Helsinki Music Center Project

Project Context

This project is located in Helsinki, Finland. The Music Centre will give Helsinki an acoustically first-class concert hall as well as other facilities providing a wide range of musical experiences for people of all ages and a place to study music. The main users of the building will be the Sibelius Academy, the Helsinki Philharmonic and the Finnish Radio Symphony Orchestra.

The State of Finland, the City of Helsinki and the Finnish Broadcasting Company held a two-stage international architecture competition for the design of the Helsinki Music Centre, which was won by an entry entitled "a mezza voce" (architects Ola Laiho, Mikko Pulkkinen, Marko Kivistö) in 2000. The expected construction will start in 2007 and complete in 2009. The estimated project cost is 100M euro. Currently the project is in the design development phase.

Key Project Stakeholder

Owner: Senate properties (customer service coordination)
Construction Manager: ISS
Architect: LPR-arkkitehdit Oy
Acoustical Engineer: Nagata Acoustics Inc./Yasuhisa Toyota.
Structural Engineer: Mikko Vahanen Oy,
HVAC Engineer: Olof Granlund Oy
Electrical Engineer: Lausamo Oy

The Owner has been driving the use of BIM on this project. By mandating the sharing of project information, collaborative project delivery, and the use of interoperable technology, the Owners attempt to drive the integration of the processes and business workflows of all project participants, across all phases of the lifecycle of a facility.

The use of BIM by the Architect was focused on two aspects: 1) improving the effectiveness and efficiency of the Architect’s own working process (e.g., using area distribution reports from BIM as a design guideline, and using BIM to improve the productivity of producing room reports, detail drawings, and window/door schedules); 2) improving the quality of the Architect’s deliverables to their client and design partners.

When an architect takes on the role of the Head Planner in the BIM process, the challenges are to acquire new skills, for example, the proficiency to use BIM tools and to build expertise in information management and grasp more working knowledge of MEP design and field construction as more information from other disciplines are embedded in the model.

Model Uses and Benefits
On this project, 3D models have been used for spatial management, architectural design of complex spaces, visualization, design review and coordination, acoustical design analysis, cost estimations and cost management during the design process, energy analysis and life cycle assessment.

- **Spatial Management**

The connection between designers and the final user is important because the degree of capacity utilization should be clear when designing the facility. How to manager area and figure out the mathematics? Three clients: The main users of the building will be the Sibelius Academy (area 50% and cost 49%), the Helsinki Philharmonic (25%) and the Finnish Radio Symphony Orchestra (25%). The Architect used BIM to calculate and keep up-to-date with the area percentage all the time. The Architect developed an area calculation system on top of ADT. The Architect was able to check with the area calculation and generated the area distribution report every 15 minutes or so. This was done not for a reporting purpose but for a design purpose. The prompt feedback from the area distribution report was important because the Architect could use the area distribution report as a guideline for the further design. In addition, during the schematic design phase, the Architect had to change the space plan frequently taking consideration of the users’ requirements and the Owner’s cost target. It was important to make sure the area percentage for each user is correct and accurate. In this way, the Owner could manage the rental level for different users and the profitability of the shared spaces.

- **Architectural Design of Complex Spaces**

The Architect used the model to generate schedules, such as room reports in Excel spreadsheet). The room-relevant data such as function requirements, materials (e.g., sound insulation panels), fixtures, furniture, and equipments installed in a particular room is stored in an external database which reads from the model and the model is the access point to the data. Usually producing room reports for approximate 800 rooms in this building is a laborious task because there are constant design changes that involve a lot of complicated and detailed issues. The other example is to use the model generate door schedule. In this project, there were 1,400- 1,500 doors (excluding specialized technical doors for chases) in the model. With doors, there were other issues involved such as security, card readers, automated shutting systems, etc. Without the model, it would be difficult to update the door schedule immediately and efficiently. Along with that, there would be risks such as missing a door or doing the double work for a particular door.

The Architect also used the 3D model for his own design analysis. For instance, one of the big design changes was to move the location of the library. The Architect finalized this design decision with the study of a dozen of variations, which would not happen without the use of 3D model.

- **Visualization**

The Architect used 3D models to communicate design ideas with the violinists.
• **Design Review and Coordination**

At the time of interview, the Architect just started to combine architect’s walls, doors and windows with the structural framing and the HVAC plant and piping, to create a composite model in Navisworks. This composite model was intended to enable the Architect to coordinate the integration of design from various disciplines and to detect clashes between trades. All the design-related issues found out from this model review are discussed and solved on the weekly design coordination meeting which is independent of the product modeling meeting. One of the Architect’s remarks is that the benefits of BIM for the entire project team are not shown until the composite model is created.

• **Acoustical Design Analysis**

On this project, the model-based analysis made by the acoustics design engineer has a significant influence on the architectural design. For instance, the Architect initially designed one of the partition walls as a straight wall. But the feedback from the acoustic designer suggests a titled wall instead of a straight wall because the sound reflection effect is not satisfactory in the latter case. Also the ceiling shape was finalized with the prompt input of the acoustic designer.

• **Energy Analysis and Life Cycle Assessment**

The HVAC Engineer did CFD simulations of the Foyer area. In doing so, they optimized the design by comparisons of different supply air terminal devices. CFD simulations enabled over 20% reduction in the HVAC system of the Foyer.

**Level of Detail in 3D Models**

The Architect won the architectural competition for the project in 2000. The architectural design at that time was actually 2-D based rendering of design concepts. After a 3-year standstill, the Architect started their design work in BIM in August 2004 and has been moving into the design development phase. During the schematic design phase (August 2004 – April 2005), the Architect first converted the old drawings that were prepared for the competition into a 3D model. This model only entailed sketchy information including walls, spaces, and slabs without windows, doors, and details (the printing scale of 1:500). This model was updated and enriched as more design information came along. The Architect has been designing this project directly with the model (in the 3D mode rather than the 2.5 mode). One of their experiences was to avoid huge time losses during the 3D modeling due to the tendency to incorporate more detail in the 3D models than necessary for the respective design stage. The Architect still had to put enough details in the model so as to produce all the 2D plans (1: 100) and most 2D elevation and section drawings (1: 50) directly from the model. In this case, the product model was not comprehensive enough for generating all the drawings and 2D drafting had to be used for patching the construction documents.
In Finland, architects are not only responsible for schematic design and design development but also responsible for detailing. How much detail should be put in the 3D model if it is used for drawing production? The architect on the Helsinki Music Center project categorized details into 3 main groups. Model-based details would have the printing scale of 1 to 50 for sections and elevations. These kinds of drawings were linked directly to the 3D model and updated with the model. Hybrid details were details that might have their major components generated from the model (such as a wall section), with smaller components like clothes hooks drawn on top of the model-based elements. 2D details at the printing scale of 1 to 10 or 1 to 5 were created completely from 2D geometry and had no real link to the model.

The complex IFC naturally results in big exchange files for big models. With ADT, the Architect had to keep the file size versus the model size low and figure out the way to split the model into smaller pieces of chunks because the file size of the whole model became so huge (150 MB) that almost reach the modeling limit (due to the memory footprint of the model) of HVAC engineer’s software (200 MB). Currently the Architect split the model by levels (stories). One of the challenges is the split-level in which the floor level of one part of the building is about half way between a floor and its ceiling of the other part of the building. One solution is to split the model by each elevation including the floor levels and split levels. The other solution is to split the model merely by the floor levels which have all the elevation variations inside of each floor. The adoption of a particular solution depends on the purpose of model use. For example, the second solution is sufficient to handle typical cases. But for the purpose of architectural design, the first solution is adopted. Beyond that, the architect also further split the model according to the different functions of spaces. Therefore, the architect has split the model to a lot of small pieces (approximate 1,000 files).

One of the Architect’s viewpoints is that the level of detail in the model is determined by the purpose of model use. For example, for the purpose of design, it is wise to model the curtain wall system with a high level of detail so as to study the feasibility of some innovative design concepts and to look into the impact of one aspect of design (e.g. connections between the curtain wall and the main structure) on the whole building. But for the purpose of cost estimation, there is not necessary to model the profile such as every parts and connections for the curtain wall. Another viewpoint of the Architect is that the more important and interesting part, besides the level of detail in the model, is the information behind the model. Even a rough-looking model can have rich information attached to the model.

The modeled scope of work in the current structural model was the main concrete structure. The Structural Engineer also followed the Architect’s way of splitting model by levels. One of the challenges that come along with the BIM process is the constant design change, for example, the change of member sizes.

**Model Sharing and Data Exchange**
The Architect has been publishing two kinds of models onto the project bank/server: official models and unofficial models. When there was a need for cost estimation every two or three months, the Architect did a formal model checking with Solibre, completed the cleanup of the model, and made sure the model was accurate enough for quantity takeoff. Afterwards the Architect published the official model. Every week or two, the Architect published an unofficial model or a working model to demonstrate the design progress.

The Architect also passed the model on to the Construction Manager (CM) for quantity takeoff and cost estimating during the design phase. The Architect also double-checked the quantities derived from their model and compared that with the CM’s list of quantities. The Architect also shared the model with the Structural Engineer, the HVAC Engineer, the electrical engineer, and the Acoustics Design Engineer. They used the architectural model as the reference for their own design. The Architect also shared the model with the city planners who were piloting the use of BIM for design review and building permitting.

The way to share the model on this project was still in the fashion of information push rather than information pull. That is to say, the Architect simply delivered the whole model to the Structural Engineer and it was the Structural Engineer’s call to decide which wall or slab from the architectural model he/she would like to incorporate into the structural model. Every week varied parties on the project convene and discuss all the BIM-related issues on the product modeling meeting.

3D Software

ADT was used as the architectural design tool because: 1) the long time tradition of using AutoCAD in the Architect’s firm; and 2) it is more efficient and secure to deal with a large and complex project by dividing a big model into multiple files; 3) AutoDesk provides more flexibility in its API for developers customize the modeling tool.

One of the interoperability issues was that ADT (the software used by the Architect) can not read the style information of a 3D object in AllPlan (the software used by the Structural Engineer). To solve this issue, the Structural Engineer put all the 3D objects that had the same style in one layer and used the layer name to denote the style information. The layer information from AllPlan was then stored in the IFC file and then read by ADT. Another interoperability issue occurred because different 3D modeling software has different ways to handle a model. The Architect handled the model in ADT with multiple model files while the CM handled the model in ArchiCAD with one model database. Initially the Architect had to spend half a day every week putting together different model files and delivered them the CM for cost estimating. Later the Architect developed an applet on top of ADT for the purpose of file organization. Consequently, the file organization process only takes 15 minutes.

The Architect has two items on the wish-list of improving their BIM practice: 1) experimenting with other tools such as Revit; 2) more efficient and effective use of modeling software by developing customized project tools.
Allplan was used as the structural design tool because: 1) The Structural Engineer’s firm is a comprehensive design firm and Allplan has a whole software suite that specific modules for Architecture, Geo, Structural Engineering and Analysis. 2) The Structural Engineer’s firm has established a strategic partnership with Nemetschek AG. On the structural engineer’s wish-list is the improvement of data exchange in IFC. For example, one of the problems they came across was that the curved walls were missing when the model was converted to the IFC format. In Allplan, the actual design and data creation process happens in drawing files. The Structural Engineer worked with the files and filesets dialog box, drew the individual building elements (such as walls, stairs, labeling, etc.) on different drawing files, then displayed and edited several files simultaneously.

The Electrical Engineer and HVAC Engineer both worked with MagiCAD

**Work Process**

The Structural Engineer’s firm is working on developing company-wide standards and guideline for BIM such as file naming, layering standards, handling external (non-graphic) data, color and line weight mapping, guidelines for external references, and the actual process of data export and import, etc. They also follow the national standards Talo 2000 in the process of modeling (e.g., the drawing number).

The Structural Engineer’s firm has a project team working on the HMC project. Three major function roles in this team are structural calculation engineer, structural modeling engineer, and drafting engineer. The 3D structural model not only helped the structural calculation engineer better understand the design but also provided information such as dimensions, frame, and locations, etc to the calculation engineer for the purpose of structural analysis. The calculation engineer, in return, gave the modeling engineer input such as structural member sizes. The drafting engineer used the structural model as an underlay for the actual detail drawing.

The electrical design involves defining the location and routing for components to comply with design and operations criteria. The Architect handed the architectural model (in DWG file format rather than IFC format) to the Electrical Engineer. The HVAC Engineer passed the HVAC model (in DWG file) to the Electrical Engineer. The Electric engineer imported the DWG files to MagiCAD Electrical as reference drawings, and worked on the design of electrical and lighting system both in the conventional 2D and in full 3D. The Electrical Engineer drew the cable trays and luminaries in their actual 3D dimensions (by adding the elevation information). In this way, they can avoid costly mistakes at the early stages of your project. In addition, the Electrical Engineer checked the collisions with ADT objects directly from the reference drawing and found the locations where the electrical installations may collide with other installations or structures. Because the Electrical Engineer and HVAC Engineer both worked with MagiCAD, they can cross-check the collision between the ventilation, piping and electrical installations any time. This is a great benefit. Valuable time can be saved and cooperation among project partners gets very easy. The modeled scope in the electrical
model included the distribution system (generator, switchgear, and control board), cable trays, conduit/wire, switches, sockets, luminaries.