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Full Length Research Paper

A proposed dynamic model for a lean roadmap

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Lean manufacturing is an integrated socio-technical system. Its main objectives are to eliminate waste and reduce the variability of suppliers, customers, and internal resources and processes. A "lean" roadmap guides the transition from an existing operation to one that fully implements a "lean" philosophy and its best practices. In this study a comparative literature review showed that there is no standard model in use for implementing "lean". Existing research indicates that there are 3 phases that incorporate 22 steps to "leanness" and the following "lean" steps are frequently cited: pilot project, planning, objectives, training, and value stream mapping. Based on the findings, a dynamic model for a "lean" roadmap was proposed to account for the dynamic conditions of a high variability environment.

Key words: Lean manufacturing, lean journey, lean roadmap, dynamic model.

INTRODUCTION

To compete with global competition, many companies have moved toward implementation of lean manufacturing (LM) lately because it provides increased quality, reduced costs, on-time delivery and many other factors. The concept of LM is to minimize the amount of time and resources used in the manufacturing processes and other activities of an enterprise, with an emphasis on eliminating all forms of wastage (Womack and Jones, 1996). LM has been proved to be a valuable aid to achieve competitiveness among manufacturers. So that to survival in competitiveness, identifying the nature of the product and the character of enterprises (monopoly, oligopoly, and duopoly), and optimizing policies should be determined (Alam and Khalifa, 2009); It depends on crucial factors like, price, quality, perceptions, values, network of coverage and availability (Ali et al., 2010); as well as establishing "quality E-management system" (Hashim et al., 2010) to "leanness". However, the number of manufacturers that sustain a truly Lean system is still very low. The reason for this low number could be due to the mistakes committed during the implementation of "lean."

When studying the common mistakes that manufacturers have made in their "lean" implementation it is clear that they are at a very practical level. To avoid these common mistakes in future implementations there is a requirement to define a proven path for the implementation of LM at a very practical level (Moutabian, 2005; Kessler, 2006; Tamma et al., 2009). Pavnaskar et al. (2003) identify the main reasons for "lean" pitfalls: "use of a wrong tool to solve a problem", "use of a single tool to solve all the problems" and "use of all the tools on each problem".

Incorrect application of "lean" tools leads to waste of an organization's time and resources, and a reduction in employees' confidence in "lean" tools and techniques and philosophy (Marvel and Standridge, 2009). So, a well-planned procedure for applying "lean" tools would make the implementation of "lean" concepts more effective, therefore a "lean" roadmap is needed to build a foundation that consistently yields company–wide improvements (Tamma et al., 2009). The present research consists of qualitative and review methods. The aim of this study was to provide a clear description of the popular and successful routes to "lean" implementation in

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dynamic conditions, and to focus on the transition to "lean" at a very practical level.

To realize the aim of this research the following four objectives were developed:

1. To investigate "lean" roadmaps.
2. To provide a comparative study among different Lean roadmaps with respect to different authors' views.
3. To identify the steps needed to assess the movement of companies toward Leanness.
4. To propose a Lean roadmap with a dynamic structure.

In order to achieve these objectives, this paper introduces some viewpoints and recommendations of "lean" implementation, and an attempt was made to identify a "lean" roadmap based on steps, tools and techniques. Moreover, in this research the following questions were addressed in relation to the existing literature:

1. What is the contribution of the literature to the field of "lean" implementation in companies?
2. What are the experts'/researchers' perspectives toward "leanness"?
3. What is the relative importance of the common viewpoints in the "lean" roadmap?
4. How does a roadmap cover all enterprises?

LEAN MANUFACTURING

Definition of LM

LM is a mixed socio-technical system whose main objectives are to eliminate waste and reduce the variability of suppliers, customers, and internal resources and processes (Shah and Ward, 2003). LM can reduce waste and increase value for customers (Ko, 2010). In other words, LM is a philosophy of production that places emphasis on the minimization of the amount of all the resources used in the various activities of an enterprise. It involves recognizing and eliminating non-value-adding activities in design, the production process, and in the management of customers and the supply chain. LM provides adaptability to market evolution, active involvement of versatile human resources, and the ability to establish subcontracting relations (Ale et al., 2010). The "lean" philosophy is applicable when market demand is predictable and buyers' decisions are highly dependent on the lowest price criterion (Ambe and Badenhorst-Weiss, 2010). LM encompasses such practices as employee involvement in worker teams, problem solving, integrated product designs, statistical process control, reengineering setups, cellular manufacturing, pull production, supplier information sharing and partnership, supply base rationalization, in-house designed technology, and customer requirements integration (Olsen, 2004).

Fundamental LM tools and techniques include cellular manufacturing, people training, team decision making, visual control/management (Panizzolo, 1998); pull systems, Kanban, supermarket, production leveling, flow, mistake proof (Wan et al., 2008); manufacturing layout, quality, and continuous improvement (Hook and Stehn, 2008). Hence, "lean" cannot work with isolated tools (Shingo, 1989; Sanchez and Perez, 2001; Elliott, 2001; Rea, 2001; Meier, 2001; Liker, 2004), and it should be implemented based on a path to "leanness". The five primary elements to consider when implementing LM are manufacturing flow, organization, process control, metrics, and logistics (Feld, 2003). These elements represent the variety of aspects needed to sustain a successful LM implementation program. As a result, the LM program may be, mistakenly, viewed as a failure in the early stages of implementation (Cunningham and Fium, 2003).

The more successful the implementation, the more rapid the reduction rate of waste (David and Kumar, 2006). LM focuses on getting the 'right things' to the 'right place' at the 'right time' in the 'right quantity' to achieve perfect work flow, while minimizing waste and being flexible and able to change, leading to satisfied managers, workers, suppliers, customers, and stakeholders (Moutabian, 2010).

Lean approaches

There are three approaches to LM. In the first approach (Bicheno, 2004; Bhasin and Burcher, 2006), "lean" is a set of tools and techniques that continuously help in the recognition and elimination of waste. In the second approach to LM, which is promoted by Toyota, "lean" is not the tools but the reduction of three types of waste:

Muda 'non-value-adding work', muri 'overburden', and mura 'unevenness'.

In this approach, LM is used to reveal problems systematically and LM tools are used when the ideal cannot be achieved.

In addition it focuses on improving the flow by using some tools and techniques such as production leveling, pull production and the Heijunka box (Womack et al., 1990; Holweg, 2007). Lean as a philosophy is the third approach (Moore, 2001; Bateman, 2002; Pullin, 2002; Turfa, 2003; Liker, 2004). Therefore, LM can be considered as a synergistic set of integrated modern manufacturing management practices, commonly classified under subsets of just-in-time (JIT), total quality management (TQM), total productive maintenance (TPM), and a collection of supportive human resource management practices including teamwork and employee empowerment (Alam, 2009a).

Lean implementation by lean roadmap

A “lean pathway” can be called a roadmap (Ginn and Finn, 2007); a roadmap helps “lean” practitioners identify and address waste and its drivers, as well as understand how and when to apply the various “lean” approaches in the organization in order to achieve business excellence. A roadmap would also help “lean” practitioners use the full suite of tools to realize the greatest benefits (Ginn and Finn, 2007). A “lean” roadmap provides a systematic implementation process: specific actions in order of precedence that are milestones in the journey from mass to “lean” production (Crabill et al., 2000). The various phases should be regarded as checkpoints to make certain that the elements in the previous phase are in-place to some degree, or are being addressed, before proceeding to the next phase (Crabill et al., 2000). A “lean” roadmap is not a cookbook of actions that must be strictly followed for every implementation because every implementation will be singular, in that every company has its own culture, and inheritance policies and systems, which will either support or delay the “lean” journey (Alam, 2009b). Consequently, several conceptual roadmaps for “lean” implementation are used in organizations today, and the sequences of implementation are dependent on the nature of the manufacturing process, and may vary based on the type of waste identified or on the specific usage (Ginn and Finn, 2007).

There are no clear-cut guidelines as to how systems should be implemented in every specific case; rather, the implementation should take into account the individuality and the special requirements of each production system (Standard and Davis, 1999; Lathin and Mitchell, 2001). Karlson and Ahlstrom (1996) emphasize that the important point to note is that “lean” should be seen as a direction rather than as a state to be reached after a certain time. The importance of the human factor in lean thinking (LT) cannot be overstated. LT should be viewed as a way of thinking, and both culture and strategy should go in parallel to reach the required results: We need to think, see, and practice “lean” (Moutabian, 2005).

So, many people are anxious about when LM implementation should be started; LM cannot be applied effectively without a strategic approach and LM techniques cannot just be implanted (Razmi, 2008). A high level of knowledge and useful experience are needed to identify the correct tools (Wan and Chen, 2009). Managers and practitioners need to learn how to get started, where to start and how to proceed, in addition to knowing the available tools. For this purpose, leadership, “lean” training, identifying current and future value stream mapping (VSM) and sequencing of “lean” tools are four major activities to initiate a “lean” implementation cycle (Lee, 2003). Workplace/5S (Liker and Meier, 2006), and standardized work (Huang, 2008) are the first steps of “lean” implementation. Community resource coordinator (CRC) after VSM, 5S and standard work must be the top priority of techniques (Cudney, 2009), so that by starting the “lean” journey with standardized work a real foundation for the organization to improve continuously and promote “lean” culture is created.

Consequently, “lean” needs to be seen as a journey, “lean” is not just a set of projects, it is a journey about learning (Houshmand and Jamshidnezhad, 2006). “lean” thinking (Hines et al., 2004) is a generic approach (Koskela, 2004) that never ends (Turfa, 2003) because “leanness” is a process, a journey, not an end state (Liker, 1997).

Lean journey

Lean journey with a view to initial steps

According to the research literature there are various pathways to “leanness”, therefore there is no unique direction. Some models and guidance to “lean” implementation are discussed here. Shingo (1989) recommends a model in a ‘Gantt chart’ format in which key elements of “lean” can be implemented during one year. Shingo schedules 15 items, elements, tools and techniques (for example initial survey, single minute exchange of dies (SMED), creating suitable space, poke yoke, leveling, Kanban, etc.) for “lean” implementation in a year. He believes that to provide rapid responsibility you should create suitable space for educating managers, reducing setup times, improvement of layout on shop floor, setup time elimination, leveling production, and one-piece flow. However, he does not take into account the other sub-systems of “lean” principles in-depth; on the contrary, he focuses on preventive actions and the supply chain (Alam et al., 2010). Kowalski (1996) suggests a 10-step Ford model: Plants improvement, development of effective teams, standard work, decreasing layout time, focus on maintenance, preventive operations for development of confidence, leveling production, JIT (pull system), minimizing inventory, and decreasing costs. He focuses on the development of effective working systems and standardization of work. Beck (1999) proposes an integrated model of a production system based on 10 steps: Informing production and assembly unit, reducing or elimination of alignment, providing integrated quality control, applying integrated PM, leveling and balancing production, Kanban, reducing setup time, sale planning, automation, and computerizing the systems.

This model focuses on design and layout planning (based on cellular design); it only emphasizes the hardware aspect, not software. Hilbert (1998) suggests a model to “lean” transition with four stages: Building a shared vision, planning and designing the change, managing the change, and celebration and continuous improvement.

He emphasizes seven steps before the four main stages. The seven preparing operations are: Identifying a launch team, production team and key leadership; establishing a shared vision among stakeholders; establishing a method of evaluating the performance of the change effort; establishing stability of current system; providing a definition for suitable policy to integrate social and technical aspects of “lean” elements; creating design process with regard to coordinating hardware and software resources to “leanness”; and offering necessary alternatives to solving the probable conflicts.

Also, he insists that the seven initial and basic actions to LM are necessary otherwise transition to “lean” leads to failure. It seems that Kowalski’s Ford model is similar to Beck’s and Shingo’s models. Hilbert (1998) places more emphasis on social, cultural, and educational aspects instead of focusing on implementing tools and their operational components. In addition, Johnson (1998) proposes a three-stage model. This model is named the Toyota leadership model of Johnson because he focuses on leadership. His recommendations and direction in three phases are: Determination of policy and direction, obstacles prevention and removing, and manpower promotion.

It can be concluded that the models of Shingo, Beck, and Ford generally focus on a hardware approach toward “leanness”, whereas the models of Hilbert and Johnson concentrate on cultural and social aspects (software). Furthermore, there is a major criticism of the five models: lack of focus on change in viewpoints and visions. Some authors propose that there are four main levels to implementation of change within an organization: Events, behavior, system, and mental model (Senge, 1990).

How to get started and proceed to lean

Authors’ proposed steps within each stage of “lean” implementation are categorized in Table 1. For example Harbour (2001) presents “lean” implementation in four steps (creating organizational “lean” providing “lean” workforce, applying tools and techniques, and continuous improvement); Mehrban (2005) offers LM in five stages (determining VSM, efficiency standards, ideal condition, continuous implementing and improvements); whereas Drew et al. (2004) propose five phases (preparatory, assessment of current and future states, implementing a pilot, and continuous improvement). Huang (2008) emphasizes training and standardized work, and then implementing “lean” tools; Rother and Harris (2001) focus on pre-implementation planning; whereas Moutabian (2010) insists that “lean” implementation should start only if there is management commitment, a change agent, and a crises (for example productivity). Shingo (1989) describes the stages of “lean” implementation as: Process stability, standardized work, level production, JIT, quality, visual control, production stop policy, and finally continuous improvement (Womack et al., 1990; Detty and Yingling, 2000). Liker and Wu (2000) add to Shingo’s stages: Developing a close relationship with transportation carriers, setting stringent delivery requirements, adopting effective loading methods, and compensating for geographical distances.

The Ford Motor Company identifies five phases to achieve “lean”: Process stabilization, continuous flow, synchronous production, pull authorization, and balanced production (Liker, 1997).

Some authors (Dennis, 2002; Atkinson, 2004; Shukla, 2005; Koenigsaecker, 2005) discuss the implementation steps at a very high level, whereas other authors discuss the implementation steps at a very deep level (Page, 2004). It is noteworthy that all the authors agree on the following eight steps in the “lean” process: Management commitment, team management and learning about Lean, an appropriate value stream must be selected, the selected stream should be mapped, improvement indexes should be determined, a desirable process should be drawn and based on the gap between the current situation and the desired one, some Kaizen projects should be identified, and an identified plan/program should be launched (Womack and Jones, 1996). Allen et al. (2001) recommend three main stages for any “lean” implementation project: Preparation, design and implementation.

They also make the point that it is crucial for any company to spend time on the preparation and design stages before implementation. In this research, these recommendations have been followed and the three stages have been used as a guide. Eighty resources were selected based on a methodology that has been used to identify high-quality studies. The 28 authors and the 22 steps recommended through this methodology are presented in Tables 1 and 2. Table 2 shows the citation of “lean” steps. The first column is divided into the three main stages to “leanness”, the second column shows the “lean” steps and the viewpoints of the authors about “lean” steps are noted in columns 3 to 30.

The 31st column shows the frequency of entries in previous columns, and the “lean” steps are ranked based on frequency in the last column. The data in Table 2 are discussed in “lean” stages.

Lean stages

The results of the literature review that was conducted to find a roadmap of “lean” implementation are presented in Table 2. The results indicated the “lean” steps emphasized by the authors: Several authors place emphasis on a pilot case, for example Womack and Jones (1996), Feld (2003), Aernoudts (2004), Badurdeen (2007), Mehta and Monroe (2007), and so on. Some

Table 1. A category of authors/researchers for lean implementation in 3 stages and 22 steps.

Stages	Steps	*Authors/Sources
Stage 1: Preparation	Gap assessment strategic planning	1, 2, 3, 4
	Understanding waste	3, 5, 6
	Establishing the objective	3,4,5,7,8,9,10,11,12,13,14
	Getting the organizational structure right	4, 5, 11, 15, 16, 17, 18
	Finding a change agent	3, 4, 13, 14, 19, 20, 21, 22
	Creating an implementation team	10,13,14,18, 21, 23, 24, 25
	Training the staff in team building and lean principles	2, 9, 13, 18, 19, 20, 4, 16, 21, 24, 25, 26
	Suppliers and customers involved	2, 5
	Recognizing the need for change	2, 3, 4, 7, 8, 16, 19, 22, 23, 25
Stage 2: Design	Mapping the value streams	2, 3, 4, 8, 10, 14, 16, 19, 22, 24, 26, 27, 28
	Analyzing the business for improvement opportunities	7, 8, 9, 10, 12, 13, 14, 15, 16, 19, 25, 28
	Planning the changes	1, 3, 4, 7, 8, 11, 12, 13, 14, 17, 18, 20, 22, 23, 24, 26, 27, 28
	Identify indicators to measure performance	3, 4, 6, 22
	Creating a feedback mechanism	3, 4, 26
Stage 3: Implementation	Starting with a pilot project	1, 2, 3, 6, 7, 8, 9, 10, 12,13, 15, 16, 18, 19, 20 , 22, 23,24,25, 26, 27, 28
	Starting the next implementation projects	4, 7, 9, 10, 12, 13, 16, 19, 24, 27
	Evaluating and sustaining changes	2, 3, 4, 7, 8, 21, 22
	Changing the material SC systems and philosophies	3, 9, 10, 11, 15
	Selling the benefits of “lean” thinking	3, 10, 11, 15
	Pursue perfection	1, 2, 3, 4, 20, 23
	Expand the scope	3, 4, 20, 24

*Sources: 1- Feld (2003); 2- Aernoudts (2004); 3- Moutabian (2010); 4- Crabill et al. (2000); 5- Hines and Taylor (2000); 6- Badurdeen (2007); 7- Jordan and Michel (2001); 8- Allen et al. (2001); 9- Lewis (2004); 10- Page (2004); 11- Atkinson (2004); 12- Shukla (2005); 13- O’Neill (2005); 14- Raymond (2006); 15- Makeham (2002); 16- Alukal (2003); 17- Chaneski (2003); 18- Koenigsaecker (2005); 19- Womack and Jones (1996); 20- Singh (1998); 21- Chaneski (2003); 22- Wilson (2009); 23- Drew et al. (2004); 24- Mehta and Monroe (2007); 25- Hoskins (1997); 26- Dennis (2002); 27- Mehrban (2005).

authors, for example Feld (2003), Atkinson (2004), Shukla (2005), O’Neill (2005), Raymond (2006), Koenigsaecker (2005), Wilson (2009), focus attention on ‘planning for the change’. Whereas Singh (1998), Crabill et al. (2000), Hines and Taylor (2000), Jordan and Michel (2001), Alukal (2003), Lewis (2004), Page (2004), O’Neill (2005), and Wilson (2009) place emphasis on training, VSM and analyzing. Consequently, it can be concluded that most of the research emphasizes that every “lean” plan and implementation should be tested in a pilot. This means that there is no unique roadmap to “leanness”; it is different for every company because it depends on their conditions. Table 3 presents the frequency of citation of “lean” steps in three levels as shown in the columns: High, intermediate and low.

A proposed dynamic model

Wan and Chen (2006) state that different templates of roadmaps should be applied to different types of industries (for example service sectors, repetitive manufacturing and non-repetitive manufacturing systems). Lewis (2000) emphasizes that organizations should not employ the same roadmap of “lean” tools to different types of industries that are at different current states: owing to the variability in their processes, a variation in the roadmap should be developed. Hence, this research focused on the

Table 2. Prioritization of lean steps.

Authors		Womack and Jones (1996)	Hoskins (1997)	Singh (1998)	Hines and Taylor (2000)	MIT Roadmap (2000)	Jordan and Michel (2001)	Allen et al. (2001)	Dennis (2002)	Makeham (2002)	Alukal (2003)	Chaneski (2003)	Feld (2003)	Lewis (2004)	Atkinson (2004)	Page (2004)	Aernoudts (2004)	Drew et. al. (2004)	Shukla (2005)	O'neill (2005)	Koenigsa (2005)	Mehrban (2005)	Raymond (2006)	Mehta (2006)	Badurdeen (2007)	Wright (2008)	Wilson (2009)	Moutabian (2010)	Present model	Frequency	Ranking
Steps		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28		
Preparation stage	1												×				×											×	×	4	14
	2					×																							×	2	15
	3				×																				×			×	×	4	14
	4				×	×	×	×						×	×	×			×	×		×	×					×	×	13	5
	5				×	×				×	×	×			×						×								×	8	10
	6	×		×		×						×						×		×				×			×	×	×	10	8
	7											×				×		×		×	×		×	×		×			×	9	9
	8	×	×	×		×					×	×		×			×	×		×	×			×		×		×	×	15	**3**
	9				×	×											×											×	×	5	13
	10	×				×	×	×			×						×	×							×	×	×	×	×	12	6
Design stage	11	×	×			×			×		×		×			×	×					×	×	×		×	×	×	×	15	**3**
	12	×					×	×	×	×	×			×					×	×		×	×			×		×	×	14	4
	13		×	×		×	×	×	×			×	×		×			×	×	×	×	×	×	×			×	×	×	19	**2**
	14					×																			×		×	×	×	5	13
	15				×	×																						×	×	4	14
Implementation stage	16	×	×	×		×	×	×	×	×	×		×	×		×	×	×	×	×	×	×		×	×	×	×	×	×	24	**1**
	17	×					×		×		×			×		×			×	×				×				×	×	11	7
	18					×	×	×				×					×										×	×	×	8	10
	19									×				×		×	×											×	×	6	12
	20									×					×	×												×	×	5	13
	21			×		×							×				×	×										×	×	7	11
	22			×		×																		×				×	×	5	13

Table 3. A frequency of lean steps from the literature review.

Most frequencies	Intermediate frequencies	Least frequencies
Pilot project	Evaluating changes	Gap assessment
Planning for the changes	Need for change	Expand the scope
VSM	Change agent	Selling of lean thinking
Analyzing system	Determining objectives	Feedback mechanism
Lean training	Organizational structure	Measure performance
	Team working	Strategic planning

development of a dynamic “lean” pathway that would produce different roadmaps for different types of industries depending on their current states, and would lead to achievement of the highest “leanness” level. One of the most important things to be considered in a company while transforming into a “lean” state is to understand the current state of the company and its desired state (Nightingale and Mize, 2002); in order to accomplish this a “lean” roadmap is necessary. There are two priority orders of tools; one is the priority order of the tool based on the type of the company: In terms of the volume of products and repetitiveness in the manufacturing environment.

The other priority order of the tool is based on the current state of the company in order to determine the current “leanness” level. However, a roadmap for the current state of the company is not enough on its own because it is not possible to use the same roadmap for a customized and a mass-production company because they both differ in their processes and the required type of “lean” tool. It is also insufficient to have a “lean” roadmap for the volume and repetitiveness and the type of industry the company is based on without knowing how far they have implemented “lean” concepts and their awareness of these concepts; without this information we cannot judge which is the more important tool to be implemented in that industry. Therefore, it is necessary to know these three factors (volume, repetitiveness, and type of industry) before deciding what the order of the tools or the “lean” roadmap for the implementation of LM techniques should be. This paper proposed a solution to problems in existing roadmaps.

In this research, a dynamic roadmap has been developed which will determine the tools that need to be implemented in the firm based on its current state as well as the type of the industry. This dynamic roadmap will change the order in which the tools need to be implemented in a firm with respect to the state of the firm and its type. So, a template roadmap of “lean” is proposed (Figure 1). The aim of this template was to fit aspects of volume, industry and so on in different companies that are implementing “lean”. As shown in Figure 1, this model is organized in four major phases and one initial phase for assessment of Lean implementation. A detailed description is presented as follows:

Phase 0- Initial investigation

In the first step, you have to assess the company to find the answer to three basic requirements for “lean”: Is there any crisis (sales, profit etc.); is there a level of commitment of management, change agent; and is there “lean” knowledge to apply tools and techniques in terms of the capability and resources (that is “cognitive, skills and attitudes” among managers and people, (Oloruntegbe and Alam, 2010)? If so, then it is desirable, otherwise you cannot start to implement “lean”.

Phase 1- Preparation

In this phase, design and thinking activities for strategic planning using Hoshin Kanri/Balanced Scorecard are carried out. Then, it should be investigated whether there is “lean” knowledge in the lean promotion office (LPO) and in people. Are “lean” experts available? If so, you can begin the next step, if not, employees will have to learn about “lean”.

Finally, it is necessary to analyze the whole system, on aspects of organizational structure, resources, limitation, and delimitation, with regard to identifying value, objectives, policies, product family, procedures, metrics, feedback system, and determining the managers of VSMs.

Phase 2- Focus on specified pilot

In the first step of this phase, a family product as a sample is selected to map the value stream into current and future status. Then you can, based on future VSM, implement by continuous flow, stability, flexibility, and pulling.

Although there is a relationship between tools and techniques they are not obvious when considering them together, so the researchers arranged techniques according to their major role and their sequences. Hence, in this phase, 5S, Kanban, Automatic Guided Vehicle, waste elimination and flexible work systems by group technology and cellular manufacturing can be tried out to create continuous flow. Standard work, 5S, TPM, Jidoka/autonomation, Poka Yoke, self controlling, and visual management are used to achieve the stability conditions; and to have ideal flexibility, multi-skills works, implementation of SMED and Heijunka/leveling, and some tools/techniques such as Takt time, pace maker, “one piece flow”, FIFO line, supermarket, fit for use of pulling are used.

Phase 3- Expand to whole system

After the pilot study, the model can be expanded to the whole system. First of all, it provides current and future VSM (door-to-door) for all products. Then, “lean” is implemented according to future VSM, and “lean” is implemented considering four main methods (continuous flow, stability, flexibility, and pulling) in the last phase. Ultimately, it can be rolled out to the office and to organizations outside the enterprise (suppliers and customers).

Phase 4- Perfection

In the final phase, measurement performance is founded on ‘maturity matrix’ and lean enterprise self assessment tool (LESAT) so that indicators and metrics previously identified can be conducted. In this phase, there is an emphasis on measurement, feedback, and continuous improvement. It is notable that “lean” needs to be seen as a journey, it is a journey about thinking, learning and trial to achieve perfection, which never ends. Hence, it needs to have feedback of outcomes, and a measurement system

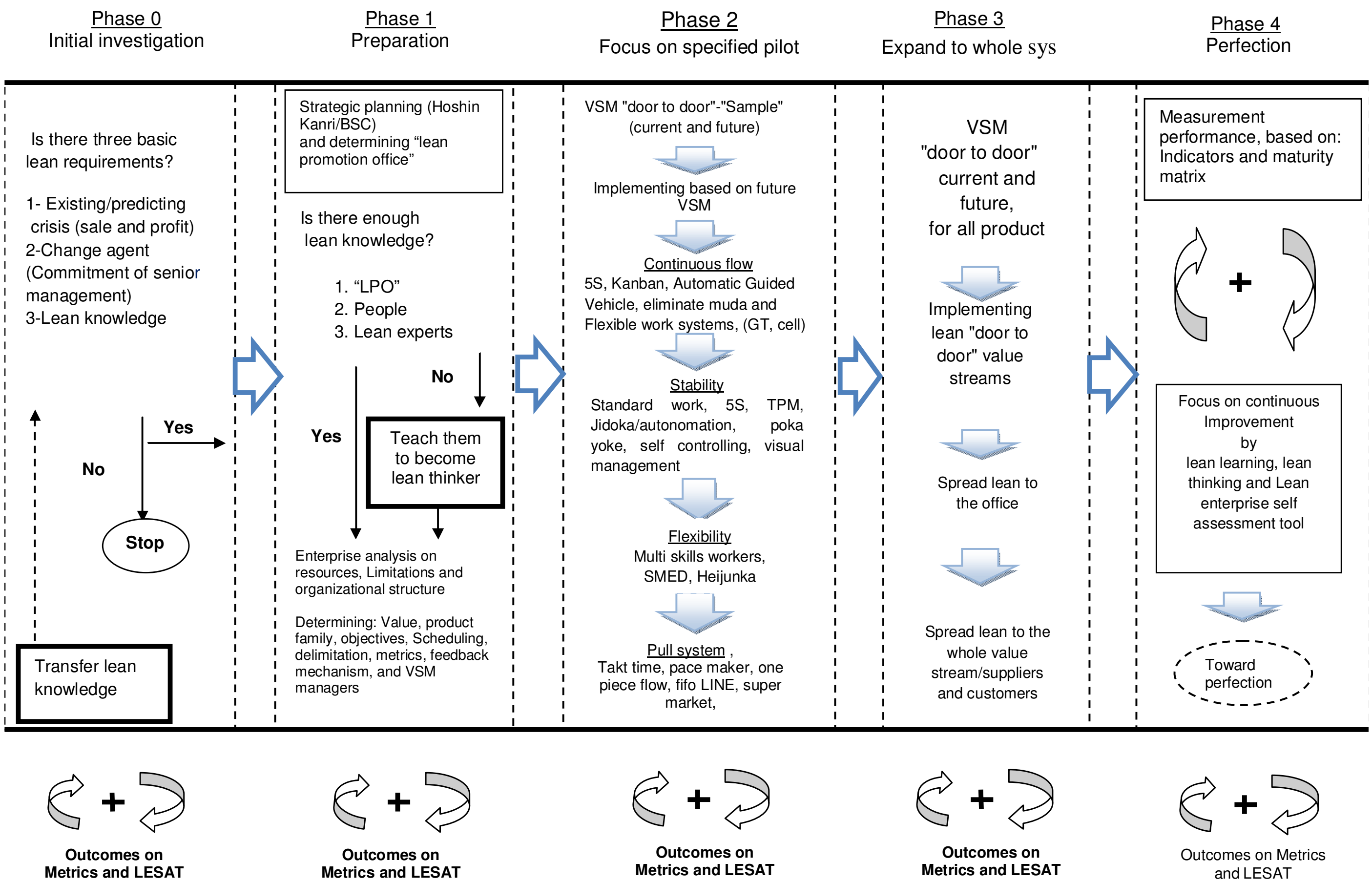

Figure 1. A proposed dynamic model to leanness.

based on LESAT and 'matrix maturity' in all phases, processes, and internal steps required to achieve a dynamic system in a highly variable environment. So, the proposed dynamic model provides us with a dynamic condition covering aspects of: Allocation, scheduling, check, analysis, leading to a dynamic balance, to stability and survival in a differentiated and competitive environment.

DISCUSSION AND CONCLUSION

Lean is about producing with the minimum amount of materials, equipment, labor, and space regarding the customers', suppliers', stakeholders', workers', and managers' satisfaction. The goal of an enterprise that adopts "lean" is to make each process as efficient and effective as possible, and to connect those processes in a stream or continuous chain that is focused on maximizing customer value. A roadmap is needed to provide sequencing for transforming an enterprise from non-"lean" to "lean". A "lean" roadmap focuses on leadership, people, "lean" knowledge, objectives, and strategic planning issues, and it provides an organizing framework for enterprise-wide transition. Consequently, the understanding of who, what, where, when, why and how in Lean transformation attempts is increased. The first objective of this research was to investigate "lean" roadmaps and their chain of events. To meet this objective, we defined LM, and discussed "lean" approaches and their implementation. The second objective was a comparative perspective of researchers' approaches toward "leanness". In this case, 28 different perspectives were illustrated. It was found that all of the researchers believed that a roadmap of "lean" implementation is necessary.

The results of the comparative study of roadmaps showed that no two roadmaps are the same, and most research emphasizes the following "lean" steps: Begin with a pilot project, change planning, VSM, analyzing the system, and training of "lean" advantages and implementation.

The third objective was to identify the steps needed to assess the movement of companies toward "lean", and in our research we found that 3 stages and 22 steps were described in the research literature as necessary for a successful implementation of "lean". Finally, we presented a "lean" roadmap with a dynamic structure that can be used in a high variability environment; it was developed to cover all enterprises. The proposed model will determine the tools and techniques that need to be implemented in a company based on its current state as well as the type of the industry. Also, in this research, four questions were addressed. The first question asked what the contribution of the literature had been to the field of “lean” implementation. In response to this question we identified and categorized 28 studies of “lean” implementation. The second and third questions asked what the researchers’ perspectives toward “leanness” were and their common viewpoints. We responded to this question with a comparative perspective of researchers’ approaches toward Leanness. It was found that all of the researchers believed that a roadmap is necessary and that no two roadmaps are the same. Most researchers emphasized the following “lean” steps: Pilot project, planning, VSM, analyzing, and training.

Moreover, in this research, 3 stages and 22 steps were proposed for a successful implementation of “lean”. The fourth question asked how a roadmap covers all enterprises in different conditions. We proposed and presented a “lean” roadmap with a dynamic structure that can be used in a novel environment. This model will determine objectives, strategy, policy deployment, the tools and techniques that need to be implemented, operation process, and continuous improvement to perfection, for a company based on its current state as well as its industry type. As a result, it was developed to cover all enterprises. The dynamic roadmap is a resource that clearly explains in logical building block steps the design of a “lean” vision for implementation of “lean”.

Companies in a high variability environment require proper design, planning and ongoing management to realize attainment of goals through a dynamic method. This model encourages managers and change agents toward better means to “leanness” because it combines all the high variability values of selected “lean” practices. This proposed dynamic model not only provides a guideline in dynamic conditions, but also it could be viewed as a technical transformation as well as a cultural transformation. The benefits of this proposed roadmap to enterprises are listed as follows: It builds vision: it requires a commitment to learning and to the implementation of “lean” by senior and middle managers so that it leads to the creation of an internalized vision. It also identifies and empowers change agents, adapts structure and systems, creates and refines the transformation plan, sets goals and metrics, identifies and prioritizes activities to implement “lean” initiatives, and conveys requirements to “leanness” (by committing resources).

Furthermore, it discusses what activities should be done in the process, creates a procedure that leads to the fostering of “lean” learning, identifies and determines “lean” structure and behavior, organizes resources for “lean” implementation, focuses on VSM, continuous flow, and continuous improvement. Moreover, it monitors “lean” progress (LESAT), captures and adopts new knowledge, refines the plan, and it provides repeated education and training. Lean is not only a set of tools and techniques, methods, elements and projects, but also, in a high variability environment, it is a journey about learning and “lean” thinking that is a continuous generic approach to perfection.

RECOMMENDATION

For future research, the authors suggest a comparative study between the proposed roadmap and other roadmaps using the fuzzy MCDM method.

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Dynamic systems modeling in educational system was proposed by Groff [17]. He mentioned that applying this tool to educational policy analysis offers insights into the hidden dynamics of the current system and can be an invaluable tool in designing future scenarios. He explored underlying dynamics of the current US educational system using system dynamics modeling and offered an analysis of this tool and its practical application in the US educational system through a case study on the US state of Rhode Island in the 2007-2008 school year.Â In the proposed dynamic model the effect of new technology is considered on lean manufacturing. These effects act as bidirectional, meaning that lean manufacturing also affects technology.