXT

Result

The implementation of an openBIM methodology has benefited Warbud SA in a several ways, most notably, through the easy sharing and utilisation of geotechnical and geology data, the ability to share model data using the IFC standard and the creation of a standardised calculation data workflow for structural design. The openBIM approach allowed all stakeholders to build their own workflow to reflect their preferred software and the process was found to be easy to adapt and develop.







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WINNER

Smart BCF Solution "to a Generalized BIM"

École des Ponts Paris Tech, France

About the Project

This project was undertaken by students in the Master BIM program at École des Ponts ParisTech with a view to create a solution that increases the usage of BIM and paves the way for all stakeholders in the French construction industry to work together using digital models. To do this, two important limitations need to be overcome. The first is the expense of modelling software, which many simply cannot afford. Secondly, many contributors on a construction project may not possess the necessary modelling skills required when inputting information to the digital model.

The project team used openBIM standards, IFC and BCF, to develop the Smart BCF solution.

Core Objectives

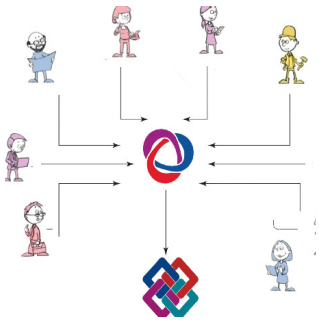
The objective of this project was to produce a solution that will facilitate accessibility to and uptake of the digital model within the French construction industry.

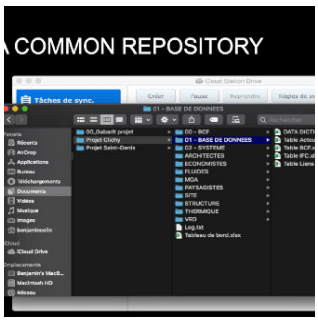
Project Description

Smart BCF is a solution based on five complementary components, using openBIM standards BCF and IFC. It's an intuitive and easily implemented solution that allows all stakeholders of a project to use the BIM model.

The five components are detailed as follows:

- A **Common Data Environment** (CDE) that centralizes exchanges and shares models, files, and data relating to a project, structured in such a way as to respect the ISO19650 standard, with separation between the project statuses (e.g. "work in progress", "archived", etc.).
- A **database** into which all information extracted from BCF comments and IFC models are regularly saved. This database provides documentation and traceability of exchanges and modifications of a project.





- A **tool for modifying and informing the IFC model**, was the central component of the solution. In the description part of the BCF, the user enters a command specifying the parameter and its value. This is linked to the CDE, meaning the user can use the tool without changing their framework, and, after a validation circuit, the model is updated. This tool was tested for many use cases (programming, design, construction., etc) and shown to be fully functional and operational.
- A **property creation assistant**, in the form of an interface, that allows the user to check if a property is already present in the data dictionary and give access to the property definition before creation. In this way, property definition errors can be avoided, thus ensuring the reliability of the data structure. The project team envision the next step would be to link the created properties to a data dictionary, such as the buildingSMART Data Dictionary (bSDD).
- This tool also makes it easier for the user to follow the exact command syntax required to successfully modify the IFC model, as the command that is typed in the description of the BCF must follow a precise writing convention, otherwise the code will not work.
- A **tool for updating the native model**, which is a methodology for using the appropriate visual programming tool for the native modelling software (e.g. Dynamo for Revit, Grasshopper for ArchiCAD, Visual Scripting for AllPlan, Marionnette for Vectorworks).

Highlights

- The project is not a rival solution to existing platforms, but rather complements them by offering the ability to produce information (not only view it), validating the modifications before executing them, and tracking the information flow
- The project garnered interest from contractors and owners
- The solution doesn't need large investment to implement
- The solution is easily deployable

buildingSMART openBIM Solutions

IFC 2x3, IFC4, BCF, bSDD

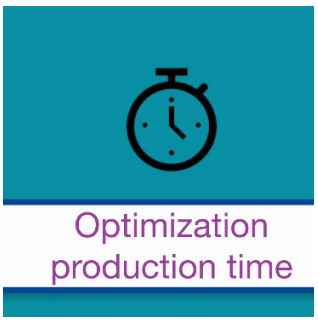
Software Used

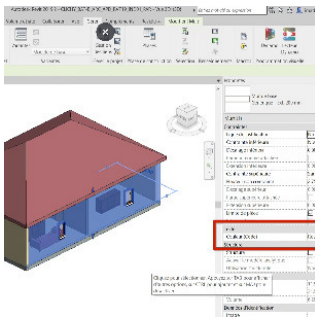
Evebim, Python

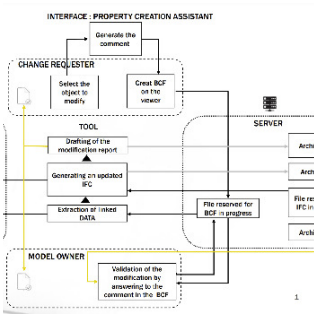
Result

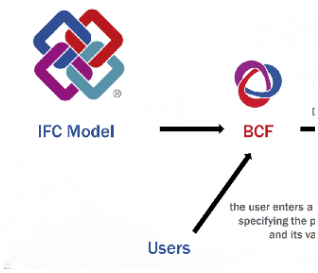
The Smart BCF solution gives workers in the French construction industry the ability to enhance 3D models with relative data, freeing them from software dependencies and costs. Through the application of openBIM and the use of IFC and BCF file formats, the solution aims to give every stakeholder the opportunity to participate in the BIM process.

The project team identified several further potential benefits of the application of Smart BCF, including better centralization of exchanges, productivity gains, better traceability of data enrichment and optimized production time.









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FINALIST

BIM Workflow Integration Between Architectural and Structural Designs for Prefabrication in LWF

USP - University of Sao Paulo, Brazil

About the Project

This Master's research project from the University of São Paulo studied a Brazilian housing prefabricator, Tecverde, who use the Light Wood Frame (LWF) construction system. Tecverde is a "construtech" company focused on the manufacture, supply and assembly of buildings using the LWF system for sustainable social housing.

Although the company has experienced huge growth since its foundation, it suffers from BIM workflow issues, specifically in the structural analysis phase. Historically, once the conceptual design is conceived, it is sent to the structural design company as paper-based documentation, forcing the structural engineers to redesign the architectural walls from scratch.

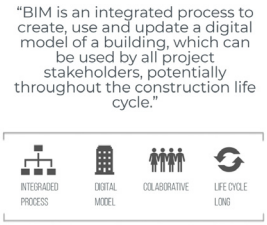
This project presents a technical solution for BIM integration in the design flow between the architecture and structure disciplines involved in the creation of Tecverde's product, using the standards and open methods of IFC, IDM (Information Delivery Manual), and MVD (Model View Definition).

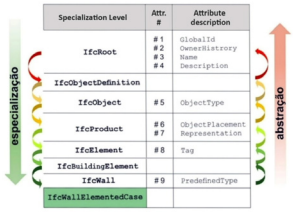
Core Objectives

The objective of this research project is to analyze the possible contributions and limitations of BIM to the practice of prefabrication. Specifically, it looks to investigate how the use of integrated BIM in the LWF prefabricated construction system could add value to the production chain in architecture, engineering and construction (AEC).

Project Description

Studies in the world market show there is a renewed interest in the use of prefabricated products and the development of modular projects arising from the broad and growing adoption of BIM. The intent when using prefabricated structures is to minimize the





building's route-to-market, to reduce work on the job site, and, most importantly, maintain control over the whole process.

Following a preliminary analysis of Tecverde's design workflow, it was concluded that the company wasn't fully realizing the advantages of prefabrication. It was proposed to intervene to adjust one of its production bottlenecks (the execution of the detailing design) through the adoption of BIM interoperability between the architectural and the structural design, the latter of which is done by a separate company. It was found that the lack of interoperability in the design process — which required information to be shared between three specialized BIM applications — lead to the re-inputting of data and up to three redesigns of some projects, which was time and resource consuming.

It was proposed to apply an openBIM approach to make this process more efficient. The solution used the integrated IDM/MVD methodology as a tool for discovering which dataset should be part of the Exchange Requirements (ERs) for interoperability to occur.

The IDM method lists information in a non-technical way so that stakeholders can perfectly understand and interact with each other to identify the information pre-requisites for a flexible design workflow between BIM applications.

Once the ERs were identified, Exchange Models (EMs) were proposed. An IFC4-based data exchange between the stakeholders' distinct software was implemented by building an exchange MVD specific for that purpose. Every element in the company's system used in the LFW prefabrication was identified, one by one, and mapped out in the IFC schema to exchange data between the authoring tools.

The resultant EMs have to potential to serve as a guide for possible future automation of the project process through the implementation of the corresponding MVD. Thus, it is intended, from this case study of Tecverde, to generalize the exchange requirements necessary for BIM interoperability in the process of designing residential units by the LWF system.

Highlights

- Overcame information handover shortage between stakeholders
- Mitigation of human error, which was common
- Avoidance of SMEs needing to buy native exporting BIM modules
- Improvement and flexibility in the overall workflow

buildingSMART openBIM Solutions

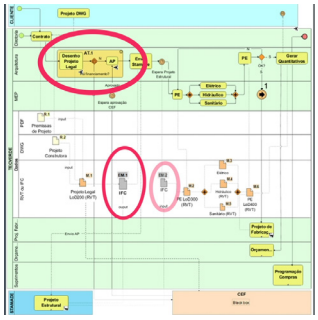
IFC4, MVDs

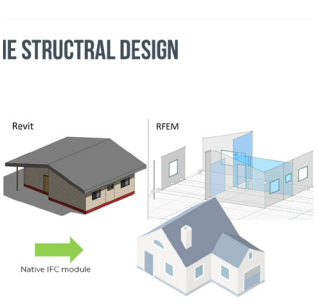
Software Used

Revit, SEMA, Dlubal RFEM and IfcDoc

Result

The application of the IFC format improved the process of exchanging data between the architects and structural designers and enhanced performance workflow rates in the project deployment. It was concluded that openBIM is well suited to improving interdisciplinary collaboration and shortening the time-to-market of a prefabricated product, thus, advancing the competitiveness of Tecverde in the marketplace.





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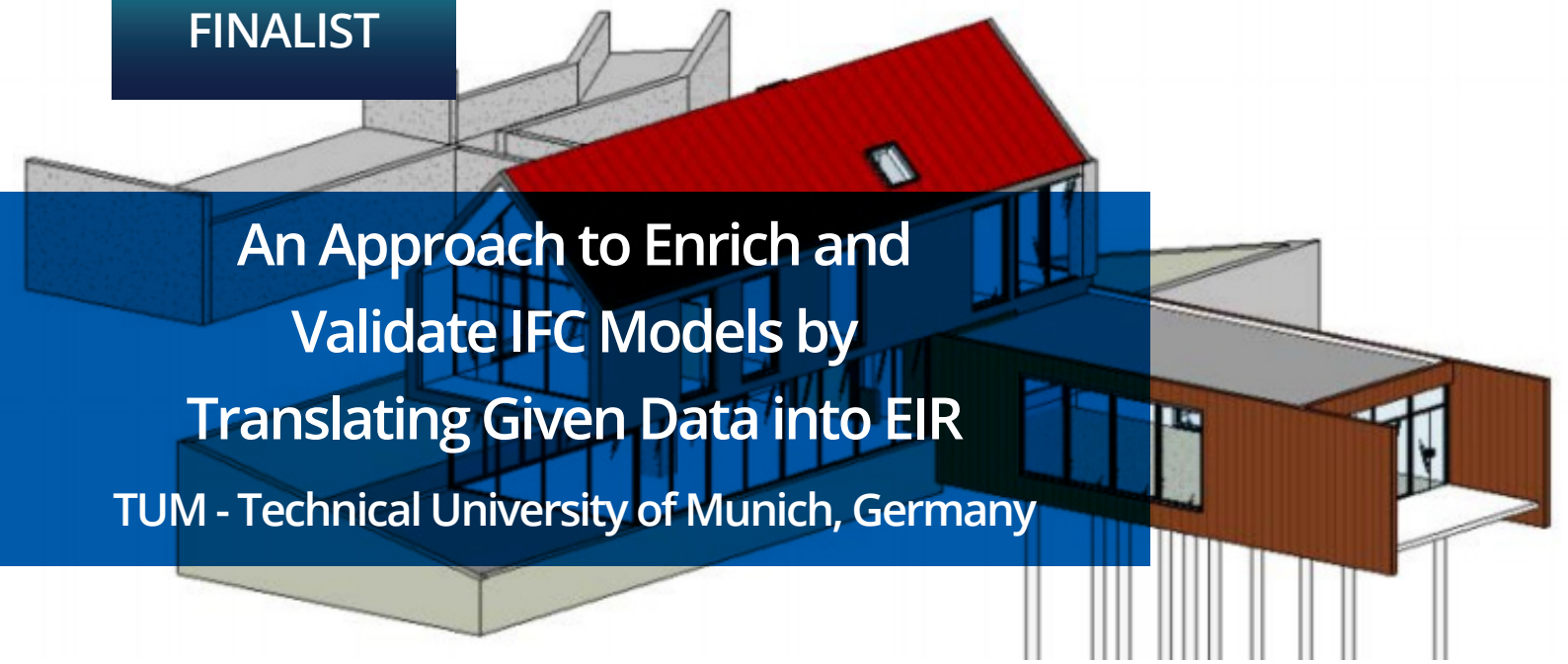


An Approach to Enrich and Validate IFC Models by Translating Given Data into EIR

TUM - Technical University of Munich, Germany

About the Project

This research project from the Technical University of Munich (TUM), presents a novel approach to enrich BIM models, in the IFC format, by translating provided information into internally standardised information requirements based on Exchange Information Requirements (EIR), but also extend them by another dimension: the labelling requirements. The author proposes the model of Internal Model Information Requirements (IMIR) to store and maintain both dimensions. Additionally, it introduces hierarchically structured information requirements.

Core Objectives

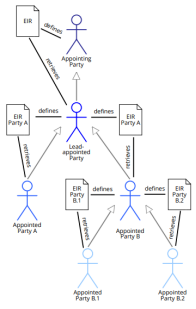
The project aimed to improve the semantic quality of a BIM model by preparing it for automatised downstream processes, such as model-based quantity take-offs (QTO) or model-based energy analyses..

Project Description

BIM models comprise extensive data that project teams can use to automatise BIM uses based on algorithms. However, these algorithms query and analyse information using their labelling and, as various stakeholders may label the same information using different words, project participants need to update their algorithms manually for every data exchange.

This creates a significant workload when considering that there are thousands of properties in a model, especially so when applying multiple uses on one BIM model.

To address this challenge, the project proposes a novel approach to enrich IFC models by mapping provided information with internally standardised EIR, which contain all information requirements for every data exchange.



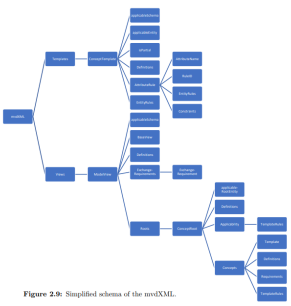


Figure 2.9: Simplified schema of the mvdXML

Technical Implementation of EIR

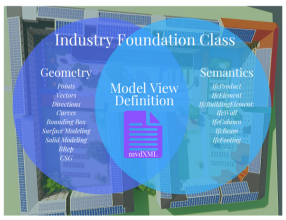


Figure 2.8: mvdXML describes a subset of the IFC schema technically. (Speiser, 2019)

Central to the solution is a data model (IMIR) that structures EIR hierarchically. This is essential as different data requires different information requirements. For example, wall material "concrete" requires different property information (reinforcement ratio) than the material "timber" (tensile strength). A hierarchical structure can represent requirements better than a list, which becomes significant when it comes to model validation. From this IMIR data model, the solution allows for mvdXML export, which can both store information requirements and be used to validate BIM models.

The second part of the project looked at a process to assign given information from an IFC model to the requirements defined in the EIR. The open IFC standard was chosen for this, as this format made it possible to create a solution that applied to multiple BIM uses and across a variety of software. By using IFC, no matter which software the creator of a BIM model uses, the receiver of the model can process the data.

The resulting "Enrich-IFC-model" stores these assigned pairs and derives an enriched IFC model containing both the original information and the internally standardised information. Moreover, the Enrich-IFC-model allows for model validation and export of model-related errors for collaboration in the form of BCF files. The exported BCF files are used to communicate issues between stakeholders, such as missing attributes and components. In a later version of the solution, the BCF files were colour coded to visualise the nature of the information contained within. For example, where they define a material, they are coloured green.

The author further developed this approach into a prototype that provides core functionalities of the Enrich-IFC-model, including a graphical user interface. Although the Enrich-IFC-approach does not yet decrease the workload, further development of the usability of the prototype and its application to multiple BIM uses is expected to drastically minimise manual work.

Highlights

- Coherent workflow from defining the information requirements to model validation including issue communication via BCF
- Integration of bSI standards IFC, mvdXML, BCF
- Fully open-based approach
- Prototype supporting the basic features between stakeholders

buildingSMART openBIM Solutions

IFC 2x3, BCF, mvdXML

Software Used

Xbim toolkit, Xbim Xplorer (for testing), BimQ (for testing), Autodesk Revit (for testing), BimCollab Zoom (for testing)

Result

The project brings value to openBIM by demonstrating how to integrate the three buildingSMART standards — IFC, mvdXML, and BCF — into an open-based software tool. Compared to a conventional approach, the main benefits of the Enrich-IRC approach are that it helps stakeholders to maintain a coherent and flexible structure of their information requirements, to validate models and communicate issues through BCF, and, innovatively, to prepare BIM models for fully-automatised BIM uses, such as cost estimation.

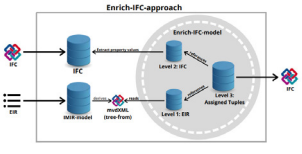
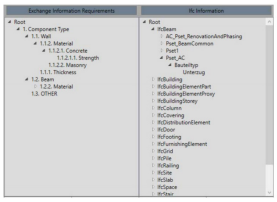
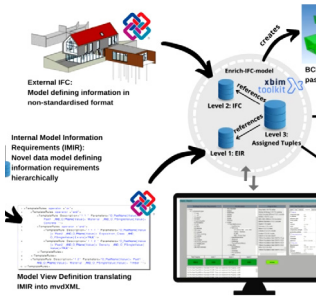


Figure 5.1: The roles of the two data models within the Enrich-IFC-approach.



Tree view of the GUI after reading the data from the IFC model and the MVD



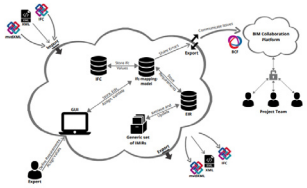
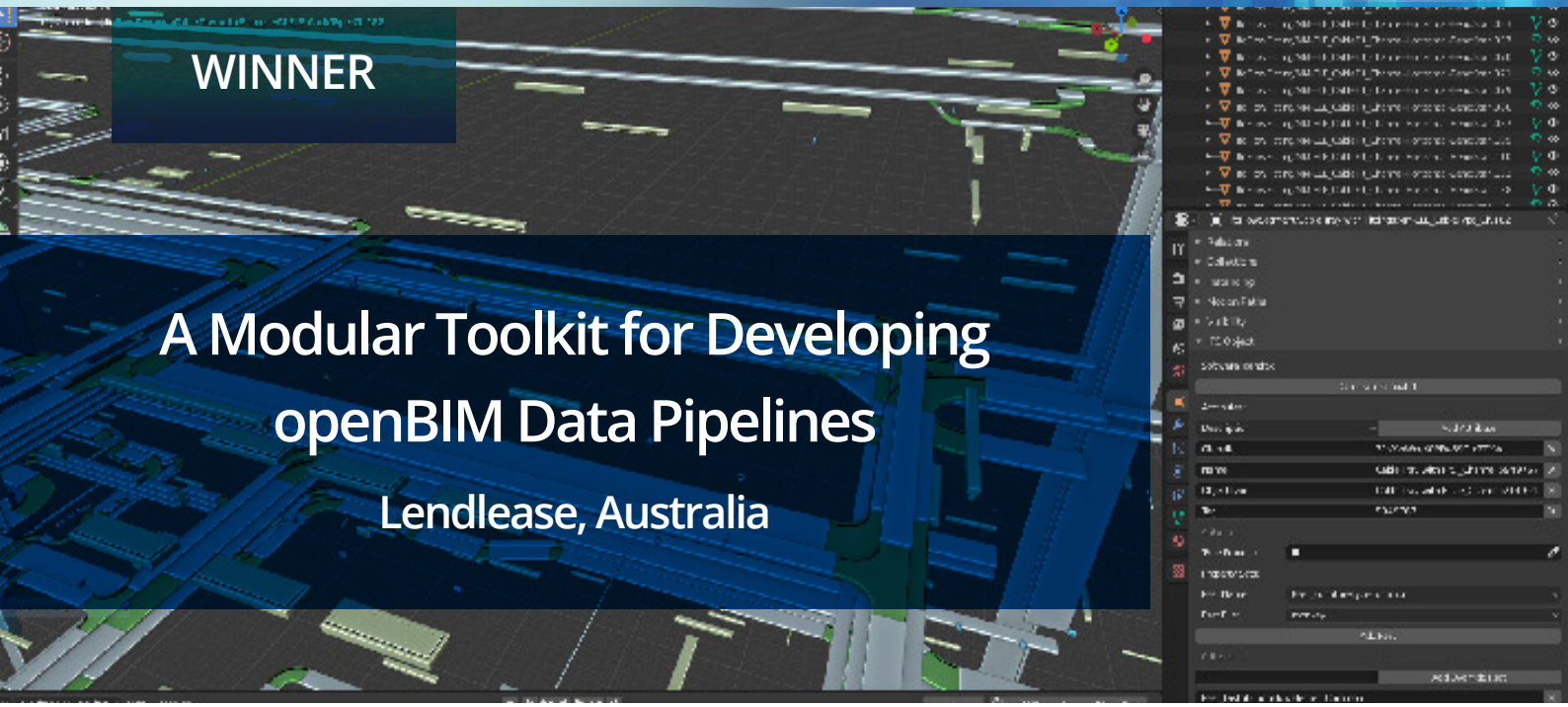


Figure 6.1: Overview of the ideal system design.

buildingSMART International



WINNER

A Modular Toolkit for Developing openBIM Data Pipelines

Lendlease, Australia

About the Project

Smaller market players, cross-platform users, those who cannot afford proprietary tools, those ideologically preferring free software (e.g. non-profits, governments, academics, FOSS advocates), and the general community are having increasingly less access to their own built environment data. This project recognized that combining free software with openBIM increases its exposure to a wider market, whilst also allowing larger players to build their own digital pipelines more rapidly compared to relying on external software vendors.

Core Objectives

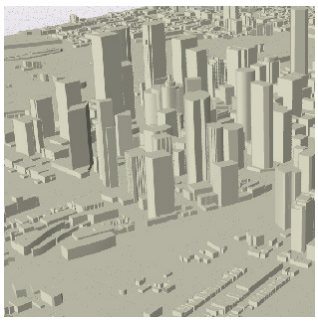
To combine the use of openBIM with free software to give greater access to built environment data and to help develop data pipelines without reliance on proprietary software.

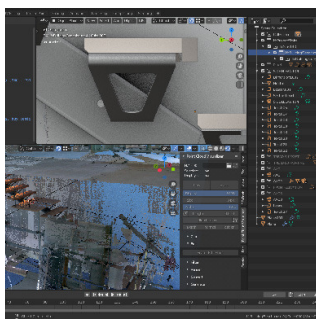
Project Description

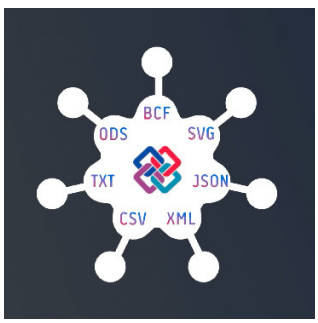
Lendlease developed a suite of seven Unix-influenced modular, decoupled, and cross-platform openBIM tools under free and open-source software licenses, to include a wide spectrum of functionality. openBIM was treated as a core native format and database, as opposed to a transfer methodology between program imports and exports; without openBIM the development of a technology pipeline such as this would not have been possible.

The suite was developed in under a year, in an open and transparent manner, targeting a variety of use cases at multiple project phases to be used by different stakeholders. Each tool uses IFC data as an input format and reads directly from the IFC as a native database. Further functionality includes BCF management, IFC collision detection, 2D IFC construction drawings, IFC data validation for exchange requirements, COBie analysis, IFC comparison, and IFC building physics simulation.

On a small prototype project, the pipeline was used to deliver a building (~250m2) from concept design through to construction.







The entire model was designed with IFC as the native file format. No other native format, proprietary or otherwise, was required to capture the data. This openBIM requirement also includes all construction documentation. 2D drawing data and annotation was stored in IFC, and further translated into the SVG open standard, with zero proprietary software. This guaranteed that all documentation was derived from openBIM data

On a larger commercial / infrastructure project, the client mandated the delivery of openBIM data, with the COBie MVD. Approximately 3.3GB of IFC data was delivered each fortnight by a diverse set of disciplines: architectural, structural, MEP, fire, and landscape. A custom model delivery procedure and data auditing pipeline was developed to process this openBIM data.

During the development of the tools, a new online architecture, engineering and construction (AEC) community was started, with a focus on integrating free software and open data, where the community heavily participated in the testing, suggestions, and collaborative development of the pipeline. This community has brought together volunteer software developers to help form an integrated pipeline revolving around openBIM standards accessible to everyone.

Highlights

- A suite of seven cross-platform, Unix-style tools were developed under free software licenses, tackling a variety of openBIM use cases across multiple project phases
- A small project was delivered from design to construction using only IFC and SVG (for documentation) as native formats (no other CAD/BIM formats were used) with no proprietary tools, demonstrating the feasibility of openBIM as a native format
- An automated, openBIM auditing procedure was implemented on a large government mixed-use infrastructure project
- A new, open-source architecture community was started, garnering 330 members within the first six months

buildingSMART openBIM Solutions

IFC 2x3, IFC4, MVDs, mvdXML, BCF

Software Used

IfcOpenShell, Blender, BlenderBIM Add-on, FreeCAD, IFCDiff, BIMTester, Git, Git-LFS, Bitbucket, Pipelines, Revit

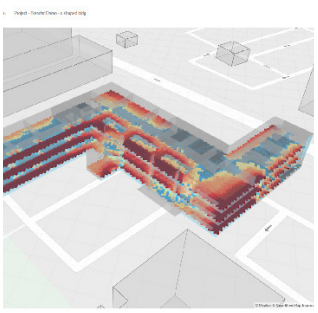
Other Standards

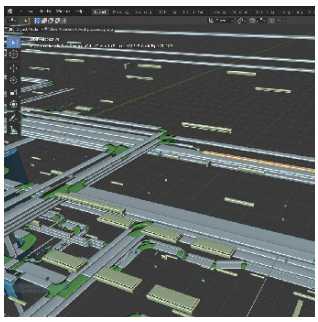
COBie, Uniclass, SVG, JSON, XML, HTML, Git, J/XUnit XML, Gherkin Syntax

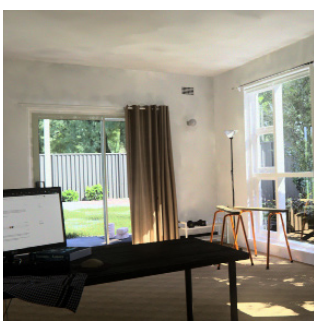
Result

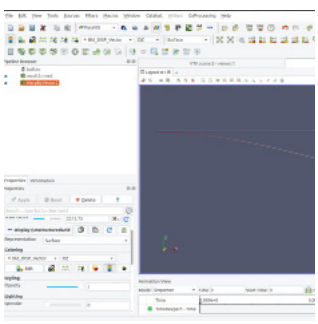
Lendlease found that their toolkit, with its wide spectrum of functionality, was better able to satisfy client requirements than existing proprietary software. The data-focused, modular toolkit is easier to digest, requires less translation, allows stakeholders to use the best tool for the job, results in high quality data, is easier to develop, and helps to rapidly deploy new standards.

Lendlease recognised that for openBIM (a fundamental component of this project) to succeed, increased accessibility for the entire industry and empowerment through available tools is necessary. For this reason, Lendlease release their toolkit and source code for free, for use within the industry.









buildingSMART International

FINALIST

The BIM & Scan openBIM Cloud Platform: AutoCorr and AutoGen - Validation and Reconstruction Tools

BIM & Scan, Ireland

About the Project

BIM & Scan Ltd. was established in Dublin, Ireland in 2015, and is led by an experienced team of construction, enterprise software and construction professionals.

They have created two cloud-based commercial products: BIM & Scan® AutoCorr V1.4, and they are currently bringing to market BIM & Scan® AutoGen V1.0. AutoGen is an automated solution for generating a BIM-based model from a point cloud 30x faster than traditional manual practices. AutoCorr is a software solution that can automatically check the IFC models from AutoGen. These patent-pending software algorithms have many use cases across a wide variety of industries.

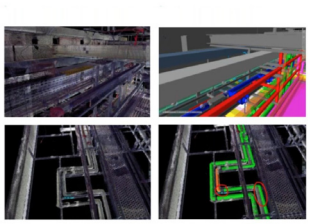
Core Objectives

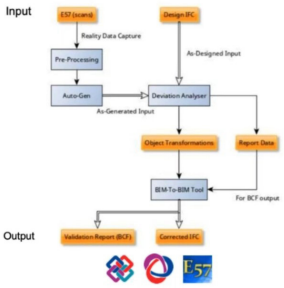
To create novel and unique solutions for common problems in construction projects using big data algorithms and advancements in 3D laser scanning.

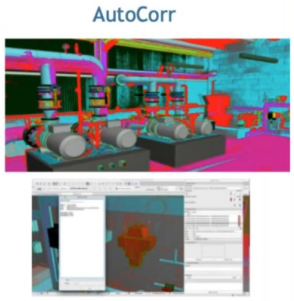
Project Description

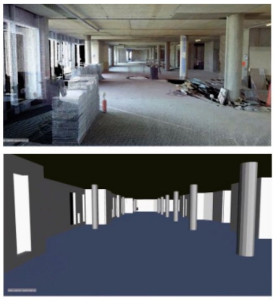
It was decided when developing AutoGen and AutoCorr to build on the open file format IFC as the backbone of these tools, with AutoGen generating IFC CV 2.0 MVD files from open standard E57 point clouds and AutoCorr consuming them. Doing so opens many doors that would have otherwise been closed should a proprietary route to development been followed and means that users do not need to buy a new app or viewer.

AutoGen's function is to create LOD 200 architectural and structural models to speed up the Scan-to-BIM process, in which laser scanners are used to create 3D models of a site or building. The automatically created IFC coordination models from point clouds can be used immediately as the basis of design, e.g. during retrofit or simply planning.









These models can be amended in the native tool if needed, because they are automatically linked to the design application API via the IFC data model.

AutoCorr, on the other hand, is a Scan-vs-BIM solution that not only checks AutoGen models but can also be used for manual Scan-to-BIM checking, As-Built handover BIM checking, construction monitoring and site equipment install monitoring. The software uses open standards IFC, BCF, and E57 to communicate and compare design BIMs to corresponding point clouds within a user-defined tolerance.

AutoCorr creates automatic BCF messages for all issues found and automatic camera views for all entity type objects for full accountability. Where planned objects deviate from the built assets, these deviations are serialised automatically in a new patent-pending semantic point cloud enriched by a corresponding colour representation of the IFC type itself, a feature unique to AutoCorr. This enables quick quality assurance decisions to either modify the as-built BIM or correct the construction on site.

Harnessing the BCF open format, AutoCorr allows for issues to be communicated on a scale that would not be physically possible for humans to do manually. For example, semiconductor and airport facility projects contain far too many objects and assets on the sites (as many as 100,000+) for humans to investigate all issues.

These software have been used on many real-world projects, showing drastic improvements in speed, efficiency, quality, and value. During the development of these products, AutoGen was trialled in one project resulting in the duration being cut by a third and, to add more savings and value, AutoCorr was used for automatic QA/QC. For example, poured concrete columns were automatically generated for a 6-storey building. Each column was unique and AutoCorr checked all columns automatically for accuracy, then outputted a BCF for all columns with camera views, showing all columns were 100% correct within the given tolerance.

Highlights

- Novel use of BCF
- Automatic IFC coordination models from point clouds
- Automatic object recognition using IFC and point clouds

buildingSMART openBIM Solutions

IFC 2x3, BCF, MVDs

Software Used

BIM & Scan AutoCorr and AutoGen, Archicad, BIMcollab Zoom, Revit, Navisworks

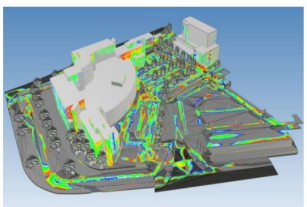
Other Standards

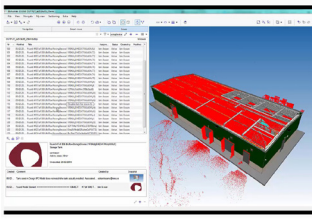
E57 ASTM

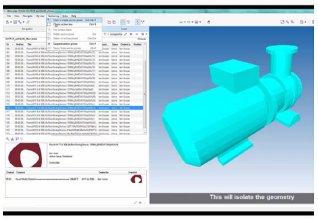
Result

openBIM has enabled BIM & Scan to create platform-neutral software tools that can be used by anyone globally who are participating in a built environment project, irrespective of the software they are using. These products are particularly valuable in automatically validating IFC formatted BIMs and/or site installs based on IFC coordination design BIMs, automatically communicating issues via BCF, and updating or automatically reconstructing IFC BIMs using point cloud data.

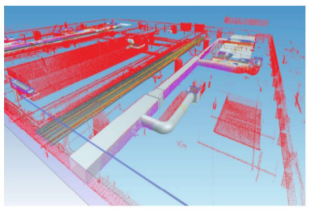
Roads & Streetscapes







Airports



buildingSMART International

FINALIST

InBIM - BIM for Linear Infrastructure. Automatic Generation of BIM Models of Existing Roads

Ineco, Spain

About the Project

Ineco is a transport engineering and consultancy company that develops innovative, comprehensive and technological solutions to contribute to safe and sustainable mobility.

The company's InBIM software is a tool that allows BIM model generation for the thousands of kilometres of existing roads in Spain, with the intention that the maintenance and operation of these linear infrastructures can be done with BIM without having to redraw them line by line with a layout software.

Core Objectives

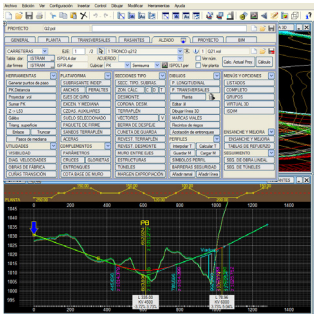
To develop software capable of automatically generating BIM models of existing roads in IFC format (openBIM) using information obtained by road scanning, from inventory data or the computer files generated from original construction projects.

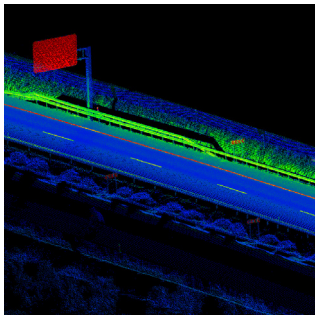
Project Description

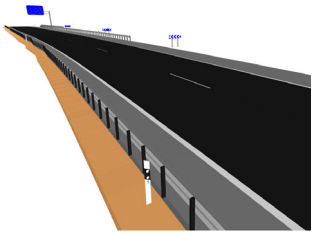
InBIM is Ineco's solution for automatically generating IFC models of existing linear infrastructure on a massive scale. To do this, InBIM requires inputs in the form of digital data that characterize the infrastructure (primarily the road geometric characteristics), asset type (signals, etc) and asset location. The formats that are compatible with the solution are Excel, .csv and .shp files. The InBIM generator uses these inputs to create IFC open format files that can be used by companies or organisations responsible for a road's management or operation regardless of the software they use.

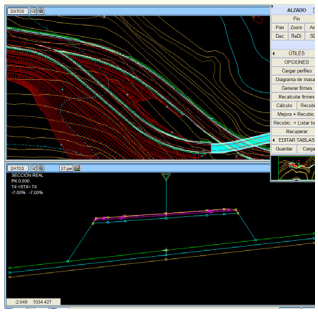
InBIM generates the IFC file by following these steps:

1. Creation of the file structure with the associated general information.









2. Creation of each element:

    a) Geometric information

    b) Semantic information, PropertySet

    c) Relationship information, type assigned to each element

3. Element integration in the complete model.

There are two primary sources of road data that can be used as inputs for InBIM. In the first instance, where modern road construction projects have been built using design software, the software files contain the information needed for InBIM to automatically create linear infrastructure BIM models. This required digital data can be sourced from inventories in Access, Excel and other databases, GIS inventories, and inventories in commercial asset management systems. The data available from these sources can be exported into Excel or .csv files and then inputted into the InBIM solution for IFC model generation.

Where these sources of data are not available, the second option is to acquire data by using a mobile mapping system for road scanning. The combination of a terrestrial LiDAR (light detection and ranging) instrument and a spherical camera, aided by a geopositioning system, provides the necessary information to characterize the infrastructure. The implementation of these tools allows for road scanning at a rate of

between 100-200 km/day to obtain the required geometric information.

Although the resultant LiDAR point cloud visually represents reality very accurately, the data points produced cannot be associated with objects. Further processing of the point cloud data is required to create the BIM model. To do this, raw data from road scanning and collected images can be treated through algorithms to produce an input file for the InBIM tool. From the cloud points, object models are generated, and properties and characteristics are associated with those objects to enable the creation of the BIM model.

Highlights

- A section of the A-92 highway in Spain was scanned by a mobile mapping system and the data inputted into InBIM to generate an openBIM model of this road section
- Existing data from another section of Spanish highway were exported to Excel and InBIM was used to generate an IFC model
- Models are generated in a matter of minutes
- Models contain road information for every metre of highway, such as axle coordinates, number of lanes, lane width, shoulder width, berm width, longitudinal slope, transverse slope, radius of curvature, etc. Novel use of BCF

buildingSMART openBIM Solutions

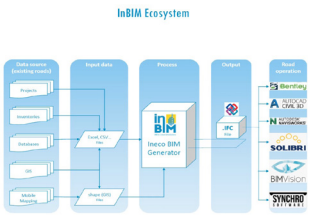
IFC4, ifcXML

Software Used

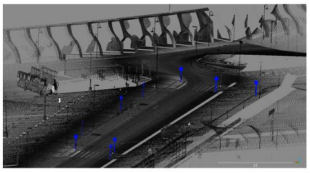
InBIM

Result

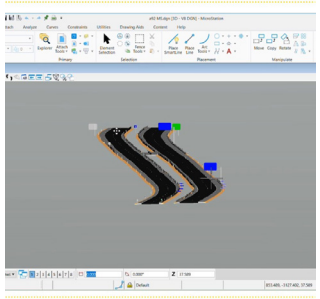
Through the use of the IFC format, the InBIM solution is capable of generating BIM models of thousands of kilometres of road each week, with the potential to apply the solution to railway infrastructure as well. By applying an openBIM methodology in the development of InBIM, Ineco has created a tool that allows end users to use the resultant models without having to change their BIM software, which is beneficial from both a collaborative workflow and a cost efficiency perspective.



Object identification

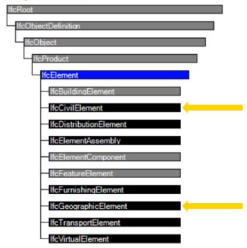


300 km/day



IFC4Add2

Entity inheritance



buildingSMART International

WINNER

usIFC.server: The Revolution in the Use of IFC Files from Static to Dynamic

ACCA Software, Italy

About the Project

An IFC model is thought of as a static snapshot at the time of construct or, rather, as a specific exchange of information for a particular purpose. It is known that IFC models are monolithic, difficult to manage and update. But an IFC model can be much more than that—it can, and should, be an evolving object that has the same life span as the building / infrastructure that it represents. IFC models, in fact, are the openBIM digitalization of the building / infrastructure itself and should therefore undergo the same changes and updates as the "real" counterpart.

usIFC.server, developed by ACCA software, enables IFC files to be simultaneously available to multiple users who collaborate and share their model in the openBIM format with the ability to read and modify it dynamically, even when using different software or devices. openBIM and, in particular, the IFC file format are the foundation of this project in its entirety.

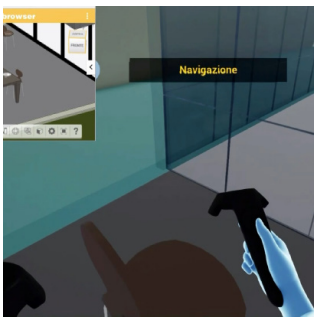
Core Objectives

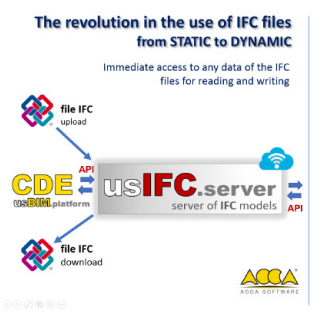
To revolutionize the current concept of IFC files by transforming their use in the BIM process from static to dynamic.

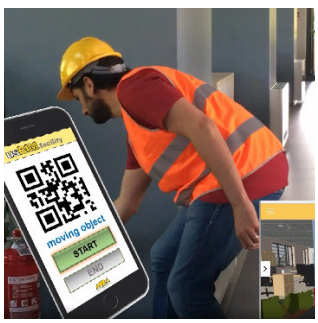
Project Description

usIFC.server is a cloud server where the open IFC data structures can be stored. This allows IFC files to be made simultaneously available to multiple users, who can collaborate with each other in real time and share the model completely in openBIM format. With the ability to read and modify the model dynamically with different software or devices, the client can read and write (hence update) every single piece of information relating to the IFC model.

In order to achieve this, and to flatten the IFC STEP complexity, the usIFC.server exposes high-level Application Programming Interfaces (APIs) for common updating operations, so the client does not need to have a deep knowledge of the







complex IFC data structures, but can nonetheless accomplish the necessary updates quickly and with ease. However, usIFC.server also has more elaborate APIs that can go into the very finest details of the IFC complexities, should that level of detail be necessary.

In the event data is required from only part of the model (or part of different models, as in the case of visualization), the server will do partial model exchange, in order to optimize the traffic generated. Updates or edits to such entities will be automatically updated in the model, making the federation of models seamless for the end user.

This project is revolutionary as IFC models, normally thought of as a "static" snapshot can now really be understood as "dynamic" models that evolve over time. From a maintenance perspective, models can be updated years after handover to reflect objects that are moved/added/removed or updated with the specifications of properties and objects as they inevitably change over time.

Highlights

- Revolutionized the concept of an IFC file: from a static to a dynamic and evolving object
- Possibility of high-level server interaction from any client and any source
- Edit and update of the IFC models during all the life cycle of the building / infrastructure projects
- Querying of the information of the IFC models, even federated models
- No need to know the cumbersome of the STEP IFC specification, whether editing or querying information

buildingSMART openBIM Solutions

IFC 2x3, IFC4, ifcXML, MVDs

Software Used

usIFC.server, usBIM.platform, usBIM.editor, usBIM.browser, Revit, usBIM.facility, Solibri, usBIM.viewer+, usBIM.reality

Other Standards

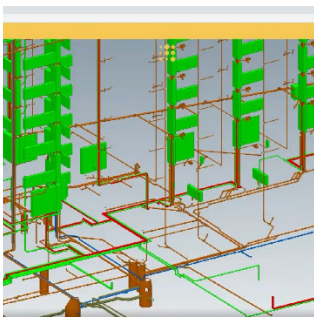
JSON

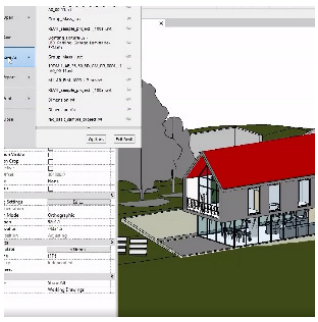
Result

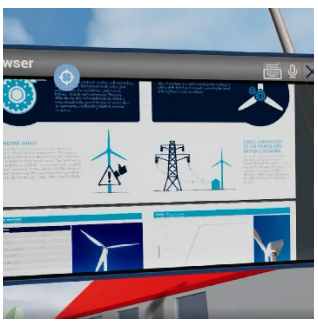
The results achieved are unique in the world, never having been seen before, even with the use of proprietary formats. usIFC.server is proof that buildingSMART's vision is feasible and the technology stack available today is already sufficient for the task at hand.

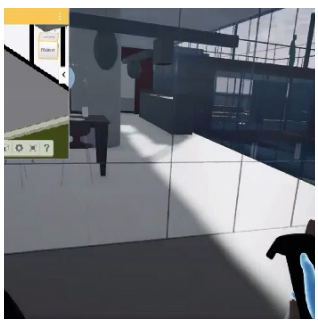
> "The buildingSMART Awards is an incredible opportunity to showcase solutions and technologies that really are solving current challenges, and are also a sneak peek into the future to see developments being made by the cutting-edge companies that support the use of openBIM for interoperability and how they are setting the milestones for an interoperable future."

Michelangelo Cianciulli, ACCA Software









buildingSMART International

SPECIAL MENTION

Digitally Designed Concert Hall, Theater Zuidplein, Offers Acoustic and Visual Spectacle

Studio RAP, The Netherlands

About the Project

On 15 May 2020 the new Theater Zuidplein in Rotterdam was released to the press. The City of Rotterdam commissioned Studio RAP to design the interior of the main theatre hall to a tight budget and schedule. The project was designed using algorithms, which resulted in a rippling ocean of thousands of triangles. The eye-catching design is composed of 6,000 uniquely shaped pieces, which enclose the main auditorium and optimize the acoustics within.

Design, engineering and production phases had to overlap to achieve execution of this complex structure within the set schedule and budget. This required good and reliable, yet simple, digital communication between the project partners. openBIM is at the heart of this project's communication system.

Core Objectives

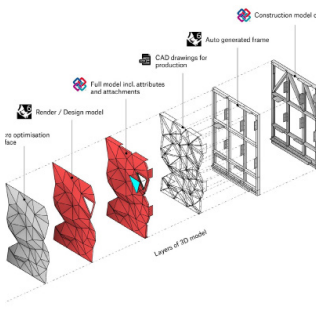
The interior of Theater Zuidplein's main concert hall was designed to achieve optimal acoustics with the use of parametric design. The goal was to evenly distribute the sound, so every visitor can have a great experience of the performance they attend.

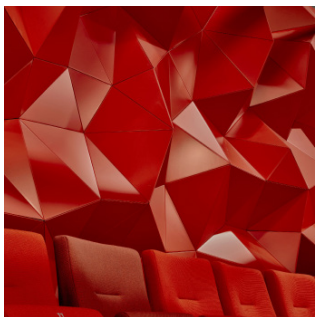
Project Description

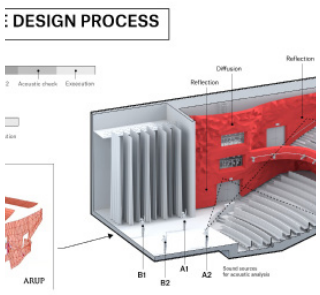
The project team conducted countless theatre hall simulations, "digitally kneading" the sound until the optimal shape for Theater Zuidplein was identified.

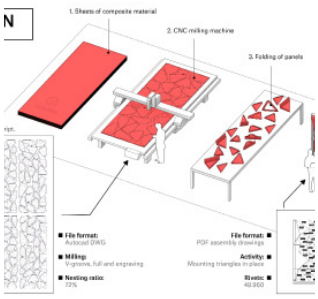
Using advanced software, calculations were made to measure how curvature in the design affected the reflection of the sound of a speaker or musician on the stage. The optimal shape for the interior of the hall was translated into smaller triangular panels to create an even distribution of sound across the entire auditorium.

Since every element in this project is unique in shape, orientation and position, a "traditional" BIM approach would not have been convenient. Therefore, the project team decided to assign the BIM information, including production numbers,









to each element of the 6,000 panels and 2,000 construction elements parametrically.

To exchange information between the stakeholders, the project used openBIM standards. The main contractor was responsible for setting up a document management system (DMS) environment, which was kept up to date with BIM models.

The 3D models used were digital and parametric, meaning they were easily adaptable and changes in construction, design and project scope could be accommodated until very late in the design process. Due to the algorithmic approach, the BIM models, production drawings and execution data were updated instantly when the design was changed.

Additional information about openings for electrical and audio-visual installations was added, based on IFC models, by the technical advisors. The IFC model of the project was then exported simultaneously with technical drawings and the production drawings of each element.

Through the use of BCF files, Studio RAP was able to communicate with the main contractor on collisions and issues. Every issue was accompanied by a description and the panel's reference number. This workflow ensured there were no misunderstandings with respect to panel positioning, thus saving time and preventing failures in the project.

The use of openBIM ensured that the project was executed with "zero-millimetre-tolerance" construction, with every panel fitting exactly with its neighbours.

The result of this project is an IFC model that is both usable in the construction and maintenance phases. In the future, if a part of the interior gets damaged or has to be replaced, it will be easy to identify and order the specified part despite the complexity of the design. This will be done by simply opening the IFC model in a model viewer (e.g. Solibri) and ordering the specified part(s) at the manufacturer.

Highlights

- Designed and realized according to a complete digital workflow
- Over 8,000 unique and labelled objects
- Construction executed with 0mm tolerances, within time and budget
- No complicated software exports/imports because of IFC standards
- Automated generation of BIM objects, makes BIM easily adaptable to changes
- Documentation of production files for the execution, quality control and maintenance phase

buildingSMART openBIM Solutions

IFC 2x3, BCF

Software Used

Rhino 3D, Grasshopper, Solibri

Result

Complex projects ask for innovative ideas and processes; for Theater Zuidplein, communication through openBIM was the key to efficient and effective project execution. Studio RAP's innovative approach of completely digitizing the wall design from start to finish with self-developed algorithms meant the project was delivered within budget and on time.

buildingSMART International

SPECIAL MENTION

PPP A 10/A 24: Using IFC 4 for Digital Construction from Design to Operation

ARGE A 10/A 24 Havellandautobahn, Germany

Construction Joint Ventre Wayss & Freytag Ingenieurbau AG (submitted) and HABAU Group

About the Project

Heavily trafficked segments of the A10 and the A24 motorways in the Berlin region are to be extended or renewed to cope with future traffic volumes. The design, build, finance, maintenance and operations contract comprises the widening of the A10 to six lanes and the complete reconstruction of the A24. In addition to the motorway, the construction scope of works also includes several bridges, noise protection walls, traffic sign bridges, traffic management installation, interchanges, rest areas and secondary/agricultural roads.

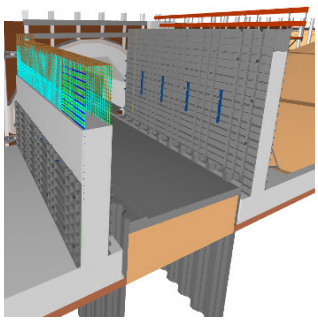
The German Federal Ministry of Transport and Digital Infrastructure (BMVI) selected this project as a pilot for the preparation and testing of BIM Level 2, as specified within the adoption plan for digital construction in Germany. Project "Availability model A10/A24" represents the first time, in a German private-public partnership (PPP) infrastructure project, BIM applications are to be holistically implemented throughout the entire lifecycle from design to operation and maintenance (O&M).

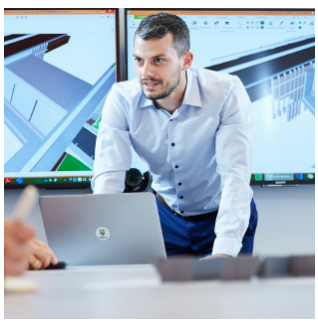
Core Objectives

Currently, there are almost no openBIM methods and standards for the implementation and application of BIM in infrastructure and civil engineering in Germany. The German government used this project as a pilot to introduce and evaluate the adoption plan of BIM standards based on an openBIM approach.

Project Description

As a pilot project, BIM methodology was contractually required for a 4km section of the A24. The model-based approach served as the foundation for processing the project-specific use cases and enabled information acquisition, data management, transparent communication and improved cross-disciplinary collaboration (36 BIM users/specialists across eight companies).





Category of Integrated Project Delivery

BIM Use Cases

- A structural model was developed to integrate structural design into the BIM process.
- 2D plan documents were derived from the 3D models and made available in the Common Data Environment (CDE) for plan checks by the client.
- Regular federation of the discipline models in a coordination model formed the basis for subsequent automated collision checks
- Public relations work was supported by model-based visualization and animation.
- The construction phase progress was visualized and monitored by linking the activities of the schedule with the model.
- Machine control and plant automation using model-based information.
- At the transfer of the model, the conservation measures and model-based visualization can be displayed and located.

Highlights

- Measurable added value through BIM in all project phases thanks to integrated project delivery involving the client, designers, construction joint venture and O&M
- Collaborative development of project specifications for BIM uses and information requirements throughout the project lifecycle
- Official pilot project of the German government to adopt and further develop national BIM standards based on an openBIM approach (native and IFC formats mandated) and ISO 19650
- 20 models from five disciplines in six different authoring software with a total of over 137,000 IFC structural objects
- Intensive knowledge sharing with 16 lectures and three publications (1 peer-reviewed)
- IFC files were imported into energy analysis software to evaluate the energy consumption as it is and as it will be, to make informed decisions
- Structural engineers used the model to plan surveys and cores
- The model, enriched with information about the installed plant, will be used to maintain the building

buildingSMART openBIM Solutions

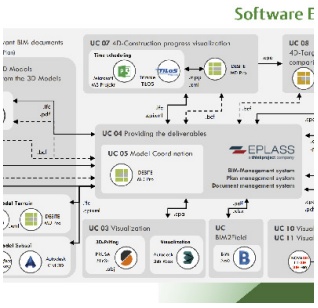
IFC 2x3, IFC4, BCF

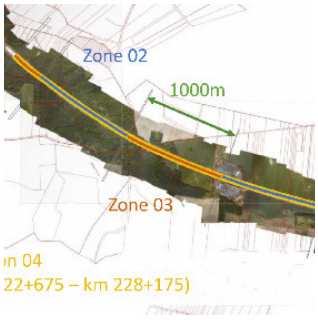
Software Used

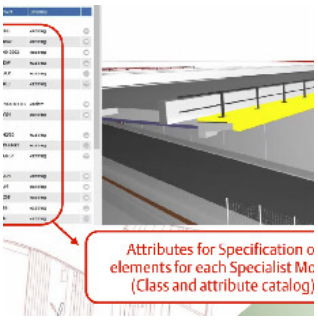
Autodesk Revit 2020, Autodesk Civil3D 2020, Dynamo, Nemetschek ALLPLAN, card_1 Version 9.1, AKG Vestra Infravision Build 55, RIB iTWO Civil 2020, think!project DESITE MD Version 2,6, EPLASS CDE, Microsoft Project 2019, TILOS, RIB iTWO5D, NOVASIB, TT-SIB, SIB-Bauwerke, Autodesk BIM 360

Result

The openBIM approach has proven to be very efficient and successful in the A10/A24 project, helping to overcome the challenge of bringing together the different trades involved in infrastructure construction (bridge, track, equipment, etc.). The consistent use of data and integration of data from the various specialist planners in a CDE means that errors in design or interdisciplinary coordination can be detected at an early stage. By avoiding such errors and improving communication, the quality of the planning and ultimately of the entire project will be improved in the subsequent project phases.







buildingSMART International

SPECIAL MENTION

DigitalTWIN - Digital Tools and Workflow Integration for the Building Lifecycle

Werner Sobek AG, Germany

About the Project

DigitalTWIN (Tools and Workflow Integration) is a German government-funded research project whose partners develop IT solutions for critical interfaces along the building lifecycle. By 2021, project partners from industry and research in the construction, IT, communication and automation sectors will have further developed digital tools and methods to bring together automated services, processes and workflows along the construction value-creation chain.

The aim is that open platform architecture, along with more advanced broadband communication systems and computer vision technologies, should simplify planning, production and coordination with the building site.

Core Objectives

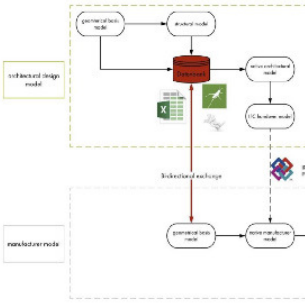
One of the main objectives of the research project is to enhance the utilization of continuous digital processes within the building sector through an asset's entire lifecycle.

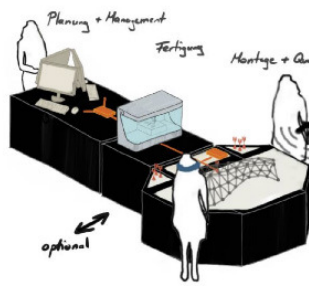
Project Description

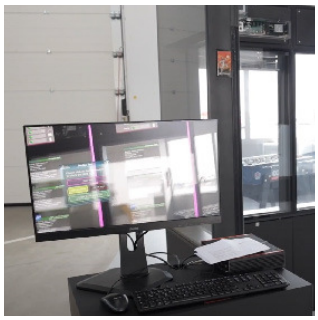
The optimization of the interfaces between different planning participants is an essential challenge in modern digital workflows. Building projects are subject to changing actors, replanning, and reorientation of the course of a project. Therefore, the goal of this research project is to develop a workflow, formulated in a way that is universally valid, that can be used as a basis for different interfaces, users and projects by applying openBIM standards.

With DigitalTWIN project partners coming from various sectors of the building and construction industry, the digital planning of demos and use cases, processes and communication had to be based on a mutually agreed collaboration infrastructure.

Standards like IDM, IFC and BCF were the basis for that infrastructure since every project participant







had a general understanding of how to use them. In addition, the partners all use a variety of different software and tools, on whose interfaces openBIM standards crucially influenced the ability to guarantee a continuous exchange of information.

The DigitalTWIN team defined three application scenarios that represented different phases of the building life cycle and six demos were developed to highlight challenges, demonstrate the application of technologies and provide integrated IT solutions at critical interfaces. The resultant solutions show how open standards can be used—and further developed—and can link IT solutions through open, modular and scalable private cloud cluster technologies, thus providing orientation for different users and software developers.

Use Case 1 deals with building operations and features the easy availability and visualisation of live measured data at the building through the digital twin using edge cloud and cluster computing technologies.

Use Case 2 deals with the application of modern VR and AR technology in manufacturing and quality assurance to enable a more continuous, effective and seamless process for the production and inspection of welded steel components.

Use Case 3 deals with assembly and live interaction between a construction project's stakeholders and data from the planning and manufacturing phase. It demonstrates more effective and efficient installation by using the digital tools, as well as their flexible and safe use in harsh site environments.

Highlights

- Integration of different hardware components currently used (or most likely used in the future), flexible combination of modular software tools, integration of existing workflows and software solutions via open standards and interfaces (IDM, IFC and BCF)
- Live analysis, combination and use of dynamically accumulated geometric and parametric data, point clouds and metadata
- Cluster infrastructure for decentralized, but synchronized, data management
- Modular user interface for XR devices
- 5G wireless technology for building sites
- 6 finalized demos, 4 additional in preparation

buildingSMART openBIM Solutions

IFC 2x3, IFC4, BCF, IDM, MVDs

Software Used

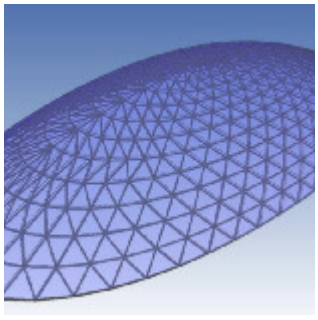
Rhino, Grasshopper,Excel, Revit, Dynamo, BIMCollabZoom, HiCAD, Tekla, Visual Studios, XBIMViewer, scaleIT, PTB, Unity, NodeJS, Matlab (bei HHI)

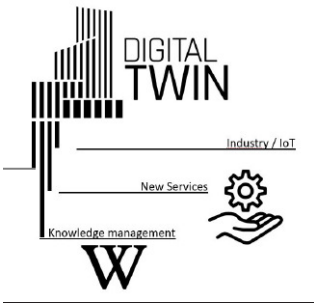
Other Standards

JSON, BIMSWARM, scaleIT, REST, MQTT

Result

Although the research project is not yet completed, it was awarded a "special mention" at the buildingSMART Award 2020 in the category "Professional Research using openBIM". This acknowledges the value of the project in implementing openBIM standards for digital twins. It underlines the relevance of digitalization in the building sector and shows that project partners from different disciplines can successfully work together to develop a collaborative and integrated way of working.





buildingSMART International

SPECIAL MENTION

Investigating, Structuring and Launching Australia's Most Innovative openBIM-Compliant University Program

Bond University, Australia

About the Project

Increasingly, Australian clients require their medium and large construction and infrastructure projects to be delivered using BIM and Integrated Project Delivery (IPD) systems. Since 1 July 2019, all Queensland Government construction projects with a value of $50 million or more are required to use BIM from the early planning phase and all major government infrastructure projects will transition to implement BIM by 2023.

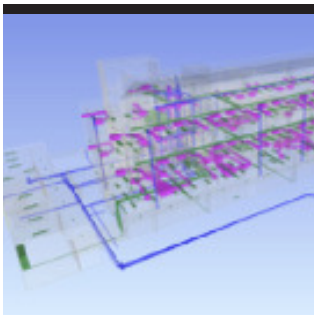
Dr Alan Patching, Professor of Construction and Quantity Surveying at Bond University, identified in the Australian education landscape that no post-graduate programs existed for the in-demand specialist skillsets of BIM (and associated subjects Lean and IPD) for complex projects. A leadership position was adopted, and the university launched a first-of-its-kind suite of postgraduate programs that integrate education on BIM, IPD, and Lean in a manner informed by industry, which will produce graduates capable of immediately contributing to an industry in which the skills learned are, and are expected to continue to be, in high demand.

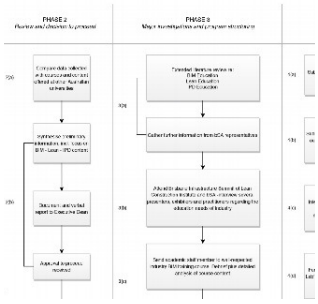
Core Objectives

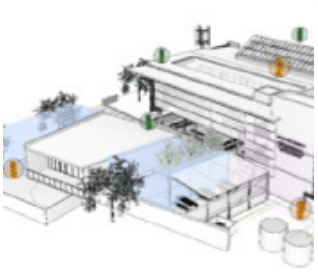
To research, strategize and launch Australia's most innovative, stand-alone post-graduate university BIM program to meet industry demands and produce graduates immediately employable because of their openBIM immersion. The course should be designed and structured to comply with buildingSMART's openBIM philosophy and uses and teaches exclusively openBIM-compliant and IFC-friendly software.

Project Description

The project was conducted in four stages consisting of initial investigations, review and decision to proceed, major investigations and programme structuring, and final approvals and launch. Thorough and extensive research into peer-reviewed publications of education in BIM revealed the essential importance of openBIM







emphasis in university education. Further, extensive consultation with industry professionals and, in particular, substantial support from buildingSMARTAustralasia (bSA) members, reinforced the need for an openBIM and IFC emphasis in all subjects.

Within eight months of conception, Australia's first thoroughly (and formally) researched and industry-informed stand-alone suite of three 'stacked' post-graduate programs in BIM, with relevant associated Lean construction and IPD content, were launched. The three course programs, a post-graduate certificate, a post-graduate diploma and a master's degree, have been designed to teach strictly in alignment with bSA-endorsed BIM frameworks, and use/teach only openBIM-compliant software compatible with IFC format usage.

Using openBIM for these university education programs demonstrates to students the interoperability of various BIM software platforms and allows them to experience exporting and importing files across platforms in various subjects of the programs using IFC.

The programs were developed to reflect the practical needs of people working in the industry, and thus the post-graduate BIM courses were structured in the form of eight 'micro-credential' subjects requiring only three days of study each. Similarly, there were no assignments or end-of-semester examinations that would interfere with professionals' already heavy work commitments, so all assessment was conducted on practical and authentic lines during face-to-face teaching time—a first for BIM programs in Australia. At least 50% of the program time was dedicated to practical work using BIM software that is IFC-friendly and openBIM compliant.

Highlights

- Australasia's (possibly the world's) first openBIM-centered master's degree program
- The first university BIM program in Australasia to be accredited by bSA
- Designed to meet the needs of government and industry
- Overall 50% practical work using openBIM software in dedicated openBIM lab with minimal 'chalk and talk' teaching
- First phase 'micro-credential' subject assessed during class—no external assignments or exams necessary
- Integrates Lean Construction principles and IPD studies (20-25% of the program) into full master's degree

buildingSMART openBIM Solutions

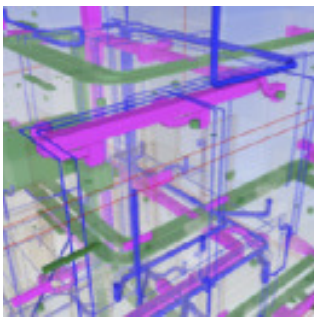
IFC 2x3, bSDD, BCF, IDM, MVDs, ifcXML

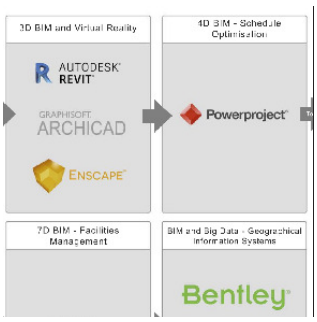
Software Used

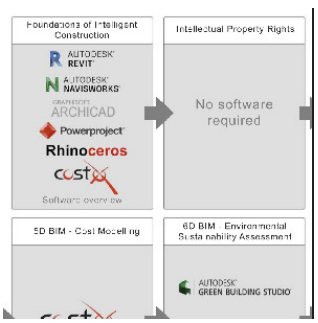
Revit, Archicad (overview), Rhino (overview), Autodesk Fabrication (overview), Enscape, Asta Powerproject, CostX, Green Building Studio, Insight, DROFUS, Solibri, Bentley Context Capture, ArcGIS, Navisworks

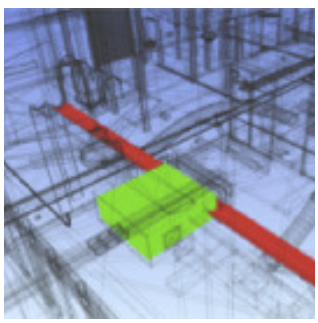
Result

The decision to teach only openBIM-compliant, IFC-friendly and bSA-aligned content results in graduates ready to practice openBIM in the workplace, confident of being able to contribute effectively from their first day. This clearly benefits both graduates and the Australian construction industry, given the rising demand for a BIM approach and, therefore, for skilled practitioners. and how they are setting the milestones for an interoperable future.









buildingSMART International

SPECIAL MENTION

Use of BIM to Improve the Energy Performance of the Existing Multifunctional Centre "Ciro Colonna"

The Sapienza University of Rome, Italy

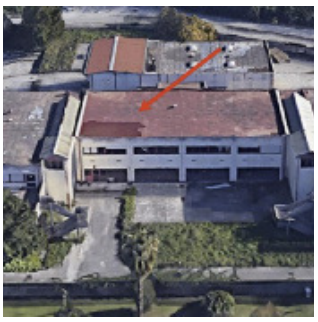
About the Project

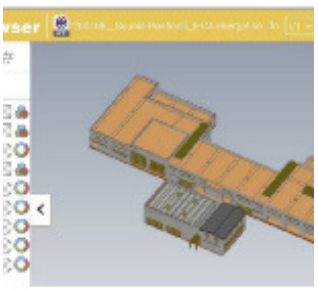
The Ciro Colonna building is an abandoned former elementary school in Naples, Italy, consisting of two buildings, the gym (350m2) and a second two-story building (3,650m2).

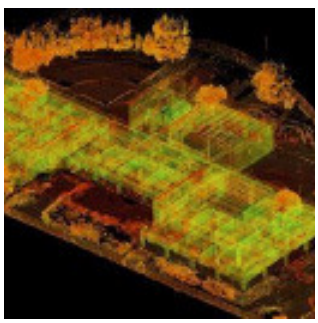
Maestri di Strada (street teachers), which is an association of educators and professionals working to counter early school leaving and promoting the citizenship of young people, obtained the concession for the use of part of the school by the Naples municipality. Thanks to a new design, developed using BIM software, the building will be revamped and used as a social and training centre to enable young people who have not been able to finish their studies to find employment. The final BIM model will be used for training purposes and the management of the facilities—by the users of the centre themselves—to reduce maintenance costs.

Core Objectives

- To reproduce the geometric design of the existing building;
- To gather information about the opaque and transparent walls' thermal properties;
- To use BIM, integrated with the above information, to evaluate the yearly energy consumption of the building;
- To use this data to design an HAVC system integrated with automation systems to ensure the best energy performance and comfort;
- To share the BIM model with all professionals and the final users of the building to ensure the optimal use of spaces;
- To use the BIM model to manage and maintain the building:
- To use the BIM model to train the school's students and local citizens, and for the refurbishment of other schools







Project Description

Maestri di Strada asked the Italian buildingSMART International (bSI) chapter to help realize the project in BIM in order to analyse the cost-effectiveness of different energy solutions and to use the model for the management and the maintenance of the building. Several Italian bSI members supported the project on a voluntary basis and their contributions included the creation of an IFC model in Revit using manual measurements, the production of a point cloud survey using a laser scanner to create a reliable geometry of all the building, the development of the 3D model in Archicad, geotechnical sampling (which provided the thermal properties of existing surfaces) and an energy diagnosis. A graduate energy engineering student from Sapienza University of Rome interfaced with all the different members and supervised the exchange of information through the application of an openBIM workflow.

Using the BIM model, several analyses were undertaken to compare the efficiency, comfort and economic value of different possible energy technologies for the redevelopment of the building. The resultant reports were uploaded into a Common Data Environment so all professionals could access and consult them. Through this collaborative platform, the users of the property and the energy engineer created a detailed use profile for each classroom of the property to estimate the energy consumption.

Through the use of openBIM and the creation of a single file, readable by all the professionals involved, the process of identifying the best energy solution was faster, cheaper and of better quality.

Highlights

- The design of the school was generated by the point cloud and transformed into IFC files
- IFC files were imported into energy analysis software to evaluate the energy consumption as it is and as it will be, to make informed decisions
- Structural engineers used the model to plan surveys and cores
- The model, enriched with information about the installed plant, will be used to maintain the building

buildingSMART openBIM Solutions

IFC 2x3, MVDs, IDM

Software Used

ARCHICAD, TerMus, ACCA Platform, Solibri Model Checker, Cypetherm, Termolog

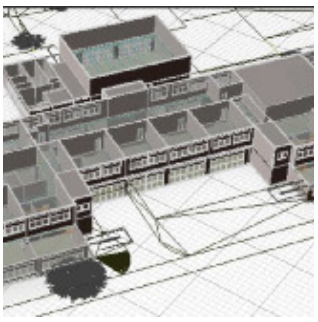
Other Standards

JSON, BIMSWARM, scaleIT, REST, MQTT

Result

One of the main advantages of using openBIM for the project was the ability to share the IFC file among different professionals belonging to different companies using different software. The IFC standards have saved time and costs while streamlining the process of identifying the best performing and best value energy solution.

The collaboratively produced model will continue to serve this project's objectives as it enters its later phases, including as a tool for training and maintenance.



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buildingSMART International

SPECIAL MENTION

Proof of Concept BIM Based Permit Check in Estonia

Future Insight, Estonia

About the Project

In Estonia, BIM is an integral part of an e-construction strategy to create more efficient public services and to provide open access to public data related to the built environment. By involving stakeholders from both the government and the building industry, a great deal of support for the approach has been established.

As the first step in this strategy, and to improve productivity within the sector, a working prototype of an online, automated permit-checking service, fully based on open standards (IFC, BCF), was created by Dutch company Future Insight for the Estonian government.

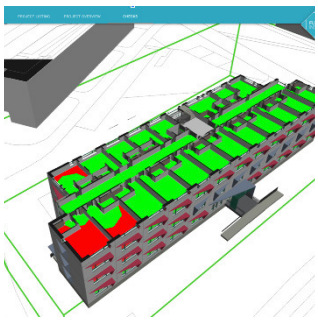
Core Objectives

In this project, the goal was to set up a BIM-based model-checking proof of concept for the Estonian government that:

- checks both building and usage permit,
- is web-based,
- has an easy-to-use interface,
- implements rule-based and (preferably) algorithm-based checking,
- uses openBIM standards (IFC, BCF),
- works based on the Estonian BIM standard.

Project Description

The first step in the project was to research comparable initiatives from other countries and to investigate the state of BIM in Estonia. The most important lesson learned was that a distinction has to be made between rule-based and algorithm-based model-checking. The algorithm-based checking approach is newer and is a response to issues that arise from the rule-based approach. It is less dependent on the quality of BIM models supplied and depends on more complex algorithms. Therefore, the advice was to develop



as much as possible using the algorithm-based checking approach.

The proof of concept was built in a full web-based environment using open-source components, making it scalable and easily accessible. Open standards like IFC, CityGML and BCF were used, as well as visualisation standards like WebGL 2. At the request of the Estonian government, the React JavaScript framework was also used. Everything was based on open buildingSMART and W3C guidelines and standards.

Through the web-based interface, IFC models could be uploaded then automatically stored in a database and visualized. Nine example checks (e.g. building height, evacuation routes, façade materials) were automatically run on the models and the results shown in the interface. Mostly algorithm-based checks have been set up for the proof of concept, but some rule-based checks were configured as well, to show the difference and illustrate the consequences.

Finally, user experience designs—in the form of mockups— were made to show how the BIM-based model-checking solution could be integrated within the Estonian Building Registry. These helped to explain to both the permit applicants (e.g. architects, project developers) and permit issuers how such a solution could make permit processing easier. During the stakeholder meetings, they understood the opportunities the solution presented and were very enthusiastic.

Based on the experiences from the prototype, a tender has been set up to create a fully functional solution to implement within the Estonian e-construction platform. In the long run, the project will increase the use of BIM and construction digitisation in Estonia, which will ultimately lead to the reduction of building lifecycle costs. Also, the efficiency and quality of public services related to the building lifecycle will improve.

Highlights

- Based on IFC and BCF standards
- Minimal additional requirements for the IFC designs
- Using an algorithm-based checking approach needs fewer bespoke requirements and makes the checks less error-prone
- By using open standards and web-based open (source) components a very flexible and scalable solution has been created

buildingSMART openBIM Solutions

IFC 2x3, IFC 4

Software Used

Open-source BIM Server, open-source BIM Surfer, open-source Voxel Server

Other Standards

CityGML for 3D city models

Result

By using the available openBIM standards, it was possible to quickly develop a working prototype that already fits in well with the daily business of both the government and the building industry in Estonia. Through the use of openBIM standards, the project team was able to develop a nationwide BIM service that connects easily to all BIM authoring tools, meaning the government can offer a software-independent service.

The solution is currently being fully integrated within the central Estonian e-construction platform, making it an accessible and reliable service for all stakeholders in Estonia.