Using AutoCAD Civil 3D in Railway Engineering: Vault as the Basis of Smooth Work and Quality

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Learning Objectives

- Learn to complete a railway project using AutoCAD Civil 3D – from concepts to detailed drawings

- Find out how to create a consistent, dynamic infrastructure BIM model using AutoCAD Civil 3D

- Find out how the Vault ensures smoother and more efficient collaboration between project team members

- Find out how Vault increases the quality of the project

Description

The session will focus on dynamic railway engineering using AutoCAD Civil 3D software. You will find out how you can use AutoCAD Civil 3D to complete a railway project from engineering solutions to detailed drawings. The session will reveal the possibilities of AutoCAD Civil 3D software in the creation of dynamic Building Information Modeling (BIM) infrastructure models, such as railways, roads, pipelines, and so on. We will show how Vault software facilitates the efforts of the entire Project Team, ensures smoother transfer of information, and increases the efficiency of AutoCAD Civil 3D software data shortcuts. We will provide practical examples on how Vault software helps to ensure higher quality for the project and avoid possible human error.

Your AU Experts

Darius Šimkūnas is the CIO/BIM Strategist at JSC Kelprojektas, the biggest infrastructure engineering company in Lithuania and the Baltic countries. He is responsible for the strategy, development, and adaptation of Building Information Modeling (BIM) and engineering software. Darius has over 10 years of experience with Autodesk, Inc., products, consulting and training the company's employees. He was an Autodesk University speaker in 2013 and 2014. He has been working with AutoCAD Civil 3D software since 2005 and has a portfolio of functionalities for specific regional and company needs. He is an AutoCAD Civil 3D Certified Professional, and has been an Autodesk Developer Network (ADN) member since 2008 working on infrastructure projects using new technology and methodology. Since 2012 he has been responsible for the implementation of Vault software in Kelprojektas. As the project manager he directly participates in the stages of implementation, resolution of strategic and technical issues, and enhancement of product functionality according to the company's needs.

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Introduction

Kelprojektas has been designing infrastructure since 1956, but railways were picked up only in 2009 when the demand for such projects increased dramatically. Currently, Lithuania has been engaged in intense modernization of the existing network of 1767 km (around 1000 miles) railways and the construction of a new railway line of different gauge that will cross the entire country. We are also preparing the designs for the track that will span Estonia (220 km or 130 miles).

During the past five years, Kelprojektas alone has prepared designs for over 300 km (180 miles) of railways. These include not only reconstructions of the existing tracks and additions of new ones, but also the construction of a different gauge railway.

This crucial period required software enabling fast, efficient and complex solution of tasks at hand. Civil 3D was the tool that allowed us to design railways and the surrounding infrastructure in a fast and efficient way.

About JSC Kelprojektas

JSC Kelprojektas is currently the largest group of transport infrastructure engineering companies in Lithuanian that designs transport communications, public use buildings, engineering systems, and performs territorial planning works, etc.

The company was set up in 1956.

The main headquarters of Kelprojektas has always been located in Kaunas with later additions of regional subdivisions in Vilnius, Klaipėda, Šiauliai, as well as Tallinn.

JSC Kelprojektas currently has around 350 employees.

Almost 6,000 projects ranging in scope and complexity; several dozen thousands of kilometers of roads, streets, and railways built and renovated; bridge projects; territorial planning projects that have received great appreciation and highest ratings – all of this is just a fraction of Kelprojektas group's contribution to the modernization of the national transport infrastructure.

The objective of the company is continuous progress. In order to ensure premium services, Kelprojektas continually invests into advanced solutions, innovations, and up-to-date engineering technologies, improves work processes as well as personnel skills.

Specialists of JSC Kelprojektas work with various software:

- Autodesk: AutoCAD, AutoCAD LT, AutoCAD Electrical, AutoCAD Architecture, Robot Structural Analysis, AutoCAD Map, 3ds Max Design, AutoCAD Civil 3D, Vault Pro;
- Bentley: Microstation, STAAD;
- SoFisTik, ANSYS/Structuraland etc.

Autodesk products make up about 80% of company's engineering software portfolio.

The main software is AutoCAD Civil 3D and Autodesk Vault Pro.

Railway designing concept – from current situation analysis to detailed drawings

Current situation, 3D surface

The existing ground surface is composed from the point cloud (LIDAR data, laser scanning, etc.) or points and break lines measured by topographers. Point cloud is an optimal choice for the initial stages, while precise measurement using instruments is carried out once the suitable alignment is selected.

For railway reconstruction, individual break lines and surface are created across the top of the rail heads.

Information on how to create a surface can be found online:

http://knowledge.autodesk.com/support/autocad-civil-3d/getting-started/caas/CloudHelp/cloudhelp/2016/ENU/Civil3D-Tutorials/files/GUID-1004AD99-E042-463F-A024-96327E90A58F-htm.html

http://knowledge.autodesk.com/support/autocad-civil-3d/getting-started/caas/CloudHelp/cloudhelp/2016/ENU/Civil3D-Tutorials/files/GUID-F6A629B7-EB6B-443A-91EE-491076F71440-htm.html

Alignments, profiles, turnouts and other railway elements

Alignments are created using standard Civil 3D functions with axis type: rail.

A lot of useful information on how to create and edit axes can be found online:

http://knowledge.autodesk.com/support/autocad-civil-3d/getting-started/caas/CloudHelp/cloudhelp/2016/ENU/Civil3D-Tutorials/files/GUID-D625ABC3-2224-425A-BF5C-971439403C30-htm.html

There are several methods to create turnouts:

- Using standard or dynamic blocks
- Using blocks in combination with Cogo points
- Using additional Civil 3D functionality – Rail Turnouts and Crossings
- Using Structures

When creating turnouts, it is important to have a dynamic link with the profile view. When designing a crossing between the turnouts of two tracks, the design altitudes of the main tracks have to be visible in the longitudinal section. This information has to change automatically when the design position is adjusted.

In big projects, the plan – the alignment and turnouts – is stored in a single file at the scale of the plan, while profiles are stored in another file at another scale.
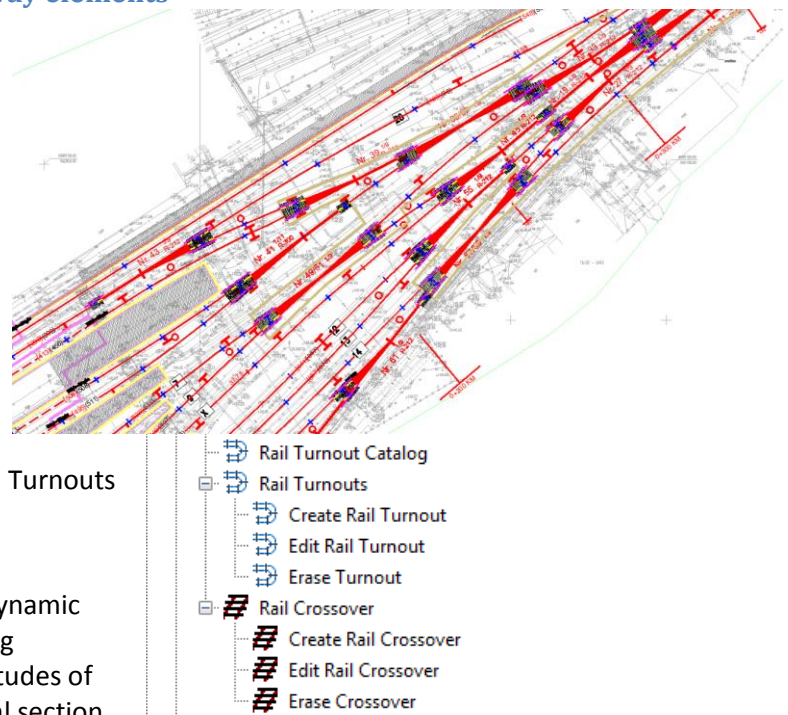
The use of standard or dynamic blocks enables us to create the required 2D plan view, but does not allow to generate bills of quantities for turnouts and to create a projection in a profile, when the profile and its view are stored in a different file.

The use of Cogo points for designing turnouts adds an option to generate a dynamic bill of quantities for turnouts created according to your needs. Depiction in the profile is only allowed in the same file, which is not recommended when working on big projects.

Civil 3D add-on called Rail Turnouts and Crossings enables us to use the existing library of turnouts and to supplement it if necessary. This add-on allows to create turnouts and crossings and to generate bills of quantities in a fast and convenient way. However, it does not allow automatic depiction of turnouts in the profile view stored in a different file.

Standard functionality for creating turnouts does not allow the creation of the dynamic link between the profile and the plan files.

The dynamic link between the profile and the plan files can be created using Structure functionality.

Turnout structure designing workflow:

1. Design the railway axes;
2. Load the existing surface, which will be used as the reference altitude for creating turnouts-structures);
3. Create well styles for each turnout type in use (select suitable blocks for each style for the depiction in the plan);
4. Use Data Shortcuts functionality to publish the network of turnouts for the project;
5. Create design profiles and profile views in the profile view file;
6. Create corridors for each design profile using a simple subassembly with 0% grade;
7. Create design surfaces for eath corridor;
8. Create a reference of shared Pipe Network data shortcut and set – Override reference surface with your surface if you would like to see the turnouts in the design altitude;
9. Prepare appropriate depiction style and you will have the dynamic view of the turnouts in the profile.
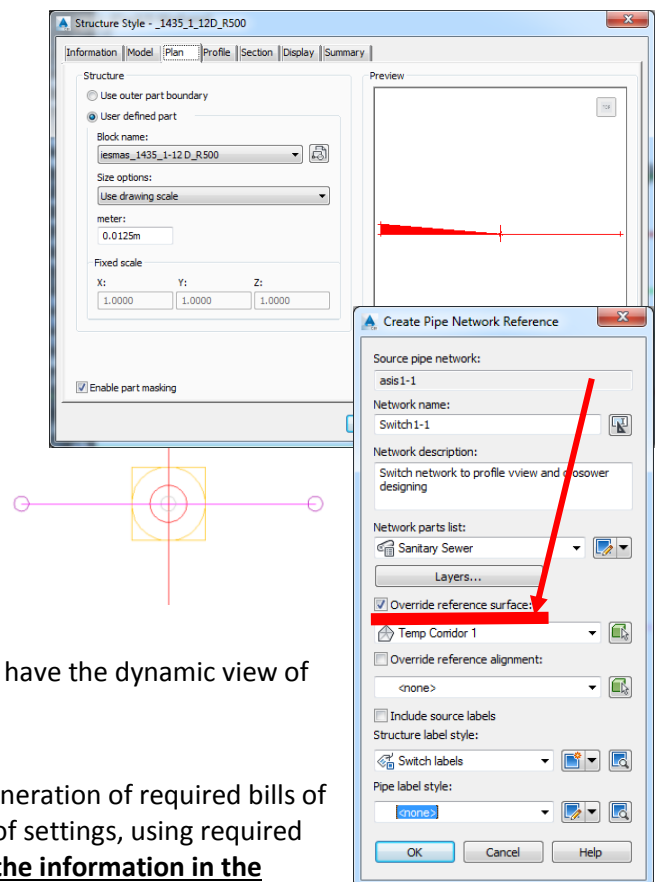
The available turnout-structures network enables the generation of required bills of quantities and reports, fast and convenient adjustment of settings, using required annotations. **When adjustments are made to the plan, the information in the profile view will be updated automatically.**

Rail crossover designing

1. Once the main tracks have been designed, draw the connecting axis;
2. In the profile file, create a profile with the existing ground surface;
3. Add your turnouts-structures according to the created design surface;
4. The altitude of turnout insertion is the design altitude of your tracks, which is dynamically linked to the planned position of the turnout and design altitudes of the main tracks.
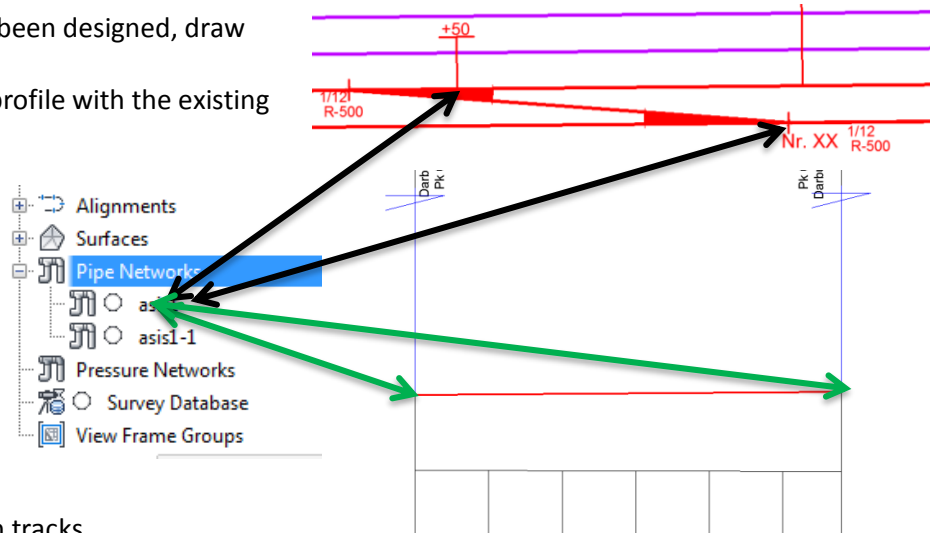
Profiles, projections of plan elements in the profile view

With the dynamic link between the plan elements and the profile view, you can easily create projections in the profile view and depict turnouts according to your needs.

The simple Acad object projection option can be used for fixed objects, but you have to remember to update information in case of any adjustments.
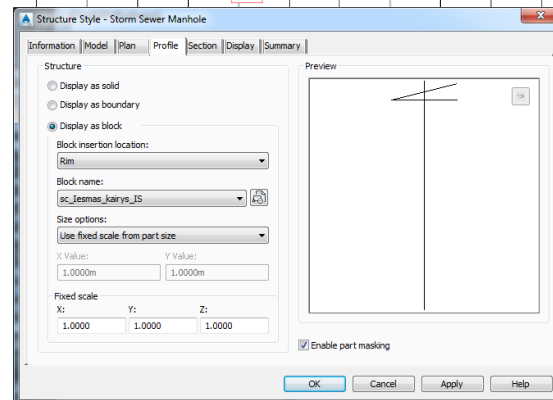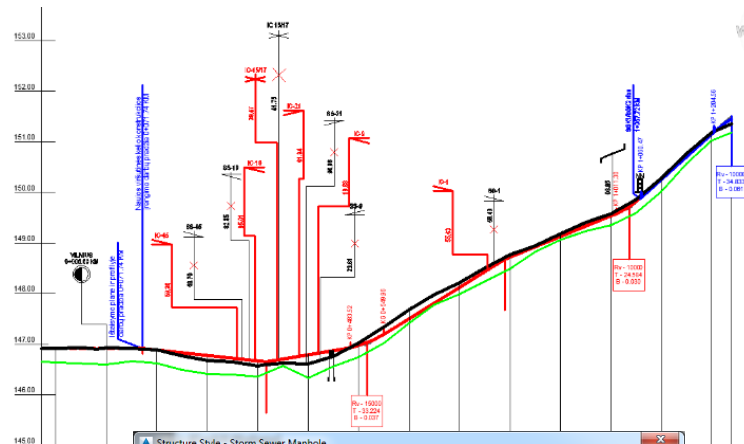
Creation of a 3D model and corridors

Standard Civil 3D elements are used for modeling corridors with the addition of subassemblies created for specific purposes.

Kelprojektas has been using Civil 3D since 2005. Our employees are highly experience in using it as well as creating additional applications.

VB.NET enables the creation of subassemblies of required geometry. The geometry of a subassembly is not static, but we can define as many parameters as necessary. We can define standard point and link codes and allow the user to modify or supplement them. We can define offset and height targets for required points. It is important to understand that the view we see is just a visual representation of a mathematical formula.
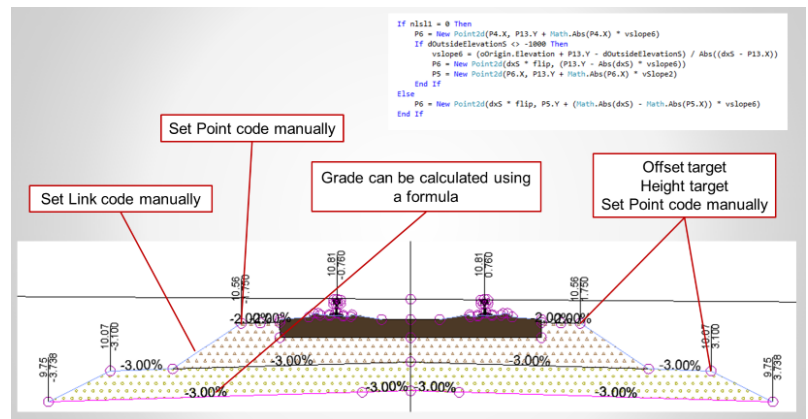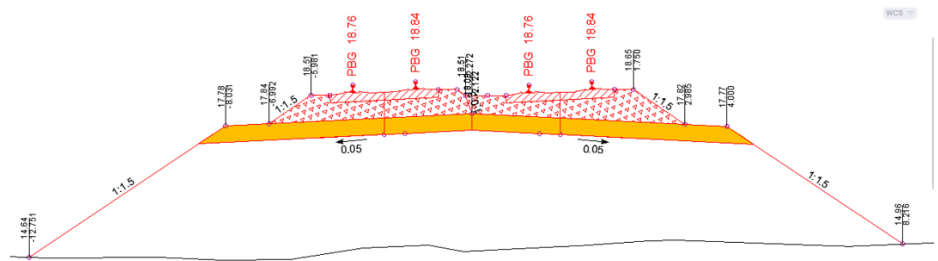
More information about the creation of structure elements using Civil 3D SDK can be found in the supplemental material of the AU lecture of 2014:

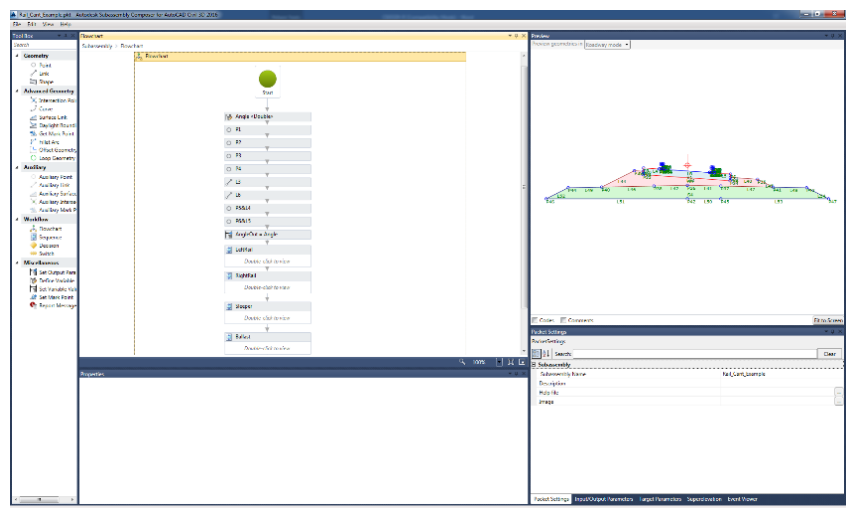http://au.autodesk.com/au-online/classes-on-demand/class-catalog/2014/autocad-civil-3d/cv5762-r-p#chapter=0

Useful information on how to create Civil 3D structures using Vb.NET can be found here:

http://knowledge.autodesk.com/support/autocad-civil-3d/learn-explore/caas/CloudHelp/cloudhelp/2016/ENU/Civil3D-DevGuide/files/GUID-E295BF67-F60C-49D3-A918-329D1E4FAFC5-htm.html

Specialized subassemblies can be created without the knowledge of programming. Autodesk has developed a software package for creation of specific subassemblies in graphic environment.

More information can be found here:

http://knowledge.autodesk.com/support/autocad-civil-3d/learn-explore/caas/CloudHelp/cloudhelp/2016/ENU/Civil3D-SubassemblyComposer/files/GUID-C569F4E7-D548-410E-B7D6-942A927FFD0B-htm.html?v=2016
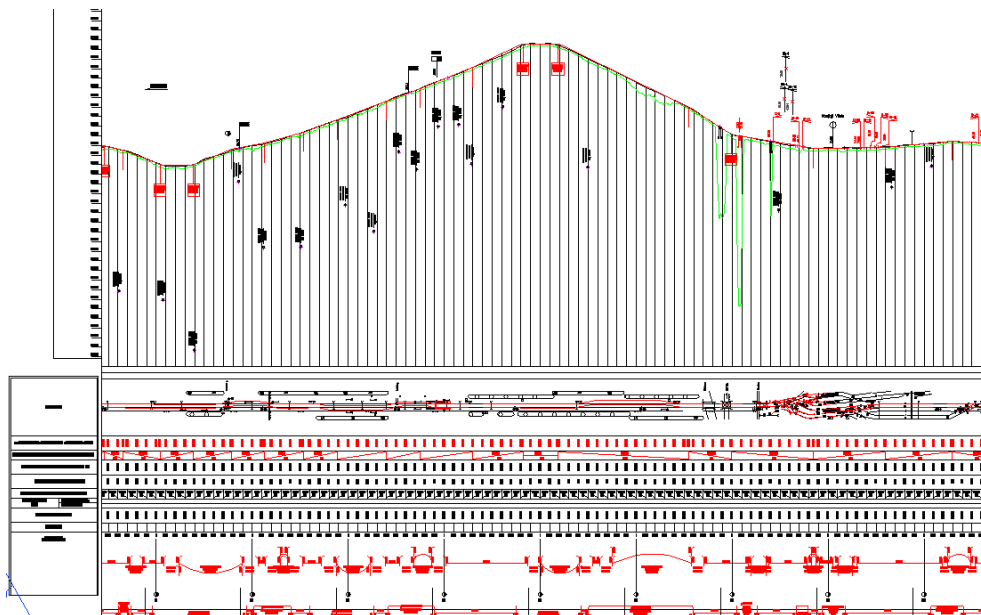
Output Data

Workshop drawings

The ability to set and modify styles in Autodesk Civil 3D enables the creation of the most complex or specific views. In exceptional cases, Vb.Net can be used to develop a specific application to meet your requirements. Here are a few examples:
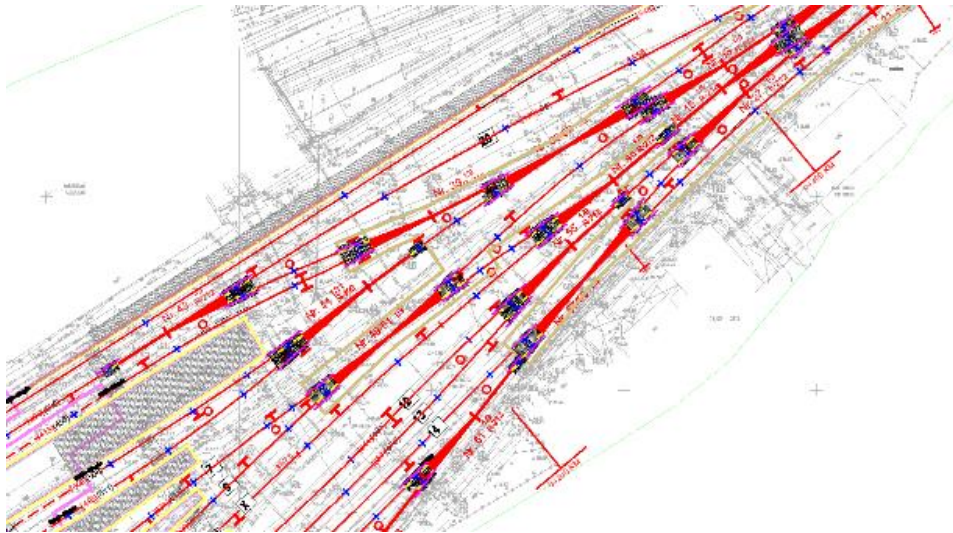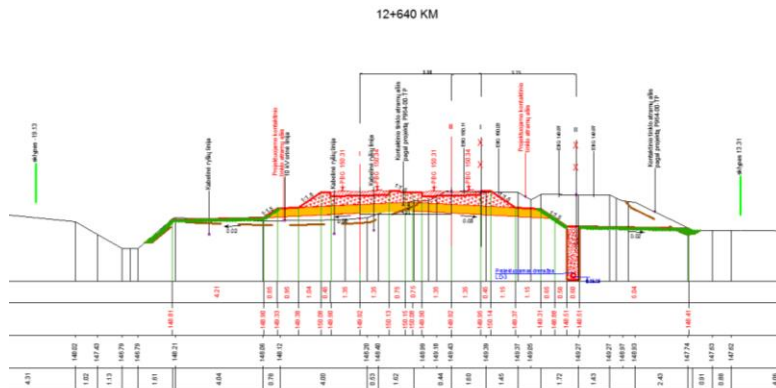

Plan view.

Profile view.

Cross-section view.

Quantity take off

A well-done railway structure will allow to generate the report on the volume of each layer and earthworks. Standard reports can be used or more suitable versions can be created by editing the XML file. VB.Net functionalities allow to take data from a Civil 3D model, process it, make calculations and present the report in Excel or another format.

Asis: kelias
Sample Line Groupe: Skersiniai - 2
Pradzios Pk: 0+00.000
Pabaigos Pk: 9+10.000

Piketas.	Sl Pav.	Sk Pl mxm.	Turis Cu.m.																			
0+00.000	Sl1	0.29	0.00	Sl2	0.44	0.00	Sl3	0.44	0.00	Sl4	2.03	0.00	Sl5	0.00	0.00	Sl6	0.20	0.00	Sl7	0.51	0.00
0+20.000	Sl1	0.29	5.78	Sl2	0.44	8.72	Sl3	0.44	8.80	Sl4	2.03	40.65	Sl5	0.00	0.00	Sl6	0.20	3.95	Sl7	0.50	10.02
0+40.000	Sl1	0.29	5.78	Sl2	0.44	8.72	Sl3	0.44	8.80	Sl4	2.03	40.65	Sl5	0.00	0.00	Sl6	0.20	3.95	Sl7	0.49	9.82
0+60.000	Sl1	0.29	5.78	Sl2	0.44	8.72	Sl3	0.44	8.80	Sl4	2.03	40.65	Sl5	0.00	0.00	Sl6	0.20	3.95	Sl7	0.49	9.77
0+80.000	Sl1	0.29	5.78	Sl2	0.44	8.72	Sl3	0.44	8.80	Sl4	2.03	40.65	Sl5	0.00	0.00	Sl6	0.20	3.95	Sl7	0.49	9.85
1+00.000	Sl1	0.29	5.78	Sl2	0.44	8.72	Sl3	0.44	8.80	Sl4	2.03	40.65	Sl5	0.00	0.00	Sl6	0.20	3.95	Sl7	0.50	9.89
1+20.000	Sl1	0.29	5.78	Sl2	0.44	8.72	Sl3	0.44	8.80	Sl4	2.03	40.65	Sl5	0.00	0.00	Sl6	0.20	3.96	Sl7	0.50	9.92
1+40.000	Sl1	0.29	5.78	Sl2	0.44	8.72	Sl3	0.44	8.80	Sl4	2.03	40.65	Sl5	0.00	0.00	Sl6	0.20	3.96	Sl7	0.50	9.95
1+60.000	Sl1	0.29	5.78	Sl2	0.44	8.72	Sl3	0.44	8.80	Sl4	2.03	40.65	Sl5	0.00	0.00	Sl6	0.20	3.96	Sl7	0.50	9.97
1+80.000	Sl1	0.29	5.78	Sl2	0.44	8.72	Sl3	0.44	8.80	Sl4	2.03	40.65	Sl5	0.00	0.00	Sl6	0.20	3.96	Sl7	0.50	10.00

Machine control

Modern machines accept design surfaces in XML format. This is not a problem if you have a properly created 3D model. You just have to create the surface of the design layer and export it to XML.

If the machinery requires a specific format, you may have to develop additional applications using SDK and prepare information according to the requirements of the equipment in question. Civil 3D contains all the necessary information in the 3D model – you just have to read it and present it in a proper format.

BIM data

Civil 3D allows to export 3D models to ACAD Solid, 3D/2D Polyline and other elements by attaching required attribute information. This information may be used in such software packages as InfraWorks or similar products of other developer.

Railway track – the backbone of an infrastructure project

When we are designing a new railway or reconstructing an existing one, we replace the entire surrounding infrastructure. Often the project involves ten or more teams of engineers from different fields. They all have to work in a unified system and coordinate their actions.
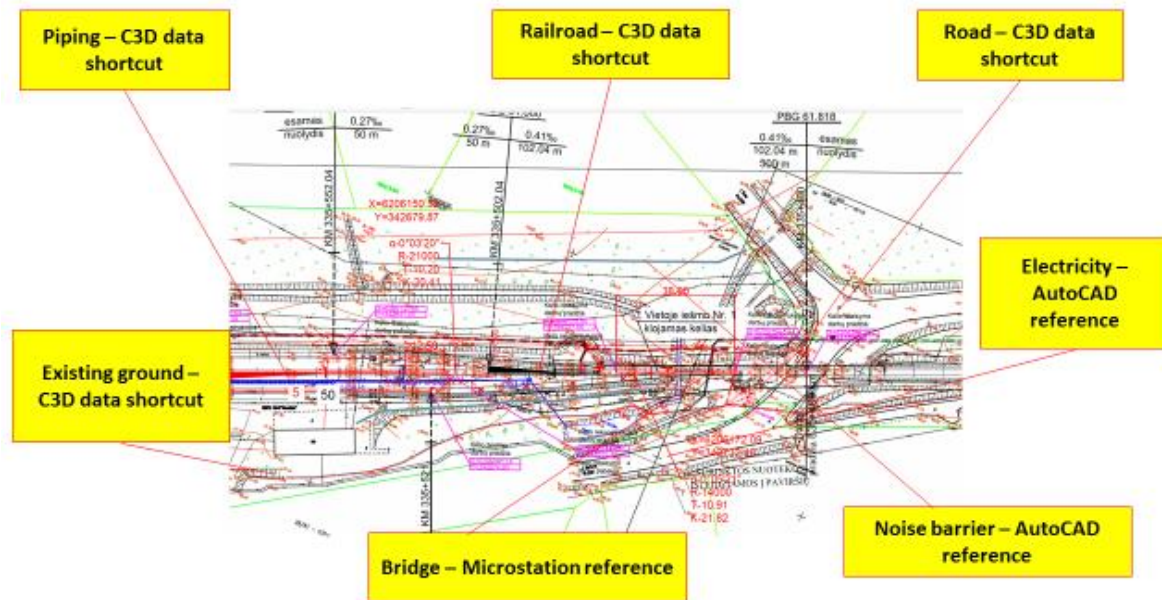
Three main types of information exchange can be defined:

- Exchange of 2D data (ACAD Xrefs DWG, DGN DXF)
- Exchange of 3D models (DWG, DXF, DGN, IFC)
- Teamwork on Civil 3D objects.

The first two methods are used to coordinate interrelated solutions. The software used to control a 3D model (Autodesk NawisWorks or similar) allows to connect all project parts, verify solutions and identify errors. This is an optimal choice when, for example, several different companies are working on the project.

The work has to be even more efficient inside the company. It is not enough to ensure that parametric models are matching – we also have to use information of one parametric model in another parametric model. We have to know that a parametric model on one engineer will automatically respond to the changes made to the solutions by his or her colleague. For example, when a road engineer adjusts the design surface of the road, the altitude of the manhole cover has to change automatically. Such effective management of the model comes from the Civil 3D data shortcuts technology.

When designing a railway, we often work hand in hand with road engineers. Both road engineers and railway engineers use Civil 3D, which enables efficient teamwork.

Road engineers not only design connecting roads and crossings, but can also make contributions to the railway design.

Railway engineers create the axis and longitudinal section of the track, while the road engineers shape the embankment, ditches and slopes. Pipeline engineers design run-off systems. Everything is designed on the existing ground surface created by topographers.

All the information is published for the project using data shortcuts. The adjustments made to any of the elements are visible to all participants and the parametric model will be modified according to the updated information.
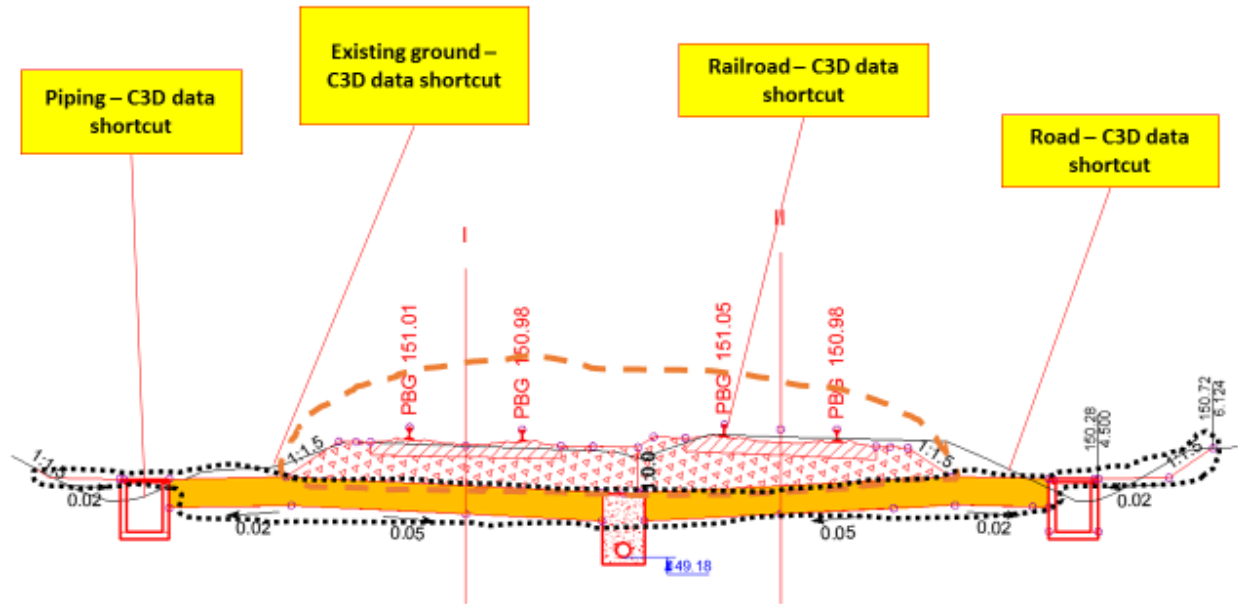
## Autodesk Vault helps the project team to work even more efficiently

JSC Kelprojektas digital project scheme
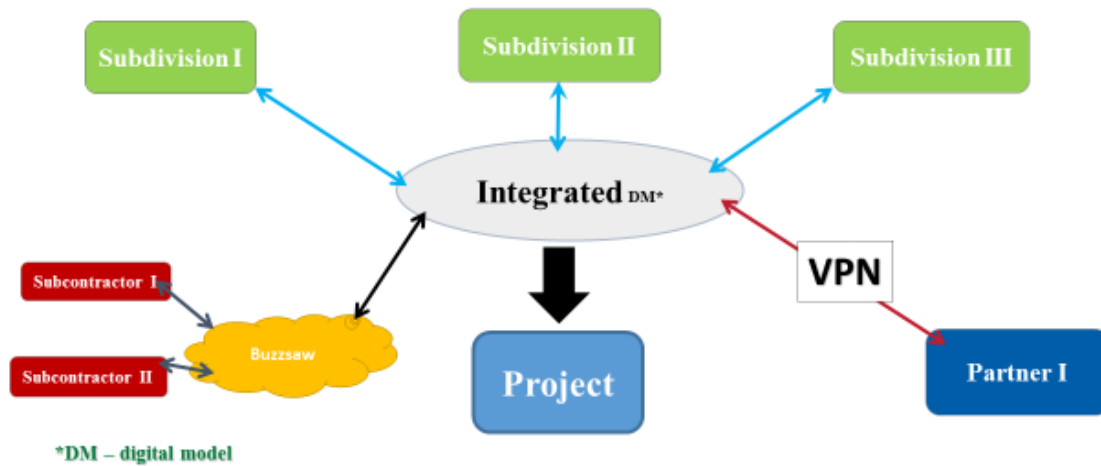
Above you can see the scheme of implementation of an integrated digital model in Kelprojektas. All of the participants of the project are connected to a single system – Vault – regardless the office they are working in. Our long-term partners also connect to the Vault via a VPN connection or dedicated tunnel. External partners receive and update information through the Buzzsaw. Kelprojektas' employees have only one source of information – Vault.

When work is carried out in a big team – even if only inside the company – managing all the information and making the workflow efficient can be quite a challenge.

File Share Server no longer meets modern requirements as we not only want to store the entire project in a single place, but also to enable efficient work with huge amounts of data.
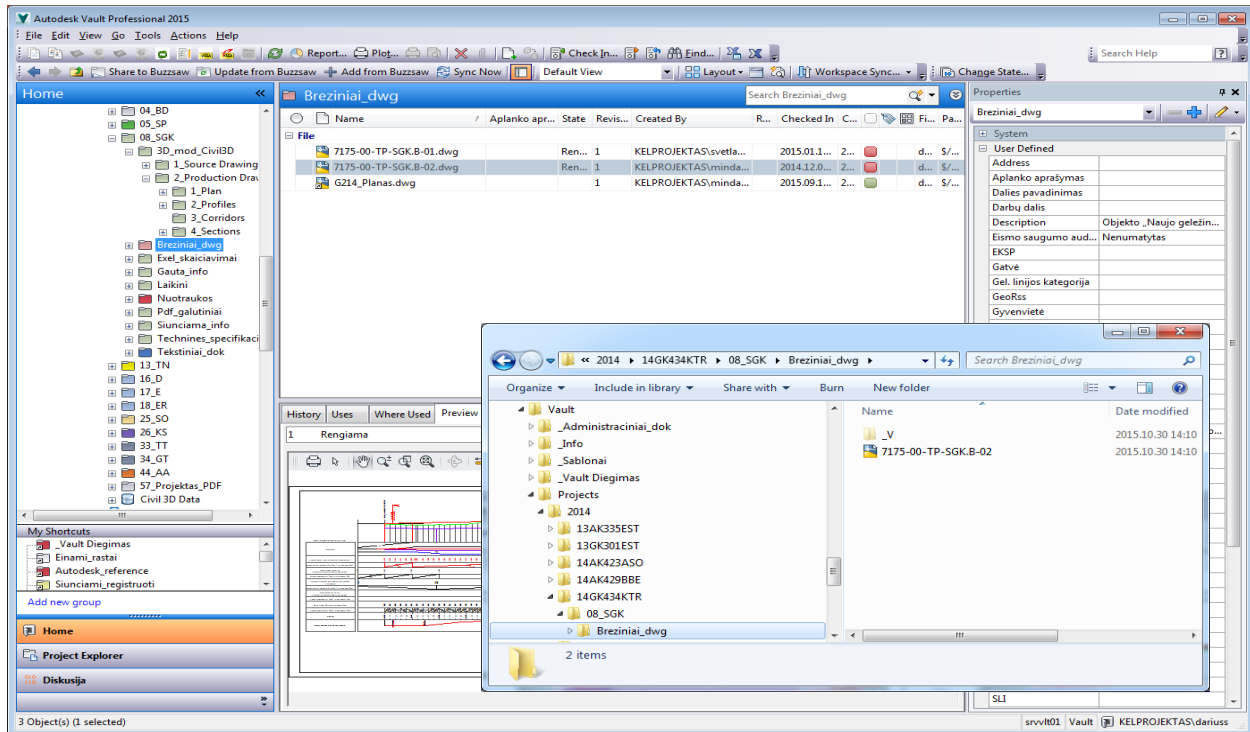
Before the file is opened for viewing or editing, Vault will first send it to your computer. This is especially important for those working in remote offices. When you are working with Vault, you always have the file on your disk so there is no dependency on the connection with the server. When you check out the file for editing, you can work on it without direct connection to the server and then you can update all the information once you come back to the office or connect to the VPN. Your colleagues will see who has checked out the file and will not be able to make any adjustments to it in the meantime. This prevents creation of two or more different versions of the same file.

Vault enables efficient management of files as well as:

- Seeing when the file was checked in and by whom;
- Seeing connections (what files are attached to your file, and where your file is used);
- Having versions, revisions of the files;
- Easy and fast search for required information, grouping, report generation;
- Working with external partners using Buzzsaw cloud.

How Vault helps to improve the quality of the project and avoid human errors

Clear, standardized, managed project structure

- **The entire project in a single place**
- Clear and standardized project structure
- Clear and standardized structure of file names
- Searching and filtering system enables easy and fast checking if all the standards have been applied
- You can see when the changes are made and by whom
- File versions and revisions with comments enable fast decision making
- Additional file attributes provide all the necessary information
- Everyone knows what needs to be done
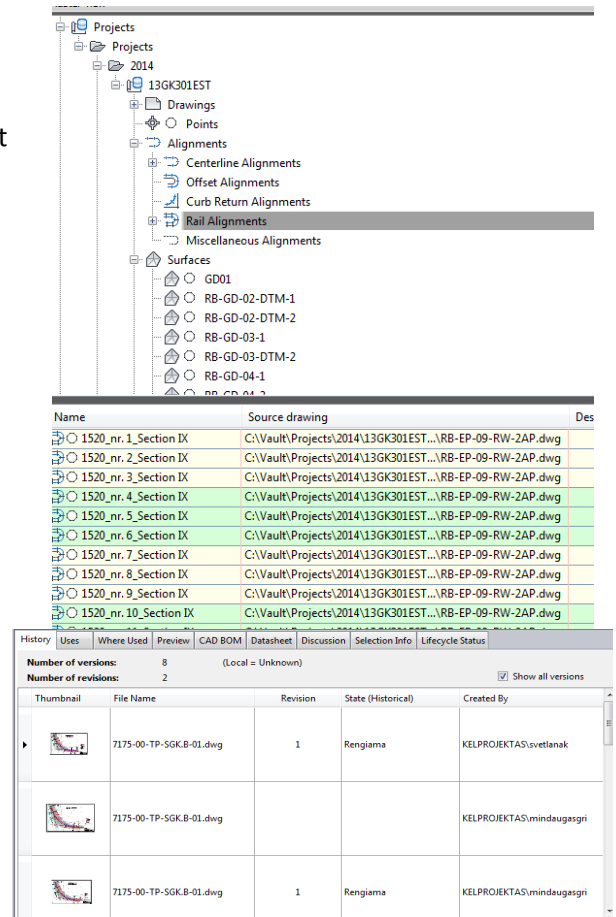
## Life Cycle – Clearly defined, controlled responsibilities

Life Cycle is very important for project management. It clearly defines the limits of responsibilities of project participants. Each employee knows which stage the file is in, who can edit it and when it is safe to use. When we are working in a big team it is important to see whether the version of the file is final or not. This is very important when work is done across multiple divisions or at different times.

Vault always contains the latest relevant information and its status.

You can filter all documents that need to be checked using search.

In addition to adding clarity to project management, Life Cycle can also automate processes. When moving from one stage to another you can automatically carry out desired actions (e.g. update the list of attributes, send an e-mail to the inspector of the document, generate DWF, PDF, or publish the document to the Buzzsaw or SharePoint). An event is initiated during the transition from one stage to another. Programming can help you carry out all the required actions with the file and the information it contains. It all depends on your needs.
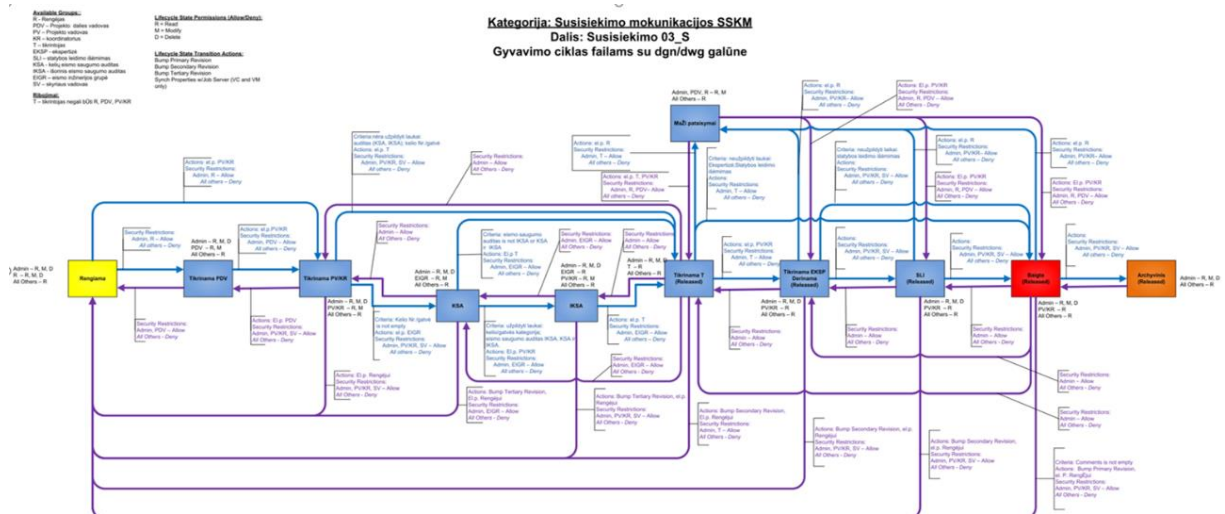
Summary

The possibilities of the software depend on the user. One user uses Civil 3D to draw 2D polylines in the 0 layer, while another may create 3D parametric BIM models.

Civil 3D has a wide range of tools. Only you decide how you will use them. Don't limit yourself to standard functionalities.

Civil 3D has an invisible side called SDK which expands your possibilities even further.

Good design tools are not enough for efficient work. You will also need a system connecting all participants of the project into a united team. Our choice is Vault.