Planning and Optimization of Internal Transport Systems

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Summary. The digital transformation is increasingly affecting the field of intralogistics. In order to develop corresponding concepts in logistics planning in a short time, software tools should profitably transfer the theoretical knowledge into practice and support the user in the best possible way. This article gives insight in particular into the typical tasks involved in the planning and optimization of internal transport processes and how LOGSOL addresses these with the help of the RoutMan planning tool.

1. Introduction

Jeff Bezos, founder of the online sales company Amazon, described the current digital transformation of society with the emphatic phrase "There is no alternative to digital transformation" – transformation which now seems to us to be not only fundamental but also irreversible. In this context, the fourth industrial revolution encompasses all those structural changes that occur in the course of digital transformation in logistics and production (Hompel and Henke 2020).

And indeed, it is hardly surprising that logistics – with its algorithmic and deterministic nature – is one of the earliest areas of application for new technologies such as artificial intelligence or the Internet of Things (Hompel and Henke 2020). At the same time, it represents the link between companies in the value creation network and the interface between internal company functions, and thus proves to be a predestined playing field for continuous improvement (Hofmann and Nothardt 2009). Within this overall supply chain, intralogistics represents only one logistics task, but its role – as the process stage that determines the type and timing of material supply – can certainly be described as central (Miebach and Müller 2006). It, too, is subject to constant optimization initiatives. In this context and due to the fact that they are often still manually operated, internal floor-based transport systems in particular have a high potential for improvement (Wehking 2020).

Lean design in intralogistics has been a primary objective of logistics planning at least since the worldwide establishment of the Toyota Production System. The challenge here is not only to realize high quality and efficiency with low lead times, but also to simultaneously optimize space utilization, personnel deployment, and inventory reduction (Liebetruth and Merkl, 2018). Even today, digital solutions such as automated guided vehicles, indoor tracking, E-KANBAN and many more already offer versatile possibilities for optimally exploiting the potential of internal transport concepts and their control. LOGSOL encounters such developments daily in the practical environment of logistics planning. In order to contribute to the growth of digitalization and the ongoing need for optimization in the planning of internal transport systems, LOGSOL developed a software-aided planning tool in the last few years.[1] In this context, LOGSOL also cooperates with scientific facilities and institutes, such as the Chair of Material Handling at the Technical University of Dresden.

2. Planning of internal transport processes

Planning internal transport processes is undoubtedly an extensive undertaking that depends on many factors. Although every project in this context is individual, established planning methods can be applied in almost every case and the complexity of the planning task can be reduced by a standardized procedure. The first stage of the planning process usually begins with the identification of potential transport concepts.

Over the past 30 years, both the technologies used in in-plant transportation and the associated processes have changed. In the course of time, highly complex and mostly partially digitalized conveyor systems have been created, the dimensioning and optimization of which requires considerable effort. A wide variety of transport concepts are available. Most widespread and relevant in terms of planning is the classification of these according to their underlying application concept. The most elementary distinction should be made between continuous conveyors – used to create a continuous transport flow through stationary line connections – and discontinuous conveyors – used to create an interrupted material flow (Jünemann and Schmidt 2000). The latter are used in particular for direct supply of materials to production (Wehking 2020).

Floor-bound non-continuous conveyors are characterized not only by the intense planning and control efforts associated with them. They also represent the group of conveyor technology that has experienced massive automation in recent years. The most common technologies include tugger trains, forklifts and automated guided vehicles (AGVs). Although they all come under the same classification, these conveyor systems differ from each other in many ways. Among the critical criteria to consider for their planning are (Wehking 2020):

- Flexibility in the event of changes to the layout, infrastructure or material flows
- Technical parameters, such as the conveying direction, load capacity and the turning radius
- Degree of automation as a factor influencing personnel costs and controllability
- Interactions among themselves and with each other and with adjacent processes
- Control effort
- Investment requirement

The selection of a suitable transport concept depends on a large number of contributing factors. One of these factors is the preexisting, internal company requirements for the transport system

[1] The planning and control of internal transport systems are closely interlinked. However, in practice, the focus is usually on digitalization in operational areas and not in planning (i.e., the design and dimensioning of flexible internal transport processes).

being planned. Three planning paradigms play a decisive role here, regardless of the conveyor technology (see following figure).

Figure 1: Planning paradigms

The *spatial dimension* includes conditions within which transport processes are to be conceptualized. They refer to all storage, picking, transport and handling arrangements that constitute the framework for the transport of goods. The first step of their analysis starts with the visual recording and graphic mapping of abstract, mostly geometric basic structures of the company facilities (Martin 2016). Based on these planning fundamentals, initial considerations can then be made regarding the design of the transport system. Relevant here is the definition of sources – delivery points where materials are made available – and sinks – receiving points where materials are required (Liebetruth and Merkl 2018). The transport task to be performed, such as production supply, disposal, or transport between storage points, determines both the number and type of sources and sinks. With the help of this spatial visualization, organizational principles can be determined in the next step. If sinks are in a linear arrangement, flow production can be assumed. Much higher planning efforts result from a station or island-like arrangement (Lieb et al. 2017). In any case, the analysis of spatial dimensioning provides an adequate first point of reference for possible restrictions and thus for the delimitation of potential transport concept right from the beginning of planning.

Material dimensioning is mainly about the goods to be transported and their characteristics. In this context, the generic dimensions should be addressed in more detail. The assessment of these qualitative properties of the material to be transported is essential in order to narrow down the applicable transport concepts, due to the requirements of the material for the transport process (Martin 2016). Quality standards for the materials to be transported also play a decisive role. For example, the planner is confronted with questions regarding the additional effort required for unpacking, packing or creating sets (Liebetruth and Merkl 2018). Aside from this, the quantitative dimensions also play a decisive role in material dimensioning (Martin 2016).

No less essential for the planning of the transport system is *time dimensioning*. This planning paradigm is a frequent reason for exclusion of unsuitable transport concepts, especially for transport assignments supplying production. The most important aspects include operating speed, cycle time, and replenishment time (Liebetruth and Merkl 2018). Taking into account these planning requirements, conveyor technology can be evaluated and selected for speed and flexibility.

The process of recording and analyzing all of these planning fundamentals can be more or less complex, depending on the project conditions. In order to at least partially simplify and standardize it, planners draw on various supporting methods and tools.

The basis for all planning projects is initially the compilation of the numerical data. This includes the compilation of qualitative and quantitative information on the transportation process. These are typically composed of the planning paradigms already presented and rely on the availability of relevant data. Often these already exist in the company, but it is not uncommon to have to collect missing data during the planning process. Some methods and tools for transportation planning that have proven to be effective will be presented in the following.

The MTM method is often used in practice, especially when it comes to recording and analyzing time planning dimensions. Since the data situation for determining relevant time requirements does not always correspond to planning needs, the need for analog recording of working hours sometimes cannot be avoided. With the help of the MTM method, processes can be grouped into modules and evaluated independently of employees on the basis of statistically determined standard times (Liebetruth 2020).

Since planning a transportation system does not always involve a full-scale redesign, existing structures may need to be analyzed. The distance-intensity diagram supports the planner by classifying material flow relationships according to their intensity – i.e., transport demand – and the distance between source and sink (distance). They can be classified and prioritized according to their effort. Using a classic heat map, the traffic intensity can also be visualized. The planner can see the line load distribution and optimization potential at a glance.

3. LOGSOL's approach to planning and optimizing internal transport processes

Over the past 20 years, LOGSOL has gained a wealth of experience in planning and optimizing transport processes. While there is still a relatively high degree of freedom and relatively few restrictions in new plant planning or expansion, the restructuring of an existing transport system presents a much greater challenge. Typical reasons for having to adapt planning are, for example, fluctuations in demand – triggered by internal or external factors – and structural changes, such as the conversion of a production facility from workshop to assembly line production or a change in the product manufacturing portfolio.

Another reason for the need to plan a transport system, which is already relevant today and will remain so in the future, is the increasing digitalization of logistics processes. The introduction of new conveyor technologies that are able to collect multidimensional data, communicate or operate fully automatically is now one of the most important reasons for replacing or restructuring existing transport processes. In practice, there is a considerable amount of catching up to do here, as the focus is usually on control and less on planning, which generally provides the guidelines for operational management.

Depending on the motivations for planning a transportation system and the information available on the company's internal planning paradigms, the level of effort required may vary. A decisive factor here is hidden in the planning and optimization process itself. A variety of data-driven analysis tools now exist to make the planning process more efficient. However, these usually come from different providers and involve significant integration effort. To overcome this barrier in its own planning projects and for its customers, LOGSOL developed a software-based application for comprehensive planning and optimization of internal transport processes, as part of a research and development project.

As already shown, the planning of a transport system requires four basic pieces of information relevant to design, whereby the technical planning paradigm refers to the conveyor technology itself and the spatial, material and time dimensions represent the company's existing structural characteristics. In the first step in software-aided planning, data on the relevant means of transport are recorded within RoutMan® so that a complete master data library is available as a basis. The next step is the dimensioning of the planning scenario. For the design of a spatial planning basis, hall layouts and route networks as well as sources and sinks are stored in the system and attractively displayed. To define the material requirements, quantitative properties are recorded, and qualitative characteristics based on the type and design of carriers to be transported are stored. Ultimately, the time dimension can be mapped using process-based analysis methods. Transport routes can be generated both manually and automatically based on various criteria, such as conveyor sections or container types.

Once all relevant data has been recorded, various analyses can be carried out by the planner with the aim of optimizing the process. RoutMan® uses various established calculation methods, including VDI Guideline 5586 Sheet 2 "In-plant milk-run systems - Planning and dimensioning", and relies primarily on the evaluation of performance-oriented key figures to map process efficiency according to cost, quality and time-specific criteria. An added value that is particularly visual and realizable in terms of data is created by the mapping of the traffic intensity in the heat map and the distance-intensity diagram (see following figure). Furthermore, the generated results, such as tour start interval and route guidance, as well as the driver pooling created to level the employee workload, can be used as input variables for operational control.

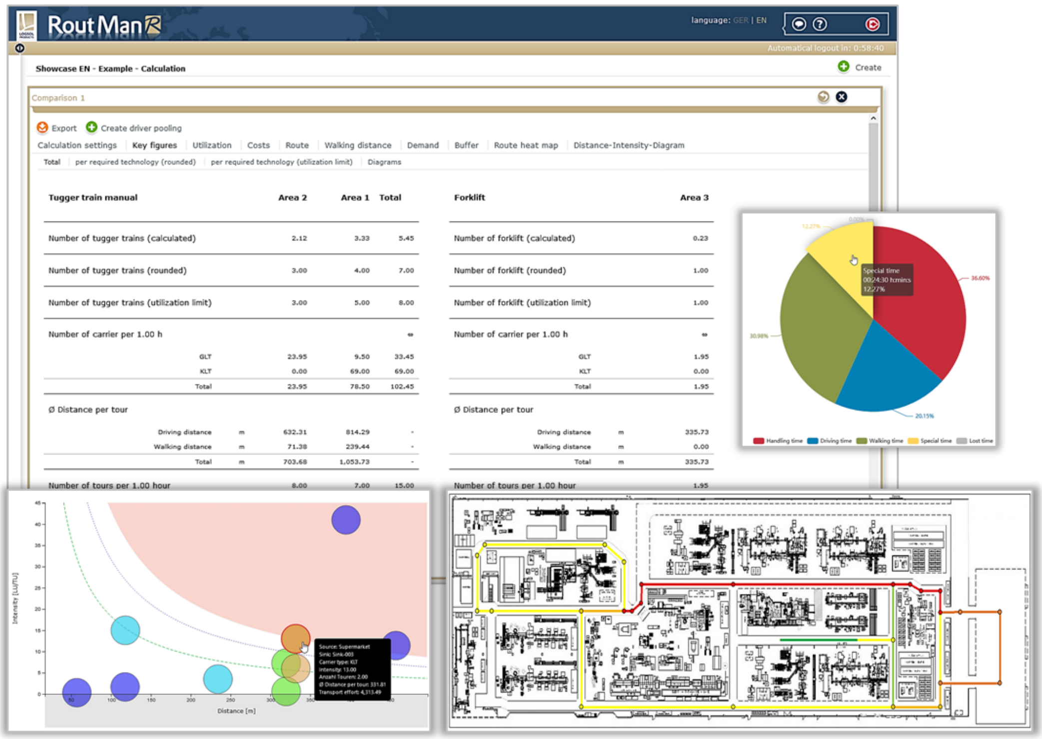

Figure 2: Exemplary evaluation of the RoutMan planning tool

Software-aided planning processes and automated data evaluations make a fundamental contribution to simplifying optimization projects for complex internal transport systems. However, parallel to the increasing need for planning, demands on the transport systems are also growing daily. In this context, their design must become faster, simpler and more automated. In order to keep pace with the developments of these turbulent times and to continue to provide an effective basis for planning, LOGSOL is continuously working on expanding the functions of RoutMan®. New ideas and expanded functionality are to be developed continuously – for example, through cooperation with academic institutes such as the TU

Dresden. By calculating envelope curves, for example, the software should be able to identify risks of tight curves right from the planning stage. Likewise, the extent to which queuing models can provide additional insights for the planner is currently being evaluated.

4. Conclusion

"Progress lies not in enhancing what is, but in advancing toward what will be." This quote from the philosopher Khalil Gibran (von Hehn, Cornelissen and Braun 2015) essentially sums up the core of planning logistics processes today. Society and logistics, with intralogistics as a significant component, are experiencing a transformation that not only forces them to continuously adapt to internal and external changes, but also leads to efficiency-related peak performance.

From this point of view, the planning of internal transport systems represents one of the great challenges facing the logisticians of our time. Planners are faced not only with the automation of individual processes and complete systems, but also with the need to work as efficiently as possible. The availability of an orienting planning concept and evaluative software can nowadays be the decisive factor for the success of a planning project – and not only in the area of internal transport.

This article provides an insight into how best to proceed in practice when planning and optimizing internal transport processes, and which supporting methods and tools are used. The massively increased relevance of digitalization in planning, which should not stop at data collection and analysis in established office solutions, should also be emphasized. Here, other software tools can be usefully added to support the entire planning process. With the development of the RoutMan® planning tool, LOGSOL has managed to lay its own foundation for internal transport planning of all kinds. In doing so, the web-based software can be used not only to address the specific planning challenge, but the tool is also suitable for further training and the creation of standardized planning processes. Last but not least, this is the reason that RoutMan® is used not just by experienced logistics planners. The planners of tomorrow can use this tool too, to link theoretical approaches with practical case studies. This is why LOGSOL also offers the tool in the RoutMan® Academy (see following figure).

Figure 3: RoutMan Academy

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