Systematic Innovation in a Lean Management Context

Helena V. G. Navas
E-mail: hvgn@fct.unl.pt
UNIDEMI, Departamento de Engenharia Mecânica e Industrial,
Faculdade de Ciências e Tecnologia, FCT, Universidade Nova de Lisboa, Portugal

V. Cruz Machado
E-mail: vcm@fct.unl.pt
UNIDEMI, Departamento de Engenharia Mecânica e Industrial,
Faculdade de Ciências e Tecnologia, FCT, Universidade Nova de Lisboa, Portugal

Abstract:
The lean implementation environment requires advanced analytical tools and methodologies (ex. VSM and A3), but there is not much work done on tools for generation of solutions.
TRIZ systematizes solutions that can be used for different technical fields and activities. The inconsistencies are eliminated by modification of the entire system or by modification of one or more subsystems.
This paper intends to propose a conceptual model that explores the relationships between LEAN and TRIZ practices and methodologies. As a potential solution generator, the authors believe that the use of TRIZ may help to promote improved Lean management environments.

Keywords: Lean Management, Problem Solving, Systematic Innovation, TRIZ.

1. Introduction

Lean Philosophy is a systematized approach for continual improvement. Its extent is a methodical search of process improvement through reduction of wastes and inefficiencies. Lean can be applied to all areas of enterprise and it supposes improvement of efficiency and effectiveness.
Lean has been adopted in a large number of companies from different industry sectors; it has moved away from being merely a “shop-floor focus” on waste and cost reduction to

an approach that consistently drives to increase value for customers by adding product or service features and removing wasteful activities (Machado et al., 2008).

Lean Production is focused in the value stream that originates the product, aiming at maximizing value and eliminating Muda (waste in Japanese), optimizing the whole and not just parts of the process.

The idea is that the value should flow continuously all over the organization, to reach the costumer as quick as possible. A lean thinking environment requires a “learning to see” approach, in order to find obstacles (waste) to be removed; this means that it is vital to research a problem solving methodology which improves the value stream.

Lean Thinking includes all employees and requires significant changes in their attitudes and professional behavior. Lean has a profound effect on both the organization and people that make up the organization.

2 Innovation in Lean with TRIZ

Systematic innovation is crucial for increasing organizational effectiveness, enhancing competitiveness and profitability. The Lean management philosophy depends on the creation of systematic innovative solutions to improve processes.

At the start of Lean implementation, the vast majority of improvements can be achieved by simple solutions. While Lean implementation process moves forward, it depends more and more on the really innovative solutions and radical changes.

Traditional engineering and management practices can become insufficient and inefficient for the implementation of new scientific principles or for radical improvements of existing systems. Traditional way of technical and management contradictions solving is through search of possible compromise between contradicting factors, whereas the Theory of Inventive Problem Solving (TRIZ) aims to remove contradictions and to remove compromises.

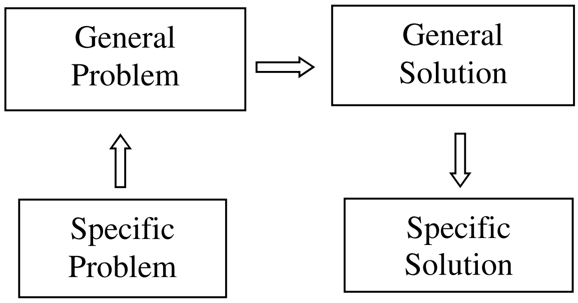
Traditional Lean tools are Value Stream Mapping, Quick Changeover/Setup Reduction, Single Minute Exchange of Dies (SMED), Kaizen, Flow Manufacturing, Visual Workplace/5S Good Housekeeping, Total Productive Maintenance (TPM) and Pull/Kanban Systems (Ikovenko et al., 2004).

The TRIZ method consists of a set of different tools that can be used together or apart for problem solving and failure analysis. There are many techniques and concepts within Lean where TRIZ might be applied (Campbell, 2004).

Generally, the TRIZ's problem solving process is to define a specific problem, formalize it, identify the contradictions, find examples of how others have solved the contradiction or utilized the principles, and finally, apply those general solutions to the particular problem.

Figure 1 shows the steps of the TRIZ's problem solving.

Figure 1 – Steps of the TRIZ's algorithm for problem solving



(Radeka K., 2007)

It is important to identify and to understand the contradiction that is causing the problem as soon as possible. TRIZ can help to identify contradictions and to formalize problems to be solved. The identification and the formalizing of problems is one of the most important and difficult tasks, with numerous impediments. The situation is often obscured.

The problem can be generalized by selecting one of the TRIZ problem solving tools. The generic solutions available within TRIZ can be of great benefit at choosing of corrective actions.

3 TRIZ Plus Approach for Lean Philosophy

The merger of Value Engineering Analysis (VEA), Root-Cause Analysis (RCA), Flow Analysis (FA) and several other engineering analytical methods with TRIZ originated several integrated methodologies based on TRIZ: ITD, TRIZ Plus, I-TRIZ.

The integrated methods combine the analytical tools with the inventive ability of TRIZ, so they present real advantages, specially integrated on applications with organizational methods like Lean.

There are several key principles for successful application of Lean techniques into a business environment (Womack et al., 1996):

— value;
— value stream;
— flow;
— pull;
— perfection.

The approach to value in TRIZ Plus has the same objective as Lean Value Principle: to determine the value of different operations of the process or components of the product. The traditional Lean seven types of Muda are:

— overproduction;
— inventory;
— extra processing steps;
— motion;
— defects;
— waiting;
— transportation.

Table 1 shows the comparison between the approach to value in TRIZ Plus and Lean Value Principle.

Table 1 – Approach to value in TRIZ Plus and Lean Value Principle

Lean	*TRIZ Plus*
Overproduction	*Excessive functions*
Inventory	*Corrective functions*
Extra processing steps	*Providing & corrective functions*
Motion	*Providing & corrective functions*
Defects	*Insufficient, excessive or harmful functions*
Waiting	*Insufficient functions*
Transportation	*Providing functions*

(Ikovenko et al., 2004)

After the value has been specified, the next step is to identify the value stream.
Table 2 shows TRIZ Plus tools that can be used in the approach to the value stream and the Lean Value Stream Principle.

Table 2 – Approach to value stream in TRIZ Plus and Lean Value Stream Principle

Lean	*TRIZ Plus*
Value Stream Map (current)	*Function Model of the Process*
Value Stream Map (future)	*Trimming, Cause-Effect Chain Analysis*
Value Stream Map (internal)	*Function Model of the Process*
Value Stream Map (internal)	*Function Model of the Supersytem*
Product Family Matrix	*Function Models of separate product lines*

(Ikovenko et al., 2004)

Flow is defined as a fabrication process from raw material to final product without interruption or delay.

The key tools for Flow implementation are (Ikovenko et al., 2004):

— “Takt Time”;
— Standardized Work;
— 5S;
— Work Balancing;
— Leveled Production.

Table 3 shows Lean Flow tools and TRIZ Plus tools.

Table 3 – Approach to flow in TRIZ Plus and Lean Flow Principle tools

Lean	*TRIZ Plus*
“Takt Time”	*Rhythm Coordination approach*
Standardized Work: What, Who, How	*Inventive Principles, Standard Solutions*
5 S	*Transition to Supersystem, Trimming, Standard Solutions (class 4)*
Work Balancing	*Function model , function re-allocation, new function architecture*
Leveled Production	*Transition to the Supersystem (different mechanisms), Trimming*

(Ikovenko et al., 2004)

The Pull Principle identifies the need to be able to deliver the product to the customer as soon as he needs it.

Table 4 shows Lean Pull (the Kanban) tools and TRIZ Plus tools.

Table 4 – Approach to pull in TRIZ Plus and Lean Pull Principle (the Kanban) tools

Lean	*TRIZ Plus*
Production/Instruction Kanban	*Inventive Principles, Standard Solution (class 4), Trimming*
Withdrawal Kanban	*Inventive Principles, Standard Solution (class 4), Trimming*

(Ikovenko et al., 2004)

The TRIZ tools cannot be applied directly to Perfection Principle, however some Inventive Principles and Standard Solutions are appropriate here (Ikovenko et al., 2004). The implementation and deployment of Lean Thinking in organizations will be more sustainable if the Lean approach be supported by a set of TRIZ Plus tools.

TRIZ can support Lean product development by strengthening a team's ability to leverage and reuse knowledge across the enterprise and pull in knowledge from other companies and industries.

4 TRIZ's Substance-Field Analysis in Lean Environment

Substance-Field Analysis is a useful tool for identifying problems in a technical system and finding innovative solutions to these identified problems. Recognized as one of the most valuable contributions of TRIZ, Substance-Field Analysis is able to model a system in a simple graphical approach, to identify problems and also to offer standard solutions for system improvement (Mao et al., 2007).

There are mainly five types of relationships among the substances: useful impact, harmful impact, excessive impact, insufficient impact and transformation (Savransky et al., 2000). Substance-Field Analysis has 76 standard solutions categorized into five classes (Terninko et al., 2007):

— Class 1: Construct or destroy a substance-field (13 standard solutions);

— Class 2: Develop a substance-field (23 standard solutions);

— Class 3: Transition from a base system to a super-system or to a subsystem (6 standard solutions);

— Class 4: Measure or detect anything within a technical system (17 standard solutions);

— Class 5: Introduce substances or fields into a technical system (17 standard solutions).

These 76 solutions can be condensed and generalized into seven standard solutions (Mao et al., 2007):

— General Solution 1: Complete an incomplete Substance-Field Model;

— General Solution 2: Modify substance S_2 to eliminate or reduce harmful impact;

— General Solution 3: Modify S_1 to be insensitive or less sensitive to harmful Impact;

— General Solution 4: Change existing field to reduce or eliminate harmful impact;

— General Solution 5: Eliminate, neutralize or isolate harmful impact using another counteractive field F_x;

— General Solution 6: Introduce a positive field;

— General Solution 7: Expand existing Substance-Field Model to a chain.

General Solution 1: Complete an Incomplete Substance-Field Model

The Substance-Field Model is incomplete if any of its three components is missing.

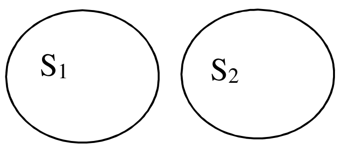
Lean Thinking reveals a lot of situations like this in industrial activities.

The General Solution 1 can be very useful to find and to solve problematical situations like this.

For example, an operation batch contains some pieces with characteristics out of specifications.

Figure 2 shows the problem (Problematic Situation 1 - Incomplete Model).

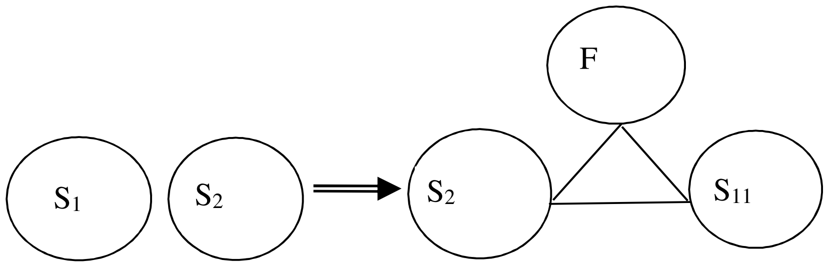
Figure 2 – Problematic Situation 1 - incomplete model



The Substance-Field Model is incomplete, a field is missing. The problem corresponds to Problematic Situation 1 and can be solved resorting to General Solution 1.

Figure 3 shows the solution.

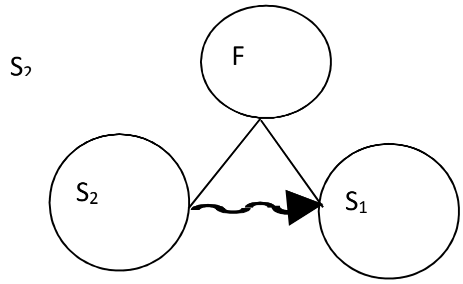
Figure 3 – General Solution 1 for Problematic Situation 1



The possible specific solution is to inspect pieces before the operation, putting aside faulty components from acceptable ones. Then the model becomes complete.

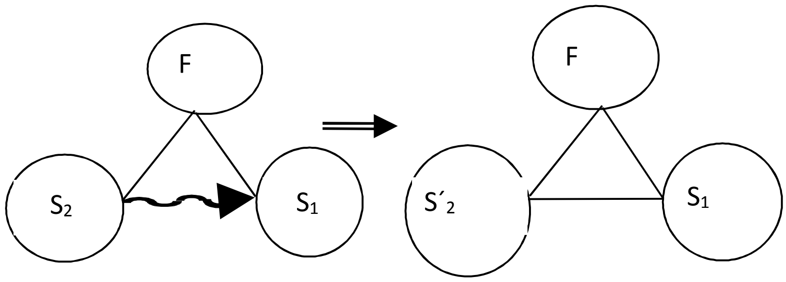
General Solution 2: Modify substance S_2 to eliminate or reduce harmful impact
Lean activities often identify situations with harmful or undesirable interactions between the substances. The General Solution 2 can be very useful to find and to solve problematical situations like this. The characteristics (physical, chemical and/or other) of substance S_2 are changed in order to eliminate or reduce harmful impact. The changes can be internal and/or external, can be temporary or permanent. The modification can change substance S_2 into another form, material or system. Sometimes it is necessary to add new elements (additives) to the system in modification.
For example, a machine-tool fixture used for certain fabrication operation is damaging the lateral surfaces of the worked piece.
Figure 4 shows the problem (Problematic Situation 2 - Harmful Interactions between the Substances).

Figure 4 – Problematic Situation 2 - harmful interactions between the substances



The Substance-Field Model is complete however the interaction between the substances is harmful. The problem corresponds to Problematic Situation 2 and can be solved resorting to General Solution 2.
Figure 5 shows the general solution.

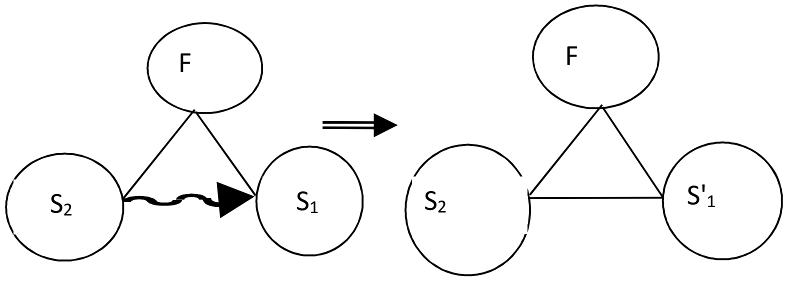
Figure 5 – General Solution 2 for Problematic Situation 2



The possible specific solution is to use another machine-tool fixture system or to modify the actual fixture in order to eliminate or reduce damages at the lateral surfaces of the workpiece. Then the harmful interaction is reduced or eliminated.

General Solution 3: Modify S_1 to be Insensitive or Less Sensitive to Harmful Impact
The problematic situation is the same (see Figure 4).
General Solution 3 is similar to General Solution 2, but instead of substance S_2 modification, the substance S_1 is modified. The characteristics (physical, chemical and/or other) of substance S_1 are changed in order to become it less sensitive or insensitive to a harmful impact. The changes can be internal and/or external, can be temporary or permanent.
The physical and/or chemical characteristics of substance S_1 may be altered internally or externally, so that it becomes less sensitive or insensitive to a harmful impact, as seen in Figure 4. The modification may be either temporary or permanent. Additives may be needed in the modification.
Figure 6 shows the general solution.

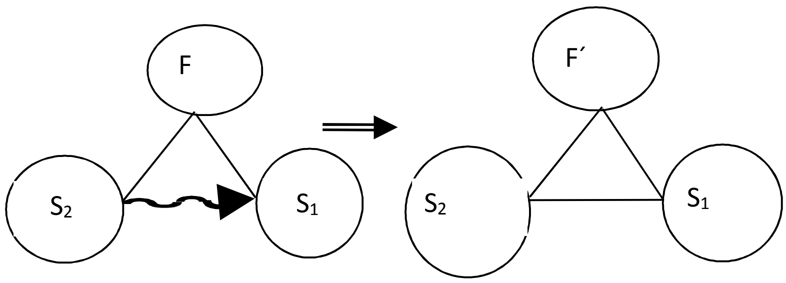
Figure 6 – General Solution 3 for Problematic Situation 2



The possible specific solution is to create protection for the lateral surfaces of the worked piece. Then the harmful interaction is reduced or eliminated.

General Solution 4: Change Existing Field to Reduce or Eliminate Harmful Impact
The problematic situation is the same (see Figure 4).
General Solution 4 is similar to General Solutions 2 and 3, but instead of substances modification, the field F is modified.
Changing the existing field while keeping the same substances may be a choice to reduce or removing the harmful impact. The existing field can be increased, decreasing, or completely removed and replaced by another one.
Figure 7 shows the general solution.

Figure 7 – General Solution 4 for Problematic Situation 2

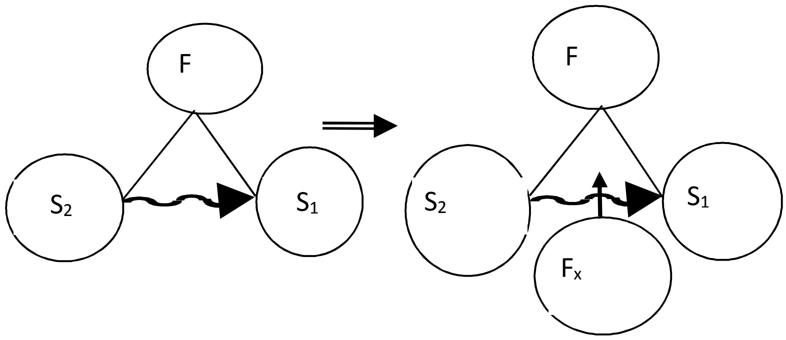


The possible specific solution is to change the technological process and its operations keeping the same substances in order to reduce or eliminate the harmful interactions.

General Solution 5: Eliminate, Neutralize or Isolate Harmful Impact Using Another Counteractive Field F_x
The problematic situation is the same (see Figure 4).

General Solution 5 presupposes introduction of a counteractive field F_X in order to remove, neutralize or isolate the harmful impact. The substances S_2 and S_1 and the field F will not change its characteristics in this solution.
Figure 8 shows the general solution.

Figure 8 – General Solution 5 for Problematic Situation 2



For example, a technological operation is creating significant superficial tensions in worked pieces. The possible specific solution is to introduce a tempering operation (heat treatment) in order to reduce the superficial tensions.

5 Conclusion

Lean Thinking is a highly evolved method of management and organization that aims to improve the productivity, efficiency and quality of products and services. Lean Philosophy focuses on streamlined work process without delays, with maximized production, minimized nomenclature and bureaucratic proceedings.
The current lean approach is to use sensitivity analysis to try to find the best compromise. The TRIZ approach is to find out how to avoid the compromise or trade off (Campbell, 2004). While TRIZ tends to focus more often on smaller problems, lean is used more for systems level examination (Bligh, 2006).
TRIZ and Lean Thinking are both ways of improving the operation of a system. Both TRIZ and Lean look to optimize the use of available resources. TRIZ focuses on individual elements to optimize, where lean takes in the entire system to find potential efficiencies.
TRIZ could be useful to find solutions that utilize available resources currently seen as waste (“muda” in Lean) (Bligh, 2006).

Acknowledgments

The present authors would like to thank the Faculty of Science and Technology of The New University of Lisbon (UNL) and the Portuguese Foundation for Science and Technology (FCT), under grants Strategic Project nº PEst-OE/EME/UI0667/2011, for the work carried out in the framework of the research centre UNIDEMI.

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Curriculum Vitae:

Helena V. G. Navas é Professora do Departamento de Engenharia Mecânica e Industrial da Faculdade de Ciências e Tecnologia da Universidade Nova de Lisboa e Investigadora do UNIDEMI - Unidade de Investigação e Desenvolvimento em Engenharia Mecânica e Industrial. É consultora e formadora em Inovação Sistemática e TRIZ, Membro da *International Executive Board* da ETRIA (*European TRIZ Association*) no mandato 2011-2012, *Chair of 12th ETRIA TRIZ Future Conference 2012*.

V. Cruz Machado é Professor Catedrático, Presidente do Departamento de Engenharia Mecânica e Industrial da Faculdade de Ciências e Tecnologia da Universidade Nova de Lisboa, Coordenador do UNIDEMI - Unidade de Investigação e Desenvolvimento em Engenharia Mecânica e Industrial, Presidente do IPEI - Instituto Português de Engenharia Industrial. É investigador, consultor e formador em Lean, *Lean thinking & philosophy, Lean Management, Lean Supply Chain Management, Lean & Green Systems, Strategy deployment & Honshi* Kanri.

Authors Profiles:

Helena V. G. Navas is Professor of Department of Mechanical and Industrial Engineering, Faculty of Science and Technology, New University of Lisbon and Researcher in UNIDEMI - Unit for Research and Development in Mechanical and Industrial Engineering. She is a consultant and trainer in Systematic Innovation and TRIZ, Member of the International Executive Board of ETRIA (European TRIZ Association) from 2011 to 2012, Chair of 12th ETRIA TRIZ Future Conference 2012.

V. Cruz Machado is Full Professor, President of the Department of Mechanical and Industrial Engineering, Faculty of Science and Technology, New University of Lisbon, Coordinator of UNIDEMI - Unit for Research and Development in Mechanical and Industrial Engineering, President of IPEI - Portuguese Institute of Industrial Engineering. He is researcher, consultant and trainer in Lean, Lean thinking & philosophy, Lean Management, Lean Supply Chain Management, Lean & Green Systems, Strategy Deployment & Honshi Kanri.