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Achieving Strategic Targets through Ergonomics Improvement

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Abstract

Manufacturing and assembly firms in high-wage rate jurisdictions have strategic goals of productivity improvement and utilization of automation in their direct operations. In this environment, ergonomics is often thought of as an activity to mitigate injuries in the workplace and remain compliant with health and safety standards rather than a tactic for achieving operating cost targets derived from corporate strategy. This reflective case study illustrates how a lean Canadian auto parts supplier achieved productivity targets through ergonomic improvement of an indirect operation. A legacy material handling process involved the manual transfer of boxes at different stages of the assembly operation in two different departments. Many operators performed this task throughout the workday and was not identified as an ergonomics problem; however, it consumed significant operator time when considered in the aggregate, and operators were rotated through the job frequently to prevent fatigue. After redesign, manual transfer of boxes was eliminated and operator available time was increased. Subsequently, a direct operation that was being performed in a separate subassembly cell could be moved online, eliminating the need for that cell. Additionally, automation opportunities have been identified in the new material handling process.

Keywords
Ergonomics, Strategy, Continuous Improvement, Toyota Kata

1. Introduction
Auto parts manufacturing and assembly is a fast-paced environment where job tasks are highly standardized and repetitive. While this results in high levels of productivity and quality, potential negative consequences can be injuries to workers as a result of repetitive strain and lifting. To mitigate this risk, firms engage ergonomists to aid in the design of jobs to ensure compliance with all Health and Safety standards for workers. Ergonomics is often considered from this compliance-based perspective; once the job elements are within standards, improvement efforts are focused elsewhere. Auto parts firms located in high-wage rate jurisdictions face global competition. Many have adopted Lean Manufacturing strategies and Continuous Improvement tactics to gain a competitive advantage. These efforts seek to eliminate waste and minimize variation in value-added processes. The following case describes how a lean auto parts manufacturer in a high wage rate jurisdiction achieved productivity improvement targets by focusing on ergonomic improvement of a material handling operation. The transformed process yielded significant improvements in employee satisfaction and provided a pathway for further gains through automation.

2. Literature Review
Ergonomics is defined as “the study of the mental and physical capacities of persons about the demands made upon them by various kinds of work” (Cayne and Lechner 1988). The field dates back to ancient Greece, but post World War II in the United States, a derivative profession known as Human Factors Engineering emerged, primarily concerned with how humans interacted with physical devices (Wilson 2000). In most current industrial contexts, ergonomics is the concern of the Health and Safety Department, who need to ensure that the design of physical work complies with standards for human limitations. Wilson argues that the challenge for the profession is to become more

proactive in the design of work rather than reactive in the correction of poor design (Wilson 2000). Others suggest that ergonomics should be linked with company strategy and business objectives (Dul and Neumann 2009). Companies under financial pressure employ workforce reduction strategies to reduce costs. When ergonomics is not part of the implementation, there is a risk of increased workplace injury and reduced employee well-being. The result is that the strategy is labeled a failure due to poor implementation (Dul and Neumann 2009).

Many automotive companies have tried to replicate the success of Toyota, and have adopted their business practices, termed "Lean Manufacturing" in North America (Womack, Jones et al. 1990, Womack and Jones 1996). In some cases, Lean Manufacturing has acquired a negative connotation when it is viewed as a method for headcount reduction, thereby increasing the workload on the remaining staff. However, in the Toyota Production System (TPS), the basis of Lean, one of the goals is to eliminate *muri* or the overburden on human beings (Liker 2004). Another principle of TPS is *kaizen*, or continuous improvement; incremental steps toward an ideal state, conducted scientifically to increase organizational learning (Rother 2010). In many instances, however, physical ergonomics are improved to the level of compliance, or to minimize negative outcomes; not often is optimizing ergonomic conditions the ideal state being sought. The following case illustrates how a Lean auto parts manufacturer achieved workforce productivity improvement by focusing on optimizing ergonomics.

3. Case Study

3.1 Background – the Company and the Product

TRQSS, Inc. (TRQSS) is a supplier of seat belt assemblies for passenger vehicles manufactured in North America. TRQSS is located in Tecumseh, Ontario Canada, and is part of the Tokai Rika Group, a global auto parts supplier in the Toyota group of companies, based in Nagoya, Japan. TRQSS operations consist of injection molding of plastic components, automated assembly systems, final assembly and testing, and all logistics and technical support required for a full-service Tier 1 supplier to North American auto assembly plants. TRQSS is a practitioner of the Toyota Production System, or Lean Manufacturing, and assembly operations are comprised of a blend of automation and manual processes. Due to the nature of high-volume repetitive tasks, TRQSS retains the services of an ergonomics consultant to evaluate manual work and propose recommendations to minimize the potential of repetitive strain and lifting injuries. If injuries are incurred, the ergonomist designs jobs for workers with restrictions as they undergo rehabilitation.

Each seat in a passenger vehicle has a restraint system consisting of two primary items: a retractor, and a buckle, which are located on opposite sides of the seat. The retractor frame contains the seat belt webbing on a spool, and is usually mounted to a body pillar in the vehicle and covered by the interior trim; the exposed end of the webbing is anchored to the floor of the vehicle. During normal use, webbing is extracted from the retractor and latched to the buckle with an integrated metal tongue. In the latched position, the occupant is free to move about comfortably, until the vehicle experiences a sudden momentum change (such as a crash situation). At that instant, sensing and locking mechanisms within the retractor prevent any further webbing extraction, thereby restraining the occupant in the seat. After use, the tongue is unlatched and the webbing retracts back into the system.

For all front seat retractors, TRQSS uses a common subassembly architecture that can be customized for application in several unique vehicles, as illustrated in Figure 1. The subassemblies are produced on an automated assembly line, then transferred to another area where several different finishing lines install the webbing, mounting hardware, and identification labels, then package the retractors in specific customer returnable containers for shipping.

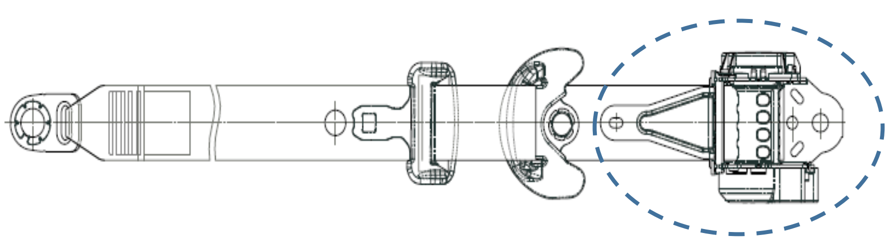


Figure 1. Retractor assembly (common subassembly portion encircled)

3.2 Material Handling Process (Before Improvement)

The retractor subassemblies are produced on the automated line and placed in a plastic tote measuring 23" x 14" x 4.5" and weighing 3.85 lbs. Each retractor subassembly weighs 2.1 lbs. and each tote holds 8 retractor subassemblies. Each full tote weighs approximately 21 lbs. The full totes are then transferred by an operator from the loading rack to a cart with a capacity for 16 full totes. The cart is designed for heavy loads, with a spring-loaded platform to maintain a working height between 30 and 45 inches from the floor. This cart is then moved to a work-in-process inventory (WIP) location between the subassembly area and the finishing area. The operator then transfers the full totes from the cart to a roller conveyor mounted at floor level. Totes are stacked on the conveyor (maximum height of 11 totes) before being advanced. The cart is then returned to the subassembly area.

When a finishing line requires retractor subassemblies, an operator will take a small cart to the WIP area and retrieve 3 totes at a time, manually transferring them from the roller rack to the cart. After the finishing line has used the subassemblies, the operator takes the empty totes using the same cart and transfers them to a specified roller rack. The operator then returns with the cart to retrieve another 3 totes of subassemblies. Periodically, another operator from the subassembly area retrieves the empty totes from that rack with a cart designed for this purpose and returns them to the subassembly area to be refilled by the automated line.
See Figure 2 for a schematic of this system.

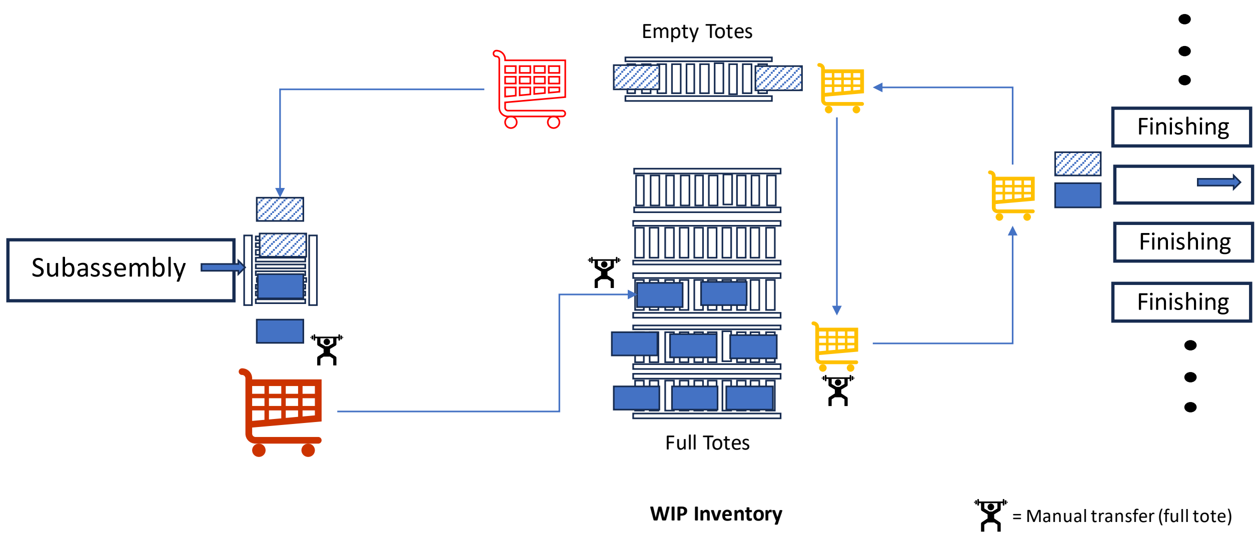


Figure 2. Material Handling Schematic (before improvement)

3.3 Improvement Targets

Each finishing line is staffed with 2 operators: one operator performs the direct on-line assembly functions using semi-automated equipment; the second operator performs the required indirect tasks offline, such as scheduling, set-up stocking, quality checks, and packing. The operators rotate positions every hour throughout the shift for ergonomic reasons. TRQSS had set a target for productivity improvement in the retractor finishing area, and one target was to decrease the ratio of offline to online operators from 1:1 to 2:3. All of the tasks performed by the offline operators were investigated for cycle time reduction, but the focus of the effort turned to the retrieval of retractor subassemblies, specifically when the CEO observed during a plant tour that "the system as a whole requires a lot of manual tote handling."

The manager of the Assembly area began working with the Section Managers of each area, as well as the Team Leaders and the Operators. The team followed the Toyota Improvement Kata methodology but started by first quantifying the current condition: how much manual tote handling was being done by all operators across both assembly departments? The subassembly area produced approximately 90 totes per hour working 18 hours per day. The finishing area used the totes at a collective rate of 100 per hour as this area worked only 16 hours per day. The current condition for tote handling is summarized in Table 1.

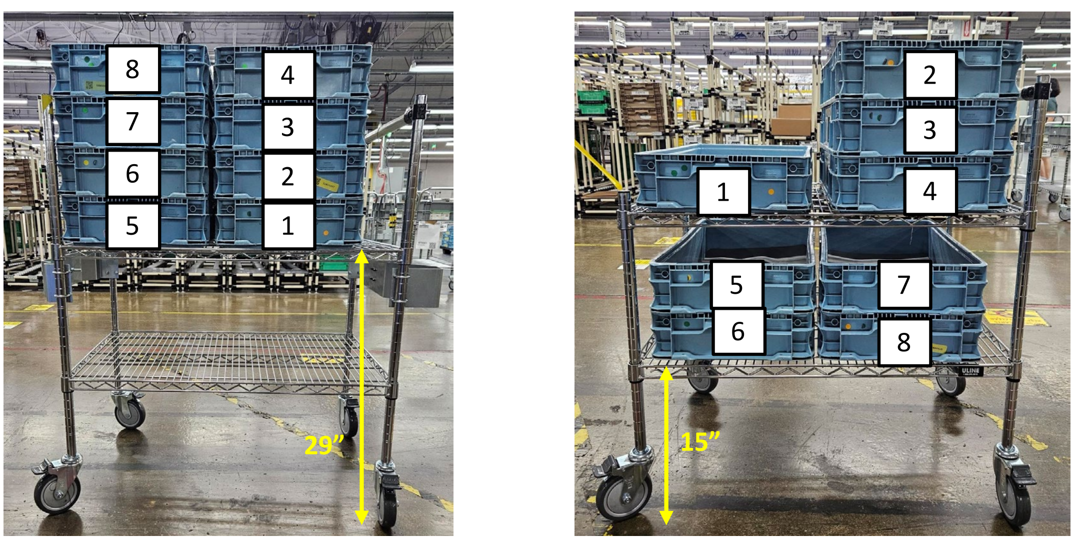
Table 1. Quantification of manual lifting of full totes (“Current Condition”)

Area	lifts /hr	lb / lift	Min. ht (in)	Max. ht (in)	time/lift (s)	Total Time (min)	Total Weight (lbs)
Subassembly	180	21	3	48	3	9	3,780
Finishing	100	21	3	48	3	5	2,100
Totals						14	5,880

Although the manual task of lifting a tote weighing 21 lbs. was not considered to be a health and safety issue (in fact the process had been in place for a long time), the team was surprised to find that collectively 14 minutes out of every hour was spent by operators across both assembly areas lifting full totes at a range of working heights between 3 and 48 inches. More astonishing was that the total weight of that lifting amounted to 5,880 lbs.! The team quickly determined that the focus of the improvement would start with the ergonomics of this material handling operation, with the Ideal Condition statement, “No lifting of full totes.”
With the Ideal Condition articulated, and the Current Condition understood and quantified, the team had to determine the next Target Condition.

3.4 Running the Experiment

Since the finishing line process was accessing the retractor subassemblies directly from the tote on a cart, one of the first considerations was to investigate having the subassembly area deliver the totes on the same style of cart, thereby eliminating the floor-mounted flow rack and 2 manual transfers of each full tote. Because of the differences in delivery and retrieval frequencies and quantities, neither of the existing carts was optimal, and a compromise was necessary. Following some experimentation, the two areas decided that 8 totes was the optimal quantity for a unit load. The next step was to design a cart that could accommodate 8 totes, at a working height that was acceptable to the finishing line operators. Another design requirement for the cart was the ability to accommodate the empty totes generated as the parts were consumed by the finishing lines. The team quickly realized that with a properly designed cart, the separate material handling loop for empty totes could be eliminated as well; when a cart of full totes was delivered to the area, a cart of empty totes could be taken on the return trip. The first Target Condition was to deliver a quantity of 8 full totes and retrieve a cart of 8 empty totes in one cycle, eliminating the floor-mounted flow rack and 2 manual transfers. The team decided to experiment on a small subsection of 2 finishing lines using a common part number to determine the effect of this idea. The cart design and configuration of totes is shown in Figure 3.



Cart with Full Totes

Cart with Empty Totes

Figure 3. Material Handling Cart with Full totes and Empty totes

3.5 Results of the Experiment

As expected, the secondary handling of empty totes was eliminated. Another observation was that the visual management of the WIP was improved, as each cart represented approximately 40 minutes of production for a finishing line. This was easier to see at a glance than multiple stacks of 11 totes on a flow rack; subsequently, the quantity of totes in WIP inventory was reduced by 38%. Two other results were revealed, both expressed by the operators involved. First, the finishing operators had more available time, as they were retrieving subassemblies less often and not stopping to manually transfer boxes at all. Second, all the operators expressed feeling less fatigued at the end of the shift after only 2 days of implementation. This last result increased operator satisfaction so much that there was widespread demand for full implementation.

The next target condition that the team identified was eliminating the one remaining manual transfer by having the subassembly process load parts directly into totes on the cart, the reverse method of what the finishing lines were doing. This experiment was able to be run quickly, and it was determined that the cart could accommodate this method as well, and the loading rack at the subassembly process was eliminated. Based on the results of these experiments in the pilot area, the new carts were fabricated and the system was implemented in the entire area. Refer to Figure 4 for a schematic of the improved Material Handling system.

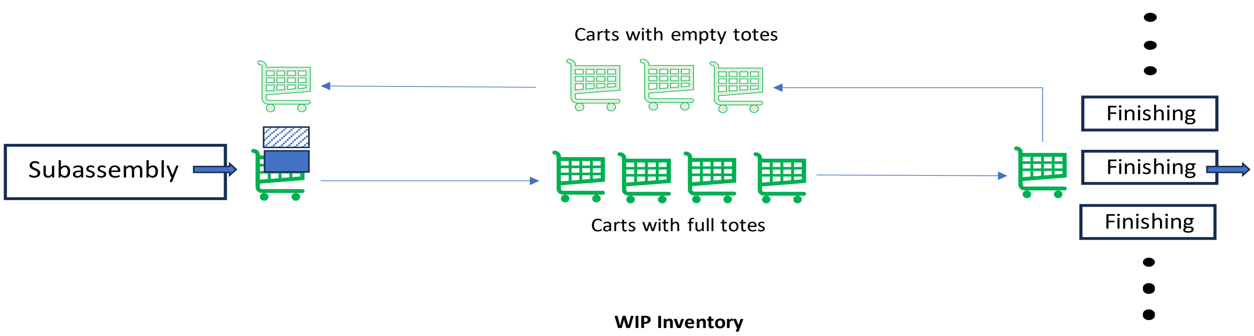


Figure 4. Material Handling Schematic (after improvement)

4. Results and Discussion

The result of this project was a transformation in how these materials were transported in the facility.
The first and most notable result was the improved operator satisfaction. By eliminating the repetitive lifting and stacking of full totes from work heights ranging from 3” to 48”, operators remarked that they felt less fatigued at the end of the day. In both areas, the availability of operators to perform the material handling tasks increased; operators who had work restrictions regarding lifting had not been permitted to do the job, but with lifting eliminated, they were now able to do so.

Finishing line operators also reported that they had more available time in their cyclical work, as they were making fewer trips to retrieve totes of retractor subassemblies, they did not have to make the secondary trip to drop off empties, and they no longer had to load full and empty totes on and off their cart. The increased time was not sufficient to reduce the ratio of online to offline operators in Finishing as originally conceived. However, there was another subassembly supplying the finishing line from another centralized subassembly cell. The team devised an experiment to determine if there was enough time among the finishing operators to do that work on each of their respective finishing lines. After experimentation, the offline subassembly work was moved directly to the finishing lines, and the need for the separate subassembly cell was eliminated. The original productivity target for the assembly area was achieved, and the reduction in staff was managed through natural attrition.

The third and very significant result of this improvement was the simplification of the process to the point where automation using Automated Guided Vehicles (AGVs) or Autonomous Mobile Robots (AMRs) could realistically be considered and evaluated. The unit load for delivery has been standardized, and cycle times for the delivery and retrieval of carts is constant; the remaining variation is a function of distance travelled. With defined routes and deterministic cycle times, further improvement opportunities through investment in automation can be calculated and simulation or experiments could be performed.

5. Conclusion

At the beginning of the Fiscal Year, TRQSS had established some improvement targets and a general focus area. As the team looked at the system, they decided to start with an ergonomics target – not to reach a compliance threshold, but to make the task as easy as possible for all operators. As a result, the collective time saved from the ergonomics improvement enabled the absorption of a subassembly area, and the improvement targets were achieved. There are some interesting conclusions to be drawn from this case. First, in a socio-technical system like an assembly plant, ergonomics should be a primary consideration in process design – not just to comply with health and safety, but to maximize operator satisfaction. With this objective as the primary target, operators are much more enthusiastic about subsequent improvements. At TRQSS, the concept of unit loads and carts has been carried through several other material handling areas as well. Operators have even devised their own systems for First in First out (FIFO

Second, it is important to observe the entire system to identify opportunities for productivity improvement. Initially, the company was focused on the offline operations in the finishing area. When the scope was widened to include all operators performing the material handling task, then enough collective capacity was created so that the secondary subassembly area could be absorbed. Ultimately, the reduction in labor requirements achieved the original target.

A final conclusion is that if automation is an element of a company's strategy, then it is imperative to first simplify and minimize variation in the targeted process. Many of these processes will have a manual element, and variation in the process can come from capability differences between individuals. This variation can be eliminated when we change our perspective of ergonomics from compliance to excellence.

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Biographies

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