PLM as Enabler for Industry 4.0

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Foreword

We are delighted to present you with this whitepaper on the NTT DATA vision for Product Lifecycle Management (PLM) in the age of Industry 4.0 and the Internet of Things (IoT). A clear vision lays the groundwork for an effective PLM strategy.

Over the last 25 years, PLM for companies in the manufacturing industry has transformed from an administrative system for product data management to a general management concept and a cornerstone of enterprise IT. A comprehensive PLM vision covers product data management throughout the entire product lifecycle in the company and with partners.

In order to implement Industry 4.0, parts of the established PLM vision need to be expanded and existing concepts need to be reprioritised.

We are certain that this whitepaper will provide you with valuable ideas for further developing your PLM vision and strategy.

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Introduction

Leading companies in the manufacturing industry have expanded their PLM methods and systems in recent years to ensure increased coverage of the product lifecycle and stronger integration of processes along the entire value-added chain. The age of Industry 4.0 and the Internet of Things poses new challenges:

- The development of smart products
- The planning of smart factories
- The integration and digital networking of processes
- The designing of new business models, in particular new service offers

Global manufacturing companies need to meet local market demands and develop differentiated offers. Gartner summarised the relevant technology trends in the ‘Hype Cycle for Discrete Manufacturing and PLM, 2014’ as follows:

- Digitalization and merging of the physical and digital worlds
- Software-supported products and systems, such as the Internet of Things (IoT) and Machine-to-Machine (M2M) communication
- Interacting effects from social, cloud, mobile and big data/analytics
- 3D printing

The trends influence product development and production in equal measure. The German government is focusing on a new direction in the future of production with Industry 4.0. This is to be characterised by customised products, flexible production, integration of business partners and (end) customers in company processes and the pairing of products and production with services.

How can PLM support Industry 4.0 and the IoT using the above-named trends? And what needs to change in product development to transform this vision into reality? This whitepaper provides the answers and food for thought.

- What is PLM?
- What is Industry 4.0?

Definitions

Product Lifecycle Management as management concept
Product Lifecycle Management is a management concept for integrated processes during the product lifecycle that is supported by IT systems. A core function is product data management for example:

- CAD models, bills of material
- software, requirements
- throughout the entire product lifecycle
- across departments, locations and partner companies

Another core function is process management:

- changes, releases
- with integration of the involved functions and systems

**From drawing management to PLM**

An NTT DATA appraisal

PLM has transformed in the last 25 years from a simple drawing management system to a cornerstone of enterprise IT, alongside ERP, CRM and SCM. To start with, the focus was on mapping complex product data structures and integrating CAD systems for mechanical design. Globally distributed development processes (global collaborative engineering) could be supported with functions for collaboration across multiple sites and data exchange.

Drivers for this development include increasing demands from customers, such as systems engineering for the development and safeguarding of mechatronic products, or digital manufacturing for the integrated planning and development of production processes, tools and logistics. Understanding of PLM is also growing, meaning that earlier phases of the product lifecycle, i.e., innovation, target and requirements management, as well as the later phases, such as service and recycling, are also covered. Thanks to after-sales PLM, current product data for customer services and technical documentation is provided, and new service offers can be created as well.

Providers of PLM software are preparing themselves for this development by expanding their product range. That is why the PLM market has been characterised by mergers and acquisitions in the past few years. Points of focus include solutions for systems engineering (requirements management, application lifecycle management, system modelling and simulation), for digital manufacturing, including manufacturing execution, and for service lifecycle management (technical documentation, replacement part management, maintenance planning). Most recently, there has been increased investment in solutions
for the Internet of Things, for example, for the development of embedded software, apps and backend systems.

Industry 4.0 as Business Scenario

**Industry 4.0: Evolution or revolution?**

An NTT DATA appraisal

The steering committee for the Industry 4.0 Platform, initiated by the German government, agreed on a concept definition and vision of ‘Industry 4.0’ in 2013: “The term Industry 4.0 describes the fourth industrial revolution, a new level of organization and control for the entire value-added chain throughout the product lifecycle. This cycle focuses on increasingly individualized customer requirements and ranges from the idea and the contract, development, manufacturing and delivery of a product to the end customer, right through to recycling, including the associated services. The basis is the availability of all relevant information in real time by networking all instances involved in creating added value, as well as the ability to derive an optimal added-value stream from the data at any time. The linking of people, objects and systems leads to dynamic, real-time optimized and self-organizing cross-company added-value networks, which allow costs, availability and resource consumption to be optimized according to various criteria.” From our perspective, Industry 4.0 is not a revolution. “Production technology and the associated processes are not undergoing a radical transformation, the change is rather evolutionary in nature. It is even more difficult to predict when Industry 4.0 will become prevalent because there is currently no complete scenario. Most projects currently focus on individual facets.” (Dr Andreas Pauls, Executive Management intelligence Germany, NTT DATA Group).

While Industry 4.0 implements the technology trends of the Internet of Things, mobile, cloud, and big data for production, smart products use the same technologies in the end products. When combined, end-to-end processes from the manufacturer right through to the customer with new business models are possible.

**Action areas: PLM and Industry 4.0**
01: Digital models

Digital models of the product, production, supply chain and service processes are a necessary requirement for integrated, digitally networked processes in an Industry 4.0 scenario. PLM provides these digital models in an up-to-date manner throughout the entire product lifecycle according to requirements.

Challenges:

- Integration of component models
- Universal semantics (Standards)
- Digital models
- Action areas: PLM and Industry 4.0

Models are digital maps of reality, with real objects and processes. They enable the integrated development and safeguarding of complex systems. Models form the basis for integrating the virtual and real world, for example, with crash simulations for vehicles, line balancing of assembly processes based on working time, production and logistics models, or with 3D CAD models as input for 3D printing.

Since models are a simplified mapping of reality, they are ideal for communication between process partners, for example, for the use of 3D CAD by the end customer in a product configurator or for the graphically supported ordering of replacement components. The efficient evaluation of data (analytics) requires a data model that includes relationships between objects.

PLM provides authoring systems for various component models (geometry, electrical/electronics, function, assembly, durability, etc.) It also serves as a platform for managing the models. Model-based systems engineering (MBSE), the integration of various component models at system level, is currently the supreme discipline. In this respect, the virtual system model should contain all disciplines such as mechanics, electrical, electronics, and software, including all interdependencies.

The vision in an Industry 4.0 scenario is an end-to-end digital chain from product development, production planning, production and logistics, right through to the service. This therefore enables simulations of entire business models or total costs.

The integration of component models poses various challenges. Although systems can be modelled with SysML, for example, if production, logistics and service also need to be integrated in addition to product models, there is often a lack of standards and universal, cross-company semantics. The Industry 4.0 Platform thus called for standards for universal semantics and improved tool support in the 2014 research and development whitepaper. The ProSTEP iViP association is working on these kinds of standards.

02: Smart products

Products become 'smart' especially by software, networking into the Internet of Things (IoT) as well as with additional services. The creation of added value for manufacturing companies is therefore moving in the direction of software, cloud and services, and allows for completely new business models. Product development and thus PLM cover embedded software, apps, backend systems and services, alongside hardware. Systems engineering provides methods for developing these systems and managing their complexity.

Challenges:

- Model-based systems engineering
- Methods and tools for IoT
Modern products are not just pure hardware; instead they constitute complex systems with micro-processors, sensors, communications interfaces, embedded software and accompanying apps. This is how the number of connected cars is set to multiply by six, from the current 23 million to 152 million in 2020 (IHS Automotive). Smart products can be personalized and remote-controlled, as well as enabling new services such as remote update and monitoring. The Internet of Things (IoT) networks these objects with each other and the Internet. It combines technological advances in IT (storage capacity, processor performance, communications infrastructure, social, mobile, big data and cloud) with trends from the information society (power of the individual, knowledge society, always-on).

For manufacturers, this means that conventional products also now need to be transformed into ‘smart’ ones, resulting in the development of mechatronic systems. Systems engineering provides methods for developing and safeguarding these kinds of systems. However, manufacturers also need to invest in the cloud for the networking of smart products, particularly in the secure link-up and development of special cloud services for expanded product functions. These investments are worth it if further revenues can be generated with after-sales services for the product. New business models need to be developed for this, earnings need to be increased throughout the entire product lifecycle and new partners need to be integrated where required.

PLM initially manages the product data and controls processes, such as requirements management, change management and approval. However, apps and user interfaces for smart products, cloud services including backend systems, business models with a focus on services, and big data solutions for analyzing data findings need to be developed for the systems described above – with an integrated system.

**03: Smart factories**

Smart factories set themselves apart in the Industry 4.0 scenario with cyber-physical systems (CPS), i.e., autonomous, networked systems that can directly influence their environment with sensors and actuators. This enables high flexibility and small batch sizes for customer-specific products. PLM provides methods and tools for digital manufacturing to form the basis for factory and process planning.

**Challenges:**

- Production of smart products
- 3D master (drawing-free production)
- Integration of PLM, ERP, MES and SCM
- Development of CPS

The working committee for Industry 4.0 gives the following definition of smart factories: “An individual company or an association of companies that uses ICT (Information and Communications Technology) for product development, production systems engineering, production, logistics and coordination of interfaces to the customer in order to be able to react more flexibly to demands. The smart factory masters complex processes, is less prone to disruption, and increases production efficiency. It goes without saying that people, machines, and resources communicate in the smart factory just as in a social network.”

Flexibility and individuality are also achieved using electronics/software as well as networking of production resources, i.e., the cyber-physical systems (CPS). Compared to smart products, further aspects need to be considered in the production environment, for example, self-optimizing of components and systems, human machine interfaces and energy efficiency. In order to create smart factories, PLM offers
the traditional methods and tools for digital manufacturing, beginning with factory planning, assembly planning, ergonomics simulation and CNC programming, right through to robot control. New approaches are required for the development and safeguarding of CPS. 3D printing is also an option for flexibility and customization of production. PLM provides the required 3D models in up-to-date form.

A key challenge is the production of smart products, for example, software logistics for the flashing of control devices on the assembly line with up-to-date, compatible software. Products no longer only comprise hardware manufactured in production, meaning that quality management and logistics also need to cover aspects such as apps, services and communications infrastructure in order to deliver a full service. Finally, more in-depth integration of PLM, ERP, MES and SCM is necessary for seamless communication in the smart factory. The replacing of 2D drawings with 3D models is just the beginning.

04: Smart service

Smart service provides customers with added value as opposed to just the product. The manufacturer has access to new business models to increase profits and customer retention and reduce warranty costs. In particular, smart products enable new service offers. After-sales PLM ensures integrated development of services and service processes during product development. Furthermore, it provides product data for technical documentation, replacement part management or maintenance planning.

Challenges:

- Use of development data in service
- Mobile online services
- Feedback from the service for development
- Field-monitoring of products.

Smart products enable smart after-sales service. The monitoring of product use and data analysis allow for preventive maintenance, optimization of replacement parts logistics, and the development and appropriate processing of warranty cases. Errors can be resolved with remote updates, and new functions can also be incorporated into the products, for example, as a paid-for upgrade or ‘online accessory.’

Manufacturers can set themselves apart with the right mix of product functionality, mobile online services and networking with other systems. There is a significant increase in customer retention, since the customer now uses a complete system and the amount of interactions with the manufacturer increases during product use.

After-sales PLM incorporates PLM functionalities from development into the after-sales processes. With PLM as a backbone, product data is used in technical documentation to ensure integrated content management. On this basis, planning of replacement parts, maintenance activities, service offers and upgrades during the product lifecycle can take place parallel to product and process development.

The challenges in this scenario are the major changes in service organization and processes for service provision. Less field-service personnel are needed thanks to preventive maintenance and remote updates, but this requires the development of mobile online services, including backend systems. High standards regarding IT security are to be complied with when processing customer data. Finally, it is necessary to standardize diagnostic and error data across various products and service organizations to effectively evaluate service data in the development department.

- Industry 4.0 is a meaningful evolution
- PLM is an enabler for Industry 4.0
Focus of the PLM vision and strategy on Industry 4.0

Conclusions and recommendations

Industry 4.0, including IoT, is no short-lived hype. Instead, it is a vision for the future that can be implemented in many small steps. The results may appear revolutionary in hindsight but the implementation of Industry 4.0 is, in fact, evolutionary.

This whitepaper has examined the contribution of PLM to Industry 4.0 in four action areas as well as identifying the existing challenges. These analyses clearly demonstrate that PLM is an enabler for Industry 4.0. PLM provides digital models for the integrated development of product, production and services. The development of smart products means the development of connectivity, backend applications, services and business models, in addition to systems engineering for mechatronic products. The vision is an end-to-end digital chain from product development, production planning, production and logistics, right through to the service.

The recommendation is therefore to keep the focus of the PLM strategy on Industry 4.0 as one of the most comprehensive business scenarios not only for production, but for product development and service as well. Technology trends such as digitalization and IoT are to be considered during this process and too close a focus on pure production scenarios is to be avoided.

The PLM strategy now ultimately needs to cover the entire product life cycle to enable end-to-end processes and plan the corresponding structuring of the IT landscape. Individual projects in the PLM roadmap can be reprioritized in favor of increased standardization. Integration of the affected IT systems becomes more important, meaning concepts such as SOA* and OSLC* also increase in importance just as much as IT security.
Use the NTT DATA framework for developing PLM strategy and structuring in order to systematically implement the necessary transformations for business scenarios such as Industry 4.0. You can discover more about the relevant trends for the information society and technologies with our analyses in the NTT DATA Technology Foresight report.

* SOA: Service-oriented architecture
* OSLC: Open Services for Lifecycle Collaboration

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Technology programme for supporting Industry 4.0 projects
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