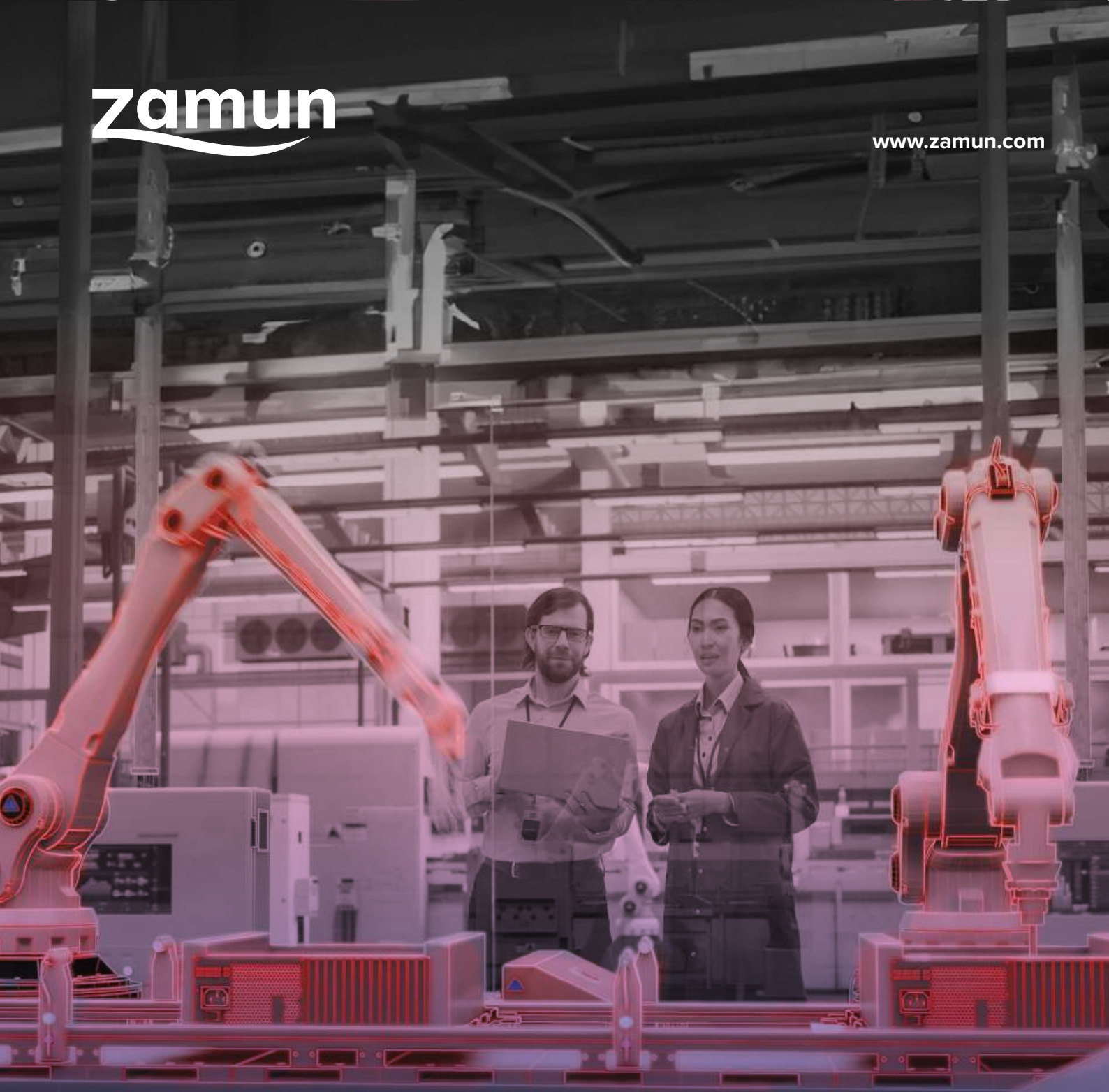

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Wired to Win

Wireless, Cloud, Networking Technologies for Elevating Indian Manufacturing

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Business

Whitepaper 2024-25

What to expect inside

Network tech helps capture great manufacturing opportunities

.. and there's a stepwise way to choose it wisely

The world of manufacturing is going through some major transformations, across business and technology drivers which are creating fundamentally new opportunities. The pandemic was a major game changer. Initially, there was a manufacturing slowdown, then accelerated focus on digital connectivity. There is also a shift in global sourcing strategies with many countries going for the "Make here" incentive programs, data hosting in-country and non-dependence on China.

Consequently, India has set an ambition of increasing the manufacturing sector's contribution to 25% of GDP[1], up from 13% today[2]. This is supported by 'Make in India', that has led to nearly $0.45 trillion in exports[3] at 6% growth during FY23. Now large and small manufacturing setups will need a networked environment to deliver this growth. A careful choice of technology approach should identify relevant trends, set KPIs and work out a suitable networking technology stack. With the advent of autonomous systems, a substantial advancement in technology maturity is seen, moving beyond pre-programmed functionality, towards intelligent machines capable of learning, adapting, and operating within complex environments[35]. There is also the need to develop talent, with skills in cloud and AI technologies, enable data capture and governance and set an approach for better future readiness.

We propose a stepwise TASK-ICAN approach to ensure the right return on technology investment. The need is to first define the TASK at hand – by tracking technology implications, articulating ambition, setting stack specification and keeping KPIs well-defined. These metrics drive the right choice of ICAN: digital instrumentation, connectivity, collaborative applications and networking technologies.

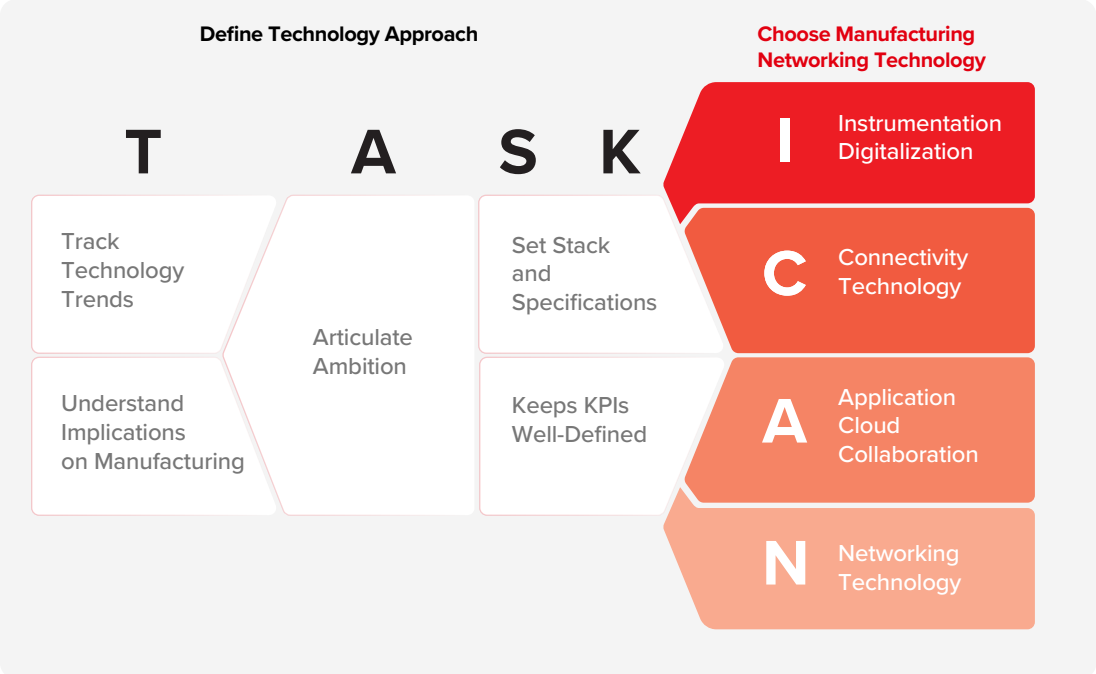


Figure 1: Manufacturing Networking Technologies

Indian Manufacturing sees Unprecedented Opportunities

and some surmountable challenges

"The PLI scheme is not to make the beneficiaries dependent on government services but can be utilised as **a boost in the manufacturing sector, an initial support** for the long journey ahead. Ultimately competition will prevail,"

Piyush Goyal
Commerce and Industry Minister, India

The Indian Manufacturing sector is experiencing five key trends, driven by global shifts, historical constraints and growth ambitions. The focus on global trade, specialization, connectivity, and distributed supply chain has led to interesting implications:

1. **Geopolitical concerns** about supply chain access and local manufacturing jobs. Growth ambition and opportunity for the Indian has been shaping policies.
   a. **'Make here' policies** such as 'Make in India' – with incentive schemes, like India's PLI[4], for land availability, tax holiday, and export promotion.
   b. **China +1 policy** for supply chain non-reliance. China's Zero-Covid Policy had shot up lead times, forcing the US and Europe to look at India as an alternate source. India's advantage is its young population[5], albeit with low skills[6].

2. **Environmental and sustainability concerns.** As the world focuses on SDGs, Sustainable Development Goals, the manufacturing sector is held responsible for lifecycle emission control and living conditions.
   a. **Moving factories away** from urban centres. Industrial relocation policies, such as the 1999 Supreme Court mandate to shutdown Delhi factories, aim to combat pollution.
   b. **Measuring and eliminating emissions** and carbon credits. Migration to decarbonization, renewables, and new digital ways of working accelerate the net-zero transition. To achieve the Paris Agreement's 1.5°C limit for global temperature increase, emissions need to drop by 45%[7].

3. **Faster customer needs evolution.** In a hyper-connected world disruptive tech is released daily and digital distribution has accustomed people to updates.
   a. **Shorter product lifecycles** – faster obsolescence, disposal, reusability and recycle concerns create time pressures to deprecate products with less opportunity to learn and amortize costs.
   b. **Shorter new product development cycles** – faster prototyping and testing have reduced time to market to 42 weeks in 2021, going to 29 weeks in 2026[8]. (Figure 2)

4. **Manufacturers are looking for business metrics,** not just technical specifications to deliver Return on Investment .
   a. **Tech companies are delivering business metrics** that impact business. For e.g. Slack offers KPIs of increasing awareness, customer growth, and sales pipeline[9] .
   b. **Manufacturers are asking tech providers to commit outcome SLAs** like production cost per unit, reduced cycle time, and not just tech SLAs like link uptime. A two-wheeler manufacturer that produces a vehicle every 20 seconds, has asked for an SLA for productivity enhancement to 15 seconds per vehicle.

5. **Lack of data and technical talent** leads to slow adoption of high-end AI use cases. According to a McKinsey report, India could face a potential skill gap of specific technical skills of 85-90 million workers by the year 2030. Increasingly, 1/3rd of manufacturers are investing heavily and actively using AI[10].

Given these trends, Indian Manufacturing sector leaders need to invest in technology and talent to overcome environmental concern, speed up development and deliver on business RoI.

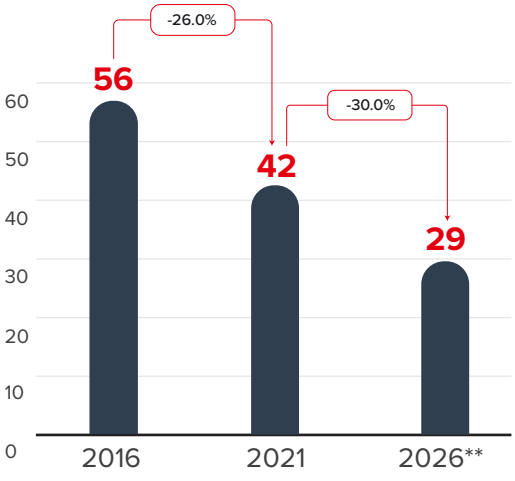


Figure 2: Time to market in weeks

Technology is driving Performance through Learning Methods

.. and by creating faster decision and better controls

"A very tangible benefit in engineering and design is reduced cycle time for design iterations,"

"AI speeds up the process by homing in on the specific parameters that you need to focus on. We've had design cycles being cut from 12 months to less than six months. That's an easily quantifiable benefit."

Gunaranjan Chaudhry
Director, Data Science, SymphonyAI

- Manufacturing has always led in the usage of technologies such as SCADA. Today, technology is driving efficiency, productivity and sustainability across OT and IT. As 93% of the industrial manufacturing industry has started using AI[11], it has become the top adopter of AI.

- Smart, connected products require a new "technology stack" made up of new product hardware, embedded intelligence, connectivity, cloud software, security tools, a gateway, and integration with enterprise systems[12].
- Manufacturing efficiency requires new production methods and R&D with live inventory view and real-life prototyping. These are supported by enhancements in the Manufacturing Performance Layers and the Learning and decision layers. (Figure 2)

Manufacturing Performance Layers

- **New Materials**. The industries of Energy generation and storage, Aerospace & Defence, Medical and Biotechnology, and Automotive and Transportation are leading the use of new-age and lightweight materials, such as composites, ceramics, advanced aluminium alloys, and performance alloys[13].

- **New Manufacturing Technologies.** 3D printing helps visualize, develop and produce fast. India's 3D printing market revenue will grow at 20.3% CAGR from $111 million in 2022 to $705 million by 2030. The U.S. market was estimated at $4.46 billion in 2022 and expected to grow at 15.7%[14].

Learning and Decision Layers

- **New Digitized Sensing Technologies and Precise Controls** can digitally measure temperature, pressure, location, etc. AGVs (automated guided vehicles) and AMRs (autonomous mobile robots) are becoming prevalent in warehouses to remotely handle tasks such as picking, packing, and transporting goods, without infrastructure modifications, leading to improved accuracy with less staff. India's robot density is 148 per 10,000 employees and can grow to China's level of 772[15].

- **New Analytics and Simulation**[16]- 29% of global manufacturing companies have implemented digital twins driving future market growth at 42.6% from US$9 billion in 2022 to US$137 billion by 2030[17].

- **New Judgement and Decisioning** – AI's first use cases[18] are in Predictive Maintenance, R&D[19], then automated factory control[20]. An early adopter is the semiconductor industry, where about 1,000 specialists are needed to manufacture a GPU. Now Nvidia has developed an AI system, co-designed by chip design companies Synopsys and Cadence, that aims to accelerate production by speeding up the engineers' work[21].

Collectively this group of tech trends are known as Factory 4.0 – enabling connectivity, visibility and automated decisioning across the supply chain. Industry 4.0 has led to increased integration of IT and OT. While this improves efficiency, it also creates new cybersecurity challenges for manufacturers[33] as Learning Layers expose Performance Layers to open networks. Many manufacturing systems still rely on legacy OT infrastructure, which may lack robust security features. Organizations must address these challenges to build a resilient OT security program.[34]

The Next evolution of the Manufacturing Technology is Industry 5.0 – a fully integrated low latency human-to-machine collaboration, enabled by the current advances in automation and Generative AI.

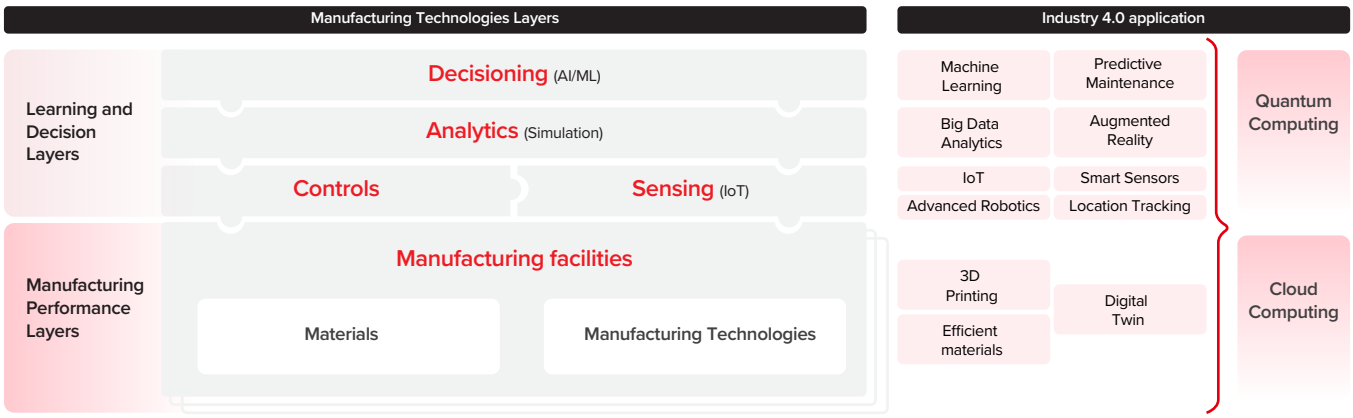


Figure 3: Manufacturing Technologies and Industry 4.0

Implications of Trends on Manufacturing Connectivity

"Everyone in **manufacturing is excited about AI,** but relatively few are using AI at scale to transform the way they work."

Philippe Rambach
Chief AI officer of Schneider Electric

Beyond driving India's growth ambitions of 25% these trends require an environmentally and humanly responsible approach, while handling talent and skill shortage[22]. Connectivity and cloud solutions, come to the rescue for manufacturing companies if they strategically choose a desired level of maturity to avoid reckless expenses and management complexity.

There are 4 levels of maturity, with increasing value beyond a Standalone facility, that has disconnected devices. Expectedly, they require higher hardware, software and talent investments. The key is to identify the level of maturity that gives the highest ROI. These level of maturity are (Figure 4)

1. **Connected:** Business processes and OT (Operating Technologies) are reflected in IT systems and data processing systems for smoother manufacturing and logistics operations across:
   a. All machinery and plants for process implementation
   b. The vendor and distributor ecosystem for collaboration

2. **Visible:** The visibility of metrics from sensor and controls data helps real-time awareness, running controls remotely, improving product development, supply chain and customer interactions. A "digital twin" can be created to visualize what is happening.

3. **Predictable:** Pre-fitted models are used to calculate future event likelihood to predict machine maintenance, quality issues, demand trend analysis, supply chain roadblocks, and operational downtime.

4. **Autonomous:** Data is used to automatically train AI models, enhance decisioning logic and help in maintenance, product design and development, optimization and many other advanced use cases. (Figure 5)

As Manufacturers go up the technology maturity curve, they deliver products and services more efficiently, and fare better than their competition in the market.

Increasing technology maturity fundamentally relies on connecting more layers of devices with programming. The following diagram shows how technology maturity increases by a high level of connectivity and starts to deliver higher benefits.

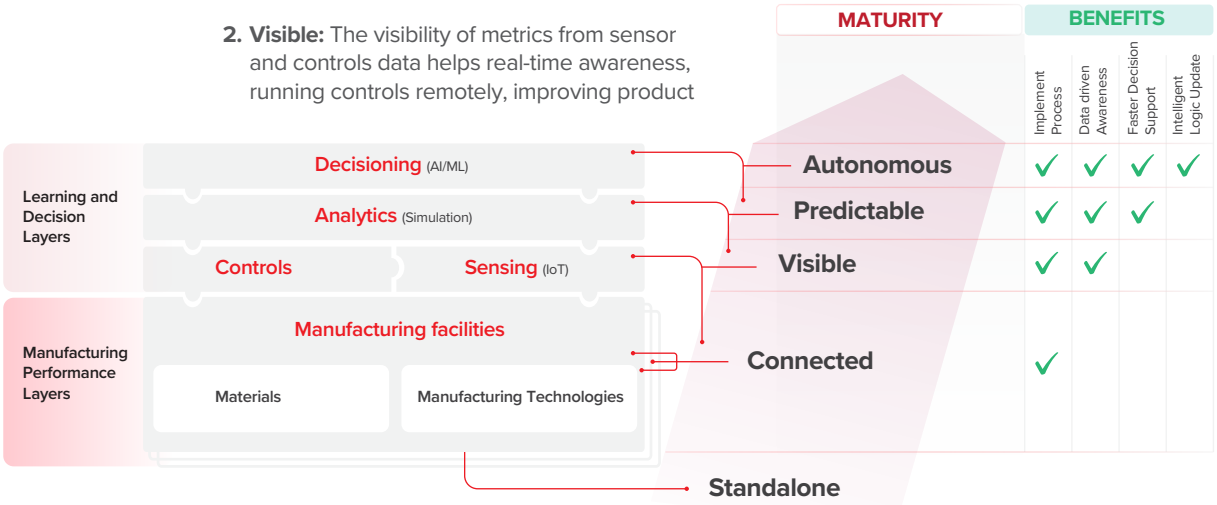
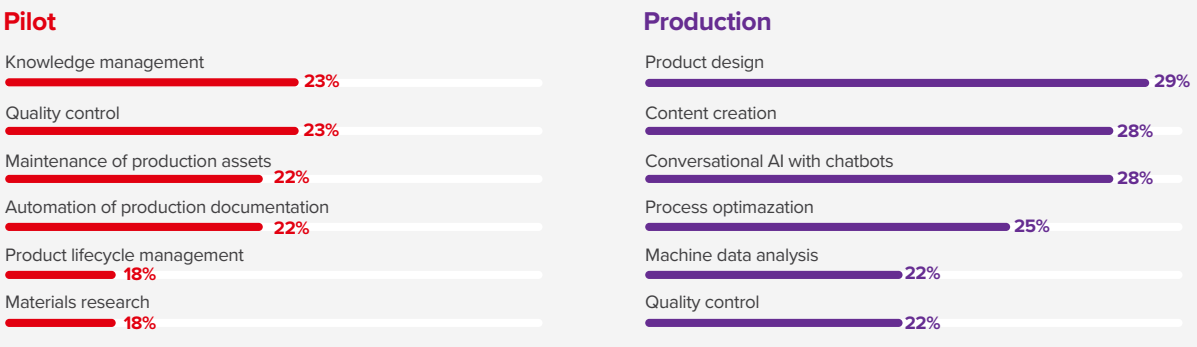


Figure 4: The 5 Stages of Technology Maturity

Respondents rated top use-cases currently in pilot and production stage



Source: MIT Technology Review Insights Survey, 2024

Figure 5: Top AI use-cases in pilot and production

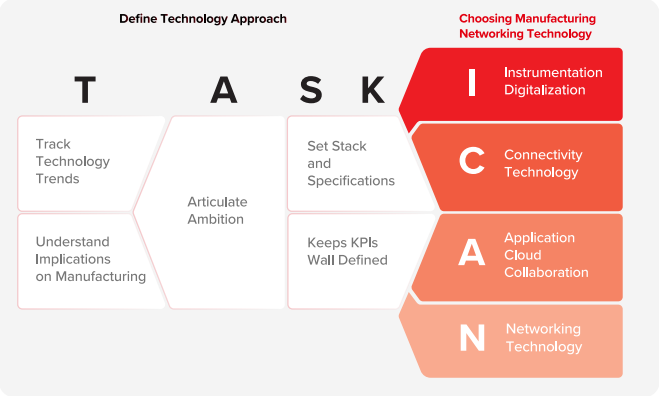
Choosing the Right Tech Stack

Given the desired technology maturity companies must elegantly make a choice of the technology stack they will deploy in a stepwise process. The TASK-ICAN approach starts with having a good understanding of your environment and ambitions. It starts with making sense of trends from your company's perspective.

Track Technology Trends in the context of how industry leaders and competitors are using them. Start with **Defining your Industry Manufacturing Complexity** along 4 core areas:

1. **Method of Manufacturing**
   - **Discrete vs. Continuous vs. Job-shop.** The nature of your process defines the focus on speed, quality and changeovers. (Figure 6)
     - Discrete or Batch Processes need speed of change to reduce downtime during process changes.
     - Repetitive or Continuous processes need to boost the throughput of high-volume consistent, repeatable production lines.
     - Job-Shop Processes are highly specialized or small batch-runs –focused on high quality, performance-sensitive work, at lower throughputs. They are prevalent in R&D, Process Development and Premium products.
   - **Volume and Consistency of demand.** In high demand and low margins situations, the need is non-stop production. With cyclicality in demand of product lines, the focus will move to switch-overs. For e.g. An E-bike manufacturer needs 99.9% uptime to meet its consistently high demand.

2. **Dynamism** of customer needs changes prioritization and can happen due to three primary reasons:
   - **Regular business cycles,** such as hour-of-day, month-end, year-end. These lead to change in focus from converting sales, supply chain inventory integration to closing of books with auditors.
   - **Product and technology release cycles –** As new versions get released, the production line has to be reoriented and many new steps are added potentially every week or month.
   - **Introduction of disruptive technologies –** such as mobile commerce, GPS-tagging, visual AI analytics, can create new data streams that need to be prioritized.



3. **Spread** of Manufacturing setup, has a deep impact on the choice of technology.
   - **Measurements of different metrics** through sensors, cameras and controls
   - **Size and distance of facilities** can vary due to input costs, supply lines, process complexity and regulations
   - **Mobility requirements.** Discrete, job-shop processes and supply movements need data from mobile devices
   - **Multiplicity of locations and production lines.** Larger companies need to aggregate multiple lines and locations working in sequence or in parallel.

4. **Collaboration** of Manufacturing Ecosystem is between the company, its Supply Chain and Distribution partners to drive productivity and customer service.

Articulate Ambition based on the understanding of manufacturing complexity and technology trends. The maturity levels can range from Standalone, Connected, Visible, Predictable to semi or fully Autonomous. In the context of manufacturing, an autonomous system is an entity having the capability to control the execution of its plans and strategies and the ability to recover without modifying scheduling. It can structure its own action and environment independently, without needing any external influence[36].
The 4 technology elements are a) connections across different lines, factories or companies, b) digitalization of sensing data, c) precision, automation of controls, d) analytics and simulation of manufacturing environment, and e) AI/ML based judgement and decisioning required.

One example of how manufacturing methods can create different levels of desired technology maturity is shown below:

Manufacturing Methods	Technology Maturity Levels			
	Connected	Visible	Predictable	Autonomous
Repetitive or Continuous processes	• Scada Integration	• Energy Management & Distribution • Video Assisted Application • Industrial Sensors • Process Monitoring	• Predictive maintenance • ML for quality analytics • Process Automation • AR/VR enabled Collaboration	• Autonomous material handling using AMRs or AGVs
Discrete or Batch Processes	• Factory Floor Connectivity • Product Lifecycle Management (PLM)	• A digital twin to manage assets • Asset, inventory management • Product Design Management • Video Assisted Application • Remote Plant Monitoring/Visibility	• Predicted Maintenance cycles • AR/VR enabled Collaboration	• Automated Product Quality Management • Assisted Assembly
Job-Shop Processes	• Collaboration • Design Management	• "Smart Product" Development • AR/VR enabled Collaboration		

Figure 6: Methods of Manufacturing impact Desired maturity

Set Stack and Specifications. Manufacturing organizations need to formulate the technology stack levels based on the chosen technology maturity, across the 4 technology elements. We are trying to answer these basic questions on tech stack and specifications based on the ambition. Here's how Manufacturing Complexity can impact a company's Technology need:

Complexity Dimensions		Technology Need	Tech Metrics	Basic question it answers
Method of Manufacturing	Discrete vs. Batch vs. Job-shop	Multiple iOT measurements	**a. Uptime**	How often is connectivity needed (Active / overall time)
	Volume and Consistency of demand	Non-stop production	**b. Reliability**	Variation in availability, no jitter (needs spectrum diversity)
Dynamism of customer needs	Regular business cycles	Ability to prioritize and change fast, without physical visit	**c. Agile Prioritization**	How much variability is expected in use cases priority with No click provisioning
	Product and technology release cycles	Connectivity with design partners	**d. Secure Cloud**	How secure should the data transfer been against vulnerabilities
	Introduction of disruptive technologies	R&D connectivity with academia		
Spread of Manufacturing setup	Measurements of different metrics/dimensions	Visual (high bitrate) Two-way communication	**e. Bandwidth** **f. Backhaul**	How much data needs to be downloaded or taken back across concurrent channels (Backhaul = Upload)
	Size and distance of production facilities	Large Area, Long distance connectivity	**g. Coverage**	How secure should the data transfer been against vulnerabilities
		Connection with many devices in a dense area	**h. Device Density**	How many devices per area, with concurrent active connection
	Mobility requirements of data capture	Moving materials to measure Robots and moving controls	**i. Mobility**	How much do data providing sensors move
	Multiplicity of locations and production lines	instantaneous long-distance communication	**j. Latency**	How quickly we want to see response across long distance locations
Collaboration of Manufacturing Ecosystem	Supply Chain	ERP, production collaboration	**k. Cloud Collaboration**	How often is connectivity needed (Active / overall time)
	Volume and Consistency of demand	Logistics, Marketing collaboration tools		

And here is an example of selecting the right maturity level for a few technology metrics:

Example Tech Metrics	Connected	Visible	Predictable	Autonomous
b. Reliability	Three-nines	Four-nines	Six-nines	Six-nines
e. Bandwidth	1 – 10 kbps	10 kbps – 10 mbps	1– 25 mbps	1– 100 mbps
h. Device Density	1,000 – 10,000/km²	~100,000/km²	~100,000/km²	~100,000/km²
j. Latency	<100ms	<30ms	<10ms	<5ms

Keep KPIs Clear. Given the time and cost investment, business and technology teams should define metrics such as production volume, timely delivery, etc. to connect tech with business ambition. Some metrics for regular review:

- Production efficiency
- Supply chain response times
- Customer response times and experience
- Maintenance repair/shutdown times
- Quality of control decisions

As the manufacturing company defines its relevant technology trends, ambition, technology stack and specification and the right KPIs, it becomes relatively easy to choose the elements of the Network Technology Stack across the four levels : (Figure 7)

Instrumentation (Sensory and Motor) Digitalization technologies – for converting instrument measurements into digital data and taking control actions remotely - the choice between iOT technologies.

Connectivity technology – for picking data from devices in a reliable and useful manner. - the choice between mobile and Wi-Fi.

Application Cloud Collaboration technology – for collaboration securely for ERP and Marketing– the choice of cloud date centres.

Networking technology – for bringing together applications from all locations and companies - the choice between SDWAN vs. LAN.

In the following sections, we detail the choices, pros and cons and relevant manufacturing use cases for these technology choices

Converting Business Ambition to Technology Choice

Now it is easier to pick up each of the technology choices and check their performance against the relevant technology metrics of: a) Uptime, b) Reliability, c) Agile Prioritization, d) Secure Cloud, e) Bandwidth, f) Backhaul, g) Coverage, h) Device Density, i) Mobility, j) Latency, and k) Cloud Collaboration.

With this comparison, it becomes clearer which technology helps a manufacturing company achieve its desired state of maturity at the best Return on Investment. Let's see these by each technology element in the following sections

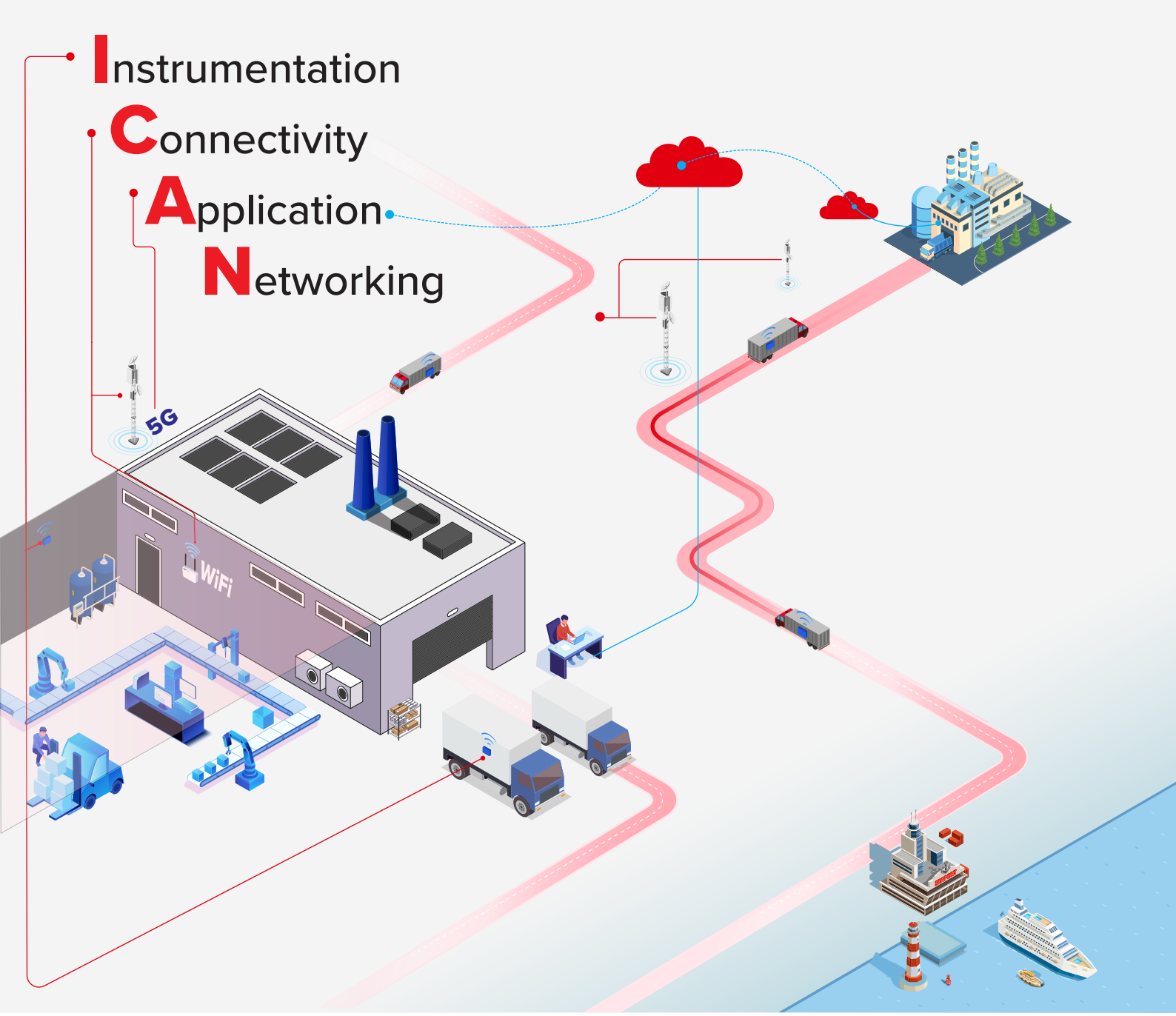


Figure 7: Network Technology Stack in Manufacturing

1. Instrumentation Digitalization Choice

The choice of instrumentation digitization is the foundation of creating a connected manufacturing setup and hence is fundamental to all the higher maturity stages. The key use cases that are relevant here are:

i. **Point of Sale instruments,** such as:
   a. **Sound boxes** for e-commerce and m-commerce transactions
   b. **Smart meters** for Utilities such as EV charging and household power
ii. **Telematics for remote information** and control of vehicles, such as for opening doors, activating ACs, infotainment, seeing driving speed and acceleration, reading maintenance schedules for fleet vehicles
iii. **Logistics and Fleet management** (for containers, trucks, taxis) for smart location tracking
iv. **Managing Industrial Equipment** to drive optimal usage, reduce damages, avoid theft, ensure good technician work approach

Today, the use of IOT technologies is really growing exponentially. Industrial IOT Deployment which were at 15.7 billion devices in 2023 are likely to grow to ~39 billion devices by 2030[23] , at a growth rate of 16%.

The key considerations here are primarily mobility, uptime and reliability since a small amount of data must be sent mainly for analytics and transaction purposes. Bandwidth millisecond latency and agility are not as essential, unless the use-case elevates to autonomous or remote-controlled vehicles.

Available Options for Instrumentation Digitalization Technology

There are primarily two options for this digitalization technology:

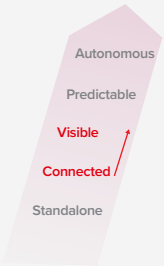
a. **GPS based tracking,** with Sim-card based mobility tech – This technology is high location accuracy and can provide high upload bandwidth. Since it can be on a smartphone operating system it can be upgraded on the cloud. However, it is expensive, and needs direct line of sight to GPS satellites

b. **Cell phone Tower based tracking** – This technology triangulates location based on cell phone tower locations and hence is low cost and does not need direct line of sight to satellites. However, it is lower accuracy and has low data upload bandwidth. It can also track assets without dependency on the fleet owner. Such technology comes in a low size, and with standard batteries – leading to easy use and replaceability for rugged use conditions.

Case Studies of iOT Instrumentation Digitalization Technology

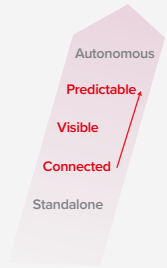
Remote Genset Monitoring

The Problem Statement	The IOT Solution	The Benefit
A large manufacturer was deploying gensets in remote locations and was **unsure about fuel usage levels and security** of the same.	The IOT solution used was an end-to-end IOT platform with an Edge Gateway, and Integration hub, a centralized Data Management platform and a Web/Mobile application for tracking the solution. The IOT system was deployed along with the genset to provide real time insights into the performance of the genset.	Based on the incoming data stream, the genset manufacturer was able to **build models that predicted genset breakdowns** 30-40 hours before they happened, leading to pre-emptive repairs. This led to major benefits • 25% reduction in product breakdowns • 30% in reduction in warranty costs • 2**5% improvement** in MTTR (mean time to repair)



Theft in transit

The Problem Statement	The IOT Solution	The Benefit
Companies transporting raw materials and finished goods in remote areas have a major issue of **loss from theft or negligence** due to poor visibility and controls. Remote areas have poor connectivity and cost of expensive devices is not affordable.	The IOT solution deployed was a cellular connectivity triangulation to track and monitor assets to minimize losses. This works on basic cellular connectivity and can have 20-25 days battery life with a 1 hour ping.	**Remote area asset tracking** of high value assets was achieved with: • Instant alert on parameters. • Automation tools like Geofence, Route replay, Live location • API Integration with customer's telematics/logistic platform • 70% lower cost compared to traditional GPS tracker



2. Connectivity Technology Choice

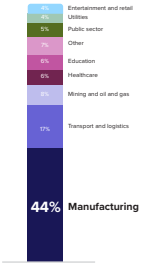


Figure 8: 5G share of publicly announced private LTE/5G networks, 2022

After choosing the instrumentation digitalization method, we move to connectivity. The key considerations here are a) Uptime, b) Reliability, e) Bandwidth-spectrum slicing, g) Coverage, h) Device Density, i) Mobility, and j) Ultra Low Latency

Available Options for Connectivity Technology

There are primarily four potential Connectivity technologies to choose from:

* 4 choices to deploy Private 5G
lower capital expenditures, with right security.

1. Isolated Private 5G,
2. Hybrid private 5G - Remote Core Network,
3. Hybrid Private 5G – Shared RAN,

A. Private 5G – provides the best mix of latency, long distance coverage, device density and security. Private 5G implementations tend to require higher upfront capex typically in the range of ₹5 cr or more, which can be optimized by utilizing one of the shared deployment scenarios*. Private 5G, however, turns out to be reasonably low on operating expenses for Massive IoT.

a. **Dedicated access and bandwidth** - Use of special 13-digit SIM card for devices to differentiate from human users. Use of dedicated Access Point Names APNs, rather than GPRS, so that the private 5G core is dedicatedly available

b. **Ability to handle high-volume data for both downloads and uploads.** With low latency and great mobility hand-offs, such as CCTV HD video, drone data, robots and AGVs.

c. **Future Readiness** – as 5G networks ability to take on more device density and bandwidth is already there, more devices and use cases can easily be added without adding more Access Points, and no further capex is required.

B. Public 5G – also provides the right latency and coverage, in case the Public 5G infrastructure is reliable. This solution compromises on security and might not be possible in remote areas with poor connectivity. For e.g. when government services are needed for high volume of use cases, at low cost, with less security concern then Public 5G gives all the desired benefits such as Metro and transport.

C. Private 4G - can be utilized in cases where latency and bandwidth requirements are low, while the requirement for device density, coverage and mobility are high

a. Security and dedicated access at par with Private 5G, at nearly the same investment

b. Ability to handle good data downloads, but restricted in uploads for e.g. HD CCTV.

D. Wi-Fi – is the simpler solution for a low device density, and low power requirement IoT scenario. Suitable only for indoor applications as fixed IoT devices, don't need mobility

The global market opportunity for Private 5G Networks excluding China has been $1.2B in 2024, and will increase to $21 B by 2030[25]. Manufacturing will account for ~40% of global private 5G deployments.

Key Metrics	Private 5G	Public 5G	Private 4G	WiFi
a) Uptime	99.9999%	99.9999%	99.9999%	99.9% not possible
b) Reliability	Very high	Very High	High	Lesser
c) Agile Prioritization	Can be achieved by creating a secure network			
d) Secure Cloud	Fully Secure	Not Secure	Fully Secure	Not Secure (WPA vulnerable to hacking)
e) Bandwidth	Upto 1 GBPS	Upto 1 GBPS	Upto 100 MBPS	Upto 1 GBPS
f) Backhaul	Upto 1 GBPS	Upto 1 GBPS	Upto 10 MBPS	Upto 10 MBPS
g) Coverage	Indoor + Outdoor	Indoor + Outdoor	Indoor + Outdoor	Only Indoor[24]
h) Device Density	100-1000 per node	100-1000 per node	50-100 per node (??)	30-35 per node
i) Mobility	Pan India	Pan India	Pan India	Fixed Location
j) Latency	~ 1ms	~ 1ms	20- 50 ms	> 100ms
k) Cloud Collaboration	Can be achieved by creating a secure network			
Others	• Targeted for Industry 4.0 • 10-year IoT device battery life • High spectrum diversity eMMB, ULRCC, mIoT supported	• Capable for Industry 4.0 • 10-year IoT device battery life • High spectrum diversity eMMB, ULRCC, mIoT supported	• Part capable for Industry 4.0 (good for mobility and downloads) • 10-year IoT device battery life	• Part capable for Industry 4.0 (good for static uploads - HD Video streaming) • Very low device battery life

Case Studies of Private 5G Connectivity Technology

Patchy Wi-Fi Limiting Industrial Automation

The Problem Statement

The existing Wi-Fi network at a Automobile plant was **impacting the plant's efficiency due** to patchy coverage and high latency. This further hampered customer's goal to deploy industrial use-cases to connect assemblies and Production units, and to drive more efficient Inventory Management and Fleet management.

The Private 5G Solution

The Private 5G Solution created a network to connect 1500 devices using an On-premise Core and 7 industry grade radios (5 Indoor + 2 Outdoor)

The Benefit

The Automobile manufacturer was **able to run various Industry 4.0 use cases** seamlessly with increased production, automated data reporting and reduced network blind spots

Paint Defect Detection needed Machine Learning

The Problem Statement

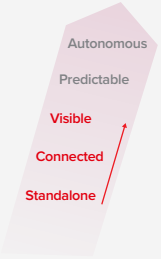
The automobile manufacturer needed to **accurately identify paint defects** in the production line, while the Local CPU was not able to do HD image processing

The Private 5G Solution

The Private 5G + Machine Learning Solution enabled real time HD video streaming to the Private Cloud, enabling all HD images to be processed on a cloud hosted GPU

The Benefit

Cloud image processing with ultra-low latency and Massive IoT device density ensured that paint defects were identified while the production line was in process, allowing for in process solution of the paint defect, reducing final production errors entirely.



3. Application Cloud Collaboration Technology Choice

Multi-location manufacturing ecosystems work together for better R&D and operational efficiency. Increasingly collaboration applications are using AI for language support, image identification, chat-bots and analytics. which can only be served from a high-compute, high-data, machine learning environment – on the cloud. We see 5 key use-cases for Cloud collaboration:

1. **ERP Connectivity –** Enterprise Resource Planning across locations and partner ecosystem is essential for better production efficiency and has to be done in a real-time secure manner.
2. **BCP and DR** – Business continuity and Disaster Recovery highly depend on data recovery, which is best done on cloud with auto back-up settings.
3. **Logistics** – Visibility of raw material and finished goods inventory through iOT devices and partner data is possible only through a shared network, ideally the cloud.
4. **NPD** – New Product Development needs remote data sharing and control for working across countries and with academic institutions, all of which are available on the cloud and use the higher end AI services.
5. **Marketing** – has become highly digital-first and all customers and influencers are online, hence managing the marketing platform is best done on cloud-applications, using language, image and conversational AI tools.

While the early use cases of ERP and BCP focus mostly on a) Uptime, b) Reliability, g) Coverage, h) Device Density, and j) latency; the higher order use cases of logistics needs much higher i) mobility; and insight dependent use-cases of NPD and Marketing needs much higher d) Security, e) Bandwidth, f) Backhaul and k) Cloud Collaboration.

Available Options for Cloud Collaboration Technology

A. **On-premise Cloud** – This gives full control and security, however, has the immense need for upfront capex and direct ongoing maintenance responsibilities, with less features. This option might only be reasonable where data centre and hyperscale cloud solutions are not available.
B. **Dedicated Private Cloud** hosted by Data Centre Providers – Gives full control on privacy and security, while removing the hassle of maintenance. However, the capex and upgrade investment remain with the manufacturing company and applications availability is limited.
C. **Multi-tenant Cloud** hosted by Data Centre Providers- This converts all capex to opex as the Data Centre provider takes over responsibility of setup and regular upgrades. However, the access and provisioning are still physical, while AI application availability is limited. New partners cannot be added instantaneously.
D. **Hyperscaler Cloud** hosted by global providers - AWS, GCP, Azure – the most advanced version, where provisioning is fully virtual, allowing for scalability to new partners, access to AI/ML applications and fully virtualized BCP and DR.

The global cloud market for engineering and manufacturing Operations was $13 billion in 2021 and is growing at 26% CAGR to reach over $107 billion. This is driven by PLM systems, and design and simulation systems such as CAD/CAM[23]

Cloud Technology Options

Use Cases	On-premise Cloud	Dedicated Private Cloud	Multi-tenant Cloud	Hyperscaler Cloud
ERP Connectivity	Local data analytics for SCADA	Sharing across locations	Sharing across Locations and partners	Sharing and AI/ML applications
BCP and Disaster Recovery	Secure backup	Backup as a service	Disaster Data recovery as a service	Data + Application recovery
Logistics	-	IOT backwards data availability	IOT across supply chain	IOT + Data analytics and automation
New Product Development	-			
Marketing	-	-		

Case Studies of Cloud Collaboration Technology

Secure critical server infrastructure

A large scale process manufacturing company need to avoid zero-day threats while there was lack of **skilled security experts at remote locations.** The presence of Industry 4.0 applications had exposed many functions to operational risks as the digital supply networks were widespread and open.

The Hosted Data Centre Security Solution enhanced physical and virtual security across on-premise, hybrid, and cloud-based data centers. This was done by application whitelisting, fine-grained intrusion detection & prevention, including system & admin lockdown, integrity and configuration monitoring

Secured network benefits were available instantaneously across the nationwide network in partnership with global security products and Service OEMs
- High uptime increases production and helps meet demand
- Network security protection against perimeter breaches for critical manufacturing assets

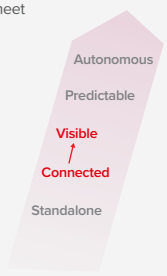
The Problem Statement → The Private Cloud Solution → The Benefit

High operational efficiency and agility

A leading seed manufacturer company. It had IT infrastructure across 17 countries, and the lack of standardization, due to local 3rd party data centers, led to high TCO. This **lack of network flexibility and agility** was hindering business visibility, scale and time to respond to market needs.

The Private Cloud Solution brought together all the core IT infrastructure under highly scalable private cloud. The new platform could handle change in workloads and also improved security with a world-class firewall management

The enhancement of standardized visibility and controls led to better market responsiveness, lower technology opex and TCO, **higher productivity with enhanced security.**



4. Networking Technology Choice

For industrial complexes where many different units come together to form an integrated value chain, it is critical to have an integrated visibility across all partners. For remote factory locations, many times reliable connectivity may not be available and a single connectivity provider may not be sufficient. In such a situation, a solution is required to create a network across multiple providers and network types. They might share the same application ecosystem, the same cloud, or go to link based data exchange, but will need a virtual network regardless of this method. There are fundamentally two use cases:

1. Manufacturers who work with many vendors, using ERPs and APIs. Auto manufacturers typically source over 2,000 parts from multiple vendors from nearby vendor zones and remote places.
2. Direct Consumer Marketers that work with distribution dealerships. They need virtual network for dealer management, especially for remote locations such as Leh and Thar.

Given connected manufacturing setups are now very complex with multiple plans, and companies connected across the supply chain, it becomes imperative to create a single network feel with very low latency and high bandwidth across multiple networks and locations. This needs the creation of a 'virtual network' that brings all types of networks – whether Wi-Fi, LAN, WAN or 5G, into one network for all practical purposes, without losing security.

Available Options for Networking Technology

1. **MPLS or Multiprotocol Label Switching** is a routing technique that directs data from node to the next based on labels rather than network addresses.
   a. MPLS **needs purpose-built devices** to access the network using label switching. It works on pre-tunnelled routing and hence it is very reliable although limited to where these dedicated routes have been created.
   b. MPLS is **inherently secure,** given its closed device-constrained nature
   c. MPLS **bandwidth is expensive and limited**, and cannot be shared
   d. MPLS **can not be prioritized for variable use cases** once the provisioning has been done. It typically needs physical access to devices to change application and data prioritization.

2. **SDWAN or Software-Defined Wide Area Network** is a wide area network that uses software-defined networking technology over the Internet using overlay tunnels which are encrypted.
   a. SDWAN is based on IP based routing, and hence **dynamic tunnel creation** can happen, allowing for easy addition of new entities on the network.
   b. SDWAN can enable **load sharing of traffic** based on criticality, availability and latency, while still offering secure and dedicated channel. This result is significant cost optimization of IT and communication expenditure.
   c. SDWAN can aggregate over **two or more service providers,** thus increasing overall capacity. It also allows higher reliability by switching and prioritizing traffic during failure modes.
   d. SDWAN can also aggregate **across network types** such as MPLS, 4G, 5G, satellite internet, RF, VSAT and hence is not dependent on any provider or technology to create a high bandwidth network, if they work on the IP protocol. SDWAN providers such as Airtel have partnered with multiple local MSOs[27] such as evotel, SDL, local cable providers to provide access to all available networks, beyond their own.
   e. SDWAN can do **dynamic allocation of network** as new digital use cases emerge, by creating primary and secondary SLAs and QoSs. This is possible through centralized controller and software defined provisioning.
   f. SDWAN allows **secure sharing of data between different organizations,** such as ERP, supply chain information, dealer management to update their demand and inventory levels directly over a secured channel.

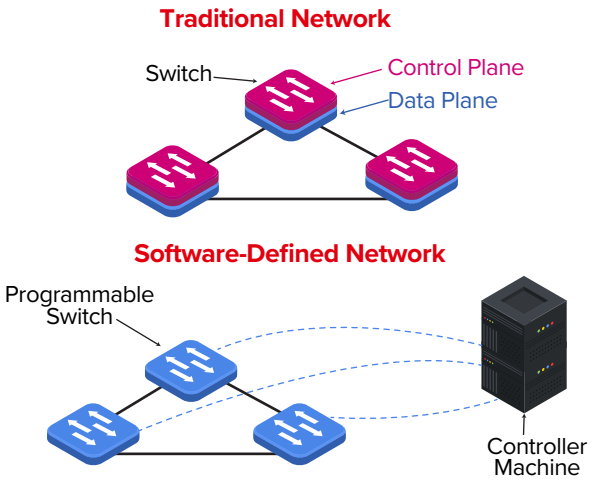


Figure 9: The difference between SDNs and traditional networks

Here's some architecture[29] and metric wise comparison that can help companies choose their virtual networking technology[30].

Key Metrics	SDWAN	MPLS
a) Uptime	99.9999%	99.9999%
b) Reliability	Very High	Very High
c) Agile Prioritization	Instantaneous re-prioritizable	Not possible without visit
d) Secure Cloud	Can be secured with SASE	Fully standalone and Secure
e) Bandwidth	Can be aggregated across multiple networks	Must be built using only one provider's network
i) Mobility	Pan India	Where there is a defined providers network
k) Cloud Collaboration	Can be achieved by creating a secure network	Sharing not possible unless on the same device network
Costs	Low Capex, can merge across all network types	High Capex, needs purpose-built devices
Others	• Dynamic tunnel creation • Can create network across different providers and network types • Can dynamically change QoS and SLAs	• Pre-planned device-based tunnel • Can create network only on one provider • Dynamic QoS changes not possible

Here are some most cited reasons to deploy SD-WAN with the leaders of SD-WAN technology[31].

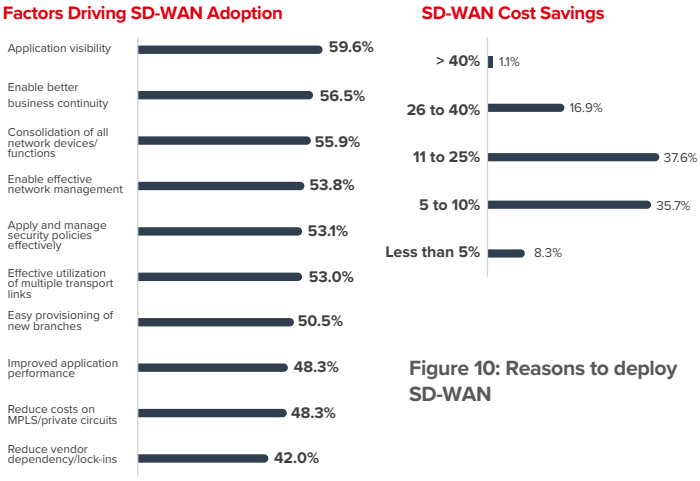


Figure 10: Reasons to deploy SD-WAN

SDWAN can also be integrated with MPLS to get both benefits as appropriate[28]. Additional Security can be offered in SDWAN through Secure Access Service Edge (SASE) where individual devices can be configured for secure remote collaboration. This allows organizations to enable effective work from home policies and remote work ecosystem. Remote yet secure access can be enabled despite using Broadband/LTE/5G internet.

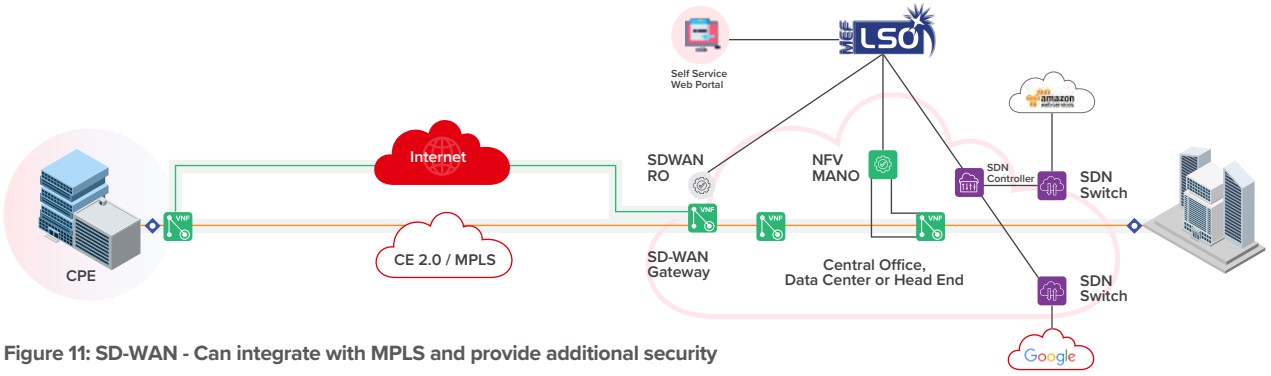


Figure 11: SD-WAN - Can integrate with MPLS and provide additional security

IDC forecast data shows that in 2022, the SD-WAN infrastructure market grew 25.0% and through 2027, the market will grow at a compound annual growth rate of 10.1% to reach $7.5 billion[32].

Case Studies of Networking Technology

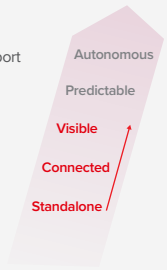
Central inventory view across 190 factories

An Indian auto parts and tyres manufacturer wanted to have a **central view of the raw materials and WIP** inventory across all locations – may of which were in remote areas, while some were in well-connected zones

SDWAN created a virtual tunnel across 190 factories, while aggregating 5G, Lan and 4G connections. This created a full view across all assembly lines. The OT Operating Technology and SCADA views across all these lines was now visible in a central office over the cloud, with no need to set up a fully private network. The connectivity was provided with one main provider, and a secondary backup provider for enhancing reliability of uptime and reducing jitter.

Cloud based VPN allowed the company to:
- Create a bandwidth of up to 10MBPS by using an aggregation of up to five, 2MBPS connections, that allowed for HD video along with SCADA integration across locations
- SLA uptime of 99.99% availability, 60-80 ms latency from pop-to-pop was reliably achieved
- Dealer management system was able to move from prioritization of Sales, Service to Support with regular SLA re-prioritization (e.g. from tracking to billing), with real-time provisioning using pre-set templates, without local tech support

The Problem Statement → The SDWAN Solution → The Benefit



Multiple Connectivity, Centralized Management & Security

A multinational electronics manufacturer was facing **over-utilization of MPLS bandwidth** as all traffic was routed through one central hub and there was no centralized console to check network performance while there were security vulnerability to cyberattacks

SDWAN enabled Active-Active mode and auto failover on MPLS over Internet. Provided a centralized console for all policy and change management. Solved the security issue with a secure channel local internet breakout for cloud applications.

This new virtualized WAN created much better
- Network agility through application aware routing with a mesh network
- Security of cloud applications with local internet
- Operational efficiency and failover support with centralized management

Getting started to set the right technology

As you set up your manufacturing organization to set up your leadership ambition, it becomes clear that setting the right environment for business benefits from technology is necessary. While the above approach focused on defining the TASK right, and then going onwards to set the ICAN technology stack, there are few other considerations that are needed. Specifically, these are organizational set-up requirements, that cover areas of leadership, vision, skill, investment approach and review mechanisms.

We believe that the following steps will help in drive the best return on the technology investment:

a. **Explicit Leadership Engagement –** Most CXOs of the manufacturing organization need to be aligned with the choice of use-cases and the technology implications of the same. As technology investments only work out, when they are implemented well and utilized with an increasing number of use cases. The enthusiasm of the leadership team cascades across the organization leading to better long-term ROI and competitive advantage.

b. **Detailed Strategic Vision** – The leadership team should explicitly mention the vision they have with the increasing use of the technology. Metrics should be connected to what will be tangibly achieved so that the teams are aligned and excited.

c. **Skill Development and Staff Engagement** – The lack of technical skills and organizational talent is the main reason why some organizations are unable to invest in the right technology or, worse still, unable to leverage the investment. A focused approach to train on use cases must be done and key technology people should be encouraged to learn the new technologies, like AI. Additionally, hiring for the right skill set is essential.

d. **Stage-wise Investment Approach** – It's important to set up key metrics, both operating and financial to ensure that these are being achieved. Metrics need to relate to goals that are tangible – such as increase in production or revenue and customer satisfaction. At the same time, they also need to be connected with technology metrics so that technology gets the impetus to run smoothly – to deliver on the purpose. Once metrics are achieved, the plan should be extended to the next stage of use-cases as trust in technology is built across the organization.

e. **Regular Review Mechanisms** – Measurement will get visibility, but there will always be missing pieces and unknown root-causes. A data-driven and analytical review process, with good follow-up program management is necessary to drive the value from technologies, especially for manufacturing companies with high spread.

Figure 12: Steps to maximize return on technology investments

Conclusion

Manufacturing companies have a huge opportunity to drive profitable growth by better integrating devices with analytics and AI across their supply chain in a secure and real-time manner. By evaluating technology trends and setting ambitious use-cases, manufacturing enterprises can identify their business KPIs and technology metrics that allow for the right choice of networking technologies across IoT, Connectivity and Application Collaboration.

To ensure a definitive move towards the most mature "Autonomous" stage of Manufacturing Networking Technologies, manufacturers need to align development of technology, business models and ecosystem relationships in multiple steps of maturity. Such a stepwise approach will ensure the right future-readiness, while ensuring good Return on Investment of Networking Technologies.

Why Airtel Business for Network Technologies Choices

Airtel Business is a leading provider of integrated communications solutions in India. With a wide gamut of end-to-end solutions spanning cellular IoT, connectivity, cloud, data centre, cyber security and cloud-based communications, the company's offerings are engineered to deliver high-speed connectivity, unparalleled wide coverage and scalable bandwidth to customers across enterprises, governments, carriers and small and medium businesses (SMBs).

I Instrumentation Digitalization

Airtel Business Benefits

- Real-time tracking with solutions like basic SIM, Bluetooth, and GPS-based tracking.
- Data Acquisition Gateway with sensors measure different parameters (temperature, pressure, or electrical output).
- Equipment Monitoring of industrial equipment, leading to proactive maintenance, reduces the breakdown by 25% and improves the MTTR by 25% .

Unique Features

- Airtel Edge Gateway with Sensor Integration
- IoT integration hub for centralized and analytics plateforms data
- Variety of Tracking Solutions

C Connectivity Technology

Airtel Business Benefits

- Future Readiness – 5G networks allow deploying Industry 4.0 use cases like Autonomous Mobile Robots, Smart Surveillance, and OT connectivity.
- Enhances customer experience through a
- digital environment and seamless internet.
- Cost Efficiency for Wi-Fi controllers and AAA (Authentication, Authorization, and Accounting) infrastructure making it a pay-as-you-grow service model.

Unique Features

- Private 5G Network with a reduced blind spot
- Centralized Wi-Fi setup
- Carrier-Grade security and compliance

A Application Cloud Collaboration

Airtel Business Benefits

- Scalable Infrastructure – Nxtra by Airtel offers the largest network of secure, scalable, and sustainable data centers.
- Targeted marketing - Airtel Martech, AI / ML powered platform for fast, reliable, secure communication.
- Cloud Collaboration - Data Center Security for physical and virtual servers in on-premise, hybrid, and cloud-based data centers. .

Unique Features

- Strategic Data Centre Locations
- AI / ML-powered Marketing platform
- 24x7 operational Enterprise-Grade Support

N Network Technology

Airtel Business Benefits

- End-to-end network management through Enterprise Network Operations Centre
- Secure sharing of data between different organizations, such as Enterprise Resource Planning
- Uniform Network Connectivity with MPLS and internet network offerings bundled with SDWAN

Unique Features

- Centralized network management
- Integration with Siebel ER
- Maximized CRM application usage

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Manish Sinha, leads Zamun - a Marketing strategy firm focused on B2B Engineering and Tech firms. He has over 25 years of experience across consulting, operations, tech startups and public enterprises in India, Europe and the US.

Abhishek Khamrai is an industrial engineer with 15 years of experience cutting across manufacturing, business consulting and technology research.

Aradhika Mehta is an accomplished marketing professional with 15 years of experience of leading iconic lifestyle brands and startups. She builds brands to drive high growth and premium results across diverse industries.

Akshita Kabra holds a Master's in Microbiology and has over 4 years of experience in scientific and technical writing. Having worked at CSIR-NBRI, she excels in creating well-researched, precise, and engaging content across various technical domains.

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