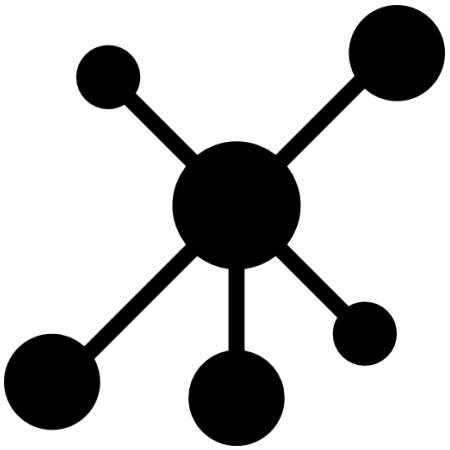
EIT Digital **Summer School** 2022



# parschnell

*parse + schnell*

*easily processed components & quick*


**TEAM E2- HAWE**

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# 1. Executive summary

Automation is the use of machines to perform tasks previously performed by humans or, increasingly, to perform jobs that would be impossible without them. Although the term "mechanization" is frequently used to describe the straightforward substitution of machines for human labor, automation typically connotes the incorporation of machines into a self-governing system. The term is frequently used in the context of manufacturing, but it is also used outside of it in relation to a number of systems where human effort and intelligence are significantly replaced by mechanical, electrical, or computational activity [1].

HAWE Hydraulik [2], a mid-sized global operating firm with its headquarters in Munich, proposed to us to automatise their current production system, which is related to the fact that the definition of the assembly process is defined code by code by the senior engineers, with the help of huge tables containing all the atomic actions required. This not only is a time-consuming process but is also prone to high human-related errors. Therefore, they gave us the following use case: *define an automated process that, given a code for a specific product, returns the list of the assembly action needed to guide a working operator in the assembling process.*

To overcome this challenge, *parschnell* provides a state machine-based solution which is capable of generating all the possible assembly processes for any different product that the company has to produce. The final solution comes as a website in which the operators can insert the code of the product they have to assemble and automatically displays a dynamic interface to guide them through the processes. The state machine is directly integrated into the website and can be simply modified by the engineers adopting specific software. With this solution, not only do we speed up the production process, but also reduce the number of human-related errors as well as the expenditures in raw material.

Along with our first customer, HAWE Hydraulik, we offer our services to other manufacturing, automation or assembly companies, focusing on a Business-2-Business (B2B) model. Due to the amount of companies working in this field, the market opportunities are countless.

As to our service, we have opted for distributing it on-premise. This distribution comes as a license-based and usage-based sales, by adding add-ons to the basic product. These revenue streams will make *parschnell* to have a net present value above €118.000 within the first three years. To make this possible, we will need an initial investment of €165.000 for the first year of development.

# 2. Problem and Solution

## 2.1 Case Description

The assembly of each individual product is extremely complicated as a result of the significant product diversity. The assembly is partially highly automated in order to reduce complexity, but this requires a comprehensive specification of the product as well as accurate definitions of the combination of assembly actions and processes that is unique to the product. A type code is used by HAWE Hydraulik to configure products on the sales side. A specific product variant from the full product range is specifically identified by the type code, where each part of the code gives information regarding the corresponding assembly piece of the final product. The product variety must be modeled in a feature model or variability model that must be developed by HAWE Hydraulik and, if necessary, enhanced by the development team of the Summer School with additional relevant information. What components or groups are included or excluded based on an activated feature should likewise be specified in the feature model.

A pool of assembly actions that comprise assembly stages also exists. It must be determined whether the characteristics can define atomic or fine-grained assembly stages. The necessary assembly operations should be picked and merged automatically in the background when features are specified (through the provided type code). However, it should also be remembered that features can impact other features in a reciprocal manner, which means that the assembly process can also change. This reciprocal connection is also seen for the atomic assembly actions themselves: a specific action might require a predetermined follow-up, therefore the full complexity should also consider these pre or post-conditions.

Finite automata or state machines of the (UML/SysML) can be used as modeling notation for this type of problem. The approach makes it possible to define the entire assembly process piece by piece automatically. The overall goal of the business case is that the product "knows" how to be put together on its own, using just the features that the end-user has chosen, basically creating what in the industry is called a Digital Twin. The idea is that the sales team will define the product in collaboration with the customer, and the product (or digital twin) will "know" how to be processed and assembled as soon as the order is placed.

To better understand the steps involved, it is possible to look at the figure provided by HAWE Hydraulik: the *feature model* is our state machine, where all the combinations are defined by states and edges, and the *specification* and the *decision-making* are automatically done by the

logic with which the state machine is created and the output is the fully defined *assembly process*.

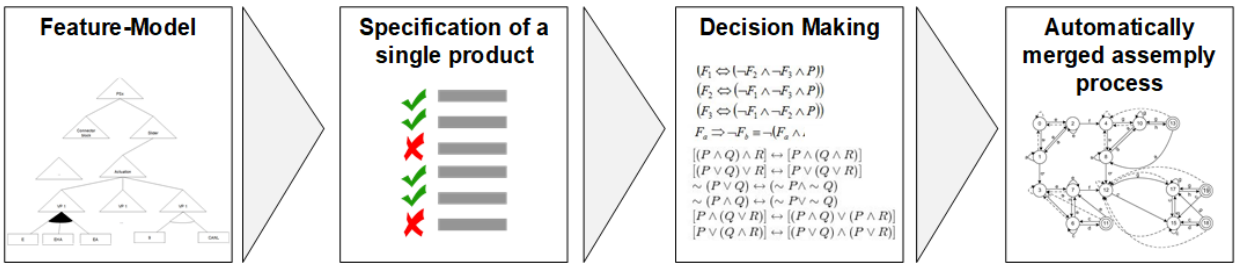


Figure 1: Use Case Problem

## 2.2 Solution Summary

As anticipated in the executive summary, the solution we provided is composed of two main parts: the finite state machine and the website.

We designed the state machine using Enterprise Architect software. Together with all the other possibilities that this software offers, the one we consider the most interesting is that it allows exporting the code of the state machine in many programming languages. To simplify the integration with the website, we exported it in JavaScript.

### 2.2.1 State Machine Definition

In the state machine, every action group of the assembly process provided by HAWE Hydraulik is modeled as a node and each node has its own logic. Passages between nodes are modeled with edges and on each of them, it is possible to define their trigger conditions. The huge number of products that the company has to manage is intrinsically modeled in the state machine through the exponential number of combinations that it is possible to obtain following different paths between the nodes. This aspect is the main advantage of this solution concerning the adoption of a simple feature model designed as a tree. With this last model indeed, every time a block is used it is necessary to repeat it in the specific branch, complicating the design. In the state machine instead, each block is repeated only once and the possibility to use it many times is given by the connections between the nodes, simplifying both the understanding and the management of the model.

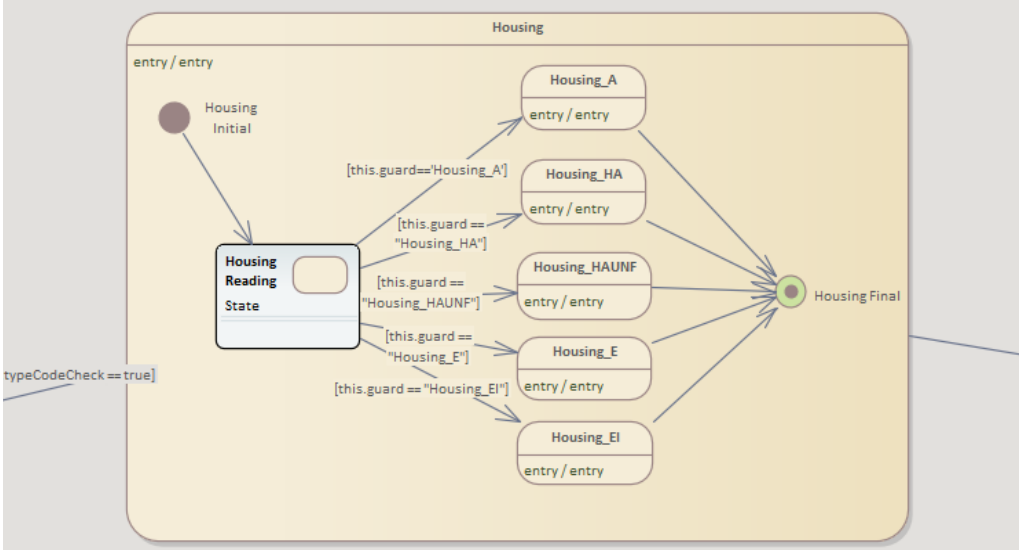


Figure 2: State machine node on Enterprise Architect - An example

### 2.2.2 Website MVP

The website of our MVP can be considered as a means for interacting with the state machine. Along with HTML and CSS, we developed the user interface whereas with JavaScript we coded the logic for the dynamic creation of the pages and the interaction with the state machine.

The reason behind the adoption of a website instead of a desktop application (such as any .NET application) is that this simplifies access to the platform from different devices. To run a desktop application, it is necessary to develop it for the specific operating system and it is necessary to install the application on every device that wants to access the production system. On the other side, to access the web application it is only necessary for the device to run a web browser and to be connected to the same network in which the server is listening. The server can be hosted within the company LAN or on a remote server depending on the customer's needs, allowing a closed environment where the data cannot spill out or allowing the decentralization of the processes.

### 2.2.3 Final solution

In the final solution, the website is not only a way of interacting with the state machine, but it is the fundamental pillar for the creation of the digital twin of the whole assembly process. The website will have a login page and the workers will have to insert their credentials to access the functionalities. In this way, we can track how much time a worker takes to follow an assembly

process, and the steps that require more time and we will be able to give access to specific parts of the website depending on the accessing policy (e.g. reserved data or process). This list contains just a couple of examples, but the real possibilities are many more.

Another aspect of the MVP that needs further development for a real installation is the integration of a connection to the company database containing the real data of the assembly steps. For the time being, our software does not know the real description of the process, does not have access to any piece of real information and cannot yet retrieve any data usage on the assembly procedure. In the final version, the state machine will be filled with an identifier for each of the entities involved in the process and the website will be able to fetch the data for every entity querying the database with the id retrieved by the state machine. After that, the data will be displayed on the user interface. Right now, the Human Machine Interface (HMI) of HAWE Hydraulik's assembly lines are coded to follow a specific process for a specific product (static approach). With our solution, the HMI will dynamically change depending on the type of product the worker has to assemble.

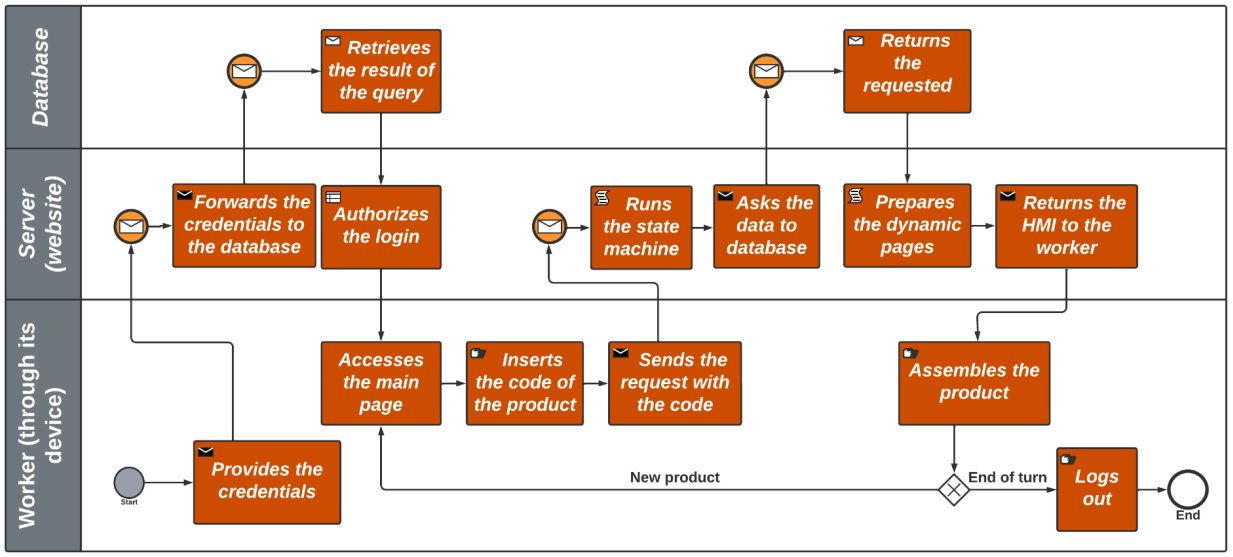


Figure 3: BPMN for the basic utilization of the parschnell solution

# 3. Business Modelling and Planning

## 3.1 Business Model Innovation (BMI)

The IT-based solution devised for HAWE Hydraulik consists of the automation of the definition of the assembly process which otherwise is a tedious task as it consists of over 100 million combinations of assembly processes. The proposed model is aimed at manufacturing and assembling industries which require automation and other IT-based solutions. In this manner, we figure out the BMI or the Business Model Innovation for our product. The *Who* consists of the industry workers who we aim to benefit from with the usage of our product in the longer term. The *What* is the product, parschnell, whose core is currently a state machine able to define the assembly steps for any product of the HAWE Hydraulik given that the parsing rules for the code are modeled in the state machine. *Why* we need this product is to reduce the manual effort required for the programming of the assembly process and to improve the productivity and work environment through shift flexibility in the longer run. Finally, the *How* we do this is by integrating the state machine to a web page with a graphical interface for the operators that can be accessed by the authorised professionals within the local area network. The figure below collates and presents the BMI of the business plan.

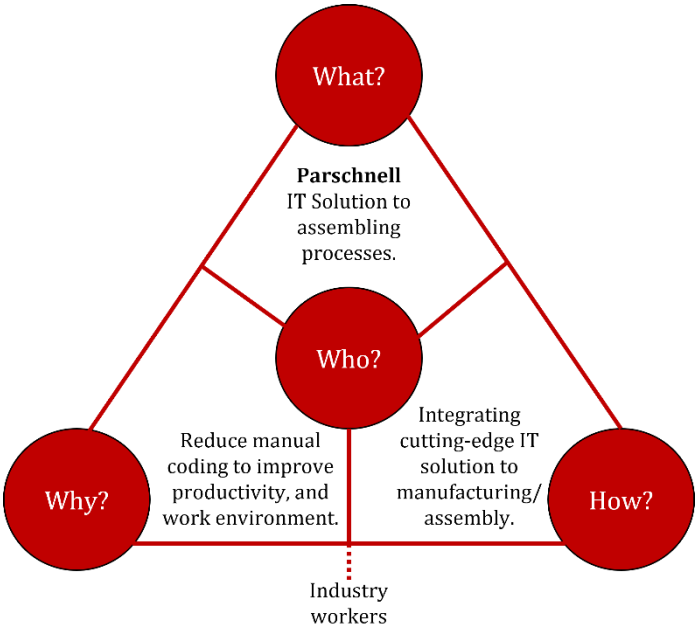


Figure 4: Business Model Innovation (BMI)

## 3.2 Business Model Canvas

<table>
<tr>
<td rowspan="2"><u>Key Partners</u><br><br>Manufacturing and assembling industries<br><br>Automation companies<br><br>IT Solutions</td>
<td><u>Key Activities</u><br><br>State machine and other automation-based solutions.</td>
<td rowspan="2"><u>Key Propositions</u><br><br>Automation of existing manual model- Cost reduction, faster production rate, flexible work hours, job inclusivity<br><br>Diagnostic capabilities of the assembly line maintenance<br><br>Competitive feature</td>
<td><u>Customer Relationships</u><br><br>On-premise installation, maintenance and technical support<br><br>Customer- sales and technical support through email, video call.</td>
<td rowspan="2"><u>Customer Segments</u><br><br>Manufacturing, automation, and assembly plants.<br><br>Other companies are looking at integrating state machines.</td>
</tr>
<tr>
<td><u>Key Resources</u><br><br>A licensed state machine building software such as Enterprise Architect.<br><br>LAN to access the website which acts as the GUI for the customers to utilise the state machine.</td>
<td><u>Channels</u><br><br>Customer loyalty business model and customer lock-in.<br><br>Freemium, open-source web-based trials.</td>
</tr>
<tr>
<td colspan="3"><u>Cost Structure</u><br><br>▪ Team (5P): €12500/month<br>▪ Hardware/Software: €8000<br>▪ Cloud-based hosting: €2400/month<br>▪ Housing/office space: €3780/month</td>
<td colspan="2"><u>Revenue Streams</u><br><br>▪ License<br>▪ Usage-based<br>▪ Customer loyalty and Lock-in<br>▪ Service fee</td>
</tr>
</table>

Table 1: Business Model Canvas

In Table 1 we report the Business Model Canvas. Apart from HAWE Hydraulik as our main partner, the other key partners that were identified for *parschnell* belong to the manufacturing and assembling industries. The top leading companies in this field include the Volkswagen Group, Toyota, General Motors, Ford, and Honda. Other electronic companies which also build their own products such as Apple and Samsung can also be targeted as our key partners.

Apart from these, ABB, Siemens, Mitsubishi Electric, and Schneider Electric are some of the top companies in the field of automation which can also be the key partners of *parschnell.* The aim of *parschnell* is to build networks through HAWE Hydraulik and further deepen the market approach for automation and IT-based solution services. The business model also aims to cater for the needs of academia and R&D by automation of test beds in research labs and thus collaborating with the world's leading universities and research labs in the field of robotics, mechanical engineering-based innovation, and design.

The key activities of *parschnell* will be to provide state machines and other automation-based solutions to manufacturing companies. Through this, the aim is to automate the existing manual methods which will create a huge impact on the economic and social aspects of society. We discuss these aspects in the envisaged PESTLE and SWOT study of the business model. Given the automation and the decentralization, the customers will be able to store the data in a single database and this will allow them to monitor the assembly line health conditions and any inconvenient or unnecessary maintenance of the assembly line machines. Also, the competitive feature of the model will put the target industries and key partners among the top companies in their field and thus improve the market reach.

*parschnell* will be an on-premise installation company, where the technical representatives of the company will be present at the target company for the installation and the integration of the product. This will not only bring a personal touch to the service but will also allow the operators at the target company to get hands-on training from the professionals and builders of the product. Further, for the maintenance of the product, the technical team will be on-premise for any help. Apart from the premise, the technical team will also be available during the weekdays and work hours over email, phone calls, and video calls. This will build customer loyalty and further the outreach and network of the business.

The key resources required for the business are cloud-based services for the storage of the database of the key partners and customers. Next, the business will need licensed software which supports UML, SysML, and State Machine programming. And finally, the employees of the *parschnell* will require an office space, computers, phones, and other such office appliances. From the customers and the partners, the requirement will be a secure local area network which can be used to set up the installation and integration of the state machine with the industry. The channels that the business uses to connect with the customers and expand its database are customer loyalty and lock-in. The business will also utilise the Freemium and

Open source web-based trials to further the expansion and development of the company and establish itself as a trustable organisation.

## 3.3 Business Model

The business plan is to distribute the product license for a fixed cost and also supply add-ons for individual partners and customers based on their requirements. The license will be proprietary and the owners will be the developers and the founders of the business model. The revenue stream will depend upon the number of licenses sold in a year and certain usage-based versions of the license distributed. The interaction through this business model will be one-to-many and the business will interact with other businesses to fulfil their IT-based requirements, making *parschnell* a B2B company.

| | |
|---|---|
| Distribution | On-premise |
| Code Licensing | Proprietary |
| Revenue Stream | License + Usage-based |
| Interaction | One-to-Many |
| Target Audience | B2B |

Table 2: Business Model - Source Code Licensing

## 3.4 Financial Analysis

Having established the business model, it is now possible to conduct the investment appraisal of the proposed plan. The goal is, firstly, to verify whether the business will be economically viable and, secondly, numerically prove the reliability of the plan for the investors. Several assumptions that we made for this financial forecasting were based on the web search volume as well as the market research.

### 3.4.1 Economical Feasibility

**Sales**

As discussed earlier, there are two main revenue sources for the *parschnell* product, here briefly described.

- Licence-based

  In the current year, further research and development of the project will be needed to grow into a start-up phase, hence, no sales are expected this year. After reaching out to potential customers via the proposed channels, the sales in the first year are projected to amount to €150,000 from 15 clients. As the company will evolve, the client base is

expected to enlarge by 20% annually. This is due to the wave effect on the manufacturing industry; the automation of the assembly is not regarded as a trend, but rather as a necessity, and avoiding it will result in losses.

- Usage-based

  Regarding the second revenue stream, it is projected to constitute around 2/3 of the Licence-based earnings. The reason for this is that Licence-based customers will fully integrate our software into the production and connect it to the internal processes. In this sense, as opposed to the usage-based approach that implies a one-off relation, we provide them with a seamless environment and form a long-term partnership. In the following years, it is anticipated to grow at an 8% rate annually.

**Other Income**

- Maintenance and updates

  As a part of our business model, we plan to offer add-on value to our product, which will take the form of maintenance service, state machine improvement and annual updates of the web interface.

**Expenditures**

- Salaries

  Due to the nature of our company's activity, salaries represent the largest part of expenditures, more precisely 67%. Based on the data for the average salary of entry-level positions for both software engineers and analysts, we estimated the monthly salaries for the team members [9]. The average salary for a Junior Software Engineer in Germany is €42,162.

- Software subscriptions

  To develop the demo version of the *parschnell*, the tech-team outsources software like Enterprise Architect to create a state machine. In order to bring the product to the production level, we would need to use the paid subscription for this software. An estimate of the Enterprise Architect software with its add-ons is €1000/year.

- Hardware

  In order to work on the project, the employees will require basic office electronics and appliances such as computers, printers, projectors etc. Estimated expenditure for the hardware can be around €15000 one-time investment followed by an average of €100 per year on maintenance.

- Cloud-based Hosting

  In order to save the data from our key partners and customers the business will require an unlimited subscription for data storage for under €250/year.

- Housing/Office Space

  Renting an office temporarily via ShareYourSpace, prices for a furnished office for 8 people in Munich start at 315 € per month for 90 $m^2$, the equivalent of 3.50 €/$m^2$ [10].

### 3.4.2 Numerical Review

The graphical representation of the forecasted revenues and expenditures can be found in Figures 5 and Figure 6.

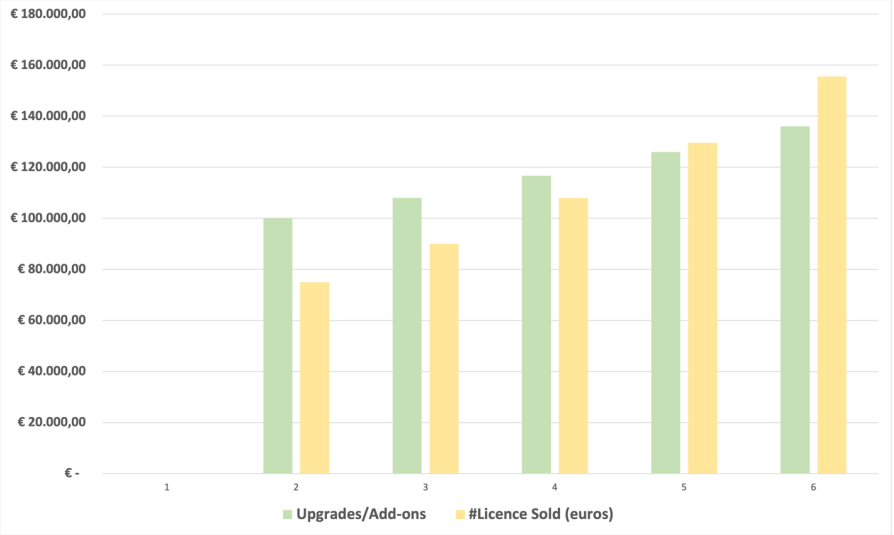


Figure 5: Annual growth in Sales (Licence-based and Upgrades/Add-ons) for the 5 years from 2022 to 2027

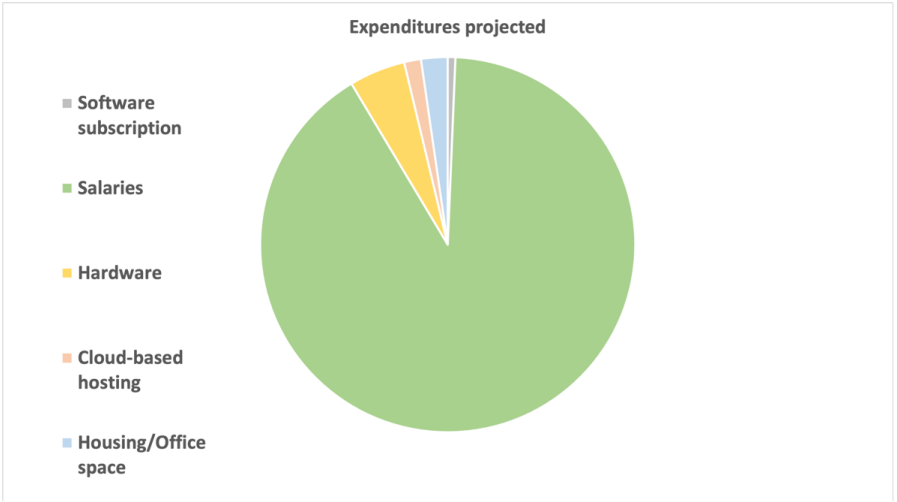


Figure 6: Breakdown of the main expenditures to be incurred by the company annually

There are several ways our company can attract funds for the development. Potentially, key partners such as the EIT Digital Organisation and the affiliated universities can provide funds as a part of their Business Incubator Programmes (one, in particular, could be the EIT Digital Accelerator). Another option is to attract funds publicly through platforms such as Kickstarter or Patreon.

For that purpose, an investment appraisal was performed for the project. It was decided to evaluate the net present value of the start-up. As a discounting factor, we used an average value of a weighted average cost of capital in an industry sector in Germany. Using this metric, it was possible to discount the annual cash flow to the present date so as to follow the time value cost of money concept. The calculations were conveyed in the following manner: first annual net cash flows for each of the 5 years from 2022 to 2027 were determined as a Total Revenue for the year minus Total Expenditures. Then, a corresponding discounting factor was multiplied by each year's net cash flow and a sum of discounted net cash flows was found.

| | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 |
|---|---|---|---|---|---|---|
| Net Cash Flow (NCF) [€] | 165.268,00 | 18.132,00 | 41.137,00 | 67.782,05 | 98.718,35 | 134.721,20 |
| Discounting Factor | 1 | 0,9384 | 0,8804 | 0,8255 | 0,7784 | 0,7264 |
| Discounted NCF [€] | 165.268,00 | 17.009,38 | 36.200,80 | 55.955,54 | 76.448,52 | 97.870,07 |

Table 3: Progression and growth off the company over 5 years

Using the formula for calculating present value:

$$NPV = \frac{R_t}{(1+i)^t}$$

where NPV is the net present value, $R_t$ is net cash flow at time t, i is the discount rate (WACC of 6,6%) and t the time of cash flow.

Overall, we get a net return of €118.216,31, which indicates the profitability of the project. In a percentage form, it represents 72% of the initial investment of €165,268.

**Investment Appraisal**

| | | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | |
|---|---|---|---|---|---|---|---|---|
| | Year | 0 | 1 | 2 | 3 | 4 | 5 | |
| sales | #Lisences Sold (units) | € 0,00 | € 15,00 | € 18,00 | € 21,60 | € 25,92 | € 31,10 | by 20% |
| | Price per Licince | € 0,00 | € 5.000,00 | € 5.000,00 | € 5.000,00 | € 5.000,00 | € 5.000,00 | |
| | Upgrades/Add-ons | € 0,00 | € 100.000,00 | € 108.000,00 | € 116.640,00 | € 125.971,20 | € 136.048,90 | by 8% |
| | #Licence Sold (euros) | € 0,00 | € 75.000,00 | € 90.000,00 | € 108.000,00 | € 129.600,00 | € 155.520,00 | |
| other income | Maintanance | € 0,00 | € 500,00 | € 505,00 | € 510,05 | € 515,15 | € 520,30 | by 1% |
| expenditures | Software subscription | € 1.088,00 | € 1.088,00 | € 1.088,00 | € 1.088,00 | € 1.088,00 | € 1.088,00 | |
| | Salaries | € 150.000,00 | € 150.000,00 | € 150.000,00 | € 150.000,00 | € 150.000,00 | € 150.000,00 | |
| | Hardware | € 8.000,00 | € 100,00 | € 100,00 | € 100,00 | € 100,00 | € 100,00 | |
| | Cloud-based hosting | € 2.400,00 | € 2.400,00 | € 2.400,00 | € 2.400,00 | € 2.400,00 | € 2.400,00 | |
| | Housing/Office space | € 3.780,00 | € 3.780,00 | € 3.780,00 | € 3.780,00 | € 3.780,00 | € 3.780,00 | |

Figure 7: Table containing all the information regarding the business side developed

## 3.5 PESTLE Analysis

The business is envisaged to have a quick break-even and high rate of turnover projected in five years as discussed in the previous section. Hence, in this section, we discuss the impact of the business on the key partners and how it leads to major political, economic, social, technological, legal, and environmental changes in society. As the key partners venture into Industry 4.0 utilising the digital twin provided by *parschnell*, they enter another competitive environment with the leading companies in their field. With competitive prices of the products and fast delivery through mass production, the key partner expands into the international arena and its neighbouring countries. This strengthens political and international trade relations due to the investment of the key partners in the foreign market. Furthermore, as the senior engineer responsibilities are dispersed among the operators and automation reduces human involvement, better work safety environments are created. And finally, as the complexity of the job is reduced following the automation, it will become easier for the customer companies to hire operators from diverse backgrounds, and also refugees with expertise in other fields.

One of the major impacts of *parschnell* that we see for the partner and customer companies is in the field of economics. By creating automation of manufacturing and assembly processes we reduce the manufacturing time, reduce the raw materials required by removing the error due to manual work, and hence the overall cost of product decreases. This creates an increase in throughput. Additionally, the competitive prices expand the foothold of the partner and customer companies in their consumer market which directly leads to an increase in sales. Table 4 *(see Appendix - PESTLE Analysis)* gives a collation of the PESTLE analysis of the overall impact of the business model or the solution that *parschnell* provides to the key partners or customers.

One of the most important impacts of the business model when integrated with the partner companies is the social impact. As envisaged with the current model, it shows that the simplification of the assembly process is going to reduce the senior engineer workload and the job can be done by common operators. This gives an opportunity for the unskilled workforce to get more responsibilities in the industry which then leads to the development of the community. The local families benefit from this model as the employment generated is suitable for people from diverse backgrounds. Since the workload is lower than before it is also forecasted that shift management can be done more easily thus giving a comparatively stress-free environment for the employees. This model also benefits the company because now the task of modelling the assembly process is simplified and the extraction of the assembly steps is automated, thus reducing the extra hours needed for the senior engineers which will hence save the revenue spent on extra working hours for skilled labour.

The other major impact the *parschnell* solution has on the partner companies is through the technological output. Not only does the solution lead to faster manufacturing and reduced costs, but also to the simplification of the processes. The new method removes the human involvement in the coding aspect of the assembly processes and creates a more seamless environment when integrated with the HMI software. This reduces the learning time for new employees as well as the past employees.

Since now the workload shift is observed from skilled to unskilled employees, it is predicted that new wage laws for the company will be set up based on the extra work hours and other employee benefits. The work environment becomes more inclusive since now the employees can be from different engineering backgrounds thus causing a shift in the policies of the company. Further, since human error has been eliminated from the manufacturing or assembling process, it is going to lead to a reduction in raw materials which were wasted before due to human error. This will call for a new climate action plan by the company as the carbon footprint will be considerably reduced.

The environmental impact of the business model is seen through its integration with the key partners and customer industries. As the raw material usage is reduced, the model saves on the possible rare earth materials and more material optimization. Due to a reduction in downtime, the company further leaves an impact on environmental conservation. The sustainable manufacturing method through automation and optimization further brings the carbon footprint down. In the next section, we present the results of the SWOT analysis for *parschnell* integrated manufacturing.

## 3.6 SWOT Analysis

The major strengths of the *parschnell* integrated manufacturing or assembling process are the decentralization, uniqueness, and the secure control the model provides. The decentralised model means that the state machine is available to authorised personnel within the local area network. This way the data is stored in multiple locations but can be collated at a single server as well. Decentralization reduces the burden on senior engineers, facilitates diversification, encourages the development of the operator staff, helps in better control and supervision, and would lead to quick decision-making. However, the business model suggested (the proprietary license) acts as a weakness as the freedom to edit and manipulate the code is restricted. The state machine can be controlled, edited, and modified only by the developers at *parschnell,* or by engineers of the customers' companies upon proper education, in the form of manuals, given from us.

The automation and decentralisation of the assembling and manufacturing process will lead to employment generation which will further lead to regional or local area development and also includes more operators from diverse and unfavourable conditions. The expansion of the automated industry into developing countries will further contribute to the development of the region. However, putting the partner company among the leading companies in the field will cause sudden and new competitive situations and might act as a threat. Lastly, the launch of a new method always causes a learning curve for the employees and the phase may last longer than anticipated. These threats can be overcome by being prepared for tough competitors and providing thorough training sessions for the operators by the technical team at *parschnell* to reduce the learning time of the new model. *(See Appendix - SWOT Analysis)*

# 4. Business Development Process

The initial stages of the development of the business model involved the understanding of the problem statement. The team members, being from diverse backgrounds, brought their own understanding to the table and helped each other out with the literature and other helpful materials to understand the problem in a more detailed manner.

After the first presentation of the problem, we thought that the main task to accomplish was to be able to reorder a list of tasks always respecting a set of constraints defined by the company for each product. The solution to that problem is a well-known algorithm called on literature topological sort. Fortunately, we soon changed our minds since this way was definitely the wrong direction.

After having received the material we understood that the problem was different and we started thinking about the state machine implementation. The decision to adopt a state machine has to be found in two main considerations. The first is that we had lessons during the summer weeks that specifically aimed to teach us the modelling theory and the state machine is one of those models more and more adopted in industries. The second is that the state machine plays a perfect role in simplifying the definition of the behaviour of a software given a certain state and a specific input (in this case represented by the code). Its usage is related to concepts like divide-et-impera, graph theory and modeling, which are based on a strong theory and so are robust and largely adopted.

After having discussed the solution idea with all the members of the group, we proposed it to the HAWE Hydraulik representatives who confirmed that we were on the right direction, showing real interest in our approach.

Fortified by the confirmation, the team began to look into the solution methods of the same. This involved diving into the various coding platforms which allowed the possibility to design and extract a state machine. Given the time constraint and the will to present a complete solution to the Use Case, the team decided to use the software suggested in one of the lectures by Prof. Van Houser: Enterprise Architect. This software helps to trace high-level specifications to analysis, design, implementation, test and maintenance models using UML, SysML, BPMN and other open standards. It is a multi-user, graphical tool designed for building robust and maintainable systems. Using high-quality, built-in reporting and documentation, one can deliver a shared vision easily and accurately.

## 4.1 Group Tasks Definition

Reaching this point, the team was split into two main subgroups: the group with the software engineers worked on the MVP whereas the business analysts worked on understanding the market for *parschnell* and creating a five-year financial plan. However, we always worked in the same room and had constant contact, thus we always gave each other opinions on the work done in the form of feedback and suggestions. In particular, at the end of each working day, we had more consistent sessions to get synchronized with the progress of the project.

During the first week, the main focus from the product development side was to learn the Enterprise Architect software. Being so huge, it can be used for a myriad of different purposes. To find the right commands to define the behaviour of the model it is often necessary to dive into the documentation. We were able to simulate the state machine for processing the example of the codes provided by the HAWE Hydraulik team only after one entire week of work. Once we obtained that result, it was necessary to export the state machine as a JavaScript code and prepare a website to permit interaction with it. We worked on this part of the MVP for two entire days and we were able to finish and publish the website just the night before the presentation. Below, can be seen a couple of screenshots from the website running the MVP.


Figure 8: Homepage of the MVP

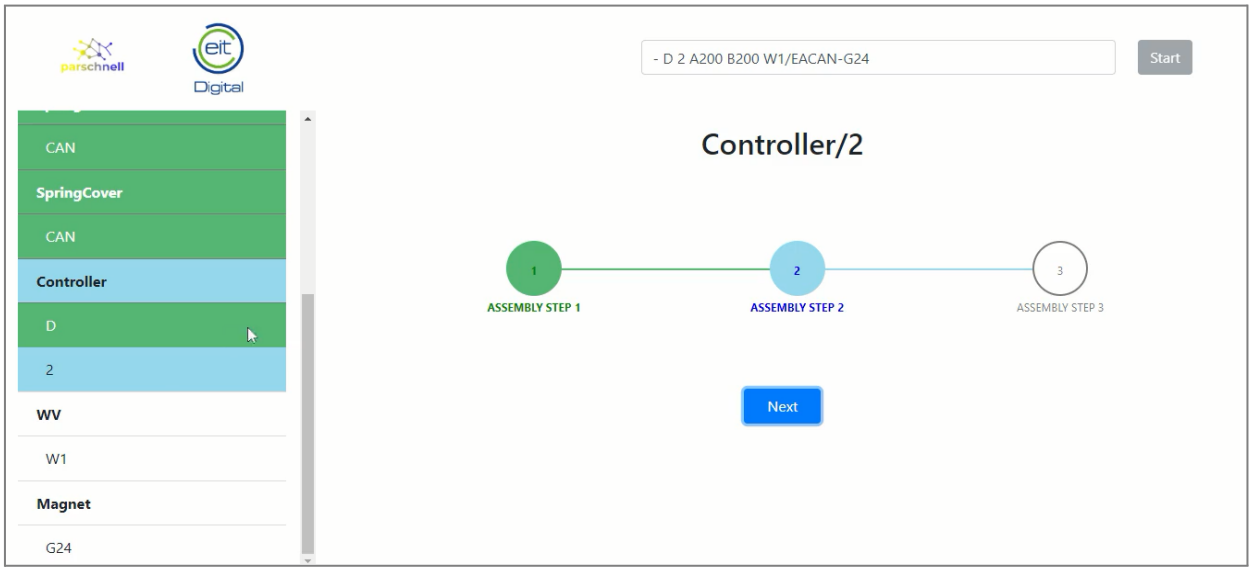


Figure 9: Simulation of the assembly process given the code

For the business part, the business model was chosen based on the developed product and how it could be utilised to its maximum capacity. In this regard, the proprietary license was found as one of the most appropriate methods not only to monetise the product but also to find its maximum utility. Further, it was determined that the now-developed code can be scaled and also modified to provide more utilities, hence, a usage-based business model is also added to the existing business model. The add-ons will be provided to the customers on a usage-based method, which can then be divided among pay-per-use based on the complexity of the add-on. Finally, the revenue stream will also be from the service and maintenance of the product installed at the customer's end. The installation is proposed to be on-premise in order to retain

the intellectual property of the product and also build a stronger relationship with the customer through on-site training.

Some of the major terms used to explain the business model are described below:

1. Proprietary Software License: A proprietary license model is predicated on the idea that the software developer maintains control over the code of the software, as well as its features and use [3].
2. Usage-based: Customers are only charged for a product or service when they use it, according to the usage-based pricing model. The consumer is typically charged at the conclusion of the billing period. No matter how frequently the consumer uses the service, they are still paid a cost under a flat subscription pricing plan. A usage-based price, on the other hand, varies depending on how much the consumer actually uses. Metered services are another name for usage-based pricing [4].
3. Pay-per-use: In the pay-per-use business model, the company owns and is responsible for the product or service, and the client pays a charge for use as needed. Due to their preference for just paying for the services they actually use and demand, many customers favor this arrangement. They frequently also get better service as a result of the manufacturer's increased commitment to making durable products [5].
4. On-premise: When consumers are in a specifically designated geofenced or "Blueprinted" location, on-premise marketing, also known as on-premise targeting, enables marketers to connect with them in real-time [6].
5. Add-on: The fees or costs that are added to the base cost of a good or service in exchange for additional features or benefits, such as the accessories fees or costs that are added to the cost of an automobile. The true secret is to include high-margin goods and services [7].
6. Intellectual property: The term "intellectual property" refers to the collection of intangible assets that a business or individual owns and is legally entitled to protect against unauthorized use or application by third parties. A firm or individual may own intangible assets, which are non-physical assets [8].

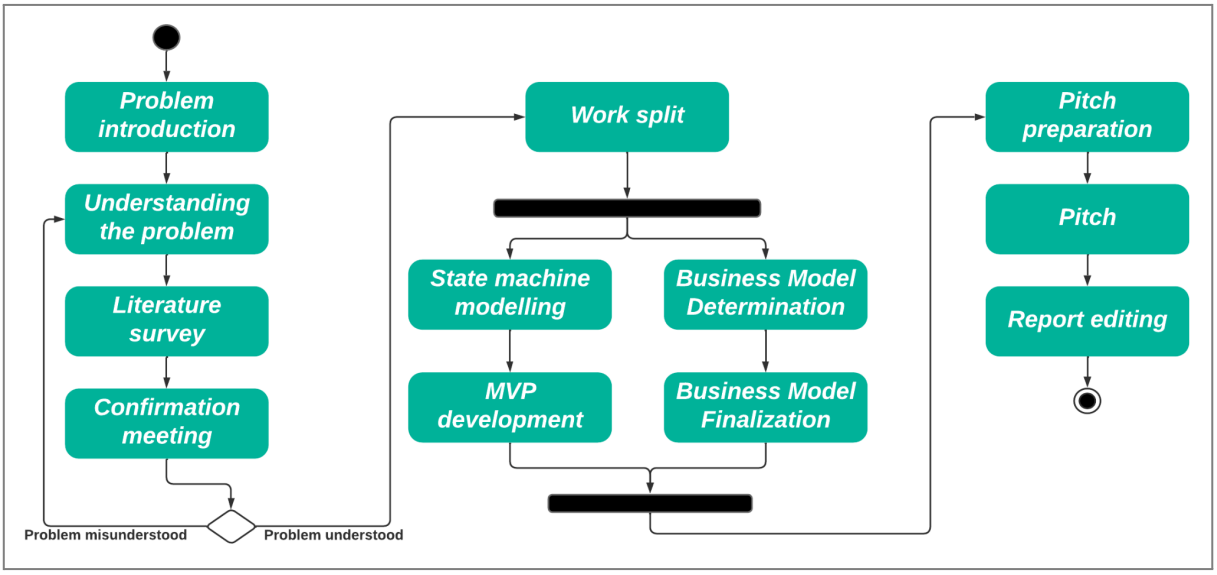


Figure 10: Workflow of the Use Case Study and Solution

# 5. Self-Evaluation and Team Reflection

| Technical Knowledge | Business Knowledge | Interpersonal |
|---|---|---|
| • UML, SysML<br>• BPMN- Sequence Chart, Activity Diagram<br>• State Machine<br>• Enterprise Architect | • Business Model<br>• Financial Analysis<br>• PESTLE Analysis<br>• SWOT Analysis | • Teamwork<br>• Responsibility division<br>• Work-life balance<br>• Working under deadline |

Table 6: Self-Assessment Elements

## 5.1 Team Objective and Capabilities

The first goal of the team was to create a working MVP that could be used in real-case scenarios from HAWE Hydraulik. Since the first presentation of the study case, we thought that a first solution, sort of a prototype, could be fairly reached fast and therefore we spent a lot of effort and time on creating a working product. This would show our capabilities to HAWE Hydraulik and could lead to future job positions offered to us in order to completely develop the state machine needed to reach a fully autonomous communication between the sales department and the assembly department.

To reach this goal, we had to split and diversify the required tasks: the members with a stronger background in coding focused on developing the state machine, the members prone to a business analysis focused on the business solution. Inside the coding team, Riccardo was the

main coder since he knew where to find the proper tools and methodologies to reach the final goal, and Daniele and Sergio. Given their shallower knowledge in coding, they were mainly helpers that focused on enabling Riccardo's work. In the business team, Vera and Rupal worked side by side helping the team when it was needed.

### 5.1.1 Technical Knowledge

At the end of the project, each member of the team saw at least a couple of times each technical aspect of our solution. We gained knowledge about the general implementation of SysML paradigms, BPMN and Activity Diagrams, which was crucial in the definition and development of the proposed solution, by exploiting and studying Enterprise Architect, which was presented to us during the summer school. All the members of the coding team knew about the existence of state machines, therefore that notion was just presented to the business team and was fully understood

### 5.1.2 Business Knowledge

For what concerns the business aspect of the solution, everyone in the team already knew what a Business Model was and how to conduct a Financial Analysis. Nevertheless, the notions of PESTLE and SWOT analyses were new to many members of the team and this helped us enrich our knowledge and better present our intentions and final product. The business team that worked on the redaction of these two analyses did a superb job at presenting them to the coding team, allowing them to fully understand the potential reach and power that the final product could offer. In the daily briefing sessions, the coding team presented the new implementation and together with the business team brainstormed more ideas which were added to the PESTLE and SWOT analyses, making it a true team effort.

### 5.1.3 Interpersonal Development

This Summer School helped every single member of the team to understand how to work under pressure and in a multidisciplinary team with people from different cultures (Italian, Spanish, Indian, Bosnian), backgrounds (in this group people came from four different universities and five different courses of studies) and knowledge (post-doc, master's degree students, bachelor's students). This helped us increase our responsibility for the work done and taught us how to balance work and life outside the university since we had the pleasure to know each other and spend time together in the beautiful city of Munich.

# References


[1] Mikel P. Groover. Encyclopedia Britannica. *"Automation"*. Available online: https://www.britannica.com/technology/automation

[2] HAWE Hydraulik. Solutions for a World under Pressure. Available online: https://www.hawe.com/de-de/unternehmen/

[3] Ivanti. *"Software License Types Explained: What You Need to Know"*. 2020. Available online: https://www.ivanti.com/blog/software-license-types

[4] TeachTarget. *"Usage-based pricing"*. Available online: https://www.techtarget.com/searchcloudcomputing/definition/usage-based-pricing#:~:text=Usage%2Dbased%20pricing%20is%20a,often%20they%20use%20the%20service.

[5] Vincent Wauters. *"What is Pay-Per-Use (PPU) and how can it benefit your business?"*. Available online: https://www.bundl.com/articles/trends-what-is-pay-per-use-ppu-and-how-can-it-benefit-your-business#:~:text=Under%20the%20pay%2Dper%2Duse,services%20they%20require%20and%20use.

[6] GroundTruth. *"On-premise Marketing"*. Available online: https://www.groundtruth.com/glossary_term/what-is-on-premise-marketing/

[7] Preferred CFO. "*The Add-On Business Model and Why it Rocks*". Available online: https://preferredcfo.com/the-add-on-business-model-and-why-it-rocks/

[8] Investopedia. "Intellectual Property". Available online: https://www.investopedia.com/terms/i/intellectualproperty.asp

[9] PayScale. *"Average Junior Software Engineer Salary in Germany"*. Available online: https://www.payscale.com/research/DE/Job=Junior_Software_Engineer/Salary

[10] ShareYourSpace. *"What does an office rental cost in Munich?"*. Available online: https://www.shareyourspace.com/en/rent-office-space/munich#:~:text=We%20don't%20have%20to,%E2%82%AC41.00%20(high%20end).

[11] KPMG. Cost of Capital Study 2021. *"Sustainability vs. Return – ESG as a key driver for long-term performance?"*. Available online: https://home.kpmg/de/en/home/insights/2021/10/cost-of-capital-study-2021.html

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# Appendix

**PESTLE Analysis**

| | | |
|---|---|---|
| **P** | Political | ● Increased international trade relations.<br>● Improved workers' health and safety policies.<br>● Work opportunities for Ukrainian refugees- specific engineers not needed. |
| **E** | Economic | ● Time is money<br>● Mass production/fast production- higher sales<br>● Competitive method<br>● Automation- raw materials efficient use- less raw materials to buy<br>● Cost of the product is reduced<br>● Increase in throughput |
| **S** | Social | ● Easy training methods<br>● We change the way engineers define the action.<br>● Inclusive and stress-free environment: more engineers will join who are trained in state machine models, and state-of-the-art technologies. good advertisement for the company.<br>● Cheaper labour as unskilled can do the same job<br>● Shift management due to automated process<br>● Worker safety: removing humans from hazardous environment<br>● The operator doesn't depend on the engineer anymore. |
| **T** | Technological | ● Easy to learn/training process<br>● Process simplification of complex/time-consuming processes<br>● Collecting data through digital twinning<br>● Easy to expand: the solution is far more scalable than the current used model<br>● Automation of the current manual process.<br>● Easy understanding of the code and the method. |
| **L** | Legal | ● New wage levels analysis: engineers with non-specified degrees can be hired. Hydraulik engineers go into prototyping and have less software-related work to do.<br>● Software developers can be hired, thus new legal forms.<br>● Better climate action program with sustainable manufacturing. |
| **E** | Environmental | ● Sustainable manufacturing process<br>● Raw material management |

| | | |
|---|---|---|
| | | • Lower carbon footprint- less downtime |

Table 4: PESTLE Analysis

**SWOT Analysis**

| | |
|---|---|
| [S] Strengths<br><br>Decentralization: The data and the codes are decentralized and become a part of the pool bank providing easy access to anyone with authorized access.<br><br>Uniqueness: Automation of the process stands out as a unique alternative to the existing model<br><br>Secure Control: Separate servers with LAN access | [W] Weaknesses<br><br>Software house: The product requires authorization and manipulation only provided by the software house. |
| [O] Opportunities<br><br>Area Growth: Increase of rate of production will increase the scope and size of the company thus leading to local area development.<br><br>Working Families: Unskilled labor (operator) will bring income into more families from diverse backgrounds. | [T] Threats<br><br>Competition: Even though the automation model will put the company ahead of the competitors, the increase in IT solutions in the manufacturing domain stands as a threat. Now the competition is with bigger and better companies.<br><br>Being unprepared: The launch of the automated process may create an initial learning curve phase which may take longer than anticipated. |

Table 5: SWOT Analysis