WHITE PAPER

IoT implementations in the European manufacturing industry – from vision and challenges to best practice examples

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teknowlogy GROUP

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INTRODUCTION

THE VISION OF AN "IDEAL" IOT IMPLEMENTATION

teknowlogy sees a shared vision across many leading manufacturing companies as to what the best possible IoT implementation should look like. The best approach to IoT seems to be the ability to build applications for different IoT use cases on top of an integrated IoT data management platform. This platform forms a central data lake for all IoT data, which mainly comes from the OT (operating technology) side of the company. This is important because the effective processing of massive amounts of real-time sensor data is different from typical data management requirements that we see on the IT side of a manufacturing company. There are three main reasons for this: First, real-time sensor data is sometimes incorrect (also called "dirty" or "noise") and requires a dedicated approach to data collection and cleaning/filtering. Second, to unlock the value of real-time sensor data, you have to see it in the right temporal context with other data. Third, data processing in the OT space has to happen as fast as possible to support quick decision-making and achieve operational efficiency, in addition to ensuring the safety of involved workers. Thus, it is imperative to have a dedicated approach to data processing (archiving, contextualization, visualization and analytics) to best cater to IoT services.

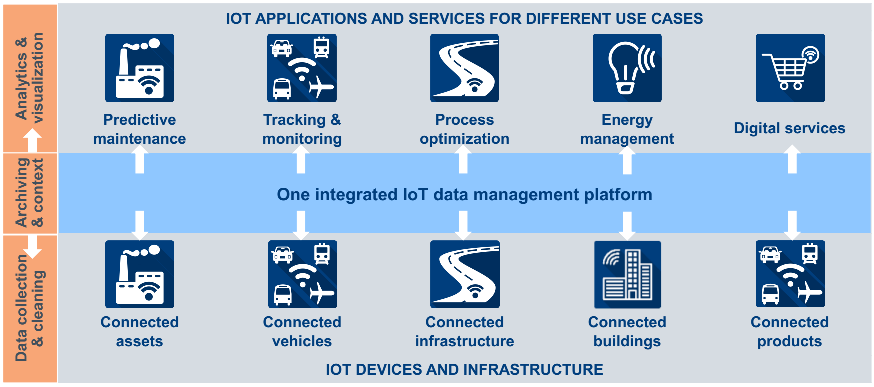

Fig. 1: The vision of an ideal IoT implementation

Besides the above-mentioned specific requirements for handling IoT data, an integrated IoT data management platform can provide three distinct advantages for manufacturing companies based on a joint IoT data model and application development framework. First, the integrated approach gives developers a powerful tool for bigger innovation around IoT. Second, it allows more experimentation and agility, thus enabling faster implementation and usage (time to market) of newly developed IoT applications. Third, an integrated IoT data management platform provides better scalability of implemented IoT applications in order to leverage successfully tested IoT use cases quickly on a much larger scale across the company.

However, realizing this vision is not an easy task for companies.

THE CHALLENGES OF REALIZING THE VISION

There are several challenges which represent real roadblocks in achieving the vision of an “ideal” IoT implementation in the short run.

First, there is **no “ideal” IoT platform** available in the market today that represents the perfect choice for a manufacturing company to implement all the different IoT use cases they have in mind. All available platforms have sweet spots and limitations, due to the heterogeneous breadth and depth of their IoT capabilities across device management and connectivity, data orchestration and analytics, application development and integration. This is no surprise given the complexity that comes with the different types of IoT devices and connectivity options on the one hand, and the different data models, analytics methods, and machine-learning algorithms on the other. One thing is clear – waiting for an ideal IoT platform to become available is not an option for many manufacturing companies; the degree of competition is very high.

The integration of everything on one common platform sounds simple but is often hard to achieve. The complexity is caused by the fact that factories and the related OT landscapes are often very heterogeneous and spread around the world. In these cases, the integration of the **fragmented OT landscape** may lead to very time-consuming projects for manufacturing companies. And such an investment in integration would just be the starting point for implementing IoT use cases on top of this platform. Manufacturers have to start using IoT, even from a fragmented starting point. Again, competitive pressure is too strong to wait.

Another challenge for many manufacturing companies is the **limited availability of skilled IoT application developers**. This is not only a challenge for mid-market companies in Europe; large-enterprise clients face the same issue and have to bring in external resources to get IoT projects done in time. The current situation is not expected to change in the short run, as the same limitations exist in other newly emerging IT domains (e.g. analytics, machine learning, blockchain) in the European market. Again, waiting for the problem to be solved is no option for manufacturing companies.

BEST PRACTICE EXAMPLES

Based on the above-mentioned vision and challenges, manufacturers have to balance two important aspects in order to leverage IoT in the best possible way. On the one hand, they have to **create value from IoT technology in the short run by coping with the existing challenges**. On the other hand, they have to **move in the direction of an "ideal" IoT implementation to support the creation of even more value from IoT in the long run**. teknowlogy sees different approaches by companies in the European manufacturing industry to **balance their short-term and long-term goals** and make their IoT initiatives a success. The following section presents the most promising examples from manufacturing companies that we observe in the market today.

EXAMPLE 1: THE INNOVATOR APPROACH – LEADING IOT INNOVATIONS DRIVEN BY AN INCUBATOR TEAM

Approach & architecture: One approach we see among manufacturers focuses completely on the enablement of innovations to realize short-term success with IoT. This approach is bottom-up. It basically leaves the existing IT/OT landscape unchanged and immediately starts with the development of individual IoT applications. The starting point for this approach is always a specific use case and the calculation of a business case to put it in place. Once the business case has been approved, the technical architecture is implemented specifically for this use case. In a very independent environment, this approach can create silos of different IoT architectures (connected devices with specific data platforms and individual applications) that may not be easy to overcome in the future.

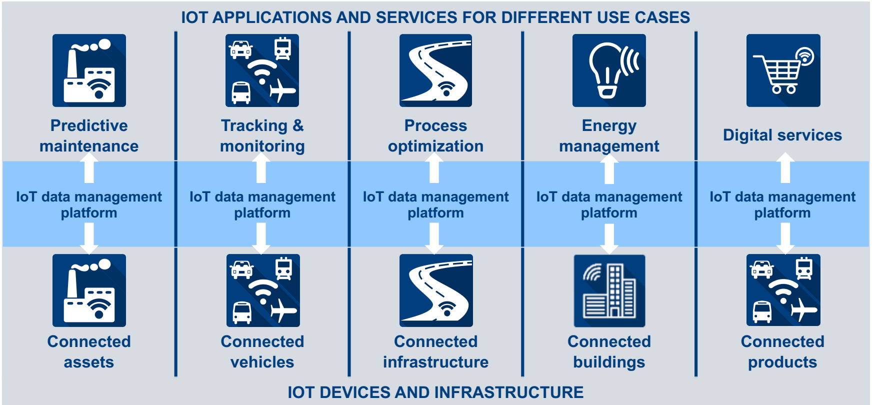

Fig. 2: The Innovator approach

Organization: To get this approach up and running, it is necessary to initially pool developer resources and internal consultants in an internal incubator organization or an independent external start-up. In well-established companies, independence from existing business units often helps create an innovative environment for new ways of thinking, experimenting, and fast learning. One example in the market is Bosch, which created an internal incubator (Bosch Software Innovations) with a high degree of freedom to think out of the box and start bottom-up in testing and implementing many individual IoT use cases for internal, and increasingly also for external clients. Another example is AXOOM, a subsidiary of TRUMPF.

Deployment stages: As the first step, you have to pool developer resources and internal consultants in a separate organization. The second step focuses on the identification, evaluation, and ranking of IoT use cases based on their business value. This can be done by the incubator or start-up alone or together with the lines of business. In the third step, developers start implementing the most promising use cases and check the success of these implementations based on predefined success factors. The next step requires a continuous identification process for new use cases. Newly implemented use cases, especially around operational efficiency, are often directly assigned to an operational unit. However, a new use case may also drive a new business (e.g. a new service for clients). In this case, it may make sense for the new use case to remain under the control of the incubator for some time (to allow for initial growth) and be handed over to a business unit (including some of the team members) at a later stage, when the business starts scaling. After the handover, the incubator focuses on a new use case and starts to grow a new business.

Strengths & weaknesses: Agile innovation is the main positive aspect of this approach to build a common IoT data management platform. Another advantage is that you can choose the best available IoT platform for each individual use case. The downside of this is that the task of integrating different use cases on one common platform is put off until a later point in time, and the scalability of implemented IoT applications can also be very limited. IoT projects typically start very small, with a proof of concept (POC), but large-scale deployments often require a completely different architectural setup. Another positive aspect is the buildup of in-house capabilities around IoT application development, which helps avoid the current shortage of experienced developers in the market. Over time, these internal resources can also be used for external IoT projects – ultimately you can become an IoT service provider for other clients. On the other hand, building in-house capabilities requires time.

EXAMPLE 2: THE FAST-FOLLOWER APPROACH – AGILE UTILIZATION OF IOT, DRIVEN BY ENABLED SUBJECT MATTER EXPERTS

Approach & architecture: This approach bears some similarities to the previous one as it aims for agile, bottom-up trials with IoT to realize quick success. However, a closer look reveals two key differences from the approach in example 1. This approach also keeps the existing IT/OT landscape basically unchanged but creates an additional integration layer on top of it which combines the IoT-related data. The second difference is that no pool of developers is required to build new applications as the purpose of the extra layer is to enable subject matter experts, which often have no developer skills, to easily create IoT applications themselves. These platforms are often called "low-code/no-code platforms" or "platforms for rapid application development/deployment".

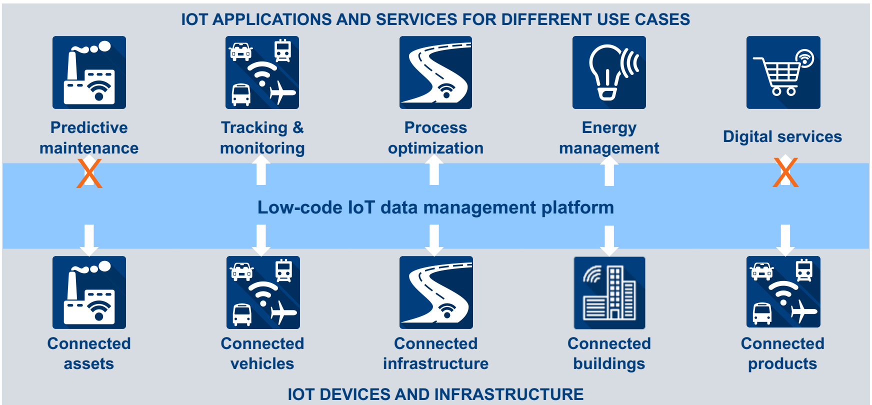

Fig. 3: The Fast-follower approach

Organization: From an organizational standpoint, this approach is very simple to implement as it is not necessary to change the existing organization. The main task here is the enablement of all subject matter experts via training and support. Besides, there may also be the need for a program to motivate subject matter experts to use the implemented "low-code platform". This may particularly be required in environments where subject matter experts are not very IT-savvy.

Deployment stages: The first step is to implement a low-code platform and connect relevant IoT data sources to it. The second step is the training of subject matter experts and the implementation of an internal support team. This internal support team is very important as it ensures that subject matter experts are given quick support whenever they need it. In the third step, it is advisable for the support team and subject matter experts to do initial projects together, as this allows to overcome initial barriers very fast and avoids resistance by the subject matter experts to using the new platform. Last but not least, the IT team should frequently add more IoT data sources to the data pool in response to requests from subject matter experts.

Strengths & weaknesses: The main advantage is of course that subject matter experts are enabled to innovate quickly by themselves. As no developer skills are required, this approach clearly helps to cope with the shortage of IoT developer resources in the market. Nevertheless, we need to keep in mind that the success of this approach depends on the motivation and training of the subject matter experts who will use the platform. If they refuse to use it, the approach will fail. Another advantage is that the initial setup project is typically not too complex and time-consuming. Low-code platforms do not always require a deep integration in the existing IT landscape, as they run on top of it and integrate existing data sources via APIs (Advanced Programming Interfaces). The downside is that the low-code platform may cause some latency, which means that real-time capabilities, which are often highly relevant in the OT space, may be limited. In addition, low-code platforms often work well for rather simple IoT use cases such as remote monitoring of machines, vehicles, or buildings, where dashboards or simple event processing are sufficient and real-time capabilities are not critical. But these platforms do have some limitations when it comes to more complex use cases such as predictive maintenance or other digital services. Such complex use cases often cannot be implemented out of the box with the simple-to-use but limited functionality of a low-code platform. This is why these platforms are more suitable for a fast-follower approach than for innovation leadership.

EXAMPLE 3: THE THINK-BIG APPROACH – BUILD ONE PLATFORM TO QUICKLY SCALE IOT ACROSS THE ENTERPRISE

Approach & architecture: Besides the two approaches described above, which focus on innovation and/or agility, we observe a third approach in the market, with clear focus on the scalability of implemented IoT use cases. Especially large enterprises in the process industry adopt this approach. These companies have already established a strong market position within a specific industry. They have a large-scale operation (many factories) and a big supplier network. They are leaders in operational excellence. Their main focus is on defending their strong market position. For this purpose, scalability – the fast deployment of new IoT applications on a large scale – is a priority. Thanks to this approach, even small improvements through IoT can generate significant value for the company as a whole. Therefore, these companies do not aim for leadership in innovation or agility but for fast scalability of successful IoT applications to reach all corners of their company, and maybe even beyond, covering their supplier network. The cloud implementation represents an interesting deployment model for this approach, and companies considering a shift to IoT can also start large digital transformation projects for cloud adoption.

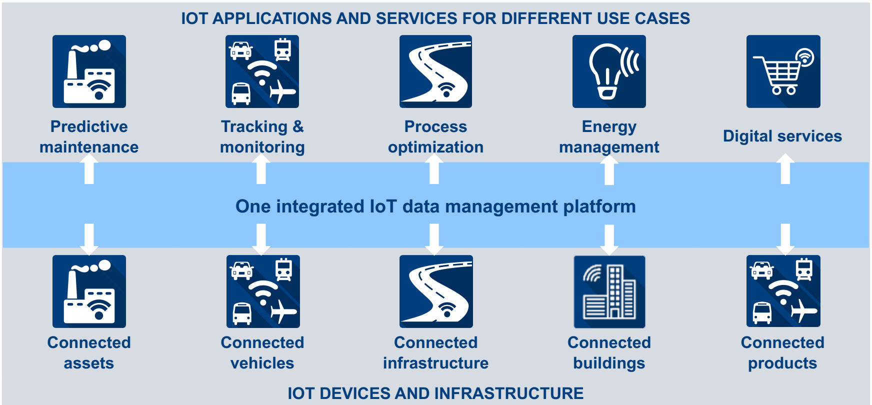

Fig. 4: Landlord approach in the process industry

Organization: To consolidate the fragmented OT landscape, a centralized approach is required not only for the IT architecture, but also from an organizational standpoint. A central organization should be established to orchestrate the transition and to support the different internal functions in the long run. As the transition phase usually requires a lot of manpower within a short time frame, we expect large IT partners to be involved in the implementation and also to support the transformation in the long run. This typically includes not only consulting and system integration services, but also managed services and outsourcing.

Deployment stages: To allow for fast scalability of new applications across the company, the fragmented OT landscape needs to be consolidated. This approach leads to a large-scale integration project that requires an initial selection process to identify the right partner to support the transformation project. After the selection process, it is essential to define the new platform and start collaboratively with the integration of the OT landscape and the implementation of IoT use cases. New IoT use cases should always be tested in a very small environment and, if successful, be scaled fast to all factories, and maybe even to the supplier network to maximize the total value. Over time, this leads to the evolution of an ecosystem of users around various IoT applications on a joint platform.

Strengths & weaknesses: On the plus side, these companies can leverage IoT implementations quickly on a large scale (across the entire company and even including the supplier network) to maximize value. They also benefit from the skills that the transformation partner brings to the table. The downside is the “risk to fail” which comes with large transformation projects.

EXAMPLE 4: THE DUAL APPROACH – SPLITTING IOT INTO SMART PRODUCTS/SERVICES AND SMART OPERATIONS

Approach & architecture: The dual approach is not an independent approach in itself. It is more of an enabler for implementing two of the three previously described approaches in parallel. The dual approach is especially suitable for discrete manufacturing companies as they typically manage two completely different sets of "things": on the one hand, 'shop-floor equipment' within their own operations, such as machinery and equipment in their own production facilities; on the other hand, 'smart products' which are produced by the manufacturing companies and operated by their customers. This situation makes it possible to split the IoT approach and architecture into smart products and smart operations. Volkswagen (VW), for example, follows this dual approach with AWS in its factories (think-big approach) and with Microsoft in the connected car space (also think-big approach). Companies from the process industry can also split their IoT approach into smart operations and smart client services, but this only makes sense if the two areas are disconnected to some degree.

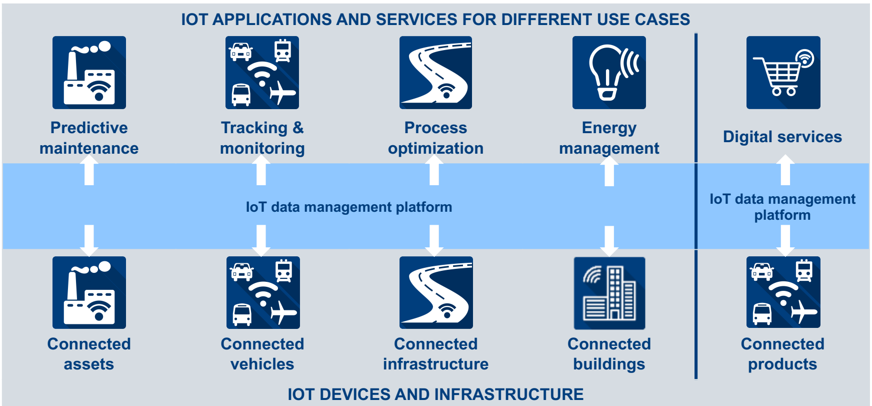

Fig. 5: Landlord approach in discrete manufacturing

Organization: This dual approach seems more complicated from an organizational point of view. However, it fits the existing organization of many manufacturing companies much better and allows for the IoT implementations for the factory (OT) team and the product or client service team to progress independently.

Deployment stages: The steps depend on the two approaches a company adopts. The respective deployment stages are as described in the previous approach descriptions.

Strengths & weaknesses: Pros and cons also depend on the two approaches a company adopts. An additional benefit is that different IoT platforms can be used in the smart operations space and in the smart products/services space. This simplifies the selection process as requirements often vary greatly between the two areas.

SUMMARY AND COMPARISON OF BEST PRACTICE EXAMPLES

The table below summarizes the basic strengths and weaknesses of the described IoT implementation approaches (example 4 is not listed as it is just a combination of two of the three mentioned examples) to help manufacturing companies become more innovative, agile, and/or scalable around IoT.

	Innovator approach	Fast-follower approach	Think-big approach	Dual approach
Current level of adoption	+	+	+	-
Expected level of adoption in the coming 12-24 months	O	O	+	+

+ strong / 0 average / - weak

As the following table underlines, the hype around IoT is coming to an end, and pure innovators and fast followers are increasingly turning towards scaling IoT internally. The think-big approach will become increasingly relevant in this context. This means that organizations which are currently following innovator and fast-follower approaches will shift their focus completely to think big, or will at least adopt a dual approach (innovator + think big or fast follower + think big).

	Innovator approach	Fast-follower approach	Think-big approach
Enabling innovation	+	O	-
Enabling agility	O	+	O
Enabling scalability	-	-	+

+ strong / 0 average / - weak

This paper was produced in close cooperation between Infosys and teknowlogy.

ABOUT INFOSYS

An Indian multinational corporation with close to $12 billion revenues and 230K employees, Infosys Limited provides business consulting, information technology and outsourcing services and has a 1200+ client base spread over 50+ countries. Most of Infosys Digital Offerings have been incubated by its Engineering services – IoT is an integral part of engineering services, forming an ecosystem which leverages core engineering components.

With engineering expertise from sensors to insights, an extensive Internet of Things (IoT) ecosystem and a practical approach towards IoT-led digital transformation, we help clients realize tangible and significant benefits from IoT. IoT practice is 2000 employees strong and we have completed over 160 projects across 20 countries for about 85 clients, spread over 15 industry domains like core manufacturing, aerospace, pharma, oil and gas, mining etc. Infosys IoT services have been recognized by multiple Analyst Research firms. Our service offerings are comprehensive providing the entire gamut of end to end services under the following broad categories:

- Advisory and Consulting for transformation into digital factories
- Implementation & Integration of IoT solutions and platforms for smart machines
- Analytics Driven process and Business Insights
- Support and monitor manufacturing applications and production operations

Infosys has developed niche suite of solutions, which include end to end domain specific solutions e.g. Smart Factory, Digital Mines, Connected Cars, Smart Buildings, etc. as well as generic solutions which address tactical problems e.g. Condition Based Monitoring and Predictive Maintenance, Smart Metering Solution etc. We have our own share of IP solutions, some of which are listed below:

Solution	Description
KRTI 4.0	RAMS solution for large assets, plants and systems enables remote tracking of asset health via sensors & IoT platform. https://www.infosys.com/engineering-services/service-offerings/Pages/ai-framework-industry-operations.aspx
Infosys IoT Gateway	Software with MODBUS/OPC-UA/OPC/BACNET/FOCAS industrial protocols is used for solving data acquisition, via Edge Computing. Infosys IoT Gateway framework is a software capable of executing ML and AI.
Smart Spaces	Based on SCALE framework, the offering helps enterprises transform physical infrastructure to smart spaces and enables personas to deliver the right experience and cost benefits to organizations. https://www.infosys.com/engineering-services/service-offerings/Pages/smart-buildings-spaces.aspx

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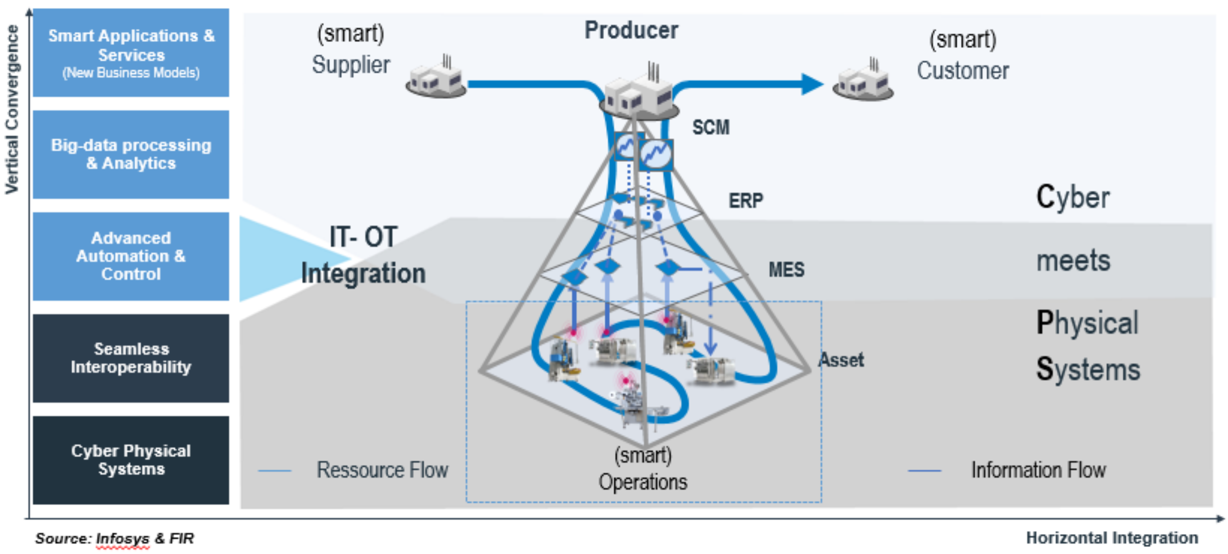
Drone based Image Analytics	• Drone imaging for crop stress analysis and identification • Imaging solution for volumetric analysis and stockpile analysis • Crowd monitoring solution https://www.infosys.com/industries/agriculture/industry-offerings/Pages/farm-mechanization.aspx
IoT Security Solution and Testing	Plant Network, Controller, OT, Platform Security, Data Protection, Data Privacy, GDPR, IOT platform scalability, performance, reliability testing Device Testing, Device Validation. https://www.infosys.com/industries/high-technology/case-studies/Pages/edge-analytics.aspx

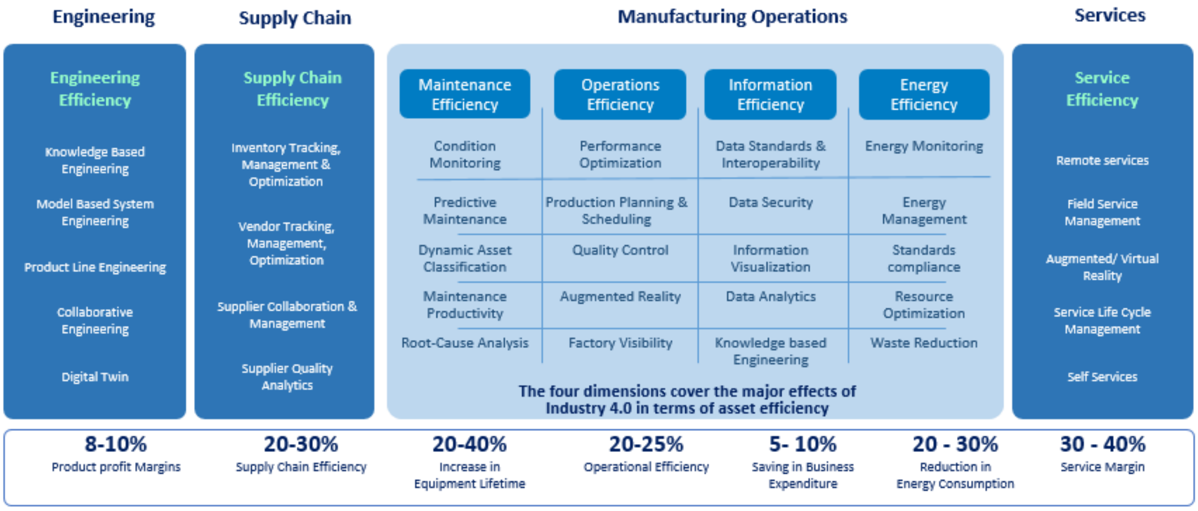
IoT Adoption in Manufacturing: While in Infosys, we handle projects and build solutions around adoption of IoT in industrial, consumer applications, enterprise campuses and communities, the bulk of the IoT usage is seen in the manufacturing world. In manufacturing, Infosys provides transformation solution for discrete, batch and process manufacturing industrial clients.

Skilled labour shortages along with rising labour and logistics costs, high cost of inventory storage, fulfilling varied and multi-channel demand, shorter product life cycles and reduced time to market are some of the key challenges every manufacturing organization is grappling with in this decade. Every manufacturing enterprise is feeling the need to transform into a smart digital factory to augment manufacturing. This is supported by the advent of Industry 4.0., that helps in digital transformation to boost enterprise productivity, product quality and process efficiency while sustaining the competitive advantage.

Smart Factory/ Digital Manufacturing: Infosys partners with manufacturers to create a digital manufacturing system which reinforces their core strengths and enables them to adopt advanced tools to navigate the complexities of IT-OT (Operational Technology) integration and embrace innovation at a product, process and business level.

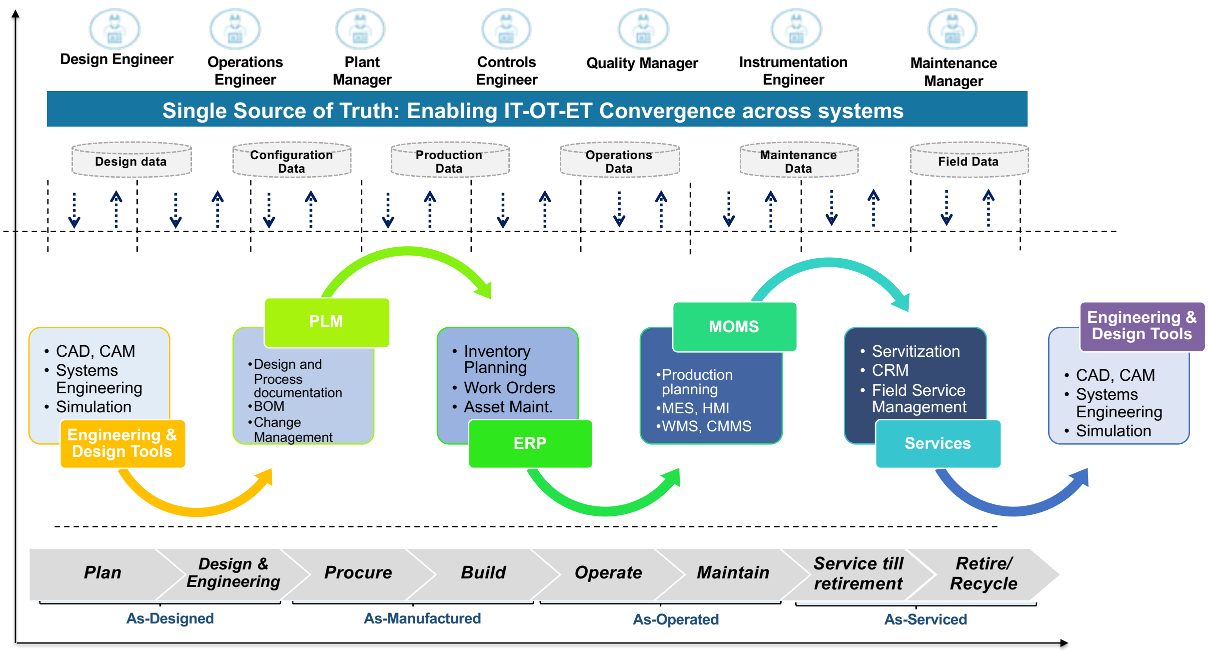


Our Digital Manufacturing Solution transforms a manufacturing organization with IT-OT integration and drives efficiencies across the organization value chain, thus enabling the manufacturing organization to realize immense value in productivity, efficiency and quality.



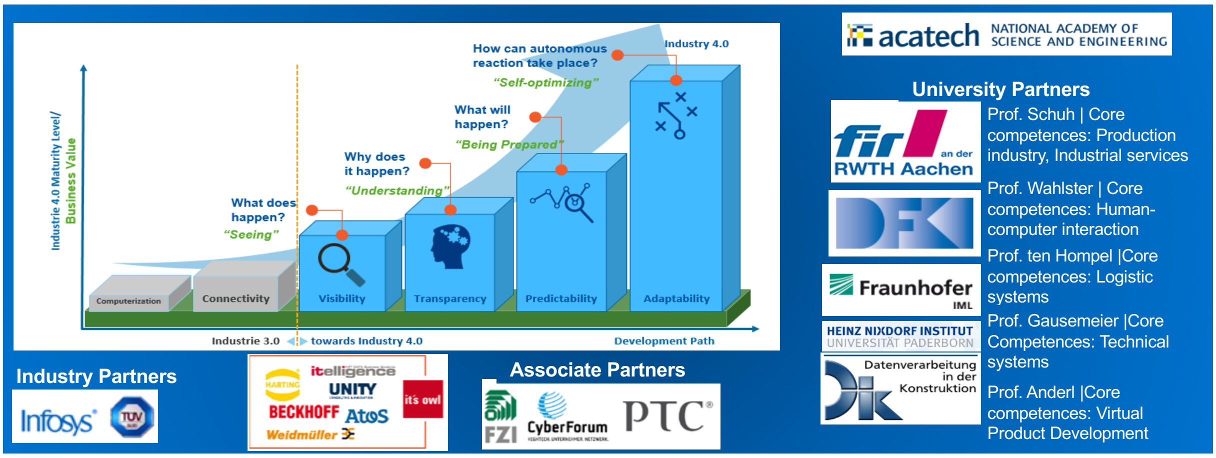
Source: Findings from the Infosys – FIR Joint Study on Industry 4.0 'The state of the Nations'

Our solution approach is based on a phased approach of connected machines, connected people & processes, connected systems and connected ecosystem, thereby enhancing an organization's competitive advantage, customer experience, increase in operational efficiencies with increased revenue upside and reduced cost of operations. The solution establishes an end-to-end closed loop 'digital thread' across the manufacturing value-chain enabled by the advent of cyber-physical systems (CPS).



Source: Infosys

Industry 4.0 alignment: As part of our Industrial IoT solutions, Infosys also partners with organizations to assess their Industry 4.0 maturity and create roadmaps for successful digital manufacturing transformation and IoT implementations. The assessment is carried out with an Industry 4.0 Maturity Model, a distinctive methodology that bundles the Digital Diagnostics and Target State steps, which has been developed in collaboration with Acatech Consortium and Aachen University (Germany). The Acatech Maturity Index, which is part of the model, enables companies assess their readiness and defines the appropriate next steps to enable digitization.



Source: Infosys

Case Study: Transformative manufacturing to "Configured To Order" from "Engineered To Order" paradigm for an EU based Manufacturer of Heavy Electrical Equipment and Automation Technology

Business Driver: Long lead time in aligning machines to meet order configurations, leading to order fulfilment delays

Our Solution:

- Implemented an end-to-end integrated solution with a new product configurator solution, integrated with the Product Lifecycle Management (PLM) and Enterprise Resource Planning (ERP) packages
- Parameterization of Bill of Materials (BOM), Engineering BOM and machine configuration enabling quick shift in configuring line for new customized order production
- Full Visibility from Inbound Order to Outbound Dispatch

Outcome:

- Reduced new product variant manufacturing lead time from 6 weeks to 2 weeks
- Reduction of order delivery time for product variants from 28 days to 8 days

Case Study: Industry 4.0 Maturity Assessment and Roadmap for one of the world's largest pharmaceutical companies, based out of Germany
Business Driver: Assess the Digital maturity and identify actionable improvements for the product lines considering Production Operations, Maintenance and Quality
Our Solution: A thorough 5-week exercise at the plant site to assess the As-Is Maturity followed by Gap Analysis and identification of use cases for digitization. Based on prioritization of use cases, a custom roadmap was developed highlighting quick wins.
Outcome: • As-Is vs. Target maturity levels • Prioritized use-cases & quick-wins, sequenced-out into roadmaps • Synergies with in-flight IT initiatives • Cultural implications of the Industry 4.0 transformation

Our Enablers

Innovation Labs

Innovation labs, spread across India, USA, Germany and Australia, provides facilities to enhance the smart manufacturing solution with partner products in addition to providing our partners and clients an opportunity to work with us and co-create innovative solutions to address specific needs.

Strategic Partnerships

Partnerships enable us to build smart solutions on complementary partner technology stacks. Our partnership strategy is based on the following key principles: Bring in complementary skills, Co-create a joint solution for customer specific needs and Strong focus on people enablement.

Varied Engagement Models

Our engagement models are based on solution maturity and customer acceptance: IP Licensing based for IP driven products, Outcome based with revenue tied to delivering the committed outcome, Turnkey projects for New Product Development and Bundled Pricing inclusive of service delivery, hardware, 3rd party software, etc.

Consulting Focus

Focused Centers of Excellence (CoEs) responsible for development of process, domain, package and solutions. 300+ experts and multi-skilled teams across Industry Domain, Process, Architecture, Technology, Program Management Consultants, Design Thinking experts etc. work on niche customer solutions and drive market differentiation through thought leadership.

ANNEX

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ABOUT TEKNOWLOGY GROUP

teknowlogy Group is the leading independent European research and consulting firm in the fields of digital transformation, software, and IT services. It brings together the expertise of three research and advisory firms, each with a strong history and local presence in the fragmented markets of Europe: CXP and PAC (Pierre Audoin Consultants).

We are a content-based company with strong consulting DNA. We are the preferred partner for European user companies to define IT strategy, govern teams and projects, and de-risk technology choices that drive successful business transformation.

We have a second-to-none understanding of market trends and IT users' expectations. We help software vendors and IT services companies better shape, execute and promote their own strategy in coherence with market needs and in anticipation of tomorrow's expectations.

Capitalizing on more than 40 years of experience, we operate out of seven countries with a network of 140 experts.

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