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## WEBSITE DEVELOPMENT PROCESS IMPROVEMENT IN SMEs USING TPS WITH THE IMPLEMENTATION OF LEAN AND AGILE METHODOLOGIES – AN EMPIRICAL STUDY

DOI: 10.21008/j.0239-9415.2019.080.09

The main aim of the article is to improve the website development process by using the Agile Development Toolkit: Lean Software Development which is developed from the combination of Lean and Agile principles and the theory of waste elimination from the Toyota Production System. This article explains the definitions of the kinds of wastes that are generated during the website development process within an IT Company and generally in SMEs in India and by taking preventive steps, improving the process by eliminating generated waste. The main aim of the research is to use Lean Software Development, a toolkit of Agile Development, that can be implemented within IT SMEs to overcome wastes. This article focuses on finding root causes of problems within the website development process and applying principles of Lean Software Development to remove those problems and accelerate the website development process.

Another analysis was performed to show which principles of Lean Development and Agile Development can be correlated if a website/software is developed using any of these two development methodologies, and not specifically Lean Software Development.

**Keywords:** Operation Management, Website Development, Lean Software Development: Agile Development Toolkit

### 1. INTRODUCTION

“Operation management is a systematic approach to addressing issues in the transformation process that converts inputs into useful, revenue-generating outputs” (Mahadevan, 2010, 5). Effectively fulfilling customer needs by using the least resources possible while delivering value to the customer is the ultimate goal.

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Throughout the years, operation management changed and various contributors were involved in this by making a huge contribution that changed the perspective on the operation environment (Fig. 1).

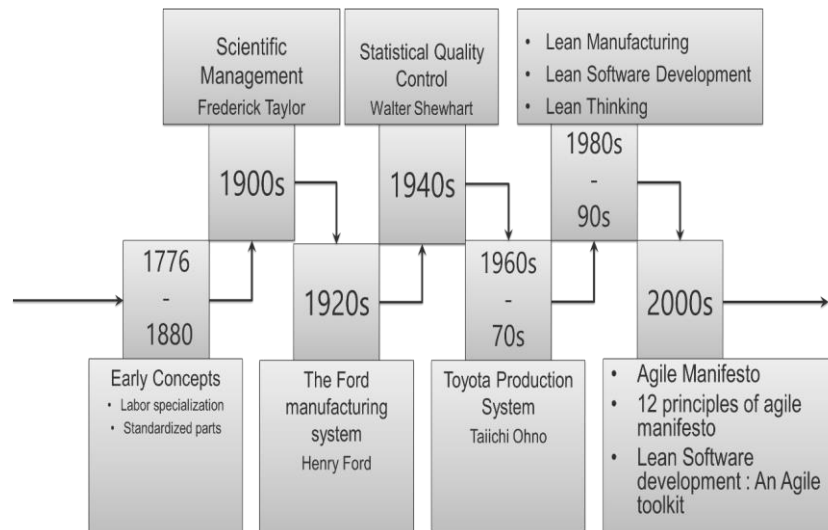


Fig. 1. History of changes that took place over the years. Created from own study

Also, it is changing its shape and methods rapidly in recent years and an era of new operation management is emerging. Many people are doing research and trying to come up with new ways to be more efficient and effective in operation management.

## 2. ERAS OF MODERN OPERATION MANAGEMENT

The modern era of operation management started from around 1776 when the main point of convergence was a focus on costs. Initial concepts included making more efforts in labour specialisation and parts standardisation so that whatever cost is related to operations can be minimised and increase profits for the business. And these concepts prevailed for a long time until the early 1900s when some changes occurred by the contribution of different persons. During the early 1900s scientific management came into the picture that uses Gantt charts and process analysis. Scientific management came into existence because of Frederick Taylor who is considered as one of the first management consultants. His book *The principles of scientific management* influenced many persons and businesses around the world for years.

Taylor's scientific management consisted of four principles and it is summarized in Table 1.

Table 1. Taylor's 4 principles of scientific management

1	Scientifically study each part of the worker's task and develop the best method for performing the task, which replaces the old rule of thumb.
2	Scientifically select the works and train them to perform the task by using the scientifically developed method.
3	Co-operate fully with workers to ensure that they use the proper method.
4	Divide work and responsibility between the management and workers so that the management is responsible for planning work methods using scientific principles and workers are responsible for executing the work accordingly.

Source: Bagad, 2009, 22.

This also provides a base to mass production techniques that surfaced during the 1920s. Henry Ford was a key figure for the concept of mass production by introducing the Ford manufacturing system. Henry Ford was the owner of Ford Motor Company and he developed an assembly line technique for mass production. He also gave the concept of the five-day work week (Henry, Crowther, 1922, 80).

According to Henry Ford:

The principles of assembly are the following (Henry, Crowther, 1922, 80):

- Place the tools and the men in the sequence of the operation so that each component part shall travel the least possible distance while in the process of finishing.
- Use work slides or some other form of a carrier so that when a workman completes his operation, he drops the part always in the same place – which must always be the most convenient place for his hand – and if possible have gravity carry the part to the next workman.
- Use sliding assembling lines by which the parts to be assembled are delivered at convenient distances.

Next progress in quality management included Statistical Quality Control which was developed by Walter Shewhart during the 1940s. Statistical control was explained by Walter as quality control in three steps (Shewhart, 2012, 1):

- The specification of what is wanted.
- The production of things to satisfy the specification.
- The inspection of the things produced to see if they satisfy the specification.

Around the 1960s and 1970s a phenomenal change occurs. During this period the Japanese company Toyota Motors was trying to compete with American and European motor companies. At the end of World War 2, Toyota was struggling because of problems with its supply chain management and depression-level demand for their automobiles. In these conditions, Toyota couldn't follow the Detroit model of mass production and endure on the market.

With strong backing from Eiji Toyoda, Taiichi Ohno helped establish the Toyota Production System, and built the foundation for the Toyota spirit of “making things” by, for example, creating the basic framework for the Just-in-Time method by Taiichi Ohno (Toyota Motor Corporation, 1995–2018). The concept of the Toyota Production System spread widely in a short time and became more popular worldwide. During the 1980s–1990s, a book came out with the title *The machine that changed the world* in which the word Lean was first used (Womach, Jones, Roos, 1990). After the initial introduction to Lean production, it spread very rapidly among businesses that are either in manufacturing or providing a service.

Simultaneously, software development was making progress and emerging as a future potential technology. Many scientists developed various concepts of software development throughout time. Many models were adopted in support of the software development life cycle. The most popular among them was, the waterfall model that was created in the manufacturing and construction industries, both operating in a vastly organised environment where alterations can be too costly or sometimes impossible. The waterfall model was first tossed into the picture during the 1970s by Winston W. Royce. For many years it was followed for the software development life cycle and also evolved into different variations of it.

During the 1990s, when Toyota Production System and Lean Manufacturing was getting very popular among industries, Dr Robert Charette adapted the idea behind these two concepts for developing his creation of Lean Software Development. Charette gave his idea of Lean development in a software environment in terms of strategic determinations and also introduced 12 principles of his methodology in his publication later in 2003 titled *Challenging the fundamental notions of software development*.

Agile Software Development was not seen before the 2000s. It was first seen in 2001 in an article that was published by a group of 17 software developers called Agile Alliance with the title *Manifesto for Agile Software Development*. This published article provides details about 4 values and 12 principles of Agile software development. Agile is applied in several projects and management methods now but when it was first presented it was purely suggested as a better way of developing software.

Around 2003, when Lean and Agile concepts were in conflict about a clear agenda for both methodologies, Tom and Mary Poppendieck, published a book titled *Lean Software Development: An Agile Toolkit*. The authors briefly describe how seven forms of waste in Lean Manufacturing and the Toyota Production System are related with the 7 principles of Lean development that are presented in the book. By implementing Lean as a harmonising method inside the Agile environment in their book, they bridge the gap between Lean and Agile while also simultaneously strengthening the idea of Lean as a software development methodology.

### 3. TPS, LEAN, AGILE AND LEAN SOFTWARE DEVELOPMENT

The interrelated bubble of TPS, Lean and Agile methodologies is illustrated in Figure 2.

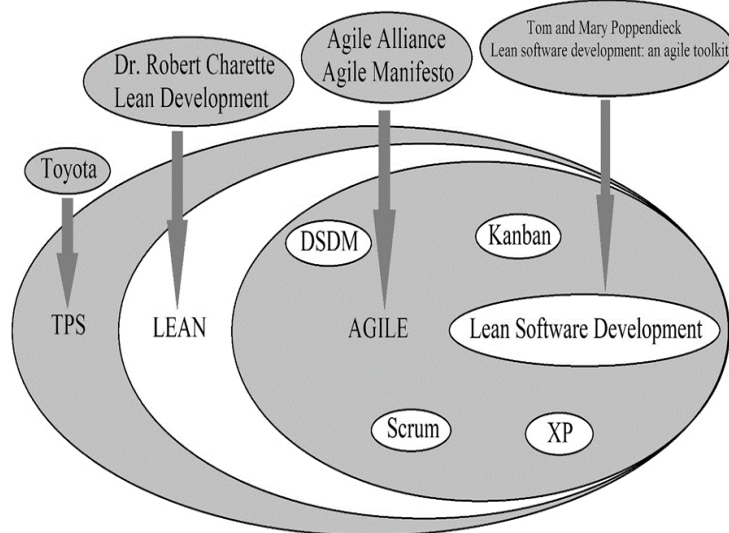


Fig. 2. TPS, Lean, Agile and Lean Software Development. Own creation

From Figure 2, it is understandable how the changes in methods of operation management came about and how Lean Software Development came into the picture as a toolkit for Agile methodology. In other words, to fulfil the purpose of JIT manufacturing that is the elimination of seven forms of waste defined by Taiichi Ohno. Later, an eighth form of waste was added to waste elimination. Observing Lean and Agile Development principles, goals and values are aimed at protecting against the production wastes of TPS. Lean Software Development is an agile toolkit that represents the TPS wastes in the context of software development.

## 4. WEBSITE DEVELOPMENT PROCESS AND CONNECTED FACTORS

### 4.1. Identifying the operation process

**Description of the product to be developed:** The main goal is to construct a website according to the requirements of the customer. The development of the project is always reliant on customer requisite. The specifications, working mode, quality of

a website depends on various terms such as A Logical Roadmap, Crucial Business Information, Contact Information, Clear Navigation, Security, Social Media Integration, A Mobile-Ready Version, FAQ, Good Hosting, Ignore some of the feature use over a website.

**Identification of technologies applied:** A website is not a single page that can be seen over a web browser. Many people who are not related to software development think that it is but the answer is not that simple. A website is layered at so many levels and very complicated in some cases. Vitality lies behind proper knowledge of each building block of a website and selecting the most suitable technology that is perfect for a website. A website is made of multiple layers and each of those layers has a different technology lying inside. The functionality and purpose of each of these technology layers is unique to maintain a website. Choosing the right technology for the right layer impacts overall website performance. Layers and the connected technology can be explained as follows: Client-side coding, Programming Language, Framework / Platform, Database Engine, Web Server Software, Operating System, Web Stack.

**Identification of workstation used:** Most important are the workstations on which the website is developed. Imagine a workstation that lags and gets stuck while developers are creating work on a tight time schedule. A good developer needs a good workstation to show their work and ability. All developers have unique requirements and to support that a workstation should be carefully built and purchased. All efforts can go to waste if a proper workstation does not fulfil specific needs.

While building a workstation, the things that should be taken into consideration:

Operating system selection – Every operating system comes with its own advantages and disadvantages. A workstation can be created with different specifications but also the operating system has some specifications that should be fulfilled. An operating system should be discussed before building a configuration for developing something as it is closely related to support hardware and programming language. The most common operating system that is used in web designing and development is Linux, Windows, Chrome OS and Mac OS.

Setting a Budget – A simple budget for a workstation can fall under one of the following categories – \$250–350 Budget, \$350–700 Mid-range, \$700–1,000 High-End, \$1,000 or more High Performance.

Selecting the appropriate specifications – Listing the tasks that are going to be performed using the workstation is useful while selecting and comparing specifications before starting to look for a workstation.

**Identification of operation performed:** A process map lays out a clear understanding of the process and its various stages. A process map can be designed for anything like a manufacturing process, service process or a project plan. The chronological order of separate steps of a process can be illustrated by the use of a flowchart. In Figure 3, there is a linear flowchart that shows different components

such as decisions that are taken, entry into service or exit from service, people or resources that are involved in website development.

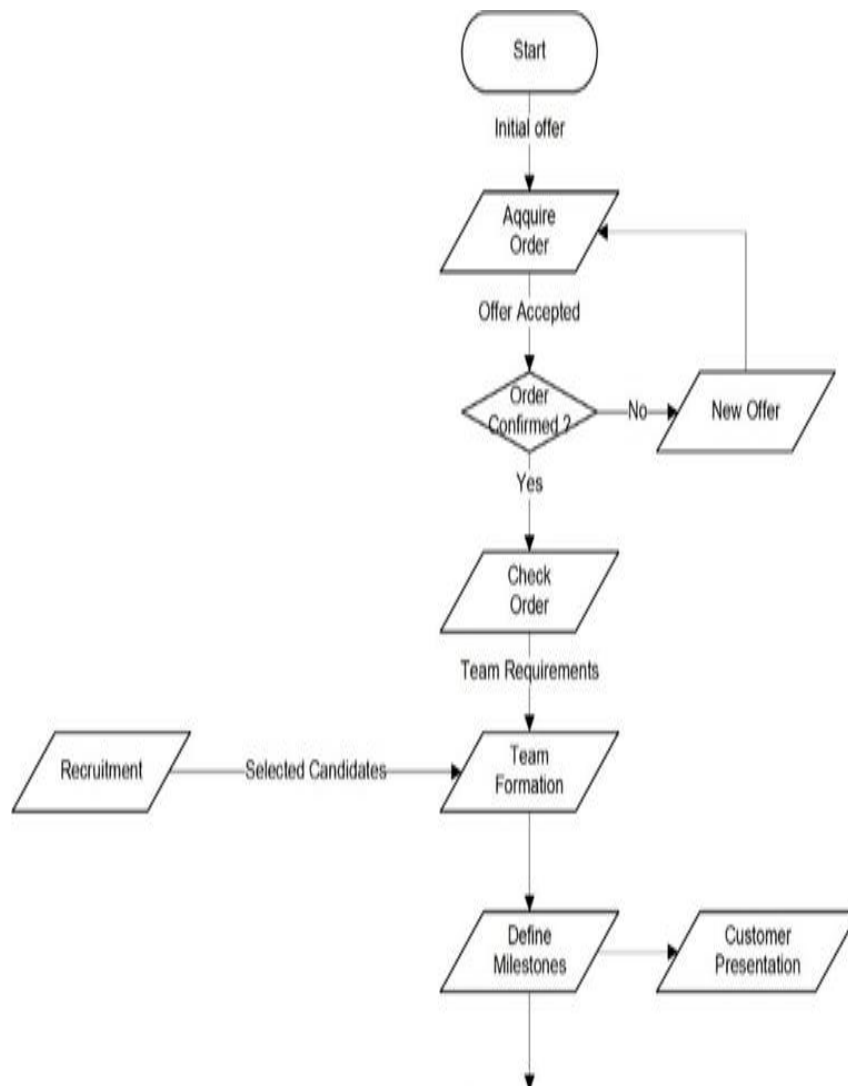


Fig. 3. Website development process. Own creation

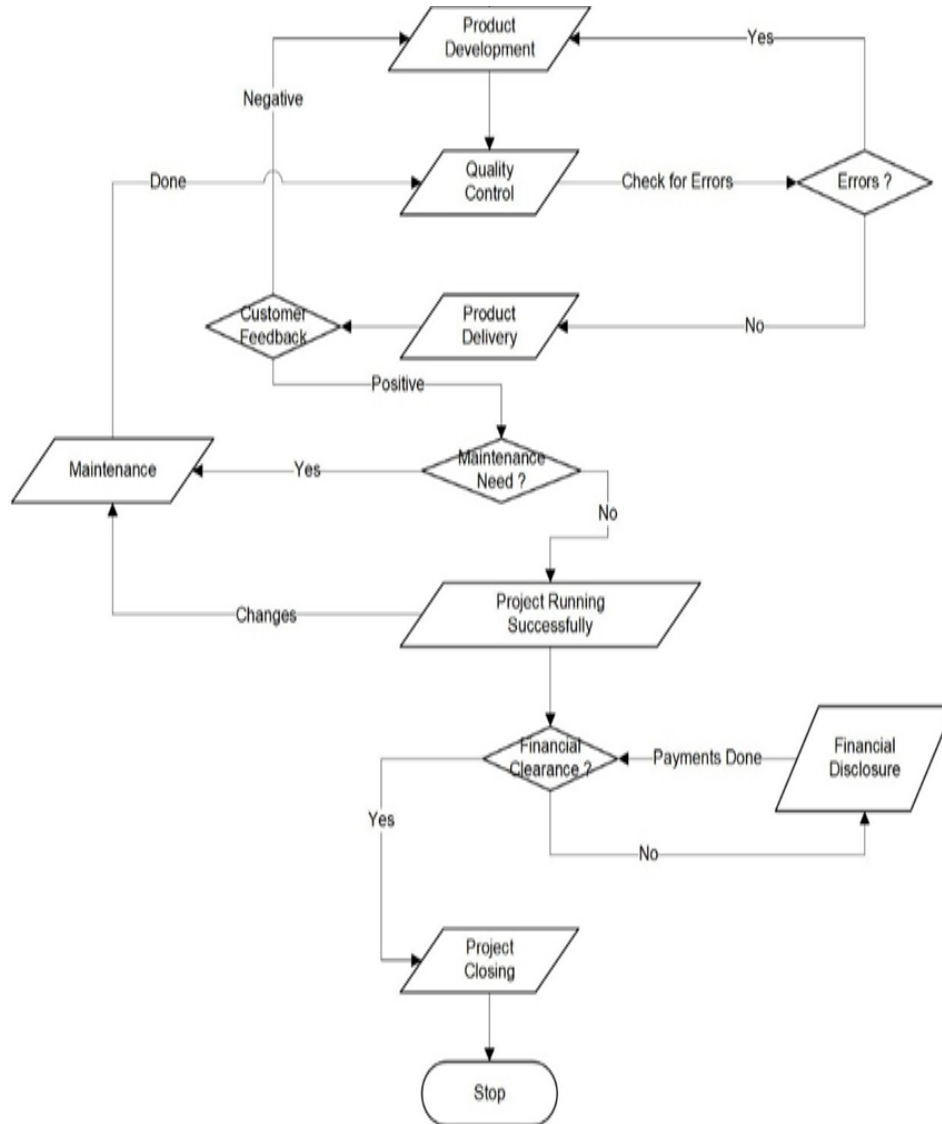


Fig. 3. Website development process, continue

## 4.2. Control forms for website development

**Quality control:** Quality control of a website needs to look at various factors, i.e., – Perfection in Design, Content Management with High Standards, Creativity,



Content, Functionality, E-commerce Functionality, Search Engine Optimization, Code Quality, Responsive and Mobile Friendly, Responsive web design.

**Stock control:** Most of the IT Website projects are simply built when they are needed. Therefore, there is no need for stock control. The main base for the whole project would be dependent on the customer's particular requirements. Every customer has unique needs that should be fulfilled. So when a customer arrives, their proposal is heard and after a discussion, a project can be started.

**Order processing / chasing against schedules:** IT SMEs have a generalised idea of order processing or chase scheduling of work that can be described as follows:

Website/Software – standard delivery time: small project – 4 weeks, medium project – 8 to 12 weeks, large project – 1 or more years, the accuracy of competency of projects: 50–60%, defect in products: 5–10%, handling maintenance: 1 or 2 weeks.

**Cost control (budgeting):** IT SMEs have various products that can have different price rates and that is always dependent on projects. There are some categories like small, medium or large projects and each category also has some subcategories, however, it is fully customizable according to the project.

**Productivity:** Employee performance is the only factor that can measure an organization's productivity. However, many factors from the outside have a huge impact on productivity, such as competition, national economic recession, but those are not controllable from within an organisation. Although the productivity of an employee can be calculated very easily, it has a high impact on the resulting profits for an organisation. The productivity of an employee can be calculated as for an individual employee or for the working team and if it is a huge organisation then even for a department. As an example, let's take into consideration an IT SME of fifteen employees. All employees work for 192 hours a month. The salary depends on the department and position of the employees. Labour productivity can be measured by dividing the total input from the total output. The IT SME generated \$20,000 worth of goods or services (output) utilizing 2,880 labour hours (input).

$$\text{Labour productivity} = \frac{20,000}{2,880} = 7 \text{ \$ per hour of work.}$$

Labour productivity can be also measured in terms of individual employee contribution. In this case, instead of using hours as the input, the number of employees is used.

$$\text{Labour productivity} = \frac{20,000}{15} = 1,333 \text{ \$ per employee a month.}$$

### 4.3. Operation level control activities for website development

**Control points at various phases of website development:** Website development has various phases and most of IT SMEs in India are following an iterative waterfall method for developing a website. It has six phases but inside those phases, there are some critical control points that can change the course of the project for website development. Table 2 illustrates those critical control points of the website development process that have to be carried out carefully for better succession and for efficient flow in developing a website.

Table 2. Critical control points in the website development process

States	Requirement analysis	Requirement analysis to Designing	Designing to Implementation
Control points	Identify system Feasibility check Documentation Confirmation of project Implementation study	System design Component design Task assignment (designing) Design submission	Task assignment for coders Development of components Implementation
States	Implementation to Testing	Testing to Deployment	Deployment to Maintenance
Control points	Working system Test strategy Test method Test feedback	Final system quality check Create a system as a whole Deploy system	Working system Regular checkups Problem occurrence Solution requirement Solution deployment Maintenance carried out

Own creation.

**Control methods:** To implement control on department and employees of the company, two types of control techniques are used. Management by Objectives (MBO): MBO facilitates planning and control. It must fulfil the following requirements: Objectives for individuals are jointly fixed by the superior and the subordinate. Periodic evaluation and regular feedback to evaluate individual performance. Achievement of objectives brings rewards to individuals (Akdeniz, 2015). This technique is going to be used for control from the heads of departments or by a team leader. Superiors will plan the strategy and divide work for individual end workers. The tasks are provided and supervised during an inspection and the superiors notify end workers of necessary changes. A deadline is decided and also care

is taken that the tasks are completed within the deadlines. Self-Control: This technique will facilitate the end workers. As individual worker is given a proper task with deadlines, they have to manage and control the task to complete it within the given task deadline. They can develop their own given task and should submit it to superiors for a quality check. In website development all developers have their own style of coding. If a worker's own style is influenced the task can last longer and may be confusing. Therefore, it is most important that the end worker be given liberty over task completion.

**CPP (Control Process Parameter) for a website development process:** For website development the given process parameters can be taken into consideration to define standards of a website and monitor and control the progress of building a website:

**Feasibility check** – Feasibility check is the first initial starting point for any website project. During a feasibility check, it is checked whether or not the project that is going to start is feasible for company standards and profits. All the sides of feasibility are checked, from the availability of developer to the completion of the project. Standards to measure (Parameters): product cost, profit margin, the time span of the lifecycle, availability of workforce, system requirement.

**System design** – This control point concentrates more on the designing part for the website project. It is measured according to design feasibility. Standards to measure (Parameters): design requirements, an available system to handle the new website, customer approval, RWD (responsive web design).

**Implementation** – This control point is the most critical part of website development. Here the process of creating an actual product takes place. A little problem here can greatly complicate the whole process. Here the whole task is divided and components are made by different developers. Different developers make a website in their own way so it is necessary to define some coding standards among them to collaborate the process. Standards to measure (parameters): task time span, code standard, code style, code format, component gathering.

**Test method** – This is another valuable process of website development. Here the final product is made from component gathering and will be checked using various tests. The selection of testing method is very important because it must check all the working conditions of the website before launching it for the customer. Standards to measure (parameters): functionality testing, usability testing, compatibility testing, database testing, crowd testing, interface testing, performance testing and security testing.

**Final system quality check** – This control point is performed by the superiors of the company. Before product launch, all the components are gathered and checked using various testing methods to check if the product is working well as a whole. Later when the product is ready it is forwarded to superiors/specialists to check the final product. Standards to measure (parameters): design check-up, coding check-up, view check-up, performance check-up, bug check-up.

## 5. CONCEPT IN ACTION

**DEFINE** – find waste – Taking overall process and state those points which are not necessarily required and are a waste within the company operation.

**PROBLEM** – find root cause – when waste is defined, further investigation over possible root cause of generating such wastes.

**SOLUTION** – find a relevant solution – problems examined according to different Lean and Agile principles and also finding a relevant solution to how root causes of problems can be avoided and process improvement can be achieved (Boutros, Cardella, 2016).

**Define:** Definition in terms of the original definition and in the website development process.

Defects can be defined as information, products and services that are incomplete or inaccurate and in website development it can be defined as a website that involves bugs and is defective. Overproduction can be defined as making more of something, earlier or faster than needed and it can be defined in website development as writing more code that is actually not desired by the customer or not even demanded in the first place. Waiting can be defined as waiting for information, equipment, materials, parts or people and it can be defined in website development as the customer waiting for delivery or when a developer is on standby and that creates an interruption. Not utilizing skills can be defined as not properly utilizing skills, knowledge or creativity and it can be defined in website development as the absence of human cooperation or firm roadmap existence. Transportation can be defined as unnecessary movement of materials, information or equipment and it can be defined in website development as assigning too many teams with the same developer and execution of manifold handovers is unproductive. Inventory can be defined as the accumulation of parts, information, applications, etc. beyond what is required by the customer and it can be defined in website development as an incomplete website that has no value to anyone. Movement can be defined as any movement by people or of information that is not of value to the customer and it can be defined in website development as, for example, a task not reaching all relevant persons, or the team is not situated in the same place, or the owner is not available to consult. Excess processing can be defined as any steps that do not add value in the eyes of the customer and it can be defined in website development as process steps that are not needed and add no value, repetition within data, extra copies of the report, overly explained data.

**Various viewpoints:** A general categorisation of all waste according to the principles of lean, agile and lean software development.

Defect – customer satisfaction (Lean), technical excellence and working software as a metric (Agile), amplify learning (LSD). Overproduction – minimalism (Lean), simplicity (Agile), eliminate waste (LSD). Waiting – 80% solution today (Lean), frequent cycles of delivery (Agile), as fast as possible (LSD). Not utilizing

skills – team effort (Lean), stakeholder collaboration (Agile), the culture of trust (Agile), team reflection (Agile), amplifying learning (LSD). Transportation – team effort (Lean), self-organizing teams (Agile), the culture of trust (Agile), support and motivation (Agile), empowering the team (LSD). Inventory – 80% solution today (Lean), customer satisfaction (Agile), as fast as possible (LSD). Movement – customer participation (Lean), team effort (Agile), face-to-face communication (Agile), stakeholder collaboration (Agile), eliminating waste (LSD). Excess processing – minimalism (Lean), simplicity and working software as a metric (Agile), eliminate waste (LSD).

**Problem:** The appearance of a problem within the website development process for all types of waste.

Defects – a large amount of error found in the code line by developer mistake or bug eventually generated after hosting the website. Overproduction – a developer trying to build everything at once, 50% of the features developers create are rarely or sometimes never used. Waiting – commonly finalizing a website design that can fulfil all requirements of the website owner and satisfy. Not utilizing skills – some other developer is working on the problem; every developer has his/her own way of thinking. Transportation – excessive email between employees or between the employer and employee or website owner and employer or website owner and employee. Inventory – while a developer is working on a project and there is no proper way to store data in storage systems. Movement – communication among the team. Excess processing – repetition of coding lines by developers, when an error occurs in a huge file with thousands of code line one must go through all of it to find a tiny bug within.

**Root cause:** Findings about the possible root causes that are generating the problem.

Defects – no proper knowledge, hiring workers that are just out of university. Overproduction – overthinking about a project, without knowing customer requirements. Waiting – unclear design, the developer gets two different instructions to design the same thing. Not utilizing skills – one developer stuck on one problem in one project. Transportation – many email conversations without any proper sequence. Inventory – the developer is storing the same data in multiple places on the same storage drive or different storage drives by forgetting prior storage of the same data. Movement – seating arrangement, no proper e-communication channel. Excess processing – an amateur coder who is new to professional and formal coding.

**Solution:** Steps to prevent wastes from generating within website development process according to principles of Lean Software Development.

Defects – if a new employee is hired there will be no defects if a new web developer undergoes a training period under a specialist in the field before working on live projects. Overproduction – build what is needed at the time and with the further possibility of expansion when needed. Waiting – predevelopment design specification and requirements, proper tool implementation to track, notify changes other than an exchange of email or verbal communication. Not utilizing skills –

rotation by making teams, opportunity to identify hidden skills of the developer as well as knowledge about all projects. Transportation – maintain the order of communication, eliminate repeatedly sending an email and wasting time over finding or answering the same email again and again. Inventory – maintain the order of storing data with proper name formatting. Movement – changing the seating arrangement or establishing a proper network of communication. Excess processing – iterative and incremental development standards of the agile software development life cycle.

**Improvements:** After taking preventive steps, the improvement of the website development process by eliminating wastes.

Defects – fewer defects in the timed delivery of the product can be achieved and more productive staff can be generated. Overproduction – faster process because no more features are developed than needed, following clear instructions and organized and structured development with reusability of written code lines. Waiting – staying in touch on both ends will make it easy and fast to deliver final product design efficiently and easily. Not utilizing skills – someone changes jobs and that empty position has to be temporarily handled by another developer. Transportation – simple completion of the task using email can be achieved. Inventory – the data is understandable to the developer when stored for next time, even if some upper-level person wants to access the data they do not lose track of the vision of the project. Movement – save time and speed up the process. Excess processing – fast and reliable development.

## 6. CONCLUSION

The article presents the evolution of operation management and its development into its modern form. The article shows the history of operation management and concentrates more on software engineering/development as a website is a part of the software and it is essential for website development. Further, it includes an explanation of the involvement of the Toyota Production System over lean and agile development and the emergence of Lean Software Development as an Agile Development Toolkit. After an overview of the history, next the website development process is explained in brief with all the processes involved and factors that affect the processes. Afterwards, the article explains how to use the Lean Software Development toolkit by comparing principles that will be involved in different development techniques. The article shows that there are eight forms of waste that are generated within the working environment of IT SMEs that create problems in the operation of IT SMEs and make the website development process slower. These problems or waste are found and analysed for the root causes that are generating this problem within the operations of IT SMEs. Defining a specific principle from Lean Software Development is helpful to find a solution for all eight forms of

waste and eliminate it from the process. By implementing those specific principles and taking the necessary steps that form of waste is eliminated and what changes or improvement it will bring in website development is defined.

Concluding, the website development process is a very crucial part of IT SMEs and it is necessary to make it waste free, which may be achieved by Lean Software Development, a method specifically developed for eliminating wastes through the combination of the Toyota Production System with Lean and Agile Development methodology with its own specific principles.

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### DOSKONALENIE PROCESU ROZWOJU STRON INTERNETOWYCH W MSP WYKORZYSTUJĄCYCH TPS Z WDROŻENIEM METOD LEAN I AGILE – BADANIA EMPIRYCZNE

#### Streszczenie

Głównym celem artykułu jest usprawnienie procesu tworzenia stron internetowych za pomocą zestawu narzędzi programistycznych Agile: Lean Software Development, który został opracowany przez Toyota Production System na podstawie powiązań Lean i Agile oraz teorii eliminacji strat. Wyjaśniono w nim definicje rodzajów strat generowanych w procesie tworzenia strony internetowej w firmie informatycznej i ogólnie w małych i średnich przedsiębiorstwach w Indiach, jak również podjęto kroki zapobiegawcze, ulepszając proces

i eliminując straty. Głównym celem badań jest wykorzystanie Lean Software Development – zestawu narzędzi Agile Development, które można wdrożyć w małych i średnich przedsiębiorstwach IT w celu wyeliminowania strat. W artykule przedstawiono sposób usunięcia omawianych problemów i przyspieszenia procesu tworzenia strony internetowej przez wykrycie przyczyn tych problemów i z zastosowaniem zasady Lean Software Development.

Kolejną analizę przeprowadzono, aby wskazać, które zasady Lean Development i Agile Development mogą być skorelowane, jeśli strona internetowa / oprogramowanie są rozwijane z użyciem którejkolwiek z tych dwóch metod.

**Słowa kluczowe:** zarządzanie operacjami, tworzenie stron WWW, Lean Software Development: Agile Development Toolkit