

# MIGRATION STRATEGIES TO DIGITAL AUTOMATION IN THE INDUSTRY 4.0 ERA

*A Guide for Smooth Transition to Industry 4.0*

# Preface

The FAR-EDGE Migration Services support manufacturers, plant operators and solutions integrators in planning and realizing a smooth migration from conventional industrial automation systems (like ISA-95 systems) to the emerging Industry 4.0 ones (like edge computing systems). The services leverage a Migration matrix tool that considers all the necessary improvement steps and strategies needed to enable a smooth migration from traditional control production systems towards decentralised control automation architectures based on edge computing, Cyber-Physical Systems and Internet of Things technologies.

Further information regarding the Services and Solutions provided by Edge4Industry can be found here: [www.edge4industry.eu](http://www.edge4industry.eu)

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## Support

Please direct any questions in connection with this White Paper to the Edge4Industry team, using the contact form available: [www.edge4industry.eu/contact/](http://www.edge4industry.eu/contact/)

## Edge4Industry Initiative

The Edge4Industry initiative was created by the FAR-EDGE Consortium, as its own Ecosystem portal in order to allow that the ecosystem remains active, functional and independent beyond the FAR-EDGE project.



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## 1. Market Context: Rise of the Fourth Industrial Revolution

In the era of globalization manufacturers are under extreme pressure to realize a shift from conventional mass production models to novel mass customization models such as Made-to-Order (MTO), Configure-to-Order (CTO) and Engineering-to-Order (ETO). At the same time, they increasingly strive to move production operations closer to the source of innovation and to customer demand, rather than off-shoring them to low labour countries. In order to achieve these strategic goals, manufacturers need to build hyper-efficient plants that feature:

- **Very flexible production lines** that can be rapidly customized to the needs of different production orders as a means of supporting mass customization.
- **Unprecedented automation** that eliminates human mediated error-prone tasks and makes the labour cost a less important factor of the total production cost.

The development of such plants is propelled unprecedented and accelerated growth of digital technologies such as Big Data, Artificial Intelligence, Augmented Reality, Edge Computing, Advanced Robotics, Digital Fabrication (3D Printing) and the Internet-of-Things. These technologies are the digital enablers of the fourth industrial revolution (Industry 4.0), which entails the deployment of Cyber-Physical Systems in the shopfloor as a means of digitizing industrial processes and bridging Operational Technology (OT) with Information Technology (IT).

Industry 4.0 opens new horizons in manufacturing and is expected to lead to phenomenal cost efficiencies, better product quality and increased worker safety. During the last couple of years, many industrial organizations in the developed world have validated the merits of digital manufacturing in use cases with a proven Return-on-Investment (ROI), including flexible automation, predictive maintenance, zero defect manufacturing and digital simulations. In the coming years, we expect a tremendous growth of the Industry 4.0 market: [Research firms project that the Industry 4.0 market will reach \\$214B by 2023](#), being one of the fastest growing areas for digital technologies.

## 2. Industry 4.0 Migration Challenges

Being a revolution, Industry 4.0 is expected to take nearly fifty (50) years to realize its full potential. Nevertheless, manufacturers are nowadays very much concerned about their migration to Industry 4.0, given that there is no easy way to replace existing production systems with CPS and IoT based systems. Manufacturers migration concerns are very intense as a result of the following factors:

- **Manufacturer's Conservatism:** Manufacturers are traditionally conservative against the adoption of digital technologies. In particular, they need to make sure that any new technologies are introduced with minimal disruption to their existing production operations. At the same, they need to be confident that the new systems will help them improve production time, quality and cost. They will never accept production systems that compromise the efficiency of any of the above parameters.

- **Protection of Existing Investments:** Most industrial organizations have invested very heavily in their legacy Operational Technology (OT) and associated production systems. Hence, they are quite reluctant to adopt the new wave of digital systems that could make legacy systems obsolete. Therefore, a new change culture is needed, which is hardly available within most industrial organizations.
- **Lack of Test Environments and Testbeds:** Industrial plants are complex production environments that involve physical systems and human workers. As such they can be hardly emulated or simulated. Hence, testing and validation of Industry 4.0 solutions can be very challenging: Despite public and private investments in pilot lines and experimental testbeds, there is no easy way to test digital manufacturing solutions without disrupting production operations.
- **Industry 4.0 Complexity and Outlook:** Industry 4.0 is based on the integration of a large number of complex digital technologies, including several emerging technologies whose evolution is associated with uncertainty. For most enterprises, the realization of the full potential of the fourth industrial revolution is a long-term journey, rather than something that will happen overnight. Hence, a smooth migration path in the medium and long term is essential.
- **Talent Gap in Digital Technologies:** There is a proclaimed talent gap in Industry 4.0 technologies in general and its digital enablers in particular. Thus, most enterprises and their industrial solution vendors do not always possess enough qualified people towards a rapid transition to digital manufacturing.
- **Steep Learning Curve:** Industry 4.0 is associated with a steep learning curve for all stakeholders. Industrial enterprises are therefore keen on taking small safe steps, rather than realizing large scale changes to their production operations. These small steps can allow them to gain experience and confidence in Industry 4.0 prior to proceeding with disruptive changes to production operations at scale.

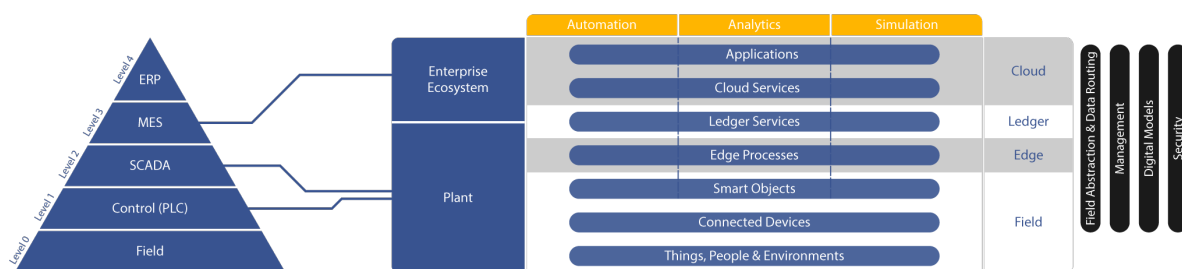
For all the above reasons, manufacturers and other industrial organizations are seeking for a smooth migration path from their existing automation architectures to the emerging digital automation architectures. Such a path entails one or more of the following:

- A phased migration from legacy automation systems (e.g., the popular ISA-95 compliant systems) to emerging digital automation ones. In practice this implies a transformation of conventional centralized automation architecture to distributed and decentralized ones.
- A gradual replacement of old-fashion OT systems with emerging digitally enhanced production systems and devices.
- Co-existence of legacy automation systems with emerging digital automation platforms in the shopfloor. It is likely that digital automation is deployed in selected production lines and for selected production processes, till full migration is realized.

The above guidelines are plausible, but rather high level, since they do not provide concrete recommendations and a practical path for realizing the migration towards digital manufacturing.

### 3. The FAR-EDGE Migration Matrix

FAR-EDGE and its Edge4Industry initiative ([www.edge4industry.eu](http://www.edge4industry.eu)) have introduced a Reference Architecture for the development of digital automation platforms based on edge computing and blockchain technologies. Moreover, they have provided a concrete digital automation platform implementation, which adheres to the principles of the Reference Architecture and provides automation, simulation and distributed data analytics functionalities. Along with this platform, Edge4Industry provides support services that aim at mitigating manufacturers' conservatism in migrating their existing infrastructures to the emerging Industry 4.0 automation platforms such as the FAR-EDGE platform. In particular, Edge4Industry provides roadmaps and guidelines that facilitate a smooth and low-risk transition towards decentralized or hybrid control architectures. These guidelines address the migration from the conventional ISA-95 standard automation pyramid, towards emerging digital automation solutions in-line with the FAR-EDGE reference architecture. Emphasis is paid on realizing a progressive and phased transformation that applies future technologies in existing infrastructures with legacy systems through incremental migration steps, as a means of lowering risks for manufacturers and providers of industrial automation solutions.



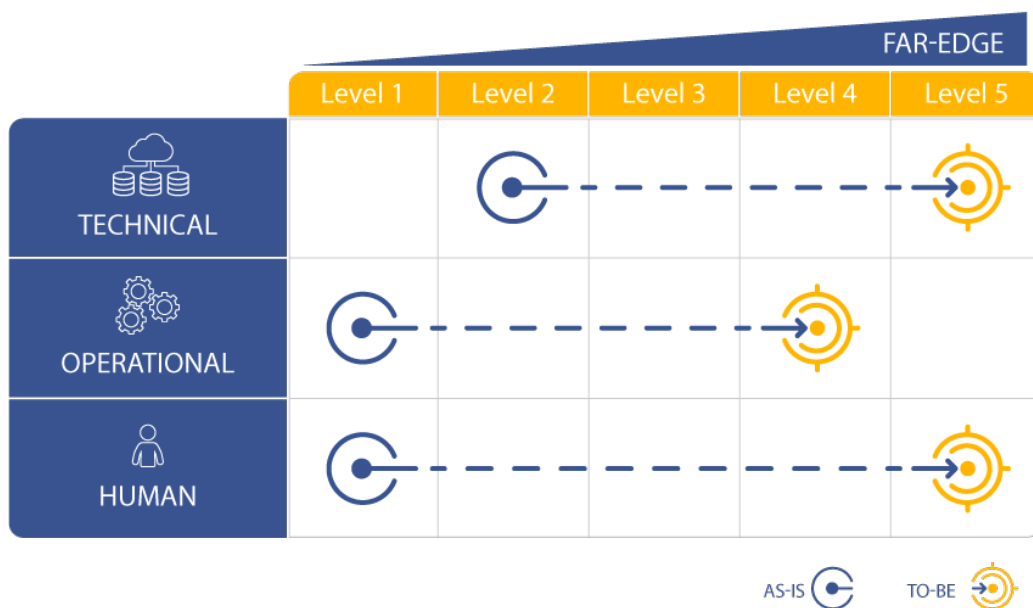
In order to mitigate risks related to the implementation of innovative technologies, it is important to identify how a migration solution towards FAR-EDGE affects the overall industrial system. The challenge is to identify the architectural blueprints of the migration considering not only the technology dimension but also the operational and human ones from a business process point of view. The impact of the new solution is, thus, analysed at different dimensions of the factory in a holistic approach.

A key element of the FAR-EDGE Migration approach is the Migration Matrix, a tool that boosts the identification of all possible and necessary improvement steps for a traditional production system towards the vision of digital factory, based on the analysis of its current situation. The Migration Matrix splits the digital transformation in five scale-levels and covers three impact dimensions: technical, operational and human. By using a 5-levels scale it is possible to specify within a defined structure what are the capabilities, the characteristic and the potentiality a company has at each dimension.

The Migration Matrix helps manufacturers to document a snapshot of their current situation, as a means of identifying the steps needed for adopting digital automation in a smooth and stepwise way. To this end, the rows of the Matrix represent the relevant application fields with high potential of improvement by concepts implementation on a digital automation architecture that adheres to the principles

and functionalities supported by the FAR-EDGE architecture. In-line with the targeted dimensions (technical, operational, human), they refer to technology innovations, factory process maturity and human roles. On the other hand, the columns of the Matrix describe the development steps for each application field towards a higher level of production flexibility, intelligent manufacturing and business process in the direction of a digital automation implementation. Therefore, the five columns represent five levels of production system's digital maturity. These five levels are based on the Capability Maturity Model Integration (CMMI) and adapted to the three dimensions:

- **Level 1 – The production system has not the proper technological and IT tools for implementing a digital infrastructure;** there is no engineering activity to ensure repeatability or extensibility; and only dividing workforces.
- **Level 2 – The production system lacks of enabling technologies to follow and control the decision taken by supervisor;** processes are partially planned based on the planner experience; and humans present lack of related knowledge and skills.
- **Level 3 – The constraints on the production system technologies avoid a full interoperability and interconnection;** good practices are implemented but with integration and interoperability gaps; and skills to guide job activities are not well defined but there is a little synergy in the organization.
- **Level 4 – The control architecture is more sophisticated and is able to optimize the change process to have a full collaboration;** the processes are fully planned and implemented using common and shared standards; the organization uses quantitative analysis of workforce capabilities to predict organization performance.
- **Level 5 – The production system is based on a solid technology infrastructure that enable systems full interoperability and interconnection;** the process is digital oriented and based on fast, robust and secure information exchange; the organization is focused on continuous improvement and change management is dealt according to well-defined principles.



According to the main functional aspects of the FAR-EDGE Reference Architecture, the Migration Matrix is based on the analysis of three main sub-dimensions: automation, analytics and simulation.

The maturity levels scale is equivalent for all dimensions in order to give a democratic and neutral view of all aspects of manufacturing company could be affected by the FAR-EDGE implementation. In particular:

- **The “Automation” sub-dimension** includes all the processes and functionalities that support automated control and automated configuration of physical production processes. It is usually bi-directional communication with low latency constraints
- **The “Analytics” sub-dimension** involves those activities related to multivariate analysis of a process aiming at developing a statistically based understanding, leading to process improvement and/or optimization.
- **The “Simulation” sub-dimension** is closely related to the digital enable factory concept, which offers an integrated approach to enhance the product and production engineering processes and simulation is a key technology within this concept.

The current situation of the factory, at technical, operational, and human dimensions, is identified through a questionnaire and the main results are mapped within the Migration Matrix. In this way, the Migration Matrix provides a clear map of the current (*AS-IS*) and desired (*TO-BE*) conditions of a factory, revealing different alternatives to achieve a specific goal, by means of a digital automation system and towards the vision of digital factory.

Migration alternatives are then evaluated according to the business strategy, considering also strengths and weaknesses points. Based on this evaluation, the migration approach ends-up specifying adequate architectural blueprints that match the needs of the organization and the estimation of the overall benefit of the digital automation solution for the analysed production system.

The FAR-EDGE Migration Matrix tool is a result of close collaboration and consultation between some of the world’s leaders in manufacturing and industrial solutions integration. It has been already used by several manufacturers (including large high-tech industries and innovative SMBs (Small Medium Businesses)) as a means of shaping their migration strategies for Industry 4.0.

## 4. Conclusions and Outlook

At the dawn of fourth industrial revolution, manufacturers try to dispel the hype and take solid and safe steps towards the adoption of Industry 4.0 technologies. They also need to make sure that any digital automation deployments improve production time, quality and costs simultaneously. In order to meet these objectives, manufacturers have to implement a gradual and phased transition to digital automation solutions as part of a smooth migration path.

FAR-EDGE introduces a Migration approach that can ensure a smooth and low risk digital transformation of traditional production systems to digital automation solutions, notably the automation, simulation and analytics solutions that are aligned to the FAR-EDGE reference architecture. To this end, the implementation of the FAR-EDGE migration approach requires high commitment of the factory management: Business goals and digital solutions need to be evaluated together in order to ensure continuous and successful improvement towards the digital factory concept.

At the heart of the FAR-EDGE Migration approach lies a Migration Matrix tool, which facilitates manufacturers in jointly considering the ever important technical, operational and human aspects. A 360° consideration of these aspects ensures that all possible hurdles are sufficiently considered, along with relevant mitigation strategies that lead to a smooth transformation towards an Industry 4.0 production paradigm. Aside technical aspects, the human aspect is very crucial towards ensuring the operation, management and further development of a digitized and automated production paradigm. This includes considering the implications for skills and work organization within their migration strategy.

As part of the FAR-EDGE project and the Edge4Industry ([www.edge4industry.eu](http://www.edge4industry.eu)) initiative, we would be keen on discussing with interested parties tangible cases of digital transformation and migration to Industry 4.0 automation solutions.