The three principles that make hardware product development go agile at scale

Digital twins enable agility in car body engineering and manufacturing

By Christoph Weber, February 20, 2022

Automakers are turning into tech companies. While software developers leverage agile methodologies to deliver new product increments every few weeks, hardware engineers still rely on waterfall project management with 2-4 years development cycles. In our past projects, we have identified the three principles that make hardware product development go agile at scale. This article describes their application, shares real-life cases from automotive car body manufacturing and explains how digital twin technology serves as enabler. We seek to inspire managers from any traditional industry to dare taking the next step towards higher agility and customer centricity.

Automakers are under pressure to quickly launch new electric models, meet tech-savvy consumer expectations, and win the war for talents in the new work age. Still, traditional disciplines like car body engineering may believe that digital and agile disruption would not apply to their own field, since lead times and heavy investment in tooling, press lines and welding robots seem to dictate detailed upfront planning. The truth is that today’s digital twin technology is ready to enable a full digital and agile transformation even for complex hardware products.

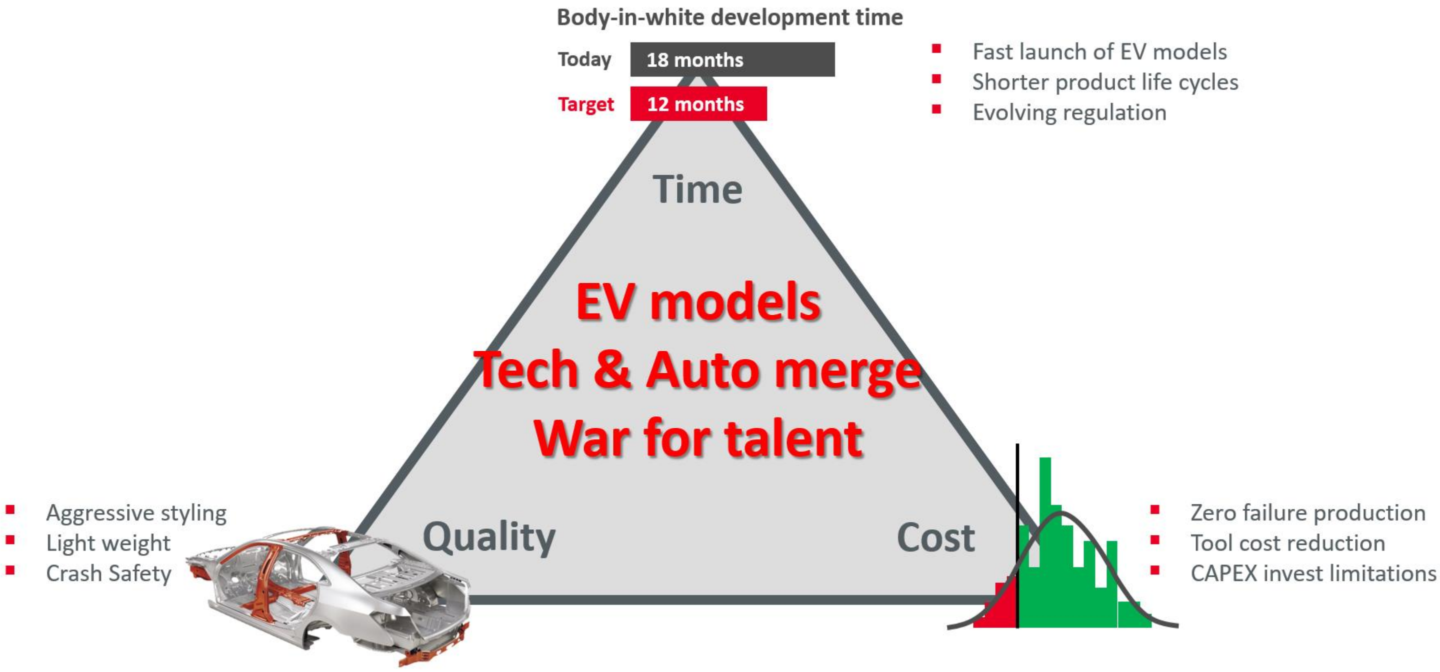

Figure 1: Car body engineering and manufacturing must become faster, cheaper and customer centric

In projects with automakers and suppliers over the past three years, we have identified three lean-agile principles that allow traditional hardware producers to become agile at scale: end-to-end responsibility, fast feedback loops based on working systems and cross-functional teams. An average automaker can speed up start of production by six months, save over USD 10 Mio/year, and inspire higher customer and employee engagement through a digital and agile transformation in car body engineering and manufacturing.

Figure 2: Three principles enable agility in hardware product development

1) End-to-end responsibility

Multiple departments and suppliers need to work together when developing a complex product like a new car model. However, each department has its own milestones and KPIs in a waterfall organization. Each department may use different tools to work out product design and production concepts. Different tools – such as software, spreadsheets, historic data or individual experience – are based on different models and understandings of the same reality.

As a result of this organizational and technical disconnect, engineers focus on their subset of targets and may not fully consider other departments' constraints and goals. The lack of mutually accepted data slows down cross-departmental decision making. Automated feedback loops are impossible. The hand-offs between these functional silos lead to waste and delays – such as over-engineering, late discovery of integration problems, missing cost saving and light-weighting potential, and therefore budget and time schedule overruns.

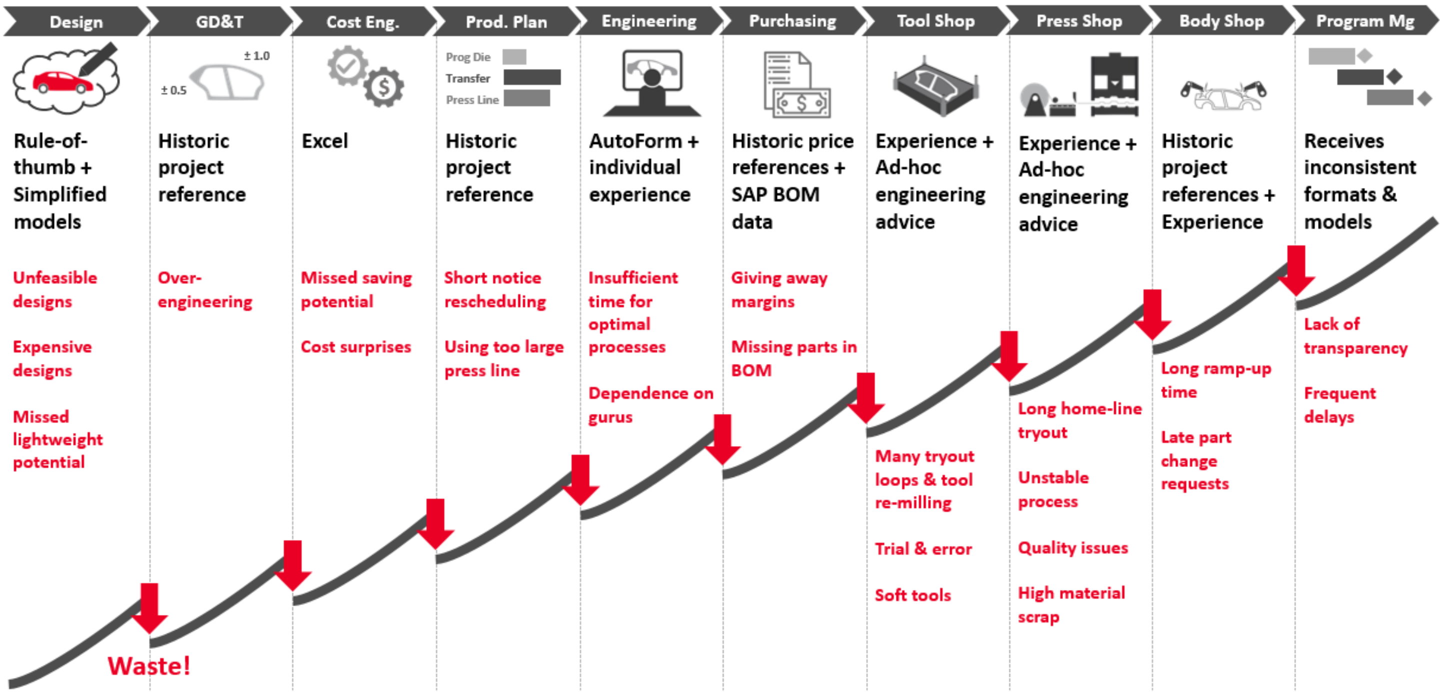

Figure 3: Functional silos' hand-offs lead to waste and delays

Agile enterprises break functional silos and establish cross-functional teams with end-to-end-responsibility for each value stream. Each value stream delivers one module, e.g. the car body or powertrain, of the entire solution, i.e. the vehicle. Each value stream and sub-stream requires clearly defined interfaces and should be as independent from one another as possible. Teams take end-to-end responsibility from design to production in order to optimize flow and enable system thinking instead of sub-optimization. A digital end-to-end platform with integrated software tools should support each team. The Scaled Agile Framework© provides further guidance on this approach.

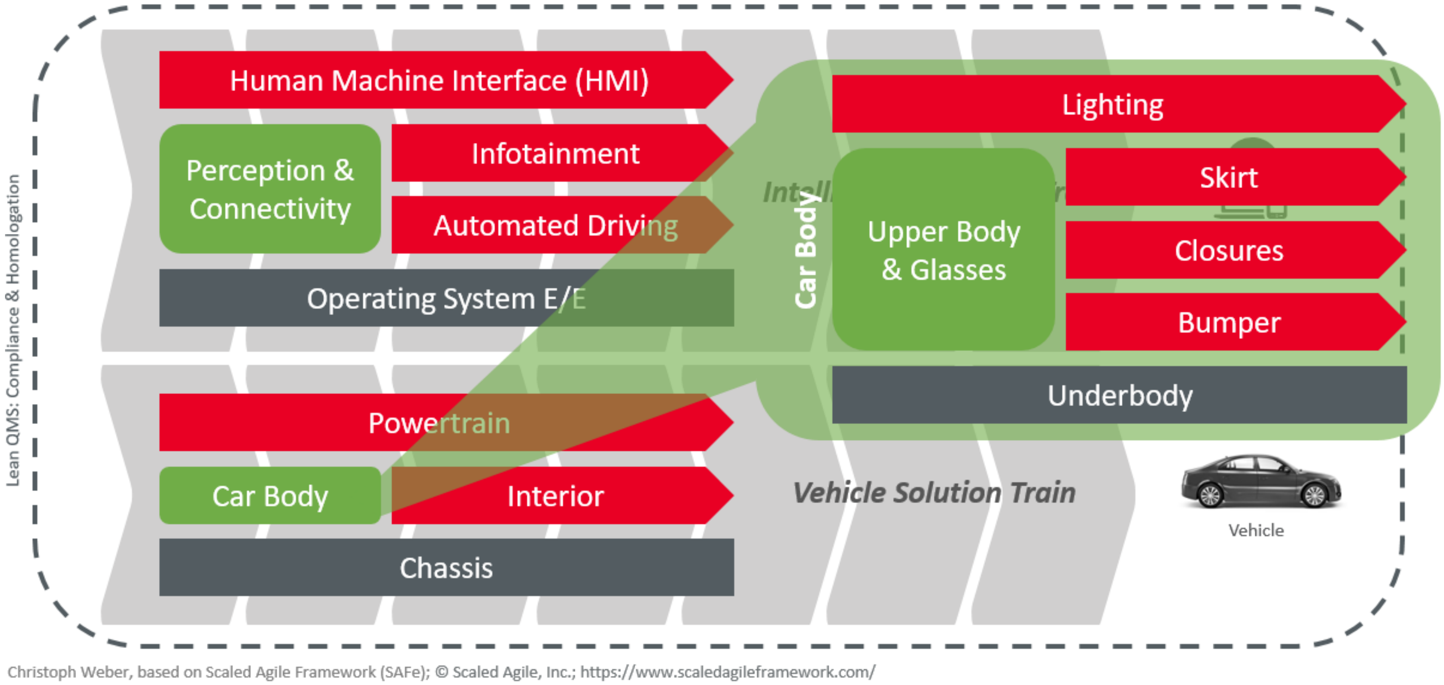

Figure 4: Value stream organization optimizes flow and system thinking

A **German automaker** has successfully connected the functional silos of car body stamping and assembly. Traditionally, most carmakers sub-optimize single part stamping and car body assembly separately, which leads to additional correction loops. In the new approach, stamping and assembly engineers share end-to-end responsibility to optimize the complete car body system. They integrate the digital process models of stamping and assembly in order to optimize single part shapes for the car body assembly. As a result of this system optimization, the pioneering automaker cut production ramp-up time from twelve to six months for a hood assembly.

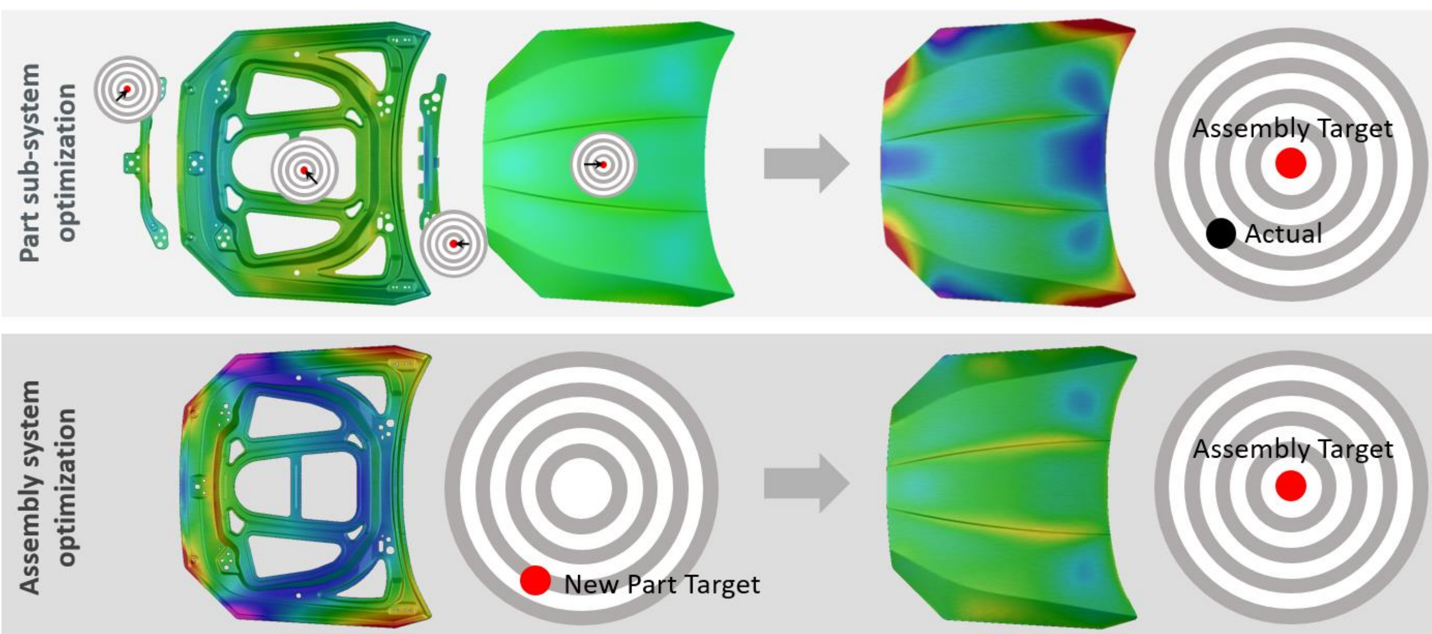

Figure 5: System optimization cuts over-engineering and waste

2) Fast feedback loops based on working systems

The traditional product development approach is to proceed through several waterfall project planning phases over 2-4 years before launching a new car model with a "big bang" to market. As a result, customer feedback can only be considered once per model every few years. Furthermore, manufacturing and integration issues may only be discovered in the production ramp-up phase. In contrast, agile product development tests and delivers small product increments in regular sprints every few weeks. Early and frequent incorporation of customer feedback and surfacing of manufacturing issues reduces the risk of product and feasibility failure.

Software product increments can be tested within seconds by the click of a mouse button. However, hardware products like a car body require several months lead time and heavy investment in tooling, press lines and welding robots. This is where digital twins – virtual models of real-life objects or processes – can step in to replace physical prototypes and testing. Physics-driven digital twin technology enables engineers to test product performance and manufacturability even for complex hardware products in every product iteration within a matter of hours. This ensures built-in quality from the beginning in every product increment. For any change in design or manufacturing concept, the digital twin provides immediate feedback on the impact on quality, cost and time. Internal and external customers can provide meaningful feedback on this base.

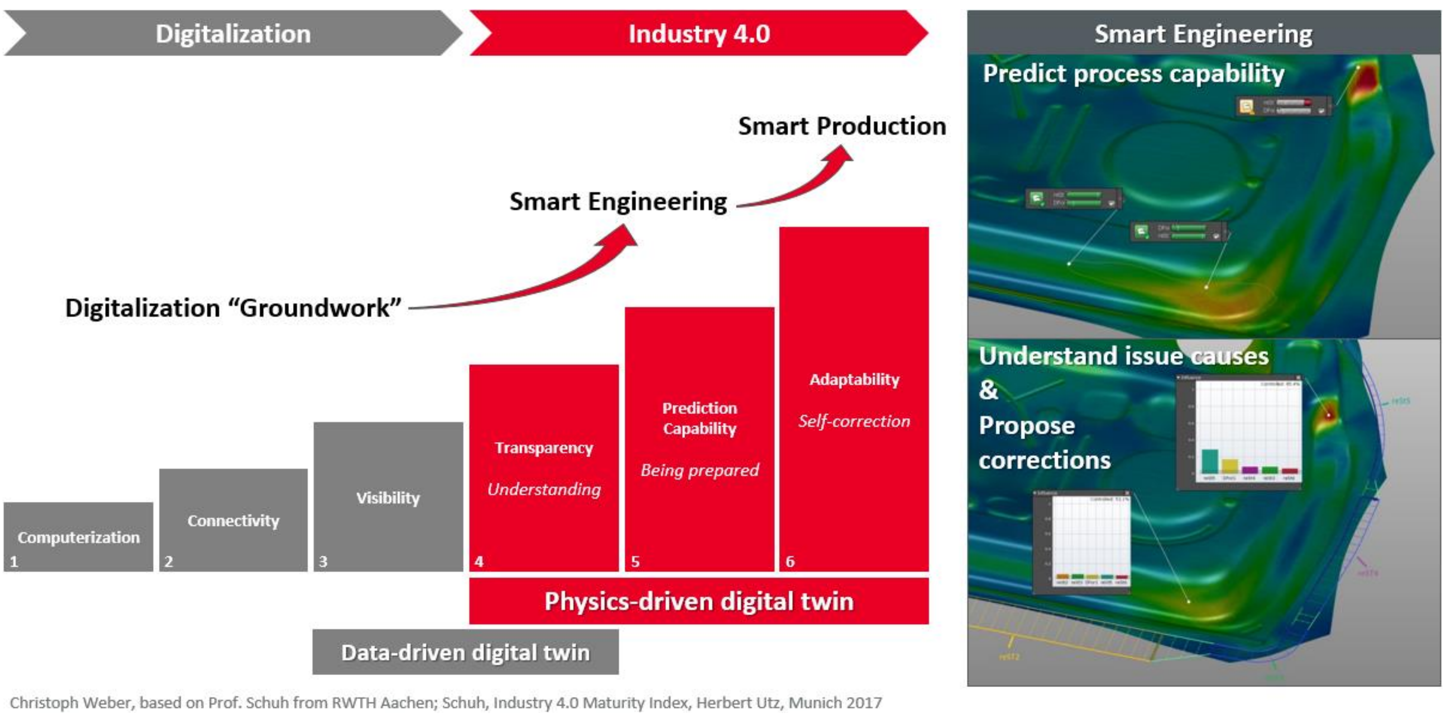

Figure 6: A physics-driven digital twin enables prediction and self-correction

A **Japanese automaker** maximizes customer value by systematically exploring hundreds of alternative product designs and production processes tested in fast iterations by digital twins. For instance, they analyzed the stamping process of an aluminum hood component with alternative material thicknesses and shapes by a digital process twin. They excluded unfeasible designs and then selected the one with lightest weight and lowest cost – reducing weight by 7% and material cost by EUR 1 per part.

3) Cross-functional teams

Our customer survey revealed that 50% of stamping process engineers do not systematically attend the stamping tool tryout. This shocking disconnect between engineering and shop floor teams essentially cuts the connection between the engineered "digital twin" and the actually manufactured "physical twin". The Engineering team may not be aware of production realities and lack the feedback needed to build an accurate digital twin model. The shop floor team may receive poorly designed tools and re-engineer the process in a trial-and-error approach instead of building on the existing process knowledge.

The solution is to connect designers, engineers and shop floor workers on an end-to-end platform to work collaboratively on one digital process twin. Engineers must be held accountable for quality targets on the shop floor and test all KPIs based on digital process twins. For instance, engineers should ensure a stable production by conducting a process capability analysis. Shop floor workers should enter actual manufacturing data into the system, in order to align the digital and physical twins and reach accurate predictions. Based on this, the physics-driven process twin calculates and provides guidance on how to reach a robust production process in the most systematic fashion.

Figure 7: A digital process twin connects teams on end-to-end platform

A **Chinese tool supplier** leveraged cross-functional teamwork to cut quality loops for a challenging A class aluminum hood project. Today, most auto and toolmakers in China take over ten quality loops to deliver aluminum panels with high surface and dimension quality – resulting in circa one-year time delay and significant cost for tool re-milling. In this consulting project, we followed up closely with every department and supplier to model and manufacture an accurate digital process twin, including material test data and process capability analysis. As a result, we could accurately predict and compensate dimensional springback and deliver good parts in the first tryout.

Conclusion & Implementation

Hardware product development in automotive and other industries must go agile in order to become faster, cheaper and more customer centric. Today's digital twin technology enables a full digital and agile transformation. The following three principles make hardware product development agile at scale:

1) End-to-end responsibility: Establish teams around value streams to optimize single parts for the complete system
2) Fast feedback loops based on working systems: Maximize customer value through fast optimization loops tested by physics-driven digital twins
3) Cross-functional teams: Connect engineering and shop floor teams on end-to-end platform to work collaboratively on one digital process twin

Digital and agile transformation is a leadership task. C-level support is required to set strategic goals and review business structures and processes, software and technology, people and culture.

Below overview shows the goals and key measures from a recent transformation project with an automaker in China.

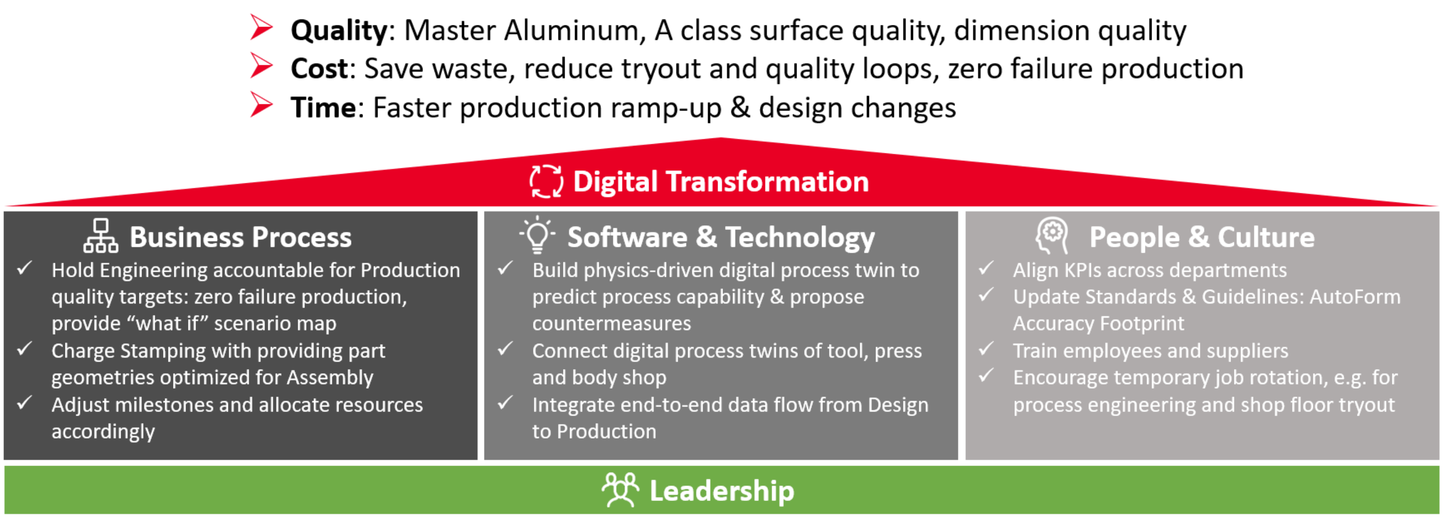

Figure 8: Digital and agile transformation is a leadership task

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