Simulation driven design

The outlook from the future design is within the simulation.

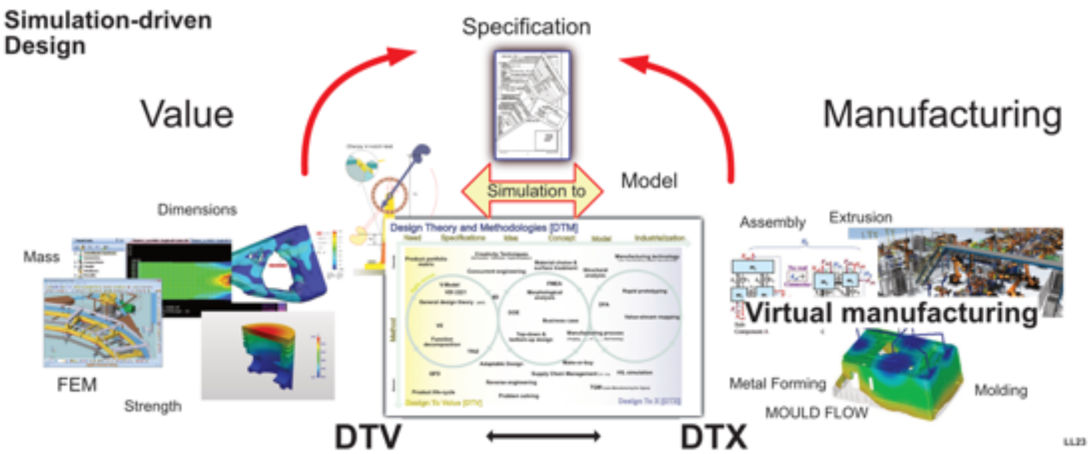


Fig: Simulation driven design

Designing in the future is using simulations to investigate all aspects.

With the increasing capacity of computers, simulations can be performed easily. The Industrial Revolution, Manufacturing 1.0 to 4.0, has led to vertical integration of all aspects of manufacturing. But what about design?

In an effort to increase innovation, cut costs, increase customer value and streamline design and production, lead-time is very important.

In the past it was common for a product that came on the market to be full of teething problems. There was also talk of that so-called Monday morning quality. Today this is no longer accepted. A product that is now being marketed must be of good quality. Teething diseases are not accepted. Another factor is the speed with which the product must be brought to market. Postponing or waiting costs a lot of money. These two aspects: quality and lead time require a simulation approach to the design.

In this white paper, we discuss the design process perspective with regard to simulation.

Before discussing the future of the design process, a brief definition of the features of the design process should be made.

Design specification

Design essentially starts with translating the wishes of the market, linked to the requirements set by the government, into a design specification. The design team then gets to work with this specification.

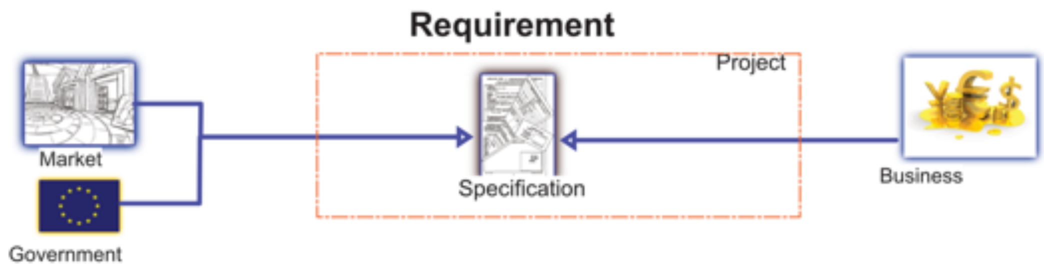
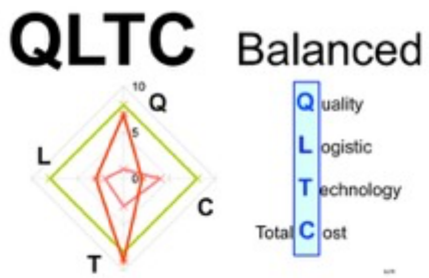


Fig: Requirement

How you arrive at a solid specification is another story. In a nutshell the design is an optimum between; Quality, Logistic, Technology and Cost.
The QLTC balanced.



For more information, see the book 'Methodical Design Explained' ISBN: 9789403679723.

Designing in the past

In the past, design was a craft. A craft that you could learn from a master. By learning early at a young age, the design knowledge was transferred. The journeyman master system. In this way, the knowledge to build pyramids, cathedrals or bridges was passed on.

One of the first guidelines for inventions *(design)* was developed by Fritz Kesselring *[Kesselring, 1954].* In his book *'Technische Kompositionslehre'* he describes a guideline called *'Guideline for inventions'* based on his own practical experiences. His goal was to scientifically explain the design, the process of how you come up with something.

Later with the invention of the slide rule, some additional calculations could be performed on the design.

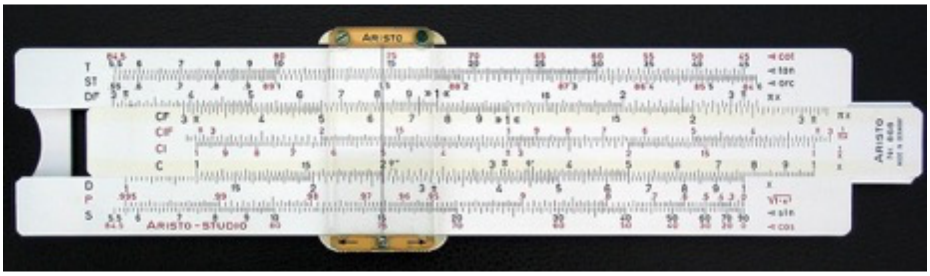


Fig: Slide rule © *Wikipedia*

In the 1990s, many guidelines and methodologies were devised to make designing more efficient. With the advent of increasingly powerful computers, the description of the models (drawings) has been transferred to a 3 D model. The 3D model is a mathematical description of the reality. This mathematical description made it possible to perform operations on it. One of the first applications was the so-called FEM methodology. The finite element method (FEM) is a method for numerically solving differential equations arising in engineering and mathematical modeling.

First simulations

Over time, more and more simulation applications were devised. This made it possible to assess the design in advance, to validate it against the set requirements. Until then, testing with real products was carried out to determine whether the design met the set requirements.

Now it is unthinkable that a design is released without several simulations applied to it.

Simulation driven design

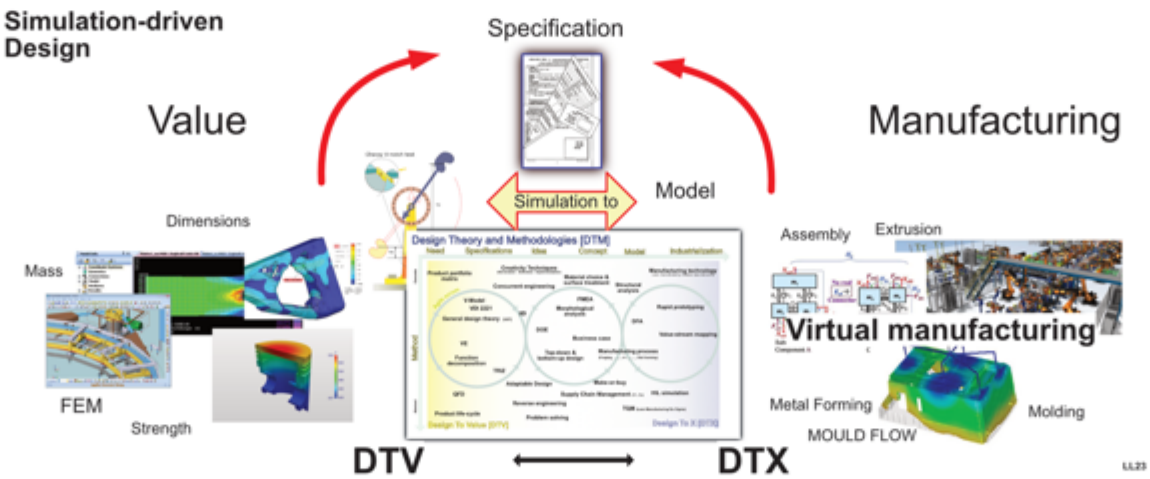
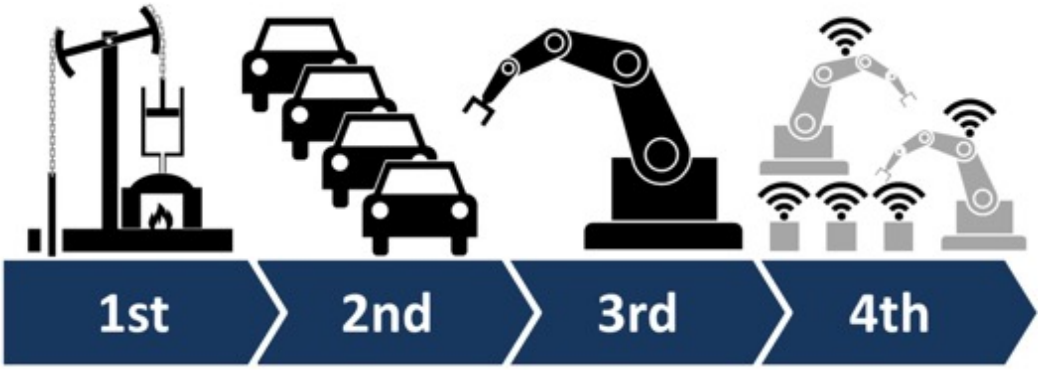


Fig: Simulation driven design

Assuming that everything can be stimulated in the future. Then there are two simulation starting points. Simulate to function and simulate to make it.

So much for the future. Where are we standing right now!

Manufacturing 1.0-4.0



Industrial Revolution © *Wikipedia*

First Industrial Revolution

The First Industrial Revolution was marked by a transition from hand production methods to machines through the use of steam power and water power. The implementation of new technologies took a long time, so the period between 1760 til1840.

Second Industrial Revolution

The Second Industrial Revolution, also known as the Technological Revolution, is the period between 1871 and 1914 that resulted from installations of extensive railroad and telegraph networks, which allowed for faster transfer of people and ideas, as well as electricity. Increasing electrification allowed for factories to develop the modern production line.

Third Industrial Revolution

The Third Industrial Revolution, also known as the Digital Revolution, occurred in the late 20th century, after the end of the two world wars. The significant development was the increasing power of the computer, with extensive use in communication technologies and in the production process.

Fourth Industrial Revolution

In essence, the Fourth Industrial Revolution is the trend towards automation and data exchange in manufacturing technologies and processes which include cyber-physical systems (CPS), IoT, industrial internet of things, cloud computing, cognitive computing, and artificial intelligence.

Smart manufacturing

Smart manufacturing, also called virtual manufacturing, utilizes big data analytics, to refine complicated processes and manage supply chains.

Smart manufacturing is a set of combined technologies that optimize the entire ecosystem of the production process.

In a nutshell: smart manufacturing is the combination of digital-driven applications that are implemented to constantly optimize efficiency and uncover opportunities to improve production performance, and lower costs - making processes smarter.

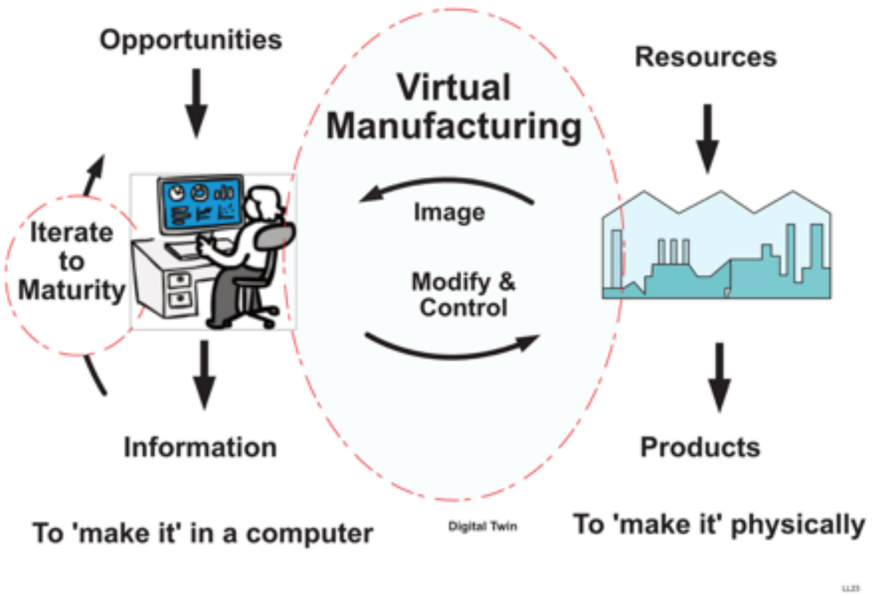


Fig: Virtual Manufacturing

Virtual manufacturing makes it possible to simulate opportunities in the virtual product. There is then a virtual model of the product on which all kinds of tests and trials can be carried out until the desired result is achieved. After meeting the requirements in the virtual world, it can be deployed in the real world.

Digital twins

A digital twin is a digital representation of an intended or actual real-world physical product, system, or process (a physical twin) that serves as the effectively indistinguishable digital counterpart of it for practical purposes, such as simulation, integration, testing, monitoring, and maintenance. *(Ref: https://en.wikipedia.org/wiki/Digital_twin)*

Digital twins are a powerful smart manufacturing tool that support production. A digital twin is the creation of an identical virtual product or system before a physical prototype is manufactured. This virtual environment allows designers and manufacturers to run simulations, iterations and testing on the design of a product to ensure viability before extensive production costs are incurred.

Later on, the digital twin can merge the product physical and virtual space. The digital twin enables companies to have a digital footprint of all of their products, from design to development and throughout the entire product life cycle. Broadly speaking, industries with manufacturing business are highly disrupted by digital twins. In the manufacturing process, the digital twin is like a virtual replica of the near-time occurrences in the factory.

Product Lifecycle Management (PLM)

The digital twin is disrupting the entire product lifecycle management (PLM), from design, to manufacturing to service and operations.

Fig: ERP process

Nowadays, PLM is very time-consuming in terms of efficiency, manufacturing, intelligence, service phases and sustainability in product design. Due to the Internet of Things, digital twins have become more affordable and could drive the future of the manufacturing industry. Thousands of sensors are being placed throughout the physical manufacturing process, all collecting data from different dimensions, such as environmental conditions, behavioral characteristics of the machine and work that is being performed. All this data is continuously communicating and collected by the digital twin.

A benefit for engineers lies in real-world usage of products that are virtually being designed by the digital twin. Advanced ways of product and asset maintenance and management come within reach as there is a digital twin of the real 'thing' with real-time capabilities.

Digital twins offer a great amount of business potential by predicting the future instead of analyzing the past of the manufacturing process.

Simulation

The representation of reality created by digital twins allows manufacturers to evolve towards ex-ante business practices. It is gaining momentum because it may offer real-time transparency.

The progression of the future path for digital twins depends of the ability of; IoT, AI and big data. The number of unknowns and the known unknowns will certainly ensure that new economic activities will arise.

As there is an increasing digitalization in the stages of a manufacturing process, opportunities are opening up to achieve a higher productivity. This starts with modularity and leading to higher effectiveness in the production system. Furthermore, autonomy enables the production system to respond to unexpected events in an efficient and intelligent way. Lastly, connectivity like the Internet of Things, makes the closing of the digitalization loop possible, by then allowing the following cycle of product design and promotion to be optimized for higher performance. This may lead to increase in customer satisfaction and loyalty when products can determine a problem before actually breaking down. Furthermore, as storage and computing costs are becoming less expensive, the ways in which digital twins are used are expanding.

Summary

Developing a product is one of the most complex phases in the entire development process, translating a customer need into a product that meets it. It is therefore predictable that the "whole" spectrum of knowledge and skills will be addressed in the development process. With the current rapid developments in automation, this should be possible in the (not too distant) future. In essence, the final development and production process is then: “The direct translation of customer needs into a concrete product or service.”.
The future of design and manufacturing revolves around the following four aspects: modularity, autonomy, connectivity and digital twin.

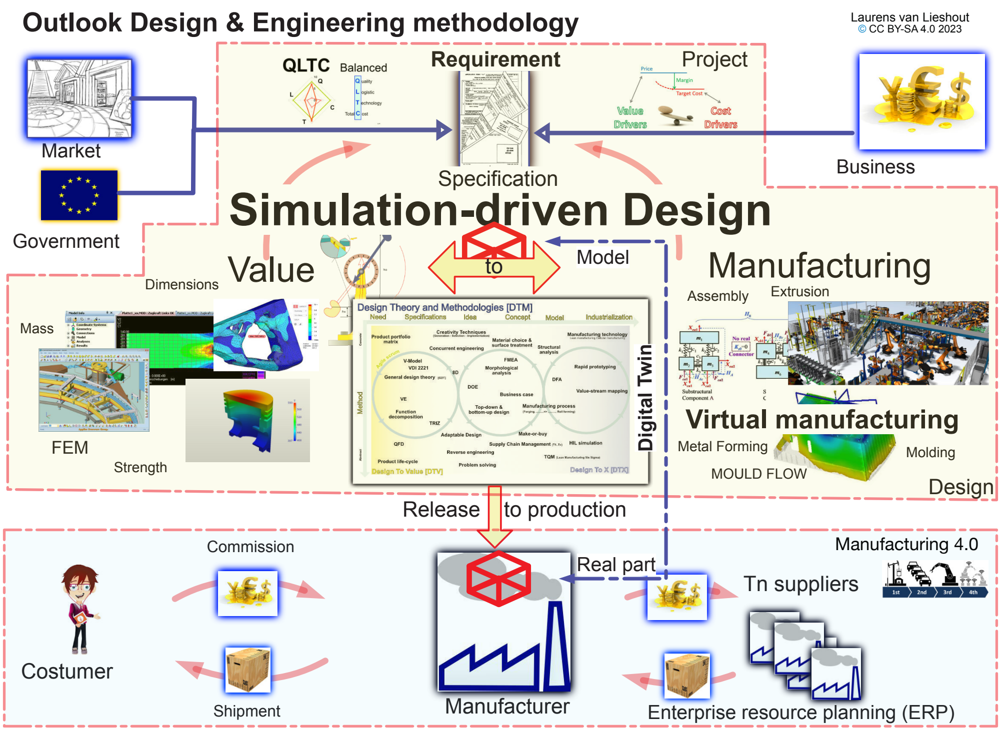


Fig: Outlook design process.

The holy grail!

In the simulation-driven design, we miss a good translation between the DFF and the DFX. The translation of the functional design to the manufacturing process. We need a simple real-time AI algorithm that determines whether a chosen process is executable. The real simulation can then be done later in the design process. This is the holy grail in the design process.

Accountability

This white paper was created to emphasize the importance of sharing knowledge for the manufacturing industry.

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The purpose of the KSC academy is to provide support to companies and organizations in the above field.