A Solid Implementation Protocol towards the “Forth Industrial Revolution - Industry 4.0” for Hong Kong Entrepreneurs – A “Smart” approach of HK Industry to become “Innovation Enterprises”

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ABSTRACT
In sight of the new industrial strategic initiatives — Industry 4.0 (I4.0) initiated and coined by the German, many local Hong Kong enterprises are keen on I4.0 transformation to combat with tough market challenges and catching up with latest market and technology trends. In this study, a holistic I4.0 implementation protocol will be introduced with the evaluation of related tools and models. The model was initially applied in a local toy manufacturing enterprise, and is expected to act as a pioneer role model for the Industry to take as reference.

Keywords: I4.0, IoT, IoS, CPS, Smart Factory, ERP, MES, IPS, 3D Printing, FMT, V/AR, CPPS, OBM, Smart Production, Smart Logistics, Smart Products, Smart Services, KBM, ROI

1. Introduction

“Industry 4.0 – The Forth Industrial Revolution”, which refers to a state-of-the-art management and manufacturing operation concept and standard, has been initiated by Germany in 2013 with the core aims of achieving both sustainable business growth & revenue and operational excellence in terms of productivity & efficiency. Hence, Industry 4.0 focuses on boosting business benefit by putting forward the development of entirely new business models with smart services and smart products, as well as smart innovation; Achieving operational excellence by developing smart manufacturing operation and supply chain management practices. The vision of I4.0 has incorporated a critical component which called Cyber Physical System (CPS), fusing the physical and virtual world including complex machinery and devices with networked sensors and various business and execution software, decentralizing self-control actions from manual operation to artificial intelligence, achieving the goal of smart manufacturing. In sight of the ever-changing business environment, how can local HKSMES or entrepreneurs around PRD areas can incorporate the concept from the German and lead a successful transformation of business towards Industry 4.0 in global market?

2. Literature Review of Industry 4.0

2.1 I4.0 Key Concept and Principles

Industry 4.0 encompass Four key components – Internet of Thing (IoT), Internet of Service (IoS), Cyber Physical System (CPS) and Smart Factory, and the components are embedded with Six major design principles – Interoperability, Virtualization, Decentralization, Real-Time capability, Service Orientation and Modularity, While the concepts are realized by a number of advanced enabling technologies such as Internet Connected Machines, Integration of Various Enterprise & Manufacturing Systems (ERP, PLM, MES), Warehouse Management by RFID, Robot & Sensor Application...etc., the blend of hardware infrastructure and software support makes up the core of I4.0 — CPS. The depth of I4.0 implementation defines into Four integration levels – Horizontal integration, Vertical integration, Digitalized Engineering Life Cycle Management and CPS, and is further classified as Five I4.0 Maturity levels – i) Standardized Manufacturing Landscape, ii) Transparent Factory, iii) Digitalized Factory, iv) Smart Factory and v) Industrialized Ecological System. In general, Industry 4.0 is a collective term for technologies and
concepts of value chain organization and integration and advocates the idea of CPS which monitors physical processes with real-time virtualization of down floor production, making decentralized decisions. The above-mentioned concepts and principles are incorporated and collaborated seamlessly in actual deployment, aiming to realize a flexible, smart and self-optimizing factory.

2.2 Overview of Local enterprises – Are we ready for Industry 4.0?

Focus on Hong Kong SMEs, the production modes are still mainly labour intensive or semi-automated production (classified as Industry 2.0-3.0). These production approaches are not capable and flexible enough for the companies to meet the frequently changing customers’ demands around the globe. In fact, global industrial buyers have also been starting to dissolve the Industry 4.0 elements in their procurement guidelines or as contractual binding requirements for enterprises to follow. Failure in complying with these requirements may jeopardize the business relationship between those enterprises and their upper-tier customers, eventually lost touch from the global market.

It is significant for the local enterprises to step forward to Industry 4.0 now, by formulating a solid and practical solution — “Short-Mid-Term Strategic Upgrade Roadmap” which composes of pilot projects in compliance with Industry 4.0 design principles and related enabling technologies.

To address the trend and aid the industry to step forward, a solid and practical benchmarking model and implementation guidance is developed for HKSMEs to follow particularly and will be introduced in this paper, with consideration of their present status and industry 4.0 pilot project preferences involving minimum hardware and software investment in order to enhance their competitiveness for business sustainability after effective planning and deployment of Industry 4.0.

3. Stepwise Implementation Protocol and Deployment Methodology
The forth industrial era evokes disruptive changes in today’s manufacturing business, which blends a list of technologies and series of I4.0 value drivers, companies are encouraged to conduct I4.0 transformation in stepwise manner. Since the deployment of Industry 4.0 may vary among different enterprises, a deployment methodology has been identified to assist companies developing blueprint and grasp a better understanding about company’s full landscape at present and in future.

3.1 Enterprises shall commence the I4.0 deployment with the formation of i4.0 implementation team, involving managerial level, project manager and deployment officers…etc. The implementation team will then go through training with 9 modules involving I4.0 concepts and principle consolidation to give the team a holistic insight facilitating the implementation onwards.

3.2 The next step is to conduct Enterprise Maturity Benchmarking Analysis in six dimensions, namely i) Innovation, ii) Cooperation & Network, iii) Machinery & Technology, iv) Product & Service, v) Expert & Knowledge Management and vi) Data & Information Management, aiming to classify the enterprise positioning in the above dimensions.

3.3 SWOT Analysis will be conducted as well for the team to revisit the internal and external factors, in order to better understand the company’s current positioning and defining directions for future development. In sight of the unique needs and company development blueprint, enterprises’ decision makers will also conduct trend analysis to propose some potential I4.0 pilot projects to be implemented, identified as the preliminary wish list of tasks.

3.4 To further evaluate the preliminary wish list of tasks, I4.0 benchmarking tool and a matrix of interrelation of Four Components and Six Design Principles would be used to support enterprises in identifying possible Industry 4.0 pilot projects, and aligned with various I4.0 core concepts and principles, as well as the ROI estimation. Pilot projects will be evaluated and examined to match into one of the five maturity levels depending on the degree of integration in the maturity landscape of the I4.0 upgrade. The matching of desired pilot projects and the benchmarking criterion can give a glimpse to the managerial level where the I4.0 transformation will brought the enterprise to.

3.5 Project Priority Identification Tool is simultaneously used to aid the decision makers to decide the implementation priorities of different pilot projects. The tool requires user input multiple variables to generate a priority score for users’ reference in justifying the worthiness and priority of the I4.0 tasks in the preliminary wish list. Eventually the results will be shown in a “Planning of Strategic Implementation Roadmap” which shows a macro view of the pilot projects to be deployed in the company blueprint of coming years’ development. The initial planning process is substantially completed and various functional departments of the enterprise will be contributing towards the goals stated in the Planning of Strategic Implementation Roadmap.

3.6 To maintain the momentum of I4.0 deployment and implementation of each pilot project, Smart Manufacturing Performance Management is identified as another key deployment step. It was targeted to sustain the transformation process towards I4.0 with corporate governance and change management.

3.7 To recognize the milestones of I4.0 development toward Smart Factory, 5 levels of certification were established with certified institute to ensure the enterprise fulfilled the standard. It can encourage the enterprise to make continuous improvement and recognize their effort using a standardized model.

4. Discussion

4.1 Overview of local enterprises and overall PRD manufacturing environment

Looking into local HKSMEs’ status, most of them are OEM which manufacture products for foreign renowned brands, with labor-intensive production lines (identified as Industry 2.0 level), the business model of these enterprises mainly focus on parts related to pure production, while innovation and R&D part is comparatively disregarded. Due to the nature of OEM manufacturing, enterprises are facing tough
challenges including internal factors such as low profit margin, high staff turnover rate and soaring land cost…etc., and external factors like fast-changing end-user trends and customer requirements…etc. For instance, overseas buyers have been gradually including the requirements of Industry 4.0 as the contractual requirements that give direct and immediate compliance pressure to the majority of HKSMEs. Failure to comply with their new stipulated requirements will be disqualified gradually. All of the above mentioned factors exert pressure in those enterprises. The rising running cost and need for business flexibility has urged the enterprise to revolute and increase their competitiveness in order to stay in the market. Industry 4.0 encourages enterprises to conduct business review and trend analysis, understanding company’s current strength and weaknesses with prediction of market and industry trends to understand external environment’s opportunities and threats, and correspondingly applying the I4.0 concepts to transform the company into a self-organizing, labour-independent and highly effective, flexible enterprise to overcome the challenges ahead.

4.2 Difficulties encountered when using Germany’s concept to deploy i4.0

Industry 4.0 was initially put forward by a group of German professionals, which aims at achieving production excellence by incorporating “smart” features into the manufacturing system and building a holistic industry network, connecting units in the entire value chain. However, there are quite a number of foundational differences between German and PRD area’s manufacturing industry environment. Knowing that Germany is one of the most advanced country in manufacturing sector, most of the German factories have already equipped with automatic production lines, and managed by digitalized information systems, (i.e. running business in Industry 3.0+ level), German enterprises are more readily to step forward to I4.0. That HKSMEs are mostly OEM and ODM and are mainly Industry 2.0 in nature, the input of effort and investment concerning I4.0 transformation is expected to be in long-run and higher for local HKSMEs. Therefore, with the lack of clear business case to justify potential investment, most owners perceived there is heavy investment in hardware but losing the focus on stepwise deployment, human resource development, integration of system, etc.

4.3 Evaluation of Deployment Tool

4.3.1 Trial Application on a Local Toy Manufacturer
The above-mentioned implementation protocol is initially applied on a local toy manufacturing enterprise. According to the designated tools and models, HKPC has delivered on-site evaluation, staff training sessions and deployment consultancy effort on the mentioned local enterprise. Thanks to the contribution of both parties, the project was turned out a success with encouraging outcomes. The deployment tool will be discussed and evaluated in following paragraphs.

4.3.2 9 modules professional training series on i4.0
Referring to deployment methodology in 3.0, nine training modules are formulated to provide comprehensive I4.0 knowledge transfer to different personnel in enterprises including top management, middle management, technical teams and I4.0 implementation team. Modules are designed to fit different personnel’s’ needs and concerns. For instance, in the case of HK toy manufacturer, I4.0 implementation team consisted of top management (i.e. Directors) and middle management (i.e. Departmental managers). Before the case study, they did not process any I4.0 concept and the core value of I4.0 while after the participation of the nine training modules, they have equipped with solid ground for later stage of deployment methodology especially for conducting Enterprise Maturity Benchmarking Analysis and generating preliminary wish list of Industry 4.0.

4.3.3 Enterprise Maturity Benchmarking Analysis
After the completion of enterprise knowledge transfer on i4.0, structured enterprise maturity Benchmarking Analysis was conducted through on-site evaluation. Six dimensions of Enterprise Positioning are defined to cover all facets of enterprise operation and business. (Refer to figure 2.) Based on the integration level of different facets, level of maturity can be classified as five levels including the lowest ranking level to highest: “Standardized Manufacturing Landscape”, “Transparent Factory”, “Digitalized Factory”, “Smart Factory” and “Industrialized Ecological System”. In the case study, I4.0 implementation team of the toy manufacturer should clearly understand each integration level in order to understand their current status in different dimensions. It has assisted the generation of project ideas and targeted business benefits to compile a comprehensive preliminary wish list of I4.0. In sync with majority of HK enterprises’ status, toy manufacturer positioned at Standardized Manufacturing Landscape of
traditional production practices in different dimensions, for example, Injection automation has been implemented for “Machinery & Technology”, ISO140006: Eco-design and Environmental Management Systems has been implemented for “Product & Service”, etc. It should be noted that Enterprise Resource Planning (ERP) has been implemented to manage production, quality and logistic data partially but not fully which was identified as the first step to “Transparent Factory”.

<table>
<thead>
<tr>
<th>Four Integration Level</th>
<th>Industrialized Ecological System</th>
<th>Smart Factory</th>
<th>Digitalized Factory</th>
<th>Transparent Factory</th>
<th>Standardized Manufacturing Landscape</th>
</tr>
</thead>
<tbody>
<tr>
<td>Enterprise Positioning: Six Dimensions</td>
<td>Innovation</td>
<td>Cooperation &amp; Network</td>
<td>Machinery &amp; Technology</td>
<td>Product &amp; Service</td>
<td>Expert &amp; Knowledge Management</td>
</tr>
<tr>
<td>Open Innovation with agile organization</td>
<td>Self-optimized supply chain from supplier to customer</td>
<td>Fully automated production and logistic system</td>
<td>Production part including master, historical and steering data (Total system)</td>
<td>Highly qualified operator with decision making competence</td>
<td>Self-managing alliance of client and vendor groups</td>
</tr>
</tbody>
</table>

![Figure 2](image2.png)

<table>
<thead>
<tr>
<th>Project Description</th>
<th>Industry 4.0 Compliance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project No.</td>
<td>Project idea</td>
</tr>
<tr>
<td>1</td>
<td>Raw Material handling and sensor application</td>
</tr>
<tr>
<td>2</td>
<td>Smart Logistic Management</td>
</tr>
</tbody>
</table>

![Figure 3](image3.png)
4.3.4 Preliminary wish list with I4.0 Benchmark

With evaluated current maturity status, I4.0 implementation team can target on six dimensions to generate innovative project ideas which would potentially upgrade enterprise positioning. The idea generation process should not be limited by cost and technology consideration at this stage to enable unbounded enterprise innovation. The generated project ideas were then filled into the preliminary wish list and essential information including project description, involved department, current condition and benefits of the upgrade/improvement...etc. are required to complete by the team. The list was then discussed by I4.0 expert to define the degree of I4.0 compliance with related I4.0 core components, design principles and strategic integration focus.

4.3.5 I4.0 Pilot Project Priority Identification Tool

An I4.0 Pilot Project Priority Identification Tool is simultaneously developed to aid the planning of strategic implementation roadmap which shows a macro view of the pilot projects to be deployed in the company blueprint of coming years’ development. The tool requires user input of investment value and project duration for the pilot projects, as well as consideration of the project complexity, intangible benefit, estimated return, i4.0 Compliance and readiness of prerequisite resource to generate a priority score for i4.0 implementation team’s and management’s reference in justifying the worthiness and priority of the I4.0 tasks in the preliminary wish list. For instance, a priority score and a radar diagram for each pilot project were generated based on parameters input as below. With consideration of all parameters, project No. 1 has higher priority score then project No. 2 with higher investment and project duration.

**Figure 4**

The radar diagram can aid the comparison between different pilot projects to determine their priorities, generally, the bigger the area of the pilot project shows in the radar diagram, the higher the priority score it has. After the evaluation and selection of the pilot projects to be implemented, a strategic roadmap of I4.0 Project Implementation will be generated.
4.4 Classified I4.0 Key Pilot Projects

With the assist of above evaluated tools, numerous of pilot projects are assessed and prioritized into i4.0 strategic roadmap. According to the case study, these pilot projects can be classified into below i4.0 key pilot projects that other HKSMEs would refer and consider their i4.0 landscape.

4.4.1 Smart Product & Smart Service

Before development of I4.0 pilot project, the toy manufacturer did not provide any value-added service and smart product to clients. These create less customer value and hence lower margin on the business portfolio currently. According to Capgemini (2015), Smart product incorporate self-management as well as communication capabilities, it can be equipped with sensors providing information about their environment or customer usage to possibly trigger autonomous reactions to change and feedback. Connectivity provides Smart Products with the ability for machine-to-machine communication, and embedded or application interfaces enable interaction with human users. And hence, it enabled the Smart Service delivery.

In toy industry, they focused on R&D of RFID tag and reader or Bluetooth device which can be embedded into the smart toy as connectivity agent. Feedback and reaction can be delivered through smart toy itself or associated mobile application. It aided on collecting customer usage pattern and feedback through user interaction with mobile application associate with smart toy, in order to assist business decision making related to smart product lifecycle, innovation management, new business opportunities, production efficiency improvement...etc.

I4.0 implementation team realized the huge potential revenue growth by enhancing user experience and improving the total cost of ownership which significantly intensifies the customer relationship and brand loyalty. They foresee that this will enable completely new value propositions and business models in coming three years after smart product and smart service deployment.

4.4.2 Smart Production

To fully support and enable the manufacturing of smart product and delivery of smart service, I4.0 implementation team anticipated the urgent needs to upgrade their production process step by step to reach “Smart Production” in 2020. Multiple sub-pilot projects were identified to improve different production processes including “Smart raw material handling”, “Plastic injection automation and IOT development” and “Manufacturing Execution System implementation”.

For “Smart raw material handling”, it is targeted to eliminate human handling of raw material and correlated potential problem of product quality, material usage, data record, job safety, etc. As plastic toys are the main product portfolio, “Plastic injection automation and IOT development” become the key component in smart production. Embedded computers will be installed in current plastic injection machines to control the production process. Connectivity can be achieved through wireless connection of embedded computers which collect machine status in real time. “Manufacturing Execution System” will be centralized processing agent for IOT enabled machines at which data are analyzed and presented to field and middle management for business decision making of production status and efficiency. All mentioned sub pilot projects enabled toy manufacturer to establish smart factory in coming years. From this experience, it is found retrofit of current machines was the cost efficient solution which is widely acceptable for HKMSes other than new machine purchase. Sensors to be embedded into current machines are one of the common solutions of retrofit to collect production data including volume, temperature, humidity...etc.

4.4.3 Smart Logistics

I4.0 implementation team has identified the gap between production and logistic in terms of part traceability. Both inbound and outbound logistics were targeted as improvement areas toward Smart Logistics. To minimize the effect on ongoing smart production pilot projects and user acceptance, outbound logistics was focused in the first year. To achieve this, warehouse management system will be implemented and integrated to ERP to monitor the finished goods movement in warehouse. Wireless infrastructure will be established to support part traceability through RFID technology. For instance, RFID tag will be embedded into pallets, RFID readers will be installed for each key logistics terminal, counter sensors will be installed to maintain check-in/out record. Once finished good tracing is enabled and smart product development completed, the technology can be applied to inbound logistics and down to each parts involved in production process to enable fully de-centralized production.
4.4.4 Smart Manufacturing Performance Management

According to joint research program of MIT Center for Digital Business and Capgemini Consulting (2012), the success of Digital Transformation is highly dependent on clear top-down governance. An uncoordinated array of bottom-up initiatives will block the path towards Industry 4.0. Organizational silos must be aligned to a common target setting with concrete objectives. To master transformative changes, adequate resources should be allocated to accompany the organization. For instance, Smart Manufacturing Performance management was identified as effective tool to implement and sustain i4.0 deployment. Detail illustration of “i4.0 Strategic Map” which is the device used for top-down communication was made with the support of “Balanced Score Card” as the strategic linkage describing shorter term management priorities and objectives. Hence, detail and tangible Key Performance Indicator (KPI) was clearly defined in each department based on the action plan and project charter. Last but not least, monthly review will be conducted to confirm the achievement and review action plan or KPI if needed.

5. Conclusion

Vision of HKSMEs —Mastering Industry 4.0 The vision of Hong Kong local enterprises for the coming decades is mainly internal process optimization and new paradigm of self-organization of operation, where enterprises are granted the opportunity of transforming into i4.0 innovative enterprises. In practice, this paper provided a stepwise protocol to upgrade an enterprise to achieve the i4.0 vision with the philosophy of “Think Global, Act Local!” Thanks to the cut-edge I4.0 transformation, local HKSMEs can stay competitive among global market, progressively transforming to an innovative OBM from traditional ODM/OEM. Local HKSMEs should seize the opportunity and take further steps to master Industry 4.0, answering for the trend of reindustrialization advocated by HK Government.

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Authors’ Backgrounds

Mr. LEE Kwok Keung, is the General Manager of the Smart Manufacturing & Materials Division at Hong Kong Productivity Council, a Fellow Member of the Institute of Mechanical Engineers, UK and also a Fellow Member of the Hong Kong Institution of Engineers. Mr. Lee received a Bachelor degree in Mechanical Engineering and a Master degree in Industrial Engineering at The University of Hong Kong. With almost 28 years of experience in various industries, Mr. Lee specializes in technology research and development, and quality and production management. He is responsible for consultancy service in quality & production management, advanced manufacturing technology, machinery safety standards and testing, automotive components development, and feasibility studies.
Mr. SHAN Ming Yin, Raymond, is the Principal Consultant of Smart Manufacturing & Materials Division of Hong Kong Productivity Council (HKPC) responsible for the state-of-the-art technology transfer of metal & metallurgy and sector-specific manufacturing management system deployment. He leads a team of professional consultants in HKPC to provide various types of industry-wide upgrade programme, consultancy services and training for different manufacturing sectors. In particular recently, he is qualified as “Certified Industry 4.0 Trainer & Expert”, leading the Industry 4.0 Implementation Team in HKPC to build up various types of Sector-specific I4.0 Model and is establishing an “I4.0 Smart Demo Factory” for industry benchmarking. Mr. Shan received the Master Degree (MSc) in Manufacturing Engineering from Warwick University and other Professional Credentials as Trainer & Auditor.

Mr. Calvin Wu, is the executive directors of Shing Hing Plastics Manufacturing Ltd. leading OBM plastic toy manufacturer with global sales network and manufacturing plants in Guangdong Province. After graduation, Calvin joined the company in 1998 when he succeeded his family business of OEM plastic toy manufacturing business. He is currently responsible for formulating overall business development strategies, management team development and daily operations of the company. Under Calvin’s leadership, the company successfully shifts from OEM to ODM and OBM to raise profitability and gain market share. He is also instrumental in enhancing competitiveness of the company, in particular promoting i4.0, and is active in exchanging ideas of technology, research and innovation for production by participating in various exchange tours to Germany, Japan and etc.

Mr. Kwan Chung Yin, Jacky is the Associate Consultant of Smart Manufacturing & Materials Division of Hong Kong Productivity Council (HKPC) responsible for the project implementation of manufacturing system and various manufacturing technologies. He is also one of the core project members of Industry 4.0 team in HKPC which provide industry 4.0 consultancy services to Hong Kong enterprises. Mr. Kwan received Bachelor degree of Science in Computing and Bachelor degree of Business Administration in Management at The Hong Kong Polytechnic University.

Miss Lam Cheuk Lok, Chairon is the Assistant Project Officer of Smart Manufacturing & Materials Division of Hong Kong Productivity Council (HKPC), is responsible for project management of various metal manufacturing consultancy projects and support of technology development. She is one of the core project members of the Industry 4.0 Implementation Team in HKPC, providing project management support to the team and preparing the I4.0 Deployment Methodology for the consulting team to use. Miss Lam was graduated from Hong Kong Polytechnic University with a Bachelor degree in Product Engineering with Marketing.
## Appendix 1: 9 Modules Professional Training series on i4.0

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<th>Module No</th>
<th>Module Name</th>
<th>Content</th>
<th>Target Audience</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Overview of i4.0</td>
<td>Background, Goal &amp; Concept, General Definition, Technical definition, Benefits, i4.0 Demo Factory</td>
<td>Top Management, Middle Management &amp; i4.0 Implementation Team</td>
</tr>
<tr>
<td>2</td>
<td>Application Area of i4.0</td>
<td>Smart Production, Smart Logistic, Smart Product, Smart Service</td>
<td>Middle Management &amp; i4.0 Implementation Team</td>
</tr>
<tr>
<td>3</td>
<td>Technical Perspective of i4.0</td>
<td>Key Enabler – Smart Sensor, Smart Data &amp; Smart Network, Key Component - IoT, IoS, CPS, Smart Factory, Design Principle, Case Study of I-rig Technology Centre of HKPC</td>
<td>Middle Management &amp; i4.0 Implementation Team</td>
</tr>
<tr>
<td>4</td>
<td>i4.0 Enabling Material &amp; Technology</td>
<td>Additive Manufacturing, Lightweight, 3D Forming, Robotic, Virtual Reality, Augmented Reality, Intelligent Assistance System, Part &amp; Process Traceability Device, Sensor, Cyber Physical System</td>
<td>Middle Management, Technical Personnel &amp; i4.0 Implementation Team</td>
</tr>
<tr>
<td>5</td>
<td>i4.0 Enabling Business &amp; Manufacturing Solutions</td>
<td>Enterprise Resource Planning (ERP), Product Life Cycle Management (PLM), Intelligent Planning &amp; Scheduling (IPS), Intelligent Manufacturing Execution System (IMES)</td>
<td>Middle Management, Technical Personnel &amp; i4.0 Implementation Team</td>
</tr>
<tr>
<td>6</td>
<td>i4.0 Innovative Product &amp; Process Realization Tool</td>
<td>Application of Trend Analysis &amp; Outcome Adoption, Design for X, Design for Manufacturability/Automation, Kaizen Model &amp; QFD, Predictive Maintenance, Advanced Product Quality Planning, Benchmarking, Scrum, DAPFMEA</td>
<td>Middle Management, Technical Personnel &amp; i4.0 Implementation Team</td>
</tr>
<tr>
<td>7</td>
<td>i4.0 Delivering Capabilities</td>
<td>Process Flexibility &amp; Optimization Capability, Business &amp; Manufacturing Process Automation &amp; Information Management, Digitalized Product Life Cycle Development Management, Robotic Application &amp; Man-Robot Collaboration, Machining Connectivity and Sensor Application, Smart Data Application and Analysis, Digitalized Product &amp; Process Design and Virtualization</td>
<td>Middle Management, Technical Personnel &amp; i4.0 Implementation Team</td>
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<td>8</td>
<td>i4.0 Implementation Tool</td>
<td>Formation of i4.0 Team, Trend Analysis, Matrix &amp; Interaction of Key Component &amp; Design Principle, i4.0 Pilon Project Identification &amp; Evaluation Tool, Holistic Strategic Plan, Case Study</td>
<td>Middle Management &amp; i4.0 Implementation Team</td>
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<tr>
<td>9</td>
<td>i4.0 Integration &amp; Level of Maturity</td>
<td>Horizontal Integration, Vertical Integration, Digitalized Engineering Life Cycle Management, Cyber Physical System, Level of Maturity</td>
<td>Top Management, Middle Management &amp; i4.0 Implementation Team</td>
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