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Technology in Industry Report

Holistic Adoption: Unlocking the Full Potential of Industry 4.0 Technologies

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The greatest misconception about the Fourth Industrial Revolution is that it is, at its core, about technology. Indeed, the impressive array of technologies, ranging from AI and connected smart devices to nanotechnology do represent great potential but they will be unleashed only by applying a fundamentally different mindset from that of the previous age – the age of linear computerization. Each of the industrial transformations that humanity has so far experienced has been based on emergence. The phenomenal shifts of the Second Industrial Revolution that was ushered in by pioneers like Henry Ford and Thomas Edison were accomplished through a new worldview, entrepreneurial developments, and a new operating system for production – the mass production line. The disruptions to emerge from Industry 4.0 are sure to come not from using smart devices to create faster products and processes, but to leverage them in dynamically reconfiguring systems based on the principle of emergence. With emergence, the holistic system takes on a fundamentally new nature which would not have been obvious by reductionist analysis of the constituent parts.

Emergence for Industry 4.0 is still on the way and these effects will certainly be seen in the form of dramatic changes in marketing and sales, customer relationship management, manufacturing, product development, production scheduling and operations management, supply chain management, and indeed all areas of the extended enterprise. Industry 4.0 is a technology-driven industrial revolution. These technologies are illustrated in Figure 1. The evolution and spreading of this industrial revolution are heavily dependent on the maturity levels of these technologies, and those technologies are developing fast. In order to get a feel of how fast those technologies are developing, we just need to look at the hype cycle of emerging technologies published annually by Gartner Inc, which illustrates the research progress of those technologies. Figure 2 lists the results of 2017 and 2020. The actual progress of many of the technology developments have been faster than predicted in 2017, such as deep learning, machine learning, and IoT platforms.

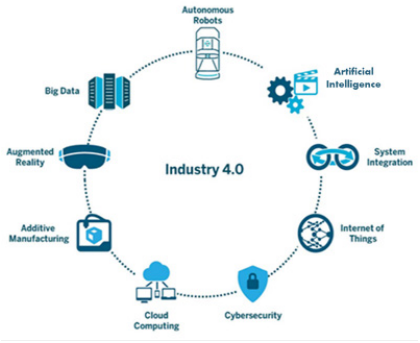
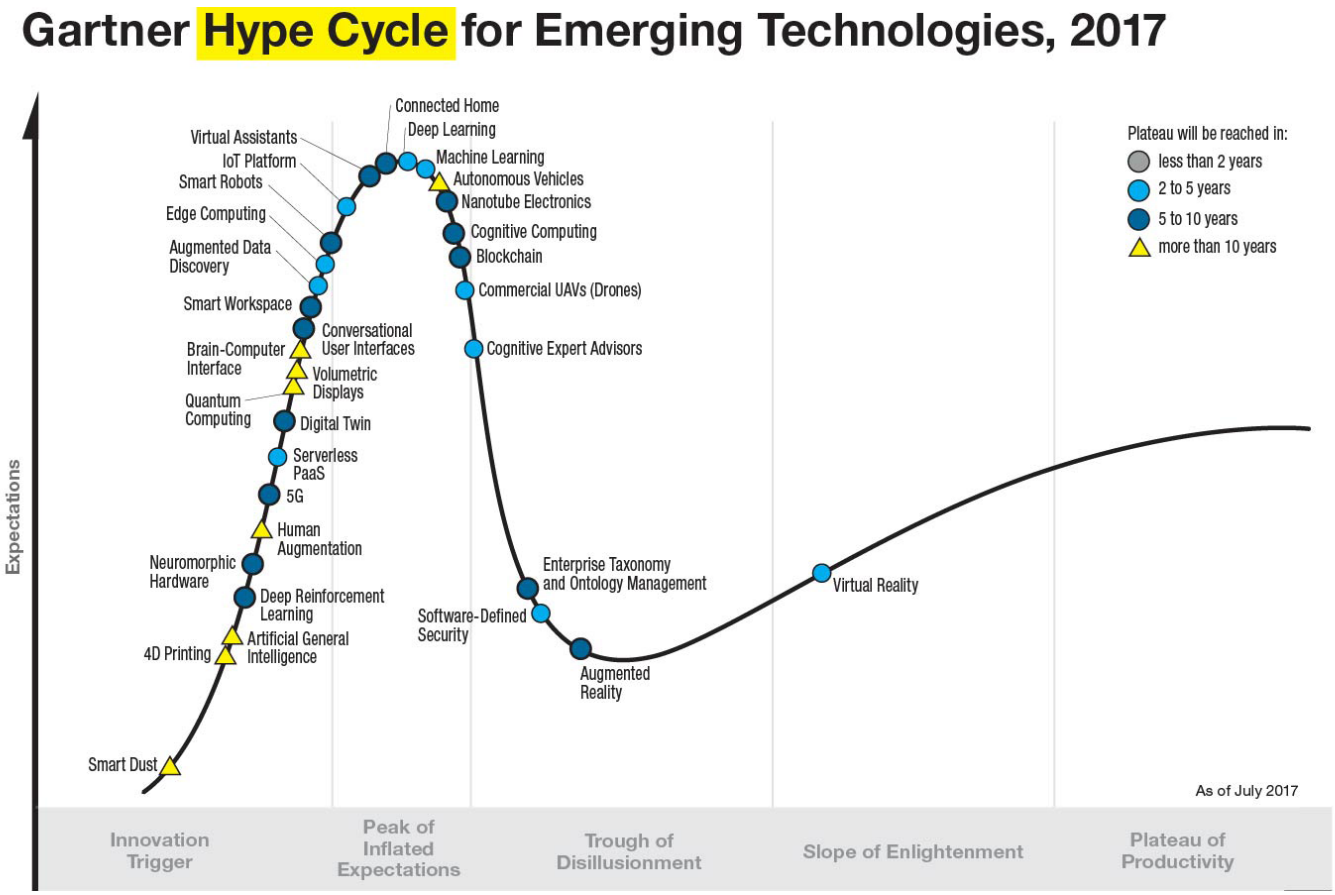


Figure 1: Key Industry 4.0 Technologies



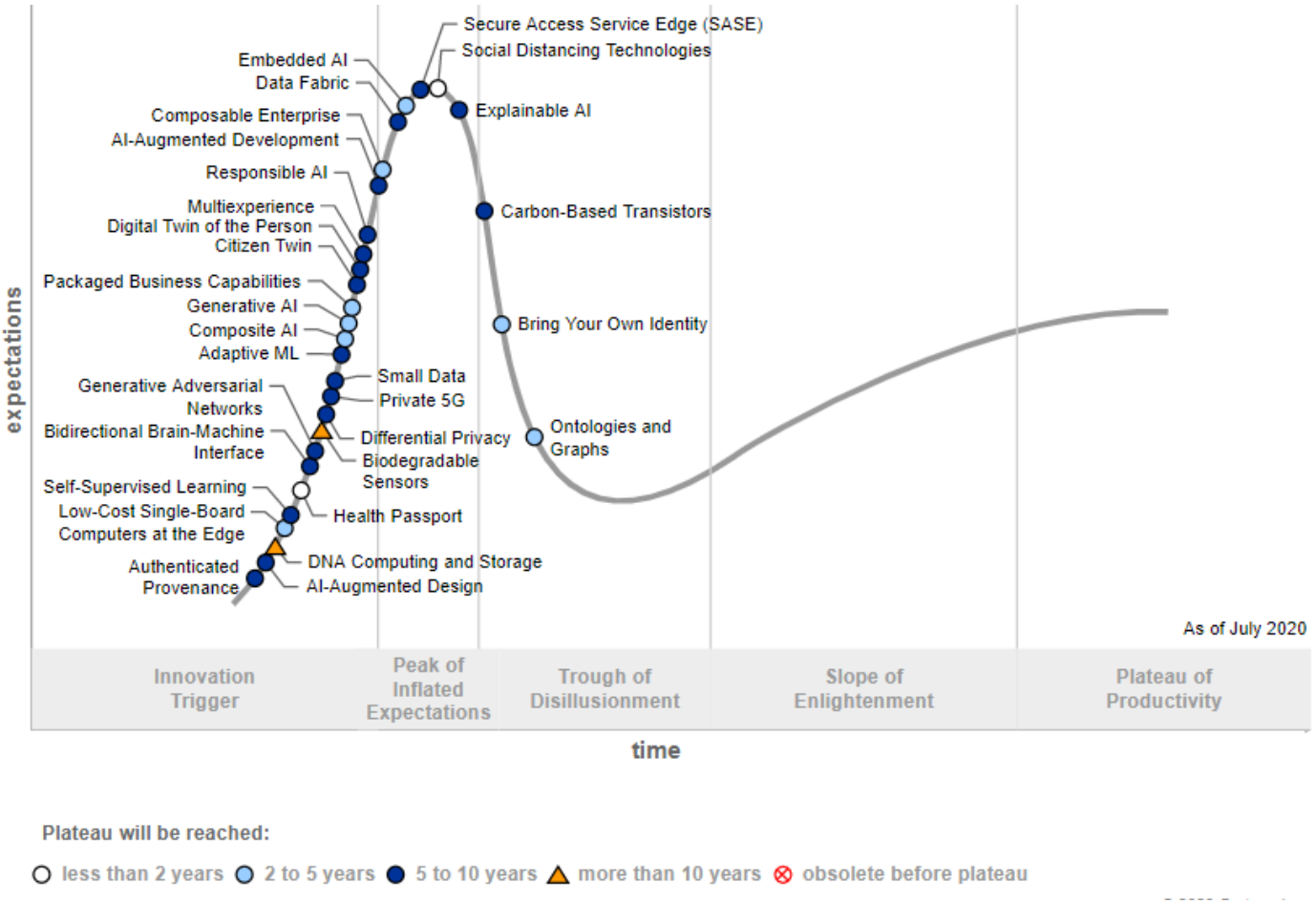


Figure 2+3: Garner's Technology Forecasts, 2017 and 2020

The Current State of Industry 4.0 Application

The scope for Industry 4.0, both in terms of core technologies and application areas, is vast. The technologies range from Internet of Things (IoT) to massively connected smart machines and devices and enabled by tools such as wireless technology (5G), artificial intelligence (AI), scalable analytics (Big Data), and augmented reality. The integration of these technologies into complex cyber-physical systems marks the current state of Industry 4.0 application which is still working towards maturation and steady state implementation that shows a return on investment for businesses and society. The applications of Industry 4.0 are not limited to manufacturing but extend to every field of human endeavor, including energy, agriculture, health care, and government.

The current state of Industry 4.0 application is illustrated by the National Institute of Standards and Technology (NIST) Smart Manufacturing Ecosystem [1] that shows application 4.0 technologies and processes (the automation pyramid) as applied to the product, production, and business dimensions of the enterprise. The Smart Manufacturing Ecosystem, with both horizontal and vertical integration, has five characteristics: [i] Digitization, [ii] Connected Devices & Distributed Intelligence, [iii] Collaborative Supply Chains, [iv] Integrated Energy & Resource Management, [v] Advanced Sensors and Big Data Analytics.

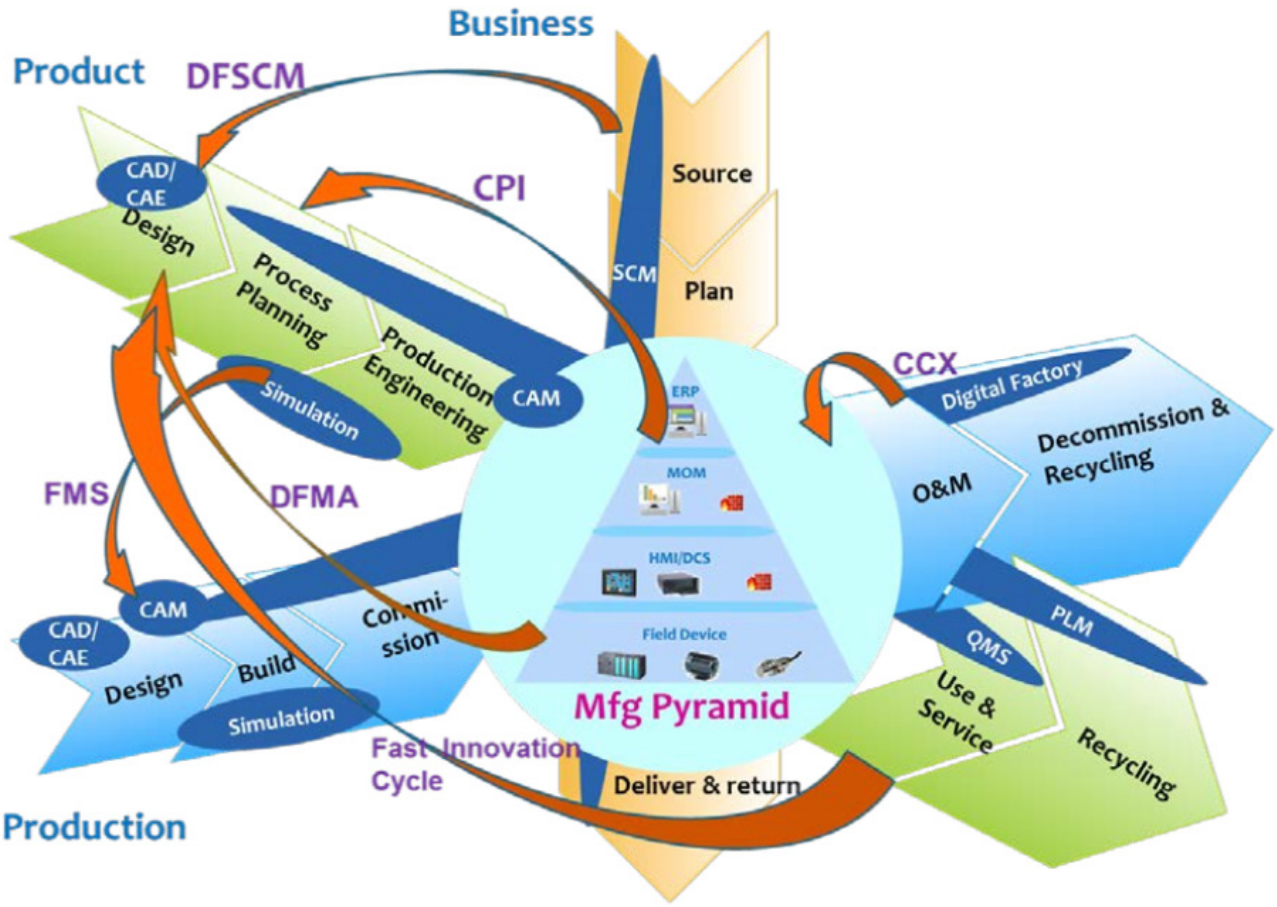


Figure 4: The NIST Smart Manufacturing Ecosystem (Lu et al. 2015)

Typical Smart Manufacturing Ecosystem applications are mapped onto various capabilities in the enterprise. These are:

- Throughput or production capacity,
- Overall Equipment Effectiveness (OEE),
- Material & Energy Efficiency,
- Labor Productivity,
- Responsiveness to change or Flexibility,
- On-Time Delivery,
- Fault Tolerance,
- Product Quality,
- Innovation at product or process levels,
- Variety or Customization of Products or Services,
- Customer Service,
- Product Integrity (life cycle),
- Process Integrity, and
- Logistics Effectiveness.

The technologies are arranged in a hierarchy from Level-1 Smart Field Devices and Sensors, to Level-2 Smart Machines, Human Machine Interfaces (HMI) and Distributed Control Systems (DCS), to Level-3 Connected Manufacturing Operations Management (MOM) or Manufacturing Executions Systems (MES), and then Level-4 Integrated Enterprise and Extended Enterprise functionality [1].

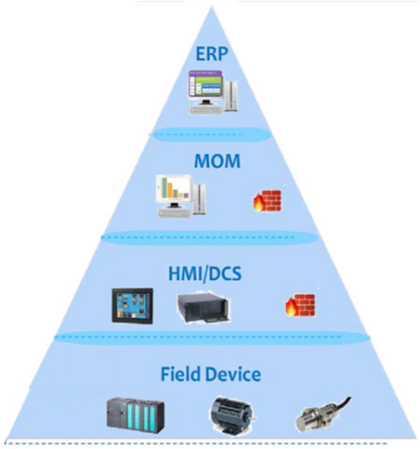


Figure 5: The Industry 4.0 Technology Pryamid (Lu et al. 2015)

Future State: Holistic Industry 4.0 Adoption

The current state of Industry 4.0 application is marked by progress in technology and process innovation. Now, the core challenge as we. Move towards full emergence of Industry 4.0 is to establish deep and sustainable application, not. As a mere technology add-on, but as a fundamentally new configuration of industry and business operation. The holistic adoption of this new system within a broad range of industries, as well as diverse areas within the enterprise, will mark the attainment of this goal. The future, without doubt, will be marked by structural and ontological transformations to realize the Industry 4.0 mindset.

The IQ4.0 framework, the Operating System for holistic value creation, outlines dimensions for the emerging Industry 4.0 mindset and there are three of the core principles that are particularly crucial, (i) co-creation, (ii) radical customization, and (iii) intuition-leveraged intelligence, that we must focus on as we progress towards Industry 4.0 emergence and maturation [2]

Figure 6: The IQ4.0 Operating System Framework [2]

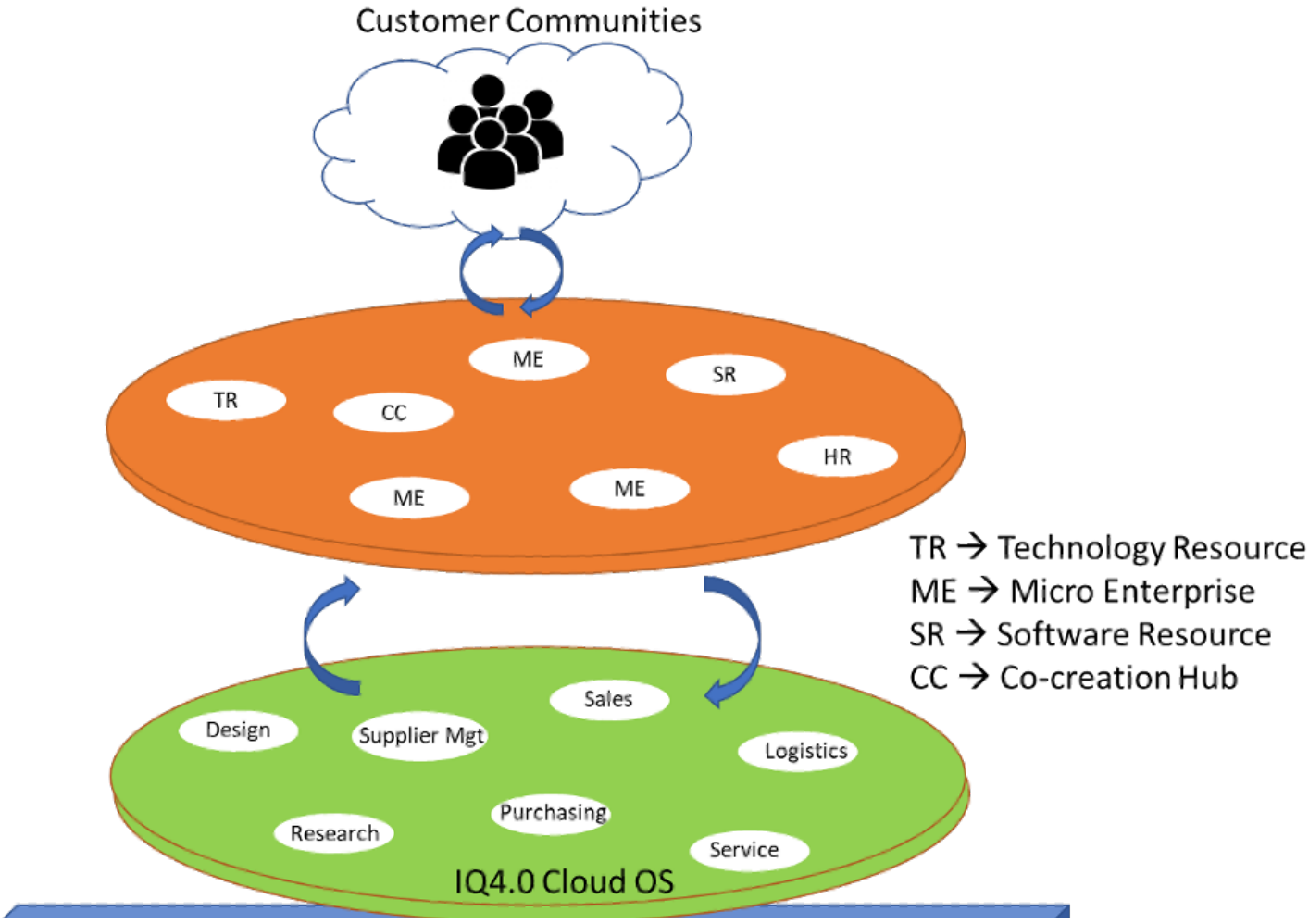


Figure 7: Illustration of Virtual Cloud Business Model (adapted from CosmoPlat).

The co-creation mindset applies the Industry 4.0 smart tools and technologies as an enabler for transforming the relationship between producer and consumer into one of prosumers as predicted by futurist Alvin Toffler [3]. Early signs of the blurring of boundaries between design, production, and consumption into a process of continuous co-creation, is already visible today in the popularity of the makerspace movement. Further developments in this direction by companies such as IKEA [4] are also important for discovery of co-creation strategies that will be effective. The radical customization mindset is the drive to leverage Industry 4.0 technologies as an enabler for design and production that targeting precise niches of the business ecosystem far beyond the capabilities of mass customization. With this mindset traditional design with statistical parameters and tolerances based on customer categories is replaced by individualized design, "tailor-fitted" products and services. The intuition-leveraged intelligence mindset holds staunchly that human intelligence and machine intelligence are complimentary niches in the intelligence ecosystem of Industry 4.0. Thus, intelligence must not be entirely artificial, but instead integration the powers of human intuition and creativity along with the powers of AI in terms of deductive speed and ability to process huge datasets. Whether applications are in embedded intelligence in products or the search trees for design optimization, or in the operations and production processes (including quality management), algorithms must provide the necessary hooks for input from creative humans.

The integration of the core principles of the Industry 4.0 mindset is well illustrated by the Intelligent Composable Business Architecture [5]. An intelligent composable business is one that is designed to adapt and reconfigure itself based on different business contexts that it encounters. The Intelligent Composable Business transforms decision-making using large-scale context data for modular flexibility in business reconfiguration, creating of new business models, facilitating autonomous operations, and establishing new products, services, and business channels. The composable business architecture, as an artefact of Industry 4.0, is an acceleration of digitization and offers both the customer and employee an agile experience, ensuring real-time adaptability. The connectedness of Industry 4.0 technology opens up an opportunity for restructuring the extended enterprise to match the actual structure of the internet – a highly decentralized entrepreneurial network of enterprises and microenterprises in overlapping ecosystems.

COSMOPlat, a recent winner of the Gartner Supply Chainnovator Award, [6] provides a good illustration of a composable business architecture in practice as shown in figure 6. The top layer represents the customer ecosystem where demand for products and services are created. The middle layer represents the enterprise modeled as micro enterprises (MEs) with each micro enterprise interacting directly with customers or teaming up with other MEs to target specific opportunities in customers ecosystem. In the CosmoPlat example, the company has over 4,000 entrepreneurial MEs and most of them have only 10 to 15 employees (Ref-HBR article). With a modular ME structure, the entire is able to leverage the Industry 4.0 technologies and reconfigure itself dynamically based on different emerging opportunities or threats. Layer 3 is the cloud-based platform, the infrastructure for supporting all common activities such as product development, logistics, supplier development, etc. for the entire extended enterprise.

Action Points for Your Industry 4.0 Springboard

Moving towards holistic Industry 4.0 adoption will require proactive steps by every company and there is no doubt that early adopters will be the ones to gain from the disruptive potential of the potential opportunities. The Industry 4.0 holistic adoption springboard consists of three steps, [i] Readiness Assessment, [ii] Strategic Planning, and [iii] Scalable Implementation.

Schumacher et. al [7] have proposed a maturity model for Industry 4.0 assessment which covers basic enablers which are Products, Customers, Operations and Technology as well as dimensions of Strategy, Leadership, Governance, Culture and People. In-depth examination of these enablers and dimensions provide the opportunity to identify areas to enhance and solidify foundations as the starting point for a successful Industry 4.0 journey. Automation Alley has also developed an Industry 4.0 Assessment for small manufacturers. This assessment, which emphasizes the status of your culture, finance and technology, can be accessed here: https://automationalley.com/Initiatives/ACT-40.aspx.

Developing your Industry 4.0 Strategic Plan is necessary for defining the Composable Business Architecture [8] for your Industry 4.0 emergence. Building on the results of your assessment, the Strategic Plan should outline the rationale or Business Case for Industry 4.0 holistic adoption, the organizational and culture changes required, and incremental time-phased implementation activities for achieving Industry 4.0 transformative leverage.

As they say, “Rome was not built in one day” and so also your Industry 4.0 implementation must follow a step-by-step approach. First build necessary infrastructure foundations in both culture change and technology. Then follow-up with initial pilot projects and small steps and gradually scale up as your organizational capability and maturity develops. Strategies for successful implementation will vary greatly depending on implementation context but several key points are universal.

1. Set clear expectations for each step of implementation,
2. Ensure strong support from top management,
3. Communicate with the entire workforce on impending changes and the reasons behind each one,
4. As much as possible involve key Customers and Suppliers in your development projects, and
5. Be highly flexible to adapt your plan as real-world conditions inevitably change.

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