Journal of Industrial Intelligence
https://www.acadlore.com/journals/JII

Optimization of Industrial Process Management in Postal and Logistics Centers Based on Transit Time Quality Standards

Momčilo Dobrodolac*

Faculty of Transport and Traffic Engineering, University of Belgrade, 11000 Belgrade, Serbia

* Correspondence: Momčilo Dobrodolac (m.dobrodolac@sf.bg.ac.rs)

Received: 02-05-2025 **Revised:** 03-15-2025 **Accepted:** 03-20-2025

Citation: M. Dobrodolac, "Optimization of industrial process management in postal and logistics centers based on transit time quality standards," *J. Ind Intell.*, vol. 3, no. 1, pp. 12–19, 2025. https://doi.org/10.56578/jii030102.

Abstract: Transit time in the transportation and logistics sector is typically governed either by contractual agreements between the customer and the service provider or by relevant regulatory frameworks, including national laws and directives. In the context of postal services, where shipment volumes frequently reach millions of items per day, individual contractual definitions of transit time are impractical. Consequently, transit time expectations are commonly established through regulatory standards. These standards, as observed in numerous European Union (EU) countries and Serbia—the focus of the present case study—define expected delivery timelines at an aggregate level, without assigning specific transit time to individual postal items. Under this conventional model, senders are often unaware of the exact delivery schedule but are provided with general delivery expectations. An alternative approach was introduced and evaluated in this study, in which the transit time is explicitly selected by the sender for each shipment, offering predefined options such as D+1 (next-day delivery) and D+3 (three-day delivery). The impact of this individualized approach on operational efficiency and process organization within sorting facilities was examined through its implementation in a national postal company in Serbia. A comparative analysis between the traditional aggregate-based model and the proposed individualized model was conducted to assess variations in process management, throughput efficiency, and compliance with quality standards. The findings suggest that the new approach enhances the predictability of sorting operations, improves resource allocation, and facilitates more flexible workflow planning, thereby contributing to higher overall service quality and customer satisfaction. Furthermore, it was observed that aligning operational processes with explicitly defined transit time commitments can lead to more efficient industrial process management in logistics and postal centers.

Keywords: Postal service; Efficiency; Processes; Sorting center; Quality; Transit time

1 Introduction

Postal services play a crucial role in the functioning of society, supporting economic activities, everyday life, and governmental administration [1, 2]. While traditionally focused on information transfer [3], their role has expanded in the digital era to include the transportation of goods [4]. As a result, the efficiency of postal operators is a key concern that impacts numerous stakeholders [5, 6]. The shipment transfer process generally consists of four phases: collection of items, sorting activities, transportation, and last-mile delivery [7]. This research primarily focused on the sorting phase.

Several studies have investigated how to improve the efficiency of postal and logistics sorting centers. Huo et al. [8] examined how vehicles can contribute to the mentioned issue, especially with consideration of energy consumption. Liu et al. [9] investigated how adequate path planning can improve the operational efficiency of intelligent logistics centers. Further, Ding et al. [10] considered the efficiency of sorting lines depending on the machine vision. Zhang et al. [11] applied a deep learning algorithm to optimize the resources in the sorting system. Finally, Qu et al. [12] modeled a relationship between newly implemented technologies in an express distribution center and employees in the sense of operator fatigue and operation efficiency.

This study aims to explore ways to enhance the efficiency of the postal and logistics sorting centers by introducing a new postal service concept. The concept of postal service is defined according to the principles of universal service obligation. This obligation implies that all citizens and legal entities should be provided with a certain set of postal services of predefined quality and equal terms for all users in the state territory. Such expectations from the postal

companies limit the possibility of significant changes in the concept of postal services. However, this study analyzes some new possibilities. If the states conclude that this would benefit their economy, the regulations could be adjusted. Therefore, the central hypothesis to be investigated is that the design of postal services influences the efficiency of the technological process, particularly the sorting phase.

The study is organized below. Sections 2 and 3 outline the differences between traditional and new proposed postal service concepts. Section 4 presents the data utilized in the research. Section 5 discusses the resource calculations for both the traditional and proposed postal systems. Section 6 concludes by highlighting the benefits of applying the new concept, particularly in the sorting phase.

2 The Current State Considering Quality in the Postal Sector

The quality issue of postal services can be considered from several perspectives. Three main aspects are most often analyzed, which involve the scope of offered services, the territory coverage, and the transit time. This study focuses on the last aspect. The quality standards regarding transit time within the EU are outlined in the EU Postal Directive [13, 14]. However, a similar approach exists in many other countries that are members of the Universal Postal Union.

The standards for intra-community cross-border mail are specified for each country, based on the fastest standard category of postal shipment. They follow the formula D+n, where D is the deposit date, and n represents the number of working days between the deposit and the delivery date to the recipient. The deposit date is considered to be the same day as the item is submitted, provided it is before the last collection time specified for that access point. If the item is deposited after this time, the deposit date will be the next working day. The specific values of these standards are detailed in Table 1. These standards must be met not only for the entire intra-community traffic but also for each bilateral flow between two member states.

Table 1. Objectives of transit time in the EU [13]

Transit Time	Aim of the Quality Standard
$D+3$	85% of postal volumes
$D+5$	97% of postal volumes

The concept of quality considering transit time for national postal services is similar across most European countries. A specific time frame is set (such as D+1, D+2, D+3, etc.) and it must be met to a certain degree (e.g., 87%, 95%, or similar) based on the total volume of mail handled by a postal company. As a result, under the traditional postal service model, a user sending a shipment does not know the exact transit time for their letter or parcel.

3 A Proposed Concept of Postal Service

The proposed postal service concept would allow users to select a specific transit time, such as D+1 for next-day delivery or a longer period. Unlike the traditional model, this approach implies that the sender can request the exact transit time of their postal items at the moment of sending.

Based on the alternative to the D+1 postal transfer, there are three possibilities for a new postal service concept. In the first scenario, the alternative to a D+1 postal service is the D+2 transit time, meaning the postal item must be delivered within two days. This approach would lead to some optimization possibilities of organizing last-mile delivery in the sense that there would be certain days with low volumes and others with high. During the high volumes, part-time workers could be engaged in order to optimize costs for salaries. The concept of the first approach is shown in Figure 1.

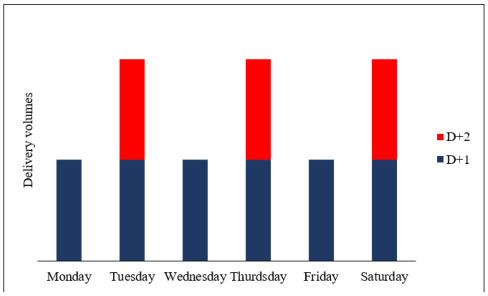

Figure 1. The concept of D+1 and D+2 postal service

The second scenario implies a D+3 time limit as an alternative to D+1 transfer. This concept provides even more possibilities for the optimization of delivery costs. This approach is shown in Figure 2. The third approach is specified by two alternatives to D+1 transfer; there is a possibility for a sender to select a D+2 or D+3 time frame. This approach is illustrated in Figure 3.

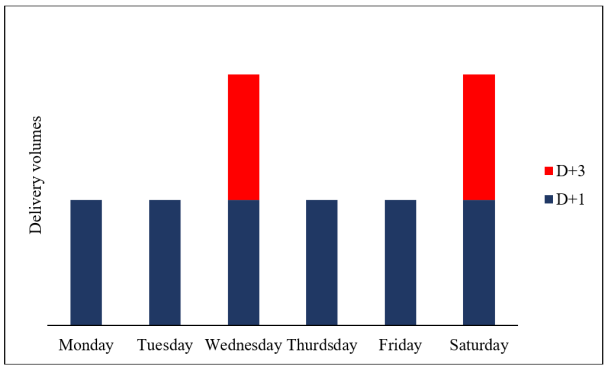

Figure 2. The concept of D+1 and D+3 postal service

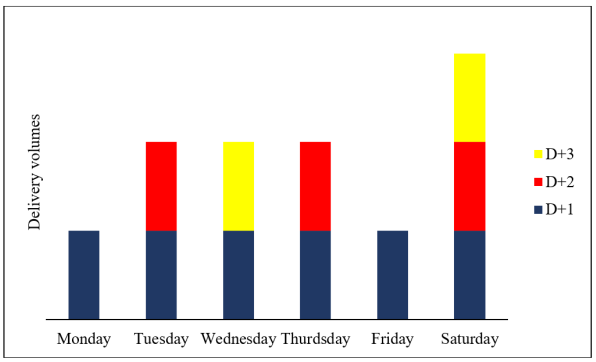

Figure 3. The concept of D+1, D+2 and D+3 postal service

This paper specifically analyzes the scenario in which the sender can select D+1 or D+3 service options; however, the research procedure would be almost identical for other scenarios as well.

The proposed postal concept is characterized by enhancing service quality to improve customer satisfaction and increase the efficiency of the postal operator. Efficiency improvements are particularly evident in terms of sorting activities, last-mile delivery, and profit. While last-mile delivery and profit aspects have been previously discussed by Dobrodolac et al. [15], this study focuses on further analyzing the sorting process.

4 Description of the Considered Problem

The implementation of the proposed methodology is illustrated in the case of the Regional Sorting Center (RSC) in Belgrade, Serbia. The postal item volume data used in this study was sourced from the study by Dobrodolac et al. [15] and corresponds to the assessed values for 2025. The final calculated volumes of shipments are presented in Table 2. The regional postal center (RPC) in Belgrade oversees twelve local postal centers (LPCs), as shown in Table 3. For this study, it is assumed that the sorting plan should be defined by these expectations: postal items destined for Belgrade should be sorted by delivery area (a total of 823 areas), while all other mail should be sorted only by LPC (eleven in total). A delivery area is part of the territory served by one postal branch where the last-mile delivery is performed by a single courier.

5 A Case Study – Measurement of the Efficiency of Used Resources

In the procedure of calculating the required resources, the study evaluates the efficiency of the RSC based on the number of automated Letter-Sorting Machines (LSMs) required for processing incoming postal items. A possible concept of such a machine is presented in Figure 4. This resource was considered in this study because it represents one of the largest investments in the RSC and is assumed to be a variable resource that depends on the postal service concept.

Table 2. Mail volumes as input to the model [15]

	Traditional Concept	New Concept	
		D+1	D+3
The assessed volumes of postal items of the company for the year 2025	356,774,711	112,783,720	243,990,991
Postal items collected Belgrade and other postal centers during a day with high demands	904,831	391,336	846,597
Postal items prepared for the last-mile delivery in Belgradeduring a day with high demands	613,446	265,312	573,964

Table 3. Local centers governed by the RPC in Belgrade [15]

Postal Center	No. of Delivery Postal Branches	No. of Delivery Areas
Belgrade	90	823
Požarevac	39	112
Valjevo	30	88
Šabac	52	129
Užice	57	140
Čačak	36	107
Kragujevac	55	133
Smederevo	26	84
Pančevo	72	152
Jagodina	55	115
Kraljevo	43	141
Priština	23	75

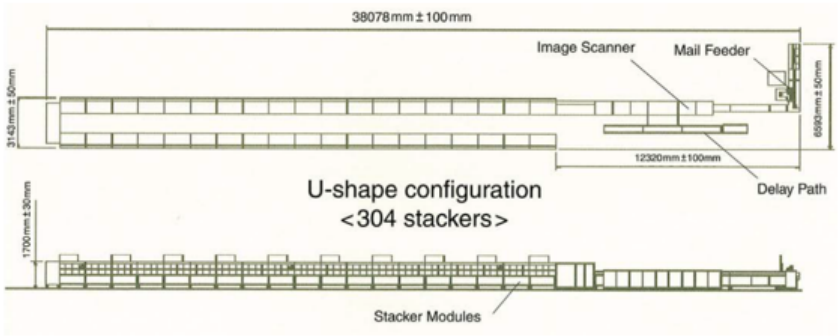

Figure 4. The concept of LSM [16]

The necessary number of LSMs is determined using the following key input parameters:
- The time frame for processing postal items,
- The volumes of shipments that need to be sorted, and
- The sorting capacity of the LSM per unit of time.

5.1 Sorting Efficiency Measurement in the Traditional Postal Concept

Postal items that senders hand over to the postal branches within Belgrade throughout one workday reach the RPC at different times. Postal branches, which operate a single shift and close at 2:00 p.m., dispatch their postal items to the designated center after closing. Meanwhile, post offices operating in two shifts continue accepting shipments until 6:30 p.m.

At the RPC, the machines can begin sorting the mail at 4:00 p.m. The first shipments from Belgrade's two-shift postal branches start arriving at 7:00 p.m. Subsequently, starting at 8:30 p.m., items from the LPC and other RPCs are consolidated with the existing Belgrade volumes (Figure 5).

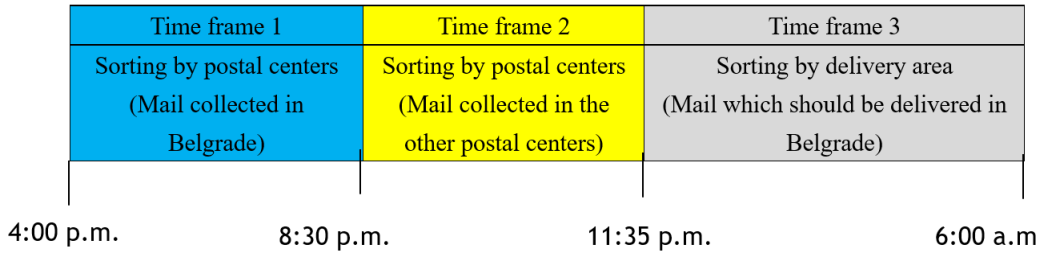

Figure 5. A method of using the sorting machine in various time frames in the traditional postal concept

An LSM can sort approximately 50,000 postal items per hour [16]. Given that all three key parameters – time frame, mail volumes, and machine capacity – are defined, the required number of machines for the RPC in Belgrade can be determined. For time frames 1 and 2 (from 4:00 p.m. to 8:30 p.m.), the calculation is represented in Eq. (1).

$$N_{1,2} = \frac{x_{1,2Bgdm}}{x_{rs} * N_c} \tag{1}$$

where, $N_{1,2}$ is the needed number of LSMs, $x_{1,2Bgdm}$ is the volume of postal items to be sorted in the time frames 1 and 2 (904,831), x_{rs} represents the number of working hours (7 hours and 35 minutes), and N_c denotes the capacity of an LSM. Based on these parameters, the result that the required number of machines for time frames 1 and 2 can be obtained, which is $N_{1,2}$=2.386, meaning that three LSMs should be installed to meet the demand.

For time frame 3, the required number of LSMs is determined using Eq. (2):

$$N_3 = \frac{x_{3Bgdm} * \frac{x_{da}}{x_{st}}}{x_{rs} * N_c} \tag{2}$$

where, N_3 represents the number of LSMs required for time frame 3, while x_{3Bgdm} denotes the volume of items that should be sorted in this period (613,446 items). Additionally, x_{da} is the number of delivery areas (823) and x_{st} represents the number of stackers per machine (304). The calculation results in N_3= 5.176, meaning that six machines would typically be required. However, the obtained value can be reduced by certain reorganizations. Since only 12 stackers are used during time frames 1 and 2, part of the workload from time frame 3 can be shifted to these earlier periods. This redistribution effectively doubles the available processing time, reducing the final required number of machines to three. Thus, the total number of required LSMs is $N_{1,2,3}$ = 3.

5.2 Sorting Efficiency Measurement in the Proposed Postal Concept

As mentioned in the third section, the proposed postal service concept allows the sender to set the transit time for its concrete postal item by choosing between D+1 and D+3 transfers. The key technological advantage of the new postal service compared to the traditional model lies in the level of LSM usage. In the traditional approach, machine sorting occurs within a fixed time frame – from 4 p.m. to 6 a.m. on the following day (Figure 5). However, under the new scenario, LSM operation could be distributed throughout the entire day. This can be explained by the fact that the company would only need to process D+1 postal items within the standard 4 p.m. to 6 a.m. window, while D+3 consignments could be handled during the remaining hours, optimizing machine utilization.

When it comes to time frames 1 and 2, using the volume data for D+1 items presented in Table 2 and along with the given machine capacity, the application of Eq. (1) yields $N_{1,2}$ =1.0321. Therefore, to accommodate the D+1 service during the considered time frames, two LSMs should be installed. For time frame 3, Eq. (2) was applied using the volume data from Table 2, the time frame from Figure 5, the specified machine capacity, the number of delivery areas (823), and the number of stackers per machine (304). Based on these parameters, the calculation shows that N_3 =2.23.

The results indicate that three LSMs would be needed at the RPC Belgrade for processing D+1 items during the third time frame. However, the obtained value can be reduced by implementing an optimized sorting plan in the first and second frames. Given that each LSM has 304 stackers and that there are only twelve LPCs, a joint processing plan can be introduced in time frames 1 and 2. Under this plan, shipments destined for Belgrade would be sorted by delivery areas, effectively doubling the available working hours. As a result, the number of LSMs needed at the RPC Belgrade for processing D+1 items is reduced to two, i.e., $N_{1,2,3}$ = 2.

Next, it is essential to verify whether the two LSMs, which are sufficient for processing D+1 items, can also handle the classification of D+3 shipments. In the beginning, whether two LSMs can process D+3 items by the LPC within a 10-hour working period (from 6:00 a.m. to 4:00 p.m.) was assessed. Applying Eq. (1) yields $N_{1,2}$ (10 hours) = 1.6932, which is less than two, confirming that the capacity is sufficient. However, when considering D+3

items for the territory of Belgrade, where sorting is done by delivery area, Eq. (2) must be applied. The result N_3 (10 hours) = 3.1077 exceeds the available two machines. To fulfill this demand with just two LSMs, the usage of the LSMs between 4 p.m. and 6 a.m. should be analyzed to determine whether the surplus mail volume can be processed during this frame.

To process the D+1 items by delivery area for the period between 11:35 p.m. and 6:00 a.m., N_3 was calculated to be 2.2387. By adjusting the processing plan before 11:35, the required number of machines was reduced to 1.1193. This results in a machine utilization rate of 55.97%, indicating relatively low utilization. This presents an opportunity to shift some of the D+3 postal items into this time frame for sorting. To determine the proportion of D+3 items that can be transferred, Eq. (3) was applied:

$$x_{transf} = x_{3Bgdm} - \frac{N_{1,2,3} * x_{rs} * N_c}{\frac{x_{da}}{x_{st}}} \tag{3}$$

The obtained value from Eq. (3) indicates that 204,584 D+3 postal items, or 35.64% of the total, should be transferred to the previous time frame.

Next, it is essential to verify whether this earlier time frame has sufficient capacity to sort the specified number of items, considering that 44.03% of the machine utilization remains available. To determine this, Eq. (4) was applied:

$$N_{1,2transf} = \frac{x_{transf} * \frac{x_{da}}{x_{st}}}{x_{rs} * N_c} * \frac{1}{0.4403} \tag{4}$$

The application of Eq. (4) gives the final value of 1.7970, indicating that two LSMs are sufficient to process the considered traffic.

Ultimately, the operational schedule for the two LSMs under the proposed postal service concept is illustrated in Figure 6.

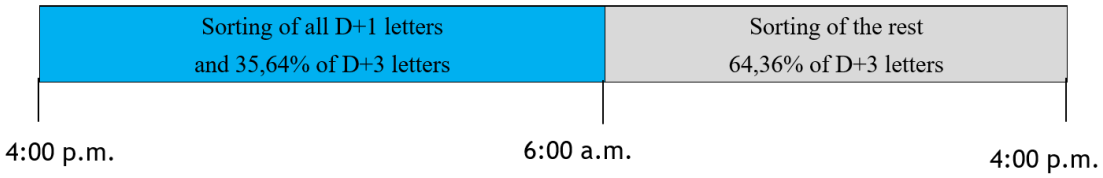

Figure 6. The method of operation for two LSMs in the proposed concept of postal service

6 Managerial Implications

This research shows that the concept of postal service can significantly affect the efficiency of postal and logistics centers. Analysis of the concrete case study of the postal company from Belgrade shows that three LSMs are required to meet the demands in the traditional approach. However, in the proposed new concept, only two LSMs would be enough. Bearing in mind that the price of such a machine is measured in millions of US dollars, the investment saving is evident.

The advantage of the proposed concept is not just in the improved efficiency of the sorting facilities. This approach also brings a higher satisfaction level to customers. The reason lies in the fact that by choosing the D+1 or D+3 service, the users would be more precisely informed about the transit time of their shipment. This represents a better service portfolio for the postal companies and enables customers to adequately select the postal service according to their needs. Since the advantage is evident compared to the traditional concept, the number of provided services is expected to increase, which would lead to increased profit as well.

It is interesting to mention that the concept of D+1 postal service is similar to express postal services considering transit time. However, the difference is that express services are elite postal services that provide, besides strict and short transit times, certain additional conveniences for the customers, such as courier arrival to the home or business address of the sender to collect the shipment for delivery, the service of packing the sending item and similar. Because of the mentioned similarity, one can argue that there is no need to introduce the proposed D+1 postal service. However, the D+1 service would be a service with a slightly lower price compared to express service, which brings a better diversification of services in the postal market.

7 Conclusions

The market of postal services is very competitive and the users are constantly more demanding. Accordingly, the postal companies need to search for the models to improve their business. Therefore, this study aims to provide a

contribution to the considered field by comparing the efficiency of resource utilization in the RSC based on different postal service concepts.

The final conclusion of the capacity calculations for automated postal item sorting, by comparing the traditional and proposed postal service concepts, is that the proposed approach is more efficient for the technological processes in the case of RPC Belgrade. Implementing the proposed concept would require only two LSMs, whereas maintaining the traditional system – currently in use by the considered postal company from Serbia – would necessitate three LSMs to achieve a sorting system up to the delivery area, as considered in this study.

The impact of the proposed savings in resource utilization becomes even clearer when considering the cost of an LSM. With an average price of approximately two million US dollars per machine, it is evident that postal operators should carefully evaluate the postal service concept they adopt, as it directly affects both operational efficiency and financial investment.

Therefore, the advantages of the proposed new concept of postal services are evident, but there are certain limitations when it comes to the implementation of this approach in practice. Postal companies need to follow strict regulations considering the concept of postal service. This is due to the existence of a universal service obligation, i.e., an obligation imposed by a state to serve every citizen or legal entity in the whole territory with some set of postal services. In most countries, the transit time, as well as the price of services, is strictly defined by state authorities. However, since the proposed concept of postal service is of interest to customers, it is expected that if recognized by a certain society, it should not be an obstacle to adjust the regulations to the new circumstances.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The author declares that they have no conflicts of interest.

References

[1] A. Drab-Kurowska and M. Kuscinski, "E-services of national postal operators - A "must have" current times to ensure the functioning of the state's critical infrastructure," *Eur. Res. Stud.*, vol. 26, no. 3, pp. 523–533, 2023. https://doi.org/10.35808/ersj/3229

[2] B. Jovanović, D. Šarac, and N. Čačić, "Performance benchmarking of European postal incumbents with TOPSIS and BMW-TOPSIS," *Util. Policy*, vol. 91, p. 101845, 2024. https://doi.org/10.1016/j.jup.2024.101845

[3] A. Drab-Kurowska, "Spatial Critical Infrastructure and the role of the national postal operator in improving the flow of information," *Eur. Res. Stud.*, vol. 26, no. 3, pp. 325–332, 2023. https://doi.org/10.35808/ersj/3216

[4] A. Fitriningrum, A. H. Pulungan, and P. Darusidhi Government, "State-owned enterprise, and liberalization of universal postal obligation services," *J. Policy Stud.*, vol. 38, no. 3, pp. 25–40, 2023. https://doi.org/10.52372/jps38303

[5] M. Blagojević, P. Ralević, and D. Šarac, "An integrated approach to analysing the cost efficiency of postal networks," *Util. Policy*, vol. 62, p. 101002, 2020. https://doi.org/10.1016/j.jup.2019.101002

[6] P. Ralević, M. Dobrodolac, and D. Marković, "Using a nonparametric technique to measure the cost efficiency of postal delivery branches," *Cent. Eur. J. Oper. Res.*, vol. 24, pp. 637–657, 2016. https://doi.org/10.1007/s10100-014-0369-0

[7] V. Simić, D. Lazarević, and M. Dobrodolac, "Picture fuzzy WASPAS method for selecting last-mile delivery mode: A case study of Belgrade," *Eur. Transp. Res. Rev.*, vol. 13, no. 1, 2021. https://doi.org/10.1186/s12544-021-00501-6

[8] X. Huo, X. He, Z. Xiong, and X. Wu, "Multi-objective optimization for scheduling multi-load automated guided vehicles with consideration of energy consumption," *Transport. Res. C-Emer.*, vol. 161, p. 104548, 2024. https://doi.org/10.1016/j.trc.2024.104548

[9] C. Liu, B. Li, C. Gu, L. Song, and Y. Zhao, "Tws-based path planning of multi-AGVs for logistics center auto-sorting," *CCF Trans. Pervasive Comp. Interact.*, vol. 6, no. 2, pp. 165–181, 2024. https://doi.org/10.1007/s42486-024-00151-2

[10] Z. Ding, Y. Gong, L. Kong, and J. Zheng, "Design and implementation of an intelligent log diameter grading and sorting line based on machine vision," *Forests*, vol. 15, no. 2, p. 387, 2024. https://doi.org/10.3390/f15020387

[11] K. Zhang, Z. Wang, Z. Zhang, Z. Shi, Y. Qi, M. Du, Y. Chen, T. Liu, Y. Chen, and Z. Yin, "Design and application of coal gangue sorting system based on deep learning," *Sci. Rep.*, vol. 14, no. 1, p. 16508, 2024. https://doi.org/10.1038/s41598-024-67323-z

[12] Y. Qu, N. Zhao, and H. Zhang, "Digital twin technology of human–machine integration in cross-belt sorting system," *Chin. J. Mech. Eng.*, vol. 37, no. 1, p. 33, 2024. https://doi.org/10.1186/s10033-024-01012-w

[13] B. Jovanović, D. Šarac, and N. Čačić, "Performance benchmarking of European postal incumbents with TOPSIS and BMW-TOPSIS," *Util. Policy*, vol. 97, p. 101845, 2024.

[14] P. Tabak and S. Kaštela, "EU postal directives and croatian regulatory frame," *Promet - Traffic Transp. J.*, vol. 22, no. 4, pp. 309–317, 2012. https://doi.org/10.7307/ptt.v22i4.196

[15] M. Dobrodolac, P. Ralević, L. Švadlenka, and V. Radojičić, "The impact of a new concept of universal service obligations on revenue increase in the Post of Serbia," *Promet Traffic Transp. J.*, vol. 28, no. 3, pp. 235–244, 2016. https://doi.org/10.7307/ptt.v28i3.1835

[16] TOSHIBA. (2017) High-Speed OCR Letter Sorting Machine TT-1200. https://www.global.toshiba/content/dam/toshiba/migration/infrasolution/www/infrastructure/en/security-automation/assets/pdf/TT-1200.pdf