

# **A Strategy for Design, Construction and Management Services Collaboration**

Sharing information based on the Virtual  
Building™ and the IFC object sharing protocol

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## Introduction

The *Virtual Building (VB)* is demonstrably the best solution for supporting the demands of the AEC industry for greatly increased quality, significant time savings and better value for money.

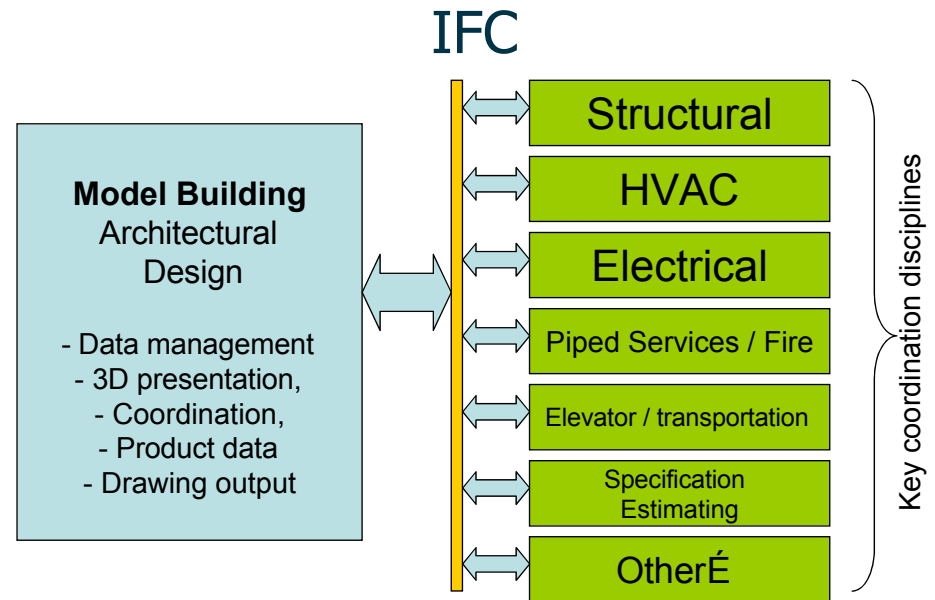
ArchiCAD's **Virtual Building™**, pioneered by Graphisoft and with over 100,000 users worldwide, offers many advantages to architects and designers, the most significant being:

- an accurate 3D representation of the building
- superior visualization & animation for design development & presentation
- automated documentation, calculation & estimation, etc.

The Virtual Building concept, based on the integrated 3D object model paradigm, is the most effective technology for the **life cycle support of buildings**, and is rapidly becoming the preferred technology for contractors and clients.

The most important benefit is that Graphisoft provides *open accessibility of data*; not just custom interfaces to one-off applications, but industry standard, *open interoperability*, based on the **IFC protocol**, allowing communication and data exchange with the many and diverse building engineering, construction and management applications now integral to an everyday project.

This, we believe, gives our users the ultimate flexibility to choose partners and tools based on prioritized business needs, performance and project requirements, rather than being restricted to proprietary alliances.



**Fig 1: IFCs enable true design collaboration, optimized building performance & lifecycle support.**

The Virtual Building concept, based on the integrated 3D object model paradigm, is the most effective technology for the life cycle support of buildings, and is rapidly becoming the preferred technology for contractors and clients. Graphisoft is committed to delivering the *definitive Virtual Building application* – providing a rich and comprehensive representation of a facility, in a language familiar to its users. In effect a powerful building model editor, the application will support the winning of business, carrying that business out more efficiently and a subsequent reduction in risk.

IFC opens up many new and more effective business processes; the whole facility development team can share data, not duplicate it. The efficiency of working processes can be increased, new performance criteria met, operations run more cost effectively and assets and property utilized more efficiently.

## The need for better quality collaboration

The integrated model concept allows default architectural coordination and design resolution through its intelligent objects. By virtue of the 3D representation of all building elements, a user can see or automatically check for clash detection, etc.

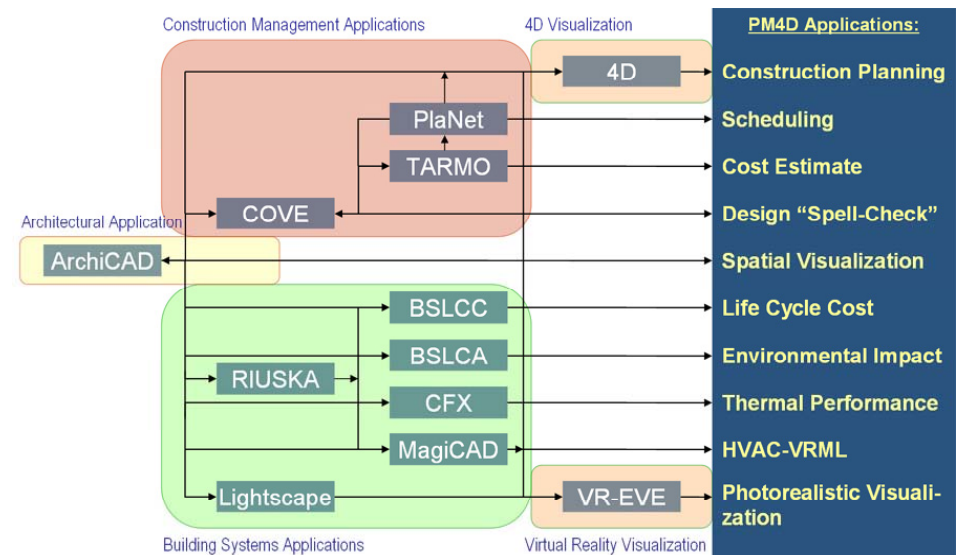
To date, this function has benefited designers as they develop the building concept. What an architect has not been able to do - due to the lack of data - is to coordinate those parts of the building that are the responsibility of external consultants, particularly structural and building services engineers. And for other users of integrated models, such as contractors and facility managers, accessing product information, procurement and asset information has been equally very difficult or impossible to obtain.

Why is *engineering* coordination so important? Because this turns out to be the very area where most errors on the construction site occur<sup>1</sup>. This is not really so surprising, considering that 2D drafting, full of many approximations and drafting conventions, ignores the 3<sup>rd</sup> dimension. In today's increasingly complex buildings, incorporating more and more technologies to support user functions and better working environments, manual coordination can never be wholly reliable and this is consistently and repeatedly borne out by independent studies.

Thus, the crucial potential advantage of reliable coordination cannot be realized for the very aspect of an architect's business where errors are most likely to occur! This is because the majority of consultants, engineers and, indeed, other participants in the facility development process, use 2D CAD, based on a proprietary format, DWG, without any agreed semantics or information standards.

The result? A multitude of information barriers, even between the same native DWG applications, or, to be more precise, a *lack of interoperability* in the processes and activities that comprise a building project. This example is based on engineering coordination, but the situation is generic for virtually any AEC application, and is widespread across the industry.

Recognizing these fundamental limitations and flaws of the 2D drawing paradigm, and the use of a multiplicity of proprietary data formats was the genesis of the International Alliance for Interoperability (IAI).



**Fig 2: Major Benefits were achieved in this milestone Helsinki University new Auditorium project**

"During the early schematic phase, object-oriented modeling software and IFCs allowed the project team to shorten the time for design iteration, develop a reliable budget for effective cost control, and eliminate the need to re-enter geometric data, thermal values, and material properties as different disciplines contributed to the design progress. Additionally, visualization tools such as photo-realistic rendering software, Virtual Reality-Experimental Virtual Environment (VR-EVE) fostered early communication among the end-users, owners and the project team, who then captured valuable inputs and effectively translated the client's intent into long term values. Building on the resulting efficiency and time-savings, the project team was able to conduct a variety of in-depth life-cycle studies and alternative comparisons on thermal performance, operation costs, energy consumption and environmental impacts. Compared to a conventional approach, these relatively seamless data exchange and technology tools substantially expedited design and improved the quality of interdisciplinary collaboration. The PM4D Approach empowered the building owners to better align the long-term facility values with their strategic plans".

*Taken from PM4D Final Report, CIFE Technical Report Number 143 by Martin Fischer and Calvin Kam, October 2002*

<sup>1</sup>See the Egan Report 'Rethinking Construction', the Department of Trade & Industry, UK, July 1998.

## A Productive Global AEC Industry

The IAI<sup>2</sup> (International Alliance of Interoperability) promotes interoperability within the AEC/FM industry by publishing an open, freely available, non-proprietary data model specification, known collectively as the Industry Foundation Classes (IFC's). Software applications supporting the IFC data model are able to exchange data with other applications also supporting the model. The advantage of a non-proprietary data model is that the content, integrity, and reliability of the data can be independently verified. Moreover, and perhaps most significantly, the commissioners of the data, i.e. the end users, can exercise independent control over their data, simply because they are not tied to a proprietary data format.

Graphisoft has been a member of the IAI since 1996, and ArchiCAD provides the most comprehensive support to users of IFC model based data sharing. Add-Ons have been provided for every IFC release to date.

The adoption of the IFC exchange protocol as an ISO standard has been a major milestone; it is now **the** definitive global construction exchange protocol; but an equally significant milestone was reached in May 2003 with the publication of the latest release, 2x2, of the IFC model.

New functionality is now available for:

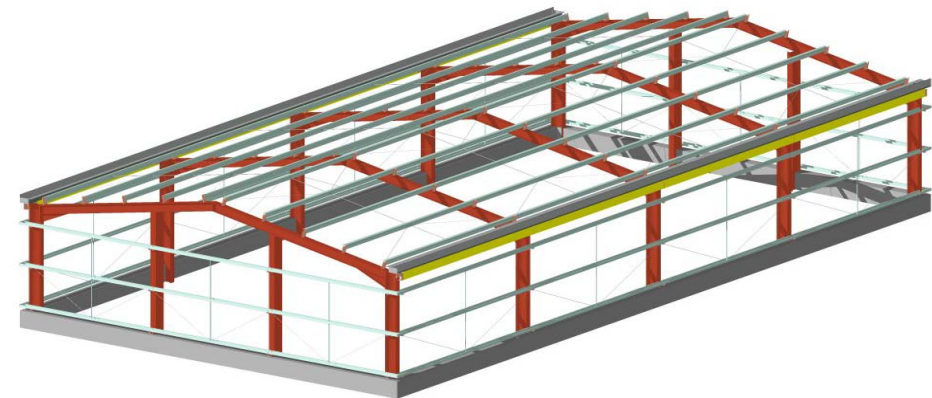
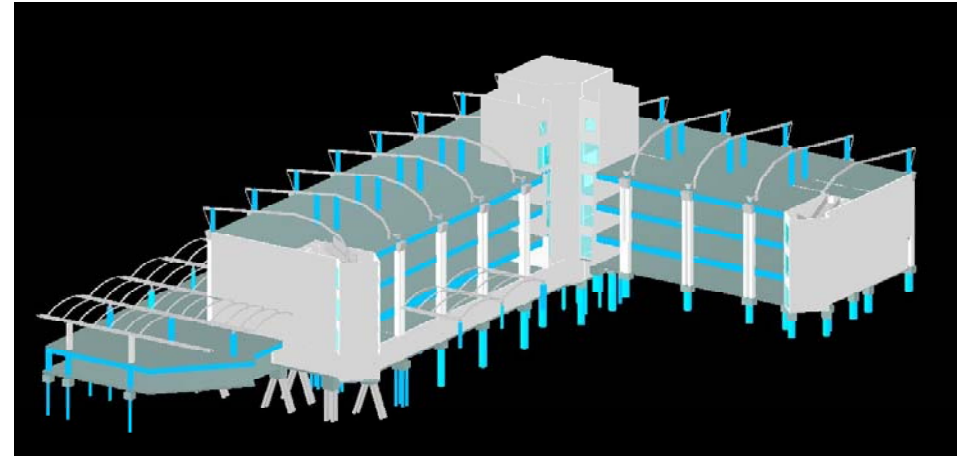
- visualization (rendering and lighting)
- structural analysis & engineering (concrete & steel structures)
- HVAC design and performance simulation
- electrical design
- facilities and property management

This release can be considered as the transition from the shell of the building to the services and systems contained in it. In functional terms, a move from plain geometric coordination to design, simulation and management processes integration. This was never possible in the 2D CAD environment.

Related processes, such as costing, construction management, procurement, and facility management, together with augmented design are now possible. With this latest addition, the IFC model now addresses the representation of all the major elements and processes in the procurement and management of a building, and is a mature version ready for widespread implementation *This is the real turning point in Object Model Development!*

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<sup>2</sup> see <http://www.iai-international.org/>



**Figs 3 & 4: Two structural models, Concrete Elements, Wallace Building, TAFE, Brisbane Australia & Factory Proposal, Ward Engineering, Ireland.**

The structure is a crucial activity in the building phase as the majority of construction activities depend on the structure being in place. For designers the structure represents a key element of the design concept, and integrating and coordinating this with HVAC services is a major task.

## Enabling your business

Our experience and ongoing dialogue with users has made us aware of the need to make this new collaboration process as natural and easy to use as possible. We are aware of the potential dangers in attempting to write software outside our expertise, for example HVAC.

Instead, our solution is to provide a data sharing mechanism to enable connection to *any application* supporting the IFC standard. This will extend our users' options well beyond our current thinking, and allow the collaborating partners to maximize their respective roles in ways never envisioned in the 2D paradigm.

In this more detailed view of the object model paradigm, let us now consider the collaboration between an architect and an HVAC engineer. Traditionally, the architect gives the plans, elevations and typical sections of the building to the engineer.

The engineer has to establish the room usage, calculate room volumes from the plans and sections, determine the construction materials and work out the building location and orientation before the HVAC load can be calculated. Only then can the routes and sizes of ductwork, etc. be put into plans, which are then sent back as a new layer on the 2D plans originally provided by the architect.

Contrast that with the ArchiCAD IFC enabled approach: The architect sends the engineer the full geometry of the building concept in an IFC file; the engineer has immediate access to the spatial layout, dimensions and room volumes, and can see if the architect has selected specific construction types for the walls, skeleton, etc. The HVAC engineer, now accessing much richer and more integrated data from the architect directly via the application, fills in the missing design parameters and begins designing the HVAC system.

Instead of repeating this at significant points in the major design, the architect and engineer are now free to simulate multiple concepts at a broad level, or to fine tune a selected concept using specific optimized solutions.

In this example, the engineer's library is based on intelligent 3D objects, the system automating the selection of these, once the system parameters are set. Subsequently the service proposals are returned to the architect; not as a set of plans, but as a compilation of 3D objects embedded accurately in the architect's master model. The architect can now truly coordinate as the design is refined, inconsistencies can be identified and accurate visualizations of the building viewed, initially with the client & subsequently with e.g. the construction manager.

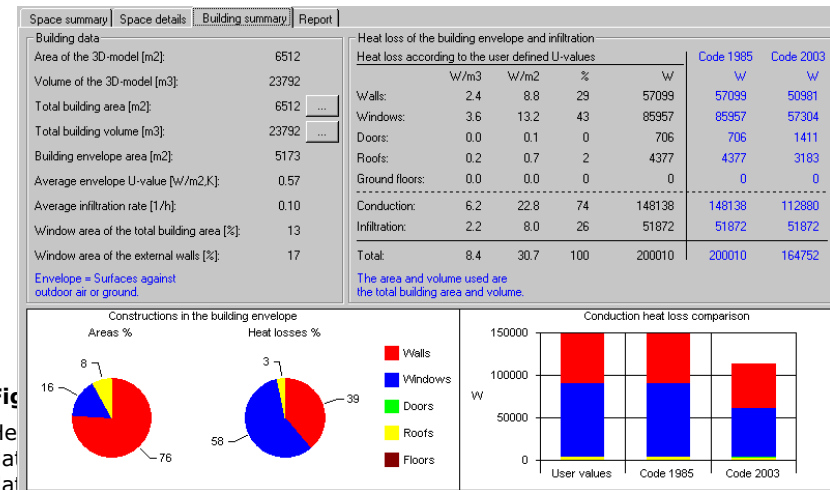
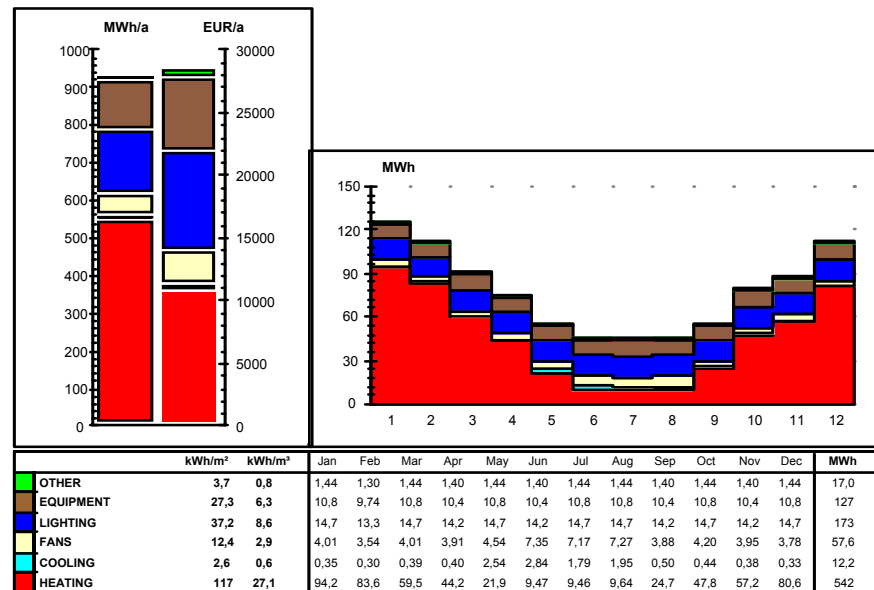


Fig 1. Heat data based on thermal performance was quickly calculated and the design compared both against the current and new (Oct. 2003) Finnish energy codes.



## AEC Industry-wide Data Compatibility?

That is exactly Graphisoft's second mission:

*To support object based collaboration with the most comprehensive range of industry users and application software, using the IFC protocol, enabling the building of high quality, accurate models to support the whole lifecycle development of facilities.*

The rich model now becomes an indispensable asset for contractors for estimation, procurement and construction management, and, once updated, a fundamental resource for owners and clients to plan and manage their assets.

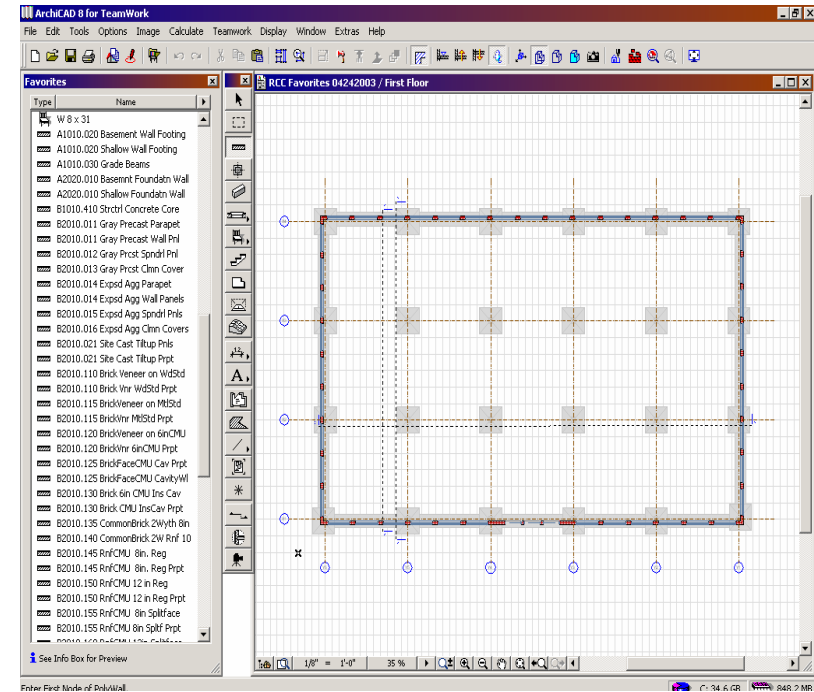
We are currently implementing new solutions to enable an architect, design manager, contractor or owner to manage a master model, composed of multi-disciplinary data, shared through the IFC protocol. This new functionality, web-enabled and based on technology already established in the advanced manufacturing sector, will allow the development and selection of multiple design concepts, versioning, auditing and, of course, the management of each specific discipline or an individual consultant's data.

## Complete Lifecycle Collaboration.

We are currently implementing new solutions that enable an architect, design manager, contractor or owner to manage a master model, composed of multi-disciplinary data, shared through the IFC protocol.

This new functionality, web-enabled and based on technology already established in the advanced manufacturing sector, will allow the storage and selection of multiple design concepts, versioning, auditing and, of course, the management of each specific discipline or consultant's data.

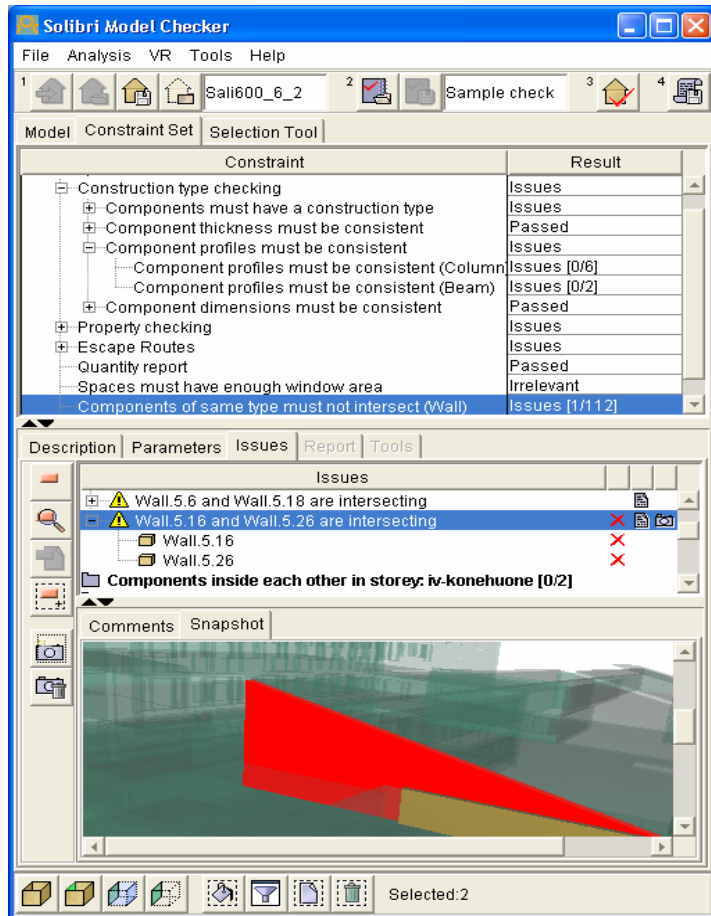
Complementing this commitment is our open invitation to application vendors, government agencies and companies to work with them to implement IFC based collaboration and to assist them in their implementation efforts.



**Fig 7: Construction Costing, R Creveling Consultants, Fort Collins, USA.**

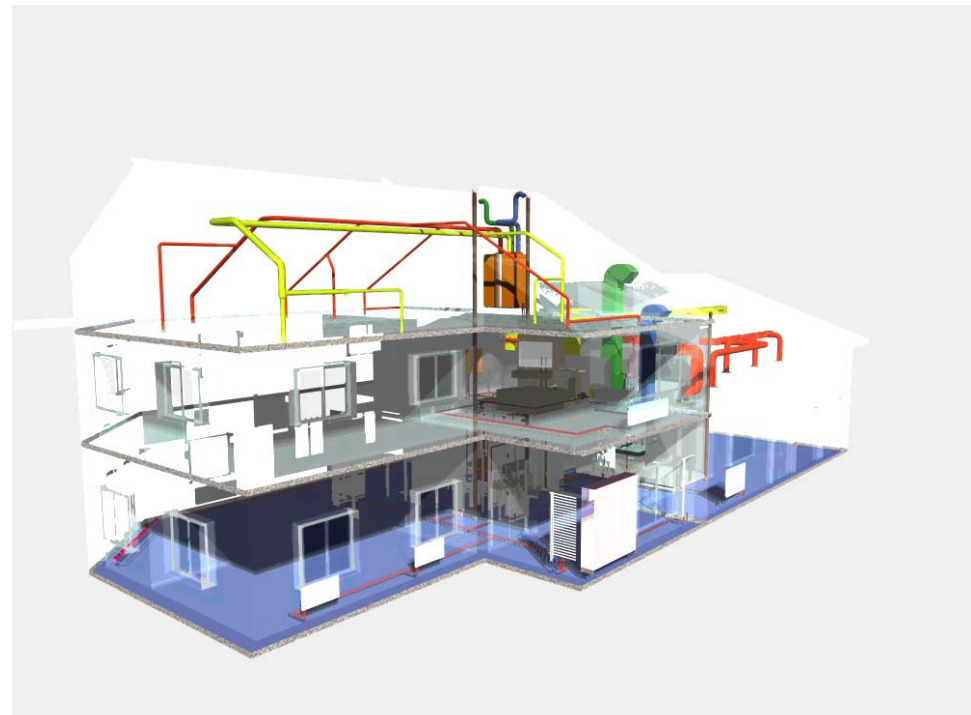
Using a predefined construction cost classification wizard in ArchiCAD, and then exporting an IFC file allows automation of estimations in Timberline's PECAD. With the cost code already defined, reducing efforts by several man-days, estimators can focus instead on applying correct rates, searching for missing or incorrect data, and concentrate on using their discipline experience to improve the final result.

These new ways of working may change the roles and tasks for some members of the facility development team. Graphisoft is committed to developing new interfaces to make it easier to populate a model with data that improve the collaboration processes, and lead to improved building solutions.



**Fig 8: Solibri Model Checker, HUT600 Project, Finland.**

Building integrated models demands new tools. The models contain much more information than 2D databases, and data are re-used by many more processes. SMC imports the IFC file, and then analyses the data based on spatial logic, 3D geometry and custom rules defined by organizations to support their business processes. In this example, SMC has found two objects overlapping each other in a spandrel wall at the roof. Other rules can check for material specification, performance against certain criteria such as security, etc.



**Fig 9: Martin Building, Building Services Modeling, Data Design Systems, Norway.**

Modern building services systems are increasingly complex; fitting HVAC components between the building elements, structure, piped services and electrical networks requires a high level of coordination from all designers involved.

When being 'briefed' by the architect an HVAC engineer should be able to expect a model of the design proposal containing the following data:

- Room size & use
- Load factors
- Key environmental factors
- Glazing & External wall exposure, etc.

Using these data the engineer can fill in the missing parameters and design the HVAC system using product information meeting the design requirements. The design can be made to adapt to any other services in place externally or internally, as the model allows for checking of such details. Alternatively, SMC (see opposite) can be used to run a series of tests and auditing procedures. The process change is a key issue, moving from drawing and documenting to designing and simulating.

## Object Model Technology in the Real World

Graphisoft is proud to be associated with many leading international IFC based projects. Some notable examples are:

*Government of Singapore Code Checking Project* – In November 2003 the government will require building approvals to be submitted in IFC format and processed by an internal expert system. Graphisoft's role to date has been to accelerate the development of our IFC 2x Add-On to support the code checking system. This system is attracting widespread international interest, including several European governments and the Ministry of Construction in China.

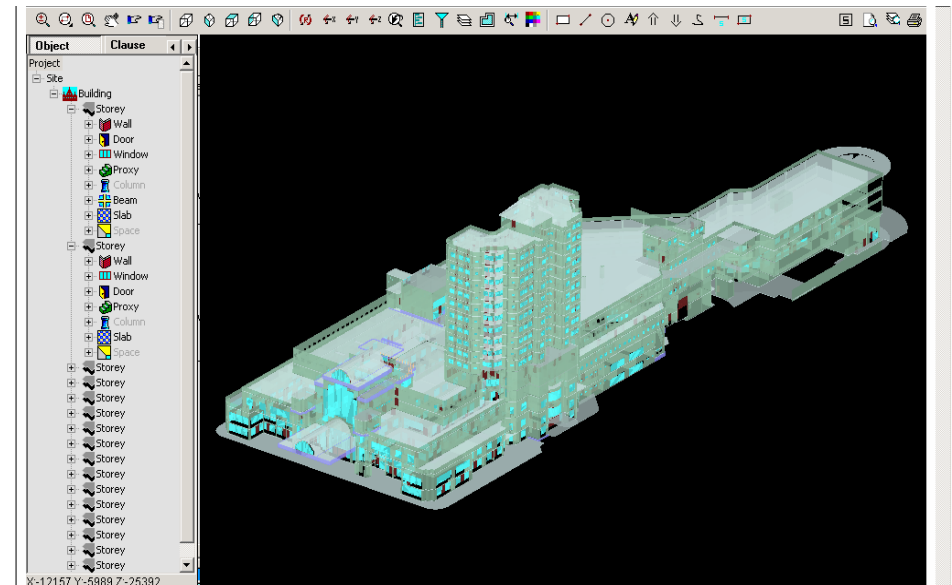
*Finland* – The Nordic region of Europe is the world's leading adopter of model based design, property and real estate management. Supported by the Finnish TEKES Vera program which undertook a 5-year construction IT program centered on object model technology, many pilot and subsequently production projects have been realized. The Helsinki University of Technology New Auditorium Project, completed in 2002, has been independently reviewed by CIFE, Stanford. The study covered both successful and less successful aspects of the project and made many recommendations for future developments, whilst their overall message strongly endorsed the approach. ArchiCAD has become the object modeling software of choice throughout the European Union Construction Research community, and is being used by leading client groups, practitioners and construction organizations.

*European Commission* – Object Model Technology, and the use of neutral IFC exchange has become the focus of the new Information, Science and Technology research program (FP6), and is expected to achieve widespread improvements in construction, based on the effective use of IT.

## Conclusion

Object Model Technology, with its supporting standard, IFC, has reached a point of critical maturity. An international protocol, the IFC model is **the** definitive open model for the representation and exchange of information throughout the construction industry.

Much has changed in the industry, and a new opportunity now exists to achieve much improved project information collaboration, thereby underpinning advanced optimization, better building performance and improved construction quality.



**Figure 10: Building Construction Authority & NovaSprint, Singapore Building Code Checking System.**

Graphisoft partnered NovaSprint in developing the IFC2x add-on for ArchiCAD to accelerate the Authority's development program. In November 2003 the Government will commence accepting Building Approval submissions using only an IFC2x export. Several other nations such as China (which has already signed an MOU with BCA Singapore), Norway, Finland and the UK are assessing the benefits of implementing similar expert object based code checking systems.