June 22, 2011 (Wednesday) 55th EOQ Congress

CONCURRENT SESSIONS **Wednesday 8:30 – 12:30**
KEMPINSKI HOTEL CORVINUS **Erzsébet tér 7-8, Budapest V.**

REGINA BALLROOM I. **Wednesday 11:00 – 12:30**

18.1. SIX SIGMA AND LEAN MANAGEMENT

Session Chair: ***Charles Aubrey****, Anderson Pharmaceutical Packaging an AmeriSource Bergen Company, USA*

11.20 Integrating Six Sigma and Lean for Better Results
Lars Sörqvist, Sandholm Associates and Royal Institute of Technology, Sweden

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INTEGRATING SIX SIGMA AND LEAN FOR BETTER RESULTS

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SUMMARY
By integrating Six Sigma and Lean, many synergic effects could be reached. Together, the two concepts create a new way of working that is more powerful and effective than any of the two concepts individually. This paper includes a comparison between Six Sigma and Lean; a deeper discussion about strengths and weaknesses of the two concepts, and strategies for integration between them. The paper presents how Lean tools and methodology could be integrated into Six Sigma to create a successful Lean Six Sigma program, and how tools and methods from Six Sigma could be integrated into a Lean production system to create an effective Six Sigma Lean production system.

1. INTRODUCTION
Today, Six Sigma and Lean are the two most used concepts for continuous improvements and process development. Most companies are using at least one of them. More and more companies are using both. In some companies, this results in two separate programs; one program for Six Sigma and one for Lean. This is not usually successful. Many of the possible synergic effects between the two concepts are missed and often conflicts arise between the two programs. Some people believe that it is necessary for a company to choose between implementing either Six Sigma or Lean. Due to this dilemma, a very important and relevant question emerged: How does one integrate Six Sigma and Lean successfully? This paper will describe important experiences for the successful integration of Six Sigma and Lean. The research is based on studies done at the Royal Institute of Technology in Stockholm, experiences from practical integration within Volvo, SKF, Ericsson, and ABB, and from many years of personal experience by the author then acting as Master Black Belt in Six Sigma and as a Lean Leader.

2. SIX SIGMA AND LEAN – LONG TIME EXPERIENCES IN MODERN PACKAGES
Six Sigma and Lean were both introduced as concepts in the late 1980´s and are today more ore less global norms for quality management and operational excellence. Today, Six Sigma and Lean are found in most sectors; both private and public. If the two concepts are studied more deeply, a long historical background is found. Lean is based on experiences and research from Toyota's very successful production system (TPS) that was founded during the 1950´s. Six Sigma was founded within Motorola during the 1980´s and was later further developed within General Electric and other companies. Many of the structures and models in Six Sigma are strongly influenced by the ideas and theories of Dr. Joseph Juran (see Juran, 1964 or Juran & Godfrey, 1999) who was (not coincidentally) working as a consultant at Motorola when they developed their famous company-wide improvement program. This brings up the level of significance of Juran's work, and the historical connection between what we today call Six Sigma and Lean, as Juran, together with Edwards Deming, were two of the persons that strongly influenced the Japanese into developing their quality initiatives in the early 1950´s. Among the Japanese companies that learned from Juran and Deming where Toyota.

Much has improved since Six Sigma and Lean were introduced more than 20 years ago. A fantastic evolution and development has taken place within both of them. Although many of the tools are the same and existed long before Six Sigma and Lean, the structures, models, and work methods have changed significantly. Years of experience from thousands of companies have been the ground for improving the two concepts. Today, most of the knowledge developed during the last 50 years regarding continuous improvement and process development are found within Six Sigma and Lean. The two concepts could because of this, be seen as best practice in their respective areas.

3. SIX SIGMA – CONTINUOUS IMPROVEMENTS AND PROBLEM SOLVING BASED ON FACTS
Six Sigma (see Sörqvist & Höglund, 2007 or Rath & Strong, 2003) has nearly become a global norm for continuous improvement and problem solving. The concept is based on a project-based structure that includes an effective infrastructure with clear roles, common problem solving models, and many useful tools. The infrastructure for improvements is based on

three roles (see figure 1). All employees must take part in the improvement projects that are being run in the organization. Managers must be present on all levels in order to steer the improvement work within their organizations and take responsibility for reaching acceptable results (Sponsors/Champions). Well-trained and competent improvement coaches/specialists must be there to support the ongoing improvement work on different levels (Green Belts, Black Belts, Master Black Belts, etc). Normalized competences and training programs exists for all roles.

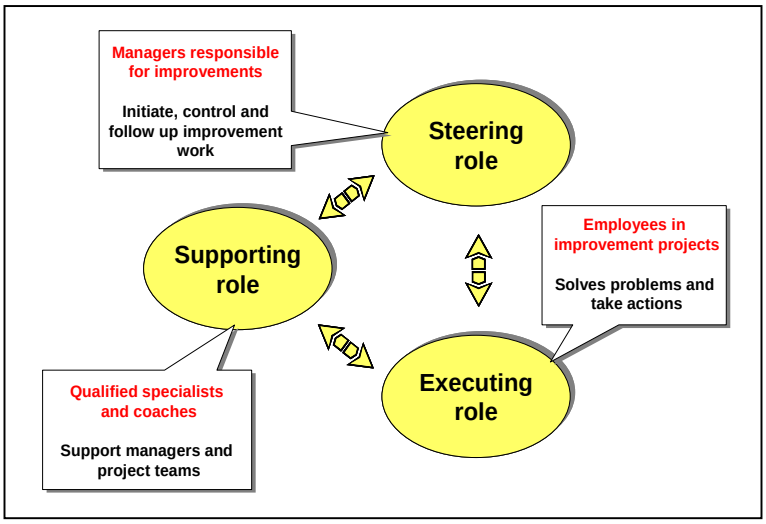

Figure 1. The ground for the Six Sigma infrastructure that gives improvement projects a good chance of succeeding (Sörqvist & Höglund, 2007).

Six Sigma has a common problem-solving model (DMAIC) that creates a structure for all improvement projects that are run (se figure 2). With this, an analytical work structure based on facts is guaranteed. The problem is carefully defined and delimited. Facts and data are collected through measurement; while root causes and suitable solutions are decided through analysis. The chosen solution is implemented and followed-up to secure long-lasting effects.

THE DMAIC METHODOLOGY				
DEFINE	MEASURE	ANALYZE	IMPROVE	CONTROL
Define the project goals and scoop	Define information need	Identify all possible causes	Generate possible solutions	Identify need for control
Define financial impact and business case	Identify Critical to Quality (y) and all inputs (x)	Identify root causes	Prioritize solutions	Standardize the process and new way of working
Develop high level process map (SIPOC)	Define and analyze demands and specifications	Analyze root causes and develop understanding	Validate and test solutions	Implement control and follow up
Identify customers and define voice of the customers	Develop a suitable data collection method	Validate results	Develop execution plan	Analyze results and benefits
Create project charter	Analyze and test measurement system		Implement solutions	Share experiences
	Establish baseline and collect data		Check results and effects	Finalize project report and presentation

Figure 2. The DMAIC problem solving model.

4. LEAN – PROCESS DEVELOPMENT AND EFFECTIVE FLOWS

Lean (see Womack & Jones, 2003 or Liker, 2004) focuses on transforming the flows and processes of the business into a homogeneous production system that is controlled by the needs and demands of the customers (a pull system). High cost effectiveness and high customer satisfaction could be reached by focusing on value creation and by systematically eliminating all work and activities that do not create results for the external customers. Other important steps then implementing a Lean based production system include the development of a continuous process flow, balancing and levelling the workload in the process, standardizing the best working methodology, and implementing a takt time. Some of the most important principles of Lean are shown in figure 3.

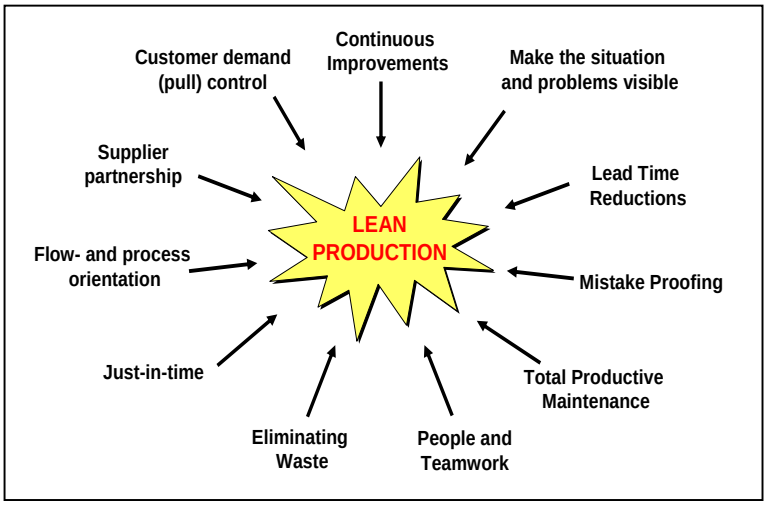

Figure 3. Important principles and methods of Lean (Sörqvist, 2004).

The biggest challenge is not the physical changes it requires; it is the complete cultural change it usually means to the organization. The most dramatic change being the change of perspective for both the leadership and the employee. Lean means total co-operation towards the mission and the fulfilment of customer needs. A strong common commitment in improvements is a fundamental condition. To develop a Lean organization takes long time and represents a new way of thinking that requires management with strong purposefulness and understanding. If the job is done properly, early results and effects usually turn-up quickly, even if the total transformation takes years.

5. SIMILARITIES AND DIFFERENCES

There are many similarities between Six Sigma and Lean. At first glance, they can look rather different, but once one understands the two concepts more deeply, the similarities become clear. They both have a strong focus on quality and continuous improvement. Management commitment and understanding are central. The work is based on the deep knowledge and understanding of the companies' customers and processes. People are trained and involved; often even suppliers and customers are involved.

Many of the more immediately prominent differences between Six Sigma and Lean could be explained as a result of cultural differences between the western world and Japan. Six Sigma was founded within Motorola and further developed in companies like General Electric and Ford. In the west, organizational structure, responsibilities, and facts and measures are of the utmost importance. Lean on the other hand, is based on Toyota's very successful production system. In the Japanese culture, principles, philosophies, general structures, and behaviour are more central. This is probably a major reason why Six Sigma has more structures, roles with clear responsibilities, one common model (DMAIC), and many of systematic tools; while Lean is based on principles, change of behaviour, and company culture. Once one understanding the concepts, it becomes clear that the underlying meaning is very similar despite those cultural differences.

The most important difference between Six Sigma and Lean has to do with purpose (see figure 4). Six Sigma is a program intended for running continuous systematic improvements in an organization. Lean focuses on building a production system for the entire business; which means transforming the organization and its processes into a completely new way of doing the work. A production system created out of the Lean principles is also based on continuous improvements, but using fewer

tools and structures than Six Sigma. A total Lean transformation is a much bigger challenge than the implementation of a Six Sigma program, as it means a totally new way of running the business. Lean is more like a total paradigm shift. Compared to Toyota's success with their production system, very few companies have succeeded in really implementing Lean (though most manufacturing companies and many service organizations are using some selected Lean tools). One reason is perhaps that a Lean transformation takes a significant amount of time to implement, and western management and stockowners don't have the maturity or patience needed. With Six Sigma it is often easier to succeed as Six Sigma is a separate program. A Six Sigma program provides visual results rather quickly, as it is based on running many improvement projects simultaneously and that those results are measured financially. This usually makes it easy to motivate top management to become personally committed and to enlarge the Six Sigma initiative.

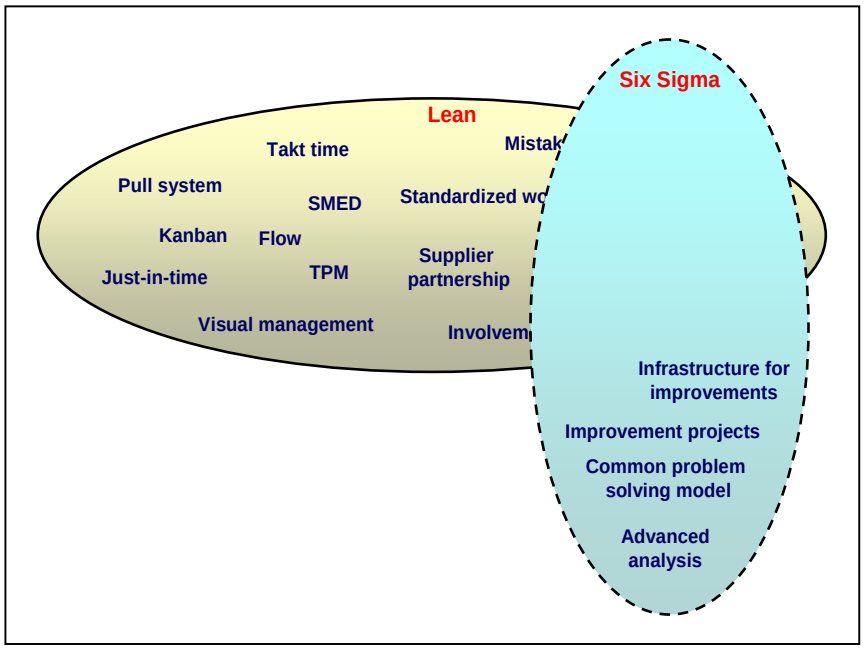

Figure 4. A comparison between Lean and Six Sigma. Lean is primary focusing on process development and flow optimization while Six Sigma is primary focusing on continuous improvements and problem solving (Sörqvist & Höglund, 2007).

When comparing Six Sigma and Lean, it is possible to identify both the strong and weak qualities of each concept (see figure 5). Six Sigma has a stronger focus on results, clear roles and responsibilities, and has numerous effective problem solving tools; while Lean focuses more on the full perspective and the total transformation of the work approach, has a stronger focus on involving all employees, and aims at a total change of the company culture. By integrating Six Sigma and Lean, we create the possibility to take advantage of most strong areas while avoiding weak ones.

Lean	Six Sigma
+ Flow and process development	+ Problem solving
+ Employee participation	+ Distinct leadership
+ Cultural change	+ Strategic result focus
+ Strong philosophy with resolute principles	+ Clear role structure, common methodology and many tools
+ Focus on quality	+ Financial focus
+ Local improvement teams	+ Cross-functional improvements

Figure 5. Strong sides of Lean respective Six Sigma.

6. INTEGRATING SIX SIGMA AND LEAN

Six Sigma and Lean can be integrated in two directions. Selected Lean tools can either be integrated into a Six Sigma improvement program, or improvement methodology and selected tools within Six Sigma can be integrated into a Lean production system. The results will be distinct. If Lean tools are integrated into Six Sigma, better improvement and problem solving concepts will be created, which are flexible enough to handle many different situations. If Six Sigma tools are integrated into a Lean production system, a more effective production system is created, which enables much better improvement capabilities.

6.1 Lean Six Sigma

By integrating selected Lean tools into Six Sigma, a wider and more effective improvement program is created. By complementing the traditional statistical methods within Six Sigma with tools like Value Stream Mapping, Poka Yoke, Cycle Time Reduction, Standard Work, and Theory of Constraints, it is possible to handle and solve a wider range of problems. Six Sigma becomes a complete problem solving and improvement program that can handle any problem; from elimination of variations, to making flows and processes more effective. This kind of integration is usually called *Lean Six Sigma*.

Today, most Six Sigma programs and training courses are based on Lean Six Sigma (see George, 2002), while traditional Lean tools have more or less became a part of Six Sigma. Regardless, there is often much to learn about how to really integrate Lean tools into the DMAIC and to make them a natural part of Six Sigma. Other important areas that are vital to adapt in order to enrich Six Sigma with methodology from Lean are: the running of local improvement initiatives in workgroups (Quality Circles), the development of a company-wide improvement and quality culture, and the focus on a total-process perspective.

The DMAIC could be used as a company global model for improvements and problem solving. Historically, the model is made for more complicated Black Belt projects where many different tools are used. It is also used for less complicated Green Belt projects where one of the major differences is that less advanced tools are needed. Some companies have also enlarged the model by developing a more simplified version (se figure 6) based on the five steps that are used by the local improvement teams as part of their daily production output. Good examples of this can be found within Volvo Cars and Coca-Cola in Sweden. In this way, the DMAIC model has become a general model for all kind of improvements.

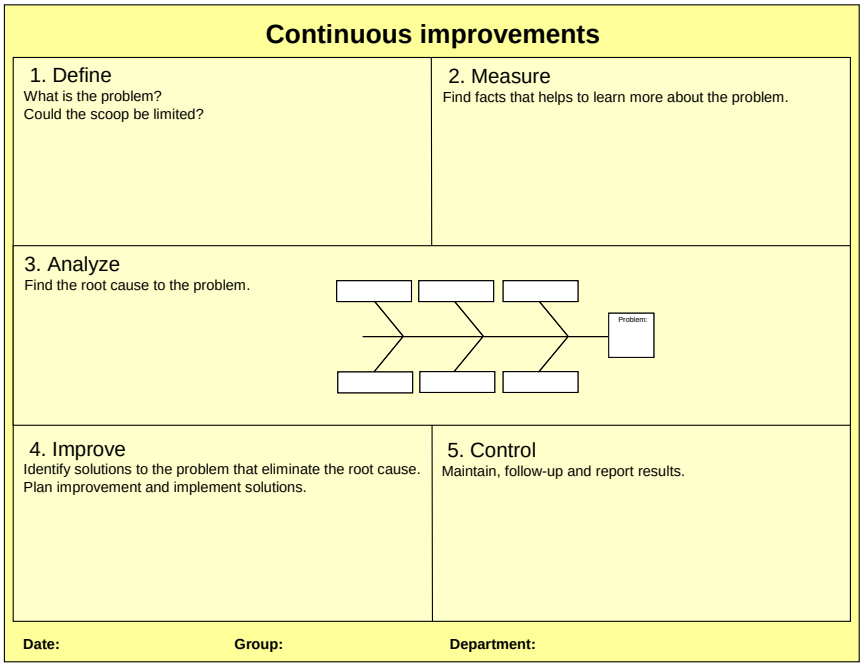

Figure 6. Example of a simplified method of using the DMAIC-model in local improvement teams.

6.2 Six Sigma Lean

The integration of Six Sigma into a Lean production system is much less common than integrating Lean tools into Six Sigma. It seems that people working with Six Sigma have understood and accepted the advantages of bringing Lean tools into Six Sigma more than people working with Lean have accepted and understood Six Sigma. In any case, it is of great importance to change this and create an extended version of a Lean production system that uses Six Sigma as a structure and methodology for improvements and development. This kind of integration could be called *Six Sigma Lean*.

Six Sigma has much to gain from implementing aspects from a traditional Lean production system. Better understanding for and control of variations in processes are fundamental for succeeding in building a production system based on customer demands and JIT (just-in-time). It is not possible to have short cycle times through small batch sizes, takt time, and a Kanban system if process variations are not are in control. Statistical tools like control charts and capability studies from Six Sigma could (because of this) be a breakthrough for the possibilities to create a successful Lean production system.

Lean's improvement methodology could be significantly developed through the implementation of the more powerful tools and methods from Six Sigma. Organizational role structures and competence aspects from Six Sigma could be brought into Lean. The management side of Six Sigma with its strong connections to overall business goals, clear leadership responsibilities and the reporting of financial results achieved are also of great relevance when a Lean production system should be taken to a higher level. An interesting and well performed example of this can be found within Volvo, where the DMAIC model and Six Sigma tools are used successfully as a ground for Kaizen Events in their Lean program. Those Kaizen Events are also led by Volvos Six Sigma Black Belts.

7. INTEGRATION OF DESIGN FOR SIX SIGMA AND LEAN PRODUCT DEVELOPMENT

Another area of interest for the integration of Six Sigma and Lean is design and product development. Today, there is a strong movement within both Six Sigma and Lean to focus on new product development. This is in most companies, a difficult area to influence, but very important as it probably is the only way to build quality from the beginning. Within Six Sigma, a special methodology for product development; DFSS (Design for Six Sigma), has been developed. DFSS focuses mostly on the tools and methodology of the design work. By working in a more structured manner and using better tools, designs will improve, and the risk for failure diminishes. Similarly, more and more companies are discussing Lean Product Development and are using the Lean principles and philosophies in their design processes. The primary effect of Lean Product Development will usually mean a faster and better process for design and product development.

Both DFSS and Lean Product Development are rather new areas that have only been in focus for the last 5 to10 years. Very few companies have yet implemented successful programs, although many are struggling to do it. Both areas have knowledge in common, even if their main focus is slightly different (tools vs. flows). Again, there is a fantastic opportunity to integrate these two initiatives and learn from their respective differences. This could perhaps make it easier to convince employees in design areas to change their traditional behaviour and work methodologies within design and development.

8. HOW TO INTEGRATE

Many companies have tried to work with Lean and Six Sigma as two parallel concepts within their organizations. This has often been more instrumental in creating misunderstanding, cultural clashes, and building barriers between the two sides. An integration of the two concepts is important. Some companies try to do this by putting one concept on top of the other. Often, this becomes unclear and difficult to understand. The structures and packages of Lean and Six Sigma are too different to make this practically useful. A successful integration has to be much deeper. Tools, working methodologies, and techniques have to be integrated with each other.

There are some different areas there Lean and Six Sigma could be integrated to make the total integration easier and more natural for the organization. Some of the most important areas are the following.

8.1 Integration through management and leadership

It is very critical for succeeding with Lean and/or Six Sigma to have strong management commitment and a leadership focusing on quality and improvements. When integrating Lean and Six Sigma it is important that top management and managers on all levels of the organization makes improvements to a natural part of the daily work. Continuous improvement should play an important role to meet the goals of the organization. Quality is strategy. By this Lean and Six Sigma gets a natural position in the way the organization is managed and focus is on results and on the business instead of on the methods and the tools them self. Running continuous improvements through Lean and Six Sigma becomes by this a way of leading the organization.

8.2 Integration through competence and training

Succeeding with integration has a lot to do with building a common cross-functional competence between the two concepts. By getting the same people to learn both Lean and Six Sigma in detail, deep understanding can be reached. Thus, when the situation requires it, the knowledge to combine the best techniques and tools from each concept can be used. A person can then fully understand both concepts since many of the barriers and misunderstandings automatically disappear. To succeed, it is of great importance to have a strong result focus and get rid of method focus and fundamentalism. It is important to stop looking at Lean and Six Sigma as pre-defined methodologies that should be run in a pre-determined fashion. They should be treated as competence packages with high flexibility that can be combined in the best possible ways.

8.3 Integration through roles and organization

By creating one common organization with common roles for running improvements and develop the business based on both Lean and Six Sigma the two concepts are easier melting together. Having the same organization for all kind of improvements, as local improvement teams, rapid improvement events and cross functional improvement projects, prevents sub-cultures that otherwise obstructs the integration of Lean and Six Sigma. One alternative that is used by more and more organizations today is to base this on the role structure of Six Sigma with Black Belts and Master Black Belts leading and coaching more complicated and cross-functional improvements projects, Green Belts for leading and coaching local improvements and Yellow Belts (all employees) for running local improvements directly in the daily work (se figure 7). Another alternative is to give the roles names based on Lean like Lean Leaders and Lean Coaches.

	BB-projects	GB-projects	Daily improvements
Sponsor/ Champion	Principal	Principal	Principal
Black Belt	Project manager	Coach	-
Green Belt	-	Project manager	Coach
Yellow Belts	Project member	Project member	Project manager/member

Figure 7. Using Six Sigma's role structure for all kind of improvements.

8.4 Integration through tools

A common way of working with all the tools and techniques learned from Lean and Six Sigma has to be found. Using the best tool in every situation. Mixing tools to support continuous improvements as much as possible. It does not matter if a tool historically belongs to Lean or Six Sigma.

One important consequences is that the total scoop increases, and the number of tools and techniques increase dramatically. The new integrated concept becomes more and more complete, and has the ability to handle progressively more different situations. This is of course very positive, and results in a much better improvement program. On the other hand, the methodology simultaneously becomes more vague and undefined. The specific way of working and solving problems becomes more and more situation-specific. This is something that has to be accepted. What is of the utmost importance is to treat this as a competence and power to problem solve, develop processes, and run improvements rather than as a pre-defined methodology that should be followed in a specific way.

8.5 Integration through methodology

Instead of using different methods in different situation it is important to standardize the methodology. An example is to use the DMAIC model for all kind of improvements and scale it to fit the actual situation instead of using the PDCA model for local improvement teams and the DMAIC model for cross-functional improvement projects. Good examples of this are found within Coca-Cola and Metso Paper. Another interesting example is Volvo there the DMAIC model is used in Kaizen Events.

9. CONCLUSION

Six Sigma and Lean have much to offer each other. There are many similarities, but also differences. By integrating the best parts from each concept, a new and much better concept could be created. This has both to do with the tools and techniques

that are associated with each concept and with the working methodology advocated by them. It is very important to integrate Lean and Six Sigma on a very deep level. Putting them on top on each other is usually not successful. In some situations it can become worse; with conflicts arising between them. Instead, Lean as Six Sigma have to be integrated into a common competence where tools, techniques, and working methodologies are combined and mixed in the best possible way.

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