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CREATION AND MAINTENANCE OF MATERIAL REPLACEMENT CHAIN

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Tämän opinnäytetyön tarkoituksena oli kerätä ja jäsentää tietoa tämänhetkisistä haasteista ja kehitysideoista materiaalinumeroiden korvausketjujen hallinnassa yrityksessä X.

Työn teoriaosuus keskittyy tuoterakenteeseen ja tuotetiedon hallinnointiin liittyviin seikkoihin, sekä edellä mainittujen vaikutuksesta materiaalihallintoon. Lähdeaineisto haasteiden ja kehitysideoiden jäsentämistä varten kerättiin laadullisessa kyselylomakkeella, joka lähetettiin valituille sidosryhmien edustajille yrityksessä.

Tämän opinnäytetyön tuloksena syntyi tämä tiedosto, jossa on jäsennettynä osallistujien esittämät haasteet sekä kehitysideat materiaalikorvausketjujen luontiin ja hallintaan liittyen. Opinnäytetyön kirjoittaja suoritti sähköpostikyselyn lisäksi haastattelut kyselyyn osallistuneille henkilöille, joista syntyi yhteensä 6 tuntia nauhoitteita. Haastatteluryhmien koko vaihteli yhden ja neljän henkilön välillä. Nauhoitteet luovutetaan tilaajaorganisaatiolle analysointia ja mahdollista jatkokehitystä varten.

Avainsanat tuoterakenne, tuotetiedon hallinta, tuotteen elinkaaren hallinta

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ABSTRACT

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The purpose of this thesis was to gather and structure data of current challenges and development ideas for the creation and maintenance of the material number replacement chain within Company X.

The theory part of this work focuses on product structure and product data management and on the impact of said topics to material management. The information for the actual development process was gathered by a qualitative questionnaire directed for selected stakeholder employees.

The outcome of the thesis is the file which structures the presented challenges the company is facing regarding the creation and maintenance of the material number replacement. Development ideas which were presented by the participants are also structured and contained in this file. In addition to the email questionnaire, the author conducted live interviews with the participants, resulting in a total of 6 hours of interview recordings. The live interview groups consisted of varying sizes between one to four people. These recordings are handed over for the client organization of this thesis.

Keywords Product Structure, Product data management, Product lifecycle management

CONTENTS

LIST OF ABBREVIATIONS

BOM	Bill of materials
CM	Change Management
CR	Code resolution
DMS	Document Management System
ECO	Engineering Change Order
ECR	Engineering Change Request
ERP	Enterprise Resource Planning
ID	Part identification number
MDM	Material data maintenance
MM	Material Management
MN	Material number
PDM	Product Data Management
PLM	Product Lifecycle Management
R&D	Research and development
RACI	Matrix defining responsible, accountable, consults and informed
RFC	Request for change
RPL	Replacement
SM	Supply Management
TS	Technical Service

WF Workflow

WOW Way of working

LIST OF FIGURES AND TABLES

LIST OF APPENDICES

The appendices contain confidential information and are removed from the public version.

1 INTRODUCTION

External and internal variables force companies to constantly improve. One topic of improvement is product lifecycle management. Product lifecycle management or PLM is a set of systems and methods which allows effective managing of a company's products comprehensively through their lifecycles. /2, p. 192; 3, p. 1/.

Due to various reasons parts are constantly updated. Some parts may not be longer supplied or something has to be changed in a part due to technical reasons. Also material number standardization causes companies to replace their old product with a new one. The old and the new product should somehow be linked together to establish effective managing of product data. The studied company in this thesis manufactures different kinds of end products. One part could be located in multiple end products and due to this deep analyses are required every time when a part should be replaced with another.

The purpose of this thesis is to gather and structure information of the current way of working and improvement ideas regarding material number replacement chain creation and maintenance in this company. Information for this thesis was gathered by a qualitative questionnaire via email. The results of the questionnaire are presented in this thesis. Live interviews were also conducted for the same people that participated in the questionnaire. The live interview data is not processed in this thesis but is handed over to the client organization for further development work in this scope.

2 BACKGROUND

This chapter will explain the purpose of the project and thesis itself and will go through the triggers and aims of the project and the purpose of the thesis. The thesis will be used as a base for further development of this project.

2.1 Purpose of the Project

The client organization has started a project to further develop their way of working on product data management. Product data is maintained in the ERP system. ERP stands for Enterprise Resource Planning. The studied company is using SAP as their ERP program. Their database consists of thousands of items and physically the same part could exist under multiple part ID's in their system. This leads to a situation where similar parts are stored in different bins in the warehouse. This has triggered part ID standardization within the company to streamline their product data.

Occasionally new product IDs are generated in the system to replace old ones. The new product ID will be linked as a replacement in ERP to the old ID. From now on this concept will be referred to as replacement chain. Figure 1 shows an example of a made replacement chain.

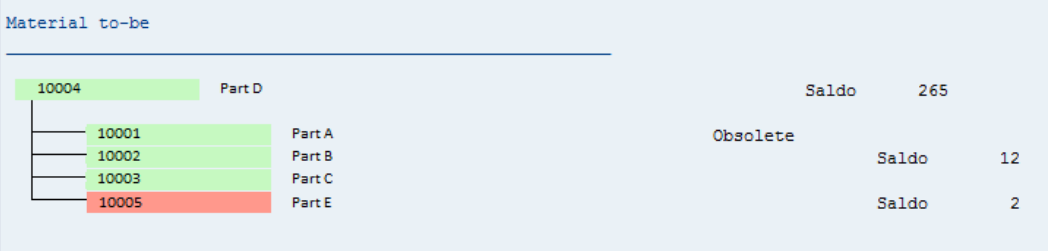

Figure 1. Replacement chain in SAP

In the above figure Part D with part number 10004 will be replacing other parts mentioned below it.

Replacement chains are created for multiple reasons. One major reason is part ID standardization where old part IDs will eventually be discontinued and the consumption of those parts will be under a new part ID. Sometimes the same part exists under multiple different part IDs. Multiple similar parts can also be a result of the company acquiring and purchasing other companies. The purpose of the standardization is to bring physically same parts in to the same warehouse bin.

The company has different types of end products. These end products may contain parts that are physically identical with each other but are maintained with different product IDs. In the picture below there is an example of a possible situation.

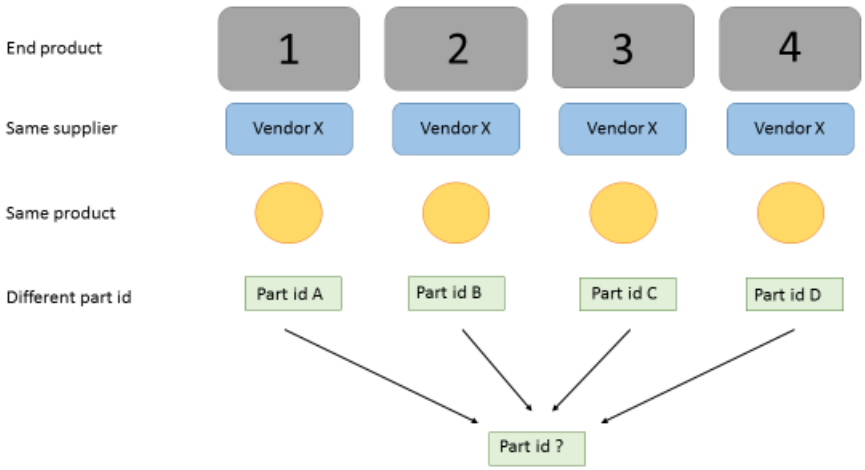

Figure 2. Part ID ownership example 1

In the example above all four end products use physically same part but with different part IDs. The question is, which one of these four different part IDs will be chosen for future use to all of these end products. In this kind of situation the internal owners of different end products are consulted. Each and every product owner wants to keep their own part IDs. If a replacement chain is needed and many end products are affected then it can be hard to know which part ID should be selected.

Product ID standardization is an example of an internal reason for replacement chain creation. Replacement chains may have to be created also for external rea-

sons. This could include a situation where a supplier has discontinued their product and replaced it with a new version. The new version could have changes in its physical attributes, and this could have a huge impact on many end products.

Sometimes products are replaced with new versions (and product IDs) which are directly interchangeable. This means that all the relevant attributes are the same in the old and the new product. This can result from both internal and external reasons. The reason for this kind of interchangeable replacement chain creation could be for example a change of material used in the product or logistical reason, e.g. a more efficient supply of said part.

One of the targets of this project is to define the owner for who has authority to make the decisions for replacement chains. This could help the decision making when multiple end products are affected. Another target is to define the process and the way of working for replacement chain creation. It should also be agreed who distributes the information to relevant stakeholders and who monitors that needed actions are taken. Currently there is no standardized way of working or decision making in replacement chain creation process.

2.2 Purpose of the Thesis

The purpose of this thesis is to support the project which was explained in previous chapter. The target is that this thesis work and its outcome could be used as a base for further development of the replacement chain creation and maintenance process by the client organization and other stakeholders. The information used for later development will be collected by interviewing selected members from different stakeholder organizations.

The development process will be explained more detailed in chapter 5 “Description of the development process” on page 18.

3 PRODUCT LIFECYCLE MANAGEMENT

Multiple information systems and managing methods are developed to master the processes and product data management within companies. Product lifecycle management or PLM is a set of systems and methods which allows effective managing of the company's products comprehensively through their lifecycles /2, p. 192/ /3, p. 1/. The following chapters mainly focus on product data management, which is an essential part of the PLM concept.

3.1 Product Data

Every product (or service) can be seen as a package consisting of components. Product structure is a concept model which structures components and its information in relation to other components. These components can be on multiple levels and the product structure illustrates in which order the components have to be put together. Basically the product structure defines hierarchically what is included in a product. The product itself is on top of the hierarchy and below are the sub-assemblies and components which form the product. /1, p. 123, 2, p. 27, 193/.

Product structure is often confused with bill of materials, which strictly speaking is not the same. Bill of materials (BOM) is a single-level part list typically used by manufacturing. This single-level part list informs what components are needed to build the product at hand. The bill of materials do not contain component, assembly or product structure hierarchy. /2, p. 17/.

Product data is the core of business functions in industrial manufacturing companies. Product data consists of three different kinds of specifications. Definition data of the product specifies the physical and functional attributes of the product. Lifecycle data includes technological research, design, production, use, maintenance, recycling and destruction data of the product. The Meta data contains information where information is located, what kind of information it is and how it can be accessed. /2, p. 7-8, 17/.

External and internal functions create and use product data in their daily operations. Internal functions include designing, manufacturing, service, spare part and purchasing functions. /2, p. 17/.

3.2 Product Data Management

3.2.1 General

Product data management is a method to manage product data. PDM is an important aspect of product lifecycle management and its magnitude is growing. It is a tool which helps engineers and other employees to govern the development process of a product. The main tasks of product data management is to create and store product related information, and help users to find the correct information when needed. At best PDM increases the performance of the company's business by improving productivity, because product data management helps to increase usage, quality, communication and development of product data. Product data management thus has a possibility to decrease product specific expenses, which can increase competitiveness, market share and revenue. /2, p. 9-18, 3, p. 207-208/.

3.2.2 Typical Product Data Management Related Problems

Typical problems in companies:

- Product data is not efficiently managed. There are multiple similar types of components in the company's part library. Typically it has been easier to establish a new title in the library than search for an already existing one.
- Designing and manufacturing are not utilising standard components from other assemblies and product families to the full extent. Standard components could be utilised more in different stages of designing and manufacturing.
- Purchasing may be using different suppliers to purchase parts that are identical to each other for different assemblies, and these parts are also stored separately in the warehouse.

- Product development and purchasing departments are maintaining product data of overlapping titles and their suppliers.
- Fast and uncontrollable changes in replacements and new designs lead to procurement of wrong components and invalid stock. /2, p. 102/.

Root causes:

- Difficulty of maintaining, searching and managing the product data often lead to procedure where new items are established when necessary because it is challenging to find up-to-date and accurate information from the existing part library.
- Difficulties of internal and external communication regarding product data changes. /2, p. 103/.

3.2.3 Change Management

Change management is a tool to convey latest information to the right need, to the right time /2, p. 21-23/. Change management enables the traceability for changes that are made into documents, titles, and configurations. Change management brings noticeable development opportunities to all change processes in companies making possible following cases:

- Controlled changes – change process is done in a beforehand determined controlled way.
- Announcing of changes that are made or are currently under process. Informing can happen for example via email.
- Digitalization, streamlining and expedition of change processes.
- Scheduled changes to existing titles – Certain change can come into force at a certain date or triggered by a certain event, for example when the available units of the to-be-replaced part are consumed from the warehouse.
- Storing relations of product data between old information and made changes. /2, p. 38-40/.

3.3 After Sales

After sales has seen a great increase in usage of PDM systems in their segment. The after sales market is especially important to companies which manufacture products that require noticeable monetary investments from their customers. The significance of the after sales market keeps on growing in these types of companies. As the products need to keep up to changing demands of the market, new product revisions are constantly introduced. /2, p. 44/.

New product revisions expose companies and their products to changes which require management to be efficient.

3.4 Integration of PDM and ERP Systems

The PDM system is an essential part of information systems in an industrial company, which can convert manual processes to digital. Software that is specialized in product data management generally have a lot of functions especially for handling of (product) titles and documentation. These functions are rare in an enterprise resource planning software. On the other hand PDM software usually do not contain the functions that are generally included in an ERP software. These two systems complement each other. /2, p. 61/.

3.5 Part Numbering

Part numbering means assigning unique identifiers to a specific set of attributes about a product. Part numbering is used to simplify the information processing and communication across the organization. By using part numbering the need for specifying product attributes when conveying information is eliminated. This is working well when the amount of products are limited and the products are simple. /5, p. 164/.

But as the number of products grow rapidly due to growing scale and globalization, it is difficult to have a shared understanding of specifications for different products. One solution is that each functional area (engineering, manufacturing and service) develops their own part numbers that their function needs to deal

with. /5, p. 164-165/. However, this makes it harder for using standardized part numbers between the business functions. The purpose of standardization is to prevent processes, products of services from varying over time. /1, p. 668/.

3.6 Traceability

Traceability is the ability to source the path of a product back to its origin. For continual progress traceability is important. Lack of traceability can lead to wasted time, energy and material. In some products traceability might be a legal and moral obligation. /5, p. 86-89/. Changes that are made into product structures and part libraries need to be done in a way which ensures that traceability is not lost.

4 RESEARCH METHODS

Quantitative and qualitative research are two possible methods for conducting research. Interest for quantitative research is to acquire numeral information. Respectively qualitative research method is used when the target is to receive information which helps to understand a phenomenon or circumstance. /4, p. 49-50/. Next chapters will present these research methods and compare which method suits this study better.

4.1 Quantitative research

Interest for quantitative research is to acquire numeral information. Quantitative research method suits studies which want to describe information in numeral ways or describe how something has changed in relation to something else. The purpose is to explain functions technically and numerally. /4, p. 49-50, 81/.

Information can be gathered by using various methods. Most common method for quantitative research is a standardised questionnaire. This method can be used when the studied subject can be measured, meaning that the answers to the questionnaire must be able to be converted to measurable form. /4, p. 49-50, 81/.

4.2 Qualitative Research

Qualitative research methods basically consist of different kind of interview methods. Interviews can be structured, focused or open-ended. /4, p. 101/.

In structured interviews it is typical that the questions are pre-formed. The structured interview is a valid method to gather information when the research problem is not very wide. If the desired amount of interview data can be reached with 3-6 structured questions, the method is valid. /4, p. 101/.

The focused interview method is commonly used in qualitative research. In a focused interview the questions are related to essential topics in which the research is trying to find answers to. The handling order of the topics in the interview is not relevant. Important is that the interviewee gets to provide his or her own view of every topic. /4, p. 102/.

An open-ended interview is not built upon questions and themes. The research topic can be discussed several times with the interviewee and he or she can freely speak of topics that he or she find important. Open-ended interviews are often executed individually (1 person at a time) and it is based on interaction between the interviewer and interviewee. The interviewer may perform additional questions that are based on answers to earlier questions. The target of the interviewer is to build a solid continuum with the help of additional questions. /4, p. 104/.

4.3 Chosen Method

The research method is chosen based on topic and nature of the research. The topic and desired results of this study are so complex that qualitative research method is a natural choice. The questionnaire for this thesis is a structured interview done by email. The interview method chosen for face-to-face interviews is the focused interview method with typical aspects from an open-ended interview, such as asking additional questions based on received answers.

5 DESCRIPTION OF THE DEVELOPMENT PROCESS

The data for this thesis was collected by a questionnaire which is sent via email. The participants in this interview process were briefed by a live introduction session. All the participants agreed to take part in this study.

The participants were interviewed in two rounds. The first cycle was done by email. The first cycle included 7 questions. The questionnaire form that was sent to the participants can be seen in appendix 1. The author also conducted live interviews for the participants, and they were conducted once all persons had answered to the questions in the first round. Face-to-face interviews were recorded and the recordings will be later used by the client organization of this work to further develop their processes. A total of 18 persons were interviewed. The process of this thesis is pictured in the chart below (Figure 3).

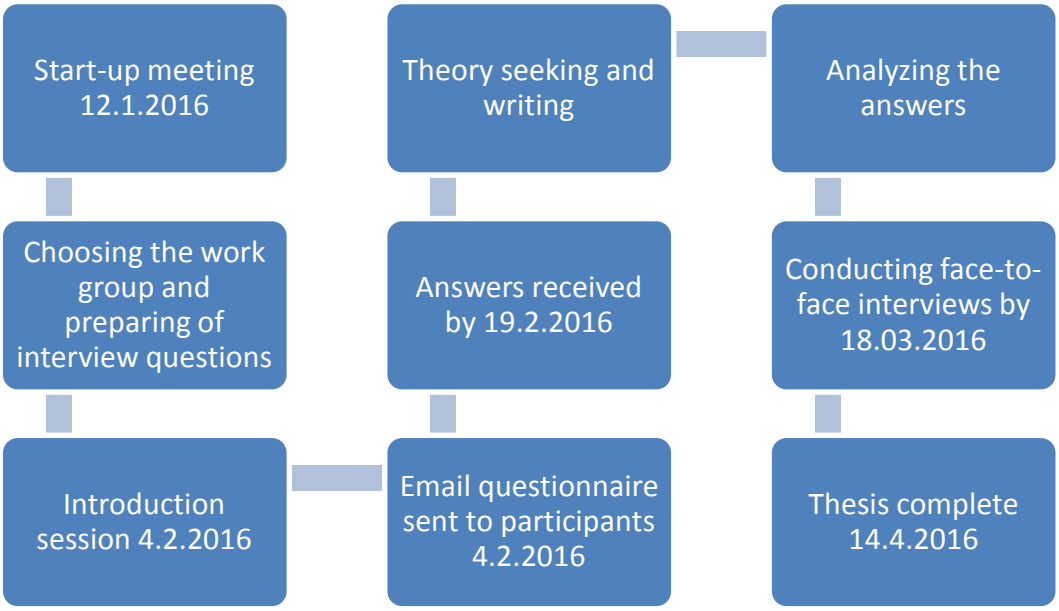

Figure 3. Thesis process chart.

The persons taking part in this study were from different departments that the client organization has seen essential to include. The stakeholders in this study included people who create and manage replacement chain data and people who use it.

The purpose of the next chapter is to present the answers from the first question round in a structured way.

6 RESULTS OF THE DEVELOPMENT PROCESS

Different kinds of replacement chain scenarios challenge the people in the company differently depending on each of their department and role in the organization. Some people create and maintain the replacement chains while other people are users of created replacement chains. The following chapters are based on results received from the questionnaire that was done in company X.

6.1 Effect of Material Number Lifecycle on Work

Input for material replacement chain creation can come from multiple directions. It can come from Supply Management, Product Management or Technical Service. The decision making process varies a lot depending on which products are affected by the replacement. Many times it can be challenging to know who the correct persons to contact are. Regardless of the case it is always the same department that activates the replacement chain in SAP.

> *"It's usually the requester who informs which material number should remain in use, but due to a lot of special cases we might have to create them in a different way." P1*

Purchasing is the main interface towards the suppliers. Purchasing gets frequently asked for offers by sales for materials that are obsolete. The task of the Purchasing is to check if requested goods are really obsolete.

> *"If not available then we need to find replacements if no replacement chains exists already. This requires checking material interchangeability with technical service." P4*

Technical Information is to be informed and made sure that replacement chains are done correctly when replacements are needed.

Purchasers may also receive information from the supplier that the company is using double material numbers to order the same part or simply that required part is replaced. Changes can be in the physical product or only in the part ID. If only part ID is changed, purchasers need to update it to the purchase info record. If the

product has been changed, then further details of the change are requested, and based on those details a new part ID can be created or the existing part ID updated.

> *"Product development are usually contacted to create replacing materials linked to drawings whenever a material specification or redesign for adaption is required. One factor that adds complexity is that an obsolete material might be used in many different ways…" P14*

This means that the same material might be used in many product types and in many product generations of each product type. This adds complexity to decision making because each and every product owner wants to keep their own part ID.

6.2 Challenges and Improvement Ideas

The questionnaire answers were used to build following sections. These sections are the main topics which appear in the responses.

6.2.1 Roles and Responsibilities

Most of the problems today in change management are related to the lack of unified way of working and responsibilities.

> *"There is no a clear process (roles and responsibilities) how to manage Request for change (RFC) and ramp-up and down of new/old/replacement material numbers…" P10*

Right now it is unclear who should make the decisions because replacements have the possibility of affecting multiple end products.

> *"Who should decide which material number should be used?*

Replacement chains are also created and maintained in several different locations.

> *Do we have similar understanding of maintaining this data in different locations?" P5*

For this reason global approach is required which defines the responsibilities and way of working.

> *"--the most important thing is to define the responsibilities and have unified way of working and some kind of global ownership. At the moment there are many projects ongoing in improving the master data, all by different departments. Which department that should be, I don't know, however, global unified approach and ownership would be needed." P8*

Multiple respondents indicated that there should be more common rules to the responsibilities for handling the replacement chain creation. This includes defining the owner and a way of working for this process. This was already assumed by the project team from the start and the results of the questionnaire strongly support this assumption.

Global ownership:

> *"At this point, I think the most important thing is to define the responsibilities and have unified way of working and some kind of global ownership." P8*

> *"It could be improved with proper material number change management, meaning that a team or organisation -- would manage and monitor changes to designs, material numbers etc…" P3*

Unified way of working:

> *"At this point, I think the most important thing is to define the responsibilities and have unified way of working…" P8*

> *"Common rules between businesses: Replacement chains should be handled in a similar way." P1*

> *"Define process, RACI matrix and owner" P5*

"People involved need more information about the best practise and the process." P6

"Having a global process for handling this with clear accountabilities and responsibilities defined." P7

"I think there should be some common practice which stakeholders to involve when making material replacement" P13

"We should maintain lifecycle with one WoW." P4

Having responsibilities defined is seen as a key topic in improving the replacement chain creation and maintenance. Defined responsibilities would also open possibilities for further developments, such as workflow implementation, which is presented later in this study. With responsibilities defined it would also be possible to create a process chart how the replacements should be created. In the live interview with P7 it came up that this process could utilise the stage-gate model.

The stage-gate model breaks a process into smaller stages which are divided by gates. Evaluation is made in each gate whether to continue with the process or not (go/kill decision). /6/. Each gate could have a responsible who fills in necessary information needed to continue each gate. Figure 3 shows the basic principle of the stage-gate model.

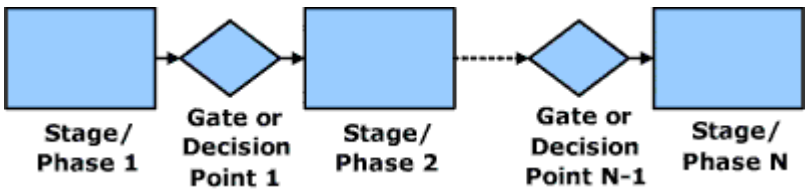

Figure 4. Stage-gate model /7/

Deliverables of this stage-gate process could be:

- The decision if replacement chain is made
- Chosen replacement part
- Decision what to do with replaced parts that are possibly left in the warehouse.

6.2.2 Who Should Make the Decisions?

According to the questionnaire results, the department making the decision should be based on the reason for replacement.

> *"It depends on the reason for the replacements:*
>
> - [Company X] *designed components, TS in cooperation with R&D and PM*
> - *Non*-[Company X] *designed components – purchasing (?)*
> - *Upgrade solutions – Product Management*
> - *Duplicate reducing standardization – Product Management" P2*

Support/decision from technical service is needed every time technical evaluation of a replacement is needed.

> *"Technical Service: Has to evaluate the replacement suggestions from a technical perspective." P1*

> *"--we need to have support from TS. We need to trust that technical service takes all possible installations and assemblies into account in their decision making." P4*

> *"It is also very important that when/If new parts are introduced it must be technically verified that the component is fit for purpose before the replacement can be made, for example not make replacements to o-rings that we already know will fail.." P15*

Material management (purchasing) usually gets the information if the part has become obsolete and may receive suggestions what to do from the supplier. Material

management also has consumption, cost and delivery time information available, which may help choosing the replacement.

> *"Material Management: Is the contact point to the vendors and usually gets the information that an old part isn't available anymore and what the vendor suggest that should be used instead. MM also knows which materials number could remain in use based on consumption, cost, delivery time etc." P1*

Technical information is the executer of replacement chain and their responsibility is to make the replacement work as intended in SAP.

> *"There might be needs for sales texts, condition based replacement chains, CR-updates etc. Also the information behind material numbers may have influence on which material number that remain in use for two equal material numbers…" P1*

There were few suggestions for the organization that should be the owner of the replacement chain process. From the division point of view it was seen that Service would be the owner of replacement chains.

> *"Currently would see that owner of the replacement chain is Service from division point of view even though new build side has some impact also." P5*

Two suggested organizations for the owner of replacement chains were Product Management and Technical Information.

> *"Product Management as a "owner" of the products and therefore also replacement chains" P5*

> *"--technical information is the department who should have the overall control and ownership of our master data. -- it would make sense if we would concentrate this material master knowhow in one place and once we have clear owner for it then also changes for us to keep it up to date to*

support our business is better than currently since there are quite some grey areas about the roles & responsibilities." P16

Decision making is not everything in replacement chain creation process. Naturally somebody has to analyse which end products and assemblies are affected by the replacement. This could be done by a dedicated team which coordinates and monitors the replacement chain creation.

6.2.3 Coordination

Right now there is no standardized way who for example analyses which end products are affected and therefore who to contact. Depending on the background of the requestor he or she might be able to do that, but not always.

The ownership and way of working could be supported by a team or organization that would coordinate and monitor that needed replacements are made. Especially the people that are involved in creating the replacement chains indicated that there should be dedicated team that would coordinate the material replacement creation process.

"The best would be to form an own team that would have this task as their primary duty, and the workload would not be a problem as we have thousands and thousands of changes each month." P3

"There should be some "committee" a small group of people who communicate the need and the schedule and then one nominated person who starts the automated process (in the WF)." P6

"From operative purchasing point of view it's MDM who create replacement chain, but obviously there is a need to analyse effects and background of the material numbers to be "killed" because there might be different consequences with different material numbers. Probably shared responsibility is no one's responsibility." P12

> *"No existing department can do it now* [make decisions regarding material number lifecycle]. *A cross divisional function is needed to manage this as replacements affect all." P11*

This team could be involved from the beginning of the stage-gate model and distribute the request for replacement to the corresponding owners. This would make it clear for all stakeholders from the beginning that which is the first contact point.

P3 suggested in the live interview that benchmarking could be done to demonstrate the possible benefits a dedicated coordination team would bring by comparing the costs that are currently caused by inefficient managing of the replacements versus cost savings and other benefits by having a dedicated team to coordinate material number replacement chains.

One possible tool which may help coordinating the replacement chain creation is shown in Table 1 below. This table stores key information of the replacement to be made and also the responsible stakeholders that have accepted the change. Filling this form could be a condition for creating the replacement chain.

REQUEST FOR REPLACEMENT CHAIN								REPLACEMENT CHAIN ACCEPTED GLOBAL BY			NOTICED GLOBAL BY	
OLD MAT NO	MATERIAL STATUS IN SALES SIDE	MATERIAL STATUS IN PURCHASE SIDE	POSSIBLE SALES TEXT	NEW MAT NO	MATERIAL STATUS IN SALES SIDE	MATERIAL STATUS IN PURCHASE SIDE	POSSIBLE SALES TEXT	TS	PM	SP	PLANNERS	SALES SUPP.
AAAA	Z3	99	NONE	BBBBB	NONE	00	DO THIS AND THAT…	TSA001	PMA001	PMA001	PLA001	SSA001
CCCCC	02	02	NONE	DDDDD	NONE	00	NONE	TSA023	PMA023	PMA023	PLA023	SSA023

Table 1. Request for replacement chain

6.2.4 Direct Replacement and Automatic RPL Updates

Direct replacement means that a part will be replaced in the system so that the old, discarded part will become non-existent. In other words the old part will be over-

written with the new part in e.g. SAP. This is not a good way to manage changes because the traceability is lost in these kind of scenarios.

> *"Worst case scenarios are cases where there is no new material numbers created for the replacement product. Only existing material is updated. If we do it like this, we will lose traceability and perhaps don't identify possible root cause if parts suddenly start fail in field." P4*

Identifying the root-cause may be challenging if a supplied part was replaced this way and starts to fail. This is the reason why replacements in BOM structures are not done automatically.

It has a downside that replacements in BOM structures are not automatically updated. It creates manual work for many different stakeholders. Purchasing for example needs to update the BOM manually when replacement is made. When subcomponents in an assembly are replaced, it needs to be informed to the system supplier, so they do not put old components into assembly.

> *"We have also seen that replacements are not always updated into assembly BOMs." P4*

> *"If changes are made to a BoM or material number in SAP, the same change would need to be reported also to CM organisation so that we could correct the PDM data at the same time assuring that PDM and ERP data are always 1:1." P3*

> *"Also Material Management -- have issues with material numbers in Bill of Materials, since old material numbers are not automatically updated (replacement chains aren't activated)." P1*

> *Many requests from purchasing to change material number/s reservations (in pp-order) from old material to new and vice versa" P9*

One practical example:

> *"Material number, which is a kit, was in top of replacement chain and had a BOM with many subcomponents. One of the subcomponents was incor-*

rectly added to the same replacement chain, which prevented the system to count the subcomponent requirements correctly. This caused shortage of the kit and delays to customer. Root cause, it was not checked if the replaced material is used in some other material number's BOM." P12

It would be beneficial for many departments if replaced materials in BOMs were automatically updated. Traceability must be ensured if automatic updates in different processes are wanted to be utilised.

"Replaced materials in BOMs / assembly drawings, BOMs and drawings should be updated

"Automatic updates in all processes: Sales orders and – quotations, Bill of Materials, Purchase Requests etc." P1

Answers to the questionnaire did not indicate in which way automatic updates should be handled to ensure that traceability is not lost.

6.2.5 Several Similar Components

Each and every product owner wants to keep their own part ID's in use. Owners have different preferences which makes it challenging to standardize the part libraries.

"Stake holders want their own MN to remain in use even though it might not be the most suitable one concerning double materials." P1

"Different preferences on the different production sites makes it also challenging to standardize Global standard component libraries." P11

Having several similar components active can sometimes lead to a situation that it is impossible to predict which one will be delivered to the customer the next time.

"When a replacement chain with several similar versions of a component exist in the system it is not possible to predict which version will be delivered next time to a customer." P2

Suppliers are also identifying duplicates for their products, but common understanding of which material number should be left for use is not always achieved. The main reason for this is that the duplicate materials may each have different owners.

> *"Suppliers are identifying duplicates for their products but* – [we are] *not always able to find common understanding which mat.number should be left for usage especially if duplicates includes different "countries"" P5*

The inability to identify possible replacement chains lead to creating even more part ID's.

> *"New material numbers created a lot even though there is existing in the system; applies especially for auxiliaries. SM/MM trying to take care of master data by asking replacement chains and on the other hand side those are not identified and new inquiries from the customers often ending up as a new material number" P5*

When replacement is made a decision should be made what to do with the replaced parts that are left in the warehouse.

> *"We should ensure that old stock will be used before starting to use new material. This should be done system wise -- Now forecast for the new material is put right away. And we start to buy new material right away. Can we put sales block to new material as long as we have old stock left?" P6*

There are some special customers for which it is not allowed to change the material numbers without a lot of extra work.

> *"Due to special rules -- parts can't be replaced (without a lot of extra paper work), we need to change the replacement chain requests concerning the material number that should remain in use." P1*

> *"We cannot be sure if replaced mat no affects to some other department's work. For example for some -- customers it's not allowed to change mat no, and we have to keep duplicate materials open." P12*

In urgent sales cases it would be beneficial to notice if there is the physically same part available under different material number. But due to the high amount of material numbers in the systems they have a high chance of not being noticed.

> *"In escalation cases, where it would be important to find material quickly and we have e.g. no stock. Then it would be really helpful to know if we would have the same material available maybe elsewhere, but due to multiple material numbers it will be never noticed." P8*

Standardizing the part library even further reduces the amount of individually stored titles in the warehouse and helps users to find the available parts easier. Also it eliminates the need to store the product and supplier information of overlapping items.

> *"We should constantly try to harmonize our material numbers and try to get rid of double material numbers." P4*

> *"Overlapping material numbers should be cleaned in order to increase stock visibility and to have the replacement chains in place" P8*

> *"Material to material –change to be done when having a material with two different MNs in stock" P9*

The previously explained stage-gate model could be used as a supporting tool for decisions of which parts to leave for use of the overlapping parts.

6.2.6 Communication

Currently communication regarding replacement chain creation is done in scattered way. Very sudden changes and lack of way of working are mostly why the information is transmitted in many ways.

> *"The biggest challenge today is to get information about "change decisions / needs". Today we receive this information in a very scattered way (e-mails, phone calls, corridor talk …. or not at all)" P7*

Sometimes replacement chains are created without all the necessary information in place. This includes information what to do with the replaced parts that are left in the warehouse.

> *"Not all related information in place from beginning, for example information if old material should be scrapped or not or can we use up old stock and after that begin to use new material number." P6*

Lack of information can lead to a situation that the replaced parts are left to the warehouse unused while the replacement part may not yet be available. All this can culminate into a situation that the company is facing unavailability towards the customer while scrapping the old possibly usable parts.

> *"--sales not using the old materials -> we end up devaluating and scrapping and at the same time we are facing unavailability towards the customer…" P6*

Information on what to do with the old stock should be available from the point replacement is made and then stored somewhere. That knowledge should be easily accessible for those who need that information.

One suggestion for improving the communication when creating replacement chains was that communication would be done through a workflow tool in e.g. SAP. SAP help portal describes the workflow tool in a following way:

> *"SAP Business Workflow can be used to define business processes --. These may be simple release or approval procedures, or more complex business processes such as creating a material master and the associated coordination of the departments involved. SAP Business Workflow is particularly suitable for situations in which work processes have to be run*

> *through repeatedly, or situations in which the business process requires the involvement of a large number of agents in a specific sequence." /9/.*

The author of this work has formed a perception that having a workflow tool would increase the efficiency to manage the replacement chains a lot. This perception is solely based on interviewing the people who are involved in creating the replacement chains.

> *"You can also use SAP Business Workflow to respond to errors and exceptions in other, existing business processes. You can start a workflow when predefined events occur, for example an event can be triggered if particular errors are found during an automatic check." /9/.*

The workflow process can contain fixed fields which would collect and pass forward important information.

> *"We should have fixed fields where required information is filled and this information would be visible in all relevant tools." P4*

If the process would be done in the workflow, communication could possibly be more streamlined. Having a workflow is seen beneficial in many ways:

> *"Having a work flow tool (e.g. in SAP) that supports the process. This would enable statistics, bottleneck identification, resource planning etc." P7*

> *"People involved need more information about the best practise and the process. On-time information. Automation! WF forms that you need to fill and you can't get forward with the task if there are open questions." P6*

> *"Easier replacements should be more automatic, if replacement chain is for material where we have not had any or minor consumption it does not need to be checked by planners at all. This could be something that should be taken into account by giving some categorization and priority according that. This could be fixed in WF." P6*

Global ownership and responsibilities should first be established before considering implementing replacement chain creation to the workflow.

6.2.7 Data Quality

The quality of information behind each individual part number varies. Sometimes it may be challenging to make replacement decision just by comparing the data.

> *"One challenge is to know if a part is replaceable with another just by comparing data as the quality is very varying. Experience is needed from both systems and real life to be able to decide, and sometimes investigation is needed to other departments and even workshop floor to be able to decide." P11*

Sometimes replacements are done based on existing data which can lead to compatibility issues when sufficient background checks are not completed.

> *"Sometimes I see that there can be made material replacement made by Material Management (Purchasing) without sufficient background check if the new material is compatible with all the application where that old material has been used." P13*

Parts may face compatibility issues within the end products when background checks are not done thoroughly. Insufficient background checks and/or using not tested or technically verified parts can also eventually lead to increased warranty costs and dissatisfied customers.

> *"Replacements to not tested or technically verified parts when no technical persons have been involved, causing warranty costs and dissatisfied customers…" P15*

6.2.8 Material Statuses and Sales Text

Sometimes there is a need to temporarily unblock certain obsolete material so that a process can be completed, for example creating a delivery for parts of which one is marked as obsolete in the system.

"Material statuses needs to be changed due to some process that can't be completed -> lack of information when the statuses can be changed back, unwanted processes can be initiated (new purchase- or sales orders) during the time the material number is "released"." P1

There is no standardized way how long the material status will remain open. During that time some unwanted processes might be initiated. Minimizing the amount of unwanted processes could be done by minimizing the time frame that the obsolete material remains "open".

Sales texts are often a result of outcome that cannot be achieved by a replacement chain.

"In some cases it's not possible to create replacement chains since the old material number and the new one is not 1:1 or the replacement chain is only valid for certain conditions -- Then we have to rely on sales texts." P1

Occasionally the sales text might be unclear or too technical to understand for certain stakeholders.

"Sales texts are often unclear, resulting unnecessary work trying to understand what is being meant with the material text." P8

"Since the texts are often quite technical, it might be difficult to write them so that all stake holders understand them and can act according to the information." P1

It is also possible that sales texts are not read when they should be. Process improvements are needed to ensure that the most vital sales texts are noticed.

"Process improvements concerning the necessity to read the sales texts and act according to the information.

Sales texts could also be more standardized:

A more standardized form for the sales texts: What to do, Why, Who to contact etc." P1

6.2.9 No Replacement

Sometimes it happens that part has become obsolete and there is no direct replacement specified. Another possibility is that replacement is done for the obsolete material, but the new part does not yet exist in stock.

"Replacing material can be also obsolete.

The replacing material is already in CR, but there is none in the stock whereas the old material would be still in stock. (Long lead times-> customer not ordering from us)" P8

In both of these situations lead times are usually long and the customer may end up not ordering the parts from the company.

"Obsolete materials not having the replacement chain -> could these be proactively updated and not wait until there is order or quote as it at that stage will cause huge delays into order and quote handling -> again, response time, unsatisfied customers" P8

6.2.10 Different Data in ERP and PDM Systems

Currently replacements are managed in ERP and there is little to no information transferred back to the PDM system. Therefore, people who only use the PDM system are not receiving up to date information of replacements.

"--difficult to -- identify the correct material numbers when we have different SP BoMs or different material numbers in use in PDM vs. SAP. Many times the change has been corrected in SAP but the old wrong data is still in the PDM system." P3

Engineering mainly maintains their data in PDM system. All other systems including SAP are the responsibility of other organizations. Changes to parts in the PDM system are informed by change notice.

> *"--we can only affect directly what is in PDM (and DMS) and all other systems are the responsibility of other organizations. We see many times that the data in SAP in not maintained according to the instructions in CN and differently between the different plants." P11*

Responses indicate that the dataflow between PDM and SAP is not bidirectional. This means that the information flow is only from PDM to SAP.

> *"Today the information flow is only from PDM -> SAP (as far as I know). This would mean that replacement chains should be handled in PDM and perhaps also material statuses should be there. On the other hand, as long as SAP is the system used for the management of parts / sales / purchasing etc., we should perhaps have a transfer of information also from SAP –> PDM. If a material is blocked as obsolete in SAP, the information should also be visible in PDM as well as the replacement chain." P1*

Because SAP is the main tool for sales and purchasing functions, the material statuses and replacements are also currently handled there.

> *"--it should be made impossible to send obsolete data from PDM to SAP, but that seems now to be under construction." P3*

The information should be the same in both systems. Right now the material statuses and replacements are handled separately in both systems.

> *"Information should always be the same in both. We have a lot of cases where TS does not have ability/skill to check information from SAP and they are only relying on drawings from DSM/PDM. It could be so that when new revision/design is made, some dedicated persons check those and contact relevant functions. Current d-messages are often too hard to read and understand for purchasers." P4*

Changes in SAP should also be updated to the PDM system by the CM organisation:

> *"If changes are made to a BoM or material number in SAP, the same change would need to be reported also to CM organisation so that we could correct the PDM data at the same time assuring that PDM and ERP data are always 1:1. On the other hand it should be made impossible to send obsolete data from PDM to SAP, but that seems now to be under construction." P3*

Ongoing PDM program should bring the material master to PDM.

> *"I suppose that this will come via the work ongoing in the PDM Program. The Material Master will be in PDM. So in -- the future -- no changes should be done in SAP. SAP will only be the "Slave" to PDM." P7*

> *"--want to highlight that when PDM utilization will come fully in force later on this year, sufficient training for relevant functions is a mandatory" P5*

6.2.11 The Reason for Replacement

Knowing the reason why a certain replacement chain has been done could be valuable in many situations. This came up many times in the questionnaire answers.

> *"Records of the reason to change should be behind each material number and who has made the decision." P10*

> *"--it should be easier to track when and why certain replacement chains are done" P4*

> *"--in some cases there is nowhere to find information why there has been made a material replacement. I.e. is it due to obsolescence, technical problem, duplicate material number, or something else." P13*

> *"I also think there should be some internal note field somewhere where one could see the reason to the material replacement." P13*

Nowadays the reason for replacement is added into the system when creating replacement chains. Older replacements currently do not contain the reason in the system and the reason need to be asked when needed.

> *"Good addition was when additional info can be found in replacement chain nowadays (cannot still find info of older chains though.)" P12*

Appendix 2 contains instructions how to check the reason for new replacements.

> *"Also it should be easier to track when and why certain replacement chains are done. Currently in problem cases we need to contact MDM and ask who has done each replacement chain. -- If we have luck, the person has relevant emails still saved or stored somewhere. -- Perhaps we should have some simple form that needs to be filled in case of replacements and this form would be shared to relevant functions and stored afterwards." P4*

The above scenario still applies for older replacements, because the reason for replacement in only added to the replacements that are being done today. The reason for older replacements needs still to be asked from the MDM team. The stakeholders are able to see the requestor for the new replacement and also a short reason why it has been made.

6.3 Live Interviews

The live interviews were recorded. The interviews resulted in total of 6 hours and 15 minutes of recorded material. Interviews focused mainly on process improvement ideas and rules to material number replacement chains. All the participants had the opportunity to provide information that they think would be relevant for this study. The recordings are handed over to the project team which will use the interview material for further development work.

7 CONCLUSIONS AND EVALUATION

7.1 Credibility

The content and the length of the answers varied between the persons. Not all participants responded as detailed as others. For this reason some matters are handled in more detailed way than the others. One person out of eighteen persons did end up not participating in this study. This has to be taken into account when reading the results.

It is possible and likely that some aspects are not brought up by this thesis. However, this work gathers together mentioned challenges and development ideas and the author thinks that this work gives a good starting point for the project team as they are now all mapped in one file.

For credible research it was seen important to distinguish the author's words from the participants'. This is done in the work.

7.2 Summary of Interviews and Results

While doing this thesis it has been confirmed that the scope of this study is very wide, and future development is needed. There are some main aspects which create challenges. These aspects were also presented in Chapter 6 of this work.

The main thing that came up is that the process for change management is not defined. There could be a defined process supporting the replacement creation, and above all, the decision making. The need for a defined process was already assumed by the project team from the start, and this thesis confirms that need.

Defined responsibilities is a second big thing which would need to be addressed. Two suggestions for a process owner were presented, and they were Technical Information and Product Management. There are still open questions regarding other undefined responsibilities in the process, for example who should make decisions in each situation and who should coordinate the replacement chains and their information flow.

According to the results, one possible solution for coordinating the replacement chain requests and decisions is forming a dedicated team. This team could monitor and coordinate the replacement chain creation process. Piloting this type of team on a smaller scale might be reasonable.

Direct replacements are causing challenges in the bill of material structures. On the other hand, manual replacements create more work. For this reason it could be investigated how this could be improved by for example automating the process.

As mentioned earlier, the communication regarding replacement chains is done in a scattered way. One method to improve the communication is to build a workflow process in ERP which supports the process. This would bring in also other benefits in addition to streamlined communication:

- statistics
- bottleneck identification
- resource planning

Another main concern was the information flow issues between PDM and ERP software. This topic is under investigation of another project, which might be able to offer solutions to one-way information flow. In the future all the replacements might be handled in PDM instead of ERP.

From time to time users would like to have information why certain replacement is done. Basically today this is possible, although the reason that is visible in the ERP is only a short description of the reason. The detailed reason need still to be asked from the MDM team.

7.3 Ideas for Future Development

Naturally the first future development idea that comes to mind is analysing the live interview data that was generated during this thesis.

It is clear that a process with responsibilities needs to be defined for the replacement chain creation, i.e. who to contact and when. Later on when the process is

defined it could be possible to implement it in to the SAP workflow, which would enable many benefits according to the questionnaire results. Defining the process and the responsibilities is a subject in this scope which needs the attention before anything else.

This thesis contain inputs from 18 persons who represent eight different organisations. This thesis has attempted to provide a general view of challenges and improvement ideas the participants presented. To get a deeper understanding of the challenges each stakeholder are facing, maybe it would be beneficial to continue this work by focusing on individual departments one by one.

The dedicated coordination team to manage replacement chain creation process could be piloted by assigning certain amount of people for this specific task.

7.4 Conclusions

A need for defined responsibilities, improved communication and coordination were the key findings of this work.

The respondents stated that the responsible for making the decision of the replacement can vary based on what type of replacement is needed. When the reason is a business reason, it is usually purchasing who should – and is – making the decision. When the change is due to technical change then it is Technical Service that is making the decision. Technical Information is acting according to the decision and activating the replacement chain.

Currently communication is done in scattered way and the respondents indicated that a uniform approach is required. This could be achieved by a dedicated coordination team that was suggested many times. Their primary duty could consist of collecting information from needed stakeholders to make a decision of replacement chain, and also monitoring the process.

While doing the thesis it has become clear that this topic is important for the interviewed persons and for the company in general. All in all the thesis process was successful. The biggest challenges were in understanding the whole scope of

this study and implementing the received information in a concluded form. At this point this work has received positive feedback from the client organization.

The whole replacement chain scope is very wide and this thesis has just scratched the surface. I hope that this work and the recorded interviews will help push this project onwards. It will be interesting to see what the project will be able to develop.

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