IMPLEMENTATION OF PDM/PLM IN A TECHNOLOGY COMPANY

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This thesis is a study on the current ways of working at RemaSawco, a company in the sawmill industry. The company had no PLM system in place, but as a growing company they realised the need for one. The company's product portfolio was unclear and they had expressed a need for a clearer product structure. The company wished to have a way of defining a product and its lifecycle. This thesis presents a solution that utilizes a PLM to form and conceptualize the product structure, as well as a method for keeping track of the product lifecycle in a PLM.

PDM (Product Data Management) and PLM (Product Lifecycle Management) systems offer companies a way to handle their data and product lifecycle. PDM and PLM are software that store product data and define it in a systematic manner using items. Items are entries in the software that are given a unique identification code, and they hold product data and the file metadata. The item data is stored in one or more centralized data servers.

The implementation of a PLM takes time and resources and has many challenging aspects to it. However, a PLM system can bring great business benefits, the biggest of which is time saving. The transition to using a PLM is an essential step to take for any tech company aspiring to succeed in the 21st century's market.

PLM systems and implementation processes were studied for this thesis. The author also worked closely with RemaSawco, gathering information. A solution for the product structure was developed and implemented into Aton PLM software. The implementation of a PLM system and the preparations required from a company are examined. How the product lifecycle is managed after the deployment into the field is explained and a solution of a track-keeping system is provided. The PLM implementation at RemaSawco is a case study illustrating the challenges of implementing such a system, whilst also presenting its potential and business benefits.

Keywords PDM, PLM, Product structure, Aton

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Abbreviations

PDM Product Data Management

PLM Product Lifecycle Management

CAD Computer Aided Design

BOM Bill of materials

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1 Introduction

The purpose of this thesis was to study the implementation process of a PLM into the workflow of RemaSawco. RemaSawco is a tech company in the sawmill industry and their product portfolio consists mainly of wood measuring products. Along with implementing the PLM system, the goal was to define a product/project structure and supply chain. RemaSawco had not previously used a PLM so the implementation was done from ground up. This allowed for freedom in the methods of product and project definition as there was no earlier model in place. The central objective of this thesis is made clear by the following research question: What is the implementation process of a PLM like and how can a PLM be used in defining a product structure?

In the beginning of this thesis the theoretical background will be explained as well as the programs and concepts regarding product data and lifecycle management. After this the company RemaSawco and its functions are introduced along with their goals and the current problems they are facing. The thesis will then proceed into implementation of PLM and the defining a product and a project. How the aforementioned products and projects operate in a PLM, what the workflow using the new system is, and how product lifecycle is managed are discussed in detail. In the end there is a conclusion that summarizes the work, as well as a brief look at future implementation.

During the writing of this thesis the author worked very closely with RemaSawco and used Aton PLM daily, transferring documentation into it and defining their products and projects using Items and Documents (features of Aton). Since the company was at the implementation phase of a PLM, many aspects of the topics discussed would change during the writing process, which was to be expected. This thesis captures a snapshot on how things were at the time of writing.

2 Theory

In the information era of the 21st century there are several concepts and softwares that are useful in the everyday life of an engineer. Product data and product lifecycle management applications and CAD softwares are useful — perhaps even essential — tools in any modern product development company. As tools and technologies that enhance a company's efficiency in many ways, they create not only bottom line savings but also top-line revenue growth and great cost savings. (Sääksvuori & Immonen, 2008, pp. vi, 2–3; Apilo et al., 2008, p. 95)

In this chapter the terms PDM and PLM will be defined. The applications and usefulness of the two will be discussed as well as the differences between them. The PDM software Aton and the CAD software SolidWorks are also explained here. What they are, how they are used and what they bring to the table in the scope of this thesis are discussed in detail below.

2.1 PDM & PLM

PDM, or Product Data Management, is a system of managing product data. Product documentation, CAD files, technical drawings and other data can be managed from start to finish in a systematic manner using a PDM (Sääksvuori & Immonen, 2008, p. 249). The core of product data management is the creation and management of product related information so that it can be found and refined with ease in a company's everyday workflow (Hietikko, 2008, p. 171).

PLM, or Product Lifecycle Management, is closely associated with PDM. The main difference of the two is that PLM tackles a wider system in terms of scope and is usually involved with all company functions. PLM expands throughout the company, whereas PDM is mainly a tool for managing product data. PLM ranges from sales and procurement to service in order to control every stage of the lifecycle of a product. It is a system which connects all functions of a company together with the help of a centralized digital platform. The term PDM can be thought of as an older name for PLM. (Sääksvuori & Immonen, 2008, pp. vii, 13, 249; see also Hietikko, 2008, p. 174)

Generally, all commercial PLM softwares have the same core functions (Sääksvuori & Immonen, 2008, p. 18). One of these functions is item creation. When transferring anything to a PLM, an item is created. Sääksvuori & Immonen (2016, p. 249) define "item" as the following: "Item is a systematic and standard way to identify, to encode, and name a physical product, a part, a component, or some material for a product or service." In practical terms, turning anything into an item is a process of uniquifing it. Items are given unique ID-numbers which can be tracked. (Sääksvuori & Immonen, 2008, pp. 11–12)

Within different PLM systems there are usually various ways to categorize and structurize items for ease of use and manageability. It is an essential step that items are categorized to classes and subclasses, but this needs to be kept at moderation to avoid forming a slow, overly precise catalogue (Sääksvuori & Immonen, 2008, p. 12). For example in Aton items are categorized to "items" and "documents" and the two have different purposes and uses. Essentially, items are the core feature of any PLM.

PLM systems operate using one or many central servers, usually referred to as data vaults, to which files are uploaded. These data vaults provide data access control, data security and data integrity. The two types of data uploaded to these data vaults are product data and metadata. Product data is data generated by applications, e.g. CAD models and operating manuals, while metadata is specific indexing information, e.g. file creator name and file creation date. The data is made into an item and users of the system can access these items and reserve them for use with something called "check-out" and "check-in" functions. (Crnkovic, Askund, & Persson, 2002, pp. 22–23; Hietikko, 2008, pp. 170–171)

As a user checks out an item, the file is reserved for the user and transferred to the user's PC. It can then be modified freely and checked back in, returning the edited file back to the PLM. This reserve-release system prevents duplicate data from being formed, since it prevents multiple people working on the same item simultaneously. (Crnkovic, Askund, & Persson, 2002, p. 22)

Figure 1 illustrates an example system where two vaults are in place: the WIP (work in progress) vault and the Release vault. The workers have access to the WIP vault from which they submit ready items to the Release vault accessible only for supervisors. This system builds a natural hierarchy between workers and supervisors and allows for a smoother workflow in a company.

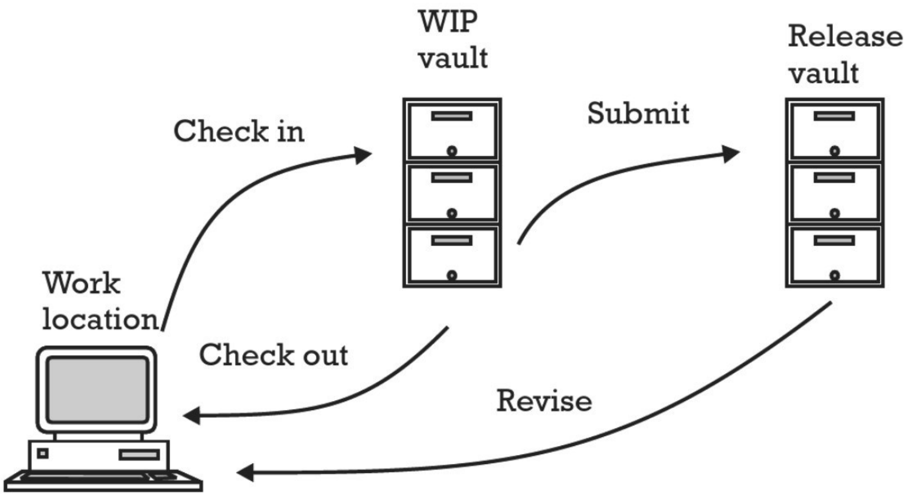


Figure 1: Example of a vault system (Crnkovic, Askund, & Persson, 2002, p. 23).

PLM systems require adminstration, which is complicated and contains many tasks. Some of these tasks are installation and maintenance, database and network configuration, data backup and security, user authorizations, and role management. Many roles ranging from mechanical and software designers to project managers are involved in the lifecycle of a product and different roles need different access rights to product data. Proper role management is one of the key factors to a succesful PLM integration. (Crnkovic, Askund, & Persson, 2002, pp. 29–30)

2.2 Aton

Roima Aton PLM (hereafter referred to as Aton) is a PLM software owned by Roima Intelligence Inc. (Roimaint, n.d.). Aton is the PLM in use by RemaSawco. A change management process and project/product structure management are the main uses of Aton in the bigger picture. Aton has a large number of features, some of which are planned to be taken in use by RemaSawco. The features that are relevant to the scope of this thesis are examined in detail below.

2.2.1 Items and documents

In order to prevent confusion between a general PLM item (see chapter 2.1 PDM & PLM) and Aton item, the term “item” will hereafter refer to an Aton item. If referring to a general PLM item, the term “general PLM item” will be used.

An item in Aton is one of the two classifications Aton uses for general PLM items, the other being a document. Aton provides multiple ways of generating a unique ID with prefixes or suffixes. At RemaSawco it was decided that the ID does not need to give other information than whether the general PLM items is an item or a document. Items are always given an ID-number in the 2-million series. From there, running numbers are used to give each item a unique ID (2001656, 2001657, etc.). For documents the numbering is in the 1-million series. This programmed numbering rule makes it easy for the two to be distinguished at a glance as well as improving searchability. A million in each group is also enough to avoid running out of numbers.

Items and documents can be categorized to admin defined groups. Groups are a way to arrange items and documents into subcategories, making it easier to find them and improving the general usability of the PLM. As mentioned in 2.1, this categorization is important, but overdetailing should be avoided when creating subgroups. Figure 2 shows an example of the RemaSawco top-level document and item groups.

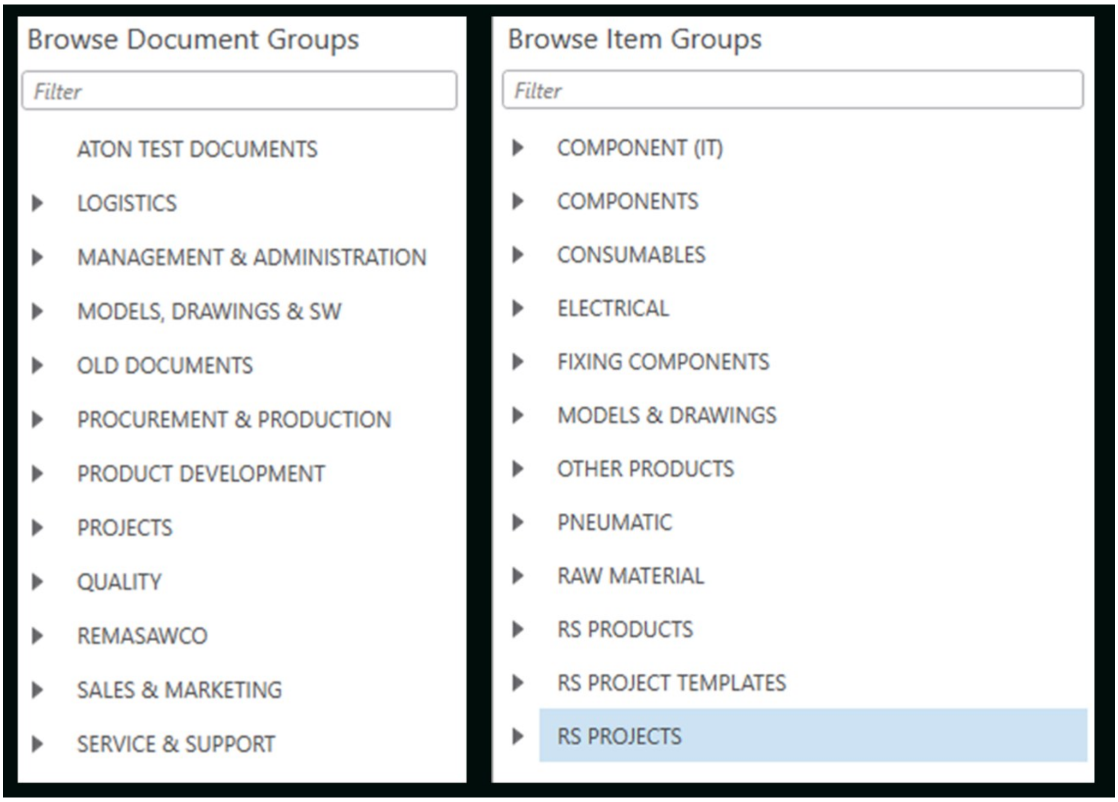


Figure 2: RemaSawco's document groups (left) and item groups (right) in Aton software.

Aton allows the creation of dictionaries, which are similar to item and document groups. A dictionary in Aton is a list of pre-determined namings and terms, which can be translated to multiple languages. An item's description field can be a dictionary input.

In Aton, the item is a database entry that holds metadata, attributes and status information. It can be created without a file attached to it. An example item and the information it holds in Aton is shown in Figure 3. Document on the other hand is for product data and always requires a file such as a .pdf-file or a CAD-model.

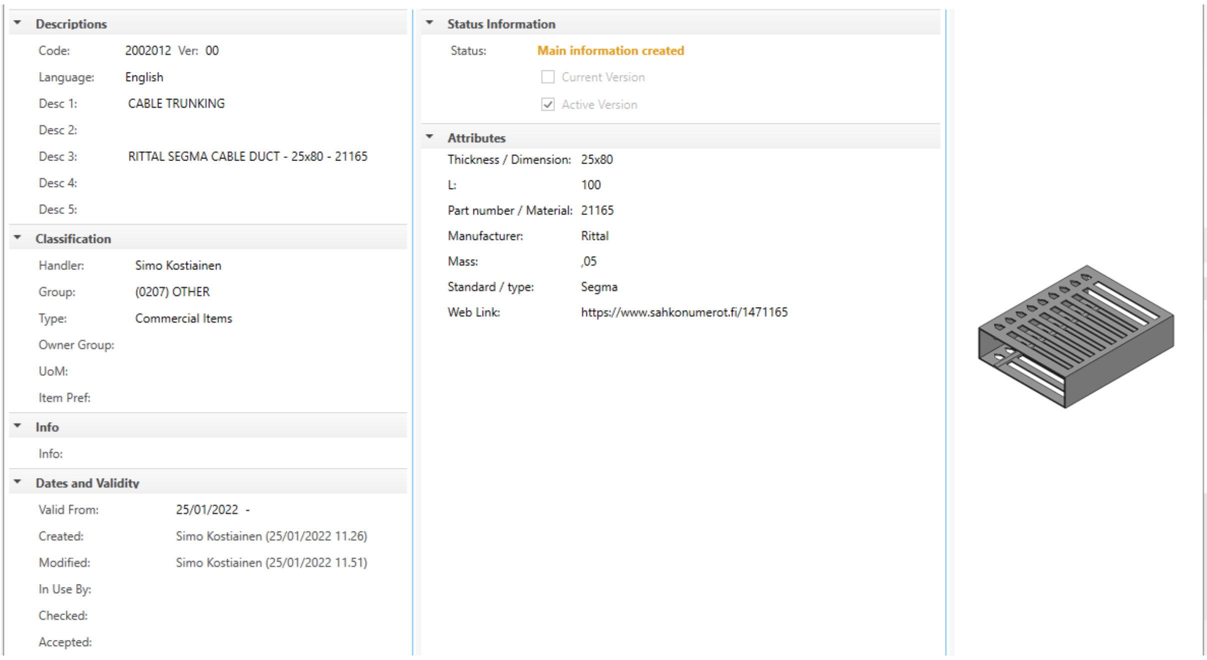


Figure 3: Example item in Aton software.

Any product data will be linked to an item as a document using Aton's "relationship" feature. Relationship creates a link between an item and a document that can be a critical one, such as CAD model or technical drawing, or a miscellaneous one, such as a datasheet or user manual. Figure 4 shows an example of the link created by a relationship in Aton. It is noteworthy that the "Main Model" and "Main Drawing" are generated automatically by

SolidWorks when linking a 3D-model and its drawing to an item. Figure 5 is a visual illustration of the link between an item and a document created by the relationship.

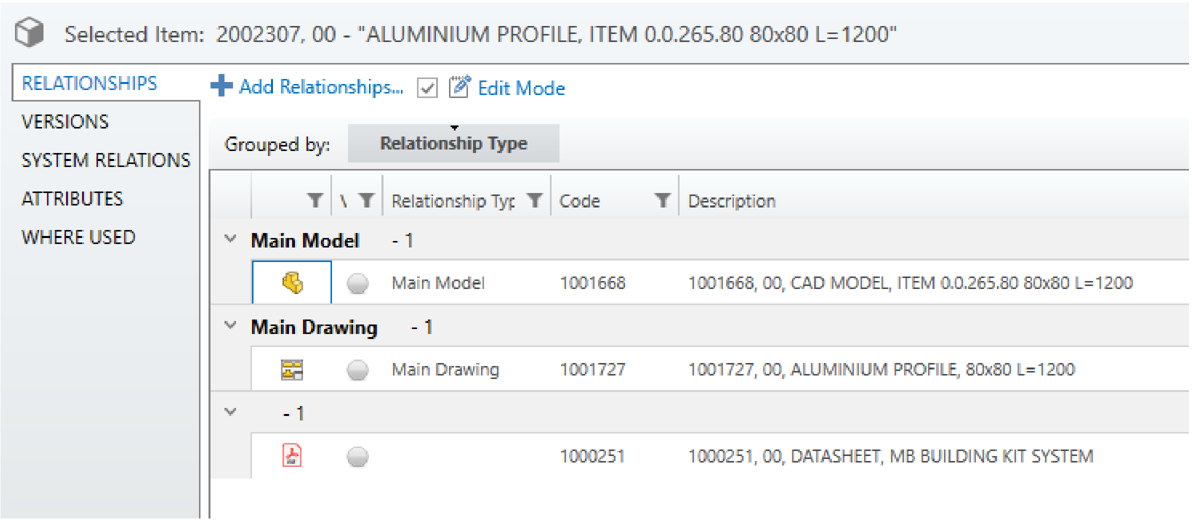


Figure 4: Example of relationships linking documents to items in Aton software.

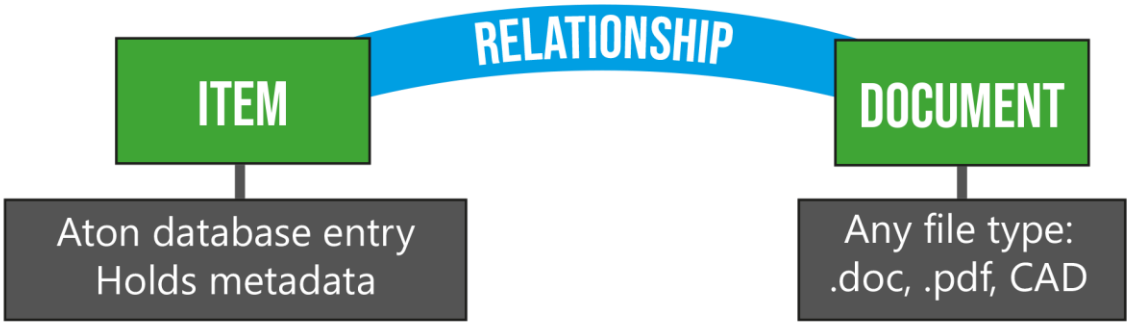
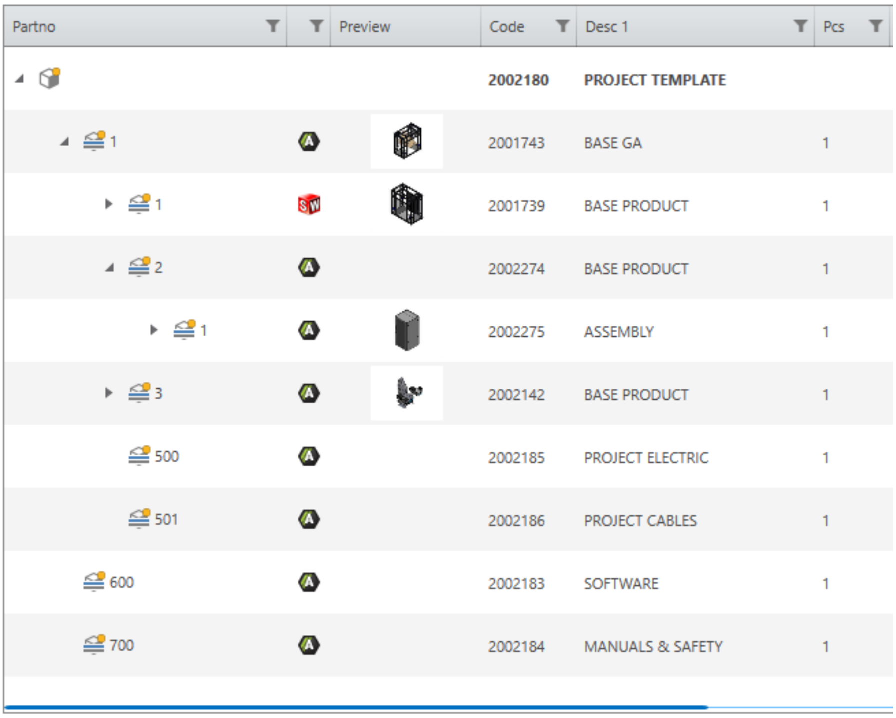


Figure 5: Visual illustration of a relationship between an item and a document.

2.2.2 Aton structures

Structure is a feature of Aton where items can be grouped under an upper-level item. An example of this is an assembly, where the individual parts are grouped under the assembly item. A SolidWorks assembly automatically creates a structure in Aton, but one can be also created manually from items. The items in a structure are given a part number and their individual amounts can be inputted. From this structure, a BOM can be created.

Structures are used in the scope of this thesis in defining the product and project structure. Figure 6 shows an example of a “Project Template” structure. In it, the products are compiled under a “Project Template” item, the structure of which can then be copied to future projects.



Partno		Preview	Code	Desc 1	Pcs
			2002180	**PROJECT TEMPLATE**	
1			2001743	BASE GA	1
1			2001739	BASE PRODUCT	1
2			2002274	BASE PRODUCT	1
1			2002275	ASSEMBLY	1
3			2002142	BASE PRODUCT	1
500			2002185	PROJECT ELECTRIC	1
501			2002186	PROJECT CABLES	1
600			2002183	SOFTWARE	1
700			2002184	MANUALS & SAFETY	1

Figure 6: Example of a "Project Template" structure in Aton software.

2.2.3 Workspaces

Workspaces in Aton are admin-generated folders where information can be structured in sub-folders (comparable to the Windows file explorer). Different privileges to the workspace folders can be set for users from different company sections. These folders are separate from items, documents and item structures. Instead, they act as shortcut links to specific items or documents. Multiple different but important shortcut links can be added to a workspace folder and they will provide quick access to e.g. the main project item, project serial number, product change logs and information documents, repairs change logs and other important links the company wants to highlight. Example workspace structure that RemaSawco uses is shown in Figure 7. Each folder holds the items and documents relevant to the project and folder in question respectively. All documents in a workspace folder can be exported from Aton in .pdf form using a feature called “file export”.

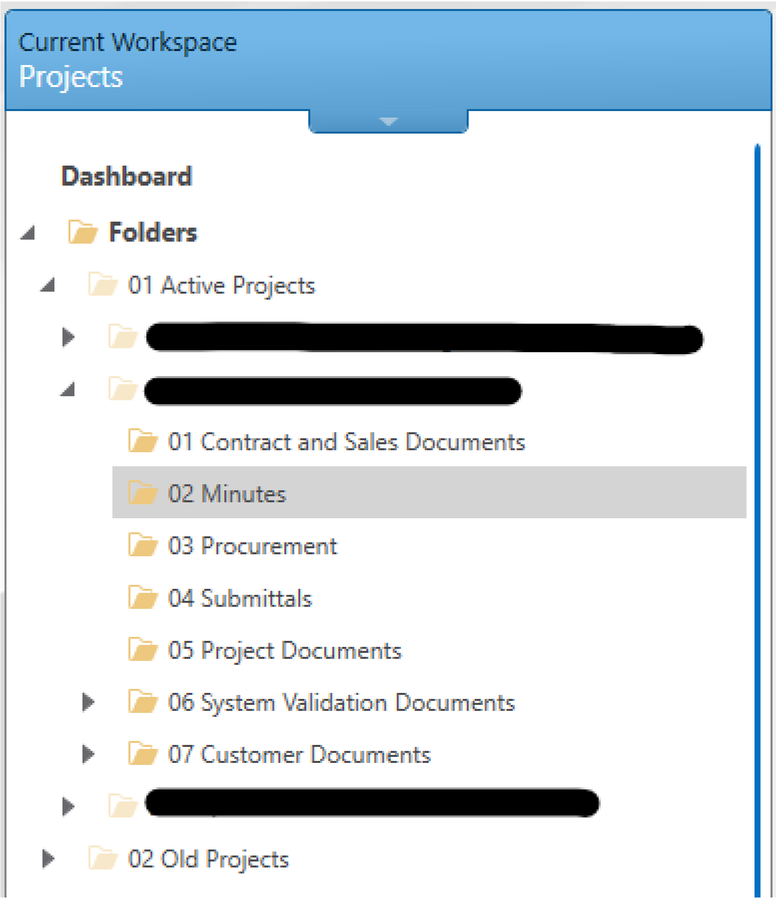


Figure 7: Workspaces and their folder-like structure in Aton software.

2.2.4 Serial number

Serial number is an Aton feature that is essentially the same as an item structure, but with a key difference. Serial number takes an existing Aton item structure and extracts a snapshot copy of it under a new unique serial number (e.g. #0000002). The created serial number structure can then be modified at will without affecting the original Aton structure. The modifications to the serial number structure are logged and timestamped within it. For example, if a new replacement part is introduced and the old one deleted, this is saved into the structure and the deleted file can be seen under a “show deleted items” tab.

2.3 SolidWorks for Aton

SolidWorks is a CAD software made by Dassault Systemes. It can be used to create 3D-models and technical drawings of parts and assemblies. (SOLIDWORKS, n.d.)

Using an add-in “Solidworks for Aton”, Solidworks and Aton can be linked together. This allows for item creation from SolidWorks as well as the inspection and editing of existing items that have a CAD-model linked to them. When creating an item from SolidWorks, the CAD-model document is automatically created and linked as a “Main Model” for the item. Figure 8 and Figure 9 showcase the user interface of the add-in. Items can be looked up, opened as read-only and checked out and in without leaving SolidWorks. This creates a smooth workflow between the two.

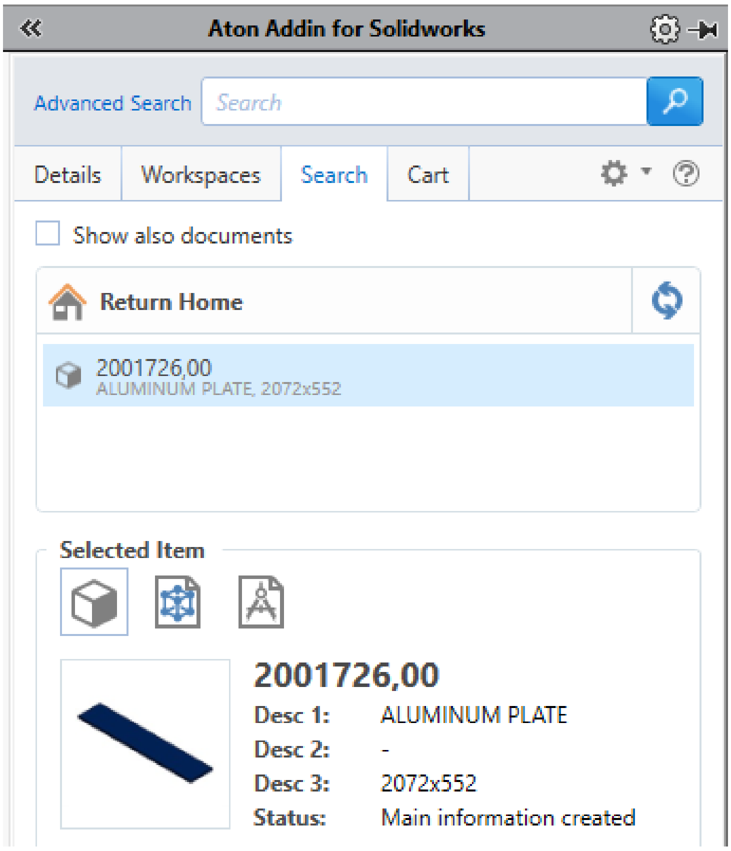


Figure 8: "SolidWorks for Aton" -add-in interface in SolidWorks software.

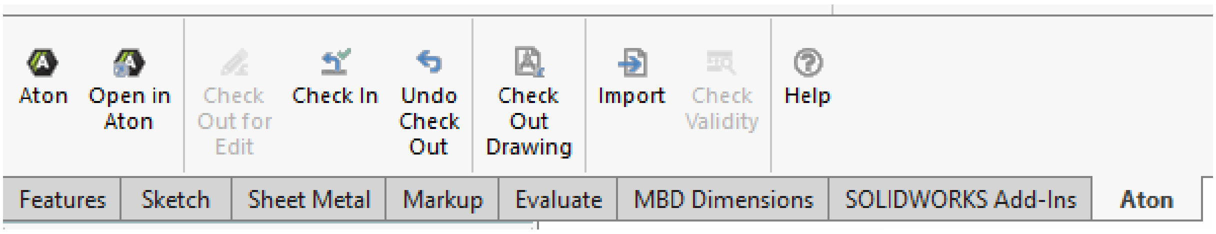


Figure 9: "SolidWorks for Aton" -add-in direct check in and check out functions in SolidWorks software.

3 RemaSawco

RemaSawco is a technology company based in Sweden with offices also in Norway and Finland (RemaSawco about page, n.d.). RemaSawco is a company in the sawmill industry, designing and delivering measuring devices for log sorting, board sorting and sawline (RemaSawco front page, n.d.). Sweden based Image Systems bought the companies Rema, Sawco in 2012 and created RemaSawco AB in Sweden (Image Systems Group, n.d.). In 2018 Image Systems acquired the Finnish company Limab Oy and renamed it to RemaSawco Oy for operations in Finland (English, 2018).

The information in this chapter was gathered from unstructured interviews and conversations with the author's supervisor and other RemaSawco employees during the time working with the company. The interviews were conducted by the author asking questions about the relevant topics and taking notes from the answers. These interviews and conversations were conducted in the course of the roughly three months of working on the thesis, and this chapter is written in the author's own words using said information.

3.1 RemaSawco as a business environment

RemaSawco's business consists mainly of CapEx (Capital Expenditure) investments which are project deliveries. The company also provides service, maintenance and spare part sales. The company is not a reseller of third-party equipment. RemaSawco works typically as a subcontractor in bigger projects meaning that a company has already bought a process line and RemaSawco supplies the measuring equipment for it. Strategically the company identifies as a tech company.

One of the company's strategies is to focus more on product lifecycle services on top of smooth project deliveries. After the delivery the lifecycle of the product is followed. This includes operations such as setting up yearly service contracts and collecting data analytics. This is better for the company ARR (Annual Recurring Revenue) as customer deliveries can be unreliable and seasonal.

3.2 RemaSawco organization

RemaSawco has five core functions: Sales, finance, products, operations and service. The role of sales is selling solutions out. Operations and service are concerned with projects and bid management as well as buying components and selling spare parts. Products are divided between software and hardware and they have a product management function that governs them. On the service side, RemaSawco offers hardware service and also a support helpdesk. Figure 10 is an illustration of the organization's structure.

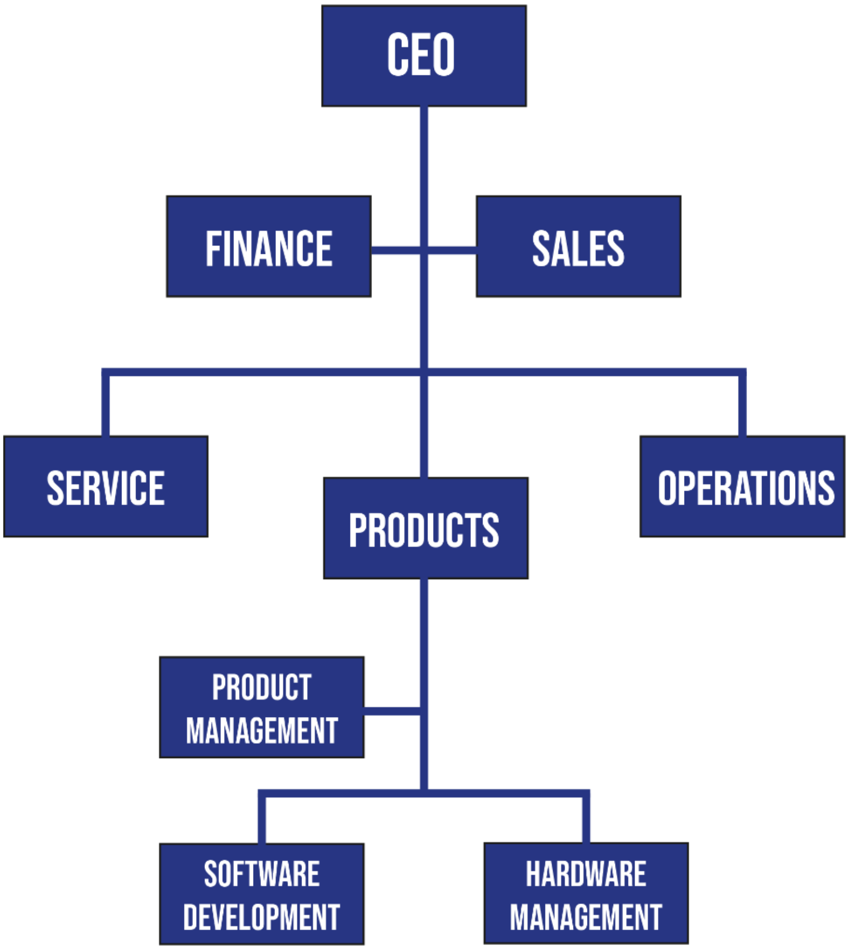


Figure 10: RemaSawco organization structure tree.

3.3 Product management challenges

After the merging of the companies in 2018, RemaSawco has seen major changes in most of its functions and management. These radical developments have left the company in a state of dissarray. Different divisions have different ways of working, and there is no clear company-wide system of data management in place. There is no PLM, which means that all documentation and files are kept on local hard-drives. Files are shared between workers by request via email.

The system is fragmented between departments and it is unclear who holds what data and where. For example, as an individual worker, getting the required data for a project can take hours or even days.

3.4 Goals of RemaSawco

The general goal of RemaSawco is to improve information accessibility and structure businesswise, which will lead to savings in time and costs. For this to be achieved, the processes must be refined. One goal is to recognize the core competence that is required in the product delivery supply chain. The ultimate long term goal is to lay a strong foundation for business scalability.

3.4.1 Business processes

Due to the reorganization in the company, the business processes have been revised. A PLM system brings opportunities for the overhaul of processes but it also brings challenges. Aton PLM is inspected to see how it supports existing processes, and new company processes are created with Aton’s functionalities in mind.

The creation of new processes is currently the major focus of RemaSawco. Due to large company-wide overhauls, roles and functions have been re-created in every department. As the company is finding its bearings, bringing a new system to change management and integrating it is a difficult task.

3.4.2 Core competence and business scalability

To control product information, core competence is required. One aspect of core competence is being able to answer questions related to products. For example, if there is only occasionally a project that requires an electric engineer, is outsourcing the answer or should there be one in house? When documentation needs to be created, can the company outsource it? To answer these questions, one must understand the product fully and have core competence to outsource the resources. Outsourcing can be a viable option, but the bought services have to be well defined and understood. Core competence and outsourcing are one definable aspect when building an organization around products and deliveries.

In terms of business scalability the goal is to expand the business without increasing the costs. In other words it is enabling a productivity increase with same resources. To double the revenue, it is not feasible to double the personnel. Instead, more output should be achieved for less input. (Lund & Nielsen, 2018, p. 3)

One of the hardest parts of scaling businesses is recruiting and training competent employees. Creating a business model that enables efficient scalability is naturally a great challenge. Identifying the most intelligent manner of configuring the business model is the key to unlocking exponential growth in return of investment (Lund & Nielsen, 2018, p. 15).

4 RemaSawco's approach to PLM

RemaSawco did an investment comparison of PLM systems and the company chose the Aton PLM. The implementation of Aton is one of the ways to achieve the goals of the company. A PLM improves operational efficiency across the board by allowing all groups across the value chain to work faster by virtue of advanced retrieval, sharing and reuse of data (Sääksvuori & Immonen, 2008, p. 2).

4.1 Common problems before PLM

As mentioned in chapter 3.3, RemaSawco has no PLM system in place. In a company without any system of data management, the fragmentation of data is common if not inevitable. In the worst case scenario, some of the data can be found only in written papers or as tacit knowledge (Apilo et al., 2008, p. 28). A common problem is that the terms, acronyms and concepts are not defined within a company and there is a lack of guidance and documentation. This causes information to be spread over many different terms. Another problem arising from this is that information is often lacking in completeness and consistency, as different people have different approaches to the protection and handling of information. This creates trust issues in the company and duplicates as it is often faster to redo certain documents than to check the validity of existing ones. When a company is in this state, duplicated and self-conflicting information is commonplace. (Sääksvuori & Immonen, 2008, pp. 9–10, 69)

The problem is not that the data does not exist. Within a company, there is usually a lot of information and special expertise to run operations. The problem is that this information and expertise is bound to very specific individuals in the company and cannot be made useful for the organization as a whole. Productive time is lost in the gathering of this information from these individuals. The benefit of a PLM system here is that it converts individual knowledge into shared intellectual capital useful for the whole company, greatly reducing the resources used to retrieve, maintain and gather product related information. (Sääksvuori & Immonen, 2008, pp. 99–101; see also Apilo et al., 2008, p. 107)

Figure 11 is an illustration of what Sääksvuori & Immonen (2008, p. 92) describe as the “vicious circle of deteriorating product data.” As the amount of data grows, the access to it becomes even more limited and slow. The effect of this is that employees start looking for alternative ways to manage the data. The circle can only be broken by standardizing, harmonizing and improving the system of data management. PLM is a tool built for this purpose. (Sääksvuori & Immonen, 2008, pp. 91–93)

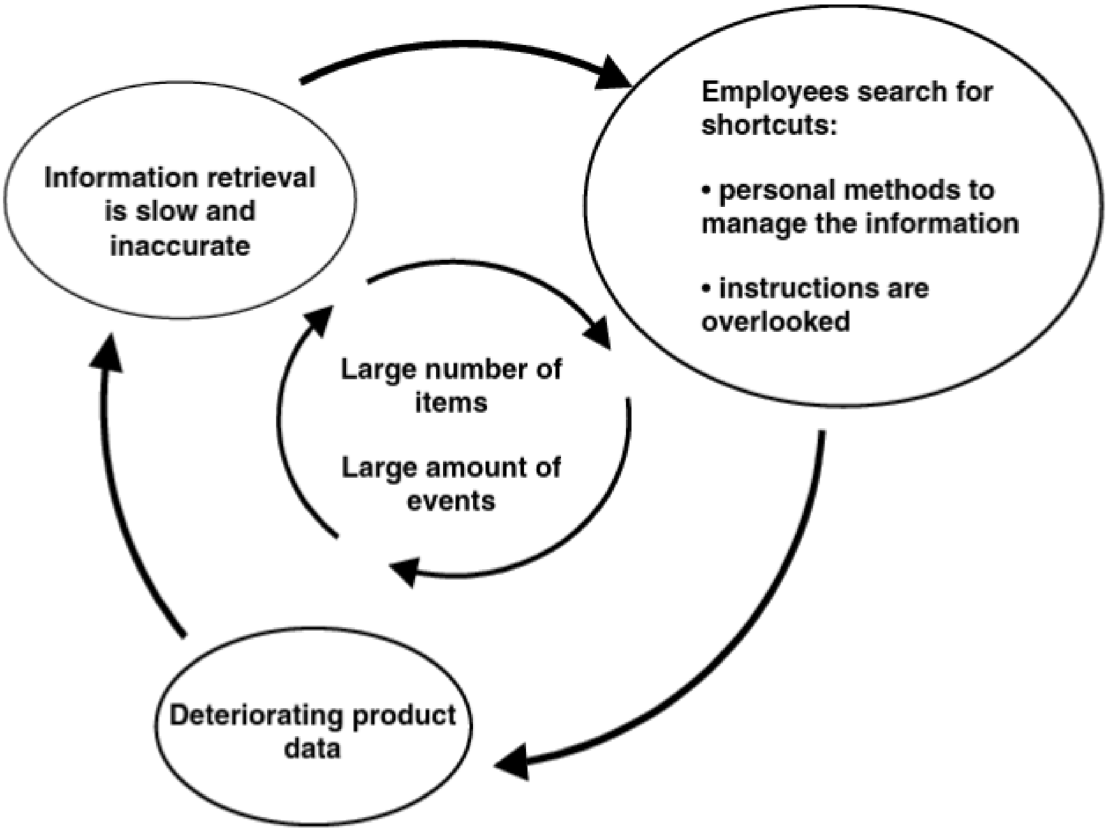


Figure 11: Product data deterioration cycle (Sääksvuori & Immonen, 2008, p. 92).

4.2 PLM business benefits

Deployment of a PLM brings a major change in business and competetiveness, though the direct conversion of the benefits of a PLM to money is difficult. However, there are ways to measure the advantages. As the company's processes become more efficient, the business benefits can be observed in two ways. In terms of savings, they come from the intensification of operations and the decrease in expenses and working capital. The time saved also opens up new and increased earning possibilities and strategies for the company. (Sääksvuori & Immonen, 2008, p. 97; Apilo et al., 2008, pp. 109–110)

Through a well structured and operated PLM, a company can get a clear picture of its parts and component stock. This often brings to light the similarities between components and the amount of unused or unavailable components. Optimizing the products by reducing various similar parts into a handful of working solutions help in reducing material costs and inventory tied capital. This also has the secondary effect of focusing on and improving the information and documentation on the remaining items. (Sääksvuori & Immonen, 2008, pp. 97–99; see also Apilo et al., 2008, p. 108)

5 Implementation of PLM

The aim of PLM and data management in general is to organize the business and to create general practices among different parts of a company. Effective data management is required so that the correct information is available at the time when its needed. (Apilo et al., 2008, p. 29)

For any tech company looking to improve their processes, PLM is a great tool. However, it cannot be used at will without preparations. The groundwork that needs to take place is essential. A PLM is not to be used as an "information landfill" – great care and careful consideration must be taken when setting up the system. The move to a PLM is no small feat. It is an intense and laborous process, but for the benefit and betterment of the company the labor is worth doing. (Sääksvuori & Immonen, 2008, pp. 71, 104)

5.1 Preparations and maturity

Before a PLM can be implemented, the need for change has to be understood. There may be problems regarding product data management that trouble the company for a long time before the realization is made. Eventually it becomes evident that the company can no longer continue with its present ways. When the need for change is understood, the level of expertise and understanding about PLM systems needs to be increased. It is of great significance that the uppermost management understand what a PLM is and the improvements it could bring to the company. The commitment of both the management and the workforce is required for the succesful investment and deployment of a PLM (Apilo et al., 2008, p. 109). Only then can the implementation process begin. (Sääksvuori & Immonen, 2008, pp. 68–69)

Implementation of PLM requires a high level of discipline on the company processes. Optimally, a company should know its own situation and know what it wants developed and how the development should be done, prior to the introduction of a PLM. The concept of a PLM maturity model – a model on how well a company can develop and extend and generally take in the PLM concept and the processes and IT systems related to it – is derived from the generic COBIT maturity model. COBIT is a framework based on five principles that allow for consistent and clear guidance for a company’s management of IT (Bernard, 2012, pp. 9–10). A practical application of the maturity model is for evaluating the current situation for each unit or product area. Some parts of a large corporation may have been developing at different paces making the quality of work inconsistent throughout the company. This is illustrated in Figure 12. To get a better scope on the current situation, the PLM maturity model can be used. (Sääksvuori & Immonen, 2008, p. 70)

The PLM maturity model has five stages:

1. Unstructured
2. Repeatable but intuitive
3. Defined
4. Managed and measurable
5. Optimal

In the unstructured stage, the company has recognized the need for change and agreed on the importance of a PLM. At this stage there are no defined approaches concerning lifecycle management yet as it is done mostly by individuals on a case-by-case basis. On the second stage, people are following similar procedures on the same tasks but a formal definition or training on the standardization is still missing. Only individual knowledge is relied upon and this is bound to cause errors. (Sääksvuori & Immonen, 2008, p. 72)

The defined stage of the maturity model is where processes and basic concepts get standardized, defined and documented. Manuals and training are introduced to relay this information to the workers. When the processes can be monitored and action can be taken to improve where things are not going well, the company enters the fourth stage of the model. In the final optimized stage the concepts and processes have been fully refined to the highest level. Continuous benchmarking and improvement is made, IT is well integrated to the systems and process automation is in wide use in all parts of the company. (Sääksvuori & Immonen, 2008, p. 72)

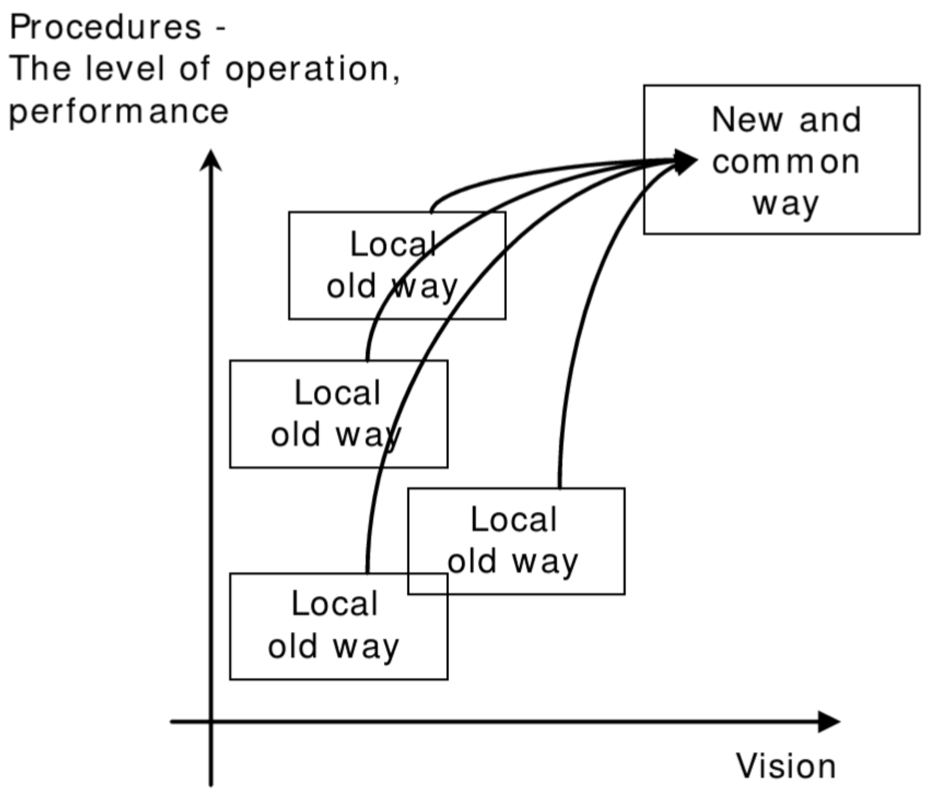


Figure 12: Variance in maturity and performance efficiency in different sections of a company (Sääksvuori & Immonen, 2008, p. 71).

At the time of writing, RemaSawco is on the second stage of the maturity model. While employees working with Aton are following the same procedures, a formal definition is still lacking. Information about the procedures is mainly shared via word of mouth, but progress is being made towards a proper instruction document. The company is steadily moving towards the third step.

5.2 Defining the stored product information

RemaSawco has various products for measurement using 3D scanning and x-ray technology. These products are generally organized to groups, but the current system defines what the word “product” means only at the stage of the project delivery. The project deliveries are done by assembling the required parts and creating a solution for the customer. This is a viable strategy for a small business. However, as the company grows, an effective system for defining a product structure becomes necessary.

A project delivery includes the products but also other uncategorized components such as spare parts and safety fences. With the current way, these are simply included in the delivery and dealt with on site. Service is done on demand and is an overlooked aspect in the structure of the project. Figure 13 illustrates the current client project delivery structure in which the delivered system is thought of as the product. Due to highly unique client environments and processes, the delivery projects often require adaptation based on the customer’s needs. As a standardized product portfolio is missing, a great amount of NRE (Non-Recurring Engineering) is required for every project delivery.

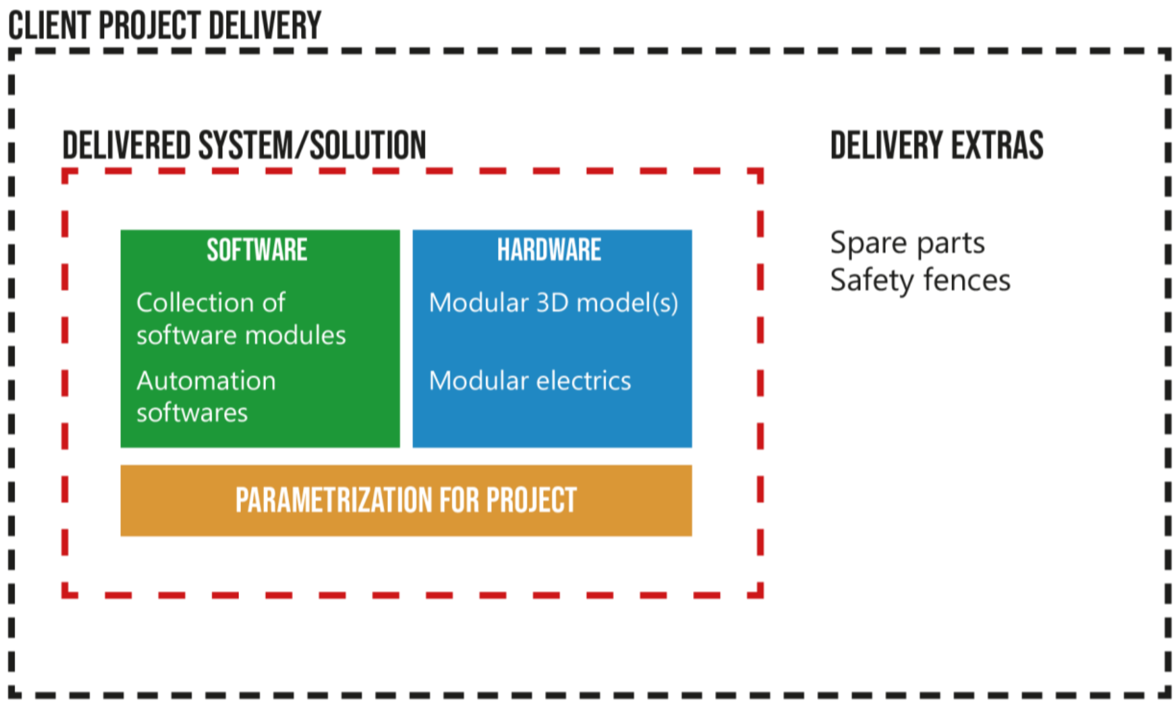


Figure 13: Current client project delivery structure.

The implementation of a PLM in the current business model raises a couple of questions. When the project is in a PLM, where do the uncategorized components sit? What is the interface of a product inside the project? The answer to these questions is to separate the product, project and service and to create a well defined skeleton that can be inserted into a PLM.

It is important to thoroughly inspect the product information and recognize how it changes along the project supply chain. As Figure 14 illustrates, every stage of the chain can introduce changes in product information. It is critical to discern what product information is held and controlled by which party – product, project or service. A PLM alone will not solve this problem as there needs to be a plan for change management, but it helps in governing said change management processes.

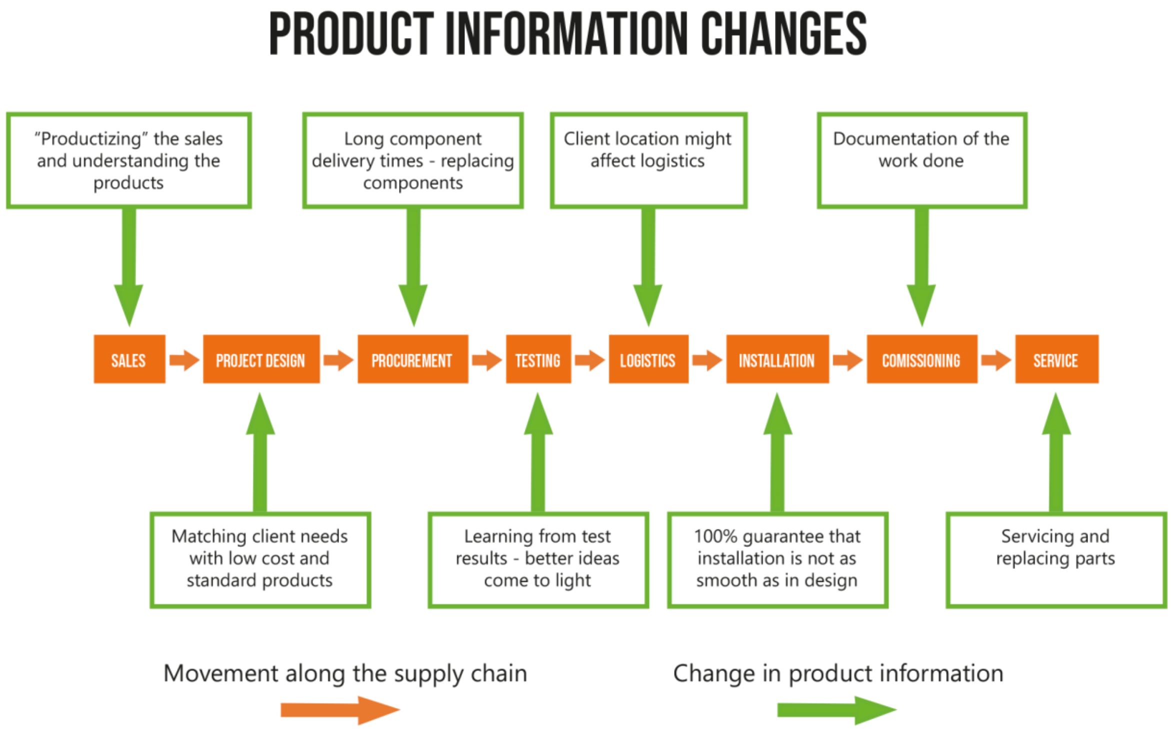


Figure 14: Product information changes along the supply chain (RemaSawco internal document).

5.2.1 Product

A product structure can be formed of a main assembly that consists of smaller sub-assemblies that are made from even smaller assemblies and parts. There are different ways of approaching the product structure depending on the amount of detail needed. A good way to form a product structure is to think of it physically. It is a structure of parts and assemblies attached together with no loose parts. (Hietikko, 2008, pp. 172–173)

The goal in building a product structure for a PLM is to recognize and keep only the best technologies, change management processes and documentation principles. This can be a laborous process, but it forces the company to examine their data and make a judgement call of what is useful product information and what is not. Inserting the product structure into a PLM with this in mind naturally streamlines and declutters the product portfolio.

As mentioned in the beginning of chapter 5.2, the company thinks of the delivered system as a whole, a product. By inspecting past projects and looking at common client needs and requests, it can be recognized where the change usually happens. A method of creating a product structure is by “caging” the changes within the borders of the product’s interface. If the system is divided into well defined product structures, product changes have to be made to just that product and not the whole system. This works in the other direction as well; if an aspect of the system needs changes, the products within it can stay unchanged. This is one of the keys to less NRE.

5.2.2 Project

In a project the aim is to have a clear skeleton of the integration to the client environment. The existing project drawings were inspected on how the product structures interact with eachother. The idea of making a General Arrangement (GA) model of the client hardware environment was researched. A GA is a presentation of the overall layout, showing the location of components and assemblies and their relations (Designing Buildings Wiki, n.d.). How the products would sit in a GA, and what is to be included in a GA in terms of a project delivery were discussed.

As is illustrated on Figure 14 in chapter 5.2, the product information changes throughout the project supply chain. In the company the project documentation was inspected and the internal and external documentation were differentiated. Internal documents are documents that are part of the project delivery but not depending on the client. An example of an internal document is a general x-ray safety document. External documents on the other hand are project documents based on the client, such as safety fences which are always done on a per-project basis.

5.2.3 Service

In the current state of the company, service is not compatable with a PLM. A structure for it needs to be built. As service is relevant only after deployment to the field, the structure for it should reflect this. How service work is done and documented, e.g. keeping track of replaced parts, was studied and a functioning service model in PLM was developed using serial numbers.

5.3 Setup of the system

Aton is available as SaaS (Software as a Service) or as an on-premises solution (Roimaint, n.d.). RemaSawco opted for the on-premises option and a server for Aton was created to and is hosted at the RemaSawco Oy Finnish office in Mikkeli. Client-based VPN access to the server was created, so the PLM can be accessed from all RemaSawco offices.

The parametrization of Aton was set in motion. This included steps such as the definition of the user groups as well as creation of document templates, document groups and item groups. The dictionaries were created as well as different item statuses. Item attributes, which are specific product information, were thought of and introduced. Examples of these item attributes are the supplier information of a bought component, weight and dimensions of a part. Special attributes were also formed, one of which is “spare part stock priority”. This attribute describes how critical a part is to the proper function of the product it is used in. A good example of a very critical part is a camera that is used in 3D scanning. A limitation of this is that the same part can have a different function, and thus a different priority, in different assemblies. The attribute is merely an additional spare part sales feature accessible from PLM.

Utilising item groups and an item dictionary, component libraries based on the RemaSawco’s warehouse were formed in Aton. As the implementation process went on, the products of RemaSawco Ab and the whole product portfolio was taken into a closer inspection. It was noted that many products use similar components but from different brands and suppliers. Having the component library in the PLM, helped in indentifying this issue, as was also mentioned in chapter 4.2. From the current products, the “pilot” products for the system were selected. Work on creating the project deliveries from modular product structures was started.

6 Defining the product and project structure

As previously mentioned, the main objective for RemaSawco is to find a way to separate a product's lifecycle in Aton PLM. The lifecycle goes from R&D product to project delivery and continuation of service and support. To achieve this, products and projects and their structures are defined in PLM using Aton structures. The use of Base Product, Base GA and Project Template is introduced. The organization of service and support is made possible with Aton Serial number structure, which is showcased here.

6.1 RemaSawco updated project and product model

When the products were inspected, many overlapping elements were found. Essentially, there were many versions of the same product with slight variance to each other. This lead to the creation of the Base Product model, which is the definitive version of that product. Ideally the Base Product is made from the most common variable of the product and is used as the default. The aim is that sales start with the Base Product, and variations to it can be made according to the customer's needs.

One of the greater questions was how many Base Products should be created. It was decided that the less of them, the better. Some product types had variants that were very close to each other and finding the Base Product variant was relatively easy. A certain product type however had substantial variations, so the solution was to find the variants with most common elements and group those together to a Base Product.

As the Base Products were made, changes in the product element structure were made as well. The old electric and mechanic were combined to form the hardware element, while software and PLC together formed the software element. Figure 15 illustrates the changes between the old and new product element model.

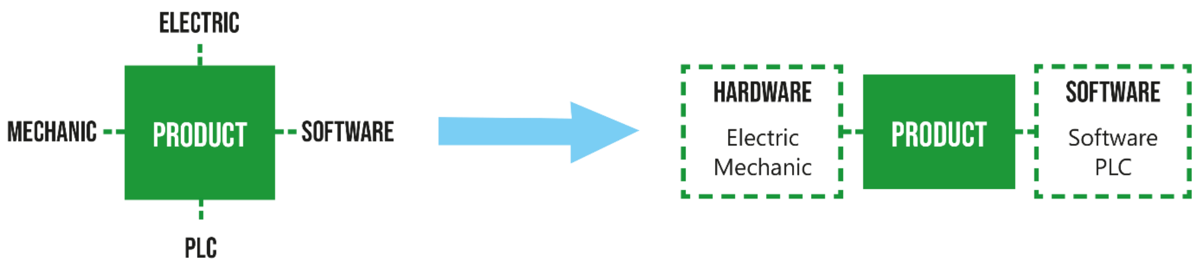


Figure 15: Old (left) vs. new (right) product element structure.

The new way of product definition has two elements: Hardware and Software. When the standardization was done, it was decided that every product should include the two whole elements. Some products may not include every subpart such as the PLC, but this was deemed acceptable.

The project supply chain is built heavily around hardware. Hardware includes design work, construction, testing and physical installation. Software elements in the project chain are installation, parametrisation, UI, testing and commissioning work on site. Hardware can be thought of as the physical skeleton of the project, while software is the brain.

6.2 Defining a product in PLM

The importance of product definition should not be overlooked. As Sääksvuori & Immonen (2008, p. 45) put it: "The product structure forms the foundation of the PLM system." Modular Base Product models were formed from the existing products. The Base Product is a version of the product that includes all the possible product variations within its structure.

How this works in the Aton structure is that the structure itself contains all the variants. If the customer wants the Base Product variant, it can be placed into the project as is. By removing some items or changing the amount of them, a variation is created. This variation is renamed as a customer specific product and then moved to the project structure. An example of this is a 3D scanner that can be used as standalone product, but also alongside an x-ray scanner. If it is used standalone, it has protective shielding. If the two are used together, the shielding is not part of the product as they share a protective cabin. The "with shields" version is the Base Product as the structure is the same as the "no shields" version but with additional parts. When the variation of “no shields” is made, the shield parts are simply removed from the structure and no other modifications are needed. All Base Products are categorized under the “Base Products” item group in Aton.

The Base Product model has many benefits. It makes the assembly depth lighter as this has to be taken into account when copying the structure to a new variation. The modularity of the structure eases manufacturing and testing. Base Products are separate from the viewpoint of the customer delivered system – the system is made from Base Products. This way if the customer wishes to customise a part of the system, only that Base Product has to be modified and not the whole system.

The Base Product model reduces NRE by utilising existing structures. The client-based solution is formed by parametrization of the model. From the viewpoint of R&D, the Base Product model is beneficial as the project delivery is always done from the latest and most up-to-date version of the product. This helps in minimizing errors.

6.2.1 3D mechanical design configurability

With a modular system, favourable technical and economical solutions can be provided when they can be based on a few defined modules. When variation is needed, it is important to look for variants that can be produced without changes in basic design and working principles. (Pahl, Beitz, Feldhusen, & Grote, 2003/2007, pp. 495, 503)

3D mechanical design configurability is a key aspect that was taken into account when creating the Base Product. When R&D (Research and Development) is done and modifications to the products have to be made, having a fragmented system with different variations of the product would be a disaster as the same work would have to be done multiple times. As the Base Product is the template, all modifications should be done to it. The Base Product includes all the variations so the changes will be made to those variations as well. Using the 3D-CAD software SolidWorks can be greatly utilised in the fine-tuning of the modularity as well as in the generation of the technical drawings for production.

A modular product structure is ideal for production (Hietikko, 2008, p. 173). Companies often realise the need for modularity and initiate it after it becomes clear that what was originally conceived as an individual product is realised to produce a large number of variants. The benefit of having a fully-kitted solution such as the Base Product is that all the components can be tested to work (FAT testing, safety, etc.) and stripping the solution does not require extra testing as parts are removed and not added. An example of this is the aforementioned 3D-scanner with shielding. (Pahl, Beitz, Feldhusen, & Grote, 2003/2007, pp. 495–496)

6.2.2 Electric design

Regarding electric design, it is important to distinguish what are the product's internal electrics. The Base Products within the system have electricals between them, as well as usually a main power center, but these should not be included inside the Base Product. They are looked at as individual elements. The electric design between the Base Products is done in the GA, which is the client delivered system. The same rule applies for cabling. Inside the Base Product there is an electrical box and only the cables running between that box and the Base Product's components are included within the Base Product.

6.2.3 Software integration to PLM

All the products that RemaSawco produces are controlled by software. The operator of the machines uses these softwares from their operator environment which has a PC-rack. This PC-rack holds the computers that run the software, and these computers should be defined and standardized. As a project delivery is done, it needs to be known what computers are included in the delivery.

A software in Aton is a Base Product item but for each customer project delivery, a new copy of the software item is always made to control the version handling. Updating the software should only affect the Base Product item and not the custom item in the customer project. Otherwise the version would be mismatched to the one that is actually deployed in the field.

The unavoidable custom setup in the software side is one reason why separating the system to smaller modular Base Products is vital.

Different products have different software and if a delivery includes for example the 3D-scanner and x-ray scanners, they require separate softwares. If the delivery only has the 3D-scanner however, only that software is required. The challenge in integrating the software into PLM is that one computer can have multiple softwares installed to it since there is usually no reason to have separate computers for different softwares. Having all softwares installed onto a computer as the default is also not ideal as some softwares require a stable environment which other softwares might crash. The software architecture and system designing is in a key role when defining the integration of software and hardware.

One way of solving this challenge is using item relations. In the computer's Aton item there is no software. Instead all the required software is added as an item relation to the main project software item in the project tree. This way there is no need to have a custom computer item for each project.

6.3 Defining a project in PLM

Projects in Aton PLM are created using item structures. It is important to distinguish between a project and product in Aton. In the structure, the project is the uppermost structure level and the products and project documentation are under the project item. The project and product structures are always the same regarding electricity, cabling, safety and software. These items are in the 500, 501, 600 and 700 positions in the Aton structure respectively.

Projects are created using Project Templates. A Project Template is a fully functional client delivery systems that utilizes Base Products as a template for project delivery. When a customer project is made, the structure of a Project Template is copied to a new Project item and renamed accordingly. The Project Template has a Base GA and the empty structure for everything related to the project and the client environment.

The Base GA is the uppermost hardware level assembly. It has Base Products and project electricity in it as well as possible extra components such as spare parts. Some parts of a project delivery require engineering Base GA and Base Product work the same way in terms of customization; a new “Solution GA” item is created with the structure of the Base GA and the customization is made in the new Solution GA.

Figure 16 is an illustration of the Project – GA – Product structure tree. The 3D-models of the Base Products are created with SolidWorks and take up positions 1-499 in the Aton structure tree. This is enough headroom since no assembly has over 500 components. The project electricity and cabling are inside the GA, since they are a part of hardware. The product safety and software are labelled as templates, since they are empty when the structure is copied. The naming convention helps to distinguish between modified and unmodified items at a glance. This same logic applies to the naming of Base GA and Base Product.

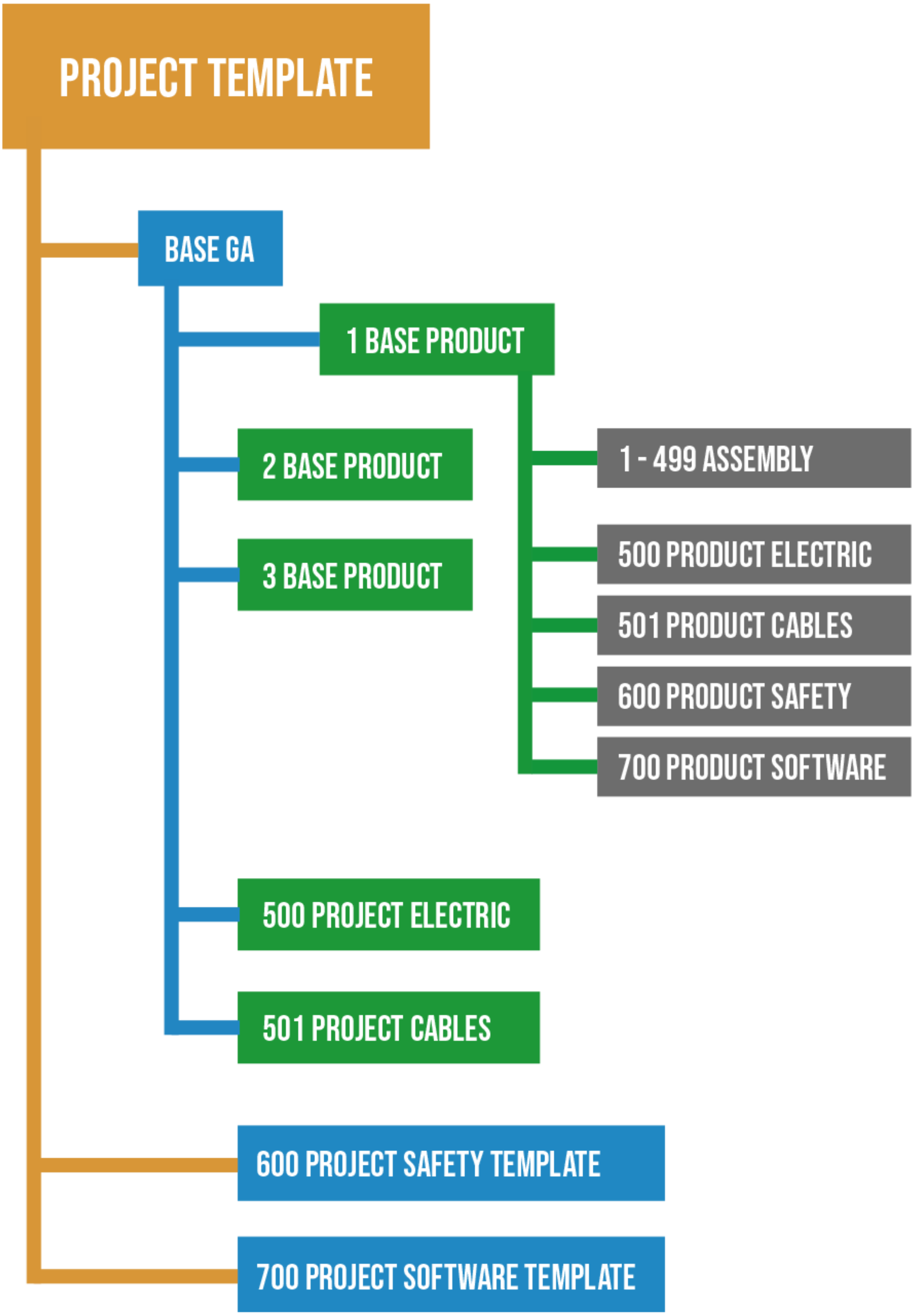


Figure 16: Project Template structure tree.

While the Project Templates ease the workload of the engineer, some design work is still required in every project. The customer's customization has to be implemented when necessary. Electrics between products in the project have to be designed on a project-by-project basis, since for example the location of the main power center is unknown. This could be solved by having many extra cables, but that would be more costly than the design work. Safety is also one of the things that is impossible to fully design into the Project Template. Every deployment field is different and if the project is an integration to an existing system – which is often the case – the existing safety solutions have to be taken into account. The Project Template includes an empty "Project Safety template" in its structure, which is then filled with customer specific documentation. The relationship between product and project design is that good product R&D work eases the design work of the project.

6.4 Defining service and support in PLM

The importance of PLM is realised through the fact that often aftersales and service need to be able to service and repair a product after what could be tens of years after deployment to the field. Product structures and used components may vary greatly from when the product was designed and more product variants may have been deployed. Specific information about product structure is needed. When a PLM is built properly on stable grounds, this information can be gathered and used with ease. (Apilo, et al., 2008, p. 86)

When the project is deployed to the field of the customer, the responsibility of change management switches over to service personnel. For this, the solution was found to use the Serial number structure function in Aton. The serial number structure freezes the project structure at the time of deployment to the field. All changes to the project after deployment will be logged into the serial number structure. For example, when a part needs to be replaced, the old item will be deleted and replaced with the new one. The toggle "show deleted" will display the previous items along with their validity date. Another functionality is that maintenance documents can be added on to the serial number structure, but they won't be added to the main project structure. The serial number stays purely in the use of maintenance/service and is ideal for this exact use.

7 Conclusions

This thesis was a review of the implementation process of a PLM and product structure definition within it. The zero point for this project was that the company had no system of data management in place and no defined product structures. The solutions provided were researched by studying PLM systems and working with the company during the implementation process.

The research question posed in the beginnin of the thesis was "What is the implementation process of a PLM like and how can a PLM be used in defining a product structure?" To answer the question: The implementation process of a PLM requires preparations and thorough planning of the company's processes. A PLM provides a company with a set of tools to handle their product's structure, lifecycle, version control and documentation. The inclusion of service into Aton PLM demonstrates the capability of a PLM to connect different company functions together, as was indicated in chapter 2.1. The use of Aton's groups mentioned in chapter 2.2.1 helped in the formation and track-keeping of the Base Product, which was one of the main solutions to the product structure problem. The Aton for SolidWorks add-in introduced in chapter 2.3 was a key tool in the visualization and production of the Base Product and the GA.

The partial move into the PLM system was underway at the writing of this thesis. The Base Product and Project Template structures were formed but could not be tested on any actual projects yet. The move into the serial number structure for service and support could not be initiated as the function was going through heavy changes in personnel.

As the topic discussed in this thesis was new to the author, there were some limitations. Even if the theory side is understood, extensive hands-on experience with a PLM system is required to fully grasp the benefits it can bring as well as the drawbacks of the system. Working from Finland, getting a proper picture of the company as a whole was challenging. Seeing how things develop in the company also takes some time, but the groundwork for development has been made.

RemaSawco gave the following comments on the work: The overall scope of the work was challenging as the topic is rather wide. A lot of thinking outside the box was required to achieve results, both from the author and from the company's perspective. Due to these factors, the final shape and structure might change from what was written in the thesis. However, RemaSawco is satisfied with the result as a clear skeleton of the product portfolio was achieved and many unclear terms were defined. The company also understood that the extent of the work requires the documentation of everything along the way, to keep the bigger picture from disappearing.

While the work of rethinking the product structure is nearly done and the solutions were found, adapting them as the main way of working and the implementation of the PLM system as a whole is still underway in the company. The observed disorganization and fragmentation of the company is very heavy, and the progress is slow. There has been a lot of work put into the implementation, however, and in the future the company may embrace the PLM fully and integrate it into their process workflow.

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