7th European Conference on Industrial Engineering and Operations Management
Augsburg, Germany, July 16-18, 2024
Publisher: IEOM Society International, USA DOI: 10.46254/EU07.20240113
Published: July 16, 2024

Bridging the Communications Gap between Lean Practitioners and Production Planners in Value Stream Design: A visual Tool for a Lean PPC Configuration in multi-level Product Structures

Roman Ungern-Sternberg
Head of Business Unit End-to-End Operations
Fraunhofer Institute for Manufacturing Engineering and Automation IPA
Stuttgart, Baden-Württemberg, Germany
Roman.Ungern-Sternberg@ipa.fraunhofer.de

Lena Langenfeld
Research Assistant Operational Excellence
Fraunhofer Institute for Manufacturing Engineering and Automation IPA
Stuttgart, Baden-Württemberg, Germany
Lena.Langenfeld@ipa.fraunhofer.de

Abstract

Coming from a different educational and practical backgrounds, lean practitioners' and production planners' view on production system differ – making communication and alignment of improvements difficult. While the former focus on resources and use value stream maps for communication, the latter concentrate on production orders and their interdependencies. Based on the value stream map and the order net, the paper develops a product-production map as a common communications tool to discuss and visualize improvements. The map was successfully tested in a high variety steel production. It could be extended to visualize live data (e.g. from IoT devices) for production control.

Keywords
Production Planning and Control (PPC), Value stream method, Visualization, Potential analysis, product-production map

1. Common and conflicting goals in PPC and Lean – Missing due dates
Short delivery lead times and high throughput are the common goals of lean practitioners and production planners. However, planners and lean practitioners often have completely different backgrounds leading to different control mechanisms (cf. Wiendahl 2011). Lean practitioners, often coming from a mass production environment, focus on output and inventory at hand and less on due dates. In mass production, decoupling of multi-level products is often done via inventory, e.g. by Kanban. Kanban is a classic example of system controlled by *quantities*: Due dates are irrelevant for such a control system as long as the bins are filled. However, in a high-variety production the control via *due-dates* is dominant: Time bound production orders control every production step. To maintain system transparency, it is important to close the right production order with the correct due date – and not only produce the quantity needed.

The production planning and control (PPC) systems often run with outdated standard time offsets (e.g. lead times, queue times) neglecting the actual system structure. The lead times are mostly correct on order level, but deviate

heavily on operations level as standard queue times do not reflect the actual (technical) process limitations (e.g. neglecting batching and cure times). Wrong due dates reduce trust in the planning and lead to local control activities such as manual progress lists and backlog control. The situation intensifies with successful production improvements. Reducing actual production lead times should lead to lower inventory levels. However, if production planners do not reduce time offsets, orders are released too early and the inventory level does not change at all.Summarized, the different backgrounds and behaviors between production planners and lean practitioners can contradict the efforts to reduce inventory and lead times. An effective measure to create common understanding are shared models and communication tools. Value stream maps have proven to be a successful tool for production improvement. However, they fall short on visualization of due dates and offsets in the system (Ungern-Sternberg 2023). This leads to the papers research question:
How to visualize multi-level product-production system to support communications between production planners and lean practitioners, enabling focused system improvements?

Following the motivation, section 2 outlines the core objects in a multi-level production system from PPC perspective. Section 3 compares existing visualization methods while section 4 synthesized the approaches to a combined product-production map. The empirical validation in a steel production facility is discussed in section 5. Section 6 gives an outlook for application in daily operations management.
How to visualize the product-production system to support communications between production planners and lean practitioners enabling focused system adaptions?

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2. Core objects for planning and controlling multi-level production systems

Product and production structure of a high variety product family are closely interlinked. First, critical decisions and their effects on production planning and control are outlined. Second, the key objects for controlling such variety production are described.

2.1 Strategic Product-Production Decisions with Production Effects

During system configuration and sales and operations planning, two strategic decisions are made with strong effects on the structure and behavior of the production system:

Modularization is the combination of functional requirements into producible components. The modularization has a strong effect on the complexity (volume and variety) of different production orders and the effort to control and synchronize them for producing a single unit (Krause and Gebhardt 2023). Well-defined modules separate customer specific components produced on demand from standard components produced in bulk. (Ungern-Sternberg 2023)

Closely linked with modularization is the **Order Penetration** (or customer demand decoupling). It is the decision which components are produced only with customer demand and which components are produced in advance (based on either previous consumption or future predictions). In multi-level production structures, the decision has to be made several times for several groups of components. (Wiendahl 2011)
Customer decoupling allows for short delivery lead times even if the production lead times are much longer.

Modularization and order penetration have a strong influence on the shop-floor organization and thus the specific decisions should be visualized to enable discussion and alterations.

2.2 Core Objects in Production Planning and Control used in PPC systems

In production planning, three core object types are used to organize production. The section briefly describes the objects shown in Figure 1, the strategic decisions that are linked to their main attributes and which characteristics should be visualized.

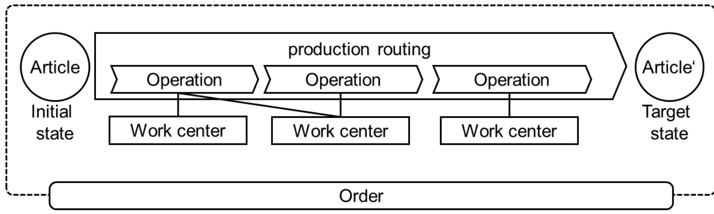

Figure 1: Core Objects in Order Management (Ungern-Sternberg 2023, Wiendahl 2011)

Articles (or items) are the units a product or component is made of. For each article, an inventory strategy is chosen. Standard strategies are make-to-order, make-to-stock, and make-to-forecast, leading to different stock levels of the respective article. Higher article variety usually leads to higher stock levels to guarantee the same service level. Usually similar articles necessary for a product are grouped into component families. (Wiendahl 2011, Krause and Gebhardt 2023) A transparent visualization should be able to reflect groupings of several articles.

A **production routing**, consisting of several operations, describes the technical processes necessary to transform an article from an initial state to a final state. The single steps are performed by work centers. The logistical coordination of the transformation is coordinated by production orders. (Ungern-Sternberg 2023, Wiendahl 2011) A visualization should show the link between routing and production order as the lead times are often determined by the complexity of the routing.

Orders synchronize the customer demand with the production supply. As shown above, the synchronization is done with due dates. Well-defined queue times between operations allow for the calculation of reliable due dates and thus an accurate production control, e.g. by backlog management. (Wiendahl 2011) A visualization should clearly show the start and finish of an order. To avoid several critical paths, non-critical orders are often scheduled ahead using offsets and safety times.

Work Centers provide the capacity to transform articles from one stat to another. The necessary buffer in front of a work center (work-in-progress) is a function of the targeted utilization rate, the order size etc. Generally, work centers with low changeover times and high capacity flexibility require smaller buffers. (Wiendahl 2011, Nyhuis and Wiendahl 2012) In production orders, the buffer is expressed by the queue time between consecutive operations and should be visualized.

With these core objects, planning systems can implement the strategic decisions into tactical planning operations.
A main characteristic of a planning system is the clear distinction between articles and their stock level and production orders and the buffer levels. The buffer level before and after a work center can be determined by linking the operations in the order to the respective work center. (Ungern-Sternberg 2023)

2.3 Conclusion and Requirements: A new modelling approach and visualization is needed

The collaboration and communication of lean practitioners and production planners is inevitable in modern multi-level production systems. Supporting communication by visualization tools has proven to be extremely useful:
Humans acquire more information through vision than through all other senses combined. A huge quantity of information can be rapidly interpreted if presented well (Ware 2013). Visualizations function as cognitive tools. They range from standard 2D displays such as bars to the combination of KPIs in elaborate dashboards (Keim and Ward 2003, Hichert and Faisst 2022). The main goal is to present the correct information level to the user.
In order to be understood and used by all parties, to avoid misunderstandings, and to foster communication, the visualization has to built upon a common language of lean practitioners and production planners.
To satisfy the requirements of both parties and to combine shop floor and PPC view, the core objects (sec. 2.2) and their attributes have to be depicted and clearly distinguished. Moreover, the visualization should foster the identification of potentials. Based on general requirements for visualizations and the requirements derived from sec. 2.2., a visualization has to fulfill the following requirements:

- **R1:** To reduce complexity for multi-level production systems and to create comprehensibility for experts from different domains, the visualization has to be **simple, clear, and transparent** while showing the **complete structure** and the necessary steps to fulfill a customer order.

- **R2:** The visualization has to include an **order perspective**, showing orders with their starting and finishing points.
- **R3:** The visualization has to include a **resource perspective** and clearly distinguish work centers according to their modeling in the PPC systems.
- **R4:** The visualization has to include an **article perspective** and differentiate it from the order perspective. It has to differentiate between articles and orders and therefore between inventory, that is linked to articles (e.g. 50 pieces in the warehouse), and buffers, that are linked to work-in-progress orders (e.g. 5 open orders with 10 kitted pieces attached to it). This is a crucial distinction for the planning system, especially in order release.
- **R5:** The visualization should use a **unified time scale** allowing for a quick comparison of elements and an immediate identification of the critical path.
- **R6:** The inclusion of **actual and planned (or standard) values** allow a quick comparison of the shop floor situation and the PPC system and the identification of critical discrepancies that might lead to delays.
- **R7:** The **subdivision of lead time** into its parts, namely queuing times, operating times and safety times, further enriches the visualization and simplifies the analysis of value adding time proportions and potentials for optimization.

3. Existing visualizations for lean product-production systems

Both the way an individual perceives and creates a visualization depends on his background: When creating a visualization, the creator chooses a specific perspective, a specific excerpt of reality, of the element that is to be visualized (Stachowiak 1973). When visualizing production, visualizations differ in the core object visualized (sec. 2.2) and the objects in focus:

- Practitioners with a training in lean philosophy and flow production systems put the product in focus as it is generating value for the customer. The value stream method therefore mainly follows the article perspective (sec. 3.1).
- Practitioners with a background in planning and scheduling job shops focus on orders that are represented in the PPC system (sec. 3.2). The use diagrams following the order perspective.

Thus resulting visualizations differ substantially. Sections 3.1 and 3.2 show both approaches. Section 3.3 concludes the absence of a visualization that combines both worlds - which is necessary for a common understanding and purposeful discussions.

3.1 Shopfloor-oriented visualization: The value stream map

The value stream method is an established method for optimizing lean manufacturing systems (Erlach 2013). It consists of an analysis and a design phase. Goal of value stream analysis is the clear depiction of the production processes and buffers to derive actions for improvement. The practitioner should be empowered to understand the production by literally *seeing* the shopfloor situation at one glance (Rother and Shook 1999). The simplifying symbols and the KPIs enable the communication with all hierarchy levels in a factory.

The value stream analysis consists of four phases (Erlach 2013):

1. **Product family deduction:** Products are aggregated into product families based on their production similarities. The product family formulation allows consolidating the broad product portfolio in a manageable number of distinct product families, which enable production segmentation.
2. **Customer demand determination**: The customer demand is determined for each product family.
3. **Value stream mapping**: The value stream is mapped for each product family.
   During a shop floor tour, the processes and buffers and their actual key parameters (e.g. cycle time, buffer reach, setup times) are recorded and summarized in a value stream map. The value stream map uses common illustrations for processes, material flow, and information flow as exemplarily shown in Figure 2.
4. **Potential identification:** Besides the immediate improvement actions (Kaizens) the value stream method has two additional visualizations to identify potentials:
   - The balancing chart compares cycle time and customer takt time, can show capacity bottlenecks and waste.
   - The timeline compares the total operation time with the lead time, Reducing buffers can increase the flow rate (Erlach 2020).

Core strengths of value stream mapping are the clustering in product families and the comprehensible symbols and syntax used. The value stream map provides a holistic overview of the actual production that is recorded comparatively quickly and easily.

Current research focuses on the digitalization of the value stream method. With continuously recording the current production state, the values can be shown in real time and improvements can be derived automatically and implemented continuously. (Erlach et al. 2023, Erlach et al. 2021)

► Originating from the lean philosophy (Ohno 1988) in serial production systems, the value stream map is particularly suitable for linear flows. In high-variety multi-level production systems with material flows that are not linear but divergent and convergent, the simplicity and transparency are heavily reduced.
The value stream method focuses the value for the customer. It maps the flow of the product and the operations needed for the transformation. It reflects the article perspective but ignores the order structure (see Koch 2018). It does not distinct between inventory and buffers but pretends they were the same. (Ungern-Sternberg 2023)
The value stream map partly includes the resource perspective when analyzing the flow of articles and the processes needed, but the shown processes do not necessarily reflect the PPC system's structure. This impedes the integration of planned values from PPC systems, which could enrich the actual values shown in the value stream map (Ungern-Sternberg 2023).

With the balancing chart and the timeline, the value stream method acknowledges the importance of immediate potential identification, but the lack of a unified time scale impedes the immediate identification of the critical path.
The value stream map aggregates the lead time from storage ranges – inventory or buffers – but without the order perspective the differentiation of queueing times or safety times of orders is not possible.

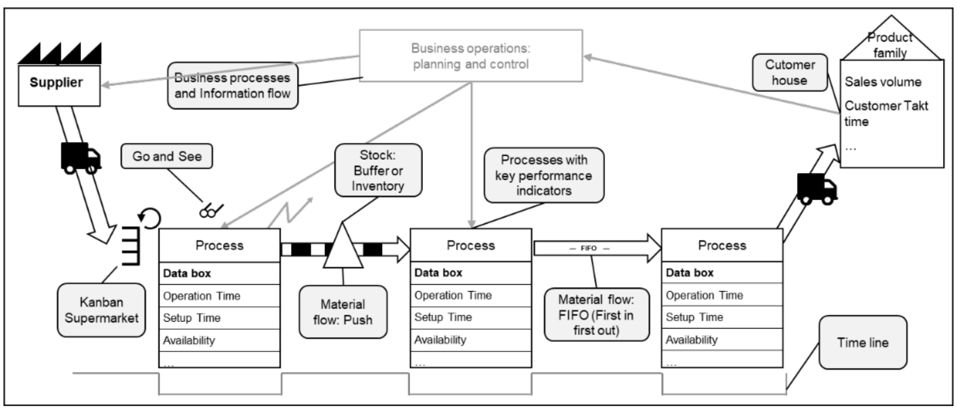

Figure 2: Core elements of the value stream map

Planning-oriented visualizations: Throughput diagram, process plan, order perspective and product net

The funnel theory models each capacity unit as a funnel with the capacity determining the width of the funnel. Incoming orders, modelled as throughput elements with a specific work content, have to pass the funnel (Nyhuis 2012). The visualization approaches presented in the following base on this model. They origin from the PPC view and use planned or standard values presented on a scaled time axis. Figure 3 shows examples of the different visualizations.

The throughput diagram shows the behavior of one capacity unit over time. Input and output of orders are cumulated over time (Wiendahl and Tönshoff 1988). The combination of several funnels shows the complete flow of an order through several capacity units. The **order throughput diagram** (Figure 3.1) shows the resulting structure. Further generalizing the behavior of the funnel results in characteristic operating curves, that show the behavior of core values like output, lead time, and backlog depending on the inventory level of the system (Nyhuis and Wiendahl 2012, Wiendahl 2014).
► The order throughput diagram presents the order perspective with its structure. It does not represent the resource perspective or the article perspective: Work centers are not explicitly presented and distinguished and neither the transformation of articles including operations and buffers nor inventory echelons are depicted.

Schönsleben used a **process plan** (Figure 3.2) to show the structure of processes to complete a product. He includes operations and operation times in the visualization. The horizontal axis shows the offset time compared to the final

date. To focus the main elements and behavior, the process plan aggregates orders to order families, and combines comparatively short operations to bigger operations and small capacity units to bigger ones. The result is an aggregated rough view that shows all elements that have to be planned explicitly. (Schönsleben 2020)
► The process plan includes the order perspective as well as the resource perspective. Stock echelons and buffers are not included and times are not further split into parts, only work plan times are shown.

The **product net** extends the process plan for high variety products. It uses component families to group similar articles into and depicts them as branches of the product structure. The product net uses an extensive syntax to show planned and actual values as well as several bottlenecks. The echelons of the product break the linear time axis, which makes creation as well as understanding of the net rather complicated. (Ungern-Sternberg 2023)
► The product net depicts the order perspective in detail with an extensive syntax. However, it does not show the resource perspective and drawing by hand is difficult due to a non-linear time axis.

H.-H. Wiendahl developed the **order net** (Figure 3.3) to describe the processing from the order perspective (Wiendahl 2023). The order net simplifies the order throughput diagram into a typical manufacturing diagram. It shows the overall structure of all in-house and external production orders necessary for a customer order, represented as one-dimensional flow elements, and the inventory system. Different focus of the user can result in different representations, e.g. to distinguishing different order penetration as shown in Figure 3.4.
► The order net allows abstracting the BOM-structure to a user specific structure. The order net does not zoom into work centers and thus does not reflect the resource perspective or the article perspective. It does not provide a deeper understanding of production or any inherent elements as queues or buffers.

H.H.-Wiendahl furthermore presents the **PPC-Layout** (Figure 3.4) to show the superordinate relations of functional units. The PPC-Layout shows areas of responsibilities like purchasing and production, links to subcontractors and suppliers, and main inventory points between departments (Wiendahl 2023).
► The PPS-layout helps to comprehend superordinate relationships on an aggregate resource perspective but does not necessarily increase the understanding of the production system, processes, or the order structure due to its high level of aggregation of the resource perspective.

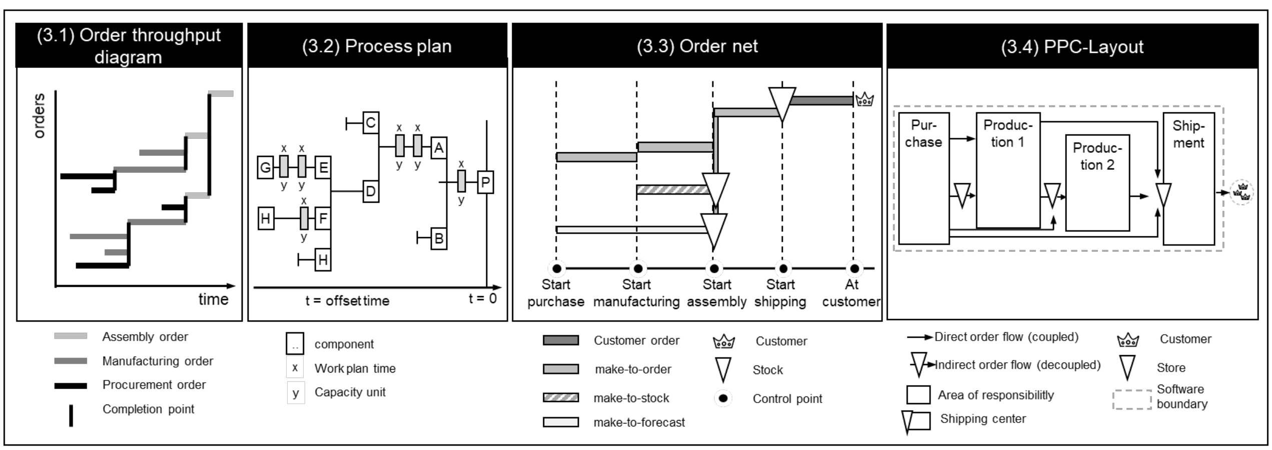

Figure 3: Examples for visualizations of the order perspective

Necessity for a combined visualization

Users of the shopfloor-oriented value stream map (sec. 3.1) and the planning-oriented diagrams (sec. 3.2) originate from different philosophies which results in different perspectives. All discussed visualizations fulfill their purpose for a particular use but have limitations with regard to the requirements deduced in section 2.3. Figure 4 summarizes the shortcomings that prevent the visualizations from being suitable as a common tool for lean practitioners and production planners:

Transparency, simplicity and holistic system perspective (R1):

All shown visualizations aim at reducing complexity to facilitate the understanding and communication – but only in their field of application and in dedicated framework conditions:

- The shopfloor-oriented value stream method reaches its limits in transparency when flows are non-linear and several echelons are depicted.
- The planning-oriented visualizations show structures of PPC systems but do not show processes or buffers and do not provide information to understand the production system as a whole.

► None of the shown visualizations is transparent and simple in multi-level production systems and at the same time fosters the understanding of the complete production and product structure.

Visualization of different perspectives (R2, R3, R4):
The shopfloor-oriented value stream method and the planning-oriented visualizations of order structures represent different perspectives on the core elements of order management:

- The value stream method shows the article perspective, neglecting orders or the resource structure used in the PPC-system. Inventory and buffers are not distinguished.
- The planning-oriented approaches focus the order perspective, only partly including the resource perspective in the process plan and – on a fairly abstract and superordinate level – in the PPC-Layout. Omitting the details on the resource and the article level leads to neglecting the process sequences and the buffers. The differentiation between inventory (articles) and buffer (orders) is not included in the visualizations.

► None of the shown visualizations is representing and clearly distinguishing the article, order, and resource perspective and their attributes.

Visualization of time (R5, R6, R7):
Analyzing and showing different time elements is of importance in both analysis on the shop floor and in production planning and control, but only party reflected in shown visualizations:

- The value-stream method does not use a unified time scale. This complicates the identification of the critical part. However, the time line helps to identify the composition of lead time, though not including order queuing times or safety times. The value stream method shows actual values.
- Visualizations with order perspective use a unified time scale. With the data from the PPC-system, planned or standard values are used, no actual values. The visualizations do not allow analyzing the composition of the lead time immediately. The PPC-layout focuses superordinate structures and does not show any time values.

► None of the shown visualizations shows actual and planned values to allow their comparison. The analysis of the lead time components like queuing and safety times is not supported.

○ Not fulfilled ◑ Partly fulfilled ● Completely fulfilled			shopfloor-oriented	PPC-oriented				
			Value stream map	**Order throughput diagram**	**Process plan**	**Product net**	**Order net**	**PPC Layout**
	R1	Holistic, simple, transparent	○	◑	◑	◑	◑	○
Visualization of different views	R2	Visualization of order perspective	○	●	●	●	●	○
	R3	Visualization of resource perspective	◑	○	●	○	○	●
	R4	Differentiation between order and article perspective	○	○	○	●	○	○
Visualization of time	R5	Visualization with unified time scale	○	●	●	◑	●	○
	R6	Differentiation of actual and planned / standard values	○	○	○	●	○	○
	R7	Detailing of lead time	◑	○	○	◑	○	○

Figure 4: Comparison of visualization approaches (sec 3.1 and sec. 3.2) and requirements (sec. 2.3)

Despite long-standing basic skepticism on both sides, lean practitioners and production planners admitted defeat over the years and identified inevitable collaboration to develop synergies in increasingly complex production systems (Lödding 2016). Therefore, a visualization of both perspectives is needed as a basis for common understanding and communication of lean practitioners with a shop floor focus and production planners with a PPC-focus.

4. Product-production map for visual communication

Goal of the product-production map is the visualization of lead times and their causes to enable the identification of critical paths and foster fact based discussions on measures for lead-time reduction.

Thus, the production-product map combines the production and product perspectives in an inter-linked two-level graphic. The first level is the product perspective drawing the general structure of production orders and their lead times needed to fulfill customer orders. The second level shows the necessary work centers to fulfill the production orders and justifies the lead times by showing the queue and buffer times in production. The approach is in line with the visual information seeking mantra "Overview first, zoom and filter, then details-on-demand" (Shneiderman 1996), that can help as basic idea to ensure user-friendliness on different levels of meaningful abstraction with the option to see more detail if necessary.

The following section describes the development of the product-production map for the artificial example of a load carrier (Figure 5). The load carrier consists of side panels, components like hinges or elements for inner customization, and two alternative cover types. The components are not obligatory but their need depends on the carrier type.

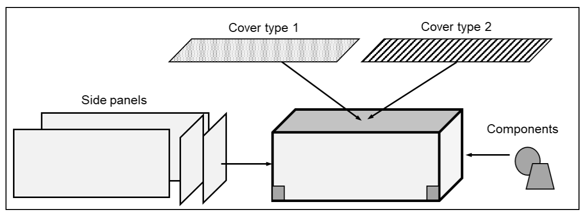

Figure 5: Example of load carrier and its components

Figure 6 shows the resulting product-production map for the load carrier. The side panels and the components are prepared in a pre-assembly step. Subsequently, they are assembled to form the load carrier. In the final assembly, one type of previously pre-assembled outer covers is added.

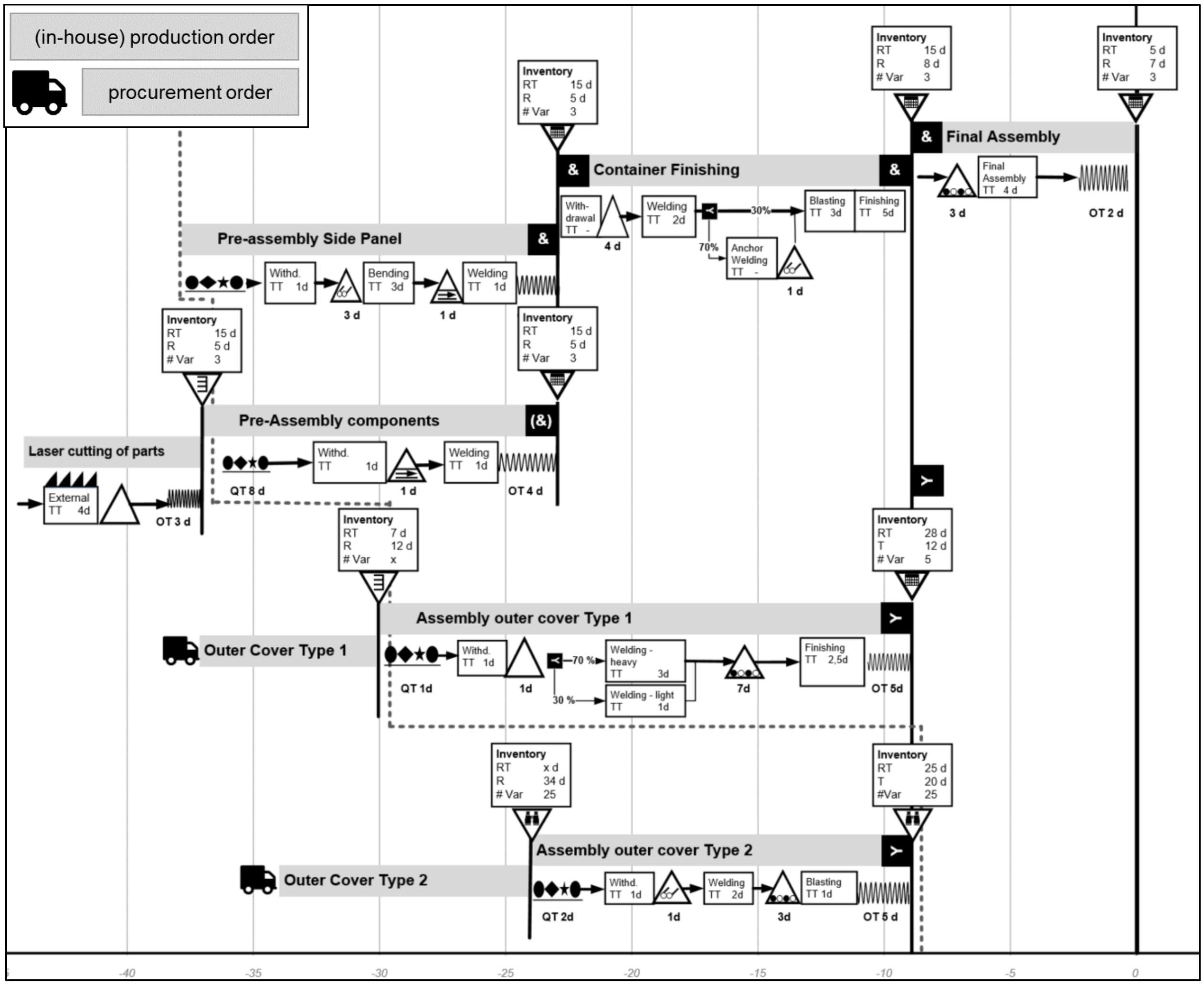

Figure 6: Example of a product-production map for a examplatory load-carrier

The following sections describe its production including the production planning perspective (sec. 4.1) and the lead time perspective (sec. 4.2) with the respective steps.

4.1 Mapping the product from a production planning perspective

The mapping is split into three steps, increasing the level of detail and thus the ability to understand root causes with every step.

Step 1: Product structure. The production orders to produce the necessary components are grouped into component families. A component family clusters, similar to a product family in value stream method (see sec. 3.1), all components that have similar technical (e.g. process flows) and logistical (e.g. lot sizes) requirements. Bars, scaled to the average lead time of the production orders represented, show the component families.

In variety production, not all components are always necessary to produce a product from a product family. Four different symbols represent the completion conditions between components: An ampersand represents an AND-connection. All linked components are necessary to create the following component. A switch represents a branching connection. Only some of the linked components are necessary. An ampersand or switch symbol in brackets shows an optional connection.

Figure 7 shows the product structure of the load carrier and the used completion conditions. The length of the bars reflects the lead time of the production order.

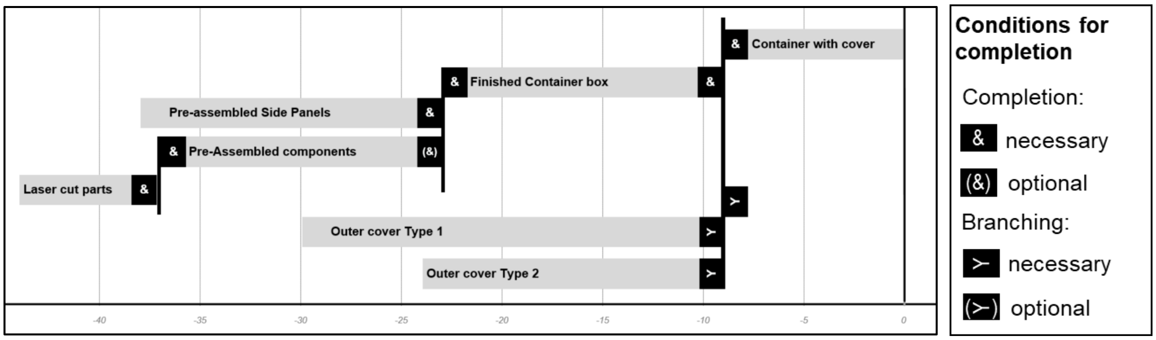

Figure 7: Load-carrier example: Product structure with completion conditions

Result of the first step is a clear overview of the product structure including the lead times as well as a division of critical from optional or less relevant component families.

Step 2: Inventory management strategy and inventory reach. The production orders are connected by inventory (see sec. 2.2). Based on the inventory management strategy of each inventory point, the customer decoupling is derived. The map differentiates make-to-order, make-to-stock, and make-to-forecast inventory points, where the first one is within the customer specific part of production and the latter two are customer neutral production. Data boxes can add information about the inventory, e.g. replenishment time, reach, number of variants, or safety stock. The resulting product structure and inventory management strategy for the product-production map of the load carrier production are presented in Figure 8.

Step 3: Identification of potentials. The figures show two optimization potentials:

- First and most intuitive the critical path from customer perspective. It is the longest chains of production orders necessary to fulfill the customer order. Second is the longest overall path in the network. The longer a path the higher usually the forecast error and thus the necessary stock for a specific service level.
- Second, the order penetration line can be drawn to distinguish make-to-order from make-to-stock and make-to-forecast (see Figure 8).

Both potentials can be mitigated by reducing lead times in the processes, which will be detailed in the next step.

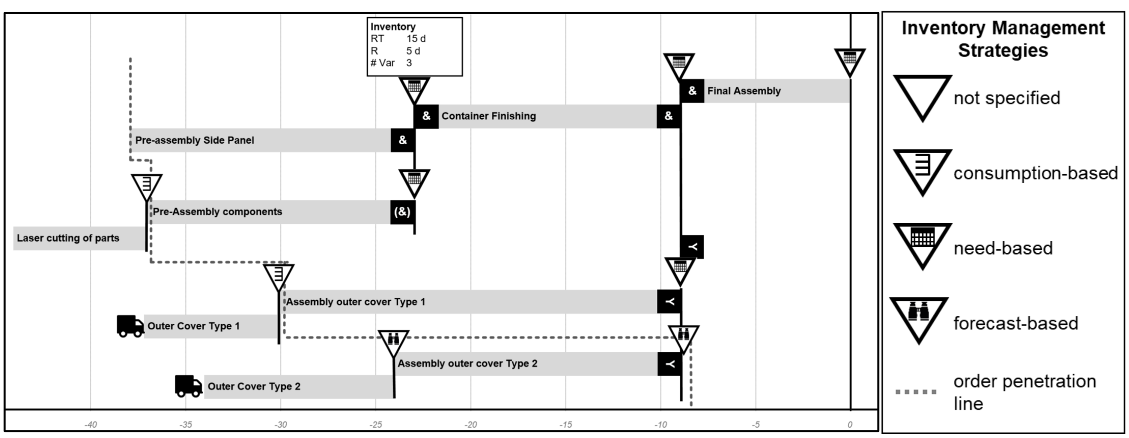

Figure 8: Load-carrier example: Inventory management strategies and order penetration line

4.2 Mapping the production from a lead time perspective

The detailing of the component family with the necessary production processes is also split into three steps, increasing the level of detail and thus the ability to understand root causes with every step.

Step 1: Process chain and actual buffers sizes. The first step is based on the classical value stream analysis by drawing the production processes and their flow. However, two changes are introduced in the symbolic: A triangle

preceding each process represents the orders waiting for processing. Arrows with different weight show the percentage distribution of the material flows. The actual buffer reach indicates the average actual reach for each process.
An additional symbol represents sequencing rule applied for the buffer:

- Planned sequence: A (central) planning instance plans the sequence. It has to be followed as closely as possible.
- First-in-first-out (FIFO): Incoming and outgoing sequence are the same.
- Go-and-see: Operators define the sequence based on experience and material availability.

Figure 9 shows the application of this step to the side panels and components needed for the load-carrier production and the symbols used to visualize the different buffer rules. Further-more, specific symbols differentiate internal work centers from external ones and the thickness of arrows differentiates main material flows from subordinate ones.

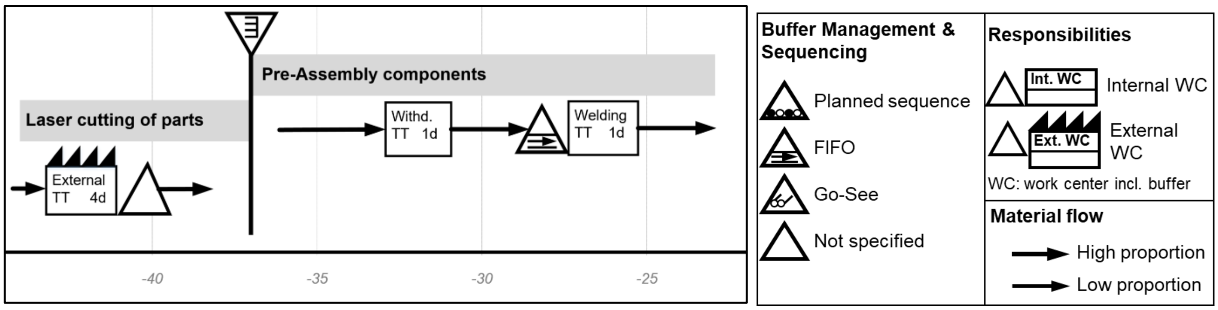

Figure 9: Load-carrier example: Buffer rules, responsibilities, and material flow

Step 2: Planned times and comparison. The second step adds three different types of planned times:

- Buffer Times: The planned time between operations are indicated in the buffers
- Order queue time: The planned time between the start date of the production order and its actual (physical) entry of the order in the buffer before the first operation. This time is often used when several orders are batched before the first operation (e.g. sorting by color).
- Offset time: The offset time is the planned preproduction of an order (and thus early supply) compared to the demand of the following order. This is often used to further decouple non critical components from the critical path to increase robustness of the production (e.g. production of small components several days ahead of the planned assembly start date)

Figure 10 shows the refinement with planned times for the pre-assembly of side panel and components as well as the used symbols.

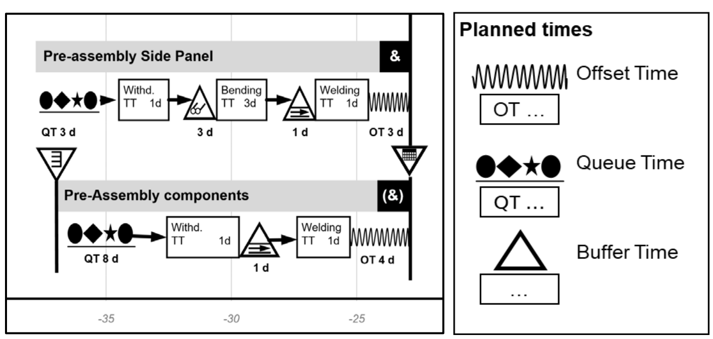

Figure 10: Load-carrier example: Planned times

The split into three types of planned time enables a detailed optimization of several parameters (e.g. a closer synchronization of different production streams – provided the delivery performance of a process chain is reliable).
The comparison of planned and actual times furthermore allows identification of discrepancies between planning and actual shop floor reality (e.g. too high planned buffers leading to unnecessary stock on the shop floor). Following a lean approach the actual values should be added to the map during a shop floor visit and actual counting. Deviations could then be highlighted using different colors.

5. Empirical validation in steel production

The company in focus is a SME specialized in complex steel products. Due to recent growth in volume and variety, two projects were initiated by the operations management team: First, the workshop-oriented production is reorganized to a value stream oriented production system by product family segmentation and layout rearrangements. Second, the production planning and control is undergoing a transformation from a manual system to a standard PPC solution.
The projects can run relatively independent from each other. However, two questions have to be solved in common:

- How do we setup the product structure and which components are produced in a flow, respectively on a single production order?
- How do we dimension the inventory levels, respectively how do we control the components inventory, especially for component families with high variety?

To solve the first question and to group the articles in the bill-of-materials into component families, initially only the product structure was drawn in a product net. However, without showing the underlying production routings and work centers the team had difficulties in making the decision as critical information was missing. Showing the work centers helped setting up the orders and grouping the articles.
Following the lean logic, an initial concept focused on inventory management via Kanban. By showing the number of variants and hence the necessary inventory levels the inventory management strategy was changed to make-to-order production for the majority of the parts. When shown the data lean practitioners and planners unison opted for the make-to-order strategy. The detailed split of every single production order including each operation and the sequencing rules helped in understanding and improving lead times.

Overall, the rather simple symbols and syntax enabled a fast and targeted discussion between production management, planning, production and lean team. Further, the clear distinction between buffer and inventory highlighted the importance of daily material bookings for the production team.

Though designed with simple symbols and an intuitive syntax, a learning curve is attached to the new product-production map. Especially the link between offsets and queue times and the following inventory and buffer levels could be visualized more intuitively.

6. Conclusion and Outlook

The simultaneous visualization of product structure from a planning perspective and the production structure from a lean perspective improves common understanding and identification of deviations and potentials in lead-time reduction.
The developed product-production map focuses on internal production and root cause analysis of lead-times. Further development is needed to map complete supply chains, including external procurement or inter-company production. The approach is focusing solely on analysis. Further research is needed on how to support planners and lean practitioners on parameter definition (e.g. ideal buffer dimensions) based on existing data.
A further application of the map could be production control. For this, a systematic visualization of actual values and deviations should be implemented.

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Biographies

Roman Ungern-Sternberg is head of business unit "End-to-End Operations" at the Fraunhofer Institute for Manufacturing Engineering and Automation IPA in Stuttgart, Germany. As a researching consultant, he gained experience in lean production, factory planning and digital production planning and control. His research focus is on visualization of complex productions systems to derive improvement actions. He holds a doctorate degree from the University of Stuttgart.

Lena Langenfeld is research assistant in the group for Operational Excellence at the Fraunhofer Institute for Manufacturing Engineering and Automation IPA in Stuttgart, Germany. Holing a Master of Science Degree in Mechanical Engineering and in Management and Technology both from the Technical University of Munich, she deepened her background in lean production and mathematical modelling and optimization as a research assistant at the chair of Production and Supply Chain Management at the Technical University Munich. Since 2021 she is working as a researching consultant at the Fraunhofer IPA with focus on production optimization and factory and logistics planning, in both industry and research projects.