Maintaining your competitive edge

PlaneSense: process improvement in aviation maintenance

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Publication date
2015

Document Version
Final published version

Amsterdam University of Applied Sciences

CENTRE FOR APPLIED RESEARCH TECHNOLOGY

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PLANESENSE: PROCESS IMPROVEMENT IN AVIATION MAINTENANCE

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07

Amsterdam University of Applied Sciences

A publication in the Centre for Applied Research Technology of the Amsterdam University of Applied Sciences series

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Text editor: Stephen Johnston, Scribe Solutions, www.scribesolutions.nl

Layout: Nynke Kuipers, www.elkedageentekening.nl

Printed by: SDA Print+Media

ISBN 9789492219008

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PREFACE

Aircraft Maintenance – be it line, system, or component-related – provides an ever growing contribution to the total revenues generated by companies active in the aerospace sector. As such, MRO (maintenance, repair and overhaul) constitutes an important element in the overall value chain, and provides companies of different sizes with business opportunities...provided that these companies are prepared for the various challenges facing them in a global, competitive environment. Airlines typically demand that MRO activities be performed efficiently, at competitive prices, with improved product and/or service quality and fast turn-around-times.

Large players, such as KLM Engineering & Maintenance, have access to internal and external expertise to develop and implement product and process improvements in response to these customer requirements. However, Small and Medium-sized Enterprises (SMEs) often lack the resources and access to knowledge they need to continuously improve their operational performance. In recognition of this, the Aviation Academy of the Amsterdam University of Applied Sciences, supported by the Dutch Ministry of Economic Affairs, initiated a RAAK program (Maintain Your Competitive Edge) to assist SMEs in successfully identifying and implementing process improvements.

A specific, hands-on approach was created by capitalising on one of the inherent strengths of SMEs: learning by doing. Elements such as performance management and process optimisation were discussed in 'expert groups' formed by participating companies. Each participating company then started to identify process improvements relevant to their operational environment and began to implement them internally. Meetings were also organised between SMEs to share information about their Maintain Your Competitive Edge experiences and to discuss practical solutions to commonly-encountered challenges. For example, company culture was recognised as an important factor in successfully implementing process improvements and ensuring that improvements could be maintained. As a result, some companies adjusted this aspect of their organisation.

As the project drew to a close, the companies involved were able to stand on their own when it came to continuously improving their internal processes. Going forward, collaboration with the Aviation Academy and interaction with their peers will help participating SMEs continue to address process improvement initiatives successfully. Moreover, a Maintain Your Competitive Edge toolbox now provides each SME with even more abilities on their journey towards operational excellence.

I have had the privilege to work in the aerospace MRO sector for over 20 years, and I am convinced that the outcome of the RAAK program as embodied in this publication provides SMEs with a roadmap and toolbox which can make them more competitive in the demanding international MRO arena. I would like to thank the Aviation Academy, the Nationaal Regieorgaan Praktijkgericht Onderzoek SIA and the Ministry of Education, and of course the participating companies for contributing their time and efforts in helping the Dutch aviation industry to become best-in-class.

René van Doorn

Voorzitter Netherlands Aerospace Group

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INTRODUCTION

The Aviation Academy of the Amsterdam University of Applied Sciences is proud to present the results of the Maintain Your Competitive Edge project in this booklet. The seeds for this project were planted in 2011 by students in our initial Aviation Engineering honours class, who identified the need for smaller maintenance companies to improve their competitive position by applying Lean principles. After some initial improvement projects, we were awarded a grant by what is now called the Nationaal Regieorgaan Praktijkgericht Onderzoek SIA early 2012. This allowed us to extend the scope and intensity of the Maintain Your Competitive Edge project, which addressed a number of questions relating to SMEs in the MRO sector:

- What method is currently used to measure performance, which performance indicators are relevant, and what is the current performance level?
- What concepts, methods and techniques make it possible to improve performance?
- How can this knowledge be transferred to smaller maintenance organisations to help them improve their processes with minimum external support?

During the course of this project we performed research to answer these questions, and we have been able to define and justify an approach that facilitates the improvement of maintenance-related processes. We have also successfully rolled this method out across a number of SMEs. This booklet reflects the expertise that we have generated over two years of hard and enjoyable work. We hope that what we have developed will turn out to be beneficial to current participants as they continue to improve, as well as to the many maintenance SMEs not yet acquainted with the Aviation Academy – including those outside Europe and in other domains.

This project and this publication could not have been realised without support from the participating companies, the expert panel, and the consortium members who provided guidance for our research. Many teacher-researchers were also involved, as well as the various student cohorts who executed the literature reviews and many of the in-company sessions. Other students made toolbox prototypes, websites and simulation games. I would like to thank all of these people for their hard work, enthusiasm and spirit: we made it happen.

Robert J. de Boer

Lector Aviation Engineering

1 AN OPTIMISATION PROGRAM FOR AVIATION MAINTENANCE ORGANISATIONS

This publication presents the results of the Maintain Your Competitive Edge project, aimed at identifying ways for smaller aviation maintenance companies to improve their competitive position by applying Lean principles. The project was made possible by the Nationaal Regieorgaan Praktijkgericht Onderzoek SIA through a RAAK grant (see Appendix I 'What is Raak?' for an explanation of the RAAK subsidy). The project looked at the process optimisation challenges faced by Small and Medium-sized Enterprises (SMEs) in the aviation Maintenance Repair and Overhaul (MRO) sector. As such, it generated ways in which SMEs could apply process optimisation in an aviation MRO environment, including:

- The creation of a framework to apply process optimisation in an aviation maintenance environment;
- The different phases of continuous process optimisation and how to realise them;
- The supporting tools that provide SME MRO organisations with the knowledge and expertise they need to succeed in their working environment.

This publication contains an approach – resulting from the project – aimed at strengthening the competitive position of maintenance companies in aviation. Feedback provided by participating companies (see Appendix II 'Participating Companies' for a list of all companies involved) and instructor expertise (see Appendix III 'Research Partners' for a list of internal and external parties and expert group companies) rounded out the results. This led to a set of general guidelines that can – and should – be adapted to each company's specific characteristics.

1.1 The current position of MRO SMEs

1.1.1 MRO SMEs are under pressure

Aircraft maintenance is seen as a focal point by Dutch industry and society when it comes to a potential growth market for the knowledge economy[1.2.3]. Starting at the turn of the century, the Dutch aviation industry experienced growth far greater than that of average Dutch industry[4]. In fact, maintaining aircrafts, systems and components now represents about 70% of the total revenue in the Dutch aviation cluster[5]. The Netherlands is home to three large maintenance organisations: KLM Engineering & Maintenance, Fokker Service and Woensdrecht Logistics Centre. 50 smaller organisations are also active in this sector[6]. All of them perform maintenance on aircraft and aircraft components. Those that work on aircraft can be further divided into those that work on small business jets and propeller-driven aircrafts, and those that work on commercial airliners. Other specialised companies focus on engines, aircraft cleaning, and the disassembly of end-of-life aircraft. The aircraft maintenance industry in the Netherlands is united under the Netherlands Aerospace Group (NAG), which also represents the aerospace manufacturing industry. Since the financial crisis, many organisations have had to reduce costs and maximise income to prevent bankruptcy. For example, the Air Transport Association has estimated that airlines lost $11 billion US dollars in 2009[5]. Losses were also seen in the private jet sector[7]. Effects from the crisis have echoed throughout SMEs in the MRO sector[8]. These companies now face a number of threats to their existence, as customers – with challenges of their own – become more demanding when it comes to price, delivery, reliability and lead times. Some airlines are insourcing maintenance to utilise excess capacity, and Original Equipment Manufacturers (OEMs) such as Boeing are offering maintenance with their new products (such as the Goldcare program). Other OEMs are extending their footprint in Europe – Bombardier's new Amsterdam service centre for business aircraft opened its doors in 2010[9]. To meet the new service levels required, many of the smaller maintenance companies are investigating ways to optimise their maintenance processes.

1.1.2 A variety of process optimisation approaches

We define process optimisation as a collective term for methods that eliminate non-value-added activities and reduce the complexity caused by the wide variety of suppliers, customers, internal resources and processes[10]. Process optimisation methods include Lean, Six Sigma, Total Quality Management (TQM) and Theory of Constraints (ToC).

Each of these methods has its own philosophy and purpose:

- Lean: a reflection of the Toyota Production System. Its purpose, as defined by Womack and Jones, is to eliminate non-value-added activities (waste) in every process, including customer relations, product design, the supplier network and factory management[11];
- Six Sigma: a system used to achieve, maximise and sustain business succes. It is driven by the understanding of customer needs, the use of facts, data, and statistical analysis, and attention to managing, improving, and reinventing business processes[12];
- Total Quality Management (TQM): defined as a continuously evolving management system. The purpose of TQM is to increase both external and internal customer satisfaction with a reduced amount of resources[13];
- Theory of Constraints (ToC): an identification of sequenced system constraints to provide the largest and fastest benefits[14].

This project identified the common denominators for these methods, and used them as guiding principles for our improvement approach.

1.1.3 MRO SMEs lack process optimisation knowledge

SME aircraft maintenance organisations are starting to realise that cost saving and lead time reduction can mean the difference between bankruptcy and survival. At the same time, researchers now have a great deal of knowledge about ways to implement process optimisation, as evidenced by the Lean and Six Sigma methods mentioned above. However, it appears that this knowledge has not been implemented by SMEs in the aviation MRO sector. They are still asking questions such as:

- "How can we increase delivery reliability in the aircraft maintenance process?"
- "How do I keep my material flow transparent to prevent long lead times and achieve cost savings?"
- "How can we decrease lead times, increase punctuality and increase predictability in an environment with high product variation?"

Our initial research at these organisations helped us identify two fundamental reasons why these organisations have not put this knowledge to full use[15,16]:

- Small organisations have a limited connection to previously-developed knowledge. For example, they are not members of knowledge institutions and cannot always free-up management resources for training;
- Small organisations are challenged by low volumes, product variability and the nature of maintenance – unpredictable response times from support operations and external suppliers, and complex and unpredictable flow paths. This makes it difficult to design a standard and predictable process that can function as a foundation for further improvement.

Any new approach to support SMEs in the MRO sector therefore needs to take these constraints into account.

1.2 The role of the Aviation Academy

Quite recently, universities of applied sciences in the Netherlands and across Europe have been tasked with executing practical research. This was deemed necessary not only to ensure a higher quality of graduates, but also to bridge the gap between academia and industry. Academic output (as defined by the amount and level of scientific publications) is quite high, but this knowledge has limited application in companies and has not improved their competitive position. The Amsterdam University of Applied Sciences has therefore supported the development of the Aviation Academy to execute practical research in the domain of aviation, and to ensure synergy with the educational program for aviation engineers (see Appendix IV 'The Aviation Academy' for a full description).

During recent years, Aviation Academy interns have suggested process improvements at several Dutch and Swedish aircraft maintenance organisations. However, these small projects did not solve the previously-mentioned structural problems identified in the Aviation Academy's initial research. For instance, there was still a lack of knowledge and resources about how to implement process optimisation methods such as Lean and Six Sigma to unpredictable maintenance processes. A way was needed that would allow individual aircraft maintenance organisations to apply process optimisation by themselves, with minimal external support. The question leading this research was therefore:

What possibilities exist for maintenance organisations to improve and consolidate their performance, given their specific situations?

This project conducted research into the possibility of applying process optimisation methods such as Lean and Six Sigma within the unpredictable conditions of maintenance as performed in aviation and aviation-related areas. The results build on state-of-the-art knowledge from scientific literature and practical knowledge from institutions such as T.U. Delft, the Schiphol Group Lean Office, the KLM Lean Six Sigma Office and TNO, all of which are represented in this project's 'expert group'. Additional expertise was made available through collaboration with the University of Tennessee's Dr. Melissa Bowers and Dr. Mandyam Srinivasan (whose expertise had recently become

available for the general public through the publication of their new book: *Lean Maintenance Repair and Overhaul*[17]*).* Project participants included a variety of small aircraft maintenance organisations, represented by the NAG and JetSupport. Previously-existing relationships also made it possible to include a variety of foreign aviation maintenance organisations in this project.

Aside from assisting MRO SMEs in performance optimisation, the Maintain Your Competitive Edge program also had the additional purposes described in Figure 1.1.

1.3 Project approach and justification

The project was divided into four stages, with participating company feedback used between each one to help provide input for the next stage[15]. Although the project stages were sequentially planned, there was overlap between them.

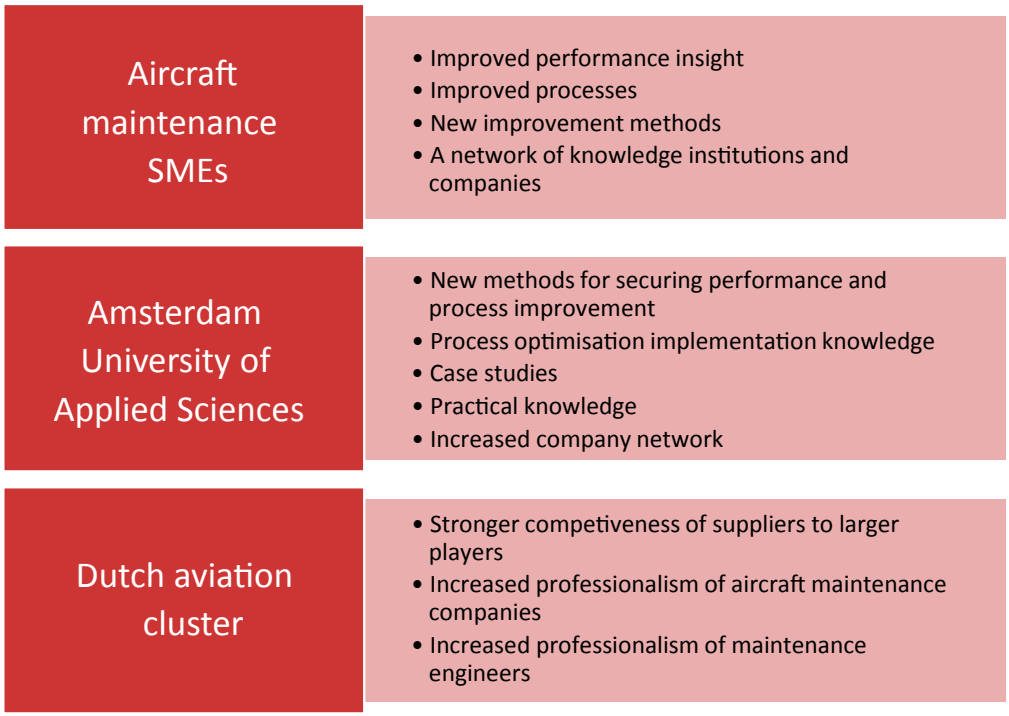


Figure 1.1 Purposes of the Maintain Your Competitive Edge project[15]

Stage 1: Diagnoses for improvement

During the first stage, we focused on providing organisations with insight into how they currently dealt with performance measurement and process improvement. This insight helped the companies decide where to begin their improvement efforts. The project team then developed an improvement roadmap based on the available process improvement literature. This roadmap merged steps from different process optimisation techniques into six generic improvement steps, which were used to start improvement projects.

Stage 2: Definition of optimal methods

The purpose of this stage was to improve and test the process optimisation roadmap developed in Stage 1. Stage 2 input included the typical characteristics of MRO SMEs, and how they related to existing knowledge within the field of process optimisation. Aside from improving and testing the roadmap, research was conducted to measure participating companies' performance levels.

Stage 3: Executing the roadmap

The purpose of Stage 3 was to provide participating companies with improved knowledge about our tailored methods for process optimisation, as reflected in the execution of the roadmap. This execution was monitored and adjusted when necessary by the project team. Additional research was also performed around the factors that enabled – and supporting tools that assisted – process optimisation success. Companies received a lot of help with their improvement projects during this stage.

Stage 4: A framework for self-optimisation

Stage 4 combined research results with a roadmap execution experience to create a framework that is central to this booklet and is described in the following chapters. We have called this the PlaneSense framework to reflect its focus on assertion and its logical form. We have also disseminated our findings through conferences[18,19,20,21,22,23] and other publications[24]. The PlaneSense framework allows SME aircraft maintenance organisations to optimise processes by themselves.

As we developed our methodology, we applied an Action Research approach[25]. A comprehensive literature review helped us develop an improvement approach, which was tested with the participants. This experience allowed us to modify our approach for the next case study, and the framework gradually grew. Our methodology was further enhanced by challenges from the expert group and the project consortium, as well as through our interactions with other experts associated with Lumics GmbH, the KLM Lean Office, and the University of Tennessee College of Business Administration.

Lack of progress caused by employee resistance at a few participating companies prompted us to develop the Critical Success Factors, many of which are designed to overcome this type of bottleneck. A lack of alignment between improvement projects and company objectives further led to the introduction of Hoshin Kanri. During the last few months, we assessed everything that we had learned and grouped the successful modules into a single approach: the PlaneSense framework.

1.4 The PlaneSense framework

The PlaneSense framework – developed as a result of the project – is presented in Figure 1.2 and applies to problems currently experienced by MRO SMEs, such as the unpredictable nature of maintenance, low volumes and product variability. It has proven to be a useful starting point for organisations just getting their process optimisation journey under way, but has also been used effectively to realign more experienced companies during their journey. By applying the PlaneSense framework, organisations are able to gradually move from multiple small improvement projects to larger projects. Ultimately, these companies will reach a steady-state in which they can constantly improve without major shocks to the system. The PlaneSense framework represents the interaction between process capabilities and improvement capabilities. The philosophy behind the framework is that process optimisation will not succeed if it merely focuses on process capabilities or improvement capabilities by themselves. Instead, process optimisation will only succeed when hard factors (process capabilities) are developed next to soft factors (improvement capabilities). Therefore, the PlaneSense framework

identifies tools, techniques and Critical Success Factors (or CSFs) to facilitate process optimisation. A 'tool' is defined as a single device that has a clear role and use of its own, while a 'technique' has a wider application, including thought, skill and training[16]. CSFs refer to factors that are essential for process optimisation success, including human and organisational factors.

The process optimisation journey begins with a Quick Scan. As the name implies, the scan is performed quickly, allowing you to start your improvement journey immediately. It defines the best combination of process optimisation methods for your company's specific characteristics, targeting both hard and soft factors, and identifies the strategically important improvement projects with which to start.

The Quick Scan also includes a baseline measurement to assess your current level of Critical Success Factors (CSFs) and to subsequently propose a development plan to develop the low-scoring ones. CSFs address the human and organisational factors that need to be aligned with 'hard' process improvement capabilities to ensure that the improvement journey does not stagnate.

The process improvement cycle is initially executed in multiple small improvement projects. This enables you to learn the fundamentals of process optimisation – learning by doing. As you gain more experience, the projects become larger. Incongruity with the operations strategy and company goals may start to appear, leading to the need for realignment. After realignment, the process improvement cycles can then continue

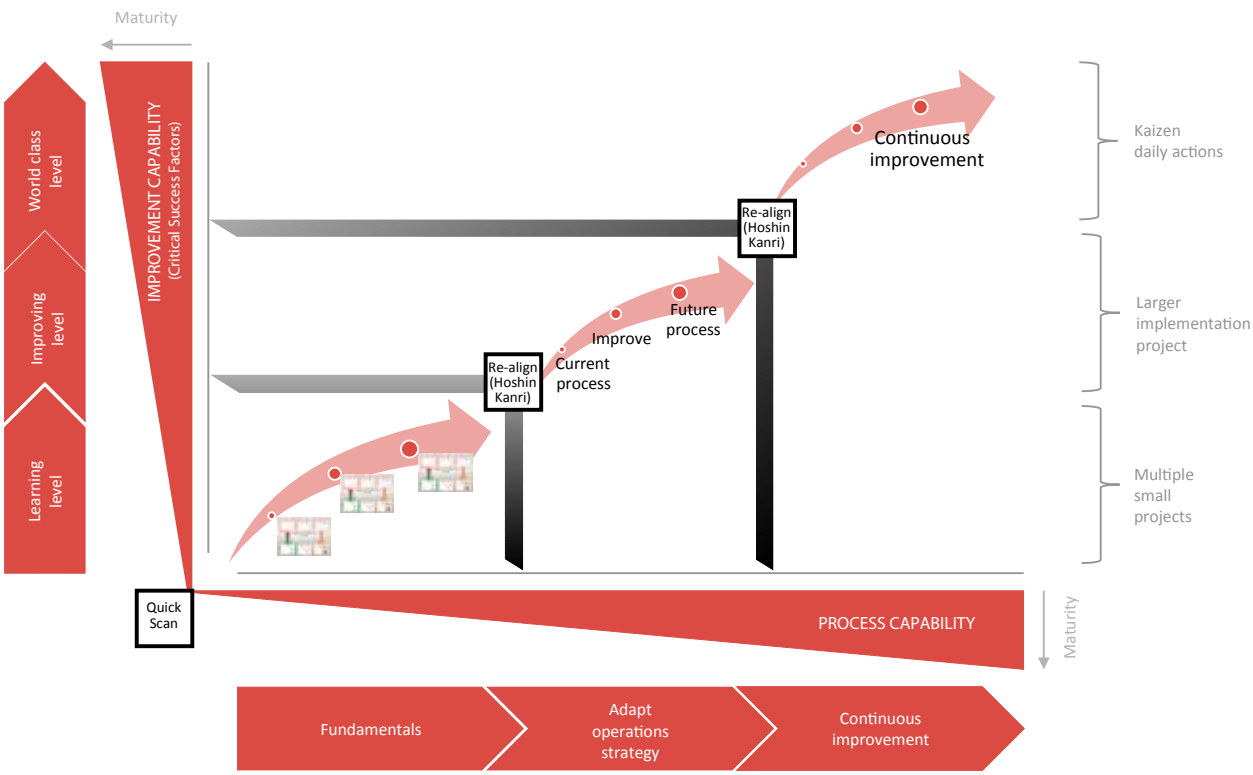


Figure 1.2 The PlaneSense framework for process optimisation at SMEs in the MRO sector

and increase in scope. In time, and possibly after more realignment, the process improvement cycles will become part of company culture, and you will be well on the way to continuous improvement.

Process optimisation is a continuous process...it never stops. Each time a process improvement cycle is completed, a new beginning is made with another improvement suggestion. If no improvement suggestion is available, then you should consider re-aligning company strategy as a basis for defining new improvement suggestions. At the same time, you should be mapping and using new CSF levels to track progress and realign development for even more success[27]. The ultimate goal of the PlaneSense framework is to involve and motivate every person within your organisation to strive for process optimisation. This can be enhanced by daily Kaizen events, which represent progress within a rapid improvement program that eliminates non-value-added activities within a system or process[28].

1.5 The PlaneSense toolbox

The interpretation and start-up phases of process implementation require time – something SMEs in the MRO sector are traditionally short on. These companies may also have limited connection to previously-developed knowledge. To help, the project team created a toolbox intended to assist in the implementation of process optimisation framework fundamentals. The main requirement was that the toolbox should be able to motivate, inform and support MRO SME organisations as they implement process optimisation[29]. The PlaneSense toolbox design is presented in Figure 1.3.

The PlaneSense toolbox is published as a website that the Aviation Academy frequently updates to keep up with new trends in process optimisation. It mirrors the PlaneSense process optimisation framework, from which organisations can consult the different topics as required (Quick Scan; Critical Success Factors;

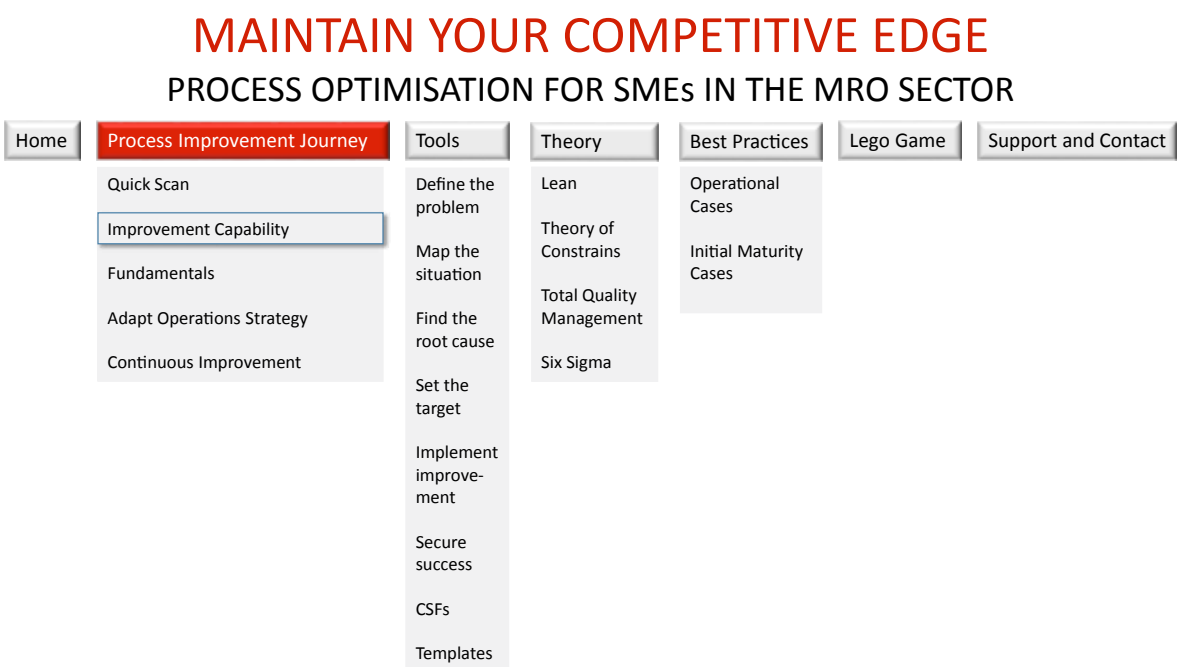


Figure 1.3 The PlaneSense toolbox design

The PlaneSense framework at Nedaero

Nedaero is a component maintenance specialist company and a manufacturer of avionic instruments. They repair and manufacture for maintenance centres and aircraft manufacturers around the world. Core MRO staff consists of approximately ten people, but can be increased by allocating manufacturing staff. Short delivery lead times that conform to customer standards of 7 to 14 days are vital to their MRO business, and these lead times are becoming increasingly shorter. Delivery reliability is important too, as their customers plan for replacement units. An increase in productivity was needed to be able to sustain high performance and technical innovations.

Nedaero's journey started when the project team noticed that the company's plans to introduce a milestone-based control process in their MRO business showed remarkable similarities to Theory of Constraints (ToC) principles. They described the strength and added value of these principles to Nedaero, which resulted in cooperation that started with a Quick Scan to discover the gap between current Nedaero practices and full implementation of ToC principles. This in turn resulted in a set of activities that would make it possible to implement Critical Chain Project Management and Drum Buffer Rope ways-of-working.

The plan was set in motion, and the project team analysed data from the company's existing ERP system, providing lead times, delivery reliability, portfolio composition and customer-specific performance. These insights, along with other specific implementation actions, led to improvements across all of their KPIs.

The projects involved intensive cooperation between the Operations and Customer Support managers, who were trained and educated along the way. After a few months, Nedaero decided to implement daily whiteboard meetings on the shop floor as well as at the Customer Support department. Ruud Kleinendorst, CEO, says: "In terms of daily actions, we have introduced whiteboards for daily morning group meetings at customer support and we will soon be doing the same in the shop. This allows people to reflect on what has been achieved and what can be done better on a daily basis."

The need for Aviation Academy support diminished. However, Nedaero recently requested more assistance to ensure that their Lean initiatives were aligned with company objectives. We therefore executed a Hoshin Kanri strategy alignment in a small number of sessions. This allowed Nedaero to visualise goals and planning priorities, measure and display KPIs, and discuss problems and risks for the days to come. Employees appreciated the clear information based on the results of their work, and became more involved in discovering problems and finding solutions. Although their output had never been larger, they felt like they had less work to do. This was an important signal – it demonstrated a new "in control feeling" throughout the company.

The next step for Nedaero will be to take on even larger improvement projects: adapt the shop floor layout and introduce visual management/ logistics in the shop. This will further reduce waste and contribute to the implementation of ToC principles. Nedaero has already achieved considerable improvements in lead times, delivery reliability and output, and they are set to keep on improving. It won't be long before sales volume will become the critical growth factor...operations can currently just handle all customer requests.

Process Improvement Cycle; Realignment of the Process Optimisation Journey; and Continuous Improvement). The toolbox also presents process optimisation tools to help you realise improvement. It allows organisations to self-assess their business with regard to improvement capability (the soft side) and to determine the focus for organisational development. It then offers references to MRO simulations and training for further organisational development.

1.6 Reading guide

This chapter has introduced the motivation of the Maintain Your Competitive Edge project, the current position of MRO SMEs, and a framework that allows SMEs in the MRO sector to improve and consolidate processes as much as possible by themselves. The PlaneSense framework is the foundation of this book and is described in detail in the chapters that follow. We have also described the PlaneSense toolbox that supports users in their process optimisation journey.

Chapter 2 introduces the Quick Scan as a way to define specific process improvements within organisations. The PlaneSense simulation is also introduced as a serious game used to acquaint the organisation with process optimisation and the ways in which it can yield benefits. Chapter 3 addresses the fact that tools and techniques alone do not create process optimisation success. Instead, success results from the interrelationship between these hard factors and 'human' and 'organisational' factors, called the CSFs of process optimisation. Chapter 4 describes the journey to a process optimisation culture, starting with some small improvement projects to get the organisation involved. Chapter 5 discusses the three phases of moving the process optimisation culture forward, using Hoshin Kanri sessions to realign the roadmap to company goals. Chapter 6 describes the last phase towards a process optimisation culture, through continuous improvement via daily Kaizen events. The final chapter contains some concluding remarks and hints for process optimisation success.

The rest of this book will address you, as the reader, directly. We hope that this will provide even more motivation for you to apply the PlaneSense framework and reap the extremely beneficial rewards.

2 GETTING STARTED: SIMULATION AND QUICK SCAN

Most Lean and Six Sigma project leaders find it difficult to find the right place to start their process optimisation journey. It is therefore beneficial to use a front-end analysis mechanism to focus on strategically important projects for the organisation – projects from which the process improvement may yield greater benefits. We propose a Quick Scan audit method to do this and to help you identify small projects with a maximum return on investment[30]. The Quick Scan also includes an initial assessment of the Critical Success Factors (CSFs) that address human and organisational factors.

SMEs in the MRO sector usually have little knowledge or experience in the field of process optimisation, and spend much of their time putting out fires instead of structurally solving problems. The project team has therefore developed a PlaneSense simulation to support the introduction of Lean at your company. This simulation is a serious game that accurately mirrors the dynamics of the MRO environment, and is perfect way for you to help participants become acquainted with Lean process improvement principles before you start the Quick Scan.

2.1 The PlaneSense simulation

Our initial research revealed that companies like yours – SMEs in the MRO sector – often have a limited connection to previously-developed process optimisation knowledge. Typical SME and MRO characteristics might also make it difficult for you to implement this type of knowledge when you do acquire it. In response, our project came up with the PlaneSense simulation game to help teach the fundamentals of process optimisation and get team members off to a good start.

The PlaneSense simulation provides a controlled MRO environment based on LEGO airplanes (see Figure 2.1). It is an ideal way to provide the complexity necessary for an accurate representation of reality while maintaining ease of manipulation for speedy insight. During the simulation, you and the other participants will gain immediate information about process improvement opportunities – insight that you can then rapidly use to implement improvements based on Lean and the Theory of Constraints methodology. The game simulates the most important characteristics of MRO companies, including the wide variety and unpredictability of maintenance tasks. The process will also challenge you to think beyond the boundaries of departments to view the MRO process as a whole.

You will leave the simulation with concrete process optimisation knowledge, including:

- An understanding of the overall process;
- Solutions for improvements within your MRO organisation;
- Knowledge of Lean and the Theory of Constraints methodology;
- An understanding of where you require assistance in applying Lean and the Theory of Constraints;
- The identification and elimination of waste within MRO processes;
- The application of Key Performance Indicators (KPIs).

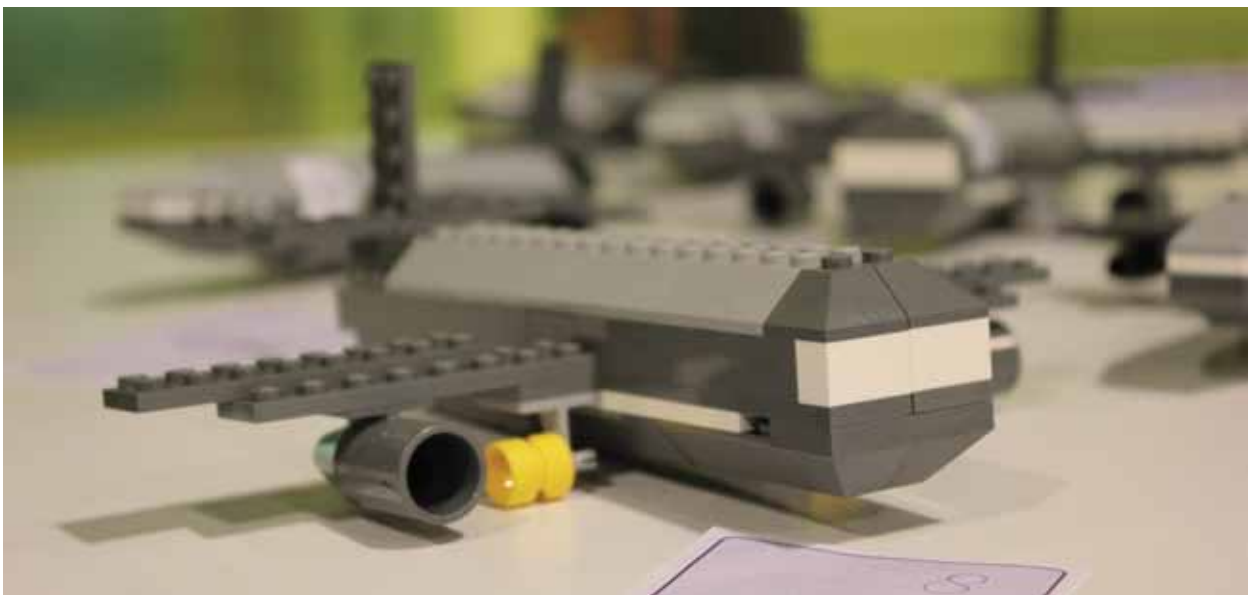


Figure 2.1 Maintenance check on a LEGO aircraft

The simulation gradually introduces Lean and the Theory of Constraints implementation over a period of a few sessions, providing knowledge about improvement methods such as 5S, 7 Waste's, and Flow and Pull. At the end of each session, you and the other participants can provide feedback and come up with new optimisation improvements for the simulated MRO process. The idea is to reduce all waste while implementing the right methods at the right time and within the right department to achieve greater results.

This PlaneSense simulation is played in a realistic setting, involving a variety of parties from the MRO organisation including managers, maintenance engineers, inventory checkers, and so on, to simulate the organisation's current environment. Input for the game is delivered by sending LEGO aircraft requiring maintenance to the MRO organisation. Maintenance checks range from A, B, C and D-checks to AOG-checks. As in the real world, the interval in which a check occurs and the time it takes to complete a check varies. The different types of LEGO aircraft also contribute to an environment with high product variability.

As you play the game for the first time, you will see that it reveals typical SME characteristics in the MRO sector: maintenance engineers have to wait for parts before an inventory-checker hands them over; planes requiring maintenance start to build up in front of the hangar due to lack of capacity, and aircraft are not delivered on time due to an extensive checking program that is not integrated into maintenance procedures. The results of the first round will make it clear that keeping track of the right KPIs is extremely important: to measure is to know. Interestingly, most participants are able to devise improvements even without preliminary training.

The fact that Lean contributes to a better process will also become clear once you have mapped the current process and made a distinction between value-added and non-value-added activities. This insight is the starting point for an improved situation, which will then become evident once you play the game incorporating the suggested improvements and eliminating the non-value-added activities as much as possible. More aircraft will be delivered on time.

However, the simulation also emphasises the challenges of implementing Lean, as you start to work out process improvements. For instance, one participant may come up with an improvement suggestion, only to find that the person responsible for implementation says it is not feasible. They may then introduce another suggestion that is feasible, leading to an improved situation.

After playing the game, you will leave the room with a clear idea of the benefits that process optimisation can bring in terms of realising improvement. Three or four sessions in one day are usually enough to provide sufficient understanding of the process improvement principles.

The PlaneSense simulation game

The PlaneSense simulation game has generated the following reactions from participants:

"More interaction and communication between all employees as well as more responsibility and competency within the workforce leads to better solutions and results, and also are decisive factors in Lean production. Improved communication about – and concentration on – the essentials leads to a continuous improvement process."

"Each department on its own is an important link in the chain within the MRO process and every change made in the MRO process must be fully understood by each department before implementation. It is important to look at each individual department step (customer, planner, worker, inventory supplier, checker, etc.) and see them as part of a whole process. Improvements implemented during the course of the simulation will have the most impact if they are carefully communicated between each department. Communication is key."

2.2 The Quick Scan

The Quick Scan is a stepwise approach that you can use to identify strategically important improvement projects for the organisation – projects through which Lean and Six Sigma may yield large benefits.
A Quick Scan includes interviews, the mapping of selected value streams and an assessment of the Critical Success Factors. It is typically executed in three days (see Figure 2.2).

The result of the Quick Scan is a set of improvement suggestions ready for implementation and documented in a kick-off document. It provides the starting guidelines as well as background information about processes, bottlenecks and CSF levels.

2.1.1 Introduction of the Quick Scan

To introduce the Quick Scan, hold a session with your company management – including the General Manager and the Quality Manager. They can contextualise the need to improve, and explain their priorities regarding the processes to be addressed. You – or facilitators from the Aviation Academy – can then introduce the PlaneSense approach to determine the data requirements and processes to focus on.

2.2.2 Project charter

Companies who participated in our project were very clear that process optimisation was likely to fail without employee engagement. Therefore, once the Quick Scan has been introduced you should explain the project to the employees, including its focus, scope and schedule, as well as the specific company characteristics and the improvement opportunities that management is looking for. Ideally you should do this during some kind of get-together and support it by a written charter. This will give the project team a place to start, and provide initial focus to ensure employee engagement and motivation throughout the process optimisation journey.

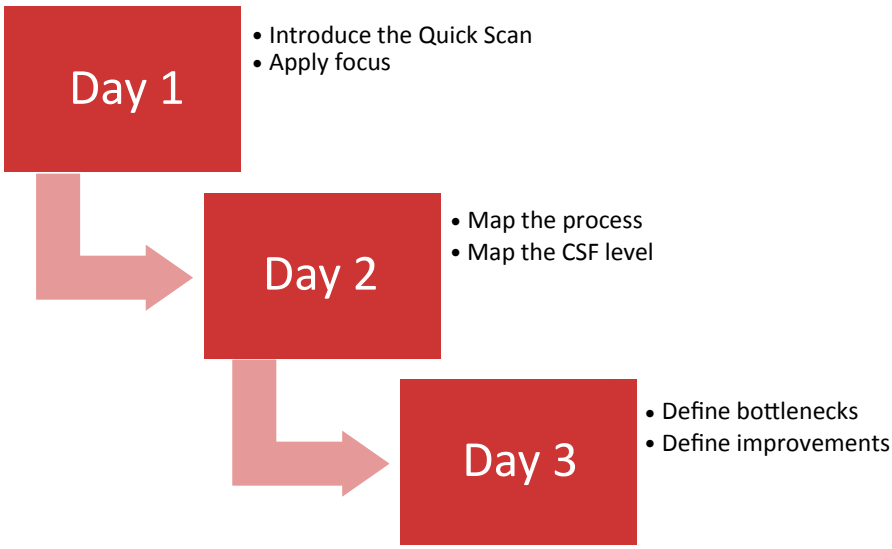


Figure 2.2 Quick Scan planning and phases

2.2.3 Map the process and Critical Success Factors

Once you have identified the focus of the initial improvement opportunities, it is time to map (using post-its, for instance) the main characteristics of the current situation to better understand the process and involved parties. This will include a variety of parameters (such as lead time, true value created for the organisation, etc.) for each process step to gain a clearer view of what exactly is supposed to happen.

You should gather this data through the on-site attendance of the Quick Scan team to perform diagnostic activities based upon four sources[23]:

- Qualitative questionnaires;
- Value stream maps;
- Semi-structured interviews;
- Data analysis.

Qualitative questionnaires should be filled in by key members of the organisation who have the knowledge and capability needed to provide the required data. Value stream maps provide a detailed overview of the material and information flow for a specific process and the ratio between value-added and non-value-added activities (you can read more about this in section 4.1 and in the toolbox itself). This will reveal the typical characteristics of small maintenance organisations, such as unpredictable response times from support operations and external suppliers, and complex and unpredictable flow paths.

Semi-structured interviews with both senior and middle management will assist you in acquiring and verifying data for the qualitative questionnaires and value stream maps (see Figure 2.3). Middle managers who are more involved in work floor processes will be especially valuable as you gather information. Finally, data analysis may help you to calculate value-added and non-value-added time based on measurements performed in the past. Note that further support for each of these techniques is offered through the PlaneSense toolbox (see section 1.5).

Alongside mapping processes, you also need to conduct a self-assessment of the soft factors – Critical Success Factors – needed to facilitate improvement. People at the top of an organisation may view things differently than those at lower levels, so responsible parties for this activity should ideally come from three company layers; a top manager, middle manager and shop floor employee. This will garner representative input from across the organisational hierarchy. The results of this mapping will serve as input for the definition of improvement projects to stimulate the development of low-scoring CSFs. This will be covered in more detail in the next chapter.

2.2.4 Define bottlenecks

Bottlenecks can rise to the surface during the process of defining company characteristics, mapping and interviews. Categorise these bottlenecks (i.e., waiting time, stock, weakest link) and then verify them using a 'fishbone diagram' (see Figure 2.4) to identify their root causes. Fishbone diagrams provide insight into why and how things happen by continuously asking why the phenomenon is present within the organisation. Ask yourself and the organisation "Why is this bottleneck present?" and enter the answers into the fishbone diagram. After you have done this, ask yourself and the organisation "Why is this cause present?" and enter those answers as well. Keep asking why a phenomenon is present until the true root cause rises to the surface. These are the ones you want tackle.

Once you have identified the true causes of the bottlenecks, prioritise the sequence in which you want to tackle them. You can do this according to

Figure 2.3: Acquiring data for the value stream maps

two variables: the impact that improving a root cause will have and the effort it will take to tackle it (expressed in resources). Plot these variables against each other in a graph to address the most efficient bottleneck-solving sequence. Keep in mind that CSFs will be developed alongside the improvement projects because you want to integrate your CSF development plan – wherever possible – into the improvement project to achieve maximum results. As always, organisational commitment will be vital for dealing with this aspect of proposed improvement projects.

2.2.5 Define improvement projects

Your chosen initial processes, combined with the bottlenecks and the level of CSFs, will result in a number of improvement projects to start the process optimisation journey. These projects should be published in a kick-off document that provides starting guidelines as well as background information about the processes, bottlenecks and CSF levels. This background information will show employees that the identified bottlenecks are a real problem in the process, and not just ideas based on 'a feeling'.
It is important to publish and distribute the document throughout your entire organisation to make sure everybody is involved and engaged.

You can also create future state value stream maps based on pre-defined organisational goals to show the organisation where to aim. A future state value stream map is a visual representation of the ideal process and ways to incorporate improvements into your organisation's current value stream. These improvements are aimed at creating more value for the customer by reducing the number of non-value-added activities. The future state then functions as a goal for your organisation to work towards.

Figure 2.4 Making a fishbone diagram

The Quick Scan at Braathens Technical in Sweden

We started by meeting the Braathens management team to define opportunities and gain insight into the company. We then determined the topics we wanted to investigate, choosing the work floor to look for opportunities to reduce waste. We also interviewed employees across different levels of the company to further investigate the opportunities brought up by the management team (which were on a strategic level).

After the first day we were given permission to operate a camera during the night shift. We positioned the camera so that it gave a clear image of the work floor. We then analysed data from the camera to extend the observations that we made on our own during the first part of the night shift. This provided us with insight into what maintenance was being performed and how technicians were performing it.

During the next few days we verified our information, brainstormed possible solutions, entered data into informational charts and presented our ideas at a management team meeting on Friday.

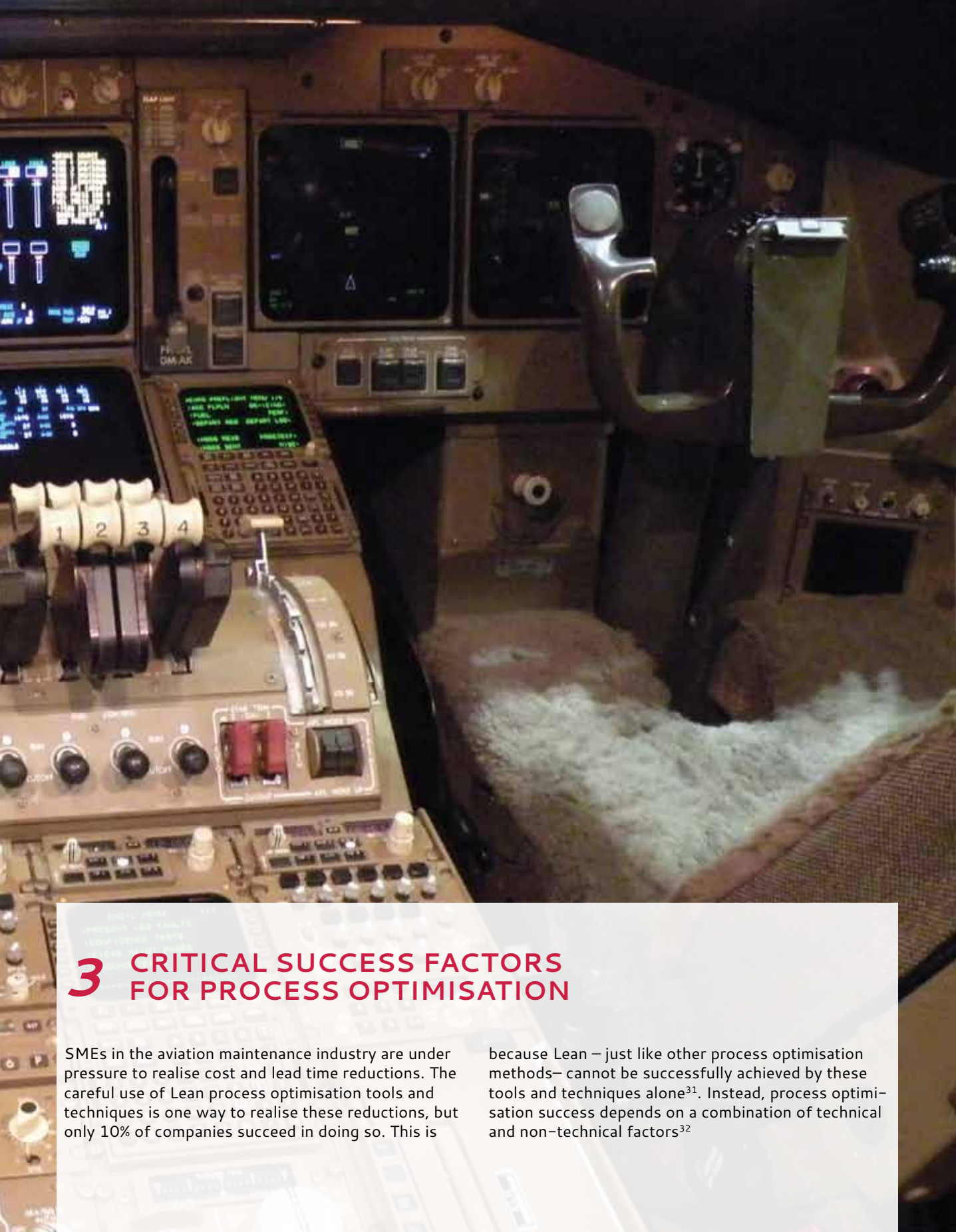
This approach provided Braathens with an outside perspective regarding improvement opportunities – a perspective that was substantiated through data and interviews, as well as solutions and examples from our own experience. Dennis Westin, Area Manager Headquarter, Braathens Technical, says: "I think you did a pretty good job for the short period you were here!"

The Quick Scan at an Aircraft Maintenance SME

The aircraft maintenance organisation wanted us to investigate a specific process, which meant that we didn't start with a normal Quick Scan. They wanted to be able to send an invoice on the day an aircraft left the hangar, but weren't currently able to do it. The invoice process at the organisation touched nearly all maintenance processes within the company, and was also related to different organisational levels and directly linked to the customer. We were able to quickly review the required information while remaining within the project's scope. This allowed us to achieve the Quick Scan goals of identifying further improvement projects and starting the process optimisation journey.

Interviews demonstrated that bottlenecks preventing on-time invoicing included the watertight and timely registration of actual task time, the waiting time for third party supplier invoices, and the complicated nature of the invoice system. Working closely together with employees, we made a value stream map of the invoice process. This gave us a starting point from which to look for solutions, and provided initial data from which to base our questions. We needed a better understanding of what kind of orders flowed through the company and thus what kind of invoices needed to be sent. We therefore conducted data analysis that included historical information about the amount of work flowing through the company, and found different root causes using a fishbone diagram.

It turned out that the same complicated invoice system was used for every service order (from very small to very large), which was a very time-consuming process. The company also had a general lack of resources for finishing all invoices on time (given their complicated invoice system), as well as limited access to specialists during the weekends, even though aircraft were delivered then. We also identified a number of other improvement areas, leading to a variety of small improvement projects.



3 CRITICAL SUCCESS FACTORS FOR PROCESS OPTIMISATION

SMEs in the aviation maintenance industry are under pressure to realise cost and lead time reductions. The careful use of Lean process optimisation tools and techniques is one way to realise these reductions, but only 10% of companies succeed in doing so. This is because Lean – just like other process optimisation methods– cannot be successfully achieved by these tools and techniques alone[31]. Instead, process optimisation success depends on a combination of technical and non-technical factors[32]

3.1 The nine CSFs for process optimisation

Keep a focus on the following nine CSFs as you apply process optimisation and become acquainted with its corresponding theory[27]:

- Management commitment;
- Education and training;
- Customer focus;
- Employee involvement;
- Supplier management;
- Project management;
- Leadership;
- Organisational infrastructure;
- Performance measurement.

Although no distinction is made regarding the importance of each individual factor, management commitment is mentioned most frequently in the international literature, followed by education and training. But what exactly do each of these factors mean?

Management commitment

Management commitment means that all managers actively participate in, support and are dedicated to process optimisation initiatives33. As you move forward in this area, you should[33,34,35]:

- Create contact between managers and the process optimisation initiator;
- Appoint the right responsibilities to enthusiastic managers who can make the process clear, propose the future state, and take responsibility for implementation;
- Discuss changes and visualise future changes to gain acceptance;
- Use a pilot implementation project to increase commitment.

Education and training

Education and training means learning the philosophy and implementation techniques of process optimisation methods supported by personal development, employee empowerment and characteristic skills[36]. As you move forward in this area, you should[37]:

- Design and implement a training policy that emphasises top management support and a company culture that is committed to education and training;
- Link and rate the effectiveness of your training in terms of management and stakeholder vision.

Customer focus

Customer focus refers to processes that the customer is willing to pay for. It aims to eliminate waste and non-value-added activities, thereby maximising value-added activities. As you move forward in this area, you should[38,39,40,41]:

- Motivate people through examples and goals (this can be done in the Lean simulation game);
- Allocate people to customer focus roles to increase motivation;
- Check the market in terms of current and future customer needs;
- Create a new plan and verify it with the customer;
- Test and roll out the plan with the customer;
- Roll out the plan to other customers;
- Move to a culture of continuous customer focus.

Employee involvement

Employee involvement is reflected in the level at which employees, teams and departments feel involved and participate in actual improvement activities[42,43]. As you move forward in this area, you should[44,45,46,47]:

- Communicate organisation-related information through newsletters, meetings, and so on;
- Increase internal marketing to involve employees in the process;
- Increase the expressive nature of employee relationships, in which employees feel like they are valued and trusted members of one big family;
- Establish speed of delivery requirements to help drive involvement;
- Flatten the organisation to increase involvement.

Supplier management

Process optimisation also focuses on external processes to maximise optimisation results and create more customer value. Supplier management therefore includes matching delivery processes to the internal processes of the organisation. As you move forward in this area, you should[48,49,50]:

- Learn supply chain management, logistics and business skills;
- Gradually change from an indirect to a direct supplier relationship to secure long, ongoing customer relationships;
- Flatten the organisation to improve relationships and help create more customer value.

Project management

Project management depends on a wide range of skills, and relates to project monitoring and performance tracking. As you move forward with project management, you should[51,52,53,54,55,56]:

- Learn project management skills in technical, managerial, financial and legal areas;
- Create a project definition incorporating end-user needs;
- Define the project scope, including quantity, quality and tasks involved;
- Identify project stakeholders;
- Define measurements;
- Estimate costs;
- Plan the project, including role assignation, strategies and tasks;
- Implement project tracking, comparing actual values to expected values;
- Perform a final evaluation.

Leadership

Process optimisation leaders are able to motivate others to participate in process optimisation initiatives. A good leader is comfortable with process change, is oriented towards achieving results and is able to foster development in others. As you move forward in this area, you should[57,58.59,60]:

- Perform a needs assessment;
- Identify critical leadership competencies;
- Select the appropriate people;
- Integrate leadership into company infrastructure and culture;
- Integrate feedback acceptance into company culture;

Figure 3.1 Average CSF scores for SMEs in the MRO sector[27]

- Develop a learning system with both theoretical and practical lessons;
- Evaluate your leadership development plan.

Performance measurement

Performance measurement focuses on measuring customer needs. If well designed, the system provides an early warning system for required action. As you move forward in this area, you should[61,62,63]:

- Comply with the CSFs of a performance measurement system;
- Align measurements with strategic company goals and customer value;
- Set up measurements which will evaluate company performance, sketch the current situation of the company, remain up-to-date and realistic, and incorporate both financial and non-financial features;
- Identify small targets to achieve better improvements.

Organisational infrastructure

Organisational infrastructure refers to the hierarchy of the organisation. A horizontally structured organisation stimulates cross-functionality between departments which results in higher service quality to the customer[61]. This stimulates information sharing and collective responsibility. As you move forward in this area, you should[64,65,66]:

- Flatten the organisation;
- Facilitate support facilities by implementing a team focus, investing in human resources for empowerment and creating a supportive and committed company culture;
- Focus on cross-functionality within the company;
- Focus on decentralised authority;
- Focus on adaptive and flexible skills.

3.2 Development of the Critical Success Factors

CSF development levels vary among SMEs within the MRO sector. Although variations of the CSFs are present within these organisations, they are generally underdeveloped. A study of eleven organisations (conducted as part of the Maintain Your Competitive Edge project[27]) revealed that although some organisations scored good-to-excellent on a specific CSF,

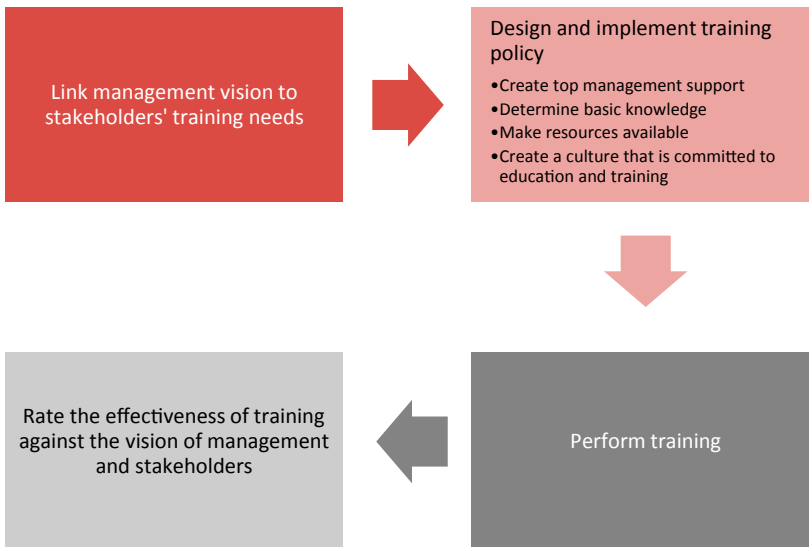


Figure 3.2 Development protocol for education and training

most of them scored much lower. 'Unsatisfactory' was not exceptional. On average, though, the CSFs scored between 'unsatisfactory' and 'satisfactory' (see Figure 3.1). This section describes a general plan to assist in the development of CSFs, which will increase process optimisation success.

3.2.1 Perform a self-assessment

First, perform a self-assessment using a questionnaire to provide a baseline measurement – the current level of CSFs in the organisation – for prioritising CSF development. In our PlaneSense framework, this is included in the Quick Scan (see Chapter 2). The self-assessment includes CSF characteristics as they relate to process optimisation. The self-assessment consists of a large number of statements. Respondents rate the extent to which they agree that each CSF element (i.e., the characteristic) is present in your organisation on a five-point Likert scale ('strongly disagree', 'disagree', 'neutral', 'agree', 'strongly agree'). It covers the nine CSFs with an average of six statements each. Results can be shown in a radar plot.

3.2.2 Prioritise the development

The next step is to identify improvement area priorities. Because SMEs in the MRO sector usually have limited resources and knowledge, an effort to develop all CSFs up to their maximum level at the same time is unrealistic. We recommend developing the CSFs gradually and in a balanced manner, focusing on those that are lagging and in consultation with stakeholders to increase commitment for development. This will maximise the use of limited resources while ensuring that these CSFs – all of which are important – contribute to the success of the project. It will also align with the CSF ideal about maintaining focus on areas containing 'the things that must go right'[67].

3.2.3 Development plan for Critical Success Factors

Once you have prioritised the CSFs, development can start. Literature in this area (available in the toolbox) provides a choice of improvement trajectories for the development plan. Each CSF improvement is achieved through a series of steps, or protocols. For example, the steps for the development of education and training are depicted in Figure 3.2. They are also contained in the toolbox, which:

- Provides short instructions for realising the steps;
- Describes the location in the process optimisation framework in which the step should be performed;
- Explains why each step is important for realising that particular CSF improvement.

You can formulate specific targets during a group meeting before the improvement cycle kick-off. Keep in mind that these basic instructions should be further tailored to your company characteristics. You can measure the level of your success by repeating a CSF self-assessment after all steps of the protocol have been completed. This will provide a new baseline from which to either realign the development vision or move forward. The extent to which the organisation succeeds in achieving the targets can be tested during subsequent self-assessments.

The Critical Success Factors at JetSupport

JetSupport is located at Schiphol-Oost in the Netherlands and provides technical and support solutions for business aviation and special purpose aircraft. A top- and a middle-manager performed a CSF self-assessment for the company, revealing that JetSupport was doing well on 'Customer focus' and 'Employee involvement'. However, the organisation still needed to improve in areas such as 'Performance measurement' and 'Leadership'. After completion of the self-assessment for CSFs it became obvious that a number of factors needed to be developed in sequence to progress through their own process optimisation journey. The Aviation Academy used this radar to discuss improvement areas with the company, after which JetSupport decided to focus on 'Leadership', 'Project management' and 'Performance management'. Specific actions have now been identified using the steps of the development plan.

4 THE PLANESENSE PROCESS IMPROVEMENT CYCLE

The identification and performance of improvement projects is the first step to actually realising tangible business results. However, how do you perform improvement projects in such a way that they sustainably achieve your intended objectives? Each process optimisation method has its own framework for implementation. Although philosophies differ among these methods, the steps are similar. For example, the first step in Lean is to identify value, while the first step in TQM is to identify the problem. Both steps are all about identification.

Our PlaneSense process optimisation cycle combines steps from the different methodologies into a general roadmap that you can use to implement an improvement project in an SME MRO environment. The PlaneSense cycle can be used for the strategically important improvement projects that were identified in the Quick Scan, as well as for subsequently identified opportunities.

4.1 Overview of the PlaneSense improvement cycle

The PlaneSense improvement cycle is best compared to the Define-Measure-Analyse-Improve-Control (DMAIC) cycle of Six Sigma. However, the DMAIC cycle has five steps while the process improvement cycle has six – the extra step being the roadmap and targets set before improvement implementation. The PlaneSense improvement cycle's steps (see Figure 4.1) are designed to allow you and your organisation to improve a specific process and sustain this change through a 'learning by doing' principle.

Step 1 functions as a handhold for your organisation to address problems that could prevent you from achieving your mission, vision and strategy. Step 2 starts to map current processes, with two purposes in mind: to visualise process steps and to quantify them through assigned measurements. In Step 3, you use these mapped processes to reveal bottlenecks, which are then submitted to a root cause analysis that can help to clarify why the bottlenecks are present. This leads to Step 4, in which you set targets, goals and a direction for the improvement strategy. You also update the project charter at this point with new insights obtained during the previous steps of the improve-

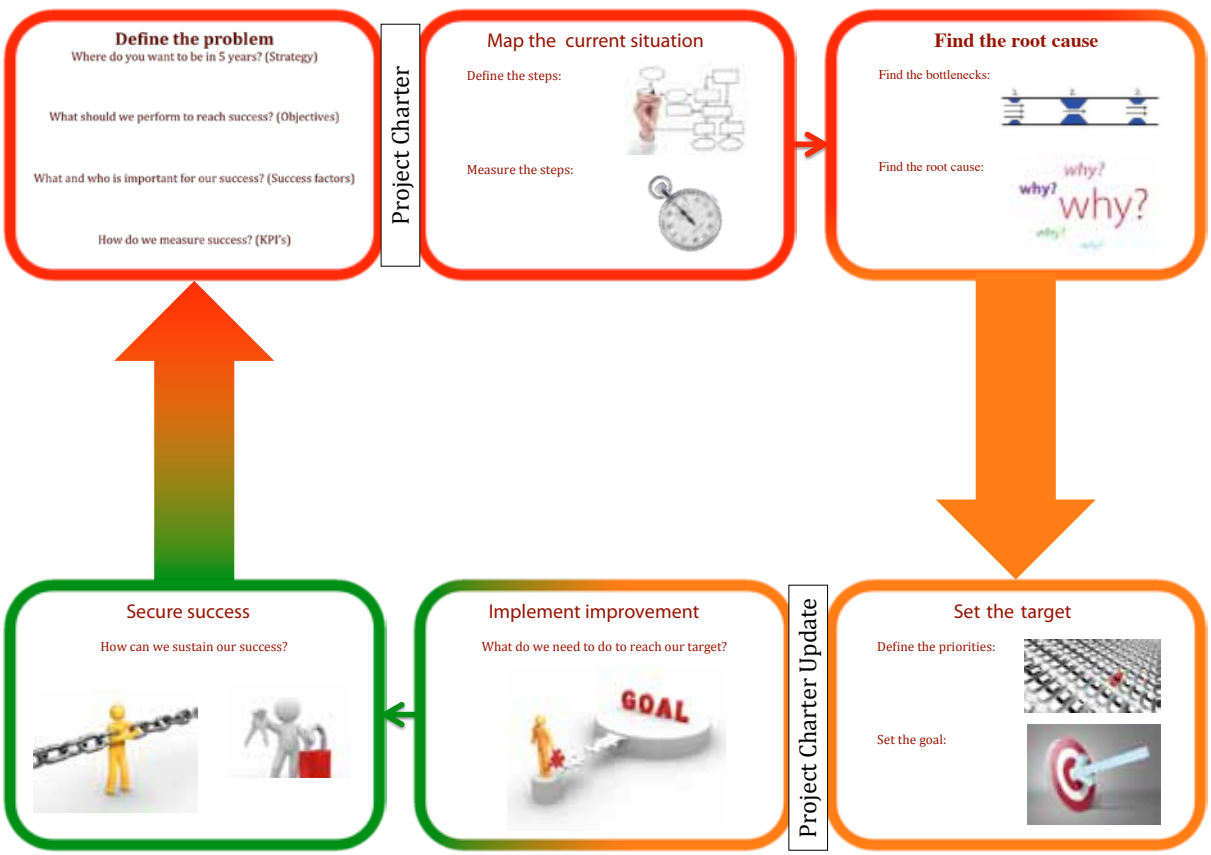


Figure 4.1 Steps in the PlaneSense improvement cycle

ment cycle. In Step 5 you implement the improvement itself, and in Step 6 you apply mechanisms to secure sustainable success. Each of these steps is described in more detail below.

4.2 The steps in the PlaneSense improvement cycle

Step 1: Define the problem

The purpose of Step 1 is to provide insight (note that this step may be superfluous if the PlaneSense cycle directly follows a Quick Scan). Clearly defining your mission, vision and strategy can help you recognise improvement areas as you uncover the specific KPIs that will provide a good 'snapshot' of your company's current position. Remember that your customers are the reason your company exists, so make sure to translate customer requirements into KPIs that become 'holy' for your organisation. You can start this process by answering questions such as:

- Where do we stand?
- Where do we want to go?
- Who are our customers?
- What do our customers need?
- What are our KPIs?
- To which processes do our KPIs apply?

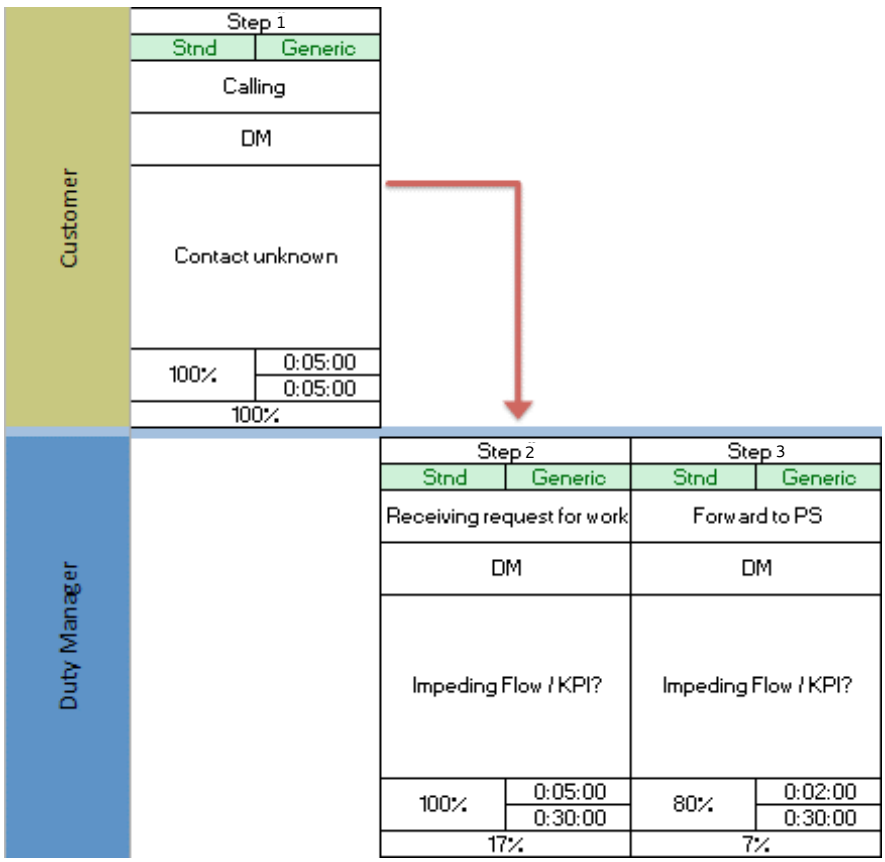


Figure 4.2 An example of a value stream map

The result of Step 1 is a project charter that highlights specific improvement areas, planning and responsible parties, and ways to measure success.

Step 2: Map the current situation

In Step 2, you map the process based on opportunities that were defined in the previous step (or the Quick Scan). You do this by identifying the relevant parts of the value stream. The value stream consists of information, resources and materials (consisting of goods and services) that together produce value for customers. The stream consists of both value-added activities (activities for which the customer is willing to pay or in which the condition of the product is changed) and non-value-added activities. You plot process steps in this value stream map to visualise constraints – such as the typical characteristics that can inhibit small maintenance organisations from improving their processes – after which you can identify opportunities for improvements. You can also quantify the processes using measurements or historical data to provide an indication of possible cost savings. Usually, a value stream map is first sketched on paper in a workshop format and then reproduced in a computer package such as Microsoft Excel. A snippet of a typical value stream output is provided in Figure 4.2.

Value stream maps are valuable tools for complete process documentation. This figure depicts a customised map that allows for additional notation of the process type (e.g., generic versus specific). 'Generic' means that these characteristics are identical independent of service type or scope of work. 'Specific' means that the characteristics of this step are specific to each product, service or scope of work. Other aircraft, inspection types, and so on might yield different characteristics. The nature of the process (variable versus standard) is also indicated to further identify the process causing potential bottlenecks. 'Variable' means that the process step characteristics (mainly times) are variable and unpredictable, as opposed to fixed and predetermined. The figure also includes more traditional information such as (top to bottom): step number, activity or process step, operator, evident obstacles in achieving required quality, estimated performance quality of the step (left side), cycle time and throughput time (right hand side). The bottom part of the map shows the ratio between cycle time and throughput time.

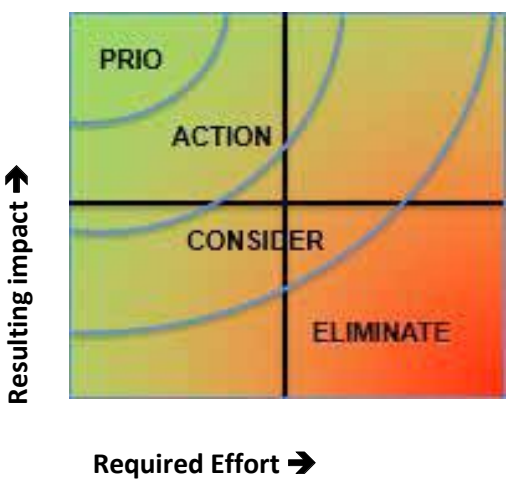


Figure 4.3 An impact/effort diagram to identify improvement priorities

Step 3: Find the root cause

In Step 3, you investigate the problem by searching for its underlying cause, which is not necessarily the most visible one. You can bring underlying issues to the surface by using the '5 Why' method, often used in Lean, Six Sigma and Kaizen approaches. This iterative technique asks questions such as ("Why is this happening?"), the answer to which ("Because of that,") forms the basis for the next question ("Why is that happening?") and so on. Next, you categorise the issues and submit them to a Pareto analysis to identify which are most active – you can't tackle all issues at the same time. The Pareto method highlights the most frequent issues by placing individual values in descending order by bars and drawing a line representing the cumulative total. The most frequently occurring issues are then plotted in an impact/effort diagram to focus on the ones with highest impact and lowest improvement effort (see Figure 4.3.)

The issues in the top left corner have the highest priority because they have the largest impact yet require the least effort.

Step 4: Set the target

Targets are set by analysing what the ideal situation should look like compared to the problem and surrounding factors. You should create a future state value stream map during this step because it helps to visualise your ideal situation and desired targets. A future state value stream map is essentially the same as that for the current state but with as much non-value-added time eliminated as is realistic. This should be done for each root cause. Next, define how you will tackle each root cause and which team will be responsible. Define KPI's to measure the success of the improvement.

Step 5: Implement improvement

Once all of the previous steps have provided you with clarity, you can then implement the actual improvement. This implementation may take some time as your company releases resources and obtains the required commitment from work floor employees and management. Activities may include training, improving working procedures, rearranging flow, and implementing specific Lean / Theory of Constraints principles such as Kanban, 2-Bin and 5S (see the toolbox for an explanation). You can monitor improvement progress using the A3 methodology, in which results of the previous steps – together with the implemented improvement steps – are presented on a single piece of paper. You should keep track of the KPIs both during and after implementation to monitor the effects of improvement on company performance.

Step 6: Secure success

Process optimisation is never finished. To secure success, it is vital that any improvement be sustainable over time. Depending on the improvement that has been implemented, you'll need to write down new working procedures, make sure that performance requirements are visible and monitored, and appoint a process owner. Part of this approach will involve your organisation's mentality as you strive for perfection through continuous process optimisation cycles that gradually lead to ever improved processes (see Figure 4.4).

Project tracking is also important – you need to monitor improvement expectations, deal with scenarios which may deviate from reality, and make the necessary adjustments.

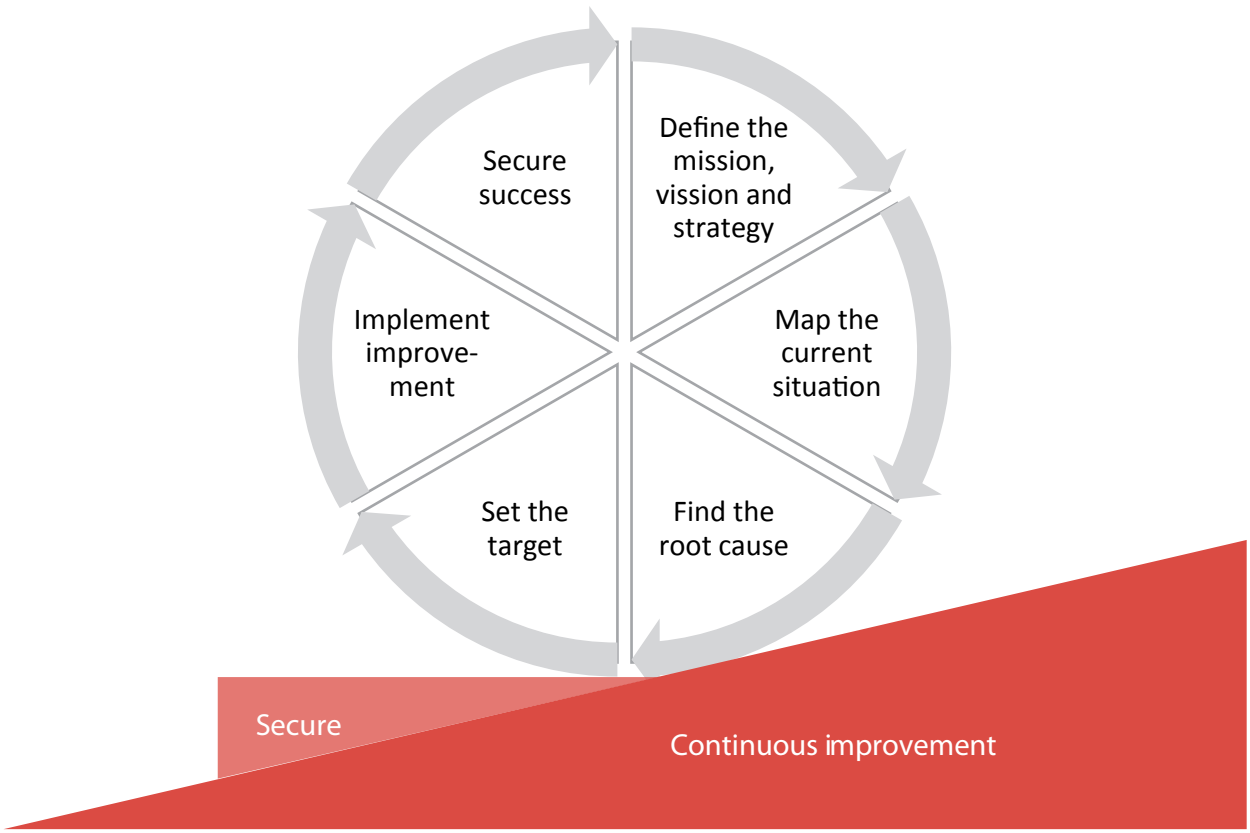


Figure 4.4 Securing process improvement success

The Process Improvement Cycle at the Royal Netherlands Air Force

The Logistics Centre of the Royal Netherlands Air Force at Woensdrecht in the south of Holland is responsible for the maintenance of assets such as the Chinook, NH-90 and Apache helicopters, and the F-16. Engineers at the base complained that they had to wait too long before receiving the required tools and operating materials, so this was the starting point for defining an improvement project (Step 1). In Step 2 the team mapped the current situation, which revealed an interesting finding: engineers felt that the waiting time for aircraft tools was the main problem, but data from the issue desk revealed that the main problem was that these tools were frequently out on the floor and not available for someone else to use until they were returned. It seemed (Step 3) that storing the tools behind the issue desk rather than close to the work place was a big part of the problem. A Pareto analysis defined the most frequently distributed tools, representing 50% of the total issues. The team therefore decided that a target to reduce the waiting time for aircraft tools by 50% was realistic (Step 4). They decided to place the most frequently-used tools in the maintenance docks, first prototyping this approach to find out whether the improvement would have a positive effect. After this turned out to be the case, the approach was implemented in the other F-16 docks and for other military aircraft types as well (Step 5). Finally, the organisation was now made responsible for implementing and maintaining the improvement themselves (Step 6).

Major Jeroen van Leeuwen from the Maintenance-Squadron 980 at Woensdrecht says about the application of the PlaneSense improvement cycle: "Together with the Maintain Your Competitive Edge team we performed a roadmap which will eventually result in increased flow in our 'waste-reduced' maintenance process. Process optimisation is an important element at the RNLAF, and [...] is resulting in the realisation of handy improvements and insights."


Metalmair

5 REALIGNMENT OF THE PROCESS OPTIMISATION JOURNEY

You have done all you can to motivate employees to participate through a multitude of improvement suggestions. You have succeeded in sustaining improvement across multiple small projects. However, you may still find that you start to suffer from a lack of focus across all of these initiatives. At this point, a Hoshin Kanri session can help to align new initiatives with the organisation's goal and strategy.

Hoshin Kanri is a strategy deployment, planning and implementation approach that underlies the development of one of the most effective production systems in the world – Toyota. Hoshin Kanri aims to define an organisation's focus for the years ahead. It is especially important for Lean projects, because it helps Lean penetrate to the core of the organisation[68]. The Hoshin Kanri approach consists of six steps. Steps two, three, four and five of the strategy deployment system are similar to the well-known Plan-Do-Check-Adjust (PDCA) cycle, preceded by direction setting. Hoshin Kanri is a cycle, so in effect, the process never ends. Step 6 therefore represents the continuous efforts towards improvement.

We have incorporated the Hoshin Kanri approach into the PlaneSense framework, focusing on the realignment aspects (Steps 1 and 2) here. Steps 3, 4 and 5 are represented in the PlaneSense improvement cycle (see Chapter 4). Step 6 (continuous improvement) is the subject of the next chapter.

5.1 Step 1: Define the 'true north'

During Step 1, you achieve agreement by defining the organisation's strategic and philosophical 'true north'. This 'true north' compromises both hard business goals and broad brush goals[71]. An example of a hard business goal would be a financial objective, such as increasing revenue by USD 300 million. An example of a broad brush goal (what the Japanese call Hoshin) would be increasing customer satisfaction – something more broadly interpreted based on the vision, direction and intention of the organisation. The goals usually cover a time span of between five and ten years and are often formulated as guideline questions, such as:

- What does failure mean for the community?
- What do customers really want?
- What advantages do we have compared to our competitors?
- What do we have to do to compete against them?

Figure 5.1 True North cascaded into mother strategies

The 'true north' is generally developed by a senior leadership team over several sessions. The value of 'true north' as a compass for the organisation increases tremendously when it is translated into specific metrics. Iterations usually occur when the long term goal is split into annual targets and compared to actual results, making the gap keenly visible. An example of 'true north' could be given in terms of profit growth, turnover, OEM partnerships, turnover per employee, risk profile as determined by the civil aviation authority, Net Promotor Score, turnaround time, or employee satisfaction. Of course, every company will have its own metrics with unique targets. Some of the desired metrics may not be immediately available, so make sure you can devise ways to collect them if necessary. In any case, it is a good idea to maximise the number of metrics to no more than ten – a manageable number for most companies. This will also make it easier to collectively document the metrics on one landscape A3 sheet of paper.

5.2 Step 2: Translate company goals into strategies

To achieve 'true north', it will be necessary match goals and targets with a few 'mother strategies'. A mother strategy groups a number of similar true north goals together, allowing you to answer questions such as:

- What is the difference between the target and achieved results?
- What are the bottlenecks in realising our targets?
- What are the causes, in sequence of importance?
- What countermeasures can be taken to tackle the root causes?

Most companies choose between three and seven mother strategies. In the case of the example mentioned previously, we identified mother strategies for marketing & sales and internal communication, cash flow, productivity, human resources, and 'professional organisation' (See Figure 5.1).

Use an A3 sheet to describe each mother strategy – an A3 sheet tells the story behind the strategy as well as ways in which it can be realised. Pascal Dennis's *Getting the Right Things Done* [68] provides an example of this type of A3 template, which many companies find useful. It is available in the toolbox. This type of A3 sheet displays the metrics directly relevant to 'true north' in the top left box. Graphs here should clearly identify the gap between the target and actual results. You can document possible explanations for the gap in the middle box, and describe new projects for closing the gap in the bottom left box. You can also schedule projects in a Gantt chart in the top right box, and document open actions in the bottom right box.

Appoint deployment leaders to manage each of the mother strategies on behalf of the management team. These deployment leaders should provide leadership for the planning and execution of the projects, and they should also take responsibility for achieving the desired results. They should track progress, make obstacles visible and develop the required management systems[66]. When formulating a mother strategy, it is important to reach agreement between colleagues about the projects to be undertaken and resources required to close the gap between targets and actual results – 'true north' should not be a subject open to debate. The mother strategy is initially planned on an annual level, but can be adapted to other periods.

Allocate a 'baby A3' to each of the projects identified in the mother strategies (these baby A3s can also be allotted to functional departments rather than projects if appropriate). It will help you to identify what needs to be done for each project – the template is focused on problem-solving rather than just execution. The number of baby A3s that you choose to use will depend on the size of your organisation, and can range from simple to extremely detailed plans. Whichever level of detail you use, remember that you don't have to write down everything, and that all the plans in the world won't help unless they are translated into action.

The power of the A3s is that you can discuss progress factually and quickly at weekly stand-up meetings. The allocated deployment leaders will not be able to hide slow progress, and colleagues can help devise additional measures if needed.

Strategy Deployment at JetSupport

Management at JetSupport felt that they had executed multiple Lean projects successfully, but that the projects were not contributing sufficiently to the company's strategic goals. Therefore, they decided to hold a series of Hoshin Kanri sessions facilitated by Aviation Academy staff. Initially, 'true north' was described in qualitative terms, providing little project guidance. Having read about A3s, some of the management team members came up with projects that were eloquently described in the template, but which were unfortunately not at all tied to the company strategy. If implemented, they would have used up scarce resources with very limited contribution to company objectives. Over the course of several sessions and hot debates about what we really wanted to achieve, we were able to pin down 'true north' in nine metrics and determine long-term targets for each of them. Some of these metrics were already available, while others had to be developed. A complete set of metrics is now available and it forms a basis for prioritised projects that will contribute to the realisation of 'true north' in the coming years. Baby A3s are being created to describe projects that will contribute to company objectives, and more importantly: projects that have limited added value are being scrapped. The mother and baby A3s have allowed the management team to take collective responsibility for achieving JetSupport's long term objectives without micro-management or social loafing.

6 CONTINUOUS IMPROVEMENT

We have already discussed process optimisation as a collective term for methods that eliminate non-value-added activities and reduce the complexity caused by the wide variety of suppliers, customers, internal resources and processes[8]. However, what matters in the end is that process optimisation is a continuous search for improvement – as the references to 'cycles' throughout this book attest. This is particularly important for small aviation maintenance organisations, as they experience high product variability and change processes on a continuous basis. The last phase in the PlaneSense process optimisation framework is continuous improvement, leading to world class performance at the improvement capability level.

You can think of continuous improvement as climbing a set of increasingly higher mountains. To reach each peak, you will definitely need good equipment. This 'equipment' is obtained during the initial phase of the process optimisation framework, where you acquaint yourself with the fundamentals and gain the skills you need for sustainable improvement. Hoshin Kanri sessions for strategy deployment and mother strategies formulated at a high level in the organisation will help to initiate larger projects (often described in baby A3s).

Your organisational goals will usually be formulated in terms of five or ten years, so it could be a while before the improvements defined in your mother strategy become fully visible. However, this is not necessarily a bad thing. You should spend a lot of time developing the human and organisational factors needed for process optimisation success. In fact, as you move forward you may even experience resistance from certain employees and management positions who are not committed to the process optimisation philosophy. Changing their mindset can be challenging, and will be

influenced by the size of your organisation – a workforce of 240 employees will require more minds to change than a group of 20 people.

However, when everybody in the organisation is looking at 'the top of the mountain' and when large process improvement projects are starting to help realise organisational goals, then the process of continuous optimisation can really get underway. A second Hoshin Kanri session can serve as the foundation for further activities.

6.1 Kaizen events

The culture of a process optimisation organisation can be influenced by what are called 'Kaizen events' – times during which employees are pulled away from their regular work for a set period of time to think about process improvement solutions. This is especially useful when obvious waste has been identified and the solution has minimal implementation risk[69].

The Kaizen event approach can be characterized as:

- A well-defined project that covers purpose, scope and boundaries;
- Teams dedicated to the project for the set period of time, with enough to do to make their Kaizen event contribution productive and effective;
- Immediate implementation of the solution;
- Support and resources during the Kaizen event.

A typical Kaizen event plan is depicted inTable 6.1[69].

A manager who visits the work floor on a daily basis to listen to employee improvement suggestions is another example of a more basic Kaizen event. The manager can weigh pros and cons to decide on the

Typical plan for Kaizen	
Preparation	• DEFINE the project • Identify participants • Gather background information • Prepare training • Secure resources
Monday	• Brief the team about the define session results • Provide training when needed • Solve questions of the participants • Start MAPPING
Tuesday	• Continue MAPPING until all data has been collected • ANALYSE the results of the MAPPING process until the root cause has been identified
Wednesday	• Set the TARGET for the organization to work towards • Implement the IMPROVEMENT that corresponds with the TARGET
Thursday	• Finish the IMPROVEMENT and implement SECURE mechanisms
Friday	• Present the results to management • Solve questions of the participants • Get approval
Follow-up	• Monitor the IMPROVEMENT • Make adjustments when necessary

Table 6.1 Typical plan for Kaizen event following the steps of the process improvement cycle

most efficient solution, exhibiting management's commitment to employee involvement and process optimisation. This solution is a great alternative in small organisations without the capacity requirement to facilitate the full type of Kaizen event described above.

6.2 The Moonshine approach

Another – more creative – version of a Kaizen event is called Moonshine, a term that originally described the product of American prohibition-era distillers, who worked at night, away from scrutiny. At the Boeing Company, for instance, employees have the opportunity to spend time in a 'creation shop' as they work out improvement ideas, turning them into finished concepts and then presenting them to management[78]. According to the company, the purpose of Moonshine is to improve production flow by developing production redesigns, equipment and processes that focus on transformational steps. In other words, Moonshine 're-engineers' the process[70]. The approach has proved to be successful in terms of quality improvement, shorter development time, better products, cost savings, waste reduction and increased efficiency. KLM Engineering and Maintenance has similarly adopted several tools developed during Moonshine events, such as brake cradles, brake lifts, wheel lifts, and so on[71]. This approach is based on a 'try-storming' approach in which tool prototypes are built, tested and redesigned without management intervention. Afterwards, the best design is reverse-engineered and adopted as a legitimate tool. This concept can be useful for many MRO SMEs positioned in a technical environment with on-site tools and equipment. However, facilitating a creation shop may be a challenge for smaller organisations with more limited capacities.

Continuous Improvement at Dynamic Aviation

Dynamic Aviation is a small general aviation MRO company located at Lelystad airport. Its main activity is to provide maintenance for small, mostly privately-owned, aircraft, performing scheduled checks and corrective repairs/maintenance when necessary. Dynamic Aviation has applied the PlaneSense framework quite extensively over the last two years, and has put mechanisms in place to enable continuous improvement on a daily basis.

Dynamic Aviation's vision is to develop its business into an excellent component maintenance centre for general aviation while improving the processes and organisation of its current business. The company strongly believes that Lean methods can help them achieve these goals. The initial improvement projects led to some quick wins which generated enthusiasm among the employees. As further waste reductions and lead time improvements were realised, results became visible in improved on-time reliability and being able to deliver more aircraft with the same effort. Erik Jesterhoudt, CEO of Dynamic Aviation says: "The main success factor for us was the involvement of employees. This is expressed in them coming up with improvement suggestions. The self-assessment also gave us insight into what goes well and where improvements must be made."

After a brief period of realignment (when improvements stagnated), Dynamic Aviation is now continuing to find best-fit ways of working and is improving its operation continuously through Lean and ToC principles. It has also adopted a routine of twice-daily whiteboard meetings to discuss problems and improvement ideas in a dedicated approach to continuous improvement. Erik Jesterhoudt says: "Our employees live continuous improvement, making process improvement observations throughout the day. We perform Lean sessions every day at 14:55 to harvest these ideas, which we elaborate on a Lean-board."

CONCLUDING REMARKS

This publication is intended to serve as a set of guidelines for implementing process optimisation at your organisation. As we have learned, SMEs in the MRO sector have specific characteristics – the unpredictable nature of maintenance, low volumes and product variability – which can all lead to challenges in the implementation of process optimisation. Although every organisation in this area is unique, these main characteristics are generic across aviation MRO. After reading these guidelines, we hope you will have a better understanding of your own process optimisation journey.

The Aviation Academy and its partners are available to help you apply these guidelines if needed. Students from the Aviation Academy are available for internships and graduation assignments, and staff members are currently conducting further research in logistics, the use of health monitoring data, and safety management systems in the area of MRO. Please contact us for further information (see www.hva.nl/aviation for details).

As you move forward, keep in mind the following six hints that we have developed as a result of our hands-on project experience:

- *Implementation won't happen overnight.* Process optimisation is an extensive process. It requires motivation from your organisation – motivation to change and do things differently, to remain open to new ideas, and to be willing to do the work required to ensure sustainable change over time.

- *Focus on CSFs along with tools and techniques.* At the beginning, you will be creating change at the process level. But this change can dissipate due to employee resistance, a tendency to fall back into old habits, and a lack of upper management commitment. The key is to make CSFs a priority from the start. If you can motivate your organisation, then your journey will have a much greater chance of success.

- *Base your ideas and improvement suggestions on facts and performance measurements.* Basing change on 'gut feelings' may result in a focus on areas that are not the real problem. This in turn will reduce organisational trust and waste time. Measure first!

- *Don't get too ambitious right out of the gate.* Enthusiasm is definitely a positive quality in any initiative, but we suggest starting with some small improvement projects to gain experience and work on the fundamentals of process optimisation. Get your organisation involved and then gradually start implementing larger improvement projects. The fundamentals of each phase must be in place before starting the next one.

- *Listen to employees – the people who really add value to your organisation.* Value is not necessarily created at the management level. Remember to focus on the work floor employees who actually make or fix your organisation´s products. Without them, your company would fail. Do everything you can to encourage management to facilitate employee contribution to the project.

- *Be creative.* One of the biggest misunderstandings when it comes to process optimisation is that it requires large investments in new tools and equipment. This is not always true. Small adjustments can realise big improvements, often at little or no cost.

Glossary

2-Bin: An inventory control method for small or low-value items.

5S: Part of Lean methodology, 5S organises work space for efficiency and effectiveness by identifying and storing the items used, maintaining the area and items, and sustaining the new order. Translated from the Original Japanese (seiri, seiton, seiso, seiketsu and shitsuke), 5S stands for: Sort, Straighten, Shine, Standardise and Sustain.

7 Wastes: Part of Lean methodology, 7 Wastes is a key concept in Toyota's Production System to increase profitability by reducing seven types of waste: Transportation, Inventory, Motion, Waiting, Over-processing, Over-production and Defect.

A3: An A3-sized paper depicting project activities.

Action Research: Research initiated to solve an immediate problem, often involving a process of reflection. Generic steps include planning, action and fact-finding about the result of the action; often executed by collaborative teams of researchers and company representatives[25].

AOG: Aircraft on Ground.

Aviation Academy: Part of the Amsterdam University of Applied Sciences created to serve the aviation industry.

Baby strategy: Different aspects of a Mother strategy (see below) arranged across departments.

Bottleneck: Problems that arise during process optimisation that slow down or halt progress.

CBT: Computer-based Training.

CSF: Critical Success Factor.

DMAIC: Define-Measure-Analyse-Improve-Control, a five-step Six Sigma process used to manage variation.

Fishbone diagram: A diagram used to provide insight into the root causes of bottlenecks.

Flow and Pull: Part of Lean methodology, in which you create 'flow' by eliminating waste and respond to the customer's 'pull' by understanding and creating processes to deal with customer demand.

Hoshin Kanri: A six-step strategy deployment, planning and implementation method associated with Lean.

HvA: Hogeschool van Amsterdam / Amsterdam University of Applied Sciences.

Improvement capability: The 'soft' Critical Success Factors of process optimisation, including human and organisational factors.

Kaizen event: A time during which employees are pulled away from their regular duties to focus on process improvement solutions.

Kanban: A system used to control the logistics chain from a production point of view, developed by Toyota to improve and maintain a high level of production.

KPI: Key Performance Indicator.

Lean: A customer-centric methodology used to continuously improve any process through the elimination of waste.

Moonshine event: A type of Kaizen event intended to allow creativity away from managerial scrutiny.

Mother strategy: A main strategy for aligning goals and objectives across team members and organisational levels, incorporating results, bottlenecks, and countermeasures.

MRO: Maintenance, Repair and Overhaul.

NAG: Netherlands Aerospace Group.

PlaneSense Course: An annual event organized by the Aviation Academy in collaboration with the University of Tennessee Centre for Executive Education. It focuses on MROs and targets mangers, engineers, Lean change agents and others involved in implementing Lean concepts in MRO organisations.

PlaneSense framework: An interactive roadmap for the development of process and improvement capabilities as applied to problems currently experienced by MRO SMEs.

PlaneSense simulation game: A controlled environment in which LEGO airplanes provide exercises in complexity that mirror the characteristics of MRO organisations.

Process capability: Hard factors such as tools and techniques used to achieve process optimisation.

Process optimisation technique: A technique with a wider application than a 'tool' (see below), including thought and training.

Process optimisation tool: A single device with a clear use of its own.

Quick Scan: A scan that defines the best combination of process optimisation methods given a company's specific characteristics.

RAAK: A subsidy for universities of applied sciences in the Netherlands, originally aimed at Regional Attention and Action for Knowledge circulation.

Root cause: An underlying reason for a bottleneck or problem.

SIA: Stichting Innovatie Alliantie (Innovation Alliance Foundation), now called Nationaal Regieorgaan Praktijkgericht Onderzoek SIA and part of Nederlandse Organisatie voor Wetenschappelijk Onderzoek (Dutch Organisation for Scientific Research). SIA manages and awards the RAAK subsidies.

Six Sigma: A disciplined, data-driven approach and methodology for eliminating defects (driving toward six standard deviations between the mean and the nearest specification limit) in any process – from manufacturing to transactional and from product to service.

SME: Small- and Medium-size Enterprises.

TNO: Nederlandse Organisatie voor Toegepast Natuurwetenschappelijk Onderzoek (Netherlands Organisation for Applied Scientific Research).

ToC: Theory of Constraints.

Toolbox: A website that presents the process optimisation framework, allowing users to investigate specific areas of framework interest such as Quick Scan, Improvement Capability, Fundamentals, Align Improvement Strategy and Continuous Improvement.

TQM: Total Quality Management.

V**alue Stream Map:** A detailed overview of the material and information flow of a specific process and the ratio between value-added and non-value-added activities.

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Appendices

Appendix I. What is RAAK?

RAAK stands for 'Regional Attention and Action for Knowledge circulation'. The implementation of RAAK is in the hands of the National Transition Board Practical Research SIA (Stichting Innovatie Alliantie, or in English: Foundation Innovation Alliance). The RAAK program has strengthened practical research in the professional sector by enabling organisations and institutions to tackle and answer specific questions together with universities of applied sciences. RAAK also makes use of its network to encourage researchers, entrepreneurs, professionals and students to further the development, circulation and application of new knowledge by the business community, public sector and universities (for further information visit www.regieorgaan-sia.nl).

On April 15, 2013, the Covenant National Transition Board Practical Research SIA was signed. By doing this, the Ministry of Education, Culture and Science, the Netherlands Organisation for Scientific Research and the partners in SIA established a Transition Board. This board has a place within the Netherlands Organisation for Scientific Research, and finances and stimulates practical research by universities of applied sciences, who rely heavily on this type of funding. Research collaboration with the business community and the public sector is crucial for universities of applied sciences to create new knowledge and distribute it in the education and professional sector.

Appendix II. Participating companies

Appendix III. Research Partners
Maintaining Your Competitive Edge Research Team

Amsterdam University of Applied Sciences
Aviation Academy
Monique Heiligers, Program Manager

Maintain Your Competitive Edge Research Team
Ellen Budde (Project Manager)
Robert Jan de Boer (Professor)
Arjan Stander (Lecturer-Researcher)
Peter Bos (Lecturer-Researcher)
Eric van de Ven (Senior Researcher)
Enos Postma (Research Assistant)
Mathijs Marttin (Research Assistant)
Damy Snel (Research Assistant)

Consortium
Amsterdam University of Applied Sciences
Netherlands Aerospace Group
Schiphol Group Lean Office
TNO
TU-Delft
JetSupport

Expert Group
Schiphol Group
TNO
KLM Engineering & Maintenance
KLM Lean Six Sigma Office
Royal Netherlands Air Force
TU-Delft
NAG
Project One
JetSupport

Student theses
M. Marttin, J. Ligthart (2013), "Prestatiemanagement in MKB MRO
D. Snel, R. Bandurski (2013), "Onderhoud je marktpositie, fase 1, procesoptimalisatie
R. Bleeker (2014), "The applicability of the STAMP methodology in securing process optimisation
S. Jongerden (2014), "Designing a toolbox that motivates, initiates and supports process optimisation in SME MRO
T. Leferink (2014), "Onderhoud je marktpositie, Fase 2, kwantitatieve prestatie- en proces-metingen in het MKB MRO
D. Snel, J. de Groot (2014), "Development of Critical Success Factors in the aviation SME MRO sector
R. Bandurski (2015), "Tools and techniques for SME MRO
K. Brinkman (2015), "Verification of SME MRO process improvement

Appendix IV. The Aviation Academy

The Aviation Academy is part of the Amsterdam University of Applied Sciences and was created to serve the European aviation industry. Its mission is to provide the current and next generation of professionals with the skills they need to meet international aviation challenges during the next 10 to 15 years. It combines educational excellence, state-of-the-art knowledge and a solid grounding in business processes – the things future professionals will need to create real change. To do this, Aviation Academy focuses on three main activities: education, practical scientific research and peer mentoring.

The PlaneSense course

The PlaneSense course is an annual event organized by the Aviation Academy in collaboration with the University of Tennessee Center for Executive Education. The course is the first of its kind to focus exclusively on MROs, targeting mangers, engineers, Lean change agents and others involved in implementing Lean concepts in MRO organisations.

The course teaches the principles of Lean enterprise and the Theory of Constraints, combining presentations with extensive participant discussion. Participants share ideas, collaborate with others and engage in hands-on simulations similar to the LEGO game, as they learn:

- How to eliminate waste and improve quality;
- How to create flow and respond quickly to customers;
- How to apply Lean principles and the Theory of Constraints;
- How to apply hands-on methodologies with industry-experienced faculty.

These competencies are all examined within the context of MRO-specific issues such as high demand variability, uncertainty of work scope, product variability and material requirements, and complex and unpredictable flow paths.

Education

The Aviation Academy offers two types of Bachelor of Engineering degrees in Aviation:

- Aviation Engineering, which focuses on Flight Operations and Maintenance, Repair & Overhaul;
- Aviation Operations, which encompasses Aviation Logistics, Air Transport Development and Security & Technology.

Practical scientific research

The Aviation Academy conducts practical scientific research focused on real-world problems in the aviation sector, with the goal of improving and innovating professional practice. The four main themes are: maintenance, safety, capacity and composites.

Peer mentoring

Peer mentoring brings international students, teachers and researchers together with industry, government and other research institutions. We do this through master classes, workshops, lectures, networking events, round table sessions and events such as the Aviation Management Conference, the Security & Technology Seminar and the Aviation Knowledge and Career Day.

The School of Technology

The School of Technology at the Amsterdam University of Applied Sciences is the largest technical Higher Vocational Education in the Netherlands. The domain consists of eight different technical study programs with different learning routes and graduation tracks. The education palette is diverse, from E-Technology to Logistics, from Civil Engineering to Forensic Investigation and from Maritime Studies to Aviation.

Research at the School of Technology

Research has a central place at the School of Technology. This research is rooted in the professional sector and contributes to continuous improvement in educational quality and practical innovation. The practical research at the Amsterdam University of Applied Sciences has three functions:

- Knowledge development;
- Ensuring that this knowledge benefits the professional sector and society;
- Ensuring that this knowledge applies to education, including the professionalisation of teachers.

The School of Technology has three research programs which are all closely related to the study programs:

- Aviation;
- Forensic Investigation;
- Urban Technology.

The Centre for Applied Research Technology combines and exchanges the results of practical research.

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Amsterdam University of Applied Sciences

ISBN 9789492219008