How can Earned Value Management and Lean improve a project management system in the construction industry?

How can Earned Value Management and Lean help to maintain the ex-ante agreed shape of the ‘project management triangle’ in the construction industry?

SSM CASE STUDY

NIKOLAOS CHITAS
How can Earned Value Management and Lean improve a project management system in the construction industry?

SSM case study

ABSTRACT

Working as a building construction engineer and project manager for more than 8 years I gained first-hand experience concerning the problematic areas of modern construction. These areas involve the three dimensions of the well-known ‘project management triangle’, i.e. quality, cost and time. In this respect, there is an extensive literature which highlights the benefits of the Earned Value Management (EVM) as cost and time forecasting and controlling tool. Moreover, the ‘Lean’ thinking is another well-respected project management method which achieves to improve quality and reduce time wastes.

SSM was selected as the case study as it is a growing company with a vision of continuous improvement which aims at stabilizing its position in the construction industry. Moreover, the company was willing to provide project related data and cooperate throughout the research conducted by this thesis so as to develop its project management strategy in the right direction.

The thesis proposes a combination of the aforementioned methods with those already existing in the company's project management system in order to upgrade the current strategy and develop a tailor-made system which will better address issues regarding the control of the ‘project management triangle’.
How can Earned Value Management and Lean improve a project management system in the construction industry?

SSM case study

Table of Contents

ABSTRACT .................................................................................................................. 1

CHAPTER 1: INTRODUCTION .................................................................................. 5
  1.1 Defining the Problem ....................................................................................... 5
  1.2 Background, Personal Experience and Motivation ............................................ 6
  1.3 Contact with ‘Earned Value Management’ and ‘Lean’ Thinking ......................... 7
  1.4 Why SSM ....................................................................................................... 7
  1.5 Purpose .......................................................................................................... 8
  1.6 Limitations ..................................................................................................... 8

CHAPTER 2: METHOD ............................................................................................ 9
  2.1 Methodology and Roadmap ........................................................................... 9
  2.2 Validity and reliability ................................................................................ 9
  2.3 Literature Review .......................................................................................... 9
    2.3.1 Earned Value Management .................................................................... 9
    2.3.2 Lean ....................................................................................................... 10
  2.4 Company ...................................................................................................... 11

CHAPTER 3: LITERATURE .................................................................................... 12
  3.1 Earned Value Management ........................................................................... 12
    3.1.1 Step 1: Define the Objectives of the Project ........................................... 12
    3.1.2 Step 2: Scope (Work Breakdown Structure WBS) .................................. 13
    3.1.3 Step 3: Organization Breakdown Structure (OBS) .............................. 13
    3.1.4 Step 4: Responsibility Assignment Matrix (RAM) .............................. 14
    3.1.5 Step 5: Time Schedule ......................................................................... 14
    3.1.6 Step 6: Planned Value (PV) ................................................................. 15
    3.1.7 Step 7: Actual Cost (AC) ..................................................................... 15
    3.1.8 Step 8: Achieved Performance ............................................................ 16
    3.1.9 Step 9: Value of the Achieved Performance ....................................... 16
    3.1.10 Step 10: Analysis .............................................................................. 16
  3.2 EVM’s Planning Phase (Step 1 – 6) ............................................................... 17
  3.3 EVM’s Implementation Phase (Step 7 - 10) ................................................... 17
  3.4 EVM’s Benefits – Recognition – Usage ....................................................... 18
  3.5 ‘Lean’ Thinking ........................................................................................... 18
CHAPTER 4: SSM CASE STUDY

4.1 Case Study Roadmap ................................................................. 24
4.2 SSM’s Method ........................................................................... 24
  4.2.1 Process Map ......................................................................... 24
  4.2.2 Vision – Targets - Objectives .................................................. 25
  4.2.3 WBS – Time schedule .......................................................... 25
  4.2.4 Cost Control ......................................................................... 25
4.3 Earned Value Management in SSM ............................................. 26
  4.3.1 Objectives ............................................................................ 26
  4.3.2 Scope – WBS ......................................................................... 26
  4.3.3 OBS ...................................................................................... 26
  4.3.4 RAM ...................................................................................... 26
  4.3.5 Time Schedule ..................................................................... 27
  4.3.6 PV ......................................................................................... 27
  4.3.7 AC ......................................................................................... 27
  4.3.8 Actual Work – EV. ................................................................. 27
  4.3.9 Analysis ................................................................................. 28
  4.3.10 Synopsis Table .................................................................... 28
4.4 Lean in SSM ................................................................................ 28
4.5 Implementing Lean ..................................................................... 29

CHAPTER 5: ANALYSIS - PROPOSALS .............................................. 30

4.1 Roadmap .................................................................................... 30
5.2 Planning Process Proposals ......................................................... 30
5.3 Production Process Proposals ....................................................... 31
5.4 Data Collection and Control Proposals ......................................... 31
5.5 Forecasting Proposals .................................................................. 32
How can Earned Value Management and Lean improve a project management system in the construction industry?

SSM case study

5.6 Storing Knowledge Proposals ................................................................. 32
5.7 Communication Improvement Proposals ................................................ 33
5.8 Assignment of Responsibilities Proposals ............................................. 33
5.9 Change Management Proposals ............................................................ 33
5.10 Training and Education Proposals ....................................................... 33
5.11 Synopsis Table ..................................................................................... 34
5.12 New Management System Proposal .................................................... 34

CHAPTER 6: CONCLUSIONS – FURTHER RESEARCH ................................. 36
6.1 Conclusions ......................................................................................... 36
6.2 Further Research .................................................................................. 37

REFERENCES ............................................................................................ 38
Books ........................................................................................................... 38
Articles ......................................................................................................... 39
Internet ........................................................................................................ 39
INDEX .......................................................................................................... 40
CHAPTER 1: INTRODUCTION

1.1 Defining the Problem

The task confined to a project manager can be described effectively as following: the project manager is responsible to deliver efficiently in terms of the scope, the time schedule and the cost of the project. The scope of the project refers to the outcome, either product or service, and the agreed quality of the project. The time schedule of the project specifies its ex-ante planned duration. Lastly, the cost of the project is defined as the amount of money spent, including both human and material resources, for the completion of the project (Kojter et al., 2011: 4). In the same vein, in a number of definitions for the success of a project we can find that: a successful project is the one completed within its targets including the time, the cost and the quality that it is requested from and agreed among the stakeholders (PMI, 2013: 35).

The aforementioned three main elements of a project are interconnected via the ‘project management triangle’ (Figure 1). The triangle is also known as the ‘triple constraint triangle’ as it demonstrates the existence of a trade-off amongst the three elements. Taking into account that the ex-ante defined triangle is the desirable one, the main challenge that a project manager faces is to keep the balance between the three elements at the pre-defined level throughout the whole process of the project (Philipson and Antvik, 2012: 13).

![Figure 1: ‘Project management triangle’ (source: Training in Managing Small to Medium Sized Projects, ULR: http://www.dba.co.uk/tips/vol3/vol3iss6.htm, 22 April 2014)](image)

The ex-ante shape of the triangle reflects the prioritization amongst its three elements. Hence, the prioritization among quality, time and cost is of critical importance for the project and must be clearly set and understandable from the beginning to all involved parties. For example, if at the start of the project time is the first priority, followed by cost then it is known that the quality of the project is to be compromised (Antvik and Sjöholm, 2012: 64).

However, the form of the ‘project management triangle’ can be distorted during the process of the project, if the focus given on its three elements is not consistent. Therefore, the shape of the triangle can change in an undesirable way so that we would witness a curve in one, two
How can Earned Value Management and Lean improve a project management system in the construction industry?

SSM case study

or even all three of its angles. For instance, the project can be delivered too late changing the time angle, or it can exceed the planned cost and so on and so forth. Based on the above analysis, scholars conclude that the ‘project management triangle’ is an effective means to capture the status of the project at each point in time and compare it to its ex-ante desirable shape (Philipson and Antvik, 2012: 11, 12).

Nevertheless, one should keep in mind that during the process of the project we may witness the arising of new unforeseen parameters resulting in a desirable reconfiguration amongst the three elements (Antvik and Sjöholm, 2012: 64). In this respect, the change in the shape of the triangle is not distortional but rather reflects the outcome of rational analysis.

An extensive literature has been developed with the aim to identify the main causes that distort the shape of the ‘project management triangle’ in the field of the construction industry. Miscellaneous researches have correlated this distortion with wastes in human and material resources. Furthermore, they have highlighted that the wastes are substantially high. For instance, an article published in January 2005 at The Economist ‘Construction and the internet’ argued that up to 30 per cent of the actual (ex-post) construction cost is related with mistakes, delays and problems in the communication (Forbes and Ahmed, 2001: 3). In the same vein, the Construction Industry Institute (CII) stated that in the United States 10 per cent of the actual (ex-post) construction cost goes to reworks almost 50 per cent goes to wastes whereas a big percentage of the waste costs reflect the lack of communication between the involved parties (ibid.). Hence, this literature argues that the construction industry suffers from significant wastes, resulting in low productivity, that distort the ex-ante ‘project management triangle’.

Another strand of the literature building on the elements of the ‘project management triangle’ adds another dimension, namely safety. Following the premises of this strand, success in the construction industry is highly correlated with 4 different factors: cost, time, quality and safety.

The importance of maintaining productivity at a high level in any kind of project is self-explanatory and construction industry projects are no exception. The role of productivity is even more prominent in this industry as construction projects usually involve a substantial amount of financial, human and material resources. The above analysis justifies the pivotal role of the project manager. This is due to the fact that the project manager is the person who has the expertise to identify sources of potential distortions and put into practice the corresponding tools and techniques so as to restore the original ‘project management triangle’ and maintain productivity at a high level.

1.2 Background, Personal Experience and Motivation

I have a Bachelor degree in civil engineering specializing in building construction. After completing my undergraduate studies, I acquired more than eight years of professional experience as a self-employed engineer and project manager. During my professional career, I completed more than 20 building construction projects and therefore I have gained first-hand experience as regards the problems that a construction project manager faces throughout the process of a project. My professional experience has taught me that the most important issues concern the waste of resources related to the elements of the ‘project management
How can Earned Value Management and Lean improve a project management system in the construction industry?

SSM case study

triangle’ which result in a distortion of its ex-ante shape. I also realized that the need of controlling the triangle and give a permanent solution was increasing with the complexity of the projects. Hence, my practical experience goes hand-in-hand with the findings of the literature in terms of the challenges faced by a construction project manager.

1.3 Contact with ‘Earned Value Management’ and ‘Lean’ Thinking

Since September 2013, I am pursuing a Master of Science in ‘Project Management and Operational Development’ at the Royal Institute of Technology (KTH). During this rigorous program, I developed a thorough understanding and a solid interest in the tools and techniques used in project management. Most of those tools and techniques aim at the improvement of the quality while keeping always in mind the initial time and cost.

To my opinion, the two most effective methods that are available to a project manager are the following: the ‘Earned Value Management’ (EVM) and the ‘Lean’ thinking.

On the one hand, EVM is a practical forecasting tool that focuses on the time schedule and the cost of a project. It can be efficiently applied not only at any project but also at any stage of an underlying project even at the very early ones. Therefore, one of its main advantages is that it can give an accurate trend of how the project is performing in terms of time and cost from a very early stage. Its strong forecasting nature combined with its high degree of accuracy render the EVM also an effective communication tool. The EVM by providing accurate forecasting data creates a scope for corresponding actions from the management team in case the data show that the project will not be delivered within the planned time and cost.

On the other hand, Lean is a way of thinking developed and firstly implemented by Toyota. It then became popular and was embraced by manufacture and production-driven organizations and construction companies. In contrast with EVM, ‘Lean’ thinking is a more holistic approach that focuses on quality, time, cost and safety. It strives to achieve its objectives through among others developing internal and external communication and collaboration channels, standardizing the tasks assigned, focusing on the individual and eliminating wastes during the construction.

1.4 Why SSM

SSM is a building construction company that is mainly focused in the region of Stockholm. It was founded at the early 90’s by two entrepreneurs, Ulf Morelius and Ulf Sjöstrand and continues improving throughout all these years (SSM Företagspresentation, ULR: http://ssmfastigheter.se/, 22 April 2014). Having over 20 years’ experience in building construction, the company has been dealing with all kind of problems troubling the contemporary construction industry. The company has managed to overcome many of its problems related to project management and has consistently tried to find new ways and solutions to improve all corresponding processes (SSM Företagspresentation, ULR: http://ssmfastigheter.se/, 22 April 2014). With a business plan that involves a new vision of continuous improvement for the upcoming years, the need of controlling even more the ‘project management triangle’, is growing within the company.
SSM has attracted my attention as it is a dynamic construction company, adaptable to challenges and always opens to new ideas and developments in the field of project management. I share the company's values and interests and I believe that applying my professional experience and academic knowledge to its current management approach will be an interesting researching project benefiting both my professional development and the company itself.

1.5 Purpose

The purpose of this thesis is to propose ways to further develop the project management approaches already used by SSM. In order to achieve its objectives the thesis firstly, attempts to apply the EVM on an ongoing SSM project and proposes amendments to the monitoring and controlling system currently used by SSM; and secondly analyses and presents the benefits that the ‘Lean’ thinking could bring to the company. Furthermore, the thesis combines at a practical level project management methods with the aim to create a more effective project management system in terms of all dimensions of the ‘project management triangle’. All in all, the thesis addresses the following two questions:

- “How can Earned Value Management and Lean improve a project management system in the construction industry?”
- “How can Earned Value Management and Lean help to maintain the ex-ante agreed shape of the ‘project management triangle’ in the construction industry?”

1.6 Limitations

After defining the purpose of the thesis the next important element which has to be defined is the thesis limitations. Purpose and limitations combined generate the scope of the thesis which clearly sets the boundaries of the analysis. The thesis limitations concern a difficulty in the implementation of proposed methods which stems from the fact that the project was already in an advanced phase. The advanced stage of the project is associated with a limited time period available for implementation combined with non-availability of all relevant data. As a result, a comprehensive implementation of the proposed project management system is not possible within the boundaries of this thesis. Hence, the thesis does not assess either quantitatively or qualitatively the practical effects of the proposed system in terms of controlling the ‘project management triangle’. Lastly, the thesis focuses on the planning and production processes of the project and does not take into account safety, the so-called fourth dimension of the ‘project management triangle’.
CHAPTER 2: METHOD

2.1 Methodology and Roadmap

The rest of the thesis is organized as follows. Chapter 2 presents the roadmap and methodology, engages in a literature review and briefly presents the company and identifies the key project management aspects that this thesis focuses on. Chapter 3 presents the EVM and the ‘Lean’ thinking approaches from a literature standpoint. Chapter 4 is divided in two parts. The first part, presents the current approaches at a practical level used by the SSM to monitor and control the development of the ‘project management triangle’ throughout a given project. Furthermore, it attempts to practically apply the EVM on an ongoing SSM construction project. The second part of Chapter 4 engages in a similar analysis at a more theoretical level and highlights that although the ‘Lean’ thinking is part of the SSM management project strategy its application remains limited and segregated. Chapter 5 presents the main argument which is based on a synthetic, combining approach between theories and practice, in other words between ‘Lean’ thinking and EVM, in order to address the research question. Chapter 6 recapitulates and concludes.

2.2 Validity and reliability

The validity of this thesis is supported from the following factors. As the author was based in SSM during the compilation period, all relevant data and information used were collected either through interviews held with SSM employees or directly via the company's software databases without the intervention of external sources. Therefore, the process of data collection is reliable. Moreover, the data per se are also reliable as on the one hand, interviews were held with SSM experts and members of the project management team and on the other hand, data extracted from databases were produced by SSM existing reliable cost controlling method as the thesis argues in chapter 4.

2.3 Literature Review

2.3.1 Earned Value Management

PMBOK (2013) defines a successful project as the one which the project manager manages to finish within the programmed time, the programmed cost and with the quality expected from the customers. The same approach we find from Forbes and Ahmed (2011), mention that the project manager should be able to keep the balance between those constrains. Antvik and Sjöholm (2012) take a more nuanced approach and discuss the priorities among those elements, highlight that priorities are different from project to project and show how this can affect the balance among them. Philipson and Antvik (2012) adopt a more practical approach by presenting the different shapes that the ‘project management triangle’ can take, depending on the element that has the problem each time.

Antvik and Sjöholm (2012) acknowledge also the need of a tool that can predict and help the project manager to have a clearer view of the project. Consequently, they propose the ‘ten step’ model of planning and implementing a project, widely known as the EVM ‘ten step’ model. The same approach can be found in other sources, among them Humphreys and
How can Earned Value Management and Lean improve a project management system in the construction industry?

**SSM case study**

Associates (2013) and Kojter et al. (2011), which present a slightly modified version of a step by step model. One should consider though that EVM can be found in some sources as a separate tool that does the same job without the ten step model. At a more practical level, PMI (2005) and US DoD (2006) published respective books with a view to explain how EVM can be used.

An extensive literature has been developed as regards the advantages of EVM in the field of project management. Forbes and Ahmed (2011) argue that the EVM is a very important tool for modern constructions. Fleming and Koppelman (1996) as well as Philipson and Antvik (2012) present many of EVM's advantages. Christensen (1998) states that the tool was first developed from the US DoD and that nowadays it is widely accepted and acknowledged by many organizations all over the world. Kojter et al. (2011) go into detail and mention a number of prominent institutions and organization that have embraced EVM such as the PMI, AACEI, NDIA, PMSC, ANSI, and IPMC. Similarly, the Humphreys and Associates (2012) mention among others the DoD, NASA, DoE, DHS, FAA, DoT, the intelligence community and HHS.

### 2.3.2 Lean

At a more theoretical level, Liker (2004) presents the 14 principles that the Toyota is using as a way of thinking in terms of project management. These 14 principles form the basis of what is widely known as ‘Lean’ thinking. Throughout the years, however more principles have been developed, for instance, the Engineers Australia (2012) guiding principles or the Womak and Jones principles. Lichtig (2005) argues in favor of about five big ideas in the construction industry that are based on ‘Lean’ thinking. Forbes and Ahmed (2011) after presenting some of the common problems in the construction industry, apply some fundamentals principles of ‘Lean’ thinking in the area of the construction industry. Those principles focus on waste areas that might appear during the construction of a project.

There are many tools and techniques which a project manager can apply in order to eliminate or reduce the aforementioned wastes. Many of those tools, techniques, applications and ways of thinking are found in Forbes and Ahmed (2011) as well as in Ortiz (2006), in Engineers Australia (2012) and in Liker (2004). Lean is one of those methods which give emphasis on keeping a balance between the time, cost, quality and safety of a certain project. Deming (1986) analyses the 14 steps which as he argues, if followed, result in a high quality project. He also identifies and characterizes the 7 deadly diseases that should be avoided during the process of a project. Forbes and Ahmed (2011) present those principles from a construction industry standpoint and highlight the importance of safety on site, the potential waste that safety can create and the ability of ‘Lean’ thinking to improve the level of safety.

Both Liker (2004) and Forbes and Ahmed (2011) analyze the steps that a company should follow in order to implement ‘Lean’ thinking as a project management method in the field of construction. Among others, they specify where the focus should be placed and who should be involved in the implementation process. Lastly emphasize on the significance of the company's willingness to change the state of play in project management so as to develop a more holistic and dynamic of thinking.
How can Earned Value Management and Lean improve a project management system in the construction industry?

SSM case study

2.4 Company

SSM is a construction company founded in 1993 by two entrepreneurs, Ulf Morelius and Ulf Sjöstrand, who shared common values. According to the SSM business plan, as published in its official webpage, Ulf Morelius argued that the necessary conditions are met for SSM to become the leading company in its field (SSM Företagspresentation, ULR: http://ssmfastigheter.se/, 22 April 2014). He also defined his vision as a synonym of improvement and innovation. Ulf Sjöstrand's vision has a more practical dimension and focuses on building the right organizational structure so as to add value at the construction industry. The development of the company is a continuous interaction with operators, property owners, financiers and competitors.

At the beginning of 2013, SSM adopted its new business plan which emphasizes the need and determination for continuous improvement. It also aims at establishing and reinforcing the company’s position in the market for both after request and ready-made affordable properties in the area of Stockholm. Moreover, it elevates the importance of expanding and securing a more efficient process flow and of empowering the company with more experienced and skilled personnel.

Looking at the company's SWOT analysis we can find its Strengths, Weaknesses, Opportunities and Threats. According to this analysis, SSM's strengths include a good portfolio in terms of construction projects, a highly satisfactory sales rate combined with a good location of upcoming projects and an increasing request for new apartments. As far as opportunities are concerned, the company can take advantage of and profit from the improving favorable conditions for new investments, the new developments in finance, the new properties to be acquired and the current low interest rates. In terms of threats, the company faces the continuous change of the regulations regarding the construction industry and the increasing competition. Finally, the SWOT analysis shows that SSM's main weaknesses are the absence of a detailed planning process which results in low quality, high cost and excess time issues. This thesis, explores the possibility of effectively dealing the main weaknesses of SSM by using a combination of project management methods.
CHAPTER 3: LITERATURE

3.1 Earned Value Management

From the beginning of a project and throughout all its stages, the project manager and the project management team have to address many questions. The most common questions are those who deal with the time schedule and the projected cost of the project. For instance, are we ahead or behind schedule? How efficiently are we using time? When will we likely finish the project? Are we under or over budget? How efficiently are we using our resources? How efficiently must we use our remaining resources? How much is the project likely to cost? Will we be under or over budget at the end of the project? How much will the remaining work cost? (PMI, 2005: 16).

Therefore, being able to forecast time and cost in projects and give an answer to the above questions, with accuracy, is crucial for any project manager. EVM is a very powerful tool which is able to address the above questions and thus substantially benefit the project manager and the project management team.

EVM consists of ten steps which are known as the ten steps of EVM. The first six steps concern the planning phase of the project and the next four focus on the project implementation (Antvik, 2013: 44).

The ten steps of EVM are:

3.1.1 Step 1: Define the Objectives of the Project

The first step considers the definition and specification of the objectives. As Antvik and Sjöholm (2012: 59) argue the needs, the requirements and the expectations of the stakeholders must be used as the basis to set the objectives. In the same vein, Kerzner (2009: 296) argues that there must be at least one objective to any project and that this objective must be clear and known to all participants. The reason is that poor communication leads to unclear objectives and unclear objectives can cause the failure of the project. Furthermore, unclear objectives lead to conflicts and struggles which makes it almost impossible to define the roles and the responsibilities clearly (ibid: 211, 212).

The objectives show what needs to be done and what is kind of information is valuable to the customers, to the members of the team and in general to all interested parties regarding a project (Antvik and Sjöholm, 2012: 59). Some of the critical questions that should be answered so as to define the objectives of a project are ‘what needs to be done?’, ‘why does the project need to be carried out?’ and ‘how are we going to achieve the strategic goals?’(ibid: 60).

The objectives of a project can be divided into stage objectives or partial objectives, depending on how large the project is and of how many smaller projects it consists. An effective way to remember the objectives is by using the acronym SMART, which stands for Specific, Measurable, Accepted, Realistic and Time limited. Specific refers to the fact that the objectives should be described in a certain way; Measurable refers to the fact that they should be comparable; Accepted refers to the fact that the objectives should be accepted by all
How can Earned Value Management and Lean improve a project management system in the construction industry?

SSM case study

involved parties; Realistic refers to the fact that the objectives should be reasonable and thus feasible; and lastly, Time limited refers to the fact that the objectives should have a deadline in terms of time (Antvik and Sjöholm, 2012: 62, 63).

As objectives refer primarily to the three dimensions of the ‘project management triangle’ one could argue that objectives are also exhibiting trade-offs among each other. Therefore, it is crucial that objectives are also prioritized following the relative weight given among quality, time and cost (Maylor, 2010: 54).

3.1.2 Step 2: Scope (Work Breakdown Structure WBS)

The second step of EVM, known as the scope of the project, includes all the individual work which is required for the completion of the project. It is very crucial to set the scope of the project as it makes it easy for everybody to know not only what needs to be done but also what is outside of the scope of the project. The main benefit of clearly defining the scope is that it provides all involved parties with a direction and a corresponding guidance for the development of the project (PMI, 2013: 105). This step also provides information about how the scope will be defined, controlled, monitored, developed and verified (ibid: 107, 108).

According to Antvik and Sjöholm (2012: 65) an efficient and commonly used structure to define the scope of a project is to analyze and interpret it in terms of the three elements of the ‘project management triangle’.

In order to start developing the scope accurately, a project manager must take under consideration the needs and the requirements of key stakeholders, such as customers, owners, shareholders etc. (PMI, 2013: 110, 111). That means that there has to be a clear view of what will be excluded as well as of what will be included in the scope of the project (ibid: 120, 121). The scope should also be validated with a formalizing acceptance of what the project will deliver. This could take place in parallel with the quality control process (ibid: 133, 134). Last but not least, the scope itself should be controlled and monitored. This way all necessary changes and recommended actions can be effectuated so as to maintain the scope unchanged throughout the project (ibid: 136, 137).

The Work Breakdown Structure (WBS) is a useful tool which aims and achieves a better definition of the project scope by giving a detailed description to all parties involved of what needs to be done (Antvik and Sjöholm, 2012: 66). From a general point of view, WBS breaks down the work of the project into smaller pieces/elements, which are easier to manage and control. As the work breaks down from bigger pieces/elements to smaller ones, called work packages, the cost, the resources and the time schedule of each part becomes visible (ibid: 67). A code number is used for each of these elements, in order to identify all different parts of the project. Furthermore, WBS is supplemented by a WBS Dictionary, which is a document providing even more detailed information for each piece/element of the WBS. Among other types of information it contains quality criteria, needed resources, milestones, work description, schedule activities etc. (PMI, 2013: 132).

3.1.3 Step 3: Organization Breakdown Structure (OBS)

The third step, is called the Organization Breakdown Structure (OBS), and is the organization chart of each company presenting its personnel. As far as it represents the organization
SSM case study

structure of a company, OBS contains the departments involved in a project and their respective domain as well as the names and the specific occupation of all involved employees that are taking part in the project (PMI, 2013: 261). Therefore, as PMI argues it represents the relationship between the activities of a project and the units and persons that will perform these activities (PMI, 2013: 548).

3.1.4 Step 4: Responsibility Assignment Matrix (RAM)

The Responsibility Assignment Matrix (RAM), the fourth step of EVM, is a communication tool, which communicates what needs to be done and by whom in a project. RAM connects the work packages resulting from WBS with the team members and units that will be part of the project (PMI, 2013: 262). Therefore, one can argue that it brings together and synthesizes step 2 with step 3. Because of its nature RAM is considered very effective in terms of ensuring that no part of the project will be forgotten (Antvik, and Sjöholm, 2012: 45).

3.1.5 Step 5: Time Schedule

Every project has a time schedule that needs to be followed. This schedule includes all functions of a project such as policies, procedures, developments, management, execution, monitoring and control. After clearly defining the time schedule, the next step is the identification of activities and actions that should be adopted for the completion of the project. However, one should also notice two more dimensions that should be taken under consideration. These dimensions concern the close interrelation among activities and the estimation of necessary resources, in terms of material, human capital, equipment and suppliers (PMI, 2013: 141).

The use of the above combined with the WBS characteristics result in the calculation of the duration of each activity, taking under consideration the available resources and the desired quality (PMI, 2013: 165). This way the time that is required for the completion of each separate activity can be calculated (ibid: 167).

This phase of the project involves also uncertainties that could appear during the project's life cycle. Uncertainties are problematic by nature as they cannot be measured. This is the reason why additional time should be added in principle to the planning time schedule. The time addition can be done either at each phase of the project or only at the end of the project taking into account all the phases of the project in an aggregated manner (Antvik and Sjöholm, 2012: 110). However, it is crucial that this extra time is planned very carefully and also tailored according to each specific project and its underlying characteristics (ibid).

There is a variety of methods and tools that can be used so as to track the duration of the project. For instance, one could mention the activity list, the milestone plan, the Gantt chart and the network diagram. However, the specific method or tool that is used for a certain project depends on how well it fits and addresses other needs of the company (Antvik and Sjöholm, 2012: 110).

Finally, the time schedule of the project has to be continuously monitored, assessed and controlled throughout all the stages of the project by the manager and the project management team. A continuous monitoring is critical for identifying deviations from the ex-
How can Earned Value Management and Lean improve a project management system in the construction industry?

SSM case study

anted defined time schedule and therefore creates scope for the adoption of corresponding amending and corrective actions (Antvik and Sjöholm 2012: 115).

3.1.6 Step 6: Planned Value (PV)

The work that needs to be done, after being evaluated, is called planned value (PV) or Budgeted Cost of Work Schedule (BCWS) (Forbes and Ahmed, 2011: 36). PMI (2005: 7, 9) refers to PV as the actual work that needs to be done and establishes the time and the cost of all the tasks of a project. Other definitions interpret it as the baseline of the budget and the time of a project (Vanhoucke, 2009: 4) or the summarization of the performed budget for all the work scheduled and completed at a given point in time (Ernst, 2006: 91). Lastly, PV is also defined as the actual work which should have been accomplished, at a particular given moment, within the projects life cycle (PMI, 2013: 218).

Via WBS it is very easy to calculate the cost of each individual task of the project. This can be used as the base to monitor and control the budget of the project. PV can be the outcome of the combination between the budgeted cost and the time schedule of a certain project and therefore can be presented as an $S$ – curve in a two dimensional diagram with time at the horizontal axes and cost at the vertical. Many factors should be taken under consideration for the design of this curve, among others the total sum of all costs both from human and material resources needed for the completion of the project.

3.1.7 Step 7: Actual Cost (AC)

The seventh step of EVM is called the actual cost or as it known otherwise the Actual Cost of Work Performed (ACWP) (Ernst 2006: 91). The AC represents the cost which is recorded in practice and is related to the work that is performed during a certain period of time and as Ernst (2006: 91) argues it includes all possible costs incurred. In the same vein, PMI (2005: 8) argues that the AC is an indicator of the financial resources used for the completion of a specific work performed during a specific period of time. In a more contemporary definition, PMI refers to the AC as the realized cost that has been collected from the team, for a work that have been performed, during a specific period of time (PMI, 2013: 224).

It is crucial that the AC is directly compared to the budgeted cost under step 6 as calculated via the WBS (Ernst, 2006: 123). Hence, each company should have a reliable tracking system in order to accurately measure the AC (PMI, 2005: 3). This system must be capable of identifying all possible costs ranging from the cost of materials to costs related to human capital (Ernst, 2006: 123). One should notice at this point that as Ernst (2006: 8, 9) argues it is of high importance that the relevant data is collected properly from the company's accounting system so that the calculations are as accurate as possible.

Another critical dimension which should be taken under consideration is that the AC should refer to the same period of time as the achieved performance (Earned Value) (Ernst, 2006: 117) which is the eighth step of EVM. This results from the fact that there should be a relation between the work load that has already been completed during a fixed period of time and the cost of resources used for its completion. As Vanhoucke (2009: 129) argues this relationship should be stated very clearly.
How can Earned Value Management and Lean improve a project management system in the construction industry?

**SSM case study**

Finally, the most important step is to compare the AC with the PV so as to determine the relation between the amount of financial resources used in practice and the projected one. Graphically, this is done by placing the AC curve next to the S-curve representing the PV (Antvik and Sjöholm, 2012: 47). However, up to this point, there is no information regarding the work that was performed so far.

### 3.1.8 Step 8: Achieved Performance

The achieved performance refers to what has been delivered up to a specific point in time. It refers to the actual work that has been delivered in contrast to the planned performance, which refers to what should have been delivered according to the plan. The comparison between the achieved performance and the planned one can be depicted via the Gantt chart used also previously for the time schedule. The significance of this comparison is apparent as it allows for an early detection of what went wrong and therefore facilitates the adoption of the necessary corrective actions (Antvik and Sjöholm, 2012: 47).

### 3.1.9 Step 9: Value of the Achieved Performance

The ninth step of EVM refers to the evaluation of the achieved performance in financial terms, while using the budgeted cost as a reference. This is called Earned Value (EV) or Budgeted Cost of Work Performed (BCWP) and refers to the value of the work delivered during a specific period of time (Antvik and Sjöholm, 2012: 47). In other words, EV is the actual value of the work performed expressed as the planned value for the same work (PMI, 2005: 8). Lastly, as Ernst (2006: 91) argues EV is the value of all the work that has been completed up to a specific point in time expressed in terms of the budgeted value for the same work.

As already mentioned above the calculations for the EV should be done for the exact same period as the calculations for the actual cost of the project. This budgeted cost of the work performed so far should be shown in the same S-curves that we mention before. At the end we will have three curves at the same figure to compare, the PV, the AC and the EV.

The difference between the AC and the EV is the Cost Variance (CV). The CV shows the added valued of the work performed. The difference between the PV and the EV is the Schedule Variance (SV). The SV shows the time needed to finish the job compared to the ex-ante planned time. The Cost Performance Index (CPI) and the Schedule Performance Index (SPI) are used for the prediction of the final cost and time needed for the completion of the project, if the work continues to be performed at the same pace (Antvik and Sjöholm, 2012: 142).

### 3.1.10 Step 10: Analysis

The tenth and last step of EVM is the analysis of the findings of the aforementioned steps. After the calculation of all above parameters, we would be able to accurately predict from an early stage the final cost and time schedule of a project. Precisely, we could have four different scenarios resulting from the analysis, all of which are shown in figure 2 below. The first scenario (up and left), the worst case scenario, shows that the project is delayed and that it costs more than expected; the second scenario (down and left) shows that the project is
How can Earned Value Management and Lean improve a project management system in the construction industry?

**SSM case study**

completed within the planned deadline yet with an excess cost; the third scenario (up and right) shows that the project is delayed but yet costs less than expected; and lastly, the fourth scenario, the best case scenario which is the rarest of all, shows that the project is completed within the expected deadline and cost projection.

![Figure 2: Four different scenarios of EVM](http://www.pmknowledgecenter.com/dynamic_scheduling/control/earned-value-management-overview-project-performance-scenarios, 23 April 2014)

**3.2 EVM’s Planning Phase (Step 1 – 6)**

The planning phase of a project incorporates the first six steps of EVM. All of them are equally important for the project. The planning phase starts with defining the objectives and the scope based on the WBS and then moves on to combine the WBS with the OBS in order to create the RAM and assign specific responsibilities to the personnel. Lastly, it includes the Gantt chart which is able to track time developments and the PV which serves as a reference to be used for a three-dimensional comparison with the AC and the EV.

**3.3 EVM’s Implementation Phase (Step 7 - 10)**

The last four steps of the EVM take place at the implementation phase of a project. This phase starts with the calculation of the AC, moves to the calculation of the EV so as to once again to enable a three-dimensional comparison among the AC, the EV and the PV. Such a comparison is crucial for every project manager and every project management team as it
How can Earned Value Management and Lean improve a project management system in the construction industry?

SSM case study

represents a reliable method of early problem identification which can lead to the adoption of corresponding corrective actions and provide answers to questions as those shown in table 1.

<table>
<thead>
<tr>
<th>PROJECT MANAGER QUESTIONS</th>
<th>ANSWERS FROM EVM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Questions Concerning Time</td>
<td>Schedule Analysis</td>
</tr>
<tr>
<td>Are we ahead or behind schedule?</td>
<td>SV=EV-PV or SV(%)=SV/PV (%)</td>
</tr>
<tr>
<td>How efficiently are we using time?</td>
<td>SPI=EV/PV (%)</td>
</tr>
<tr>
<td>When are we likely to finish work?</td>
<td>EACt=(BAC/SPI)/(BAC/MONTH)</td>
</tr>
<tr>
<td>Questions Concerning Cost</td>
<td>Cost Analysis</td>
</tr>
<tr>
<td>Are we under or over budget?</td>
<td>CV=EV-AC or CV(%)=CV/EV (%)</td>
</tr>
<tr>
<td>How efficiently are we using our resources?</td>
<td>CPI=EV/AC</td>
</tr>
<tr>
<td>How efficiently must we use our remaining resources?</td>
<td>TCPI=(BAC-EV)/(BAC-AC)</td>
</tr>
<tr>
<td>What is the project likely to cost?</td>
<td>EAC=BAC/CPI</td>
</tr>
<tr>
<td>Will we be under or over budget?</td>
<td>VAC=BAC-EAC or VAC(%)=VAC/BAC</td>
</tr>
<tr>
<td>What will the remaining work cost?</td>
<td>ETC=(BAC-EV)/CPI</td>
</tr>
</tbody>
</table>

Table 1: EVM and basic Project Management Questions (PMI, 2005: 16)

3.4 EVM's Benefits – Recognition – Usage

Fleming and Koppelman (1996) argue that the EVM is a very powerful tool and among others mention the following benefits: it provides the management team with reliable data for further analysis which can result in an early warning indication in terms of cost, time schedule and performance (Christensen, 1998: 10). Moreover, as Philipson and Antvik (2012: 54, 55) argue the EVM also ensures that the project manager can been warned from an early stage of the project and hence it reduces stress, it increases profit and it facilitates the monitoring and control of the project. Lastly, EVM is deemed necessary for proactive actions and for risk management analyses (GAO, 2009: 23).

EVM is recognized as an important project management tool by organizations such as: the Project Management Institute (PMI), Association for the Advancement of Cost Engineering International (AACEI), National Defense Industrial Association (NDIA), Program Management Systems Committee (PMSC), American Standards Institute (ANSI), and International Performance Management Council (IPMC) (Kojter, et al, 2011: 5).

Finally, EVM is practically incorporated in the project management strategy of the following organizations: Department of Defense (DoD), National Aeronautics and Space Administration (NASA), Department of Energy (DoE), the Intelligence Community, the Department of Homeland Security (DHS), the Federal Aviation Administration (FAA), the Department of Transportation (DoT), Health and Human Services (HHS) (Humphrey and Associates 2012: 1).

3.5 ‘Lean’ Thinking

As showed above the EVM is mainly used for the identification of cost and time issues and therefore effectively addresses two of the three dimensions of the ‘project management triangle’. However, ‘Lean’ thinking is a less practical and more holistic approach of project
How can Earned Value Management and Lean improve a project management system in the construction industry?

SSM case study

management which highlights the necessary methods and techniques in order to maintain the quality of the project at a high level. ‘Lean’ thinking was first developed from Toyota and then expanded to the manufacturing and the production industry. The need to control the quality of a project and find a well-functioning balance among the three dimensions of the ‘project management triangle’ brought ‘Lean’ thinking to the construction industry as well.

3.5.1 The ‘Toyota’ Way

As already mentioned above, the ‘Lean’ way of thinking was firstly introduced by Toyota with the Toyota Production System (TPS). This system was developed by Toyota between 1950 and 1975. Dr. Liker (2004: 35-42) developed and presented 14 principles as following:

1. Adopt a long term philosophy regarding your management related actions and decisions. According to Lean's premises, all parties involved should believe in themselves, accept their responsibilities and continuously try to improve their skills. Furthermore, develop trust and mutual respect so as to produce value for the customers while being patient is a key issue.
2. Maintain a continuous process flow in order to bring problems to the surface. Redesign the processes in order for resources and information to move faster in the organization. This way the flow will be continuous and the problems will be more evident and clear.
3. Try to use the pull system and not the push, in order not to have overproduction. This implies providing customers Just In Time (JIT) what, when and much they want. Minimize the stock by paying close attention to customers' demands.
4. Level off the work. Work like a turtle and not like a rabbit. Do not overload the people and the used equipment and try to keep the scheduled balance.
5. Adopt a way of thinking that focuses not only on identification but also on a quick solution regarding the problem at stake in order to safeguard the quality of the project at stake. Involve everyone to the quality control and stop or slow down the work to achieve quality. Create a system which can alert for the problems and a team able to support and solve them.
6. Standardize all tasks and actions. Find the best practices and standardize them as a stable method creates a stable timing and a stable output. However, allow and encourage creativity and expression so as to support improvement.
7. Create a visual control system in order to have a clear understanding of all problems. Be concise and to the point by producing single pages reports so as to avoid time inefficiency.
8. Use only technology that has been tested before and is considered reliable. Conduct tests regarding any available new technology that could be also used and if it proves reliable, modify the current one if necessary while trying to maintain the flow.
9. Create leaders who master the work and understand the vision and the philosophy of the company. Be proactive so as to take advantage of them as they could be good teachers.
10. Channel the company’s culture to the people and to the teams. The culture should be strong and able to survive for many years. Train and educate people towards this philosophy. Train and educate people to work together as cross function teams in order to improve the quality of the project outcome.
How can Earned Value Management and Lean improve a project management system in the construction industry?

SSM case study

11. See your partners as part of the organization, trust and respect them. However, challenge them so as to develop and grow together.
12. Be proactive in terms of personally observing a problem by being involved directly in identifying and analyzing the origins of a problem in order to have a clear view of it.
13. Consider all available and feasible opinions before making a decision.
14. Continue improving the structure of the organization and always be open and flexible towards new ideas and developments. Detect problems, identify their root causes, discuss alternative solutions, evaluate them, make a rational decision and lastly standardize the procedure. Apply the continuous improvement tools to all processes.

3.5.2 Lean Construction

The application of Lean to the construction industry has resulted in the development of various new principles. For instance, according to Engineers Australia (2012: 4, 5) Lean should also promote principles that can challenge the status quo of a company, map the value and strive for perfection on a daily basis. Similarly, Lichtig (2005 cited in Forbes and Ahmed 2011: 68, 69) argues that when Lean is used as a management method in the construction industry it should incorporate also the following five principles: a close collaboration between all involved parties (e.g. designers, builders, owners); a continuously growing relationship between all the above parties; a commitment between them; a collective approach that emphasizes the optimization of the project and refrains from personal interests and lastly a connection between the acting and the learning.

However, there seems to be a consensus among scholars and organizations in terms of the five fundamentals principles Lean has to follow when applied at the construction industry. Following Forbes and Ahmed (2011: 66) these principles are:
1. Focus on the customer;
2. Maintain focus on the individuals and on the vision of the organization;
3. Organize and standardize the working environment;
4. Eliminate all wastes and continuously improve the work.

3.5.3 Waste Areas – Waste Management

As far as wastes during a construction project are concerned, Lean acknowledges that wastes are diffused among all processes and thus interrelated. However, it is widely accepted that those wastes can be classified in seven distinct and one general waste area. According to (Forbes and Ahmed, 2011: 63, 64, 65) those areas are: overproduction, time wastes, transportation wastes, processing wastes, inventory wastes, operation motion wastes, defective work and lastly other waste areas including insurance wastes and wastes related to the inability of identifying individual skills.

In order to identify and eliminate the above wastes, Lean provides the project manager and his team with a number of tools and techniques. Some of those tools and techniques are useful for the diagnosis of a problem while others are useful for the organization and the standardization of the work.

The most important of those tools or techniques are the following:
How can Earned Value Management and Lean improve a project management system in the construction industry?

SSM case study

1. The 5 why analysis. Simply by posing the question “why” for approximately five times the manager can identify the root causes of the underlying problem and therefore effectively deal it (Forbes and Ahmed, 2011: 112). A similar “why” approach is followed by tools such as the prioritization root cause matrix and the fishbone diagram (ibid: 265-267). However, those two tools are more sophisticated as they take into account the division of the overall project into smaller pieces/elements, known as manpower, machines, materials, methods, measurements and environment, so as to reach a more precise conclusion in terms of the root cause (ibid.).

2. Value stream mapping. It consists of a method that aims to provide the project manager with the tools necessary so as to assign tasks efficiently among the personnel based on their individual potential (Forbes and Ahmed, 2011: 117).

3. Kaizen methodology. This methodology presents a number of distinct actions that are crucial for the efficient completion of the project such as a continuous daily effort to eliminate wastes, a well-functioning intra-company communication and regular meetings (Ortiz Chris A., 2006: 7, 8, 9).

4. A3 report. It is a report drafted in an A3 paper and contains the background, the current conditions, the goals, the root cause analysis, the Plan-Do-Check-Act or PDCA cycle, the effect confirmation and the actions to follow (Forbes and Ahmed, 2011: 124).

5. Supply Chain Management. It is a system that promotes sharing of all kind of information among the members of a project. Information about resources, people, problems, performance among others. All parties involved share the same commitment, schedule and vision (Forbes and Ahmed, 2011: 128).

6. Information and Communication Technology (ICT). This is an approach that organizes and standardizes the work with the use of technology, computer software and internet. (Forbes and Ahmed, 2011: 203). The Building Information Modeling or BIM is part of the ICT. According to BIM the decision regarding the common software which is to be used by the team members should be made on a collective consensual basis (Engineers Australia, 2012: 16).

7. 5S method. This method uses 5 words that start with an S on an everyday basis. The 5S are the following: Sort refers to keeping the unnecessary items out of the way; Straighten refers to organizing in the best way the remaining parts; Scrub or Shine refers to keeping everything clean; Standardize work; and Sustain refers to retaining the flow (Ortiz Chris A., 2006: 39).

8. Just In Time (JIT). Is a way of thinking that emphasizes customers' needs and expectations by replying to the question of what, when and how much a customer needs the product or service (Engineers Australia, 2012: 74).

9. Continues improvement of the PDCA cycle as mentioned above.

3.5.4 Quality Improvement

Lean, as a holistic way of project management thinking, prioritizes the quality of the project outcome. Deming (1986: 23, 24) proposed the 14 principles that a project manager should follow so as to safeguard the quality of the underlying project. These principles, as adapted to the construction industry by Forbes and Ahmed (2011: 234, 235), are:

1. Create a program focused on the continuous improvement of the final product or service.
How can Earned Value Management and Lean improve a project management system in the construction industry?

SSM case study

2. Streamline and update this program based on the philosophy and the vision of the company.
3. Base the quality on the everyday performance of the personnel and not scarce inspections.
4. Build a relationship of trust with the suppliers that provide the best quality of inputs.
5. Design and construction should improve continuously.
6. Focus on continuous on-the-job training.
7. Leaders and top managers should set an example for the commitment to quality.
8. Create stability in the working environment in order to improve productivity.
9. Remove barriers between departments in order to increase inter-department collaboration.
10. Treat employees on an equal basis by removing personal targets.
11. Introduce clear uniform standards in terms of quality, time, cost and safety.
12. Provide the employees with the necessary supervision, information and resources.
13. Create an educational program for everyone.

Deming (1986: 97, 98) also highlighted that a project manager should avoid seven specific actions which can reduce the quality of the project. These seven actions, known as the seven Deadly Diseases, are presented below as developed again by (Forbes and Ahmed, 2011: 235).

1. Lack of stability.
2. Focus on short term profits.
3. Evaluate by performance.
4. Flexibility of management.
5. Focus only the visible figures.
6. Over budgeted cost of insurance.
7. Over budgeted cost warranties.

The most important practical tools to improve quality are the ISO standards, the Monte Carlo simulation and the six-sigma method.

3.5.5 Lean Implementation

However, at this point it is crucial to acknowledge that the inclusion of ‘Lean’ thinking in a company's project management strategy relies heavily on nine parameters developed by Forbes and Ahmed (2011: 133, 134). Those parameters are:

1. There should be willingness and a commitment to change on behalf of the company.
2. There should be a training and educational program available to all.
3. There should be a consistent program focused on improving quality.
4. There should be a uniform, collective view in terms of the vision and the culture of the organization.
5. There should be a specific, detailed plan regarding the reduction of waste and the stabilization of safety.
6. There should be a plan for cost and performance measurement.
7. There should be a collective commitment from all involved to implement ‘Lean’ thinking in all processes.
8. There should be a sufficient level of trust among all parties involved.
How can Earned Value Management and Lean improve a project management system in the construction industry?

SSM case study

9. Technology information systems should be used in order to enhance intra-company cooperation.

3.6 Lean’s benefits – recognition – usage

According to the Lean Construction Institute (LCI), Lean is an effective method that can be used so as to manage constructions (Forbes and Ahmed, 2011: 45). The Construction Industry Institute (CII) argues that Lean is a method which focuses on continuous improvement of processes and deals with the waste in constructions, helps to meet the customers' needs and expectations and always pays attention to the value stream (ibid.). Koskela (2002 cited in Forbes and Ahmed, 2011: 45) argues that Lean is a system that minimizes the waste in order to produce the maximum amount of value.

Lean construction provides for a solid answer to some of the most important problems of the construction industry as it can lower the cost of the project, decrease the delays in terms of time, decrease the wastes related to the project and lower the level of uncertainty as regards the final outcome of the project (Forbes and Ahmed, 2011: 57).
How can Earned Value Management and Lean improve a project management system in the construction industry?

**SSM case study**

**CHAPTER 4: SSM CASE STUDY**

The thesis uses as a case study a project which has been randomly selected by SSM so as to avoid any potential bias. This project, named Kungsterrassen by SSM, is a building at the stage of construction in the Stockholm area.

**4.1 Case Study Roadmap**

The methodology used by this chapter is the following: firstly, the thesis presents the method currently used by the company; secondly, it attempts to apply the EVM ‘ten step’ model to an ongoing project; and thirdly, it compares the findings of the above methods. In order to facilitate the comparison, the thesis presents the existing method using EVM terms. Lastly, by using the same approach and by interviewing people from the company, the thesis attempts to explore whether, and if so how, SSM implements already a ‘Lean’ way of thinking.

**4.2 SSM’s Method**

On the practical level, the project management method currently used by SSM for the completion of Kungsterrassen can be described as follows.

**4.2.1 Process Map**

The processes that SSM is using, which are the same for all projects, are divided into five different stages. The first stage presents the idea for a new project and is followed by the second stage which includes the acquisition of the area where the project will develop. The third stage is the planning process which is divided into sub processes and the fourth stage is the actual production of the project. The final stage is the guarantee policy of the company regarding all its projects. A visualized view of those processes can be found in figure 3 below:

![Figure 3](https://via.placeholder.com/150)

**Figure 3**: Processes mapping based on data provided by SSM (Created with Microsoft – Visio 2013).
**4.2.2 Vision – Targets - Objectives**

Chapter 2 has already discussed the general SSM’s vision, targets and objectives as well as the new business plan and the separate targets that have been set for each department. However, as happens in every project, also for Kungsterrassen, the SSM has set distinct and clear objectives which are again divided among the SSM's departments. Those objectives include among others the need of the company to follow the rules, laws and the regulations, the good organization and the good team work, the professional behaviour towards the customers, the good information flow and zero mistakes and zero accidents. However, the most important objectives are a continuous focus on reducing and/or maintaining the planned budget, on clearly separating responsibilities and on the time schedule and the quality. Hence, one can argue that in Kungsterrassen SSM follows a strategy that aims to balance the three dimensions of the ‘project management triangle’.

**4.2.3 WBS – Time schedule**

Each department of SSM prepares a time schedule document based on data that the department collects separately and not via a common database. This document will be used by each department as a benchmark in terms of the time needed for the completion of the tasks assigned to it. This document can be perceived as a collection of Gantt charts where one can find corresponding charts for all the core processes of Kungsterrassen such as planning, purchase, finance, design and construction. Furthermore, in those charts one can also find a list of all works and activities necessary for the completion of Kungsterrassen. Therefore, in this case the time schedule document is also a very detailed WBS. Regarding the project planning process, shown in figure 3, although the project management team is able, if necessary, to monitor and control the time schedule that does not happen periodically. However, during the construction, a periodical check is carried out by the construction manager on-site. At this point it is crucial to take into account that there is no forecasting tool for the duration of Kungsterrassen. In order to solve related problems, the project management team deals with delays only ex-post, i.e. after they appear.

**4.2.4 Cost Control**

SSM's current project management strategy also gives emphasis on successfully controlling the cost of Kungsterrassen. Towards this direction, the project manager and his team have developed a system that not only monitors and controls Kungsterrassen’s programmed budget, but also forecasts its final cost. This system is depicted in a table (Table 2) which shows the data resulting from the time schedule, the WBS, the planned cost, the purchase value, the reserved value, the first cost forecast, the actual cost, the cost for the follow up and the final cost forecast of Kungsterrassen.

At this point, one should note that the above mentioned forecasts are based on data from similar previous projects, expert opinion, brainstorming and interviews. For the last forecast SSM takes into account collected data for the actual cost. This system is being updated and controlled every month by the project manager and the project management team.
How can Earned Value Management and Lean improve a project management system in the construction industry?

SSM case study

<table>
<thead>
<tr>
<th>ACCOUNT No</th>
<th>NAME</th>
<th>PLANNED VALUE</th>
<th>PURCHASE VALUE</th>
<th>RESERVE Cost</th>
<th>COST FORECAST</th>
<th>ACTUAL COST</th>
<th>FOLLOW UP</th>
<th>LAST FORECAST</th>
</tr>
</thead>
<tbody>
<tr>
<td>1234</td>
<td>Arch.</td>
<td>XX</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1235</td>
<td>Struct.</td>
<td>XX</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1236</td>
<td>Electr.</td>
<td>XX</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SUM DESIGN</td>
<td></td>
<td>XXXX</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2134</td>
<td>……..</td>
<td>XX</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2135</td>
<td>……..</td>
<td>XX</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SUM SALES</td>
<td></td>
<td>XXXX</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TOTAL SUM</td>
<td></td>
<td>XXXX</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 2: Cost Evaluation table based on data provided by SSM.

4.3 Earned Value Management in SSM

As already mentioned in chapter 3, EVM is an accurate forecasting tool for the control of cost and time. Therefore it would be interesting to see how the EVM could be applied in the case of Kungsterrassen and what kind of benefits could bring to it. However, the information needed for the implementation of EVM requires a specific method of data collection which is not used SSM. Moreover, the time restrictions of this thesis make it impossible to collect all relevant data and fully implement EVM on Kungsterrassen. Therefore, this thesis attempts to only partially implement EVM on Kungsterrassen and compare it accordingly with the existing project management method.

4.3.1 Objectives

Starting with the planning phase and following the first step of EVM the team must set the objectives of Kungsterrassen. As mentioned above, the objectives of Kungsterrassen were made clear towards everyone involved in the project. Therefore, one can conclude that SSM values the objectives of Kungsterrassen in the same way that EVM does.

4.3.2 Scope – WBS

The second step of the ‘ten step’ model is to find the scope of the project by creating a WBS. Again as already mentioned, SSM's time schedule document provides the same information as the WBS. Thus, one can conclude that EVM's second step is also part of the existing project management method.

4.3.3 OBS

The third step of EVM, namely the OBS, also exists in SSM.

4.3.4 RAM

The fourth step of EVM which is the synthesis of the second and the third step in a responsibilities assignment matrix is not explicitly part of the SSM's strategy even though according to SSM employees each of them has a clear view of its personal responsibilities.
How can Earned Value Management and Lean improve a project management system in the construction industry?

SSM case study

based on the OBS. Figure 4 below depicts a version of how RAM would look like for Kungsterrassen.

**Figure 4:** WBS, OBS and RAM proposal (Created with Microsoft – Visio 2013).

### 4.3.5 Time Schedule

The fifth step of EVM, the time schedule, is already incorporated in SSM’s project management strategy through a number of Gantt chart as argued before.

### 4.3.6 PV

The sixth and final step of the planning process of the ‘ten step’ model of EVM is the PV. However, as some departments of SSM do not specify ex-ante the duration of their tasks and simply refer to start dates it is impossible to collect the necessary data for the creation of the PV S – curve.

### 4.3.7 AC

Moving to the implementation phase, the seventh step of EVM is the AC. As already mentioned SSM is using a monitoring system for the actual cost that is updated every month. Therefore, they can have more accurate forecasting results for the final cost. Again and because of the lack of data concerning time, the design of the S – curve for AC according to the EVM premises was impossible.

### 4.3.8 Actual Work – EV

The eighth and ninth step of EVM, the EV and the actual work as presented in chapter 3, are closely related to each other. The follow-up of the actual work can be done via the Gantt chart. Once again the lack of data concerning the duration of each work combined with a non-periodically follow-up of the work already performed made it impossible to create the EV S – curve.
How can Earned Value Management and Lean improve a project management system in the construction industry?

SSM case study

4.3.9 Analysis

The last step is to calculate all the different parameters as those presented by table 1 in chapter 3. SSM is using a different but accurate method so as to calculate cost, which according to its experts has been very effective in all the projects that it has been implemented. For all aforementioned reasons, it was not possible to fully implement the EVM and obtain data for forecasting the time schedule and cost of Kungsterrassen.

4.3.10 Synopsis Table

<table>
<thead>
<tr>
<th>EVM ‘TEN STEP’ MODEL</th>
<th>SSM’S METHOD</th>
<th>COMMENTS FOR KUNGSTERRASSEN</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. OBJECTIVES</td>
<td>OBJECTIVES</td>
<td>Project objectives are clear to all departments.</td>
</tr>
<tr>
<td>2. SCOPE (WBS)</td>
<td>WBS</td>
<td>Detailed WBS for each department via a Gantt chart.</td>
</tr>
<tr>
<td>3. OBS</td>
<td>OBS</td>
<td>OBS is present.</td>
</tr>
<tr>
<td>4. RAM</td>
<td>RESPONSIBILITIES</td>
<td>Responsibilities stated in SSM’s OBS.</td>
</tr>
<tr>
<td>5. TIME SCHEDULE</td>
<td>GANTT CHART</td>
<td>Gantt chart for each department (not a standardized method for all departments).</td>
</tr>
<tr>
<td>6. PV</td>
<td>NO PV</td>
<td>No graphical depiction of time and cost in one diagram.</td>
</tr>
<tr>
<td>7. AC</td>
<td>AC</td>
<td>AC control at the company level every month.</td>
</tr>
<tr>
<td>8. WORK PERFORMED</td>
<td>NOT PERIODICALLY</td>
<td>Evaluated by the project manager and the construction manager.</td>
</tr>
<tr>
<td>9. EV</td>
<td>NO EV</td>
<td>No graphical depiction of time and cost needed for the work already performed in one diagram.</td>
</tr>
<tr>
<td>10. ANALYSIS</td>
<td>COST FORECASTING</td>
<td>There is an accurate controlling and forecasting tool concerning cost but not time.</td>
</tr>
</tbody>
</table>

Table 3: EVM ‘ten step’ model compared with SSM’s method.

4.4 Lean in SSM

Lean is a theoretical project management method which can be best characterised as a way of thinking as already analysed in chapter 3. From the research conducted by this thesis, it is clear that although the SSM project management team is familiar with Lean, the company does not officially incorporate Lean in its strategy and implements it on a limited basis. Therefore, Lean principles are present only in some of the SSM processes. Those principles are: a good communication and cooperation among the different departments, a clear and standardized method regarding the collection of cost data, a willingness to change and improve the underlying procedures and a constant strive to improve or maintain quality in processes.

However, ‘Lean’ thinking is fully taken into account by one SSM construction manager who broadly implements the Lean principles on his construction sites. The method he uses has been developed by him based on his personal experience, his observation and his attendance of Lean seminars. The aforementioned method is briefly presented below.
How can Earned Value Management and Lean improve a project management system in the construction industry?

SSM case study

The method clearly states the need to create a continuous flow, the need to avoid overproduction, the need for a quality-focused process from the beginning of each project, the need for a continuous improvement and the need to involve personnel in all processes. The method also specifies the steps that one needs to follow in order to implement it. These steps are: a productive and collaborative working relationship among all parties involved; a solid and viable ex-ante financial plan; accurate plans regarding time, used resources and the working conditions; as well as well-defined monitor, control and preparation plans.

A more detailed analysis of this method reveals other principles which can be linked to Lean. These principles are a clear state of responsibilities, a focus of the leadership on visualization and structured work and periodically meetings with all involved parties. Those meetings have a clear and specific agenda which ranges from the working environment, to the time schedule of the upcoming weeks and to answering personnel questions. Furthermore, the meetings of the managers follow the same standardized structure and mainly cover subjects related to production and quality. The time schedule is visually clear to everyone involved in a way which allows for everyone to make notes on it using colored paper – sticks.

Lastly, based on a similar structure the method used is enabling the provision of important data via the creation of a number of plans related to construction such as a transportation plan, a framework plan, a cleaning plan and so on. Moreover, the method also focuses on safety issues by including the safety rules along with a list of the most common construction accidents. The last pages of this methodology are dedicated to the customer and SSM corresponding quality promise.

4.5 Implementing Lean

Due to the limitations already mentioned in this chapter, this thesis proposes a Lean implementation based on a theoretical approach and attempts via this methodology to argue in its favour. One should notice at this point that a practical application of Lean would necessitate a change in the current project management strategy. A very important dimension in this respect is that this thesis finds that there seems to be a willingness on behalf of the management team to adopt the ‘Lean’ way of thinking in order to stabilize the working environment.
CHAPTER 5: ANALYSIS - PROPOSALS

As it is mentioned in chapter 2, SSM is a growing construction company with a focus on continuous improvement. Its project management team, coming from different backgrounds and companies in Sweden, has gained important experience in effectively managing a project. The system that its project management team has developed emphasizes the effective monitor and control of a project, in terms of cost – time – quality, throughout all its processes. This thesis focuses on improving and upgrading the existing system through a combination of practical and theoretical project management approaches, i.e. the EVM and the ‘Lean’ way of thinking. As already argued in Chapter 3, those two methods are accurate and if used and applied appropriately, they can improve the quality of a project while at the same time safeguarding the targets in terms of time and cost. Hence, this thesis argues that the combination of the above methods can provide a solid answer to the question of how to balance and control the ‘project management triangle’.

5.1 Roadmap

This chapter attempts to define and analyse some important problems that SSM currently faces and presents corresponding solutions based on a combination of the existing project management method, the EVM and the ‘Lean’ thinking. Those methods will later be used to create a new, unique and more standardize management system which aims at a more efficient and accurate control of the project. The scope of this chapter is to improve the quality of all related processes while eliminating the waste areas and controlling the cost and the time of a project. Based on the findings of the literature, as presented in chapter 3, the thesis argues that the combination of the aforementioned project management methods which focuses on a continuous improvement management system can lead to a better control of the ‘project management triangle’. The willingness of the company’s project manager and his team to change and to develop is the driving force which will urge SSM to improve its project management methods and therefore create value. This chapter starts by broadly defining quality in terms of planning and production, the two main processes found in the SSM map and depicted in figure 3; identifying potential risky areas; and proposing corresponding actions. However, the thesis takes into account Deming's (1986) argument which portrays quality as a multidimensional variable and therefore acknowledges the limitations of any detailed related definition.

5.2 Planning Process Proposals

As far as the planning process is concerned, quality can be perceived as the creation of a planning phase which is focused on a continuous improvement of the final product or service as regards all dimensions of the project management triangle. The way to achieve that is through identifying the root causes of the underlying issues and eliminating corresponding time, quality, cost and safety wastes. For instance, a problem which identified via the analysis conducted by this thesis refers to a huge waste of money and time during the design process. By applying the 5 Why’s analysis and asking the “why” questions to company experts, the thesis was able to identify a solid root cause. The causal relation which resulted is the following: the time and waste delay is due to a continuous rework of the design which is caused by a continuous change of plans. This change of plans largely results from the
company itself as the SSM did not have clear objectives of Kungsterrassen at the very early stages of its planning phase. Clearly setting the objectives of a project and deciding from its very early stages what needs to be done is a crucial step as acknowledged by the EVM ‘ten step’ model and Lean. Therefore, the thesis proposes to SSM to start its planning process earlier which will make sure that the objectives are clear before the beginning of the design process. The corresponding new process plan could look like the one in figure 5.

**Figure 5:** Processes mapping proposal (Created with Microsoft – Visio 2013).

### 5.3 Production Process Proposals

Moving to the production phase, quality can be defined in terms of safety and customer satisfaction deriving from the use of the final product. The thesis argues that the method presented in 4.2, as developed by an SSM construction manager, has proven to be efficient as far as achieving the desired outcome. However, there is scope for improvement and in this direction the thesis proposes a combination of the method with the tools and techniques presented in chapter 3 which will result in a substantial upgrade. Further developing this method and training accordingly all personnel involved in the projects, following a tailor-made approach, SSM could manage to improve quality even more while reducing time and cost wastes and keeping safety at high levels.

### 5.4 Data Collection and Control Proposals

Another important issue identified by this thesis analysis is the diverse method that each department uses so as to collect time data. Despite the fact that SSM already uses a common and unique way to collect data for cost there is no analogous collection method for time and therefore the certain and standardized principles of Lean do not apply in this case. In order to address this issue, the thesis proposes the use of a common software for all departments, which could function as an inside network (intranet). This proposal makes it possible for everyone involved in a project to upload and update relevant data. Furthermore, periodical updates can facilitate a more efficient and accurate time control. Hence, by applying this method SSM can manage to have a continuous flow in terms of project control, as it is depicted in figure 5 with the two cycles in each process.
How can Earned Value Management and Lean improve a project management system in the construction industry?

SSM case study

5.5 Forecasting Proposals

Moreover, the application of Lean principles in the process of collecting information will enable the project management team to obtain the data necessary for a time forecast with the use of EVM. Hence, table 2 can be updated by incorporating the extra variables and data of table 4.

<table>
<thead>
<tr>
<th>ACCOUNT No</th>
<th>NAME</th>
<th>EARNED VALUE</th>
<th>TIME %</th>
<th>SCHEDULE - AHEAD OR BEHIND</th>
<th>EFFICIENCY IN TIME</th>
<th>FINISH OF THE PROJECT</th>
</tr>
</thead>
<tbody>
<tr>
<td>1234</td>
<td>Arch.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1235</td>
<td>Struct.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1236</td>
<td>Electr.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SUM DESIGN</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2134</td>
<td>.....</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2135</td>
<td>.....</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SUM SALES</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TOTAL SUM</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Table 4:** Time evaluation table proposal

The method that SSM uses for forecasting cost can also be updated if combined with EVM. The result will be an augmented table 2 by the extra variables and data of table 5. Hence, also in this case the application of EVM can benefit the project management team.

<table>
<thead>
<tr>
<th>ACCOUNT No</th>
<th>NAME</th>
<th>BUDGET %</th>
<th>BUDGET – OVER OR UNDER</th>
<th>EFFICIENCY IN RESOURCES</th>
<th>COST FORECASTING</th>
<th>COST OF REMAIN WORK</th>
</tr>
</thead>
<tbody>
<tr>
<td>1234</td>
<td>Arch.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1235</td>
<td>Struct.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1236</td>
<td>Electr.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SUM DESIGN</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2134</td>
<td>.....</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2135</td>
<td>.....</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SUM SALES</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TOTAL SUM</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Table 5:** Cost evaluation table proposal

Both approaches were presented by the author to members of the project management team and received positive feedback. Hence, this thesis argues that there is scope for SSM to consider the application of such approaches.

5.6 Storing Knowledge Proposals

Combining expert opinion with the data collected from previous projects is widely accepted as one of the most critical knowledge areas of every company. In this respect, the thesis proposes again the introduction of common software accessed and updated by all involved
How can Earned Value Management and Lean improve a project management system in the construction industry?

**SSM case study**

parties. This software can contain valuable information such as relevant rules and regulations, directions, standardized positions, problematic areas, proposed corresponding solutions, position papers, questions and answers (Q&A) and thus act as a means to store knowledge. Moreover, such common accessible software can reduce the training time of new members and contractors.

**5.7 Communication Improvement Proposals**

Another important issue which this thesis addresses is the need for cooperation and good communication of all involved parties. The nature of construction industry, which includes a number of different but closely interlinked processes being carried out by different people, give to this need fundamental importance. As already mentioned in chapter 3 trust and mutual respect should grow at a continuous basis between all involved parties. Parties involved can refer to architects, engineers, designers, suppliers and so on and so forth. Furthermore, one should also note that these parties do not necessarily remain the same but rather can change from project to project which further complicates communication issues. For effectively addressing the aforementioned problems, the thesis proposes if possible for SSM to standardize its external partners and stakeholders so as to be able to build essential trust and respect. However, following Lean, in chapter 3, the relationship with those parties should not be treated as static but rather as a dynamic process of improvement based on a continuous positive challenge.

**5.8 Assignment of Responsibilities Proposals**

Despite the fact that so far the assignment of responsibilities has not caused any important issues, this thesis argues that the continuous complexity of projects combined with the increasing number of people involved over time will create a need for the adoption of a new and clearer strategy in this respect. RAM, as presented in the ‘ten step’ model of EVM, can be a very useful tool to help in this direction.

**5.9 Change Management Proposals**

The above proposed methods are able to solve some of the most important project management problems that SSM faces. However, their implementation will most probably bring to surface other problems which have been hidden so far. Therefore, they will spur a new cycle of discussions and productive dialog. However, it is crucial that the corresponding necessary changes follow the PDCA cycle. The PDCA cycle is described as: Plan the change, then Do it to see the results, Check if those results are according to plan and consistent with the desired outcome and Act by standardize the change or, if necessary, try another approach from the beginning.

**5.10 Training and Education Proposals**

Lastly, the thesis acknowledges the need for training and education program for all parties involved which will enhance the application of the all above proposed methods. Without such a program the effectiveness of the above methods will be of only limited value.
How can Earned Value Management and Lean improve a project management system in the construction industry?

SSM case study

5.11 Synopsis Table

<table>
<thead>
<tr>
<th>PROBLEM</th>
<th>PROPOSALS</th>
</tr>
</thead>
<tbody>
<tr>
<td>ROOT CAUSES PROBLEMS</td>
<td>5 WHY’S, FISBONE DIAGRAMM</td>
</tr>
<tr>
<td>DESIGN CAUSES DELAYS AND OVERBUDGET</td>
<td>EARLIER PLANNING PHASE</td>
</tr>
<tr>
<td>CONSTRUCTION WASTES</td>
<td>LEAN – STANDARDIZED WORK</td>
</tr>
<tr>
<td>TIME SCHEDULE CONTROL</td>
<td>COMMON SOFTWARE - INTRANET</td>
</tr>
<tr>
<td>TIME FORECASTING</td>
<td>EVM</td>
</tr>
<tr>
<td>KNOWLEDGE AND EXPERTS OPINION SHARING</td>
<td>COMMON SOFTWARE - INTRANET</td>
</tr>
<tr>
<td>COMMUNICATION IMPROVEMENT</td>
<td>TRUST BETWEEN INVOLVED PARTIES</td>
</tr>
<tr>
<td>RESPONSIBILITIES</td>
<td>RAM</td>
</tr>
<tr>
<td>NEW PROBLEMS</td>
<td>ROOT CAUSE ANALYSIS - PDCA CYCLE</td>
</tr>
<tr>
<td>CONTINUOUS IMPROVEMENT</td>
<td>TRAINING AND EDUCATION</td>
</tr>
</tbody>
</table>

Table 6: Problems and proposals

5.12 New Management System Proposal

A synthesis of best practices in the area of practical and theoretical project management methods will provide a solid answer to the SSM project management challenges and enable the company to develop its own management system. This management system will be unique as it would be developed according to SSM's needs and preferences.

The system could also include periodical meetings and brainstorming, Risk Analysis based on statistical tools such as the Monte Carlo simulation and the 6σ. By testing various methods, tools and techniques and keeping only those that address its needs and expectations, SSM could easily create a management system to eliminate waste and better address time and cost issues while improving at the same time the quality.

This system should be built on the premises of the SSM vision and culture which is based on a continuous focus on customers, employees and society. It should also be consistent with the new business plan terms of the targets regarding all dimensions of the project management triangle and safety. In addition, by following the principles of ‘Lean’ thinking and using the tools already mentioned it will succeed in standardizing the best procedure and create stability without neglecting the need for continuous improvement.

A visual depiction of such a system could be found below.
How can Earned Value Management and Lean improve a project management system in the construction industry?

**SSM case study**

*Figure 5: Management system proposal (Created with Microsoft – Visio 2013).*
CHAPTER 6: CONCLUSIONS – FURTHER RESEARCH

6.1 Conclusions

SSM is a dynamic construction company with a strong desire and willingness to grow and establish its position in Stockholm’s market. With a new vision and a corresponding new business development plan, the company is focusing even more on improving its processes and creating a stabilized, efficient working environment. With a strong attention to customers, employees and society, the company's main priorities are to improve quality, reduce time and cost wastes, establish safety and achieve all other targets of the new business plan. Furthermore, the need for a more effective control of the triple constrain triangle is constantly growing as SSM is continuously expanding. Therefore, the thesis proposes that SSM develops a new and tailor-made project management system which will be able to successfully address its needs and expectations. Such a management system could be the outcome of a combination of various best practices regarding project management methods, tools and techniques.

The thesis acknowledges that SSM is already using an accurate tool for forecasting and controlling project costs. However, it raises awareness in terms of the need to create and implement analogous methods for the other dimensions of the project management triangle, i.e. time and quality. As far as time is concerned, the thesis proposes EVM because of its ability to produce accurate forecasts from the very early stages of a project. Furthermore, EVM's flexibility enables the project manager to combine it with other tools and also to apply it in all the processes of a project. Flexibility and adaptability are also indispensable elements of the ‘Lean’ way of thinking. The adoption of Lean’s holistic approach will enable the creation of a new project management system which will improve early planning, deliver a communication and cooperation plan supporting teamwork, produce a more efficient and accurate identification and elimination of waste areas, suggest a better way for knowledge sharing and lastly, facilitate the development of an intra-company training and educational system accessible to all.

Returning to the questions addressed in chapter 1.5, the thesis argues that all methods presented, either those already used by SSM or those proposed by the thesis, can be efficiently combined in order to create a unique management system according to SSM's needs. Special focus should be placed on incorporating the whole spectrum of EVM while in parallel adopting a holistic project management approach based on Lean premises. The new improved management system should not disregard the existing one which fares well in terms of accuracy and reliability for cost projections and data. Hence, by integrating elements of SSM's currently applied project management method, EVM steps and Lean principles into a unique system the thesis argues that the new system can effectively control and maintain the ex-ante agreed shape of the ‘project management triangle’.

SSM should test various combinations of the methods, techniques and tools presented above in order to find the right balance among them, standardize the procedure and create stability. Based on a way of thinking which focuses on continuous improvement and is supported by its personnel and using a coherent, stable and dynamic management system, SSM can succeed in constantly faring better as regards all dimensions of the project management triangle.
How can Earned Value Management and Lean improve a project management system in the construction industry?

SSM case study

![Continuous improvement approach](Created with Microsoft – Visio 2013).

**Figure 6:** Continuous improvement approach (Created with Microsoft – Visio 2013).

### 6.2 Further Research

Finally, the thesis creates scope for further research at a theoretical level and further upgrade of the methods proposed at a practical level. On the one hand, future research should engage in further developing the proposed combining approach so as to identify new potential for improving performance and reliability. On the other hand, at practical level more case studies will be crucial so as to identify possible problematic areas of the approach and therefore propose corresponding amendments. Some of the questions that could be interesting for future developments are:

- “Does the actual implementation of a project management system based on a combination of existing methods result in an effective control of the ex-ante agreed shape of the ‘project management triangle’?” This would require a comprehensive quantitative and qualitative ex-post analysis.
- “How can the proposed project management system be expanded beyond the planning and production process?”
- “Does a cost-benefit analysis still support the implementation of the proposed project management method in economic and financial terms?”
- “How willing are construction companies to change the status quo regarding their project management system?”
- “How can the proposed system be upgraded with the integration of new methods?”
- “How can we incorporate the safety dimension of the ‘project management triangle’ in the proposed project management system?”
How can Earned Value Management and Lean improve a project management system in the construction industry?

SSM case study

REFERENCES

Books

Antvik, Sven (2013), Styrning av projekt – om användning och vidareutveckling av Earned Value, Stockholm, Management and Aviation

Antvik, Sven & Sjöholm, Håkan (2012), Project Management and Methods, first edition, Lund, Studentlitteratur

Deming, Edwards (1986), Out of the crisis, Massachusetts, Massachusetts Institute of Technology (MIT)


Kerzner, Harold (2009), Project Management – a system approach to planning, scheduling and control, tenth edition, New Jersey, Wiley publishing Inc.


Ortiz, Chris A. (2006), Kaizen Assembly – Designing, constructing and managing a Lean Assembly line, Boca Raton, CRC Press


Project Management Institute (2005), Practice Standard for Earned Value Management, Pennsylvania, Project Management Institute


Vanhoucke, Mario (2009), Measuring time, improving Project Performance using Earned Value Management, New York, Springer
How can Earned Value Management and Lean improve a project management system in the construction industry?

SSM case study

Articles


Engineers Australia (2012), Recommended Practices for the Application of Lean Construction Methods to Building New Australian LNG Capacity, Engineers Australia


Humphreys & Associates (2012), Basic Concepts of Earned Value Management, EVMS Education Center, Humphrey and Associates

Internet


How can Earned Value Management and Lean improve a project management system in the construction industry?

SSM case study

INDEX

AACEI Association for the Advancement of Cost Engineering International

AC Actual Cost

ACWP Actual Cost of Work Performed

ANSI American Standards Institute

BAC Budget At Completion

BCWP Budgeted Cost of Work Performed

BCWS Budgeted Cost of Work Schedule

BIM Building Information Technology

CII Construction Industry Institute

CPI Cost Performance Index

CV Cost Variance

DHS Department of Homeland Security

DoD Department of Defence

DoE Department of Energy

DoT Department of Transportation

EAC Estimate At Completion

EACt Estimate At Completion time

ETC Estimate To Complete

EV Earned Value

EVM Earned Value Management

FAA Federal Aviation Administration

HHS Health and Human Services

IC the Intelligence Community
How can Earned Value Management and Lean improve a project management system in the construction industry?

*SSM case study*

**IPMC** International Performance Management Council

**JIT** Just In Time

**KTH** Royal Institute of Technology

**LCI** Lean Construction Institute

**NASA** National Aeronautics and Space Administration

**NDIA** National Defence Industrial Association

**OBS** Organization Breakdown Structure

**PDCA** Plan, Do, Check, Act

**PMBOK** Project Management Book Of Knowledge

**PMI** Project Management Institute

**PMSC** Program Management Systems Committee

**PV** Planned Value

**RAM** Responsibility Assignment Matrix

**SMART** Specific, Measurable, Accepted, Realistic, Time limited

**SPI** Schedule Performance Index

**SV** Schedule Variance

**SWOT** Strengths, Weaknesses, Opportunities, Threats

**TCPI** To Complete Performance Index

**VAC** Variance At Completion

**WBS** Work Breakdown Structure