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INTRODUCING SIMULATION AND OPTIMIZATION IN THE LEAN CONTINUOUS IMPROVEMENT STANDARDS IN AN AUTOMOTIVE COMPANY

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ABSTRACT

The highly competitive automobile market requires automotive companies to become efficient by continuously improving their production systems. This paper presents a case study where simulation-based optimization (SBO) was employed as a step within a Value Stream Mapping event. The aim of the study was to promote the use of SBO to strengthen the continuous improvement work of the company. The paper presents all the key steps performed in the study, including the challenges faced and a reflection on how to introduce SBO as a powerful tool within the lean continuous improvement standards.

1 INTRODUCTION

Continuous improvement is and will be one of the key aspects of the survival of any organization. This is especially true in the extremely competitive automotive sector. Continuous improvement can be defined as the activities performed by an organization to eliminate existing waste; it is also highly correlated to the organizational culture of sustaining improvement (Liker 2004; Singh and Singh 2015). Lean is a management philosophy focused on customer satisfaction and based on the elimination of non-value-added activities via continuous improvement. The main method within lean to identify the material and information flow, as well as the value-added and non-value-added activities, is Value Stream Mapping (VSM) (Rother and Shook 1999). While VSM offers many benefits, it also has some limitations, mainly due to its static nature. Simulation has been recognized by many authors as the right complement to VSM to overcome these limitations (McDonald et al. 2002; Abdulmalek and Rajgopal 2007; Lian and Van Landeghem 2007; Marvel and Standridge 2009; Solding and Gullander 2009; Gurumurthy and Kodali 2011; Schmidtke et al. 2014; Helleno et al. 2015; Atieh et al. 2016).

Discrete Event Simulation (DES) is one of the most-applied simulation techniques for studying and improving manufacturing systems (Negahban and Smith 2014). It provides the possibility to design and evaluate the current and future states of complex and dynamic systems, as well as insight about possible improvement possibilities. Simulation-based Optimization (SBO) is a technique that links simulation and optimization algorithms to offer optimal or nearly-optimal system configurations (April et al. 2004).

This paper presents a case study where simulation was employed as part of a VSM event. The aim of that event was to draw the current state map of a semi-automated automotive component assembly line and to identify the bottlenecks of the system as well as the existing improvement possibilities. Simulation and optimization were introduced in this event to show the opportunities that the tool may offer and to try to establish simulation as a natural step in an improvement event in the company. The company had established standards to include simulation analysis as an important step of any new system design and all the lines of the plant have been modeled by a team of simulation engineers. However, simulation is not employed as a support tool for continuous improvement. Having all the models ready to be employed and not using them for continuous improvement was considered a waste by the team of simulation engineers who also see the benefits to support the company in this matter. As defined by Robinson et al. (2012), combining lean and simulation is a way to make lean more sustainable in the company and simulation more employed for continuous improvement and decision-making support.

This paper is structured as follows: Section 2 presents a literature review on the combination of lean, specifically VSM, and simulation. A background on the experience of the company regarding lean and SBO is provided in Section 3. The detailed description of the steps taken to conduct the case study is presented in Section 4. Section 5 reflects on how to introduce SBO within the continuous improvement standards. Finally, Sections 6 and 7 reveal the discussion and conclusions, respectively.

2 LITERATURE REVIEW

Lean is a management philosophy composed by values, principles, methods, and tools to support organizations to eliminate waste and create value for the customer (Liker 2004). One of the most-employed lean methods to visualize, analyze, and design production systems is VSM (Bicheno and Holweg 2009; Gurumurthy and Kodali 2011). It is a tool that can be employed in many different sectors, but it is mainly applied to design and identify improvement possibilities in manufacturing lines (Shou et al. 2017). VSM offers many benefits including: 1) its ease of use and simplicity; 2) no additional cost than the man-hours expended in the process of VSM creation; 3) understanding the flow and value-added activities; 4) providing a good base for system design and improvement; and 5) the creation of a team to draw and analyze the VSM, sharing the view of the current and future state (Solding and Gullander 2009). However, despite the usefulness of VSM, its static nature leads to some limitations, of which some are highlighted in Table 1. Although other authors in the literature, such as Braglia et al. (2009), identify the limitations of VSM, all the authors identified in Table 1 propose simulation as a tool to complement VSM and overcome its limitations. Some of these authors present their case studies where simulation and VSM have been employed together (McDonald et al. 2002; Standridge and Marvel 2006; Abdulmalek and Rajgopal 2007; Marvel and Standridge 2009; Anand and Kodali 2010; Helleno et al. 2015; Atieh et al. 2016). Some others present tools that generate a simulation model based on a VSM (Lian and Van Landeghem 2007; Jia 2010). These tools are nowadays also available in some commercial simulation software packages. On the other hand, Solding and Gullander (2009) describe in their paper the opposite, a simulation model that generates a VSM. The case study presented in this paper follows the same approach as the latter.

The combination of lean and simulation is defended by Robinson et al. (2012), who point out that it is surprising that despite that both have the same objective, they have not been combined more often in the literature. Diamond et al. (2002), when analyzing the future of simulation, also pointed out the need for including simulation as a standard tool within lean, to make it “a natural activity in process improvement alternatives”. Adams et al. (1999) present a step-by-step flow where simulation can support the continuous improvement process. Goienetxea Uriarte et al. (2015) have highlighted the benefits of integrating lean with simulation and optimization for system design and improvement. Additionally, SBO provides a very good scenario for decision-making purposes (April et al. 2004) regarding system design and improvement. This combination will be especially interesting for the companies to adopt, particularly taking into account the importance that the digital twins will have for decision-making support in the forthcoming industrial revolution, i.e., Industry 4.0. However, even if the approach of combining lean, simulation and optimization may sound promising, if it is not integrated into the company's standards for system design and improvement, it just becomes a nice theory.

Table 1: Limitations of VSM and authors identifying them.

Limitations of VSM	Authors
Only the flow of one product can be analyzed at a time.	Solding and Gullander (2009), Pehrsson (2013), Atieh et al. (2016).
It is a "paper and pencil" map of just one specific moment on the shop-floor, not necessarily representing the complete reality, but just a simplification.	Solding and Gullander (2009), Anand and Kodali (2009), Lian and Van Landeghem (2007), Atieh et al. (2016), Jia (2010), Helleno et al. (2015).
It is a tool to design current and future states, but it does not allow for any evaluation of the future states before implementation.	Standridge and Marvel (2006), Marvel and Standridge (2009), Solding and Gullander (2009), Abdulmalek and Rajgopal (2007), Jia (2010).
It highlights possibilities for improvement without proposing any solution.	Anand and Kodali (2009).
The uncertainty, variability, and the dynamic nature of a production system cannot be represented by a static tool.	Abdulmalek and Rajgopal (2007), Standridge and Marvel (2006), Marvel and Standridge (2009), Lian and Van Landeghem (2007), Atieh et al. (2016), McDonald et al. (2002), Jia (2010).
It lacks the ability to map complex systems and the interactions between its components.	Marvel and Standridge (2009), Standridge and Marvel (2006), McDonald et al. (2002), Jia (2010).
When building the future VSM, an assumption is taken based on estimates of the outcomes that possible improvements will take. Difficult to understand how it will be translated into reality.	Anand and Kodali (2009), Lian and Van Landeghem (2007), McDonald et al. (2002).

3 COMPANY BACKGROUND

The studied company strives to become a first-class manufacturer in the automotive business sector. The production plant in Sweden, where this case took place, is one of the company's main component production plants. The plant is divided into several production processes where the semi-automated assembly is one of them. In this assembly line, components are assembled into the delivery unit. The company has designed and implemented a management philosophy based on lean, the so-called Lean Production System (LPS). There is dedicated staff in the plant who provide education and support the implementation of lean principles and tools as part of the deployment of the LPS. The VSM event is one of the standards that has been implemented by this team. It is conducted on a yearly basis in each and every production area of the plant to benchmark the status compared with the previous year and, most importantly, to detect improvement possibilities in the production lines.

Additionally, taking into account the advances that Industry 4.0 will bring and require, digitalization of production systems is becoming crucial at the company. There is a dedicated group of employees in the Department of Manufacturing Engineering (ME) who work with DES, SBO, and decision support. This department is mainly focused on designing, evaluating, and implementing new or rebuilt production flows through a series of projects. Each project follows a quality assurance matrix where flow simulation using DES is performed as a natural step in order to advance to the next steps of the project. All production lines in the company's component manufacturing plants are currently modeled in Plant Simulation or FACTS Analyzer (simply FACTS hereafter), which are commercial software systems. The use of one simulation software or the other depends mainly on the required level of detail when modeling the system under analysis, as well as on the profile of the modeler (knowledge and skills required). Simulation can offer the possibility to support the design of a new system or its improvement. The simulation group in ME is mainly focused on new system design and evaluation, which are strategic projects that usually: 1) require high investment; 2) may not have an existing current state where to base the future state on; and 3) involve high complexity. However, even if all the production lines are already modeled, this group does not actively work supporting continuous improvement. An educational program about simulation, and specifically on FACTS (Frantzen and Ng 2016), was provided to production technicians and engineers in order to promote its use as a natural step within continuous improvement. However, just a few engaged production engineers use it actively nowadays. For the particular value stream presented in this case study, a FACTS model was available and is employed on a regular basis by a production engineer. However, there was still some skepticism regarding the accuracy and reliability of this model. Moreover, kaizen and VSM events were conducted within the continuous improvement work for this production line, totally disregarding the existence of the simulation model and the support this could provide. This is probably because there is no interaction between the lean engineers promoting LPS, the simulation engineers in ME, and the production engineers working with simulation; even if all of them pursue the same objective of supporting a better company performance. Having the model ready to be employed, in lean terms, it is a waste not to use it to support continuous improvement. Additionally, as explained in the previous section, VSM provides a good visualization of the production flow. However, the company has replaced mass production by product mix lines producing several variants. This usually involves high process complexity and variability, which is hard or impossible to account for in the analysis part of the VSM event. These made the VSM event a good candidate to start introducing simulation as a natural step. The simulation group in ME had already designed a module to create automatically a VSM from the simulation model, similar to the one presented by Solding and Gullander (2009). This module is called Simulated Value Stream Map (S-VSM) and was mainly created to facilitate communication of results by employing the same icons and terminology as in a traditional VSM.

Additionally, according to the maturity model presented by Goienetxea Uriarte et al. (2017), this plant can be considered as having a high maturity on lean and SBO. Having reached this level of maturity, the model suggests that the next step is to start integrating SBO within the standards of the company, including the continuous improvement standards. This work is the starting point in that development, aiming at introducing simulation as a natural step in a VSM event.

4 CASE STUDY DESCRIPTION

The main steps followed in the case study are defined in Figure 1 and a detailed description of each one is provided in the following subsections. These main steps are: 1) definition of the current state via VSM and simulation; 2) definition of the target to be achieved; 3) design and evaluation of the future state; and 4) decision-making and implementation. This paper focuses on the first three stages due to the fact that the fourth one is currently taking place.

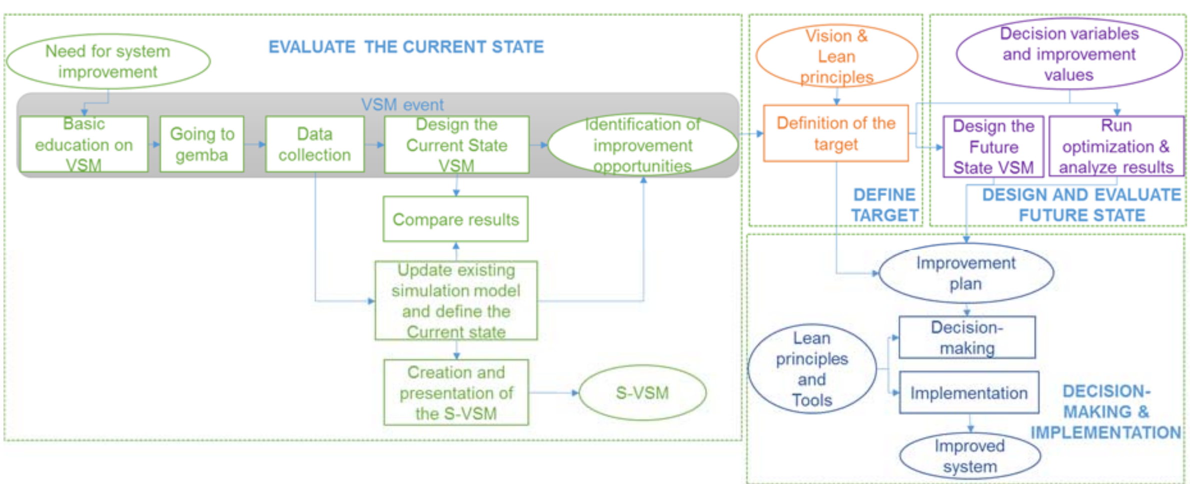

Figure 1: Process followed to conduct the case study.

4.1 Evaluating the Current State

A VSM event is done on a yearly basis in the semi-automated assembly production line. For this particular event, a team of 17 people was gathered, including the superintendent of the line, shift leaders, team leaders (2 per shift), operators, production engineers, a lean engineer, a simulation engineer, and a researcher from the university. A whole week was reserved for the purpose of defining the current state VSM and to identify and prioritize the improvement possibilities for the line. The week started with a basic training in VSM and identifying data requirements. After the training, the project team went to Gemba and followed the product flow through the different stations and buffers to gain a common view. The previous year's VSM was employed when visiting Gemba. After this visit, detected changes in the assembly line were introduced in the new current state VSM, including station updates, number of people working on semi-automatic stations, quality control stations, as well as the Work in Process (WIP) and maximum capacity of the buffers. In the consecutive step, the team was divided into different groups to focus on the data collection, which took four days. The data collection was done via time studies to get the Cycle Time (CT) (30 measurements/station). The average values for the CT were introduced in the VSM. Additionally, value-added (VA), necessary non-value-added (NNVA) and non-value-added activities (NVA) per station were measured through work sampling studies and documented in the VSM. Historical data were employed to get the availability of each station and to calculate the Overall Equipment Effectiveness (OEE) and Internal Equipment Effectiveness (IEE) values. To analyze the results, a diagram was drawn showing per station the values of OEE, IEE, CT, and the percentage of the CT being VA, NNVA, and NVA. The Takt time and the designed cycle time for each station were also drawn for comparative purposes (the diagram is not presented due to data confidentiality). The analysis highlighted the need to improve the CT and availability on stations 20, 40, and 340, to balance the work between stations 285 and 305, as well as to try to eliminate the NVA activities on station 190.

The question now on everybody's mind was whether SBO would pinpoint the same improvement needs and whether it would include more detailed information on the required improvement level to achieve the objectives.

4.1.1 Creating the Current State with Simulation

The main purposes of this step were: 1) to compare the results obtained via VSM and simulation; 2) to gain the trust of the production staff on the use of SBO to support decision-making in continuous improvement; and 3) to consider it as a natural step towards continuous improvement in any VSM event (and kaizen event) in the future.

For this case study, there was no need to build a new DES model of the current state. This was already built in Plant Simulation and FACTS five years ago when the line was designed (Figure 2). Since then, the Plant Simulation model has sporadically been employed by the simulation engineers, mainly for updating product and process changes.

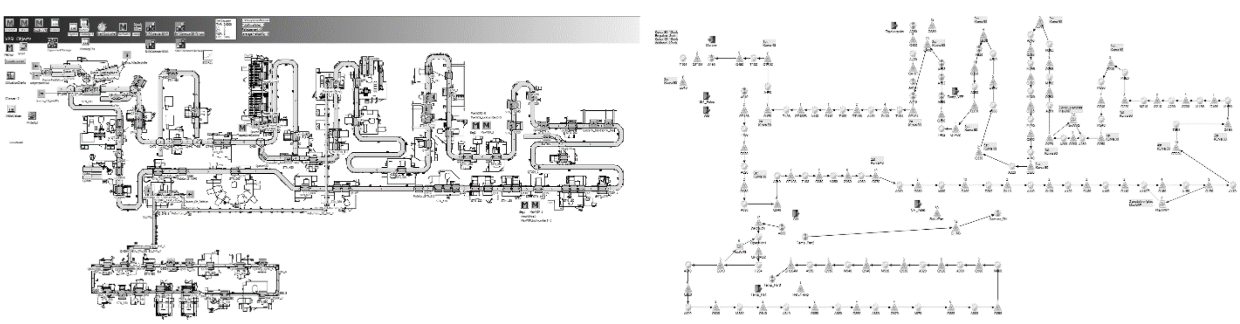

Figure 2: Snapshots of the simulation models of the assembly line under study, developed in Plant Simulation (left) and FACTS (right).

The FACTS model, on the other hand, has been used regularly on a weekly basis by a production engineer for identifying bottlenecks in the system. In the VSM event, the Plant Simulation model was chosen based on the ability to define customized experiments in order to present the results in a way that is requested by production managers.

The Plant Simulation model was updated including new cycle times and availabilities, based on the data employed to build the VSM. Additionally, a standard mean downtime of 2 minutes was introduced in the model, even if this was not taken into account in the VSM. The model was run during the meeting and when the simulation horizon had been reached, the results were presented to the team. These included the throughput, lead time and WIP values, the utilization chart of the stations, as well as the S-VSM. The model had previously been verified and validated when it was built. However, as not all the participants of the VSM event team were familiar with simulation, an animation of the model was presented to perform face validation. Face validation is a validation technique in which a model is presented to the people who know about the real system behavior (Sargent 2011). These subject matter experts were asked if the model was behaving correctly and producing reliable results according to their knowledge and experience, which they confirmed.

The in-house developed S-VSM was also generated during the VSM event. The main purpose was to show how fast a VSM could be generated from the DES model (Figure 3).

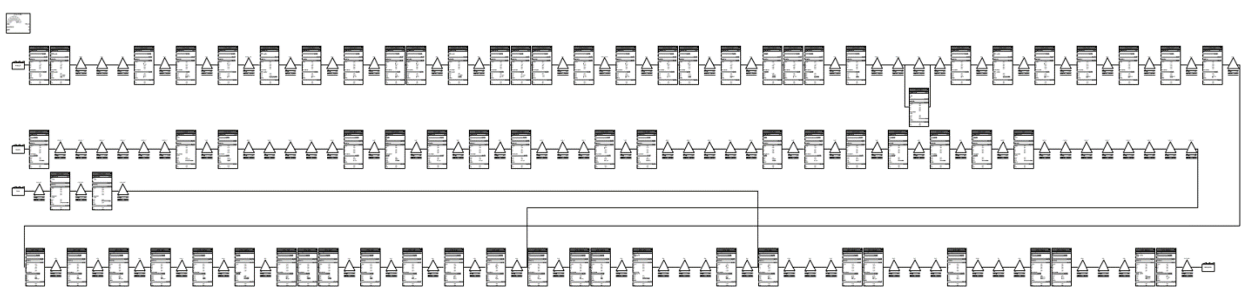

Figure 3: The S-VSM generated from the simulation model.

The next step was to analyze the results and to detect the bottlenecks of the system and its improvement opportunities. In order to present the results the same day, the utilization chart for each equipment was presented. Utilization charts may help the identification of bottlenecks, implying that high utilized stations (especially with long queues leading in) may be the bottlenecks of the system (Law and Kelton 1991). The process of updating the model, introducing new data and getting the results, was done in less than 30 minutes. The critical stations detected via VSM were also detected in this analysis, plus two additional stations identified as possible bottlenecks of the system, station 10 and 440. Although more reliable results could be achieved by including more accurate data, the purpose of this simulation was to prove the validity of the approach of employing simulation, to present the advantages that it may offer when building the future state and what-if scenarios, and the possibility to run optimization. As the team was impressed by the quick update of the simulation model and the quality of the obtained results, they decided to continue to further analyze the results and to run an optimization experiment.

4.2 Define the Target

The 2020 vision of the company states that the aim is to reduce the dock-to-dock time considerably and to increase the throughput of the system. Following this last aim, an SBO experiment was run. Additionally, a future state map was also developed. Lean principles were taken into account when deciding on how to prioritize improvements.

4.3 Design and Evaluate Target Conditions

As there are more reliable techniques available in finding the bottleneck than just analyzing the utilization of each equipment, the simulation engineer decided to run a simulation-based COnstraint REmoval (SCORE) analysis (Pehrsson 2016). This method is based on Simulation-based Multi-objective optimization (SMO). The aim of SCORE is to find and identify the impact of particular constraints of a system, remove them and thus improve the performance of the system. Each input parameter has one binary value, i.e., original or improved, and each constraint is ranked according to how frequently they occur in the optimization results. It is very accurate in identifying the system's bottlenecks and also the cause for them being bottlenecks (Pehrsson 2013). The improvement variables that were included in this case were the CT and availability of the stations, to match the analysis done in the VSM event.

The previously chosen bottlenecks were verified by the SCORE analysis and the detected seven most critical stations were added to a new SMO run. The objectives introduced in the optimization algorithm were to maximize throughput and minimize the number of changes in the system. One change was defined as + 1% availability or -1 seconds on the cycle time of these stations. This configuration of the optimization problem pursued to offer the team a result that is not based on pre-identified changes in the system, but rather on how possible combinations of small or big improvements in each station result in system throughput increases. In order to reach the requested relative throughput increase of 35% (real data is masked for confidentiality purposes), an example of an optimal configuration of the system is shown in Figure 4, illustrating that five improvements are needed (+4% availability in station 20 and +1% availability in station 40).

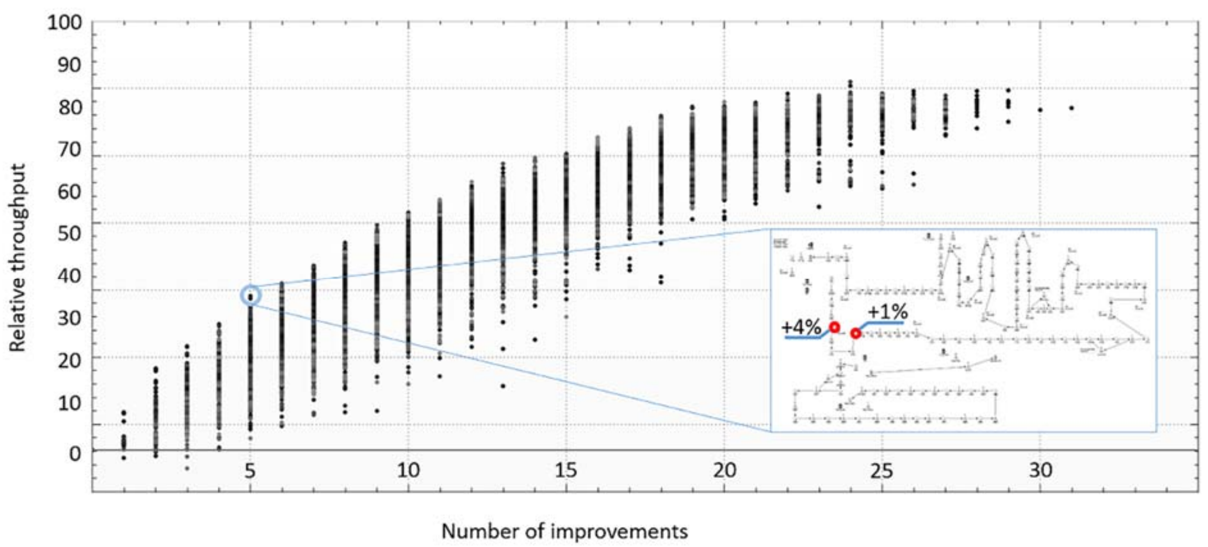

Figure 4: Optimization results. An example is chosen and identified in the simulation model where the improvements in two stations lead to the required relative throughput.

This selection might, however, demand costly alterations to the selected stations and, thus, another selection might be preferred in reality. As in any multi-objective optimization, to select the best solution among the ones presented by the optimization is the task of the decision makers. This analysis may be extended and include the cost that each improvement will inflict.

Due to the time needed to do all the optimization settings and the running time of the model, these results were presented to the team in a follow-up meeting two weeks after the VSM event. During this meeting, an improvement plan including the improvements detected from the VSM event was developed. The team was interested in continuing with the analysis of the optimization results, mainly to prioritize and to define in which stations to perform these improvements, as well as at which level.

4.4 Decision-making and Implementation

As both the VSM and the simulation model showed the same constraints in the system, it was an uncontroversial decision to start the implementation of these improvements right after the VSM event. These are an ongoing task designated to the production team and led by the participants of the VSM event. Different lean tools are being employed at this stage.

5 INTRODUCING SIMULATION AND OPTIMIZATION IN THE COMPANY'S LEAN CONTINUOUS IMPROVEMENT STANDARDS: A REFLECTION

The company has a high level of experience in implementing lean tools and even employing SBO for new production system design. SBO is considered as a natural step when developing or rebuilding a new system. These cases are normally part of the strategic plan of the company, in which the time frames of the changes to be performed are usually medium- to long-term. The cost and needed investment for this kind of changes are also usually high. As these characteristics have many implications, it seems that the management is convinced about the possibilities that SBO can offer to support the decision-making process. However, the participation in the VSM event showed that there is still a gap on the use of SBO to support the continuous improvement process inherent to lean. In these cases, the time frame to detect the improvement, decide, and implement the changes is typically short, and it does not necessarily involve much investment when compared to a new system design. Although the production engineers in the company have training on SBO, just a few of them employ it to support their work. Having all the production lines of the plant already modeled, it is a "waste" not to employ them for continuous improvement work. Therefore, the authors believe that to define working standards where SBO is included will be beneficial for the company.

The benefits of a combined approach of lean and SBO were discussed among the researcher, simulation engineers, and the lean engineers of the company. One of the first matters that were discussed was a need for a closer collaboration between the lean and simulation engineers. Additionally, the inclusion of SBO as a step in every VSM and kaizen event was also considered. The S-VSM module was presented more in detail to the lean engineers as well as the possibility to tailor it to their needs. A future transformation of the VSM event could include using the simulation model as the VSM generator. Standardized data collection files developed by the simulation engineers, where the team members could introduce the data collected in a VSM event and the simulation model could directly read from it, was also presented. The possibility to present the results of the SBO in a configurable A3 was also shown. The lean engineers confirmed an interest on integrating SBO within the working standards they develop, this would include even introducing SBO as a step in the standard PT-light file (the file with the list of activities to perform in any continuous improvement project). Simulation engineers, on the other hand, showed the interest on participating in the technical periodical meetings with the production staff in order to be up to date and collaborate actively on continuous improvement projects.

Furthermore, taking into account the role that simulation will have in the future Industry 4.0 in which virtual factories or the so-called digital twins (Jain et al. 2015) will be a key element for decision-making support regarding system design and improvement, it accentuates the need to start employing SBO as a standard tool. The coming industrial revolution will even ease the data collection and simulation model building tasks (Rodic 2017). It is, therefore, essential to create the need for using SBO in the company to support decision makers. Some actions taken to create this interest involve the creation of workshops for the industry and the creation of courses to train the staff on simulation. A simulation forum has also been created in the company, where every three months the simulation engineers present their projects and the advances made with their working standards related to SBO. However, the commitment of the management will be a requirement to succeed in the integration of lean and SBO.

During the case study, the team members were informally interviewed about the benefits that they perceived with the VSM approach. Some of these benefits, that are not usually gotten via a traditional simulation project, are: 1) the feeling of being part of a team; 2) going to Gemba, which provides the chance that everyone in the team gets the same picture of the current state, the chance to talk to workers on the line, identify the causes for failures or the most typical problems, etc.; 3) to get an ownership of the defined improvements, the team gets engaged to conduct the detected improvements; 4) VA, NNVA, and NVA are identified as a source of improvement; 5) the VSM of the current and future states are hanging on the meeting wall, always accessible, and facilitate discussions in future meetings after the VSM event; and 5) the participation in the whole process guarantees a learning of all the team members on the status of the system under analysis and possible improvements. The proposed standard to the company does not necessarily eliminate these beneficial characteristics of the VSM, rather it proposes an SBO process in which the initial steps of the VSM of going to Gemba and data collection are still performed by the same team of people. Nevertheless, instead of taking decisions on a static map, the proposal is to take them based on the results of a dynamic map created via SBO. These results will provide knowledge about the current state and a prioritization of the improvements to implement in the system. The trial and error approach for improvement inherent to lean, even if providing a good learning opportunity, can be extremely time-consuming and the use of SBO can reduce this time considerably, providing prioritized improvement alternatives. Then, the S-VSM module can still generate a static map with a terminology that everybody understands and that can be placed on the wall to visualize the current and future status of the line for further discussions. Additionally, the amount of time that is saved with the SBO approach can be spent on improving the system under analysis instead. Under this implementation phase, the lean tools will support the improvement detected via SBO. SBO provides the answers to "what" to improve and in "which order and level" make the improvements, and the lean principles and tools will support "how to" conduct these improvements.

6 DISCUSSIONS

The company presented in this case study is a company with a high maturity on lean and SBO. To have all the production lines modeled gives the advantage of, by simple updates, make use of them for continuous improvement. This may not be a reality for other companies, especially those with lower maturities. Even the use of S-VSM may be very advanced and they may prefer to start with a VSM and then create the simulation model (for further recommendations for your company, see Goienetxea Uriarte et al. 2017). Additionally, the effort, time, and knowledge required to employ SBO may be a barrier for its use on continuous improvement that needs decisions in the short term. More aggregated models may be employed for this purpose.

To include SBO in the lean working standards is a must if the company wants to succeed in the introduction of SBO as a natural step for continuous improvement. Otherwise, the risk is that this study will become just an exceptional case.

It seems that the optimal solution for SBO to be employed within continuous improvement is to have the production engineers developing the models and using them in their daily work. This continuous model update task would be too arduous for the simulation engineers, working in a different department and with strategic projects. However, the majority of the production engineers have not been working actively with SBO. So initially, the simulation engineers may help them until the standards are established, although their roles should be clarified from the beginning, not to compete for the same projects.

One of the simplicities of VSM includes the low amount of data needed in comparison to the amount of data to build a reliable simulation model. However, with the low amount of data that is usually employed to draw a VSM, the risk is also that lower confident decisions are taken. Therefore, in any case, SBO will be a better alternative to VSM for decision-making support.

When developing the future state VSM, the simulation engineers were not included. This shows the existing gap in the understanding of the possibilities that SBO offers. Similarly, after the VSM event, it took time to get the optimization results and present them at the next technical meeting of the team. During this time lap, some changes were already implemented in the line, without reporting them to the simulation engineers. This is again a lack of the standardized practice to include SBO as a natural step in continuous improvement.

7 CONCLUSIONS

This paper describes a case study where SBO was introduced as a step in a VSM event in an automotive component production plant. The study was focused on creating a VSM of the current state of the semi-automated assembly production line, to gain knowledge about its actual situation and to detect opportunities for improvement. The aim of this study was to promote the use of SBO as a natural step to support continuous improvement. All the major steps conducted in the study are described in the paper and a reflection on how to introduce it within the lean continuous improvement standards is provided. This experience may be valuable for other companies that are trying to introduce SBO as a standard tool for system design and improvement. We may have very advanced tools, but if they are not introduced in the companies' standards, they are not employed, and, subsequently, it means they are useless. Future work will focus on the introduction of SBO in other VSM and kaizen events. The interaction between simulation and the lean engineers will hopefully also be strengthened. This will favor the extended use of SBO to support decision-making as well as to get more effective lean actions and improvements.

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