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Continuous Improvement in the Plant Facility Department at AVL List Technical Center Shanghai

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Declaration of Originality

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Abstract

The objective of this research is to implement several improvement actions that were elaborated, with the help of a consultant from the Kaizen Institute, in the Plant Facility Department at AVL List Technical Center Shanghai. For this thesis two research questions were defined:

1) What measures are necessary to implement the actions, that were generated in facilitating workshops and can target dates be reached in time?

2) Will the change-mentality be adopted by employees to the extent that it is integrated into the company culture?

During the research two additional tasks were added; the implementation of Daily Kaizen boards and the conduction of 5S in the office area as well as the main facilities of the department. The given tasks could be completed successfully, some hurdles had to be overcome to complete the action list but especially the execution of the 5S campaigns and the implementation of the Daily Kaizen boards worked out well. The answer to the second research question must be a clear no, the Plant Facility Department has made great efforts to achieve the desired result but when comparing the situation at the end of the research with the eight-stage change process by John Kotter it is clear that the department has not reached the eighth stage.

Kurzfassung

Ziel dieser Forschung ist es in der Plant Facility Abteilung am AVL List Technical Center Shanghai eine Liste an Verbesserungsmaßnahmen umzusetzen, welche mit Hilfe eines Beraters des Kaizen Instituts in der Abteilung erarbeitet wurden. Für diese Arbeit wurden zwei Forschungsfragen definiert:

1) Welche Maßnahmen sind notwendig um die Verbesserungsvorschläge umzusetzen, welche in Seminaren ausgearbeitet wurden und deren Zieltermine rechtzeitig erreichen zu können?

2) Wird die Change-Mentalität von den Mitarbeitern übernommen und in die Unternehmenskultur integriert?

Während des Verlaufs der Forschung wurden zwei weitere Aufgaben ergänzt: die Einführung von Daily-Kaizen-Boards und die Durchführung von 5S Kampagnen sowohl im Bürobereich als auch aller wichtigen Räumlichkeiten der Abteilung. Die aufgetragenen Aufgaben konnten erfolgreich abgeschlossen werden. Manche Hürden mussten überwunden werden, insbesondere um die Verbesserungsmaßnahmen umzusetzen; aber vor allem die Durchführung der 5S-Kampagnen und die Einführung der Daily-Kaizen-Boards waren erfolgreich. Die Antwort auf die zweite Forschungsfrage muss eindeutig nein sein: die Plant Facility Abteilung hat große Anstrengungen unternommen um das gewünschte Ergebnis zu erzielen, aber beim Vergleich der Situation am Ende der Forschung mit dem achtstufigen Veränderungsprozess von John Kotter ist es klar, dass die Abteilung nicht die finale Stufe erreicht hat.

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Abbreviations

AVP	AVL Improvement Process
CAE	Computer-Aided Engineering
CI	Continuous Improvement
CIP	Continuous Improvement Program
Dev. & Cal.	Development and Calibration
DK	Daily Kaizen
EHS	Environment Health and Safety
ETC	Engine Test Cell
ETV	Electrification Transmission Vehicle
EUR	Euro
Fin. & Admin.	Finance and Administration
GM	General Manager
HR	Human Resources
IT	Information Technology
KO	Kaizen Office
KPI	Key Performance Indicator
MD & TF	Mechanical Development and Test Factory
PDCA	Plan Do Check Act
PF	Plant Facility
PI	Performance Indicator
PM	Project Management
PTS	Power Train Test Specification
RMB	Renminbi
SIPOC	Supplier Input Process Output Customer
SK	Support Kaizen
SKTL	Skill Team Leader
STC	AVL List Technical Center (Shanghai) Co. Ltd.
TL	Team Leader

1 Introduction

1.1 Task Description

The purpose of the research is to ensure that the actions generated in the facilitating workshops with the consulting company (the Kaizen Institute) are implemented, the change-mentality reaches every employee in the department and that a positive attitude towards change is achieved in a sustainable way, so that it continues after the cooperation with the Kaizen Institute ends. The following two research questions result from this objective:

What measures are necessary to implement the actions, that were generated in facilitating workshops and can target dates be reached in time?

Will the change-mentality be adopted by employees to the extent that it is integrated into the company culture?

This thesis deals with the introduction of Continuous Improvement in the Plant Facility Department. At the same time, the colleagues Lucas Wartscher and Georg Kolb conducted researches to the same topic in the Mechanical Development & Test Factory and the Development and Calibration department. Due to the analogy of the topic the researchers dealt with, the chapter 1 Introduction was co-authored by the three researchers Lucas Wartscher, Georg Kolb and Christof Walz.

1.2   AVL List Technical Center Shanghai

AVL List Technical Centre Shanghai (hereinafter referred to as AVL STC) opened in November 2003 and is located in China´s second largest city, Shanghai. AVL STC is a subsidiary of the AVL headquarter Graz with the order to fulfil the expectations of the customers in China. AVL STC offers a wide range of activities in the field of design, simulation and development of petrol and diesel engines as well as vehicle electrification. The provided services are system engineering and development of powertrain systems including new energy powertrains as well as design and simulation of powertrain components. Further, the calibration of engines and transmissions as well as emission testing on and off the road by Chassis Dynamometer is provided. Other services are battery pack assembly and testing, vehicle integration and demo vehicle build up, drivetrain electrification, various assessments and benchmarking of vehicle drivability.

The prerequisite for the realization of these services is the correct equipment for that AVL STC implemented fourteen engine development test beds (two with e-motor capability), one powertrain test bed and one cold chamber, two chassis dynamometers (one four-wheel drive capable), two battery testers and electrification lab as well as various confidential customer workshops, AVL DRIVE® and AVL MOVE® Systems.

However, the best service and equipment is worth nothing without a working organization behind. Therefore, AVL STC established nine different main departments with the objective to offer the best service to the customers (see Figure 1-1: Organigram STC). On basis of strategic reasons and the distribution of tasks, the departments are divided in various teams.
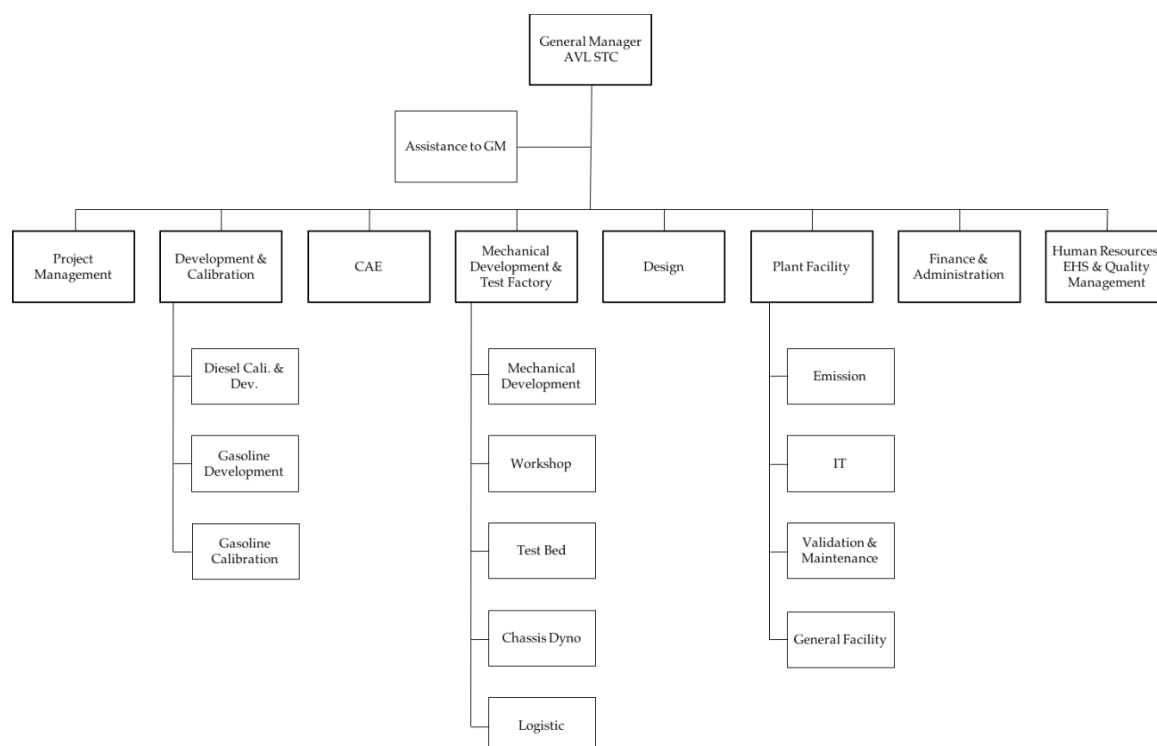

Figure 1-1: Organigram STC

The General Manager is on top of the organization; he is responsible for the managing, effective planning and coordinating of STC. The level below is formed by nine main departments. Firstly, the Project Management department that is responsible for initiating, planning and monitoring of customer projects. A customer project is a contract that comprise the time frame including the start and delivery date, the content of the service and the project costs between the customer and STC. Secondly, the Design department provides the task of constructing and modelling prototype engines as well as powertrain components. Thirdly, the CAE (Computer Aided Engineering) department includes the field of activity in the simulation, validation and optimization of prototypes and powertrain components. The CAE and Design department works in close cooperation. Another important section is the ETV (Electrification Transmission Vehicle) department with the scope on development and control of electrification systems, battery and software as well as the calibration of transmission and vehicle electrification. There are also the Finance department and the HR (Human Resources) department. The Finance department includes the accountant, the cashier, the technical purchase as well as order processes. HR includes the Human Recourses office, Quality Management and Environmental Health & Safety.

In total, there are 251 employees at STC (June 2017). The following diagram (see Figure 1-2: Number of Employees at STC) shows the development of the employment figures in the period from 2008 to 2017.
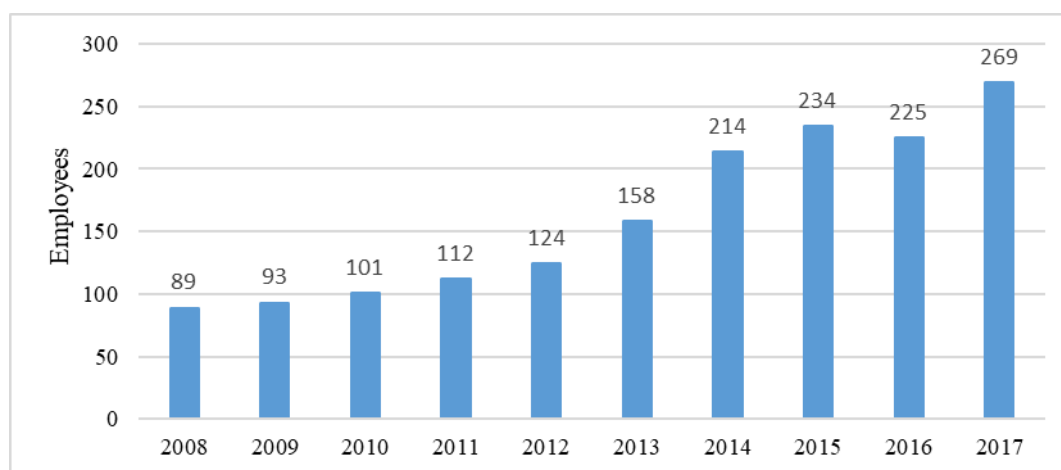

Figure 1-2: Number of Employees at STC

As noted in Figure 1-2: Number of Employees at STC, the number of employees increased continuously every year. The reason for that is the completion of test facilities 2011 and the increase of projects every year.

The correct handling and protection of data is a core issue of AVL to be competitive on the global market. Therefore, the data in Figure 1-3: Growth of Projects and Revenue at STC is based on an index. If an area has a value of 100 in the year 2012 and 200 in 2016, the area doubled the value in the last four years. The values "Number of Projects" and "Employees" are without an index and illustrate the real values.

After the expansion of 2011, AVL STC doubled the production capacity in the period from 2012 to 2016. In 2013, the order intakes increased enormously, therefore AVL opened a Technical Center in Tianjin to fulfil the requirements of the customers. The steady growth is represented by the "Number of Projects" that reflect to the revenue. The extent and the requirements on the projects are very high. Therefore, STC plans to achieve a total of 300 employees by the end of 2017.
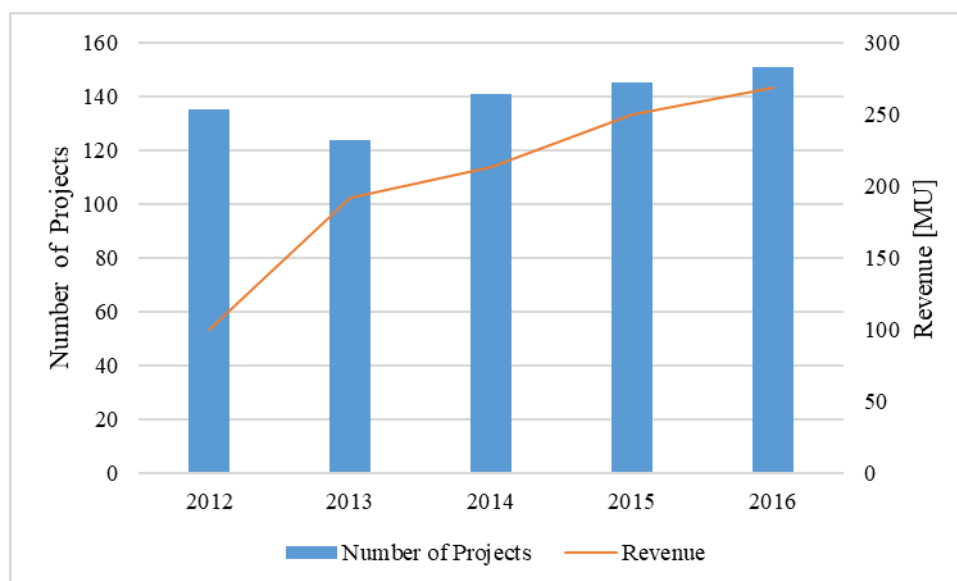
Figure 1-3: Growth of Projects and Revenue at STC

Since each of the Researchers had the task to implement the CIP in different departments, a special focus will be laid on those. In the following, the departments of Development & Calibration, Mechanical Development & Test Factory and Plant Facility are going to be introduced in more detail.

1.2.1 Mechanical Development & Test Factory (MD&TF)

The MD & TF department consists of five teams and has in total fifty-nine employees. The teams are the Mechanical Development, Logistic, Workshop, Chassis Dyno and Test Bed. The head of the department is the SKTL who has two assistants that support the management of the department. The tasks of the teams in the department will be described as follows.

Firstly, the Mechanical Development team is responsible for the mechanical testing and validation of engines, transmissions, after treatment of exhaust gases as well as hybrid systems. In addition, the team executes functional development of various systems of the engine. Further, the MD engineers support the Design & CAE department in the development of powertrain systems and in trouble-shooting. Other activities are the conducting of durability tests and the support in the calibration of engines.

The three main tasks of the Workshop team (mechanics) are to build up the engine, the installation of the engine on the test bed and the refitting of vehicles for the chassis dynamometer.

The engine build-up is the assembly of the components to an engine. The next step is to assemble the engine on a pallet to meet the requirements for connecting the engine to the test bed system. In specific cases, some machining parts for the pallet setup are needed, thus three people of the team are responsible to provide these parts in the machining room. Finally, the team installs the pallet on the test bed (installation of cooling system, fuel pipe etc.)

and connects the sensors and actuators to the system. If the three steps are implemented in a correct way, the basis for a successful test has been laid.

The refitting of the vehicle contains the preparation of the vehicle for emission tests, the setup of demo cars for the calibration as well as build-up efforts for the powertrain integration.

The functions of the Test Bed team (operators) include the operation and control of the test bed. Moreover, the operators analyse and interpret the out coming results, and they identify occurring errors on engines and test beds. In addition, they report the utilization and breakdown of the test facility. Besides, the operators support the mechanics by the installation of the pallet in the test bed.

The chassis dynamometer is designed for the simulation of various load conditions (e.g. real road) for the testing and the development of vehicles. The Chassis Dynamometer team carries out a number of tests, which include emission tests, mileage accumulation tests, as well as development tests. The chassis dynamometer is designed to simulate various load conditions (e.g. real road) for the development of vehicles.

The fourth group is the Logistic team that was established in summer 2016. It is responsible for the warehouses as well as the management of incoming and outgoing goods. Further tasks are the preparation and on schedule provision of engines and vehicles for testing, as well as to guarantee the availability of parts and components.

1.2.2   Development & Calibration Department

The Development and Calibration department (D&C) of AVL STC is responsible for planning, execution and analysis of diesel and gasoline engine related customer requests. Ranging from single, specific tasks to full turnkey-projects, the targets of these projects can include engine performance targets, engine fuel consumption targets, engine oil consumption targets, engine noise emission targets, exhaust emission targets and various other, more specific targets. However, engineers operate within certain boundaries which are not only defined by the component costs a customer is willing to accept, but also by the respective target market, like the available fuel quality and the legal frameworks (e.g. emission standards).

1.2.3   Plant Facility Department

The Plant Facility department is subdivided into four teams, General Facility, Measurement System, Emission System and IT. Facilities include the department's office, the Measurement team's repair room, the Emission team's repair room, a gas room for storage of consumable gases and an IT warehouse. The responsibilities of the individual teams are the following:

- General Facility (4 members): This team is responsible for the management of spare parts, daily inspection and modification of the general facilities, planned maintenance, and urgent issue handling.
- Measurement System (10 members): The Measurement team is responsible for test bed and CD installation, equipment calibration and maintenance, test bed setup, troubleshooting, data analysis and spare parts management concerning measurement related parts.
- Emission Test (6 members): The Emission team handles equipment maintenance and calibration, project support as well as spare parts and consumption parts maintenance.
- IT (2 members): The IT team consists of two members and equips new employees with IT equipment, an account, keycard, and e-mail address. They also handle network maintenance, user support and service computers.

1.3 Continuous Improvement @ AVL List STC

1.3.1 Reasons for Continuous Improvement

<u>Initial Situation</u>: Continuous Improvement (CI) is part of AVL List's structural improvement program, which is an organization-wide program applied to many, but not all subsidiaries of AVL List. CI is part of STC's quality policy, effective as of June 2014. It includes a suggestion scheme called AVP (AVL Improvement Process) that offers monetary rewarding for raised improvement suggestions. This compensation consists of a standard 100 RMB reward for accepted ideas plus an additional bonus if the proposal proves to result in substantial savings (max 2500 RMB). At the start of the research for this thesis in November 2016, there were no signs of AVP being in place; this was evident since most employees did not know how to make suggestions, receive rewards or they had no knowledge about the program's existence.

<u>Urge for Change</u>: Due to the rapid growth of AVL List STC in recent years, it was close to reaching its maximum facility utilization in 2016. All 13 available engine test beds and both vehicle test beds were constantly occupied. Previous efforts to increase efficiency and the implementation of AVP had not shown the desired results and employees remained too unmotivated to recognize waste and take actions to reduce it.

<u>Desired State</u>: The objective of the program is the implementation of Continuous Improvement throughout STC and as part of the company culture. The specific goals are:

- Higher efficiency
- More available time within the teams for strategic & value adding activities
- Greater employee satisfaction
- Maximum internal and external customer orientation

<u>Strategy</u>: To free resources, a Continuous Improvement program was initiated in late 2016 with the goal of reaching higher efficiency, customer satisfaction and competitiveness. These results are being achieved by increasing standardization and by reducing the waste of resources. The Kaizen Institute[1] was chosen as a strategic partner to deliver methodology, tools, expertise and grant guidance during the implementation phase. The Kaizen approach is a very effective and proven strategy to reach the desired goals; it is a bottom up approach that focuses especially on the involvement of all employees and has the potential of changing the company culture (see 2.2 Kaizen). The program objectives were chosen to be:

- Gain efficiency and utilization improvement
- Awareness for CI
- Set up the detailed CIP management system
- Install CI culture to the organization

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[1] (KI, 2017)

1.3.2   Roles and Responsibilities

To make sure that the whole company is involved in the CI process, specific roles (Figure 1-4: CI Hierarchy) and responsibilities (Figure 1-5: CI Responsibilities) are distributed among STC employees. The steering committee consists of the General Manager and the Skill Team Leaders of every department. Its main objective is to make decisions about important CI topics that apply to STC in general or interdisciplinary topics that apply to more than one department. The Kaizen office is held by one single person, the Kaizen officer, and serves the function of central intelligence to the whole program. For every department, a coordinator is elected to grant the involvement of each department in the program. For each of these roles, specific responsibilities are defined, as pictured in Figure 1-5: CI Responsibilities.
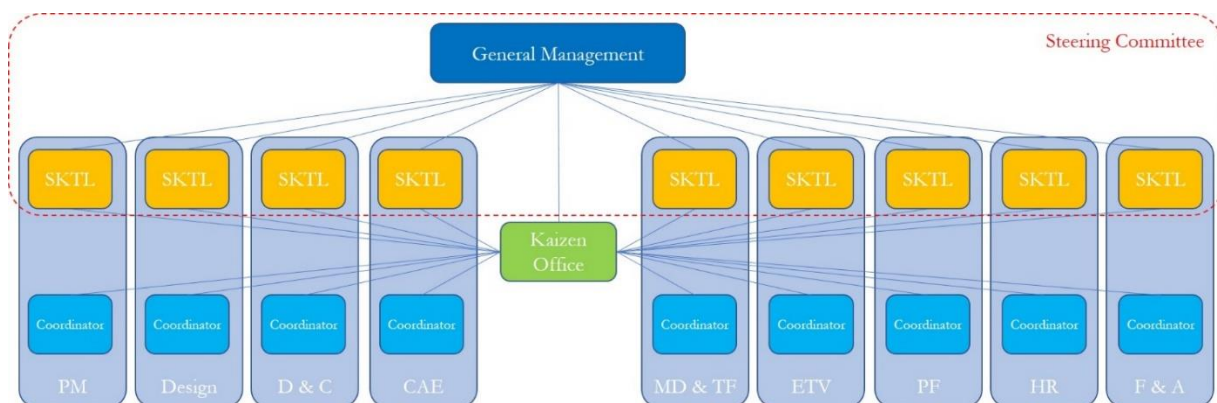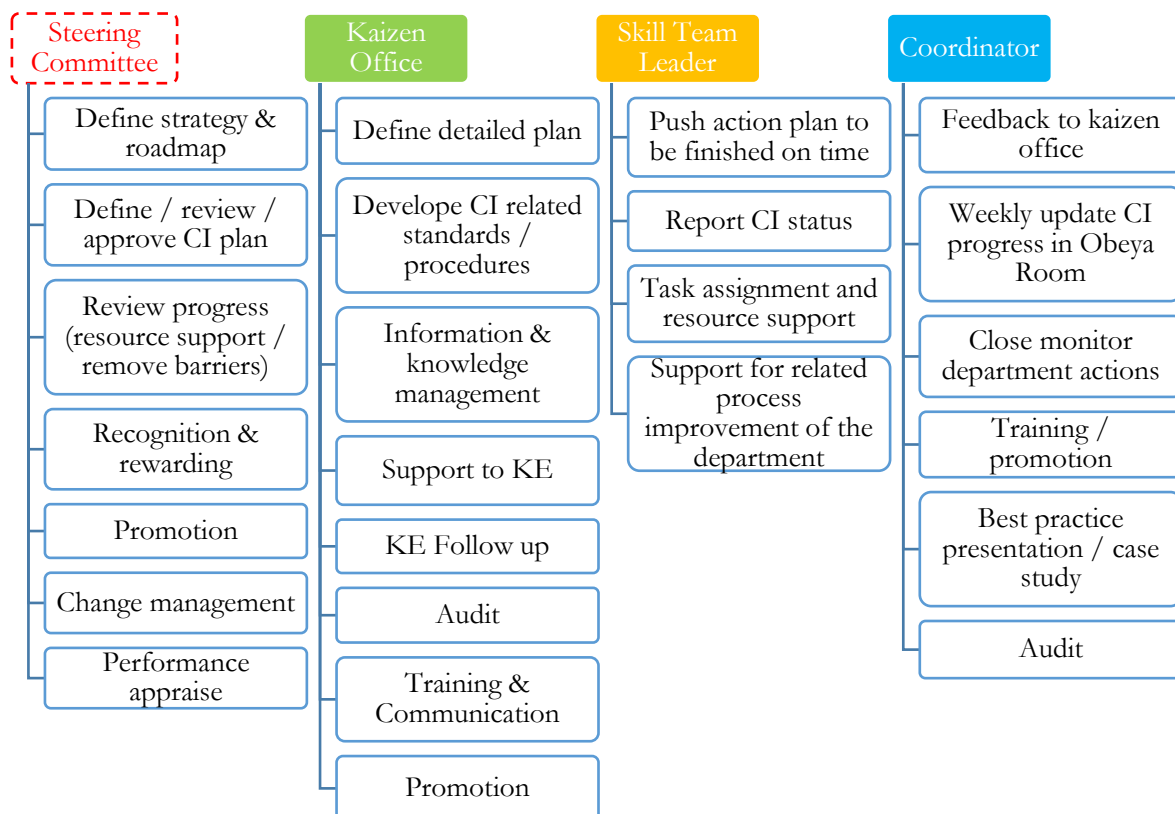

Figure 1-4: CI Hierarchy

Figure 1-5: CI Responsibilities

1.3.3 Content

The content of the CI program includes a modified version of AVP as part of Daily Kaizen but is far more extensive, consisting of the four main topics: Awareness Training, Facilitating/Coaching, Support Kaizen (SK), and Daily Kaizen (DK). These four themes and their essential elements are displayed in Figure 1-6: CI Content.
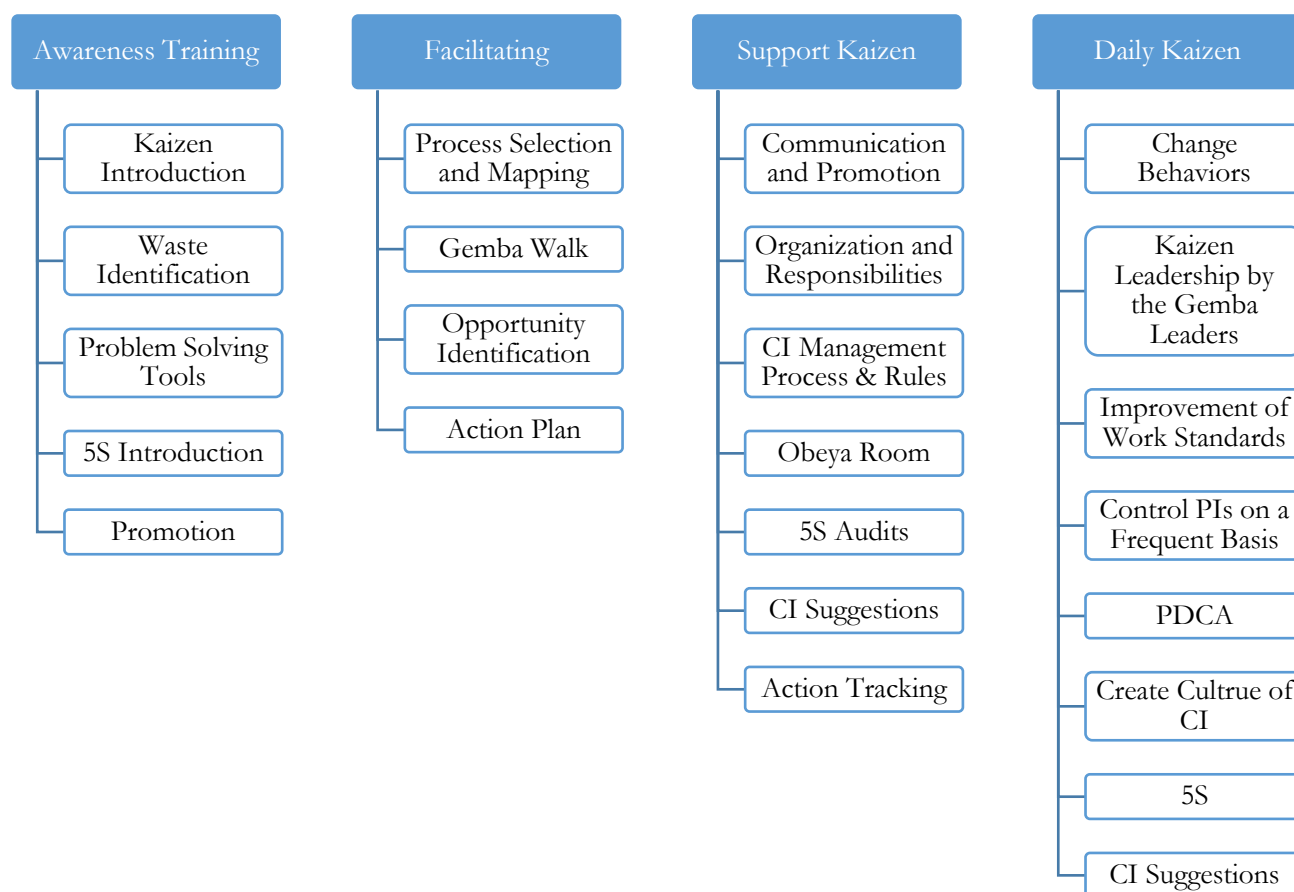
Awareness Training	Facilitating	Support Kaizen	Daily Kaizen
Kaizen Introduction	Process Selection and Mapping	Communication and Promotion	Change Behaviors
Waste Identification	Gemba Walk	Organization and Responsibilities	Kaizen Leadership by the Gemba Leaders
Problem Solving Tools	Opportunity Identification	CI Management Process & Rules	Improvement of Work Standards
5S Introduction	Action Plan	Obeya Room	Control PIs on a Frequent Basis
Promotion		5S Audits	PDCA
		CI Suggestions	Create Cultrue of CI
		Action Tracking	5S
			CI Suggestions

Figure 1-6: CI Content

Awareness Training: The objective of the awareness training is to create a common CI awareness among employees and make Continuous Improvement a part of the company culture. The initial awareness training for the steering committee, the Kaizen office, and the coordinators is conducted by the Kaizen Institute. The training of all other employees is done by the Kaizen officer and the coordinators. Promotion plays a crucial role in the program and is an ongoing process. Positive results and awarding are promoted to the employees at department meetings through WeChat[2] groups, via E-Mail or on Daily Kaizen boards by the coordinators.

Facilitating: Facilitating and coaching serve the purpose of finding deficiencies within every department and defining actions to resolve these issues. Initially, facilitating is conducted through workshops with each department by the Kaizen Institute, but later by the Skill Team Leaders and coordinators themselves.

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[2] (Schulz, 2016)

Support Kaizen: SK involves all the activities that help monitor the CI process and progress. SK's most important element is the Obeya room where most CI meetings are held and where a whole wall is dedicated to displaying CI progress charts permanently. Roles involved in the Obeya room meetings are the steering committee, Kaizen office, and the coordinators.

Daily Kaizen: DK either takes place on department or team level. Its focus lies on the communication of CI between STC employees, coordinators, and Skill Team Leaders. DK ensures the ongoing improvement and enables every employee to participate in CI. A Daily Kaizen board helps departments to visually manage information such as improvement suggestions, performance indicators, and general notifications. Team meetings are regularly held in front of the board either by the Skill Team Leader or by the team leader with the frequency depending on the displayed contents updating cycle.

1.3.4 Implementation Plan

The first training by The Kaizen Institute was on 12 September 2016. This day marks the official start of the CI program at AVL List STC. Awareness training was the logical first step for the program and took place until the end of November, starting with the steering committee and followed by the individual departments. The first awareness training dealt with the concept of CI and basic methodologies. As time passed, the awareness training got more specific, picking up the other topics such as Support Kaizen, Facilitating, Daily Kaizen and 5S. Awareness training was held by a consultant and the Kaizen officer in the beginning, later by the Kaizen officer and the coordinator. Support Kaizen, Facilitating, Daily Kaizen and 5S were introduced over time; a consultant trained the Kaizen officer and coordinator who then passed on the methodologies and tools to the individual departments. The time of introduction of these topics varied widely and depended on the workload and availability of the departments.

	Sep-16				Oct-16					Nov-16				Dec-16				Jan-17					Feb-17				Mar-17				Apr-17				May-17				
Week	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
Date	05	12	19	26	03	10	17	24	31	07	14	21	28	05	12	19	26	02	09	16	23	30	06	13	20	27	06	13	20	27	03	10	17	24	01	08	15	22	29
5S														5S →																									
Daily Kaizen										Daily Kaizen →																													
Facilitating					Facilitating →																																		
Support Kaizen					Support Kaizen →																																		
Awareness Training	Awareness Training →																																						

Table 1-1: CI Time plan

1.3.5 Role of Researchers

The three Researchers Georg Kolb, Lucas Wartscher and Christof Walz each joined a different department at the beginning of November, shortly after the introduction of the Kaizen Institutes coaching. Georg Kolb was allocated to the Development & Calibration department, Lucas Wartscher to the Mechanical Development & Test Factory and Christof Walz to the Plant Facility department. The role within the departments was similar to the coordinator's, although special precaution was given to support the coordinator instead of replacing her/him in order to ensure the continuity of the program after the Researchers leave the departments. The specific tasks of the Researchers are stated in chapter 1.1 Task Description.

1.3.6   The KAIZEN™ Institute

Founded in 1985 by Masaaki Imai, the Kaizen Institute provides consulting and training in the fields of Kaizen methodology, Lean Management and Continuous Improvement. Today, the services of the Kaizen Institute are available in more than sixty countries worldwide, being present in China since 2008.[3]

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[3] (KI, 2017)

2 Theoretical Background

This chapter describes the theoretical basis of CIP and Kaizen as well as various methods and tools, which are applied in chapter 3. Additionally, Change Management will be discussed as it is an essential topic during the implementation of a CIP.

2.1 Continuous Improvement Process

Continuous Improvement Process (CIP) or Continuous Improvement (CI) can be based on many different improvement principles such as Kaizen, Six Sigma (SS) or Lean Manufacturing (LM). Often, CI programs are formed by combining elements of these policies. CI is more an idea or concept rather than a defined program. The Kaizen methodology, on the other hand, was developed by Masaaki Imai and is probably the most common approach to CI programs. It was introduced to the world through his famous book "Kaizen: The Key to Japan's Competitive Success"[4]. The word *Kaizen* is Japanese and can either be translated to *Change for the Better or Continuous Improvement* [5]. Other famous concepts that strive for efficiency improvement within companies are Lean Manufacturing and Six Sigma[6]. The primary distinction of Kaizen compared to the other principles is the continuity of the program. LM and SS are often applied in situations when drastic change is required immediately, whereas Kaizen deals with small changes that result in drastic changes eventually. Another core distinction is the structure of the program; CI takes place where value is created and therefore is applied by every single employee. This approach is often referred to as bottom-up, whereas LM and SS use the bottom-down approach and are actively induced by management.

In its early stages, CI was focused exclusively on the production industry. Due to its great success, CI later was applied to many other industries, including the service sector. A recent example is a research done on effect process improvement in maintenance management with the goal of service improvement[7]; this approach is especially similar to the one used for this research, where the improvement findings in the Plant Facility department affect the final service quality.

In China, there was no need for efficiency improvement for a long time because labour costs have always been meagre. When productivity needs to be increased, the usual approach still was to add workforce. If, however, improvement is desired, a conventional method is the application of improvement projects based on previous work experience because most Managers in China do not have the skill to analyse and improve business processes[8]. In recent years, however, because of the fast growth of the middle class and thus rising salaries throughout China, the old approaches can no longer be applied and companies are forced to operate more efficiently. The early appliers of CI in China were inter alia international and especially Japanese companies with subsidiaries in China. Recently

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[4] (Imai, 1986)
[5] (Medinilla, 2014) p. 4
[6] (Warick, 2013)
[7] (Jao Abreu, 2013) p. 320
[8] (Yefei Yang, 2016) p. 690

research has been done with the goal of analysing Kaizen activity transfer to Chinese subsidiaries of Japanese businesses in nine medium and large sized automotive suppliers[9]. Also, Chinese companies in other industries are catching up to the CI trend, as e.g. construction firms that have elaborated the extent of CI implementation in the building industry[10]. In the Chinese services sector, research has been done on the influence of CI regarding new service development [11].

CI will continue to play a significant role in future business development in China as companies will continue to strive for efficiency improvement. This can be said for companies in Chinas production industry as well as other industries, like the automotive service industry, the industry in which AVL List STC operates and in which this research is conducted.

2.2 Kaizen

After the second world war, Japanese production factories were forced to be more efficient due to limited resources; this lead to an inexpensive management system that increased the personal efficiency of every employee. The term for this scheme, Kaizen, was coined and has gained international recognition through the publications of Masaaki Imai, as mentioned above. In his opinion, the goal of any Kaizen strategy is quality improvement, not only of products but also of processes.

2.2.1 Major concepts of Kaizen

Kaizen and Management: According to Imai, management can be divided into two principal components: Improvement and Maintenance. Maintenance has the objective of keeping current standards and includes all actions that strive to do so. Improvement refers to activities with the goal of improving current standards. The latter can further be divided into innovation and Kaizen. innovation deals with drastic changes that happen rapidly and often involve substantial investments, Kaizen on the other hand deals with the constant improvement which is ongoing and requires less capital.[12]

Process versus result: In the Kaizen philosophy, the right process will lead to the correct result, and a corrupt process will end in erroneous results. Therefore, more emphasis must be put on the right process and subsequently the correct result. In western management, these values are often contrary.[13]

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[9] (Aoki, 2008) p. 518
[10] (Gao Shang, 2013) p. 18
[11] (Yefei Yang, 2016) p. 275
[12] (Imai, 1997) p. 3
[13] (Imai, 1997) p. 4

Following the PDCA/SDCA cycles: This is the base of any process within the Kaizen principle. The steps *Plan*, *Do*, *Check*, and *Act* include the sequence and continuity of change, chapter 2.3.3 The PDCA-Cycle offers a more extensive explanation of these steps.[14]

Putting quality first: This concept refers to the quality, cost, and delivery-time trilogy. The Kaizen attitude in this regard is distinct; quality must come first and has the highest priority. Without superior quality, the company cannot successfully compete on the market.[15]

Speak with data: Data is the key to understanding problems, and without data, it is doubtful that the right measures are taken to resolve the problem. Only analysing the correct data will lead to optimal results.[16]

The next process is the customer: Every process has an input and output. When seeing the company in a larger picture, the input is delivered by the suppliers, and the output is provided to the customer. Within a company, the supplier and customer provide the process steps before and after the current one. The Kaizen philosophy views each internal customer as if it were an external client, meaning that the output of a process must always comply with the highest quality standards and must never be incomplete or faulty. This mindset leads to extremely high quality throughout the process chain and is exponentiated towards the final product.[17]

2.2.2 Key Elements for a Successful Kaizen Program

Total Quality Control/Total Quality Management: Total Quality Control was coined in Japanese management as control over the entire quality process. "Total" refers to the involvement of employees and emphasizes that everybody is involved in the quality of the process, especially shop floor workers. The last part, "Control", refers to changes made in the process. This means that the process must be modified in a way that leads to the best results. Total Quality Management derives from Total Quality control and has become an internationally used system.[18] A Just-in-Time Production System (Toyota Production System): Just-in-Time (JIT) stems from the Toyota Production System developed by Taiichi Ohno. Its ultimate goals are cost reduction and on-time delivery; these are achieved by eliminating waste by applying a series of Kaizen activities.[19] Total productive maintenance: In contrast to Total Quality Control, which concerns the quality of a company, Total Productive Maintenance is concerned with the quality of equipment. It mainly focuses on preventive maintenance, which expands the lifetime of the equipment. This is commonly achieved through successful implementation of 5S systems (See Chapter 2.3.5 5S of Good Housekeeping).[20] Policy Deployment: top management must set clear objectives as to what the goal of the program

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[14] (Imai, 1997) p. 4
[15] (Imai, 1997) p. 6
[16] (Imai, 1997) p. 6
[17] (Imai, 1997) p. 7
[18] (Imai, 1997) p. 7
[19] (Imai, 1997) p. 9
[20] (Imai, 1997) p. 9

is. These goals must be broken down through the hierarchy of a company and adapted to each level, right down to the shop floor workers. The goals are set by the higher hierarchical level and have to be tangible for the lower one.[21]

The Suggestion System: Every suggestion system's goal is the involvement of every employee. In the Kaizen methodology, Managers encourage employees to participate in these systems to strengthen their involvement in their work and boost their morale. Often, suggestions are implemented even before a form is completed. The result includes Kaizen-minded employees that show self-initiative towards improving their own work. Monetary rewarding is usually obstructive for such systems because employees only submit suggestions if they can expect a financial benefit; this way, small ideas are often neglected and suggestions regarding other employee's work are encouraged, resulting in a blame game.[22]

Small-group activities: The most common activities are quality circles that deal with cost, safety and productivity. These activities are usually voluntary, informal, and carried out by intracompany groups in a workshop character. Especially the intracompany mix of employees from different departments allows for many points of view on issues that otherwise are not given.[23]

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[21] (Imai, 1997) p. 9
[22] (Imai, 1997) p. 10
[23] (Imai, 1997) p. 10

2.3 Methods & Tools

2.3.1 The PDCA-Cycle

The PDCA-Cycle, also known as Deming-Cycle, is the formal frame work for problem solving within the Kaizen-method. The idea is to tackle problems as fast as possible to undermine a stacking of problems that could lead to complexity, thus making problems harder to solve. PDCA stands for Plan-Do-Check-Act, describing the four stages it consists of (see Figure 2-1: Elements of the PDCA-Cycle):

- **Plan:** At first, the problem must be identified and described. A cause analysis should be done. A goal must be set and solutions must be found to achieve this goal. In the plan-stage, most of the work is done; approximately 80 – 90 % of the workload of the whole cycle.

- **Do:** Once an appropriate countermeasure is developed, it is implemented in the do-stage. It is crucial to just implement one countermeasure at a time to not distort the result.

- **Check:** In the check-stage, the effectiveness of the countermeasure is investigated upon its effectiveness.

- **Act:** If the countermeasure is successful, it gets implemented as the new standard. Otherwise, the PDCA-Cycle must be rerun until a sufficient solution is found.[24]
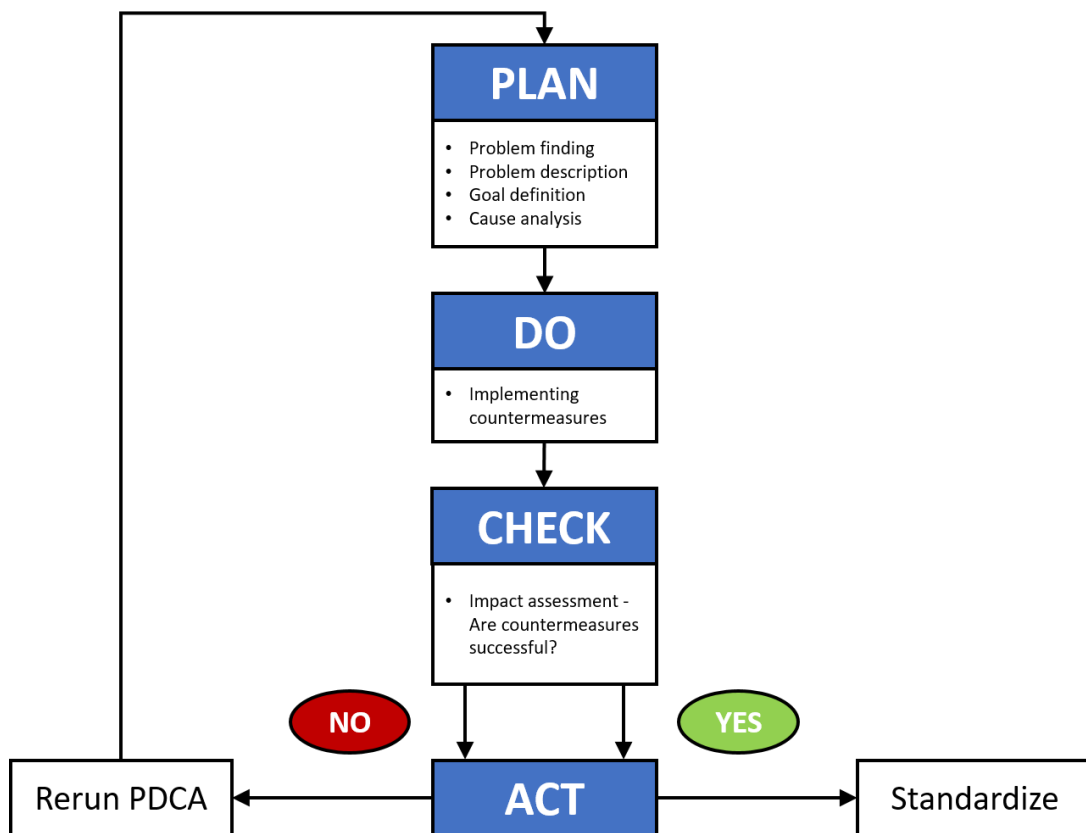

Figure 2-1: Elements of the PDCA-Cycle [25]

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[24] (Kühnle, 2016) p. 250, 251
[25] (Gierszewski, 2016) p. 373

The PDCA-cycle is one of the most important concepts within the Kaizen-method. Whenever a problem is solved and a new standard is established, the PDCA-cycle revolves again, this time challenging the new status quo. This ever revolving PDCA-cycle is the vehicle for continuous improvement (see Figure 2-2: The PDCA-cycle and its role in continuous improvement).[26]
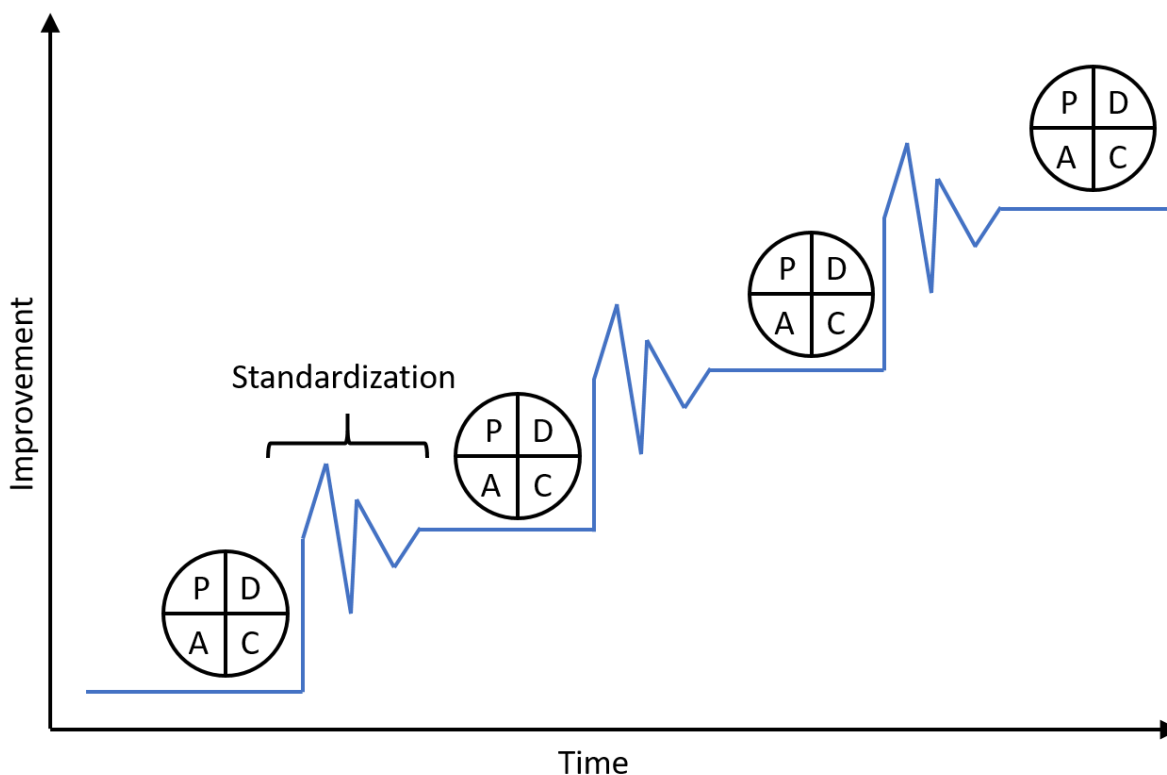

Figure 2-2: The PDCA-cycle and its role in continuous improvement [27]

2.3.2   Visual Management

The goal of *Visual Management* is to provide permanent and instant feedback to all employees, including Managers and Supervisors. When information about problems emerges, it passes through several layers of abstraction until it reaches the management team. By making problems and processes visible, they can be observed by every employee. In other words, Visual Management shortcuts the distortion of information about problems and reduces the time needed for information transport. [28]

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[26] (Imai, 2012) p. 23 - 24
[27] (Imai, 1997) p. 54
[28] (Imai, 1997) Chapter 8

2.3.3 Process Optimization

Optimization stands for the improvement of procedures, processes and systems to its best. The Process Optimization deals with the objective to develop and implement approaches for the improvement of operations and conditions. The optimization of processes is based on five main criteria which are Time, Costs, Quality, Flexibility and Investment.[29]

Process: A process consists of five main elements: Supplier, Input, Process, Output and Customer. A process could be the start- or the endpoint of other processes, and it can be divided in various sub-processes. Basically, the task of a process is to create an object for that at least one Customer exists. These objects could be depending on the process e.g. Information or Material flow. Each process could be in a relationship with the Supplier or Customer.[30]
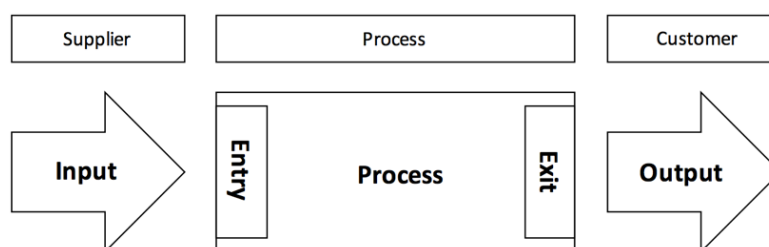

Figure 2-3: Process Elements [31]

2.3.4 Methods for Process Optimization

There are various methods known for the optimization of processes, but at the outset, it is important to clarify which processes and how many changes have to be implemented simultaneously. The following chapters describe, how the optimization methods vary within Process-Reengineering, Process-Optimization and the Continuous Improvement Process.[32]

2.3.4.1 Process-Reengineering

This method describes the complete redesign of the company processes. The objectives are the massive cost reduction, the elimination of waiting times and the improvement of the customer service and working behaviour. Therefore, three steps are considered for the execution of Process-Reengineering.[33]

1. Reconsider the business purpose
2. Restructuration of company processes
3. Set-up of substantial improvements

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[29] (Becker, 2007) p. 8, 13
[30] (Becker, 2007) p. 7 - 8
[31] (Becker, 2007) p. 7
[32] (Becker, 2007) p. 20
[33] (Becker, 2007) p. 22

The two most important things regarding the application of this method are the commitment of the top management and the consistent reconsideration of the processes. For many companies, Reengineering is the last chance to improve their processes before they go down.[34]

2.3.4.2 Process-Optimization

The objective of this approach is to make existing processes more efficient and flexible. The main task is the transformation of the sequence by consisting structures. Therefore, every process-step, sub-process and activity are discussed individually. The following steps show the procedure through the execution of this method.

1. Definition of the project
2. Understanding of the process
3. Improvement of the process
4. Measuring and monitoring
5. Continuous Improvement of the process

For the successful implementation, the support of the top management is essential. Further, the use of various methods to reach the desired objectives is important. In addition, Awareness Training for the employees has to be executed to facilitate innovative thinking.[35]

2.3.4.3 Continuous Improvement Process

The focus of this approach is the improvement of the process in small steps. Therefore, the employees are skilled in a tool e.g. DMAIC (Define Measure Analyse Improve Control) of Six Sigma or the 8D Report to execute the improvement.[36]

The goal is the direct realization of the improvements, which results in the fact that the changes compared to other methods do not have the same extent. The Continuous Improvement Process is not suitable to modify the whole process. This method can provide big improvements through the execution in small steps over a long period. Further, all employees in the company should be part in this process, and the commitment of management is significant.[37]

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[34] (Becker, 2007) p. 23, 27
[35] (Becker, 2007) p. 28, 29, 30
[36] (Becker, 2007) p. 31
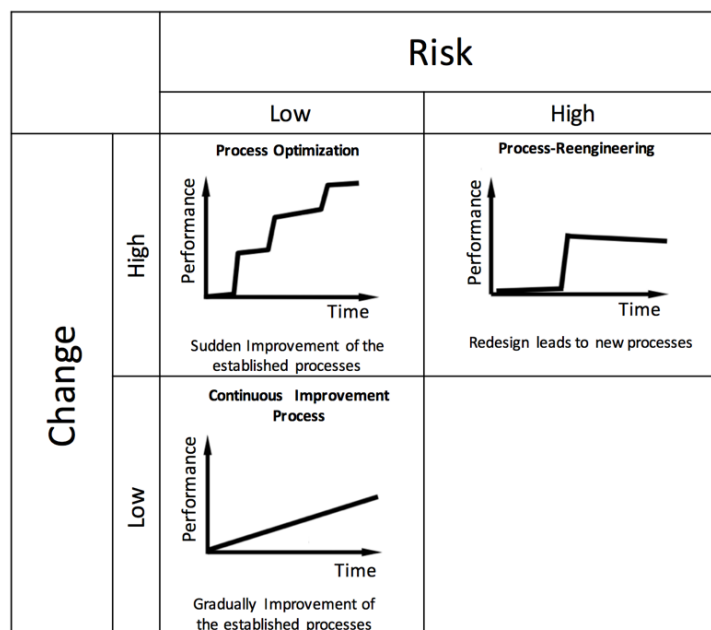[37] (Becker, 2007) p. 21

Figure 2-4: Methods for Process Optimization [38]

2.3.5 5S of Good Housekeeping

The 5S of Good Housekeeping is one of the first steps during the introduction of Kaizen into the company. 5S has been developed and applied in the area of production, but it can also be used in service-oriented companies.[39] The 5S campaign is not only about a clean and tidy workplace, but makes a significant contribution to process optimization and continuous improvement in the company. That means that 5S forms the basis of the identification and elimination of waste for an effective and sustainable improvement of the working environment. In industry, waste can be divided into seven various types such as *Transport*, *Inventory*, *Motion*, *Waiting*, *Overproduction*, *Overprocessing* and *Defects*. All seven types of waste can be determined and reduced by 5S. This is what makes the method very attractive and helpful in the early stages of a CIP.[40] Furthermore, 5S offers the opportunity to involve all employees in the improvement process that forms a prerequisite for a successful implementation of Kaizen in the company.[41] 5S stands for the following five Japanese words *Seiri*, *Seiton*, *Seiso*, *Seiketsu* and *Shitsuke*.

Seiri is the separation of the items in two categories: "necessary" and "unnecessary". The latter one is to be subsequently eliminated from the working environment.

Seiton is the configuration of the remaining items in a way to find and handle them easily.

Seiso means to keep the workplace and its environment clean and tidy.

Seiketsu are the standards that have to be set in order to maintain the neatness and cleanliness in the working environment.

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[38] (Becker, 2007) p. 21
[39] (Imai, 2012) p. 200 - 201
[40] (IFAA, 2016) p. 3
[41] (Imai, 2012) p. 202

Shitsuke means to develop self-discipline and sustain the first four steps in order to avoid relapsing into one´s old habits.[42]

The following graphic (see Figure 2-5: The five steps of 5S) demonstrates, how the five steps stand to each other. It shows that Self-discipline is central and influences each individual step.[43]
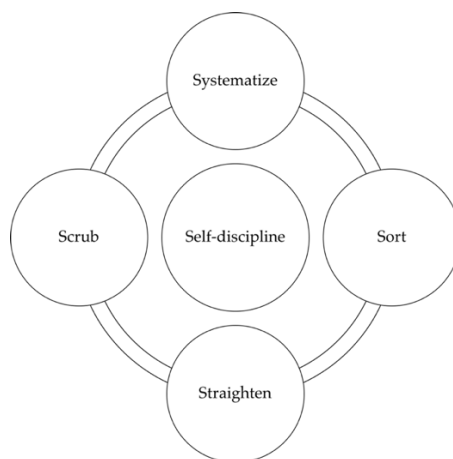

Figure 2-5: The five steps of 5S [44]

In order to gain a better understanding, Western companies replaced the Japanese words into *Sort, Straighten, Scrub, Systematize* and *Standardize*. This way, they are easier to remember which is helpful during the implementation.[45] The following gives a closer look to the five steps of 5S as well as some suggestions for reaching a 5S condition in the working organization.

2.3.5.1 Seiri

The first step of the 5S campaign is about sorting. The objective of sorting is the division of all items in the working environment into two categories, "necessary" and "unnecessary". There are all kinds of stuff in the working environment, but only a fraction of it is useful at daily work. The decision of which items are unimportant is often not easy. A simple rule implied that, if an item was not used in the last thirty days, it should be sorted out.[46] Another useful practice is the *Red Tag* campaign to sort all useless things out of the working area. Therefore, a selected 5S team attaches red tags on every item that is unnecessary as well as on those where they are not sure if they are important or not.[47] Guided by the principle "the more, the better", the area could be full of tags. In the case that tags are on useful items, the employees have to demonstrate the necessity, otherwise it will be removed. Occasionally, there are objects in the working environment that will be useless in the next thirty days, but might not be in the future. Therefore, the objects must be taken to their rightful places (e.g. warehouse). As a consequence of the

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[42] (Imai, 2012) p. 203 - 204
[43] (Imai, 2012) p. 212
[44] (Imai, 2012) p. 213
[45] (Imai, 2012) p. 203
[46] (Imai, 2012) p. 214
[47] (IFAA, 2016) p. 12

campaign, employees are faced with uncomfortable questions and ask themselves, "Why were we so unwise?" Furthermore, the campaign procures an overview of the supplies, work in process as well as other parts and provides space that leads to higher flexibility in the working area. At this point, the precise number of items is known and it has to be determined to prevent old mistakes, such as high inventory or supplies. Altogether, the *Red Tag campaign* gives both managers and employees an overview of how people work and how efficient the operation works. 5S is applicable in many fields as well as in the office area. Similar to the production sector, the office is full of clutter such as toothbrushes, sweets, medicine or, the other way around, there are too many useful items for example rubbers, writing pads or pencils. To gain an overview, every object should be classified by usage, and the maximum number of items must be defined, with the consequence that any item over the maximum number is thrown out of the area. The next step is to define a place in the office for storing supplies what is called the *Recycling bank*. In case that an item will be needed, the bank provides it. One employee is responsible that are enough available supplies at the bank at all times. Having considered these proposals, the obvious cluttering of items in the office area is abolished. To sum up, *Seiri* can be applied in various business segments and working areas. It helps to keep the environment neat and tidy as well as to develop self-discipline and to improve the working behaviour.[48]

2.3.5.2   Seiton

The second step of the 5S campaign is *Seiton* or *Straighten*. After a successful implementation of *Seiri*, only a small number of necessary items is still left in the working environment.[49] This part deals with the objective to place items in a way to find and handle them easily in order to reduce search time and effort. For this purpose, every item needs a designated name, an assigned location and address. The designated place should be marked by painting a rectangle on the floor or by putting labels on boxes to ensure that every item is at the correct place. The silhouette of tools could be drawn on surfaces to avoid that the wrong tools are stored at the wrong places. Finally, the hallway has to be marked clearly for a smooth transit as well as for safety reasons.[50] In the office area, the equipment, accessories and material need designated spaces. The folders and racks (e.g. for incoming post) has to be labelled. Space is a valuable asset in a company and should not be crammed with useless objects.

2.3.5.3   Seiso

The next step of the campaign is *Seiso*. The primary purpose of this part is about cleaning the working environment, tools and machines. Following the principle of *Cleaning is Checking*, this step could help to save money by detection of grievances that lead to high costs. A mixture of oil, soot and dust are the reason why it is difficult to find defects such as oil leakage, crack initiation on covers or loose nuts and bolts. In any case, with regular cleaning, these problems could be discovered and remedied easily before more severe damage occurs.[51]

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[48] (Imai, 2012) p. 214 - 220
[49] (Imai, 2012) p. 220
[50] (Imai, 2012) p. 221 - 223
[51] (Imai, 2012) p. 224 - 225

2.3.5.4   Seiketsu

The next phase of the 5S program is about *Standardization* and focuses on the continuity in the working environment. At the beginning of the campaign, some people think that 5S is a one-off sequence and that after the first three steps, it is over. Concerning that issue, the fourth part acts with the intention of carrying on the continuous work on the first three steps *Seiri*, *Seiton* and *Seiso*. Without any intention to continue 5S, the campaign will sooner or later fail. Therefore, management has to implement various standards and procedures such as guidelines, checklists or indicators to guarantee the continuation of the campaign (see Figure 2-6: The Principle of Standardization). Furthermore, the commitment, support and involvement of management to and in 5S is essential. [52]
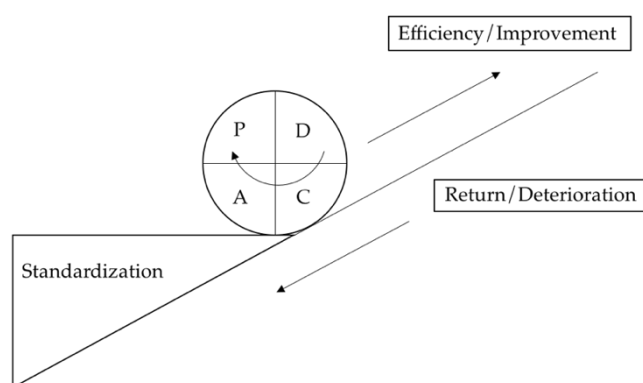

Figure 2-6: The Principle of Standardization [53]

2.3.5.5   Shitsuke

The last step of the 5S campaign is *Shitsuke* that means self-discipline. The employees who perform the steps *Seiri*, *Seiton*, *Seiso* and *Seiketsu* continuously in daily work for a certain time, gain self-discipline.[54] For reaching the fifth step, it is essential that everyone has the discipline to execute every single step correctly according to the corresponding rules. Management has to ensure that standards are established at every step.[55] In addition, activities should be taken to evaluate the progress of each step. The latter contributes to increase the self-discipline by demonstrating the results of the evaluation to the employees. Another practice is a competition between different teams or departments whereby the best gets an award or recognition and the worst a broom and a bucket. 5S is easy to implement and generates quick profits, but it is difficult to maintain. Management should develop a system to guarantee the continued existence of the 5S campaign.[56]

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[52] (IFAA, 2016) p. 21
[53] (IFAA, 2016) p. 21
[54] (Imai, 2012) p. 227
[55] (IFAA, 2016) p. 47
[56] (Imai, 2012) p. 229 - 230

2.3.5.6   Conclusion

The *5S of Good Housekeeping* is a process that requires time because it is inevitable to understand the philosophy behind its concept. Employees and Managers often underestimate the performance of 5S and spend too little time to implement this process in their daily work life. They want the process to be finished as fast as possible so that they can pay attention to more important issues.[57] It is necessary to clarify that 5S is a change process in the working environment thus, everybody in the company needs to be mentally prepared before starting the campaign.[58] It is a fact that, who does not even master 5S in daily work, will fail on topics such as CIP and Lean Management.[59] The task of the manager is to conscientiously plan the project as well as to ensure the correct execution. The benefits have to be communicated clearly to everyone. Such benefits are:

- Establishment of a safe and tidy working environment
- Enhancement of the worker's incentive and morale
- Recognition and removal of the seven types of wasting in the working area
- Support of the acquisition of self-discipline to ensure the compliance of standards
- Detection and elimination of the mistakes at facilities, such as machines and supplies
- Identifying of the quality issues leads to the reduction of the costs
- Increasing the working behaviour as well as the efficiency in daily work

When both employees and management understood the benefits and the positive impact on the working environment, the organisation can go forward with the continuous improvement program.[60]

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[57] (IFAA, 2016) p. 1
[58] (Imai, 2012) p. 231
[59] (IFAA, 2016) p. 1
[60] (Imai, 2012) p. 231 - 234

2.4 Change Management

Doppler and Lauterberg describe *Change Management* as a "*modern, colloquial collective term for every form of change which is practiced nowadays in corporations*".[61] They also note that Change Management is short-term to medium-term-oriented. Hence, Change Management happens in a specified timeframe that differentiates it from *Organizational Development*, which is rather long-term-oriented.[62]

A more specific definition is provided by Lauer: "*Change Management is the optimal arrangement of the path from the current state to the target state*".[63] This definition implies that a target state exists and that Change Management is applied as a support technique for conducting single, clear-cut tasks (see Figure 2-7: Change management as steering change from A to B). Such tasks might be:

- Takeover of a corporation

- Complete or partial reorganization of a corporation

- Outsourcing of organizational units

- Introduction of new technologies or processes

- Initial deployment of rules and methods primarily affecting employees[64]

A = Actual State   B = Target State
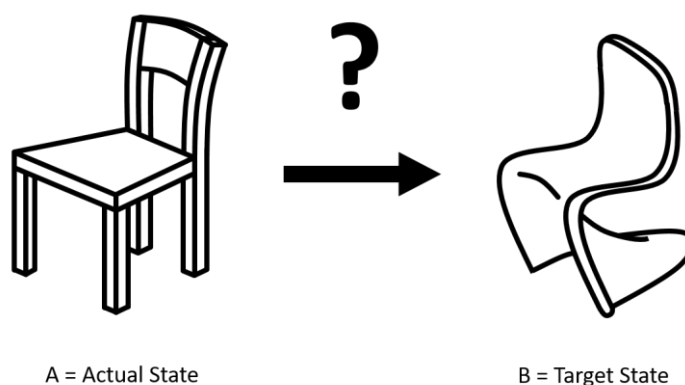
Figure 2-7: Change management as steering change from A to B [65]

2.4.1 Resistance

A survey among 1000 German-speaking corporations, conducted by the Hernstein-Institut, shows that 38 % of all change projects are declared as failed. The main factor for this failure can be found in *Resistance*.[66]

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[61] (Doppler, et al., 2014) p. 99
[62] (Doppler, et al., 2014) p. 93 - 100
[63] (Lauer, 2014) pos. 446.
[64] (Lauer, 2014) pos. 439 - 541
[65] (Lauer, 2014) pos. 456
[66] (Lauer, 2014) pos. 1279 - 1290

Next, as for rational reasons why an individual in a corporation might resist change, there are several psychological sources of possible resistance:

- **Habit:** Humans tend to stick to certain behaviours. These behaviours often have at track-record of past successes. Even if the circumstances, in which a certain behaviour was successful, changed, the behaviour often remains as it is part of the *Comfort Zone*. Leaving the comfort zone requires effort. In Change Management, the individual should be convinced that leaving the comfort zone harvests more benefits than staying in would.

- **Operational blindness:** If something is only known in a certain context, people are often not able to establish new relations. The new gets rejected as irrelevant.

- **Reactance:** Reactance is the urge to restore threatened freedom. It gets triggered in cases the change process cuts out possibilities and alternatives.

- **Defending self-image:** Things that are created under much effort get integrated into one's self-image. When these (concepts, plans, behaviours) are questioned, people switch into defensive-mode to protect their self-image.

- **Preservation of power structures:** If a change process threatens to break up established hierarchies, the loss of privileges is feared by employees in power positions. So, they often use their power to herd the doubtful and unwilling employees and create an alliance against change.

- **Group pressure:** Instead of people in power, pressure can also come directly from the resisting parts of a group (department, team).

The different forms of resistance can be illustrated as a *Wall of Resistance* (see Figure 2-8: Wall of resistance, based on Steiner and Landes), which must be overcome to succeed with change efforts.[67]
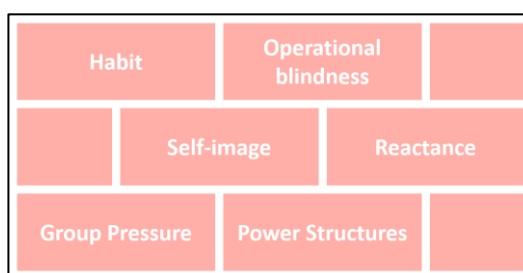

Figure 2-8: Wall of resistance, based on Steiner and Landes [68]

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[67] (Landes, et al., 2014) p. 4 - 12
[68] (Landes, et al., 2014) p. 12

2.4.1.1   Shapes of Resistance

Once triggered, the mentioned resistances (see section 0) find their expression in different forms, active or passive and verbal or nonverbal (see Figure 2-9: Shapes of resistance).

- **Opposition:** Direct disagreement, can be factual or in the form of accusations and threats
- **Agitation**: Stirred up atmosphere, rumours
- **Avoidance**: Indirect disagreement, minimizing and stultifying affected topics
- **Apathy**: Not appearing for meetings, laziness, inner resignation[69]

	Verbal (talking)	Nonverbal (behavior)
Active (attack)	**Opposition** Refutations Accusations Threats	**Agitation** Conflicts Rumors Intrigues
Passive (flight)	**Avoidance** Trivialisation Stultification Silence	**Apathy** Staying away from work Inner resignation illness

Figure 2-9: Shapes of resistance [70]

2.4.2   Different Cultures and Different Worlds

Apart from resistance, Lauer notes that misunderstandings in communication provide another major reason for failed change projects. Every communication is prone to errors in general. A gap between the message intended and the message received is very common. This gap occurs on a whole new level if individuals from different cultures are involved in the communication.[71]

Geert Hofstede describes *Culture* as *"the collective programming of the mind that distinguishes the members of one category of people from another".* The *collective programming* represents influences through the social environment like family, friends, teachers, media and so forth. To make those various cultures from different parts of the world tangible, Richard D. Lewis proposes the *LMR-model.* The LMR-model categorizes cultures on ranges in between three different poles (see Figure 2-10: The LMR-model). To these three poles, *Linear-Active*, *Multi-Active* and *Reactive*, certain behavioural aspects can be assigned. Following, a narrowed down selection:

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[69] (Lauer, 2014) pos. 1456-1486
[70] (Lauer, 2014) pos. 1537
[71] (Lauer, 2014) pos. 1365-1382

- **Linear-Active cultures:** doing one thing after another, minding their own business, sticking to plans, following procedures, confrontation through logic, separating social and professional.

- **Multi-Active cultures:** doing many things at a time, acting inquisitive, changing plans, pulling strings, confrontation through emotions, interweaving social and professional.

- **Reactive cultures:** reacting, acting respectful, making slight changes, networking, avoiding confrontation, connecting social and professional.
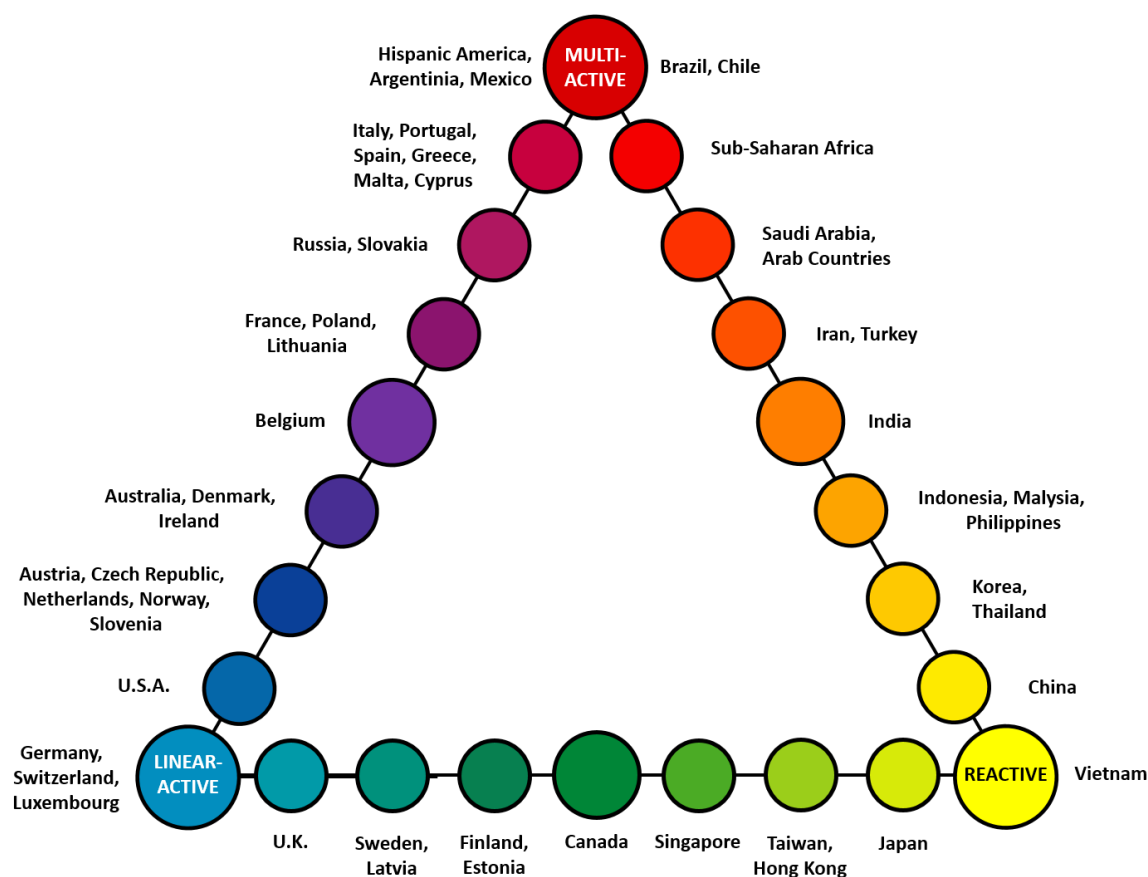
Figure 2-10: The LMR-model [72]

These attributes and behaviours find their expression in the respective language. Language, in turn, reflects the way a person perceives objective reality, as higher levels of thinking are interconnected with one's language. Therefore, communication between individuals or groups of people, which are far apart on the LCM-model, not only leaves out parts of the information on the communicator's side; the remaining conveyed information is only partly understood too. Consequently, the ways complex topics are comprehended, differ vastly among the categories. Table 2-1: Notions of change among different culture categories shows how different cultures understand the shades of the concept of change. It is obvious that without bridging this gap in perception, the interpretations of change are opposed by default in many cases.[73]

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[72] (Lewis, 2006) p. 42
[73] (Lewis, 2006) p. 1 - 97

Linear-Active	Multi-Active	Reactive
Change is constantly necessary	Change is imaginative and exciting	Change should be gradual
Change stimulates growth and improvement	Change stimulates people	If it ain't broke, don't fix it
Plan in detail, then change	Change charismatically, then plan details	Plan change slowly, in harmony with others
Change should be profit-oriented	Change involves the social reputation of the company	Change should be employment-oriented
Change is top-down	Change after key lateral clearances	Change if all agree
Democratic brainstorming is an excellent way to foster creativity	Brainstorming is great, but it must be restrained in the presence of superiors	It is better to think in silence than aloud
Show support for other's new ideas but voice any reservations about them immediately	Imply you agree to others' suggestions for innovations but modify or drop them later	Approve of others' new ideas even if you fully disagree
Any change is better than no change	Change usually benefits top dogs	Change is often dangerous

Table 2-1: Notions of change among different culture categories [74]

Leadership and decision making

Within the context of business practice, the notions of leadership and decision making deserve particular attention. In China and its area of influence, organizations apply a *Confucian* model. This model has large similarity with family structures. The major distinction to the Western model is the self-perception as a part of a group, instead of seeing oneself as an individual. The concept of *Face* descends from the Confucian model. Whereas the face in western societies is just a superficial layer, in China it is the source of the personality. Therefore, the preservation of face is a core value, and any losing of face must be avoided. In result, relationships are harmony-oriented and conflict-avoiding. Furthermore, relationships are unequal, hierarchy-based and paternalistic - like in a traditional family, for example father – son, male – female, and so on. In combination, this yields into a leadership style which is top-down and demands total obedience, but which is also consensus-oriented to prevent the loss of face. German leadership is autocratic too, but contrary to the Chinese way, consensus is reached through individual confrontation and clarification – unthinkable in China. Figure 2-11: Leadership and decision-making patterns in Germany and China illustrates the different patterns of leadership structures in China and Germany. [75] [76] [77] [78] [79]
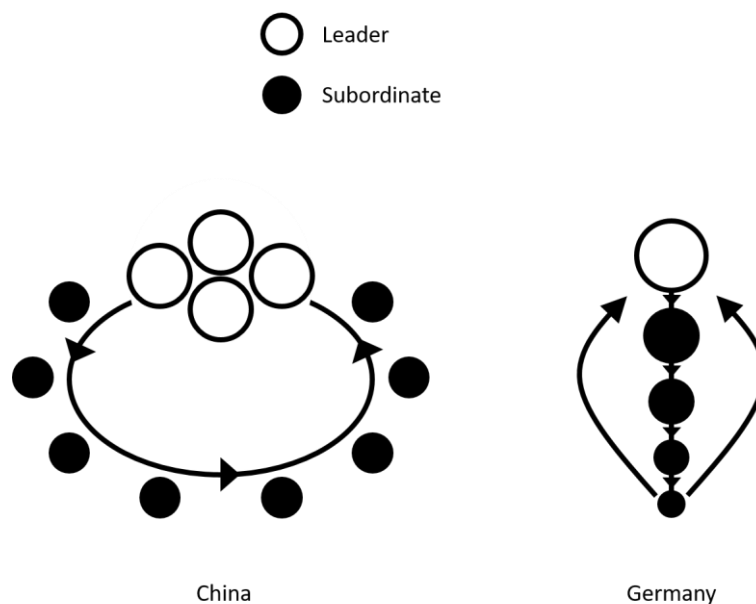
[74] (Lewis, 2006) p. 127, 128
[75] (Ascencio, et al., 2014) pos. 36 - 330
[76] (Ascencio, et al., 2014) pos. 492 - 738
[77] (Ascencio, et al., 2014) pos. 636 - 1251
[78] (Lewis, 2006) p. 101 - 103
[79] (Lewis, 2012) p. 77 - 103

Figure 2-11: Leadership and decision-making patterns in Germany and China [80]

Concluding, successful change can only be undertaken when both, the psychological obstacles of individuals and the different perceptions of reality, are taken into account. In a globalized world, where individuals from different upbringings and cultures must deal with each other on a daily basis, the performing officers of change have to carry out heightened awareness to these aspects more than ever.

2.4.3   Guidelines for Change

Social psychology and management literature offer indications on how to successfully perform change.

2.4.3.1   Field Theory as a Framework

Kurt Lewin, a pioneer in social psychology, developed the so-called *Field Theory* amidst the twentieth century. Following physics, Lewin proposed force fields in social domains. Central to this approach, regarding change processes, is the interplay of two types of opposing forces: The *Driving Forces,* which act towards change, and the *Restraining Forces*, which counteract change. The different forms of resistance examined above (see chapter 2.4.1) are equivalents of those forces.
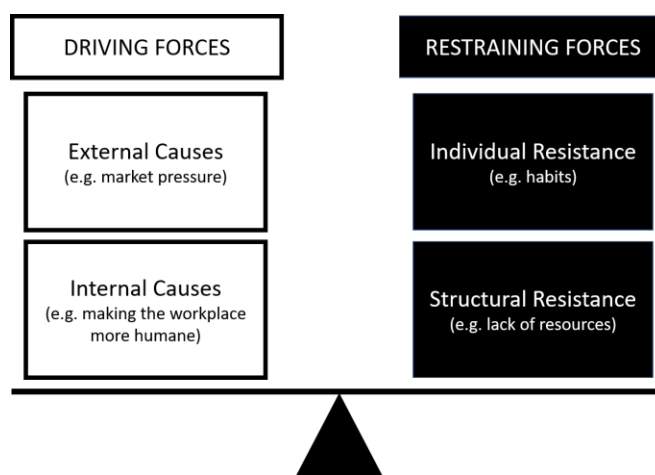
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[80] (Lewis, 2006) p. 108, 109

Figure 2-12: Field theory by Kurt Lewin [81]

These two types of forces strive for balance (see Figure 2-12: Field theory by Kurt Lewin). If one type of force is dominant, destructive effects may occur. In case the restraining forces are prevailing, the system falls into gridlock or even retrogression. In the other case, if the driving forces outweigh the restraining forces, the system is unable to balance itself, which ultimately leads to performance drops. Based on this framework, Lewin developed the *Three-Stage Model for Change*, which still serves as a blueprint for more recent and further developed change models.[82]

2.4.3.2   Basic Building Blocks for Change: The Three-Stage Model

In the first phase (*Unfreezing*), it is important for the driving forces to prevail. This can be accomplished by strengthening the driving forces, reducing the restraining forces, or by redirecting restraining forces into driving forces. In the second phase (*Moving*), the actual transformation effort is made to change the system by using the surplus of driving forces released in the first step. After successful change has occurred, in the third step (*Freezing*), the balance of driving and restraining forces is re-established, leading the system back to stability. In conclusion, a practicable method for performing change must take all the factors mentioned above into account and can be shown in a summarizing way (see Figure 2-13: Process of success of effective change, based on Lauer).[83]

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[81] (Lauer, 2014) pos. 1649
[82] (Lauer, 2014) pos. 1628 - 1681
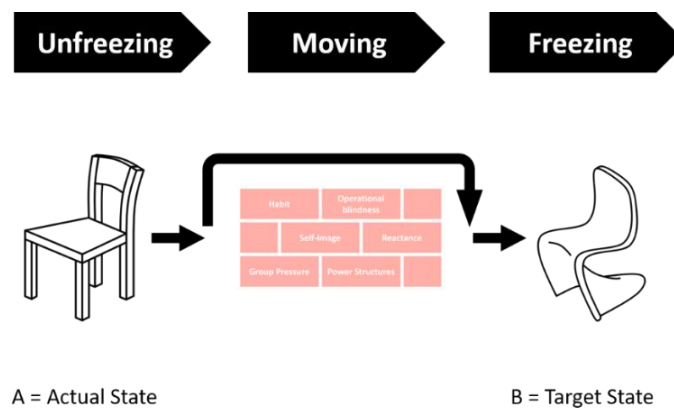[83] (Lauer, 2014) pos. 1681 - 1765

Figure 2-13: Process of success of effective change, based on Lauer [84]

2.4.4 The Eight-Stage Process

A model that meets all the requirements illustrated in Figure 2-13: Process of success of effective change, based on Lauer is the *Eight-Stage Process for Change*. The eight-stage process was developed by John F. Kotter and gained popularity through his 1996 book *Leading Change*, ranked among the 25 most influential business management books by TIME magazine.[85] As the name suggests, the eight-stage process for change consists of eight, sequential steps.[86]

2.4.4.1 Step One: Establishing a Sense of Urgency

In step one, the primary task is to overcome complacency by installing a sense of urgency. Complacency is the first layer of resistance, which keeps the driving forces in their starting holes. Employees must understand on an emotional level that change is necessary. Just providing logical reasons is not sufficient in most cases. This first step often demands bold and risky actions to break up initial resistance, like allowing a big quarterly loss or selling parts of the company, actions which push people out of their comfort zone. One way to accomplish this is to having a visible **Crisis**. A crisis can be natural or artificial. In the crisis scenario, when the future of the company seems unclear and thus the jobs of the employees too, it is difficult to conduct business as usual. Apart from a crisis, further methods to raise urgency can be used:

- Setting targets so high, that they cannot be reached without overstretching
- Holding more people accountable for company targets
- Removing obvious examples of excess
- Distribution of information which indicates weakness
- Expose employees to problems by confronting them with consultants or unhappy customers[87]

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[84] (Lauer, 2014) pos. 1715
[85] (TIME, 2011)
[86] (Kotter, 2012) p. 25 - 27
[87] (Kotter, 2012) p. 37 - 52

2.4.4.2   Step Two: Creating the Guiding Coalition

In step two, it is crucial to combine a powerful team which spearheads the change process, the *Guiding Coalition*. Two pitfalls are very common in this step:

1. The isolated CEO: These days, issues have become so complex that the CEO, even though she or he holds superior hierarchical position, is very likely to fail in making the correct decisions.
2. The low-credibility team: Key players are missing on the team. For instance, it is often seen that the head of Human Resources is running the change process without the back-up of the leaders of the departments.

A powerful team combines people with the following important characteristics:

- **Positional power**: People who possess hierarchical power, like Main Line Managers.
- **Expertise**: People who have the necessary know-how of the topics affected by the change process so smart decision can be made.
- **Credibility**: People who have a good reputation among employees.
- **Leadership**: Enough people with proven leadership skills must be on board. This characteristic is particularly important. leaders drive the change, whereas Managers keep the process under control. Without the right balance of management and leadership skills in the guiding coalition, the process is set up for failure (see Figure 2-14: Profiles of four different guiding coalitions). As Kotter mentions, generations of Managers have been developed over the last decades, leadership skills, on the other hand, were neglected.[88]

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[88] (Kotter, 2012) p. 53 - 68
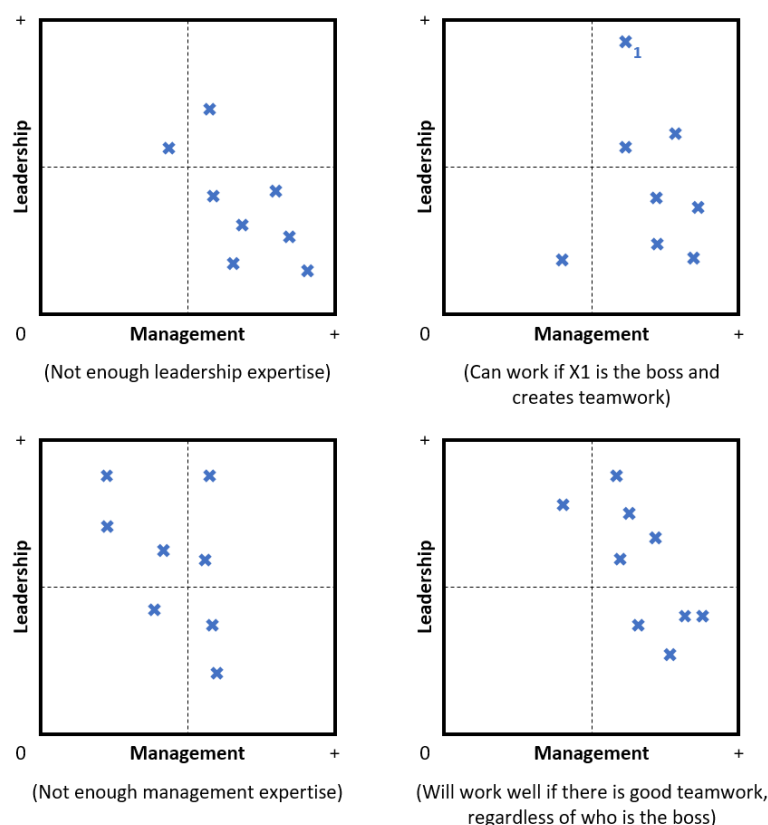
Figure 2-14: Profiles of four different guiding coalitions [89]

2.4.4.3   Step Three: Developing a Vision and Strategy

A vision is an imaginable picture of the target state and thus provides a direction for the change process. It not only motivates people; it also helps their coordination in the groups within they are involved differently. Apart from being imaginable, the vison should be desirable to release additional motivation. Adding feasibility to the vision gaps the bridge between the actual state and the target state, enabling people to also imagine the path to completion. It is evident that a well-constructed vision brings everything together. Hence, creating a vision should not be done half-hearted, which would undermine its purpose.[90]

2.4.4.4   Step Four: Communicating the Change Vision

Step four gets neglected on a regular basis. A carefully crafted vision has no effect if it is not communicated so that everybody in the company understands it. Therefore, the communicational hurdles mentioned in chapter 2.4.2 must be overcome. Kotter advises the use of metaphors, analogies and examples as these forms of communication provide vivid pictures, which are easy to comprehend. Simple messages in general are preferred because they do not require previous exposure to a topic, unlike technological talk and jargon does. Also, many different forums should be used, like memos, meetings, direct conversations, presentations, bulletin boards. New information needs some

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[89] (Kotter, 2012) p. 60
[90] (Kotter, 2012) p. 69 - 86

time to get soaked up, so constant repetition is crucial. Finally, if inconsistencies or questions appear, the change agents should seek out dialogue and leave no topic unresolved. Finally, key players must embody the vision and lead by example.[91]

2.4.4.5 Step Five: Empowering Employees for Broad-Based Action

After step four is accomplished, employees are ready to go. Very often, immediate action is not possible because structural barriers exist (see Figure 2-15: Barriers to empowerment). The core to step five is to remove these barriers. This can be done through the following measures:

- ***Providing the needed training***: If people cannot act towards the vision, they feel unempowered.
- ***Aligning systems and structures to the vison***: Unaligned information and management systems block the needed action.
- ***Handling troublesome Supervisors***: Works best in the form of direct confrontation and honest dialogue. Outmanoeuvring troublesome Supervisors may shed an unflattering light on the change agent if it is discovered.[92]
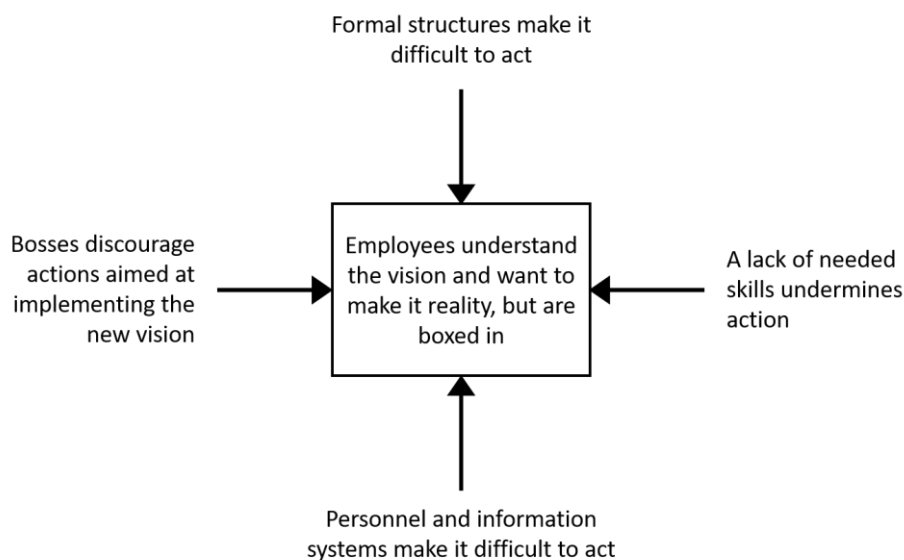

Figure 2-15: Barriers to empowerment [93]

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[91] (Kotter, 2012) p. 89 - 103
[92] (Kotter, 2012) p. 105 - 119
[93] (Kotter, 2012) p. 106

2.4.4.6   Step Six: Generating Short-Term Wins

After the change process is on its tracks, evidence that the efforts yield fruit must be provided by generating short-term wins. This evidence has multiple purposes. Firstly, it rewards employees that are heavily engaged in the change process. Secondly, it undermines resisting employees by dispersing their doubts. Thirdly, it builds momentum. As the guiding coalition cannot hope for quick wins, they should plan and pressure for it. Good short term wins have the following characteristics:

- **Visibility**: To make the impact of the successful change process omnipresent and graspable by large numbers of people.
- **Unambiguity**: The achievement must be without downsides so that the positive impact cannot be questioned.
- **Relation to Change:** To establish the relationship between achievements and the change process.

The key purpose of step one to six combined is to build up strong driving forces and stabilize their magnitude over the restraining forces for the major changes to come.[94]

2.4.4.7   Step Seven: Consolidating Gains and Producing More Change

Nowadays, in order to survive in the highly competitive market, organizations are focusing on speeding up processes, constantly lowering costs and on high customer orientation. Although varying across industries, these trends led to a high degree of interdependence. E.g., in the past, organizations had big inventories to buffer an eager Sales department – making production somewhat independent from sales. Shot-term wins are by nature very often accomplished in independent organizational areas, avoiding the entanglement and restraining forces, which come with high interdependence. Organizations often make the mistake to rest after the short-term wins; urgency tends to decrease. But to break up these connections within the organization and to make the big, significant changes, more urgency is needed. Therefore, Kotter suggests:

- Adding more people to support the change process
- Leadership and management form below for specific projects
- Senior management focusing on leading the change process with a clear vision
- Identifying and reducing unnecessary interdependencies[95]

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[94] (Kotter, 2012) p. 121 - 135
[95] (Kotter, 2012) p. 121 - 135

2.4.4.8   Step Eight: Anchoring New Approaches in the Culture

The anchoring of the new approaches in the corporate culture is the final step of the change process. This can be especially hard, as corporate culture is very often invisible and yet extremely powerful for three specific reasons:

1. Corporate culture finds its expression in every action of every employee every day and therefore gets continuously reinforced.
2. These actions are governed by a subconscious level and thus hard to discuss
3. Corporations tend to hire employees that already share some of their corporate values

New approaches only get accepted if it is evident that they are superior to the old way of doing it. So, constant verbal reinforcement and pointing to the successes must be done. Also, only people who embody the new approaches should be hired and promoted. Making room for these heralds of the new approaches might involve some turnover – especially in key positions.[96]

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[96] (Kotter, 2012) p. 153 - 166

3 CIP in the Plant Facility Department

3.1 Introduction and Goals

The research for this thesis started on November 1st, the practical work at AVL List Shanghai Technical Center was conducted from Jan 2nd to May 19th, 2017 and dealt with the introduction, adoption and subsequent evaluation of Continuous Improvement in the Plant Facility Department. Initially, the objective was to execute the actions, generated in the Facilitating workshop held by a consultant from the Kaizen Institute. During the research, the scope was appended by 5S campaigns in the office and workshop area as well as Daily Kaizen boards and activities throughout the department. In general, the goal of the CI program was to increase the overall efficiency and utilization of the department, create more team available time for strategic and value-adding activities, maximize internal and external customer orientation, and increase employee satisfaction. All of this should be achieved by creating awareness for CI, setting up a detailed CI management system and ultimately adding CI to the culture of the organization.

The Researcher was involved by participating in the training provided by the Kaizen Institute, transferring the gained knowledge to the department through workshops, pep talks and presentations - and therefore enabling the employees to independently improve the efficiency of their work while always being able to receive support from the Researcher whenever it was required. Communication between the Researcher and the workforce was difficult sometimes, since many of the Plant Facility Department's members had a basic understanding of English only, and the Researcher had a basic knowledge of Chinese language only. The Team Leaders, Skill Team Leaders and Coordinator, however, had a sufficient understanding of both languages to translate, if necessary. Training materials were usually provided in both English and Chinese.

For a better understanding of the saving amounts that appear in this document a conversion rate of 7.5RMB to 1€ can be used, which was the average conversion rate at the time of the research in the beginning of 2017.

3.2 Actions

3.2.1 Action List

The initial actions, listed in Table 3-1: Plant Facility Actions, originate from the CI Facilitating workshops held throughout all STC's departments. The Plant Facility Department's workshop took place on October 25th 2016 and produced actions No. 2 - 13. Participants of the seminar were the Kaizen Officer, the Coordinator, the Plant Facility Department's Skill Team Leader, and Team Leaders as well as a consultant from the Kaizen Institute who conducted the workshop. The process leading to this action list included process mapping, waste identification, a Gemba Walk, the finding of solutions, prioritization of solutions and finally the definition of actions. The Dev. & Cal. Department defined action No. 1, the Project Management Department action No. 14 and 15 for the Plant Facility Department.

No	Action	Owner	Status	Due Date		Saving (¥)	Saving (¥/week)
1	Define standard for equipment responsibility	Li Yanlu	0%	31.12.2016			
2	Catetory drawing batch machine sample probe	Xiao Jun/Hengyang	0%	31.12.2016			
3	Troubleshooting review meeting 1 per two months	Li Yanlu	0%	30.11.2016			
4	Set up typical TST database	Zhao Quancai	0%	30.11.2016			
5	Record malfunction over 1H in troubleshooting record	Li Yanlu	0%	31.10.2016			
6	Fuel pipe installation standardize	Zhao Quancai/Heng Yang	0%	30.04.2017			
7	Parameter offline/simulator	Zhu Jihua	0%	31.05.2017			
8	Spare parts safety stock check once per half year	Zhou Di/Zang Chunlai	0%	31.10.2016			
9	Power socket installation for ETC1-6	Liang Yongli	0%	30.04.2017			
10	Puma operation table extend	Zhao quancai	0%	30.05.2017			
11	Repair room management	Zhao Quancai/Xiao Jun	0%	31.01.2017			
12	5S/Visual Management	Li Yanlu	0%	31.12.2016			
13	Keycard computer application combined	Huang Jianxiong	0%	30.11.2016			
14	Timely transfer ETTS data to ProCalc	Huang Jianxiong	0%	28.02.2017			
15	Instrument, transducers equipment owner list	Li Yanlu/Andrea Pagnini	0%	31.12.2016			
Overall Saving (RMB)						¥0,00	¥0,00

Silo of Waste (table header)

Table 3-1: Plant Facility Actions

This list is updated after completion of each loop and displayed in the Obeya Room for visualization towards the Steering Committee. The owner of the action was expected to be familiar with the cause that led to the creation of the action. Therefore, the contact was familiar with the means and individual employees, necessary to complete the action. The due date, associated with each action, was defined in the Facilitating workshop without the department's utilization in mind and therefore it only served as an indicator for an action's urgency when comparing it with other actions. The percentage of completion was also updated after the end of the loop and may not be 100% if the action was not completed before the loop end date. Savings calculations were conducted after an action was completed and therefore they were only available at the end of each loop.

3.2.2 Action Tracking

The initial action list also referred to as silo of waste, was divided into three loops each filled with not more actions than could be handled by the department in addition to the usual utilization. The objective of tracking was ensuring, that actions were completed before their due date was reached. action tracking is a powerful tool because of the reminding and checking; especially for tasks that are necessary but not prioritized by employees. Each action follows the PDCA scheme which is a basic principle of CI and ensures the continuity of improvement. A detailed description of the PDCA scheme can be found in chapter 2.3.1 The PDCA. For action tracking, the scheme was slightly modified and extended by a Description and Savings Calculation:

Description: The Description clarifies the initial situation, describes the problem and explains why the action is expected to solve this issue. In some cases, it also describes the expected results after completion of the action.

Plan: Planning the execution of the action involves the responsible person, the Coordinator and the Researcher. A meeting was held for every action to clarify the sub steps necessary to reach the desired goal. For each sub step, a responsible person and due date were declared, keeping the person in charge's normal workload in mind. If applicable, deliverables were discussed and identified. The collected information was entered into a unified table and displayed in the Obeya Room.

Do & Check: These parts of the PDCA scheme are the most important ones as they ensure the execution of the action. The unified table in the Obeya Room was extended by this part for weekly review during the Coordinator meeting. Throughout this chapter, the Do & Check section will focus on what it took to get sub steps completed, why some could not be completed and what adjustments were made to fulfill the objective(s) of the action.

Act: The last step of the PDCA cycle is called Act and has the aim of correcting issues that arose during the Do & Check phase. This last step can also be referred to as standardizing because often a standardized process can be defined at this point. Throughout this chapter, Act starts with a comparison to the initial situation explaining if the situation has improved and whether the expected results were achieved. It also offers lessons that can be learned from the Do & Check phases and possible countermeasures to fulfil the objective of the action.

Savings Calculation: This is a crucial part of action tracking because cost savings is one of many methods to increase efficiency. Being able to translate improvements to a monetary saving gives us an idea of which impact the program has on the economics of the department and STC in general. The approach for quantifying the savings is to identify a countable parameter for waste that is being reduced by the action, then figuring out how many times more this parameter occurs without the action being in place and working out the cost of the parameter. The saving is then calculated by multiplying the eliminated occurrence with the expense of the parameter. The resulting amount of savings must be handled with particular precaution since the parameters are based on estimations.

3.2.3   First Loop

The first loop took place between 11/16/2016 and 12/15/2016. For this loop actions 2, 3, 4, 8, 11, 13, and 15 were chosen. action 11 was applied to the repair room associated with the Emission Team in this loop, leaving the possibility to implement it to other workshops in future loops. The selection of actions was made based on their priority and the available capacity of the department's utilization. Table 3-2: First Loop Actions lists the selected actions of this loop.

NO.	Date of Issue	Originator	Action Item	Responsible Person	Target Date
2	10/25/2016	Plant Facility	Category drawing batch machine sample probe	Xiao Jun / Heng Yang	12/31/2016
3	10/25/2016	Plant Facility	Troubleshooting review meeting 1 per two months	Li Yanlu	11/30/2016
4	10/25/2016	Plant Facility	Set up typical TST database	Zhao Quancai	11/30/2016
8	10/25/2016	Plant Facility	Spare parts safety stock check once per half year	Zhou Di / Zang Chunlai	10/31/2016
11	10/25/2016	Plant Facility	Repair room management (Emission)	Zhao Quancai / Xiao Jun	1/31/2017
13	10/25/2016	Plant Facility	Keycard computer application combined	Huang Jianxiong	11/30/2016
15	11/11/2016	Project Management	Instrument, transducers equipment owner list	Li Yanlu / Andrea Pagnini	12/31/2016

Table 3-2: First Loop Actions

NO. 2 "Category drawing batch machine sample probe."

Description: Every motor that is set up and prepared for testing is fitted with an exhaust probe. This exhaust probe is manufactured individually and assembled according to the diameter of the exhaust pipe. After the project ends, the probe must be disassembled. Per project, this results in much time for assembling and disassembling probes. The exhaust pipes of the tested engines are very similar, and diameters vary only marginally. The action proposes that a batch of standard probes for exhaust pipes with different diameters is to be produced, complimented with a drawing visually positioned close to the samples to grant easy identification of size. This action is expected to result in savings of assembly and disassembly time.

Plan:

Sub Steps	Responsible	Due Date	Output
Collect drawing scope/common exhaust pipe size	Xiao Jun	09.11.2016	
Confirm drawing requirement with Heng Yang	Zheng Congxing	10.11.2016	
Print/seal/hang the drawing in machining room	Zheng Congxing	11.11.2016	Drawing
1 batch production	Heng Yang	17.11.2016	
probe pipe checking	Zheng Congxing	17.11.2016	
Mark the difference	Heng Yang	17.11.2016	VM
Visual work instruction for assembly	Zheng Congxing	18.11.2016	WI
Assembly training	Zheng Congxing	22.11.2016	Record

Table 3-3: Action No. 2 Sub Steps

Do & Check:

Sub Steps	Nov-16				Dec-16				Jan-17				
	46	47	48	49	50	51	52	53	1	2	3	4	5
	07	14	21	28	05	12	19	26	02	09	16	23	30
Collect drawing scope/common exhaust pipe size	✔												
Confirm drawing requirement with Heng Yang	✔											`	
Print/seal/hang the drawing in machining room	✔												
1 batch production		✘		✔									
probe pipe checking					✔								
Mark the difference					✔								
Visual work instruction for assembly					✔								
Assembly training						✔							

Table 3-4: Action No. 2 Checking

Problem "1 batch production": The production of one batch of probes took longer than expected. The work was completed whenever there was a window of free time during every day work. The available time for the production was extended to a total of three weeks; all other dates were also rescheduled accordingly.

Act: A total of 30 probes was manufactured and assembled. Four different sizes were identified that suffice to cover the most common exhaust pipes. The new batch of sample probes was more convenient and saved time. The work instructions on the wall decreased the possibility of faulty installation. Most probes were produced too short for the exhaust pipes though, so longer probes had to be made. The ends of the probes were welded to grant air tightness; this makes it difficult to insert the probe into the exhaust pipe due to a rough surface finish after welding. The new probes had to be closed off with a plug.

Savings Calculation: Having a batch of assembled sample probes available eliminated the assembling time of five probes per week, which each took half an hour for assembling at a rate of 320RMB for the employee. Additionally, searching time was reduced - this usually occurred two times per week for about fifteen minutes at the cost of 320RMB for the employee. The reduction in downtime due to mistakes amounts to one issue per month causing one hour of downtime at a rate of 1000RMB for the test-bed plus 320RMB for the employee. The total savings resulting from this action amount to 1290RMB per week.

NO. 3 "Troubleshooting review meeting 1 per two months."

Description: Whenever an engine on a test-bed must be stopped due to faulty behaviour, troubleshooting takes place to distinguish the cause to the issue. Downtime is costly and therefore must be kept to a minimum. Often, however, failure occurs due to the same cause and troubleshooting. It takes as long because different engineers and technicians work on the engine and information between employees is not shared efficiently. This action aims to reduce troubleshooting time by creating a standardized list that is updated whenever troubleshooting takes place. Also, every two months a troubleshooting review was added to the agenda of the weekly department meeting, issues and their causes were shared to bring everybody onto the same page. This action was expected to reduce troubleshooting and therefore downtime. I It had a high potential of reducing reoccurrence of issues and adds to the problem-solving capabilities of every employee within the department by highlighting practical examples.

Plan:

Sub Steps	Responsible	Due Date	Output
Trouble shooting record list template review&Modify	Xiao Jun/Xu Saihua	15.11.2016	template
Training	Xiao Jun	17.11.2016	Record
Pilot run for 1 month	Zheng Congxing	13.12.2016	Record
Summary&Preparation	Zheng Congxing	15.12.2016	report
Internal meeting	Xiao Jun	16.12.2016	MOM

Table 3-5: Action No. 3 Sub Steps

Do & Check

Sub Steps	Nov-16				Dec-16				Jan-17				
	46	47	48	49	50	51	52	53	1	2	3	4	5
	07	14	21	28	05	12	19	26	02	09	16	23	30
Trouble shooting record list template review&Modify		✔											
Training		✔											
Pilot run for 1 month						✔							
Summary&Preparation						✔							
Internal meeting						✘ ✔							

Table 3-6: Action No. 3 Checking

Problem "Internal meeting": The pilot run took place according to plan. The summary and preparation were done at the end of week 51, but because the weekly department meeting is held on Mondays, the troubleshooting topic was added to the next week's agenda. During the pilot run four troubleshooting events occurred, these were added to the record and shared in the weekly department meeting after the pilot run. It can be expected that improvements will be visible after several cycles.

Act: There are no changes required at this point, several months will have to pass before a conclusion can be drawn.

Savings Calculation: This action targets to achieve savings by reducing the number of repeat issue and maintenance effort. It is estimated that the repeat issues can be reduced by two per week, each with an average duration of

approximately half an hour, involving one employee at the cost of 320RMB. This action resulted in savings of 320RMB per week.

NO. 4 "Set up typical TST database."

Description: For every engine test on a test-bed, a new test parameter document (TST) must be entered manually in the Puma Host project (test-bed software application). This leads to many TST files in the project folder that cause confusion and induce mixing them up. Many of the tests use similar or the same parameters, so it makes sense to create a database with frequently used TST files. This action is expected to save time by not having to enter TST files for every new test and ensures that the right parameters are used by selecting the right template from the new Puma Host project.

Plan:

Sub Steps	Responsible	Due Date	Output
Create new project on Puma Host	Zhao Quancai	07.11.2016	Puma Project
Insert frequently used TST parameters	Measurement Team	11.11.2016	TST in Puma Project
Inform all team members about change	Zhao Quancai	15.11.2016	

Table 3-7: Action No. 4 Sub Steps

Do & Check:

Sub Steps	Nov-16				Dec-16				Jan-17				
	46	47	48	49	50	51	52	53	1	2	3	4	5
	07	14	21	28	05	12	19	26	02	09	16	23	30
Create new project on Puma Host	✓												
Insert frequently used TST parameters	✓												
Inform all team members about change		✓											

Table 3-8: Action No. 4 Checking

The TST files were added to the Puma Host project as expected and no delays occurred.

Act: The TST parameters need to be regularly updated and are therefore added to the routine maintenance plan.

Savings Calculation: Instead of setting up the standard TST files on each individual test-bed this is only done once, and the templates are stored on a server so they can be accessed from every test-bed. The savings this action results in can be calculated by multiplying the 13 test-beds, that are spared from setting up the TST database, with the 2,5 hours it takes four engineers at a rate of 550RMB to set up the database individually. This results in a one-time saving of 71500RMB.

NO. 8 "Spare parts safety stock check once per half year."

<u>Description:</u> Occasionally the stock for certain parts in the warehouse is zero. For this reason, the safety stock check frequency must be increased from once per year to once every half year. Larger or more expensive parts are usually re-stocked after being drawn from the warehouse. Sometimes, however, this is forgotten, and especially for frequently consumed goods, no orders are being placed. A more frequent safety stock check is the most effective solution to prevent future stock shortages.

<u>Plan:</u>

Sub Steps	Responsible	Due Date	Output
Meeting for planning	Fin. & Admin. Warehouse/Zhou Di/Zang Chunlai	09.11.2016	

Table 3-9: Action No. 8 Sub Steps

<u>Do & Check:</u>

Sub Steps	Nov-16				Dec-16				Jan-17				
	46	47	48	49	50	51	52	53	1	2	3	4	5
	07	14	21	28	05	12	19	26	02	09	16	23	30
Meeting for planning	✓												

Table 3-10: Action No. 8 Checking

<u>Act:</u> The safety stock check is added to the warehouse's standards. Which's release is planned for the third loop by the Finance and Administration Department. Also, the safety stock level is going to be updated after every check.

<u>Savings Calculation:</u> This action's objective is to save time on looking for parts and waiting on missing parts. The issues occur too infrequently to gain reliable estimations on savings, and therefore the savings are not quantifiable.

NO. 11 "Repair room management (Emission)"

<u>Description:</u> The amount of equipment in the repair room of the Emission Team has grown over the last years, and objects continuously are being added. The room is unorganized, work benches are misused for storage-area, tool carts are standing in the middle of the room, shelves are not labeled, and objects are stored under tables. The room looks messy, stuffed and it's hard to find more storage space. The decision is made to run a 5S campaign on the repair room of the Emission Team. This action is expected to make it easier for employees to find things, clear up space in the storage shelves and to make for a cleaner appearance.

Plan:

Sub Steps	Responsible	Due Date	Output
Training	Xu saihua	08.11.2016	Record
Take pictures	Zheng Congxing	08.11.2016	STC folder
Sorting/cleaning	Zhang Wenyong	14.11.2016	Pictures
Audit	Xu saihua/Qian Meili	14.11.2016	Report
Straighten	Zhang Wenyong	14.11.2016	
▪ Plan	Zheng Congxing	17.11.2016	Action list
▪ Material preparation	Zheng Congxing	22.11.2016	
▪ Implementation	Zheng Congxing	25.11.2016	Summary

Table 3-11: Action No. 11 Sub Steps

Do & Check:

Sub Steps	Nov-16				Dec-16				Jan-17				
	46	47	48	49	50	51	52	53	1	2	3	4	5
	07	14	21	28	05	12	19	26	02	09	16	23	30
Training	✔												
Take pictures	✔												
Sorting/cleaning		✔											
Audit		✔											
Straighten		✔											
▪ Plan		✔											
▪ Material preparation			✘							✔			
▪ Implementation										✔			

Table 3-12: Action No. 11 Checking

Problem "Material preparation": The delivery time for the required materials was not considered. In this specific case, it took two months for the ordered items to arrive and therefore, the action was delayed. Many suggestions were necessary for the team to recognize waste, unnecessary and misplaced objects. The progress of the 5S campaign had to get checked daily, and pep talks were needed to motivate the team to recognize the benefit of an organized work environment. The result is a tidy work environment with printed working standards and freed up storage spaces. The team found the new repair room to appear as a more professional work environment.

Act: This action was only concerned with two of the five S's. Over the course of the research, also the other three S's will be implemented, and multiple 5S audits are going to be executed to encourage employees to improve their workspaces and environments continuously. More information about the 5S campaigns is covered in Chapter 3.4 5S.

Savings Calculation: Savings gained by this action result from a reduction in search time and an increase in storage space. While it is not convenient to put a price on the increased storage area, the reduction in searching time results in two employees searching for two and a half hours less per week, a rate of 320RMB. The total amount of savings is estimated to amount to 1600RMB per week.

NO. 13 "Keycard computer application combined."

Description: Every new employee must complete two forms, one for the key card application and another one for a computer application. Much information on the two documents is identical but must be completed twice. Also, the approving manager has to sign two pieces of paper. This action aims to combine the two documents to one; this results in a simpler process that saves time and paper.

Plan:

Sub Steps	Responsible	Due Date	Output
Create Form	Huang Jianxiong	02.12.2016	
Get Input from Roman Ziegler	Huang Jianxiong/Roman Ziegler	09.12.2016	
Finalize form	Huang Jianxiong	15.12.2016	

Table 3-13: Action No. 13 Sub Steps

Do & Check:

Sub Steps	Nov-16				Dec-16				Jan-17				
	46	47	48	49	50	51	52	53	1	2	3	4	5
	07	14	21	28	05	12	19	26	02	09	16	23	30
Create Form				✖									
Get Input from Roman Ziegler					✖								
Finalize form						✖							

Table 3-14: Action No. 13 Checking

Problem "Create Form": The form could not be realized because the managers responsible for signing the forms are not the same. The key card application must be approved by the head of Finance & Administration Department; the computer application is signed by the department manager to which the new employee is hired. Furthermore, the key card application form is also handed out to visiting customers who never require a computer. Creating a single form could be confusing for the clients or might appear unprofessional. Also, the content of the two forms does not easily fit onto one sheet of paper. As a result, the action is terminated.

Act: No further acting is required.

Savings Calculation: The action is terminated, and therefore no savings are allocated to this action.

NO. 15 "Instrument, transducers equipment owner list."

Description: One of the storage cabinets managed by the Measurement Team is used to store sensors. There is no clear inventory list, only handwritten notes and labels, these are old and mostly unreadable. Sensors can often not be found, it is unclear who is using them, and they are often reordered.

Plan:

Sub Steps	Responsible	Due Date	Output
Create inventrory list for sensors	Zang Chunlai	28.11.2017	
Do 5S on storage location	Zang Chunlai	05.12.2016	
Create work instructions	Zang Chunlai	13.12.2016	

Table 3-15: Action No. 15 Sub Steps

Do & Check:

Sub Steps	Nov-16				Dec-16				Jan-17				
	46	47	48	49	50	51	52	53	1	2	3	4	5
	07	14	21	28	05	12	19	26	02	09	16	23	30
Create inventrory list for sensors				✓									
Do 5S on storage location					✓								
Create work instructions						✓							

Table 3-16: Action No. 15 Checking

A new standard was created: "Piezo sensor management process standard." The sensors are now organized, and there is an owner list of all the items that can be checked to see who has last taken which sensor. Money is saved because more sensors are reused. Putting a name down on the owner list creates a responsibility to return the items and ultimately results in a decrease of misplaced or lost sensors. Fewer sensors are reordered, and this reduces the money spent on new sensors.

Act: It is not clear if everybody has read and understood the standards. Therefore, the Piezo sensor management process standard must be included in the new employee training for the Plant Facility Department. Additionally, the new standard is introduced at the next weekly department meeting to ensure that current employees are familiar with the new standard.

Savings Calculation: This action's objective is to save time on looking for parts. The issues occur too infrequently to gain reliable estimations on savings, and therefore the savings are not quantifiable.

First Loop Conclusion

From the seven actions that were chosen for the first loop, five could be completed on time, and one was terminated. In Table 3-17: Silo of Waste after First Loop, action No. 11 is marked with only 50% completion, this is because the 5S campaign was only applied to the Emission Team's repair room, as stated at the beginning of this chapter. The estimated savings totaled out at 71.500RMB in one-time savings and 3.210RMB in weekly savings.

No	Action	Owner	Status	Due Date		Saving (¥)	Saving (¥/week)
				Silo of Waste			
1	Define standard for equipment responsibility	Li Yanlu	0%	31.12.2016			
2	Catetory drawing batch machine sample probe	Xiao Jun/Hengyang	100%	31.12.2016		¥0,00	¥1.290,00
3	Troubleshooting review meeting 1 per two months	Li Yanlu	100%	30.11.2016		¥0,00	¥320,00
4	Set up typical TST database	Zhao Quancai	100%	30.11.2016		¥71.500,00	¥0,00
5	Record malfunction over 1H in troubleshooting record	Li Yanlu	0%	31.10.2016			
6	Fuel pipe installation standardize	Zhao Quancai/Heng Yang	0%	30.04.2017			
7	Parameter offline/simulator	Zhu Jihua	0%	31.05.2017			
8	Spare parts safety stock check once per half year	Zhou Di/Zang Chunlai	100%	31.10.2016		¥0,00	¥0,00
9	Power socket installation for ETC1-6	Liang Yongli	0%	30.04.2017			
10	Puma operation table extend	Zhao quancai	0%	30.05.2017			
11	Repair room management	Zhao Quancai/Xiao Jun	50%	31.01.2017		¥0,00	¥1.600,00
12	5S/Visual Management	Li Yanlu	0%	31.12.2016			
13	Keycard computer application combined	Huang Jianxiong	0%	30.11.2016		¥0,00	¥0,00
14	Timely transfer ETTS data to ProCalc	Huang Jianxiong	0%	28.02.2017			
15	Instrument, transducers equipment owner list	Li Yanlu/Andrea Pagnini	100%	31.12.2016		¥0,00	¥0,00
	Overall Saving (RMB)					¥71.500,00	¥3.210,00

Table 3-17: Silo of Waste after First Loop

3.2.4   Second Loop

The second loop was decided to take place between 12/20/2016 and 02/20/2017. For this loop actions 5, 6, 11 and 12 were chosen. action 11 was decided to now be applied to the repair room associated with the Measurement Team. The selection of actions is again made, based on their priority and the available capacity of the department's utilization.

NO.	Date of Issue	Originator	Action Item	Responsible Person	Target Date
5	10/25/2016	Plant Facility	Record malfunction over 1H in troubleshooting record	Li Yanlu	10/31/2016
6	10/25/2016	Plant Facility	Fuel pipe installation standardize	Zhao Quancai / Heng Yang	4/30/2017
11	10/25/2016	Plant Facility	Repair room management (Measurement)	Zhao Quancai / Xiao Jun	1/31/2017
12	10/25/2016	Plant Facility	5S/Visual Management (Office)	Li Yanlu	12/31/2016

Table 3-18: Second Loop Actions

NO. 5 "Record malfunction over 1H in troubleshooting record."

Description: Troubleshooting issues are recorded. But because there are so many it hard to determine which ones are most important. Therefore a separate list with issues where the troubleshooting lasts longer than one hour should be created. These problems are thought to cause the most downtime and therefore they require special attention. Separate lists for the Emission Team and the Measurement Team must be created. This action strives to achieve a substantial reduction in downtime.

Plan:

Sub Steps	Responsible	Due Date	Output
Create Excel Sheet for recording	Zhu Jihua	09.12.2016	
Confirm Excel Sheet with Li Yaanlu	Zhu Jihua/Li Yanlu	09.12.2016	Excel Sheet
Forward location of Excel Sheet + information to coworkers	Zhu Jihua	16.12.2016	

Table 3-19: Action No. 5 Sub Steps

Do & Check:

Sub Steps	Dec-16				Jan-17					Feb-17				Mar-17				Apr-17				May-17				
	50	51	52	53	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
	05	12	19	26	02	09	16	23	30	06	13	20	27	06	13	20	27	03	10	17	24	01	08	15	22	29
Create Excel Sheet for recording		✓																								
Confirm Excel Sheet with Li Yaanlu		✓																								
Forward location of Excel Sheet + information to coworkers			✓																							

Table 3-20: Action No. 5 Checking

After a two-month cycle, the Emission Team had recorded five and the Measurement Team three issues. Some issues were solved by updating usual maintenance standards.

Act: No further acting was required.

Savings Calculation: This action was expected to have a great impact on the reduction of downtime eventually. The aspired outcome was a reduction of issues, by one per month, which was a reasonable median estimation. In the beginning, the reduction was expected to be greater but later, as the number of problems decreased the reduction rate became less significant, or a reduction was not possible at all. The drop by one issue per month, with an average downtime of one hour at the cost of 1000RMB for the test-bed plus 320RMB for the employee, results in savings of 330RMB per week.

NO. 6 "Fuel pipe installation standardize."

Description: This action is concerned with the fuel pipe that connects the flow meter to the engine. Currently, there are different materials (stainless steel, Kevlar, and rubber), different diameters and different connectors for the fuel pipe being used. These issues are a great concern for long term projects where engines are reassembled between tests. A standard for fuel pipes will solve these problems and grant better repeatability and comparability of test results.

Plan:

Sub Steps	Responsible	Due Date	Output
Kickoff meeting	Zhao Quancai/Heng Yang	23.01.2017	Content of Standard
Collect Data	Measurement Team & Mechanical Team	27.03.2017	
Review meeting/Check Data	Zhao Quancai/Heng Yang	03.04.2017	
Apply Improvements	Measurement Team & Mechanical Team	17.04.2017	

Table 3-21: Action No. 6 Sub Steps

Do & Check:

Sub Steps	Dec-16				Jan-17					Feb-17				Mar-17				Apr-17				May-17				
	50	51	52	53	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
	05	12	19	26	02	09	16	23	30	06	13	20	27	06	13	20	27	03	10	17	24	01	08	15	22	29
Kickoff meeting								✔																		
Collect Data																	✔									
Review meeting/Check Data																		✖		✖						
Apply Improvements																										

Table 3-22: Action No. 6 Checking

Problem "Review meeting/Check Data": The meeting was postponed due to more important issues that came up during everyday work, it was rescheduled to take place at the end of May.

Act: This action was not completed at the end of the research period, reason here fore was that the Measurement Team constantly had more pressing issues to work on and no time for the definition of standards.

Savings Calculation: This action gets rid of problems that occur because different types of fuel pipes are used. Testing currently must be stopped once per month for an average of 2.5 hours causing downtime costs of 1000RMB for the test-bed plus 320RMB for the operator. This action results in total savings of 825RMB per week.

NO. 11 "Repair room management (Measurement)"

Description: The repair room of the Measurement Team initially is as unorganized as the one of the Emission Team. Here workbenches are also misused for the storage area, as well as above as under the tables. Shelves are not labeled, and their content is not properly sorted. The room is chaotic, unorganized, and impossible to clean, which results in long search times and an unsafe work environment. The action is expected to make the chamber more organized, cleaner, safer and to cause a reduction in search time.

Plan:

Sub Steps	Responsible	Due Date	Output
Sorting/cleaning	Measurement Team	02.01.2017	
Audit	Chris	09.01.2017	
Straighten	Measurement Team	16.01.2017	
▪ Plan	Measurement Team	16.01.2017	
▪ Material preparation	Measurement Team	06.02.2017	
▪ Implementation	Measurement Team	13.02.2017	

Table 3-23: Action No. 11 Sub Steps

Do & Check:

Sub Steps	Dec-16				Jan-17					Feb-17				Mar-17				Apr-17				May-17				
	50	51	52	53	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
	05	12	19	26	02	09	16	23	30	06	13	20	27	06	13	20	27	03	10	17	24	01	08	15	22	29
Sorting/cleaning					✓																					
Audit						✓																				
Straighten							✓																			
▪ Plan							✓																			
▪ Material preparation							✓																			
▪ Implementation							✓																			

Table 3-24: Action No. 11 Checking

A pep talk was held before the start of the 5S campaign, explaining the reasons for the campaign and CI in general. Training on waste identification and explanation of the PDCA principle was given to the team, and it was guided through the campaign with explanations before and after each of the first two S's.

Act: This action was only concerned with the first two of the five S's. Over the course of the research, multiple 5S audits were executed that encourage employees to improve their workspaces and environments continuously. More information about the 5S campaigns can be found in Chapter 3.4 5S.

Savings Calculation: Savings gained by this action result from a reduction in search time and an increase in storage space. While it is not possible to put a price on the increased storage area, the reduction in searching time results in two employees searching for two and a half hours less per week, a rate of 320RMB. The total amount of savings is estimated to be 1600RMB per week.

NO. 12 "5S/Visual Management (Office)"

Description: Just like other parts of STC, the office of the Plant Facility Department has substantially grown in the last years, and because of the growth the number of employees in this department has more than tripled since the beginning. Due to this fact, desks and storage space have also continuously been added and now contain many items that are not used frequently or never at all. This action is concerned with the workspace of each employee within the department. It strives to create a neat and tidy workspace that provides a strong foundation for creative and efficient work while teaching every employee waste identification and how to sustain their workspace.

Plan:

Sub Steps	Responsible	Due Date	Output
Define Content (Personal)	Chris	07.12.2016	
Send Mail to Coworkers (Personal)	Meili	07.12.2016	E-Mail
Office Walk / Identification (Shared)	Meili/Chris	07.12.2016	
Info to Teamleader (Shared)	Meili	08.12.2016	E-Mail
5S (Personal)	Facility Department (Everybody)	16.12.2016	E-Mail/Pictures
5S (Shared)	Xiao Jun/Zhao Qunlai/Huang Jiangxiong/Liang Yongli	16.12.2016	
PreAudit (Shared + Personal)	Meili/Chris	19.12.2016	
Rework (Shared + Personal)	Facility Department (Everybody)	21.12.2016	
FinalAudit	Emma	22.12.2016	Audit Form

Table 3-25: Action No. 12 Sub Steps

Do & Check:

Sub Steps	Dec-16				Jan-17					Feb-17				Mar-17				Apr-17				May-17				
	50	51	52	53	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
	05	12	19	26	02	09	16	23	30	06	13	20	27	06	13	20	27	03	10	17	24	01	08	15	22	29
Define Content (Personal)		✓																								
Send Mail to Coworkers (Personal)		✓																								
Office Walk / Identification (Shared)		✓																								
Info to Teamleader (Shared)		✓																								
5S (Personal)			✗		✓																					
5S (Shared)			✗		✓																					
PreAudit (Shared + Personal)			✗		✓																					
Rework (Shared + Personal)						✓																				
FinalAudit						✓																				

Table 3-26: Action No. 12 Checking

Problem "5S (Personal)" and "(5S Shared)": Extensive promotion and information sharing was done and every employee had been encouraged to participate in the campaign independently. Still, no self-initiative was visible, and the office did not change during week 51. The sub steps were rescheduled, and the 5S campaign was carried out with every employee at their own desk. The employees eventually could execute the campaign on their workspace while either the Coordinator or Researcher was watching them and assisting them when questions came up.

Act: Additional improvements included labels for all folders, office utility boxes, a shelf for one side used paper and folder management. Over the course of the research, multiple 5S audits were executed that encouraged employees to improve their workspaces and environments continuously. More information about the 5S campaigns can be found in Chapter 3.4 5S.

Savings Calculation: The main savings from this action result in a reduction of search time and increase in common space in the office area. The value of this action is not quantifiable because measuring benefits like increase in morale or convenience of use exceeded the purpose and scope of this research.

Second Loop Conclusion

In this loop, three of the four chosen actions could be completed, Table 3-27: Silo of Waste after Second Loop additionally shows that action No. 11 now has been completed totally since both the Emission and Measurement Team have completed their 5S campaigns at the end of the second loop. Only action No. 6 remains unfinished. The estimated savings from the actions stayed the same in one-time savings but increased to 5.965RMB in weekly savings.

No	Action	Owner	Status	Due Date		Saving (¥)	Saving (¥/week)
1	Define standard for equipment responsibility	Li Yanlu	0%	31.12.2016			
2	Catetory drawing batch machine sample probe	Xiao Jun/Hengyang	100%	31.12.2016		¥0,00	¥1.290,00
3	Troubleshooting review meeting 1 per two months	Li Yanlu	100%	30.11.2016		¥0,00	¥320,00
4	Set up typical TST database	Zhao Quancai	100%	30.11.2016		¥71.500,00	¥0,00
5	Record malfunction over 1H in troubleshooting record	Li Yanlu	100%	31.10.2016		¥0,00	¥330,00
6	Fuel pipe installation standardize	Zhao Quancai/Heng Yang	50%	30.04.2017		¥0,00	¥825,00
7	Parameter offline/simulator	Zhu Jihua	0%	31.05.2017			
8	Spare parts safety stock check once per half year	Zhou Di/Zang Chunlai	100%	31.10.2016		¥0,00	¥0,00
9	Power socket installation for ETC1-6	Liang Yongli	0%	30.04.2017			
10	Puma operation table extend	Zhao quancai	0%	30.05.2017			
11	Repair room management	Zhao Quancai/Xiao Jun	100%	31.01.2017		¥0,00	¥3.200,00
12	5S/Visual Management	Li Yanlu	100%	31.12.2016		¥0,00	¥0,00
13	Keycard computer application combined	Huang Jianxiong	0%	30.11.2016		¥0,00	¥0,00
14	Timely transfer ETTS data to ProCalc	Huang Jianxiong	0%	28.02.2017			
15	Instrument, transducers equipment owner list	Li Yanlu/Andrea Pagnini	100%	31.12.2016		¥0,00	¥0,00
	Overall Saving (RMB)					¥71.500,00	¥5.965,00

Table 3-27: Silo of Waste after Second Loop

3.2.5 Third Loop

The third loop was decided to take place between 03/01/2017and 04/28/2017. For this loop actions 1, 7, 9, 10 and 14 were chosen. These are the remaining actions of the initial action list; they are given in Table 3-28: Third Loop Actions.

NO.	Date of Issue	Originator	Action Item	Responsible Person	Target Date
1	10/18/2016	Dev. & Cal. / ETV	Define standard for equipment responsibility	Li Yanlu	12/31/2016
7	10/25/2016	Plant Facility	Parameter offline/simulator	Zhu Jihua	5/31/2017
9	10/25/2016	Plant Facility	Power socket installation for ETC1-6	Liang Yongli	4/30/2017
10	10/25/2016	Plant Facility	Puma operation table extend	Zhao Quancai	5/30/2017
14	11/11/2016	Project Management	Timely transfer ETTS data to ProCalc	Huang Jianxiong	2/28/2017

Table 3-28: Third Loop Actions

NO. 1 "Define standard for equipment responsibility."

Description: Tools between MDTF, Dev. & Cal. and ETV department are shared and borrowed without clear ownership or responsibility. Whenever equipment is urgently needed, it cannot be found within the department. Tool lists are not up to date, and most employees don't even know that they exist. This action aims to solve these issues by creating a standard for equipment handling. The desired result is a reduction in search time and better equipment availability.

Plan:

Sub Steps	Responsible	Due Date	Output
Summary of tool types, ownership and maintenance	MDTF/Dev.Cal./ETV/Xu Saihua	20.03.2017	
list all equipmment belonging to ETV & Dev. Cal.	Fanghailing/Chen Xiaodan	27.03.2017	
Global template & definition location, borrow and return	Xu Heping	03.04.2017	
Sharing process and location with concerned employees	Xu Heping	28.04.2017	

Table 3-29: Action No. 1 Sub Steps

Do & Check:

Sub Steps	Feb-17				Mar-17				Apr-17				May-17				
	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
	06	13	20	27	06	13	20	27	03	10	17	24	01	08	15	22	29
Summary of tool types, ownership and maintenance							✓										
list all equipmment belonging to ETV & Dev. Cal.								✓									
Global template & definition location, borrow and return									✗								
Sharing process and location with concerned employees									✓								

Table 3-30: Action No. 1 Checking

Problem "Global template & definition location, borrow and return": Xu Heping did not complete the global template because he was too busy with other tasks. The sub steps did not have to be rescheduled because there was sufficient time to complete the action.

Act: There now was a central list of all the tools stored in a dedicated folder on the company server. All employees that use the equipment were notified about the location and the new process. No further acting was required.

Savings Calculation: The savings consist of a reduction in search time and a decrease in waiting time. Due to a large number of people involved handling the tools, the complexity of the borrow processes and a lack of documentation, the savings of this action are not quantifiable.

NO. 7 "Parameter offline/simulation."

Description: The engineers request an automatic program to do parameter simulation. The concern is about the commissioning process before an engine test can be started. Commissioning work is first done by the Measurement Team, then by engineers and after that, the test can be started. By doing automatic parameter simulation the commissioning work of the Measurement Team, that requires a physical presence can be reduced, and the engineers can start their commissioning work while the simulation is still running. This saving in commissioning time reduces downtime and results in a better utilization of the test-bed.

Plan:

Sub Steps	Responsible	Due Date	Output
collect data	Zhu Jihua	18.03.2017	
contact with ITS support	Zhu Jihua	20.03.2017	
Finish Program	Zhu Jihua	20.03.2017	
meeting with Li Yanlu	Zhao Quancai/Li Yanlu/Zhu Jihua	15.04.2017	

Table 3-31: Action No. 7 Sub Steps

Do & Check:

Actions	Feb-17				Mar-17				Apr-17				May-17				
	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
	06	13	20	27	06	13	20	27	03	10	17	24	01	08	15	22	29
collect data					▮	✗	▮	▮	▮	✓							
contact with ITS support							▮				▮	▮	✗				
Finish Program							▮								▮	▮	
meeting with Li Yanlu								▮								▮	

Table 3-32: Action No. 7 Checking

Problem "collect data": There were too many other tasks keeping the Measurement Team busy so that they did not have time to gather the necessary data. The due dates were rescheduled.

Problem "contact with ITS support": There was still too much everyday work on the hands of the Measurement Team, so there was no time to contact ITS support. The due dates were once again rescheduled.

Act: The action was not completed at the end of the research period. The action will be finalized at a later time.

Savings Calculation: The reduction in commissioning time caused by the offline simulator is calculated by the decrease in downtime caused by an average of six issues per month with a duration of one and three-quarters of an hour involving one test-bed and one engineer at the rate of 1000RMB and 550RMB. This action, once completed, results in savings of 4067RMB per week.

NO. 9 "Power socket installation for ETC1-6."

Description: Operator rooms with more than one table only have power sockets available on one table. Because of this circumstance, the desks are not used at all, or power cables are stretching across the room if they are used. There is also test equipment that requires 12 Volt power sockets, which are not available in the operator room at all. This equipment is currently set up in the test-bed room where it is exposed to potential damage by liquids. The objective of this action is to provide sufficient power supply in the operator room. This will result in increased safety and better utilization of work space.

Plan:

Sub Steps	Responsible	Due Date	Output
Training	Li Yanlu/ Liang Yongli	09.02.2017	
Take pictures	Li Yanlu/ Liang Yongli	09.02.2017	
determine the start time	Li Yanlu/ Liang Yongli	09.02.2017	
install power socket	Liang Yongli team	04.04.2017	

Table 3-33: Action No. 9 Sub Steps

Do & Check:

Actions	Feb-17				Mar-17				Apr-17				May-17				
	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
	06	13	20	27	06	13	20	27	03	10	17	24	01	08	15	22	29
Training	✓																
Take pictures	✓																
determine the start time	✓																
install power socket									✕				✕				

Table 3-34: Action No. 9 Checking

Problem "install power socket": For the installation of the power sockets, the test-beds needed to be shut down, this normally is only the case during public holidays. During the Tomb Sweeping Day, there was scheduled fire maintenance that had not been considered while planning, the installation was postponed to the Labor Holiday.

Problem "install power socket": On Labor Holiday, the installation was completed on test-beds ETC1 and ETC6. The other test-bed's installation was postponed to weekdays at which the test-bed is available.

Act: Consideration of scheduled maintenance during public holidays.

Savings Calculation: The installation of additional power sockets results in a sufficient electricity supply throughout the test-beds and a reduction of safety concerns. These improvements are not quantifiable for a monetary calculation.

NO. 10 "Puma operation table extend."

Description: ETC 1-6 are the oldest test-beds at STC, the newer test-beds ETC 7-14 are equipped with larger tables. Due to an increase in test equipment and therefore lack of space, the older tables need to be extended. The goal is to have enough room for all five monitors, occasional laptops, and cameras.

Plan:

Sub Steps	Responsible	Due Date	Output
define how to do it	Zhao Quancai	17.02.2017	
order parts	Purchaser	03.03.2017	
define time window to do it	Zhao Quancai/Development engineer	10.03.2017	
installation and check	Supplier/measurement team	24.03.2017	

Table 3-35: Action No. 10 Sub Steps

Do & Check:

Actions	Feb-17				Mar-17				Apr-17				May-17				
	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
	06	13	20	27	06	13	20	27	03	10	17	24	01	08	15	22	29
define how to do it		✔															
order parts				✔													
define time window to do it					✘			✔									
installation and check								✔									

Table 3-36: Action No. 10 Checking

Problem "define time window to do it": The parts were received, but the sizes were not correct; so some parts had to be sent back and reordered. The installation was rescheduled.

All the tables were extended except for the one in ETC4 because a customer's cabinet was taking up space where the table was supposed to go. This one table was scheduled to be extended after completion of the current project.

Act: No further acting was required.

Savings Calculation: The extension of the Puma operation tables results in more usable desk space, a cleaner and tidier looking operator room and an increase in work efficiency. These improvements are not quantifiable for a monetary calculation.

NO. 14 "Timely transfer ETTS data to ProCalc."

Description: Engineers use a software application called ETTS to allocate their working time to the projects they are working on. ETTS synchronizes this information with ProCalc, which is utilized by the project managers to assign the engineer's working hours to the actual project. This often takes longer than 24 hours and is not timely enough for the project managers. A real-time synchronization would solve this problem and shall, therefore, be implemented by the Plant Facility Department's IT Team.

Plan:

Sub Steps	Responsible	Due Date	Output
send email to Tang Piao	Huang Jianxiong	09.02.2017	email
answer from Tang Piao	Tang Piao	09.02.2017	email
submit request to Graz IT to see if it can be realized	Huang Jianxiong	09.02.2017	email
waiting answer from Graz	AVL Graz	09.02.2017	email
realization by Graz or change internal process		28.02.2017	

Table 3-37: Action No. 14 Sub Steps

Do & Check

Sub Steps	Feb-17				Mar-17				Apr-17				May-17				
	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
	06	13	20	27	06	13	20	27	03	10	17	24	01	08	15	22	29
send email to Tang Piao	✓																
answer from Tang Piao	✓																
submit request to Graz IT to see if it can be realized	✓																
waiting answer from Graz	✓																
realization by Graz or change internal process	✕																

Table 3-38: Action No. 14 Checking

Problem "realization by Graz or change internal process": The action could not be completed because one of the software applications was outdated and scheduled for replacement in the close future. Because of this whether AVL Graz could supply a software solution, nor did it make sense to change the internal process. The action was terminated.

Act: No further acting as required from the Plant Facility Department.

Savings Calculation: This action is targeted to benefit the Project Management Department, not the Plant Facility Department. Due to the action's termination, no savings can be allocated.

Third Loop Conclusion

The Plant Facility Department could complete two of five actions in this loop, one was terminated, and two remain unfinished. The status of the overall action list after the third loop is that three actions remained unfinished. The one-time savings once again remain the same, but the weekly savings have risen to 10.033RMB. Six new actions were added to the action list, one of them had been suggested by another department, four came from a Facilitating workshop held within the department, and one more came from CI suggestions that were collected by the department.

No	Action	Owner	Status	Due Date		Saving (¥)	Saving (¥/week)
				Silo of Waste			
1	Define standard for equipment responsibility	Li Yanlu	100%	31.12.2016		¥0,00	¥0,00
2	Catetory drawing batch machine sample probe	Xiao Jun/Hengyang	100%	31.12.2016		¥0,00	¥1.290,00
3	Troubleshooting review meeting 1 per two months	Li Yanlu	100%	30.11.2016		¥0,00	¥320,00
4	Set up typical TST database	Zhao Quancai	100%	30.11.2016		¥71.500,00	¥0,00
5	Record malfunction over 1H in troubleshooting record	Li Yanlu	100%	31.10.2016		¥0,00	¥330,00
6	Fuel pipe installation standardize	Zhao Quancai/Heng Yang	50%	30.04.2017		¥0,00	¥825,00
7	Parameter offline/simulator	Zhu Jihua	50%	31.05.2017		¥0,00	¥4.068,75
8	Spare parts safety stock check once per half year	Zhou Di/Zang Chunlai	100%	31.10.2016		¥0,00	¥0,00
9	Power socket installation for ETC1-6	Liang Yongli	50%	30.04.2017		¥0,00	¥0,00
10	Puma operation table extend	Zhao quancai	100%	30.05.2017		¥0,00	¥0,00
11	Repair room management	Zhao Quancai/Xiao Jun	100%	31.01.2017		¥0,00	¥3.200,00
12	5S/Visual Management	Li Yanlu	100%	31.12.2016		¥0,00	¥0,00
13	Keycard computer application combined	Huang Jianxiong	0%	30.11.2016		¥0,00	¥0,00
14	Timely transfer ETTS data to ProCalc	Huang Jianxiong	0%	28.02.2017		¥0,00	¥0,00
15	Instrument, transducers equipment owner list	Li Yanlu/Andrea Pagnini	100%	31.12.2016		¥0,00	¥0,00
16	Clear up network cables under desk and mount to wall	Huang Jianxiong	0%	31.12.2017			
17	Increase budget for particle counters	Li Yanlu	0%	30.06.2017			
18	Add cassis dyno monday morning shift	Emission Team	0%	31.05.2017			
19	Add Saturday morning shift	Emission & Measurement	0%	31.05.2017			
20	Adjust spare part order quantity every half year	Zhou Di/Zang Chunlai	0%	30.06.2017			
21	Purchase and install diodes to all testbeds	Chen Bin	0%	30.06.2017			
	Overall Saving (RMB)					¥71.500,00	¥10.033,75

Table 3-39: Silo of Waste after Third Loop

3.3 Daily Kaizen

In the Plant Facility Department, the decision was made to set up three Daily Kaizen boards, one for the Plant Facility Department in general, one for the Emission Team, and one for the Measurement Team. The content of the board was chosen in a small group meeting involving the Team Leader, Coordinator, and the team member responsible for updating the board. Possible content for the team's whiteboard includes but is not limited to:

- Visual Work Plan
- Action Plan
- Indicators
- Communication Area

- Attendance Management
- Audits
- Skill Matrix
- Training Plan

- Improvement Suggestions
- Meeting Agenda
- Good Practices
- Identification of the Team

3.3.1 Emission Team

The Emission Team chose Zheng Congxing 郑从兴 to be the team member responsible for updating the content and divided the board into four sections (Figure 3-2: Daily Kaizen Board Emission Team): Attendance, Lessons Learned, Indicators and Team Member Task. Attendance: The first section includes a table with the team member's names, photos and whether they are currently in the office, out of office, in a meeting or on annual leave. Notifications: The second section serves as a notification area for lessons learned. Indicators: The third section is reserved for a performance indicator, displaying the number of troubleshooting issues per month in a chart, more might follow over the course of time. Team Member Task: The fourth section displays each team member's current task with a PDCA grid where tasks can be written onto sticky notes and moved according to their completion status.

Figure 3-1: Zheng Congxing 郑从兴
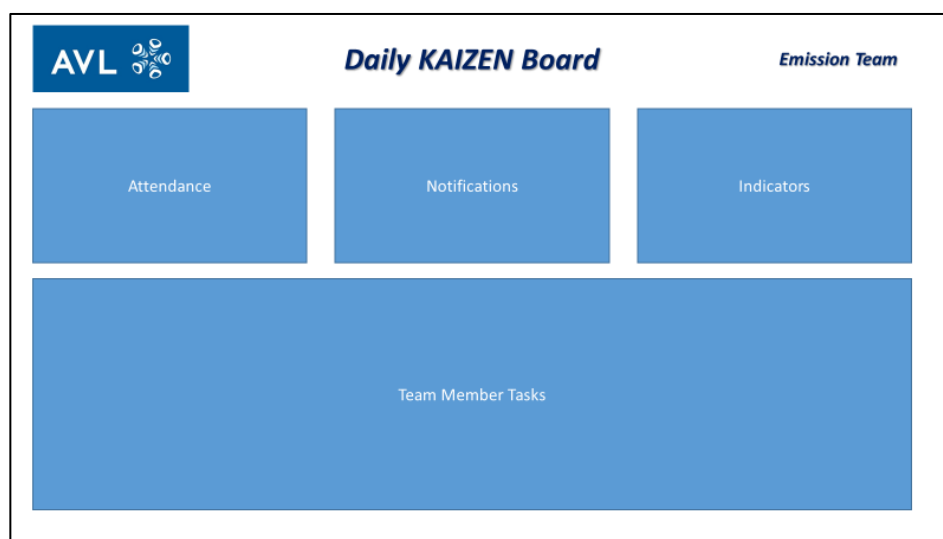
Figure 3-2: Daily Kaizen Board Emission Team

One-week review: Zheng Congxing successfully created the content, placed it, and hung the board on a wall in the team's repair room. In a short meeting, the update cycle was agreed to be weekly, except for the attendance section. An "updated" section was added to the top right corner for easier visibility that content has changed. A review was agreed to be held one month later.

One-month review: After one month, the team's feedback was generally positive, they found the attendance section very valuable because they could easily check if a team member was in the office or on leave. Also, the task plan proved to be helpful. The PDCA section, however, had not been used because the number of tasks was usually low enough to keep track of them. The lessons learned section had also only been updated once as well as the troubleshooting indicator, which only can be updated once per month. The overall design was decided to be kept by and another review to be held two months later.

Three-month review: After the board had been in use for three months the team was still convinced that the board was beneficial. The habit of use had not much changed. Therefore, only two changes were made: one to get rid of the PDCA section and two to add a general notification section.

3.3.2   Measurement Team

The Measurement Team chose Zhu Jihua 朱吉华 to be responsible for updating the content and divided it into five sections (Figure 3-4: Daily Kaizen Board Measurement Team): Attendance, Lessons Learned, Indicators, Notifications, and Task Plan.

Attendance: The first section includes a table with the team member's names, photos, and the current month's attendance, which makes it easy to see how many days of leave are left.

Figure 3-3: Zhu Jihua 朱吉华

Lessons Learned: The second section serves as a notification area for the experience gained.

Indicators: The third section is reserved for a performance indicator, displaying the quantity of troubleshooting issues per month in a chart, more might follow over the course of time.

Notifications: The fourth section serves the purpose of informing everybody about news like regulation changes.

Task Plan: The fifth section displays each team member's current task with a PDCA grid, where tasks can be written onto sticky notes and moved according to their completion status.
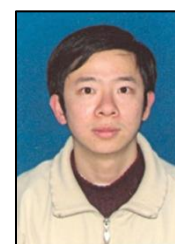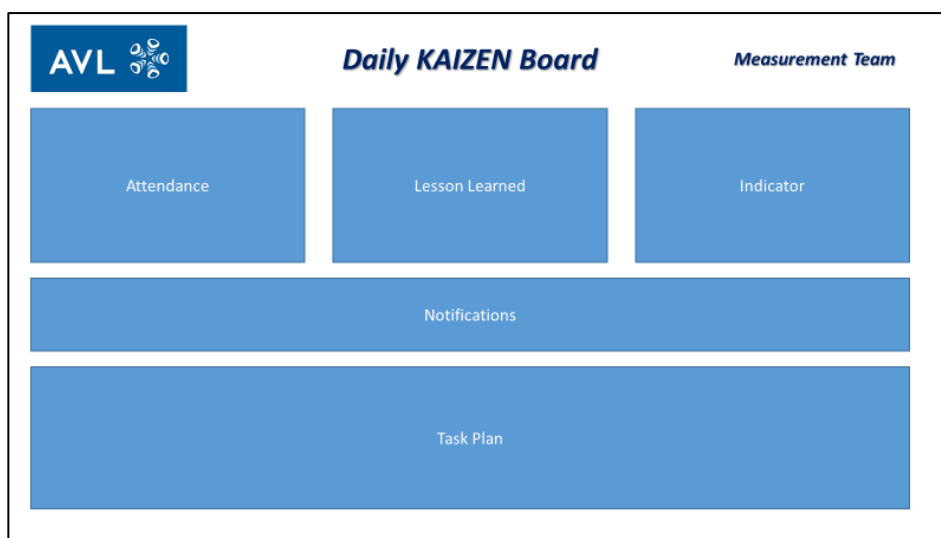
Figure 3-4: Daily Kaizen Board Measurement Team

One-week review: Zhu Jihua successfully created the content, placed it, and hung the board on a wall in the team's repair room. In a short meeting, the update cycle was agreed to be weekly, except for the attendance section. An "updated" section was added to the top left corner for easier visibility that content has changed. A review was agreed to be held one month later.

One-month review: After the board had been in use for one month especially the Measurement Team's Team Leader was pleased about it, pointing out that it gave him a structured overview of what was happening in his team and that it is a nice platform for sharing information. The team had used all the boards content except for the PDCA sticky notes because they were not sure how to use them.

Three-month review: The board is frequently being updated, and now the team is also using the PDCA section to keep track of all the individual tasks.

3.3.3   Plant Facility Department

The Kaizen board for the Plant Facility Department has the objective of being a visual tool, that displays the status of the department and giving an opportunity to make changes and steer it in the desired direction. The board is placed in a position that is visible to all employees, opposite of the office's entrance door and meetings are held in front of it on a regular basis. The board is made up of four areas, three of them reflect current happenings in the department and one section is dedicated to defining new actions. The new actions usually derive from the other three sections CIP Suggestions, Process Mapping, and Performance Indicators. These three sections are further described in the following

Figure 3-5: Qian Meili 钱美丽

chapters. The person responsible for updating the content is the department's CI Coordinator Qian Meili 钱美丽.
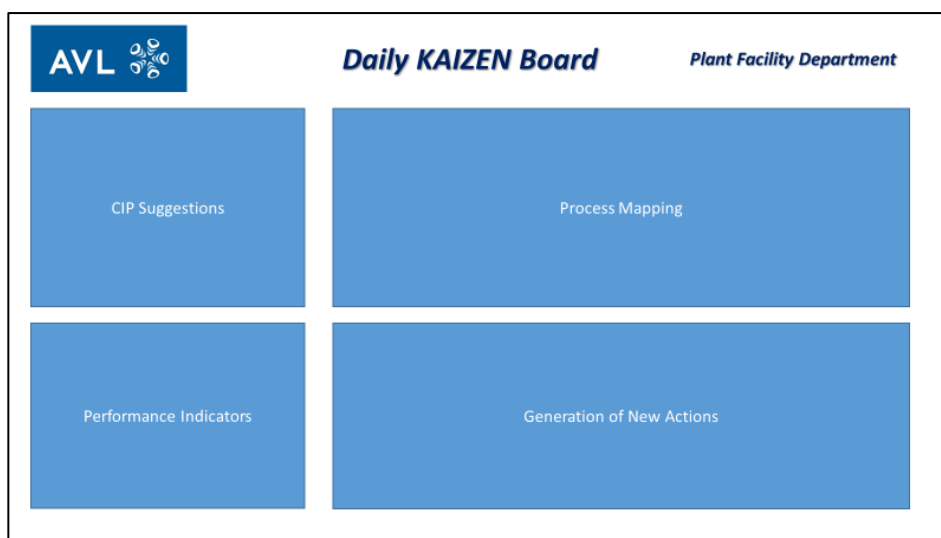
Figure 3-6: Daily Kaizen Board Plant Facility Department

3.3.3.1 Process Mapping

Process thinking is essential for Continuous Improvement because it takes employees eyes off current matters and lets them see a bigger picture. It is this change of view that lets people see their everyday work from a different perspective and as a result identify mistakes, waste, and more efficient ways of completing the work. In Process Mapping one of the department's core processes is selected, and a visualization of the current state is created. As a next step, different methods and tools are applied to identify problems, their root causes and find solutions. From these findings, actions can directly be defined. The first Process Mapping in the Plant Facility Department was done in a Facilitating workshop on October 25th, 2016 right at the beginning of the CI project, the initial action list (Table 3-1: Plant Facility Actions) was its result. A second Facilitating workshop was held on May 5th, 2017, at the end of the third loop, with the goal of finding new actions. Participants of this workshop were the Kaizen Officer and the Plant Facility Department's Skill Team Leader, Team Leaders, and the Coordinator. For this Facilitating workshop, once more, the project support process (Figure 3-7: Project Support Process) was chosen but this time a method called SIPOC (see chapter 2.3 Methods & Tools) was applied to the process step with the greatest process time, routine maintenance.

Project Support Process														
PM	KOM													
Dev. & Cal.		PTS			Pre start ECU check						Testing	Tew Request		
MD & TF			Engine pallet WS setup				Engine setup in TB				Testing	Trouble-shooting		
PF	KOM	PTS release	PARA offline	Pre start Cabling		Test Bed calibration		Cabling Channel Calibration	Equipment Setup / Check	Engine / TB comissioning	Handover	Trouble-shooting		Acceptance Documents
		Resource purchasing				Piezo snsor calibration				Data analysis			Routine Maintenance	
Process Time (H)	4	3	48	3,5		36		12	8	48	1	16	96	6	**PF Leed Time (H)**
Layover Time (H)	4	36	72	36		4		24	4	96	1			3	**561,5**

Figure 3-7: Project Support Process

The SIPOC method, thoroughly explained in chapter 2.3 Methods & Tools, inspects the interfaces between a previous (supplier), current and subsequent (customer) process step. In the case of routine maintenance, the investigated process step was additionally subdivided into scheduled maintenance, maintenance, trouble shooting and update maintenance plan. The interfaces that were identified by the participants of the workshop are listed in the input and output columns in Figure 3-8: SIPOC Analysis. Based on these findings the participants were given ten minutes to individually think of problems that occur at these interfaces and write them on sticky notes. After the particular time had passed, the findings were collected and merged into one list of issues, and the 5 Why-methodology was applied to each problem to ensure the root cause had been found. As a next step, solutions to the problems had to be found. Therefore, the goal of finding actions was kept in mind, and each solution was complimented by a responsible person and a due date. The resulting list of issues (black) and solutions (green) is listed in Figure 3-9: May Facilitating Results.

SIPOC

Supplier	Input	Process	Output	Customer
AVL Graz	• Latest Requirements • Manuals	Scheduled Maintenance	Maintenance List	Facility Technician/Engineer
Spare Parts Supplier	• Maintenance Plan • Spare Parts	Maintenance	• Maintenance Record • Pictures • Spare Parts Reorder List	Facility Engineer
Facility Engineer	• Spare Parts • Issue Description/5W	Trouble Shooting	• Troubleshooting Record/Review • Lessons Learned	Dev Engineer/Operator
Facility Engineer	Trouble Shooting Record	Update Maintenance Plan	• Maintenance Plan • Information Sharing	Facility Engineer

Figure 3-8: SIPOC Analysis

- PTS not provided early enough. By Dev Engineer > Template
1) Dev. & Cal. (JB): Provide PTS to PF on time (1 Week before TB setup) 30/06
- Label for Sensors sometimes missing. > Missing standard/no check
- TCK two pin plug: No Labels. Disconnected after part swap. > Missing standard/no check
2) MDTF (Heng Yang): Check Sensor (Label) and TCK two pin plug (Label + Connection) after pallet setup: MDTF 31/05
- Particle counter. Increase emission devices. > Changing Requirement/new legislation
3) PF (Yanlu): increase budget 06/2017
- Reference Point Check: No feedback from Dev Engineer (not on time)
4) Dev. & Cal. (JB): Supply data check feedback on time (reference points check inc. EGR rate and PN) 31/05
- Chassis Dyno: Monday morning maintenance. Conflict with Project.
5) PF (Emission): add Monday morning maintenance shift 31/05
- Many troubleshooting issues on Saturdays (Standby Day)
6) PF (Measurement) and Emission: add Saturday shift 31/05
- Quantity of spare parts for troubleshooting > Statistics from Warehouse
7) PF (Zhou Di/Zang): Chunlai Check order statistics with Warehouse and adjust spare part order quantity every half year 06/2017

Figure 3-9: May Facilitating Results

The results of this Process Mapping session were split into two actions for the Dev. & Cal. department, one action for the MDTF department and four actions for the Plant Facility Department. These actions were added to each departments silo of waste and considered for the fourth loop of actions.

No	Action	Owner	Status	Due Date
17	Increase budget for particle counters	Li Yanlu	0%	30.06.2017
18	Add cassis dyno monday morning shift	Emission Team	0%	31.05.2017
19	Add Saturday morning shift	Emission & Measurement	0%	31.05.2017
20	Adjust spare part order quantity every half year	Zhou Di/Zang Chunlai	0%	30.06.2017

Table 3-40: New Actions Process Mapping

3.3.3.2 CI Suggestions

The second section of the Plant Facility Department's Daily Kaizen board is dedicated to improvement suggestions submitted by employees. Several empty CI suggestion forms are always available on the board for employees to complete and submit suggestions to the Coordinator. Alternatively, suggestions can be sent to the Kaizen Officer by Email. To encourage the employee's participation and submission of suggestions, a rewarding system was put into place that offers monetary rewarding for every accepted suggestion and additional rewarding if the proposal results in substantial savings. Detailed descriptions of the rewarding amounts (see Table 3-41: CI Suggestion Rewarding Amounts) and the rewarding process (see Figure 3-10: CI Suggestion Rewarding Process) are displayed on the Daily Kaizen board for information and transparency towards the employees. Suggestions with the goal of improvement within the own department are evaluated by the department's Skill Team Leader (department manager). Suggestions that strive other department's improvement, are considered by the responsible department's Skill Team Leader. Accepted suggestions are directly transformed into actions and added to the responsible department's action list. Several measures are taken to promote these proposals. Further, one of these activities is that the General Manager is handing over the initial rewarding for accepted suggestions to the employee it originated from. Other measures include the announcement of accepted actions at the Plant Facility department's weekly meeting and display of the suggestions on the canteen's information board. All these activities additionally emphasize the importance of participation in the CI program and encourage employees to take action and submit suggestions.
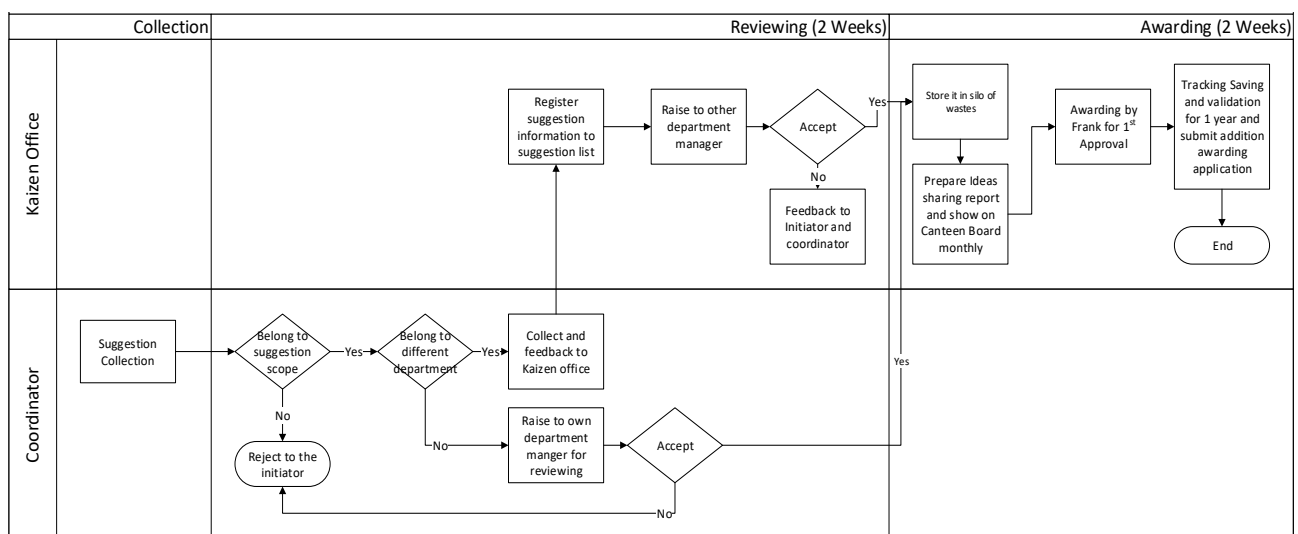
Figure 3-10: CI Suggestion Rewarding Process

Category	Rewarding
Accepted CI suggestion	Gift valued at 100RMB
Cost savings from 5000RMB to 50000RMB	Direct account deposit 500RMB
Cost savings from 50000RMB to 250000RMB	Direct account deposit 1500RMB
Cost savings over 250000RMB	Direct account deposit 2500RMB

Table 3-41: CI Suggestion Rewarding Amounts

In the Plant Facility Department, three rounds of suggestions were collected throughout the period of the research.

Round One: After setting up the CI Suggestion process and the rewarding system, it was time to gather some suggestions from the employees. An E-Mail was written to every member of the department sharing the location of the suggestion cards, the rewarding process, and the rewarding amounts; the employees were asked to make improvement suggestions. After four weeks only one suggestion had been handed in, and it came from the department's Coordinator. So, the issue was brought up in the next weekly department meeting and employees were asked again to take the initiative and hand in suggestions. Two weeks later, five more suggestions had been collected, but only one came from a member of the department, the others came from the Coordinator and the Researcher. All the suggestions are listed in Table 3-42: CI Suggestions Round .

Date Submitted	Category	Description	Action	Author	Department	Evaluating department	Evaluator	Result	Status
01.12.2016	Morale	Suggest adding different cleaning time for toilets		Qian Meili	Facility	Finance&Admin	Cheng Chen	**Accepted**	Completed
09.01.2017	Morale	Suggest using feather duster to clean each desk bed equipments since at present all test beds are dirty	1/10 Distribute the achole cleaner to all test beds	Wu Guangsheng	Facility	Finance&Admin	Cheng Chen	**Accepted**	Completed
13.01.2017	Morale	Cut-off date for trip cost was only sent to assistant instead of all staffs in STC, which need assistants to forward again.	1/13 YeJianling replied that she will send this e-mail to all colleagues.	Qian Meili	Facility	Finance&Admin	Ye Jianling	**Accepted**	Completed
13.01.2017	Morale	5S for reception area, there is a big sign in the entrance area naming CIP as one of AVLs attributes but reception could clearly use 5S.		Christof Walz	Facility	HR	Mi Limin	**Accepted**	Completed
13.01.2017	Time saving	Improvement potential in the purchase process ==> Long internal order time	2/13 Chris talked to Roman about this issue. Currently Finance Department does not see the necessity to improve the order	Christof Walz	Facility	Finance&Admin	Roman Ziegler	**Denied**	Completed
13.01.2017	Morale	Customer /Visitor involvement in CIP: -CIP cards in entrance -Hall/next to exit -Evaluation of project after completion through customer	Confirmed with HR Manager/Purchasing team, we focus on internal improvement. At present no plan to use.	Christof Walz	Facility	HR	Xu Saihua	**Denied**	Completed

Table 3-42: CI Suggestions Round One

Round Two: Since the first round was not very successfully, at the beginning of the next weekly department meeting every attendant was handed a suggestion card individually, and the importance of the suggestions and the rewarding process were once more explained in a short presentation. At the end of the meeting the participants were given extra time to complete the forms, and subsequently, the Coordinator collected the cards. In total, this led to eight suggestions (listed in Table 3-43: CI Suggestions Round) for the Plant Facility Department and a successful method of collecting suggestions that could be repeated in the future. Furthermore, there now were a number of employees in the department that had filled out a form successfully and could do so again themselves or assist other employees

in the future. Unfortunately, after evaluating the cards, it turned out that most of the suggestions had been related to morale and not efficiency improvement. The evaluating department denied all the suggestions.

Date Submitted	Category	Description	Action	Author	Department	Evaluating department	Evaluator	Result	Status
16.01.2017	Morale	The shuttle bus is not crowded, and suggest extending to Jiading, 8-10 persons more	It may take 2 hours to arrive at Jiading. And not all these persons have the needs to take the bus.	Liu Wei	Facility	Finance&Admin	Cheng Chen	Denied	Completed
16.01.2017	Morale	Increase annual leave dates for emplyees who worked STC more than 10 years	The matter cannot be decided by AVL STC. The topic was rejected by AVL China before.	Huang Jianxiong/Xiao Jun	Facility	HR	Jasmine Jin	Denied	Completed
16.01.2017	Morale	Increase benefits for employees who work in STC for more than 5 years	The matter cannot be decided by AVL STC. The topic was rejected by AVL China before.	Zhu Jihua/Zhou Di	Facility	HR	Jasmine Jin	Denied	Completed
16.01.2017	Morale	Suggest providing transportation allowance for employees who don't take shuttle bus	The matter cannot be decided by AVL STC. The topic was rejected by AVL China before.	Ma Zhen	Facility	HR	Jasmine Jin	Denied	Completed
16.01.2017	Morale	Suggest changing Birthday card to shopping card	Birthday card is especial for birthday.	Wang Qianfeng/Ma Zhen	Facility	HR	Jasmine Jin	Denied	Completed
16.01.2017	Morale	Suggest buying work clothes with ESD protection, can contact gasoline during gasoline calibration and fuel pipe maintenance	Sha Qi replied the special work clothes must be sent to special place for washing, and staff needs to wear ESD cloth from	Zang Chunlai	Facility	HR	Sha Qi	Denied	Completed
16.01.2017	Morale	Suggest canceling 5RMB lunch cost	This was discussed once, so not available at present	Ma Zhen	Facility	Finance&Admin	Roman Ziegler	Denied	Completed
16.01.2017	Morale	Suggest adding more days for festivals compared with national mandatory days	The matter cannot be decided by AVL STC. The topic was rejected by AVL China	Ma Zhen	Facility	HR	Jasmine Jin	Denied	Completed

Table 3-43: CI Suggestions Round Two

Round Three: As can be taken from Table 3-44: CI Suggestions Round , during the next few weeks one more suggestion was submitted independently. At another weekly meeting on March 27th, 2017 again suggestion cards were handed out to attendants with the plea to focus on efficiency improvement instead of morale, this made for four more cards that were submitted over the course of the next few days. Two weeks later another suggestion was handed independently. This system seemed to be working, and it was agreed that suggestion cards would be handed out at weekly meetings every two to three months by the Coordinator to on the one hand receive suggestions on a regular basis and on the other hand remind employees about the importance of suggestions continuously.

Date Submitted	Category	Description	Action	Author	Department	Evaluating department	Evaluator	Result	Status
28.02.2017	Quality	From 2014 on output temperature of intercooler is controlled by solenoid valve instead of water flow, which caused electromagnetic interference and engine data loss sometimes. Suggest adding diode to the solenoid valve winding to shield electromagnetic interference. 2014年起由PID阀控制水流量来控制中冷温度变更为由PID控制喷水电磁阀控制中冷器温度，阀不停开关引起信号干扰，导致台架测试数据丢失。在中冷器控制电磁阀线圈两端并接续流二极管，来消除线圈与断开时产生的电磁干扰，避免发动机实验时所测信号失真。	Purchase and install diodes to all test bed. 购买续流二极管，改造中冷器控制电磁阀。 –Feb. 2017	Chen Bin	Facility	Facility	Li Yanli	Accepted	Completed
27.03.2017	Safety	Add AID Box near test bed or machining room so that employees can contain immediately if injured. 在台架附近及机加工等员工容易受伤处，设立醒目的医药急救箱，方便有人受伤时，快速施救	4/15 Plan in the end of May	Zang Chunlai	Facility	HR	Sha Qi	Accepted	Evaluation
28.03.2017	Morale	The shelding on the east side is not consistent, which is not good for peoples to open the door. Suggest adding the shelding especially above the door near MDTF department. 现状： 厂房东侧雨搭不连续，雨天时，行走不方便。 建议： 增设雨搭。尤其是在一层东侧靠近机械开发部的门口处，以及靠近台架厕所旁通往二层技术层的楼梯处。	The suggestion is not related with Waste reducing.	Ma Zhen	Facility	HR	Xu Saihua	Denied	Completed
29.03.2017	Cost Saving	Mr. Wu Guangsheng from Facility department proposed the following suggestion: Present employee cards are easy broken and dirty, which impact our image. Suggest distribute protective jacket which has been applied in TTC and Graz. 建议STC参考Graz和TTC做法，将员工卡用塑料小盒装起来，再挂在脖子上或者胸前。 当前STC工卡很容易磨损或弄脏之后，没法挂在胸前或挂在胸前影响形象太脏。当下新员工越来越多，客户也多，不挂工卡，不容易辨识	4/6 IT replied the badge film was distributed 2 months ago.	Wu Guangsheng	Facility	Facility	Chen Junjie/ Cheng Chen	Denied	Completed
01.04.2017	Safety	Suggest changing the alarm sound of fast door which could be different from Fire alarm of Test bed. 建议将蓝色快速卷帘门的警报声改成和台架消防火警声不一样的，不然很容易听错。	4/7 replied:Sha Qi told me he has tried to change it before but failed. And I confirmed with Ling Jian that alarms in the market have the same sound, and they will not make the change at present.	Zhao Quancai	Facility	HR	Sha Qi	Denied	Completed
13.04.2017	Cost Saving	Self produce current clamp to replace special current clamp by FLUKE oscilloscope, which will save hunderd thousands each year. 自制电流钳替代FLUKE示波器专用电流钳。目前使用FLUKE示波器电流钳成本高 ，使用时平均每2个班需要更换9V电池。自制电流钳成本低，直接使用台架电源，无需更换电池。	4/27 Mr. Li Yanlu replied it's a good suggestion but he need to confirm the accuracy.	Zhang Tangjian	Facility	Facility	Li Yanlu	Evaluation	Evaluation

Table 3-44: CI Suggestions Round Three

One action for Plant Facility Department could eventually, after evaluation, be derived from this round of suggestions and it was directly added to the department's silo of waste; so it could be considered for the next loop of actions. It derives from the proposal made on February 28th, 2017 and is listed in Table 3-44: CI Suggestions Round Three and Table 3-45: New Actions CI Suggestions.

No	Action	Owner	Status	Due Date
21	Purchase and install diodes to all testbeds	Chen Bin	0%	30.06.2017

Table 3-45: New Actions CI Suggestions

3.3.3.3   Performance Indicators

The third way of finding actions for further improvement is the monitoring of performance indicators. The three indicators troubleshooting time, 5S audit score and CI suggestions were chosen for the Plant Facility Department.

<u>Troubleshooting time</u> is one of the departments largest concerns; it's reduction directly results in the reduction of test-bed downtime. The department has already taken measures to address this issue. One example includes the prioritization of solving troubleshooting sessions that last longer than one hour and the bi-monthly troubleshooting review meeting.

<u>5S audit score</u> displays the audit scores over the course of time for the Measurement Team's repair room, Emission Team's repair room and the Plant Facility Department's office area.

<u>CI suggestions</u> displays the number of proposals received every month. The latter two indicators were chosen because they reflect the department's performance in the CI program. The Coordinator, who is responsible for monitoring and updating the charts, has a direct influence the indicator's performance and can immediately set countermeasures, should the desired results not be achieved. At the end of the research, so far, no actions had been derived from the performance indicators.

3.4 5S Campaigns

The 5S campaigns are an essential element to any CI program because they involve the participation of all employees, especially while applied to the office. When executed properly, the employees learn waste identification, organizing work spaces, and keeping the office neat and tidy in a sustainable way. At STC the campaigns were initiated through the action list, because the Gemba walks, during Facilitating, revealed great potential for efficiency improvement in the department's facilities. 5S campaigns were applied to the Plant Facility Department's office, the Measurement Team's repair room, and the Emission Team's repair room.

3.4.1 Office

Action No. 12 "5S/Visual Management (Office)" was the start for 5S in the office area; it focused mainly on the first three S's during the action. For the introduction to the employees training material with example photos, before & after pictures and special instructions for a desk, shared space, computer, and the meeting room were provided in an E-Mail campaign. As described in chapter 3.2.4 Second Loop, the action was not an immediate success because of a lack of self-initiative among employees. This led to an unfortunate result, compared to other departments, in the first audit held on Jan 6th, 2017 by Support Kaizen. The Plant Facility Department reached a score of 93% (see Figure 3-11: 5S Office - First Audit Results) at this audit on Jan 6th, 2017, the lowest score throughout STC. Feedback from the audit pointed out that most desks had too many folders on them, one of the employees had 15 folders on his desk, considering the size of the desks this significantly reduces the available workspace and the folders were not used frequently enough to justify them taking up that much space. Another finding was that many desks were unorganized and most of them had trash on them. The action was completed after the audit with particular precaution to resolve the issues criticized in the audit.
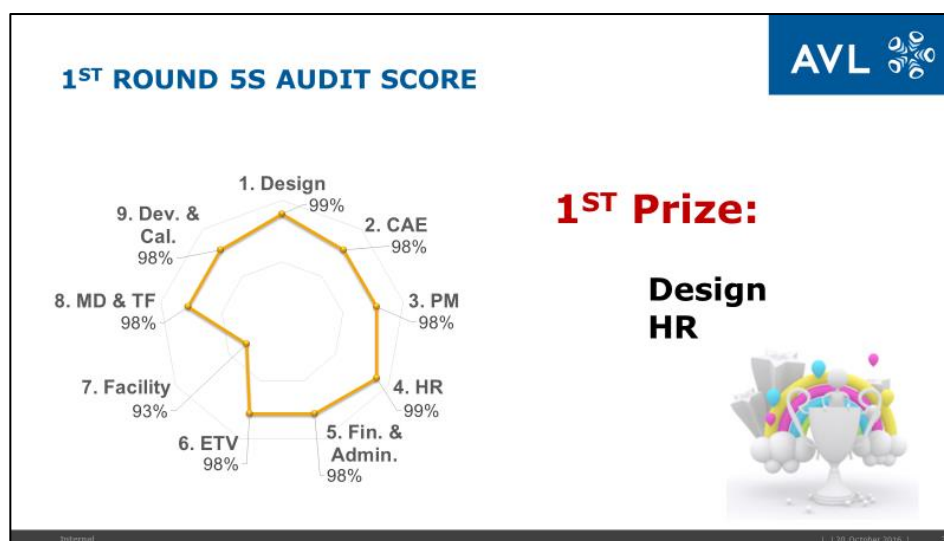
Figure 3-11: 5S Office - First Audit Results

The second audit took place on Jan 20th, 2017, shortly after action No 12 had been completed. This time the Plant Facility Department reached a score of 99% (see Figure 3-12: 5S Office - Second Audit Results) and won the audit together with the Project Management Department. The department received a gift box with snacks as a prize; these were distributed at the next weekly department meeting which made for a quick win and showed the employees that the work they had put into their office had paid off.
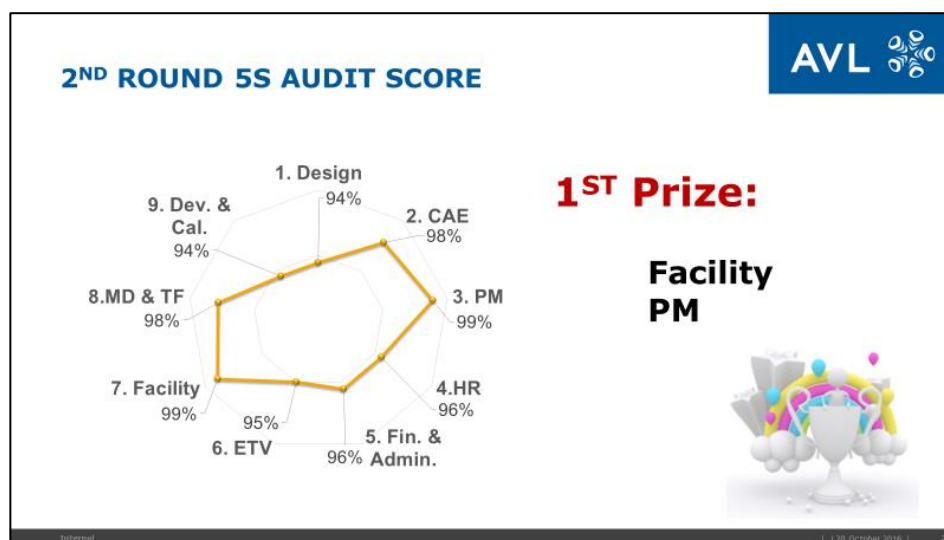
Figure 3-12: 5S Office - Second Audit Results

The result of the second audit was an excellent basis for the next two S's that were the topic of the following few weeks work of office improvement, standardize and sustain. In regards of standardizing, every employee was provided with a template for standard folder labels and urged to apply them to her / his folders. All the team cabinets were marked with the team's name and a community work station with office supplies was established next to the printer and laminator. These standards were checked on a weekly basis by the Coordinator and employees who failed to comply were constantly reminded until they completed their tasks. The fifth S, sustain is probably the most difficult phase of the 5S campaign and can only be evaluated after an extended period of time. It is up to every single employee to show self-discipline by sticking to the common standards and maintaining their own desk in a clean and organized way. The third audit conducted on Mar 31st, 2017 is proof for a successful campaign in the department.
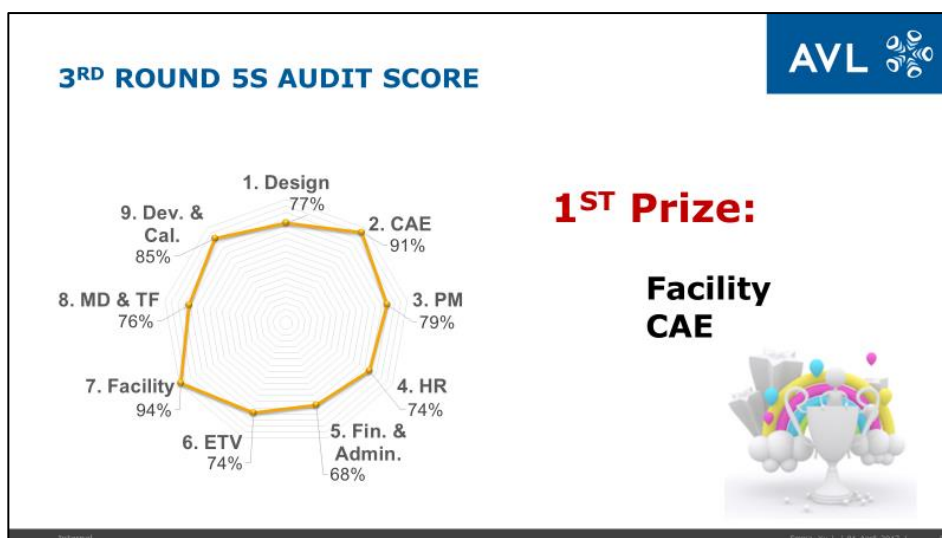
Figure 3-13: 5S Office - Third Audit Results

3.4.2   Workshops

The 5S campaigns for the workshops were completed before the audits took place. The first three S's were part of the actions No. 11 "Repair room management (Measurement)" and No. 11 "Repair room management (Measurement)"; the fourth and fifth S's were implemented subsequently.

3.4.2.1   Emission Repair Room

The 5S campaign in the Emission Team started off with a meeting conducted by the Coordinator and the Researcher. This session had the goal of introducing 5S in the workshop, teaching the team members about waste identification (7 types of waste) and repeating the reasons for and advantages of CI. The meeting especially focused on explaining each of the 5S, by allowing the team members to search for improvement potential independently for five minutes and then collecting all the teams finding and summarizing them. The team was then given one week for sorting and another week for straightening. The latter one eventually took longer than expected because some materials had to be ordered and the supplier did not have them in stock; this delay is explained in action No. 11 "Repair room management (Measurement)". After the action and therefore sorting and straightening had been completed, the remaining three S scrubbing, standardizing (see Figure 3-14: 5S Standards Emission Team) and sustaining were initiated.

Sort: In the Emission Team's repair room, many of the workbenches were used as a storage area, as well as above, as below the working surfaces. Also, many cabinets, drawers, and shelves contained items that were no longer used or had just been put there for later use but turned out not to be useful.

Straighten: All the shelves received labels, and their content was rearranged to use the space more efficiently. The workbenches were rearranged in a way that the back part of the room could serve as an office area offering proper workplaces for the employees and the front part was equipped with work stations. The cabinets were also moved

to the back of the room since they contain folders, manuals, legislations, and standards. The tool carts and mobile test stations were transferred to the front of the workshop, close to the entrance. On the workbenches themselves all the instruments and drawers were rearranged in a systematic way.

Scrub: The cleaning crew was commissioned to clean all the shelves, work surfaces and the floor after working hours.

Standardize: After having brought the repair room into a more suitable shape it was time to keep it that way. In a workshop involving the team members, the Coordinator, and the Researcher a list of standards was elaborated. These standards were summarized on a sheet, and the team member's pictures and names were added. All the affected persons were asked to sign the standards that then were hung up in the repair room so they would be visible to everybody.

Figure 3-14: 5S Standards Emission Team

Sustain: Xiao Jun the team leader of the Emission Team agreed to keep an eye on the repair room and make sure that the standards are being kept. Additionally, the team was informed that there would be audits in the future and that they were eligible for rewards if they performed well at the audits.

Figure 3-15: Emission Repair Room Before 5S

Figure 3-16: Emission Repair Room After 5S

3.4.2.2   Measurement Repair Room

Also in the Measurement Team's repair room, the 5S campaign started off with a meeting conducted by the Coordinator and the Researcher. The meeting introduced 5S in the workshop, teaching the team members about waste identification but also covered the topics reasons for and advantages of CI. The meeting especially focused on explaining each of the 5S, by allowing the team members to search for improvement potential independently for five minutes and then collecting all the teams finding and summarizing them. The team was then given one week for sorting and another week for straightening. In this team, the tasks were completed within the given time. After the action and therefore sorting and straightening had been completed the remaining three S's scrubbing, standardizing (see Figure 3-17: 5S Standards Measurement Team) and sustaining were initiated.

Sort: In the Measurement Team's repair room, there were many old boxes that were stored on top of a cabinet; most of the boxes were empty and therefore could be sent to recycling. Most of the desks in the repair room were used as a storage area, as well above as below the working surface, causing employees first to have to clear the working surface before they could use it. Some of these objects could be gotten rid of; some could be stored in another place. After clearing all the tables, one of them was gotten rid of altogether since it was never being used. In the spare parts shelves, there were many cables with connectors that were no longer being used and therefore could be sent to recycling.

Straighten: Also, there was a lot that had to be done in the repair room. The formerly described spare parts shelves had to be rearranged after sorting, the components were arranged according to their size and all of them were received labels. The folder cabinet with all the manuals, legislations and standards received labels as well. The arrangement of the remaining tables and spare parts shelves was reorganized, creating more space in the repair room and a common corner with sink, water dispenser, cabinet for the employee's tea and the Daily Kaizen board.

Scrub: Most of the shelves had dust on them, and the floor could use a scrub. STC's cleaning crew was commissioned to take care of these issues after working hours.

Standardize: After having brought the repair room into a more suitable shape it was time to keep it that way. In a workshop involving the team members, the Coordinator, and the Researcher a list of standards was elaborated. These standards were summarized on a sheet, and the team member's pictures and names were added. All the affected persons were asked to sign the standards that then were hung up in the repair room so they would be visible to everybody.

Figure 3-17: 5S Standards Measurement Team

Sustain: In regard of sustaining the tidiness of the repair room, the Measurement Team's leader Zhao Quancai agreed to make sure that the standards are kept. The team was also informed that there would be audits in the future and that they were eligible for rewards if they performed well in the audits.

Figure 3-18: Measurement Repair Room Before 5S   *Figure 3-19: Measurement Repair Room After 5S*

3.4.2.3   Audits

Audits were also applied to the workshop areas of STC. They were held during the weekly Coordinator meeting including the Coordinators, Kaizen Officer, and the Researchers. The first audit focused on the first three S and took place on March 17th, 2017. The evaluators gave ratings on a scale of one to ten, and the scores were averaged. The Plant Facility Department's Emission Team scored a 9.2, the second highest score and the Measurement Team scored a 9.5 which made them one of the winners of the audit. The winning teams received a gift box containing snacks, which were distributed among the team members. The results were brought up in the next weekly department meeting by the Coordinator who made for additional promotion and motivation within the department.

Figure 3-20: 5S Workshop - First Audit Results

The second audit took place on April 28th, 2017; this time additionally standardizing and sustaining were evaluated, and the Emission Team reached a 9.0 and the Measurement Team a 9.1, the highest scores from that audit, making both teams the overall winners. Rewarding was again received by the Teams and distributed among members, and the results were again shared in the weekly department meeting for the further motivation of the employees.

Figure 3-21: 5S Workshop - Second Audit Results

4 Conclusion

With regard to the two research questions, defined at the start of the research project, the following findings can be noted:

What measures are necessary to implement the actions, that were generated in facilitating workshops and can target dates be reached in time?

<u>Actions</u>: Most of the actions were either completed, or terminated because they were not feasible (See Table 4-1: Initial Actions - End of Research Status). At the end of the research, only three actions were not completed and still in progress. The total savings accumulate to 71.500 RMB in one-time savings and 10.033 RMB in weekly savings. Analyzing the execution of the actions, these major reasons for not meeting due dates can be found:

- Project first: actions No. 2, 6 and 7 were delayed with the excuse that the responsible persons had too much project work on hand. These delays are an indicator to a lack of importance of the CI measures within the department. As mentioned in chapter 2.2.1 Major concepts of Kaizen, process versus result is an elementary principle of Kaizen and the process must always come first since it is the prerequisite for a good quality result.

- Lack of time management: actions No. 3 and 9 could not be completed due to a lack of time management. Specifically, the issues included not considering other activities on public holidays and adding topics to the weekly department meeting instead of summoning additional meetings.

No	Action	Owner	Status	Due Date		Saving (¥)	Saving (¥/week)
	Silo of Waste						
1	Define standard for equipment responsibility	Li Yanlu	100%	31.12.2016		¥0,00	¥0,00
2	Catetory drawing batch machine sample probe	Xiao Jun/Hengyang	100%	31.12.2016		¥0,00	¥1.290,00
3	Troubleshooting review meeting 1 per two months	Li Yanlu	100%	30.11.2016		¥0,00	¥320,00
4	Set up typical TST database	Zhao Quancai	100%	30.11.2016		¥71.500,00	¥0,00
5	Record malfunction over 1H in troubleshooting record	Li Yanlu	100%	31.10.2016		¥0,00	¥330,00
6	Fuel pipe installation standardize	Zhao Quancai/Heng Yang	50%	30.04.2017		¥0,00	¥825,00
7	Parameter offline/simulator	Zhu Jihua	50%	31.05.2017		¥0,00	¥4.068,75
8	Spare parts safety stock check once per half year	Zhou Di/Zang Chunlai	100%	31.10.2016		¥0,00	¥0,00
9	Power socket installation for ETC1-6	Liang Yongli	50%	30.04.2017		¥0,00	¥0,00
10	Puma operation table extend	Zhao quancai	100%	30.05.2017		¥0,00	¥0,00
11	Repair room management	Zhao Quancai/Xiao Jun	100%	31.01.2017		¥0,00	¥3.200,00
12	5S/Visual Management	Li Yanlu	100%	31.12.2016		¥0,00	¥0,00
13	Keycard computer application combined	Huang Jianxiong	0%	30.11.2016		¥0,00	¥0,00
14	Timely transfer ETTS data to ProCalc	Huang Jianxiong	0%	28.02.2017		¥0,00	¥0,00
15	Instrument, transducers equipment owner list	Li Yanlu/Andrea Pagnini	100%	31.12.2016		¥0,00	¥0,00
	Overall Saving (RMB)					¥71.500,00	¥10.033,75

Table 4-1: Initial Actions - End of Research Status

In addition to the initial task description Daily Kaizen systems and 5S campaigns were realized, they were not part of the defined research question but the results shall not be withheld.

Daily Kaizen: Daily Kaizen Boards were successfully created for the Plant Facility Department in general and for the Emission Team and Measurement Team (See Figure 4-1: Daily Kaizen Board - Measurement Team). The boards are updated frequently and have proved to be a great support for the team leaders. The department's board offers a sustainable way of generating new actions. During the research, five new actions could be generated.

Figure 4-1: Daily Kaizen Board - Measurement Team

5S: The 5S campaigns were implemented in the office area as well as the repair rooms of the Emission Team (see Figure 4-2: Emission Repair Room - Before and Figure 4-3: Emission Repair Room - After) and Measurement Team. In total, the Plant Facility Department was able to receive rewarding in four of five audits, which proves that also the last two of the five S's, standardize and sustain, were achieved.

Figure 4-2: Emission Repair Room - Before

Figure 4-3: Emission Repair Room - After

Will the change-mentality be adopted by employees to the extent that it is integrated into the company culture?

This question can best be answered by comparing the Plant Facility Departments status at the end of the research to the eight stages of change by John Kotter (See chapter 2.4.4 The Eight-Stage Process).

1. Creating a Sense of Urgency: This step was completed by starting the campaign in the department with an awareness training. Additionally, pep talks and presentations were held at the introduction of Daily Kaizen, 5S and Facilitating.

2. Build a Guiding Coalition: The Support Kaizen system, which includes the weekly Coordinator meeting, fulfills this role on a company level. Within the department the Daily Kaizen boards meet this requirement.

3. Form a Strategic Vision: Creating a learning organization is the vision formed in the Steering Committee. The goal is not to demand changes in a top down manner but to encourage employees to contribute to the efficiency of the department and the company.
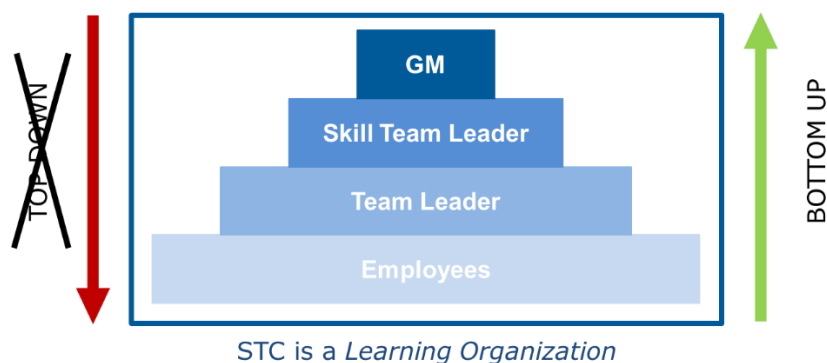
Figure 4-4: STC - Learning Organization

4. Communicate the Vision: The vision was communicated through awareness trainings and pep talks, it is questionable though, if every employee got the message. There is room for improvement in regard of the continuity of the program.

5. Empower Employees for action: The action plan and especially the suggestion system empower employees to contribute to the program. However, some employees still prioritize project work over process improvement. The importance of process improvement could be owned and communicated more by Team Leaders and Skill Team Leaders. Tools and techniques do not always end up in the department in the extent that the Kaizen Institute consultant taught them. The Coordinator could do more work to provide these tools to all the departments' members, e.g. by small group exercises.

6. Generate Quick Wins: Many quick wins were generated, some examples are the 5S campaigns including audits won by the Plant Facility Department, the rewarding for suggestion received by department members, three completed Loops of actions and three Daily Kaizen boards installed and used throughout the department.

7. Don't Let Up – Press harder and produce even more changes: At the end of the research this stage has not been reached by the department. It is crucial for the success of the program that the department learns from problems and issues and makes changes accordingly.

8. Integrate – CIP into the STC DNA: Since the eight-stage process takes place in a sequential order, also this stage has not been reached and a successful completion of the previous stage is a prerequisite for reaching integration of Continuous Improvement to the STC's DNA. This stage will successfully be reached when employees actively contribute to process improvement.

The Plant Facility Department has completed six of the eight stages in the eight-stage process by John Kotter. While most of the stages were completed thoroughly, some potential for improvement remains, especially in communicating the vision and empowering employees. It is important that the department makes up for these deficiencies, otherwise the continuity of the program is at risk. In regard of the research question it must be concluded that the Plant Facility Department has not reached an integration of Continuous Improvement into the company culture sufficiently.

5 References

5.1 Figures

5.2   Tables

5.3   Bibliography

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