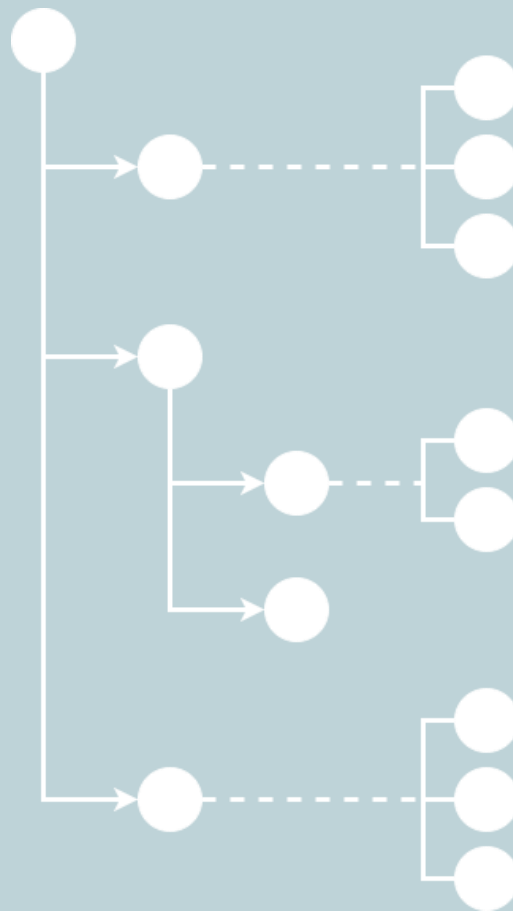


Master thesis
Industrial design Engineering

Developing an Order configurator for a standardized product line



A.P. van der Wal
DPM 2026

Abraham Pieter van der Wal
S170008

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Education:

Faculty: Engineering Technology
Study programme: Industrial Design Engineering
Master track: Management of Product Development

Company:

AVEX
De corridor 19
3621 ZA Breukelen
The Netherlands

Educational institute:

University of Twente
Drienerlolaan 5
752NB Enschede
The Netherlands

Examination board:

Prof.dr.ir. D. Lutters	(chair)
Dr.ir R.G.J. Damgrave	(supervisor)
Dr. F. Schuberth	(external member)
J. Labots	(mentor from company)
Q. Tenger	(mentor from company)

Preface

This thesis is the result of my master assignment for Industrial Design Engineering, conducted at AVEX. As someone that has always had an interest in audio-visual systems, I was more than happy that I could execute my research there. It has been quite an experience to completely immerse myself in the world of AV and see what kind of amazing systems are developed at AVEX. Besides my research I have enjoyed the extra tasks I did once in a while to get myself familiar with the AV industry. In the last week of my thesis I was informed that AVEX has hired a BRIX manager that starts in September 2023. I hope that my thesis and recommendations can help him with optimizing the product line.

First of all I would like to thank both my mentors at AVEX, Quinten Tenger and Jeroen Labots. Starting off with Quinten, our weekly discussions really supported me into pushing myself further, you had great feedback when I did not know the direction I had to go in. I've also enjoyed our long discussions about guitars and music during the break or in the train. Secondly I would like to thank Jeroen for asking me critical questions during my research. This helped me realising what I've actually been doing. The trips to distributors and clients have really benefited to my experience.

Furthermore, I would also like to thank my supervisor at the UT, Roy Damgrave. First of all for helping me get in contact with AVEX and most of all for our meetings where we discussed my research. Your feedback and advise really helped me think in different directions.

Besides all my supervisors I dedicate my wishes to my lovely family, friends and roommates (both in Utrecht and Enschede). You were there when I needed you and you have always encouraged and supported me when I needed it the most. I could not have done this without your support.

Summary

AVEX is one of the Dutch market leaders in audio-visual systems. Originally they only used an engineer-to-order strategy: a new solution is developed once a customer contacts AVEX and completely meets the customers' requirements. Since 2021, AVEX started their first standardized product line, the BRIX solutions. These products are developed before any involvement of the customer and when the customer purchases this item it only has to be produced which shortens the lead time. The BRIX solutions are systems for meeting rooms that enable the user to host videocalls or presentations in a user-friendly way. Currently it consists of 35 different. However, the sales of the BRIX solutions were not as predicted and different issues among the product line were reported.

The main goal of this thesis was to analyse the current workflow of the BRIX product line and to find the issues and their underlying causes. Based on that, a solution is proposed that would overcome these issues. By analysing the workflow, it was identified that the main issues occurred during the sales acquisition. Instead of using a standardized BRIX product for the customer, the sales managers often changes the items within the bill of material. The compatibility in this new bill of material has not been tested which has the consequence that during the production phase it is discovered that these products malfunction. An engineer is needed to evaluate the product and to find a solution. This eliminates the advantages of a standardized product and workflow. The main cause of this problem is that the sales department is unaware of the different products within the BRIX line.

An often chosen method to overcome this issue is a configure-to-order strategy. A product used in this strategy consist of several sub-assemblies that have a finite amount of variants and the customer is able to select the variants based on their requirements. A rule-based engine ensures that the customer can only choose variants that are compatible with previously chosen items. Because of this engine only products can be configured that the company offers. This strategy is often equipped with a configurator tool that lets the user customize their product via a user-interface.

In order to implement this strategy in the BRIX product line, a framework is proposed of different domains that need to be taken into consideration. Firstly, the design of the BRIX products is transferred to a product family architecture that identifies the different sub-assemblies and the variants. Based on constraints that are identified by the engineering department, a constraint-based engine is developed.

A key requirements for an order configurator within the BRIX solutions is that it is maintainable and scalable. The product range within the BRIX solutions changes twice a year and therefore the configurator has to be updated to ensure that it only displays the current availability. To ensure this two databases should be incorporated. One database for the different sub-assemblies and one database for the complete solutions.

Due to the rapid changes within the company the connection between different systems had been researched. A connection with the current ERP system will ensure that prices within the configurator are up to date and that if certain items are out-of-stock that they will not be displayed within the configurator.

Also, persuasion principles are proposed to ensure that if AVEX decides that a certain item needs to be sold that the configurator has an indication to do this. Several methods are suggested, however these could not be tested.

Lastly, a design of the user interface is proposed. Customers are often unaware of the technical differences between the products so a research has been conducted on how to translate this towards the customer. Via an A/B-test it has been concluded how the users should be guided through the configurator. Per selection the amount of presented information is researched. The user interface will present the user with a digital depiction of a meeting room which they can alter to resemble their own meeting room. Based on this visualisation the user can check if a certain BRIX product would satisfy their requirements.

Samenvatting

AVEX is één van de marktleiders in Nederland op het gebied van audiovisuele systemen. Oorspronkelijk gebruikten ze enkel een engineer-to-order strategie: een nieuw product wordt ontwikkeld nadat een klant AVEX contacteert en het product voldoet volledig aan de eisen van de klant. Sinds 2021 is AVEX begonnen met hun eerste gestandaardiseerde producten lijn, de BRIX solutions. Deze producten zijn ontwikkeld voordat de klant erbij betrokken is, nadat de klant een BRIX product koopt hoeft deze alleen nog geproduceerd te worden. Dit verkort de doorloop tijd. De BRIX solutions zijn systemen voor vergaderruimtes, die de gebruiker in staat stelt online vergaderingen of presentaties te hosten op een gebruiksvriendelijke manier. Echter viel het aantal verkopen van de BRIX producten tegen en werden er verschillende problemen gerapporteerd.

Het voornaamste doel van deze scriptie was het analyseren van de bestaande werkwijze van de BRIX solutions en het vinden van de problemen en de onderliggende redenen. Hierop moest een oplossing worden gebaseerd. Tijdens het analyseren van de werkwijze werd er geconstateerd dat het grootste probleem zich voordoet tijdens de verkoop acquisitie. Werknemers van de sales afdeling veranderden vaak de samenstelling van artikelen in de 'bill of materials'. Of deze artikelen ook compatibel zijn is echter op voorhand niet getest waardoor fouten in het product vaak pas tijdens de productie fase worden ontdekt. Een engineer is dan nodig om het product te evalueren en een oplossing hiervoor te vinden. Dit neemt het voordeel van de gestandaardiseerde producten en werkwijze. De voornaamste reden voor deze fout is dat het personeel van de sales afdeling niet altijd beschikt over de juiste producten kennis.

Een veelgebruikte strategie om dit probleem te voorkomen is configure-to-order. Een product in deze strategie bestaat uit diverse subassemblages en elke subassemblage beschikt over een aantal varianten. De klant kan op basis van diens vereiste zelf de verschillende varianten kiezen. Een database met restricties zorgt er voor dat de klant alleen varianten kan kiezen die compatibel zijn met eerder gekozen varianten. Hierdoor kan de gebruiker alleen maar producten samenstellen die het bedrijf daadwerkelijk kan produceren. Bij deze strategie wordt vaak een order configurator gebruikt, een tool waarbij de klant door middel van een interface zelf diens product kan samen stellen.

Om deze strategie te implementeren voor de BRIX solutions is er een raamwerk van verschillende facetten ontwikkeld waar rekening mee moeten worden gehouden. Ten eerste moet de productenlijn worden getransformeerd naar een product-family-structuur. Hierin zijn de verschillende sub-assemblies weergegeven en de varianten daarin. De restricties zijn verzameld in een restrictie-database.

Een belangrijke vereiste voor een order configurator van de BRIX is dat deze beheersbaar en schaalbaar is. Het aanbod van BRIX solutions wisselt twee keer per jaar en daardoor moet de order configurator ook snel aangepast kunnen zodat alleen het huidige aanbod getoond wordt. Dit is verwezenlijkt door twee databases toe te voegen, één voor de BRIX solutions en één voor de verschillende sub-assemblies

Vanwege snelle veranderingen binnen de producten is er onderzoek gedaan naar de connectie tussen de order configurator en bepaalde systemen binnen het bedrijf. Een verbinding met het huidige ERP-systeem moet er voor zorgen dat prijzen binnen de configurator up-to-date zijn en dat wanneer items -tijdelijk- niet meer leverbaar zijn dat deze ook niet getoond worden in de configurator.

Ook zijn verleidings principes onderzocht die toegepast kunnen worden als AVEX besluit dat een item tijdelijk gepromoot moet worden. Verschillende methodes zijn in dit onderzoek gepresenteerd maar deze zijn niet getest.

Als laatst is ook de user-interface ontwikkeld. Klanten weten vaak niet de verschillen tussen de producten en daarom is er een onderzoek verricht hoe dit voor de klant het best gevisualiseerd kan worden. De ontwikkelde interface stelt de gebruiker in staat om een digitale -abstracte- voorstelling te maken van hun meeting room. Op basis hiervan kan de klant onderzoeken welke samenstelling het beste past in hun ruimte. Een gebruikers test is uitgevoerd om te onderzoeken of deze vorm van de user-interface een toegevoegde waarde heeft wat het geval is. De gebruikers konden sneller een oplossing vinden die daadwerkelijk goed bij hun vereiste paste.

Abbreviations

AAS	As-a-Service
ATO	Assemble-to-order
AV	Audio-Visual
B2B	Business-to-Business
BOM	Bill of materials
BYOD	Bring your own Device
CODP	Customer Order Decoupling Point
CTO	Configure-to-order
ERP	Enterprise Resource Planning
ETO	Engineer-to-Order
FOV	Field-of-view
FTC	Floor-to-Ceiling post
GPA	Global Presence Alliance
MTR	Microsoft Teams Room
OPS	Order Process Strategy
POC	Proof-of-concept
PVM	Product Variant Modelling
QI	Quick install
RBU	Regional Business Unit
SSC	Shared Service Centre
UML	Unified Modelling Language

Glossary of terms

AV-solutions	AVEX' definition for audio-visual systems. This can be a simple system like a display with a videobar mounted beneath it or more complex systems like a recording studio.
As-a-Service	A business model where products or services are sold on a subscription basis. The company remains owner while the customer leases the product. This often includes maintenance service when the product malfunctions
Bill of Material	A list of all components or parts that are required to manufacture a product.
Bring your own device	A connection-option that enables users to project their laptop screen on a larger display by plugging in a cable to their laptops.
BRIX solution	Regards the standardized products that AVEX offers, they concern meeting-room solutions that enables videocalls and presentation in a meeting room.
Microsoft Teams Room	A connection-option for the Microsoft Teams platform. This device is a small pc with its' own Teams account. Users can control this with a provided tablet on the table. Participants don't have to use their laptop anymore for videocalls within this meeting room.
Proof of Concept	A test to prove that a certain system or solution functions as predicted and does not contain any malfunctions.
Standardisation	Reuse of a product and process within the company
Videobar	A device user for video conferencing. It integrates a camera, microphone and speaker. Is mostly used in small to medium sized meeting rooms. The software enables features like speaker tracking or group framing.

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Chapter

1

Introduction

This chapter will introduce the starting point of this thesis. The scope of the initial problem is defined and the aim and relevance of this thesis are discussed.

1.1 Research context

In companies involved in the production of complex products, it is common to operate in an engineer-to-order manufacturing environment. This approach results that the company starts developing a product only after a customer has contacted the company. Based on the customers' requirements the company starts developing the product or system (Schulze & Dallasega, 2020). Although this approach ensures a tailored product that meets the customer demands, it also comes with a high price and a long lead time (Maier et al., 2021).

To minimize costs and reduce lead time of a product, an alternative strategy involves product standardization. In this approach, the company develops the product before any involvement of the customer. When the customer contacts the company and selects the standardized product the production phase can start. The cost price of a standardized product is reduced since the development costs will be divided among the badge of products. Also, the lead time will drop significantly since the development phase has already been executed. Standardization of products often means that the product line is standardized as well: each product is handled with the same steps.

Since 2021, AVEX, a business-to-business company specialized in Audio-Visual systems, has integrated a standardized product line, known as the BRIX solutions. The product line exists of meeting-room systems that facilitate online meetings and presentations for companies. The introduction of the BRIX product line aimed to establish a clear differentiation between customization and standardization. Sales managers and engineers can now focus on large-scale projects, while smaller projects can quickly be handled by selling BRIX solutions. With the introduction of the BRIX solution AVEX also implemented a new workflow strategy for handling orders, from sales contact to delivery.

However, the current performance of the BRIX product line has not met expectations. Sales figures are lower than anticipated and issues are reported at different steps of the product line without any proof of improvement. Since the role of BRIX manager is not present within the company it is difficult to address these issues. To achieve its initial vision, AVEX wants to reassess the product line and solve the existing issues. As AVEX is a relatively newcomer to the standardized market, it is possible that certain essential elements may have been overlooked that are needed for an effective operation of the product line.

1.2 Research question

The current BRIX product line is confronted with various challenges that affect its performance and position within the company. It does not seem to operate as originally predicted and sales figures are lower than originally anticipated. It is unclear what causes these issues and what can be achieved to overcome these challenges.

The goal of this thesis is to determine the cause behind the current issues and develop a solution that could overcome these challenges. The main research question related to this problem is:

Which design tools or framework can be implemented into an existing standardized product line in order to create a division between standardization and customization?

To solve this research question four secondary research questions are proposed:

1. What approach does AVEX use to develop and produce standardized products?
2. Which issues and flaws occur at AVEX' standardized product line?
3. Which standardisation strategy would apply to AVEX' standardized product line?
4. Which tool can be applied at AVEX standardized product line?
5. What actions should be taken to implement this tool in the standardized product line?

To answer the main research questions and the secondary questions, this thesis will be divided into 9 chapters. This is structured as follows:

Chapter 2	Provides a background of the company, the standardized product line and the vision of this product line
Chapter 3	An internal analysis of the current production and development workflow of AVEX' standardized product line. Subsequently exposing the flaws and issues that occur. Lastly, a comparison is made between the current workflow and AVEX vision.
Chapter 4	A literature study towards different levels of standardization is conducted, these levels will be evaluated to observe which level would have the most beneficial impact with regard to the standardized product line. Finding a level of standardization will also be used as a guideline to find tools that could be implemented in AVEX standardized workflow.
Chapter 5	A roadmap for implementing the solution is given in the chapter. All the different elements will be explained and relations between these elements are defined.
Chapter 6 & chapter 7	The tool proposed in the previous chapter will be Each step in the roadmap will be implemented for the specific case of the BRIX product line. Since the different elements can be divided in a back-end and front-end these will be split up into two chapters.
Chapter 8	Discussions and recommendations about the tool and how it can be implemented
Chapter 9	Conclusion

Table 1: Thesis structure

1.3 Research Methodology

To solve the research question, different research methods will be implemented. To get insights within the process and the company, interviews will be conducted with stakeholders of the BRIX process, these stakeholders each possess different information and visions about specific segments within the product line. This information will be provided via semi-structured interviewees in order to get primarily qualitative data. This form was chosen to let all the interviewees speak freely on their topic within the scope of the research and to not guide them towards a certain direction. In addition, documents that were created during the start and implementation phase of the BRIX are used to gather missing information and other insights.

An exploratory literature study in scientific papers and study material is executed to build a framework of methods and tools that could be implemented to tackle the existing issues.

Eventually, a tool will be developed for the standardized workflow. This tool will consist of different parameters that need to be customized in order for it to function optimal within AVEX. Tests and experiments will be conducted to determine the most optimal settings of parameters, such as A/B tests where two different settings of a parameter are examined to determine which one creates the most desirable outcome. The test group will include AV-specialists and those who might be not that familiar with this subject. Lastly different suggestions are proposed for different facets of the tool that cannot be tested immediately.

Chapter 2

Background

This chapter establishes the necessary context that serves as a foundation for the rest of the research. It begins by providing a background overview of the company. Subsequently, it gives an overview of the different product categories that AVEX develops, leading up to the creation of the BRIX product line. Through this progression, the rationale behind AVEX's decision to create the BRIX line is explained.

2.1 AVEX profile

AVEX is a business-to-business company specialized in audio-visual (AV) systems integration. They were founded in 1988 and -as of 2022- have approximately 240 employees divided over six locations; their headquarters in Breukelen and five smaller offices in Utrecht, Zwolle, Den Haag, Brussel and London. They are one of the key players when it comes to AV-integrators in the Benelux.

2.1.1 AV solutions

'AV products' refer to all products with audio visual purposes, for consumers they are known as monitors, speakers, projectors, etc. but these could also be devices that are used behind the scenes to ensure that these everything operates in the desired manner, examples are rack systems or mixing consoles. AVEX is specialized in integrating different hardware devices into one working system, possibly combining it with software that controls the hardware. Within AVEX these AV systems are referred to as solutions (see *section 2.1.4*). In collaboration with the customer, AVEX will strive to find the best fitting solution for the purpose of the customer. The solution will differ in purpose, price, complexity and could range from a display mounted on a trolley to a rack system that controls all speakers in a large office building. The solutions are developed by the engineers at AVEX and produced in the production department in Breukelen. Thereafter, they are shipped to the customers' facility and installed on location.

AVEX does not only sell these solutions but also offers rental services. They are active in a wide range of different markets, these include the following segments (AVEX, 2022):

- Event facilities
- Culture, sport & recreation
- Hospitality
- National and local government
- Retail
- Education

Besides selling and renting solutions AVEX offers in-house content creation and real-time monitoring service to quickly find issues in the solution and if necessary solve them. Lastly, AVEX also owns three physical recording studios which companies can use for recording videos or live-events (see *Figure 2*).



Figure 1: Example of AV-solution



Figure 2: Recording studio at AVEX facility

2.1.2 GPA

Since 2016 AVEX has been part of the Global Alliance Presence (GPA): a network of 26 Regional Business Units (RBU) of AV system integrators. This collaboration has been established to create global coverage and also to share and provide knowledge among the RBUs to optimize quality and consistency. Another example of an advantage of the GPA is that a solution for a company with multiple offices around the globe can now be built at the RBU in the corresponding country instead of shipping solutions internationally. Joining the GPA has also played a key-role why AVEX decided to standardize products. In 2022 the GPA has been ranked #1 as largest AV system integrator (SCN, 2022).

2.1.3 AVEX Vision & Goals

Currently AVEX is present in the Benelux and UK-market and with the GPA-collaboration plays a role in an even larger area. Especially in the Netherlands they are seen as one of the market-leaders in the AV-industry and their position is strengthened by being visible in multiple segments of the industry, not only selling solutions or supporting events. By offering in-house content creation and secondment clients can go to AVEX for different purposes. The business portfolio has been discussed during the Business Update in April of 2023. Figure 3 shows the seven segments that AVEX is currently active in.

Since 2020 AVEX had set goals for themselves as a company to improve on certain aspects. The United Nations has provided 17 Sustainable Development Goals (SDG) that defines areas that businesses and governments could improve on (UN, 2022). These SDGs are used as guidelines by AVEX for improvement. Out of the 17 SDGs AVEX has chosen to improve themselves on the following goals:

- 7. Affordable and clean energy
- 10. Reduced inequalities
- 12. Responsible Consumption and production
- 13. Climate action
- 17. Partnerships for the goals

By joining the GPA AVEX already integrates goal 17. Besides that, AVEX improves their climate action by driving more electric vehicles, separating waste and keeping track of their energy consumption within the company. The board of AVEX also had set the goal to improve the carbon footprint of the solutions that they're selling.



Figure 3: AVEX Business portfolio

2.1.4 Solution categories

Over the years AVEX has developed a diverse range of AV-solution which vary in purpose, complexity and price. In order to maintain an overview of all different solutions and the actions that need to be taken, four labels have been established. The solutions can be categorized among one of those four labels. These are categorized predominantly by costs and complexity, as illustrated in Figure 4.

- **Product delivery (LL)**
Referred to as LL (Losse Levering), this category involves merely the shipment of different types of hardware to customer companies without any installation tasks performed by AVEX. These solutions could be products that upgrades current solutions like a videobar or screen-share device for a meeting display.
- **Quick Installs (QI)**
The Quick installs are relatively simple and often require the involvement of only one engineer to develop these solutions. The engineer is needed to ensure proper hardware connectivity and for the creation of a Bill of Material (BOM). In the workshop the QI's can be assembled swiftly. Examples of QI solutions include projector systems or displays mounted on a trolley.
- **BRIX**
This type of solution will be elaborated extensively in section 2.2. BRIX represents a derivative of the QI; they are the standardized variants of frequently sold QI solutions. Customers can choose from a catalogue of BRIX solutions, these have been engineered before any involvement by the customer. This reduces cost and lead times. Compared to QI solutions they are sold in larger volumes. Externally BRIX solutions are referred to as '*Room Solutions*'
- **Projects**
Solutions categorized as projects demand significantly more attention from the company compared to QI's. The projects are complex systems of different types of hardware and software that are integrated together into a network. The development of projects often requires the collaboration of multiple engineers and project managers to ensure successful implementation.

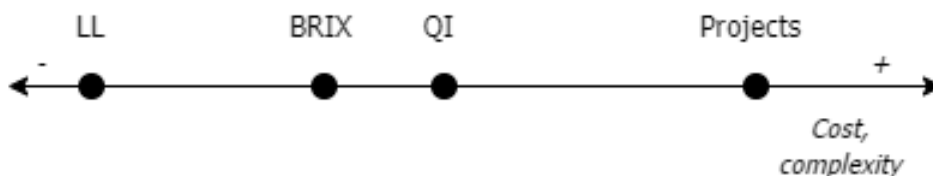


Figure 4: Different type of solutions, based on cost and complexity

2.2 BRIX

This section will explore BRIX solutions, what AVEXs' vision was behind standardization and which other steps AVEX had taken to introduce this product line to the market.

2.2.1 Definition BRIX

BRIX solutions are systems that can be used in meeting rooms for either presentation or videocall purposes. Each BRIX solution is a combination of hardware devices that can be interchanged like building bricks (hence the name BRIX). AVEX has created a catalogue (referred to as AVEX menu-list) that includes approximately 30 different BRIX solutions. These different solutions are split up into four different segments (*see appendix A*). The products were introduced on the market in 2021.

2.2.2 Standardization of solutions

In 2019 AVEX stated that they wanted to compete more in the less-advanced systems (such as displays on a trolley or wall mounting) of the AV-market but had noticed that the smaller projects and QI solutions were not profitable due to large overhead costs: for each QI solution a sales manager was involved as well as an engineer that created the technical drawings and BOM before it can finally be produced. This resulted in a lot of workhours for a product with a relatively low price, resulting in a small margin. This problem was solved by introducing a standardized product line, internally referred to as BRIX solutions. Several frequently-sold QI solutions -that could work for multiple customers- were selected and developed before any involvement of the customer. When a customer orders a BRIX solution the sales manager can select the specific BOM and the workshop can produce the solution right away without any involvement of an engineer.

The leadtime is significantly reduced since the development phase has already been conducted and because multiple steps are standardized within the order and production phase. AVEX has set the goal to deliver the BRIX solution within 48 hours after ordering. Since specific hardware devices can be purchased in larger volume since they are present in multiple BRIX solutions. This reduces the price per solution and reduces the amount of steps that the finance department has to perform. Also, because the BOM has previously been defined, AVEX can create a fixed price for the BRIX solutions. This gives a clear indication to the customer and reduces discussions between the customer and sales department.

The menu-list is updated frequently by the marketing department. AVEX stated that BRIX solutions cannot contain any end-of-life articles, this reassures that each solutions can always be produced. End-of-life articles are devices that the supplier company has stopped producing and the existing products from that line will not support any new software updates (Techopedia, 2016).

By creating standardized solutions AVEX aimed to divide the market into two segments: specialization and standardization. Meeting rooms can be provided with standardized BRIX solutions, whereas the specialization solution are typically major projects that call for multiple engineers and sales managers. AVEX strives to increase the amount of sold BRIX solutions. Eventually, only BRIX solutions should be sold instead of customized QI solutions. Engineers will then only focus on larger projects. During the implementation phase of the BRIX solutions, AVEX had set the goal that 30% of all QI-solution is sold as a BRIX solution within a year, expanding this monthly by 5%.

For customers, standardized solutions have multiple advantages:

- **Shorter Leadtime:** Since the development phase has been executed before any involvement of the customer, they only have to wait for the production phase. This reduced the lead time (Zheng et al., 2017).

- **Lower Price:** With customized solutions an engineer will develop only one product. The customer therefore pays for all the hours an engineer dedicates to the product. By creating one standardized solution the engineering hours can be divided among the amount of sold orders. AVEX also promotes this by selling the BRIX solutions with an “AV-flex”-price. This is a monthly as-a-service-price which includes the solution, full service and part replacement.
- **Clearer comprehension:** For each BRIX solution a render is created. This can give the customer a clear understanding of what to expect when purchasing a BRIX solution.

2.2.3 Standardization of workflow

Not only the products were standardized, also the process flow has been standardized. To enable this, AVEX has introduced the use of an Enterprise Resource Planning system (ERP) into their company. This system integrates activities from multiple departments such as planning, purchasing, inventory (InvestopediaTeam, 2022). This system helps to process orders from the sales department to the workshop. The complete workflow will be discussed in chapter 3.

Another aspect that AVEX uses to decrease lead time in the BRIX is commoditization; devices are so similar in specifications that the users will not prefer one brand over the other (Picincu, 2020). AVEX makes use of this principle by not specifying the brand of display when selling a BRIX solution. Rather, the employees in the logistics department will select the brand depending on what is available in stock with better margins. This eliminates the time that normally is occupied by waiting for a specific type of display. A customer only selects a display based on their preferences (display size, touch-screen ability) and based on these preferences the logistics department will select the brand of display that is available in that quantity, so a customer could end up with Samsung, LG, Sony, etc. This was partly due to the chip-shortage that started in 2020, due to this AVEX could not ensure that specific devices could be delivered

Having standardized solutions also benefits the production department. They will repeatedly work on the same solutions. Since they will get familiar with the different solutions they can assemble the solutions faster (Brandall, 2018). To ensure that everyone in the product department can assemble a BRIX solution, a production guide is made.

Each BRIX solution is displayed in a catalogue. Customers could also use a web portal to directly request a quotation for these solutions. Besides publicly-available room solutions AVEX also has a database for ‘company-standard’ BRIX solutions; if a company orders a certain solution more than ten times, this solution should be turned into a company-BRIX and documented into a database. If this company decides to order this solution again all the documents are available and this solution can be reproduced. These solutions are not included in the catalogue.

2.2.4 Advantages of BRIX solutions

The introduction of the BRIX solutions has promised beneficial impact in different departments within the company. A summary of these promised benefits for each department is given in Table 2.

Departments	Benefits
Sales	<ul style="list-style-type: none"> • Some situations can quickly be solved by selling a BRIX solutions. • Able to show a preview of the solution to the client. • No need to create a new BOM.
Engineering	<ul style="list-style-type: none"> • Hours can be dedicated to larger projects
Purchase	<ul style="list-style-type: none"> • Devices can be bought in bulk quantity.
Logistics	<ul style="list-style-type: none"> • Can select displays that are in stock rather than waiting for a specific brand.
Production floor	<ul style="list-style-type: none"> • Repeatedly creating the same solution will create consistency. • Overall standard on how it should be produced and installed.
Finance	<ul style="list-style-type: none"> • Bulk purchasing prices. • Need to only handle one purchasing order rather than multiple.

Table 2: Benefits of the BRIX per department

2.2.5 Current situation BRIX

Around September 2022 the BRIX solutions have been a part of AVEXs portfolio for about a year and although BRIX solutions are sold on a regular basis, it does not seem that the quota of 30% is met. Based on calculations, the BRIX solutions only amount to a mere 8% (these percentages will be discussed in section 3.4.1). Besides the low sales-figures, there is feedback from employees that the BRIX product line does not function according to the initial plan. During the start-up phase of the BRIX solutions, a responsible BRIX-manager was in charge of the complete process. However, he left AVEX soon after and since then tasks are divided among different departments. This makes it rather difficult to address remarks concerning the BRIX process,. This has the consequence that issues do not seem to improve.

Chapter 3

Workflow analysis

The BRIX solutions have made their debut in 2021. However, different departments have expressed dissatisfaction with how the process is currently carried out. This chapter will provide an analysis of how the workflow is carried out and how this would affect the initiated vision set by AVEX. The BRIX process can be divided into two different processes: the order process workflow and the development workflow. Firstly the order process workflow is mapped out and subsequently the development workflow. Thereafter current issues that affect the workflow will be discussed.

3.1 Order process workflow

The order process workflow starts from the moment a customer approaches AVEX until the moment the BRIX solutions are installed at the customers facility. Each step of the workflow is mapped in a swim lane diagram, as shown in Figure 5. A swim lane diagram was chosen to indicate the stakeholder per step. The workflow is obtained by interviewing employees from different departments and questioning them about their roles within the order process. Transcripts of each interview with the employees can be retrieved in appendix B.

1. Sales acquisition

The process starts with the need of a customer, they have the desire to implement a new meeting room solution within their facility. At the start they can either choose to make use of the web portal on the website of AVEX or directly contact the sales department.

On the webpage the customer is presented with all the solutions. The user can limit the product range with filters on the side of the screen. Via the portal, the customer can request a quotation for their selected BRIX, a sales manager will then contact the customer to discuss the solution.

The customer can also choose to directly contact a sales manager. The customer will describe the current situation and/or problem setting and based on this scenario the sales department will translate the problem into an AV solution. The sales manager can use the menu-list as a guide to find a BRIX solution that would satisfy the customers' needs. From there, the sales manager can persuade the customer with the advantages of a BRIX solution (fixed price, lower cost etc). The sales manager can directly show the renders that are already made for the menu-list to give the customer a better overview of the suggested solution. If there is no BRIX solution compatible for the customer then the QI process should be followed instead. In this case a sales manager or engineer will design a fitting solution for the customer.

If the customer is not satisfied with the price of the BRIX solutions, there are two alternatives:

- Select a different BRIX solution that better suits their budget.
- Develop a QI solution that might be created towards the liking of the customer with the budgetary constraints kept in mind.

2. The customer is convinced

Once the BRIX is selected by the customer, the back office of AVEX will select the BOM of that specific BRIX solution and create a quotation based on the solution and the quantity. The quotation is then discussed with the customer, and if they approve the workflow can continue.

3. A work order is placed

Upon receiving approval from the customer, the sales manager proceeds to create an order in AX. This will notify both the planning and logistics departments. The planning department will pick the items based on the BOM. Based on that, they decide which brand of display will be used for this solution depending on what is available in the right quantity. If these items are available, the planning department will 'claim' them and create a picking list so that employees can collect these items and bring them to the workshop. In cases where certain items are unavailable in the right quantities, a notification is sent to the purchasing department. They place an order for the specific parts at the distributors. This will prolong the lead time. When all parts are collected, a workorder is created for the production department. The workshop employees will check the material and the workorder and they will start producing the solutions and stock them in the warehouse once they are finished.

4. Production and delivery of BRIX solution

While the production department is assembling the BRIX solutions, the logistics department starts planning an installation moment with the customer. If the customer has also ordered a QI or project solutions then the logistics department can choose to install the BRIX solutions at the same time when the other projects are finished in order to save man hours and/or shipping costs. An installation engineer will install the BRIX on location of the client if needed.

5. After-sales care

If the customer chooses to order the BRIX solution via AV-flex, then they will be included in the service database and if a problem occurs concerning the BRIX solution the customer can reach out to the service department for repairs or maintenance.

3.2 Implementation process

The menu-list is maintained by the marketing department in collaboration with other departments that are involved in the BRIX process, such as product management and the sales department. Which QI solutions should be standardized depends on the sales of individual QI solutions. The sales are monitored by the back-office. During the start of the BRIX a rule was implemented, stating that if a QI solution is sold more than ten times, it should be standardized. Suggestions of new BRIX solutions are made based on judgement calls by the back-office employees. If they notice a trend within the sales they can share this information with the product management and decide if it is worth to standardize that particular solution. Apart from the insights gleaned by the back office, product-management might suggest new solutions themselves. This could be based on a new introduction of a product in the market.

Once a decision has been made to standardize a particular QI-solution, an engineer will start by making a Proof of Concept (POC) to assess the functionality of the solution. Subsequently, the engineer will generate essential documentation, such as installation schemas and the BOM. The Shared Service Centre (SSC) will create a new file within AX. This enables the sales department to create orders with that specific solution. After the development phase has been completed, the marketing department will incorporate the new BRIX solution in the menu-list and notify the personnel of AVEX. This implementation process depicted in Figure 6.

Furthermore, AVEX uses a rule that no solution has an end-of-life article within the BOM. If the product manager receives a notification from the distributor that an item will be discontinued, then every solution that includes this item should be updated or removed.

3.3 Current issues

The primary purpose of introducing standardized solution for AVEX was to compete more in simple solutions of the AV-market. By standardizing the solutions and the workflow, various stakeholders can dedicate their efforts to larger projects. However, several concerns have been raised by multiple stakeholders regarding the functionality and efficiency of the workflow. The objective of this section is to identify the specific flaws and issues in the workflow process. To achieve this, the envisioned workflow is compared to how it is operated currently. This will give insights in what could cause the problems and what effects it will have.

3.3.1 Inaccurate BRIX solution

A reoccurring problem occurs in the sales acquisition, when the sales manager makes the choice if a BRIX solution will satisfy the need of a customer or if a QI solution should be developed. This choice often seems to be ignored and thereby solutions that should be handled as QI solutions go through the BRIX process. The sales manager wants to fulfil the need of the customer and occasionally makes the decision to use a BOM of a BRIX but slightly alter the items, for example by implementing a hardware device that currently is not included in the BOM of that specific BRIX solution. From the moment that someone alters the BOM of a BRIX solution it should be noted that this solution is not a standardized product anymore. The consequences of this choice may vary in occurrence and severity. Figure 7 an overview of different consequences at different departments when the sales manager alters a BOM.

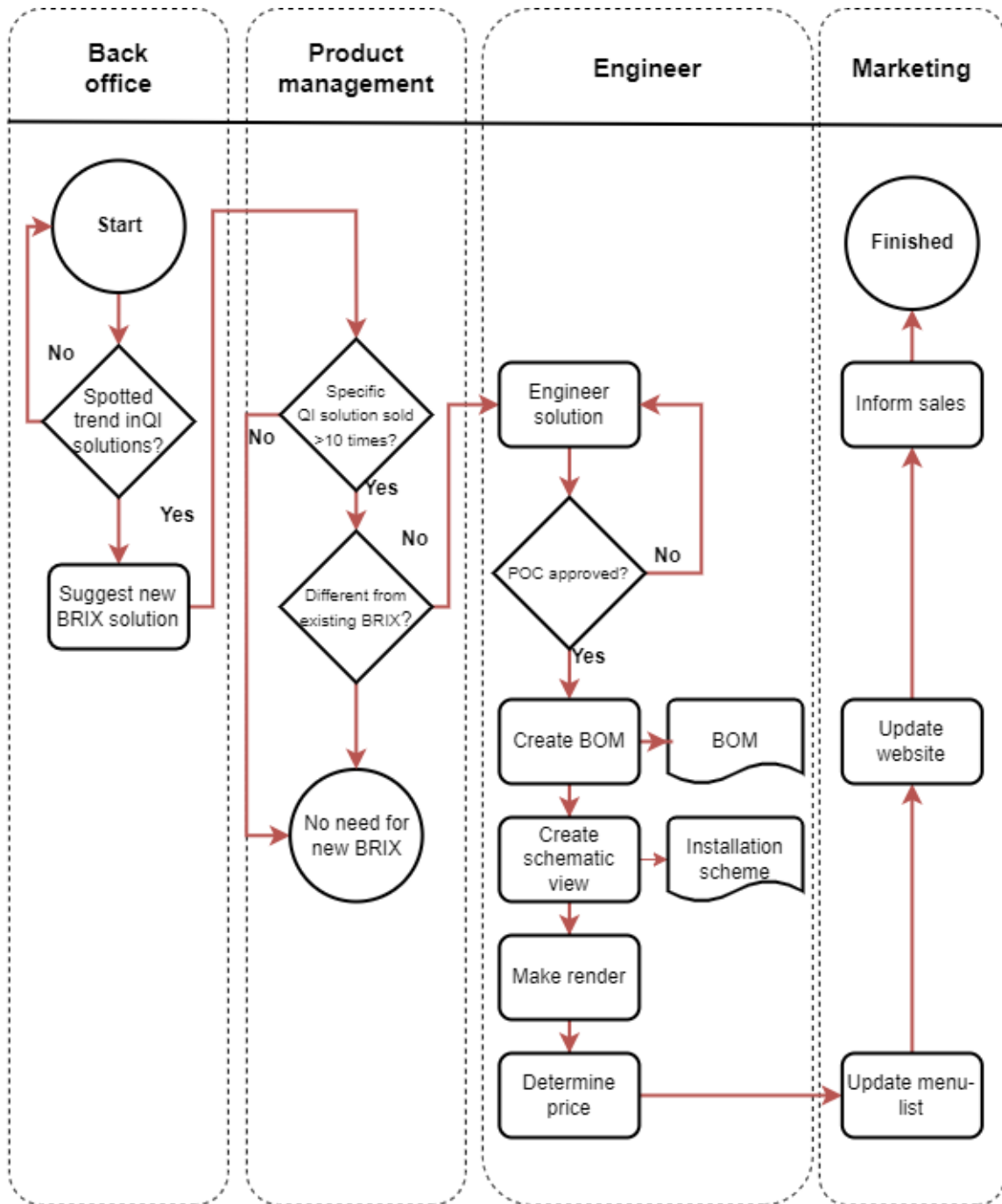


Figure 6: Swimlane diagram of implementation process

There are different consequences when a sales manager implements a different item than initially specified. Firstly it is an obstacle for the SSC, which starts the order in AX. It is technically not possible to add different items in a standardized BOM, the order should then be processed manually, which takes more time for the employee but also causes the issue that it is unclear for the logistics departments which items should be reserved. Another consequence is that the solution might not function. Not all parts are compatible due to different limitations. This can lead to a solution that cannot function as predicted. For each BRIX solution a POC has been executed but this is only done for the original BOM and not an altered version. If the sales manager is unfamiliar with the devices within the BOM then they might be unaware of potential failure and this malfunction might only be discovered in the production phase. This will bring the production to a stop and an engineer might be needed to figure out the malfunction and come up with a solution to fix this issue. This will prolong the lead time. Additionally, this will increase the production costs but since the sales price is fixed this will decrease the margins of that specific order. When asked why they decided to change the BRIX solution, a sales manager who had been interviewed, stated that meeting customers' needs is their main priority and due to a lack of knowledge, they might not always be aware of all the specifics for the BRIX solutions. They have access to the menu-list but are not able to obtain information like the BOM.

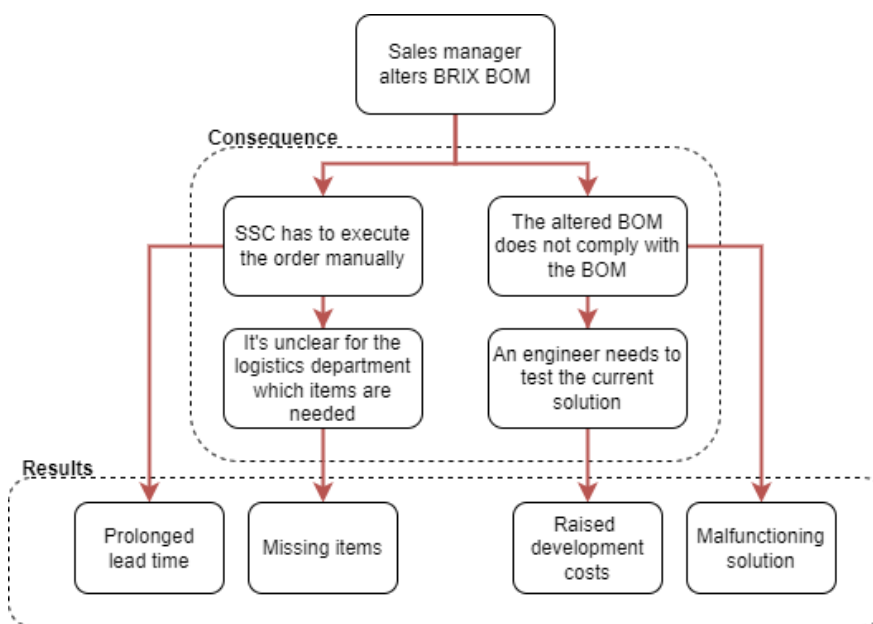


Figure 7: Consequences of faulty BRIX

Lastly, there are instances where sales managers are unaware of BRIX solutions that might match the situation of the customer. The responsible sales manager creates a QI solution that fits but with altering a few parts this solution resembles a BRIX solution. An example is given in Table 2. A customer wanted a meeting room solution for their company and specified the requirements to a sales manager. They created a BOM for this customized solution, which is shown in the second column of Table 3. This BOM describes a solution that includes a 75" display with a MTR-device. This BOM matches function-wise with the BOM of the AVXB-MTR75-LOBRA: a 75" display with a MTR device. There are differences within choice of brands. Items that match in functionality are marked with the same colour.

If the sales manager would have picked a different brand for the mounting system and did not specify the brand of the display then this could have been sold as a the AVXB-MTR75-LOBRA BRIX. There are some features that differ between the two BOM. The customized solution has a wall-mounting for the Logitech Tap (the tablet that controls the MTR device) and a mic pod mount in order to mount the microphones on the ceiling. The BRIX solution has a Tap mounting for the table and does not include a mound for the microphones since these are also placed on the table. If the customer could be persuaded to place both the mic and the Logitech tap on the table, then a BRIX solution could have satisfied the customers' needs.

Description	Customized solution	AVXB-MTR75-LOBRA
MTR-device with videobar by Logitech.	Logitech Teams room large	Logitech Teams room large
Wallmounting	Chief LTM universal wallmount	Vogels PFW 6810 Display Wallmounting, tilttable
Add on feature for the wall mounting	Chief Proximity component Storage Slide-Lock panel	Vogels accesory holder Vogels PFA 9166 Uitbreidingsset voor PFA 9165
75" display	Samsung 75" UHD 16/7 Display	75" display by Samsung
	Logitech Tap Wall mount	Logitech Tap Table mount
	Installation material	HDMI kabel 1,8m Wieland netsnoer 5m RA/GST Kaiser 4-voudige contactdoos met Wieland in/uit
Mounting for the microphone	Logitech Mic Pod mount Logitech Rally Mic pod Extension Cable 10 MTR	

Table 3: BOM of customized solution and BRIX solution (AVXB-MTR75-LOBRA)

There might be several reasons why sales managers sell customized solutions rather than BRIX solutions. It might be that sales managers tend to sell a products that is completely towards the wishes of the customer and therefore want to change several aspects. Another reason could be that new sales managers might be unexperienced with the items and/or BRIX solutions and therefore are unaware of what BRIX solutions can be offered to the customer.

3.3.2 Meaning of BRIX

Another issue that seems to occur is the lack of a clear and unambiguous definition of what standardization means within the company. There appears to be a divergence of perspectives among employees regarding the interpretation of BRIX. Some employees perceive BRIX as a method of production products, while others view them as BOM's that serve as a foundation for creating their own customized solutions. This has led to confusion among employees that expect actions from other departments.

3.3.3 Information flow

The BRIX process relies on data and knowledge gathered from stakeholders or documents. The specific documents or data required for each step are outlined in appendix C. Although these documents and files are required, not all are consistently available. A centralized database is not present. Also, when a BRIX solution gets updated not all essential documents are updated as well.

Additionally, no instruction manuals are created for how to assemble or install the BRIX solutions. Currently, one employee on the workshop is responsible for the production of the BRIX solutions and due to their experience they will not need an instruction manual in order to assemble a specific BRIX solution. However, the lack of an instruction manual becomes problematic when a new employee is tasked to assemble a BRIX solution. Moreover, if the experienced employee is unavailable for any reason, necessary information on the assembly cannot be transferred. It also leads to room for interpretation which results in multiple variants of the same BRIX solution which slight alterations.

3.4 Effectiveness within the company

Upon the introduction of BRIX solutions, AVEX aimed to establish a division between standardization and customization within their projects. They formulated a specific target: within a year 35% of the sold QI solutions should be a BRIX. Subsequently, this share should increase each month by 10% until the moment that exclusively BRIX solutions are for meeting rooms. The ultimate objective is that the engineers and sales put all their effort and time toward larger projects. This section will analyse to which extend AVEX has successfully realised this goal.

3.4.1 Quantity share

The sales coordinator for the back office at AVEX oversees the sold QI solutions and the share of BRIX solutions. To push the sales of BRIX solutions they analyse each order and see what's included in the BOM. Based on the judgement of the sales coordinator each order gets a label, as shown in Table 4. Each week the sales coordinator shares a spreadsheet with all orders and the corresponding labels. If the customer has not yet accepted the quotation the sales manager can decide to change the offered QI solution to a BRIX solution.

Label	Definition
Is sold as a BRIX	The sales manager has created an order with a BRIX solution from the menu-list.
Could have been sold as a BRIX	A solution that could have been a BRIX-solution if the responsible sales manager made changes to the order. This could for example be removing/adding different hardware products to the BOM of that order.
Could not have been sold as a BRIX	An order with a mix of items that does not resemble any BRIX-solution that is currently in the menu-list. These orders will remain QI solutions that an engineer needs to be involved in to finish.
Interesting to see if this product could be added to the BRIX menu-list.	A note is made by the sales coordinator that the order with that specific BOM could be implemented in the menu-list. This could have multiple reasons, for example that the solution has been sold often in the previous period or it fills a gap in the menu-list.

Table 4: Different label for QI-orders

The data of all the weekly spreadsheets were collected and summed up to see what quantity and percentage each label is compared to the total of QI orders in Table 5. This is the data of week 13 till week 42 of 2022.

Label	Quantity	Percentage
Sold as a BRIX	62	8,4%
Should have been sold as a BRIX	49	6,6%
Cannot be sold as BRIX	603	81,8%
Interesting as a BRIX	23	3,1%
Total:	737	100%

Table 5: Quantity of QI-orders

According to these percentages it could be concluded that most QI orders over that specific period of time are still orders that need an engineer to complete and are customized rather than standardized. Only 8% of all sold orders are actually sold as a BRIX order. 6,6% of all the orders could have been a BRIX order if the sales manager changed the order. It should be noted that after this sheet is shared with the sales manager they can choose to change the orders with the label 'should have been a BRIX' to an actual BRIX solution. This is done in collaboration between the sales department and the back office and not always an agreement can be made to change the order to a BRIX. Data about how many orders are subsequently changed is not available.

It can be estimated that the amount of percentages of sold BRIX solutions is within 8,4 – 15% (if all orders from the second label are changed to an actual BRIX solution). This is not the 35% that was initially anticipated.

It should be noted that the file used to obtain these data is done manually and based on the expertise of one person, although their experience will help getting the right project the right label, it remains a judgement call. If they notice that a certain solution is sold more often they could therefore mark it as 'interesting as a BRIX'. However, it could happen that they miss other data from the orders.

The previous percentages are based on quantity. Based on turnover, the BRIX solution have a share of 20.3%. This is a relatively large share when compared to the amount of BRIX orders are actually sold.

3.5 Summary & Conclusion

With the separation between customization and standardization it seems that most of the projects are still dedicated to customization. 81.8% of all QI solutions still need an engineer to be developed and only between and around 6,6% of the QI solutions can be a BRIX solution if altered. It is unclear if these were altered BRIX solutions or newly made solutions that resemble a BRIX.

A main reason that there is still so much customized solutions is that sales managers try to find a solution that matches all customers' requirements and therefore differ from the original BOM of a BRIX solution. This has different consequences that result in that the BRIX process cannot be executed as desired and don't reach the complete efficiency when it comes to lead time and cost price. Currently there is no check-up if the sales manager has used the original BOM and once a quotation is created by the sales manager and the customer has approved it will not be withdrawn.

Besides the issue of the incorrect BOM there are other problems like missing documents and a non-structured organization of the available documents.

To address these challenges, a tool or strategy should be developed that ensures that sales managers only use the existing BRIX solutions without modifying the BOM. Such a tool would decrease the amount of solutions that are currently labelled as 'could have been sold as a BRIX'. Moreover, this tool would preferably make customers aware of the advantages of a BRIX which would persuade customers into ordering a BRIX rather than going for a customized solution.

Additionally, as mentioned previously, there is no standard procedure to evaluate if certain QI-solution need to be changed into a standardized -BRIX- version. Personnel cannot notify a specific person for their idea and there are no set of rules that could decide if a BRIX solution is qualified to be a standardized product or not. Lastly, it is also not documented if a certain solution is disqualified as a BRIX solution meaning that someone cannot identify if their idea is already been subject to changing into a BRIX solution.

Chapter

4

Standardizing

AVEX has implemented a standardized product strategy since 2021 and is relatively new to these procedures since they have primarily worked with highly-customized orders for clients. This change from strategy might play a role for the failures described in the previous chapter. How to handle customer orders can happen on multiple levels of standardization, all with their own degrees of freedom and advantages. It is unclear on what level of standardization the BRIX solutions exactly is currently and on which level it is envisioned. Therefore this section will be dedicated into reviewing the different standardization strategies. Firstly the different strategies are summarized, then an indication of the current position of the BRIX is given and lastly a suggestion is made which strategy might be beneficial for the BRIX.

4.1 Order processing strategies (OPS)

To meet the requirements set by the customer companies should involve the customer sometime in the order process (Bogner et al., 2017). This depends on the complexity of the product and how much customization per product is necessary to meet the customers demand. The company should decide when the customer gets involved in the process, for example before the design, development or production phase. This moment is defined as the Customer Order Decoupling Point (CODP) (Olhager, 2010). Literature mainly distinguishes four order processing strategies:

Engineer-to-order (ETO)

With an Engineer-to-order strategy the process will start with immediate involvement of the customer (Bogner et al., 2017). Within the limits of the company a customer can have complete control of the customization of the product. An engineer is often needed to develop the product. Each product developed in an ETO strategy distinguishes itself from the previous one and can be seen as a new engineering project (Brière-Côté et al., 2010). An advantage of this workflow is that the customer will receive something completely to their satisfaction and every detail can be discussed. Disadvantages are the prolonged lead time since the entire process can only start after the involvement of the customer, which will also increase the cost since all the following phases are completely dedicated towards that specific solution.

Make-to-stock (MTS)

The opposite of ETO is Make-to-stock; while ETO is completely customer order-driven MTS is forecast driven (Olhager, 2010). The products have been defined, produced and then stored in the warehouse until a customer orders them. The customer therefore does not have any influence on any parameters of the products and is only able to choose within the range of products that the company facilitates. A product might still have variance but these are already defined by the company. An example is a shoe that is available in different colours and sizes. A disadvantage of MTS is the lack of individualization which can lead to the customer not able to find something to their preferences and chooses to buy another brand instead. Advantages are the short lead time since the product is already produced, the product only needs to be shipped from the warehouse to the customer. Another advantage is a lower price since the expenses of the complete process can be divided among all the products from this series.

Make-to-order (MTO)

This strategy is relatively similar to ETO but with less customization. Most of the product is designed and development without any involvement of the customer but in order to finish the product some parameters should be customized and defined by the customer. (Haug et al., 2019b). The parameters that could be customized have been identified beforehand and therefore the limitations are obtained. However some process steps still need to be performed in an MTO-strategy. An example could be the length of a certain item, which can be made precisely to the customers wishes. An advantage compared to ETO is that the engineering process has been carried out before the COPD, this will decrease the lead time. The cost can also be determined roughly since the BOM and the amount of workhours can be estimated.

Assemble-to-order (ATO)

ATO is similar to MTO but the complexity is narrowed down further by making the product consist of different sub-assemblies which can be combined by the customer. The customer can select several sub-assemblies which are assembled in the workshop to one complete product. Once again the lead time is shorter than the previous strategy but also the complexity and level of freedom for the customer are narrowed down. A difference between ATO and MTO is that in the MTO strategy products might still have parts that actually need to be produced or engineered, while ATO consists merely of sub-assemblies of which the interfaces are defined.

The CODP per strategy is illustrated in Figure 8:

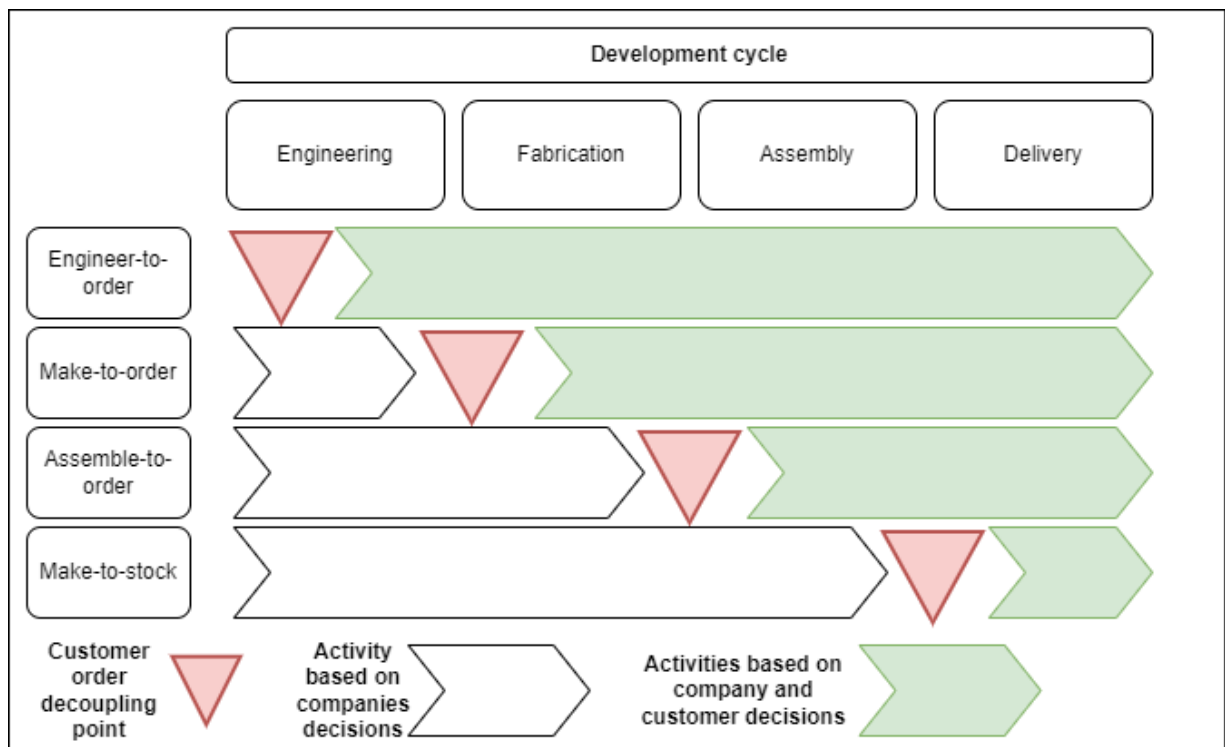


Figure 8: CODP per strategy

4.2 Current BRIX position

AVEX has started out as a company that uses an ETO-strategy; the process starts after a customer has contacted a sales manager and all phases such as research, engineering and production are done in collaboration with the wishes and requirements of the customer. An MTS-strategy would not satisfy in the environment in which AVEX operates. This would first of all mean that AVEX needs to stock all the items which is a risk since it is unclear which specific solutions will be sold. Secondly, a lot of finished solutions or items would be stocked in the warehouse, which AVEX does not have the space for.

An ATO strategy might be sufficient for the BRIX products since it consists of different sub-assemblies that are produced beforehand and need to be assembled into one functioning product. However currently it seems that the BRIX solutions still use an ETO strategy since the sales manager tend to modify the BOM by adding, replacing or subtracting different items.

4.3 Configure-to-order

A strategy that has the same CODP as ATO is Configure-to-order (CTO). A CTO serves products that are applicable for mass customization: products that focuses on satisfying the customer requirements while keeping manufacturing cost close to those of mass-produced products (Shao, 2020). Similar to ATO a CTO-product consists of one product family which serves a specific purpose. The product consists of standard components and modules which can be interchanged with involvement of the customer. Which modules can be combined is defined by the rule-based system. Products that are created should oblige to this set of rules. Beforehand the company should find the limitations and restrictions within the product and be aware of which sub-assemblies can be combined or which combinations would cause issues during the production or use phase. A tool that is often used in this strategy is an order-configuration tool, this is a software-based decision-system that lets the user (either the sales manager or the customer) configure the product by making different selections. The tool is aware of the limitations and restrictions of the product which results in that tool will only configure products that could actually be produced by the company. (Haug et al., 2012).

4.3.1 Advantages CTO

Using an order configurator creates a sense of mass customization; even though the BRIX products would still be the same 30 different options now the customer has the ability to select all sub-assemblies that fit their needs the most. Although the configurator only presents pre-defined options, the customer has the feeling of creating a product completely towards their needs (Sabioni et al., 2021).

A main advantage of the use of CTO is that the selection of sub-assemblies is restricted by the system and alterations cannot be made within the system (Haug et al., 2019b). CyLEDGE Configurator Database describes quicker response to customer inquiries and less overproduction (Cyledge, 2018). The order configurator can create more automation for example by linking it with other business systems (Bredahl Rasmussen et al., 2021). Other mentioned advantages are reduction in lead time and errors. It also saves work hours since the sales acquisition that is currently done by the sales department will then be done by the order configurator (Myrodiya et al., 2017). Usage of order configurator has also increased the sales since customers that currently might not want to contact AVEX can now use the order configurator as a way to find a product that would match their requirement, which will also decrease the lead time (Kristjansdottir et al., 2018).

Lastly the use of an order configurator might give the company insight in the preferences and requirements of the customer (Shafiee et al., 2017). This data can be used for portfolio maintenance.

4.3.2 Challenges and disadvantages CTO

To implement a CTO strategy, the standardized products should be transferred into a product family architecture and all the restrictions need to be gathered. Consequently, a software tool should be developed or be implemented (Zhang et al., 2010). This is a long and costly process for which it is unclear what the effect will be. It has been researched how companies have previously failed when trying to implement an order configurator and multiple causes of failures were discovered during the lifecycle of the configurator, such as (Haug et al., 2019a):

- Inaccessible product knowledge.
- Software that is not optimal for the specific product .
- Design of the configurator does not match the software.
- Difficult interfaces between the sub-assemblies.
- Product that is too complex to create an order configurator for.

In an industry- such as the AV-industry- products and software are quickly outdated or replaced by newer variants. When implementing an order configurator it is of great importance that the tool only presents configurable solutions that are up-to-date and do not contain end-of-life items. The tool should therefore be easy to adjust once new products enter the catalogue so that someone within the company is able to update the information themselves. If a software developer is constantly needed to change the software the costs might overrule the advantages.

Lastly if the order configurator will be used by the end-users it is required to understand what the end-user knows about the product (Franke & Piller, 2004). The interface should present the information on the knowledge-level of the customer and also be aware of the requirements that users have. Another aspect is that presented the customer with too many options will lead to a paradox of choice. Customers might be confused by the different options, resulting in dissatisfaction (Trentin et al., 2013).

4.4 Decision CTO

The current use of the BRIX solution has not achieved the desired differentiation between standardization and customization as envisioned in 2021. This can be attributed to several factors:

1. **Lack of customer awareness:**
Customers may be unaware of benefits of the BRIX solutions such as a lower price and quicker delivery time compared to customized solutions.
2. **Sales managers preferences:**
To meet customer demands sales managers tend to deviate from the standardized BOM and tailor a customized solution specifically for that customer even though this resembles a BRIX solution.
3. **Inexperienced sales managers:**
New sales managers within the company may not be familiar with the range of BRIX solutions available in the portfolio which limits them into selling these solutions in situations where a BRIX solution might be applicable.

The use of an order configurator system will limit the user to only create solutions that are enabled by the rule-based system. This will minimize the errors that are currently created by the sales department (Forza & Salvador, 2002). The specific matching of sub-assemblies in the product family is defined which will prevent that sales managers create deviant BOMs.

The order configurator provides customers with an accessible way to find a product that suits their meeting room without contacting a sales manager at AVEX. It can also effectively communicate the advantages of a standardized product compared to a customized variant.

An order configurator can be utilized in two ways (Blecker et al., 2004):

- a. **Internal tool for the sales:**
The sales team uses the configuration based on the requirements given by the customer and presents the outcome to the customer.
- b. **Tool for the customer:**
The configurator will be presented online on the company's website allowing customers to configure the product themselves. Thereafter, they can request a quotation or directly place an order.

In the last variant, the tool would create a clearer distinction between customization and standardization. The sales acquisition process will be executed by the order configurator while the sales department can focus on larger projects. This will also ensure that sales manager will not change the BOM thereafter.

Chapter 5

Requirements Order configurator

Using a CTO-strategy within the BRIX product line has the potential to optimize the standardized process that AVEX envisioned. By implementing a system that is aware of the constraints within the products, the failures that are caused during the sales acquisition can be prevented. However, there are several domains that need to be taken into consideration when implementing a CTO-strategy. This chapter will provide a framework of multiple domains that are essential to create a functional order configurator and explain the added benefits and costs. In the chapters following thereafter the framework will be applied to the BRIX product line.

5.1 Scope BRIX process

To define the parameters and domains of the configurator system, the scope of the product line in which the system will integrate should be analysed (L. Hvam et al., 2005). The BRIX portfolio depend on the items distributed by other companies, AVEX does not produce any items themselves but rather combine the items into one functioning system. Therefore, if an item is discontinued or replaced by the OEM, then AVEX is forced to stop assembling this item within their solutions. Two major international conferences (ISE and Infocomm) are the platform for new AV-product introductions. These conferences are both hosted annually. So depending on new product introductions, product management might update the portfolio twice per year.

With the start of the BRIX, AVEX promised a lead time of 48 hours. Therefore it is important that all parts that are needed are available once a customer orders a solution and that customers are not able to order a solution if certain items are not in stock.

5.2 Product architecture

A order configurator makes use of a product with different sub-assemblies that each have a finite set of variants that the user will be able to choose from. Each sub-assembly has a function and all variants within a sub-assembly serve the same purpose, but with their own characteristics which creates the different options for the customer (Schuh et al., 2014).

The information about each of the sub-assemblies and their interfaces need to be documented to build and maintain the configurator (Studer et al., 1998). Literature describes two commonly used diagramming methods to represent the product family structure: Product Variant Master (PVM) and Class Diagrams (Haug et al., 2012). Class diagrams compared to PVM are well defined and widely used in software development. On the other hand, PVM has a quicker learning curve and are easier to revise once changes have been made to the product family (Haug et al., 2010). Using a PVM will ensure that there is a common understanding about the different sub-assemblies and what can be changed by configurator.

5.3 Knowledge based system

Products within a product family consists of several modules or sub-assemblies that each have a finite amount of variants. Not all variants are compatible with each other due to restrictions in the interfaces. The information concerning these limitations is now often only possessed by experts such as engineers that develop and test the products. For someone that is not familiar with the products it might be difficult to know all limitations and therefore rely on the engineers (Haug et al., 2019b). For an configurator to function it is important that all this knowledge is collected in a database. A database, referred to as a knowledge based system, will represent all data concerning restrictions, not only product information, but also constraints within the business or customer preferences (Zheng et al., 2017). Via conversations with stakeholders the information should be translated to constraints and gathered in the knowledge based system (Haug et al., 2012). Several methods are available to store this data:

- **Rule-based**
Consists of a set of Boolean statements (If, then, else) that define which assemblies can be combined and which cannot be combined (Cao et al., 2021). This can be modelled in a decision tree or a derivation graph. A disadvantage of this method is that once a new product is introduced with new variants of sub-assemblies that it could be possible previous rules become invalid (Hvam et al., 2008).
- **Constraints-based**
Constraints describe the relations between different sub-assemblies and give explicit combinations of which variables can be combined. Each combination which is not explicitly mentioned is assumed not to be allowed (Faltings & Weigel, 1996). The use of a constraint-based system is easier to maintain and update once new products arise (Hvam et al., 2008).
- **Case-based**
Revolves around the idea that the rules are based on experience and that if a similar problem is introduced, that it can be solved with a similar solution from the past.

Although using a rule-based system is often easier to implement, the disadvantage that rules might be become invalid is major in an environment where the portfolio changes periodically. Using the constraint-based system is therefore easier to implement and maintain.

5.4 Graphic User Interface (GUI)

The order configurator can either have an internal purpose, in which the sales department will make use of the configurator or an external purpose where the customer of the company also is the user of the configurator. However, by using an external configurator, it can be assured that the BOM will not be deviated since the sales acquisition is performed by the configurator. Another added benefit is the fact that the sales department can do sales acquisitions for customized solutions. The user interface of the order configurator is often accessible via a web portal. Therefore a web-developer is needed to build this and link this portal to the actual configuration system.

Customers often lack the knowledge that is necessary to select the right product (Blecker et al., 2004). However, if information is not presented correctly towards the user they might configure a product that does not meet their requirements (Trentin et al., 2013). Therefore, the user interface should provide information that the user can utilize to make the right decision for their situation (Helo et al., 2010).

Several studies have been conducted into obtaining how a GUI for a user interface should be visualized and defined key elements that should be kept in mind. (Rogoll & Piller, 2004), (Abbasi et al., 2013). Several elements that need to be considered are:

- **Process pattern**
The GUI will guide the user through the different steps, how many steps are presented at the same time is something to take into consideration.
- **Information visualization**
The technical requirements that are necessary to assemble a product should be translated to something that user can comprehend. This can be done with text, images, schematics, etc.
- **Easy comparison capability**
In order for the user to make the right choice, they should be aware of the different options that they are able to select. The GUI should provide a system to quickly compare different options and the information between these should be standardized.
- **Support of choices**
Not every customer is on the same level of knowledge so extra information should be provided for those that require more

Besides GUI-guidelines specific for order configurators, the GUI should also oblige to the design heuristics to make sure that users are able to manoeuvre through the system (Miller et al., 2018).

5.5 Maintenance and connections with systems

The product family that is supported by the configurator will undergo changes over time, products get updated, some items will be out-of-date. Therefore, it is important that when an item within the product family is updated, the configurator is updated as well. Otherwise the configurator will lose its validity (Hvam et al., 2008). Not being able to perform maintenance to the configurator is labelled as one of the main causes for failures of configuration systems (Haug et al., 2019a).

A requirement for the configurator is thus that it can be managed easily if somehow has to make any adjustments to the BRIX portfolio. This is preferably done in a system that does not require any programming to add/update or remove products. Developing such a system might have higher prelaunch costs but this will decrease operational costs since it can then be managed by an employee of AVEX.

5.6 Systems integration

Specific data concerning the BRIX solutions, such as cost price, item availability or visualizations, is stored in different databases or systems. Specific data of these solutions might be off relevance for the configurator. Creating an integration between the different systems and the configurator can ensure that different data is always up to date. Subsequently, it can create more automation of steps by for example automatically forwarding orders. Several methods can be used to integrate different business systems such as Application Programming Interfaces (API) or Enterprise application Integration (EAI) (Altexsoft, 2021).

5.7 Portfolio management

Currently, a team of experts within AVEX keeps track of the sales of BRIX solutions and use this as a guideline when updating the product portfolio. The order configurator offers different data as well that could support this team into design decisions. In order to implement this feature, the different data from the configurator should be visualized and translated. For example, in a dashboard. This dashboard could also visualize other data streams from within the company that could help the team recommend new design decisions. Adding this could result in minimization of stock and therefore less costs.

Chapter 6

Back-end Order configurator

The previous chapter proposed a framework of domains that need to be taken into account when implementing an order configurator into an existing product line. The following two chapters give a proposition on how to implement the different domains from the previous chapter into the BRIX product line. This chapter will work out the back-end of the configurator while the next chapter will propose a user-interface for users to interact with.

6.1 Product family architecture

A configurable product consists of different sub-assemblies that all have a certain functionality. These should be represented in a diagram that displays information about each sub-assembly. A PVM visualization was selected since PVM has been described to be easier to learn for people without programming experience. The PVM consists of two parts, a left side with the Part-of-structure which displays all different sub-assemblies that occur in the product and on the right side there is the kind-of-structure that displays the different variants that are available per module. Integers before each sub-assembly indicates the amount that is used in this structure. (Wotawa & Pill, 2010).

In order to create a PVM diagram for the BRIX solutions, firstly the different sub-assemblies need to be identified. Each item within a BRIX solution plays a role to facilitate the purpose, which is to facilitate videocalls and presentations in meeting rooms. A matrix is created with all solutions and all items that are included per BRIX, which is displayed in appendix D. For each item the purpose is defined, the items that share the same function are therefore grouped in a sub-assembly. The items that share a certain function are therefore grouped and labelled as one sub-assembly. The names of the sub-assemblies were chosen with the functionality in mind. The BRIX solutions only include five sub-assemblies:

- **Mounting:**
Functions as a skeleton for all other devices to be assembled and places the solution somewhere in the room.
- **Connection type:**
The input for the content that needs to be displayed on the screen. Also functions as an output for the video capture.
- **Display:**
Functions as the output for the solution. Presentations and videocalls will be visible on the display.
- **Videobar:**
Records video and audio of the room which will be used to visualize the people in the meeting room during a videocall. Often includes speakers to make the content of the user audible.
- **Additional features:**
Devices that could extend the experience. Currently the only device available, is a device that lets the user share their screen wireless.

Each of the sub-assemblies are visualized in a PVM diagram in Figure 9. Currently, it is not expected that more sub-assemblies will be added since these five are the essential for serving the purpose of the BRIX solution. Rather different sub-assemblies might be combined, for example a display with integrated speakers and videobar.

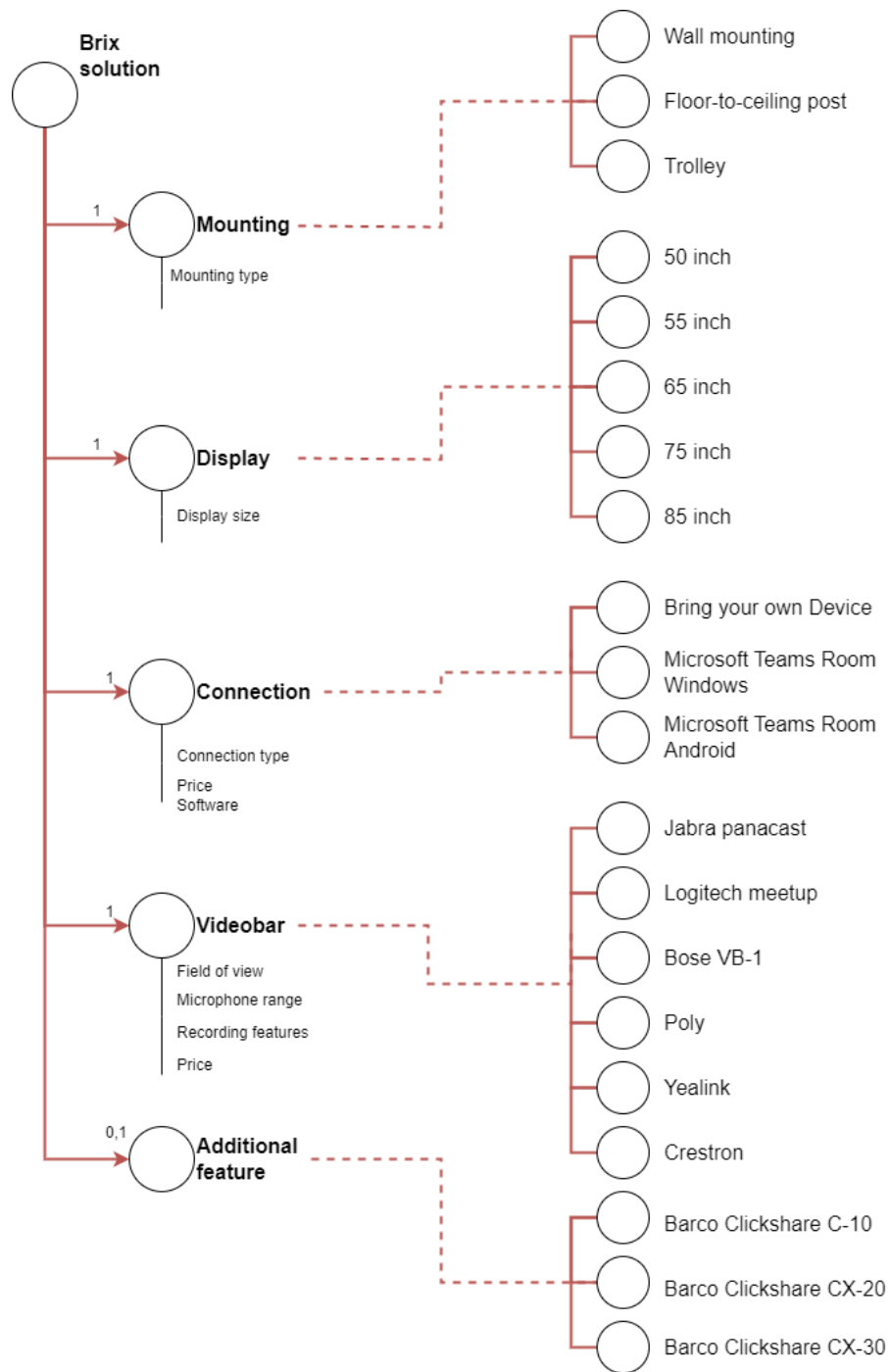


Figure 9: PVM diagram BRIX solution

6.2 Knowledge based system

Now that the product family architecture is visualized, the connections between each interface need to be identified. These will define the restrictions that are used during the configuration of a product. As stated in the previous chapter, there are several structures for the knowledge based system. However, it is advised to use a constraint-based system in an environment with rapid changes. Since this is the case for BRIX solutions, a constraint based system will be applied. Each constraint-statement indicates the different sub-assemblies and the combinations that can be made. For example:

C1: Car-type, Engine

Allowed value combinations:

(Sedan, Engine A) (Sedan, Engine B) (Hatchback, Engine B)

In this example constraints are given between different car-types and different engines. Every combination that is not mentioned implicitly is ruled out. A sedan car-type can have either engine A or engine B, while a hatchback car-type can only be combined with engine B.

To create a constraint-based system, the knowledge from different experts should be obtained and interpreted into constraints (Haug et al., 2012). Constraints were obtained by conversations with product management and engineers. These can be found in appendix F. To indicate which relations are concerned per constraint, figure 10 visualizes the sub-assemblies and their individual relations. The constraints per sub-assembly are also visualized.

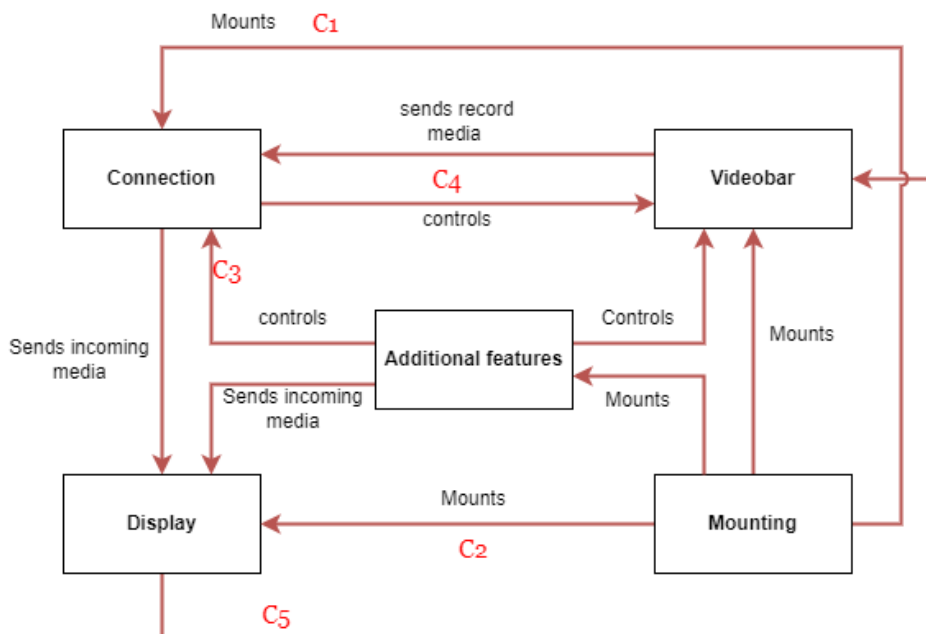


Figure 10: Interfaces between the sub-assemblies within the BRIX

There are constraints between sub-assemblies that might not have a direct relation, in Figure 10 it can be seen that constraint 5 concerns display and videobar, while in reality the videobar sends data to the connection and the display receives data to the connection. The constraint is due to the fact that if a videobar has a small microphone range or field of view, it would not be logical to assemble this with a large screen (e.g. 85”) since people tend to sit further away from it. Documentation is needed for motivation behind constraints.

6.3 Configurator management

With the new items being introduced twice per year by distributors, the product management might want to change the configurator as well. It is off the essence that the configurator has a system that can be easily maintained. This chapter will propose a method for easy maintainability.

Updating the portfolio

The variants in the product family architecture will depend on what is included in the current BRIX portfolio. Before any steps are taken within the order configurator it is important to distinguish three types of actions that can be taken within the portfolio. The three actions and their consecutive steps are:

1. *A solution needs to be removed from the portfolio.*
 - The article code needs to be removed from AX.
 - The solution should be removed from the catalogue.
2. *A solution needs to be added to the portfolio.*
 - A BOM needs to be created.
 - The selling price needs to be calculated.
 - A Proof-of-Concept (POC) needs to be executed.
 - A title needs to be made.
 - An article code in AX needs to be created.
 - A render needs to be made.
 - A product page needs to be made in the catalogue.
3. *An item within the solution needs to be replaced.*
 - The BOM needs to be changed.
 - A POC needs to be executed.
 - The price needs to be adjusted.
 - If it's a visual item that is changed, a new render should be made.

Once these changes are made within the portfolio, the order configurator should match the portfolio. As mentioned earlier, completely re-writing the code of the configurator to include a new or updated BRIX-solution would be too tedious and costly for AVEX. Therefore the order configurator could make use of a product-database. In this database new solutions or items can be added without the need to re-program the system. This database will then be managed by the product management department.

The product database will consist out of two different pages, a solution database and a sub-assembly database. A representation is shown in Figure 13.

Sub-assembly database

The sub-assembly database has a page for each variant of the specific sub-assembly. Within this page the characteristics of each variant is described. Which characteristics should be displayed depends on which information the customer needs. This will be researched in the next chapter. However, it is important that all the variants include the same information to ensure that the user can make an objective decision. The characteristics that were found to be important are described in Table 6. In the sub-assembly database, new pages can be added for a new variant. Via forms the user of this database can add the characteristics as visualized in Figure 11.

Figure 11: Adding a -fictional- videobar to the product page

Sub-assembly	Characteristic.
Connection type	Title
	Description
	Icon or graphic
Mounting Type	Title
	Description
	Render of a BRIX solution including this mounting type
Display	Size of display in inches
Videobar	Title
	Render or image of videobar
	Field of view in degrees
	Visualization of field of view
	Microphone range in meters
	Visualization of microphone range
	Tracking features (group framing, speaker tracking, etc)

Features	Title
	Description
	Extra price

Table 6: The characteristics per sub-assembly

BRIX solution database

The sub-assembly database is used as building blocks for the BRIX solutions within the configurator. In the BRIX solution database all solutions are described as a combination of the different sub-assemblies. Similar to the sub-assembly database, the solution database has individual pages for each solution which describes different characteristics, like a title, render, description and the combination of variants of sub-assemblies. The complete BOM does not have to be included in this database since the user will not have any influence on items like installation material or cables. Similar to the sub-assembly database the responsible manager can add new BRIX solutions via a page with forms to help the user, as displayed in Figure 12. This database will also be used to display the chosen solution once the end-user has finished their configuration.

Figure 12: Product page for new BRIX solution

Constraint based engine

The sub-assembly database describes which building blocks are available and the solution database describes out of which building blocks a solution consists. The constraint-based engine will decide which variants per sub-assembly will be displayed based on the previous selection. Via a connection the rule based system could automatically be updated when a new set of connections is made within a product page.

Adding new BRIX solution in the order configurator

When a new BRIX solution is added to the database it can either include sub-assemblies that were previously included or with new elements. If a BRIX solution consists of a new variant of a specific sub-assembly the steps are as follows.

1. Adding a variant-page to the matching sub-assembly and giving it the right characteristics
2. Adding a new solution page and add the different sub-assemblies on this page.
3. Update the constraint-based engine

If a new brix solution consist of merely 'existing' sub-assembly variants, step 1 can be skipped.

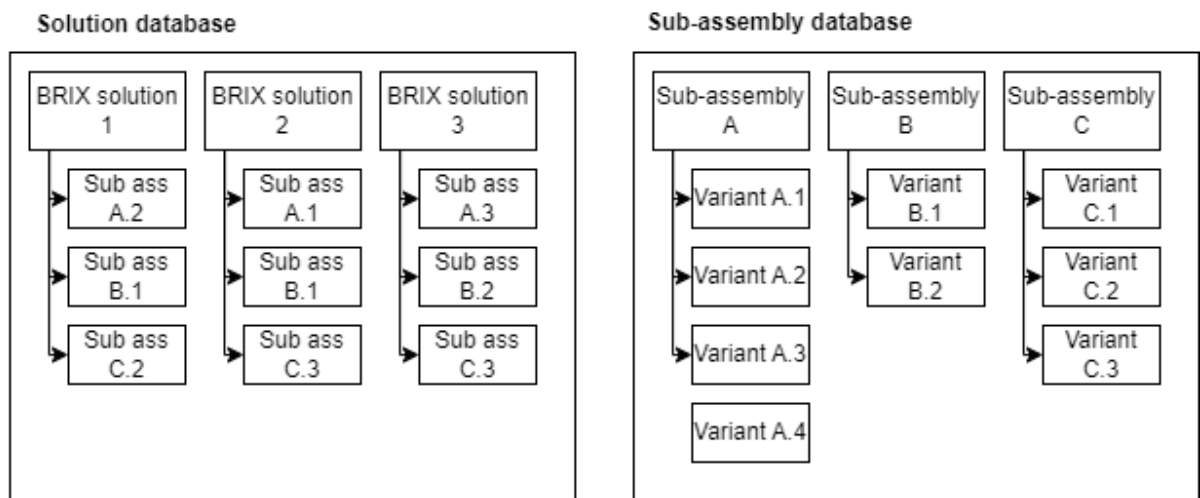


Figure 13: Three different pages for the order configurator database

6.4 Portfolio management

The portfolio of the BRIX solutions is currently maintained by a team of employees from the marketing, product management and back-office departments. They decide which solutions should be added, updated or removed. Their decisions are based on sales orders, product updates and their own expertise. This section will explore if an order configurator could support this team into making design decisions within the portfolio and which data could be of added value.

Based on the log files, generated by the customers behaviour within the configurator, data can be gathered about users preferences (Piller & Blazek, 2014). Based on this the responsible team can learn about customers preferences which could redefine the solution space. Several actions can be concluded based on data from the order configurator:

- **Decrease of sub-assembly variety**

The amount of variables per sub-assembly has been defined over time. A requirement for these different variables is that they each have their own characteristics that creates an added value for the customer. Having too many variants might result in confusion and customer dissatisfaction (Huffman & Kahn, 1998). Therefore it is important to display variants with unique characteristics. Based on the comparison between different variants and the eventual selection of one variant, it might be concluded that there is too many variety within this sub-assembly.

- **Increase of sub-assembly variety**

The conversion ratio indicates the percentage of how many people finish a certain action or process compared to how many people started this percentage (Baum, 2023). By tracking where people would stop their configuration process, it can give an indication on which step is difficult to perform or that none of the options were to the customers satisfaction.

Another option is by providing a 'help-me'-button on each page when no options are available with the previous selected configuration. The help-me button would indicate which changes could be made or to contact the sales for a customized solution. Based on this the portfolio management can get an indication where certain variants might miss within the solution space.

Besides customer data from the order configurator, different data within the company could also be collected to get an indication on the effectiveness of each BRIX solution. If a customer purchases a BRIX solution with an As-a-service subscription then this includes service and support by AVEX. Reports of a specific malfunction should be collected per BRIX solution, these reports can give an indication if a specific BRIX solution needs an update. The type of malfunction should be categorized to identify if it regards a problem with the design or something insuperable. Lastly it should also be collected how often certain QI solution are created to see if it would be worth for AVEX to implement that solution within the portfolio.

In order to facilitate this, a data-mining tool should be used within the company and be connected with the interface of the configurator (He et al., 2021). Thereafter a data-analyst is needed to translate this data in order for the portfolio management team to base their decisions on.

6.5 Consumer psychology

The order configurator is initially a neutral tool that displays each solutions as equals: no specific sub-assembly or solution is promoted over others. The options will be listed in alphabetical order and options are provided with objective and uniform information. The customer will only select the solution based on their own judgement and which is better according to their own requirements (price, functionality, features, etc.).

However there could be instances or situations where it might be relevant for AVEX to give a certain solution a boost in order to sell that solution rather than another solution. Vice versa, there might be situations where AVEX would prefer to temporarily not sell a certain solution, for example when certain articles are out of stock.

This paragraph is dedicated to finding out which reasons or situations there are within AVEX to promote a certain solution, then a literature study towards the use of persuasion principles is conducted. Lastly a list of recommendations are given on how these methods can be implemented in the order configurator designed for AVEX.

6.5.1 Factors Promotion or Demotion

Although the BRIX consist of standardized products and a standardized work-method there are still factors that can influence on which solution should be preferred to sell. First of all when it comes to selling QI solutions the product management maintains a matrix that indicates which brand is preferred per device per situation. These are defined by product management on characteristics of these specific brands.

Table 7 visualizes departments that are involved in the BRIX product line. Per department factors or situations are described that could have an influence on promotion or demoting of an option in the configurator. The last column provides clarity if a certain solution or sub-assembly should be either be promoted or demoted.

Departement	Factors	Motivation	Consequence
Workshop	A BRIX solution is currently in production.	If the workshop is already producing a certain amount of a solution, it would be easier to reproduce this solution.	↑ Solution needs to be promoted.
Purchase	A few parts of a BRIX solution are out of stock.	Without the proper parts available the lead-time of 48 hours cannot be guaranteed.	↓ Solution should be demoted.
	A part of a BRIX solution reaches end-of-life phase	BRIX solutions guarantee no end-of-life articles in their solution so solutions with these parts should be sold quick before going outdated.	↑ Solution needs to be promoted.
Management	Management want to focus more on durability.	AVEX has the vision to be a more sustainable brand. If it is clear that a certain solution is more sustainable than other than this solution should be sold more often.	↑ Solution needs to be promoted.

Sales	One item has more margin.	Due to advantages in purchase it can occur that one item temporarily has a higher profit margin.	↑ Solution needs to be promoted.
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Table 7: Factors per department

6.5.2 six principles of persuasion

Persuasion principles need to be implemented when AVEX wants to steer users towards a certain selection. Although most customers have the feeling that they have total control of their decisions when ordering a product online there are methods used that could persuade a customer to select something even though that might not be the best solution for their own situation (Jacoby & Morrin, 2015). A well-known research into consumer behaviour and influence is done by Cialdini (Cialdini & Goldstein, 2002). He described six principles that can be used in the market to influence consumers towards a choice.



Figure 14: 6 principles of persuasion, source by author.

- 1. Reciprocity:** If you do something for someone you expect something in return (and vice versa).
- 2. Scarcity:** Creating a sense of scarcity of a certain resource gives consumers the feeling of missing an opportunity if they would not buy that specific recourse.
- 3. Authority:** People that are known to have a certain expertise in something tend to convince others more easily compared to less authorised people. This is for example achieved by adding influential people on the promotion or putting a quality mark on the product.
- 4. Consistency:** People want to be consistent and would like to finish actions that they have previously started. Web-shops make use of this principle by splitting up the order form in multiple pages, once the consumer has come to the second page they feel the urge to finish all the pages.

5. **Liking:** If you feel a certain compassion for someone – for example out of similarity- then you tend to agree or be persuaded by that person more easily.
6. **Social proof:** If someone knows that other people have done it before them they have the urge to follow that behaviour.

6.5.3 Suggestion for order configurator

The six principles mentioned can have an effect on the behaviour of consumers and multiple are currently in use in web-shops. However, not all are effective for promoting one product over the other (rather making sure that the customer actually buys something). This section will discuss some of the principles that could have an effect on choice and how this can be visualized in the interface of the configurator.

2. Scarcity – This principle can be visualized with adding how much of that specific BRIX solution is left in stock, as shown in Figure 16.

3. Authority – This principle can be applied by temporarily adding a promotion-mark to a product. This could for example be a logo. This logo can then be moved around from product to product depending on which needs to be promoted. This would also work for promoting a more sustainable solution by adding a green leaf to one of the videobar options. However an info page should be added somewhere in the order configurator to explain what both logos mean and motivation on why something is selected as ‘sustainable’ or ‘better’ brand. Another way of adding authority is by adding pictures of AVEX personnel in the info pages, however this cannot easily be changed per product (see Figure 15).

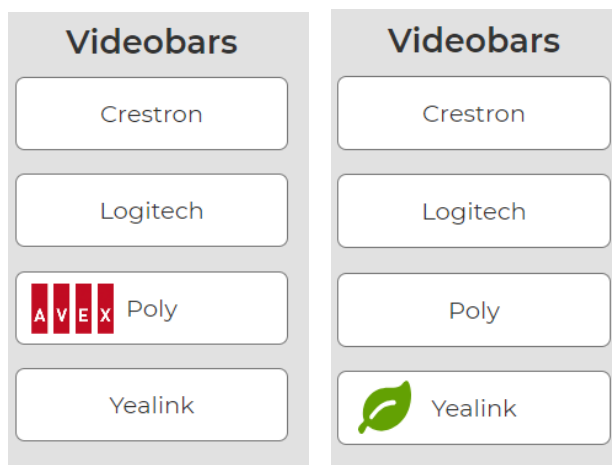


Figure 15: AVEX logo for the poly option as a promotion mark and a green leaf to the Yealink option as a sustainability-mark

6. Social proof – Adding a ‘x people have bought this solution before you’ to a certain solution can create the feeling of social proof. This text will then only be visible on solutions that need to be promoted. Also adding a review page could create a sense of social proof if users know what previous buyers think about that solution (see Figure 16).

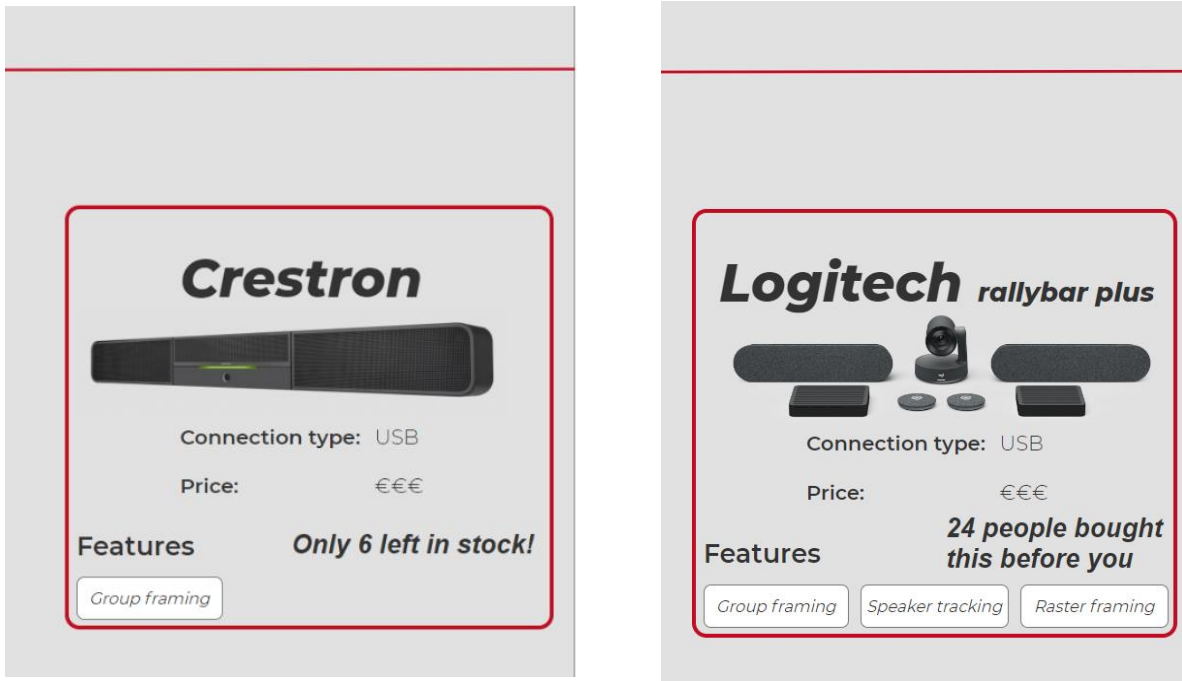


Figure 16: Adding scarcity on the videobar page or social proof

In order to manage these different settings a new interface should be made that will be managed by someone that oversees the sales and logistics. This interface shows the different products and can choose to add promotional elements to the order configurator. A mock-up of such interface is depicted in Figure 17.

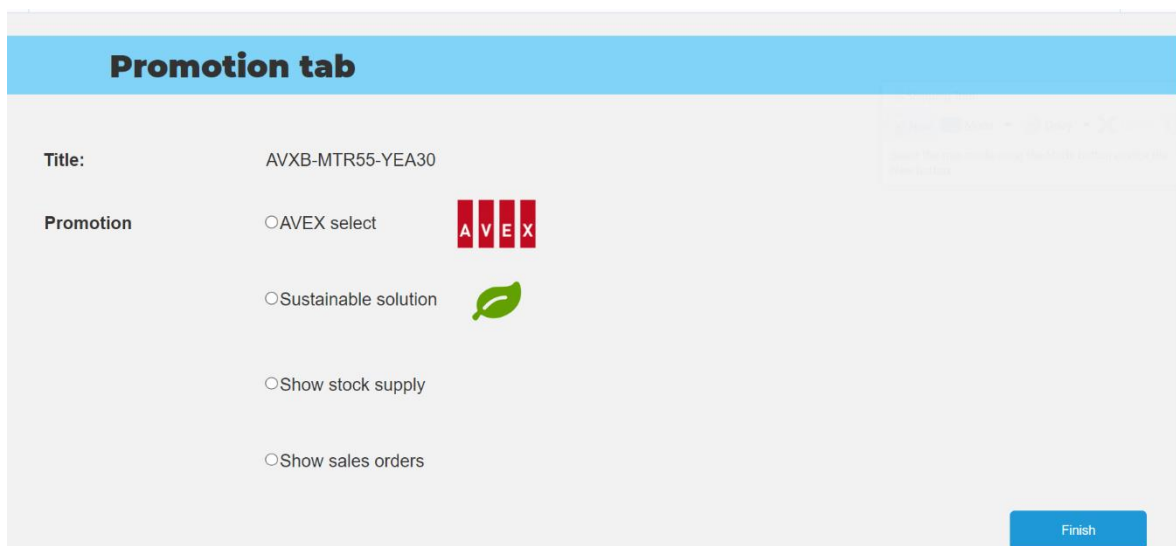


Figure 17: mock-up of promotion screen

Chapter 7

User-interface

With an order configurator the customer will be able to configure their own product based on their needs and requirements (Streichsbier, 2014). A user interface should provide the customer with decisions. Customers however, might lack the knowledge that is needed to configure their own product (Blecker et al., 2004). This chapter will aim to investigate the most optimal visualization of an user interface for this specific product category. Thereafter a prototype will be developed which will be tested and evaluated.

In order to develop an interface that users can comprehend, the following elements need to be figured out:

- **Which information per sub-assembly is required?**
Each item consists of several characteristics and features but not all information is necessary for the customer. Rather the characteristics that match the customer requirements should be presented (Haug et al., 2019b).
- **How can these characteristics be translated to user functionalities?**
Users have functional requirements that they want to achieve while the items consists of technical data. This data should be translated in order for the user to comprehend (Kristianto et al., 2015).
- **Which sequence of questions is the most optimal for users?**
Several paths are available on how to present the information to the user, it should be researched what sequence is the most optimal.

For each of these elements different suggestions are given. Based on literature research and tests within AVEX, conclusions will be drawn which suggestion would be most preferable.

7.1 Front-end pattern

The interface should provide the user with all the different options that they can select. When one selection is made, the constraint-based system should set the restrictions and consequently only show the variants that are compatible with the previously made choice.

The user has to select an option for four sub-assemblies, the additional feature sub-assembly is optional. Only one choice is possible per sub-assembly. There are different patterns on how to guide the user through the selection choices. An empirical study by Abassi et al, showed that most user-interfaces of order configurators make use of two types of patterns (Abbasi et al., 2013):

1. **Single-step pattern:** All sub-assemblies are displayed on a single screen. These can for example be presented as filters on the side of the screen (similar to e-commerce websites like amazon.com). Users selectively choose the filters that align with their knowledge and preference. For example, if the user knows their desired display size but not their connectivity type then they only use the filter for display size. The order configurator will then only present the solutions that match that display variant, a diagram is presented in Figure 19.
Advantage:
 - By selecting the variants that they have knowledge on, they will eventually be presented with all the solutions that are applicable for that situation.**Disadvantage:**
 - Users with limited knowledge on AV-solutions may end up with a long list of possible solutions and eventually still need to select one solution.

- Representing sub-assemblies as filters limits the presentation of the knowledge to text-form, while icons could be more sufficient.
 - There is a risk that if the user fills in all the filters according to their preferences that it might not match the rule-based system. This results in no matching solution.
2. **Multi-step pattern:** The selection per sub-assembly will only be visible one at the time. This framework follows the decision tree presented in the previous chapter. The sub-assemblies are shown in a sequential manner and the next will only be presented after the user has made a decision on the previous one. This pattern is depicted in Figure 20.

Advantage:

- The rule-based system can be followed and the order configurator will only present the variants that are possible in combination with the previous selection. This will always result into one solution.
- Since each step will be shown in sequence, additional information can be provided per page.

Disadvantage:

- The user is required to provide input for all the sub-assemblies, even if they are unsure what to select. This might limit them to go through with the selection process.

Each variant within a sub-assembly should be carefully selected in order to match the rule-based system and all the requirements by the customer. A guidance to this process is needed and the multi-step pattern seems to provide more guidance since each step can be provided with more information compared to text on the side in the single step pattern. Each step will limit down the range of solutions but the user can still select a variant that matches their requirement while simultaneously match the rule-based system. Abrassi et al. reflected that a multi-step is often more self-explanatory compared to a single-step pattern (Abbasi et al., 2013). This will however create extra steps during the development of the interface.

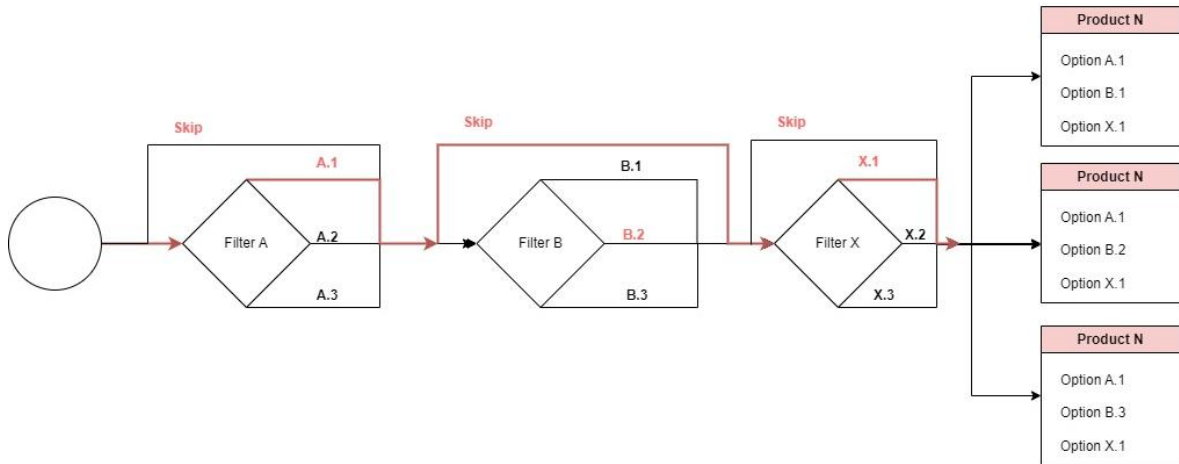


Figure 19: Single-step pattern. The red line shows the path the user has taken

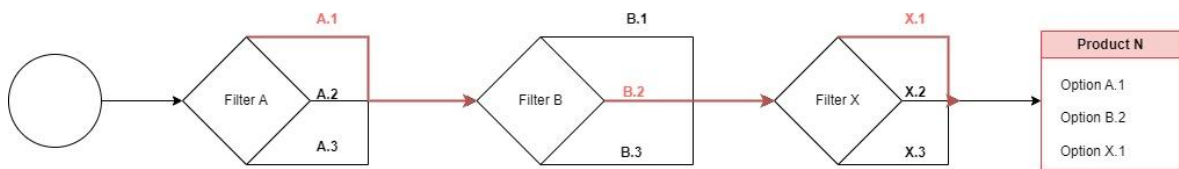


Figure 20: Sequence-style pattern. The red line shows the path the user has taken

A decision tree is created to represent the sequence of choices, which can be found in appendix G. There is a large amount of different sequences that can be used for the decision tree. This sequence was chosen since the range of products were divided in half by each step.

7.2 Translation to functionality

There are certain technical requirements that the user is unaware of, which could make it difficult for the customer to select the right configuration (Wang et al., 2022). In order to match the right BRIX solution, the choice will be based on different variant characteristics (Trentin et al., 2013). A research question that needs to be answered is: How should the information be presented for an inexperienced customer to make the right choice for their circumstance?

Every variant within a sub-assembly differs on multiple characteristics, these could be colour, size, functionalities etc. Only the characteristics that the user bases their decision on should be displayed to reduce complexity (Valenzuela et al., 2009). These characteristics should be translated into something that the user with a limited amount of AV knowledge is able to comprehend. For each sub-assembly it is described what requirements the customer uses, to make their choice. Thereafter suggestions are given on how to display this to the customer.

7.2.1 Size of display

Since AVEX makes use of commoditization of displays (see section 2.2.4), the only factor that differ per variant is the display size, which should therefore be a characteristic that is presented to the user. In order to choose the right display size for a room, different AV specialist use different guidelines (AVspecialist, 2022). Often mentioned guidelines are the dimensions of the room, amount of people or the distance between the display and the viewer sitting furthest away (Cenero, 2015). However the most accurate choice is based on the maximum viewing distance.

7.2.2 Connection type

The connection functions as an input and output for the content on the display and the videobar. The BRIX solution currently offers two connectivity options: MTR or BYOD. BYOD is a plug-and-play solution: users simply connect a cable to their laptop which let the display mirror their screen. The other option, MTR, is an integrated solution that is optimized for laptop-free video conferences. There are several factors that the user needs to be aware of before making a decision between BYOD and MTR:

- **Communication platform:**
If the customers company makes use of platforms such as Zoom or Skype then a MTR system is not compatible.
- **Operation system restrictions:**
Some companies block certain operation systems such as Android. A few MTR systems rely on Android and can therefore not be implemented in these companies.
- **Budget:**
MTR systems are generally more expensive compared to the BYOD variant.

Two interface variants were developed to test how much information is necessary for a user to understand the difference. The first option displays the options with only a logo and more information can be accessed by an information button. The second option displays one sentence of information and a table that explain the different characteristics between the models. More information can be accessed by an information button.

The two variants are displayed in Appendix I. These were tested during the A/B tested, displayed in section 7.4.

7.2.3 Mounting type

The mounting type defines how the product will be installed within the meeting room and currently consists of three options: Wall mounting, FTC and Trolley.

There are multiple restraints that can influence the selection:

- If the solution needs to be transferred to multiple meeting rooms.
- If the wall is applicable for wall mounting.
- If the floor and ceiling are applicable for FTC.
 - Are the ceiling and floor made of concrete?
 - If the ceiling is lower than 5 meters?

Based on these factors, there are two options for displaying this choice:

1. All different options are given with information about each.
2. Two questions are given subsequently, like the decision tree in Figure 21

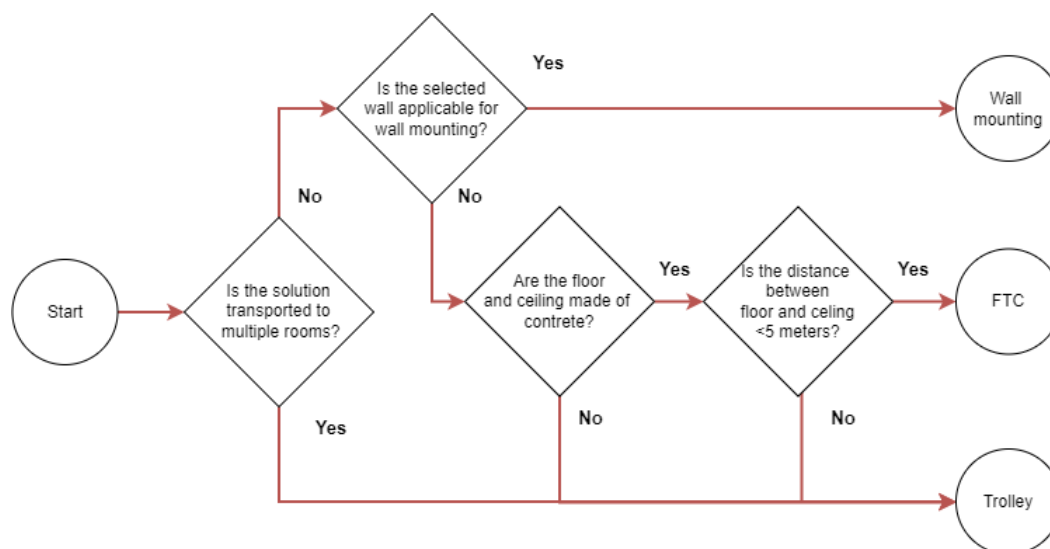


Figure 21: Decision diagram for mounting type

The first variant has been selected since users will not be able to predict that another question will appear after the first question. For that reasons if they know they cannot mount to the wall they will select a trolley instead, while an FTC would have been possible. Therefore, all three options will be presented on one screen.

7.2.4 Videobar type

As mentioned previously there are multiple videobars available in the catalogue, each videobar has their own qualities and already not all videobars are applicable combined with previously selected sub-assemblies. Users base their selection on these characteristics:

- Field of view (how wide is the angle of the camera)
- Microphone range (how far away is someone audible)
- Visibility features (some videobars provide speaker tracking, group framing etc)
- Pricing

A specification list of each videobar that is available in the BRIX solutions is presented in Appendix J.

To find out if a videobar is applicable in the room, a user could measure the depth of a room to obtain if the microphone range would be sufficient. However, to find out if everyone will be visible within the camera field is something that cannot be expressed in words. Visualization should be given to find out to compare the different FOV per room.

1. **Options selection:**

Each videobar is presented in a visual way with supporting text. A room will be visualized with shows the FOV of the videobar as a semi-transparent plane. By selecting a different videobar the user is presented with that visualisation to compare the different videobars.

2. **Dynamic selection:**

The user is presented with a room that they can modify, they can select their own table and move this within the room. Again the FOV is presented as a semi-transparent plane and by moving the table they can see if the table falls within the plane or if someone will be not visible. This can then also be done for the microphone range.

To visualize both variants, two prototypes have been developed. These will be subject to testing in the next section. Based on those findings, a choice will be made to conclude which variant is needed.

7.2.5 Additional features

Currently, the only additional feature that can be implemented with a BRIX solution is the Barco Clickshare. However, it could be possible that in the future AVEX decides to also implement other additional features, like a wireless microphone. The Barco Clickshare is not compatible with every solution and this might also be the case for new additional features. Therefore, the selection of this feature should be the last step once the main solution is configured. This ensures that the correct additional features will only be presented if the solution is compatible with these features.

7.3 Interface variants

To find out how to represent the configuration process in the most optimal way, two prototypes have been developed. The program of choice for developing these prototypes is Axure since this program enables the developer to create working prototypes without the need for programming. In this section both prototypes will be explained. In the next section they will be used for testing to obtain which prototype would give the best results.

Both variants make use of a multi-step pattern. The user is confronted with the available options of a sub-assembly. After selecting a variant they are guided towards the next sub-assembly until all sub-assemblies are defined. Each new screen only displays the options that are able to be connected with the previously selected variants. After configuring their desired product, the user is displayed with the final overview. In this screen, they can select extra features. Also a price is shown. A few screens that are used in both prototypes are shown in Figure 22. A complete overview of the different screens is depicted in Appendix K and L.

Some pages are equipped with an information button that users could click if they need more information about the sub-assembly characteristics and potential advantages for different variants. This can effectively communicate the cost, benefits and consequence of choices (Trentin et al., 2013).

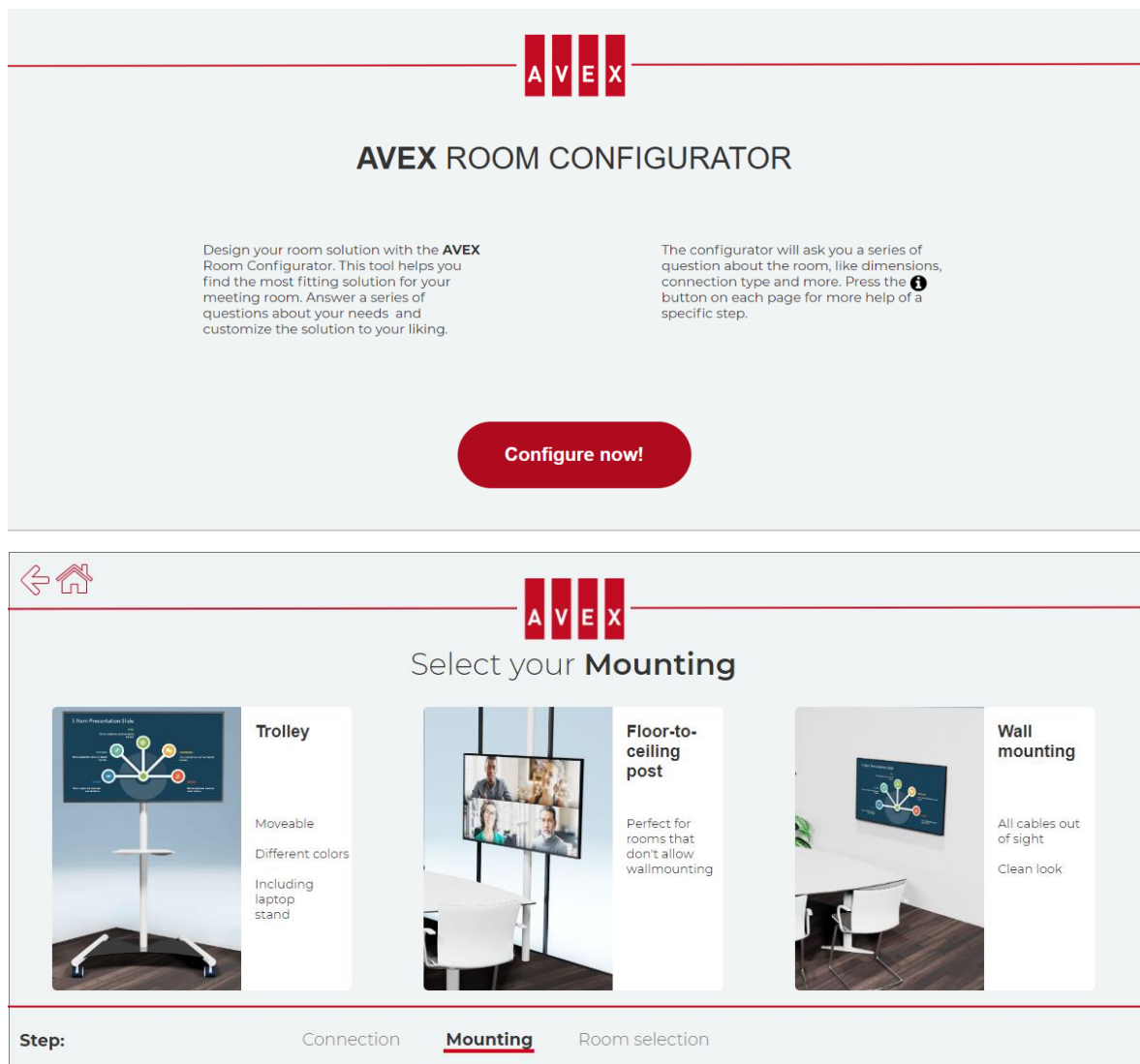


Figure 22: Two screens that appear in both prototypes

7.3.1 Options interface

Each sub-assembly is visualized by images, logo's and text. Per step an information button is available that provides the user with extra information if needed. To make the right selection of the videobar, the user sees the top view of a room that matches the selection that is previously made. By clicking on the different videobars the visualization shows what the camera would capture by a red triangle that represents the FOV.

Next to the visualization the different videobar features are displayed. By hovering over the names the room will display what that will do the videobar (see Figure 24). On the right side, the screen displays information about the videobar like, name, picture and price range (see Figure 23). A price range is used rather than an actual price since this will also be defined on other aspects besides the items, such as shipment.

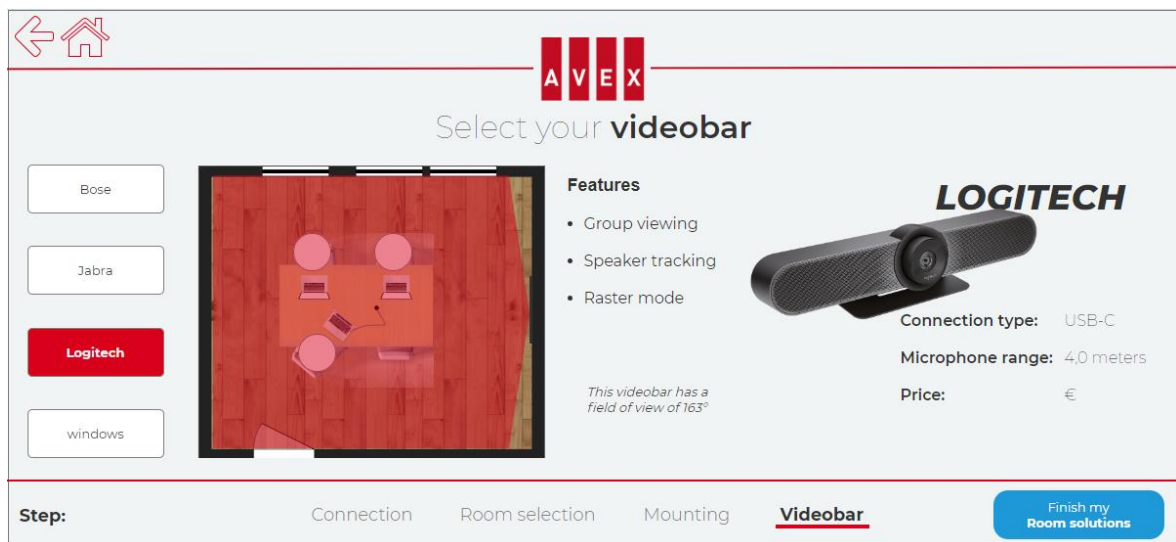


Figure 23: Overview of videobar selection

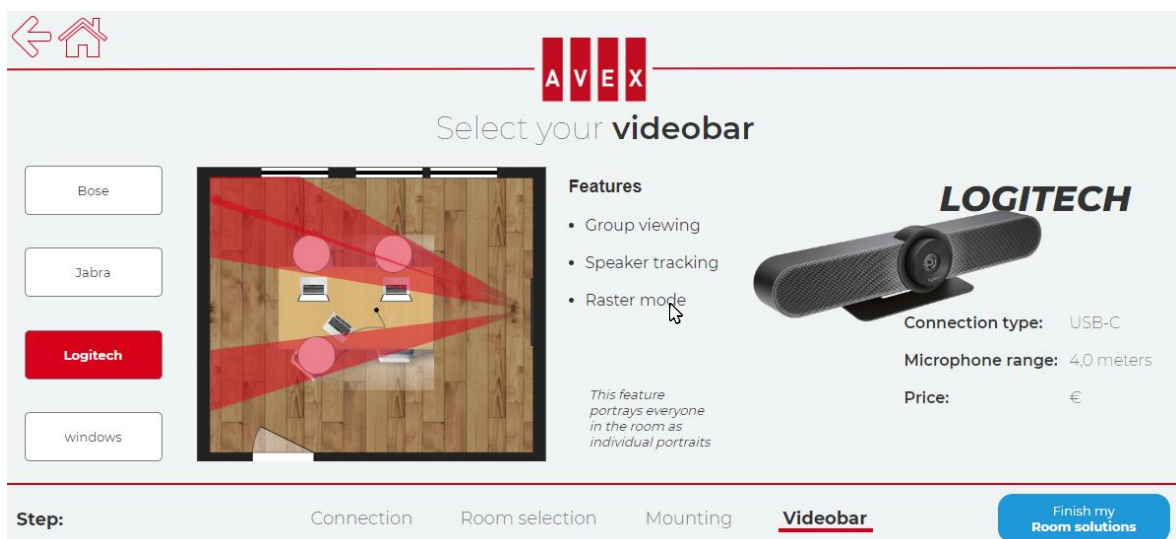


Figure 24: By hovering over the feautres, the top view will visualize what happens.

7.3.2 Dynamic-interface

Similar to the questionnaire-interface some sub-assemblies are defined by posing specific questions to the user, this will define connection type and mounting type. Defining the display size is initially skipped. Instead, a digital twin will be used to define the display size and the videobar. The digital twin depicts a top view of a room and consists of a table and a display. The user is able to select from a range of tables, differing in shape and size.

The user is able to move the table back and forth towards the display and can thus -partly- recreate their own meeting room. The configurator will measure the distance between the display and the end of the table. Based on the maximum viewing distance this will suggest a display size (see appendix J).

Based on the display size and the previously selected sub-assemblies, the configurator proposes a list of videobars that match the constraint-based system. The user can compare them by clicking the different options. The FOV will appear as a semi-transparent red area, everything within this area is visible to the camera. Based on this, the user can decide if the videobar would match their room (see Figure 25 & Figure 27). The same principle is used for the microphone range, except this is visualized by a blue area (see Figure). The microphone can record all the sound within this area, but outside there might be some loss of audio. On the right side of the screen, some information like the name, image and price of the videobar are stated. The different features of the videobar can be explored by clicking on them.

If the user would move the table too far back it could be that there is no display applicable for that configuration. In that case the user will be notified that this configuration does not yet exist and that the user should change a selection or contact AVEX for a customized solution (see Figure 28) .

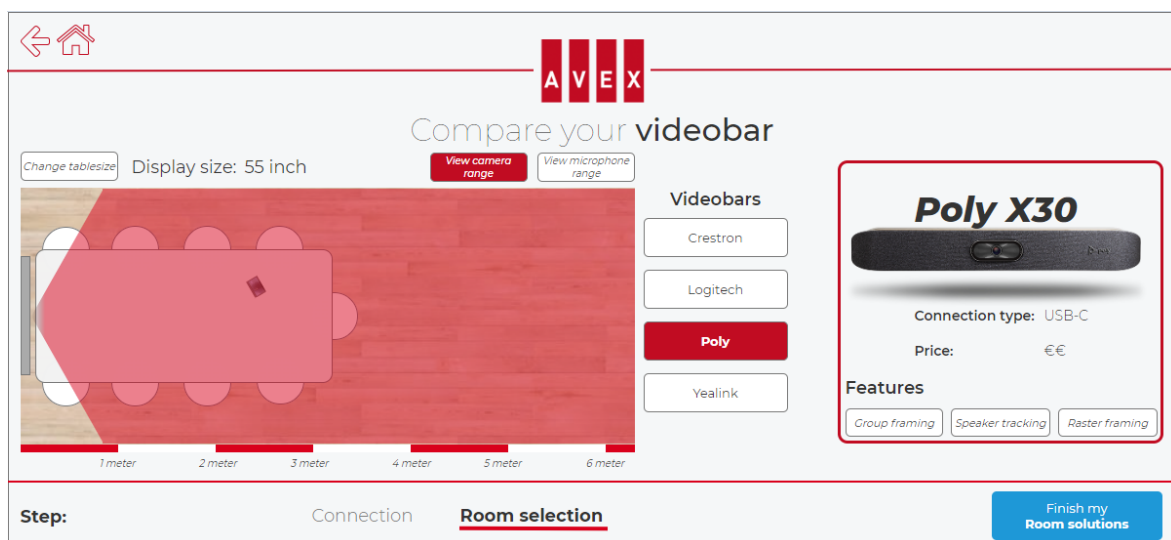


Figure 25: Using a Poly X30 would result in that the first two people on the left are cut off.

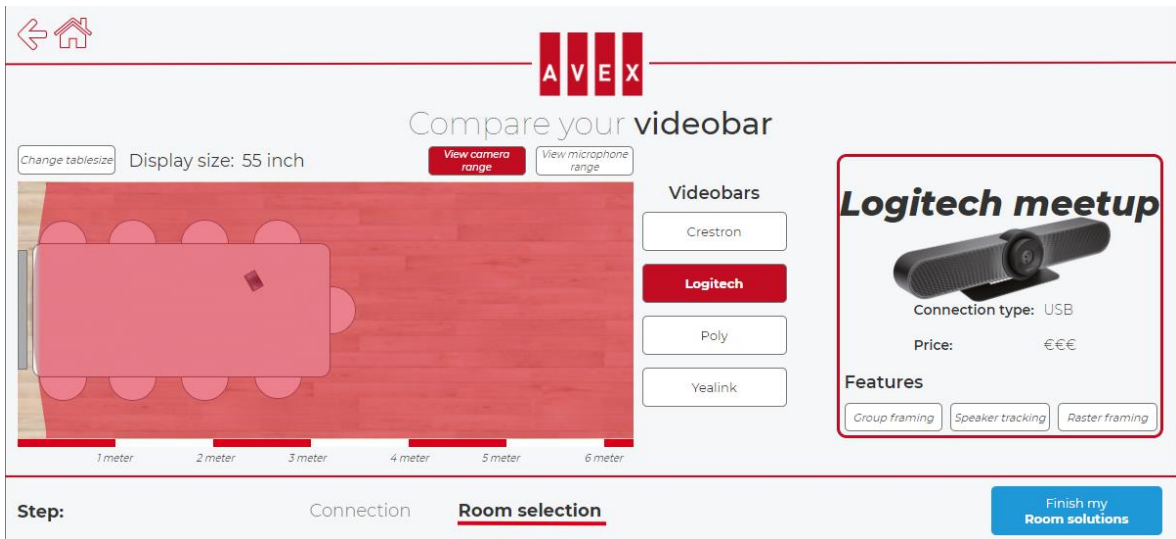


Figure 27: Using the Logitech Meetup would result that everyone would be visible on camera.

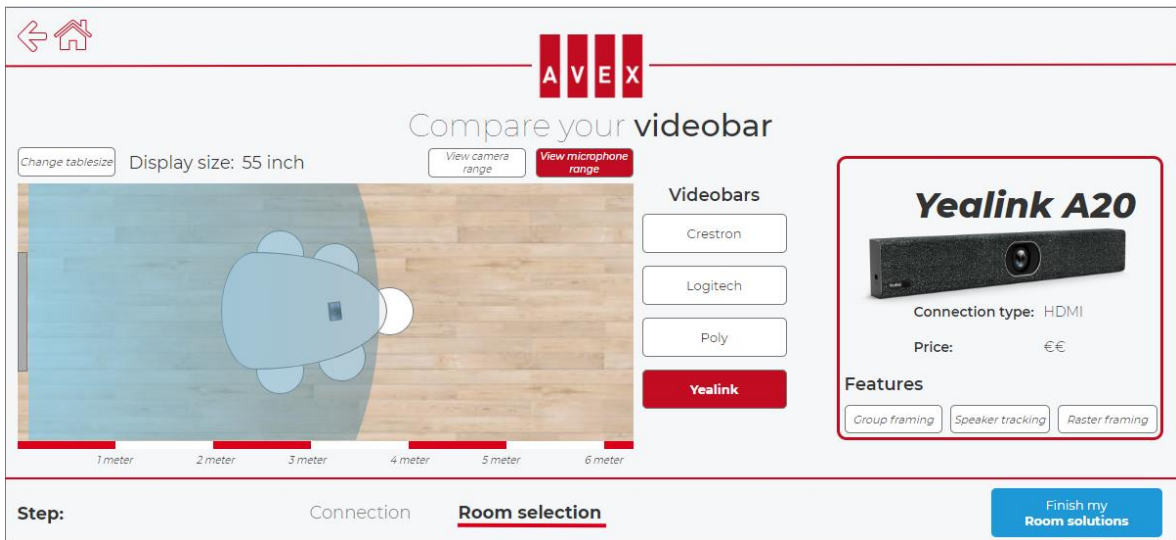


Figure 27: Using this videobar would result in that the last person is not audible.

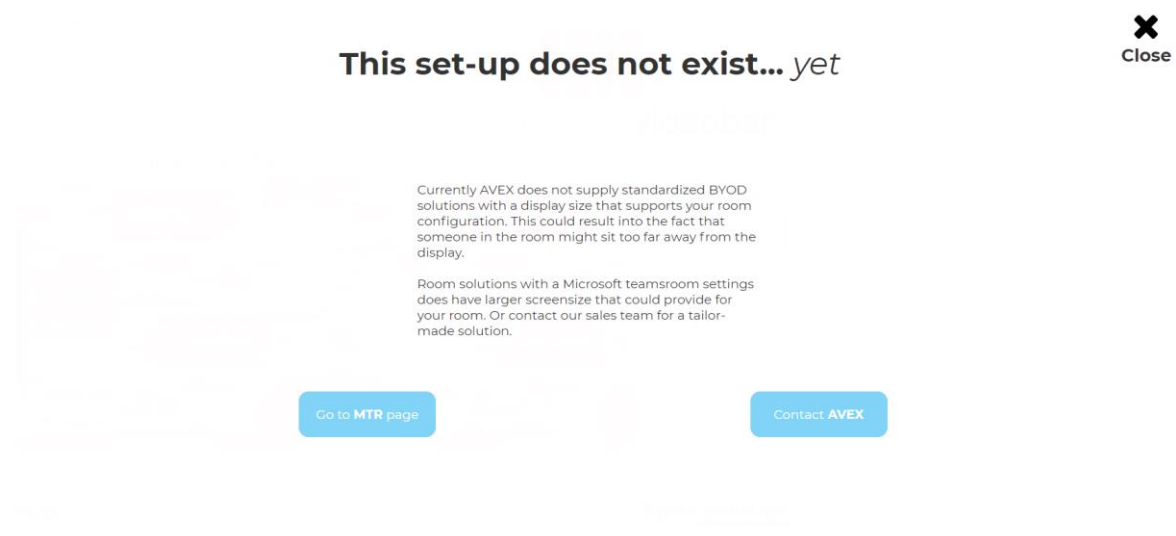


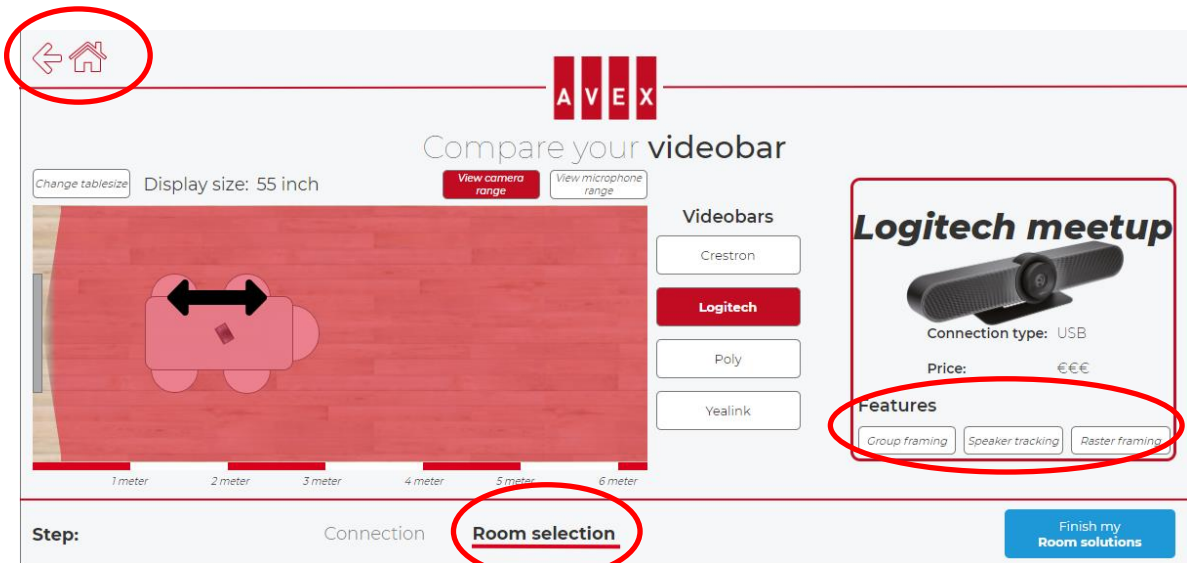
Figure 28: Pop-up if configuration does not exist.

7.3.3 Design Heuristics

Besides the specific elements for the order configurator of AV-systems, the configurator should also implement design heuristics for interfaces as for example proposed by Nielsen (Nielsen, 1994). Figure shows a screen of the order configurator with examples of these heuristics implemented. These ten principles are:

1. Visibility of system status
2. Match between the system and the real world
3. User control and freedom
4. Consistency and standards
5. Error prevention
6. Recognition rather than recall
7. Flexibility and efficiency of use
8. Aesthetic and minimalist design
9. Help users recognize, diagnose and recover from errors.
10. Help and documentation

User control: In each screen a home and back button is displayed to go back after making a mistake



System status: the red line indicates in which phase the user is

Minimalistic design: all features can be explored with a pop-up button, otherwise they are not visible.

Figure 29: design heuristics in interface

7.4 A/B test

The dynamic-interface has the advantage that it represents a digital-twin of a meeting room, this visualization can be better to comprehend for the user. However, it would require more effort in programming. Therefore it has to be researched if the dynamic-interface has an added benefit compared to the options-interface. This is fulfilled by applying an A/B test where a research group has to work in a similar setting but one half uses the option-interface while the other uses the dynamic-interface.

To represent the customers with little to no knowledge of AV-solutions, students were selected. They received a scenario for which they have to configure a BRIX-solution. The settings in this scenario are created that only two configurations would apply. Based on which configurations the test-group makes, a conclusion can be drawn if the dynamic-interface is more effective. This depends on several factors:

- **The accuracy of the configurator:**
Not every solution would match the requirements and situations of the customer.
- **Usage time:**
The time that is needed for the user to start and finish a configuration.
- **Guidance:**
Does the information speaks for itself or does the user require more information.

Another element that needed to be researched is how much information is needed to make it decision on connection type. Therefore the options-interface had no extra information when presented, this could be opened by clicking on the information button. The dynamic-interface had a table in between that explained information about both connection options. This text can be retrieved in appendix I.

7.4.1 Description AB test

Each participant will work with either the options-interface or the dynamic-interface. The scenario that the research group is given will remain consistent. This scenario depicts a fictional room and a backstory of a company. The participant needs to use this information to find a room solution for that particular room. The fictional room will give the participants about the room dimensions while the backstory gives the users information about connection type, budget or mounting. This scenario is created in such a way that only two configurations would be applicable, all the other solutions would not match the situation. Therefore, it can give an indication which order configurator would lead to better results.

The participants will be observed while they manoeuvre through the order configurator. In that manner, it will show the pages that could lead to mistakes, where more information is needed or how long it will take in total. Lastly they are questioned about their usage of the order configurator. The set-up is presented in appendix M.

7.4.2 A/B test with students

During the first A/B tests 18 students participated. The scenario depicted a room for 7 persons but due to the placement of the table only a 65” display would be sufficient. Based on the information it could be concluded that they want to implement a Microsoft Teams room with a tight budget. The complete scenario can be found in appendix N. The only two correct configurations can be the BRIX solutions *AVXB-MTR65-POX50* and the *AVXB-MTR65-YEA30*. These are wall mounted, MTR-solutions with a 65”display and a system by either Yealink or Poly.

The end-configuration and running time are given in Table 8 & Table 9. The configurations that matches the initial correct configurations are highlighted green. The digital twin gave four positive results while the questionnaire interface only gave one. Although the running times were similar among both groups the average time in the digital twin interface is 51 seconds shorter. It should be noted that one person’s running time got lost and is therefore not in the table (B.8).

Concerning the choice between connection-types eight out of nine test-participants that operated the dynamic-interface had selected the MTR option. Only five persons selected the MTR option in the options interface.

When it comes to selecting the right display size and videobar, in the options-interface only three people selected the correct display size while in the other interface all test-participants did. Concerning the videobar, four out of nine persons selected the right videobar.

Options-interface		Running time
Test-user	Configuration	
A.1	AVXB-MTR55-POX30	03:01
A.2	AVXB-MTR55-CRB30	02:56
A.3	AVXB-WB55-VLM	06:43
A.4	AVXB-WB65-BOSE	04:30
A.5	AVXB-MTR55-POX30	03:44
A.6	AVXB-W65-VBV	03:55
A.7	AVXB-W55-VBV	03:23
A.8	AVXB-MTR55-YEA20	03:31
A.9	AVXB-MTR65-POX50	03:49
Average time:		03:56

Table 8: Results of options interface test group

Dynamic-interface		Running
Test-user	Configuration	time
B.1	AVXB-MTR65-LOBRA	01:17
B.2	AVXB-MTR65-LOBRA	03:03
B.3	AVXB-MTR65-POX50	05:34
B.4	AVXB-W65-VBV	03:15
B.5	AVXB-MTR65-POX50	04:14
B.6	AVXB-MTR65-CRB30	02:15
B.7	AVXB-MTR65-YEA30	03:04
B.8	AVXB-MTR65-POX50	
B.9	AVXB-MTR65-LOBRA	01:57
Average time:		03:05

Table 9: Results of options interface test group

Based on the fact that using the dynamic interface gave more accurate results concerning the display size and the selection of videobar, it has been concluded that this variant would be used to represent the BRIX solutions towards customer as a user-interface.

7.4.3 Test with employees

After selecting the type of interface, a test will be done to find out how employees of the back office would manage with using the configurator. Again, they all receive the same scenario, which can be found in appendix O. Before using the configurator prototype they were asked to give an opinion on what they would select based on their own knowledge. Thereafter they could use the configurator.

The personnel of AVEX were given a new scenario, which can be found in appendix O. This time, the room was larger compared to the previous scenario but a 65" display would be sufficient. Also, the information text should have pushed them towards an MTR solution. Lastly, with the placement of the table within the room the test-user should find out that not all videobars will be sufficient since the microphone range of the Yealink is shorter than the table meaning that the last person would not be audible. The desired outcome are therefore the AVXB-MTR65-CRBX30, the AVXB-MTR65-LOBRA or the AVXB-MTR65-POX50.

Before using the order configurator the employees were asked to read the scenario and which solution they would pick or which particular sub-assembly. Two out of four people choose to use a trolley and suggested an MTR solution, however these sub-assemblies are not compatible so this would result in a BRIX solution that would not match the rule-based system. The back-office manager was asked how long it usually takes for an employee to find the right BRIX solution for a situation and it stated that this takes approximately 5-10 minutes.

After the configuration it became clear that two out of four test-users configured the right item. Another one selected a MTR-solution but placed the table closer to the display which resulted in a display size of 55". One test-user choose to select a BYOD solution, when asked about this they stated that they thought that would be easier to use. Also the average time of the configuration compared to the manual selection by the employee is relatively shorter.

Dynamic interface

Test-user	Configuration	Running-time
1	AVXB-MTR55-YEA20	01:23
2	AVXB-MTR65-LOBRA	05:27
3	AVXB-MTR65-POX50	02:28
4	AVXB-TLI65-VBV	01:21
Average time:		02:39

Table 10: Results of test-group of AVEX employees

Chapter 8

Discussion & Recommendation

Each individual domain has been identified within the order configurator system. This chapter will give an overview of the complete system, the associated stakeholders and the benefits of each domain. Subsequently, a recommendation is presented on how AVEX should implement this. Future work is discussed lastly.

8.1 Overview configuration system

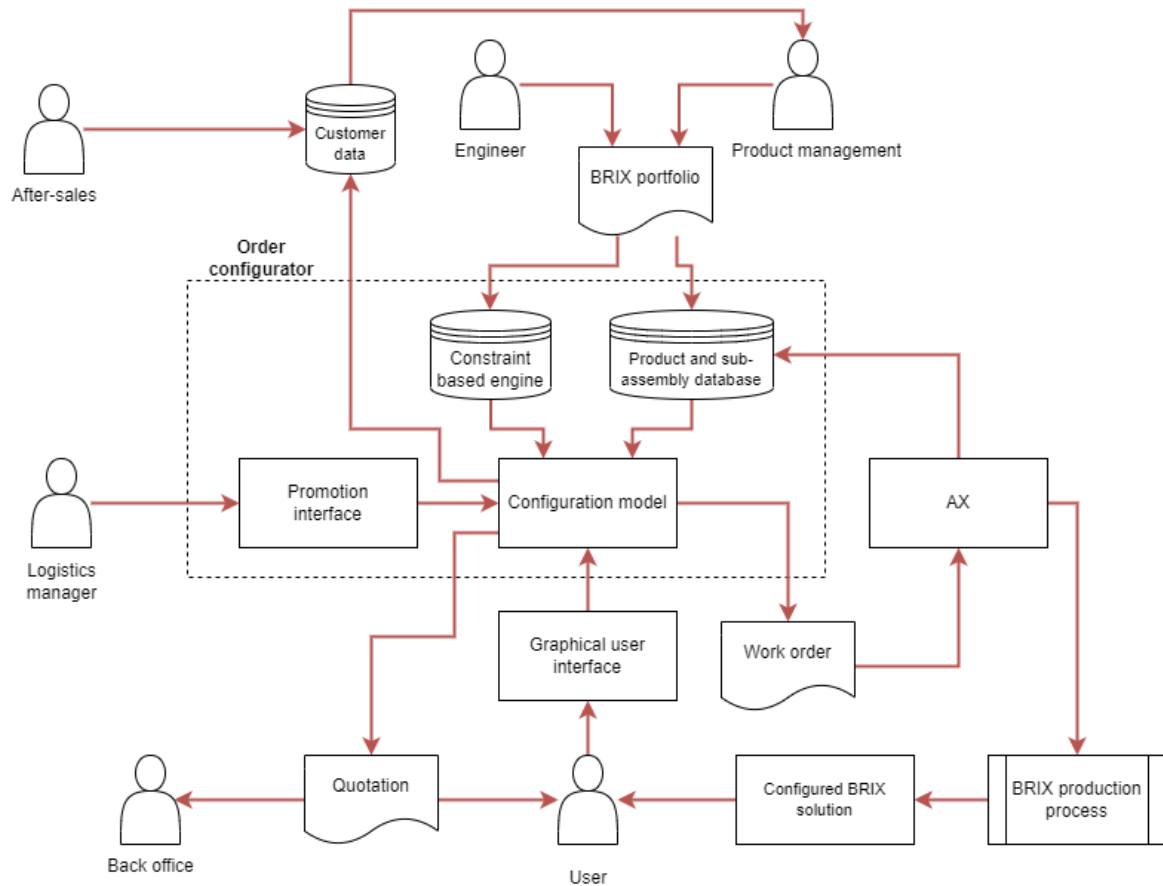


Figure 30: Overview configurator system

Figure 30 depicts a visualization of the complete model as it is described in the previous chapters. The main part is the configuration model, combined with the ‘product and sub-assembly database’ and the constraint based engine. This will provide the solution space that decide which configurations can be made. The product and sub-assembly database will consists of the items that the user will be able to choose from while the constraint based engine will provide the restrictions between each sub-assembly. Within the configuration model the sequence of selection is defined.

The control of the configuration will be provided via the user-interface, which will be implemented in a web portal. The customer will be the end-user of this system, this provides a distinction between customization and standardization. The output of the configurator is a solution that is in accordance with the requirements of the customer. A quotation can be presented if the user chooses to purchase their configured model. When the quotation is paid, then the workorder can be forwarded within the ERP system (AX) which will start the BRIX production process. Lastly the solution will be shipped to the customer.

The input for the product and sub-assembly database will be provided by the product management that maintains the BRIX portfolio. The portfolio will be the guideline for both the product and sub-assembly database and the restrictions. Before a new solution is introduced it is recommended to execute a POC and not only rely on the constraint based engine.

To maintain the portfolio the product manager can rely on the customer data as suggested in section 6.4 The customer data will be extracted from the configurator. All these data can give an indication but for each instance a threshold should be defined before action should be taken. For example; AVEX has already stated that once a QI solution is sold more than 10 times, it should be standardized and designed as a BRIX solution. For other types of data, like the amount of clicks or the amount of malfunction reports a threshold should be defined before any action should be taken.

To get last minute product updates an API connection can be developed between AX and the configurator, for example to automatically update the price or the availability. Subsequently, with an API workorders could be automatically forwarded when a quotation is paid.

Lastly a promotion interface is provided to quickly add persuasion principles to specific solutions if this is necessary. Based on trends that they have spotted this department is able to quickly add persuasion items to the configurator.

8.2 Implementation

Once AVEX has made the decision to implement an order configurator within the BRIX product line, the development process will start. The different domains need to be kept in mind to ensure that the configurator is scalable and easy to maintain when the product range of the BRIX portfolio has changed. However some parts will have more relevance than the other. The databases and the constraint based engine should be implemented firstly.

It can be possible for AVEX to completely develop the order configurator system internally since multiple software developers work at AVEX. However, the programmers at AVEX primarily develop software to control electronic devices while this concern a digital program. AVEX could also choose to use a software shell to create their configurator in. Multiple companies provide software shells for companies. Based on the previous chapters it is important the software meets the following requirements.

- **Able to design user interface**

During the tests in chapter 7 it has been researched how the configurator should be visualized in order for users to configure a model that satisfies their needs.

- **Able to maintain the database**

To incorporate the latest changes within the BRIX portfolio a database should be provided that enables product management to quickly add, update or remove items when this is necessary. Also, AVEX should be able to quickly make changes to a variant to promote this.

- **ERP connection**

With the connectivity between the configurator and the ERP system, AVEX will be able to get direct updates about products and also to create an automated process of forwarding orders.

- **Data collection**

The user behaviour can play a role in the maintenance of the BRIX portfolio.

8.3 Recommendations and future work

Suggestions were made how to persuade users into choosing for a specific variant during the configuration process. Which principle will have the best outcome can be researched via an A/B test. In this test the users once again need to configure for a specific scenario. However, one sub-assembly -that is significantly underperforming compared to an alternative gets promoted via the persuasion principle. If users tend to choose for this product then this will give an indication on the effectiveness. However a large group of test subjects are needed to get a clear indication.

Adding persuasion elements to the interface of the order configurator might change the choice of the customer and could possibly select against their own interest. So to make sure that customers are not misled no information can be left out. Adding one of these persuasions principles can then only be an extra motivation to select a certain solution.

It has been researched how data from the order configurator can provide the product manager with more information for the portfolio management. However, in order to do provide this, a data mining tool is necessary to extract this data. Subsequently, a data-analyst needs to visualize this data into something substantial. Therefore, the benefits for this might not outweigh the costs to implement this.

Chapter

9

Conclusion

The BRIX product line that AVEX developed did not initially create the division between standardization and customization as they had envisioned. During this research it has been discovered that the sales department tend to deviate from the original BOM and add or replace items. There are several reasons for the sales department to do this but they are mainly due to serving the customer needs completely or unfamiliarity with the products. Changing the BOM creates several issues during the production phase which often has the consequence that lead time is prolonged and costs price rises. This is in contrast with AVEX initial vision when starting the BRIX solutions, which was a standardized workflow for meeting room solutions that don't require any engineering steps.

To ensure that only standardized BRIX will be created, a configure-to-order strategy should be implemented. The configurator will perform the sales acquisition process and with a restriction-based system only solutions can be configured that AVEX actually sells. To ensure the success of a configurator in the BRIX workflow several domains should be implemented, most importantly a database that enables the product management team to maintain the configurator during its' lifecycle without the need for programming.

Since the customer might be unaware of the different details of the configurator, it is important that the configurator follows a multi-step pattern where selections are presented one by one. The characteristics are presented in a uniform way so that the user can make a comparison between the different variants of each sub-assemblies. The addition of a digital twin of a meeting room has significant impact on making accurate selections that meet the users requirements.

Based on tests with the back-office department it can be concluded that using the order configurator also is a quicker method to find a matching solution compared to when employees perform this action.

Different domains are recommended to implement to create more automation, such as the integration between the configurator and IT-systems but the feasibility of this depends on the amount of sales. Also using data from the configurator might benefit the company to make better design decisions, however it is advised to only implement this if the amount of orders is substantial.

Chapter

10

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Appendices

A. List of project types

At the moment the menu-list includes approximately 30 BRIX solutions which can be divided into the following four segments:

Segment	Explanation
Trolley presenters (Figure 31)	<ul style="list-style-type: none"> • A display available with different videobar mounted a trolley. • Moveable from one meeting room to the other. • Available in display size 50 to 65 inch. • Extra features like touchscreen or Barco Clickshare.
Wall presenters (Figure 32)	<ul style="list-style-type: none"> • Fixed on location • Either on wall mounting or clamping post. • Available in display sizes 50 to 65 inch. • Extra features like touchscreen or Barco Clickshare.
Microsoft teams room (Figure 33)	<ul style="list-style-type: none"> • Includes a pc that hosts a Microsoft teams account • Meetings can be hosted via that pc so no laptop is required for a meeting. • A small tablet is included to operate this MTR room. • Only available as wall mounted.
Room upgrade sets	<ul style="list-style-type: none"> • Devices that are sold separately to install to company's current solutions • Examples are videobars and Barco Clickshares.

Table 11: Different segments within BRIX solutions

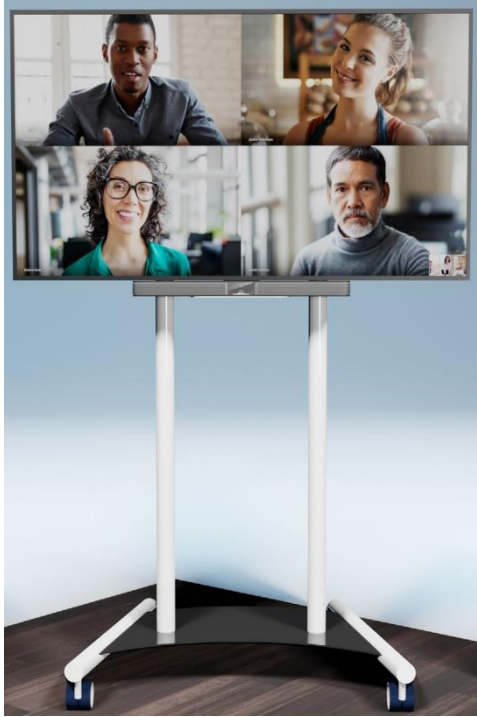


Figure 31: BRIX trolley presenter



Figure 32: BRIX Wall presenter



Figure 33: BRIX team presenter

B. Transcript Interviews with AVEX employees

Branche account manager Sales

How are you informed about the BRIX?

When I started working at AVEX a few years ago I immediately got notified about what we sell and all the different BRIX product that are available in the menu-list. At that moment it was just a few items which have expanded over the years. Beside that we get updated periodically about new items or solutions in the BRIX by the marketing team.

It is noticed that multiple persons in the sale sell QI which could have been sold as a BRIX, what could be the reasons for that?

First of all, you want to fulfil the need of the client and you sell what works best for the customer. If a client has gotten rules from headquarters that only a specific brand of display can be implemented in the building than a BRIX is already out of order since the idea of the BRIX is built upon the idea that every brand can be used which is on hand at that moment.

And even though I get updated about the BRIX monthly the information not located in one database and it is unclear where it can be retrieved. To give an example most information that I get are pictures and small descriptions from the menu list, I can see that the brand of the videobar is a Yealink but it's unclear which type it is exactly, making it difficult to give a precise description to the customer.

Lastly another problem is that it's difficult to match extra parts with a BRIX since AVEX owns two separate warehouses which are difficult to match in the AX making it difficult to create a BRIX which can be used for the customer.

How would you go about if you have an idea about a new BRIX or if you have feedback?

There is no one exact way to achieve this, I would just mention it to some people within the company that take it up from there.

Transcript Interview SSC employee

What do you think the biggest flaw in the system of the BRIX is?

BRIX or room solutions are based on standardized solutions on which the brand of the display is not defined. Depending on what the customer wants as a solution and what is available in the warehouse it is decided which brand of display is chosen for that specific customer solution. The price is defined so there is actually a margin when it comes to profit, however, when displays are ordered in a large quantity a discount can be provided. The flaw arises when a customer demands a specific type of brand for their solution, then AVEX can't work with the BRIX system which will prolong delivery time.

Another flaw in the system occurs when a sales manager wants to add another item to the solution. First of all in the AX system it is difficult to add extra items to a BRIX but also it might not directly be clear if the added item works with the BRIX system. An engineer might be needed to find out if the system actually works in that configuration. Which does not match with the workflow of the BRIX. For the customer satisfaction it's bad if the promised system doesn't match the demands of the customer.

What problems do you experience in the BRIX process?

Those are mostly related to our ERP system, Microsoft dynamics, for example you can't split different cost when we receive a discount on certain orders if we order a large quantity. If this happens for a BRIX order then we have to process this manually which isn't really a standardized process. Besides that we can't put in change orders, since all the parts of a BRIX solution are hidden behind a layer which only some people can do. Also the hours that are necessary for the production of the products can be shown in the AX but not the hours which are necessary by the 'outdoor'- service or engineering.

Transcript system engineer

How did the BRIX project got initiated?

The BRIX was initially created when employees at AVEX noticed that similar solutions were sold to multiple customers. Before the BRIX, an engineer had to constantly create a new solution for it, so drawings, Proof of concept, Bill of Material etc. So a BRIX would be a standardized solution, a finished product that when a customer orders can immediately go to the Planning department that makes sure that the product is produced in the workplace. At first those were small solutions so for example a trolley with a display and a videobar. Depending on the room size the display size and other specs change but these should already be configurations from the 'menu-list'. So in short, a solution is engineered only once and from then one it could be reproduced again and again. There was an internal discussion about including bigger projects, for example a boardroom with build-in speakers and microphones in the ceiling. However this raised the first problem; specification in standardized projects

Does this issue also apply to BRIX solutions?

Not every BRIX could fit inside a room, a standardized project should work on its own, meaning that you don't need any engineering afterwards. However not everything fits inside the room, so for example when talking about the fancy boardroom, not every ceiling is applicable for mounted speakers and mics. So this is a BRIX solution but that might need some extra engineering while the whole idea of a BRIX was a standardized product with no later interference from engineers that need to adjust small details to make it applicable for the specific situation. So solutions that are adopted in the BRIX catalogue should be applicable in every situation in which it meant for.

Why do you think the BRIX solutions sell poorly?

Sales are responsible for selling the right solution to the customer with respect to their wishes, so they should also decide if the customer might need a newly engineered solution or a BRIX. Now it can be seen that multiple employees do something that is similar to both, so selling a BRIX with small adjustments, so for example with another display or other elements. Without consulting an engineer a BOM is created that seems to work on paper but in the workplace problems can arise that were unforeseen from the BOM, so a cable won't fit, items don't fit the hanging system, etc. Employees at the workplace finds these problems and go back to the engineer to fix the problem which defeats the whole purpose of a BRIX product, a standardized product.

So overgeneralizing everyone at the company create new BRIX ideas that aren't really compatible as a BRIX product which needs a complete new drawing and work from the engineer. These BRIX are also short-lived since they might only be used once and are not added to the menu-list.

Where can I find the documentation?

Another problem is that even if the team the workplace fixed a problem mentioned earlier that this is not documented somewhere so if another 'BRIX' is sold the same problem arises.

The whole process of the BRIX is thus wrong, no one is using the existing BRIX products but are creating similar solutions which are slightly different which in the end need more engineering. A process should be created so that everyone knows what to do when they think they found a new brix solutions. It should be evaluated if a BRIX solution would have an additive value or that it would only be sold once and then shelved.

What are the company-own BRIX solutions?

It is also often mentioned that a product should be a BRIX since it is produced multiple times, so to give an example a certain solution was created for the Johan Cruiff Arena which should be produced around 30 times. Someone suggested that this could be a BRIX, however this would be a solution that would probably be only applicable for the JCA and would later never used again. So why would this be a brix, this should be documented as something else.

What data is needed to create a BRIX?

Mostly used the room dimensions of which the BRIX will be installed in, however a lot of stakeholders of the customer are involved, for example the architects in new buildings or the facility manager at current buildings, it should stick with their set-up

Transcript interview Marketing & Communications manager

How is the BRIX promoted at the moment?

Together with the portfolio managers it is decided which products are made into a BRIX solution, these are all added into a menu-list which include all the BRIX products. The sales managers are updated on the new menu-list and it's updated on the website. This is mostly done to let customers and prospects orient when looking for new solutions, this also makes AVEX more visible on search-engines like Google. It is worth mentioning that at the moment BRIX is a term that is only used internally, externally they are sold as Room solutions although marketing and sales are trying to implement the name in external sales as well. Because room solution could give the idea that it is only possible for board rooms.

Are prices visible for customer?

At the moment Room solutions are sold in the Netherlands, Belgium and the UK (since these are the countries that AVEX operates in). For all three of them menu-lists are created. For Belgium and the UK there are selling prices but in the Netherlands there As-a-service prices, so instead of buying them the customer can 'rent' them, including all the service that come with that.

With which department are you in contact when it comes to the BRIX?

First of all portfolio managers that keep us updated on the latest changes within the BRIX (new and removed items). Marketing/communications make a new menu-list item with contact creating. out of this and update this to customers and mostly sales.

Which problems do you run into in connection with BRIX?

It is unclear what is added and removed from the menu-list. This is decided by the portfolio managers but this is implemented so quickly that not all departments are aware of this, so the menu-list is not updated quick enough and the department responsible for purchasing does not have the new items in time. Having a process that could update everyone would be useful.

Transcript interview Logistics planner I

What does your job consist of?

In Microsoft AX I receive a list with jobs that should be finished or worked on and receives a receipt that describes the whole project. Once it is finished I can communicate with the customer that the project is finished and together we find a moment to install this project. The first problem with the BRIX solutions is that it is unclear when projects are finished. The warehouse needs to be checked physically to see if a project is done. This could prolong the lead time. This is crucial since BRIX usually has a 48 hour delivery period.

What happens when a sales manager changes a BRIX BOM?

For a planner a BRIX is a perfect solution, previously for smaller projects we receive a list with all the small parts that should be delivered but they might not be together. With a BRIX you'll receive a complete set of materials all together so as a planner you don't have to check if everything is. This changes once an account manager decides to add something to the BRIX solution but does not communicate that properly. So for example order: 'BRIX product X with a soundbar', its then not communicated how the soundbar should be installed until the last moment when the planner scans through the receipt list and sees in what way soundbar should be installed. As the system engineer mentioned as well the BRIX gets complicated (and redundant) if variants are created which are similar to the BRIX but are not on the BRIX menu-list.

Transcript interview logistics planner II

How did you start with BRIX?

Before the BRIX I already had a few standardized products that could easily be assembled. Therefore, I advised account managers to implement these solutions when meeting with a client. Out of this idea, an initial meeting about the BRIX was created and thus the idea for standardized products became an actual thing. A team was created with account managers, engineers, portfolio managers and more to select a few products that would be implemented in the BRIX, that to the customers would be called 'AVEX room solutions'.

What are some failures that you notice when referring to the BRIX?

When sales managers decide to add items it gets complicated what would happen in the workshop. More than often, an engineer is needed to interpret what the sales manager intend and this prolongs the lead time

What are some elements that you would add to the BRIX?

At this moment only the product is standardized but to ease up the whole process a lot more could be standardized, for example the dimensions of installation could be created into a blueprint that would be the optimized standard. A videobar could be installed left, right, below or above a display but that could have influence on the functionality, however for the installer this doesn't matter. So a blueprint that includes the standardized position of installation could make sure that all the requirements are met. If a client due to preferences want to change these dimensions that's still fine but then at least its communicated. These blueprints could also be created with preferences of the customer, they would notify for example where the closest wall-outlet is so that the installation team knows what to bring with them, this would save time and extra material. This could also lead to a lower amount of cost.

Lastly now the rule is that everything within 48 hours after the order should be produced and delivered. However sometimes a customer specifically states that due to time restrictions an order cannot be delivered within a couple of months, it would therefore be redundant to already assemble the product. This would take up to much space in the warehouse.

Transcript interview Planning department

What is your role in the BRIX?

Basically after sales, I have the responsibility over the process. After Sales has made a deal with a customer, an order is created in AX, this could be a complex project or a simpler one such as QI or BRIX. If it comes into the order system I first check if all the articles for this specific BRIX project are available, if they are not I will notify purchasing. If it finally arrives. a date of building is planned and then the items are collected and brought to the workplace where an employee can build the BRIX product. After its finished I should process this in the ERP system that assembly is complete so that the logistics department can plan a delivery moment with the customer.

What data do you use for the BRIX?

In the ERP system BRIX has one article number, however it includes several items with serial numbers. The solution gets a project number that is stuck on everything that belongs to the system. Once everything is inside the warehouse, all the parts are reserved from the free stock in the warehouse.

Does the process usually goes as planned?

Well, originally a BRIX should be out of the door by 48 hours, however due to several reasons this deadline is not always met. First of all due to missing parts, the building is planned after everything is stock. Our production staff does not always can produce right away because of other projects. Lastly, if a BRIX is sold together with a complex project, it is usually shipped together. Therefore the production time of the other project is the bottleneck.

Lastly I also keep track of the products that are being sold in order to get an overview of what is now sold often or what should be a BRIX. I send this to sales managers to give them an indication if we're on the right track

What are some problems that you notice now in the BRIX?

As I follow what is being sold I notice that Sales sell products that are made into an individual project but which could easily be a BRIX project. Somehow, a salesperson chooses not to make it a BRIX. Also, the process order is sometimes not followed and a newly created BRIX is not going through the right order and thus steps are being missed and a new project is being made without all the knowledge is being followed.

Then lastly there is a problem with clear instructions, every project should include a technical drawing but these drawings are not in unity, sometimes they include a serial number of a part other times they include a description of what the part should look like. Then also for example the dimensions of a cable are given but are changed which could lead to trouble. There should be unambiguity when it comes to this.

Transcript interview Sales back office

What problems do you notice in the BRIX solutions?

A big problem that was mentioned by other divisions is that the sales departments sells room solutions which are different compared to their original BOM. For example these solutions include parts which are not in the original BOM of that room solution. This could create trouble in the workshop when it is discovered that it does not match the installation scheme. The planning department is also aware of this and updates the Sales weekly with a spreadsheet that includes all the sold solutions which are marked with indications if it could have been a BRIX or not. Then it should be evaluated what to do with it, if it can still be a BRIX or rather a QI. However the latter one still requires engineering work.

Lastly something that I notice is that the room solutions are not leased at all by customers while this was one of the initial ideas for the BRIX. Customers prefer ownership over leasing.

C. Document list

Actor/stakeholder	Action	Related knowledge	Related document	Available?	
Customer	Tell need	Understanding of problem			
	Share information	Understanding of problem	Map of building/room		
	Accept quotation	Budget	Quotation by AVEX	Yes	
	Plan meeting for delivery			Agenda of company	
				Agenda of AVEX	Yes
Sales	Sales order intake	Experience of previous situations			
	Suggestion of room solution	Which room solutions are solving the problem	Room solution catalogue	Yes	
			Render	Yes	
	Quotation		Quotation offer		
	AX order		BOM	Partly	
Shared service centre	Calculation in AX	Price of BRIX	Room solution database + offer	Yes	
Planning	Create Picking list		BOM	Partly	
	Check Stock		Stock list	Yes	
	Create work order		AX workoder	Yes	
Purchasing	Buy low stock		Current stock list	Yes	
			Product prices	Yes	
			Planning	Yes	

	Update stock list		Ax STOCK	Yes
Production department	Check stock		BOM	Partly
	Build assembly	Experience	Workorder	Yes
			Instruction manual	No
Put assembly in warehouse		Location of assemblies	No	
Logistics	Check if solution is finished			
	Plan meeting for delivery		Agenda of company	Prob
			Agenda of AVEX	Yes
	Install BRIX		Work order	Yes
			Installation form	Partly

D. Product matrix BRIX

	AVXB-TL155-P	AVXB-TL165-P	AVXB-TL155-VLM	AVXB-TL155-VBV	AVXB-TL165-VBV	AVXB-TL155-WCD	AVXB-TEL65-WCD	AVXB-T50-MSH25	AVXB-W55-P	AVXB-W65-P	AVXB-P55-P	AVXB-P65-P	AVXB-W55-W/P
Trolley	•	•	•	•	•	•	•	•					
Wall mounted									•	•		•	
Floor-to-ceiling post										•	•		
50 inch							•						
55 inch	•	•	•	•	•	•	•	•	•	•	•	•	•
65 inch		•		•	•	•			•		•	•	
75 inch													
85 inch													
Logitech Meet up		•	•										
Bose VB-1			•	•	•								
Jabra Panacast												•	
Poly X30													
Poly X50													
Yealink A20 small													
Yealink A30 medium													
Logitech teams room small													
Logitech teams room medium													
Logitech teams room large													
Creston flex small													
Creston flex medium													
Creston flex large													
Windows collaboration display					•	•							
Microsoft Surface Hub 2S							•						
Bring your own device	•	•	•	•	•	•	•	•	•	•	•	•	•
Logitech tap touchpaneel	•	•	•	•	•	•	•	•	•	•	•	•	•
Creston													
Poly TC8 Touch paneel													
Yealink													
C-10	•	•						•	•	•	•	•	
CX-20			•	•									•
CX-30			•	•	•								

	AVXB-W55-VLM	AVXBW55-VBV	AVXB-W65-VBV	AVXB-W55-WCD	AVXB-W65-WCD	AVXB-W50-MSH2S	AVXB-MTR55-LOMEE	AVXB-MTR65-LOBRA	AVXB-MTR75-LORAL	AVXB-MTR55-CRB30	AVXB-MTR65-CRBX30	AVXB-MTR85-CRX100W	AVXB-MTR55-POX30	AVXB-MTR65-POX50	AVXB-MTR55-YEA20	AVXB-MTR65-YEA30	AVXB-T50-MSH2S	AVXB-W50-MSH2S
Trolley																		
Wall mounted	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
Floor-to-ceiling post																		
50 inch					•													
55 inch	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
65 inch			•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
75 inch							•	•	•	•	•	•	•	•	•	•	•	•
85 inch										•	•	•	•	•	•	•	•	•
Logitech Meet up	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
Bose VB-1		•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
Jabra Pancast																		
Poly X30												•	•	•	•	•	•	•
Poly X50													•	•	•	•	•	•
Yealink A20 small																		
Yealink A30 medium																		
Logitech teams room small						•	•	•	•	•	•	•	•	•	•	•	•	•
Logitech teams room medium							•	•	•	•	•	•	•	•	•	•	•	•
Logitech teams room large								•	•	•	•	•	•	•	•	•	•	•
Creston flex small										•	•	•	•	•	•	•	•	•
Creston flex medium											•	•	•	•	•	•	•	•
Creston flex large												•	•	•	•	•	•	•
Windows collaboration display				•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
Microsoft Surface Hub 2S						•	•	•	•	•	•	•	•	•	•	•	•	•
Bring your own device	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
Logitech tap touchpaneel						•	•	•	•	•	•	•	•	•	•	•	•	•
Creston										•	•	•	•	•	•	•	•	•
Poly TC8 Touch paneel													•	•	•	•	•	•
Yealink																		
C-10																		
CX-20	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
CX-30		•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•

E. Options per BRIX variant explained

This section describes the list of options that are available per sub-assembly. This is the availability during the thesis periods. Items could be added or removed thereafter.

Size of display

As mentioned in paragraph 1.2 the BRIX makes use of commoditization of display which is an advantage since this will decrease the lead time. The customer is not able to select a brand of screen, only the display size. The BRIX catalogues offers five different sizes of displays;

- 50 inch
- 55 inch
- 65 inch
- 75 inch
- 85 inch

Type of connection

The room solutions will either be used for presenting information or to host videocalls. For the latter option that are two possibilities to host these call;

- **Microsoft Teams Room (MTR)**
MTR solutions include a PC on the back of the display with its own Microsoft teams room account, which can be invited for the videocall. Once the meeting starts the MTR pc will start the display and the videobar. A small touch panel on the conference table lets the users control the pc, for example call into a meeting or share content remotely. AVEX offers MTR-solutions from multiple brands, that each have their own software and functionalities.
- **Bring Your Own Device (BYOD)**
With BYOD a cable is provided with the solution, a user will plug in the cable which will connect the laptop to the display (which mirrors the laptop screen) and the videobar (which replaces the webcam in the laptop).

Type of mounting

The mounting functions as the skeleton on which all items are assembled on. The BRIX solutions offers three types on which the solution can be mounted:

- **Wall mounting**
The display is situated on the wall via a metal mounting structure. All cables are ordered in manner that all cables are out of sight for the viewer. Cables that connect a display to a MTR touch panel on a table are concealed with a cable tray. A requirement is that the wall is able to hold a mounting and can be drilled into.
- **Floor-to-Ceiling Post (FTC)**
Some rooms might not be suited for a wall mounting, for example a room with glass walls. For those rooms a FTC can be placed. This is a post that clamped between the floor and the ceiling, the post will hold the mounting for the display. A disadvantage is that this solution is also not applicable for all situations since it depends on ceiling height.

- **Trolley**

For those that want a moveable solution a display mounted on a trolley would be the best outcome. A disadvantage of this solution is that a large screen cannot be mounted on a trolley, this would cause instability.

Type of videobar

The videobar is a device that includes a camera, microphone and speaker. AVEX offers multiple variants which differ in functionalities, qualities and price. Some brands also offer multiple variants.

- Logitech
 - Meet-up
 - Rallybar
 - Rallybar plus
- Bose VB-1
- Jabra panacast
- Poly
 - X30
 - X50
- Yealink
 - A20 small
 - A30 medium
- Crestron flex
 - Small
 - Medium
 - Large

F. Constraint-based system

C1: Connection, Mounting

Allowed value combinations:

(MTR windows, Wall mounting) (MTR android, Wall mounting) (BYOD, Wall mounting) (BYOD, FTC) (BYOD, trolley)

C2: Mounting, Display

Allowed value combinations:

(Wall mounting, 50") (Wall mounting, 55") (Wall mounting, 65") (Wall mounting, 75") (Wall mounting, 85") (Trolley, 50") (Trolley, 55") (Trolley, 65") (FTC, 55") (FTC, 65")

C3: Connection, additional features

Allowed value combinations:

(BYOD, Barco Clickshare)

C4: Connection, videobar

Allowed value combinations:

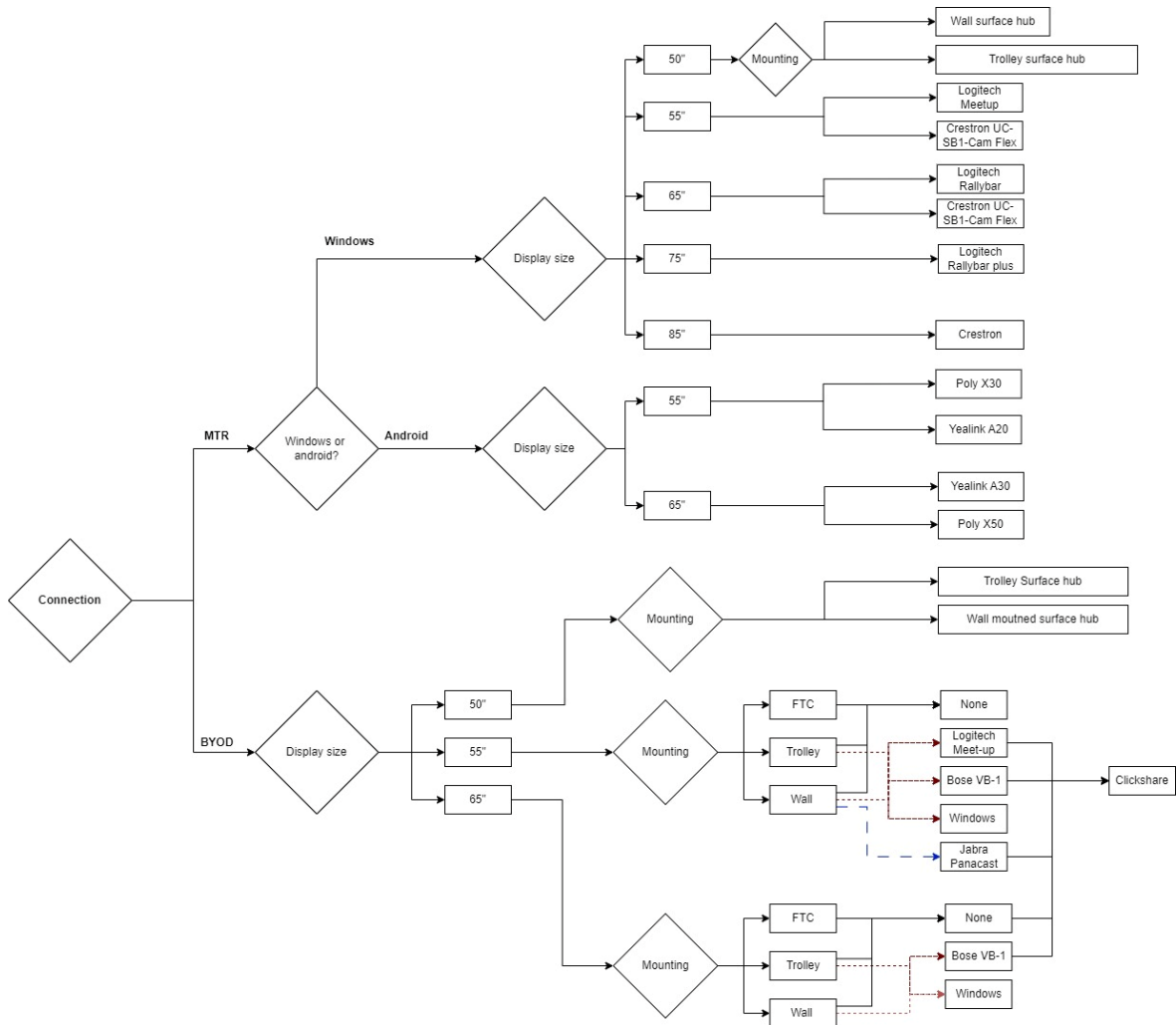
(MTR windows, Logitech Meetup) (MTR windows, Crestron UC) (MTR windows, Logitech Rallybar) (MTR windows, Logitech rallybar plus) (MTR android, PolyX30) (MTR android, Yealink A20) (MTR android, Yealink A30) (MTR android, Poly X50) (BYOD, Logitech Meetup) (BYOD, Bose VB-1) (BYOD, Jabra panacast) (BYOD, Windows surface hub)

C5: Display, videobar

Allowed value combinations:

(55", Logitech meet-up) (55", Crestron UC) (55", Poly X30) (55", Yealink A20) (55", Bose VB1) (55", Jabra Panacast) (65", Logitech rallybar) (65", Crestron UC) (65", Yealink A30) (65", Poly X50) (65", Bose VB-1) (65", Windows surface hub) (75", Logitech Rallybar plus) (85", Crestron UC)

G. Decision tree BRIX solutions



H. Display size

Display size	Maximum viewing distance	Amount of people
50"	Less than 3,7 meter	Up to 6 seats
55"	Less than 4,2 meter	Up to 6 seats
65"	Less than 4,9 meter	Up to 8 seats
75"	Less than 5,6 meter	Up to 10 seats
85"	Less than 6,3 meter	Up to 12 seats

I. Connection type variants

1. Text used for dynamic-interface

Video conference set:

Specialized for Microsoft Teams, join the meeting with one-touch join. No laptop needed.

Bring your own Device (BYOD)

One universal cable to mirror your screen. Your laptop will connect with the display & videobar.

	BYOD	VCS
Share presentations	✓	✓
Optimized for videocalls		✓
Bookable meeting space		✓
Laptop free videocalls		✓
Price range	€	€€

2. Text used for option interface:

A videocall with a BRIX solution can be divided into a Microsoft Teams Room connection (MTR) and Bring your Own Device (BYOD.) What these are and which works the best for your meeting room will be described in this segment.

Microsoft Teams Room

With Microsoft teams room there is no need for a laptop during videocalls, MTRs are built-in devices that are designed to work seamlessly with the Microsoft Teams platform. This includes a tablet that connects with the display and videobar, all of which are optimized for the meeting room. You don't need your laptop to connect to a videocall; walk into the meeting room, accept the call on the tablet and start your video call. Everything is optimized for videocalls so you don't need time to set up the meeting.

A big advantage of an MTR is proximity join; if you already have a meeting on your phone or your laptop but decide to use a meeting room instead you can switch to the videobar and the microphones in the room with a simple click, this enhances the meeting experience.

Lastly with MTR you can book the room for a videocall, making sure that no one sits in the room when you're planned to have a meeting.

Bring your own device

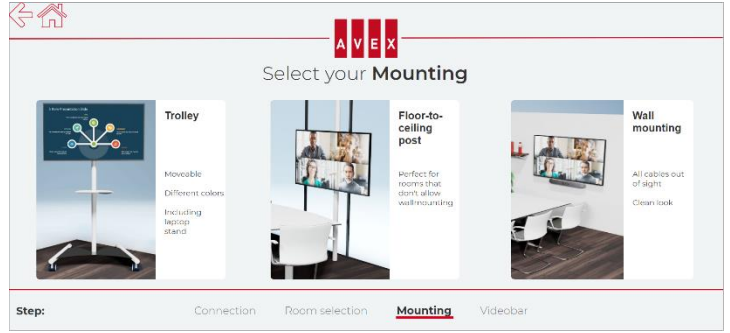
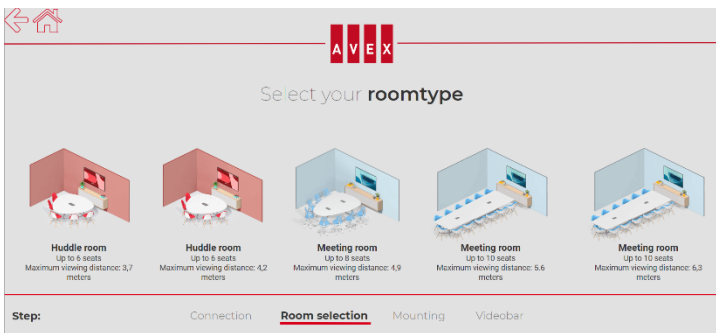
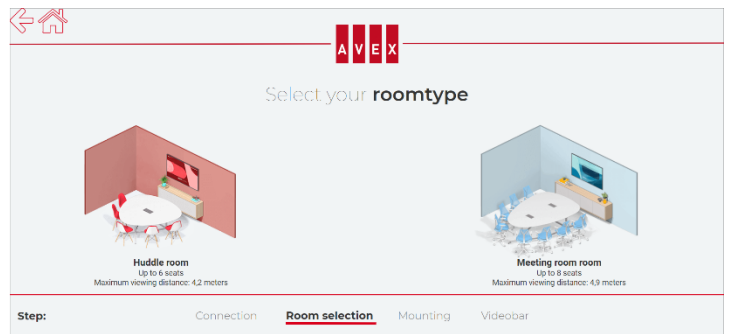
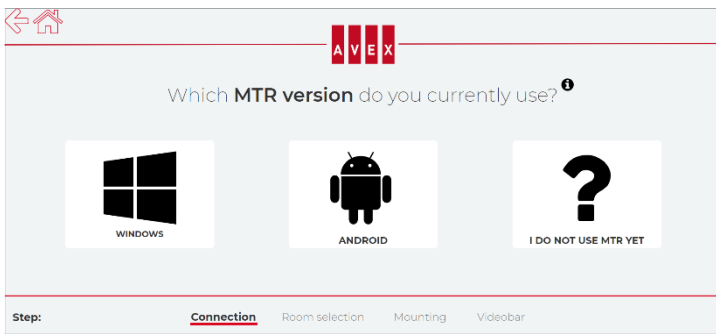
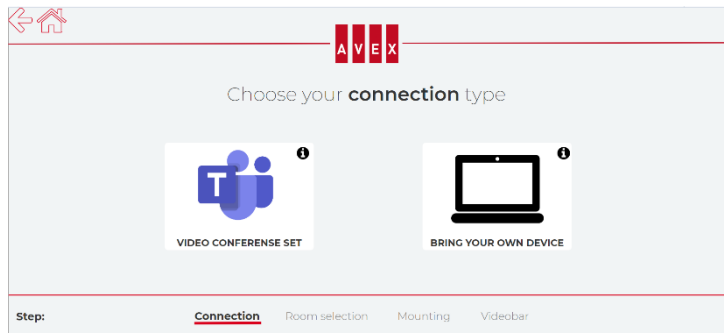
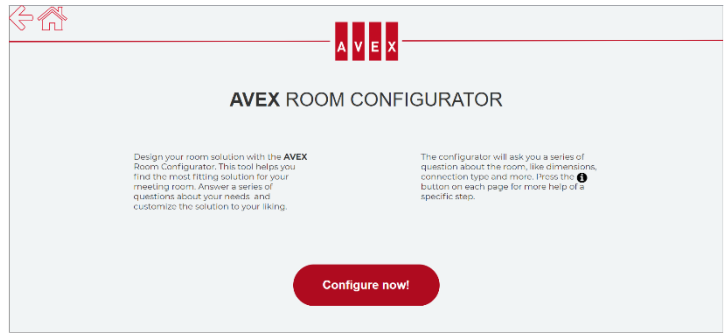
With Bring Your Own Device you need your laptop to start a videocall, simply connect the provided cable with your laptop and it will recognize the videobar and the display. The display will mirror your screen and the videobar replaces your laptop webcam for a better videocall. With BYOD your laptop is the 'brain' for the videocall and a slight disadvantage is that your laptop is required to stay the whole meeting, even if you have to leave early.

J. Videobar specifications

	Field of view (°)	Microphone range(meter)	Group framing	Speaker tracking	Raster viewing	Picture in picture	Price
Logitech meetup	163	4	X	X			
Logitech rallybar	132	7	X	x	X		
Logitech rallybar plus	262	7	X	X	X		
Bose VB-1	123	6	X	X	X		
Jabra Panacast	180	4,5	X	X			
Crestron UC-sb1-cam	120	4,5	X				
Poly X30	121	4,5	X				
Poly X50	120	4	X	X			
Yealink A20	133	3.6	X	X	X		
Yealink a30	120	3.7	X	X		X	
Windows surface hub	136	5	X				
Windows collaboration display	120	8	X	X			

K. Screens options-interface

Accessible online via: <https://4hrsox.axshare.com>



AVEX

Select your videobar

Crestron

Logitech

Poly

Yealink

This videobar has a field of view of 120°

CRESTRON

Features

- Group viewing

Connection type: USB

Microphone range: 4.0 meters

Spec 2: detail

Price: €€€

Step: Connection Room selection **Videobar** [Finish my Room solutions](#)

AVEX

Select your videobar

Crestron

Logitech

Poly

Yealink

LOGITECH MEET-UP

Features

- Group viewing
- Speaker tracking
- Multi focus framing

This feature makes sure that the videobar focuses on everyone in the room

Connection type: USB

Microphone range: 4.0 meters

Spec 2: detail

Price: €€€

Step: Connection Room selection **Videobar** [Finish my Room solutions](#)

AVEX

Select your videobar

Crestron

Logitech

Poly

Yealink

LOGITECH MEET-UP

Features

- Group viewing
- Speaker tracking
- Multi focus framing

This feature lets the videobar focus on the person speaking

Connection type: USB

Microphone range: 4.0 meters

Spec 2: detail

Price: €€€

Step: Connection Room selection **Videobar** [Finish my Room solutions](#)

AVEX

Select your videobar

Crestron

Logitech

Poly

Yealink

LOGITECH MEET-UP

Features

- Group viewing
- Speaker tracking
- Multi focus framing

This feature portrays everyone in the room as individual portraits

Connection type: USB

Microphone range: 4.0 meters

Spec 2: detail

Price: €€€

Step: Connection Room selection **Videobar** [Finish my Room solutions](#)

L. Screens dynamic-interface

Accessible online via: <https://2nlsyb.axshare.com>

AVEX

AVEX ROOM CONFIGURATOR

Design your room solution with the **AVEX** Room Configurator. This tool helps you find the most fitting solution for your meeting/video room. Answer a series of questions about your needs and customize the solution to your liking.

The configurator will ask you a series of question about the room, like dimensions, features and more. Press the button on each page for more help of a specific step.

Configure now!

AVEX

How would you like to join a videocall?

BRING YOUR OWN DEVICE (BYOD)
One universal cable to mirror your screen. Your laptop will connect with the display & videobar.

	BYOD	VCS
Share presentations	✓	✓
Optimized for videocalls	✓	✓
Bookable meeting space		✓
Laptop free videocalls		✓
Price range	€	€€

VIDEO CONFERENCE SET (VCS)
Specialized for Microsoft Teams, join the meeting with one touch join. No laptop needed.

Step: **Connection** Room selection Mounting Videobar

AVEX

Select your Mounting

Trolley
Movable
Different colors
Including laptop stand

Floor-to-ceiling post
Perfect for rooms that don't allow wallmounting

Wall mounting
All cables out of sight
Clean look

Step: Connection **Mounting** Room selection

AVEX

Does your ICT facility block any Operation System?

WINDOWS

ANDROID

I do not know/skip question

Step: **Connection** Mounting Room selection

AVEX

Compare your videobar

Change size/label Display size: 55 inch

View camera range View microphone range

Videobars

Crestron

Logitech

Poly

Yeast Ink

Logitech meetup

Connection type: USB
Price: €€€

Features

Group Huddle Speaker tracking Rear Facing

Step: Connection **Room selection** Finish my Room solutions

Close

Rectangular tables

- 5 persons
150*75 cm
- 7 persons
230*105 cm
- 9 persons
305*140 cm
- 11 persons
305*137 cm

Circular tables

- 3 persons
Ø 90 cm
- 5 persons
Ø 140 cm
- 7 persons
Ø 210 cm

Miscellaneous tables

- 5 persons
170 cm wide
- 5 persons
Ø 170 cm

Close

Group framing

The group viewing function makes sure that the videobar focuses on all the persons in the room and filters out everything aside from it, getting a better view of the participants of the videobar.

Logitech meetup

Connection type: USB

Step: Connect, Room selection

Close

Speaker tracking

The camera on the videobar tracks the sound and only shows the person that is currently speaking.

Logitech meetup

Connection type: USB

Step: Connect, Room selection

Close

Raster framing

With raster viewing everyone is portrayed as a separate individual in the videobar, rooming in on everyone in the room.

Logitech meetup

Connection type: USB

Step: Connect, Room selection

Close

Picture in picture

Picture-in-Picture tracks and frames the speaker in an individual window, which is separate from the other windows, for a panoramic view, enabling users to keep an eye on who's talking even if the speaker is located at a distance in a medium room.

Yealink A30

Step: Connect, Room selection

AVEX

Your Room solution

AVXB-W55-VJP

Screensize: 55 inch

Videobar: Jabra panacast

Mounting: Wall mounting

Connection: Bring your own device

clickshare

Start Over

AV-flex per month €117

Order now

M. Set-up A/B test

1. For each participant it is defined -by the researcher- which interface they will be using for the test.
2. The participant of the test will be invited to sit next to the researcher so they can observe how the participants manoeuvres through the interface. They are handed the scenario on paper and are shown the selected interface on a laptop.
3. The participant will start the interface and can manoeuvre themselves through the interface and can go back and forth as much as they desire until they finalize their configuration. They can explore the interface by using information buttons. Under no circumstances can they ask the researcher for help.
4. The researcher starts a stopwatch as the participant starts using the interface and ends the stopwatch once they have selected a certain room solution. It is not mentioned towards the participants that time will be recorded since this might rush the participant. However it could give the researcher an overall indication onto which interface is quicker to go through on average.
5. The researcher also observes how often information buttons are pressed and on which page. This can give an indication onto which pages are unclear in one eyesight.
6. The researcher notes which room solution the participant has selected and does not state if they are correct.
7. The researcher will firstly ask several questions regarding the choice of room solution
 - a. Why did you choose for this connection type?
 - b. Why did you choose for this display size?
 - c. Why did you choose this type of mounting?
 - d. Why did you choose this type of videobar?
 - e. Did you let the budget play a role in your choice.
 - f. Are you aware of all the functions that this videobar has, can you name them?
8. Afterwards the research will ask several questions regarding the participants use of the interface to obtain feedback of the order configurator. This will be done in a semi-structured interview, questions could be -but are not limited to-:
 - a. Which step/question did you hesitate the longest to give an answer?
 - b. Would you change any icons or descriptions?
 - c. If you used the help icon, what was the information that you hoped to find out?

N. A/B test Scenario 1

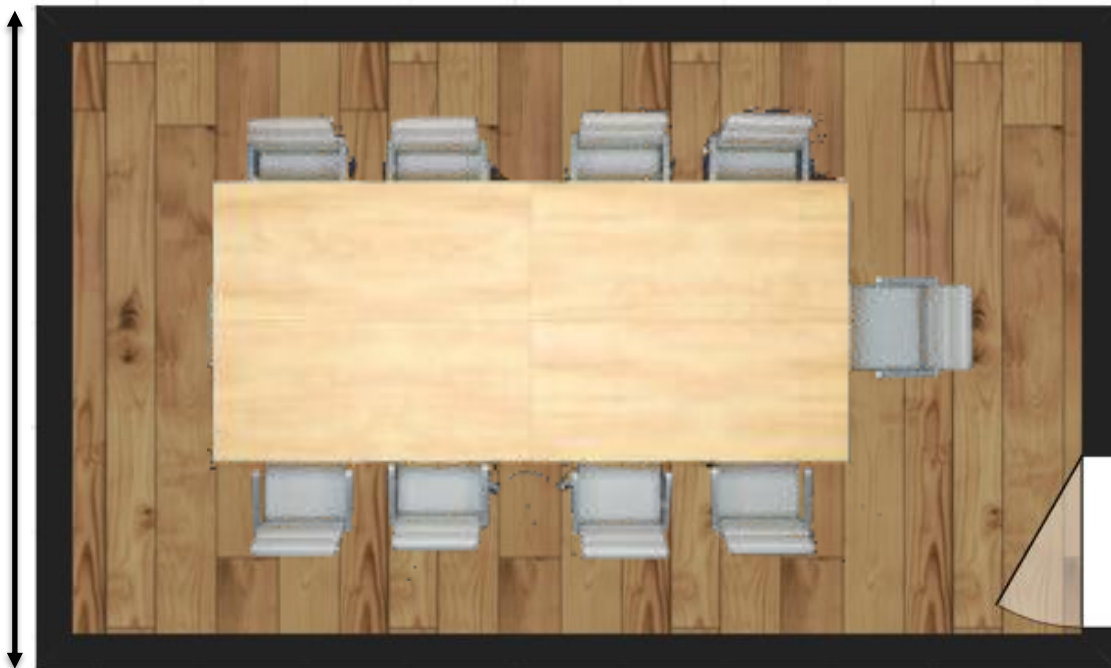
Your company wants to implement a room solution for presentations and videocalls into one of the new meeting rooms (see figure below). The room will be used for 7 people max. and the dimensions are 4,85x4,00 meters. The employees have recently started using Microsoft teams as their conference program. Since videocalls can be chaotic from spectators on the other side of the call you want to get a clear view of the presenter during videocalls. Your company does not want to spent too much money on a solution.



O.A/B test scenario 2

Description:

Your company wants to implement a room solution for presentations and videocalls into one of the new meeting rooms (see figure below). The room will be used for 9 people max. and the dimensions are 5,00x3,00 meters. The table has the dimensions of 300x130 cm. The employees have recently started using Microsoft teams as their conference program and want to host videocalls as quick as possible. Since videocalls can be chaotic from spectators on the other side of the call you want to get a clear view of the presenter during videocalls.



P. Third parties that develop order configurators

There are several companies active in creating software shells for order configurators. Software-database Capterra has created an overview of suppliers of CPQ software (configurator, pricing, quotation) (Capterra, 2023). A few companies with positive reviews are compared in this appendix. The requirements are based on chapter 5 6 and 7.

	Elfsquad (NL)	Experlogic (USA)	Epicor (USA)	Quootz (NL)	Configure one (USA)
Compatible with AX	✓	✓	✓	?	?
User interface design	?		✓	?	✓
Data Collection	✓		✓		
Rapid changes	✓	✓	✓	✓	
Product page	✓	✓		✓	✓

