CADMATIC

ARTICLE COLLECTION

Data-driven shipbuilding

Aspects of a digital revolution and vast possibilities of advanced digitalization in the marine industry.

The Shipbuilding industry is currently undergoing a digital revolution that is creating and transforming business models. It is increasingly embracing the immense possibilities offered by advanced digitalization in the shipbuilding life cycle.

At CADMATIC, we are leading the charge to assist our customers to optimize the way ship design and shipbuilding is conducted. These efforts are guided by our vision of a transformed shipbuilding industry, one that is driven by data.

Articles

Data-driven shipbuilding

Text: Ludmila Seppälä / Martin Brink

What is data-driven shipbuilding?

Data quality, consistency, and interconnectivity, as well as the maximized automation of data handling throughout the entire ship design and shipbuilding process are key factors in unlocking greater efficiency, increasing productivity and boosting profitability.

In data-driven shipbuilding, digital data streams are consistent, reliable, and reusable across disciplines, project phases and ship series. Data drives and connects the entire shipbuilding process while manual data handling is minimized or eliminated to safeguard data integrity and optimize the shipbuilding process.

The quest is not only to optimize operations, reduce errors dramatically, and to get it right the first time, but to enable shipbuilders to manage changes more efficiently when errors or other factors necessitate changes. If changes are required at any stage of the shipbuilding process, the advanced digitalization and interconnectivity of data means that upstream and downstream changes can be efficiently implemented while the consistency of data is retained.

3D CAD model at the core of data-driven shipbuilding

The core of all a ship's data is created in and resides in the CAD 3D model. A myriad of calculation and analyses programs and other systems can run on top of the CAD core, incrementally adding to and creating the digital model of the vessel.

Data integrity ensures that the ship 3D model can be used to support and drive scheduling, planning, production, prefabrication, and building for optimal results.

Embedded knowledge in 3D CAD tools

In addition to tools for 3D modeling and design, design applications have a significant amount of embedded engineering practices and standards. Harnessing the knowledge of specialists in each discipline, CAD serves as a universal knowledge hub, applying the best solutions for each part of the model and ensuring consistency of design and compliance with regulations.

Designers can benefit from customized settings, specifications, predefined modules and previously created modules and sister ship projects. The personal experience of designers is less critical in such cases and can be supported by the software.

Decades of experience and highly specialized training is no longer required to produce accurate construction information. This allows engineers and designers to focus on creating new projects and sustainable designs, while the software takes care of calculations and the accuracy of data.

Digital model and digital twin

Traditionally, CAD revolves around first modelling a vessel in a digital environment, and then building accordingly. It is a way of evaluating design options and considering different possibilities without having to do it with physical objects.

Processes and systems can be modeled, 3D layouts checked for assembly and building stages and costs evaluated before the work at the construction site begins. In this process, information flows from the digital model to the physical object in one direction.

A digital twin emphasizes a bi-directional approach. The information flows not only from the digital asset to the physical world, but also loops back, where information from the yard and production merges with the digital model. This approach resulted in information management applications inside or around CAD tools, such as CADMATIC eShare.

A digital twin does not exist in isolation. It requires a software platform in addition to hardware storage facilities. The eShare platform allows digital twins to be created incrementally. It can store and merge 3D models in various CAD formats and effectively integrate data from other systems, such as PDM/PLM/ERP/MES and more. It provides users access to all this data using the latest advanced visualization technology and by extracting the required data on demand.

Integrating systems throughout shipbuilding life cycle

A key part of data-driven shipbuilding is the integration of systems used during the shipbuilding life cycle. Traditionally, much of the data produced in ship design and shipbuilding is siloed, which has inherent inefficiencies.

The integration of CAD, CAM, ERP, MES, PDM, and PLM can deliver digital twins that have true value. This is particularly so for consolidated shipbuilding groups that have vertically integrated operations from design and prefabrication to production.

Integration can be achieved in different ways. At CADMATIC, we believe in a flexible approach. We have a web API for traditional fixed integrations, but also connect and access data of different systems via the eShare platform.

Drawingless production

In our data-driven shipbuilding vision, consistent data streams lead to drawingless production and paperless operations.

The intelligence of IT allows the provision of data in digital format that is suitable for production. For example, based on the data collected by CADMATIC, when the first 3D viewer, eBrowser, was introduced on the market in 2000, the direct estimation from shipyards was that they were able to reduce the number of drawings needed for production by 30%.

Following this development, after introducing CADMATIC's eShare as a central portal for all interlinked project information, a further reduction of 70% in the number of drawings was achieved. This is an example of how increased intelligence in IT technology has significantly affected the number and types of drawings involved in production but was capped by societal readiness to change the existing regime. Pioneering yards focused on innovation and effectiveness, were more ready to make the change than yards where tradition and maintaining the status quo were stronger driving forces. Human and societal factors often conflict with technological possibilities.

Data-driven shipbuilding unlocks next-level efficiency

Data-driven shipbuilding enables close collaboration between all disciplines, integrates processes and assures end-to-end continuity by sharing the same source of real-time information.

This single source of truth assists shipyards to accelerate the time-to-market, drive down costs, shorten lead-times, and reduce quality issues in design, manufacturing and supply chains. It unlocks next-level efficiencies, increases productivity and secures profitability via data-driven processes and decision-making.

FURTHER READING:

» Case study about shell plate development
Harnessing the knowledge of specialists in CAD/CAM software

» CADMATIC eShare
A digital twin hosting platform

» Webinar for shipbuilding and offshore professionals
eShare - Beyond 3D review information management and visualization

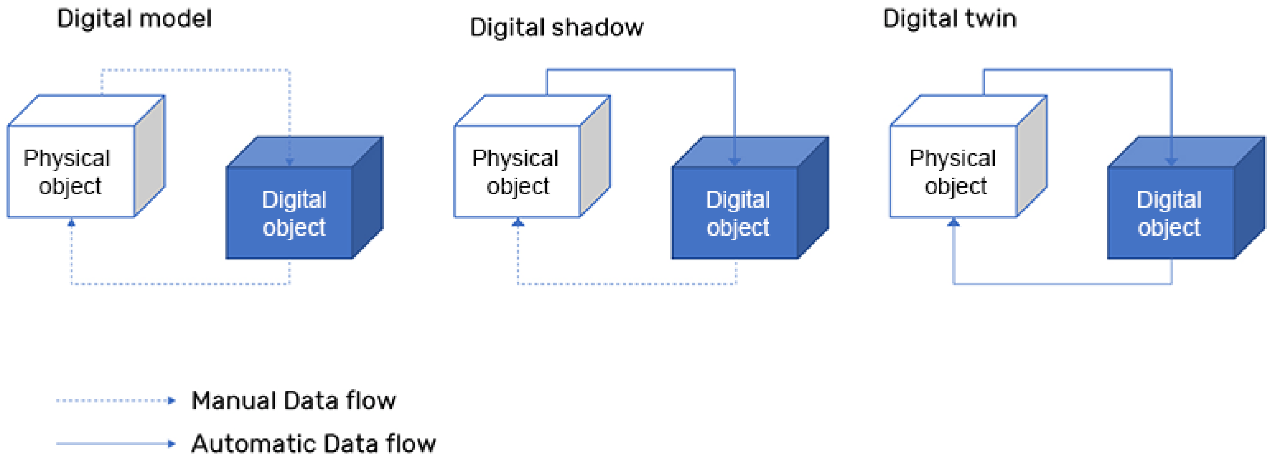
Digital model, digital shadow, or digital twin – what is at the core of data-driven shipbuilding?

Text: Ludmila Seppälä

Unlocking the full power of digitalization and fostering digital twins in the shipbuilding world has been a long-term dream. From the first 3D models dating back over 35 years to contemporary reality with IoT and big data tools, the evolution has taken a long time, and is not complete yet. The basic idea is the creation of a digital double of a complex physical object, such as a vessel or offshore platform, to enable asset management and simulation processes; it has massive potential.

First, it is worth looking at the origins and the distinction between digital models, digital shadows, and digital twins and elaborating on how the process of incremental creation of digital twins is facilitated by 3D design software and platforms for digital twins.

Digital twin is a hype term. It is often used in today's discussions about digitalization, smart production, and industry 4.0. Quite often, authors dedicate significant space in their articles to the discussion about the context and accuracy of this terminology for every use case. The digital model, on the other hand, has a more established definition.



Digital model

CAD is traditionally used to create a digital model to present a concept idea, detailed design of a ship in a digital environment, and to create production and construction documentation. It is a way of evaluating design options and considering different possibilities without the need to do it with physical objects. Equipment, construction items, and piping systems can be modeled, 3D layouts checked for assembly and building stage readiness and costs evaluated before the work in workshops and at construction sites begins.

In this process, information flows from the digital model to a physical object in one direction. The 3D model can be a simplified approximation or a 1-1 detailed model that contains a significant amount of meta-data. Usually, the purpose of such a model defines the tools used and the level of detail. For P&I diagram design or stability calculations and evaluation, even a 2D presentation is sufficient since at this stage of the project the details of 3D objects is not important. In these cases, the purpose of the digital model defines the level of accuracy. Typically, for CAD models this means a simplified 3D model for a basic project, which is used later for detailed design and production design.

Digital shadow

The reflection of a physical object in the form of its digital shadow has very specific uses. These include capturing as-built projects or using scanned laser data for retrofits or revamps. The flow of information goes from the physical world to the digital representation. As physical objects contain a large amount of detail, often the digital shadow needs simplification. A classic example would be a pipe with insulation. In addition to technology, human input is needed to recognize the correct outline of the object for the digital 3D model. Besides, meta-data is usually hidden. Based only on the physical shape of the objects, it is impossible to determine object IDs or related instructions for installation.

Digital twin

Digital twins begin with a digital model or a digital shadow to capture or initiate it. A straightforward scenario is when the digital model is incrementally created from the basic design stage, developed further in detailed design, and used to provide the needed information and to simulate changes for the construction process. This supports and facilitates the production process that results in a physical object, such as a vessel. Once the project is built and completed, the digital model might be discarded or might be used further for asset management as a digital twin. The range of needed use cases varies significantly from maintenance and modernization projects to specific cases of scenario simulation for emergency situations or personnel training.

It seems, that despite the forward leaps in the development of software and hardware, the existence of a universal digital twin is questionable. In industrial projects, different groups of stakeholders require different focus areas for information. What is essential and critical for designers, it not relevant for maintenance or other functions.

A digital twin emphasizes the bi-directional approach. The information flow not only from digital assets to the physical world, but also loops back; information from construction and asset management merges with the digital model. This is the most complex and challenging situation and requires a clear definition of needs and roles of stakeholders.

The role of the digital twin in data-driven shipbuilding

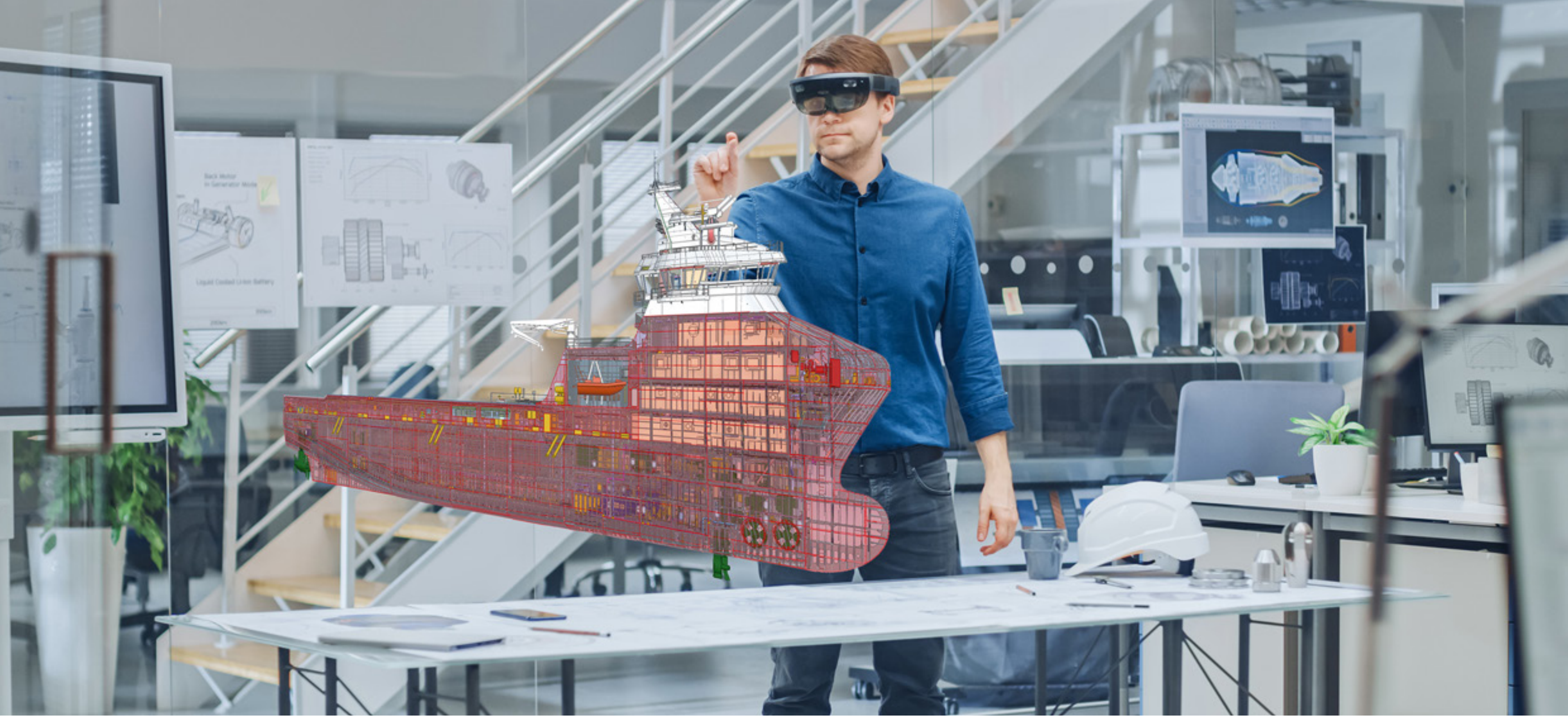
A digital twin is a process and not an object. In data-driven engineering, the digital twin plays a central role as the dynamic hub where information, such as the 3D model, a digital model with meta-data, digital shadow and all data related to the creation, building, and exploitation of a vessel evolves. Stakeholders at each stage of the life-cycle process define the use and the required scope of information for their business purposes.

The hub becomes a living entity and a process instead of being a data vault. The digital twin as a process enables close collaboration between all disciplines, integrates processes, and assures end-to-end continuity. By sharing the same source of real-time information, it drives and connects the entire process in data-driven shipbuilding.

FURTHER READING:

» CADMATIC's design applications for incremental creation of digital twin
Information management solutions for marine industry

» CADMATIC eShare
A digital twin hosting platform



Data that fuels shipbuilding – the role of CAD/CAM in data-driven shipbuilding

Text: Ludmila Seppälä

Shipbuilding has a rich history that spans centuries. Traditionally, it is considered an industry that requires a lot of intelligence and science. Vessel design requires extensive knowledge about stability, shapes, structural strength, engines, equipment, materials strength, and much more.

Modern ships are complicated autonomous floating storages and transporters, power generators, refineries, living quarters, and leisure facilities. It takes years to design and construct modern vessels: the joint effort and coordination of numerous designers and engineers, meticulously organized work in materials and equipment procurement, assembly lines, workshop floors, and shipyard process management. Months of testing and adjustments are needed to ensure operational stability, train the crew, and set up maintenance schedules.

Shipbuilding as a data flow process

Looking at the shipbuilding process from a data flow perspective is fascinating. From concept and basic design up to the shop floor and operations – a massive amount of data is created and used for various needs. Calculations performed for stability and flotation are critical in the initial stages, but not needed in production. Planning of production and work breakdown sequences can be prepared after the detailed 3D model is complete. The grouping of engineering, design, procurement, and production processes is non-linear and often simultaneous; the same can be said about data flows.

One might think that CAD/CAM/CAE packages take care of the whole cycle from the beginning of the project to the very end. However, a closer look reveals that shipbuilding's digitalization process is fragmented and often too narrowly focused. There are many types of data that originate and evolve during the shipbuilding process: engineering and calculations, 3D geometrical and meta-data, logistical sequencing, work breakdown information, and production data generated according to specific machinery needs.

Shipbuilding's intense design focus and use of AI

The shipbuilding industry is distinctively different from other industrial sectors due to the intense focus on design. The so-called CAD-centric approach emphasizes the 3D model and its role in shipbuilding as the single source of truth.

The other significant trend is the use of AI and machine learning technologies. Machine learning mechanisms can assist in design decisions made by engineers and naval architects. Regulations and best practices are embedded in CAD/CAM systems to help and act as a reliable knowledge storing facility. This process is not novel, as the first specification-driven features date back to the origin of CAD/CAM systems. However, new technologies such as neural networks and algorithms for the use of big data have opened up new possibilities.

It is true that for shipbuilding, the 3D model and related documentation extracted from it constitute a foundation. However, this leaves the shipyard processes uncovered. As a result, a functional gap was created between design data and the PLM/PDM/ERP needs to manage the shipyard operations.

Digital twins are the hub of ship information model

A common trend in modern CAD solutions is to look beyond creating the 3D model and extraction of production information. Incremental digital twin creation places the 3D model as the hub of the information model, adding layers of integrated non-centralized data. Essentially, this can be any data from any system that has an application in the shipbuilding process.

This approach aims to resolve the information gap and directly link the design and PLM-related data. The role of the CAD/CAM solution changes – instead of a tool for engineering and design, it takes on a universal 3D dashboard position. Adding information on top of the 3D model resolves the linking of data and information perception. Instead of looking through datasheets, users can see a 3D rendering of the end model and manipulate the data on a 3D dashboard. Advancements in computing power and new technologies take this even further – the data is available in any format and on any device – up to life-sized holograms in physical locations with AR/VR/MR/XR technologies and wearable devices.

The future development of CAD/CAD trends emphasizes the role of digital information flows and the process of digital twin creation. However, for the time being, it remains focused on the end product of a shipyard, a vessel that is delivered to the shipowner.

The next gap in the digitalization process is between shipbuilding data and operation, maintenance, and shipping. Creating specialized digital twins for each stage of the vessel's life cycle, seems to be a cumbersome and ineffective approach. Developing and facilitating a universal digital twin requires a broader perspective on digitalization and data flows, in which the interests of shipyards and shipowners are aligned.

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Drawingless production in digital and data-driven shipbuilding

Text: Ludmila Seppälä

Can 3D models replace traditional design drawings? If the question were formulated like this, most people would answer in the affirmative. Several would question whether it has not already been achieved and, if not, that it was only a matter of time.

If the answer to this question is that straightforward and such an obvious direction for the development, one can only wonder why this change has not happened already. 3D models have been around in shipbuilding for almost 50 years. Has this not been enough time to polish the technology and replace old artefacts, such as 2D drawings?

This article shows that the answer is not that simple and does not depend exclusively on technological aspects.

The power of creative destruction and Kondratieff's waves theory

Kondratieff's waves theory provides a broad structured view of the history of technological development. Based on the financial data from rolling 10-year returns of Standard & Poor's top 500 companies, spikes or waves can be observed that match technological changes. Figure 1 presents these waves along a timeline. Behind every significant upswing in financial returns, which moved societal development forward, there is a considerable step in the use of new technology: steam engines, railways, electricity, automobiles and petrochemicals, and information technology. None of the technologies is an isolated innovation or achievement: it is something that society was able to adapt and use profitably. Technological breakthroughs are tightly linked to societal development in terms of adaptation and acceptance.

According to Kondratieff's theory, the next and sixth wave of creative disruption will be fueled by intelligent technologies. There are many ongoing discussions in industry about digitalization, digital transformation and digital manufacturing, industry 4.0 and smart factories, as well as AI and the use of digital twins in production.

Intelligence is a key aspect of the sixth wave and differentiates it from its predecessor, which was based on information technology. One can speculate whether intelligence means actual AI or the possibility to be not only digital, but also data-driven.

One practical example of this change is the ongoing development of digital twins. As elaborated by Cabos and Rostok (2018), a digital twin is a digital representation of an object, enriched with behavioral models and configurations or conditions. As Hafver, Eldevik and Pedersen (2018) point out, the novelty of digital twins is not the existence and use of 3D models as assets, but how these models are bundled.

In other words, it is not about IT anymore; it is not about the possibility to digitalize all data and the 3D model, but about the intelligence behind this data.

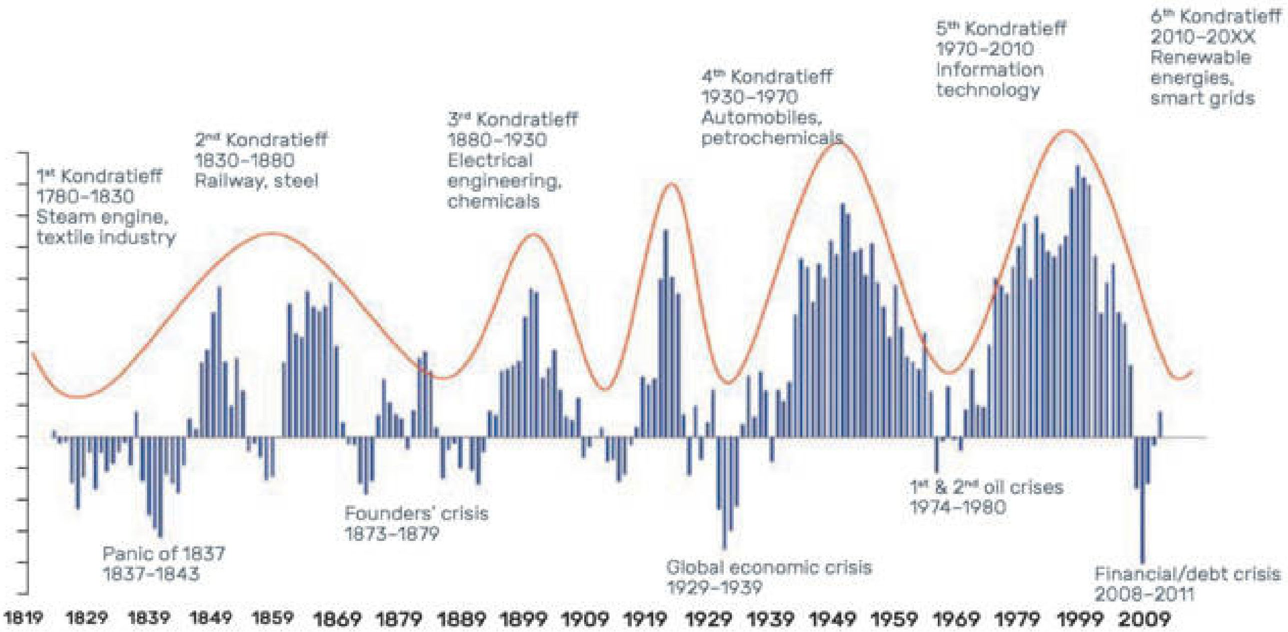

Figure 1. Kondratieff (1935) waves: linking rolling 10-year returns on the S&P top 500 and technological disruptions.

Deep transitions theory and evolution of CAD as innovation

According to the theory of deep transitions developed by Schot and Kanger (2018), there are more details inside each wave as it can be split more accurately into approximately 50-year cycles. An interesting result can be observed if this theory is applied to changes in shipbuilding. Figure 2 illustrates the main technological changes and innovations concerning deep transitions.

The era of IT in shipbuilding aligns with the beginning of commercialized use of CAD systems. Triggered by IT advancements, CAD evolved in the early 1970s from an innovation into something that became a common and essential part of shipbuilding projects. It took about 50 years for the technology to mature, for the newest hardware to be taken into use and for it to be fully accepted practice. In turn, the increased accuracy of design allowed even larger and more complex projects to be handled, a development that took shipbuilding to an entirely new level. The innovation served the industry and changed it. It was, however, not an isolated phenomenon. It was made possible by societal developments that required a large number of cargo ships and other types of vessels for global trade. As such, the context of innovation plays an essential role in the transition.

Multi-level perspective – innovations in context

The Multi-Level Perspective (MLP) framework is useful in understanding how a transition occurs and what makes it possible for an innovation to become viable and widely used.The multi-level perspective approach was originally developed by Frank Geels to explain socio-technological transitions, with a focus on sustainability. It presents a transition process in the context of three main layers: landscape, regime, and niche. The landscape layer represents the most stable structure – the existing state of things; it is a mixture of the political and economic landscape, the historically and socially stable way of doing things, and time-

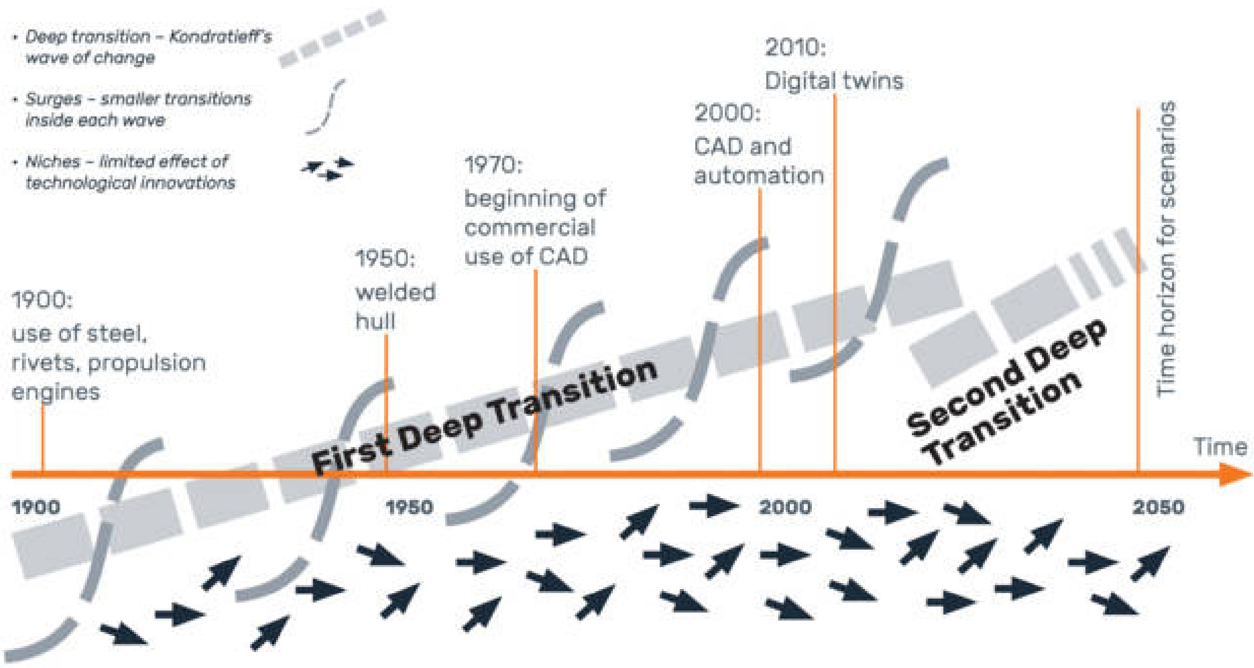

Figure 2. Deep transition transformation and historical shipbuilding milestones, including CAD development.

proofed technology that has been in use for a long time. The regime layer is more dynamic and consists of existing practices and the ways of process organization. Niches are the most dynamic places for incubation of new ideas and practices. Presumably, niches appear and frequently disappear, often having little impact on the system. However, when there is pressure from the landscape, the regime level has cracks and openings, creating space for the niche to enter the regime level and reshape it. "Niche-innovations may break through more widely if external landscape developments create pressures on the regime that lead to cracks, tensions and windows of opportunity" (Geels, 2010). The tension, caused by globalization and the development of IT technologies, such as increased computing power and graphics cards, created a "window of opportunity" and allowed CAD to progress to regime and landscape levels. A side effect of the transition was that CAD providers became significant players in the maritime industry.

Next wave of intelligent technologies

The intelligence of IT allows the provision of data in digital format that is suitable for production. For example, based on the data collected by CADMATIC, when the first 3D viewer, eBrowser, was introduced on the market in 2000, the direct estimation from shipyards was that they were able to reduce the number of drawings needed for production by 30%. The 3D model became accessible not only to CAD users – typically designers in the office – but also to production staff. It also did not require any special skills or training to use. It provided a powerful push to reduce the number of drawings. However, there are still cases when the amount and types of production drawings are justified by tradition and processes at a shipyard, and less by the practical need for these drawings in production.

> *It is not about the IT anymore, but about the intelligence behind the data*

Following this development, after introducing CADMATIC's eShare as a central portal for all interlinked project information, a further reduction of 70% of drawings was achieved. This is only one example where increased intelligence in IT technology significantly affected the number and types of drawings involved in production but was capped by societal readiness to change the existing regime. Pioneering yards, focused on innovation and effectiveness, were more ready to make the change than yards where tradition and maintaining the status quo were stronger driving forces. The human and societal factors conflict with technological possibilities in this case.

The level of automation is a key dimension in the discussion about automated production. There are many possibilities to automate production: steel cutting and bending, welding robotics, 3D printing, and automatic adjustments for workshop flows based on data analysis. Together with developments in robotics, this has become an essential factor for ship manufacturing. The cost of machinery and implementation has been a holding element in this regard.

The future of drawingless production

Figure 3 illustrates four main possible scenarios for the future of drawingless production. They are based on a division of high to low levels of IT intelligence and automation. Two stereotypical scenarios present "business as usual" and "high hopes for change" possibilities. The other two illustrate conflicting trends and tensions in the landscape that provide opportunities for innovations to grow.

While all four scenarios are possible, the continuous growth scenario is perhaps preferable, if one wants to be optimistic and disregard natural developmental limitations. A combination of scenarios for transformation and robotics would present a somewhat realistic picture in the medium-long perspective. In both cases, the gradual elimination of drawings in the production process is a likely outcome.

Considering the main driver of intelligent IT, drawings are already being gradually substituted with 3D viewers and with direct data transfer to production or manufacturing control systems. CAD plays a key role in the substitution process by providing interactivity with data and faster access to it within change management.

Originally, input to CAD was provided by users. This is slowly changing, however, towards the use of embedded design rules and the substitution of direct parameter inputs with inputs based on analysis or AI.

Interaction with data distinctively differentiates the digital era. The first attempts to standardize drawings aimed to improve readability and production quality. For the data-native generation, this poses unnatural limitations. Instead of a static snapshot, people prefer to obtain data on demand, and then manipulate it.

The following use case illustrates this process. Traditionally, many drawings in shipbuilding come from piping production data or spool drawings. Estimations are that a big cruise liner, of about 350m, has about 10,000 spools. With current practices, these drawings are automatically generated and annotated. However, about 5% (with effective use of CAD and settings matching production needs) require manual work.

The process itself is quite laborious and time-consuming. However, the main culprit is the use of these drawings in production. Every drawing must be manually examined and used as an instruction to manufacture a piece of pipe and often the data provided on the drawing is not sufficient or outdated due to changes in design by the time it reaches the workshop. The possibility to generate and visualize production data at any time would remove the disconnect between design and manufacturing.

As a practical example of such developments, some CADMATIC customers already use provide an online connection to design data in the production workshop and display the data in 3D viewers with annotated models. Alternatively, they use AR with HoloLens or VR interfaces directly with the 3D model.

The foundational technologies for drawingless production are set and the direction is well-defined. The question remains whether the window of tension is enough for the innovations to progress, spread and become part of the regime.

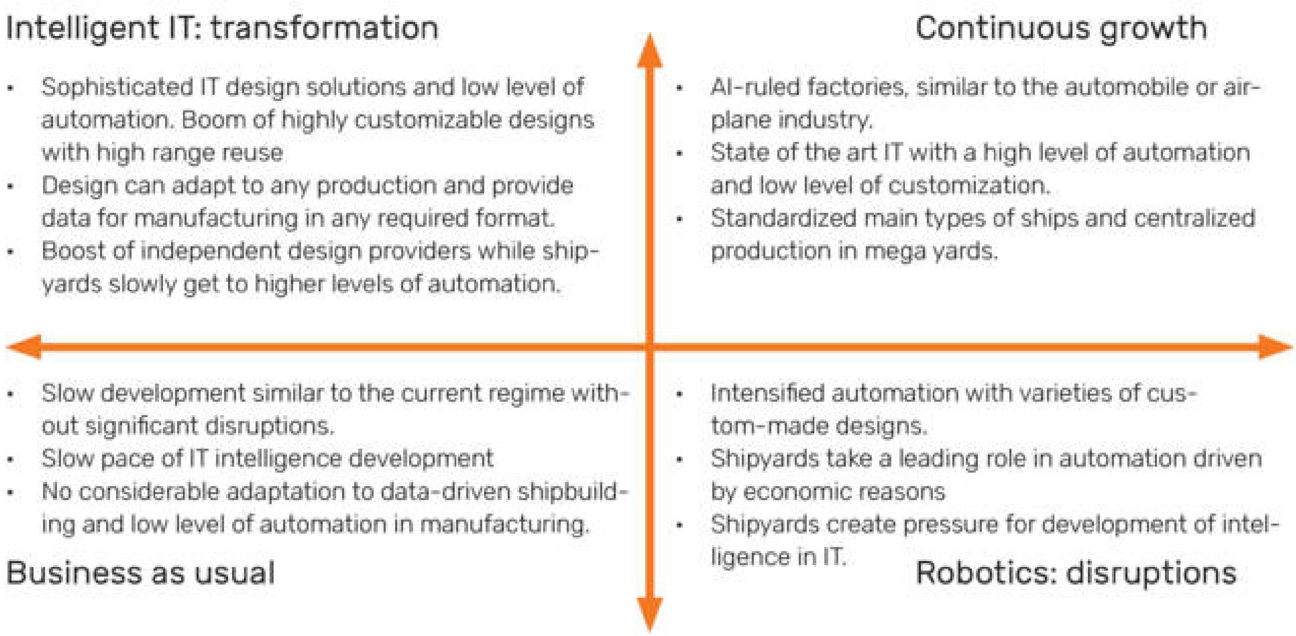

Figure 3. Future scenarios of drawingless production in digital and data-driven shipbuilding towards 2050.

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