Scientific Journal of Silesian University of Technology. Series Transport
Zeszyty Naukowe Politechniki Śląskiej. Seria Transport

Volume 124 **2024**

p-ISSN: 0209-3324

e-ISSN: 2450-1549

DOI: https://doi.org/10.20858/sjsutst.2024.124.11

Journal homepage: http://sjsutst.polsl.pl

Article citation information:
Popa, C., Goia, I. The modelling of cargo transshipment operations using the business process modelling tools. *Scientific Journal of Silesian University of Technology. Series Transport*. 2024, **124**, 157-169. ISSN: 0209-3324. DOI: https://doi.org/10.20858/sjsutst.2024.124.11.

Catalin POPA[1], Ionela GOIA[2]

THE MODELLING OF CARGO TRANSSHIPMENT OPERATIONS USING THE BUSINESS PROCESS MODELLING TOOLS

Summary. This paperwork explores the transshipment operations at the Port of Constanta, Romania, focusing on the unloading of big bags from barges. Utilizing Business Process Management (BPM) software, the study models the transshipment process to identify optimization opportunities. The investigation reveals challenges such as coordination complexities and potential cargo damage, alongside the benefits of cost-efficiency and flexibility offered by transshipment services. Through literature review and analysis, the study emphasizes the importance of efficient business processes and the role of BPM software in enhancing operational efficiency. By employing Aura Portal Modeller for simulation, the study identifies bottlenecks and proposes optimization strategies for the transshipment process. The proposed measures include real-time cargo assessment, inventory tracking systems, equipment analysis, and storage layout optimization. This research contributes to the understanding of transshipment operations and highlights the effectiveness of BPM software in process visualization and analysis, offering insights for enhancing efficiency and mitigating delays in supply chain management.

Keywords: business process management, port operations, process modelling, simulation analysis, cargo handling, inventory management

[1] Faculty of Navigation and Naval Management, Romanian Naval Academy "Mircea cel Batran", Constanta, Romania. Email: catalin.popa@hotmail.com. ORCID: https://orcid.org/0000-0002-4419-7867
[2] Faculty for Transports, „Politehnica" University of Bucharest, Romania. Email: ionela.goia@stud.trans.upb.ro. ORCID: https://orcid.org/0009-0004-6014-8063

1. INTRODUCTION – LITERATURE REVIEW

Transshipment entails the relocation of goods from one transportation mode to another and serves as a vital element within global supply networks, facilitating the smooth transportation of goods across extensive distances. While transshipment services offer advantages such as cost-efficiency, adaptability, and accessibility to inland areas, they also pose challenges such as the intricate coordination required between diverse transportation modes, potential setbacks and cargo damage, and the necessity for proficient inventory handling.

This study aims to scrutinize the transshipment procedures at the Port of Constanta, Romania, with a specific emphasis on unloading big bags from barges. Using Business Process Management (BPM) software, the study seeks to model the transshipment process and pinpoint optimization opportunities.

The outcomes of this investigation will be valuable for researchers and practitioners engaged in supply chain management, offering insights into the obstacles and prospects linked with transshipment, while showcasing the efficacy of BPM software in enhancing transshipment operations' efficiency.

1.1 Overview of transshipment services and challenges

Transshipment serves as a vital link within the intricate network of global supply chains. It streamlines the movement of goods by enabling them to seamlessly transition between various transportation methods, ultimately facilitating their delivery across vast distances. This process typically occurs at designated transshipment hubs equipped to handle large volumes of cargo. Here, cargo seamlessly transitions from one mode of transport to another, such as ships to barges, trains to trucks, or vice versa [1]. There are several types of transshipment, including sea-to-sea, sea-to-land, and land-to-land transfers. These services offer numerous benefits, including cost-effectiveness, accessibility to inland locations, and flexibility in choosing transportation options based on factors like cost, speed, and capacity.

However, transshipment also presents challenges, such as the complexity of coordinating transfers between different modes of transport, which requires meticulous planning and logistics management [2]. Delays can occur during the process, affecting delivery schedules, and there's an increased risk of cargo damage when goods are handled multiple times. Despite these challenges, transshipment remains an essential component of modern logistics, enabling the efficient movement of goods worldwide.

According to industry reports, bulk carriers currently hold the largest share of the global shipping fleet's carrying capacity. These specialized vessels are designed to transport large quantities of dry cargo such as iron ore, coal, and grains. As of 2019, they accounted for an impressive 43% of worldwide capacity [3]. This dominance appears to be continuing in 2023 [4]. Bulk transshipment terminals are essential components of the global bulk cargo supply chain, facilitating the smooth transportation of bulk commodities for subsequent distribution [5].

A significant benefit of utilizing transshipment services lies in their ability to optimize transportation efficiency and minimize associated costs. Transshipment hubs achieve cost reductions through various strategies. They function by accumulating cargo from diverse origins, enabling them to capitalize on economies of scale in transportation, storage, and handling activities. This translates to lower overall costs per unit of cargo moved. Additionally, these hubs empower businesses with flexibility. They can choose the most suitable transportation mode for each leg of the journey based on cost, speed, and reliability. This optimization in route planning enhances the overall responsiveness and agility of the supply chain [6].

Despite their benefits, transshipment services also present challenges that need to be addressed to ensure smooth operations and uninterrupted supply chain flow. These challenges include coordinating complex multi-modal transportation processes, managing cargo handling and storage capacity, navigating regulatory requirements, and mitigating risks such as delays, damages, and security threats [7].

To address these challenges and maximize the benefits of transshipment services, businesses and logistics stakeholders employ various strategies and technologies. These may include advanced tracking and monitoring systems, automation and robotics in cargo handling, predictive analytics for demand forecasting and capacity planning, and collaboration among supply chain partners to improve coordination and visibility.

1.2 The basics of business process management

At the core of every successful organization lies a well-defined set of interconnected activities known as business processes. These processes, structured and routinely executed, ensure the smooth and efficient operation of the entire business. They encompass a wide range of functions, including supply management, production, distribution, marketing coordination, and customer service provision. These essential activities work together seamlessly to maintain the uninterrupted day-to-day operations of the organization. The core functions of a business can be understood through its operational processes.

In compliance with Laguna and Marklund’s paper, business processes serve as the "foundation" for ensuring the efficient functioning of an organization, profoundly impacting its performance. By effectively managing and optimizing these processes, organizations can gain significant advantages and maintain their relevance in an ever-changing and highly competitive business environment. Thus, ensuring proper adaptation to fluctuating market demands and supporting sustainable growth in a dynamic and challenging context [8].

According to Rosenberg’s paperwork the processes are essentially a series of interconnected activities, transforming raw materials or services into desired outputs. Their goal is to achieve the organization's specific operational objectives [9]. Procurement, production, distribution, marketing, sales, and customer service are all examples of such processes, though the specific lineup will vary depending on the nature [10].

Optimizing transshipment processes requires establishing clear and achievable goals. Kunpeng, Gharehgozli, & Lee [11] emphasize the value of employing SMART objectives in this context. By setting Specific, Measurable, Achievable, Relevant, and Time-Bound goals, organizations can ensure focused direction for their optimization efforts. This allows for measurable progress tracking and ultimately increases the likelihood of achieving desired performance improvements within transshipment operations.

Measurable objectives are quantifiable, allowing progress tracking. Achievable objectives are realistic and feasible within organizational capabilities. Relevant objectives align with overall organizational strategy and needs. Time-bound objectives have specific deadlines for completion. Adhering to SMART principles ensures focused direction, measurable progress, and increased likelihood of achieving desired outcomes in operational processes [12].

In their exploration of business process performance evaluation, Nanyam & Neeraj [13] highlight the critical role of defining clear objectives and expected outcomes. This approach allows organizations to establish measurable benchmarks for success. By comparing actual results against these predefined objectives, organizations can conduct unbiased evaluations of process effectiveness and identify areas for improvement.

Clearly defined objectives are essential for effective performance evaluation within business processes. These objectives function as a performance measurement framework, allowing organizations to assess progress towards achieving desired outcomes. By comparing actual results against these predefined objectives, organizations can identify areas for improvement and ensure all stakeholders, including employees, are aligned on the goals of optimizing process performance [14] [15].

2. MODELING TRANSSHIPMENT OPERATIONS IN CONSTANTA PORT USING AURAPORTAL MODELER: RESEARCH HYPOTHESES AND APPLIED VARIABLES IN THE MODEL

2.1 Modelling approach and case study assumptions

This paper aims to analyse the semi direct transshipment operation of a barge carrying 40,000 metric tons of Clinker Big Bags within a strict 12-day timeframe. Such an endeavour demands a well-coordinated plan and streamlined processes to ensure both effectiveness and cost efficiency. To tackle this challenge, a simulation program has been devised, considering crucial parameters such as the total cargo volume, the duration of the program, and the estimated cost involved. With these factors in mind, the simulation aims to optimize the transshipment process, ensuring that all cargo is efficiently handled within the allocated timeframe.

The process is meticulously broken down into key stages within the simulation. It begins with the crane lifting a Big Bag from the ship onto a waiting tractor-trailer, followed by the transportation of the loaded bag to the designated storage area by the tractor. Subsequently, a forklift unloads the bag from the trailer and places it in storage. The cycle is completed with the return of the empty tractor to the crane for the next Big Bag and the forklift's return to the storage area. Acknowledging real-world variations, the simulation takes into consideration factors that could impact the average cycle time, such as equipment efficiency, operational coordination, and unforeseen events like adverse weather conditions or minor delays. The outcome of the simulation not only assesses the feasibility of achieving the target goal within the stipulated timeframe but also serves as a foundation for continuous improvement. Through regular monitoring and analysis of cycle times during the actual unloading process, potential bottlenecks can be identified and addressed for future optimization. Additionally, embracing technological advancements in automation and equipment efficiency can further enhance the unloading process, ensuring long-term efficiency and sustainability by remaining adaptable to changing operational needs.

Before diving into the optimized process, it's important to acknowledge potential roadblocks encountered during the simulation. While simulations are invaluable for planning and improvement, they may not perfectly mirror reality. By openly addressing these challenges, we ensure the optimized process we present accurately reflects the true needs and conditions at the Port of Constanta. This transparency builds trust and allows for a more realistic and effective optimization plan.

For process modelling, the authors used Aura Portal Helium Modeler, a free and dedicated software tool. Aura Portal is a digital business platform that streamlines process design and execution without requiring additional programming knowledge. Its core product, Aura Portal

BPM (Business Process Management), is a software application specifically designed to facilitate the creation and automation of workflows.

To ensure the model confidentiality, the company analysed in the case study has been named, "Danube Investments Ltd.", representing a typical big bag transshipment service provider in the Port of Constanta. Data on activity durations and costs have been gathered from ten similar companies to create statistically relevant averages for variables used in the model (e.g., crane operation time, personnel costs). A pre-existing transshipment model was selected, and key processes were identified to map the flow of big bags from retrieval on the barge to designated storage locations on the land platform. This comprehensive analysis ensures the model accurately reflects the big bag unloading process at the Port of Constanta, considering factors like resource allocation and travel times.

2.2 Process model description. detailed breakdown of the transshipment process activities

As main activities, the authors begin with the assumption of completed customs formalities and the ship is docked for unloading. The process has been divided in three main phases, each with subsequent tasks for a better understanding of the process.

Phase A reflects the unloading process of the cargo from the barge using the quay crane and unloading onto the tractor. The initial task entails the crane's rotation to the required height, directed by the barge foreman. Upon successful completion, the subsequent activity of moving the cargo onto the tractor trailer is followed. Herein lies a decision point: if cargo security is ensured, we advance to the next task; otherwise, the cargo must be re-secured, and the process will return to task 2 to rectify the issue before proceeding. If some big-bag is damaged during handling, it is sent for repackaging.

Following the unfastening the cargo from the trailer, the process continues with the transportation of the cargo to land using tractor-trailer units in phase B. The suitability of the tractor determines the progression, with any unsuitable choices leading to a temporary halt until a suitable alternative is found. Therefore, if the tractor is not suitable for the task, the activity will have a finish point until a suitable tractor is found. The process is followed with the transporting the cargo to land over 400 meters, leading to positioning the trailers in the optimal area of action for forklift operations.

The adequacy of personnel and resources determines progression to phase C, where the cargo is transferred from tractor to land using a forklift. If the resources are insufficient, the activity will be suspended. Upon completion of the positioning task for the forklift on the side of the trailer, guided by the docker, the process proceeds to lifting the load to the appropriate height for retrieving the big bag from the trailer. It is then assessed whether the forklift meets the unloading requirements; if not, operations are suspended until a suitable replacement arrives. Once a suitable forklift is available, the process advances to moving the forklift forward to the pickup position, guided by the docker, followed by relocating the forklift over 10 m to the designated location for depositing the big bag. If successful, the process proceeds to placing it at the indicated location. On-site workers then inspect the task's completion; if the big bag is misplaced, the process returns to the relocation task to ensure correct placement. Upon successful completion of the placement task, the process moves on to raising the hooks vertically, followed by lifting the forks, rotating the forklift, and moving it without cargo to the pickup point for another big bag, thus concluding the cycle. Tasks progress sequentially, culminating in the completion of a cycle with the final task.

In summarizing the process, in figure 1 model the authors have presented in three distinct phases, each comprising subsequent tasks for enhanced clarity as depicted below. Phase A encompasses the unloading of cargo from the barge using the quay crane and its subsequent transfer to the tractor trailer. Phase B is dedicated to transporting the cargo to land via tractor-trailer units, with the suitability of the tractor dictating the course of action. Phase C involves transferring the cargo from the tractor to land using a forklift, with the sufficiency of personnel and resources guiding the process forward. Tasks advance sequentially, culminating in the completion of a cycle with the final task.

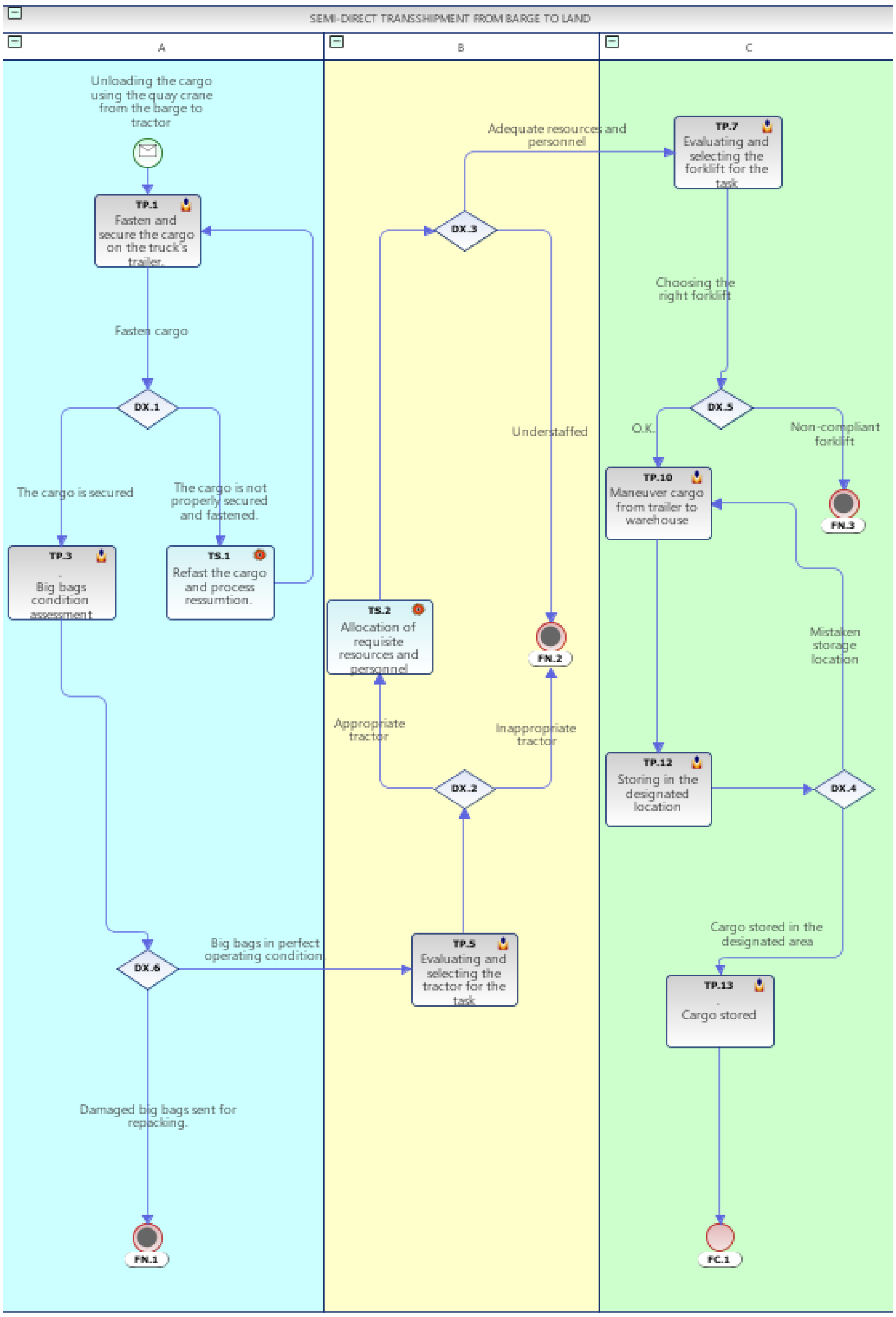

Fig. 1. Semi-Direct transshipment process modeling using Aura Portal

Once the process model has been established, powerful simulation software comes into play. This software leverages statistical data to create various scenarios that replicate real-world transshipment operations. The data focuses on activities deemed critical for successful execution, such as crane operation times or personnel requirements. By integrating these critical parameters, the simulation software can anticipate potential results like total unloading time or resource needs. It can also pinpoint areas within the process that slow down operations, allowing for targeted optimization efforts. Additionally, the software analyses how resources like cranes and personnel are currently used and identifies opportunities for more efficient deployment. Finally, it evaluates key performance indicators (KPIs) like total unloading time, cost per ton, and resource utilization to gauge the effectiveness of the entire process. Through simulation and analysis, the software empowers authors to identify and address inefficiencies, ultimately leading to a smoother, faster, and more cost-effective transshipment process in the Port of Constanta.

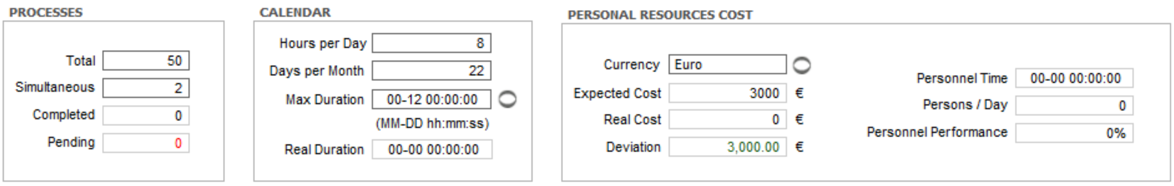

Fig. 2. Configuring parameters for initiating the process simulation

The visual representation depicted in figure no. 2 illustrates the configured parameters before initiating the simulation. Within the simulation process, a total of 50 processes have been implemented per day, enabling the unloading of 800 tons per day. Over the course of 12 days, this setup ensures the complete unloading of the entire quantity. Additionally, the simulation allows for 2 simultaneous executions, reflecting industry standards derived from sample companies' analyses. The calendar panel provides insights into simulation run times, indicating default values for working hours per day set at 8. This parameter serves as the foundation for computing simulation outcomes. For instance, if a process requires 24 hours to complete and the standard workday spans 12 hours, the total execution duration would equate to 2 working days per month. This default setting assumes 22 working days per month. The simulation is configured to run for a maximum duration of 12 days, with the actual durations of processes revealed upon completion. The total cost expenditure of the process amounts to 3,000 Euro for a twelve-days period, involving twenty individuals per day in the transshipment operation.

Upon configuring the temporal and financial parameters, the simulation was brought to a close. Throughout the simulation's execution, objects within the model illuminate in various hues corresponding to their temporal status. A green hue signifies that an object has completed its assigned tasks within the anticipated timeframe and cycle count, while orange indicates completion within an alert timeframe, and red indicates completion beyond the projected timeframe.

As shown in the figure 3, the simulation highlights opportunities to enhance the process. The current completion time identified in the simulation suggests room for improvement. To identify these, a deeper analysis of the simulation results is necessary. Focusing on bottlenecks could involve examining factors such as task allocation, training needs, or inefficiencies in the process flow itself. By pinpointing these areas, we can develop targeted solutions, such as refining process steps or implementing new technologies. These improvements will ultimately lead to a more streamlined and effective process, resulting in (positive business outcome, e.g., reduced costs, faster turnaround times, improved customer satisfaction).

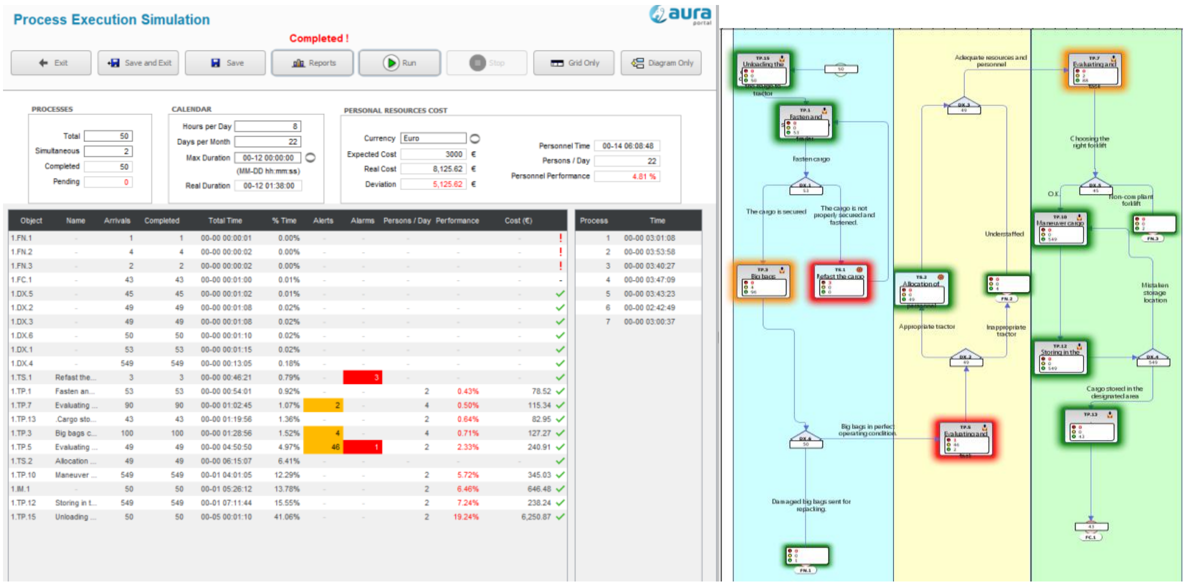

Fig. 3. Process execution simulation diagram

However, despite our best efforts, the initial budget of 3,000 euros was exceeded by 5,125 Euros due to unforeseen challenges in the procurement of specialized equipment required for the simulation. Delays in equipment delivery and unexpected maintenance costs contributed to the budget overrun, highlighting the importance of comprehensive risk assessment and contingency planning in future projects. Ultimately, achieving both optimal performance and cost-effectiveness are crucial for project success.

The simulation within the Aura portal has identified potential bottlenecks in the unloading process, requiring further analysis and improvement. These bottlenecks are indicated by the appearance of yellow and red error messages. Upon initial observation, the software, by iterating the process through the designed cycle count, identified delays in the transshipment procedure due to task overlap and resource inadequacies, leading to congestion in the operational queue.

Red Errors: Critical Issues Requiring Immediate Attention

➢ **TS1** - Refasten Cargo and Process Resumption (Red Error): This critical error signifies a severe interruption, likely due to cargo instability or safety concerns. Immediate action is necessary to refasten the cargo and resume operations safely and efficiently.

➢ **TP5** - Evaluating and Selecting Tractor for Task (Red Error): This red error indicates a significant delay in selecting the appropriate tractor for the job. Potential causes include equipment unavailability or bottlenecks in the decision-making process. Optimizing tractor selection procedures can significantly reduce these delays.

Yellow Errors: Areas for Improvement and Optimization

➢ **TP7** - Evaluating and Selecting Forklift (Yellow Error): This yellow error suggests a moderate delay or inefficiency in selecting the appropriate forklift. Resource limitations or insufficient planning could be contributing factors. Streamlining the selection process can minimize these delays.

➢ **TP3** - Big Bags Condition Assessment (Yellow Error): The presence of this yellow error highlights the need for a more thorough assessment of the big bags' condition. Inconsistencies or uncertainties in the current process require investigation and improvement.

By analysing these red and yellow errors, we can pinpoint specific areas for improvement within the Aura portal simulation. By implementing corrective actions and optimizing the identified processes, we can ensure a smoother and more efficient unloading workflow. The simulation provides valuable insights into potential problems, allowing us to proactively address them before they hinder real-world operations.

2.3 Potential bottlenecks revealed in Aura Portal Simulation: software-based optimization strategies

The Aura portal simulation has uncovered potential bottlenecks within the unloading process, emphasizing the necessity for comprehensive analysis and targeted optimization. These bottlenecks are evident through the appearance of red and yellow error messages, each indicating areas for improvement.

Red errors, denoting critical issues requiring immediate attention to prevent disruptions and ensure safety, include "TS1 - Refasten Cargo and Process Resumption" and "TP5 - Evaluating and Selecting Tractor for Task." The former signals a severe interruption, potentially caused by cargo instability or safety concerns, while the latter highlights significant delays in selecting the appropriate tractor. To address these critical issues, optimization measures such as implementing pre-departure inspections for cargo stability and enhancing communication for tractor selection can be implemented.

Yellow errors, representing areas for improvement to enhance efficiency and minimize delays, include "TP7 - Evaluating and Selecting Forklift" and "TP3 - Big Bags Condition Assessment." These errors suggest moderate delays in selecting the appropriate forklift and emphasize the need for a more thorough assessment of big bags' condition, respectively. Optimization measures for yellow errors involve developing centralized resource management systems, implementing standardized procedures, and using digital inspection systems to ensure consistent evaluation procedures.

The identified bottlenecks and optimization measures represent a starting point for continuous improvement. By regularly monitoring the simulation and analysing performance data, new areas for improvement can be proactively identified and further optimizations implemented. This data-driven approach ensures that the unloading process remains efficient, safe, and adaptable to changing demands. Ultimately, the Aura portal simulation serves as a valuable tool for identifying and addressing bottlenecks in the unloading process, leading to a smoother, more efficient, and safer workflow.

2.4 Optimization actions ensuring budget compliance

Throughout the simulation process outlined in this study, several optimization actions were meticulously implemented to ensure that the operations remained within the allocated budget. By strategically addressing inefficiencies and streamlining workflows, we were able to achieve the desired outcomes while adhering to financial constraints.

One of the primary optimization measures undertaken was the refinement of process efficiency. By fine-tuning the scheduling of tasks and maximizing resource utilization, we significantly enhanced productivity without compromising on quality or safety standards. This approach allowed us to capitalize on the available resources more effectively, ultimately contributing to cost savings.

Additionally, proactive measures were taken to mitigate potential bottlenecks and disruptions in the workflow. By identifying and addressing critical issues promptly, we were able to maintain operational continuity and minimize costly delays. This proactive stance not only safeguarded the project timeline but also prevented unnecessary expenditures associated with downtime and rework.

Furthermore, strategic resource allocation played a pivotal role in budget compliance. By allocating personnel and equipment judiciously based on task requirements and workload demands, we optimized resource utilization and minimized unnecessary expenses. This balanced approach ensured that resources were allocated where they were most needed, maximizing operational efficiency while staying within budgetary constraints.

Upon implementing the optimization methods mentioned earlier, the simulation of the process was successfully conducted according to the specified parameters. As shown in figure no 4 for the 50 processes with two simultaneous executions, the entire quantity of cargo was operated within 11-day timeframe. This was accomplished with the involvement of 20 resources in the process, while also adhering to an approximate budget of 2000 euros. This outcome objectively demonstrates the effectiveness of the optimization methods, enabling the achievement of set objectives within the defined financial constraints.

In conclusion, the successful completion of the simulation within the allocated budget underscores the effectiveness of the optimization actions implemented. By proactively addressing inefficiencies, mitigating risks, and optimizing resource allocation, we not only achieved the desired outcomes but also demonstrated our commitment to prudent financial management. Looking ahead, these optimization strategies will continue to inform our approach, ensuring that future simulations are conducted efficiently and cost-effectively.

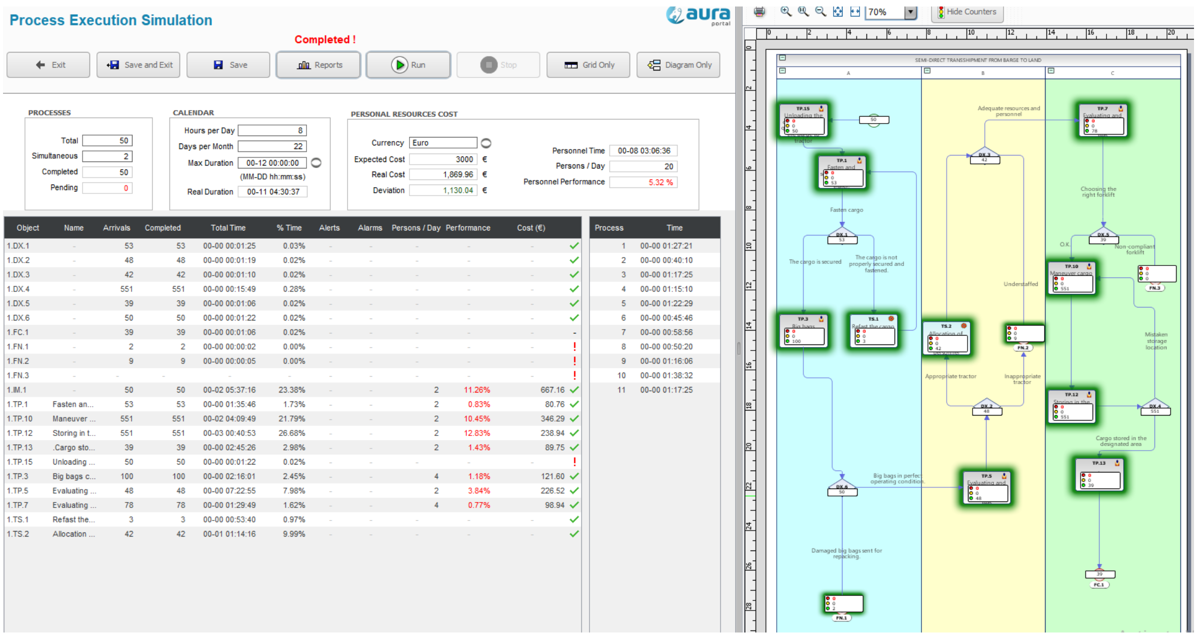

Fig. 4. Successful implementation of optimization methods: achieving objectives within budget and time constraints

3. CONCLUSION

To ensure the robustness and accuracy of the simulation results, data validation was conducted through a multi-pronged approach. Firstly, data on activity durations and costs was gathered from ten similar companies operating at the Port of Constanta. This approach leverages established practices within the industry and provides statistically relevant averages for variables used in the model (e.g., crane operation time, personnel costs). Additionally, internal validation measures were employed to enhance the reliability of the simulation data. This involved cross-checking activity durations and costs against historical data maintained by the port authorities and conducting sensitivity analysis to assess the impact of variations in key input parameters on the simulation outcomes. By employing these rigorous data validation procedures, we can confidently assert that the simulation results accurately reflect the real-world unloading process at the Port of Constanta, providing a solid foundation for optimization strategies.

This study successfully employed BPM software and simulation techniques to analyse and optimize the unloading process of big bags at the Port of Constanta, Romania. The key findings and areas for improvement are summarized below:

- The Aura Portal simulation revealed critical bottlenecks within the unloading process, including delays in cargo refastening (TS1), tractor selection (TP5), forklift selection (TP7), and big bag condition assessment (TP3). These bottlenecks were highlighted by red and yellow error messages, signifying areas requiring immediate attention and optimization opportunities, respectively.
- Software-Based Optimization Strategies: To address the identified bottlenecks, the study proposes a series of software-based optimization strategies. These include implementing pre-departure cargo stability inspections to minimize refastening delays (TS1), enhancing communication and streamlining procedures for tractor selection (TP5), developing centralized resource management systems for efficient forklift allocation (TP7), using digital inspection systems to ensure consistent big bag condition assessment (TP3).
- The study emphasizes the importance of budget adherence throughout the optimization process. Strategies like process efficiency refinement, proactive bottleneck mitigation, and strategic resource allocation were employed to ensure cost-effectiveness. Furthermore, the simulation, configured with 50 processes, 2 simultaneous executions, and a budget of approximately €2,000, successfully completed the unloading of the entire clinker cargo within 11 days using 20 resources. This demonstrates the effectiveness of the implemented optimization strategies in achieving project objectives within budgetary constraints.
- The study acknowledges the importance of continuous monitoring and data analysis to identify further optimization opportunities. By adopting a data-driven approach, the unloading process can be continuously refined for enhanced efficiency, safety, and adaptability to evolving demands.

In conclusion, this research demonstrates the value of BPM software and simulation in optimizing transshipment operations. By identifying and addressing bottlenecks, and implementing targeted optimization strategies, significant improvements can be achieved in terms of efficiency, safety, and cost-effectiveness. By continuously monitoring and analysing performance data, this approach ensures long-term optimization and adaptability within the dynamic environment of port operations. In conclusion, this study has shed light on the intricacies of transshipment operations and demonstrated the effectiveness of Business Process Management (BPM) software, particularly Aura Portal Modeller, in visualizing and analysing process flows. By leveraging statistical simulation functionalities, researchers were able to pinpoint potential bottlenecks within the process, paving the way for optimization strategies.

The proposed measures for improvement encompass various aspects of the transshipment process, including real-time assessment of cargo handling needs, implementation of tracking systems for inventory management, analysis of equipment capabilities, and optimization of storage layout. By implementing these solutions, organizations can streamline operations, enhance efficiency, and mitigate potential delays and errors.

References

1. Yang D., K. Wang, H. Xu, Z. Zhang. 2017. ”Path to a multilayered transshipment port system: How the Yangtze River bulk port system has evolved”. *Journal of Transport Geography* 64: 54-64.
2. Cigolini R., T. Rossi. 2010. ”Sizing off-shore transshipment systems in dry-bulk transportation”. *Journal of Production Planning and Control* 21(5): 508-522.
3. Kavussanos M., S. Moysiadou. 2021. ”Bulk shipping markets: An overview of market structure and dynamics”. *International Encyclopaedia of Transportation* 3:257-279.
4. UNCTAD. 2023. *Review of maritime transport 2023*. Technical report.
5. Cheng L., X. Lin, X. Bai. 2023. “Direct Transshipment Optimization in Hub Bulk Transshipment Terminal”. *SSRN* 4679152.
6. Filina-Dawidowicz L., M. Kostrzewski. 2022. ”The complexity of logistics services at transshipment terminals”. *Journal Energies* 15(4): 1435.
7. Archetti C., L. Peirano, M. Speranza, C. Archetti, L. Peirano, M.G. Speranza. 2022. “Optimization in multimodal freight transportation problems: A Survey”. *European Journal of Operational Research* 299(1): 1-20.
8. Laguna M., J. Marklund. 1998. *Business Process Modeling, Simulation and Design.* 3rd edition. New York: CRC Press.
9. Rosenberg D. 2006. *Business Process Design: The Method*. Business Process Management. Springer.
10. Lindsay A., D. Downs, K. Lunn. 2003. “Business processes – attempts to find a definition”. *Information and Software Technology* 45(15): 1015-1019.
11. Kunpeng L., A. Gharehgozli, J.-Y. Lee. 2023. “Smart technologies and port operations: Optimal adoption strategy with network externality consideration”. *Computers & Industrial Engineering* 184.
12. Doran G. 1981. “There's a S.M.A.R.T. way to write management's goals and objectives”. *Management Review* 70(11): 35-36.
13. Nanyam V., K. Neeraj. 2023. “Modeling challenges affecting the performance of major ports of India”. *The Asian Journal of Shipping and Logistics* 39(3): 26-38.
14. Simons R. 1995. “Control in an age of empowerment”. *Harvard Business Review* 73(2): 80-88.
15. Sánchez-González G., F.J. González-Castaño, L.H. Pérez-Bernal. 2019. “Business process management in warehouses: A systematic literature review”. *Journal of Industrial Engineering and Management* 12(4): 756-775.

Received 20.05.2024; accepted in revised form 29.07.2024