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Abstract

Purpose: Lean Six Sigma (LSS) is a continuous improvement (CI) methodology that has been adopted by several companies as a strategy to increase their competitive advantage. However due to the misuse of LSS theory in practice, a high rate of implementation failure occurs in many organisations today. There is a need for a structured and standardized framework to describe how the LSS initiative should be implemented and sustained over time. As a result, this study aims to develop a practical, user-friendly and accurate LSS roadmap for a Scottish manufacturing Small and Medium Enterprise (SME).

Design/ methodology/ approach: This approach was to analyse existing literature on Lean and Six Sigma that included roadmaps and critical success factors (CSFs). An in-company survey instrument was designed to collect quantitative data. The aim of the survey was to evaluate employees' perceptions on the importance of LSS CSFs for the successful implementation and sustainability of a CI initiative. Based on the literature and the results from the data collected, a LSS reference guide - in the form of a roadmap - was designed to support LSS implementation and sustainability.

Findings: A customised LSS reference guide in a roadmap format for the Scottish SME was proposed. This roadmap was developed by adopting existing successful roadmaps

from the literature into consideration and then adapting them to fulfil the company's particular perspective on CI. This study complements current literature on LSS roadmaps and corroborates LSS CSFs as crucial for successful LSS implementation and sustainability, regardless of the type of company and/or culture. However, a degree of importance is ascribed to the organisational culture.

Research limitations: Whilst a survey was used as the data collection instrument, future interviews with employees may enhance the understanding of the organisational culture and further improved the roadmap.

Originality/ Value: The authors developed a practical and strategic roadmap for a Scottish packaging Small and Medium Sized Enterprise (SME) which can be used by other similar SMEs. The proposed LSS roadmap can be replicated and/or adapted for companies in their application of LSS. The methodology by which this study's roadmap was designed can be used as a guide in the development of further CI roadmaps.

Keywords: Lean Six Sigma, continuous improvement, roadmap, sustainable implementation, critical success factors, SMEs

1. Introduction

As companies face volatile, uncertain and increasingly competitive conditions, they must seek strategies to improve operations and increase their advantage over competitors. Continuous improvement (CI) programmes are one strategy which can support companies in increasing the efficiency and effectiveness of their processes (Hayes & Pisano, 1996; Ward & Duray, 2000). The employment of a CI philosophy challenges traditional methods of working, enabling companies to frequently understand and deploy methodical improvements in order to increase efficiency, by improving process quality and speed, thereby resulting in overall reduced cost. (McLean, et al., 2015). Of the many CI methodologies, the most prominent approach has been Lean Manufacturing and Six Sigma (McLean, et al., 2015). Lean manufacturing is a methodology developed by Toyota, which aims to reduce waste and increase process speed by reducing lead time. Six Sigma is a methodology developed by Motorola, which focuses on improving quality by reducing process variations (Cudney & Fargher, 2005; Dragulanescu & Popescu, 2015). Although the implementation of either of these methodologies can be effective, they cannot solve all problems. In order to minimise deficiencies and weaknesses, companies typically opt for hybrid programmes (Drohomeretski, *et al*., 2014). Lean Six Sigma (LSS) is the most widely known CI hybrid methodology (Duarte, *et al*., 2012; Pande, *et al*., 2000; Chiarini, 2011). LSS is the result of combining Lean speed and Six Sigma quality. While LSS increases quality at a faster rate than other CI initiatives (Atmaca, 2013; George, 2002), Pedersen and Huniche (cited by de Freitas & Gomes, 2017) contend that approximately 70% of companies who have employed LSS as a CI initiative have either not achieved the expected results and/or not been able to sustain improvements over time. George (2002) claims that such failures are generally due to the misrepresentation of theory in practice.

Albiwi, *et al*. (2014) affirm that LSS failure is due to the lack of attention given to the critical factors which are necessary for its effective implementation and sustainability. Therefore, in order to successfully deploy and sustain LSS, a roadmap is required which acts as a reference guide to facilitate a company's transition from theory to practice by describing the activities that should to be carried out together with a description of the factors that must be considered. The roadmap can also provide companies with a clear sequential strategy for methodology application (Gershon & Rajashekharaiah, 2011; Thomas & Chuke-Okafor, 2000). Whilst there is a paucity of literature concerning a standard LSS roadmap; frameworks are proposed which can be used as the basis to develop an LSS roadmap adaptable to a company's conditions and culture.

2. Literature Review

2.1 Lean Six Sigma (LSS) Critical Success Factors (CSFs)

Lean Six Sigma (LSS) is a methodology for companies and individuals to improve processes and solve problems (Snee, 2010). LSS is the most recognized and preferred CI hybrid theory (Drohomeretski, et al., 2014). The application of LSS can bring benefits to companies in terms of competitive advantage; lead time increases of up to 80%, quality and operation cost reductions by 20% and improvements to delivery times of up to 99% (George, 2002). Pepper & Spedding (2010) stress the importance of finding a balance between Lean and Six Sigma during LSS implementation, as individual implementation may have unfavourable consequences. In becoming too lean, a company can become inflexible. This can impact both the market response and value creation. Furthermore, the intense pursuit of Six Sigma zero processes variation whilst ignoring the customers' requirements, can result in resource waste. LSS as a balanced implementation tool consists of satisfying the customer's needs by creating sufficient

value to maintain market share while reducing necessary variation to reduce costs. Critical success factors (CSFs) are essential input variables necessary to achieve an effective and successful LSS implementation (Antony & Banuelas, 2002). Table 1 shows 11 CSFs and the sub factors identified by Abu Bakar, *et al*., (2015), based on their review of papers focused on LSS (n=13).

Take in Table 1 LSS CSFs here.

A study by George (2002) analysed the financial data of 170 manufacturing companies from 1995 to 2000 to establish their average delivery time and percentage of improvement. The results showed that whilst some companies can effectively apply LSS, others cannot. For almost half the companies analysed, the average delivery time declined over this period, implying a decrease in quality. This was not necessarily caused by a lack of LSS knowledge but more by mistakes made during the transition from theory to practice. Nonetheless, a significant number of companies achieved an improvement rate between 100 and 300 percent. Notwithstanding, as no standard LSS roadmap or change strategy exists, the implementation of LSS can often lead to failure (Gershon & Rajashekharaiah, 2011; Pepper & Spedding, 2010; Vouzas, *et al*., 2013). In order to assure a successful LSS implementation, companies must employ a roadmap as a guide detailing steps that have to be taken in order to achieve the expected results (George, 2002). LSS roadmaps can be redesigned for different companies according to their needs (Snee, 2010). Table 2 shows common aspects that must be considered for an LSS roadmap design (Pepper & Spedding, 2010).

Take in Table 2.

Companies that have applied Lean and Six Sigma methodologies in parallel can

experience issues related to initiatives prioritization, resources distribution, financial benefits demonstration and/or the selection of the correct methodology. Salah *et al*. (2010) maintain that a concurrent application of Lean and Six Sigma methodologies is necessary, otherwise the concept of unification will not be accomplished. A high percentage of companies also fail to get any benefits or achieve the expected results from LSS deployment due to a lack of attention to CSFs throughout the implementation phase (Albliwi, et al., 2014). Consequentally, concurrent application and the consideration of CSFs must be considered in the design of an LSS roadmap.

2.2 Roadmaps

Eleven roadmaps with objectives and characteristics related to the company to which this study is directed were selected as reference models. These were LSS roadmaps (n=5), Lean roadmaps (n = 3) and Six Sigma roadmaps (n = 3).

2.2.1 LSS Roadmaps

(i) One year implementation - Three Stage Framework.

The three stage framework, developed by (George, 2002) is customized to satisfy the company's needs, with the timeline dependent on the company type and size. The one year implementation provides an advantage, as it creates a sense of urgency, which in turn typically leads to universal participation and commitment. George (2002) contends that a successful LSS implementation depends mainly on the first 100 days of detailed and accurate planning. This allows companies to achieve cost and lead time reduction as well as quality improvements in one year.

The three stages involved are Stage 1: Initiation: An infrastructure is developed to sustain LSS implementation and obtain management commitment by designing the

deployment to include; (1) a process focus on value stream processes, (2) managerial structures with "Champions" and "Belts" resources dedicated to LSS, (3) indicators to determine and track metrics, (4) recognition and compensation systems to maintain employee motivation and (5) tools to select software tools to support the implementation. Commitment is obtained from the corporate champion, executive board and business unit managers. Stage 2: Resources and Project Selection: Focuses on; selecting personnel for the LSS structure, training of Black Belts (BBs) Green Belts (GBs) and Champions and choosing high potential projects. Stage 3: Implementation and Evolution: Projects are carried out under the DMAIC (Define, Measure, Analyse, Improve and Control) methodology with their progress reviewed periodically.

George (2002) emphasized the importance of institutionalizing LSS to sustain the implementation over time by demonstrating the commitment of the CEO to maintain the initiative, showing the benefits obtained by the projects and expanding the initiative in all the company processes. This involved a three-stage deployment of Initiation; Resources and project selection and; Implementation and Evolution over a year.

(ii) Conceptual framework for the critical success factors of LSS implementation.

By focussing on the connection between LSS practices and company performance and evaluating the relationship between ten CSFs and successful implementation cases, (Jeyaraman & Teo, 2010) developed a framework for CSFs of LSS Implementation. This involved four areas namely: Formation; Execution; Promotion and; Sustention.

(iii) LSS framework for Small and Medium Enterprises.

This two-phase roadmap is based on LSS principles that aim to achieve a lean manufacturing system in SMEs. Phase 1 focuses on building the base for the

manufacturing system using a top-down approach while Phase 2 focuses on sustaining the implementation by applying a bottom-up approach (Shamou *et al*. 2010).

(iv) Continuous improvement implementation framework based on LSS in Small and Medium Enterprises.

Developed by Timans *et al*. (2016) and reinforcing the model developed by (Kumar *et al*., 2011), this roadmap consists of three phases and 13 steps. Phase A is Recognise and Prepare; Phase B is Initialise and Institutionalise and; Phase C is Sustain.

(v) A methodological approach to implement LSS in Small and Medium Enterprises.

Designed for those SMEs supportive of a CI culture whose leadership is focused on improvement, this roadmap is based on existing implementation models and comprises four phases: preparation, identification, execution and evaluation, Felizzola & Luna (2014).

2.2.2 Lean Roadmaps

(i) *Roadmap for lean manufacturing implementation.*

A project-based method (which includes nine CSFs considered in 28 lean implementation investigations) was used to design a conceptual Lean framework for manufacturing companies. Mostafa *et al*. (2013)'s roadmap for lean manufacturing implementation consists of four phases and 22 elements for monitoring and controlling.

(ii) *Dynamic model for a lean roadmap*.

Developed by Anavari *et al*. (2011) and comprising four main phases and an initial phase to assess Lean implementation, this roadmap generates different roadmaps for different industries under different conditions to achieve the highest Lean level possible.

(iii) "Leadership People Process Outcome" (LPPO) Model.

This model presents managerial commitment as a key factor in developing competencies and empowerment in people capable of optimizing processes to achieve competitive advantage. This roadmap is based on four key success factors; managerial leadership and commitment, trained personnel and synchronized and efficient processes (Dibia, et al., 2014). Change has to be promoted and inspired by the executive team with a long term vision of CI whilst the team must; ensure respect for employees, motivate participation and communicate implementation progress.

2.3.3. Six Sigma Roadmaps

(i) *Effective Six Sigma implementation*,

This framework uses a methodological approach (Plan-Do-Check-Act (PDCA)) and key variables that affect Six Sigma implementation (Jones, et al., 2010).

(ii) *An implementation model for Six Sigma programs.*

This model comprises six steps and is based on a successful implementation of an American network technology company (Chakravorty, 2009).

(iii) *Six Sigma framework, linking CSF and organisational change*.

This is based on Lewin's organisational change approach where CSFs were applied to Six Sigma implementation. It comprises three stages (Pinedo-Cuenca, *et al*., 2012):

- Unfreeze: realise that there is a need to change current practices and behaviours. This is comparable with the Define phase of the DMAIC strategy for improving processes.
- Move: change the current practices and behaviours. This is comparable with the Measure, Analyse and Improvement phases of DMAIC.

- Freeze: happens when the change has been completely adopted. This stage, whose objective is to sustain the change, is equivalent to the control phase of the DMAIC.

A conceptual model was then designed and compared to a successful case of Six Sigma implementation in order to demonstrate the importance of CSF to successful organisational change.

The table below (Table 3) presents a critical review of the aforementioned roadmaps.

Take in Table 3.

3 Case Study

This case study concerns a Scottish branch of a multinational packing organisation, employing approximately 26,000 people and maintaining operations in 37 countries with 30 sites in the UK. In 2015, the organisation decided to implement continuous improvement (CI) as a strategy to optimize their operations. The implementation of CI initiatives can represent a big challenge for organisations as it is not just the application of a set of tools, but also a journey involving a change of mentality and culture which continuously challenges the traditional way of working. Therefore, CI teams were established to manage implementations independently for every site.

The branch on which this case study was based is a box factory within the packing division. For the purpose of this study, this branch was considered to be an SME due to its size and its independence in LSS implementation. From here on, it will be referred to as the "company". The company implemented LSS for a period of four years without any reference framework. The CI team responsible for the implementation were comprised of the following personnel: a manager (black belt); team members (two

green belts and seven yellow belts). The proposed roadmap would allow the company to implement LSS in a more structured way and sustain their current efforts in CI. In the future, the roadmap can be improved based on lessons learned during the implementation and shared at a corporate level.

This study aims to introduce a redesigned roadmap to facilitate LSS implementation and ensure its sustainability. A survey of 50 employees from different hierarchical levels was undertaken. These employees shared the characteristics of participating or having participated in the implementation of a CI initiative. The survey instrument was evaluated by the CI company manager and four experts in LSS. Of the 50 respondents, 40% (n=20) were from managerial and administrative positions, whilst 60% (n=30) were operators on the shop floor of the company. For ease of administration and access to respondents, data from the first group was collected online, and operators manually completed the surveys. Where surveys were incomplete, these where designated as unusable and discarded. The usable sample came from 43 employee respondents.

In addition to seeking general information about the respondents, the respondents were asked to rate the importance of 16 CSFs which had been identified in the literature review to be related to the implementation and sustainability of CI initiatives. A five point Likert scale was used where *1 = very unimportant to 5 = critical*. (Table 4). They were also asked to rank the top five of these CFSs in order of importance. The purpose of these questions was to compare the company's CSFs and their importance to those identified in literature.

The results of the survey were included in the design and customization of the new LSS roadmap. In order to avoid confusion for the respondents, the questions were focused on CI initiatives in general not on LSS specifically, as the company was not using this term.

4 Results

The data analysis was performed by calculating the frequency at which each factor was ranked first, second, third, fourth and/or fifth (Table 4). The values were then weighted according to their perceived importance (Table 5).

Take in Tables 4 and 5 here.

The results show that 95% of the respondents selected and ranked "Top management commitment, leadership and engagement", while 53% of those respondents perceived this factor as the most important for a successful and sustainable CI initiative. The respondents defined "Recognition of the need for change" as the second most important factor followed by "Effective training", "Recognition and reward system to motivate employees" and "The connection between the business strategy and the CI initiative". The less ranked factors were: "Infrastructure dedicated to work specifically on CI", "Application of "Just in time" and "Positive relationship with suppliers".

4.1 Key Findings

The results obtained from those questions which focused on the importance of CSFs for the implementation and sustainability of CI initiatives, presented some similarities (Figure 1).

Take in Figure 1 here.

The most important factor perceived by the respondents is "Top management commitment, leadership and engagement". The results show that 100% of respondents rated this factor as very important or critical. All of the respondents ranked it in the top 5 important factors. Meanwhile, "Recognition of the need for change" and "Effective training" were ranked highly. While "The connection between the business strategy and

the CI initiative" has an average rating score of 4.3 (i.e. very important), only 37% of the respondents ranked it in the top 5 factors, of which 67% were belts and 33% were project team members. Furthermore, "Recognition and reward system to motivate employees" was not considered a critical factor to implement and sustain a CI initiative, although it appeared in the 4th place of the overall ranking. While top management and leadership are fundamental for the implementation and sustainability of CI initiatives, it is also necessary to consider the involvement of employees. CI initiatives take a substantial amount of time and can generate conflicts concerning main responsibilities and active participation in the implementation. Therefore, a system is required to recognise and reward employees related to their participation (McLean, et al., 2015). 56% of the respondents participate as team members for the development of CI projects. However, their involvement in CI initiatives is not part of their main responsibilities. Fourteen respondents (all of whom are project team members) ranked "Recognition and reward system to motivate employees" in the top 5 CSFs (Figure 2).

Take in Figure 2 here.

The CSFs which were considered not so important included: "Infrastructure dedicated to work specifically on CI", "Application of "Just in time" and "Positive relationship with suppliers". The first two factors were included only once in the top 5 CSFs while the last factor was not included at all. Furthermore, 12% of the respondents rated "Infrastructure dedicated to work specifically on CI" as unimportant, 7% of the respondents rated "Positive relationship with suppliers" as unimportant and 10% and 2% of the respondents rated "Just in time" as unimportant and very unimportant respectively. It is worth mentioning that the factor directly related to the sustainability of CI initiatives, "Plan for sustaining the initiative over the time" was selected as one of

the 5 most important CSFs by 37% of the respondents of which 64% were managers and 24% were team members.

In summary, the analysis of the collated data concerning those CSFs which are perceived as important for a successful implementation and sustainability of a CI initiative, included: Top management commitment; leadership and engagement; recognition of the need for change; effective training; the connection between the business strategy and the CI initiative; the connection between the CI initiative and customers' requirements and; recognition and reward system to motivate employees. These findings, which are in line with the literature will be used to inform the design and development of the roadmap.

5 Roadmap Development

The four conditions suggested by Pepper and Spedding (2010) to develop a solid LSS framework (Table 2) were considered in the roadmap design. Firstly, the framework was structured based on processes. Secondly, the activities were selected based on the company's needs and employees' perspective on CI. Thirdly, the roadmap methodology was balanced between Lean and Six Sigma. Finally, it was adjusted between complexity and sustainability. With the aim of developing a roadmap that would fit the needs and culture of the company, a draft of the roadmap (Figure 3) was presented to the company's CI team. The comments and modifications requested by the team are presented in Table 5.

Take in table 5.

With the proposed changes being made, the final roadmap is presented in Figure 4.

Take in figure 4.

Throughout the roadmap's implementation, it is critical that; effective communication and ongoing reviews be maintained, change fostered and constant

coaching and feedback provided. Notwithstanding, the proposed LSS roadmap comprises the following 5 stages:

Stage 1: Prepare – where the company complies with certain pre-requisites prior to the implementation of the CI initiative for LSS sustainability. According to George (2002), if the implementation does not start correctly, the company could end up wasting its efforts. The preparation stage is the basis for the success of the implementation and must start between 1-3 months before the implementation. To prepare the company, the following steps must be followed by the CI team:

1. **Recognize the need for change:** Identify the necessity of applying LSS. An analysis of the current status of the company would facilitate the identification of its strengths, weaknesses, opportunities, threats and potential changes needed (Kumar, et al., 2011).
2. **Create an LSS implementation plan:** Assign a person responsible and a deadline for all activities detailed in the roadmap e.g. establish a deadline for the implementation of the communication plan. Track the progress of compliance.
3. **Align the initiative with the company's strategic objectives:** Consider the company's strategic objectives and align to CI initiatives efforts.
4. **Create an LSS vision linked to the business strategic objectives:** Build a long-term vision for the LSS implementation linked to the business strategic objectives in order to define how the methodology would benefit the business.
5. **Hold an LSS awareness for top management:** Perform an LSS awareness session for top management to obtain their commitment and engagement to:
    - Present the methodology as an enabler to achieve the strategic objectives.
    - Present the justifications to apply LSS based on the previous steps.
    - Emphasize the importance of sustaining CI initiatives.

- Explain the LSS approach.
- Clarify expectations about the implementation.
- Define what is expected of the team for a successful implementation.

6. **Apply a change management program:** Most CI initiatives fail because the company returns to its pre-change state due to a lack of energy and/or attention. A well developed change management program is therefore fundamental in supporting a successful transformation of the way of working. As LSS is an initiative of CI, which implies constant change, it is necessary to manage that change constantly.
7. **Develop and implement a communication program:** Effective communication is fundamental to the success of LSS and must be maintained throughout every phase of the implementation. During the first stage, it supports employees in becoming familiar with the methodology, while reducing resistance through; presenting results, sharing good practices and showcasing successful projects. The CI team must; select the content to be communicated (i.e. progress, results, etc.), determine the frequency of the communications and decide the communication's delivery approach (e.g. intranet, corporate newsletters, email, meetings, screens, charts in the work place, etc.).
8. **Develop and implement a recognition system:** This demonstrates that the company values their employee's effort and work in the CI. Recognition can be shown in many forms e.g. recognition boards, letters, diplomas, public recognition in meetings, etc. Regardless of the strategy adopted, recognition should not only come from managers, but also between peers and from employees towards managers.
9. **Define performance indicators:** Establish measures to track the CI implementation's progress and results e.g. progress percentage of implementation

plan, number of projects in progress, number of active projects, number of completed projects, duration of projects, lead time, financial results.

10. **Launch the initiative - Transforming events:** in order to foster engagement and commitment from middle management. All middle managers have to be invited to this event, which should start with a welcome by the CEO, followed by a presentation explaining how the company will change and the potential accruing benefits. George (2002) suggests the use of an LSS simulation so that attendees can experience how LSS will work. As a final activity, launch the CI program (George, 2002).

11. **Target top and middle management on the methodology and the tools:** Train managers in the LSS methodology and related tools, so that they can; lead by example, promote the participation of employees and have a clear understanding of the initiative.

Stage 2: Plan resources and select projects - concerns the selection of people to participate in the LSS implementation and the projects on which they will be working. It includes;

1. **Select Green Belt (GB) and Yellow Belt (YB) candidates:**

The development of an LSS infrastructure depends on the characteristics of every organisation and how they want to manage the initiative. According to the results obtained in the survey, while the company has a belts program, it does not rate as important, the creation of a specific work infrastructure to support LSS. For an LSS implementation to be successful and sustainable, there must be sufficient numbers of trained GBs and YBs to lead the DMAIC projects. Kumar, *et al*. (2011) contend that the company's top talent should be selected as belt candidates as;

- Better talent means better results.
- Top talents attract more top talents.
- Top talents will be the organisational leaders in the future.
- This gives a message that management is engaged with the initiative.
- It motivates other employees to get involved.

Furthermore, SMEs typically do not need MBB[1]s or many BBs. However, one or two BBs are advisable. GBs should be selected from middle management levels and YBs from the shop floor (Kumar, et al., 2011). The support of management is fundamental, since they are asked to free-up time from their best resources, so that they can be trained and projects can be developed.

2. Training

The company has two options; (1) hire an external consultant or (2) do cascade training where belts with trainer skills, perform training in a hierarchical pattern e.g. a Black Blet (BB) trains a Green Belt (GB) and a GB trains a Yellow Belt (YB) (Figure 5). Training should focus not only on the DMAIC methodology but also; leadership, effective communication and project management.

Take in Figure 5 here.

3. Identify the areas of improvement

Identify the organisation's core processes and then prioritize critical processes using VSM and quality tools.

4. **Project prioritization and selection:** After identifying the improvement areas, identify possible projects (Figure 6).

Take in Figure 6 here.

Projects are selected and prioritized based on the following: the value delivered versus the effort required, alignment with business objectives and strategy, potential financial results, and the voice of the consumer (Figure7) (George, 2002).

Take in Figure 7 here.

Stage 3: Implement - concerns the execution of the DMAIC projects.

1. **Define a team for each project:** Each project must be executed by a working group formed by a GB or a YB as project leader (responsible for ensuring that all the team members are trained in the basic tools and methodology and for delivering and reporting expected results) and team members..
2. **Implement DMAIC projects:** Projects are carried out following the DMAIC methodology and using Lean tools.
3. **Perform DMAIC toll gate reviews:** Toll gate reviews must be performed by the CI manager and the processes owner after every DMAIC phase to check and validate the project's progress, evaluate the competences of the team, give coaching and feedback to the team and identify and eliminate roadblocks. If the team meet the requirements of this phase, they can continue with the next phase of the project (George, 2002).
4. **Quantify and report benefits obtained from the projects:** Calculate the financial benefits obtained by the project, validate these benefits with the process owners and the financial department and present them to the top management team.

Stage 4: Sustain – comprising;

1. **Communicate the results of the projects:** The dissemination of the positive results generated by the projects should eliminate scepticism and resistance to the initiative.
2. **Document the lessons learned:** Evaluate and document the lessons learned during the first implementation cycle in order to strengthen and improve future initiatives.
3. **Share best practices and the lessons learned:** Replicate best practices and use the same/similar techniques in other processes. The sharing at the corporate level of lessons learned during implementation will enable other branches to take these points into account.
4. **Integrate LSS with business plans:** Ensure that LSS is considered in the business strategic, operating and financial plans (George, 2002). This will send the message that LSS is a long term company initiative.

The first implementation cycle finalises with the fourth step of the **Sustain** stage. It is assumed that for subsequent cycles, top management will have given their full support and commitment. As a result, not all steps of the preparation stage will need to be repeated in subsequent cycles. However, the first 4 stages must be repeated cyclically until the company has the necessary level of maturity to expand the initiative.

Stage 5: Expand - is applied when the company has a solid mentality of CI and has adopted LSS in its daily operations. Once the initiative is solid it can be expanded to the entire value chain i.e. customers and suppliers.

In addition to the activities recommended in the five stages of the roadmap, it is advisable to apply basic CI tools (e.g. 5-S, standard work, visual management, 5 - Whys, Pareto analysis, Cause and Effect analysis and so on) to different parts of the company without the need to carry out full DMAIC projects. This will involve all employees to different degrees in CI.

Table 6 shows the top 6 CSFs as selected by the company, related to the roadmap activities.

Take in Table 6 here.

It is recommended that during the roadmap's implementation, opportunities for improvement are identified and corrective actions are taken to successfully implement the LSS cycles. Furthermore, these changes and amendments need to be documented and communicated. Employees' resistance to change is a factor that needs specific attention, as it could undermine the purpose of the roadmap implementation. Once the roadmap has been tested and considered to be sufficiently concrete, it can be replicated in other sites. All sites would then follow a single methodology and avoid working in silos (this is currently a problem). An additional recommendation is to conduct an evaluation into current CI implementation stages to identify the activities from the roadmap which have been and have not been carried out.

6 Conclusions and directions for further research

LSS is a hybrid methodology of CI initiatives whose objective is to increase quality and reduce time in processing. A successful LSS implementation can generate great economic benefits for companies. However, the majority of organisations fail to implement LSS successfully due to mistakes made during the transition from theory to

practice. The authors contend that a simple, practical roadmap would make this transformation easier. However, a thorough literature review highlighted that the standard roadmaps for LSS implementation cannot be adapted according to the needs of the company in question. Furthermore, these roadmaps are not always practical and they do not have the level of detail that companies need. Therefore, in the development of the proposed roadmap, it was necessary to critically evaluate every framework presented in the literature to identify associated strengths and weaknesses. Interestingly, a lack of literature about LSS sustainability was identified.

The aim of this research was to design a roadmap that both facilitated LSS implementation and ensured its sustainability in a Scottish packing company, which has implemented LSS for a period of four years without any reference framework. In the design of the roadmap, existing literature on Lean, Six Sigma and LSS roadmaps suitable for SMEs was reviewed and a questionnaire developed which evaluated employee's perceptions of LSS CSFs. 50 employees from different hierarchical levels (20 from managerial and administrative positions with 30 being shop-floor operators) were targeted. All employees had experience of participating in the implementation of a CI initiative. Whilst 50 were targeted, 43 responses were eligible for analysis.

In the survey, the respondents ranked and rated the importance of 16 CSFs which were described in literature as necessary for the successful implementation and sustaining of a CI initiative. The results of the survey verified that the employees recognized the importance of the CSFs as suggested by literature. The most important CSFs for the company, as selected by the respondents were: Top management commitment, leadership and engagement, recognition of the need for change, effective training, the connection between the business strategy and the CI initiative, the connection between

the CI initiative and customers' requirements and recognition and reward system to motivate employees. Those CSFs which were identified as most important by the respondents were used as a basis for the design of the new roadmap as literature recommends that a roadmap be designed based on the needs of the company. Through the deployment of the roadmap, benefits of the optimization processes can be maintained, while also saving costs for subsequent follow ups and corrective actions.

This study complements existing literature concerning LSS roadmaps and verifies that LSS CSFs are crucial for successful implementation and sustainability regardless of the type of company and/or existing culture. Additionally, the roadmap design process can serve as a guide for the development of models for the implementation of CI initiatives. This roadmap can also be replicated and adapted to other SMEs.

There are a number of limitations in this research. Firstly, there are limitations in the literature; as mentioned there is no standard framework for LSS implementation nor literature about LSS sustainability. Additionally, there is a limited number of LSS roadmaps designed based on similar characteristics to those of the company for which this research is directed. Whilst a specific roadmap was developed based on the findings in the literature and survey results, in order to design a more precise roadmap it would have been necessary to collect more information through interviews in order to obtain a better understanding of the organisational culture, the structure of the company, its operational strategy and its procedures and policies. Furthermore, the proposed roadmap shows only a generic application in a specific country and culture. In order to reproduce the roadmap, individual success factors would need to be re-assessed for the specific organisational culture in question. The long term sustainability of the roadmap depends on changes in the company and the subsequent changes in the corporate culture. These

changes need to be taken into consideration and the potential impact on the sustainability of the roadmap assessed.

As part of the future research, the authors would like to extend the survey to more employees in the organisation for wider participation of the study. Moreover, the case study organisation has several sites across the UK. This would allow the authors to collate more data so that better conclusions can be derived from the study. In addition to the survey, the authors are also planning to design an interview protocol based on the various stages of the roadmap. A number of senior managers and continuous improvement champions, managers and even process improvement specialists in the case study organisation such as Lean Six Sigma Black Belts and Green Belts will be interviewed to gain deeper insights into the implementation process. Finally, a number of continuous improvement consultants will also be interviewed to obtain their views and opinions regarding the implementation and understanding some of the challenges associated with implementation.

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CSF	*Description*
Management leadership and commitment	**Sub factor:** Leadership CI commitment and responsibility for managing the strategy, resources and implementation is crucial. **Sub factor:** Senior management must agree with strategic and implementation objectives and have general knowledge of the methodology. **Sub factor:** Top management must present facts demonstrating the need for change to motivate the team. **Sub factor**: Financial resources for implementation must be provided. (Jeyaraman & Teo, 2010; Assarlind, *et al*., 2013)
Connect LSS to the strategy	LSS projects align with company strategy as LSS objective is to achieve strategic objectives. (Albliwi, et al., 2014, Manville, et al., 2012).
Connect LSS to customer	LSS projects must be linked to customers' needs to translate them into products or services (Antony & Banuelas, 2002).
LSS competences	CI project leaders must have a high degree of knowledge of methodology and leadership competences (Jeyaraman & Teo, 2010).
Selection, prioritization and tracking of projects	Determine project selection criteria and prioritization to avoid causing demotivation, delays or frustration. Projects must align with voices of customer, process and business. Progress is tracked frequently. (Antony & Banuelas, 2002; Antony, *et al*., 2012; Antony, 2006).
Effective training	Success and organisational growth is dependent on trained staff (Jeyaraman & Teo, 2010). Employees must understand the aim and how to apply a CI initiative [Hendricks and Kelbaugh (1998) cited by Antony & Banuelas, (2002)]. Prepare and deliver training to develop competences (Antony, et al., 2012). Effective LSS training provides knowledge about project management, change management, problem solving and LSS tools.
Recognition and reward system	61% of the top performing companies apply reward systems linked to business goals [Harry and Schroeder (1999) cited by Jeyaraman & Teo, (2010)]. Recognition and reward systems encourage and motivate employees to become involved in CI projects which are aligned with the goals and objectives of the implementation (Jeyaraman & Teo, 2010).

CSF	*Description*
Infrastructure and project management	Assess implementation progress and results to identify improvement opportunities. **Sub factor:** Apply communication plans to share best practices and successes to educate, involve and motivate employees. **Sub factor**: LSS requires a new infrastructure developed through belts, sponsors and champions. (Jeyaraman & Teo, 2010). Black Belts (BB) and Master Black Belts (MBB) must have strong project management skills to deliver results and meet deadlines during project execution (Antony & Banuelas, 2002). **Sub factor:** Develop an implementation plan to ensure initiative sustainability (Snee, 2010).
Relationship with suppliers	Maintain a supportive long-term relationship with suppliers as they have a direct impact on product quality, customer satisfaction and organisational performance. (Habidin & Yusof, 2013).
Just in time	JIT application increases performance, profit and contribution margins and decreases variable cost and lead time [Callen, Fader and Krinsky (2000) cited by Habidin & Yusof, 2013)].
Cross functional team work	Cross functional teams formation encourages processes ownership, improves the communication and lets the team have an overall view of processes and improvement opportunities (Banuelas & Antony, 2002).

Framework	Analysis
Roadmap developed by George **(2002)**	✓ Friendly, detailed and accurate roadmap ✓ Applicable to any type of organisation ✓ Considers most of the LSS CSF
Conceptual framework for CSF of LSS Implementation **(Jeyaraman & Teo, 2010)**	✓ Ten LSS CSF considered important for the industry are the basis for the roadmap ✓ Activities linked to the CSF were determined × No established sequence of how to carry out the activities × Unclear how activities proposed in the model were defined
LSS framework for SMEs Enterprises **(Shamou, et al., 2010)**	✓ It is focused on the design of a manufacturing system ✓ Considers product value-stream rather than shop floor activities ✓ Presents clear and sequential activities ✓ Includes a CI phase based on constant feedback × Very technical × Doesn't consider the human factor into the implementation such as managerial engagement, motivation, etc.
Continuous improvement implementation framework based on LSS in SMEs **(Timans, et al., 2016)**	✓ Applicable to any kind of organisations ✓ The only roadmap that includes a LSS readiness test ✓ Includes actions to ensure the sustainability of the initiative ✓ A pilot project is carried out to demonstrate benefits and promote the change
A methodological approach to implement LSS in SMEs **(Felizzola & Luna, 2014)**	✓ Involves top management from the start of implementation ✓ Preparation phase to ensure a successful implementation × Doesn't include guideline on how to sustain implementation
Roadmap for lean manufacturing implementation **(Mostafa, et al., 2013)**	✓ Developed considering Lean CSF ✓ Proposes a cyclical application of the methodology ✓ Proposed continuous monitor and control of implementation × Doesn't consider all the CSF
Dynamic model for a lean roadmap **(Anvari, et al., 2011)**	✓ Applicable to any type of organisation ✓ Pre-requisites have to be meet before the initiative kick-off

	✓	Proposes the use of a self-assessment tool to continuously improve the implementation and ensure sustainability
"Leadership People Process Outcome" (LPPO) Model **(Dibia, et al., 2014)**	✓ ✓	Focused on people, who are the ones who operates the processes that deliver results. Proposes activities to promote leadership, to get people participation and engagement.
A framework for effective Six Sigma implementation **(Jones, et al., 2010)**	× ×	Doesn't detail the activities that must be carried out for the implementation Doesn't consider CSF
An implementation model for Six Sigma programs **(Chakravorty, 2009)**	✓	Structured, easy to understand and possibly apply
Six Sigma framework, linking CSF and organisational change **(Pinedo-Cuenca, et al., 2012)**	✓ ×	Relates a change management model with CSF Doesn't include activities to follow

CSF	1st	2nd	3rd	4th	5th	Total Frequency
Top management commitment, leadership and engagement	23	6	3	6	3	41
Recognition of the need for change	3	11	9	4	4	31
Effective training	5	5	4	6	5	25
Connection between the business strategy and the CI initiative	2	4	3	5	6	20
Plan for sustaining the initiative	0	2	4	5	5	16
Company financial capability	0	6	6	0	3	15
Recognition and reward system to motivate employees	8	4	1	1	0	14
Top management knowledge and understanding of the CI initiative	0	2	0	4	4	10
Effective communication of: Project success, best practices and results	0	0	5	2	3	10
Cross functional teamwork	0	0	3	4	3	10
Effective project prioritization, selection and tracking	0	0	2	1	5	8
CI project leaders technical and soft skills	2	1	0	4	0	7
Connection between the CI initiative and customers' requirements	0	1	2	1	2	6
Infrastructure dedicated to work specifically on CI (Belts program)	0	1	0	0	0	1
Application of "Just in time"	0	0	1	0	0	1
Positive relationship with suppliers	0	0	0	0	0	0

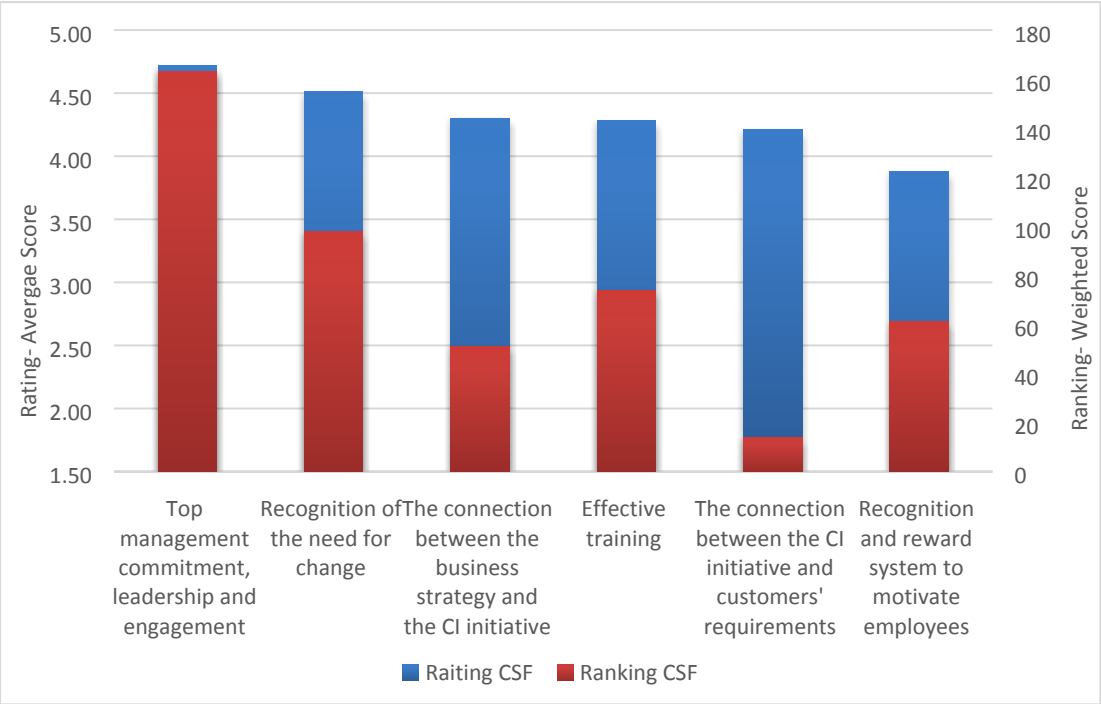
CSF	Weighted score
Top management commitment, leadership and engagement	163
Recognition of the need for change	98
Effective training	74
Recognition and reward system to motivate employees	61
The connection between the business strategy and the CI initiative	51
Company financial capability	45
Plan for sustaining the initiative over the time	35
Technical and soft skills of the improvement project leaders	22
Effective communication of: Project success, best practices and results	22
Top management knowledge and understanding of the CI initiative	20
Cross functional team work	20
The connection between the CI initiative and customers' requirements	14
Effective project prioritization, selection and tracking	13
Infrastructure dedicated to work specifically on CI	4
Application of "Just in time"	3
Positive relationship with suppliers	0

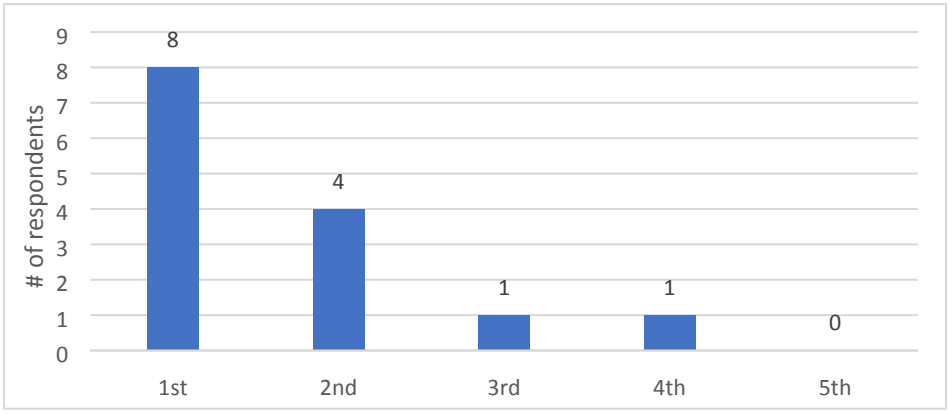
Activity	*Continuous Improvement Team feedback*
Define 3 to 5 strategic objectives	Strategic objectives are defined by the executive board and they cascade to each site. The activity must focus on the alignment of the initiative with the strategic objectives already established.
Create a LSS implementation plan	Add examples on activities that should be included in the implementation plan.
Develop a mind-set change program	Change the name of the activity to a friendlier name. The original model was proposed to implement the change management plan annually. However, this is not practical or realistic for the company.
Identify areas of improvement	The application of VSM was proposed as part of the framework to identify the areas of improvement. The application of Six Sigma tools was suggested.
Carry out brief training about methodology and tools directed to top and middle management	Include this activity into the roadmap.
Conduct a belts certification ceremony	This activity is not applicable due to the organisational culture.

Stage	*Activity*	*CSF*
Prepare	1. Recognize the need for change	• Recognition of the need for change
	2. Create a LSS implementation plan	• Connection between the business strategy and the CI initiative
	3. Align the initiative with the strategic objectives	
	4. Create a LSS vision	
	5. Hold a LSS awareness for the top management	• Top management commitment, leadership and engagement • Top management knowledge and understanding of the CI initiative
	6. Apply a change management program	• Plan for sustaining the initiative over the time • Recognition of the need for change • Top management commitment, leadership and engagement
	7. Develop and implement a communication program	• Effective communication of: Project success, best practices and results
	8. Develop and implement a recognition system	• Recognition and reward system to motivate employees
	9. Define performance indicators	• Connection between the business strategy and the CI initiative
	10. Launch the initiative: Transforming events	• Top management commitment, leadership and engagement

Plan resources and select projects	1. Select YB and GB candidates	• Plan for sustaining the initiative over the time
	2. Training	• Effective training • Technical and soft skills of the improvement project leaders
	3. Identify the areas of improvement	• Connection between the business strategy and the CI initiative • Connection between the CI initiative and customers' requirements
	4. Project prioritization and selection	• Connection between the CI initiative and customers' requirements • Connection between the business strategy and the CI initiative • Effective project prioritization, selection and tracking
Implement	1. Define a team for each project	• Effective training • Cross functional team work
	2. Implement DMAIC projects	• Connection between the CI initiative and customers' requirements • Connection between the business strategy and the CI initiative • Effective project prioritization, selection and tracking
	3. Perform DMAIC toll gate reviews	
	4. Quantified and report benefits obtained from the projects	
Sustain	1. Communicate the results of the projects	• Recognition and reward system to motivate employees

		• Effective communication of: Project success, best practices and results
	2. Document the lessons learned	• Effective communication of: Project success, best practices and results • Plan for sustaining the initiative over the time
	3. Share best practices and lessons learned	
	4. Integrate LSS with business plans	• Connection between the business strategy and the CI initiative • Plan for sustaining the initiative over the time
Expand	1. Expand the initiative to customers and suppliers	• Connection between the business strategy and the CI initiative • Plan for sustaining the initiative over the time



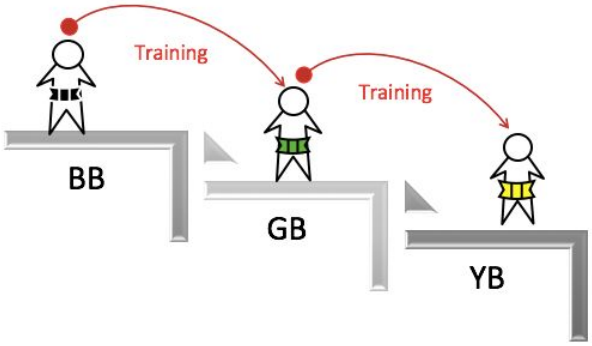


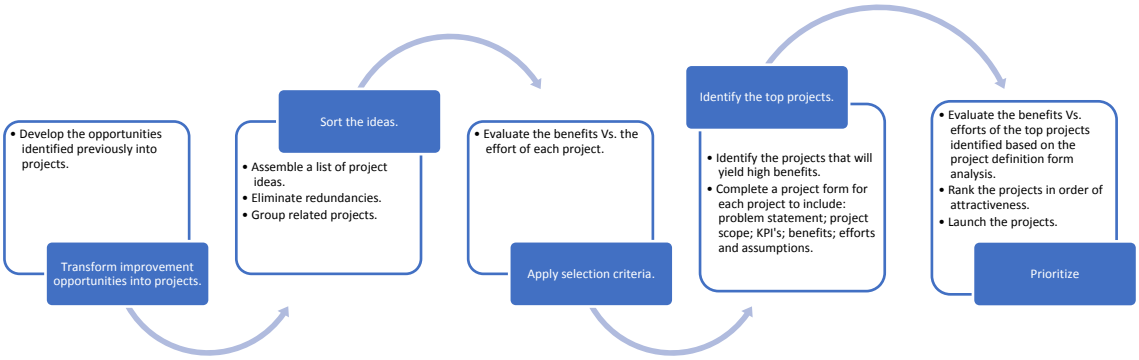
Ongoing reviews, communication, change, coaching and feedback	Prepare	1. Recognise the need for change 2. Define 3 to 5 strategic goals for the company 3. Hold a LSS awareness for the top management 4. Create a LSS vision 5. Create a LSS implementation plan 6. Develop a mind-set change program 7. Develop and implement a communication program 8. Develop and implement a recognition system 9. Define performance indicators 10. Launch the initiative: Transforming events
	Plan Resources and Select Projects	1. Select YB and GB candidates 2. Belts training 3. Conduct a Belts certification ceremony 4. Identify the areas of improvement 5. Project prioritisation and selection
	Implement	1. Define a team for each project 2. Implement DMAIC projects 3. Perform DMAIC toll gate reviews 4. Quantified and report benefit obtained from the projects
	Sustain	1. Communicate the results of the projects 2. Document the lessons learned 3. Share best practice and lessons learned throughout the company 4. Integrate LSS with business plans
	Expand	1. Expand the initiative to customers and suppliers

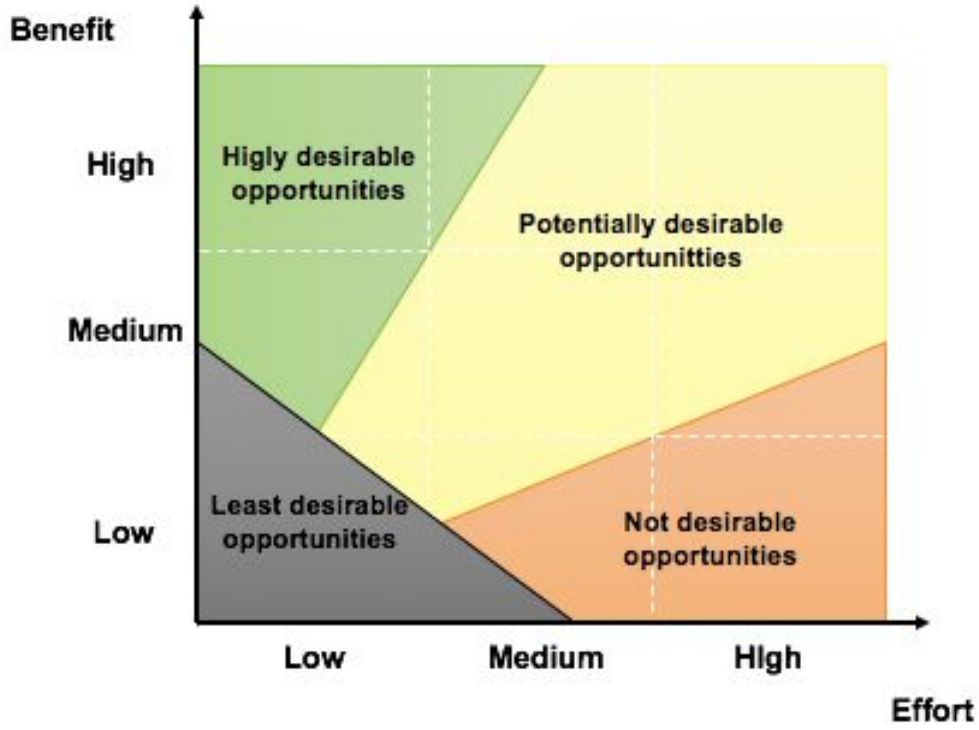
Figure 3. Proposed LSS road map draft.

Ongoing reviews, communication, change, coaching and feedback	Prepare	1. Recognise the need for change 2. Create a LSS implementation plan 3. Align the initiative with the strategic objectives 4. Create a LSS vision 5. Hold a LSS awareness for the top management 6. Apply a change management program 7. Develop and implement a communication program 8. Develop and implement a recognition system 9. Define performance indicators 10. Launch the initiative: Transforming events 11. Carry out a brief training for the top and middle management
	Plan Resources and Select Projects	1. Select YB and GB candidates 2. Training 3. Identify the areas of improvement 4. Project prioritisation and selection
	Implement	1. Define a team for each project 2. Implement DMAIC projects 3. Perform DMAIC toll gate reviews 4. Quantified and report benefit obtained from the projects
	Sustain	1. Communicate the results of the projects 2. Document the lessons learned 3. Share best practice and lessons learned throughout the company 4. Integrate LSS with business plans
	Expand	1. Expand the initiative to customers and suppliers

Figure 4. Final version of the LSS road map.






Benefit
High
Medium
Low
Higly desirable opportunities
Potentially desirable opportunitties
Least desirable opportunities
Not desirable opportunities
Low
Medium
High
Effort