*Proceedings of the 2nd World Congress on Industrial Engineering and Operations Management*
*Windsor, Canada, October 14-16, 2025*

*Proceedings of the International Conference on Industrial Engineering and Operations Management*

Publisher: IEOM Society International, USA DOI: 10.46254/WC02.20250154
Published: October 14, 2025

# Facilities Layout Planning in a TPS Environment using Deterministic and Digital Twin Tools

**Gwendolyn Holowecky, Mark Dolsen and Angie Lafferty**
TRQSS Inc.
Tecumseh, Ontario Canada
cholowecky@tramgroup.com, mdolsen@tramgroup.com, alafferty@tramgroup.com

## Abstract

Discrete event simulation is a useful tool for optimizing complex systems in an environment with process variability. One such system is layout planning for a new manufacturing facility. However, creating a model of entire shop floor accurate enough to yield useful results is time consuming and resource demanding. In the Toyota Production System (TPS), the philosophy is to eliminate as much variation so that planning is simplified using deterministic tools. This case study examines a facilities layout plan for a greenfield manufacturing plant that practices TPS. Here, a TPS focused Systematic Layout Planning tool is largely used for the deterministic portion of the planning while a digital (Tompkins, White et al. 2010) twin is used to specifically model a new automated material handling process with high uncertainty within the plan. The results demonstrate the benefits of this deterministic approach coupled with a highly-focused digital twin portion for achieving optimal facilities layout in a timely manner.

## Keywords
Toyota Production System (TPS), Systematic Layout Planning (SLP), Digital Twin, Discrete Event Simulation**.**

## 1. Introduction
Discrete Event Simulation (DES) has appeal for industrial firms as it allows them to virtually model the performance of various operational alternatives prior to the commitment of large amounts of capital. As such, the primary use cases may be those alternatives that are not practical to test in real life, such as facilities layout options that require huge infrastructure changes, or new process proposals involving expensive automated equipment with long lead times. In large and complex manufacturing systems that have variation in process cycle times, equipment downtime events, and material deliveries, DES is a tool that can predict the performance of such systems with greater accuracy than deterministic methods; however, large amounts of accurate data are required, as well as a certain level of model building expertise (Gerdin and Rifve 2018).

The Toyota Production System (TPS) is a pull production system that aims to eliminate waste and reduce variation in the entire supply chain, which simplifies operations management and decision making. Process improvement, or *kaizen*, is based on the scientific method and is incremental in nature (Rother 2010). It would seem that applications for DES would be limited in such an operating environment.

The following case describes how an auto parts manufacturer operating using TPS developed a layout for a new production facility using Systematic Layout Planning (SLP) methodology, then applied DES to evaluate and optimize the performance of a proposed automated material handling system within the facility.

## 2. Literature Review
In manufacturing, facilities planning involves designing a layout that best supports production (Tompkins, White et al. 2010). A widely accepted method for this is Systematic Layout Planning (SLP) developed by Muther, which uses

tools to quantify the relationships between various activities within the facility (EC and Keraita 2018). Discrete Event Simulation has also been applied to the facilities planning problem, usually to predict the performance of various layout alternatives created by SLP or other methods, and select the best alternative (Kurkin and Simon 2011, Suhardini, Septiani et al. 2017).

Lean manufacturing systems that operate using TPS focus on the smooth flow of materials between processes within a value stream (Womack and Jones 1996, Spear and Bowen 1999). In TPS, customer demand is levelized over a period of time, and production capacity is installed according to the levelized demand. Customer orders are pulled through the system starting from the shipping point; each process within the value stream replenishes what has been consumed by the following process. This system removes a significant amount of uncertainty in the planning process and informs the facility design. DES is often applied in Lean production systems to analyze the performance of complex processes within the value stream (Yadin and Kie 2025).

Hao and Shen applied DES to a facility that was using a Toyota style kanban system to request material from a supplier process to be delivered by Automated Guided Vehicles (AGVs) (Hao and Shen 2008). They attempted to create a system where a material request could be received by any available AGV. This would be contrary to TPS, where each customer supplier request must be unambiguous, and the flow of material is direct (Spear and Bowen 1999). Gosavi and Grasman developed a simple model for an AGV to collect material from machines and deliver to a conveyor. They then used DES to optimize the capacity of the AGVs to control the inventory level in a scaled operation using a "push" scheduling system where the machine output was variable (Gosavi and Grasman 2009).

The following case study illustrates the use of DES to optimize the number and routing of AGVs for a proposed facility layout that was designed for an automotive parts manufacturer operating a TPS pull system.

## 3. Case Study

This case involves a seat-belt manufacturer, TRQSS, located in Windsor, Ontario, Canada. TRQSS was established in 1987 and supplies mainly Toyota North America plants. In 2025, TRQSS made the decision to move some production to a second facility just 2.5 km away from TRQSS' main facility in order to accommodate new business and technology. To minimize the material movement between the two plants, two distinct portions of the seat belt assembly would be segregated: TRQSS' main plant would continue to build the retractor portion of the seat belt while the new plant would house the entire value stream of the seat-belt buckle portion. The buckle operation consists of:

- Component receiving and warehousing
- Injection molding production
- Automated and manual sub-assembly
- Manual finishing assembly
- Staging and shipping to various customers

For determining the layout for the new plant, the implementation team utilized a modified framework of Systematic Layout Planning (SLP) tool (Figure 1). Four implicit rules of TPS (Spear and Bowen 1999) guides the layout planning team in material flow and process relationships to help reach the ideal flow:

1. All work is highly specified in its content, sequence, timing, and outcome
2. Each worker knows who provides what to them and when
3. Every product and service flows along a simple, specified path
4. Any improvement to processes, worker/machine connections, or flow path must be made through the scientific method

The first three rules are related to standardization, with the goal of minimizing process variation. Low process variation is a good fit for deterministic planning tools such as SLP.

In the first step of the modified SLP framework, an ideal block layout is created (Figure 2). Arrows indicate product flow paths which are simple and intuitive. Standard material handling routes along these paths use Kanban to connect processes communicating exact product, timing, and quantities to pull. Altogether, this equals good flow of product and information, the ideal layout state.

In the next SLP stage, TRQSS added layout details while being aware of constraints such as columns, inventory buffers, aisle width, and material handling equipment needs. The initial approach for material handling was to reuse current processes and equipment for conveying components from one area to another in the new facility. Most of that material handling equipment within molding used electric tuggers and manual push carts for moving reusable totes of various size no larger than 24" x 15" x 9" (Figure 3). Once all details and constraints were inputted into the layout, an issue surfaced. The main aisle between buckle sub- assembly and buckle finishing was highly congested causing potential safety issues and poor flow. This aisle was to be used for delivery of the four major parts used in

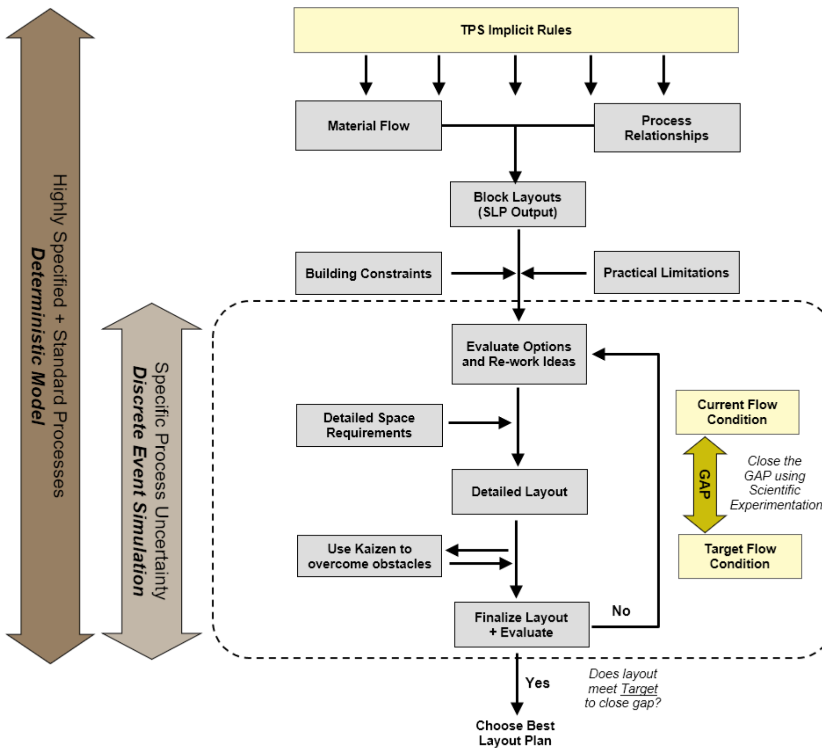


Figure 1. Modified systematic planning framework showing addition of TPS implicit rules and simulation

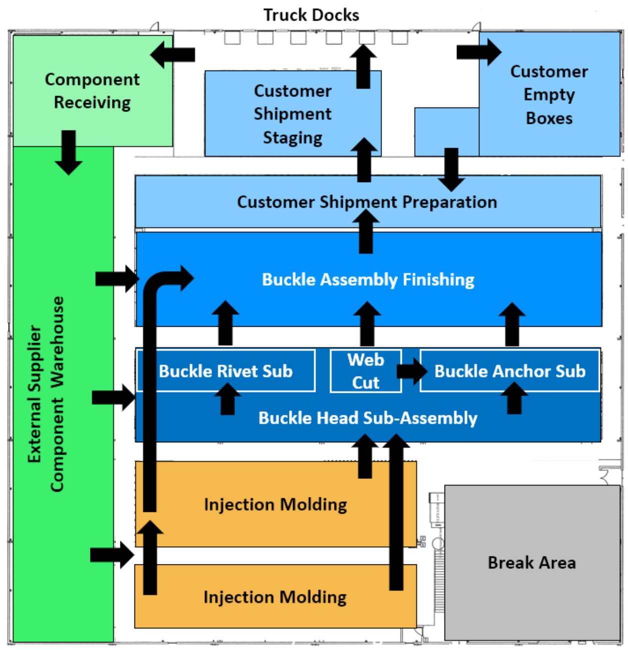


Figure 2. TRQSS Baseline block layout

the finished buckle assembly - wire harnesses, boots, covers, and buckle sub-assemblies (Figure 4). These four parts alone comprised 90% of the total components consumed by buckle finishing lines. Ideally, the two areas of buckle sub-assembly and buckle finishing should be connected for short distances given the high traffic from sub to finishing. However, buckle finishing requires the other three components of molding covers and boots, and wire harnesses to be conveyed directly to each finishing line. This drives the need for a main conveyance aisle separating subs and finishing areas.

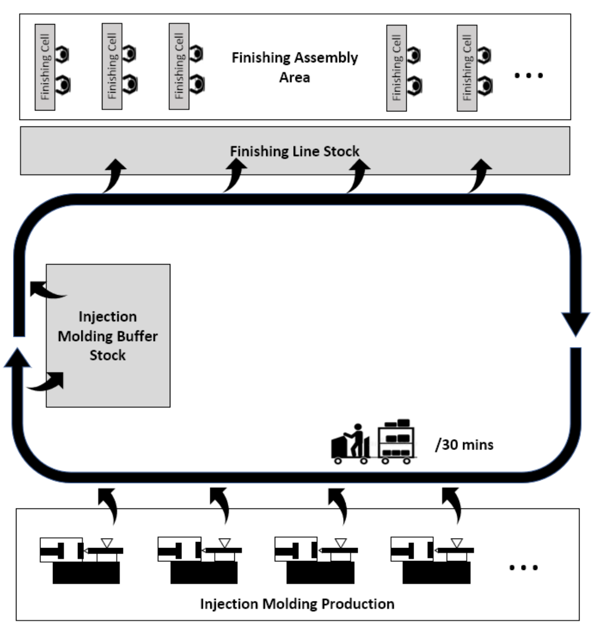


Figure 3. Current delivery method for molded parts to finishing area

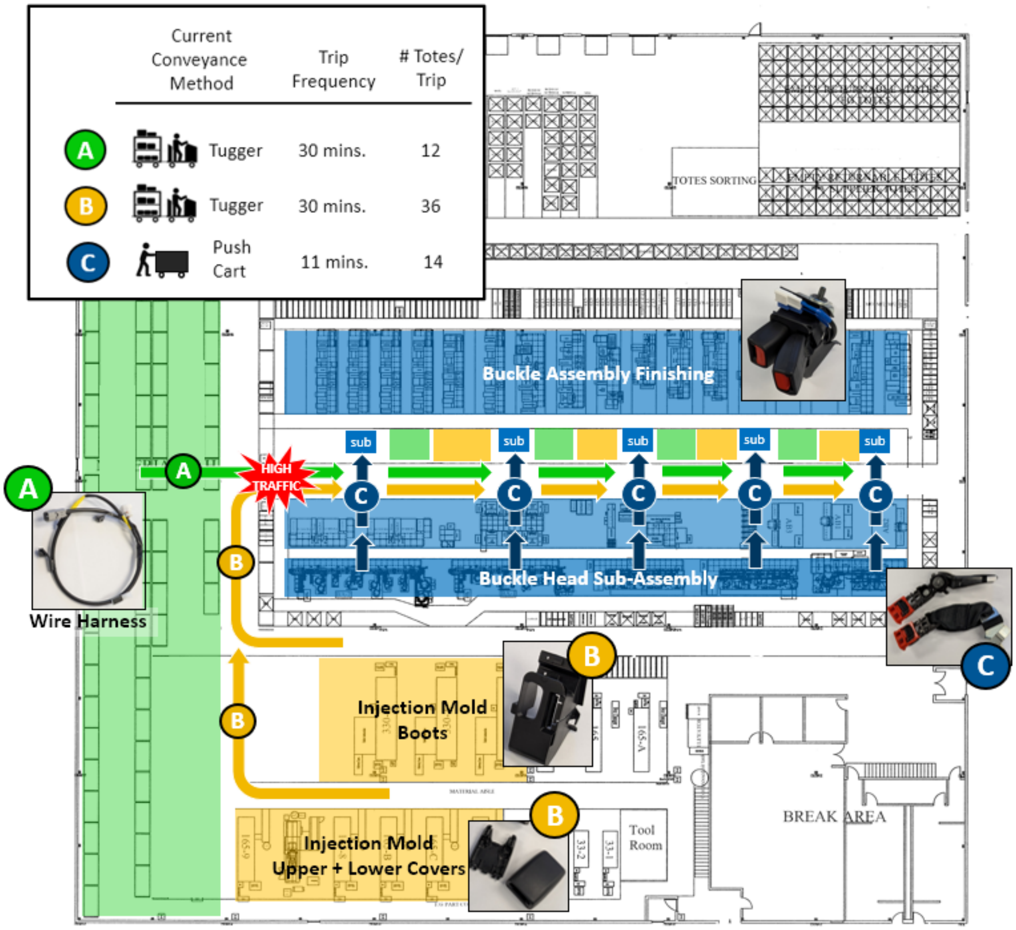


Figure 4. Poor flow (high traffic) in new facility plan

To overcome this issue of poor flow, TRQSS employed the fourth implicit TPS rule found in the modified SLP framework: scientific experimentation to close the gap between current condition (poor flow) and target condition (good flow). In terms of SLP, the ideal flow is having two areas with 'absolute necessary' closeness relationships adjacent or next to one another. There are four major buckle components areas with an 'A' relationship with finishing area. Only the buckle covers and buckle boots injection molding are not immediately adjacent to buckle finishing area (Figure 2). However, locating the molding machines so they are directly feeding the finishing lines is not practical due to infrastructure and the logistics of each mold machines supplying multiple finishing lines. Additionally, this closer molding area would push the buckle sub-assembly area further away from finishing.

In the experimentation, TRQSS started by reconsidering how to convey each buckle component part group. A chart was created to help identify which part groups were better suited to automated versus manual conveyance types (Figure 5). Three product attributes determine each product's chart position: volume, design variation, and usage variation. Volume is measured by the number of totes moved within a given time period. Design variation is measured by the total number of distinct part numbers within a product grouping.

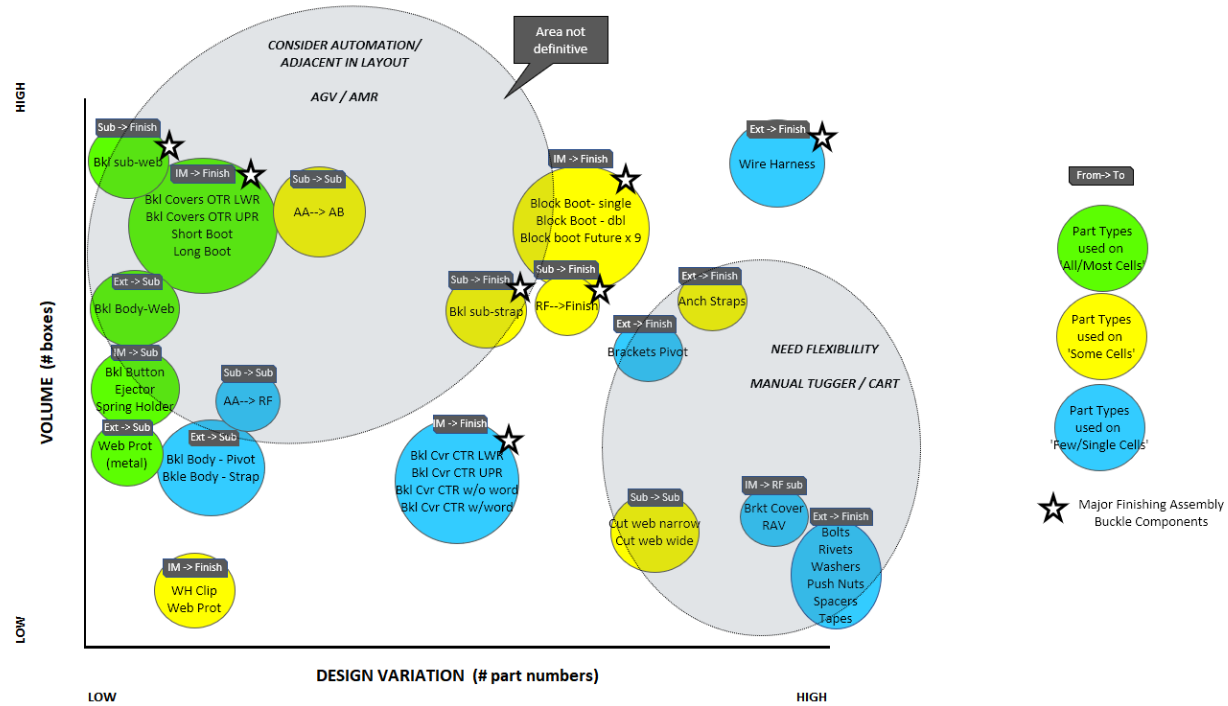


Figure 5. Material conveyance decision chart

Looking at the chart, we see product with attributes of higher volume, lower design variation, and 'used on all/most cells' are a better fit for automated conveyance. Conversely, product with attributes of higher design variation and lower volume are a better fit for manual conveyance or electric tugger/push carts in this case.
Three of the four major buckle components fall within the 'automation' outlined area - buckle subs, buckle covers, and buckle boots. After several experiment iterations, using Figure 5 as a guide, the following improvements were considered to reduce the poor flow:

- Molded covers and boots – automate the conveyance using an autonomous mobile robot (AMR) or automated guided vehicle (AGV)
- Wire harnesses – continue to convey manually, but change the delivery schedule. Rather than deliver during production hours (days and afternoon shifts), stock the inventory on the off shift (midnight shift) in bulk using a pallet jack
- Buckle subs – continue to convey using push carts. The adjacent buckle sub and finishing areas are only a short walk from one another. No changes are necessary.

The idea of automating the injection molded parts conveyance follows Toyota's automation philosophy – only automate processes that are already well-proven and standardized manual processes. Further, automation is not to replace workers but to enhance work, solve a specific problem, or meet a specific need. In the case of buckle covers and boots, the current conveyance process at the original plant is a proven, standardized tugger route. The problem to be solved is poor flow due to high tugger traffic and tote handling in the new facilities' main aisle. An AMR would bridge the distance between molding and finishing and eliminate tugger traffic in the main aisle.

To start, a new AMR process would have to be conceived. The current tugger pick/deliver process functions at a 'tote' level. If a production cell consumes a single tote of a product within a delivery cycle, the tugger only replenishes a single tote of that product the next delivery cycle (Figure 3). In comparison, the AMR would be designed to pick/delivery a cart of multiple totes of the same part (Figure 6) to minimize trips and AMR investment.

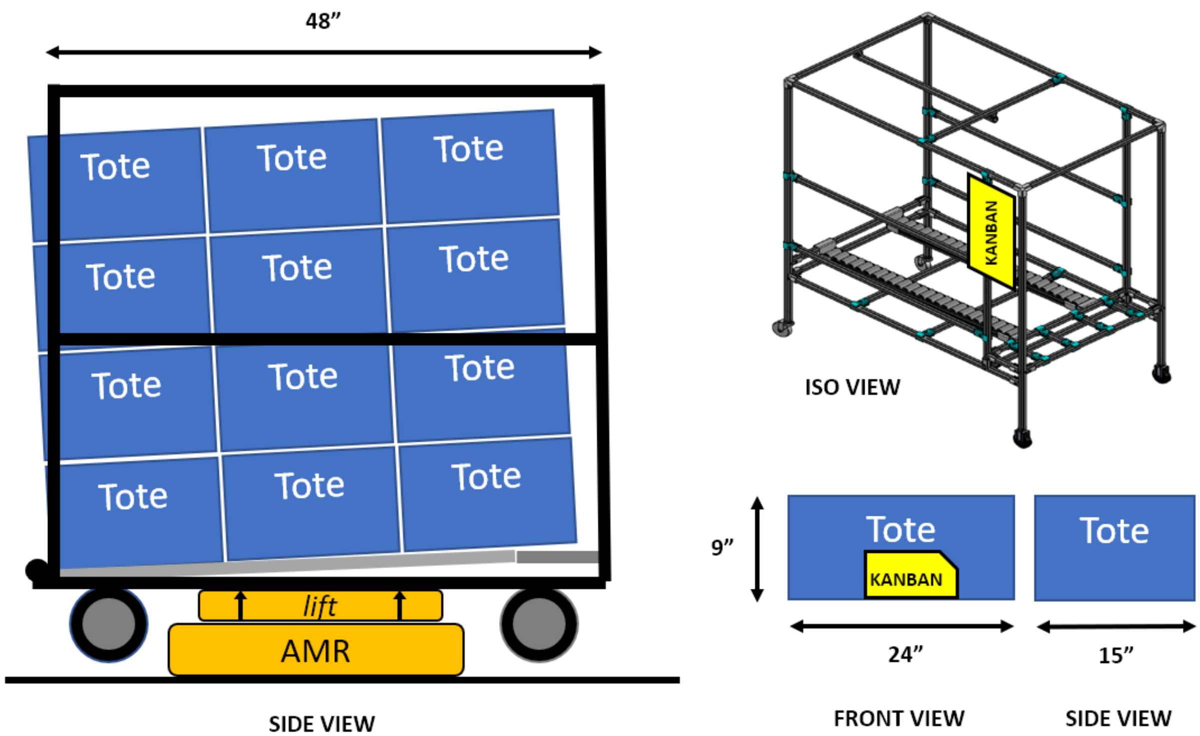


Figure 6. AMR cart concept

Before implementation, the new cart and AMR process had several questions that needed answers. How many AMRs are needed? What inventory buffers are needed? How many carts, for full and empty totes? Answering each question using a static deterministic tool would be daunting given the complexity of the production system: 7 molding machines producing 17 unique parts used in varying quantities on 14 finishing lines that produce 83 unique end items. Each molding machine and assembly cell has some level of variability:

- Production rates
- Downtime events
- Part/tool changeovers
- Customer forecast volumes are mostly level on the whole, but do vary week to week at the part level.

There are also two customers that regularly issue late ‘add-on’ orders above the original firm orders.
For a quicker and more accurate answer to these questions, a discrete event simulation (DES) would be the best tool. The simulation model can be considered an extension of the scientific experimentation carried out to close the gap towards the target flow condition. The model and its inputs and outputs are shown in Figure 7. A layout was developed tracing potential AMR paths and cart locations as the model’s starting point (Figure 8).

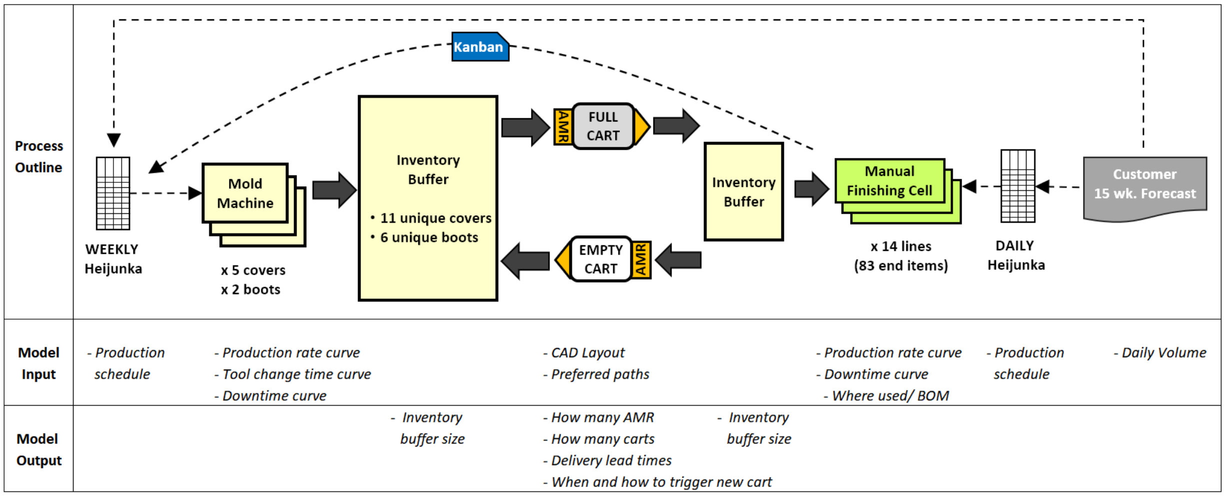


Figure 7. Outline of discrete event simulation model for buckle process

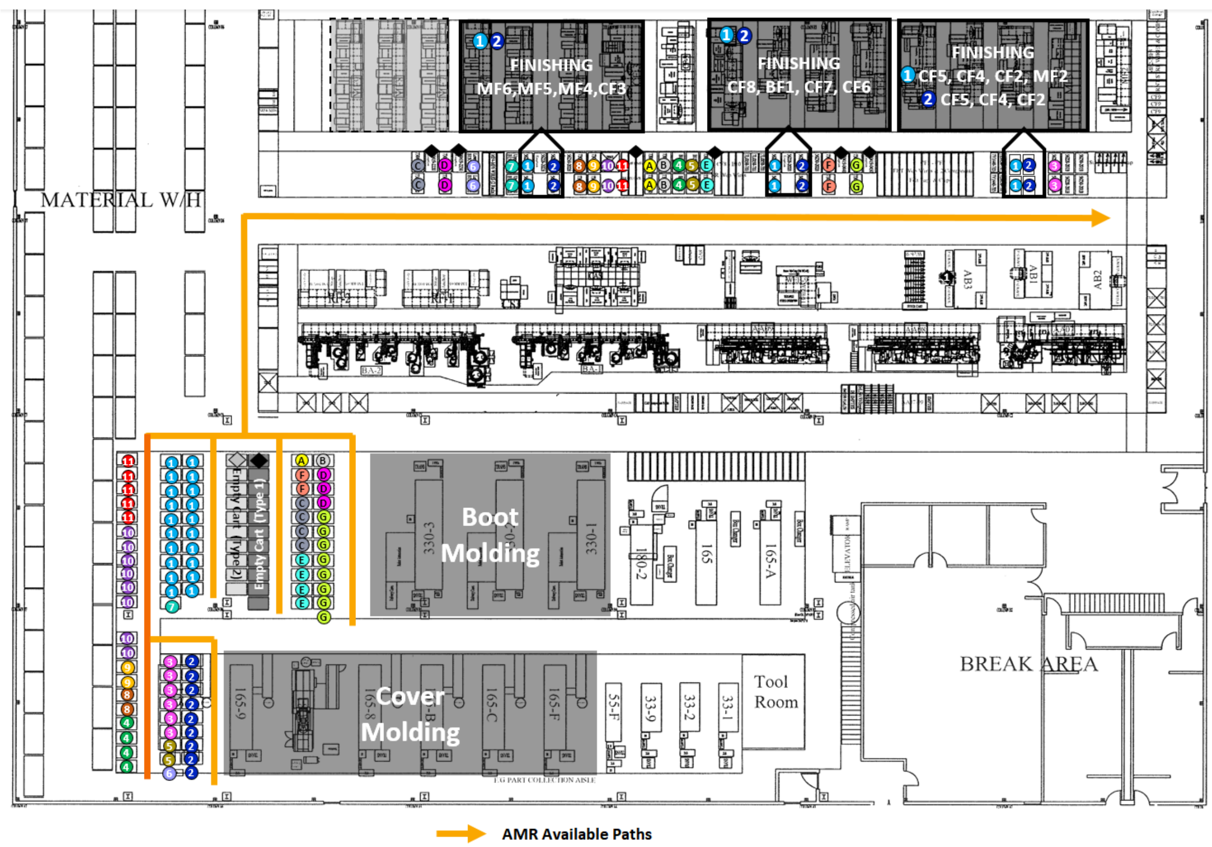


Figure 8. AMR paths and cart locations layout for simulation model

Implementing an AMR would be new territory for TRQSS and present a challenge for maintaining the true TPS pull/reorder process. The new AMR pick/deliver process must be non-ambiguous, highly specified in content, sequence, timing, and outcome. Kanbans must still communicate what's needed in product and quality, and when. Each worker must know who provides what to them and when. Keeping those rules in mind, a parts re-order process for the AMR was developed (Figure 9). Each cart would contain a single kanban identifying its contents. As full carts are cycled through the process and become full of empty totes, the QR code on the cart kanban is scanned, triggering the AMR to deliver a new full. This AMR process is a pull system, where a full cart is only delivered to replenish a consumed cart and only when the kanban is scanned. Once the QR code is scanned, an Andon light located at the consuming finishing line communicates the delivery status of the next cart. Once the next full cart is delivered, the AMR then returns the cart of empty totes back to molding, including the cart kanban.

Each of the totes on the cart also have kanbans attached. Those tote kanbans communicate the box contents when the totes are separated from the cart. The tote kanbans, along with the cart kanbans, are returned back to molding so they can be used in scheduling the next production run. Once a full cart is produced, the cart kanban gets reattached to the cart.

Ultimately, the simulation model is the tool to help verify the new AMR process designed around the TPS rules is practical.

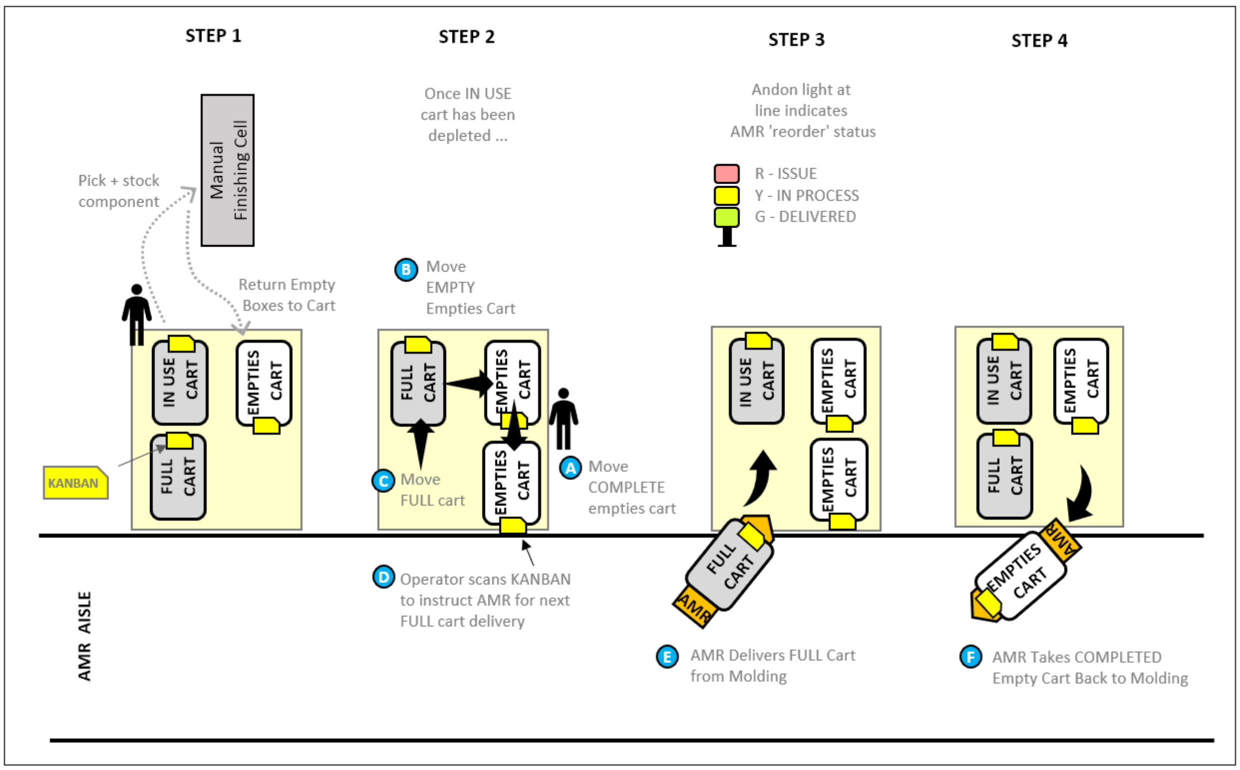


Figure 9. Standard part reorder process for AMR

## 4. Discussion

TPS is commonly mistaken as a set of tools to remove waste from processes (Lander and Liker 2007). Rather, TPS can be thought of as a set of principals or rules (Liker 2004). Bowen and Spear (2004) and Liker (2004) both discuss TPS' focus on "creating continuous flow to bring problems to the surface – create flow to move materials and information fast as well as to link processes and people together so that problems surface right away". Incorporating this principal of 'flow' into SLP framework brings a TPS context into traditional facilities planning activities. Good flow becomes the overarching goal of this modified SLP's end product. Despite practicing TPS, some process and customer variability are unavoidable (Deif 2012), working against good flow. Buffers in the form of inventory and capacity are suitable for countering variability in a TPS environment (Deif 2012). However, excessive buffers disconnect processes resulting in poor process flow. Consequently, organizations with disconnected processes from excessive buffers have no pressure to improve and learn (Lander and Liker 2007) beside the cost penalty. Another TPS principal, iterative scientific experimentation used in improving processes, is also included in the modified SLP framework. Here, experimentation helps move the layout development toward the ideal flow.

In this case study, there are several sources of variation, internal and external to TRQSS. While many of these variations are relatively minor individually, the system as a whole must be considered given the goal of 'continuous flow' for the entire process (Figure 10). Together, the process complexity and the compounding variations make experimentation using deterministic tools difficult and time consuming. To speed up the problem-solving experimentation steps and achieve an optimal solution, a discrete event simulation tool is ideal in this case.

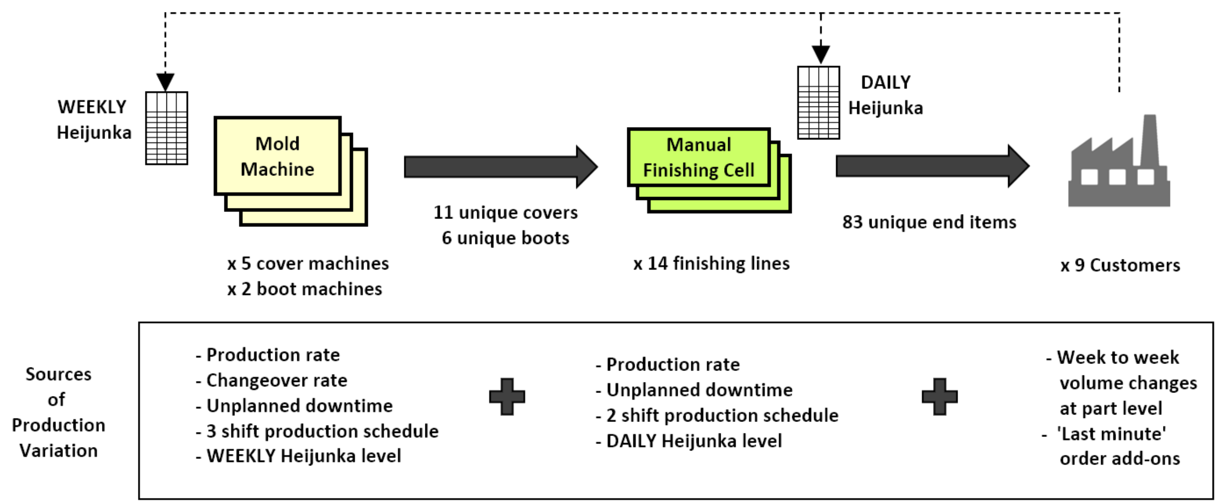


Figure 10. Process complexity and sources of buckle production variation

In the model concept validation stage, TRQSS identified several data sets needed to produce a model representing true process behaviour. This includes 6 months of historical operational data collected in real time at the production cell from numerous sources and stored in onsite databases (Figure 11). Examples of the finishing production rates (Figure 12) and downtime (Figure 13) datasets in fitted distribution curves are provided.

| Data Set | Source |
|---|---|
| Finishing production quantity and timestamp | Re-usable Kanban QR code |
| Hourly operator headcount | Associate badge barcode |
| Molding production quantity and timestamp | Molding machine capture |
| Molding changeover type and timestamp | Operator key-in |
| Production downtime type and timestamp | Maintenance key-in |
| Heijunka level (weekly production plan) | Production plan sheets |
| Customer 'Add-Ons' | Customer Add-On sheets |

Figure 11. Model data sets and sources

As discussed earlier, the model will help define the optimal inventory levels of the various molded component parts and number of AMR's that will ensure a good process flow as pre-defined in Figures 7 and 9. The model visuals are shown in Figure 14.

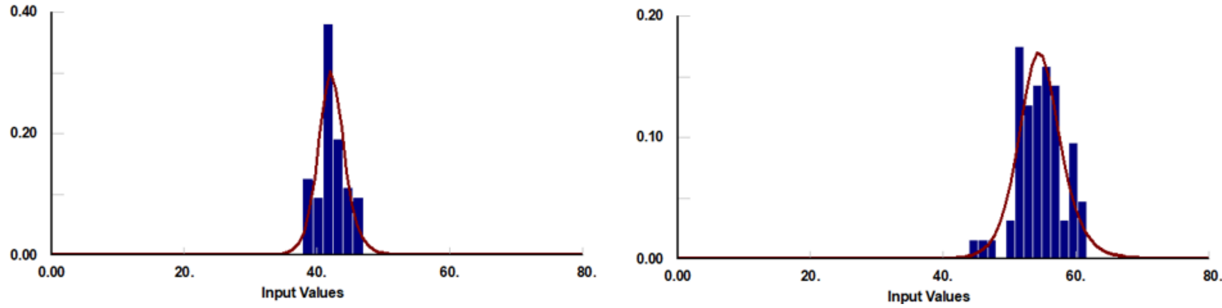


Figure 12. Finishing cell production rate distribution - simple vs more complex assembly examples

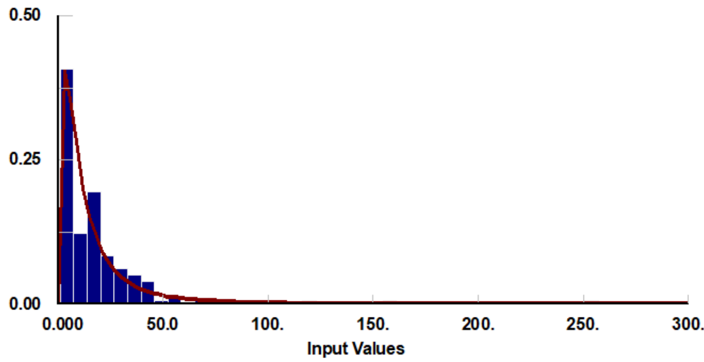


Figure 13: Finishing cell downtime distribution example

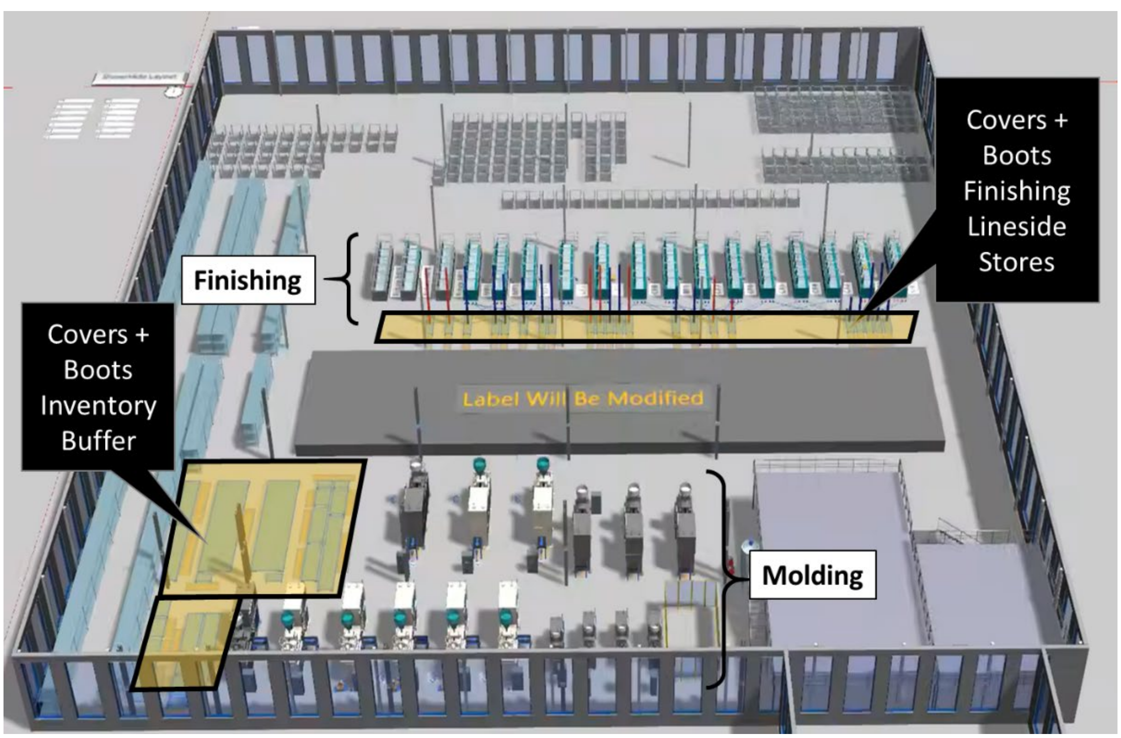


Figure 14. Simulation model

The takeaway for any organization is before modelling a complex operation with multiple sources of variation, one must have a well-defined concept process solidly built around TPS rules and principals. Developing that process before modelling will require its own set of experiments. The experimentation phase will truly be iterative and varied to reach the ideal flow.

Experimentation is just one of five mechanisms for continuous learning at Toyota (Adler, Benner et al. 2009). Learning is:

- Ubiquitous – across the entire organization all the time
- Iterative – phases of standardization and experimentation
- Gap-Driven – between current situation and ideal state
- Framed around "problems as opportunities"

The model is not completed at the time of this writing, so no firm conclusions can be drawn. Completion is still two months away. However, the entire path that TRQSS has taken in this particular SLP activity for their new plant will provide knowledge that can be applied in future problem-solving activities. The intent is to learn from this one model's experiment and expand on it for other complex flows within TRQSS as a quick and efficient way to bridge the gap towards the ideal flow.

## 5. Summary

This paper presents a case study of facility layout planning for a greenfield manufacturing site at TRQSS, applying principles of TPS within a hybrid planning framework blending both deterministic tools and simulation models, each applied where they are most effective. Contrary to the common misperception of TPS as a set of waste-reducing tools, this study embraces TPS as a system of principles—particularly the importance of creating continuous flow to surface and solve problems. A modified Systematic Layout Planning (SLP) process was used to guide deterministic layout development, with the primary goal of achieving ideal flow across injection molding, parts assembly, and final shipping processes.

However, even in a TPS environment, internal and external sources of variation—including customer demand fluctuations, machine downtime, and operator variability—introduce complexity that is difficult to address with deterministic tools alone. To bridge this gap, a focused DES is being developed as a digital twin to model a new automated material handling system. The simulation will incorporate actual historical production data from various sources throughout the value streams, such as parts production in injection molding, production interruptions, downtime events, operator variations, and customer pull signals, to reflect true system behavior and support TPS-style scientific experimentation.

The model, currently under construction, is designed to help TRQSS determine the optimal levels of component inventory, the number of AMRs required, and the ideal delivery frequencies and routes needed to support continuous flow. By tightly integrating TPS principles into both the deterministic and simulation-based planning phases, this approach offers a structured yet flexible path toward an ideal factory layout.

## 6. Conclusion

This case study highlights a TPS-aligned approach to facility layout planning that integrates deterministic flow-based methods with simulation-based experimentation to manage system variability. The modified SLP process embeds TPS principles such as continuous flow, problem visibility, and iterative learning into traditional layout development. However, when flow is disrupted by unpredictable variation—machine downtime, operator changes, and customer-driven add-ons—deterministic planning reaches its limits.

To address these challenges, TRQSS has developed a discrete event simulation model focused on the most variable part of the system: the automated material handling and inventory flow. Although the simulation is still under development, the use of real-world data and process variability factors ensures that the model will closely reflect actual system behavior. This enables more precise and confident decision-making around:

- Inventory buffers between production stages,

- Required number and utilization of AMRs,
- Delivery frequency and route optimization to support lean, just-in-time operations.

Perhaps most importantly, this work demonstrates that the path to ideal flow requires experimentation, both in the physical layout design and in the simulation environment. As with other elements of TPS, the process itself becomes a learning opportunity: an iterative, gap-driven approach where problems are framed as opportunities for improvement. While conclusions from the simulation will come after its completion, the planning approach taken by TRQSS is already a valuable model for future problem-solving efforts.

**7. Next Steps / Future Work**

The simulation model is currently in development and scheduled for completion within two months. The following steps outline the future work required to fully realize the benefits of the hybrid planning approach:

1. Finalize Simulation Development and Validation
   Complete the DES model using six months of operational data, ensuring accurate representation of:
   - Production build rates for different components,
   - Downtime patterns and changeover events,
   - Operator headcount fluctuations,
   - Customer pull and "add-on" variation.
2. Experimentation and Scenario Testing
   Use the model to run structured experiments aligned with TPS principles, including:
   - Inventory level optimization to support continuous flow without excessive buffering,
   - Determination of the minimal AMR fleet size needed for reliable delivery,
   - Testing delivery routes and frequencies to ensure flow synchronization across processes.
3. Analysis and Application of Results
   Analyze simulation outputs to guide design decisions for material flow systems in the greenfield facility, including:
   - Layout changes to reduce travel time and improve connection between processes,
   - Control strategies to dynamically adjust delivery based on real-time demand.
4. Organizational Learning and Expansion
   Use the insights from this simulation as a prototype for future modeling efforts across other complex processes within TRQSS. This supports:
   - Faster layout experimentation in future projects,
   - Embedding simulation as a standard part of the TPS-based planning toolkit,
   - Creating a culture of iterative learning and scientific thinking in operations design.
5. Feedback into the Deterministic Planning Framework
   Incorporate validated learnings from the simulation back into the SLP process to further refine and improve deterministic layout planning based on real-world behavior.

Ultimately, this simulation is not just a tool for immediate problem-solving—it is a platform for continuous learning, aligned with Toyota's broader approach to improvement through iterative experimentation and organizational reflection.

## References

Adler, P. S., Goldoftas, B. and Levine, D. I., Perspectives on the productivity dilemma, Journal of Operations Management, vol. 27, no. 2, pp. 99–113, 2009.

Deif, A. M., Dynamic analysis of a lean cell under uncertainty, International Journal of Production Research, vol. 50, no. 4, pp. 1127–1139, 2012.

EC, M. and Keraita, J. N., Improvement of facility layout using systematic layout planning, Journal/Conference not specified, 2018.

Gerdin, E. and Rifve, R., Manufacturing system improvement with discrete event simulation: A case study with simulation applied to a manual manufacturing system, Master's Thesis, 2018.

Gosavi, A. and Grasman, S. E., Simulation-based optimization for determining AGV capacity in a manufacturing system, IISE Annual Conference Proceedings, Institute of Industrial and Systems Engineers (IISE), 2009.
Hao, Q. and Shen, W., Implementing a hybrid simulation model for a Kanban-based material handling system, Robotics and Computer-Integrated Manufacturing, vol. 24, no. 5, pp. 635–646, 2008.
Kurkin, O. and Simon, M., Optimization of layout using discrete event simulation, IBIMA Business Review, 2011.
Lander, E. and Liker, J. K., The Toyota Production System and art: Making highly customized and creative products the Toyota way, International Journal of Production Research, vol. 45, no. 16, pp. 3681–3698, 2007.
Liker, J. K., The Toyota Way: 14 Management Principles from the World's Greatest Manufacturer, McGraw-Hill, New York, 2004.
Rother, M., Toyota Kata: Managing People for Improvement, Adaptiveness, and Superior Results, McGraw-Hill, New York, 2010.
Spear, S. and Bowen, H. K., Decoding the DNA of the Toyota production system, Harvard Business Review, vol. 77, no. 5, pp. 96–106, 1999.
Suhardini, D., Dewi, S. and Ardiansyah, R., Design and simulation of plant layout using systematic layout planning, IOP Conference Series: Materials Science and Engineering, vol. 277, no. 1, 2017, doi: https://doi.org/10.1088/1757-899X/277/1/012010
Tompkins, J. A., White, J. A., Bozer, Y. A. and Tanchoco, J. M. A., Facilities Planning, John Wiley & Sons, Hoboken, NJ, 2010.
Womack, J. P. and Jones, D. T., Lean Thinking: Banish Waste and Create Wealth in Your Organisation, Simon and Schuster, New York, 1996.
Yadin, K. and Kie, C. J., Optimizing production line layout in a manufacturing company using discrete event simulation, Global Business & Management Research, vol. 17, no. 1, 2025.

## Biographies

**Gwendolyn C. Holowecky** is a Manager of Production Engineering at TRQSS Inc. where she leads a team of engineers and data system analysis professionals. She earned a BASc in Industrial Engineering from University of Windsor, and MS and PhD degrees in Industrial and Systems Engineering from Wayne State University in Detroit, Michigan. Dr. Holowecky has over 31 years of experience working at TRQSS within IE, production planning, project planning, TPS, and facilities planning roles. Dr. Holowecky has authored a book chapter with a focus on flexibility within Toyota Production System, and has taught a Facilities Planning course at University of Windsor, Industrial Engineering department. In addition to teaching, she has also mentored numerous IE co-op students at TRQSS.

**Mark Dolsen** is President of TRQSS Inc., in Tecumseh, Ontario Canada. TRQSS, part of the Tokai Rika Group, is a supplier of automotive seat belt systems primarily for Toyota's North American assembly plants. He earned a BSEE degree from Kettering University (formerly General Motors Institute) in Flint, Michigan, and MS and PhD degrees in Industrial and Systems Engineering from Wayne State University in Detroit, Michigan. Dr. Dolsen has over 30 years of experience working in the automotive parts industry in engineering and management positions. He has developed and published teaching cases in the areas of product development, supply chain risk management, and ethical decision making. Dr. Dolsen has authored journal articles dealing with the innovation process, and given conference presentations on the topics of reliability and Training Within Industry (TWI). He is a member of IEOM, IISE, SAE, ASQ, ASEM, and is a Licensed Professional Engineer in the Province of Ontario, Canada.

**Angie Lafferty** is the General Manager of Production Engineering at TRQSS Inc., where she leads a diverse team of engineers and skilled trades professionals in the areas of assembly automation, injection molding, and facilities planning. Based in Tecumseh, Ontario, TRQSS Inc. is part of the Tokai Rika Group, a leading supplier of automotive seat belt systems, serving primarily Toyota's North American assembly plants. Angie holds a BASc in Environmental Engineering from the University of Windsor and is a Licensed Professional Engineer in the Province of Ontario, Canada. With over 25 years of experience in product design and advanced manufacturing systems, she applies the Toyota Production System and lean design and development principles to drive operational excellence and innovation. She actively partners with local educational institutions on research initiatives to bridge academia and industry and serves on program advisory committees for local colleges, helping align technical curriculum with evolving workforce demands. Angie is also a dedicated advocate for diversity in engineering and skilled trades, working to create inclusive, opportunity-rich environments in technical fields.