Quantum Lean: The Next Step in Lean Systems

Sean Fields, Michael Sanders

Quantum Lean: The Next Step in Lean Systems

Sean Fields, P.E.[1] and Dr. Michael Sanders, Ph.D.[2]

[1] BeehiveFund (a non-profit 501c3 corporation), The Woodlands, TX 77380, USA
[1]s.fields@beehivefund.org, [2]michael@beehivefund.org

Abstract. Based on the Toyota Production System (TPS) business model, Lean Systems were popularized in the 1990s and have helped many businesses achieve significant gains in profitability and competitiveness. Despite this, a majority of organizations that attempt to adopt this system fail to do so. One reason this can occur is an inability to adapt lean principles to specific environments. To address this problem, alternative methods like Scrum, Agile, and Quick Response Manufacturing (QRM) were developed. As a further advance to lean approaches, an alternative system called "Quantum Lean" (QL) was developed to build on the work of lean innovators and apply continuous improvement to lean systems. Compared to other lean approaches, QL offers a combination of greater simplicity, efficiency, speed, and comprehensiveness. The key to this system is a framework that is:

Time-Focused – Instead of addressing waste like traditional lean does, QL attacks time. This results in much greater simplicity by leveraging the fact that time is the fuel that feeds all waste. Instead of attacking waste in its 8 forms, addressing time is simpler.

Product-Centric – Instead of tracking time from the view of the customer/resource/owner, time is tracked and measured from the standpoint of the product and only the product. Relentlessly maintaining this framework assures consistency in conclusions and reduces the conflicting objectives (e.g., owner vs. employee vs. customer) that come with other continuous improvement approaches.

Simple and Comprehensive – QL employs a comprehensive and structured analytic methods including Product Path Diagramming (PPD). Compared to other methods like Value Stream Mapping (Traditional Lean) or Manufacturing Critical-Path Time Mapping (QRM), PPD offers greater simplicity, refined prioritization, and/or an improved ability to identify and minimize every waste and contributor to time-in-fulfillment.

Although there are additional benefits, QL's simplicity is arguably its greatest virtue and makes additional advantages possible.

Keywords: Lean, Lean Systems, Lean Manufacturing, Quick Response Manufacturing, QRM, Quantum Lean, Continuous Improvement, Value Stream Mapping, VSM, Manufacturing Critical-Path Time Mapping, MCT, Product Path Diagramming, PPD, Operational Excellence

1 Introduction to Lean Systems[1]

Due to global competition, many Western companies were investigating ways to preserve markets against low-cost countries. As a result of this, one of the movements that sustained was lean systems. Lean is an approach that's based on Toyota's business techniques (aka "Toyota Production System" (TPS)). It includes a variety of methods to achieve quality, efficiency, and quick delivery and has been deployed at many companies to great effect. It's been so successful that these techniques have been extended to services and government.

Although Henry Ford and the Japanese pioneered lean ideas, the term "lean production" was popularized by James Womack, Daniel Jones, and Daniel Roos in their 1990 book "The Machine That Changed the World". In this work, the authors articulated the methods that the Japanese used to achieve dominance in the auto industry. From there, Womack and Jones published a book called "Lean Thinking" that propounded the principles of what is known as "Lean Systems"[1].

From this point, businesses worldwide started implementing the concepts. At the same time, practitioners developed variations with the goal of addressing lean deficiencies and improving results. One example of this is Quick Response Manufacturing (QRM), which is rooted in the concept of time-based competition pioneered by the Japanese in the 1980's and first formulated by George Stalk, Jr.[2] To expand and clarify QL principles, QL will be compared and contrasted with traditional lean systems and QRM.

2 Overview of Lean Systems, Quick Response Manufacturing, and Quantum Lean

2.1 Traditional Lean (TL)[1]

While lean deployments sometimes depart from the ideas originally espoused by Womack and company, there are common principles and practices that are common to typical lean programs:

- Value-Centric – According to the book "Lean Thinking", value is defined as "the capability provided to customer at the right time at an appropriate price, as defined in each case by the customer". This idea of value is the starting point for many lean efforts.
- Precepts - According to the book "Lean Thinking", the precepts of lean are:

- Identifying Value Streams – The actions required to bring a product from concept to completion are documented. Often, a flowcharting technique called Value Stream Mapping (VSM) is used to identify activities and wastes. 26+ symbols are used to distinguish the different types if activities, events, and elements.
- Waste-Based Analysis – After the value stream is identified, **a**ctivities are typically characterized as value-added (activities that clearly create value) and non-value added (activities that clearly create no value). Non-value added work is also called "waste". To aid in identifying inefficiencies, waste is often classified according to the following 8 categories (aka, "8 Wastes"):
  - People – Not realizing the full potential of a workforce's talent, skills, and knowledge
  - Motion – Unnecessary people movements
  - Transportation – Material and product movement
  - Defects – Efforts as a result of scrap, rework, and non-conformity
  - Overprocessing – Unnecessary or non-value added processes
  - Overproduction – Manufacture of product that is not needed
  - Inventory – Excess product and material not being processed
  - Waiting – Delay in waiting for the next step of a process
- Establishing Flow – A state where the product is fulfilled with no stoppages, scrap or backflows
- Pull – Product fulfillment only initiates at the request of a customer
- Perfection – The pursuit of complete waste elimination.

2.2 Quick Response Manufacturing (QRM)[2]

As part of lean's refinement, other systems were developed to widen lean's applicability and to simplify the improvement process. One example of this is Quick Response Manufacturing (QRM). Key principles and practices of this approach include:

- Time-Focus – Quick Response Manufacturing (QRM) emphasizes the reduction of internal and external lead times to achieve sustainable competitive advantage.
- Time-Based Analysis – Activities are evaluated based on their effect on lead time. In addition, unique metrics are used to track performance.
- Manufacturing Critical-Path Time (MCT) Mapping – To help determine where improvement is needed, MCT Maps are used to define when a product is being processed and when it is waiting.
- Points of Emphasis – Frequently, QRM's points of emphasis include:
  - QRM Mindset – Instilling an understanding of the link between waste and lead time along with the creation and training of a steering committee to select and guide implementation projects.

- Organization – QRM emphasizes the establishment of QRM Cells for "Focused Target Market Segments" where products with shorter lead times can yield significant market benefits. QRM Cells use cellular production principles to expedite the production of these items.
- System Dynamics – An emphasis on system dynamics (e.g. queueing theory) to guide lead reduction efforts.

2.3 Quantum Lean (QL)[3]

To simplify the improvement process and widen lean's applicability, Quantum Lean was developed to make lean more accessible to beginners and to address incompatibilities between conventional techniques and environments that aren't mass-production. As one example of mismatched settings, there is a high probability that a VSM will fail to identify significant wastes in environments like job-shops, offices, and services. After several implementations where such a situation occurred, QL's originators concluded that a new angle was essential and developed an alternative approach to lean systems. It is easy to learn, prioritizes opportunities, and indicates corresponding solutions. As an additional advantage, it can be used in any business environment including mass production, job shops, and services.

QL Approach - Quantum Lean documents a product's in fulfillment by capturing the actions, events, and occurrences that a product undergoes. To facilitate analysis and prioritization, the time that constitutes these activities and events are classified as conversion, non-conversion, and delay and are defined as:

- Conversion – When the product is being transformed by a resource into a configuration that is closer to finished form.
- Non-Conversion - When the product is being processed by a resource but is not brought closer to the finished form. For simplicity, QL limits this category to moving, handling, rework, and inspection.
- Delay – When no man, machine, or any other resource is expending effort on the product.

The QL symbols look like the following (See Figure 1):

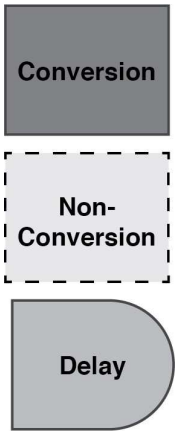

Fig. 1. Quantum Lean Diagramming Symbols

An additional and critical provision of QL is all time is strictly tracked from the standpoint of the product, and only the product. For example, if a worker spends 10 minutes finding tools, QL characterizes this as a delay for the product instead of as a non-conversion time due to a worker's excess motion.

Once the activities that comprise a product's time in fulfillment are documented and defined, QL prioritizes the activities for improvement based on the category (delay, conversion, non-conversion) that occupies the plurality of a product's time. On an assembly line where delay and non-conversion are insignificant, the first concern will be streamlining conversion activities. In a typical job shop, the priority will be minimizing delays.

From this point, each event/occurrence that falls within the prioritized category is analyzed using QL heuristics to pinpoint causes of excess time and identify solutions to eliminate or minimize it. By addressing these factors in this manner, inefficiencies are addressed without the need to identify particular wastes (i.e. "the 8 wastes").

Over time, the QL system targets and streamlines every aspect and stage of an organization's fulfillment. In addition, QL can be applied to any type of organization including mass production, job shops, offices, and services.

Overall, QL offers a simplified, comprehensive, and thorough system for systematically eliminating inefficiency in ways that other systems don't. This point will be elaborated on in the following sections comparing and contrasting QL against other approaches.

3 Comparison of Quantum Lean (QL) to Other Lean Systems

While all lean systems share a goal of minimizing time in fulfillment, each school of thought deploys different frameworks, strategies, and methods. This section compares and contrasts QL's approach with QRM and TL and will illustrate key differences with an example of each approach's analytic methods (VSM, MCT, and PPD).

3.1 Comparison of Quantum Lean (QL) to Traditional Lean (TL)

Major differences between Quantum Lean (QL) and Traditional Lean (TL) include:

- Waste-based vs. Time-Based – As a way to minimize time in fulfillment, a major precept of TL is that flow and pull need to be established. However, TL lacks an accessible and systematic framework to achieve this. For this reason, many TL implementations deemphasize flow/pull and focus on waste-reduction. Although this can be effective in mass-production environments where flow/pull is already established, a major opportunity for increasing efficiency through increased flow can be lost in other environments like job-shops, offices, and service entities.

  QL's time-based technique avoids this pitfall by providing a systematic and accessible way to maximize flow for any organization that has not yet achieved flow. In addition, QL provides a mechanism for systematically eliminating waste once flow has been established.

- Multiple Frames of Reference vs. Product-Centricity – In the field, TL implementations often use the 8 waste framework to classify activities and this approach lacks a consistent frame of reference. This results in activities being analyzed from a variety of viewpoints that include:
  - Resource – Examples include reducing labor costs, increasing resource utilization, and decreasing equipment usage (e.g. forklift travel).
  - Customer – Examples include increasing on-time delivery and customer satisfaction.
  - Money – Examples include increasing profitability, inventory turns, decreasing capital costs, and minimizing supply usage.
  - Organization – Example would include increasing market share

- When a variety of viewpoints are used, contradictory results occur. QL achieves consistent results by strictly maintaining a product-centric framework when analyzing time-in-fulfillment, prioritizing targets, and determining improvements.

Practically, these differences between TL and QL manifest themselves in the following ways:

TL is complicated compared to QL – Although the principles are simple, traditional lean methods are complicated and workforces are frequently slow to understand them. For example, Value Stream Mapping (VSM) utilizes 26+ symbols. In addition, the concept of 8 wastes further complicates implementation.

As many find it difficult to internalize waste-centric and value-centric frameworks, shortcuts are often taken and can manifest themselves into insignificant pursuits like minimizing travel or take the form of a tool-obsession where a lean tool like Kanban is adopted whether or not it is really needed.

TL is prone to inconsistent conclusions – Everyone is familiar with the idea of value. At the same time, no two opinions on it are alike. No matter how carefully value is explained, preconceived notions tend to override the most precise definition. This often results in difficulties with harmonizing stakeholders. As sound analysis requires a consistent frame of reference, this key requirement can't be met due to value's ambiguity.

In addition to value-driven contradictions, waste-based techniques compound the confusion with a constantly shifting framework. Depending on the waste, the frame of reference can center on a product (overproduction, transportation, inventory), people (motion, waiting), both people and product (defects, overprocessing), or an organization (people).

When frames of reference shift, this leads to conflicting objectives and decisions. A classic example of this is a buyer awarding a contract to a low bidder and causing production costs to skyrocket due to poor part quality. While the buyer made an optimal decision in a purchasing-centric framework, his conclusions are otherwise faulty.

TL is divisive – Classifying activity as "non-value added" carries a connotation that can alienate employees. In addition, a common understanding of goals is a must for harmonizing a workforce. With the inconsistencies associated with value and waste frameworks, it's challenging to coordinate stakeholders. Some of the potential conflicts that may result include:

- Department vs. Department - An example of this would be a purchasing department that sources lower-cost parts, but creates significant downstream quality problems for production.
- Customer vs. Company – From automated customer service to self-check at the grocery store, companies inconveniencing customers to save money is common.
- Employer vs. Employee – In the path to "lean", many companies penalize employees with cost-cutting efforts.
- Employee vs. Employee – Conventional lean approaches offer nothing to mitigate the innate friction that can occur among people whose perceived interests are in conflict.

Although conflict is inevitable in any organization, QL avoids the conflicts that are embedded in TL's structure.

3.2 Comparison of Quantum Lean (QL) to Quick Response Manufacturing (QRM)

While QL and QRM both emphasize lead time reduction, there are significant differences between Quantum Lean (QL) and Quick Response Manufacturing (QRM) that include:

Application – QRM is largely restricted toward custom manufacturers that have not established flow. Because its framework and techniques are comprehensive in scope, QL is applicable to any business at any stage of a lean transformation.

Scope – QRM emphasizes the elimination of delays and deemphasizes the streamlining of non-conversion and conversion activities. QL provides a framework for systematically addressing delays, conversions, and non-conversions in a manner that accomplishes maximum impact in the shortest time.

Granularity – The QRM technique of Manufacturing Critical Path (MCT) identifies time components of a product's time in fulfillment and subdivides them according to whether a product is being processed or not being processed. The QL product path diagram (PPD) categorizes the time in fulfillment and performs a finer classification of the time components according to the nature of the delays (e.g. WIP, batch), conversions, and non-conversions.

Practically, these differences between QRM and QL manifest themselves in the following ways:

QL is more versatile – By design, QRM relegates itself to custom organizations. By contrast, QL is highly applicable to any kind of operation including mass production, job shops, offices and services.

QL is more comprehensive – QRM's greatest utility is reserved to organizations that have not established pull or flow. Once flow/pull has been achieved, QRM's usefulness fades. By contrast, QL works equally well in all phases of a lean transformation.

QL is easier to apply – While an MRT and a PPD are similarly easy to develop, the additional granularity of a PPD and straightforward QL heuristics allow inexperienced users to quickly to prioritize targets, identify solutions, and develop sound action plans. By contrast, an MCT provides limited insight into the causes of excess time-in-fulfillment and little guidance is provided for identifying corresponding solutions.

4 Example –Product Path Diagram (PPD) and Value Stream Mapping (VSM) and Manufacturing Critical Path (MCT) Map

To compare and contrast the PPD, VSM, and MCT Map, a common scenario for a fabrication shop will be used:

- An operator waits 30 minutes to get access to a crane so he can remove sheet metal from a rack.
- Using the crane, sheet metal is removed from a shelf and moved to a computer-controlled cutting table in 10 minutes.
- Due to a lack of coordination between production control and the shop floor, the program needed to run the table will not be available for an hour.
- Once a program is available to run the cutting table, setup operations require 30 minutes.
- After setup, the sheet metal is cut into 30 pieces at a rate of two minutes per piece.
- After cutting is finished, a forklift arrives in 15 minutes and the parts are moved to assembly in five minutes.
- Since assembly is working on another order, the parts are placed in queue.
- After 100 minutes in queue, assembly is ready to process the cut pieces.

4.1 Value Stream Mapping (VSM) - Fabrication

For the fabrication shop example, a VSM would look like this (See Figure 2):

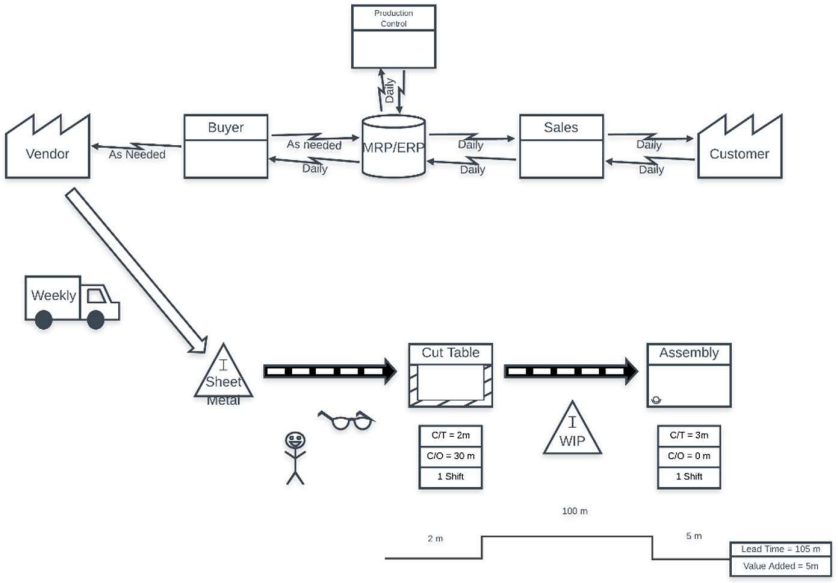

Fig. 2. Fig. 2 – Value Stream Map (Fabrication)

Despite abundant opportunities to improve, the VSM gives few indications of this:

- The VSM contains several symbols, but little insight can be gleaned about what to work on and to what priority order.
- The only potential targets that can be identified from this diagram include:
  - WIP – Assy – This can be identified from the timeline at the bottom of the VSM
  - Setup – This can be identified from the information box associated with cutting table operation.
- Missing waits and wastes include:
  - Wait for Program
  - Batch
  - Wait for Crane
  - Wait for Forklift
  - Move to Table
  - Move to Assy

4.2 Manufacturing Critical Path (MCT) Map - Fabrication

For the fabrication shop example, an MCT map would look like this (See Figure 3):

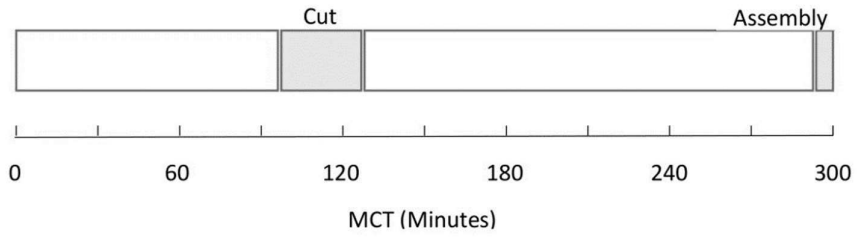

Fig. 3. – MCT Map (Fabrication)

The MCT prioritizes areas to improve but does not indicate potential causes for wait times. These causes will need to be identified in a subsequent investigation. In addition, no wastes are specifically identified. Some points:

- An MCT Map is virtually identical to a VSM timeline. An MCT Map could possibly be characterized as a VSM without any VSM icons.
- Once the time between Cut and Assembly is prioritized for reduction, the task of determining what to work on and to what priority remains.
- With QRM almost solely focused on addressing the contribution of system dynamics to lead time, significant impacts for lead time reduction (like non-conversions and their associated delays) may be overlooked.
- Since wait times between conversion operations often consist of multiple events and actions, it is possible that the priority established by an MCT Map may result in addressing targets that offer suboptimal impact.

4.3 Product Path Diagram (PPD) - Fabrication

The PPD for the fabrication shop example looks like this (See Figure 4):

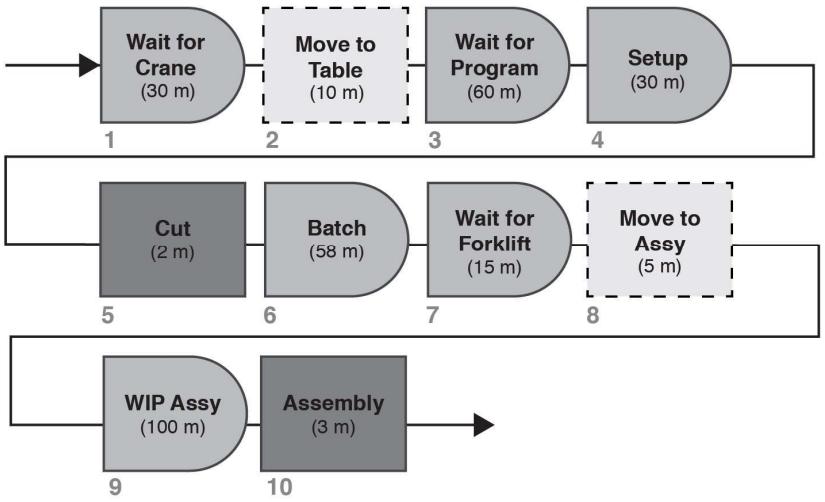

Fig. 4. – Product Path Diagram (Fabrication)

The PPD accurately reveals a target-rich environment. As each element is addressed, QL heuristics guide the user in prioritization, determining potential reasons for the time contributor, and identifying appropriate lean tools to minimize or even eliminate the time. Since the bottleneck is not in the portion of the shop being diagrammed, the PPD indicates that the following targets should be addressed in the following priority order:

- WIP – Assy
- Wait for Program
- Batch
- 4a) Wait for Crane
- 4b) Setup
- Wait for Forklift
- Move to Table
- Move to Assy
- Assembly
- Cut

5 Advantages of Quantum Lean Systems

Benefits afforded by Quantum Lean include:

- Simplicity – QL methods for analyzing and optimizing processes are much simpler than waste-based techniques. Where the QL diagramming method uses three symbols, Value Stream Mapping (VSM) employs 26+. Also, QL's focus on minimizing a product's time in fulfillment sidesteps the challenge of identifying 8 (or 12) types of wastes. Reducing the number of flowcharting symbols from 26 to 3 and the things employees have to look at from 8 to 1 correspondingly reduces complexity.
- Versatility – Without modification, QL can be applied in any setting including product development, production, and office. By contrast, other lean systems vary their approach based on environment. For example, where there are 8 wastes assigned for manufacturing, there are 12 for product development. In addition, QL diagramming techniques can be used for improving job methods and single minute exchange of dies.
- Comprehensiveness – QL seamlessly addresses every phase of a lean implementation including the implementation of pull, flow, and waste elimination. QRM only addresses the establishment of pull and flow. Frequently, TL only addresses waste elimination.
- Speed – With enhanced versatility and simplicity, QL techniques accelerates a workforce's learning curve. In addition, as QL is easier to understand and remember, the odds of QL being misapplied is much lower than when other approaches are used.
- Buy-In – With QL's product-centricity, personnel aren't put on the defensive. For example, if an employee has to walk several hundred feet to get tools, typical lean efforts will zero in on a person's excess travel. Conversely, a product-centric approach looks at the same situation as the product having to wait for tools to become available. Approaching lean the latter way deflects undeserved blame for problems away from employees. In addition, employees appreciate QL's simplicity.
- Cost – QL's versatility and simplicity reduces training costs, minimizes misfires, and accelerates deployment. Overall, this results in lower implementation costs and a quicker return on investment.

Although there are additional benefits, QL's simplicity is arguably its greatest virtue and what makes the other advantages possible.

6 Summary

Lean systems have accomplished much and offers a compelling and positive vision with the possibility of wins for owners, employees, and customers alike. As it has made such a significant difference, the world owes a tremendous debt to its founders. Like

any school of thought, improvement is possible and Quantum Lean (QL) offers next-level performance for lean systems that includes greater simplicity, increased workforce buy-in, quicker deployment, and lower cost of implementation. With a similarly positive and compelling vision, QL offers the same benefits as TL, but is formulated to deliver them more efficiently and effectively. Compared to QRM, QL is applicable to all phases of a lean implementation, offers benefits more comprehensively, and allows an entire workforce (instead of a steering committee) to identify targets and solutions.

References

1. Weigel, A., 2000. [online] Web.mit.edu. Available at: <https://web.mit.edu/esd.83/www/notebook/WomackJones.PDF>
2. Suri, R., 2010, It's About Time. The Competitive Advantage of Quick Response Manufacturing, Productivity Press.
3. Fields, S., Sanders, M., 2020, Quantum Lean: Taking Lean Systems to the Next Level. 1st edn. J Ross Publishing, Ft; Lauderdale, FL USA.