AS124409

Revit for modular design, prefabrication and repetitive layouts.

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Learning Objectives

Get insight into a large-scale hospital project with an ambitious BIM delivery and a proposed modular and panelized construction.

Learn effective ways to evolve a project from conceptual phase to an industrialized developed design.

Learn new Revit workflows to effectively control and develop a modulation strategy which can also be used for repetitive design.

Get examples of cross-disciplinary modular information flow and the types of analysis used to assess the modulation strategy and the project as a whole.

Learn strategies for streamlining modular information to the building industry and simulating construction sequencing.

Description Showcasing the 100,000m2 University hospital of Stavanger we will introduce new workflows in Revit for the seamless design of cross discipline modular and prefabricated components. The Scandinavian hospital proposes a giant lego-like assembly in its construction and tests new workflows and currently unreleased Revit functionalities to enable the efficient control and development of the prefabrication strategy parallel to the overall project design. We will present an interdisciplinary BIM workflow for the drawing and analysis of prefabricated modules and show new techniques in data management which have allowed us to monitor component changes, identify deviations, and align project outputs with the information demands of the building industry. This class will also demonstrate how this methodology can be applicable to schools, hotels and other repetitive or prefabricated projects.

Bridget White

Architect / BIM Manager Nordic Office of Architecture

Bridget White is originally from New Zealand, and completed an honors degree in Architecture at Victoria University in 2006. After beginning her career working in New Zealand she moved to Norway to start at one of the countries largest practices - Nordic Office of Architecture. She is an Architect, Breeam AP, BIM manager, and BIM Coordinator for large scale airports, hospitals, schools, national governmental facilities and transportation hubs. She is part of a team of experts at Nordic using a wide range of Autodesk products and implementing new office workflows involving complex analysis, virtual reality, integrated sustainability, and streamlining the flow of information between architects and the building industry

Kristoffer Tungland

BIM Manager / Electrical engineer COWI

Started as an electrician and later he completed electrical engineering education in Bergen, Norway. He has a like to solve and program processes, which are often performed repeatedly, to get a better flow in the design phase. He has experience from the construction process and uses it in combination with programming to solve disciplinary and interdisciplinary challenges. Works daily with customization and an add-in for Revit in the company and for projects.

The Stavanger University Hospital (SUS 2023)

Introduction

The Project

The Stavanger University Hospital project in Norway proposes a 100,000m2 first phase with a dedication to providing high quality hospital and research facilities within the allocated budget, with onsite completion in 2023.

The site lies adjacent to green areas and its four main buildings are situated around a central court with collective transportation routes along a main axis. The buildings are connected through an underground culvert and a continuous ring of glass bridges on the second and third floors. The hospital provides emergency, helicopter and operation facilities, bedroom wards in three of the buildings, and well allocated spaces for staff and visitors. Its 628 bedrooms are all single occupant with on suites, and with central atriums in each building, the connection to nature and natural daylight is prioritized for enhanced patient recovery. The project is standardized to the greatest extent possible for good patient safety, flexible use, and easy to change functions in the future.

The project team consists of two architecture firms: Nordic Office of Architecture and AART, two structural firms: COWI and Aas Jakobsen, MEP: COWI, and landscape architects: SLA.

Above: Site plan of SUS. The buildings are positioned around a square with a collective axis and connected by a ’Ring’ of glass bridges on the second and third floors.

Below: Bedroom and courtyard interior perspectives.

Project BIM delivery

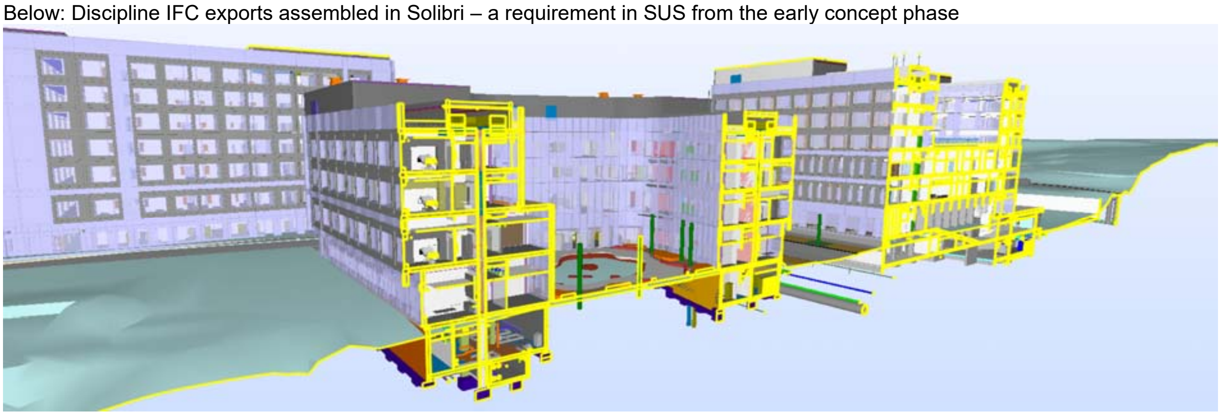
The projects ambition for efficiency through digital based communication, lead to a high level BIM strategy from the early phases.

This delivery currently includes the following:

- All disciplines delivering full BIM models in IFC (exports from e.g Revit, Tekla, Civil 3D)
- Wind analysis
- Full analytical analysis and airflow analysis
- Energy analysis, daylight analysis, environmental performance analysis
- Synchronization with room database (dRofus)
- Quantity take off from sketch phase
- Area control
- Augumented reality – Oculus rift with Revizto and Enscape
- BIM cave
- Object status
- Crash control
- BIM model connection to critical path – construction simulation
- Paperless
- Model connection to PIMS / Safran

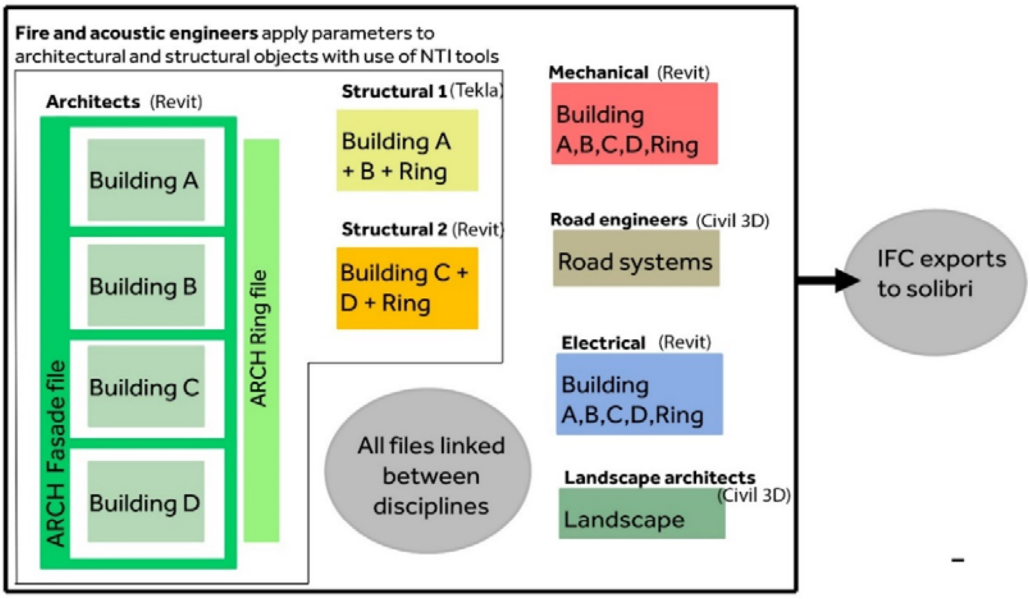
Above: The use of the BIM Cave to communicate the project design in 1:1 with use of the model

Below: Discipline IFC exports assembled in Solibri – a requirement in SUS from the early concept phase



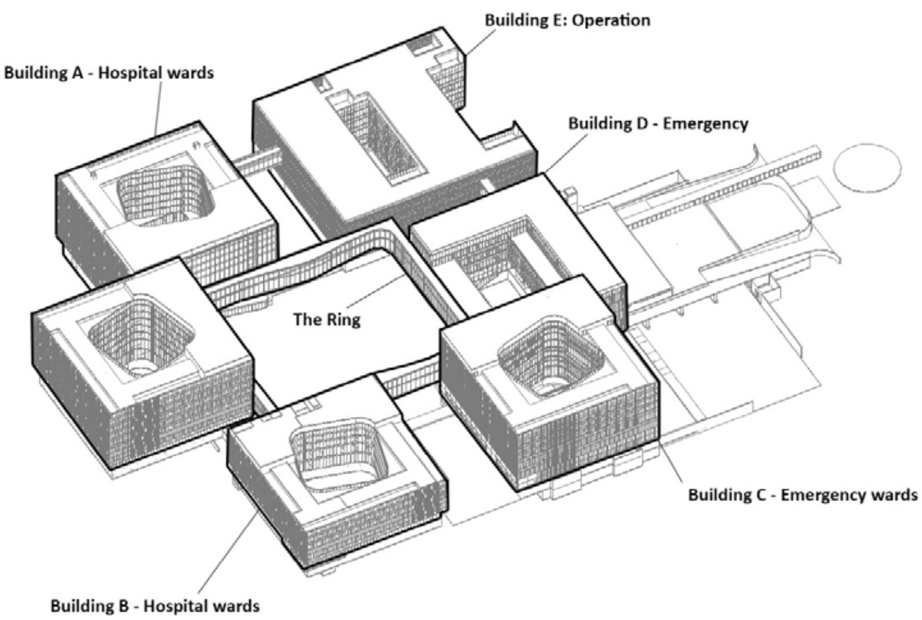
Project file structure

In the conceptual phase project files were divided up as follows due to size.
The delivery file format for this type of project is - in Norway - determined by the government, which stipulates that all projects are exported to IFC.



Above: In the initial phases, only the architectural file was divided due to file size. All files are linked but exported to IFC for file delivery.

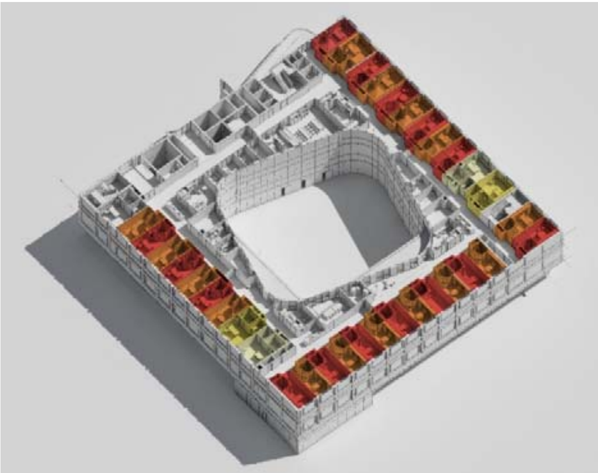
Below: SUS building names and functions.

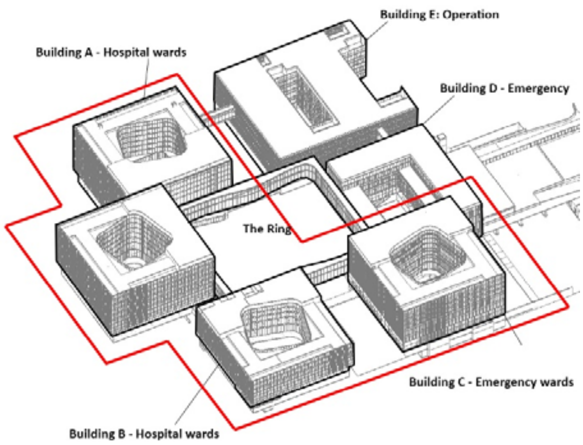


SUS 2023 - The conceptual phase

Early evidence of repetition

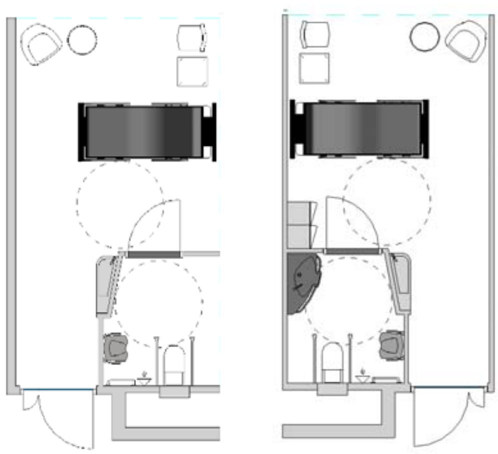
Due to the nature of the project, repeating geometry is abundant, and in the early phases grouping in Revit provided the opportunity for most disciplines to increase the effectiveness of modelling duplication.
This type of element repetition can be substantially different per discipline. For example for the architects: the repetition of hospital bedroom/bathroom layouts, and MEP: duplicate system solutions per zone and repetition of outlets and light fixture placement.





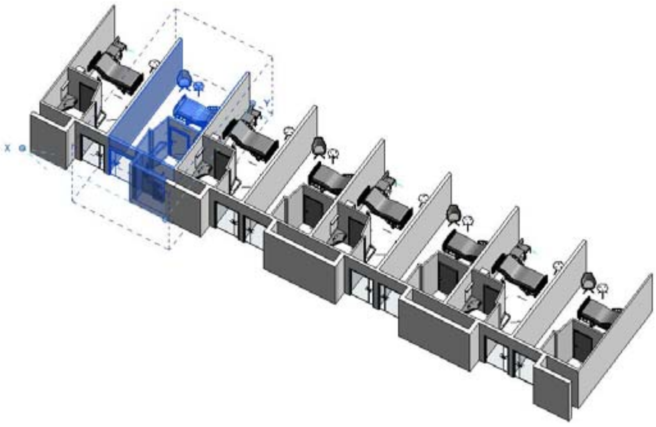
Above: The architectural model identifies design repetition with duplicated bedroom layouts in the ward buildings.

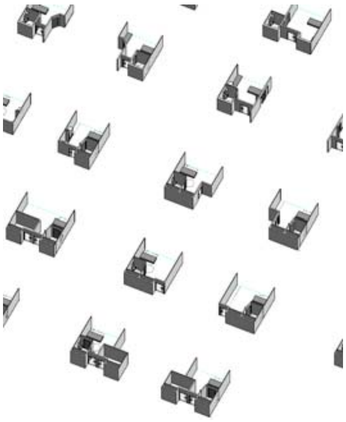
There are pros and cons to the use of groups to model repeating design and due to the complexity of evolving alternative layouts in the conceptual phase and the need for consistently accurate quantification, many architectural groups were reduced or separated to ‘furniture’ room groups and one sided room grouping.
If you are planning to use groups for repeating design in the early phases, consider your team structure and deliveries and make an organization strategy.



Beside: Two methodologies of grouping repetitive elements in the early phases. The example of the left (half walls) results in extra calculative work to remove double quantities, and the example on the right gives warnings for overlapping walls with room separation lines.

One of the major benefits of grouping repeating design is the existance of a local base point within the group allowing the switching in and out of different solutions by aligning these points. With this we can also create a library of layouts for future use.



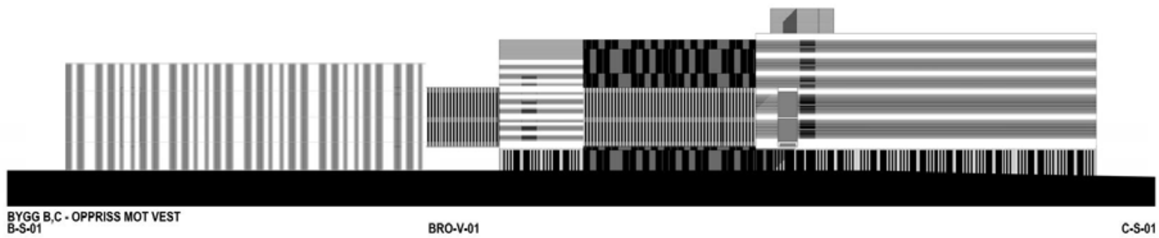


Above left: Bedroom groups can be swapped in and out by their base point location. Right: Revit retains a history of groups -like a library.

Note! Only one person can work on one group at a time resulting in reduced collaboration, and if using design alternatives, groups must be modelled <u>cleanly</u> as intersecting geometry will cause problems in their interaction with main model elements.

The evidence of repetition in the façades

With 50,000m2 of façade area, façade repetition was also a key area for advantageous modelling strategies. In the initial concept phases, the facades were quantified traditionally and drawn using curtain wall workflows, taking advantage of the duplication of singular material panels by using global parameters and intelligent curtain wall types.



Above: Early phase façade studies using curtain wall types

SUS - The developed design phase

The introduction of a modular strategy

The project, after completing the initial conceptual phases with traditional build quantification, moved forward with the concept of an industrialized construction strategy.

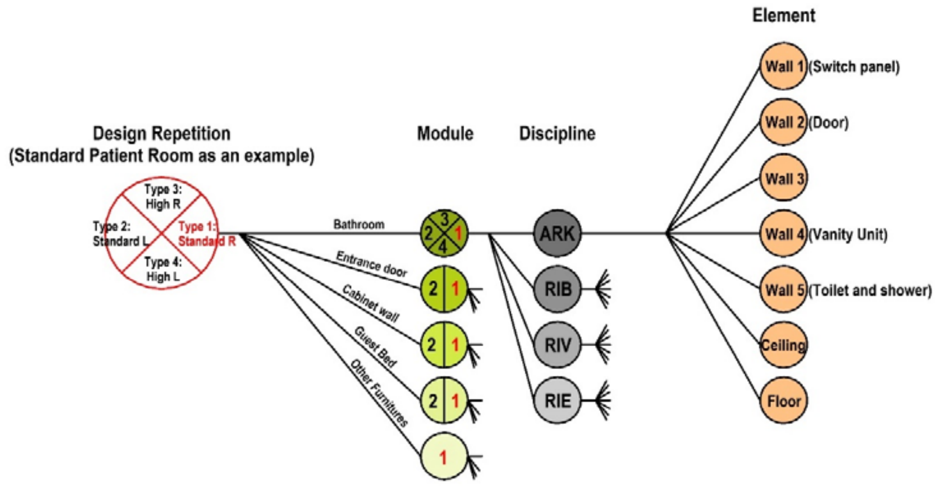
Why industrialised?

Besides cost, quality assurance, standardization and increased building efficiency, innovation using industrialization is the perfect fit for SUS due to a recent down turn in local oil production. This has resulted in many highly skilled engineers and industry workers left unemployed. Using the fabrication expertise from the Stavanger oil industry, the project and the available workforce together has become a highly effective collaboration.

Designing the strategy

To assess the project for possible areas for industrialization the project went through a 'potentials map' design process.
The 'potentials map' was populated with opportunities but also defined by constraints coming from both local and project based factors. Some examples included –

- The limitation in the transportation size of elements in Norway restricting module dimensions
- The use of medical gas meaning certain systems can never be part of modules (regulations for installation and the joining of parts)
- A client approved design layout meaning the modulation strategy could not create additional structure appearing in undesired locations.



Above: identifying potential modulation opportunities in SUS

To legitimize the buildability of the modulation strategy after the 'potentials map' assessment, the project involved industrialization professionals Bryden Wood. Bryden Wood currently have active projects involving innovative modular workflows, and use BIM actively for project projection analysis and accuracy in the breakdown of parts.

Improving the efficiency of repetition using BIM

This type of construction strategy highlighted an already identified potential for better control of repeating parts in Revit. It also created the need for cross discipline information specifically tied to the modulation strategy.

After a series of meetings and workshops with Autodesk and prefabrication experts Project Frog, we formed a BIM process development plan to:

'Design BIM workflows for the seamless development of cross discipline modular and prefabricated components in parallel to the overall project'.

<u>Process development objectives</u>

- Enable more efficient cross discipline control and analysis of the modulation strategy
- Take better advantage of duplication
- Present the modulation strategy through open platform file format (IFC).
- Align project outputs to the information demands of the building industry and produce the right level of information at the right time.
- Take control over modular construction sequencing

<u>Whilst</u>

+ Upholding the demands of the design deliveries and full visualization
+ Upholding the demands for full project analysis
+ Maintaining a workflow that is suitable and accessible to all users

The result - an industrialized approach to Revit

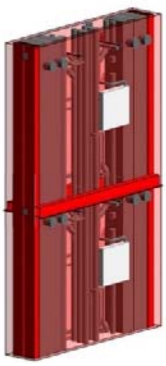
New team organization – responsibility structure

The project created a dedicated responsibility structure for the modulation strategy. In addition to the per building responsibility structure, modulation team members were given a per module responsibility and a dedicated module BIM manager.

Module type-list

A type-list formula was established to ensure both panel and module organization within the model, and this system of categorizing would be translatable to the building industry.

Module	Code/dRofus nr.	dRofus Name	Specification	
V-Module	8V1.A.N.001	V-Module 1, 3630mm, Neutral, Material 1	V1 = V-Moduel Type 1 (1st. room+1st. room) A = Height 3630 N = Orientation Neutral 001 = Material 1, Standard	ARK
				RIB
				RIV
				RIE



Above: Type list formula example – vertical module.

Technical application

Due to the importance and speed of the industrialization information flow (both between disciplines and to the building industry), the module and panel duplication is prioritized over the evidence of design repetition, however - the same workflow can be used for repeating design layouts in similar types of projects. The resulting industrialization of the model is divided in two parts due to differing workflows:

- 1 Modules
- 2 Façade panelisation

1 – Modules

In response to the concepts of our 'industrialized BIM' objectives, the SUS MEP engineers developed an add-in co-ordination tool to Revit based on a dynamo script with a simplified interface, and the BIM team developed a corresponding cross discipline workflow. The coordination tool understands and controls:

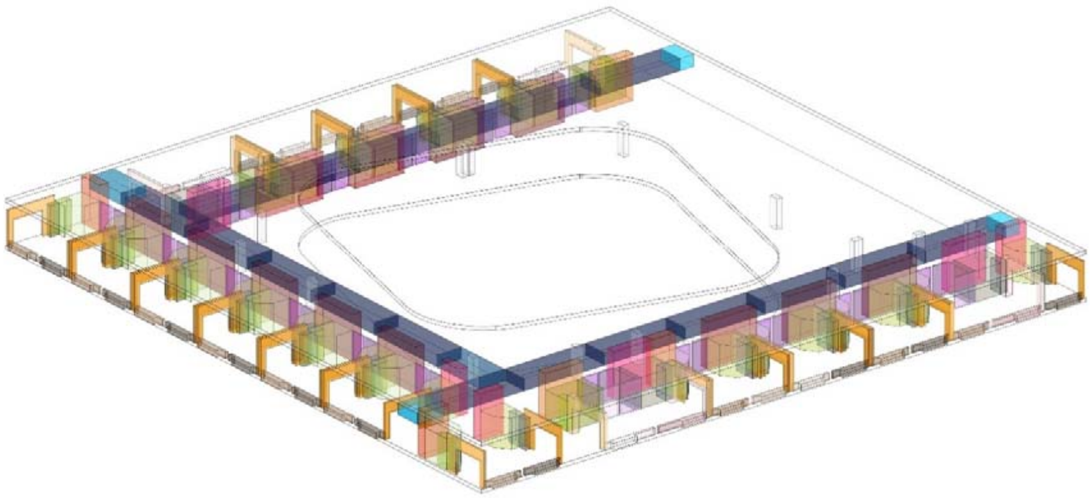
- The position (cross discipline) of modules in a model
- Relationships between elements in a module
- Parameter values of all elements within modules
- Auditing and tracking of module changes and movements

File division - the 3 file types

We use three different types of models to create an efficient and collaborative modulation workflow for the team.

A – The placeholder model (for conceptual module design)

The placeholder model is a new separated model with instances of 'placeholder' elements. These placeholder elements (masses) define the outline and location of project modules - essentially family types with local origins. The placeholder model is uploaded to a central location, and every discipline model has a link to this conceptual module model.

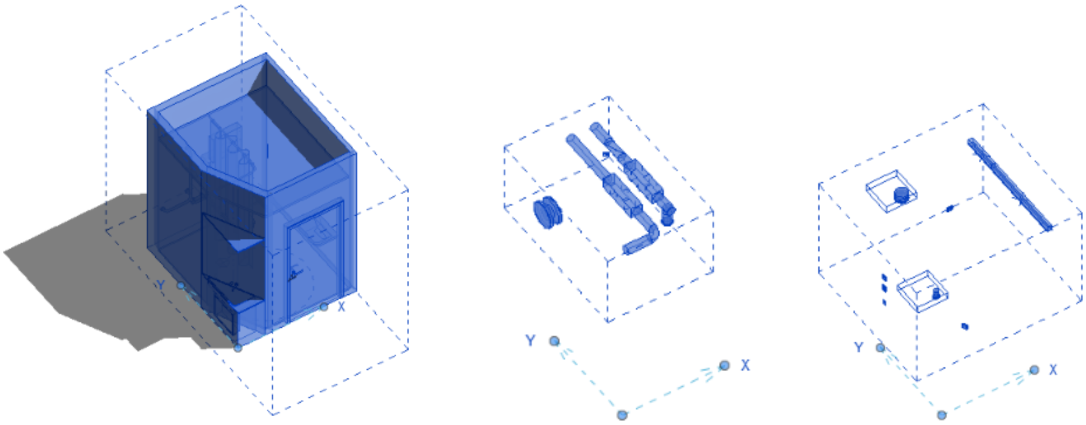


Above: One level within the placeholder file – conceptual modulation.

B - Discipline models (per discipline files – normal working file)

Within the regular discipline file, for every type of prefabrication module, one Revit group will define the discipline part of each module. All disciplines models need to have -

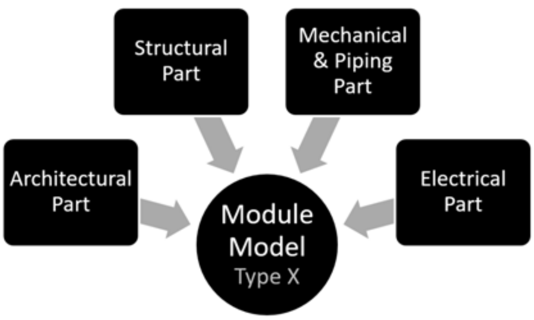
- Split elements so that modules are geometrically separated
- Made one group (or assembly) per module type and named it according to the type-list
- Assigned a group basepoint per module location (these will be in the same locations as the corresponding mass in the placeholder file)

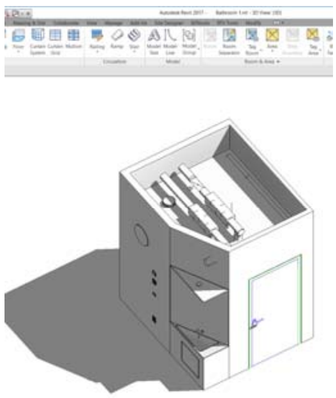


Above: Example of a Revit module group (ARCH-MEP) with a specifically assigned basepoint.

C - Module model (isolated module files created by saving out groups)

The 'module model' contains individual modules as links from all disciplines - formed by each discipline saving out their module groups as individual files. This file can be used as a complete module for prefabrication. For every type of prefabrication module in the project there exists one unique module model. Groups when saved out can also be edited and reloaded into the discipline file and these files can be used for isolated module development.





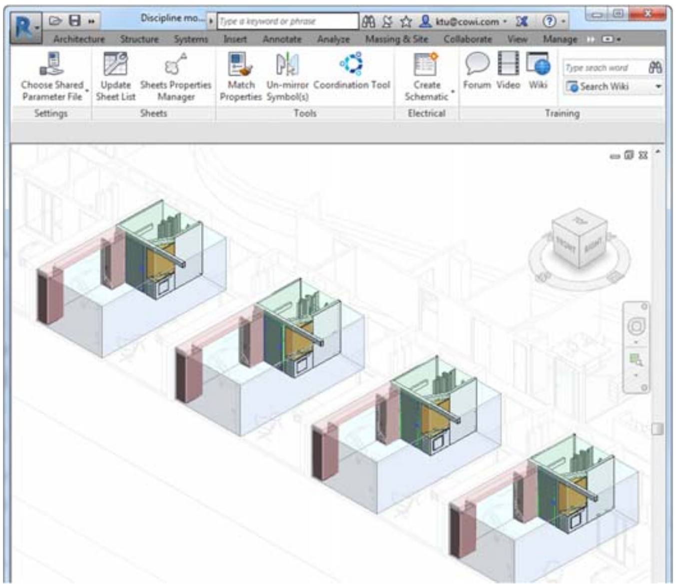
Above: Diagram explaining the module model make up of group links. (Right) The bathroom module model.

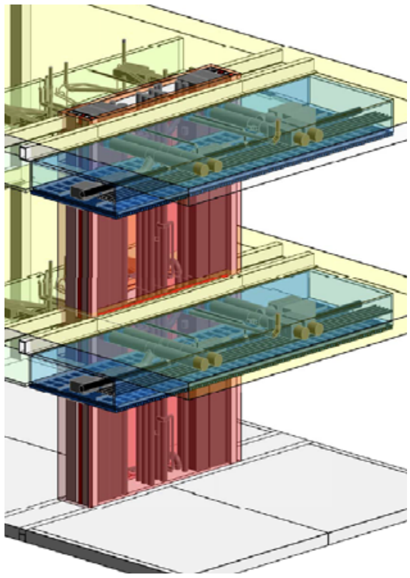
The coordination tool (automatic placement of modules)

The placeholder model is linked to each discipline model. The coordination Tool add-in is designed to search the model or linked models for elements based on a rule set of parameter values and place an object, group or an assembly on the same place as the found elements (base object). The inserted object has a GUID reference to the base object for monitoring the placement and parameter values.

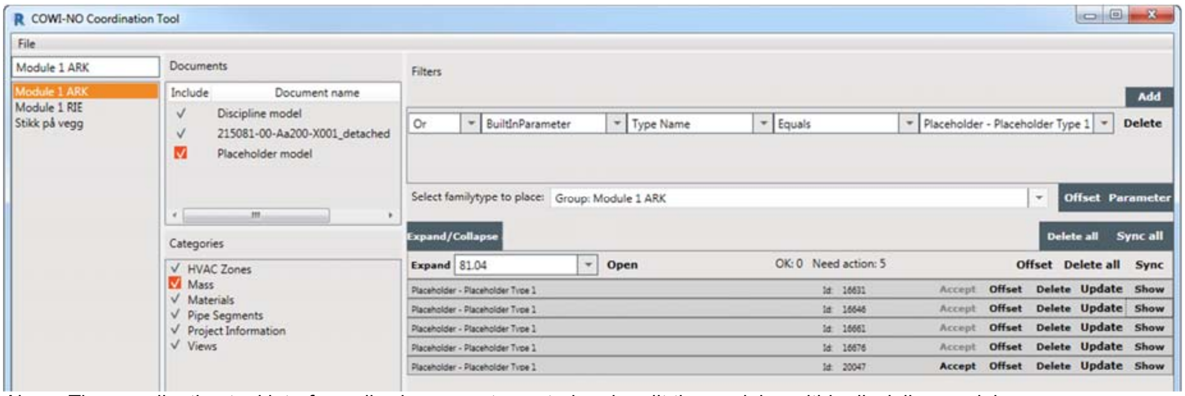
If a placeholder instance is moved in the placeholder file the module has a monitor on its instance and it knows to be moved to the same place. The interface also brings warnings to accept or reject changes made which do not correspond to the placeholder file.

The location of any module group / assembly can be updated or offset, and their instances altered, replaced or deleted with each deviation being audited, accepted or denied. The tool can also copy and set parameter values to all elements enclosed within the placeholder masses, and this is used to automate the attachment of information to the modulation strategy.





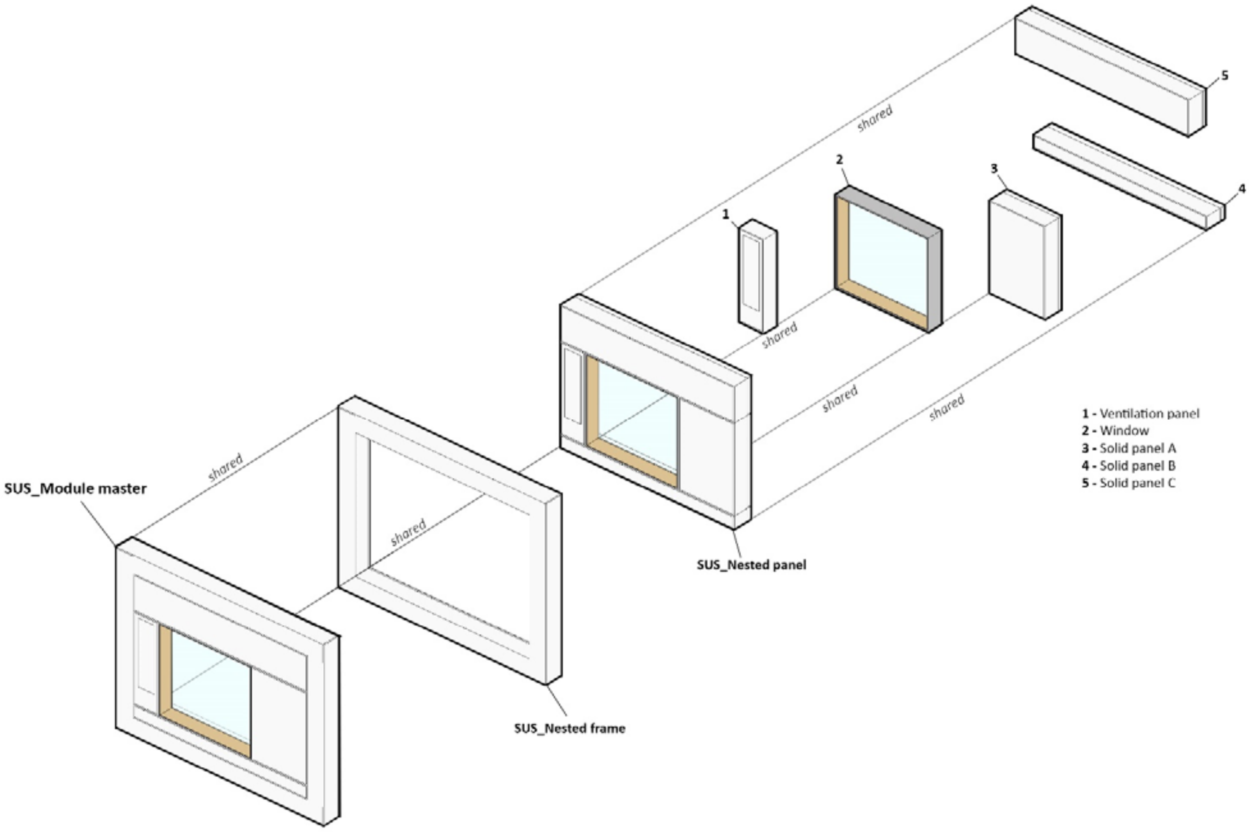
Above: (Left) The architectural discipline model with the linked placeholder file. The tool copies out bathroom modules in the exact position of the bathroom masses in the placeholder file. (Right) Vertical and horizontal modules enveloped in the placeholder file.



Above:The coordination tool interface allowing users to control and audit the modules within discipline models.

2 Façade panelisation

To align our modelling strategy with the proposed panelisation of the facades, the team designed a series of master curtain panel families made up of parametrically editable and nested parts. This has allowed extensive conceptual flexibility, adaptability to per building deviations and accurate quantity take off. Each panel is modelled with all industrialised components included– the module master appearing exactly as it will be produced. The complex type-list allows the separation sorting of modules and module parts for specific information deliveries to the building industry.



Above: The master module is broken down into a series of parts and controlled by both parameters within the nested and shared families and curtain wall grids within the project.

Above: One façade shown with the panel master in use. Room sizes define the grid placement of panels.

<11 CURTAIN PANELS - 8FP2 (tett modulfasde)>					
A	B	C	D	E	F
SUS_Byggnummer	Type Mark	Material-/fargekode	Area	Count	Type Comments
21					
21	8FP2.A	M08	1578 m²	292	GRC kassett
21	8FP2.C	M08	348 m²	58	GRC kassett m/solavskjerming
21	8FP2.D	M08	838 m²	107	GRC gesimskassett
21	8FP2.E	M08	309 m²	121	GRC hjørnekassett
21: 578			3072 m²	578	
71					
71	8FP2.A	M07	892 m²	268	GRC kassett
71	8FP2.C	M07	77 m²	85	GRC kassett m/solavskjerming
71	8FP2.D	M07	426 m²	63	GRC gesimskassett
71	8FP2.E	M07	65 m²	58	GRC hjørnekassett
71: 474			1460 m²	474	
81					
81	8FP2.A	M06	2310 m²	560	GRC kassett
81	8FP2.C	M06	116 m²	135	GRC kassett m/solavskjerming
81	8FP2.D	M06	747 m²	109	GRC gesimskassett
81	8FP2.E	M06	217 m²	155	GRC hjørnekassett

Above: Taking out modular information from the façade panels

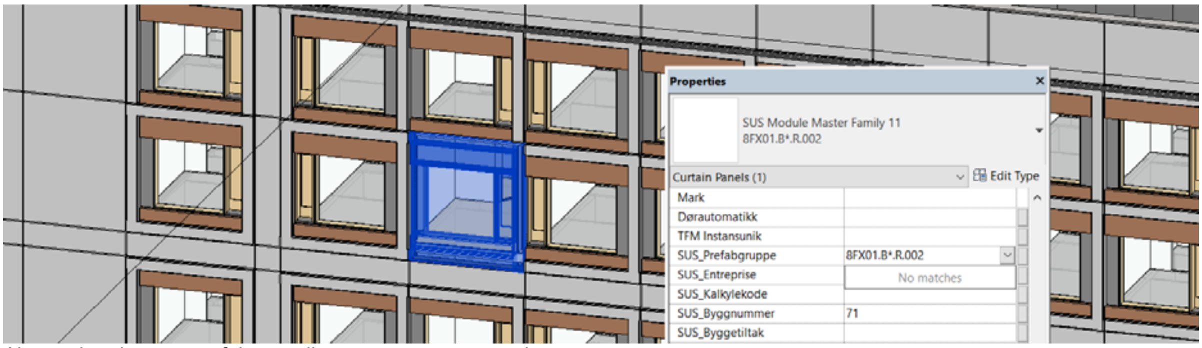
Note! Modelling a curtain panel family with multiple materials (without using nested families) results in incorrect quantities.
See *https://forums.autodesk.com/t5/revit-architecture-forum/material-take-off-from-curtain-panels-that-use-multiple/m-p/6923162#M142413*

The delivery of industrialized information to the building industry

With the placement of the prefabrication typelist parameter (and any required additional parameters) on modules and on each panel within the façade, we can count, analyze and translate information connected to the modulation project to the building industry via IFC.

Automised parameter placement

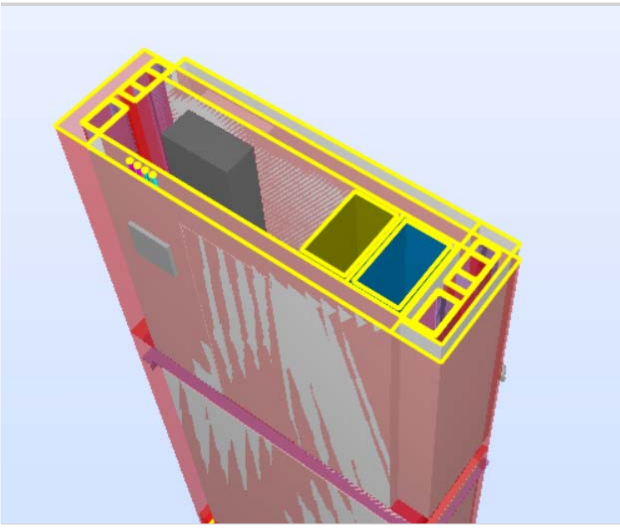
Automisation of the parameter placement to elements within modules is done using our coordination tool, and checked through specific filtered views in Revit. In Revit 2018 we also have the ability to tie the parameter to groups as entities and schedule them.
The coordination tool can copy and monitor the module type code and module instance id from the placeholder family instance to the group and all of its elements members. Note - it's important to setup the parameters to "Values can vary by group instance" to have an instance id on every element inside a group.
Panel parameter placement is type based and checked within the façade file before exporting.



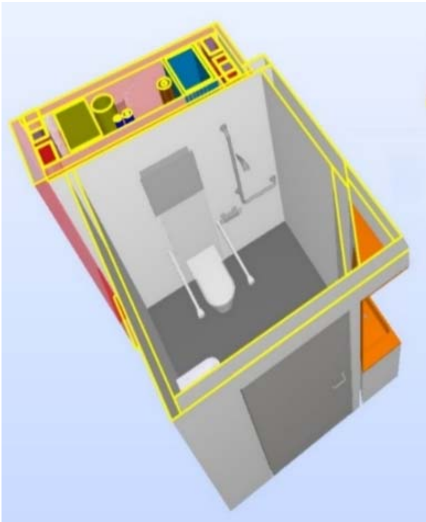
Above: the placement of the typelist parameter to a panel

To the building industry

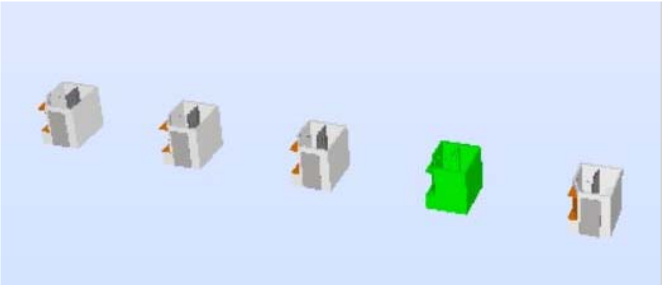
Using the type-list parameter values we can create filters and module-specific views in Solibri allowing the efficient and visual communication of the modulation strategy between the project team and the building industry. Using exports from the discipline model and the module models, we can deliver specific information types catered to the needs of the recipients.



Above: Vertical module

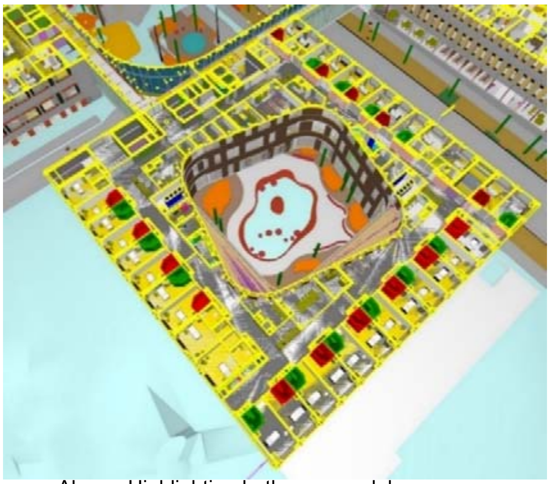


Above: Bathroom module connection to vertical module



Above: Isolated bathroom modules

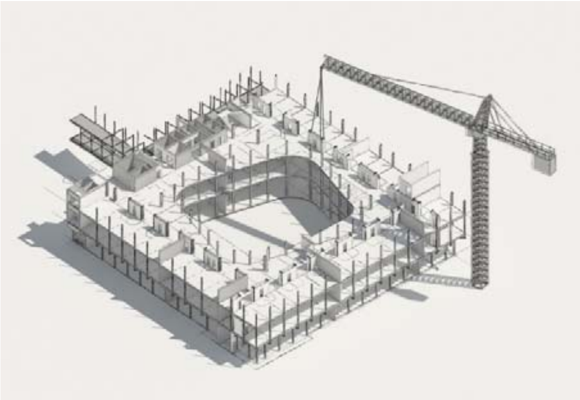
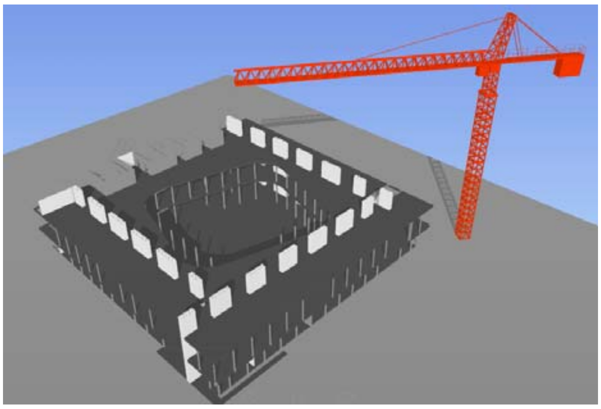
Above: Highlighting panel types



Above: Highlighting bathroom modules

The future development of modulation tools
Due to the ongoing development of tools for modular and panelized components in collaboration with Project Frog and Autodesk, the future tools part of the session will not be documented in the handout but will be presented at AU.

Construction sequence control
Using the information contained in models, which have been aligned directly with the industrialization strategy, we can connect modules, panels and all other elements with the critical path and using Navis works or Synchro simulate the expected industrialized construction sequence, ensuring full control of the assembly before it begins on site.

Above right: Using Navis works 'Timeliner' to connect the modulation project to the critical path and simulate an onsite construction sequence. Synchro can also be used for this.

Summary
The resulting methodology for cross discipline industrialization has allowed us to develop a traditional BIM with repeating layouts into a set of modular and panelized components whilst upholding both the architectural, analytical and visualization demands of the overall projectt. Through automisation we have increased our ability to be effective, assure the strategy, allow adaption and provide appropriate information between disciplines and to the building industry. In adapting to new workflows we aim to better align ourselves with an evolving building industry moving towards manufacturing: The creation and assembly of parts.