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Point of View

# Software-Defined Manufacturing for Production

# Introduction

Digitizing manufacturing processes and plants has been on the rise in recent years, According to a recent report from Gartner, 80% of CEOs are increasing their digital technology investments to overcome challenges and gain competitive advantage. Manufacturing CIOs are leveraging the latest technologies like Artificial Intelligence (AI), the Internet of Things (IoT), and Data Analytics to drive growth. To achieve this, Companies are optimizing their current processes and creating new digital-led revenue channels around data and mobility services. One of the Crucial aspect that is necessary to drive Industry towards Digital Era is to "Modernizing OT infrastructure" which can improve the overall competitiveness of the manufacturing sector. To Maximize Value, a systematic approach is necessary to move from siloed initiatives to organization-wide transformation. **Software-defined manufacturing (SDM)** systematically focuses on optimizing and modernizing all aspects of Manufacturing from Hardware, connectivity, storage, Security, and underlying software with Embedded Intelligence across IT and OT landscapes.

# Key challenges to be addressed as part of plant modernization

- **Legacy Network Devices:** Outdated network devices in the plants hinder digitization initiatives due to high latency, incompatibility with modern technologies, and vulnerability to security flaws.

- **Lack of hardware standardization:** Inconsistencies across critical IT/OT infrastructure impede scalability and innovation across the product value chain.

- **Undefined isolation protocols:** Security protocols and standard procedures for data transfer between IT and OT infrastructure are essential for achieving end-to-end security and data protection. These are usually undefined, and there is no focus on upgrading and refreshing the network and security systems.

- **Modernization of endpoint devices:** Legacy OT devices and protocols are not designed for internet connectivity. They require an end-point upgrade to enable the latest communication and security protocols, which are quite expensive.

- **Ethernet cable-based connectivity:** Cables are prone to rupture or cut movement of heavy machinery and high environment variation.

- **Internet Access:** Very often, there may be black zones in the network coverage within a plant, resulting in the non-availability of the systems and insights.

SDM focuses on eliminating these challenges and is pivotal in delivering value on infrastructure investments for manufacturing plants.

# The software-defined approach to manufacturing

Software-defined manufacturing is one of the critical foundational elements upon which all the manufacturing intelligence can be developed to deliver key insights. SDM is  is a software layer that focuses on optimizing and modernizing aspects of infrastructure from hardware, connectivity, storage, and security across IT and OT. The figure (Figure 1) below illustrates the strategy and critical pivots for SDM and the outcomes achieved by implementing SDM Methodology.

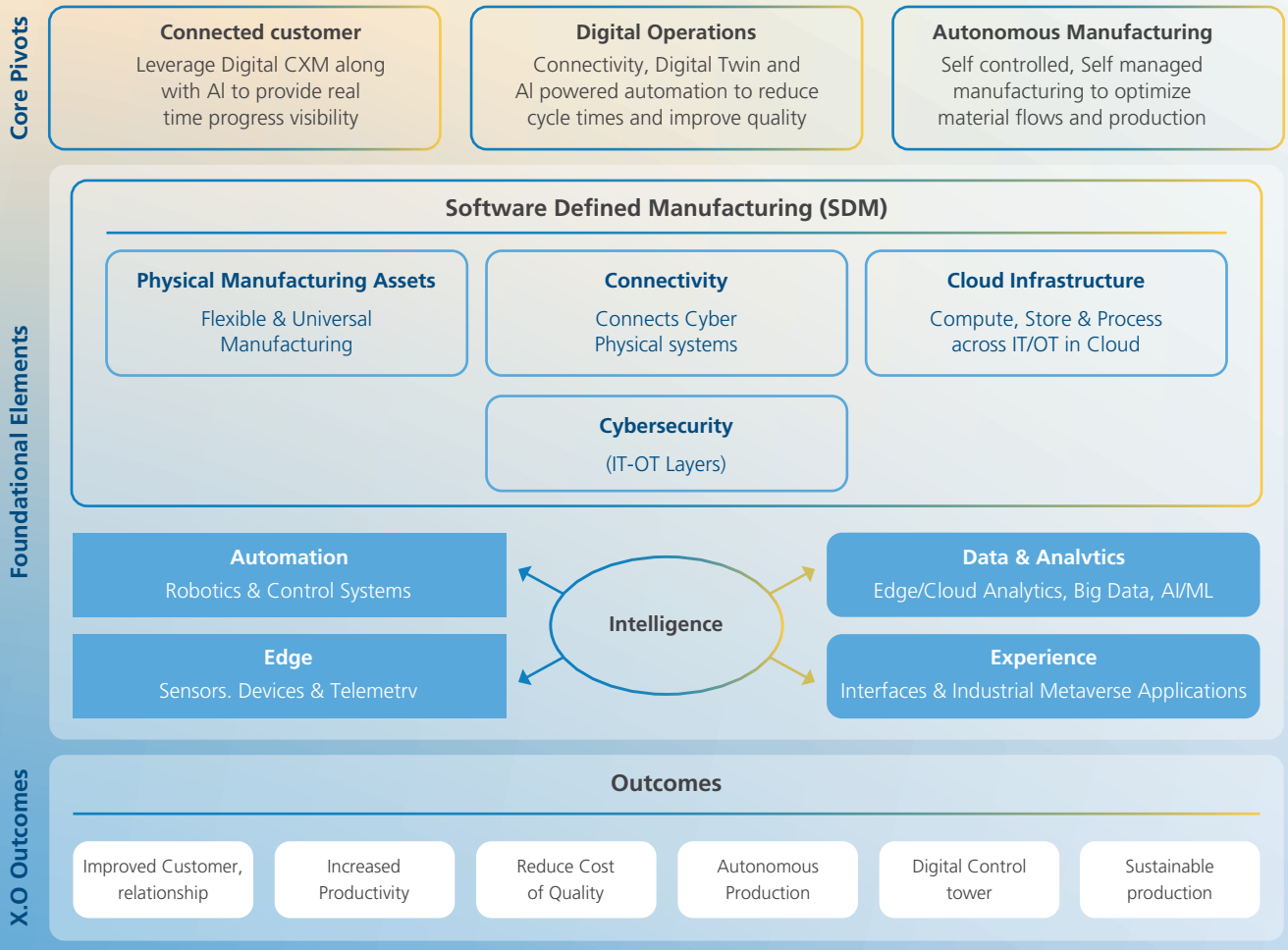


*Figure 1: SDM methodology and core pivots*

The core idea of SDM is that organizations can see benefits if the initiatives are implemented at scale and need to focus on all critical foundational elements, as shown in the above figure. A brief overview of each of the foundational elements of SDM is given below.

## Physical infrastructure and assets

Upgrading physical assets enables them to be connected to the Internet. It helps organizations to have a flexible and universal manufacturing environment. The key aspects of asset upgradation are stated below.

01

Ability to support universal production and can be utilized across multiple sites

02

Software-controlled equipment that multiple practitioners can share

03

Unified device and machine landscape by retrofitting or standardization

04

Supports flexible manufacturing and can deal with variations in part assembly, support design, and production volume changes

05

Assets don't belong to any specific entity and are virtually available for all with a defined resource allocation process.

## Connectivity

This is a critical element of SDM as it ensures systematic communication / between Cyber-Physical systems. Organizations update all the access points in the plant with higher bandwidth devices with sufficient redundancy and coverage. The critical aspects of connectivity are listed below.

01

Bridging the cyber and physical worlds, enabling reliable connections between computation infrastructure and physical infrastructure

02

A configurable layer based on features and connections for manufacturing

03

Creation of network templates for normal, high-speed, and low-latency hardware designs

## Cloud infrastructure

The cloud provides scalability, diversified and universal manufacturing capabilities to improve efficiency and reduce lifecycle costs by optimal utilization of resources. SDM proposes to replace/refresh all the physical servers with the cloud and ensure all the new investments are made on the cloud. It should combine centralized cloud infra for heavy storage and computation and multiple edge computation centers with specific VMs to execute the manufacturing processes. The key aspects to consider for cloud infrastructure are listed below.

01

Manages the computing and storage of designs and processes and comprises a large number of computation and storage nodes

02

Cloud stores and processes intense R&D work and Edge controls operations of the Manufacturing nodes

03

Cloud infrastructure is shared across different sectors in the organization

## Cyber security

This is a critical yet regularly forgotten aspect of digitization. OT Infra was considered secure as it wasn't connected to the internet and cloud. However, as we move towards digitization, legacy OT infra will be exposed to cyber threats. The key aspects are listed below.

01

Creating a De-Militarized Zone (DMZ) between IT and OT layers and ensuring firewalls and access control are initiated across all the layers from the assembly line to the plant level

02

Isolation in the multi-owners/user infrastructure

03

Co-ordination across different zones takes priority

04

Improving the safety of manufacturing assets

# SDM components

The figure below depicts the SDM Components Architecture, which shows a secured and resilient network ecosystem to deliver high speed, high accuracy business benefits.

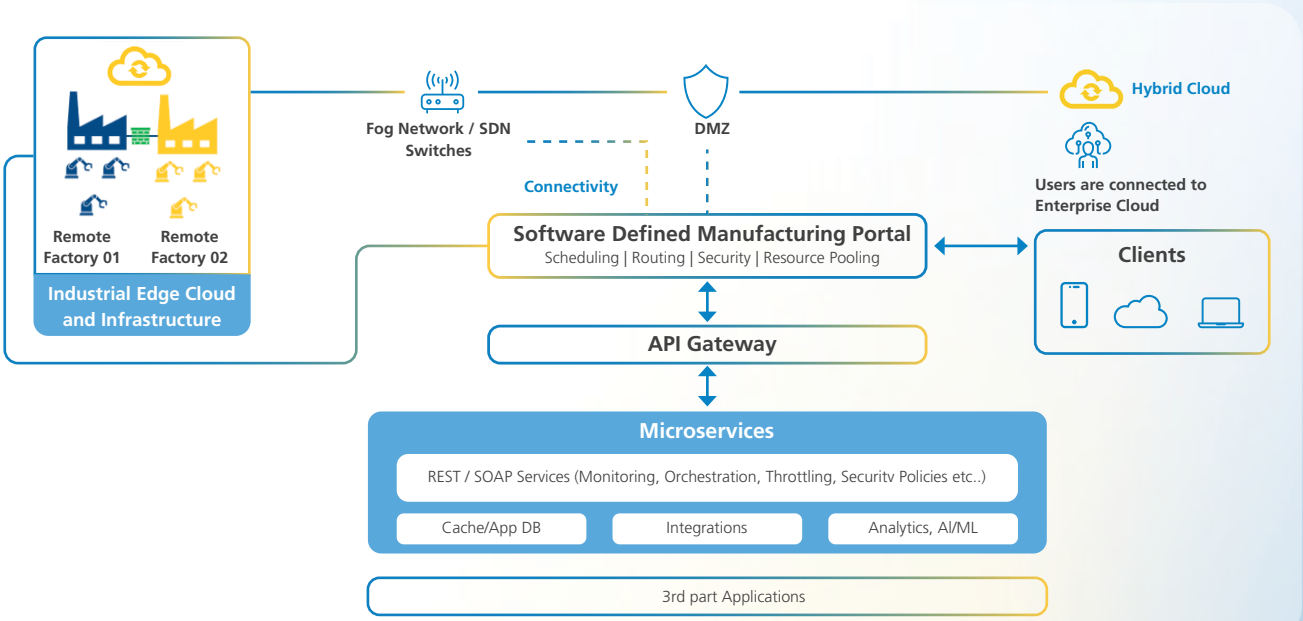


*Figure 2: SD Components for a manufacturing plant*

## Segmented and Secured Architecture

It includes establishing a Secure zero-trust environment with zone and conduit network architecture deployment and micro-segmentation at all levels. One such example is to deprecate NAT and adopt IPV6 for improving OT network visibility and monitoring.

## High Available Network

Implement SDN Switches to ensure physical separation of the network control plane where each network device is isolated from other devices in the network. Some of the critical elements required for a high-performing network are:

**01**
Wi-Fi 6 adoption and improvement density based on RF Survey

**02**
SD Based Network Hardware deployment and Configuration.

**03**
5G Implementation

**04**
Hybrid WAN (MPLS + Internet+5G WAN) implementation

**05**
Adopt Industrial grade cable network and update blueprints

## IT/OT isolation and bridging

IT/OT integration and isolation with well-defined and controlled protocols and security is critical for processes and controls to be seamless with end-to-end data flow.

## Security

As the network gets interconnected between IT/OT, it is necessary to upgrade the security and improve posture, covering the newer devices and endpoints. Tech refresh and modern dynamic cyber defense platforms and strategies must be realigned and paced with the network and device modernization.

## Centralized SDM Portal

As SDM connects end-to-end design and production systems, a centralized routing and scheduling system is necessary, which becomes the brain of the entire SDM. This is achieved

via a centralized SDM portal, which is responsible for scheduling jobs across multiple plants, lines, and machines and managing traffic across the plants for optimal efficiency. In simple words, the SDM portal maintains a global view of the factory core network, remotely controls the SDN switches, and monitors the data transferred from Edge Infrastructure. In addition, other functions of the SDM portal include:

**01**

Setup of every single communication flow across IT/OT

**02**

On-demand provisioning of virtualized network deviceswith no change in hardware

**03**

Ensuring traffic to switches goes through virtual machines

**04**

Performing necessary configurations in a timely and efficient manner

An SDM portal is developed using a microservices architecture with integrations across IT/OT systems and other third-party systems.

These SDM components integrated with a centralized SDM portal to have a converged Network Operations Centre (NOC) / Security Operations Centre (SOC) monitoring for events across the network landscape (IT and Plant Infra) with unified self-service catalogs across IT/OT network for Zero Touch Provisioning, Firewall Provisioning, and Automated Guided vehicle (AGV) / Vision Guided Vehicle (VGV) by automated network configuration deployment.

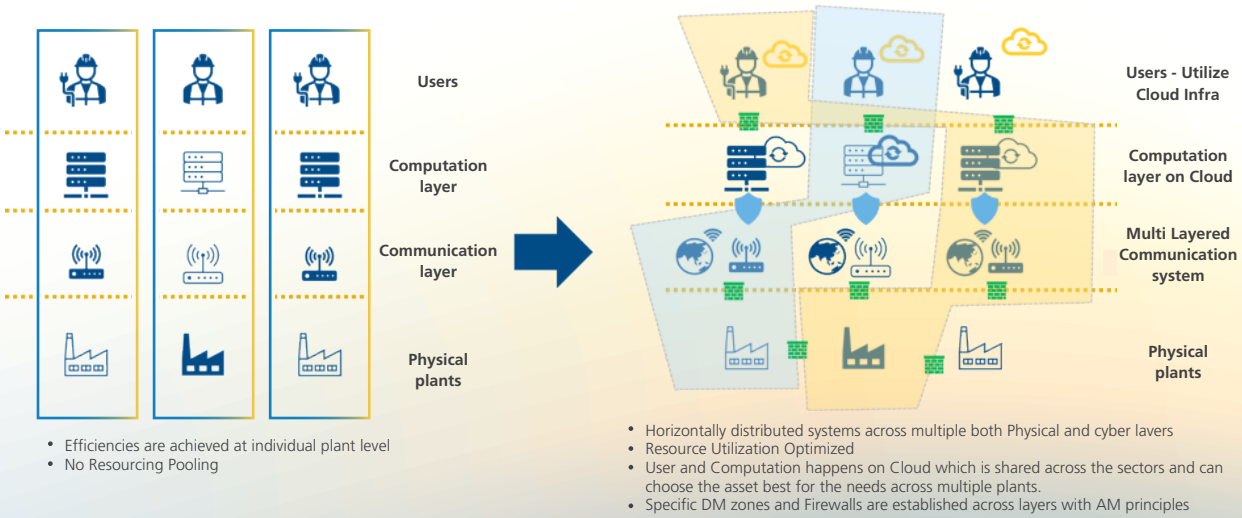


*Figure 3: Conventional manufacturing vs. Software-defined manufacturing*

The figure above depicts the significant difference between conventional and software-defined manufacturing (SDM). Conventional manufacturing is a vertically scalable system, which shows the effort of R&D, modernization, and digitization initiatives. It includes AGVs, improving production efficiency, eliminating waste, etc., under current framework users. Computation, communication, and machinery in plants are restricted to a single production plant and do not allow cross-utilization of resources for optimization.

SDM proposes a horizontally scalable system that breaks the boundaries between plants and makes the landscape a shareable and more optimized system. In SDM, physical plants are autonomous, not owned by anyone, and available to be utilized by users. They are fully controlled by the SDM portal, which handles routing and scheduling of the Manufacturing jobs. The user connects to the SDM portal via the cloud to schedule a job. Once scheduled, systems connected to the cloud manage computing and storage tasks, and the centralized cloud infra is shared across multiple plants. Infrastructure on the cloud is connected to physical assets via a multi-layered communication system (Wi-Fi/5G, etc.) and separated by firewalls and DMZs to protect the information flow across the layers.

By dividing the manufacturing ecosystem horizontally instead of vertically, SDM Methodology transforms the business model of manufacturing by breaking silos and enables the organization to reach its business objectives like:

**01**
Improving flexibility and resiliency of supply chain and processes

**02**
Improving collaboration across manufacturing units and teams

**03**
Improving the throughput and overall efficiency

**04**
Accelerating innovation

**05**
Cost reduction

# Case in point

A leading manufacturer of heavy engineering equipment like refinery boilers and nuclear reactors faced constraints like rising input commodity costs, reduced output prices, and shorter cycle times. In addition, clients demanded greater visibility into the manufacturing process to understand the quality of such critical equipment better. This required a complete industry transformation across 3D Design, Product Life cycle Management (PLM), and Industrial Internet of Things (IIOT), completing the digital thread and aligning this with strategic supplier relationships and workforce management.

More than **90% Network coverage** with the removal of dead spots

**50% reduction** in TCO with solution design and vendor attribute selection

**Wi-Fi 6G/5G** evolutionary design in line with transformation use cases

# Modernization with SDM

Here's a recommended approach for modernization:

## Discover and Assess

Understand the key transformation use cases planned over the next three years. Balance this prioritization with an external view from industry use cases. Other activities include assessing current architecture concerning the OT Purdue Model, conducting an RF survey and cable testing, and assessing cyber security and organization readiness.

## Design and Build Foundation

Provide a clear roadmap of the use case realization, associated business benefit, and the business case for measuring outcomes.

Develop standards, processes, operating models, and architecture to consume modern technologies

Map business cases with 5G, CRUB, WiFi-6, and other modern solutions

Implement programs to upskill the resource pool

## Deploy MVP

Roll out the SDM solution for an MVP plan based on the defined roadmap, validate and optimize the services and performance based on feedback, including people, processes, and technologies.

## Scale and Establish

Expand the solution across various plants/units and improve adaption.

# Conclusion

In this POV, we have described the methodology for digitizing manufacturing plants with a software-defined approach. It provides flexibility to deal with uncertainties in the supply chain and production demand by focusing on horizontally distributed systems. These systems communicate with each other for optimized resource utilization using a centralized SDM Portal integrated with all the layers and other third-party systems which can deliver Business Value on Manufacturing Infrastructure Investments.

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Ram has more than 10 years of industry experience across aerospace, automotive, healthcare, and pharma domains. He has experience delivering programs and solutions for design, analysis, additive manufacturing, data analytics, and manufacturing. As a Senior Manager, Ram focuses on developing cutting-edge solutions in IOT and solutions across Industry 4.0 technologies like simulation, edge analytics, big data, and industrial platforms.

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