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MASTER'S THESIS

THE CASE STUDY OF IN-HOUSE DEVELOPED CUSTOM APP FOR MANUFACTURING DEPARTMENT IN HILTI

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LIST OF ABBREVIATIONS

AI - Artificial Intelligence

AR - Augmented reality

CIP - Continuous Improvement process

ERP - Enterprise resource planning

GDPR - General Data Protection Regulation

GM - Global Manufacturing

HR - Human resources

IIoT- Industrial Internet of Things

IoT – Internet of things

IT - Information Technology

LCDP - Low-code development platform

MES - Manufacturing Execution System

MVP - Minimum viable product

SAP BAS - Business application studio

SAP BTP - Business technology platform

SSO - Single sign-on

UI - User interface

UX - User experience

INTRODUCTION

Industry 4.0 (I4.0) and digitalization are bringing huge changes to modern manufacturing. I4.0 represents the development of "cyber-physical systems (CPS) and dynamic data processes that use massive amounts of data to drive smart machines" (Strange & Zucchella, 2017). Many different technologies drive the development of Industry 4.0 including big data analytics, the Internet of things (IoT), and huge advances in the field of artificial intelligence. Thus, businesses need to keep up and include new trends in their everyday processes. Hugely influential for the manufacturing sector is the concept of a Smart factory. Lucke, Constantinescu, & Westkämper. (Lucke, Constantinescu, & Westkämper, 2008) define a Smart Factory as a context-sensitive manufacturing environment that can handle turbulence in real-time production using decentralized information and communication structures to ensure that production processes are managed optimally. Many factors influence the success of a Smart Factory but at the core, it is a quick development and modification of IT support.

Low-code development can directly influence such development and modifications. The goal is to simplify the development of new solutions and enable business users (referred to as citizen developers) to build their own solutions. These platforms use drag-and-drop components through visual interfaces without requiring in-depth programming skills to develop adaptable programs in a short amount of time (Sahinaslan, Sahinaslan, & Sabancıoglu, 2021). In doing so, they help to increase productivity, reduce costs of development, and empower users (Bock & Frank, 2021). This enables them to get the benefits of Industry 4.0 and digitalization. Users can improve or automize processes themselves. The apps they create can be integrated with other solutions which enables them to prevent double work, decrease bureaucracy, and simplify their everyday tasks.

This master's thesis presents a case study of the development of a low-code app for a Manufacturing organization in Hilti. The company produces equipment and provides solutions that are designed to make work on construction sites easier, faster, and safer. Hilti is a hardware-driven company that mainly creates power tools, anchors, and many other products.

This case study focuses on the development of an app for the Continuous Improvement Process in Hilti (CIP). The CIP is managed by the Lean community, and it has thousands of users that regularly participate in the process. This app is created as a part of the Manufacturing Apps initiative which aims to deliver customized in-house developed low-code solutions in the Manufacturing organization of Hilti. The case study will describe the development process of creating the CIP app. The app also serves as proof that low-code development platforms (LCDPs) have great potential to improve processes within Hilti.

Based on findings from the CIP app development, I created the Manufacturing Apps framework. This framework includes the best practices identified through theoretical research and consultations by relevant experts in Hilti. Since the framework mostly focuses on the development of an individual app, I additionally included topics that are important for the management of Manufacturing Apps as an initiative.

The purpose of this master thesis is to improve the understanding of the usability and development process of solutions developed using low-code platforms for manufacturing organizations. To achieve this, I set several goals. The goal of the first part of this thesis is to provide the theoretical framework of the processes and activities described later. I look for opportunities that can help optimize the process of development and implementation of the CIP app in the Hilti Manufacturing department. The goal of the second part of the thesis is to analyze the process of app creation. The main goal of the analysis is to present the process of creating an app that starts with an idea and ends with a prototype. Additional goal is to determine critical success factors of the development of the low-code app. The last goal of this thesis is to present a framework for future development of low-code solutions. This framework describes all the necessary steps that are needed when developing an app. Additionally I also present how an entire initiative of low-code app development could be managed, which includes all the main principles and activities that need to be performed.

1 THEORETICAL BACKGROUND

1.1 Industry 4.0 and digitalization

Industry 4.0 and digitalization are now household names. These terms have gained immense popularity over the last few years. They often represent repackaged old ideas and an ongoing process that started a long time ago (Tomat & Trkman, 2019). Industry 4.0 and digitalization should not just remain fancy buzzwords used by consultants and management boards. They need to have a defined meaning, otherwise, these terms mean everything and nothing at the same time. Furthermore, awareness of the implications of Industry 4.0 and digitalization is the basis for understanding the paradigm behind the LCDPs and the Manufacturing Apps initiative. Therefore, I will start with an introduction to Industry 4.0 and digitalization, as well as the main trends that impact the manufacturing environment.

Industry 4.0 (I4.0) and digitalization go hand in hand. Nowadays there is common knowledge regarding both parts, and everyone is using them when talking about the future of manufacturing. Gartner Glossary (2021) describes digitalization as “the use of digital technologies to change a business model and provide new revenue and value-producing opportunities; it is the process of moving to a digital business.” Other authors describe digitalization as “the adoption or increase in the use of digital or computer

technology by an organization, industry, country, etc." (Parviainen & Tihinen, 2017). Kuusisto (2017) warns that people use the term digitalization as a vague term to describe many different things depending on the context. Therefore, he defined digitalization as "the usage of any digital assets organizations can use to improve their performance and the effects of these technologies have had on how the world works."

The term Industry 4.0 was supposedly used for the first time by the German government as the name for their new high-technology strategy (Strange & Zucchella, 2017). Since then, it is commonly used to refer to the development of "cyber-physical systems (CPS) and dynamic data processes that use massive amounts of data to drive smart machines" (Strange & Zucchella, 2017). KPMG describes Industry 4.0 as "a collective term used around the world to describe the convergence of IoT-driven technologies, augmented decision-making, and advanced automation." (*Industry 4.0 explained*, 2017) PwC claims that the focus of Industry 4.0 is the end-to-end digitalization of all physical assets and integration into digital ecosystems with value chain partners (Geissbauer, Vedso, & Schrauf, 2016). McKinsey defines Industry 4.0 as the "digitization of the manufacturing sector, with embedded sensors in virtually all product components and manufacturing equipment, ubiquitous cyber-physical systems, and analysis of all relevant data (McKinsey Digital, 2015)." Wang, Wan, Li, & Zhang, (2016) state that the core idea of Industry 4.0 is the use of new technologies in a way that causes the integration of business and engineering processes which would result in a flexible, efficient, and green way of high-quality and low-cost production. Frank et al. (2019) conclude that the essence of the I4.0 is the establishment and integration of smart manufacturing, smart supply chain, smart product service system, and smart working.

In this thesis, I use digitalization as the term that combines all the above-mentioned definitions. It represents the use of digital technology in any part of the processes and business. Industry 4.0 is specifically the digitalization of industry. One of the main specifics is the physicality of the products that are manufactured. While these cannot be digitalized, we can digitalize the technology and processes around them.

Wang et al. (2016) state that it is crucial for Industry 4.0 to "implement the horizontal integration of inter-corporation value network, the end-to-end integration of engineering value chain, and the vertical integration of factory inside." Vertical integration enables companies to optimize their agility and flexibility. In Industry 4.0, vertical integration strives to connect all the logical levels of a company, from the manufacturing floor up to the different departments, such as R&D, quality assurance, product management, IT, sales, marketing, etc. (Schuldenfrei, 2019). Data needs to flow easily and openly up and down these levels, allowing for data-driven strategic decisions. To achieve this, these systems must be fully integrated. The term Horizontal integration is, meanwhile, used to describe the process of integration of all the parts of the entire supply chain (Tabim, Ayala, & Frank, 2021). This will give companies a better overview of how to efficiently react to the market situation. They will have all the required information available and

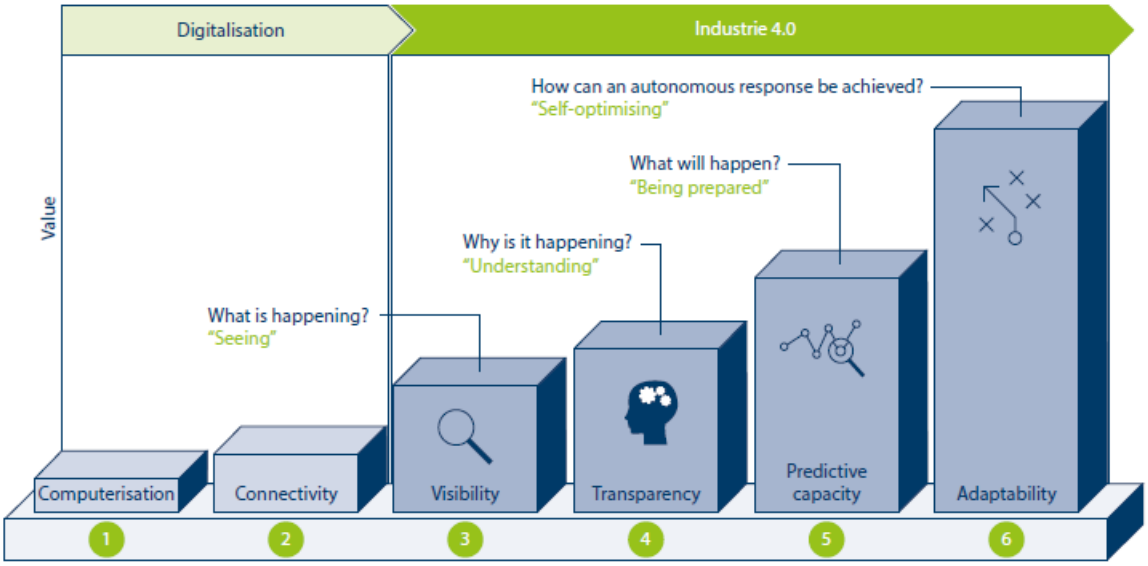
not stored in data silos.

1.2 Industry 4.0. maturity models

Maturity models are created to help organizations reach I4.0. They offer detailed instructions and a path for further improvement (Gökalp & Martinez, 2021). Many companies are aware of the potential that I4.0 could have for them. However, they first need to understand what is the current status of I4.0 implementation in the company and what are the right steps to reach the next level. One such framework is the Industry 4.0 Maturity Index created by Acatech, the German Academy of Science and Engineering, which is presented in figure 1. This framework defines the six stages that a company should complete reaching the full potential of Industry 4.0.

Companies can use such a framework to assess their level of I4.0 adoption and define the next steps to move forward. Companies must first evaluate the resources, information system, software and hardware, organizational structure, and culture in different functional areas. Based on that assessment, they plan their future strategy to be able to reach the desired level of I4.0 adaptation. One of the goals, especially in the manufacturing environment, is to create smart factories.

Figure 1: Industry 4.0 Maturity Index



Source: Schuh, Anderl, Dumitrescu, & Krüger (2020).

1.3 Industry 4.0 and Cybersecurity

Cybersecurity is an issue that has a hugely destructive impact on businesses if companies do not ensure sufficient levels of protection. Companies already face many threats in their day-to-day work.

In fact, Industry 4.0 and digitalization will bring even more threats. IoT will dramatically increase the number of devices connected to the network. The problem, in terms of cyber security, is that as soon as attackers can access even one device, they can exploit the opening and cause problems. The need to protect critical industrial systems and manufacturing threats, therefore, becomes much stronger (Russmann et al., 2015).

Cyber security measures are now always present in our digital work to help fight these threats. Companies use complex identity management and access management systems to ensure proper authentication. Employees are required to use VPNs when working remotely and to attend mandatory cybersecurity pieces of training. Nonetheless, it is also crucial for companies to have strong company-wide defense systems to prevent cyberattacks (Erboz, 2017).

1.4 Pillars and technologies of Industry 4.0

Different authors have attempted to describe the different pillars of Industry 4.0. However, the most common are (Büchi, Cugno, & Castagnoli, 2020; Erboz, 2017; Geissbauer et al., 2016; Russmann et al., 2015; Strange & Zucchella, 2017; Tang, 2021):

- big data and analytics,
- autonomous robots,
- simulations,
- industrial Internet of Things (IIoT),
- cloud computing,
- additive manufacturing,
- augmented Reality,
- artificial intelligence.

1.4.1 Big data and analytics

Big data is a term used for numerous large, diverse, and complex datasets that influence strategy and organizational decision-making (Erboz, 2017). These technologies capture, archive, analyze and disseminate large quantities of data (Büchi et al., 2020). Three key factors that increase the importance of big data are volume, velocity, and variety (McAfee & Brynjolfsson, 2012; Wang, Xu, Zhang, & Zhong, 2022). It is estimated that in the year 2020, 64.2 zettabytes of data/information were created. Additionally, it is

estimated that by the year 2025 the number will have increased to 181 zettabytes (IDC & Statista, 2021). This number will only increase with the implementation of Industry 4.0 and technologies like smart sensors and the Internet of Things. Among other advantages, business analytics capabilities improve agility by increasing information quality, as well as innovative capability (Ashrafi, Zare Ravasan, Trkman, & Afshari, 2019). Finally, there is variety: different sensors create different types of data. Some sensors produce just pure strings of letters and numbers while other types of sensors signal GPS locations or the number of certain products left in the store. Just gathering the data is not enough. The problem with intelligent manufacturing is that companies still face great challenges to make full use of the data (Wang et al., 2022). Companies need to analyze the gathered data and understand the findings that are derived from them. That is helping businesses to better understand their customers, processes, supply chains, as well as all other business functions.

1.4.2 Autonomous robots

Robots have already been in use for decades, for example, to tackle complex assignments and the most repetitive tasks (Gentile, Miroudot, Vries, & Wacker, 2020; Russmann et al., 2015). In recent years, they have been evolving even faster than before. They are becoming able to interact with each other and humans which will make them more autonomous, flexible, and cooperative (Russmann et al., 2015).
Autonomous robots will be used in many areas in Industry 4.0 with the highlight on the production, logistics, and distribution activities (Erboz, 2017). Companies are also developing robots that can work with humans and learn from them. One notable example is a so-called cobot (collaborative robot) named *LBR iiwa* produced by Kuka in 2014 (KUKA, 2022). It is designed to work safely side by side with humans and to communicate with them and other robots to coordinate their activities.
This autonomy is a consequence of the usage of smart sensors, AI (which enables robots to react and make instant decisions), and IIoT, all of which I will describe below. Sensors help to create the data which is needed for data creation. Based on the data from the device, as well as the data from other devices from IoT, we can train AI to understand the environment around it and act accordingly.

1.4.3 Simulations

A simulation is a tool that uses the existing data to predict the outcome using complex modeling. It involves reproducing the physical world in virtual models (Büchi et al., 2020). It can save companies huge amounts of money. It is already widely used in the development of products and to test their performance before any physical products are made. In the era of I4.0, simulations will get even wider usage in plants (Russmann et al., 2015) using simulations in other fields, such as quality control will enable companies

to test their processes or products and find improvements. Using real-life data from the past as the starting data and they will make accurate estimations regarding the optimal settings and changes (Erboz, 2017). They can perform the analysis, quality testing, and prototyping in simulations. Except for the licenses for the simulations and labour costs, there are no additional costs (such as material or logistics). This enables them to do adjustments virtually in the simulations without the need to interfere with complex systems in the factory.

An emerging concept in manufacturing is also digital twins. The concept was first proposed by Grieves back in 2003 (Grieves & Vickers, 2017). It represented a 3D model with information about the physical and digital products, as well as all the connections between them. The definition used in most cases now was created by NASA (Glaessgen & Stargel, 2012). The concept describes an integrated multiphysics, multiscale, probabilistic simulation of an as-built product or system that uses the best available physical models, sensor updates, and more to mirror the life of its corresponding twin. The digital twin, therefore, has three main components: physical products in the physical world, digital products in digital world and the connected data that is connecting the two (Qi & Tao, 2018). Digital twins were therefore introduced as a pragmatic way to seamlessly integrate and fuse/combine the physical and virtual spaces to solve real-time optimization problems (Wei, Ma, Li, & Hu, 2020). Qi & Tao (2018) also identified three main applications of the digital twin in manufacturing: Digital twin-based production, smart manufacturing in digital twin workshop/factory, and, lastly, product digital twin for usage monitoring. All these help improve manufacturing efficiency, shorten the product development cycle, and ensure accuracy, stability, and quality.

1.4.4 Industrial Internet of Things (IIoT)

Internet of things in its essence meant the connection of physical objects and systems to the network (Erboz, 2017). It is a system that allows for real-time, intelligent, and autonomous access to the collection, analysis, communications, and exchange of process, product, and/or service information within the industrial environment to maximize overall production value (Boyes, Hallaq, Cunningham, & Watson, 2018). This system may include networked smart objects, cyber-physical assets, associated generic information technologies, and optional cloud or edge computing platforms. More and more products nowadays are equipped with smart sensors or identifiers. They capture the data, process it, and communicate it to other devices or people (Strange & Zucchella, 2017). The Internet of Things means that devices that are integrated into the system and communicate, as well as react, to each other. The potential of the IoT is great in the everyday environment and even greater in an industrial environment. The IIoT will provide real-time data to companies. Among other things, this will enable autonomous robots to collaborate, as well as help implement decentralized decision making. Even devices that do not use computing will be given individual identifiers

(such as RFID) which will communicate with other devices. IIoT is integral to big data analytics as it revolutionized the way data is collected and transferred.

Each IIoT system needs (Posey, Rosencrance, & Shea, 2022):

- devices that can gather data and communicate it,
- data communications structure,
- analytics, which transforms raw data into useful information and knowledge,
- storage for the data gathered,
- people to operate the entire system and utilize the findings.

1.4.5 Cloud computing

Cloud computing is a fundamental change in the way IT solutions and services are invented, developed, deployed, scaled, updated, maintained, and paid for (Marston, Li, Bandyopadhyay, Zhang, & Ghalsasi, 2011). Cloud computing allows users to use storage and processing capabilities in a virtual system (Erboz, 2017) – the so-called ´cloud´. That means that services are performed off-site, which means not in the factory but on a server wherever in the world. With the increased and improved capabilities and performance of cloud computing, companies can use them to perform big data analysis, IoT processes, or numerous other processes in the cloud much faster and cheaper than they would be able to perform these operations by themselves on-premise. Cloud computing also enabled the emergence of Software as a Service (SaaS), Platform as a Service (PaaS), and Infrastructure as a Service (IaaS) (DaSilva, Trkman, Desouza, & Lindič, 2013).

Cloud computing will become even more prominent with the emergence of 5G. Martin Sandelin (personal conversation, 20/09/2021), former vice president of Nokia, stressed in his lectures that the attributes of 5G are perfect for improving the quality of cloud computing. High transfer speeds, low latency, and large bandwidth help further improve the process. 5G also makes edge computing much more relevant (Sandelin, personal conversation, 20. 09. 2021).

Edge computing is a specific type of cloud computing. The crucial attribute of it is the fact that the server is located nearby the client, usually up to 100 km away from the location. Edge computing is used for use cases where low latency, high transfer speeds, and big bandwidth is crucial. One such example is autonomous vehicles where delay can cause a deadly accident. Edge computing will also greatly impact the successful implementation of IoT. Due to its attributes, companies will be able to perform even better data processing which will enable them to react in a matter of milliseconds.

1.4.6 Additive manufacturing

Traditional manufacturing relied on the removal of material to create the product (cutting /drilling/sanding/grinding) (Strange & Zucchella, 2017). The technology of additive manufacturing simply did not exist. Additive manufacturing or 3D printing as it is also known is a process where the product is built layer by layer until the final design is created. First, a 3D model is built using CAD. As soon as a 3D model is created, anyone with appropriate knowledge can use it and create the product. This is especially important because it provides the opportunity for the product to be printed anywhere in the world if the person has access to the file and access to a 3D printer (Strange & Zucchella, 2017). This model will then be uploaded into the slicer software. The software will slice the product into individual layers and create a code that will tell the printer exactly how to print the product.
The product will be created out of filament, particles, or resin. Plastic (e.g. PBA) is the most used material for 3D printing. However, numerous different materials can be used for 3D printing including glass, ceramics, and metals, such as aluminum, copper, and steel (Strange & Zucchella, 2017).

Additive manufacturing has many benefits: It is an ideal tool for proof of concept and rapid prototyping (Gilchrist, 2016). It creates the ability to produce small batches of customized products (Russmann et al., 2015). These products can be printed as soon as the 3D model is created. Traditional manufacturing would need much more time to create the same product. The biggest delay is caused by the need to either program a CNC machine to perform all the right operations to successfully remove material in all the right places or to create the prototype manually. That is why additive manufacturing can cause a huge decrease in lead time (Erboz, 2017). Furthermore, some pieces can only be created using additive manufacturing methods. Due to the design of the product, it is not possible to create some parts of the product. In traditional manufacturing, we must always ensure that the drill of the machine will be able to reach the exact spot where the material needs to be removed. That is not a problem for additive manufacturing as the object is built layer by layer, which ensures the material is only printed where needed. Creating products using additive manufacturing will also vastly reduce waste because there is little to no waste when producing the products.

Due to its benefits, additive manufacturing has been touted as the big next thing because it can be to manufacturing what the internet was to music distribution (Anderson, 2014). Additive manufacturing enables enthusiasts to collaborate and with the use of digital design and rapid prototyping drive the next wave of manufacturing. This will give users the power of creating and inventing which was limited before. However, the progress has not been as dramatic as predicted in 2014 since there are still obstacles that need to be solved. These include a shortage of well-trained designers and technicians, limited consideration of factors and impacts for business case calculation, and, lastly, technical challenges in terms of materials, process implementation, post-processing, and quality

assurance (Staffen & Proff, 2019). A problem for commercial implementation of additive manufacturing is also cost per product. With traditional manufacturing cost per product decreases over time. Based on the current research, there is no evidence of a positive effect of increased volume on unit cost when additive manufacturing is used at full capacity (Baumers & Holweg, 2019). So far, the applications of additive manufacturing have only included either customized parts or production on small scale.

1.4.7 Augmented reality

Augmented reality (AR) is defined as an interactive technology that allows the virtual world and its users to coexist while the virtual world is used as a part of the real world (Erboz, 2017). Combining computer-generated visuals and physical objects in the real world, it could be used in a variety of applications. Users can then control the AR by using a smart device or with different sensors integrated into the AR system by utilizing sensor technologies to control certain tasks. AR is most commonly used with the help of glasses and headsets that project the image over the real world.

AR can positively impact many aspects of the manufacturing process. One example is that it can be used for the virtual training of employees. Furthermore, one of the main benefits of using AR glasses is the ability to see the instructions in the field of sight. There is no need to consult a paper manual or a screen mounted nearby to see what necessary steps need to be performed (Russmann et al., 2015). Furthermore, companies are not just limited to glasses. Another example of AR is optical projection systems for directing and monitoring assembly processes by presenting instructions to the operator in real-time (Sempre Group, 2022) Almost zero training is necessary for untrained personnel to accomplish jobs efficiently and accurately. It will highlight individual parts that need to be used at a certain step of the process making long and complex processes effortless even for inexperienced workers.

AR is also extremely helpful for maintenance workers. Before being capable of maintaining equipment or networks, technicians had to attend training classes and build skills over the years (Gilchrist, 2016). Because in-depth data manuals and service guidelines, as well as 3D schematics and drawings, are now available in the cloud, AR allows for faster training. The technician can obtain specific troubleshooting procedures by projecting this information directly alongside the AR view of the physical machine and the 3D image projected onto the physical product will show them exactly where parts are located and how to reach them. AR can also help with interactive visual learning and the gathering of data.

1.4.8 Artificial intelligence and machine learning

Big data enabled users to predict the outcome of specific situations much better than they were ever able to do it before. That is a consequence of the data users gathered. The main value comes not from gathering the data but from the ability to successfully process them and extract different outputs that will then influence our decisions. Data scientists may apply their data analysis abilities to identify patterns in data, which is at the heart of Machine to Machine (M2M) communication and comprehension while also asking the right questions to extract genuine value from the data (Gilchrist, 2016). Crucial for the success of machine learning is the usage of quality data. The entire field has seen rapid development in recent years and its usage has spread to many fields, including smart manufacturing.

AI is an umbrella term used for many different types of algorithms and models which all work in their specific way. They can be classified into 16 categories (Cioffi, Travaglioni, Piscitelli, Petrillo, & De Felice, 2020): reasoning, programming, artificial life, belief revision, data mining, distributed AI, expert systems, genetic algorithms, systems, knowledge representation, machine learning, natural language understanding, neural networks, theorem-proving, constraint satisfaction, and theory of computation.

With the help of AI, products and machines become smart in the sense that they not only have computation, communication, and control (3C) capacities but also autonomy and sociality (Wang, Wan, Li, & Zhang, 2016).

1.5 The smart factory implementation

As mentioned throughout their description these trends are intertwined. Without sensors from IoT, we gather much fewer data. Without big data, there are no large data sets needed to train AI. And AI can drastically improve the development speed and performance of autonomous robots, simulations, or augmented reality. All these big trends that are described earlier will play a huge role in the manufacturing environment. Companies must be aware of the developments in all the above-mentioned fields. Only in that way, they will be able to maintain their relevance in the market. And many companies are already working on creating a so-called ´smart factory´ which tries to include all these trends.

The smart factory is a phrase that is used both by academics and industrial practitioners (Radziwon, Bilberg, Bogers, & Madsen, 2014). However, it still represents different meanings to different people: some describe it as a factory of things, others as a real-time factory or as an intelligent factory of the future. Lucke, Constantinescu, & Westkämper (2008) define a smart factory as a context-sensitive manufacturing environment that can handle turbulence in real-time production using decentralized information and communication structures to ensure that production processes are managed optimally.

There are also technical challenges that must be faced to be able to construct a smart factory. These challenges include intelligent decision-making and negotiation mechanisms, manufacturing-specific big data and its analytics, modularized and flexible physical artifacts, system modeling and analysis, high-speed IWN (Intelligent wireless network) protocols, and lastly, cyber and property security (S. Wang et al., 2016).

1.6 Experience canvas

Different tools can help users be successful when implementing solutions. One tool that we use when starting the project is experience canvas, a tool created by Atlassian (Huval, 2022). It is an adaptation of the Lean Canvas created by Ash Maurya. Lean Canvas was based on the Business Model Canvas which was developed by Alex Osterwalder (Huval, 2022). Experience Canvas is a framework designed to help clarify the problem and the plan on how to solve it. It has ten different fields. The process starts with the *Hypothesis*, in which a quick summary of the project can be defined. The second step is the *Problem*. We define the problem and all of its root causes. We try to go in-depth to truly understand the origin of the problem. Only at this point, it will be possible for us to find the appropriate solution. The third step is *Customer personas*. In this stage, we present to the users what their pain points are and what their end goal is. This step is followed by *Stakeholders*. We proceed to present all other relevant stakeholders that will be influenced by the app or that have requirements and the ability to support or block the project. Moreover, we decided to add additional requirements that must be included at this stage. We must also delegate or recognize who are the decision-makers in the project. Each project should have a business and a technical owner. The responsibility of the business owner is to present the use case, ensure necessary resources (both funding and team members with good knowledge of the process that can describe the problem) for the app, and make the decisions that are related to the content of the app. As the name already suggests, the technical owner of the app is responsible for the technical part. He or she is in charge of providing technical consultations to the organizational counterpart and making decisions regarding the development and any technical support of the project. The last step in presenting different roles is the *Team*. In this step, we must define who will participate in the project and what skills are needed for its successful completion. The sixth step is defining the *Value*, in which all the different benefits users will gain are described. We should mention potential savings created by the app, time savings, technical benefits, and all others. The seventh step is defining the *Ideas*. The team works together to come up with ideas for prototypes describing how we could solve the users' problems and difficulties while simultaneously following stakeholder requirements. Users usually already have an idea of how they want to solve their problems. The task of the Manufacturing Apps team is to take that idea, check if it is technically viable, and decide if it is possible to improve their solution further. Following the *Ideas*, there is a *Minimum viable experience*. The user and developer define the *Minimum viable product* (MVP). This solution is just good enough for the

user. The MVP will provide the user with the ability to test if it solves the problem they are facing. In the ninth stage, we define *Metrics*. Using metrics and milestones, it can be checked if the project was successful or not. They need to be defined and determined how, when, and by who they will be measured. We must also ensure to pick objective and measurable metrics (not just to gather the feelings of the users). The last step of the Experience Canvas framework is an *End-to-end demo.* In this final stage, a story that presents the process from beginning to end is created. There are different ways to do it: using mock-ups, wireframes, or other types of demos. Based on the findings of this canvas, we then define the requirements and scope of the project.

Zangiacomi, Pessot, Fornasiero, Bertetti, & Sacco (2020) identified some practices and challenges of implementing I4.0 projects using case studies of 20 different companies. Among other findings, they recognize the importance of implementing lean management approaches before investing in I4.0. Lean approaches act as both prerequisite and enabler for I4.0. Furthermore, they should strive to structure the organization to be leaner, even if it is already flexible and ready to face the new technology adaptation. The importance of continuous improvement is also widely recognized. It is even included in ISO 9001 quality standard (Keen, 2018). One such process used in Hilti is the Continuous Improvement Process.

1.7 Continuous Improvement Process

Continuous Improvement is the practice of making incremental and breakthrough changes to products, services, and processes over time (ASQ, n.d.). These attempts might aim for "continuous" progress or "breakthrough" improvement all at once. There are many Continuous Improvement frameworks available, including Total Quality Management, Six Sigma, and Lean (Lizarelli, de Toledo, & Alliprandini, 2021). Even though the definitions and processes differ between these methods, they all strive to achieve a similar goal.

There are many benefits of implementing a Continuous Improvement approach. Profozich (2021) states that benefits include increased productivity, improved employee satisfaction and morale, improved quality, reduced costs, decreased delivery times, and reduced employee turnover.

Of course, there are also problems users face when trying to implement CIP. The main challenges are not having resources and commitment for implementation, unclear roles and responsibilities, too slow of a feedback cycle, and lacking participation of all employees (Nieminen, 2021).

The basis of the CIP routine is the PDCA model (also sometimes referred to as the PDSA model where a check is replaced by a study). Organizations must implement different frameworks for improvement in different parts of the organization and for achieving

different goals (Nieminen, 2021). A similar framework to Continuous Improvement is also A3, which employs the principles of PDCA to methodically address the root causes of the problem systemically before finding a solution for it (Schwagerman & Ulmer, 2013). Another framework widely used is also Kaizen (Nieminen, 2021). To encourage improvements, we can also create a Kaizen corner (where users can give their suggestions), Gemba walks (going to the shop floor to witness the processes in a real environment), implement the 5S framework (Sort, Set in order, Shine, Standardize, Self-discipline), implement the mentality of Five Whys (ask yourself five times why to get to the true root cause of the problem), or start using digital Continuous Improvement tools.

PDCA model has four main steps (Donnelly & Kirk, 2015):

1. Plan – During the *Plan* stage of the process users examine what needs to be improved while taking into account places where change is possible (Soković, Šaković Jovanović, Krivokapić, & Vujović, 2009). The main questions users try to answer are 'what are they trying to achieve', 'what is the problem', and 'what is the root cause of the problem' (Donnelly & Kirk, 2015). Based on the answers users innovate and plan how to solve the problem sustainably.
2. Do – This stage is where users implement the changes they planned in the previous step. They must also document any problems or unwanted observations (Moen & Norman, 2006).
3. Check (Study) – The third step of the process is about checking (studying) the success and impact of the change they made earlier during the *Do* stage. Users should compare the result to their predictions and summarize the learnings (Donnelly & Kirk, 2015; Moen & Norman, 2006).
4. Act – *Act* step matters because the user must evaluate what means and processes are in place to guarantee that whatever solution or solutions users implemented stay successful. Users must ask themselves about the improvements required to proceed and ensure the preparedness to make another change, which leads to the creation of a strategy for the next PDSA cycle (Donnelly & Kirk, 2015).

W. Edwards Deming is attributed to presenting the PDCA cycle in Japan in 1950 (Moen & Norman, 2006). The cycle was a modified version of the Shewhart cycle. Over the next decade, the PDCA cycle has grown into an improvement cycle, and a management tool used in Japan. Together with the QC story format, it established the cornerstone for improvement (kaizen). The cycle was given a few additional modifications over the years to evolve into the version that is used nowadays.

1.8 Low-code and no-code platforms

Term ´low-code´ was first used by Forrester Research in 2014 (Sanchis, García-Perales, Fraile, & Poler, 2019). Low-code software development (LCSD) is a new paradigm for quick application development that uses minimal source code with interactive graphical interfaces (Al Alamin et al., 2021). These platforms provide high productivity and multifunction capabilities in central, departmental, or employees' IT tasks (*Magic Quadrant for Enterprise Low-Code Application Platforms*, 2022). LCSDs allow citizen developers to spend less time thinking about coding and more time thinking about the application's aesthetics and usefulness, which reduces the amount of time required for troubleshooting and implementing (Waszkowski, 2019). Low-code/no-code platforms, such as Appgyver or MS Power Apps, gained a lot of traction over the past few years. The idea behind these platforms is that they allow business users to build their own apps with emphasized visual interfaces that enable people without a technical background to create and configure as well as deploy business apps with increased speed and agility (Sanchis et al., 2019).

LCDPs are located in the cloud and benefit from using automatic code generation, cloud infrastructures, and graphical abstractions to develop an entirely functional app . Instead of using complex and ´high´ coding languages and hard-coded programming techniques, a low-code development platform uses visual user interfaces with basic logic and drag-and-drop capabilities. Users with no formal experience in coding or software development may use these straightforward tools to create apps for a variety of purposes, including mobile apps and corporate apps. This is possible due to multiple factors (Sahay et al., 2020): graphical user interface, interoperability support with external services and data sources, security support, collaborative development support, reusability support, scalability support, business logic specification mechanisms, application build mechanisms, and deployment support.

There are many benefits to using LCDPs (Sanchis et al., 2019). These include rapidity of development, cost reduction, complexity reduction, increased ease of maintenance, involvement of business profiles, and minimalization of unstable or inconsistent requirements. Additional benefits include enhanced agility, accelerated innovation, greater productivity, optimized collaboration, democratized development, better governance, easier maintenance, seamless multi-experience, and cross-platform capabilities (Sulak, 2020).

LCDPs are available in many different licensing options. They are often available as a free part of an existing license (e.g. Microsoft Power Apps) as part of a freemium model or using pay-per-user or pay-per-app licensing (Richardson & Rymer, 2016). This provides a lot of flexibility for users to see what the best possible solution for their needs is.

Ability to efficiently involve employees in innovation initiation and have them develop the application themselves is a central premise behind LCDPs (Krejci, Iho, & Missonier, 2021). This is a concept of Citizen developers. Gartner defines a citizen developer as "a citizen developer is an employee who creates application capabilities for consumption by themselves or others, using tools that are not actively forbidden by IT or business units. A citizen developer is a persona, not a title or targeted role. They report to a business unit or function other than IT (*Definition of Citizen Developer—Gartner Information Technology Glossary*, 2022)." The main idea of citizen developers is to empower and enable the business user to develop applications using LCDPs. This helps relieve some of the tasks from the professional developers who face increasing demand for new applications enabling citizen development. Therefore, it helps reduce the load on the main IT department, decreases the amount of shadow IT, improves business agility and staff efficiency, increases app speed production, and reduces the costs of app development (*The Benefits of Implementing Low-code Development Platforms*, 2019). The emergence of citizen developers also suggests the strategic role of LCDPs (Banda, 2022) because they allow users to use the LCDPs as a sandbox and allow business users and citizen developers to use it for prototyping without the dangers of corrupting data or creating security risks.

Even with the establishment of the citizen developer concept, the majority of the apps in LCDPs are still developed by professional developers (Vizard, 2021). Using LCDPs can increase their productivity, especially when it comes to simple workflows.

There are of course some risks when it comes to using the low code platforms. The main disadvantage is the limitation of customization and scalability. Due to the specific nature of LCDPs, there is only a limited number of tools and functionalities available. In some platforms, it is even impossible to add new functionalities that are not included in the default library (Sahay et al., 2020). Furthermore, to include new functionalities in the rest of the platforms, users often need to contact professional developers because they are unable to do it themselves. Furthermore, there is a lack of standards making collaboration between various developers harder. Additionally, without proper governance, there is a threat of low visibility which is due to the specific nature of LCDPs (Madou, 2021). Citizen developers can develop apps with business logic flaws, security flaws, or endanger data integrity. Hoogsten and Borgman (2022) identified six perceived risks of LCDPs: quality assurance, poor architecture apps, data security, maintainability, orphan apps, and low-impact apps. During their interviews, they also found concern that citizen development may result in data security vulnerabilities without clear guidelines and control and, as a result, dangerous applications. To mitigate all these risks, it is crucial to achieve a good overview and governance of LCDPs.

1.9 Low-code development platforms and shadow IT

One of the main benefits of LCDPs is the ability to manage citizen developers and their projects, thus fighting the appearance of shadow IT in the company. Gartner (*Definition of Shadow It—Gartner Information Technology Glossary*, 2022) states that the term shadow IT ”refers to IT devices, software, and services outside the ownership or control of IT organizations.” As a consequence, they generally exist without the awareness, acceptance, and support of the IT department (Rentrop & Zimmermann, 2012). Therefore, in most cases shadow IT technologies are incompatible with corporate policies on security, compliance, cost, service level agreements, documentation, reliability, and more (Sasi, 2022). The cause of shadow IT is the disconnection between IT priorities and the needs of business users (Banda, 2022). However, it is becoming more important as more users have a greater demand for IT services while the IT department cannot provide a sufficient solution due to various limitations. Therefore, especially younger employees tend to use primarily web-based technologies that allow easy access and use. However, this phenomenon is not only limited to web-based solutions. A great example of shadow IT are Excel Macros that users create to manage the process. These Macros are usually created by users. They are used by and known to only specific groups of people. However, these products present big risks for the company.

The main risks posed by shadow IT are lack of security, performance issues, and data loss (Yatsenko, 2018). These are all the results of users creating an app that is good enough for their purposes without knowing the problems they create or how to optimize code. Due to employees lacking expert knowledge they do not realize the risks they create for the company. Another problem with shadow IT is the loss of knowledge. Shadow IT apps are rarely properly documented. This means that once an employee that created the app leaves his position, there is no one able to do the upgrades or maintenance on the app without spending excessive time trying to understand the underlying logic.

Lundegaard Hannisdal (2022) claims LCDPs are the best answer for shadow IT. He identified different ways in which LCDPs can contribute to the management of shadow IT. LCDPs are mostly able use APIs, which means they can be integrated with other solutions and databases to be able ot consume and store data. Most of the platforms also provide advanced out-of-the-box security and authentication solutions. That, for example, enables users to use SSO or other authorization methods used for authentication in a company and its IT environment to be used in LCDPs. Another benefit is the ability to have development, testing, and production environments or spaces. These environments allow for easy deployment and rollout of the apps.

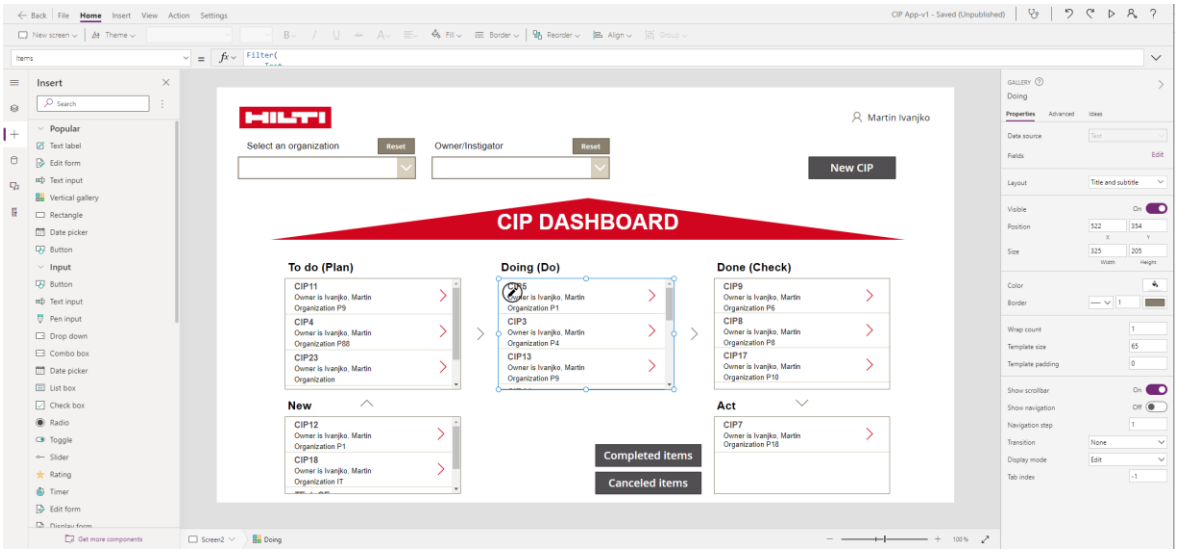
Doerrfeld (2020) lists steps that can improve the governance of LCDPs. He stresses the importance of permissions and authentication, which are to be used for applying

governance for data models, users, and access to the applications. Another important step is the creation of good documentation that enables (approved) code to be reused for different applications.

1.10 Microsoft Power Apps

An example of LCDP is Microsoft Power Apps, which was used for the development of the CIP app as described in chapter 3. Microsoft Power apps "is a suite of apps, services, and connectors, as well as a data platform, that provides a rapid development environment to build custom apps for your business needs (Microsoft, 2022)." It is part of Power Platform which also includes Power BI, Power Automate, and Power Virtual Agents. Users can create canvas apps, model-driven apps, and portal applications (Pearson, Knight, Knight, & Quintana, 2020). The canvas apps are created in Power Apps studio as shown in figure 2.

Figure 2: Power Apps studio

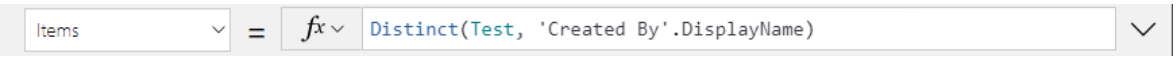


Source: Own work.

Users use a library where different types of inputs, galleries, forms, and media are available. They use drag and drop to design the interface that will be used by the user. Attributes of the item are defined using a menu on the right side of the screen. Users can use the user interface provided by the platform or they can access the advanced menu where they can use code to assign responsiveness or other attributes to the app.

Users define the logic of the app using Microsoft Power Fx, the formula language that is presented in figures 3 and 4.

Figure 3: Example of Power Fx



Source: Own work.

It is a low-code language that is used in Power BI- or Excel-like formula bars. This code can be assigned to a different property of the item (Pearson et al., 2020). An example of this is the option *OnSelect* of the gallery which is shown in figure 4:

Figure 4: Example of the ´OnSelect´ property in Power Apps



Source: Own work.

Power Apps enables simple integration with other platforms and databases using connectors. An example of this is an enhancement of the app using Power Automate flows, the inclusion of PowerBi visualization, or integration with SharePoint lists.

An example of this is the User function. When writing code, we can use the expression *User().DisplayName* which will display the name of the selected user (Pearson et al., 2020). Power Apps is connected to the Azure Active Directory (AAD) because they require an Office account which is managed in AAD to be able to sign in. This integration allows users to pull data from AAD without any additional integration.

On top of that, Power Apps give users the ability to monitor the app and perform tests on it. This ensures the quality of the app. The platform also provides version management and AI capabilities, such as a text recognizer, business card reader, and more.

The app can be launched on Power Apps mobile app which acts as a launcher. All the individual apps that the user has access to are available in the said launcher. Apps can also be accessed in a browser or they can be integrated into Microsoft Teams.

The main advantages of Power Apps according to Gartner are innovation (e.g. implementation of innovative expression language), market understanding, and responsiveness (e.g. good positioning between citizen developers and professional developers), as well as the business model and overall visibility (e.g. integration and synergies with Microsoft 365) (Wong, Kimihiko, Leow, Jain, & Vincent, 2021). Based on their estimation, it is the most used LCDP which they attribute to the widespread use of Office 365. Nevertheless, there are also some points where users need to be careful: pricing (e.g. after the free version complex pricing when using external connectors and

per-user/per-app pricing), marketing execution (e.g. confusing name changes), and business logic and workflow (e.g. limitation in complex business process automation).

1.11 Customization or standardization

One of the eternal questions that are always relevant when talking about creating processes or apps is the question of customization or standardization. Both options have clear benefits and disadvantages. We have seen both increased standardization and customization in recent years.

Standardization offers businesses a low-cost and highly effective way to implement smart manufacturing which includes increasing production efficiency, quickening market response, maintaining quality and sustainability, lowering cost, using fewer resources, and having a smaller environmental impact (Wei et al., 2020). It is desirable because it provides regulatory compliance, technical interchangeability, and increased customer confidence (Trkman, 2010). Velasquez Villagran et al. (2019) even argue that standardization plays a key role in the adoption of I4.0. Users need to implement common standards to enable communication between different devices and solutions.

For this thesis, the type of customization or standardization I want to talk about is on the level of adapting the requirements to the specific needs of different users.

If standardization is selected, the same app will be used all over the company. One of the advantages of this decision is that everyone is then using the same app. They will be familiar with the process and data from different locations can be easily compared. A standardized global solution is also easier to implement and maintain because there is only one version of the app. The disadvantage of standardization is the lack of customization. Users are obliged to use the standardized version which is completely rigid and prohibits any changes that users want to implement to improve the usability for their specific use case. Therefore, the main challenge of standardization is how to preserve flexibility (Trkman, 2010).

Customization on the other hand allows users to completely adjust the app to their needs regarding function and content. They can add requirements that are unique to their way of working. That improves the usability of the solution. Many processes are also hard to define. If we enforce strict rules for users, it can decrease innovation, reduce accountability, and harm performance (Trkman, 2010). On the other hand, it is much harder to maintain such solutions. Since there are different versions of the same product, they all need to be taken care of independently because they all have unique attributes. Customization also vastly increases the complexity of solutions. We can often cover 80% of the requirements with a standardized solution. This will mean we have lower costs and all the main requirements covered. However, if that is not enough, we will face an exponential rise in costs to add the last 20% which will create complete

customization. Another disadvantage is also harder integration with other devices or apps due to the specific nature of each app.

There are of course different levels of customization available. On one side, we have a completely standardized system with no customization options. The other extreme is a completely independent solution for every single user. The optimal solution is usually somewhere in the middle. When researching the customization of ERP systems, Uppstorm et al. (2015) concluded that a certain degree of customization is always needed. However, users have a different understanding of what customization is and what type of customization should be implemented. In the case of cloud ERP, they identified configuration and interface development as viable customization options. Customization also poses a big challenge when trying to create a common solution for everyone as is the case also with the CIP app that we will discuss later.

2 CASE OF HILTI

2.1 Methodology

I started the entire process with extensive theoretical research on different topics. Doing that helps me present and analyze relevant theoretical research to achieve a good understanding of the current trends, different opportunities that these trends offer, and, lastly, potential threats and underlying problems Hilti might face in the future.

The second part includes a case study of the process of creating the CIP app, a new custom low-code application. This application also serves as an important proof of concept for Hilti. To be able to do a case study, I performed interviews with relevant stakeholders and personally participated in the process. At the beginning of the thesis, I present the initial status and other details important for understanding the purpose and motivation behind the creation of the app. The following is the stage of gathering the ideas and the process of defining and prioritizing the requirements. Then, the development of the app is presented. When developing the app, I developed several different versions of the app. However, most of them were smaller reiterations and upgrades based on the optimization of the code and logic of the app or based on user feedback. In the end, I recognize the crucial success factors of the entire process based on my experience and conversations with other stakeholders.

Lastly, I created the Manufacturing Apps framework, which is used to develop future apps. I started the process of creating the framework by researching IT governance. The topic is already well-researched, and it will provide us with the best practices and guidelines that were created by different authors with their expert knowledge. The problem I faced when researching the topic was that most of the articles were focused on the company-wide IT governance strategy while my interest was focused only on the governance of a low-code platform and apps delivered using these platforms. I also consulted with

experts from Hilti which helped me better define and understand the needs and requirements. I talked to Product Owners and co-workers working on different digitalization, industry 4.0, and IT topics: a member of the team responsible for Hilti Cloud, a member of the team creating mobile apps, a Product Owner of SAP BTP, an enterprise architect, and members of the teams working on industry 4.0 projects. Based on all these discussions, I combined the findings to create the Manufacturing Apps framework. Additionally, I also described in more detail other topics that are important to successfully run Manufacturing Apps in the future.

2.2 Company description

Hilti Aktiengesellschaft (AG) is a multinational corporation based in Liechtenstein. It employs more than 31,000 employees and sells products to more than 120 countries. The company achieved CHF 6 billion in sales in the year 2021. There are eleven main production locations with headquarters in Schaan, Liechtenstein. The company produces different equipment and solutions that are designed to make work on construction sites easier, faster, and safer. Hilti's offer includes anchor systems, construction chemicals, tools used for cutting, sawing, and grinding, tools used for drilling and demolition, cordless systems, equipment for diamond coring and cutting, direct fastening and installation products, firestop and insulation systems, modular support systems, measuring and aligning systems, façade systems, On!Track (software), fleet and asset management, engineering services, and more (*Hilti Product Overview*, 2022).

Hilti places quality, innovation, and direct customer relations at the center of its business activities. The products, system solutions, software, and services developed and sold by Hilti focus on added value for the customer. Hilti is differentiated compared to other competitors so that it only uses direct sales to professional customers. In contrast to others, the products of Hilti are not available online or in hobby stores because they are aimed specifically at professional users.

Hilti strives for absolute technology and quality leadership based on its broad technological know-how and intelligent coverage of the value chain. Due to the size of the product spectrum, economies of scale, e.g. in the production facilities used, and energy effects can be achieved through the multiple uses of (technological) innovations in different products which secure the company's productivity and flexibility advantages over the competition.

2.3 Current status of digitalization in Hilti

Hilti is a hardware-driven company that mainly creates power tools, anchors, and other products. However, digitalization will be a big part of Hilti's future and they can transform by adding digital technology throughout the value chain (vom Brocke et al.,

2017). Hilti wants to help customers also with their processes. That means not just providing users with reliable and effective power tools but also helping them increase productivity on job sites and improve business processes. To help achieve that, they need digital solutions like On!Track, which is a field resource management and fleet management system. To be able to use such products, Hilti must ensure that the tools and other products can be integrated into the system and tracked. Therefore, many of the Hilti tools already include code or NFC identifiers that allow quick identification in an app, such as On!Track. Another example is also putting a code on an anchor. The latter provides identification and information about all the parameters from the production.

The focus of this master's thesis is the analysis of the digitalization of Hilti plants. The Manufacturing Apps team is part of the Digital Value Creation department in Plant 4 located in Thüringen, Austria. Activities in Plant 4 are focused on component manufacturing and final assembly of many various tools that are part of drilling and chiseling technology, direct assembly, and diamond technology business. It is the leading Hilti plant in terms of digitalization and the introduction of new use cases.

Digitalization in service departments, such as HR, finance, and controlling is mainly driven by big IT initiatives and solutions, such as Workday or Salesforce. They follow state-of-the-art industry standards as a fast follower, not a first mover.

The situation is much more complex in operational departments, such as manufacturing, logistics, or repair departments. It is much harder to implement digitalization there because these are the most complex fields for digitalization. It is extremely hard to integrate all the machines, processes, and specific requirements. Depending on the task, this could cause much more resources wasted compared to the potential benefits of digitalization. Hilti is planning to transform its processes to be in line with the paradigm of Smart Factory. These new projects will help shorten and simplify the processes. At the same time, they will improve productivity, transparency, and intuitiveness. However, it would be extremely hard for Hilti to reach a level of automation and digitalization achieved by e.g. car manufacturers due to the nature of their products.

Hilti has currently been running the biggest single SAP S4 account in the world. When defining the strategy, Hilti's CIO and his team decided to go for the ´solid core and flexible boundary' concept (vom Brocke et al., 2017). This concept is still in use today, which I also witnessed during discussions about the use of new platforms. The principle behind this concept is to distinguish between mature production crucial processes and other solutions that require a lower level of integration. This concept enables Hilti to bring in new technologies while still having total control over all the crucial areas of business. As I was told in the discussions with one of the product owners in Hilti, when it comes to IT infrastructure in Hilti, the main priority is always the stability and quality of the systems. Therefore, any changes to the core systems or any connection to the central ERP system require rigorous review before they can be implemented.

The focus of this master's thesis will be on the Global Manufacturing (GM) unit because this is the unit where Manufacturing Apps are implemented. Many solutions are standardized and are provided by specialized firms. Here, we should especially mention SAP and all its products, which can be easily integrated and are now standard all around the world. SAP Fiori offers several thousand different applications to help business users with their daily activities. Nevertheless, standardized solutions are not enough. Even different plants inside the same company have specific processes and ways of completing tasks. Moreover, Smart Factory brings unique challenges of its own. To be able to provide the information needed, standardized solutions require a lot of customization and integration. In addition, there is a need for more flexible software able to provide a better solution for each task. That can be achieved with the help of custom apps designed for completing specific tasks. They fill the void that appears when standardized solutions are no longer able to fulfill the needs of demanding users.

One such example is Cronetwork, a standalone solution used by the maintenance department in a specific plant. Such a solution can cover the needs of one plant. Due to the non-standardized process and different requirements of different plants, however, there is a problem with scaling such a solution to other plants. Users in the plant in Austria use specific visualization to plan maintenance activities and monitor the status of tickets. Meanwhile, in other plants, this visualization is not used and they have other requirements and priorities. In a different plant, they are currently performing initial testing using SAP Fiori technology to display standard SAP ERP transactions using mobile devices. Even such products, however, do not satisfy all the needs of the users. An example of this is a use case where users want to access 3D models of machines and parts that serve as instructions for the maintenance department. This functionality is not available in Cronetwork or as a Fiori. Therefore, they require an additional solution that can do it.

To solve that problem, we created the so-called Manufacturing Apps initiative in Hilti. Its purpose is to use the team for use cases that cover the specific needs of specialized teams. This initiative is the most custom and personalized initiative that will help create solutions for the use cases that are not covered by a standardized global solution. Therefore, the goal of the Manufacturing Apps is to create simple apps to support the manufacturing organization within Hilti and help them with the digitalization and optimization of the processes. These apps will be customized to follow the requirements created by the users. Users will have the ability to build an app using the recommendations and guidelines of the IT department that will be able to manage and support the entire process. These apps can be globally standardized or they can be customized for every department. This is a complex decision that will always be relevant, no matter the specific requirements of the app. We are striving to implement solutions that can be scaled globally and used by more than just one plant because they often have similar needs. This will also allow us to bring added value to our apps.

All the solutions mentioned above are part of the digitalization strategy in Hilti. The company decided to use the *acatech* Industry 4.0 maturity index as a backbone framework to support the digitalization process. The process started with an assessment of the current status of digitalization, connectivity, and maturity of IT infrastructure in Hilti plants. Based on the assessment, Hilti determined goals for each plant and then performed a target gap analysis. Based on the analysis, they implemented a roadmap describing how to achieve targets and select/prioritize use cases. This roadmap includes local and global initiatives (used by only one plant or more/all plants).

Digitalization efforts across all of the GM are aligned and steered in regular Smart Factory meetings. In these meetings, product owners of different topics (e.g. IIoT, Machine Connectivity, Manufacturing Apps, etc.) present their progress, issues, and next steps. This ensures alignment, as well as knowledge transfer throughout different departments and locations.

2.4 Continuous Improvement process in Hilti

The Continuous Improvement process (CIP) is one of the main global processes used by Hilti. It is an approach to ensure, that improvement opportunities of different sizes from anyone anywhere in the organization can be addressed and managed. CIP is used to tackle small problems and the potential for improvement in the workplace spontaneously and systematically. In doing so, we work out an on-the-spot solution and act independently to implement the results.

The goal of the CI process is to improve products and processes. The process is managed in a way that ensures that users discuss the problem and analyze the cause of the problem. Then, they find and implement an optimal solution. This process also encourages users to improve both, social and technical skills. The CI process focuses on smaller problems and ideas. If there is a need for bigger action, users will use another process/framework, e.g. Kaizen or A3.

The main benefit is the empowerment and support for employees to give ideas and implement solutions quickly and independently. In Hilti, there are over 6000 individual CIPs created annually. It causes constant improvement of processes, workstations, or products. Even though most of the CIP actions bring small savings to the company, the cumulative savings create millions of CHF of savings every year. The process also helps improve the working environment in Hilti and helps employees to improve their problem-solving skills. CIP is used throughout Hilti. That includes GM, GL (Global Logistics), AMS (After Market Services), and Market organizations. Currently, it is also in process of implementation in BUs (Business Units).

2.4.1 Lean community in Hilti

The process is managed and steered by the Lean community in Hilti (internally also known as Lean@Hilti). Lean community includes members throughout Hilti. The main task of the community is to implement lean principles in Hilti. Hilti CEO Christoph Loos states: "We need a total quality and efficiency mindset in everything we do and foster a culture of continuous improvement. Lean@Hilti introduces a philosophy, principles, and specific tools that help us achieve this objective and enable sustainable value creation for Hilti." (*Lean@Hilti SharePoint*, 2022).

Dr. Stefan Nöken, a former member of the Executive Board of Hilti explains the principles of Lean@Hilti (DOL Lean Management team, 2022): "Lean allows us to find ways to serve our customers better and more efficiently … essentially Lean means eliminating waste and continually improving our performance." They try to improve alignment (vertical and horizontal integration), engagement (encourage users to actively engage, learn and strive towards improvement), and improvement of processes throughout Hilti. That creates benefits for the company (higher performance, operational excellence, sustainability, increased differentiation, highly motivated employees), benefits for the customer (improved quality, improved delivery, improved services), and benefits for the employees (better work environment, improved safety, and ergonomics, empowerment, increased effectivity, simplified way of work). The community is centrally managed. However, there are smaller communities in all organizations and plants.

The entire lean paradigm started in 1983 when Martin Hilti went on a trip to Japan to perform benchmarking and learn about new processes. He was incredibly impressed by the lean way of work in Japanese factories. Therefore, he implemented the use of Quality Circle in Hilti (QC). The main purpose of QC was to assess and understand the problem before solving it. However, the process was too complex for common use and in 2010 they developed QCPlus, which was a simplified version of the QC. In this period Speedy Quality Circle was also developed (SQC). SQC is the main predecessor of what is now the CI process in Hilti. SQC was created for smaller topics. However, it was still over-engineered and the general feedback was that it was too similar to QCPlus. Moreover, there was confusion about when to use QCPlus and SQC because they were very similar. To tackle this problem, they started the process in 2019 to transform the QCPlus into the A3 framework as it is known now. They also transformed SQC into the CIP. They performed co-development with lead users and Lean communities from different plants and different organizations. The focus was on the main problems in the existing system and why it is not working. Dimensions that they focused on throughout the development were transparency, coaching, empowerment, simplification, and recognition. The current version of the CIP process was implemented in 2020 and is still in use throughout Hilti. When the new system was introduced, it received overwhelmingly positive feedback. This was also transformed into an almost 200% improvement in terms of

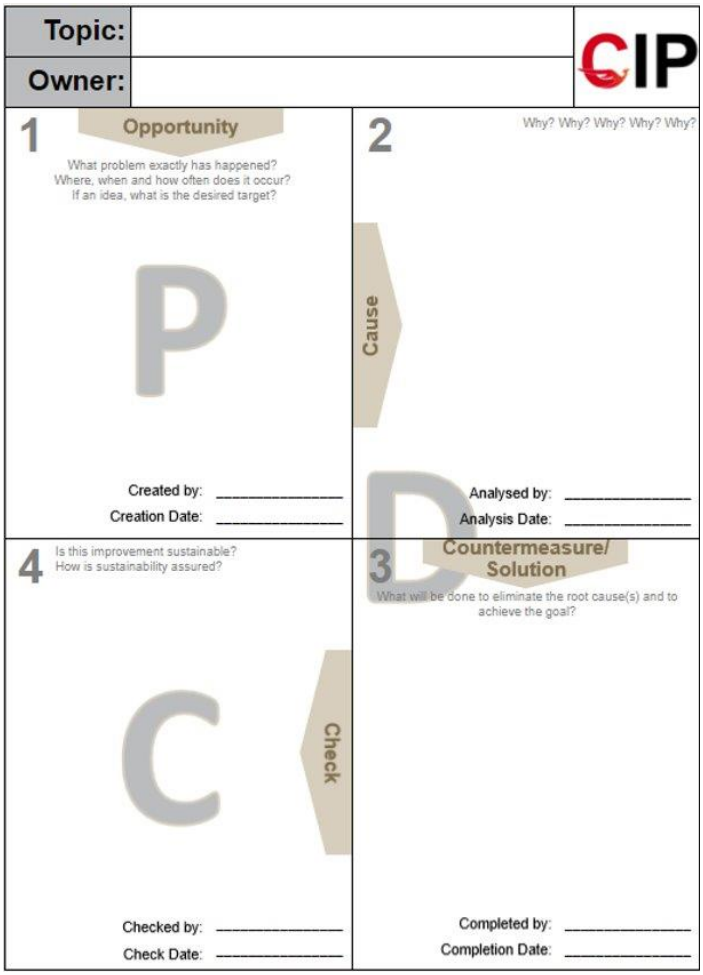
engagement and impact (number of CIPs and savings from CIPs). At this time, SharePoint lists that are used to store CIPs were also created. Hilti is currently using the CIP routine, A3, and Kaizen workshops as the three main processes to support the activities of Lean communities.

2.4.2 Steps of the Continuous Improvement process

The CIP follows the PDCA framework which was previously described in chapter 1.7. Lean community in Hilti prepared dedicated special templates to help users complete and manage the process. The purpose of these templates is to support the process when performed physically using paper on the shop floor.

The first template is used for managing individual CIPs (figure 5). The template is very basic and only requires the answer to four main questions that are based on the PDCA cycle and were already presented earlier. This paper template is then moved around the dashboard as it will be presented below.

Figure 5: CIP template for users



Source: Hilti (n.d.-b).

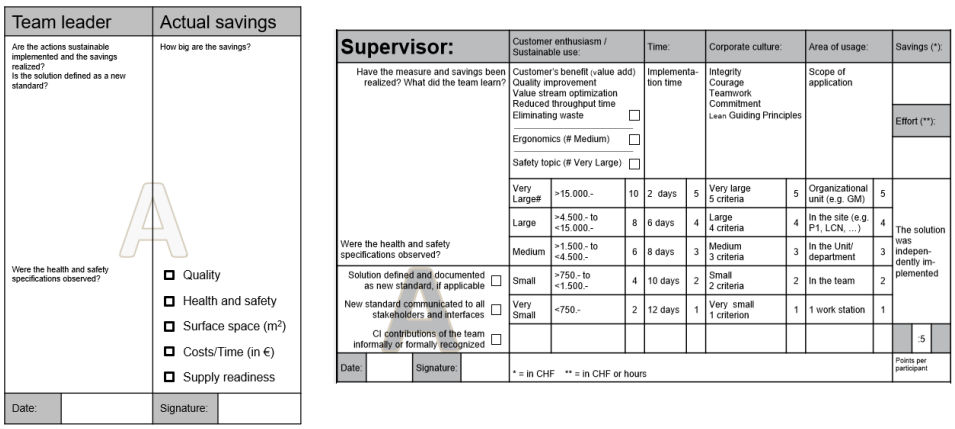
The main questions that need to be answered by the owner of any CIP:

1. Opportunity-P (What problem exactly has happened? Where, when, and how often does it occur? If there is an idea, what is the desired target?).
2. Cause-D (Why? Why? Why?).
3. Countermeasure/Solution-D (What will be done to eliminate the root cause(s) and achieve the goal?).
4. Check-C (Is this improvement sustainable? How is sustainability assured?) .

The front end of the template is completed by the owner/initiator of the CIP. This is the person that got the idea for the CIP and performed the activities to make the improvement.

The Act stage of the process is completed by the coach of the owner/initiator. He or she assesses the impact of the CIP on Hilti. In doing so, he or she considers monetary savings, the length of implementation time, the effect on corporate culture, the scope of usage, general effort, and the effectiveness of the solution. There are two main types of templates used throughout Hilti at the moment. Both templates are presented in figure 6 (a bigger version of both templates are included in appendices as appendix 2 and appendix 3). The original one has a points system to objectively assess the impact of the CIPs. However, many users considered this approach overengineered and too complex for daily use. Therefore, they created a simplified version of the template. The template still covers all the same areas as the original template. Still, there is no points system and users only need to assess the areas they find relevant for a specific CIP.

Figure 6: Example of Simplified and Points-based template for Act stage

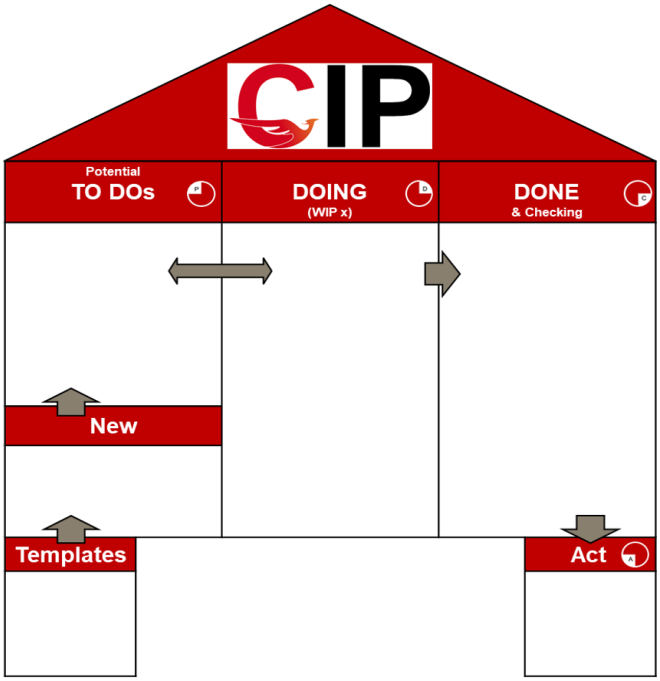


Source: Hilti (n.d.-d).

The third template provided to users is a CIP dashboard (as shown in figure 7) used to manage the entire CIP routine of the team. This dashboard is printed and placed on the shop floor. The template has six individual fields that require specific action. The first

field is *Templates*. There, users can find empty templates for individual CIPs. To start the process, they take a template and fill out the *Topic*, *Owner*, and *Opportunity* fields. This is a basic description of the idea and other relevant information. The user then places the paper in the *New* section. The team gathers and checks the status of CIPs in dedicated meetings (most commonly weekly and during Friday's shop floor meeting). There, they check the progress and try to solve potential problems, and work on finding the best solutions for the problems. Part of this meeting is also checking the CIPs in the *N*ew section. They check if the idea is relevant, meaningful, and creates value. If the team agrees with the idea, they move the paper to the *To Do* section. This section serves as a waiting point before the CIP is actually performed. Once they decide to start working on the CIP, they move it to the *Doing* section. The goal is to only have a limited number of CIPs in *Doing* at any time. The purpose is that they focus on quickly completing the existing CIPs in the *Doing* stage before starting additional CIPs. This also makes sure the team has the resources available to be able to complete the CIP.

Figure 7: CIP dashboard template



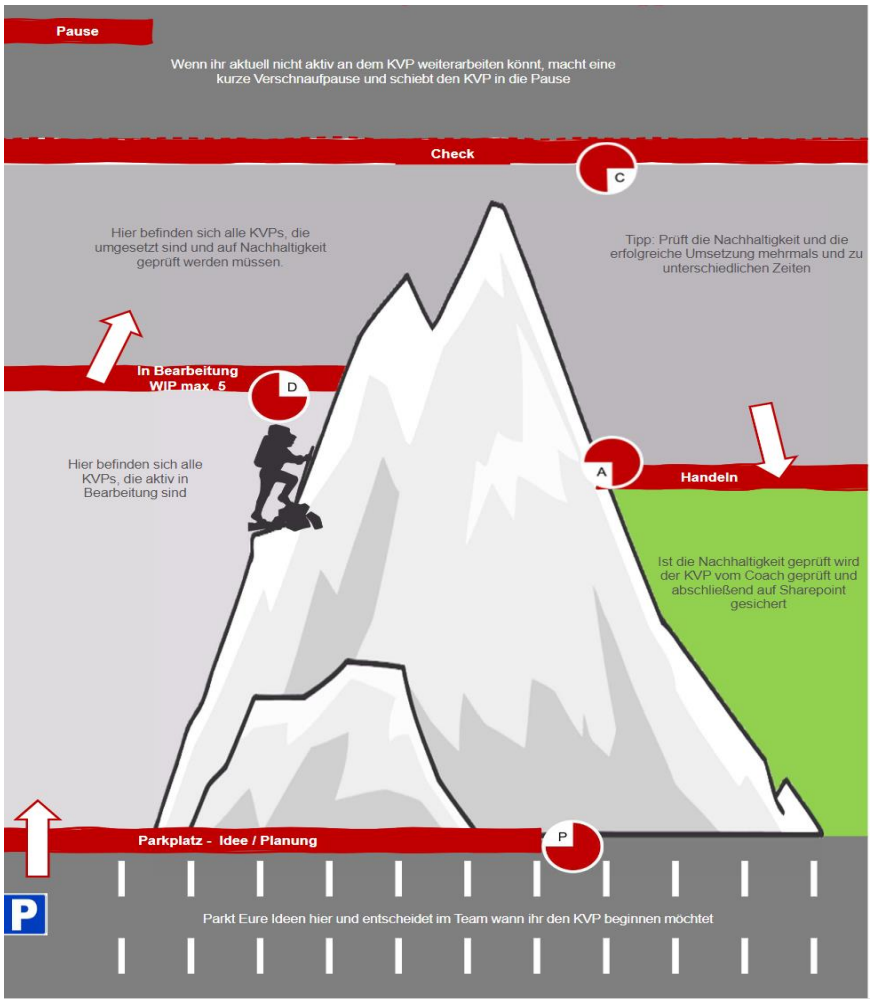
Source: Hilti (n.d.-a).

As mentioned before, the *Doing* section is where CIPs are actively worked on. The length of implementation of the CIP depends on the complexity and availability of resources. Some CIPs require some specific material to be ordered or the presence of e.g. a maintenance team to be able to perform some change that the production employees are unable to do themselves. In that case, the CIP is moved back to *To Do* section until the availability of all resources that are needed for the completion of the CIP.

When CIP is completed, it is moved to the *Done* section. The purpose of this section is for the workers to review if the CIP solves the problem it was tasked with solving. If it is determined that CIP still requires additional work, it is moved to the *To Do* section. Meanwhile, if it is completed, it is moved to the *Act* section of the dashboard. While the worker can individually perform the entire process up to that point, he is unable to do *Act*, the last step. That step is performed by their coach. They assess the impact of the solution on the areas that are provided by the standardized CIP template.

The CIP process has a global standard that everyone is required to follow. However, plants currently still make modifications to the process. One such example (presented in figure 8) is the dashboard used in the plant in Thüringen. This dashboard is used instead of the template shown in figure 7.

Figure 8: Example of alternative CIP dashboard template



Source: Hilti (n.d.-c).

The dashboard still has all the main fields that are required by the global standard. The team in Thüringen decided to make the template more user-friendly and tries to increase worker participation in the process. Therefore, they created a template that uses the

mountain as an example. *New* and *To Do* sections are replaced by parking below the mountain – a CIP arrives at the mountain, assesses it, and plans how to climb up before actually attempting the climb. The *Doing* part is represented by the climb up the mountain because that is where the most work is required. The top of the mountain is the *Done* section – we completed our challenge. Going down the mountain represents the *Act* part. Here, they assess the success of the climb, e.g. if they had the right equipment and resources to complete the climb and what is missing to be even better next time. An interesting addition is the *Pause* section on top of the template. This section is available for the CIPs that cannot be completed at the time due to different reasons (waiting for a part to arrive or waiting for a maintenance technician to be able to support the action). Nevertheless, that is incorrect based on the global standard. In case, there is a need to wait before users implement CIP, they are supposed to move it back to the *To Do* section.

Once the CIP is completed, the coach uploads it to the SharePoint list. This list is used to keep track of all the completed CIPs, as well as knowledge storage of how the CIP was completed. Different managers can manage the process as a whole using reports that are based on the entries in the SharePoint database. One of the big problems of the current system is that CIPs are uploaded online only once they were completed. This means that there is no overview of ongoing CIPs.

3 CASE OF A SPECIFIC APP: DIGITAL CONTINUOUS IMPROVEMENT APP

As already mentioned before, the CIP is one of the main global processes in Hilti. During the development, I identified these six goals of the app:

- decreased bureaucracy,
- improved user-friendliness with a mobile app,
- guidance through the CI process,
- real-time reporting and increased transparency of ongoing CIPs,
- increased transparency that is also beneficial for improving the CIP system, and
- reinforcement of positive behaviors.

The Lean community implemented many SharePoint lists that form Global Lean Database to help improve and manage the CIP routine. Global Lean Database was the first step in providing transparency and data for further analysis that helps improve the process. This data is then presented in PowerBI dashboards to be able to monitor the CIPs and key performance indicators (KPIs). These reports are used by management and the Lean community to try to improve the CIP process. These SharePoint lists are, however, far from an ideal solution. They are meant to be used as a backend while users would have a different frontend that would be used to manage and perform the process.

Therefore, there was a decision within the Lean community in Hilti to create an app that would support the CIP process. Because the database and existing process is based on the SharePoint list, we decided that the app will be done with Power Apps.

3.1 Status before the beginning of the process

SharePoint is provided by the Lean community in Hilti. The Global Lean database is used for all Lean activities (including A3, Kaizen, and Upskilling) and not just for the CIP actions. Therefore, it uses content types to show the right view and columns to the users. These SharePoint lists have a mandatory list of columns that must be filled before the CIP is submitted. These columns include the PDCA cycle and other important information about the CIP.

Previously there was an attempt by the Lean community in collaboration with two co-workers from my department to try to create an app to support the CIP routine but it failed. The reason for that was a rejection of the platform that was used to create the app. The use of the platform was rejected by IT which meant that all the prototypes developed with the platform were discontinued and blocked. However, the previous version of the CIP app was very useful at the beginning because it was a good starting point for further efforts.

3.2 Preparations and scope defining stage

I was introduced to this project by my Hilti mentor because he was the one responsible for the development of the app. He already oversaw the development of the previous version of the app which was later discarded due to the rejection of the platform. He introduced me to the use case, purpose, basic requirements, and the team. Initially, we decided to document everything related to the app on Confluence because it would then enable everyone to access the documents and all other relevant information. Confluence is a cloud solution developed by Atlassian. It essentially acts as a corporate wiki page and it was created to be used in conjunction with other Atlassian products, especially Jira (agile project management software) or Bitbucket (git repository). These tools – together with other Atlassian products – create an environment that enables users wholesome project management environment.

In addition, a project order was prepared. That is an internal document describing the use case, the purpose of the project, and all other relevant information about the project. It serves as a single source of truth.

The entire process started with the creation of a ´core team´ with eight members. The number of team members changed a few times during the process because some colleagues changed their positions or joined/left Hilti. The members of the core team

include members of the Manufacturing Apps team that were tasked with developing the app, a leader of the GM Lean community, a global CIP process owner, and representatives/core users from different plants and organizations.

Initially, we started the process with a kick-off meeting to align the expectations and initiate the project. First, we defined the purpose of this app and the goal of the entire process. The *Why?* was summarized in two main sentences: "Currently CIP is done on paper which is hard to manage" and "Lack of overview and transparency". We also defined the two main points for the *Goal of the process*:

- We create an add-on for the existing SharePoint list.
- We want to achieve digitalization and standardization of the process.

During the meeting, we created an approximate timeline of the process and informed participants about Confluence, a tool that will be used to document the process and upload all the documentation.

There was a lot of discussion regarding how to continue, what the requirements of the app should be, and what organizational topics still needed to be tackled. The main tasks at this stage were aligning the ideas and requirements of different plants and users.

To save time, I asked users to add their thoughts to a shared Experience canvas before the next meeting. Before sharing the Experience canvas with others, I filled the fields with my suggestions so that they understood better what was the purpose of each field. The Experience canvas was then aligned in the next meeting. Based on the feedback, we figured it was incredibly helpful if we provided users with an example of what should be written in each field. Many of them were completely unfamiliar with the concept and purpose of such a canvas and what should be included in a certain field. One such example is the difference between stakeholders, the team, and customer personas. Therefore, we received some answers that were not in line with what was supposed to be in that specific field. We discussed all of the different answers in the next meeting where we summarized and merged all of our answers. The result of this alignment can be seen in figure 9.

The main benefits we identified are related to the fact that the entire process will be performed fully digitally. Some of the main benefits are increased transparency, overview, and live tracking of all CIPs. Before the app was created, users performed this process on paper. If the coach wanted to check the actual status of the CIPs, he would need to walk to the shop floor where the board with the CIPs was located and check each paper individually.

Figure 9: Experience Canvas for the CIP app

1. Hypothesis

The app will simplify the management of the CIP routine and digitalize the entire process. It will increase transparency and create better user experience for the users.

2. Problem

- Manual handling of each CIP (on paper)
- No possibility to check current status of all CIP items
- Working on a CIP and documenting it are currently 2 completely different systems causing double work
- Employees usually upload a CIP form only when finished
- Improving the CIP process itself is really hard without data
- Low transparency and lack of overview of live CIPs
- Poor user interface on SharePoint for creating new CIPs
- Disadvantages of using paper- CIPs can get lost, paper tears, someone needs to ensure templates are always available...
- SharePoint list available only in English

7. Ideas

- Create an add on solution fully integrated with SharePoint lists
- One standardize CIP platform for all plants
- App that enables simple and intuitive creation and management of CIP items
- It allows users to independently create CIP, move it to different stages and finish the process
- Collection of metadata (time stamps), for analysis on how to improve the CIP
- Ability to filter CIPs based on department/owner

8. Minimum viable experience

- PowerApps app that is integrated to SharePoint test data with option of editing and creating new CIP items
- Functional product to test in real CIP routine with users incl. link to SharePoint

6. Value

- Vastly increased transparency
- Real time reporting/tracking of individual CIPs
- Remote access to ongoing CIPs
- Easier creation of new CIP
- Simple and intuitive support of CIP routine
- Unified CIP process over different plants and departments
- Faster processing (remove double processing -e.g. manually writing on paper and then uploading to SharePoint
- Metadata for improving the process itself
- Increased engagement in the entire CI process
- Consequentially increased number of CIPs crating savings for the company
- Coaches get a digital tool that can be used during shopfloor meetings to manage the process
- Additional languages
- Fully digital process - elimination of paper waste
- Available on computers and mobile devices (tablet/phone)

4. Stakeholders

- Digitalization department
- Global IT
- Lean community
- Team responsible for managing PowerPlatform in Hilti

5. Team

- Manufacturing Apps Team
- CIP product owner
- Lean managers
- Lead/core users

3. Customer personas

- Lean manager- responsible for the CIP, managing and looking for ways to improve the process
- Production workers and other employees - main users of the app, creating and implementing CIPs
- Coaches - assessing the impact of CIPs, creating their own CIPs

10. End to end demo

The app should enable worker to create a new CIP, independently manage the process all the way to the ACT stage where he should be blocked from proceeding. Only user with coach rights should be able to complete the ACT phase.

CIPs should be presented according to standardized template ("CIP house"). Users should be able to see the CIP, edit it and move it to different stages.

The app should be fully integrated to the SharePoint, ensuring any change in the app is immediately visible in the SharePoint and vice versa.

9. Metrics

1. Number of CIP items created by the app
2. Number of users using the app
3. Relative change of CIPs created before the usage of the app

Source: Own work.

Because the app will be fully integrated into the SharePoint lists, it will ensure that as soon as there is a change in the app, there will be a change in the SharePoint list and vice versa. The app will ensure vastly better UI/UX for users creating and managing new CIPs. Digitalization of the process will also enable users to gather metadata and then, through analysis, find a way to improve the entire CIP routine. An additional benefit of the app is providing coaches with a tool to manage shop floor meetings. This will both give a flexible tool to managers, as well as eliminate paper waste that is created because of the CIP routine.

The process of writing the canvas was very beneficial for the team. Based on conversations with team members, this process really helped everyone to have the same understanding of the problem, proposed solution, and functionalities needed. Before this exercise, we had similar ideas but the understanding of some team members had crucial differences in terms of scope and functionalities included. One such example is the creation of analytics reports. The goal of this project was to create an app to support the CIP. Some colleagues were also expecting that we will create reports based on the data created by the app. Because we are not the team with the right competencies, and we wanted to focus solely on creating an app, we quickly decided that the creation of analytics reports will be out of the scope. This document forced us to have a focused discussion about such specific parts of the solution.

3.3 Requirements gathering stage

After the creation of the Experience canvas, I started the process of gathering the requirements which turned out to be extremely complex. The main cause of complexity stemmed from the fact that different plants performed the CIP routine in slightly different ways. These specific requirements of the individual plant were, however, extremely important to them and an app without these requirements would not be used by their plant. Different SharePoint lists used by different plants were using additional columns that are not part of the global standard.

The starting point of our process was the conclusions that were used to create the previous version of the app. Based on them, I prepared my suggestion of what the app should look like. After that, we discussed the requirements in several meetings. We identified the requirements that would be used globally and the ones that would be used locally. A lot of work was invested to understand the specific process of each plant better and establish what common points are and what are the differences between plants. As already mentioned, CIP is a standardized process defined by the Lean community in Hilti. However, plants are allowed to adjust the CIP routine to best fit their needs and goals. That means that different plants require more/less information than others. An example of this is adding an additional column with the type of the machine to SharePoint. This enables users to quickly identify all the CIPs related to the specific

machine. Some plants also reward engagement in the CIP process. Depending on the location, the number of CIPs can be reflected by the yearly bonus. For this purpose, they also have an additional field in the SharePoint list. Elsewhere, there is a competition for CIP of the month, in which winners receive practical rewards. Another example of differences between plants is also the use of Points/simplified templates in the *Act* stage.

We also asked coaches and production workers for their input. I asked them to walk us through the process and explain what is the purpose of each step. In addition, they were asked about their pain points to be able to tackle them in the app. Solving these problems for users will be one of the main benefits/selling points to persuade them to use the app regularly. We received valuable information from workers and coaches who have a different point of view compared to lean managers (who are mostly involved in the process on the higher level and not shop floor meetings) or our team (who are not daily involved in the CIP routine). The main takeout of these sessions was some of the functionalities that we either did not think of or did not see any additional value, and, therefore, we did not include them. The ideas included adding a sorting button to the main dashboard, disabling the editing function for completed CIPs to ensure the CIP cannot be modified after the process finishes, and notification for a coach when the CIP reaches the *Act* stage of the process. We also learned different coaches require a different overview of all CIPs based on their current process. Some overviews followed a standardized template (dashboard template from figure 7) while others preferred their own template with a focus on employees. They created an additional MS Excel file to manage their team. This overview helps the coach to see easily whether all their workers participate in the CI process and at what stage their CIPs are located. An interesting finding was also that some departments use the CIP template (figure 5) as a general problem-solving framework, even when it is not technically in the scope of CIP.

The requirements-gathering process lasted longer than expected, mainly due to two reasons. The first reason is purely logistical. Organizing meetings with ten members who have extremely busy schedules can be complicated. It often took two or three weeks before we agreed on the next available time slot. The situation improved after we selected a fixed time for regular biweekly meetings The second reason is the CIP routine is different in different plants. We faced many problems because we had to decide whether we will allow the customization of the app for individual apps. Many plants were adamant about including their specific requirements. If not, they would not use the app.

Based on all the discussions and facts, we decided to start only with the global standard with the addition of a few functionalities that, everyone agreed, would bring added value to the app. This decision also meant we could be more efficient in previous meetings in discussing what functionalities we should include from specific plants. If we agreed on the global standard from the beginning, we could avoid part of these discussions. I want to stress it was important to have a good understanding of how different users do the

process. However, the time invested in deciding what specific feature should be included in the app could be spent better discussing other important topics.

We also decided to prioritize the requirements for the CIP app into three different versions due to multiple factors. The first one is time. We communicated to our stakeholders the approximate testing date of the app. Due to unforeseen complications with the Power Apps development and permissions, we needed to postpone the development of some functionalities to be able to have a version ready for testing the app. As soon as we would receive the right permissions from the IT admin, we would be able to add more functionalities. The second reason is cost. We did not want to fully commit to the project before being certain that the platform will be approved and that users are satisfied with the app. Starting with the smaller version of the app, we test the essential functions. The last one is the ability to include users and stakeholders in testing as soon as possible. That way users can give their feedback before it is too late and when things can still be easily changed. This ensures the best possible user experience and satisfaction because users will influence the app and make sure the functionalities work as desired.

The first version of the app is called MVP-v1. This version includes all the basic requirements – the creation of the main dashboard, the ability to create a new CIP, and the ability to bring it through all the stages. The MVP also needs to be fully integrated into SharePoint.

The second version (v2) would add some features that users defined as nice-to-have. One such feature is the creation of timestamps that would note every change in the CIP status. These features are not part of the standardized process. However, stakeholders and users agreed they would bring additional value to the app.

The last, third version (v3) of the app would include all the optional requirements of individual plants, e.g. CIP of the month, an additional column in SharePoint for the coach area, and more.

The process of prioritization started with me gathering all the requirements we collected during the process and writing them down in a list. The business owner of the app was then tasked with prioritization of the requirements which determined if they should be part of v1, v2, or v3. The list of prioritized functionalities is available in appendix 4.

As the prototype was already developed, I did not initially include all the requirements in the prototype. However, they are all included in the MVP version that was presented to the users to gather feedback.

3.4 Development of the app

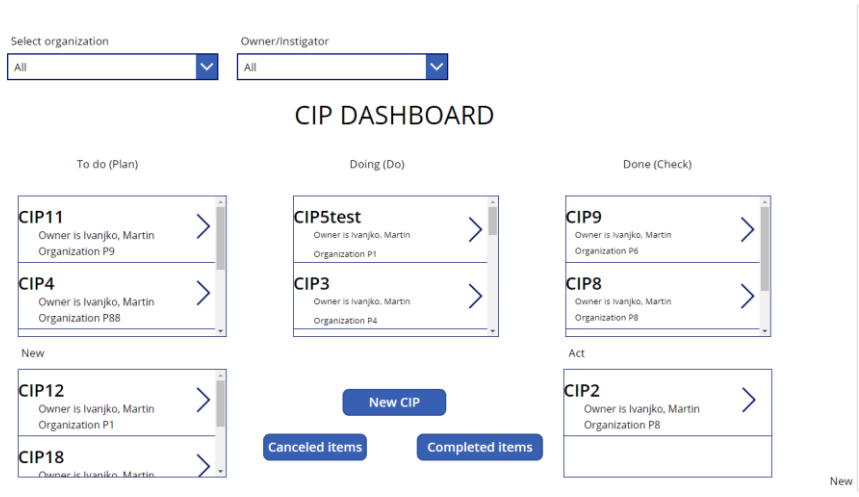
When I started the process of development, I faced a major obstacle. Nobody in Hilti had ever used Power Apps before. The team initially did not have any know-how or support regarding Power Apps. Thus, we decided to only develop a prototype initially to learn what is possible in Power Apps and learn how to use it as a platform. The very first version of the app is presented in figure 10.

I started the process with research about the basics of Power Apps. That included reading through Power Apps documentation, reading online tutorials, and watching YouTube videos describing how to get the desired functionality to work. I also created a new SharePoint list in our private SharePoint space. This list was a copy of the actual list used for storing the CIPs. However, it did not include all the required fields as the main objective of the list was only to have the ability to test different types of columns (e.g. choice, date and time, person, single/multiple lines of text, etc.) and see how they react when used in Power Apps app.

I quickly realized that the connection to SharePoint was working flawlessly, solving one of the main concerns when we started the project. Luckily, to connect SharePoint to the Power Apps, the user just has to find the right connector and paste the web address of the SharePoint list in the dedicated field. That makes the process incredibly simplified because there is no need for the creation of an API (Application Programming Interface).

During my development, I experienced a very steep learning curve. Initially, I needed to understand the way that Power Apps work. I had to tackle basics, such as what a gallery is, what a form is, how to ensure the right data is pulled from the gallery to the form which is located on a different screen, how to set different variables, and much more.

Figure 10: Example of CIP dashboard in the app while in development



Source: Own work.

The prototype of the app was successfully developed which proved that Power Apps is a perfect platform for the CIP use case. We then decided to start with the development of the MVP of the CIP app. The development of the MVP started as an upgrade of the initial prototype. I used the existing app and added all the requirements that were prioritized to be used in v1.

During the process of the development of the MVP, we also received additional support from Microsoft. We were given the contact of a customer engineer from Microsoft who specialized in Power Apps. He helped us solve some of the more complex problems we faced and showed us how to simplify and optimize the code to make it faster and not as cumbersome. One such example is presented in figure 11.

Figure 11: Example of code optimization

```
If(
//For all and all
Dropdown1.Selected.Result="All" And Dropdown2.Selected.Result="All",
Filter(Test, Status.Value="To do"),
//All and selected owner
Dropdown1.Selected.Result="All" And Dropdown2.Selected.Result<> "All",
Filter(Test, Owner.DisplayName= Dropdown2.Selected.Result && Status.Value="To do"),
//Selected organization and all
Dropdown1.Selected.Result<>"All" And Dropdown2.Selected.Result= "All",
Filter(Test, Organization= Dropdown1.Selected.Result  && Status.Value="To do"),
//Selected org and owners
Dropdown1.Selected.Result<>"All" And Dropdown2.Selected.Result<> "All",
Filter(Test, Organization=Dropdown1.Selected.Result And Owner.DisplayName= Dropdown2.Selected.Result And Status.Value="To do")
)
```

↓

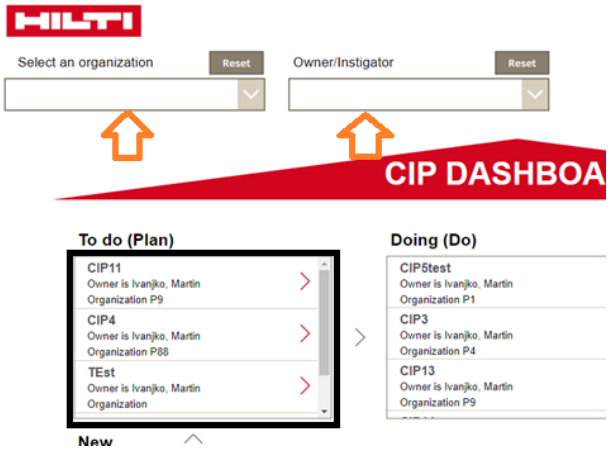
```
Filter(
    Test,
    (Organization = Dropdown1.Selected.Result || IsBlank(Dropdown1.Selected.Result)) And
    ('Created By'.DisplayName = Dropdown2.Selected.Result || IsBlank(Dropdown2.Selected.Result)) And Status.Value = "To do"
)
```

Source: Own work.

This is a code that defines what to show in the gallery of the main dashboard. We want to show only the CIP with the appropriate status (To Do), and we want to filter the CIPs based on two dropdown filters: organization and owner of the CIP. These filters are shown in figure 12.

The first code was created as a combination of several different tutorials and our understanding of Power Apps. The code is written in such a way that it defines every possible option and what to display in that case. Later, I realized that there were updates available in the Power Apps development studio since the tutorial was created, which made this problem much easier to solve. It became possible to set the value of the dropdown as empty. Due to this change, there was no need for the workaround I initially used with the main objective of creating a collection to add an empty value as an option in the dropdown. The code was therefore optimized and the performance of the app improved.

Figure 12: Example of filters that are used in the app

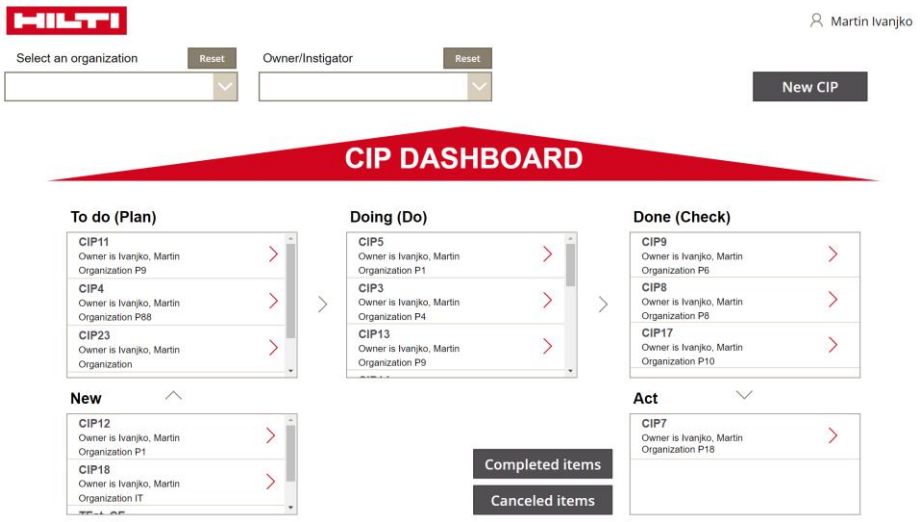


Source: Own work.

Except for a few quick consultations by a customer engineer provided by Microsoft, I developed the app completely independently. This is important for the Manufacturing Apps topic because we proved to our stakeholders that we can deliver the projects from our backlog in Power Apps. I learned how to develop an app, connect it to the database, and understand the low-code paradigm better. Additionally, I learned from different more or less common problems that I faced when developing the app. Research performed to solve these problems helped ne to improve my knowledge and understanding of both Microsoft Power Fx (coding language used in Power Apps), and the logic used in the backend of the app.

At this stage, I completed the MVP of the app as seen in figure 13. This version of the app was then presented to users for testing purposes.

Figure 13: CIP app prototype dashboard



Source: Own work.

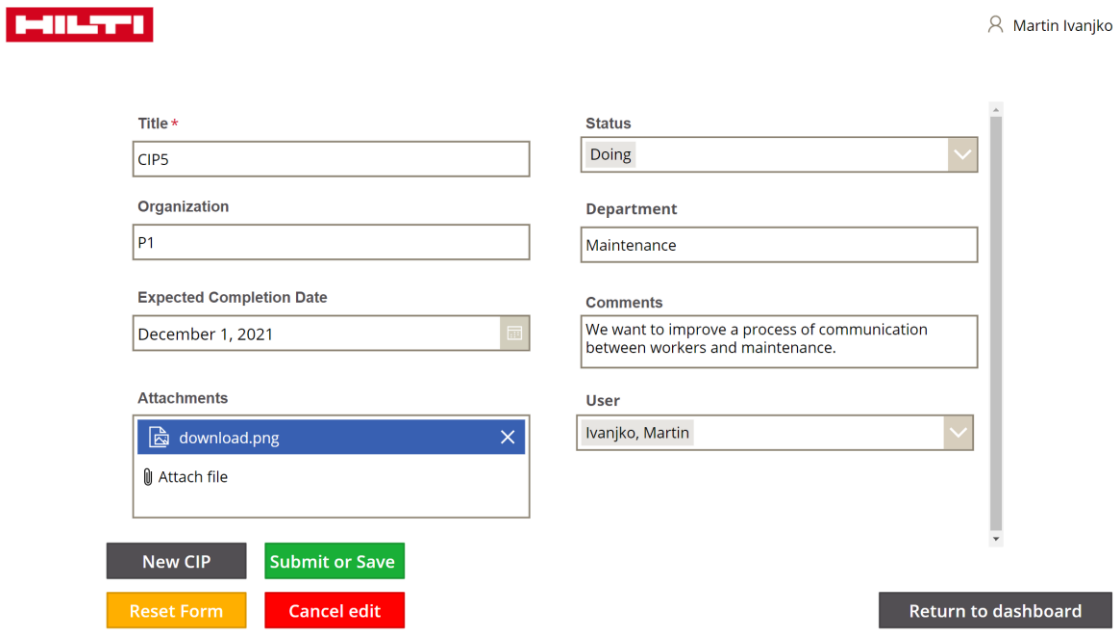
3.5 Testing the MVP-v1 of the CIP app

We initially presented the app and how each requirement is included in the prototype to the core team. The general feedback was positive. There were comments regarding some specific functionalities because they had ideas on how to improve them. One such example is a comment about how the UI used for MVP can be improved. During the development process, I already followed guidelines regarding the use of Hilti colors, the use of the right font, and similar. However, the app can be further improved. Hilti has defined UI patterns that need to be followed when developing an app. As this was only the first MVP, we especially wanted to test the functionality and focus on improving the UX/UI after. An example of a possible improvement is the layout of the buttons, especially on the screen for editing CIP attributes, which is shown in figure 14.

I already used signaling colors to try to communicate to the user what is the purpose of the button (green – Submit or Save, red – Cancel edit, yellow – Reset Form). Nevertheless, during testing, we received feedback that it is still not as intuitive as we want it to be for the user.

During the meeting, we wrote down all the suggestions for potential upgrades. We then discussed the suggestions and decided what changes were needed before we introduced the app to the users and what changes would be nice-to-have and could be included in the v2 or v3 of the app.

Figure 14: ´Edit CIP´ page in the CIP app



Source: Own work.

The testing of the app was performed with the help of ten different end-users. Most of these end-users were also included in the process in the stage of gathering requirements. This meant they were already familiar with the process and the goal of the app. Additionally, we included eight users that were not involved in the process of gathering requirements to get feedback that is not related and based on previous discussions or expectations which could influence their opinion.

As they were already familiar with the CIP routine, there was no need to explain the underlying process. I did need to introduce the app, give users a quick demonstration of how it should be used, and present what I believed would be the main benefits of the app. Next, I asked the users to test the app themselves. There were two main things I wanted users to test: creating a new CIP and moving the CIP between stages. Additionally, they were given time to check everything else they were interested in.

I was really happy with the feedback. During testing and based on the conversations afterward, users expressed they were really satisfied with the outcome of the process, and they were eager to also test the app in the production environment. An example of a quote we received is: “I am already familiar with the shape so it is intuitive. The visualization is much better than before and it will be nice to eliminate the paper templates.” Of course, they also had a few ideas on how to improve the app and what functionalities could be beneficial. These include adding information about how long the CIP was at a certain stage of the process, adding a coach level of filtering, and the need for the search function. They also exposed some inconsistencies in logic or some topics we have not considered so far. Two examples include the option to move backward during the process and the need to block editing of the CIPs in the *Completed* stage. Nevertheless, at this stage, we already covered most of the requirements, and most of their suggestions were already planned for v2 or v3 of the app. Looking back at the process I know that we could improve this step. We should let the users test the app without showcasing it first. That way we would get even better feedback and we could learn more about the app.

After the testing sessions with both the core team and end-users, I once again modified the app to reflect the feedback we received. Once these changes were done, we came to the decision together with the core team that the MVP version of the app was ready to be implemented and tested by selected teams in the production environment.

Unfortunately, there was a level of uncertainty over the app during the entire process. That is due to the fact the Power Apps were not yet approved for use in Hilti. The EA review was not completed yet and Global IT still evaluates the platform. In addition, this meant that we were unable to do proper testing with users over a longer period. Consequently, it also prevented the full roll-out of the app in the production environment. We knew that was a possibility from the beginning. Still, we hoped the evaluation would be completed before the planned rollout of the MVP.

3.6 Success factors influencing the development of the app

All the main success factors of application development and project management apply to the development of the low-code app. The main success factors identified during the development of the CIP app are:

- well-defined requirements,
- management support,
- transparency and open communication,
- skilled resources/employees,
- successful change management, and
- availability of appropriate software and hardware.

Some success factors are more specific to the LCDPs:

- open mindset for new technologies,
- understanding of the platform and its capabilities, and
- managing standardization and customization trade-offs.

I will argument these factors with practical examples from our development.

Well-defined requirements are one of the crucial success factors of the project. What was surprising was the length of the stage of gathering the requirements for the CIP app. I expected the process to be much more straightforward and that there is a common understanding of what is needed in the app. The reality was different. All users have their own opinion of what is the ideal app, how functionalities should be implemented, and what should be the scope of the app. Without a designated decision-maker, the process can come to a standstill because there can be long discussions without any final decision. I was participating in the project as a low-code developer and a project manager at a later point. However, I am not an expert in the CIP routine, and therefore, I initially faced problems because there was no alignment on how to implement the specific requirement. A great example is how to implement the *Act* stage of the process in the app. As already described, some plants use the template with points and detailed assessment of the impact while other plants use the simplified and less structured template. Therefore, designating a process owner of the CIP as a designated decision-maker was crucial. Having a decision-maker made the meetings faster because he had the final say which would be then respected by everyone else. This proved crucial at the stage of prioritizing the requirements. He is also the one that decided to only include the standardized features in the CIP app and leave specific requirements of individual plants for later stages.

During some specific stages of the process, we also witnessed the importance of management support for the project. It can make the entire process easier, especially if

they use their influence to help make decisions that are needed for the successful completion of the project. This support proved important in different stages of the process. Management support helped us make the tough decisions. They were also crucial to help us get the support we needed to get the resources available to create the app. They also helped streamline IT processes to get fast feedback or additional permissions.

Another important factor is transparency and open communication. We always strived to provide full transparency to all stakeholders. They were given access to all the documentation and we had biweekly meetings where we discussed any progress or issues and define the next steps. This was especially important after the delay due to the Power Apps approval. Open communication prevented any misunderstandings and ensured quick reactions from everyone involved. The core team immediately focused on finding solutions or potential alternatives and not on the cause of the problem where they have no influence.

During the project, we also recognized the benefit of having skilled resources. Everyone in Hilti, including me, was without any relevant know-how in Power Apps when we started the project. During the process, I employed the idea of learning by doing. By the time I was done with the MVP, I already gathered a decent knowledge of Power Apps. Building a similar app would now take drastically less time compared to the time spent developing the app initially. We also experienced the benefits of skilled resources during the consultations with a Microsoft customer engineer. Those few meetings helped us optimize the code and quickly solve problems. Technical expertise is also crucial in the prevention of bugs and code optimization.

During the implementation of the app, there are additional critical success factors. The first one is change management. The app strives to be as intuitive and straightforward as possible. That will help ensure the success of the app with the workers. Some users do not use computers daily in their role and prefer doing the process on paper. To convince such users to use the app, they must see a clear benefit that the app will bring to their workday. Change management was also one of the main topics that needed to be covered in the past when they were introducing SharePoint lists to users throughout Hilti.

As already mentioned, we faced a delay due to the approval of the Power Apps. This is another important takeaway because it is not the first time it happened. A company as big as Hilti has strict guidelines and processes in place to ensure the quality and security of any solution that is used. However, that can pose a problem if the team uses a solution or platform which has not been approved yet for use. It can cause the entire project to get delayed or even shut down completely. Therefore, the availability of appropriate software is crucial.

Furthermore, we must also ensure users have the means available to access the app. That means they need to have access to a computer, tablet, or mobile phone. This is not always the case in the manufacturing area. Many users can only use the computer located in the shop floor area that is connected to the TV in the designated area for shop floor meetings. It would also be very inconvenient to always need to log on and log off the app whenever the user wants to use the app. Because there are more similar use cases that would require the use of mobile devices, there is a global effort in Hilti to introduce mobile devices or tablets to all its employees. However, it is still unclear when that will be possible.

Connected to the previous two topics is also open-mindedness towards new technologies. Due to Power Apps being a new solution, we also faced the problem of convincing IT and others of the benefits of using Power Apps. They were resistant to using this platform and suggested that we can fulfill all the functionalities using SharePoint, Service Now, or Jira. That is partially true. However, when objectively comparing the alternatives, Power Apps was by far the most logical tool for such an app because of its ease of development and cost of the app. As we were using Power Apps, there was no need to find a highly specialized developer to create the app. Using the platform, I was able to do it myself in a short time. Additionally, the cost of the development and especially the usage of the app was prohibitively high in Service Now and Jira. The yearly cost for licenses for one plant in said services would be much higher than the development of a custom web application, let alone a Power Apps solution. Therefore, the Power Apps app would offer the best user experience and be the easiest to use. This problem is of course not isolated to only Power Apps. I had similar problems trying to introduce other technologies and concepts. During one of the discussions, one of the IT colleagues mentioned: “The IT is not yet ready for such platforms and for the flexibility they bring to the company. They are always putting out fires and are trying to solve a problem that should have been completed yesterday. Due to that, they are not used to dealing with new technologies because their mindset is not yet open enough.”

Specific to LCDPs is understanding the platform and its capabilities. Due to the nature of the LCDPs, there are some limitations. Some things that are easily solved using traditional development can be hard to solve in LCDPs. Examples we experienced are user permissions and connection to SharePoint. Users should ideally only have access to the data in the app but they could not directly access the SharePoint list with the CIPs. That is unfortunately not possible due to the way Power Apps works. The platform will show you only the data from the sources you have access. That means that if the user wants to use the app, he or she would need to have editing rights to the SharePoint list. We also faced more limitations like user management but later realized they can be managed using user groups. However, if this was not possible, we would have a serious problem because we would need to manually perform user management for an app with thousands of users. Understanding the limitations and possibilities of the platform is crucial to prevent difficulties during its development.

Lastly, I want to mention the trade-off between customization and standardization. It is an extremely complex topic. As I mentioned before, different plants had different requirements for the app. If we were to include all of them, we could spend months developing everything. In the case of the CIP app, we agreed in the end that we want a quick prototype that we can start using and that additional functions can be developed later. LCDPs offer simple personalization of the app to different needs. Therefore, a strategy needs to be set that developers should follow. In our case, the general strategy is to focus on standardization and fast delivery of the service. That way we can deliver more solutions that will have a greater impact because they can be used by more plants (and not just one).

4 MANUFACTURING APPS FRAMEWORK

During the development of the CIP app, we identified the need to standardize our process of managing the app lifecycle, as well as to better define all the topics that need to be covered by the Product Owner of the Manufacturing Apps and by the rest of the team. I believe that with a better structure, we could solve some problems before they even appear. An example of this is creating regular meetings from the beginning of the process, a bigger focus on (what we now know are important) details during the requirements gathering stage (we wasted a lot of time with certain discussions that were irrelevant in the end). It is important to mention that the entire initiative of Manufacturing Apps is still in development at Hilti. We now define the standards and the basis for future projects. To manage the individual projects, we decided to create a framework that would be used when working on the apps. The main goal is to provide a good foundation for the team to be able to do the work in an organized and well-managed way while simultaneously ensuring the team will follow the best practices. Furthermore, the documentation that will serve as the guideline for managing Manufacturing Apps was prepared. The first part of this chapter will present the Manufacturing Apps framework. The second part is aimed mostly at the topics that are relevant on the broader, topic-wide level.

This framework is based on the learnings from the development of the CIP app. Additionally, it includes relevant findings from the theoretical research. Lastly, I consulted Product Owners and co-workers working on different digitalization, industry 4.0, and IT topics: a member of the team responsible for Hilti Cloud services, a member of the team tasked with creating mobile apps, a Product Owner of SAP BTP, an enterprise architect, and members of other teams working on industry 4.0 projects. These interviews helped me better understand the needs and all the different aspects that need to be covered while managing an app as well as what is needed to manage the entire platform/topic.

Together we identified five main areas that need to be covered to be able to successfully manage Manufacturing Apps:

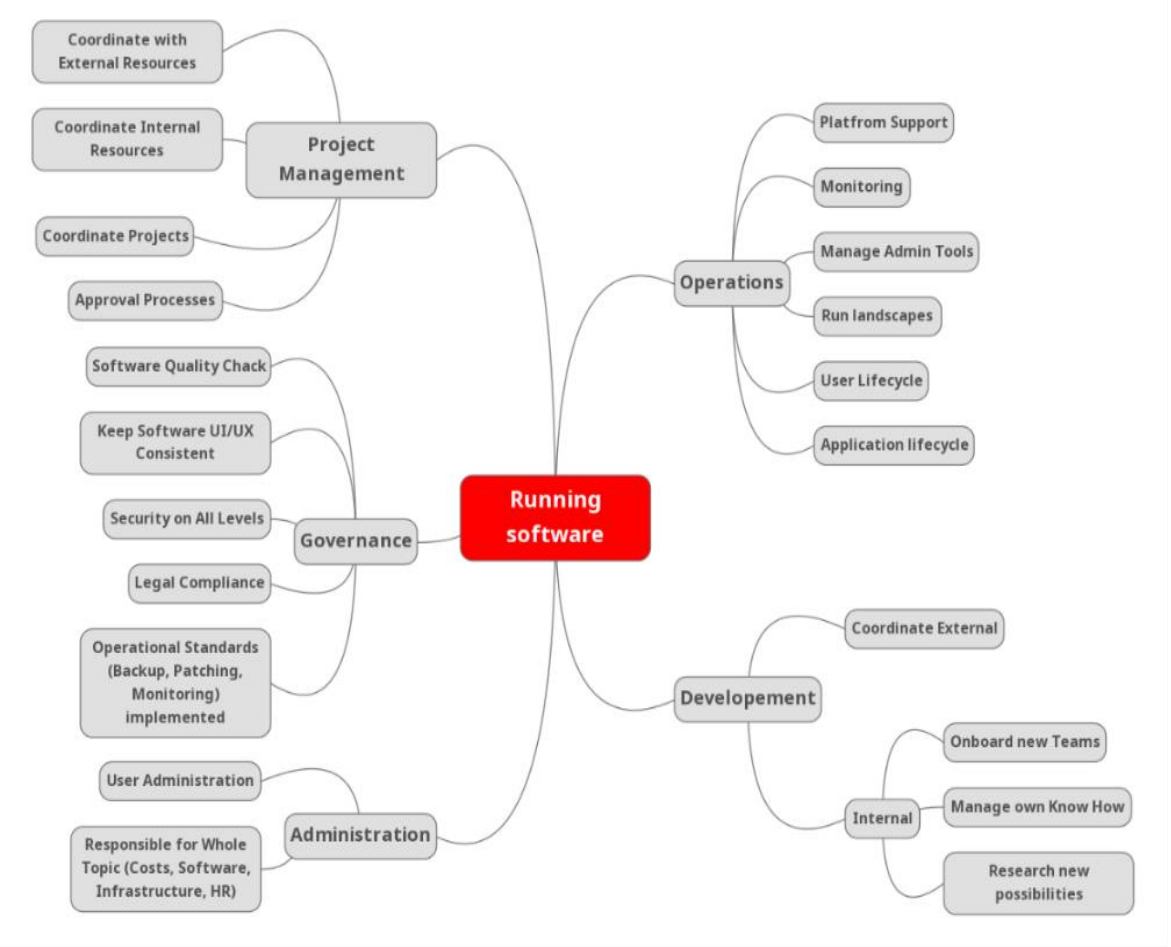
- administration,
- governance,
- operations,
- project management, and
- development.

All these fields must be taken care of if we want to make sure that the process will be standardized and follow best practices.

Based on all the information, research, and content that I received I created a mind map (figure 15) that is created for the needs of the Manufacturing Apps. It helps to categorize all the aspects in groups and provides a structure for future work. This was later used as a starting point when creating a Manufacturing Apps framework.

This mind map alone is not enough. It provides a basic structure. However, there are no guidelines and operational standards that can be followed. Therefore, I created the Manufacturing Apps framework and the rest of the documentation. All the above-mentioned documentation is accessible on the Confluence page of Manufacturing Apps. Users can upload and share documentation and files. The Manufacturing Apps Confluence page has four main sections: *Documentation and framework, Ongoing Projects, Completed Projects,* and *Backlog*. All these sections include the so-called ´child´ pages. These are pages that are lower in the hierarchy and can only be accessed through the ´parent´ page. On the page *Ongoing Projects*, the documentation of the projects that are currently in process of development is included. These pages enable developers and stakeholders to find all the relevant information they might need regarding the project. Required documentation will be presented during the introduction of the planning stage. On the page *Completed Projects*, users can find the projects after the ´Go live´ stage. I also created a checklist template that can be then applied to a new project. That way, we can ensure that all required steps of the process will be followed. The last page is *Backlog*. This page includes information on potential future projects. The backlog is reviewed at regular intervals. There is a spreadsheet presenting all the potential projects and necessary information about them. This page also includes documents or presentations provided by the users that would require the app.

Figure 15: Mind map of all the aspects that need to be covered while running software

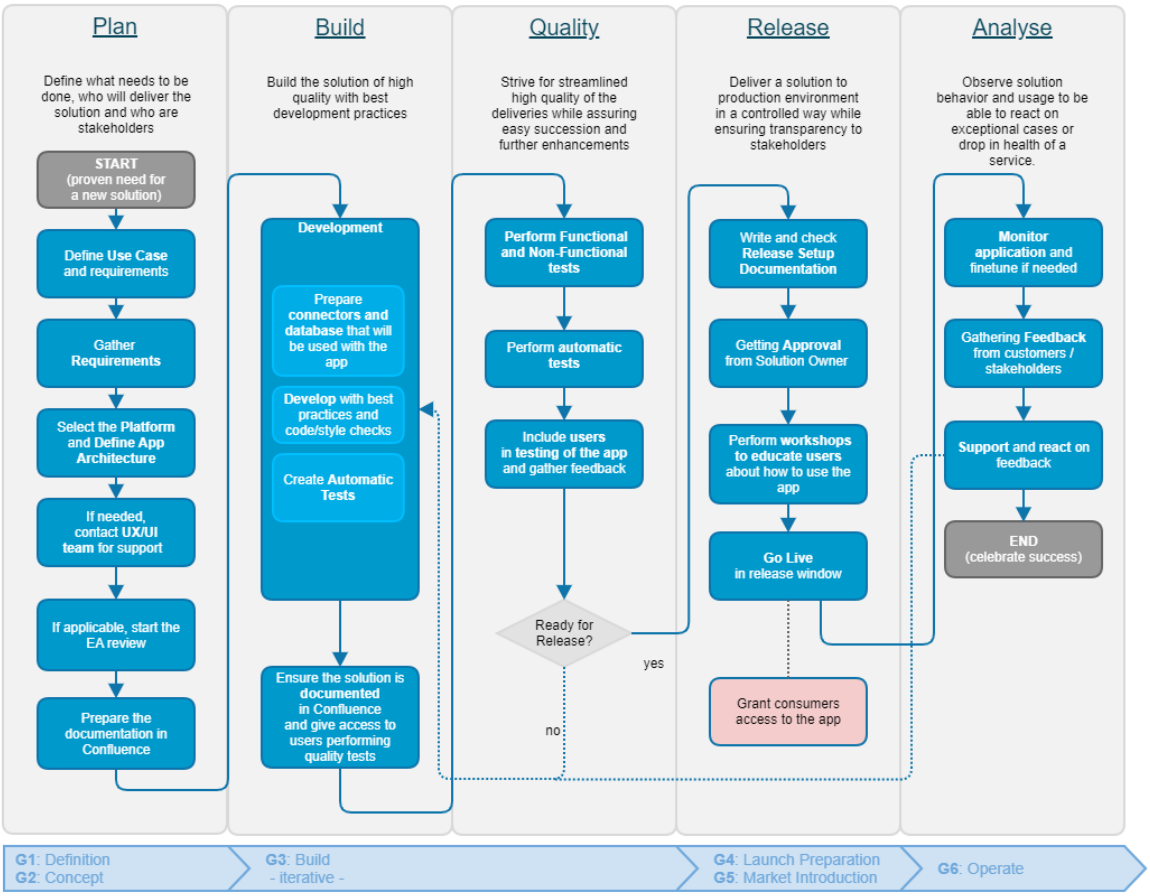


Source: Own work.

There are five main steps in the process: *Plan*, *Build*, *Quality*, *Release*, and *Analyze*. Each of these stages is then described in further detail. The entire framework is shown in figure 16.

The goal of the framework is to guide the project manager responsible for the specific project (app) to complete the project while maintaining high-quality standards. Individual stages are completed sequentially apart from the Build and Quality stages which are done simultaneously. The framework should be used for managing one individual app from the beginning to the successful implementation. To manage the entire initiative of Manufacturing Apps, we also need to manage the platforms and all the aspects that were described before. These topics will be presented in more detail in the second part of this chapter.

Figure 16: Manufacturing Apps framework



Source: Own work.

4.1 Plan

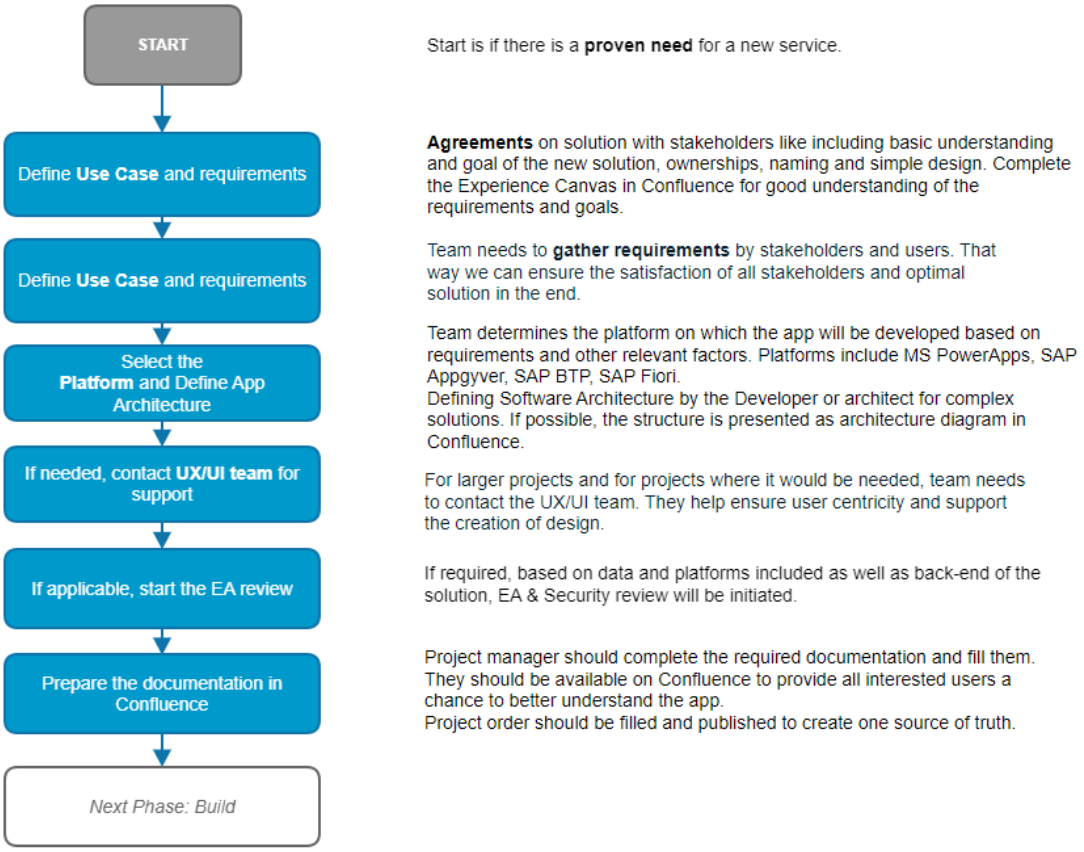
Every project starts with the *Plan* phase (figure 17). The main goal of this phase is to set up a good foundation for the successful completion of the project. The project needs to be well-defined, and the owner must ensure that all stakeholders have the same understanding of the goal and requirements of the project.

Once we select the project from the backlog and include it in the roadmap the work begins. The project should only be started if there is a proven need for a new service. This also means the team must first check whether there is an alternative solution available and whether it fulfills the needs of our stakeholders. The project needs to be aligned with all different stakeholders. The most important stakeholders are of course customers and users of the app. Very often these are the same person. However, it is not always like that. They present the problem, current solution, potential alternatives, and what would be a solution for their problem.

Other stakeholders also include different roles, platform Product Owners, owners of the

specific process (such as CIP), and so on. To help communicate all these facts clearly, a team member of Manufacturing Apps organizes a session with users/customers to define the specifics and understand the problem.

Figure 17: Plan stage of Manufacturing Apps framework



Source: Own work.

In the very beginning, the team needs to create the so-called ´Master slides´. These can later be used whenever they need to present the project or give an overview of the current situation. The slides should include the purpose and benefits of the project, the team, the scope (what is and what is not included), the business case, important decisions, and the current status. Throughout the project, the team then updates the slides with relevant information. Outdated slides can be stored at the end of the presentation. They can be reviewed at any time to check the past situation.

A new project page should be created in Confluence where all relevant documentation, including Experience canvas, will be stored. The following step is one of the most crucial ones for smooth development and a successful outcome of the project. The team needs to gather requirements from users and stakeholders. To do it they need to have a detailed understanding of the problem and the pain points. The team must also talk to relevant expert communities within the company to get a better understanding. This can

increase the likelihood that the app will be used globally and not just locally at one plant. The entire process of gathering requirements needs to be user-centered. The team should strive to visit the workplace of the user to observe and experience the problem, and current solution, and gather information first-hand from actual end-users. All these requirements should be aligned with all relevant stakeholders. Without their support and approval, the possibility of success drastically decreases.

While defining the requirements, the team must not forget to set the expectations and the scope of the project. If this step is not completed properly, that is a potential future problem. When defining the scope of the CIP app, we stated that we want to create a mobile app (responsive web app, not a native app) and a desktop version. We also stated that report building or the creation of any analytics based on the data from the app was out of the scope of this project. This was beneficial later when we received the request from the stakeholders if we could help them to adjust the reports based on the SharePoint list. As we clearly stated from the beginning, that is not part of the project. I could then decline this request to focus on other, for the app's more important parts.

Once the team has a good understanding of the problem, they define the platform that will be used for the creation of the app. The primary platforms used for Manufacturing Apps are MS Power Apps or one of the options provided by SAP BTP. Power Apps is an ideal solution if the project is connected to the Microsoft environment (SharePoint, OneDrive, etc.). Similarly, SAP BTP works well with SAP-related products. In the next step, the solution architecture is defined. Architecture defines how the app works. It explains where the data is stored, and what connectors need to be used to access the data. Team also defines user access, deployment, and the components that will be needed for developing or using the app. The architecture for simple apps will be defined by the developer while solution architects will support the process for more complex apps.

The team will also contact the internal UX team in Hilti to support the project if needed. The team is focused on ensuring the best possible user experience while following Hilti guidelines. There are different options for collaboration with the UX team. The most common is the execution of the Design Thinking workshop, designathon or cooperation during the entire project. Their work is based on user interviews which give the team crucial insights that will help to ensure the team brings user-centricity to the spotlight. The UX team also supports the project later during development to ensure the development is in line with the guidelines and designs that were created in earlier stages. The team should perform relevant UX activities to design the best possible app. This includes creating personas, user stories, a wireframe, and later clickable mock-ups for the user to test and provide feedback. This should also help align the developer, stakeholders, and users to share the same understanding of the requirements given and prevent miscommunication or misunderstandings.

At this stage, the process of Enterprise Architecture review (EA review) should be started if it applies to the project. The main goal of the EA review is to review the ideas, methods, and functionalities utilized in the design and implementation of an enterprise's information systems and IT infrastructure. They ensure a high standard of safety and quality. Hilti has dedicated solutions and enterprise architects that deal with EA. The project always requires EA approval if it is introducing new elements to the Hilti environment or if the cooperation of external developers is needed.

Project order is another document that needs to be submitted before the project can move on. It is an internal Hilti document that serves as a single source of truth. The information included in the project order is used by Hilti to manage the ongoing projects. They include information about stakeholders, finances, milestones, benefits, strategic value, and more. The team must ensure to gather all the required documentation in Confluence before moving to the next stage. That way it will be available for everyone interested or needing documentation in the future. They will be able to understand the motivation for the app and follow the process.

4.2 Build

The app is developed during the *Build* phase (figure 18). The development is performed internally with the potential support of external partners where needed.

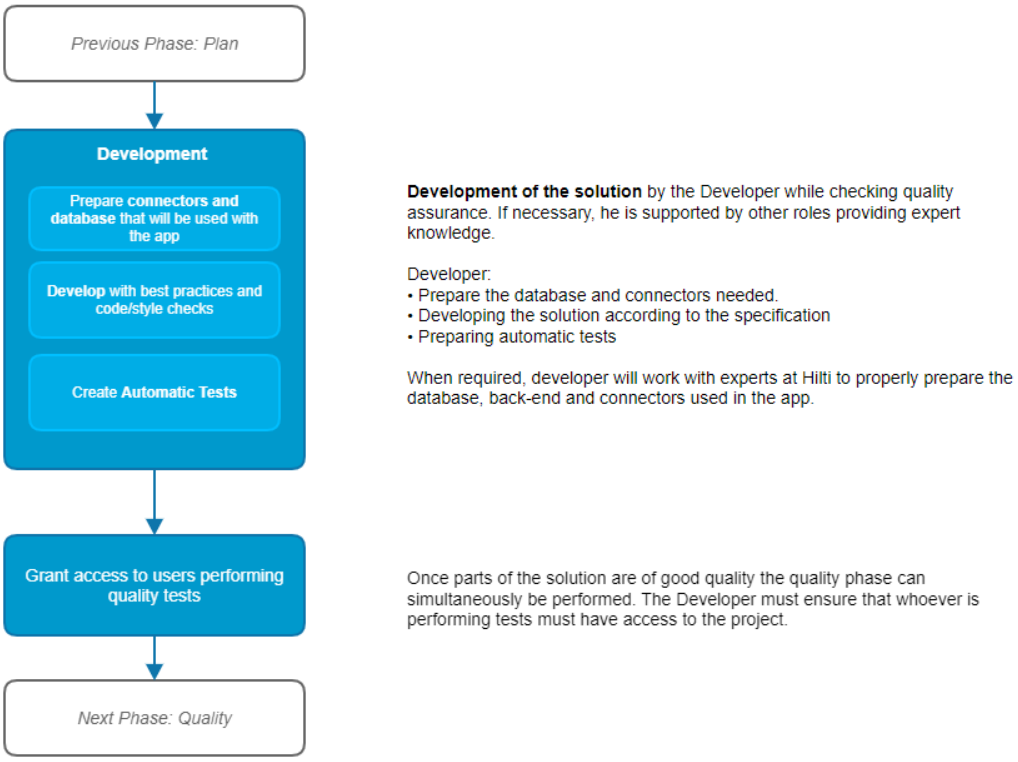
The first stage of the process is to prepare the database and connectors that are needed for the app. The database or a different source of information could already exist and be in use (such as the SharePoint list used for the CIP app). Other projects do not have a defined database for the storage of data. Therefore, the developer must first determine the best possible database (e.g. SAP HANA Database) or other storage for data (e.g. SharePoint). It is also possible that the project will rely on data from ERP. In that case, the team has to ensure they have an available service (API or OData service) that reveals the right data to the app. That is determined case-by-case to ensure the optimal performance of the app. After defining the type and location of storage, they also need to define how the app will be connected to the data. Power Apps platform has connectors built into the platform. Therefore, it can be as simple as pasting the URL of the OneDrive file or SharePoint list into a designated field in the platform. If that is not possible, they need to prepare connectors manually.

The developer can start developing the app once the database and connectors are prepared. While developing the app, they need to follow the best practices and the requirements given by the user.

Platforms enable different versions of the app to be saved automatically. This can act as both a version management tool and backup. A detailed discussion on this topic is in section 5.1. Governance.

The developer should also create automatic tests where possible. That will ensure easier testing in the testing stage. Core users should be given access once the app is at a sufficient stage of development. Using that access they are then able to test the functionality of the app.

Figure 18: Build stage of Manufacturing Apps framework



Source: Own work.

The goal is that when the developer develops the requirement or functionality the process immediately moves to the *Quality* phase. The functionality is tested, and the testing team provides feedback. This loop is then continued as many times as needed for the functionality to be following requirements and reach the necessary quality standard.

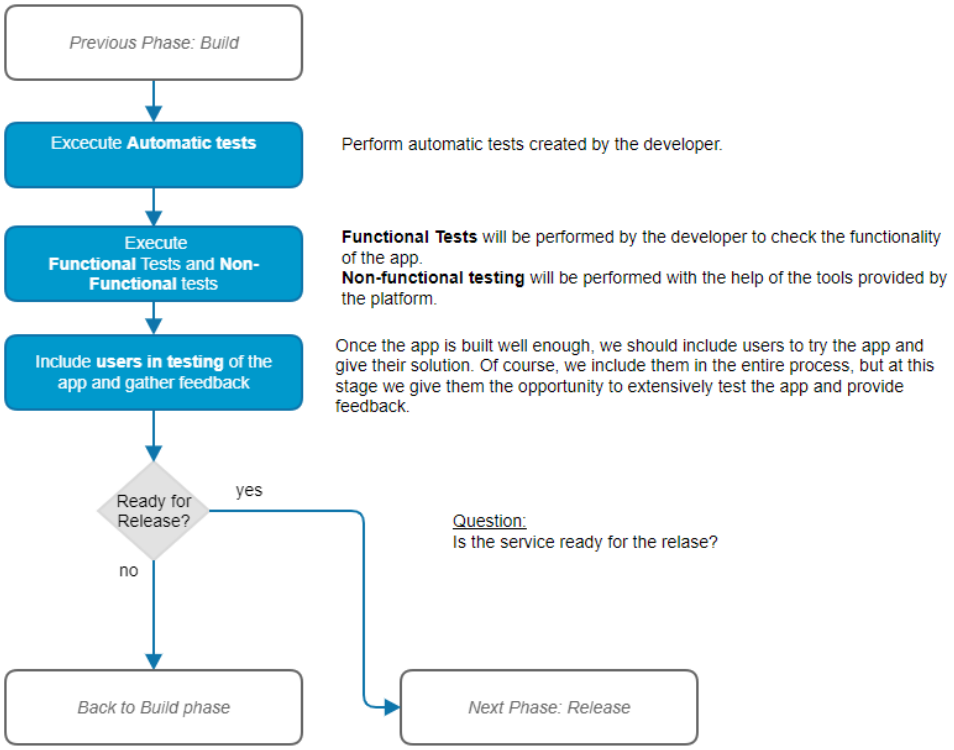
Once the users determine the app, it fulfills the requirements needed for MVP. Then, the process moves to the *Release* phase and not back to the *Build* stage because there is no need for further development at this stage.

4.3 Quality

The purpose of the *Quality* stage of the process is to ensure the good quality of the app developed (figure 19). All functionalities must be up to a high standard for quality, performance, and safety. As already mentioned before, this stage is part of the loop with forms with the *Build* phase.

The process begins with the tester performing the automatic tests created by the developer. This tests the basic functionality of the developed component.

Figure 19: Quality stage of Manufacturing Apps framework



Source: Own work.

The person performing testing should perform functional and non-functional testing. The purpose of functional testing is to test whether the app is functional: Does it complete the task it is supposed to complete? The purpose of non-functional testing is to test whether the app will be able to perform well. The main targets of non-functional tests are performance, usability, scalability, and reliability of the software (UTOR, 2020).

Once the app is at the appropriate stage of development, end users need to be included in the testing of the app. Their perspective can provide great insight that the developer and the rest of the team could miss as they are not as familiar with the process. Users should be included in the entire process of developing the app. Before the app is released to be widely used in the company, the team needs to ensure users extensively test the app. During that period, they can discover bugs or other problems with the functionality of the app. They are also able to get familiar with the app and discover some additional functionalities that would improve the performance/UX of the app.

Once the users determine the app which is good enough and has all the necessary functionalities, the process moves to the *Release* phase and not back to the *Build* phase.

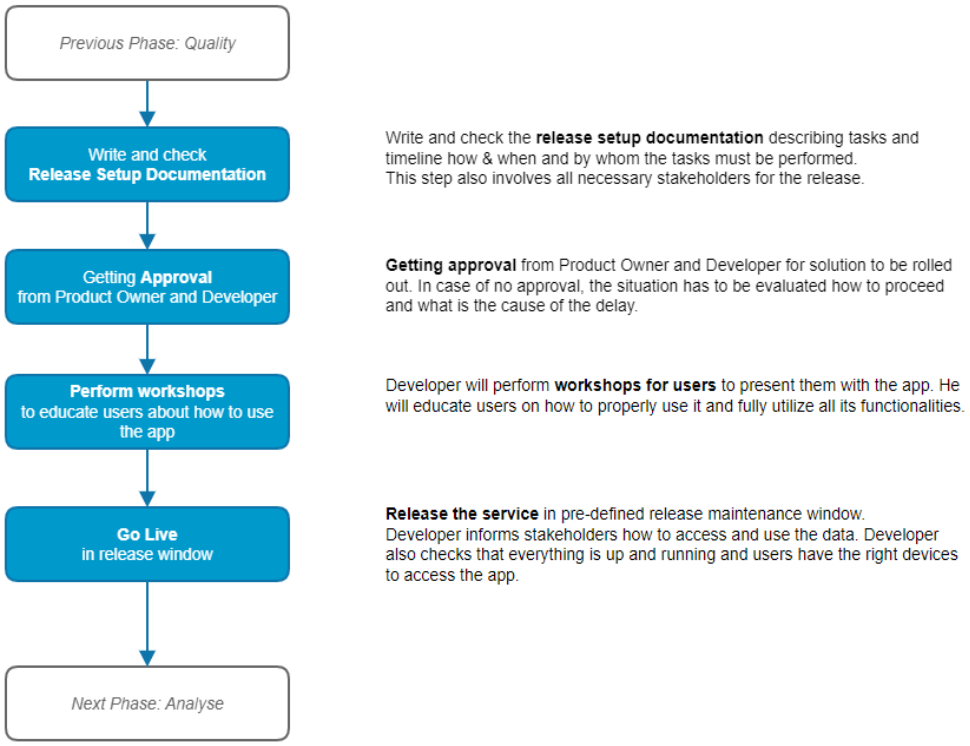
4.4 Release

In the R*elease* phase, the team prepares and delivers the services to the production environment in a controlled way while ensuring transparency to the stakeholders (figure 20). It is considered the last step of the development process. After the *Release* phase, the process enters the *Analyze* phase where services are monitored, observed and, if immediate actions are required, improved.

The *Release* stage starts with the preparation of the Release setup documentation. The documentation should include information on tasks that need to be performed for the successful rollout of the app. It should define who is responsible for performing the task and include a timeline describing how different steps follow each other. The documentation should be written in a way that someone completely unfamiliar with the project will be able to perform all the tasks required.

The team should get approval for rollout from the Product Owner and developer after the documentation is prepared. They should only approve the project if they are certain the app is prepared and that it will reach high-quality standards.

Figure 20: Release stage of Manufacturing Apps framework



Source: Own work.

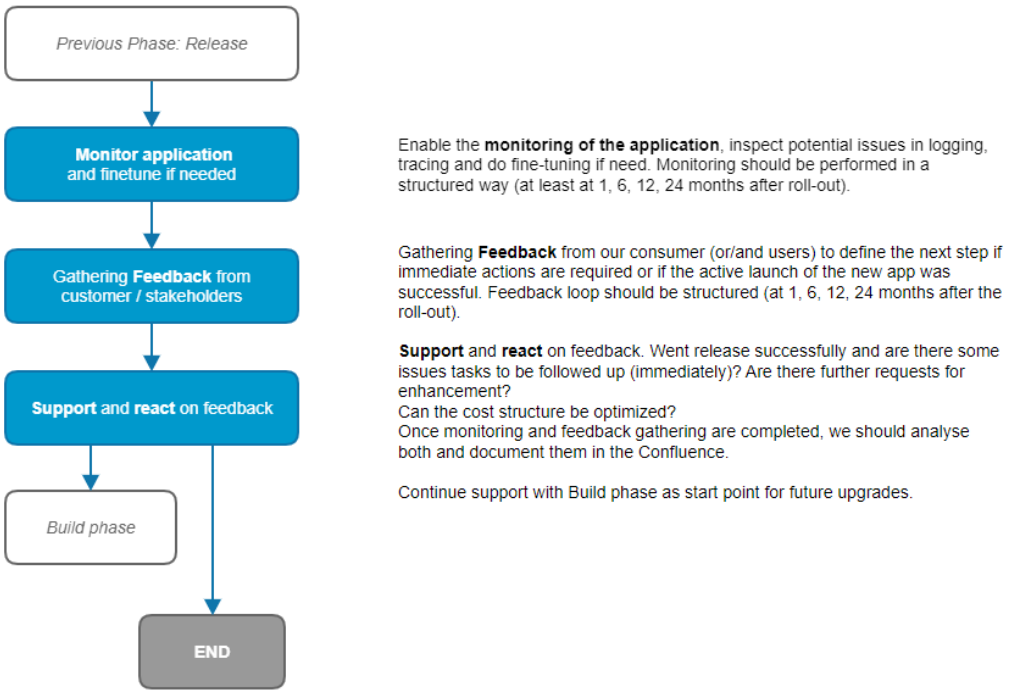
Before the rollout, they also need to educate the users to ensure they are familiar with the product. Only then, they will be able to fully utilize the app and all the possibilities it offers. The team needs to be sure they understand the main logic of the app and can use all the functions properly.

The last step of the *Release* phase is the actual rollout. They need to execute all the steps prepared in the documentation, give users access to the app and publish the app. The team needs to monitor the process to ensure they can quickly solve any unexpected problems that might appear during the rollout. If the rollout is successful, the process moves to the last stage of the process, *Analyze*.

4.5 Analyze

In the *Analyze* phase, the new app is observed and analyzed by our new app. The team needs to check how it behaves in production and judge whether and which actions require immediate attention, as well as plan future upgrades (figure 21).

Figure 21: Analyze stage of the Manufacturing Apps framework



Source: Own work.

After the rollout, they need to monitor the application. This monitoring should check whether all functions work as they should, whether there are any potential issues, and determine whether there is fine-tuning required. This process needs to be structured and

planned, otherwise, it will likely not be performed. The team will complete checks of the app one, six, twelve, and twenty-four months after the roll-out.

The team also needs to gather feedback from the users and stakeholders. This feedback will help them analyze the success of the rollout and the app as a whole. Very often, users also realize that some functionalities are not needed or some crucial ones that no one thought of are missing. Therefore, gathering user feedback is crucial for future upgrades of the app. Feedback gathering also needs to be structured. The team will perform it in the same interval as monitoring (1, 6, 12, and 24 months).

Once they finish the specific monitoring period and gather feedback, the team needs to understand the problems and react accordingly. The first step of this support is to determine whether there is a need for immediate reaction (in case some function is not working). If needed, they also need to plan future upgrades and enhancements. Additionally, they have to consider whether there is a possibility to improve the cost structure of the app.

Once they analyze the feedback and data from monitoring and make the decisions, they must log the information on the Confluence page of the project. That is necessary to ensure transparency and store the knowledge for future use.

If there is a need for upgrades, the process returns to the *Build* phase. The *Build, Quality, Release,* and *Analyze* stages need to be repeated for every new version of the app.

5 ADDITIONAL FACTORS IMPACTING MANUFACTURING APPS AS AN INITIATIVE

The Manufacturing Apps framework is not sufficient for managing the entire initiative. It is focused on the development of an individual app. Other elements of IT governance and administration need to be defined on a topic level (and not on the level of a specific app) to be able to successfully run all platforms and projects. The main questions that still need to be tackled on a topic-wide level are Governance, Administration, and Operations. Development and Project management are mostly covered with the Manufacturing Apps Framework.

5.1 Governance

Governance is another wide topic that enforces high quality and safety standards. It is already widely included in the Quality phase of the Manufacturing Apps framework. Below, there will be a short recap of all the different aspects with a focus on the ones that were not covered in detail before.

Good governance is one of the main benefits of Manufacturing Apps compared to previous solutions used by the customers. These solutions were often unregulated and not properly maintained. They were built ad-hoc with the purpose of a quick, good enough solution. They were a perfect example of the shadow IT phenomenon. With good governance, we ensure that all solutions follow the strategy of the company and that they are created according to quality standards set up by the company. Additional knowledge regarding the creation of the app will be codified and preserved for future needs. This solves a big pain point caused by Shadow IT: only the owner of the solution (e.g. Excel Macro) knows how the solution works and what is the logic in the backend. Therefore, he or she was the only person capable of fixing any potential problems without first spending a considerable amount of time understanding how everything works. By governance, we also enforce security standards in the usage of the app. Previous solutions might have created undetected threats to the Hilti IT environment. They could either be a weakness allowing attackers to access Hilti systems or they could unknowingly damage the data and the database. Solutions that will be created as part of the Manufacturing Apps will undergo security checks and potentially EA review. One example of a security feature is authentication: it is not possible to use the app without logging in using the Hilti SSO. This is just a very small change compared to current solutions but it will immediately increase the security of the apps.

5.2 Administration

Good administration is crucial for the team to be able to do their work. It lays the foundation that is the basis for all other activities.

The first step is to determine the ownership of the platforms. It must be clearly determined who is responsible for what part of the platform. An example of this in Hilti is that there is a global owner responsible for SAP BTP. He provides the infrastructure, sets up the environment, and gives users the appropriate access and rights. He sets up the subaccount that can be used by the Manufacturing Apps team. After that, everything else is the responsibility of the team: user management, governance of that environment, as well as development and deployment of new services.

There must also be clear responsibility when it comes to costs that are created by the apps. It is often that the use of the platform is already included in the existing license. This is also the case with Manufacturing Apps. However, it is different when it comes to the usage of the apps created using these platforms. There are different options available to the users: One option is that the cost is calculated per user per app. The second option is that the cost is already covered by the existing licenses. The last common option is that the company pays a fixed price for the usage of all the apps. That also means they are not limited by the number of users that are allowed to use the app. It is up to the owners of the platforms to understand and act accordingly based on what

is the best cost structure for each platform that the team is using relevant to the use cases and their requirements. They need to calculate the breaking point and decide which is the optimal option.

The job of the Manufacturing Apps team is to determine what are the costs that are associated with the specific app and then transfer this cost to the users/customers of the said app.

Part of the administration is also user administration and management of the team working on Manufacturing Apps. Of course, assigning team members and ensuring sufficient resources is a much broader topic that is not solely covered by the team. It is determined by the plant, circumstances, and availability of employees. What the Manufacturing Apps team can influence is good management of the team. All team members must have clear responsibilities and a good understanding of their tasks.

Currently, there are two major roles in the team of Manufacturing Apps, Product Owner and Project manager/Low-code Developer.

5.2.1 Product Owner

A Product Owner is a person responsible for the success of the topic. The owner needs to understand the processes happening in the factory, the logic, and motivation behind them as well as the business aspect of the process. The Product Owner coordinates the entire process. He delegates individual projects to team members and oversees the status of the projects. That includes ensuring that the project is going as planned, ensuring the costs are as expected, that all stakeholders are satisfied, and much more.

Product Owners must also ensure that projects have a sufficient budget. This is usually a straightforward process because the customer will pay for the solution. However, the projects can be more expensive than expected or there might be several customers and stakeholders included in the project and it is unclear who is going to be covering the costs. It is up to the Product Owner to clarify the financial status and, if necessary, negotiate with stakeholders to ensure sufficient funds are available based on the timeline (how quickly should the solution be delivered), requirements/scope (simple app/complex app with many functionalities), and other factors. If external partners are included in the project, it is the responsibility of the Product Owner to facilitate the negotiations (with a focus on the commercial part of the contract) and, in the end, approve the contract with the external partner. He is also responsible for managing the roadmap, backlog, and filtering/selection of the next projects. It is also up to the Product Owner to present the topic to potential stakeholders and relevant communities in the company.

5.2.2 Project Manager/Developer

The second role is Project manager/Developer. This is the person responsible for the actual development of the app. This role is focused especially on the operational part of the topic. He or she makes sure the process is progressing as planned. He or she provides support to users and manages the lifecycle of the apps. To help them successfully, he or she completes all the tasks they should use the Manufacturing Apps framework. This person should gather the requirements from the stakeholders and align all the requests to propose the optimal solution for everyone. It then depends on whether the app is done internally, which is the preferred version, or in collaboration with external partners. If the app is done internally, it is up to this person to develop the app. He or she manages the project, organizes necessary meetings, and develops the actual solution. When necessary, he or she is supported by other functions (IT, internal/external consulting) to be able to perform all the required tasks. When the app is developed by an external developer, the role of this person is closer to the project manager. He acts as the contact person with all the information for all stakeholders and customers. It is his responsibility to gather the requirements, clearly communicate them to the developer, and take lead in (technical) negotiations with the external partner. It is also up to him to support the rollout of the solutions and gather feedback from the users.

5.2.3 Software Quality Assurance check

Quality assurance will be performed in the Quality phase of the process. The team will first perform automatic tests created by the developer. In the next step, functional and non-functional testing will be performed to ensure the quality of the app. After the tests, the team gathers feedback and makes the upgrades when needed. These tests should be documented and stored. This will provide transparency in the process while simultaneously storing documentation which can be useful when facing problems in the future.

The team will use different environments during different stages of developing the app. The app will be created in the development environment where it will be tested and optimized before roll-out when it will be moved to the production environment where it will be used by customers. This adds another level of security and ensures that any potential wrong settings in the development of the app will not compromise the entire Hilti production environment. Unfortunately, that is currently impossible due to the delayed IT evaluation of the platform.

The team will also strive to maintain the integrity of the data and databases used by the app. Where possible (e.g. SharePoint connection with Power Apps) the team will use a standardized connector that is created and provided by the platform. When the app will require a data connection that is more complex or of higher importance, relevant experts

need to be consulted for their help with connectors and to ensure the proper use of the data.

5.2.4 User experience and user interface of the apps

Both the User Interface (UI) and User Experience (UX) of the apps will follow the guidelines and standards created by Hilti. Using these standards will help maintain a consistent feel and look of all the solutions. User-centricity should be the focus of the team during the entire project. It is especially important at the beginning of the process when the team tries to understand the problem and gather requirements. Often, the most convenient solution for the team will be to just gather information in meetings in the office where we analyze the problem and potential solutions with core users. The team should also observe the process in action and talk to as many users as possible. That way, they can gather different points of view and expand their understanding of the problem.

If needed, we should involve the internal UX team. They can provide consultations to inform the team of the best practices and how to best follow the guidelines. They are also able to support specific projects and give suggestions on how to improve the final solution.

5.2.5 Security on all levels

All the apps and platforms that are used or developed by the Manufacturing Apps team undergo an initial EA review. The goal of the EA review is to review the technologies and components used by the app, check data storage, and other relevant topics that are relevant for the quality and safety of the said solution. The solution architect is tasked with helping the team set the best possible architecture while enforcing quality and security. The platform and individual functionalities of the app only need to be checked the first time they are used. After the initial review, only the features that are used for the first time and have not yet received approval need to go over the EA review.

All apps will require authentication to use. That will ensure that only the users with the right access will be able to use the app. The authentication will be performed using Single Sign-On using their Hilti account. The access to individual apps and services will then be determined using roles and groups in Azure Active Directory. That will ensure easy management of the user lifecycle.

5.2.6 Legal compliance

The team will consult legal experts when needed. The main potential legal problem the Manufacturing Apps team should face is ensuring compliance with the GDPR.

However, since Manufacturing Apps are only created for internal use within Hilti and most of the apps are replacing existing solutions, this is not an issue.

An additional problem the team could face is workers' unions. They can set different restrictions on the usage and functionalities of the app. It is the responsibility of the customer (business side representative) to ensure the agreement with the unions. The Manufacturing Apps team will support but not lead these negotiations.

5.2.7 Operational standards

The Product Owner will create operational standards for the app. The latter will be available on Confluence. These standards will define common processes that are needed for all apps to prevent potential problems. They will define the processes, how frequently it needs to be performed, and the person responsible for the process. Topics, where standards are defined, are backup of the apps, version management, patching and updates, monitoring, and feedback gathering of the apps. More will be determined.

5.3 Operations

Operations describe certain actions that must be performed by the team to ensure that projects will be successfully developed, maintained, and prioritized. Without these activities, projects will face problems that might cause failure of the projects.

5.3.1 Platform support

Platform support will be run by the Manufacturing Apps team or relevant internal/external partners. The first contact for any questions is the project manager that was managing the development of the app. If he or she is unable to solve the problem, he or she will contact relevant internal or external partners to help find the solution and solve the problem.

Where appropriate (especially if the app has a large number of users) we will educate the business owner of the app to be able to provide initial support to all workers.

5.3.2 User lifecycle

The user lifecycle is an important part that must be managed or defined by the Manufacturing Apps team. The team must ensure users can get the appropriate access to the apps they need. However, the user lifecycle is not just about the access for the new users. It is also about managing the users who no longer require access to the app (e.g. employees changing positions or leaving the company). To help manage the access roles and security groups will be used. Using roles and groups, it is easy to quickly give

or remove additional access to individual users or groups of users at the same time. The initial access will be managed by the Manufacturing Apps team. For apps with a larger number of users, however, this responsibility will be passed on to the relevant business owner of the app. It is also important to manage the lifecycle of the Manufacturing Apps team. We need to ensure they have appropriate access to the platforms they need. The team must also make sure that any user leaving the team is not the sole admin of any solution/platform. That way they can prevent the problem of not being able to fully manage the platform. After the member leaves, the team removes him from any roles and cancels their access to the platforms.

5.3.3 Onboarding new team members

When a new team member joins the team, the mentor makes sure they prepare all the needed usernames and accounts with the right permissions. By new team members, I mean colleagues that are joining the initiative for the first time and interns that will be part of the team. The Manufacturing Apps team is currently very small with one full-time member and an intern that is supporting the team. Onboarding will be performed by the Product Owner or other team members that will act as a mentor to the new employee. During the onboarding process, the team needs to introduce the new team members to the topic. At the end of the process, they should understand what the purpose of Manufacturing Apps is, how projects are conducted (Manufacturing Apps framework), and what standards/guidelines the team follows when operating and developing new apps, as well as others.

To manage the onboarding process better, I created a checklist of the topics that should be covered in the onboarding process. This checklist covers the main part of the technical onboarding topics. Team members would additionally need specific onboarding sessions based on their tasks and responsibilities. They would also need to complete an organizational onboarding session prepared by the HR department.

To help the user understand the platforms used by the team better, new team members need to start with some easy tasks or introductory projects. Such an example is the App-in-a-day project. App-in-a-day is training designed by Microsoft to help users understand the logic of Power Apps and show them the possibilities offered by the platform. The environment should be prepared by the admin and all the necessary permissions should be given to the new team member to be able to work on the project.

5.3.4 Managing admin tools and Running landscapes

The team is responsible to manage the platforms and tools they use. Some platforms are fully managed by IT, and we can only use them without any admin roles and without power to change the platform set up. Others require that team manage the platform

actively. That means user lifecycle management, setting up appropriate environments for development, testing, rollout, monitoring the usage of the platform and apps, and much more.

The team needs to invest time to get to know all details of the tools they use. They need to understand the workflow and underlying processes of the platform to be able to set up good structures and procedures. Other platforms require only maintenance and occasional update of the content.

An example of such a platform is SAP BTP which includes SAP Business Application Studio where users can create apps using Fiori Elements, a Low-code environment, a Mobile development kit, and more. The team will also start using Jira to help manage the projects. However, the structure needs to be defined first and agile project management needs to be used by all team members.

5.3.5 Backlog

The team is also responsible for managing its backlog. The process starts with the request for a solution from the employees and coaches in the plant. One of the team members will meet with the responsible person/customer to get a better understanding of the use case, especially what the underlying problem is and what would be a solution that would solve it. If the team determines that it is a use case that would work well with the concept of Manufacturing Apps and the team can provide a good solution, the use case is stored in the backlog with all the documentation provided by the customer.

The backlog is then reviewed at regular intervals. The projects will then be selected according to the pull from the customers, the capacity of the team, and especially the prioritization/necessity of the project. It will be determined by the team. However, they will align the next steps with other stakeholders and customers.

Using the Manufacturing Apps framework and following other guidelines and best practices for administration, governance and operations should provide a good basis for the team to be able to do the projects as well as possible. The team must have the necessary know-how to be able to develop the app successfully as we witnessed during the development process. Only after I learned enough about the process, I managed to really optimize the app and develop a better solution. Additionally, good soft skills are required to be able to get the agreement of all the stakeholders and manage their expectations and the skills necessary for the project. Management of expectations helped prepare users for potential problems that could otherwise be a complete shock to the user. After the problem happens, clear and honest communication that presents current options and alternatives presents itself as the best possible option. This ensures the trust and support from stakeholders that enabled us to face the difficulties.

6 DISCUSSION

The concept of citizen development helps to decrease the workload of IT departments and it helps users to create quick and custom solutions without any additional support needed. Using citizen development, business users create solutions that solve the problems they face in a completely personalized way to create the best possible way they can.

A big question is, however, when organizations are ready for such development. Very often they talk about such projects with great interest but fail to successfully implement concepts, such as LCDPs. The two opportunities identified during this process are the need for modernization/adjustment of the EA review process and change management.

The concepts of LCDPs and citizen development differ from traditional IT paradigms. They empower users to create things themselves and use the tools available instead of limiting them with different permissions and several levels of authorization. However, when operating a big multinational corporation, there are a lot of threats that can bring production to a standstill. This includes IT infrastructure. If an ERP system fails, the company can lose millions every hour. Therefore, we do require oversight of IT infrastructure and software that is used to maintain high quality and a high level of cyber security.

Nevertheless, the existing rigorous EA activities can completely block the successful implementation of LCDPs, as well as neutralize any advantages that they could bring to the company. It is not sustainable for developers to spend weeks or even months approving the solution they created (in the best case) in days. These changes require a big shift in mindset. If the company decides to start using LCDPs, they need to adjust its processes (EA review as well as other processes) accordingly. For example, the EA review needs to evolve into a more streamlined process with specialized experts for such platforms. Of course, that does not mean everyone can do everything and that governance/oversight is not needed. But creating a simplified EA review for low-code apps is a step in the right direction. This would be applicable for apps of smaller scope that do not contain production critical data and are not connected to any production environments. This can be initially used as a proof of concept before tackling bigger use cases.

Secondly, more change management is required to implement a topic, such as Manufacturing Apps, successfully. Citizen developers must convince IT experts that they are not a threat. On a contrary, if the concept of citizen development succeeds, it will be a great addition to traditional IT. If users are enabled to solve their own problems, there will be less need for IT support and interventions. They will be able to focus on the tasks where they can bring true value to the company instead of dealing with small use cases.

Additionally, an often overlooked fact is that many of the no-code and low-code platforms were developed for professional developers. They are meant to make their life simpler because they remove unnecessary time needed to set up a project or create a code. A great example of this is the LCAP (the low-code application platform) which is part of SAP BAS. Users can generate simple data models, services, and user interfaces using low-code capabilities. This is also simultaneously described in Node.js code which can be used to expand the app and add additional functionalities. During one of our discussions with SAP experts, they also explained that business users could complete about 80% of the work alone. However, they would require the support of a professional developer for the last 20%. That means that LCAP is a great tool. For business users, however, it can be overengineered and without extensive effort to learn about the platform, they will not be able to use it. During my work so far, I found Power Apps to be the easiest and simplest to use for non-developers. Of course, that does not mean that other platforms cannot be used. On the contrary. They are amazing tools but only skilled developers will be able to truly extract the full potential of these platforms.

CONCLUSION

As already indicated, Industry 4.0 and digitalization are drastically changing the current business environment. Part of this disruption is also LCDPs which created a new paradigm of solutions development. They enable citizen developers to create the applications independently with IT only providing the necessary infrastructure. With their unique properties, they enable users to prototype new apps quickly and easily while reducing the time needed, costs, and complexity. They also help combat shadow IT and improve IT governance in the company. To achieve that, companies must have a clear strategy and processes in place that ensure the quality, security, and general success of the apps.

Hilti is one of the companies that realized the potential of said platforms and decided to start using them. I used a low-code platform from Microsoft called Power Apps to develop a prototype of an app that is used to support the Continuous Improvement process in Hilti. As the process was performed on paper before, this will bring many benefits to its users, including decreased bureaucracy, improved user-friendliness, guidance through the process, real-time reporting, and increased transparency.

After completing different stages of the development process, I developed a working prototype of the app successfully. I identified the main success factors that were crucial for the success of our development: well-defined requirements, management support, transparency, open communication, skilled resources/people, successful change management, and availability of appropriate software and hardware. Additionally, I also highlight three, that are more specific to LCDPs: an open mindset for new technologies,

understanding the platform and its capabilities, and, lastly, managing standardization and customization trade-offs.

Current processes are not sufficient for the sustainable development of solutions in line with best practices. To solve that, we require a standardized process. I created the Manufacturing Apps framework that describes the steps required in all stages of the app lifecycle. There are five main stages in the framework: Plan, Build, Quality, Release, and Analyze. The elements of each stage are then described in detail to ensure all the necessary steps are completed.

Lastly, I expanded the Manufacturing Apps framework to also include the rest of the relevant topics, such as administration, governance, and operations to ensure the entire initiative is well-managed and organized. This ensures that all the steps that present the basis for the development of the apps are completed.

The thesis has several limitations. All the conclusions are partly specific to the environment and requirements of Hilti. Still, they can be used as a good example for other firms in the manufacturing environment that are interested in the development and governance of custom low-code apps. I was also partially limited by a lack of previous studies in the research area. Many of the topics I discussed are still emerging and, therefore, there is little academic literature available in the field. Furthermore, the conclusions are mostly based on the work with MS Power Apps. Additionally, I did not have a chance yet to test the Manufacturing Apps framework when creating a new app. Since the CIP app that I created has not yet been approved by IT, I also could not test the app in a productive environment and track the satisfaction of the users. All the limitations can serve as a basis for future research.

Manufacturing Apps and LCDPs are a huge opportunity with great potential for Hilti and other companies. With their unique proposal of citizen development and rapid prototyping, they can fulfill the custom requirements that global and standardized solutions are unable to fulfill. Of course, there are still challenges that must be faced as both are relatively new products and they need a certain time to mature and separate the hype from reality. However, with proper governance and a structured approach, many of the problems can be managed. Therefore, I believe, the importance of LCDPs will only increase in the future due to increased pull for custom solutions.

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APPENDICES

Appendix 1: Povzetek (Summary in Slovene language)

V okviru magistrske naloge predstavim postopek razvoja aplikacije z nizkokodno razvojno platformo. Poleg tega predstavim ključne faktorje ki vplivajo na uspešnost razvoja aplikacij z uporabo nizkokodne razvoje platforme. Na podlagi razvoja te aplikacije sem ustvaril ogrodje z definiranimi postopki za razvoj bodočih aplikacij.

Industrija 4.0 (I4.0) in digitalizacija prinašata velike spremembe v sodobnih proizvodnih procesih. I4.0 predstavlja razvoj "kibernetsko-fizičnih sistemov in dinamičnih podatkovnih procesov, ki uporabljajo ogromne količine podatkov za delovanje pametnih strojev in naprav" (Strange in Zucchella, 2017). Na razvoj industrije 4.0 vplivajo številne različne tehnologije, vključno z analitiko velikih količin podatkov (big data), internetom stvari (IoT) in velikim napredkom na področju umetne inteligence (AI). Podjetja morajo slediti novim trendom in jih vključiti v svoje vsakodnevne procese. Za proizvodni sektor je zelo pomemben koncept pametne tovarne. Lucke, Constantinescu, & Westkämper (2008) opredeljujejo pametno tovarno kot kontekstno občutljivo proizvodno okolje, ki lahko obvladuje turbulence v proizvodnji v realnem času. Z uporabo decentraliziranih informacijskih in komunikacijskih struktur se zagotovi optimalno upravljanje proizvodnih procesov. Na uspeh pametne tovarne vplivajo številni dejavniki, njeno bistvo pa je hiter razvoj in spreminjanje informacijske podpore.

Razvoj aplikacije z uporabo tako imenovane nizkokodne razvojne platforme (low-code development) lahko pozitivno vpliva na implementacijo pametne tovarne in industrije 4.0. Cilj je poenostaviti razvoj novih rešitev in omogočiti poslovnim uporabnikom, da sami gradijo svoje rešitve. Nizkokodne razvojne platforme uporabljajo programiranje prek vizualnih vmesnikov, ne da bi zahtevale poglobljeno znanje programiranja za razvoj prilagodljivih programov v kratkem času (Sahinaslan idr., 2021). S tem se poveča produktivnost, zmanjšajo stroški razvoja in opolnomočijo uporabniki (Bock & Frank, 2021). Uporaba nizke kode omogoča poslovnim uporabnikom samostojno ustvarjanje aplikacije, pri čemer je naloga IT oddelka le zagotavljanje potrebne infrastrukture. S svojimi edinstvenimi lastnostmi uporabnikom omogočajo hitro in enostavno izdelavo prototipov novih aplikacij. Hkrati zmanjšujejo čas trajanja razvoja, stroške in poenostavijo razvojni proces. Za uspešno realizacijo morajo imeti podjetja jasno strategijo in opredeljene procese, ki zagotavljajo kakovost, varnost in optimiziran razvoj aplikacij.

Hilti AG je eno od podjetij, ki so spoznala potencial nizkokodnih razvojnih platform in jih začelo uporabljati. Za razvoj prototipa aplikacije, ki se uporablja v podporo procesu stalnih izboljšav, sem uporabil nizkokodno razvojno platformo podjetja Microsoft, imenovano Power Apps. Ker se je proces prej izvajal na papirju, bo uporaba aplikacije uporabnikom prinesla številne prednosti. Najpomembnejše so odprava podvajanj dela v procesu stalnih izboljšav, izboljšanje uporabniške izkušnje, vodenje skozi proces, poročanje v realnem času in večja preglednost.

Z uporabo nizkokodne razvojne platforme Power Apps sem uspešno razvil delujoč prototip aplikacije. Opredelil sem glavne dejavnike, ključne za razvoja aplikacije: dobro opredeljene zahteve, podpora vodstva, preglednost, odprta komunikacija, usposobljeni viri/ljudje/uporabniki, uspešen proces upravljanja sprememb ter razpoložljivost ustrezne programske in strojne opreme. Poleg tega sem opredelil tudi tri značilne dejavnike za razvoj aplikacij z uporabe nizkokodne razvojne platforme: odprtost za nove tehnologije, razumevanje platforme in njenih zmogljivosti ter obvladovanje kompromisov pri standardizaciji in prilagajanju.

Na podlagi ugotovitev, pridobljenih pri razvoju te aplikacije, sem ustvaril ogrodje z definiranimi postopki za razvoj bodočih aplikacij. To ogrodje vključuje najboljše prakse, ki temeljijo na strokovni literaturi in znanju ter izkušnjah strokovnjakov v podjetju Hilti. To ogrodje je standardizirano in se osredotoča na razvoj posameznih aplikacij. Ker je bilo ogrodje osredotočeno na razvoj posamezne aplikacije sem v nadaljevanju vključil teme za celostno načrtovanje in upravljanje z projekti, ki uporabljajo nizkokodne razvojne platforme.

Razvoj aplikacij z uporabo nizkokodne razvojne platforme predstavlja področje z velikim potencialom za Hilti in tudi za druga podjetja. Z edinstvenim načinom razvoja za poslovne uporabnike brez poglobljenega programerskega znanja in možnostjo hitre izdelave prototipov lahko zadovoljijo specifične zahteve, ki jih globalne in standardizirane rešitve ne morejo zadovoljiti. Seveda še vedno obstaja veliko izzivov, saj je koncept razvoja z uporabo nizkokodnih razvojnih platform razmeroma nov (oziroma popolnoma nov v Hiltiju). Potreben je določen čas, da ločijo pretirano navdušenje in previsoka pričakovanja od realnih zmogljivosti. Z ustreznim upravljanjem in strukturiranim pristopom je lažje obvladati številne potencialne težave. Tako zagotovimo kar največ možnosti za uspeh aplikacije. Zaradi vse večjega povpraševanja po prilagojenih specifičnih rešitvah pričakujem, da se bo pomen razvoja aplikacij z uporabo nizkokodnih razvojih platform le še povečal.

Appendix 2: Simplified version of the Act stage

Team leader		Actual savings	
Are the actions sustainable implemented and the savings realized? Is the solution defined as a new standard?		How big are the savings?	
Were the health and safety specifications observed?		☐ Quality ☐ Health and safety ☐ Surface space (m^2) ☐ Costs/Time (in €) ☐ Supply readiness	
Date:		Signature:	

Appendix 3: Points version of the Act stage

Supervisor:	Customer enthusiasm / Sustainable use:			Time:		Corporate culture:		Area of usage:		Savings (*):
Have the measure and savings been realized? What did the team learn?	Customer's benefit (value add) Quality improvement Value stream optimization Reduced throughput time Eliminating waste ☐ Ergonomics (# Medium) ☐ Safety topic (# Very Large) ☐			Implementa-tion time		Integrity Courage Teamwork Commitment Lean Guiding Principles		Scope of application		Effort (**):
	Very Large#	>15.000.-	10	2 days	5	Very large 5 criteria	5	Organizational unit (e.g. GM)	5	The solution was indepen-dently im-plemented
Were the health and safety specifications observed?	Large	>4.500.- to <15.000.-	8	6 days	4	Large 4 criteria	4	In the site (e.g. P1, LCN, ...)	4	
	Medium	>1.500.- to <4.500.-	6	8 days	3	Medium 3 criteria	3	In the Unit/ department	3	
Solution defined and documented as new standard, if applicable ☐	Small	>750.- to <1.500.-	4	10 days	2	Small 2 criteria	2	In the team	2	
New standard communicated to all stakeholders and interfaces ☐	Very Small	<750.-	2	12 days	1	Very small 1 criterion	1	1 work station	1	
CI contributions of the team informally or formally recognized ☐										:5
Date:	Signature:	* = in CHF ** = in CHF or hours								Points per participant

Version Nb.: 1.0
Version Date: 10.06.2020

Appendix 4: Prioritization of requirements for the CIP app

ID	Screen	Description	Comments
#	MVP-v1		
1	Connectivity	Any change in CIP App is reflected in the SharePoint database	
2	Settings	Select area (GM, GL, AMS...), plant/region (P1,P4...) ... goal-set user to right sharepoint list	(Can be also determined automatially)
3	Main dashboard	Standardized CIP board template	
4		Filter- organization	
5		Filter - owner/initiator	
6		Search bar	
7		New CIP button	
8		Completed CIP	
9		Sort button - CIP within their statuses (by age)	
10		Limit the number of CIPs in doing phase (if possible)	
11		If you (double?)click on the CIP you can see all the attributes of the CIP	
12	CIP View	Landing page: Header info/opportunity/cause/countermeasure/check/act	You cant move to doing until the Plan phase question (opportunity) is completed
13		Button to move to a different stage if CIP card sections are completed	
14	Stage changing	Select the status that you want for the CIP	
15	Details page-header info	Open header info (all columns with text) -possibility to edit)	Title, Owner/initiator, Organization, Status, Attachments, Closing date, Days since start
16	Details page- PDC phases	Textbox where we can input text for Opportunity, cause, countermeasure, check	
17		Ability to add attachment (picture/video) to the CIP	
18	Act stage optionality	Select between with or without points system	
19	Act stage-without points	Textbox-with questions (assign to act part of the sharepoint list)	
20	Act stage-points	Same input fields as the backside of the card, all combined in the act column of the sharepoint list	
21	New CIP	Go to header info-assign all the values to mandatory columns in Sharepoint	
22	Status based CIP list	List showing all the CIPs assigned to specific status. Needed completed	
23		Filter - organization (if possible default based on the setting of the person)	
24		Ability to move the CIP back into different stages	
25	Mobile layout	possibility to use in private mobile phone as well	
26	Languages	English/German	
#	v2		
27	Main dashboard	Automatic notification at Act stage to Team leader (teams/mail)	
28		Automatic filtering option for My CIPs/My Teams CIPs	
29		Canceled CIPs button	
30		Days since creation (select)	
31		Days since status change	
32		Drag and drop possibility to move CIPs between stages	
33	Act stage optionality	Only coach can access and can start the act stage	
34	Details page-header info	Days since status change	
35	Status based CIP list	Including all other statuses if clicked on the header of specific status in the dashboard	
36		Include filter -owner/initiator, search bar	
37	Languages	Chinese	
38			
#	v3		
39	Additional input fields	Current optional columns in SharePoint (CIP of the month, technology, Coach area...)	
40			