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E-Kanban Application and Value Stream Mapping in the Optimisation of Logistics Processes

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Abstract
The article focuses on the issue of streamlining logistics processes by applying selected VSM and kanban lean tools, which are also of great importance in the current digital age, especially from the point of view of finding the potential for eliminating processes and activities that do not add value. Unlike traditional supply systems, the new dynamic approach to inventory management is that it considers unique procurement methods, unique demand, and product flows through the manufacturing process. The mentioned approach aims to define the optimal amount of stock, which can ensure the required level of supply service and, at the same time the efficiency of material flows in production and assembly and reflect on fluctuations in demand In the analysis and verification of outputs, methods of lean production, VSM, OEE monitoring, and kanban were used. An object-oriented approach to business process modelling using ARIS software was used for process algorithmizing.

Keywords
Lean, kanban, value, efficiency, logistics, process.

Introduction

Businesses today collect a large amount of information and data about their products, their variants, production processes, employees, suppliers and customers, and apply their enterprise software systems. However, these systems cannot effectively integrate and process data from different areas. When switching to the concept of the so-called smart production with the support of smart logistics, it is necessary to electronically record, organize and complete data, and then with the help of software support create an information network for the company, which will provide the possibility of management and coordination of all production and non-production operations – production, logistics, quality control, maintenance and the like. The goal is to create a computer-connected intelligent logistics network of the production process that will bring added value through communication between relatively autonomous entities, thereby achieving speed, flexibility and quality of the value stream (Grznar et al., 2019; Knapcikova et al., 2020; Straka et al., 2022).

The current convergence of the physical world with the world of digital technologies represents a new paradigm of an autonomous and decentralized environment in the field of production. The digitization of production and products is not the only driving force of Industry 4.0, it is also the possibility of networking technical systems in real-time (Fedorko et al., 2018; Edl et al., 2014; Rosova & Malindzakova, 2014).

Such an environment in connection with Industry 4.0 creates a new business ecosystem. Creating partnerships, open networking of manufacturers with suppliers and customers, or even with competitors (opening up opportunities for customer involvement in the product development process, i.e. shifting certain activities to the customer) creates the basis for the development of new business models, and this can be considered revolutionary.

Interesting for further research is the study by the authors (Gdowska & Książek, 2013) aimed at testing the mixed integer programming model, which was used

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to solve the cyclical delivery planning problem for customers with different priorities. Emphasis is placed on the use of a genetic algorithm to optimize warehouse sorting in their study (Grznar et al., 2021; Wozniak et. al., 2016). Another work of the authors and a mixed-integer programming (MIP) model that was developed to solve cyclic delivery synchronization with vehicles serving fixed routes (Gdowska & Książek, 2015). It is also important for the long-term sustainability of the high efficiency of logistics processes to deal with the area in the context of environmental approaches, which are pointed out by the authors (Vegesoova et al., 2019; Malkus et al., 2023; Moravec et al., 2021) and with societal impacts in terms of political and economic factors that affect a specific country (Glova et al., 2020).

The aim of the study (Kreutz et al., 2021) was to develop a self-learning e-kanban system with automatic order management using machine learning and data collection from autonomous sensor modules that measure the level of filling of carriers. This study has application potential in various industries and to increase the effectiveness of the implementation of kanban in practice.

An interesting study from the point of view of finding effective route management, which is crucial for the optimization of supply, is the study by the authors (Aungkulanon, P., 2024), where the authors focused on the optimization of real estate maintenance. The authors study three distinct algorithms: Saving, Nearest Neighbour, and an Evolutionary Algorithm (EA) customized with Dual Response Surface Optimization (DRSO).

Authors (Mayo-Alvarez, L., 2024; Tomaszewska, 2023) focus in their study on the integration of the Drum-Buffer-Rope (DBR) method with Scrum-kanban and the use of Monte Carlo simulation to maximize throughput in agile project management. They demonstrate that linking DBR with Scrum-kanban maximizes Throughput and minimizes ending inventory.

Inventory optimization is a necessary condition for ensuring a smooth flow and achieving a high level of flexibility, efficiency and productivity. It is necessary to balance supply vs. demand. Solving the causes of fluctuations in warehouses is possible by introducing modern information and communication elements. It is important to gain control over what is in the warehouse and what range of activities the warehouse provides.

Integrated planning and management of logistics systems and networks based on digital models, methods and tools, which are built on a common flexible information and communication platform, are a necessary condition for maintaining a high level of competitiveness.

Materials & Methods

The introduction and active use of the kanban system has been steadily increasing in recent decades. It is a Japanese production planning and management system with the aim of minimizing inventory and work-in-progress and thus increasing efficiency within production. kanban belongs to pull production systems.

The kanban card is the basic component of the kanban system. The card placed in the appropriate place is a signal for the movement of material, work in progress or finished products within the production company, from the supplier to the production company or from the production company to the customer.

For the successful implementation of the kanban system, it is necessary to observe the following basic principles:

- Visualization of the process – the effort is to visually map the entire course of the process in its current state, that is, before the implementation of the kanban system. Based on this visualization, bottlenecks and deficiencies in the production process can be identified. Visualization also serves to communicate and represent achieved results by comparing the future state with the starting point.
- Reduction of work-in-progress – the goal of the kanban system is to increase efficiency in production, especially by decreasing excess production, which leads to an increased state of work-in-progress and other resulting waste. The essence of kanban is to start production based on customer demand, which prevents the creation of excess stocks and bottlenecks.
- Focusing on flow – flow needs to be monitored and analysed to ensure smooth production. Smooth flow is characterized by the movement of material or of production in progress within the production process without delay, while there are no frequent stops and restarts of production.
- Continuous improvement – kanban system requires continuous tracking and monitoring in view of constantly changing customer requirements to continuously improve the flow of production.

With a manual kanban system, demand information is transmitted via physical kanban cards. Signals to start production are also sent manually from the customer to the supplier. However, this traditional kanban system has its limits. Improper handling of the cards, either by moving them at the wrong time or by loss or duplication of cards jeopardizes the flow of production.

With the ever-shortening production times and increasing volumes of production, the number of kanban cards and the associated problems for maintaining and clarifying the kanban system are also increasing. Thanks to technical progress, the physical kanban system is gradually being replaced by an electronic system, where demand signals are generated and sent automatically based on the current need. These signals are transmitted electronically. Each signal is recorded and stored, which enables comparison of historical data. By implementing electronic kanban, it is possible to achieve:

- kanban data management
- increasing speed of information transfer
- transparency of the system
- support of the existing kanban system
- continuous improvement within the kanban system

Electronic kanban must follow the same principles as the traditional manual kanban system. These principles mainly include the creation of a smooth material flow, the synchronization of production operations, the elimination of bottlenecks and the creation of a traction system in production. Like manual kanban, electronic kanban must support continuous improvement, which is generally considered the most important feature of a kanban system. The effort is to minimize stocks and production batches to a minimum, which leads to the detection of deficiencies in the production process and their elimination after taking corrective measures. By collecting data, reporting on production operations and the movement of materials and stocks, electronic kanban contributes to continuous improvement according to the possibilities of data archiving. The working environment of the online kanban system should be intuitive and easy to use correctly. The electronic kanban system should be as user-friendly as possible to suit the capabilities of all users within the organization. Compared to the traditional approach, electronic kanban brings solutions in many areas, in particular:

- elimination of card manipulation
- elimination of problems related to frequent loss of cards
- improved visibility of signals for starting production
- improved communication with suppliers within the production process
- analysing the efficiency of the supplier within the production process
- delivery of the required material, production in progress or finished products always at the right time
- minimization of downtime due to missing material
- improving the transparency of the supply chain

Electronic kanban solves many of the problems that occur when using physical kanban cards. The process becomes clearer, faster and more reliable. It helps to solve problems related to the error rate of production equipment, the quality of the produced production or the flow of material and values within the production process. An indisputable advantage of electronic kanban is access to the system even outside the production process or even the production plant. Users and managers thus can monitor and evaluate current data about the production process in real-time. Online kanban makes it possible to convey information about the status of each production station.

Electronic kanban enables the implementation of a pull system of production even where traditional kanban often fails. These are productions with frequently changing customer demand. In this case, the electronic kanban within the computer application reacts more flexibly to changes and adapts production accordingly. Currently, electronic kanban allows to evaluation of the impact of errors and malfunctions on machines and equipment in the production process thereby minimising the negative impact on the production plan.

The following Tab. 1 captures the main differences between the traditional kanban system, which uses kanban cards and kanban boards to transmit information, and electronic kanban, which runs as a program on a personal computer.

Table 1
Comparison of traditional and electronic kanban systems

Traditional kanban	Electronic kanban
• usually chaotic data management – accesses, excel, etc. • difficult handling of many kanban cards • limited possibilities of sending kanban cards over long distances • low transparency of orders and stocks – not in real-time • problematic definition of priorities • no record of historical data • manual data transfer to the superior system	• a specific system created for kanban • many items is not a problem • automatic sending of data worldwide • current overview of orders and stocks in real-time • priorities generated automatically • data is archived and evaluated using various tools • automatic transfer of data and reports

Source: own work

Online kanban, unlike traditional manual kanban, in many cases works with the use of barcodes or RFID chips, which are used to mark material, work-in-progress and finished products. RFID technology is mostly applied internally, within the organization. Barcodes are suitable for the introduction of an online kanban system in the entire production chain, i.e. from suppliers of materials and components to the final customer. Through these technologies, the movement of material in production is captured, either by scanning barcodes or collecting data via RFID readers. The data is displayed on an electronic kanban board. This board can be visualized on personal computers as well as mobile devices such as tablets, mobile phones, etc.

The trend of recent decades is the constant increase in the flexibility and efficiency of production processes. This trend is also valid in the field of production planning and management. Considering the basic principle of the kanban system, i.e. continuous improvement, the creation of an electronic kanban system is a natural development.

The general methodology, which was the starting point and was subsequently modified for the needs of processing the study, is shown in Fig. 1.

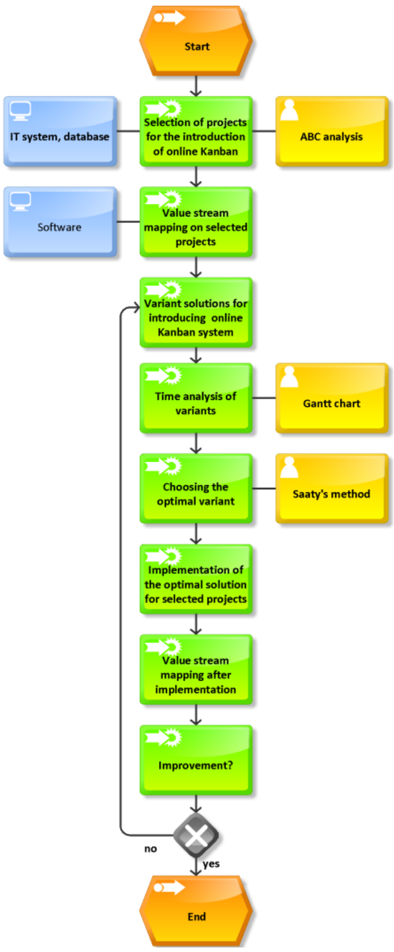


Fig. 1. General methodology for kanban – own processing

The implementation of kanban requires relevant input data on flows in production. This data can be obtained using the material flow analysis method, so-called VSM, which was applied in the case study. This is an industrial engineering method focused on mapping the value stream in all processes from the input of materials into production to the actual shipment of materials to customers. This method detects processes with added and without added value in production, logistics, administrative and service processes, which open possibilities for improving the efficiency and productivity of processes. The goal of VSM is not only to track the material flow but also the information flow in the representative labelling of individual processes according to given standard procedures. The goal of value stream mapping itself is not only to map the current state, but it is also necessary to create a map of the future state of the value stream. Value stream optimization is necessary for a successful understanding of possible improvements and their benefits for the future value stream.

Case study

The car seats of the L405 project are currently among the most luxurious and therefore also the most expensive car seats that the company currently produces. At the same time, these car seats are also the most complex project within the plant due to the complexity of the construction. These are rear car seats that are fully electrified. The car seat contains 21 motors that ensure the movements and displacements of the car seat, i.e. its perfect adaptation to the demands and needs of the driver. The functions that rank this car seat among the luxurious ones include e.g. possibility of massage, adjustable footrest, adjustable armrest, memory functions, refrigerator in the interior of the vehicle and many others. These car seats are produced in 3 versions: for the European market where the driver's seat is on the right side of the car, for the English market and a car seat for the European market containing a refrigerator.

These car seats are delivered separately to the JIT plant. It is only in the JIT plant that they are assembled into a single unit, and the assembly of individual plastic covers, foam and cover parts. Subsequently, the car seats are delivered to the OEM, where they are assembled and tested directly in the car structure.

The production company produces and distributes 8 separate sales items within the L405 project.

For the needs of value stream mapping, it is necessary to determine a product representative from the product group for the L405 project. For this purpose, we will create a product process matrix (Tab. 2).

Table 2
Matrix process/product L405

	Process				
	Pressing	**Bending**	**Bending**	**Varnishing**	**Assembly**
X260 40 RH		×	×	×	×
X260 40 LH		×	×	×	×
X760 40 RH		×	×	×	×
X760 20			×	×	×
X760 40 LH		×	×	×	×
X760 100	×	×	×		×
X260 100	×	×	×		×
X761 40 RH			×	×	×
X761 20			×	×	×
X761 40 LH			×	×	×
L560 20			×	×	×
L560 40 LH		×	×		×
X260 SB		×	×		×

Source: own work

Based on the process/product matrix, for the needs of value stream mapping, the product group Armrest LH appears to be suitable. The product representative for this group will be the moulding, which is one of the first components entering the production process. This moulding is a purchased part from an external supplier.

The production process of the LH support begins with resistance welding, in which the pressing or product representative welded the nut through resistance welding technology. This nut secures the motor during the assembly process. The created substructure is stored in the box and subsequently enters the riveting process. Since the scoring and riveting equipment are located nearby and have similar process times in terms of material flow, a minimum stock is created between them. During the riveting process, another moulding is attached to the sub-assembly by riveting. This subassembly is stored on a rack used for work-in-progress and creates an intermediate stock of 220 pieces.

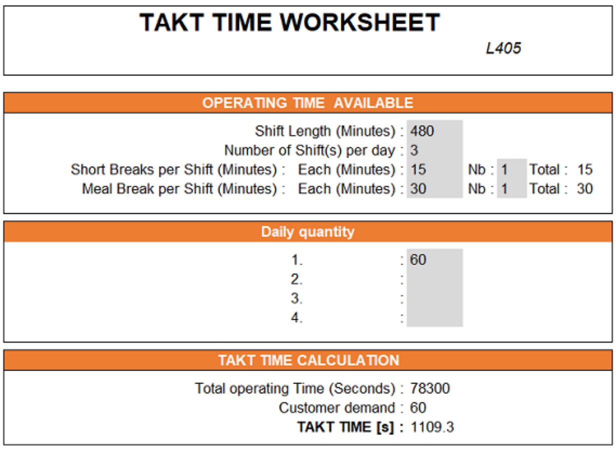
The process of robotic MAG welding follows during which the subassembly becomes part of the LH support. After robotic MAG welding, the supports are placed on racks and transported to the paint shop area. Electrophoretic dip painting in black is in progress. After painting, a safety stock is created, when the armrests are stored on special stands protecting the armrests from damage. From this stock, the stands with armrests are transported to the assembly area, where the car seat is completed. At the end of the assembly line there is a tester that checks the presence of components, the functionality of the motors as well as the correct range of movements of the armrest. After testing, the armrests are packed by the operator in a specific customer package and are taken to the warehouse of finished products by the logistics operator using handling equipment.

To implement the VSM method, it is necessary to know:

- tact time,
- frequency and size of deliveries from the supplier,
- frequency and size of deliveries to the customer,
- production process:
- production time,
- size of production batches,
- variability,
- occupancy of machines,
- utilization of the machines.

Figure 2 shows the calculation of the cycle time for the L405 project, considering the current daily demand from the customer of 60 pieces, which is determined from the weekly demand recorded in the ERP system. Due to the need to analyse the application of OEE (represents the total time a facility is expected to produce, starting with the production time, and examines all productivity and efficiency losses that occur during that time, the goal is to limit or eliminate these losses.) when introducing an online kanban system, this indicator is calculated for each machine, as shown in Fig. 3 and written into the value stream map.

From the value stream map for the L405 project (Fig. 2), it is apparent that the total production time for the LH abutment is approximately 170 hours. Thus, after 170 hours, the LH support leaves the production


TAKT TIME WORKSHEET
L405

OPERATING TIME AVAILABLE

Shift Length (Minutes) :	480		
Number of Shift(s) per day :	3		
Short Breaks per Shift (Minutes) : Each (Minutes) :	15	Nb : 1	Total : 15
Meal Break per Shift (Minutes) : Each (Minutes) :	30	Nb : 1	Total : 30

Daily quantity

1.	: 60
2.	:
3.	:
4.	:

TAKT TIME CALCULATION

Total operating Time (Seconds) :	78300
Customer demand :	60
TAKT TIME [s] :	1109.3

Fig. 2. Project L405 cycle time calculation. Source: own work

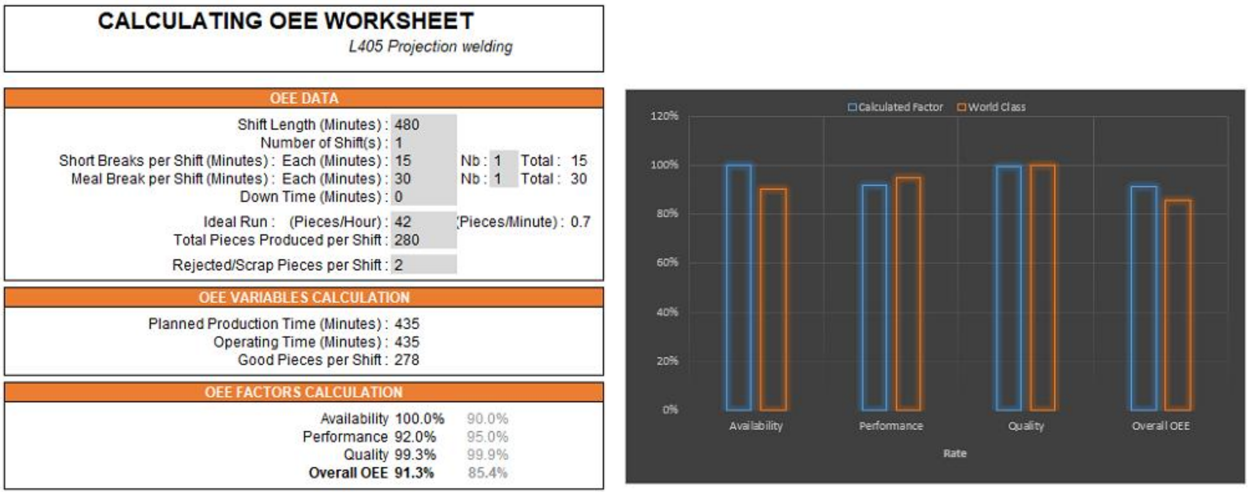


Fig. 3. Calculation of OEE for a resistance welding workplace. Source: own work

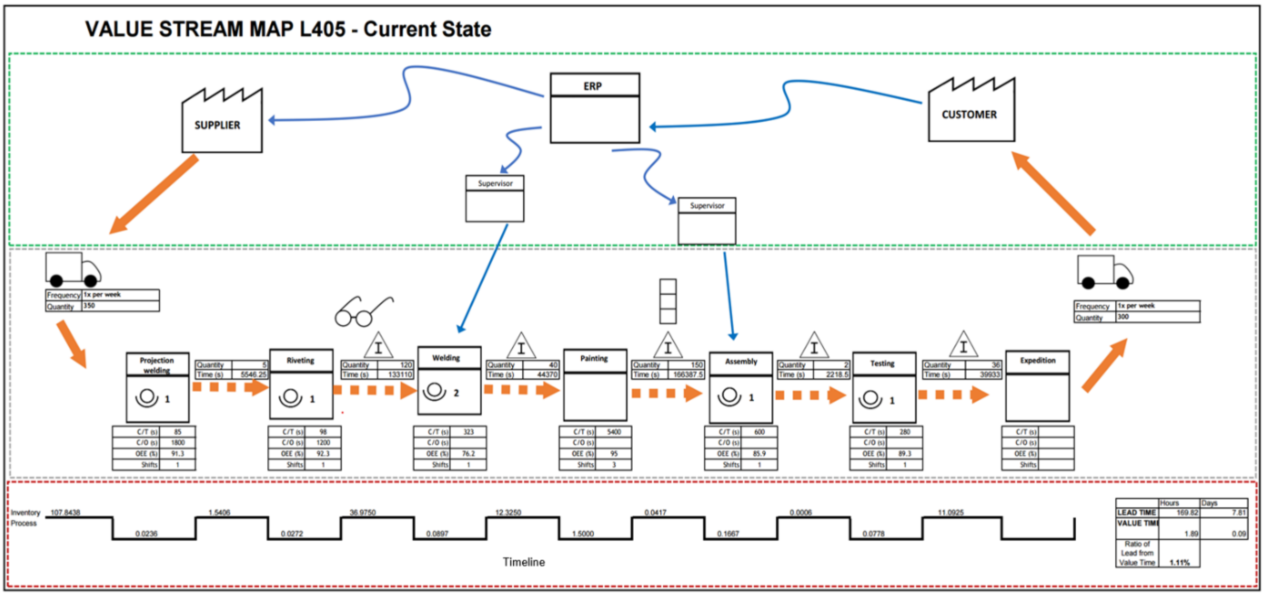


Fig. 4. Value stream map for the L405 project – current status, schematic representation. Source: own work

process. However, if we take into account only the time during which the input material is transformed into a finished support, this time is 1.89 hours. The ratio of these times represents 1.11%, Fig. 3. Value stream map for the L405 project – current status, schematic representation is processed in Fig. 4. VSM output for L405 project is shown in Fig. 5.

	Hours	Days
LEAD TIME	169.82	7.81
VALUE TIMI	1.89	0.09
Ratio of Lead from Value Time	1.11%	

Fig. 5. VSM output for L405 project Source: own work

Using the corporate information system, the logistics department sends the production plans to the welding and assembly supervisors, who then compile partial plans. Production planning for the riveting process is carried out by the "Go and see" system, which is indicated by the symbol of glasses in this process. The same planning method also applies to the resistance welding process, since the riveting process and the resistance welding process are connected to each other.

Results

Analysis of the L405 project after the implementation of the online kanban system

From the point of view of information flow, the introduction of the online kanban system will bring change, especially in the form of the implementation of software that directly communicates with production equipment. There is no longer communication with the production components using the ERP system, i.e. by supervisors, who then manually plan production at individual workplaces, often using the "Go and see" system. The communication is two-way, so from the software to the production equipment, production requirements are directed, and from the production equipment to the software, current information and data are transferred.

From the point of view of the material flow, the introduction of the online kanban system will bring a significant reduction in interoperation stocks or production in progress. Figure 6 captures the expected state after the implementation of the system on the L405 project, where it is possible to set optimal stocks between the riveting workplace and the welding workplace. A significant reduction in stock occurs after painting, where, however, there remains a safety stock of the size of 2 production racks, i.e. 20 pieces. This stock serves to ensure the necessary number of pieces in case of a breakdown at the welding workplace, where the OEE is only 76.2% due to the frequent unavailability of production equipment due to technical failures. In case of unavailability of the welding workplace, the safety stock is set for 2 hours, during which it is necessary to identify and eliminate the cause of the technical failure.

There is no change in inventory between the assembly and testing workplaces, as the workplaces are located nearby and there is minimal inventory between them. Stock reduction is possible even after the testing itself, where a stock of 15 pieces in one customer package will be created before shipping.

After the implementation of the online kanban system, it is therefore possible to reduce the production time for the L405 project from the original 169.82 hours to 132.5 hours, while the ratio of the production time to the value-creating time would increase to 1.42% (Fig. 7).

	Hours	Days
LEAD TIME	132.50	6.09
VALUE TIMI	1.89	0.09
Ratio of Lead from Value Time	1.42%	

Fig. 7. Estimated VSM output for project D7. Source: own work

By introducing e-kanban, the company achieved the goal of adapting to changing demand. When using the physical kanban system, the number of tags is set depending on the real demand and following the replenishment time.

VALUE STREAM MAP L405 - Future State

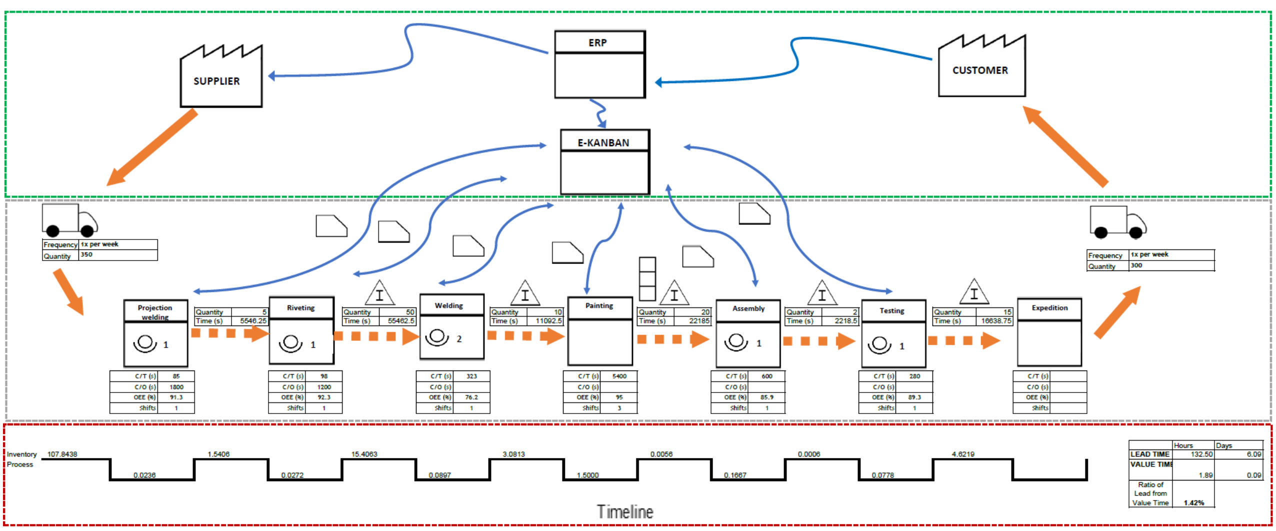


Fig. 6. Value stream map for project L405 – future state, schematic representation. Source: own work

When changing the demand, it is necessary to add or remove physical kanban cards from circulation to effectively reflect changes. In practice, it is difficult to achieve an optimal state of cards in circulation, which causes an excess or lack of supplies. The introduction of virtual kanban cards contributed to solving this problem, as the system is dynamic and capable of flexibly adjusting the number of virtual kanbans according to specific changes.

Benefits from the implementation of online Kanban system

For the needs of implementing an online kanban system, it is necessary to carry out an analysis and a detailed description of the individual steps of the procedure for implementing this system, while it is necessary to take into account the specifics of the manufacturing company, to know the level of IT support in the plant, to know the technologies that the manufacturing company has and which could be beneficial during the implementation online kanban system. Since the analysed manufacturing company has digital twin technology and Tecnomatix Plant Simulation software, we will also consider using these tools when introducing online kanban in the manufacturing company.

The detailed design process for introducing an online kanban system in a manufacturing company will be implemented through an object-oriented approach to modelling business processes, specifically in ARIS Express software (Software AG, ARIS, 2024). Due to the existence of several possible ways of introducing an online kanban system, several models will be created.

The first stage in the introduction of an online kanban system in a manufacturing company is the creation of a deployment project, which consists of the creation of a functional and design structure. The goal will be mainly workplace analysis, logistics analysis, production process analysis, enterprise ERP analysis and system rules analysis. Within this stage, the technical specifications of the system should also be identified, such as data collection, evaluation, interpretation, display and data transmission. So this is a proposal of a data model. Since the manufacturing company has digital twin technology, it is possible to use this platform in the creation of a data model as follows, Fig. 8:

- data from the production line are sent to the OPC (Open Platform Communications) server,
- from the OPC server, the data is redirected to the SQL (Structured Query Language) server,
- data from scanners or readers of logistics workers are sent directly to the SQL server,
- this is followed by data evaluation according to established technical specifications,
- in the digital environment, a virtual SQL server is created with which the digital twin platform will work and in which real production data is mirrored,
- interested persons will then analyse the created data model.

For the successful implementation of the online kanban system, it is necessary to define the deployment schedule, Fig. 9. The first stage of the introduction of

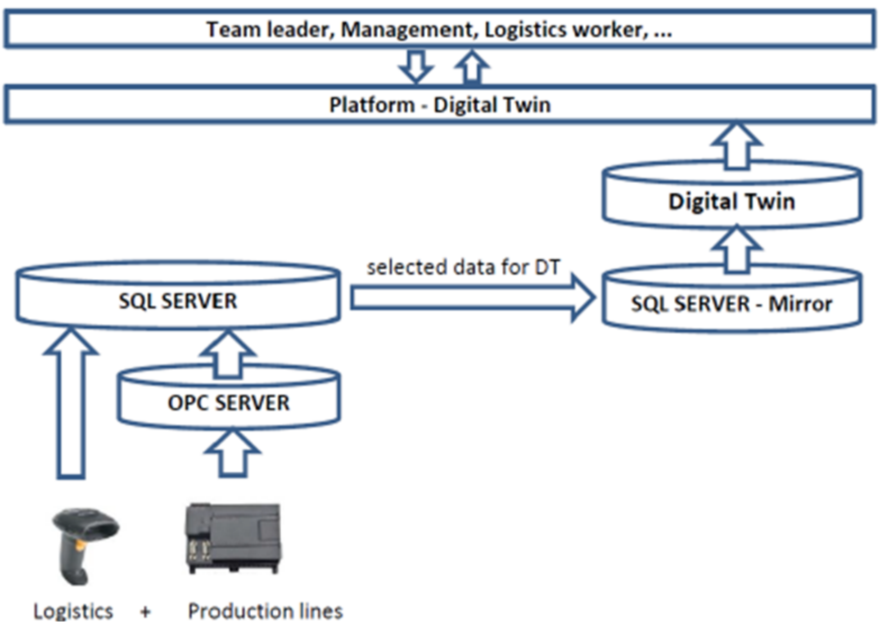


Fig. 8. The principle of creating a data model using the digital twin platform Source: (Grznar et al., 2021)

the online kanban system will be completed with the approval of the solution and the deployment schedule by the responsible management of the production company. If the solution and deployment schedule are not approved, they need to be revised and resubmitted for management approval.

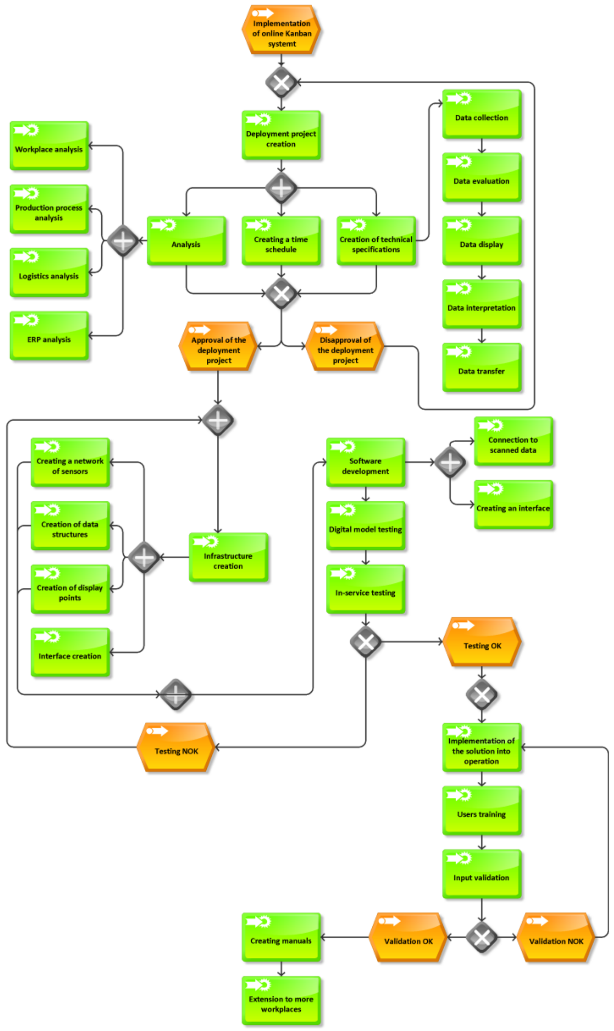


Fig. 9. Proposal for introducing an online kanban system Variant A. Source: own work

The second stage of implementing online kanban will consist of the creation of the infrastructure itself in the production company. This is the introduction of sensors or another technique depending on the preferences of the production company at workplaces used for collection, evaluation and management using the online kanban system. The creation of display points for logistics will also be included. The next steps in the second stage will be the creation of data structures on the servers and the creation of a user interface, e.g. readers, PCs, etc.

The next stage is the development of the software itself, considering the requirements and specifics of the production company. Part of it is the creation of a link to real scanned data as well as the creation of an interface for end users, in this case, logistics workers or production operators.

This is followed by the phase of pilot testing in operation at the selected workplace. With this method of testing, it is necessary to carefully consider the choice of the workplace due to the possible downtime that may occur during testing. Testing will take place at one separate workplace. If the online kanban system runs smoothly, it is possible to proceed to the final stages of the kanban system implementation process. In case of identification of faults or the possibility of improving the system will result in its revision.

The next and at the same time the final stage is the creation of manuals necessary for controlling the system and putting the system into operation. After the successful implementation of the online kanban system at one workplace, it is a matter of course to extend the system to other workplaces in the production company.

Analysis of the introduction of variants of the online kanban system using a Gantt diagram

In the following part, we will focus on the time analysis of the introduction of the online kanban system in the production company, the general evaluation of individual variants and the choice of the optimal variant.

Time analysis will be carried out using the principle of the Gantt diagram, where for each activity belonging to the individual stages, approximate implementation times expressed in working days will be defined based on assumed estimates and experience while considering the smooth progress of the introduction of online kanban without identifying errors and subsequent additional adjustments to the system.

When designing and analysing the time implementation of the introduction of the online kanban system for Variant A (Fig. 7) we will consider the beginning of June as the start date of the design project. For the overall stage of the creation of the functional and design structure, a duration of 39 working days is assumed, while 23 days belong to the analysis of the current state of production. At the same time, it is possible to identify the time schedule of the introduction. After knowing the current state of production, it is possible to implement activities related to the creation of technical specifications within 15 days. According to the Gantt chart in Fig. 10, is the approval of the proposed deployment project.

The infrastructure creation stage is considered to require 22 days. The work related to the creation of the sensor network represents 11 days. This is followed by the creation of data structures in the duration of

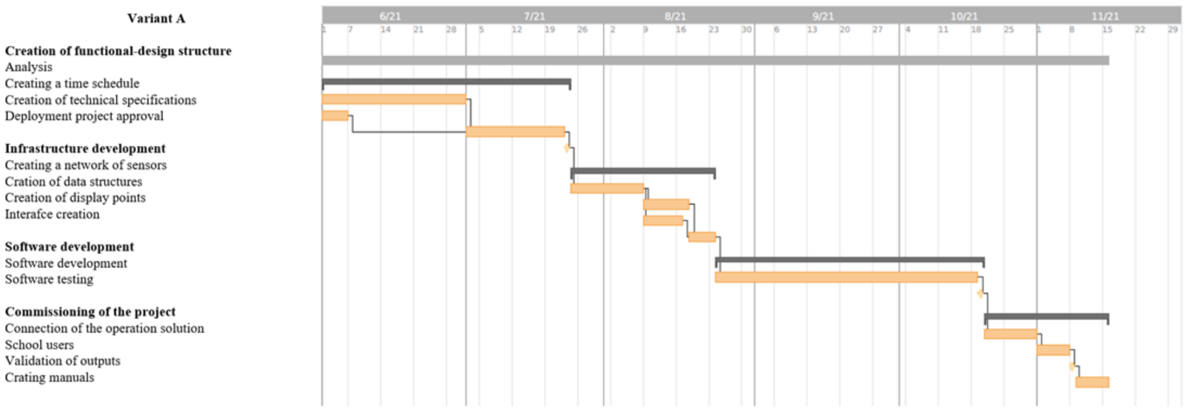


Fig. 10. Gantt chart for Variant A Source: own work

7 working days, and at the same time, it is possible to realize the creation of display points for logistics in the expected duration of 6 days. After the completion of the creation of data structures, the user interface creation process takes 4 days. The development of the software itself, considering the individual specifics of the production operation, is a critical activity in the entire process, and as such it deserves 39 days. Another milestone follows, which is the testing of the designed system solution in operation. After successful testing, it is possible to connect the designed solution to operation within 8 working days. Detailed training of all users at different levels of the organization is expected to last 5 days. Output validation is the last milestone in the online kanban system design process. The last step is the creation of user manuals during the next 5 working days.

The entire online kanban system design process for Variant A is expected to take 120 working days.

Discussion

The article focuses on the issue of streamlining logistics processes by applying selected VSM and kanban lean tools, which are also of great importance in the current digital age, especially from the point of view of finding the potential for eliminating processes and activities that do not add value. Unlike traditional supply systems, the new dynamic approach to inventory management is that it takes into account unique procurement methods, unique demand, and product flows through the manufacturing process. The mentioned approach aims to define the optimal amount of stock, which can ensure the required level of supply service, at the same time the efficiency of material flows in production and assembly and reflect on fluctuations in demand.

According to the opinions of experts (Hofmann & Rüsch, 2017), the operation of Industry 4.0 is different at the strategic and operational levels. This is due to the simpler automation of processes at the operational level, which is characterized by high labour and repeatability. However, some experts believe that it is the introduction of technologies at the operational level that will trigger changes at the strategic level of logistics chain management. This is also in context with the main idea of Industry 4.0, which was presented in Hanover (2011), i.e. increase the competitiveness of German industry, without the need to move production to low-cost countries. The potential for maintaining competitiveness is to focus on piece production (serial production equal to 1) with personalization of products in the broadest sense and at a price comparable to mass production, in cities and regions to focus on B2B/B2C, i.e. to be close to the customer, to produce products with a zero error rate, the so-called ZDM/Zero defect manufacturing, produce with short delivery cycles, with a new production paradigm, i.e. networking economies, not scaling. It is possible to define the main tasks of integrated logistics from the outputs of professional studies and our own scientific and research activities:

- itegrated planning, management and optimization of logistics: implementation of electronic kanban, JIT/JIS to ensure inputs, capacity requirements, etc.
- visualization of logistics processes and networks with the possibility of interactive project activity,
- streamlining the expenditure of logistics costs for various variants of the supply process,
- standardization of the planning process, which contributes to the optimization of the business system as a whole,
- increasing the level of supplier-customer relations through the introduction of flexible communication technologies.

By introducing information and communication elements in the context of digitization (CPS, IoT, Internet of Things, cloud computing, big data) of business processes and systems, space is created for the processing of effective forecasts, thereby contributing to the flexibility of reaction time to requests, supporting seamless data integration, automated ordering, real-time feedback and status update via stack indicators, etc. In practice, the most used platforms or technologies for monitoring such as RFID, e-link, barcode, Filling-Level Sensors, and Smart Scales, only provide presence detection and require the installation of sensory gates that do not copy the flexibility of material flow movement. The introduction of RTLS technology, which increases the quality of forecast values ??based on the processing of daily data available online, has a significant impact, which contributes to the efficiency of the supply system. The use of RTLS technology in connection with e-kanban has potential primarily in connection with monitoring the movement of the material flow in real-time and the possibility of evaluating its direction, intensity, quantity, etc.

Conclusions

Optimizing the company's inventory plays a key role in balancing supply and demand. Solving the causes of overcrowded warehouses is possible by introducing modern information and communication elements. It is important to gain control over what is in the warehouse and what range of activities the warehouse provides. Integrated planning and management of logistics systems and networks based on digital models, methods, and tools, which are built on a common flexible information and communication platform, is currently becoming a necessary condition for maintaining competitiveness.

The use of lean principles when finding effective solutions is still important despite digitization, or precisely because of digitization, it is necessary to approach the analysis of processes in detail and define the nature of individual activities. The article describes the procedure for introducing e-kanban with a timetable related to its introduction and the preparation of conditions for a digital twin. The basis for the introduction of electronic kanban is a preparation for the creation of a complex intelligent logistics network of the enterprise with added value in the form of interactive communication between relatively autonomous entities, thereby achieving speed, flexibility, and quality of the flow of values.

Currently known and used tools focus on the creation of a digital enterprise, where digital models can be heterogeneous and can be used well in several projects. An indicator of the transformation of the supply chain to a smart level is, on the one hand, the pressure from the introduction of new technologies into business processes and systems due to the influence of Industry 4.0 and, on the other hand, increasingly demanding customer requirements for customizing products and services. Supporting a new concept for procurement of inputs in combination with capacity management to ensure flexible dimensioning of supplies is a way to increase the efficiency of using the potential offered by digitization. Further research can be directed in this direction.

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