CI2283 – BIM workflow on the Highway A4 construction project
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CI2283
In this class, we will guide you through the Building Information Modeling (BIM) process of an actual project: the construction of the Highway A4 in The Netherlands. After a contract and project overview, we will dive into the process that makes this project succeed as a true BIM project. Learn where to start, what to do, and what to avoid to have your own success. Find out how to let designers use their favorite program and then bring the intelligent model together in Autodesk® Navisworks® software for your contract management.

Learning Objectives
At the end of this class, you will be able to:
- Successfully implement BIM in civil projects
- Explain how to use Navisworks for contract management
- Explain the importance of think-before-you-start
- Describe the Autodesk® Infrastructure Design Suite workflow

About the Speaker
Jeroen is an experienced Road Design Specialist from the Netherlands. At Van Hattum en Blankevoort he uses his knowledge of a wide range of Autodesk products to streamline the process of BIM in large construction projects. Jeroen was one of the founders of the C3D User Group Benelux (www.c3dbenelux.eu), together with other power users. At present, Jeroen is head of design on the Highway A4 construction project in The Netherlands.
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Cristian is a BIM Advisor who works on large scale infrastructure projects. He is primarily engaged in integrated road design projects, including bridges, tunnels, and other structures. He also implemented 3D modeling in design and build processes. Cristian currently uses AutoCAD® Civil 3D®, Revit® Structure, Autodesk® 3ds Max® Design, Autodesk Navisworks® and Autodesk Design Review. As a board member of the Civil 3D Usergroup Benelux and Revit usergroup for infrastructural projects, he is stretching the possibilities of integrated design. At present, Cristian is working on the Highway A4 construction project in The Netherlands.
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BIM introduction

We have chosen to implement BIM in this project. Because BIM was relative new to most of the people involved in the project we have held a number of sessions explaining the way we see BIM on this construction project.

<table>
<thead>
<tr>
<th>BIM is</th>
<th>BIM is not</th>
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</thead>
<tbody>
<tr>
<td>☑ About collaboration</td>
<td>☑ Everyone for themselves</td>
</tr>
<tr>
<td>☑ A Helping Hand</td>
<td>☑ An end in itself</td>
</tr>
<tr>
<td>☑ Use of 3D models</td>
<td>☑ Just Software</td>
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<tr>
<td>☑ Communicate better</td>
<td>☑ A solution to everything</td>
</tr>
<tr>
<td>☑ Share Information, Save and Re-use it</td>
<td>☑ A sole application or database</td>
</tr>
<tr>
<td>☑ Supporting multidisciplinary organizations and projects</td>
<td>☑ Just something the design department does</td>
</tr>
<tr>
<td>☑ Usable in all project phases (full project lifecycle)</td>
<td>☑ Working conform standardized methodologies</td>
</tr>
<tr>
<td>☑ Detect errors sooner and prevent them</td>
<td>☑ For Sale</td>
</tr>
<tr>
<td>☑ Not possible without coding/naming conventions (eg Systems Engineering structures)</td>
<td>☑ Fully Developed</td>
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Shift towards preliminary design

The mcLeamy curve shows us the importance of looking at alternatives in an earlier project phase. On this project it meant adding more resources in the earlier design stage of the project.
(post bidding) and less in the final design. This was not in the actual budget. So the preliminary design phase budget has been not been entirely met, but we have made up for that during the detail and construction phases as most of the decision making has been done.

**Lean**

LEAN is an imported methodology at the construction site. We applied it during the design phase (e.g. planning), during the supply chain and the site itself. Applying LEAN to the software usage, however was new to us.

Three most valued questions that we asked ourselves were;

- How makes what models?
- What tools do they use?
- What is their input and output?

After this we put together a software exchange chart. Each color representing an application or tool. Each block is divided in an input (left), process (middle) and output (right) part. So if you see an input line in purple, it is output from Civil3D.

Each line is an exchange of data. This can be as simple as a file copy, download or edit, but can also mean some more work done by an external party. For instance a point cloud needs to be corrected before use and this process is not shown in this chart.
The results of this exercise have been first of all the awareness of so much software applications being used potentially. And secondly so many exchange of data between them. We have identified almost 20 software applications (including some excel sheets for calculations…) that needed input and/or provided project output. After analyzing some of the exports being made, it seemed that either these were not actually used by someone else. Furthermore some software required manual change of the input format that could easily be discarded when the export that was used was amended a little. So someone with software A had to do a little more to help someone with software B be quicker about it. In the end – it saved time.

For each link and each software we created instructions on how this should be done. This way we could make sure that everybody involved in the project (internal and external) would know how it should be done and what requirements should be met upon releasing a new version for example. One of the instruction is provided as part of this handout under the "Tunnel modeling from preliminary design to a detailed design" section.

To facilitate the clash sessions and support the concurrent engineering we have bought a touch screen that would allow us to navigate through the Navisworks model and discuss issues arising from it. Normal “A0” drawings are on 1:1 scale on the 65” panel.

We organize regular sessions with all project disciplines. Cover issues and report those using either the Autodesk® Navisworks® model or the construction drawings in Autodesk® Design Review.

**Organization changes**

**Project role changes**

We have seen two major (new) roles. Draftsmen have had the opportunity to grow into a new function as “Modeler”. Having more focus on 3D with the technical knowledge from their previous jobs. A new role has been the model operator or model driver. This person is responsible for collecting all data into one Autodesk® Navisworks® model, connecting the planning for 4D purposes, reporting clashes and taking part of clash sessions with all disciplines.

**Organization impacts**

Management needs to facilitate BIM adoption. Together with an enthusiastic workforce, this we be most important. As BIM can be approached with LEAN in mind, it helps optimizing the exchange of files and data itself.

One of the key learning points in this project have been the importance of involving all project discipline as early as possible in the decision process. And when decided to implement a
chosen design, stick to it. Till the end. We have asked commitment for this and although it might not be the best option a half year later, it was at that time. This will be beneficial for the planning and the total project outcome, even though it might not be the most optimal for one discipline.

For the preparatory work, implementing BIM will allow them to have easy model accessibility and availability at all times. Analyzing the planning is as easy as pressing the play button.

For the construction site itself, preforming inspections and tests is made easier. We have created two addition programs to make this easier.

**Add project value**

We have identified ten project values that are part of BIM. These are identifying all our questions and BIM possibilities at the project start. In this handout, at the end of this section you will see part of the excel sheet we put together to identify each item and help us choose whether or not to implement this.

**Project 1: Add 4D**

The 4th dimension is added by linking each line in Primavera planning with an object in Navisworks. This can be done manually, but the best way of doing this is automatically by searching for identical properties. We have added a “BIM code” to each line in the Primavera database. Depending on the source of the object in Navisworks the BIM code can be found in a Revit® property, 3ds Max® objectname, layernname, filename, etc.

**Project 2: Temporary Works and building Sites in 3D**

In general it’s safety first. Meaning that creating objects for temporary works and detours is as important as the final design for clash detections. During construction it is now possible to take temporary works into account. The temporary works and safety zones were created using AutoCAD® Civil 3D® with Subassembly Composer.

**Project 3: Model integration, clash detection and interference checks**

What are all the disciplines involved in the project? In what detail will they be constructing 3D models and what is needed? For Clash detection we used Autodesk® Navisworks® Manage. See a detailed explanation after project 10.

**Project 4: Visualization and communication**

Being able to create visualizations at any given place within the 3D model and using the model for road and drive analysis, camera placement, etc. We used Autodesk® 3ds Max® Design with Civil View (see class CI2284) for road design analysis and visualization. Communicating with other, external parties was partly also done with exports from either Autodesk® Revit® Structure or Autodesk® 3ds Max® Design. Internally and with the client we used the Autodesk® Navisworks® model in all project phases.
Project 5: Construction Drawings
Will it be possible to not create drawings? Can some drawings be setup differently? How can we get from 3D to 2D? Do we involve Ipad? We used Autodesk® Revit® Structure and AutoCAD® for all the constructions.

Project 6: Add 5D
Help the project be more cost-aware by linking costs and budgets to the 3D model and 4D phasing. We have done this only in the bidding process. In the project construction phase all the costs are linked to the primavera project planning.

Project 7: Rebar in 3D
Can we link to construction factories? How do we design rebar in 3D? What are the possibilities? Rebar was done at an external company in Indonesia. The Revit model is exported to IFC and could be easily imported and used to define the rebar in 3D.

Project 8: Machine control
GPS setout directly from the 3D model. 3D Site checks using the 3D model. With AutoCAD® Civil 3D® we creating all our setout models and surfaces.

Project 9: Quantities from a dynamic model
Creating quantities during the construction phase. How are we doing on progress related to the amount of earthworks up until now? See point 8.

Project 10: Verification, as-built and maintenance
Can we effectively utilize the 3D model for the as-built and the verification process? How can we take it to the next level: the maintenance. Design reviews are done using Autodesk® Design Review and Autodesk® Navisworks® Freedom. Freedom also enables everyone to see the project progress as the model evolves through time.

For the maintenance phase we are currently working on some databases to address this. For this project only the Tunnel Technical Installations are under maintenance for a 8 year period. The next project however will have 25 years of maintenance for all project deliverables.

Below is an extract of Project 3. This excel sheet is part of the class materials.
For each project value we have looked at the importance and relevance for each project phase. Is it useful to do this and is the amount of work not much, it’s getting a green line. Meaning that we will incorporate this into the BIM model. When the amount of work is a little more, it might still be interesting, but does not get the highest priority. This way we were able to identify a number of must and nice to haves.

### Linking to external databases

At the A4 project we have linked two external information sources to the Navisworks model.

#### Link to Requirements database (Relatics)

We have an external database setup for our System Engineering methodology. This database consists of all project requirements of each object. Each of these object have unique names according to the SBS and WBS structure. These object names are available in de Navisworks model by object properties. We created a tool that will iterate through the Navisworks database and find each item within the Requirement database and then link the two. After this, a user can easily click on an object in Navisworks and fire up the requirements.

#### Link to Documents (SharePoint)

We did the same for adding a link from the object to the SharePoint site. This way, any documents associated with the object can be easily found within SharePoint.
Creating the additional I in BIM

Field applications
Having to go through a paper checklist, make pictures, and upload those for verification purposes is not something a site construction guy likes in general. Because all of our requirements are in de requirement database, we created a tool that runs on a mobile phone or tabled. This tool will allow the user to view the verification process and upload directly to it. This saved up much time.

Another application, but easier to implement in every project is the addition of a QR code in construction drawings. In this project some of the drawings are still printed and used at the construction site. Having the latest version of these is of the most importance.

The QR code links directly to the SharePoint server and checkes if the generated link addresses the latest version. If yes, it’s all green in the screen. Otherwise, red.
Tunnel modeling from preliminary design to a detailed design

If you have made a tunnel corridor with Civil 3D, you have the ability to export this model to solids.

These solids will be very handy for the following workflow, to create a detailed design model for the tunnel in Revit Structure.

Before importing the corridor solids in Revit Structure, you can edit the solids in Inventor Fusion.

From the Civil 3D ribbon it is possible to open the solids in Fusion. After finishing the solids you can send them directly back to Civil 3D.
After this, save the solids to another dwg file. Now we can start the design workflow:

1. Load the corridor solid model in a Revit Structure project;
2. Make Masses on the imported solid model;
3. Link your Mass model to the detailed design;
4. Start adding detailed structural families to your mass model.

Load the corridor solid model in a Revit Structure project

Open a new Revit project where you can import the 3D solids in a mass family. Make sure you place it in a world coordinate system.

By importing the solids in a mass family you will have better SNAP functionality.

Architect & site ➔ Mass in place ➔ Give name ➔ Insert ➔ Link CAD ➔ select file
By placing the solids in different layers you can turn parts on and off via Visibility/Graphic (VV).
Make Masses on the imported solid model
After this you can easily select faces of the solids to place Revit mass families on these faces.

This is still conceptual. The mass model is easily made and gives information about the geometry; quantities can be used as a working model to make the detail design model.

You can use a Roof mass to create a roof or a floor, Walls and Curtain System.

A Curtain System works in the same way as the Roof and Wall family but has more functionality.

Floors can’t be used to create mass on a face of a solid object.
Giving the tunnel parts a number gives you the possibility to add the mass parts to a filter. This can be helpful when working on the detailed design model.

**Link your Mass model to the detailed design**

When the mass model is finished you can link it to the Revit project of your detailed design.

Be sure the project base point of both files have the same coordinates.

Insert ➔ Link Revit ➔ select file
Now the mass model is linked to the project you have several options:

1. Hide/unhide objects
2. Use the phasing of the linked model
3. Change display settings (in Visibility/Graphic)

Start adding detailed structural families to your mass model

Now detailed design modeling can start. For tunnel modeling structural families are helpful.

Use the Beam Structure. The tunnel has an alignment and is therefor line based. Structural framings can be easily added.

Load the family and then:

Home ➔ Beam ➔ Place Beam ➔ 3D snapping ➔ select the family ➔ fill in the constrains ➔ pick Lines ➔ place family.
This way you can build the complete tunnel.

**Points to note:**

- Know to which reference line you attach the family
- which information do you want to retrieve from the model
- Make sure that the model is flexible enough to add changes
- Making good detailed families costs time