Digital Twins for Agility in Car Body Manufacturing

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Over the past months, several carmakers announced aggressive cost-cutting initiatives to brace for the volatile market and allocate sufficient resources to emerging technologies. Is now the time to overcome organizational friction and capture the untapped potential of digital transformation?

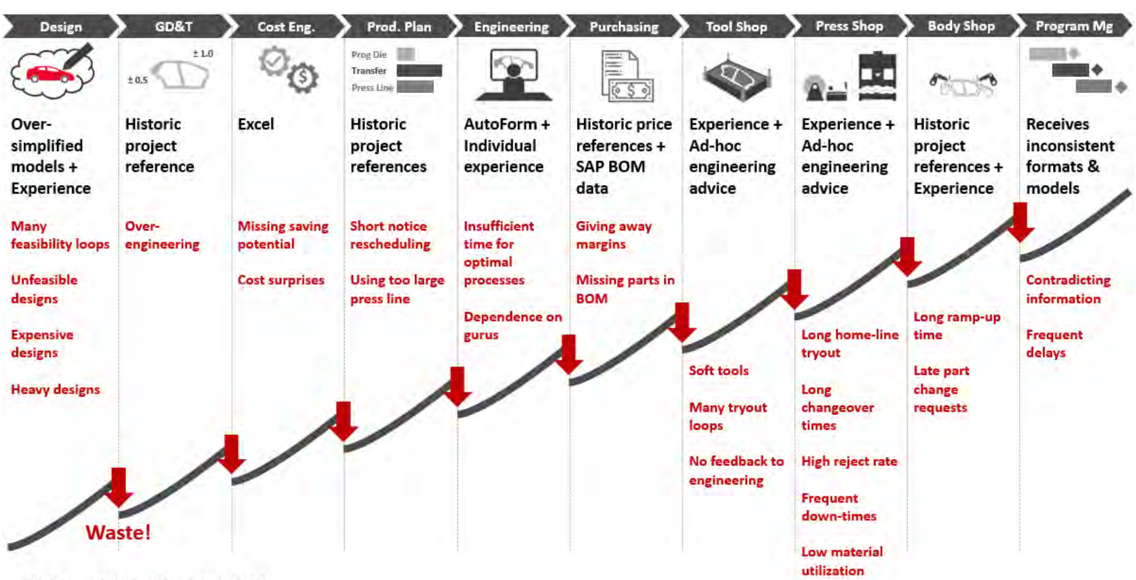
Automotive companies have been transforming into agile enterprises in sales and software development. This article explores how a physics-driven Digital Twin enables agility in the traditional discipline of car body stamping. Read how to generate return-on-investment (ROI) by eliminating waste and increasing speed and reliability in this volatile environment.

Automotive OEMs need to invest in emerging technologies - new power trains, automated driving, connectivity - while trimming costs to adjust for the 'new normal.' Nissan, for example, announced it would cut 20% costs by 2023 in its latest revival plan. Another Japanese OEM aims to reduce up to 24% costs in the same time frame, through digitalization and simulation technology, among others.

1) The Challenge: Project Management Today

Multiple departments and suppliers need to work together when designing and manufacturing a new car body. However, each department has to achieve its own set of milestones and targets in a waterfall organization. Each department may use different software tools or rely on historical references and individual experiences to complete their design and manufacturing concepts. Each of these tools is based on a different understanding and underlying manufacturing process model.

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. A significant part of the work progress is wasted, since information and data are not fully transferred from one department to another. Automated feedback loops are impossible. The below graph presents common process models per department and the consequences of this decoupling in the form of waste and unreliability.



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The product design already defines 60-70% of manufacturing costs. Still, manufacturing feasibility in design departments mostly relies on rule-of-thumb judgment, with deeper analysis only taking place in separate departments. This results in many loops between departments and, ultimately, in more expensive and heavy product designs than necessary.

Little to no process simulation data flows from engineering to the shop floor. And vice-versa, there is no systematic feedback data flow from the shop floor to engineers. Engineering departments may ignore real-life constraints on the shop floor, and technicians on the shop floor may not trust the engineering intent and improvise based on their individual experience. This builds a vicious cycle, which increases the disconnect in information, trust, and culture over time. We need to break the silos!

Instead of leveraging their internal knowledge on the manufacturing process, cost engineering and purchasing departments rely on historic cost references. This causes the company to lose its saving potential and puts them in a weaker negotiation position with suppliers. Program management may receive contradicting information and face frequent delays, since different departments base their analysis on different process models.

2) The Solution: Digital Twins for Agility in Car Body Stamping

The solution is to share one process model on one platform with all departments and suppliers. The Digital Twin process model connects the virtual and physical worlds and consists of two entities:

1. The Digital Master - created in the virtual world during the design and engineering phase and represents the engineering intent or 'as engineered' model.
2. The Real-life Twin - the physical execution of its Digital Master on the shop floor, providing 'as manufactured' data.

A physics-driven Digital Twin can predict behavior already in the virtual phase and self-correct deviations in the physical production phase. This enables agility in car body stamping through immediate feedback loops and focus on the body-in-white end result.

The below visual presents an agile project cycle from product design to production, in which the design and manufacturing concepts are matured in iterations. On the right-hand side, the Digital Master is built and refined during the design and engineering phase. For any change in the design or manufacturing concept, the Digital Twin provides immediate feedback to anyone connected to the platform on the impact on the body-in-white end result. This allows all departments to align their targets to optimize the body-in-white for quality, function, weight, cost, and timeline. Instead of optimizing single parts, we can optimize the complete car body assembly.

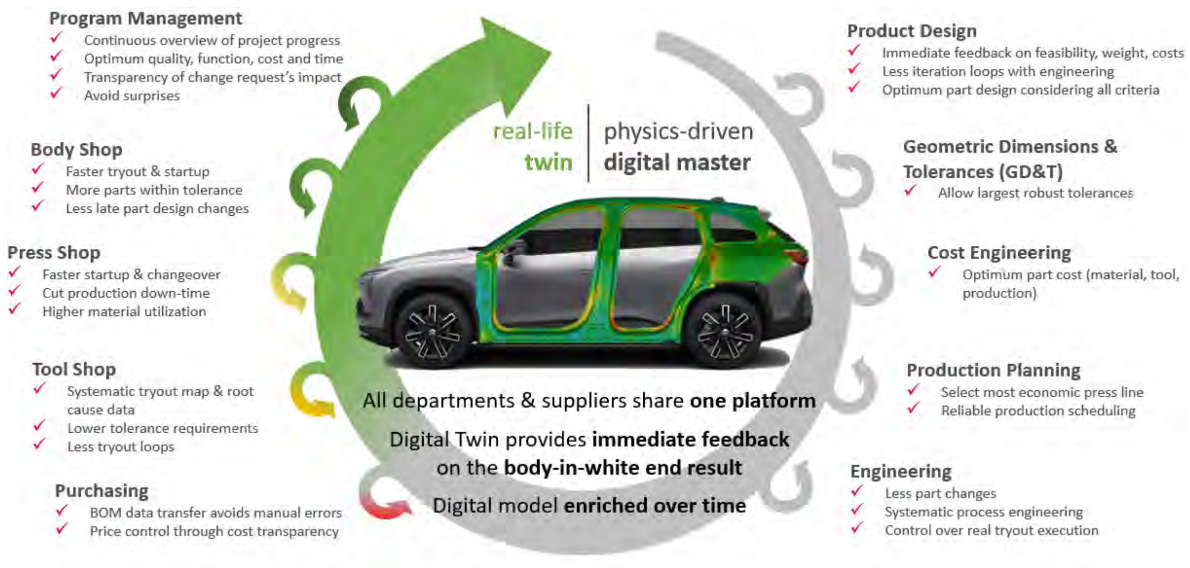
The left-hand side represents the Real-Life Twin, which is the exact replication of its Digital Master in the physical world. The knowledge and data of the entire value chain are put into use on the shop floor. Actual manufacturing data is fed back to the platform in order to improve the Digital Master's process model over time.

The Program Management is automatically updated on the project progress, as well as any design and manufacturing concept. Departments coordinate regularly, and information becomes more reliable since everyone uses one platform with a consistent process model. Project cycles and change executions become faster and more agile.

3) The Process: From Digital Master to Real-life Twin and Back

First, engineers build and refine a Digital Master of the manufacturing process in the design and engineering phase. A meaningful process model provides the base for virtually predicting issues and optimizing design and manufacturing concepts.

Second, all Digital Master's 'as engineered' data is provided to the shop floor in a digestible format, e.g., on a computer tablet. The Real-life Twin is executed and actual 'as manufactured' measuring data is returned to the platform in order to close the feedback loop. The physics-driven model calculates deviations and provides guidance to the shop floor on how to reach compatibility – and, ultimately, a robust production in the most systematic fashion.



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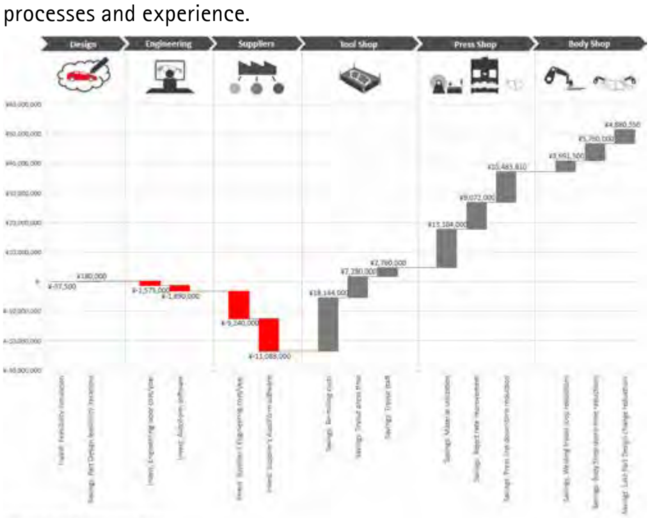
Close and trustful cooperation between engineering and shop floor teams is vital for success. The engineering teams must understand technical constraints in order to design meaningful manufacturing processes. The shop floor technicians need to execute the engineering intent with high diligence, and feedback any deviations to the system. Improvising or working off the record would undermine the process, and cannot be tolerated. A cultural gap between the academic-minded engineering department and the hands-on shop floor team must be overcome.

Today, most carmakers are on a digital transformation journey. So far, no one has reached a full implementation of the Digital Twin concept over the entire value chain of car body manufacturing yet.

How does the implementation of the physics-driven Digital Twin for agility over the entire value chain in car body stamping contribute to the targeted cost efficiency gains? For this, we have interviewed automotive OEMs and suppliers in China about their cost and performance data in order to draft a representative ROI template. The below chart shows a business case for a representative, anonymized carmaker in China. This carmaker produces 1.2 million cars and develops four new vehicle projects and additional two face-lift projects per year. We defined improvement goals, which are realistic to achieve within a 1-2 year project. An investment of circa 24 million CNY/year is required, especially in the early phase of Part Design and Engineering. We expect a return of over 75 million CNY/year, in particular during the physical shop floor stage - an ROI of over 300% per year for the first 1-2 years. The ROI is expected to further increase in the following years, as the continuous improvement cycles further mature the process model and the enterprise's processes and experience.



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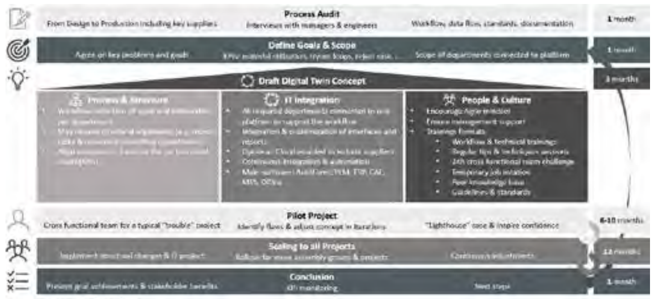
4) The Implementation Plan

The first step of implementation is to conduct a process audit over the entire value chain from design to production. Based on the findings, management shall decide on the most pressing challenges and achievable goals for the implementation project within a 1-2 year period. Furthermore, management must approve the scope of departments that should be connected to the Digital Twin platform.

The core project team drafts a Digital Twin concept with a workflow to define input and deliverables per department. Structural alignments may be required. Next, the IT department outlines a structure to connect all required parties to one Digital Twin platform in order to support the workflow, commonly based on existing Product lifecycle management (PLM) and Enterprise Resource Planning (ERP) systems.



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This transformation of processes and IT technology must be supported by a transformation of people and company subcultures. The implementation should be conducted in an iterative process. A pilot project should prove the drafted Digital Twin concept on a small scale, before implementing the structural changes and IT integration. This pilot delivers a verified concept and the first 'lighthouse' case to inspire confidence. After that, the drafted structural alignments and IT integration can be implemented, in order to scale the Digital Twin implementation gradually to all projects. The team should review goal and KPI achievements and define adjustments and next steps.

Conclusion

Project management for car body design and manufacturing usually follows a traditional waterflow model, where each department works in silos. The organizational, technological, and cultural disconnect between departments results in massive waste, in the form of optimization for sub-goals, over-engineering, missing optimization opportunities, time waste, and losing reliability. The solution is to connect the entire value chain to one platform, sharing one consistent physics-driven Digital Twin process model. This enables agility by providing immediate feedback loops and aligning all departments to optimize the body-in-white end result in terms of quality, function, costs, and time.

The implementation of a physics-driven Digital Twin concept for agility in car body manufacturing requires process and structural alignments, IT technology integration, and connecting people and subcultures of different departments for cross-functional collaboration. This is recognized as a classic organizational change process that needs to overcome friction. Today's economic environment forces automotive OEMs to overcome friction in order to capture the targeted gains in an agile and efficient way. A typical carmaker in China can significantly increase its competitiveness by implementing the Digital Twin concept in car body stamping, with an ROI of several hundred percent per year.

Christoph Weber is leading the AutoForm organization in China, counting all major carmakers as customers. He is the Automotive Working Group Leader at the German Chamber of Commerce in China | Shanghai. Christoph is a member of CATARC's World Automotive Industrial Research Committee and a founding member of the International Coalition of Intelligent Manufacturing to promote international best practices in China and beyond. He can be reached at: info@autoform.com.cn