White Paper

THE BUSINESS CASE FOR SMART MANUFACTURING
Leveraging Strategy Design to Reap the Benefits of Industry 4.0

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The Smart Factory market is expected to be value at $215Bn by the end of 2025.

- Future Market Insights

Investments in Industry 4.0 capabilities are expected to reach 5% of annual revenues.

Smart Factories are revolutionizing manufacturing by enabling a 7x increase in overall productivity by 2022.

- Forbes

Smart Factories have the potential to add $500B to $1T in value added to the global economy in 5 years.

- Forbes

76% of manufacturers either have a Smart Factory initiative that is ongoing or are working on defining one, with 14% of companies satisfied with their level of accomplishment.

- Forbes

The Smart Factory concept could be worth $10-$15 Trillion to global GDP over the next 20 years.

- GE ‘16

"This is nothing less than a paradigm shift in industry: the real manufacturing world is converging with the digital world to enable organizations to digitally plan and project the entire lifecycle of products and production facilities."

- Helmut Ludwig, CEO, Siemens Industry Sector, North America
Industry 4.0 refers to the fourth industrial revolution focused on innovation of business operating model within the context of an industrial organization. It leverages transformative technologies for managing interconnected physical systems, computational capabilities and human collaboration within an industry. It is a broad area that supports transformation across industries, such as manufacturing, healthcare, electric power grids, agriculture, and transportation. In manufacturing context, it involves transformation with respect to data, processes, services, systems, production assets and people by producing and consuming of actionable information as a way and means to realize smart manufacturing thereby becoming a Smart Factory.

There are multiple variations on how Industry 4.0 is described by subject matter experts. For those of you not familiar, German trade and invest describes the best - “smart manufacturing” or “Industry 4.0” refers to the technological evolution from embedded systems to cyber-physical systems. Put simply, it represents the coming of fourth industrial
revolution on the way to leveraging Internet of Things, Data and Cloud Services.

Industry 4.0 represents a paradigm shift from “centralized” to “decentralized” production, made possible by technological advances which constitute a reversal of conventional production process logic. Humbly put, industrial production machinery no longer simply “processes” the product, but that the product communicates with the machinery to tell it exactly what to do. Industry 4.0 connects embedded system production technologies with smart production processes to pave the way for new technological age which will radically transform industry and production value chains, and Business Operating Model of BOM (e.g. evolution of “Smart Factory”).

There are also several versions of Industry 4.0 principles, areas of innovation, challenges, approaches, and solutions presented by experts across the industry to ease the path for manufacturing industries big and small to move towards industry 4.0. There is no singular definition or agreed upon understanding of this revolution, however everyone seem to reach a consensus of its impact to all industries including manufacturing.

**KEY TAKEAWAYS**

- To achieve anticipated benefits and value realization, Industry 4.0 initiatives must have a coherent Strategy, compelling Business Case and an actionable Transformation Roadmap.
- The CEO (and the Executive team) must demonstrate commitment via leadership and re-allocation of capital investment.
- When businesses adopt Industry 4.0, they will be making a positive impact and enhancing the following areas: Operating Model Innovation, Operational Excellence and Experience Design. This future state transforms the traditional manufacturing concern into an agile and Smart Factory, with increased efficiencies and the flexibility to meet ever changing customer demands.
- Industry 4.0 accelerators, benefits and values impact all types of manufacturing - repetitive, discrete, job shop and process (batch or continuous), regardless of company size or manufacturing footprint.
- Industry 4.0 is driven by Agile Manufacturing which impacts the Four Key Elements of the digital customer persona.
- Four (4) major business enablers and influences in Industry 4.0 include: (1) Manufacturing Innovation Accelerators (MIAs), (2) Agile Manufacturing, (3) Cyber Security and (4) Integrations - both horizontal, vertical and end-to-end.
- There are six (6) critical building blocks that must be addressed in order for any business to succeed in Industry 4.0.
GOALS, CHALLENGES AND BENEFITS

BUSINESS GOALS

Industry 4.0 will transform the production of goods and services within Internet-enabled operations. This transformation will facilitate innovative products and customizable services, achieving cost-effective, efficient Internet-based diagnostics, maintenance, product support, etc., to new value streams and revenue models. Manufacturing organizations embracing Industry 4.0 will realize additional competitive advantage when change not just based on logical but heuristic methods as well. This will create new strategic operating concepts and smart controls that satisfy ever-changing consumer needs and enable the business to transform and grow. Smart Factories will emerge in the world of Industry 4.0, characterized by three overarching objectives.

Operating Model Innovation

Production in Smart Factory environment will be distributed and flexible; new development processes, infrastructure and services will arise. Products will become modular and configurable so that the product can be adapted to the specific requirements. Smart Factory assets such as automated systems and equipment, internal logistics systems and operating supplies are consistently intermeshed with help of cyber technology, such as Internet and Wi-Fi communication services, smart sensors, actuators and telecommunication technologies. This enables Smart Manufacturing with the most efficient processes and services, giving rise to new innovations with value propositions and Business Operating Model that supports optimal resource utilization and intelligent management of existing assets.

Operational Excellence

Smart Factory will allow high flexibility both in the development, diagnostics and maintenance as well as operation of automated systems. During development, you will have the choice to select the right vendors, suppliers, technologies, products, components, modules and services. The diagnosis can be carried out with access to

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2 Leveraged to solve transformational challenges across people, process, data and technology to provide solutions and strategize improvements during Industry 4.0 journey
Big Data that assists in automating the diagnostic procedures. Required information could be retrieved on-demand, intelligently used and linked so that an automated diagnosis can be achieved. Spare parts can be ordered automatically from the most cost-effective suppliers. Mobile devices such as smartphones and tablets have already made inroads in manufacturing operations. They provide independent access to processes and services of the automated systems thereby creating a new dimension in the diagnostics and maintenance of automated systems.

Experience Design

With Smart Factory, it will be able to customize the products to specific individual needs of customers. Systems will produce products that adapt to the needs and abilities of diverse users. E.g. age groups, disabilities, safety, security, regulations. Smart Factory systems, also called cyber-physical systems, will also support workers within the organization in all aspects by complementing them throughout all their work. The human-machine interaction will drive higher productivity due to an agile, healthy and engaged workforce.
**BUSINESS CHALLENGES**

Industries are leveraging disruptive technologies in order to engage all aspects of business and society, and to drive sustainable growth. Understanding this dynamic and making the necessary changes is the context for Industry 4.0. Currently, it is vaguely understood as combining several technology innovations that spread across all business capabilities to enable operational efficiencies and consumer experience in order to create new revenue streams. This warrants organizations to evaluate the current state of its existing Operational Model and its capabilities against the Industry 4.0 enablers; this would also help in creation of a vision and design a strategy with prioritized initiatives for transformation. Without a compelling and complete strategy, transformation could be in jeopardy and demoralize all stakeholders leading and participating in the journey.

A transformation strategy provides the business case, value statement and roadmap for the transformation journey. Which is then followed by:

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**Vision and Strategy**

This is considered the number ‘one’ challenge. At the present time, there is no single definitive framework that can guide and support organizations on their journey to assess your businesses’ state of preparedness based not just on technology, but on a comprehensive picture of Industry 4.0 that enables Smart Manufacturing to achieve its goals.
• Prioritization of right business cases
• Identification of stakeholders, external partners, subject matter experts (SMEs), etc.
• Engaging stakeholders and external partners in execution of developed strategy to enable Smart Manufacturing in incremental stages.

**Investment**

The business leadership need to address investment for the transformation to Industry 4.0. It must identify sources for financial support, and figure out how to measure the Return-on-Investment (ROI).

**Talent**

Organizations would require digital transformation skills that translate to leveraging of technology for information and communication management. Due to the need for such talent across all industries, organization could face scarcity in the market.

**Culture**

At Logical Heuristics, we believe that culture is the Critical Success Factor (CSF) that drives the failure or success of any Industry 4.0 initiative. It poses challenges like existing mentality and behaviors around silo operations, decisions based on intuition instead of data, absence of calculated risk-taking, lack of tribal knowledge and low levels of collaboration among engineering disciplines. Additionally, the absence of a digital mindset generates lack of initiatives to foster attitudinal change in promoting ideal behavioral change like engaging employees to foster decentralized decision making, training or attracting and retaining talent.

**Security**

With Industry 4.0, security would need to go beyond safeguarding networks, it involves securing data expanse over the Internet of Things (IoT), cloud, mobile devices, and big data that are leveraged by all physical assets (machines, sensors) and personnel within manufacturing.

Additionally, proprietary production knowledge will also become a security challenge when it comes to access control. In Industry 4.0, enterprise security cannot be an after thought; rather it must be in the forefront of architecture design.

**Leadership**

The C-suite has to lead, champion and demonstrate commitment to Industry 4.0 initiatives by adopting a digital mindset. They would need to re-think their business operating models to foster innovation and continuous improvement mindset while re-engaging with customers, partners, suppliers, employees and investors for successful execution of the initiatives.

**Demand Alterations**

Transitioning to Industry 4.0 also requires managing customers, consumers and industrial partners who are digitally (technologically) not ready to receive your products or services. This might require
altering the demands of these stakeholders to avoid duplicity of Business Operating Model that could negate the benefits of Industry 4.0.

Execution Complexities

Several complexities could exist within manufacturing companies to realize benefits of Industry 4.0, or simply put, enabling Smart Manufacturing. Some of these include:

• Resistance to change. It is guesstimated that more than three quarters of manufacturing organization personnel equate change with pain due to personal or organizational fit-in challenges. This leads to issues around gaining support to address any of the above mentioned seven challenges.

• Legacy systems. Existing technology stack that is inflexible or challenging for adaptation.

• Existing machines that are legacy and challenging for transformation.

• Dealing with connected supply chain, that includes enabling product life cycle management beyond delivery. (e.g. collecting data once the product is purchased and used by customers).
BUSINESS BENEFITS

In a world of increasing market volatility, shorter product life cycles, higher product complexity and global supply chains, businesses are seeking to become more flexible and responsive to such market trends. The Industry 4.0 vision of enabling Smart Factory will be able to address such a disruptive, chaotic and complex business environments.

A few of the opportunities companies can leverage are as follows:

Business

Connected ecosystems in manufacturing, using cloud computing, will enable suppliers and partners to optimally align their operations, deliveries and activities to match the factory’s operations. They will be synchronized to function as in a JIT\(^4\) system.

Factory

Intelligent controls guide tool setup, production, flow of raw materials and products to match changing production plans on the shop floor. This brings stronger integration of ERP systems and shop floor systems. With such vertical integration, companies can respond faster to demand changes and implement new configurations more easily or even re-plan production much faster.

Manufacturing Systems

Businesses will become flexible and adaptable to permit discrete manufacturing of small lots of custom products by utilizing real-time data from convergence of information and operational technologies. Additionally, dynamic allocation of resources/capacity will be possible.

Products

Product life cycle digitalization allows companies to leverage data from production, engineering, technology, and social media for faster innovation. Products become “smart” and communicate to machines while in production or back to factory for repair. Through digital connectivity, higher levels of preventive maintenance are attained. Production data will be captured, stored and available for analysis and review.

Customers

Mass customization and highly personalized products are configured, priced and ordered online. The factory then responds immediately with the delivery date. The purchasing experience will be enriched along all the omni channel touch points between the customer and the business.

Human-Machine Interaction

Employee productivity will increase by automating operations using real-time data and focusing their attention to exclusively address anomalies. Additionally, these systems will support personnel in making decisions, solving problems and assisting with
tasks that are too difficult or unsafe on the shop floor.

**Shop Floors**

The digital shop floor will become more agile by adapting production volumes to real-time demand - ramping up production during off-peak times, automatically stopping production, if necessary and adapting production volumes to real-time demand.

**Resources**

Improved use of production resources, raw materials and energy management will adjust usage to actual production needs, and limit waste. Add a highly productive and flexible workforce and waste is reduced dramatically.

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**Development and Engineering**

Products will benefit from the advanced level of digitization and integration. By using the Digital Twin concept, many companies with successful implementation report quicker time to market, revenue gains and cost reduction.

**Business Continuity**

Improved due to capabilities like predictive maintenance based on real-time monitoring and leveraging of data analytics.

**Environment**

Autonomous and continuous monitoring, alerting and adjusting of the manufacturing environment (e.g. real-time temperature and humidity monitoring in the plant or warehouse) will contextualize information, thereby providing information transparency.

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Following is an indicative quantification of value drivers based on Industry 4.0 and the three (3) overarching objectives:

**INDICATIVE QUANTIFICATION OF BENEFITS**

- **Experience Design**
  - Labor\(^{M}\): 45 – 55% increase of productivity in technical professions through automation of knowledge work
  - People/Process\(^{M}\): Productivity increase by 3-5%
  - Asset Utilization\(^{M}\): Machine Downtime reduced by 30-50%

- **Operating Model Innovation**
  - Services after sales\(^{M}\): 10 - 40% reduction in maintenance costs
  - Supply and Demand\(^{M}\): 85% increase in forecasting accuracy
  - Inventories\(^{M}\): Costs of Inventory holding decreased by 20-50%

- **Operational Excellence**
  - Costs for Quality\(^{M}\): Reduced by 10-20%
  - Time to market\(^{M}\): 20-50% reduction
  - Customer Retention\(^{G}\): Consumer is 6 times more likely to recommend and repurchase products and renew services
  - Revenue growth\(^{G}\): Brand commitment to products and services of consumers to increase by 79%

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Source: \(^{G}\) Gartner, \(^{M}\) McKinsey
BUSINESS ENABLERS AND INFLUENCERS

The business objectives of the Industry 4.0 revolution is to leverage manufacturing and digital technologies to facilitate the emergence of intelligent, and connected manufacturing, also known as Smart Factory enabled by Smart Manufacturing.

Smart Manufacturing converges the power of machines with business enablers and influencers to holistically drive automation, process optimizations, productivity improvements, product and service innovations, improved consumer engagement and retention, etc., thereby providing opportunities to create new value chains and revenue sources.

Manufacturing business enablers and influencers consist of four components as depicted below:

- **Manufacturing Innovation Accelerators (MIA)**: Driven by requirements related to integration of business value chains to deliver products and increase the production capacity.
- **Agile Manufacturing**: Driven by customer centricity, market competition, consumer landscape, and MIAs to increase revenues, reduce marketing costs, increase retention, attract new customers and meet demand more rapidly, efficiently and effectively.
- **Cyber Security**: Designed to protect networks, physical and data assets from attack, damage or unauthorized access. Driven by MIA.
- **Integrations (Horizontal, Vertical & End-to-End)**: Driven by advances in technology to impact the business model for growth and sustenance.

Let’s look at each component in the following sections.
There are 10 Manufacturing Innovation Accelerators or MIAs that are briefly described with benefits that they bring to enable Smart Manufacturing.

**Cyber Physical Production Systems (CPPS)**

They are industrial automation systems that enable Smart Manufacturing through many innovative functionalities with their networking capabilities and their access to the cyber world. CPPS in manufacturing helps mechanical systems to perceive the physical world, process these perceptions as data, make computations, and inform other IT and OT systems to take actions to change process outcomes. It is considered core to Industry 4.0 revolution for manufacturing and expected to exceed current state gains with respect to efficiency, functionality, reliability, safety, adaptability, autonomy and usability.

**Industrial Internet of Things (Industrial IoT) / Internet of things (IoT)**

Industrial IoT is focused on connecting critical systems/machines with sensors, actuators, data and others in manufacturing systems to increase revenues, improve efficiencies and reduce costs. These are machines in which failure often results in high priority situations to diagnose and fix them. IoT assists in addressing such failures with agility by smart and adaptive control of the machines with feedback from support personnel or other cognitive systems that make intelligent decisions. On the other hand, Internet of Thing’s based systems tend to provide connectivity focused on external partners, vendors, suppliers, and consumers to gather, analyze and communicate information.
Companies like ThyssenKrupp, Caterpillar, and Thames Water are already reaping benefits from being early IIoT adopters. Simply put, Industrial Internet of Things is the use of Internet of Things (IoT) technologies in manufacturing.

**Big Data Analytics**

Big data is an integration of multi-disciplinary technologies and facilitates manufacturing by bringing incredible opportunities to service organization and consumers. Big data analytics refers to the information and communication technologies that tend to process and analyze huge amounts of data. This is done to derive the appropriate data for rapid decision making, leading to increased industrial productivity, seamless semantic interoperability between already existing data formats and models of different nature. It also realizes predictive diagnosis based on big data and enables Smart Manufacturing through group learning by product line equipment and configurations.

**Cloud Computing**

Cloud computing in manufacturing enable physical systems to collect real-world information and communicate them to the internal computation modules which further analyze and notify the findings to the corresponding physical systems through a feedback loop. Cloud ensures the scalability of storage, computation, and cross domain communication capabilities. Cloud computing relies on sharing of resources to achieve coherence and economy of scale.

Further, the cloud can play a role in many different stages of product life cycle from design through manufacturing, distribution and/or support of the products. Significant economic benefits with cloud have been identified in industry when configured to run backend process such as ERP systems and introducing edge based cloud computing for collecting and analyzing information in real-time while avoiding excessive data transfer and data processing delays by leveraging computing capabilities on the shop floor at physical assets. Beside economics, there are also operational benefits of leveraging cloud in executing product manufacturing. Some of these benefits are remote access to data, data aggregation and analysis. This can provide capabilities such as predictive and preventive maintenance, process improvements, product design and performance optimization, machine to machine coordination, multi-vendor coordination, and many other operational and strategic benefits. These all could be derived from cloud computing to realize the vision of Smart Factory.

**Cognitive Computing / Machine Learning (ML)**

Cognitive computing replicates human thinking in the form of algorithms in operating manufacturing systems. This is accomplished by leveraging data mining, pattern recognition and natural language processing to mimic the way the human brain works. Cognitive computing increases productivity, improves process efficiencies, reduces production and operational costs, and fosters innovation.
across the organization. This is accomplished by processing, analyzing and learning to optimize large amounts of data by combining traditional knowledge around people, products, physical assets, processes and technology with machine learning algorithms. Machine learning algorithms are a cluster of brilliant approaches that can optimize manufacturing processes and control any complex systems to enable smart manufacturing.

**Digital Twins**

Digital Twin refers to a digital replica of shop floor physical assets, that can be used for various purposes. For example, it is a digital representation of a robot with all its components and activities it performs throughout its processing life cycle.

Digital Twins also incorporate cognitive computing to create living digital simulation models that update and change as their physical counterparts change. It is primarily leveraged to optimize the operation and maintenance of physical assets such as cyber-physical production systems. They also enable augmented reality of the systems for improved support and maintenance.

**Digital Threads**

Digital Thread is the process of creation and use of information as a test bed to represent the manufacturing value chains. It is a representation of seamless digital integration of design systems, manufacturing processes and procedures, machines/CPPS, delivery and support processes. This provides the opportunity for powerful big data analytics to enable service teams and field engineers to have better awareness, insights, and practical actions to improve the servicing and maintenance of shop floor assets or delivered products. Digital threads help drives efficiency, speed, and flexibility through digitization and automation of manufacturing processes and procedures.

**Additive Manufacturing**

Smart factories in future would compete on how quickly the production environment leverages ‘data’ to run machines, and manage all shop floor components to produce components or product. The process relevant in performing such a feat is called additive manufacturing wherein machines perform both run and manage components seamlessly to produce precision products faster by adapting to multiple configurations. Some other benefits include producing production parts faster to service shop floor physical assets, manufacture low volume complex products faster to meet consumer and professional needs, reduces wastage on factory floor by consuming less resources due to shorter footprint of these machines.
**AGILE MANUFACTURING**

Agile manufacturing is an approach focused on meeting the needs of customers while maintaining high standards of quality and control over the costs involved in the production of a specific product. It places a strong focus on rapid response to the customer – with speed and agility as the key enablers, while realizing several benefits: increased revenues, reduced sales and marketing costs, increased customer retention, attracting new customers and meeting demand rapidly, efficiently and effectively. These benefits are realized by focusing on the four key elements as depicted below.

**Customer Engagement**

Focuses on understanding consumer needs and expectations throughout the relationship with the company by optimizing communication touch points across all channels (e.g. customer service and support, operations, Twitter, Facebook, etc.).

**Customer Demand**

Focuses on organizational processes, tools, and training to respond quickly to customer needs and market changes while still controlling costs and quality. It works in conjunction with lean manufacturing principles and practices.

**Customer Value**

Focuses on generating long lasting business value by putting the customer at the center of its operations. This is enabled by defining and leveraging new operational processes, policies and procedures, transitioning from product profiles to customer profiles, and leveraging MIA to align products to customers for better engagement for long term value realization.

**Customer Experience Design**

Focuses on delivering products and services that engages customers in an impactful way to promote brand, increases customer retention and loyalty, promotes innovation of products and services within the company and finally contributes in optimizing ROI across all related investments (e.g. sales, prod planning, marketing).
INTEGRATIONS

The paradigm of Industry 4.0 is essentially outlined by three dimensions: **Horizontal Integration** across the entire value creation network, **End-to-End** engineering across the entire product life cycle, and **Vertical Integration** with any networked manufacturing systems that are geographically distributed.

The **Horizontal Integration** across the entire value creation network describes the cross-company and company-internal *intelligent cross-linking and digitalization* of manufacturing operations throughout the value chain of a product life cycle and between any value chains of adjoining product life cycles that assist in increasing efficiency and effectiveness of factory output. In a Smart Factory, the intelligent cross-linking product use, and the product end of life.

The **Vertical Integration** and networked manufacturing systems describes the intelligent cross-linking and digitalization within the different aggregation and hierarchical levels of manufacturing operations from manufacturing stations via manufacturing cells, lines and factories, also integrating the associated value chain activities such as human resources, marketing and sales, or technology development.

is realized by Cyber-Physical Production

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5The intelligent cross-linking and digitalization covers the application of an end-to-end solution using information and communication technologies which are embedded in a cloud.
Systems (CPPS) which are operating in a self-organized and decentralized manner. They consist of Cyber-Physical Production Equipment (CPPE) (aka...smart machines), smart production lines, smart storage systems and other production facilitators that execute production processes cooperatively.

Core building blocks of CPPS and the smallest type of CPPE are modular and autonomous Cyber-Physical Production Units (CPPU) like robots, CNC machines or 3D printers. CPPS’ are intelligently linked with each other and are continuously interchanging data via virtual networks such as a cloud in real-time. The cloud itself is implemented in the Internet of Things and services. Also being part of a socio-technical system, CPPS leverages human machine-interfaces for interacting with manufacturing personnel.
CYBER SECURITY

Leveraging of MIAs creates a significant increase of exposure to threat elements and subsequently, increased fallout.

Typically, legacy manufacturing equipment focused primarily on functionality, and relied on isolation for security. This is no longer true. In addition, there is a legacy tendency of manufacturing personnel to prioritize operational availability, of a CPPS, at the expense of integrity and confidentiality.

As a result, the CPPS can be subject to a number of threats from cyber attackers and cyber-physical attackers, including denial of IIoT-enabled services and legacy equipment, and attacks against the integrity of the data across all connected systems (CPPS, ERP, SCM...). The effects of these attacks extend beyond mere loss of productivity, data, or the inability to access information system services, they can cause physical damage on shop floors, threaten safety of employees, and loss of user trust.

IIoT-based services are pervasive, ubiquitous and touch all aspects of the manufacturing organization. This warrants a transition journey to address all challenges to secure and protect all IoT-enabled resources and services, among them could be end-to-end entities that are geographically dispersed. (e.g., vertical and horizontal integrations)

The objective of cyber security for manufacturing is to develop and implement a capability to intelligently characterize and identify vulnerabilities in all cyber components, personnel and applications to mitigate the impacts of cyber-attacks and stop their propagation.

Leveraging existing industry frameworks to mitigate cyber security risks could be one way to proceed during the transition journey. One such popular framework comes from National Institute of Standards and Technology (NIST).

NIST drafted ‘Cyber Security Framework that focuses on critical infrastructures and encompasses a comprehensive set of cyber security activities, standards, guidelines, and practices. The framework consists of five concurrent and continuous functions: Identify, Protect, Detect, Respond, and Recover.

Holistically, this provides an abstract and structured view of the needed management of cyber security risks, with each function having the following goals:

**Identify**

The goal of the Identify function is to have a clear understanding of the resources belonging to the IT network (data, hardware and software) together with the relationships...
among such resources and the organizational activities, identifying critical assets and the associated risks.

**Protect**

The goal of the Protect function is to implement the appropriate safeguards to reduce the attack surface and limit or contain the impact of a potential cyber security event.

In addition to protecting assets, an equally important aspect is compliance. Various regulatory compliance policies affect manufacturing including EU’s newly proposed GDPR that will go into effect soon. Non-compliance can result in significant fines for few manufacturing industries.

**Detect**

The goal of the Detect function is to implement the appropriate activities to identify as soon as possible the occurrence of a cyber security event.

**Respond**

The goal of the Respond function is to develop and trigger the appropriate mitigation actions to contrast a detected cyber security event;

**Recover**

The goal of the Recover function is to activate the appropriate activities to restore the services that were impaired due to a cyber security event.

Building a robust security strategy is an integral part of the transition to industry 4.0 and considering it as part of product design can help in readiness for all eventualities.
 Industry 4.0 is expected to bring breakthrough and pervasive changes within a manufacturing organization.

‘manufacturing investments in this regard is expected to reach 5% of annual revenues as per a recent survey by PwC within next three years’

Pervasive changes are characterized as:

- Segmental transformations, which are focused on subsections of an organization, or
- Organization-wide transformation, which happens through the whole organization.

Transitioning to Industry 4.0 can be caused by two types of business situations:

- Organizations being forced to transition to position themselves and
- Organizations transitioning to capture an opportunity.

However, both situations would require innovation of current Business Operating Model to realize growth, by finding new ways to create business value and position, by configuring existing resources around data, people, process, and physical assets, to provide unique value. To guide such change, six components of effective transition have been identified and depicted in figure ‘Components of Transition’ and described below.
developed within a company, is crucial to ensure business success. Thus, there should be a tight interconnection between the processes for transition and product innovation activities.

**Service Innovation**

Service innovation differs from product innovation in some key elements, such as the dependence on the service delivery personnel and the need of physical presence of the consumer/customer. Service innovation is the means for identifying consumer-oriented solutions and emergence of different types of service-oriented Business Operating Models. It also affects all other transition components as it would bring challenges to the previous product-oriented culture and to the existing operations model for service delivery.

**Organization Culture**

Is focused on internal communications and collaboration as well as company’s norms and values in supporting the transition. It is characterized by the degree to which employees embrace innovation, risk taking, attention to detail, outcome orientation, people orientation, team orientation, adaptability to change, and consistency in following processes, innovation of the Business Operating Model could be initiated by cultural changes internally driven within a company regarding any of these aspects.

Industry 4.0 challenges companies to the core of their organization and culture, and may face rigid resistance related to lack of willingness and/or lack of knowledge.

**Technology Management**

Technology management deals with the technologies and technological knowledge within the company and their readiness for enabling Smart Manufacturing.

A review of technology management concepts includes technical aspects such as information systems, operational systems, networks, factory automation, MIAs, relevant digital business influencers and enablers such as cyber security, product UX/CX design, agile delivery, etc.

Technology has been associated to the foundation of Industry 4.0 revolution (e.g., MIAs). Three types of technological transitions can be proposed in regard to MIAs: incremental, i.e. the refinement or improvement of existing technology; architectural, i.e. finding new ways of integrating technological components into a system; and radical, i.e. introduction of a complete new core technology. For any of these three types, there is a need for an appropriate Business Operating Model and transition activities to successfully support the commercialization of the manufacturing innovation accelerators.

Manufacturing Innovation Accelerators (MIAs) are an emerging strategic means to achieve competitiveness and overcome the challenges of new markets for manufacturing industries.
Operations Execution

Considers the review of capabilities and resources needed for the production and delivery of products and services in an efficient and effective manner on the path towards Smart Factory environment. Innovations in this area can come up from a broad set of business functions that operate directly in relation to the planning, processing and managing activities that put the products and services into the market. A review of operations management concepts includes business functions such as operation systems planning and control, operational capabilities, process management and work design, outsourcing, quality management, inventory management, logistics, etc. Transitioning to Industry 4.0 will mandate small to large-scale changes in production methods or routine operations that contribute to the improvement of overall manufacturing operations, which can include technology management component merger with operations to leverage IT/OT convergence.

Performance Evaluation

Performance management systems comprise a set of measures used to assess a company's performance as well as its incentive scheme. These measures have a strong influence on the behavior and objectives of company personnel as they would concentrate on whatever is measured to reflect contributions. Therefore, this also has a strong connection with the organizational culture. The connection between organizational culture and company performance has been vastly analyzed in past literature and results commonly highlight the importance of culture for reaching better performances.

Over past two decades of digitalization impacting industries, organizational performance has also been evolving from the consideration of shareholder theory to stakeholder theory, and from the measurement of economic aspects alone to sustainability (i.e. economic, social and environmental aspects). This evolvement requires new perspectives into the way a company’s performance is measured and how it enables Smart Manufacturing or transitioning to Industry 4.0.
The Industry 4.0 Transformation Execution Model seeks to explain how an organization can better execute its strategy and facilitate continuous improvement by managing transition components in the form of tasks and activities to enable Smart Manufacturing. Each company has its Business Operating Model that sets some limits to the future strategies of the organization. When that strategy takes the form of strategic initiatives, they set priorities for the organization. To be able to execute those strategic initiatives, certain business capabilities are required from the organization, such as strategy to set up vision, mission, transition components to be improved and/or optimized, etc., leading to innovation of Business Operating Model.

As Transition Components are derived from the Business Operating Model of the organization, it defines these core capabilities and provides a basis for understanding them and their dependencies as well as offering a basis for implementing the changes that are in practice unavoidable when executing strategic initiatives. To build an adequate foundation for execution, companies and their consultants must master three key disciplines: Business Operating Model, Transition Components, and engagement readiness components in the context of execution model.

**Strategy Design**

This concerns the current state of the company on how it does business and the reasoning for transition (e.g. growth,
competitive advantage). This is a core activity that enables the execution model to kick start the transition activities. It would clearly articulate information required for transition execution such as business vision, mission, roadmap for realization of desired outcomes, guiding principles, success factors, recommended actions to be performed on transition components, etc.

**Business Operating Model Review**

Business Operating Model articulates the necessary level of business process integration and standardization for delivery of goods and services to customers also known as Business Operating Model. Different companies have different levels of process integration across their business units (i.e. the extent to which business units share data). Integration enables end-to-end processes and a single interface to the customer, but it forces a shared understanding of data across diverse business units. Thus, companies need to make clear decisions about the importance of process integration. Leadership also must decide on the appropriate level of business process standardization (i.e. the extent to which business units will perform the same processes the same way). Process standardization creates efficiencies across business units but could limit opportunities to customize services. The Business Operating Model involves a commitment to how the company will operate across its value chain.

**Transition Components**

It defines the organizing logic for execution model, reflecting the integration and standardization requirements of the company’s Business Operating Model. Transition components provides a long-term view of a company’s processes, systems, and technologies so that individual projects can build business capabilities - not just fulfill immediate needs.

**Transformation Readiness Model**

It corresponds to the system of governance, sourcing and procurement mechanisms that ensure transition activities achieve company and/or organization-wide objectives. The transition readiness model influences transition initiation decisions that include sourcing and procurement of resources (e.g. infrastructure, software, hardware, consultants, system integrators etc.), so that the transition components guide business outcomes.

The transition readiness model provides an alignment between all business unit’s objectives for transition, and coordinates the decisions made at multiple organizational levels. To do so, the model establishes linkages between leadership decisions, such as initiative prioritization based on benefits/outcomes realization, Business Operating Model impact, and transition implementation decisions.
STRATEGY DESIGN: OUR CORE INDUSTRY 4.0 OFFERING

All transformation events are change events. In Digital Transformation, as in Industry 4.0, the following areas need to be addressed for potential incremental change and optimization activities: technology, process and data. Yet the most impact and radical change will manifest itself in the organizational space. We believe that successful transformation is driven by culture and leadership. Employees and leadership will have to go through transformation to sustain change in the long run and for corporate innovation to succeed.

We call this “culture-led” transformation.

THE CHALLENGE WITH TRADITIONAL CONSULTING COMPANIES

- **Non-Relevant Management Frameworks.** Most consulting companies are using old and tired frameworks based on static management theory and practices. However, Digital Transformation and the transition to Industry 4.0 is a revolutionary event. The traits that have made incumbent companies successful today are not the same traits that will take them to a digital Future State.

- **A Single Dimensional View of the Business.** Traditional consulting companies also have a single dimensional perspective on change. Specifically, they look at a business as a purely logical ecosystem.

- **Technology Viewed As the Transformation Driver.** Current technology and consulting companies tend to view technology as the key driver for Industry 4.0. Technology consulting companies can’t help it - they have a specific agenda. Any strategy they deliver will merely position their specific products and services for adoption. Is this good for them? Yes, But is this necessarily good for the client’s business? You decide.

- **Lack of A Minimum Viable Technology Recommendation.** A management consultant has a business consulting as his/her strong core. However, he/she may not necessarily possess the tactical experience in designing and leading technology initiatives. Hence, their strategy recommendations may not be rooted on a comprehensive, viable and actionable technology implementation. A technology consultant, on the other hand, has a strong implementation background. Unfortunately, he/she will probably not have the management or business background in the following areas: operations, strategy, organizational design, governance, compliance, etc. Industry 4.0 is not a siloed event limited to the manufacturing floor; its impact is and must be felt throughout the whole enterprise and connected ecosystems.

- **Lack of Business Strategy.** Many technology providers and consulting companies pay lip service to business strategy. They are always keen on jumping on the implementation
wagon, without conducting proper due diligence. This is especially true with technology vendors since they have their own “solution”. This is part of the reason many digital transformations fail and fail miserably. The failure rate is easily at 75%.

WHY LOGICAL HEURISTICS?

At Logical Heuristics, our strategy design services is uniquely positioned to drive a successful transformation from traditional manufacturing to Industry 4.0. Why?

Allow us to elaborate:

**Strategy Is King**

As a strategy design firm, we hold strategy as a key driver for successful transformation. Whereas others see Industry 4.0 as a technology project and driven by IT, we view it as a business initiative that has a significant impact on the enterprise. Unlike any other technology advancement, disruptive technologies, managed well, has the ability to create new value chains for the enterprise. As a result, it is critical that business leaders have a firm grasp of an overarching digital strategy that clearly outlines projected benefits and value proposition.

**Technology as Business Enabler**

While we hold strategy as critical, we view technology as a means to an end. The end in itself is an ideal business outcome or state, having achieved pre-set goals and objectives. There’s nothing wrong with technology. But when technology is utilized as an end in itself, then we have a problem. Technology must be seen for its true value - it is a business enabler.
Pioneering IP

We have a patented, a leading practice framework based on formalized and structured heuristic models. LH Balance™ 6 enables us to view your business ecosystem, considering both logical and heuristic components and thus, in a more holistic way, resulting in the delivery a more balanced and complete transformation roadmap.

Logical Heuristics brings together unified frameworks and methodologies specifically designed for enabling Smart Manufacturing capabilities. Our deep domain and industry expertise means that we understand the challenges and requirements of the manufacturing industry and are uniquely qualified to help your company position itself for growth and success.

Value Realization. By partnering with us, not only we are working on co-creating and facilitating your digital innovation journey, we also make sure that we articulate the anticipated business value add at pivotal milestones. We are passionate not only with socializing the overall strategy but also articulating and celebrating the quick wins along the way.

People-Centric Transformation

As we mentioned earlier, people are the critical success factors when it comes to driving a successful Industry 4.0 initiative. And yet, how many consulting companies truly give serious consideration to culture and leadership? We understand culture. And as traditional businesses embark on a radical change initiative, the whole organization will also have to undergo a major transformation that impacts their behavior, motivation, values, aspirations, etc.

Strategic Tacticians / Tactical Strategists

We believe in the power of conversations. A melding of the minds, dialogue, and potential alignment in ideas generate sparks in the form of ideas and concepts. But in order to do this, you need a conversation partner who’s able to discuss high concept business ideas like exploiting adjacent market shares to divining the intrinsic benefits of DevOps. No worries. We can handle that kind of talk.

Multi-Disciplinary Skill Set

Our Strategy Practitioners possess inter-disciplinary expertise in the following areas: business, strategy and technology. Since Digital Transformation involves an all encompassing and ecosystem change at the enterprise level,

Deep Domain Expertise

Our practitioners have completed their boot camps and graduation in advisory and consulting services from well-respected brands in the world (e.g., Accenture, Gartner, IBM, Cognizant, etc.). In the process, we have acquired substantive expertise in the area of

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6 A series of custom algorithms applied based on Explicit and Implicit infusion of information, to determine right approaches & method/s for evaluation of current state, determine future state and building a value optimized priority roadmap as part of strategy design.
manufacturing operations. We stay humble and are grateful for the opportunity to assist global brands with strategy and innovation. But as we mature, we also saw an opportunity to help clients by amplifying our own voice as well as our unique perspectives. We decided to evolve. And this is good for you.
CONCLUSION

This paper introduced relevant aspects of ‘Transitioning to Industry 4.0’ for manufacturing organizations also referred to as ‘Enabling Smart Manufacturing’. It introduces business enablers and influencers in the form of innovation accelerators, cyber security, agile manufacturing, and integrations that realize the vision of becoming a smart factory.

Strategy design also establishes a foundation for executing the transition with descriptions on transition readiness model, business operating model and integration imperatives, while identifying and introducing the components that constitute formulation of them. Finally, the paper also introduces Logical Heuristics as a differentiator and enabler in strategy design.

Please note that this paper is neither an extensive nor a systematic review of Industry 4.0, as currently there are no standards or industry-accepted taxonomy to describe it. Our descriptions are based on our experience, expertise on the subject, and analysis on a particular set of recent publications and survey articles. It is an attempt to educate and add clarity for manufacturing companies who are thinking about 4.0 or looking to enable Smart Manufacturing.

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ABOUT US

Logical Heuristics is a strategy design consulting firm that employs a unique mix of logical and heuristic-based evaluations relevant to every one of its manufacturing clients to deliver pragmatic and adaptive solutions based on business value realization.

When establishing a strategy, we analyze and solve transformational challenges across people, product, process, data, service and technology to provide solutions and strategize improvements based on current state.

Our unique and pioneering framework and methodologies drive to:

• Enable a pragmatic approach that evaluates each area of interest with optimal criteria derived from logical approaches and heuristic methods

• Facilitate a mitigation strategy to issues and risks with agility when conventional methods prove to be insufficient through all the available cues (e.g. influence of social, cultural and market conditions)

• Support an approach that is unique to addressing an organization’s particular problems or situation

• Leverage comprehensive analysis in strategy design and roadmap development

It is our hope that the information contained in the white paper will provide an opportunity to engage in a deeper dialog on strategy design and establishing a roadmap to enable Smart Manufacturing
About the Author

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Madhu is a Chief Digital Strategist with Logical Heuristics. He focuses on digital transformation and Industry 4.0. He has worked in manufacturing industry and management consulting for more than 23 years primarily focussed on Factory Automation, ERP modernization, Business Capability Modeling and Organizational design.

NEXT STEPS

If you have any questions regarding this White Paper, or would like to chat about Industry 4.0, please feel free to reach out to me (madhu.gaganam@logicalheuristics.com).

You can also chat with any of our Strategy Practitioners by sending an email to: engage@logicalheuristics.com.

We look forward to a meeting of the minds. Thank you.

NOTE: Certain topics contained herein may result in increased descriptions and analogies for better understanding of Industry 4.0, strategy design and how it applies to individual companies, products and services.

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