YRKESHÖGSKOLAN NOVIA

Cubicle Templates with Design Tool E^3

Kristoffer Skrifvars

Bachelor's thesis

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BACHELOR'S THESIS

Author: Kristoffer Skrifvars

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Supervisors: Sven Lindberg & Ronnie Sundsten

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Summary

This Bachelor's thesis was commissioned by ABB Power Systems in Vaasa, Finland. They were at the time carrying out a transition into a new dynamical engineering tool called E^3. The design tool had not been implemented among the general public and only a few engineers were developing templates and components at the early stage of the transition time. The main purpose of this thesis was to create templates for Rittal system enclosures, with the main focus on usability and adaptability throughout the project. The resulting templates will be used by engineers in the planning and realization of several power system projects.

The result of this thesis is a Rittal cubicle in two sizes, with its base components and mounting plate. The templates were merged into the local E^3 component database and have later on been distributed globally within ABB.

Language: English	Key words: Rittal, cubicle, E^3, template

EXAMENSARBETE

Författare: Kristoffer Skrifvars
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Inriktningsalternativ: Automationsteknik
Handledare: Sven Lindberg & Ronnie Sundsten

Titel: *Design av mallbotten för panelskåp med planeringsverktyget E^3*

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Abstrakt

Detta examensarbete var ett beställningsjobb av ABB Power Systems i Vasa, Finland. De höll vid tillfället på att genomföra en övergång till ett dynamiskt planeringsverktyg kallat E^3. Planeringsverktyget hade inte blivit ibruktaget av den stora massan och endast ett fåtal ingenjörer utvecklade komponenter och ritbottnar i startskedet av övergången. Huvudsyftet för detta examensarbete var att skapa och testa dynamiska ritbottnar av Rittals panelskåp, med användbarhet och anpassningsbarhet som röd tråd genom projektet. De resulterande ritbottnarna kommer att användas av ingenjörer i planering och genomförande av olika eldistributionsprojekt.

Resultatet av detta examensarbete var två Rittals panelskåp i olika storlekar, med dess baskomponenter och monteringsplatta. Ritbottnarna implementerades i den lokala E^3-komponentdatabasen och har senare blivit distribuerade globalt inom ABB.

Språk: engelska	Nyckelord: Rittal, apparatskåp, E^3, mallbotten

OPINNÄYTETYÖ

Tekijä: Kristoffer Skrifvars
Koulutusohjelma ja paikkakunta: Sähkötekniikka, Vaasa
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Tiivistelmä

Tämä opinnäytetyö on ABB Power Systems Vaasan osaston tilaama. He olivat silloin siirtymässä dynaamiseen suunnittelutyökaluun nimeltä E^3. Työkalua ei ollut yleisesti vielä otettu käyttöön tämän työn aikana ja ainoastaan muutama insinööri valmisti komponentteja ja piirrustuspohjia projektin alkuvaiheessa. Opinnäytetyön päätarkoitus oli rakentaa piirrustuspohjat Rittalin paneelikaappeihin ja kokeilla niiden dynaamisia ominaisuuksia käytettävyyden ja sopeututumiskyvyn näkökulmasta. Valmiit pohjapiirrustukset tulevat insinöörien käyttöön eri sähkötuotantoprojektien suunnnittelussa ja toteutuksessa.

Tämän opinnäytetön tulos oli kaksi Rittalin paneelikaappia, sisältäen peruskomponentit sekä asennuslevy. Pohjakaavat implementoitiin paikalliseen E^3-tietokantaan ja ovat myöhemmin välitetty globaalisesti ABB:n sisällä.

Kieli: englanti	Avainsanat: Rittal, kytkentäkaappi, E^3, tyyppikuva

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Abbreviations

ABB – ASEA Brown Boveri, leading supplier in power- and automation technology

AI – Artificial Intelligence

ASEA – Allmänna Svenska Elektriska Aktiebolaget

ASIC – Application Specific Integrated Circuit

CAD – Computer-Aided Design

OPTI – CAD software

Rittal – Enclosure manufacturer

SAP – Enterprise software to manage business operations and customer relations

Preface

This thesis is the concluding part of the degree programme in electrical engineering at Novia University of Applied Sciences in Vaasa, Finland. The thesis work was carried out during the winter of 2011-2012 in co-operation with the employer ABB, Power Systems.

I would like to thank ABB Power Systems for the opportunity to do my Bachelor's thesis. And would also like to thank my supervisor Ronnie Sundsten at Novia University of Applied Sciences. And I would especially thank Sven Lindberg for the E^3 support provided through the project.

Kristoffer Skrifvars
Vaasa, April 2015

1 Introduction

1.1 Background

This thesis is made with the design tool E^3.series. Previously the ABB Power Systems used a CAD software named OPTI, but was step by step moving towards E^3. One step was to build up the database with needed drawings of components, assemblies and templates for complete project documentation. All this had to be done and tested before the final release to the department.

This was a large-scale ongoing project at ABB Power Systems' division in Vaasa. Since there was no efficient mean to import previous CAD drawings to E^3 and still make use of the new software opportunities, my task was to develop ready-to-use dynamic drawings of cubicles for future projects, based on knowledge already found in the company.

1.2 Approach

At the time the E^3 transition hadn't spread to the everyday user and only a selected few had access to and knowledge of working with E^3. I started by learning the basics in a course arranged by the developer CIM-Team and continued learning on my own and with the help of colleagues. Since E^3's way of making drawings is different and new to what I was used to, it took some time before I felt I had sufficient knowledge about the complete set-up and all its benefits.

My main task was to find a way that could be used to implement older OPTI drawings into E^3 and afterwards adapt them to the company's way of working. Since my results were going to be used by the company's project engineers, a fair share of time was spent on communication with them, mainly bouncing ideas and presenting new ones. The final stage of my thesis was to implement these ideas into the dynamic possibilities of E^3.

I will briefly explain the basics in how E^3 is structured and the possibilities it may give. However this thesis only touches the surface of E^3's opportunities and it's not feasible to include them all in an understandable manner in this document.

1.3 Purpose

The task given to me by the company was to explore the opportunities of using the dynamic possibilities in the E^3.series. The goal was to take advantage of them effectively and in the end save time for project engineers. ABB Power Systems in Vaasa is a project-oriented organization with many different projects and employees, hence the usability of my result was a critical priority.

Usability in this matter includes e.g.

- Easy to use by end user.
- Template drawings compatible with as many projects as possible.
- Template drawings compatible with as many components as possible.
- If needed, also compatibility with SAP and other company-used software.

1.4 Previous Research and Literature

As the E^3.series is a dynamical software and solutions may be customized to each company or department there was no specific literature available for me to use. Mainly personal communication and E^3 documentation were used. At the time of this task, only one thesis concerning E^3 had been made for ABB, Power Systems, Finland.

1.5 Problems

There were many challenges in the task I was given, and the hardest was surprisingly to get a good overview of already known solutions and problems, and where to begin. One of the biggest benefits with using a project-wide dynamic design tool as E^3 is that changes in one part of the project automatically make needed corrections in other parts of the same project. Exactly the same behavior also applies to errors and typos. This, on the other hand resulted in that, before even starting to draw in E^3, I needed to have a wide and precise knowledge of the software's structure.

2 Company

ABB is a global leader in power and automation technologies with its headquarters located in Zürich, Switzerland. The company operates in over 100 countries all around the world and employs approximately 145 000 people. ABB was founded in 1988 by the merging of the Swedish corporation ASEA (Allmänna Svenska Aktiebolaget) and the Swiss BBC (Brown Boveri & Cie). The history of these corporations extends back to the late 19th century, giving ABB a heritage of 125 years of technological innovations. (The ABB Group 2014).

2.1 ABB Oy Finland

ABB is a global leader in power and automation technologies, and its Finland department employs about 5400 people. ABB in Finland is located mainly in Helsinki and Vaasa but has smaller offices in over 30 locations all around the country. ABB Oy is divided into five divisions: Power Products, Power Systems, Process Automation, Low Voltage Products and Discrete Automation and Motion. This thesis is made for Power Systems Division. (ABB-Yhtymä 2014)

2.1.1 ABB Power Systems

Power Systems' division in Finland is a project-orientated division offering turnkey projects in the area of power production, transmission, distribution, and components related to this sector. The wide area of usage to end-customers is among many: power plants (coal, gas, hydro, solar, wind, nuclear), electrical grids, oil rigs, ships and different kinds of automation, optimization, control or any kind of combinations of these. (ABB-Yhtymä 2014)

The Power Systems' division in Finland is also divided into three local business units, Power Generation, Substations and Network Management. All three located in Strömberg Park, Vaasa, and many projects are internally shared between these units, depending on the area of expertise needed.

3 E^3.Series

E^3.series is software for design of hydraulics, pneumatics, electrical wiring and control systems. The integrated solutions in the software gives the user a lucid view of the complete project environment. E^3 may be used as a single tool through the whole project from manufacturing to realization, and may even be customized for the needs of the user. The software is divided into modules that target certain applications and purposes. (Zuken 2015)

One of the big advantages of E^3 over other design tools is that the software is dynamical, meaning it has a built-in AI that understands what changes in one part of a project may affect in others. This is very usable for projects containing hundreds of layout drawings, schematics, diagrams and part lists. The backside of this feature is that the making of the initial project or template takes much more planning and time. But if the next project is similar, you have a template to start from, and then again, much time will be spared.

3.1 Developer

The history of E^3 starts back in 1987, when CIM-Team Corporation was founded in Germany, initially as a service/design company within the area of PCB design, but the corporation has since then had a focus on CAD software in fluidal and electrical design. In 2001 CIM-Team introduced the first version of E^3 and in 2006 CIM-Team was acquired by Japanese Zuken, and as a result a name change from CIM-Team to Zuken took place in 2009. (CCS-Group 2015)

In the Nordic and Baltic countries the E^3.series is licensed by CCS-Group.

3.2 E³ Modules

The software environment is a multi-module build-up containing different licenses and tools depending on the needed solutions. The modules cover and may be used in a wide range of fields, with the most significant being electrical, automotive, hydraulic and pneumatic. The most usable modules for power system electrical engineering are:

- E^3.Schematic
- E^3.Cable
- E^3.Panel.

The module names use the naming structure E^3.*module*

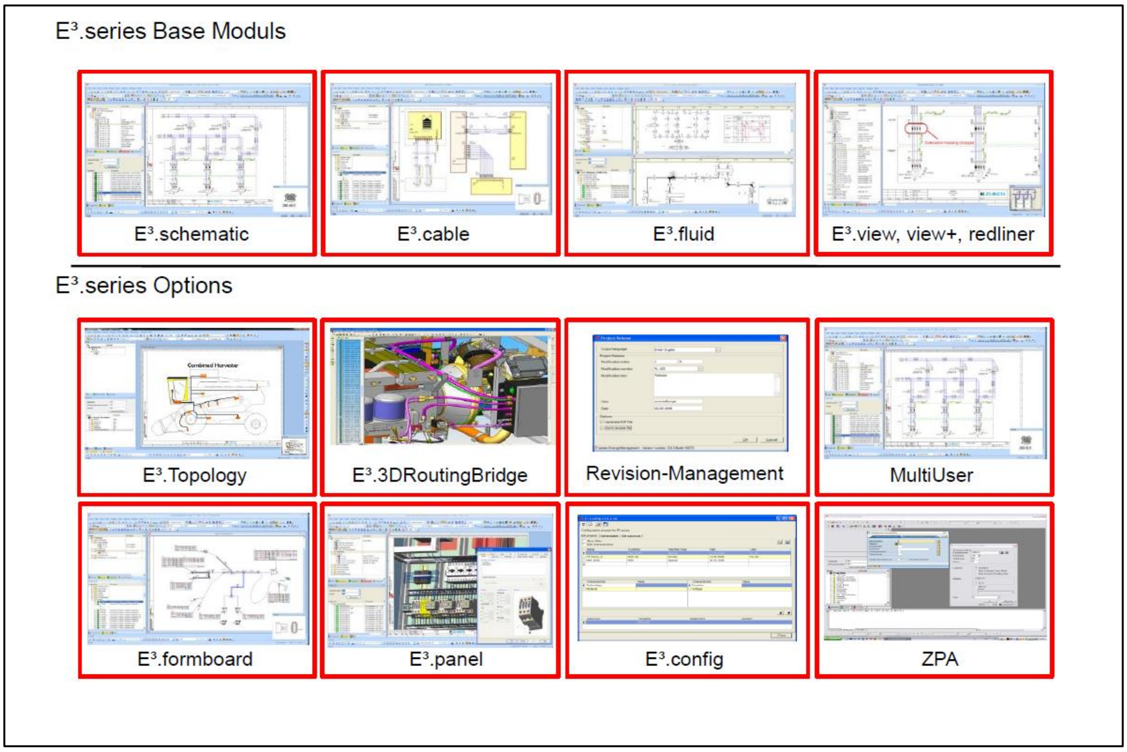


Figure 1. Overview of E^3.series and its modules. (CCS-Group, 2015, Power Point)

3.2.1 E³.Schematic

E^3.schematic is the core of the E^3.series and is also the module used for hydraulic and pneumatic design. Together with any other module this becomes a usable engineering tool. The E^3.Schematic module itself is the module that can generate circuit diagrams, terminal lists, equipment lists, cable lists and connection tables. Including functions such as automatic connections and prevention of designing short circuits makes the module versatile and usable in matters regarding electrical engineering. (CCS-Group 2015)

This module contains the E^3.series' basic database of components and a complete IEC/ISO symbol library. The E^3 library may also be customized for individual documentation reporting such as inputs/output-lists for manufacturing. One additional possibility is to communicate with PLC systems or read/write IO lists or other engineering data software e.g. Excel. (CCS-Group 2015)

3.2.2 E^3.Cable

The E^3.cable tool is made for designing e.g. machinery, and terminals and allows easy integration between electronic boxes and blocks. Adding more functionality of wiring, documentation and automatically generated user defined lists is a built in feature. Also new views of components, schematics and importation of PCB design data, is included in the E^3.cable module. (CCS-Group 2015)

3.2.3 E^3.Panel

E^3.panel is the first choice for users who need to place and connect equipment cubicles, mounting plates and even larger solutions as switchgears or complete control systems. The E^3.panel module is also fully integrated with E^3.schematic/cable. This means that the same objects are found and may be used in both. That is the core power of E^3 giving the user the possibility to first draw up the schematic in a project and then design the layout, or vice versa. The system immediately knows how different pieces of equipment are connected to each other and make needed corrections in the other modules. (CCS-Group 2015)

With the combination of the E^3.panel/schematic, the panel module has an automatic routing option which if used, may physically route and connect equipment the shortest way through cable ducts. Connection lists may then be generated including necessary data such as exact length, color, terminals, labelling, and is a usable option for pre-manufacturing wires before physical installation. E^3.panel also includes the option to make 3D models of your equipment, giving the option to visually inspect your creation. (CCS-Group 2015)

3.3 E^3 System Architecture

The E^3 software is a project and process wide application. This means that it can be used along the whole project from engineering to realization. The complete build-up and intention during the development of E^3 has from the beginning been to make a single multi-purpose software, adaptable for customer requirements. These are all important factors in order to reach out to as broad an industry spectrum as possible, and with usability as the E^3.series cornerstone. (Zuken 2015)

As all base modules and options are in practice is only one program, with its functionality controlled though license handling, there is only one installation needed. All modules share the same database. This includes components, templates, schematics and so on. This is a secured database, meaning that users can’t change objects at database level, only project-specific changes can be made. But, objects can easily be added to the database through an administrator. (Zuken 2015)

E^3.series is also a multi-view object-oriented technology, which for the user means the following. You can begin your work anywhere in the project, add components, draw circuit diagrams or construct the layout. All modifications you do to your project will be implemented simultaneously to all views. If you add a component, such as a relay, symbols will be added to the project tree, and they are easy to drag and drop into for example the schematics diagram. When two components are connected in schematics, they will be visible in panel mode and connecting wires are automatically drawn when put into the cubicle. Different views of objects give you different possibilities, such as documents for manufacturing, service or customers. And documentation, such as parts lists, terminal lists, wire connections etc. extracted from E^3 are always current and updated without manual corrections.

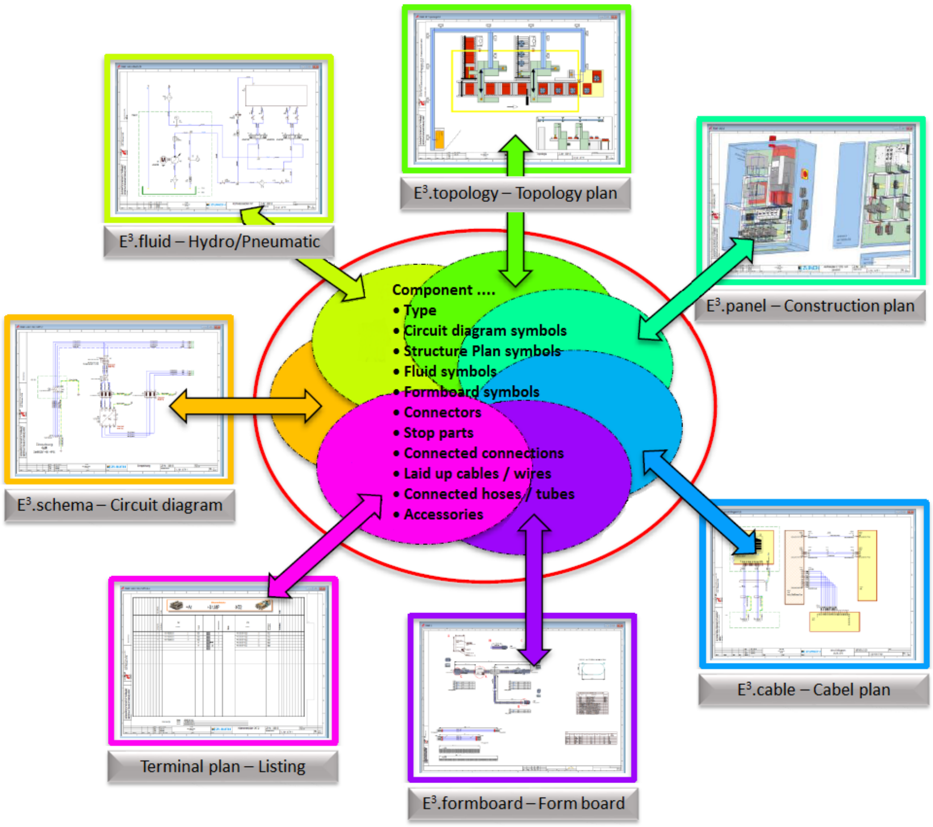


Figure 2. Graphical overview of E^3.series program structure. (Zuken, 2015, Power Point)

3.4 E^3 Database

One aspect of the possibilities and different views and modules of the E^3.series is a thorough database containing all components and their properties. To make one single drawing template you need to have an understanding of how everything is linked together and what all properties and advanced options do, otherwise it is very hard to utilize the benefits E^3 may give.

4 Cubicles

The cubicle is an enclosure for assembling electrical components such as relays, power supplies and PLCs. The cubicle may vary in size and quantity, and its build-up depends on its final use. In ABB Power Systems the cubicle is a commonly used part in several projects. The most commonly used enclosure in ABB Power Systems projects is a Rittal manufactured build-up from Rittal's TS series, typically with a height of 2200 mm and a width of 600 mm or 800 mm.

4.1 Rittal Cubicle – Main Components in ABB Power Systems' Set-up

Since the cubicle parts are critical components in project planning they needed to be found in E^3s component database, ready to be used when needed. As previously stated the enclosure setup may vary in size from one project to another, but some components are more common than others, and these were the ones that should be develop and test before implementation to E^3.

The following is a list of commonly used Rittal components:

- Cubicle frame. Views from right, left and the front.
- Cubicle door with or without glass.
- Plinth front and back with or without fan.
- Mounting plate.

4.1.1 Rittal Frame

The frame is the backbone of the cubicle. All other Rittal components used in this thesis are mounted on the frame.

Figure 3. Rittal cubicle frame

4.1.2 Rittal Mounting Plate

The mounting plate also called back plate is located inside the cubicle at the back of the frame. This is where DIN rails, cable ducts and other components will be installed. Almost every project cubicle sold by ABB Power Systems in Vaasa has a mounting plate installed.

Figure 4. DIN rails with components mounted on the mounting plate.

5 Description of Template Build-up

As the Rittal cubicles are the most commonly used setup, this was the point of origin given by the company. The reasoning was that if one complete cubicle with all its features and different components working together in E^3 were made, it could be used as a template, and only minor changes would be made to get the different sizes. The final templates implemented to the E^3 database can be found in appendix 1.

5.1 Cubicle Build-up in E^3

E^3 is in need of a certain structure and references to work properly, as everything should be done in order. As usability for project engineers was the main cause of this thesis, discussions with project engineers were critical. And as E^3, when proper templates are made, gives the engineer a “drag and drop” possibility from the project tree, there was really only one solution. Mainly because when all components is implemented to the E^3 database, engineers don’t need to do the manual drawing, as in other CAD software.

5.2 Drag & Drop

Drag and drop is a very time saving, and error free solution that may be used in E^3. Basically it means that when you start a project, you choose all needed components from the database and add them to the project tree, and then start connecting them in schematics or placing them in panels. You may have a project template, containing basic components or most commonly used components, already placed and connected. And then you can start customizing the project according to the customer requirements.

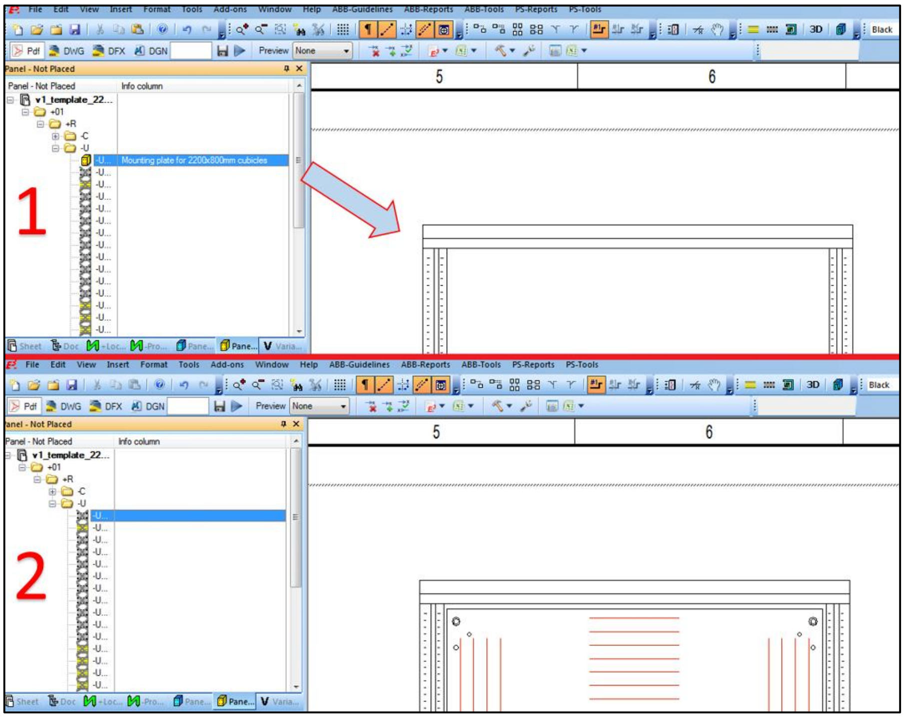


Figure 5. Showing drag-n-drop from project tree to drawing.

1) Upper half showing mounting plate available for drag-n-drop in project tree.

2) Lower half showing cubicle including mounting plate and removed from project tree.

5.2.1 Benefits

The drag and drop principle, as used in this program, doesn’t need much manual drawing. This method is time efficient, and error free, if components are built properly. Engineers only have to place components in the correct part of the project and make the connection between them. Hereafter E^3 AI draws the wires, makes correct terminal lists, labeling, and make the I/O list or other needed documentation. Before this, engineers have often been using the “copy-paste”- method from previous similar projects that often come with manual drawing errors, typos or referencing problems in a large scale project.

And since E^3 in general works on a built-up component database that is managed through engineering administrators, who over time add components to the ABB Finland database, the confusion caused by every engineer having their own different solution is eliminated.

5.2.2 Disadvantages

The benefits of the drag and drop method are many, mostly time saving and user error minimization. The disadvantages on the other hand are mostly in the commissioning phase, since the many benefits of E^3 need an enormous amount of working hours to get a functional database. Of course there are basic databases to start from, but with the size of projects and amount of components used in ABB's projects there are not nearly enough components to start from.

All components made should be built with the possibility to be attached only where this is possible in reality. And with the intelligence to understand when one component isn't placeable on another component. To take a simple example, a 2200x800 cubicle door can only be mounted on a 2200x800 size cubicle. And it should not be possible to place a protection relay in a cubicle if there is no mounting plate added before. This demands a certain knowhow of how the current database is built, and how things are put together in reality. On the other hand a lot of "trial and error" testing of different scenarios is probably needed before a functional solution is achieved.

5.3 Cubicle Structure in E^3

Since the many possibilities of E^3 don't come automatically, wanted properties need to be added already when building the component database. E^3 developers have solved this by making each component built up from several elements, all with their own purpose and place in the component hierarchy.

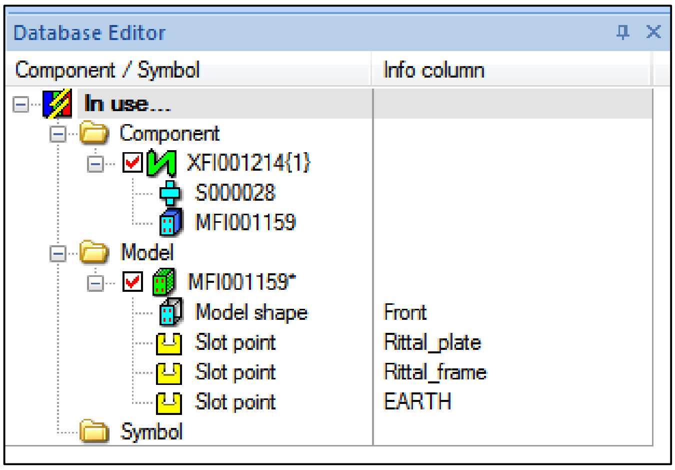


Figure 6. Showing the component structure in the E^3 database editor.

A component is built up from two elements, a symbol and a model. The model is the one containing all the properties E^3 needs to take advantage of the software's AI. And the symbol element is only the electrical symbol for the specific component. The different elements used in this thesis follow a certain naming structure. Components start with letters 'X', symbols start with 'S', and models with 'M'. Both components and models also have "FI" as second and third letters, symbolizing the local Finnish database. All element letters however are followed by a six character long numerical value.

5.3.1 Component Symbol

This is the visual symbol used in electrical circuits or schematics, not to be confused with the visual layout or the model of the component itself. This element contains all symbols the component may use in different views, such as ASIC, contact symbols or standard symbols. The symbol element consists of four sub-elements:

- Graphics
- Connection points
- Symbol texts
- Attributes.

5.3.2 Component Model

First there is the model shape. This is the one containing the layout in three dimensions and the visual element of the component, including measurements. This is also where the counterpart to the slot is chosen. In the model properties, you add a shape with the same name as the slot where the model is to be placed. If you want to place a model that has a shape named 01_Component on another component, you need to have a slot with the same name on the second component

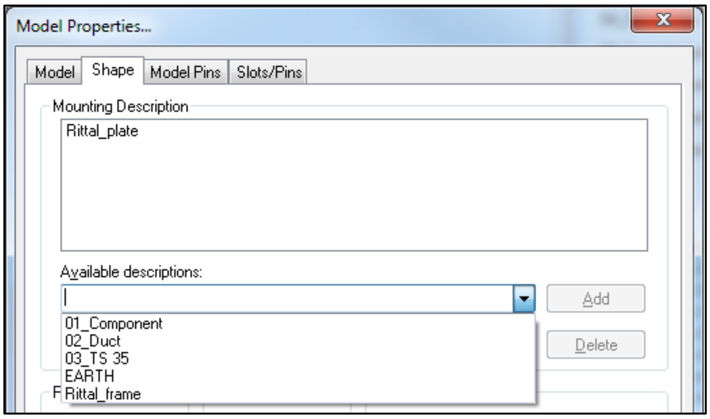


Figure 7. Showing the model properties and the drop-down menu where the shape is chosen.

Second there are one or many slots. These are the ones giving the component the drag and drop feature when used together with a shape. The slots can be given different names, such as contact type, or complete own names. Slots can only be paired with a shape of the same name. There are also different kinds of slots, depending of what you need to accomplish.

- Slot point, for attaching components in one single point.
- Slot line, for attaching components along a line.
- Slot area, for attaching components in a two-dimensional area.

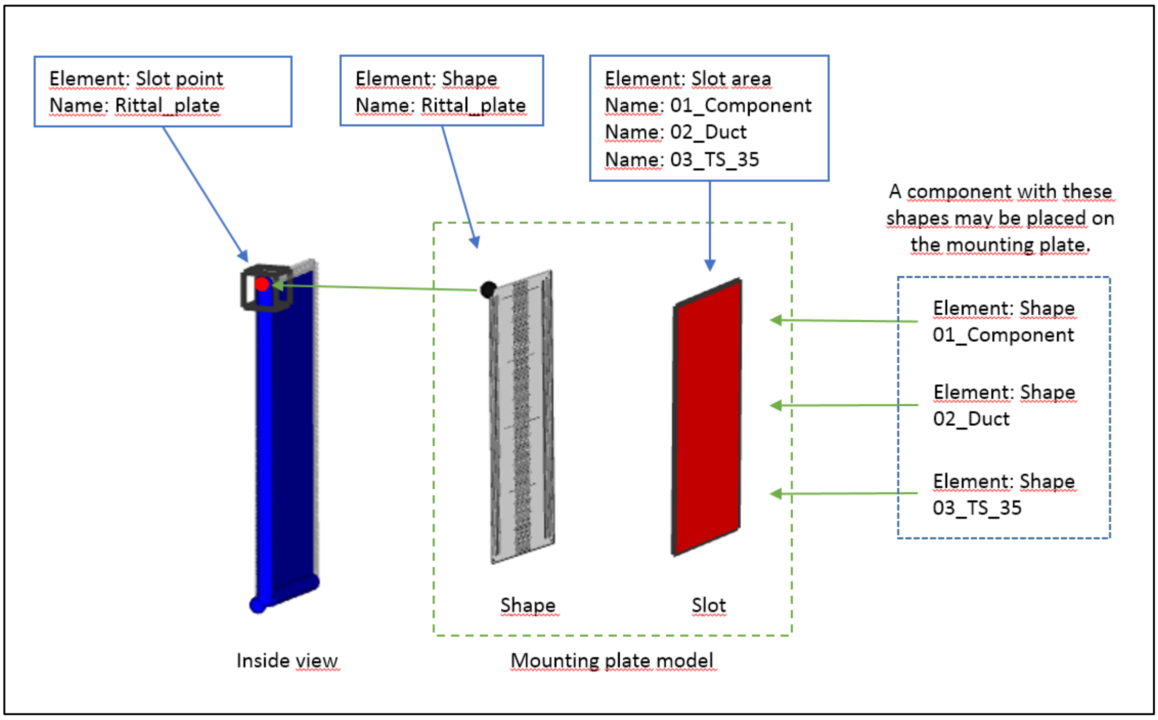


Figure 8. Showing the connection between slot and shape.

5.4 Drawing the Template

For the first template and drawings it was logical to make a first draft of a basic 2200x800 mm Rittal cubicle, mostly because this is a standard size and commonly used. In the company they have for many years already used other engineering tools such as OPTI and AutoCAD, and drawing templates in .dwg format were already made. Since the E^3 structure requires the cubicle to be built in as many parts as it is physically possible to change or replace, it was decided to start with the most basic ones.

- Left view
- Right view
- Inside front view
- Door with and without glass.

The reason why these were chosen to start with was because in my personal communication with Sven Lindberg and from the E^3 training it was known that the different slots and their involvement may cause problems and unexpected behavior. And since the mounting plate has the most anchor points, and therefore probably the most slots, the logical approach was to begin with something less demanding. One benefit from beginning with the more visual parts was also the opportunity to get a deeper understanding of E^3 behavior before taking on a possible turning point in the task.

5.5 Importing from CAD to E^3

The most efficient way to make something that was already made in another program is naturally importing drawings from one program to another. Since E^3 had this functionality the approach was to import drawings from E^3 and add the dynamical preferences. There were some known issues with this from the beginning, but no deeper investigation had been made.

5.5.1 Measurements

The strange and already known problem with importing old CAD drawings in .dwg format was that the measurements in the imported drawings were not correct. Since no further investigation into the matter had been made and no answers had been found, it was decided with the E^3 administrator Sven Lindberg that some time could be spent on analyzing this.

Due to this issue the making of the template started with exploring every setting found, even remotely associated with any kind of measuring, scale, or units. No solution was found and since this was not the main task it was decided not to spend too much time in this matter. It would be faster to make new templates from scratch in E^3.

5.5.2 Visual Differences in Drawing Workspace

Another difference that occurred during the importation of .dwg files was that objects in the old drawings were handled as lines instead of as objects. So when opening an imported drawing in E^3 although the visual layout in the old software was a box made of a square, it was when opening in E^3 a box made of four independent lines instead of a square.

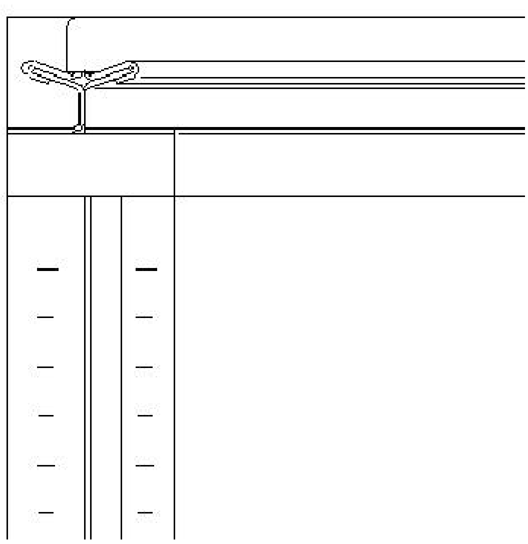
This issue affects the possibility to easily resize and change the dimensions of the cubicle. Since these templates where to be used by the rest of the department to easily make similar versions with other dimensions but retain the built-in dynamics, usability in this matter was also a critical requirement for the cubicle templates. Hence it was concluded that importing the old drawings would only result in more work than making them from scratch.

5.6 New Templates from Scratch

Since importing .dwg files was not an option, the actual task of this thesis was started with making new components in E^3 from scratch. The old drawings were still used but printed on paper, where the measurements were correct. This was actually a better idea, since now there was no need to correct all measurements manually in the E^3 environment.

5.7 Visual Design of Cubicle Frame

The opportunity to reform the template was given, and based on discussions with project engineers in the department, drawings were made accordingly. The old ones had details that were not necessary and some details that were missing. The detailed metal foldings in the corners were stripped and extra lines were removed. All details that had no other function than visual satisfaction and gave no value in planning or to the end customer were unnecessary. More accurate and visual mounting holes were added instead of previous lines, to give the engineer a more useful and obvious design. All changes were made to reach the goal of usability for project engineers.



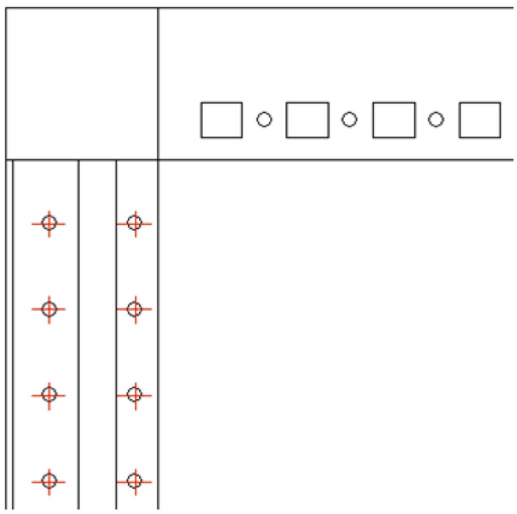


Figure 9, left. Upper left corner of older version.

Figure 10, right. Upper left corner of the new version. The red crosses are slot points.

5.8 Dynamical Properties of Cubicle Frame

The visual design itself contains no properties that give the template the dynamical possibilities of E^3. In this case when making a template for cubicles, the dynamics is added by making and choosing the correct slots for the drawing, and placing them in the best position in the drawing. Although there were no functional templates made, other components and apparatus had been built into the E^3 database. Also Sven Lindberg had given the Rittal cubicles some thought, hence the names of the slots were already determined as follows:

Already created slot names and their purpose:

- Rittal_inner, made for the inner anchor point in the frame.
- Rittal_outer, made for the outer anchor point in the frame.
- Rittal_Door, made for attaching cubicle doors.

- Rittal_plate, made for attaching mounting plates.
- Rittal_frame, made for attaching plinths.
- 01_Component, made for attaching apparatus and electrical components.
- 02_Duct, made for attaching cable ducts.
- 03_TS 35, made for attaching support rails.

5.8.1 Slot for Mounting Plate

Rittal cubicles have the possibility to add a mounting plate on which apparatus may be placed. To get the “drag-n-drop” feature between the mounting plate and the cubicle itself, a slot with the same name as the shape on the mounting plate is needed.

The maximum number of slots, on the other hand, could in theory be infinitive. But to narrow it down further it’s logical to make the assumption that every anchor point for the mounting plate should have its own slot. And since the mounting plate is attached to the cubicle with screws, the selection of slot type in E^3 is naturally a slot point. With these assumptions the amount and type of slots would be one slot point for each anchor point.

However, the criteria of usability and adaptability limit the amount of slot points even further. All cubicles should easily be expanded or reduced in all three dimensions. Because the use of several slot points restrict the possibility to shrinkable dimension to the distance between these points. And if a cubicle with smaller dimensions is ever needed, the slots will need to be moved. As a result, there will be a need of a specific knowledge of the E^3 component database, which minimizes the number of engineers able to make the changes, and in the end results in a more time demanding workflow.

Since the shape for this purpose was already named, the result was that only one slot point, named *Rittal_plate*, would be needed for attaching the mounting plate. Its location was chosen on the basis of usability with the following considerations.

- To the left, to the right or in the middle.
- Up, down or in the middle.

The middle options in both directions were rejected first, because of the fact that the templates should be easily replicated in other dimensions. The right option was excluded because the x-axis begins from the left. And finally the lower was left out because the cubicles also need a plinth that naturally is under the frame which also needs a slot. To avoid confusion between these two slots the left upper corner was chosen as the location for the slot point *Rittal_plate*. To represent reality, the inside of the frame, in the left upper corner was chosen. (E^3.series manual 2012)

5.8.2 Inner and Outer Frame Slots

The mounting holes on the sides in the cubicle frame are also screwing holes, so the natural selection here is also the use of slot points. Since the apparatus that is going to be placed on these slots is already named the slot points on the frame need to have the same names to be functional, i.e. *Rittal_outer* and *Rittal_inner*.

The components that will be attached to these slot points are for example mounting rails. This meaning they will cross over from the left side to the right. The logical assumption here is to put slot points on every screw hole on both sides. But again the usability fact of re-dimensioning needs to be taken into reconsideration. Since the fact that all components attached to these slots are rack mounted, there is no need for slot points on the right side.

5.8.3 Component Placement Restriction

Since the slots on the right side were removed due to the ability to easily resize components in the future, it’s now possible to place components that are wider than the actual cubicle. This is an unwanted disadvantage because it may result in ordering components that do not fit into the cubicle.

The solution is to create a slot area, with the purpose to restrict the placement area. A slot area and point, in combination, with the same shapes on the placeable component, result in this restriction. The slot name chosen for this was *01_Component*, since it had already been created as the fastening slot on apparatus in the database.

5.8.4 Other Slots

One other slot put in the frame is a slot point for the plinth, chosen to be at the bottom left corner. For the door a single slot point was put in the upper right corner, but on the outer edge of the frame.

5.9 Visual Design of Mounting Plate

The mounting plate is visually and physically just a metal plate where DIN rails are placed. There are no fixed anchor points for where DIN rails and cable ducts are to be mounted. They are mounted separately each time depending on the solution. One of the main goals was to give the project engineer a good visual view of the mounting plate. This because the drag and drop solution demands a good detailed overview of the cubicle to exploit all benefits. It was concluded that the mounting plate should have some kind of indication of on what height the DIN rails are placed, to ease the manufacturing process.

5.9.1 Lines Flowing Together

The first draft made consisted of a plain rectangle with its screwing holes in the corners, and a red line for every 10 millimeter. This was, however, not a comfortable solution since when fully zoomed out all lines seemed to merge, and it was impossible to estimate the height. The second draft was made with red lines for every 25 millimeter. This solution didn't have the problem with the red lines flowing together, and was used as a first draft for the testing with mounting slots.

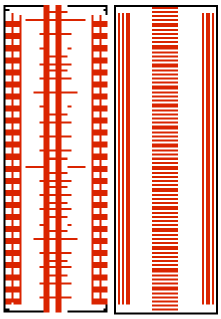


Figure 11. Showing how lines float together when zoomed out.

However, after the first draft including slots had been made, and after actual testing of the drag and drop feature with cable ducts, it was concluded that the lines were clearly visible but didn't give the ability to place components accurately. The reason was that it wasn't clear enough on what height one had placed the din rails or cable ducts. After consultation with Sven Lindberg it was decided that a better visual accuracy was needed. Based on the previous drafts it was concluded that solid red lines in every 10 millimeter was too tight and if placed in every 25 millimeters they were clearly visible.

5.9.2 Build-up of Final Draft

The last draft made followed the same basic layout as the first draft, but with different width of the horizontal red line depending on the height of it. And with most of the lines dotted, to get away from the problem that they all flowed together.

As a base all red lines were dotted, then the following changes were made, with these criteria in the same order:

- Every 5th line was made solid, symbolizing every 50th millimeter from the bottom.
- Every 2nd line of the previous lines had 20 mm added in both directions. Symbolizing every even ten millimeter.
- Every 5th line of the previous lines had 50 mm added in both directions. Symbolizing every 0.5 meter
- The lines at one and two meters from the bottom had an additional 50 mm added in both directions.

This result was a working solution giving the engineer a good overview of the cubicle. All components could easily be placed at the right position at the first drag and drop.

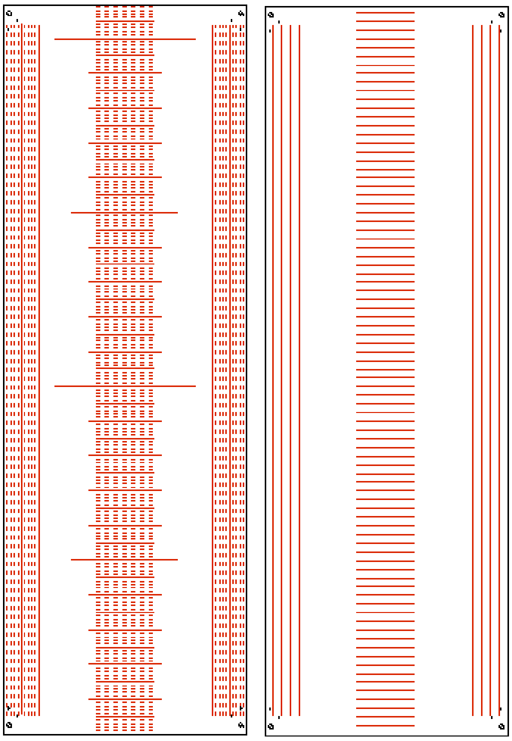


Figure 12. To the left the final draft and to the right the first draft of the mounting plate.

5.10 Dynamical Properties of the Mounting Plate

The task of this thesis was to make templates usable in all projects and adaptable to new ones, but also with the possibility to limit the typical “every engineer has his own solution” thinking, such as restrict the possibility to place DIN rails on certain heights. The restriction of DIN could be useful for manufacturing, as only certain heights would be used. This option could be enabled by using slot lines on the mounting plate instead of a slot area, which would enable mounting everywhere inside the area. (E^3.series manual 2012)

5.10.1 Slot Lines

The first draft of the mounting plate was made with horizontal slot lines every 25 mm. The spacing was believed to be suitable for two reasons.

- It would limit the possibility of anchor points into 82 pcs.
- It would be enough to get all project setups covered.

Also eight vertical slot lines were added, four to each side. These were needed because cable ducts are to be mounted also going from the bottom to the top. Same spacing between the lines was used as the horizontal lines. The horizontal lines was placed by the following reasons:

- To the sides because there was no need for vertical cable ducts in the middle of the cubicle.
- The amount of four only to get a little latitude.

5.10.2 Surprising Behavior with the Use of Slot Lines

Unexpected behavior occurred when testing the use of the mounting plate in the project environment. When adding cable ducts or DIN rails to the mounting plate, “hopping” between slot lines made it almost impossible to place the part where needed. Every time when the slot point at the cable duct crossed a slot line at the mounting plate, the duct changed direction by 90°. This gave the user the impression of “hopping parts”. This was not a very user friendly property and several attempts to avoid the hopping were made with the same result.

5.10.3 Slot Area

Since the use of slot lines was not an option it was decided with Sven Lindberg that the use of a slot area at the complete mounting plate was the only option left. This gives a more user friendly behavior and in the end a more time saving solution.

5.11 Design of Other Cubicle Parts

The design of other parts, such as plinths, was made with the same reasoning as the front view. These components are part of the exterior of the cubicle and all are mounted on the frame. No apparatus will be mounted on these parts, and therefore one slot point per part was used to attach them to the frame.

The main reason for making these parts was to get them into the E^3 component database, so they would be available to place in the project tree. Since the component properties contain the manufacturer part number, parts lists with precise information may be extracted from E^3, and forwarded to involved parties.

5.12 From Rittal 2200x800 mm to 2200x600 mm

All components made for the 2200x800 mm cubicle were resized into a 2200x600mm cubicle. This was made by changing the x-axis coordinate in all model drawings. On all the horizontal lines it was easily made inside E^3. But the software doesn't have any function that selects and moves multiple objects at the same time, and no snap tool either. Since there are 84 pcs of mounting holes in two rows, this was a frustrating and time consuming holdback. After consulting with Sven Lindberg, a database file containing the model was found that could be opened in database editor Microsoft Access where all needed objects' coordinates could be changed much more easily.

6 Main Challenges

The work of this thesis was a lot more time consuming than anticipated. Sufficient E^3 knowledge is needed through the complete project and many hours was put into learning. However there were some significant problems that required a deeper investigation.

6.1 CAD to E^3

All necessary drawings were made already in .dwg format in another CAD software. According to the E^3 documentation it should have been possible to import and add the features needed. This didn't work as promised and somehow the measurements didn't match after importing. In the import function in E^3 there somewhere are background data incorrectly handled, or numerical values improperly rounded.

6.2 Layout and Usability

One challenge with the design of the cubicles and maintaining the drag-n-drop function was that it should be easy to place apparatus or parts at the right location, without the need of zooming in and out all the time. Regarding the layout, too many lines or details may make the drawing look incomprehensible when zoomed out. But when there are too few details drawn you lose the estimation of where in the drawing you currently are located when you have zoomed in a lot, and the location is critical when placing apparatus in a cubicle. This of course is not a specific problem for E^3 only, but the drag-n-drop function makes it considerably more noticeable.

6.3 Time Consuming Workflow in E^3

A component in E^3 is built up from many sub elements, and all these need to work together both dynamically and visually. There is much testing and re-doing needed before drawings and components are ready for implementation in the database. To do this in the most time efficient manner and with few corrections you need to have a long experience of both E^3 and how the component database in question is structured.

6.4 The Usage of Slot Area or Slot Lines in Mounting Plates

The first draft of the mounting plate using slot lines gave an unusable workspace, and the result was that cable ducts and DIN rails were very hard to put in the right place. Much time was spent on testing different lengths and different spacing of the slot lines, and combinations of these. All solutions tested with same result that hopping between slot lines occurred when zoomed out a lot. Even when you zoomed in the same error occurred, and it could not be prevented by manually pressing the “R” button, which rotates the component 90°. It is though possible to prevent the rotation by holding the “Shift” button, this wasn’t the solution we wanted to achieve.

7 Conclusion

The goal of this thesis was to find and solve problems that occurred during the development of the templates. If no solution could be found for a specific problem an alternative solution was to be presented.

7.1 Result

As the result of my thesis differs from the original purpose, the final result presented is the solution for significant adversities that occurred. These unexpected concerns were however of the kind that had to be solved before any further development in the area could be done.

7.1.1 Importing .dwg Files to E^3

I was not able to find a solution or a way to evade the problem. Therefore I had to leave the importing of drawings due to lack of time. I suspect that there were probably some differences in how E^3 and AutoCAD handle background data that is not known to the user, because correlations could be found between inches and millimeters. Even though all drawings and settings in both AutoCAD and E^3 were always set to millimeters the same error occurred. When importing drawings to E^3, there was an extra 0,1mm for every inch (25.4 mm). The software manufacturers have been contacted, but even they haven't been able to deliver a working solution.

7.1.2 Slot Area vs. Slot Lines

By using slot lines one could limit the possibilities for the everyday user and minimize the amount of different solutions in use. But the hopping that occurred when using the slot lines is not a very good solution in terms of usability. Different solutions were experimented with, such as changing the amount of slot lines, the location and length of them. However, no user-friendly solution could be found.

The time saved by using slot areas was concluded to be much more valuable than limiting the possibilities for project engineers and undisputedly more user-friendly.

7.1.3 Moving of Multiple Objects

It was concluded that the moving multiple objects in a drawing is possible by changing raw data in the local database. However, to find the correct data and know what it affects in the software is a time consuming solution. If the amount of objects to be moved exceeds several hundred, the recommendation is to use the database solution, otherwise manually moving them in the E^3 environment is recommended.

7.1.4 E^3 Components Merged to ABB Power Systems' Database

The following components were made and tested with different setups, and finally merged into the ABB Power Systems' component database:

- Rittal cubicle 2200 * 800 mm
    - Front view inside
    - Side view, left and right
    - Plinth, front and back
    - Plinth, front and back with fan
    - Plinth, sides right and left
    - Mounting plate
- Rittal cubicle 2200 * 600 mm
    - Front view inside
    - Side view, left and right
    - Plinth, front and back
    - Plinth, front and back with fan
    - Plinth, sides right and left.

7.2 Reflections

This thesis is part of my education and a requirement for graduation. The work on this thesis has shown me that unexpected problems can occur and may be time consuming even though delays were expected. If these obstacles could have been prevented is hard to say. With more experience of E^3 they most likely would have been anticipated, but not in any way evaded.

The result of this thesis is also not what it was meant to be from the beginning. The original plan was to make templates of both the Rittal cubicles and also the Marshalling boxes, including electrical components such as relays and cabling. When the actual drawing of the templates began and so many unexpected problems occurred, and the needed and unavoidable solutions took so much time, the objective had to be altered.

7.3 Discussion

Before starting the work on this thesis I had been working as purchaser for ABB Power Systems division. I had during this time come in contact with the components used in the different projects and the overall project structure build-up. The use of the E^3.series and a deeper understanding of how the project engineers work were on the other hand completely new experiences.

At the beginning of my thesis a lot of time was spent on learning how to use and understand E^3 and on discussions with other project engineers that would use my solutions. Maybe the most important factor in my templates in the end would be usability, a matter that there is no definite answer to, only different user opinions. There were no wrongs and rights, only better and worse solutions, and of course the technical limitations or possibilities. The result had to be a good combination of these.

My part of this project is with the completion of the templates done. But I am certain that the cubicles made will be altered when taken into use by the department. This is because it isn’t possible to take into consideration all the possible setups used in projects, and problems that may occur during the planning of them.

The templates made in this thesis may be used to develop all different sizes of enclosures and they have already been used. The practical part of this thesis was completed already in spring 2012. Today my templates have been used to make several more enclosures with different dimensions. Sub-circuits for many cubicles are made at ABB Power Systems in Finland, and the complete TS series based on these templates are implemented globally within the ABB. The templates could also be used in development of templates for ABB MNS cubicles.

8 References

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Figure References

Figure 1
CCS-Group, Power Point (2015) *Personal communication with Lars Kvendbø* (Received by e-mail February 2015)

Figure 2
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Figure 3
Rittal Cubicle Frame
http://media.oconda.org/Media/S2/s2_Rittal_Herborn_TS_8686.300_162E58E90323BE81A8C8CDB7D2F2EF4D_B1.jpg (Fetched April 2015)

Customer : ABB Oy

Order : Thesis, Appendix 1

Plant : Power Systems

Equipment : Template Design
Rittal Cubicles

Title : Cubicle Templates with Design Tool E3

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				Approved			Resp. dept. -	Rev. ind.	Language en
				Project	ABB Oy Power Systems Thesis, Appendix 1	ABB ABB Oy	Doc. no. Appendix 1		Sheet 1
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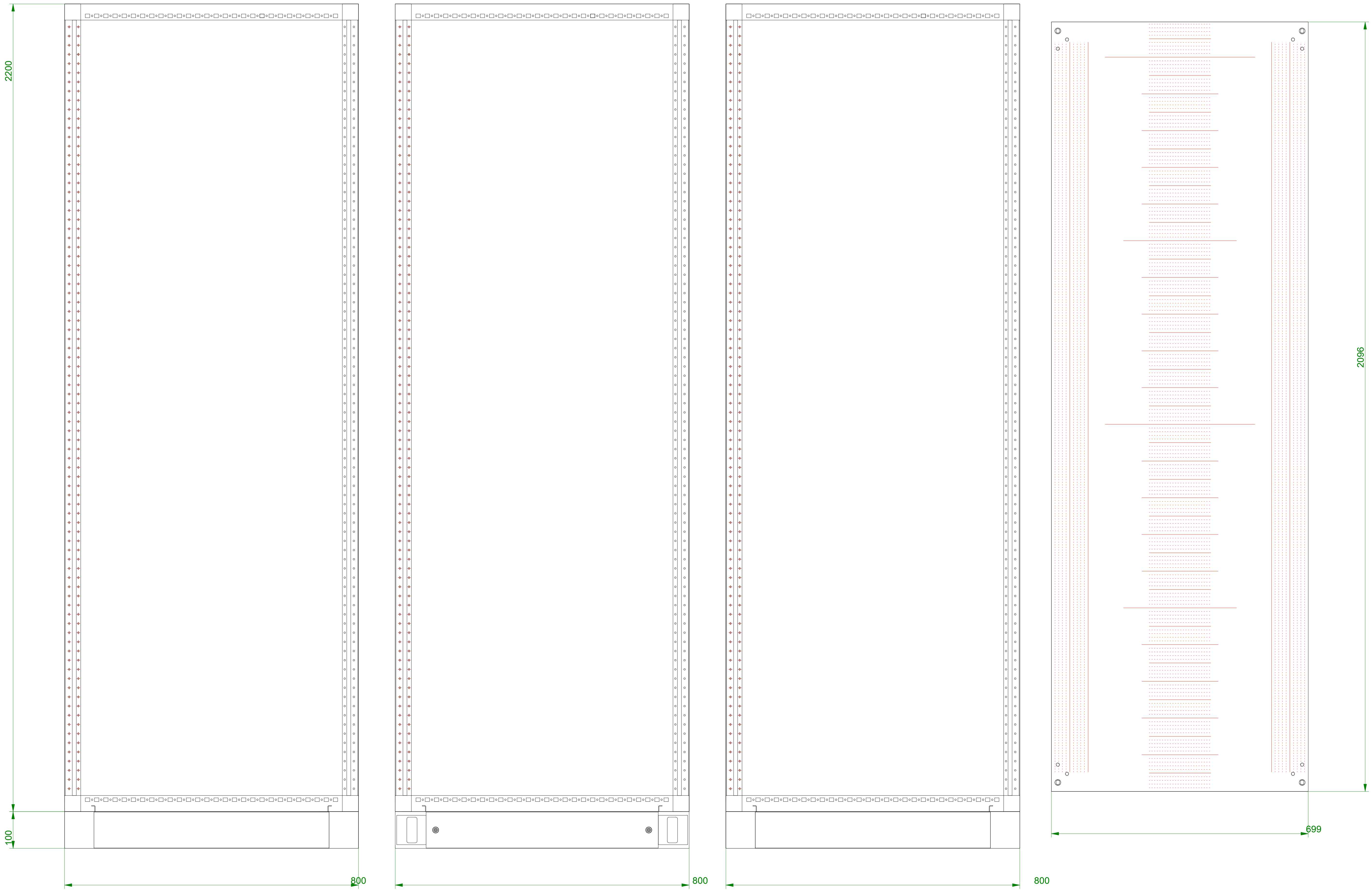

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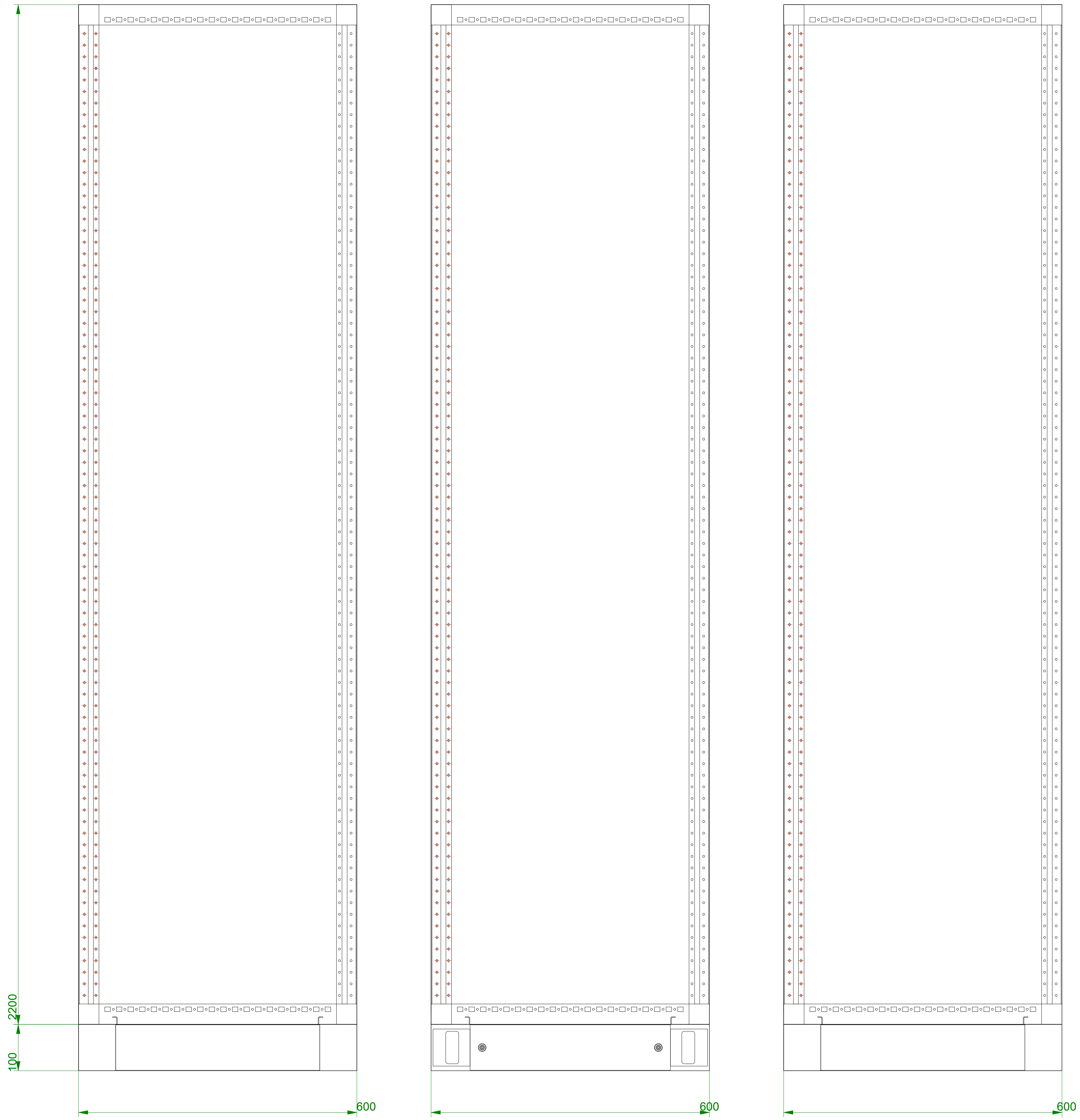

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Prepared: Kristoffer Skrifvars
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Project: ABB Oy
Power Systems
Thesis, Appendix 1

Title: Rittal Cubicles

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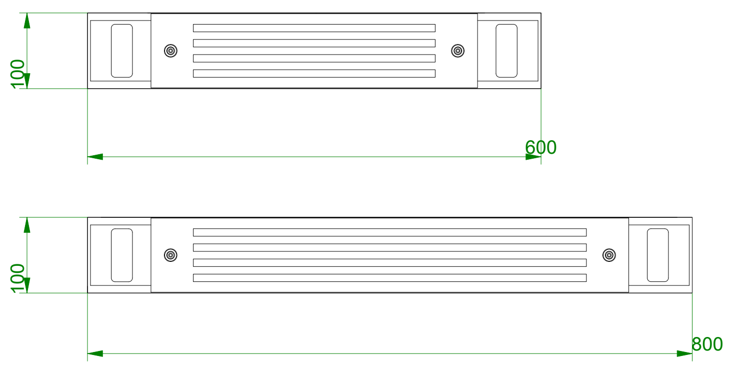

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				Power Systems		ABB Oy	Doc. no. Appendix 1	Sheet 23
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