MASTER

Developing data mining applications for the product development process : a feasibility study performed in the high volume consumer electronics industry : a case study at Philips Mainstream Television Global Design Centre Singapore

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Developing Data Mining applications for the Product Development Process; a feasibility study performed in the High Volume Consumer Electronics Industry

A case study at Philips Mainstream Television Global Design Centre Singapore

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The research experience was like a rollercoaster, at one time I felt like I could oversee the whole project. At the next moment, time was running so fast and there were so many issues to look at, it was hard to keep the overview. It was not an easy project, it was a classic research in which a lot of roads were explored, and often enough they lead me back to where I started. I carried out my work independently and I liked it that way. It learned me to work autonomous. I would like to thank Professor Dr. A.C. Brombacher for keeping me on track and providing the overall direction. Rakesh Menon, I would like to thank for his coaching and his Data Mining expertise. Dr. W. van Eerde helped me a lot with the proper execution of the interviews at Philips and she was a recognized member of the coffee breaks. At the Institute, the Managing Director, Mr. Tan and all the other colleagues at DTI really made me feel a member of DTI. Thank you very much for the kind gestures.

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Roeland W. Nollen

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ABSTRACT

Competition between companies rapidly increases on today's global market. New ways to stay ahead of the competition are needed. A trend observed within companies, is the growing amount of data stored. Today it is cheaper and easier to store data than ever before. What is done with the data stored? Not much at the moment, but could the stored data be used to learn more and faster and thus to stay ahead of the competition? This report answers these questions. This is done by looking at a case study in the Consumer Electronics Industry. The case study performed at Philips Television Development rendered interesting results. Even with newly developed analysis techniques a lot of limitations are found. It is concluded that the way in which data is recorded can make a useful analysis impossible.

SUMMARY

In contrast to two years ago there is a lot more uncertainty in the world economy today. Plausible however is that several trends observed for some time now will continue to occur such as the ever increasing global competition and the growing importance of information. These are the starting points for this research. The increased volume of data in businesses around the world in combination with the increased demand of useful knowledge make a strong argument for taking a closer look at the information sources and their interaction within the product development process. This research is a product of two Universities in two parts of the world as well as a product of two different disciplines getting together. Special attention is given to the general applicability of the research outcomes. A case study is performed at the Global Design Centre of Philips Television.

The characteristics of the research project itself are elaborately described in chapter 2. The research goal in paragraph 2.2 is stated as:

> *"Explore if applying Data Mining techniques within the Product Development Process can contribute to a higher end product quality."*

The research goal is subdivided into 4 research question that need to be answered in order to reach the research goal. A research model is setup and applied to answer the

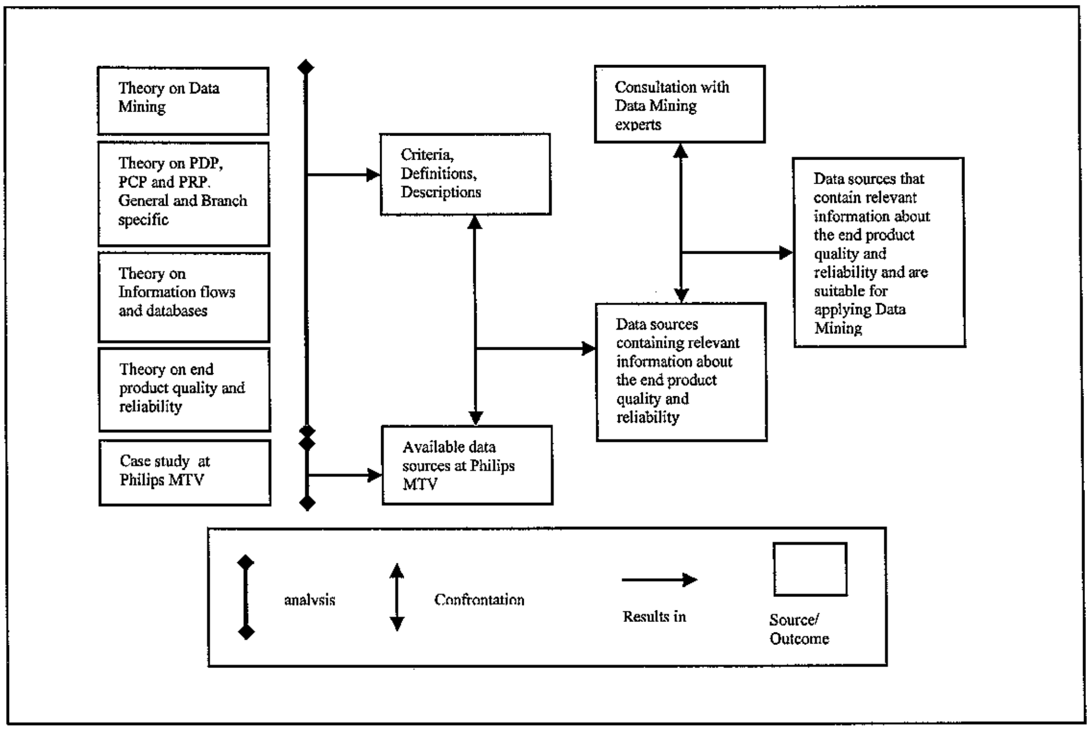

Figure 0.1 The Methodology Model

questions.

Four subjects are covered in the literature review in chapter 3.

The **Product Development Process** is presented and defined. Four different models are discussed. Each product will require a different Product Development Process. For the Consumer Electronics Industry a Concurrent Engineering framework is the best choice because the Consumer Electronics needs to a capable of producing a high Quality product in a short time frame.

Information is many-sided; it is a difficult subject to make unambiguous statements on. The following terms are used to name information.

- Formal versus informal information
- Circulating versus generic information,
- Tacit versus explicit knowledge.

Feedback loops are showed to be important to the Product Development Process and the Maturity Index of Reliability presents a way to assess the feedback loops. The up rise of Product Data Management systems is discussed as it will play a role at the case study in the future.

Quality is defined in a way so to emphasis on the technical aspects and without the customers aspect.

Data Mining is a very new and divers field of study. Many different techniques, goals and operations are available. Data Mining is also used, or at least explored, in many different fields of study. Data Mining is not mature yet. That is, it is far from returning great results with little effort. At the moment there is no such thing as of the shelve Data Mining applications that will give you the expected results in any situation. A lot more research in Data Mining is needed to use it to its full extend. The Data Mining steps are:

1. Domain understanding
2. Data cleaning (to remove noise and inconsistent data)
3. Data integration (where multiple data sources may be combined)
4. Data selection (where data relevant to the analysis task are retrieved from the database)
5. Data transformation (where data are transformed or consolidated into forms appropriate for mining by performing summary or aggregation operations for instance)
6. Data mining (an essential process where intelligent methods are applied in order to extract data patterns)
7. Pattern evaluation (to identify the truly interesting patterns representing knowledge based on some interestingness measures)
8. Knowledge presentation (where visualization and knowledge representation techniques are used to present the mined knowledge to the user)

Based on the literature review of the different subjects, criteria are setup in discussion with experts to assess if a data source is suitable and interesting to apply Data Mining techniques. Table 0.1 represents a summary of the formulated criteria.

Content Criteria	Completeness Time window Consistency, signal to noise Level of detail (4 levels) Information suppliers Potential, estimated with MIR
Composition Criteria	Structure Format Size

Table 0.1

The information flows and data sources at the case study are mapped and analysed using the criteria setup in paragraph 3.5. The result is summarized in the table below.

	The Information Content Criteria		The Composition Criteria	
Technical Product Documents	-	*Completeness*: complete *Time window*: The whole PDP *Level of detail*: Very detailed *Information suppliers*: designers, maintained by administration *Signal to noise*: low due to fixed guidelines *Potential*: MIR 1 (currently: MIR 1)	-/-	*Structure*: **No structure at all**. Loose, scattered documents. *Format*: Softcopies online available in Word or Excel, but mostly in **Multi Media format** *Size*: 26 different document, each exist for each set
Additional Product Data	-/-	*Completeness*: low, each team has a different approach *Time window*: The whole PDP *Level of detail*: Global, only overview *Information suppliers*: Project leaders *Signal to noise*: **Very high,** each team has a different approach *Potential*: MIR 2 (currently: MIR 2)	-/-	*Structure*: **No structure at all**. Loose, scattered documents *Format*: Softcopies online available in Word or Excel *Size*: Differs from project to project.
CP/CN	+/-	*Completeness*: Complete, rigid procedures. Exception: remarks field completeness low *Time window*: The whole PDP and Production *Level of detail*: Very detailed, set level *Information suppliers*: Designers *Signal to noise*: estimated on 40% *Potential*: MIR 3 (currently: MIR 2)	++	*Structure*: **1 database** *Format*: Fixed forms in softcopy online with textual and numerical content *Size*: very large
Test Results	++	*Completeness*: Complete, rigid procedures *Time window*: The whole PDP *Level of detail*: Very detailed, set level *Information suppliers*: Designers *Signal to noise*: low due to fixed guidelines *Potential*: MIR 3 (currently: MIR 2)	-/-	*Structure*: **No structure at all**. Loose, scattered documents *Format*: Fixed forms in softcopy but not always online, contains only limited numerical content (mostly only 1 value) *Size*: very small, Philips tries to reduce variety in testing because of time constraints
Doc Tool	+/-	*Completeness*: Complete, rigid procedures *Time window*: The whole PDP *Level of detail*: Very detailed, set level *Information suppliers*: Designers *Signal to noise*: Low due to fixed guidelines *Potential*: MIR 1 (currently: MIR 1)	-/-	*Structure*: Library structure *Format*: Fixed forms in softcopy but online, contains only **multi media information** and a parts list in free-text format *Size*: large
iQMS	++	*Completeness*: moderate *Time window*: The whole PDP and Production *Level of detail*: Very detailed, set level *Information suppliers*: Designers *Signal to noise*: 21% *Potential*: MIR 4 (currently: MIR 3)	+	*Structure*: **1 database** *Format*: Fixed forms in softcopy online with textual and numerical content *Size*: large
Continuus	+/-	*Completeness*: moderate *Time window*: The whole PDP and Production *Level of detail*: Very detailed, set level *Information suppliers*: **Software designers** *Signal to noise*: unknown *Potential*: MIR 4 (currently: MIR 3)	+	*Structure*: **1 database** *Format*: Fixed forms in softcopy online with textual and numerical content *Size*: large

Table 0.2

From this assessment it was concluded that the iQMS database was the most interesting option for further investigation. In the next part of the research the first Data Mining steps are applied to this database and the validity of the content is assessed by interviewing users.

The first Data Mining step, Domain Understanding, contains a more detailed exploration of the content and a formulation of plausible scenarios. Data Selection and Data Transformation are carried out. The Data Mining step itself could not be executed due to a lack of resources to this research. The first few steps however present some results on the content of the database.

The validity assessment delivered some very interesting conclusions. The iQMS database is only used as a means of communication. Due to this fact the information in the database is not complete at all. The descriptions of hundreds of problems and their solutions are readily available in an Excel format and looked promising at first sight. But unfortunately after examining the iQMS database further by assessing the data input by the designers, the conclusion is negative. The iQMS system was setup as a communication and tracking tool and not as a learning tool. Too much, and too valuable information on the Problem and Solution is communicated around the system. Even though the personnel were properly trained, they have various opinions on what information to enter in the free text fields. This conclusion is reached by mainly analysing the interview outcomes. The manual analysis of the content of the records supports the conclusion. Complete information can not be found in the iQMS database. Therefore the outcomes of a Data Mining analysis are not expected to be useful, although some unexpected correlations might be found.

Philips stores a lot of information. But Philips does not have a clear policy or strategy to manage the stored information. Philips should rethink its intended course on their information strategy. A real turnover is needed to use the information recorded for learning and prevention. The most interesting database in this case study performs well relative to its purpose. Now Philips realises as well that they could and should use this database for learning purposes and for preventing problems in the future. But this research shows it is not realistic to do this with the current setup of the database and its data recording.

The re-design of the information systems should start with formulating the goal of the information system differently. Does Philips wants to use iQMS as a communication tool or do they want to use it as a learning tool as well? According to this research it is plausible to setup a system that enables learning from past mistakes. But this research also points out that a re-design of the information policy and information systems is needed to achieve a learning capability.

Concrete, a re-design could mean, "don't use exclusively free-text to describe the problem and solution". Formulating a key-words list was shown to be one of the Data Mining steps. If a key-words list is available in the database itself and properly used, the information in the database would be a lot easier to process by a computer. One suggestion is to use a key word list where the designer can click check boxes to describe a problem. An interface could be build that facilitates a dynamic, tree like key words choice to a designer. Of course this suggested solution will have disadvantages as well. So this is an interesting subject for further research as no proof of these suggestions could be provided by this research. Currently the opportunities to retrieve relevant information from the databases within the Product Development Process at Philips are minimal.

It is clearly demonstrated how important it is for manufacturer's today to think ahead and use the large amount of information available in a company to stay ahead of competition. More and more disciplines are exploring Data Mining to do this, but so far the Product Development Process got little attention. At first sight it looks easy to use Data Mining techniques to analyse big databases in the Product Development Process. But this research points out that several points make Data Mining more difficult or even impossible. The way information is recorded is more important than recognized. Just recording information does not make sense. Before the data recording starts, a clear goal should be formulated. Giving the future usage of a database, like learning, a thought can make a big difference. It is necessary to take all the criteria presented in paragraph 3.5 into account. It is probably not possible to maximise all of the criteria, some of them need to be weighed to each other. For example, "is the content rich enough or are the formats used too divers?"

By making use of Data Mining it is demonstrated that root-causes of problems in the Product Development Process could be found (scenarios in paragraph 5.1). So by applying Data Mining to the data a higher MIR level could be reached. This argues that Data Mining should be involved as an important option during any attempt to increase the MIR level.

TABLE OF CONTENT

1 INTRODUCTION

This research is a pioneering project. It explores the possibilities of applying today's emerging techniques that are far from mature, to an incredibly dynamic process, the Product Development Process. The basis for this work is provided by two Universities. At the Technische Universiteit Eindhoven, the Capaciteits Groep PPK is continuously studying the Product Development Process. In Singapore, at the National University of Singapore, a new institute was founded in 2002 as a close co-operation between the National University of Singapore and the Technische Universiteit Eindhoven. The institute, called the Design Technology Institute has a focus group studying Data Mining. Together they provided the perfect knowledge base for this research. Philips Mainstream Television provided a case study for this research. The focus thus will be on the Consumer Electronics Development.

This chapter starts with the important motives for this research. This is done by discussing the latest trends in Product Development and in the Information Society. The nature of this research and the used methods are discussed in the second chapter. The work done so far in the fields of Product Development and in the field of Data Mining is reviewed in chapter 3. A case study at Philips Mainstream Television is dealt with in chapter 4. Chapter 5 elaborates on a particular part of the case study, where more details are provided about one database. Chapter 6 makes an attempt to generalise the outcomes of the case study to any Product Development Process. General conclusions as well as recommendations for the case study at Philips can also be found in Chapter 6.

1.1 Recent Developments in the Business Environment

In contrast to two years ago there is a lot more uncertainty in the world economy today. Plausible however is that several trends observed for some time now will continue to occur such as the ever increasing global competition and the growing importance of information. These are the starting points for this research.

1.1.1 The Effects of a Global Economy

The effect of the global economy for companies anywhere in the world is an ever increasing competition. This growing competition results in several trends within the consumer electronics business. These trends are listed below (Brombacher 2000).

Quality is not an advantage anymore. It is now a prerequisite to take part in the market. Customers became more demanding. And to the customer it's not only a matter of fulfilling the requirements at the moment of purchase of the product rather does the product keeps fulfilling its function during the economical lifespan of the product.

Time to market is now shorter than ever. New products are launched directly following each other.

Functions of products are more complex. Due to advances in technology, products can perform a lot more functions.

Diversity and mass customization increase. The customer has more options to choose from when buying a product.

Costs are even more under pressure. Prices have always been a means to compete. The profitability margin is under constant pressure.

These trends conflict with each other. No company can produce the best product, the fastest and at the lowest costs. These issues need to be balanced with each other. A company needs to control these variables in order to achieve the best fit or balance for their situation.

To control these variables in a company, information is needed. To obtain the right information and to make the right decisions in order to balance these trends is the real problem in business today. Information is the starting point for a company to make a difference.

Time to market, Costs, function and Quality are determined in the first place in the Product Development Process. An example on the costs aspects from Brombacher (figure 1.1, Brombacher 1999) shows us the total actual lifespan costs per phase of the lifecycle and in which phase the costs are determined. This is mentioned to illustrate the importance of the Product Development Process to the entire process of bringing a profitable product to the market. And a successful PDP depends heavily on the quality of the information supplied to it.

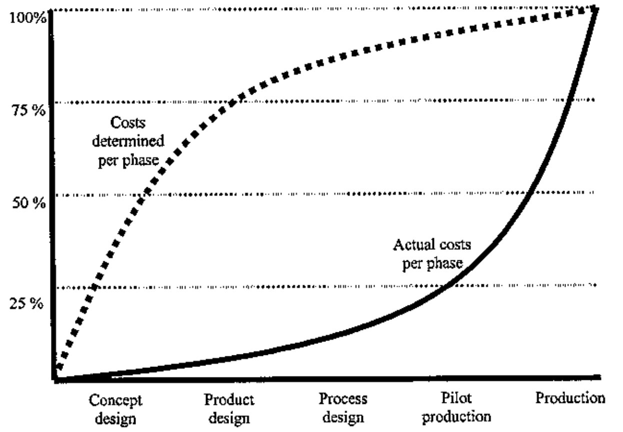

Figure 1 1 Determined and actual made costs per phase

So all together, the trends observed in the world today and in the consumer electronics business, increase the need of the right information on the right spot at the right time. This is demonstrated to be true for the Product Development Process in particular.

1.1.2 Today's Data Explosion

In today's information era we experience a paradox. On one hand the size of data in the world is reaching astronomical figures. On the other hand the demand for more and qualitative information is rising (Mulvenna 1996). The two developments lead to the emergence of new techniques. The same two global trends are apparent in the business environment as well. The two trends will be discussed in this paragraph.

The explosion of the data in the world started with the introduction of the computer. The MITS Altair was the first microcomputer. It was first introduced in the January 1975 issue of Popular Electronics magazine as a construction project. Although not the first available microcomputer (appendix 1), it was the start of the industry [source: http://www.pc-history.org/]. All the memory that came with the Altair kit was 256 bytes. The first computers were very expensive and needed highly trained personal to operate them. Today a PC is delivered with a standard hard disk of 40GB. Today's software is most users friendly. Statistics from the C.B.S. (Central Bureau of Statistics of the Netherlands) show that the number of computer related companies (in particular computer service oriented companies) has tripled since 1993. This demonstrates the rapid growth of the whole computer industry. The computer became much more affordable so the number of PC's and servers exploded as well. One billion personal computers have been sold across the world, according to hi-tech consultant Gartner Dataquest [BBC News, 1 July 2002, http://news.bbc.co.uk/1/hi/sci/tech/2077986.stm]. The amount of data stored in these computer systems around the world doubles in size every 10 months (Frawley, W. J. 1991).

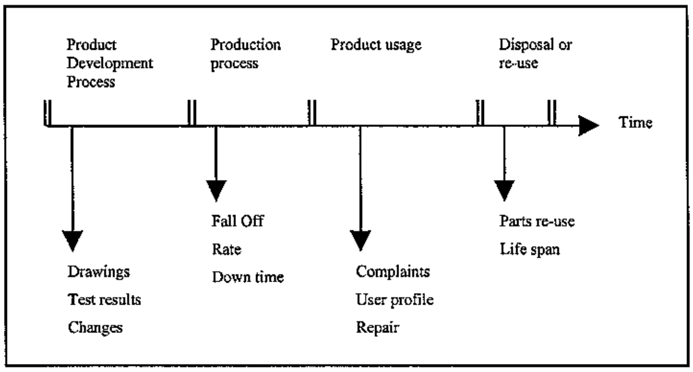

Figure 1 2 The Product Life Cycle and it's' information generation

In businesses around the world databases are also growing. Looking at the lifecycle of consumer products, there are several points where amounts of data are recorded. (Figure 1.2, Nollen 2002). Within the Product Development Process for example designs, parts lists and test results are recorded. At the production stage records of production numbers, downtime and Fall-off Rate are stored. Finally when the product reaches the customer, data recording doesn't stop there. Those customers who are not satisfied will complain or offer the product for repair. Every complaint and every repair is recorded. All together this is a large amount of information. An important question is: "what is a company doing with its information at this moment"? According to Sullivan (Sullivan 2001) "the most commonly used method in dealing with vast amounts of information is to simply ignore it". In that case there is a lot to ignore.

Concurrent Engineering and other approaches emerged to counter the conflicting trends. But although the Concurrent Engineering approach reduced the product development time; "approximately half of the designers' time is spent organizing and managing data" (Rabins et al. 1986; and Romanowski, C.J.; 2001). Almost all recently introduced methods and techniques rely heavily on information.

1.2 Data Mining, a brief introduction

So a lot of information is stored in the world today. But at the same time there is a growing need of information. The C.B.S. processed 10.000 requests for data in 2002 compared to 4.000 in 1995. Do the developments of analyzing techniques keep up with the growing information need? The answer is simple, there is an acute and widening gap between data generation and data understanding (figure 1.3, Nollen 2002). The response to these trends is the development of a new research area called Data Mining.

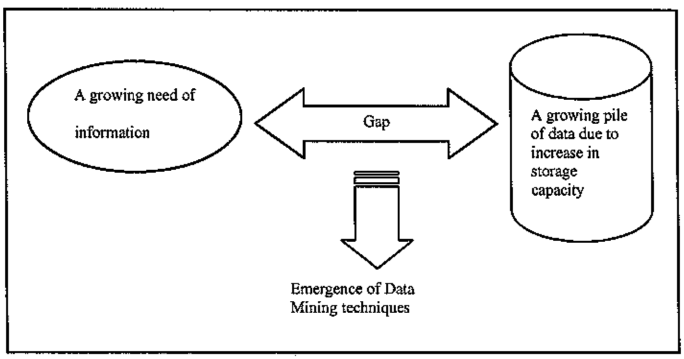

Figure 1 3 The Information Gap

Data Mining is a promising solution to the above mentioned Problem (Fayyad, Shortland and Scarfe; Fayyad, U and Stolorz, P., 1997). This was recognized at the first congress of Data Mining in 1980. Data Mining is not entirely new, it consists of old techniques. The new aspect about Data Mining is the combination of applying several known techniques. The first explorations of the Data Mining techniques took place in the Banking business, but nowadays Data Mining techniques are applied to very different fields of study; from biology to marketing there is an explosion of data that needs to be analyzed. The same phenomenon can be seen in the Product development process of consumer products.

> *"The purpose of computing is insight, not numbers"*
> R. Hamming

The overall goal of Data Mining here is formulated as "getting useful knowledge out of data". The data as well as the useful knowledge come in different forms. Techniques used, originate from Statistics, Computing, and Mathematical sciences. In addition to knowledge of the techniques, so called domain knowledge is very important. A more detailed study of Data Mining can be found in chapter 3.4.

1.3 Product Development Processes, a brief introduction

The process that starts with an idea and that ends with a tangible product produced in a factory is called the Product Development Process. The idea is often the results of analysing the needs and wishes of customers. The biggest part of a product development process is spent on designing the product. Most Product Development Processes are iterative. That means that any product needs testing before it can be produced. This process of trial and error takes the biggest part of a designers' time. A more detailed description of Product Development Processes can be found in chapter 3.1.

1.4 Conclusion

The increased volume of data in businesses around the world in combination with the increased demand of useful knowledge make a strong argument for taking a closer look at the information sources and their interaction within the product development process. The aim is to find the best possible balance between the conflicting business drivers. Hereby the importance of this research is established.

1.5 Outline of this Thesis

The sequence of chapters in this thesis follows the steps carried out in this research. Chapter 3 deals with the literature about Product Development Processes and with Data Mining. It is written for those who are not familiar with the subjects as well as the more advanced reader to provide a proper background. Though the advanced reader might only be interested in the summary of these chapters. In several ways this report can be divided in two. There is a practical part to be found in chapter 4 and a theoretical framework in chapter 3. Chapter 4 is the specific case study carried out in this thesis where as Chapter 6 relates the findings to the general case. The best way to read this thesis is to follow the chapters in their logical order.

2 RESEARCH PROJECT

The characteristics of the research project itself are described in this chapter so the reader can place this research in the right perspective. The research goal in paragraph 2.2 is the logical result of the introduction given in chapter 1 in combination with the context description provided in paragraph 2.1. The research questions in paragraph 2.2.1 outline the steps which are taken to achieve the research goal. By means of a research model in paragraph 2.3, it is explained how these steps are taken. As the research area is a new one, little information can be found in the literature. Due to the lack of this information, the nature of this research is explorative and thus the validity and generalizability need special attention. The view the authors have on this research is further explained by means of the research type description in paragraph 2.4.

2.1 Context of this Research Project

The research for this thesis is defined in the context of the Design Technology Institute (DTI) in Singapore and the Technische Universiteit Eindhoven in the Netherlands. This thesis marks the end of the Master Course in Industrial Engineering and Management at the Faculty of Technology Management. The research project for this thesis is carried out under supervision of Prof. Dr. A.C. Brombacher. The project is carried out at DTI, Singapore.

DTI is the result of a close cooperation between the National University of Singapore and the Technische Universiteit Eindhoven. DTI is a centre for technological design that has 5 major research projects including Embedded Systems, Mechatronics, Product Creation, Robust Design and Data Mining. The Data Mining group is currently working on a project called: *"Analyzing customer feedback, by means of applying textual Data Mining techniques"*. Looking at the data available within the PDP itself has not been done so far at DTI and hardly any where at all in the scientific world. The subject of this thesis is complementary to the research conducted by the Data Mining group at DTI and therefore supported by them. Philips Mainstream Television Singapore provided a case study for this research. The Quality and Support Department of the Global Design Centre of Philips Mainstream Television provided all the necessary data for this research.

2.2 Research Goal

This section describes the ultimate goal of this research. The ultimate goal of this research area is to achieve a best possible Product Development Process. The Data Mining Group at DTI is trying to get closer to this ultimate goal by means of applying Data Mining techniques on the customer feedback (Menon 2001). This thesis limits it self to assessing the data generated within the Product Development Process and exploring the possibilities that this data offers. Thus very important data that is inputted to the process by the marketing or service departments is excluded. Referring to paragraph 1.1.1, a best possible Product Development Process in the current world means a fast and reliable process that renders high quality products for a good price. This is the ultimate goal of this research area. The means that are targeted to achieve this goal are the Data Mining techniques. This states the research goal as follows.

> *"Explore if applying Data Mining techniques within the Product Development Process can contribute to a higher end product quality."*

The main research goal formulation contains the key words: explore, Data Mining, Product Development, contribute and Quality.

2.2.1 Research Questions

To reach the research goal several questions need to be answered first. A clear overview of information flows in a Product Development Process and their functions is needed.

1a	*"Which information or communication flows and which data sources are present in a Product Development Process?"*
1b	*"And which of these information or communication flows and data sources contain data relevant to the Quality and Reliability of the end product?"*

To answer this question the literature is reviewed and compared with the case study at Philips Television. Once the overview is established in chapter 3, the data sources need to be assessed on the usefulness of their content. So the second research question is formulated.

2	*"Is it possible to apply Data Mining techniques to the data sources found?"*

Once the aspects of the data sources that are relevant to the possible application Data Mining techniques are assessed in chapter 4, the next step is to present some examples of what can be achieved with Data Mining. Note that this last step can only be presented if it is possible to use Data Mining techniques.

3	*"What are (possible) results of applying Data Mining techniques?"*

Finally the obstacles to apply Data Mining successfully are to be presented. What aspects make it easier and more effective and what aspects make it impossible to use Data Mining techniques.

4	*"What are the enablers and the obstacle to use Data Mining techniques within the Product Development Process?"*

How these research question are answered, can be found in the research model in the subsequent paragraph.

2.3 Research Method and Model

First a remark is made about the researchers. Two researchers conduct the research; they carried out the first part together. The first part includes the literature review and the case study exploration at Philips as described in the first four chapters. They focus on different subjects in the second part.

This paragraph describes how the steps are carried out in this research.

The steps are visualised in the model (Verschuren 1996, 1997) in figure 1.4 and will be explained according to this model. Once the research goal and project were defined as they are now, the first step carried out was a review of the relevant literature. Theory on Data Mining, theory on Product Development, theory on Information flows and databases and finally the theory on end product quality and reliability were all examined. So were their interactions, but rarely any author describes the possible combinations of these subjects. Step two consisted of mapping the Product Development Process at the case study, including the information flows and data sources. The results of step one and two are combined, thereby enabling the research question to be answered. Together with the Data Mining specialists at DTI and the relevant literature as a backup, the research question two is answered in step three. Finally in step four, the most interesting database found at the case study is used to demonstrate what can be achieved by applying Data Mining techniques within the Product Development Process. This results in some examples given in chapter five.

At this point, it is made clear if and where Data Mining opportunities occur within the PDP.

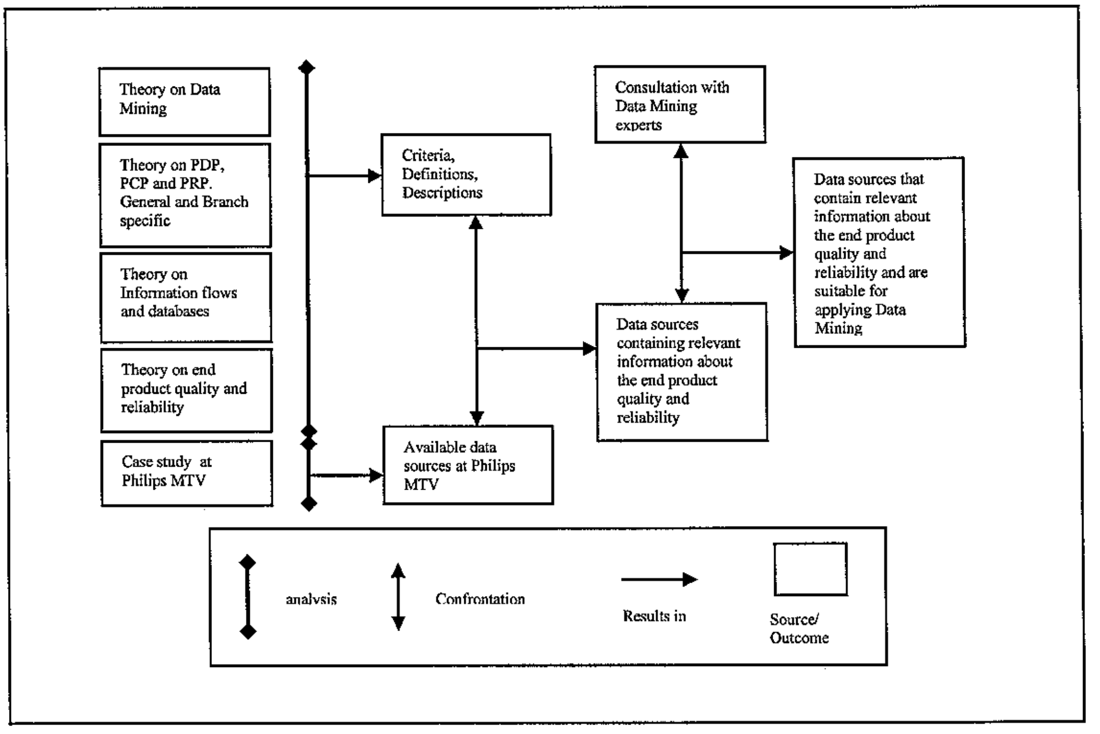

Figure 1.4 The Methodology Model

2.4 Type of Research

In order to give the reader a good understanding on how the author perceives this research, this paragraph reviews several points concerning the nature of the research itself. There are several typologies to describe the nature of a research. Here the following contrasts are used to describe the type of this research project:

- Explorative or in depth
- Empirical research or theoretical
- Qualitative or quantitative
- General or specific
- Concrete or abstract

We have chosen for an explorative research, which is empirical. The subject of the research is very new so an explorative theoretical research will be impossible due to the lack of literature and more importantly to the very nature of the work. The chosen strategy can further be described as qualitative, specific and concrete.

Next to the typology described above, Behesti (Behesti 2000) defines four types of studies subdivided by their purpose. This subdivision will further contribute to the understanding of the nature of this research. The four subdivisions are: descriptive studies, prescriptive studies, Philosophical studies and studies focused on design education. According to Behesti this research is a descriptive study, this research will not go as far as telling how things should be done. The empirical research done within this project is not solid enough to support the findings as prescriptive.

2.5 Results of this Research Project

The outcomes of this research will be of use to the next researcher or to any company who is going to apply Data Mining techniques in a similar setting. Philips Television can use this research as a guideline to prepare the organisation to become a true learning organisation. The results can not be quantified or objectively verified as this is an explorative research in a pioneering area. To counter these facts, special attention is paid to the validation and generalization of the outcomes of this research in paragraph 2.7.

2.6 Audience

The primal audiences of this thesis are the professors from the Faculty of Technology Management, who are reviewing this thesis in order for the authors to receive a master's title. In the second place the intended audience is bipartite, on one side, the Design Research field and on the other side the Data Mining field of research.

2.7 Validity and Generalizability

Validity

Validity is generally acknowledged to be a key issue in research design. The same applies for this work. As Bosk (Bosk 1979) mentions "all fieldwork done by a single field worker invites the question, why should we believe it?" In this thesis validity is defined as credibility of the research results. Validity is also relative; it has to be assessed in relationship to the purposes and circumstances of the research. The validity issue is disentangled in the validity of the descriptions, of the interpretation and of the theory applied to the case study.

The main threat to a valid description is the incompleteness of the data on which the description is based on. In order to reckon this, all the data used to generate the descriptions are given as complete as possible; at least the full data gathered is available in the appendices.

The main threat to a valid interpretation is imposing one's own framework rather than understanding the perspective of the case studied. A measure to counteract this phenomenon is built in the way the interviews at the Philips case study are setup. Open questions are used and the interviews are taped.

The threat to the theoretical validity formulated as not collecting or paying attention to discrepant data or not considering alternative explanations of the phenomena of study. Gathering and comparing theories from as much as possible different sources deals with this issue. This is called triangulation, Fielding and Fielding point out that it is not true that triangulation automatically increases validity. This compromises with the point of Maxwell; "validity threats are made implausible by evidence, not methods; methods are only a way of getting evidence that can help you rule out these threats." Thus to take the theoretical validity into account, competing explanations and discrepant data will be presented in the text. In other words, to make sure the research is not simply a self-fulfilling prophecy (Locke 1993) we present the methods and models not chosen as well, they can be found in the appendices.

General applicability of research outcomes

One of the goals of academic research is generating general applicable knowledge. Next to the attention given on validity there is a need to address this issue to what extent the results of this research can be generalized. We differentiate generalizability according to Maxwell into Internal- and External generalizability. Within the scope of this research we define the internal generalizability as within the PDP in the Philips organization. In other words, are the results applicable at other business units of Philips? External is defined as in any PDP of any company.

The generalizability will be addressed in chapter 6. During the research, the researchers kept the list of features in mind that lend plausibility to generalizations given by Hammersly (Hammersly 1992) and Weiss (Weiss 1994).

2.8 Conclusion

This research is described and characterised in this chapter. The background of important aspects like the explorative nature of the research is explained. It is made clear this research is a product of two Universities in two parts of the world as well as a product of two different disciplines getting together. Special attention is given to the general applicability of the research outcomes.

The research goal is formulated as:

> *"Explore if applying Data Mining techniques within the Product Development Process can contribute to a higher end product quality."*

The research goal is subdivided into 4 research question that need to be answered in order to reach the research goal. A research model is setup and applied to answer the questions.

3 LITERATURE REVIEW

Four subjects are covered in this literature review. The four subjects originate from different disciplines. The Product Development Process and in a separate paragraph the Quality originate from the Industrial engineering discipline. Information and Data Mining do not belong to one particular discipline but are hybrids of Mathematics, Software and Communication sciences.

3.1 Product Development Processes

A brief introduction on the Product Development Process has been given in paragraph 1.3. There is a lot more that can be said about developing new products or as you like creating new products. Different names for a Product Development Process are used and different frameworks to develop products exist. The different terminologies are explained in paragraph 3.1.1. Companies are producing a range of different products. Each product is developed in a different way. This range of different Product Development Processes can be divided into several kinds of development frameworks. In paragraph 3.1.2 four development frameworks are presented. The analysis of the case study will use the definition presented in this chapter as a starting point and will use the presented frameworks as a guide in the generalisation of the outcomes. Appendix 2 provides background information on the Product Development Process.

3.1.1 Definition

The process of developing product has a lot of names in literature. For example, Product Development is used as a synonym for:

- Design and Engineering Design
- Product Creation Process (PCP)
- Product Realization Process (PRP)
- New Product Design (NPD)

This can cause confusion. Therefore this paragraph will show that even though a lot terms are used to indicate the process of developing products, different authors tend to describe the same process using different words.

Ulrich and Epinger (Ulrich 2000) define the Product Development Process as the sequence of steps or activities which an enterprise employs to conceive, design and commercialise a product. Van Mill (Mill 1994) thinks it is important to distinguish a strategic part and an operational part in the PCP. Van Mill uses the term Product Creation Process (PCP) to emphasize the operational part. This part covers the process after the customer wishes are collected till the release of the end product. Another term used in the literature is Product Realisation Process (PRP), which is used in multiple ways. For example (Berden 2000) describes the process from collecting customer requirements till a manufactured end product that is ready for use by the customers. Other authors use the term PRP to indicate only the last phase of the Product Development Process, the steps to commercialise the end product. (Mill 1994). The last term that will be discussed here is a term used in the last few years, New Product Design process (NPD). NPD is described as optimizing a design within the constraints created by the conflicting parameters of development costs, production cost, product features, time-to-market and reliability [Globe 1998). Wheelwright and Clark (Clark 1993) split the New Product Development into two major phases namely "fuzzy front end phase" and the "operational phase".

All the described definitions share one view. They all mention the difference between the initiation and the realisation of a product. The initiation involves the specification of the market segment, user and intended usage. Starting from these basic specifications the design is created by iterative rounds of trial and error. In this thesis both the initiation and the realisation of a product are considered. This formulates the definition used in this thesis as follows:

"Product Development Process is a sequence of development processes with internal and external information flows that converts detailed technical specifications, translated from generally specific market needs or ideas, into the best possible qualitative and reliable manufacture able products, through the application of scientific, technical and creative principles."

This definition is based on the definition provided by de Graaf (Graaf 1996)

3.1.2 Different Production Development Process Models

Four different frameworks are presented. These represent the most commonly used frameworks in the Development Processes of tangible products. Other frameworks are not discussed because they are not relevant to the focus of industry adopted in this research.

3.1.3 Function Driven

The function driven Product Development Process focuses on innovative techniques. It is characterised by a low degree formalised procedures and little Quality testing and assurance. It is not possible to focus on Quality or to build up Quality experience because of the innovative and changing nature of the techniques produced. Close contact with customers is vital and will last even after the sale. Customers of innovative products that are developed by a Function Driven Development Process are in fact the Quality Controllers them self. In the innovative markets where a Function Driven is used there is no focus on cost reduction or on time to market. It is a very flexible Development Process suitable for extremely innovative products.

3.1.4 Sequential Product Development Process

Also called a "Miles stone based Development Process", a Sequential Product Development Process is characterised by exact procedures. The development activities are divided in Milestones. Milestones are clear points in the time where the requirements of a certain phase are checked. Without completing a phase there is no starting at the next one. It's a rigid way of working but it assures a clear structure and a transparent way of product development. And the risk of big disasters is minimized. Each functional department carries out its own part so it can focus and specialise in its activities. This is not a flexible way of working but the quality can easily be checked at each Milestone. The danger of this framework is the "throwing over the wall principle". Each functional department focuses only on what they themselves should do and how they can improve their own functioning. This leads to sub-optimalisation. Another drawback is the lack of flexibility. The formalised procedures are most often not suitable for radical new products. Finally the time to market of a Sequential Product Development Process can be very long if at certain milestones waiting time exists.

3.1.5 Concurrent Engineering

As the function driven Product Development Process and the Sequential Product Development Process are dated a long time ago, the Concurrent Engineering framework is much studied subject in Product Development Science today. The Japanese industry introduced this new way of product development although they did not use the name by then. The essence of Concurrent Engineering is the simultaneous execution of the development phases instead of following the rigid sequential order. The main advantage is the time to market gain. There is no need to wait for a single task to complete a whole phase and close a milestone. There is more communication between disciplines because this approach requires the different disciplines to work together in a single team. More communication and more complex teams require of course, more attention to coordination and management. It is necessary to make decisions up front; this reduces the flexibility and makes the Concurrent Engineering framework unsuitable for innovative products.

3.1.6 Dynamical Iterative

The Dynamical Iterative framework ensues from the Concurrent Engineering approach. What is done differently is the early focus on prototypes. Often in close contact to the customer, a proto type is build even before the concept is finished. By making a prototype this early, a lot of understanding of the final product can be gained by confronting the prototype to the customer. Technical problems are easier to foresee when assessing a prototype that early. The Dynamical Iterative is thus suited for highly innovative products where the Quality and Reliability risks need to be low and the cost aspects is less important.

3.1.7 Conclusion

Due to the reason that the research area of the PDP is relatively young, a lot of terms and different descriptions are used in literature. To be able to generalize the results of this thesis and in order to see in a non-trivial understanding by the reader of this research report, the key terms are defined and explained in this chapter.

The Product Development Process (PDP) is described and defined as:

" A sequence of design processes with internal and external information flows that converts detailed technical specifications, translated from generally specific market needs or ideas, into the best possible qualitative and reliable manufacture-able products, through the application of scientific, technical and creative principles. "

As a lead, one model has been chosen to make a description of a general PDP. The model is based on the VDI standard (the German Society of Engineers) and Pahl and Beitz (Pahl 1995). The model is complemented where needed and supplemented at the end with steps of the model from Ulrich and Eppinger for the sake of this research. Due to the time constrains and research reasons; the general description of the PDP is defined as shown above. This definition of the PDP does not account the translating from customer's requirements into technical specifications, the first step in the general model of a PDP. Noted is that this is one of the most important phases of the PDP, but concerns more of the marketing area. The back end of the PDP is restricted to production ramp-up. After this phase, the product will go into production and sales, no development takes place anymore.

A clear overview of the different Product Development Frameworks is given in figure 3.1. Each of these Product Development Frameworks has its own needs in terms of communication and information. Because the information flows in a Product Development Process play such a prominent role in this

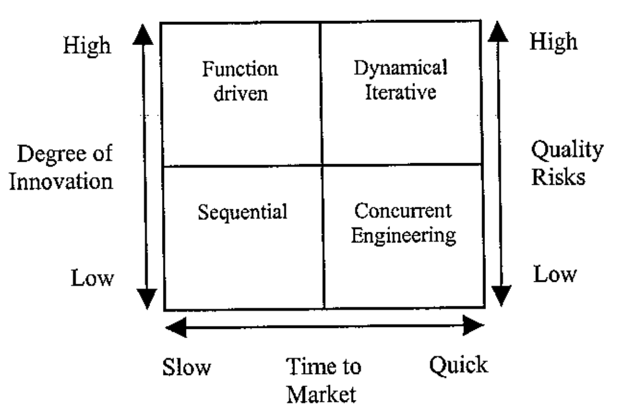

Figure 3.1 The Product Development Frameworks and their properties

research, a more elaborate review on the information is presented in paragraph 3.2.1. The discussion of information flows will use the described frameworks in this paragraph as a starting point.

As stated in the introduction, each product will require a different Product Development Process. One example is given here, an example that relates directly to the case study of this research. For the Consumer Electronics Industry a Concurrent Engineering framework is the best choice because the Consumer Electronics needs to a capable of producing a high Quality product in a short time frame. The Quality and the time aspect are more important to the Consumer Electronics Industry then the degree of innovation. The degree of innovation is very high in the high end of the Electronics Industry but rather modest in the Consumer Electronics Industry.

3.2 Information

To a certain extent, the role of information in a Product Development Process can be compared to the role of materials in a Production Process. Like a Production Process transforms a given material into a product by adding, removing or forming material, a design process translates given information into a product by adding, removing and combining other information with this information. So information takes a lot of different forms and has different states it can be found in. This paragraph deals with the different forms of information and the different goals it is used for. A definition of the term information is given in paragraph 3.2.1 and this paragraph will go deeper into the general subject of information as well. Then the connection between information and the Product Development Process is made. Two subjects in this matter get special attention, the Maturity Index of Reliability and Product Data Management. Developed at the Technische Universiteit Eindhoven, the Maturity Index of Reliability is a method setup to assess the control loops in a Product Development Process. The method is presented here because the levels of the MIR assessment will be used later on in this research. Product Data Management is a much discussed item in business literature at the moment.

3.2.1 Information in General

Value

It is cheap and easy to reproduce information, but it is most expensive to produce information for the first time. Neither cost nor value of information is related to the quantity of information produced. The value of information is therefore difficult to assess (Shapiro and Varian 1999). Information provides indirect utility in support of decisions so direct utility measurement is inappropriate (Van Alstyne 1999). Even though the value is so difficult to assess, the importance of explicit attention for information is generally acknowledged in scientific circles for some time now. In organisations people are not as conscious of the importance of information. Studies in the 80's (Tversky and Kahneman 1982) as well as later studies (Kahneman and Lovallo 1993) demonstrated that people tend to ignore available information like prior probabilities, sample size and the like. Instead, decisions are based on other subjective methods such as representative ness, availability and adjustment and anchoring (also known collectively as heuristics). Earlier experiments have also shown that people tend to be conservative and undervalue available information for the revision of a prior opinion (Branthwaite 1975). Another study (Bastardi and Shafir 1998) tested the pursuit of information for daily decisions. Participants preferred to seek information and based their choices on (objectively) non-instrumental information. In other words, people assigned positive subjective value to objectively worthless information. Theory also suggests that people seek information because it seems like the right thing to do (Feldman and March 1981) implying over-demand for information and a high subjective value. People tend to accumulate information "just in case" they may need it in the future, again leading to excessive demand (Van Alstyne 1999). The theoretical tension is, therefore, between studies indicating that information is under-valued and other research that shows that information is over-valued. Previous studies have tried to elicit the subjective value of information by using surveys or semi-structured interviews (Davies 1994; Vlahos and Ferratt 1995; Hepworth 1998). All together it can be concluded that the usage of information in this information age has not matured yet. This research attempts to elicit the subjective value of the information flows and data sources in the same way as Davies, Vlahos and Ferratt and Hepworth.

Different forms of information

There is so much you can do with information, you can create, store, transmit, retrieve, preserve and manipulate. Some speak of the lifecycle of information as design, creation and maintenance. Design in this case represents the defining of the form the information will be created in. Maintenance or perseverance lasts until the information is destroyed. There is also such a thing as reuse of information but in contrast to physical objects the original can still be used for its original intended purpose. So in the design phase of information the form is determined. That is, the first form because information can change its' form or appearance easily. Information can expire really fast; this issue will be relevant in chapter 4. In what forms do we know information? Information comes in a multitude of different forms like speech, pictures, video, office work, software, great art and kitsch, invoices, music, stock prices, tax returns, orders to attack, love letters, novels and the news. But this arrangement is not useful to this research. So what arrangements and definitions are needed for this research? The following list the terms used through out this research.

- Formal versus informal information
- Circulating versus generic information,
- Tacit versus explicit knowledge.

Note that the last contrast contains the word knowledge instead of information. Knowledge in this research is defined as information that gives the receiver the ability to do something with this information; to perform context and environment specific tasks, based on this information (Weggeman 1997). So knowledge is closely related to information, that's the reason the two terms are discussed together in this paragraph.

Formal Information: Hard information, facts, alphabetic symbols and figures that computers can handle (Owen 1983). This information creates a network that is typically vertical, follows the authority chain, and is limited to task-related communications (Robins 1993).

Informal Information: Soft information, conversations, rumours, mimics, things seen or heard, ideas in peoples heads, etc. (Owen 1983). This information creates a network that is free to move in any direction, skip the authority levels, and is as likely to satisfy group members' social needs as it is to facilitate task accomplishments (Robins 1993).

Generic Information: Information that has its origin in organisations, generated through the organisation's own activities (Van Gigch & Le Moigne 1990).

Circulating Information: "Traces" in an organisation such as an order, an invoice, a sales receipt or a bank draft that originate from outside the organisation (van Gigch & Le Moigne 1990).

Tacit knowledge: Michael Polanyi's felicitous phrase "we can know more than we can tell," As Nelson and Winter (1982) puts it, "To be able to do something, and at the same time be unable to explain how it is done, is more than a logical possibility – it is a common situation" (p. 76). Hence, one can distinguish between explicit knowledge as 'know-that' and tacit knowledge as 'know-how'.

Explicit knowledge: Only explicit knowledge can be stored in an IT system. This rather short but straightforward definition is formulated by Manuel Kolp (University of Louvain).

When the discussed characteristics of information are used to describe an information source; the description can tell more about the usefulness of the data source to the goal of this research.

3.2.2 Information in the Product Development Process

The previous paragraph argues the importance of information and it proposes a way to characterise information sufficiently for this research. The specific issue on information in a Product Development Process needs attention in particular. According to Brombacher (Brombacher 2000) a company can have three different motives to collect information if they want to enhance Quality in a Product Development Process.

Measuring: The first motive is a logistic one, for which performance measurements are needed to enable components requirements planning for repair.

Controlling: The second motive is to decrease product failures, for which information is needed about product failures.

Preventing: The third motive is to improve Product Quality by collecting information on failure causes and using this information to redesign products. The last motive requires very detailed information.

Brombacher points out that in a modern Product Development Process especially preventive information is required. This is true but Petkova (Petkova 1999) shows that most companies only gather information that can only be used to measure product Quality. Prevention in the Product Development Process does not get a lot of attention, as can be seen at the case study of this research as well. The analysis can be found in chapter 4.

Feedback loops, is a term used frequently in Product Development literature. Or a similar term and exchangeable with Feedback loops is Control loops. Feedback loops are the most important information flows to the Quality of the product. Feedback loops are signals containing information concerning deviations of the original intentions, for example failures of safety issues. Feedback loops can be found at all levels. From the smallest feedback loop like the designer who sees that his designed knob does not fit; to the longest feedback loop like the customer who doesn't understand the function of the knob. A feedback characteristic that influences quality performance is the "length" of the feedback loop or control loop. It has been shown that when feedback comes back from the individual operator to himself (short, fast loops) better quality performance is achieved (Greller 1975). Too much time between an event and feedback or too many people involved confuse decisions and reduce reaction capability and speed. The next paragraph provides a framework to assess the availability and quality of feedback loops in a Product Development Process.

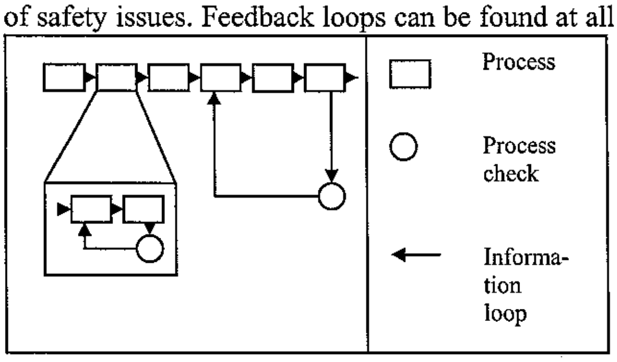

Figure 3.2 Different Feedback loops, short and long.

Maturity Index of Reliability

In order for manufacturers to control their Q&R related data and information flows in the Product Development Process, they first have to construct a good understanding of their present situation. So how good are the existing control loops and how accurate, available and accessible is the information in the organisation at this moment? Then the manufacturer can ask what to do in order to reach the situation in which he will control his Q&R

problems. The Maturity Index of Reliability assessment is a method to do this (Brombacher

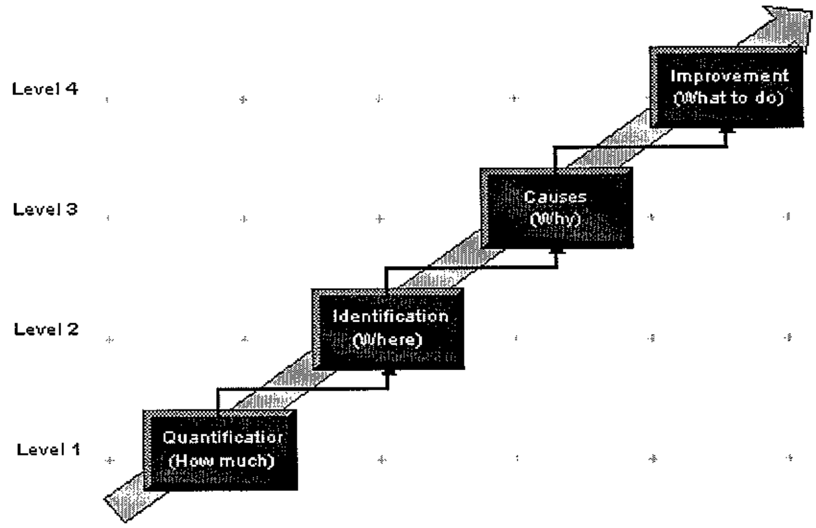

Figure 3.3 The improvement levels of the Maturity Index of Reliability (MIR)

2000). The MIR method assesses the manufacturer's situation and gives directions to a manufacturer what he has to do to achieve better Quality & Reliability control.

Formally, MIR measures the quality of the 'reliability control loop'. A reliability control loop is a validation of predicted reliability performance of a product against actual reliability performance. When inappropriate reliability prediction methods are used, the connection between predicted component failure rate and actual failure rate (field performance) is very weak. The lack of feedback on actual reliability performance in companies explains the problem of the weak connection. Therefore in those cases where a company predicts the reliability of a product it will be highly relevant to know whether the company uses a closed reliability control loop and if so, what the quality of this control loop will be. In this way the predicted reliability will always be a good approach of the reliability in the field. The quality of the reliability control loop can be measured on two aspects:

- The quality of the reliability related information in this loop.
- The deployment of this information into the business processes.

A MIR assessment can result in four levels.

MIR level 0

There is no relevant quantitative information available of customer complaints about the products. For example, this means that there is no information about the time of repairs, the age of the products or the number of products sold. No control loops are in place from the Service department back to the Development and Production department. In this situation, the process status is uncontrolled and the organisation is in an absolute chaos.

MIR level 1; *Quantification*

There is a basic feedback system that gives quantitative information, indicating the number of problems during production and the number of field failures. This information is fed-back to other relevant departments in the organisation. But still, there is no idea what the causes of the customer complaints are. This level only gives indicators of the performance during the production and the performance in the field. In order to be informative, these numbers must be seen in relation to the quantity produced and quantity sold. In this situation the process status is measured.

MIR level 2; *Identification*

The company has quantitative information about the origin of the customer complaints and knows what the primary and secondary locations are. At the primary location, the complaints can be either categorised as technical or organisational problems. This location gives insight in the quantity of design, production, material or customer use problems. The secondary location describes where the failures are located within the products, like for example the part number. This level possesses the corresponding information control loops, but there is still a lack in knowledge to define what actually the specific cause is. At this moment the process is analysed.

MIR level 3; *Root causes*

The company has quantitative and detailed information about the root causes of all the dominant failures and of the information about the behaviour of the customers in the field. These root causes can be translated into risks for future products and processes. However, the company is not able to prevent these problems in the future, which means that the process status is controlled.

MIR level 4; *Improvement*

The company has the quantity of complaints available, knows the origin of the problems, what the root causes of the problems are and what to do about it. By using methods and tools, the company is able to anticipate and prevent similar problems in the future. The problems are analysed, predicted and verified against the data from production and service. At this moment all control loops provide the right information to eliminate risks in the future and the feedback is directed to the responsible persons. At this level the company has reached the status of a learning organisation. This means that the organisation is able to react effectively and efficiently on external disturbances and creates the ability for continuous improvement. This more mature organisation will be able to learn faster and as a result can reduce the Field Call Rate (FCR) faster to its target value. The following figure presents the different MIR levels. In figure 3.3 above the four improvement levels of the MIR concept are visualised.

Organisations with low MIR levels have a poorly predictable business process. They apply a lot of new technologies, without really considering the impact on reliability and quality risks. Due to the use and development of new technologies in the early development phases, there is still a lack of predictive capabilities. This results in a considerable delay due to quality and reliability problems discovered in the later phases of the product development process. Companies with a high MIR level are able to develop products with a high level of predictable reliability. As a result, these companies are more resistant to time pressures.

It is clear that the MIR approach can be helpful in the product quality & reliability improvement of companies. The MIR approach can help visualise the problems within organisations related to their PCP and their feedback channels.

Product Data Management

Product Data Management (PDM) integrates and manages all the information that defines a product, from design to manufacture, and to end-user support. The purpose of Product Data Management is to integrate many different areas and ensure that the right information in the right form is available to the right person at the right time. To a visualize Product Data Management system one can think of a software package in combination with a network (internet for example). Data is centralised, versioned and can be used for tracking designs in an environment which supports collaboration. A change management service is provided which can be used by engineering applications to assess, control and minimise the impact of material, product and process changes that occur in complex product lifecycles.

Product Data Management systems have been around since the early 1980s and are being used not only for sharing of information within an enterprise, but also in an extended enterprise to include partners, suppliers and contractors. With the widespread use of Internet technologies, increasingly the terms CPC (collaborative product commerce) and cPDM (collaborative product definition management) are also being used in place of PDM (Kumar and Midha 2001). The worldwide market for PDM systems grew 36% between 1993 and 1994 (Iuliano). The presence of a PDM system in a company might enhance the effectiveness of a Data Mining application. Unfortunately at the case study in this research, PDM is only about to be implemented, the details are unknown at this moment.

3.2.3 Conclusion

Information is many-sided; it is a difficult subject to make unambiguous statements on. The following terms are used to name information.

- Formal versus informal information
- Circulating versus generic information,
- Tacit versus explicit knowledge.

This research has to exclude informal information and tacit knowledge as these are not recordable. Tacit knowledge however could partially be captured by analysing the explicit formal information available.

Feedback loops are showed to be important to the Product Development Process and the Maturity Index of Reliability presents a way to assess the feedback loops. The up rise of Product Data Management systems is discussed as in will play a role at the case study in the future.

3.3 Quality of Fast Moving Consumer Products

Quality is a versatile term. And because the issue of Quality plays such a prominent role in this research; the definition and the background of the Quality subject are discussed in this paragraph. Actually the term quality has passed by in this thesis already as one of the four business drivers. But there is more to say about Quality then only that. A short background and history is presented in paragraph 3.3.1. Commonly used definitions are discussed in paragraph 3.3.2 and the way the term is used in this thesis is explained.

3.3.1 Definition

"Quality is the ability of the product to fulfil its intended function through conformance to the technical specification."

To get insight into the different usage of the term quality an overview of the following groups was defined by Garvin (Garvin 1988); acknowledge being one of the worlds greatest Quality Guru's:

- Manufacturing-based: quality is the degree to which a specific product conforms to a design or a specification.
- Product-based: differences in quality amount to differences in the quantity of some desired ingredient or attribute.
- Transcendent: quality is neither mind nor matter, but a third entity independent of the two or even though quality cannot be defined, you know what it is.
- Value-based: quality is the degree of excellence at an acceptable price and at the control of variability at an acceptable cost.
- User-based: In the final analysis of the market place, the quality of a product depends on how well it fits patterns of consumer preferences.

The different groups show that the way the term Quality is used varies a lot. This research takes place in the Product Development discipline and more precisely the discipline of the Consumer Electronic Market. This would imply that the definition most suited for this research, will lie somewhere in the manufacturing, product-based or user-based subdivision of Garvin. A transcendent based quality definition is very vague and not appropriate here. Value-based definitions are taken for granted nowadays. If a company is not able to succeed in having a value-based quality product it will probably not survive a long time. The manufacturing-based definition looks appealing for the technical area. To investigate the definition of quality further, the remaining two definitions will be discussed with some additional and more recent literature.

To make the difference more clear, product quality is about making the product right while product function is about making the right product (Brombacher 1998). Reliability is the ability of a product or system to fulfil its intended purpose for a certain period of time according to Lewis. In this thesis reliability is defined as quality in the time aspect.

3.3.2 Quality Parameters

In order to determine whether Quality and Reliability has improved in a certain situation, there is a need for parameters, which can be measured. Parameters that point straight forward to the place and cause of a problem are hard to find. All of the parameters presented here depend on a lot of environmental circumstances. So unfortunately they will never show a one on one effect.

The following parameters are available in most industries; more details on these parameters can be found in appendix 3:

- Field Call Rate (FCR)
- Fall off Rate (FOR)
- Mean Time Between Failure (MTBF)
- Maturity Grid (MG)

3.3.3 Conclusion

With up and downs the issue of Quality became more important in business. Today it plays a major role in the success of any industry. In this paragraph a definition for Quality is presented and ways to measure Quality are discussed.

As mentioned in the introduction of this chapter, quality has many definitions. The field where the quality term is used will determine what definition of quality is most appropriate. This research takes place in the product development field of consumer electronic products. Through the narrow scope of the PDP, explained above, also a narrow definition of quality is most useful. Hence quality is defined emphasizing only the technical aspects and without the customers aspect.

3.4 Data Mining

Data Mining is a collection of automated techniques that are able to analyze large amounts of data in an automated way. The emergence of Data Mining is described in the first chapter. This chapter will introduce Data Mining techniques and the possibilities these techniques offer, to those readers who are not familiar with it, to the advanced readers the authors demonstrate their understanding of the Data Mining field of research. But first the term Data Mining and other relevant terms in this context will be defined. Relevant terms to Data Mining are data, information, knowledge, databases, data warehousing and Knowledge

Discovery in Databases (KDD). This chapter concludes with some examples given to illustrate the possibilities of Data Mining.

3.4.1 Definitions

It begins with Data, but what do we mean when we mention Data? Data are raw, unstructured and non-interpreted facts (Court 1995). Data comes in all kinds of forms; it can be a single number, a word, a drawing or a sentence. When a person receives data, reads it and interprets it, the data becomes information. Information is data that has a meaning to the receiver of this data (Court 1995). Or in other words, information is the result of correlating or organizing data (Porter 2000).

Information becomes knowledge if it allows for confident prediction of future outcomes. This knowledge can be measured based on how much is understood about the effects of the input variables on the outputs. Weggeman (Weggeman 1997) formulates the term knowledge in a slightly different way; he proposes that knowledge is the necessary framework for a receiver to do something with information. So according to him, information becomes knowledge as soon as the receiver can take action based on the information.

The definitions discussed show that there are no objective and exact criteria available to distinguish information and knowledge. Bohn has a solution for this dilemma. He defines data, information and knowledge as forming a continuum. By introducing figure 3.1 we demonstrate also the difference in volume and value between data, information and knowledge.

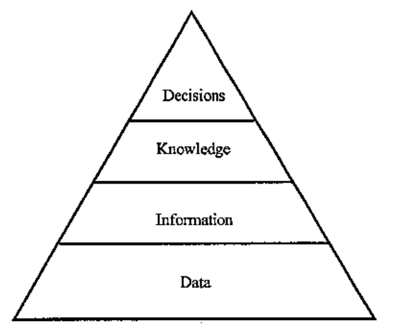

Figure 3.4 The Data Pyramid

Data Mining and KDD defined

The terms Data Mining and Knowledge Discovery in Databases can be confusing. As well the difference with Statistical Data Analysis can use some explanation. First a definition of Data Mining is presented.

"Data Mining is the process of discovering interesting knowledge from large amounts of data stored either in data bases, data warehouses, or other data sources by making use of computerized analysis techniques."

A database is a collection of interrelated data. A database system consists of a database and a set of software programs to manage and access the data (Han and Kamber 2001). A data warehouse is a repository of information collected from multiple sources, stored under a unified schema, and which usually resides at a single site.

The first part of this definition is derived from Han and Kamber. Shortland and Scarfe point out that data mining heavily relies on computerized techniques. There is no such thing as manual data mining. So "by making use of computerized analysis techniques" is added to the definition provided by Han and Kamber.

The Data Mining process consist of several steps, which involve data preparation, search for patterns, knowledge evaluation, and refinement, all repeated in multiple iterations. Fayyad points out that only the search for patterns step should be called Data Mining. For the whole process he uses the term Knowledge Discovery from Databases. Technically speaking this is more correct, but the term Data Mining is used most of the time to refer to the whole process instead of the main step. The artificial intelligence community, have a slightly narrower definition of data mining. According to their viewpoint, the underlying data analysis tools must be based on one or more sub-technology of artificial intelligence, for example machine learning, neural networks, or pattern recognition, to qualify as the data mining method (Sethi in Braha 2001).

There is a clear difference between Data Mining and Statistical Data Analysis. Statistical Data Analysis is a manual human directed search for exactly those results which one is looking for. Data Mining is an automated search, and can turn up results which are not anticipated by the human mind. A computer does not suffer from the human bias, and has capacity enough to go through the whole data. This brings up another point. The amount of data that can be analyzed by Statistical Data Analysis is limited. In contrast Data Mining techniques can handle much larger amounts of data.

3.4.2 The Data Mining Method

Data Mining is carried out in eight steps as is commonly agreed upon in literature. The description of the Data Mining steps according to Han and Kamber is presented and the first step (Fayyad 1996) is added as the authors see it as important start especially to this research.

1. Domain understanding
2. Data cleaning (to remove noise and inconsistent data)
3. Data integration (where multiple data sources may be combined)
4. Data selection (where data relevant to the analysis task are retrieved from the database)
5. Data transformation (where data are transformed or consolidated into forms appropriate for mining by performing summary or aggregation operations for instance)
6. Data mining (an essential process where intelligent methods are applied in order to extract data patterns)
7. Pattern evaluation (to identify the truly interesting patterns representing knowledge based on some interestingness measures)
8. Knowledge presentation (where visualization and knowledge representation techniques are used to present the mined knowledge to the user)

In practice most of the time is consumed by step 1 to step 5. The actual Data Mining step is not the only important step. The first 5 steps have a big impact on the outcomes of the analysis.

3.4.3 Data Mining Goals and Operations

In order to describe a Data Mining application several ways of sorting them are available. Han and Kamber present the following criteria to sort Data Mining systems:

- Sort according to the kinds of databases mined
- Sort according to the kinds of knowledge mined
- Sort according to the applications adapted
- Sort according to the kinds of techniques utilized
- Sort according to the Goals of a Data Mining application

Only the last two are presented here in more detail because they are relevant enough to the general understanding of Data Mining.

Fayyad, Shapiro, Smyth and Uthurusamy look at the goal of an application to classify the application. The possible goals of applying Data Mining are:

- **Verification** There is a correlation expected but not proven yet. The analysis of the data will prove the correlation to be true or false. This approach is much like the Statistical Data Analysis mentioned before.
- **Explaining** In case observed symptoms cannot be explained, Data Mining techniques are applied in order to find the relation between the setting and the observed symptoms.
- **Prediction** A new case is compared with the historical data by applying Data Mining techniques. In this way, predictions can be made about the new case.
- **Forensic Analysis** To find divergent records that indicates a rare event. Used to identify employees with strange phone bills.

To reach these goals the Data Miner has the following operations at his disposal. Of course combinations of these operations are common practice.

- Predictive Modelling

Predictive Modelling can be either Classification or Value Prediction. For the first one a training set is used to build a model which distinguishes records and puts them in classes with similar records. When new records are presented, they will be put in these classes based on as many as possible similar attributes. Values prediction is usually applied to numerical data to estimate missing or unavailable data. Commonly used techniques to do this are Regression and Neural Networks.

- Clustering

Also called database segmentation, it is used to group similar data in a database without using a training set. No prescribed class labels are used but the intra-group similarities are maximized to form the groups. Methods used for clustering include partitioning, grid-based, hierarchical and so forth.

- Association Analysis

This operation takes a different look at a database. It seeks to establish links between individual fields. Algorithms produce rules that imply the presence of one field if another field is true. For example, if a customer buys beer, there is a 60% chance that he will buy diapers as well. The algorithm used gives a confidence factor next to the support factor to tell how reliable the association is. This operation is used in transactional databases in particular.

- Deviation Detection

In fraud detection the hunt is on for outliers. In any other Data Mining operation outliers are regarded as noise or exceptions. In this way Deviation Detection stands out a bit, it searches for those objects that do not comply with the general behaviour or model.

- Evolution Analysis

The Time factor distinguishes this operation from the others. It focuses on models that describe behaviour over time. Examples are time-series data analysis, sequence or periodicity pattern matching and similarity-based data analysis.

3.4.4 Data Mining Drawbacks and Restrictions

First one of the most important aspects of Data Mining is considered, accuracy. Next disadvantages inherent to Data Mining techniques are discussed. Some context aspects that make the effective usage of Data Mining more complex conclude this subsection.

The accuracy of a data mining technique is difficult to prove. The most common used method for proving the accuracy is described here. Other methods are not known yet. The Data Mining application is applied to a set of data that is manually analyzed or where the intended results are known beforehand. The results of the Data Mining exercise are compared with the results known beforehand. The comparison can be expressed in a percentage of correct results.

Several disadvantages come up when applying Data Mining Techniques. To apply Data Mining techniques takes quite an investment in time and resources. Every situation where Data Mining is to be applied is different and thus needs a different approach. Data Mining is always tailor made, it is possible to apply some "off the shelf" modules but the overall picture differs every time. Thereby it is very hard to predict the value of the results due to the nature of Data Mining. Data Mining is supposed to result in so far unknown knowledge. When results are obtained of applying Data Mining techniques, two disadvantages can be expected. The knowledge outcome is known already. Data Mining can return "common sense" knowledge that does not add any value to the users. Possibly Data Mining results in some patterns found that are important and of great significance. But how these patterns are found in some instances is not comprehensible to the human mind. In such a case most users will be inclined to ignore the patterns found if they don't understand the reasons behind them.

Typical circumstances that complicate Data Mining include (Carbone, 1997):

- Large volume. Databases are capable of storing terabytes, and now petabytes, of data, therefore requiring a need to focus or pre-process the data.
- Noise and uncertainty. Noise can be introduced by faulty data collection devices. This causes uncertainty as to the consistency and validity of the data.
- Redundant information. For a variety of reasons, data can be stored multiple times, causing redundant information. This is especially a problem if there are multiple source databases.
- Dynamic data. Transaction databases are specifically set up to process millions of transactions per hour, thus causing difficulty for data mining tools which are oriented to look at static sets of data.
- Sparse data. The information in the database is often sparse in terms of the density of actual records over the potential instance space.
- Multimedia data. Databases are increasingly capable of storing more than just structured data. For example, text documents, images, video, and audio can now be stored as objects in databases, and these databases are used to handle World Wide Web sites. It is becoming extremely desirable to mine this data in addition to the traditional structured data but it creates new obstacles due to its' format.

3.4.5 Implementing Data Mining

A short note on the actual implementation of Data Mining is given in this paragraph. The actual use of Data Mining applications varies a lot. Because the field of research is relatively young, most people currently exercising a Data Mining analysis are the academic researchers. In the future two classes of Data Mining applications can be distinguished.

One extreme form op implementation is where the users himself has no knowledge about Data Mining itself. The applications he uses to execute his daily activities might be full of Data Mining applications without the user being aware of it.

On the other hand the user of Data Mining is the Data Mining expert himself. Assigned by a superior he sets up a specialised Data Mining application. Most times this is a one-time-only analysis.

3.4.6 Previous work on Data Mining in the Product Development Process

Most of the research on Data Mining so far is focused on information available within the manufacturing process (Wang 1997; Koonce 1997; Kim and Lee 1997) and the customer feedback loops (Tan 2000). Recent Data Mining research focusing on the Product Developing Process concerned mining a CAD database. Purpose of mining this database was finding old known design solutions so to prevent rework (Grabowski 2001). The publication that mentions some more case studies is the book of Braha.

3.4.7 Example of Data Mining in the Product Development Process

Data Mining for Knowledge Acquisition in Engineering Design
Authors: Yoko Ishino and Yan Jin IMPACT Laboratory, University of Southern California, Los Angeles USA
The goal of the research at IMPACT Laboratory is capturing Designer Knowledge online without bothering the Designer. The focus of this research is on an object-oriented CAD system (Computer Aided Design). The authors state that the Designer know-how is captured in the sequences of operations which a Designer executes while drawing and working in the CAD software. Without bothering the Designer during his work, software installed monitors all commands given to the CAD program. The resulting sequence can be compared to a DNA in the Biological field of study. In the DNA research, pattern matching is a common practiced method. The pattern matching method used here is the Extended Dynamic Programming approach (EDP). In a case study on the design of a gear system, the researchers show that the number of times that one specific successful part is reviewed decreases in time. By doing this they argue that it is important to review this specific part early in the process.

More examples of Data Mining can be found in appendix 4.

3.4.8 Conclusion

Data Mining is a very new and divers field of study. Many different techniques, goals and operations are available. Data Mining is also used, or at least explored, in many different fields of study. Data Mining is not mature yet. That is, it is far from returning great results with little effort. At the moment there is no such thing as of the shelve Data Mining applications that will give you the expected results in any situation. A lot more research in Data Mining is needed to use it to its full extend. The Data Mining steps are:

9. Domain understanding
10. Data cleaning (to remove noise and inconsistent data)
11. Data integration (where multiple data sources may be combined)
12. Data selection (where data relevant to the analysis task are retrieved from the database)
13. Data transformation (where data are transformed or consolidated into forms appropriate for mining by performing summary or aggregation operations for instance)

14. Data mining (an essential process where intelligent methods are applied in order to extract data patterns)
15. Pattern evaluation (to identify the truly interesting patterns representing knowledge based on some interestingness measures)
16. Knowledge presentation (where visualization and knowledge representation techniques are used to present the mined knowledge to the user)

3.5 Criteria for Useful Data Mining

So far this chapter provided a solid background for this research. All relevant aspects in the fields of Product Development, Information, Quality and Data Mining are reviewed.

At this point it is important to highlight the aspects on which the data sources at the case study in this research will be assessed. These criteria are setup in a general way so they can be used in other similar situations as well. Starting point for the criteria is the literature reviewed in this chapter and fine tuning is done by consulting Product Development and Data Mining experts.

The criteria needed to judge whether it is possible and interesting to apply Data Mining techniques fall in to two categories. These two categories are presented here and discussed separately. One remark however needs to be made about both criteria. There are no previous comparable criteria found in literature. This is not surprising as is shown in paragraph 3.4.6, but it also implicates that no objective and quantifiable criteria can be found. Due to the nature of Data Mining and of the Product Development Process, it is not expected to be possible at all to find objective and quantifiable criteria. Data Mining applications and techniques vary a lot from situation to situation. And the Product Development Process is anything but stable.

The categories of criteria come from separate disciplines. The content is judged by knowledge of the Product Development discipline. The Composition is judged by making use of knowledge from the Data Mining discipline. None of these criteria can be captured in a number or percentage. They can only be assessed in a qualitative way and they should be assessed in harmony to each other.

1. **Content**

To verify if the content is useful the Consistency of the data entered, the Completeness, the time span in which the data is gathered, the detail level the databases shows, kind of users and finally the relation between the content and quality are all assessed.

A database is **complete** if all records that logically should be present are present. No records went missing and no important aspects on the subject of the database are omitted. For example, is the set identification number at a drawing present? The completeness could, as the consistency, be expressed in a percentage as well. But it is difficult or even impossible to measure what is missing in a lot of fields. Sometimes it is obvious which information is missing and a percentage could be calculated.

The **time window** is important because in each phase different problems occur and different solutions are possible. Information generated during the customer usage phase is very different in nature and is part of the longest feedback loop. Thus has a different usefulness gradation as well. A criterion for the time window could be "the data source must be generated during the Product Development Process". And which has a minimum time span of several milestones. But this again is correlated to other criteria.

The **detail level** is important to know because too detailed information or too superficial information is not useful. For example, if a database only records the progress of projects on a global set level, nothing useful can be said about the individual sets coming back from the market. Examples of detail levels are:

- Projects
- Function areas of products
- Products
- Components

The **information suppliers** have a big influence on the content of the database. Knowing more about their activities and their view on a database tells more about the validity and content of the database. For example, a database used only by the administration department presumably contains less useful quality information than a database in use by the quality department.

By **consistency** the question is asked whether the data is entered in the intended way at all times by all users. For example, are all fields filled in the same way for each record? The consistency can be expressed in a percentage like a **signal to noise**. The percentage represents the part of useless data in proportion to the total amount of data.

The **Value of the content** is very difficult to measure or assess objectively. The criterion **MIR level** is discussed for each data source to indicate to what extend the content of a data source is expected to improve the quality of the end-product, in other words, what is the **potential** of a data source. In the context of this research it is not possible and not desirable to exercise a full and complete MIR assessment. The MIR methodology is used for this criterion to illustrate the qualitative judgement made by the author and the experts.

2. Composition

The criteria in the category Composition are more complicated to define. The minimum criteria for a database to be suitable for Data Mining operations vary according to the Data Mining operations (paragraph 3.4.3) planned. Whether the Data Mining operation is Predictive Modelling or Clustering, different criteria levels are applicable to the Composition of the database.

The form of the data can be described by the structure, the format and the size of the data source.

The **structure** can be either loose Word documents scattered around in the organisation, or a database divided in rows and columns. From loose documents or records it might be possible to construct a database but it presents a lot more difficulties. If the data already forms a database, the structure ensures the data to be more consistent and complete than otherwise. Data sources without a database structure will be disregarded in this research.

The **Format** can be characterised by being a soft- or hard-copy, web-based or not, and if the content consist of either numerical, textual or multi media data. The format criterion is that a data source should be available in soft-copy at least. Thereby multi media data is excluded from further analysis because it is not possible to analyse it with the current knowledge. The numerical content is easier to analyse by a computer than textual content. The analysis of textual content takes a lot more pre-processing steps and takes more time for the analysis itself.

Size matters in a way that a bigger size makes it possible to apply Predictive modelling operations. Small sizes of data sources limit the statistical power of conclusions. To what extend the size is important is dependent on the content and needs to be assessed again in each individual case.

The criteria are mutually exclusive, so each of them is important to consider. The criteria presented in this paragraph are used to assess the data sources of the case study. They are discussed in the next chapter.

4 CASE STUDY AT PHILIPS MAINSTREAM TELEVISION

4.1 Philips Mainstream Television Singapore

An overview of the company itself is presented together with the most important thing, the product itself. The company is described globally and its' Product Development Process and the information flows in more detail. This chapter ends with an assessment on the usefulness of the data sources found at Philips. One, the most promising, data source is paid more attention in the next chapter.

4.1.1 The Company

Philips was one of the first Western companies to settle in Singapore back in the 50's. In that time Philips built large production sites for Consumer Electronics. The reason for Philips to move their production sites to Singapore was the relative cheap labour costs for production comparing to the expensive European workforce. Now 50 years later Singaporean labour has become too expensive for production compared to labour costs in other Asian countries. In addition to this new large markets for Consumer Electronics opened up in other parts of Asia in particular China. This made Philips decide to move the production sites to Hong Kong and China. The only activities that remained in Singapore are Development Centres for Philips Consumer Electronics. In recent years Philips concentrated all the global development activities for Audio, Mainstream TV and Domestic Appliances in Singapore. This case study took place in the Global Development Centre (GDC) of the Business Unit of Mainstream Television (MTV). Philips Singapore employs 5000 people and turnover reaching S$2.2 billion in 2001. Their mission is to become the number two player in the global television industry, being a premium brand image versus Sony and Panasonic.

4.1.2 The Product

A product that can be found in almost any family house around the world and one that played a major role in recent history as a fast medium for the news. An influential development in the last decade is the emphasis on embedded software in consumer electronics in general. This applies to Televisions as well. This development together with the increased number of compatible devices like digital cameras, VCR's, DVD's, VCD's and even PC's; contribute to the complexity of the Television of today. Figure 4.1 shows the way in which a television is build making use of components and building blocks. The different disciplines use their own way of naming and structuring their parts. More about the disciplines can be found in appendix 5.

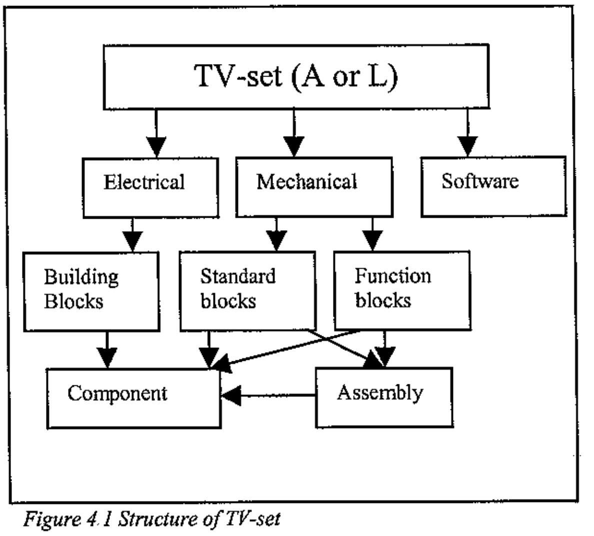

Figure 4.1 Structure of TV-set

4.1.3 *Organizational Structure*

Product Development at Philips Television is divided into two separate Management Teams. The "A-department" develops TV-sets for the higher end market. In general these are the more expensive TV-sets with more features and options. The "L department" develops TV-sets for the lower end of the market, for example small TV-sets with fewer options for the bedroom or kitchen. The Product Development Process within the two departments is almost similar. Figure 4.2 shows the hierarchy within the departments till the lowest level of detail of a TV-set, the components.

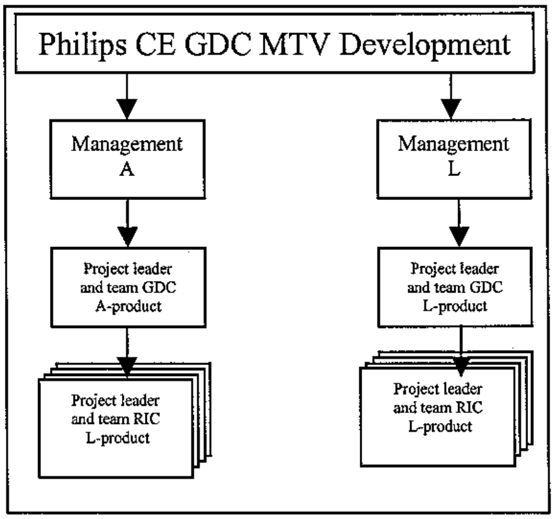

Figure 4.2 Organisation chart MTV

The Software Development is a parallel department with its own Development Process. Development of Software is a specialized process with its own character. This research will not go in detail of the Software Development Process. In this research Software is taken as it comes; developed, produced and tested.

Global Design Centre and Regional Implementation Team

Philips MTV works with a global development structure; this means that all the Product Development activities are linked to each other. More than that, the main Development activities are concentrated at one location, one Global Design Centre in Singapore. Philips MTV defined five regions in the world. Every region has its' own Regional Centre where Developments take place that are specific for that region. There are five regions in the world, namely Europe, Latin America, Pacific, Asia and North America.

4.2 The Product Development Process of Philips Mainstream Television

After some remarks on the definition of a Product Development Process at Philips this paragraph explains the phases in the Product Development Process at Philips step by step. First a little attention is paid to those phases that are not within the focus of this research.

All the Product Development Processes of the Consumer Electronic (CE) Business Unit of Philips are set up according to the same principles. Philips uses the term Product Creation Process (PCP) to indicate their whole development process. This means, from the strategic planning until the end-product rolling out the factory. From this point forth the term PCP in this thesis is used to refer to the Development Process of Philips CE specifically. The term PDP will be used to refer to the general PDP as described in paragraph 3.1.

The Product Creation Process at Philips is described in the SPEED document. The PCP is divided in two major activities, *Planning* and *Realization*, and two supporting groups, *Enabling* and *Improvement*. Figure 4.3 shows the activities and supporting groups in their relations to each other.

The PCP used to develop TV-sets deviates slightly from the PCP description given in SPEED. The description given here is based on the document SPEED and on interviews with employees. In paragraph 2.2 it is explained which part of the PDP is focused on in this research. This part corresponds to the Product Realization Process (PRP) within the PCP of Philips CE. So the Planning's phase as well as Enabling and Improvement will only be discussed briefly. More detailed information about Planning or the supporting groups can be found in SPEED.

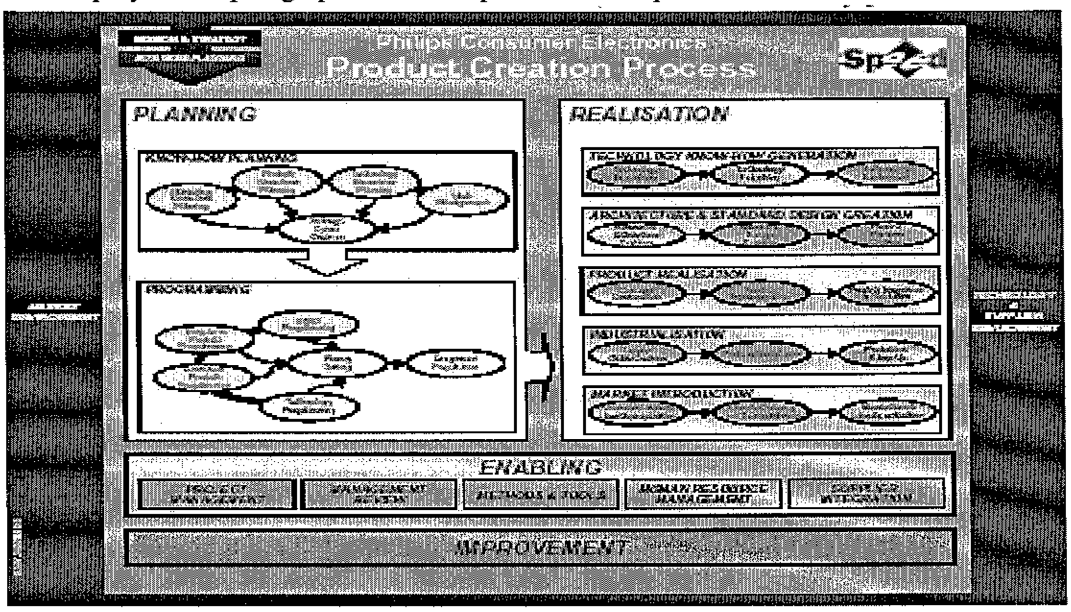

Figure 4.3 the SPEED PCP

Planning

The group Planning is divided in two processes Know-how Planning and Programming.

Know-how Planning

Know-how Planning process is a constant process, with the objective to gather and process information about consumers (end-users), trade, customers, competitors, market size and behaviour as well as assessing opportunities (externally and internally) offered by technology, suppliers, capabilities and resources. The output of this process is the "Strategic Option Creation", which contains elements as ideas, marketing reviews, technological and product "know-how"-planning and which is the input of the Programming group.

Programming

Programming is the constant process of translating Strategic Options into Long-term product plans (four and five year ahead) and Medium-term product plans (the next two years). It provides guide lines for future technologies, reference architectures, product platforms and standard designs. Priorities are set using resource constrains and technical feasibility studies. The Assignment Preparation (AP) is the output document destine for the Realization phase. The Assignment Preparation defines what the major goals of a project are and what the outline of the project is.

Enabling and Improvement

The subgroup *Enabling* is designed for support and making the different processes feasible. This includes Tasks as Human Resources, Methods and Tools Development, Supplier Integration, Management Review and Project Management.

The second subgroup *Improvement* is to ensure continuous improvement of the PCP. In order to secure the improvement process, Philips CE works with the Maturity framework. This process is split in two dimensions, process implementation and process scope. The subgroup Improvement introduced management tools as for example the so-called traffic light reporting. For the projects in progress a quarterly project status report is made. Traffic lights of the status of current projects indicate if major deviations from Contract Book exist. At the end of a project a Final Project Evaluation is made. Traffic lights in this Final Project Evaluation indicate major deviations from the original targets set at the PRS-milestone in the Contract Book (development speed, project costs, product costs and product performance). The colours used to indicate the situation are logical. If the project is right on target, the colour is green. If the project starts diverging from the targets set and risks are getting bigger, the colour gets orange. If the project is off track, the colour gets red. The boundaries, which colour to indicate what status the project has, are defined and established at the PRS stage.

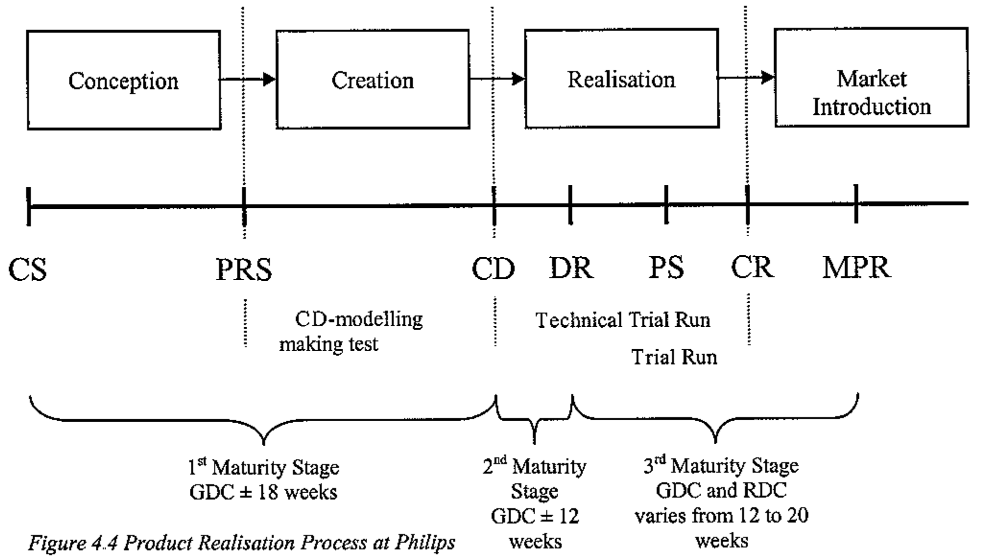

Figure 4.4 Product Realisation Process at Philips

CS	Concept Start	PS	Production Start
PRS	Product Range Start	CR	Commercial Release
CD	Commitment Date	MPR	Mass Production Release
DR	Design Release		

4.2.1 *Step by Step From Function Specifications to a Television*

The Product Realisation Process at Philips (see figure 4.4) is a milestone based Product Development Process as explained in paragraph 3.1. A new development project is initiated by an Assignment Preparation (AP) that is written in the first phase of the PCP named Programming. The AP is a rough plan which consists of ideas for a new platform or a new range within an existing platform. The plan includes the crucial specifications of the TV-sets Philips plans to produce in the next period. An AP might also be the start of a Standard Design. A Standard Design follows the same procedure as any new product. The extra aspect of a Standard Design is the intended re-use of the basic design. The details of, and the differences between Standard Designs, Platform and Range are explained in the next sub section.

At the start the AP document is rather vague. But the document will become more detailed and complete along the way as it gets updated. For each new platform or range a new project team is formed. This team consists of one project leader and a number of team members from different disciplines, for example mechanical or electrical engineering. The project-team analyses the information in the AP for different set compositions and possibly new features. This is known as the *Concept Assessment Study*. After the Concept

Assessment Study, a *Concept Feasibility Study* is performed in which an in-depth analysis of the market, technical feasibility and financial aspects is made. Based on these two studies the project team will make either a "go" or "no go" decision for the project. In case of a "go", the project starts at the first milestone Concept Start. A Target Launch Date is specified and resources (team enlargement, resources and time) are reserved for the project. The outcomes of the feasibility studies as well as the agreements between the project team and the internal and external project customers are worked out and documented. Next an Assignment Document is created to last the rest of the project. Three elements are specified in the Assignment Document. It contains a description of the Platform, the Commercial Release Date and a combination of crucial features.

Between the milestones CS and PRS (± six weeks) Global Reference Sets (GRS) are defined. A Global Reference set represents a sub-set with similar features or is targeted at the same market segment. By defining Global Reference Sets that represent several sub sets, Philips eliminates the need to develop and test each individual set. The GRS are chosen based on the experience of the designers.

The A department and the L department define GRS in a different way. The A department has less diversity and more expensive products. This results in a relative smaller number of GRS at the A department compared to the L department. This is clarified in table 4.1.

	A department	L department
Number of platforms	2 or 3	3 or 4
Diversity sets in new platform	± 300	± 700
Number of GRS in new platform	± 40	± 75

Table 4.1: differences between A and L TV-set (current state of projects)

The Product Manager defines the Parts Lists of the GRS by translating the specifications into a Bill of Materials (BOM). This has to be done before the project passes the PRS Milestone. But in practice, due to time constraints he can hardly manage to define all the sets in time. The Purchasing Department will buy components and materials as soon as they are defined in the Parts lists of the GRS. When the materials arrive the Model Shop will build the GRS prototypes. The commitment and agreements between project team and internal and external project customers are finalised in the Contract Book. The complete Contract Book is the second condition to pass the PRS milestone. The agreements described in the Contract Book concern issues like Product Quality, project organisation, specifications, development issues etc.

After the PRS milestone the diversity of sets is blown up from the original number of GRS to all the final individual sets (see figure 4.6). The smallest difference between TV sets will generate a new set with its' own serial number and an accompanying parts list. The GDC's project team will test the GRS prototypes received from the Model Shop. These tests are called the CD model-making tests and are executed to identifying conceptual problems or major issues. More details on the Tests can be found in paragraph 4.3.4. By now every department (electrical, mechanical and software) has started their development processes to solve the concept issues and problems derived from the CD model-making test. Examples of activities carried out by the departments are presented in appendix 6. Changes to the Parts Lists of the GRS are recorded in CP/CN; a system designed to track and archive Parts List changes. After ten weeks the project team will check if the project is still on schedule and ready to pass the next Milestone, the Commitment Date (CD).

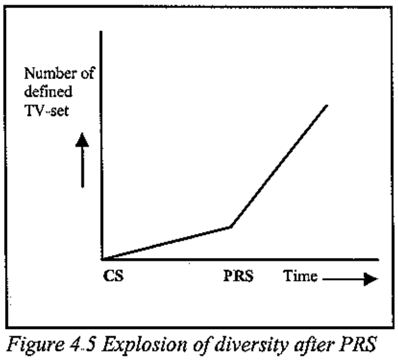

Figure 4.5 Explosion of diversity after PRS

If the project will get a "go" it has completed the first Maturity Stage. The Maturity Stages are setup to clarify what changes in the project are allowed at what time. This is mainly a management tool to control too many or too big changes in the end of a project. Note that not all the problems encountered need to be fixed at the Commitment Date Milestone. The purpose of this Milestone is to check whether the Developments take place in the right pace and that the major issues have been settled.

The trajectory from the CD Milestone to the DR Milestone is similar to the one just before the CD Milestone. It differs only in the way that at the DR Milestone all issues and other problems must be solved. In this phase the project team will detail the final specifications (parts lists) of all the individual TV-sets. Parallel to this, non-technical TV-set development processes are started, like the development of packaging. The GRS are tested again during the Technical Trial Run Test (TTR). The objective of this test is to control all the issues and problems derived from the "CD model-making test" and new arisen problems along the way. The last development changes will be made so all the GRS will pass the TTR-test. At the end of this phase the designs are documented in CP/CN and are detailed enough to manufacture them. The DR Milestone is reached in 12 weeks. Especially in this phase of the Product Development Process Philips tries to shorten the time span.

As soon as the Design Release Milestone is reached, the regions start to take over the Development Process from the Global Design Centre. The Regional Design Centre forms a Regional Implementation Team which downloads the relevant information on TV-sets from the CP/CN database and gets other relevant information by email from the Project Team. With this information from the Global Design Centre they start up a Trial Run (TR) test with materials purchased mostly locally. The trial run consists of two processes, trial run PCB and trial run product assembly. By now the project enters the Third and final Maturity Stage also referred to as process verification. This phase can take 12 up to 20 weeks depending on the region. The Regional Implementation Team will adjust the design to the requirements of the local market and will also carry out the tests specific to the local market.

After the Design Release Milestone, the Global Design Centre maintains a problem-solving and coordinating role. The Global Design Centre will remain the official owner of the design. This means that any change made at the Regional Design Centre in the design needs approval by the Global Design Centre. The trial run information is sent to the Global Design Centre by the regions by email and telephone. This is the first data that will be sent from the Regional Design Centre to the Global Design Centre as feedback on the developed TV-sets.

After the last updates from the Trial runs, TV-sets are now fully approved and ready for production. The Industrialization Release is made and the project will pass the Milestone Production Start (PS). Low-volume production starts first in order to collect early data on fall off rates, FCR, BOM and market feedback.

With the completion of the Quality Release Program (specified and finalized in the Contract Book) and the key factors within target; the process verification has succeeded. The project passes the Milestone Commercial Release (CR) and the Third Maturity phase.

From CR to Mass Production Release, the Industrialisation Phase takes about two weeks. The Industrialisation Phase consists of the Production ramp-up. The robustness of the designs has to be proven under mass production circumstances. Finally once suitability for mass production is proven, the factory takes over and the mass-production starts. The GDC project team stays together for about three months to settle the first problems encountered during mass production. At the same time the project evaluation takes place. Then the project leader will formally dismiss the project team. Key persons of the team will form a maintenance team and the leading range's name changes into GMT (Global Maintenance Team). The maintenance team helps and supports the Regional Implementation Team (RIT) as long as the TV set is produced.

4.2.2 *Quality Assurance in the Product Realisation Process of Philips*

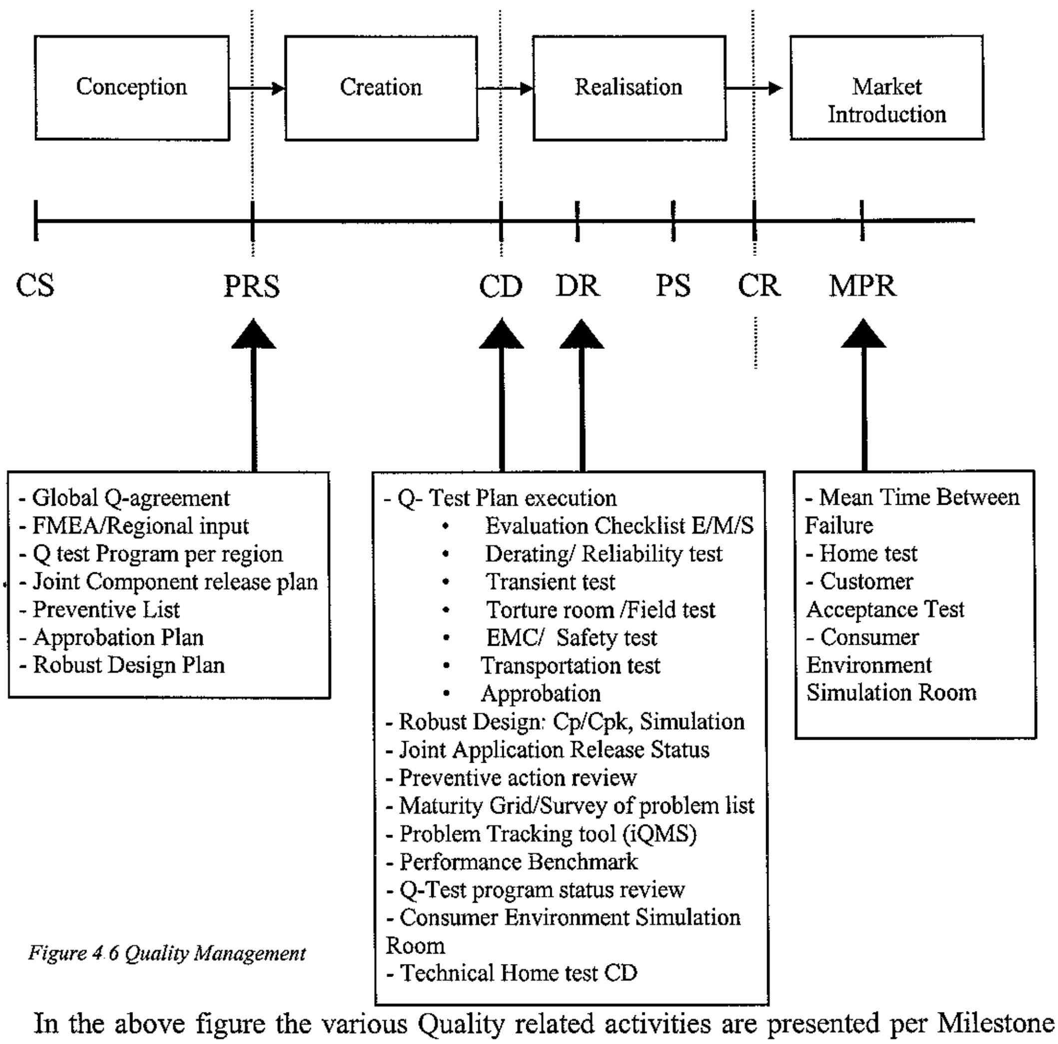

Figure 4.6 Quality Management

In the above figure the various Quality related activities are presented per Milestone in the Product Realization Process of Philips MTV. At Philips the Field Call Rate Quality parameter is used to control the processes and seen as the most important parameter. If the Field Call Rate of a certain TV-set rises above an acceptable point, an Attack Team is formed. Together with the Global Quality Team and the Global Maintenance Team action is taken. The feedback from the Customer Services Centres is used to analyse the reported problem. When cause and solution are known first corrective action, then preventive action is taken. More information on how this is done can be found in appendix 7 and 8. The result of the preventive action is recorded in the so called Black Book. The Black Book contains the major issues and their relevant preventive actions of all the projects at the Global Design Centre. It is used as a checklist and a guide for the next generation TV. The Regions have their own Black Book, and they call it their Orange Book. Additional information on Quality at Philips can be found in appendix 6.

4.2.3 *Re-use and Concurrent Engineering*

Two typical aspects of the Product Realisation Process of Philips deserve special attention. These two are the Concurrent Engineering approach and the importance of re-using designs.

Concurrent Engineering (CE) as described in paragraph 3.1.5 is a systematic approach to the integrated, concurrent design of products and their related processes, including manufacture and support. This approach makes developers consider all elements of the product life cycle from concept through disposal, including quality, cost, schedule and users requirements, from the start onwards (Menon and Syan, 1992). Philips Consumer Electronics used the Concurrent Engineering principles to setup their Product Realisation Process. Project teams are multi-disciplined and building blocks are developed simultaneously.

Re-use is encouraged as much as possible in the Product Creation Process of Philips. By re-using designs a faster time to market and a higher quality are achieved. Re-use within Philips MTV is made possible by the use of a design split strategy. The design split strategy dictates that a TV-set is designed as a composition of common building blocks. The common building blocks are developed in a standard design which is used for a longer period as a reference. Reference Architecture development is the activity of standardizing requirements, like features or functions, into subsystems. The functionality of the subsystems is mapped and the interfaces between the subsystems are defined and documented. A Standard Design is the (physical) realisation of a subsystem, which complies with one or more reference Architecture(s) and is designed for re-use.

The processes of creating reference architecture and standard designs go through similar process steps as development of any TV set design. A number of Standard Design modules result in a Product Platform, which contains a set of implemented, pre-integrated sub-systems and interfaces. The standard platform, the leading range or carrier, evolves and derivatives emerge as offspring's are produced efficiently and effectively. The derivatives of the leading range are called product-ranges. In Appendix 7 Figure A8.1 shows the relationships between Architecture design, Standard Design and Platform. Figure A8.2 explains the correlation between Platform, leading range and product range.

4.2.4 Implementation of PDM at Philips

In the next paragraph the future role of PDM in Philips MTV will be explained. The first part will describe how Philips MTV defines PDM. The second part will discuss the approach of the implementation of PDM in the existing company data structure. To conclude this paragraph, the usage of PDM in the future according to Philips is discussed.

PDM in Philips MTV

Product Data Management (PDM) is defined in Philips MTV as:

"To make use of "Information Technology" to support and manage the Product Creation Process with all its related Data and Processes and the subsequent of this data."

PDM will cover the entire lifecycle of the product across multiple working locations and on heterogeneous platforms.

Why should Philips MTV convert to PDM?

Philips MTV is convinced that PDM will offer them the following opportunities:

- Data vault and document management (authorization, distribution, notification)
- Workflow/process/lifecycle management (change, release, status management)
- Product structure management
- Component/supplier management (re-use)
- Project/program management (links to)
- User utilities (GUI) and system facilities

PDM will empower Philips MTV to manage their information in a structured way. PDM is also capable to manage information on multiple places and therefore enables the alignment of the business processes between the sites. Through structured review of the data it enhances the visibility of the workflow and the status of the project. More operational benefits of PDM are that it facilitates productivity during PCP. For example design changes are made more quickly, the number of document-types is reduced and documents are re-used and it reduces the number of errors. Above all there is less paperwork (electric notification plus vault) and one validated version for each document.

How did Philips MTV prepared for the implementation of PDM?

Now it is clear why Philips wants to use PDM and what are the benefits they expect to achieve. The next step is to find out how MTV wants to lead such a big change in their dataflow successfully into operation.

The strategy for implementing PDM in the site-specific processes is based on the description of the PCP and accompanying factors of Philips CE in SPEED. PDM will be introduced in realising to solve the important problems with high benefits and low implementation costs in the sites; this is based in the flexible "standard" applications build by the Philips CE PCP office.

In a PCP a lot of data is involved and gathered in systems like, CAD, SW, ADS, I Design, and Prod Com, which are stored in different systems like DocTool, PAFEC, (Pre)PALS, CORDIS and CP/CN. Lately a new database has been introduced iQMS. IQMS is described in another section. In the current situation all these databases are separately translated and send to the manufacturing SAP. A lot of extra information is gathered this way and also the chance to make mistakes miss out on things or other element that make the PCP less efficient and effective are much greater if the systems do not work together and are coordinated. As many large enterprises Philips never has put a lot of interests in organizing and structuralising the data and their flows. Now realizing the importance and the advantages to let all systems work together Philips CE wants to introduce PDM. The final objective therefore that PDM has to achieve within Philips CE is that all databases are fully integrated and translated. Then it is sent to the manufacturing SAP as not confusion, structured data. This will eventually have the above-mentioned benefits.

The current databases in the future PDM

The current situation of the structure of databases is that it's hardly structured and interacting with each other at all. There are a lot of different local tools (the different tools that are adapted by regional level trough the years) and all database systems like DocTool and CP/CN hardly work as one, are seen as two separate databases and are treated that way. There is also a whole area in the PCP that is not even supported at all. IQMS is also working on an individual base in the current situation.

The integrated PDM functionality will eliminate uncontrolled tools as in a sense of all the different local tools that are used now, migrate the individual operating databases as iQMS, CP/CN and DocTool and created added value in the areas that are not supported yet.

PDM will be implemented in steps and the first preparations in MTV started last year. First a structured list is made of all possible documents that can or must be produced or gathered in the PCP in order to manage a project; this list is referred to as Additional Product Data (APD) and is explained in the former chapter. The TPD list is also a requirement to make PDM work and is also explained in the former chapter. These two Product Data lists will be integrated as one in "Product Structure" component in PDM in the future. Along with the infrastructure and the site-specific structure the PDM change process in Philips MTV will be started.

To go a little in detail in the data-infrastructure, in Eindhoven Philips CE has a large Application server and a Web server. The different departments of Philips CE, the GDC's, are connected on the Web server. The vault storage is done in a large Data Base server and a File server that facilitates the application management. This is repeated downwards the organization, so for example from the GDC to the Regional Development Centres (RDC).

The PDM tool consists of an eMatrix Model, which is flexible (fits organizational changes and fits requirements on different levels) and has user interface based on graphical WEB. Advantages for Philips are for example the low maintenance costs. Before PDM-tool will be used it is very important that all the layers within Philips CE support the PDM-system. So higher management together with the employees who must be trained in using the tool and also training in working with the new data applications. Philips MTV wants to make the PDM-tool operational as soon as possible and is looking for faster implementation in use of the eMatrix.

With regards to the databases described in this research, the future is very unclear. Philips developed most of the databases structures in house. A database like iQMS is built out of an idea within the organization. It has been set up without a descent entity relationship diagram and data diagrams. If there was a problem in the database, something was not right or complete the database has just been adjusted in order to make it work again. Due to this very unstructured way of setting up databases the current databases probably cannot be used in the PDM system, which is strictly object structured, in their current state. Databases as iQMS are still evolving to what they should be when implemented in PDM. Although the Integrated Problem Management (IPM), the new iQMS, has already been set up, still is not known at this moment what the exact end form of it will be. The same goes for CP/CN and DocTool.

PDM can have a tremendous effect on the databases and data structure within the information flows in PCP of Philips CE. This automatically could have consequences for this research; as well due to the fact the PCP's databases play a key issue in this research. In this research the information out of the databases will be used and not the databases themselves. So if the structure of the databases will change but not the content, it will have minimal effect on the results of this research. However if the whole nature of the content will change as well, this research will probably have only added value to the original research question and an answer for this moment in time at Philips and will have fewer added values for future scenarios.

4.3 Information Flows and Data Sources

Many information flows and databases are used to regulate the process of the development of new products. In this paragraph the most important information flows and databases of Philips PRP will be explained. Their purpose, the way they work and other characteristics will be addressed. The criteria that are setup in paragraph 3.5 are used at the end of each sub-paragraph in this section to judge the usefulness of Data Mining the data source. First a data flow model showing the relevant information flows is presented. The next paragraph presents an overview and a conclusion on the usefulness of the data sources to Data Mining.

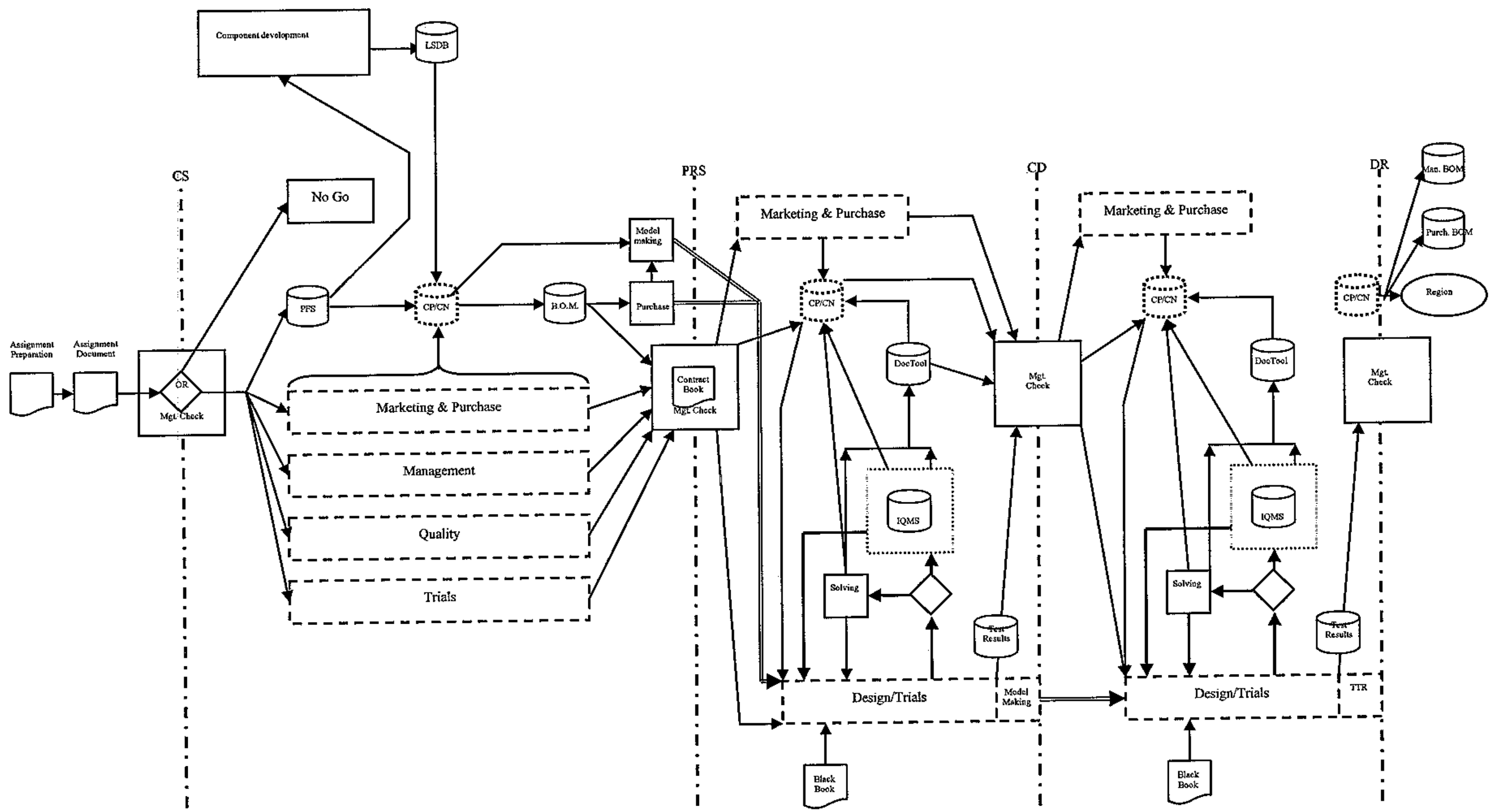

Figure 4.7 Information Flows in the PRP of Philips

4.3.1 Technical Product Documentation

The generic term for the documents related to the technical aspects of the TV-set is Technical Product Documentation. The setup of these documents is standardized by the TPD-guideline. By standardizing these documents the communication between the designers individually and the communication between the Global Design Centre and the Regional Design Centres is easier. Examples of documents standardized in the TPD-guideline are Drawings and Parts Lists. Because Technical Product Documentation is a collective noun for documents of different natures, it is difficult to characterise them as a group. Appendix 8 shows the full list of documents that belong to the category of the Technical Product Documentation. Part of the list with Technical Product Documentation is updated by DocTool, a system that will be discussed in paragraph 4.3.5.

All documents on the TPD list are checked by the project team and again by the administration department. This ensures the completeness of the TPD list. The TPD with a detail level to sets are generated during the whole Product Development Process and checked at the milestones. The potential value of the TPD list is estimated on a MIR 1 level, and so is consider being the same as the current usage. Data is recorded but the content can not be used to find directions to where to find problems. The overall conclusion on the content criteria is negative. The conclusion drawn on the format criteria is also negative. The TPD documents are scattered around the organisation and are stored at random Personal Computers throughout the organisation. The content of these documents might be setup according to fixed guidelines but the main part is still free-text which makes these documents difficult to Data Mine. A big part of the TPD documents consists of multi media content which is impossible to Data Mining. The total amount of TPD documents from current and past projects is large.

4.3.2 Additional Product Documentation

Additional Product Documentation (APD) is the counterpart of the Technical Product Documentation and contains mostly management information. But there are no guidelines for the APD documents like there are for the TPD documents. Recently an inventory was made of all the documents that belong to the APD category. This assessment was part of the implementation of PDM. The full list of APD documents can be found in appendix 9.

On the APD-list mainly Project management related documentation is found. Examples are Project Planning (Project Justification and Approbation Plan, Milestones Planning), Assignment document, and Contract Book and Quality agreements. Thereby the Tests Descriptions are on this list, note the Test Results do not fall in the APD classification. At last, a miscellaneous mix of documents is listed on the APD. These might be one time only documents and their true goals are often unknown. In many cases APD documents can only be found in hardcopy. The reason for this is to prevent too easy multiplication of these documents by unauthorized persons. Less sensitive APD documents can be found in the Team Rooms. The Team Rooms are virtual team rooms on the intranet of Philips. Members of one project are authorized to upload and download project documents from this system. Indeed, this system does have similarities with the future PDM. The Team Rooms however are only setup to share APD like documents. The actual use of the Team Rooms by the project members to access APD documents is till now rather low and in consistent.

When the criteria are applied to the APD documents it is shown that the information content is not complete. During the whole Product Development Process documents are generated, often ad-hoc. This indicates that the signal to noise ratio is high. The APD documents will mention major problems and where they occur. But the documents do not contain any technical information. Therefore a MIR 2 level is indicated for the potential and for the current use of the data. The same applies to the format criteria as did for the TPD documents. Documents are scattered around the organisation without any structure at all. Because the documents are scattered around the organisation they are difficult to count, but the estimated amount of APD is large.

4 3.3 *Change Proposal/Change Notes-system*

The Change Proposal and Change Note system is a collection of rules and procedures to manage changes to Parts List of a TV-set. Depending on the stage where the project finds it self in, different people are authorised to implement or accept changes in the Parts List. Each GRS has its' own Parts List. As soon as the individual TV-sets are defined, they will have their own Parts List based on the Parts List of the GRS. The Parts List of a TV-set (or GRS) is the core element of the final product. It is crucial to obtain a correct and always up to date Parts List at any time. In stage 0 any designer is allowed to add or change parts at the Parts List as long as the changes are not radical. The Parts List is not complete at this moment. In stage 1, a designer has to consult the project leader if he sees the need to change the Parts List. When the project reached stage 2 or 3 the Change Proposal needs approval of the Quality department. A Change Proposal can be accepted, refused, rejected or deemed for further investigation. After the Project leaders' approval the CP is accepted and becomes a Change Note. The designer is notified by the Change Note. This process and sub-processes always fall under the responsibility of the GDC even after the Design Release. As long as a platform project is running CP/CN is used to track all the changes. Changes in the Parts List caused by a design change are not the only changes that can take place in the development process. More kinds of changes exist:

- Design Changes
- Administration Changes
- Process Improvement Changes
- Supplier Changes
- Commercial Changes
- Cost Savings
- Concept Changes
- Business Changes

Recorded in the CP-document is the change (serial numbers of parts changed), which department/staff is involved, the reason of the Change Proposal (in free text form), the set concerned and finally which other parts will be influenced by the change. An example of a Change Proposal can be found in Appendix 12.

The CP/CN fields in the database are complete due to rigid procedures; the fields are required to submit a CP. All fields except the field "*CP reason*", this is the only free-text field in the database as well. So now and then this field shows interesting Quality related data. But unfortunately this field contains useless information like remarks for persons, more often than not. The CP/CN database is used during the Product Development Process and as long as production continues. This results in a large database with very detailed information. Information is as detailed as set level. The designers are free to use a "*CP reason*" which contains valuable information. Unfortunately the signal to noise ratio for the CP reason is 40% (estimate based on 50 random examples). The most interesting part is still the free text formatted reason of the change. The number of Change Proposals per phase of the Development project might tell us something interesting. But at second thought, how should be judged if a changes are positive or negative? Finally the kind of changes that occur most often or maybe specially at critical phases could be analysed. But this simple kind of analysis would not require Data Mining. Currently the usage of CP/CN is assessed to be on a MIR 1 level. The potential of the CP/CN is estimated to be at MIR 2 level, it is assumed that an analysis of the records in the CP/CN database can allocate where the problems arise. So the format criteria score quite high, the database is structured and available in soft-copy online. But the content criteria show some drawbacks.

4.3.4 Test Results

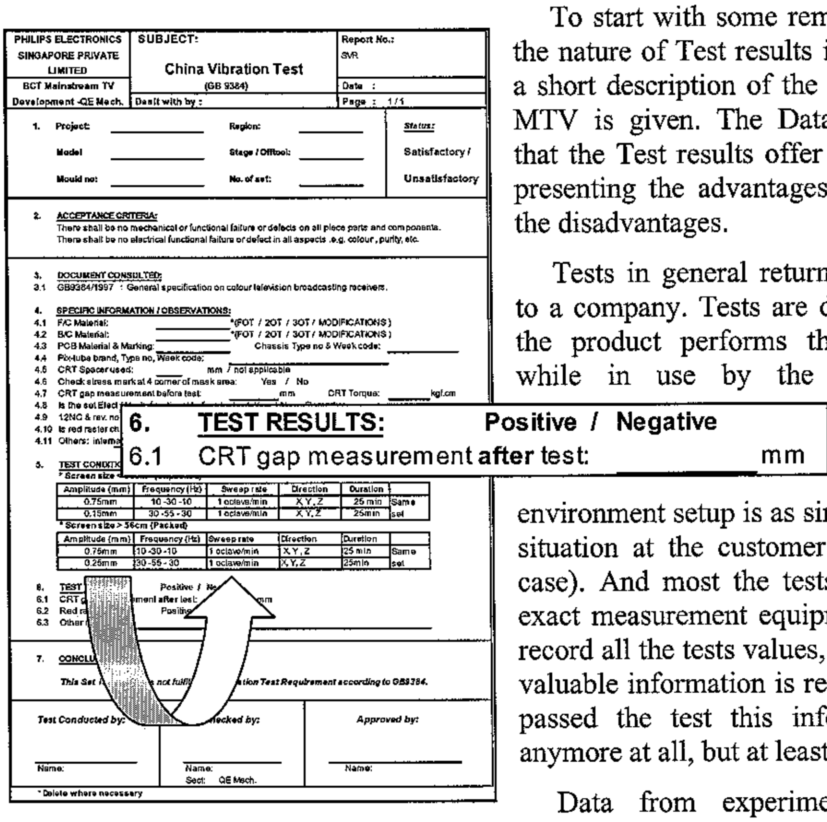

Figure 4.8 Example of a test form, the China Vibration test

To start with some remarks will be made on the nature of Test results in general. Afterwards a short description of the Test results at Philips MTV is given. The Data Mining possibilities that the Test results offer are discussed by first presenting the advantages and concluding with the disadvantages.

Tests in general return valuable information to a company. Tests are designed to find out if the product performs the intended functions while in use by the customer. The test environment setup is as similar as possible to the situation at the customer himself (in the ideal case). And most the tests are carried out with exact measurement equipment. Philips does not record all the tests values, but at quite some tests valuable information is recorded. After a set has passed the test this information is not used anymore at all, but at least the results are stored.

Data from experiments, prototypes, and numerical simulations are very appropriate for Data Mining because of two factors (Rudolph and Hertkorn, 2002). The designer who carries out a test usually has a good understanding of the relation between what he applies to the TV set and what the impact on the TV-set is. The second factor is the richness in physical unit information. This is a complicated story, but the result is that more Data Mining Techniques are applicable.

So it seems interesting to investigate the Test Results database. Actually it is not a database yet. Currently the Test Results are separate documents. But because of their homogenous structure they could be combined in a way that they form a database. But disadvantages arise because of the way Philips conducts the tests. Philips has to deal with a parts list variety in TV sets. It would be unwise to test them all. The Development teams picks out a few Global Reference Sets. These sets are tested and represent a whole range of individual sets. Besides, not all the Global Reference sets go through all the tests. This reduces the number of tests considerably and thereby also the power of an analysis. To illustrate these findings some details are presented here.

Which tests will be carried out for a particular Global set, is a decision made by the Project leader. The Project leader will make the decision based on the similarities of the Global Reference set with previous sets and on which test these previous sets have been through. Test instructions for all tests can be found on the intranet of Philips by developers. The actual Test results are entered in the Team Rooms (discussed in paragraph 4.3.2) in

	Cold Test	Electro Static Discharge	Lightning Simulation	Bump test	Drop test	Heat test	Vibration test
29PT2426/_94R	X	X		X		X	
21PT2460_94R (LG tube)			X		X	X	X
21PT2452_94R		X					
21PT2460/94R			X	X		X	
21PT2452/94R (Samsung tube)	X					X	

Table 4.2 Example of Test Database

most cases, but this is not common practice or procedure. This might change as soon as a successful PDM implementation is made. Then a possible database is formed easier.

The Tests are carried out complete and according to rigid procedures and requirements. The Test results however are not stored according to any procedures. The Tests are generated only between the PRS and DR milestones and carried out at set (product) level by designers. The signal to noise is not estimated in a number because it is clear that the signal to noise is low because a record will contain *pass* or *failed* together with a value read from some kind of measurement equipment. Estimated is a potential MIR 2, while currently the Test data are only used on a MIR 1 level. The biggest disadvantage is the small amount of tests carried out. The Composition criteria in total are judged negative because of this.

4.3.5 Doc Tool

A specific part of the Technical Product Data is Doc Tool. It performs a library function of drawings and parts lists. Of every part, component, module and TV-set; drawings and lay out documents are recorded. The drawings and lay-out documents contain front and back views as well as technical and mechanical specifications. DocTool is used by designers to retrieve the most current drawing as well as going through its history. DocTool is closely related to CP/CN. If there is any Change Proposal that has an influence on the layout and therefore the drawing of the element, DocTool will be updated with that change. Once DocTool is updated the Change Proposal is recorded in the Parts List. Almost every DocTool record has a CP/CN link. DocTool contains the parts list, and CP/CN contains the change details to the parts list in DocTool.

Most library systems have rigid procedures, DocTool alike so it makes not sense to assign a signal to noise ratio as it will be very low. The data is detailed up to component level and the designers enter the technical specifications during the whole Product Development process. But nothing more could be done with these specifications than store them. Therefore the potential of the database is set on a MIR 1 level, as the current use is also assessed to be at a MIR 1 level. Looking at the Composition criteria it can be seen that the size is very large but the biggest part contains multi media format which is impossible to Data Mining. So even though DocTool contains exact technical information, it is absolutely excluded of further analysis because it fails both criteria categories.

4.3.6 The Integrated Quality Management System

The Integrated Quality Management System is a problem tracking tool which Philips has developed in-house in 2000. The system is online available on the Philips intranet with several levels of access. The iQMS is implemented in the Global Design Centre as well as the Regional Design Centres. The official objectives of iQMS (iQMS, 2001) are threefold:

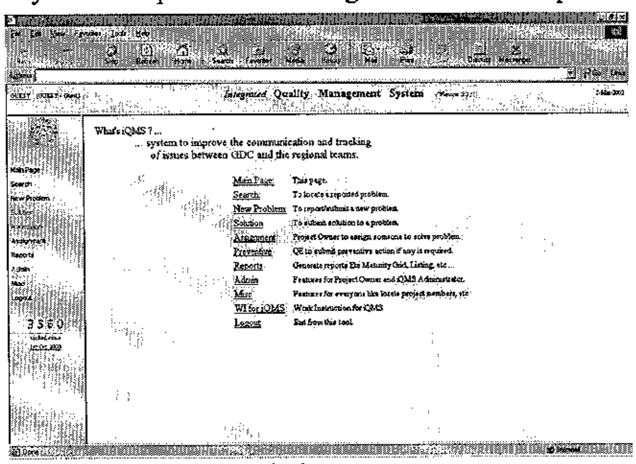

Figure 4.9 Example layout iQMS

- Tracking of problems in the Platform creation phase, Product Realization Phase and Aftercare/Maintenance Project within BCT MTV.
- Enhance communication between the Global Design Centre located in Singapore and the Regional Implementation Teams.

- Enable learning from past experience and facilitate effective preventive action with a knowledge base.

The procedure of iQMS is shown is figure 4.10 and explained here. Four types of users log in to the system. When the designer encounters a new problem and he can not find this problem already listed in the system. He creates a new problem record. As soon as a new problem is entered, the system automatically notifies the Project Leader by e-mail. He will judge the problem description and setting provided by the designer. According to the sort of problem the project leader chooses a solver and assigns the solver to the problem. A solver is an experienced designer who is specialised in some type of problem solving. The solver will receive an e-mail as well as a target time of two weeks to solve the problem. If it is a difficult problem it can be extended to two months. Once the solver has found a solution, this solution will be assessed by the Quality Department. If there is a need to take preventive action the Quality Department will do so, afterwards they will close the problem. If the project is in the Maintenance phase the Project Leader is also allowed to close the problem. The system uses a database in a Microsoft Access format. Every row represents a problem record. The database has 40 columns; the most obvious are the problem description and the problem solution. The 40 columns with some examples of problem records can be found in appendix 11. Since the start up of iQMS 1221 problems have been recorded in the database.

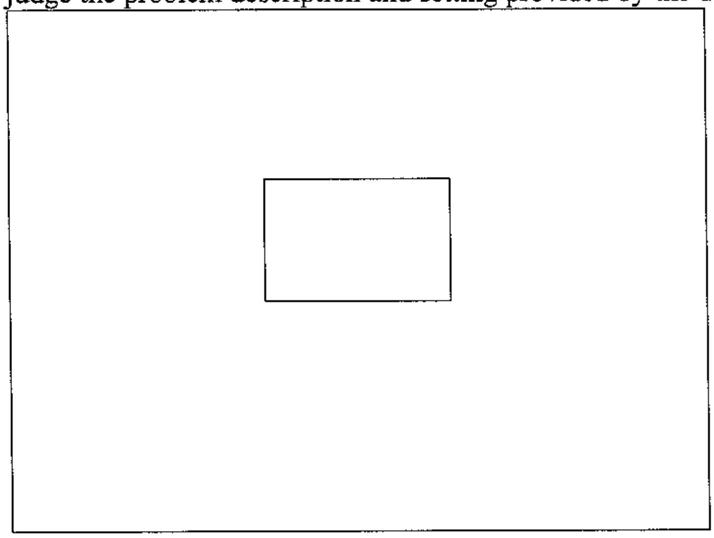

Figure 4.10iQMS model

At the moment iQMS is mainly used as a problem tracking system and to coordinate the communication in problem solving between GDC and RIT's. Problems are momentarily dealt with one by one, groups of problems of possible combinations are not considered so far. It is even impossible to look up similar problems in the history.

The information stored in the iQMS database can be of great value to Philips. It is assumed that the problems found during the Development process are related in some form or another with problems encountered by customers in the field. In particular Problems not found or not solved well will probably turn up in the market. The records covering the solutions descriptions come close to the *Tacit Knowledge* of the designers. It is alleged here that the information of the iQMS database might be suited to prevent problems. This could be achieved by obtaining a better general understanding of the relations between problems and solutions, or to state it differently, to obtain a better understanding of the functioning of a TV-set. This implies that the potential value of the iQMS database is estimated at MIR 4 level. Currently the use of iQMS is assessed at MIR 3 level because the attempts to prevent problems in the iQMS systems are ad-hoc. The other content criteria score not as good as the potential value. The data is not always complete as not all (interesting) fields are required to enter a record. More over the signal to noise ration is calculated to be 21%. This is done by manually assessing the solution descriptions and filtering those descriptions with an obvious useless content. The data recorded in iQMS is on set (product) level and is gathered starting at the Product Development Process and continues as long as the set is produced. The composition criteria are met. The database contains 1221 records (August 2002) and these records contain free-text format data as well as numerical and categorical formatted data. Some of the records in the iQMS database have a changing nature, for example the problem status (see appendix 11). These kinds of records must be ruled out for further analysis. The content criteria are met because the data looks consistent, complete and has a clear direct relation to the end-product quality.

4.3.7 Continuus

Continuus is a system very similar to iQMS. It is also developed in house by Philips. This time it is not developed by the department of Quality and Support but by the software department itself.

The Software department is the sole user of the system, and they are using it now for three years. It has some more options compared to the iQMS system. It features a key word list that makes it easier to find problems from the history of the system. Continuus and iQMS are synchronized with each other manually on a weekly basis. As the Software discipline varies too much from the other departments and the needed software background and knowledge are not available to this research; this database is not considered as an option in this research. Thereby the general outcomes of a more detailed iQMS assessment might be applicable to the Continuus database.

The two criteria categories applied to the Continuus database lead to the same results as for the iQMS database.

4.4 Is it possible to Data Mine the Databases of Philips

The description of the data sources mentioned in this chapter tell us to a certain extend if it is useful to apply Data Mining to these data sources. Two categories of criteria are used to determine if Data Mining on the data sources is possible and interesting.

- To what extend is *the content of the data* source Quality related?
- To what extend enables *the composition of the data*, Data Mining?

A subdivision of these two categories is presented in paragraph 4.4. It is demonstrated in paragraph 4.4 that both of these questions are difficult to answer. The answers can not be given in numbers or anything that can be measured. Furthermore, each of these questions needs a different expertise. In fact, this is the point of this project where the two disciplines, Data Mining and Product Development, really come together. So how are these answers found? The best possible answer is found by consulting the experts in the two disciplines and the people at Philips. Together plausible examples are formulated so they can be assessed and discussed.

Every data source is assessed on its individual adequacy. The possibility of Data Mining data combined from several sources at once is not considered in this thesis; refer to the Thesis of Van Gorp (Gorp, van 2002). The combination of data from several sources is a laborious undertaking. A key to link several sources up to one common level needs to be found; next the data needs to be transferred to one single location. It is an important option to consider but due to time constraints it is not a part of this research.

	The Information Content Criteria		The Composition Criteria	
Technical Product Documents	-	*Completeness*: complete *Time window*: The whole PDP *Level of detail*: Very detailed *Information suppliers*: designers, maintained by administration *Signal to noise*: low due to fixed guidelines *Potential*: MIR 1 (currently: MIR 1)	-/-	*Structure*: **No structure at all**. Loose, scattered documents *Format*: Softcopies online available in Word or Excel, but mostly in **Multi Media format** *Size*: 26 different document, each exist for each set
Additional Product Data	-/-	*Completeness*: low, each team has a different approach *Time window*: The whole PDP *Level of detail*: Global, only overview *Information suppliers*: Project leaders *Signal to noise*: **Very high**, each team has a different approach *Potential*: MIR 2 (currently: MIR 2)	-/-	*Structure*: **No structure at all**. Loose, scattered documents. *Format*: Softcopies online available in Word or Excel *Size*: Differs from project to project.
CP/CN	+/-	*Completeness*: Complete, rigid procedures. Exception: remarks field completeness low *Time window*: The whole PDP and Production *Level of detail*: Very detailed, set level *Information suppliers*: Designers *Signal to noise*: estimated on 40% *Potential*: MIR 3 (currently: MIR 2)	++	*Structure*: **1 database** *Format*: Fixed forms in softcopy online with textual and numerical content *Size*: very large
Test Results	++	*Completeness*: Complete, rigid procedures *Time window*: The whole PDP *Level of detail*: Very detailed, set level *Information suppliers*: Designers *Signal to noise*: low due to fixed guidelines *Potential*: MIR 3 (currently: MIR 2)	-/-	*Structure*: **No structure at all**. Loose, scattered documents *Format*: Fixed forms in softcopy but not always online, contains only limited numerical content (mostly only 1 value) *Size*: very small, Philips tries to reduce variety in testing because of time constraints
Doc Tool	+/-	*Completeness*: Complete, rigid procedures *Time window*: The whole PDP *Level of detail*: Very detailed, set level *Information suppliers*: Designers *Signal to noise*: Low due to fixed guidelines *Potential*: MIR 1 (currently: MIR 1)	-/-	*Structure*: Library structure *Format*: Fixed forms in softcopy but online, contains only **multi media information** and a parts list in free-text format *Size*: large
iQMS	++	*Completeness*: moderate *Time window*: The whole PDP and Production *Level of detail*: Very detailed, set level *Information suppliers*: Designers *Signal to noise*: 21% *Potential*: MIR 4 (currently: MIR 3)	+	*Structure*: **1 database** *Format*: Fixed forms in softcopy online with textual and numerical content *Size*: large
Continuus	+/-	*Completeness*: moderate *Time window*: The whole PDP and Production *Level of detail*: Very detailed, set level *Information suppliers*: **Software designers** *Signal to noise*: unknown *Potential*: MIR 4 (currently: MIR 3)	+	*Structure*: **1 database** *Format*: Fixed forms in softcopy online with textual and numerical content *Size*: large

Table 4.3

So data sources have often a format suited for Data Mining, but do not have a useful content. Or the other way around can be seen as well. Clearly the CP/CN database and the iQMS database are interesting candidates for a closer look. Continuus is out of the question because of two reasons; it is similar to the iQMS and assumed is that the same approach can be used as for the iQMS database to take a closer look. Secondly studying the content of the Continuus database will require knowledge from the Software discipline and this knowledge is not available to this research. One observation can be made, a large part of the data in the Product Development Process at Philips is not structured enough to analyse. "To analyse" is emphasized because this large part of data might serve the goal of communication very well. But no judgements are made on this point in this research. The introduction of PDM as explained in paragraph 4.2.4 might put this large part of the data in a right structure.

Only formal information is considered in this research. This is done deliberately because the goal is to explore Data Mining applications. Informal information cannot be Data Mined but is acknowledge being of great importance to any organisation. In certain databases information is stored that relates to the so-called Tacit knowledge. Trying to capture this Tacit Knowledge so it becomes explicit knowledge is one of the main goals of applying Data Mining techniques. So in particular these databases, iQMS and CP/CN, are of great interest.

4.5 Conclusion

The Product Development Process at Philips was described and there are no major differences observed when it is compared to a general Product Development Process next to the typical characteristics of the Philips setting discussed in paragraph 4.2. The planning task corresponds to the Planning group within Philips, which consists of Know-How planning and Programming. The next phases in a general PDP, conceptual design and embodiment design, imply correspond to the concept confirmation in the PCP of Philips. Also the second and third stage of detail and testing and refinement steps of the general PDP imply the same activities as the second and third stage from the Philips PCP. Both Development processes conclude with Mass-production ramp-up.

A more detailed study of the information flows and the data sources at Philips is presented and from these the following is concluded. The criteria setup in paragraph 3.5 clearly shows why a data source might be useful to Data Mining and when not. Each data source is discussed in this chapter and the criteria are applied to the data sources. This is done together with the description of each database and a summary and overview of these finding is presented in paragraph 4.4.

Constructing a database from several data sources is not considered in this research due to time constraints. Two databases meet both categories of criteria. Not surprisingly these two, iQMS and Continuus, are very similar. The latter is disregarded because conclusions will be similar for both databases as well; thereby the necessary Software discipline knowledge is not available to this research.

The general conclusion of the remaining data sources is that they are not or barely structured. Al lot of documents are spread around the organisation and are not managed enough to be analysed.

5 A CLOSER LOOK AT DATA MINING iQMS

The previous chapter shows that the database of iQMS contains the most interesting information of the entire data source available and thereby the iQMS database is available in a format that makes Data Mining possible. The first and second research questions are answered positive for the iQMS database according to the criteria setup in chapter 3. The format of the database is structured enough to enable Data Mining and the content is relevant to Product Quality. This chapter answers the third research question:

3	*"What are (possible) results of applying Data Mining techniques?"*

To answer this question a more detailed description of the content of the iQMS database is given. And plausible scenarios are discussed which concludes the first Data Mining step, Domain understanding. The next Data Mining step is Data selection; in this research not all fields are considered. The reason for this is explained in paragraph selection. Finally Data transformation is carried out. After presenting the Data Mining steps carried out, an analysis is presented on the validity of the iQMS database content. Interviews with users are carried out to assess the way the iQMS system is used and information is entered. The Data Mining steps and the validity assessment will be brought together in the conclusions of this chapter.

5.1 The First Data Mining steps

The first four relevant Data Mining steps are presented in this paragraph. The way they are taken and the results per step are included in the text.

5.1.1 iQMS Domain understanding step

The Fields in the iQMS database

The iQMS database includes 40 fields (columns) and contains 1221 records (dated: 8th of August 2002). The fields are presented here. The format of each field is explained and an example is given.

Field in the iQMS database:	format	remarks content	example
Problem ID	unique ID number	always present	530
Status	categories, changing in time	ASSIGNED, CLOSED, ESCALATED, EVALUATED, NEW, REJECTED, RE-OPEN, SOLVED, STUDYING	CLOSED
Project	free-text	24 different projects currently have entries in iQMS	L01L-GMT
Title	free-text	always present	X-ray protection false triggering
Description	free-text	always present	Symptoms: Sets shut down but restart for a few times before going into permanent shut down (protection mode). Description:
Conditions	free-text	always present	This phenomenon will happen during auto-tuning of set.
Category	categories	DESIGN, MATERIAL, NUISANCE, PROCESS	Design
Report Fr	categories	one of the regions or the GDC	GDC
Site	categories	where is the problem found	Singapore
Type No	free-text	mostly the 8 digit set code is used	25V/27V

Defects Gravity	classes	Philips CE uses a matrix of maturity On the one axis it shows the Gravity, on the other the Evolution Factor In iQMS this entry does not change, the revised Gravity and Evolution Factor are entered in a separate field. S: safety, A: not producible/salable, B: major difficulty, C: minor difficulties, D :deviation point	B
Evolution Factor	classes	4: cause unknown, 3: solution unknown, 2: not evaluated, 1: evaluated, 0: implemented, 9: reject	3
Discipline	categories	CESR, ELECTRICAL, MECHANICAL, SAFETY, SOFTWARE	Electrical
SW Version	free-text	a reference to a Software version is present in 66% of the records	
Enter By	name	95 people entered problems in iQMS	TOMMY HII
Submitted On	date	first entry on 15 of January 2001	11/23/01 2:41:08 PM
Assign To	name	128 people were assigned	Tommy Hii
Comments	free-text	comments are made in 63% of the records	Solution tested & implemented in Juarez. Also tracked under the PDCA of FCR Action list, and confirmed the solution is implemented on production lines
Affected Region	categories	if the problem occurs in several regions	GDC
Revised Defects Gravity	classes		B
Revised Evolution Factor	classes		0
Assigned On	date		11/30/01 9:43:36 AM
Closed By	name	56 people closed problems	KOK WAI WAH
Closed On	date		12/15/01 10:23:01 AM
Refer to Problem ID	numerical	a reference to another iQMS problem is present in 1% of the records	
Cause	free-text	73% of the records mention the cause	During auto-tuning, the H-PLL will try to sync all signals and as a result, the total range of PLL (+/- 1kHz) will be used. It's possible that EHT voltage can increase about 10% when Hout frequency is lowered with 1kHz. The increase in EHT will cause the HEW voltage and thus the voltage at emitter of 7443 to increase and the transistor turns on. As there was not enough voltage margin at collector of transistor 7443. The voltage was measured in these sets at 3.5V under normal operation condition (should be 2.1V). This is connected to pin 34 of UOC which is the EHT over voltage detection input/EHT tracking pin where protection will be triggered at 3.9V. So during auto-tuning, pin 34 of UOC was false-triggered.
Solution	free-text	always present	Resistor 3452 has been changed to 10k and 3454 to 3k9 to eliminate false triggering of EHTo protection.
(#1) CP No	numerical	a reference to a CP is present in 14% of the records	SV54133
(#2) CP No	numerical		SV54163
(#3) CP No	numerical		
Test Report	free-text	a reference to a Test Report is present in 0% of the records	

Function Area	categories	Audio, Control, Deflection, EMC, Input/Output, Mechanical, PIP, Power Supply, RC, Scaler, Scavem, Software, Teletext, Tuner IF, Video	Deflection
Solved On	date		12/3/01 1:36:53 PM
Preventive Action (PA)	free-text	some remarks about a Preventive Action present in 43% of the records	To be input the design checklist.
PA Input By	name	20 people entered PA	TAN SIONG TEE
PA Input On	date		5/21/02 6:47:54 PM
Preventive Status	categories	the Preventive Status can be CLOSED (11%), NOT REQUIRED (29%), PENDING (0%), the other records (60%) do not mention anything about the Preventive Status	CLOSED
Escalate to GDC	yes/no	Problems found in a region are supposed to be solved in the region If this is impossible, the problem is forwarded (escalated) to the GDC	No
Affect For-Off-Rate	yes/no	The Problem owner estimates if the problem he/she found will affect the FOR	Yes
Affect Field-Call-rate	yes/no	The Problem owner estimates if the problem he/she found will affect the FCR	Yes

Table 5 12 the iQMS fields

Figures on the iQMS database

Prior to any Data Mining step, the whole database has been analysed manually. In order to develop a better understanding of the iQMS database nature. The Problems without a solution (yet) were filtered out and the Solution descriptions were read one by one. The Solution descriptions were assessed of being useful or not useful at all. Of the 1220 records in the iQMS (dated August 2002) it was concluded that only half contains a Solution description that might contain a complete and useful description. Some more conclusions are presented in table 5.2.

Problem accepted as it is	5%	Status Rejected	17%
CP number available	14%	useful solution descriptions	52%
Not producible or saleable (A)	24%	useless solution descriptions	21%
Major difficulty (B)	47%	no solution description	27%
Minor difficulty (C)	18%	Discipline Electrical	43%
Deviation point (D)	0%	Discipline Mechanical	11%
Safety (S)	10%	Discipline Safety	9%
Presumably affects FOR	24%	Discipline Software	28%
Presumably affects FCR	47%	CESR	8%

table 5.2 Interesting figures (based on 1221 records)

The Problem - Solution link

IQMS presents one of the smallest feedback loops in the Product Development Process. This feedback loop serves a controlling role and is doing this by providing a communication and tracking tool. Figure 5.1 visualises what happens exactly when iQMS is used. A Designer discovers a problem, this can happen during a small check or during any official test. If the designer is unable to solve the problem by his own. In other words, a solution description is unknown to him; he will enter the problem in iQMS and the iQMS feedback loop starts. The Solver assigned to the problem will assess the information on the problem

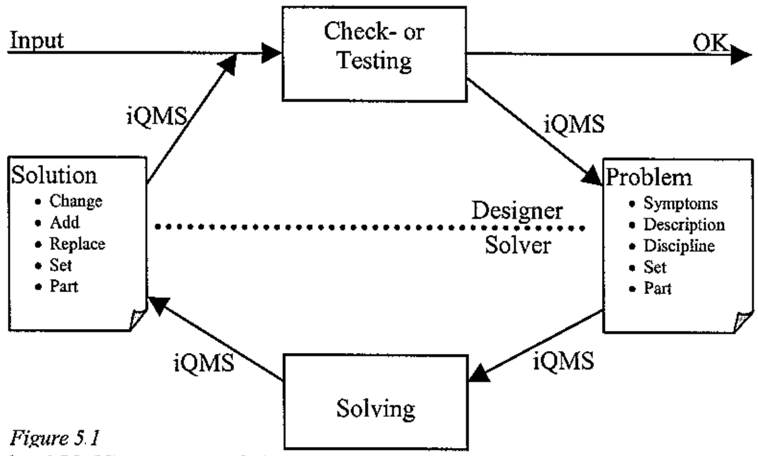

Figure 5.1

provided by the iQMS system. If the provided information is not sufficient, he will contact the Designer who discovered the problem. Once the Solver has enough information he will analyse this information. He will combine aspects of past cases and create a solution for the current problem. The Solver enters a description of his solution in the iQMS system. If the description is not sufficient for the Designer, the Designer will communicate once more with the Solver. At this point a remark is made on the introduction of PDM at Philips as mentioned in paragraph 4.2.4. The introduction of PDM at Philips MTV will change a lot within the organisation. However, as is known today, a similar system will replace iQMS. This new system is called Integrated Product Management and the core of it will remain the same. It will still function as the Problem – Solution model described in this paragraph.

Scenarios

So what kind of Data Mining application are we talking about? What might be possible? Three suggestions are presented. They emerged from discussions with Data Mining experts, brainstorming and after consulting the literature.

- **"Smart Search"** At the moment it is not possible to search the database using the free text fields. Searching the iQMS database using only the other fields like Discipline or Geographical Location does not make sense. Just a simple single word search engine

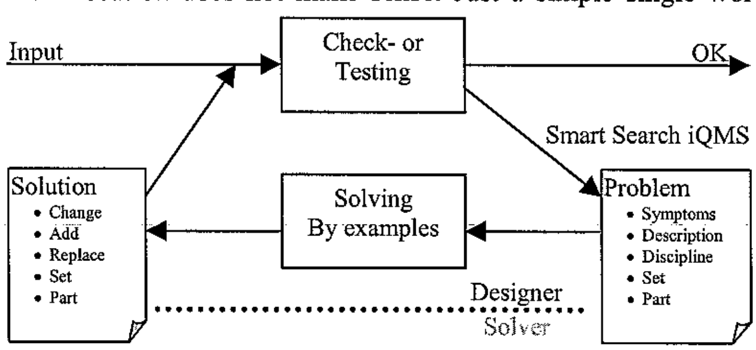

Figure 5.2

could be easily setup. A search engine capable of searching problems based on more, or combined, aspects of a problem would require the involvement of Data Mining techniques. In this way a designer could not only find exact similar problems but if they are not available, also those problems related to the unsolved problem at hand. Reviewing these selected history records might trigger a solution with the Problem owner. If the Designer finds a solution without needing help of a Solver, it will save a lot of time and the effect of the (similar) Solution is known already.

- **"Survey of Problem characteristics"** Currently surveys can be made based on fields with a categorical or class format. A survey based on similarities in the Problem Description test, found by Data Mining the text, might result in a useful and unexpected grouping of problems. These groups can point at important problem aspects that were neglected by designers who entered the problems. By identifying new groups of problems, it might be possible to emphasise more precisely on the right training and research subjects. Thereby preventing the occurrence of big groups of problems in the future.
- **"Problem Mechanism"** The Description of a problem has a direct relation with the solution of the problem. This sounds stupid to mention, nevertheless it deserves extra attention here. The Problem owner does not have a solution for a problem he experienced. He presents the problem to the Problem Solver, via the iQMS procedure. The Problem Solver absorbs the information provided, and starts a thinking process. This is the Tacit Knowledge part. The Thinking process eventually is a comparison of cases experienced by the Solver in the past. These cases might be exactly similar or might have only similar aspects. Consciously or unconsciously the relevant past problems are selected and the solutions are recalled. By combining these relevant past solutions and

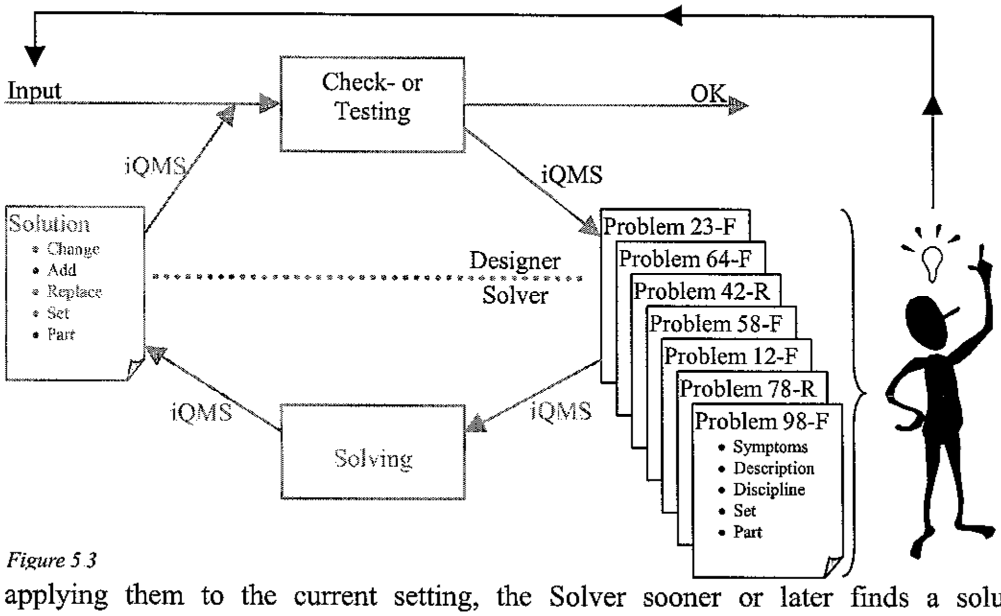

Figure 5.3

applying them to the current setting, the Solver sooner or later finds a solution. Especially the Solvers with a long experience are important to solve problems. A Data Mining application could just mimic the processes going on in the mind of the experienced Solver. Comparing all aspects of a new problem (to start with the textual problem description) will result in a list with problems that are either exactly the same or that have similar aspects. Clever combination of the aspects on this list will result in a plausible new solution put together with parts of the relevant solutions.

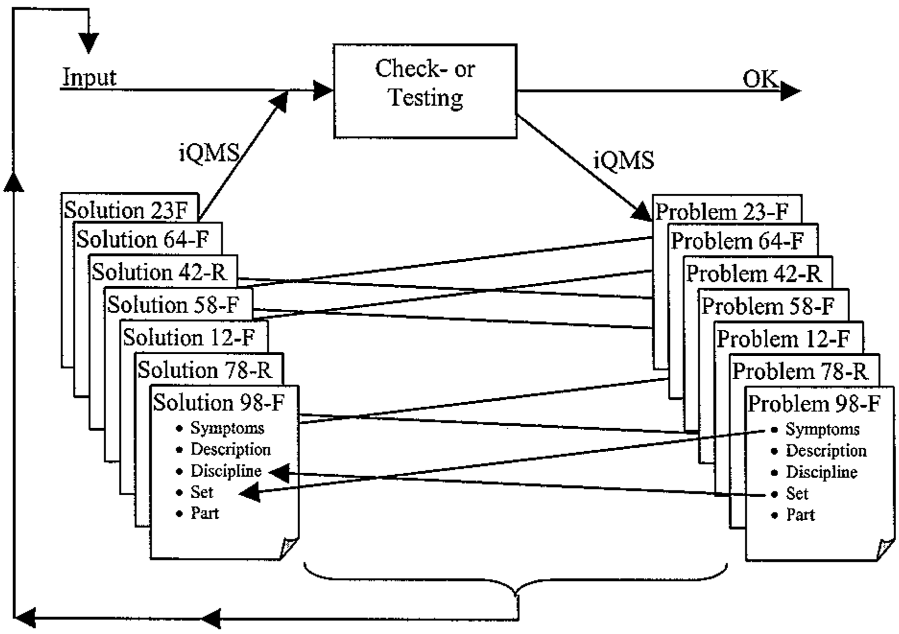

Figure 5.4

The second and third scenarios have more in common with each other than with the first. The first scenario of a "Smart Search" still serves the function of being a control mechanism. Whereas the second and third serve as a way to prevent problems in the future by adjusting the goals or limitations of a project. The difference between the second and third scenario is small. In the second scenario the problems are reviewed by using Data Mining and based on the results, it is possible to adjust training and research efforts. The third scenario uses Data Mining to assess the relation between a problem and its solution. So this analysis is larger as it contains the solution description as well.

5.1.2 Data Selection step

The Focus within the iQMS database is narrowed down for this research on the fields containing the Problem Description and the Solution Description. This selection is done for three reasons.

The iQMS system currently provides a limited option to present overviews based on the categorical and class fields. This means, that the fields can be used to filter or group records. The fields in free-text format can not be used as sorting criteria or as search criteria.

Secondly the time constraint for this research plays a role, and looking closer at Data Mining possibilities offered by the non-free-text fields is done in the research work of Karel van Gorp (Gorp 2002).

The final and most important reason to focus on the Description fields is the content of these fields. The description fields contain more specific and detailed information about a problem or description than the other fields do. This is concluded after interviews and discussions with the Philips staff and the experts who supported this research.

5.1.3 Data Transformation step

For any of the three suggested scenarios the required pre-processing steps are the same. The textual information in the Problem Description and Solution Description field needs to be converted to information understandable by a computer. The Cheetah software (Cheetah, DTI 2002) is used to do this. Cheetah is an in-house at the Design Technology Institute developed software program that performs the pre-processing steps necessary to Data Mine. Each description is taken apart and every single word is coded. Cheetah subsequently applies cleaning, stemming and indexing. This leaves out all the meaningless articles and punctuation marks, still the results is a large database with 4.000 distinct words for all the fields together. To get closer to a proper understanding by a computer of a Problem description, the most important words need to be identified. The most important words form the key-word list. The key-words list can be setup in two ways.

1. Order all the words based on number of occurrences in a Pareto diagram by making use of CHEETAH. So start with the most frequently mentioned words because they are assumed to be important words. Remember that articles, fillers etcetera are filtered out already. The advantage of a key-word list setup in this way is the lack of human bias in the list. The disadvantage is the uncertainty of value of the selected key-words. The second disadvantage is that those words that are obviously useless need to be filtered out manually. For the Problem Description field the key-word list setup by CHEETAH is presented in table 5.3. The fact that there are little words occurring very frequent and a lot of words occurring only a few times demonstrates the dynamic and varied nature of the problem solving activities. Around 1700 words occur 5 times or less than 5.

~~1~~	~~descript~~	~~70%~~	11	screen	14%
~~2~~	~~symptoms~~	~~67%~~	~~12~~	~~no~~	~~13%~~
~~3~~	~~set~~	~~38%~~	13	tune	13%
4	channel	29%	14	line	12%
~~5~~	~~not~~	~~27%~~	~~15~~	~~us~~	~~11%~~
6	picture	24%	16	AV	11%
7	TV	23%	17	press	11%
8	sound	17%	18	signal	10%
9	change	17%	19	DVD	10%
~~10~~	~~problem~~	~~14%~~	20	switch	9%

Table 5.3 Key-words based on occurrences, useless words are strikethrough. Percentage is percentage of records where the word occurs in the 1221 records database

channel	26%	power	3%
screen	14%	geometry	3%
vertical	7%	tube	3%
video	6%	mains	2%
white	5%	horizontal	2%
control	4%	current	2%
control	4%	light	2%
tuner	4%	contrast	1%
audio	4%	flash	1%
input	4%	scavem	1%

Table 5.4 Key-words setup with Philips staff ranked in order of occurrences. Percentage is percentage of records where the word occurs in the 1221 records database

2. The second key word list is set up in dialogue with the staff at Philips. Designer, Solver and Quality coaches participated in several brainstorm sessions. These sessions produced a key-word list which is shown in table 5.4. This list is compared to the Problem description field and the percentage of records where the word occurs is presented. This shows that the words suggested by the staff do not occur frequently in the iQMS database. Clearly some misunderstanding about the nature of the problems of iQMS exists.

Both key-word lists can be used in the next Data Mining step. They will just render slightly different results. But that is a good way to verify the outcomes if they can be compared to a similar approach.

5.1.4 Data Mining step

The single key-words do not reveal a lot of useful information. More words are needed to properly describe a problem. Combinations of words can be counted as well, not by the CHEETAH software but by the commercial software modules of the SAS enterprise.

The combined word count module of SAS can perform the first scenario "Smart Search". To do so, it will use the key-words list setup by CHEETAH. Unfortunately the combined word count module of SAS is not available at the Design Technology Institute. There is not substitute available at the Design Technology Institute either; therefore this analysis could not be carried out.

The second scenario uses clustering. In this way groups of similar problems are formed and they can be assessed on their similarities and differences. The clustering module of the

SAS enterprise is available at the Design Technology Institute. Several attempts are made to cluster the problems based on the key-word list. Unfortunately the Data Mining experts at the Design Technology Institute do not have experience with this module. And no useful results are obtained. To obtain clustering results, a longer period of trial and error is needed before useful results are expected.

The third scenario depends on the combined word count module of the SAS enterprise as well. It is the objective in this scenario to spot combinations of words occurring in two different columns. As this application is unfortunately not available at the Design Technology Institute, and all other no results can be presented.

5.1.5 Conclusion of the Data Mining steps

A correct and complete understanding of the iQMS database is reached. From this Domain Understanding and three plausible scenarios the next Data Mining steps are taken. The scenarios are based on the link between a problem and its accompanying solution. This link is an important issue in this report because it forms the basis for further exploration of the possibilities. Data selection and Data Transformation are carried out so everything is ready to perform the Data Mining step itself. Data Transformation is even carried out twice, so the eventual results of the two approaches can be compared. Due to time limitations and the restricted availability of Data Mining tools and knowledge, no further results can be presented.

5.2 Content Validity of the iQMS database

To assess the validity of the information entered into the iQMS system two steps are taken. The iQMS manual (iQMS 2001) is consulted and the objectives listed in the manual are verified by interviewing five users. The interviewees are carefully chosen. A selection is made of frequent and non-frequent users from different backgrounds and from different disciplines.

According to the **iQMS manual** the Main objectives of the iQMS are:

- Tracking of problems in the Platform creation phase, Product Realization Phase and Aftercare/Maintenance Project within BCT MTV.
- Enhance communication between the Global Design Centre located in Singapore and the Regional Implementation Teams.
- Enable learning from past experience and facilitate effective preventive action with a knowledge base.

The Philips Staff

In the interviews the Philips staffs is asked after several aspects of their activities where iQMS is involved. These aspects are used to support statements on the validity. The aspects presented here are derived from the literature (Alter 1999) and by consulting an expert on this subject. The Commitment of the users to the system, the resistance of using it, the threat to privacy, and the reduced autonomy are all taken into account. The results of the interviews are presented including additional backgrounds aspects. The backgrounds include the previous system used by the staff and miscellaneous points the interviewees made on the iQMS system.

5.2.1 Before iQMS

Generally the Philips staffs are happy with iQMS. They work with iQMS for a year now. Previously they used a similar system called Problem Tracking Tool. This Tool lived a short life because it was quickly flooded at the GDC by problems entered by the regions. The developers who were supposed to solve these problems could not distinguish between the important and less important problems because there were simply too many. The database of the previous Problem Tracking Tool is not compatible with iQMS. In fact it is not accessible at all anymore. The software is simply not available anymore. Flooding of the system is still a threat to iQMS. But the threat is reduced by the procedures followed by the iQMS system. The procedure requires a full local investigation of a problem found in a region. And subsequently to escalate a problem approval is needed from the Project Manager of the region. The effect is that most regional problems are solved now locally and are not escalated to the iQMS system of the GDC. But even the small amount of escalated problems together with the problems found at the GDC itself could flood the users with a large amount of problems as the users fear.

5.2.2 Training

When iQMS was introduced one year ago, all staff involved received training in a few afternoons. This training is viewed by the users as proper and sufficient. In between bugs are repaired and some minor extra features are added of which the users were notified by e-mail. No major changes took place.

5.2.3 Reproduction

All users experience the same difficulty while solving problems. The reproduction of a problem is often not possible. Especially problems that occur in test models build in one of the regions are difficult to reproduce at the GDC in Singapore. The regions use parts from their own suppliers in combination with parts from the GDC in Singapore. If a problem is not reproducible in the GDC it will take a long time before the problem is solved and a lot of additional information and communication is needed. These remarks of the users comply fully with the records in iQMS.

> "If too many people enter to many data, it becomes unmanageable. Then we will drown in problems and we will not be able to see the difference between the major and the small problems. If it happens now, the project leader will ask me, based on my experience, to assess what are the major problems. We base it on our guidelines (note: not recorded, but in the people), at CD we are only interested in problems that effect the PCB lay-out. For example EMC, cross talk which is grounding. These will affect the timing of a project. Because you will have to do a new PCB round."

Figure 5 5 Quote of a designer

5.2.4 Entering a Problem Description

A second difficulty is observed by the users. How can a problem owner enter a valid and complete Problem description into the system of a problem he himself clearly does not understand? The problem description is not revised by the solver, this is not necessary at the moment because the past records are not consulted in the future. Besides this, the remark is justified that the problems in a Product Development Process are very diverse and thus can not be captured in one fixed set of fields.

5.2.5 Incentives

Users are not influenced by incentives to use the system; they are encouraged by colleagues and superiors to use the system but not more than that. Some use the system more than others but this depends more on the project than on the person himself. Some projects that were started a long time before iQMS was launched; don't use the project. Users assess the user-interface as user friendly with a small flaw that the system is only accessible on location.

5.2.6 The Software department

The following is an important note about the Software department. Relevant software problems are manually transferred to and from the Continuus system. The Continuus system is described in paragraph 3.4.7. This takes a lot of unnecessary time and of course the Software engineers do not like to do this. In the new PDM system this situation will continue to exist.

5.2.7 Understanding of the Goal

During the training sessions the goals of iQMS were presented as well. Currently however the users formulate the goal of the system slightly different:

"Communicating problems and giving an overview of current problems to project leaders and Quality coaches."

Most users are not aware of the third goal of iQMS, learning. This inconsistency found in the opinions of the goal is reflected in the use of the free-text fields in the database. According to most interviewees, iQMS is used as a basis for communication and nothing more than a basis. Thus it is not necessary to enter a complete en precise description of the problem into the iQMS database according to most users. This remark implies that the bulk of the information on a problem is communicated in other ways then through the iQMS.

A distinction is made between the fields in free-text format and those in categorical and class format. It is assumed that the fields in iQMS that contain different classes or categories contain valid and precise data. The understanding of these fields is clear by all users as their explanation is unmistakable; there are only a limited number of options. On the fields that

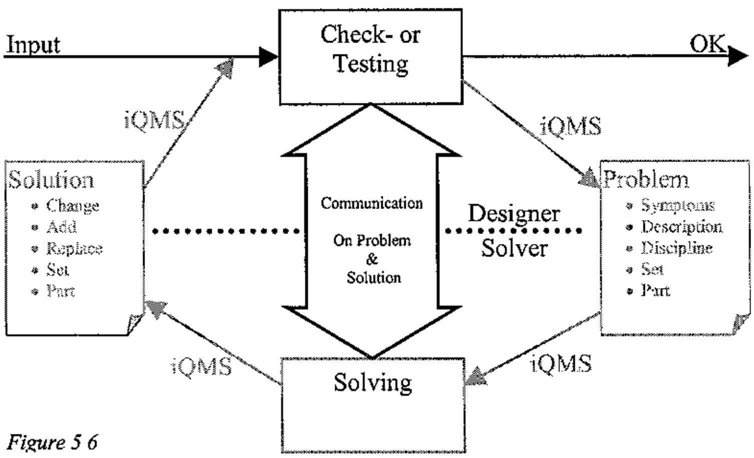

Figure 5 6

contain free text however, users have no consensus as opinions on what the *problem description* field should contain vary a lot. Remarks of users range from *"They (designers) don't reveal enough aspects."* , to *"iQMS contains all the problem information"* to *"Too much and confusing information for the solver"*.

The effect of the various opinions on what information to enter in the Problem Description field can be found in the iQMS database. Table 5.2 shows that only 52% of the Solution descriptions contain a useful description, this is the result of a manual analysis of all the 1221 records. The same is assumed to apply on the Problem description. This is a major point of attention for the further use of iQMS and influences the usefulness of the outcomes of a Data Mining analysis to a large extend.

5.2.8 Validity aspects

The commitment of the users to the system is high; they like to use the systems because it helps them performing their tasks easier. It facilitates an easier way of communication and leads to less communication errors. The resistance of using iQMS in the beginning was low. The previous system had a few obvious flaws and these were corrected in the iQMS system. The threat to the privacy of the user does not play any role. A reduced autonomy might play a minor role. By making use of iQMS it is easier for the project management to control the manpower and to decide who is assigned to which problem. This is however not experienced as very negative by the users. The advantages the iQMS system offers the users are more important to them than the loss in autonomy. These aspects do not implicate a low validity. The system is functioning well according to the perceived goals of the system.

5.2.9 Conclusion

Thus, the overall conclusion can be drawn. IQMS serves its' intended purpose, communication and giving an overview. The system assigns a "Problem ID" to each problem; this tells the developers what problem colleagues are talking about. Most of the information of a problem is communicated around it so it does not contain this information in itself. Thereby the information entered in the free-text records are not entered consistently by all users. Only the very essence of a problem description or solution description is expected to be found in the majority of the records.

5.3 Conclusion on the Usefulness of iQMS

At the first sight the iQMS database looked very promising. The descriptions of hundreds of problems and their solutions are readily available in an Excel format. But unfortunately after examining the iQMS database further by assessing the data input by the designers, the conclusion is negative. The iQMS system was setup as a communication and tracking tool and not as a learning tool. Too much, and too valuable information on the Problem and Solution is communicated around the system. Even though the personnel were properly trained, they have various opinions on what information to enter in the free text fields. This conclusion is reached by mainly analysing the interview outcomes. The manual analysis of the content of the records supports the conclusion. Complete information can not be found in the iQMS database. Therefore the outcomes of a Data Mining analysis are not expected to be useful, although some unexpected correlations might be found.

6 CONCLUSIONS AND FURTHER RESEARCH

In this final chapter of this thesis the conclusions for the Product Development Process of Philips are summarized and an attempt is made to relate these conclusions to any Product Development Process in general. This will be done by first presenting the similarities and differences between the Product Development Process at Philips and any Product Development Process in general. Next the conclusions for Philips and than the conclusions for general Product Development Process are presented. Finally, this thesis is concluded with a flashback on the research itself. What are the Strengths and Weaknesses when we look back on this research? Once the strengths and weaknesses are known, the impact of the results is estimated.

6.1 Data at Philips compared to a General Production Development Process

Obviously in any Product Development Process certain data sources like drawings and Test Results will be present. Some of the data source found at Philips might not be present in a similar format. The iQMS database might be an example of this. Any Product Development Process contains information dealing with problems and the relevant solutions. But this information might be stored in different way, or not stored at all as it remains purely tacit knowledge. Here we observe a difference between the criteria categories presented in paragraph 3.5. The content criteria will be met in the same way. The content of and the mechanisms in different Product Development Processes will not vary a lot. The format criteria however will show a larger diversity. It is assumed that the way data sources are managed and maintained will depend more on organisation culture. This is particularly true for the structure and format. So the left column of table 4.3 is expected to be useful in any Product Development Process.

6.2 Conclusion for Philips

6.2.1 Recommendation for Philips

Philips stores a lot of information. But Philips does not have a clear policy or strategy to manage the stored information. Philips should rethink its intended course on their information strategy.

A real turnover is needed to use the information recorded for learning and prevention goals. The most interesting database in this case study performs well relative to its purpose. Now Philips realises as well that they could and should use this database for learning purposes and for preventing problems in the future. But this research shows it is not realistic to do this with the current setup of the database and its data recording.

The re-design of the information systems should start with formulating the goal of the information system differently. Does Philips wants to use iQMS as a communication tool or do they want to use it as a learning tool as well? According to this research it is plausible to setup a system that enables learning from past mistakes. But this research also points out that a re-design of the information policy and information systems is needed to achieve a learning capability.

Concrete, a re-design could mean, "don't use exclusively free-text to describe the problem and solution". Formulating a key-words list was shown to be one of the Data Mining steps. If a key-words list is available in the database itself and properly used, the information in the database would be a lot easier to process by a computer. One suggestion is to use a key word list where the designer can click check boxes to describe a problem. An interface could be build that facilitates a dynamic, tree like key words choice to a designer.

Of course this suggested solution will have disadvantages as well. So this is an interesting subject for further research as no proof of these suggestions could be provided by this research. Currently the opportunities to retrieve relevant information from the databases within the Product Development Process at Philips are minimal.

Philips is about to implement PDM. As is known today, no major changes will be made to the successors of the current systems. If it works out this way, Philips has missed a big opportunity to really learn from its stored data in the future. That is, according to this research.

6.3 Main Research Findings

It is clearly demonstrated how important it is for manufacturer's today to think ahead and use the large amount of information available in a company to stay ahead of competition. More and more disciplines are exploring Data Mining to do this, but so far the Product Development Process got little attention. At first sight it looks easy to use Data Mining techniques to analyse big databases in the Product Development Process. But this research points out that several points make Data Mining more difficult or even impossible. The way information is recorded is more important than recognized. Just recording information does not make sense. Before the data recording starts, a clear goal should be formulated. Giving the future usage of a database, like learning, a thought can make a big difference. It is necessary to take all the criteria presented in paragraph 3.5 into account. It is probably not possible to maximise all of the criteria, some of them need to be weighed to each other. For example, "is the content rich enough or are the formats used too divers?"

By making use of Data Mining it is demonstrated that root-causes of problems in the Product Development Process could be found (scenarios in paragraph 5.1). So by applying Data Mining to the data a higher MIR level could be reached. This argues that Data Mining should be involved as an important option during any attempt to increase the MIR level.

6.3.1 Strengths and Weaknesses

The strength of this research proved to be the expert knowledge available at the coaches of this research. Professor A.C. Brombacher provided the Product Development knowledge and experience; R. Menon the Data Mining knowledge and the Quality Improvement Team were responsible for the input concerning Product Quality and the characteristics of the Processes at Philips. This looks like the ideal setting to carry out this research.

The weakness of this research is the lack of actual Data Mining operations carried out. Noted though is that this is an explorative research and applying Data Mining techniques takes a lot of time.

6.3.2 Impact of results

Philips is planning the implementation of PDM. This is done globally and coordinated by Philips Belgium. It is unclear if the results of this research arrive in time in Belgium, if at all, to influence the future PDM setup. The influence on the implementation could be a higher awareness of the purpose of information recording in the future.

To the research area, this research provides a general understanding of the current state and the possibilities that a Product Development Process has to offer. This research provides a good starting point for really applying Data Mining techniques within the Product Development Process in the future.

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LIST OF ABBREVIATIONS

AP: Assignment Preparation
APD: Additional Product Data
BoM: Bill of Materials
CAT: Customer Acceptance Test
CESR: Consumer Environment Simulation Room
CD: Commitment Date
CP/CN: Change Proposal/Change Note
CR: Commercial Release
CS: Concept Start
GQT Global Quality Team
DR: Design Release
DTI: Design Technology Institute
FOR: Fall Off Rate
FCR: Field Call Rate
GDC: Global Development Centre
GMT: Global Maintenance Team
GRS: Global Reference Set
iQMS: integrated Quality Management System
MG: Maturity Grid
MTBF: Mean Time Between Failure
MTV: Mainstream Television
MPR: Mass Production Ramp-up
NPD: New Product Development
NUS: National University of Singapore
PAT: Preventive Action Team
PC: Personal Computer
PCB: Printed Circuit Board
PCP: Product Creation Process
PDP: Product Development Process
Ph.CE: Philips Consumer Electronics
PRP: Product Realisation Process
PRS: Product Range Start
PS: Production Start
RIT: Regional Implementation Team
TPD: Technical Product Data
TR: Trial Run
TTR: Technical Trial Run
TU/e: Technische Universiteit Eindhoven

APPENDICES

Appendix 1: The Personal Computer, a History.

Personal computer history doesn't begin with IBM or Microsoft, although Microsoft was an early participant in the fledgling PC industry.

The first personal computers, introduced in 1975, came as kits: The MITS Altair 8800, followed by the IMSAI 8080, an Altair clone. (Yes, cloning has been around that long!) Both used the Intel 8080 CPU. That was also the year Zilog created the Z-80 processor and MOS Technology produced the 6502. Bill Gates and Paul Allen wrote a BASIC compiler for the Altair and formed Micro-soft.

In 1976, Apple's two Steves (Jobs and Wozniak) designed the Apple I, Apple's only kit computer, around the 6502 processor. That was also the year the first word processing program (Electric Pencil) and text adventure for microcomputers (Adventure) were released. Shugart introduced the 5.25" floppy drive; it would become a key component in the personal computing revolution.

The young industry exploded in 1977 as Apple introduced the Apple II, a colour computer with expansion slots and floppy drive support; Radio Shack rolled out the TRS-80; Commodore tapped into the pet rock craze with their PET; Digital Research released CP/M, the 8-bit operating system that provided the template for MS-DOS; and the first ComputerLand franchise store (then Computer Shack) opened.

Software took centre stage in 1978 when Dan Bricklin and Bob Frankston produced VisiCalc, the first spreadsheet. This turned the personal computer into a useful business tool, not just a game machine or replacement for the electric typewriter.

WordMaster, soon to become WordStar, was released and went on to dominate the industry for years. Atari leveraged their video game experience and household name to enter the personal computing market, and Epson shipped the MX-80, the first low-cost dot matrix printer.

The third important software category, the database, blasted onto the scene in 1979 with Vulcan, the predecessor of dBase II and its successors. That was also the year Hayes introduced a 300 bps modem and established telecommunication as an aspect of personal computing.

Texas Instrument's poorly designed and ill-fated TI-99/4 also shipping in 1979 as the industry's first 16-bit computer.

But 1980 was the year Commodore opened the floodgates of home computing with the $299 VIC-20. Sinclair tried to one-up them with a $199 kit computer that was quite popular in Britain, but it was destined to remain a bit player in the PC industry. The same can be said of Radio Shack's fairly impressive Colour Computer, which suffered primarily from complete incompatibility with their TRS-80 line.

Yet another 1980 disaster was the Apple ///, which shipped with 128K of memory, an internal floppy drive, and Apple II emulation. Alas, it just didn't work right, forcing Apple to recall them all, fix a number of problems, and re-release the Apple /// some time later with 192K of RAM. This was also Apple's first computer to support a hard drive, the 5 MB Profile.

Estimates are that there were one million personal computers in the U.S. in 1980.

In early 1981, Adam Osborne introduced the first portable computer. The Osborne 1 was about this size of a suitcase, ran CP/M, included a pair of 5.25" floppies, and had a tiny 5" display. The innovative machine was bundled with about $1,500-2,000 worth of software, and the whole package sold for $1,899.

The first laptop computer also arrived in 1981, the Epson HX-20 (a.k.a. Geneva). The HX-20 was about 8.5" by 11" and maybe 1.5-2" thick and used a micro cassette to store data. If I recall correctly, it displayed 4 lines of 40 characters on an LCD screen above the keyboard.

The IBM PC

Of course, the most significant event of 1981 for the personal computing industry was the introduction of the IBM PC on August 12. This computer ran a 16-bit CPU on an 8-bit bus (the Intel 8088), had five expansion slots, included at least 16K of RAM, and had two full-height 5.25" drive bays.

Buyers could get a fairly loaded machine with a floppy controller, two floppy drives, a monochrome display adapter and monitor, a colour display adapter and monitor, a parallel card, a dot matrix printer, and an operating system -- with the choice of CP/M-86, the UCSD p-System, or PC-DOS (a.k.a. MS-DOS). Pretty much everything was an option, and everyone recognized that the IBM PC was based on ideas perfected in the Apple II, particularly general use expansion slots.

The second most significant event of 1981 was dependent on the first: Microsoft got IBM to agree that DOS would not be an IBM exclusive. This paved the way for the clone industry, which in the end marginalized the influence of Big Blue.

Time magazine called 1982 "The Year of the Computer" as the industry grew up. By 1983, the industry estimated that 10 million PCs* were in use in the United States alone.

* Ever since IBM, the term PC has taken on a second meaning. Although it retains the original meaning of "personal computer," the IBM architecture has so dominated the industry that it soon came to mean IBM compatible computers to the exclusion of other machines.

VisiCalc met its match in 1983 when Lotus 1-2-3 shipped for the IBM PC. That was also the year Microsoft Word 1.0 shipped, although it remained a small player until Windows dominated.

Apple Computer introduced the first consumer machine with a mouse and graphical user interface, the Lisa. Of course, at $10,000, not many consumers could afford it, but it paved the way for the Apple Macintosh of 1984. At $2,500, it was much more affordable than the Lisa.

IBM took the PC beyond the 8-bit bus when the introduced the AT (for Advanced Technology), a 6 MHz 80286-based computer with a 16-bit bus, high density 5.25" floppies, and a new video standard, EGA.

Microsoft first shipped Windows in 1985, and the DOS shell was content to run even on old 4.77 MHz PCs, albeit slowly. That was also the year Aldus invented the fourth major software category by releasing PageMaker. Desktop publishing was born and Apple found a strong niche market for the Macintosh and LaserWriter.

Compaq, an early IBM compatible maker and the first to make a portable IBM compatible, shipped the first 80386-based PC in 1986. Compared with the typical 8-12 MHz performance of the 80286, the 16 MHz 80386 was a real barn burner. It also introduced some new operating modes that would make later versions of Windows far more powerful.

In 1987, Apple introduced slots to the Macintosh in the Mac II, IBM introduced Micro Channel Architecture with their PS/2 line, IBM and Microsoft co-released OS/2, and Windows reached version 1.01. We also saw the first fax cards that year, and Sun shipped the first RISC CPU. (The Acorn Archimedes, another early RISC computer, also shipped in 1987 and may have beat Sun to market.)

Perhaps the most significant computing event of 1988 was the first Internet worm, which infected about 6,000 computers in very short order. Microsoft updated Windows to v2.03, Apple introduced floppy drives compatible with IBM formatted 3.5" disks, and there were an estimated 30 million DOS users.

The overall count was about 54 million personal computers in the U.S. in 1989, the vast majority of them running MS-DOS. Apple shipped the heavy (over 16 pounds!) Mac Portable, the first "laptop" computer with a built-in trackball and possibly the first with an active matrix display.

Windows moved forward to version 3.0 in 1990, and it was nearly ready for prime time. The first '486-based PCs shipped, and Apple trumped the DOS world's 33 MHz computers with the "wicked fast" 40 MHz Macintosh IIfx, which was also one of the first personal computers to use an accelerated video card.

Linus Torvalds created his own version of Unix and named it Linux in August 1991. It remained obscure for a while, but it has grown to become the second major operating systems for Wintel computers and one of the leading examples of free open source software.

Windows at 3.1

Microsoft Windows 3.1 shipped in 1992. Between Windows and the hardware of the day, the resources existed for Windows to become a major player. Windows soon became the default operating system shipped with new PCs.

In February 1993, Apple shipped their 10 millionth Macintosh. The same year Intel introduced the original Pentium, a 60 MHz CPU with an undetected math bug, and Microsoft announced over there were over 25 million licensed Windows users. By the end of the year, the Apple II line -- the granddaddy of personal computers -- was discontinued.

Intel acknowledged the Pentium math bug in 1994 and issued a recall. Apple shipped the first Macintosh with a factory-installed DOS card, the Quadra 610 DOS Compatible. (There had been DOS cards for Macs going back to 1987, but this was the first to bear the Apple brand.) This was also the year Apple decided to allow licensed Mac clones and shipped the first Power Macs, Macintosh models based on the then-new PowerPC 601 processor.

Although the World Wide Web had been created many years earlier, it was in 1995 that it rocketed into public view. Window 95 shipped in August, and Intel unveiled the Pentium Pro in November. The Pentium II and Pentium MMX followed in 1997. Be began porting the BeOS to Intel hardware in 1997, 56k* modems took the industry by storm, and the first cable modems shipped.

* As explained on the No Hype 56k Modem Page, these modems could theoretically reach 56 kbps, were limited by the FCC to 53 kbps, and commonly connected somewhere in the low-to-mid-40s. Still, that was faster than the old 28.8 and 33.6 modems -- and most users never realized that what they gained in download speed (up to 56k) came at the expense of upload speed, which was still limited to 33.6 kbps and went down as download speeds went up if both processes were taking place concurrently.

Windows 98 shipped in 1998, and Intel unveiled their low-cost Celeron CPU the same year. On the Apple side of things, the iMac helped push USB as the eventual successor to the parallel and serial ports common on Windows PCs.

The Pentium III arrived on the scene in 1999, as did the AMD Athlon, which became locked in a MHz war with Intel. The Athlon reached 800 MHz by the end of the year and was first past the 1 GHz mark in 2000. That was also the year Microsoft tweaked Windows 98 to create Windows Me (Millennium Edition).

In 2001 Intel shipped the Pentium 4, a processor theoretically more powerful than the Pentium III which tended to turn in lower performance ratings at the same MHz speed. The first Pentium 4 ran at 1.4 GHz, and by September Intel was selling 2 GHz P4s. During the summer of 2001, Intel finally began shipping their oft-delayed Itanium processor, designed as a 64-bit successor to the aging x86 architecture, itself designed as a successor to the 8-bit 8080 processor of 1975.

[source: http://lowendpc.com/history/index.shtml]

Appendix 2: A description of a Product Development Process

One model has been chosen to make a description of a general PDP. It is complemented where needed and supplemented at the end with steps of the model from Ulrich and Eppinger for the sake of this research.

The model that will be used to describe the general PDP model is based on the VDI standard (the German Society of Engineers) and Pahl and Beitz (Pahl 1995) and is presented in Figure app 2.1.

A general description of a PDP model consists out of the following steps and sub steps:

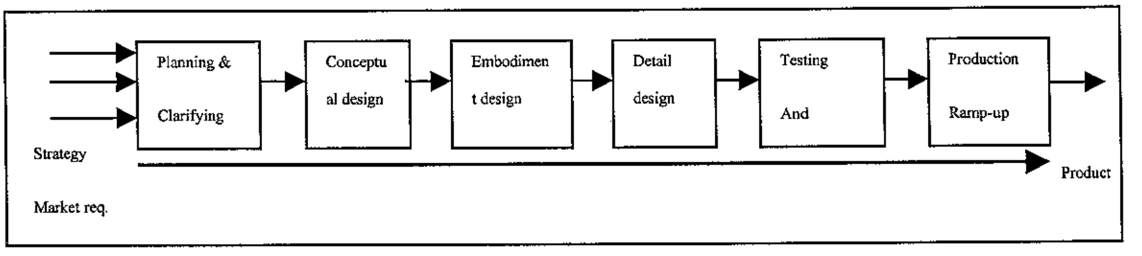


Figure app 2.1 PDP model

Planning and clarifying the task: based on the company's goal, there is a cyclic systematic search for and the selection and development promising product ideas out of the market requirements. The input variables of a PDP are Market, Company and Other Sources (economic and political changes, new technologies, environmental recycling issues). This is also were the stimuli for product plans come from. After planning the work, in order of long-term and short-term plans, continuous with defining the tasks as fully and clearly as possible so that amplifications and corrections during its subsequent elaboration can be confined to the most essential. Output: This results in a requirement list, which describes the wished product specifications, which are translated out of the market requirements.

Conceptual design: input is the requirements list of the former step. The conceptual design phase determines the principle solution out of the product ideas and broad specifications. This is achieved by abstracting the essential problems establishing function structures, searching for suitable working principles and then combines those principles in a working structure. Out of the working structure, the first setups for part-lists are made. Output: specification of principles with very global part-lists.

Embodiment design: input is the specification of principles (working structure) of the former step with the very global parts lists. From the input there are made more than one preliminary layouts to obtain more information about the advantages and disadvantages of the different variants. Therefore this design phase also ends with an evaluation against technical and economic criteria (new knowledge on a higher level!) After combination and elimination of the weak ideas the best layout can be selected. Output: as result of this follows the definitive layout. This provides a check of function, strength, spatial compatibility etc. In this phase also the first preparations are made for production, assembly and transport.

Detail design: in this phase the arrangements, forms, dimensions and surface properties of all the individual parts are finally laid down, the materials specified, production possibilities assessed, cost estimated and all the drawings and other production, assembly and transport documents produced. Output: specification of production, assembly and transportation.

Testing and refinement: input is the final design specification. This step involves the construction and evaluation of multiple pre-production versions of the product. The pieces previously designed and implemented are put together. If applicable software modules are tested with each other to make sure that outputs generated by one module match the inputs needed by another module. Also software is loaded into the hardware and operated to verify that the interface between the two is correct. When the designers are convinced that the product is complete and fully operational, a product is delivered to a formal test group that independently verifies product functionality and robustness.

Product ramp-up: the product is made using the intended production system. Purpose is to train the work force and to work out any remaining problems in the production processes. Output: the transition to gradual ongoing production. At some point in this transition the product is launched.

This is a complete description of a PDP as it can be derived from literature study. For the objective of this research not the whole PDP is relevant.

The PDP starts with planning and clarifying the task. This activity is also known as for example "research and pre-development". It is a "cyclic-process" (a continuum process in time, which follows a fixed pattern) and also referred as "fuzzy front end" the term often used in literature lately (Clark 1993). Non-cyclic processes follow the cyclic process. A non-cyclic process is a unique process with a defined end, which will not be repeated. The actual product development is a process that is started each time a new product will be developed. Table 2.1 from Boersma (Boersma 1994) clarifies these differences between the phases.

Phase	Process	Result
Research	Initiate	Knowledge
Pre-Development	Select	Feasibility
Product Development	Realize	New Product specification

Table2.1: relationships between PDP phases

However the research has certain time constrains and therefore it is not possible to explore the whole PDP. Chosen is to focus on the area that will be researched from "Conceptual design" and end with the product ramp-up. Another reason to focus in this area of the PDP is due to the fact that already lot of research takes place in the phases before and after this part of the PDP. Not in the phases of the PDP were this research focuses on.

The process before "Conceptual design" is the "cyclic" planning phase (fuzzy front end) with as one of the most important elements, translating customer requirements into a set of broad specifications for the products that will be developed in the PDP. The authors of this thesis believe that this is a whole different field of research. This is typical the field of Marketing and therefore also their responsibility in the first place. Noted is that this is one of the most important elements of the whole process. If the market requirements are not well translated into the correct product specifications, the manufacturer will produce products that are not satisfactory for the customers. Even if the products are of superb quality and reliability, customers will not buy them. The manufacturer is not making the right product. This thesis will not grant into this subject. The question in this research is about "making the product right". The technical specifications that are the results of the "Planning and clarifying the task" are considered as optimal and given. It will be used as input of the PDP as well as input of this thesis.

At the other end of the PDP the scope will focus until the product ramp-up. This means that the PDP will be tracked until the first or second months of production. Important note here is that this research will not include customer feedback of the market. Again the authors of this research noted that this is essential information for a manufacturer and for PDP's, but it is not in the scope of this research and therefore will not be accounted for.

Appendix 3: Quality Parameters

Field Call Rate (FCR) A rate that quantitatively determines how often a product fails when it is used "in the field" (STT, 2001). Four causes of failures in the field are identified in the roller coaster:

1. Early failure
2. Early wear-out
3. Random or stochastic failure
4. Systematic failure

Fall Off Rate (FOR) The FOR is the rate that shows which percentage of the products manufactured does not pass the final test before they are transported to the customer. Causes of failing the final test can be subdivided in two. Mistakes in the design can cause product deviations so the product fails to pass the final test. If there design is robust, problems during the production process can result in a product which fails the test.

Also important to note is that the FOR of a product has a time learning effect. Reasons for this are manufacturers keep improving their designs in the design process (for example with design and fully tested standard components or modules) and production methods are fine-tuned and less faults are made.

- Mean Time Between Failure (MTBF)

MTBF is a rate that shows the probable mean time between product failures. MTBF (and also MTTF: Mean Time To Failure) are important to know and for understanding the feasibility of a design capability of meeting the reliability goals needed to satisfy customer requirements. Design studies that identify platform are good sources to provide the necessary data to calculate and determine the MTBF/MTTF. Predictive modeling is used to predict or products will be conform reliability wishes/demands in MTBF/MTTF of the end customer. (Crowe, 2001)

Disadvantages:

In order to be sufficient reliable to the customer, the customer uses plays a great role. This is a complete different factor than the factor "conform technical specifications" in design process.

MTBF/MTTF is considered as a constant factor in time of the product (regardless of age of product) (STT, 2001)

- Maturity Grid (MG)

The method MG has been developed to facilitate the "GO/NO GO" decision for passing a defined milestone of a project. It also offers an opportunity to calculate a performance indicator regarding the maturity of the design at a certain milestone.

The way MD works:

Every failure established during the evaluation period in design models will be given a seriousness weighting factor as well as an evaluation factor. These factors are presented in graphical form and can be used for decision making processes.

Appendix 4: Current Business Applications of Data Mining

[http://www.rpi.edu/~arunmk/dm1.html]

Data mining has been applied to direct marketing, retail point-of-sales, financial services, business forecasting, bond trading, quality control, banking and personnel departments Non-business areas include the petroleum industry, science, forest fire prevention, chemical structure identification, crime detection and medical diagnosis.

Much of the emphasis now is in the set-up of data warehouses, since the prime concern before data mining is that data should be 'clean' of anomalies. Much of the data analysis that has evolved has been a complement of data warehousing. More often than not, data summarization from data warehousing leads to further querying and subsequent more analysis. The data warehouse provides every conceivable view of the data, and the biggest benefit comes from these 'opportunistic' ideas that come across, unlike the ones from a normal report generator. These ideas are 'mined' in a sense from this summarized information. Further querying is then carried out to develop further ideas. This section provides several real world examples of data mining.

Finance and Banking

Bank of America can now sculpt detailed demographic views of the banking habits and financial assets of select groups of its customers. Querying the 800G-byte data warehouse averages at 30 seconds as compared to the 3 month wait to access data from 100 magnetic tapes from traditional mainframes and the subsequent distribution to requesters. The system here draws data from the entire bank and its 30 business units - i.e. a truly enterprise-wide database being able to serve 1200 users making 2500 complex queries daily.

Gilman Securities uses data mining to differentiate how the financial market reacts to the volatility of different business sectors. For example, what are the relationship(s) between rate of changes between the Japanese Yen and the Government bond market?

The Canadian Imperial Bank of Commerce (CIBC), based in Toronto, Canada uses the SAS system as a data warehouse that provides management information to support decision making across CBIC. The mining analyses include statistical modelling and consulting with regards to customer traffic patterns at branches to aid in scheduling; time-stamped cash withdrawals at branches and automated banking machines to manage levels of currency holdings; traffic patterns; products sold, and the relative mix of products to plan marketing strategies and performance measures. Data is held at event level and summarized to the level of granularity appropriate for specific queries.

Retailing and Sales

The Army and Air Force Exchange Service (AAFES) determine sales patterns based on the demographics of its customers. For example, AAFES use automated data mining to predict how much a particular woman will spend annually, given the age, her dependents and her annual wage level. This level of detail helps AAFES to target their advertising and sales towards the appropriate customer base.

Wal-Mart realized early on in 1989, that parallel processing and data mining could be used to find business information out of its 6 terabyte database, and thus this became part of new business strategy. 2,300 complex SQL queries are made daily and the massively parallel processing excels at handling complex relational database operations. Data streams can be produced for piped parallelism and data can be partitioned or sliced by operators.

Credit card operations

MasterCard International processes 12 million transactions daily and uses data mining to extract all sorts of statistics about its cardholders. It is in the process of selling its data warehouse of transaction to its 20,000 business partners. This will enable viewing classes of cardholders and analyze how they use their cards to develop specialized promotions and detect fraud.

Health care

Like MasterCard, U.S. Healthcare Inc., of Blue Bell, PA, is providing data analysis capabilities to its business partners and affiliates. It is using a multidimensional tool to create data warehouses that hospitals and other health-care providers can use to measure and assess their performance.

Insurance

Metrohealth Insurance Corp., of Roanoke, VA, is using a pictorial directory of health-care providers on a CD-ROM to help its agents. Linking 200,000 pieces of data from its data warehouse with MapInfo's geographic system, MetroHealth created a CD containing programmed data for geographically oriented queries. An agent who accesses a city is given a colour-coded map indicating the population density of health-care providers.

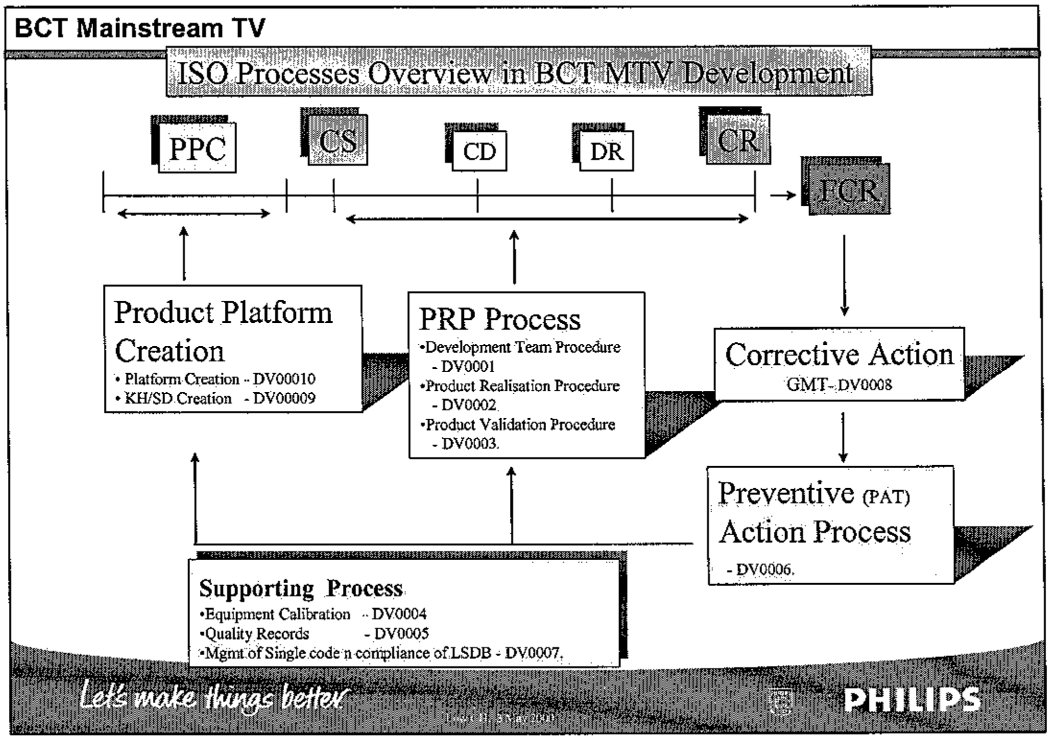
Appendix 5: Electrical, Mechanical and Software activities

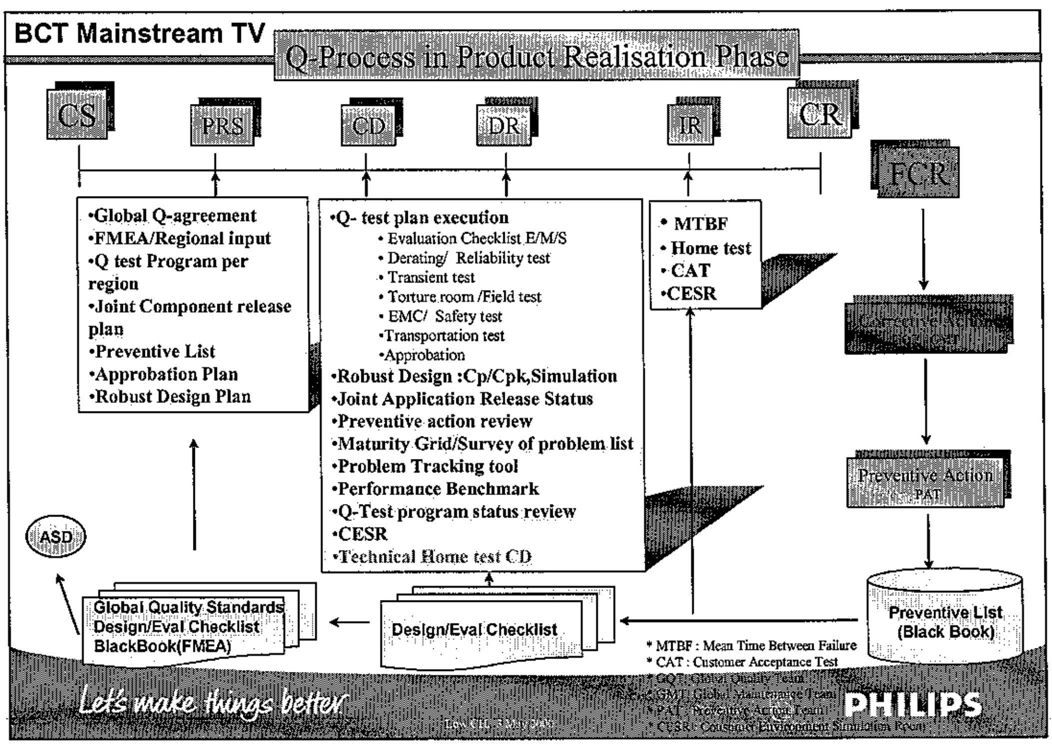
Electrical: One of the biggest development challenges for electrical is the development of printed circuit board (PCB). Because the machine that makes the PCB is very expensive, Philips tries to use as much as possible the same type of PCB but makes small changes to it to enlarge the variety of the TV-sets that can be build on one type PCB. This keeps the costs low, because Philips is able to use one expensive machine for making multiple modified PCB's.

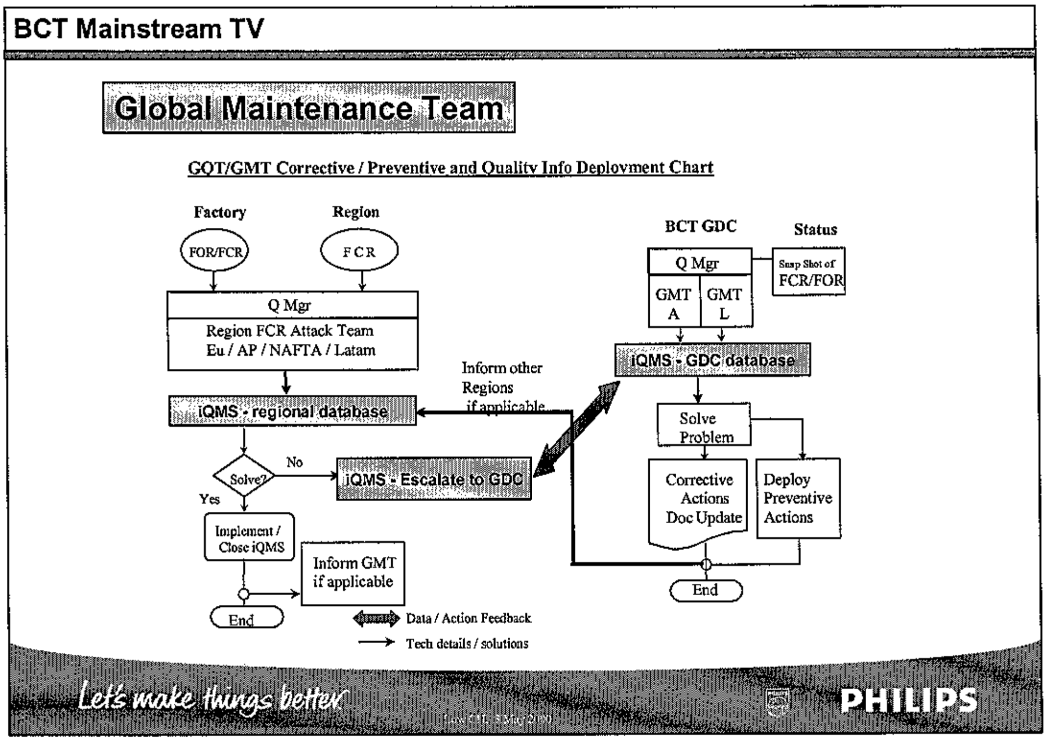
Mechanical: the development of CAD mechanical models with involvement of mould makers and moulder.

Software: software specification in terms of components, interfaces, algorithms, parameters etc. Writing and reviewing of source code and data files of software components; as well as writing and debugging test software for internal use.

Appendix 6: Quality Management at Philips






BCT Mainstream TV
Global Maintenance Team
GQT/GMT Corrective / Preventive and Quality Info Deployment Chart
Factory
Region
FOR/FCR
FCR
Q Mgr
Region FCR Attack Team
Eu / AP / NAFTA / Latam
iQMS - regional database
Solve?
No
Yes
iQMS - Escalate to GDC
Implement / Close iQMS
Inform GMT if applicable
End
Inform other Regions if applicable
BCT GDC
Status
Q Mgr
GMT A
GMT L
Snap Shot of FCR/FOR
iQMS - GDC database
Solve Problem
Corrective Actions Doc Update
Deploy Preventive Actions
End
Data / Action Feedback
Tech details / solutions
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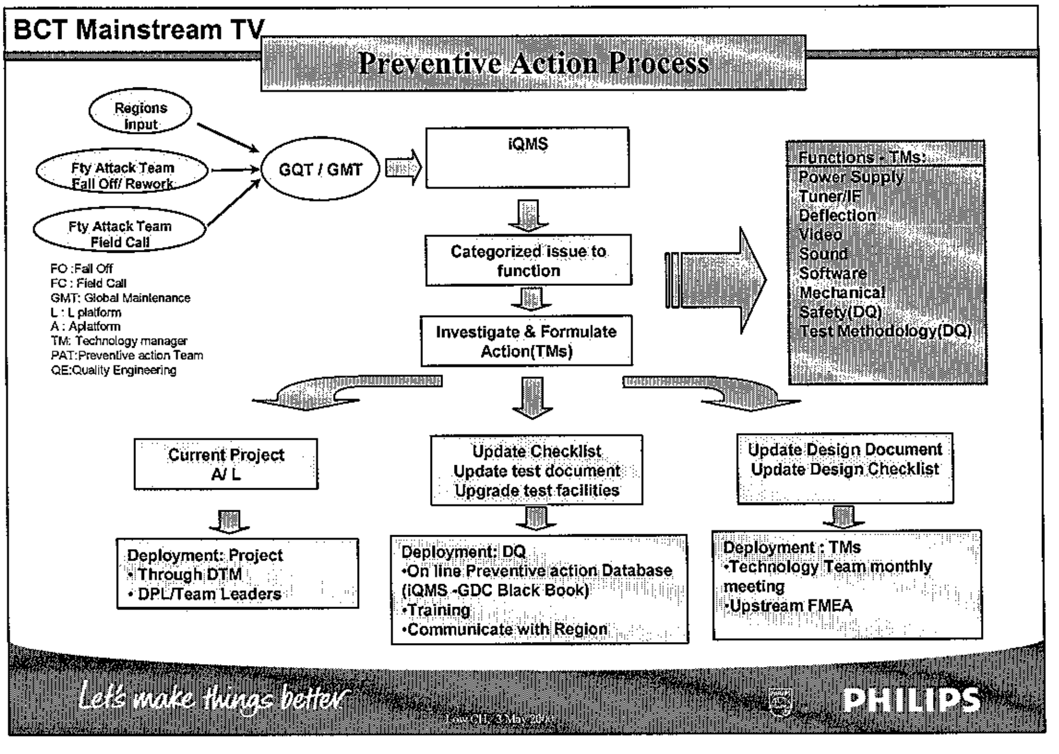
BCT Mainstream TV
Preventive Action Process
Regions Input
Fty Attack Team Fall Off/ Rework
Fty Attack Team Field Call
GQT / GMT
iQMS
Categorized issue to function
Investigate & Formulate Action(TMs)
Functions - TMs:
Power Supply
Tuner/IF
Deflection
Video
Sound
Software
Mechanical
Safety(DQ)
Test Methodology(DQ)
FO :Fall Off
FC : Field Call
GMT: Global Maintenance
L : L platform
A : Aplatform
TM: Technology manager
PAT:Preventive action Team
QE:Quality Engineering
Current Project A/ L
Update Checklist
Update test document
Upgrade test facilities
Update Design Document
Update Design Checklist
Deployment: Project
• Through DTM
• DPL/Team Leaders
Deployment: DQ
•On line Preventive action Database (iQMS -GDC Black Book)
•Training
•Communicate with Region
Deployment : TMs
•Technology Team monthly meeting
•Upstream FMEA
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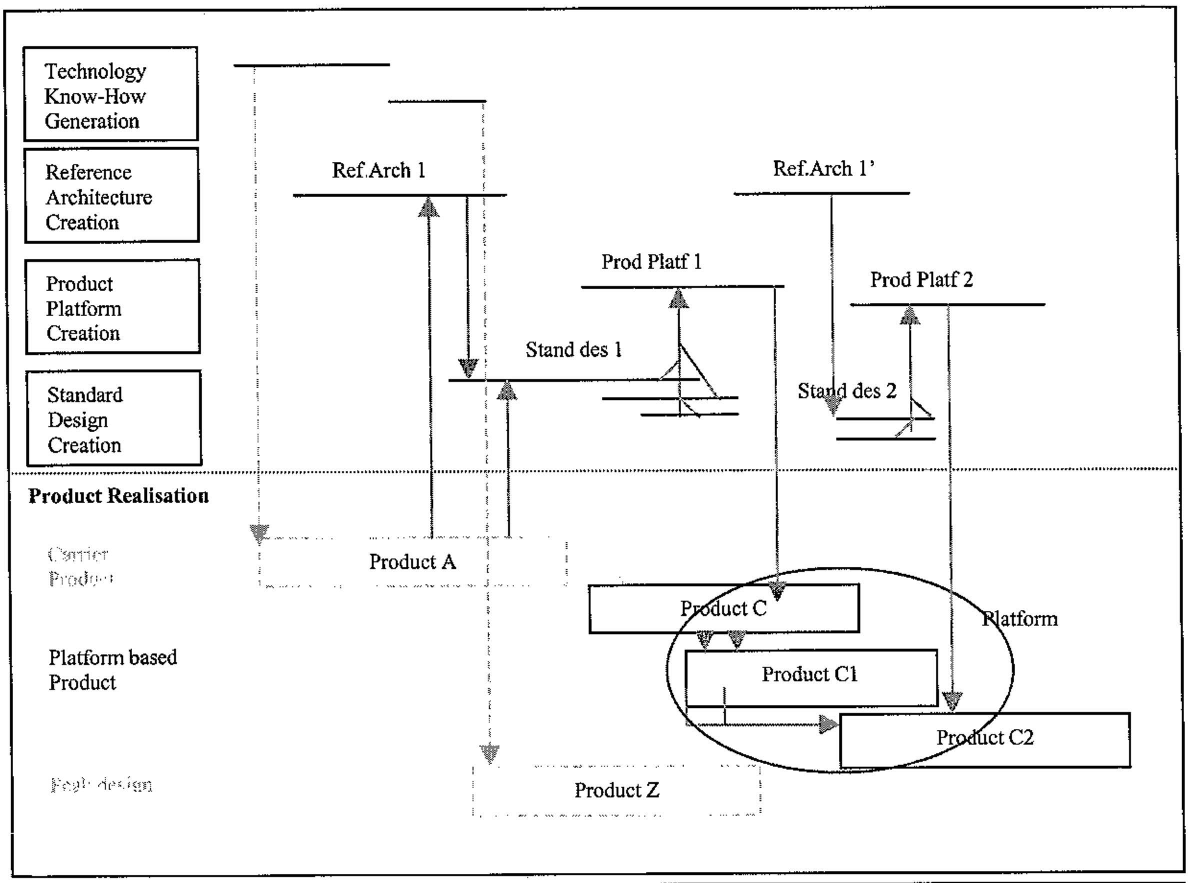
Appendix 7: Platform Design and Standard Design at Philips



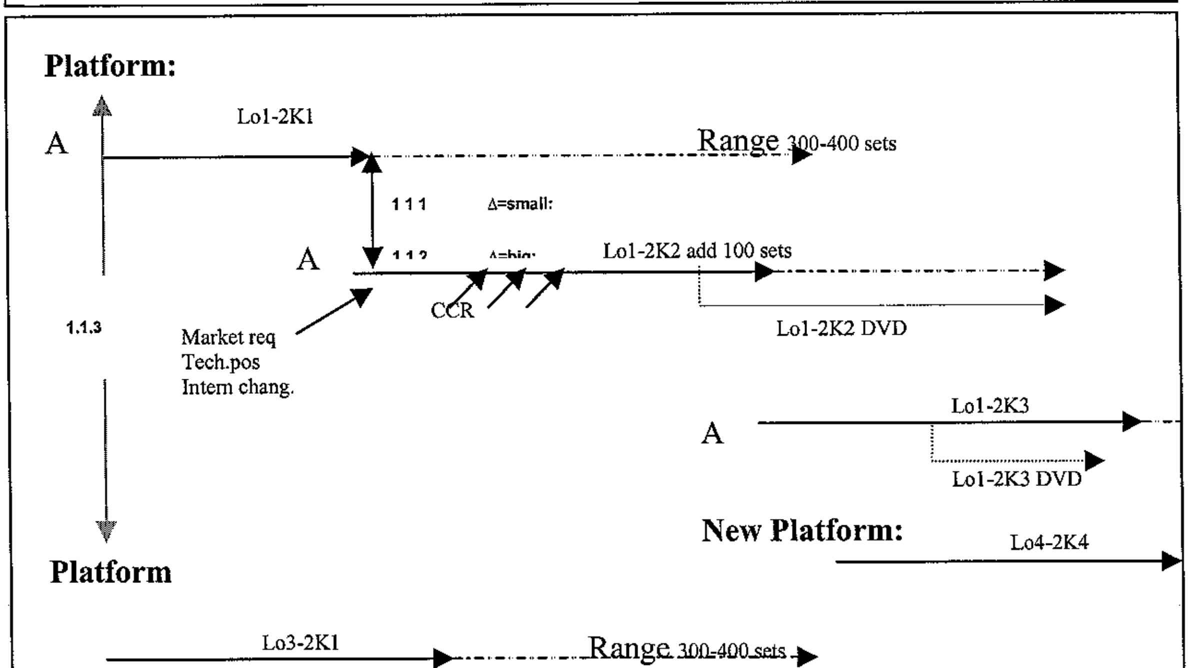


Fig X.XX: Example of an evolution in development of Platforms and Ranges (“L

Appendix 8: Technical Product Data list

- Drawings
- Mechanical parts list
- Electrical parts list
- List of alternatives
- Packing parts list
- Leads parts list
- Circuit diagram plot
- Wiring diagram plot
- Mechanical test instructions
- Electrical test instructions
- Safety list
- Final equipment instructions
- Setting/alignment instructions
- Electrical specification
- Mechanical specifications
- Styling
- Purchasing specifications
- Packing operations
- Pallet pattern parts list
- Transport packaging stacking instruction
- Mechanical part file
- Mechanical assembly file
- PCB layout file
- Circuit diagram file
- DAT file
- Photo plot files

Appendix 9: Additional Product Data list

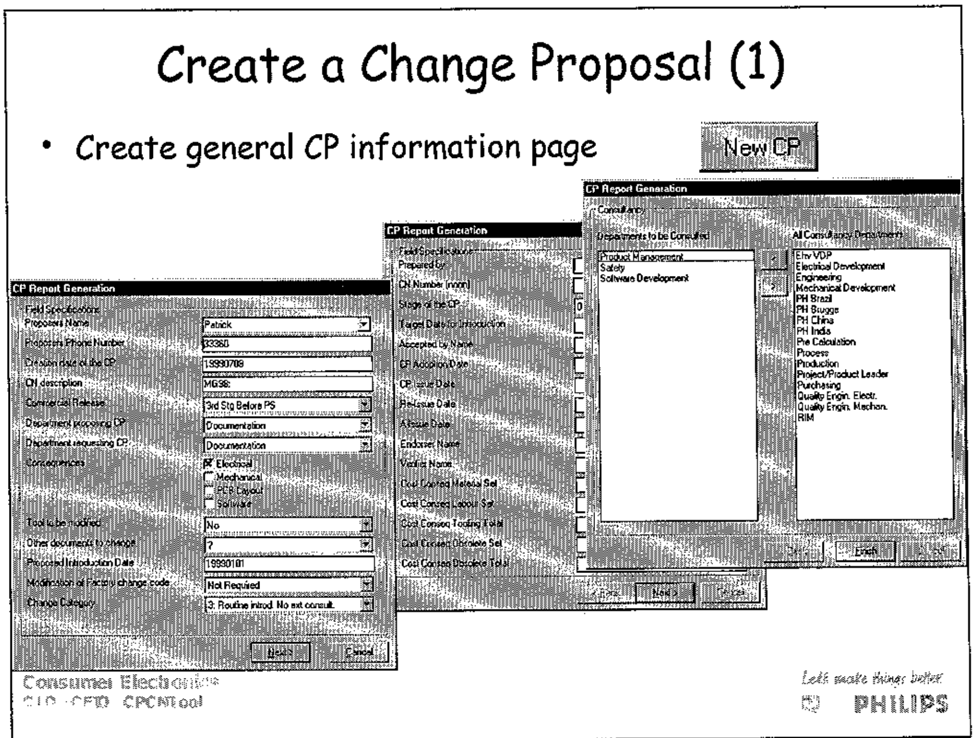
Name	Remarks
MTV Approbation plan	
MTV Assignment Document	Derived from the Global wish plan. Drafted by Planner for Platform & by Product Manager for Product
MTV Commercial Requirement Specifications (CRS)	Derived from the Global wish plan Drafted by Planner for Platform & by Product Manager for Product
MTV Component Release reports	
MTV Configuration Management Plan	
MTV Container & Truck Loading	For certain regions
MTV Contract Book	Derived from the Assignment Document
MTV DDD Cabinet Specification	Definite Design Drawing MECH: Input for Mechanical. Necessary before PRS
MTV Environmental Calculation	
MTV Executive Summary	Milestone meeting report
MTV FMEA report Elect	
MTV FMEA report Mech	
MTV Global Quality Agreement	Elect, Mech, Software & Safety
MTV Hardware Software Interface (HSI)	
MTV Initial Costing (IC1)	Manpower / Model Making / Indirect Material, needed for Project justification 4 wks before milestone
MTV Key-component list	needed for Project justification ... 4 wks before milestone
MTV Make-up Sheet	MECH: Cosmetics; used as input
MTV Make-up Sheet - Seri-Graphy	Printing on the Product
MTV Masking Release Notes	Final software release before hand over to maintenance
MTV Maturity Grid - Elec	
MTV Maturity Grid - Mech	Results of the TAPE 1 and TAPE 2 (prototypes)
MTV Maturity Grid - Overall	
MTV Maturity Grid - Safety	
MTV Maturity Grid - Software	
MTV Milestone report - Technical presentation	MTV Milestone Presentations & Minutes of meeting
MTV Milestone report Overall	
MTV Model Distribution List	
MTV Piece part release plan	
MTV Product Cost (BOM)	
MTV Product Specification (CTV Letter)	From PFS; Feature range choice, House of features. needed for Project justification ... 4 wks before milestone
MTV Project Budget	
MTV Project Justification	Total Project Costing. Also contain volume commitment
MTV Project Risk Analysis	results of risk management workshop
MTV Project Risk Management Plan	should this be tie to Risk Analysis
MTV Purchasing Project Book (White book)	Key Components, Suppliers, etc.
MTV Quality test plan Elect	
MTV Quality test plan Mech	
MTV Quality test plan Safety	
MTV Quality test Program Elect	Also indicated by Elect

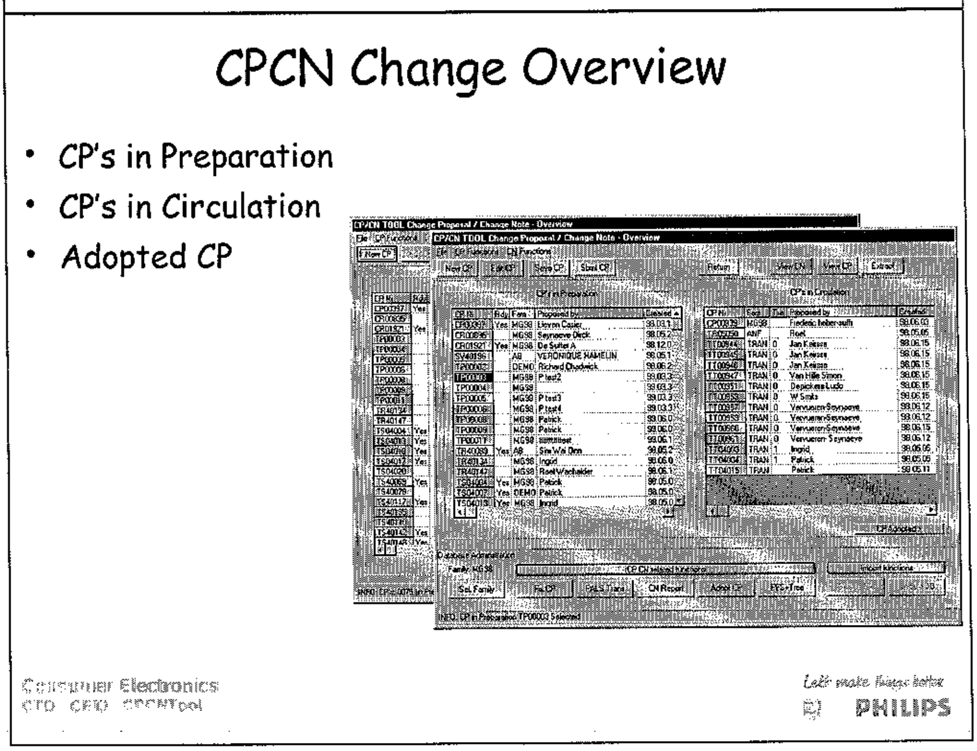
MTV Quality test Program Mech	Also indicated by Mech
MTV Quality test Program Safety	
MTV Reference Software Architecture	
MTV Requirement Specifications (FRS)	
MTV Rolling test (>55kg)	
MTV Safety test report	includes Electro-Magnetic Comparability (EMC)
MTV Stability Calculation	
MTV SW Design Documentation	
MTV SW Development Plan	
MTV SW Quality Engineering Plan	
MTV SW Stage Review	
MTV SW Test Plan	
MTV Tooling List (IC3)	needed for Project justification .. 4 wks before milestone
MTV Transfer Charter	Not Milestone driven - depends on nature of project
MTV User interface Outline (UIO)	
MTV User Interface Specification (UIS)	
MTV Bump Test	Supporting Doc - Mechanical Quality Test Report
MTV Chassis Vibration Test	Supporting Doc - Mechanical Quality Test Report
MTV China 38 parameters measurement	Supporting Doc - Electrical Quality Test Report
MTV China Sequential test	Supporting Doc - Electrical Quality Test Report
MTV China Vibration	Supporting Doc - Mechanical Quality Test Report
MTV Clamp truck test	Supporting Doc - Mechanical Quality Test Report
MTV Climatic test A - Cold test (-25°C)	Supporting Doc - Mechanical Quality Test Report
MTV Climatic test B - Dry heat (70°C)	Supporting Doc - Mechanical Quality Test Report
MTV Climatic test C - Damp heat test (40°C, 95%RH)	Supporting Doc - Mechanical Quality Test Report
MTV Cold Test	Supporting Doc - Electrical Quality Test Report
MTV Component Application / Derating	Supporting Doc - Electrical Quality Test Report
MTV Concession Notes / Performance Deviation List	Supporting Doc for Milestone report Overall (CD,DR,IR)
MTV Cyclic Environment	Supporting Doc - Electrical Quality Test Report
MTV Cyclic Humidity	Supporting Doc - Electrical Quality Test Report
MTV Design checklist Electrical	Supporting Doc - Maturity Grid - Overall (CD, DR, IR)
MTV Design checklist Mechanical	Supporting Doc - Maturity Grid - Overall (CD, DR, IR)
MTV Dew Test	Supporting Doc - Electrical Quality Test Report
MTV Drop Test (Non operational, Packed) (-10 Deg. C)	Supporting Doc - Mechanical Quality Test Report
MTV Drop Test (Non operational, Packed) Ambient condition	Supporting Doc - Mechanical Quality Test Report
MTV Electrical Fast Tansient test	Supporting Doc - Electrical Quality Test Report
MTV Electro Static Discharge (ESD)	Supporting Doc - Electrical Quality Test Report
MTV Evaluation checklist Electrical	Supporting Doc - Maturity Grid - Overall (CD, DR, IR)
MTV Evaluation checklist Mechanical	Supporting Doc - Maturity Grid - Overall (CD, DR, IR)
MTV Evaluation checklist Safety	Supporting Doc - Maturity Grid - Overall (CD, DR, IR)
MTV Evaluation checklist Software	Supporting Doc - Maturity Grid - Overall (CD, DR, IR)
MTV Father / Mother Test	Supporting Doc - Electrical Quality Test Report
MTV Flash (Laser)	Supporting Doc - Electrical Quality Test Report
MTV Flash (Mill)	Supporting Doc - Electrical Quality Test Report
MTV Key Component Verification plan	Supporting Doc - Electrical Quality Test Report

MTV Lightning Simulation	Supporting Doc - Electrical Quality Test Report
MTV Low Air Pressure Test	Supporting Doc - Electrical Quality Test Report
MTV Mains Interruption & Voltage Variation	Supporting Doc - Electrical Quality Test Report
MTV Milestone report Elect	Supporting Doc for Milestone report Overall (CD,DR,IR)
MTV Milestone report Mech	Supporting Doc for Milestone report Overall (CD,DR,IR)
MTV Milestone report Safety	Supporting Doc for Milestone report Overall (CD,DR,IR)
MTV Milestone report Software	Supporting Doc for Milestone report Overall (CD,DR,IR)
MTV Multiple drop after drop at ambient condition	Supporting Doc - Mechanical Quality Test Report
MTV Overstress	Supporting Doc - Electrical Quality Test Report
MTV Phase B tube release	Supporting Doc - Electrical Quality Test Report
MTV Prediction (FCR)	Supporting Doc - Electrical Quality Test Report
MTV Radiation & self pollution	Supporting Doc - Electrical Quality Test Report
MTV Reliability test	Supporting Doc - Mechanical Quality Test Report
MTV Thermal Cycliccum vibration	Supporting Doc - Mechanical Quality Test Report
MTV Torture Room / Field Test	Supporting Doc - Electrical Quality Test Report
MTV USA Drop:Ambient condition	Supporting Doc - Mechanical Quality Test Report
MTV USA Drop:Drop (-10 Deg. C)	Supporting Doc - Mechanical Quality Test Report
MTV USA Drop:Rolling test (>50kg)	Supporting Doc - Mechanical Quality Test Report
MTV USA Vibration:Random (Non operational, Packed)	Supporting Doc - Mechanical Quality Test Report
MTV USA Vibration:Resonance Search & Dwell (Operational, Unpacked)	Supporting Doc - Mechanical Quality Test Report
MTV Vibration Test (non-Operational, Non packed)	Supporting Doc - Mechanical Quality Test Report
MTV Vibration Test (non-Operational, Packed)	Supporting Doc - Mechanical Quality Test Report
MTV Black book extract for Milestone	Historical Problem files
MTV Commercial Change Request	Drafted by Planner for Platform & by Product Manager for Product. Optional document, but with a lot of impact on the proceding of the project from that point, Not Milestone driven - on-going
MTV Development Team Meeting Minutes (DTM)	Not Milestone driven - on-going
MTV Line chart (Phase-in phase-out plan)	Not Milestone driven but a copy must be approved before CS
MTV Non-Disclosure Agreements	
MTV Outsourcing agreements	Currently not formalized
MTV Product roadmap	Not Milestone driven - on-going, needed for Project justification ... 4 wks before milestone
MTV Project level ICAL	
MTV Project Master Plan	
MTV Project Progress Report	Not Milestone driven - on-going
MTV Project Team Meeting Minutes (PTM)	Not Milestone driven - on-going
MTV Software Change Request	Tracked by Continnus
MTV Sourcing Team Minutes	Not Milestone driven - on-going
MTV SW Progress Report	Not Milestone driven - on-going
MTV Technical Change Request	Tracked by CP/CN Tool
MTV SH 110	TPD
MTV SH 120	TPD
MTV SH 121	TPD
MTV SH 130	TPD
MTV SH 132	TPD

MTV SH 161	TPD. Supporting Doc - Electrical Quality Test Report
MTV SH 168	TPD. Supporting Doc - Electrical Quality Test Report
MTV SH 190	TPD. Supporting Doc - Electrical Quality Test Report
MTV SH 191	TPD
MTV Blue book	
MTV Intellect Property Rights document (IPR)	
MTV Ramp-up plan	start-up plan for industry

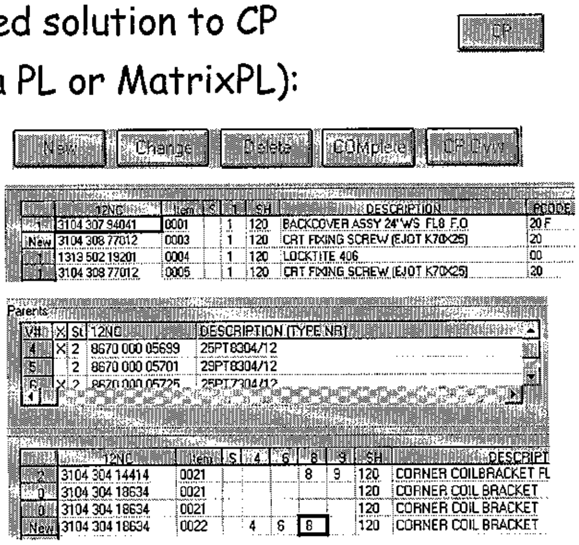
Appendix 10: CP/CN example





Create a Change Proposal (2)

- Add proposed solution to CP
- Changes (via PL or MatrixPL):
  - add
  - change
  - delete



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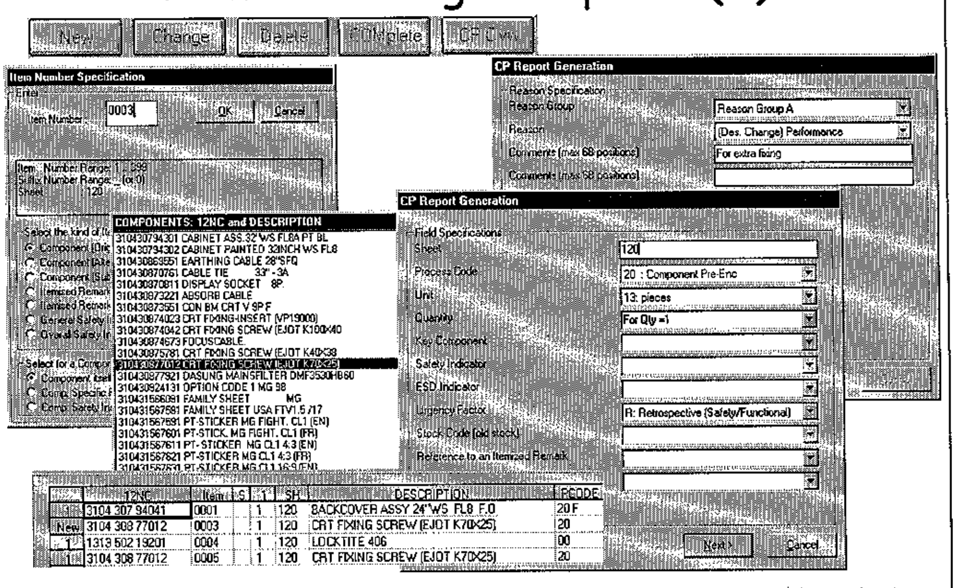
Create a Change Proposal (3)



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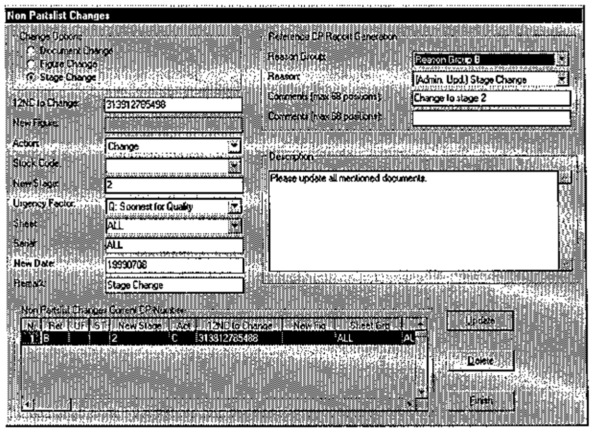
Create a Change Proposal (4)

- Non-Partslist changes (NPL) 

  - document change
  - figure change
  - stage change
- For documentation use only (no PL update!)



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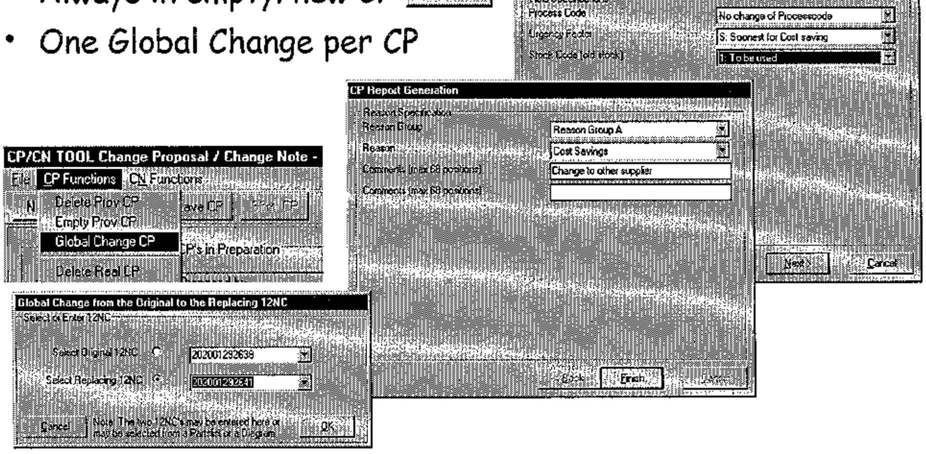
Create a Change Proposal (5)

- Global Change CP
- Always in empty/new CP 

- One Global Change per CP



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Submit a Change Proposal

- Only for Designer profile
  (Documentation profile does an 'Auto-submit')
- Press 'Submit' if CP is ready (ready=yes) Sbmt CP
- CP becomes visible for Documentation profile
- Rejections can be found...
- Delete provisional CP

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Appendix 11: iQMS example

Problem ID	Status	Project	Title	Description	Conditions	Category	Report Fr	Site	Type No	Defects Gravity	Evolution Factor	Discipline	SW Version
667	SOLVED	A02PCP	Sub Channel Off not Ok	Symptons: Description: When the sub mode set to the sub channel off , the PIP is not switched off.	Turn PIP on to see the problem.	Design	GDC	Singapore	a02pcp	B	3	Electrical	
671	CLOSED	L01MKII-LS	Horizontal Picture Expansion	Symptons:Picture Expansion horizontally after warm up. Description:When set was on from cold start, a half inch checker box is still visible on both sides of the screen, then picture after sometime slowly expand until the checkerbox is not able to be seen.	TV set using Factory CCIR signal at 189,25 MHZ with audio music.	Design	GDC	Singapore	29PT2460/94	B	4	Electrical	L011A51465a
1243	CLOSED	Eco-EMG2K2	CRT Cable (Short Lenght)	Symptons:Cable from CRT board loc 0340 looks too short... Difficult to assemble board on 36" tube (Eco EMG models) Description:Please keep only one cable for the three sizes (27/32/36V) Suyggestion: Add 50 mm to the current length of the cable.	n/a	Process	NAFTA	Juarez	37wdpv02	B	4	Mechanical	
1280	SOLVED	L01S-GMT	crack sound in Radio	Symptons:Symptons:radio is crackling - the sensitivity seems not enough Description: This problem as been also reported in L01L family as IQMS941 (submitted 15 March 2002) escalated July 2nd 2002 Analysis reports are enclosed in L01L IQMS941 .	no specific conditions	Design	EUROPE	Dreux	14PT1686	B	4	Electrical	
1301	CLOSED	L012k3 LS	Track flamed in fault condition	Symptons: Short Cuircuit 7560 pin1-pin2, the track is flame from 9633 to 6903.	fault condition	Design	AP-CHINA	Suzhou	32PT6331/37R	S	4	Safety	NA
1070	CLOSED	A10 GMT	DVD eject button loose	Symptons: On production line we found a lot of TV sets with DVD eject buttons were not clipped onto the bracket. Description:high fall off rate and presale test due to eject button was not working.	see above	Design	EUROPE	Dreux	28&32PW 6816 6826	B	4	Mechanical	
1255	STUDYING	L2002SS	Bright light in the left side of the scr	Symptons: When we set on the block channel option, we can observe a bright changing bar in the left side of the screen this bar will vary depending of the signal. Description: 1. - Tune a RF channel with a high brightness signal (white pattern) 2. - Go to autolock and block the channel 3. - The channel will get blocked 4. - A bright bar will appear in the left side of the screen	RF signal with white pattern	Design	NAFTA	Juarez	19PR11-C322	C	4	Software	2US2v1.2
981	CLOSED	L01L-GMT	"Hum" Bar on L01 pip	Symptons: Vertical bar floats through the pip window at the 60hz rate. Description: it appears similar to crosstalk but no picture information occurs only what looks like vertical blanking.	attach a outside source to a/v inputs. The bar will appear in the pip window. It will appear no matter what the source is. It appears most on A/v 2 input but can be seen on av1 input. Also is see n when you swap the tuner to the pip window.	Design	NAFTA	Juarez	pip models	C	4	Electrical	

Problem ID	Enter By	Submitted On	Assign To	Comments	Affected Region	Revised Defects Gravity	Revised Evolution Factor	Assigned On	Closed By	Closed On	Refer to Problem ID	Cause
667	Mr. Muri	1/2/02 9:32:02 AM	Mr. Zuih	Need more details for escalating to P.S . Please add details into the A02 SAlsa teamroom . 22-07-2002 (To Mr. Yang) : Please follow up with Patrick VdH & Vincent for the update of the MBF HSI document .	GDC	B	2	7/22/02 4:52:04 PM				This is a problem of the ADOC IC (Supplier problem)found in N1 and N2 versions .
671	Mr. Aberg	1/2/02 1:43:52 PM	Mr. Seel	No CP needed First Stage documentation and solution verified.	GDC	B	0	1/2/02 2:53:51 PM	Mr. Shang	1/14/02 10:06:34 AM		Set not update for correct beam current and heater voltage - leading to insufficent heat up of picture tube at initial startup (for pix release) and picture expansion will thus be visible.
1243	Mr. Teca	6/19/02 10:22:00 AM	Mr. Kop		NAFTA	B	0	6/20/02 3:19:19 PM	Miss Alt	7/18/02 10:22:28 AM		Insufficient cable lenght due to 36v set size.
1280	Mr. Letla	7/4/02 4:03:25 PM	Mr Hang	Dear Mr. Letla, Please investigate this request which is a copy of L01L IQMS 941 - Full investigation report is in IQMS 941 L01L.	EUROPE	B	2	7/4/02 6:32:50 PM				Sensitivity of FM radio is not sufficient while some area transmits lower RF radio level(< 30dbuv). The current sensitivity is marginally o.k and region just require an improvement of 2-3dB.
1301	Mr. Sehui	7/10/02 9:04:42 AM	Miss Chung		AP-CHINA	S	0	7/17/02 10:45:50 AM	Mr. Wee	7/19/02 10:09:40 AM		a large current flow though the layout
1070	Mr. Jean	4/17/02 10:31:47 PM	Miss Au Lee	Part modification required and to study compatibility with all other moulds.	EUROPE	B	0	4/18/02 8:14:58 AM	Mr. Sivije	4/23/02 6:10:46 PM		Weak catch on the DVD eject button.
1255	Mr. Ricardo	6/21/02 2:30:07 AM	Mr. Yop		NAFTA	C	4	6/21/02 7:14:32 PM				Picture raster on the extreme left hand side is not fully blank in channel block which causes the beam current to be reflected when it lands on the edge of the picture tube. The reflection causes the bright bar to be seen.
981	Mr. Dim	3/28/02 6:47:26 AM	Miss Hur	Plse confirm dressing of wires	NAFTA	C	0	4/24/02 3:21:30 PM	Mr. Shai	6/27/02 9:21:12 AM		Current in line deflection disturb the PIP input signal which is not in phase with the deflection current. The disturbance causes the vertical bar to be seen in the PIP picture.

Problem ID	Solution	(#1) CP No	(#2) CP No	(#3) CP No	Test Report	Function Area	Solved On	Preventive Action (PA)	PA Input By	PA Input On	Preventive Status	Escalate to GDC	Affect For-Off-Rate	Affect Field-Call-rate
667	software solution: set register Break_pos0=Break_pos1 or Vp1=Vp2 . There is a software workaround with the above register settings . This has to be communicated to the SOftware team and the MBF HSI has to be updated . Problem can be closed after update of HSI .					Video	7/22/02 4:59:14 PM					No	Yes	Yes
671	3482 to 8K2 (Ibeam 1.6mA) 5480 to LAL04 22uH (heater 6.06Vrms) .					Deflection	1/14/02 9:06:34 AM	N.A.	Mr. Tah	7/9/02 1:21:23 PM	NOT REQUIRED	No	No	No
1243	to increase cable lenght by 50mm. refer to CP CR16722						6/20/02 6:21:29 PM					Yes	No	No
1280	Changing resistor 3238 value from 270R to 180R, the sensivity of FM radio can be impoved 2-3dB and did not find any side effect. This change has been communicated to the region and currently waiting for their reply.						7/16/02 6:08:31 PM					Yes	No	Yes
1301	Add a fuse resistor (10ohm)between 16V and input pin of 7560	SV57089					7/17/02 11:13:23 AM					Yes	Yes	Yes
1070	To reduce the thickness of the knob's catch and clearance on the catches.	SV56053				Mechanical	4/22/02 3:54:39 PM	1x full functional check by quality coaches during off-tool evaluation. To be incorporated in the Mech Quality test program.	Mr. Tah	6/18/02 8:30:33 AM	CLOSED	Yes	Yes	Yes
1255	Propose to set HBL bit (wide blanking) to "1" in channel blocking mode. Solution under investigation.											Yes	No	Yes
981	The issue is related to concept and cannot be improved and has been accepted by region for all L01 sets.					Audio	6/25/02 3:50:11 PM					Yes	No	No

Notes: