A Roadmap Approach For Implementing Theory of Constraints In Manufacturing Organisations

Prof. ND. Du Preez¹, Louis Louw²
¹University of Stellenbosch, Industrial Engineering Department, South Africa
²Indutech (Pty) Ltd, South Africa

Abstract
Implementing the Theory of Constraints (TOC) requires significant changes in the processes, policies and behaviours of an organisation. In order to ensure a successful and lasting implementation it is important to have an implementation plan, as well as keeping and managing implementation documentation. This helps to get and maintain organisational commitment; to teach the organisation how the system works; as well as using the knowledge for future continuous improvement. A roadmap methodology provides a plan or map for making the transition from where the organisation is today to where it will be in the future. This paper describes a roadmap approach to facilitate the successful execution of a TOC implementation, as well as capturing and managing the TOC knowledge within the organisation.

Keywords
Theory of Constraints, Roadmaps, Knowledge Management

1 INTRODUCTION
The Theory of Constraints (TOC) is a systems-management philosophy developed by Eliyahu M. Goldratt in the early 1980s. One of the fundamental principles of TOC is that constraints establish the limits of performance for any system. Most organizations contain only a few core constraints. TOC advocates suggest that managers should focus on effectively managing the capacity and capability of these constraints if they are to improve the performance of their organization.

Implementing TOC requires significant changes in an organisation (in processes and behaviours, and ultimately the culture of the organisation). The implementation process is a system to build and maintain consensus to change (a process of ongoing improvement). In order to ensure successful company wide implementation of TOC, it is important to address the change management, system design, and project management aspects of the implementation process. Much has been written in the research literature on the concepts and benefits of TOC, while little attention has been given to the implementation aspects. To ensure successful implementation it is important that all members of the project implementation team are guided along a common implementation path. Another important aspect is the capturing and management of the knowledge surrounding the TOC implementation. This helps to ensure sustainable and ongoing use of the implemented TOC concepts, even when the consultants or TOC experts that drove the implementation have left the organisation.

Roadmaps supported by an information management software platform can be a valuable tool to aid in the successful implementation of management philosophies such as TOC. This paper discusses the use of roadmaps for guiding such implementation projects, as well as supporting the knowledge management and project or programme management requirements.

First, a brief overview of TOC as well as roadmaps is given. This is followed by a discussion on how roadmaps can assist in implementing and maintaining a TOC solution. Lastly, an example roadmap and software tool (called Eden™ ) for supporting TOC implementations will be discussed.

2 OVERVIEW OF THE THEORY OF CONSTRAINTS (TOC)
The Theory of Constraints (TOC) philosophy was developed by the Israeli physicist Eliyahu Goldratt and is grounded in the concepts of constraints and constraint management. The core premise of TOC is that any organisation or supply chain's performance is limited most by a "constraint" — the thing that most blocks throughput (or the rate at which the system generates money through sales). Identifying the nature and location of the system's constraint is the key to continuous system improvement [1]. The Theory of Constraints was first introduced by Goldratt in his book 'The Goal' (1986) as a logistical system for controlling a manufacturing plant [2]. This logistical system became known as Drum-Buffer-Rope (DBR). Gradually the focus of this concept moved from the production floor to encompass all aspects of business, and by 1987 the overall concept became known as the Theory of Constraints (TOC) [3]. This is viewed as an overall theory for running an organisation and consists of the so-called “five focusing steps” of continuous improvement (which are discussed in section 5 of this paper). Under this overall theory it is recognised...
that the main constraint in most organisations may not be physical, but rather related to management policies [4].

3 ROADMAPS

A roadmap as defined by Indutech (Pty) Ltd. is an interactive representation of a project/programme lifecycle that facilitates better understanding and execution of the project/programme, by using a structured methodology approach. The roadmap guides a team through the starting, planning, execution and closing phases of a project/programme, while ensuring the control and achievement of all the project/programme objectives. A roadmap therefore provides guidance to its users along a specific path (such as an implementation plan, a project life cycle, a product development life cycle, etc.), while supporting the capturing and dissemination of information and knowledge. A roadmap specifies what needs to be done, by whom, with what tools and techniques, how, and when it should be executed. Specifically, it provides:

- A means by which information and knowledge can be identified, captured and organised according to the relevant project/programme phases or steps.
- Easy access to captured knowledge and information resources.
- Communication and collaboration capabilities, that enables people to easily share and use information and knowledge.

The benefits of a roadmap methodology for a project management process are the following:

- Structured Approach: The Roadmap provides a structured, visual approach to the project management process. It contains a guiding structure that consists of high-level steps or phases that can be divided into sub-steps depending on the required level of detail. The structure is best presented by means of a graphical representation. The structure should contain a time component and represent the life cycle of the project/programme. This structure allows team members to visualise the entire project from the initiation as well as direct all efforts towards the project outcomes. New team members can also be quickly brought up to speed when joining the project after its initiation.

- Guidance: Guidance information such as, Definitions and Descriptions, Examples and Templates and Outputs are linked to the steps and sub-steps of the roadmap. The definitions and descriptions clearly define and describe the “what” and “how” that must be achieved in a step or sub-step. The Examples and Templates provide best practice information, or company policies and guidelines. The Outputs clearly define what outputs such as documents are required under each step of the project.

- Control: A roadmap contains checklists that provide an easy to use mechanism to monitor the progress of the steps and sub-steps of the project.

An example of a roadmap for the management of a project life cycle is provided in Figure 1.

![Example roadmap for a project life cycle](image)

**Figure 1.** Example roadmap for a project life cycle

This roadmap specifies the different phases of the project life cycle (from Conceptual to Closure), as well as the different steps and sub-steps under each phase. Linked to each phase, step, or sub-step is a definition and description describing the “what” and “how” that must be achieved under that step or sub-step; the output documents required for that step or sub-step; templates and guideline documents that will aid in executing that specific step or sub-step; as well as checklists for monitoring and control.

4 HOW ROADMAPS CAN ASSIST IN IMPLEMENTING AND MAINTAINING A TOC MANUFACTURING SOLUTION

According to [5], there are four elements for a successful, sustainable implementation of TOC:

1. Commitment and Leadership from Senior Management
2. A sound strategy for managing the change that will take place
3. A robust design of the new system
4. A commitment to ongoing improvement

Two of the main contributors to a successful TOC implementation are a good process design and a well-executed implementation process, which has to do with the management of change. It is of no use having a good idea or design, but not being able to successfully implement it. Managing the implementation project for a TOC manufacturing solution is one area where a roadmap methodology
can proof to be invaluable. A roadmap provides the following functionalities that will facilitate guiding and controlling the planning and execution of a TOC implementation project, as well as structuring the project knowledge within a project life cycle context:

1. Project step guidance - The roadmap structure is comprised of the different phases and steps of the TOC implementation plan. Guiding information such as step definitions and descriptions, document templates, and guidelines and policy documents are linked to the steps of the roadmap and thereby providing the relevant guiding information where required. Deliverables required per project step are also provided, as well as the different roles and responsibilities for each step. This ensures that everyone involved with the TOC implementation project know what to do during each step of the implementation process, as well as how to do it. People therefore know where they are going with the implementation, which helps to get and maintain organisational commitment.

2. Control through checklists - Checklists are comprised of the required tasks for a step or sub-step and fulfill the purpose of both a step or sub-step review and a progress indicator. As deliverables are produced and tasks completed, checklist items can be ticked off. This is useful for auditing and control to monitor what has been accomplished within a specific project step.

3. Capturing and dissemination of knowledge - The project roadmap structure serves as the categorisation structure for storing and managing all project related information and knowledge in context. All documents produced during project execution (such as new or updated policy documents) can be captured within the relevant area of the roadmap. In this way a complete history of the TOC implementation project is kept. Knowledge regarding the implementation is therefore captured and kept within the organisation.

This is important, since many times a TOC implementation is conducted by an external consultant (or consultants). When the implementation is over, all the implementation knowledge leaves with the consultant. In order to ensure sustainability of the implementation, it is important that the knowledge regarding the implementation is kept within the organisation. In the future when improvements are made to the implemented TOC solution, the organisation can go back to the knowledge captured during implementation and see why certain decisions were made or processes configured in specific ways. All policies and procedures developed are kept within context of the implementation roadmap, which makes it easier to reference these policies in the future when making new improvements. Sometimes changes in management can also kill implementations. The new person does not understand the system, and returns to the conventional way. Knowledge surrounding the TOC implementation captured within the roadmap structure, will help the new management team to quickly gain an understanding of the new TOC system.

4. Training – A roadmap populated with the new policies and procedures developed during the TOC implementation, facilitates teaching the organisation how the new system works.

5 ROADMAP DEVELOPED FOR TOC MANUFACTURING IMPLEMENTATION

A roadmap for implementing Theory of Constraints in manufacturing organisations was developed with a software tool called Eden™.

Eden™ facilitates the building and display of roadmaps in an interactive fashion, and also provides document management and searching functionalities in order to better support the capturing and management of knowledge surrounding the project.

![Figure 2. TOC implementation roadmap](image-url)
The roadmap built is based on the implementation plan described by [5]. The graphical view of the implementation roadmap is displayed in Figure 2. This roadmap guides the organisation through the following implementation phases:

- **Project initiation and launch** - The start-up phase where commitment is obtained to implement the project.
- **Assessment of the current system** - To understand the current order fulfilment and planning processes and have the constraint(s) identified.
- **System design** - Define the to-be state of the order fulfilment and planning process.
- **Implementation** - Involves the detailed design and implementation of the new order fulfilment system and planning processes based on the TOC philosophy and its production control system called drum-buffer-rope.
- **Organisational alignment** - Involves aligning the internal functions of the business to the constraint.

Figure 3 shows this roadmap in a tree structure format within the Eden™ software. On the top right hand area of the Eden™ interface is the process definition area defining and describing each of the roadmap steps. Information such as outputs or deliverables for the step, as well as roles and responsibilities can also be defined in this area. Below the definition and description area is the additional information area.

This area contains documents that support the user in completing the step. Typical documents that are stored in this area are examples, templates, guidelines, and company policies.

By clicking the checklist icon from the toolbar, the user is provided with a checklist that has been set up for every step. This checklist provides the user with a high level list of those items already completed, and those still outstanding. This also gives the team high level control of the progress that has been made on a step.

The areas described above combine to provide the user with a roadmap to completing a TOC implementation project. The roadmap within the Eden™ environment gives structure to the project or change process, providing a framework within which to produce innovative solutions and capture implementation knowledge.

On the bottom right of the Eden™ interface is the User Data and Document Management Section. The document management system in Eden™ assists the users to control the specific documentation of a project. The system includes document version control, a document audit trail, and a functionality to capture document Meta Data.

This area is specific to every step. In this area the user can create folders and assign security rights to the respective folders allowing the company to selectively provide users with documents within these folders.

![Figure 3. TOC implementation roadmap in Eden](image-url)
The User Data Section serves as a pigeonhole for storing and managing user documents. These documents are therefore grouped and linked to a specific project step.

In order to support continuous improvements to the organisation, a continuous improvement roadmap was also built based on the five focusing steps of continuous improvement of the TOC philosophy [6]:

- **Step 1. Identify the system’s constraints.** The first step is to identify the constraint in the system that limits throughput or progress toward the goal. Tools and techniques that can be used to help with the identification of the constraint or bottleneck can be defined and described in the roadmap. Reasons for the identification or selection of the specific constraint can also be captured in the improvement roadmap, which is useful for future reference and obtaining organisational alignment to the constraint.

- **Step 2. Decide how to exploit the constraint(s).** Decide on a plan for the primary constraint that best supports the system’s goal. This requires taking advantage of the existing capacity at the constraint, which is often wasted by making and selling the wrong products, and by improper policies and procedures for scheduling and controlling the constraint. The plans made for exploiting the constraint should be documented and stored within the context of the improvement roadmap.

- **Step 3. Subordinate everything else to the above decisions.** Alter or manage the system’s policies, processes, and/or other resources to support the above decisions. The new policies should be documented and captured within the improvement roadmap.

- **Step 4. Elevate the constraint(s).** Add capacity or otherwise change the status of the original resources as the dominating primary constraint. In this step, additional capacity is obtained that will increase (elevate) the overall output of the constraining task or activity. This differs from step 2 in that the added output comes from additional purchased capacity, such as buying a second machine, tool, or implementing new technology. Again the decisions made for elevating the constraint should be documented and stored within the improvement roadmap.

- **Step 5. Return to step 1.** Don’t let inertia become the new constraint - go back to step 1, but do not allow previous decisions made in steps 2 to 4 to become constraints. As a result of the focusing process, the improvement of the original constraining task or activity may cause a different task to become a constraining task or activity. Inertia could blind management to additional steps necessary to improve the system’s output now limited by a new constraint.

Management directs its efforts toward improving the performance of the constraining task or activity and any other task or activity that directly affects the constraining task or activity. Guidelines for effectively subordinating to the constraint can also be made available in the roadmap, thereby supporting or guiding the improvement team in the subordination effort.

The continuous improvement roadmap as developed in Eden™ is displayed in Figure 4. A continuous improvement roadmap template can be set up containing all the generic guiding information and tools and techniques for supporting and guiding the improvement process.

![Image](Figure 4. TOC continuous improvement roadmap in Eden)
Each time a new improvement cycle is started, a copy or instance of the improvement roadmap can be made. All the knowledge gained from improvement process can then be captured within this specific improvement roadmap.

In this way an improvement knowledge history or library can be developed consisting of all previous improvement cycles, which can be used as a knowledge reference for future improvement cycles.

6 CONCLUSIONS

This paper presented a roadmap methodology for guiding TOC implementations and improvement projects in manufacturing organisations, as well as capturing and managing the knowledge surrounding implementations and improvements. The first roadmap presented guides a team through the implementation process of TOC in a manufacturing organisation. It consists of the planning structure for the implementation process, with guiding information linked to the implementation steps. This ensures that everyone involved with the TOC implementation project know what to do during each step of the implementation process, as well as how to do it. People therefore know where they are going with the implementation, which helps to get and maintain organisational commitment. It also ensures a more structured and focused implementation process, as well as better control because of the visibility of the whole process. Knowledge in the form of documentation (such as new policies and procedures) can also be captured within the roadmap, which is useful for future reference when making improvements to the implemented system. Capturing the implementation knowledge within a roadmap helps to keep the knowledge within the organisation. This ensures that implementations go on after the consultants have left the organisation, and supports maintaining the TOC solution. Furthermore it better safeguards against killed implementations caused by management changes, since new individuals or teams can use the knowledge captured in the roadmap structure to quickly gain an understanding of the TOC system.

The improvement roadmap presented (based on the five focusing steps of TOC) supports continuous improvements in the organisation. Knowledge from such improvements is captured within the roadmap, which serves as a useful reference for future improvement projects. Specifically all policy and procedure changes are documented and stored, which makes it easier to identify policy constraints during future improvement cycles. Furthermore guidance information contained in the improvement roadmap guides a team through the improvement process.

A roadmap methodology therefore helps to provide a plan or map for making the transition from where the organisation is today to where it will be in the future. Having the necessary documentation of the future state is critical to get people to buy in to the new TOC system. A roadmap methodology supports an organisation in managing this information, as well as effectively executing the transition plan.

7 REFERENCES


8 BIOGRAPHY

Prof. Niek du Preez is Chairman at the Stellenbosch-University Industrial Engineering Department. He is also Chief Executive Officer of Indutech.

Louis Louw holds a B.Eng (Industrial) degree, as well as a Ph.D in industrial engineering from the University of Stellenbosch. He is currently working for Indutech (Pty) Ltd (South Africa).