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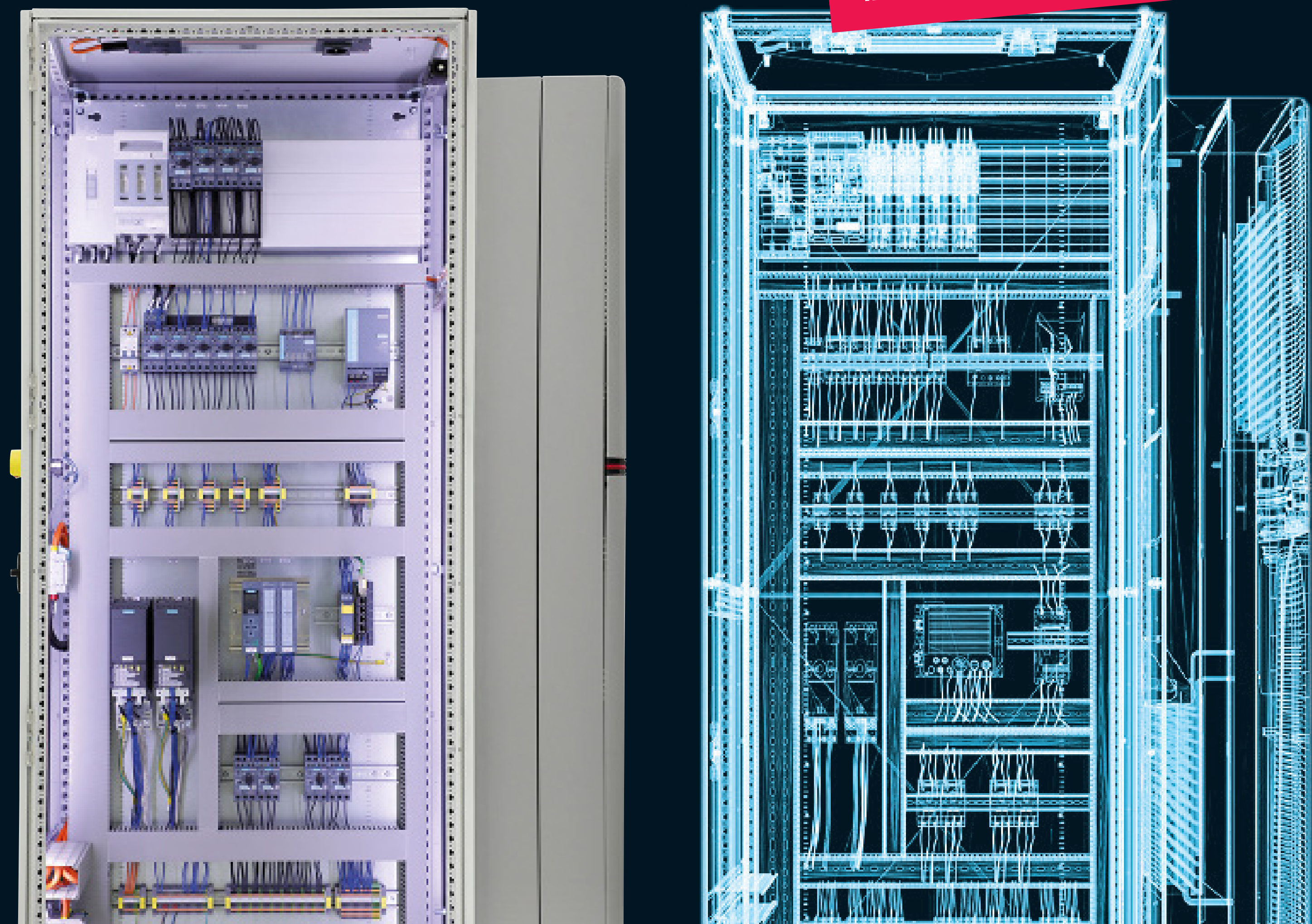

White Paper

Electrified – The Digital Twin

Electrified – The Digital Twin

New pathways for designing and documenting cables and wire harnesses

In a nutshell

Gartner says it. Deloitte says it. Eplan says it, too: the digital twin is becoming the driving force of industrial production in the twenty-first century. The question is not whether the digital twin will find its way from engineering to production to maintenance, but when. Embedded into the megatrends of Industry 4.0 and the Industrial Internet of Things, the digital twin brings significant advantages for manufacturing companies across the entire product life cycle.

This whitepaper, “Electrified – The Digital Twin”, will first show what a digital twin consists of and which disciplines and fields can work with it. With a special focus on the engineering field of “designing and documenting wires and wire harnesses in 3D”, the paper examines how the virtual/physical discipline of wire harness development, which traditionally uses hybrid means, can utilise the digital twin to achieve better results. It quickly becomes clear that enriching the digital twin with electrical information opens up substantial advantages over the long term – particularly in times of increasing product complexity and product variety, shortened development cycles, and in change management and the generation of manufacturing documentation, not to mention working with suppliers.

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1 The Digital Twin: Single Source of Truth

The platform is called Industry 4.0. The application environment is the Industrial Internet of Thing (IIoT). Its information carrier is the digital twin. Formerly just a simple designation for static digital images of real objects in a CAD environment, the definition of the digital twin is more broadly defined today: "Digital twins are software representations of assets and processes that are used to understand, predict, and optimize performance […]. Digital twins consist of three components: a data model, a set of analytics or algorithms, and knowledge."*

Used for industrial applications, the digital twin – as a complete, application-independent digital description of products, devices, machines, systems, factories and systems and/or processes – serves as a bridgehead for every IIoT application: it connects people, physical assets, digital units and systems and/or processes, whether in the interaction between digital twins of different products or processes, in the acquisition of continuously available information of physical assets or as a data hub and interface for human-initiated influences.

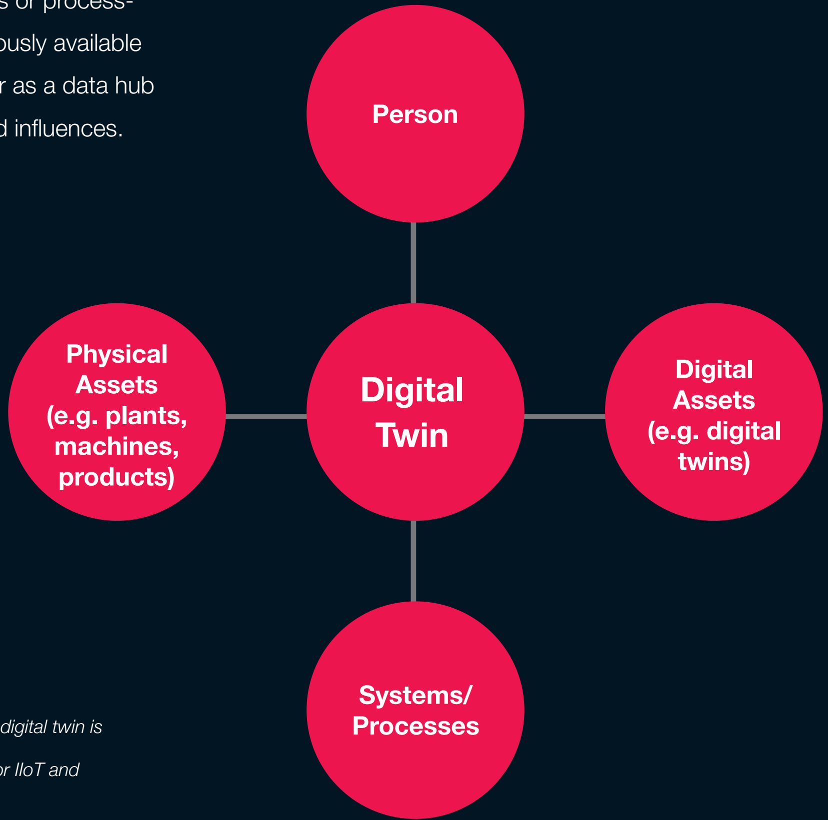

Figure 1: Media and data repository: the digital twin is capable of mapping all factors relevant for IIoT and integrating this information.

* Source: https://www.ge.com/digital/applications/digital-twin

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2 The Key Element: On practical relevance

The use of the digital twin as an information container is particularly relevant in view of the time-space dimension, which is reassessed with product life cycle models; once created and made available in the cloud, the digital twin can always be used from anywhere. The digital twin integrates information from various sources in each phase of the life cycle. It opens up potential for value creation from CAx-supported design and development – as the so-called digital prototype at an early stage in the process – through product manufacturing, sales and operations on to maintenance, servicing, recycling and even reengineering. Accordingly, consultants at Deloitte have defined the dynamic role of the digital twin "as an evolving digital profile of the historical and current behavior of a physical object or process that helps optimize business performance. The digital twin is based on massive, cumulative, real-time, real-world data measurements across an array of dimensions."*

** Source: Deloitte Consulting: Industry 4.0 and the digital twin – Manufacturing meets its match. Deloitte University Press, 2017.*

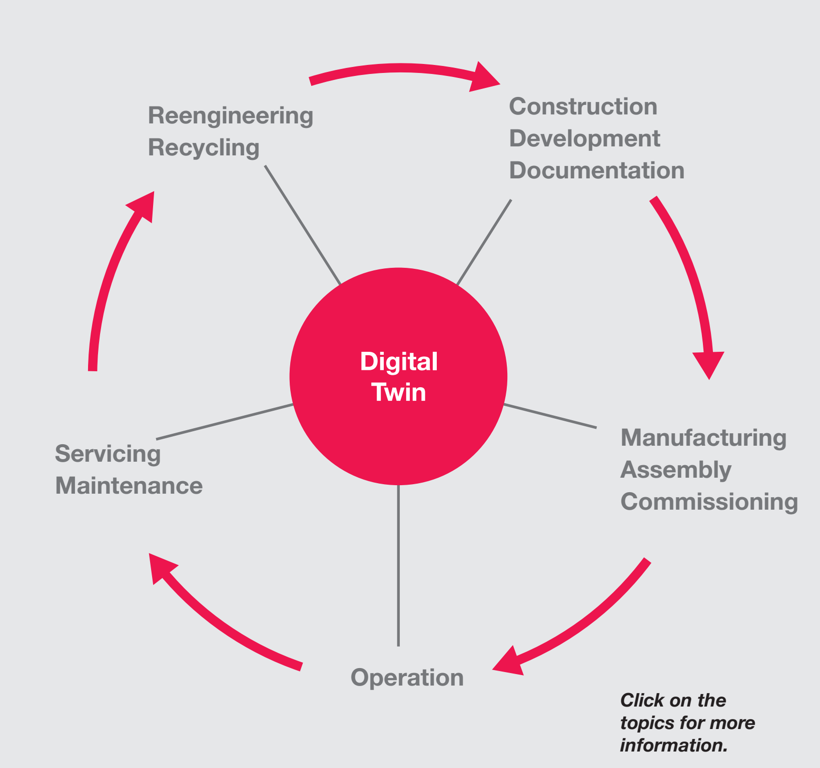

Figure 2: In the product life cycle, the digital twin represents the single source of truth.

Electrified – The Digital Twin

Construction, Development, Documentation

- Engineering preplanning
- Integrated engineering (parallel instead of sequential project progress/agile methodology)
- Intersubjectively comprehensible basis for dialogue (departments/divisions, companies, partners, customers/users)
- Basis for validation (design simulation, behavioural prediction, physical/virtual comparison)
- Data consistency as the single source of truth – no duplicate entries
- Controlling project process (status report)
- Ongoing change management
- Database for generating complete manufacturing documentation
- Database for repetitive work/reengineering

Manufacturing, Assembly, Commissioning

- Manufacturing instructions: current, complete manufacturing documentation with production/ assembly instructions available
- Basis for validation (data basis for manufacturing evaluation)
- Database for production runtimes, procurement, warehousing, logistics
- Intersubjectively comprehensible basis for dialogue (departments/divisions, companies, partners, customers/users)
- Implementation of “design-to-manufacturing” scenarios without prototype construction/sample production
- Virtual commissioning/testing

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Operations

- Instruction manual
- Plant visualisation
- Process visualisation
- Operating status display
- Key performance indicators for controlling
- Basis for dialogue for reengineering scenarios

Servicing, Maintenance

- Maintenance manual
- Functional status display
- Predictive maintenance
- Database for augmented reality applications (smartphone, tablet, data goggles, etc.)
- Database for diagnoses and prognoses
- Database for replacement parts management
- Basis for dialogue for reengineering scenarios

Reengineering, Recycling

- Disposal/recycling instructions
- Database for repetitive work/ reengineering (learning effects)
- Database for future configuration/ customisation projects

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3 At a Glance: Characteristics – Opportunities – Benefits

1. Digital asset definition: “single source of truth”
2. Conceptualisation: direct insight into the actual situation (as-designed/as-built)
3. Virtual/physical comparison
4. Collaboration: can be realised independently of time/space – process integration and data integration
5. Shortened development cycles, faster time-to-market
6. Reduced proposal times and delivery times
7. Increased quality/dependability of both products and processes
8. Improved resource efficiency and energy efficiency
9. Protection of company expertise
10. Cost-effective risk evaluation and analysis
11. Improved sales and service management (controlling)
12. Basis for repetitive work and predictive/preventative maintenance
13. Data mining: pioneer for new business models in the product and service segments

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4 Play the digital twin: 10 reasons for 3D electrical information

Gartner, one of the world's leading IT research and consulting companies, predicts that billions of products, processes and systems will be represented using their digital image in just a few years. On the product side, Gartner finds that the digital twin is one of the top ten strategic projects in the technology segment. The advantages from a digital prototype to a fully developed digital twin already become evident in the product development process. Enriching the digital prototype with 3D electrical information drives interdepartmental cooperation and also raises individual disciplines – such as the designing and documentation of wire harnesses – to a new level of efficiency.

1. Anyone who documents cables and wire harnesses in a conventional manner is familiar with the problems: since the information content of the wire definition is insufficient – both in the electric schematics themselves and in the mechanical design – the manufacturing documentation must be created manually. This is time consuming and prone to error, particularly since every change requires the proverbial re-invention of the wheel.

2. Determine beforehand how it will work later: this cannot happen without a complete digital prototype that also contains 3D electrical information. How else, for instance, can limitations for cables and wire harnesses be anticipated with respect to installation and assembly for the target application? Using conventional methods, the physical prototype is where this is first tested. That may be nice for nostalgia, but not for the market.

3. "How should I route the wires?" "I don't have enough space for all the wires." "What are the specific assembly steps?" "Where should I start?" When employees in manufacturing – either in-house or with external partners – ask these sorts of questions, it's almost certain that there isn't any digital prototype available. Suboptimal work in manufacturing begins with the exclusively experience-based estimation of wire lengths, which usually leads to reworking and additional materials costs.

4. The question is: How can the quality of cables/wire harness design be ensured if the wire lists and connection information aren't part of the virtual prototype? Wire routing must be defined at the technical level so that standards and requirements can be adhered to and so that wiring can be reproduced – regardless of who manufactures the product.

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5. Thinking in terms of product life cycles isn't a trend, it's an unmistakable demand from the marketplace. How else can maintenance and servicing be efficiently carried out if the documentation for the manufactured product isn't available or isn't up to date? The digital twin – an as-built documentation – serves here as a clear and consistent source of product data.

6. The virtual prototype fully demonstrates its strengths in scenarios for collaboration. Each of the disciplines participating in product creation can understand the impact of changes using the complete digital prototype and discuss new scenarios in a balanced exchange.

7. The digital twin opens up new intellectual space for taking action. "Design for manufacturability" scenarios are just as possible as "design for test" schemes. Potential problems can be identified and rectified in a cost-effective manner during the design phase. The digital twin is changed on the computer with just a few mouse clicks, not its actual counterpart during the manufacturing process or in the workshop.

8. Standardised and complete documentation is indispensable when wire harness manufacturing is outsourced to an external partner. The digital twin helps avoid misunderstandings, allows a company's own demands to be met and also ensures that cooperation is effectively organised.

9. Digitisation of the entire product can be used as a data source for implementing augmented reality/virtual reality strategies. These technologies benefit many stakeholders, including manufacturing, maintenance, marketing, sales and so on.

10. The digital twin is the perfect medium for entering into a constructive dialogue with customers – whether during the specification process, the development phase for design reviews or for marketing purposes.

5 KISS – Keep it short & simple: 3D wire harness development

The engineering and documentation of wire harnesses can be understood as a critical point at the interface of design and production. In traditional workflows, work takes place sequentially (see Figure 3). Production-relevant data is first determined from the physically constructed prototype. Iteration loops and reworking details are just as common as increased scrap material and critical project time windows.

Traditional Design Workflow

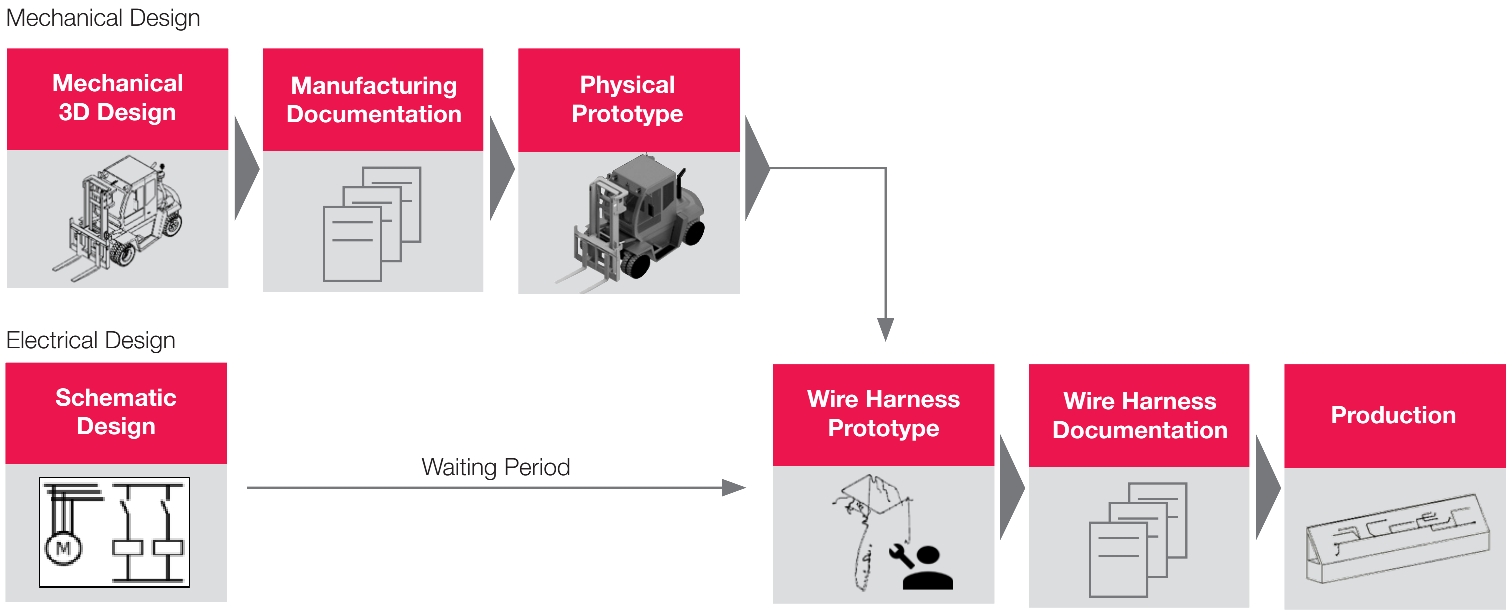

Figure 3: Traditional workflow.

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Documentation in the traditional workflow is generally considered problematic since large amounts of effort are necessary to get complete and consistent data and it requires a lot of work before it can be delivered. Manufacturing instructions and assembly directions remain fragmentary. Bills of materials are compiled manually. Any changes increase the problems that ultimately arise in production (Figure 4).

Critical Areas

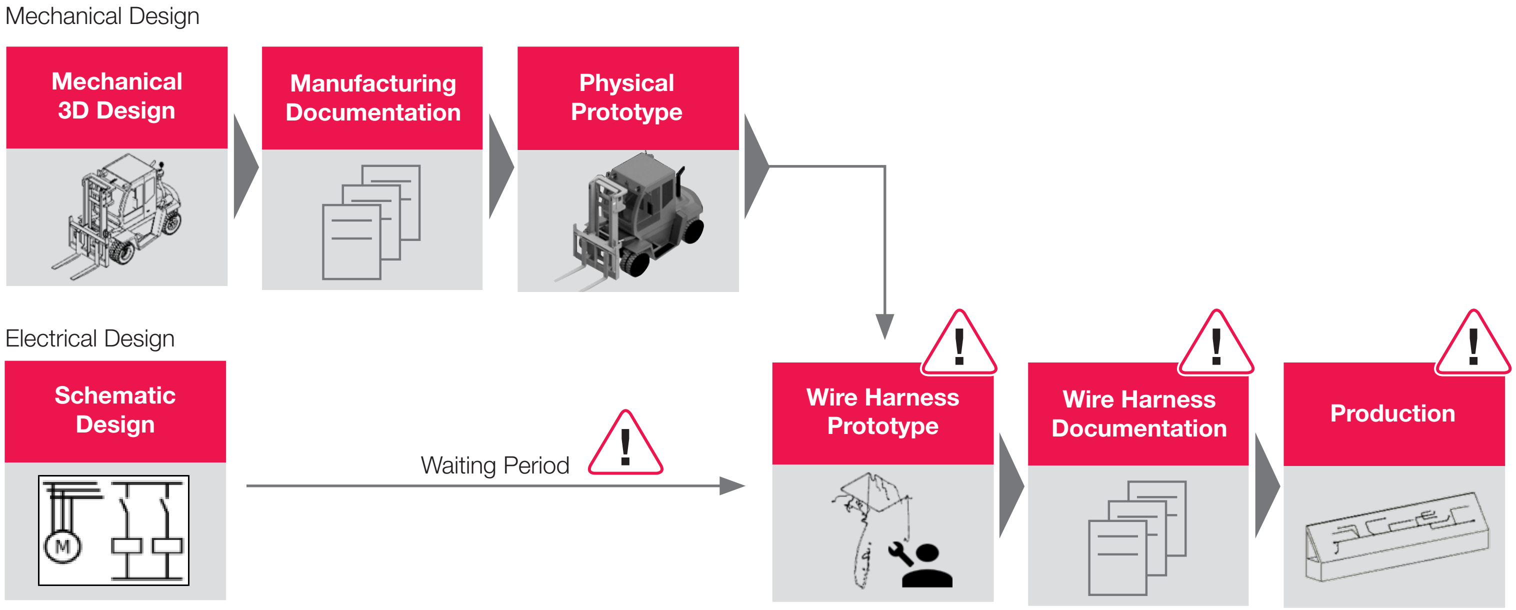

Figure 4: Waiting periods in traditional workflow.

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In contrast, 3D wire harness development based on a virtual prototype opens up the possibility of working in parallel in engineering while including all the electrical and mechanical components relevant for the wire harness (Figure 5). Virtual prototyping enables complete validation of all designs. This allows companies to preventatively avoid the trial-and-error process of traditional methodology that is a familiar part of prototype construction and production. This comes about in part because decisions for changes from a mechatronic perspective can be made early in the virtual design process. The automatic generation of manufacturing documentation – without having to wait for the physical prototype – ensures reliability for expectations and for planning in production. Every necessary work step – from design to production – can thereby be shortened while also increasing the quality of both the process and the final product. Ideally, the work step of prototype construction is omitted entirely. The parallel processing of the virtual prototype additionally reduces the time-to-market.

Possible Design Approach

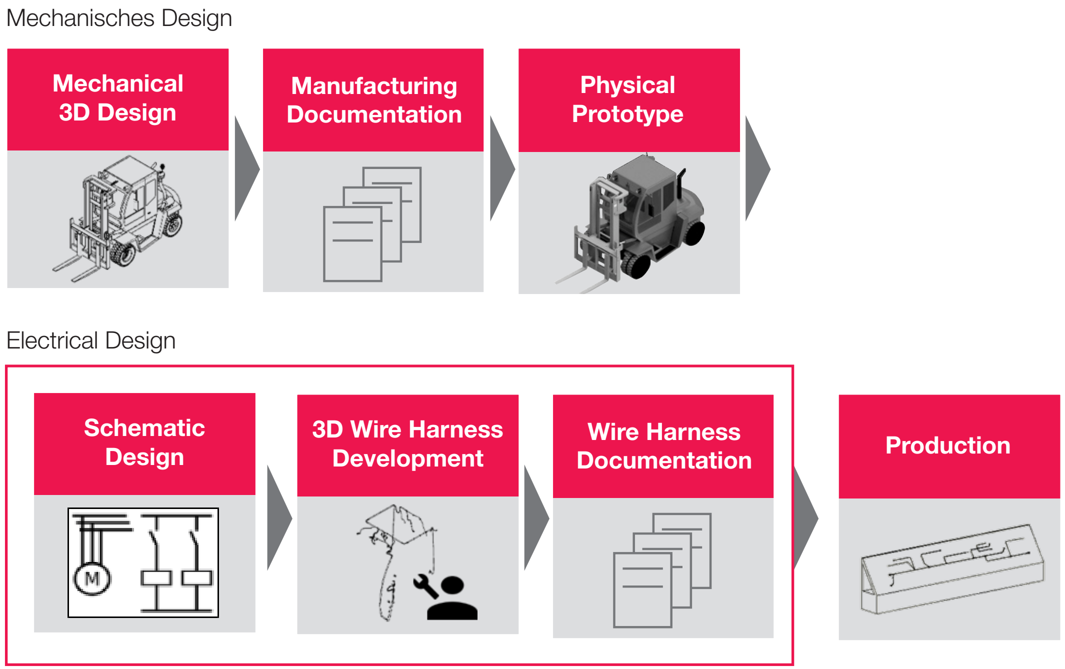

Figure 5:
3D wire harness development with a digital prototype shortens the development process, increases quality and ensures efficient production over the long term.

6 At a Glance: Challenges in traditional wire harness development

1. No multidisciplinary development
2. Lack of a complete virtual prototype or digital mock-up
3. No virtual validation
4. Insufficient integration of the various groups in the design process
5. Suboptimal integration of the design tools
6. Late problem identification on the physical prototype
7. Late consolidation of the wire harness bill of materials/protection

7 Speeding Things Up: Reducing latency times

Those wishing to generate new gains in efficiency must focus on processes. A simple look at the technical infrastructure isn't nearly enough. Reducing latency times with the interdisciplinary and consistent use of the digital twin is a very promising approach in order to significantly accelerate engineering and production processes and to reduce costs over the long term. Latency time is understood as the time from an event happening (e.g. a malfunction in a machining centre, the necessity for construction changes on a prototype) to the completion of the associated measures (e.g. procuring and installing spare parts, permanent documentation of design changes). There are distinctions amongst the following:

- Data latency
- Analysis latency
- Decision latency
- Implementation latency

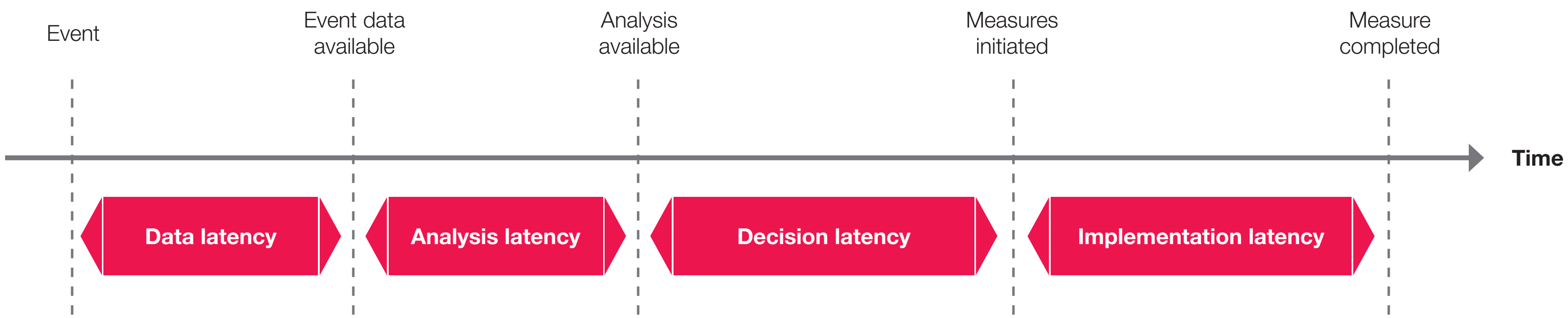

Figure 6: There are considerable latency times from an event to action being taken in conventional workflows.

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In the design/development and production segments, data, analysis and decision latency have the greatest efficiency potentials. This is about drastically reducing the time required and costs incurred while simultaneously increasing the quality of the measures taken. The comparison of analogue and digital strategies outlines the considerable potential.

If design/development and production is done conventionally – meaning successively, reactively and primarily on the basis of paper-based and/or individual knowledge – a sequential sequence of stocktaking, analysis and deciding on appropriate measures is indispensable (Figure 6). The more unstructured and decentralised the documentation and availability of asset data (for products, plants, etc.), the more time each individual work step takes.

The alternate digital plan based on the digital twin consistently networks data and processes for strategic planning, development, documentation and manufacturing. If real-time data is available for the digital twin through the coupling of information flows and industry-specific software, shortcomings such as excessive latency times can be overcome (Figure 7).

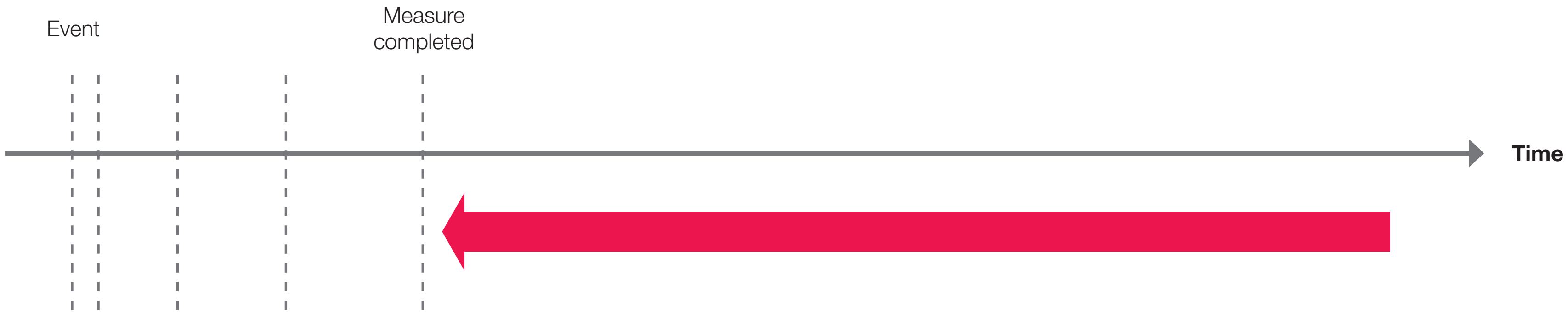

Figure 7: The availability of a digital twin significantly reduces latency times.

8 Recommended Actions: CAE software and the digital twin

From the digital prototype to the creation of complete manufacturing documentation: CAE software solutions can provide an easy entry into simple, sustainable and efficient design and documentation of wires and wire harnesses in 3D. They provide the collaborative environment in which electrical engineers can design their wire harnesses while considering both the electrical and mechanical constraints. What are the software requirements for this?

1. Ideally, both information sources can be imported: the electric schematics from electrical engineering and the mechanical geometries from the MCAD system. This closes the gap between the two disciplines so that instead of working sequentially, work now takes place in parallel.

2. What is needed are user-friendly functions for the virtual installation of wire harnesses and cables in 3D, to define the wire paths and to implement design checks to ensure consistent quality.

3. Manufacturing documentation including wire harness and wire drawings, nail boards, bills of materials, wiring lists, etc. can be created from the virtual prototype.

4. Using company templates ensures that the information is complete and standardised and that it meets the specific requirements and the requirements for the wire harness manufacturer. The digital prototype contains all the information necessary to prefabricate the wires.

5. Future-proof CAE software solutions are suitable for seamless integration into PDM landscapes.

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9 EPLAN Harness proD: Integrated 2D/3D wire harness development

EPLAN Harness proD is a state-of-the-art software for the efficient design and documentation of cables and wire harnesses. Automated steps – from reading the EPLAN project to routing the wires and creating the documentation and 2D nail boards – are the strengths of the system. EPLAN Harness proD, with its openness for transferring mechanically relevant information from a wide variety of MCAD systems and ECAD connection information, offers the potential for seamless integration into PDM landscapes. Designing the wire harness does not depend on the availability of a mechanical prototype. The bottom line is that development times are shortened, productivity is increased and project quality is improved over the long term.

"With EPLAN Harness, we can check everything in advance and detect errors early in the process without having to build an initial prototype: mounting options, wire routing paths with respect to the space in the target application or the accessibility of plug connections. Ninety per cent of the tasks can thereby be resolved in 3D and the efforts required for the prototype can be reduced to a minimum."
Christopher Bern, Team Leader for Battery System Development, Voltabox AG

"By parallelising mechatronic product development with EPLAN Harness proD, we can considerably speed up market entry for our customers."
Heinz Aitzetmüller, CEO, VDS Getriebe GmbH

"EPLAN Harness proD allows us to start with wire planning early in the digital phase of the mechanical prototypes. Many errors that previously went unrecognised until the physical prototype was built – meaning very late in the development process – can now be eliminated during the product development process. This reduces the time it takes to complete a project."
Ding Zuhui, Production Processes Engineer, CSR

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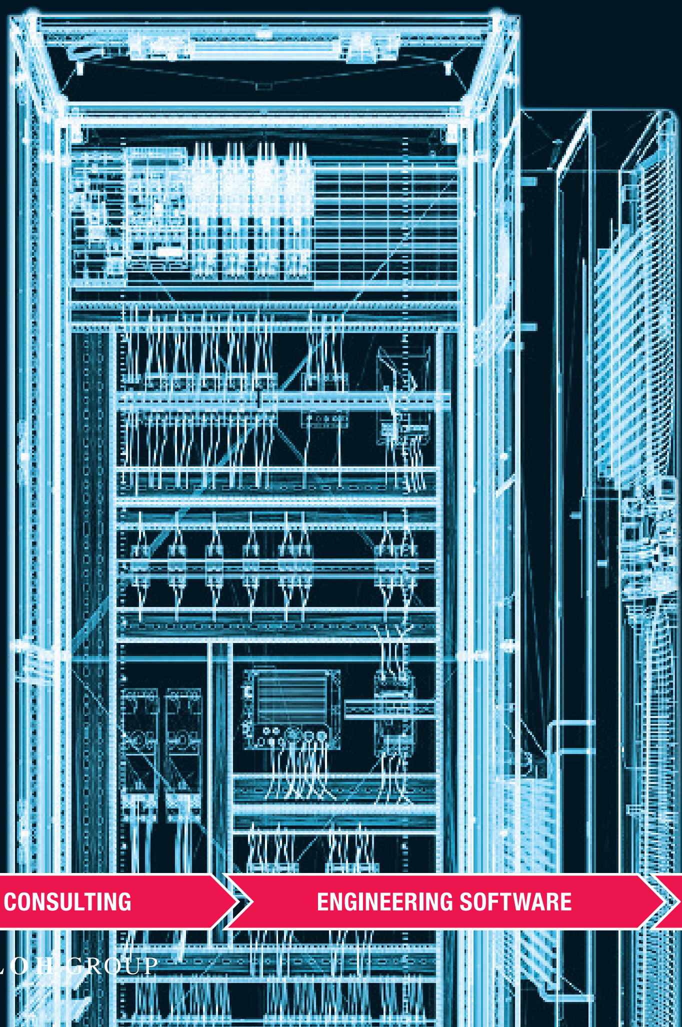

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