Engineering to order: Substation design process—high potential by using a 3D model

Wolfgang Eyrich
Managing Director – entegra gmbh
<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
</table>
| 1 | 4 min | Introduction  
Just what are we here for anyway? |
| 2 | 5 min | Engineering to order process  
Overview! What are the benefits of a 3D model? |
| 3 | 12 min | 1. Drafting vs. Modelling - 2D and 3D drawings  
Substation design with AutoCAD® and primtech + AutoCAD® MEP |
| 4 | 9 min | 2. BOM/BOQ - Bill of Quantity  
Generation of bill of material – using attributes |
| 5 | 8 min | 3. Building design with AutoCAD® MEP  
See advantages in using AutoCAD® MEP |
| 6 | 4 min | 4. Substation 3D model - Calculation  
Calculation of min. distance, lightning protection |
| 7 | 3 min | Conclusion  
2D, primtech + AutoCAD® MEP – Overview |
Wolfgang Eyrich

- Co-founder and Managing Director of entegra gmbh
- Head of Software Development Department 15+ years
- Developed *primtech – intelligent substation design*

- Worked on studies of integrated data models in the engineering process
- Researched in artificial intelligence (AI) in the ETO process field

- AutoCAD user 20+ years
- Inventor user since version 1.0
Class Summary

This class will provide an overview of the wide range of possibilities and advantages of using a 3D model, especially for an engineering-to-order process, I will show you how to easily and quickly design a substation. Learn how to create a rough plan, refine it, and derive a detailed plan within a few mouse clicks. We will use a single data model designed with primtech® 3D on AutoCAD® MEP.
Learning Objectives

At the end of this class, you will be able to:

- Describe optimal and cost-reducing solutions for the engineering-to-order process
- Design a 3D data model in early project phases
- Produce high-quality drawings for every process
- Prepare specialized bills of material (BOM)
- Use key features to optimize your design process
Just what are we here for anyway?
ETO
substation design - Engineering to Order Process
# ETO vs. MTS

<table>
<thead>
<tr>
<th>ETO “engineer to order”</th>
<th>MTS (Manufacture to stock), MTO …</th>
</tr>
</thead>
<tbody>
<tr>
<td>layout/Set-up plans</td>
<td>manufacturing documents</td>
</tr>
<tr>
<td>project design (risky)</td>
<td>product design (manufacturing design)</td>
</tr>
<tr>
<td>project includes all Engineering costs</td>
<td>costs are allocable to n units</td>
</tr>
<tr>
<td>limited period of time/ Little time for engineering</td>
<td>more time for engineering work</td>
</tr>
<tr>
<td>at least 3 phases (tender, offer, implementation)</td>
<td>just one phase</td>
</tr>
<tr>
<td>comply with several standards (company, supplier, customer)</td>
<td>usually one standard</td>
</tr>
</tbody>
</table>
High voltage substation design process

- Basic engineering parameters
  - Static and dynamic forces: Weight, short-circuit forces, wind forces, earthquake
  - Phase-phase and phase-ground distances, clearances
  - Observe multiple HV-specific engineering rules and standards (e.g. company, customer, national, international)
Design process requirements

- Highly iterative
  - Focuses on editing

- Manage the high potential of:
  - Using data from previous phase (less information loss)
  - Reusability of templates, legacy and standard data

- Must focus on
  - Relevant cost drivers (cost intensive aspects and risks)
  - Concurrent design (e.g. physical, architectural, civil and electrical)
  - Simultaneous management of concrete and unspecific (yet unknown) data
Today 2D is standard. Why use 3D?

- Provides consistent 2D views of a 3D model
  - Provides real measurements for calculations
  - Supports automatic BOQ/BOM generation

- Fast detection / easier recognition of cost driving factors
  - Consistent parts list allows precise cost calculations
  - Reduces drastically COPQ (Cost of poor quality)

- More positive effects
  - Use of a modern “state of the art” tool
  - Better documents for marketing and sales
  - Helps acquire young engineers
Tool landscape

- Tools currently used:
  - 2D AutoCAD®, Microsoft Visio, Microsoft Excel
- Less usage of manufacturing 3D-CAD systems
  - Customizing is necessary
  - 2010 market analysis by ABB shows that parametric standard CAD system covers only a small amount of ABB’s requirements
- Intelligent CAD system on MEP
  - Is used as system of choice in engineering departments in Siemens, ABB-PK, EnBW …
  - Study results of the ABB evaluation widely recommends primtech for the substation design process
The optimal 3D process should

- Follow “Efficient Engineering” focused on time saving and cost reduction
  - 2 to 10 times faster than 2D (efficiency)
  - Shorter project times than in 2D (collaboration)
  - Use the same data model for all design phases
- Be easy to execute
  - Quickly edit specific intelligent HV-objects
  - Reach a high frequency of reuse
  - Enable easy exchange of 2D drawings
- Offer an automatic BOQ/BOM generation
  - Including an intelligent and consistent numbering system for bubbles/BOQ/BOM
- Include physical, architectural, electrical and civil design
Substation design: Classes 1-4
Substation design: Classes 1-4

- We will see first the typical practices of a 2D user then a 3D user in direct comparison
- Finally we will see intelligent substation design using AutoCAD® MEP / primtech®

- Short tutorials, each divided in:
  - 2D user - typical practices
  - 3D user
  - 3D with primtech + AutoCAD® MEP
Produce high-quality drawings for every process
1. Drafting vs. Modelling

- Editing existing substation
  - Insert new devices
  - Change devices
  - Connect components with wires

- See the differences between working with 2D, 3D and an intelligent substation design tool
Summary 2D

- Changes in Drawings
  - Have to use different 2D blocks in different views (Front, Top)
  - Needs to be updated manually for every view
  - Easy to use because of only 2 dimensions
  - Note: pay attention to layers, line types, colours etc.

- Layout Creation
  - Create layouts from a template
  - Any new plan means starting from zero
  - Use blocks with attributes for title blocks
Summary 3D

- Changes in Drawings
  - Is able to cut the model for specific views
  - Is able to save many individual views
  - Every change needs to be done just once
  - Note: spline modification only possible in 2D plane (object snap tracking)

- Layout Creation
  - Existing Drawings are automatically updated
  - Create layouts from a template
  - Fast creation of almost infinite plans
Summary intelligent substation design

- **Modelling**
  - Very easy and fast modelling and editing
  - Intelligent HV entities are available e.g. wire – curve, sag
  - Easy positioning with Connection Points
  - Easy/Intelligent editing – wire curve follows equipment

- **Drawing Creation**
  - Existing drawings are automatically updated
  - No readjustments are necessary in the viewports
  - New drawings are created at the drop of a hat
Prepare specialized bills of material (BOM)
2. Prepare and generate bill of material

- Insert multileader or bubbles
- Count devices
- Measure wire length
- Generate BOM/BOQ

- See the difference in BOM generation using 2D, 3D and an specialized substation design tool
Summary 2D

- Position numbers
  - Can be drawn quickly by using multileaders
  - Need to be updated manually

- Bill of materials
  - Length of wires can be taken off the properties palette
  - Different Excel sheets (bays) can be consolidated into a single total sheet
  - Number of parts or wires need to be counted manually
Summary 3D

- 3D blocks and objects
  - Blocks can have attributes with any information you like
  - Every wire or part appears only once in your model
  - Drawing wires in 3D is difficult when using polylines
  - Taking splines as wires means not having any length information for the data extraction
  - Position numbers can be placed on the layouts

- Bill of materials
  - Block attributes and length of objects can easily be extracted and saved as an Excel-file
  - Extracted information needs to be copied into the BOM
Summary intelligent substation design

- Bubble, Position numbers
  - Bubbles get Position Numbers automatically
  - Consistent Position Numbers throughout the whole project
  - All identical objects get the same number

- Positions parts list
  - Automatically created in Microsoft Excel
  - Structured by part families
  - Structured by bays
  - Wires and tubes with length value
How to design your Control Building
3. Control Building

- Create building in 2D
- Draft views
- Use attributes
- Generate BOM
- Use predefined walls, doors etc. in AutoCAD® MEP

- See the difference in using AutoCAD® MEP compared to 2D.
Summary 2D

- **Drafting**
  - Excellent 2D-tools
  - Use the object snap tracking to draw faster
  - Editing your plans is easy with the stretch command

- **Calculation**
  - Use blocks with attributes to tag your objects or rooms
  - Measure length, areas, angles etc. with the measure-tool
Summary AutoCAD® MEP/primtech

- Building design
  - Draw and change buildings faster and easier than in 2D
  - 3D model creation in passing
  - Get the correct quantities of your design at the earliest time

- Predefined walls (outside, inside), windows, doors and roofs
- Predefined Layers
Calculations—Key features to optimize your design
4. Calculation

- Lightning protection area
- Minimum distance illustration
- Clearance calculations with the clash detection function of Autodesk® Navisworks® Manage

- See the great possibilities of a 3D data model
Summary calculation

- Lightning protection area
  - No way to do this with a 2D drawing, works only with a 3D model
  - As soon as there is an intelligent model, we have a way to optimize the lightning protection components

- Clash detection
  - Minimum requirement is a 3D model
  - If there is an intelligent substation model, where we know which components are electrical conductors and which components belong to phase 1, 2 or 3, then we can use Autodesk® Navisworks® Manage for clash detection
Conclusion

Direct comparison of 2D and 3D clearly shows

- 2D is still needed and AutoCAD is the best tool
- 3D is faster, the more plans are needed
- 3D is faster, as soon as a BOM is needed
- 3D gives you added advantages
- By following the rules of Efficient Engineering, 3D can be very easy
Thank you for your attention!

special thanks to:

M. Sc., B. Eng. Sabrina Heuser
Product Sales Manager – entegra gmbh

Dipl. Ing. Richard Bornhoffer
Substation Design Evangelist - ABB Germany

Prof. Dr. Ing. Schlingheider
HTW Berlin