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Comparison of WinMOD and SIMIT for virtual commissioning of an automotive production line

Bachelor's thesis in Mechanical Engineering

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CHALMERS UNIVERSITY OF TECHNOLOGY

Gothenburg, Sweden 2023

DEGREE PROJECT 2023

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Abstract

This study presents a comparative evaluation of two virtual commissioning software tools: SIMIT and WinMOD, explaining their functionalities and potential boundaries within existing industrial processes. A hands-on test project was carried out using SIMIT to comprehend the software's technical specifications as well as the broader concept of Virtual Commissioning (VC). This practical approach provided the insights and knowledge needed to formulate appropriate queries during the following interviews. Experienced engineers, each proficient in one of the software, were interviewed to gain insight about the important factors for transitioning between the software, as well as their benefits and limitations. In the software transition process, the study emphasizes the importance of toolkits, efficient workflow management, and cost considerations. The decision between SIMIT and WinMOD was based on industry-specific requirements, compatibility with existing systems, and the ability of each software to meet organizational needs. The findings contribute significantly to the ongoing discussion on digital transformation and automation in the industrial sector, laying the groundwork for future research to optimize the use of these technologies. Further research is recommended to delve deeper into each software's capabilities, efficient workflow designs, and the impact of transitioning from one software to another, supplementing the decision-making process for organizations contemplating a software transition.

Keywords: Virtual Commissioning, SIMIT, WinMOD, comparison, auto-generation, Digital Twin, interviews, industrial automation, PLC, simulation.

Acknowledgements

This thesis was a challenging project to perform and despite some obstacles along the way it could not have been done without these people who deserve gratitude.

Firstly, we would like to thank our examiner Björn Johansson together with our supervisor Ninan Mathew who provided guidance in planning the project as well as writing this report.

We want to thank our supervisor at AFRY Alexandros Tzikas, whose constant support and mentoring has helped our entire thesis work. We would also like to thank Anton Albo from Chalmers who helped us formulate the idea for the project and for guiding us throughout the whole project.

Lastly, we would like to express our gratitude to Atle Zvantesson and Andreas Persson working at the Simulation team at AFRY for their support and skillful guidance during this project.

Filip Brattwall & Mathias Börjesson Gothenburg, 2023

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List of Abbreviations

VC – Virtual Commissioning

I/O – Input/Output

PLC – Programmable Logic Controller

CAD – Computer Aided Design

OT SW – Operational Technology Software

FAT – Factory Acceptance Test

SAT – Site Acceptance Test

RDT – Real Digital Twin

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1 Introduction

In this section, the background, purpose, aim, and delimitations are introduced.

1.1 Background

AFRY is one of the leading consultancy firms in Sweden, and they are involved in a vast variety of fields, where the automotive industry is one of them. Within this industry Volvo Cars is one of their largest and most important clients. Volvo Cars has bought consulting services from AFRY for a long time, and they have played a crucial role in a large number of projects. Virtual Commissioning (VC) is one area where AFRY has been able to supply their expertise. This has been accomplished primarily with Siemens' in-house VC tool known as SIMIT. With the implementation of Volvo's new standard, they are moving from SIMIT to another software for Virtual commissioning called WinMOD. SIMIT and WinMOD share a lot of similarities regarding functionality, but the way engineers work with the two softwares differ. This means that the current configuration AFRY has in place with SIMIT has to be modified in order to comply with Volvo's newly implemented global standard.

1.2 Purpose and Aim

The aim of this project is to present a comparative study of two virtual commissioning software tools, WinMOD and SIMIT. This means looking into their unique functionalities, strengths, and limitations. Furthermore, the purpose of this comparison is to point out the implications of switching from one software to another (WinMOD to SIMIT), highlighting any technical, logistical, or financial considerations that may be required for such a change.

1.3 Delimitations

The scope of the project includes working with a part of the material handling system in the TC-factory at Volvo's production plant in Torslanda. Which means that only automotive applications will be handled in this project. It does not include the delivery of actual implementations in relation to the production facilities.

Another vast delimitation is that licenses to only one of the softwares will be available to the group due to external circumstances. SIMIT is the only program that licenses will be provided for, and those are only demo licenses which puts a limit to the size of the projects that can be created. No hands-on testing can be done in WinMOD.

1.4 Research questions

- What are the key differences between SIMIT and WinMOD?
- How would a software change impact current workflows?

1.5 Stakeholder Analysis

In order to gain a comprehensive understanding of the virtual commissioning projects using SIMIT and WinMOD, it is essential to consider the different stakeholders involved in the process. This section will analyze the key stakeholders, their interests, and their expectations in relation to the virtual commissioning projects.

1.5.1 AFRY

- Role: Engineering and consulting firm specializing in virtual commissioning projects
- Interests: Efficient project delivery, cost savings, client satisfaction
- Expectations: Smooth transition between virtual commissioning tools, minimized learning curve, maintain or improve project quality

1.5.2 Volvo

- Role: Client and user of virtual commissioning tools
- Interests: Improved production efficiency, reduced downtime, cost savings, standardize components and previous projects.
- Expectations: High-quality virtual commissioning projects, effective collaboration with Afry, easy integration with existing systems

1.5.3 WinMOD

- Role: Developer of WinMOD virtual commissioning software
- Interests: Widespread adoption of their software, positive user experiences, continued development and improvement
- Expectations: Showcasing the capabilities and advantages of their software, maintaining a competitive edge over other solutions, addressing user concerns and feedback

1.5.4 Siemens SIMIT

- Role: Developer of SIMIT virtual commissioning software
- Interests: Similar to WinMOD, with an emphasis on their specific software
- Expectations: Similar to WinMOD, with an emphasis on their specific software

Understanding the various stakeholder perspectives is essential for interpreting the results of the virtual commissioning projects and formulating appropriate recommendations. By considering their interests and expectations, we can ensure that our analysis and recommendations are relevant and actionable for all parties involved.

2 Theoretical Framework

In this theoretical framework, key aspects of digital transformation are discussed. Some examples of these aspects include digital twins, virtual commissioning, industrial automation, and the utilization of software tools such as WinMOD and SIMIT.

2.1 Digital Transformation

The incorporation of digital technologies into various aspects of a business, thereby fundamentally altering its operations and the delivery of customer value, is referred to as digital transformation. The term "digital transformation" refers to the implementation of a wide range of technological advancements in the manufacturing industry, such as digital twins, advanced automation systems, and virtual commissioning, among others (Visual Components, 2022). Some of the primary drivers driving the manufacturing industry's digital transformation include a greater emphasis on increasing productivity, improving product quality, lowering costs, and enabling more agile and data-driven decision making (Aheleroff, Xu, Zhong, & Lu, 2021). Digital transformation also facilitates the development and implementation of Industry 4.0, which refers to the fourth industrial revolution and is defined by the integration of cyber-physical systems, the Internet of Things (IoT), and cloud computing in manufacturing processes (Berglund Fast & Salunkhe, 2022).

2.2 Digital Twin

A Digital Twin, according to IBM (IBM, 2023) is a virtual replica of a physical object or system created by aggregating data from multiple sources to create the digital version of the real thing. It simulates behavior, detects potential problems, and optimizes performance. Digital twins enable proactive maintenance and decision-making through real-time monitoring and analysis, resulting in reduced downtime and costs. Engineers will build a three-dimensional model of the system and then connect it to various data sources to recreate the system's actual physical structure. Digital twin simulations help improve system performance by highlighting areas for improvement and pinpointing potential sources of error; as a result, both productivity and dependability are increased. Digital Twins provide a significant opportunity for making data-driven decisions (Nan, Rami, Nikos, & Georgis, 2022), which can lead to decreased costs, improved performance, and increased uptime.

2.3 Virtual commissioning

According to Siemens (Siemens, 2023) VC is a solution that allows manufacturers to reduce the time and cost associated with commissioning new production systems. Manufacturers can identify and resolve problems in the real world by simulating and testing automation systems in a virtual environment. This means that potential hazards and errors can be detected and remedied much earlier in the development, which leads to a reduction in expenses. Engineers can also test various scenarios and optimize the system's performance using a digital twin and simulation software. Connecting the simulation model to a PLC (Programmable Logic

Controller) and defining the I/O signal list, which can be imported into the virtual model, is one of the prerequisites for VC.

2.4 WinMOD

WinMOD is a software application (WinMOD, 2023) utilized by engineers in a variety of industries, including the automotive industry, to simulate and perform virtual commissioning of production lines. WinMOD enables users to create digital twin models of their production lines, allowing them to test and refine these models prior to deploying them in the real world. Additionally, WinMOD facilitates the integration of new technologies and processes, as well as redesigns and adaptations, into existing production lines. WinMOD is a useful tool for optimizing manufacturing processes because it improves production performance while lowering automakers' production related expenses. Mainly by minimizing downtime and risks involved when commissioning a production line.

2.5 Siemens Software

Siemens (Siemens, 2022) offers a variety of different softwares related to Simulation depending on what is to be simulated e.g., production, robot cells. automation or behavior models. Nevertheless, Siemens claims that to get started with VC these three softwares are needed, SIMATIC TIA portal and PLCSIM Advanced.

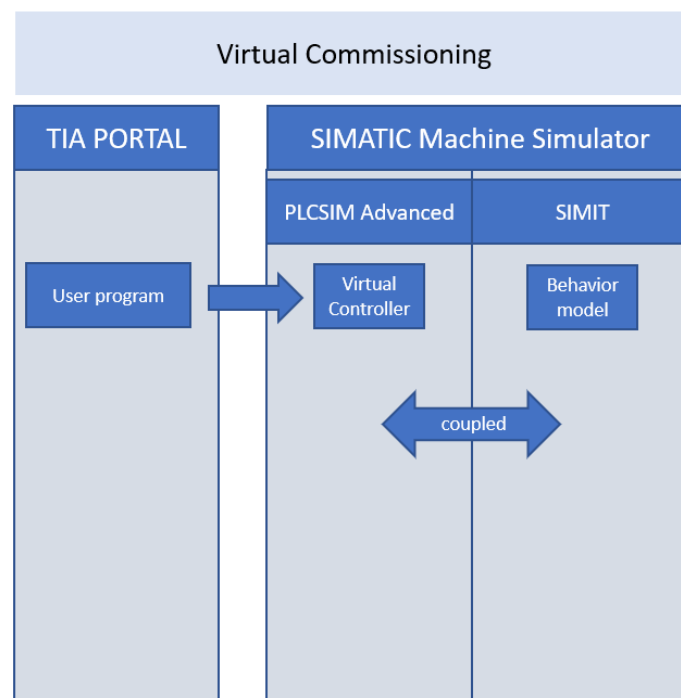


Figure 1 Visual Explanation of involved software

2.5.1 SIMIT

SIMIT is a software made by Siemens used for real-time simulation, virtual commissioning, and operator training. In this project, it is mainly the virtual commissioning part of the program that will be in focus. The use cases and benefits of SIMIT are pretty much the same as for WinMOD, which can be read about above (Siemens, 2023).

2.5.2 Totally Integrated Automation Portal (TIA)

TIA is a software developed by Siemens that provides engineers with automation tools. The software is used to integrate different areas and components in an automation project, as well as to simulate products before implementing them in the real world (Siemens, 2023). The TIA portal contains some of the packages listed below:

- SIMATIC STEP 7: Which is used for writing PLC code, it offers engineers the ability to write code in 5 different languages, which are Ladder diagram, Function block diagram, Structured Control Language, Graph, Statement List (LAD, FBD, SCL, STL) (Siemens, 2018).
- WinCC is Siemens' software for all HMI applications which is used to create and visualize control panels. Which makes it possible for operators to monitor data and operations (Siemens, 2023).

2.5.3 PLCSIM Advanced

PLCSIM Advanced is used to simulate PLC controllers in the virtual world. Engineers are able to simulate system behavior using PLCSIM Advanced. The integration of PLCSIM Advanced with the TIA portal is an important feature. It enables engineers to create projects through the TIA portal and simulate those projects using PLCSIM Advanced

2.6 Industrial automation and PLCs

Industrial automation has become increasingly common in modern manufacturing due to its ability to produce high-quality goods at a faster rate while maintaining efficiency and consistency. Key components of automation systems include sensors, actuators, and controllers, which are used to monitor and regulate various aspects of the manufacturing process (Zhao & Xian, 2022). Programmable Logic Controllers (PLCs) serve as fundamental components of automated systems, providing a dependable and robust means of controlling production equipment and processes. PLCs are functional and can be programmed to regulate a wide range of machines and processes, making them a critical element in the production systems of contemporary factories across various industries, including manufacturing.

2.7 Integration of WinMOD and SIMIT with other tools

WinMOD and SIMIT can be combined with a variety of software tools to enhance the performance of the programs and accelerate the virtual commissioning process. For instance, it is possible to import 3D models of components or assembly lines using CAD software (Suthida, Alexander, & Rainer, 2017). In addition, production processes in SIMIT can be monitored and controlled by SCADA systems that can send signals and feedback to the VC model (Welday, 2022). Consequently, the accuracy and efficiency of the process are enhanced.

2.8 Industry Standards and Best Practices

When it comes to ensuring the quality and dependability of the results of virtual commissioning, industry standards and best practices are necessary. A relevant industry standard, the ISO 22400 series for manufacturing operations management, offers a framework for managing and optimizing manufacturing processes. This standard was developed for the manufacturing industry (Zhu, Johansson, Varisco, & M. Schiraldi, 2018). The use of realistic simulation models, validation of simulation results with real-world data, and the participation of stakeholders in the virtual commissioning processes are some of the best practices for virtual commissioning. Both WinMOD and SIMIT are compliant with these standards and best practices, and both tools offer features and functionalities that support the implementation of these standards and best practices. Nevertheless, there is distinctions in how the two tools approach particular aspects of virtual commissioning.

3 Real Digital Twin Configuration and Simulation in SIMIT

In this section the implementation and use of the Real Digital Twin Configuration in SIMIT with the context of AFRY is discussed. It discusses the transition from their previous way of working to their current. The section also explores the specifics of the Real Digital Twin and how it contributes to reducing costs, time, and risk. Further, it covers the use of templates and auto-generation in SIMIT, particularly with data imported from Excel files.

3.1 Previous project form at AFRY

Up until recently, AFRY had what they today refer to as “traditional project” for Virtual commissioning projects.

This traditional project was divided into different phases over a period of time. Typically lasting six months or longer, depending on the scope. Several other steps had to be completed before Virtual commissioning could be implemented, as it emerged late in the implementation process. These phases included Mechanical construction, Electrical construction, PLC, OT SW (Operational technology Software), off-site testing (FAT), commissioning (SAT), and ramp-up.

- The mechanical construction phase of the project involves the actual building of the machinery and infrastructure that will be required for the completion of the project.
- Installation of various electrical components is the focus of this stage of the electrical construction process.
- PLC: Programmable Logic Controllers are what are used to control the machinery and the other processes that are involved in the project.
- OT Software: This piece of software is utilized for the purpose of monitoring and controlling the physical processes.
- Off-site test (FAT): The Factory Acceptance Test is conducted off-site to ensure that the equipment and systems comply with the performance and design specifications.
- Commissioning (SAT): The Site Acceptance Test is very similar to the FAT; however, it is carried out on site with the customer present.
- In the stage of the project, known as ramp-up, both the production and the operations of the business are put into motion.

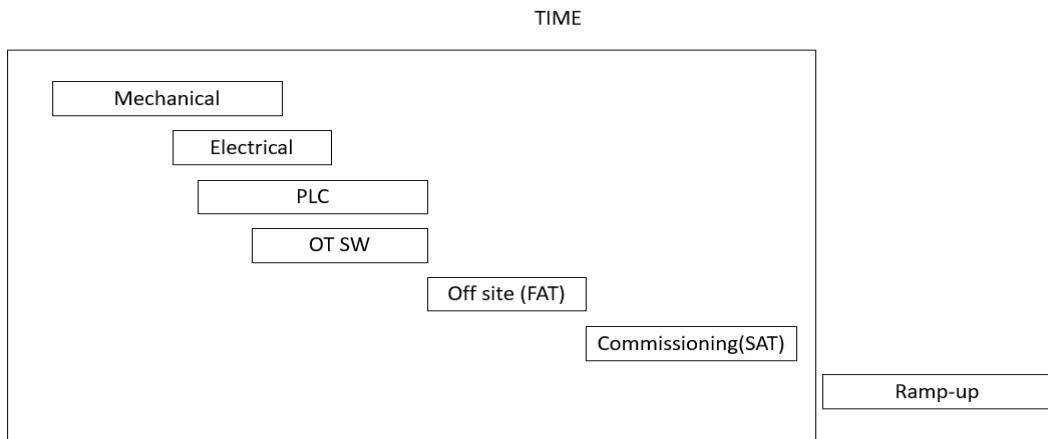


Figure 2 AFRY's previous project form

3.2 Present project form at AFRY

Today, AFRY has adopted a new method of working on these projects that is more agile. As a result, the overall quality of the work has improved, and the costs have decreased. The primary distinction lies in the fact that, as opposed to the more common sequential approach, they now work in an iterative manner. Because of this, problems that arose in earlier stages of the project have been fixed, which is a change from how things were done previously. This is accomplished by stress testing the system as soon as possible and allocating time in the project schedule for the implementation of Real Digital Twins at various points throughout the process.

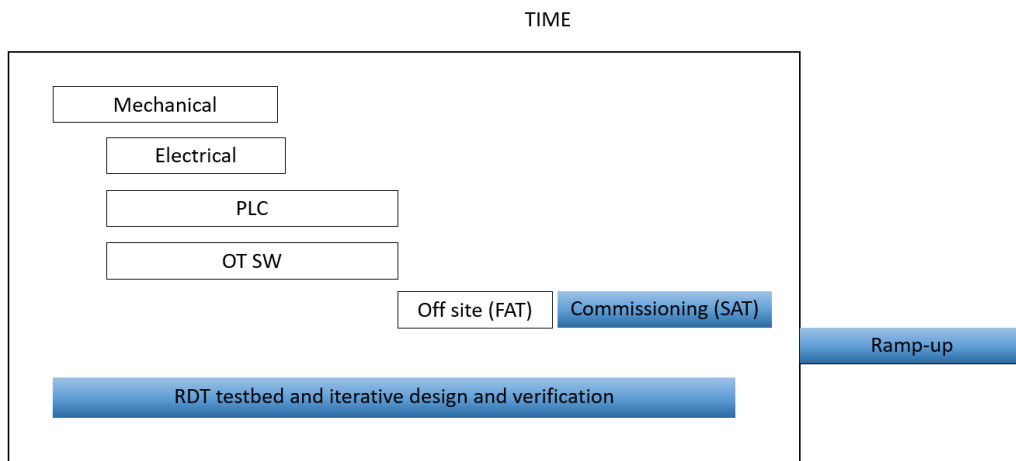


Figure 3 AFRY's current project form

3.3 Real Digital Twin (RDT) Configuration at AFRY

AFRY's RDT configuration is an integral part of their agile way of working. With the RDT, it is possible to create digital replicas of physical systems. This enables real time monitoring, simulation, and analysis of a system's performance or behavior. AFRY has created their configuration with key components that work together to create accurate models.

The configuration contains different models, such as electrical wiring and hardware, which could contain motors, transmitters, etc. These are generated from a master list, which contains the I/O list. When a command signal is received, the models generate feedback signals and convert the commands to values. Their model is built using a step-by-step approach that has a system I/O simulator (RDT 1.0), component behavior (RDT 2.0), system response, and simulation logic. With this method, AFRY can iteratively test and improve their configuration. Further, AFRY has a library of pre-built objects and components that they are able to reuse. For example, if in a project a frequency-controlled motor is present, AFRY would construct a replica of the motor's components for the configuration. When using a RDT for a physical process, projects can save costs and reduce risks. As well as identify problems that may arise early and make sure the system meets performance criteria.

3.4 Templates and auto generation

Simit allows engineers to create templates that can be auto generated with the help of Excel or XML files. Since AFRY primarily works with Excel, that is what is going to be studied.

In general, templates can be created for different simulation objects, such as, sensors, motors, conveyors etc. When a user wants to create a simulation based on a template, they start by first importing data from an Excel template. SIMIT, then, based on the template and imported data auto generate a simulation project. This method alone saves time and reduces errors that can occur by manually creating objects from scratch (Siemens, 2021) as well as enabling easier troubleshooting and correction.

3.4.1 Creating a template

To create a template in SIMIT, a user can use a placeholder which in this case could be “{ }” to designate where the data should be. Variables indicated with the “\$” are for specifying a variable in the template. For example, a template for a temperature sensor can be created with variables for the sensor type and range like this: (Siemens, 2018)

- Sensor Type:{\$type}
- Sensor Range:{\$range}

The variables can be defined when using a template for the creation of a new object, and the values from the Excel file can be inserted into the variables, for instance, if there is data in the Excel file regarding a temperature sensor that has type “Temperature Sensor”, range of “0-100 degrees C”.

4 Methodology

The approach that will be taken to complete this project has been broken down into several stages. Which can be seen in figure 4 below. The initial stage and first part of the project consisted of a literature study, where excessive information regarding the topic of Virtual Commissioning was collected. Second stage of the project was data collection with regards of how AFRY utilizes their own configuration in their own projects. Simultaneously, workshops in SIMIT were carried out before the test project was created during the second part of the project. During which a second round of data collecting was carried out, this time with the comparison of the two software's as the primary focus. Lastly, interviews were conducted with engineers from AFRY who use SIMIT and engineers who use WinMOD. Conclusions could be finalized after the test project, comparative research, and interviews were concluded.

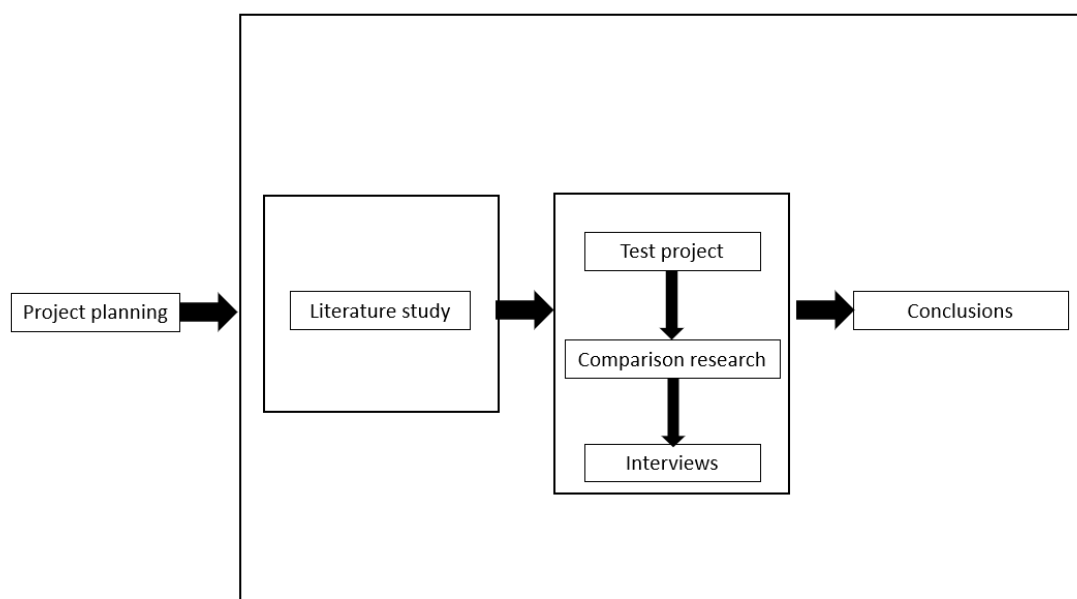


Figure 4 Structure of Methodology

4.1 Literature review

As part of the literature review process, an analysis of previously conducted research, articles on the topic, and other theses were considered. The research area for this project, virtual commissioning, digital twins, and the application of SIMIT and WinMOD has not been extensively explored in academic literature, which requires a thoughtful and inductive approach to establishing a theoretical framework (Streefkeerk, 2023). The field of virtual commissioning was the focus of most of the research that was analyzed for this study. Principal search terms included virtual commissioning, digital twin, SIMIT, WinMOD, automation, digitalization, and Industry 4.0. Numerous databases, including Google scholar and the Chalmers library, were searched exhaustively and in depth to accomplish this goal.

Worth mentioning is that Google “search” was used to gain knowledge on certain topics but not presented as a reference. Priority was given to those articles with the most recent publication dates. Regarding the research evolving around Siemens software, Siemens own library containing manuals, videos, and explanations was also considered.

The process of selection and analysis of literature was set up by certain inclusion and exclusion criteria. The inclusion criteria were:

1. Studies that explicitly focus on the topic of virtual commissioning, digital twins, and the use of SIMIT and WinMOD.
2. Articles published in peer-reviewed journals or conference proceedings.
3. White papers or technical documents from recognized industry players or research institutions.
4. Research conducted within the past decade to ensure relevance and accuracy with respect to the current technological landscape.

On the other hand, the exclusion criteria were:

1. Studies that do not directly relate to the elements of the project—virtual commissioning, digital twins, and the application of SIMIT and WinMOD.
2. Articles or papers not published in peer-reviewed sources.
3. Studies published more than a decade ago unless the older work presents seminal concepts or theories still relevant in the current context.
4. Research papers not written in English due to potential misinterpretation arising from translation.

4.2 Research and collaboration for understanding differences between SIMIT and WinMOD

As mentioned earlier, there will only be licenses available for one of the programs, SIMIT. Therefore, research will be conducted to determine what can be discovered about the two software’s as if none of the software’s were available. For this, previous work with both software’s, other published material and information from the suppliers themselves will be evaluated.

Prior to the research, presentations were given by stakeholders from both Volvo and AFRY outlining the operation of their respective virtual commissioning setups. Volvo’s presentation showcased their use of various software systems, fully utilizing WinMOD for their

automotive line and outlining future considerations. A presentation very similar to it was given by AFRY, but this time with SIMIT. A workshop was also initiated from AFRY's side, and representatives from WinMOD hosted it. During this workshop, WinMOD revealed in-depth explanations and demonstrations on how their software works, as well as different projects where WinMOD has been used for virtual commissioning.

4.2.1 Expanding knowledge

AFRY also took the initiative to organize smaller workshops in the early stages of the project, during which real projects were investigated. It was possible to look through the various past projects because the majority of them had thorough documentation. This provided an overview of how the different components of the software interact with one another as well as how the structure of how it is laid out is organized. In addition, the manuals that came packaged with the SIMIT software were investigated. There are manuals that provide detailed explanations of the system's individual components (Siemens, 2013) as well as manuals that provide a comprehensive understanding of the system as a whole (Siemens, 2018).

4.3 Test project as a method

A test project will be created in SIMIT to get a deeper understanding of virtual commissioning, as well as identifying key features and potential issues that may occur while doing the transition to WinMOD. This knowledge and experience will be crucial while formulating interview questions as well as relevant supplementary questions during the interviews. The project that will be used for this purpose is a sub-pallet buffer located at Volvo Cars Torslanda.

This project was chosen for several different reasons. For example, the project was recently completed by AFRY themselves, which means that there are people available in house with relevant knowledge and experience working on this exact project. This also means that there is a completed project that can be used as a reference, and the PLC-code can be reused so that the group can put their focus towards the actual aim of the thesis rather than surrounding work.

4.3.1 Sub-pallet buffer

The sub-pallet buffer is located in Volvo Cars factory in Torslanda, and it is used to store/buffer sub-pallets. There are three different types of sub-pallets used at Volvo Cars: front, center, and rear sub-pallets. They are all used to hold specific components in place during a part of the production flow. For example, the front sub-pallet is used to hold the engine in the correct

position, to enable it to be mounted easily, and according to specification, later down the flow. Since there are three different types that have to be kept apart, the sub-pallet buffer consists of three separate rows, each with four floors. Each row contains roller conveyors, accumulating conveyors as well as elevators. There are three different elevators in each row. Two of them can reach all four floors whilst the last one only travels between the first two.

Due to limiting factors from the demo license for SIMIT, only one of the three rows will be created in this project in order to stay within the 4000 tags available. The row that will be created is the one handling the front sub-pallet. This row will also be modified by removing the top floor and one of the elevators as well as adding a turntable. This is done to increase the variety of components being used while decreasing repetitiveness in order to get the most out of the limited number of simulation tags provided with the demo license. The PLC-code to run the simulation will be provided to the group.

4.4 Interviews

Semi structured interviews with relevant representatives from AFRY, Volvo and WinMOD will be held in order to understand the differences between SIMIT and WinMOD and get an indication on how difficult the transition from one to the other will be. The interview with WinMOD will strictly focus on the technical properties of the software. This is due to the fact that any statements of preference and/or comparison between the two will inevitably be highly biased in favor of WinMOD. This will be accounted for while drawing any type of conclusion based on that interview. On the other hand, the main goal while conducting interviews with AFRY (working in SIMIT) and Volvo (working in WinMOD) is not necessarily to compare the technical aspects of the two softwares, but rather explore how the way of working differs from one another. What is required to build a simulation and how that affects the expected time of the project is also a question that will be investigated, together with the ability to utilize templates to auto generate parts of a simulation.

4.4.1 Semi structured interviews

The use of semi structured interviews has been found to be effective (Hove & Anda, 2005) due to the interviews' combination of structure and adaptability. Which makes sure that the research stays on track while enabling spontaneous exploration based on the responses.

For the investigation of SIMIT and WinMOD, this approach is ideal. The semi-structured format allows the interviewer to form a set of questions concerning the properties of the software such as, the process of building simulations, project timelines, and the use of template etc. At the same time, if any new information emerges about the differences or any other

problem in transitioning from one software to another, the interviewer is free to explore those aspects as well.

Consequently, semi structured interviews allow for a comprehensive understanding of the topic and ensuring that the research is not only thorough but also compliant to the distinct insights that might appear during the interviewing process.

5 Test project

The test project that was created will be broken down and explained in this section.

5.1 Layout

The layout that was chosen for the test project is a modified version of a sub-pallet buffer located in Volvo Cars factory in Torslanda, as previously mentioned. At the start of the line there is an in-feed where material (sub-pallets) is placed. In the modified version the material is placed here manually, but in the actual sub-pallet buffer this process is automated and connected to the surrounding material handling system. Following the in-feed there are three standardized roller conveyors leading to the turntable. The turntable allows the material to either continue straight ahead, towards the first lift, or do a 90 degree turn to the left. This path leads to one of the two outfeeds.

If the material instead carries on straight, it arrives to one of the two lifts. These lifts carry material between the three floors in the system, but they have limited functionality (this will be described in detail later in the report). All three floors consist of three roller conveyors each. Following the second lift there is a single roller conveyor actin as the other out-feed. The figures below show the layout in both 2D (figure 6) and 3D (figure 5) as well as the naming of the components used. The names and their importance for creating the simulation will be explained later in the report.

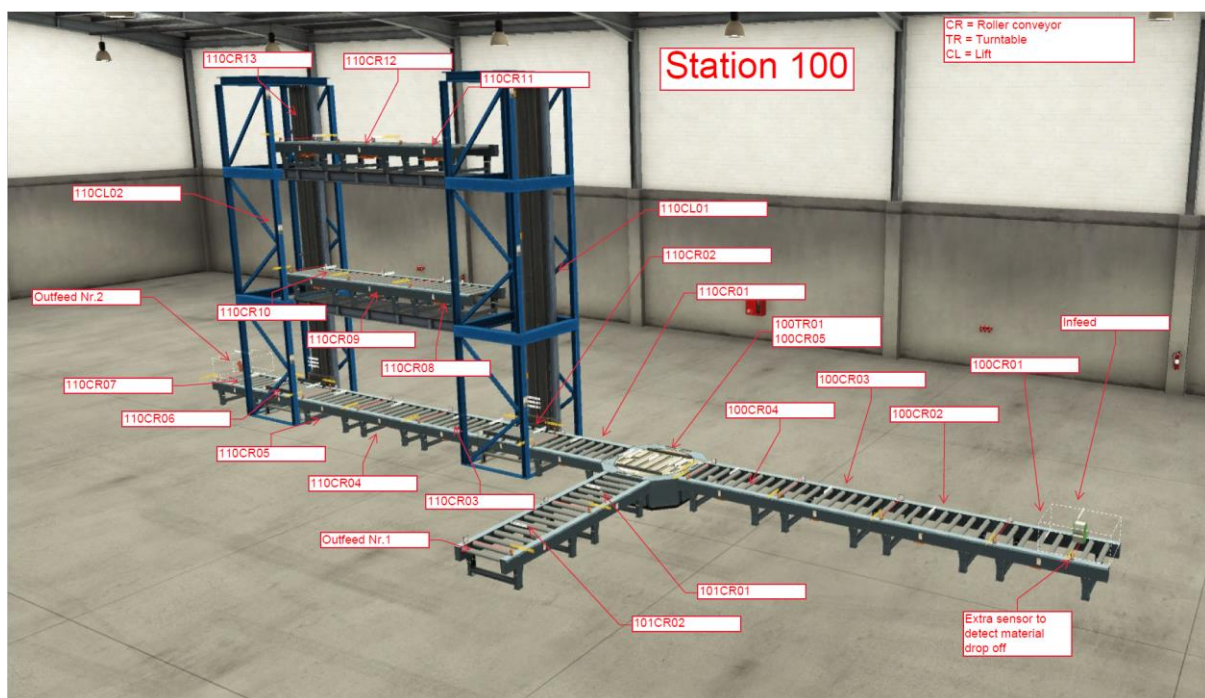


Figure 5 3D-Layout presented in Factory IO

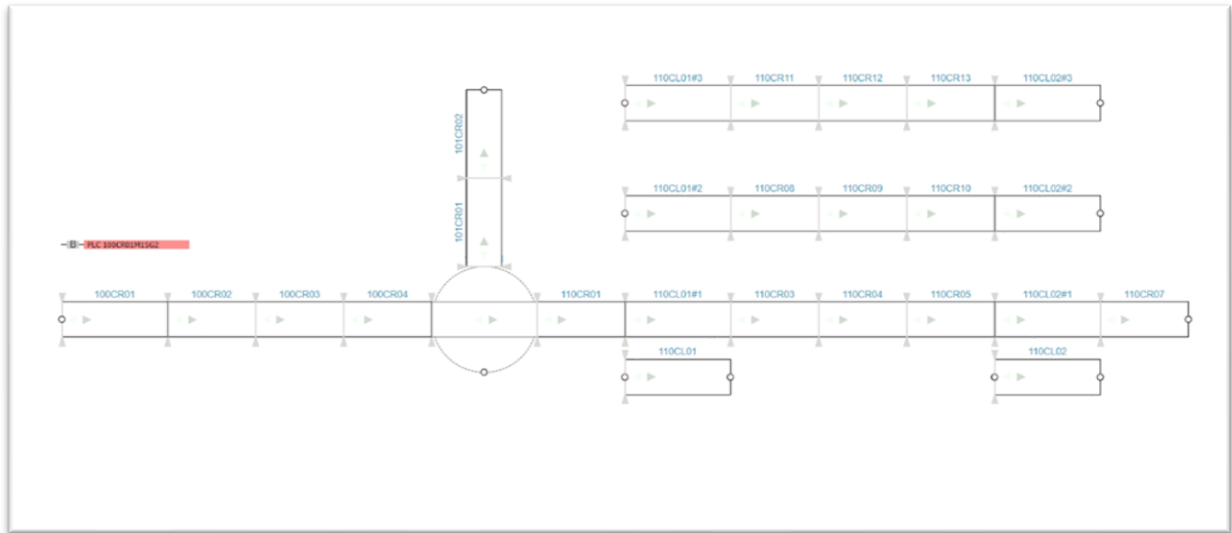


Figure 6 Layout in SIMIT

5.2 Components

All the different components used in the test project will be explained in this section.

5.2.1 Conveyors

All conveyors, except for the in-feed and the ones in the lifts, are of the same type. They are roller conveyors (figure 7) capable of running in only one direction. This means that they require just one signal from the PLC to run the motor. They are also equipped with one stop sensor at the end of each conveyor. The only thing differentiating the infeed conveyor from the rest is that it has a second sensor to detect new material that has been placed on the conveyor. The ones in both of the lifts also have two sensors. These sensors are used to ensure that the material is stationary and safely within the boundaries of the lift to prevent collision with either the conveyors on the other floors or the structural parts of the lift tower. This is done in the PLC-code by only allowing the lift to move when both sensors are either on or off. Therefore, the

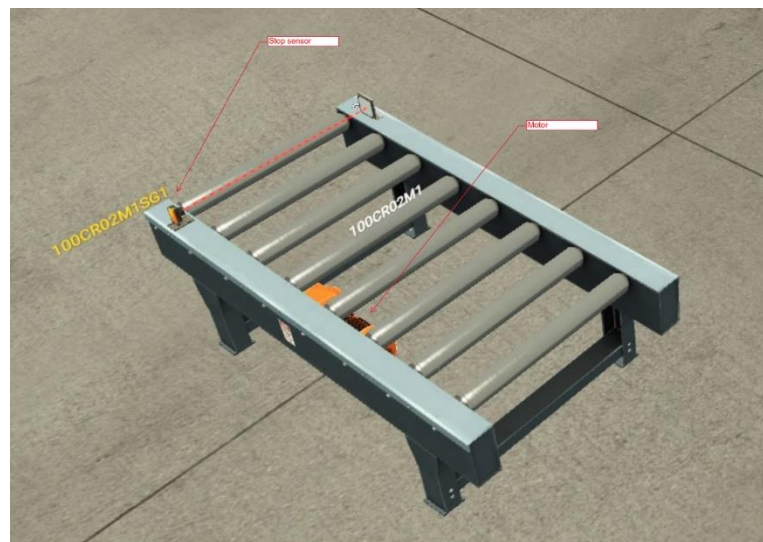


Figure 7 Standardized roller conveyor

sensor's placement along the length of the conveyors is based on the size of the material being transported.

5.2.2 Lifts

Both lifts in the model are physically identical, but they are used differently. The first one is used to transport material from the first floor to the second and third floor (never between second and third) whilst the other lift is used to transport material from the two upper floors back down to the first one (also never between second and third). This limitation is due to the number of sensors being used as well as their placement. Each floor has two sensors (displayed using arrows in figure 8). One low speed sensor and one stop sensor. On the first floor the low-speed sensor is placed above the stop sensor allowing the lift to only stop while arriving from the higher floors. On the second and third floors the sensor placement is reversed compared to floor one. This means that the lift only can come to a stop while arriving from below.



Figure 8 Lift

Since the lift can travel at two different speeds going both up and down it uses three signals to control the motor. One up signal, one down signal and one slow signal. When combining the slow signal with either the up or down signal the lift travels at the predetermined slow speed in that direction.

5.2.3 Turntable

The turntable is used to change direction of material flow between the lifts and the first out-feed. This is done by rotating the conveyor 90 degrees to the left and back to straight again. The conveyor utilizes two signals in order to run the motor both forwards and backwards. Since the conveyor can run both ways, it is equipped with two stop sensors. One at each end. The rotation of the turntable is done with only one signal giving either the value 100 or -100 which results in a rotation clockwise and counterclockwise respectively. The turntable is equipped with two position sensors that ensures that it only stops when aligned with either connecting conveyor.

5.3 PLC Coupling

The coupling between SIMIT and PLCSIM Advanced allows SIMIT to access the complete I/O-list. The different I/O-signals can then be used when building charts in order to get the desired functionality compared to the real-world system. Alternatively, a model can be built based on drawings and system requirements if the system is not already commissioned.

Using the correct signals from the PLC code enables the simulation to replicate the physical system's behavior. Within the simulation environment, the I/O-signals can be manipulated or monitored, offering a flexible environment for system modeling. The simulation platform's flexibility allows for the replication of a wide range of scenarios. Different scenarios can be mimicked by changing the input signals. Monitoring the output signals, on the other hand, offers feedback on the system's response.

5.4 Naming of components and signals

It is crucial that the way components are named is following a standard that makes the names traceable, logical and allows for future expansion. If the name of the first conveyor is used as an example (the first conveyor is named 100CR01), the 100 in the name determines in what zone of the system the component is located. The test project consists of three different zones. Zone 100, 110 and 101. The CR tells the user that the components is a roller type conveyor. And lastly the 01 indicates that it is the first component in Zone 100. Using this naming method allows for expansion in a natural way by adding either more components within an existing zone or expanding the system with another zone.

The names of the signals follow the same principles. They always include the full name of the component followed by information further specifying the signal's function and direction (whether it is an in or out signal). The second conveyor in zone 100 (100CR02) have one stop sensor and a motor capable of running in only one direction meaning that the conveyor utilizes two signals in total. The signal from the stop sensor is called 100CR02M1SG1, where M1 indicates that the signal is used for the main function of the conveyor, which is moving material forwards. SG1 indicates that it is the first (and in this case the only) sensor on the conveyor. The signal that tells the motor to start is called 100CR02M1 where the M1 has the same meaning as in the name of the stop sensor.

5.5 Utilization of templates and auto generation

Each component, including conveyors and lifts was standardized and its own template was created for each type. For instance, the conveyor template (Figure 9) was a pre-configured model with set parameters that could be replicated.

This standardization of components enables their re-use throughout the system, thereby reducing the time required to define the attributes of each instance. As an example, the auto-generation of conveyors within the system was made possible by using standardized naming. By following the naming standard, such as 100CR01 for the first conveyor, it was possible to generate all conveyors automatically. The logic in the method of naming not only made the system understandable and traceable but also enabled the expansion of the system in a structured and logical manner. These templates can also be used in other projects as long as they also follow the same naming standard which further implies the importance of standardization and consistency while building simulations.

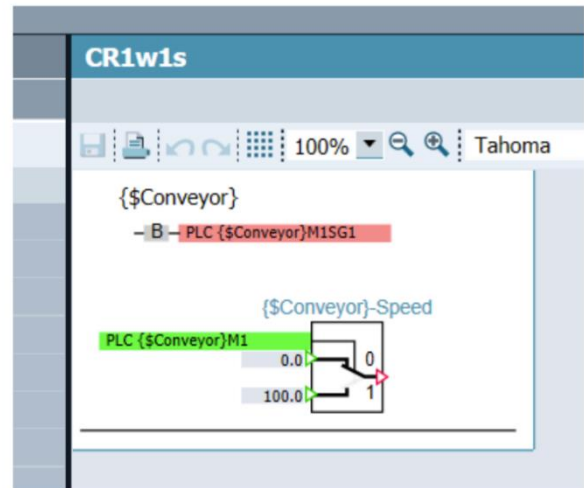


Figure 9 Template for Conveyors

5.5.1 Bulk engineering

In the context of the test project, bulk engineering was used for operations such as setting conveyor speeds, moving sensors and other similar features on multiple components at once. This results in a significant time reduction as well as minimizing the risk of human error associated with manual inputs on each component individually. One important aspect for making this process more effortless was to give the components a logical and consistent naming structure. The process of identifying and changing several components at once in the simulation environment was made substantially more efficient with an affective naming method.

6 Results

In this section the findings from the project will be presented.

6.1 Initial differences based on previous work

The sources provided offer a diverse range of perspectives and insights on SIMIT and WinMOD, as well as virtual commissioning and simulation in general. These sources have been selected based on their scientific rigor, relevance to the topic, and their contribution to understanding the differences between the two software platforms.

Source #	Main Focus
1	Development of simulation-based approaches for smart production concepts in the automotive industry
2	Systematic methodology for virtual commissioning and a new simulation model building approach
3	Virtual commissioning of a robot assembly cell with a focus on cooperation between robots
4	Development of a digital twin in a robotic environment using SIMIT
5	Analysis of available virtual engineering tools for building manufacturing systems digital twin
6	Migration process of 3D simulation software within a digital twin framework, addressing challenges and opportunities
7	WinMOD software's capabilities and TeraWatt Group's experiences with virtual commissioning
8	Computer-aided methods for concurrent engineering in mechatronic systems controlled by a PLC, examining their effectiveness
9	Software in Loop (SIL) virtual commissioning implementation at Volvo Cars Torslanda
10	Development of a Virtual testing simulator and acceptance test for Azipod X AIU using WinMOD
11	Creation of a software-in-the-loop testing environment for the Vessel Management System using WinMOD

Figure 10 Sources used for comparison.

Source 1 (Thiel, 2018) focuses on the application of simulation-based development methods, smart production, concepts of manufacturing and control systems in automotive industries. While also providing insights to the use of WinMOD in this sector.

Source 2 (Hoffmann, 2016) suggests a structured method for virtual commissioning simulation research, alongside a novel technique for constructing a new simulation model. This aids in comprehending the process of building simulation models in context of virtual commissioning.

Source 3 (Makris, Michaels, & Chryssolouris, 2012) showcases the virtual commissioning of an assembly cell with cooperating robots, offering a practical example of virtual commissioning in action.

Source 4 (Claesson & Hedetoft, 2022) in this source a case study on the development of a digital twin in a robot environment is presented, specifically using SIMIT for virtual commissioning of a robot cell. The study provides valuable insights into SIMIT's capabilities, as well as its integration with other software tools and platforms.

Source 5 (Konstantinov, o.a., 2023) discusses an analysis of available virtual engineering tools for building manufacturing systems with a digital twin. This provides an overview of various tools and their capabilities for creating digital twins for manufacturing systems. This source is relevant as it helps to understand the landscape of virtual engineering tools, including both SIMIT and WinMOD, and how they compare in terms of functionality and application areas.

Source 6 (Becerril & Prsanna, 2021) explores the migration of 3D simulation software in a digital twin framework, demonstrating the potential for integrating SIMIT into digital twin environments.

Source 7 (TeraWatt Group, N/A) offers an overview of the TeraWatt Group's experience with WinMOD software for virtual commissioning, showcasing its features and compatibility with various systems.

Source 8 (Bathelt & Meile, 2008) focuses on computer-aided methods supporting concurrent engineering when designing mechatronic systems controlled by a PLC, highlighting the use of WinMOD in these applications.

Source 9 (Ganesan & Dharmaraj, 2019) examines the implementation of Software in Loop (SIL) virtual commissioning at Volvo Cars Torslanda, showcasing a real-world application of virtual commissioning in the automotive industry.

Source 10 (Laitinen, 2020) presents a case study on the development of virtual testing simulator and acceptance test for the ABB Azipod interface, which is an Electrical propulsion

system used in the Marine industry using WinMOD. The study demonstrates WinMOD's ability to create a virtual environment for real time testing.

Source 11 (Mononen, 2020) discusses the development of a software-in-the-loop testing environment for the Vessel Management system using WinMOD. The study highlights WinMOD's ability to simulate complex systems.

Additionally, source 12 which is the official website for SIMIT (Siemens, 2023) and source 13 which is the one website WinMOD (WinMOD, 2023) will be reviewed as well.

- Use cases: Based on the websites the use cases appear to be similar. However, SIMIT seems to be more used within the process industries, including oil & gas, chemical and pharmaceutical sectors (source 4). In contrast, WinMOD appears to have a stronger presence in the Automotive industry and factory automation (Source 1). Both source 11 and 12 showcase VC in the marine industry as well using WinMOD.
- Software Compatibility: SIMIT has demonstrated to work well with Siemens PLCSIM and PCS7 (source 4), WinMOD is highly compatible with a range of PLCs and other systems (source 7). The official websites provide further details on the compatibility and integration capabilities of both platforms (source 10, source 11).
- Digital twin integration: SIMIT has been shown to have potential for the integration of Digital twin environments (source 6). Even though WinMOD is not explicitly discussed in the context of digital twins, its use in virtual commissioning and simulation suggests that it has similar capabilities. However, in source 13 it is highlighted that WinMOD has been used to simulate vessel automation.
- Developer: SIMIT is developed by Siemens, which is a global technology company with a long history and extensive resources. WinMOD is developed by Mewes & Partner, a smaller company with a niche in Virtual Commissioning and simulation.
- Flexibility and customization: Both SIMIT and WinMOD offer a certain level of customization and flexibility. Some users find SIMIT's user interface more intuitive (source 6) other users may prefer WinMOD's software environment, which they claim offers a flexibility in model creation and the ability to customize simulation models for specific production processes (source 9).

6.2 Interviews

Two conducted interviews with engineers working with SIMT and WinMOD respectively is presented below.

6.2.1 Interview 1

Interviewee 1 is an engineer that works with Virtual commissioning in the SIMIT software. In addition, the interviewee has years of experience in the field of virtual commissioning and simulation.

The interviewee revealed some concerns about switching software to WinMOD, some of it was related to the technical limitations associated with the software and how these would impact on the work. One of the concerns was related to bus synchronous data reading and writing, as well as synchronization with PLC. The engineer was keen to understand these limitations in depth to properly address them.

Another significant point that was made apparent was the possibility of creating custom components in WinMOD; what prerequisites and process involved for doing so. Which in contrast was described as a thought to process in SIMIT. Insights into how other companies organize and manage their workflows and how they distribute tasks surrounding the software were also sought.

Furthermore, the engineer emphasized that most of the work in the software was not the most value-adding aspect of their job. Even though the program could have some effect on efficiency, it was noted that this was a small portion of the total work time. The focus was instead on the importance of managing toolkits and creating efficient workflows to optimize the value-added elements of the work. What was more revealed is that cost is a significant aspect of a transition. The understanding of why Volvo, mentioned as an example, aims for uniform software throughout the company was acknowledged in the interview. It was discussed that having an existing knowledge base and surrounding toolkits were key elements to facilitate a smooth transition and efficient utilization of the system.

Something that was underscored from the interview was the importance of toolkits. The engineer explained that these toolkits are used for generating import files and integrating them into the software would become useless if the program (WinMOD) is not compatible with them. Which highlighted the evaluation of the toolkit compatibility when transitioning to a new software.

6.2.2 Interview 2

Interviewee 2 is similar to 1, an experienced engineer specializing in the use of the virtual commissioning software WinMOD. With years of expertise in the field of virtual commissioning and simulation, the interviewee's insights were significant in understanding the functionalities and operation of WinMOD, as it is and compared to SIMIT.

When it came to choosing a software for the, at the time newly started, VC department the engineer chose WinMOD for its user-friendly interface, ease of use, and wide compatibility with various PLCs and surrounding softwares. WinMOD's potential to create a customized environment based on specific needs was highlighted. In contrast to SIMIT, WinMOD doesn't impose limitations on the number of simulation tags, thus providing more flexibility.

WinMOD's compatibility with various external software through add-ons and plugins was commended. WinMOD provides a variety of components and even offers support in creating custom components. The availability of components in the WinMOD library was also identified as an advantageous feature since it covers multiple vendors and not just Siemens, as is the case with SIMIT.

The technical support from WinMOD was praised for being both efficient and helpful, providing assistance through remote connections and expert intervention. The licensing structure of WinMOD was another point of interest, where base packages can be purchased, and additional modules acquired based on specific needs.

The engineer provided insight into their workflow with WinMOD, emphasizing on the importance of clear communication between different teams. It was revealed that they have separate teams for PLC programming, robot programming, and simulation, with the simulation team primarily using WinMOD. Efficiency in their workflow has been achieved through their proprietary program called "Macro," which helps standardize naming between robot tags and PLC tags.

6.3 Results from Test project

The test project was focused on exploring the functionalities and capabilities of SIMIT by simulating a simple conveyor system, the conveyor system configuration was based on a sub-pallet buffer system from the Volvo Torslanda plant and included: Conveyor belts, a lift, a turntable, and several sensors.

The projects objectives were twofold:

1. SIMIT hands-on exploration: The team wanted to get hands-on experience with SIMIT's features, interface, and functionalities. This included creating and implementing a simulation within the software as well as interacting with external control systems like a PLC.
2. Preparing for expert interviews: The hands-on experience with SIMIT helped in identifying key features, potential difficulties, and areas of interest, which were then

used to develop specific, relevant questions for subsequent interviews. These questions were created to gather information about WinMOD's capabilities, features, and limitations in comparison to SIMIT.

The test project's results were encouraging and successful in meeting the objectives. The SIMIT simulation successfully recreated the Volvo Torslanda plant's sub-pallet buffer system. This accomplishment not only demonstrated SIMIT's practical capabilities in accurately modeling real-world industrial systems, but it also laid the groundwork for understanding the features and requirements of a good virtual commissioning software.

Due to lack of a license the project did not include a direct hands-on experience of WinMOD; However, the practical insights and experiences gained from SIMIT were instrumental in driving the interviews. With this approach, the team was able to ask informed and insightful questions regarding WinMOD and virtual commissioning.

7 Discussion

To summarize the key finding from the research, SIMIT and WinMOD are both capable softwares in the area of virtual commissioning and simulation. They offer largely the same capabilities and at first glance the choice may seem unimportant and insignificant. But there are a few differences that may cause a buyer to favor one over the other. These will become clear after discussing the two research questions.

RQ1: What are the key differences between SIMIT and WinMOD? For instance, the price and licensing structure is something that sets the two apart. The compatibility with different vendors for PLCs, robots etc. is another area where differences may be important to make sure that the chosen software can fit into a predetermined engineering pipeline. The quality and availability of technical support is also something that may be of importance for certain customers, and in that area WinMOD appears to have an advantage. They also seem to have an advantage in the extent of the components in their library that are relevant to the automotive industry.

RQ2: How would a software change impact current workflows? It has been disclosed that the impact on current workflows associated with a software change mainly depends on the surrounding toolkits and their interface with the chosen virtual commissioning software. Another aspect is that different enterprises have utilized their own set of toolkits that is their own intellectual property which means that workflows in a software are personal to the people in that enterprise.

The result presented in the report is mainly based on knowledge accumulated from previously published work as well as a summary of years of experience from engineers working in both programs. These are both reputable sources to use as grounds for a comparison. They do however bring a few uncertainties. Mainly the interviews are a cause of concern since both interviewees have a vast majority of their professional experience in just one of the programs. This almost certainly causes a bias towards the software they usually work with. This is mainly noticed in the case of user interface and ease of use, which is an area of comparison that is largely based on personal preference and habit rather than hard data and performance.

Another aspect to consider is that a large portion of the reports found on WinMOD is written in German. Which means that the information presented in those could not be taken into account since the group member's German is insufficient. For this reason, a majority of the information, based on volume, was on SIMIT which may have impacted the result, even though the quality of information was equivalent for both softwares.

One of the main factors to consider is that the group only had access to SIMIT during the project since licenses for WinMOD was not acquired. This was not the plan to begin with, but due to unfortunate circumstances the project plan had to be revised in order to make the most out of what was available. It is possible that the result of the project may have been different if the initial plan was possible to proceed with. Therefore, a strong suggestion for further research on the topics covered in this report is to enable a test group (preferably students) to gain the same amount of experience in both SIMIT and WinMOD, and then base a part of the comparison on that. This reduces the risk of biased preferences based on dissimilarity in previous experiences with the programs.

Even further research could provide more insights into the detailed capabilities of each software and the impacts of transitioning from one software to another on a deeper, more technically advanced level. There is also a significant opportunity for research into the best practices for optimizing the use of the software. This could involve developing methodologies for efficient workflow design, identifying techniques for effective simulation, or establishing guidelines for the integration of these tools with other systems and processes within an organization.

To summarize, both research questions have been answered even though the second one could be further expanded on if access to both softwares was available.

8 Conclusion

Firstly, both SIMIT and WinMOD have proven to be reliable tools for creating and implementing digital twin models and virtual commissioning in various industries. Their diverse capabilities and ability to integrate with a range of PLCs and other systems makes them a valuable asset for the digital transformation. However, the two softwares use cases differ: SIMIT is more prevalent in process industries such as chemical, oil and gas, as well as pharmaceutical while WinMOD appears to have a stronger presence in automotive and factory automation.

Both software's compatibility and flexibility are valued features, each of them highlights its strengths in different areas. SIMIT integrates well with Siemens PLCSIM and PCS7. WinMOD, on the other hand, is praised for its broad compatibility, model creation flexibility, and ability to simulate complex systems such as vessel automation. It is also praised for not limiting the number of simulation tags.

In terms of technical support and licensing, WinMOD has been highly regarded for its support system and flexible licensing structure. Which allows companies to purchase base licenses and additional modules based on their specific requirements.

Furthermore, the interviews highlight some concerns and considerations for the software transition. The first interviewee questioned the technical limitations, impacts on workflow, and the compatibility of existing toolkits with WinMOD. Among these technical limitations, the lack of built-in bus synchronization in WinMOD was brought up as a significant difference from SIMIT. The importance of handling toolkits, developing efficient workflows, and taking costs into account were also emphasized. The second interviewee outlined the benefits of WinMOD, such as its ease of use, user-friendly interface, extensive compatibility, and technical support.

In conclusion, both SIMIT and WinMOD are capable software tools for implementing virtual commissioning and digital twin models. The choice between these two would depend on the specific requirements of the industry, the compatibility with existing systems and workflows, and the strengths of each software that align with the company's needs.

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