Next Gen Manufacturing: Industry 4.0
A look at the changing landscapes in manufacturing
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The fourth industrial revolution is already on its way. Revolutions are fast, disruptive and destructive. And there is no going back. Is India prepared for the change? Industry 4.0 will be a challenge and may also have the answers for India's continued advantage in the global manufacturing industry!

The Fourth Industrial Revolution and Industry 4.0

We have already witnessed three industrial revolutions, which could also be described as disruptive leaps in industrial processes resulting in significantly higher productivity. The first improved efficiency through the use of hydropower, increased use of steam power and development of machine tools. The second brought electricity and mass production (assembly lines), and the third and most recent further accelerated automation using electronics and IT.

<table>
<thead>
<tr>
<th>First industrial revolution</th>
<th>Second industrial revolution</th>
<th>Third industrial revolution</th>
<th>Fourth industrial revolution?</th>
</tr>
</thead>
<tbody>
<tr>
<td>1784 Mechanical weaving loom</td>
<td>1923 Introduction of a &quot;moving&quot; assembly line at Ford Motors</td>
<td>1969 First programmable logic controller (PLC)</td>
<td>2014 Cyber-physical-systems</td>
</tr>
<tr>
<td>Introduction of mechanical production assets based on water and steam power</td>
<td>Introduction of mass production based on division of labor and electrical energy</td>
<td>Introduction of electronics and IT for higher automation of production</td>
<td>new winners, new losers!</td>
</tr>
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</table>

The fourth industrial revolution is already on its way. However, while some areas will see fast and disruptive changes, others will change slowly and steadily—"more "evolutionary" pace. This time, physical objects are being seamlessly integrated into the information network.

Since the beginning of the twenty-first century, we have been experiencing a digital transformation – changes associated with innovation in the field of digital technology in all aspects of society and economy. Some experts say that what we have seen so far only accounts for a tenth of what is still ahead. This trend is also affecting the way goods are manufactured and services are offered.

The Internet is combining with intelligent machines, production systems and processes to form a sophisticated network. The real world is turning into one giant information system.

"Industry 4.0" provides relevant answers to the fourth industrial revolution. It has to be differentiated from smaller concepts such as the "Internet of things", "Big Data" or "3D Printing".
Industry 4.0 emphasizes the idea of consistent digitization and linking all productive units in an economy. Let’s look at the key characteristics of the new industrial landscape:

1. **Smart Robots and Machines**

Robots have already replaced human workers in the last revolution. In the future, they will become intelligent, which means they will be able to adapt, communicate and interact. This will enable further productivity leaps for companies, profoundly impacting cost structures, skills landscape and production sites. Smart robots will not only replace humans in simple structured workflows within closed areas but also expand to complex intelligent tasks in other areas of manufacturing.

In particular, BRIC nations are significantly behind the average industrial automation rate in manufacturing. South Korea has already begun its journey of adopting Industry 4.0 to leverage the productivity enhancement and flexibility available through the use of industrial robots.

In Industry 4.0, robots and humans will work hand in hand, so to speak, on interlinking tasks and using smart sensored human-machine interfaces. The use of robots is widening to include various functions: production, logistics, office management (to distribute documents) and basic customer service. The robots performance requirements are significantly different for each industry. Below we discuss four key industries with high demand for robotics:

### Industry dynamics: Development of robotic capabilities across industries

<table>
<thead>
<tr>
<th>Automotive</th>
<th>Medtech</th>
<th>Consumer goods/electr.</th>
<th>Energy</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>SPEED</strong></td>
<td><strong>3</strong></td>
<td><strong>3</strong></td>
<td><strong>3</strong></td>
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<tr>
<td><strong>PRECISION</strong></td>
<td><strong>3</strong></td>
<td><strong>1</strong></td>
<td><strong>1</strong></td>
</tr>
<tr>
<td><strong>COMPLEXITY</strong></td>
<td><strong>2</strong></td>
<td><strong>1</strong></td>
<td><strong>2</strong></td>
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<tr>
<td><strong>DATA COLLECT</strong></td>
<td><strong>5</strong></td>
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<td><strong>4</strong></td>
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<tr>
<td><strong>ENVIRONMENT</strong></td>
<td><strong>3</strong></td>
<td><strong>2</strong></td>
<td><strong>3</strong></td>
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<tr>
<td><strong>VISION</strong></td>
<td><strong>2</strong></td>
<td><strong>1</strong></td>
<td><strong>4</strong></td>
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</table>

> Complex assembly processes (e.g. laser welding); ever more precision needed due to quality requirements
> Standard industrial environment
> Need for better traceability
> Automotive already with fast cycle times (<5 seconds)

> Processes so far less complex (handling of plastics, glass, etc.) but complexity will increase (higher electronics content in "intelligent devices")
> Still gap to close with regard to vision, data collection and traceability (due to implantable devices, liability)

> Mature processes, lower complexity
> Environmental requirements will increase (e.g. vacuum, minimize decontamination)
> Need for traceability (process control)
> Ever shorter product life-cycles require faster time-to-market and production speed respectively

> Precision and speed still the biggest gaps to be closed
> As products/processes are not yet mature no high-end automation approach (lower complexity)
> Lower need for traceability

Technical requirements towards automation today
Source: Expert interviews, Roland Berger

Technical requirements towards automation tomorrow (2020)

<table>
<thead>
<tr>
<th>Republic of Korea</th>
<th>Japan</th>
<th>Germany</th>
<th>USA</th>
<th>France</th>
<th>Australia</th>
<th>United Kingdom</th>
<th>China</th>
<th>Brazil</th>
<th>Russian Federation</th>
<th>India</th>
</tr>
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<tbody>
<tr>
<td>Automation Rate: Industrial Robots/1,000 Workers</td>
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<tr>
<td>The Leaders</td>
<td>490</td>
<td>330</td>
<td>225</td>
<td>140</td>
<td>125</td>
<td>75</td>
<td>60</td>
<td>23</td>
<td>8</td>
<td>3</td>
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<tr>
<td>The Aspirers</td>
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<td>The Laggards</td>
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Source: World Robotics 2013

<table>
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<tr>
<th>Country</th>
<th>Automation Rate</th>
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<tr>
<td>USA</td>
<td>490</td>
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<td>Japan</td>
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<td>Russian Federation</td>
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</tr>
<tr>
<td>India</td>
<td>3</td>
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</tbody>
</table>

Global Average | 30

Source: World Robotics 2013
2. Big Data

Data is often referred to as the raw material of the twenty-first century. Indeed, the amount of data available to businesses is expected to double every 1.2 years. A plant of the future will be producing enormous amounts of data that will need to be saved, processed and analysed (unlike being limited to the current general understanding of Big Data’s usage, that is, selling and customer profiling).

The means employed to do this will significantly change. Innovative methods to handle Big Data and to tap the potential of cloud computing will create new ways to leverage information. Let’s consider the example of the automotive industry. The eco-system that BMW has developed for its connected vehicles strategy is directed to take advantage of this unique opportunity.

Big Data and its applications will tremendously impact even the logistics industry with enhancements in existing concepts like fully-automated warehouses to fully-automated order fulfilment, predicting and delivering the items to the customers directly. The concept of automobiles itself is about to change and will result in new challenges for the transportation industry.

With technologies adopted by manufacturers like BMW and use cases like Google's "Self-Driving Car" for highly/fully automated driving will take over all decision making from the driver. We predict that by 2018, we will begin to see commercially viable examples of "Highly Automated Driving".

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**Ecc-system overview – Example BMW**

- **Hardware**
  - Connected services: internal/ not published
  - Cloud services/Infrastructures and analytics
  - WirelessCar
- **Software**
  - HMI Applications
  - Middleware/ CS
- **Content (selected)**
  - ALR
  - Core
  - REUTER
- **System**
  - Primary Tier 1 integrator: HARMAN
  - Secondary Tier 1 integrator: Continental
- **Telecommunications**

**Assistance** (Modified) Target values for longitudinal, lateral and vertical vehicle dynamics

- **I. Spatial recognition:** exact vehicle location, nearby environment & traffic rules
- **II. Plan safe trajectory:** based on predicted behavior of others, pot. dangers) and decide on car control

**Partially automated driving (NHTSA level 2)**

- **Target values for longitudinal, lateral and vertical vehicle dynamics**
- **Decision making & control**
- **Sensor/object data fusion incl. calculation/prediction of vehicle status**

**2018 Highly automated driving (NHTSA level 3)**

- **Target values for longitudinal, lateral and vertical vehicle dynamics**
- **Emergency Control**
- **Sensor/object data fusion incl. calculation/prediction of vehicle status**
- **Real-time dynamic spatial recognition**
- **Planning, monitoring and control of global and local paths as well as of alternative possible safe trajectories**
- **Fast decision making capabilities**

**2025/2030? Fully automated driving (NHTSA level 4)**

- **Target values for longitudinal, lateral and vertical vehicle dynamics**
- **Hardware redundancy**
- **Sensor/object data fusion incl. calculation/prediction of vehicle status**
- **Real-time dynamic spatial recognition**
- **Planning, monitoring and control of global and local paths as well as of alternative possible safe trajectories**
- **Fast decision making capabilities**
3. Cyber-Physical Systems and Marketplace

IT systems today are already at the heart of the production system. In Industry 4.0, those systems will be far more connected to all sub-systems, processes, internal and external objects, and the supplier and customer networks. Complexity will be much higher and will require sophisticated marketplace offerings.

IT systems will be built around machines, storage systems and supplies that adhere to a defined standard and be linked up as cyber-physical systems (CPS). Using these technologies will make it possible to flexibly replace machines along the value chain. This will enable highly efficient manufacturing in which production processes could be changed at short notice and downtime (e.g. supply shortages) can be offset.

The level of efficiency, quality and customization that will be possible through the combination of automation, big data and CPS will revolutionize the manufacturing industry.

In the global IT industry, India has a significant advantage in the IT enablement part of the value chain for CPS. As per NASSCOM estimates, while Indian IT exports are likely to grow in the range of 13-15 per cent per annum, the domestic market is expected to rise by a modest 9-12 per cent.

Indian IT companies are now well recognized for delivering quality, have proved their capabilities of timely execution of projects and are best positioned to ride global recovery. This gives India a unique advantage of positioning itself at the forefront of one of the key elements of Industry 4.0.

4. New Quality of Connectivity

While at the beginning of the 21st century connectivity was a feature of only the digital world, in Industry 4.0 the digital and real worlds are connected. Machines, work-pieces, systems and human beings will constantly exchange digital information via Internet protocol. This means physical things will be linked to their data footprint.

German toolmaker Trumpf, an Industry 4.0 supplier and worldwide market leader of laser systems, has put the first "social machines" to work. Each component is “smart” and knows what work has already been carried out on it. Because the production facility already knows its capacity utilization and communicates with other facilities,
production options are automatically optimized. Customers can receive pictures of the machines in real time during the production process and have the chance to provide feedback very early on, which can help to build even better machines.

This is also demonstrated by the trends in automated warehousing. Automated Warehousing is already being implemented across US and Europe for high volume package handling business models. For example, Kiva Systems is a firm that manufactures mobile robotic fulfilment systems that uses hundreds of autonomous mobile robots and sophisticated self optimizing control software system enables extremely fast cycle times with reduced labour requirements, from receiving to picking to shipping. The result is a warehouse that is quick and low-cost to set up, inexpensive to operate and easy to change anywhere in the world.

With the help of Kiva's automated warehouse, Zappos, an online US retailer, gained widespread popularity in 2009 for delivering items within 24 hours of a purchase and grossed over $1 billion in that year, which eventually led to Amazon paying $1.2 billion to acquire Zappos. Based on the success of the warehouses at Zappos, Amazon also acquired Kiva Systems in 2012, for $775 million.

Extending the example above, production with interconnected machines becomes very smooth: one machine is immediately informed when the part is produced in another machine, as well as the conveyor or the logistic supply robot. Machines automatically adapt to the production steps of each part to manufacture, coordinating almost as in a ballet to automatically adjust the production unit to the series to be manufactured.

5. Renewables and Energy Efficiency

Climate change and scarcity of resources are megatrends that will affect all Industry 4.0 players. These megatrends leverage energy decentralization for plants, triggering the need for the use of carbon-neutral technologies in manufacturing.

Using renewable energies will be more financially attractive for companies. In the future, there may be many production sites that generate their own power, which will in turn have implications for infrastructure providers. In addition to renewable energy, decentralized nuclear power – e.g. small-size plants – is being studied as a way to supply big electro-intensive plants, thus providing double-digit energy savings.

India was the first country in the world to set up a ministry of non-conventional energy resources, in early 1980s. Domestic policy support for wind power has led India to become the country with the fifth largest installed wind power capacity in the world.

With the new government’s track record and preference of promoting renewable energy, it is expected that Indian companies will be favourably placed to reduce their dependence on carbon based fossil fuels. Though the journey for India overall will be much longer considering majority of the current energy generation is still based on coal.
FACTORY 4.0 gives an overview of the firm as an interconnected global system on a microeconomic level. Our graph depicts the key factors: outside the factory we see a 4.0 supplier network, resources of the future, new customer demands and the means to meet them. Inside the factory, we envision new production technologies, new materials and new ways of storing, processing and sharing data.
Will it be a threat or an opportunity? Both, as it turns out. Manufacturing companies, in the traditional sense, will surely remain in the market. But established players will undoubtedly change their organizations, processes and capabilities in whole or in part during the industrial revolution. And there will be new competitors with radically new industrial business models.

Industry 4.0: What is changing for Indian Companies?

We are describing the big picture of a profoundly transformed industry landscape. New technologies such as the Internet or mobile phones have not been successful just because they were new, but because they were also followed by a societal transformation.

The Internet as a technology did not invent social networks, but social networks developed thanks to the Internet, and also enabled it to develop further. The same thing will happen with Industry 4.0, by bringing new functionalities that will change the rules of the game for the industry players. The development will proceed at different rates in different industries. Here we have tried to identify some cross-industry implications:

1. Output: Personalized, Local Production and Mass Customization

Industry 4.0 brings more freedom and flexibility into the production process. It will become possible to create products tailored to segment-by-one customer needs at relatively low marginal cost. Also distribution processes for spare parts or not too complex customer goods might get easier as only data (requirements and specifications) will need to be transferred to the parent organization, while the physical production can be done locally.

Will the low cost manpower of India be made redundant in the face of a significantly more efficient and mistake proof manufacturing method?

This becomes visible in the broadening of 3D printer usage; a 3D printing plant can become economically viable and competitive in a high-cost country, by being less sensitive to labour cost while still providing the proximity necessary for affordable personalization.

Advanced robotics combined with 3D printing are already here. One of the largest companies currently using this method of production is Japan based FANUC (Factory Automatic Numerical Control) Ltd. This company specializes in robotics manufacturing: servo motors, mechanical arms etc. There is minimal human involvement in the entire process. What they’ve essentially produced is robots that build other robots.

As you sit here reading this, FANUC robots are building and assembling other robots at a rate of about 50 per day (remember, they don’t need to take breaks) and can run unsupervised for as long as 30 days. The only time humans visit is to deliver the robots to their clients, primarily auto manufacturers. According to FANUC vice-
president Gary Zywiol, “Not only is it lights-out, we turn off the air conditioning and heat too”. These robots are so efficient, companies like Panasonic have been able to produce up to 2 million plasma screen televisions per month, all with a whopping 15 people monitoring the factory floor.

German manufacturing giant Siemens, an industrial user, is implementing an Industry 4.0 solution in medical engineering. For years, artificial knee and hip joints were standardized products, with engineers needing several days to customize them for patients. Now, new software and steering solutions enable Siemens to produce an implant within 3 to 4 hours.

2. Competition: Converging Frontiers

Traditional industry boundaries are becoming blurred, as are the boundaries between industrial and non-industrial applications. Going forward, the focus will be on industrial working methods, including the reproducibility not only of identical products but also of services.

Services can be mass-produced too. High-quality digital (outsourced) services and a fail-safe, comprehensive digital infrastructure are becoming the fundamental prerequisites for successful Industry 4.0. And there will be even closer dovetailing between IT/telecommunications firms and traditional manufacturing companies. The former might in some cases become the new industry leaders.

The most recent examples: Social media giant Facebook has acquired a stake in the drones business (Ascenta) and Internet giant Google also bought a drone manufacturer, Titan Aerospace. Google is also entering robotics through Boston Dynamics and appliance markets through Nest (thermostatic sensors for home appliances).

Today, physical machine and tooling suppliers harvest the biggest margins with their industry clients. But in a cyber-physical system world, these suppliers may lose importance. Instead, suppliers of sensors, IT and software might take their place in Industry 4.0, while machine and tooling companies shift down to tier 2.

This is not only limited to industries but also countries. India faces the risk of being crowded out by the increasing technical capability of China and Europe’s focus on medium-value segment. Historically, China has focussed on the low technology-low manufacturing value add space while Europe has focussed on high technology – high value add segment. India manufacturing zone of comfort has been in the middle, both on the technology and value add axis.

There is a significant push from China to move up from the low technology – low value add zone and expand into the medium technology zone thereby expanding the market for Chinese companies. Concurrently there is a push from Europe to move down from the high technology – high value add zone and expand into the medium technology zone thereby expanding the market for European companies. This is leading to a crowding out effect impacting India’s manufacturing base in addition to increasing competition from emerging manufacturing bases like Vietnam, Turkey and Taiwan.

Changing manufacturing landscape

Technical capability vs. Manufacturing value-add

1) Size of bubble – Total manufacturing value add
3. Business Models: Redefinition of the Value Chain

In a complex and intertwined manufacturing network, the roles of designers, physical product suppliers and the interfaces with the customer (contractor) will change. Companies built on “new media” are clearly very cash rich, (USD 19 Billion for Whatsapp acquisition) and are also very focussed on getting closer to the consumer. In Industry 4.0, the supplier hierarchies/pecking orders are likely to change.

Will Google use its acquisitions to integrate itself into our consumers homes and leverage that data to further predict their needs or will Facebook use its drones to provide 24/7 free high speed internet to the remotest parts of the world so you can instantly upload your spelunking video from the jungles of Africa? Yes, because that’s what these companies are, “Integrators”, they are not limited by what they are supposed to be, all parts of the value chain that they need will be absorbed and optimised.

Tired of the slow pace of expansion in connectivity in high speed internet connections, Google has also entered the distribution of broadband through “Google Fibre”. What will it mean for the telecom value chain when the ISPs are rendered irrelevant? These companies will also enter the space earlier reserved for traditional manufacturing companies, will Google extend its integration to consumer products like refrigerators that make shopping lists, coffeemaker that orders coffee etc.

Traditional supply chain is already being disrupted by online shopping, brick and mortar retail companies in India face increasing pressure from mammoths like Amazon and Alibaba. We have seen recent product release trends regarding “online only” availabilities. Clearly there are higher margins and greater customer insights for manufacturers to deal with entities like Amazon, but where does that leave traditional retail? As business leaders rethink and restructure their value chains, new challenges in regard to cost and profit ownership arise.

4. Skills: Interdisciplinary Thinking is the Key

The dominant technologies of Industry 4.0 will be IT, electronics and robotics. But it will also embrace other knowledge areas such as biotech and nanotech. It is to be expected that businesses in Industry 4.0 need both enhanced social and technical skills.

There will be a shift toward design thinking instead of production thinking. Corporate cultures with continuous training and development in the workplace and lifelong learning are becoming a core competency. A lot of collaborative and cross-cultural competencies will be required to be able to work in network environments sustainably.

On the technical side: connecting the network will mean a lot of standardization. Therefore, the technical competency profile will be interdisciplinary than specialized. Analytics specialists, engineers and programmers will have to be able to think across business models, production processes, machine technology and data-related procedures. New job titles have emerged such as data scientist and cyber defenders.
3D Printing/ Additive Manufacturing: Spotlight on the Future

The market for 3D printers and related services rose to EUR 1.7 billion in 2012, and is estimated to rise to about EUR 4.4 billion annually by 2017 (Quadruple over the next 10 years).

The ability to manufacture metal objects without virtually no limitations on geometry and without tools offers the opportunity to create new products that help boost product performance (e.g. tool inserts with cooling channels or highly efficient injection nozzles) or manufacture batch sizes consisting of just one item (e.g. medical applications, design objects) using special highly resistant alloys.

With about 1% of the machine tools market, the share of 3D printing is relatively small. The supplier base for 3D printing machines is dominated by German suppliers. In addition, an infrastructure of engineering and 3D printing service providers has developed close to technological leaders in aerospace, turbine development and motorsports production.

ADVANTAGES

- Freedom of design – 3D printing can produce an object of virtually any shape, even those not producible today
- Complexity for free – Increasing object complexity will increase production costs only marginally
- Potential elimination of tooling – Direct production possible without costly and time-consuming tooling
- Lightweight design – 3D printing enables weight reduction via topological optimization (e.g. with FEA/1)
- Part consolidation – Reducing assembly requirements by consolidating parts into a single component; even complete assemblies with moving parts possible
- Elimination of production steps – Even complex objects will be manufactured in one process step

DISADVANTAGES

- Slow build rates – Various inefficiencies in the process resulting from prototyping heritage
- High production costs – Resulting from slow build rate and high cost of metal powder
- Considerable effort required for application design and for setting process parameters – Complex set of around 100 material, process and other parameters
- Manufacturing process – Component anisotropy, surface finish and dimensional accuracy may be inferior, which requires post-processing
- Discontinuous production process – Use of non-integrated systems prevents economies of scale
- Limited component size – Size of producible component is limited by chamber size

In certain areas, the technology has already achieved manufacturing readiness (e.g. dental or design objects), whereas in the aerospace and turbine industry, process development and complex field testing are ongoing. The potential of 3D printing in these industries is extremely high, which means that 3D printing is on the agenda of every CTO.

The costs of this technology are significantly higher than for conventional production, so it can be only justified by special benefits in the lifecycle or tooling costs. Increasing competition for powder supply will reduce today’s mark-ups and increasing volume will reduce production costs. Service providers will investigate and develop alternative suppliers to machine OEMs. Machine utilization is expected to drop slightly due to multiple laser scanners and rising complexity.

Forecast is based on current market structure with several small players with low R&D budgets – Entry of larger players with higher investment budgets may bring down costs even faster.

A detailed analysis of the current manufacturing cost and evaluation of expected improvements reveals a cost reduction potential of about 50% in the next 5 years and another 30% within the next 10 years. These reductions will significantly boost the market for metal 3D printing.
Can Industry 4.0 change the dynamics of global manufacturing from low cost labour manufactured products offshore to locally built by robots programmed in high cost country? And can India continue to bet on remaining a low manpower cost arbitrage led manufacturer?

Approach for India to take on the Industry 4.0 Challenge

Industry 4.0 is an opportunity to change the economic rules of the industry, especially to overcome the dependence of India on the labour arbitrage based manufacturing work.

We have hypothesised that industrial (r)evolution will change the game for industrial users, infrastructure suppliers and technology providers. New aspects need to be considered: how open is the economy and industry? How excellent are innovation networks? How qualified, flexible and interdisciplinary are employees in order to trigger Industry 4.0 within their companies?

We believe that above and beyond the current actions taken by the government, associations and companies themselves to bolster the manufacturing sector, the new industrial revolution will require an enhanced approach to protect the future of India’s competitiveness. Key steps needed to address this are:

1. **Accelerate Innovation**

Industry 4.0 encompasses a broad set of technologies with a huge field for innovation and creative solutions. Pioneering business models will create new opportunities for adding value, but those will depend on breakthrough innovations for technology and the ability to bring them to market.

This is an area where public and private partners have to collaborate closely. Industrial bodies need to and already have started to take the lead in promoting innovation by providing avenues for all stakeholders to come to a common forum.

A sustainable partnership model is essential between government, private firms, industry bodies, research and financing institutions for promoting Industry 4.0.

While private R&D centres can carry out product oriented research, long term fundamental research needs to be carried out by universities and government research labs. In 2011, the “Cyber-Physical Systems Innovation Hub” project was launched under the auspices of the Ministry of communications and Information Technology to conduct research into a variety of areas, including humanoid robotics.

Financing institutions play an important role in promoting innovation by providing instruments for hedging risk and building joint venture platforms for collaborative research.
2. Develop Future Champions

Technology is evolving rapidly. The danger is not keeping up with technologies required to offer integrated solutions. Many traditional players that produce tangible products will move into intangible new technology fields and buy software start-ups or Internet companies.

For Example, a champion in machine-tooling that does not build up Internet-of-things technologies will not be able to develop the new machine generation. Therefore, players must develop a technology strategy and close the gaps.

In India, almost all manufacturing firms want higher automation (low cost) and high energy efficiency machines. Manpower costs are increasing for the industry due to increase in labour rates, low labour productivity, shortage of skilled manpower, labour management problems across the country. Low cost automation desired for pick and place, loading and unloading system, auto counting and material handling.

As a measure of competitiveness, R&D ratio to revenue of domestic machine tool manufacturers is ~5 times lower than foreign machine tool manufacturers.

![Chart showing Domestic vs International R&D ratio]

Competition is strong: Global players from Japan, Germany and emerging players from China – Indian companies will have to become world class in their mind-set and internal capabilities. Organic & inorganic growth strategies, focused technology development, R&D and global market access will define champions. Strict supplier management, continuity in management, continuous optimization and improvement will ensure sustainability.

Patterns of success – The champions’ cockpit

**BUSINESS MODEL**

1. Growth with measured judgment
2. Technology leadership
3. Price/premium strategy
4. Global market coverage with adapted regional structures
5. Concentration of the value chain
6. Maturity and stability

**FINANCIAL BASE**

7. Cash optimization
8. Continuity in investment strategy
9. Adjusted financing

**VALUE CHAIN**

10. Performance-oriented organization and continuity in management
11. Optimized R&D allocation
12. Integrated supplier network
13. Efficient processes with a high level of automation
14. Intelligent sales management
15. Excellence in basics

**LEVER**

Champions’ approach

1. Growth model
   - Aggressive
   - "Go to market fast"
2. Technology strategy
   - Innovation leader
   - Late follower
3. Product positioning
   - Niche focused
   - Broad base in mass market
4. Distribution model
   - Early global stronghold
   - Focus on domestic market
5. Value chain strategy
   - Fully integrated
   - Heavily outsourced

Source: Industry report, IMTMA, Roland Berger
3. Establish a Dynamic Infrastructure

The digital aspect has become mission-critical for many products and services. Therefore, “new” industry needs a competitive environment that fosters dynamic telecommunications and Internet usage. Infrastructure providers can contribute in this field, not only by providing structures for reliable power and telecommunications supply, but also by developing standards for large data transfer and security procedures.

It's not only digital services that are suffering, but also the key areas of energy, transportation and financing. This might include incentives for industrial users to invest in the transition to Industry 4.0 or funding for infrastructure development.

On the Network Readiness Index of the World Economic Forum (WEF), surprisingly India is the least performing of the BRICS economies, considering the size of the Indian IT industry, and is continuing on its declining trajectory to arrive at 83rd place in 2014 from 68th place in 2013.

Overall, WEF believes, India’s networked readiness profile remains hindered by the quality of its political, regulatory, business/innovation environment and its lack of digital infrastructure. In terms of readiness, WEF states that, the most worrisome signals of insufficient progress on the digital agenda come from the lack of skills build-up, dependence on manual labour due to low literacy rate, so even if the systems are available manufacturing teams are just not able to leverage it.

A new EUR 13.6 billion government program called “Digital India” to build a national optical fibre network has been launched by the new government. Directionally, it is designed to address the gaps stated above; however the effectiveness of the program will define the preparedness of India for the coming revolution.

4. Foster New Talent

Besides infrastructure, this dynamic digital environment also needs to foster new talent. Backward looking education policies and ancient content will need to be radical changed to enable adoption of Industry 4.0. The new competency fields required by Industry 4.0 need to be embedded in education now as the gap between academia and industry will significantly expand going forward.
Government needs to take a lead in developing specialized vocational programs with partnership of industry associations and academia.

### India’s training requirements

<table>
<thead>
<tr>
<th>1. Skills</th>
<th>Required elements in India’s training model</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt; Application and practice-oriented education</td>
<td>&gt; Alternating learning in academia and industry as per dual principle^1</td>
</tr>
<tr>
<td>&gt; Workforce with in-depth knowledge of new age technology and processes in manufacturing industry</td>
<td></td>
</tr>
</tbody>
</table>

### 2. Content

| > Updated curriculum | > Programs to be carried out in private-public partnership (PPP) |
| > Well-regulated and industry-recognized certification mechanism | > Effective coordination between different government levels, industry bodies and other stakeholders |

### 3. Processes

| > Active participation from private sector in codifying skill requirements, curriculum design and standardization | > Joint funding mechanism between government and industry with training taking place in academia and private work-sites |
| > Private sector participation in organization and supervision of vocational training programs | |

^1) “Dual principle” refers to the integration of theory and practice, thinking and acting, systematic and case-based learning

5. **Create a Strategy 4.0**

There are two ways to move into Industry 4.0: transforming existing (legacy) plants or making greenfield investments. Both will require a strong change management approach.

Industry 4.0 will probably penetrate the quickest through greenfield investments, coming from new business opportunities. The other approach is to progressively adapt the legacy manufacturing footprint. Transforming a legacy plant into a modern 4.0 factory will mean a significant social impact and requires a good change management capability to enable competency shift and new ways of working and manufacturing.

Companies should consider seizing the opportunity to use 4.0 technologies by developing tailored manufacturing strategies that best leverage the new technologies. This is a good opportunity to establish 4.0 tech shows in all end-user industries because the overall solutions will be extremely specific: 4.0 in the automotive industry won’t be the same approach as in the railway or aviation sectors, simply because the production factors are fundamentally different.

**Key elements of footprint strategies**

<table>
<thead>
<tr>
<th>I: Transparency</th>
<th>II: Scenario development</th>
<th>III: Scenario evaluation</th>
<th>IV: Recommendations</th>
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<tr>
<td>Current footprint &amp; production technologies</td>
<td>Footprint principles</td>
<td>Evaluation scenarios (quant.), business case (payback, NPV etc.)</td>
<td>Footprint strategy</td>
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<tr>
<td>Platform strategies</td>
<td>Restrictions (inventory, technology etc.)</td>
<td>Reality check (future requirements)</td>
<td>Footprint transformation plan including optimized investment and capital plan</td>
</tr>
<tr>
<td>Regional sales and project forecast</td>
<td>Competitor strategies</td>
<td></td>
<td>Roadmap vertical integration (operational plan, resources, capability, timing etc.)</td>
</tr>
<tr>
<td>Vertical integration (supplier structure)</td>
<td></td>
<td></td>
<td>Organizational setup</td>
</tr>
<tr>
<td>Macroeconomic/financial modeling</td>
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</table>
Risks in Implementing Industry 4.0

Some of the hopes generated by the initial euphoria for Industry 4.0 remain unfulfilled in practice. There is a great deal of uncertainty in this new field – and it is therefore imperative to query more closely the processes and steps required. We look at three key risks below:

1. Data Security

The major risk with recording, storage and analysis of large volumes of customer data is the inappropriate or sometimes illegal use of the said data. Many business have suffered significant backlash from a highly activist user community for recent issues like the end user agreement revisions by companies like Facebook and Instagram which has also led to class action lawsuits being filed against similar companies.

Companies are also under pressure from governments for disclosing user data for pattern analysis related to illegal activities. The issue with this is that when data access requests are extended to "everyone", the lines between security and constitutional rights become blurred (for example PRISM program of National Security Agency in US).

One leading example of building consumer trust has been taken by Apple. It has in its latest version of the mobile operating system, iOS 8, removed any and all backdoor access that even the company maintained for the purposes of providing data recovery to the users (in case of data loss) and court sanctioned government requests.

Companies who choose to integrate concepts like Big Data and Internet of Things will also be liable for the protection of the data created through these interfaces.

2. Lack of standardization

Though concepts like sharing of data and integration of technology are not new, however lack of standards or rather prevalence of proprietary standards is going to be a key roadblock. A simple example of such an issue would be the multiple sizes of charging ports in mobile phones.

This issue also extends to manufacturers of machines and robotics. Due to the need for protecting proprietary technology and potential for higher margins in the service value chain, OEMs insist on creating incompatible standards which leads to higher dependence of users on such manufacturers. In such a scenario, a disproportioned amount of power will be held by such proprietary OEMs leading to machines not being able to integrate with each other seamlessly. The risk also extends to creation of roadblock for further up-gradation of equipment and facilities.

3. Social Impact

Numerous actions are possible for the implementation of Industry 4.0, but companies will have to take social aspects into account. Any significant automation in manufacturing processes is generally met with "job loss" argument. This specific issues will require a structured approach with regards to up-skilling and new job creation.

For instance, the French Robotics Association has launched the "Robocaliser" program. Since French unions still perceive robotisation as a job killer, the program promotes the idea of using robots as a way to avoid delocalization and bringing industry back to France hence creating new jobs. The social impact of such technologies will required planned response to expected objections from conservative governments, labour unions and society at large.
Conclusion

The next industrial revolution lies directly ahead, and will likely prove to be a source of huge opportunities. Moving toward Industry 4.0 makes it possible to preserve India’s edge in manufacturing and create a sustainable ecosystem with qualified employees which supports energy transition and can adapt to large-scale customization.

It will be difficult to manage the process centrally, but there will be reinforcing effects if the right levers are applied by the players in the system. Therefore it is crucial to communicate the idea that players in the corporate sector (technology suppliers, infrastructure providers and industrial users) and government will profit the most if their Industry 4.0 initiatives go hand in hand.

We think that in the future, switching over to Industry 4.0 will be a major competitive advantage for an economy over its global competitors. But speed is of the essence – the time to move forward and capture this opportunity is now.
The Confederation of Indian Industry (CII) works to create and sustain an environment conducive to the development of India, partnering industry, Government, and civil society, through advisory and consultative processes.

CII is a non-government, not-for-profit, industry-led and industry-managed organization, playing a proactive role in India's development process. Founded in 1895, India's premier business association has over 7200 members, from the private as well as public sectors, including SMEs and MNCs, and an indirect membership of over 100,000 enterprises from around 242 national and regional sectoral industry bodies.

CII charts change by working closely with Government on policy issues, interfacing with thought leaders, and enhancing efficiency, competitiveness and business opportunities for industry through a range of specialized services and strategic global linkages. It also provides a platform for consensus-building and networking on key issues.

Extending its agenda beyond business, CII assists industry to identify and execute corporate citizenship programmes. Partnerships with civil society organizations carry forward corporate initiatives for integrated and inclusive development across diverse domains including affirmative action, healthcare, education, livelihood, diversity management, skill development, empowerment of women, and water, to name a few.

The CII theme of ‘Accelerating Growth, Creating Employment’ for 2014-15 aims to strengthen a growth process that meets the aspirations of today’s India. During the year, CII will specially focus on economic growth, education, skill development, manufacturing, investments, ease of doing business, export competitiveness, legal and regulatory architecture, labour law reforms and entrepreneurship as growth enablers.

With 64 offices, including 9 Centres of Excellence, in India, and 7 overseas offices in Australia, China, Egypt, France, Singapore, UK, and USA, as well as institutional partnerships with 312 counterpart organizations in 106 countries, CII serves as a reference point for Indian industry and the international business community.
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