A Case Study for a Digital Twin of Body-in-White Production Systems

General Concept for Automated Updating of Planning Projects in the Digital Factory

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***Abstract* — Increasing competition in the automotive industry makes cost-saving integration of more and more vehicle derivatives and variants such as sedans, coupes, cabriolets as well as electrical and combustion engine models into existing production systems necessary. At the same time, the production planners face a major challenge while integrating vehicle bodies-in-white. In contrast to the original concept and rough planning state, the automated production plants are continuously optimized during the detail planning phase as well as after the start of production as a result of improved processes and model upgrading. For fast integration of new vehicles, a current digital image of the real production plant ─ the so-called Digital Twin ─ is groundbreaking. This Digital Twin of a factory consists of a current bill of resources for cost calculation and a current layout planning state. The paper describes a concept for creating a Digital Twin of a body-in-white production system for the concept and rough planning projects. In the internal concept planning phase, planners do cost calculations and layouts for ordering factory suppliers. However, for integration planning, the original concept and rough planning project have to be updated. Therefore, a new concept has been developed which uses current information from the cyber-physical system and a current 3D scan to update the bill of resources and the layout planning on demand.**

Keywords — digital twin, cyber-physical systems, concept planning, robotic simulation, 3D point cloud

I. MOTIVATION

The automotive industry has the challenge to require shorter product life cycles and to offer more individual variants [1]. The result of these trends is that a high number of variants have to be produced using the same production system [2]. These new variants such as sedan, coupe, cabriolet as well as combustion engine and electric models have to be integrated into existing body-in-white (BIW) production systems. For low-cost integration, the methods and models of the Digital Factory can be used. According to a survey, the methods and models of the Digital Factory can avoid approximately 70 percent of the planning errors, reduce about 30 percent of the planning time, reduce about 15 percent of the change costs and increase the planning maturity by roughly 12 percent [3]. The digital models and methods for production planning are essential, critical parts of the Digital Factory to increase quality, reduce costs and process cycle time [4]. Hence, an on-demand created Digital Twin forms a major future component of the Digital Factory.

At the start of production (SOP), the Digital Factory has a current digital model of the real production system. The robotic simulation as a key part of the detailed planning phase, where the engineering is performed, offers a good image of real production. However, requirements do not remain stable as the factory, its resources and structures go through a continuous change process [5]. Possible triggers for a change in existing production systems are new products, changing requirements, new technology [6] as well as model upgrades [7]. The implementation of such changes in a real production system leads to a changing planning state which has to be regarded and evaluated [5] with the Digital Factory. Sometimes these changes will not be documented sufficiently in the original planning projects [7]. At this time, planners already work on future projects, and the original planning projects are not updated. Furthermore, a manual update of the original concept planning states would cause high costs through a larger workforce.

In future, it will be essential that the knowledge of existing processes, real conditions and configurations of the factory lead back into the digital model [8]. This would enable a basis of current resources and current structures for further integration planning or further development of new production systems. [5] [9]

Otherwise, production planners face a significant challenge when integrating new vehicle BIWs. Only if the Digital

Factory reflects the current state of the real factory can the planning states be used for integration planning [9]. To face this challenge, the Digital Factory needs an on-demand created Digital Twin which reflects the current state of the real factory in detail. Such Digital Twins of the factory would support concept planners and robotic simulation engineers for integration planning. Concept planners and robotic simulation engineers would gain a quick overview as well as detailed information through the Digital Twin for their integration project. Furthermore, it would support product developers for product influencing at an early product development state. With a Digital Twin of the production system, they can influence the new product development in a better manner. That would enable better product integration into the existing production system.

In section II, the state of the art as well as the research gap are described. Section III presents the concept for creating a Digital Twin of production systems. In section IV, a case study of the concept of real stations in a body-in-white production system is presented and discussed. The conclusion and further work follow in section V.

II. State of the Art

The National Aeronautics and Space Administration provided one of the first public definitions of a Digital Twin in 2010. This Digital Twin was used to mirror the life of its flying twin and is described as an integrated multi-physics, multi-scale, probabilistic simulation of a vehicle or system that uses the best available physical model [10].

Since this point, the Digital Twin was used in production, especially in simulation and virtual commissioning. It has often been described as a software model for the development and testing of different configurations [11] [12]. Nowadays, the Digital Twin is defined as a realistic model and a current state of the process and the behavior of the real objects with its structure and all elements that are connected to it [12]. Furthermore, there are different Digital Twin models of highly-detailed simulation models, for example of spacecraft, airplanes or parts of airplanes such as a gas turbine that tries to reproduce its physical behavior [13] [14]. However, the Digital Twin in the simulation aspect is just one of many concepts which have to be considered. There are also the planning and operation of a plant. [14]

This paper is about a Digital Twin in planning, particularly the concept and rough planning projects in the Digital Factory.

After the internal concept and rough planning with cost calculations, resource planning and layout, the automotive original resources manufacturer (OEM) instructs suppliers to build the assembly [7]. The supplier who builds the assembly line carries out all engineering steps and the detailed planning with equipment design, robotic simulation and virtual commissioning. In this phase, detailed 3D models are designed by using CAD (Computer-Aided Design) software tools [15]. The robotic simulation is a key part in the detailed planning phase; here, the individual manufacturing cells are imaged in detail. Thus, it is also often called cell simulation. In robotic simulations, the robot programs are designed as well as the detailed robot motions simulated. The robotic simulation is one of the last engineering steps and contains detailed information about the installation and the position of the devices. According to the robotic simulation, the real cell will be built. After the production system is built and production has started, there will be some changes; for example, through optimization of the production assembly, new safety regulations of the assembly as well as vehicle or model upgrading. Some of these changes will not lead back to the concept planning [7], whereby it is then not updated. At this point, the automatic creation of a Digital Twin of BIW production systems for the concept and rough planning projects is necessary.

There are many Digital Twins described in the literature [16], but there is no method regarding holistic, automated creation of the Digital Twin. However, there will be some changes in the real production system; hence, a Digital Twin is not in current state after a short period. This paper presents a solution concept to address this issue.

One solution would be the manual maintenance of concept planning states [17]. However, this manual maintenance of the Digital Twin by the production and maintenance employees or serial planners requires a workforce and is cost-intensive. This paper focuses on a solution for the automated creation of a Digital Twin on demand. This concept which has been developed offers a significant advantage for faster integration of new vehicle derivatives and variants through the creation of a Digital Twin of the production system. Moreover, a Digital Twin will accelerate planning and facilitate the commissioning of new production system parts [18]. With the use of the Digital Twin, planners can rely on the planning state and acquire up-to-date shop floor information easily. This can also be helpful for reusing an old production system. The Digital Twin in concept and rough planning consists of a current bill of resources as well as the current layout of the factory and faces the aforementioned challenge.

III. The Concept for Creating a Digital Twin of Production Systems

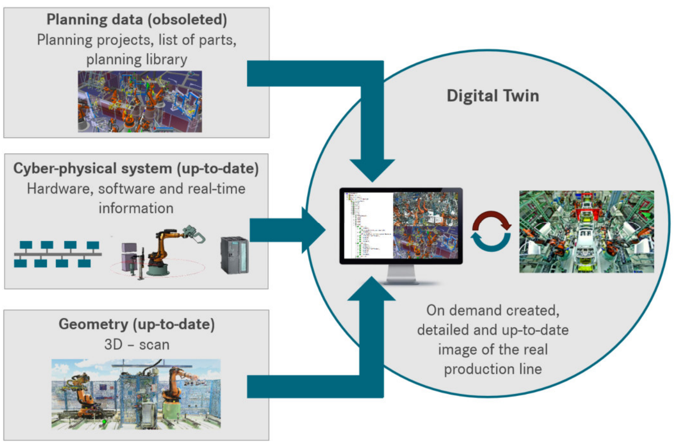

Figure 1: Basic concept of an automatically created Digital Twin

After the SOP, the responsibility of the production system transfers to other departments [7]. During its life cycle, there are many optimizations in the production system. The optimizations improve the production system to produce more quickly, or the production system must be adapted for a model upgrade. Sometimes these changes in the production system do not lead back to the concept and rough planning projects at the moment. For updating the bill of resources from old rough planning projects, the information about current hardware comes from the cyber-physical system (CPS). The cyber-physical system (CPS) is a set of embedded systems which communicate and interact with each other in a communication network [19]. The cyber part of the CPS can monitor and control the physical entity. On the other side, the physical entity sends data which can be used to update its virtual model [20] [21]. The idea that every electric device in production has its virtual counterpart [20] [22] is used to update the bill of resources in the Digital Twin for the concept and rough planning (Figure 1). However, the electric components do not contain any information about its position. This information cannot be detected through the electric and mechatronic devices in the CPS until now. Furthermore, there is no current information about factory ventilation channels, body shop transport systems as well as cable channels and safety fences around the production system in the digital model. Therefore, a third data source is needed – a visual or graphical admission which optimizes the layout of the digital model. This graphical admission can be realized through a 3D scan of the production system. The 3D scan can be used to update the layout planning very efficiently [23] [24] by loading the current point cloud of the factory directly into the planning project. Figure 1 shows the basic concept of the automated creation of a Digital Twin on demand. This is a Digital Twin with an automatized update of the bill of resources on one side. On the other side, there is a layout in combination with the real point cloud of the factory. With this data source, a very detailed Digital Twin of the current production system is created. To create a current Digital Twin for the concept and rough planning department, it is necessary to understand the different planning steps up to the production phase (Figure 2).

A. *Creation of a current bill of resources*

To create a current bill of resources in concept planning projects in BIW production, the method in Figure 2 can be used. The figure describes a reverse engineering method along the planning process in reverse. The figure shows a data fusion between the resources in the CPS and detailed planning data from the robotic simulation if in a current state. In the second step, this combined structure is mapped with a resource library. The result is an update to the obsolete rough and concept planning projects.

1) *Information fusion*

The essential data source for this method is the CPS of the production line. It delivers a current list with detailed information about the electric and mechatronic devices. This current asset information can be delivered in different ways. One method is an up-to-date network scan which shows all electric and mechatronic devices in the CPS. The second method is to parse the offline configuration of the PLC and robots in the CPS, which also offers all electric and mechatronic devices. Also, this method offers information about sensors and actors. [25]

The result is a current list of all Internet of Things-compatible devices from the CPS. These are intelligent devices which have an IP address and which can communicate with each other. In the first step, the electric and mechatronic devices are mapped with the detailed planning project (robotic simulation).

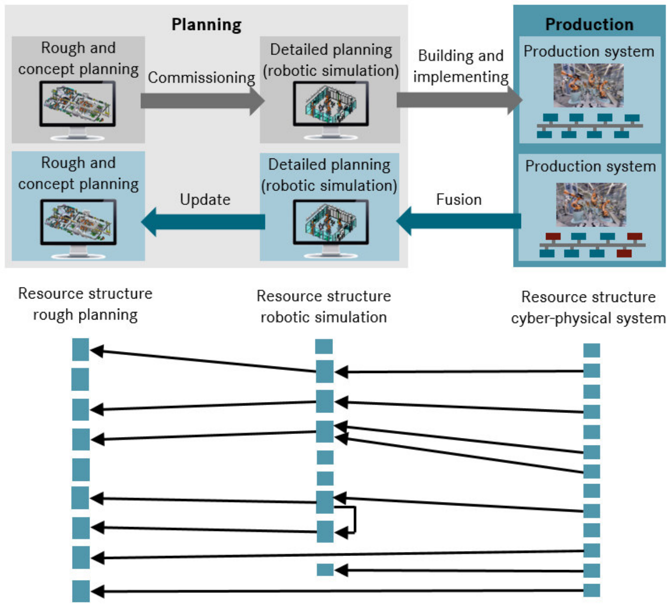

Figure 2: Mapping method to update the bill of resources in concept planning projects

Mapping is a connection between the real device and its counterpart in the planning library. For mapping between the electrical devices and robotics simulation, standardized naming of the components is required. Standardization is one of the most advanced implementations of products, processes and model solutions and forms the basis for instructing IT tools and methods [9][25]. This standardized naming must contain the function group, the device classification and a device number of the electric device as well as information about the location. The location information contains the production site, area, building number, production line, PLC area and station. The device classification describes what kind of device (switch, controller) is involved. The function group describes the function of each device; for example, if it is a robot or a gripper. The device classification, as well as the function-oriented names, are common in the engineering phase. The function-oriented device names are also provided in the robotic simulation. Hence, the electric and mechatronic devices from the shop floor can be mapped with the electrical and mechatronic devices from detailed planning. However, there are only electrical and mechatronic devices that can be mapped. Mechanic devices cannot be mapped because they cannot be detected in the CPS. In contrast to this, the electric part of the devices from the robotic simulation can be mapped. Consequently, this mapping is simply a mapping with electrical and mechatronic indicators. However, if this indicator can be mapped, this part of the production area has not been changed. Thus, the planned area from the detail planning phase can be adopted. By merging the different data sources with current information from the shop floor and using such electrical and mechatronic indicators, an additional benefit which also contains mechanical devices is created. Through this adoption of mechanical devices from robotic simulation, the rough planning of the Digital Twin becomes complete. If there will be new devices detected by the CPS that have no indicators in the robotic simulation, a particular part or area in the planning project can be detected which is obsolete. The new device from the CPS will update the bill of resources in the detail planning project. However, if the indicator device is not found in the robotic simulation, the mechanical part, as well as the position from the robotic simulation, are not up to date and cannot be used to automatically create the Digital Twin.

2) *Resources update*

The resources update is carried out by the mapping between the concept planning library and the combination of current resources from the CPS and the detailed planning – robotic simulation state. In the concept and rough planning, a resource library is used to accelerate the planning process that contains standard resources models [26]. The resource library consists of standard resources components which contain a general name and different library IDs for cost calculations. Consequently, in concept planning projects, there are no specific names. The challenge with the resources update is to implement mapping between the concept planning library and the data combination of the CPS and detailed planning. After this mapping, the current data from the information fusion can be transferred to a concept planning project. By transferring the bill of resources from the data combination to the concept planning projects, the positions in the layout are adopted from detailed planning. After these mapping steps, the concept planning projects are updated with a current bill of resources.

B. *Layout update*

The layout is largely updated by updating the bill of resources with the position of the robotic simulation project. Only components which are new compared to the detailed planning (information fusion) will be added from the CPS directly to the concept and rough planning project. However, they have no positions. The reason is that the electrical devices do not have the information about their exact physical position in the layout. Furthermore, cable channels, safety fences, and other aspects can differ from the detailed planning project state. For a layout update, one more visual or graphical data source is needed. One solution for a visual data source which can be used for a layout update is a 3D scan [23] [24]. Consequently, the third data source is a current point cloud of the production line. This procedure is the most challenging part of automating in the future.

To create a 3D point cloud, a 3D scan of the production system is required at different measure points. The 3D measurement can be taken with a terrestrial 3D laser scanner [27]. To generate a 3D point cloud, the 3D laser scanner measures the distance by emitting laser-beams at surfaces and capturing the returned reflection. For a data overlap between the planning model and a 3D point cloud, it is necessary to have the same coordinate system and coordinate basis as the 3D scans. Thus, a uniform coordinate system during all planning phases and 3D scans is necessary. After merging the different laser scans, it is possible to select a particular part of the production system and load the point cloud into the planning tool. This technology enables planners to detect differences between the layout planning and the real production system.

IV. CASE STUDY ON A REAL STATION IN A BODY-IN-WHITE PRODUCTION SYSTEM

The following case study demonstrates the implementation and evaluation of this general concept for automated updates to planning projects on a real data set. Figure 3 describes the action of this case study. There is a Digital Twin application which uses the mapping method of Figure 2 to map the resources from the CPS and robotic simulation with the planning library. This application contains different functions; one of these is an AutomationML (AML) export function. This export function creates a current AML resource structure for rough and concept planning projects.

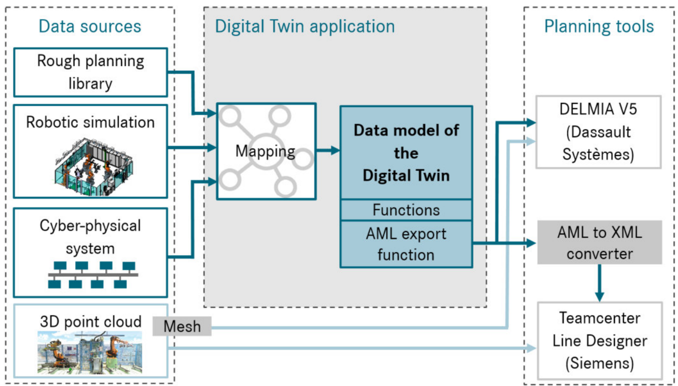

Figure 3: Automated update of concept and rough planning projects in the Digital Factory

To verify the described concept, two leading planning tools (DELMIA Process Engineer DPE V5 and Teamcenter with Line Designer) were used. For DELMIA, there is an internal AML interface to import the resource structure. However, for Teamcenter, there is no AML interface available. Hence, the existing PLM/XML interface was used to import the structure. The AML structure was transferred to PLM/XML through an AML to XML converter.

On the other side, it was necessary to mesh the point cloud for the 3D scan overlap with the digital model in DELMIA V5. In the case study in a real automotive BIW production system, two example stations were automatically created with this method based on the CPS. These stations (station 20 and station 30) are three years old, so the model updating stands as before.

A. Creation of a current bill of resources

1) Information fusion

After acquiring the device list from the CPS, the devices can be dedicated by their long standardized name code to the production site, area, building number, production line, programmable logic controller area (PLC area) and station [25]. The resources of the CPS are ordered from a flat list (network scan/offline parsing) to a hierarchical list as it is used in the bill of resources in planning projects. After ordering the devices, the information about the location is not needed. Hence, in the following, the electrical device will be illustrated with its short variant of the standardized name, which contains only a three-digit station number, a three-digit function group, and a three-digit unique device number. The function-oriented naming comes from the engineering phase and is used for all constructive life cycle phases.

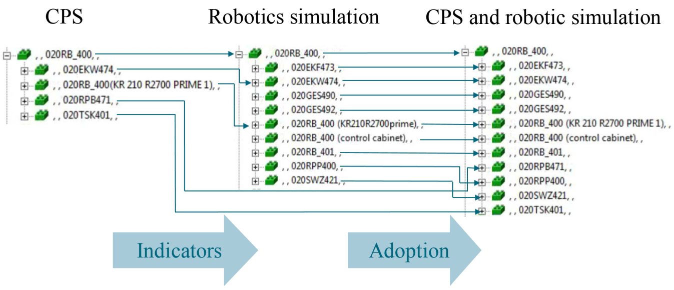

Figure 4: CPS indicators and adopted robotic simulation resources

In this information fusion step, resources from detail planning will be adopted by current devices from the shop floor by the CPS. The resources from the CPS are considered on the left side in Figure 4. Some of these function groups can act as indicators if the robotic simulation is in a current state (Figure 4, center). On the right side in Figure 4, there is the combination of resources from the CPS as well as from the robotic simulation.

Investigations of approximately 70 stations have shown that two-thirds of the functional groups in the detailed planning can be mapped with the functional groups in the CPS. Example indicators are loading magazines, the geo stations and the robot modules such as in the robot modules, grippers, resistance welding controllers, the measuring system controllers, sealer controllers and electric tipchangers, for example, that mechatronic device can act as indicators. These indicators of the CPS can detect if some parts or some PLC areas have changed in reality compared to the robotic simulation project state. All of these defined indicators can be found in the robotics simulation, which means the robotic simulation is up to date and the mechanical parts from each module can be adopted through these indicators. With these indicators, the robotic simulation can be checked if it is up to date.

An excellent example of this adoption method is the electric tipchanger, an indicator that is included in booth data. The electric tipchanger and the resistance welding controller belong to an electric tipdresser and a welding gun in the robotic simulation so that this component can be adopted. Through this method, a full up-to-date Digital Twin is yielded. Furthermore, a significant advantage of this step is that the current position of each device in the robotic simulation can also be adopted and thereby used for the Digital Twin in concept and rough planning.

2) Resources update

After the fusion of the device from CPS and robotic simulation, it is necessary to map these resources with the planning library. Therefore, the combination of the devices is mapped to the counterparts in the concept planning library.

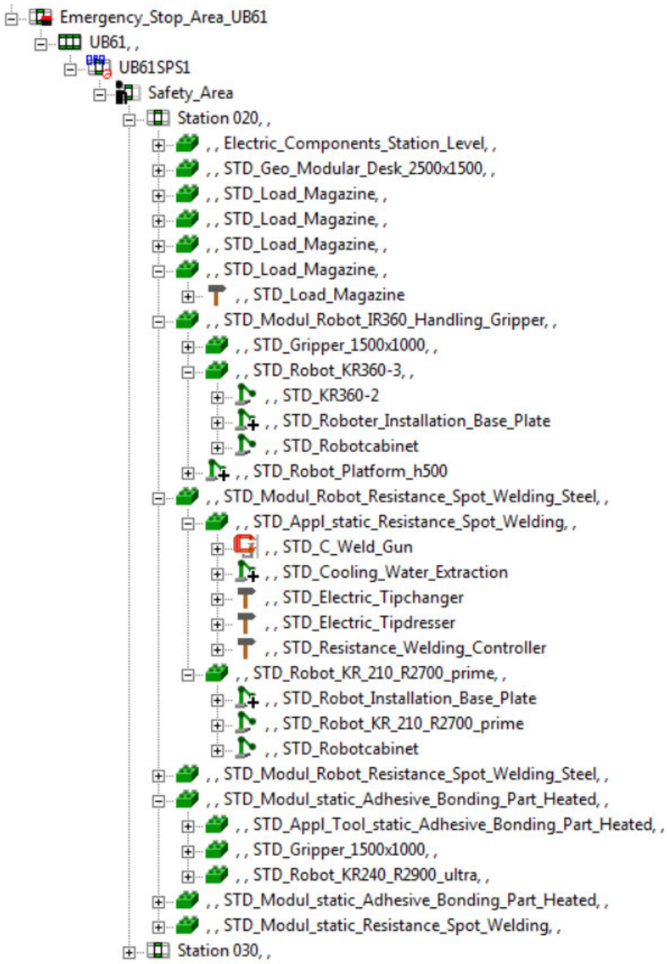

Figure 5: Example of the updated bill of resources in the concept planning of station 20 in DELMIA

There are also some devices which have no direct counterpart in the planning library because it is a simplified planning library for planners. In these cases, the combination of functional groups was used to identify these resources in the planning library. The updated bill of resources in the concept planning project contains exact positions and the library ID which can be used for a cost calculation by integration planning. Hence, the individual device names of each device in the CPS changed through the mapping to standard names from the library. As a solution for the mapping, a current bill of resources is generated in the concept planning as illustrated in Figure 5. In the figure, there is illustrated the updated bill of resources in the concept planning of station 20 in detail. The figure shows the resource structure in planning tool DELMIA Process Engineer V5. Through an AML interface, it was possible to load the resulting AutomationML file into the planning tool. Teamcenter has no AML interface at the moment, so it was necessary to convert the AML file to PLM/XML. Through this step, it was also possible to load the current resource structure in Teamcenter and use it in Line Designer.

B. The layout update

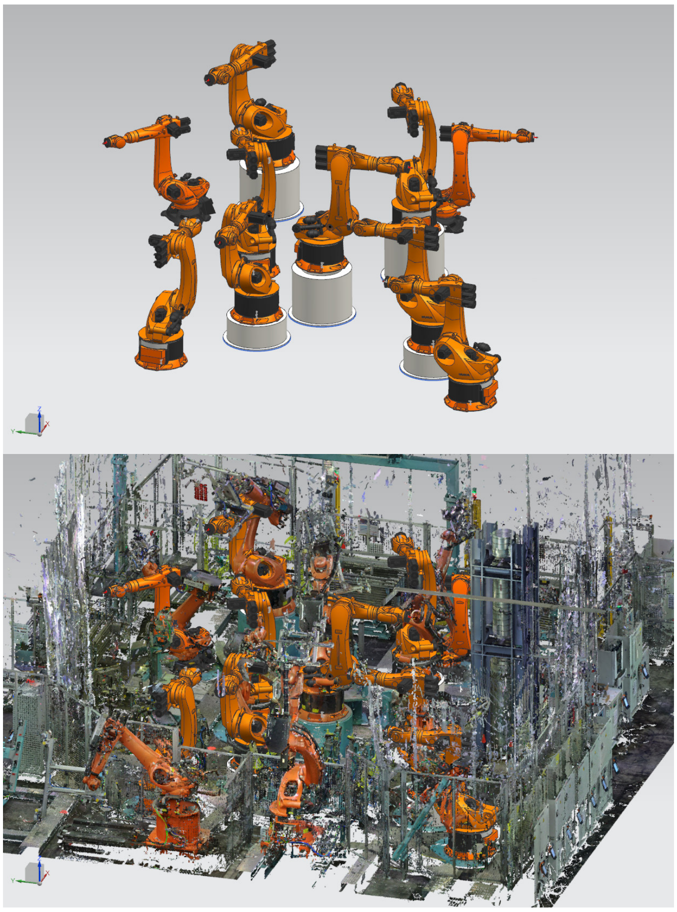

Figure 6: Example of a digital model and a 3D point cloud overlap of automatically created robots from station 20 and station 30 in Teamcenter – Line Designer

In addition to the update of the bill of resources, a 3D point could is used. Each 3D scan has taken between 3 and 10 minutes, depending on the resolution. After scanning the production system, the resulting current point cloud from station 20 and station 30 could be chosen. Afterwards, this part of the point cloud was uploaded directly into planning tool Line Designer. Figure 6 shows the overlap between the digital model and the 3D point cloud. In this figure, the fundamental principle of the concept is shown and the positions for the robot and robot platform from station 20 and station 30 are adopted from the robotic simulation to the concept planning. This digital model is overlapped by the 3D scan of station 20 and station 30. With this comparison, differences between the planned layout and current shop floor devices, the detailed deviations between the robot and its positions can be detected. However, if a planning tool cannot load the point cloud directly, it is also possible to mesh the point cloud and load the mesh into the planning system. For planning tool DELMIA Process Engineer V5, the current point cloud needs to be meshed. After this step, it was also possible to load the mesh into the tool and overlap it with the current planning model.

C. Discussion

Figure 5 illustrates that an automated update of the bill of resources in concept planning is possible. Furthermore, the combination of functional groups such as grippers and resistance spot welding (adhesive bonding) can be found in the concept planning library as well as in the combination of the robotic simulation and devices from the CPS. However, there are also some components which are not included in the robotic simulation but the concept planning and the CPS. Hence, some devices can be mapped between the CPS and the concept planning library directly. Furthermore, there are also some challenges to mapping with the planning library. In the planning library, there are different models of grippers, for example. The function group of a device alone does not show the kind of gripper. For mapping in this use case, it was necessary to include the number of stretchers and clamps for the mapping with the right gripper as well as the geometry in the robotic simulation. In the examined production system, there were no Internet of Things-capable sensors and actors. Hence, the right number of stretchers and clamps was only given by parsing the offline configuration of the PLC and robots in the CPS. Another example of this challenge was mapping with the modular geo desk. There are also different modular geo desks in the simplified planning library. Here, also the number of clamps and fixing pins as well as the geometry of the desk in the robotic simulation were needed for the mapping. Another challenge was the accurate mapping of the robot platform due to the fact that there are different platforms which differ in height. This mapping was allowed by the calculation of the robot height from its position in the robotic simulation. A further challenge is the mapping of the adhesive bonding process. There are different adhesive bonding processes in the planning library, such as full heated and partly heated adhesive bonding. For this mapping knowledge about the planning process, it is necessary to perform the right mapping in this case.

The updating of the position with the adoption of the positions from the robotic simulation delivers an excellent basis for the layout (Figure 6). However, new detected resources from CPS have no counterpart in the robotic simulation; hence, they have no position. These new resources can only be positioned manually by overlapping the 3D point cloud. Through the overlapping of the point cloud and digital model, the manual correction of the layout by a planner is expedited. However, there will always be a difference between the point cloud and the layout from concept planning because the planning library is modeled with simplified constructions for a concept. At the moment, there are no cable channels and safety fences in the rough planning layout. Due to the 3D point cloud, it can be considered in concept planning. So at the moment, the layout of the Digital Twin consists of the digital model of the resources and the point cloud. The 3D point cloud enables direct visualization of the safety fence, cable channels, and building parts.

Through this general concept for the automated creation of a Digital Twin, it was possible to update the bill of resources with current information from the shop floor as well as update the layout with a point cloud overlap. Through this combination, a current Digital Twin of a BIW production system is created. Although there are some challenges to be faced, this example shows that a general concept for the automated creation of a Digital Twin by the CPS and a 3D scan is possible. Regarding the original concept planning state, it is necessary to update the bill of resources as well as the layout. In the original concept and rough planning phase, there was no robot module adhesive bonding planned for station 20. One reason for a difference can be a late update of the product by the body-in-white product development. There are many differences as the update of the original concept planning projects is economized for station 20 and station 30. An analysis of a production system of approximately 70 stations has shown that the number of robots differs approximately 10 percent between the last rough planning project state and the real production system.

The case study exhibits that concept planning and detailed planning can differ for individual modules. Such changes between the concept and detailed planning (robotic simulation) show that this method with two-step mapping is convenient for generating a Digital Twin of the production system for concept planning. This offers an advantage of the described mapping method. In the method, the resources from the CPS are used to update the concept planning state over a loop way via the detailed planning instead of directly with the concept planning phase. This appears to be a good solution because there can be substantial changes between the concept planning and detail planning. On the other side, it is also possible that there are some differences from time to time between the CPS and the detailed planning (robotic simulation), which were not the case in this example. The production system was just three years old, and the module upgrading stands as before. For this case, there was an advantage of the two-step mapping because of the characteristic, function-oriented naming of the engineering phase such as the same unique standardized device names that interconnect the robotic simulation and the electric and mechatronic devices from the CPS. In this way, the dimension of a change can be detected. Another advantage is the detailed position that can be adopted for the resources which have not changed. This general concept shows that such costs of a manual update for a concept planning project can also economize in future through the automated creation of a Digital Twin.

V. Conclusions and Further Work

A. Conclusions

As seen in the case study, it was for the first time possible to create a Digital Twin automatically through current information from the cyber-physical system. It was illustrated how to create a Digital Twin of a body-in-white production system for rough and concept planning projects. The automatic creation of a bill of resources through mapping form robotic simulation and the CPS makes a Digital Twin for concept planning more accurate. Furthermore, it offers the possibility of an automated update on demand. This paper shows that the general concept to create a current resources structure and update the layout works.
The following points summarize the result of this case study.

- Substantial engineering costs can be saved through an automatically created update of planning projects, and the start of production of new products can be accelerated.
- The case study illustrates that an automated creation of a Digital Twin of the concept planning through the described concept is possible.
- There can be a large difference in the bill of resources between the concept planning and the real production system.
- A major future challenge is the mapping between the resource library of concept planning and current device information.
- An easy standard data exchange or a shared data backbone for the concept and rough planning, detail planning, and the real production system would solve the described challenge.

Through such an automated creation of a Digital Twin, a great deal money and time can be saved. On one side, there is the money that can be saved through the creation of a current concept planning state instead of manually generated documentation. On the other side, a great deal of money can be saved through a more independent mandate for follow-up orders. This is enabled through detailed information about the production system by using the Digital Twin. Another benefit is that product planners can influence the development of new cars by current production data from the Digital Twin so that it can be produced more accessible with the consistent production system. The most important advantage is offered through the Digital Twin for production planning by integration of the new vehicle and vehicle derivative into the existing production system. This is given by saving time through a quick inventory of planners. Furthermore, they can acquire more detailed information about the layout by overlaying the 3D point cloud of the real production system with the digital model.

B. Further work

As seen in the case study of a real BIW production system, there are some unsolved challenges with mapping, such as the diversity of resources in the planning library. Future work will be the analysis if the mapping can be optimized through implementing background knowledge from planning as well as machine learning methods. A significant challenge can also be that more detail information is needed to challenge the diversity of a planning library. So one of the further essential work projects will be the improvement of the mapping between the current data from the CPS and the planning library from concept planning. Another step will be to transfer the concept to other production systems, production areas, and other production sites.

However, another significant further development for a Digital Twin in concept planning would be a common and central data backbone for the entire planning, construction, engineering and production phases. Such a data backbone can be realized through shared databases. Also, other current data from software or from running processes of the CPS which is essential for concept planners such as current information about individual cycle times and the degree of utilization of the stations, robots, and individual processes in the production system will be needed.

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