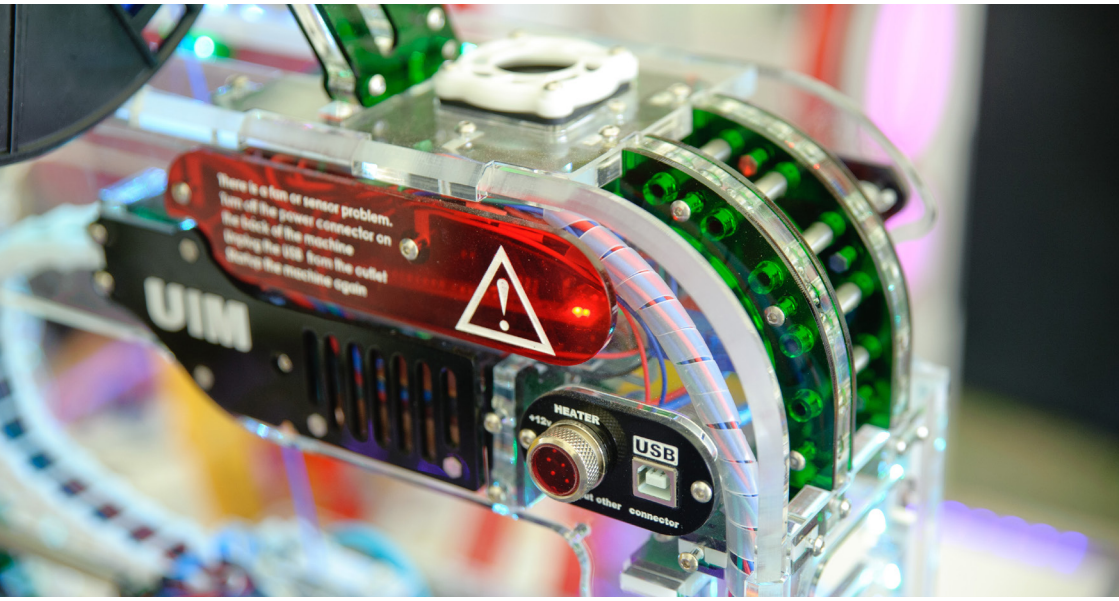
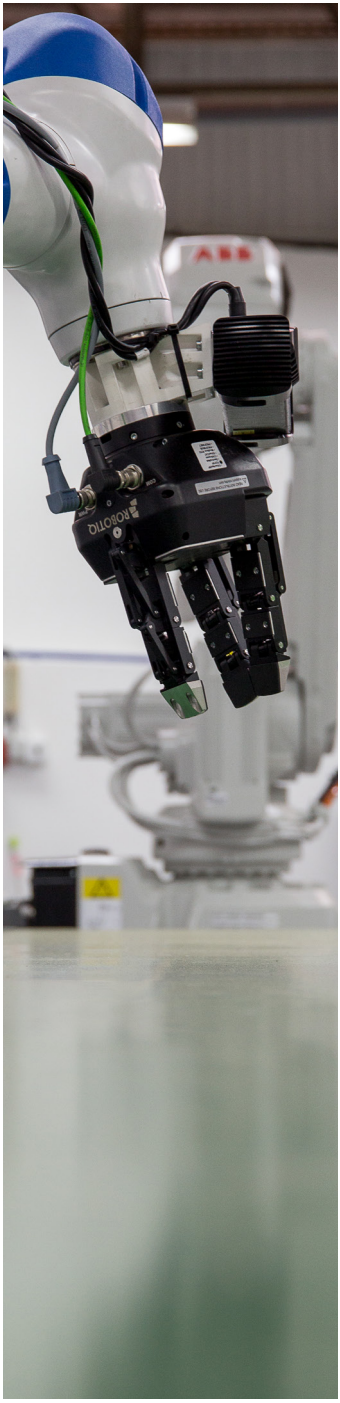
WHITE PAPER ON
IMPLEMENTING DIGITAL TRANSFORMATION IN INDUSTRY



MAKE DIGITAL TRANSFORMATION HAPPEN

INESCTEC

INTRODUCTION AND CONTEXT



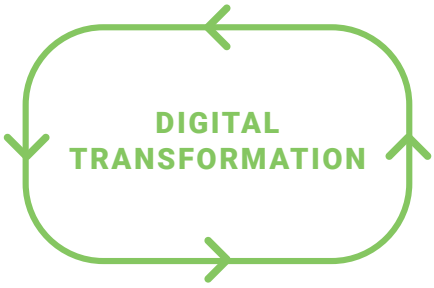
The Manufacturing Industry is globally going through a period of accelerated transformation and evolution. As the backbone of economy, it drives a cycle of economic and job growth, while being able to quickly respond and adapt to changes in trends, challenges, and demands.

In Europe, such capability was achieved through an intense and continuous effort and investment in innovation with the ultimate goal of (re)gaining global leadership in an extremely competitive environment.
The application of newly developed digital-based technologies allows the opening of new paths and possibilities that may be immediately adopted, or otherwise abandoned, by the market.

Consumers are the focus of such digital transformation, and companies, mainly SMEs, need to quickly deliver the high value-added products and services they personally need. This leads to larger portfolios of increasingly complex and customized solutions. Products are often based in new business models and new value chains, developed in increasingly shorter cycles, and produced in smart(er) and networked factories.

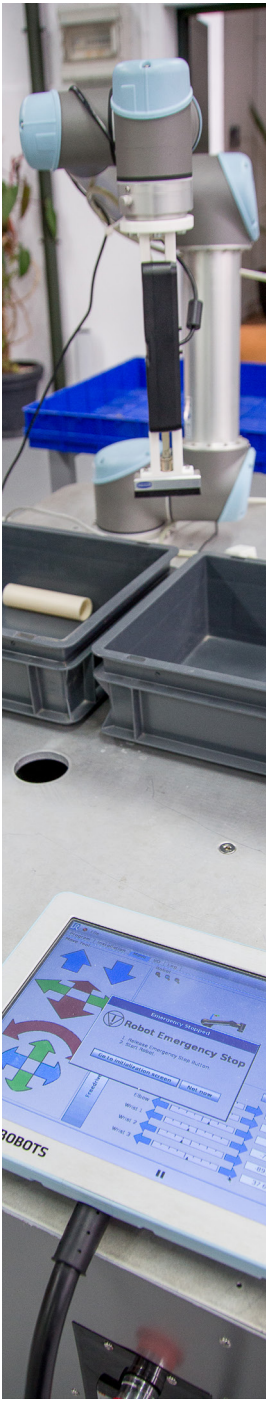
To remain competitive, companies have to develop a clear digitalization strategy while being more efficient, productive, and sustainable. After their organizational transformation, they apply technology and use data to achieve their vision and business goals. The implementation of new and evolved technologies ultimately shape today's and tomorrow's integrated digital factory beyond the Fourth Industrial Revolution, of which cyber-physical production systems, autonomous robots & advanced automation, sensorization, machine learning, additive manufacturing, simulation and optimization, augmented and virtual reality, are some examples.

OFFER
Product Complexity
Product Variety
Reduced Life-cycle
Value Networks



DEMAND
Volatility
Uncertainty
Complexity
Ambiguity

DIGITALISATION CHALLENGES AND ENABLING TECHNOLOGIES



As digitalisation is driven primarily by knowledge and know-how, it presents a huge opportunity to build on Europe's strengths and its capability to compete on the market. As such, digitisation, and accompanying social and economic policies, can become a job opportunities for Europe to establish itself as a global leader and main hub for expertise, while sustaining and improving Europe's societal and economic model (European Commission, 2018).

There are three main types of digitalisation to open up new opportunities for growth and to generate new jobs:

Efficiency-driven

Increased efficiency and scale from digitalisation will impact production chains and potentially make certain layers redundant. This will clearly have disruptive effects on the labour market: a future-oriented and lifelong-learning employment and education strategy will be essential to re-train and upskill people for the new jobs created by digitisation. It is important to recall that increased efficiency will give more people access to products at lower costs and therefore support standards of living and well-being. An example is the application of automation in the logistics sector.

Evolution-driven

With respect to the evolution of new products and services, the resources and number of jobs are more or less stable, although higher- quality jobs will emerge. An example is the development of new smart phone generations with new technology/service features that enable new types of business and activities.

Market-growth oriented

With respect to applying digitalisation to open/access new markets and developing new business models, new job profiles will develop and the number of jobs will increase. Examples are the various data-based approaches using digitalisation technologies that open up new business models and innovation.

MAIN CHALLENGES

Manufacturing companies are facing important challenges regarding the adoption and development of innovative concepts – technological, business, organisational, social – around Industry 4.0. To overcome uncertainty and to maximize success, it is crucial to define suitable strategies and action plans, while scoping all complexity and dimensions of the adoption of i4.0 in industrial organisations.

Challenges were very seldom about the availability of technology. The most common issues faced by companies are due to internal factors. (MIT Sloan, 2018; Medium, 2017)

1. Scarce Talent
Attract, retain and requalify multidisciplinary talent; understand employee pushback and resistance.

2. Misaligned Organisational Structure
Re-think and re-align the organisation.

3. Lack of Digitalisation Expertise and Strategy
Define a long-term strategy

4. Limited Budget
Define priorities and implement test pilots

5. Unrealistic expectations
Digitalisation and technology will not solve the problems, re-organisation will.

Although these challenges are transversal to companies, their relevance can be different depending on company size. This means that the organizational structure affects the way digital transformation should be addressed and implemented.

TOP 5 DIGITAL TRANSFORMATION CHALLENGES BY COMPANY SIZE

Less than 100 Employees

1. Lack of Expertise to Lead Digitalisation Initiatives
2. Employee Pushback
3. No Overarching Strategy for Digitalisation
4. Business Partners Unable to Support
5. Limited Budget

100-1,000 Employees

1. Employee Pushback
2. Organisational Structure Gets in the Way
3. No Overarching Strategy for Digitalisation
4. Limited Budget
5. Lack of Expertise to Lead Digitalisation Initiatives

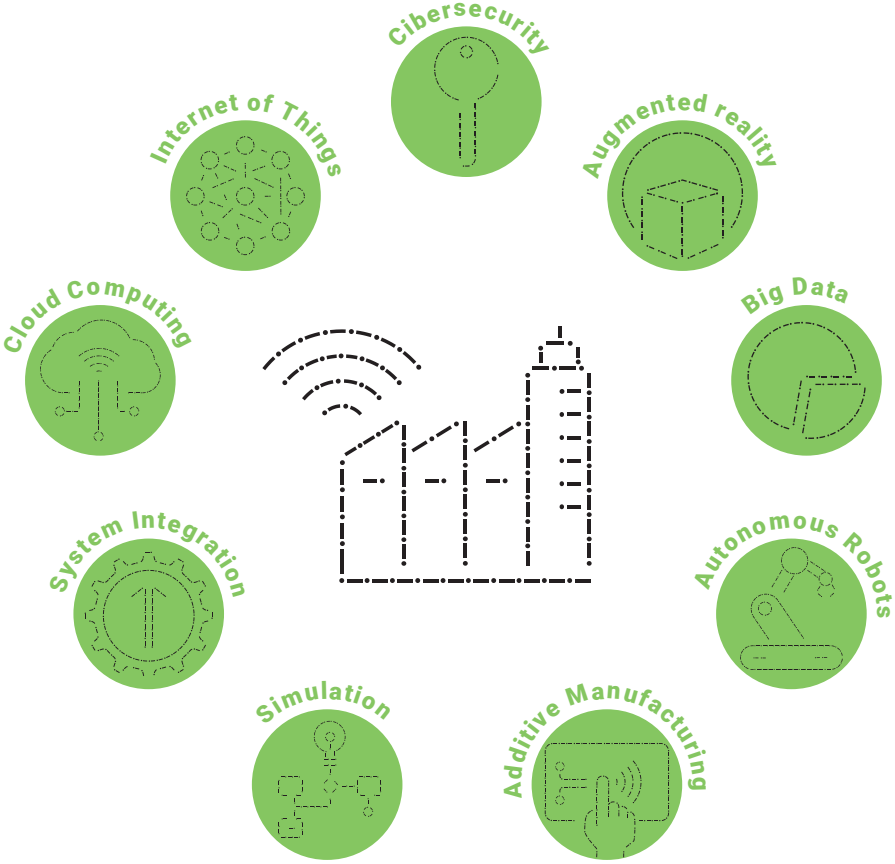
1,000-5,000 Employees

1. No Overarching Strategy for Digitalisation
2. Lack of Expertise to Lead Digitalisation Initiatives
3. Limited Access to the Required Technical Expertise
4. Employee Pushback
5. Limited Budget

More than 5,000 Employees

1. Lack of Expertise to Lead Digitalisation Initiatives
2. Organisational Structure Gets in the Way
3. No Overarching Strategy for Digitalisation
4. Limited Access to the Required Technical Expertise
5. Employee Pushback

Source: Medium.com

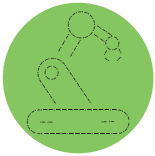


ENABLING TECHNOLOGIES

Nine enabling technologies support Industry 4.0. Many are already used in manufacturing, even if frequently isolated and disintegrated. With digital transformation, they will be fully connected, operating and communicating in real-time to optimize production and information flow towards action. Networked factories will be part of a value chain working as a whole (BCG, 2015).

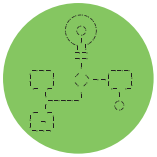
Big Data and Analytics

Analytics based on large data sets has emerged only recently in the manufacturing world, where it optimizes production quality, saves energy, and improves equipment service. In an Industry 4.0 context, the collection and comprehensive evaluation of data from many different sources—production equipment and systems as well as enterprise- and customer-management systems—will become standard to support real-time decision making.



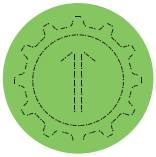
Smart Robots

Manufacturers in many industries have long used robots to tackle complex assignments, but robots are evolving for even greater utility. They are becoming more autonomous, flexible, and cooperative. Eventually, they will interact with one another and work safely side by side with humans and learn from them. These robots will cost less and have a greater range of capabilities than those used in manufacturing today.



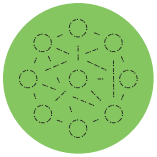
Simulation

In the engineering phase, 3-D simulations of products, materials, and production processes are already used, but in the future, simulations will be used more extensively in plant operations as well. These simulations will leverage real-time data to mirror the physical world in a virtual model, which can include machines, products, and humans. This allows operators to test and optimize the machine settings for the next product in line in the virtual world before the physical changeover, thereby driving down machine setup times and increasing quality.



System Integration

Most of today's IT systems are not fully integrated. Companies, suppliers, and customers are rarely closely linked. Nor are departments such as engineering, production, and service. Functions from the enterprise to the shop floor level are not fully integrated. Even engineering itself—from products to plants to automation—lacks complete integration. But with Industry 4.0, companies, departments, functions, and capabilities will become much more cohesive, as cross-company, universal data-integration networks evolve and enable truly automated value chains.



The Industrial Internet of Things

Today, only some of a manufacturer's sensors and machines are networked and make use of embedded computing. They are typically organised in a vertical automation pyramid in which sensors and field devices with limited intelligence and automation controllers feed into an overarching manufacturing-process control system. But with the Industrial Internet of Things, more devices—sometimes including even unfinished products—will be enriched with embedded computing and connected using standard technologies. This allows field devices to communicate and interact both with one another and with more centralized controllers, as necessary. It also decentralizes analytics and decision making, enabling real-time responses.

Cybersecurity

Many companies still rely on management and production systems that are unconnected or closed. With the increased connectivity and use of standard communications protocols that come with Industry 4.0, the need to protect critical industrial systems and manufacturing lines from cybersecurity threats increases dramatically. As a result, secure, reliable communications as well as sophisticated identity and access management of machines and users are essential.

The Cloud

Companies are already using cloud-based software for some enterprise and analytics applications, but with Industry 4.0, more production-related undertakings will require increased data sharing across sites and company boundaries. At the same time, the performance of cloud technologies will improve, achieving reaction times of just several milliseconds. As a result, machine data and functionality will increasingly be deployed to the cloud, enabling more data-driven services for production systems. Even systems that monitor and control processes may become cloud based. Vendors of manufacturing-execution systems are among the companies that have started to offer cloud-based solutions.

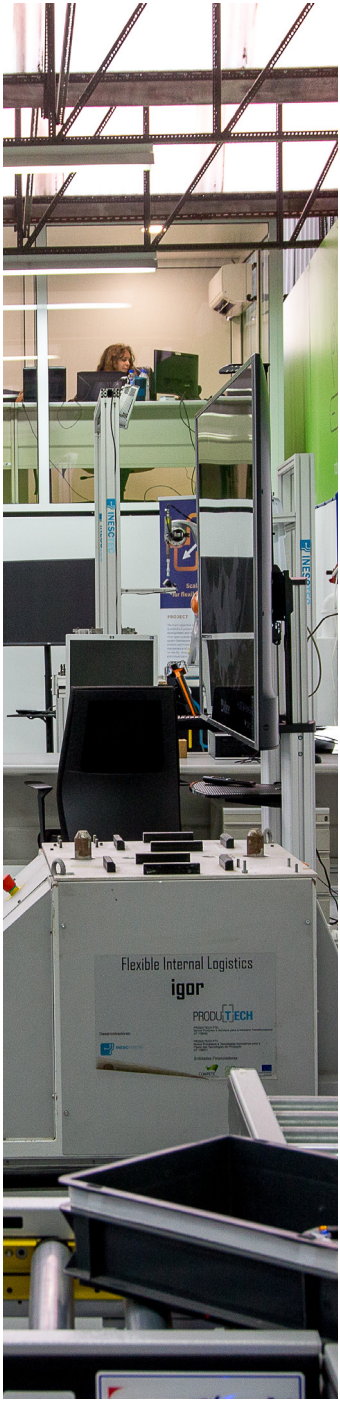
Additive Manufacturing

Companies have just begun to adopt additive manufacturing, such as 3-D printing, which they use mostly to prototype and produce individual components. With Industry 4.0, these additive-manufacturing methods will be widely used to produce small batches of customized products that offer construction advantages, such as complex, lightweight designs. High-performance, decentralized additive manufacturing systems will reduce transport distances and stock on hand.

Augmented Reality

Augmented-reality-based systems support a variety of services, such as selecting parts in a warehouse and sending repair instructions over mobile devices. These systems are currently in their infancy, but in the future, companies will make much broader use of augmented reality to provide workers with real-time information to improve decision making and work procedures. For example, workers may receive repair instructions on how to replace a particular part as they are looking at the actual system needing repair. This information may be displayed directly in workers' field of sight using devices such as augmented-reality glasses.

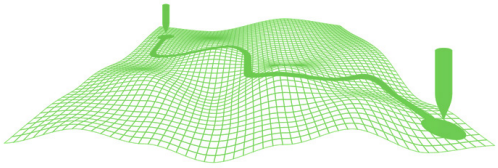
TRANSFORMATION ROADMAP

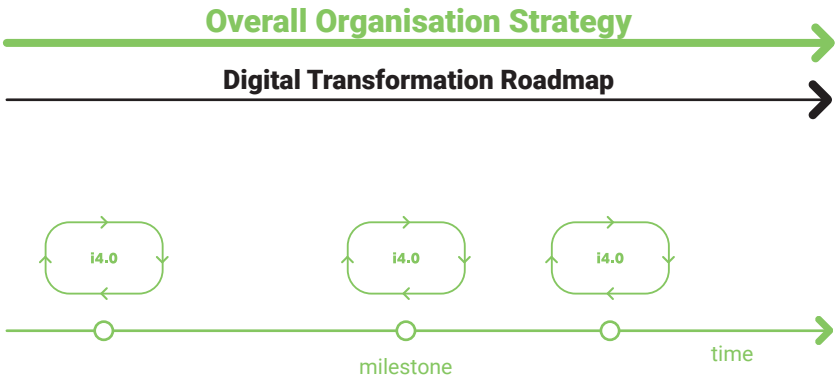


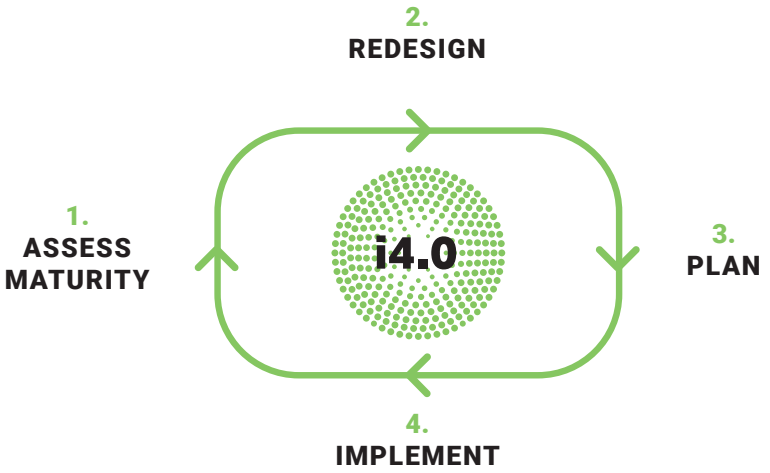
"If you don't know where you're going, you will probably end up somewhere else."
Laurence J. Peter

A digital transformation strategy follows the organisation's strategy vision: it is the destination. To arrive there successfully, and before starting the journey, an organisation has to define its clear vision and goals to be able to define the transformation roadmap.
The overall organisation strategy will guide the digital transformation roadmap, which is an instrument to support strategy implementation. Along the roadmap, the digital transformation methodology will be repeatedly executed, producing results that will feed the following stages. This will allow the organisation to mature and evolve, while adapting and aligning itself according to its strategic goals.

Developing models that support and guide industry with technology implementation projects has been a key topic in Industry 4.0, whose implementation methodological models focus in four steps relevant for the organisational transformation:







1. Assess the Organisational maturity;
2. Redesign the Organisation;
3. Plan the (new) Organisation;
4. Implement the (new) Organisation.

The Business maturity level is a cornerstone to enable business transformation towards Industry 4.0 paradigm. It provides the necessary organisational requirements and predisposition to embrace technological, technical, and process changes. However, organisations struggle to measure their current maturity level, access suitable indicators, and find the necessary environment that will help them ensure successful Industry 4.0 project implementation.

In maturity models, the baseline phase – Digitalisation, concerns the establishment of the required structures to enable the technological implementation for data management.

This phase consists of two levels, Organisation and Computerization level and Connectivity level.

Organisation and Computerization
Map: design the organisation
Connectivity level
Inform: integrate the organisation

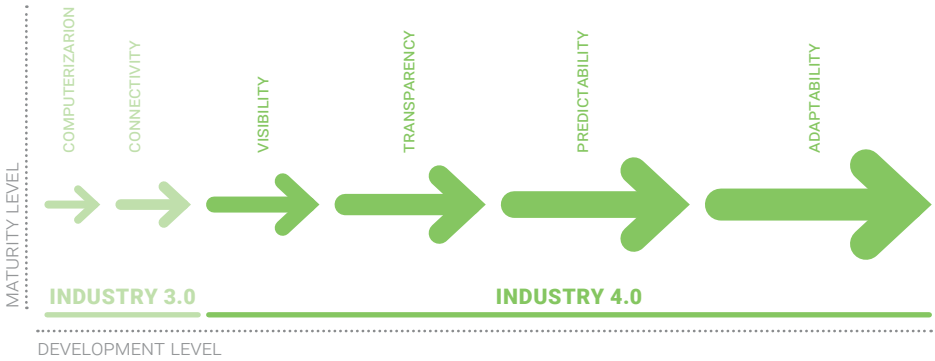
The Industry 4.0 phase, is where the Industry 4.0 technological proposals are envisioned, sourced and commissioned. This phase consists of four levels, Visibility, Transparency, Predictability and Adaptability.

Visibility
See: what is happening

Transparency
Understand: why is it happening

Predictability
Prepare: what will happen

Adaptability
Change: autonomous decision-making



Textile

Textiles have now become a heavily technology-driven process. Thanks to advancements in predictive analytics, IoT, artificial intelligence and ERP, there is an extraordinary opportunity for textile players to achieve Industry 4.0 leadership and deliver automated control over the textile fabrication process from design and colouring to fibre construction, fabric creation, finishing and delivery.

Footwear

The Portuguese footwear industry is one of the most dynamic sectors of national economy, with a total value of €1.96 billion and accounting for 95% of exportations to markets such as France, Germany, Netherlands, Spain, UK (Facts and Numbers report 2017, APICAPS 2017). The industry is transforming itself by adopting industry 4.0 paradigm and technological proposals.
However, the Portuguese footwear industry is composed mostly of Small and Medium Enterprises (SMEs), which can pose as a challenge to implement Industry 4.0-enabled projects due to its inherent characteristics: economical, power, time and organizational restrictions. Mobilization projects and innovation clusters assemble consortiums with businesses and relevant partners (e.g., machine supplier and software houses) to enable a transformation roadmap for the industry. Through proofs of concept and industrial experimentation of technologies, new business and production capabilities are tested and prepared for maturity. Innovations such as customized open-source IIoT platforms, cyber-physical-enabled machines, autonomous vehicles, flexible and accessible data and systems architecture transformation, collaborative platforms and optimization & simulation tools, are now being tested and validated with the industry and stakeholders. One of these projects is FAMEST – Footwear, Advanced Materials, Equipment's and Software Technologies - which involves the participation of INESC TEC as an Industry 4.0 innovation partner.

Automotive

To handle current business challenges such as product complexity, shorter product life-cycles, customization, rapid time-to-market and increased international competition, automotive manufacturing organizations continuously seek out for processes' flexibility, changeability and adaptability. The close cooperation between the worker and the automated systems is an emergent strategy to address these challenges. Therefore, automotive manufacturing companies are experiencing an increase in human-machine interactions and in the use of collaborative robots (cobots). To make full use of cobots, it is essential to understand the drivers for adoption, as well as how these drivers are aligned with the companies' strategic objectives. Empirical results reveal "operational efficiency" and "ergonomics and human factors" concerns as important drivers in the adoption intent. In terms of strategic objectives, it was found that drivers are aligned with productivity and flexibility improvements as well as quality improvement of strategic objectives.

Understanding these drivers can help to drive manufacturing companies into adopting cobots, in facilitating their adoption, and in reaping the benefits of this technology.

Aerospace and Defense

It is believed that the Aerospace & Defense (A&D) sector is among those with greatest potential to benefit from Industry 4.0 paradigm. Benefits around €20 billion, in terms of cost reduction (~3,7% per year) and revenue increase(~2,7% per year), are expected over the next years through the adoption of these digital technologies (Industry 4.0 Summit&Expo, 2019; European Commission, 2017). The A&D digital transformation is mainly related to 6 drivers (Industry 4.0 Summit&Expo, 2019; EY, 2018): customer relationship - experience and involvement; new products and services; digitalization of business processes; new workforce; value chain ecosystem; and efficiency. Despite being early adopters of advanced technologies, few companies are currently making wide use of digital tools. In addition, they have been focusing investments in specific applications and not considering the entire organization. Surveys revealed that the adoption and leveraging of digital technologies, the efforts for vertical integration and the inclusion of local players in the global supply network are the most important directives present on A&D companies' strategies (Deloitte, 2019; EY, 2018). The challenge for the sector lies on the product innovation and on the creation of new business models, which should consider customer engagement, new products/services and platforms, intelligent assets and a collaborative supply chain. Despite the benefits, the digital transformation requires important organizational changes and process adaptations. In order to take advantage of industry 4.0 technologies, companies should care for workforce qualification, new business dynamics of continuous changing and the complex & integrated value chain.

Forest-based

Forest-based supply chains are at the core of bio-economy, paving the way to a global circular economy. The forest industry faces major challenges related to higher resource efficiency, which include forests, soil, water and energy, while mitigating the negative impacts in the environment and contributing to a greater social welfare.
Process digitization and technology-driven innovation can be instrumental for attaining the goal of producing the same or more with less resources, while increasing the forest-based products lifecycle through active reuse and recycling. Novel sensors and similar technologies are now used for remote forest inventory, providing low-cost, up-to-date data regarding the status of the resources for decision-makers. Operator-aid devices embedded in the equipment help to increase productivity and sustainability in forest and logistics operations. Internet of Things and big data analysis are more and more a reality, fostering data exchange between companies. Advanced planning tools support better real-time planning of supply chains.

Process-based

I In large organizations, particularly in the oil and gas industry, the process of digital transformation is complex due to the number of processes, people and technologies involved. Although the technology is already adopted on a large scale, processes, systems and people are still disaggregated and misaligned. The phenomenon of functional silos is easily observable, including the adoption of heterogeneous practices, processes and technologies, leading to a huge dispersion of data and information, greatly reducing the operational efficiency and effectiveness of the organization.

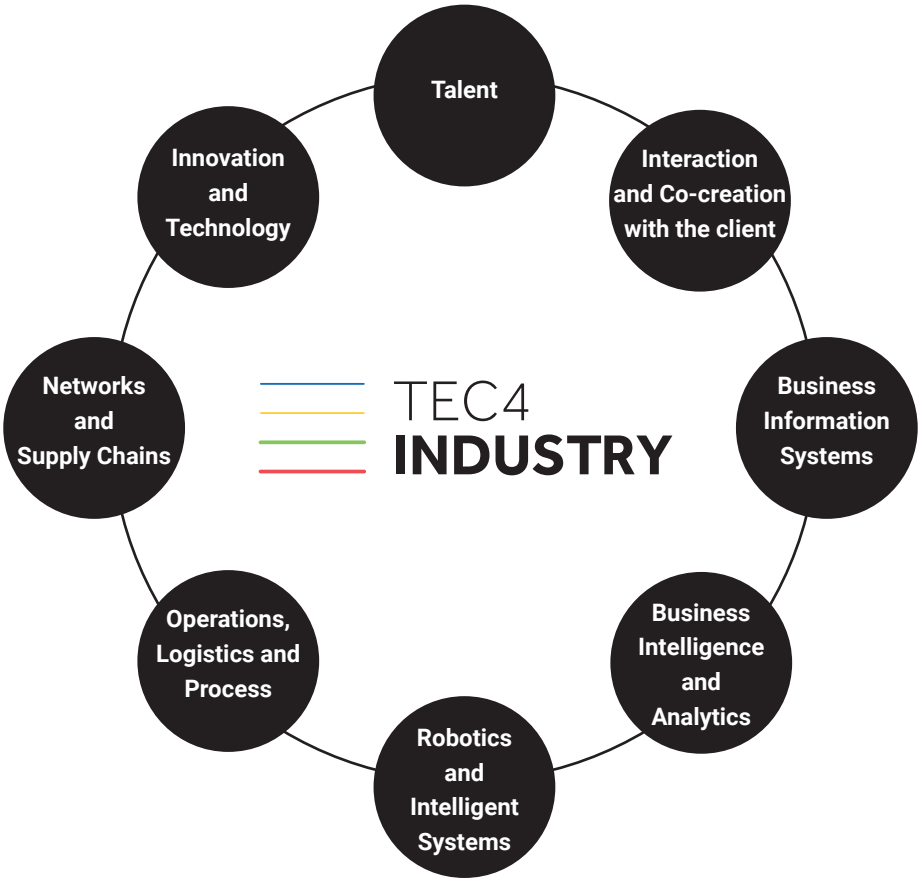
One of the great advantages of the digital transformation is the aid in eliminating these functional silos, making the processes more integrated and fluid, in order to aggregate and provide real-time data, from the OT layers to the decision support systems' layers, supporting proactive decision-making and, thus, increasing the assets' efficiency and profitability.

The creation of structural and transversal digital initiatives such as the adoption and improvement of communication networks, asset sensing and integration of OT and IT systems, build the basis for later implementation of tools that improve communications, achieve a more integrated management of operations, as well as foster the use of business intelligence and analytics tools, making the organization more agile and data-driven.

HOW CAN INESCTEC ENABLE YOUR DIGITAL TRANSFORMATION INITIATIVE

INESC TEC, as a leading Science and Technology institute, is supported on a broad multi disciplinary team, combining synergies from diverse areas of knowledge and industry. INESC TEC activities range from research to innovation, developing and applying customized state-of-the-art solutions to transform businesses for over 30 years. INESC TEC's research track-record, and extensive consultancy experience in

developing and deploying solutions for industrial enterprises and value chain management, enables the offering of high-value services to help companies assess, design, plan and operationalise Industry 4.0 strategies.
INESC TEC's Industry 4.0 framework has been developed using a multi-methodological and multidisciplinary approach, which includes the conceptual modelling as well as qualitative and quantitative methods for field validation.



iilab INDUSTRY & INNOVATION LAB

The industry and innovation lab is a key instrument within INESC TEC's ecosystem to enable digital transformation initiatives in Companies. It combines complementary competences and capabilities to deliver integrated Industry 4.0 solutions in areas such as Industrial Internet of Things, Advanced Robotics and Automation, Business Intelligence, and Man-Machine Collaboration.
The iilab works alongside each Company to understand and address its specific challenges and needs in development, experimentation, prototyping, or advanced training to provide them R&D-based solutions.

Mission

To carry out applied research and to disseminate state-of-the-art advanced manufacturing technologies knowledge and competences through demonstration of R&D results, training, and hands-on experience.

Objectives

• To demonstrate concepts and technologies of advanced robotics and automation, and cyber-physical system (industrial internet of things)
• To disseminate INESC TEC's competences to industry and the community
• To provide an experimentation and prototyping space to technological-based companies
• To deliver tailor-made training to executives and top managers from industrial companies

services@iilab.inesctec.pt
info@iilab.inesctec.pt

Hipercentro
Centro Empresarial - Porto
Rua Dr. Eduardo Santos Silva, 261
4200-283 Porto, Portugal
Fração C1

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OBSERVATION:
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INESCTEC

Campus FEUP
Rua Dr. Roberto Frias
4200-465 Porto, Portugal

T +351 222 094 000
info@inesctec.pt
wwww.inesctec.pt

COMPETE 2020
PORTUGAL 2020
UNIÃO EUROPEIA
Fundo Europeu de Desenvolvimento Regional
FCT Fundação para a Ciência e a Tecnologia
FITEC Fundo de Inovação, Transferência de Tecnologia e Economia Circular
PROGRAMA INTERFACE
Programa Nacional de Reformas
REPÚBLICA PORTUGUESA