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Establishing the digital footprint in a Smart Factory

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ABSTRACT

Smart Factories have dominated discussions and conferences for the past few years. It is, in fact, a ground-breaking concept and has the capability of being a game changer, which can create a sustainable competitive advantage. They have the potential to address many challenges that the manufacturing world faces today. So much so that, sometimes they are projected as "panacea" to most of the problems. Experience of early adopters does suggest that they can help us solve many problems. However, companies face challenges in terms of structuring their smart factory journey into phases, identifying the pre-requisites, selecting the right vendor(s), justifying the ROI, forming the right teams, etc. This paper attempts to provide a high-level approach to set up a smart factory and tries to answer some of the questions raised.

Keywords*— Smart factory, Digital, IoT, Robotics, MES, ERP*

1. INTRODUCTION

Manufacturing world has undergone multiple changes in the past decade. It had lost its "attractiveness" at the height of Information technology boom during the nineties and during the first decade of the twenty-first century. Ironically, the boom opened multiple vistas of innovation in manufacturing; robotics, IoT & analytics, augmented reality, 3D printing etc. As trade becomes global, companies are facing intense competition to retain and grow their market share. They are addressing this challenge through sustainable differentiation, cost leadership, focus on specific market segments & building a highly efficient supply chain network. For manufacturers, cost leadership and differentiation through innovation and product quality are the keys to success. It's highly unlikely that they will achieve these twin objectives using the same techniques and processes that have been using for years. It's imperative that they revisit their manufacturing ecosystem and make changes to face future challenges.

The next big question is, what does a factory of the future look like? In all likelihood, factories of the future are going to be "Smart" factories (some experts call it Industry 4.0!). They will have an optimum mix of man and machines (aka robots, TUGs, etc.). They will be able to make sense out of volumes of data generated on the shop floor and take corrective actions if required. They will have optimized process steps (e.g. 3D printing) and will adhere to the highest quality standards.

Most manufacturing-centric companies have embarked upon their journey to set up smart factories and, in most cases, willing to retrofit an existing plant to make it smart. However, one of the challenges they face is how to go ahead in setting up a smart factory. This paper will try and provide a high-level approach to set up a smart factory.

2. FACTORY THROUGH YEARS

Factories have undergone massive changes over the years. These changes have fundamentally altered the way factories operate. At a high level, this can be mapped using four dimensions; people, process, equipment, and systems. The following section briefly explains the changes in each dimension.

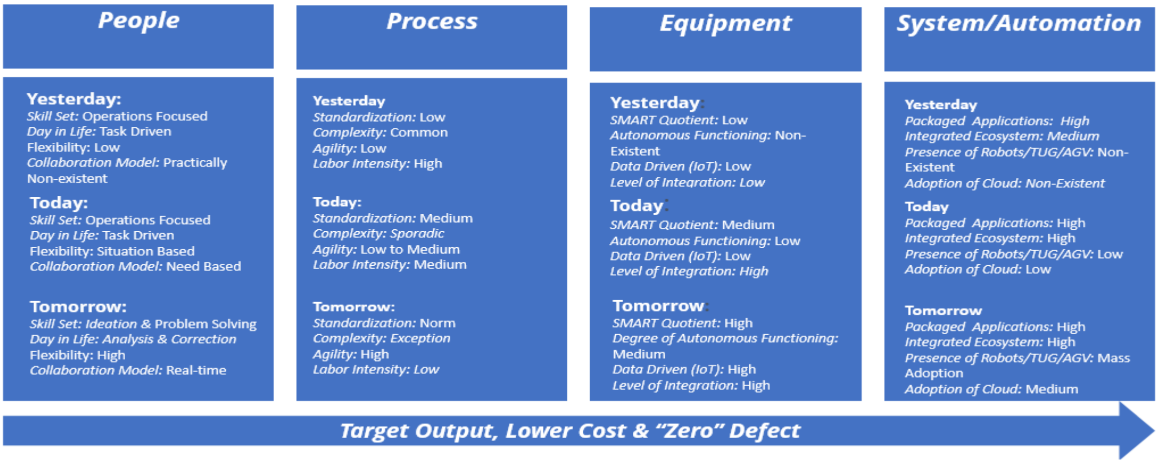
2.1. People

Skillset: It used to be, and still to a large extent is "Operations Focused." Personnel on the shop floor are primarily focused on performing highly repetitive steps in their respective process areas. In the coming years, they need to develop an attitude toward solving problems. Even an Operator needs to stay alert to identify an anomaly in the line and alert her supervisor immediately.

Day in Life: So far, it has been "Task Driven." Going forward, there will be increased emphasis on analysis and course correction.

Flexibility: It must be higher in terms of learning new skills, working across different process area(s), relocating to a different geography etc.

Collaboration Model: It must be literally real-time among teams located in different geographies in different time zones.



2.2. Processes

Standardization: Standardization of manufacturing process steps will be the norm. However, plants should have the ability to churn out different product types to satisfy customers in different segments. At first glance, both these aspects look contradictory, however, on a closer look, we would realize that they complement each other. Normally, there are multiple common process steps irrespective of end products which can be standardized. For example, restaurants have scores of dishes, however, they standardize basic steps such as preparing sauce, keeping the core content such as rice and pasta ready. The same is true with automobile companies. They have a wide range of models, but the same basic steps such as gearbox assembly, fuel Injection system assembly can be standardized.

Complexity: Complexity will not be desirable.

Agility: Agility needs to be very high going forward; e.g. new products need to be launched within a very short interval targeting different geographies and different customer segments.

Labor Intensity: This will have a decreasing trend. This doesn't necessarily mean "job losses", rather less labor will be required to run a production line. Another part of the labor force can focus on more value-added activities such as root-cause analysis of issues, productivity improvement initiatives.

2.3. Equipment

Smart Quotient: Smart quotient will be increasingly higher with the passage of time. More and more machines will adhere to industry standard protocols such as SECS/GEM. Extraction of data captured by the machines will become streamlined.

Autonomous Functioning (aka machine learning): Currently machines require human intervention for their smooth functioning especially to address out of control (OOC) situation, to analyze defect, to implement the solution etc. Increasingly, they will leverage machine learning to take care of many of the situations mentioned above. This will help shop floor personnel focus on longer-term improvement areas.

Data-driven: Most equipment generates large volumes of data which mostly remain unexplored. Going forward with machine learning, IoT will be able to analyze these data and provide actionable plans to improve Overall Equipment Effectiveness (OEE), Yield etc.

Level of integrations: Integration of Programmed Logic Controllers (PLCs) with overall system architecture, commissioning of Robots will become the norm.

2.4. System/Automation

Packaged Application: Plants have been implementing "packaged ERP" (Enterprise Resource Planning (ERP) such as Oracle EBS, SAP, and Microsoft Dynamics as their back-end application to manage costing and financial reporting. They are going for "packaged MES" (Manufacturing Execution System). MES marketplace has many options for organizations to choose from. This trend will continue and most plants will embrace packaged applications.

Integrated Eco-System: Increasingly, plants will have an integrated ecosystem to drive automation and productivity. PLC will be integrated with shop floor execution system, which in turn will be integrated with Enterprise Resource Planning (ERP) system and Statistical Process Control system.

Presence of Robots/TUGs/AGVs (Adoption of Robotic Automation): Robotic automation is not a new concept. It has been around for decades now. Considering the pressure to reduce costs, to improve productivity and to improve OEE and yield, there will be an increase in robotic automation.

Cloud Adoption: Cloud adoption for manufacturing execution system may not be high in the future. This is because shop floor execution systems are really "high speed" application where thousands of transactions are logged every minute and there will be literally "zero" tolerance for latency. Connectivity must be super-fast, which may not be possible in geographies such as Asia and Latin America where manufacturing operations are concentrated.

However, during the years factories will be focused on three key KPIs:

- Meeting Target output
- Lowering Cost per Unit
- "Zero" defects

Other factors such as OEE, Yield, throughput etc. directly or indirectly tied to one of these three parameters.

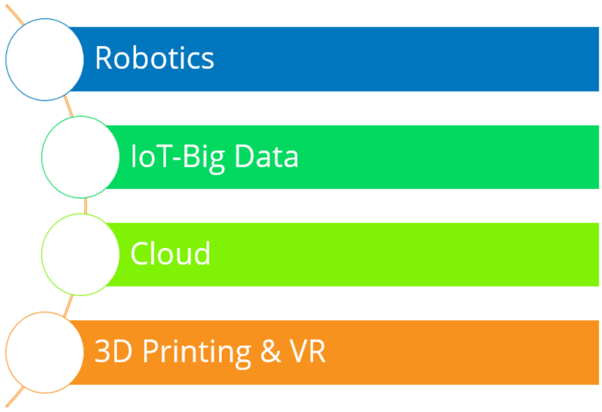
3. CURRENT CHALLENGES IN FACTORIES

Factories currently, face three key challenges:

- *Following an aggressive cost reduction Roadmap:* In most industry verticals, companies must stick to an aggressive cost reduction roadmap to retain their market share and to grow them. Every year, factories are required to meet the same or increased production target at a lower cost. This becomes more difficult to achieve dues to increase in the cost of labor and raw materials over time.
- *Maintaining Traceability & Quality:* Companies must maintain traceability with a high level of accuracy to address customer complaints effectively. This also helps maintain a high level of quality with minimum, if possible "zero" defect. To achieve zero defect is really challenging, as there are complexities involved. For example, operators will make mistake or there will defect in one of the thousands of lots, which is difficult to detect.
- *Having Agility to launch new products at frequent intervals:* Organizations have to launch new products frequently to address new markets and new customer segments. Factories should be flexible enough to support this requirement, with minimal incremental investment and minimal disruption to existing operations.

Innovative system architecture and new disrupting technologies hold the promise to help achieve the above three objectives.

4. DIGITAL MANUFACTURING: DISRUPTING THE PRESENT TO BUILD THE FUTURE



Robotic Automation: Robotic automation in manufacturing facilities has existed for about three decades. The ability of robots to perform specialized tasks has increased significantly and they are now on the cusp of mass adoption

IoT-Big Data: They have empowered us to make sense out of tons of data generated by machines, which in turn helps us improve uptime, reduce defects and drive productivity.

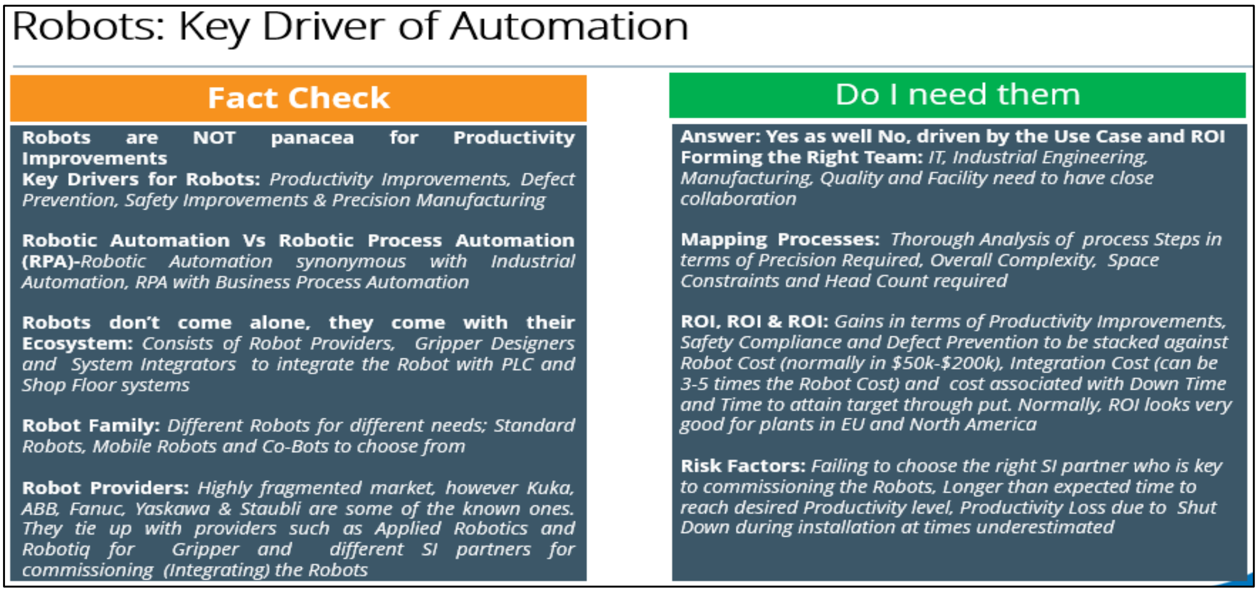
Cloud: Provides a robust, relatively secure and scalable platform to host the entire application stack. It helps us focus on value-adding initiatives

3D Printing & VR: Another frontier in manufacturing and driving customer experience. Organizations are increasingly adopting them to drive productivity and customer satisfaction

The following section examines how each one of the above can help organizations address the challenges outlined in earlier sections.

5. ROBOTS: THE KEY DRIVER OF AUTOMATION

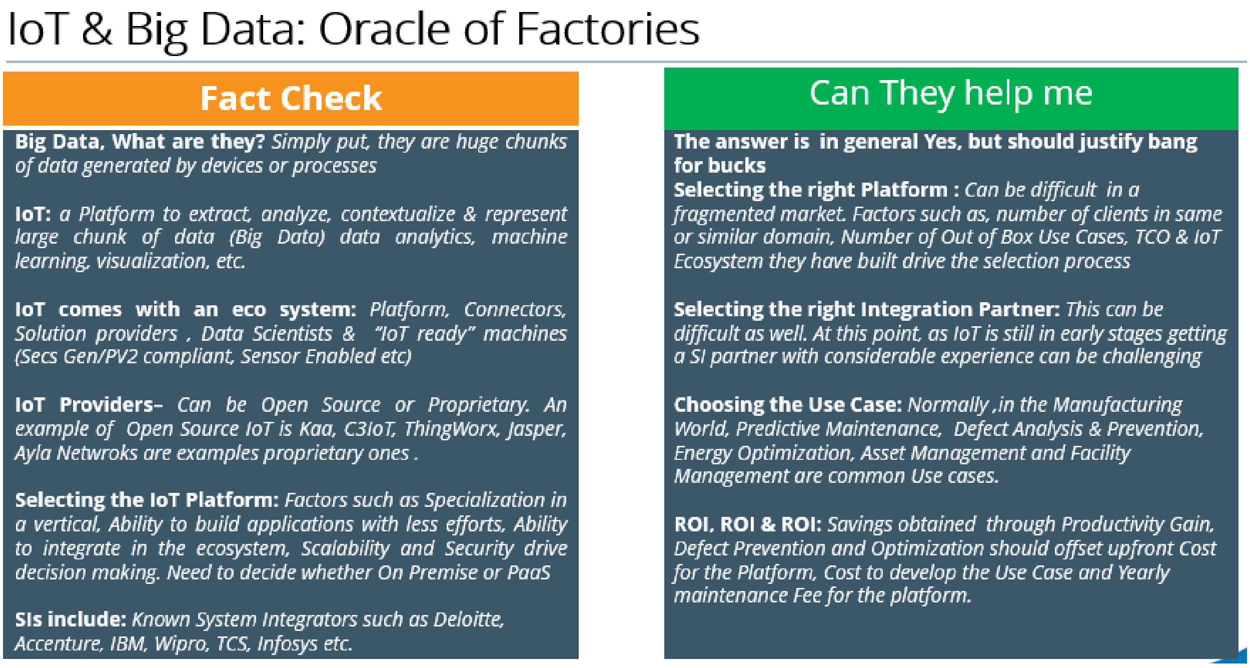
As mentioned in the previous section, robots have existed for decades. However, at present and in the future, they will play a significant role in addressing the challenges that factories face. The following illustration captures key information which will help decide if an organization should consider using robotic automation.



As can be seen from the above findings, Robots can't be a panacea for productivity improvements. They are effective agents to improve productivity when applied in the right geography, for the right use case, and with the right expectations. Last but not the least, ROI must be at least reasonable.

6. IOT & BIG DATA: ORACLE OF FACTORIES?

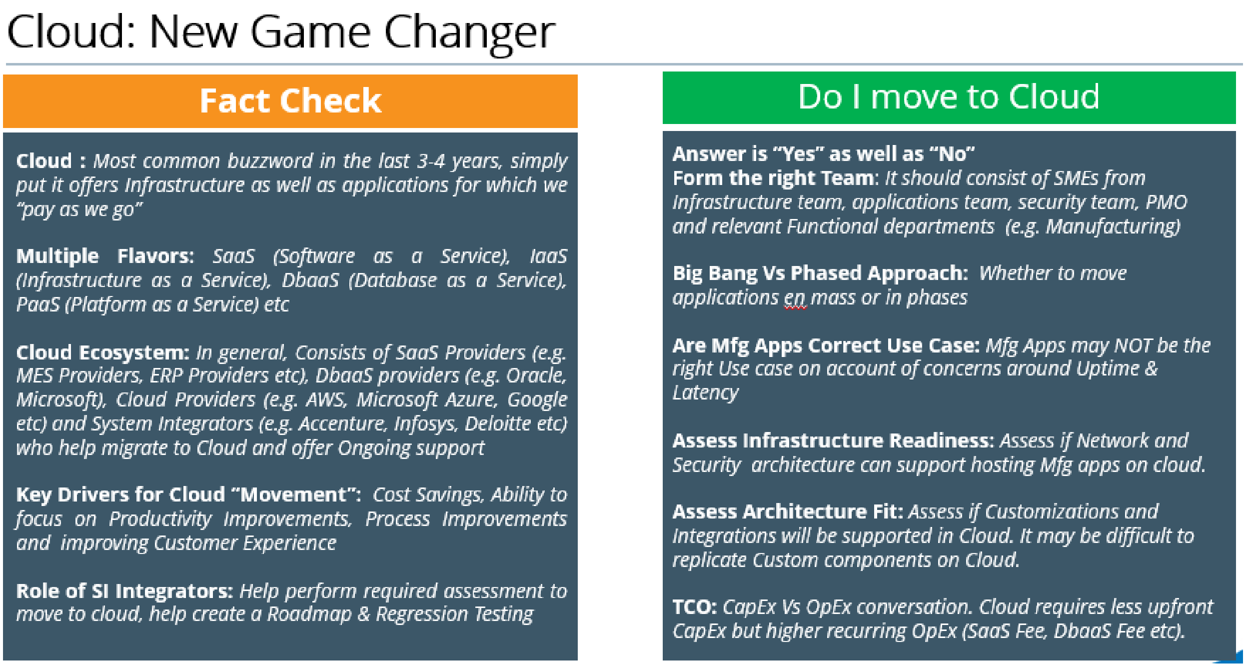
IoT & Big Data has caught a lot of attention in the last few years. Tons of data captured by machines on the shop floor, which otherwise went unnoticed, started to draw the attention of Data Scientists. Patterns could be identified and applied to improve operations on the shop floor. However, it takes a while to figure out how to leverage IoT and Big Data on the shop floor. The following section summarizes key points about IoT and Big Data.



This indicates IoT and Big Data hold a lot of promise for factories. However, we can unleash their true strength by choosing the right IoT platform, right SI partner, right Use Case and having a pool of bright Data Scientists. It may be called out that IoT and Big Data is relatively new areas, it's really challenging to find the right talent. The time required to reap benefits may be a bit longer as well.

7. CLOUD: NEW GAME CHANGER

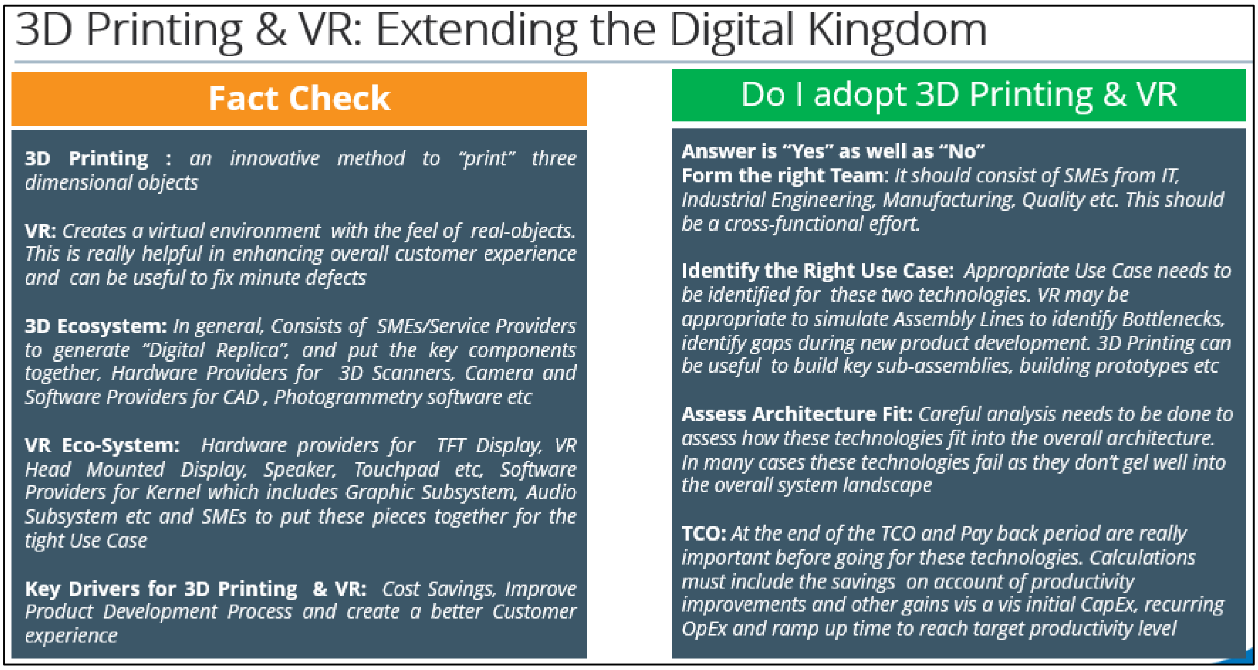
Cloud has dominated the conversation in the recent past. There is so much jargon around cloud, SaaS, PaaS, DBaaS, IaaS etc. Then there is a "public cloud", "private cloud", "hybrid cloud," etc. It can be really confusing. Then, there are questions around if we want to move applications to the cloud or our infrastructure to cloud and so on. The following summary attempts to answer many of these questions and provides a broad direction for cloud transition.



A detailed due diligence needs to be undertaken to assess if manufacturing applications can be transitioned to cloud. Moving manufacturing applications to the cloud may not be the best solution, especially when plants are in Asia and in Latin America. This is primarily because connectivity may be an issue when thousands of transactions are logged real-time. Any latency would not be acceptable. While assessing the Total Cost of Ownership (TCO) for cloud transition, it's a CapEx Vs OpEx conversation. If an organization will like to pay for upfront higher CapEx and lower recurring OpEx or they will go for low or no initial CapEx, but a higher recurring OpEx.

8. 3D PRINTING & VR: EXTENDING THE DIGITAL KINGDOM

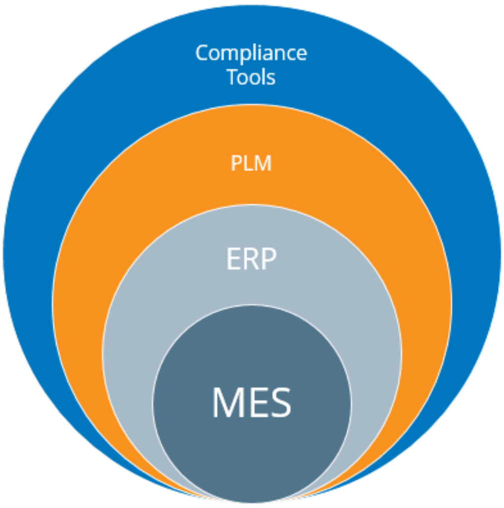
3D printing and Virtual Reality (VR) are another dimensions of the Digital Revolution. 3D printing, as a concept, has existed for decades. It has gained traction in the last few years.



Initially, these two technologies were relevant for very specific use cases. As mentioned in the above summary, they are now applied to a variety of use cases across industries. Organizations should start looking at them more as mainstream technologies rather than looking at them as technologies which are niche.

Before the Digital journey, organizations need to ensure that they have the required system architecture in place which to facilitate such a journey. Creating such a System architecture is a two-step process, getting the "Base" ready and then creating a "seamlessly" integrated ecosystem on top of the base. The following two sections describe these two steps in detail.

9. SECURE THE BASE



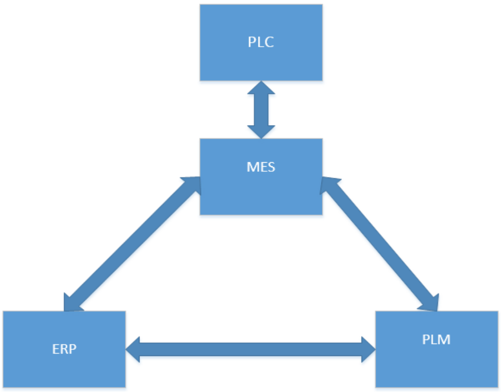
Three KPIs drive system architecture in factories:

- Efficient Transaction Processing, which drives productivity and target output (Efficient= minimum number of clicks/transaction, the minimum number of data entry/transaction & minimum latency to commit a transaction
- Total Cost of Ownership (TCO), which drives lower cost/unit
- Lower defects and traceability

Three pillars are to create a strong base:

- MES - Which supports efficient transaction processing, provides strong traceability, supports equipment integration, helps defect prevention, has attractive TCO and is scalable
- EBS - Which provides a platform for costing, consolidation, planning, financial & statutory reporting
- PLM - SKU creation and management

10. CREATE SEAMLESSLY INTEGRATED ECOSYSTEM



Create an integrated eco-system. The secure base integrated with industrial control systems to drive productivity improvements

- Automated transaction processing for multiple process steps
- Little or no data entry for the process steps automated
- Automated equipment status monitoring
- Automated product classification

Finally, it's important to keep in mind that quality is of utmost importance. The following section outlines the quality framework which will complement the Digital Architecture.

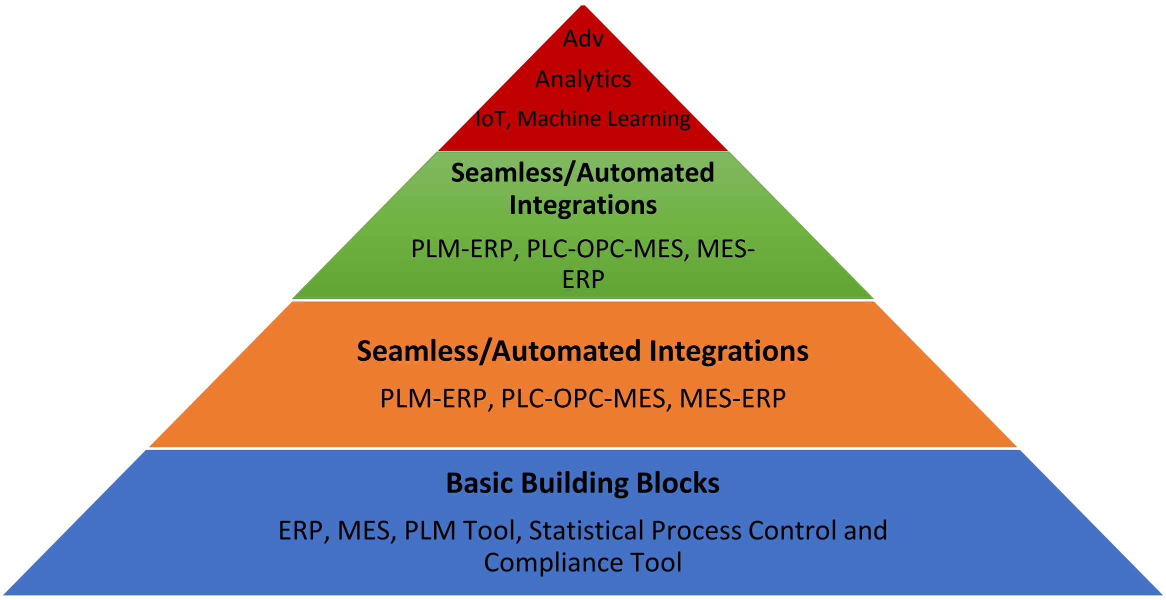
11. CREATE A QUALITY FRAMEWORK FOR DIGITAL JOURNEY

Defect Analysis & Resolution: Get to the root cause through 5 Whys, 8D, Fishbone diagrams etc., and apply a permanent fix. Organizations may consider a packaged quality module vis-a-vis a homegrown quality application

Statistical Process Control: Alerts occurrence of Out-of-Spec (OOS) or Out-of-Control (OOC) events to facilitate corrective actions. Organizations may leverage built-in SPC module that comes with MES a specialized SPC package.

Defect Prevention & Continuous Improvements: MES provides a platform to put in place checks and balance to prevent defects. Problem Solving is the key to continuous improvements

12. PUTTING ALL THE PIECES TOGETHER



The following paragraph summarizes a typical multi-phase approach for setting up a smart factory:

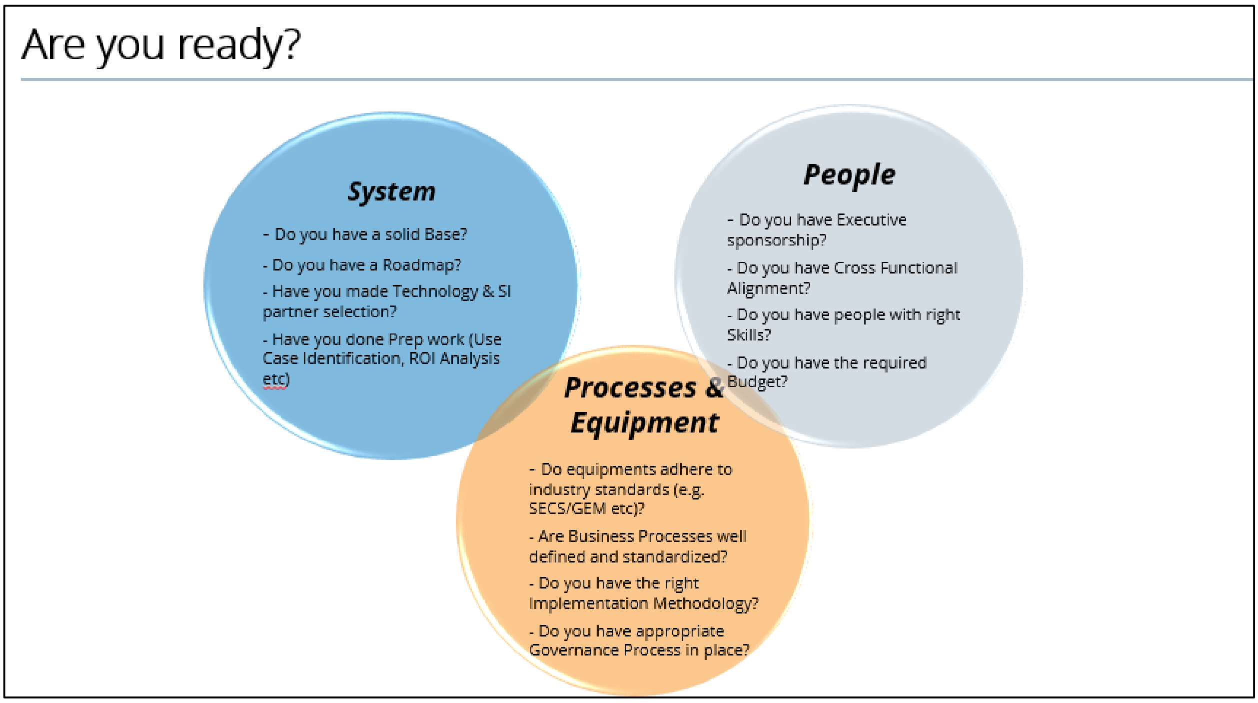
Phase-I: Secure the Base-Implement packaged Enterprise Resource Planning (ERP), Manufacturing Execution System (MES) & Product Lifecycle Management(PLM) product and build basic integrations.

Phase-II: Create a seamlessly integrated ecosystem with MES integrated with Industrial Control System-PLC on one hand and with ERP system on the other hand. PLM tool integrated with EBS

Phase-III: Introduce robots for process steps justifying ROI.

Phase-IV: Advanced analytics in terms of implementing use cases on IoT platform leveraging machine learning etc.

13. ARE YOU READY?



The following are essential considerations as an organization start their digital journey

13.1 System

- Do you have a solid base?
- Do you have a roadmap?
- Have you made a technology & SI partner selection?
- Have you done prep work? (Use case identification, ROI analysis, etc.)

13.2 People

- Do you have executive sponsorship?
- Do you have a cross-functional alignment?
- Do you have people with the right skills?
- Do you have the required budget?

13.3 Processes & Equipment's

- Do equipment adheres to industry standards? (E.g. SECSGEM etc.)
- Are Business Processes well defined and standardized?
- Do you have the right Implementation methodology?
- Do you have an appropriate governance process in place?

14. CONCLUSION

Building a smart factory is a journey which can take years. There should be a clear vision, well laid out & phased approach and executive sponsorship to make this happen. There should also be an appetite to accept a longer wait period to see the results. All in all, it can be summarized using the saying "no one told you that it's going to be an easy journey, but definitely it's going to be worth your effort."

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APPENDIX

ROI : Return on Investment
MES : Manufacturing Execution System (Shop Floor Transactional system where the operators log the process steps, material consumption etc)
ERP : Enterprise Resource Planning (OLTP-Online Transaction Processing system; Oracle, SAP etc)
PLC : Programmed Logic Control (Industrial control system which controls the actions/movement of equipment through Ladder Programming)
OPC : Open Platform Communications (Middle Layer between MES & PLC)
PLM : Product Life Cycle Management (Item Hub)
IoT : Internet of Things
FG : Finished Goods
WIP : Work in Process
SKU : Stock Keeping Units
BOM : Bill of Materials
UAT : User Acceptance Test
MW : Mega Watt (Measure of Energy generated)
WO : Work Order

