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Lean Management

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The Production Cultural Biorhythm as a New LEAN Learning Process

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Abstract. Bottlenecks limit value streams, extend lead times and thus cause high costs. ADaM24 provides a new approach to bottleneck problems by offering Advanced Data Management over 24 h for individual and organizational learning to eliminate bottlenecks (Langer et al. 2021). The basic principle to this new approach is to determine a standard day by recording it in minute intervals which are averaged over a longer period of time.

When ADaM24 is deployed at a company, it reveals six previously undiscovered and characteristic patterns of waste. These are MURA patterns of human-machine interaction, which we call "ProductionCultural Biorhythm" or PCB due to their company-related specificity. Patterns and the expression PCB were first established by Langer et al. (2021) [1] and can be demonstrated across different industries and company sizes. The processes measured at companies show that the maximum possible capacity is actually never used, in particular at bottlenecks. ADaM24's clear and easy to grasp graphical representations open up new opportunities for learning about how to make desirable behavioral changes. Moreover, it provides managers with new intervention options. Now time slots within 24 h can be selected for optimization projects, during which not only the radicality of an intervention, but also its improvement dynamics and implementation stability can be measured.

Overall, the PCB topology offers a wealth of new approaches, such as the integration of AI or even the ability to continuously identify bottlenecks "now and next" in dynamic value streams.

Keywords: Mura · Key figures · Bottleneck

1 Making Unexpected Potentials Easily Visible

ADaM24 analyzes and visualizes the results and effects of a production in a completely different complementary way, independent of the chosen production control methods or used IT systems. It is the central point of view how a workforce and the management team deals with bottlenecks in principle = culture at the bottleneck.

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1.1 Idea and Basic Principle Behind ADaM24 and PCB

In the LEAN context, daily shop floor management is one of the essential ways of integrating the benefits of the LEAN world into the day-to-day work of the relevant workforce. Up to now, key figures have been entered into monthly charts on a daily basis at fixed points in time (Fig. 1 left). It is thus possible to identify deviations from the nominal value, spot problems and initiate appropriate activities. The disadvantage of the monthly charts typically used is that each month is recorded in a separate template so that trends cannot be identified. The collected data is rarely presented in the form of key figures in a chart with a continuous time dimension (Fig. 1, center).

As part of ADaM24, key figures are continuously recorded based on short time intervals, typically five minutes, over the entire day or shift - instead of a single measured value per day or shift. In the next step, these measured values are averaged over a longer period of time, for example three months. This is how the profile of a standard day is created (Fig. 1 right). The higher the temporal resolution and the more representative the selected averaging period, the more meaningful information is included in the profile. This data collection method is the core element of ADaM24, i.e. Advanced Data Management over 24 h. It helps visualize the so-called ProductionCultural Biorhythm PCB in the form of the ROP (Real Output Profile, Fig. 1 right). These profiles allow users to identify inefficiencies, and thus provide the basis for valuable learning experiences for both staff and management. In addition, this method used to determine the standard day is not dependent on product mix or employees and is therefore considered uncritical by employees' representatives.

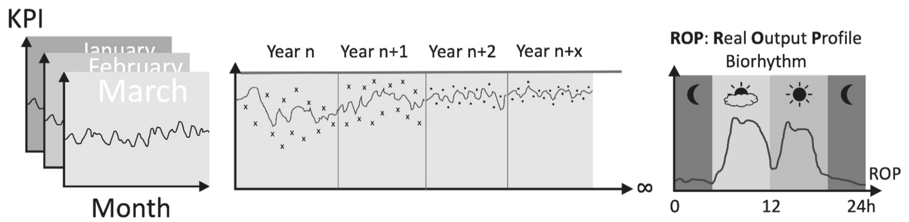

Fig. 1. Left: monthly charts; center: time series toward infinity; right: profile of a standard day (Real Output Profile ROP)

1.2 Data Collection in the Digital Age

Actual data collection in the digital age is still often laborious and performed manually. Ideally, the desired data is automatically collected from the machine controls or sensor technology. However, this state of technology has not yet been broadly implemented in the SME sector. Alternatively, data can be collected via existing MES (Manufacturing Execution Systems) or through logging operational data, although data quality remains a critical factor.

To overcome this problem, our research group is planning to develop a so-called "MuraBox". The aim is to create a plug-and-play solution, which automatically records the tact of a machine or a workstation and visualizes the ROP. In addition, it will automatically determine and present the potential analyses. This helps automate data collection in the digital age, independent of interfaces, and provides an easy-to-use solution for small and medium-sized businesses. Furthermore, data analysis is simplified by means of AI. Data will be collected using the following collection matrix:

– a single machine or a single workstation, a line or an entire plant
– manual, partially or fully automated processes
– production, logistics or indirect areas.

Interesting values are, for example: output in pieces, power consumption in kW, first time through, which refers to the percentage of faultless products in the first run, logistical activities or ERP bookings.

2 In 6 Learning Steps to LEAN Success: The ADaM24 Procedure Model According to Langer and Mussler

As a structured standard method, ADaM24 offers the possibility to use collective learning for the implementation of precise change projects in order to turn them into strong habits. The implementation of the current improvement process automatically becomes the new, familiar reference and is visualized accordingly. In doing so, we place a new layer of habit on top of the previously familiar operational levels when developing new solutions in an unfamiliar environment. This corresponds to the idea of a meta-KATA. Figure 2 illustrates the process.

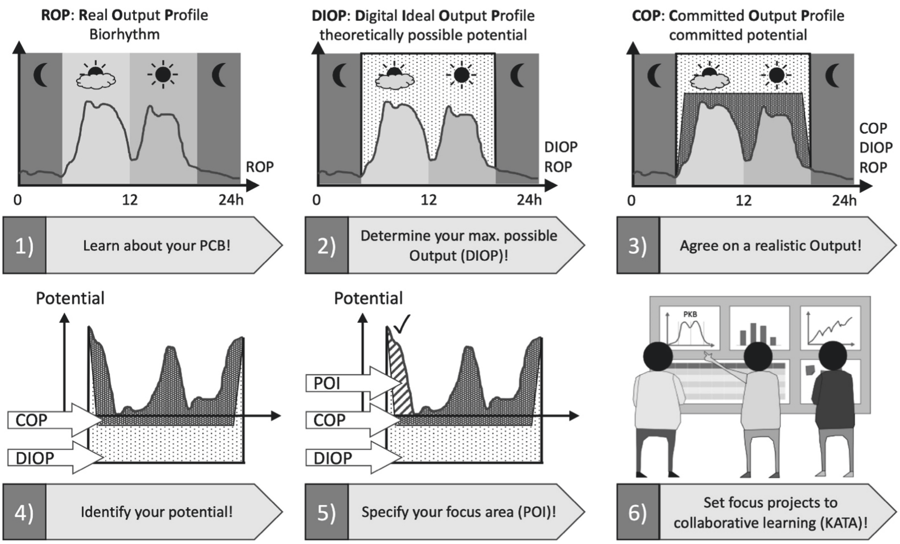

Fig. 2. The six steps of the ADaM24 model according to Langer and Mussler

1. At a bottleneck machine (according to Goldratt "*Step 1: Identify the System's Constraints"*) the ROP is determined and visualized. Previously hidden or easy to conceal inefficiencies become visible at first glance. This new form of transparency reveals phases of low productivity both in terms of shifts and in the form of deviations spread out over the day in a variety of ways. Hiding singular events proves to be advantageous. Measured phenomena, typical of the production process being examined, are shown. These are the production-cultural effects.
2. The DIOP (Digital Ideal Output Profile) visualizes what would be expected from machines, facilities and workstations according to the investment. The delta between ROP and DIOP is the potential that can be assessed using ADaM24. According to Goldratt, this corresponds to "*Step 2: The bottleneck has to be utilized to the maximum"*.
3. The COP describes the part of the potential that management and the workforce are confident of realizing. At the same time, the radicality R_V = COP/DIOP of the change becomes measurable for the first time.
4. The DIOP potential view is the difference between DIOP and ROP. It makes the maximum potential of improvement obvious. The COP potential is the difference between COP and ROP and the focus of the activities that will follow. The information can be given e.g. in pieces, EUR, capacity gain or also throughput optimization at the bottleneck. It reveals the need for action and thus has a motivating effect on all those involved.
5. As we know from Change Management, it makes sense to start at one point and achieve initial success there. For this purpose, we define a Point Of Interest (POI) timed over the course of the day on a COP potential basis as part of the ADaM24 method. The choice of this point is a good opportunity to turn those affected into actors: the workforce determines this starting point itself, which activates self-esteem, autonomy motive and self-commitment. An approach that is congruent with the motive significantly increases the chances of success.
6. Optimizations are now carried out mono-causally through POI-focused projects – this can be done by using KATA (Rother 2013 [2]), for example. After reaching the COP at the POI, additional POIs can be set according to step 5 until the total COP is reached.

The ROP approaches the DIOP as part of the ongoing optimization progress. The dynamics of change can be visualized by the dynamic PCB, while sustainability can be ensured by the static PCB. When going through the six steps, the superior and his/her team are able to jointly and consciously enter the terrain of unknown potential. A collective learning process is thus fostered, lessons learned increase the organizational knowledge base.

3 ADaM24 in Action Against Bottlenecks

It makes sense to prioritize mainly constraints for ADaM24 projects. To this end, it is required to know these bottlenecks. Detecting them is a challenge due to the shifting of the bottlenecks. There are numerous different bottleneck methods available, but only few of them work reliably with shifting bottlenecks (Lima et al. 2008 [3]). The bottleneck walk is recommended for shifting bottlenecks for most real-world systems (Roser et al. 2015 [4]). Another solution is the active period method for highly digitized systems or simulation-based experiments (Roser et al. 2001 [5]). The bottleneck walk does not detect the bottleneck directly, but instead analyzes which inventory or process waits for other processes in order to determine the bottleneck. The active period method defines the bottleneck at any given time as the process covering the longest period without waiting for another process (the active period) at that time.

System performance is defined by the bottleneck, or in most real-world production systems, by the interaction and change of shifting bottlenecks over time. Following the biological biorhythm, bottlenecks can be seen as constrictions of the arteries of the production system. The PCB of a production system also reflects the behavior at the bottleneck.

Figure 3 shows that when using the PCB, it is helpful to first have a look at the dominant bottleneck machine (M3 on the left) and possibly reach the DIOP (M3 on the right). This helps increase the throughput at the critical spot and thus resolves the bottleneck. The M4 machine becomes the new bottleneck. It is not advisable to start using ADaM24 for non-bottleneck machines; this would result in more push throughput, growing inventories and even longer lead times, as known from value stream mapping.

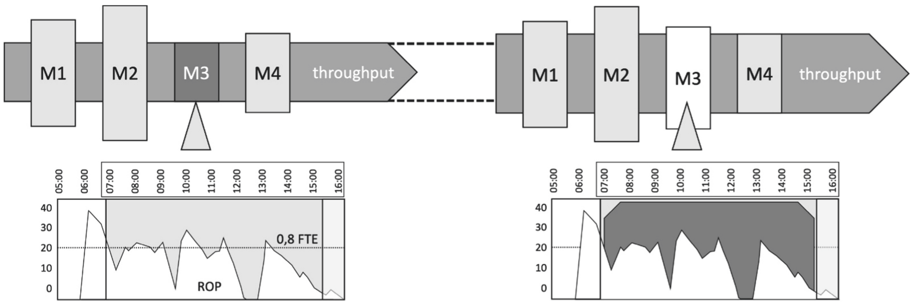

Fig. 3. Increase throughput based on POI projects

A broader view helps to identify patterns over time intervals (e.g. per week, month or quarter). As a result, we can identify phenomena such as bottlenecks that occur at different locations/points on monday morning than on other days of the week, for example.

The previously mentioned MuraBox is used to match the ADaM24 and the work-in-process inventories, so that the current bottleneck and the bottleneck that follows after unblocking the previous constraint (now and next) can be determined predictively.

4 PCB in the Context of LEAN Thinking and Industry 4.0

LEAN managers are always on the lookout for new innovative ways to optimize and increase efficiency. ADaM24 allows them to visualize company-specific MURA patterns and discover a new perspective on industrial production processes. Within the scope of LEAN consulting mandates, project works, bachelor's and master's theses, approx. 280 profiles have been created and examined for PCB patterns.

Figure 4 shows a selection of ROPs for different supply levels (OEM, Tier 1 - Tier n), industries and company sizes. The ProductionCultural Biorhythm reveals weaknesses in production, logistics, operations and so on.

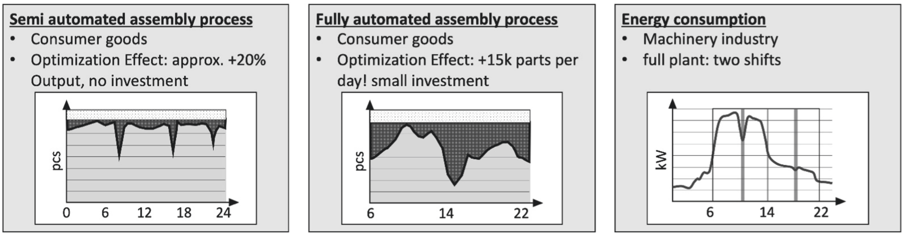

Fig. 4. ROP examples in industry

In most cases, superiors and employees are equally surprised by the patterns of the PCB effect. During interventions where ADaM24 was used to help change human behavior and human-machine interaction at bottleneck machines, significant improvements of up to 83% could be achieved.

5 Cybernetics and PCB in Learning Organizations

The PCB methodology opens up a new perspective on managing complex systems. It applies cybernetics to control and regulate a system according to its purpose, whereby various problems of system control are to be solved by the manager (Steckelberg and Harrer 2021 [6]). In doing so, it is essential that managers lower the degrees of freedom and/or reduce complex issues to merely complicated ones.

Measurement of the PCB does not initially reduce the degrees of freedom of the system, nor does it restrict the state of workers, machines, lines or plants. However, the PCB does represent a crucial and novel variable that is provided as feedback to system managers. This enables them to make targeted interventions within complex systems. This system approach is also described in models of the learning organization according to Senge 2021 [7]. The PCB suggests that teams and managers look into the following questions:

- Which of our cultural behaviors are causal to the ROP identified?
- What level of radicality R_V do we want to aim for in change projects?
- How do we achieve general organizational, technology-related and cultural learning through the PCB?

These questions, stimulated by the PCB, enable learning in the process of change. The PCB thus provides cybernetic system access at a previously inaccessible, cultural level of production units.

6 The Psychology of Learning in Use for the Implementation

How hard can it be? Why can't they just do it? How can I get my people on the right track? Experienced LEAN managers are all too familiar with these types of questions. There is no universally valid answer to these types of questions. The answer always depends on the personality traits, relationships and relationship histories of the people involved, as well as on the traits of the organization. We have picked three possible use cases, in which answers become transparent through the PCB: Employees.

- receive an additional break as a result of wrongdoing,
- get to pay back experienced injustice or
- feel clever by subverting "the system".

When managers try to stop this wrongdoing, they are actually asking a lot from these employees: "Employees are expected to give up their personal goals in favor of the goals of the manager".

From the employees' point of view, there have to be very good reasons to do so. Many change management procedures fall short here, because they focus on replacing one process by another that is perceived as equivalent. Changing habits in this sense proves difficult enough - but getting employees to adopt an inner attitude that involves giving up their personal goals is a far greater challenge. If this is achieved, so-called "extra-productive behaviour" sets in - and LEAN principles are followed in accordance with a deep, inner attitude.

There is no standard solution when it comes to implementing the PCB. We know from Dalal's (2005 [8]) meta-analysis of 45 studies with a total of 16,721 respondents that the difference between counterproductive and extra-productive behavior is significantly determined by the personality trait conscientiousness as well as by job satisfaction, commitment, and perceived fairness.

Determining a concrete procedure requires a business-psychological and organizational diagnosis supported by ADaM24.

7 PCB Topology Shows Concrete Lines of Action

The PCB topology depicts the ADaM24 and PCB action map. In addition to the procedure model, other interesting research, action and transfer strands are derived:

- To date, six basic MURA patterns have been identified that are independent of industry and organization. Further patterns are to be discovered by means of AI in order to develop generic, industrial solution approaches.
- Radicality R_V is examined as an evaluation measure for change processes.
- Determination of the POI or COP/DIOP potential is to be automated, initially at machine or workstation level, and later for the entire value stream.
- It is now possible to show the sustainability (stability) of change activities as a measure via the static PCB.
- The change dynamics of change processes can now also be made visible as a measure via the dynamic PCB.

– In addition, the robustness of processes can be determined by the static PCB and subsequently by the dynamic PCB.
– The visualization of dynamic bottlenecks (now + next) on shop floor level is a powerful management tool that motivates employees and steers them in the right direction.
– New indicator lamps with a count- and sum-up display show "now + next" downtimes right at the bottleneck machines.

From all this we may conclude that ADaM24 and the PCB make a significant positive contribution to change activities in organizations and consulting business when it comes to bottleneck optimization.

References

1. Langer, B., Gems, B., Wenger, D., Schäfer, T., Roser, C.: Auch Maschinen haben einen Biorhythmus [Machines also show a biorhythm]. ZFO Zeitschrift Führung + Organisation **90** (2), 74–82 (2021)
2. Rother, M.: Die Kata des Weltmarktführers: Toyotas Erfolgsmethoden [The Kata of the Global Market Leader: Toyota's Success Principles]. 2nd edn. Campus, Frankfurt/Main (2013)
3. Lima, E., Chwif, L., Pereira Barreto, M.R.: Methodology for selecting the best suitable bottleneck detection method. In: 2008 Winter Simulation Conference, WSC 2008, pp. 1746–51 (2008). https://doi.org/10.1109/WSC.2008.4736262
4. Roser, C., Lorentzen, K., Deuse, J.: Reliable shop floor bottleneck detection for flow lines through process and inventory observation: the bottleneck walk. Logist. Res. **8**, Article No. 7 (2015). http://link.springer.com/article/10.1007/s12159-015-0127-2
5. Roser, C., Nakano, M., Tanaka, M.: A practical bottleneck detection method. In: Peters, B.A., Smith, J.S., Medeiros, D.J., Rohrer, M.W. (eds.) Proceedings of the Winter Simulation Conference, vol. 2, pp. 949–53. Institute of Electrical and Electronics Engineers, Arlington (2001)
6. Steckelberg, A.V., Harrer, C. (eds.): Leadership & Management. Ganzheitliche Betrachtung von Führung und ästhetikbasierte Qualifizierung von (Nachwuchs-)Führungskräften. 1st ed. Springer Fachmedien Wiesbaden GmbH; Springer Gabler, Wiesbaden (2021)
7. Senge, P.M.: Die fünfte Disziplin. Kunst und Praxis der lernenden Organisation. [The Fifth Discipline: The Art and Practice of the Learning Organization], 11th edn. Schäffer-Poeschel, Freiburg (2021). (Systemisches Management) [Systemic Management]
8. Dalal, R.S.: A meta-analysis of the relationship between organizational citizenship behavior and counterproductive work behavior. J. Appl. Psychol. **90**, 1241–1255 (2005)