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TOWARDS SMART FACTORIES: THE DEVELOPMENT OF AUTONOMOUS MOBILE ROBOTS FOR INTRALOGISTICS 4.0

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Abstract

The evolution of Industry 4.0 underscores intralogistics as a critical enabler of smart factories, where responsiveness and adaptability outweigh the rigid path structures of Automated Guided Vehicles (AGVs). Autonomous Mobile Robots (AMRs) have emerged as a viable alternative, yet their validation under production-like conditions remains limited. This study introduces ProdigiMover-Small, a skid steering AMR prototype designed through additive manufacturing and controlled via the Robot Operating System (ROS). The platform integrates LIDAR, wheel encoders, and inertial sensing in a compact and cost-efficient design. When validated in a workshop-like environment, the system demonstrated reliable navigation, maintaining localization accuracy within 2–4 cm in workstation targets and 4–6 cm along traversed routes, while positioning operations achieved a high overall success rate. Comparative analysis further revealed that additive manufacturing reduced development lead time by more than half and overall costs by approximately 90%. These results confirm that task proximal precision, modularity, and adaptability are decisive for intralogistics performance. The presented prototype illustrates a scalable pathway from laboratory proof-of-concept to industrial deployment. It also provides a foundation for future research on multi-robot coordination, human-aware navigation, and digital twin integration in Intralogistics 4.0.

Keywords: Industry 4.0; Intralogistics 4.0; Autonomous mobile robots; Robot Operating System; Smart factories.

1. Introduction

Manufacturing systems are undergoing a systemic reorientation with the proliferation of Industry 4.0, where digitalisation, automation, and intelligent decision-making are fundamentally reshaping traditional production processes [1], [2]. The seamless integration of cyber-physical systems, real-time data, and networked devices reinforces the necessity for redefined approaches to intralogistics [3], [4]. Conventional AGVs, constrained by fixed routes and limited adaptability to dynamic environments, prove insufficient for the requirements of modern intralogistics [3], [4], [5]. Such constraints impede factories from attaining the flexibility and responsiveness that lie at the core of smart manufacturing systems [2], [4].

Previous studies have consistently underscored intralogistics as the essential pillar of smart factories, where the timely coordination of material flows directly supports production efficiency [2], [5], [6]. In this regard, research on AMRs has primarily focused on navigation, localisation, and path planning, frequently implemented through ROS [7], [8], [9]. Although numerous prototypes and simulation models have been introduced, a persistent gap remains in translating these advances into practical intralogistics applications under real factory conditions [3], [4], [6]. To bridge this gap, the present study introduces the development of a skid steering AMR integrated with ROS, designed to facilitate intelligent material transport in manufacturing environments. The design emphasises real-time navigation capabilities and flexible control mechanisms, ensuring suitability for dynamic manufacturing environments. The proposed approach illustrates how robotics and intralogistics can be systematically integrated in alignment with Industry 4.0 principles.

This work contributes by illustrating how ROS enabled AMRs extend beyond the conventional capabilities of AGVs, delivering modularity, adaptability, and interoperability in intralogistics. As a proof-of-concept, the system demonstrates the integration of robotics and material handling functions, advancing the operational foundations of smart factories. Subsequent research will advance toward multi-robot collaboration, the incorporation of advanced perception systems, and leveraging digital twins to enable predictive logistics management. These research directions are expected to foster the evolution of Intralogistics 4.0, consolidating the role of AMRs as key enablers of fully automated and intelligent manufacturing ecosystems.

2. Literature Review

The transformation toward Industry 4.0 has shifted manufacturing from rigid, centralised production lines to smart factories that operate as cyber-physical systems, emphasizing reconfigurability, real-time data integration, and human-machine collaboration. Within this transformation, intralogistics has become a decisive driver of industrial competitiveness, as the precise synchronization of material delivery with production demands directly determines the agility and resilience of manufacturing networks [5]. At the core of this transition stand AMRs, surpassing the rigid path dependency of AGVs. By uncoupling intralogistics from static infrastructure, AMRs enable decentralised, adaptive, and human-aware operations across dynamic manufacturing environments [7]. Foundational studies have introduced the concept of autonomous intralogistics systems, proposing autonomy levels across transport, storage, and order-handling tasks and highlighting the shift from centralised AGV style control toward networked, adaptive decision-making; in this regard AMRs equipped with onboard perception and navigation systems provide greater responsiveness to environmental changes, thereby enabling decentralised and reconfigurable logistics operations [8], [10].

The adoption of AMRs in intralogistics brings clear advantages, such as enhanced productivity, improved safety, and reduced manual workload [11]. However, challenges remain, including high integration costs, energy constraints, and limited human-robot collaboration in semi-structured environments [12], [13]. Recent studies further show that AMR enabled networks can outperform traditional conveyor (or AGV) based systems when cost and shift conditions are favourable [5], while reviews continue to highlight persistent gaps in safety, interoperability, and scalability that limit widespread deployment.

At the motion level, AMR performance hinges on robust localisation, mapping, and planning capabilities. Surveys classify approaches ranging from graph-based global routing to local obstacle avoidance under sensing and computation limits, underscoring trade-offs among optimality, smoothness, and real-time feasibility [8], [9], [14]. Comparative analyses further highlight when sampling-based planners (e.g., RRT variants), search-based planners (A* derivatives), or optimisation-based model predictive control (MPC) planners are best suited under industrial constraints such as narrow aisles, mixed traffic, and safety zones [15]. Beyond technical motion planning, human-aware navigation introduces additional requirements (predicting worker trajectories, respecting proxemics, and signalling intent) so that robots can coexist safely without excessive conservatism [16]. Industrial contributions complement this by integrating explicit environmental cues, such as safety line detection, to simplify perception and enforce compliance with plant safety policies [17]. Locomotion strategy likewise shapes intralogistics performance. Kinematic comparisons of differential, mecanum, and omnidirectional wheelbases clarify how controllability and manoeuvrability affect throughput in tight layouts, positioning operations, and pallet pickup [15]. Within this spectrum, differential or skid steering platforms remain the most widely adopted due to their structural simplicity, robustness, and ability to handle higher payloads at lower cost [7], [15]. While omnidirectional bases offer superior manoeuvrability, their sensitivity to floor conditions and higher integration cost often limit their scalability in industrial contexts. This positions skid-steering AMRs as a pragmatic solution for dynamic shop floors, where reliability and cost efficiency are prioritized over unrestricted mobility. Although their inability to perform true lateral motion imposes kinematic constraints in confined or mixed traffic environments, recent studies suggest that advanced navigation algorithms, hybrid path planners, and adaptive control strategies can mitigate these limitations thereby extending the applicability of skid steering robots beyond traditional domains. Against this backdrop, the present research contributes by developing a skid steering AMR specifically tailored for intralogistics operations, aiming to reconcile industrial practicality with the flexibility demands of Intralogistics 4.0.

From a systems perspective, the challenge extends beyond driving robots to orchestrating them within complex workflows. Recent navigation architectures adopt modular, platform-agnostic layers with semantic mapping, profile switching, and distributed control to improve robustness across heterogeneous fleets and changing layouts [10]. Parallel work on process-level orchestration emphasises intuitive, visual programming interfaces that allow non-experts to configure missions, parameterise behaviours, and monitor fleets, thus facilitating adoption in brownfield sites [12].

Application-level evidence demonstrates both benefits and pitfalls of AMR integration. In Smart Factory contexts, MiR100 platforms integrated with MES/WMS and wireless I/O achieved millimetre-scale repeatable positioning accuracy using visual markers, while also exposing failure modes in narrow spaces [18]. Case studies in remanufacturing show that AMR-driven material delivery increases throughput and reduces nonvalue adding time when paired with lean practices such as 5S and Kaizen [13]. Multi-case warehouse research further identifies adoption drivers (layout decoupling, ERP/WMS integration) and barriers (legacy safety zoning, change management), highlighting how organisational readiness influences total cost of ownership [11].

Despite these advances, several gaps persist. Current approaches to production logistics integration often remain offline or myopic, lacking predictive scheduling and receding horizon fleet control [5]. Safety-aware navigation requires verifiable behaviours that degrade gracefully under sensor faults, layout changes, and mixed traffic [19]. Human-in-the-loop orchestration remains underdeveloped, yet essential for acceptance, requiring explainable intent, ergonomic task design, and clear collaboration protocols [20]. Finally, learning-augmented forecasting, particularly trajectory prediction of workers and forklifts, offers a promising direction to reduce idle time and congestion by coupling human motion prediction with task allocation and path planning [16].

Collectively, the literature positions AMRs as critical enablers of Intralogistics 4.0, but only when navigation, fleet control, and process orchestration are co-designed with production scheduling, safety governance, and human workflows. These converging insights provide a rationale for research into new robotic platforms such as skid steering AMRs tailored for dynamic manufacturing environments aiming to bridge the persistent gap between theoretical advances and practical deployment in smart factories.

3. Prototype Development for Intralogistics Applications

Although recent research in intralogistics has made significant progress in path planning, localisation, and fleet coordination for AMRs, much of this work remains confined to simulations or idealized laboratory tests. To ensure applicability to manufacturing practice, AMRs must be evaluated in production-like environments that capture the complexity of real material handling workflows. Simulation studies often fail to reflect practical constraints such as narrow aisles, positioning operations, or interactions with human workers. To address this gap, the present study introduces a 3D printed skid steering prototype conceived as a proof-of-concept platform for intralogistics applications. Skid steering was selected due to its mechanical simplicity and robustness under varying payload conditions, despite its limited lateral mobility, which was considered acceptable for intralogistics environments dominated by linear and aisle-based flows.

The prototype was developed to be compact, cost efficient, and sufficiently robust for repeated laboratory testing. PLA filament was selected for its accessibility, low cost, and suitability for rapid prototyping. While adequate for laboratory testing, its limited durability under high-load or high-temperature conditions suggests that future iterations could adopt reinforced polymers or composite materials to meet industrial robustness requirements. The platform integrates four wheels in a skid steering configuration, a locomotion principle widely adopted in industrial applications due to its mechanical simplicity and manoeuvrability. Differential motion is achieved through the coordinated actuation of the left and right motor pairs. To ensure realistic kinematic behaviour at reduced scale, proportional downscaling was applied, harmonizing chassis dimensions, wheel diameter, and motor torque. In this way, the compact platform-maintained consistency with larger AMR concepts while being more accessible for experimental validation. This scaling approach ensured that turning radii, wheel slip characteristics, and manoeuvrability constraints remained representative of industrial-scale AMRs, thereby preserving the validity of experimental observations despite the reduced size. Key specifications of the prototype are summarized in Table 1, highlighting the compact yet functional design of the robot.

Component	**Specification**
Chassis	3D-printed frame, compact skid-steering design
Wheels	4 wheels, 85 mm diameter × 38 mm width, rubber with nylon-reinforced rims
Motors	DC motors with proportional downscaling, integrated incremental encoders
Sensors	2D LiDAR (YDLidar G2), wheel encoders, IMU
Control Unit	Onboard computing with Ubuntu + ROS Noetic
Power Supply	Rechargeable battery pack (compact, lightweight)

Table 1. Technical Specifications of the Prototype

The physical prototype developed for this research is presented in Fig. 1. The compact skid steering platform integrates 3D printed structural components, encoder-equipped motors, and a ROS-based control unit. Its lightweight and portable design enables efficient testing of navigation and mapping functionalities, serving as a proof-of-concept platform for intralogistics research.

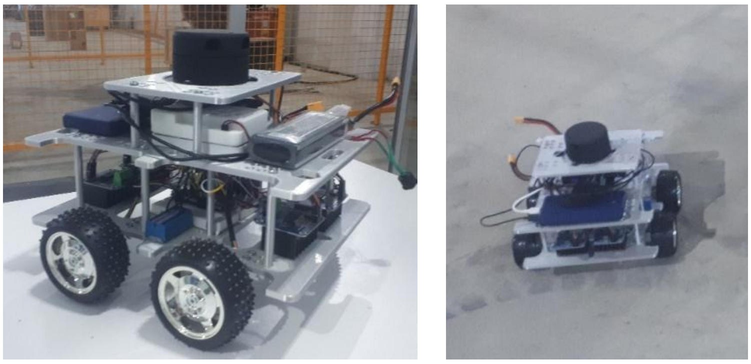

Fig. 1. 3D Printed Skid-Steering Robot Prototype for Intralogistics Applications

The compact prototype, named ProdigiMover-Small, was developed using additive manufacturing to replicate the essential features of larger autonomous mobile robots. The platform integrates four wheels in a skid steering configuration, encoder-equipped DC motors, and a ROS-based control unit. Its lightweight and modular structure provides a cost-effective solution for proof-of-concept experiments in production-like laboratory environments. Validation was conducted in a production-like laboratory environment designed to resemble a small-scale manufacturing workshop. The facility is equipped with conventional machine tools such as turning and milling machines, a KUKA robotic manipulator for handling tasks, and buffer areas arranged with palletised storage zones. These elements provided realistic obstacles and spatial constraints that reflect actual shop floor conditions. The layout of the laboratory allowed the prototype to be tested in scenarios involving manoeuvring through narrow pathways, positioning in front of workstations, and navigating around static industrial equipment. Such an environment ensured that the prototype was not only tested under controlled conditions but also challenged by the types of constraints typical of intralogistics operations.

The platform employs four rubber wheels (85 mm diameter and 38 mm width) with nylon-reinforced rims, selected to provide sufficient grip on laboratory floor surfaces. Motion is actuated by DC motors with integrated incremental encoders, controlled via a compact motor driver. Power is supplied by an 11.1 V 3S Li-Po battery, balancing autonomy with portability. For perception and localisation, the robot integrates a YD LIDAR sensor and an MPU-9250 IMU, complemented by encoder feedback for odometry. Low-level actuation and sensor interfacing are managed by an ESP32 microcontroller, while high-level navigation and decision-making tasks are executed on a Raspberry Pi. Beyond raw sensor fusion, the combined odometry estimates were subjected to filtering within the ROS framework, which attenuated noise and compensated for drift. This additional layer of processing yielded smoother trajectories and reinforced localisation stability, particularly during extended navigation tasks.

The control system was designed as a layered architecture in which low-level actuation and sensor interfacing were managed by the ESP32 microcontroller, while high-level decision-making and navigation modules were executed on the Raspberry Pi. This hardware division enabled reliable real-time control of motors and sensors, while ensuring sufficient computational capacity for ROS-based tasks such as localisation, mapping, and path planning. The overall architecture was implemented within the ROS framework, with nodes for odometry calculation, LIDAR based environment scanning, navigation via the ROS Navigation Stack, and teleoperation. Standard ROS message types (e.g., nav_msgs/Odometry, geometry_msgs/Twist) facilitated communication among modules. By relying on widely available open-source ROS packages, the system demonstrated both modularity and portability, ensuring that the prototype's architecture can be directly transferred to larger AMR platforms.

4. Results and Discussion

The developed skid-steering AMR prototype (ProdigiMover-Small) was validated in a production-like lab setup. The 3D printed chassis showed adequate rigidity for repeated trials; ROS-based modules (odometry, LIDAR perception, local/global planners) communicated reliably and supported both teleoperation and autonomous runs. For the small-scale platform, localization accuracy remained within 2–4 cm in target-proximal positioning operations and within 4–6 cm along the traversed routes, which is consistent with the literature's emphasis that fine, localized accuracy, rather than uniform global precision, determines success in station approach and precise positioning [14], [21]. Path planning experiments confirmed that the standard ROS Navigation Stack generated feasible routes in semi-structured layouts; using Hybrid A* improved path smoothness and reduced in-place turning compared to grid-based A*. Positioning trials in front of workstation targets reached a 92% success rate, demonstrating practical applicability despite the kinematic limits of skid-steering noted in prior work [15]. These observations are consistent with recent results that recommend coarse-to-fine localization and task-phase-aware planning to bridge global navigation with high precision, target-zone maneuvers [21]. From a prototyping perspective, additive manufacturing proved decisive for iteration speed. In our case, 3D printing reduced chassis production lead-time by more than 50% relative to conventional fabrication, enabling rapid design test loops. This aligns with current manufacturing science that highlights AM as a lever for fast iteration and shorter time to market in robotics development [22].

A comparative bill of materials assessment indicated that, relative to typical industrial scale AMRs reported in the literature, our scaled down prototype achieved approximately 90% lower material and component cost while reproducing core behaviors. The primary substitutions were smaller wheels and lower torque motors (consistent with reduced wheel diameter from geometric down-scaling) and a PLA-based 3D printed chassis; sensing and compute subsystems remained the same as LIDAR and IMU, ESP32, Raspberry Pi, and power distribution. This pattern underscores a modular architecture where scale primarily affects mechanical elements, not perception or control, a finding that dovetails with industry reports advocating modular, reconfigurable intralogistics solutions [18], [23]. Modularity and transferability also emerged on the software side. Although our implementation used ROS Noetic, the broader ecosystem's evolution (e.g., Navigation2 on ROS 2) emphasizes reliability, modularity, and practical operational feasibility in facilities, qualities that make it straightforward to port the presented stack from small proof-of-concept platforms to larger AMRs as requirements scale [24]. These simulation results reinforced the experimental findings by showing similar accuracy trends in localization and navigation performance. Experiments conducted in Gazebo mirrored real world performance trends unsurprising given that Gazebo is reported as the most commonly used ROS-compatible simulator for Industry 4.0/5.0 contexts, making it a sensible testbed before shop-floor piloting [25].

Although this study focused on a single prototype, preliminary insights at the fleet level suggest broader implications for multi-robot systems. At the fleet-level, our single robot results point to expected system level bottlenecks, chiefly deadlocks in narrow intersections and contention around shared operational stations. Recent agent-based evaluations show that proactive deadlock/collision prevention policies can improve throughput by about 39%, reinforcing the value of integrating positioning-aware planning with multi-robot coordination in follow up work [26]. It should be emphasized that this study does not claim a larger platform; rather, it demonstrates that a smaller than typical prototype can faithfully reproduce key behaviors of industrial AMRs at a fraction of the cost and time, while preserving architectural modularity. This supports prior DAAAM findings on pragmatic intralogistics deployment and human-robot workflow integration [18], [21], and aligns with the growing consensus that high-accuracy positioning near targets, not omnipresent precision, is the practical lever for robust intralogistics [14], [21].

5. Conclusion

This paper presented the development and validation of a compact skid-steering AMR prototype, ProdigiMover-Small, designed as a proof-of-concept platform for intralogistics applications under Industry 4.0 principles. The study confirmed that a scaled-down, 3D printed platform can reproduce the essential behaviours of industrial AMRs such as navigation, localisation, and positioning while significantly reducing cost and development time. ROS-based implementation proved modular and transferable, demonstrating how widely available open-source tools can accelerate prototyping and facilitate the transition from laboratory validation to industrial deployment. The findings emphasize that precision near workstations, modularity of design, and adaptability to dynamic layouts are more decisive for intralogistics than universal high-accuracy positioning. Additive manufacturing further supported rapid iteration, reinforcing its role as an enabler of agile development in robotics research. Future work will extend the presented prototype towards multi-robot coordination, advanced human-aware navigation, and integration with digital twin frameworks, thereby advancing the realization of Intralogistics 4.0 and resilient smart factory ecosystems.

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7. References

[1] Smit, J.; Kreutzer, S.; Moeller, C. & Carlberg, M. (2016). Industry 4.0, European Parliament, Directorate General for Internal Policies, Policy Department A: Economic and Scientific Policy, Brussels.

[2] Albrecht, T.; Baier, M.-S.; Gimpel, H.; Meierhöfer, S.; Röglinger, M.; Schlüchtermann, J. & Will, L. (2023). Leveraging Digital Technologies in Logistics 4.0: Insights on Affordances from Intralogistics Processes, Information Systems Frontiers, 26, pp. 755–774, DOI: 10.1007/s10796-023-10394-6

[3] Yan, J.; Zhang, M. & Fu, Z. (2019). An intralogistics-oriented Cyber-Physical System for workshop in the context of Industry 4.0, Computers in Industry, 115, 103162, pp. 1178–1190, DOI: 10.1016/j.compind.2019.103162

[4] Aron, C.; Sgarbossa, F.; Ballot, E. & Ivanov, D. (2024). Cloud Material Handling Systems: A Cyber-Physical System to Enable Dynamic Resource Allocation and Digital Interoperability, Journal of Intelligent Manufacturing, 35, pp. 3815–3836, DOI: 10.1007/s10845-023-02262-6

[5] Fragapane, G.; Ivanov, D.; Peron, M.; Sgarbossa, F. & Strandhagen, J. O. (2020). Increasing flexibility and productivity in Industry 4.0 production networks with autonomous mobile robots and smart intralogistics, Annals of Operations Research, 308(1–2), pp. 125–143, DOI: 10.1007/s10479-020-03526-7

[6] Fragapane, G.; Ivanov, D.; Peron, M.; Sgarbossa, F. & Strandhagen, J. O. (2021). Autonomous mobile robots in intralogistics: Potentials and challenges for the smart factory of the future, Annals of Operations Research, 314(1), pp. 1–29, DOI: 10.1007/s10479-021-04445-0

[7] Fottner, J.; Mascolo, J. E. & Freund, T. (2021). Autonomous systems in intralogistics: State of the art and future research challenges, Logistics Research, 14(1), pp. 1–17, DOI: 10.23773/2021_11

[8] Bernardo, R.; Sousa, J. M. C. & Gonçalves, P. J. S. (2022). Survey on robotic systems for internal logistics, Journal of Manufacturing Systems, 62, pp. 738–762, DOI: 10.1016/j.jmsy.2021.12.013

[9] Demir, N.; Demircioglu, P. & Bogrekci, I. (2024). Advancing Industry 4.0 with ROS: A Case Study on Autonomous Mobile Robot Technological Advancements, International Journal of 3D Printing Technologies and Digital Industry, Vol. 8, No. 1, pp. 130–142. DOI: 10.46519/ij3dptdi.1366132.

[10] Taranta, D.; Marques, F.; Lourenço, A.; Prates, P. A.; Souto, A.; Pinto, E. & Barata, J. (2021). An autonomous mobile robot navigation architecture for dynamic intralogistics, Proceedings of the 2021 IEEE 19th International Conference on Industrial Informatics (INDIN), pp. 1–6, ISSN 2156-1676, ISBN 978-1-6654-4131-5, DOI: 10.1109/INDIN45582.2021.9557531

[11] Grover, R. & Ashraf, M. H. H. (2024). Leveraging autonomous mobile robots for Industry 4.0 warehouses: A multiple case study analysis, The International Journal of Logistics Management, 35, No. 3, pp. 188–209, ISSN 0957-4093, DOI: 10.1108/IJLM-09-2022-0362

[12] Niermann, H.; Schake, L.; Gómez Palm, D.; Grimm, S.; Lukas, S.; Schomburg, G. & ten Hompel, M. (2023). Intuitive and flexible process control for autonomous mobile robots: A case study in a large logistics enterprise, Procedia CIRP, 119, pp. 123–128, ISSN 2212-8271, DOI: 10.1016/j.procir.2023.08.028

[13] Pizoń, J.; Wójcik, Ł.; Gola, A.; Kański, Ł. & Nielsen, I. (2024). Autonomous mobile robots in automotive remanufacturing: A case study for intra-logistics support, Advances in Science and Technology Research Journal, 18, No. 1, pp. 213–230, ISSN 2299-8624, DOI: 10.12913/22998624/177398

[14] Sánchez-Ibáñez, J. R.; Pérez-del-Pulgar, C. J. & García-Cerezo, A. (2021). Path planning for autonomous mobile robots: A review, Sensors, 21, No. 23, 7898, ISSN 1424-8220, DOI: 10.3390/s21237898

[15] Tagliavini, L.; Colucci, G.; Botta, A.; Cavallone, P.; Baglieri, L. & Quaglia, G. (2022). Wheeled mobile robots: State of the art overview and kinematic comparison among three omnidirectional locomotion strategies, Journal of Intelligent & Robotic Systems, 106, No. 3, 57, ISSN 0921-0296, DOI: 10.1007/s10846-022-01745-7

[16] Löcklin, A.; Dettinger, F.; Artelt, M.; Jazdi, N. & Weyrich, M. (2022). Trajectory prediction of workers to improve AGV and AMR operation based on the manufacturing schedule, Procedia CIRP, 107, pp. 283–288, ISSN 2212-8271, DOI: 10.1016/j.procir.2022.04.046

[17] Karamanos, X.; Bechtsis, D.; Vlachos, D. & Mastos, T. (2021). Safety lines detection as a means of navigation in industrial facilities, Proceedings of the 32nd DAAAM International Symposium, pp. 0256–0261, Katalinic, B. (Ed.), DAAAM International, Vienna, Austria, ISBN 978-3-902734-33-4, ISSN 1726-9679, DOI: 10.2507/32nd.daaam.proceedings.036

[18] Herčík, F.; Zavřel, J.; Heriban, P.; Štefánik, J. & Kočí, V. (2022). Implementation of an autonomous mobile robot in a SmartFactory: Case study with MiR100, Applied Sciences, 12, No. 17, 8912, ISSN 2076-3417, DOI: 10.3390/app12178912

[19] Niloy, M. A. K.; Shama, A.; Chakrabortty, R. K.; Ryan, M. J. & Badal, F. R. (2021). Critical design and control issues of indoor autonomous mobile robots: A review, IEEE Access, 9, pp. 35338–35370, ISSN 2169-3536, DOI: 10.1109/ACCESS.2021.3062227

[20] Sidiropoulos, A.; Sidiropoulos, V.; Bechtsis, D. & Vlachos, D. (2021). An Industry 4.0 tool to enhance human–robot collaboration, Proceedings of the 32nd DAAAM International Symposium, pp. 0617–0622, Katalinic, B. (Ed.), DAAAM International, Vienna, Austria, ISBN 978-3-902734-33-4, ISSN 1726-9679, DOI: 10.2507/32nd.daaam.proceedings.087

[21] Yilmaz, A. & Temeltas, H. (2024). A multi-stage localisation framework for accurate and precise docking of autonomous mobile robots (AMRs). Robotica, Published online. ISSN 0263-5747, DOI: 10.1017/S0263574724000602.

[22] Klenam, J. S.; Amegah, K. E. & Asante, J. P. (2025). Additive manufacturing of non-metallic materials: A review and outlook. Applications in Engineering Science, 40, 100224, ISSN 2666-4968, DOI: 10.1016/j.apples.2025.100224.

[23] Raamets, T.; Majak, J.; Karjust, K.; Mahmood, K. & Hermaste, A. (2024). Autonomous mobile robots for production logistics: A process optimisation model modification. Proceedings of the Estonian Academy of Sciences, 73, No. 2, pp. 134–141, ISSN 1736-6046, DOI: 10.3176/proc.2024.2.06.

[24] Horelican, V.; Cveticanin, D.; Ali, S. & Dobi, L. (2022). Utilizability of Navigation2/ROS 2 stack in industrial facilities and its reliability. IFAC-PapersOnLine, 55, No. 10, pp. 261–266, ISSN 2405-8963, DOI: 10.1016/j.ifacol.2022.06.018.

[25] Flores-Gonzalez, F.; Coronado, P. D. U. & Yamanobe, N. (2025). ROS-compatible robotics simulators: A review in the context of Industry 4.0 and Industry 5.0. Applied Sciences, 15, 8637, ISSN 2076-3417, DOI: 10.3390/app15158637.

[26] Turhanlar, E.; Ren, J.; Wen, J.; O'Brien, P. & Cormican, K. (2024). Autonomous mobile robot travel under deadlock and collision prevention algorithms by agent-based modelling in warehouses. International Journal of Logistics Research and Applications, 27, No. 8, pp. 1351–1376, ISSN 1367-5567, DOI: 10.1080/13675567.2022.2138290.