
Tech Mahindra
Tech Mahindra POV
5G Implications for Industry 4.0:
IIOT & IOT in Manufacturing
Connected World. Connected Experiences.

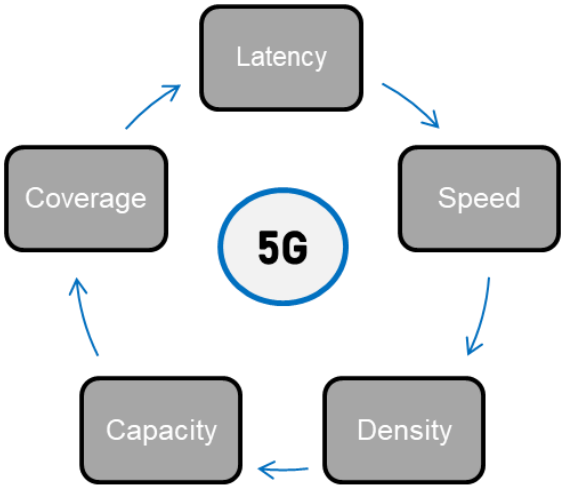
Introduction

Global manufacturing is modernizing and adopting Industry 4.0 and Smart Manufacturing in their factories. The new factories of the future are being envisioned to deliver innovative old and new smart products to satisfy and service demanding customers across the globe. These factories shall depend on extended global supply and local chains and manufacturing. Digital and manufacturing transformations are being pursued to enhance competitiveness, increased service revenue and servitization of manufacturing to improve profits. This change depends on exploiting the rapidly evolving new technologies, Cyber Physical Systems, robust state of the art ICT networks connecting all customers, assets, design, manufacturing, suppliers participating in the global value chain.

Another very important caveat is Cyber Security for 5 G networks and deployments is a given (Indispensable) especially when factories of the future envision managing complex chemical and biochemical processes in real time. The nature of cyber threats is very real, complex, malicious, by state and private actors and need to be addressed at the very inception of the implementations. Though many Telecom participants are hyping 5-G; the standards are not yet established and proven out. This is a serious concern in the context of the US President's National Security Telecommunications Advisory Committee told him in November2018, *"the cybersecurity threat now poses an existential threat to the future of the Nation."*

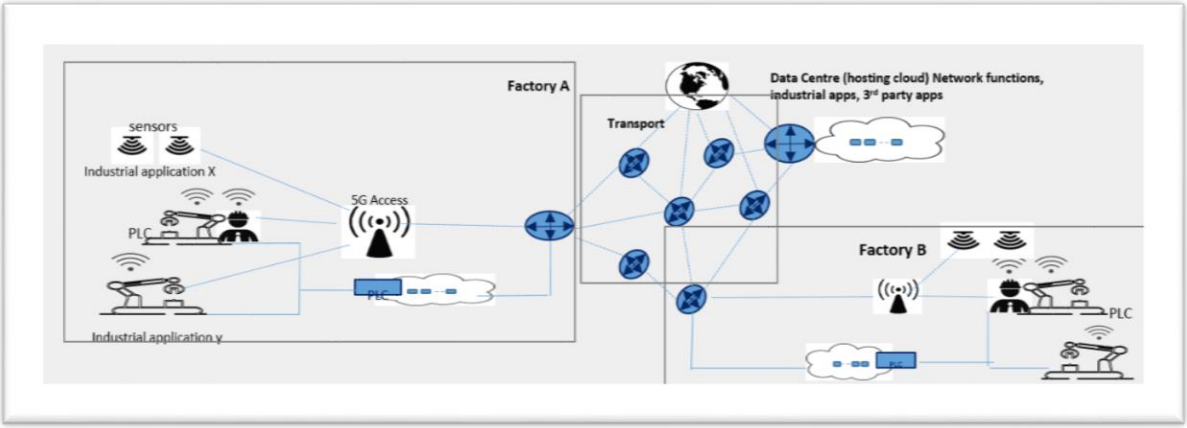
The advent of 5G wireless communications promises to be a key accelerator for driving and enabling the manufacturing in factories of the future across the value chain. 5G technologies are slated to deliver a powerful unified communications and command platform for the desired manufacturing ICT networks to connect the Cyber Physical Systems in real time and with large bandwidth performance. This drives unprecedented new use cases, applications; business models to transform; manufacturing, monetize and deliver services and reap benefits

5G promises benefits in every key aspect for manufacturing



"5G technologies have the potential to amplify and accelerate the ongoing manufacturing transformation, and to unlock a next level of efficiency gains in manufacturing" - "5G-PPP"

Deploying 5G technologies entails global commercial service providers supporting new digital platforms, in cities, factories, and across the globe with 5G technologies that will provide seamless communication between the connected enterprise, connected factory, connected products and connected infrastructure while embedding CPS in all devices, products, and support extensive digitization and product servitization. IIoT, IoT and CPS systems powered by 5G technologies will be fully operationalized to realize the full potential of the factories and value chains.



5G Enabled Smart Factory Scenario

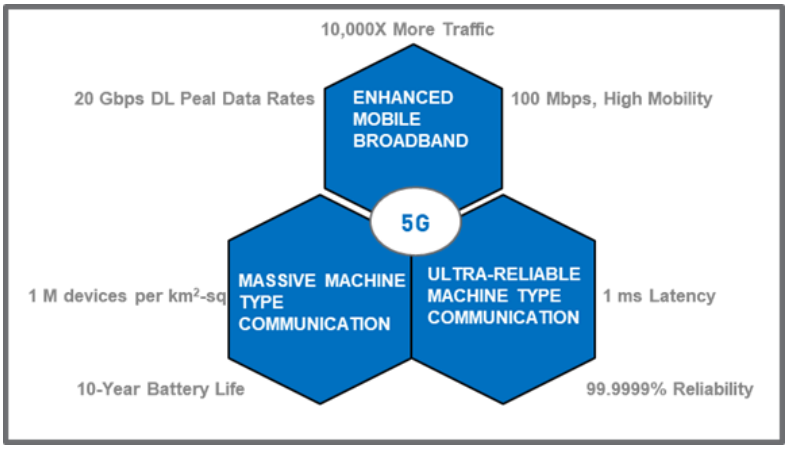
5G presents great advances to speed up manufacturing transformation to accomplish innovative, sustainable enterprises and factories as envisioned by Industry 4.0 & Smart manufacturing initiatives to realize an agile, flexible, reconfigurable, adaptive, scalable and safe integrated manufacturing eco systems.

Factory automation will become easier where 5 G networks used by autonomous vehicles including fork lifts, AGV's, to track and deliver materials, automation and machinery embedded with small, inexpensive, low power sensors and edge devices for product & process monitoring and quality. Pervasive networking of all humans and sensors and machines contributes to real time inventory management & visibility thus reducing waste and time and achieving MUDA. Remote maintenance and diagnostics of all plant machinery and equipment becomes very rapid with 5G connected factory for trouble shooting and predictive maintenance. Additionally, to manage and realize the following:

1. Real time Edge Analytics, & Big Data Analytics (Operational, Maintenance & SCM)
2. Carbon footprint reduction
3. Automation & Energy conservation
4. Data & knowledge sharing, collaboration in large enterprises and factories
5. Monetization of Product and Services

Three main 5G basic core services are as follows:

1. Extreme mobile broadband (eMBB) will provide high bandwidth up to 20 Gbits of data from the end users towards the network. The user plane latency shall be below 4 ms.
2. Ultra-reliable and low latency communications (uRLLC), or critical machine type communication, requires a user plane latency of less than 1 ms.
3. Massive machine type communications (mMTC), will allow to connect to one million devices per km^2 with the given quality of service (QoS).



Source: National Instruments

5G will likely trigger, a very rapid growth in Internet of Things (IoT), IIoT, Streaming media, Robots, Drones, Autonomous vehicles and immersive virtual reality (VR) simulations. In manufacturing it will hasten rapidl monetization, servitization and shorten product and manufacturing life cycle times. 5G also facilitates horizontal and vertical integration coupled with the convergence of IT&OT systems in manufacturing and the Factories of the Future to benefit from seamless data access in real time for actionable and proactive decision making and process optimization

The 5G infrastructure will comprise hardware and software with features like Dense networks, Network Slicing, Network Virtualization to ensure the following:

a. *Real time performance of time-critical process optimization for productivity and quality(low latency)*
b. *Higher network speed for remote maintenance, monitoring, and control resulting in optimal operations.*
c. *Large Bandwidth for real time streaming; for AR/VR & Video streaming*
d. *Dense network connectivity for pervasive sensorization etc.*

The above enables seamless intra-/inter-enterprise communication for Intelligent & Connected products, and finally to monetize new value-chain added services.

FOF – 5-G Network Infrastructure Elements

It is imperative for Industry 4.0, & Smart Manufacturing, to adopt the platform strategy and a data exchange strategy to achieve data ingestion, translation, transformation, aggregation, orchestration, to support the business model with end-to-end integration.

Modern high-speed automation and machinery are very sophisticated and can communicate in real time. The need for speed, bandwidth and a robust ICT network is necessary to realize new seamless manufacturing with complete visibility, flexibility and productivity.

Use-Case Category	Scenario	Impact
Time-critical processes	• Real-time, closed-loop robotic control • Video-driven machine-human interaction • AR/VR for maintenance & training	Increased efficiency & yields; safety
Non-real-time processes inside factory	• Tracking products & machine inventory • Non-real-time sensor data • Remote inspection & diagnostics	Optimized management of production facilities
Enterprise communication	• Logistics & warehousing • Employee & back-office communications • Tracking goods post-production	Improved business operations

Source: Heavy Reading, adapted from 5G-PPP "5G and the Factories of the Future"

Architecture Overview

The 5G enabled factory of the future will comprise of the following architecture elements comprising of 5G Sensors, Modems, Base Stations, IIOT Edge Gateways and Network Elements, Network Operating systems. SDN will augment virtualization, Network Slicing etc. to support high bandwidth real time factory connectivity and interoperability within and with remote devices and locations.
It is possible to deploy advanced networking techniques to adapt to different needs from different devices, such as Mesh Networks, point to point network, or a combination of networking strategies to provide failsafe cyber secure 5G network capability and performance. 5G network gateways can also contains storage and processing resources, with edge cloud services to the connected devices.

The modern factory of the future is made up a wide variety of automation equipment, Machinery, Tools, Robots, PLC's, Computers, Embedded microprocessors, RFID.

devices, 5G enabled intelligent digital, analog, sensors, actuators, in addition to conventional network field busses and legacy automation. Some of these devices are sophisticated that they can internally compute and communicate in real time; they consume and produce all kinds of data from control bits, process parameters, process data, calibration data, maintenance data, faults and production data!

The proposed new 5G features are very pertinent to the connected manufacturing enterprises and factories of the future being concepted and planned:

- Time Sensitive Networking for determinism & time critical applications has emerged as a unifying baseline priority for IIOT
- Realtime machine learning and artificial intelligence (AI) – analytics for making the networks self-optimizing and secure
- 5G NR – a new radio interface/access with large bandwidth, very high data rates, with very low latency, ultra-high reliability and availability
- Virtualization with Network slicing to provide dedicated virtual networks with customer-specific functionality
- Distributed Cloud – this enables placing of workloads closer to the edge for better QoS such as latency

5G networks will evolve to be the foundation communications fabric, to connect seamlessly and to manufacture at the "edge of the network" and share live communications with a local or worldwide community of customers and suppliers. Support for "digital twins" across the enterprise and customer value chain, coupled with products embedded with 5 G communications chips in devices and appliances like a Microwave etc., where the edges can self-organize a semi-autonomous network for live customer interaction.

Use cases

a. Smart Manufacturing with 5 G enabled automation, sensors, tracking devices vision devices, and connectivity coupled with increased distributed intelligence on the factory floor to facilitate mass customization, efficiency optimization, global value chain streams, and knowledge sharing, etc.
b. Autonomous guided vehicles (AGVs) powered by 5G will use real time networks to deliver materials within the factory as they're needed either asynchronously or synchronously on demand or just in time and sequence. Ubiquitous communication needed for the enterprise; supply chain, and customers networks to monitor supply replenishment and shipping finished products.
c. Machine condition monitoring, distributed sensing etc., with 5G Network wireless sensors on processes and machinery will not only be monitoring operating parameters like set points like pressures & temperatures, viscosity, vibration and sound, but will also be enhancing process control, edge analytics and prescriptive maintenance, alerts etc. in the factory.
d. Smart equipment will communicate with each other as well as other related parts of the processes enabling closed-loop control systems that need to work reliably and in real time to support Analytics
e. 5G bandwidth enables workers to wear Augmented (AR) Devices to see Realtime information layered on top of the live equipment and processes, so they can monitor and control actively to optimize / repair machines and processes
f. Infrastructure modernization, virtualization and decentralization by the integration of a mobile communication using 5G, network slicing, eMBB, uRLLC and mMTC to support next generation 5G wireless architectures resulting in good Signal to Noise ratio for very low interference and robust connectivity, which reduces expense and physical maintenance.

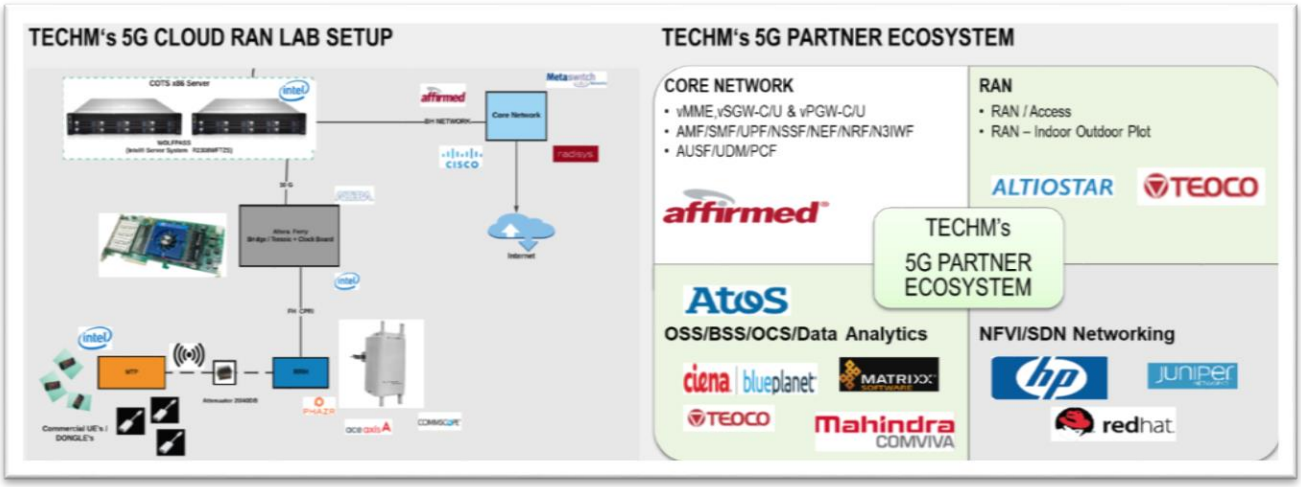
g. Growth of 3D printers at retail and mass market gives rise to collaboration, creation, integration and assembly of products near the customer. User communities and developers collaborate on 5g networks to add value and support manufacturing

h. The integration of the supply chain between the FOF, Distribution Centers and Customers is enabling the visualizing and managing complex chains to attain JIT/JIS and prevent disruption

Conclusion

5 G technologies will spur innovation over and above merely improving communication latency and bandwidth; soon it will enable open interoperability, from the edge to the enterprise sits) This eliminates the need for siloed solutions to help bridge FoF needs; with an extremely virtualized enterprise and internet platforms for connecting thousands of applications. As 5G-NR technologies evolve and mature with intrinsic security; the virtualization, containerization, API capabilities; are going to assure that these new applications function and interface more easily and efficiently.

To get started on the 5G journey for Manufacturing, TechM has set up a 5G lab in US & India to help our customers start realizing use cases.



Acronyms:

(Muda) is "futility; uselessness; wastefulness", and is a key concept in lean process thinking, like the Toyota Production System (TPS)
Extreme mobile broadband (eMBB).
Ultra-reliable and low latency communications (uRLLC),
Massive machine type communications (mMTC)
Acknowledgements & References:

5GPPP Architecture Working Group, "View on 5G Architecture."
[Online]. Available: https://5g-ppp.eu/wp-content/uploads/2018/01/5G-PPP-5G-Architecture-White-Paper-Jan-2018-v2.0.pdf

A 5G Architecture for The Factory of the Future
Stephan Ludwig_, Michael Karrenbauery, Amina Fellany, Hans D. Schotteny, Henning Buhrz, Savita Seetaramanz, Norbert Niebertz, Anne Bernardyx, Vasco Seelmannx, Volker Stichx, Andreas Hoell{, Christian Stimming{, Huanzhuo Wuk, Simon Wunderlichk, Maroua Taghoutik, Frank Fitzekk, Christoph Pallasch__, Nicolai Hoffmann__, Werner Herfs__, Elena Eberhardtyy and Thomas Schildknechty
National instruments white paper
Nokia Images 497778-new-value-architecture-weldon-nokia-brooklyn-5gQualcom
5G New Radio: Introduction to the Physical Layer
White Paper "5G and the Factories of the Future"
© 2015 authors of this paper 1 of 31
Source: Roland Berger

Thank You

Visit us at www.techmahindra.com