MADE White Paper

Addressing production efficiency improvement in the digital age: a matter of information flow

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This white paper sums up knowledge and learnings about production efficiency improvement in the digital age drawing on the results from relevant MADE projects with the manufacturing industry.

Efficiency improvement: a top priority in the digital age

Digitalization as a lever for competitiveness

The Industry 4.0 agenda has proposed digitalization as the key competitiveness lever for manufacturing companies – especially for manufacturers that have to compete globally while producing in high-labour cost countries (such as Denmark).

Production efficiency improvement – whether to reduce costs or to increase capacity - has emerged as the main goal for Danish manufacturers interested in adopting digital solutions to innovate their production systems.

In 2017, to address the need for digital innovation in the manufacturing domain, MADE – the Manufacturing Academy of Denmark - established an entire platform dedicated to this topic: MADE Digital. This acted as a bridge between universities, research and technology organizations, and production companies, facilitating innovation projects where these three actors collaborated to understand how to identify, develop, assess, and implement digital solution in a manufacturing environment.

Translating digitalization into actual production value: still a challenge

Despite the major efficiency improvement promises, digital transformations have a core problem: they are often unsuccessful.

Research from 2018 showed that only about 16% of the digital transformation initiatives succeeded (De la Boutetière et al., 2018), and that only 10% of the digital transformation initiatives have translated into actual business value for the companies that started them (Geissbauer et al., 2018) *(Figure 1)*.

Only 20% of the manufacturers that engaged in a digital transformation journey had a clear digital transformation roadmap in place (McKinsey, 2016), which is considered a fundamental tool for succeeding in a digital transformation (Matt et al., 2016; Hess et al., 2016) *(Figure 1)*.

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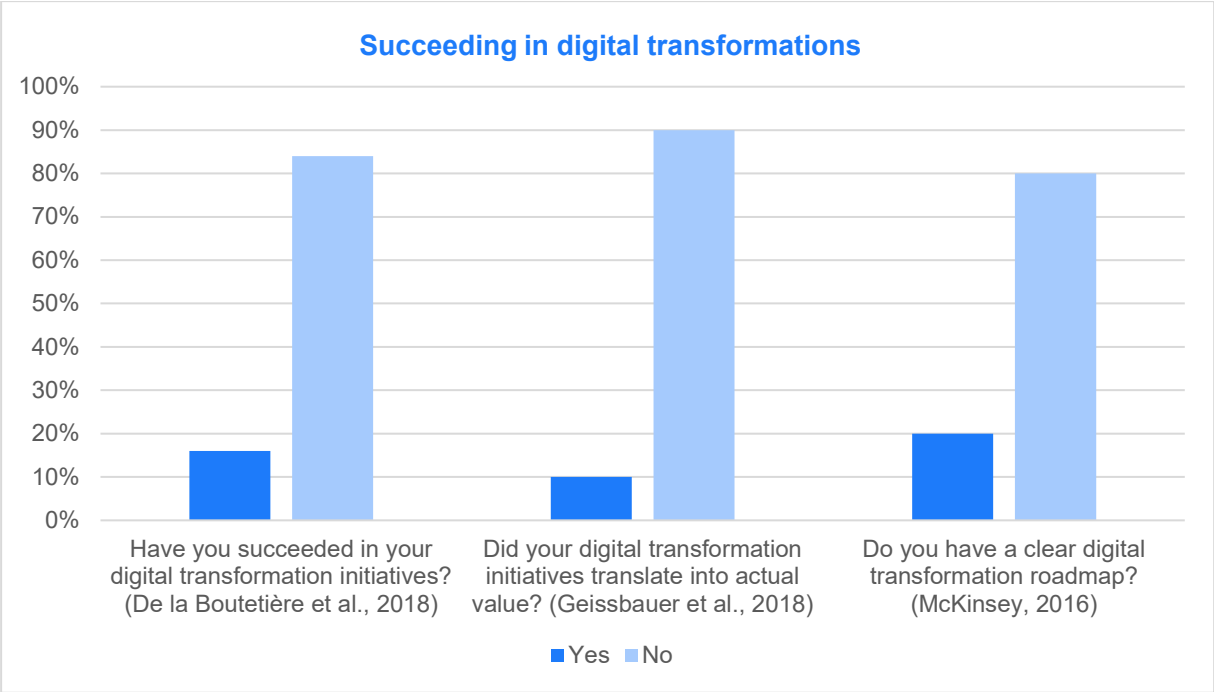

Figure 1 – Succeeding in digital transformations

The barriers to address

Fortunately, researchers tried understanding the causes behind the low success rate of digital transformation initiatives (Schmitz et al., 2019) – the most relevant ones being:

- The lack of a clear business case. This is necessary to justify a transformation project and get the allocation of the necessary resources to support it.
- The lack of short-term benefits, and of the projects to deliver them. This help generating the necessary traction for moving forward with the transformation activities.

To overcome these barriers, there are two key activities to perform:

- Quantify the potential of digital transformation projects, to enable the formulation and assessment of a business case.
- Prioritize digital transformation projects, to ensure short-term benefits acting as a foundation for a long-term transformation.

Making it happen: focus on the information flow

Identifying and prioritizing efficiency improvement opportunities: an old story?

The need for identifying and quantifying the impact of production improvements is nothing new. The Lean toolbox has been offering a very specific tool to do so: the “Value Stream Mapping”. This tool has been (and still is) extensively used by many manufacturers to map the production flow, systematically identifying non-value-adding activities and quantifying their impact on production efficiency.

Isn’t this enough?

The importance of the information flow

While Value Stream Mapping focuses on the flow of materials going through production, it has lately become clear that digitalization also impacts the flow of information which is increasingly necessary to support any proces on the production floor.

What to do then?

The idea of extending the Value Stream Mapping tool by including the information flow has then been operationalized with the "Digital Factory Mapping" approach (Colli et al., 2019).

But how does this new approach identify improvement opportunities by looking at the information flow?

Dealing with the information flow efficiently: a matter of digital maturity

The ability to process a flow of information depends on the data processing capabilities - and hence in the digital maturity - of an organization: the higher the data processing capabilities (and digital maturity), the more efficient the way a flow of information is processed.

A way to identify where to intervene for enabling improvements is to spot all information flows where the data processing activities are performed inefficiently *(Figure 2)*.

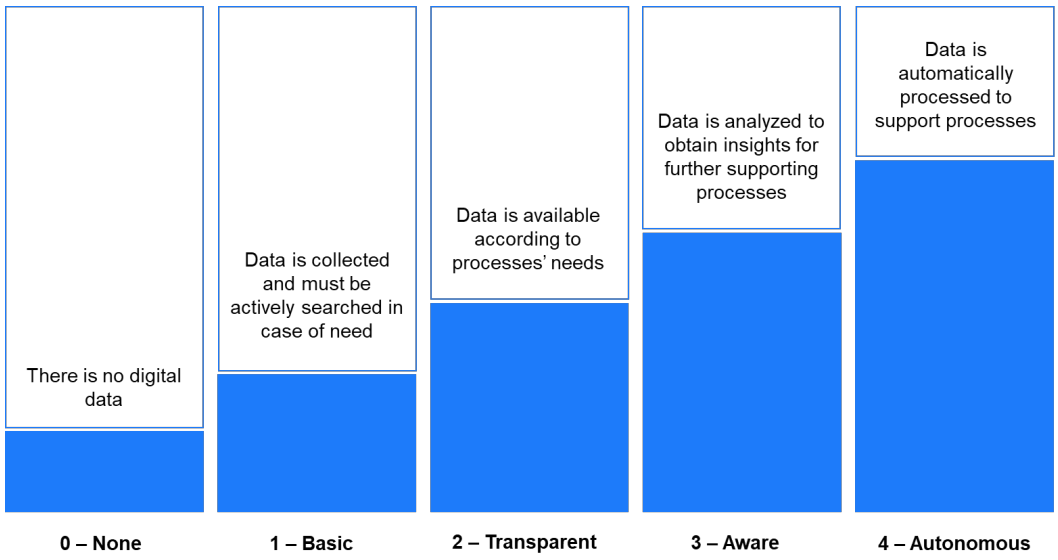

Figure 2 – Data processing capabilities across different digital maturity levels (inspired by Colli et al., 2019)

The Digital Factory Mapping approach

FORCE Technology has developed the "Digital Factory Mapping" approach to focus on two analyses at the same time: the *physical analysis* and the *digital analysis (Figure 3)*.

The *physical analysis* focuses on mapping the flow of material across production, and the related tasks required to support it, going from the transportation of raw materials to the manufacturing and assembly activities and, eventually, the transportation of finished products to the shipping area.

The *digital analysis* focuses on mapping the flow of information across production, and all the related tasks required to process it for supporting the execution of the different production processes.

While the *physical analysis* highlights the physical bottlenecks, the *digital analysis* raises red flags where – across such bottlenecks – the flow of information is processed inefficiently, and hence where digital solutions can have a role in resolving a bottleneck, leading to an overall production efficiency improvement.

There are generally two scenarios when it comes to improving how the flow of information is processed, leading to a general production efficiency improvement:

- Scenario 1: the information flow is processed inefficiently due to low digital maturity (i.e. the current data processing capabilities are not enough to process the information flow efficiently). The process can be improved by introducing a more advanced digital solution.
- Scenario 2: the information flow is processed inefficiently due to a mismatch between available digital maturity and used digital maturity (i.e. the available data processing capabilities are good enough to process the information flow efficiently, but they are not used to their full extent). The process can be improved by better using the available digital solutions.

If the identification of one of the two scenarios provides an initial overview of how to approach the problem, the mapping of the lost resources to cope with the current inefficiencies provides clear information about the potential benefits behind it.

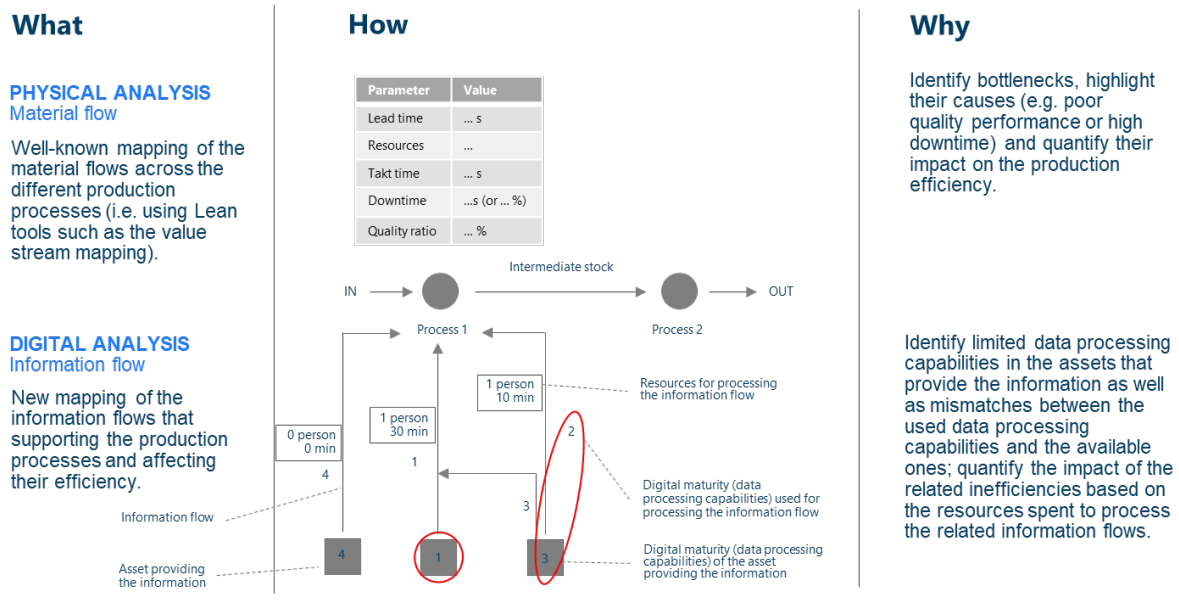

Figure 3 – The Digital Factory Mapping approach (from Colli et al., 2021)

The output of a Digital Factory Mapping is:

- A mapping of the production processes, including both the material and the information flow.

- A list of the most relevant efficiency improvement opportunities with the related impact.
- A roadmap of prioritized activities to address efficiency improvement opportunities according to their impact, dependencies, and maturity requirements.

This enables a follow-up search of the available solutions on the market (and of the related suppliers) to address selected efficiency improvement opportunities, an evaluation of the identified solutions, and an assessment of their business case.

Strategically approaching digitalization for efficiency improvement

The question is: "How can a company address its digitalization activities to improve production efficiency in a structured way?"

There are four key steps to go through (Figure 4):

- *Step 1 – Scoping*: definition of the mapping scope according to the company challenges, ambitions, and key performance indicators.
- *Step 2 – Data collection*: mapping of the production processes – both including the material and information flows - and of the related key performance indicators.
- *Step 3 – Data analysis*: identification of efficiency improvement opportunities and quantification of their potential.
- *Step 4 – Roadmap formulation*: discussion and formulation of an activity plan according to the findings built through the project.

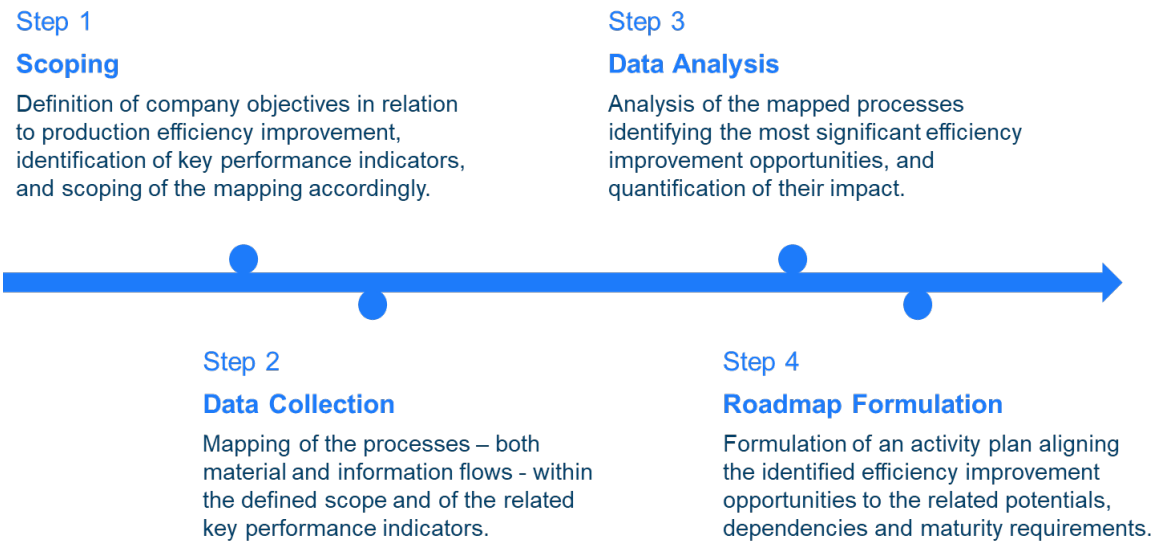

Figure 4 – The general Digital Factory Mapping activity plan (figure from FORCE Technology)

The Digital Factory Mapping has initially been performed as a MADE Samarbejdsprojekt (i.e. cluster projects), following these four steps through four workshops bringing together a cluster of companies (Louis Poulsen, LPM Production, PE-Redskaber, and Stenhøj Holding).

Scoping

The first step consists of introducing the mapping approach and its deliverables, understanding the company business and the related challenges, ambitions, and key performance indicators, and eventually scoping the mapping accordingly (e.g. which processes to map, which products to include, and which key performance indicators to consider for obtaining the desired outcome).

Data collection

Data is then collected across a multiple day-workshop where, according to the scope of the mapping, all relevant stakeholders are onboarded (e.g. *the production planner, the responsible for the different manufacturing and/or assembly processes, the quality responsible, the shipping responsible, the IT responsible, etc.*) to show and describe the respective processes step-by-step, along with the related key performance indicators (such as lead time, cycle time of the different process steps, quality rate, and number of involved operators).

The provided data is mapped to clearly provide an overview of each process and the related process steps in the most practical way and with the related key performance indicators.

Process	Lead time	Process steps	Cycle time	Number of operators
Mixing	94 min/order	The mixing operator goes to the planning room, checks the next order to be processed, picks up the related production order paper and walks back to the mixing station (information flow)	6 min/order	1
		The mixing operator reads the order specification on the production order paper, opens the mixing setup Excel arc, and finds the mixing setup parameters matching the order specification (information flow)	5 min/order	1

		The mixing operator manually introduce the mixing setup parameters on the HMI of the mixer (quality issues 2% of the times, which entail the need for repeating the mixing process for the order, and the waste of the order with quality issues) (information flow)	2 min/order	1
		The mixing operator goes to the warehouse and, with the help of the logistics operator, finds the raw materials to mix, transports them to the mixer, and loads them (material flow)	20 min/order	2
		The mixing operator starts the process and visually supervises it while running, continuously adjusting mixing parameters if necessary (material flow)	38 min/order	1
...	...	...	...	...

Figure 5 – Simplified example (extract) of a sequence of mapped processes

Data analysis

Once the processes have been mapped, data is analysed by a pool of experts identifying and quantifying efficiency improvement opportunities that could be captured through the introduction of digital solutions.

Such opportunities are generally linked to those information flows characterized by either (1) a generally low level of digital maturity or (2) a mismatch between the available data processing capabilities and the data processing capabilities that are actually used to process the information flow.

For each efficiency improvement opportunity, a solution proposal is defined, together with the related potential impact on manual labour and/or on production capacity, calculated using the collected time data.

Roadmap formulation

The identified production efficiency improvement opportunities are presented to the company stakeholders, together with the related solution proposals and their potential impact.

These are discussed in relation to their feasibility and put in a roadmap *(Figure 6)* taking into account their:

- *Potential impact*, as some activities have bigger potential benefits (short- and long-term) than others
- *Dependencies*, as some activities "build up" on other activities that need to be performed first
- *Maturity requirements*, as some activities can be performed with the current level of "digital maturity", while others will require an evolution of the organization's digital capabilities before being considered

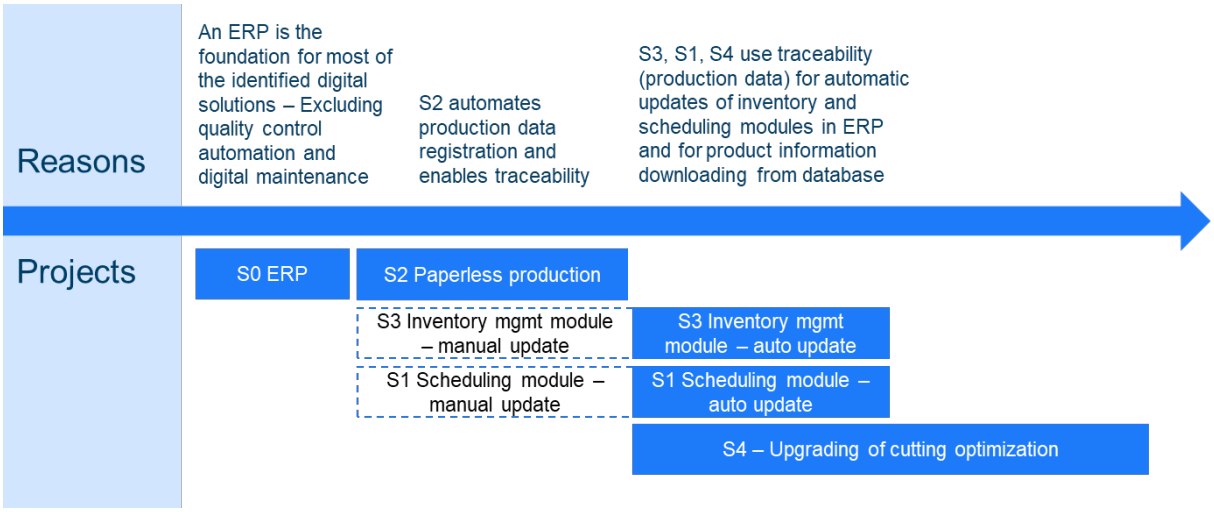

Figure 6 – Roadmap example (figure from FORCE Technology)

> *The Digital Factory Mapping helps create awareness of the actual state of the operations from a digital perspective: I discovered that in many of the processes we were simply not taking advantage of our internal capabilities as I was expecting (...) It is a great tool to open and sustain innovation discussions with the management, showing what are the actual problems and quantifying the improvement potentials. If ideas might already be present, numbers to ground them are often missing, and they are necessary to transform ideas into actual projects.*
> Kristjan Björn Arnason, Engineering Manager at PE-Redskaber.

> *The Digital Factory Mapping supported us in learning about our own production gaps and about the potential in closing these gaps with digitalization (...) To have some numbers indicating the level of our current capabilities as well as their actual use made very clear for us where to focus the attention.*
> Henrik Berg Jepsen, Head of Digital Transformation at Stenhøj Holding

Louis Poulsen - Case example

Louis Poulsen – a manufacturer of high-end lighting solutions - has been one of the participants of the MADE cluster project led by FORCE Technology in 2020 and focused on Digital Factory Mapping.

Due to a significant increase in sales, the company was interested in finding new ways to increase its production capacity, taking advantage of digital solutions.

Through the Digital Factory Mapping, four particularly relevant problems (and related production efficiency improvement opportunities) have been identified: (A) a bottleneck across a machining activity generating a significant capacity loss, (B) the time spent to manually register or retrieve order information across the different processes, (C) sub-optimal planning and control due to a lack of overview of the actual production performance, and (D) the impossibility for the quality control station to keep up with future demand.

According to these, four digitalization projects have been proposed: (A) the introduction of a collaborative robot to support loading/unloading activities across the bottleneck process, (B) the adoption of identification tags following each order and of a barcode/QR code scanner to automate the (currently manual) registration and retrieval of order information (e.g. needed quantity and quality or time spent to processing the order), (C) a dashboard showing the order performance and the actual overall equipment effectiveness (OEE) in production, and (D) the introduction of an automated vision-based quality control system.

Based on these findings, Louis Poulsen planned and executed five pilot projects, which 8 months after the conclusion of the Digital Factory Mapping were already running in production and have been presented to the public during a MADE event (MADE 2021a, MADE 2021b, MADE 2021c) *(Figure 7)*.

For Louis Poulsen, *"the suggested initiatives provided support for formulating a digital strategy, and a tangible idea of how to move towards a digital factory"*. (Ole Hoffgaard Munk and Martin Iversen, respectively production and industrial engineering manager and change agent logistics - Louis Poulsen)

The full case article can be read here https://www.made.dk/artikler/louis_poulsen_gar_digital/ (MADE, 2021a).

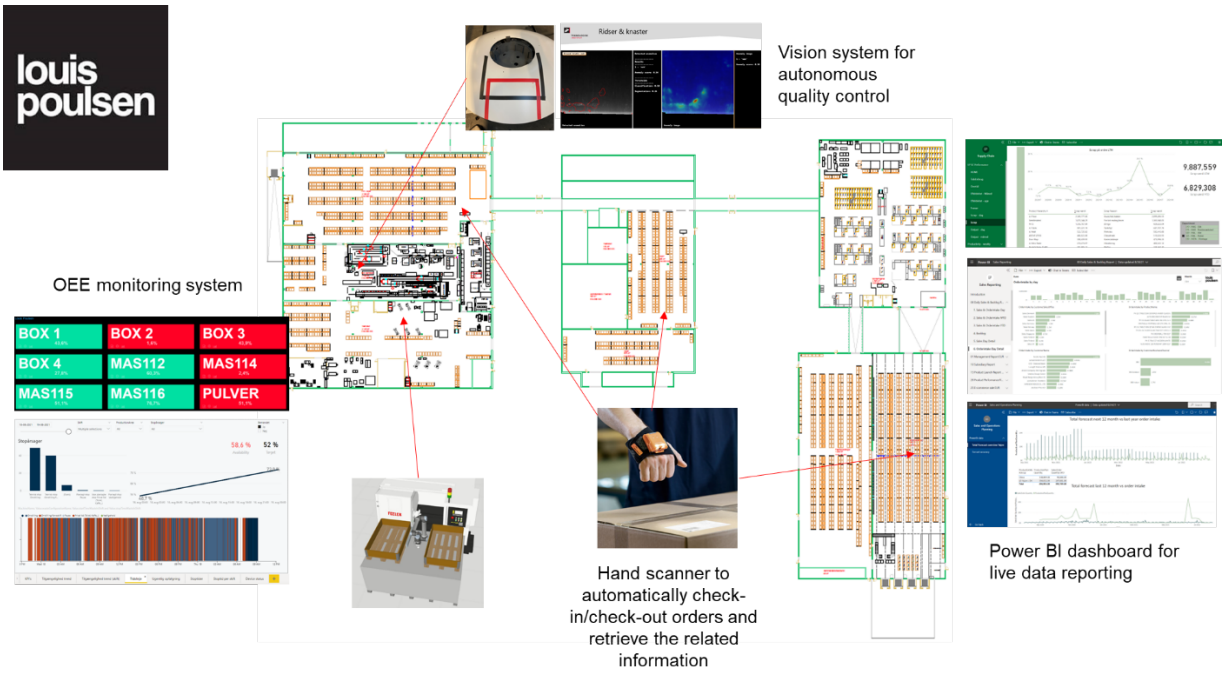

Figure 7 – The pilot projects that have been started at Louis Poulsen after the Digital Factory Mapping (figure from Louis Poulsen)

Conclusions and recommendations

Efficiency improvement remains a top priority for production companies, and digitalization is a key lever for that.

Nevertheless, challenges in identifying digital transformation initiatives that can bring short-term benefits and in building clear business cases around them are key barriers to success in translating digitalization into actual production efficiency improvement.

To address these issues, FORCE Technology has developed the Digital Factory Mapping approach, first used in a MADE cluster project and then scaled to 20+ companies through the Digital Factory Acceleration program, co-financed by Industriens Fond (you can read about the most recurrent improvement opportunities emerged through the Digital Factory Acceleration program here: https://forcetechnology.com/-/media/force-technology-media/pdf-files/unnumbered/iot-and-digital-technology/white-paper---key-challenges-and-recurrent-production-improvement-opportunities-for-smes.pdf (Colli, 2023a)).

The approach led participating companies to the identification of efficiency improvement opportunities enabled by digitalization, and to the quantification of the related potentials, to support them in the formulation of a prioritized roadmap and, ultimately, in the definition of a digitalization strategy.

> *The Digital Factory Mapping should be performed every year or every second year, to keep on guiding the company in its transformation and monitor its progress*
> Ole Hoffgaard Munk and Martin Iversen, respectively Production and Industrial Engineering Manager and Change Agent Logistics at Louis Poulsen.

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