SUMMARY

The primary objectives of this thesis work are to develop a digital model of a demo center, simulate its operations, compare different layouts, conduct an economical analysis, and create a guideline for future development of demo center. These objectives aimed to explore the potential of digital modelling in optimising manufacturing processes and to provide a comprehensive evaluation of different transportation methods within a demo center.

Concepts of digital twins, digital models, 3D simulation, and visualisation for manufacturing were studied and defined. This work highlights the importance of digital models in offering detailed and credible simulations of real-world production processes. The literature review also examines how virtual environments enhance manufacturing by enabling pre-emptive analysis of layouts, material handling options, and automation strategies. This allows for minimising risks and improving production system efficiency.

This thesis work also delves into a concept of demo centers that serve as facilities to demonstrate product qualities and manufacturing processes without full-scale production equipment. They are pivotal in testing automation processes, introducing students to equipment, and integrating VR for immersive learning experiences. The literature review further discussed the synergy between digital models, digital twins, and VR in creating smart manufacturing environments.

Four of the most common software tools were analysed and compared: AnyLogic, FlexSim, Visual Components, and Plant Simulation by Siemens. The tools were compared based on user interface, modelling capabilities, integration, learning curve, and costs. Visual Components was selected for its user-friendly interface, robust 3D simulation capabilities, and compatibility with CAD systems, making it the most suitable for developing a detailed digital model of the demo center.

A comprehensive concept for the demo center was developed, focusing on producing a plastic globe. The production stages included 3D printing, deburring, product assembly, and packaging. Equipment such as AONIQ 888 3D printers, Tormach 1100MX CNC milling machines, Omron TM12 cobots, and MiR 250 mobile robots were selected based on their capabilities and suitability for the requirements. Initial parameters were defined to ensure realistic simulations, considering transport speeds and process times.

We also analysed two distinct layouts: one using mobile robots for transportation and the other relying on human labour. The simulations assessed key metrics such as travel distance, transport utilisation, and the time taken for products to fill the warehouse

shelf. Results showed that human labour achieved higher peak utilisation and completed tasks faster. The human layout completed the delivery of six globes in approximately 11 minutes, compared to 13 minutes for the mobile robot layout. At the same time, while mobile robots offer more consistent and predictable usage patterns, the benefits they bring fail to mitigate the advantage of using human operators in the set conditions.

An economic analysis was conducted to compare the total costs of each layout over one year, including initial equipment costs and operational costs. The human operator layout proved more cost-effective in the short term, with a total cost of €120,662 compared to €153,327 for the mobile robot layout. The higher initial cost of the mobile robot layout was offset by lower operational costs, suggesting potential long-term benefits under continuous operation. However, in an educational setting where continuous operation is not typical, the human operator layout remains more economically beneficial.

Although the mobile robot loses out to humans in terms of efficiency and economic viability, its use is also advantageous in a demo center environment. Mobile robots are widespread in modern industries, and therefore familiarising students with their operation and the conditions of human-robot cooperation will be useful for students. Moreover, using a robot alongside a human offers a field for exploring ways to optimise cooperation, which is also useful in an Industry 4.0 world.

This work also produced a guide for developing a digital model of a demo center. By properly assessing initial parameters and goals of DC, researchers can streamline the process of developing a digital model. This guide is particularly useful for further research in the field of digital modelling.