TAMPERE UNIVERSITY OF TECHNOLOGY
Degree Programme in Information and Knowledge Management

SANNA UUSIMÄKI

IMPLEMENTING METRICS FOR MANAGING SOFTWARE R&D PROJECTS

Master of Science Thesis

Prof. Antti Lönnqvist has been appointed as the examiner at the Council Meeting of the Faculty of Business and Technology Management on May 5th, 2010.

ABSTRACT

TAMPERE UNIVERSITY OF TECHNOLOGY
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The objective of this thesis is to research how measuring systems are implemented when metrics have already been selected and what needs to be taken into account when measuring in business environment. Operative metrics for project management of a research and development (R&D) teams will be implemented to support this thesis. The thesis reconciles typical usages for these metrics, which will be examined by researching metrics in general. Research and development implementation is assumed to have similarities with metric implementation.

End result of this thesis is to confirm or revoke claims in literature regarding research and development implementation. This thesis, with support of theoretical backgrounds, implements metrics selected by a company. The material in this thesis relies on a literature review and observations made during the empirical research. The implementation project offers access to a real live business environment for the researcher to observe different process steps and thus enables this research. Interviews are used to make observations during the implementation phase at the beginning of the project and during the training period at the end.

As a product of this thesis a dashboard was created for a R&D teams for operative usages. The main purpose of the dashboard is to be a tool for project management, but it also acts as a part of larger business intelligence system. The thesis created example interpretation guides for each metric implemented. The thesis observed that measurement system implementations have partially converging practices with business intelligence system implementations. The implementation process requires comprehensive support if the metrics should be widely aggregated through multiple business units. Even a small-scale visual dashboard was found to help to perceive unit operations.

TIIVISTELMÄ

TAMPEREEN TEKNILLINEN YLIOPISTO
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Tämän diplomityön tavoitteena on selvittää, miten liiketoimintatiedon hallintajärjestelmä voidaan ottaa käyttöön, kun mittarit on jo valittu, ja mitä mitattaessa on yleisesti huomioitava. Tutkimuksen tukena implementoidaan ohjelmistokehityksen tuotekehitysyksikölle operatiivisia mittareita projektijohtamiseen. Tutkimuksessa selvitetään näille mittareille esimerkinomaiset käyttötavat ja tätä varten tutkitaan mittaamista yleisesti. Mittariston ja liiketoimintatiedon hallintajärjestelmän implementoinnissa oletetaan olevan yhteneväisyyksiä.

Lopputuloksena vahvistetaan tai kumotaan kirjallisuudessa esitettyjä väitteitä liiketoimintatiedon hallintajärjestelmän implementoinnista. Tutkimuksessa teoreettista taustaa soveltaen implementoidaan yrityksen valitsemat mittarit. Aineistona käytetään kirjallisuustutkimusta ja tukeudutaan tutkimuksen edetessä tehtyihin havaintoihin. Implementointiprojekti tarjoaa tutkijalle pääsyn aitoon liiketoimintaympäristöön havainnoimaan prosessin vaiheita ja siten mahdollistaa tutkimuksen. Havainnointi tehdään haastatteluin implementoinnin alkuvaiheessa ja lopuksi koulutusvaiheessa.

Tutkimuksen tuotteena syntyi ohjelmistokehityksen tuotekehitysyksikön operatiiviseen käyttöön visuaalinen mittaristo (dashboard), jonka pääasiallinen tarkoitus on olla projektijohdon työväline, mutta jota käytetään myös osana yrityksen laajempaa liiketoimintatiedon hallintaa. Tutkimuksessa jokaiselle mittarille laadittiin esimerkinomainen tulkintaohje. Tutkimuksessa havaittiin, että liiketoimintatiedon hallintajärjestelmän käyttöönotossa ja operatiivisen mittariston kokoamisessa on osin yhtenevät käytännöt. Implementointiprosessi vaatii laajaa tukea, jos mittareiden informaatiota halutaan aggrekoida useamman yksikön kesken. Visuaalinen mittaristo auttaa pienimuotoisenakin hahmottamaan yksikön toimintaa.

PREFACE

The thesis writing process has been very surprising experience in many levels. I learnt a lot, for example according to one of the books, two highest levels of information are wisdom and truth. Wisdom requires an intuitive ability to see beyond the apparent situation. It is clear that this level cannot be captured with IT, so it won't get a role in this thesis. The truth is also a subject of different type of research as "it will be misused by president of EU", stated one of the books... It is written in a book so it must be true.

All things have to come to an end. For this thesis that point was when my patient examiner pointed out that it is now or never. I am not sure, if it was only my mother who had the *wisdom* to see this thesis to be completed.

I am grateful to Ville Luoma from ABB for an opportunity to do this research and work with wonderful team in Vaasa. I also thank examiner professor Antti Lönnqvist for guiding me through this process and standing overdue of the thesis.

Thank you all who participated very very much!

Best Regards,

Sanna Uusimäki

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ABBREVIATIONS

BI	Business Intelligence
BIS	Business Intelligence System
BSC	Balanced Scorecard
CMMI®	Capability Maturity Model-Integrated (Kasse 2004, p. xix). CMM® Integration project combined three source models to one improvement framework with which organizations can pursue enterprise-wide process improvement (Kasse 2004, p. 3).
IED	Intelligent Electronic Device
KM	Knowledge Management
R&D	Research and Development
SDIP	Software Development Improvement Program of ABB (Inside c).

1. INTRODUCTION

In a complex business environment it is often hard to recognize developing trends and effects of the actions intended to develop processes and strategies of the organization. A well planned and implemented measuring system with good reporting capabilities can give an advantage in facing these challenges. A measuring system will help to see the potential opportunities and the changes in the business environment, to do analysis early enough and to make well justified decisions based on accurate information.

It seems to be every-day problem that big picture of the situation at hand is missing or at least somewhat blurry. There is pressure for a quick judgment as competitors are moving fast and decisions might be forced to be made based on information what is known right now and the information most likely is scattered. It would be easier to gain benefits out of decision making, if the overall view of the situation was clear or at least known. It is easier to communicate and understand the changes in an organization based on facts, than it is to do so without compatible data that is presented in a way that is easy to understand. When there is knowledge about the present state, it also becomes possible to anticipate what the future state might be.

This thesis describes what to take into account when doing technical implementation of measuring system. The process is applied in a project where the previously chosen metrics are implemented to be used the case organization. One objective is to demonstrate, how the case organization can benefit these metrics in managing their software research and development teams.

1.1. Business and Technology Perspective in Implementing and Using Metrics

Business performance management can be efficient only if there is enough valid information available to make wise decisions. The information must be timely and accurate but it must also present the “commonly agreed-upon, consistent, enterprise-wide view of reality across departments, divisions, and corporate functions” (Wong, Fryman & Downey 2008, p. 66). Information and knowledge management is a process where knowledge is created, acquired, stored, distributed and adapted (Sydänmaanlakka 2007 p. 176). Measuring is here seen as a function that supports this process.

A traditional measuring system usually measures short-term financial goals and is therefore inadequate to represent the actual business situation. There is a need to

measure also such progress that cannot instantaneously be seen from financial measurements but is crucial to the future success of the company. Depending on the use of a measuring system, the type of the metrics naturally varies. When measuring system needs to evolve, there might also be reasonable to take intangible assets of business into account.

In measuring system implementation process has several phases that have different critical success factors. In this thesis the emphasis is on implementation phase. It must be planned carefully and it should be constructed in a way that it is easily understandable, accessible and readable. A measuring system must also be easy to use to make decisions altogether. Other way the system is purposeless. This thesis is about how to use the collected information to learn, develop and maybe predict better with the help of the reporting system.

There are different reasons to choose specific metrics among the almost endless possibilities. There is a lot of literacy on how to succeed in choosing process. Selected metrics should support the business and the strategy. Right metrics provide answer to the questions otherwise challenging to perceive. The model with which metrics relate must be as effortless as possible to understand. The lack of model rather than a missing data will hinder the interpretation of situation. There must be understanding, how to react to the metrics and how the changes effect on metrics. In other words the must apply system thinking to view the big picture. When processes are described and used, it is possible to follow the effects of the decisions made with the metrics. A measuring system with reporting and distributing functions can also be used as a tool to communicate the strategy. The communication between different teams and organizational levels is more reliable and see through, when it is based on commonly known metrics.

It is said that you get what you measure; that means that people react more easily to those issues which are measured than to those which are not. It is essential to drive metrics from the strategy in a way that they support it. Almost every company has written a business strategy but they also need to ensure that their strategy is translated to appropriate actions. One way to spread the strategy to the organization is to try to visualize it. Management should also be able follow the fulfillment of the strategy to be able to evolve strategy and follow the quick shifts of business environment and make right adjustments. Bad strategy can make situation worse than “no strategy” (Senge 2006, p. 48). In context of this thesis business environment is a viewed from the perspective of middle management because the metrics are designed as a tool for that level.

Basic reporting process involves four steps that are; fetching the data from the source systems, ETL (Extract, Transform, Load), forming the data warehouse and the interface

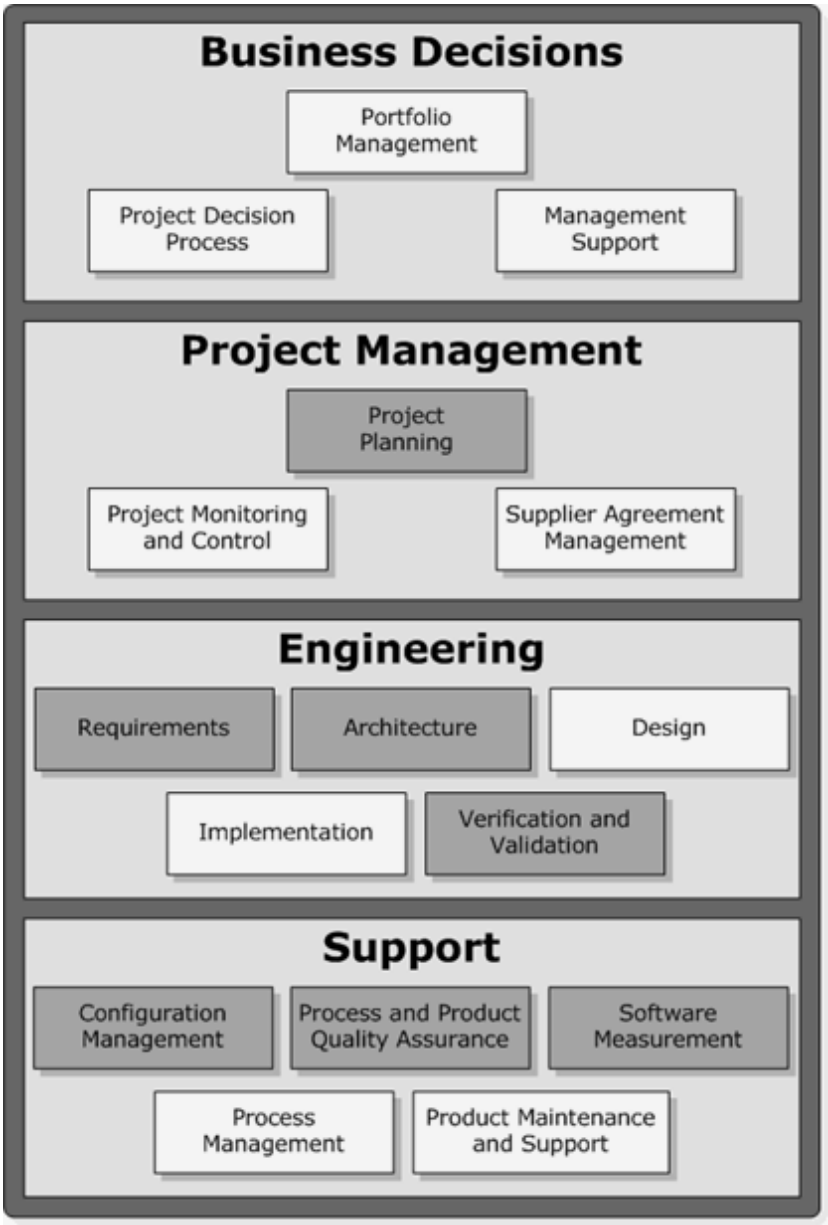
through which the user can use the information. Beside this technical phase there is also need for a planning phase where the right data is chosen and the proper way to present the data is selected to gain information as planned. Data quality is important for any measuring system. It must be right data chosen on right reasons. Besides the traditional reports there are other ways of presenting information demonstratively.

In the empirical part of this thesis, a significant effort is put to construct a dashboard from the pre-selected metrics. Dashboard is a platform that collects the metrics together in a way that they can be evaluated together. The challenge is to find the data for all of them, to create the required analysis system and then introduce it to the organization. This process is referred as a technical implementation in this thesis.

1.2. The Case Organization

ABB is an international company that has a global organization and a wide power product repertory. Their slogan is "Power and productivity for a better world™" (Inside a). ABB has a global metrics project which main goal is to make software development projects more transparent in the company. The case organization for this thesis participates to the project and the deadline for its part is on December 2010. There have been chosen nine operational level metrics to be implemented in software units of ABB. The metrics implementation is a section of Software Development Improvement Program (SDIP) (Inside c). It is global organization inside ABB. The SDIP is more closely introduced in chapter 2.3, but the general structure and scope of the program can be seen in the Picture 1.

Software Development Framework in SDIP has three views; process, people and technology. The Process view has four sections; Business Decisions, Project Management, Engineering and Support. The measurement implementation is in the Support section. These four sections of SDIP can be seen in the Picture 1. (Inside b.)



Picture 1. *Software Development Framework – Process View (Inside b).*

The case organization for this thesis is a part of the software unit in Vaasa, Finland. They will be the first of the software units to adopt the all nine metrics. There are three metrics to follow that are more strategic but they are out of scope of this thesis. A one part of this thesis is to create a dashboard and teach key persons to use it. To be able to have a better perception of the situation the two teams are called Team T and Team P from here on. Both teams design and develop software to user interface of protection and control relays (Tuotteet ja järjestelmät) and have worked with the current products since 2004. The Team P has 20–25 developers and it uses agile development method. It is purely software development team as the product of the team is a user interface for transformer protection and control IED (Intelligent Electronic Device). The Team T is little bigger with 40 developers in it. Team T uses staged software development system

also has hardware development along the software development as they are responsible also for IED. These differences naturally affect the metrics dashboard.

There are nine metrics that needs to be implemented into R&D process development if it is possible. The metrics are quite carefully detailed but the data for them needs to be found and collected. These metrics are gathered together as a dashboard in a way that they all can be evaluated at the same time. There is some reporting software in use in the case organization but there are limited possibilities to use and customize or modify them. There is some metrics already in use in the case organization but they are not planned to form a solid business intelligence system so they are excluded from this study.

The situation before implementation process took place was that the metrics project had already begun. Thesis work started in a situation where defined project with nine metrics needed to be implemented. Major interest of the case company was that the thesis work includes this implementation project. The timetable, most of the resources, metrics and implementation plan were made in global level. Same scheme were going to implement same time in Sweden and some of it in India.

The metrics are well specified and they are chosen among over hundred other metrics by global software development team. The usual situation for the thesis work would be to choose the metrics. In this case as the metrics are already chosen the interest lies on how the implementation process can be executed, how the chosen metrics can be interpret and can they be used to anticipate some events in the process development work.

The two case teams did know that some metrics project is about to start when the thesis work began. However the proper informing was performed in the interview situation. The main reason for the interviews in this study was to inform the employees about the metrics project and to gain their trust. As the data collection is laborious and challenging task for the outsider it helped tremendously that employees were familiar with the project and with me.

The researcher has previously worked in the case organization as a summer trainee in the other of the two case teams. Therefore she has familiarized herself with the people, interior, culture and programs used. This is a great advantage especially at the beginning of the research, when whole implementation project is introduced and planned. It is important to the researcher to be trusted to be able to gain access (Gummesson 2000, p. 25). The researcher had already had an opportunity to gain trust in her former employment in the same department, which is a great advantage to the research process at the beginning of it.

Part of my duties within the case organization was that I had a responsibility of the dashboard implementation project. The implementation project is not a project is a part of the thesis project. There were no predefined processes for the implementation project. Although I could not work as fully outside researcher, the role was beneficial. As the implementation process belonged to me, it was possible to get a thorough insight into it. The implementation of the metrics is not necessary for purposes of this thesis per se. Nevertheless it would not have been possible to gain access to the team members and to the metrics project without this somewhat heavy involvement into it.

1.3. The Scope of the Thesis and Research Questions

The objective of this thesis is to research how to do to a technical phase of a measuring system implementation. The practices found are applied in a project where operative metrics for project management of a research and development unit have already been selected. Based on the literature review and the implementation project, the observations are made, what needs to be taken into account when measuring in business environment. The thesis gives exemplary usages for these metrics. There is a hypothesis that measuring system implementation and business intelligence system implementation have similarities.

The main research question can be defined as:

RQ: *How to implement a metrics system?*

Other questions that need to be answered are:

Q1: *What should be taken into consideration when building reporting system?*

Q2: *How to use the metrics dashboard in managing software R&D?*

Q3: *What role the data has in the implementation process?*

The main reason this study is conducted is that case organization wants to know whether the improvement projects have been successful or not. They want to visualize the situation. Therefore the main objective for this thesis is to comprehend, how the metrics can be used in managing the R&D process development. Also research determines whether the metrics can provide information that project management finds helpful when anticipating the true amount of resources needed in project planning phase. From the case organization point of view, one of the main objectives is that the by the end of the thesis work time period they have an informative dashboard implemented into they every day routines. In other words they have these nine metrics

implanted and they know how to interpret the dashboard the metrics comprise. One of the most important parts of this study is to create the managing procedures based on the metrics. Although it will require a considerable amount of work to collect the data it is necessary to build the dashboard to gain access to the knowledge needed for this research.

The point of view in this thesis is the middle managers view to using metrics as one of the managing tools. Especially the focus is on what is needed to implement one. The dashboard is intended and designed to be mainly a tool for a project and line managers. As the SDIP is global program there seem to be also some interests to standardize the metrics in a way that they can be compare among the teams and aggregating the measured metrics to unit wide metrics. The link between the metrics and strategy is feeble, if the collected data is not used in making decisions (Kankkunen et al 2005, p. 19). The dashboard most likely provides new knowledge about for example trends in requirement handling and help anticipating the work resources. When succeeding this research provides a new management tool to case organization and the information needed to use it properly and efficiently in making decisions.

The scope of this thesis includes only parts of two teams of one software unit in Finland, although the metrics project is global. The case organization consists of two product teams that learn to use the dashboard in the first implementation phase. They are a kind of pilot team that gains the experience needed to be able to implement the metrics to the whole software unit. Other of the two teams is solely a software R&D team and the other has both hardware and software development. There are also other metrics that are already in use in the case organization. This thesis will not take a stance on whether those are good or not, but mainly takes into account that they exist. Though, they will be not included to the dashboard as the focus of this dashboard is only on quality and processes of R&D team rather than report of the whole performance.

This study should clarify what aspects to consider when doing technical implementation of measuring system and what to take into account when building reporting system. There is some examples how to use metrics dashboard in managing software R & D project and how to make sure that the data gathered is properly chosen.

1.4. Research Methods and Methodology

This study has strong hermeneutical features as it aims to provide understanding of the situation in the case company. “It is hermeneutical feature that the evidence of the research results is based on understandability in the way that the result is reliable” (Olkkonen 1994, p. 33, 52, 54). Information for this thesis is gathered via literature review, interviews, and from variety of information sources to compare the given

implementation challenge to the other somewhat similar projects that aim to do a technical part of the implementation of a measuring system. There is a literature review conducted on how to build and use a measuring system that is compared to the results and observations gained in the empirical part of the study.

The empirical part of the thesis consists of two parts. First part is to conduct interviews among the teams and implement the metrics dashboard. The implementation is done in iterative cycles where there are one or two metrics added to the dashboard at the time. For the implementation there are also conducted short interviews about the current atmosphere within the case teams. The second part of the study is to evaluate the resulted dashboard, and analyze how it could be used and train the employees to use it. In this part there is also interviews conducted to gain understanding, if they find it a good tool to support decision-making. After this the case organization can have recommendation how to pursue the metrics development process.

This study has an exploratory nature and it is a is a kind of pilots study for other units in the ABB can utilize in their implementation projects and they can use this study to help them interpret the metrics. They have the same metrics and therefore they can employ this study although the study might not be generalized very widely. Study tries to explore the ways to utilize metrics in this case and then generalize some observations.

There is no dashboard tool existing so it has to be created first, which might be rather laborious to create. Nevertheless it is necessary because there is no other way to gain access to all necessary information. The participation to the implementation project is fruitful way to collect data for the research and is therefore seen mandatory. The dashboard tool needs to be created with common office software, systems and databases. There is however an intention to implement the reporting system into some of the information systems already used in the case organization.

2. MEASURING IN THE BUSINESS ENVIRONMENT

Organizations measure their actions to understand how they are doing and to make decisions to continue their business. Nevertheless it is not the same what are the metrics they are following and how the metrics are interpret. People using the metrics need insight about the content of the metrics and power to make decision based on them. The measuring system should be carefully considered, planned, implemented and then taken into use to be efficient tool for the organization. In the research conducted 2013 by Sofigate and The Finnish Information Processing Association, FIPA (Tietotekniikan liitto ry) (2013, pp. 21 – 24) there is evidence that ICT of the Finnish companies are not measured with proper metrics and the ICT can be lead only partially based on these metrics.

Every organization has their own reasons and needs to measure their operations and functions. Kujansivu, Lönnqvist and Sillanpää (2007, p. 159 - 160) say that the main reasons to build the measuring system is to control the results of the planned actions, to use it as a tool to take strategy into actions and use the metrics to communicate the situation and plans to the personnel. The reasons can also be such as to have for knowledge to support decision making, to motivate personnel, to question the working models that are today, to anticipate future business development, learn from the organization behavior and to communicate the resources of the organization. At the beginning of the metrics project the strategy needs to be defined explicitly. (Kankkunen et al. 2005, p. 92). The major deficiency in measuring systems is their lack of actualizing the strategy (Kankkunen et al. 2005, p. 19). The strategy with vision is important when developing the processes. Without strategy or vision the development might have no direction and it could bounce back and forth without good results.

2.1. Measuring as a Concept

As there are different objectives and needs in the different environments there are different kinds of measuring systems developed for these situations. Usually a measuring systems are divided into three types of measuring systems stakeholder oriented, KPI (Key Performance Indicator) systems and strategic measurement systems. The stakeholder systems or scorecards are concentrating on the most important stakeholders. Every stakeholder view have its' own targets to meet. The KPI systems as Balance Score Card are focus on the most important measures for the company and they

usually are lagging indicators. In strategic measurement system the relationships between the measures are analyzed and focus is to create indicators if the targets set are going to be met. (Malmi et al. 2006, pp. 34 – 38.) Metrics are the measuring units in these measuring systems.

Regardless of the basis how the measuring system is build metrics should be used in decision the making process. They can be used for example in a kind of process that starts with the documenting and measuring of the current situation. Then the target situation is defined and the actions towards it are decided and made. After the actions are taken into effect, the situation is measured again and based on the gathered information, a decision is made whether the actions were right or not and if some corrective actions should still take place. This means that even the strategy can and even should be put under observation. (Kankkunen et al. 2007, p. 175.)

Kankkunen et al. (2005, p. 27) found five features that are in common to successful measuring systems. The system needs to be aligned with strategy and well balanced between the stakeholders and time horizons. The goals for measuring systems cascade up and down to make certain that the system supports the whole organization. It is good to bare in mind that if the system is not used, there cannot be any gain from it. Therefore it is a desirable that metrics are used regularly. The only constant thing is change and consequently also the measuring system needs to evolve. (Kankkunen et al. 2005, p. 27.) Malmi, Peltola and Toivanen (2006, p. 99) refer to Toivanen's model to add above the statement that the cause-chains behind the metrics need to be defined at least on a high level. The metrics will become clearer after the system has been used for a while. Malmi, Peltola and Toivanen also add that as the metrics must be in align with the strategy they also must be driven from strategy in a way that the metrics support and fulfill it. Training and communication are equally important. The need to build a measuring system should be communicated with assertiveness and then personnel must be trained to use the system properly. It might be reasonable to also have some sort of pilot period so that some of the issues come clear at earliest possible time. In addition to all this, organizations have to be able to question their strategy every time, so that they are able to adjust it if necessary. (Malmi et al. 2006. p. 99.)

A consulting company Schiemann & Assosiates discovered myths that complicate the creation of a measuring system. The first myth is that when you measure hard values, the soft values follow. Soft values are proven to play a strong part in making a successful business. Soft values are mentioned to be leadership, customers and innovations that can also be described as intangible assets. The second myth is that all measurements are only for finance the department, but it is known that measurements are a task for the whole organization. It is also a myth that measuring only gives information about the past. The measurements should be chosen in a way that they indicate future problems and trends thus there will be more time to action. It is also a

myth that measuring is inhuman. The analyzed results must be presented to the employees and metrics must not be a controlling system. This way the possible negative effects of measuring on the working environment can be avoided. The final myth is that, more is better, applies to measuring. If the dashboard of metrics is too big, it becomes too hard to understand. (Kankkunen et al. 2005, p. 25–26.) It is good to be aware of these myths when the measuring system is being implemented and developed further.

When the organizations with good measuring systems where examined, five common features were found:

Alignment	(there must be strong connection to strategy),
Balance	(between interest groups and timelines),
Cascade	(measurements should follow the measures the higher organizational level is using),
Deployment	(measures must be a natural part of the working routines)
Evolment	(the measuring system is continuously developed to meet the needs).

This form is a so-called ABCDE-model. (Kankkunen et al. 2005, p. 27.) There are also different types of measuring systems that have different focuses. In big organization wide measuring systems the focus can be on for example the stakeholders, KPIs (Key Success Factors) or strategy. If the focus is on the stakeholders, there might only be a loose connection to strategy, and therefore also to how the objectives will be reached. When the focus is on KPI there might be a lot of metrics that support strategy but they do not connect or correlate to each other. (Malmi et al. 2006, pp. 34 – 35). Even if the measuring systems focus is not an organization wide and high level organization lead supportive system, it is beneficial to follow the ABCDE-model.

In measuring business performance there are at least economical, customer, process and learning points of view to consider. In the full balanced measuring system like Balance Score Card the vision of the organization should be perceived from all of these points of view but they can be added too. (Olve et al. 1998, p. 44; Malmi et al. 2006, p. 24.) In the model designed by Kaplan and Norton the four basic points of view were those mentioned but also personnel is quite commonly added to the views (Olve et al. 1998, p. 57.) The public sector companies have in Finland used the model of Ojala and Määttä (1999) where the points of view are “resources and economic”, “Effect” (citizen, customer, politics), “processes and structures”, “renewability and working ability”. Other additional points of view could be environmental and social points of view. (Malmi et al. 2006, p. 24.) More recently also the view of the intangible capital might be taken into measurement system, as a growing portion of the organizations functions is based on knowledge and other intangible factors (Lönnqvist 2004).

In an economical point of view can be used to mirror the success of strategic choices made in the other points of view. The long term objectives, investment strategy, sales objectives and other traditional economical metrics usually are driven from this point of view. (Olve et al. 1998, pp. 58 – 59.) The risk factor might also be taken to balance the economic measures. This point of view could also be called as owners' point of view. (Malmi et al. 2006, pp. 25 – 26.). It is important to tell the difference between strategic and operational statistics. All the operational metrics does not represent the strategy but to communicate the strategy some operational metrics might be needed. Strategic measuring can be seen as a way to communicate the strategy of the organization to different interest groups. (Kankkunen et al. 2005, p. 21, 11.)

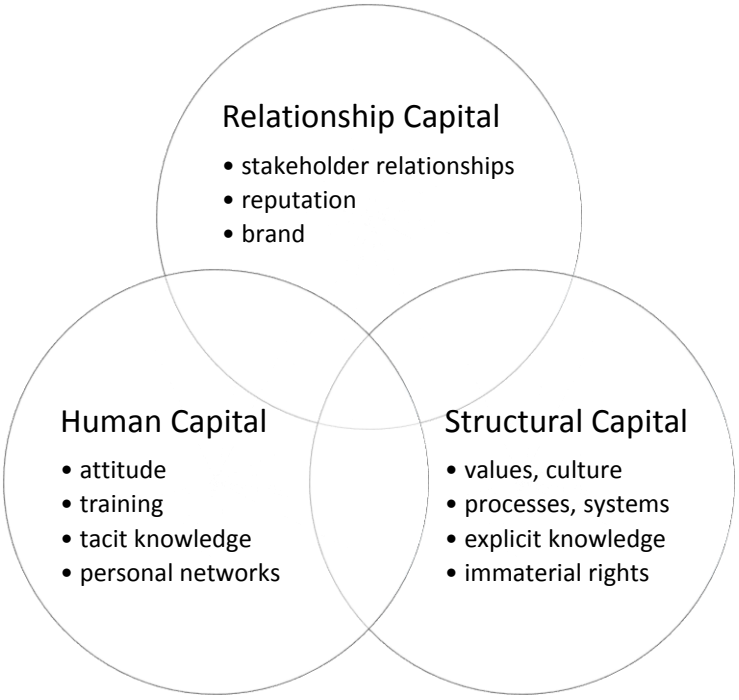
The customer point of view the metrics are set to describe the customer satisfaction and customer strategy itself. If the right kinds of services are lacked to produce the whole business is in danger. The metrics related to customer point of view might be market share, customer loyalty, the rate of new customers and profitability of the customer relationship. (Olve et al. 1998, pp. 59 – 60.) The metrics can be divided into two categories. One group is so called basic metrics that include for example the market share to measure the success on the markets and on the customer interface as viewed from the organization. Other group could be described as metrics that define the promises made to the customers. These metrics can be a delivery accuracy, a quality of the product or even the imago of the company. (Malmi et al. 2006, p. 26.)

The processes are important point of view. In considering this point of view for example there are different models to help with the chose but the main idea is to follow the processes all the way from the beginning to delivery. They key of this point of view is that the process are documented and therefore they can be followed. The customers naturally have a great role within this point of view. (Olve et al. 1998, pp. 60 – 62.) As there are plenty of the process, all of them do not need to be followed but the most important ones. Kaplan and Norton (2003) have divided the types of followed processes into four groups that are innovations process, the operations process and the service, customer follow up process and legislative and social processes. (Malmi et al. 2006, p. 28.)

Learning and knowledge form one point of view to the measurement system. Measuring the learning, skills and knowledge an organization can follow and be assured that it can renew and innovate and ultimately – survive. To set the objectives and strategy to learning the organization should analyze its current state. Organization should know what it knows, how the skills are utilized, does it have the key skills to satisfy the customer expectations and is the organization capable to change. (Olve et al. 1998, p. 63 – 64.) If not measured separately the intangible learning measures usually are present in this section (Malmi et al. 2006, p. 29). But as there are intangible factors in the other point of views too, it might be reasonable to perceive them as a group also.

Focus in the CMMI (Capability Maturity Model), that is a process improvement and model framework used in the case organization, is on the process level. The basic metrics described in the CMMI contain metrics to the project management. These measures are example schedule, attributes of the work products like size and complexity, staffing profiles, resources and knowledge and skills acquisition of project personnel. There should be both metrics to follow the project status as well as its effectiveness. (Kasse 2004, pp. 228 – 229.) "Process performance is characterized by both process measures and product measures. Typical process measures include effort, cycle time and defect removal effectiveness. Typical product measures include reliability and defect density" (Kasse 2004, p. 232). This is quite practical view of measuring and to achieve better results in measuring but there are also signs of the softer side of measuring as the training and personnel skills are also taken into consideration.

As the traditional points of view, that are taken into account in BSC-type measuring system and these kinds of systems, have existed several decades already, the newest point of view intangible assets deserve to be more closer viewed as they might be beneficial to the organization to consider its intangible assets as a separate entity. The intangible capital is not the new thing but the new point of view. The amount of information and human knowhow has grown remarkably recently making these resources more important to the company. (Kujansivu et al. 2007, p. 37.) Many companies probably manage and measure intangible capital (IC) in some level but Intangible Capital Management (ICM) is a fairly new issue in many companies and ICM models are rare (Lönnqvist 2008). The terms intangible capital, intellectual capital, intangible assets and knowledge assets are used in English rather similar way. The intangible capital can be defined as "the abilities of the employees, the resources and customs of the company and stakeholder relationships related matters of the company" (Kujansivu et al. 2007, p. 28). As its name states the intangible capital is the intangible factors in the company that enhance organizations performance and value. In many companies there are already some actions made to develop the intangible capital, for example the development discussions, but the intangible factors are not seen as a whole. (Kujansivu et al. 2007, p. 45.) A one way to define the intangible capital more precisely is to divide it into three main sections of human capital, relationship capital and structural capital (Kujansivu et al. 2007, p. 28; Malmi et al. 2006, p. 29) as seen in the Picture 2.



Picture 2. The three types of intangible capital in company (adapted from Kujansivu et al. 2007, p. 29).

The non-physical nature of IC makes it challenging to measure. There is however some methods developed both non-financial and financial. The financial metrics are easier to compare between the companies as the non-financial are quite impossible. As an example one method could be mentioned to calculate IC that is Calculated Intangible Value (CIV) that is designed for lenders' needs to estimate the value of a knowledge-intensive company. (Steward, 1997 according to Kujansivu & Lönnqvist 2007, pp. 273–275.) Stewart (1995) calculated Merck's IC value ($ 11.1 billion (Kujansivu & Lönnqvist 2007, p. 275). However this business intelligence like intangible factors like innovativeness, customer relationships and business data are crucially important for a company to master.

The target of a measuring system is to provide information to support the decision making process of the organization management. The decisions might be answers to questions like "Can it be done?", "How much value does each piece of the process add?", "How would you quantify the value of the process improvement investment?" (Kasse 2004, p. 223 – 224.) The using purposes of the business performance measurement have been researched among Finnish leaders (Lönnqvist 2002). It is discovered that managers judge the use the measurement system to get an idea of the current situation in the company; to communicate the important objectives; to guide the actions of the personnel; to spot the problems early; to manage personnel bonus system; to concretize the strategy into actions; to satisfy the needs of the parent company and to gaining information from the information systems to decision making. The personnel

uses metrics to follow their work, to spot the things that need the most improvement, to understand how their own work links to the business and to recognize the factors that management finds the most important in their work. (Lönnqvist 2002, p. 117 - 118.)

Guiding the people with the help of metrics was found hard by Finnish managers. Measuring system should be used to communication but it might feel like controlling. (Lönnqvist 2002.) Measuring itself does not change anything. The results of the measuring can be seen when people react to the measures. Ways of communicating measuring results are for example frequently refreshed report in the intranet or in the information tables, the review of the metrics in the weekly or monthly team meetings.

One of the purposes of using the metrics in this thesis lies in the process development. The other two strong points of view to use measurement system are personnel guidance and learning as well as using metrics to gain foresight. There are plenty of reasons to use measuring system for example to follow up the finance situation of the company but here the focus lies in these areas because other hand they were most interesting from the case organization opinion and on the other hand because the according to Lönnqvist (2002) it seems that companies struggle with these subjects.

Based on the research conducted by Lönnqvist (2002. p. 98) it seems to be challenges in using metrics as a predictive tool, in using them to perceive the causal relationships between the critical success factors for learning and in using the to motivate the personnel. The management seems to struggle to analyze the reports they are receiving. To be able to use metrics in a way that truly gives leverage there might be a need to change how the organization is used to work and be prepared for the future challenges. In rigid and formal planning there is not enough room to internalize, learn and understand all the functions of the company. Not even a great amount of planning can prepare the company to all discontinuities in business. (Kankkunen et al. 2005, p. 75.)

Besides communicating that the new system taking action, there is also preferred to communicate the strategy, values and action models at the same time to get the user motivated and interested. There might be reasonable to for a thorough communication plan to make sure it is implemented thoroughly to organization. (Malmi, Peltola & Toivanen 2006, p. 120 - 122). When using a measurement system to support strategy the strategy and values themselves should also be clear. Then after that is done the measurement system can support them and help to follow how the strategy is working and then develop it.

“The role of intangible factors is significant in research and development (R & D) projects. In addition to financial resources, intangible input factors such as employee competence and knowledge regarding customers’ needs and competitors’ actions are important”, states Vuolle, Lönnqvist and van der Meer (2009, p. 25). It seem sto be

difficult to be able to make cleac conclusion based on solely on metrics (Vuolle et. al, 2009, p. 31) therefore some problem based starting point of business intelligence might be beneficial to measuring.

A full measuring system and business intelligence system have some similarities. There is a lot of literature about technical implementation of business intelligence systems as there is not that much literature how to do the actual technical implementation of a measuring system. Both systems have similarities although they are different. As one part of this thesis is to actually implement the metrics chosen there is a need to research also technical implementation literature. Good quality and timely data is the most important requirement to be successful and able to respond in competitive environment in these days increasingly fast changing environment. Business intelligence (BI) can be defined as all the data needed to manage and lead an enterprise or organization. BI is a process to process important data into from where it can be used to support decision making. ‘The kind of environment that documents what they know, where they are can always look back to understand what is going to happen next (Senge 2005, p. 289).

Metrics in a Measuring System

There is wide range of metrics to measure different issues in business environment. Metrics can be physical metrics that measure physical variables. Physical metrics are typically used by company healthcare in form of decibel or temperature measurements. Then there are financial metrics with which are common in business. Every enterprise needs to follow financial metrics and at least do financial statement. Financial metrics typically follow the physical capital of an enterprise. But there are also intangible factors that affect to the business environment (Kujansivu et al 2007, p. 27).

There are metrics in use in almost all of the companies. They measure for example profits, order and delivery situation and storage size. Usually these metrics are dispersed. However to gain better understanding can metrics be gathered to one dashboard. A Dashboard of metrics is a tangible management tool that can help to manage complex business systems (Kujansivu et al. 2007, p.159). When gathered into one dashboard the metrics have leverage from each other and provide more information than single metrics would. Metrics should be chosen based on the need of an individual organization. If the dashboard is well planned, it is possible to deduce the strategy in use with it. (Kankkunen et al. 2005, p. 17.)

Planning a metrics can be divided into phases. First the measured action or object is chosen and then the metric or metrics s that reflects it are derived from it. (Kankkunen et al. 2007, p. 168, 170). It is difficult to give thorough instructions how to build a metric as it depends heavily on the characteristics of the metric. For example the progress of the software project can be measured based on a codechurn that leans

heavily on the technology that is used to collect the data and with the burndown chart that is subjective form with the team.

The metrics should be derived from strategy but this does not mean that the metrics are same on all organization levels. Every unit of the organization have their own metrics thus them should correlate with the strategy. (Kankkunen et al. 2005, p. 161 – 163.) All the points of views are related to the others as for example the personnel and processes have strong impact on customer relationship (Olve et al. 1998, p. 94.) When deciding to what point of view measure should be added there are three things to consider. It might be reasonable in some cases put the measure in the group where it is not usually put because it might be teaching. Secondly the measure should be in the highest group or point of view possible because then the causality becomes followed. The balance of the measures is the third thing. Although the measuring system would be only partial, the metrics should be balanced against each other in the way that subject measured is fully covered. (Malmi et al. 2006, pp. 30 – 31.)

It is important to choose only the key metrics because it is difficult to understand and follow them, if there are too many of them (Malmi, Peltola & Toivanen 2006, p. 96). Balance of the metrics is important and it typically requires improvement in the Finnish companies (Kankkunen et al. 2005, p. 26–27). Metrics as any statistics can easily be misleading and they can be interpreted in various ways. Therefore the causal chains behind the metrics should be recognized. In the planning and implementing phases there must be bore in mind the using phase. The most important thing is that the measuring system is efficiently usable. These questions should be asked multiple times during designing process: how often to measure, who is responsible of the metric, to whom the metrics should be reported and how, where the results are discussed and is there a connection to the personnel bonus system (Kujansivu et al. 2007, p. 176). In the successful strategic metrics project different organizational levels know the critical success factors of theirs. Every level has a goal and the metrics to reach those goals. Considering the differences between the teams, the metrics should be analogical. Always when metrics are taken away from the team, the meaning of the metrics might be lost. Therefore caution is required. Properly used metrics are updated and used in decision making regularly. (Kankkunen 2005, p. 159–161.) Although the metrics in this case are more operational than strategic, the principals are same as with the strategic metrics.

When metrics are designed they should be evaluated before taking next step. This kind of evaluation should be going on also after metrics are implemented, in other words the metrics should be evaluated continuously. The questions helping in the evaluation are following: Is the metric valid in the way that it measures the information intended?: Is the metric reliable or is there a risk of having errors in the data?; Is the metric usable and understandable?; Is it affordable?; Does it provide adequate information to support

decision making?; Does it guide the actions to the right direction?; Can it be manipulated?; Is it the best metrics to describe what it measures? (according to Kankkunen et al. 2007, p. 172.)

The metrics can be divided to groups. First group is the direct and indirect metrics and the second group is the objective and subjective metrics. A direct metric measures exactly what it is counting whereas indirect metric measures something that is connected to the thing that is wanted to follow. For example the skill matrix tells direct the number of skilled people as the training hours indicate the same thing but only indirectly. (Kankkunen et al. 2007, p. 168.) Especially when indirect metrics are in question it is important to know and define explicitly why the metric has been chosen as the causal relationship between the metric and the measured object might not be clear to all of the users. The data to objective metrics are gathered with the help of some measuring device such as a scale. They do not contain any subjective analysis so they are traditionally considered as good metrics. In business environment for example the delivery time is an objective metric. Subjective metrics are based on opinions and estimates like customer satisfaction. (Kankkunen et al. 2007, p. 170.)

Tangible measurements might need some intangible measures to support them. It might be challenging to define what they should be at the same time as tangible measurements are rather obvious. Usually measuring has focused on hard values money and time. Financial measurements have been, and usually are, in an excellent condition. In the organizations that have started to gather the strategic dashboard, the softer values have gained footage. Usually these softer values are challenging to measure. Financial measures, when used solely, provide only a rear mirror to past. Beside it the successful management needs means to recognize the key success factors for the future. (Kankkunen et al. 2005, p. 20.) Knowledge management and intangible capital are therefore closely related (Kujansivu & Lönngvist 2008, p. 161).

One of the most known measuring system Balance Scorecard usage was studied in. Among both the companies that utilized Balance Score Card and those who do not, the clear majority claimed that the portion of the non-economic metrics has been growing (Lönnqvist 2002, p. 84). But in the same research it seemed to be that all of the metrics are not used as efficiently as the leaders would want (Lönnqvist 2002. p. 92). However the usage of the metrics has changed to support more personnel guidance and strategic decision making than it have used to. Also the metrics are open to more openly and widely in the organization than before. (Lönnqvist 2002, p. 119.) There should be taken into account though that personnel seem to feel that measuring is a tool for controlling them (Lönnqvist 2002, p. 133). This should be recognized early in the implementation process and let also the personnel take part into to planning and implementing measurement system. One of the key elements for measurement system to be efficient in supporting communication between the managers and personnel is that the managers

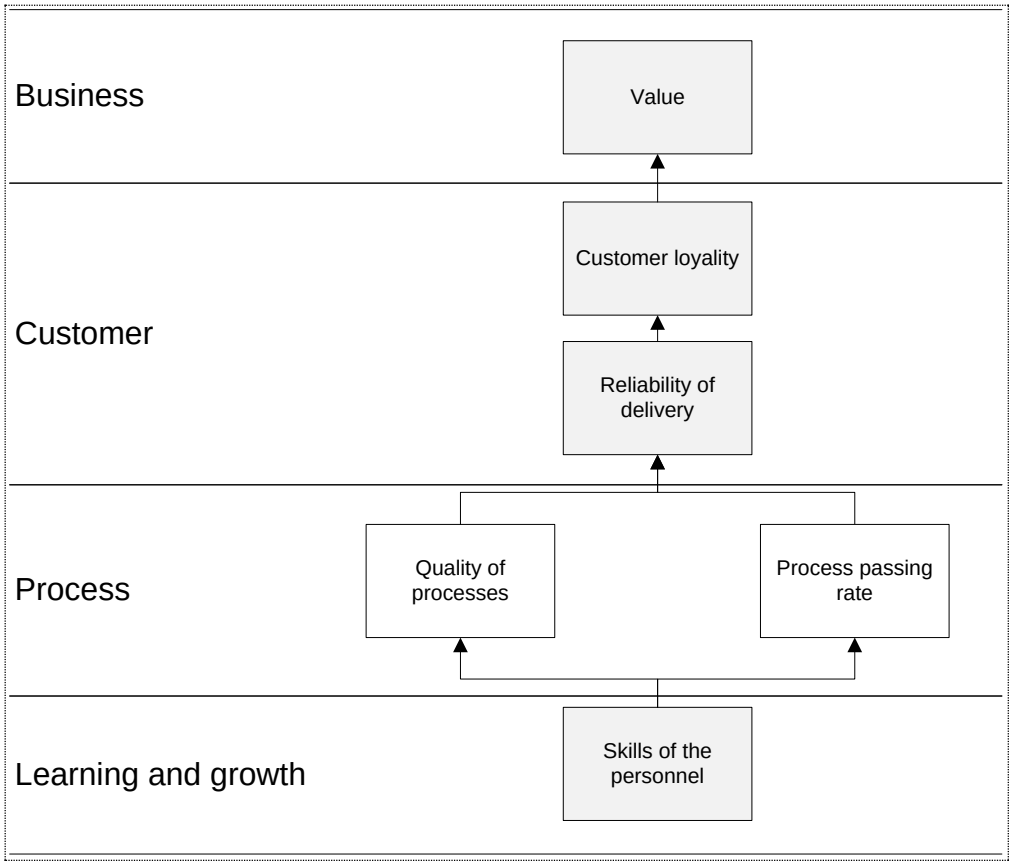
have been bonus system as in BSC but there is a risk to transform the measurement system into controlling able get the personnel assured of the importance of the system. The metrics can be tie to system. (Malmi et al., 2006, p. 99.) Interaction between the teams that not usually interact can be provided via common business intelligence or measuring system (Knight et al. 2010, p. 3). There are need for both managers and leaders, but the emphasis might be on the latter as there must be a vision formulated and then generated throughout the organization. This usually is demanding to those involved. (Tranfield & Smith 1990, p. 48.)

2.2. Environment for Measuring

Decisions support is based on learning and knowledge creation – better you are able to adopt new information and transform it into knowledge the better decisions you are able to make. There are a lot of causalities in an enterprise to begin to understand, one example of this can be seen in the Picture 3. Structured environment makes it easier to learn causalities within business. Structured environment is also easier to follow with metrics although there are already methods to follow also unstructured data (for example e-mail and memo contents) (Inmon et. al 2005, p. 45). It is also important to understand how organization learns to get insight how it can be developed and how it is going to evolve. The better decision makers whether on the management team or laborers how and why things work as they do the better they can drive their efforts to right things.

A company needs to organize itself in a way that its operations can continue. One way to do that is to view organizations within the company as business processes (Kujansivu & Lönnqvist 2008, p. 162). When operations are divided into processes they might be understood, managed and monitored more closely than without this kind of structure. Naturally once created processes need to be also developed as not only the business environment but also the company and its products are continuously changing. There are various ways to define a process. A process can be defined as a chain of action that has focus on the outcomes, the most important of all, to the customer satisfaction (Kohlbacher 2009, p. 399). A business process is a collection of tasks, "which consists of activities to design and produce a product or service" (Sandhu & Gunasekaran 2004, p. 677).There should also be noted that the process size can vary and a big process like "handling the customer feedback" usually contains several sub processes (Sandhu & Gunasekaran 2004, p. 676). The main function of process is to imply how work is done in the organization rather than what is done (Davenport 1994 according to Sandhu & Gunasekaran 2004, p. 677). Like process also project can be defined in various ways but in this case can be defined in the same way as Sandhu & Gunasekaran (2004, p. 673) have defined it: "a group of inter-linked activities with a starting and finishing point, in which human, financial, and material resources are organized in such a way as to

undertake a unique scope of work, of given specification, within constraints of cost and time, and requiring a central intelligence to direct it". In other words a project is a unique work that needs to be planned from the beginning as available resources vary.



Picture 3. *Example of the causal chain (Malmi et al. 2006, p. 70).*

There are several methods to follow to improve the company policies or actions. One of which is the process management or Business Process Management (BPM). BPM is defining, implementing, and institutionalizing processes to achieve effective, repeatable and long-lasting organization (Kasse 2004, p. 253). Also discovery, design, deployment and execution of business processes are components of Business Process Management as well as interaction, control analysis and optimization of the processes. BPM refers to the current management of the process-oriented organization. It should not be confused with Business Process Re-engineering (BPR) that refers to the radical redesign of business processes.(Kohlbacher 2009, p. 399.) Managers have recognized BPM as a beneficial tool that have helped obtain improvements in customer service, increased productivity, better the quality and so on. The business processes can be developed by trying to remove all the features that do not add value to the process and make the process therefore more efficient (Kujansivu et al. 2007, p. 148). Identifying, analyzing and implementing existing and new ways to create value to customer is the way to

distinguish oneself in process development. Although the development might be costly and the results might not be seen immediately. There might not be any organization to monitor long-term development. (Sandhu & Gunasekaran 2004, p. 676). Process Development is an important part of Business Process Management. The main difference between a traditional organization and a process enterprise is that in the processes need to have a process owner. The process owner has an end-to-end responsibility of the process and therefore also he or she is responsible for the process development. (Kohlbacher 2009, p. 399.)

BPM as a system requires maintenance resources and strong support from the management (Kohlbacher 2009, p. 399; Kasse 2004, p. 253). Business process view also needs some cultural background to be effective. (Arminstead & Machin 1997, p. 891). It is also strongly related with people as employees might consider their own interest higher than creating value for the customer. That leads to a challenge of encourage personnel to reach for the same goals. (Sandhu & Gunasekaran 2004, p. 676). Process improvement cost resources and therefore it is worthwhile to design them to be repeatable, effective and long-standing in the first place (Kasse 2004, p. 254). In Business Process development there is reasonable pilot the planned process before it is widely taken into use in the organization. Based on the experience gained from the piloting project of phase the process can be improved and issues solved. (Lecklin 1999, pp. 210 - 211; Martinsuo et al. 2010, p. 14). This means that if there are decisions made to imporve the process based on the information gained from the metrics, there is some cases wise to try it on the small scale before implementing the change to the whole organization. Flowcharts as a tool might not help to gain understanding about the big picture how the processes are linked together (Arminstead & Machin 1997, p. 889) and therefore can be used when estimating the effects of the changes too. Big changes are challenging to manage so the improvements are rather small if they take place in short time. (Arminstead & Machin 1997, p. 892).

It can be expensive to develop appropriate business processes and there traditionally is not a permanent organization to monitor the long-term effects of the development (Sandhu & Gunasekaran 2004, p. 676). When effective measuring system is combined with BPM there are great possibilities to develop the processes and functioning of the organization. When organization has access to the measuring information it is capable of determining whether processes are working and consistent, identifying the parts of the process to be improved and the best practices thus there must be kept in mind that characteristics of variation must be understood when using the metrics (Kasse 2004, p. 233, 235.)

It would be a lot easier to make good decisions if one could see the future. Metrics cannot predict future but there are means to that help in gaining foresight, if metrics indicate that it might be reasonable to improve or change the strategy. For example

Bensoussan and Fleiser (2008) represent in their book ten such tools that are BCG Growth/Share Portfolio Matrix, Competitor Analysis, Financial Ratio and Statement Analysis, Five Forces Industry Analysis, Issue Analysis, Political Risk Analysis, Scenario Analysis, Macroenvironmental (STEEP/PEST) Analysis, SWOT Analysis and Value Chain Analysis. One this kind of tool is also the roadmap. There might be a need for these analysis tools to challenge current way of thinking. The tool chosen is matter of purpose for example roadmapping is mainly a tool for collaborative strategic planning (Kamtsiou et al. 2006, p. 164).

To understand the most challenging managerial issues requires seeing the whole system that generates the issues (Senge 2006, p. 66). Companies appear to be expanding continuously and they have international functions, which force them to develop policies to maintain their organization working efficiently and the business profitable. At the same time these policies need to be adjusted to meet the real life situations. It would be advantageous to describe and gain understanding over organizations behavior and causal relationships. Almost every company seems to strive to attain better quality products or services and more efficient working environment in the company.

A causal chain begins from the objective that is tried to achieve. From that objective man can try to think what the affecting action is behind it. After identified one ore many the next step is to perceive what are the actions behind that one and this continues as long as it goes or seems reasonable. An example of the causal chain can be found for example presented by Malmi, Peltola and Toivonen (2006, p. 70) in the Picture 3. In practice these causals might be difficult to find and challenge the managerial insight as there might easily build up several causal chains that cannot be put in the importance order. Other problem might be that if the objects can be achieved rather short time the metrics might get old in a way that there comes more relevant metrics to follow. If there are many these kind of situations the measurement system is constantly changing and trends might be difficult to identify. This phenomena might make the maintenance of the measurement system rather labourious. (Malmi et al. 2006, p. 236 – 237.)

There are various challenges in system thinking. One of the greatest is the fact that cause and effect are not always closely related in time and space. (Senge 2006, p. 63). “Tackling a difficult problem is often a matter of seeing where the high leverage lies, a change which – with minimum of effort – would lead to lasting, significant improvement.” (Senge 2006, p. 64.) System thinking is a sensibility to recognize eclectic relationships among system that gives it its character (Senge 2006, p. 69.) Oversimplifying the complex problems is dangerous and can mislead an organization into making bad decisions. One of the key cautions is a tendency to generalize situations. Generalization occurs when an individual explain larger phenomena or population based on one’s own experience. Recognizing inevitable gaps and blind spots is crucial. (Bensoussan & Fleisher 2008, p. 22.)

If a human has some health problems there is no point in only treating the symptoms if the disease causing them leaves unnoticed. As the work in the process led organizations is viewed in a little piece at the time it might be difficult to spot the original cause for problems. To be able to understand critical problems, the underlying structures have to be looked into. Structure can be understood here as systemic structure, that "is concerned with the key interrelationships that influence behavior over time". Usually there is no visible structure rather than feelings how to act. However, the structures can create patterns of behavior and therefore there is a need to understand it. (Senge 2006, pp. 42–45.) Effective organization is able to challenge itself in a way that in can continue to develop and create new knowledge of itself and its environment.

Knowledge creation is worth noticing because innovations or extensions to organizations or teams capabilities. New knowledge creates potential but it also demands decision-making alongside, because only by making decisions this potential can utilized. On the other hand new innovations tend to create also new uncertainties. (Choo 2002.) Knowledge creation is therefore beneficial but requires some familiarization before all of the benefits can be fully utilized. Leading the knowledge and skills of the personnel requires information about the current and future capabilities of the personnel. (Kankkunen et al. 2007, p. 113.) From the learning point of view the main question for organization is that can it produce value to its owners and customers and to develop (Tuomi et al. 2006, p. 28). The value created by learning is important asset in today's business environment and therefore there is a need to measure it.

Knowledge can be seen as a part of the capabilities of the employee and therefore a part of the organization. The knowledge can be divided into tacit and explicit knowledge. The explicit knowledge is written knowledge for example the team guidelines in intranet or the contact information. The explicit information is rather easy to transfer and share via emails, intranets and memorandums. The tacit knowledge is the knowledge than is not written and is possessed by individuals. The tacit knowledge is more challenging to share than explicit knowledge because of it nature. It is experiences, knowledge and skills that people have. It is a really important to the organization but the managing tacit knowledge can be challenging. (Kankkunen et al. 2006, pp. 126 – 128.) Choo (1996, p. 334) point out that: "knowledge creation is achieved through a recognition of the synergistic relationship between tacit and explicit knowledge in the organization, and through the design of social processes that create new knowledge by converting tacit knowledge into explicit knowledge".

Information can be divided into two types. There is the kind of information that is written and stored in information systems and the kind of information that is hold only by individuals. (McLure Wasko & Faraj 2000, p. 156.) The information or knowledge that is hold only by individuals is called tacit-knowledge and the type of knowledge

recorded somewhere is called explicit knowledge (Nonaka et al 2000, p. 7). Choo (2002) also suggests rules and routines to be third form of knowledge. In that way also circumstance matters. In the matter of a measuring system it is impossible to gather data that is not explicit to reports. Whenever the needed data is not explicit, the processes to collect the data have to be observed and possibly redefined.

Knowledge creation can be described as a process. The knowledge creation process is spiral process and needs shared context to knowledge creation, and inputs and outputs (Nonaka, Toyama & Konno 2000, p. 5). The knowledge creation process is called SECI as Socialization, Externalization, Combination and Internalization. In socialization the tacit knowledge is shared and new tacit knowledge is created. Socialization may happen through informal meeting or some other social events where tacit knowledge such as mental models and world views can be shared. Externalization means putting tacit knowledge into explicit form and therefore will be more easily shared and has a structure. In combination the explicit knowledge is combined together and new knowledge is formed. (Nonaka et al. 2000, p. 9.) This phase might be the most crucial in using measuring system as a help to in externalization as it usually requires connecting the datasources to support decision making. Internalization is where explicit knowledge is transformed again into tacit form as it is absorbed by a user (Nonaka et al. 2000, p. 10). In measuring this usually means also analysis making. The tacit knowledge can be transformed then again into explicit knowledge by writing down the results of the analysis conducted.

As the tacit knowledge has a great role in knowledge creation its characteristics should be mentioned. In sharing the tacit knowledge the perception and language has a great role. The tacit knowledge that is held by the people who has a real high stage of an experience it might be challenging to communicate it as it might not be in verbal form. The other point is that the novices in the field might not share the same language as highly experienced people. Sharing tacit knowledge is also time consuming compared to sharing explicit knowledge. Usually sharing tacit knowledge requires face-to-face meetings and the personnel with high level of tacit knowledge might find it hard to find time to share their knowledge. The last challenge is notice the value of knowledge. Tacit knowledge is hard to measure and requires indirect metrics so therefore it is rarely acknowledged in organizations (Haldin-Herrgard 2000, pp. 361 – 363.)

Choo (1996, p. 329) claimed already in 1996 that: “An organization uses information strategically in three areas: to make sense of change in its environment; to create new knowledge for innovation; and to make decisions about courses of action”. He continues that: “Through sensemaking, people in an organization give meaning to the events and actions of the organization. Through knowledge creation, the insights of individuals are converted into knowledge that can be used to design new products or improve performance. Finally, in decision making, understanding and

knowledge are focused on the selection of and commitment to an appropriate course of action". These three usages are linked together. Therefore it is important to gather and utilize the information that lies in the organization and turn it into knowledge.

The CMMI, which is followed in the case organization, is partly based on Peter Senge's idea of the learning organization and system thinking. Senge (2006, p. 69) finds system thinking as a fifth discipline that gives to decision-makers a language with which to talk about the non-linear dependencies and see problems differently. The essence of system thinking is to see interrelationships instead of only cause-effect links and seeing whole change process instead of only a snapshot of the current situation (Senge 2006, p. 73).

In system thinking the linear way of thinking causal relations is replaced with the idea that things are linked together as a system. The small change can have wide consequences but the greatest areas of leverage are often the least expected (Senge 1990, p. 63). "The essence of the discipline of system thinking lies in a shift of mind: seeing interrelationships rather than linear cause-effect chains and seeing processes of change rather than snapshots" (Senge 2006, p. 73). The key idea is to strive to see whole circle of cause and effect. The cause-effect line is never linear to only one direction. (Senge 2006, p. 75.) Mental models might block the view of the situation on hand but it might be really challenging for a person to question them. There should be some tools to help identify the mental models and raise personal awareness. (Senge 2006, p. 170–171).

Strong beliefs can hinder the decision making ability. "Individuals with strong beliefs about the relationships between the variable tend to make decisions on the basis of these beliefs even when presented analytical evidence that contradicts them. Additionally these individual often seek and use data only when it confirms their beliefs while ignoring data that contradicts them. (Bensoussan & Fleisher 2008, p. 22.) Strong believes can also be called mental models. "To achieve and sustain competitive advantage companies in turbulent environments need to scan the business environment to capture weak signals of early opportunities", (Ilmola & Kuusi 2006, p. 909). A weak signal is rather hard to recognize at present, but what is a strong trend in the future and they can only be captured by challenging one's mental models. Mental models are the cognitive knowledge structures that are used in sensemaking process. They have strong impact on how the information is processed. (Ilmola & Kuusi 2006, p. 909.) Those making decisions must acknowledge that they might do decisions based on their beliefs and paradigm in other words based on their mental models when it should be time to see the change. To do this the analysis tools and innovation tools might be needed and appropriate information is obligatory. Mental models are essential and they are always there as a basis what a person thinks is a good or bad decision as long as it is kept in mind that they can also block from seeing obvious gaps and hinders (Vitt et al. 2002, p. 19).

It is far too easy to try to find who is guilty. The system that consists of processes and people should be analyzed and developed instead of finding who has not succeeded. System thinking is needed to manage the process development and system thinking requires good skills and adequate tools. Although all models are simplifications (Senge 2006 p. 167) the common language and right mindset with the simplified model can solve critical problems. In having a learning organization the communication is one of the key factors. Communication should aim at advocacy and inquiry. Communication should leave space for personal insight. The situation where someone simply says how thing are might not be as efficient as a situation where there are space to state your own opinion. (Senge 2006, p. 186–187.) It leaves possibilities to have a desirable conversation and room for questions.

Senge (2006 p. xiii) defines the working teams to be the fundamental learning units. He describes the core learning capabilities of teams to be the seating part of a three legged stool, where the system thinking, reflective conversation and genuine aspiration are the three legs. A learning organization needs all of them to be able to function. Correcting and finding errors is called organizational learning. It can be one-loop learning where founded defects are simply corrected without questioning why they occurred. When asking the question why it happened the organization has a possibility to develop its underlying policies and objectives – that is called double loop learning. (Argyris 1977, p. 116.) Although it sounds rather simple it requires time and effort form an individual or a team to internalize and take into practice.

The environment and the culture are important in knowledge creation and learning (Choo 2002). The structures in the organization must favor for new knowledge creation. In this case the processes must be developed in the way that leaves room for new knowledge creation. The dashboard could be used as a tool when communicating both tacit and explicit knowledge. The interpretation and conversation over the figures in the dashboard provide a good environment to share tacit knowledge and be supported with the explicit knowledge. Knowledge can be also considered as a public good that is owned by the community. If this is the common opinion in the community, knowledge exchange is motivated by moral obligation and community interest. (McLure Wasko & Faraj 2000, p. 155.) In learning and knowledge creation the culture has great impact on success. Very skilled people might not be the most skilled in learning new things. Instead they might protect the current situation and knowledge. It is not desirable behavior as all companies including the case organization struggle to develop their processes and businesses to maintain their competitiveness. Senge (2006, p. 177) states that: “Generative learning, in my experience, requires people at all levels who can surface and challenge their mental models before external circumstances compel them to do so”. The importance of intuition should not go unnoticed. There are numerous studies conducted recently that have proved that experienced managers and leader rely

their intuition quite heavily (Senge 2006, p. 157). Successful interpretation needs both rationality and intuition.

2.3. Implementing a Measurement System

A measuring system only offers value and benefits when used. The deployment phase as the deployment phase of the technical implementation of the measuring system is critical in this matter. Here the deployment is considered to be the phase in the building a measurement or reporting system where the personnel or users can start using it. The deployment phase determines how well the goals set to the measuring system will be fulfilled in the end. The main task for deployment phase is to engage the users into using them. To succeed in this there must be enough communication, enough training and possibility to practice. (Malmi, Peltola & Toivanen 2006, p. 120 - 122).

Building a measuring system requires resources. Besides knowledge and money there must be enough time to build up the system. Based on its experience Xerox has made a suggestion that proper time needed in a measuring project is one year per organizational level. Nevertheless, it is possible to implement a measuring system in shorter time period, if and only if the managing level gives it full support to the project and has a clear vision about the objectives of the measuring project. (Kankkunen et al. 2005, p. 24.) It should also be kept in mind that measuring is not always the best possible tool in leading, as there might be subjects that are better led based on other kind of information (Kankkunen et al. 2007, p. 173).

In BSC literature there are few models presented, how to deploy a measuring system. They are usually for quite comprehensive and vast measuring systems but same step must be taken in the smaller measurement building project also. Malmi, Peltola and Toivanen (2006, p. 88 – 102) present three models with which to BSC can be built to the company. Maybe most well-known of them is Kaplan and Norton's model, where the main focus is to build strategic measuring system. The main steps in that are to

1. define the measuring architecture
2. building a common understanding based on strategic objectives
3. choosing the metrics and planning them
4. planning the deployment of the measuring system.

Malmi, Peltoja and Toivanen also present Olve's, Roy's and Wetter's model a model that chances the focus on the different viewpoints. They also present a model that is derived from these two but also it has been modified based on their study. They call it Jouko Toivanen's model. It consists of 10 phases and can be seen in Table 1. These models try to describe the whole process of deploying the measuring system and

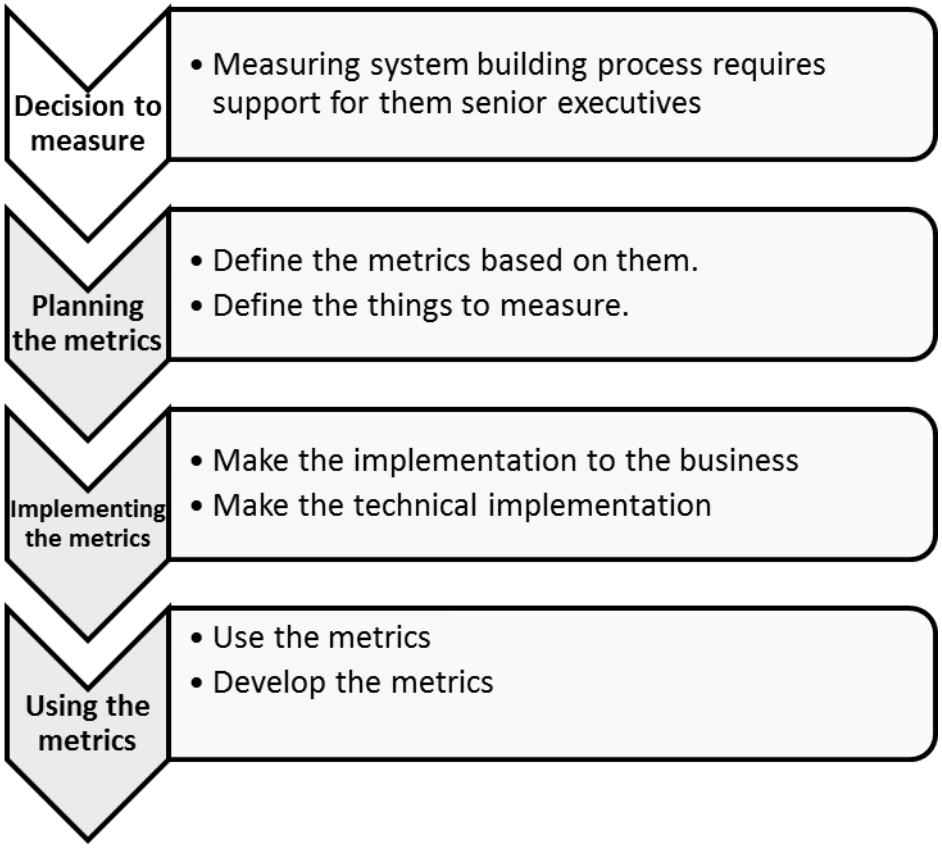
therefore the technical implementation phase is somewhat vaguely described although these steps and points should be kept in mind also during the technical implementation.

1. Decision	Clear decision that project is about start., resources for it, and risk analysis
2. Executive commitment	It is essential that the high level management is supporting the project
3. Clarify strategy and vision	Simple vision and clear strategy that are easy to communicate and common agreement what they are.
4. Perceive the critical success factors of the company	Stakeholder analysis, that can be done for example with the SWOT analysis
5. Set the objectives and define the metrics	Choosing the view points, objectives and perceive the causal-chains
6. Commitment	Open communication and taking personnel as a part of the process.
7. Checking the metrics again	There should not be too much metrics to follow.
8. Fitting the metrics to different parts of the organization	When metrics are derived to lower levels in organization the link to the strategy must be preserved.
9. Making an action plan how to achieve the set objectives	How the metrics are used in everyday work
10. Continuous development of the measurement system	Based on using experience gained using the metrics there should be improvements and learning based on that.

Table 1. *BSC project model (*adapted from *Malmi et al. 2006. p. 102).*

First thing towards a measuring system is to make a management decision to take one into action. It is critical for the measuring system and for the change management, that the whole process has support of the executive level of the company (Malmi, Peltola & Toivanen 2006, p. 99; Transfield & Smith 1990, p. 43). After the need is recognized the building process can begin. Building a measuring system in business environment

consists of three phases that are planning, implementation and using the systems and they can be seen in the Picture 4. (Kujansivu, Lönnqvist & Sillanpää 2007, p. 165). All of the phases are equally important. The planning phase consists of two main tasks: to define the matters to measure and then to define the actual metrics that reflects them. In the implementation phase the data for the metrics is gathered. The reporting system can vary based on how it is intended to be used. (Kujansivu, Lönnqvist & Sillanpää 2007, p. 165.) The technical solutions may vary from spreadsheet implementations to wide reporting system like IBM Cognos based solutions. The last phase is to use the built measuring system to make decisions. However advanced the reporting system is, it is pointless to build, if it is not taken into a part of daily decision making routine. The whole building process should also be iterative in the way that the selected metrics should be under constant evaluation and development. It might be challenging, but if some metric is no longer usable, it might be more harmful to keep gathering the data than leave the old metric out.



Picture 4. *The basic measuring building process (adapted from Kankkunen et al. 2007, p. 166).*

In CMMI the process of building the measuring system contains following steps: establish the measuring objectives, specify measures, specify data collection and storage procedures, specify analysis procedures, collect and analyze the measured data, store the measured data and analysis results (Kasse 2004, pp. 225 – 228). This process emphasizes on data analysis and storage, which is additional to the typical process.

When system is fully implemented and used for a while it can be evaluated. The questions that can be asked are for example: are the users happy with it, is it missing something relevant, is there something useless in it? If there are some issues noticed they should be fixed. The system itself should be checked regularly if it should be renewed in any way. Throughout the implementation process there should be time to question the metrics and data that is chosen to them. The metrics should be valid, reliable, usable, affordable, providing decision support, guiding the actions, cannot be manipulated and should be the best to measure in its area (Kujansivu et al. 2007, p. 172). Same as it is with the mechanical devices, the measuring system might be more harmful than beneficial, if it is not functioning properly. (Kujansivu et al. 2007, pp. 188 - 189.)

The operative personnel and employees whose actions are under measuring should be taken into the decision making and planning that will make them more committed to the system than it would be, if there would not be possibility to have an effect on it. (Kujansivu et al. 2007, p. 172.) There is an great impact to the system by the people who are defining it (Bourne et al. 2002 according to Kujansivu et al. 2007, p. 173). Also time schedule might be an issue. In BSC project the estimated time to technically implement the metrics is about four months but taking it as a part of the leading system takes at least 26 months (Malmi et al. according to Kaplan and Norton, 2006, p. 91).

Data, information, knowledge, intelligence, information system, knowledge creation and system thinking are essential concepts when planning a measuring system, analyzing the outcomes of metrics and distributing gained knowledge. These terms provide a vocabulary with which to form a model to understand the key contents of measuring system implementation. In this thesis the metrics dashboard is a main tool to create information, to support decision-making as well as to distribute information as it collects data and provides information to the project.

Information system is built from different information hierarchy levels that might be confusing if they are not properly explained. The terms like information and knowledge can be used in many different ways. The data, information, knowledge and intelligence can be used almost as synonyms but there are differences between them in this context. Awareness of these levels can help determine what kind of system is needed and how important or valuable it is. Thierauf (2001) have defined the relationship of these levels in a way that is illustrative.

Thierauf (2001) have described six levels of information: data, information, knowledge, intelligence, wisdom and truth. These levels are defined more detailed in the next chapter. Data, information and knowledge are the most important to understand considering this study. Intelligence is mainly considered from the perspective of business intelligence (BI).

The base for all other levels is data. Data is the simplest level. It is the unstructured facts and figures that do not provide any decision support to the management. Data is disconnected from its meaning and can be described as "data glut" that can be distracting and even confusing for the manager. The ability to rank data deteriorates in direct relationship to the amount of data. (Thierauf 2001, p. 7.) It is rare that management needs this "raw" data. It might be used to find some errors like misspellings but it provides no use in decision-making.

Term information can be little confusing. It might be used as a general term that stands for all the levels mentioned here. In this case information is still regarded as Thierauf (2001) has defined it. Information is structured data that already has some utility to the management. Information is data that has context and it can be aggregated and ranked. As there used to be "five M's" manpower, machines, money, material and management, but according to Thierauf (2001) among the others information has recently gained its place as a sixth resource. Information technology (IT) is have utilized in many ways and it has provided advantages to business life, but information that is used needs to be a good quality and right timed. (Thierauf 2001, p. 8.) The amount of information without rational IT can be overwhelming to the managers.

Knowledge is the next level in hierarchy. It is a combination of experience, individual learning and information. Knowledge is an ability to interpret the information, see the trends and patterns in it, and make decision based on gained knowledge. Therefore information turns into knowledge when an expert interprets it. (Thierauf 2001, p. 9.) A knowledge system is for example the system that collects the solutions made by professional in the way that other people can use them. Thierauf (2001, p. 9) sums up: "while information is data about the data, knowledge is basically information about the information". In Nonaka, Toyama and Konno's (2000, p. 7) theory of the knowledge-creating process they describe knowledge also as 'justified true belief' where emphasis is on "justified" rather than "truth".

The fourth level is intelligence. IT has developed promptly and has capacity to compute vast amounts of data, information and knowledge. It is possible to drill through the information system and find the "distilled essence of customers' and employees' personal experiences" and accompany that with the knowledge and information of the current competitive situation and combine them to intelligence. In other words it intelligence is an ability to combine the knowledge and information and find new

interrelationships of presented facts. (Thierauf 2001, pp. 9 – 10.) Intelligence is requires human knowledge and experience to be combined to form. Thierauf (2001, pp. 10 – 11) sums up: "Broad-based view of intelligence center on developing and examining appropriate interactions and interrelationships as they effect on company's customers and its own operations on a periodic basic, including a daily basis". Intelligence is not only problem solving it is also problem finding that requires good insight of how situation is going to evolve (Thierauf 2001, p. 11).

"Data becomes business intelligence when it is in the hand of decision makers who know what to do with it" (Thierauf 2001, p. 4) Understanding and defining data is therefore a key to success. Defining information and understanding the differences between written and tacit knowledge and differences between data, information, knowledge and intelligence makes it easier to understand and use them as a decision-support. When understanding the nature of information it also might be easier to distribute it. There are technical solutions to help with this task and save time. Intelligence and knowledge are strategic level resources to the company as the data and information are more tactical and operational level resources to the company (Thierauf 2001, p. 10).

The analysis itself might even be more challenging task to do than building the measuring system and collecting data for it. To make most of the measurement system the analysis tools can give support in making decisions with "three E's – efficiency, effectiveness, and efficacy", (Bensoussan & Fleisher 2008, p. 16). In making analysis there should be right analysis tool to the situation. The financial analyses are not always a right choice as the analysis should also give answers to how something can be fixed not just what is broken. In measuring system and in analysis it is important to recognize the difference between the data that is easily accessible and the data that is actually needed. (Bensoussan & Fleisher 2008, p. 16 – 17.) There is no point in measuring things just because it is possible as there is no point in analysis only because it can be analyzed. The analysis tool to use is dependent on the metrics used, the situation at hand and the organization involved.

3. THE IMPLEMENTATION OF BUSINESS INTELLIGENCE SYSTEM

3.1. Information System and Business Intelligence

Business intelligence is understood here as a way to collect, transform and interpret the knowledge from the functions of the organization and its environment. It means that the organization gathers the data and uses it to make decisions about the actions done to manage operations. (Vitt et al. 2002, pp. 13 – 16; Alexander 2008, p. 1.) Business intelligence is rather multifaceted concept than can be sum up to be concept that aims to convert data into information. Information then can be used to making better decisions faster and based on rational approach. (Vitt et al. 2002, p. 13.) The successful coexistence of strategic and tactical decision support requires business and technical solutions (Watson et al. 2006, p. 17). The need for BI-solution derives from the fact that data in the organizations is created in various information systems and data sources and it needs to be converted into easily accessible and analyzable form.

There have been three generations of Data Management in Decision Support. The first generation was Decision Support Systems (DSS) that emerged in the early 1970s. The data collected from operational system was customized for the DSS and therefore it was very application centric. The importance of data as cornerstone of DSS was recognized. The second generation is data warehouses in the late 1980s. The data is collected to the data warehouses that support variety of applications. The third generation, in the year 2000, was the real-time data warehousing. The use of data warehouses changed from only analyzing the past or anticipating the future events, to using the data in real-time decision-making. (Watson et al. 2006, p. 8.) All of the three generations are still used and needed. In this thesis the main focus not the data warehouse but the next step after the metrics implementation process might be to combine the collected pieces of data to the well-designed data warehouse.

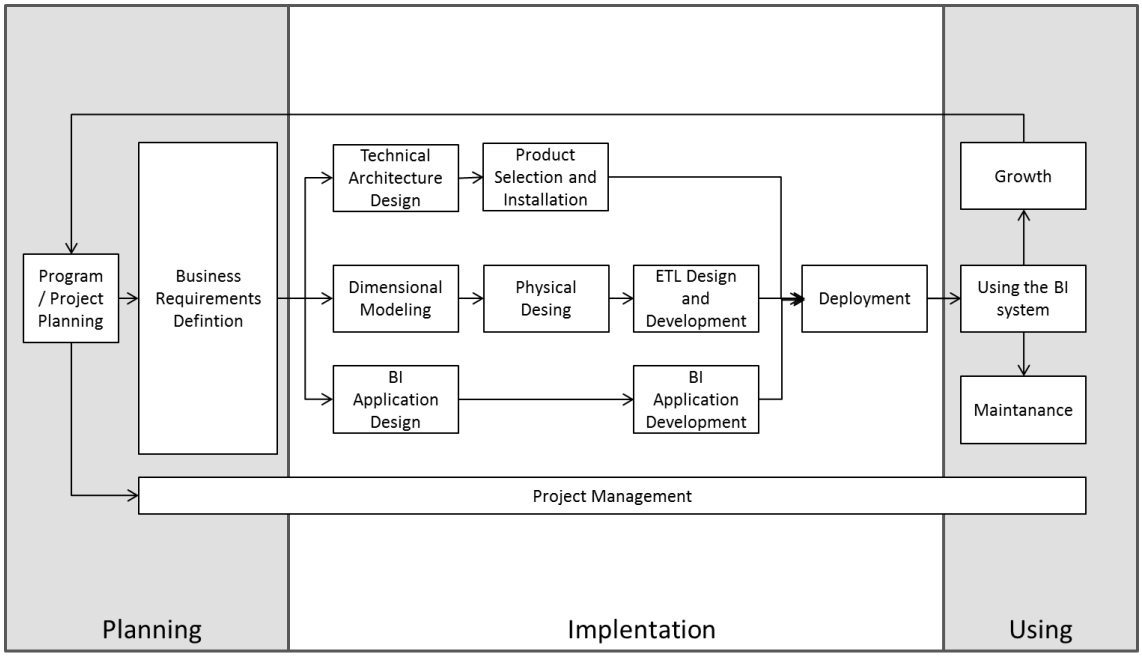
Vast amount of data and continuously faster frequency of business are putting a lot of pressure to decisions makers. Copying and fast following is easier than before which means that the ability to benefit from the data faster than others can be cutting edge to the competitors. In the BI scene this means that the data warehouses cannot be silos but rather accessed at the same time and preferably at the same time. There already are different types of BISs for different type of situations. There might be a greater advantage of business intelligence, if the information is available in real time. This can

be accomplished with real time data warehousing. (Watson et al. 2006, p. 7.) By moving to real-time BI, firms can utilize it affects in current decision making, which is positively important in customer-facing applications (Watson et al. 2006, p. 7). Customer voice must be heard especially in software development where a big part of the product is the user interface as it is in the case organization.

The justification for business intelligence system (BIS) is different than it is for the other information systems. For example the benefits of implementing a new efficient accounting system can be calculated in form of costs of saved time. The business intelligence system provides better understanding, intelligence, to make better decisions. These are complicated benefits to calculate in money. Although there might be some visible saving gained, no one seems to come up with adequate model or system to estimate the advantages. (Thierauf 2001, p. 160) The measuring system itself can help in following the benefits of business intelligence system.

3.2. Implementing a Business Intelligence System

In this thesis deployment of a measuring system is considered to consisting three phases planning, implementing and using the system after making the first decision to start measuring project. Process of building a BI system consist rather same phases. The phases are demonstrated in the Picture 5 where they are drawn into the Kimball Lifecycle diagram (Kimball et al. 2008, p. 3). Focus in this thesis is on the implementation phase of the business intelligence system deployment and there the emphasis is on the technical decisions. Choosing the metrics and reviewing the strategy is considered here as a planning phase and actual utilization of the BI-system to me a using phase. The “Using the BI system” box is also added to the Kimball Lifecycle diagram (2008, p. 3) in addition to three phases. It is maybe the most crucial point in the lifecycle, as emphasized several times. It’s importance can be also deduced for example from the books of Vitt et all (2002), Malmi et al. (2006) and Bensoussan and Fleisher (2008), where the authors have given plenty of corporate examples of the decision making based on metrics to encourage also the reader to do so. The usability of the measuring system however depends heavily on the planning and implementation phases. Here the latter is examined in detail.



Picture 5. The Kimball Lifecycle diagram modified (Kimball et al. 2008, p. 3).

There are two sides in the implementation process of the measuring system; the technical and the functional. (Malmi et al. 2002, p. 119, 122) as there is in the business intelligence system. In technical part there must be constructed a system that gather, process and report the information needed (Kankkunen et al. 2007, p. 174). Rather similarly a business intelligence system is a solution to gather data from various source systems and transform it into unified model where data is available for analysis, reporting and data mining (Knight et al. 2010, p. 4).The term business intelligence collects the methods and ways to improve fact-based decision making under the same umbrella. The challenge in all of those is to turn vast amounts of data into knowledge and intelligence. (Alexander 2008, p. 1.) A measuring system implemented in this thesis can be considered as a part of a more comprehensive business intelligence system than just operative metrics. The implemented metrics combined with financial metrics and for example competitor information would already give possibilities for managers to perform analyses also outside the team.

A BI system implementation is more similar to enterprise resource planning (ERP) system implementation than it is to conventional application-based IT project such as transactional systems. That is that implementing a BI systems is a complex undertaking that requires appropriate infrastructure and resources for a rather lengthy period rather than somewhat simple combination of software and hardware. (Fuchs 2006 according to Yeoh & Koronois 2010, p. 23.) It is a desirable situation that system implementation does not induce too much extra work to the personnel. If implementation or

maintenance of the system is too laborious at the first phase, the motivation to keep the implementation process ongoing might fall (Kakkunen et al. 2005, p. 24).

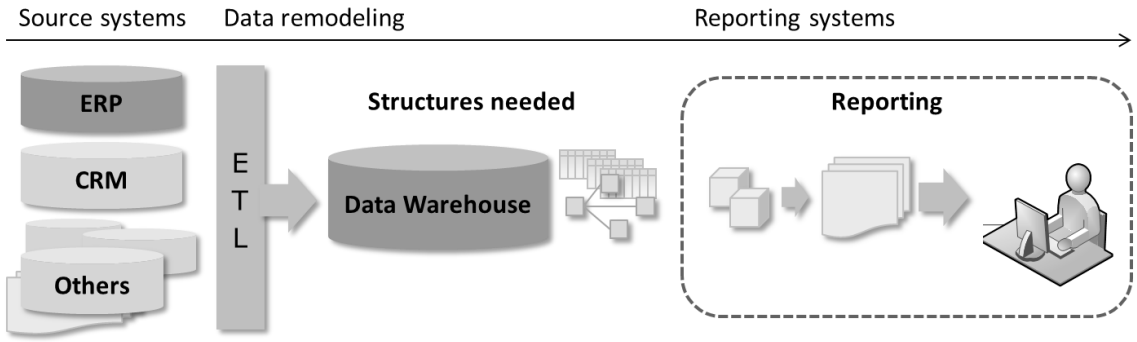
Critical success factors for BI implementation process lie on organization, processes, and technology segments. Organizational factors are related to vision, management support as process factors include team related, project management and change management related factors. Infrastructure and data are the factors on technology segment that are related to success. Next to all these is the business orientation and implementation success. Within implementation phase infrastructure and process performance effect on success of the BI critically. (Yeoh & Koronois 2010, p 25.) As the CSF are widely cross the organization the management support is crucial for a BI implementation. Management must be committed and sponsorship must be strong to secure necessary resources. It seems also that it is more beneficial for to project that the sponsorship is strong especially on the business side of the enterprise. This presumption is supported by a study by Watson et al. (2001). "The commitment and involvement of senior management is imperative, particularly in breaking down the barriers to change and the 'states of mind' within the organization", states Yeoh and Koronois (2010, p. 26.)

A BI implementation project cannot be left solely to IT team to handle as it requires solid business insight. The design must be maintainable and robust to be able to react to changing requirements. (Yeoh & Koronois 2010, p 27; Inmon et. al 2005, p. 47.) .Therefore the implementation team should consist of both IT and business personnel to be able to ensure that system will meet the business needs. Skills are well needed as typically there are lot of different platforms, interfaces and legacy systems to draw data from. "The most experts recommended that a BI team should identify and include business domain experts, especially for such activities as data standardization, requirement engineering, data quality analysis, and testing". To be able to gain management supports and sustain it, the BI system must be business driven and support business decision making. To be able to build a successful model for the business the BI team must have a participant or participants that understand the business and can predict the needs of focus group but at the same time understands the main architecture of the BI solution. Team should also involve key users that they understand and influence the architecture. (Yeoh & Koronois 2010, pp 26-27.)

The implementation phase usually is laborious (Kankkunen et al. 2007. p. 174) and may require knowledge that the organization does not usually need in their everyday work. The possible problems in this phase might be that personnel resists the change, the information systems are complicated, the top management loses interest, the metrics turn out to be ill designed and there might come projects that have higher priority (Bourne et al. 2003; Hacker & Brotherton 1998; Leinonen 2001; according to Kankkunen et al. 2007, pp. 174 – 175).

A technical implementation of the measuring system consists roughly said from three phases that are to gather the data required, process it in appropriate way and then distribute the processed information. (Kankkunen et al 2009. p. 174.) In a BI-system, according to Kimball (2008 p. 3), the implementation phase is divided into three processes. One includes Technical Architecture Design and Product Selection and Installation that is closely related to other process that contains how to model the data with three steps of Dimensional Modeling, Physical Design, ETL Design and Development. The third is about presenting and distributing the information formed with two steps BI Application Design and BI Application Development (Picture 5).

As in many other projects also in the business intelligence project or in a smaller reporting project the user requirements are the crucial part of the preparation. (Alexcander 2008, p. 12). The technical solution only represents the necessary data but the requirements define which of the data to present. There might be need to create new source systems, do some kind of ETL-process, build and datawarehouse of some kind and finally decide how to report the information. The technical solution of a business intelligence system usually follows structure described in the Picture 6.



Picture 6. *A technical solution of a business intelligence system.*

Technical architecture and BI solution needed often are related but not necessarily. There is numerous different BI-oriented information systems developed. Systems vary from complicated data mining and analyzing systems to simple data organizing tools. The choice of tool is depending on requirements and resources dearly. Main idea in all of them is separation of data, analysis and presentation although linked to each other (Alexander 2008, p. 24). In this thesis the BI tool chosen is Microsoft Excel although it is not developed for this purpose only. Main reasons to choose this tool are that the user are already familiar with it, it is quite effortless and quick to modify, it has multiple ways to connect to the source systems and it is inexpensive to use. These qualities make it convenient to use when the measuring process is new and the organization is taking

only the first step towards comprehensive measuring system. The technical architecture of the business intelligence system there should be technical architecture made as a blue print and for anticipating as many issues as possible in implementing the system (Kimbal et. al. 2008, p.110).

“A BI system must be able to accommodate scalability and flexibility requirements in line with dynamic business needs”, (Yeoh & Koronois 2010, p. 28). There might be worthwhile to take the system maintenance point of view into consideration as early stage of the implementation process as possible. Data, analysis and presentation must be separated because for the maintenance purposes these three must not be too depend on each other (Alexander 2008, p. 24). On the other words the presentation should be changeable without change in data model and on the other hand if the data source changes the appearance can be maintained the same. In CMMI there is a suggestion that at least in the middle sized and large organizations there should be formed a measurement team that maintain the measurement system and keeps the interest up towards it. There should be people from all or almost all organizational levels. They should help in gathering, storing, analyzing and calculating the data. They should be determining the appropriate way to analyze the data and coaching managers in using the data. They have to ensure that the measures also include the information how to interpret the data collected. (Kasse 2004, pp. 66 – 67.)

Gathering and Modeling Data

Especially when measuring intangible asset but also in general there is a challenge with the source data. There might be the situation that although the data could be transformed from various systems and then loaded to the reporting system there just might not be a source system to collect the data needed. (Kankkunen et al. 2007, p. 173.) When the source data must be collected and then maintained manually, it almost always becomes vulnerable for errors. The process to gather the data from the process might get as arduous as the process itself. This of course is a risk to the organization and should be noticed when the systems and processes are developed. It is nearly impossible to develop an efficiently and working dashboard at once. The dashboard created should be flexible and renewable as the organization and its measuring needs change. (Kankkunen et al. 2005, p. 23.) The system to handle the source data must be flexible in a way that it can adapt the changes in source systems. "We might be accustomed to thinking about data as a fixed value to be analyzed, but data is a moving target. - - Data comes from the real world where there are no absolutes!" (Fry 2008, p. 3)

The challenge is to use only the necessary and important data per view and not to include too much interesting but irrelevant data to the reports. One advice how to recognize irrelevant data from relevant is given from Alexander (2008, p. 13) that is to place the measurements to a question and then placing the questions into the draft

version of the report layout. The approach should be that first to decide what is that data wanted to gather and only after that how to gather it. If using all the data available the focus might get unclear. There must metadata of the data to keep track what collected data means. Metadata is the information that describes what is in the actual data. Data warehouse should not be the set in technology that cannot be easily changes (Kimbal et. al. 2008, p.45).

There are two basic types of data –structured and unstructured. Sturcuted data is data that comes repetitively in the same format and layout, usually through the issuance of transactions. Unstructural data exists in two basic forms textual and non-textual. Textual unstructured data occurs in many places. Non-textual unstructured data occurs as graphics and pictures. Unstructured data is not handled very well yet. Books and manuals are unstructured data in terms of information gathering as there is too little metadata to title the data into information (Yeoh & Koronois 2010, p 34). To be able to use such data it is mandatory that terminology is rationalized and normalized (Yeoh & Koronois 2010, p.38).

The data source must be accessible and frequently enough refreshed. The owners and maintainers of the data sources must be identified and checked the processes needed to gain access to the data source. It might be the case that data does not even exist. (Alexander 2008, p. 14.) Therefore after defining the user requirements the next major step is to define access to the data. Alexander (2008, p. 15) also points out that "Conventional wisdom says that the measures on your dashboard shouldn't be governed by the availability of data. Instead, you should let dashboard KPIs and measures govern the data sources in you organization".

The process of modeling data depends on the type of data analysis executed. For example in finding new knowledge through data mining, where purpose is to find unusual patterns in data, the process consists of four steps that are iterative. First formulating the query with which to find the relevant data form large data set, extracting the data to a tool to modify it, visualizing it and then analyzing the results and formulate a new query based on them. (Gray et al. 1996, p. 29 – 30.) "*A model that can be understood is a model than can be trusted*" (Thearing et al. 2002, p. 212).

OLTP that stands for online transaction processing is one of the source systems for business intelligence system. It serves the transactions made in the firm and produces data, but the data itself have to be processed to be used in decision making. There for example is not much of the use for the information what a customer did yesterday rather than how the whole shop managed last month. (Vitt et al. 2002, p. 33.). Analyzing transaction data is called online analytical processing (OLAP) and it core is to provide a data model that is easy to understand and can be seen through multiple filters or dimensions at they can also be called. Terms used in data modeling phase are

dimension, fields and filters. Dimension is a data category to organize business data. Fields are the filters are used to narrow down the data in the fields (Alexander 2008). . In OLAP the data is organized into a structure that people naturally use to do analysis (Vitt et al. 2002, pp. 35 - 36.) This forms a sort of cube of data where information can be either partitioned or aggregated quickly. OLAP is rather simple and nowadays the data can be processed even in real time through rather complicated analyzing algorithms as the memory capacity has increased tremendously. Real-time BI blurs the line between decision support and operational systems (Watson et al. 2006, p. 17). There might not be a need to make them two separate solutions as they might have great leverage from each other.

One of the most important tools in implementing an enterprise wide BI system is a data warehouse that is subject oriented, integrated, time-variant and non-volatile collection of data from varied source systems (Inmon 2005 according to Yeoh & Koronois 2010, p. 23). Implementation of a BI system often encounters problems with underlying original source systems and processes that are not adapted for BI applications. These result commonly that data quality is poor and maintenance process tends to be ill-defined. (Fuchs according to Yeoh & Koronois 2010, p. 23.) Datawarehousing can mean different things in different organizations. It is a single, complete and consistent storage of data that is gathered from various source systems. It is supposed to give unified picture of the company's data. Datawarehouse consists of the extracting the data from source, database that maintains the data and a system that provide data to the users. Its main function is to support decision making and operational system. The actions done to source data before datawarehousing might contain among others these: denormalization, summarization and aggregation, validation, integration-

3.3. Reporting and Visualization

Main purpose to collect data in a form of dashboard or report is to be able to draw some sort of analysis of them and make a good decision. Analyzing must be done properly as that is beneficial to the enterprise or organization (Bensoussan & Fleisher 2008, p. 6) and therefore the data and information on the reports must be designed with care (Fry 2008, p. 2). The main purpose for a BI system is to present that vast amount of data in a perceivable form; hence it is exceedingly important to present only the most important parts of it in a rational way. Therefore rule number one in designing reports and dashboards is to keep them simple (Alexander 2008, p. 10). Visualizing data models is done to make understanding possible in a way that can be trusted (Thearling et al. 2002, p. 211). A subway map can be used as an example of a data presentation and its purpose. They abstract the shape of the city to a simple understandable form from very complex geographical map. They answer to the question how a passenger can get from one place to another, but cannot be used to cycle through city. (Fry 2008, p. 3.) Neither

does the map tell to passenger where to go rather how. The more specific is the question why data is collected the more clearly it can be presented (Fry 2008, p. 4). Data visualization is therefore as important as data gathering or capturing, data storages and the actual analysis and knowledge creation. "There is consensus that the next breakthrough will come from integrated solutions that allow end-user to explore their data using graphical metaphors". (Fayyad et al. 2002, p. v.)

A report can be defined as a set of information presented in a format that is meant for reading and viewing but it will not lead the decision making. It only provides and presents the information for the judgment but is not suggesting how to react, although it may contain aggregation, drilling or charts. (Alexander 2008, p. 10.) Drilling is a feature in a table that allows viewer to choose the level of information by navigating for aggregated level of information to detailed level of information and other way around. *A dashboard* is a kind of summary report for some particular business process or objective. They are typically graphical, present only data that is relevant for the purpose and therefore contain some conclusions or targets to help user to see at one sight the situation or progress of that aim. (Alexander 2008, p. 11.) For example if there is many metrics to follow it is convenient to make them "traffic light" –style and therefore illustrative and easy to follow. (Kankkunen et al. 2005, p. 22).

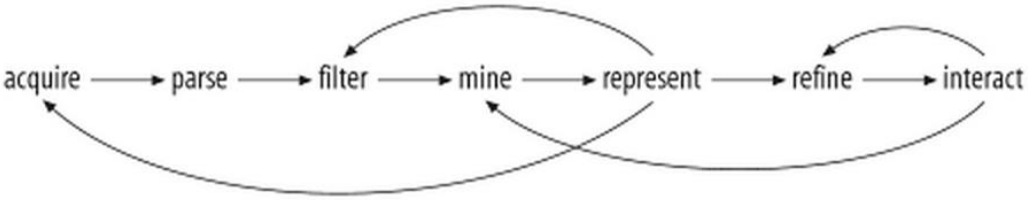
"Each set of data has particular display needs, and purpose you are using the data set has just as much an effect on those needs as the data itself", states Ben Fry (2008, p. 2). Data can be presented in various ways depending where it is gathered for example in datamingin the results are in cluster trees or circles and in competitive intelligence the results might be the newsfeed or summary of news. Nevertheless the reports and dashboards are probably the most common way to represent business intelligence.

When implementing reporting system there are these principles to take into account. Already mentioned that more simple the appearance of the reports or dashboards the better. Only the information necessary should be presented and not to turn the reports into repository of data that you might need or present data only because it is available. The formatting and size should be kept low. The layout is affecting to what information the viewer is noticing. Particular attention is paid on the upper-left of the document as seen in the picture. The number and title formatting must be paid attention and there must always be a timestamp in the document to unambiguously tell the period of time that document is representing. (Alexander 2008, p. 19.) This is a lot to do with curiosity and communication. A good vizualisation begins with good questions rather than only mathematically oriented thinking. Good visualization is to provide a clear answer to the question asked without any redundant details. (Fry 2008, p. 4.)

Data visualizing process can be divided into seven steps according to Fry (2008). The steps are acquire, parse, filter, mine, represent, refine and interact. The steps are

iterative in nature that is illustrated in the Picture 7. The connections between the steps indicate that it is important to have a team or a person how has a view through whole process. There might be a temptation to divide the process to different teams. If that is the case the communication between the project phases might be challenging. (Fry 2008, p. 5, 15.) There are three other principles that Fry (2008, pp. 15 – 16) points out; each project has its own unique requirements that are driven from the data needed; avoid using too much data – use as little as possible; know your audience.

When the question need to be answered is clear the data can be collected. Process can be simple read function or a complex collection from various data sources. When data is acquired it must be organized in a way that it forms information in other words the data must be parsed. When data is in a form of information it must be filtered that is removing all the irrelevant or redundant data. Mining means here the operations data needs for example some calculations or aggregations. Representing is only one step out of seven. There the actual layout of the visualization is decided based on the data needed. The layout will be refined to emphasize particular data and to improve readability. Interact phase means the choosing the visibility rules and letting user control. (Fry 2008, pp. 5 – 17.)



Picture 7. An example of how data visualizing process phases can affect and interact with each other according to Fry (2008, p. 15).

Also report or dashboard layout itself can be used to emphasize certain data. "Various studies have shown that readers have a natural tendency to focus on particular regions of a document. For example, researcher at the Poynter Institute's Eyetracker III project have found that readers view various region on a screen in a certain order, paying particular attention to specific regions on the screen" , states Alexander (2008, p. 19). An illustration of attention paid to a document can be seen in Table 2. There number on is representing an area that viewer is going to pay most attention and number three the least. In dashboard layout it is a best practice to limit it to one printable or viewable page so that all the data is viewable at the same time. Viewer tend to believe that areas that can be accessed only by scrolling are less important. (Alexander 2008, p. 18.)

1	1	2	3
1	1	2	2
2	2	2	3
3	3	3	3

Table 2. A demonstration of how attention is paid on a document according to Alexander (2008, p. 19).

Formatting should be kept to a minimum. In designing representation the colors must also be taken into account. Colors should be used to emphasize the key data point. Background colors only distracts viewer. Same principle applies to borders. There should be enough natural white space between the charts so that borders are not needed. If they are necessary they should be lighter than the lines indicating data. Although many reporting programs offer a lot of different effects these should be avoided as they again are more of a distraction than help. (Alexander 2008 p. 18.) Numbers on reports must represent logically; the number of decimals must on the right level and the monetary values must be clearly separated from other numbers. Numbers should be presented in a same way throughout the reports for example thousand separator must by same in all of the reports. Some kind of visual guideline might be good to develop and then follow. Rather than adding effects on reports the effort might sensible to focus on distribution and how and who is going to use the information gathered and presented.

It is a desirable situation at this point of the metrics implementation that metrics do not induce too much extra work to the personnel. If implementation or maintenance of the dashboard is too laborious at the first phase the motivation to keep the implementation process ongoing might fall (Kakkunen et al. 2005, p. 24). Therefore there is an intention to plan the use of dashboard to merge into the practices that personnel already has and to support decision-making that way.

4. RESEARCH METHODS AND MATERIAL

4.1. The Research Process

The research process in this thesis begins with literature review over academic literature about measuring, business intelligence systems, gathering data and reporting. Based on that review the empirical implementation project is conducted in the business environment. The empirical part consisted of gathering the expectations of participants and data for the metrics. The information is gathered through interviews that are conducted in the beginning of the implementation process and after it. The interviews after implementation are combined with the training of the participant.

Next phase of the research is to gather the information and form an analysis of the metrics and some recommendations how to use them in practice based on empirical study and the literature review. Although the research process is divided into two logical parts the work is iterative in nature. Based on this knowledge creating process the theoretical framework is developed to technical implementation of reporting in a business intelligence system.

After this research the main objectives of this study can be answered. These are how chosen metrics can be used in the case organization and what should be taken into consideration when building reporting system. Also there is answer how to implement a metric system report and what kind of role does data has in this process.

The information for the metrics was found in information systems, source systems and partly straight from the processes. The change management system (CMS) is the most needed source system for these metrics. From the metrics point of view the intranet of the company, among the interviews were the most important information and knowledge sources.

There were planned to be five interviews that were supposed to serve also as a briefing about the metrics implementation. The main reason the interviews were conducted was to gain idea of the attitudes and anticipations towards the metrics (Notes 2010, 16.6.). The interviews were conducted as a group interviews that were quite close together.

The interviews were conducted to inform the managers and the engineers about the metrics implementation and SDIP. The interview presented the nine metrics chosen to be implemented quite specific level to the people who will use them. One goal also was

to gain general idea of the current metrics and what kind of metrics interviewees would like to have.

Interviews were conducted early to give the participants of the metrics implementation time to get accustomed to the idea of the dashboard. It also seemed that the participants would be more interested about the implementation if they felt they were informed enough. The participants could and did provide considerable help and support during the data collecting. In the conversations and in the interviews conducted the managers in the case organization affirmed that they need more information to be able to monitor the results of process development.

There were five group of people participated to the interviews. All of them interviewed separately in small groups three to six people in each. The groups were constructed in a way that it would be easy to comment and make opinions. All the members of the interview group were roughly from the same organizational level. The groups were: engineers, line managers, project managers and product managers. The fift group would have been cross-organizational managers but there was not enough time to interview both especially at the same time. There were phone conversations but not a proper interview. My role was more a spokesman than an interviewer.

The interviews were conducted within a week. All of the interviews were recorded. The cell phone was used as a recording device. A cell phone was a good choice as it is that common that it was easy to forget that it existed. As the groups were fairly small the atmosphere was relaxed in almost every interview. In a small group the question also seemed to be easy to ask.

The interviews were necessary to be able to start the project and gain the confidence of the case organization. At the end the informing and gaining the trust was the most important outcomes from the interviews. Everyone in the organization did not know who I was, so these interviews also were a good way to introduce myself. In every group there were a lot of hints where the needed data might be found and some details and features that were expected from the dashboard. The attitude and opinions about how the dashboard would fit to their everyday work also gave invaluable knowledge to the creation work of the dashboard and on the other hand they gave a perspective to the search the literature. Almost all of the groups seemed be interested in the metrics.

4.2. Metrics Dashboard Implementation

There was need to build a metrics dashboard to be able to conduct the Thesis research at ABB. ABB as a company provides interesting environment to study how new kind of metrics can be used. The benefits of the implementation of metric could be subject of another thesis project. Within this thesis it is possible to implement the metrics, learn

how metrics can be used and whether they can be used to develop the processes in software R&D projects at least in theoretical level. This research is also about using metrics the help to analyze prospective circumstances. The dashboard of metrics can potentially be used gaining foresight of the operational situation in the team. The good foresight can give advantage in process development.

The organization that controls the metrics implementation on global level is called SDIP. SDIP team is cross-organizational team. The metrics implementation seems to have a rather strong support from the management though there also are some confusion and lack of knowledge in the lower levels of organization. The metrics project is global and the Finnish case organization is one of the first ones to implement the metrics. The set of metrics was predefined. There had been wide interviews among employees, and based on those interviews and some criterion the nine metrics were chosen to be implemented by the SDIP on a global level. There are over hundred metrics to choose from. There are also three additional metrics that need to be implemented in the second phase.

Before any metrics can be studied the metrics must be implemented by the case organization. In Finland and in the range of this thesis there are two different teams or product lines that took part to this pilot phase. The idea is that these two teams test the metrics and after pilot phase the metrics are taken into use. There are differences between these groups and because of that there are also differences how the metrics can be implemented. The implementation of the metrics was on my responsibility.

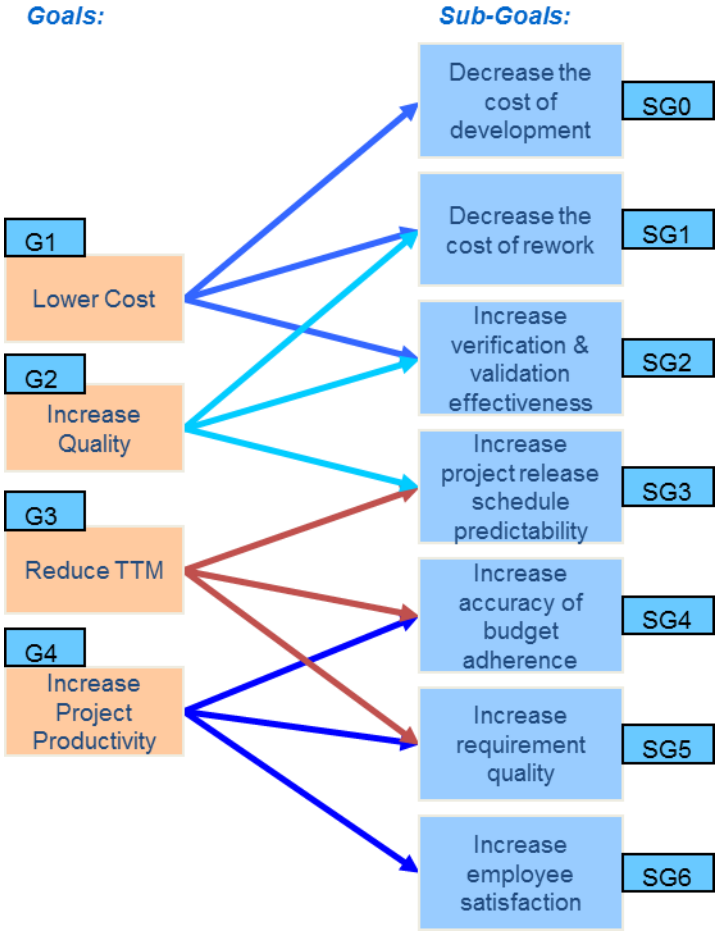
The meetings concerning the implementation were documented in memos. Some of the memos were sent to everyone who participated and some are written to the diary. The memos and diary are not specific enough to draw any conclusions, but it can be used as a reference.

There are nine metrics that were chosen from the over hundred metrics. Beside these there are the three metrics that ought to be implemented after the nine metrics are in use. Selection process had been done before this thesis work began and therefore there was not any way to have any effect on that. The nine metrics must be implemented by December 2010. The metrics are very carefully described and there are even successions of how to implement the metrics in the same document. There was no need to describe or define the metrics themselves but how to collect the necessary data for them. This phase was necessary to gain access to the case organization and gain insight of the operational situation in which the metrics are interpreted.

There were no limitations what tool to use when constructing the dashboard. Nevertheless Excel was selected as tool quite quickly. The data for the metrics were also collected to the dashboard Excel. Each team has their own a dashboard. The

dashboard is formed from two Excel files in a way that the monthly followed metrics are other file and the weekly followed metrics are in the other. This was a practical choice.

The goals of the metrics implementation are to lower cost, increase quality, reduce time-to-market (TTM) and increase project productivity. The lower level goals that are linked to these main goals are can be seen in the Picture 2. (Software Metrics User Stories.) Most of the metrics can be linked to more than one goal. The team can also set their own goals beside these main goals.



Picture 8. *Goals of the Metrics project that is part of SDIP (Software Metrics User Stories).*

There needs to be enough training and possibilities to train. The training must take place before the first review of the metrics to able the proper use of it. There has to be a plan how to use the new tool in process development work. Plan must include the guidelines how to communicate with the help of the metrics. In other words there should be same language to avoid misinterpretations.

Time Schedule

The definition of my work at the beginning was quite clear what comes to the company side of it. However the work definition evolved as the scope of the study got focused. Therefore also research plan has evolved.

The deadline for the metrics dashboard was December 2010 and it is the same for the few other countries too. The research process was defined by the end of May 2010. The interviews and briefing of the managers and engineers were conducted in June 2010. The construction of the dashboard began short after the interviews and continued until October 2010 as the data collecting and constructing the analysis level was quite laborious and involved a lot of people. Training took place from October until January 2011 as the metrics were tested and developed at the same time. The teams began to use the metrics already in December 2010 but independently it began on January. From January until April 2010 the analysis of metrics took place. The purpose of the analysis is to find out how the metrics can be used to anticipate the forthcoming events and gaining foresight for the process development to be efficient.

Metrics

These are the nine metrics that were chosen by SDIP for the first implementation phase:

- Percent of Milestones on time
- Defect Backlog for a Release
- Customer Reported Defect aging by Severity
- Test Case Pass Rate
- Percent of Requirements with Traceability to Test Cases
- Percent of Customer Support and Maintenance Effort
- Burndown Chart
- Percent of Requirement Volatility
- Incremental Code Churn

(Software Metrics Definition 2009).

Every metric has someone designated as responsible and accountable. The responsible is the person who is responsible for collecting and reporting the measurements. The accountable it the one that owns the object of metric and the accountable is the one who must take action based on the metric. There are four levels of project work that these metrics involve. They are: Work Package, Release Project, Product and Program. A Work Package is the lowest level of project management and time tracking. Next level is a Release Project. There are metrics that serve only every release project at the time. Then there is the Product level that is served with the metrics that take multiple releases

that still are within a consistent family of software or in other words that are under the same product. Program is the highest level served by these metrics. It contains multiple projects that are part of common software platform or common product release hierarchy. (Software Metrics Definition 2009.)

Percent of Milestones on time

Percent of Milestones on time counts the milestones reached on time in a time period. The metric is cumulative and the target is to maximize this metric. The Project Manager is both responsible and accountable of this metric. There is a need to document the number of milestones on time within the time period and the milestone that are planned to occur within that time period. This metric is followed monthly. (Software Metrics Definitions 2009, p. 6.)

The data for the metric Percent of Milestones on time is collected manually to the dashboard. The data is typed to the dashboard when the dashboard is used. In that way the dashboard is kept up-to-date and clear. The agile team did not implement this metric in this phase but the staged lifecycle team did.

There are few challenges in the Percent of Milestones on time. The first of all there must be consensus, how to define the milestone to be able to measure them. There must be also clear decision how to handle the milestones that are changed "with permission". The metrics is only for teams that use staged-lifecycle software development, but could it also be useful to agile development teams. There are not the data for this metric recorded at the moment in the present processes. It means that this metric requires some extra work from the person who is responsible and without systematic use of dashboard the data for this metric might decay.

Defect Backlog for a Release

Defect Backlog for a Release tracks the defects per the release that is currently under development. The open, changed, closed and moved defects are taken into account. The target is to minimize the changes in the defects when the releasing date comes closer. In ideal development process the defects corrected for the release are already known in the beginning of the project and they steadily get closed when approaching the release date. The goal of this metrics is to increase quality (SG2) and it provides indication of the responsiveness of organization to resolve the identified defects. It can also be used to prioritize the defect fixes. SDIP intends this metric to be used by the both software development lifecycle models. This metric is weekly reported. (Software Metrics Definition 2009, p. 9.)

The data for the metric Defect Backlog for a release could be found from the existing report of change management system (CMS). The report is ran in the CMS and then copied to the dashboard. To be able to track also the defects that are moved to the next

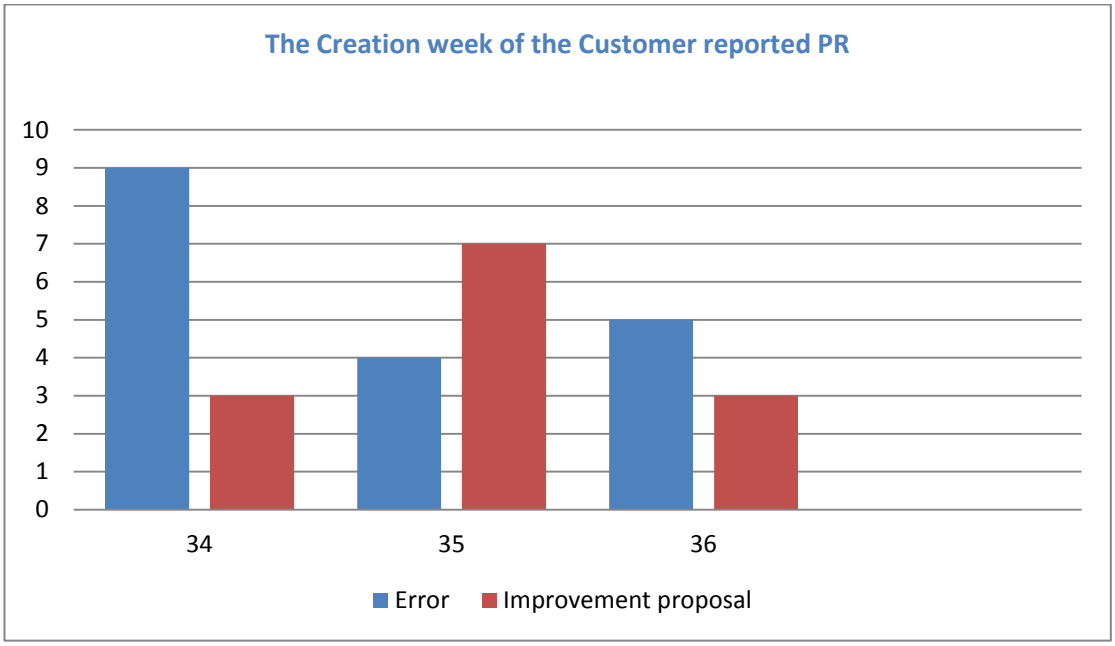
release the report of the next release is also ran and copied. The situation can be followed from these two pictures. There are two types or levels of defect documentation in the case organization. Therefore there are the four reports that must be ran: two levels of documentation and two reports per documentation level.

The SDIP divided this metric to different backlogs for different group of people. There is only one backlog that contains all defects. In other words the management and the engineers have the same information. There is no change to this situation in sight. The data is slightly laborious to retrieve compared to the possibility that it could be updated directly from the dashboard.

Customer Reported Defect aging by Severity

Customer Reported Defects aging by Severity is a metric that is needed to gain idea how fast the development organization responses to customer. The goal of this metric is according to SDIP to decrease the cost of rework (SG1). This metric can be applied to all life-cycle methods. (Software Metrics Definitions 2009, p. 12.)

The data for the metric Customer Reported Defects Aging by Severity could be found from the change management system (CMS). There was found a new container where all of the new customer reported defects must be linked. Several persons do the linking that all need to be inform and tough how link defects to the right container. When the defects are linked to the same container the content of the container can be uploaded and transformed to proper form for Excel. In the Dashboard Excel there is a pivot table that separates the severity levels which can be seen from the **Picture 9**.



Picture 9. Customer reported defects aging by severity (Monthly Dashboard).

The customer reported defects are not marked separately in the way that they could be filtered from the CMS. That is way the new defect container was needed to separate the customer reported defects from the self-found defects. This is not the best way to storage and filter data. The statuses of the defects also deeds to be maintained and updated carefully to gain true understanding.

Test Case Pass Rate

Test Case Pass Rate is simply a status of the testing activities. The goal for this metric is to increase verification and validation effectiveness. There must be data from test cases that passed, test cases that are executed and the test cases that are not completed. If test case is run several times only the last is counted. This cumulative metric is followed weekly. Different test levels could be aggregated. (Software Metrics Definitions 2009, p. 14.)

The data for this metric can be found from the testing systems of the teams. The data can be fetched to the Excel directly from the testing system. Nevertheless there were some problems in processing the data with the Excel. The inconsistent test sizing can also affect the result (Software Metrics Definitions 2009, p. 15). The value of this metric might be challenging to interpret it depends on the amount of test cases.

Percent of Requirements with Traceability to Test Cases

Percent of Requirements with Traceability to Test Cases is a metric that aims to increase product quality be assuring that the requirements have been tested at least once. The metric is a cumulative and it should be followed monthly. The base measures for this metric are the count of requirements that need to be tested and number of approved requirements that have traceability to test cases. The scope of requirement can be for example the functional areas within a product release. (Software Metrics Definitions 2009, p. 17.)

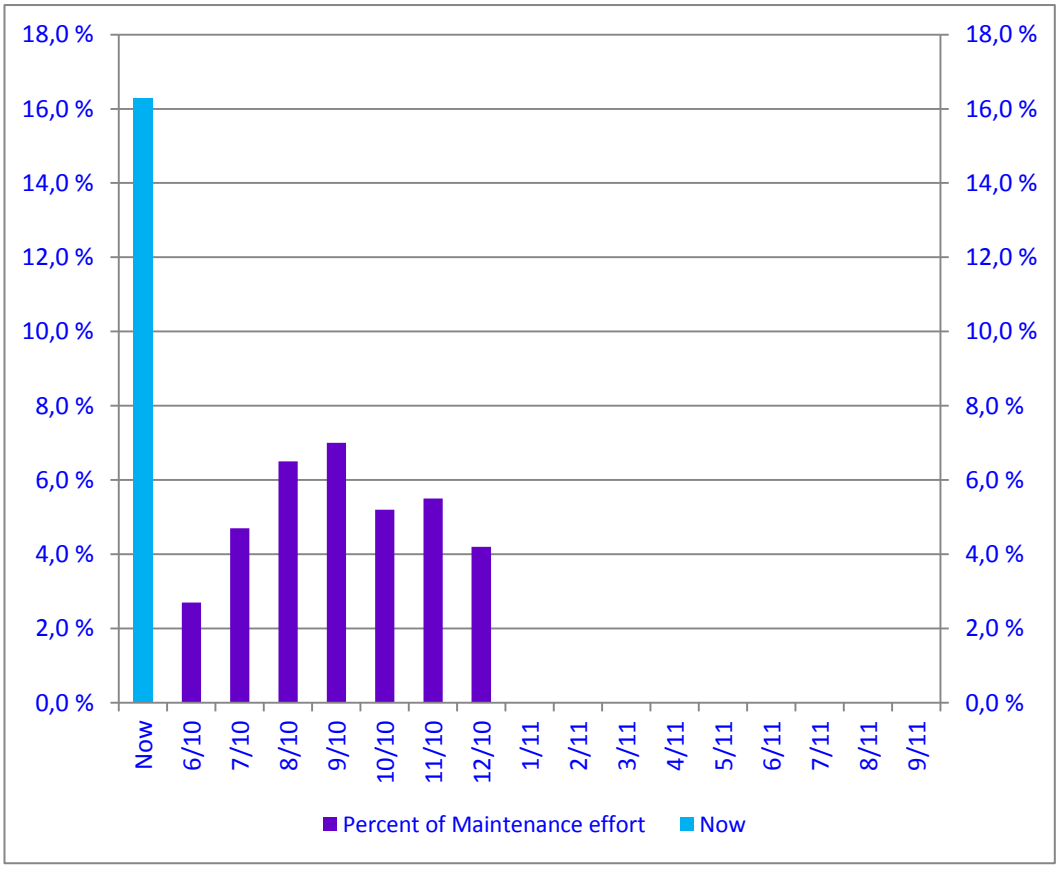
This metric could be able to implement if there were the process of tracking the test cases to the requirements. It is now followed manually and is quite laborious. This metric can be implemented when the testing system is updated. There is a build in tool for tracing in the new quality system that has not been implemented yet.

Percent of Customer Support and Maintenance Effort

Percent of Customer Support and Maintenance Effort measures the effort of the R&D team that is taken away from new development. The goal of this metrics is to decrease the cost of rework. This is a good metric for both software development life-cycle models in use in the case organization. The metric is followed on monthly basis. (Software Metrics Definitions 2009, p. 19.)

The data for this metric can be retrieved from the ERP system as a standard report. The report must be created, copied and then pasted to an analysis sheet on the dashboard Excel. The engineering hours are separated from the management hours and after that the hours reported on maintenance and support projects are calculated with the total management hours. This metric requires manual work but it is still rather easy to update.

The target for this metric is according to SDIP (Sofware Metrics Definitions 2009, p. 19) that the value of this metric need to me minimized. Better target might be some kind of compromise, because also customer support is important. The ideal situation is not that the customer support hours are minimized altogether. Customer service is important part of software development. The inconsistent time reporting corrupts the data (Software Metrics Definitions 2009, p. 20).



Picture 10. The Percent of Maintenance Effort metric (Monthly Dashboard).

Burndown Chart

A Burndown chart is a basic tool in software development method called SCRUM. The purpose of this metric is to monitor project progress in agile team. The goal pursued is to increase product release schedule predictability. For this metric the team must make some estimation of the workload per person, per time period and per requirement. From

the dashboard can be followed the ideal burndown of the effort and the actual burndown.

The agile team is already using this method. Therefore the burndown chart they already used could be used for the dashboard too. The challenge with this metric is to keep up the good planning practices. The burndown chart might rapidly lose its eligibility if planning process is not followed carefully.

Percent of Requirement Volatility

Percent of Requirement Volatility means the fluctuation of the requirements during a release. The goal is to increase requirement quality by assuring that projects are carefully planned. The number of requirements needs to be counted before project starts. During the project the requirements added, modified or deleted needs to be monitored. The number of changes can be counted by following volatility. It is obvious that this metric apply only for staged developing method. (Software Metrics Definitions 2009, p. 23.) The burndown chart is representing this metric for the agile teams.

It is essential for this metric that the project plan is made in a way that it can be compared to the former version. The Requirement volatility can be followed in the Requirement Management system (RMS). There is a possibility to take a snapshot or review of the planned requirements and compare snapshots. The number of changes needs to be manually typed to the dashboard but the RMS compares the snapshots and presents the change report.

The challenges within this metric are the manual work that it requires, the strict planning protocol that is needed and the need of retrospective meeting to be able to learn from this metric. There are also some differences between the calculation method used by RMS and the calculation instructions given by SDIP.

Incremental Code Churn

Incremental Code Churn is for monitoring the rate of change in the code. It is used during the development to assess the readiness of the developed release. The changes should be big at the beginning of the process and then be leveled down towards the end of the project. The goal is to decrease the cost of rework by monitoring the progress. At the beginning there should be a lot of changes and therefore a big code churn. When project get closer to the releasing there should not be much changes anymore. In other words the code should churn back and forth at the beginning of the development but as the project is close to a finish the churn should stop. This metric should be followed weekly. (Software Metrics Definitions 2009, p. 25.)

The good code quality tools are needed to follow Incremental Code Churn. The lines of code (LoC) is more common metric and that can be followed but that is not the same thing as LoC does not

4.2.1. The Implementation Process

In this case the implementation consists of three phases. The implementation process was planned and the metrics were introduced to the managers and engineers involved. The second phase was to collect the data to the metrics and build the dashboard and finally the dashboard was introduced and deployed. Because the metrics where decided on a global level and the planning phase in that matter was not needed.

The metrics are described rather in detail in Software Metrics Definitions and in Software User Stories. These documents are applied on a global level in the organization. There was no need to interfere with the definitions but they were scrutinized carefully. The confusing details were handled with the person responsible of the quality management. To ensure that the metrics were understood right, the definitions were also discussed in the interviews.

To get the general view more clear the interviews were conducted. The purpose of the interviews was to clarify the initial situation: what are the attitudes towards the metrics, are there any metrics in use at the moment, how they use them and what metrics would they want to have. Besides getting the general view the purpose of the interviews was to inform the teams that they are a part of a pilot project that was about to start. I also introduced myself and tried to become acquainted with the people that belonged to the case organization.

Data to the dashboard is scattered widely to the organization and the information systems of the organization. There is no tool addressed to collect this kind of data. Although there are suitable software already used within the company. Nevertheless all software in question is used elsewhere and due to tight schedule of the implementation process there in fact were not any other software to choose from.

Excel was convenient choice to dashboard tool for various reasons. Excel as software is familiar to all the members of case organization, it is quite flexible and has plenty of calculating tools integrated. There also are no extra costs beside the data storage costs when using Excel. Downside of the Excel is that it is fairly constrained when it comes to information drilling features. The size of an Excel file also grows quite easily and data losses are difficult to prevent. Furthermore there is no good way to storage history data and there are not that many tools to create metrics although there are various ways to present the data. The data analysis function of the dashboard needs to be built from the very beginning.

The data was collected to the dashboard by interviewing the members of the team. This was quite slow process as the information often was hard to access or not in any information system at all. Some of the data uploading processes would have needed changes to the information system or process. The data collection was planned to end in before the construction of the dashboard began but there was new data found all the time. For example the data for Percent of Customer Support and Maintenance Effort metric changed little bit in January that caused an error in analysis sheet.

4.2.2. The Dashboard Execution

A dashboard in a measuring or business intelligence system can be referred to a dashboard of a car. It is supposed to help man to drive a car and gives information for example about the speed and fuel level but the decision to fill up the tank must be made by driver, not the dashboard. In reporting system project the kind of "dashboard" is build, where it is possible to easily check the status of the organization, but also give more detailed information when needed. A good dashboard system provides an opportunity also check "under the hood" or in other words drill deeper to gain more specified information. With dashboards an organization can follow the current situation and when the analysis and planning is combined with it, management has the tools for business performance management (Wong, Fryman & Downey 2008, p. 66).

The process for creating the dashboard tool consists of four phases. At first the history information needs to be collected and examined. Then the necessary data has to be located and the quality and reliability of these measurements needs to be adjusted in reasonable level. Then a reporting system or dashboard needs to be created. Third step is to assimilate the dashboard to be part of the routines.

Data model for dashboard depends to some extent on the technology solution chosen. In this case the dashboard is built with excel. There should be three layers in the BI excel to avoid confusion. The layers are a data layer, an analysis layer and a presentation layer or in this case the dashboard. (Alexander 2008, p. 24.) This rule can be seen also in the dashboard in this case. In the optimal case the user would see only the presentation layer but in this case almost all of the data sheet need to be visible or updating the metric would not be possible. Another reason is that the user can see the data and spot possible faults if needed.

Because there is as many as nine metrics to be handled at once, they are divided into two files; those that are updated on weekly basis and to those that are updated on monthly basis. All of the metrics implemented supported same purpose of seeing a status of a project at one sight, but as the metrics were followed with to different frequency and it supported technical solution the two different dashboards were found justifiable. These two files will be relatively easy to review at the same time even

though the information is in two different files. Two files might also make it easier to update the metrics, as the monthly metrics do not distract the weekly metrics. To view the whole dashboard the both – monthly and weekly dashboards – need to be opened and eyed simultaneously. Also the two teams have their own files. Another reason for two separate files is that the size of an Excel file crows quite quickly too big to process.

4.2.3. Training

The training already began in the first interviews. At the beginning of the interviews the dashboard idea and rough plan of implementation process was presented to the managers and engineers. The nine metrics were presented one by one so that the interviewees get the general idea. In the interviews the participants also had a chance to learn a new thing together. A benefit of a common learning experience was pursued (Kankkunen 2005, p. 84). During the data collection the people involved were briefed about the whole process and of course about that certain metric that was in the making. This way the awareness of the metrics implementation arose. People paid notable interest to the metrics (Notes 2010) that made the whole process proficient.

The actual dashboard training was given when dashboard was almost ready. The training was given to both teams separately. The material and separate updating instructions were placed to the same directory as the dashboard. The material needs to be accessible so that people can recollect the instructions and those who did not make it to the training meeting can learn independently. The training material consists of the dashboard, an instruction slideshow and more detailed updating instructions. In few cases the one who was named responsible for the updating the metric was given also more detailed guidance.

Also the interpretation of the metrics was given a notable role in the training, although there are no interpretation rules in the material. The dashboard was compared to a car. The team is a car and the dashboard is a dashboard or a part of the dashboard of the car. The interpretation can be made in a many ways considering the situation at hand. In the training the dashboard was introduced and some examples were discussed. These discussions were not recorded but similar examples were used in the material and can be found from the Software Metrics Definitions (2009).

The participants had a change to have an effect on the appearance of the dashboard. For example the order of the metrics in the dashboard was enhanced due to the discussion in the training meeting (Notes 2010, 27.10.) It seems important to give the participants a change to affect the circumstance and to create the environment that allows a self-guided development. In this way the motivation is easier to uphold. (Kankkunen 2005, p. 82–83.)

One of the most important functions that training had was to address the roles to the participants. The accountable and responsible persons were decided together. This was to ensure that the person knew his or her part and could ask if there were anything confusing left. Also the right person for the right understanding about the data was hoped to be found this way.

5. RESULTS

In the literature there were found a lot of similarities in technically implementing a measuring system and business intelligence system. These observations were used in implementing the metrics to the business environment.

Object of this study was to find ways to develop processes with the help of nine previously chosen metrics that are Percent of Milestones on time, Defect Backlog for a Release, Customer Reported Defect aging by Severity, Test Case Pass Rate, Percent of Requirements with Traceability to Test Cases, Percent of Customer Support and Maintenance Effort, Burndown Chart, Percent of Requirement Volatility and Incremental Code Churn. The metrics are here scrutinized one by one. The analysis of them all together will require quite significant knowledge and expertise over the case organization although some causal relationships can be pointed out. This is also a moving target and depends what is the nature of the project. As the project lead was not the ones who decided that these metrics are the best for them the final user of the metrics was a little ambiguous.

Things that can be predicted with the help of these metrics are limited for many reasons. Main reason is that the metrics are given from other organization than the one using them. The idea might have been that the metrics should be the kind of that can be aggregated and the metric would tools for higher management levels. The implementation process however is done from the point of view of the local management. One of the main goals for this theses set by the local management was to form some kind of guidelines how management should interpret the changes in the metrics. As this thesis will most likely be good starting point there are required a lot more guidance from the higher management levels to local managers on using the dashboard. If the main goal is to gain information that can be aggregated the tools and especially processes used to gather the data for the dashboard must be unified. At the moment there are a lot of differences in data gathering already between the two case teams. Therefore all of the chosen metrics are not applicable.

The dashboard however is a good tool for the local management for the local purposes. There was a possibility to upgrade the dashboard with the metrics of the local organizations. With this kind of upgrades the metrics dashboard can be used locally to enhance the processes and anticipate the coming workloads, time schedules and therefore also budgets. This project can be seen as a pilot project or rehearsal for the

R&D team or the unit when they start to build the more thorough business intelligence and measuring system for them.

5.1. Results of the Implementation Process

How to interpret the dashboard was one of the main concerns of the case organization. It makes no sense to maintain a system that cannot be pursued. The interpretation is not the only issue concerning the dashboard. There are at least three challenges in using it. They are: to keep it up to date, use it when making decisions and to analyze it properly. Only way to benefit from the dashboard and metrics is to use them to make decisions. The dashboard that is perfectly updated and analyzed will not help at all if no actions are made. Nevertheless the data needs to be correctly analyzed that it supports the process. Maybe the greatest challenge in case organization is however the data quality. As there are no proper integrated reporting system in use rather than somewhat vulnerable Excel-dashboard the data quality is laborious to maintain. For same reason the data comparison between the teams might be difficult.

Although a dashboard might not be difficult to use as is, the training is necessary. The technology in measurement system can be as simple as spreadsheet but there must be some training in where the data to the metrics is driven from and why it have been chosen to be in this metrics system. The ability to anticipate the right decisions is desirable ability to anyone. Anticipation is a mixture of knowledge, business intelligence and good quality data. These all also need to be up to date. As everyone has a unique repertory of knowledge they also interpret the same data slightly differently although there are some interpretation guidelines.

The dashboard can be used in doing many kinds of decisions. A well-executed metrics dashboard that has relevant metrics in it can be used in doing the resource planning, process development, as a strategy communication tool and it might even help perceiving the causal relationship that would not be visible otherwise. Although there are many ways to understand the metrics here are at least few than could be mentioned.

Percent of Milestones on time

Probably project managers have quite good idea about this in most cases. The standardized metric would however give a possibility to follow the development of the planning process. This metric can be eyed for example with the Percent of Customer Support and Maintenance Effort to investigate the dependence of customer demands and project planning. The Requirement Volatility might also affect to the milestones if volatility is not taken into account in project planning phase.

This metric is for a staged software development only. For agile teams the corresponding metric is the Burndown Chart. The Percent of Milestones on time is

characteristic project planning tool. It also might provide essential information for product managers when it is aggregated to gain the overall status of several projects.

Defect Backlog for a Release

This metric provides an indication about the responsiveness to resolve defects found in the product and it can be used to assess the readiness of the product. Most probably it is already used as a tool to prioritize the defects and to monitor the current workflow and to approximate the effort needed to reach the milestone. (Software Metrics Definitions 2009, p. 10.)

Defect Backlog for a Release already is a good metric on its own but it can also be viewed in the dashboard with the other metrics. For example this metric can be eyed at the same time with the Customer Reported Defects Aging by Priority to determine how many of the defects found important and repaired are reported by customer. This metric can also be viewed on the process-planning phase together with the Percent of Milestones on time. The history data combined with the current status of defects can in that case help to plan a new project.

Customer Reported Defect aging by Severity

The main function for this metric might be that it can be used to monitor that high severity defects are given appropriate attention (Software Metrics Definitions 2009, p. 12). With this metric the customer relationship process can be examined. If there seems to be a lot of delays in fixing the customer reported defects the process needs to be taken into closer analysis.

Customer Reported Defects aging by Severity might be sensible to view together with the Defect Backlog for a Release and Percent of Customer Support and Maintenance Effort. There are different sized defects so only the number of defects does not tell the whole story. This too is a good project planning metric if it is viewed together with the other metrics in making sure that the product that is already in production is satisfactory. This might be also great help in anticipating future workload.

Although there is fairly good data for this metric, there are some development needed to make it sustainable. The customer reported defects must be continuously linked to the container or some other method for that is developed. The customer reported defects should be easily filtered and followed in the CMS. There is a need to define and follow the good values of each severity level. It is already visible that the most severe problems need to be closed, but adding the target values could develop this metric further.

Test Case Pass Rate

Test Case Pass Rate is already monitored in some level. This metric gives quite versatile information about the software project. It indicates for example the amount of rework

left, quality of the software, how close the product release is and if some extra work or focus is needed to get the project ready (Software Metrics Definitions 2009).

This metric is also a good dashboard metric. The readiness and quality of the product can be concluded when this metric is eyed with the Code Churn and Traceability to Test Cases. There are quite many possibilities to improve the data for this metric in the case organization as the data at this time is quite scattered. There are various software solutions to ease following process and they might be beneficial in deciding whether the product is comprehensively tested to be functioning.

Percent of Requirements with Traceability to Test Cases

Percent of Requirements with Traceability to Test Cases was not possible to implement to the dashboard because the lack of data. This metric would nonetheless be important. This metric helps to determine and monitor the quality of the product and therefore reduce the risk of delivering defective software (Software Metrics Definitions 2009, p. 17).

Percent of Requirements with Traceability to Test Cases has connection with the Test Case Pass Rate and Incremental Code Churn but also with the Defects Backlog for release. This metric could also give an indication of how ready the product is but also how good the quality is. If traceability to test cases is good and the defect backlog looks good there might be the project seems quite successful.

There is no possible way to implement this metric at the moment, but it is recommended to develop the testing process in the way that this becomes possible.

Percent of Customer Support and Maintenance Effort

Percent of Customer Support and Maintenance Effort indicates how much there is time left for new product development, how well the customer voice is heard and even the stability of certain products (Software Metrics Definitions 2009, p. 20). With this metric can be estimated the schedule, customer support and future actions needed. This metric can eyed with almost all of the other metrics. The most important might be the Milestones on time or Burndown chart, but also the Requirements Volatility and Defect Backlog for Release. It has also strong connection to the quality.

Burndown Chart

This metric has its origins in predicting. It is the purest prediction metric among the nine metrics implemented. When the scrum team begins the new sprint they use their group in defining the anticipated workload. The estimation is followed with burndown chart that is visible to everyone in the team. If estimation did not meet reality, it is discussed why in the retrospective meeting after the sprint and before new sprint begins. In that

way the team can learn to do better estimations and anticipate the challenges beforehand.

Percent of Requirement Volatility

Percent of Requirement Volatility indicates the successfulness of project planning. It also tells how well the customer needs were investigated before project began. This metric is probably the metric that would gain from proper retrospective evaluation. Properly analyzed the data from previous projects can be used to plan the next.

Incremental Code Churn

Incremental Code Churn needs to be evened before the new project starts (Software Metrics Definitions 2009, p. 25). This metrics would estimate the readiness of the product and even the quality. It can be foreseen that if the code changes a lot at the end of the project there is a great risk that it cannot be tested as well as possible. This metric can be eyed with the Test Case Pass Rate and Traceability to Test Cases to assess the quality and readiness of the product. Project manager should be alerted if Code Churn is high and the test case pass rate low, the engineers might feel rushed on a detriment of the quality. If the traceability to test cases is low but code churn is high there might be some big problem that hinders all other development work. The possible causes behind the metrics should be analyzed in a group. There might be even need to discuss about the matter in cross-team management meetings.

There are differences between the case teams that caused differences in the dashboard. The Team T uses staged software development model and therefore there is not possible to form a burndown chart for them. The Team P cannot form the metrics that are for

The Dashboard

It takes time and patience to create functional dashboard that can be properly used. There are several steps and various people that must be involved. Communication thorough the organizational levels is crucial for measuring as a whole and for maintaining the measurement tools.

None of the implemented metrics were monetary and no benefits were given based on them. This made them operative in nature and maybe they could be trusted a little more than if they were associated with benefits as the team members had no personal benefit on making the numbers look better than they do. On the other side this might make them a little less interesting for R & D team members as they might not see the benefit of the metrics to them. Nevertheless based on the interviews and trainings atmosphere for the measuring was welcoming.

Motivation is a necessity in everything we do. In this case the possibility to local people to solve they own problems seem to be one motivator. But as organizational hierarchy is slightly complicated there is also a need to communicate between the hierarchy levels. There might be possibilities for all organization levels discussed to use the same metrics but not the same dashboard. In other words different management levels can use the metrics to gain foresight but the metrics set might be different. To enhance communication there might be need for a master data project where the basics for the metrics are given a though. As the organization is really massive there will always be differences between the data produced in the different units but there are few basic metrics that might be aggregated. That would though probably require organization wide process planning and unifying.

In this case there might also be some benefits to have a review of the business processes from IC point of view. It might provide better understanding of the metrics in use. There should be more resources and guidance to set target to ease the dashboard interpretation. As these were not already though out it was somewhat hard for the team to understand what the metrics stated. It showed that metrics were not gathered a specific question in mind rather than based on some other purpose or only common practices on software R & D field.

Gaining foresight might be the most interesting part of the metrics dashboard project. Usually people want to see the future to be able the plan their actions accordingly. In using dashboard one might do too quick interpretations about the state of the organization and end up correcting things that are not broken. For example the burndown chart of workload seems to do almost every time some curve rather than go straight down, but still the work might get done in the timeframe set. Senge has thought up a descriptive “take two aspirins and wait”-rule. You have to wait for a while the aspirin to have effect rather than take a new one every five minutes. (Senge 2006, p. 50.)

The importance of intuition should not go unnoticed. There are numerous studies conducted recently that have proved that experienced managers and leader rely their intuition quite heavily (Senge 2006, p. 157). Successful interpretation needs both rationality and intuition. The metrics dashboard should be used kind of the same way as a dashboard in a car. The better you understand how the car works the more information you can get out of its dashboard. After you have some kilometers behind you, you can see form the dashboard how well your car is running. To be able to pick also the right way you must have also have a map and a good insight of where you want to go.

5.2. Recommendations

In the operative level the most important suggestions are to keep up the meeting, update the few metrics that could not be implemented because lack of data and create a dashboard of their own to the next phase metrics. If it is possible the dashboard software might be reasonable to implement. On the strategic level the recommendations consider the development of planning by developing personal and team related anticipating skills.

The most obvious recommendation is to keep the development process going. The dashboard execution is secondary to the development process. The meeting could be the forum to continuously discuss about the work done and share the thoughts and anticipations. In that way some weak beneficial signal might be apprehended. Depending of the resources the meetings might be sensible to hold on a monthly basis.

There is proper software that can help with the dashboard updating process. The right kind of software helps when the culture of using the dashboard already exists and the data is handled regularly. It might also encourage people to use the dashboard and collect the data if there would be a proper and easy tool to do it with.

There were few metrics that could not be executed because lack of data. The Incremental Code Churn and Test Case Pass Rate and Traceability to the Test Cases are the three most important metrics to be implemented. In the SDIP there is at least three more metrics that are a bit more strategic in nature. At least these three metrics should be related with the nine metrics used in this research. In the first phase the three metrics should be collected into their own Excel-table and be examined together with the nine other metrics.

5.3. Discussion of the Results

The implementation process was very iterative and it met exactly the challenges written in literature. Source systems varied, there was not enough involvement form the management level. There was not clear enough vision what kind of knowledge dashboard is offering and what are numbers in it indicating. Nevertheless dashboard got good response and it was still in use after a year of usage. The maintenance process was easy enough and team was able to develop dashboard themselves. Only after the implementation process was already done the leadership addressed that they would want to aggregate the measures. However this would require another project as there should be clear view, what are the other teams that should collect same kind of data, what their data source systems are and how management should interpret the results. At least that point there were no communication about what are targets that management would want to achieve by aggregating the data.

As a result this thesis verified that principles used to define bigger business intelligence project are applicable also in this kind of small operative measuring implementation process. Research was not thorough on how to use metrics as that would have required an extensive support from management. However the metrics were successfully implemented and the idea how to learn to interpret them was delivered to the R & D team through the implementation process and trainings

The implementation process of metrics system seems to take approximately one year as claimed in the literature. The foresight with the metrics requires familiarization to the techniques, metrics and to the case organization. The learning process related to the use of metrics dashboard as a tool occupies resources and requires motivation but this thesis suggests that there can be some assistance of metrics in decision-making. There could already be seen the objects met for the process development after a year. Although following the results of measuring system was not in scope of this thesis some improvements could be pointed; for example the first metric, Percent of Milestone on time, showed that might be a need for an unambiguous and public milestone monitoring practices in the current processes. The milestone monitoring through the dashboard could be the right tool to do that if used properly and maintained regularly. The implementation process could be judged if there was more time to use. Within the scope of this thesis it is not possible.

In this case the effects of the metrics implementation would be interesting to follow. This study could go further by comparing numbers on the dashboard and economical measurements. There should be some correlation if the dashboard is used to support decision-making. If the situation could be followed, it would be interesting to know what kinds of decisions were made in the case organization and by who. It might also be interesting to study relationship between anticipating skills and knowledge creation.

There is a thin line between academic research and management consultant (Gummesson 2000, p. 2) and there might be some criticism of the academic value of this study. Although this study has a fairly descriptive it still provides insight to what is a one possible way to use metrics as a tool among other tools in process development. In other words the academic value of this study is the knowledge whether this sort of metrics dashboard could help to anticipate the forthcoming events. The empirical part of this study could be used as a case example of the measurement implementation. The common belief seems to be that the more organized company the more efficient it can be. But it seems that problems sometimes need some rule breaking to be solved and new knowledge creates some instability to the company. It appears that the struggle between the organized work and rule breaking. Learning to see underlying structures rather than events is a starting point. There is no point in building a system that only hides the real causes of actions.

It would be really interesting to compare the change management issues in measuring project to a project where company adopts some new manufacturing technology. It seems to be corresponding phenomena. As the research process kept going on longer than expected there could've been interesting to research the possibilities social media adds to the measuring process. Only 41 % of the Finnish firms use some internal social media according to the FIFA and Sofigate (2013, p. 38) so best practices to use it are still to be documented.

6. CONCLUSIONS

The first objective was to reconcile, how to implement a metrics system. There was a hypothesis that a measuring system implementation and business intelligence system implementation share the same main practices. Hypothesis was found to be true. The phases are roughly to make the decision to start the project, to plan it and gather the requirements for the implementation, to design and implement the system with the help of different stakeholders and to use and maintain the solution.

The first helping research question was what should be taken into consideration when building reporting system. When implementing a BIS, measures or reporting the first thing to take into consideration, is why it is needed and what are the objectives for it. There are a lot of measures and ways to gather data but without clear purpose they will only strain the decision making process. That is excatly opposite of the purpose of these kinds of decision support systems. System thinking and mental models are good to internalize before the process begins.

Critical success factor for BI implementation process lie in all organizational levels. The communication between participants is really important to be open so that everyone participating understands the purpose of the project. It is also important that the participants of an implementation team know both business and the technology side well. It is recommended that there is at least one person in the team that understands these both sides. Only IT driven project will not see the purpose of the metrics as clearly as the business might and on the other hand business rarely possesses the skills to gather and modify the data. It is important that management supports the project as it requires a lot of time and other resources. Management should have a clear view what there is to gain from the business intelligence system.

Second helping research question was the most interesting for the case organization: how to use the metrics dashboard in managing software R&D? The strongest emphasis thorough this thesis is that these systems are for decision support and only effective when used that way. There are some recommendations how to interpret the metrics in the chapter *5.1 Results of the Implementation Process.*

Last question was what role the data has in the implementation process. Data is the key element in building a measurement system or BIS. It is like a corner stone of a system. Data must be rightly chosen, accurate, understood, timely and presentable. It is usually case that there is a lot of data and there is a temptation to use all of it or data that is

easily accessible. Nevertheless it should be chosen for a certain purpose and there should be a clear, easy to understand model how the data presented is processed.

As traditional measuring systems usually measure tangible assets and the traditional business intelligence system collects data from more intangible sources there could be a lot of leverage to combine these metrics. It is really important for a company or even an organization to understand where they are and have an idea or vision where they want to go. Therefore also intangible factors like innovativeness, customer relationships and business data are crucially important for a company to master. Number of published results whether patents or manual etc. are telling of the amount of explicit data in the company and data is key element to find new knowledge with the help of different information systems.

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