Industry 4.0 Transformation – A Holistic Model Based Solution Approach

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Where earlier industrial revolutions were marked by single technology innovation, the 4th industrial revolution includes several major technology innovations.

Industry 4.0 definitions refer to the combination of multiple major technology innovations. However, it is necessary to realize that enterprises need to undergo a major transformation, which is usually performed using a pragmatic agile approach. Current approaches have revealed to be insufficient to drive digital transformation projects for Industry 4.0, simply because they lack insight for the broad variety of stakeholders. As a consequence, these projects are often over budget, over time or even terminated. In other cases, these projects are not even able to kick off. Three of many examples are:

- MES (Manufacturing Execution System) related projects: global roll out or upgrade, change and management of a MES template, harmonization across multiple sites.
- Integrated horizontal and vertical value chains: PwC described this as: integrated vertically to include every function and the entire hierarchy and horizontally linking the suppliers, partners, and distributors in the value chain and transferring data among them seamlessly.
- Creation of an IT-OT (Information Technology – Operational Technology) architecture according to Reference Architecture Model Industry 4.0 (RAMI 4.0).

Traditional approaches focus on a single system at a time; however, in Industry 4.0 everything is much more connected and integrated and therefore the dependencies are a multifold higher than in current environments. These interdependencies require projects to use a holistic approach and manage these dependencies. To be able to achieve this, a digitized model based approach is proposed that can be used to drive the full life cycle of such transformation.

These models will be key for Industry 4.0 transformation, the solution approach in this paper is a holistic model based transformation approach.

In this paper, the approach is described on an impact level, while the details of the modeling solution itself will be described in a separate paper.

Holistic model based transformation

Besides several major technology innovations, Industry 4.0 is also characterized by new ways of collaboration, product development, the need for integrated horizontal and vertical value chains and new business models. All these need to be fully transparent and give the right (exception based) insights to the user, anytime, anywhere.

The fundamentals of the proposed solution are based on dynamic system thinking and modeling. In the holistic model based approach 6 constituents are defined for Industry 4.0 transformation that can be described as dimensions.
Six integrated dimensions are defined:

- **Dimension of users**: this can be internal, external or a combination of both aligned with the defined collaborative eco landscape
- **Dimension of enterprises**: includes the internal as well as the external parts of enterprises that collaborate to reach Industry 4.0 business benefits
- **Dimension of processes**: includes internal processes as well as the integrated processes of the value chain needed to deliver the defined benefits or products
- **Dimension of applications**: all applications to support the system of processes and product lifecycle
- **Dimension of physical assets**: all machines involved in the eco landscape
- **Dimension of infrastructures**: to support and facilitate the above; support for communication and integration

Following such a solution approach makes it possible to structure, organize and execute in an agile matter, with full flexibility executing the strategy and roadmap.

However, the typical Industry 4.0 transformation challenge remains: the transformation is overwhelming and difficult to control. This is where the holistic model based solution and the need for digitized dynamic models kicks in. For this the following possible model types are defined: dimensions, subsystem, building blocks and artifacts.

Dimensions are incrementally created and extended following a bottom-up approach. A dimension is first instantiated with small building blocks that at least as a whole or partly can be reused in subsystems, which at the end will contribute in defining the dimension. Artifacts can be created by combining dimensions, subsystems and/or building blocks. Artifacts can fulfill the dynamics of the Industry 4.0 using transformation cases. A project usually produces an artifact containing multiple building blocks that belong to different dimensions.
A key artifact is the **IT-OT architecture** that merges the Information Technology and the Operational Technology worlds and contains the integrated constituents of the above. A holistic model based approach makes it possible for enterprises to design, build and implement their **IT-OT architecture** with optimal flexibility.

As Industry 4.0 includes mission critical, high performance, quality and rapid market demand behavior, the models should be formalized, sustainable and at the same time be accessible and interactive in the different system dimensions through the subsystems and building blocks.

In general, a holistic model based solution for Industry 4.0 should exist of at least the following components:

- Model creator, designing the models;
- Management and governance on how to work with the different model types;
- Data contextualization of the artifacts to enable fact based decisions and analytics.

**Value of holistic models**

To directly receive value out of holistic models, a seven-step approach is described that creates a path towards Industry 4.0 transformation.

The main difference to a typical traditional approach is that the steps are supported by dynamic digitized models.

- **Step 1 – Perform Digital Maturity Assessment**: Here an As-Is and To-Be digital maturity analysis is done, to understand the gap and the ambition. The difference with traditional approaches is that now the As-Is and the To-Be are modeled, which makes the activities sustainable and visible. This dramatically helps to understand benefits, challenges, use cases and maximize leadership as well as secure shop floor commitment.
• **Step 2 – Execute proof of concepts and pilot projects:** How and which proof of concepts, pilots and projects to start could be quite a challenge, but you need to start. Combining an agile execution approach with the first created models gives the possibility to understand fact based impact as well as complexities, costs, benefits and quick wins. This gives a first insight to showcase and understand the started transformation in an early stage.

• **Step 3 – Identify Enablers & Accelerators:** As all knowledge, lessons learned and gaps are captured, this is linked to the models. Holistic sustainable insight will continuously evolve within the enterprise and gives feasibility of enablers and accelerators. Execution and roadmap can be adjusted accordingly, whilst showing impact and benefits from an operational perspective.

• **Step 4 – Design and create IT - OT Architecture:** Deployment and transformation are directly tied to the enterprise architecture capabilities. Industry 4.0 demands that the business information technology architecture should be integrated with the engineering and manufacturing IT (Operational Technology) architecture. As this is more than just integration or data communication, this could be seen as a fusion of architecture (models). This is where the ‘mother of Industry 4.0 models’ of your enterprise should be defined, created and managed and thus will be the enterprise’s gold assets.

• **Step 5 – Build Analytics Capabilities:** Analytics should not be limited to data, but should extend to processes, applications, infrastructure and assets. Contextualization and dynamic behavior capabilities are characteristic analytics requirements for Industry 4.0.

• **Step 6 – Drive Digital Transformation:** Culture and user experience are essential for successful transformation. Changes should be visualized before and during such transformation, giving users interactive access and involvement. As digital transformation has direct and constant impact on a global reach into every square meter of the enterprise, knowledge sharing, capturing and interactive feedback should be part of any global deployment.

• **Step 7 – Sustain Eco landscape:** Integration of horizontal and vertical value chains requires tight collaboration and knowledge sharing on multiple levels, such as product development, manufacturing and associated business processes. The whole eco landscape should benefit of the value creation.

### Traditional vs Holistic Model Based Approach

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<tr>
<th>Traditional</th>
<th>Holistic Model Based</th>
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<tr>
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<td>5. Build Analytics capabilities</td>
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<td>6. Drive digital transformation</td>
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<td>7. Sustain eco landscape collaboration</td>
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Within each of these steps sprints can be defined, using the models to:

- Analyze, test and validate: understand the current situation either before starting the project or as an evaluation of the implemented to-be situation; the focus here is on validating that the model is (still) consistent with reality
- Plan and decide: define the to-be state of your project; identify dependencies, understand design alternatives and their consequences, etc.
- Execute and implement the plan based on the planned activities

**Holistic model based approach vs. traditional**

An example is used to explain the advantages of using the holistic model based approach vs. the traditional approach. In this example two use cases ‘real-time process track and control’ and ‘real-time visualization and action taking’, projects are running.

On the right side, a typical traditional approach shows that there is interoperability and dependencies between several initiatives, but there is no mechanism to capture and align the impact between the several initiatives. This increases complexity, uncertainty, level of assumptions, misinterpretation and miscommunication.

The left side shows the holistic model based approach, where several initiatives are supported and guided by respective Industry 4.0 models to incorporate and manage interoperability and dependencies. The model based repository handles the complexity in the background while updating the models with all changes. Each designated user can have customized access and have joined interpretation and a collaborative way of working. The user can perform analytics on the models to receive insight on the requirements and respective goals.

For each of the projects the relation with the transformation dimensions can be understood, making it possible to manage and have insight on interoperability and dependencies.
Typically, an enterprise will have multiple initiatives at the same time, increasing the challenges for Industry 4.0 transformation. This is where the holistic model based approach will make sure to provide full clarity and control, regardless of the number of initiatives, their interoperability and the dependencies during their lifecycle.

To be able to drive transformation with a magnitude as Industry 4.0, a solution approach is needed that is capable to handle, simplify and visualize the complexity and dynamics of Industry 4.0 in an agile matter. The holistic model based approach is suitable to facilitate the life cycle of Industry 4.0 transformation making sure enterprises capture the full potential of it.

Note that the model based repository details will be described in a separate paper.

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