DENWA
Consulting & Configuring

6 Dangerous Pitfalls to Avoid When Implementing CPQ Solutions Based on Mass Customization

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If you can recognize a picture of your customers generally becoming more and more demanding in terms of wanting **unique solutions** tailored to their specific needs, while simultaneously insisting on **low lead times**, **high uniform quality** and a **competitive price-tag**, chances are that **mass customization** will be the savior you have been waiting for!

Mass customization aims to combine the advantages of standard processes, high uniform quality and economy of scale, known from traditional *mass production* with customer specific customization and flexibility as of *customized production*.

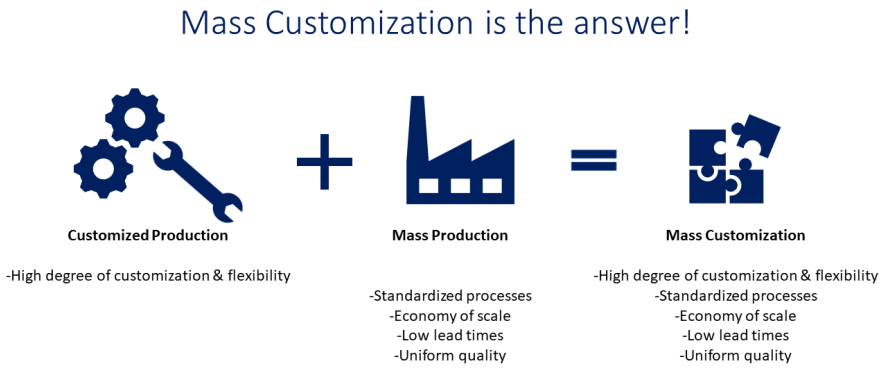

Figure 1: Combined benefits of mass production and customized production within mass customization.

Some of the key benefits that can be achieved through mass customization efforts are listed below:

Sales

- Significantly faster quoting, offering and fabrication of sales documents
- Better product overview
- Securing better and more uniform quality in quotes to customers
- Better prioritization of customers and orders
- Less orders lost due to high lead times or faulty cost prices
- Improved customer loyalty and preferences
- More customers can be handled and thus revenue will increase

Manufacturing

- Reduced storage costs
- Improved and more uniform quality of goods
- Reduced purchasing costs
- Reduced cycle times
- Less scrap, overproduction, & rework lowering costs & environmental footprint

1.1 Convert the Decoupling Point to CTO and Get the Best of Both Worlds!

To realize the benefits above, a good place to start is with a Configuring, Pricing and Quoting solution (CPQ), which will radically change the business process within sales.

For B2B enterprises, this would mean the business process taking place from the moment of receiving a customer request to being able to send a quote, where the costs on which prices are based are reliable, and all technical information about the particular customized product is fully specified. The renewed business process is strongly related to the decoupling point of the product, and is with CPQ shifted from *Engineer To Order* (ETO), towards *Configure To Order* (CTO) as illustrated in Figure 2. Having a CTO decoupling point instead of ETO, essentially means, that the vast majority of customer requested products can be combined from standardized modules using a configurator, instead of redesigning the product all over for each specific customer request.

Actually, the famous Pareto Principle can be applied so that for 80 % of the current customer base it is possible to fulfill their needs, simply by combining modules according to a set of rules, connectivity to other modules and constraints. Then, there will typically be 20% of customer request that deviates too much from what can be handled by the configurator, and it must be decided if the old business process for handling deviating requests should be optimized and made more lean, so that all customers can continue to be served, or whether it is actually most beneficial in the long run to refuse such clients. This is highly dependent on the situation the company operates in, and there can be several reasons for doing both. An argument to keep on serving a customer who deviates greatly from standard configurations could be that this is a big customer who will buy a lot of other products that fits the frame of standard configuration. On the other hand, the opposite could be the case, and the serving of that particular customer would end up in potentially lost profits, as the resources could have handled several more customers in the same time they would spent preparing the quote for the deviating customer.

For a B2C enterprise, there is also the possibility of having customers use an online configuration tool, to put together the exact product they demand themselves, and have a fully automated quote sent or presented to them immediately. This technique is well known from various car manufactures, where the customer can decide the color of the car, the amount of equipment, look of interior, type of rims etc. This way, the car manufacturer can keep the assembly generic until the very last moment, in terms of the decoupling point. This will give the customer a sense of flexibility and participation in the process, while simultaneously reducing costs as safety stocks can be significantly reduced since there is no longer a need to keep every single possible combination on stock "just in case", but a generic car is produced in great volumes, while modifications are made using pull-techniques, so it is only *Just in Time* (JIT) that the modifications requested by the customer are added.

For B2C enterprises the decoupling point is often categorized as either *Make To Order* (MTO), or *Assemble To Order* (ATO). Similar to B2B enterprises discussed above, it is highly desirable if the decoupling point can instead be shifted towards the CTO, as illustrated in Figure 2, and thus, keep the level of standardization when it comes to manufacturing and assembly processes, while providing a customer freedom similar to that of the ETO.

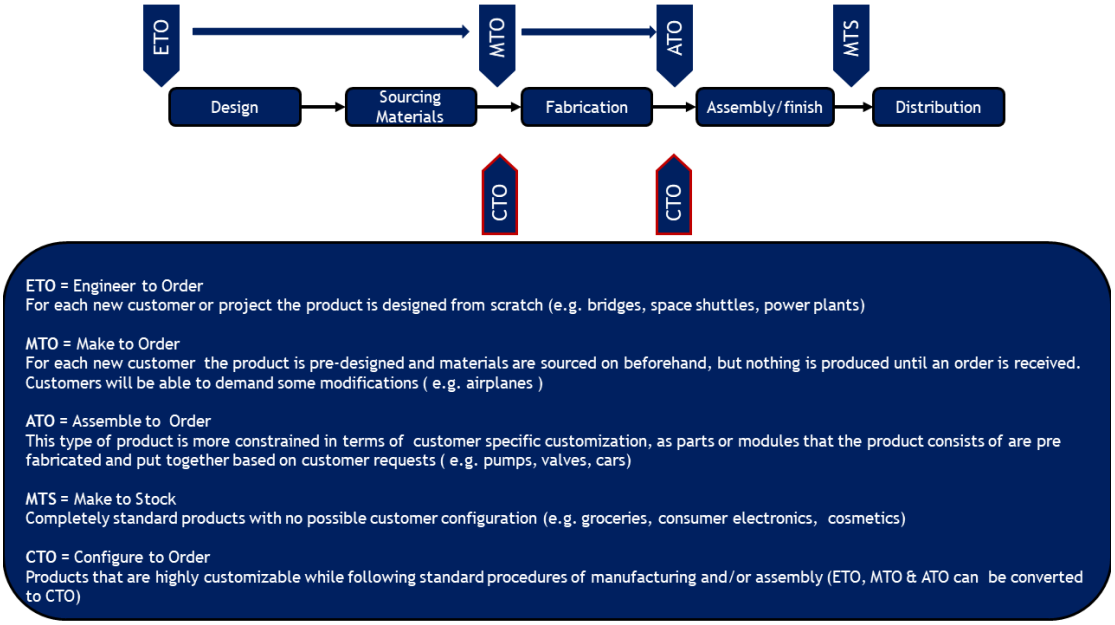

Figure 2: Decoupling Point

1.2 How to Use CPQ to Capture That Tremendous Value...

The following is a brief and on-point description of how and why CPQ will help you obtain the awesome benefits discussed above, so that the business will prosper and thrive to gain a serious competitive edge.

Significantly faster quoting:

Is kind of one of the main points of implementing a CPQ solution, as we remember that the "Q" stands for Quoting. CPQ will thus enable the user to configure products fast and efficiently, combining only valid modules and components to make up the exact product that the customer has demanded. The configurators are typically governed by rules or constraints meaning that if I as a customer state that I'm going to use my configurable bicycle for "competition purposes", it constrains the rest of the product configuration to only allow for me to chose external gearing, and a carbon frame. When I have the product that fits my exact needs, I as the customer will in B2C situations have an instant overview of how different selections and de-selections are priced and what the total sum of my configured product will be. Likewise, the salesman of a B2B setting can instantly see the costs of the configured product(s) and can make sales offer adjustments and pricing accordingly. When the pricing is done, the customer can see the quote on the web page for B2C, and a quote can be generated automatically for more technical products that are typically associated with B2B settings, where the quote might contain technical drawings, flow-curves, and other technical computations.

Literature states that the quoting time can be reduced as much as several thousand percent!

And yes, it is not a mistake, since CPQ solutions have proven themselves to reduce highly complex and technical quotations that previously took several days, to a matter of minutes, whereas a concrete example of the CPQ software provider Tacton, reduced custom quotation time of Siemens from 8 weeks to somewhere around 10 minutes, smashing all sanity with a wobbling time reduction of:

$$100\% - (\frac{10\ min}{60\ min \cdot 7.5\ hours \cdot 5\ days\ \cdot 8\ weeks} \cdot 100)\ = 100\,\% - 0.056\,\% = \mathbf{99.94}\%$$

Better product overview:

CPQ solutions will enable it's users to get a much better overview of the products, in terms of what can be combined and what can't, product architecture (what does the product consist of), associated costs of modules, parts and components, interconnection between product modules, physical appearance visualized with drawings, technical information, and many other things that all contribute to a good thorough understanding of the product.

When understanding the product at a very deep level, it will become much easier to suggest new solutions for product improvements and upgrades, which might lead to the creation of ever better products.

Better and more uniform quality in quotes:

When utilizing the great benefits of CPQ, you will not only be able to generate the quotes by a fraction of the time used before, the quality of the quoting document itself will increase!

"Why is that?" you might ask, "I'm very thorough in my work and I always double check the quotes before sending them to a customer." Well, while you are obviously the perfect employee, your coworker in the sales department, let's call him Ben, is not always trustworthy, and is at times sloppy in his work. You know who we are talking about! Everybody has a Ben at their workplace, who is always a little behind and can't seem to do his job properly! It is a mystery why Ben was even hired in the first place. Even if you are one of the few people who doesn't have a workplace Ben, chances are that there will still be a Chris, who does things slightly different from the way you do it including customer quotations.

With a CPQ solution, your time dealing with Ben's and Chris's in the workplace will be over, as the software will provide the best practice standard, not just once in a while or if you are making the quote, always!

Better prioritization of customers and orders:

Yet another thing that CPQ will help you and your business improve is the prioritization of customers and orders. If you are sitting right now thinking, "I don't discriminate between my clients. An order is an order, and I'm striving to get every customer the same amount of attention and time!" - Well... sorry to break it to you but however noble that thought may be, you are being foolish!

Why is that? Well for starters, it is a well known fact that for the majority of businesses the famous Pareto principle applies to an array of elements within the business, meaning for instance that it is more than likely that 20% of your customers will generate 80% of your total revenue! Apart from a designated Customer Relations Management (CRM) system, a CPQ system will also help you prioritize, as ABC-analysis is often used as the basis for the products handled, whereas product types/families that are frequently sold while bringing in a solid margin are marked as AA products, and vice versa poor performing products in terms of sales frequency and margin are marked CC. By focusing on the customers who places large orders of your AA, AB, or BA products, you can win their loyalty, and satisfaction meaning that they keep on coming back, for you to generate a truckload of profit with minimal effort!

And yes, revenue might decrease slightly, if you are saying no to some customers, but what does it matter when you are only serving customers you earn good money on? Many companies have many project sales that actually generates negative margins, meaning that you are loosing money by serving that C customer supplying them with CC products! This phenomenon is seen all across different sectors of business and it typically looks as illustrated below in Figure 3:

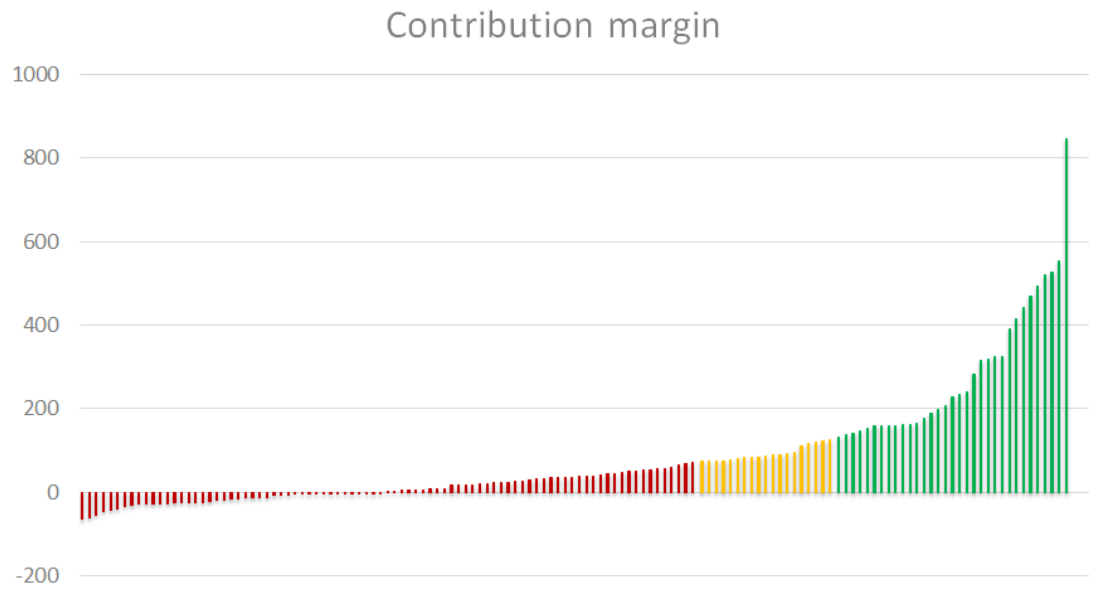

Figure 3: Profit margins of typical product portfolio

And yes, there are several valid reasons for keeping some C products within the portfolio, such

as good customers buying AA-products only if they can also get one of the C-products. That is a fair reason, HOWEVER the majority of products specified as C products can be removed over night and no one would miss them!

And additional argument, relates itself to you asking yourself the question: why not take some of the time from a C customer buying CC products, out to try and be service-minded towards an A customer buying A products? If you can nurture those customer relations carefully, then you will get a much higher return of investment (ROI) for your time. Time is money, don't waste yours!

Less orders lost due to faulty cost prices:

In a world that spins faster and faster where customers expect more and more of you, it is of the greatest essence to be able to perform accurate costing and thus also pricing. As previously mentioned the "P" in CPQ, stands for exactly pricing. This is not a coincidence. If you have technically challenging products with a great number of product variants and possible customer specific modifications, inaccurate pricing can lead to you losing the clients to a competitor if they are too steep, or you can end up offering your products at a price where you are just barely over your cost prices, and in some cases selling the products at cost price or in severe cases cheaper than the costs. Obviously, the latter is pretty much an own goal and will not exactly drive the business towards prosperity and solid profits on the bottom line.

Improved customer loyalty and preference:

CPQ can help you get the happiest customers and when you've made them happy they will also be loyal to you. Is this really true? - Well yes, it is and here is why:

By providing the products that fit your customer's exact need, faster than your competitors, in the same quality as them or even in some cases outperforming the quality while simultaneously having an affordable and very competitive price-tag, it is not so weird that the customers will start looking your way. And when they from time to time experience that same consistency when doing business with you, they start to trust you to deliver every time. At this point, you will have a customer for life, who will never settle for less!

The happy, loyal lifetime customers will most likely know people working within the same or similar industries, and whenever they change jobs their mouths talking up your reputation will be better advertisement than money can buy! This will accelerate new customers coming in to the fold, which will put more than plenty of food on the table for you and your business.

More customers can be handled and thus revenue will increase:

As we learned earlier, some absolutely mind blowing reductions in quoting times can be achieved with CPQ. Does that mean that the the majority of sales employees will be cut from the staffing list? Absolutely not!

Or at least it shouldn't, first and most importantly for moral reasons since it would not be fair to lay off hard working people who day in and day out have contributed to the companies well-being.

Secondly, a purely rational argument is that they can now use all the freed up time, on extra carefully following the sales process of products that are categorized as special projects, so that fewer mistakes will be made as a direct result of urgency. Furthermore, they can also engage more heavily in other sales and marketing activities, such as customer care, maintaining and developing the relationship for existing customers, or approaching new interesting prospects.

Finally, it is also possible to ramp up marketing efforts to generate more interested sales leads, who can be turned into well-paying customers, and it will be no problem to handle the extra load, since many more customers can be handled without increasing the staffing within the sales department.

Reduced storage costs:

A well performed CPQ project can significantly lower complexity, as products that are not performing or providing enough value, revealed by the ABC-analysis can be cut from the product portfolio. This obviously means, that the need for storing will decrease and thus save the company large sums of money.

Furthermore, this benefit is further strengthened by effects of the transformed decoupling point, where the risk pooling strategy "*postponement of customization*" comes into play. This will allow you to only store the modules or components that the different products consists of, instead of storing countless different variants of finished goods. This will in the majority of cases further reduce storage costs greatly, and items sits in the warehouse for a shorter period of time.

If the vast cost reductions that could be achieved is further combined with a revision of the warehouse layout, components making up A-products can be placed closets to the assembly line or area, and thus reduce the overall lead time.

Improved and more uniform quality of goods:

The software-based product configurators being the main driver of CPQ solutions, can also be used to improve documentation, specification and processes *after* quoting a customer.

There are various examples on configurators that connects a broader range of the overall business process, typically in relation to both the sales, engineering and production departments.

Can we do even more, and obtain more benefits? Yes we can! For instance the software typically associated with CPQ can depending on the software platform applied, help automate or semi automate technical drawings, Bill of Materials, production schedules and or instructions and other technical documents.

The fact that these key documents of high importance to the further process, are generated and controlled by the configuration software, notably reduces chances of faulty specification and documentation. Having control over your processes that are highly standardized, however simultaneously supporting customer specific modification, will lead to good and trustworthy outputs.

When the production receives such documents, they serve as a handover from sales or engineering, and are now used as inputs. As the inputs are of high quality, it will positively affect and increase quality for the following processes of manufacturing and assembly, thus ending up with a better and more uniform quality for the end product!

Reduced purchasing costs:

With the better overview of the revised product portfolio, reduced storage costs, and the configuration handled by the configuration system, an additional benefit relates to the reduced purchasing costs.

First of all, less safety stock is needed, and obviously a direct consequence is ordering closer to what is actually needed. However, this may vary from case to case as there can also be effects related to economies of scale or quantity discounts, which would then be countered by ordering less. Therefore this aspect will have to be assessed and evaluated for each particular project.

A second effect that could also cause your organization to keep more money when purchasing materials, components and other things for the production and/or the assembly, is related to complexity management. With a good foundation and overview of the product types, the components they are made up of and the constraints that are to be enforced upon configuration all provided and supported through the product configurator, it is possible to reduce product complexity. One of the ways to do so, is to make small modifications so that the same components can be used for as many product types/ families as possible.

That means that when your coworker Penny from procurement, are ordering goods, components, and materials, she will order less or none of some things that were usually ordered, and for other

purchases the quantity will have increased. Obviously you reduce your costs on items that you are no longer purchasing. Furthermore, the before mentioned effects of quantity discounts may be achieved if agreements are renegotiated for the remaining purchases.

Reduced cycle times:

The standardized and highly controllable processes imposed on the manufacturing and assembly departments of the organisation, coming from quality documentation and specification leaves room for dicing and slicing the cycle times quite a bit!

Having reliable drawings, production plans, bill of materials and other key documents for initiating production, will make processes stable and uniform, and thus form a solid foundation to build on, using other methods, tools and approaches such as for instance lean to further optimize processes and eliminate unnecessary non-value adding tasks and reduce necessary non-value adding tasks.

Less scrap, overproduction, rework and environmental footprint:

The last massive benefit we are going to mention (there are several more), is something that will benefit your time schedule, reduce your costs and at the same time help you minimize the damage done to our lovely planet that we call home.

Since there is better and more accurate documentation and flow of information, the number of errors will be reduced. Furthermore, you are likely to spot the mistakes that you actually do make, way sooner in the process where it costs less to fix it. When you are making fewer mistakes in handovers, drawings, bill of materials, production schedules etc. obviously the number of times where something wrong is put in motion, decreases as a direct result, from procurement, to processing to assembling, and you will have to make fewer corrections and there will be less scrap!

As mentioned this will save you time and money AND you'll order and process less material and cut on the freight emissions too.

1.3 CPQ Is Not for Everyone and Is Not All Benefits...

The standard CPQ systems found in the market have a wide range of application. Being generic and developed by huge software companies, they can be applied in several operating systems and word processing systems, and are used everywhere in industry.

There are, unfortunately, not only advantages in using standard systems. As the main disadvantages, we can mention 4 different topics as described below.

Over-hasty decision:

It can be dangerous to introduce a standard system on the basis of too poor an analysis or via an over-hasty decision, as the company can subsequently run into some of the problems mentioned below.

Supplier dependency:

It might not be possible, or at least it can be very challenging to change supplier without considerable costs. The company gets more or less involved with the supplier of the system. If the supplier goes broke or becomes unstable, it may be difficult to get support for the system or to get the system updated as a result of changes in the market and/or organisation.

Integration/Adaptation:

It is important to ensure that the standard system can be adapted to the company's wishes and needs, and can be integrated into the company's other business processes and IT systems. Solution of any integration problems may require many resources, since the changes must be carried out by the system supplier.

Altered working conditions:

Some users will need to adapt their working procedures to the standard system. This may lead to some of the procedures becoming less efficient.

Finally, no software system is best in all situations. Which CPQ software suits your company best is dependent on your own business characteristics. Therefore, it is necessary to consider the current situation and then choose the optimal software on this basis.

On that note, that is one thing that DENWA excels in as we provide consultancy, analysis, a tailored CPQ system designed with you for you or help on clearing the path for you to identify and successfully implement and maintain the solution that is best suited for your organisation, in terms of where you are, and where you want to go! Whether you are completely new to CPQ or experienced within the field we will always go that extra mile to get you to the end-zone!

Well enough advertisement! Let us get down to business as we now are ready to take a closer look at one of the benefits listed above, mass customization efforts and projects revolving around CPQ that can help you become more sustainable organisation that creates value in terms of economy, society, and environment.

2 Implementation of CPQ

Lets start by definig what is CPQ. It is a configuration software used for programming product models. The name comes after "configure, price and quote" software (CPQ), which is a term used in the business-to-business industry to describe software systems that help sellers quote complex and configurable products. Regarding the types of configuration softwares, there are several categories to be found: geometry-based, ERP, expert systems, spreadsheet (e.g. Excel), database (e.g. Access), and traditional programming language. The expert systems are often used to solve complex configuration problems. They are used for example by FLSmidth to configure cement factories and can be further divided into three basic types: rule-based, model-based and case-based expert systems. Model-based systems can be divided into constraint-based and resource-based expert systems. For configuration of industrial products, rule-based or constraint-based expert systems are commonly used. However, according to the literature, experience shows that rule-based expert systems can be difficult to maintain, therefore, most development today is focused on constraint-based systems. In addition, it is concluded that compared to the other types of programming, expert systems are characterized by high representational strength, high reasoning strength, and high reasoning efficiency.

In order to decide the most suitable configuration software for the company, the literature define some relevant criteria: Software functionality, Software structure and Software interfaces (external relations to the system, including system integration). Furthermore, these criteria can be deeper dived into more topics for choosing the right software for the company: Company profile and visions; Market share; Product development (R&D); Quality; Service/support; Training; Resources; Trade knowledge and trade-specific solutions; References (number of installations/licenses/users, user groups); Geographical position; Price and License conditions. The CPQ software industry has many vendors offering different solutions, some examples are: Autodesk Configure One; Configit Quote; Oracle CPQ Cloud; SAP Configure, Price, and Quote; and Tacton Systems CPQ.

2.1 Pitfall 1: What Comes in Comes out...

One of the things people keep on forgetting over and over again when implementing any new software based system or tool is that it despite the many benefits to be harvested, is not a magic spell that will change everything overnight.

It would be nice if you could just skip to the end of the race and hold the trophy high above your head in glorious triumph. We are however, whether we like it or not living in the real world, and in this world one has to make sacrifices and endure pain and hardships to get to the goal we set out for. To stay in the analogy of the race, implementing configuration systems is definitely not a sprint, but it is a long hard marathon, and we won't be able to see the finish line for many kilometres to go (not going to use miles since the only useful units of measure belongs to the metric system).

The intention is not at all to scare you or in any way intimidate you, but first and foremost to align your expectations. If you were thinking that it would be a walk in the park, well... think again!

The first thing we need to understand is the essence of well-structured, reliable, updated, and accessible data. In toady's world of globalization, increasing competition, technology, and instant communication, data is the key to success within any business sector! We are collecting data as never before, but so much of it is never used for anything or the data it self is of poor quality. It is not about collecting the most data, it is about collecting the right data!

If you feed a configuration system with unreliable, outdated and incomplete data what do you think you are going to receive as outputs in the other end? - You've guessed it! It will be exactly

as unreliable, outdated and incomplete as the data that went in. So whatever you do don't make the critical mistake of underestimating the massive task of collecting, structuring, analysing, and apply your data.

If you fail to do so the benefits you will achieve through CPQ systems, will be mediocre at best, while there is also a chance of having wasted the time and energy put into the project completely, and in severe cases ending up actually harming the business. If you do manage to have some of the desired benefits, the value will be short-termed and fragile to the slightest of change.

On the other hand, if successfully carried out configuration systems will make the business bath in gold! - Well okay that might be a slight exaggeration... But there will be long lasting value and competitive advantages for many years to come, and you will most certainly give your competitors some sleepless nights as they are trying to keep up with you.

So without further due, let's dive into it! At DENWA we have developed a 7 step process which is based on the suggested frameworks and best practices of leading research experts within the field of mass customization. We call it "*The DENWA way*". The DENWA way further divides the 7 process steps into 3 phases: *analysis*, *building* and *maintaining*. The entire 7 step process is summarized at a later point, but for now lets focus on the first three process steps, all belonging to phase 1; the analysis phase.

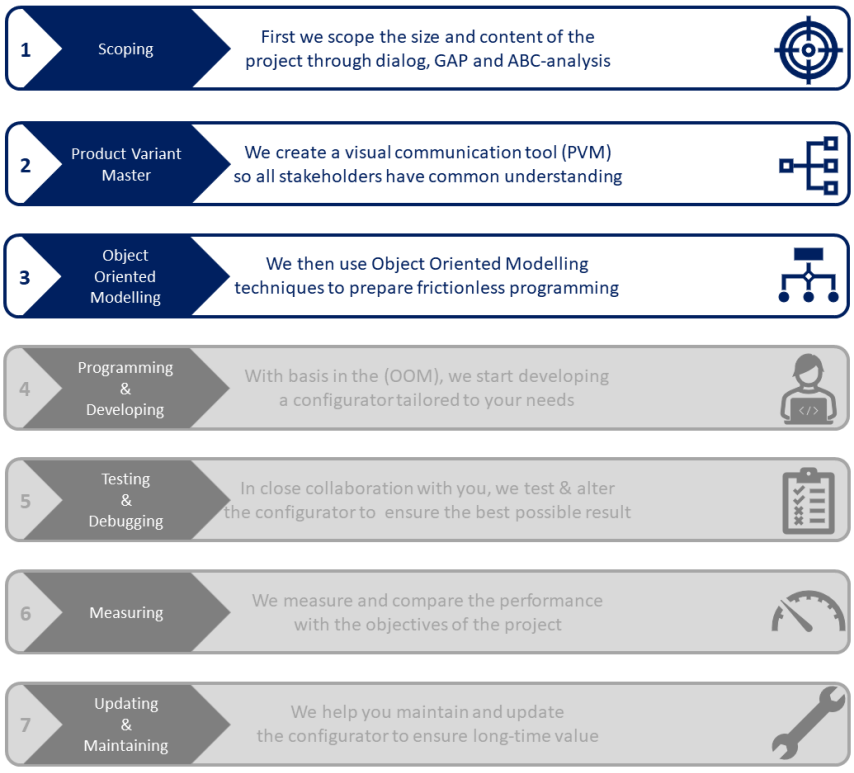

Figure 4: The process of implementation re-written

The first step of the analysis phase is called the *scoping* phase. Here the aim is as indicated by the name of this step to delimit the project and the scope, so that one is ambitious without being foolishly over optimistic in terms of the scope of the project, as there will be a limited amount of human and monetary resources, and there will also be time frames with deadlines that needs

to be kept. Remember it is better to realistic and actually build something of value, than being unrealistic and wanting to do too much at once, and thus not ending up with anything but thin air. More on that in the next section. So what we need to consider in this process step is to first identify which current business processes the CPQ solution should interact with, and then map the processes. After mapping them we need to measure on their performance in the form of a number of selected KPI's. It could for instance be very relevant to look at the average time spent from a customer enquiry comes in the door until the salesman is able to provide an initial quote to that particular customer. That would then lead to the question, how much of what we currently do adds value to the customer? Thirdly, it could be very relevant to look at the quality of documentation, prices etc. how often does mistakes occur in the process? What are the costs related to the current process and what are the costs of products, components, and modules? Having figured out a clever way to measure the above KPI's or others that are considered suitable, this will be used in a so-called gap-analysis. The gap analysis highlights where we are now vs what we want to achieve or our goals of a desired future state. After the whole project comes to an end we need to measure on those same KPI's once more to see how much we have actually improved. Another yet important element of the scoping phase is to identify which product families or types we are actually going to model and feed into the configurator. This is done with an ABC-analysis, that typically would consider profitability on one axis and sales frequency on the other, though other parameters could be compared as well. The ABC analysis reveals the best performing products according to the two specified criteria of analysis, which are marked AA products, while the poorest performing are specified as CC products.

In the next step called *Product Variant Master* the data collected in step one is used as a basis for diving deeper down into the product composition. What are the parts,components, and modules that the product(s) of interest are made up of, how are they interconnected and constrained according to other components and what information needs to be provided for/by the *customer*, *engineering & design* and finally *production & assembly*. This data and information needs to be collected and communicated to all relevant stakeholders to ensure the construction of a strong robust and well functioning configurator.

In the third step of the DENWA way, being the last step within the data gathering and analysis phase, we need to get acquainted with *Object Oriented Modelling* (OOM). The purpose of OOM is to enable programmers and software engineers to be able to construct the actual configurator, as they will have all of the elements of the products that go into the configurator "translated" into code. As mentioned in the paragraph above, we thus need to ensure that we have enough good quality data in terms of what we want to go into the configuration system, and what should be excluded. The translating OOM models and methods, will enable a third party coder to build the configurator in a way so that code functions optimally, and is created fast even if she hasn't got the slightest idea about the product that she is building a configurator for. Of course this might not be necessary, if the person developing the configuration is also well aware of the products and the modules they consist of, for instance if a spreadsheet CPQ solution is initially implemented before turning to more advanced expert system solutions. However, we still think it can be a good idea to do the OOM exercises such as *class diagram* or *Class Responsibility Collaboration* cards, which we'll get back to at a later point, simply to obtain a good solid overview and understanding of the product(s).

Across step 2 and 3 we need not only to know how the end products are composed. We also need to know the cost of manufacturing different modules or parts of the product, varying set up time costs related to desired batch size, shipping and distribution costs, cost of potential agents, certificates and many other product related cost. Whether this data is stored in an ERP system, a spreadsheet or any other type of database, it will require to be validated and verified. If the costs are inaccurate, the whole foundation that the following pricing of goods rely on, will also be unreliable. This means that you can by accident price your products to expensively and thus lose customers to your competitors, or the opposite may very well happen where goods are

priced too little where you won't be able to turn a profit or in worst cases actually lose money. Therefore, we cannot stress enough that you need to be like a bloodhound when it comes to chasing down every single aspect of the costs. Though it is an utopia to think that you can ever have 100% costing and pricing accuracy, that doesn't mean you should ever stop chasing and aiming for it! There is always a way to make your costs slightly more accurate, and by doing so you give yourself a much better overview on what you can do and can't do for your customers. Knowing your costs like the back of your hand will enable you to significantly amplify your sales efforts where it actually makes sense and let someone else deal with customers that will take up precious time only to reward you with a small or non existing profit. You'll be able to see things clearer and spotting those golden eggs inside the basket, and throwing the rotten ones out. Make sure to use a lot of energy on verifying and constantly monitor your costs!

Though costs are the most important factor that you need to be aware of and verify, you'll also have to some serious and dedicate effort into verifying the other types of data that you have collected as they are discussed above. Therefore, you really need to dedicate resources as the data is your key for a successful CPQ project. If you under prioritize the field and data is only collected, handled, and monitored whenever there is "time for it", your CPQ project doesn't stand a living chance! What will happen is... nothing, and the so vital supply of oxygen that is data for the project, will be cut and the project will suffocate and die. Don't waste time or resources trying to achieve the benefits of CPQ if you are not ready to go all-in on it. You will have to assign resources to data, and prioritize it or you shouldn't start trying at all!

2.2 Pitfall 2: Steering the Ship Through the Storm

When you are to implement a CPQ system, it is like setting sails into the unknown, trying to find a land of abundance. And yes it is a dangerous voyage and many sailors have been lost at sea. However, legend tells that there were those who actually made it to the land of abundance, and so can you if equipped with a compass, chart, and the guidance of the Northern star. Too often people fall into the pitfall of not dedicating enough effort to actually managing the change, and they get lost in the fog at see, hit wreck or simply arrives at the wrong destination. Don't do that!

The famous framework of John Kotter & Holger Rathgeber depicted in Figure 5 will help us find your way across the roaring seas of change within the organization, as work processes, ways of thinking, data discipline, and culture will change radically if CPQ is successfully implemented. The framework consists of four phases, which is again divided into 8 concrete chronological steps that will help envision, delivering and sustaining the changes. Let's take a closer look at it together shall we?

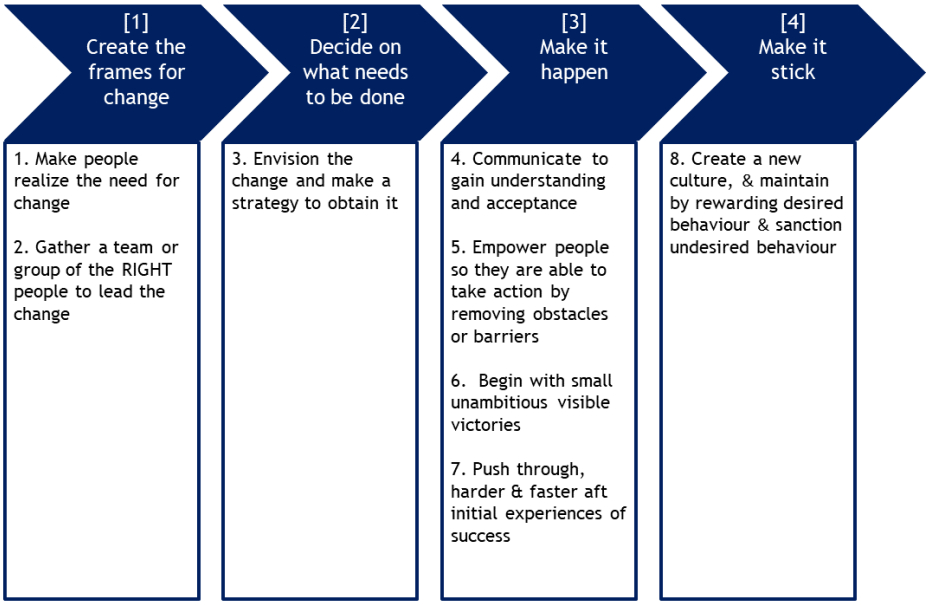

Figure 5: A framework of managing change

Phase 1: Create the frames of change

Phase 1 of the framework is kind of a preliminary phase where we want to create the right surroundings and frames for the change to flourish an thrive.

Step 1: Make people realize the need for change

In this preliminary step of managing the change related to embedding CPQ systems in an organization we need to make people realize that changes are necessary, while simultaneously stressing the element of urgency. We need to change, and we need to change now! In the context of of building, implementing and maintaining a CPQ solution, this would mean that our first task is to warn people on the trends of ever more demanding customers, a rapidly changing market, and a world where product life cycles are shorter than ever, thus calling for radical action if we are to stay relevant and competitive in the marketplace without being overtaken by our competitors. We need to preach that we will lose competitive advantage and markets to competitors if we do not change and not tomorrow but today. We need to convince people that the change will not only make the business survive an be a float, but there is actually an awesome opportunity to be so much better than competition and dominate the sectors you are already operating in and potentially exploit new markets and business opportunities!

Step 2: Gather a team or group of the RIGHT people to lead the change

Having alerted people that we need to change and we need to start doing it yesterday, we'll need to gather a group of skillful people that we can rely on to carry through with the change, and will put dedicated effort into accomplishing the goals we have set. Depending on the size of the organization these groups may vary in size, and there might be multiple smaller teams each dedicated to a specific aspect of the change to be carried through. It is important that these groups are not to large, so they keep agile and can move fast and relatively independent, so that they can skip or bypass the majority of bureaucratic processes existing within the company. The groups will have to be relatively autonomous, having a direct and simple chain of command with as few "layers" of reporting as possible.

Phase 2: Decide on what needs to be done

Within this phase we need to concretize the change further.

Step 3: Envision the change and make a strategy to obtain it

By first clearly envisioning the change that is about to happen and transform people, their workflows and processes radically you ensure that you are all on the same page and aim to achive the same. Having a clear vision is then used to setting clear, realistic yet bold objectives of exactly what we want to achieve after which we can form a battle plan and strategies to reaching the goals we have set for the change initiative.

Phase 3: Make it happen

Phase 3 is as the name indicates calling for action, where we want to actually carry through with the envisioned change that we want.

Step 4: Communicate to gain understanding and acceptance

After having started the work of actually making the change, in this case the process and product analysis to be used as input for the CPQ, coding of the actual solution, implementation and sustaining we will have to put great effort into communicating to all stakeholders involved. It should be open and transparent what is happening, what are the aims, and how we are going to do it. Be honest about potential challenges that you will have to overcome to succeed. Communication is a two way thing and it should never be just you telling people what to do, but give them room to question things and actually listen to their concerns and what they identify as roadblocks or barriers. Remember, there is a reason you have two ears and only one mouth! That last bit about listening to problems, fears and concerns of the people that are and/or will be affected greatly by the change taps perfectly into the next step of the phase.

Step 5: Empower people so they are able to take action by removing obstacles and barriers

Though communication in context of the model is assigned to step 4, really it is something that needs to undergo the whole process of change. On that note, we should also act upon the things that we learn from communicating a long the way. We as human beings are very tied up to our ways and habits, often way more than we know! You will be surprised how much of your

day you actually go through "on autopilot". This is related to the fact that when solving a completely new problem that you have never faced before you are likely to come up with smart, innovative and creative solutions, but it costs! It is way more mentally draining to use this thinking system, sometimes called "slow thinking". If it is a task that we on the other hand will have to perform many times only with little or no variation, it quickly becomes a habit which goes into the autopilot system or "quick thinking". Autopilot very much like the cruise driving system in a car is very economic in terms of mental energy consumption. It is very fast when it comes to responding to challenges or processes that are stored in the brain as a routine or a habit. The BIG drawback of using this thinking system is that it is much like a child naive and in no way critical to the answer that it will provide. This means that habits or routines are hard to break out of and in the vast majority of cases, pure motivation or will power simply won't get the job done! Even if it does happen it will be a matter of time before the change is ruled back to the way it was. But shouldn't we hire people who are more motivated and extremely dedicated? Well, that is not the point here. People generally want to help you carry through with the change and they want to be loyal and dedicated to do whatever is in their power for the changes to be a success, but right there we have it. It simply is NOT within their power, simply because they are human. It is against our nature. We as a species will always try to preserve energy for when we really need it.

Therefore, you should not be very concerned with giving great motivational speeches though that also can be fine. Where you really need to put in a lot of effort to push the desired change through is by removing obstacles and barriers that will have to be overcome for people to do "the right thing", and oppositely make it very hard to do "the undesired thing". In other words we need to create processes and design systems that work for us, and empowers people by easing desired behaviour and make undesired behavior very difficult and unpleasant.

Step 6: Begin with small unambitious visible victories

Rome was not build in a day, slow and steady wins the race, if you win enough battles you win the war are all sayings that are very true for step 6 of the phase. You want to make people that are affected prior, during and especially after the change has been carried out, feel like they are getting somewhere. We need to make small unambitious goals that we know the stakeholders of the change will be able to actually achieve. This will make them believe that this could actually lead to something, and will give them a feeling of having contributed to something that actually moved the organization forward. The change needs to start out slowly, but for each turn of the wheels gradually pick up more and more pace, and making the next objectives harder to accomplish though they should never be unrealistically difficult or impossible. Don't start by setting goals about super advanced almost autonomous systems managing all data in the CPQ process for all products perfectly by tomorrow! We'll get there but we will have to arm ourselves with patience and keep on setting up goals that are Specific, Measurable, Achievable, Relevant and Time-bound (SMART). Thereby we ensure that the majority of people will get behind the change and keep on driving it forward, as they are not as likely to lose faith in the objectives.

Step 7: Push through, harder and faster after initial experiences of success

Obviously, it is important to try to affect people and influence or/and nudge them to do what is desired regarding the changes. However, you should be extra attended to this matter right after they have experienced a success, whether it is minor or major. Why does the timing matter, you might ask and to answer that question let us briefly revisit step 5 where we learned that motivation rarely has as much to do with the successful and unsuccessful changes as we would like to think. Though the motivation and "pure willpower" is rarely able to stand alone, we would still like to have it among the people we are leading through the change, or even for ourselves so we are not trying to go through with changes we are not motivated for. It can be very hard to "re-motivate" someone who has lost motivation, or simply motivate or simply motivate a completely unmotivated person is difficult and will in many cases cost you a lot of dedicated effort. However, being part of a journey where very clear experiences of success are had by all, motivation will be strengthened and we can without much effort build upon the motivation that is already there! And that, is the reason why we would always have to push even harder or make so-called sprints right after the success experiences large as small for the stakeholders involved in the project.

Step 8: Create a new culture sustained by rewarding and sanctioning of behaviour

Finally, we will have to put a great deal of energy and time into sustaining the changes after they have been fully rolled out. To do so, we will need to create a new culture that embeds the changes as the "new normal" or the new routines and workflows. This may sound trivial, though it most certainly is not! As explained in step 5 we humans are most of the time controlled by our "auto-pilot" system, which also means that before a habit or way of thinking has been changed and then thoroughly nurtured through repetition and continuous support, we all tend to fall back into the old ways very quickly and often times without even thinking about it.

A way of maintaining the new culture is through a classic behavoiouristic approach. We need to bring in the good old carrot and stick mentality, and thus also the way we evaluate, asses and measure performance. Undesired behaviour should be both difficult as we learned in step 5 but the whole system surrounding the process, workflow or whatever has been the scope of the change needs to sanction undesired behaviour and ease, simplify and reward desired behaviour.

2.3 Pitfall 3: Don't Save the World!

It is widely known that a good project starts with a well defined scope, and a configuration project is no different. The company must be aware of its needs! -You need to understand where you are, and where you want to go, and the best way to do that is having a well defined scope. Actually, this is the first step of the "DENWA" way, which is referred as the "Scoping" step.

After having a well-defined scope, it is time to tackle your problems. And here is where people start messing things up. - "You don't have to save the world!". What is meant by that is that it is necessary to determine problems that you can actually solve, and at a pace where it can be realistically tested, debugged, implemented and sustained. If a problem seems too big and hard to be achieved, then you should break it down into smaller problems and go for them individually. You want to start building the soap box car NOT the Ferrari! If you start with smaller projects you will have valid learning's along the way and a solid foundation to improve the rest of the CPQ vehicle, building a more sophisticated engine, brakes, suspension, interior and so on... you get the point. Start simple, start small and keep moving forward in a pace that can actually be realised in terms of processes, workflows, systems and build from there.

To often companies want all the benefits at once and will build a CPQ solution that is perfect the first time. We say that it is only a fraction of companies that actually have the resources and financial muscle to pull through with this overly ambitious approach. Yes, some companies do pull it off but the vast majority end up spending a lot of time, money and human resources on something, where they will never be able to collect the fruits of their hard work and dedication! As we learned previously, building configuration and CPQ systems into the organisation to obtain the massive benefits of mass customization is not a 100 m sprint but a marathon. And no, there is nothing wrong with great ambitions and you'll never hear us say the opposite BUT you can't expect the radical changes to be a short sighted endeavour. Therefore your end goal may be very ambitious, but the path to reaching the ambitious goal of the long term strategy, requires dedication, hard work and several iterations of more short sighted realistic goals along the way!

In summary, you should only define goals that you can reach, within the timeframes and resources you have available and if you stay consistent you too will arrive at a point where mass customization is fully embedded into the organisation. Of course, as projects are dynamic, the scope can be constantly revised and new limitations can be applied, in order to continuously improve the configuration project over time.

To conclude, at DENWA consulting, we believe in attacking the problem with a structured an pragmatic way. Focusing on the customer needs and developing the best approach to come up with the most suitable alternative when it comes to product configuration. The "DENWA" way which will be presented later can further demonstrate how to tackle the dangers of this pitfall in a highly relevant and useful approach, based on frameworks and methodologies suggested by leading experts and top researchers of the field .

2.4 Pitfall 4: Choose... Wisely

When it comes to choosing the software to be used as your "CPQ" to deal with your product configuration, some relevant topics should be considered. If the wrong software is selected, then there is a real chance of choosing a highly expensive solution that will not give you the benefits you were hoping for, and will simply die out after a period of time as the organisation simply isn't fully mature for the solution, or the solution does not fit with other structures and systems that you are already using.

Companies have different needs, at different points in time. Maybe your company is already really mature and will need a highly dedicated so-called "expert system" to handle the complexity of the product portfolio and business processes inside the company. On the other hand, the company might be at a too immature stage to implement an expert system and they will end up having a really good expert system capable of handling vast complexity, but many of the features can't be combined with existing business processes or are simply not even needed. No one likes to pay for stuff they don't want or need! In addition, engaging with the wrong software providers of the before mentioned expert systems can be catastrophic due to very tight and long contracts, that might end up tiing up a lot of money and restricting your possibilities to change to another provider.

We are not saying that expert systems are no good we are telling you that the wrong system or the wrong timing can be fatal, so be careful! Don't rush into the first software that pops up in your google web search for a CPQ. No matter what is the case it cannot be stressed enough that you should clearly define the needs and pains of the organisation and find a solution that is actually suited for you!

There are several types of CPQ software's in the market and to briefly point out the most important aspect to consider when choosing one we urge you to consider the "Software functionality", the "Software structure", and the "Software interface". With these three topics in mind, make a thorough research in the market to avoid a miss-lead decision.

Below we have provided a recap of the different types of configuration systems and what the benefits and disadvantages are and some of the questions you need to ask yourself in terms of *functionality*, *structure* and *interface* of the software:

CPQ Software Type

Firstly, one must recognize that there are several types of CPQ software available. Some of the most well-known types include: geometry-based, ERP, expert systems, spreadsheet (e.g., Excel), database (e.g., Access), and traditional programming language (Hvam et al., 2008).

Geometry-based configuration, is typically seen in 3D modelling software, also known as "Computer Aided Design" (CAD) software.

Here configurators can be build in to the CAD software.

An example could be the 3D-modelling of a wheel rim. The rim might come in different sizes of the nominal diameter, and in different materials. Instead of the designer doing frustrating repetitive work of designing the rim over and over with different dimensions, and materials, she can instead set-up some rules/constraints, and then use the built-in configuration in the software to define and generate various types in seconds.

ERP-based systems is another option since some ERP-systems, have built-in CPQ functionalities and features. An example is the well known and widely used SAP software.

One of the main advantages of having integrated CPQ modules within ERP systems, is the transferring of data. When something is updated in the ERP system, this will immediately and smoothly transfer to the configurator, so that costs, components, bill of materials and other key data is always updated.

A disadvantage of choosing an integrated ERP, CPQ solution is that not all ERP systems offer an integrated solution. The ones that do, vary in quality, since this for many providers is an "additional feature", and not the core software.

If you are however using an ERP system that supports an integrated CPQ module of good quality, which is able to accommodate the needs of the organization, this type might be the optimal solution for you.

Expert systems are often used to solve complex configuration problems. They are used to configure numerous distinct products and can be further divided into three basic types: rule-based, model-based, and case-based expert systems.

Model-based systems can be further divided into constraint-based and resource-based expert systems.

For configuration of industrial products, rule-based or model constraint-based expert systems are commonly used (Hvam et al., 2008).

However, according to Hvam et al. (2008), experience shows that rule-based expert systems can be difficult to maintain, therefore, most development today is focused on constraint-based systems. In addition, Hvam et al. (2008) conclude that compared to the other types of programming, expert systems are characterized by high representational strength, high reasoning strength, and high reasoning efficiency.

Spreadsheet-based solutions can be optimal for some small or medium sized companies starting out with a solution that is more simple and essential compared to the expert systems discussed above, since they build or buy CPQ software created in spreadsheet software such as MS Excel.

This can be a very good point to start in order to move the company in the right direction, and it will in the vast majority of cases be significantly less costly and faster to implement.

Though being a less sophisticated solution, it can dependent on the products in the portfolio and the organization where it is applied, help secure most of the benefits but at a fraction of the cost.

Obviously, such a solution can not handle the same complexity as a dedicated expert CPQ system, so as complexity in or around the organization and the product portfolio increases, it will at one point be extremely difficult to maintain, update and debug.

In summary, a spread sheet solution might be "good enough" for the needs of some organizations, while others will need to place larger investments in time and money in order to implement a sustainable robust CPQ solution

Database access control is yet another area where configurators are used, to manage roles, responsibilities, and access of people in an organization. Depending on the configuration one member of the organization might be denied entry to a database, while another has full access to the very same database.

This type of configuration is in the vast majority cases already built in to the control systems of computers.

When implementing CPQ in an organization, it is of incredible importance, that only the right people have the right authorities and accesses. This is a prerequisite for trusting the tool and the outputs obtained.

Finally, CPQ solutions can be build within *traditional programming languages* such as Python, C++, Matlab etc.

It is not too common, since programming languages are not clearly dedicated or optimized specifically to creating CPQ solutions, and thus the solutions will in many cases perform worse than those dedicated expert systems such as Tacton, Configit or SAP.

Criteria of Evaluation Before Choosing CPQ

Having identified the overall type of configuration software, that is best suited to match the faced challenges and needs of the organization, we will now have to consider the three software criteria.

1 Software Functionality

This criteria not surprisingly relates to evaluating whether the functionality of the CPQ software of the chosen type is a good match for the desired end-goals and needs of the organization.

In other words, find the CPQ tool that is best aligned performance wise with what is needed.

This might sound simple, but can in practice be both difficult and time consuming. However, time spent evaluating this criteria is well spent, and will most definitely be worth the effort!

Below is a list of sub-criteria to asses when studying the functionality:

Dynamic configuration:

> Configuration within a software system is referred to as "dynamic" if the solution space is reduced for each individual choice made throughout the configuration.

Price & cost calculations:

> Can the software handle complex pricing principles for computation of costs and prices?
>
> How are prices maintained?
>
> How are various prices handled in different market settings?
>
> How are various monetary standards handled?
>
> How are units handled?
>
> How are specific customer discounts handled?

Online/offline configuration:

> Is it possible to configure online, or only locally?

Reporting/quote generation:

How much and in which quality can the software generate standardized documentation for specific configurations?

Sub-models:

Can the software align with sub-models, and if so to which degree?

Version control:

How well does the software manage version control of product models?

How well does the software manage version control of the software itself?

Backup:

What backup systems are embedded in the software to counter loss of data or other configuration work?

Administration of users and system:

How well does the system handle multiple users or other stakeholders with different rights, roles, responsibilities, and restrictions?

2 Software Structure

The second highly important criteria to consider and evaluate, is related to the structure of the CPQ software.

To support the process of evaluating this criteria, there is yet another set of sub-criteria's we advise you to look into:

Type of system:

It is important to be clear of what type of configuration system the will match ones need, whereas the characteristics of the different systems were discussed above in this article.

Use of technology, client/server environment:

Can the software of choice connect, and function together with other already existing IT-systems?

How can it support integrate and align itself with other systems in general?

Adaptation of standard systems:

Will the configuration software of choice be able to adapt to known development languages and tools such as for instance VBA, C, C++, Java or Python?

Web-enabling:

Is it possible to enable the CPQ to web-based solutions, for instance on a web-page?

Time of reasoning :

How slow or fast can the software reason, according to the configuration problems that are sought resolved with the solution? Does the reasoning happen during compilation, at runtime before any making any choices in the configuration or during run time after the necessary choices of configuration have been made?

Data security :

How well is the CPQ system at protecting confidential data, such as costs, sales margins or technical data?

Degree of visualization :

Which degree of visualization does the system support? -No visual representation, 2D drawings and illustration or dynamic 3D visualization?

3 Software Interfaces

The third and final overall criteria that one will have to asses when implementing a CPQ solution, is related to the interfaces of the software, or put in a different way how people interact with the software.

Below is a list of sub-criteria to consider:

User interface :

How is the user interface, and is it automatically integrated into the software or will it have to be programmed?

Can the system handle multiple user interfaces, for instance varying dependent on the role or department of the person interacting with the software so that a salesman and a planner would have different user interfaces?

Integration with Microsoft Office products :

Since the majority of all businesses use Microsoft Office products on a daily basis, it is very relevant to evaluate whether the CPQ can collaborate & be integrated with Office desktop applications.

Is it for instance possible to extract or handle data to/from Excel?

Furthermore, another aspect is the intuitive feeling the user has when interacting with the software. If it is similar to the Office products, more people will be able to adapt and quickly learn utilizing the CPQ solution of choice.

Users :

Additionally, it is important to consider the human factor of the CPQ solution, assessing it according to the people who are to use it!

How many can use the solution and at what cost?

Is it necessary to train resources and if so how much?

Is it necessary to hire external specialists?

Can users of the software use it simultaneously?

Stability :

Finally, but not less important is the evaluation of the software stability.

How often does it crash, and how stable is operation?

To conclude, knowing how to choose the most suitable "CPQ" software for your company can be complicated, therefore, a consultation with a specialized company can be the best solution when going through this important decision. To help you with that, DENWA is a Product Configuration specialist and can provide you with the best consultancy approach.

2.5 Pitfall 5: Go Hard or Go Home!

When it comes to implementing a CPQ there is no easy way around it. Once it is decided, there is no tuning back. The best way to deal with it is focus and hard work. If there is not enough dedication the whole project may crumble between your fingers never getting to realise the desired outcome.

Generally, companies designate internal resources to take on some extra roles within the implementation process. In many cases it is not going to be sufficient. You need to be aware that the implementation of a CPQ system will certainly require at least one person who is dedicated full time for the project, at least when choosing, building, and iteratively implementing. It is not uncommon to have the need of hiring extra staff just for the implementation, even if it is on a project basis. What is the right amount of resources to allocate, and how much training will they need to receive varies greatly and is up to you to figure out internally. We are only trying to emphasize just how important it actually is. We are all busy, and if your company is anything like other companies, there will constantly be fires to put out that can derail focus of such a project. The paradox being that the reasons for these constant wildfires spreading through the organisation on a daily basis, often occur as a direct result of time consuming business processes, that are out of control. This is exactly what can be countered using the principles of mass customization, among them CPQ solutions. Therefore it can be put so simply that you need to prioritize it and assign the resources to carry it through. Don't wait for the success to come, get the work done!

Do what is necessary for the CPQ project to thrive, or don't do it at all. If that means that you feel like you don't have the right resources internally, to handle the extra workload or the necessary knowledge or skills then hire professional external resources. It may be expensive, but the alternative is a project leading into a dead-end. Fur We suggest you to search for a good consultancy firm and outsource the implementation, if you have any doubts of whether you can tackle the immense challenges internally. You can of course plead help for different stages of the project if you don't have the bank book to pay for "the whole circus". There are several advantages gained by outsourcing a resource to be responsible for the implementation, such as: full dedication; specific knowledge; experience in the subject; agreed costs for the project. If you have such a resource internally use that person. It doesn't matter if it is an internal resource or an external, as long as you commit yourself fully to the project.

However, it is highly important to keep in mind the further activities that proceed after the implementation. The maintenance and updating of the system still requires a considerable amount of work. And this is where the training of the internal team becomes relevant. It is essential to be aware of the personal training for the post implementation phases.

3 Best Practice

Experience from a long series of configuration projects has shown that the structure of knowledge described in a configuration system is of great significance for various factors, such as maintenance, or overall performance. According to the literature, developing and designing configuration systems generally requires seven steps described below.

Phase 1 - Development of specification process:

In phase 1, the purpose is to map the current specification processes (AS-IS state) and the current performance. From here on, goals are made for the desired future outcomes (TO-BE state). Tools and methodology typically applied within this phase is often related to process mapping, data gathering and measurement of relevant KPI's, GAP analysis, and the proposals of different scenarios for solid foundation of further evaluation, typically in the form of a traditional cost-benefit analysis.

Phase 2 - Analysis of product range:

In phase 2, the purpose is to create an overview of the product range, and obtain insights about the product composition and which product families to include and exclude in the configuration system. The product range within a company is often huge and there is a high number of variants. In order to get a better overview of the products, it is visualized in a product variant master (PVM).

Phase 3 - Object-oriented modelling:

In phase 3, the purpose is to "translate" the PVM into conseptual models enabling programmers or software engineers to build a configurator for products that they have no knowledge about whatsoever. This is often done with a class diagram and CRC cards. The class diagram is conducted from the PVM, and it shows the relations between the parts in the product range. The CRC cards are created to show a detailed level of each class.

Phase 4 - Object-oriented design:

In phase 4, the purpose is to determine software for the configuration system an fitting it to the the object oriented models. It is important to adjust the object oriented modelling to fit the software structure, since the information would be put into the configuration system.

Phase 5 - Programming:

In phase 5, the purpose is to program the configuration system based on the object orientated modelling including class diagram and CRC cards.

Phase 6 - Implementation:

In phase 6, the purpose is to implement the configuration system and to ensure that the intended users implement it in their work. It is important to ensure that the program is user friendly, and also involve users at an early stage. Moreover, the users should be trained in order to become familiar with the system.

Phase 7 - Maintenance and further development:

In phase 7, the purpose is to update the software when the product range changes. The configurator must be updated continuously, so it does not become outdated. When updating the configurator, it is necessary to go through the documentations for PVM and OOM, and then update the configuration software.

4 The DENWA Way

To ensure high quality and efficiency in every project we engage in, we have developed a well structured 7- step process inspired by expert researchers within the field of mass-customization.

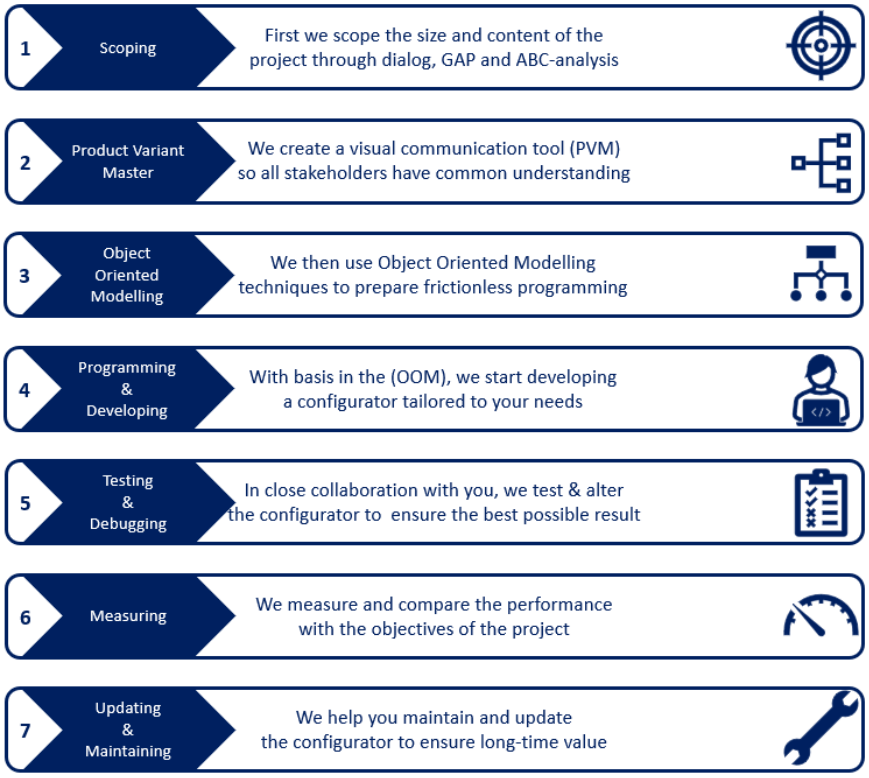

Figure 6: Combined benefits of mass production and customized production within mass customization

During the analysis, we apply structured and well researched methods and tools from multiple different disciplines, such as LEAN production, mass customization, and general complexity management. Below is a short introduction to the methods and tools applied along the 7 step process, which serves as a solid framework for analyzing, implementing and preserving CPQ systems.

4.1 Step 1: Scoping

Firstly, we offer help scoping out a Configuring, Pricing & Quoting (CPQ) project in a structured manner, to ensure that all relevant stakeholders are well aware of the objectives, available tools and resources as well as the boundaries of the project.

Lean Methodology Process Mapping

Within this step, we start out by mapping the current process of configuring products, computing product costs, pricing and quoting. We identify the value-adding tasks, the necessary non-value adding tasks, and the unnecessary non-value adding tasks.

Gap Analysis Based on Highly Relevant KPI's

Having mapped the current process (AS-IS), we now identify a set of highly informative and relevant "Key Performance Indices" (KPI's) in close collaboration with you. We then measure

the performance of the AS-IS process according to these KPI's. Furthermore, the current AS-IS state, is documented in a gap-analysis, where it is compared to goals related to the same KPI's for a desired future state (TO-BE).

At a later point when a project has been finalized, the new AS-IS state can then be mapped and compared to the original state, but also to the objectives set when initializing the project. In other words the gap-analysis will provide answers to the following two questions:

How much have we improved compared to the starting point?

Did we meet our expectations and objectives?

ABC-Analysis

Having the processes and objectives in order, we now strive to delimit the product side of the project. This is achieved using an ABC-analysis where products or product families are ranked according to the frequency of sales for that particular product or product type on one axis, and the profit made on the product on the other axis.

Thus a product that is frequently sold, and generating high profit is scored as an AA-product, and oppositely a product that is rarely sold and have low or even negative profit margins will be scored as a CC-product.

It is worth noting, that in the majority of cases, products follow the Pareto principle, meaning that 20% of the products, generate 80% of the revenue!

The analysis is used to help prioritize the products in terms of embedding them into CPQ solutions.

4.2 Step 2: Product Variant Master

Having scoped and delimited the CPQ project regarding both processes and products, we now create a visual communication tool that will communicate the configured product(s) to all stakeholders, in a simple way so that it is fully understandable whether one has a technical background or not.

This is done with a Product Variant Master (PVM), that will quickly visualize and explain what the products consist of. The PVM looks similar to a tree, that "branches" the product down, so that it is broken down to all of it's components and the relation between them.

The PVM is divided into the three following "point of views"; customer view, engineering view, and production view.

Customer View

The customer view is what the customer sees or/and will have to give input for the configuration. For the example of the bike, it could be to state their height which would then automatically be translated into a specific size of the frame by the configurator.

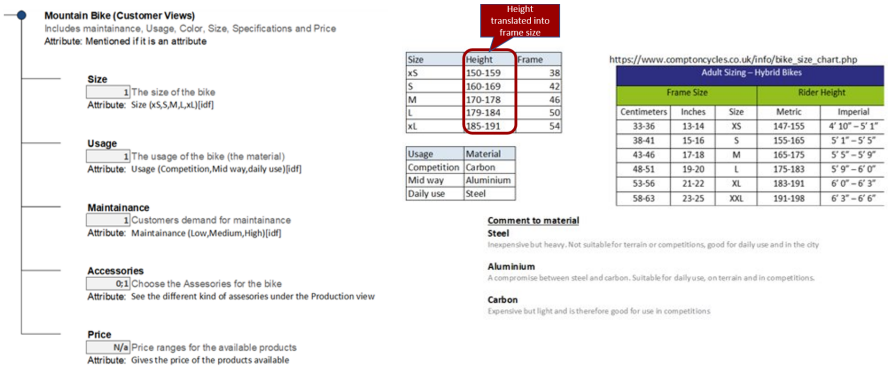

Figure 7: Combined benefits of mass production and customized production within mass customization

Engineering View

The engineering view further divides the branches of the PVM into two categories, "part-of", and "kind-of" structure.

A simple example, would be a bicycle as the overall product. A brake is then "part-of" the bike, whereas you can have several "kind(s)-of" brakes, for instance handbrake and/or footbrake, as illustrated below:

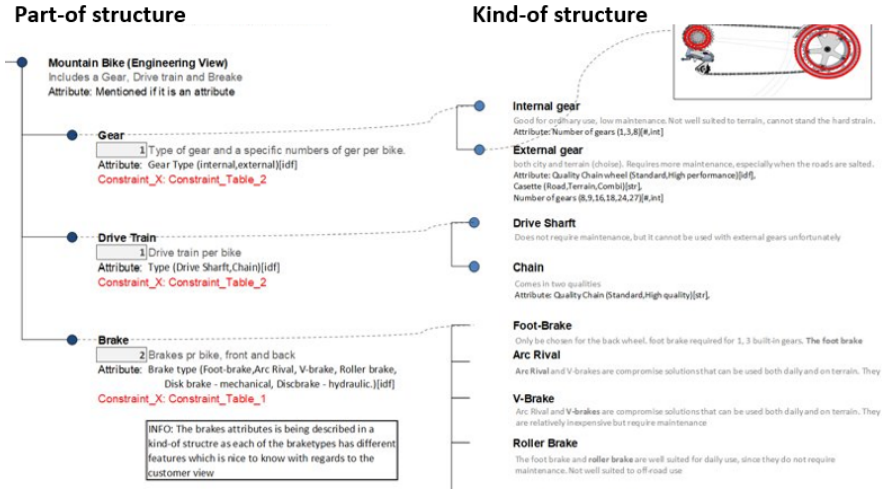

Figure 8: Combined benefits of mass production and customized production within mass customization

In this view the design engineering is the main focus, ensuring that only valid combinations of components and sub-components can be combined so that no interdependent constraints or rules are violated.

Production View

The third view of the PVM is called the production view, and refers to how the product is to be assembled. For the example of the bike this would mean that all of the overall types of components that makes up a bike must be listed and visualized within this view, see illustration below:

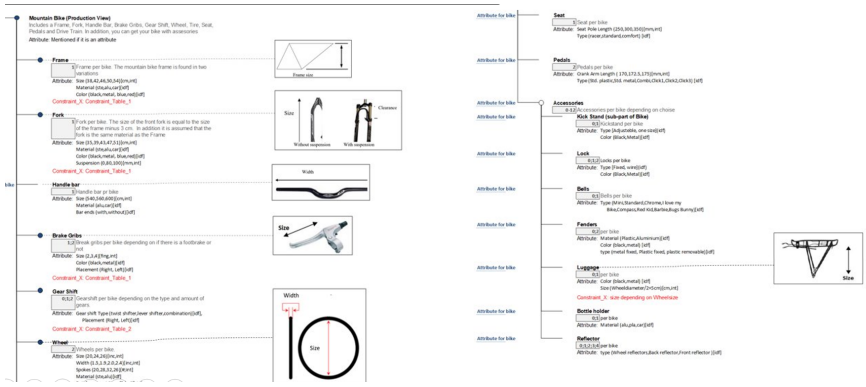

Figure 9: Combined benefits of mass production and customized production within mass customization

4.3 Step 3: Object Oriented Modelling

Now “Object Oriented Modelling” (OOM) is applied to translate the products into a “common language”. The aim of this is that skillful programmers or configuration engineers can build the configurator for the product(s) without knowing anything about the product on beforehand. She doesn’t even have to know what the product is used for or who it is sold to, but can build a high performance customized CPQ solutions, within a short timeframe.

For our OOM we use the notion of the “Unified Modelling Language” (UML).

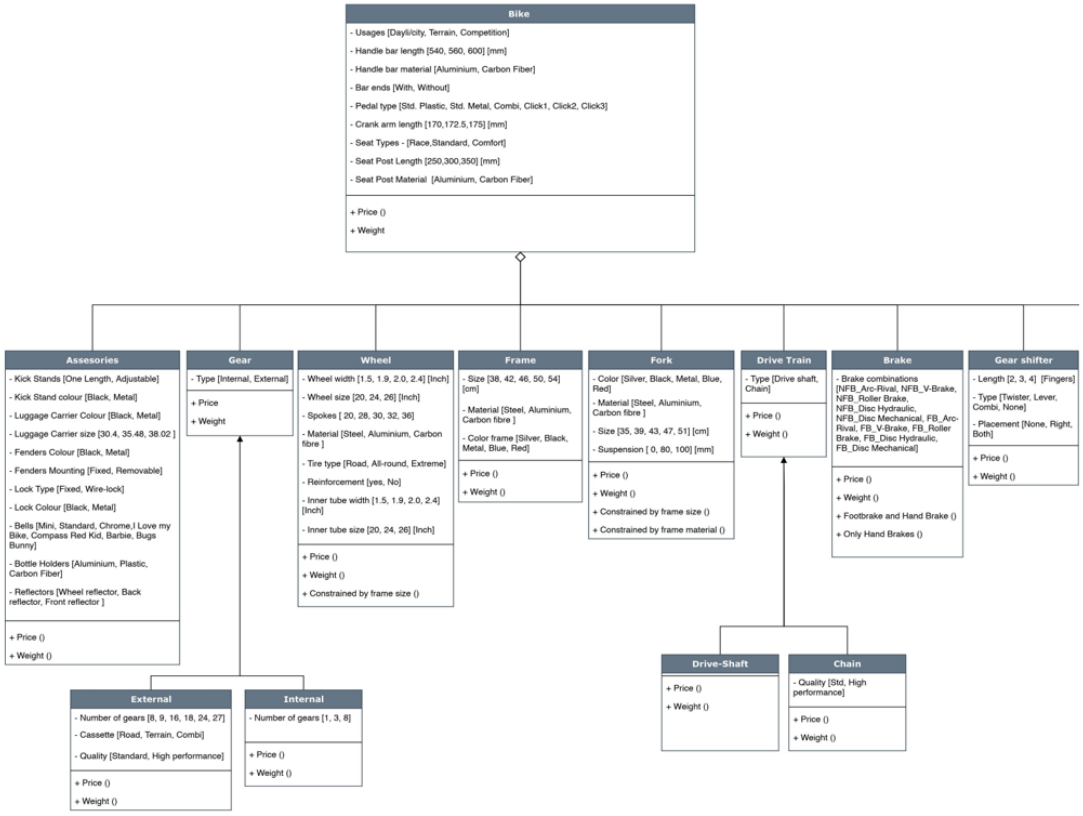

Figure 10: Combined benefits of mass production and customized production within mass customization

4.4 Step 4: Programming and Developing

As previously defined in "Step 1", the Scoping, the software to be utilized by the company was chosen. It can either be a simple, yet efficient Excel-based program, or an expensive and complex software. Either way, the CPQ is then developed in this step, by considering the preceding steps, "Product Variant Master" and "Object Oriented Modeling". At DENWA we are focused on tailoring the CPQ software according to the customers needs. Therefore we are specialized in excel programing. We have the abilite to provide our clients an Excel-based CPQ which is cheap and ready to be used by the employees.

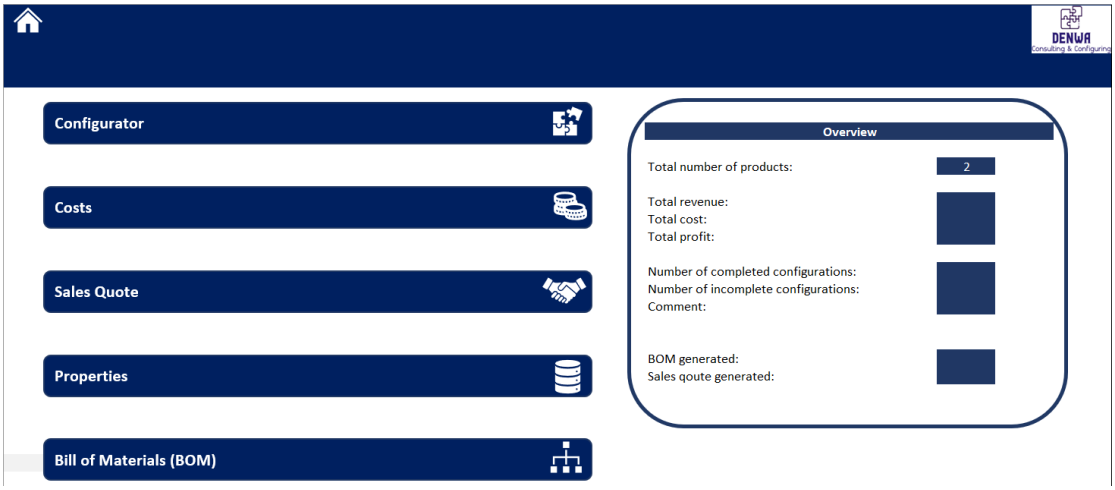

Figure 11: Example of a tailored Excel-based CPQ by DENWA.

As can be seen in Figure 11, it is possible to program a completely functional CPQ within excel. With a friendly interface, the CPQ is easy to be used and simple to learn. In addition, the maintenance and updating of the tool can be performed by any employee with a reasonable knowledge on Excel.

4.5 Step 5: Testing and Debugging

In this step, the CPQ tool is put to test. The users start adopting the software and understand the functionalities. Of course, this steps is also where the feedback is gathered and all the process is sharpened. All the support is given by DENWA, during the test and debugging. Being on the side of the client and users is most important to have a smooth run of the tool. Likewise, the tailored CPQ requires further exchange of experiences and data. At DENWA we are aware of this condition and conscious of performing a thorough test and debugging of when implementing a CPQ software.

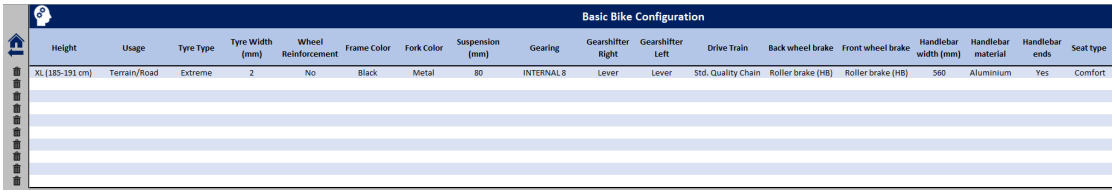

Figure 12: Example of test of product configuration within an Excel-based CPQ.

Above, in Figure 12, a brief example of a configuration table is presented. The configurator needs to be quickly put into test by the users and programmers. The debugging must not be underestimated, as the tool should be running smoothly and considering the right parameters in order to reach the desired outcome stipulated int the scope phase.

4.6 Step 6: Measuring

To compare the performance the CPQ is providing to the company, this step takes place. The objectives once developed in the scope of the project are checked with the current scenario

after the implementation of the CPQ. All the requisites need to be matched. To start from the beginning, the specification processes are mapped and key performance indicators (KPIs) are defined. The KPIs are analysed one by one, and the result should be satisfactory, as expected by the customers' scope. This comparison can be then presented into a so called GAP Analysis, where the measurements, objectives, to-be scenario, as-is scenario, and after implementation scenario can be found. The most relevant KPIs that can be mentioned are the "Lead Time", "Quality of technical specifications", "On-time delivery", "Working hours" and "Accuracy of cost estimation". However, it is important to keep in mind that the selection of KPIs may vary from case to case, depending on the goals of the client. Figure 13 below shows an example of a GAP Analysis containing the mentioned KPIs.

SUBJECT	AS-IS	TO-BE	GAP	COMMENTS
Lead time	7-21 days	Standard products: 2 days Non-standard products: 1 week	Standard products: Up to 19 days Non-standard products: Up to 14 days	*This is in cases where sales cannot extract information from internal system.*
Quality of technical specifications	20% contains errors	<2% contains errors	25%	*Errors are in the BOM and list of operations going into the production phase.*
On-time delivery	75%	95%	20%	*Sales department often promises 2 weeks for non-standard products that require 6 weeks.*
Work hours	2-120 hours	45% reduction of man hours used	55% (assuming AS-IS is 100%)	*Reducing non-value adding tasks.*
Accuracy of cost estimations	40% of proposals have cost estimations that deviate > 20%	Estimations never deviate more than 5%	35%	*Deviation from estimations means that cost is either over- or underestimated.*

Figure 13: Example of test of product configuration within an Excel-based CPQ.

As can be seen in 13, this is a primary analysis. It considers the as-is scenario and the to-be scenario, making a comparison between them, resulting in the GAP. However the DENWA way has added a small twist into the GAP analysis in order to improve the results. That is, once the CPQ implementation is done, another analysis is made and the "new current scenario" is measured and put into consideration. This will lead to a study of what can be improved, is it enough how it is, should we put more effort somewhere else, etc. FUrthermore, DENWA believes that by having this constant as-is analysis the company manager will have more information in hands to act upon changes in a faster and leaner way. In addition, a NET present value of the resources needed to achieve the goals is better calculated and visualized when having the right data on a higher frequency of time.

Finally, with a flexible CPQ software, such as an Excel-based provided by DENWA, it is possible to considered further KPIs which are not commonly offered by the normal software providers.

The measurement of emissions, reduction of environmental impacts, to name a few, all can be translated from the CPQ into relevant KPIs to be put into the GAP analysis and made available for the company's appreciation.

4.7 Step 7: Updating and Maintaining

The last step of the implementation of a CPQ Software is the Updating and Maintaining. This step is crucial, as the further development and continuous progression of the company's transition to a leaner production is dependant on the proper management of the software.

To have control over the CPQ, the configuration system is documented by using the product variant master, class diagrams, and CRC cards. The system can be documented further, for example, by using flow charts, case diagrams, descriptions of user interfaces etc. When having a well documented process of implementation, it is possible to combine the different elements used, end update them quickly when needed. Figure 14 shows the relation of the Product Variant Master (PVM) with the Class-Responsibility-Collaboration (CRC) card.

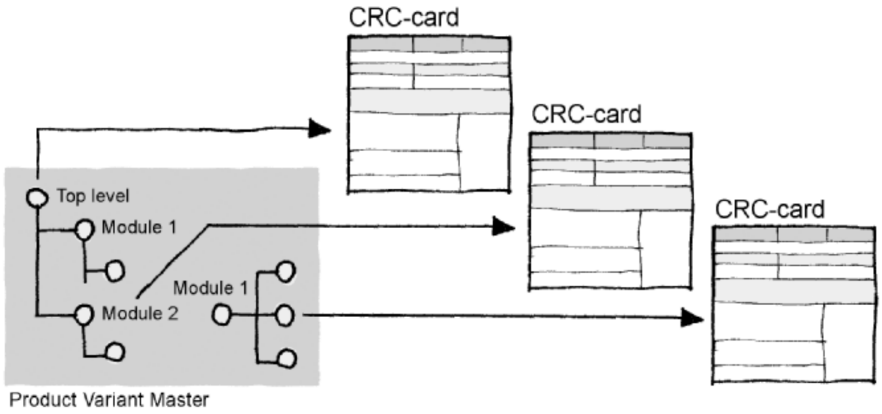

Figure 14: PVM and CRC cards as documentation. (Retrieved from: Product Customization, Hvam et al., 2008.)

There are several ways to document the configuration process, therefore every company should study what is the most suitable way taking into consideration the current company structure. However, what is commonly found in the literature, and also recommended by DENWA, is that it is easier to understand the product variant master, as its notation is closer to the concepts and structures the domain experts are familiar with in their daily work.

As already mentioned before, after the implementation, the system enters the actual operational phase. When configuration systems are used, knowledge about products and possibly life-cycle systems are formalized and incorporated into an IT system. This results in a series of changes in the way in which work of specifying products and for example the manufacturing instructions is performed. In addition, the use of configuration systems leads to a series of new tasks appearing in the organisation, while other tasks disappear. Some of the everyday tasks involving working out specifications in the form of offers and manufacturing instructions disappear. On the other hand, the sales staff have to use the configuration systems for carrying out the task of selling. Therefore, it is necessary to maintain and further develop the model that has been developed and the configuration system, in order to ensure that the configuration system preserves its validity. This means that a series of new tasks appear, which are related to maintenance and further development of the model and the corresponding configuration system. These tasks typically have to be performed by people who have the necessary knowledge of the products and the relevant life phase systems, such as production, assembly and delivery.

Maintenance and further development, therefore, involve a number of different people. As an example of how the task can be organised, Figure 15 shows a diagram of the roles with one or two people (model managers) responsible for the overall model, and one or two people (programmers) responsible for updating the configuration system and the program itself, including the user interface and integration with other systems.

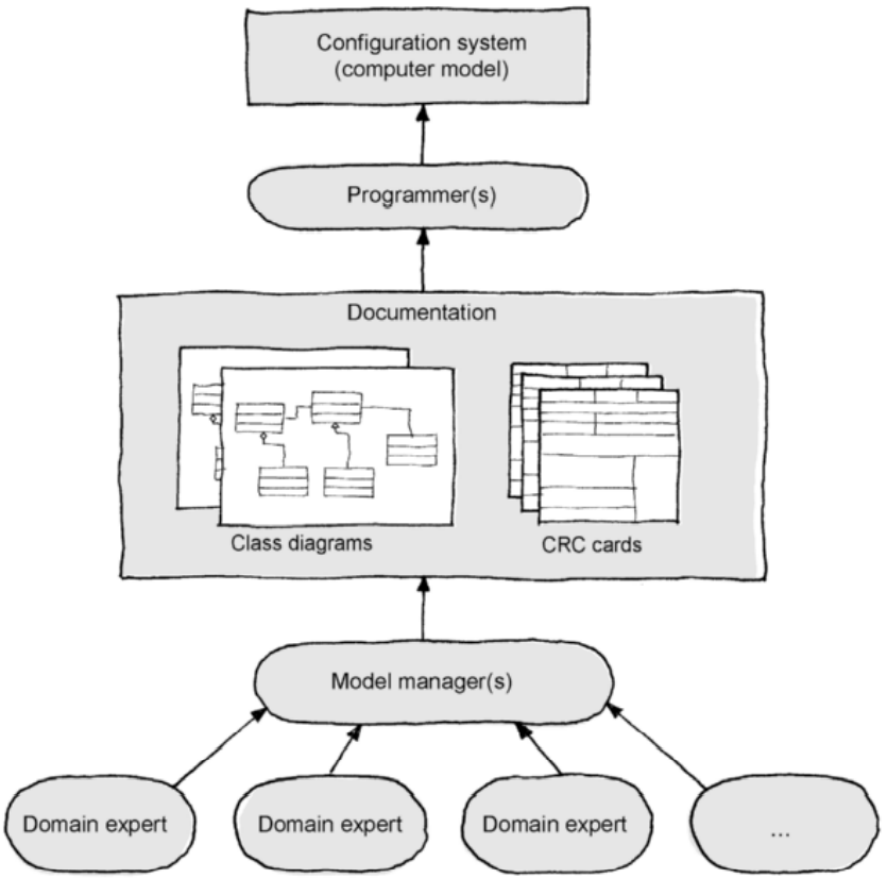

Figure 15: Roles in the operation/maintenance phase. (Retrieved from: Product Customization, Hvam et al., 2008.)

The people responsible for the overall models (model managers) then delegate the task of maintenance/further development to individual specialists who are each given the responsibility for maintaining that part of the model which they know about. In other words, the individual specialist is typically assigned responsibility for maintenance and further development of a series of object classes and the associated CRC cards.

In connection with development and maintenance of the models, it is essential that updating the models and the configuration system takes place at the same time. A configuration system which is not documented rapidly becomes difficult or even completely impossible to maintain and further develop.

5 Authors

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Professional Skills:
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He has previously from scratch built a real-life Excel-configurator used by the sales force at Pres-Vac also a part of G&O Maritime Group, which he currently is responsible for updating and maintaining.

Furthermore he has taken the courses “Mass Customization”, “Complexity Management” , “Supply Chain Analytics”, “Design of Production Logistics Systems (Lean)” and “Management of Sustainable Organizational Changes” which have provided valuable knowledge, and structured methodologies which can be applied to real-life settings.

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He recently finished his Masters Thesis in a project for FL Schmidt, developing a structured approach to improving pricing accuracy for their existing CPQ solutions.

He is currently engaged in a PHD project under the supervision of expert researcher in the field of mass customization, Lars Hvam (DTU).

He is very keen on helping businesses thrive and prosper through real life application of his mass customization skills learnt at DTU.

6 Learn More...

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