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Implementation of a Continuous Improvement Program in the Mechanical Development and Testing Area at AVL Technical Center Shanghai

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Affidavit

I declare that I have authored this thesis independently, that I have not used other than the declared sources/resources, and that I have explicitly indicated all material, which has been quoted either literally or by content from the sources used. The text document uploaded to TUGRAZonline is identical to the present master thesis.

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Abstract

International companies face many challenges. One of them is to maintain an efficient work environment so that employees are able to do their work properly; but also employees have to contribute to an efficient work environment. Especially for international active companies, bringing employees on the same understanding of the concept "efficiency" can constitute a difficult task. Due to cultural aspects, the understanding of effective work behaviour may vary. Therefore, the company has to train their employees to bring them on the same level and to introduce its concept of efficiency. This process is also known as "change management".

The focus of the thesis lies on introducing a Continuous Improvement Program (CIP) in an international company specialized on the development of powertrain systems. The objective of the CIP is to reduce waste and increase the efficiency, utilization as well as working behaviour in Development and Testing area of a Powertrain Engineering company. A key problem of companies in the field of development is that there are complex processes in various areas that complicate the evaluation of improvable activities and thus, to find potential solutions for improvement. Therefore, the Researcher optimizes different processes and sets up activities to improve the efficiency in the daily work. Further, various tools and methods are implemented to develop a Continuous Improvement culture in the department. The understanding of CIP and its significance is indispensable, because it is an ongoing process that has no definite end.

The thesis is implemented by an empirical research in which knowledge was generated from observation and experience through an internship in the company. Objective of the internship was to implement a CIP in the Development and Testing Area, which laid the basis for maintaining and extending this program in the department.

Kurzfassung

Internationale Unternehmen stehen in der heutigen Zeit vor vielen Herausforderungen. Eine davon ist ein Umfeld zu schaffen, indem die Mitarbeiter ihrer Arbeit effizient nachgehen können. Speziell in international tätigen Unternehmen, in denen Menschen aus verschiedenen Ländern und mit unterschiedlichem kulturellen Hintergrund zusammenarbeiten, kann die Auffassung von *"Effizienz"* variieren. Um dieser Entwicklung entgegenzuwirken, muss ein Unternehmen seine Mitarbeiter schulen und auf den selben Nenner in Sachen *"Effizienz"* bringen. Solche Maßnahmen führen meist zu Veränderungen in der gesamten Unternehmenskultur. Im Mittelpunkt der vorliegenden Arbeit steht die Einführung eines kontinuierlichen Verbesserungsprozesses (KVP) in einer Abteilung eines international tätigen Unternehmens, dessen Tätigkeitsschwerpunkt in der Entwicklung von Antriebssystemen liegt. Das Ziel von KVP ist es, Verschwendungen aller Art zu reduzieren und die Effizienz, Auslastung sowie das Arbeitsverhalten zu steigern. Im Zuge des Masterprojektes wurden verschiedene Prozesse der Abteilung für *"Development und Testing"* optimiert und Aktivitäten zur Verbesserung der Effizienz in der täglichen Arbeit des Unternehmens eingeführt. Darüber hinaus wurden verschiedene Methoden implementiert, um eine kontinuierliche Verbesserung in der Abteilung zu erreichen. Das Verständnis eines kontinuierlichen Verbesserungsprozesses und seine Bedeutung stellen einen essentiellen Bestandteil für den Erfolg von Unternehmen dar. Dieser stetig andauernde Verbesserungsprozess, der kein bestimmtes Ende vorsieht, muss von den Mitarbeiter verinnerlicht werden, damit diese zum Erfolg des Unternehmens beitragen können.

Die vorliegende Arbeit wird durch eine empirische Forschung umgesetzt, aus welcher Wissen aus Beobachtung und Erfahrung im Zuge eines Praktikums im Unternehmen generiert werden konnte. Das Ziel dieses Praktikums war es, einen kontinuierlichen Verbesserungsprozess in der Entwicklungs- und Testabteilung einzuführen. Dies legte den Grundstein für die Aufrechterhaltung und Erweiterung des fortlaufenden Verbesserungsprozesses in der Abteilung.

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List of 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
Fin. & Admin.	Finance and Administration
GM	General Manager
HR	Human Resources
IT	Information Technology
KO	Kaizen Office
KPI	Key Performance Indicator
MD	Mechanical Development
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
SDCA	Standardize Do Check Act
SIPOC	Supplier Input Process Output Customer

SK	Support Kaizen
SKTL	Skill Team Leader
SS	Six Sigma
STC	AVL List Technical Center (Shanghai) Co. Ltd.
TL	Team Leader

1. Introduction

In course of the Double Degree Program offered by Graz University of Technology (TUG) and Tongji University in Shanghai, the Researcher completed an internship at AVL STC during which the Master Project was developed. The Researcher Lucas Wartscher and two other students, Georg Kolb and Christof Walz, had the opportunity to prepare their Master Projects during the internship at AVL. The Master Project dealt with the implementation of a Continuous Improvement Program at AVL STC. The Researcher and the other two students shared the same topic but were responsible for implementing the CIP in different departments of the company.

Georg Kolb was allocated to the Development and Calibration department, Christof Walz to the Plant Facility department and the Researcher Lucas Wartscher was responsible for carrying out the task in the Mechanical Development and Test Factory department.

1.1. Task Description

AVL is the world's largest independent company for development of powertrain systems as well as instrumentation and test systems. The competition on the global market is getting harder and the pressure by customers increases year by year. To continue providing the best service for AVL´s partners, the implementation of a CIP is necessary. The objective of this research is to reduce waste and increase efficiency in various development and testing processes.

The Researcher support the MD & TF department at the implementation of the CIP. The detailed task description is as follows:

- Execution and support of process optimization for the generation of actions to increase the efficiency and working behaviour of daily work
- Mentoring, implementation and evaluation of the generated actions from the process optimization
- Direction of awareness training for the employees for a better understanding of the meaning of CIP
- Introduction of Daily Kaizen and Support Kaizen into the MD & TF work organisation
- Implementation of various CI methods and tools to support the advent of the program into the MD & TF department

The thesis is divided into four main parts. Due to the fact that Researchers Georg Kolb, Christof Walz and Lucas Wartscher processed the same topic but in different departments, the Researchers decided to split up the first and the second part. The third and the fourth part will be discussed by the Researcher

who is responsible for the respective department. Fig. 1 illustrates the division of the thesis into the four main parts and the competences to each part.

| 1. Introduction | 2. Theoretical Background | 3. CIP in the MD & TF Department | 4. Conclusion |

Georg Kolb

Christof Walz

Lucas Wartscher

Lucas Wartscher
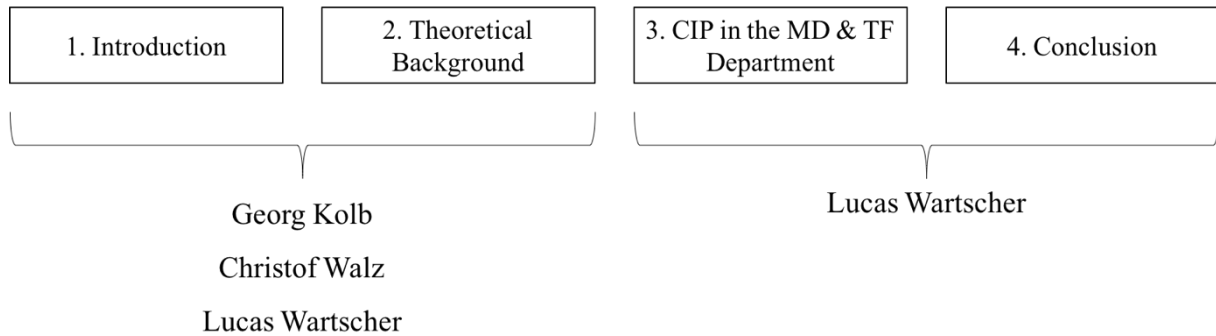
Fig. 1: Division of the present thesis

1.2. AVL List Shanghai Technical Center

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 Fig. 2). On basis of strategic reasons and the distribution of tasks, the departments are divided in various teams.
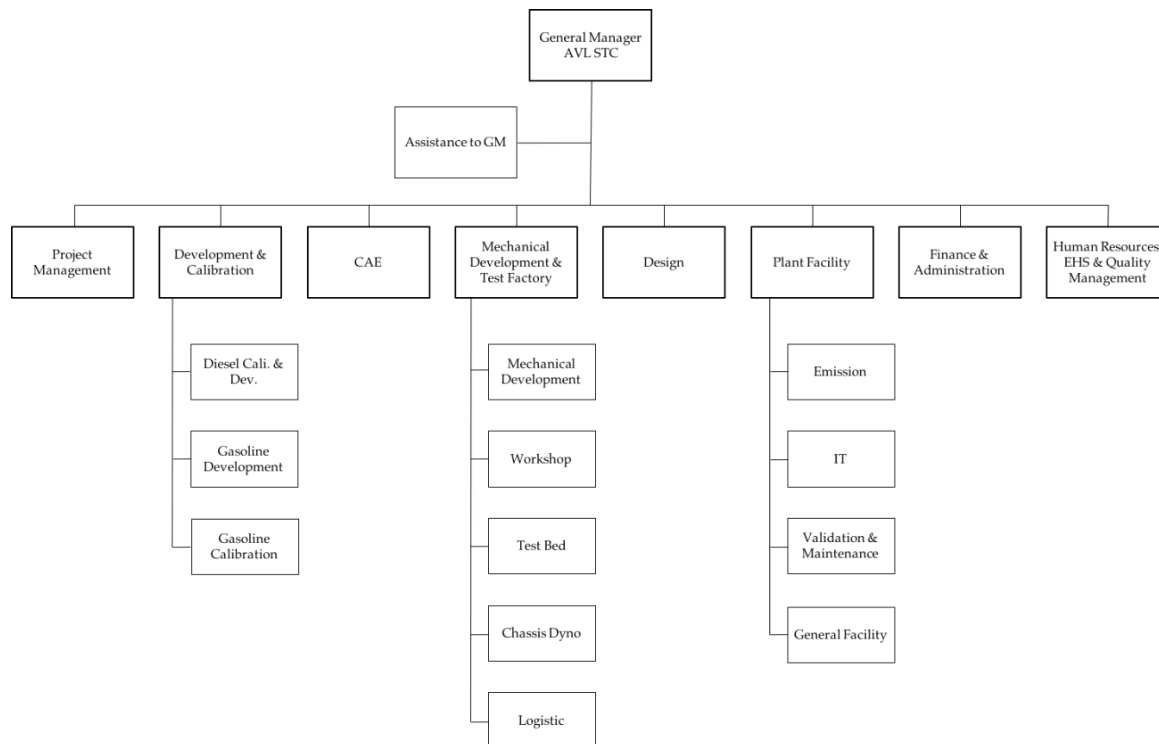
Fig. 2: Organigram STC

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 Fig. 3) shows the development of the employment figures in the period from 2008 to 2017.
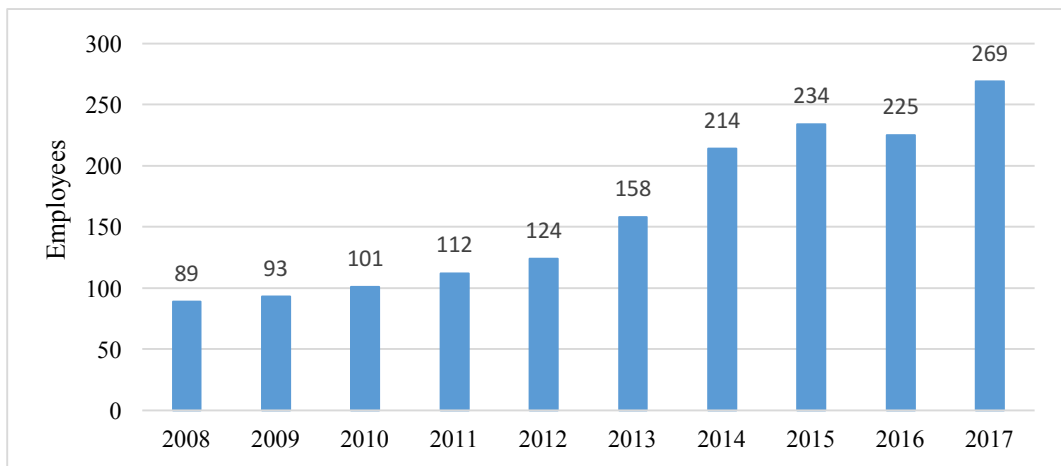
Fig. 3: Number of Employees at STC

As noted in Fig. 3, 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 Fig. 4 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.
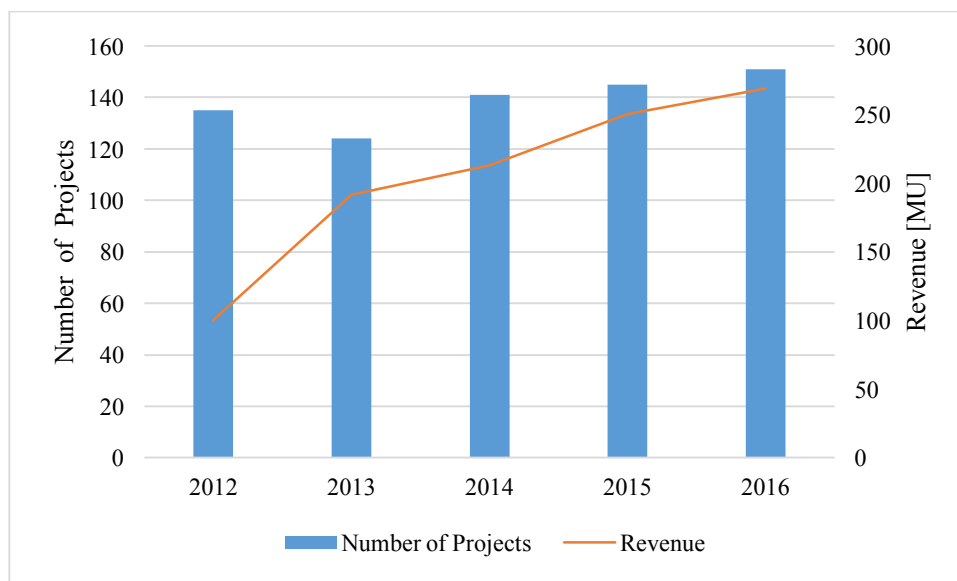
Fig. 4: Growth of Projects and Revenue at STC

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. 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

Initial Situation:

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.

Urge for Change:

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.

Desired State:

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

Strategy:

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

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[1] *Kaizen^TM* Institute. 2017: online available: https://www.kaizen.com/about-us.html#history, [accessed: 17th of September, 2017].

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[2]. 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

1.3.2. Roles and Responsibilities

To make sure that the whole company is involved in the CI process, specific roles (Fig. 5) and responsibilities (Fig. 6) 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 Fig. 6: CI Responsibilities.
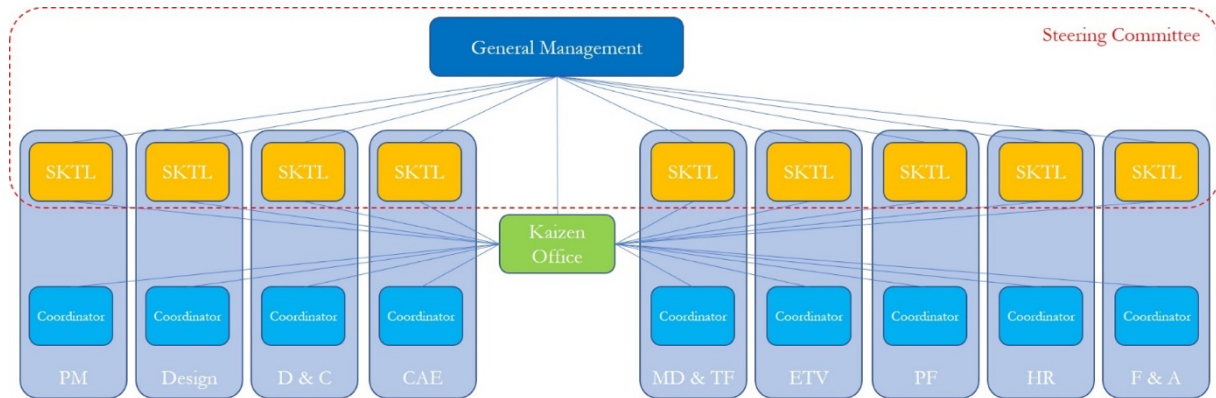
Fig. 5: CI Hierarchy

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[2] More details to the Kaizen approach can be found in Chapter 2.2.
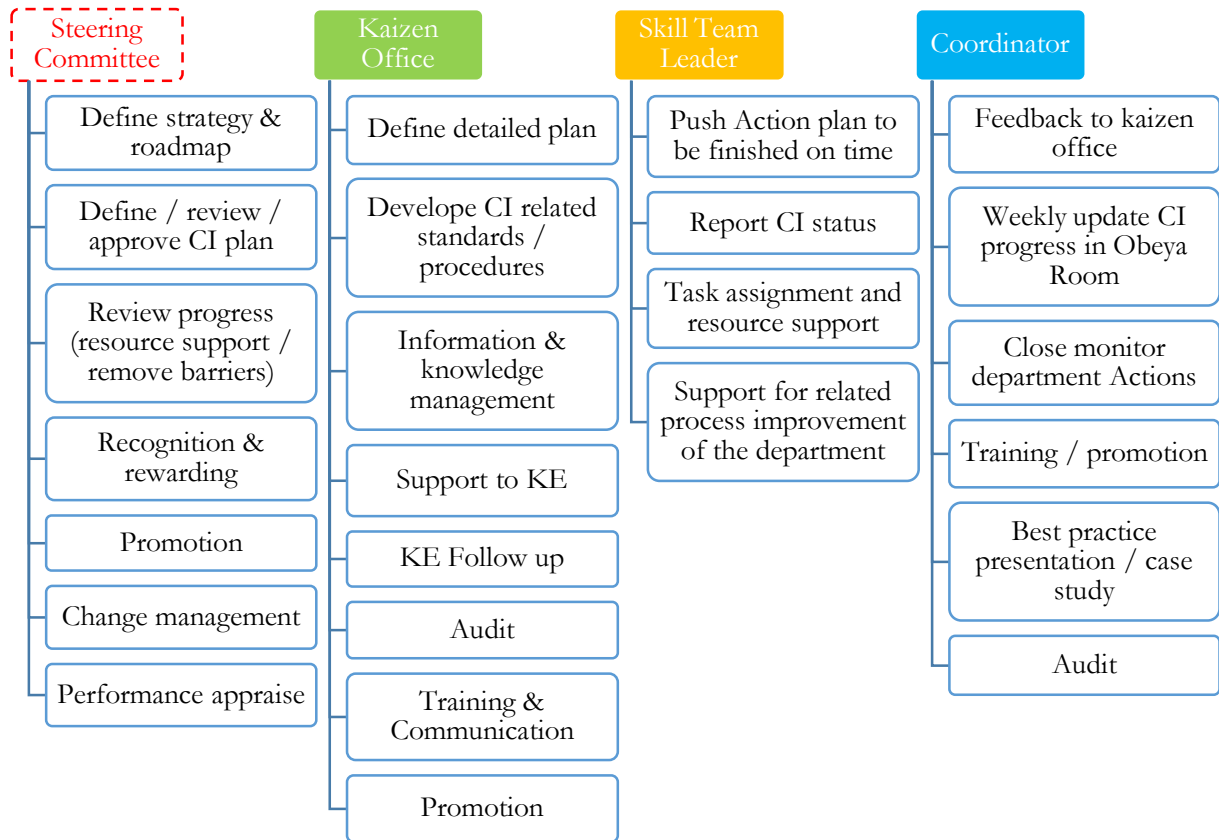
Fig. 6: CI Responsibilities

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 Fig. 7: CI Content.
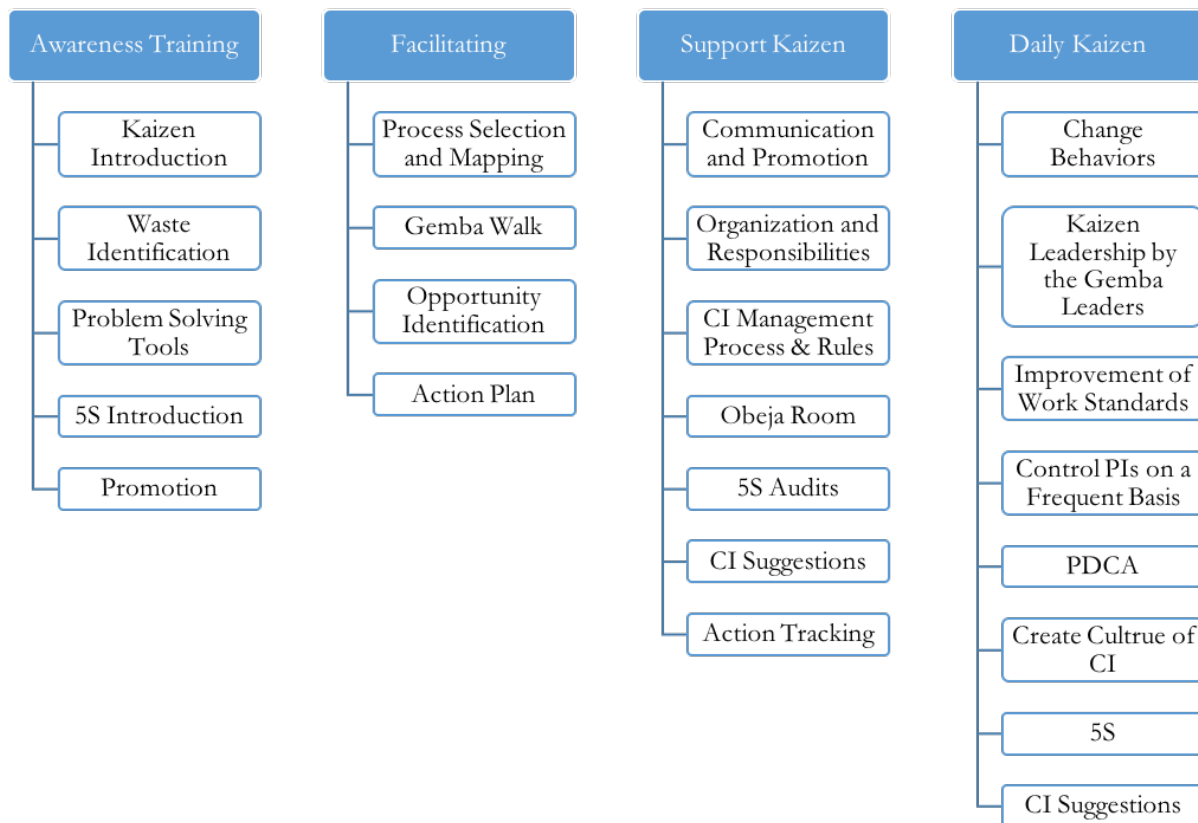
Fig. 7: CI Content

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[3] 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.

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

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[3] *Schulz S.*: online availabele: http://www.spiegel.de/wirtschaft/unternehmen/messenger-apps-wie-china-die-mobile-zukunft-erfindet-a-1071815.html, [accessed: 22nd of September, 2017].

CI progress charts permanently. Roles involved in the Obeya room meetings are the steering committee, Kaizen office, and the coordinators.

<u>Daily Kaizen</u>:

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				
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	
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	

Gantt bars:
- 5S (from week 50 onward)
- Daily Kaizen (from week 46 onward)
- Facilitating (from week 41 onward)
- Support Kaizen (from week 41 onward)
- Awareness Training (weeks 37–45)

Table 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.[4]

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[4] *Kaizen^TM Institute*. 2017: online available: https://www.kaizen.com/about-us.html#history, [accessed: 17th of September, 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. CIP

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"[5]. The word *Kaizen* is Japanese and can either be translated to *Change for the Better or Continuous Improvement*[6]. Other famous concepts that strive for efficiency improvement within companies are Lean Manufacturing and Six Sigma[7]. 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[8]; 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

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[5] *Imai M.,* The Key to Japan's Competitive Success, McGraw-Hill, 1986.

[6] *Medinilla Á.,* Agile Kaizen, Springer-Verlag, First Edition, 2014, p. 4.

[7] *Waurick T.,* Prozessreorganisation mit Lean Six Sigma, Springer Gabler, 2013.

[8] *Abreu J., Ventura Martins P., Fernandes S., Zacarias M.,* Business Process Improvement on Maintenance Management a Case Study, ScienceDirect Procedia Technology, 2013, p. 320.

and improve business processes[9]. 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 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[10]. 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[11]. In the Chinese services sector, research has been done on the influence of CI regarding new service development[12].

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.[13]

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[9] *Lee K.T., Chuah K.B.*, A SUPER methodology for business process improvement – An industrial case study in Hong Kong/China, International Journal of Operation & Production Management Vol. 21 Issue: 5/6, 2001, p. 690.

[10] *Aoki K.*, Transferring Japanese kaizen activities to overseas plants in China, International Journal of Operations & Production Management, Vol. 28 Issue: 6, 2008, p. 518.

[11] *Shang G., Pheng L.S.*, Understanding the application of Kaizen methods in construction firms in China, Journal of Technology Management in China, Vol. 8 Issue: 1, 2013, p. 18.

[12] *Yang Y., Lee P. K.C., Cheng T.C.*, Continuous improvement competence, employee creativity, and new service development performance: A front line employee perspective, Elsevier Int. J. Production Economics 171, 2016, p. 275.

[13] *Imai M.*, Gemba Kaizen: A Commonsense, Low-Cost Approach to Management, First Edition, McGraw-Hill, 1997, p. 3.

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.[14]

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.[15]

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.[16]

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.[17]

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.[18]

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

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[14] *Imai M.*, Gemba Kaizen: A Commonsense, Low-Cost Approach to Management, First Edition, McGraw-Hill, 1997, p. 4.
[15] *Imai M.*, Gemba Kaizen: A Commonsense, Low-Cost Approach to Management, First Edition, McGraw-Hill, 1997, p. 4.
[16] *Imai M.*, Gemba Kaizen: A Commonsense, Low-Cost Approach to Management, First Edition, McGraw-Hill, 1997, p. 6.
[17] *Imai M.*, Gemba Kaizen: A Commonsense, Low-Cost Approach to Management, First Edition, McGraw-Hill, 1997, p. 6.
[18] *Imai M.*, Gemba Kaizen: A Commonsense, Low-Cost Approach to Management, First Edition, McGraw-Hill, 1997, p. 7.

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.[19]

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.[20]

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).[21]

Policy Deployment: top management must set clear objectives as to what the goal of the program 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.[22]

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.[23]

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.[24]

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[19] *Imai M.*, Gemba Kaizen: A Commonsense, Low-Cost Approach to Management, First Edition, McGraw-Hill, 1997, p. 7.
[20] *Imai M.*, Gemba Kaizen: A Commonsense, Low-Cost Approach to Management, First Edition, McGraw-Hill, 1997, p. 9.
[21] *Imai M.*, Gemba Kaizen: A Commonsense, Low-Cost Approach to Management, First Edition, McGraw-Hill, 1997, p. 9.
[22] *Imai M.*, Gemba Kaizen: A Commonsense, Low-Cost Approach to Management, First Edition, McGraw-Hill, 1997, p. 9.
[23] *Imai M.*, Gemba Kaizen: A Commonsense, Low-Cost Approach to Management, First Edition, McGraw-Hill, 1997, p. 10.
[24] *Imai M.*, Gemba Kaizen: A Commonsense, Low-Cost Approach to Management, First Edition, McGraw-Hill, 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 Fig. 8):

- *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.[25]

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[25] *Kühnle R.*, Lernen zu lernen – Praxisbeispiel einer Lean-Umstellung im Produktionsunternehmen, First edition, 2016, p. 250, 251.
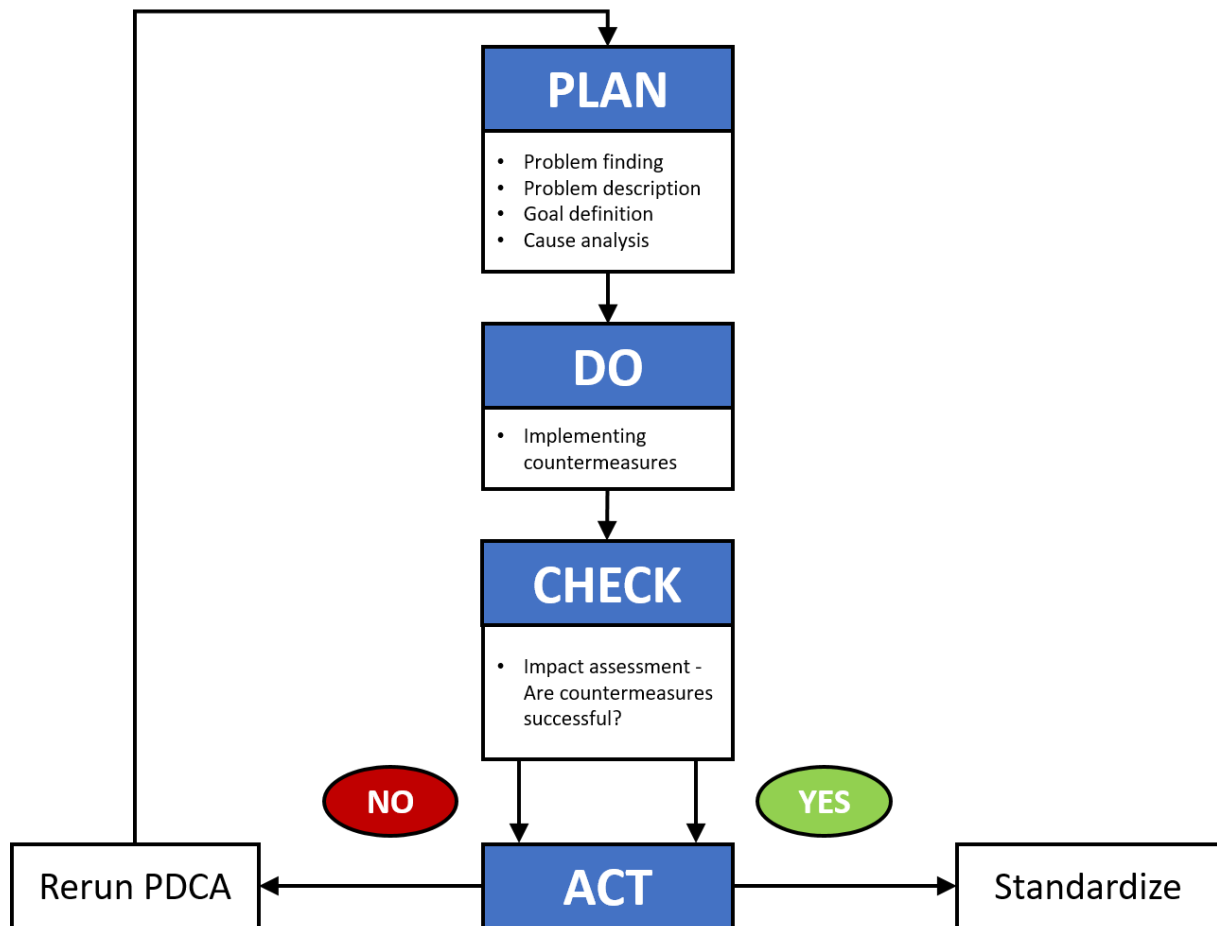
Fig. 8: Elements of the PDCA-Cycle
Source: Gierszewski, Stephan. 2016: *Lean ist kein Projekt – Kriterien für erfolgreiches Lean Management*, First edition, Springer-Verlag, p. 373.

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 Fig. 9).[26]

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[26] *Imai M.,* Gemba Kaizen: A Commonsense Approach to a Continuous Improvement Strategy, Second Edition, McGraw Hill, 2012, p. 23-24.

Fig. 9: The PDCA-cycle and its role in continuous improvement
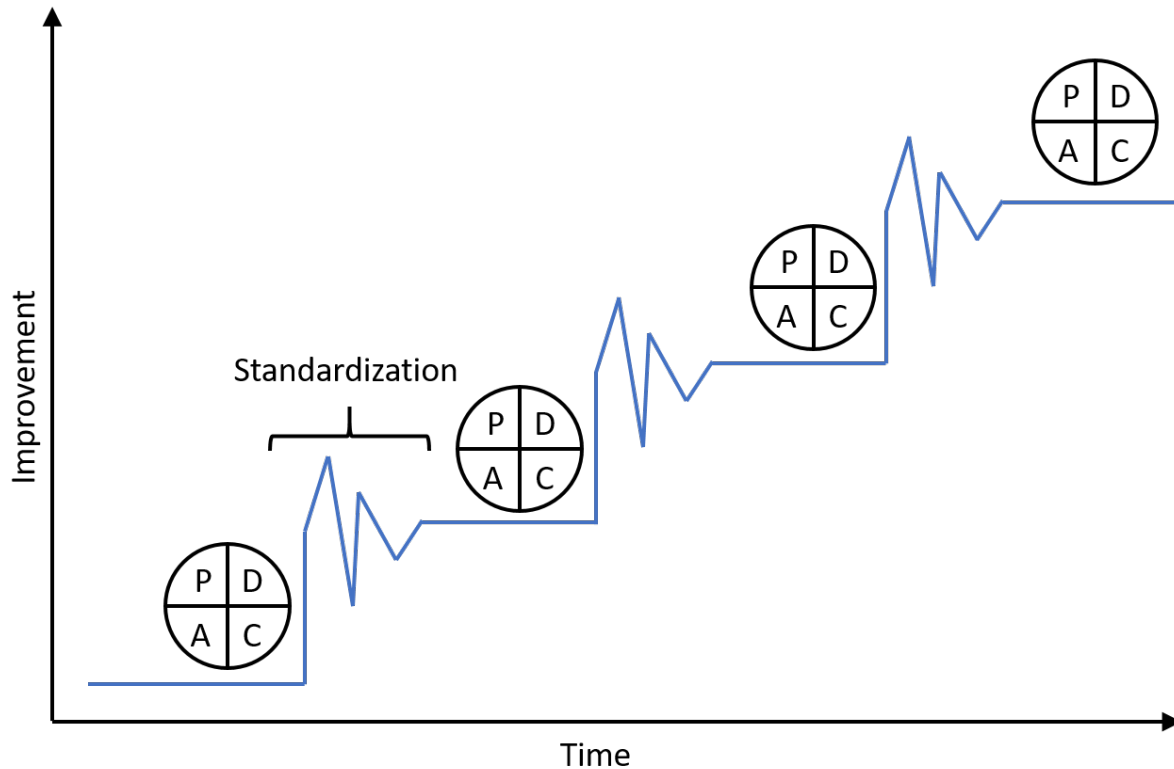Source: *Imai M.*, Gemba Kaizen: A Commonsense Approach to a Continuous Improvement Strategy, Second Edition, McGraw Hill, 2012, p. 54.

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.[27]

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.[28]

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[27] *Imai M.,* Gemba Kaizen: A Commonsense Approach to a Continuous Improvement Strategy, Second Edition, McGraw Hill, 2012, p. 290-297.
[28] *Becker T.*, Prozesse in Produktion und Supply Chain optimieren, Second Edition, Springer, 2007, p. 8, 13.

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.[29]
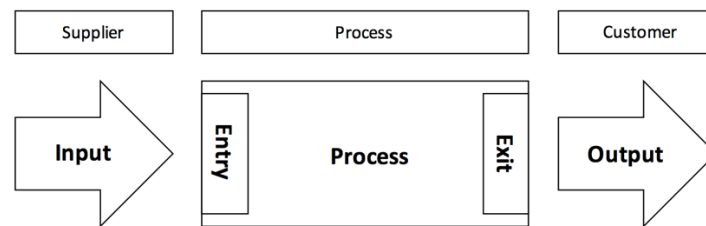

Fig. 10: Process Elements
Source: *Becker T.*, Prozesse in Produktion und Supply Chain optimieren, Second Edition, Springer, 2007, p.7.

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.[30]

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.[31]

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

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.[32]

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[29] *Becker T.*, Prozesse in Produktion und Supply Chain optimieren, Second Edition, Springer, 2007, p. 7-8.
[30] *Becker T.,* Prozesse in Produktion und Supply Chain optimieren, Second Edition, Springer, 2007, p. 20.
[31] *Becker T.,* Prozesse in Produktion und Supply Chain optimieren, Second Edition, Springer, 2007, p. 22.
[32] *Becker T.*, Prozesse in Produktion und Supply Chain optimieren, Second Edition, Springer, 2007, p. 23, 27.

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.[33]

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.[34]

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.[35]

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[33] *Becker T*., Prozesse in Produktion und Supply Chain optimieren, Second Edition, Springer, 2007, p. 28, 29, 30.
[34] *Becker T.,* Prozesse in Produktion und Supply Chain optimieren, Second Edition, Springer, 2007, p. 31.
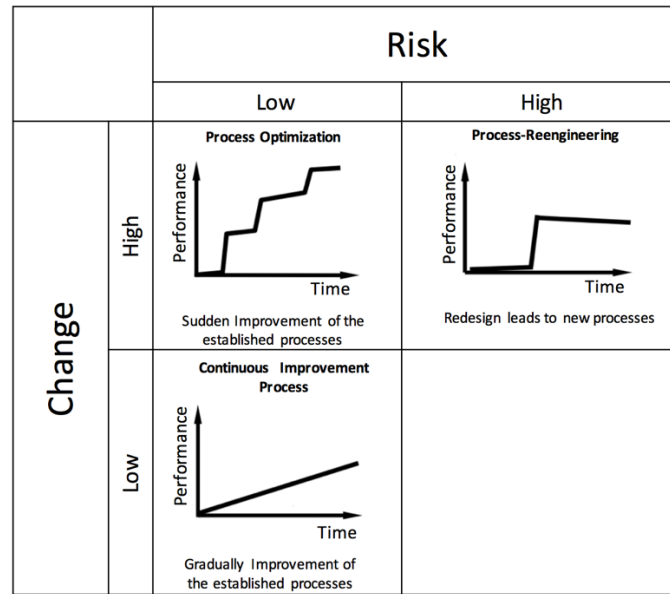[35] *Becker T.,* Prozesse in Produktion und Supply Chain optimieren, Second Edition, Springer, 2007, p. 21.

Fig. 11: Methods for Process Optimization
Source: *Becker T.*, Prozesse in Produktion und Supply Chain optimieren, Second Edition, Springer, 2007, p. 21.

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.[36]

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.[37] 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.[38] 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.

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[36] *Imai M.,* Gemba Kaizen: A Commonsense Approach to a Continuous Improvement Strategy, Second Edition, McGraw Hill, 2012, p. 200-201.

[37] *Institut für angewandte Arbeitswissenschaften e. V. (ifaa)*, 5S als Basis des kontinuierlichen Verbesserungsprozesses, Springer Vieweg, 2016, p. 3.

[38] *Imai M.,* Gemba Kaizen: A Commonsense Approach to a Continuous Improvement Strategy, Second Edition, McGraw Hill, 2012, p. 202.

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

Shitsuke means to develop self-discipline and sustain the first four steps in order to avoid relapsing into one´s old habits.[39]

The following graphic (see Fig. 12) demonstrates, how the five steps stand to each other. It shows that Self-discipline is central and influences each individual step.[40]
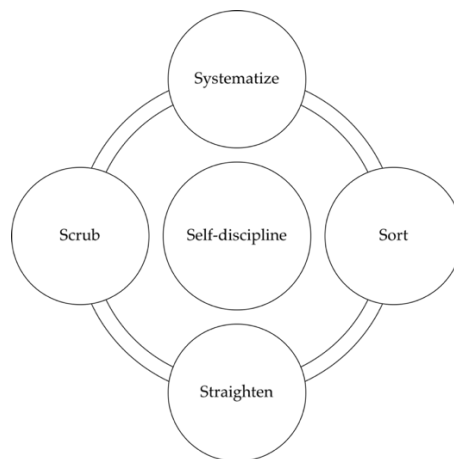

Fig. 12: The five steps of 5S
Source: *Imai M.,* Gemba Kaizen: A Commonsense Approach to a Continuous Improvement Strategy, Second Edition, McGraw Hill, 2012, p. 213.

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.[41] 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.[42]

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[39] *Imai M.,* Gemba Kaizen: A Commonsense Approach to a Continuous Improvement Strategy, Second Edition, McGraw Hill, 2012, p. 203-204.

[40] *Imai M.,* Gemba Kaizen: A Commonsense Approach to a Continuous Improvement Strategy, Second Edition, McGraw Hill, 2012, p. 212.

[41] *Imai M.,* Gemba Kaizen: A Commonsense Approach to a Continuous Improvement Strategy, Second Edition, McGraw Hill, 2012, p. 203.

[42] *Imai M.,* Gemba Kaizen: A Commonsense Approach to a Continuous Improvement Strategy, Second Edition, McGraw Hill, 2012, p. 214.

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.[43] 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 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.[44]

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.[45]

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

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[43] *Institut für angewandte Arbeitswissenschaften e. V. (ifaa)*, 5S als Basis des kontinuierlichen Verbesserungsprozesses, Springer Vieweg, 2016, p. 12.
[44] *Imai M.,* Gemba Kaizen: A Commonsense Approach to a Continuous Improvement Strategy, Second Edition, McGraw Hill, 2012, p. 214-220.
[45] *Imai M.,* Gemba Kaizen: A Commonsense Approach to a Continuous Improvement Strategy, Second Edition, McGraw Hill, 2012, p. 220.

marked clearly for a smooth transit as well as for safety reasons.[46] 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.[47]

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 Fig. 13).

Furthermore, the commitment, support and involvement of management to and in 5S is essential. [48]
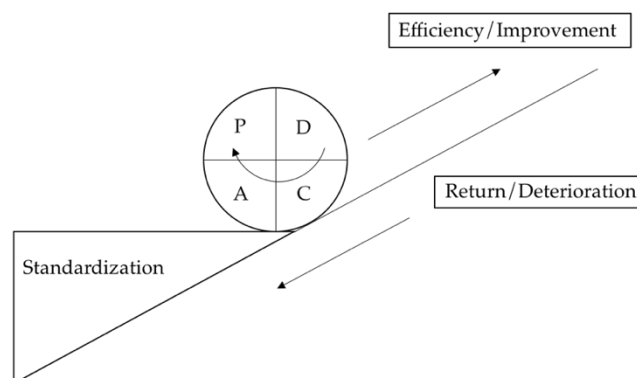
Fig. 13: The Principle of Standardization
Source: *Institut für angewandte Arbeitswissenschaften e. V. (ifaa),* 5S als Basis des kontinuierlichen Verbesserungsprozesses, Springer Vieweg, 2016, p. 21.

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[46] *Imai M.,* Gemba Kaizen: A Commonsense Approach to a Continuous Improvement Strategy, Second Edition, McGraw Hill, 2012, p. 221-223.

[47] *Imai M.,* Gemba Kaizen: A Commonsense Approach to a Continuous Improvement Strategy, Second Edition, McGraw Hill, 2012, p. 224-225.

[48] *Institut für angewandte Arbeitswissenschaften e. V. (ifaa)*, 5S als Basis des kontinuierlichen Verbesserungsprozesses, Springer Vieweg, 2016, p. 21.

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.[49] 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.[50] 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.[51]

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.[52] 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.[53] It is a fact that, who does not even master 5S in daily work, will fail on topics such as CIP and Lean Management.[54] 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

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[49] *Imai M.,* Gemba Kaizen: A Commonsense Approach to a Continuous Improvement Strategy, Second Edition, McGraw Hill, 2012, p. 227.

[50] *Institut für angewandte Arbeitswissenschaften e. V. (ifaa)*, 5S als Basis des kontinuierlichen Verbesserungsprozesses, Springer Vieweg, 2016, p. 47.

[51] *Imai M.,* Gemba Kaizen: A Commonsense Approach to a Continuous Improvement Strategy, Second Edition, McGraw Hill, 2012, p. 229-230.

[52] *Institut für angewandte Arbeitswissenschaften e. V. (ifaa)*, 5S als Basis des kontinuierlichen Verbesserungsprozesses, Springer Vieweg, 2016, p. 1.

[53] *Imai M.,* Gemba Kaizen: A Commonsense Approach to a Continuous Improvement Strategy, Second Edition, McGraw Hill, 2012, p. 231.

[54] *Institut für angewandte Arbeitswissenschaften e. V. (ifaa)*, 5S als Basis des kontinuierlichen Verbesserungsprozesses, Springer Vieweg, 2016, p. 1.

- 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.[55]

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*".[56] 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.[57]

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*".[58] 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 Fig. 14). 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[59]

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[55] *Imai M.,* Gemba Kaizen: A Commonsense Approach to a Continuous Improvement Strategy, Second Edition, McGraw Hill, 2012, p. 231-234.

[56] *Doppler K., Lauterburg C.,* Change Management – Den Unternehmenswandel gestalten, Thirtennth edition, Campus Verlag, 2014, p. 99.

[57] *Doppler K., Lauterburg C.,* Change Management – Den Unternehmenswandel gestalten, Thirtennth edition, Campus Verlag, 2014, p. 93-100.

[58] *Lauer T.,* Change Management – Grundlagen und Erfolgsfaktoren, Second edition, Springer-Verlag, 2014, pos. 446.

[59] *Lauer T.*, Change Management – Grundlagen und Erfolgsfaktoren, Second edition, Springer-Verlag, 2014, pos. 439-541.
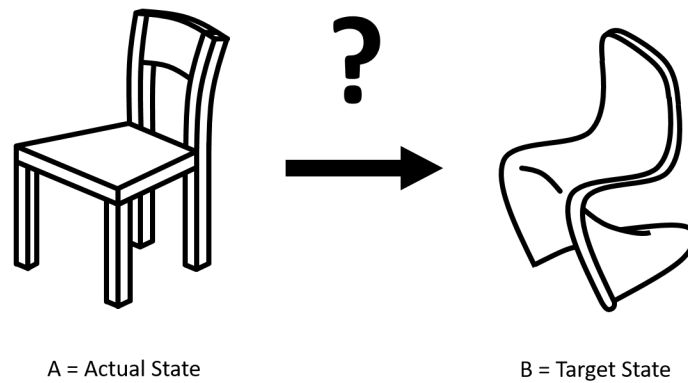
Fig. 14: Change Management as steering change from A to B
Source: *Lauer, T.*, Change Management – Grundlagen und Erfolgsfaktoren, Second edition, Springer-Verlag, 2014, pos. 456.

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*.[60]

2.4.1.1. Roots of Resistance

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.

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[60]*Lauer, T.*, Change Management – Grundlagen und Erfolgsfaktoren, Second edition, Springer-Verlag, 2014, pos. 1279-1290.

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 Fig. 15), which must be overcome to succeed with change efforts.[61]

Fig. 15: Wall of resistance
Source: *Landes, M*., *Steiner, E*., Psychologische Auswirkungen von Change Prozessen – Widerstände, Emotionen, Veränderungsbereitschaft und Implikationen für Führungskräfte, Springer Fachmedien, 2014, p. 12.

2.4.1.2. Shapes of Resistance

Once triggered, the mentioned resistances (see section 2.4.1.1) find their expression in different forms, active or passive and verbal or nonverbal (see Fig. 16).

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[62]

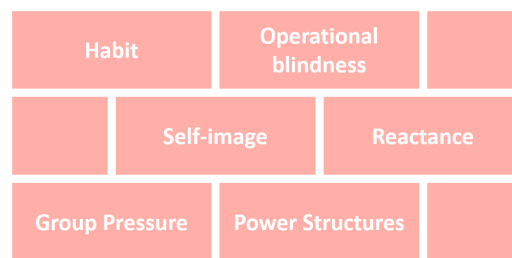[61] *Landes M., Steiner E*., Psychologische Auswirkungen von Change Prozessen – Widerstände, Emotionen, Veränderungsbereitschaft und Implikationen für Führungskräfte, Springer Fachmedien, 2014, p. 4-12.
[62] *Lauer, T., Change Management – Grundlagen und Erfolgsfaktoren*, Second Edition, Springer-Verlag, 2014, pos. 1456-1486.

	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

Fig. 16: Shapes of resistance

Source: *Lauer*, *T*., Change Management – Grundlagen und Erfolgsfaktoren, Second edition, Springer-Verlag, 2014, pos. 1537.

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.[63]

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 Fig. 17). To these three poles, *Linear-Active*, *Multi-Active* and *Reactive*, certain behavioural aspects can be assigned. Following, a narrowed down selection:

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.

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[63] *Lauer T.*, *Change Management – Grundlagen und Erfolgsfaktoren*, Second edition, Springer-Verlag, 2014, pos. 1365-1382.

Fig. 17: The LMR-model

Source: *Lewis, R. D.*, When Cultures Collide – Leading Across Cultures, Third edition, Nicholas Brealey Publishing, 2006, p. 42.

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 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.[64]

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

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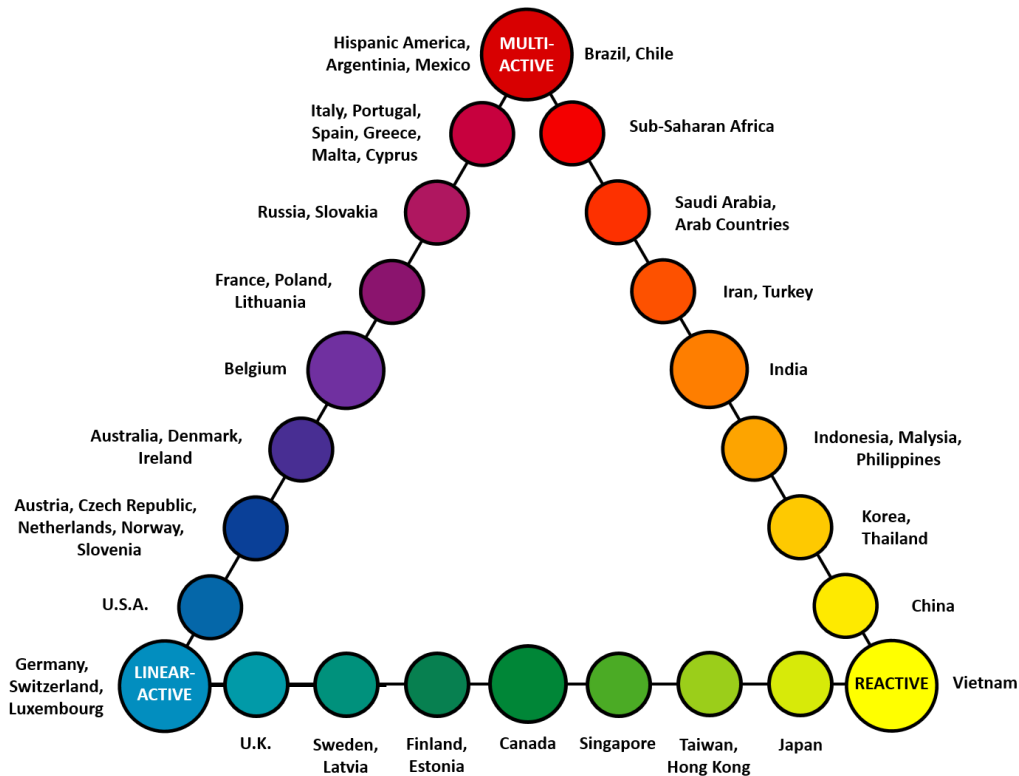[64] *Lewis R. D., When Cultures Collide – Leading Across Cultures*, Third edition, Nicholas Brealey Publishing, 2006, p. 1-97.

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: Notions of change among different culture categories
Source: *Lewis*, *R. D.*, When Cultures Collide – Leading Across Cultures, Third edition, Nicholas Brealey Publishing, 2006, p. 127,128.

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. Fig. 18 illustrates the different patterns of leadership structures in China and Germany.[65]

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[65] *Ascencio C., Rey D.,* Working Successfully with the Chinese Part 1 -Understanding the Chinese Way, InterculturelChine Publishings, 2014, pos. 36-330; *Ascencio C., Rey D.*, Working Successfully with the Chinese Part 2 – How Chinese Work? Chinese Management Practices, InterculturelChine Publishings, 2014, pos. 492-738; *Ascencio C., Rey D.*, Working Successfully with the Chinese Part 3- 7 Best Practices to get the Best from Chinese Teams, InterculturelChine Publishings, 2014, pos. 636-1251; *Lewis, R. D.,* When Cultures Collide – Leading Across Cultures, Third edition, Nicholas Brealey Publishing, 2006, p. 101-103; *Lewis, R. D.*, When
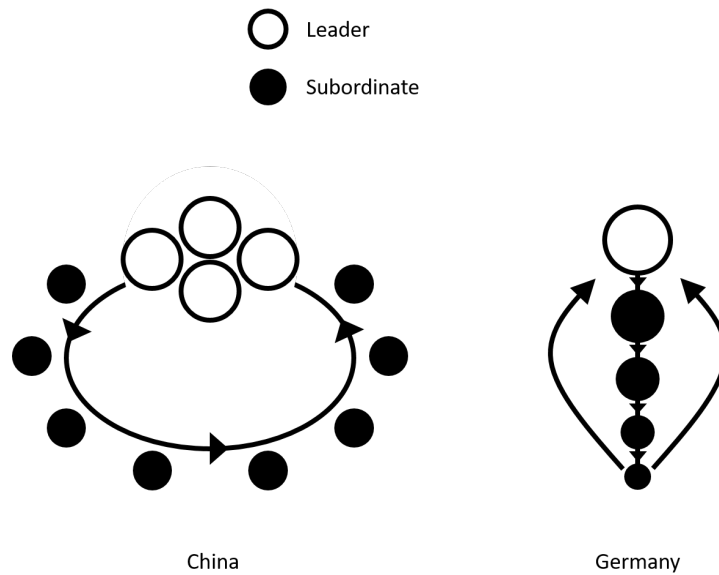
Fig. 18: Leadership and decision making patterns in Germany and China
Source: *Lewis, R. D.,* When Cultures Collide – Leading Across Cultures, Third edition, Nicholas Brealey Publishing, 2006, p. 108, 109.

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.

Teams Collide – Managing the International Team Successfully, First edition, Nicholas Brealey Publishing, 2012, p. 77-103.
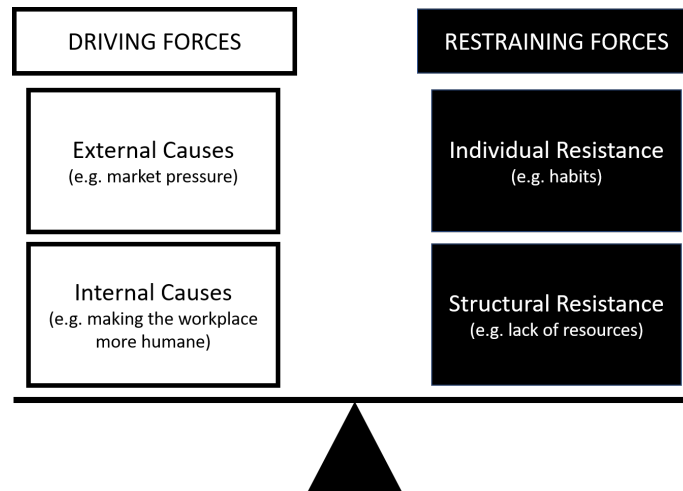
These two types of forces strive for balance (see Fig. 19). If one type of force is dominant, destructive effects may occur. In case the restraining forces are prevailing, the system falls into gridlock or even retrogression. In the other case, if the driving forces outweigh the restraining forces, the 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.[66]

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 Fig. 20).[67]

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[66] *Lauer T.,* Change Management – Grundlagen und Erfolgsfaktoren, Second edition, Springer-Verlag, 2014, pos. 1628-1681.
[67] *Lauer T.,* Change Management – Grundlagen und Erfolgsfaktoren, Second edition, Springer-Verlag, 2014, pos. 1681-1765.

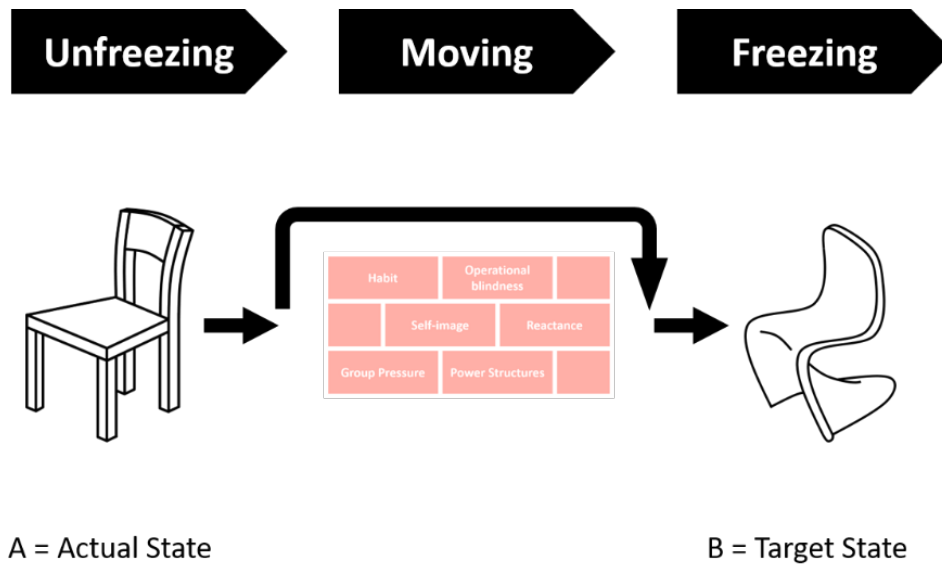A = Actual State   B = Target State

Fig. 20: Process of success of effective change

Source: *Lauer, T.*, Change Management – Grundlagen und Erfolgsfaktoren, Second edition, Springer-Verlag, 2014, pos. 1715.

2.4.4. The Eight-Stage Process

A model that meets all the requirements illustrated in Fig. 20 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.[68] As the name suggests, the eight-stage process for change consists of eight, sequential steps.[69]

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:

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[68] TIME Magazine. 2011: online available: http://content.time.com/time/specials/packages/article/0,28804,2086680_2086683_2087679,00.html, [accessed: 30th of August, 2017].

[69] *Kotter J. P.*, Leading Change, Revised edition with new preface by the author, Harvard Business Review Press, 2012, p. 25-27.

- 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[70]

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 Fig. 21). As Kotter mentions, generations of Managers have been developed over the last decades, leadership skills, on the other hand, were neglected.[71]

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[70] *Kotter J. P.*, Leading Change, Revised edition with new preface by the author, Harvard Business Review Press, 2012, p. 37-52.
[71] *Kotter J. P.*, Leading Change, Revised edition with new preface by the author, Harvard Business Review Press, 2012, p. 53-68.
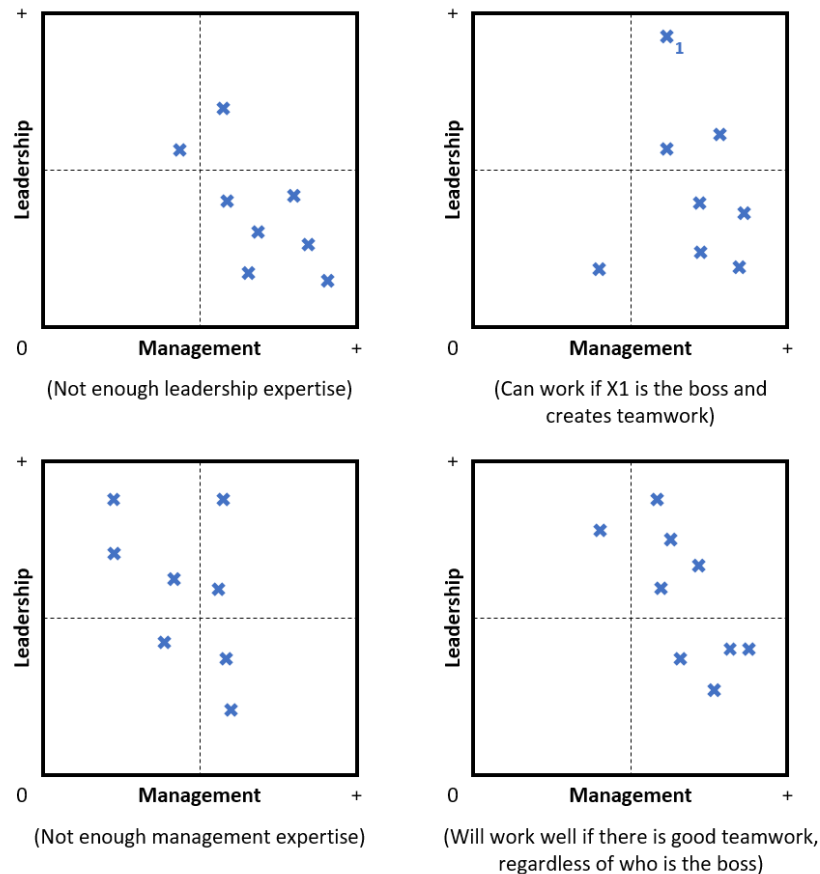
Fig. 21: Profiles of four different guiding coalitions
Source: *Kotter*, *John P*., Leading Change, Revised edition with new preface by the author, Harvard Business Review Press, 2012, p. 60.

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.[72]

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

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[72] *Kotter J. P*., Leading Change, Revised edition with new preface by the author, Harvard Business Review Press, 2012, p. 69-86.

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 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.[73]

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 Fig. 22). 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.[74]
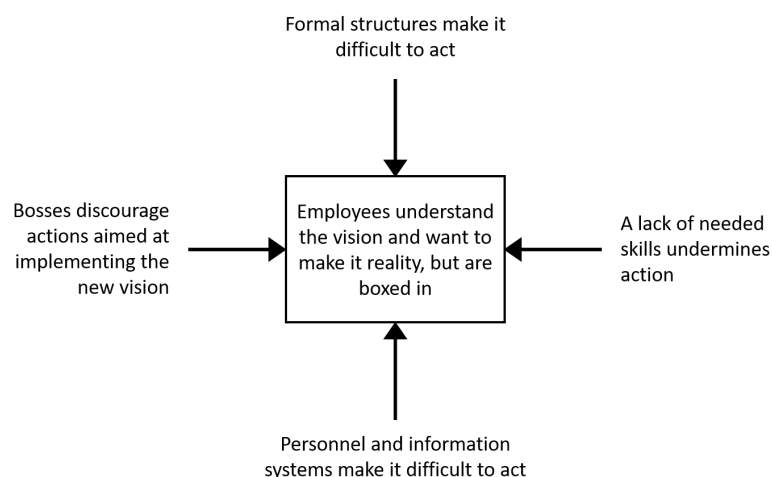
Fig. 22: Barriers to empowerment
Source: *Kotter, John P.*, Leading Change, Revised edition with new preface by the author, Harvard Business Review Press, 2012, p. 106.

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[73] *Kotter J. P.*, Leading Change, Revised edition with new preface by the author, Harvard Business Review Press, 2012, p. 89-103.
[74] *Kotter J. P.*, Leading Change, Revised edition with new preface by the author, Harvard Business Review Press, 2012, p. 105-119.

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.[75]

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[76]

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[75] *Kotter J. P.*, Leading Change, Revised edition with new preface by the author, Harvard Business Review Press, 2012, p. 121-135.
[76] *Kotter J. P.*, Leading Change, Revised edition with new preface by the author, Harvard Business Review Press, 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.[77]

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[77] *Kotter J. P.*, Leading Change, Revised edition with new preface by the author, Harvard Business Review Press, 2012, p. 153-166.

3. CIP in the MD & TF Department

The General Management of AVL STC decided at the beginning of 2016 to implement a CIP in the company. In the course of 2016, the departments started with the introduction of the program accompanied by the Kaizen Institute. The MD & TF department was the last department to start the implementation of the program in October 2016. They did not implement such a program ever before and the experiences of the employees with CI in the daily work was moderate.

This chapter discusses the implementation process of the CIP as well as the executed methods and tools that have been applied through the Researcher to increase the efficiency and working behaviour in the department.

3.1. Introduction & Goals

The official start of the Continuous Improvement Program in the Mechanical Development and Test Factory department was the first meeting with the Kaizen Institute in October 2016. The participants in this meeting were the SKTL, the TL, the CIP coordinator, the Leader of the KO, the Researcher and the Lead consultant of the Kaizen Institute.

The Lead consultant started with an Awareness Training and explained the philosophy of CIP. After the training, the participants got an introduction of the Kaizen rules, the identification of waste, process mapping, 5S, Visual Management and Daily Kaizen.

The objective of the first meeting was to find an approach for the implementation of CIP in the MD & TF department. As a result, the Lead Consultant, the coordinator, the leader of the KO and the Researcher decided to execute the CIP on five main topics (see Fig. 23).
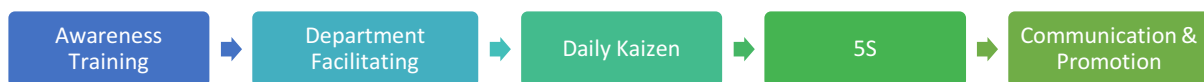
Fig. 23: CIP Phases

These five steps consist of various methods and tools that will be applied during the implementation of the CIP. This meeting was also the starting point for the Researcher in the MD & TF department at STC. The Researcher's tasks and objectives have been clarified with the General Manager of STC and the head of the Kaizen office. The Researcher is responsible for the mentoring, implementation and assessment of the outcoming actions from the CIP meetings, as well as the introduction of CI tools and methods in the MD & TF department. The role of the Researcher in the department is as follows:
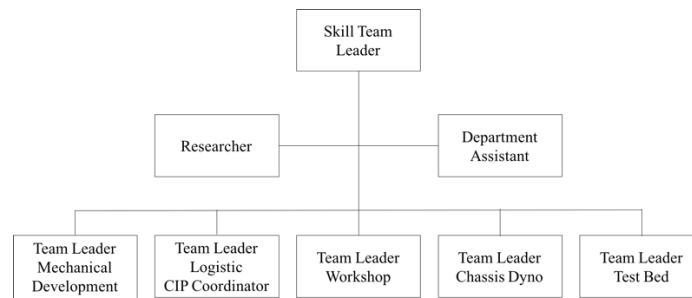
Fig. 24: Department structure

The Researcher is not subordinated to any team and has an independent role within the department. The TL of the logistics is the CIP coordinator and therefore in close cooperation with the Researcher. In addition, the coordinator supports the Researcher with translations from English into Chinese because some engineers and mechanics do not speak English.

In later chapters, cost savings of various CIP Actions are discussed. The amount is declared in the Chinese currency "Renminbi RMB". For a better understanding: The current exchange rate between "Euro" and "RMB" is 7,8123 RMB (date: 01.09.2017).

The implementation of CIP in the department starts by the Awareness Training, which constitutes an important role in the program.

3.2. Awareness Training

The awareness training is a very important part of the implementation of CIP. For many employees, it was their first experience of a Continuous Improvement program at STC. Hence, it was important that the execution of the training was clear and comprehensible for the employees.

The MD & TF department has more than sixty employees, therefore the Researcher and the TL decided to divide the department in six different teams. Firstly, to guarantee the maintenance of the daily business and secondly, to ensure that the training can be executed in small teams. Every team obtained a detailed introduction of CIP and was confronted with the questions "What is CIP?" and "Why do we implement CIP?". The content of the Awareness training was as follows:
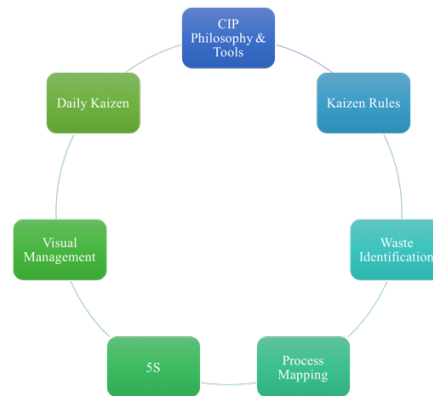
Fig. 25: Awareness Training Content

The Awareness Training is a recurring task and must be implemented depending on the situation. Together with the CIP coordinator, the Researcher frequently executed the awareness training in the department to ensure that every employee understands the CIP. In addition, they were informed about the further strategy.

3.3. Process Optimization in the MD & TF Department

The generation of actions is necessary to continue the CIP in the department. "Actions" can be defined as activities to improve the efficiency of processes and to reduce waste. With successfully accomplished actions, money can be saved and the work behaviour of employees can be increased.

For this purpose, the SKTL, the TL, the coordinator, the Researcher and the Lead consultant executed process mapping to generate some actions. The focus was therefore on the mechanical engine development process, which is the main task of the MD & TF department. The complete work process (see Fig. 26) was outlined by the TL to discuss where actions should be set to increase the efficiency and to reduce effort. The following figure describes the process and the interfaces to other departments. After that, the single process steps will be described.
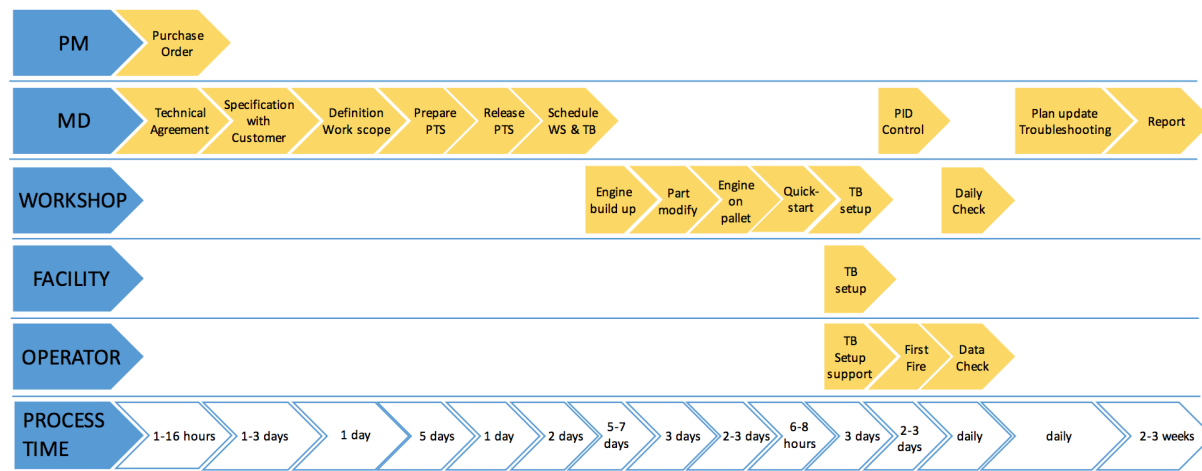
Fig. 26: Work Process of the MD & TF department

The first step of the process is the Purchase order from the Project Management department. The PM department defines a contract with the customer and determines the requirements. At the same time, the MD engineers specify the technical agreement that is a part of the contract. The technical agreement defines the target and stipulates what kind of tests are necessary to fulfil the customer requirements. After a detailed discussion with the customer and confirmation of both sides, the engineers can precise the work scope. The work scope is part of the technical agreement and includes various design phases as well as different fields of development (e.g. performance and emission, mechanical, durability and engine calibration).

The next step is the preparation of the PTS (Powertrain Test Specification). The PTS is the most important part for the engineers during a project at STC. All information concerning the development and testing of an engine is comprised by the PTS. It contains the basic project data, the test concept, the limit monitoring, information about the engine and the operating media, as well as details about the equipment such as load unit, intake turbo, exhaust, fuel, coolant and so on. The preparation and release of the PTS is a key role where the project managers, MD engineers, Workshop team, Facility department and operators are involved. Following approval, the schedule for the Workshop Team and the test bed are being prepared. Then, the Workshop team can start with the engine build up and part modification for the installation of the engine on the pallet. After a successful quick start, the engine is brought into the test bed for further setups. In the test bed, the Workshop and Facility team starts with the mounting of the test equipment and sensors. The operators support the teams in the test bed during the installation of the engine. The next step includes the first fire of the engine and the check of leaks, the engine behaviour, the alarm system and the measurement channels. After the conformation of the engineer and operator, the test bed is being released for development and testing. The operator and engineer perform the test according to plan and the Workshop team makes a daily check on the test bed. During and after the tests, the engineer does the plan update, troubleshooting and meetings with the customer. Finally, the mechanical development engineer prepares the report and the evaluation and assessment of the development and test results.

3.4. Generation of Actions

On the basis of the process mapping, the SKTL, the TL and the Researcher defined some actions to increase the efficiency and the work behaviour. The whole process was plotted on the whiteboard and the participants had the task to write down some actions on post-its and stick them to the specified process steps. The participants brought valuable ideas on how to improve the several process steps. In total, the team created eight actions that were very helpful to achieve the defined target.

No.	Action List	Owner
1	Set up procedure for special tools management	Logistics
2	Preparation of engine build up lesson learned summary	Workshop
3	Review and double check critical pages of the PTS	Mechanical Dev.
4	Set up and release internal part application procedure	Logistics
5	Create easy-understanding operation manual for Operator training	Operator
6	Create customer parts receiving procedure	Logistics
7	Guarantee Engineers to apply latest procedure	Skill Team Leader
8	Prototype Warehouse 5S	Logistics

Table 3: Action List

The next step was to divide the actions in various loops. The head of the Kaizen office decided that in the first loop, there should be three actions that are easy to implement and that have a high impact on the daily operations. Therefore, the SKTL selected Actions No. 1 "Set up procedure for special tools management", No. 3 "Review and double check critical pages of the PTS" and No. 7 "Guarantee Engineers to apply latest procedure" for the first loop.

A loop is a framework that includes all chosen actions in a defined schedule. The loop gives the opportunity to divide the actions in various sub-actions, which leads to a precise tracking of them. The first loop had a timeframe from 16 November to 15 December 2016.

3.5. Action Plan

Every action will be described in an Action Plan, which includes the description of the action, a detailed Plan phase, a Doing and Checking phase and an Act part. This phases will be mentioned in the following as "Plan", "Do", "Check" and "Act".

In total, eighteen actions were carried out during the CIP. These actions were divided in four loops which were carried out consecutively.

By introducing every single action in the following chapter, a description of the action will be given initially. Then, the several phases that apply for each action will be demonstrated. This should provide a better overview and supervision of the several actions in the department.

3.5.1.Description

The description defines the initial situation and the reason why the implementation of the action is necessary. The Researcher had to understand the root cause of the problem because he was responsible for the schedule and the tracking of the actions. Additionally, the Researcher was involved in the execution of the most actions and had to provide the presentation of the achievements for the management meeting.

3.5.2.Plan

For a better understanding and tracking, the Researcher divided every action in various sub-actions. The responsible engineer and the Researcher agreed on the different steps, but sometimes it was not easy to find the right solution and it took time to define those steps. After the definition achieved, every step was assigned a due date for its implementation, which supported also the tracking of the action.

3.5.3.Do & Check

This phase helped the Researcher with the verification of the sub-actions. It was necessary that the responsible engineer executed every single step on time. In this way, the Researcher had the overview and was able to check the results and if the implementation was on time or delayed.

3.5.4.Act

The Act phase described the new standard of the procedure. The actions have an impact on various processes and this phase explained the new approach as well as the benefit on the daily work. The new standard was not put down and could be improved every time depending on the situation through the implementation of a new action.

3.5.5.Savings Calculation

Basically, all actions were implemented to increase the efficiency and working behaviour of the daily work. In some cases, it was possible to calculate the cost savings through the implementation of the action. The SKTL and the Researcher were responsible for the calculation of the cost savings and tried to reach satisfactory results.

3.6. 1ˢᵗ CIP Loop for the MD & TF Department

The period of the first loop was between 16 November to 15 December 2016. For the department, it was the first contact with such a CIP method. Therefore, management decided to select three actions from the Action List that were easy to implement in practice.

Action 1-1: Set up procedure for special tools management

Action 1-2: Review and double check critical pages of the PTS

Action 1-3: Guarantee Engineers to apply latest procedure

3.6.1. Action 1-1: "Setup procedure for special tools Management"

Action 1-1:	Set up procedure for special tool Management
Team:	Logistics
Name:	Xu Heping/Lucas Wartscher
Timeframe:	16.11.2016 - 15.12.2016

3.6.1.1. Description

The installation of the engine on the test bed and the performance of the requirements of the test cycles required some special equipment. Different teams such as operators, Dev. & Cal. engineers, mechanics and MD engineers use this special equipment for their daily work. This equipment is expensive and stored in six lockable cabinets located in the measurement room. Every item has a serial number and is registered in a list, but the current inventory had not been updated. That means that the amount of items in the list was not equal to the amount of items in the cabinets.

Furthermore, the tools and devices had no defined area and no location number what makes it difficult to find them.

The TL of the logistics team is responsible for the special equipment and is the key holder of the cabinets. In the case that the employees need some tools, the logistics TL has to unlock the cabinets and provide the tools. So far, the tools and devices were dispensed without documentation, what led to the fact that nobody knew what equipment was distributed.

3.6.1.2. Plan

Action 1-1 was implemented to solve the issues with the special equipment. Firstly, the cabinets, the layers and the boxes got a location number and a signage; thus, the equipment had a defined location. Secondly, the equipment list was updated, which means that from now on, every tool and device was registered correctly. The next step was the generation of a registration form. The form consists of nine columns, which are divided in *tool description*, *serial number*, *tool location*, *borrower name*, *project*

number, *use place*, *borrow date*, *expected return date* and *actual return date*. The last step was to inform the employees about the new standard.

PLAN				DO & CHECK						
				Nov-16			Dec-16			
Action 1-1: Set up procedure for special tool management				47	48	49	50	51	52	53
No.	**Sub actions**	**Expected Results**	**Due Date**	14	21	28	05	12	19	26
1	Define area, location number	Signage	21.11.16		✓					
2	Make the completed tools list	Updated Tool lists	28.11.16			✕				
3	Generate a template	Registration Form	05.12.16				✓			
4	Inform engineers/managers/mechanics	Meeting & Mail	12.12.16					✓		

Fig. 27: Action 1-1

3.6.1.3. Do & Check

The Leader of the logistics team Xu Heping and the Researcher were responsible for the implementation of the action. Sub-actions 1, 3 and 4 have been executed on time but Sub-action 2 was delayed for two reasons. Firstly, the Logistics' field was established in summer 2016 and the TL was engaged with the development of the team. Secondly, the condition of the cabinets was not good and it took a lot of time to add the equipment to the recording list. The Researcher supported Xu Heping during the execution of the first and second sub-action and created the third sub-action by his own. With a one-week delay, the list was updated and the employees were informed about the new procedure.

3.6.1.4. Act

If an employee needs a special equipment, the new standard stipulates the following procedure. The first step is to look into the tool list and to check where the tool is located. Next, the employee needs to get the key from the key holder and take the tool from the cabinet. Afterwards, the employee needs to bring back the key and fill out the registration form.

This procedure helps to make the dealing with special equipment manageable and transparent. In addition, the cabinets need to be in a good condition since from that moment on, every item has a specified location. Furthermore, the implementation of this action increases the efficiency, reduces search time and improves the working behaviour.

3.6.1.5. Savings Calculation

No financial benefit is gained from Action 1-1. It serves to improve the daily work behaviour for employees. The saving of costs is not calculable.

3.6.2. Action 1-2: "Review and double check critical pages of the PTS"

Action 1-2:	Review and double check critical pages of the PTS
Team:	Mechanical Development
Name:	Hu Junwei
Timeframe:	16.11.2016 - 15.12.2016

3.6.2.1. Description

The PTS is one of the most important documents in a project. The MD engineer has an essential role by the preparation of the document. The engineer is responsible for the draft of the PTS and is the interface between the PM department, Customer, Facility department, Workshop, Warehouse, Logistics and MD team based in Graz. The information about the project plan and the contract derives from the PM department. The customer provides the engine specification, part lists, assembly and operation manual, maintenance plan and specific requirements.

3.6.2.2. Plan

The PTS is a document with a lot of information about the project. Action 1-2 was implemented to define the most important pages that have to be checked by a Senior MD engineer to avoid critical mistakes. The Leader of the MD team, Hu Junwei defined the pages "Limit Monitoring" and "Parts Engine" as very important.

The "Limit Monitoring" page includes the cold run definitions and the standard limits of an engine during the test. The standard limits are defined by an upper and a lower level. If one of the values is not in the range between the levels, the engine stops or skips into the cold run mode. This page is essential and must be checked by a senior; if one of the limits has the wrong value settings, the engine or the test bed could be damaged.

The other page concerns the Engine Parts and Operating Media. This part includes information about the engine type, auxiliary unit, the intake and exhaust system as well as the fuel unit and the coolant system. Together, these systems and units have a significant influence on the work on the test bed. Therefore, a specialist has to check the data of this page before starting the development and test process.

PLAN				DO & CHECK						
Action 1-2: Review and double check critical pages of the PTS				Nov-16			Dec-16			
				47	48	49	50	51	52	53
No.	**Sub actions**	**Expected Results**	**Due Date**	14	21	28	05	12	19	26
1	Define important parts of the PTS	Power Point Slides	28.11.16			✓				
2	Inform engineers after definition	Meeting & Mail	05.12.16				✓			

Fig. 28: Action 1-2

3.6.2.3. Do & Check

Action 1-2 was implemented immediately because this topic has a direct impact on the successful execution of the project. The responsible engineer Hu Junwei implemented the action on time without any delay.

3.6.2.4. Act

The new standard provides improvements in safety requirements and troubleshooting. In addition, the procedure supports the internal training material for inexperienced employees to avoid mistakes.

3.6.2.5. Saving Calculation

The achieved cost savings of Action 1-2 comply with the situation in which an engine or other mechanical equipment on the test bed gets broken. The costs of a broken engine on the test bed is about 350.000 RMB.

3.6.3. Action 1-3: "Guarantee Engineers to apply latest procedure"

Action 1-3:	Guarantee Engineers to apply latest procedure
Team:	Skill Team Leader
Name:	Andrea Pagnini
Timeframe:	16.11.2016 - 15.12.2016

3.6.3.1. Description

AVL develops periodically updated test procedures to meet the highest standards. Therefore, the AVL iCAE server is installed to share the latest procedures with the Technical centres worldwide. Only the SKTL has access to the server and is responsible to provide the present procedures to the engineers. To ensure that the engineers use the latest procedure, the SKTL has to update the files before starting a new project.

3.6.3.2. Plan

Action 1-3 was divided in two sub-actions. First, the responsible engineer Andrea Pagnini defined a request procedure to ensure that the engineers have the latest information before starting a new project. Second, the responsible engineer communicates to the other engineers that the procedure was updated. So the engineers are fully aware that they have access to the latest information before starting a new project.

PLAN			DO & CHECK						
Action 1-3: Guarantee engineers to apply latest procedure			Nov-16			Dec-16			
			47	48	49	50	51	52	53
No.	Sub actions	Expected Results	**Due Date**	14	21	28	05	12	19	26
1	Define a request procedure before start of the test	Folder on the server	28.11.16			✓				
2	Communicate to the engineers after definition	Meeting & Mail	05.12.16				✓			

Fig. 29: Action 1-3

3.6.3.3. Do & Check

Action 1-3 was successfully implemented by the SKTL. The sub-actions were done on time without any delays.

3.6.3.4. Act

The latest procedure is filed in a folder on the MD & TF server. Every engineer has now access to the server and is authorized to download the procedure. The impact of this action is high for the daily work of the engineers because it secures that they use the latest procedure before starting every new project. Concerning this standard, there are no further actions necessary.

3.6.3.5. Savings Calculation

Action 1-3 has no direct impact on cost savings. The implementation of the action ensures that the employees use the best available service for the customers, but a calculation of the cost savings is not feasible.

3.6.4. Conclusion of the 1st CIP Loop for the MD & TF Department

The first loop was executed successfully, and all actions were implemented on time. Only in Action 1-1, some problems occurred with the sub-actions, but still, the action was done within the schedule of the

loop. For many employees, this procedure was the first contact with a CIP method and at the beginning, some were sceptical of the new method. For this reason, management decided to start by actions that did not require too much effort in their implementation. The standards that were set increased the efficiency and the working behaviour tremendously. As a result, the employees were able to comprehend that the implementation of this CIP method improved their daily work. Finally, the MD & TF department reached cost savings of about 350.000RMB which was certainly a pleasing aspect for the top management. Management was satisfied with the result and was looking forward to the performances of the second loop.

3.7. 2nd CIP Loop for the MD & TF Department

After the successful execution of the first loop without any major difficulties, management decided to include the rest of the actions from the initial process mapping into the second loop. The time frame for this loop was from the 20th of December 2016 to the 20th of February 2017. The second loop consists of five actions, which are as follows:

Action 2-1: Prepare engine build up lesson learned summary

Action 2-2: Set up and release internal part application procedure

Action 2-3: Create easy understanding operation manual for operating training

Action 2-4: Create customer parts receiving procedure

Action 2-5: Customer parts Warehouse 5S

3.7.1. Action 2-1: "Prepare engine build up Lesson learned summary"

Action 2-1:	Prepare engine build up Lesson learned summary
Team:	Workshop
Name:	Heng Yang
Timeframe:	20.12.2016 - 20.2.2017

3.7.1.1. Description

In some cases, and depending on the project, the Workshop team is confronted with the task to build up a new engine at the first time at STC. Therefore, problems may occur, such as too less information in the assembly manuals, missing data of torque strengths, or wrong information about the camshaft timing, just to name a few. To avoid that the same problems arise again with every new engine build up, "Lesson learned summary" should be implemented for the documentation of every single step during the first engine build up. In case that the same new engine has to be built up again, the summary provides the information that the engineers need for a successful engine build up.

3.7.1.2. Plan

The first step was to find a process to collect and share the information about a new engine during the build up phase. After the definition of the process, the responsible engineer of the action created a Power Point presentation for collecting the information. Finally, the engineers of the workshop were informed about the new procedure of dealing with a new engine at STC.

PLAN				DO & CHECK										
Action 2-1: Prepare engine build up lesson learned summary				Dec-16		Jan-17					Feb-17			
				52	53	1	2	3	4	5	6	7	8	9
No.	Sub actions	Expected Results	Due Date	19	26	02	09	16	23	30	06	13	20	27
1	Finding a process to collect/share the information	Process	30.01.17							✕				
2	Preparation of a ppt to save the information	Power Point	06.02.17								✓			
3	Inform employees about the new summary	Meeting	13.02.17									✓		

Fig. 30: Action 2-1

3.7.1.3. Do & Check

Due to a high capacity utilization of the Workshop team, the responsible engineer was too busy and had no time to execute the action during the normal working hours. The engineer had to work on weekends to implement the action on time. Due to this, a demotivation against CIP occurred in the department. The Researcher discovered this development and set up a meeting to discuss the issue. This problem led to the delay of the first sub-action. At the meeting, the Researcher communicated the goals of CIP again and explained that CIP does result in an increase of workload. It should rather help to simplify the daily work on a step by step basis. After the meeting, the engineer understood the meaning of CIP and organized the daily work in a way to have enough time for the CIP during the regular working hours. Due to this meeting and clarification, the second and the third sub-action could be done without any problems or delays.

3.7.1.4. Act

The new standard ensures that, if a new engine is built up the first time at AVL STC, the engineers have to document every single step. The TL allocates Power Point slides to collect information (e.g. notes and pictures) about the engine build up. The slides are stored on the MD & TF server and are accessible for every engineer.

3.7.1.5. Savings Calculation

The cost savings were calculated in consultation with the SKTL and the Researcher. In the case of a new project, the result is as follows: Through the new procedure, the mechanics save two weeks of time in building up the engine. Further, two workdays of a Project Manager and four workdays of an engineer can be saved for various reasons, such as meetings with customers or support of the workshop. In total, the cost savings are about 65.000 RMB each time the "Lesson learned summary" is used.

3.7.2. Action 2-2: "Set up and release internal part application procedure"

Action 2-2:	Set up and release internal part application procedure
Team:	Logistics
Name:	Xu Heping/Andrea Pagnini
Timeframe:	20.12.2016 - 20.2.2017

3.7.2.1. Description

Action 2-2 dealt with the implementation of the prototype part logistics procedure. The objective was the standardization of the management process, including the receiving, storage, distribution and disposition of prototype parts. Based on the procedure, it was possible to monitor the inventory accuracy and to protect the customer property.

3.7.2.2. Plan

The action was divided in three sub-actions and conducted by the Leader of the Logistics team. The first step was the generation of an application record. After that, a distribution record was generated. Finally, a shortage alert was set up.

	PLAN			DO & CHECK									
	Action 2-2: Set up and release internal part application procedure			Dec-16		Jan-17					Feb-17		
				52	53	1	2	3	4	5	6	7	8	9
No.	**Sub actions**	**Expected Results**	**Due Date**	19	26	02	09	16	23	30	06	13	20	27
1	Generation of an application record	Document	09.01.17				✓							
2	Generation of a distribution record	Document	16.01.17					✓						
3	Set up shortage alarm	Procedure	06.02.17							✓				

Fig. 31: Action 2-2

3.7.2.3. Do & Check

Each of the three sub-actions required three weeks of time for its implementation. The responsible employee did a good job and each sub-action was completed in time. In addition, the SKTL checked the results himself because the procedure was of importance for the department.

3.7.2.4. Act

The procedure was saved as a document on the MD & TF server and every engineer has now access to the document. Furthermore, everyone at STC who is handling prototype parts has to follow the new procedure. In addition, the new standard is applicable for all kind of prototype parts at STC.

3.7.2.5. Savings Calculation

Through the implementation of the procedure, the Logistics team carried out a new organization of the warehouse. Therefore, the searching time of the forklift driver and the waiting time of the operators and engineers could be reduced. The calculated cost savings per year are about 463.000 RMB.

3.7.2.6. Action 2-3: "Create easy understanding operation manual for Operator training"

Action 2-3:	Create easy understanding operation manual for Operator training
Team:	Test Bed
Name:	Li Wei
Timeframe:	20.12.2016 - 20.2.2017

3.7.2.7. Description

The command of the PUMA Operation System is an essential skill for all operators at STC. The system is a Test Bed Automation System and includes all operations that are needed to work on the test bed. Such operations are the manual and automatic control of the test bed, the regulation of the test bed services (e.g. climate, ventilation) and the controlling and regulating of rotation speed, torque and fuel consumption. Action 2-3 was implemented to provide training materials for newcomers to learn the PUMA System by themselves.

3.7.2.8. Plan

The Leader of the Test Bed team was responsible for the implementation of the action. In the first step, the engineer defined the important parts of the PUMA System. Subsequently the training material was prepared and saved on the MD & TF server. In addition, training material was prepared including information about the Test Bed Safety, the recorder and the PUC, which are also important systems for operators.

PLAN			DO & CHECK										
Action 2-3: Create easy understanding operation manual for operator training			Dec-16		Jan-17					Feb-17			
			52	53	1	2	3	4	5	6	7	8	9
No.	**Sub actions**	**Expected Results**	**Due Date**	19	26	02	09	16	23	30	06	13	20	27
1	Define important parts for newcomers	Document	09.01.17				✓							
2	Preparation of training materials	Document	06.02.17								✕			
3	Information about the procedure to the engineers	Meeting/Mail	20.02.17										✓	

Fig. 32: Action 2-3

3.7.2.9. Do & Check

The responsible engineer received a lot of time for carrying out the sub-actions on time, because the PUMA operation manual is very extensive. The definition and the preparation of the training material was time consuming. The implementation of the action required experience, and only the Leader of the Test Bed team could accomplish this task successfully. The operators work in two shifts, early and late shift, and the TL works at the late shift. Furthermore, the TL has a lot of organizational work to do and it was therefore difficult for the Researcher to find time to track the sub-actions. In case of further actions, the TL and the Researcher decided to discuss at the beginning of the late shift the pending tasks related to CIP.

3.7.2.10. Act

The new standard includes training material for the Test Bed Safety, PUMA Operation System, Recorder and the PUC. Related to the fact that the operators are working in two shifts and do not have enough time for the training of newcomers, the material supports the daily work in a high degree.

3.7.2.11. Savings Calculation

It was calculated that through the implementation of Action 2-3, the work of one day on the test bed could be saved. Furthermore, the working hours of one day of an operator and an engineer could also be saved, which means that the saving costs are about 65.000 RMB for each newcomer to be trained.

3.7.3. Action 2-4: "Create customer parts receiving procedure"

Action 2-4:	Create customer parts receiving procedure
Team:	Logistics
Name:	Xu Heping
Timeframe:	20.12.2016 - 20.2.2017

3.7.3.1. Description

Action 2-4 is about the identification of engine parts and components for projects. Many engine parts and components are used at STC and sometimes it is not clear if certain parts can be used for testing actions. Therefore, a new procedure is implemented that supports the engineers in the differentiation of the parts and components. The following three different states are defined in the company:

- If the part has a red label, it is prohibited to use it.
- A yellow label stands for an unclear situation and only after a consultation or depending on the condition, the part can be used or not.
- No label means the part is good and can be used.

3.7.3.2. Plan

The action was divided into three subsequent sub-actions: First, an identification of the correct contacts and the clarification with the engineers about the new procedure. A similar procedure was already implemented but did not work out well, therefore the engineer updated the old procedure and implemented a new one. The last step is the release from the SKTL of the new procedure.

PLAN				DO & CHECK										
				Dec-16		Jan-17					Feb-17			
Action 2-4: Create customer parts receiving procedure				52	53	1	2	3	4	5	6	7	8	9
No.	Sub actions	Expected Results	Due Date	19	26	02	09	16	23	30	06	13	20	27
1	Identification of the right contacts	Meeting/Mail	02.01.17			✓								
2	Procedure review and update	Document	09.01.17				✕	■						
3	Procedure release	Document	25.01.17							✓				

Fig. 33: Action 2-4

3.7.3.3. Do & Check

The fact that a similar procedure existed already before starting Action 2-4 made the implementation easier. The second sub-action was delayed for one week because a meeting with a specialist of the QM department was necessary. The third sub-action is about the checking and the release of the new procedure by the SKTL.

3.7.3.4. Act

After the execution of Action 2-4, the new standard was implemented at STC. The red or yellow labels could be attached on the part itself or right on the boxes were they are stored. The new procedure supports the engineers at the selection of the engine parts or components and reduces searching time.

3.7.3.5. Saving Calculations

The implementation of the procedure supports the engineers in their daily work for two reasons. Firstly, the engineers can be sure to use the right parts or components; therefore, the time to clarifying the identification of the parts becomes redundant. The cost savings due to the action is about 125.000 RMB per year.

3.7.4. Action 2-5: "Customer parts Warehouse 5S"

Action 2-5:	Customer parts Warehouse 5S
Team:	Logistics
Name:	Xu Heping/Lucas Wartscher
Timeframe:	20.12.2016 - 20.2.2017

3.7.4.1. Description

The introduction of the Logistics team at STC in the year 2016 was the start of a new organization of the storage system. Action 2-5 was implemented to execute 5S at the customer parts Warehouses 1 and 2. "Warehouse 1" stores oils, reused parts and test bed pallets, "Warehouse 2" stores project engines and parts. The location of the items in the warehouses was not clearly defined, and there were no records for incoming and outgoing goods or any store type planning. This action is linked to Action 2-4 because it deals with the handling of engine parts and components.

3.7.4.2. Plan

The first sub-action was to set up store type regulations, which include a reorganization of the warehouse. The next step was to define the new locations of the goods. After the implementation of the first and the second sub-action, the responsible engineer and the Researcher conducted an audit related to 5S. The results of this audit were analysed and (where necessary) subject to some modifications.

PLAN			DO & CHECK										
Action 2-5: Customer parts warehouse 5S			Dec-16		Jan-17					Feb-17			
			52	53	1	2	3	4	5	6	7	8	9
No.	**Sub actions**	**Expected Results**	**Due Date**	19	26	02	09	16	23	30	06	13	20	27
1	Set up store type regulations	Document	02.01.17			✓								
2	Definition of the locations	Document	09.01.17				✓							
3	5S Audit	Document	25.01.17									✓		
4	Analysis of the 5S audit	Presentation	25.01.17										✓	

Fig. 34: Action 2-5

3.7.4.3. Do & Check

The action was executed by the Leader of the Logistics team and the Researcher. For the implementation of Sub-action 1 & 2, the logistics engineer was responsible. No problems or delays occurred during the execution. Sub-action 3 & 4 were done at the end of Loop 2 because of time schedule reasons of the Researcher.

3.7.4.4. Act

The new structure of the Warehouses 1 and 2 has a high impact on the storage system of STC. From now on, all prototype parts are stored in Warehouse 2 and the oil barrels are stored in Warehouse 1. The benefit of this action was the placement of all parts that need a registration form in Warehouse 2. In the future, an employee of the Logistics team assigned to take care of the registration in Warehouse 2. Furthermore, the infrastructure of Warehouse 1 is more suitable for the handling with oil and pallets.

3.7.4.5. Savings Calculation

The cost savings of this action are related to Action 2-4, which means that the calculated savings of Action 2-4 also apply to this action.

3.7.5. Conclusion of the 2nd CIP Loop for the MD & TF Department

Due to the successful execution of the first loop, management decided to put the remaining actions of the process mapping into the second loop. This approach was an optimistic but also realistic objective because most of the employees had no experience with a CIP. The coordinator and the Researcher executed the awareness training to prepare the employees for the upcoming situation. The result of the second loop was highly satisfactory. Only some sub-actions were delayed but in total all actions were implemented in time. At the end of the second loop, the Researcher had a meeting with General Management about the achievements of the loop and the forecast for the third loop. In total, the

department reached cost savings of about 463.000 RMB per year and 215.000 RMB each time depending on the project that holds the highest value of all departments.

3.8. 3rd CIP Loop for the MD & TF Department

The schedule of the third loop was from the 1 March to the 28 April 2017. The loop included five actions that were related to four teams of the MD & TF department. Due to the fact that all actions from the process mapping have been implemented, the Researcher decided to generate the actions for the third loop by means of the Daily Kaizen board. The Daily Kaizen board is a useful method in the implementation of CIP and will be discussed in more detail at Chapter 3.10.

3.8.1. Action 3-1: "Storage of the customized wooden boxes of each engine"

Action 3-1:	Storage of the customized wooden boxes of each engine
Team:	Logistics
Name:	Xu Heping
Timeframe:	01.03.2017 - 28.04.2017

3.8.1.1. Description

The customer's engines are delivered as sea freight, air freight or road freight. To protect the engine against any damages through transport, the goods are packed in wooden boxes. After the delivery to STC, the employees dispose the boxes in the rubbish heap. The engine will be sent back to the customer after the test cycle and STC has to organize new boxes for the delivery. This issue led to high costs that can be avoided easily.

3.8.1.2. Plan

The action was divided in three sub-actions, which are the following. Firstly, the implementation of a decision-making tool to help decide if packages are needed or not. Secondly, the preparation of a record list that informs the logistician about which boxes are available. The third sub-action is to define the location of the boxes.

	PLAN			DO & CHECK										
				Mar-17				Apr-17				May-17		
	Action 3-1: Storage of the customized wooden boxes of each engine			10	11	12	13	14	15	16	17	18	19	20
No.	**Sub actions**	**Expected Results**	**Due Date**	06	13	20	27	03	10	17	24	01	08	15
1	Finding of a potential location	Location	30.01.17				✓							
2	Distinction of needed and unneeded packages	Process	06.02.17				✓							
3	Preparation of a record list	Document	13.02.17						✓					

Fig. 35: Action 3-1

3.8.1.3. Do & Check

The execution of the action was implemented without any delays or problems. The action was a special request of the Leader of the Logistics team and therefore, the action was done as soon as possible.

3.8.1.4. Act

Through the new organization of the storage system, the execution of the action did not require any great effort. The new storage place for the boxes was not the best approach, but given the limited space at STC, the procedure was a good interim solution and helped the company to save money. Concerning the boxes, further actions are definitely required, but for now this interim solution works.

3.8.1.5. Savings Calculation

The costs for one wooden box is about 1.000 RMB. In average, STC gets three boxes from the customers that can still be used for further shipments. That brings cost savings of about 36.000 RMB each year.

3.8.2. Action 3-2: "Set up a process of handling the tools for the Test Bed Team"

Action 3-2:	Set up a process of handling the tools for the Test Bed Team
Team:	Test Bed
Name:	Li Wei/Lucas Wartscher
Timeframe:	01.03.2017 - 28.04.2017

3.8.2.1. Description

The Test Bed team has their own tools for the daily work on the test beds. In the past, it occurred that employees of other departments used these tools for their work, too, and did not bring them back to the Test Bed team. This led to the issue that the operators had delays on the test bed schedule because they did not have the tools they need. The action was implemented to develop a process to handle the tool organization, so that only the operators can use them and no more tools get lost in other departments.

3.8.2.2. Plan

Firstly, it was necessary to find a process for dealing with the tools. Secondly, a list of all missing tools was made and the tools were ordered. Thirdly, the tools needed to be distributed and the operators needed to be informed about the new approach.

PLAN				DO & CHECK										
Action 3-2: Set up a process of handling the tools for the test bed team				Mar-17				Apr-17				May-17		
				10	11	12	13	14	15	16	17	18	19	20
No.	**Sub actions**	**Expected Results**	**Due Date**	06	13	20	27	03	10	17	24	01	08	15
1	Definition of a new approach	Approach	30.01.17			✓								
2	Recording of the missing tools	Document	06.02.17				✓							
3	Distribution of the tools and inform operators	Meeting/Mail	13.02.17						✓		✕			

Fig. 36: Action 3-2

3.8.2.3. Do & Check

The Leader of the Test Bed team and the Researcher were responsible for the execution of the action. The first and the second sub-action were done in time. The third sub-action was not implemented in time because the supplier of the tools had problems with the delivery and therefore, the sub-action was delayed for two weeks. It was not a big problem because the responsible engineers did not make any mistakes that caused the delay.

3.8.2.4. Act

The new standard with the test bed tools stipulates as follows: Four tool carts are provided for the tools. Every tool cart contains the same tools and is located on a strategic place so that the operators have easy access to it. Two operators are the key holders for one tool cart which means that, if a tool is needed, the operator has to open the cart and provide the specific tool. In addition, the key holder has to document the name of the borrower and the tool. At the end of each month, the key holders have to check if the tools in the cart are stocked completely and in good condition.

3.8.2.5. Savings Calculation

The two main reasons for cost saving are the reduction of searching time and the saving of costs because of missing tools. The costs for the missing tools are about 7.600 RMB and the costs of the searching time of an operator per year is about 5.400 RMB. In total, the cost savings through the action are about 13.000 RMB per year.

3.8.3. Action 3-3: "Shared equipment/tools status identification in Workshop"

Action 3-3:	Shared equipment/tools status identification in Workshop
Team:	Workshop
Name:	Heng Yang/Lucas Wartscher
Timeframe:	01.03.2017 - 28.04.2017

3.8.3.1. Description

There is one cabinet in the workshop that includes special equipment and tools, such as big torque wrenches or measuring instruments. The mechanics can use the tools for special work steps but have to return them to the cabinet. Before the action, the number of equipment and devices, that did not belong in the cabinet, was rising. There was no defined area and there were no labels on the boxes. In addition, a tool list was missing. The mechanics put things in the cabinet which did not belong there, simply because they did not know where to put them. The action was implemented to solve this issue and to find a particular place for the tools in the workshop.

3.8.3.2. Plan

The first step was to sort out all equipment that did not belong into the cabinet. Next, a tool list was created and the location of the tools was defined. Afterwards, labels were put on drawers, boxes and layers. The last step was to inform the mechanics about the new handling of the cabinet.

	PLAN			DO & CHECK										
				Mar-17				Apr-17				May-17		
	Action 3-3: Shared equipment/tools status identification in workshop			10	11	12	13	14	15	16	17	18	19	20
No.	Sub actions	Expected Results	Due Date	06	13	20	27	03	10	17	24	01	08	15
1	Classification of the tools in needed and unneeded	Approach	30.01.17				✔							
2	Generation of a tool list and fitting of labels	Document	06.02.17					✔						
3	Inform the mechanics about the cabinet	Meeting/Mail	13.02.17					✔						

Fig. 37: Action 3-3

3.8.3.3. Do & Check

The Leader of the workshop and the Researcher were responsible for the execution of the action. The Researcher was supported by a mechanic during the implementation of the first sub-action. During the second sub-action, the Researcher was supported by the assistant of the MD & TF department for generating a tool list and labels in Chinese characters. The last step was executed by the Researcher himself. All sub-actions were done in time without any problems.

3.8.3.4. Act

The new handling of the cabinet is very simple. Every tool and equipment has a designated location. There is a tool list on the cabinet door, which describes what tools can be stored in the cabinet. One mechanic is responsible for the cabinet and has to check the condition once a month. The Leader of the Workshop team renounced the implementation of a record list for various reasons.

3.8.3.5. Savings Calculation

The implementation of the action supports the mechanics to find the tools and equipment easier and faster. Therefore, the action reduces searching time and the cost savings for a mechanic per year is about 5.400 RMB.

3.8.3.6. Action 3-4: "Shared equipment/tools status identification in Chassis Dynamometer"

Action 3-4:	Shared equipment/tools status identification in Chassis Dynamometer
Team:	Chassis Dynamometer
Name:	Chen Lilli/Lucas Wartscher
Timeframe:	01.03.2017 - 28.04.2017

3.8.3.7. Description

The Chassis Dynamometer has three cabinets with tools and equipment for their daily work. An inventory of the tools has never been executed before. Therefore, the exact number of tools and equipment is unknown. In addition, nobody is responsible for the cabinets and takes care of them. Furthermore, there is no record of the equipment what leads to problems of tracking it.

3.8.3.8. Plan

The first step is to update the status of the tools and the equipment. Afterwards, the Leader of the Chassis Dynamometer team defines a person that will be responsible for each cabinet. Next, a record for the borrowing of tools is generated. The last step is to inform the engineers about the new procedure with the cabinets.

PLAN				DO & CHECK										
Action 3-4: Shared equipment/tools status identification in Chassis Dynamometer				Mar-17				Apr-17				May-17		
				10	11	12	13	14	15	16	17	18	19	20
No.	**Sub actions**	**Expected Results**	**Due Date**	06	13	20	27	03	10	17	24	01	08	15
1	Evaluation of the status of all tools in the cabinets	Document	30.01.17				✓							
2	Definition of the responsibility of the cabinets	Meeting/Mail	06.02.17					✓						
3	Generation of a record for borrowing the tools	Document	13.02.17					✓						
4	Inform the employees about the new procedure	Meeting/Mail	13.02.17						✓					

Fig. 38: Action 3-4

3.8.3.9. Do & Check

The action was executed by the Leader of the Chassis Dynamometer team and the Researcher. The Researcher generated the tool list and the record. The TL defined the responsible persons for the cabinets and informed the engineers about the new procedure. All sub-actions were implemented on time without any major problems.

3.8.3.10. Act

The new procedure helps the Chassis Dynamometer team to track and monitor the tools and equipment. The approach is the same as in Action 3-2. If an engineer needs a tool, the responsible employee provides the key for borrowing it. Subsequently, the engineer has to fill out the recording document before taking the tool. The employees that is responsible for the cabinets has to check the condition of the equipment periodically.

3.8.3.11. Savings Calculation

The cost saving for the action is equal to the calculated savings of Action 3-3, which are 5.400 RMB per year.

3.8.4. Action 3-5: "Process to collect and visualize the Suggestions/Ideas"

Action 3-5:	Process to collect and visualize the Suggestions/Ideas
Team:	MD & TF
Name:	Lucas Wartscher
Timeframe:	01.03.2017 - 28.04.2017

3.8.4.1. Description

For the development of the CIP in the MD & TF department, the implementation of a process for dealing with the suggestions and ideas of the employees is essential. Unfortunately, collecting ideas was not in

focus of STC. Together with the Kaizen office, the Researcher decided to implement a process to collect and evaluate the suggestions and ideas from the employees of the MD & TF department.

3.8.4.2. Plan

The first step was to find a process for collecting the ideas. The next step was to define an approach to discuss and evaluate the ideas with the TL. The last steps were to sustain the process in the department and to inform the TL about the new approach.

					Mar-17				Apr-17				May-17		
Action 3-5: Process to collect and visualize the suggestions/ideas					10	11	12	13	14	15	16	17	18	19	20
No.	Sub actions	Expected Results	Due Date		06	13	20	27	03	10	17	24	01	08	15
1	Finding a process to collect the suggestions	Document	30.01.17					✓							
2	Finding an approach to evaluate the suggestions	Meeting/Mail	06.02.17						✓						
3	Implementation of a sustainable process	Document	13.02.17						✗	▮	▮				
4	Inform the Team leaders about the process	Meeting/Mail	13.02.17									✓			

Fig. 39: Action 3-5

3.8.4.3. Do & Check

The first and second sub-action were implemented rapidly, but the third sub-action took a lot of time. It was difficult to find a date for all TL. They were aware of the importance to discuss the ideas and suggestions. But still, the fact that the project needed to be executed on time was the most important aspect, and therefore, they did not find the time for a meeting. After a discussion between the SKTL and the Researcher, the SKTL decided that a meeting for the evaluation of the suggestions should be held every two weeks.

3.8.4.4. Act

The new process for the collection of ideas is as follows: The TL collect the suggestions/ideas in the course of their weekly meetings. Every two weeks, the SKTL, the TL and the Researcher hold a meeting to discuss and evaluate the ideas. Depending on the idea, the SKTL decides if the idea will be implemented or not.

3.8.5. Conclusion of the 3rd CIP Loop for the MD & TF Department

The implementation of the action was very successful and increased the working behaviour of the employees. Only Action 3-2 was delayed due to the delivery of the tools. In total, the cost savings through the implementation are about 59.800 RMB per year, what is a satisfactory result. Management was satisfied with the achieved results and praised the excellent work of the department.

3.9. 4th CIP Loop for the MD & TF Department

The schedule for the fourth loop was from the 1 June to the 31 July 2017. The Researcher was responsible for the generation of the actions, but not for the execution and implementation because the internship at STC ended in this period. The creation of the actions will be described in more details in Chapter 3.10.3.

3.9.1. Action 4-1: "Engine build up training and practice for New comers"

Action 4-1:	Engine build up training and practice for New comers
Team:	MD & TF
Name:	Hu Junwei/Heng Yang
Timeframe:	01.06.2017 - 31.7.2017

3.9.1.1. Description

The newcomers at STC have too little experience in engine technology. Therefore, every engineer and operator with less than three years of work experience should build up an engine to gain more expertise in this field. The workshop will provide a test engine for the practice.

3.9.2. Action 4-2: "Machining training for all Mechanics"

Action 4-2:	Machining training for all Mechanics
Team:	Workshop
Name:	Heng Yang
Timeframe:	01.06.2017 - 31.7.2017

3.9.2.1. Description

Only a few mechanics in the Workshop team are able to produce parts through milling, drilling and welding. In order to prevent dependency and delays, all mechanics in the Workshop team should exercise a training to learn various manufacturing processes.

3.9.3. Action 4-3: "5S Improvement for Test Beds"

Action 4-3:	5S Improvement for Test Beds
Team:	Test Bed
Name:	Li Wei
Timeframe:	01.06.2017 - 31.7.2017

3.9.3.1. Description

Before and during the project, the customers come to STC and check the progress of the project. The main development work is done at the test beds and therefore, they have to be in best condition. The 5S audit (see Chapter 3.11.2.1.) delivered an unsatisfying result and the SKTL decided to implement an action to improve the condition in the test beds immediately.

3.9.4. Action 4-4: "Improvement of Test Bed waiting time"

Action 4-4:	Improvement of Test Bed waiting time
Team:	Test Bed
Name:	Qiu Yanyi
Timeframe:	01.06.2017 - 31.7.2017

3.9.4.1. Description

The waiting time for the operators in the test beds is too long what leads to delays of the project time and causes costs. One of the reasons is that the operators start their shift at 6 a.m. and the mechanics and engineers at 9 a.m. This implies that, if a failure occurs between 6 a.m. and 9 a.m., it takes too much time until a mechanic can start with the repair work.

3.9.5. Action 4-5: "Prevention of Engine Failures"

Action 4-4:	Prevention of Engine Failures
Team:	MD & TF
Name:	Hu Junwei/Gu Yukang
Timeframe:	01.06.2017 - 31.7.2017

3.9.5.1. Description

Sometimes the engine on the test bed gets broken during a test. This situation is very bad for STC and the customer because it costs time and money. Additionally, it is not clear whether it was the STC or the customer that was responsible for the mistake that caused the breakdown. Therefore, the engineers of the MD team want to establish a procedure that enables a clear definition of an occulting failure including assignment of responsibility for the course of failure.

3.10. Daily Kaizen Board

The Daily Kaizen board has been implemented to support the employees at the execution of CIP. The idea is to create a culture of continuous improvement and the board should be a contact point to discuss the topics during the implementation of the program. In addition, the board will support the implementation of better work standards. In case of grievances, it will give the opportunity to react immediately with suitable measures. Furthermore, the board provides a platform to demonstrate KPIs. At STC, the employees have the opportunity to choose the content of the board. Therefore, the TL have defined a selection of the following topics.

- Visual Work Plan
- Action Plan
- Indicators

- Communication Area
- Attendance Management
- Audits
- Skill Matrix
- Training Material

- Kamishibai[78]
- Improvement Suggestions
- Meeting Agenda
- Good Practices
- Identification in the team

Every team can choose on how they think it is best for them to work with the Daily Kaizen board. It can be expected that every team will choose other topics for their boards due to different work scopes.

3.10.1. Daily Kaizen Board in the MD & TF Office

The Researcher decided to implement the first Daily Kaizen board in the MD & TF office area for two reasons. Firstly, the office desk of every TL of the department is located in the MD & TF office. This means that the team leaders can see the tasks on the board immediately and thus, conceive the board´s performance. Secondly, it is a good practice for the team leaders to get used to the Kaizen board before starting the implementation of the board to their teams.

The team size is about eight people and in the optimal range of a Daily Kaizen team. The members are the SKTL, the leaders of the Workshop, the Test Bed team, the Chassis Dynamometer and Logistics team as well as the department assistants and the Researcher. The SKTL and the Researcher decided to hold the meeting every two weeks in the first phase of the implementation. The content of the board for the office was defined by the Researcher and includes the following topics, which will be introduced hereinafter.

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[78] *Kaizen[TM] Institute India*. 2013: online available:
https://kaizeninstituteindia.wordpress.com/2013/05/03/kamishibai/, [accessed: 22nd of September, 2017].
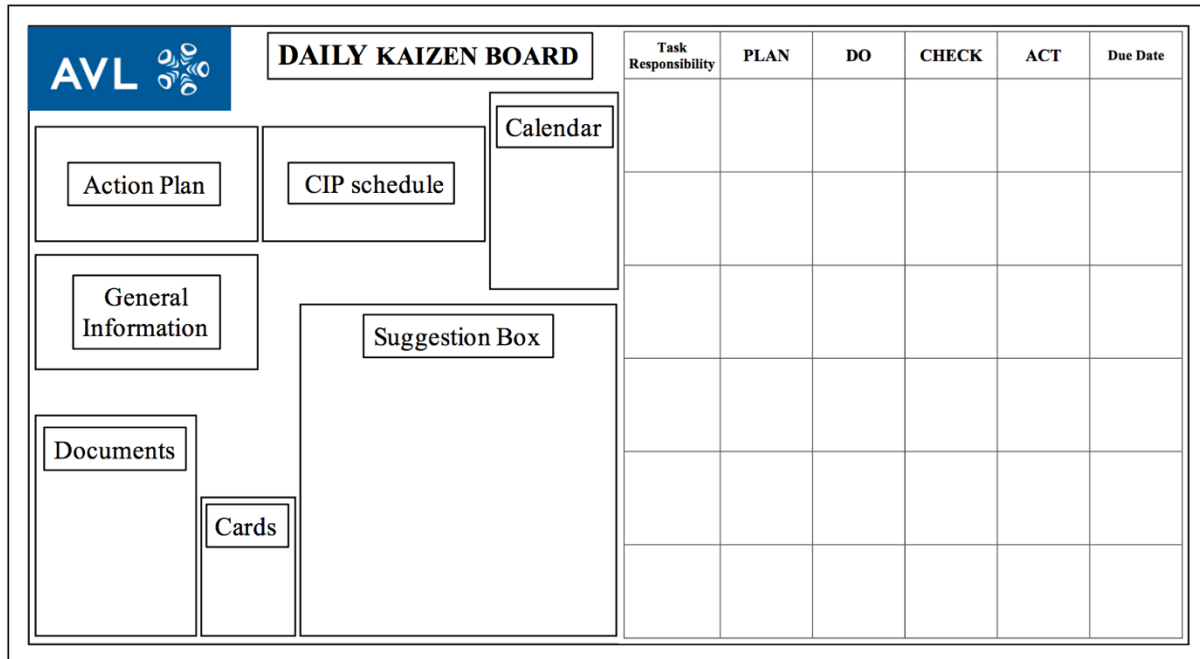
Fig. 40: Daily Kaizen board office

3.10.1.1. CIP schedule

The plan illustrates the schedule of the CI methods and tools. The start and end dates of every single action loop as well as the dates of the 5S audits in the office area, workshop and test beds are shown. Thus, every employee in the department is informed about the appointments related to the CIP.

3.10.1.2. Improvement Suggestions

The suggestion box is an area on the board where every employee has the opportunity to share the ideas and suggestions with the department. The teams can see the ideas in every meeting on the board and can discuss further actions. The suggestion cards that should be used for placing the ideas on the board are located next to the box.

3.10.1.3. Action Plan

The Action Plan shows all relevant details about the current and past actions. The plan provides the information about the responsibility at a glance and contains the expected results, the due dates and the forecast achievements of the actions.

3.10.1.4. Document holder

Due to lack of space, it is not possible to visualize all documents on the board. Thus, the Researcher put a document holder on the board for storing important documents such as meeting agenda, attendance list and results of previous audits.

3.10.1.5. General Information

This area of the board contains the proclamation of important information. The CIP is a constantly changing process, which leads to the pronouncement of much information every week. "Communication and Promotion" is one of the big issues of a CIP. To keep the employees up-to-date, this area provides the space for sharing the information.

3.10.1.6. Calendar

The calendar is important for planning the actions during the PDCA cycle. The exact determination of the due dates is essential because every delay costs time, effort and money. The specific STC calendar provides all holidays and additional working days on Saturday and Sunday and supports the employees in the planning phase.

3.10.1.7. PDCA

The PDCA approach supports the engineers during the implementation of new actions. The objective is to discuss suggestions and ideas in front of the Daily Kaizen board. In case, the team leaders agree that an idea or suggestion can increase the efficiency in the department, it is converted into an action and implemented in the PDCA cycle. Every two weeks the engineers have a meeting in front of the board and discuss the status and progress of the actions in the PDCA approach.

3.10.2. Generation of Actions for the 3rd Loop

The generated actions by the process mapping were implemented and no further actions related to the first and second loop were necessary. The next step was to create new actions for the third loop. Therefore, the Researcher decided to use the Daily Kaizen board and asked the team leaders to collect some suggestions or ideas of the employees during the daily and weekly meetings. The focus of the suggestions should be on how to increase the efficiency and moral of the working behaviour as well as quality and safety. The team leaders had a time-frame of two weeks to collect the suggestions and ideas. After two weeks, the Researcher held the first meeting in front of the Daily Kaizen board and summarized the achievements of the first and second loop. The second topic was the generation of actions for the third loop. Based on the ideas from the team leaders, five actions have been generated which are as follows.

3rd Loop Actions	Team	Responsibility
3-1: Storage of the customized wooden boxes of each engine	Logistics	Xu Heping/Lucas Wartscher
3-2: Set up a process of handling the tools for the test bed Team	Test Bed	Li Wei/Lucas Wartscher
3-3: Shared equipment/tools status identification in workshop	Workshop	Heng Yang/Lucas Wartscher

3-4: Shared equipment/tools status identification in Chassis Dynamometer	Chassis Dyno	Chen Lilli/Lucas Wartscher
3-5: Process to collect and visualize the suggestions/ideas	MD & TF	Lucas Wartscher

Table 4: Actions for the third Loop

Every TL in the department was responsible for an action in the third loop. The due date for the actions was 28 April 2017, which was also the dateline of the loop.

3.10.3. Generation of Actions for the 4th Loop

The actions for the fourth loop have been generated in the same way as in the third. The Skill Team Leader, the team leaders and the Researcher defined five actions by using the Daily Kaizen board.

4th Loop Actions	Team	Responsibility
4-1: Engine build up training and practice for New comers	MD & TF	Hu Junwei/Heng Yang
4-2: Machining training for all Mechanics	Workshop	Heng Yang
4-3: 5S Improvement for test beds	Test Bed	Li Wei
4-4: Improvement of test bed waiting time	Test Bed	Qiu Yanyi
4-5: Prevention of engine failures	MD & TF	Hu Junwei/Gu Yukang

Table 5: Actions for the fourth Loop

Action 4-1 and 4-2 included suggestions that were implemented in the Action List. Action 4-3 was the result of the unsatisfied evaluation from the 5S audit that will be described in more detail in Chapter 3.11.2.1. Actions 4-4 and 4-5 were generated after a discussion between the engineers and the SKTL.

3.10.4. The Daily Kaizen Board in the Logistics Team

The first team that implemented the Daily Kaizen board was the Logistics team. It is the youngest and smallest team at the MD & TF department. At first, the TL and the Researcher decided to put three essential topics on the board that were very important for the daily work.

3.10.4.1. Attendance Management

A lot of employees at STC need some equipment from the warehouses every day. Therefore, it has to be obvious if a logistician is available or not. The attendance management is divided in four sections such as "In office", "Go out", "Meeting" and "Annual leave". Every employee of the team has to update the status every day.

3.10.4.2. Visual Work Plan

The work plan supports the logistician to have a better overview of the Incoming and Outgoing goods related to the projects. The Logistics team is responsible to provide the parts, the equipment and the engines that are needed during a project. Generally, the logistician has a list with a weekly schedule of the Incoming and Outgoing goods, but the TL decided to put the schedule on the board because it is important for the daily work of the team. The schedule consists of six columns. Firstly, "No." which ensures a consecutive numbering of the tasks. Secondly, "Project" which includes the project name and number. Next, "Customer" which stands for the name of the customer. The columns "Incoming" and "Outgoing" stand for the dates of the arrival and shipped goods. At least, "Amount" gives information about the quantity of the incoming and outgoing goods.

3.10.4.3. Calendar

The specific STC calendar is essential for the team. It provides the information of the holidays and the additional working days at STC. It supports the team with the planning of incoming and outgoing goods.
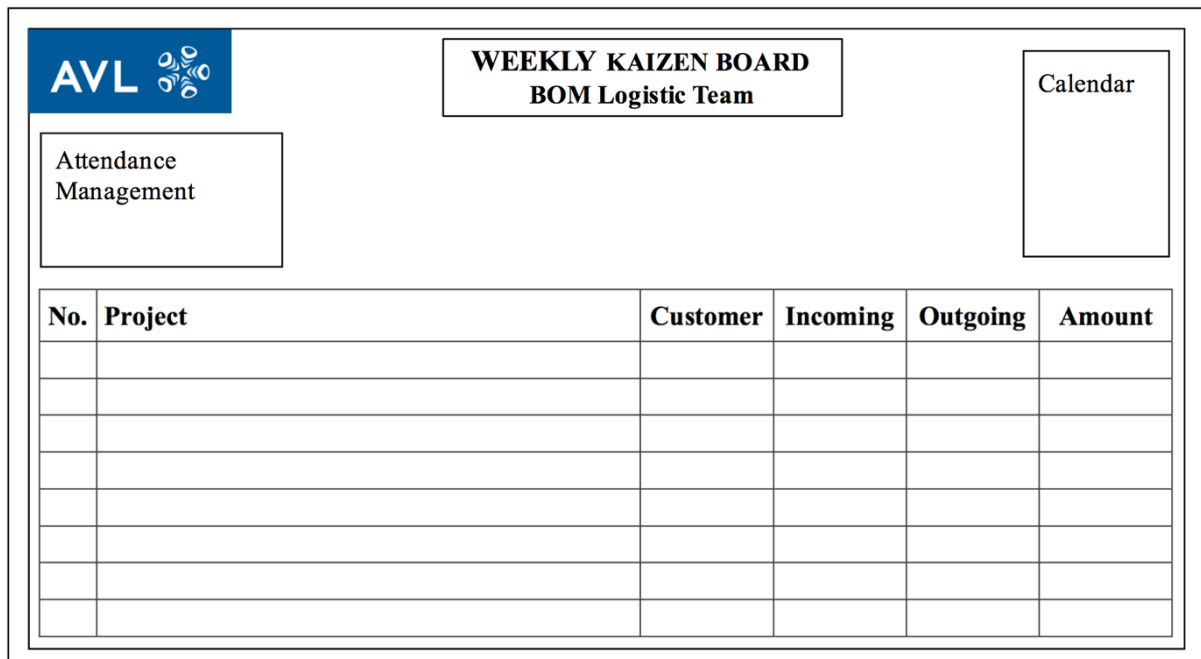
Fig. 41: Weekly Kaizen board Logistics

3.10.4.4. Usage of the Daily Kaizen Board

The team decided to use the board weekly, which makes it a Weekly Kaizen board. Every Monday, the TL is holds the meeting in order to the topics of the work plan. There is spare space left on the board for other topics, but the TL decided to start with these topics and to increase the selection step by step.

3.11. 5S in the MD & TF Department

The 5S campaign was the first contact with a CI method for all employees in the department. The coordinator and the Researcher decided to split the department in two areas, the office area and the production area. The Researcher decided to start with the execution of 5S in the office area first because this is the area where the team leaders have their office desk. Also, it is good practice for them to see how it works. The team leaders are supported by the Researcher. They are responsible for the implementation of 5S in the teams as they have to know how the method has to be executed.

3.11.1. 5S in the Office Area

The Researcher was responsible for the execution of 5S in the office area. Overall, fifteen employees are working in the office including the SKTL, all team leaders, six engineers, two assistants and the Researcher. The Researcher provided training materials and checklists for the employees to implement the method. Additionally, the Researcher created an office desk in a "5S best practice" condition, so that the employees can see how a perfect 5S office desk looks like. Furthermore, an order list was provided so that the employees can order equipment such as book holders, pencil holders and folders to fulfil the 5S standard. Templates and labels were also created for a standardized marking of folders and cabinets. Every office desk got a nameplate that makes it easier for the employees of other departments to find the right person.

The employees had two weeks of time to bring their office area in 5S condition. Before the 5S audit from the Kaizen office was executed, the Researcher did an internal audit in the office to exhibit possible shortages.

3.11.1.1.   5S Audit in Office Area

The first audit was at the beginning of January 2017 and had been executed by the KO. The aim of the first audit was to check if the 3S, *Sort*, *Straight*, *Scrub* had been successfully implemented. The 4S and 5S are about "Standardize" and "Sustain" and can only be evaluated in further audits. The KO was divided into two groups and each team got designated departments that had to be checked.

Group	Auditor	Departments
Group 1	Xu Saihua	PM/CAE/ETV/ Dev. & Calibration/Facility
	Cheng Chen	
	Zhang Junqiang	
	Xu Heping	
	Lucas Wartscher	
Group 2	Li Jianhong	HR/Finance & Administration/ Design/MD&TF
	Tang Piao	
	Qian Meili	
	Ma Qingjun	
	Georg Kolb	
	Christof Walz	

Table 6: Division 5S audit

The rules for the audit were clarified as follows: Each group should not spend more than ten minutes in one department. The group had a checklist and evaluated the results together. Additionally, the team took 5S Best "tags" and prized the best office desk of each department with a tag that would be shown on the Canteen board.

3.11.1.2. 5S Audit of 9th January 2017
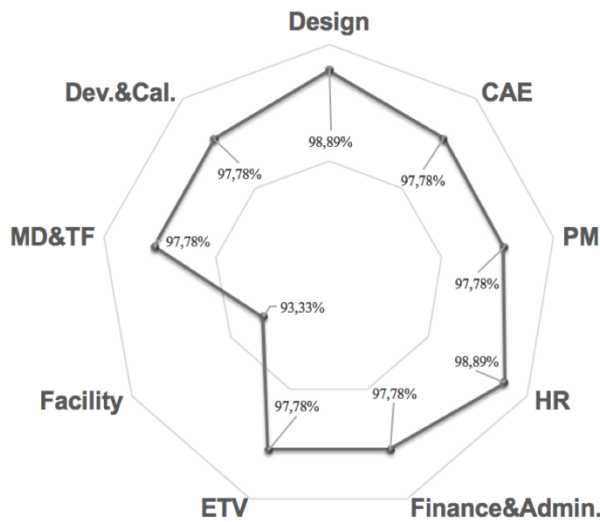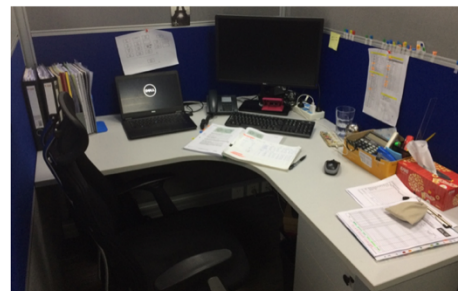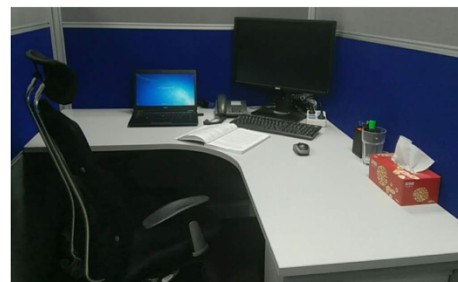
Fig. 42: Results of the first 5S audit in office area

The best result of the audit was achieved by the HR and Design department followed by the other departments, except the Facility department. Fig. 42 shows the improvement of the condition of the office desks in the department by the implementation of 3S. The result of the audit was satisfying, but there were still some things that needed to be improved for the next audit. Therefore, the Researcher

prepared a presentation with the results of the audit and provided some improvement suggestions to the employees.

3.11.1.3. 5S Audit of 20th of January 2017

Table 7 shows the results of the first and second audit. This comparison demonstrates the progress of the 5S campaign at STC. The focus of the second audit was to check the 3S condition of the office and the implementation of the suggestions from the first audit. The procedure for the second audit was the same as in the first, but the auditors had more experience and found more details that had to be improved.

Department	Score [%]	
	9th January	20th January
Design	99	94
CAE	98	98
Project Management	98	99
Human Resources	99	96
Finance & Administration	98	96
ETV	98	94
Facility	93	99
Mechanical Development & Test Factory	98	98
Development & Calibration	99	94

Table 7: Results of the first and second 5S audit in office area

Table 7 illustrates the comparison of the results of the first and second audit. It shows that some departments got a worse result and others made a great improvement. The MD & TF department got the same evaluation as in the first audit. The suggestions of the first audit had been implemented, but other topics such as "Sorting" and "Straighten" were not as well performed as in the first round and so no improvement was achieved.

3.11.1.4. 5S Audit of 30th March 2017

The KO decided to execute the next audit for the office area on the 31st of March 2017. The time between the second and the third audit was rather long and the employees had time to standardize the condition in the working area. In addition, the third audit gave the opportunity to check the sustainability of the 4Ss. The Researcher communicated the date of the audit to the employees, but this time he did not prepare any training material to improve the office condition consciously. The employees already received all information about 5S before the two audit rounds were held.

Department	Score [%]	
	20th January	30th March
Design	94	77
CAE	98	91
Project Management	99	79
Human Resources	96	74
Finance & Administration	96	68
ETV	94	74
Facility	99	94
Mechanical Development & Test Factory	98	76
Development & Calibration	94	85

Table 8: Results of the second and third 5S audit in office area

The focus of the third audit was on the implementation of the fourth and fifth S, which are "Standardize" and "Sustain". The audit was executed by the KO and the procedure was the same as in the first two audits.

The result of the audit was moderate because none of the departments reached the result of the prior audit. The MD & TF department did not get a satisfactory result and it showed that especially the fifth S, "Sustain and "Self-discipline", was not implemented in a good way. The Researcher realized that the employees needed more time to understand the principle of 5S and CI. Self-discipline is essential for the existence of the CIP and the employees, so the Researcher tried to provide more training and practices.

3.11.2. 5S in the Workshop, Test Beds and Warehouse

The following figure shows the distribution of the three main areas. Every area has different rooms and for a better overview, the coordinator and the Researcher decided to assign a responsible person for each room.

Area	Room	Owner
Warehouse	Warehouse Finance & Administration	Xie Yongwei/Li Xiuming
	Prototype Warehouse 1&2	Xu Heping
Workshop	Engine Build room/Tools room	Heng Yang
	Machining Room	
	Measurement Room	Xu Heping
Test Bed	ETC1	Yuan Jiahua/Xiao Hongwu
	ETC2	Zhang Hualong/Tang Aiqiang
	ETC3	Wang Weizhou
	ETC4	Wang Jigao/Li Wei
	ETC5	Zhu Pengfei/Zheng Zhiqiang
	ETC6	Sun Yang/Xioing Yadong
	ETC8	Zhang Shuaihui/Liu Songwei
	ETC9	Li Liang/Li Wei
	ETC10	Fu Jun/Wang Boxun
	ETC16	Xu Liangrong/Lu Yingjiao
	PTC1	Bao Xiaocheng

Table 9: 5S Responsibility in warehouse, workshop and test beds

All employees in the workshops, test beds and warehouses got detailed training in 5S by the coordinator and the Researcher. The team leaders gained experience when they were handling the 5S during the implementation at the office area. In case that the employees had questions about the TL, the coordinator and the Researcher were available every time to answer. The Researcher spent a lot of time to support the employees with the implementation of 3S, but sometimes it was difficult because some engineers in the Workshop team did not speak English very well.

Before the first audit, the head of the KO, the coordinator and the Researcher executed a pre-audit in every area to show the employees some opportunities to improve the working condition. Table 10 illustrates the findings in the warehouses and workshop rooms that had to be improved before the first audit.

Location	No	Improvement Opportunities	Location	No	Improvement Opportunities
WH2	1	Current labels on the oil cabinet are not clear	Special Tool Room	1	Labels for boxes
	2	Move forklift head cover to assigned location		2	Thermocouples should be in order and sort out the unnecessary
	3	Emission pipes have to be moved to preparation room	Machining Room	1	Unnecessary equipment on the cabinets
	4	Boxes are not in order		2	New micrometer does not have a serial number
	5	Labels for the maximum weight on the shelves		3	Unused parts and equipment are stored
	6	Add the ground labels for machines	Measurement Room	1	Measurement device need to be repaired
WH1	1	Installation of information boards on cabinets		2	Bring equipment in order and ready for using
	2	Transportation of the big boxes to the empty shelf		3	CMM Calibration overdue

Table 10: Improvements for warehouse and workshop

The team leaders and engineers got the information about the findings and were instructed to consider it. In addition, the Researcher held a pre-audit in the test beds to support the operators at the execution

of 3S. The condition in the test beds was not good and the Researcher discussed with the TL how important it is to work on the 3S.

5S Improvement Actions for Test Beds				
ETC 1	Clean and Sort the desk, remove all unneeded things	ETC 16	Remove boxes on the floor	
	Store customer engine parts in cabinet		Clean and Sort the desk, remove all unneeded things	
	Store shoes in restroom		Store shoes in restroom	
ETC 3	Remove Oil and Coolant cans	ETC 10	Remove the boxes from the floor	
	Clean and Sort the desk, remove all unneeded things		Remove Oil container from the floor	
ETC 4	Remove folder from the top of the air-conditioning	ETC 2	Remove Leak Detector from the floor	
ETC 8	Clean and Sort the desk, remove all unneeded things		Remove boxes from the floor	
	Remove boxes with coolant		Clean and Sort the desk, remove all unneeded things	
PTC 1	Good 5S condition	ETC 6	Remove equipment from the top of the air-conditionin	
ETC 9	Good 5S condition		Clean and Sort the desk, remove all unneeded things	
ETC 5	Clean and Sort the desk, remove all unneeded things		Remove boxes from the desk	

Table 11: Improvements for test beds

The Researcher supported the teams with the implementation of the findings and assisted the improvement of the condition of the rooms.

Before:

Fig. 43: Situation in test beds and workshop before the audit

The initial situation in the test beds and workshops was not satisfying. There was a lot of unneeded clutter in the test bed area, such as boxes, packages, useless devices, backpacks and shoes. Moreover, there was a mess on the desks and on the floors since there was no designated location for the equipment that was really needed. Many documents were sat on the desks because no folders were present. It was not clarified, which equipment was supposed to stay in the test bed or not. The situation in the workshop was similar. Many useless documents were stored on the cabinets. The tools, raw material, Oil cans and containers were not stored at the correct location. The boxes for storing screws and other equipment did not have any labels. Further, the condition of the cabinets was not satisfactory because the tools had no designated location and a lot of unused equipment was stored.

After:

Fig. 44: Situation in test beds and workshop after the audit

The implementation of 5S in the teams brought a lot of improvements in some areas. The operators sorted out all unnecessary equipment and put the remaining things in order, so that they were easy to handle. Every item got a designated location. Moreover, folders to store documents have been provided. The mechanics moved the tools and raw materials to their correct places and also labelled the boxes and racks of the cabinets. Some operators and mechanics did a good job and increased their working behaviour by the implementation of 5S massively.

3.11.2.1. 5S Audit in the Workshop, Test Beds and Warehouses

The execution of the audits has been done in the same way as for the office area. The coordinators have been divided in two groups. One group evaluated the test beds and the other group the repair rooms, workshops and the warehouses. The dates for the audits were 17 March and 28 April 2017.

Location	Room	Score [%]	
		17th March	28th April
Repair room	Emission repair room	92	90
	Test equipment repair room	95	91
Warehouse	Warehouse of Finance & Admininstration	92	81
	Prototype Warehouse	95	81
Workshop	Engine build room/Tool room	not audited	82
	Machining room	85	65
	Measurement room	75	75
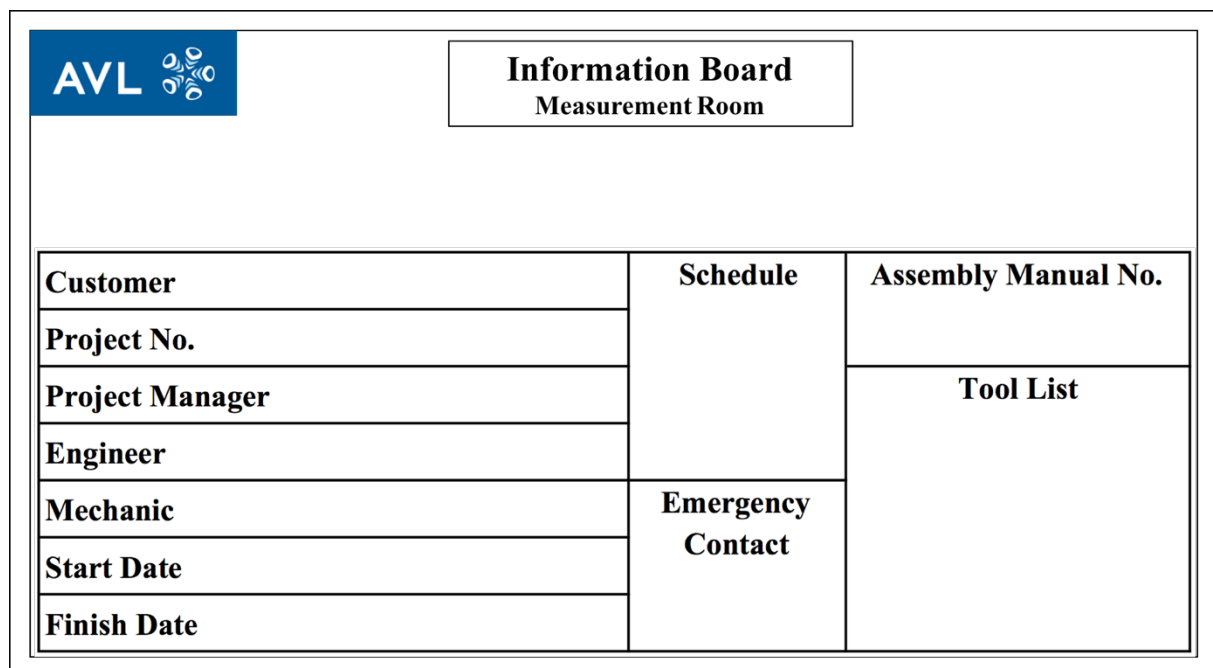
Test Bed	Score [%]		Test Bed	Score [%]	
	17th March	28th April		17th March	28th April
ETC1	80	63	ETC8	75	83
ETC2	75	58	ETC9	70	77
ETC3	85	73	ETC10	80	88
ETC4	85	80	ETC16	75	53
ETC5	70	78	PTC1	75	80
ETC6	65	68			

Table 12: Results of the first and second audits

The results of the audits for the repair rooms, warehouses and workshops show that the scores of the first audit were better than at the second audit. The effect was the same as in the office area and illustrated that it takes time to gain self-discipline. A special case is the machining room, where the employees have a lot of working experiences, but they need more time than others to understand how important it is to acquire continuous improvement. The engine-build room could not be evaluated at the first audit due to reconstruction measures.

The results of the first audit in the test beds was not as good as expected. The reason was that many engineers, mechanics and operators were working at the same test bed with the consequence that disorder and mess could occur. Furthermore, the responsible operators do not care about keeping the test beds in a good condition because they are not responsible for the disorder of their colleagues. This situation is a big problem because there are customers at STC nearly every day, especially at the test beds. The Researcher discussed the topic with the SKTL and he gave finding a solution to this problem the highest priority. Therefore, the Researcher set an action for the fourth loop that focused on the 5S approach in the test beds.

The responsible engineer of the Measurement room is the Leader of the Logistics team, but many other engineers and mechanics use the room depending on the project. Sometimes, the room is not in a good condition and nobody knows who is responsible for the mess. Therefore, the Researcher installed an Information board (see Fig. 45) in the room. Every engineer and mechanic who uses the room has to fill out the board before starting to work. This approach should help to keep the conditions in the Measurement room satisfactory.

Fig. 45: Information Board Measurement Room

3.12. CIP Suggestion Process

The generation of suggestions and ideas is a main part during the implementation of CIP. To keep the improvement process going, it is important that all employees have the opportunity to share their ideas with the company. The focus of the suggestions should be the improvement of efficiency, quality, safety, moral and cost reduction. Therefore, a process has to be implemented to support the motivation of the employees to increase their working behaviour.

The employees have various possibilities to communicate their suggestions and ideas with the department. Firstly, every employee has the opportunity to use the Suggestion box on the Daily Kaizen board in the office. The associated cards (see Fig. 46) and pens are beside the board. Secondly, the employees who have email-access can write their suggestions to the coordinator and the Researcher by mail. They take care that the suggestion will be discussed at the next Daily Kaizen meeting.

Thirdly, the coordinator and the Researcher installed a Suggestion post box (see Fig. 47) in the workshop area. The box is close to the employees in the workshops, warehouses and test beds and gives them the opportunity to share the ideas anonymously.

Fig. 46: Suggestion Card

Fig. 47: Suggestion Box

3.12.1. Suggestions Implementation Process

The following figure shows the process of dealing with the suggestions of the employees in STC. The KO and the Researcher developed the process in a way in which all suggestions will be considered. Further, the process guarantees that if a suggestion is accepted, the employee receives an award by the GM.
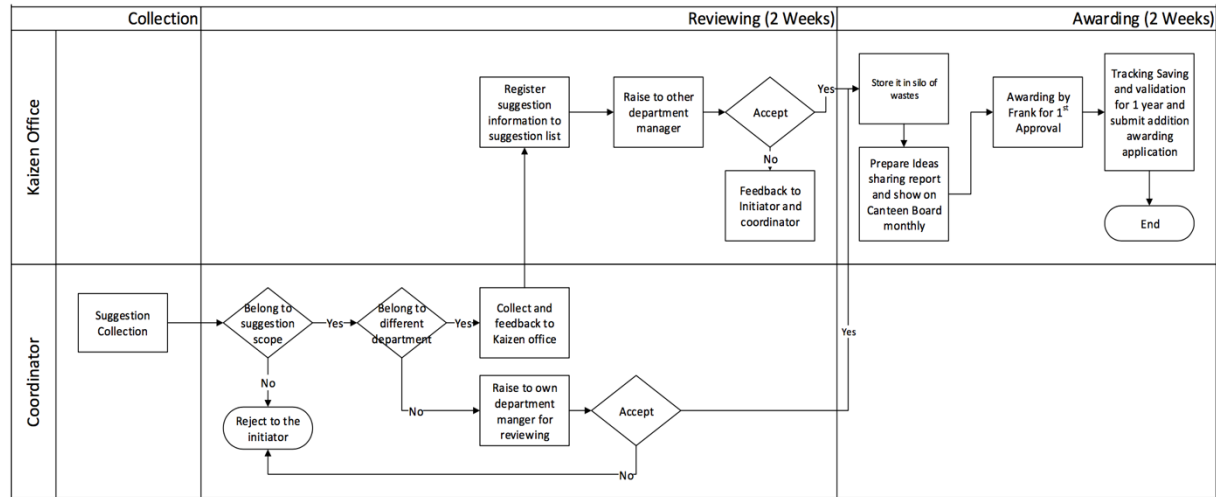
Fig. 48: Suggestion Process

This process has been accepted by the GM and applies to all departments at STC. After the definition, the Researcher discussed the process with the SKTL and they decided to change the sequence a little bit to avoid that other departments may appear in a bad light.

Every suggestion that is not related to the own MD & TF department has to be checked by the SKTL before its registration in the suggestion list. The mission of the MD & TF department is to do everything to improve the efficiency and working behaviour in the own department first and then the others.

3.12.2. Awarding & Promotion

Every accepted suggestion that fulfils the Suggestion scope receives an award of 100 RMB by the GM. The best suggestions will be summarized and presented at the management meeting and on the Canteen board. Depending on the cost savings through the implementation of the Suggestion, the value of the gift could be higher.

Cost Savings	Gift
Cost Savings from RMB 5.000 to RMB 50.000	Gift valued at RMB 500
Cost Savings from RMB 50.000 to RMB 250.000	Gift valued at RMB 1.500
Cost Savings of RMB 250.000 or more	Gift valued at RMB 2.500

Table 13: Suggestion awarding

3.12.3. Overview of the Suggestions from the MD & TF Department

The following figure illustrates a detailed overview of all collected suggestions in the department. In total, the department generated thirteen ideas during the period from January to May 2017. Eight suggestions have been accepted. Four of them are related to the MD & TF department and the rest to the other departments. Of the four suggestions related to the department, two were executed immediately

and the other two have been implemented as actions in the fourth loop. Only four suggestions were denied because they could not be implemented for various reasons.

ID #	Date Submitted	Category	Description	Action	Author	Department	Evaluating department	Evaluator	Result	Status
1	25.10.16	Time saving	Suggest reducing safe-guard call CD engineers for frequent coming visitors	11/7 Negiotiation with Gaochao and safety specialist, update the customer visitor list quarterly. But due to safety consideration, still make a call if the visitor is not included. 11/25 Confirm with Lily, at least 50% time is saved.	Chen Lili	MD&TF	PM	Gaochao	Accepted	Completed
7	11.01.17	Morale	Professional skill competition • Goal : to motivate our guys to have a good command of professional skills and learn experience from each other .to create a professional learning environment in STC for newcomer. • Content : from operators side ,we can organize the competition of operating PUMA or INCA. o from mechanics side , the competition of assembling engine .we can evaluate the speed and the accuracy.	1/18 Heng Yang & Li Wei replied that we don't have the time to prepare this activity.	Xiao Hongwu	MD&TF	MDTF	Heng Yang/ Li Wei	Denied	Completed
22	19.01.17	Safety	We still have wasted material (see picture) forgotten for years and even if last year Sha Qi had tried to make it better, it is still not finished. I think it's also a matter of 5S and CIP, can you please have a look also outside the building? For example this material should be quickly thrown away, also really not nice because on the street where everyone can see it. I also suggest to put a cover on the wire mesh because there are confidential vehicles totally exposed to the public.	The unused materials have been handled by Ayi. 2/10 Cheng chen has asked the quotation from supplier. 4/6 Cheng Chen replied Roman and Andrea have a deep discussion, to be discussed on EHS meeting.	Andrea Pagnini	MD&TF	Finance&Adr	Roman Ziegler	Accepted	Evaluation
38	14.03.17	Time saving	Inventory List of MD&TF cabinet and BOM receiving, better cooperation with Design Department	4/6 Xu Heping replied we just keep the present status, but Li Jun replied the process is not acceptable. The inspection should only be performed for 1st Lot.	Xu Heping	MD&TF	Design	Li Wei	Denied	Completed
39	14.03.17	Time saving	Process for handling "not working tools" with Facility Department	4/6 Pressure sensor recycling, but no feedback when completion. Since some sensors (0-4MPa) not enough. All repaired sensors will be retrived and bad ones are also returned to Xu Heping and run the scrap process. Ma Zhen replied 压力传感器坏了维修后返还，如果修不好就报废，温度传感器坏了后，但因为接头是通用的，焊接后还可使用。一般是1个月返还。	Xu Heping	MD&TF	Facility	Ma Zhen	Denied	Completed
49	06.04.17	Quality	The 1st thing I am just thinking about is to let new comers (development/calibration/MD/test operator) with working experience less than 3 years to build up one engine as the 1st step in AVL. One old engine (gasoline engine is OK) and its buildup manual should be prepared for this operation.	4/6Andrea agree.	Hu Junwei	MD&TF	MDTF	Andrea Pagnini	Accepted	evaluation
ID #	Date Submitted	Category	Description	Action	Author	Department	Evaluating department	Evaluator	Result	Status
50	07.04.17	Time saving	Maintenance repairs should be done outside of the Testing Time in Chassis Dyno. Ensure that we don't change the schedule of our customers.	4/12 Xiao Jun replied that they will change maintenance & checking time from the whole Monday morning to 7 to 9a.m. or for maintenance, move to Weekend. 4/27 Mr. Li Yanlu replied • They will try to implement troubleshooting during the over time if the colleagues want to work overtime and the troubleshooting is not too complicated. 基于本人自愿，Troubleshooting工作量不是很复杂的情况下，实施加班完成工作，以确保第二天能按时做实验。	Chen Lili	MD&TF	Facility	Li Yanlu	Accepted	Completed
51	07.04.17	Quality	Prototype engine build up, pallet set up and measurement of parts for all guys in the workshop team also test bed set up and test bed support for newcomers		Heng Yang	MD&TF	MDTF	Andrea Pagnini	Accepted	Evaluation
52	07.04.17	Quality	Training in the machining room (drill holes, cut screw thread etc.) for all guys in the workshop team		Heng Yang	MD&TF	MDTF	Andrea Pagnini	Accepted	Evaluation
53	07.04.17	Time saving	Whiteboard for Measurement Room to give Information about Project, Tools, Working		Xu Heping	MD&TF	MDTF	Andrea Pagnini	Accepted	Evaluation
65	26.04.17	Safety	Suggest adding deceleration strip (entrance/exit) to prevent vehicles run too fast then cause accident. 建议厂区内增加减速带（各出口处增加），防止厂区内车辆车速过快，发生意外。	4/27 Sha Qi agreed to implement this action, but the purchasing application needs to be approved by Roman and Jasmine 5/10 The suggestion has been accepted, waiting for customers to measure the size.	Lv Xinhua	MD&TF	HR	Sha Qi	Accepted	Evaluation
66	26.04.17	Morale	建议： 办公场所保持整洁干净固然重要，但我认为除了这些软环境方面的改进外，还应重视办公室的气氛，始终保持办公室的安静，有利于大家保持愉快的心情。下面一些不文明行为经常在办公室出现： 1. 大声说话或讨论问题，影响他人正常工作； 2. 说脏话、粗话，严重影响公司形象； 3. 打电话声音很大； 4. 电话铃声很大，声音刺耳； 5. 动作粗鲁（扔东西，使劲摔鼠标、电话、键盘等），制造很大的声音。 建议规范这些人的不文明行为。	4/27 This suggestion was not related in CIP scope, but Jasmine has discussed with the person.	Zhang Gengqian	MD&TF	HR	Xu Saihua	Denied	Completed
	18.05.17	Safety	现在客户的手机摄像头都是只贴后面，其实前面也能拍到的，因为有一次我过来拿工具的师傅用前置摄像头拍了一些送检的工具，我才注意到。我昨天问了门卫，他们说，领导是要求门卫只贴后摄像头的。然后贴前置的话，可能会损伤手机贴膜。我后来试了一下贴纸的粘度，对贴膜没啥影响的。		Li Yali	MD&TF	HR	Sha Qi	Evaluation	evaluation

Table 14: Suggestions of the MD & TF department

Table 14 shows a summary of the Suggestions at the category and the status of the implementation. The department collected suggestions in every category and reached a respectable result with eight accepted ideas.

The suggestion approach is on the right way but it needs time for the full implementation in the department. The Researcher is satisfied with the results and hopes that employees will maintain the process and bring new suggestions to improve their work environment in the future.

4. Conclusion

In this Chapter, the Researcher summarizes the achieved results and gives an assessment about the implementation of the CIP based on the "Eight Stage Process" by John F. Kotter. As described in Chapter 1.1, the Researcher took actively part during the execution of Process Mapping. Furthermore, he was responsible for the generation and implementation of Actions to increase the efficiency and working behaviour of the department. Next, the Researcher held some Awareness Trainings to explain the meaning of CIP and thus benefits to the daily work. At last, the Researcher was responsible for the implementation of various CI methods and tools such as Daily Kaizen, 5S and the Suggestion process.

4.1. Achieved Results

The following facts show the results that were achieved through the work of the Researcher at STC.

- Generation and Implementation of 18 Actions
- Achieved Cost savings through the Implementation of the Actions of about 1.127.800 RMB
- Introduction of Daily Kaizen through the installation of two boards
- Execution of 5S in the office area, warehouses, workshops and test beds
- Development and Implementation of a Suggestion process

Fig. 49 shows the results of the collected Suggestions by the category and the Implementation status. In total, the department acquired 13 Suggestions, which were related to all four topics to increase the efficiency.
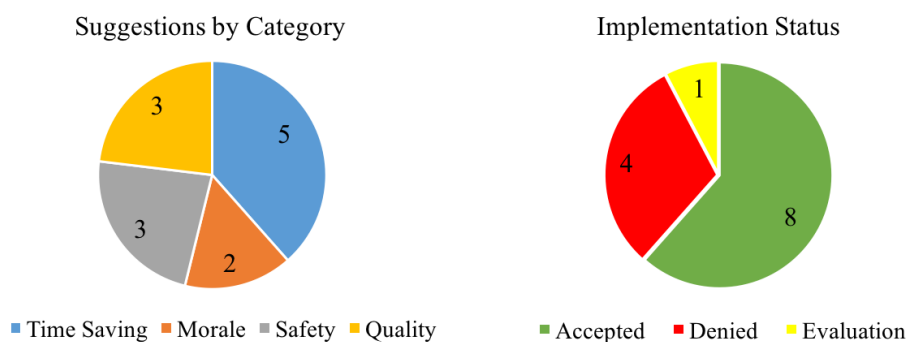
Fig. 49: Suggestion Status

In the following chapters, the Researcher describes the implementation process of the CIP at STC on the basis of the "Eight Stage Process" by John F. Kotter, what is one of the most famous Change processes.

4.2. Establishing a Sense of Urgency

The fundamental question was "Why do we need this program?". The first weeks during the implementation, the employees did not know the importance of the program. AVL China hold an Annual Party to announce the values of the previous year. In the year 2016, the results have shown that STC made a significant contribution to the success of AVL China. Therefore, the employees were wondering about the importance to the implementation of a CIP.

It transpired that it was difficult for the employees to handle the new situation. A conflict between the Project work and the CIP occurred. The employees did not know what topic has more relevant and that issue led to misunderstandings. It occurred that employees did not attend meetings and trainings and CIP tasks had been postponed.

The Researcher tried to explain the relevance of the program during the execution of the Awareness Training. The results of the last years were satisfactory and STC is growing year by year, but management wanted to set new incentives to develop the company culture. The implementation of the program needs time so that every employee in the company understands how important it is to improve the working behaviour and efficiency every day, because standstill means a step backwards.

4.3. Creating the Guiding Coalition

For the implementation of the CIP, the Kaizen office and the coordinators were introduced at STC. The coordinator of the MD & TF department was the Leader of the Logistics team. The team was established in summer 2016 and the coordinator was employed by building up the team. The communication between the Kaizen office, the coordinator and the Researcher was fine and together, they implemented certain tools and techniques in the department. The coordinator and the Researcher cooperated closely with the SKTL who supported the Researcher in important decisions. Together, the KO, the SKTL, the coordinator and the Researcher were a cooperate effective coalition during the implementation.

4.4. Developing a Vision and Strategy

The vision and strategy for the CIP at STC was clearly stated. The objective was to form STC to a Continuous Improvement organization. That means that the employees should be integrated in the improvement process and are actively involved by the creation of a new company culture.

In many companies, ideas and suggestions are generated and realized by management, but STC want the employees to be a part at the generation of the future of the company.

4.5. Communicating the Change Vision

The communication with the employees about the CIP is an essential topic. The Researcher executed various Awareness Trainings to make the program comprehensible for the employees. In the department, there are more than sixty co-workers and the Researcher divided them into different groups to guarantee a comprehensive training.

It has shown that the Awareness Training in groups is not enough and personal conversations were necessary. The employees are following their TL and therefore it was important that the team leaders understand the meaning of CIP.

4.6. Empowering Employees for Broad-Based Action

Through the implementation of Actions, Daily Kaizen, 5S and the Suggestion process, the employees were empowered to be involved in the CIP. The generation and execution of the Actions were done by the employees and the Researcher. This method offered the opportunity to set activities, which have an impact on the daily work. Through the conflict between the project work and the process, a few delays occurred at the sub-actions, but all Actions were still implemented on time. Daily Kaizen and the Suggestion process were implemented to provide the employees with a platform for generating and discussing possible improvements to increase the efficiency and working behaviour.

4.7. Generating Short-Term Wins

In total, the department implemented eighteen Actions, which were divided into four loops. Every team in the department was responsible for certain Actions. Two Daily Kaizen boards were introduced in the MD and Logistics team. 5S was executed in all teams and it was the employee's first liaison with such a CI method. Additionally, audits and awardings were set to demonstrate the importance of the program. Furthermore, the Researcher established a process to handle the employees' suggestions.

4.8. Consolidating Gains and Producing more Change

Chapter 7&8 describe the next steps that should be set for a successful implementation of the CIP. The Researcher gives some proposal for the next steps in order to continue the program in the department. Firstly, the coordinator should learn from the arisen issues and try to avoid that the same problems occur again. Furthermore, to guarantee a knowledge transfer between the departments, the cooperation of the coordinators should be better. Thirdly, the standardization of the implemented methods and tools is

necessary. Actions for the next loops have to be generated to continue the Improvement process. The introduction of further Daily Kaizen boards is essential. Therefore, the Workshop, the Test Bed and the Chassis Dynamometer teams have to start with the implementation of their boards. The start of the 5S approach is done and improves the condition of the department massively, but this level has to be standardized and enhanced to avoid that the condition falls back to the initial situation. The promotion of the Suggestions has to be better. The employees must be motivated to share ideas and to be a part of the CIP.

4.9. Anchoring New Approaches in the Culture

After the standardization of the implemented methods and tools, the next step should be the introduction of new approaches. To avoid the conflict between the Project work and the CIP, management should establish time spans so that the employees can be creative to support the CIP in the department. Furthermore, the implementation of Key Performance Indicators is helpful in order to make the improvements visible. It supports the development of the CIP and provides the employees with an overview of the progress. The establishment of new methods and tools such as Six Sigma and FMEA (Failure Mode and Effects Analysis) could help by the continuation of the program, but it has to be checked in advance in which fields it does make sense to implement them.

It should be emphasised that under consideration of Change and Cultural aspects the start of the CIP in the MD & TF was well satisfactory. The occurred problems were only natural through the implementation of a Change Process, but with a strong organization in the back based on the SKTL, the KO, the coordinator and the Researcher, the problems could be successfully removed. The basis was laid to continue the CIP at STC. Therefore, the Researcher wishes STC and particular the MD & TF department all the best for the continuation of the CIP.

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