

# Lean Roadmap: A Step by Step Guide for a Process Manager

Younes Tiamaz, Nissine Souissi

**Abstract:** *This paper aims to build a generic roadmap for implementing Lean in different domains in order to improve the business processes. The customization of this roadmap makes it possible to adapt the steps to be followed for Lean implementation, the process manager's requirements and available resources. An application has been developed in order to facilitate the customization of this roadmap. An analysis of methods from a literature review for Lean implementation was conducted in order to identify the steps to be included in the roadmap. A rigorous approach based on set theory, was therefore proposed and followed to build the roadmap. This roadmap is defined as a set of phases associated with principles, and each phase is defined as a set of steps associated with tools. This roadmap shows to the process manager, the objectives to aim for, the Lean principles to satisfy, and the Lean tools to use.*

**Index Terms:** *Business Process, Continuous Improvement, Lean Method, Lean Roadmap.*

## I. INTRODUCTION

Lean is originated from the Japanese automotive industry [1]. It is about a business process improvement approach, which arouses the interest of numerous researchers; however, these researchers don't share the same vision and their opinions diverge. [2] underline that eliminate all forms of waste to reduce expenses and maximize the use of worker capacity are the basic concepts of the Lean approach. [3] defined Lean approach as a set of tools for identifying and eliminating waste. The Lean principles tools should not be dissociated to allow process flow improvement and waste elimination according to [4]. [5] considered that Lean is an operational strategy whose primary aim is to reduce wastes.

Implementing Lean in an organization isn't an easy task. [6] underline that few organizations obtain significant improvements. [7] stated that industrial manufacturers strive to adopt lean philosophy but they find it difficult to achieve. They also noted that failure to implement Lean results in wasting resources and reducing employees' confidence in Lean practice. [8] considered that the primary reasons behind Implementing failures of the lean approach: trying to solve a problem using an in appropriate tools or using a single tool, or using specific tools in order to solve any problems.

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**Younes Tiamaz**, SIWEB Team, Mohammadia School of Engineering, Mohammed V University, Rabat, Morocco

**Nissrine Souissi**, Computer Science Department Rabat School of Mines, Rabat, Morocco & SIWEB Team, Mohammadia School of Engineering, Mohammed V University, Rabat, Morocco

In addition, [9] indicated that the selection of appropriate tools for process improvement, as well as their applicability

and integration into operations, is a major problem for many organizations. However, [10] stated that the implementation of Lean requires besides tools, the involvement of managers and employees that depends on the culture of the country and that of the company.

[11], [12] stated that failure to implement Lean is due to a lack of understanding of this approach. [13] also pointed out that there are various definitions for the Lean adopted by the researchers, therefore there is no common terminology. In addition, [3] concluded that there are no standard methods for implementing Lean. [14] classified the problems that Lean implementation encounters, in eight categories namely: Terminology, organizational momentum, functional and professional silos, data collection and performance measurement, resistance to change, hierarchy and management roles, personal and professional skills and perception. [15] pointed out that there are four main reasons why companies fail to achieve the desired objectives from Lean implementation. The first reason is that the managers do not understand the real impact of the Lean approach, the second is that they are not able to accept that cultural change is indispensable, the third is that companies do not have the right people in the appropriate positions, and the fourth one is that companies choose Lean as a business process improvement approach without any prior study.

To sum up, Lean is a continuous improvement approach of business process, which enables organizations to achieve their business objectives. However, [16] mentioned that the objectives achieved by the organizations is only a small part of the desired objectives. In fact, it is necessary to provide a Lean roadmap that will allow the business process manager to overcome the problems that prevent a successful Lean implementation. This roadmap needs to highlight Lean principles in order to involve managers and employees and encourage them to accept change. In this paper, we build a roadmap that proposes steps to follow, tools to use and principles to satisfy. In addition, the generic aspect of the roadmap, allows the manager to customize it, making it adapted to the resources of the company.

Section 2 presents our building process of the roadmap. In section 3, we give the proposed roadmap. Section 4 discusses the related works. In section 5, we focus on the application that allows the business process manager to customize the roadmap. Finally, we present conclusion and perspectives.

## II. ROADMAP BUILDING PROCESS



This section presents the process followed in order to build the Roadmap. This process is illustrated in Fig. 1.



**Fig. 1 The Roadmap building process**

- Lean methods definition

We consider that each Lean method consists of several phases and that each phase consists of several steps. A semantic and syntactic analysis is necessary here in order to redefine all the methods of Lean in the form of steps that are grouped into phases.

Let  $M$  be the set of all the lean methods resulting from articles found in literature:

$$M = \bigcup_{i=1}^n M_i$$

such that  $n$ : Number of lean methods,  $n \in \mathbb{N}$

$$\forall i \in [1, n] \quad M_i = \bigcup_{j=1}^{s_i} P_{ij}$$

such that

$P_{ij}$ : Phase number  $j$  in method  $M_i$

$s_i = \text{card}(P_{ij})$ : Number of phases in Lean method  $M_i$  and  $\forall i, s_i \geq 1$

$$\forall j \in [1, s_i] \quad P_{ij} = \bigcup_{k=1}^{e_{ij}} E_{ijk}$$

such that

$E_{ijk}$ : Step  $k$  of phase  $P_{ij}$  in lean method  $M_i$

$e_{ij} = \text{card}(E_{ijk})$ : Number of steps of phase  $P_{ij}$  and  $\forall i, j, e_{ij} \geq 1$

As a result:

$$M = \bigcup_{i=1}^n \bigcup_{j=1}^{s_i} \bigcup_{k=1}^{e_{ij}} E_{ijk} \quad (1)$$

- Steps identification

From the set  $M$ , we will identify the steps mentioned in lean methods.

Let  $l$  be the number of steps identified for all the methods:

$$l = \sum_{i=1}^n \sum_{j=1}^{s_i} e_{ij}^2 \quad (2)$$

Since Lean methods are independent but aim for the same objective, which is implementing Lean, there may be steps that have the same semantics but have different names. In order to remove this ambiguity, we conducted both a semantic and syntactic analysis. These analyses made it possible to avoid any eventual redundancy of the steps.

Let  $E'$  be the set of steps remained after the semantic and syntactic analysis of the  $l$  steps.

$$E' = \bigcup_{k=1}^{l'} E'_k \quad (3)$$

Such that  $l' = l - \text{number of redundancy}$

- Phases definition

In order to ensure that our process of building the Roadmap is compliant with the definition we have proposed in (1), we will group the steps of  $E'$  into phases. To do this, we linked the steps that meet the same objective to the same phase.

Let  $q$  be the number of phases defined:  $q \in \mathbb{N}$ . Let  $P'$  be the number of phases defined  $P'_i$  be a partition  $E'$ .

$$\forall i \in [1, q] \quad \bigcup_{i=1}^q P'_i = P'$$

$$\forall i \in [1, q] \quad P'_i \neq \emptyset$$

$$\forall i, j \in [1, q] \quad P'_i \cap P'_j = \emptyset$$

The definition of a phase consists first in linking steps to it and then in assigning a name to it. Since we have grouped steps that have the same objective into one phase, this phase bears then the name of this objective.

Let  $lab$  be the set that contains all the labels, which designate the objectives of the phases:

$$Lab = \bigcup_{i=1}^q Lab_i$$

such that  $Lab_i$ : label of the phase  $P'_i$

We make an assignment of the set  $Lab$  to the set  $P'$  via the function  $f$ .

$$f : \begin{cases} P' \rightarrow Lab \\ P'_i \rightarrow f(P'_i) = Lab_i \end{cases} \quad (4)$$

Assignment of principles and tools

Let  $Pr$  be the set of principles that must be verified by the phases such us:

$$\forall i \in [1, pr] \quad Pr = \bigcup_{i=1}^{pr} Pr_i$$

such that  $pr$ : Number of principles

Let  $O$  be the set of tools associated to the steps of  $E'$  such us:

$$\forall i \in [1, o] \quad O = \bigcup_{i=1}^o O_i$$

such that  $o$ : Number of available steps.

Let  $g$  be the function assigning the tools to the steps:

$$g : \begin{cases} E' \rightarrow (O)^{c_1} \\ E'_i \rightarrow O'_i \end{cases} \quad (5)$$

such that  $c_1$ : Number of tools available for a step and

$$\forall i \in [1, l'] \quad O = \bigcup_{i=1}^{l'} O'_i$$

Let  $h$  be the function affecting the principles of the phases:

$$h : \begin{cases} P' \rightarrow (Pr)^{c_2} \\ P'_i \rightarrow Pr'_i \end{cases} \quad (6)$$



such that  $c_2$ : Number of principles in a phase and

$$\forall i \in [[1, q]] Pr = \bigcup_{i=1}^q Pr'_i$$

- Validation of steps and phases

The validation of the steps and phases concerns the supervision of the implementation of Lean and not the construction of the Roadmap. To go from one phase to another, we must satisfy principles and in order to achieve a step, we must use at least one tool--if it exists-- among the tools associated with the step.

Let  $B$  be the function indicating whether a step is validated or not:

$$B : \begin{cases} E' \rightarrow \mathbb{N} \\ E'_i \rightarrow \begin{cases} 1 \text{ if at least one of these tools is used} \\ 0 \text{ if not} \end{cases} \end{cases} \quad (7)$$

Let  $C$  indicating whether a phase  $P'_i$  is validated or not:

$$C : \begin{cases} P' \rightarrow \mathbb{N} \\ P'_i \rightarrow \begin{cases} 1 \text{ si } \forall E'_i \in P_j \ B(E'_i) = 1 \\ 0 \text{ if not} \end{cases} \end{cases} \quad (8)$$

Therefore,

$C(P'_i) = 1 \Rightarrow$  Principles of phase  $P'_i$  are verified.

$C(P'_i) = 0 \Rightarrow$  Phase  $P'_i$  remains non-validated

### III. THE PROPOSED ROADMAP

After the presentation of building process of our roadmap, we follow up with its application to determine the roadmap components, namely: phases, principles, steps and tools.

#### A. Application of the Roadmap Building Process

##### 1) Lean Methods Definition

In order to conduct our literature review of lean methods, we formulated the following research questions (RQ):

RQ1: What are the Lean methods proposed in literature?

RQ2: How can we associate the steps mentioned in the lean methods with their tools, their principles and their objectives in a single Roadmap?

To answer these questions, we used combinations of the following keywords in our research: «Lean approach», «Lean model», «Lean method», «Lean transformation », «Lean philosophy», «Lean principles», «Lean thinking», «Lean management», «Lean methodology», «Lean production», «Toyota management system», «Lean modeling», «Lean roadmap», «Lean Framework», «Lean Work instruction». The articles found contain these words in title, abstract or in the list of keywords. Only articles published between 2010 and 2017 have been chosen to work with.

The selected articles that answer our research questions are grouped together as  $M$  and have been studied in [17].

$$M = \{[5], [12], [18]–[39]\}$$

Using formula (1), we move on to identifying steps, tools and phases.

##### 2) Lean Steps identification

From the set  $M$ , we have used the formulas (2) and (3). So, the steps have been identified and grouped together in the set  $E'$ .

$E' = \{\text{Define the target objectives } E'_1, \text{ determine and measure the performance indicators } E'_2, \text{ build lean expert team } E'_3, \text{ teach lean's philosophy and principles } E'_4, \text{ review lessons learned training } E'_5, \text{ organize lean's multidisciplinary team } E'_6, \text{ make observations } E'_7, \text{ select processes } E'_8, \text{ build a team dedicated to the process } E'_9, \text{ organize the work space } E'_{10}, \text{ establish a process mapping } E'_{11}, \text{ measure the processes } E'_{12}, \text{ identify added and non-added values activities } E'_{13}, \text{ identify waste } E'_{14}, \text{ classify waste } E'_{15}, \text{ prioritize waste } E'_{16}, \text{ identify root causes of identified waste } E'_{17}, \text{ classify root cause of identified waste } E'_{18}, \text{ prioritize root cause of identified waste } E'_{19}, \text{ organize meetings } E'_{20}, \text{ prioritize and develop solutions } E'_{21}, \text{ apply the proposed improvements } E'_{22}, \text{ evaluate the progress } E'_{23}, \text{ evaluate the indicators selected } E'_{24}, \text{ promote a culture of continuous improvement } E'_{25}, \text{ update procedures } E'_{26}, \text{ expand lean practices } E'_{27}\}$

##### 3) Phases definition

From the set  $E'$ , phases have been defined to group the steps that meet the same objectives such as  $q=9$ . Using the formula (4), we have obtained the following result:

Define the goals  $P'_1 = \{E'_1, E'_2\}$ , Provide Training  $P'_2 = \{E'_3, E'_4, E'_5, E'_6\}$ , Understand the environment  $P'_3 = \{E'_7, E'_8\}$ , Prepare the environment  $P'_4 = \{E'_9, E'_{10}\}$ , Understand the process  $P'_5 = \{E'_{11}, E'_{12}, E'_{13}\}$ , Manage wastes  $P'_6 = \{E'_{14}, E'_{15}, E'_{16}, E'_{17}, E'_{18}, E'_{19}\}$ , Implement  $P'_7 = \{E'_{20}, E'_{21}, E'_{22}\}$ , Revise  $P'_8 = \{E'_{23}, E'_{24}\}$ , Sustain the results  $P'_9 = \{E'_{25}, E'_{26}, E'_{27}\}$

##### 4) Assignment of principles and tools

The principles and tools are collected from the articles presented in the set  $M$ . Using the formulas (5) and (6),  $Pr$  represents the set of principles and  $O$  represents the set of tools.

$$Pr = \{\text{Involve managers } Pr_1, \text{ accept}\}$$

change  $Pr_2$ , manager should coach not fix  $Pr_3$ , respect every individual  $Pr_4$ , go and see for yourself  $Pr_5$ , employee empowerment  $Pr_6$ , self-directed work teams  $Pr_7$ , cross-functional work force  $Pr_8$ , involve employees  $Pr_9$ , focus on process  $Pr_{10}$ , quality at the source  $Pr_{11}$ , create value for the customer  $Pr_{12}$ , stop to fix problems  $Pr_{13}$ , self-directed work teams  $Pr_{14}$ , continuous improvement culture  $Pr_{15}$ , pursue perfection  $Pr_{16}$

$O = \{\text{Project charter } O_1, \text{ benchmarking } O_2, \text{ voice of customer } O_3, \text{ survey } O_4, \text{ kano model } O_5, \text{ 5S } O_6, \text{ Kanban } O_7, \text{ Poka Yoke } O_8, \text{ cellular manufacturing } O_9, \text{ VSM } O_{10}, \text{ Spaghetti diagram } O_{11}, \text{ gemba, Swim lanes } O_{12}, \text{ calculate takt time } O_{13}, \text{ critical to quality flowdown } O_{14}, \text{ data collection plan } O_{15}, \text{ multiple activity chart } O_{16}, \text{ brainstorming } O_{17}, \text{ 5 whys / ishikawa } O_{18}, \text{ pareto chart } O_{19}, \text{ SMED } O_{20}, \text{ heijunka } O_{21}, \text{ cellular manufacturing } O_{22}, \text{ TPM, line balancing } O_{23}, \text{ Standardization } O_{24}, \text{ Kaizen } O_{25}\}$

The result of the functions (7) and (8) used to assign the principles to phases and tools to steps are illustrated in Table I

## B. The Roadmap

The phases and the steps defined above require execution in a specific order to help managers to achieve their objectives. **Error! Reference source not found.** shows a sequence of the phases and the steps.

## IV. RELATED WORKS

This paper proposed a roadmap based on a set of Lean methods from literature. We compare in this section our roadmap to other Lean methods. The majority of Lean methods [5], [8], [18], [20]–[22], [24]–[27], [29], [31]–[33], [36], [39] considered that the Lean approach is a set of tools to apply. [19], [37] emphasized on the principles to satisfy. [35] focused on the objectives to achieve, unlike our roadmap that takes into account the objectives to be achieved, the principles to be satisfied as well as the tools to be used. The other methods [12], [23], [30], [34], [35], [38] considered at least two elements among the objectives, principles and tools. But we noticed that [34], [38] did not present an operating mode to follow.

[23] incorporated Lean approach into the requirements of ISO 9001:2008. So, according to [23], in order to implement Lean approach, it is necessary to also integrate ISO 9001: 2008. Thus, if ISO 9001: 2008 is already implemented or migration to a new version such as ISO 9001: 2015 this method is then needless. Similarly, [35] incorporated Lean and Six Sigma approach into the requirements of ISO 9001: 2015. [12] presented a method with four phases and in each of

these phases, they presented a set of steps, but they linked the tools to the phases. It will then be difficult to determine which tools to use in a particular step. [30] used the 12 principles of [1]. For each principle, they added sub-principles with guidelines for its implementation. Afterwards, they described the sub-principles and mentioned the tools in their descriptions. However, the absence of steps and phases makes the application of this method as well as the evaluation of the progress of Lean implementation difficult.

**Table I** The result of the assignment functions of principles to phases and tools to steps

Phases	Principles	Steps	Tools
$P'_1$	$Pr_1$	$E'_1$	$O_1$
		$E'_2$	
$P'_2$	$Pr_2, Pr_3, Pr_4$	$E'_3$	
		$E'_4$	
		$E'_5$	
		$E'_6$	
$P'_3$	$Pr_5$	$E'_7$	$O_2, O_3, O_4, O_5$
		$E'_8$	
$P'_4$	$Pr_6, Pr_7, Pr_8, Pr_9$	$E'_9$	
		$E'_{10}$	$O_6, O_7, O_8, O_9$
$P'_5$	$Pr_5, Pr_{10}$	$E'_{11}$	$O_{10}, O_{11}, O_{12}, O_{13}$
		$E'_{12}$	$O_{14}, O_{15}, O_{16}, O_{17}$
		$E'_{13}$	
$P'_6$	$Pr_5$	$E'_{14}$	$O_{18}$
		$E'_{15}$	$O_{19}$
		$E'_{16}$	$O_{20}, O_{21}$
		$E'_{17}$	$O_{19}$
		$E'_{18}$	$O_{19}$
		$E'_{19}$	$O_{20}$
$P'_7$	$Pr_{11}, Pr_{12}, Pr_{13}$	$E'_{20}$	
		$E'_{21}$	$O_{18}, O_{19}, O_{20}$
		$E'_{22}$	$O_{21}, O_{22}, O_{23}, O_{24}, O_{25}$
$P'_8$	$Pr_5, Pr_{14}$	$E'_{23}$	
		$E'_{24}$	
$P'_9$	$Pr_{15}, Pr_{16}$	$E'_{25}$	$O_{26}, O_{27}$
		$E'_{26}$	
		$E'_{27}$	

## V. APPLICATION FOR THE PROCESS MANAGER: CUSTOMIZATION OF THE ROADMAP

We believe that the use of an application to generate a personalized roadmap by the process manager,





indicating the phases and steps to follow; the principles to be satisfied in each phase; the tools to be used in each step, will facilitate the implementation of Lean. In this sense, we have developed an ergonomic application that is easy to use by

business process managers. It offers two main services: generation of the roadmap and supervision of the implementation of Lean (Fig. 3).

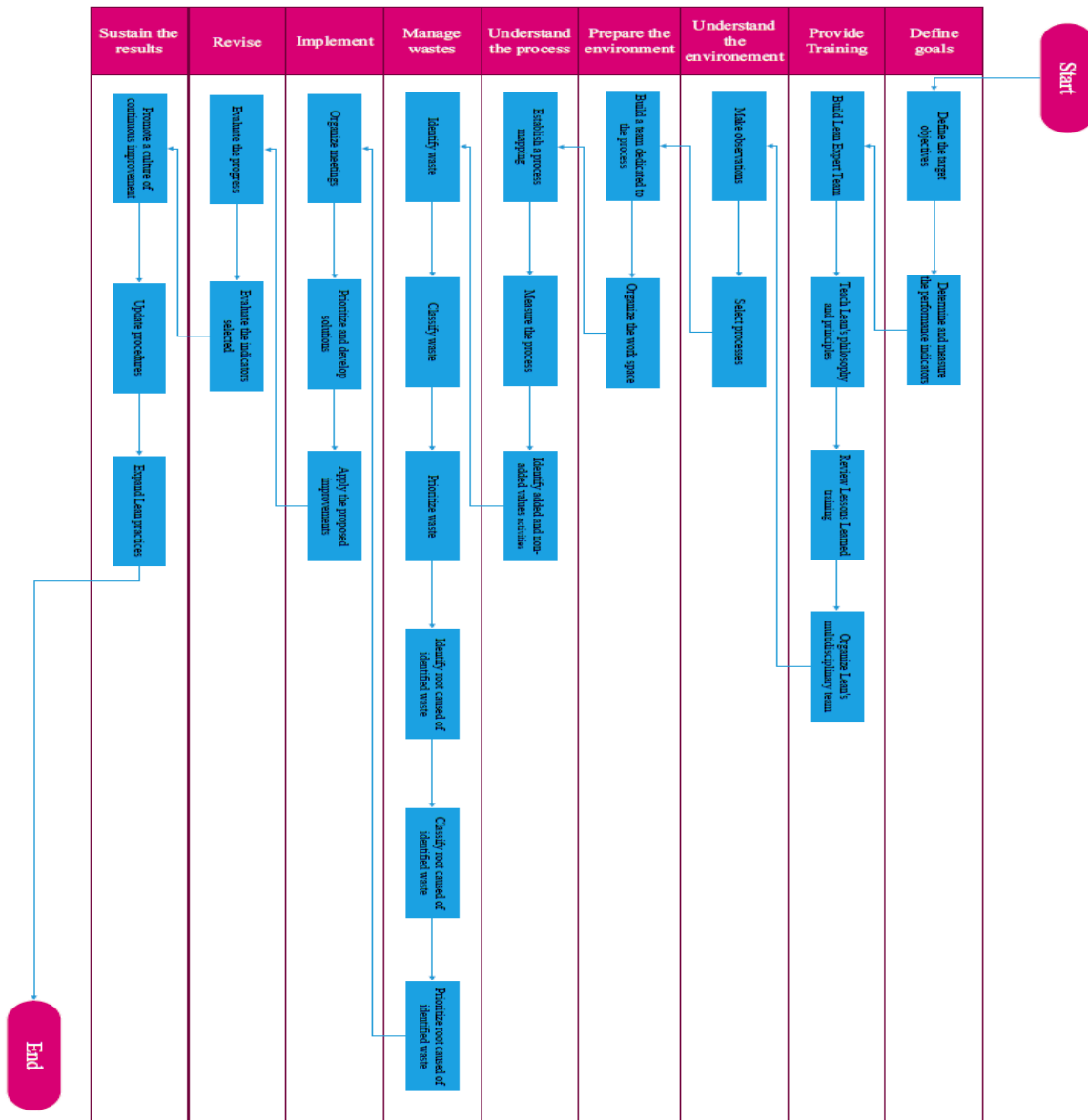


Fig. 2 Sequencing of steps and phases

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Fig. 3 Home page

When selecting the "Roadmap", the page illustrated in Fig. 4 is displayed and allows either to display the default roadmap, or to customize the Roadmap.

The choice of default parameters gives an overview of all the phases that build the roadmap, which are illustrated in Fig. 5. In this case, the manager considers that each of these phases is essential to sustaining the improvements.



Fig. 4 Roadmap Options page

To display the steps of a phase as well as the tools associated with each step, the manager selects a phase in the roadmap (Fig. 6).

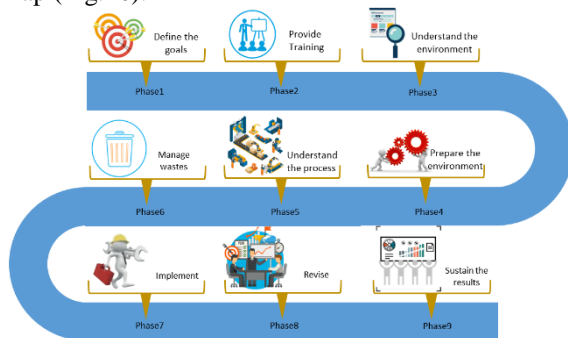


Fig. 5 Default roadmap



Fig. 6 The selection of phase 5

This option helps to present the roadmap in a simple way despite the amount of information it provides. The manager can intervene and change the default settings. To do this, he/she chooses the phases that he/she considers appropriate for the context, the steps of each phase and the tools used in each step (Fig. 7). This operation consists of unchecking the unwanted phases and / or steps and / or tools. In this example, the manager does not want to apply the training phase. Even though the related steps and tools are checked in the "Training" phase, the application will not take them into consideration because the "Training" phase is unchecked.

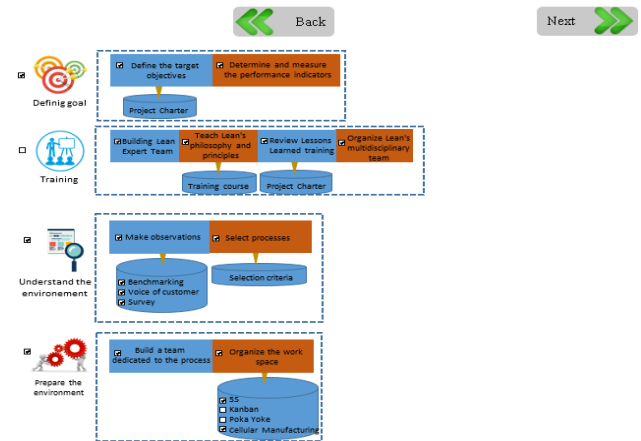


Fig. 7 Customization of the road map

This option makes it easier for the manager to disable a phase as well as the steps. When unchecking a step, the application ignores the tools associated with it. The roadmap adapts to the changes made by the manager as shown in Fig. 8.

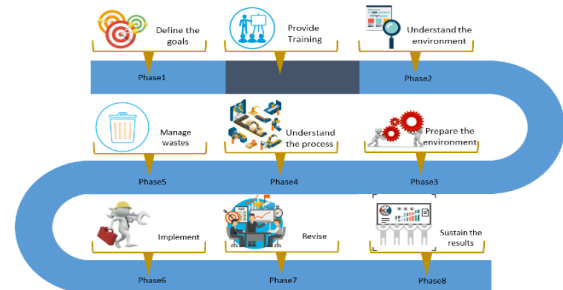


Fig. 8 Customized roadmap

In this example, the manager removed the "Training" phase. As a result, the color of its zone in the application changed and the numbering of the phases was updated accordingly. When the manager disables a phase, its zone will no longer display the steps and the tools it contains because the application only displays the phases, steps and tools selected.

## VI. CONCLUSION

This paper has proposed a generic roadmap with the possibility to customize it to meet the requirements of process managers, while taking into consideration the available resources of the company. A literature review was conducted to determine the key steps of Lean implementation. A definition of a Lean method has been proposed in this sense; it is a set of phases where each phase designates a set of steps. Tools have been associated to the steps, and principles have been associated to the phases. In order to identify the phases, steps and tools, a rigorous approach has been proposed and applied. Additionally, an application that offers intuitive interfaces for easy manipulation by non-expert users to generate roadmap has been developed. We began implementing our roadmap to improve a process of the hospital system of Moulay Ismail Hospital in Meknes, Morocco and the preliminary results are satisfactory.

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## AUTHORS PROFILE



**Younes tiamaz** is a Phd Student at Mohammed V University, Rabat, Morocco and member of Information System and WEB (SIWEB) in EMI School. he obtained his engineering degree from MINES-RABAT School, Morocco in 2015. His research interests include process engineering, business process management and continuous improvement approach.



**Nissrine SOUISSI** is a fulltime professor at the MINES-RABAT School, Morocco. She obtained a Ph.D. in computer science from the UPEC University in 2006, France and an Engineer degree from Mohammadia School of Engineers in 2001, Morocco. Her research interests include process engineering, business process

management, databases, data lifecycle, smart data, hospital



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