Confidential Anonymized Focus Group Transcript

Theme 1: Industry 4.0 and configuration of production

P#6: Now, think back on a situation where one or more machines are part of a production – what should be in place to execute a production task?

P#2: Interfaces across machine and between the machines. A connection on the site – stable connection that secures connection between machines. A clear workflow – so systems/subsystems are aware of what they should do.

P#3: The intuitive usability, so the interfaces, or the ease to be able to reconfigure or adapt. Because the fact is, that these systems need to be continuously adaptive, so they need a way to operate adaptively and very flexible.

P#4: I think simulation is a key to working with architecture, and it would also come in the direction of AI, ML, and real time monitoring. If the manufacturing processes can be digitalized through the interface components, it opens the door for my exception of I4.0.

So, with ML, Simulation and AI we discover how big the step is before we actually can connect in a digital way.

P#1: Some of the items we are looking at is monitoring standard for metrics and events, and sandboxing. So, if you make changes to your setup, you can actually sandbox it, before you deploy those changes. We are also looking toward standardization and beyond OPC-UA, which has had a very slow adoption, we are also looking for how to standardize the interoperability capabilities of our robots and other shopfloor equipment. It is an immature space. It is also deployment of control systems and the ways they operate. We talked with Siemens and many others and all have their own proprietary solutions for deployment and shopfloor machinery interfacing.

P#2: As companies invest in I4.0 systems, they would also expect high availability, because the cost of interruptions/disruption are exceptional growing, because it is a chain of events, there will not only be one machine stopping, but there will also be a chain of machines or process stopping. So, there should be a high availability promise. Clear KPIs that are set by manufacturing managers. Redundancy, failover and policies in that direction should be set to support those KPIs and high availability. Because risk is great for the manufactures. So that are also some of the key elements to the systems.

P#6: Can you mention some cases where you had to configure machines?

P#1: Remote access..., but there are also cyber security concerns, this has also become a big thing. Our system has an open API (which is a big issue) and it is up to our distributors/customers to configure the way our system operates and interoperates with other machines. We have a simple thing in the way we open and share controls of doors. It can be done in many ways. People usually set up an external module to communicate with doors where we can set registers opening and closing doors through a wise module. We also have elevator control. The first solution was to have elevator control in the robot so it could push the button on the elevator through the Wi-Fi. But as soon as the robot was in the elevator it lost connection to the Wi-Fi, because it was in a faraday gauge….., it didn't know when it was on the right floor. It lost its view of the world. We moved that capability to a central control instead. But sort of the protocol for interfacing/interacting with the elevator was a propriety thing done by a small company. We tried to move to a more open OPCUA

standard, but we still had defined our own interface. There are no standards for interacting with an elevator. There is OPCUA protocol, but we had to write our own drivers and interface. Our customers have to implement their own OPCUA servers that can interface with our elevator control. Our resources are not just ours; we have to share it. There are no good standards for sharing resources in a dynamic way.

P#2: Accessing machines on the shopfloor remotely is done in many folds. First, it is the setup phase, accessing them and connecting them. Not all equipment is cutting edge. There are legacy systems and legacy partners/skills. The architecture is not well through in the past decades. When setting up the system we are seeing requirement to have low code configuration interfaces or low code integration interfaces between systems such that non-technical people can connect the systems. This is an abstract requirement, but we keep receiving it day after day. Because not all know REST full interface, many are PLC backgrounded people on the shopfloor. Therefore, in configuration and setup phases we see a need for low code configuration wizard.

P#1: No two deployments are the same. People need to reinvent the wheel every time they want things to work. There is no standard.

P#2: There are many different systems, e.g. robotic, PLC, and safety .... What is the best deployment strategy that enables the highest performing connection across those systems? That is why Siemens is working on edge solutions to include all these solutions. They believe that configuration, setup, troubleshooting, error analysis, and everything will be more convenient, and the integration and connection will be more powerful compared to decentralized systems.

P#1: Are you P#6 working on a draft architecture. Is that part of your work?

P#6: Yes, we are working on investigating middleware software architectures for Industry 4.0 production.

P#4: Are we tapping into now - what it takes for our existing manufacturing lines to be rebuilt and updated so that they can connect to the story we hear here? When we put a new PLC in, we take some of the steps but not all of the steps. If we want to go the I4.0 digitalization journey, first, we must ask ourselves how much data to assess to interact with software in this way.

P#3: I agree with P#4. From our perspective. We see the world of functions or modules of functions. It would be a mix of third-party vendors. The challenge is to connect these systems. Expecting to control it would be further out because it would require a unified way of setting up machines.

We use PackML as the standard of programming and OPCUA as the communication interface. If we are able to control modules/functions with these standards, we see this as a huge first step.

P#4: Then the checklist is - what mechatronics products do we need to connect in this way? Because our components are too old to connect and get the data needed in the I4.0 digital journey. The industry should start a dialogue about how we rebuild our equipment such that we can connect into the software in the digitalization journey.

P#4: Here Alpha company is an important player. Is there some mechatronics product that can create the bridge between the information we need and then onboard partners that can build those components and connect existing manufacturing processes. Cross-competencies and teamwork are needed to make this successful.

P#6: How are the machines typically configured (steps) in a production?

P#5: That varies from printing out a paper that tells them what to do, e.g. turn on a dial, to the automated deployment of a series of settings for a long range of machines that do an automatic changeover. The essence here is the information about what needs to change for the next order in order for a successful changeover. You need to know what to change to, but also how to change it. What we see is missing is good modeling of the equipment. What happens is we develop equipment that is good for doing something, and it can stand on its own island for ten years and do well. But if you continuously want to update and integrate it with other equipment and the rest of the factory and automated flow and the supply chain, then that is not thought into the models. Whereas if we had models, what is where, what can equipment do, and where do I access information about this and that of the equipment?

P#4: We are still in the beginning of the journey; we are still prototyping....it will still take many years...

P#5: We do changeover all the time, we run something in for a few hours, or a few weeks, depending on where you are in the production. Then when you go from product a to product b you reconfigure the equipment. To reconfigure, you need to know what to reconfigure – you get a list of settings or a recipe for how to run product b in the best way. And then that needs to be transferred to the equipment. If the equipment is old, the transfer method is in the hands of operators, and if the equipment is newer and more connected, transferring is automatic.

P#7: Are those transfers standardized or individual from equipment to equipment. How is that handled.

P#5: They can be standardized, but the thing with standards is that there is one for every taste. You can have a lot of standards for different equipment, so yes, it can be standardized. One thing is to have the communication protocol established, and we all agree on we speak english, e.g. OPCUA, but that is not the same as agreeing on what we say and how we understand it.

P#4: Big topic we are talking about...Digitalization a few years ago was monitoring the uptime, and capacity. It was not more. Now we should inform the operator about the setting. On analog setups we rely 100% on the operator.

P#6: Who figures out how machines should be configured for the next production. Manual process or do you have a system to figure that out.

P#5: We have a predefined list of instructions, but we also rely on craftsmanship and skilled operators to make equipment run well. Sometimes the setup is totally locked to run in a certain way and other times the setup is adaptive where the operators optimize the process.

P#3: Changing the machine requires a recipe – which is manually – what we are trying to do is to connect machines e.g. AGVs, robots, a longer line of machines. Two different things are happening. Distribution of the order recipe and the coordination of the functions.

P#5: The configuration is the operation to perform when you do a changeover. But when you produce and when the equipment begins to talk with other equipment further down the line or call for an AGV or tells planning that the order is complete or tells the operator that something is wrong and you need to come and fix it, is totally different story.

P#3: Agree – things we have been discussion is when we get mechatronics systems where we are able not to only transport boxes items, but on an item level, the ability to connect – when pieces become items – the trackability of items is something we have been interested in to part of the

software. How do we do that – how do utilize that- how do exploit that in mechatronics systems where we have unique transport of the items.

P#4: Traceability is central in this digitization, close to not existing in today's digitization. We are under the way – we are touching it – but this kind of traceability - we make automatization, but we are lacking traceability which is central in the digital thread which is central.

P#7: What is the specific level of traceability, on an item level?

P#4: If we go in the direction of a closed loop, ML and AI then we need the data so that we have the traceability. We can compare the data, we can find the root cause, we can find the deviations and so forth. That is what I think is part of the digitalization. The software is the computer power that tells us where the deviations are. When we have the knowledge, then we can change the setting based on closed loop regulation and have an adaptive production setting.

P#3: Traceability in my mind is linked to a production process – let's say, we are assembling items, so for each process we should be able to trace the unique item that has been handled and the process is either ok or not ok, and what are next step etc. All of this is possible because we unique identifiers throughout the process of the process steps. It is available – the ability to increment the knowledge of what's it going on – if you what do a really fast changeover – one of the benefits with mechatronics systems is obviously you can do it – but we also know we went through process step 1 and 2 out of 10 – we know when we enter them we can trash them… we can do that intelligently now – before we had to clear the whole line and get rid of all – the knowledge of what we have been though is so valuable, e.g to cost optimize line clearances.

P#4: We need machine learning; we use the sensors in a smart way – and we let the ML adjust the process. Then the ML helps to discover what the setting produces the highest procession for our elements.

P#3: Agree – but the first step is to connect and then we can use microservices and ML. But we need the base in place first.

P#4: Then we have Beta company that has sandboxes. And how do we utilize the I4.0 lab in relation with Industry. There is a huge distance between where we are today and when we talk about the future.

Theme 2: Reconfiguration of production

P#6: Now, consider you had to specify requirements to the software that could change/reconfigure a running production.

Now, I want you to collaborate about the steps or journey changing the production from a software perspective, e.g. going from one production to another production - what should the software platform be able to do

P#1: Iteratively change the production while it is running. You need to access those changes using data. You can start by testing the changes in a sandbox, after which you can deploy them. Many of the things done today are based on gut feelings and experiences. Rather than doing a complete change of the production, you need to be able to, like you do with software, do the revisions incremental. Then you need the tools to observe incremental to monitor the KPIs and the differences in production efficiency. It eliminates the gut feeling that it runs better today and so forth. You need a system that monitors the efficiency of production. Because the efficiency of the

production – depending on how dynamic the production environment – it is different every day – you cannot just make an incremental change and then look at the day after and conclude it runs better today than the day before – you need a long term data set – it is not that easy to evaluate upon – but the incremental steps to improve your production is key – the ability to monitor the events/performance/metrics /interventions – it is all about getting the data – once that is in place you can do predictive algorithms that replace the gut feeling that is more objective … making it evident to the operators on shopfloor that actually runs better – how do we explain it ….

P#4: When we look into tool manufacturing processes – we create molds – we try to design a fingerprint strategy – every time we move one step forward in the manufacturing process – we get feedback telling us we are in control or out of control – we are not there yet. We are working on this quality assurance process. In this process, we have full traceability of the BOM, and cutting tools this way, we begin to capture the data and then take first major step in this direction.

P#3: Equipment are connected – what are the steps to reconfigure – we know the different paths we know the different configurations – not changing the layout every - we have mechatronics modularity – you have diverse path using AGVs etc. – we have functions that we can drag and drop – these function have behavior – if is a conveyor we can set the behavior – it is programmed into these modules which allows us to call functions on it – than we connect it – than we can deploy it in our recipe and the distribution of production order - and then we can simulate it - then we can see how it would operate if it was the first time – then we can deploy it onto real setting – rearrange the modules – and because it is mechatronics it adapts easily physically - and the software reconnect the operations in this sense.

We are seeing the need to define the modules and show the capabilities of different layouts using the different technologies is where the real value. Then we can apply ML.

P#1: What about legacy systems….

P#3: Yes - use them or position them in the most optimal way in the production setup. Some will be in a transition phase where they are evolving a production because they are stuck with these modules. Or you are in a green field with new equipment.

P#2: In context of reconfiguration, preparation is key, digital twin and sandbox capabilities, validation of the potential change, justification of change, and data driven benchmarking before and after.

P#4: There is a minimum plug and play functionality in the process, software is able to plan the next change over, support the operator with the next step, a lot of craftsmanship is involved in the reconfiguration process.

P#6: What scenarios cause the system to change configuration?

P#4: We are demand driven, we also have high volume, what is most important might not be the most optimal.

P#6: So, when you get a new production order – what is the journey from receiving a new production to a new configuration in the production?

P#4: We are a big company. The molding we deliver to the warehouse where the changeover is minimal, and we do high volume production – after molding we are more demand driven when we go into finish packing and prepacking – but we still have many changeovers in molding.

P#3: But the challenge is changeovers will still be there. So either optimized way of doing changeovers or optimize by utilizing the exiting batch running - as a correlation with batch 3 using that instead not changing so many machines – the other way is to build flexible flows, cause we been doing simulation with pharma companies – and what that shows is, by increasing the number of available machines – no the component of a changeover is constructed by the productivity of the machine – the time you consume in doing the changeover check while you are doing the line clearance and the ramp up and ramp down. These are the components we need to challenge, and the first one , the performance of the machine, we close to be very high on the optimization of the machine, but if we want to challenge the ramp up and ramp down, we need to optimize the path and the availability of the production modules and this were we generate parallel tracks or multiple tracks into production areas or using AGVs bringing components in so that we don't have to wait for it. So, what we are looking at is to find a modular, that could be an intelligent module in the path using ML to optimize the optimal path to optimize changeovers. It is an intelligent fleet management.

P#6: Do you see any particular responsibilities in the software that handles a reconfiguration?

P#4: What we are starting here – all the masterdata to run the production is handled in the software – all the instruction is for example given to the operators by the software – traceability data should help to figure out the optimization and deviations

P#6: Could any of you imagine to close down production when reconfiguring or could it be done when the production is running

P#4: from my point of the software will tell us when we need to close down and make a running changeover… it would be a big step if the software could tell us the most optimize way of doing changeovers, with a minimum of change overs

P#3: Agree – we have seen it many times in discrete event simulations showing double modules – double stations of whatever is the bottleneck during changeovers – it pays back so fast in reduced changeovers. We shouldn't have any downtime. That is the target.

P#6: Can you think of any criteria for carrying out a reconfiguration successfully?

P#3: Obviously reduced downtime, and this dual processing or redundant which gives a backup if things are failing.

P#4: P#5 you have been working with digital changeovers in many contexts – also to bring the changeover times down – and capturing the learning and variance?

P#5: That really depends on what you are doing – if I was manufacture of windmills then I probably would be more concern with finishing the windmill more than if I spend half a day on changeovers to the next products – whereas if I do high volume with a lot of changeovers then I would be concern with my changeover time – and I some cases I would be worried about my planning – but again if I had five planning people using a system deciding what 200 people do every day , where would I then put my efforts in order to optimize – would it then be better to look at if I could optimize the same work with 150 people instead of 200 people. Making a generic statement of the integration from the ERP to execute a production for any sort of production is a little far from my head. That said, many of the things are interesting things and trends we desire, but the answer will be different depending on where you want to apply it.

P#4: Maybe we could show alternatives – maybe that is the feedback – because we are stuck with our procedures and what we did yesterday – so how do we make it visible and show there are smarter alternatives. Don't you think it could be one of the benefits of this software?

P#5: Absolute- it is not crystal clear to me what this software will do – but if that is the case – sure, yes.

P#2: We experience it varies from zero downtimes to a system that is predictable, and I can schedule a downtime for a change.

P#1: No dynamic changes are not welcome – the system is dynamic, so if you introduce dynamic behavior in the software, then it becomes even more unpredictable – but of course, making the system more intelligent solving problems by itself – but what's important is to inform the user about the decisions – give proper feedback if something is not working well – give proper information about Manuel interventions to do error handling in the system – it is so important to give this level of understanding – for instance if the robot takes another route – we need to inform why the robots do so. It is pretty complex. For many years we have been doing the robot good, going from one point to another point. Now we need to make that behavior understandable. We are working on more centralized control of how the robot takes the journey from a to b.

P#2: Evolution in the shopfloor – going from independent disconnected - Now when you are more integrated, you should be more predictable and accountable towards upper systems and parallel systems.

P#2 and P#4 discusses: Paperless, multiple sites; blueprints for other sites – plug and play; reusability of existing configurations.

Theme 3: Introduce the template

P#5: It is very broad in the sense of what goes where – I am firm believer that if we want I4.0, we have to enable our systems or equipment to interact and have events that can be triggered – but I don't think we create one golden system that could work for any production - it would be hard to create the same system for Gamma company.

P#2: Two AGVs, with different payloads, two different configurations – a change that only affects one machine – reconfiguration that doesn't affect other machines – adapt with no code.

P#3: what you are trying to achieve is to write a sequence events of the control functionality of the changeover – the AGV example is just behavior or adaptability of possible paths it can take that belongs to that module – part of accessible operations you can choose in that recipe – what you are trying to define is based on the capabilities of the module layers – we can only be flexible within the capabilities that we have – to me it looks quite ok.

P#3: How deep down do you want to be modular? If you take different types of processes. In molding, change the molds. In assembly, you need to change the tools/grippers. If it is packing, you need to change it to different sizes. Then you need to define what is mechatronics, e.g. what is flexible, then it is the modularity of the path – this draw of different variables is very important to understand in the transport systems, in the transport of components, in the operations, and on top of it what is actually needed to change with software. We are shifting from stiff mechanical systems to flexible mechatronics systems that can easily adapt themself or can be adapted with 3d grippers – then they can have multiple functions, or they can be changed – intelligent adaption with fixtures –

because then we can change it with software. We are capable of being flexible, which sets demands to the software.

P#4: We need to use our masterdata in another way in the software. The masterdata is the key. For example, if a new cell needs to be connected, we can use the masterdata to simulate if there are some gaps in the way it's connected. We need a systematic way to calculate the smartest changeover. Maybe you are touching on the information here, else we would see it when we begin to work with it, meaning what is covered and what we are missing. It's a starting point.

P#6: What are the most relevant parts of the template?

P#3: I think there are some base functionalities that are outlined here. But then I need, is the ability to add parameters – adaption parameters on the modules – what are the terms of flexibility of each module – there will come standards – streamline types of flexibility areas in the system – it covers the base functionality – the ability to track and trace is important.

P#4: If the output is handling that information in the system – when I have this data – if I then put a new order in the system – from the system there is no gap in what I need to make this production – I know how long the changeover time takes – I can see the price for electricity – I know the price and I know the time – then you know all the surprises for a changeover.

P#6: We have an assessment part, which is what you are talking about?

P#4: Yes, it is a good selling point – if we can predict the things beforehand within the timeframe within the price.

P#6: We also have validation part contained in the assessment part.

P#4: I don't know how much we are collecting – how much learning there is - when you start the production - cause in some ways – that is the feedback from after production reconfiguration – that you know we can adjust in that and this way – we can do it smarter next time – I think when we work with data in a systematically way – productivity will come when we find the deviations that is not wanted –

P#6: Would the template help you in (re)configuring your own systems (why/why not)?

P#2: A recipe to a change?

P#3: It will help the end-user in defining requirements to suppliers – for instance , this component reconfigure that component or whatever we should call it – it is a missing hole today – it is not there and that is why we don't see full utilization of components in a consolidated way of collaborating – and that is exactly what you are testing out in the lab – and the optimization on top of this – these components are not present because there is no standard for specifying such requirements – what the guideline is needed for - to bring such thing in a market by machine … or technology providers – we can be promoters of it – but no technology provider would take such a thing as granted – it should come from the end-user, because we believe in this way of connecting things so this is how you should build it. Then it could help the IT department to support the integration.

P#4: It is a specification for an open I4.0 platform – so the supplier of software/hardware is plug and play – isn't it?

P#3: Yes – a uniform way handling different units that you buy into your equipment park. Exactly.

P#4: This template is helping to create minimum interface to connect manufacturing line into this paradigm – that could be cool – examples on that could be useful.

P#3: This is what is happening in the I4.0 lab – this kind of connectivity – orchestration of modules.

P#4: Then it could be cool to say – you need this kind of description or reconfigurable checklist to ensure it is plug and play and would be starting point for a dialogue for standardization

P#4: And if we know we need some interfaces between what we have today and connect to this – then we know how to define this because I am pretty sure in the future, we need a lot of interfaces that can translate the data between the different brands without missing core information.

Round up

P#6: Do you have any other information that could help me understand the configuration or the reconfiguration process of a production?

P#3: If you haven't already – come and see different types of production on how they do changeovers – what is it actually they modify – so you get a physical feeling of what they are changing (more than what Gamma company is doing) – the vision here is to connect more processes seamlessly – I can support showing a machine build with full modularity with filling – full mechatronic flexibility – also with transportation track in the lab – I can give some background knowledge to the software

P#4: You are also welcomed to maybe show the counting machines.

P#6: What do you see as the biggest challenge at the moment when reconfiguring, e.g. handle the reconfiguration process, apply the configuration or to measure the success of reconfiguration?

P#4: End-user, change management, understanding of digitalization, productivity and automatization are winning over digitalization, accept that the I4.0 highway is data and digitalization (ML, AI, Simulation), but also what skills and capabilities it takes.

P#3: We believe that we have mechatronic components, component interfaces, structure of the code, and the machine that can interface in a unified way - but what we are missing is that connectivity – we need a broker - connecting these things in an intelligent way – the challenge is that we are lot of technology providers that may want to do part of it – for instance Beta company want to do some of the intelligent path planning – but where is actually best situated – because it is correlated with where is the best possible flow in that line – how should have that broker responsibility – that is the black hole we see.

P#4: We might not have talked much about it. But this digitalization empowers our operators. The process is becoming visible -they can see if they can produce the product – they can see the challenges – the main benefit here is to create a much better workplace. The benefit will not come without digitalization.

P#3: Besides the broker functionality - we also need to demonstrate the usability – when people hear about it they get scared – it is to abstract – we need to bring to some sort of teach pedant to do this – we believe the values lies within the changeovers – we call it the hidden factory – this broker that can optimize order recipes or flows in the factory – today modules are bought and lined up and they create bottlenecks continuously – this is the biggest challenge – you get inefficient machines into the factory.

P#4: Reconfigurable has been in the industry for a long time - maybe the digitalization has opened up for the real benefits for reconfiguration in productions – it is plug and play and you want to simulate and capture the learning.

P#6: Are there any other questions that we should discuss in this session?

P#4: It is work for many years

P#3: You have narrowed it down – you have a good perspective on the space where the problem is and trying to describe it.