LEAN MRO FACT SHEET
Applying LEAN principles for better competitiveness of SME MRO
Introduction
Between 2013 and 2015 the Aviation Academy, part of the Amsterdam University of Applied Sciences, performed research into application of process improvement principles and methods within the aircraft maintenance repair and overhaul [MRO] sector, while focussing on small and medium sized [SME] companies. Process improvement according to philosophies like LEAN have constantly become more important, since they provide companies with a way of adjusting to the changing markets and demands and keeping a competitive edge. This factsheet provides information about the origin of LEAN, implementation of LEAN methods by leading companies, and describes Aviation Academy research and implementation of LEAN into the working methods of SME MRO companies.

The origins of LEAN
Manufacturing has undergone radical and fundamental changes over the past few decades (Crute, Ward, Brown, & Graves, 2003). During the era of mass production, companies focussed on producing the greatest amount of products as possible with a fixed number of assets. This had the purpose of being able to deliver products with great quantities against low cost. This type of manufacturing was clearly demonstrated by the Ford Motor Company during the period of production of the Ford Model T from 1913 and onwards (Ford Motor Company, sd). Ford started manufacturing one type of vehicle with limited to no variance per product on a large scale. The transition from producing a single product at a time to using a moving production line for manufacturing resulted in several benefits. The price for each product was considerably reduced, which made the product affordable for more customers. The customer demand for such a standard product was great, with little customer desire for product variation.

Nowadays, demand is characterized by a number of aspects that are not in line with the mass production methods. Current markets require manufactures and service providers to develop work methods that are more flexible and unique. Production should be able to deal with a varying customer demand, customization of the products, and agile organization of the work processes (Crute, Ward, Brown, & Graves, 2003).

Around World War II Taichii Ohno, then employee of Toyota, developed a philosophy to comply to a market that had to deal with specific demand and flexibility more and more. This philosophy became known as the Toyota Production System. A key feature of this system was the implementation of a supermarket-like inventory system. Ohno was inspired by descriptions of American supermarkets, which had customers pick the products needed from the shelves where after the shelves were restocked with just the required quantity. However, the key principle of the Toyota Production System was not the supermarket inventory system, but performing work intelligently and eliminating wastes in order to achieve minimal inventory and high efficiency (Ohno, 1988).

The Toyota Production System became highly successful in the decades following, since customer demands kept becoming more fluctuating. Complemented with further development of the production system, it eventually became known as LEAN or LEAN production system after the research and publications by (Womack J. P., 1991) and (Krafick, 1998).

Practicing LEAN principles in manufacturing: Scania
Toyota has played a leading role in manufacturing according to the process improvement principles. Since then, other companies have adapted their production methods and implemented process improvement techniques.
One of the most prominent European examples is the truck manufacturer Scania, with its production facility in Zwolle, The Netherlands.

Scania has made efforts over the past 16 years to constantly improve the manufacturing process. And with success, in the past few years Scania reached an improvement of the productivity of around 6% per year (Ede, 2014). The interpretation of LEAN principles by Scania is called the Scania Production System. With a total of 1,300 employees and 20 to 25 trucks assembled per employee per year, the production facility is one of the leading truck manufacturers. However, to stay competitive Scania has implemented a number of LEAN principles. These principles offer structure and guidance for the employees on the field of improving the work methods. Team leaders, called ‘Kaizen leaders’, have been assigned completely dedicated to providing guidance with the improvement initiatives. Furthermore, each production team of five employees is supplemented with a sixth employee called the ‘Andon’. Andons are employees that perform regular production, but are also responsible for the documentation and analysis of problems as well as waste noticed by the production team.

The key principle practiced successfully by Scania is just-in-time delivery of parts, subassemblies, and materials. Parts are delivered to the production line precisely at the moment they are required for assembly. Subassemblies, such as the cabin, which is assembled in Sweden, enter the factory through a side door and meet the chassis on the spot and in time for assembly.

Scania is an example of a large-scale manufacturer that has and still is applying and evolving LEAN principles in a successful manner.

The LEAN principles

So, what exactly is LEAN? Lean in the physical sense can be described as lightweight, thin, speedy, and agile. In a way this is a correct description of the principles of LEAN. However, LEAN goes further than that. It is also a certain discipline, a way of doing things and responding to situations. When looking at the Toyota Motor Company and describing what is noticed, (Krafcik, 1998) stated that a LEAN company showed the following aspects when compared to companies performing conventional mass production: less effort is required to design, make, and service products; companies require less investments; fewer defects; fewer suppliers; key processes are performed in less time; less inventory at each step; and fewer employee injuries (Sayer & Williams, 2007). These aspects are mostly beneficial for the company, however they are also beneficial for customers, since as a consequence products are delivered faster, cheaper, and more reliable.

At the basis of LEAN is one principle that forms the foundation for reaching these advantages. The removal of waste is an essential step to provide customers with products that have a maximum value in return for the price...
that is paid. Supporting tools, specifically designed to provide insight into the company process and subsequently improve it, can are applied. Strictly performing consequent improvement steps and applying supporting tools achieve methodological improvement.

Maximizing customer value by reducing waste
Waste is defined as being a movement, inventory, or other part of a process that is not adding any value for the customer. (Ohno, 1988) described seven types of wastes: transport; inventory; motion; waiting; overproduction; over processing; and defects. During recent years more types of wastes have been added (Womack & Jones, 2011), however these seven types of wastes still form the key foundation for LEAN. While improving the company processes the goal is always to reduce waste and maximize customer value along the way. In practice, a perfect situation will never been reached as further improvement from the norm is always possible.

Continues systematic improvement
Removing waste within the process is performed according a five-step cycle (Figure 2). The first step of the cycle is identifying the value. Value is the product or product-characteristic the customer is willing to pay for. This can be described as a product, a service, or a combination of both. The second step is identifying the value-stream in which value is created for the customer and rooting out any steps that do not add value. Then, the value creating steps should be managed in such a way that they are performed in a tightly as possible sequence. This should result in products or services ‘flowing’ without any interruptions. When flow is introduced in the process, products or services are then ‘pulled’ from the upstream activity. This means production should be on-demand, and not constantly providing without demand (overproduction / inventory). The process is repeated and a state of continuous perfection is reached (Sayer & Williams, 2007).

Supporting tools and guiding principles

A key principle of the LEAN philosophy is to achieve continuous flow within a process. According to (Ohno, 1988) flow can be noticed by a constant movement of the products, without wasting resources on stockpiling or non-value-adding transport. Flow within a process means that products are processed at each station or step without waiting times and perfectly complying with the demand by the next step in the process and eventually the customers.

Figure 2 Five-step thought process for guiding the implementation of LEAN techniques

One commonly heard term with regard to LEAN is ‘just-in-time’. As the name implies, just-in-time is a method of supplying parts, subassemblies, and materials to a production line. It is a basic pillar for achieving flow within a process. In a perfect state, just-in-time production produces and delivers exactly the products needed, at the moment they are needed, and without any imperfections or defects. In a service environment, like MRO, just-in-time can be applied just as well as in a manufacturing process. However, flow as a result of just-in-time delivery will not be so prominent.
An agile and efficient process is controlled by the demand of customers. To prevent wastes in the form of inventory, overproduction, and warehousing, the process should be initiated by the last step. This means execution of the process will initiated from the last station within the process and signaled back to the supplying parts of the process. The early steps of the process only deliver when demand for the end product of a step is established. A process operating on the basis of pull facilitates flow.

A method for facilitating pull is the ‘Kanban’ system. Kanban is a Japanese term for visualizing by means of a card or board. Kanban can be practiced by means of paper cards or electronic signals form the end of a supply chain to the start of a production or service process. Each step of a process communicates to the previous step of the process with the request for parts or services. The essence for Kanban is that the demand for end products of each step of the process is not a predicted or forecasted value, but it is the actual customer demand.

Why apply LEAN in the MRO sector
The automotive industry has played a leading role in the development and implementation of LEAN. Existing methods for process optimization have proven themselves to be successful in industries other than the manufacturing sector as well. However, the implementation of LEAN within the MRO sector faces some difficulties, caused by the specific characteristics of this sector. Characteristics such as low volume of processed products, the unpredictable work-scope, variable customer demand, and a large variation of products are far from those dealt with in mainstream LEAN literature. Still, these companies will encounter a number of benefits if they succeed in improving their work methods, and the pursuit of MRO organizations to meet customers demand is key to stay competitive within this sector. As (Ayeni, Baines, Lightfoot, & Ball, 2011) describes:
“Severe economic turmoil and ever-increasing global competition introduce the opportunity for the adoption of a resilient, tried, and tested business operation model such as LEAN.”

Maximize asset availability and minimizing downtime
Companies operating within the MRO industry constantly have the pressure of not disturbing the day-to-day operation of the product they work on. For example, if maintenance of an aircraft is delayed and is not performed within the planned timespan, operation might be interrupted and flights will not be performed. If an MRO is able to perform the required work quicker and more effectively, not only will the aircraft be able to continue operation within a shorter timeframe it will also increase throughput and sales for the MRO.

Practicing LEAN principles in MRO: Lufthansa Technik
A leading company that shows the implementation of improvement principles within an aircraft maintenance environment is Lufthansa Technik. It is one of the major aircraft maintenance facilities in Europe, with around 25,000 employees and 580 customers worldwide (Kohrs, 2008).

Lufthansa Technik has brought LEAN implementation into practice within the service environment from 2004. It then initiated small projects aimed at improving various parts of the maintenance process. Training staff, smarter usage of tools and inventory, and recognizing wastes within the process, accomplished this. In the years following Lufthansa Technik has broadened the scope of the improvement activities and aims for improvement of the entire maintenance process as a whole. In a number of ways this approach has been successful. Employees have been closely involved in the process of recognizing wastes, coming up with improvements, and bringing the improvements into practice. This is achieved by organizing Kaizen sessions, which focus on interaction with and involvement of the employees being part of the particular process.

Furthermore, Lufthansa Technik has set up a performance measurement system to have constant understanding of the effects of implemented changes and to provide feedback for employees. The feedback is considered a vital factor for motivation and understanding. Targets of each division are made clear and communicated through posters on all departments.

Optimizing SME MRO processes
Previous research of the Amsterdam Aviation Academy has determined that applying process improvement to the aviation MRO SME sector requires special attention (Boersma, Vries, & Wennink, 2011). A number of unique characteristics such as unpredictable customer demand; the variance of services to be performed; low volume of products; lack of resources (turnover; manpower); lack of operational data require careful adaptation of traditional LEAN thinking.

Maintain Your Competitive Edge
In February 2013 the Amsterdam Aviation Academy initiated the Maintain Your Competitive Edge [MYCE] research project aimed at identifying ways for smaller aviation maintenance companies to improve their competitive position. The project was made possible by the Nationaal Regieorgaan Praktijkgericht Onderzoek SIA through a RAAK grant.

The project conducted research into the possibility of applying process optimization methods such as LEAN and Six Sigma within the unpredictable conditions of maintenance as performed in aviation and aviation regulated areas. The results build on state-of-the-art knowledge from institutions such as T.U. Delft, the Schiphol Group Lean Office, the KLM Lean Six Sigma Office and TNO, all of which where represented in the project’s ‘expert group’. Additional expertise was made available through collaboration with the University of Tennessee’s Dr. Melissa Bowers and Dr. Mandyam Srinivasan.

A careful diagnosis with partner SME MRO’s enabled a characterization of SME MRO’s necessary for designing a custom approach. In parallel, process optimization initiatives where deployed and extensive literature review was performed to refine best practices for the sector. Academic literature and action research resulted in the formation of a comprehensive improvement roadmap and a custom made toolbox. (See page 8 to receive the toolbox free of charge.)

The framework (see Figure 4) depicts a two dimensional development as an organization progresses along its process improvement journey. It represents the interaction between process capabilities (i.e. how efficient is my process / organization) and improvement capabilities, where improvement capability refers to the required building blocks for a continuous improvement organization (i.e. leadership development, training, etc.).

**Getting started - simulation and quick scan**

Initial research showed a limited connection between smaller organizations and process optimization knowledge. Therefore, organizations just getting started with improvements can make use of a MRO specific LEAN simulation incorporating typical SME MRO elements to acquaint themselves with basic LEAN principles in MRO. The simulation provides a controlled MRO environment based on LEGO airplanes.

A two-day quick scan allows organization to quickly determine improvement projects and establish a baseline for improvement. It includes interviews, mapping of the current value stream, but also a self-assessment for easy benchmarking against process improvement critical success factors.

**Critical success factors for process optimization**

To increase the change of improvement success for SME MRO’s, an extensive literature review lead to the identification of so-called critical success factors (see Figure 5). All of these elements were operationalized...
and included in a self-assessment part of the quick scan and also made available in the toolbox.

Figure 5  Radar diagram indicating the presence of critical success factors

A toolbox for assisting implementation
A digital toolbox, consisting of an interactive framework and SME MRO tailored set of tools. The tools provide a straightforward approach for application of traditional process improvement tools within an industry with challenging characteristics. Included with the toolbox are: a test for the presence of critical success factors for process optimization; an improvement cycle guide for performing process optimization; a process improvement simulation game; and other tools offering assistance and guidance with improving company processes within the SME MRO sector.

Field for further research
Over the course of the past decade the use of process improvement philosophies like LEAN have led to positive results. Most of the successes have taken place in the field of manufacturing, which is eminent since the process improvement philosophies have their roots in this industry.

Continued competitiveness of the MRO sector requires constant improvement of working methods and small organization will need to follow. Research and consultation projects like the MYCE project have proven to be successful on the field creating awareness and education of employees of SME MRO companies. A customized approach proved to be effective in realizing process improvement within this sector.

The Aviation Academy of the Amsterdam University of Applied Science continuous with research and education in MRO optimization. Follow-up research will have to be performed on the previously stated fields to further validate improvement principles and assist with innovation in the MRO sector. Also LEAN MRO course continue to be offered to interested companies active within and outside the aircraft MRO industry.

Get started with process optimization
The Aviation Academy offers expert advice and tools to guide professionals with implementing process optimization methodologies within aviation MROs.

Feel free to contact the LEAN MRO helpdesk of the Aviation Academy to request the extensive toolbox and the booklet containing the results of the Maintain Your Competitive Edge research project.

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Glossary

- **Maintenance, Repair, and Overhaul (MRO):** Involves repairing any sort of machinery or part. It is also known as repair, unscheduled, or causality maintenance.
- **Small and Medium Enterprises (SME):** Companies that employ less than 250 persons and have an annual turnover not exceeding 50 million euro.
- **Key Performance Indicator (KPI):** Variables to analyse the performance of a company. A KPI transforms the objectives and targets of a company to measurable results.
- **Maintain Your Competitive Edge (MYCE):** Research project performed by the Amsterdam Aviation Academy as part of the Amsterdam University of Applied Sciences to the development of process improvement methods for the aircraft SME MRO industry.
- **Aviation Academy:** Part of the Amsterdam University of Applied Sciences created to serve the aviation industry.
- **Toolbox:** A web-based application that presents the process optimisation framework, allowing users to investigate specific areas of interest.

References


Image references (top to bottom, left to right)

Front page
http://www.adi.aero/common/images/slide5.jpg

Figure 1
Flickr.com. Scania Group
https://www.flickr.com/photos/scania/2869194523

Figure 2
LEAN.org. Principles of LEAN
http://www.lean.org/images/5stepslean.gif

Figure 3
Flickr.com. clg20171
https://www.flickr.com/photos/clg20171/8127818258

Figure 4 and 5
Maintain Your Competitive Edge research publication. See references.

Dutch Summary

LEAN en procesverbetering worden steeds belangrijker in de dagelijkse operatie van bedrijven. LEAN is voortgekomen uit een nieuwe manier van werken waarbij constante focus ligt op de eliminatie van verspillingen binnen het productieproces. Onderzoek van de Hogeschool van Amsterdam heeft aangetoond dat het lonend is voor vliegtuigonderhoudsbedrijven behorende tot het midden- en kleinbedrijf om procesverbetering door te voeren. Echter, de uitdaging is dat deze sector wordt gekenmerkt door factoren die de toepassing van traditionele proces verbetertechnieken bemoeilijken. Deze bedrijven kunnen wel groot voordeel behalen, met name doordat het concurrentievermogen met grote onderhoudsbedrijven wordt vergroot. Vervolgonderzoek is nodig om de toepassing van LEAN binnen deze sector voort te zetten.

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