الإمارات العربية المتحدة
وزارة الصناعة
والتكنولوجيا المتقدمة

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INDUSTRIAL
TECHNOLOGY
TRANSFORMATION
INDEX

INDUSTRIAL TECHNOLOGY TRANSFORMATION INDEX

Use Case Guide 2.0

Prepared in collaboration with EDGE

الإمارات العربية المتحدة
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01 INTRODUCTION

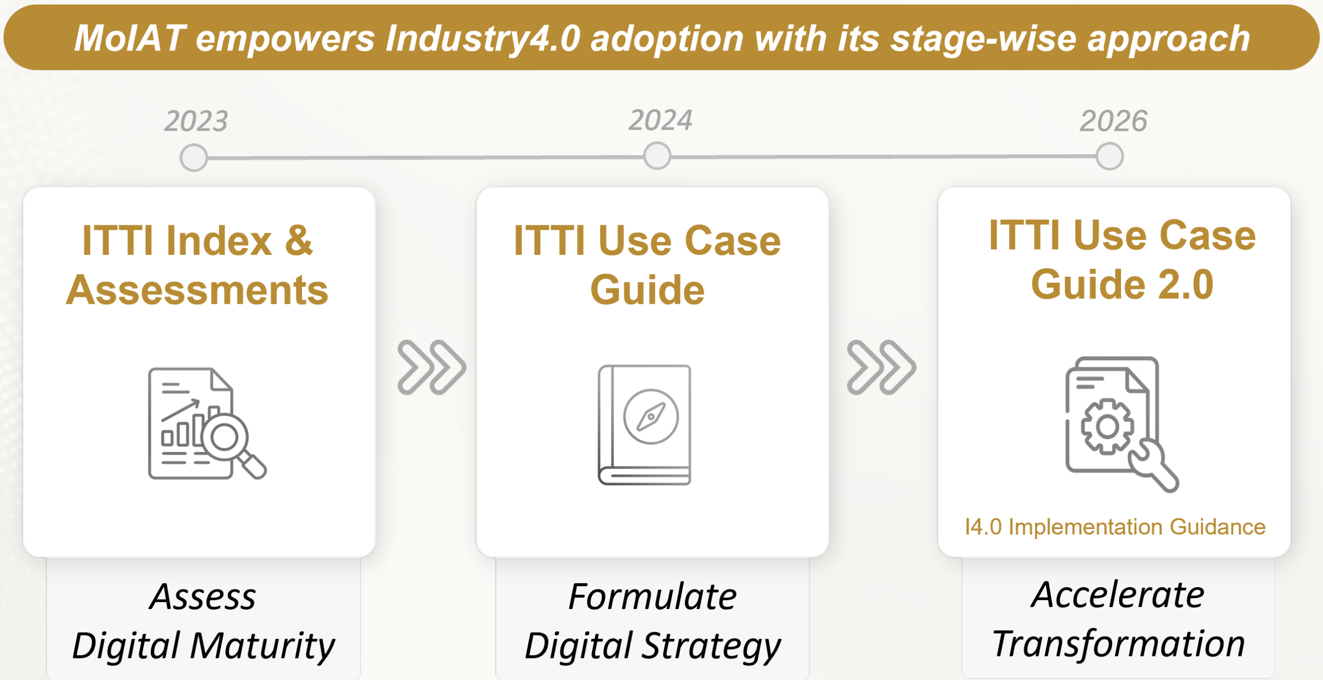
EXECUTIVE SUMMARY

The manufacturing world today is moving towards a more productive and sustainable industrial development, empowered by adoption of Fourth Industrial Revolution (Industry 4.0). As an innovation and manufacturing hub, United Arab Emirates (UAE) is at the forefront of this shift, enabling and supporting the UAE's manufacturing ecosystem for faster adoption of Industry 4.0 solutions.

The Ministry of Industry and Advanced Technology (MoIAT) plays a vital role in advancing the industrial sector through promoting the adoption of advanced technologies among other aspects. As part of the broader Technology Transformation Program (TTP), the Ministry leads several key initiatives and programs such as the Industrial Technology Transformation Index (ITTI), while also providing incentives and enablers such as the ICV bonus and Golden Visa scheme, to develop an integrated and sustainable industrial economy.

By providing a comprehensive assessment tool, the ITTI framework helps the manufacturers to understand their digital maturity and identify key focus areas to kick-start their transformation journey. Further, the Ministry has published 'ITTI Use Case Guide' and 'Industry Pulse Report' to promote the adoption of advanced technologies through the dissemination of detailed insights and strategic guidance.

These resources aim to support the industrial community by empowering them to make informed, strategic decisions related to their respective Industry 4.0 transformation journey. By sharing distilled knowledge on key use cases, the 'ITTI Use Case Guide' serves as the guidepost for the organizations to decide on right use cases and formulate their digital strategy.



To further augment the strategic guidance provided in the ITTI Use Case Guide, this 'ITTI Use Case Guide 2.0' has been **prepared in association with EDGE Group's Industry 4.0 team.** This 'ITTI Use Case Guide 2.0' builds on top of the 'ITTI Use Case Guide' and provides practical guidance on how to implement the use cases.

By **providing detailed implementation guidance**, this guide targets to **accelerate the Industry 4.0 adoption** across UAE, while nurturing greater collaboration among the UAE manufacturing ecosystem.

In short, this 'ITTI Use Case Guide 2.0' is targeted to act as a guidepost for accelerated and successful adoption of Industry 4.0 solutions.

This 'ITTI Use Case Guide 2.0' focuses on bringing out a step-by-step practical implementation guide for these 20 use cases from the ITTI use case guide. Along with these 20 use cases, this guide also covers additional 10 use cases – which are either recommended as foundational solutions or solutions that enable synergy. Thus, this guide provides practical guide for implementation of 30 use cases in total.

For each of the use cases, this guide provides solution details, ideal candidates who should adopt the solutions, when to embrace the solutions, key tools and techniques required for each solutions, step-wise implementation guide addressing the overall project lifecycle, best practices to follow and pitfalls to avoid, cost estimates and influential case study references.

By providing these rich inputs, MoIAT strives to accelerate the Industry 4.0 adoption across UAE's manufacturing ecosystem and enhance their manufacturing prowess with productive, agile and sustainable production environment.

02 OBJECTIVES OF THE GUIDE

MoIAT Accelerates Knowledge-Driven Transformation in UAE's Manufacturing Sector

United Arab Emirates' (UAE's) national industrial strategy is aimed at transforming the manufacturing sector into a key driver of economic growth and diversification. The Ministry of Industry and Advanced Technology (MoIAT), as a part of its Technology Transformation Program (TTP), has introduced initiatives, programs, incentives and enablers to accelerate this transformation and ensure manufacturing as one of the key engines for sustainable national economic growth.

The Industrial Technology Transformation Index (ITTI), launched in 2023 under the Technology Transformation Program, was a significant step forward for the entire industrial community. By providing a comprehensive assessment tool, ITTI has enabled the manufacturers to evaluate the current state of their manufacturing, and subsequently provided recommendations targeted at transforming manufacturing and enterprise operations.

As a next step, in 2024, MoIAT has published 'ITTI Use Case Guide', empowering manufacturing organizations to make informed, strategic decisions on their transformation journey. By sharing distilled knowledge on key use cases and their business benefits, the ITTI Use Case Guide serves as the guidepost for the organizations to plan and formulate their manufacturing transformation strategy.

Relevance of the ITTI Use Case Guide 2.0

To further enable the manufacturing sector, this year MoIAT introduces this "ITTI Use Case Guide 2.0", focused on providing implementation guidance for Industry 4.0 adoption. Additionally, this guide nurtures greater collaboration amongst the UAE manufacturing ecosystem by sharing best practices to achieve better business results through Industry 4.0 adoption.

Key Objectives

01 Guide the organizations to **evaluate and validate** selected Industry4.0 solution to address their business problem

02 Support the business and the in-house technology team to **better prepare** themselves **before initiating the implementation** of the identified solution

03 Provide **step-by-step guidance for the entire project lifecycle** for better project execution and **accelerate the Industry4.0 adoption** by leveraging the learnings from previous implementations

04 Provide references of past implementations to help organizations **understand the solution and its impact better before making the investment**

Intended Audience

This Guide aims to support key stakeholders of manufacturing operations who strive to improve and optimize their manufacturing and intralogistics operations. Key people who are enabled with this guide, include:

Senior Management Team:
Get better information on cost of the solution, its likely impact on business, thereby facilitating informed decision-making on Industry 4.0 investments.

Factory Managers & Engineers:
Unlock the underlying potential existing manufacturing setup, by leveraging the power of Industry 4.0 solutions. The targeted benefits include, improving quality and efficiency, reducing costs, establishing transparency, and ensuring operational safety.

Digital Transformation Team:
Provide implementation teams with step-by-step guidance throughout the project cycle, enabling them to implement more efficiently and avoid costly mistakes.

Factory IT & Technology Teams:
Assist the teams with better preparation for Industry 4.0 adoption, by highlighting pre-requisites, tools & techniques required for project implementations.

The Guide Outlines Key Objectives to Drive Industrial Transformation

Enhancing collaboration in the UAE's manufacturing ecosystem	Enhances collaboration amongst the UAE manufacturers by inspiring the manufacturing community by sharing information on successful Industry 4.0 solution adoptions, accrued business benefits and guidance to accelerate the Industry 4.0 implementations.
Support better preparation before implementation	Provides details on all the tools and techniques that need to be implemented to realize the delivery of the project. This aids the organization to make preparation for all the pre-requisites well in advance, and ensure that implementations start with full enablement.
Providing step-by-step guidance for entire project lifecycle	Provides step-by-step guidance on all key phases of the project – starting from value evaluation, requirements gathering, vendor identification, solution design, implementation, till go-live and stabilization.
Transferring the experiences from successful implementations	Helps save months of efforts by sharing the knowledge on pitfalls to avoid and best practices from past implementations that shall aid organizations prevent costlier mistakes.

03

LIST OF INDUSTRY 4.0 USE CASES

ITTI USE CASE GUIDE AS A CORE FOUNDATION

The 'ITTI Use Case Guide' formulates the core foundation of this 'ITTI Use Case Guide 2.0'. Presenting a wide-range of use cases across multiple industries, ITTI Use Case Guide has provided rich inputs on prominent Industry 4.0 use cases that are widely rolled-out across the globe. The 'ITTI Use Case Guide' has enlisted 20 unique use cases.

R&D and Engineering

- Digital Twin for Simulated Product Design

Marketing and Sales

- Customer Integration for Automated Logistics Workflow

Supply Chain Management (Inbound)

- Supplier Integration for Automated Workflows
- Integrated and Automated Production Planning and Scheduling
- Material Traceability for Warehouse Operations
- Supply Chain Control Tower
- Fleet Management and Route Optimization

Manufacturing/Production

- Intra-Plant Material Handling
- IT/OT Integration for Centralized Monitoring and Control
- Controller Virtualization
- Integrated and Automated Production Planning and Scheduling
- AI/ML for Process Optimization and Production Efficiency
- Integrated Quality Inspection and Production Control
- Predictive Maintenance for Shopfloor Machinery
- Digital Twin for Production Simulation and Optimization
- Robotics for Automated Assembly Line Activities
- Energy and Utility Optimization

Customer Service

- Customer Integration for Automated Logistics Workflow

Supply Chain Management (Outbound)

- Material Traceability for Warehouse Operations
- Integrated and Automated Production Planning and Scheduling
- Supply Chain Control Tower
- Fleet Management and Route Optimization

Enterprise Administration

- Automating Enterprise Processes Using RPAs
- Enterprise Cybersecurity Measures

Strategy and Organization

- I4.0 Capability Building (AR/VR)

Sustainability

- Recycle and Reuse of Material Waste/Scrap Material
- Wastewater Treatment Optimization Using Artificial Intelligence (AI)

*These Use Cases have the potential to be implemented across sectors

Data & IT OT Network solutions

1. IT/OT integration
2. Controller Virtualization

Secure & Self learning solutions

3. Predictive Maintenance
4. Integrated Quality Inspection
5. Integrated and Automated Production Planning and scheduling

Collaborative workspace solutions

6a. Digital Twin for Simulated Product Design
6b. Digital Twin for Production Simulation
7. AI/ML for Process Optimization
8. AR/VR enhanced training
9. Robotics for automated assembly
10. Automated material handling
11. Material Traceability for Warehouse

Supplier/Customer Network and Enterprise Administration solutions

12. Customer Integration for Automated Logistics Workflow
13. Supplier Integration for Automated Workflows
14. Fleet Management and Route Optimization
15. Supply Chain Control Tower
16. Automating Enterprise Processes Using RPAs
17. Enterprise Security Measures

Sustainability related solutions

18. Recycle & Reuse of Material Waste
19. Energy & Utility Optimization
20. Waste Water (Effluent) Monitoring

This guide - 'ITTI Use Case Guide 2.0' - focuses on bringing-out a step-by-step practical implementation guide for the 20 use cases from the ITTI use case guide. Along with the 20 use cases mapped out in the 'ITTI Use Case Guide, this 'ITTI Use Case Guide 2.0' also covers additional 10 use cases – which are either recommended as foundation solutions or provide better synergy when implemented with other solutions. Overall, this guide provides practical guide for implementation of 30 use cases, in total.

20 Unique Use Cases from ITTI Use Case Guide

→ **16** Manufacturing & Sustainability Usecases

→ **2** External Supply Chain Usecases

2 Enterprise Administration Usecases

\+ **10** Additional Usecases (Manufacturing & Sustainability)

» **Focus of this ITTI Use Case Guide 2.0**

"HOW TO IMPLEMENT"

Total = **30 Usecases**

Industry 4.0 Use Cases:

The primary objective of the guide is to support users in the efficient and scalable implementation of Industry 4.0 use cases across the industrial value chain. Understanding inter-dependency of the use cases and acknowledging the need to implement the foundational use cases before other use cases, the 30 use cases have been classified into 5 categories:

1. **Data & IT OT Network solutions**
2. **Secure & self learning solutions**
3. **Collaborative workspace solutions**
4. **Supplier/Customer network solutions**
5. **Sustainability related solutions**

The respective use cases are grouped under the relevant classifications and presented below:

Data & IT OT Network solutions	Secure & Self learning solutions	Collaborative workspace solutions	Supplier/Customer Network solutions	Sustainability related solutions
IT/OT integration for centralized monitoring & control	Condition Monitoring	Digital Twin for Product Design	Customer Integration for Automated Logistics Workflow	Energy and Utility Optimization
Controller Virtualization	Predictive Maintenance for Shopfloor Machinery	Digital Twin for Production Simulation	Supplier Integration for Automated Workflows	Air Quality Monitoring
Digital Andon	Integrated Quality Inspection and Production Control	AI/ML for Process Optimization and Production Efficiency	Fleet Management and Route Optimization	Waste Water (Effluent) Treatment with AI
Digital Work Instructions	Automated Optical Inspection	AR/VR Enhanced Training	Supply Chain Control Tower	Recycle & Reuse of Material Waste/ Scrap Material
Digital Shopfloor Management Solution	Integrated & Automated Production Planning & Scheduling	AR based Remote Maintenance	Automating Enterprise Processes Using RPAs	
OEE Dashboard		Robotics for Automated Assembly Line Activities	Enterprise Security Measures	
		Intra-plant Material Handling		
		Material Traceability for Warehouse Operations		
		Automated Storage & Retrieval		

This guide focuses on charting out step-by-step implementation guidance for each of these 30 use cases to enable the manufacturing ecosystem to make informed business decisions, accelerate the implementations and avoid costlier mistakes by learning from past implementations. The next section details the structure of the guide and how one shall leverage this document to gain maximum benefits for their business.

04 INDUSTRY 4.0 IMPLEMENTATION JOURNEY

INDUSTRY 4.0 IMPLEMENTATION JOURNEY

Planning the Implementation:

Owing to the complex nature of Industry 4.0 solutions and their components, better planning forms the base for successful implementation. Every Industry 4.0 use case is unique in terms of their goals, requirements, components involved, team capabilities and the execution methodology. Broadly, the Industry 4.0 implementation passes through 6 major phases of project lifecycle:

01 VALUE ANALYSIS PHASE

Evaluate the targeted KPI improvements and compare them against the cost of the solution to understand the economic value of implementation. Also, evaluate the cost of not implementing the solution & decide whether to go-ahead with the solution or not.

02 REQUIREMENTS GATHERING PHASE

Define the business problem clearly and describe high-level solution requirements. Establish a baseline of the existing system/process' metrics and infrastructure.

03 VENDOR EVALUATION PHASE

Explore potential teams who can support the implementation, and select the right vendor based on their qualifications, solution cost, timeline, and past credentials.

04 SOLUTION DESIGN PHASE

Define the detailed design of the solution, by carefully studying the existing infrastructure, targeted future state, existing gaps in realizing the target state and the elements required to attain the target state.

05 INSTALLATION & COMMISSIONING PHASE

Initiate procurement, mobilize resources, orchestrate the overall implementation of the project while ensuring targeted delivery of the estimated key benefits.

06 GO-LIVE & STABILIZATION PHASE

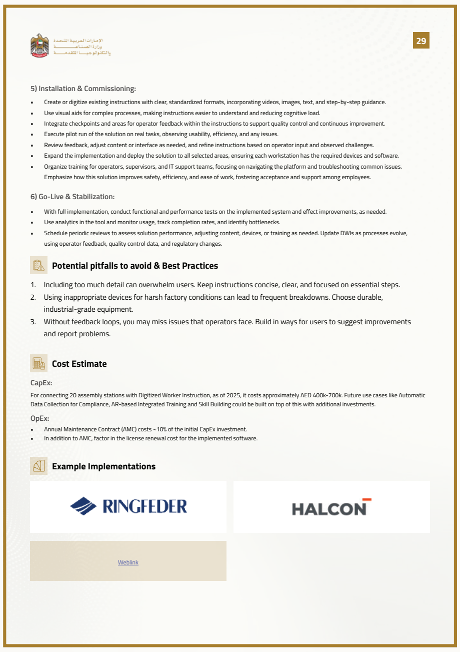
Implement the project, do the required testing, prepare documentations, train the users and ensure smooth hand-over of the project through proper change management.

While each project is unique, tailoring these 6 phases as specific to the particular project, will ensure better implementation journey. This guide targets at providing a structured step-by-step guidance for each use case, so that the users shall accelerate their Industry 4.0 adoption with ease.

How to use this guide:

The next section in this 'ITTI Use Case Guide 2.0' provides detailed implementation guidance for the 30 different Industry 4.0 use cases introduced in earlier sections.
Each use case is detailed out in 3 pages, where we provide details on the solution, ideal candidates who should adopt solution, when to embrace the solution, key tools and techniques required for each solution, step-wise implementation guidance addressing the 6 phases of project implementation, best practices, cost estimates and influential case study references.

A sample implementation guide is presented for the usecase 'Digitized Work Instructions' below:



The focus of each of the key headers are presented below:

1 Solution Introduction:
Provides an overview on type of business challenges that necessitate this solution.

2 Ideal Candidates:
Helps identify the right organizations who are front-runners for adopting the use case.

3 When to opt:
Ideal business situation which triggers the need for the solution.

4 Tools and Technologies involved:
Provides an overview on the wide-range of capabilities – both technologies as well as technicians – required to realize the project.

5 Solution Implementation Guidance:
A step-by-step guide to help an organization navigate the implementation journey. By providing distilled knowledge on the implementation steps, this provides valuable information for the organization to save months of efforts in planning and execution of the project.

6 Potential pitfalls to avoid & Best practices:
Helps the organization to avoid costlier mistakes by helping them learn from the past implementations.

7 Cost Estimate:
Helps the organizations to make informed decisions while budgeting.

8 Use cases:
Provide inspiration and reference details from past implementations.

*Disclaimer: The cost estimation presented in this use case are for indicative purposes only. Actual costs may vary depending on the organization's current maturity, implementation scope, vendor selection, and project timeline.

05 USE CASES IMPLEMENTATION GUIDE

A) Data & IT-OT Network solutions | Linked with ITTI Use Case Guide - page #96

Usecase #1: IT/OT Integration for Centralized Monitoring and Control

Solution Introduction:

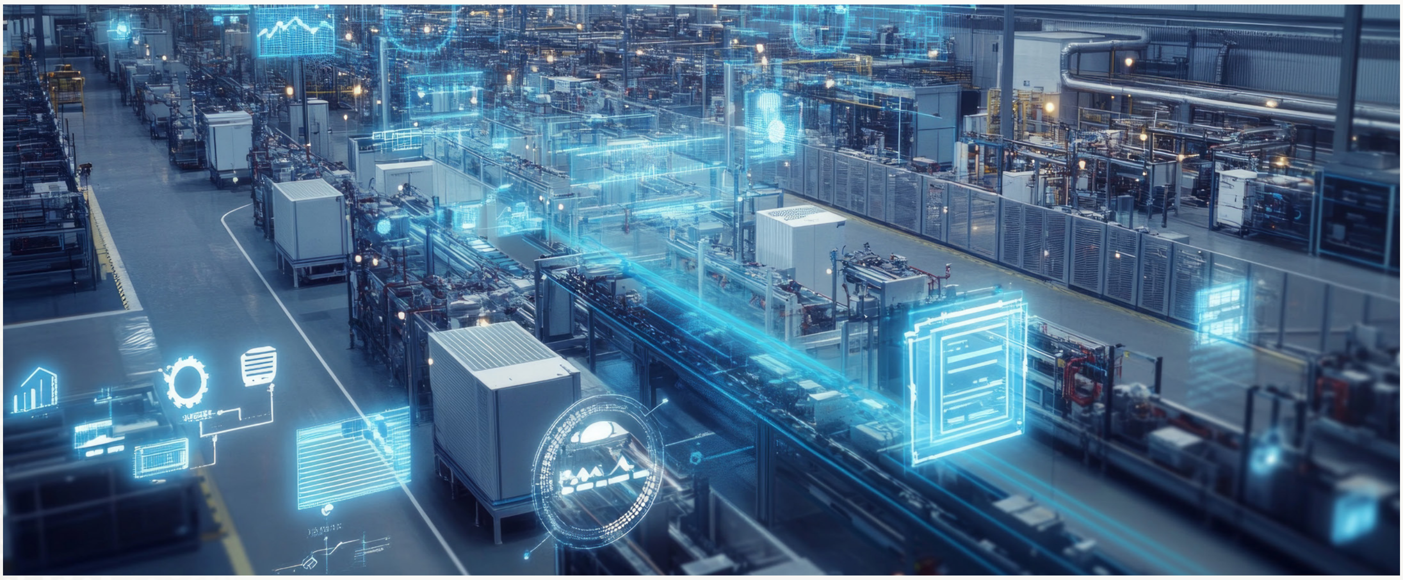
The integration of IT (Information Technology) and OT (Operational Technology) is becoming increasingly essential in modern industries. Traditionally, IT and OT systems operated separately, with OT focusing on monitoring and controlling physical processes, machines, and factory equipment, while IT dealt with data management, cybersecurity, and enterprise systems. For any organization, that embarks on Industry 4.0 journey, IT/OT integration acts as the first-step, as it captures the machine and operations data in digital format and thereby enabling future use cases.

Ideal candidates for adopting IT/OT Integration

Industries that rely heavily on operational technology and data- driven decision-making, such as

Discrete manufacturing	Energy & utilities firms
Process Industries like oil & gas, pharmaceuticals, and Transportation	

Generally, it is recommended to adopt this solution in production asset-heavy industries, where the machineries formulate major share of their cost structure.



When to opt for IT/OT Integration

It is recommended to integrate IT/OT when the organization targets one of the following:

1. Enhance operational efficiency
2. Improve real-time data insights
3. Optimize asset performance
4. Strengthen cybersecurity
5. Reduce downtime
6. Ensure better collaboration between IT and industrial operations
7. Implementing future usecases like OEE Monitoring, Condition Monitoring (Early Warning System), Predictive Maintenance, Digital Shopfloor Applications etc.,

Tools and Technologies Involved

1. Sensors: Temperature sensors, pressure sensors, humidity sensors, proximity sensors, vibration sensors, flow sensors, and level sensors.
2. Platforms: SCADA, MES, IIoT Platforms, Cloud-based Analytics
3. Protocols: OPC-UA, MQTT, Modbus, PROFIBUS
4. Edge Computing: Deploy Edge devices to process OT data locally before sending it to the cloud or on-premise IT systems.
5. Cybersecurity Solutions: Firewalls, VPNs, Endpoint protection.
6. Analytics: Data-models and intelligent algorithms to power future usecases on predictive maintenance, fault detection, and operational optimization.

Solution Implementation Steps

1) Value Analysis Phase:

- Identify the business objectives for IT/OT integration, such as increasing efficiency, improving operational visibility, or enhancing cybersecurity.
- Liaise with IT and OT teams, including executives, engineers, operators, and security personnel and identify the list of machines/production assets that need to be integrated to address the business requirements.
- Identify the future use cases that would be powered through this IT/OT integration (like OEE monitoring, Condition Monitoring, Predictive Maintenance etc.)
- Typically, this solution is treated as an enabler solution for future use cases and to get real- time visibility on production operations, hence it is recommended to conduct a qualitative study for Return-on-Investment, instead of a quantitative exercise.Typically, this solution is treated as an enabler solution for future usecases and to get real-time visibility on production operations, hence it is recommended not to conduct a qualitative study for Return-on-Investment, instead of a quantitative exercise.

2) Requirements Definition Phase:

- Evaluate the OT landscape (types of machines and sensors, number of machines and sensors, protocols in use, digitalization capabilities and data points).
- Evaluate the IT systems (shop floor systems, enterprise systems, embedded and proprietary software for machines) specifically regarding integration capabilities and requirements for identified use cases.
- Define the target state with detailed specification of all machines, required datapoints additional sensors and technologies for the targeted use cases.
- Specify the requirements for IT/OT integration layer based on the identified relevant use cases and all involved machines and sensors.
- Prepare the 'Requirements Specification document' encapsulating the current state, business objectives and target state definition, along with the details captured in the above steps.

3) Vendor Evaluation Phase:

- Conduct market research to identify potential vendors, and create a shortlist based on their capabilities, reputation, and experience relevant to the industry.
- Issue an RFP to shortlisted vendors including detailed requirements and expectations.
- Evaluate proposals for their commercials as well as technical proficiency.
- Arrange (on-site) vendor demonstrations.
- Conduct contract negotiation including pricing for defined high-level scope, delivery schedules, support agreements, and warranties before finalizing the agreement with the vendor.

4) Solution Design Phase:

- Enable the vendor team to do a detailed study of the following:
  -Study the production assets to be connected
  -Identify the list of data points to be collected for each of the production assets
  -Study requirements on infrastructure integration & evaluate different communication protocols
  -Evaluate the need and quantum of edge computing that is needed in the production assets
  -Conduct a study on information security and risk assessment of the OT assets
- Vendor team to prepare low-level design of the target solutions by evaluating the possible solutions options and making right choices on the solutions components based on business need, feature requirements, existing infrastructure and cost targets.
- Vendor team to prepare final Bill-of-Materials and in case of major deviation from the earlier scoped proposal, effect required Change Request and then place procurement order for required hardware and software licenses.

5) Installation & Commissioning:

- Once the required hardware and software are sourced, start with a pilot integration. Start with a small-scale implementation to evaluate the effectiveness of IT/OT convergence. This will help identify any issues before a full-scale rollout.
- In the pilot phase itself, conduct tests on Cybersecurity. Test security protocols such as firewalls, intrusion detection systems, and incident response plans.
- Then, track the pilot phase's performance, focusing on data flow, efficiency improvement and system latency.
- Once the pilot phase is observed to be successful, then roll-out in phases. Gradually integrate the entire organization to avoid disrupting operations. Start with the most critical assets and expand it to all production assets.

6) Go-Live & Stabilization:

- With the full implementation is done, implement real-time monitoring tools to ensure the system is performing as expected. Optimize based on feedback and performance metrics.
- As needed, continuously update the infrastructure, software, and security protocols to address emerging threats and evolving technologies.

Potential pitfalls to avoid & Best Practices

1. Design the IT/OT architecture to be scalable as the business grows or new technologies emerge. Specify connectivity requirements for future machines and sensor to reduce sub- sequent integration efforts.
2. Choose an integration platform that support as many protocols and technologies as possible to enable the solution for future use cases as well.
3. Ensure high coverage of network equipment (wifi/ethernet) on the shopfloor as soon as possible. This is a prerequisite for connecting to your shopfloor equipment.
4. Stay flexible to incorporate new I4.0 technologies like 5G, AI & advanced automation tools.
5. Ensure the converged IT/OT system complies with industry regulations, such as GDPR, HIPAA, or specific industrial safety standards.

Cost Estimate

CapEx:

For connecting 50 machines with IT/OT integration, as of 2025, it costs approximately AED 500k-2,500k depending on OT data availability. Future usecases like OEE, Condition monitoring, Predictive Maintenance could be built on top of this with additional investments.

OpEx:

- 1) License cost ranges between 100k-200k AED
- 2) Annual Maintenance Contract (AMC) costs 10-15% of the initial CapEx investment.

Example Implementations

ALPLA

IPM ITTIHAD PAPER MILL L.L.C.

Lipton

A) Data & IT-OT Network solutions | Linked with ITTI Use Case Guide - page #97

Usecase #2: Controller Virtualization

Solution Introduction:

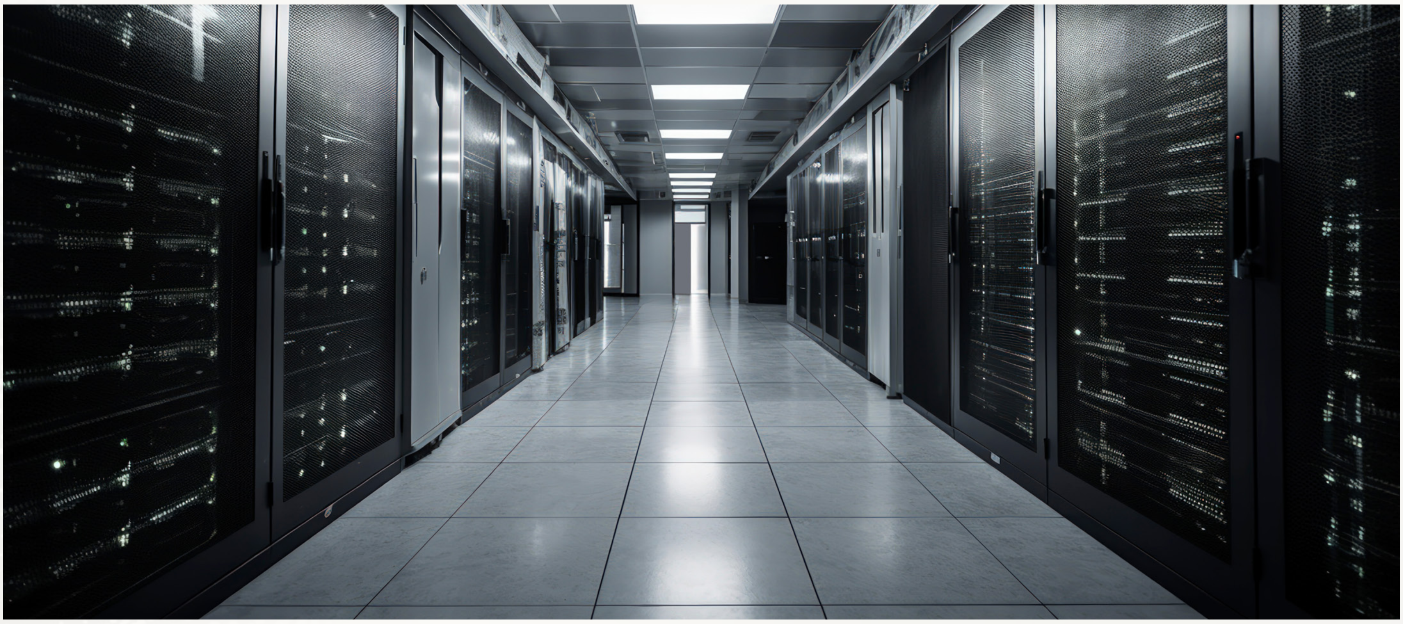
In order to move towards Industry 4.0 revolution, it is imperative to bring together the data generated from multiple data sources in the production ecosystem. One of the major challenges observed in terms of data collection is dependency on specific-OEM hardware like controllers, that limit the data sharing to the central inter-operable system.
Controller virtualization refers to the process of abstracting the hardware layer of industrial controllers, such as Programmable Logic Controllers (PLCs), Supervisory Control and Data Acquisition (SCADA) systems or Distributed Control Systems (DCS), into virtual machines or software-based environments. This modern industrial automation solution allows multiple control functions to run on shared or cloud-based computing resources, improving flexibility, scalability, and resource utilization.

Ideal candidates for adopting Controller Virtualization

Industries that deploy diverse set of industrial controllers in their production ecosystem, such as

Discrete manufacturing	Energy & utilities firms
Process Industries like oil & gas, pharmaceuticals, and Food processing industries	

Generally, it is recommended to adopt this solution in the industries, where there are variety of PLCs, SCADAs or DCS systems that are controlled by OEMs that created vendor lock-ins.



When to opt for Controller Virtualization

- Transition from traditional hardware-based control systems to virtualized environments
- Scale-up your factory's production control systems to accommodate changing production demands or the ability to manage operations from a centralized platform
- Improve disaster recovery capabilities
- Enable remote monitoring and control

Tools and Technologies Involved

1. Virtualization Platforms: Hypervisors, Technologies for containerization
2. Control Software: Software-based virtual PLCs, Simulation Tools
3. Industrial Automation Software: HMI software, PLC/SCADA/DCS systems
4. Networking/Connectivity Technologies: Software-Defined Networking, IIoT Platforms
5. Data Management and Analytics Tools: Data Historians, Big Data Analytics
6. Security Solutions: Firewalls and Intrusion Detection Systems, Endpoint Protection
7. Monitoring Tools: Virtual Machine Management & Performance Monitoring tools
8. Backup and Disaster Recovery Solutions

Solution Implementation Steps

1) Value Analysis Phase:

- Identify the business objectives for Controller Virtualization, such as reducing (automation controller) vendor lock-ins, cost reduction, improved scalability, or enhanced disaster recovery.
- Liaise with industrial automation, production & IT teams, including their executives, engineers, operators, and security personnel to identify the list of systems (PLC / SCADA / DCS) for which we need to address the stated business objectives.
- Identify the future use cases that would be powered on top this Controller Virtualization use case.
- Typically, this solution is treated as an enabler solution for future use cases and to get real- time visibility on production operations, hence it is recommended to conduct a qualitative study for Return-on-Investment, instead of a quantitative exercise.

2) Requirements Definition Phase:

- Assess existing control systems, hardware, and software to determine compatibility and necessary upgrades.
- Identify the assets for which the controller data need to be monitored and managed and enumerate the datapoints needed for the same.
- Define the target state with detailed specification of all machines, systems, datapoints and high- level architecture.
- Compile this information into and prepare 'Requirements Specification document'.

3) Vendor Evaluation Phase:

- Conduct market research to identify potential vendors (including existing list of vendors providing the existing controllers) and create a shortlist based on their capabilities, reputation, and experience relevant to the industry.
- Issue an RFP to shortlisted vendors including detailed requirements and expectations.
- Evaluate proposals for their commercials as well as technical proficiency.
- Arrange (on-site) vendor demonstrations and understand their Point-of-View for implementation.
- Conduct contract negotiation including pricing for defined high-level scope, delivery schedules, support agreements, and warranties before finalizing the agreement with the vendor.

4) Solution Design Phase:

- Enable the vendor team to design the Virtual Architecture by
  - Selecting right Virtualization Platform by choosing suitable hypervisors or container platforms based on project requirements.
  - Determining the system requirements by specifying CPU, memory, storage, and network needs for virtual machines or containers that will host the control functions.
  - Designing the network topology to enable secure and efficient communication between virtualized controllers and other systems.
  - Conducting a security assessment and prepare the information security plan.
- Vendor team to prepare low-level design of the target solutions by evaluating the possible solutions options and making right choices on the solutions components based on business need, feature requirements, existing infrastructure and cost targets.
- Vendor team to prepare final Bill-of-Materials and in case of major deviation from the earlier scoped proposal, effect required Change Request and then place procurement order for required hardware and software licenses.

5) Installation & Commissioning:

- Once the required hardware and software are sourced, start with the integration.
- Setup and configure the software by installing the Virtualization Software, creating Virtual Machines and installing Control Software (virtual PLCs, SCADA systems, and HMI software) on the virtual environment.
- Integrate the virtual environment with the existing systems (legacy systems) and ensure seamless data flow between virtualized environments and enterprise systems (e.g., MES, ERP)
- Once integrated, validate and test the system by conducting functional tests, performance tests and security tests
- Prepare the right documentation for hand-over and train the associates for day-to-day operations.
- Once the associates are trained, plan a phase-wise migration to mitigate disruption to operations and monitor them continuously to ensure seamless implementation.
- To ensure business continuity, set up regular backup schedules for virtual machines and data. Also, regularly test the recovery process to ensure that systems can be restored quickly and effectively in case of failure.

6) Go-Live & Stabilization:

- Once the full implementation is done, implement real-time monitoring tools to ensure the system is performing as expected. Optimize based on feedback and performance metrics.
- Establish mechanism to gather feedback from the users and fix the required enhancements.
- Implement updates and patches periodically to keep the virtualization environment secure and efficient.

Potential pitfalls to avoid & Best Practices

1. Failing to fully evaluate the existing control infrastructure and operational needs can lead to compatibility issues or underperformance after virtualization.
2. Virtualized environments may introduce latency and may affect time-sensitive operations. Hence test the virtualized system under real operational loads.
3. A poorly designed network architecture can create bottlenecks, affect communication between virtual controllers, and increase downtime risks. Hence pay extra attention to build a robust network infrastructure plan.
4. Virtualized environments can expose new attack surfaces if security is not properly considered from the outset, leading to breaches in critical control systems. In order to avoid this, do security planning as part of design and development stage itself.
5. Ensure adequate provisioning for computing power, memory, and storage to avoid degradation in controller performance.

Cost Estimate

CapEx:

Depending on scope and scale of the integration, the project investments ranges from 100k AED to 1Mn AED.

OpEx:

- Annual Maintenance Contract (AMC) costs ~15% of the initial CapEx investment.
- In addition to AMC, factor in the license renewal cost for the implemented software

Example Implementations

ENGIE

MITSUBISHI HEAVY INDUSTRIES

A) Data & IT-OT Network solutions	Newly Added Use Case

Usecase #3: Digital Andon

Solution Introduction

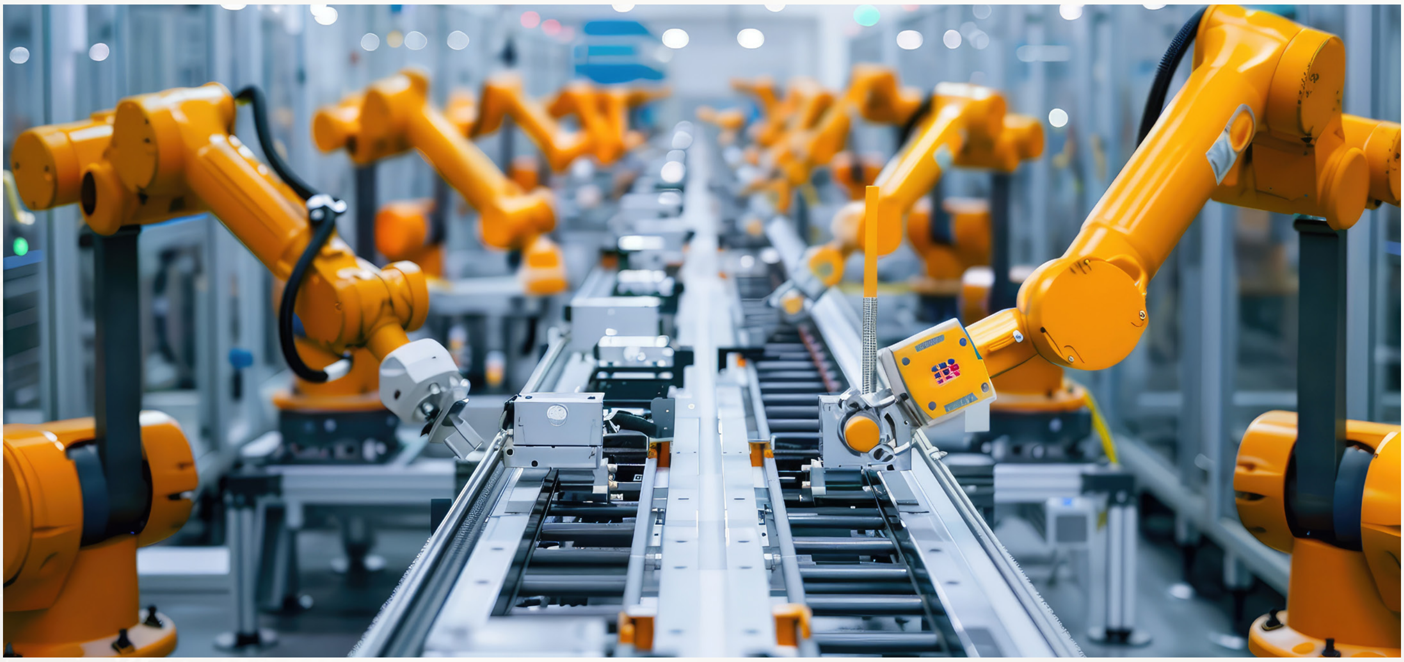
Andon systems act as a key enabler for establishing a lean production line, that is free from unwanted delays that could be avoided with timely intervention by right people. A Digital Andon solution is a technology-driven system designed to enhance real-time communication and issue resolution on manufacturing floors. Originating from traditional Japanese Andon boards, digital systems modernize the concept by integrating LED displays, sensors, and IoT capabilities to instantly signal production status and alerts.

By providing real-time, standardized alerts for issues like machine downtime, quality concerns, or material shortages, Andon systems allow teams to respond immediately, reducing downtime and ensuring consistent product quality. This quick response capability streamlines workflow, minimizes operational costs, and supports continuous improvement across manufacturing processes.

Ideal candidates for adopting Digital Andon

Generally, it is recommended to implement Digital Andon in

Manufacturing companies with assembly lines	Machining centers with serial production operations
Order fulfillment centers (picking operation line)	Operations that need product and process traceability



When to opt for Digital Andon

- Frequent Delays or Downtime during operations
- Inconsistent communication on machine/process downtime and its reasons
- Need for data insights to study and improve the processes

Tools and Technologies Involved

1. HMI Displays (For operators to key-in important events)
2. IoT Devices and Sensors (To automatically read from machine conditions)
3. Display and Alert Mechanisms: LED boards, monitors, or tablet screens. Optional additions include buzzers, sirens, and flashing lights.
4. Communication Networks: Wi-Fi, Bluetooth or Wired ethernet
5. Andon Software & Platforms: Andon Control Software, Mobile Applications, Dashboard and Visualization Tools.
6. Data Analytics & AI/ML Models: For extracting additional insights from the Andon system
7. Data & Network security solutions: Firewalls, encryption & secure communication protocols

Solution Implementation Steps

1) Value Analysis Phase:

- Identify the business objectives for Andon systems, such as reducing downtime, enhancing response times, or improving quality control.
- Liaise with plant manager, production supervisors, Operators & IT teams
- Identify the list of processes and machines for which this solution to be implemented.
- Identify the future usecases that would be powered on top this Digital Andon use case.
- Typically, this solution is treated as an enabler solution for future usecases and to get real-time visibility on production operations, hence it is recommended to conduct a qualitative study for Return-on-Investment, instead of a quantitative exercise.

2) Requirements Definition Phase:

- Analyze existing production or operational processes to identify critical control points where Andon alerts would be most valuable.
- Identify triggers for alerts, such as equipment malfunctions, quality issues, or process deviations, and define thresholds for each trigger.
- Decide on type of alerts that need to generated (visual / audio / mail communication).
- List the requirements, including the types of alerts, performance metrics, reporting needs, and user access levels.
- Compile these information into and prepare 'Requirements Specification document'.

3) Vendor Evaluation Phase:

- Conduct market research to identify potential vendors and create a shortlist based on their capabilities, reputation, and experience relevant to the industry.
- Issue an RFP to shortlisted vendors including detailed requirements and expectations.
- Evaluate proposals for their commercials as well as technical proficiency.
- Arrange (on-site) vendor demonstrations and understand their capabilities.
- Conduct contract negotiation including pricing for defined high-level scope, delivery schedules, support agreements, and warranties before finalizing the agreement with the vendor.

4) Solution Design Phase:

- Facilitate the vendor team for
  - Studying the overall production operations, the production assets and the required alerts.
  - Selecting appropriate input device (HMI's), sensors (e.g., temperature, vibration, proximity) and IoT devices based on the triggers and control points identified
  - Determining the types and locations of visual display screens (e.g., LED boards, tablets) and audio devices needed to notify teams in real-time.
  - Choosing a software platform that meets the system's requirements, offers real-time alerting, and is compatible with IoT devices.
  - Planning the future integrations required (with MES / ERP systems)
  - Studying the existing network infrastructure and communication protocols
- Vendor team to prepare low-level design of the target solutions by evaluating the possible solutions options and making right choices on the solutions components based on business need, feature requirements, existing infrastructure and cost targets.
- Vendor team to prepare final Bill-of-Materials. In case of major deviation from the earlier scoped proposal, effect required Change Request and then place procurement order for required hardware and software licenses.

5) Installation & Commissioning:

- Configure the input devices and IoT sensors on identified production assets.
- Establish the required communication network.
- Set Up Data Storage and Processing infrastructure.
- Configure the Andon system software and set up alert conditions, thresholds, and workflows within the Andon software, and customize notifications for different types of issues.
- Configure real-time dashboards, performance metrics, and reporting features to ensure actionable insights are readily available.
- Assign access levels based on team roles, enabling operators, supervisors, and management to receive relevant alerts and access necessary data.
- Train users on how to operate the Andon system, respond to alerts, and use the data effectively.

6) Go-Live & Stabilization:

- With this full implementation, conduct functional and performance tests on the implemented system and effect improvements, as needed.
- Establish mechanism to gather feedback from the users and fix the required enhancements.
- Use data insights to identify areas for improvement and optimize alert configurations, workflows, and processes to maximize Andon system benefits.

Potential pitfalls to avoid & Best Practices

1. Set up specific alert thresholds and prioritize critical issues. Use categorization for alerts (e.g., minor, major, critical) and tailor notifications to avoid alert overload.
2. Ensure the Andon system is compatible with your current technology stack and integrate it with other systems for a seamless flow of data, helping operators access and respond to information quickly.
3. Customize the Andon system to the specific needs of your processes, defining different types of alerts for various teams or departments and customizing response protocols.
4. Ensure that your Andon system has robust data visualization and analysis tools. Enable dashboards and alerts to provide real-time insights that are easily accessible and actionable for operators and managers.

Cost Estimate

CapEx:

For connecting 20 machines with Digital Andon solution, as of 2025, it costs approximately AED 300k-500k. Future use cases like AI/ML based production optimization, OEE monitoring could be built on top of this with additional investments.

OpEx:

- Annual Maintenance Contract (AMC) costs ~10% of the initial CapEx investment.
- In addition to AMC, factor in the license renewal cost for the implemented software.

Example Implementations

TOYOTA

HALCON

A) Data & IT-OT Network solutions | Newly Added Use Case

Usecase #4: Digitized Work Instructions

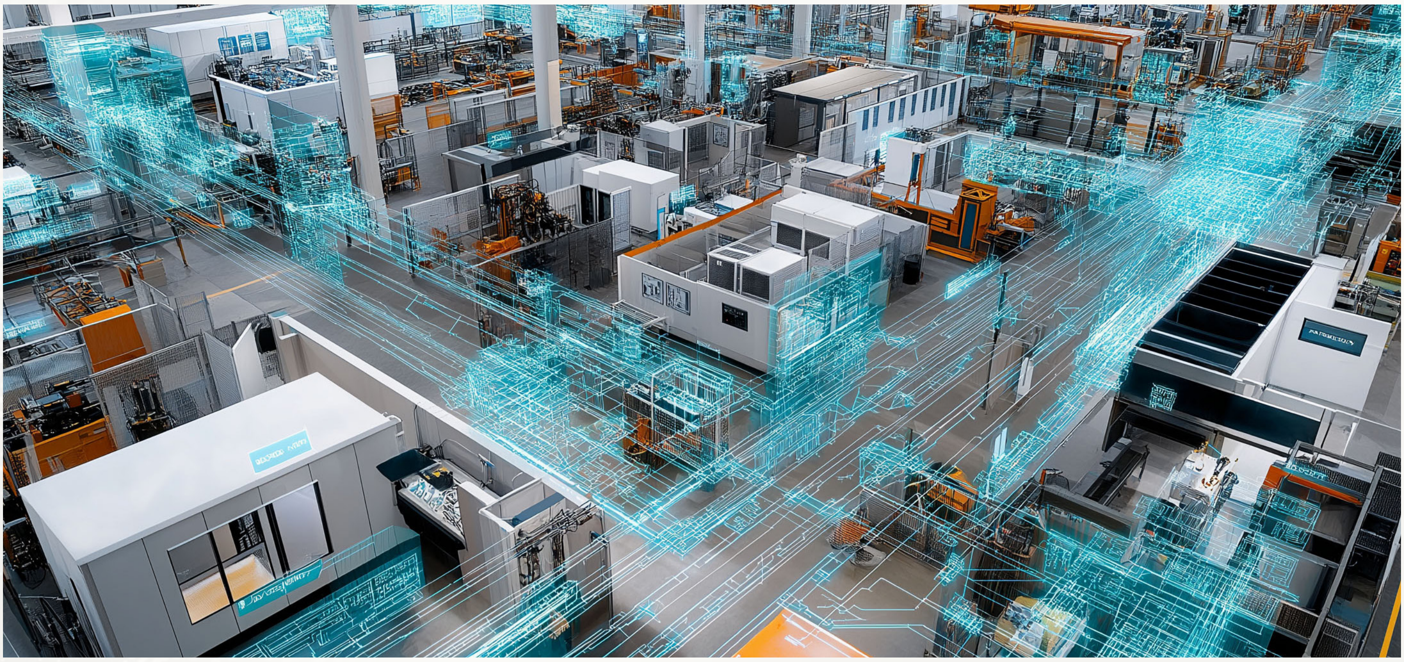
Solution Introduction

Industry 4.0 aims at transforming traditional manufacturing facilities into a highly-flexible and highly- productive manufacturing facilities. One of the core enablement is to convert the production line into a multi-model line, catering to wide range of product assemblies. While switching between models, one of the key challenges faced by the production crew is about fetching the right instruction to carry out their production operation.
Digitized work instructions are digital versions of step-by-step guides for tasks, often presented on tablets or computers. They replace paper manuals, providing real-time, interactive, and often visual support to help employees complete tasks accurately and efficiently. They improve consistency and compliance, particularly in industries with complex processes or strict quality standards.

Ideal candidates for adopting Digitized Work Instructions

Manufacturing facilities that deal with multiple product assemblies in same line and those with complex processes, stringent compliance requirements, or high variability in tasks are recommended to adopt this ease-to-implement solution. Typical examples include:

- Manufacturing companies with multi-model assembly lines
- Machining centers handling diverse part va riances
- Logistics team responsible for picking & kitting



When to opt for Digitized Work Instructions

- Companies scaling their production operations
- Manufacturers experiencing high employee turnover
- Operations with complex and error-prone production processes
- Facilities where work processes or compliance regulations change frequently

Tools and Technologies Involved

1. Authoring Software
2. Knowledge Management Systems
3. Industrial-Grade Tablets or Wearable Devices
4. Barcode/QR Code Scanners
5. Real-Time Connectivity and Cloud Integration
6. Data Collection and Analytics
7. Connectivity to ERP / MES systems

Solution Implementation Steps

1) Value Analysis Phase:

- Define what the business wants to achieve - e.g., improve efficiency, reduce errors, standardize processes.
- Liaise with plant manager, production supervisors, Operators & IT teams to determine which manufacturing processes or areas will benefit most from this Digital Work Instruction solution.
- Define KPIs to track improvements, such as error reduction, training time, or productivity gains and thereby define the As-Is benchmark and also establish the target To-Be state.
- Typically, this solution is treated as an enabler solution for future use cases and to get real- time visibility on production operations, hence it is recommended to conduct a mix of quantitative and qualitative study for Return-on-Investment, instead of just a quantitative exercise.

2) Requirements Definition Phase:

- Prepare the list of stations/machines which need this solution.
- Review current work instructions, identifying gaps, redundancies, or outdated information.
- Engage operators, process engineers and quality control team to understand their specific needs and challenges.
- Work with the IT team and check if existing hardware and network connectivity are compatible or require upgrades.
- Compile this information and prepare 'Requirements Specification document'.

3) Vendor Evaluation Phase:

- Conduct market research to identify potential vendors and create a shortlist based on their capabilities, reputation, and experience relevant to the industry.
- Issue an RFP to shortlisted vendors including detailed requirements and expectations.
- Evaluate proposals for their commercials as well as technical proficiency.
- Arrange (on-site) vendor demonstrations and understand their capabilities.
- Conduct contract negotiation including pricing for defined high-level scope, delivery schedules, support agreements, and warranties before finalizing the agreement with the vendor.

4) Solution Design Phase:

- Enable the vendor team to prepare the low-level-design of the solution by performing following activities:
  - Study the overall production operations, volume of work instructions and the work force's preference for interacting with the digital work instructions.
  - Choose durable devices (tablets, industrial PCs, AR/VR devices) suited to your factory environment.
  - Select the right authoring software and content management platform that supports multimedia, cloud/on-premise storage, data integration, and customization.
  - Evaluate the required integration with existing/upcoming systems like ERP & MES.
- Vendor team to prepare low-level design of the target solution by evaluating the possible solutions options and making right choices on the solutions components based on business need, feature requirements, existing infrastructure and cost targets.
- Vendor team to prepare final Bill-of-Materials. In case of major deviation from the earlier scoped proposal, effect required Change Request and then place procurement order for required hardware and software licenses.

5) Installation & Commissioning:

- Create or digitize existing instructions with clear, standardized formats, incorporating videos, images, text, and step-by-step guidance.
- Use visual aids for complex processes, making instructions easier to understand and reducing cognitive load.
- Integrate checkpoints and areas for operator feedback within the instructions to support quality control and continuous improvement.
- Execute pilot run of the solution on real tasks, observing usability, efficiency, and any issues.
- Review feedback, adjust content or interface as needed, and refine instructions based on operator input and observed challenges.
- Expand the implementation and deploy the solution to all selected areas, ensuring each workstation has the required devices and software.
- Organize training for operators, supervisors, and IT support teams, focusing on navigating the platform and troubleshooting common issues. Emphasize how this solution improves safety, efficiency, and ease of work, fostering acceptance and support among employees.

6) Go-Live & Stabilization:

- With full implementation, conduct functional and performance tests on the implemented system and effect improvements, as needed.
- Use analytics in the tool and monitor usage, track completion rates, and identify bottlenecks.
- Schedule periodic reviews to assess solution performance, adjusting content, devices, or training as needed. Update DWIs as processes evolve, using operator feedback, quality control data, and regulatory changes.

Potential pitfalls to avoid & Best Practices

1. Using inappropriate devices for harsh factory conditions can lead to frequent breakdowns. Choose durable, industrial-grade equipment.
2. Without feedback loops, you may miss issues that operators face. Build in ways for users to suggest improvements and report problems.

Cost Estimate

CapEx:

For connecting 20 assembly stations with Digitized Worker Instruction, as of 2025, it costs approximately AED 400k-700k. Future use cases like Automatic Data Collection for Compliance, AR-based Integrated Training and Skill Building could be built on top of this with additional investments.

OpEx:

- Annual Maintenance Contract (AMC) costs ~10% of the initial CapEx investment.
- In addition to AMC, factor in the license renewal cost for the implemented software.

Example Implementations

RINGFEDER POWER TRANSMISSION

HALCON

A) Data & IT-OT Network solutions | Newly Added Use Case

Usecase #5: Digital Shop Floor Management

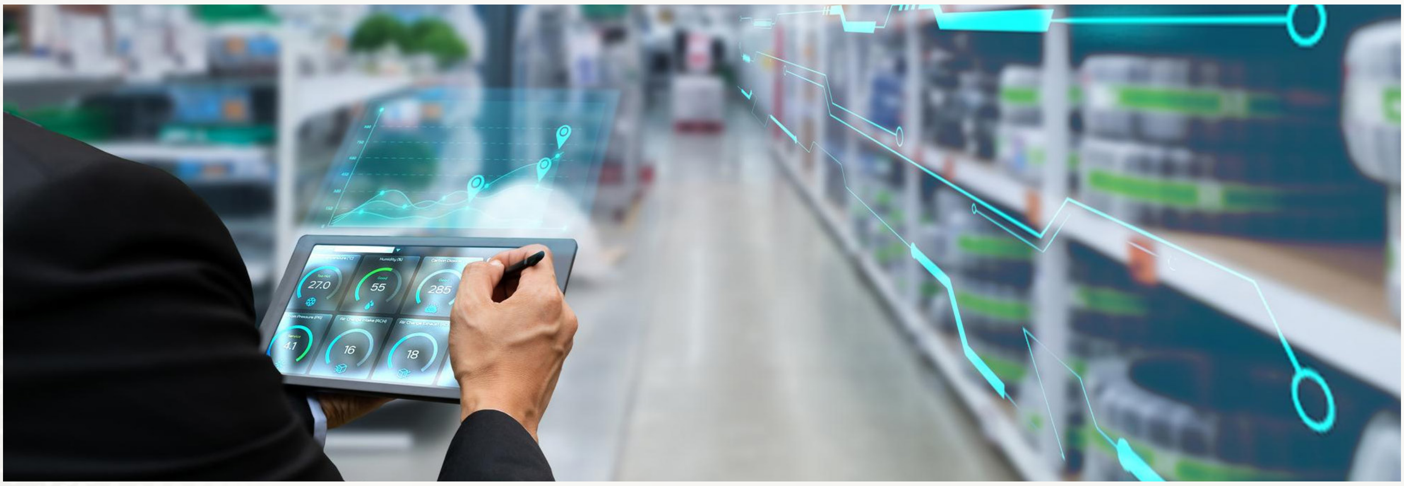
Solution Introduction

Factory shop floors are usually loaded with paper-based records and paper-based management of daily activities, leading to delays and inefficiencies in the way day-to-day operations are carried out. The conventional ways of managing the data, discussing with the team, doing problem-solving as a team, assigning activities and tracking their progress are time-consuming and difficult to manage with the paper-based system.
Digital Shop Floor Management (DSFM) digitalizes these processes and provides a unified view of production, empowering managers and operators for doing collective problem-solving, arrive at actionable insights to make faster, data-driven decisions, assign and track the activity progress and continuously improve operational efficiency and quality.

Ideal candidates for adopting Digital Shop Floor Management

Ideal candidates for adopting a Digital Shop Floor Management (DSM) solution are typically manufacturers and industries that can benefit from improved visibility, efficiency, and control over their production processes. Key candidates include:

Industries Requiring Strict Quality Control	Industries Focused on Lean and Continuous Improvement
Companies with Multiple Facilities	Industries trying to digitalize their data and knowledge to enable adoption of Industry4.0 technologies



When to opt for Digital Shop Floor Management

When to opt for Digital Shop Floor Management

- Fragmented operational data across multiple systems
- Managing multiple facilities or a dispersed workforce
- Transitioning toward data-driven decision making
- Need to standardize problem-solving and leverage past knowledge
- Lack of real-time visibility into production metrics and workflow status
- Difficulty in tracking activity progress on the shop floor

Tools and Technologies Involved

1. IoT Devices and Sensors: IoT gateways, additional sensors, Edge devices
2. Machine-to-Machine Communication Protocols: OPC UA, MQTT, and Modbus
3. Data Infrastructure and Cloud Platforms: Data Lakes, Data Warehouses, Cloud Computing
4. Data Processing and Analytics Tools: ETL tools, Real-Time Analytics Engines
5. Existing data sources: MES, ERP
6. Visualization and Dashboarding Tools: e.g. Power BI, Tableau, and Grafana
7. Digital Workflow and Collaboration Tools: e.g. IBM Maximo, ServiceNow

Solution Implementation Steps

1) Value Analysis Phase:

- Define the key objectives of the DSFM implementation, such as real-time monitoring, faster report generation, standardized problem-solving and leveraging past knowledge.
- Liaise with plant manager, production supervisors, Operators & IT teams to source their inputs on KPIs being tracked in the production operations.
- Collaborate with stakeholders to outline functional and non-functional requirements, including KPIs, reporting needs, data security, and compliance standards.

2) Requirements Definition Phase:

- Document existing shop floor processes and workflows and prepare the process map.
- Prepare the list on data requirement from each of the shop floor asset / process.
- Evaluate the current technology stack, including machinery, connectivity, sensors, and data collection capabilities.
- Identify interfaces for integrating existing systems (ERP, MES, SCADA) with the DSFM solution.
- Analyze and select the right set of problem-solving tools and frameworks relevant to the respective shop floor.
- Identify the requirements from the operations team – in terms of data unification, problem- solving procedure, required customized dashboards and action tracking requirements.
- Choose an appropriate DSFM software platform that aligns with the requirements (e.g., cloud- based, on-premises, edge computing).
- Compile this information and prepare 'Requirements Specification document'.

3) Vendor Evaluation Phase:

- Conduct market research to identify potential vendors and create a shortlist based on their capabilities, reputation, and experience relevant to the industry.
- Issue an RFP to shortlisted vendors including detailed requirements and expectations.
- Evaluate proposals for their commercials as well as technical proficiency.
- Arrange (on-site) vendor demonstrations and understand their capabilities.
- Conduct contract negotiation including pricing for defined high-level scope, delivery schedules, support agreements, and warranties before finalizing the agreement with the vendor.

4) Solution Design Phase:

- Once onboarded, enable the vendor team to prepare the low-level-design of the solution by performing following:
  - Identify the team members / processes / production assets that need to be integrated to the DSFM solution.
  - Identify the existing set of data points that are already connected and available in other systems.
  - Design the data acquisition, processing and analytics systems in line with other solutions.
  - Implement ETL (Extract, Transform, Load) processes to ensure that collected data is clean, standardized, and ready for analysis.
  - Set up secure access control, encryption, and compliance mechanisms to protect sensitive data.
  - Design a scalable data architecture to handle shop floor data from multiple sources.
- Prepare detailed design of the target solution by evaluating the possible solutions options and making right choices on the solutions components based on business need, feature requirements, existing infrastructure and cost targets.
- Basis the gathered inputs and target solution, vendor team needs to prepare the final Bill-of- Materials.

5) Installation & Commissioning:

- First, install additionally required sensors and deploy edge devices to perform data processing at the shop floor level, reducing latency and bandwidth requirements.
- Integrate the DSFM solution with ERP, MES, and other enterprise systems to enable data flow and streamline workflows.
- Ensure data consistency across systems and establish regular data synchronization intervals to keep information updated in real time.
- Create a unified data model and standardized formats, evaluate data integrity, and ensure accurate integration into a harmonized system.
- Customize and configure the dashboards in line with the production team's needs.
- Implement the features for tracking production tasks, and activities assigned during morning meetings.
- Configure the identified/standardized problem-solving frameworks and link them to Knowledge Management System for recording and archiving the analysis for future references.
- Start using the DSFM solution for the first line alone and gather user feedback and perform functionality test for the application.
- Improve the implemented DSFM solution basis the pilot run on first line and incorporate required enhancements as needed.
- Once stabilized, move towards full implementation.

6) Go-Live & Stabilization:

- With this full implementation, conduct functionality and usability tests by performing rigorous testing on all the lines where the solution was implemented.
- Train operators, technicians, and managers on using the dashboard, interpreting metrics, and responding to alerts and provide the required documentation.
- Schedule checks for sensors and data connections, and update software and models as needed.

Potential pitfalls to avoid & Best Practices

1. Start with essential data related to your KPIs and gradually expand as needed.
2. Tailor dashboards, tools, and interfaces to user needs for higher engagement and productivity.
3. Design the solution for scalability and standardize processes for seamless expansion.
4. Set up a continuous improvement loop to adapt and evolve the DSFM as needs change.

Cost Estimate

CapEx:

For connecting a production line with DSFM solution, involving data integration, dashboard configuration, and problem solving framework modules, as of 2025, it costs approx AED 300K-3Mn depending on the OT data availability and Enterprise system integration.

OpEx:

- Annual Maintenance Contract (AMC) costs <2% of the initial CapEx investment.
- Annual license cost ranges from 20k-40k AED per production line.

Example Implementations

Tereos

EDGE

A) Data & IT-OT Network solutions | Newly Added Use Case

Usecase #6: OEE Dashboard

Solution Introduction

The true potential of Industry4.0 could untapped with the data generated in the Shopfloor and the insights that are derived out of it. One of the key metrics in any manufacturing facility is OEE (Overall Equipment Effectiveness) and it need to be monitored on frequent basis, to identify and fix issues that reduce the production output or quality.
This solution integrates directly with factory equipment through sensors and gateways to track equipment utilization, flag issues, and streamline decision-making. With clear visualizations and timely notifications, the dashboard empowers teams to address bottlenecks swiftly, enhancing production flow and overall equipment reliability. Ultimately, it drives operational efficiency and reduces costs across the manufacturing process.

Ideal candidates for adopting OEE Dashboard

Typically, all manufacturing facilities that target to improve their performance in terms of production output and quality are recommended to adopt this solution. Following set of organizations are recommended to adopt this solution:

Discrete and process manufacturing companies
Manufacturing organizations handling High-Volume / High-Value Operations
Organizations planning to implement multiple data-driven solutions in the Shopfloor in future

When to opt for OEE Dashboards

- Striving for operational efficiency improvements
- Managing multiple production lines
- Facing challenges in identifying root causes of inefficiencies
- Experiencing high maintenance costs
- Evaluating future investment decisions to add new capacity

Tools and Technologies Involved

1. Data capturing tools: IT/OT integration, Controller virtualization, PLCs, IoT Sensors
2. Communication protocols: e.g. OPC UA
3. Data consolidation tools: IIoT platforms, SCADA
4. Data storage: Databases, Cloud storages
5. Data processing & analysis tools: Extract, Transform, Load tools, Analytics algorithms
6. Cloud / Edge computing platforms
7. Visualization and dashboarding tools
8. Data security tools: Single-sign-on & Role-based access controls
9. Reporting and alerting tools
10. APIs & Integrators

Solution Implementation Steps

1) Value Analysis Phase:

- Identify the business objectives demanding the need for OEE dashboard (e.g. improve productivity, reduce downtime, enable predictive maintenance or implement future use cases)
- Liaise with plant manager, production supervisors, Operators & IT teams to source their inputs on the metrics/KPIs that need to be tracked to achieve the targeted business objective
- (e.g. availability of machines; operations performance; quality)
- Determine which production assets / processes that would require the OEE dashboard solution
- Record and analyze the current state of the targeted KPIs. Then, define the specific KPI targets.
- Typically, this solution is treated as an enabler solution for future use cases and to get real- time visibility on production operations, hence conduct a mix of quantitative and qualitative study for Return-on-Investment. Once the business case is validated, move ahead to the next phase.

2) Requirements Definition Phase:

- Enumerate the list of stations / machines which need this solution.
- Identify existing systems (MES, SCADA, ERP, or PLCs) storing machine and production data.
- Engage operators, process engineers and quality control team to understand their needs.
- Work with the IT team and check if existing hardware & network connectivity are compatible or require upgrades. Check if IoT devices/additional sensors needed for real-time data collection.
- Verify network capabilities and decide whether a cloud solution, edge computing, or on- premises system is preferred.
- Compile this information and prepare 'Requirements Specification document'.

3) Vendor Evaluation Phase:

- Conduct market research to identify potential vendors and create a shortlist based on their capabilities, reputation, and experience relevant to the industry.
- Issue an RFP to shortlisted vendors including detailed requirements and expectations.
- Evaluate proposals for their commercials as well as technical proficiency.
- Arrange (on-site) vendor demonstrations and understand their capabilities.
- Conduct contract negotiation including pricing for defined high-level scope, delivery schedules, support agreements, and warranties before finalizing the agreement with the vendor.

4) Solution Design Phase:

- Enable the vendor team to prepare the low-level-design of the solution by performing following:
  - Study the overall production operations, production assets that are earmarked for OEE dashboard solution, their work center grouping and respective team's shift configurations.
  - Select IoT sensors, PLCs, or other devices to collect needed additional machine data.
  - Evaluate integration tools to unify data from multiple sources (OPC/IIoT/middleware).

- Select the dashboarding tool (e.g., Power BI, Tableau, Grafana or custom IIoT application) based on visualization needs, customization options, and user access requirements.
- Choose data storage and processing solutions by evaluating and deciding between SQL/NoSQL databases, cloud storage, or time-series databases.
- Evaluate the required integration with existing/upcoming systems like ERP & MES.
- Develop a data model that includes data fields and calculations for OEE.
- Map the dashboard layout, including charts, gauges, and KPIs, to ensure user-friendly navigation and clear insights.
- Design dashboard that provides both real-time insights & historical trend analysis.

▪ On the basis of above details, the vendor team to prepare detailed design of the target solution by evaluating the possible solutions options and making right choices on the solutions components based on business need, feature requirements, existing infra and cost targets.
▪ Vendor team to prepare final Bill-of-Materials.

5) Installation & Commissioning:

▪ First, connect the data sources - MES, SCADA, PLCs, and other systems - leveraging integration protocols (e.g., OPC UA).
▪ Use ETL tools to extract, transform, and load data into the database, ensuring clean, structured, and relevant data.
▪ Ensure data quality by applying validation rules to detect and handle data discrepancies, ensuring accurate OEE calculations.
▪ Use visual aids for complex processes, making instructions easier to understand and reducing cognitive load.
▪ Develop the OEE dashboard with the selected visualization tool, incorporating KPIs, charts, and real-time alerts.
▪ Establish conditions for alerts (e.g., downtime, threshold breaches) to notify users of critical issues in real-time.
▪ Configure automated reporting for daily/weekly/monthly frequency.

6) Go-Live & Stabilization:

▪ With this full implementation, conduct functionality and usability tests by performing rigorous testing to ensure data accuracy, real-time updates, and an intuitive user experience.
▪ Get feedback from operators, supervisors, and managers to fine-tune the dashboard.
▪ Roll out the dashboard in the live environment, ensuring smooth integration with other systems.
▪ Train operators, technicians, and managers on using the dashboard, interpreting metrics, and responding to alerts and provide the required documentation.

Potential pitfalls to avoid & Best Practices

1. Use data validation and cleansing processes to ensure accurate, complete, and consistent data before it reaches the dashboard.
2. Use scalable tools to accommodate future growth and additional data sources.
3. Prioritize a user-friendly interface with simple navigation, clear visuals, and easily interpretable metrics. Involve end users in the design phase to ensure their needs are met.
4. Integrate the dashboard into broader improvement initiatives, such as lean manufacturing or Six Sigma, to drive ongoing progress to ensure faster and better adoption.

Cost Estimate

CapEx:

For connecting 50 machines for OEE dashboard, as of 2025, it costs approximately AED 800k – 1,200k. Future use cases like Condition Monitoring, Predictive Maintenance, Energy Optimization could be built on top of this with additional investments.

OpEx:

▪ Annual Maintenance Contract (AMC) costs ~10% of the initial CapEx investment.
▪ In addition to AMC, factor in the license renewal cost for the implemented software.

Example Implementations

By Appointment to The Royal Danish Court
BISCA

CARACAL

B) Secure & Self-learning solutions	Newly Added Use Case

Usecase #7: Condition Monitoring

Solution Introduction

Condition monitoring of machines is a proactive maintenance solution that leverages real-time data to assess equipment health and predict potential failures. By continuously tracking parameters such as vibration, temperature, pressure, and noise, it helps identify early warning signs of wear or malfunction. This approach minimizes unplanned downtime, extends asset lifespan, and optimizes maintenance schedules. With the integration of IoT sensors, data analytics, and AI, condition monitoring ensures improved reliability, reduced costs, and enhanced overall efficiency in industrial operations.

Ideal candidates for adopting Condition Monitoring

Ideal candidates for condition monitoring include industries with critical, high-value, or high-wear assets. It's ideal for environments with rotating, high-wear, or high-value machinery where early detection of issues can prevent costly repairs or replacements.
Following industries are highly recommended to adopt this solution:

Manufacturing (CNC machines, conveyors)	Power generation (turbines, transformers)
Oil and gas (pumps, compressors)	Mining (heavy equipments)

When to opt for Condition Monitoring

- When equipment downtime significantly impacts production
- When maintenance costs are high
- Where asset reliability is critical
- When strict safety and compliance are highly required

Tools and Technologies Involved

It is highly recommended to implement the OEE Dashboard solution first, before venturing into this solution. With OEE dashboard in place, following additions are suggested:

1. Sensors and IoT devices: Vibration, Temperature, Pressure, Acoustic and Ultrasonic sensors
2. Data storage and processing: Databases, Cloud storages
3. Data processing & analysis tools: Extract, Transform & Load (ETL) tools and Analytics algorithms
4. Analytics & Machine Learning algorithms: Predictive Analytics Tools, Machine Learning Models
5. APIs & Integrators
6. Visualization and Dashboarding Tools: BI Tools, Custom Web Dashboards
7. Alerts & Notification Systems

Solution Implementation Steps

1) Value Analysis Phase:

- Identify why condition monitoring is needed (e.g., reduce downtime, extend equipment life, prevent failures).
- Liaise with plant manager, production supervisors, Operators & IT teams to source their inputs and define key performance indicators like uptime, maintenance cost reduction, or mean time between failures (MTBF).
- Identify critical or high-value assets that impact production or safety and benefit most from condition monitoring.
- Earmark target improvement in the identified assets and convert them into monetary metrics to evaluate the Return-on-Investment potential. Once the ROI/business case is validated, move ahead to the next phase.

2) Requirements Definition Phase:

- Enumerate the list of stations/machines which need this solution.
- Identify existing systems (MES, SCADA, ERP, or PLCs) storing machine and production data.
- Determine parameters to monitor by defining parameters (e.g., vibration, temperature, pressure) relevant to each asset.
- Engage maintenance engineers and quality control team to understand their challenges.
- Work with the IT team and check if existing hardware & network connectivity are compatible or require upgrades. Define additional IoT devices/additional sensors, as needed.
- Compile this information and prepare 'Requirements Specification document'.

3) Vendor Evaluation Phase:

- Conduct market research to identify potential vendors and create a shortlist based on their capabilities, reputation, and experience relevant to the industry.
- Issue an RFP to shortlisted vendors including detailed requirements and expectations.
- Evaluate proposals for their commercials as well as technical proficiency.
- Arrange (on-site) vendor demonstrations and understand their capabilities.
- Conduct contract negotiation including pricing for defined high-level scope, delivery schedules, support agreements, and warranties before finalizing the agreement with the vendor.

4) Solution Design Phase:

- Enable the vendor team to prepare the low-level-design of the solution by performing following:
  - Study the existing IT-OT solution, IIoT platform and the OEE dashboard. As much as possible, try to leverage the existing hardware/software from the other solutions.
  - Identify the machine parts (like bearings, rotors, fluid meters, engine) that need monitoring.
  - Based on parameters decided and their sensor range, choose appropriate sensor models.
  - Design the data acquisition, processing and analytics systems in line with other solutions.
- Basis the details mentioned above, the vendor team to prepare low-level design of the target solution by evaluating the possible solutions options and making right choices on the solutions components based on business need, feature requirements, existing infra and cost targets.
- Vendor team to prepare final Bill-of-Materials. In case of deviation from earlier scoped proposal, effect required Change Request accordingly.

5) Installation & Commissioning:

- First, connect the sensors and related data sources - MES, SCADA, PLCs, and other systems
  - leveraging integration protocols (e.g., OPC UA) and with the existing IIoT/OEE solutions.
- Install the sensors, as designed in 'Solution Design Phase' and connect them to the IIoT platform / OEE solutions.
- Coordinate the installation of retrofitting devices and networking equipment. Support executing the connectivity plan by installing / retrofitting devices, gateways & networking equipment.
- Create a unified data model and standardized formats, evaluate data integrity, and ensure accurate integration into a harmonized system.
- Once the sensors are connected, to start with, use historical data or use parameter values mentioned in the machine manual to establish normal operating ranges. Define alert conditions for each parameter and set thresholds based on operational limits.
- Deploy Machine Learning Models to help the algorithm define the right threshold value basis the operating conditions and maintenance requirements learned over next few months/years.
- Develop the Condition Monitoring with the selected visualization tool, incorporating KPIs, charts, and real-time alerts.
- Configure alerts and real-time notifications to maintenance team for specific thresholds/events.

6) Go-Live & Stabilization:

- With this full implementation, conduct functionality and usability tests by performing rigorous testing to ensure right alerts and notifications based on actual machine condition.
- Get feedback from operators, maintenance engineers & managers to fine-tune the dashboard.
- Regularly check system accuracy, update thresholds, and calibrate sensors.
- Train operators, technicians, and managers on using the dashboard, interpreting metrics, and responding to alerts and provide the required documentation.
- Schedule checks for sensors and data connections, and update software and models as needed.

Potential pitfalls to avoid & Best Practices

1. Ensure data accuracy by calibrating sensors regularly, validating incoming data, and setting up automated data cleansing processes.
2. Properly position sensors based on equipment requirements, and routinely calibrate them to maintain accuracy.
3. Set alerts only for critical thresholds or anomalies and allow users to customize notification settings to reduce alert fatigue.

Cost Estimate

CapEx:

For monitoring 50 machines basis their operating conditions, as of 2025, it costs approx AED 500k – 800k, assuming the IIoT platform & OEE dashboard are already in place. Future usecases like Predictive Maintenance could be built on top of this with additional investments.

OpEx:

- Annual Maintenance Contract (AMC) costs ~10% of the initial CapEx investment.
- No additional license cost, apart from the ones paid for IIoT platform / OEE solution.

Example Implementations

Danfoss

HALCON

B) Secure & Self-learning solutions	Linked with ITTI Use Case Guide - page #101

Use Case #8: Predictive Maintenance for Shopfloor Machinery

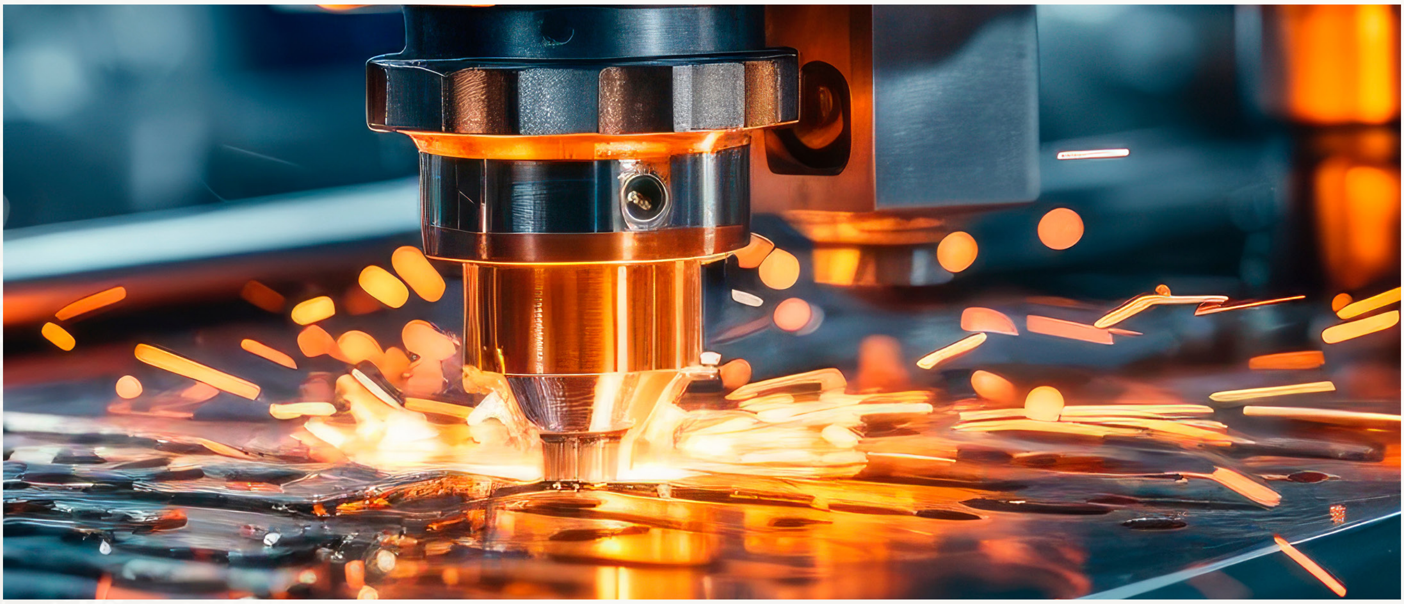
Solution Introduction

Predictive maintenance solutions are essential for modern factories aiming to maximize equipment uptime and reduce unplanned downtime. By utilizing real-time data from sensors that monitor parameters like vibration, temperature, and pressure, predictive maintenance systems can detect early warning signs of wear or potential failures.
This proactive approach allows maintenance teams to address issues before they escalate, minimizing costly repairs and production disruptions. Moreover, predictive maintenance enhances asset longevity, optimizes maintenance schedules, and reduces labor and parts expenses.

Ideal candidates for adopting Predictive Maintenance

Ideal candidates for predictive maintenance are similar to those of condition monitoring solution. The list includes industries with critical, high-value, or high-wear assets. It's ideal for environments with rotating, high-wear, or high-value machinery where early detection of issues can prevent costly repairs or replacements.
Following are highly recommended to adopt this solution:

Manufacturing (CNC machines, conveyors)	Power generation (turbines, transformers)
Oil and gas (pumps, compressors)	Mining (heavy equipments)



When to opt for Predictive Maintenance

- When equipment downtime significantly impacts production and cost of operation
- When maintenance costs are high
- When the machine's asset value is high
- Where it is tough to keep all machine spares in stock at all times
- When strict safety and compliance are highly required

It is recommended to implement this solution to the machines which are bottleneck to production.

Tools and Technologies Involved

It is more economical and provides high value, if this Predictive Maintenance solutions is built on top of Condition Monitoring solution. With Condition Monitoring solutions already in place, following additions are suggested:

1. Data processing & analysis tools: Extract, Transform, Load tools, Analytics algorithms
2. Advanced analytics algorithms & Machine Learning Models
3. APIs & Integrators
4. Visualization and Dashboarding Tools
5. Alerts & Notification Systems

Solution Implementation Steps

1) Value Analysis Phase:

- Liaise with plant manager, production supervisors, Operators & IT teams to source their inputs for prioritizing high-impact, critical or high-value assets, where failure would significantly impact production, costs, or safety.
- Earmark target improvement in the identified assets and convert them into monetary metrics to evaluate the Return-on-Investment potential and check its economic impact.

2) Requirements Definition Phase:

- Study the existing Condition Monitoring solution for its infrastructure and algorithms used.
- Define the additional values that need to be enabled through Predictive Maintenance solution (e.g., predicted failure time, remaining useful life, required replacement units, etc.).
- Compile this information and prepare 'Requirements Specification document'.

3) Vendor Evaluation Phase:

- It is recommended to continue with the 'Condition Monitoring' vendor team for this use case as well, as there is a huge leverage possible through 'Condition Monitoring' knowledge enabled.
- If you prefer to change the vendor, then follow the standard vendor evaluation phase explained in other use cases.

4) Solution Design Phase:

- Enable the vendor team to prepare the low-level-design of the solution by performing following:
  - Study the existing IT-OT solution, IIoT platform and the Condition Monitoring solution. As much as possible, try to leverage the existing hardware/ software from the other solutions.
  - Identify the machine parts (like bearings, rotors, fluid meters, engine) that formulate the major causes for machine failure.
  - Define the data-analytics model and algorithms to estimate the required metrics (Remaining Useful Time, Predicted failure time, Potential failure parts etc.,)
  - Study the existing data that is generated through other usecases and the new ones to be enabled as part of sensitization introduced in this project.
- Decide the right analytics model

The key success of this project lies in the data analytics models selected for this project. Refer following guidelines to pick and choose right model(s) for this solution.

1 **Time-Series Forecasting Models:** Analyzes data over time to predict when a parameter (e.g., temperature, vibration) might reach a critical level.

2 **Regression Models:** Uses historical data to predict outcomes (e.g., failure probability) based on variables like usage hours, operating conditions, and maintenance history.

3 **Anomaly Detection Models:** Identifies deviations from normal operating conditions that could indicate potential failures. Techniques include clustering (K-means, DBSCAN) and statistical methods (z-scores).

4 **Failure Mode and Effects Analysis (FMEA):** Systematically evaluates potential failure modes in a system to understand the impact and root causes of each failure

5 **Remaining Useful Life (RUL) Prediction Models:** Estimates the time remaining before an asset is likely to fail or require maintenance.

- **Survival Analysis:** Uses historical failure data to estimate the probability of equipment survival over time.
- **Prognostics Models:** Based on machine learning, they predict RUL based on real-time sensor data, operating conditions, and past usage patterns.

6 **Supervised Learning Models:** Use labeled historical data to predict equipment failures.

- **Classification Models:** Algorithms like logistic regression, decision trees, or random forests classify equipment status as healthy/deteriorating/near-failure.
- **Regression Models:** Linear regression and support vector regression (SVR) predict continuous variables, like remaining useful life (RUL).

7 **Unsupervised Learning Models:** Work on unlabeled data to detect anomalies/patterns.

- **Clustering:** K-means or hierarchical clustering groups similar data points, identifying patterns or anomalies in equipment behavior.
- **Principal Component Analysis (PCA):** Helps to identify key variables that influence equipment health.

8 **Deep Learning Models:** Detects complex patterns in large datasets and is particularly useful for assets with nonlinear relationships between sensor data & equipment health.

- **Recurrent Neural Networks (RNNs):** Ideal for time-series data and sequences, commonly used for RUL predictions.
- **Convolutional Neural Networks (CNNs):** Effective in image-based diagnostics, such as analyzing visual data from cameras on equipment.

5) Installation & Commissioning:

- Install the sensors, as designed in 'Solution Design Phase' and connect them to the IIoT platform / Condition Monitoring solution.
- Build one or more of the following analytical models, taking relevant ones for your usecase. Refer section 4 above for recommendation on analytics models.

6) Go-Live & Stabilization:

- With this full implementation, test the system on a small scale to verify data accuracy, model performance, and alert reliability. Adjust algorithms and alert settings based on pilot results and feedback from users.
- Train operators, technicians, and managers on using the dashboard, interpreting metrics, and responding to alerts and provide the required documentation.
- Schedule checks for sensors and data connections, & update software and models as needed.

Potential pitfalls to avoid & Best Practices

1. Implement the solution in the decreasing impact-order of machines. First start with the bottleneck machines and move to next bottleneck in the process.
2. Train predictive models using accurate, well-labeled data that reflects various operating conditions, failure modes, and maintenance activities to improve model reliability.
3. Choose analytics models that match your use case. For example, use time-series analysis for trends, anomaly detection for unusual patterns, and classification models for failure prediction.

Cost Estimate

CapEx:

For predicting maintenance for 50 machines, as of 2025, it costs approx AED 500k – 2,000k, assuming the IIoT platform & Condition Monitoring are already in place.

OpEx:

- Annual Maintenance Contract (AMC) costs ~10% of the initial CapEx investment.
- License cost for IIoT platform / dedicated data analysis software.

Example Implementations

bin ghalib GROUP OF COMPANIES | RAK CERAMICS | أدنوك ADNOC

B) Secure & Self-learning solutions	Linked with ITTI Use Case Guide - page #100

Usecase #9: Integrated Quality Inspection and Production Control

Solution Introduction

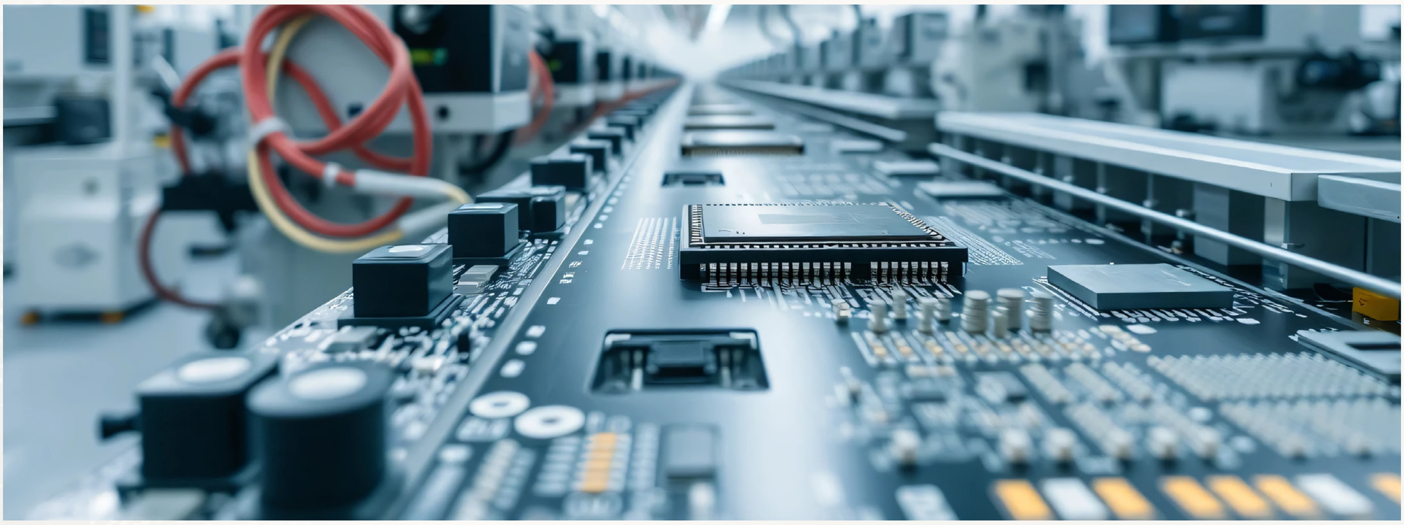
Integrated quality inspection incorporates advanced technologies like machine vision, sensors, and data analytics directly into the production line, allowing manufacturers to detect defects, measure tolerances, and ensure consistency at each stage of production. This proactive approach minimizes waste, enhances efficiency, and prevents defective products from progressing through the line, ultimately saving time and reducing costs.

Automated inspection systems, such as 3D vision cameras, laser measurement devices, and sensor arrays, monitor each component as it moves through the assembly line. Coupled with Industrial Internet of Things (IIoT) and Artificial Intelligence (AI), these systems provide real-time feedback, alerting operators to potential issues or initiating automatic adjustments. Data from these inspections is stored and analyzed, offering insights for continuous process improvement and predictive maintenance. As industries adopt these systems, they build a foundation for smarter, more resilient manufacturing that adapts to the demands of modern production.

Ideal candidates for adopting Integrated Quality Inspection & Production Control

Ideal candidates for adopting Integrated Quality Inspection & Production Control are:

Food and Beverage Processing	Pharmaceuticals and Medical Devices
Aerospace Industry	Consumer Goods and Packaging
Automotive Industry	Electronics and Semiconductor Manufacturing



When to opt for Integrated Quality Inspection & Production Control

- High Defect Rates or Quality Issues
- Increasing Production Scale
- Tight Regulatory or Safety Standards
- Adopting Advanced Manufacturing Technologies
- Demand for Traceability and Real-Time Data Tools and Technologies Involved

Tools and Technologies Involved

1. IoT Devices and Sensors (IoT gateways, additional sensors, Edge devices)
2. Vision Systems (2D and 3D Cameras, Machine Vision Software, Laser Scanners)
3. Non-Destructive Testing (Techniques such as ultrasonic, radiographic, & magnetic testing)
4. Defect detection - Artificial Intelligence and Machine Learning (AI/ML) algorithms
5. Statistical Process Control (SPC) and Quality Management Software
6. Traceability Tools (Barcode and RFID Tracking)
7. Automated and centralized reporting dashboard

Solution Implementation Steps

1) Value Analysis Phase:

- Liaise with plant manager, quality lead and the manufacturing heads.
- Define the key quality objectives aligned with your business goals, such as reducing defects, increasing efficiency, or improving customer satisfaction.
- Define key performance indicators to measure success (e.g., defect rates, yield rates, customer complaints).

2) Requirements Definition Phase:

- Evaluate the existing process and identify the weaker areas where the quality issues create increase in production costs and those which delay the production delivery
- Evaluate the key issues that hamper the quality of production output
- Evaluate the existing Quality Management System (QMS)
- Pinpoint areas where digital transformation could add value, such as in data collection, analysis, or decision-making
- Define phased implementations to gradually integrate the required digital elements into the organization's Quality Management System.
- Compile this information and prepare 'Requirements Specification document'.

3) Vendor Evaluation Phase:

- Conduct market research to identify potential vendors and create a shortlist based on their capabilities, reputation, and experience relevant to the industry.
- Issue an RFP to shortlisted vendors including detailed requirements and expectations.
- Evaluate proposals for their commercials as well as technical proficiency.
- Arrange vendor demonstrations and understand their capabilities.
- Conduct contract negotiation including pricing for defined high-level scope, delivery schedules, support agreements, and warranties before finalizing the agreement with the vendor.

4) Solution Design Phase:

- **Once onboarded, enable the vendor team to prepare the low-level-design of the solution by performing following:**
  - Detailed study of the production processes and identify the key areas where quality issues are reported.
  - Map the quality issues to the potential point of generation of those quality issues
  - Conduct a 'Pareto Analysis' to prioritize the points where we shall make maximum impact with this solution.
  - Plan different means and tools to fix the quality issues (including IoT sensors, automated scanning, vision systems, non-destructive-testing techniques like ultrasonic devices)
  - Prepare the data infrastructure plan (such as cloud storage and data lakes) to aggregate and centralize quality-related data.
  - Identify the right set of predictive analytics algorithms, AI, and machine learning models to identify trends, predict failures, and optimize quality processes.
- **Basis the details mentioned above, the vendor team to prepare low-level design of the target solution by evaluating the possible solutions options and making right choices on the solutions components based on business need, feature requirements, existing infra and cost targets.**
- **Vendor team to prepare final Bill-of-Materials. In case of deviation from earlier scoped proposal, effect required Change Request accordingly.**

5) Installation & Commissioning:

- Once the required hardware and software are sourced, start the implementation of the solution. Install IoT-enabled sensors, vision systems and other quality data capturing devices on machines to monitor and collect real-time data on quality parameters.
- Calibrate machine vision systems and other automated inspection equipment to ensure accuracy in defect detection and dimensional measurements.
- Run validation tests on the inspection systems to ensure they reliably detect defects and meet quality standards.
- Connect all the data from inspection systems and production control systems to a central data repository (data lake or cloud storage).
- Set up automated feedback mechanisms where quality inspection data directly influences production adjustments. Configure real-time alerts to notify operators of deviations or defects immediately, prompting corrective actions.
- Implement SPC tools that continuously analyze production data to detect trends, shifts, and potential issues. Use AI and machine learning to predict potential quality issues based on historical and real-time data.
- Create dashboards to visualize quality and production metrics for operators, quality inspectors, and management.

6) Go-Live & Stabilization:

- With this full implementation, Test the full system on a limited scale to validate performance, identify issues, and make necessary adjustments. Fine-tune inspection thresholds, analytics models, and automated feedback mechanisms, as needed.
- Train operators, technicians, and managers on using the dashboard, interpreting metrics, and responding to alerts and provide the required documentation.
- Continuously monitor data from inspection and production control to identify areas for further improvement. Schedule checks for sensors and data connections, and update software and models as needed.

Potential pitfalls to avoid & Best Practices

1. Take a phased approach to implementation, starting with high-impact areas, and gradually expand to other processes or lines.
2. Choose scalable technologies and modular solutions that can grow with your production demands, facilitating easier expansion.
3. Implement closed-loop feedback systems that enable real-time alerts and automated corrective actions, minimizing downtime and waste.
4. Ensure that all systems and processes comply with relevant industry standards and regulatory requirements (such as ISO, FDA, etc.) throughout the implementation.

Cost Estimate

CapEx:

Owing to diverse nature of the solution and its scope, the capital investment for this solution varies widely ranging from 1 Million AED to 4 Million AED.

OpEx:

- Annual Maintenance Contract (AMC) costs 15% of the initial CapEx investment.
- Annual license cost ranges from 200k-500k AED for the QMS and related software.

Example Implementations

RAK CERAMICS

HALCON

SHARJAH CEMENT FACTORY

B) Secure & Self-learning solutions	Newly Added Use Case

Usecase #10: Automated Optical Inspection

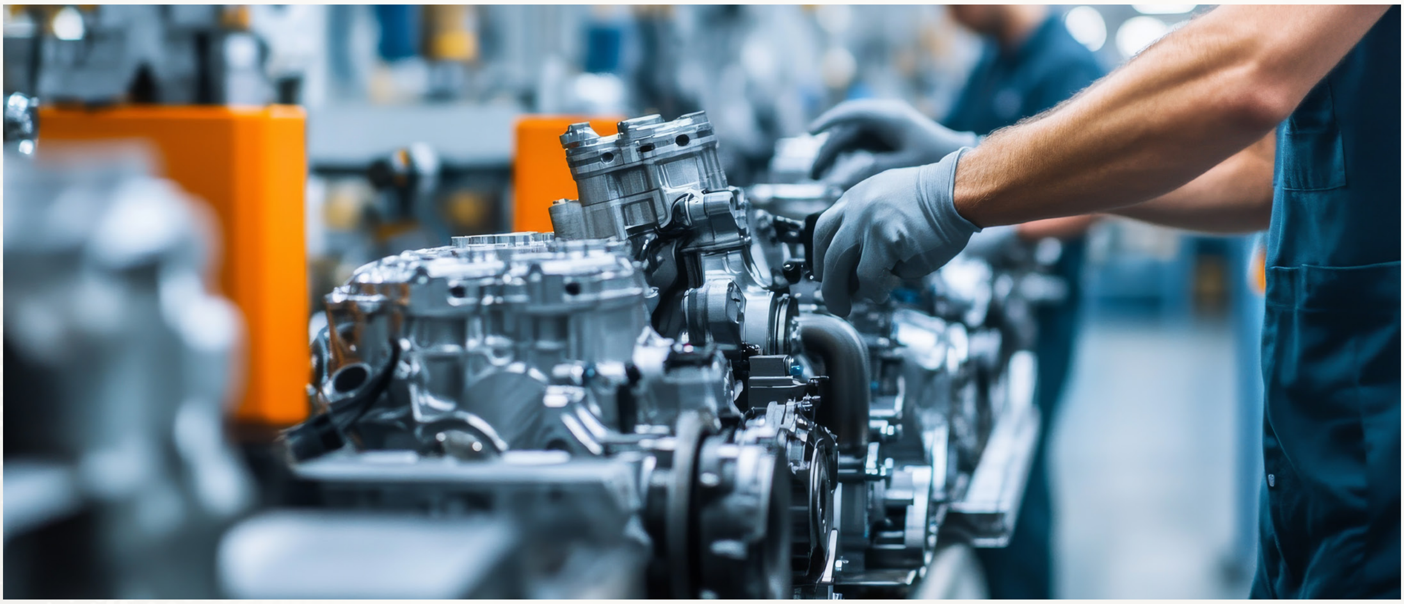
Solution Introduction

The need for Automated Optical Inspection (AOI) solutions arises from the demand for high-quality, defect-free products, particularly in electronics, automotive, and precision manufacturing. AOI systems use advanced imaging to detect and analyze flaws—such as misalignments, missing components, and surface defects—that are challenging for human inspectors to catch consistently. With increasing production speeds and complexity, manual inspection can be slow, prone to error, and costly. AOI solutions enhance quality control, improve production efficiency, and reduce rework costs by ensuring that only fully inspected, compliant products move forward in the manufacturing process.

Ideal candidates for adopting Automated Optical Inspection

Ideal candidates for adopting Automated Optical Inspection (AOI) are manufacturers in industries where precision and quality are critical and production volumes are high. Key candidates include:

Automotive Industry	Electronics Manufacturing
Aerospace Industry	Medical Device Manufacturing
Precision Engineering and Optics	Pharmaceutical Packaging



When to opt for IT/OT Integration

- Quality Demands Are High
- Production Volume Increases
- Complexity of Components are high
- Human Error is Significant
- Compliance and Traceability Requirements are high
- When the organization moves towards highly automated production systems

Tools and Technologies Involved

1. High-Resolution Cameras
2. 3D Imaging and Scanning devices
3. Lighting Systems
4. Optics (Lenses & Filters)
5. Image Processing Software.
6. Data Analysis and Machine Learning algorithms
7. Defect Libraries and Reference Models
8. Conveyor and Handling Systems
9. User Interface

Solution Implementation Steps

1) Value Analysis Phase:

- Liaise with production and quality teams, including managers, supervisors and operators to understand their pain points in terms of existing quality of output.
- Identify the cost of poor quality in the production line. Out of the overall list of quality issues, those related to surface irregularities and missing components are ideal candidates to be addressed with AOI. To understand the potential impact of AOI, identify the monetary value of loss incurred owing to surface defects and missing components.
- Identify the list of production assets from where the respective defects are originating.
- Identify the list of intervention points needed to implement the AOI solution in the selected production value stream.
- Now do a high-level rough-order estimate cost check for the solution in the market for the required scope. Compare it against the monetary loss being incurred owing to quality defects. If the break-even point is favorable for the organization, proceed with the next steps. Recommended break-even point for this solution is 3-4 years.

2) Requirements Definition Phase:

- Determine what defects or attributes the AOI system needs to detect, such as missing components, misalignments, solder defects, or surface imperfections. Define acceptable defect thresholds and quality metrics to align the AOI solution with your production requirements.
- Determine if the AOI system should operate in-line (real-time) or off-line, based on production speed and complexity of the components. Prepare the list and details on the intervention points and the associated production assets that will employ the AOI solution.
- Enumerate the overall list of quality parameters that would be addressed through this solution.
- Compile all these points together and prepare an 'Request for Proposal (RFP) document'.

3) Vendor Evaluation Phase:

- Conduct market research to identify potential vendors, and create a shortlist based on their capabilities, reputation, and experience relevant to the industry.
- Issue an RFP to shortlisted vendors including detailed requirements and expectations.
- Evaluate proposals for their commercials as well as technical proficiency.
- Arrange vendor demonstrations, preferably on-site demonstrations.
- Conduct contract negotiation including pricing for defined high-level scope, delivery schedules, support agreements, and warranties before finalizing the agreement with the vendor.

4) Solution Design Phase:

- **Enable the vendor team to perform the following:**
  - Study the production assets to be fitted with the AOI solution
  - Identify the list of data points to be collected for each of the production assets
  - Decide based on inspection needs—2D AOI is suitable for surface inspection, while 3D AOI is better for inspecting height, volume, and shapes
  - Choose high-resolution cameras and suitable lighting setups to ensure clarity and accuracy for the specific parts being inspected
  - Select the right software that supports the necessary image processing, pattern recognition, and machine learning capabilities for optimal defect detection
- **Vendor team to prepare low-level design of the target solutions by evaluating the possible solutions options and making right choices on the solutions components based on business need, feature requirements, existing infrastructure and cost targets.**
- **Vendor team to prepare final Bill-of-Materials. In case of major deviation from the earlier scoped proposal, effect required Change Request and then place procurement order for required hardware and software licenses.**

5) Installation & Commissioning:

- Once the required hardware and software are sourced, start integration of these AOI devices to the required production assets. Place the AOI system at an optimal point in the production process, ideally right after a critical process stage (e.g. like soldering in PCB manufacturing)
- Ensure smooth transport of parts to and from the AOI system without disrupting production flow. Automated conveyors and robotic arms can assist in high-speed lines.
- Once the setup is done, conduct initial testing on sample products to understand how well the AOI system identifies defects and handles variability.
- Fine-tune inspection parameters, such as lighting angles, exposure times, and defect tolerances, to maximize accuracy.
- Compare AOI results with manual inspection results to validate defect detection accuracy and minimize false positives/negatives. Prepare a defect database with known defect types and acceptable tolerances to improve inspection precision.
- Run the AOI system in a controlled, limited production environment to validate its performance and make adjustments if needed. Train the system to recognize complex patterns and new defects by using machine learning, which can improve detection accuracy over time.

6) Go-Live & Stabilization:

- Adjust the system periodically to maintain accuracy, especially in high-variation or high-speed environments. Conduct periodic audits to ensure the AOI system is functioning as intended and continues meeting quality standards.
- Once the system stabilizes, train the people and hand-over the project to the production team with Standard Operating Procedure (SOP) defined.

Potential pitfalls to avoid & Best Practices

1. Carefully assess if 2D or 3D imaging is better suited for your inspection needs; 3D AOI is more appropriate for applications requiring depth, height, or volume measurements.
2. Optimize lighting conditions, including light angles and intensity, and ensure cameras are positioned to capture all critical areas clearly.
3. Customize the defect database and inspection algorithms to match your specific products and quality standards, and update these regularly as new issues or products arise.
4. During initial testing, carefully analyze and adjust system parameters to minimize false positives/negatives and continue refining the system based on inspection results.

Cost Estimate

CapEx:

For connecting 5 machines with automated optical inspection, as of 2025, it costs approximately AED 500k-800k.

OpEx:

- License cost ranges between 50k-150k AED
- Annual Maintenance Contract (AMC) costs 10-15% of the initial CapEx investment.

Example Implementations

BMW

BOSCH

B) Secure & Self-learning solutions | Linked with ITTI Use Case Guide - page #98

Use Case #11: Integrated and Automated Production Planning and Scheduling

Solution Introduction

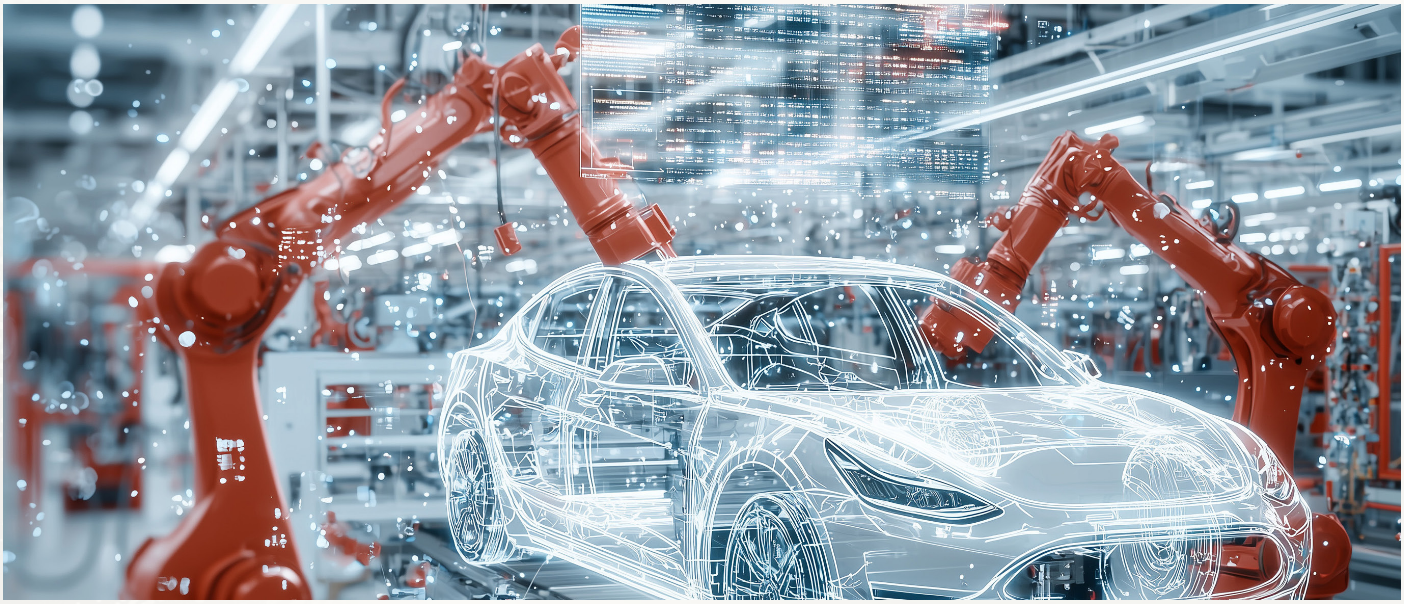
Integrated and Automated Production Planning and Scheduling is a modern approach to optimizing manufacturing processes by leveraging real-time data, automation, and advanced analytics. This strategy unites key elements like demand forecasting, resource allocation, and predictive maintenance into a cohesive system that enhances efficiency and flexibility. By connecting machinery, inventory, and workforce data, it enables dynamic scheduling that adapts instantly to changes, such as urgent orders or machine downtime.

With a focus on reducing idle time, maximizing productivity, and minimizing costs, this approach helps manufacturers respond faster to market demands, improve product quality, and deliver superior customer satisfaction in competitive industries.

Ideal candidates for adopting Integrated and Automated Production Planning and Scheduling

Ideal candidates for adopting Integrated and Automated Production Planning and Scheduling are companies with complex, high-volume, or demand-driven manufacturing processes like,

- Large-Scale Manufacturers (automotive, electronics & machinery)
- High-Variability Manufacturers (consumer goods & fashion)
- Supply Chain-Intensive Industries (pharmaceuticals & food and beverage)



When to opt for Integrated and Automated Production Planning and Scheduling

- Frequent Changes in Orders or Priorities
- Frequent Production Bottlenecks and Inefficiencies
- Heavier dependence on global supply chain
- Higher demand fluctuations from market
- Raise in complexity in production owing to increased customization / variation needs.

Tools and Technologies Involved

1. Advanced Planning & Scheduling Software
2. Manufacturing Execution Systems
3. Enterprise Resource Planning
4. Supply Chain Management
5. Robotic Process Automation
6. Collaborative Platforms and Communication Tools (digital dashboards, mobile apps, and role- based access systems to stakeholders informed with real-time data)
7. Artificial Intelligence & Machine Learning algorithms

Solution Implementation Steps

1) Value Analysis Phase:

- Form a cross-functional team that includes representatives from production, IT, supply chain, finance, and other key departments.
- Identify the specific goals for the project - like improving on-time delivery in full, enhancing production efficiency, reducing lead times, or optimizing resource allocation.
- Earmark target improvement for the identified KPIs and respective processes.
- Usually, this solution is bound to incorporate more of qualitative benefits to the organization. So while evaluating the business case for the implementation, weigh-in these factors accordingly.

2) Requirements Definition Phase:

- Conduct a thorough assessment of existing processes, technology infrastructure, and current planning and scheduling capabilities.
- Identify and shortlist tools that will support this Integrated and Automated solution, such as Enterprise Resource Planning (ERP), Manufacturing Execution System (MES), and Advanced Planning and Scheduling (APS) software.Ensure chosen tools integrate well with existing systems and are scalable to accommodate future needs.
- In case of any gaps in the existing data, plan for additional data capturing mechanisms – either with installation of new sensors or sourcing of data from other relevant systems.
- Define the target state and scenarios to meet the business objective with this solution goes-live.
- Compile this information and prepare 'Requirements Specification document'.

3) Vendor Evaluation Phase:

- Conduct market research to identify potential vendors and create a shortlist based on their capabilities, reputation, and experience relevant to the industry.
- Issue an RFP to shortlisted vendors including detailed requirements and expectations.
- Evaluate proposals for their commercials as well as technical proficiency.
- Arrange vendor demonstrations and understand their capabilities.
- Conduct contract negotiation including pricing for defined high-level scope, delivery schedules, support agreements, and warranties before finalizing the agreement with the vendor.

4) Solution Design Phase:

Once the vendor is onboarded, design the target architecture of the solution by following:

- Study the overall processes, required improvements and required automation in planning and scheduling activities.
- Identify data sources relevant to production planning and scheduling, including sales forecasts, inventory levels, machine data, and workforce availability.
- Map the data points to the relevant systems of origin.
- Define the target architecture by designing the right connections between the systems and ensuring seamless data exchange between multiple data systems.

5) Installation & Commissioning:

- Standardize and integrate data across ERP, MES, and other systems to create a unified and accessible data structure.
- Integrate relevant and required data from suppliers and logistics teams with the Supply Chain Management (SCM) software.
- Configure Advanced Planning & Scheduling (APS) software to create optimized production schedules based on real-time data, constraints, and priorities.
- Implement scheduling algorithms that can adapt to changes in demand, production capacity, and resource availability.
- Set up data analytics and reporting tools to track KPIs, production trends, and process efficiency.
- Use insights from analytics to make data-driven adjustments and improvements to planning and scheduling.
- Develop intuitive, role-specific dashboards for planners, operators, and managers to access production schedules and real-time data.

6) Go-Live & Stabilization:

- Train staff on new Integrated Production and Scheduling tools, focusing on how to access schedules, monitor production, and respond to changes.
- Test system performance under different scenarios to ensure stability and reliability.
- Monitor system performance and gather feedback to fine-tune scheduling rules, data integration, and reporting mechanisms.
- Update and refine IPPS components, scheduling algorithms, and processes to align with evolving production goals.

Potential pitfalls to avoid & Best Practices

1. Implement in phases, starting with pilot projects, to test effectiveness and make adjustments before full-scale deployment.
2. Tailor the system to actual operational requirements. Prioritize ease of use and scalability rather than unnecessary complexity.
3. Standardize data formats and establish data governance to maintain data integrity across the organization.
4. Involve employees early in the planning process, provide adequate training, and clearly communicate the benefits to ensure acceptance.
5. Use adaptive algorithms that allow for real-time schedule adjustments based on changing conditions. Meanwhile, allow manual interventions and monitoring, ensuring human oversight to catch issues automation might miss.

Cost Estimate

CapEx:

Depending on scale of operations, scope of coverage and the diversity in the information systems involved, the investments range from 1.5Mn AED to 10Mn AED, as of 2025.

OpEx:

- Annual Maintenance Contract (AMC) costs ~15% of the initial CapEx investment.
- License cost for the newly configured software.

Example Implementations

ALPLA | أدنوك ADNOC | UNIVERSAL CARTON INDUSTRIES | Lipton

Use Case #12: Digital Twin for Simulated Product Design

Solution Introduction

Digital twin technology has transformed product design by enabling real-time simulation, monitoring, and optimization throughout a product's lifecycle. A digital twin is a virtual replica of a physical product, system, or process, enriched with live data from sensors and IoT devices. This data-driven approach allows designers to model complex products, test performance in various conditions, and identify potential issues before actual production begins. In product design, digital twins streamline workflows by reducing the need for multiple physical prototypes, saving time and resources while enhancing accuracy. Designers can simulate product interactions, monitor performance in real-time, and gather feedback, allowing them to make informed adjustments rapidly. With predictive insights, digital twins also help in anticipating maintenance needs, reducing downtime, and ensuring longer product life. This technology enhances collaboration among cross-functional teams, as stakeholders can view and interact with the digital model remotely.

Ideal candidates for adopting Digital Twin for product design

Digital twins are ideal for high-stakes industries where physical testing may be expensive or limited.

Aerospace	Automotive	Machinery builders (OEMs)
Construction & Architecture	Energy & Utilities	

When to opt for Digital Twin for product design

Typical scenarios in which one need to opt for digital twin for product design are as follows:

- When working with complex products that demand iterate design adjustments
- When physical testing is expensive or limited
- When product innovation cycles are faster and highly in-demand in market
- When it is time-consuming to gather different usage conditions from the usage points
- During simultaneous engineering where it needs cross-functional team collaborations Tools and Technologies Involved

Tools and Technologies Involved

1. Connectivity through IoT sensors
2. 3D Modeling and CAD Software
3. Simulation Software
4. Analytics tools and machine learning algorithms
5. Edge computing devices
6. Data transmission network
7. APIs & Integrators
8. Cloud Computing and Data Storage
9. Visualization and AR/VR Tools
10. PLM Systems

Solution Implementation Steps

1) Value Analysis Phase:

- Liaise with design team, testing team and customer facing teams to understand the need for digital twin in the product design and source related information to further build the usecase.
- Define the purpose of the digital twin and its priority features. Decide whether it's needed for real-time monitoring of product performance, or testing selective features or improving the product's life or combination of these objectives.
- Select the right parameters / KPI's that need to be tracked to measure the success of Digital Twin deployment in the design environment. Measure those parameters' current state.
- Define the target KPI with the implementation of the Digital Twin for the product design.
- Evaluate the business case for this solution deployment with the current state KPI and the targeted KPIs. Typically, this solution is treated as an enabler solution for future usecases Hence conduct a mix of quantitative and qualitative study for Return-on-Investment. Once the business case is validated, move ahead to the next phase.

2) Requirements Definition Phase:

- Identify the specific product components or systems you wish to model and simulate.
- Define the target features that need to be part of the final solution.
- Enumerate the parameters, data and characteristics that need to be activated to achieve the targeted features.
- Document and organize the data to understand what real-world aspects the digital twin will need to replicate. Identify and enumerate all the datapoints that are currently captured in the existing environment and highlight the existing gaps in the data being captured.
- Compile these information and prepare 'Requirements Specification document'.

3) Vendor Evaluation Phase:

- Conduct market research to identify potential vendors and create a shortlist based on their capabilities, reputation, and experience relevant to the industry.
- Issue RFP to shortlisted vendors including detailed requirements and expectations.
- Evaluate proposals for their commercials as well as technical proficiency.
- Arrange (on-site) vendor demonstrations and understand their capabilities.
- Conduct contract negotiation including pricing for defined high-level scope, delivery schedules, support agreements, and warranties before finalizing the agreement with the vendor.

4) Solution Design Phase:

- Enable the vendor team to prepare the low-level-design of the solution by performing following:
  - Studying the design aspects of the product under design.
  - Studying the CAD model of the product being built.
  - Identifying the necessary data required to build the simulation model
  - Mapping the data needs to different sensor requirements
  - Planning the data transmission framework
  - Selecting the right simulation software and visualization tools/platforms
- Vendor team to prepare final Bill-of-Materials. In case of deviation from earlier scoped proposal, effect required Change Request accordingly.

5) Implementation Phase:

- **Choose right Digital Twin platform** that integrates well with your current design tools and supports product simulation. Select the platform basis their Support for real-time simulations and product behavior analysis, Integration with CAD and PLM systems, Ability to model complex systems and multiphysics simulations (e.g., mechanical, thermal, fluid, electrical).
- **Gather data for the Digital Twin model** by sourcing the CAD files and integrating details about geometries, material properties, tolerances, and configurations of the product under design. Integrate operational data, such as material performance, environmental conditions, or user data, that will influence product performance. Use historical data from similar products to enhance simulations, including failure data, performance metrics, and service history.
- **Create a 3D digital model of the product** using CAD tools and incorporate all relevant components and subsystems. Integrate real-world physics into the model, such as mechanical forces, heat transfer, fluid dynamics, electrical systems, and material properties. Model how the product will behave in different operating conditions, including stresses, loading conditions, thermal effects, and environmental factors.
- **Integrate the developed model with the simulation software** tools such as Finite Element Analysis (FEA), Computational Fluid Dynamics (CFD), or Multibody Dynamics (MBD) to simulate specific aspects of the product's design.

6) Go-Live & Stabilization:

- **Perform virtual testing** by simulating product performance under different conditions, including extreme scenarios such as high loads, extreme temperatures, or stress limits.
- **Evaluate product performance** by analyzing how the product behaves under different conditions & scenarios. Identify potential weaknesses, failure points, or areas for improvement.
- **Improve the product design through iterative changes** basis the test results. The major benefit of this solution is that we shall rapidly prototype new designs in the virtual environment without the need for physical prototypes.
- **Integrate the Digital Twin with PLM systems** to ensure that the design, testing, and optimization process is fully tracked, managed and enabled with version control of different design iterations and allow collaboration among design, engineering, and production teams.

Potential pitfalls to avoid & Best Practices

1. Begin with a small, manageable project to demonstrate the feasibility and value of digital twins within your organization.
2. Engage teams across design, engineering, maintenance, and IT to foster collaboration, ensuring the digital twin supports various needs and enhances the overall design process.
3. Use predictive analytics and machine learning algorithms to enhance the twin's ability to anticipate and diagnose potential issues, improving the twin's predictive capabilities.
4. Treat the digital twin as a dynamic tool; continuously improve it with new data and insights, refining its accuracy and usefulness over time.
5. Invest in training and ensure a skilled team is in place to handle complex digital twin applications.

Cost Estimate

CapEx:

For building a digital twin for design of an automotive subsystem, enabled with real-time model, robust analytics, cloud infrastructure & simulation capabilities costs 1.5 – 4 million AED, as of 2025.

OpEx:

- The license cost vary widely from 200k – 800k AED per year, depending on the scope and scale of the implementation.

Example Implementations

LIN SCAN A PIPECARE COMPANY

الخليج للسحب Gulf Extrusions

C) Collaborative workspace solutions	Linked with ITTI Use Case Guide - page #103

Use Case #13: Digital Twin for Production Simulation and Optimization

Solution Introduction

A digital twin for production simulation and optimization is a virtual model that replicates a physical manufacturing environment in real time. This digital counterpart mirrors every aspect of production, from machinery and workflows to raw material handling and product assembly, allowing businesses to visualize and experiment with production processes without disrupting actual operations. Using real-time data, the digital twin updates continuously, reflecting changes in equipment performance, production rates, and other variables.

Digital twins for production simulation and optimization are powerful tools for enhancing manufacturing agility, resilience, and operational efficiency. For example, engineers can test process changes or new equipment virtually to see their effects on productivity, cost, and quality.

Ideal candidates for adopting Digital Twin for production simulation

Digital twins are ideal for production organizations with complex set of systems, running high-volume or high-variety production operations. Typical adopters list include:

Aerospace manufacturing	Automotive manufacturing	Energy & Utilities
Electronics manufacturing	Food and beverages	
Pharmaceuticals and Biotech	Logistics and supply chain organizations supporting	

When to opt for Digital Twin for production simulation

- When production involves complex, interdependent processes, & strict regulatory standards
- Industries where downtime is extremely costly, such as energy or pharmaceuticals
- When an organization scales its operations by introducing new machineries in batches
- When businesses strive to establish sustainable operations by reducing utilities / resources
- During simultaneous engineering where it needs cross-functional team collaborations Tools and Technologies Involved

Tools and Technologies Involved

1. Data generation & integration tools: IoT devices, edge gateways, connectivity protocols
2. Data Management and Processing tools: High-capacity databases, middleware, data lakes
3. Modeling and Simulation tools: CAD for 3D modeling, Simulation tools like MATLAB
4. Simulation Engines
5. Monitoring tools: SCADA Systems
6. Digital Twin Platform
7. Visualization and AR/VR Tools
8. PLM Systems

Solution Implementation Steps

1) Value Analysis Phase:

- Liaise with production manager, line supervisor and the management to understand the business need that demands exploration of digital twin as a solution.
- Determine the specific process to be mirrored (e.g., manufacturing, logistics, production, or supply chain processes).
- Define the goals for the digital twin, such as improving efficiency, reducing downtime, predicting maintenance, or enhancing process flexibility.
- Establish metrics to assess the success of the digital twin, such as productivity, energy usage, quality control, or time-to-market. Measure those metrics' current state.
- Define the target KPI with the implementation of the Digital Twin for the production optimization.
- Evaluate the business case for this solution deployment with the current state KPI and the targeted KPIs. Typically, this solution is treated as an enabler solution for future usecases Hence conduct a mix of quantitative and qualitative study for Return-on-Investment. Once the business case is validated, move ahead to the next phase.

2) Requirements Definition Phase:

- Document the Process Flow by breaking down the physical process into individual steps, components, and systems. Create a process flow diagram.
- Identify all inputs (raw materials, energy, data) and outputs (finished products, waste, data).
- Determine the process variables which impact process performance, such as temperature, pressure, speed, cycle time, and resource usage.
- Define the target features that need to be implemented to aid the process simulation and optimization.
- Enumerate the parameters, data and characteristics that need to be activated to achieve the targeted features.
- Document and organize the data to understand what real-world aspects the digital twin will need to replicate. Identify and enumerate all the datapoints that are currently captured in the existing environment and highlight the existing gaps in the data being captured.
- Compile this information and prepare 'Requirements Specification document'.

3) Vendor Evaluation Phase:

- Conduct market research to identify potential vendors and create a shortlist based on their capabilities, reputation, and experience relevant to the industry.
- Issue RFP to shortlisted vendors including detailed requirements and expectations.
- Evaluate proposals for their commercials as well as technical proficiency.
- Arrange (on-site) vendor demonstrations and understand their capabilities.
- Conduct contract negotiation including pricing for defined high-level scope, delivery schedules, support agreements, and warranties before finalizing the agreement with the vendor.

4) Solution Design Phase:

- Enable the vendor team to prepare the low-level-design of the solution by performing following:
  - Studying the details of the production process.
  - Studying the inputs, outputs and production variables that affect the performances.
  - Identifying the data maturity and data gaps to build the simulation model
  - Defining the architecture for building the digital twin solution
  - Selecting the right digital twin platform, simulation software and visualization tools/platforms
- Vendor team to prepare final Bill-of-Materials. In case of deviation from earlier scoped proposal, effect required Change Request accordingly.

5) Implementation Phase:

- **Ensure required data capture** by installing devices and sensors required to capture real-time data from the physical process.
- **Choose right Digital Twin platform** to build the digital process twin that can integrate with ERP, MES, and SCADA systems for seamless data flow and process control.
- **Create a 3D visual representation of the production processes** & systems using CAD tools or 3D modeling software.
- **Create models that replicate how the process reacts** under different conditions, such as changes in demand, machine breakdowns, or raw material quality variation.
- **Ensure real-time data from sensors and devices is streamed to the digital twin**.. Set up data pipelines & storage systems for processing, and storing real-time & historical data.
- **Implement Analytics and Simulation models.** An illustrative list of models include,

  1. **Process Monitoring:** Use analytics tools to monitor real-time performance data from the process twin, allowing for tracking of deviations and inefficiencies.
  2. **Predictive Analytics:** Integrate machine learning algorithms to predict process outcomes, such as equipment failures or quality issues, before they occur.
  3. **"What-If" Simulations:** Run different scenarios and simulations in the digital twin to see how process changes (e.g., equipment settings, resource allocation) affect performance.
  4. **Optimization Algorithms:** Recommend process adjustments for improved performance

- **Enable 'Decision-support-system'** for the associates through a dashboard, by giving them actionable insights into the process based on the digital twin's analysis.

6) Go-Live & Stabilization:

- **Perform virtual testing** by simulating production performance under different conditions, including change in demand, change in machine configurations and operating conditions.
- **Evaluate production performance** by analyzing how the production behaves under different conditions & scenarios. Simulate the same by varying the process variables and choose the best condition that optimized the production process according to the business needs.
- **Deploy the solution for day-to-day operations** by integrating it with daily operations for real-time monitoring, analysis, and optimization.
- Once successfully implemented for one process, **replicate the digital twin framework across other similar processes or departments.**

Potential pitfalls to avoid & Best Practices

1. Start with a minimum viable digital twin for specific processes, gather feedback, and iterate. An agile approach allows for continuous refinement and improvement.
2. Design the digital twin to be modular, so you can add components over time and adapt it as requirements change, ensuring it remains scalable.
3. Establish a regular update and maintenance protocol, ensuring the twin remains an accurate reflection of the real-world system

Cost Estimate

CapEx:

For building a digital process twin for a mid-sized production hangar, enabled with , robust analytics, cloud infrastructure & simulation capabilities costs 2 – 5 million AED, as of 2025.

OpEx:

The license cost vary widely from 500k – 900k AED per year, depending on the scope and scale of the implementation

Example Implementations

bin ghalib
GROUP OF COMPANIES

Linked with ITTI Use Case Guide - page #99

Use Case #14: AI/ML for Process Optimization and Production Efficiency

Solution Introduction

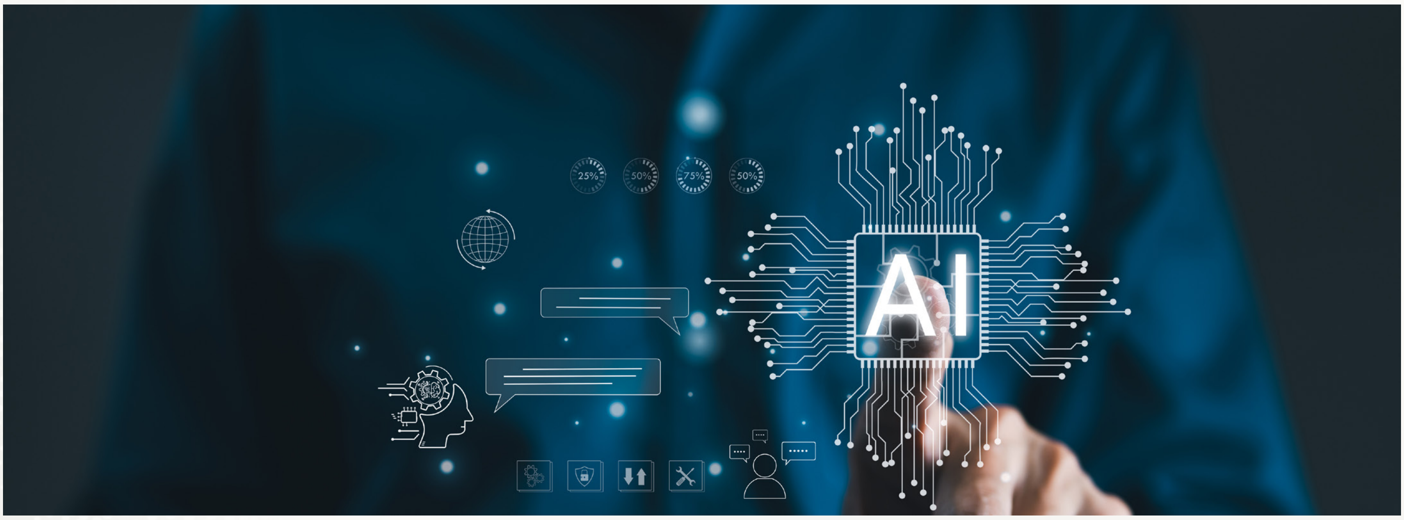
Artificial Intelligence (AI) and Machine Learning (ML) play pivotal roles in process optimization and production efficiency by analyzing large volumes of data to uncover patterns, predict trends, and automate complex decisions. ML algorithms learn from historical data, enabling predictive maintenance and minimizing downtime. AI-driven systems can monitor production in real-time, optimizing parameters to reduce waste and improve quality. AI and ML enhance the "golden sample" by analyzing vast data sets to define optimal production standards. Through pattern recognition and anomaly detection, they ensure each output meets high-quality benchmarks.

Ideal candidates for adopting Digital Twin for production simulation

Ideal candidates for adopting this solution are those looking forward to enhance their production throughput and the quality of outputs. High-value, high-precision production lines like jewelry making, defense, aerospace and automotive industries are front runners to leverage AI/ML for enhancing their process and improve their production efficiency.

Organizations with the following prerequisites stand the highest chance of success:

Digitized shopfloors with extensive data gathering capabilities:	High-maturity production lines:
Production lines with sensors and modern machinery that generate sufficient production data for analysis.	Production lines that have been optimized manually can achieve the last percentages of optimization through AI.



When to opt for AI/ML for Process Optimization

- When there's a significant amount of production and operational data to analyze
- When processes are too complex for manual monitoring or optimization
- When maintaining consistent quality standards is challenging
- When the production line is replicated to scale up for demand, and there is a need to carry forward ideal working conditions to consistently achieve 'golden samples' (highest quality output)
- When equipment breakdowns or downtime are costly
- Facilities are focused on reducing waste, energy use, or material costs

Tools and Technologies Involved

1. Data Collection Tools: IoT Sensors, Edge Devices, PLC & SCADA devices
2. Integration and Communication Protocols: OPC-UA Protocol, Message Queuing Protocols – MQTT & AMQP, API Management Platforms
3. Predictive Maintenance Platforms & Process Optimization Platforms
4. Data Management & Storage tools: Data Lakes, Data Warehouses, Cloud Platforms
5. Analytics & Visualization Tools: Real-Time Dashboards, Business Intelligence Platforms
6. AI/ML Software and Frameworks
7. Computer Vision Tools
8. AI-Driven Automation Tools

Solution Implementation Steps

1) Value Analysis Phase:

- Form a cross-functional team that includes representatives from production, IT, supply chain, finance, and other key departments.
- Identify the specific goals for the project - like improving on-time delivery in full, enhancing production efficiency, reducing lead times, or optimizing resource allocation.
- Earmark target improvement for the identified KPIs and respective processes.
- Usually, this solution is bound to incorporate more of qualitative benefits to the organization. So while evaluating the business case for the implementation, weigh-in these factors accordingly.

2) Requirements Definition Phase:

- Conduct a thorough assessment of existing processes, technology infrastructure, and current planning and scheduling capabilities.
- Determine the data sources required, such as sensors, ERP systems, historical logs, or SCADA systems. Evaluate the completeness, accuracy, and consistency of the data. Address gaps through cleaning and preprocessing.
- In case of any gaps in the existing data, plan for additional data capturing mechanisms – either with installation of new sensors or sourcing of data from other relevant systems.
- Define the target state and scenarios to meet the business objective with this solution goes-live.
- Compile this information and prepare 'Requirements Specification document'.

3) Vendor Evaluation Phase:

- Conduct market research to identify potential vendors and create a shortlist based on their capabilities, reputation, and experience relevant to the industry.
- Issue an RFP to shortlisted vendors including detailed requirements and expectations.
- Evaluate proposals for their commercials as well as technical proficiency.
- Arrange vendor demonstrations and understand their capabilities.
- Conduct contract negotiation including pricing for defined high-level scope, delivery schedules, support agreements, and warranties before finalizing the agreement with the vendor.

4) Solution Design Phase:

Once the vendor is onboarded, design the target architecture of the solution by following:

- Study the overall processes, required improvements and required automation in planning and scheduling activities.
- Identify data sources relevant to production planning and scheduling, including sales forecasts, inventory levels, machine data, and workforce availability.
- Map the data points to the relevant systems of origin. Plan for data cleaning, identify the features to be extracted from the data sets. If supervised learning is required, plan for labelling the data with outcomes or classifications. Also, plan to normalize or standardize data for algorithms sensitive to scale.
- Define the target architecture by designing the right connections between the systems and ensuring seamless data exchange between multiple data systems.

5) Installation & Commissioning:

- Decide whether the solution will run on edge devices, on-premise servers, or cloud platforms. Establish the IT & data infrastructure as needed.
- Standardize and integrate data across ERP, MES, and other systems to create a unified and accessible data structure.
- Integrate relevant and required data from suppliers and logistics teams with the Supply Chain Management (SCM) software.
- Select the suitable AI/ML algorithms based on the problem type:
  - Supervised learning for defect prediction or yield optimization.
  - Unsupervised learning for anomaly detection or process clustering.
  - Reinforcement learning for dynamic process control.
- Train the model using historical data. Validate the model with unseen data to assess performance and prevent overfitting.
- Embed the AI/ML solution into the production workflow. Test the solution on a small scale to evaluate its impact and address any integration issues.
- Implement dashboards and monitoring systems to provide real-time insights and alerts. Incorporate real-time data for continuous learning and improvement of models.
- Periodically retrain models with new data to maintain accuracy as processes evolve.

6) Go-Live & Stabilization:

- Train staff on the implemented AI/ML algorithms and educate them on how to leverage this algorithm to better finetune their processes.
- Test system performance under different scenarios to ensure stability and reliability.
- Monitor system performance and gather feedback to fine-tune scheduling rules, data integration, and reporting mechanisms.
- Gather feedback from operators and engineers to refine the system.
- Once the pilot is proven successful, Expand the solution across other production lines, processes, or facilities.

Potential pitfalls to avoid & Best Practices

1. Underestimating the computational and integration requirements can lead to deployment failures. Hence plan for scalable infrastructure, robust integration, & reliable real-time systems.
2. Models that perform well on training data may fail to generalize to new scenarios. So, use proper validation techniques, like cross-validation, & monitor model performance on live data.
3. Relying solely on AI/ML without considering domain expertise can result in suboptimal models. Work closely with domain experts and leverage their domain knowledge for better outcomes.
4. Use adaptive algorithms that allow for real-time schedule adjustments based on changing conditions. Meanwhile, allow manual interventions and monitoring, ensuring human oversight to catch issues automation might miss.

Cost Estimate

CapEx:

The scale and scope of the projects vary widely and therefore their costs as well. For improving production efficiency of 20 CNC machines, it costs from 1.5Mn-5Mn AED, as of 2025.

OpEx:

- Annual Maintenance Contract (AMC) costs ~15% of the initial CapEx investment.
- License cost for the newly configured software.

Example Implementations

IPM
ITTIHAD PAPER MILL L.L.C.

أدنوك
ADNOC

C) Collaborative workspace solutions

Linked with ITTI Use Case Page #105

Usecase #15: AR/VR Enhanced Training (Expert Capture)

Solution Introduction

AR/VR-enhanced training is revolutionizing workforce development in production factories by combining immersive technologies with real-world applications. Augmented Reality (AR) overlays digital information onto physical environments, providing workers with real-time guidance, instructions, and data visualization. Virtual Reality (VR) creates immersive simulations, enabling employees to practice complex tasks in safe, controlled environments.

These technologies are particularly valuable for training in equipment operation, maintenance, and safety protocols, reducing learning curves and minimizing errors. By replicating real-world scenarios, AR/VR fosters hands-on learning without disrupting actual production. This innovative approach enhances skill retention, boosts productivity, and ensures that workers are prepared for dynamic manufacturing environments.

Ideal candidates for adopting AR/VR Enhanced Training

Typically, all manufacturing facilities that target to improve their associates' skillsets are potential candidates for adopting this solution. The top candidates will possess one of the following:

Widely involve high-skill, complex tasks in their operations	Has high number of safety-critical roles
Expanding and onboarding new associates	Has lot of advanced machineries
Companies aiming for standardization	In an industry where the employee turn-over is very high

When to opt for AR/VR Enhanced Training

- Increasingly adopt complex production operations
- While facing challenges in training and onboarding new associates for production
- In plans to buy complex machineries
- Safety critical operations pose challenges in rotating associates to different work zones
- When it is critical to clearly document the expert's knowledge in an easy to interpret format

Tools and Technologies Involved

1. AR Devices: Smart Glasses/Headsets, Smartphones and tablets using AR apps
2. VR Hardware: Standalone VR Headsets, PC-Connected VR Headsets, Haptic Devices
3. AR/VR Content Creation Tools
4. Simulation and Modeling Tools
5. Learning Management Systems
6. AR/VR Deployment Software
7. 3D Modeling and Animation software
8. Cloud/On-premise infrastructure, Network infrastructure

Solution Implementation Steps

1) Value Analysis Phase:

- Identify the business objectives demanding the need for adopting the AR/VR enhanced trainings
- Liaise with plant manager, production supervisors, Operators & HR teams to source their inputs
- Identify the metrics/KPIs that need to be tracked to achieve the targeted business objective (e.g. time taken for onboarding new associates to the job, number of complex activities documented)
- Identify the workforce segments (e.g., new employees, maintenance teams) who will benefit from AR/VR training.
- Analyze existing training methods and their shortcomings. Determine whether AR or VR (or both) is suitable for the identified training needs.
- Estimate the cost of hardware, software, and implementation. Prepare the business case and validate it before moving ahead to the next phase.

2) Requirements Definition Phase:

- Define the training scenarios, such as equipment maintenance, safety protocols, or assembly line procedures. Develop the details of the usecase in focus.
- Determine how AR/VR tools will integrate with existing systems (e.g., ERP, CAD models, or IoT data).
- Engage operators, process engineers and quality control team to understand their needs.
- Work with the IT team and check if existing hardware & network connectivity are compatible or require upgrades.
- Compile this information and prepare 'Requirements Specification document'.

3) Vendor Evaluation Phase:

- Conduct market research to identify potential vendors or developers specializing in AR/VR for manufacturing.
- Issue an RFP to shortlisted vendors including detailed requirements and expectations.
- Evaluate proposals for their commercials as well as technical proficiency.
- Arrange (on-site) vendor demonstrations and understand their capabilities.
- Conduct contract negotiation including pricing for defined high-level scope, delivery schedules, support agreements, and warranties before finalizing the agreement with the vendor.

4) Solution Design Phase:

Enable the vendor team to prepare the low-level-design of the solution by performing following:

- Basis the business need, select devices such as AR glasses (e.g., HoloLens) or VR headsets (e.g., Oculus Quest).
- Choose platforms for content development and deployment (e.g., Unity, Unreal Engine, or specialized AR/VR tools).
- Create immersive 3D simulations or AR overlays, using CAD data or 3D modeling tools.
- Simulate real-world situations, including assembly tasks, equipment troubleshooting, and safety drills. Adapt content for different languages, if needed.

5) Installation & Commissioning:

- Run a pilot program with a small group of employees.
- Collect user feedback on usability, effectiveness, and areas for improvement.
- Refine the training modules based on feedback.
- Create a phased deployment schedule across different teams or locations.
- Provide initial guidance and support for employees using AR/VR tools.

6) Go-Live & Stabilization:

- Track usage rates and user engagement to monitor the adoption.
- Expand the deployment from pilot region to full-scale roll-out.
- Evaluate success using KPIs like reduced error rates, improved task completion times, or enhanced retention of training material.
- Continuously update content and technology based on performance data and new requirements.
- Encourage workers to embrace the technology by highlighting its benefits.
- Add gamified elements to training (e.g., scoreboards, rewards) to make learning more engaging.

Potential pitfalls to avoid & Best Practices

1. User Experience is the key in ensuring project success. Test AR/VR solutions with small group to identify potential issues, gather feedback, and make necessary adjustments before scaling.
2. Involve employees in the development process to ensure the content is intuitive, practical, and relevant to their workflows.
3. Create modular training scenarios that are easy to update and adapt for various tasks or roles.
4. Choose AR/VR solutions that integrate seamlessly with existing factory systems, such as IoT, CAD, and ERP platforms.
5. Select durable, ergonomic AR/VR devices and use reliable platforms for content creation and deployment.

Cost Estimate

CapEx:

For enabling training on 10 major assembly stations with 2 AR/VR headsets on on-premise setup in a factory will cost AED 1,200k – 1,800k as of 2025.

OpEx:

- Annual Maintenance Contract (AMC) costs 10-15% of the initial CapEx investment.
- In addition to AMC, factor in the license renewal cost (~200k/year).

Example Implementations

HALCON

ADCAN Pharma

C) Collaborative workspace solutions	Newly Added Use Case

Usecase #16: AR based Remote Maintenance

Solution Introduction

Augmented Reality (AR)-based remote maintenance is revolutionizing manufacturing by enhancing efficiency, reducing downtime, and streamlining complex processes. Leveraging AR, technicians can access real-time, interactive 3D overlays on machinery, enabling precise diagnostics and repairs without needing extensive manuals or on-site expertise. Remote experts can guide on-site personnel through complex tasks using AR annotations, video streaming, and step-by-step instructions, minimizing travel costs and response times. This technology improves collaboration, ensures consistent maintenance quality, and enhances worker safety by providing clear, contextual information. AR-based remote maintenance represents a critical innovation in Industry 4.0, driving productivity and fostering resilience in manufacturing operations.

Ideal candidates for adopting AR based Remote Maintenance

Ideal candidates for adopting AR-based remote maintenance include industries and organizations where operational efficiency, reduced downtime, and enhanced collaboration are critical. Examples include:

Manufacturing companies with complex machines	Energy and Utilities (like windfarms, oil & gas companies)
ealthcare Equipment Providers & Hospitals	High cost transportation assets (aircraft engines, ships)
Mining and Extraction (to mitigate exposure to hazardous environments)	

When to opt for AR based Remote Maintenance

- While carrying out complex equipment maintenance activities
- Whiel facing high downtime costs
- Firms with remote or hazardous locations
- Teams with limited skillsets
- When equipment requires regular or predictive maintenance
- When teams in different locations need to collaborate on diagnostics or repairs

Tools and Technologies Involved

1. AR Devices: Smart Glasses/Headsets, Smartphones and tablets using AR apps, AR headset
2. AR Platforms
3. Remote Collaboration Tools
4. Cybersecurity Tools
5. IoT integration
6. Data Management Systems

Solution Implementation Steps

1) Value Analysis Phase:

- Determine the specific maintenance challenges AR will address (e.g., reducing downtime, improving training).
- Liaise with plant manager, production supervisors, Operators & IT teams to source their inputs
- Identify the metrics/KPIs that need to be tracked to achieve the targeted business objective (e.g. Mean Time To Repair, Total downtime loss)
- Estimate the return on investment (ROI) by comparing AR implementation costs with potential benefits like downtime reduction and productivity gains.

2) Requirements Definition Phase:

- Engage operators, process engineers and quality control team to understand their needs.
- Evaluate equipment, operational workflows, and user requirements to outline necessary features and functionality.
- Assess existing hardware, network, and software capabilities. Work with the IT team and check if existing hardware & network connectivity are compatible or require upgrades.
- Detail out the required remote assistance activities through the Augmented Reality solution.
- Compile this information and prepare 'Requirements Specification document'.

3) Vendor Evaluation Phase:

- Conduct market research to identify potential vendors or developers specializing in AR for manufacturing equipment.
- Issue an RFP to shortlisted vendors including detailed requirements and expectations.
- Evaluate proposals for their commercials as well as technical proficiency.
- Arrange (on-site) vendor demonstrations and understand their capabilities.
- Conduct contract negotiation including pricing for defined high-level scope, delivery schedules, support agreements, and warranties before finalizing the agreement with the vendor.

4) Solution Design Phase:

Enable the vendor team to prepare the low-level-design of the solution by performing following:

- Choose suitable AR devices (e.g., smart glasses, headsets) based on use cases and user comfort.
- Opt for AR development tools, collaboration platforms, and IoT-integrated systems that align with business needs.
- Create 3D models, step-by-step guides, or real-time annotations tailored to your equipment.

5) Installation & Commissioning:

- Ensure the application captures and uses live data from IoT-enabled devices for contextual maintenance insights.
- Implement reliable, high-speed networks (e.g., 5G or Wi-Fi) for seamless communication.
- Establish data storage and processing systems to support AR functions.
- Deploy measures to secure sensitive data and communications.
- Prototype the application, conduct user testing, and refine based on feedback.
- Run a pilot program with a small group of employees. Collect user feedback on usability, effectiveness, and areas for improvement. Refine the training modules based on feedback.

6) Go-Live & Stabilization:

- Educate technicians and maintenance teams on how to use AR tools effectively. Train personnel in remote collaboration and IoT-enabled system operations
- Deploy AR-based maintenance in a small-scale setup to evaluate effectiveness.
- Identify areas for improvement through feedback from technicians and stakeholders.
- Expand AR implementation across all relevant operations and sites.
- Track KPIs like downtime reduction, maintenance time, and user satisfaction.
- Regularly update AR applications and content to adapt to evolving needs.

Potential pitfalls to avoid & Best Practices

1. Engage technicians, IT teams, and management throughout the process to ensure the solution meets operational needs.
2. Slow or unstable internet connections can disrupt AR experiences, leading to frustration and inefficiencies. Ensure robust & reliable network capabilities, such as 5G or high-speed Wi-Fi.
3. Implement strong cybersecurity protocols, including encryption and secure authentication.
4. Keep the solution intuitive and scalable, with a focus on simplicity and usability.

Cost Estimate

CapEx:

For enabling 3 AR-based remote assistance devices in a factory (with all pre-requisite IT requirements established) will cost AED 500k – 800k as of 2025.

OpEx:

- Annual Maintenance Contract (AMC) costs ~15% of the initial CapEx investment.
- In addition to AMC, factor in license renewal cost (200k AED per year).

Example Implementations

Coca-Cola

PBC Linear

C) Collaborative workspace solutions | Linked with ITTI Use Case Guide - page #104

Use Case #17: Robotics for Automated Assembly Line Activities

Solution Introduction

Robotics for assembly automation is revolutionizing modern manufacturing by integrating programmable machines into the assembly line to handle repetitive, precise, and labor-intensive tasks. Automated robotic systems bring speed, consistency, and efficiency, often outperforming human labor in terms of accuracy and productivity, especially in high-volume production environments. These robots are equipped with advanced sensors, machine vision, and AI-driven algorithms, enabling them to make real-time adjustments, handle delicate components, and work alongside humans in collaborative settings.

Automated assembly robots can perform a range of functions, from picking and placing components to fastening, welding, soldering, scanning and quality control. These capabilities make them invaluable across industries such as automotive, electronics, and consumer goods, where reliability and quality are critical. By minimizing human intervention, robots not only reduce the risk of human error but also enhance worker safety by taking on hazardous or repetitive tasks.

Ideal candidates for adopting Robotics for Automated Assembly

High-volume low-variance products are highly recommended to embrace robotics for their activities. Typical adopters include,

Automotive manufacturers (OEMs)	Tier-1 & 2 suppliers
Consumer durables manufacturers	Electronics & semiconductor manufacturing
Food & Beverage processing	

When to opt for Robotics for Automated Assembly

Typical scenarios in which one need to opt for robotics in assembly line are as follows:

- Higher production volume that demands reduced production cost per unit
- Assembly activities demand high precision and repeatability
- The product design is matured
- Production environment is stable and do not change frequently
- Tools and Technologies Involved

Tools and Technologies Involved

1. Robotic arms: Articulated Robots, SCARA Robots, Cartesian Robots
2. End Effectors / End of Arm Tools: Grippers, Welding Tools, Screwdrivers, Drill Heads, Vacuum suction cups
3. Visual systems: 2D and 3D Cameras, Machine Vision Software, Laser Scanners
4. Programmable Logic Controllers (PLCs) & Human Machine Interface (HMI)
5. Conveyors, AGV's/AMR's
6. Sensors & Feedback Systems: Proximity, Force/Torque, Temperature & Pressure sensors
7. Artificial Intelligence and Machine Learning (AI/ML) algorithms
8. Robot operating system
9. Data Analytics platform and Manufacturing Execution Systems
10. Simulation software

Solution Implementation Steps

1) Value Analysis Phase:

- Analyse the product features and dimensions to understand the feasibility of automation
- Analyse the production processes to understand the automation feasibility.
- Prepare a high-level business case by comparing the production cost per unit in the current setup and the targeted future setup. For calculating the future cost, take a budgetary estimate of investments required (using the information gathered through market interactions).
- If the business case is positive (recommended break-even is 4 years), proceed to next phase.

2) Requirements Definition Phase:

For the automation-feasible activities, prepare requirements document by analyzing following:

- Analyse the product and part structure
- Types of activities required on each parts (positioning, welding, inspection, movement…)
- Details on existing machinery and IT landscape
- Existing environment conditions (space, temperature, power, hazardous environment…)
  In parallel, while carrying out the analysis, note down the design-optimizations required for automation and initiate required design change requests to the engineering team.

3) Vendor Selection:

- Conduct market research to identify potential vendors, and create a shortlist based on their capabilities, reputation, and experience relevant to the industry.
- Issue an RFP to shortlisted vendors including detailed requirements and expectations.
- Evaluate proposals based on functional and non-functional (availability, integration capabilities, costs…) criteria.
- Arrange (on-site) vendor demonstrations.
- Make final decision and contract negotiation including pricing, delivery schedules, support agreements, and warranties.

4) Solution Design & Procurement:

- Define shopfloor layout with specification for robotic-automated process steps & areas (manual area, cobot area, automated area) and safety barriers and sensors if needed.
- Detail the activities conducted by each robot. Specify robot type for each automated activity
- Define infrastructure layout to support robots in all required areas.
- Specify interfaces between robots or existing machines and IT-systems.
- Create robot operating model including maintenance plans, guiding principles and trainings for working with robots.
- Finalize the Bill of Materials for both hardware and software and initiate the procurement

5) Installation & Commissioning:

- Develop robot programs for each robot-automated activity.
- Develop interfaces between robots and all required IT-systems (MES, ERP, IoT systems).
- Implement all infrastructure requirements (connectivity, power supply, compressed air).
- Restructure shopfloor layout according to the solution design
- Test E2E production process including all robotic operations for multiple process variants.
- Conduct trainings for all shopfloor workers that are in contact with robots.

6) Production Stabilization:

- Ramp-up production with increasing workload, transitioning from testing to full production.
- Monitor all robotic operations and regularly review performance till production stabilizes.
- Fix all the major issues and plan for transitioning of the project to the operations team.

Potential pitfalls to avoid & Best Practices

1. Having vendors and partners based out of UAE provides better planning & execution.
2. Order long lead items well in advance. Preferably, as soon as the detailed design is ready.
3. Plan the transportation and delivery of the hardware with additional buffer to account for uncontrollable external factors during shipment.
4. Involve a dedicated team member from production operation from the initial days of solution design, to ensure better design, configuration, smooth production stabilization and better management of systems post-go live.
5. Chose robot system with easy software integration and interfaces to company systems.
6. While designing the communications & network systems, ensure compatibility with existing systems and make provisions for future advanced solutions (like AR/VR, IoT systems…)
7. Evaluate the existing constraints in the layout and resolve them in parallel while the procurement and solution configuration is in progress.
8. Ensure the Standard Operating Procedure is prepared with clear details on roles and responsibilities of the organization and the vendor teams.

Cost Estimate

CapEx:

For building an automated assembly line with 6-8 robots typically costs 10 Million AED – 13 million AED, as of 2025.

OpEx:

Annual maintenance cost is ~15% of CapEx invested. Software subscriptions cost ~500k yearly.

Example Implementations

bin ghalib GROUP OF COMPANIES

HALCON

C) Collaborative workspace solutions	Linked with ITTI Use Case Page #94

Usecase #18: Intra-Plant Material Handling

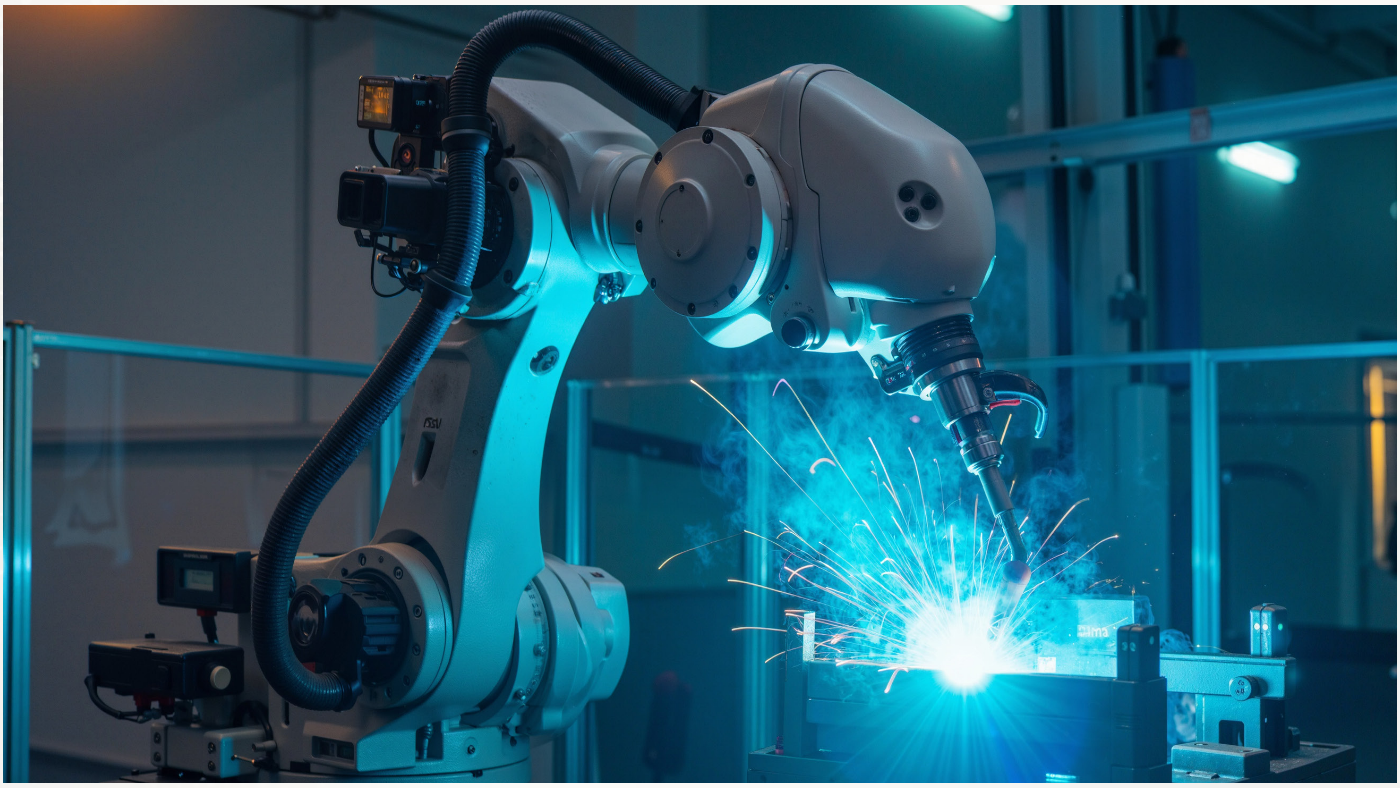
Solution Introduction

Automated intra-plant material handling systems are transforming modern factories by streamlining the movement, storage, and management of materials within production facilities. These systems include advanced technologies such as conveyor belts, robotic arms, automated guided vehicles (AGVs), Autonomous Mobile Robots (AMR) and overhead cranes, all designed to optimize workflow and reduce manual intervention.
By automating material transport, factories can minimize production downtime, enhance precision, and improve workplace safety. Integration with IoT, Fleet Management software, artificial intelligence, and real-time tracking systems further enables intelligent decision-making and agile supply chain within the factory. Ideal for Industry 4.0-ready environments, automated material handling enhances overall efficiency, ensures just-in-time delivery of components, and supports scalability. This innovation is key to achieving higher productivity, operational resilience, and sustainable manufacturing processes in competitive industrial landscapes.

Ideal candidates to adopt Automated Intra-Plant Material Handling

Ideal candidates for adopting automated intra-plant material handling systems are factories and industries where material movement is frequent, labor-intensive, or requires high precision. Examples are as follows:

Automotive Manufacturing (supporting just-in-time)	Electronics Manufacturing (for handling delicate materials)
Food and Beverage (for continuous flow with conveyors)	E-commerce and Warehousing (Automating sorting, picking, and moving operations)
Metals and Heavy Equipment Manufacturing (aircraft engines, ships)	Aerospace (for handling oversized components)



When to opt for Automated Intra-Plant Material Handling

Organizations should consider opting for automated intra-plant material handling when facing following conditions:

- High Material Movement Frequency
- Repetitive and Labor-Intensive Tasks
- Safety Concerns dealing with size and weight of the materials
- In need of space optimization
- When the organization need to increase the accuracy of delivery in Just-In-Time practices
- When the firm needs to cut down on its recurring operational expenses

Tools and Technologies Involved

1. Material Handling Equipment: Conveyors, Automated Guided Vehicles - AGVs, Autonomous Mobile Robots - AMRs, Over-head Cranes and Gantry Systems, Robotic Arms
2. Control Systems: PLCs, SCADA & Warehouse Management Systems
3. IoT & sensors: IoT Devices, Proximity and Motion Sensors, RFID and Barcode Scanners
4. Software and Integration Tools: Fleet Management solutions, ERP systems
5. Power systems: Battery Management Systems, Energy efficient drives

Solution Implementation Steps

1) Value Analysis Phase:

- Liaise with plant manager, production supervisors, planning teams to understand the business need for adopting automated material handling systems within the factory
- Understand the KPIs that are targeted to be improved with the implementation of the solution (like on-time deliveries, delivery accuracy, labor cost, space optimization)
- Measure the current metrics and earmark the target metrics with the solution to be deployed
- Evaluate the different options – both in terms of their functional capability as well as commercial value – and shortlist the right system that will address the factory's needs.
- Plan for workforce changes, such as reskilling or reallocating roles.
- Estimate the return on investment (ROI) by comparing implementation costs with potential benefits. Once the business case is validated, proceed to the next stages.

2) Requirements Definition Phase:

- Analyze current workflows, bottlenecks, and material handling inefficiencies.
- Identify needs by assessing specific requirements, such as load capacity, speed, and precision.
- Evaluate factory layout, space constraints, and compatibility with automated systems.
- Select automated systems like conveyors, AGVs, AMRs, robotic arms, or cranes based on requirements.
- Select warehouse management systems (WMS), IoT platforms, and control systems like PLCs or SCADA.
- Detail out the required features – in terms of delivery frequency, routes to be charted, volume to be handled - through the Automated material handling solution.
- Compile this information and prepare 'Requirements Specification document'.

3) Vendor Evaluation Phase:

- Conduct market research to identify potential vendors or developers specializing in automated material handling solutions for the factories.
- Issue an RFP to shortlisted vendors including detailed requirements and expectations.
- Evaluate proposals for their commercials as well as technical proficiency.
- Arrange (on-site) vendor demonstrations and understand their capabilities.
- Conduct contract negotiation including pricing for defined high-level scope, delivery schedules, support agreements, and warranties before finalizing the agreement with the vendor.

4) Solution Design Phase:

Enable the vendor team to prepare the low-level-design of the solution by performing following:

- Create a detailed layout showing paths, stations, and interaction points for automated systems.
- Use digital twins or simulation tools to model and optimize the system.
- Ensure compatibility with existing equipment and IT systems, such as ERP or inventory management.
- Consider collision detection, emergency stops, and compliance mechanisms to the design.
- Enumerate the list of equipment needed and prepare the final Bill-of-Materials. In case of change in the scope, route through the Change Request process to kick-start the procurement.

5) Installation & Commissioning:

- Purchase and set up the selected hardware and software.
- Ensure all components work together, including IoT sensors, robots, and control systems and test the integration.
- Run a pilot project to evaluate performance and resolve issues.
- Track metrics such as efficiency, throughput, and error rates during the pilot.
- Use feedback from operators and stakeholders to make improvements.
- Adjust workflows, routes, or configurations for better efficiency.

6) Go-Live & Stabilization:

- Train staff to operate and maintain the automated systems. Ensure workers understand safety protocols and emergency procedures.
- Do a pilot go-live of the solution. Observe its performance for few weeks and incorporate changes as needed.
- Expand the system across the facility or to additional locations for full roll-out of the solution.
- Keep software and equipment up to date with the latest advancements.
- Continuously evaluate KPIs to ensure long-term success.

Potential pitfalls to avoid & Best Practices

1. Plan for future needs by selecting modular systems that can expand with production growth.
2. Test the system on a small scale to identify issues and optimize before full-scale deployment.
3. Integrate safety measures such as sensors, alarms, and compliance with industry standards.
4. Track key performance indicators (KPIs) like throughput, downtime, and cost savings to evaluate system effectiveness and guide improvements.

Cost Estimate

CapEx:

For automating the in-plant logistics with 3 AMRs in a factory, along with the Fleet Management System, will cost AED 1.5Mn – 3Mn as of 2025.

OpEx:

Annual Maintenance Contract (AMC) costs ~15% of the initial CapEx investment. Also, factor in the license renewal cost of 200k-500k AED per year.

Example Implementations

Mai Dubai — water is life

RAK CERAMICS

Lipton

C) Collaborative workspace solutions | Linked with ITTI Use Case Page #95

Use Case #19: Material Traceability for Warehouse Operations

Solution Introduction

Warehouses, stores, and shop floors often face challenges in efficiently managing stock or inventory. Manually handling tasks, such as rules application (FIFO/LIFO), storage location allocation, item retrieval, shelf or expiry life management, and recall or warranty management are highly prone to discrepancies. Further, traceability using analog tools, such as paper, Excel, mail, or manual entry into IT systems increases the likelihood of errors.

Material traceability adds the ability to track, trace and retrieve products from its source to the final destination. It also adds track and trace capability, ensures unique identification of each of the finished products or raw materials. Optionally, it also holds potential to leverage sensor-based condition monitoring of inventory in store.

Ideal candidates for Material Traceability for Warehouse Operations

Ideal candidates for adopting material traceability in warehouse operations are industries and organizations where accurate tracking, regulatory compliance, and efficient inventory management are critical. Examples include:

Logistics and Distribution Centers	Retail and E-commerce Warehouses
Manufacturing and Assembly Plants	Pharmaceutical and Healthcare Industries
Food and Beverage Industry	Chemicals and Hazardous Materials storage areas

When to opt for Material Traceability for Warehouse Operations

Organizations should opt for material traceability in warehouse operations when the following conditions apply:

- Organizations which are facing stricter regulatory compliance requirements
- Organizations with complex supply chain
- Those storing perishable / hazardous materials in their inventory
- Firms facing high recall issues or quality assurance demands
- Those handling large inventory volume
- Those storing high-value, fragile, or sensitive items (e.g., electronics or medical devices) with special handling and tracking needs.
- While facing risks of counterfeit products and in need of a custom solution.

Tools and Technologies Involved

1. Identification and Tracking Tools: RFID Tags/Barcode
2. Software Solutions: Warehouse Management System – WMS, Enterprise Resource Planning – ERP, Inventory Management Software, Traceability Platforms
3. Data Collection and Communication devices
4. Automation Tools: AGVs, AMRs, Robots, Conveyors
5. 3D visualization tools

Solution Implementation Steps

1) Value Analysis Phase:

- Liaise with the organization's leadership team to understand their business need to establish traceability – such as improving Operational improvements or Health, Safety and Environment requirements.
- Define the KPIs to be improved with this solution (on-time delivery, accurate picking, improved delivery rate etc.,). Measure the as-is metrics of the same and define the target state.
- Map material flows within the warehouse to identify traceability points.
- Estimate the scope of implementation and prepare a budget estimate based on secondary price checks. Similarly, understand the potential savings with the deployment of this solution.
- Evaluate the business case for this solution deployment. Typically, this solution is treated as a basic hygiene solution in few industries like Food & Beverages and Pharma. Hence conduct a mix of quantitative and qualitative study for Return-on-Investment. Once the business case is validated, move ahead to the next phase.

2) Requirements Definition Phase:

- Define the required traceability needs and the number of nodes that need to be monitored to build the solution.
- Assess existing systems (e.g., WMS, ERP) and warehouse layout. Review industry-specific compliance requirements. Prepare a budget for hardware, software, and training.
- Choose between barcodes, RFID, or IoT-enabled systems based on operational needs.
- Select a WMS or inventory management system that supports traceability.
- Detail out the operating conditions and the reporting requirements of the solution to be deployed.
- Document and organize these requirements in to a 'Requirements Specification document'.

3) Vendor Evaluation Phase:

- Conduct market research to identify potential vendors and create a shortlist based on their capabilities, reputation, and experience relevant to the industry.
- Issue RFP to shortlisted vendors including detailed requirements and expectations.
- Evaluate proposals for their commercials as well as technical proficiency.
- Arrange (on-site) vendor demonstrations and understand their capabilities.
- Conduct contract negotiation including pricing for defined high-level scope, delivery schedules, support agreements, and warranties before finalizing the agreement with the vendor.

4) Solution Design Phase:

- Enable the vendor team to prepare the low-level-design of the solution by performing following:
  - Detailed study of the existing processes
  - Benchmark study on the existing KPIs related to material tracing, picking and storing.
  - Identify critical points where materials need to be tracked (e.g., receiving, storage, picking, and shipping).
  - Standardize item identification using unique codes, batch numbers, or serial numbers.
  - Ensure compatibility between the traceability system and existing workflows.
  - Estimate the number of handheld scanners, RFID readers, and IoT sensors needed for this solution.
  - Basis this, prepare the low-level-design and follow-up discussion with the warehouse team and the leadership, to prepare final Bill-of-Materials.
- In case of deviation from earlier scoped proposal, effect required Change Request accordingly.

5) Implementation Phase:

- Procure handheld scanners, RFID readers, and IoT sensors.
- Deploy barcode scanners, RFID systems, or IoT devices across the warehouse.
- Integrate traceability tools with existing WMS and ERP platforms.
- Establish reliable internet or intranet connectivity for real-time data synchronization.
- Implement the system in a specific section of the warehouse to evaluate performance. Gather feedback, identify issues, and make necessary adjustments.

6) Go-Live & Stabilization:

- Roll out the system across the entire warehouse.
- Document standard operating procedures (SOPs) for traceability workflows.
- Provide hands-on training for employees on using scanners, software, and tracking tools. Ensure staff understands the importance of traceability and how to handle exceptions.
- Measure performance indicators such as inventory accuracy, recall response time, and system uptime.
- Ensure the system evolves with the business, handling increased inventory volumes and complexity.
- In future, add advanced capabilities like blockchain for transparency or AI for predictive analytics.

Potential pitfalls to avoid & Best Practices

1. Engage warehouse staff, IT teams, and management in the planning and implementation process to ensure alignment.
2. Select the tracking devices based on the operating conditions and the materials being stored/transited.
3. While designing, ensure new systems can work seamlessly with existing technologies, including warehouse management and enterprise resource planning systems.

Cost Estimate

CapEx:

Owing to the wide scope range (types of traceability solutions) and the scale of operations, the cost varies widely. For a 1000 m^2 warehouse storing 1000 pallets, traceability solution alone for its materials will cost 800k to 1200k AED, as of 2025. It is important to note that, implementing an automated storage and retrieval solution along with this traceability solution has huge potential to tap the hidden synergies.

OpEx:

The Annual Maintenance Contracts are usually ~15% of CapEx investments

hotpack

RAK CERAMICS

CARACAL

C) Collaborative workspace solutions	Newly Added Use Case

Usecase #20: Automated Storage & Retrieval

Solution Introduction

An automated storage facility in a factory is a cutting-edge solution that optimizes space and enhances efficiency in material handling. Featuring a high-density, modular storage system, the facility utilizes robotic shuttles, cranes, vertical lifts and automated guided vehicles (AGVs) to store and retrieve goods. The system is integrated with conveyors that seamlessly move items between sections, reducing the need for manual intervention. Real-time data is displayed on digital dashboards, providing visibility into inventory levels and operational performance.

This technology is designed to maximize storage capacity while improving retrieval speed, making it ideal for industries with high-volume storage needs. With its compact, space-efficient design, an automated storage facility supports streamlined workflows, reduces human error, and contributes to the overall productivity of the factory.

Ideal candidates to adopt Automated Storage & Retrieval

Ideal candidates for adopting automated storage and retrieval systems (ASRS) include industries and organizations that prioritize efficient material handling, high storage density, and operational accuracy. These candidates typically operate in high-demand or precision-focused environments. Examples include:

Manufacturing and assembly plants	Logistics & distribution centers, E-commerce warehouses
Pharmaceutical and healthcare	Food and beverage industry
Cold storage and freezers	chemical and hazardous material storage area

When to opt for Automated Storage & Retrieval

Organizations should consider opting for automated storage and retrieval systems (ASRS) when the following conditions apply:

- Limited storage space
- High inventory volumes
- Need for improved efficiency
- Demand for accuracy and traceability
- Seasonal or high fluctuating demand
- Regulatory compliance needs
- Labor shortages or rising costs
- Cold or hazardous environments

Tools and Technologies Involved

1. Storage Units (Racks, bins, shelves, or modular grid systems)
2. Robotics (Shuttles and Lifts, Autonomous Mobile Robots - AMRs)
3. Conveyors, Cranes, Pick Modules (Workstations equipped with automated tools)
4. Identification and Tracking Tools (Barcode Scanners, RFID & IoT sensors)
5. Software Solutions (Warehouse Management System, ERP, Inventory Management Software)
6. Networking and Communication devices
7. Safety and security tools
8. Visualization and analytical tools

Solution Implementation Steps

1) Value Analysis Phase:

- Liaise with plant manager, production supervisors, planning teams to understand the business need for adopting automated material storage within the factory
- Understand the KPIs that are targeted to be improved with the implementation of the solution (improving storage density, reducing labor costs, or enhancing retrieval speed)
- Measure the current metrics and earmark the target metrics with the solution to be deployed
- Evaluate the different solution options – both in terms of their functional capability as well as commercial value – and shortlist the right system that will address the factory's needs.
- Estimate the return on investment (ROI) by comparing implementation costs with potential benefits. Once the business case is validated, proceed to the next stages.

2) Requirements Definition Phase:

- Identify storage challenges, workflow inefficiencies, and capacity constraints.
- Assess existing warehouse layout, inventory types, and operational workflows.
- Evaluate factory layout, space constraints, and compatibility with automated systems.
- Evaluate automated systems like conveyors, AGVs, AMRs, robotic arms, or cranes based on requirements. Shortlist the ones that would address the business goals and fit the budget planned for the solution.
- Detail out the required features – in terms of delivery frequency, in-stock visibility, volume to be handled – targeted with the solution.
- Compile this information and prepare 'Requirements Specification document'.

3) Vendor Evaluation Phase:

- Conduct market research to identify potential vendors or developers specializing in automated material storage for the factories.
- Issue an RFP to shortlisted vendors including detailed requirements and expectations.
- Evaluate proposals for their commercials as well as technical proficiency.
- Arrange (on-site) vendor demonstrations and understand their capabilities.
- Conduct contract negotiation including pricing for defined high-level scope, delivery schedules, support agreements, and warranties before finalizing the agreement with the vendor.

4) Solution Design Phase:

Enable the vendor team to prepare the low-level-design of the solution by performing following:

- Design a facility layout considering storage density, vertical space utilization, and workflow optimization.
- Select suitable solutions like automated storage and retrieval systems (ASRS), vertical lift modules (VLMs), or robotic systems based on inventory types and factory requirements.
- Plan for integration with existing systems like Warehouse Management System (WMS) or Enterprise Resource Planning (ERP) software.
- Consider collision detection, emergency stops, and compliance mechanisms to the design.
- Enumerate the list of equipment needed and prepare the final Bill-of-Materials. In case of change in the scope, route through the Change Request process to kick-start the procurement.

5) Installation & Commissioning:

- Procure storage racks, shuttles, conveyors, and robotic systems. Opt for WMS, inventory tracking systems, and real-time monitoring tools.
- Modify factory layout to accommodate automated systems, including power & network requirements.
- Install storage racks, conveyors, shuttles, and robotic systems according to the design plan.
- Install safety features such as motion sensors, light curtains, and emergency stop mechanisms.
- Integrate WMS, ERP, and material flow controllers with the hardware.
- Verify seamless communication between devices and software.
- Do a pilot testing of the solution. Observe its performance for few weeks and incorporate changes as needed.

6) Go-Live & Stabilization:

- Educate employees about new workflows, safety protocols, and troubleshooting procedures.
- Run a pilot in a specific area to evaluate system performance and identify potential issues.
- Use insights from operators and technicians to fine-tune the system.
- Roll out the solution across the entire facility.
- Document standard operating procedures (SOPs) for consistent operations.
- Use KPIs like throughput, downtime, and inventory accuracy to evaluate effectiveness.
- Scale the system to handle increased inventory volumes or changes in production demands.

Potential pitfalls to avoid & Best Practices

1. Test the system in a controlled area to identify potential issues and refine processes before full-scale deployment.
2. Design layouts that maximize vertical space, improving storage density & accessibility.
3. Incorporate safety features like motion sensors, alarms, & fail-safe mechanisms, as needed.
4. Opt for modular systems that can be expanded as the factory grows or needs change.
5. Ensure seamless integration with existing systems like ERP, WMS, and IoT platforms for real-time data synchronization.

Cost Estimate

CapEx:

The costs vary based on the type of storage system and its scope. For a typical 1000 m^2 warehouse handling 1200 pallets, the automated storage and retrieval system with shuttle & crane set-up will cost AED 5Mn – 7Mn as of 2025.

OpEx:

Annual Maintenance Contract (AMC) costs ~15% of the initial CapEx investment.

Example Implementations

MBM MAISON-B-MORE

CARACAL

D) Supplier/Customer Network solutions	Linked with ITTI Use Case Page #93

Usecase#21: Customer Integration for Automated Logistics Workflow

Solution Introduction

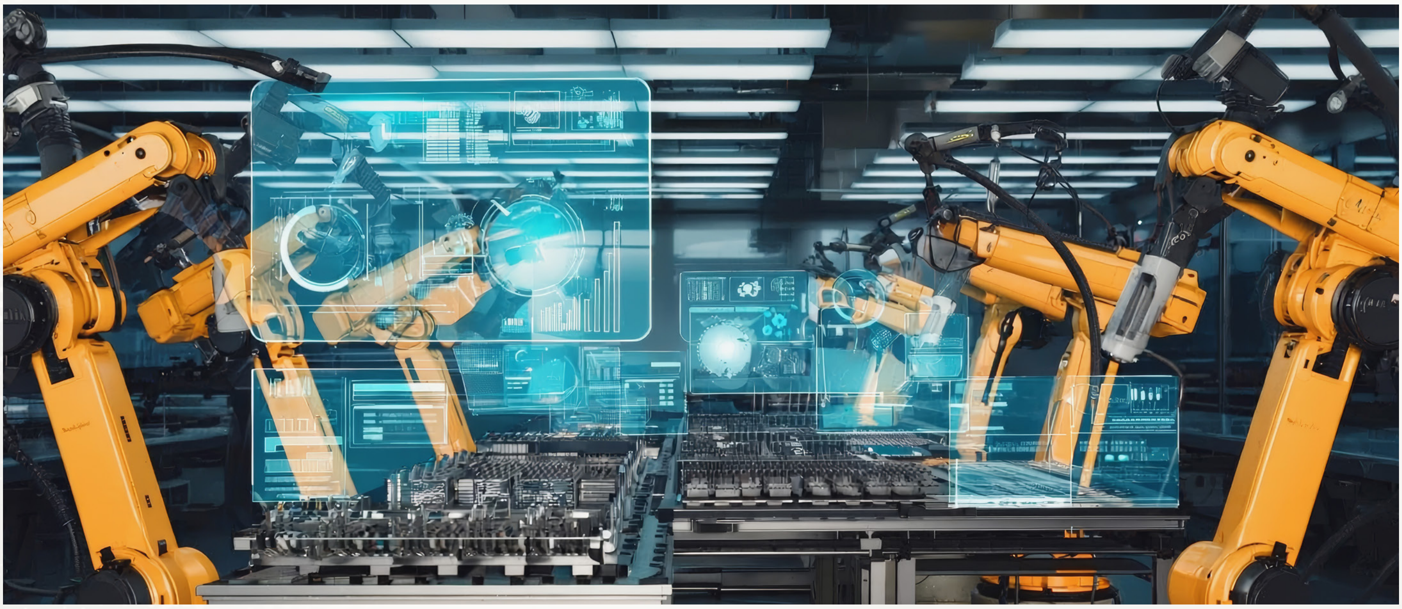
In the modern manufacturing world, there is an increased need for end-to-end horizontal integration to instill customer centricity at the core of business. Seamless customer integration with automated logistics workflows is vital for optimizing supply chains and enhancing customer satisfaction. By leveraging advanced technologies like Internet of Things (IoT), data analytics, and real-time tracking, manufacturers can create interconnected systems that streamline order processing, inventory management, and delivery operations.

Customer integration for automated logistics workflow enables customers to integrate with manufacturers through EDI or RPA-enabled portals. It empowers customers with accurate, up-to- date information, enabling real-time tracking of shipments, faster deliveries, and improved transparency. As businesses adopt smart logistics solutions, they achieve better resource utilization, cost savings, and a competitive edge in the global market, ultimately revolutionizing how manufacturers meet dynamic customer demands in today's fast-paced environment.

Ideal candidates for adopting Customer Integration for Automated Logistics Workflow

Companies managing complex supply chains and serving diverse customer bases benefit significantly from streamlined logistics and automated processes. Typical candidates include,

Large-Scale Manufacturers (automotive, electronics & machinery)	E-commerce-Driven Manufacturers
Automotive and Spare Parts	Retail and Fashion
Industrial Equipment Suppliers	Manufacturers embracing Just-In-Time delivery to its customers



When to opt for Customer Integration for Automated Logistics Workflow

It is recommended to opt for this solution when the organization faces one of the following:

- E-commerce expansion
- Growing customer demand
- Managing complex supply chains
- High order volume
- In need for real-time visibility
- Facing heavier industry competition
- Facing stricter regulatory compliance needs Tools and Technologies Involved

Tools and Technologies Involved

1. EDI Software: Converts business documents to EDI format
2. Integration Middleware: Integrates ERP system and the EDI system
3. Secure Data Transmission Protocols: AS2, FTP over SSL, HTTPS
4. Customer Relationship Management & Enterprise Resource Planning (ERP) Software
5. Warehouse Management Systems & Logistics Management Systems
6. Data Mapping Tools: Converts custom data formats to standardized EDI formats
7. Robotic Process Automation (RPA): Streamline repetitive tasks such as data entry, invoicing, and shipment scheduling.
8. AR/VR: Enables virtual shopping or product information assistance
9. Digital Dashboards and Analytics Tools

Solution Implementation Steps

1) Value Analysis Phase:

- Form a cross-functional team that includes representatives from Sales and marketing, warehouse team, production planning and scheduling teams and other key departments.
- Identify the specific goals for the project – like improving customer satisfaction, establishing Efficient communication, ensuring on-time-in-full (OTIF), establishing accurate demand forecasting, reducing complaints and returns.
- Earmark target improvement for the identified KPIs and respective processes.
- Usually, this solution is bound to incorporate more of qualitative benefits to the organization. So while evaluating the business case for the implementation, weigh-in these factors accordingly.

2) Requirements Definition Phase:

- Conduct a thorough review of existing logistics workflows, data management practices, and customer interaction channels.
- Identify gaps and inefficiencies in the current setup.
- Clearly outline the scope of the automation, including systems, processes, and customer touchpoints.
- Select suitable software solutions, such as CRM, ERP, LMS, and WMS, that align with your business needs.
- In case of any gaps in the existing data, plan for additional data capturing mechanisms – either with installation of new sensors or sourcing of data from other relevant systems.
- Define the target state and scenarios to meet the business objective with this solution goes-live. Evaluate tools for scalability, ease of integration, and compatibility with existing systems.
- Compile this information and prepare 'Requirements Specification document'.

3) Vendor Evaluation Phase:

- Conduct market research to identify potential vendors and create a shortlist based on their capabilities, reputation, and experience relevant to the industry.
- Issue an RFP to shortlisted vendors including detailed requirements and expectations.
- Evaluate proposals for their commercials as well as technical proficiency.
- Arrange vendor demonstrations and understand their capabilities.
- Conduct contract negotiation including pricing for defined high-level scope, delivery schedules, support agreements, and warranties before finalizing the agreement with the vendor.

4) Solution Design Phase:

Once the vendor is onboarded, design the target architecture of the solution by following:

- Study the overall processes, required improvements and required automation in planning and scheduling activities.
- Use APIs, middleware, or cloud-based platforms to connect customer-facing systems with logistics operations.
- Identify repetitive and time-consuming tasks, such as order processing, routing, and real-time tracking, for automation. Plan to use RPA, AI, and machine learning to optimize decision-making and improve efficiency.
- Build a detailed solution plan with specific focus on different information systems and how they are going to be integrated. Pay attention on scope of automation required in the target state.
- Basis this, define the new software that need to be configured and also estimate the overall project implementation efforts and the project plan.

5) Installation & Commissioning:

- Standardize and integrate data across ERP, MES, and other systems to create a unified and accessible data structure.
- Integrate relevant and required data from suppliers and logistics teams. Use APIs, middleware, or cloud-based platforms to connect customer-facing systems with logistics operations
- Use RPA, AI, and machine learning to optimize decision-making and improve efficiency.
- Enhance customer-facing platforms, such as mobile apps or websites, with features like real-time tracking, delivery updates, and self-service options.
- Test the integration on a smaller scale to identify potential issues and refine the system.
- Gather feedback from internal teams and select customers during the pilot phase.

6) Go-Live & Stabilization:

- Train staff on new Integrated tools, focusing on how to access schedules, monitor logistics, delivery, and respond to changes.
- Test system performance under different scenarios to ensure stability and reliability.
- Conduct comprehensive training sessions for employees on new tools, workflows, and customer interaction processes.
- Gradually roll out the solution across all operations and customer bases. Expand the system to include additional features, geographies, or customer segments as needed.
- Continuously refine workflows and processes based on real-time insights and feedback. Update the system as per the evolving business needs in the future.

Potential pitfalls to avoid & Best Practices

1. Choose tools and platforms that can grow with your business needs, accommodating larger volumes and more complex operations.
2. Use APIs, middleware, or cloud platforms to seamlessly connect CRM, ERP, WMS, and LMS systems for real-time data sharing.
3. Implement strong encryption, regular audits, and compliance with industry standards to protect sensitive information.
4. Ensure that critical decisions or exceptions are handled by skilled personnel to avoid errors in automated processes.

Cost Estimate

CapEx:

Depending on scale of operations, scope of coverage and the diversity in the customers involved, the investments vary widely. For connecting with 5 customers to provide automated visibility on the logistics workflow, the investments range from AED 1.2Mn to 3Mn, as of 2025.

OpEx:

- Annual Maintenance Contract (AMC) costs ~15% of the initial CapEx investment.
- License cost for the newly configured software.

Example Implementations

hotpack | Lipton | ALPLA

D) Supplier/Customer Network solutions | Linked with ITTI Use Case Page #92

Use Case #22: Supplier Integration for Automated Workflows

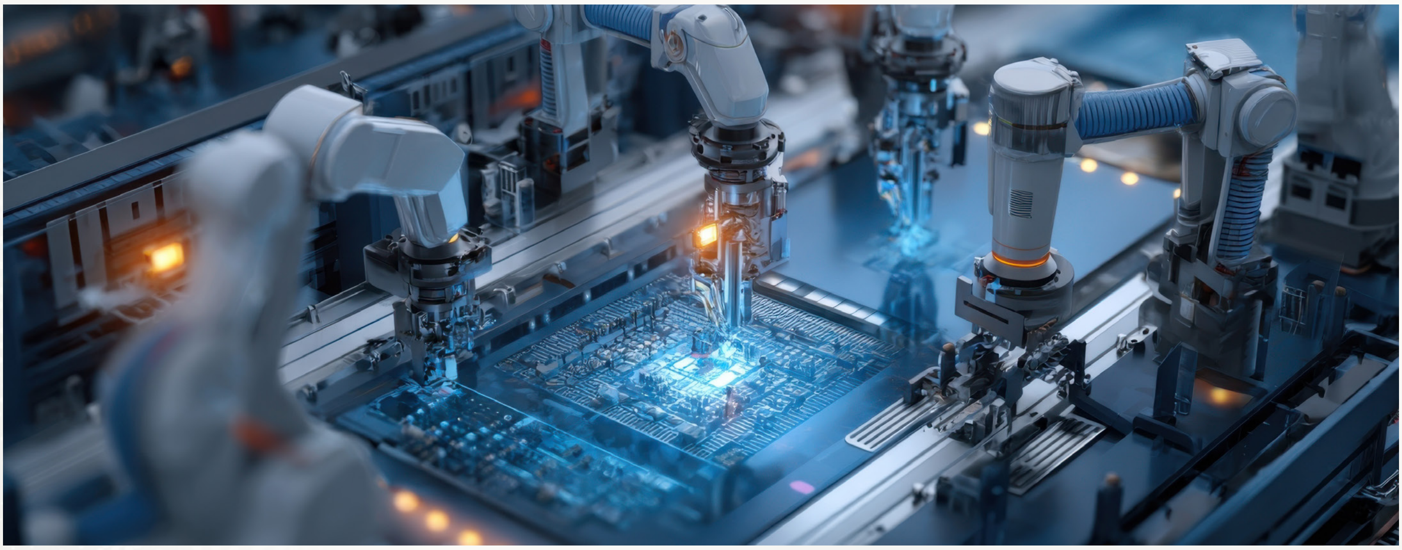
Solution Introduction

Supplier integration for automated workflows revolutionizes the way businesses collaborate with their supply chain partners. By leveraging advanced technologies like cloud-based platforms, real- time data exchange, and automation, businesses can seamlessly connect with suppliers to streamline procurement, production, and inventory management processes. This integration enhances visibility, reduces delays, and fosters efficiency across the supply chain.
Automated workflows eliminate manual errors, optimize communication, and improve overall responsiveness to market demands. As businesses face increasing complexity and competition, supplier integration serves as a critical strategy for maintaining agility, reducing costs, and ensuring uninterrupted operations in today's fast-paced manufacturing and logistics environments.

Ideal candidates for adopting Supplier Integration for Automated Workflows

Companies managing complex supply chains and serving diverse customer bases benefit significantly from streamlined supplier integration. Typical candidates include,

- Manufacturers with complex supply chains
- Pharmaceutical and healthcare
- Food and beverage industry
- E-commerce and retail businesses
- Industries with high procurement volumes (automotive, electronics, and consumer goods)



When to opt for Supplier Integration for Automated Workflows

- Increasing supplier base
- Adopting Just-In-Time (JIT) practices
- Managing complex supply chains
- When scaling operations or expanding geographically
- In need of creating a competitive advantage to its business
- Facing heavier industry competition
- Facing stricter regulatory and quality compliance needs

Tools and Technologies Involved

1. Electronic Data Interchange (EDI) Software
2. Integration Middleware
3. Secure Data Transmission Protocols
4. Supply Chain Management & Enterprise Resource Planning (ERP) Software
5. Logistics Management Systems & Integrated Procurement Systems
6. Data Mapping Tools
7. Robotic Process Automation (RPA)
8. AR/VR: Enables virtual shopping or product information assistance
9. Digital Dashboards and Analytics Tools

Solution Implementation Steps

1) Value Analysis Phase:

- Form a cross-functional team that includes representatives from Logistics provider, Manufacturing supply chain team, Logistics, Procurements teams and other key departments.
- Identify the specific goals for the project – like improving customer satisfaction, establishing Efficient communication, ensuring on-time-in-full (OTIF), establishing accurate demand forecasting, enhanced inventory.
- Earmark target improvement for the identified KPIs and respective processes.
- Evaluate the return on investment by comparing the rough order value of the budget involved and the targeted benefits with this implementation. Once the business case is validated, move forward to the next phase.

2) Requirements Definition Phase:

- Conduct a comprehensive audit of existing supply chain workflows, data management practices, and technology infrastructure.
- Identify gaps and inefficiencies that the integration will address.
- Define the scope of the integration, including specific workflows, supplier touchpoints, and technology requirements.
- Assess the technological capabilities of your suppliers.
- Select systems such as ERP, SCM, SRM, and EDI platforms that align with your business needs.
- In case of any gaps in the existing data, plan for additional data capturing mechanisms – either with installation of new sensors or sourcing of data from other relevant systems.
- Define the target state and scenarios to meet the business objective with this solution goes-live. Evaluate tools for scalability, ease of integration, and compatibility with existing systems.
- Compile this information and prepare 'Requirements Specification document'.

3) Vendor Evaluation Phase:

- Conduct market research to identify potential vendors and create a shortlist based on their capabilities, reputation, and experience relevant to the industry.
- Issue an RFP to shortlisted vendors including detailed requirements and expectations.
- Evaluate proposals for their commercials as well as technical proficiency.
- Arrange vendor demonstrations and understand their capabilities.
- Conduct contract negotiation including pricing for defined high-level scope, delivery schedules, support agreements, and warranties before finalizing the agreement with the vendor.

4) Solution Design Phase:

Once the vendor is onboarded, design the target architecture of the solution by following:

- Study in detail the existing supply chain workflows, data management practices, and technology infrastructure.
- Plan to use APIs, middleware, or cloud-based platforms to connect disparate systems for real- time data exchange.
- Identify and automate repetitive tasks like purchase order generation, invoice processing, and shipment tracking. Use technologies like RPA and AI to optimize these workflows.
- Build a detailed solution plan with specific focus on different information systems and how they are going to be integrated. Pay attention on scope of automation required in the target state.
- Basis this, define the new software that need to be configured and also estimate the overall project implementation efforts and the project plan.

5) Installation & Commissioning:

- Standardize and integrate data across ERP, Supplier Management Systems, and other systems to create a unified and accessible data structure.
-
- Integrate relevant and required data with suppliers and logistics teams. Use APIs, middleware, or cloud-based platforms to connect customer-facing systems with logistics operations
- Use RPA, AI, and machine learning to optimize decision-making and improve efficiency.
- Enhance customer-facing platforms, such as mobile apps or websites, with features like real- time tracking, delivery updates, and self-service options.
- Implement robust cybersecurity measures, including encryption, multi-factor authentication, and access controls.
- Test the system with a few key suppliers to identify issues and gather feedback.
- Gather feedback from internal teams and select customers during the pilot phase.

6) Go-Live & Stabilization:

- Conduct comprehensive training sessions for employees on new tools, workflows, and customer interaction processes.
- Test system performance under different scenarios to ensure stability and reliability.
- Roll out the integration to all suppliers gradually to minimize disruptions. Monitor performance closely during the initial phase to ensure a smooth transition.
- Continuously refine workflows and processes based on real-time insights and feedback. Update the system as per the evolving business needs in the future.
- Explore advanced features such as predictive analytics or blockchain for greater efficiency.

Potential pitfalls to avoid & Best Practices

1. Designing overly complex processes can confuse users and reduce system effectiveness. Pay special attention to build an intuitive and easy-to-use system for the end users.
2. Engage suppliers, employees, and other key stakeholders from the planning stage to ensure alignment and buy-in. Train employees and suppliers on the tools, workflows, and benefits of integration to ensure smooth adoption.
3. Evaluate supplier technology capabilities and provide support or training as needed.
4. Implement processes to ensure consistent, clean, and accurate data across systems.
5. Implement robust cybersecurity measures, including encryption, multi-factor authentication, and regular audits.
6. Ensure that critical decisions or exceptions are handled by skilled personnel to avoid errors in automated processes.

Cost Estimate

CapEx:

Depending on scale of operations, scope of coverage and the diversity in the suppliers involved, the investments varies widely. For connecting with 10 suppliers with their ERP and inventory data will range from 1.5Mn AED to 4Mn AED, as of 2025.

OpEx:

- Annual Maintenance Contract (AMC) costs ~15% of the initial CapEx investment.
- License cost for the newly configured software.

Example Implementations

ALPLA

UNIVERSAL
CARTON INDUSTRIES

D) Supplier/Customer Network solutions | Linked with ITTI Use Case Page #109

Usecase #23: Fleet Management and Route Optimization

Solution Introduction

Fleet management and route optimization are transformative use cases that enhance the efficiency and cost-effectiveness of logistics operations. By leveraging advanced technologies like GPS tracking, IoT devices, and AI-driven algorithms, businesses can monitor vehicle performance, reduce fuel consumption, and ensure timely deliveries.
Route optimization tools analyze traffic patterns, delivery schedules, and weather conditions to identify the most efficient paths, minimizing delays and operational costs. These solutions provide real-time visibility into fleet operations, improve driver productivity, and enhance customer satisfaction. As logistics demands grow, fleet management and route optimization play a crucial role in driving sustainability and operational excellence.

Ideal candidates to adopt Fleet Management & Route Optimization

Ideal candidates include:

Public transportation systems	Logistics and transportation companies
E-commerce and retail enterprises	Perishable goods distributors
Healthcare and pharmaceutical companies	construction and heavy equipment providers
Field service providers (utilities, telecommunications, and maintenance services)	

When to opt for Fleet Management & Route Optimization

- Growing fleet size
- Rising operational costs
- High inventory volumes
- Facing tight delivery deadlines
- Suffering from inconsistent service levels
- Facing frequent driver or vehicle issues

Tools and Technologies Involved

1. Fleet Management Software
2. Route Optimization Software
3. GPS and Telematics Systems
4. Vehicle Maintenance Management Systems
5. Dashboards and Analytics Platforms
6. Artificial Intelligence (AI) and Machine Learning (ML)
7. Electronic Logging Devices (ELDs)
8. Load Optimization & Dynamic Route Planning algorithms
9. Geo-fencing features

Solution Implementation Steps

1) Value Analysis Phase:

- Liaise with logistics, warehousing and supplier teams to understand the business need for adopting Fleet Management and Route Optimization
- Understand the KPIs that are targeted to be improved with the implementation of the solution (transportation cost reduction, lower emissions, faster deliveries, ensuring driver safety etc.,)
- Measure the current metrics and earmark the target metrics with the solution to be deployed
- Evaluate the different solution options – both in terms of their functional capability as well as commercial value – and shortlist the right components that will address the business needs.
- Estimate the return on investment (ROI) by comparing implementation costs with potential benefits. Once the business case is validated, proceed to the next stages.

2) Requirements Definition Phase:

- Identify existing fleet management practices, routes, and tools and assess their performance metrics in current state.
- Define the target state with clear user stories defining how the system need to be improved in the future state along with the target KPI values.
- Detail out the required features – in terms of delivery accuracy, optimal route selection, prioritizing business metrics dynamically – targeted with the solution.
- Compile this information and prepare 'Requirements Specification document'.

3) Vendor Evaluation Phase:

- Conduct market research to identify potential vendors or developers specializing in fleet optimization and management.
- Issue an RFP to shortlisted vendors including detailed requirements and expectations.
- Evaluate proposals for their commercials as well as technical proficiency.
- Arrange (on-site) vendor demonstrations and understand their capabilities.
- Conduct contract negotiation including pricing for defined high-level scope, delivery schedules, support agreements, and warranties before finalizing the agreement with the vendor.

4) Solution Design Phase:

Enable the vendor team to prepare the low-level-design of the solution by performing following:

- Conduct an audit of existing fleet management practices, routes, and tools.
- Identify inefficiencies, bottlenecks, and areas where automation can improve outcomes.
- Shortlist fleet management software and route optimization tools that align with your business needs.
- Evaluate features like GPS tracking, real-time data integration, and route planning capabilities.
- Ensure tools are scalable and compatible with existing systems.
- Enumerate the list of software and data capturing mechanisms that are needed and prepare the final Bill-of-Materials. In case of change in the scope, route through the Change Request process to kick-start the procurement.

5) Installation & Commissioning:

- Integrate GPS, telematics, fuel monitoring systems, and other data sources to create a centralized platform. Ensure seamless data flow between fleet operations, inventory management, and customer communication systems.
- Map out delivery zones, service areas, and vehicle usage patterns.

- Incorporate factors like traffic patterns, delivery schedules, fuel costs, and driver availability into the optimization plan.
- Equip vehicles with GPS trackers, telematics devices, and mobile communication tools.
- Install fleet management software on central systems and ensure compatibility with mobile apps for drivers.
- Test the solution on a small scale with a subset of the fleet and routes.
- Collect feedback from drivers and managers to identify potential issues and improvements.

6) Go-Live & Stabilization:

- Conduct training sessions for dispatchers, fleet managers, and drivers on using new tools and following optimized workflows.
- Scale-up from pilot roll-out to the full roll-out of the solution on a phased manner.
- Roll out the solution across the entire fleet and integrate with other logistics processes. Ensure smooth transition by providing ongoing support and resolving issues promptly.
- Track KPIs such as fuel efficiency, route adherence, delivery times, and vehicle utilization. Use analytics dashboards to identify areas for further optimization.
- Use fleet management tools to automate maintenance schedules, monitor vehicle health, and prevent breakdowns.
- Gradually scale the system to accommodate more vehicles, routes, or regions.
- Explore advanced features like AI-driven predictions or sustainability optimization, in future.

Potential pitfalls to avoid & Best Practices

1. Educate drivers on the benefits of the system and provide hands-on training to ensure smooth adoption. Encourage communication between fleet managers, dispatchers, and drivers to resolve issues quickly and improve workflows.
2. Implement proactive maintenance schedules to reduce breakdowns and extend fleet lifespan.
3. Choose scalable, user-friendly, and customizable fleet management and route optimization solutions that align with your business needs.

Cost Estimate

CapEx:

For optimizing the fleet of 100 vehicles and their routes for a Food & Beverages firm operating 24*7, the initial investment range from AED 3Mn – 4.5Mn.

OpEx:

Annual Maintenance Contract (AMC) costs ~15% of the initial CapEx investment; Cost of fleet management specialists and the software installed (600k AED / year) need to be factored in on top of AMC costs.

Example Implementations

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water is life

D) Supplier/Customer Network solutions

Linked with ITTI Use Case Page #107

Usecase #24: Supply Chain Control Tower

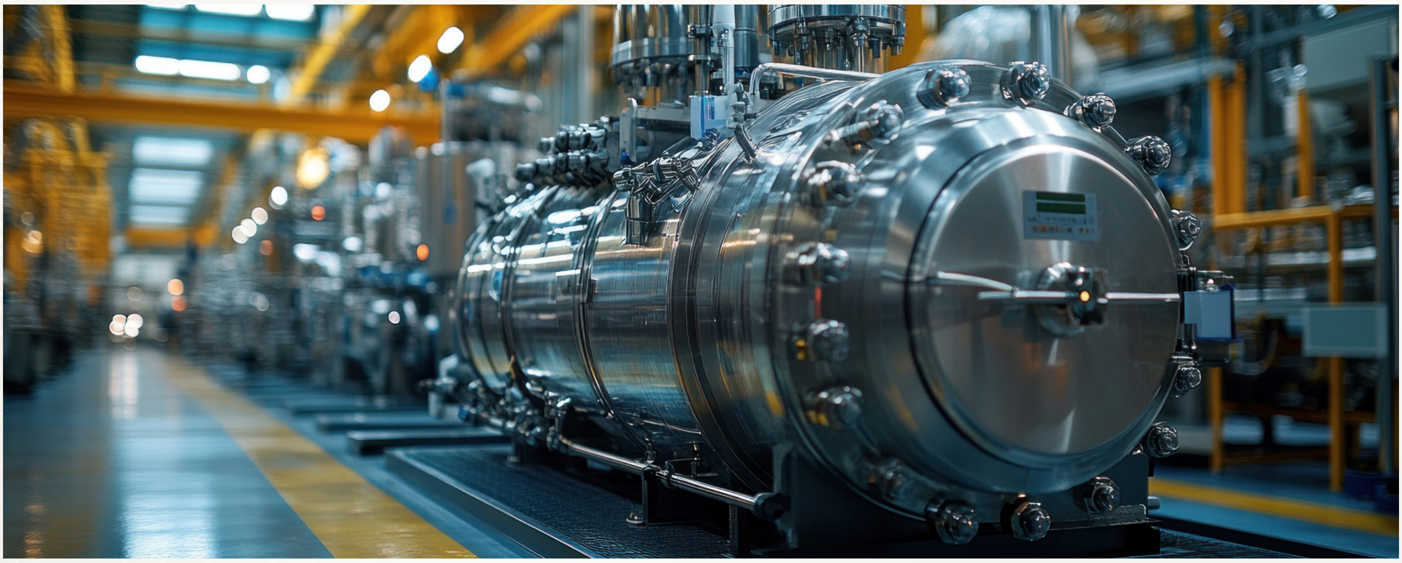
Solution Introduction

A supply chain control tower is a centralized digital platform designed to provide end-to-end visibility, real-time insights, and proactive management of supply chain operations. It integrates data from various sources, such as suppliers, warehouses, transportation systems, and customer interactions, into a single, unified dashboard.
By leveraging advanced technologies like artificial intelligence (AI), machine learning (ML), and IoT, a control tower enables businesses to monitor, predict, and resolve disruptions across the supply chain. Its key functionalities include inventory management, demand forecasting, and real- time shipment tracking.
With enhanced transparency and agility, the control tower empowers organizations to make data- driven decisions, improve operational efficiency, and enhance customer satisfaction, making it an indispensable tool in modern supply chain management.

Ideal candidates to adopt Supply Chain Control Tower

Companies with complex, multi-tier supply chains and international operations benefit from real-time visibility and coordination and are treated as ideal candidates for adopting this use case. The examples include:

Retail and E-commerce businesses	Global manufacturers
Logistics and freight companies	Pharmaceutical and healthcare providers
Food and beverage industry	Cold storage and freezer operators
Chemical and hazardous material transporters	



When to opt for Supply Chain Control Tower

- Increasing complexity in supply chains
- Facing frequent disruptions
- In need of real-time data and insights
- While scaling operations
- While facing challenges with siloed data and poor communication

Tools and Technologies Involved

1. Enterprise Resource Planning (ERP) Systems
2. Supply Chain Management (SCM) Platforms
3. Transportation Management Systems (TMS)
4. Electronic Data Interchange (EDI)
5. Robotic Process Automation (RPA)
6. Internet of Things (IoT) Devices
7. Cloud-Based Collaboration Platforms
8. Advanced Analytics and Business Intelligence Tools
9. Artificial Intelligence (AI) and Machine Learning (ML)
10. Predictive Analytics, Scenario Planning algorithms
11. Dynamic Workflow Automation tools

Solution Implementation Steps

1) Value Analysis Phase:

- Liaise with supply chain head, logistics supply & planning teams to understand the business need for adopting the supply chain control tower solution.
- Understand the KPIs that are targeted to be improved with the implementation of the solution (improving visibility, reducing costs, or enhancing customer satisfaction)
- Measure the current metrics and earmark the target metrics with the solution to be deployed
- Evaluate the different solution options – both in terms of their functional capability as well as commercial value – and shortlist the right components that will address the business needs.
- Estimate the return on investment (ROI) by comparing implementation costs with potential benefits. Once the business case is validated, proceed to the next stages.

2) Requirements Definition Phase:

- Conduct an audit of existing workflows, systems, and technologies.
- Identify pain points such as siloed data, inefficiencies, or lack of real-time insights.
- Define the scope, including processes, stakeholders, and regions to be managed by the control tower.
- Shortlist software solutions like ERP, SCM, IoT devices, and analytics platforms that align with your objectives.
- Detail out the required features targeted with the solution.
- Compile this information and prepare 'Requirements Specification document'.

3) Vendor Evaluation Phase:

- Conduct market research to identify potential vendors or developers specializing in establishing systems that provide visibility and better control over the logistics processes.
- Issue an RFP to shortlisted vendors including detailed requirements and expectations.
- Evaluate proposals for their commercials as well as technical proficiency.
- Arrange (on-site) vendor demonstrations and understand their capabilities.
- Conduct contract negotiation including pricing for defined high-level scope, delivery schedules, support agreements, and warranties before finalizing the agreement with the vendor.

4) Solution Design Phase:

Enable the vendor team to prepare the low-level-design of the solution by performing following:

- Idenfity various sources, including ERP, TMS, WMS, CRM, and IoT devices, which need to be integrated into a unified platform.
- Plan APIs, middleware, or cloud solutions to ensure seamless data flow.
- Map out workflows, data dashboards, and reporting mechanisms.
- Define roles, responsibilities, and decision-making hierarchies within the control tower.
- In case of missing data, plan for additional devices/systems to capture the data required.
- Define the low-level design of the solution and place order for new software that need to be integrated into the solution.

5) Installation & Commissioning:

- Centralize data from various sources, including ERP, TMS, WMS, CRM, and IoT devices, into a unified platform.
- Identify metrics to measure supply chain performance, such as order accuracy, inventory levels, lead times, and cost efficiency.
- Build dashboards for real-time monitoring and reporting.
- Automate repetitive tasks such as alerts, replenishment orders, and compliance reporting.
- Implement robust cybersecurity measures to protect sensitive supply chain data.
- Implement the control tower in a small, manageable segment of the supply chain (e.g., a specific region or product line).
- Gather feedback from users to refine workflows and address technical issues.

6) Go-Live & Stabilization:

- Conduct training sessions for employees, managers, and supply chain partners.
- Run a pilot in a specific area to evaluate system performance and identify potential issues.
- Use insights from end users to fine-tune the system.
- Gradually expand the control tower to encompass the entire supply chain.
- Monitor the transition closely to address any disruptions or inefficiencies.
- Regularly review the control tower's performance and gather feedback from stakeholders.
- Update tools and processes based on technological advancements and business needs.

Potential pitfalls to avoid & Best Practices

1. Involve key stakeholders, including suppliers and logistics partners, in the planning and implementation process for better alignment and collaboration.
2. Designing overly complex dashboards and workflows can confuse users and hinder adoption. Ensure the solution is built as intuitive and simple to use by the end users.
3. Implement encryption, multi-factor authentication, and regular audits to protect sensitive supply chain data.
4. Choose technologies that can adapt to future growth, additional regions, or changing supply chain requirements.

Cost Estimate

CapEx:

The costs vary widely based on the scope and scale of implementation. For monitoring the supply chain of a Food & Beverages firm handling 50 variants, with daily volume of 10,000 units each will cost AED 3Mn – 5Mn

OpEx:

Annual Maintenance Contract (AMC) costs ~15% of the initial CapEx investment.

Example Implementations

RAK CERAMICS

D) Supplier/Customer Network solutions | Linked with ITTI Use Case Page #91

Usecase #25: Automating Enterprise Processes using RPAs

Solution Introduction

In traditional manufacturing and processing environments, manual documentation, data entry and reconciliation are often characterized by repetitive tasks, long hours, and potential human error, leading to inefficiencies and inconsistencies in workflows within the company and its supplier and customer network. Automating Enterprise Processes using RPAs help reduce the reliance on labor for manual, repetitive and strenuous enterprise process activities.
Robotic Process Automation (RPA) revolutionizes enterprise operations by automating repetitive, rule-based tasks, enabling businesses to achieve higher efficiency and accuracy. By mimicking human actions such as data entry, processing transactions, or generating reports, RPA tools streamline workflows and free employees to focus on strategic activities. With scalability and flexibility, RPA empowers businesses to adapt to dynamic demands, optimize resource utilization, and gain a competitive edge in today's fast-paced, technology-driven environment.

Ideal candidates to leverage RPAs for Automating Enterprise Processes

Robotic Process Automation (RPA) tools help the organizations avoid repetitive manual tasks with automated processes, thereby aiding enhanced efficiency in enterprise processes. Top usecases involving RPAs include:

Automated Inventory Management: Monitors inventory level and generates Purchase Order.	Maintenance: Triggers maintenance request based on machine issues
HR Functions: Automates 'Hire to Retire' data entry processes.	Customer Service: Handles customer inquiries and complaints.
Finance: Manages invoice matching, data entry and approval routing.	Data Base: Analyzes and enables business reporting and decisions.

When to leverage RPAs for Automating Enterprise Processes

1. When processes involve repetitive steps with defined rules
2. Handling high volume of transactions like data entry, invoice processing, or claims management
3. Manual workflows frequently leading to errors
4. When businesses experience rapid growth and require scalable solutions
5. Handling time-sensitive operations like payroll, compliance reporting, or customer service
6. Facing frequent process bottlenecks like approvals, document routing, or data validation

Tools used along with Robotic Process Automation

1. Workflow Automation Software
2. Process Mining Tools
3. Optical Character Recognition (OCR)
4. Business Process Management (BPM) tools
5. Chatbots and Virtual Assistants
6. Data Integration Tools
7. Analytics and BI Tools
8. Low-Code/No-Code Platforms
9. Artificial Intelligence (AI) Integration

Solution Implementation Steps

1) Define Objectives & Assess Processes for Automation:

- Define the purpose of implementing RPA, such as reducing costs, improving accuracy, or enhancing operational efficiency. Determine the scope, including processes, tasks, and departments to be automated.
- Conduct a detailed analysis of current workflows to identify repetitive, rule-based tasks that are suitable for automation.
- Prioritize processes with high volumes, frequent errors, or significant manual effort.

2) Select right RPA tool and prepare detailed automation plan:

- Evaluate RPA tools like UiPath, Automation Anywhere, or Blue Prism based on scalability, integration capabilities, and ease of use.
- Consider factors like licensing costs, support, and compatibility with existing systems.
- Define the automation workflow, including inputs, outputs, dependencies, and exceptions.
- Set clear objectives to measure the success of the implementation.

3) Build a pilot program and Design the RPA process flow

- Develop a proof of concept (POC) or pilot to test the feasibility and effectiveness of the RPA solution. Focus on a single process or department to identify potential challenges and refine the approach.
- Use the chosen RPA tool to create workflows and bots for the identified processes.
- Incorporate error-handling mechanisms and dynamic features for flexibility.
- Implement robust security measures to protect sensitive data handled by RPA bots. Ensure compliance with relevant regulations and establish audit trails for accountability.

4) Test the automation & Deploy the solution:

- Conduct thorough testing to ensure the bots function as intended across different scenarios. Address errors, improve efficiency, and validate outputs against expected results.
- Roll out the bots in a live environment, ensuring minimal disruption to existing operations.
- Deploy in phases if implementing across multiple departments or functions.
- Provide training to employees on using RPA tools and managing automated processes. Educate staff on collaborating with bots and handling exceptions.
- Track KPIs such as time savings, error rates, and cost reductions to evaluate the impact of automation. Use monitoring tools to ensure bots are operating effectively and resolve any issues promptly.
- Continuously refine and optimize workflows based on performance data and feedback.
- In future, scale automation to other processes where similar benefits can be realized.

Potential pitfalls to avoid & Best Practices

1. Thoroughly analyze and optimize processes before automation to ensure efficiency and suitability for RPA.
2. Begin with a pilot project on simple, repetitive tasks to demonstrate value and refine the approach before scaling.
3. Establish a governance framework to manage bot performance, maintenance, and updates effectively.
4. Implement robust security protocols to protect sensitive data and ensure compliance with industry regulations.

Cost Estimate

CapEx:

For automating the data entry and workflow management for a medium sized firm for its 5 digital solutions by integrating with the MES & ERP system, will cost AED 0.8Mn – 2Mn, as of 2025.

OpEx:

Annual maintenance cost is ~15% of CapEx invested. Software subscriptions cost ~300k yearly.

RAK CERAMICS

SHARJAH CEMENT FACTORY

Lipton

D) Supplier/Customer Network solutions | Linked with ITTI Use Case Page #106

Usecase #26: Enterprise Cybersecurity Measures

Solution Introduction

The convergence of OT/IT systems, along with horizontal integration with suppliers and customers, has multiple benefits. However, there is a significant risk of cyberthreats that needs to be addressed as OT systems are no longer air-gapped. Manufacturers are imposed with the responsibility of establishing strong cybersecurity measures and policies to address these challenges.

Adopting enterprise cybersecurity measures protects critical data, systems, and operations from cyber threats. It safeguards sensitive information, ensures business continuity, and prevents financial and reputational losses. With increasing digitalization, enterprises must combat risks like ransomware, phishing, and data breaches while ensuring compliance with regulations and fostering trust with customers and stakeholders.

Ideal candidates for adopting Enterprise Cybersecurity Measures

Ideal candidates for adopting enterprise cybersecurity measures are organizations with sensitive data, interconnected systems, or a high reliance on digital operations. Top candidates include:

Manufacturing and Industry 4.0 Facilities	Financial Institutions
E-commerce and Retail	Healthcare and Pharmaceuticals
Government and Public Sector	Technology and IT Companies

When to adopt Enterprise Cybersecurity Measures

- Enhanced data protection
- Reduced risk
- Upscaled operational continuity
- Increased legal compliance
- Need to safeguard digital assets against unauthorized access, data breaches & cyberthreats
- Aims to build network security, data protection, threat detection and faster incident response

Tools and Technologies Involved

1. Firewalls & Intrusion Detection and Prevention Systems (IDPS)
2. Virtual Private Networks (VPNs)
3. Identity and Access Management Endpoint Security solutions (Antivirus & Antimalware, Endpoint Detection and Response)
4. Identity and Access Management (Multi-Factor Authentication, Single Sign-On, Privileged Access Management)
5. Data protection systems (Data Loss Prevention - DLP, Encryption, Backup and Recovery Solutions
6. Application security tools (Web Application Firewalls, Secure Development Tools)
7. Threat intelligence & management (Security Information and Event Management – SIEM)
8. IoT and Operational Technology (OT) Security tools

Solution Implementation Steps

1) Define Objectives & Assess Current Security Posture:

- Establish security goals, such as compliance, data protection, or operational continuity.
- Decide whether to focus on internal systems, cloud environments, remote workers, or third-party vendors.
- Identify applicable standards like GDPR, HIPAA, ISO 27001, or NIST.
- Evaluate existing security systems, policies, and practices.
- Use tools like vulnerability scanners to detect weaknesses in networks, devices & applications.
- Identify critical data, systems, and applications that need protection.

2) Develop a Cybersecurity Strategy:

- Use established models like the NIST Cybersecurity Framework or ISO 27001
- Focus on high-impact vulnerabilities and business-critical systems. Prioritize the risks.
- Incorporate a "never trust, always verify" approach across systems.

3) Secure the network:

- Implement Firewalls to monitor and control traffic.
- Isolate sensitive systems to limit exposure.
- Detect & block malicious activity by deploying Intrusion Detection & Prevention Systems (IDPS)
- Protect endpoints and devices by installing endpoint security solutions, encrypting the devices and enabling Mobile Device Management (MDM)
- Enhance identity and access management with Single-sign-on, Multi-factor-authentication, Privileged-Access-Management.
- Safeguard data with encryption, regular backups and deploying Data Loss Prevention (DLP)
- Implement monitoring and threat detection

4) Create Awareness & Plan for Incident Responses:

- Teach employees to recognize phishing and other cyber threats. Test employee readiness with phishing simulations and penetration tests.
- Create a Response Framework by outlining steps for identifying, containing, and recovering from cyber incidents.
- Assign tasks to specific teams and individuals. Conduct drills to ensure the plan is effective.

5) Testing & Auditing:

- Conduct penetration tests by simulating attacks to identify vulnerabilities.
- Regularly check for weak points in the system.
- Ensure compliance with internal & external standards with the help of audit policies & procedures
- Use advanced technologies to enhance threat detection and response.
- Adapt strategies to evolving threats and business needs.

Potential pitfalls to avoid & Best Practices

1. Use multiple security layers, including firewalls, intrusion detection systems, and endpoint protection.
2. Follow the principle of "never trust, always verify" for all access requests.
3. Keep all software and systems up-to-date to address known vulnerabilities.
4. Conduct regular cybersecurity awareness programs and phishing simulations.
5. Regularly evaluate risks and update cybersecurity strategies accordingly.
6. Create and practice a clear, actionable plan for responding to cyber incidents.
7. Follow the principle of least privilege to restrict user and system access to only what is necessary.
8. Collaborate with industry peers and cybersecurity communities to stay informed about emerging threats.
9. Perform regular penetration tests and vulnerability scans to identify weaknesses.

Cost Estimate

CapEx & OpEx:

The cost of adopting the enterprise cybersecurity measures vary widely depending on the details of business needs, the scale and scope of deployment, the level of protection and incident responses required. It is recommended to do primary quotation estimate from the vendors when the organization need to adopt these measures.

Example Implementations

Mai Dubai water is life

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Use Case #27: Energy and Utility Optimization

Solution Introduction

Energy and utility optimization deals with strategic management of resources like electricity, water, and gas to enhance operational efficiency and sustainability. Data-driven approaches, including real- time monitoring and predictive analytics, enable factories to identify inefficiencies and optimize resource consumption. By integrating AI, factories can automate processes such as load balancing, predictive maintenance, and dynamic energy allocation, ensuring optimal resource usage. Additionally, AI enables the seamless integration of renewable energy sources, further reducing environmental impact.

Ideal candidates to AI-infused Energy & Utility Optimization

The following sectors hold greater potential for business improvement with AI-infused Energy & Utility Optimization:

Energy-Intensive Industries (steel, cement, glass, and chemical production)	Utility Providers
Large-Scale Facilities (Hospitals, universities, shopping malls)	Smart Buildings and Factories
Cold Storage and Warehousing facilities	Public Infrastructure (Airports, rail systems, and urban infrastructure)

When to opt for AI-infused Energy & Utility Optimization

- When energy costs constitute a large portion of operational expenses
- When meeting ESG goals or reducing carbon footprints is a priority
- For balancing energy generation, storage and usage while using sources like solar or wind
- In areas with unstable energy & utilities (gas / water) supplies
- In environments where energy usage varies significantly

Tools and Technologies Involved

1. IoT Devices: Smart meters, temperature sensors, flow meters, and pressure sensors
2. Industrial Control Systems like SCADA (Supervisory Control and Data Acquisition)
3. Building Management Systems (BMS)
4. Cloud Computing and Edge Computing
5. AI Development Frameworks (Data Processing Tool, Python Libraries)
6. Visualization and Monitoring Tools
7. Renewable Energy Management systems
8. Automated Control Systems

Solution Implementation Steps

1) Value Analysis Phase:

- Liaise with the organization's Chief sustainability officer to understand their commitment to sustainablility. Work with Facilities Head and Plant Head understand the business need that demands exploration of AI adoption for energy and utility optimization.
- Determine the specific processes / stages that need to be improved. Determine the things to be optimized, such as energy consumption, load balancing, or anomaly detection.
- Analyze current energy consumption patterns, costs, and inefficiencies. Pinpoint inefficiencies, high costs, or regulatory compliance gaps.
- Record the current status and define target KPIs, such as energy savings, reduced downtime, or improved operational efficiency.
- Evaluate the business case for this solution deployment. For heavy-industries, typically, this solution is treated as a basic hygiene solution to enable sustainable day-to-day factory operations. Hence conduct a mix of quantitative and qualitative study for Return-on-Investment. Once the business case is validated, move ahead to the next phase.

2) Requirements Definition Phase:

- Assess the current energy management systems, sensors, and data collection mechanisms.
- Assess existing sensors, SCADA systems, and data availability. Do a rough estimation on types of sensors and other data collection infrastructure that is needed to ensure better energy and utilities management.
- Identify gaps in data, monitoring, or control systems that AI can address.
- Enumerate the key metrics that need to be improved along with their target states
- Enumerate key features that need to be enabled with AI adoption: like real-time tracking of energy consumption at different nodes & utilities disbursed through the HVAC systems; Identify ideal set points for targeted nodes.
- Document and organize these requirements in to a 'Requirements Specification document'.

3) Vendor Evaluation Phase:

- Conduct market research to identify potential vendors and create a shortlist based on their capabilities, reputation, and experience relevant to the industry.
- Issue RFP to shortlisted vendors including detailed requirements and expectations.
- Evaluate proposals for their commercials as well as technical proficiency.
- Arrange (on-site) vendor demonstrations and understand their capabilities.
- Conduct contract negotiation including pricing for defined high-level scope, delivery schedules, support agreements, and warranties before finalizing the agreement with the vendor.

4) Solution Design Phase:

- Enable the vendor team to prepare the low-level-design of the solution by performing following:
  - Detailed study of the existing data collection infrastructure
  - Evaluate the optimal data hosting mechanisms (on-premise or cloud)
  - Determine the appropriate data communication protocols to be used.
  - Enumerate the number of sensors and other data collection infrastructure to be established
  - Shortlist potential AI algorithms that would address existing problems. Clearly articulate the problem each AI model will solve (e.g., energy optimization, HVAC flow moderation).
  - Plan and design the solution architecture
- Basis the low-level-design and follow-up discussion with the production team and the leadership, the vendor team need to prepare final Bill-of-Materials.
- In case of deviation from earlier scoped proposal, effect required Change Request accordingly.

5) Implementation Phase:

- Implement the sensors required to capture the additional data points required.
- Collaborate with AI specialists, data scientists, process engineers & energy management specialists. Identify ideal set points for different energy & utility consumption nodes.
- Integrate the sensors, BMS system and the existing SCADA to the IIoT platform. Combine historical data, real-time sensor feeds, and operational records.
- Set up scalable infrastructure for data storage, processing, and model deployment. Establish robust communication protocols (e.g., MQTT, BACnet) for seamless data transfer.
- Choose the right algorithm. Some guideline on the same is presented below:
  - Time-Series Forecasting for energy demand and usage prediction.
  - Anomaly Detection for spotting irregular patterns or equipment failures.
  - Optimization Algorithms for load balancing and energy efficiency.
- Use the historical data to train machine learning models. Split data into training, validation, and testing sets to ensure accuracy.
- Test the model on unseen data. Fine-tune parameters to improve performance. Embed trained models into the energy and utilities management system.
- Set up dashboards for visualizing real-time insights and predictions.
- Integrate with existing control systems to automate responses, such as load adjustments or equipment shutdowns.

6) Go-Live & Stabilization:

- Implement the AI solution in a small, controlled environment. Track metrics to ensure the AI system meets the defined goals.
- Engage stakeholders to identify usability issues and areas for improvement.
- Once the pilot solution is proven, expand implementation across larger facilities or multiple sites.
- Test the system under various conditions to handle edge cases. Continuously monitor the system's performance and retrain models as necessary.
- Train the operators and supervisors on the implemented solution and complete the full roll-out.
- Compare energy usage, cost savings, and efficiency metrics before and after implementation. Refine models and processes based on real-world performance and feedback.

Potential pitfalls to avoid & Best Practices

1. Use cloud-based or hybrid solutions to handle future growth in data volume and computational demands. Design modular systems that allow for incremental updates and expansions.
2. Use a feedback loop to refine AI models and system configurations based on real-world performance. Regularly retrain models with updated data to maintain accuracy.
3. Use machine learning models that can adapt to changing production characteristics, seasonal variations, or operational constraints.

Cost Estimate

CapEx:

AI-enabled Energy & Utility optimization solutions for a production facility with 20 machines will cost 1.2Mn – 2Mn AED, as of 2025. The cost variance is owing to the number & type of new sensors needed & complexity involved in the AI-algorithm development and efforts required.

OpEx:

The operational costs range from 150k to 300k AED per year.

Example Implementations

Mai Dubai® water is life

RAK CERAMICS

Lipton

E) Sustainability related solutions	Newly Added Use Case

Use Case #28: Air Quality Monitoring

Solution Introduction

Digital air quality monitoring solutions for factories revolutionize how industries manage environmental health. By employing advanced sensors and real-time data analytics, these systems measure pollutants, particulate matter, and gas levels, ensuring compliance with environmental standards. The technology enhances workplace safety, reduces emissions, and promotes sustainable operations. With seamless integration into factory systems and actionable insights, these solutions empower manufacturers to maintain a healthier environment while optimizing efficiency and adhering to stringent air quality regulations.

Ideal candidates for adopting Air Quality Monitoring solution

Air Quality monitoring solutions are recommended for factories / production units that are susceptible to have impact on the air quality, pose potential respiratory risks for the associates and also those which need cleaner environment for their production. Primary candidates include:

Heavy Industries: Steel, cement, and chemical plants	Energy Plants
Food & Beverage Manufacturers	Textile Industries
Electronics Manufacturing	Pharmaceuticals

When to opt for Air Quality Monitoring in production facilities

1. When new environmental laws or standards mandate air quality monitoring.
2. If production processes emits particulate matter, gases, or Volatile Organic Compounds.
3. To protect workers in environments with potential respiratory hazards.
4. When aiming to reduce carbon footprint and promote eco-friendly operations.
5. If there are persistent community or employee concerns about air quality.
6. During upgrades or new installations to integrate modern monitoring solutions.
7. To improve processes by tracking pollutant levels and making data-driven decisions.When production involves complex, interdependent processes, & strict regulatory standards Tools and Technologies Involved

Tools and Technologies Involved

1. Sensors and Detectors: Particulate Matter Sensors, Humidity, Temperature and Gas Sensors
2. Data Acquisition & Communication Systems: IoT-enabled devices, Wi-Fi, LoRaWAN, Zigbee
3. Data Processing and Analytics Platforms
4. Software Solutions: Dashboards and mobile apps
5. Automation Systems: Integration with HVAC systems for automatic air quality adjustments
6. Reporting Tools
7. Display Screens

Solution Implementation Steps

1) Value Analysis Phase:

- Liaise with the organization's leadership team to understand their commitment to sustainablility and Health, Safety and Environment and understand the business need for establishing air quality monitoring. Work with production manager, line supervisor and the management to understand the business need that demands exploration of digital twin as a solution.
- Determine the specific process to be monitored (e.g., manufacturing, logistics, recycling processes or other supply chain activities).
- Define the goals for the air quality monitoring, such as pollutants, particulate matters and gases to be monitored; the reporting formats and mode of reporting.
- Define the control measures or corrective actions that need to effected automatically with this solution, if any.
- Evaluate the business case for this solution deployment. Typically, this solution is treated as an enabler solution and a basic hygiene solution to enable day-to-day factory operations. Hence conduct a mix of quantitative and qualitative study for Return-on-Investment. Once the business case is validated, move ahead to the next phase.

2) Requirements Definition Phase:

- Identify the areas that need to be monitored. Do a rough estimation on number of measurement spots to calculate the sensors required.
- Enumerate the different kind of gases, particulate matters and volatile organic compounds to be monitored. Also identify the supporting sensors to monitor temperature &/ humidity of the environment.
- Define the reporting mode and reporting frequency required, along with details on the consumers of the reports in order to aid estimate the efforts required for dashboard planning.
- Define the data collection, storage, consumption and delivery requirements.
- Document and organize these requirements in to a 'Requirements Specification document'.

3) Vendor Evaluation Phase:

- Conduct market research to identify potential vendors and create a shortlist based on their capabilities, reputation, and experience relevant to the industry.
- Issue RFP to shortlisted vendors including detailed requirements and expectations.
- Evaluate proposals for their commercials as well as technical proficiency.
- Arrange (on-site) vendor demonstrations and understand their capabilities.
- Conduct contract negotiation including pricing for defined high-level scope, delivery schedules, support agreements, and warranties before finalizing the agreement with the vendor.

4) Solution Design Phase:

- Enable the vendor team to prepare the low-level-design of the solution by performing following:
  - Define objectives (e.g., compliance, employee safety, process optimization)
  - Conduct a site assessment to identify sources of pollution and areas of concern.
  - Determine the pollutants to monitor (e.g., PM2.5, VOCs, CO2).
  - Technology selection (sensors, data collection, storage and communication)
- Vendor team to prepare final Bill-of-Materials. In case of deviation from earlier scoped proposal, effect required Change Request accordingly.

5) Implementation Phase:

- Choose appropriate sensors and monitoring equipment based on the pollutants identified. Select data acquisition and communication systems (IoT-enabled devices, wireless networks).
- Develop a monitoring layout, including sensor placement for optimal coverage. Integrate monitoring systems with existing factory equipment (e.g., HVAC, BMS, automation).
- Deploy sensors and data acquisition systems at designated locations. Set up data transmission infrastructure, such as gateways or cloud services.
- Calibrate sensors to ensure accurate readings. Test the system for functionality and reliability under different condition.
- Connect the monitoring system to analytics platforms, dashboards, and alert systems. Link with compliance reporting tools to meet regulatory standards.

6) Go-Live & Stabilization:

- Train staff on system operation, data interpretation, and maintenance.
- Educate employees about the importance of air quality and safety.
- Analyze collected data to identify improvement opportunities in processes.
- Adjust systems and practices based on insights for better air quality management.
- Regularly monitor air quality data for trends and anomalies. Perform routine maintenance, including sensor recalibration and system updates.
- Periodically review the system's performance and upgrade as needed.

Potential pitfalls to avoid & Best Practices

1. Placing sensors in areas with limited airflow or away from emission sources may result in inaccurate data.
2. Failing to connect the system with factory processes (e.g., HVAC) reduces its impact on improving air quality.
3. Neglecting sensor calibration and upkeep can degrade system performance over time.
4. Implementing a rigid system that doesn't allow for future expansion or upgrades can limit long-term value.

Cost Estimate

CapEx:

For building an air quality monitoring system for a mid-sized production hangar, enabled with gas monitoring, Particulate Matter monitoring along with integration to Building Management System (BMS) costs 500k-1200k AED, as of 2025.

OpEx:

The license cost vary widely from 100k – 200k AED per year, depending on the scope and scale of the implementation.

Example Implementations

بلدية دبي
Dubai Municipality

EDGE

E) Sustainability related solutions	Linked with ITTI Use Case Page #111

Use Case #29: Waste Water (Effluent) Treatment Using Artificial Intelligence

Solution Introduction

Manufacturers are constantly looking for solutions to ensure water-positive operations, addressing water scarce geographies, regulations and ESG-related compliances. Though waste water treatment serves as a high-potential solution to address the water scarcity, the need for treating wastewater comes with challenges of varying quality of wastewater, seasonal changes and emerging contaminants without compromising on the output treated water quality.
Artificial Intelligence revolutionizes wastewater treatment by optimizing processes, enhancing efficiency, and reducing costs. It enables real-time monitoring, predictive maintenance, and intelligent decision-making, ensuring sustainable operations. AI-driven analytics improve pollutant detection, resource recovery, and regulatory compliance, promoting environmental preservation.

Ideal candidates to adopt AI for waste water treatment

While all the waste water treatment facilities show potential for enhanced water treatment with AI, the following sectors hold greater potential for positive impact by leveraging AI:

Municipal Wastewater Treatment Plants	Industrial Facilities (chemicals, pharmaceuticals, and food processing)
Water Utilities and Service Providers	Mining and Energy Companies
Fertilizer Industries	Agricultural Operations

When to opt for AI adoption for waste water treatment

1. Processes like aeration and pumping that consume significant energy in operations
2. Difficulty in optimizing processes such as aeration, chemical dosing, or sludge management
3. When managing a diverse range of contaminants or variable influent quality
4. Recurring equipment failures or unplanned maintenance
5. Expansion of industrial operations or municipal services requiring process optimization

Tools and Technologies Involved

1. SCADA Systems
2. Sensors and IoT Devices: Water Quality Sensors, Flow and Pressure Sensors, pH sensors
3. IoT Platforms
4. Data Analytics Platforms
5. Cloud Computing and Edge Computing
6. AI Algorithms
7. Automated hardware solutions

Solution Implementation Steps

1) Value Analysis Phase:

- Liaise with the organization's Chief sustainability officer to understand their commitment to sustainablility. Work with Facilities Head and Plant Head understand the business need that demands exploration of AI adoption for effluent treatment facility.
- Determine the specific processes / stages that need to be improved
- Note down the current state of low rates, pH levels, turbidity, dissolved oxygen and nutrient concentrations
- Pinpoint inefficiencies, high costs, or regulatory compliance gaps
- Define the target state of the key metrics and do a rough estimate on the number of interventions required to effect the target state.
- Evaluate the business case for this solution deployment. For mining & industrial production facilities, typically, this solution is treated as a basic hygiene solution to enable sustainable day-to-day factory operations. Hence conduct a mix of quantitative and qualitative study for Return-on-Investment. Once the business case is validated, move ahead to the next phase.

2) Requirements Definition Phase:

- Identify the areas that need to be monitored. Understand the challenges of varying quality of wastewater, seasonal changes and emerging contaminants.
- Assess existing sensors, SCADA systems, and data availability. Do a rough estimation on types of sensors and other data collection infrastructure that is needed to ensure better effluent treatment.
- Enumerate the key metrics that need to be improved along with their target states
- Enumerate key features that need to be enabled with AI adoption: like real-time tracking of flow rates, pH levels, turbidity, dissolved oxygen and nutrient concentrations; Identifying ideal set points for aeration rates and establishes closed-loop controls for chemical dosing through AI models etc.,
- Document and organize these requirements in to a 'Requirements Specification document'.

3) Vendor Evaluation Phase:

- Conduct market research to identify potential vendors and create a shortlist based on their capabilities, reputation, and experience relevant to the industry.
- Issue RFP to shortlisted vendors including detailed requirements and expectations.
- Evaluate proposals for their commercials as well as technical proficiency.
- Arrange (on-site) vendor demonstrations and understand their capabilities.
- Conduct contract negotiation including pricing for defined high-level scope, delivery schedules, support agreements, and warranties before finalizing the agreement with the vendor.

4) Solution Design Phase:

- Enable the vendor team to prepare the low-level-design of the solution by performing following:
  - Detailed study of the existing water treatment facility and its processes
  - Study the existing sensors and other data collection infrastructure
  - Determine whether historical and real-time data are sufficient and reliable for AI modeling.
  - Enumerate the number of sensors and other data collection infrastructure to be established.
  - Shortlist the potential AI algorithms that would be needed to address the existing problems
  - Plan and design the solution architecture
- Basis the low-level-design and follow-up discussion with the production team and the leadership, the vendor team need to prepare final Bill-of-Materials.
- In case of deviation from earlier scoped proposal, effect required Change Request accordingly.

5) Implementation Phase:

- Implement the sensors required to capture the additional data points required (flow rate, pH values, turbidity, dissolved oxygen levels and different nutrient concentrations).
- Integrate the sensors and the existing SCADA to the IIoT platform. Combine historical data, real-time sensor feeds, and operational records.
- Collaborate with AI specialists, data scientists, & wastewater treatment engineers. Identify ideal set points for aeration rates & establish closed-loop controls for chemical dosing with AI models
- Considering varying quality of wastewater, seasonal changes and emerging Contaminants, carefully choose machine learning, deep learning, or reinforcement learning algorithms based on goals.
- Train AI models on historical and simulated data to predict and optimize processes. Run a small-scale pilot project to validate the model's performance in a real-world setting. Refine models based on pilot feedback and performance metrics.
- Set alerts to operators on process deviations to enable immediate corrective action (or) deploy automated hardware solutions on close-loop to adjust the parameters for efficient water treatment.

6) Go-Live & Stabilization:

- Continuously monitor AI performance and system outputs. Incorporate feedback to improve models and enhance predictions.
- Update AI systems regularly to accommodate changing conditions and new regulations.
- Assess improvements in efficiency, cost savings, and regulatory compliance. Evaluate reductions in pollutant discharge and resource use.
- Train the operators and supervisors on the implemented solution and complete the pilot go-live.
- Extend AI adoption across other processes or facilities based on pilot success. Innovate further in future by exploring advanced technologies, such as digital twins or blockchain, for added value.

Potential pitfalls to avoid & Best Practices

1. Implement a human-in-the-loop approach to validate AI decisions and manage exceptions. Collaborate with process engineers, chemists, and other domain experts during the AI design and deployment phases.
2. Build compliance checks into AI algorithms and regularly review them for alignment with updated regulations.
3. Use machine learning models that can adapt to changing effluent characteristics, seasonal variations, or operational constraints.

Cost Estimate

CapEx:

AI-infused water treatment solutions for a medium-sized water treatment plant might cost from 1Mn – 2.5Mn AED, as of 2025. The cost variance is owing to the number & type of new sensors needed and the complexity involved in the AI-algorithm development and efforts required.

OpEx:

The operational costs range from 150k to 350k AED per year.

Example Implementations

E) Sustainability related solutions	Linked with ITTI Use Case Page #110

Use Case #30: Recycle & Reuse of Material Waste – Digital Aids

Solution Introduction

Manufacturers address waste management through multi-faceted phases, encompassing scrap optimization during the production process, the return of defective products, recycling waste generated during its use and disposal at the end of its life. Sustainability initiatives play a crucial role, imposing mandates to ensure material circularity and guarding against false claims on environment-friendly activities (greenwashing) and fraudulent practices. This digital usecase is targeted at aiding the organizations to reduce waste generation during the production activities, ensuring right digital infrastructure to ensure proper book-keeping of material used, waste generated and right tagging to validate against green-washing claims.

Ideal candidates to adopt Digital Aids for material recycle & reuse

Digital aids enable organizations to track and treat the waste generated in its value-chain with proper checks-and-balances, thereby strengthening their commitment towards sustainable practices. Primary candidates for adoption include:

Aerospace Industry (Recycle high-value materials)	Food and Beverage Industry
Chemical and Pharmaceutical Industries	Heavey industries (Steel, Metal & Cement)
Electronics Industry	Construction and Demolition Industry

When to opt for Digital Aids for material recycle & reuse

1. Organizations which are committed to sustainable production processes
2. Factories that are regulated by authorities to reduce their wastes
3. When organizations need enhanced waste segregation processes
4. Ensure minimal consumption of materials during production processes.
5. When the factories need to reduce their material cost by reducing the wastes.
6. Enhance material reuse in production operations.
7. Enable immutable ledger for recording material transactions

Tools and Technologies Involved

1. Computer vision systems & Automated solutions
2. Additive Manufacturing / 3D printing
3. AI/ML algorithms
4. Blockchain

Solution Implementation Steps

1) Value Analysis Phase:

- Liaise with the organization's leadership team to understand their commitment to sustainablility; Health, Safety and Environment and understand the business need for reducing the waste generated in the production processes. Work with production manager, line supervisor and the management to understand the business need that demands exploration of digital aids to control the waste generated in the system.
- Determine the specific process that need to be improved (e.g., manufacturing, logistics, recycling processes or other supply chain activities).
- Define the goals for the material reuse and recycling, such as enhanced material consumption, efficient material usage, enhance waste sorting and better book-keeping of materials.
- Evaluate the business case for this solution deployment. Typically, this solution is treated as a basic hygiene solution to enable sustainable day-to-day factory operations. Hence conduct a mix of quantitative and qualitative study for Return-on-Investment. Once the business case is validated, move ahead to the next phase.

2) Requirements Definition Phase:

- Identify the areas that need to be monitored. Do a rough estimation on types of digital intervention / digital aids needed to ensure better material recycling and reuse.
- Identify the number of processes which could be introduced with new production process (like 3D printing to reduce the amount of scrap)
- Identify the processes that need better sorting mechanisms to ensure accurate sorting of wastes. Validate the type of intervention needed to make this sorting efficient (camera based computer vision / automated solutions etc.,)
- Identify the nodes where we need to ensure accurate book-keeping of materials consumed and the waste generated.
- Measure the existing KPI metrics on material usage and wastages and define the target state KPI values.
- Document and organize these requirements in to a 'Requirements Specification document'.

3) Vendor Evaluation Phase:

- Conduct market research to identify potential vendors and create a shortlist based on their capabilities, reputation, and experience relevant to the industry.
- Issue RFP to shortlisted vendors including detailed requirements and expectations.
- Evaluate proposals for their commercials as well as technical proficiency.
- Arrange (on-site) vendor demonstrations and understand their capabilities.
- Conduct contract negotiation including pricing for defined high-level scope, delivery schedules, support agreements, and warranties before finalizing the agreement with the vendor.

4) Solution Design Phase:

- a. Enable the vendor team to prepare the low-level-design of the solution by performing following:
  - – Detailed study of the existing processes
  - – Benchmark study on the existing KPIs related to material usage and waste generated
  - – Do refined estimate on the required digital interventions:
    - Number of 3D printing machines required
    - Number of machines where the existing production-run machine programs need to be refined for better material usage
    - Number of raw materials that need redesign/re-sourcing for efficient material consumption
    - Number of waste sorting mechanisms (computer vision / automated handling equipment) o Number of smart tags to be enabled to track the material consumption with more accuracy
    - Also, with enhanced block-chain algorithms, identify the number of nodes where we may need to introduce block-chain technologies to minimize returns by authenticating counterfeit claims, as needed.
- Basis the low-level-design and follow-up discussion with the production team and the leadership, the vendor team need to prepare final Bill-of-Materials.
- In case of deviation from earlier scoped proposal, effect required Change Request accordingly.

5) Implementation Phase:

- Evaluate the different interventions explained in step (4a) above and weigh their cost and benefit to shortlist the list of interventions that are targeted to be implemented.
- Improving the machine programs: Refine the machine program for key machines like CNCs and ensure reduced removal of material in the machines.
- Re-designing the raw materials and re-sourcing: Appropriately, according to the refined programs, redesign the raw materials and arrange for re-sourcing of redesigned raw materials.
- Deploying new production technique/equipment: Explore the potential for introducing newer production techniques like 3D printing to reduce the material usage. Especially for high-value raw materials, 3D printing provides greater possibility to bring down the costs.
- Introducing waste sorting mechanisms: Enhance the accuracy of waste sorting with computer vision based solutions &/ automated sorting equipments
- Introducing smart tags / block-chain algorithms: For the critical activities that need immutable ledger of records on material usage/wastage, deploy smart tagging solutions (or) authenticate counterfeit claims with help of Block-chain technology.

6) Go-Live & Stabilization:

- Train employees on how to use the digital aids effectively.
- Use the insights generated by digital aids to fine-tune production processes.
- Periodically review the system's performance and upgrade as needed.
- Roll out the solution across other areas or facilities after successful validation.
- Provide regular updates on material usage, waste reduction, and cost savings to the leadership and customers as per the business need.

Potential pitfalls to avoid & Best Practices

1. Map out the entire production process to identify key areas of material wastage or scrap generation. Select digital aids that are compatible with your existing systems and scalable for future needs.
2. Begin with a pilot project on a single line, process, or facility. Use the pilot to test, refine, and validate the solution before scaling.

Cost Estimate

CapEx:

Owing to the wide scope range (types of digital aids needed) and the scale of operations, the cost varies widely. For a production line that needs 1 polymer-based 3D-printing machine, 1 automated sorting machine and refining the CNC program for 5 machines will cost from 1.5Mn – 3.0Mn AED, as of 2025.

OpEx:

The license cost vary widely depending on the scope and scale of the implementation.

Example Implementations

hotpack

الغربية
Al Gharbia

RAK CERAMICS

06

EXAMPLE CASE STUDIES

Case Study #1: Integrated Quality Inspection & Production

COMPANY NAME	LOCATION
HOTPACK	UAE

Company Overview

Hotpack Packaging Industries, operating for over 29 years, has established itself as the largest manufacturer in the region. Through its subsidiaries, Hotpack Packaging Industries and H-Pack Packaging, the company leads in manufacturing and distributing packaging products. It serves diverse industries including consumer-packaged goods, food, retail, hospitality, healthcare, and pharmaceuticalss.

Business Requirement

The company needed a solution to ensure precise control over PET sheet thickness during the extrusion process. The goal was to automate quality control, minimize manual interventions, and consistently produce sheets with tighter tolerances of ±1%, significantly exceeding the industry standard of ±5%.

Observed Challenges

- Manual quality checks often resulted in inconsistent sheet thickness and higher variance
- Meeting tighter tolerance requirements of ±1% was difficult with traditional methods
- Lack of real-time feedback mechanisms caused delays in corrective actions
- High dependency on operator intervention led to inefficiencies and production errors

Solution Overview

Piovan automation systems and an embedded online Quality Control System (QCS) were implemented on extrusion lines. This system measures the thickness of PET sheets in real time and provides digital feedback to the die for self-correction. This enables the extrusion process to maintain sheet thickness within the desired ±1% gauge tolerance consistently.

Key Technologies Implemented

- Automation Systems (Process optimization and control)
- Online Quality Control System (QCS)
- Real-Time Feedback Loops
- Data Analytics (Extrapolated)

Realized Business Benefits

- Enhanced Precision: Consistently achieved sheet thickness within ±1% gauge tolerance, far exceeding the industry standard
- Improved Automation: Reduced reliance on manual intervention through real-time self-correction
- Operational Efficiency: Minimized production delays with immediate feedback and adjustments
- Quality Assurance: Maintained higher quality output, ensuring customer satisfaction and compliance
- Cost Savings: Reduced material waste and rework costs due to tighter control over thickness tolerances

Case Study #2: AI-Powered Automated Optical Inspection

COMPANY NAME	LOCATION
BOSCH	Brazil

Company Overview

Bosch, a global leader in technology and services, operates across mobility solutions, industrial technology, consumer goods, and energy and building technology. At its Curitiba, Brazil facility, Bosch focuses on diesel engine injection systems, serving multinational clients in the automotive, off-road, and commercial vehicle sectors. Renowned for innovation and quality, Bosch integrates advanced technologies like machine vision and robotics to maintain its leadership in precision manufacturing.

Business Requirement

Bosch required a more advanced vision inspection system to improve the quality and traceability of diesel injector nozzles during manufacturing. The goal was to automate the inspection process further, reduce the reliance on post-production manual checks, and enhance the accuracy of traceability data while supporting high production volumes.

Observed Challenges

- High reject rates increased costs and inefficiencies
- Limited traceability hindered accurate laser marking verification
- Manual post-production checks slowed operations and increased labor costs
- Complex inspection of cylindrical surfaces required advanced capabilities
- Integration of multiple processes into one system posed technical challenges

Solution Overview

Bosch implemented a vision system powered by Aurora Design Assistant, utilizing a Zebra Concord PoE frame grabber, Zebra Indio I/O card, and GigE Vision cameras. The system integrates machine vision tools like OCR, barcode verification, and image stitching to ensure precise inspection and verification. It also features LumiVision lighting, industrial robots for component positioning, and user-friendly software to manage processes with minimal operator expertise required.

Key Technologies Implemented

- Vision Inspection System (Aurora Design Assistant software)
- GigE Vision Cameras (OCR, OCV, and barcode scanning)
- Zebra Concord PoE and Indio I/O Card
- Industrial Robotics (KUKA)
- Machine Vision Tools
- Real-Time Visualization Tools

Realized Business Benefits

- Error Reduction: Reduced reject rates to less than 5% for a production volume of 7,000 parts / day
- Process Automation: Enabled automated inspection of multiple processes simultaneously with minimal operator involvement.
- Enhanced Traceability: Improved accuracy in laser marking verification and barcode matching.
- Cost Efficiency: Lowered setup and operation costs through flexible and integrated software tools.

Case Study #3: Digital Twin for Production Simulation and

COMPANY NAME	LOCATION	
HCM	Taiwan	HCM

Company Overview

Established in 1997 in the city of Taoyuan in northern Taiwan, HCM Material Business supplies lithium ferrum (iron) manganese phosphate (LMFP) cathode material for lithium batteries. The Equipment Business Division provides turnkey solutions for other manufacturers of materials with similar production processes.

Business Requirement

To stay competitive in the EV industry, the company must develop the ability to optimize workflows, validate design changes, and enhance efficiency while reducing time, labor, and resource costs in addition to addressing bottlenecks, optimizing energy use, and reducing costs to align with the core goal of lowering carbon emissions.

Observed Challenges

- Rapidly achieve maximum production capacity
- Enhance efficiency by automating production
- Lower energy and nitrogen consumption
- Speed up development of customer-specific equipment

Solution Overview

HCM implemented Siemens' Tecnomatix Plant Simulation software in September 2021. The initial phase involved simulating the existing production line to align the digital model with real-world outcomes, ensuring accurate representation of production processes. This simulation enabled HCM to identify and address manufacturing bottlenecks, optimize energy usage, and reduce costs, thereby supporting the EV industry's core value of lowering carbon emissions.

Key Technologies Implemented

- Digital Twin Technology (Plant Simulation Software)
- SCADA Integration
- MES Integration
- Automated System Simulation (Predictive Analytics)

Realized Business Benefits

- **Design Time Reduction:** Achieved a 50% decrease in design time for customer-specific, turnkey production lines.
- **Energy Consumption Reduction:** Decreased electricity usage by 5% and nitrogen consumption by 10%.
- **Production Efficiency Improvement:** Enhanced production efficiency, including a 15% increase in sand mill productivity and a 10% increase in Roller Hearth Kiln utilization.
- **Early Design Validation:** Enabled early validation of designs with customers, reducing the need for in-house testing and modifications before commissioning.

Case Study #4: Augmented Reality (AR) for Enhanced Training

COMPANY NAME	LOCATION	
U.S. AIR FORCE	USA	U.S. AIR FORCE

Company Overview

The Air Force Institute of Technology (AFIT), located at Wright-Patterson AFB, Ohio, is the U.S. Air Force's premier institution for defense-focused graduate education, research, and professional training. Accredited since 1960, AFIT has awarded over 20,000 graduate degrees and provides continuing education to 30,000 students annually in fields such as engineering, logistics, and cyberspace operations. As the Air Force's Cyber Technical Center of Excellence, AFIT drives innovation to sustain military technological superiority.

Business Requirement

The U.S. Air Force faces challenges in maintaining high performance under increasing operational demands.
It requires a solution to improve the accuracy and efficiency of aircraft maintenance processes, ensuring technicians can perform routine tasks effectively, regardless of experience levels, while adapting to evolving technological advancements.

Observed Challenges

- Enhance training efficiency for maintenance personnel
- Reduce errors in technical task execution
- Accelerate the adoption of augmented reality solutions
- Improve accuracy in routine maintenance procedures

Solution Overview

The study converted Technical Order (T.O.) information into Manifest AR content, presenting visual step-by-step instructions overlaid onto a technician's field of view via a heads-up display. Technicians completed tasks using both traditional content and Manifest AR content for comparison. A series of 25 experiments involving personnel of varying experience levels demonstrated the effectiveness of the Manifest AR platform in enhancing task performance.

Key Technologies Implemented

- Augmented Reality (AR) & Heads-Up Display (HUD)
- Remote Assistance Technology (Taqtile's Manifest AR platform)
- Cloud Infrastructure & Digital Content Management Systems (CMS)

Realized Business Benefits

- **Error Reduction:** Achieved a 53% decrease in errors and discrepancies during maintenance tasks with the Manifest
- AR platform.
- **Improved Installation Accuracy:** Reduced incorrect part installations by 57% compared to traditional methods
- **Resource Optimization:** Reduced training supervision needs and enabled tasks to be completed with 50% fewer technicians compared to traditional methods

Case Study #5: Augmented Reality For On-ground Service Support

COMPANY NAME	LOCATION	
BIN GHALIB	UAE	bin ghalib GROUP OF COMPANIES

Company Overview

VBG Intech is a privately held company specializing in the engineering, design, and manufacture of general and severe service control valves, including butterfly, plug, angle globe, 3-way globe, and flow control valves. Headquartered in Dubai with global service centers, VBG Intech delivers top-tier solutions to its customers worldwide

Business Requirement

The company required a solution to improve operational efficiency by providing quick, accurate access to panel operating parameters such as voltage and frequency. The aim was to reduce reliance on communication with the control center, streamline data retrieval, minimize manual errors, and enable faster decision-making for field service teams.

Observed Challenges

- Manual processes for retrieving panel data were time-consuming and error-prone
- Field service teams relied heavily on the control center for parameter verification, causing delays
- Lack of real-time insights into panel parameters slowed troubleshooting and repairs
- A user-friendly, portable solution was needed to facilitate independent operations for technicians

Solution Overview

An Augmented Reality (AR) tool was developed to display operating parameters of panels, including voltage and frequency, when scanned with a tablet. The solution integrated AR visualization with real-time data from panel sensors, allowing field service teams to independently access key operational metrics without needing to communicate with the control center.

Key Technologies Implemented

- Augmented Reality Application (Enables visualization of panel data through a tablet interface)
- Industrial Tablet
- Cloud Connectivity with Real-time Data Integration

Realized Business Benefits

- **Efficiency Gains:** Streamlined access to panel data, reducing time spent on manual checks.
- **Improved Decision-Making:** Provided technicians with real-time insights to act promptly.
- **Enhanced Field Independence:** Enabled field service teams to check parameters without relying on control
- center communication.
- **Reduced Downtime:** Faster parameter retrieval and troubleshooting minimized operational interruptions.

Case Study #6: Assembly Line Automation

COMPANY NAME	LOCATION	
HALCON	UAE	HALCON

Company Overview

HALCON is a regional leader in development and production of precision-guided munitions, loitering munitions and autonomous systems. Established in 2017, the company innovates and develops high-performance and cost-effective products and forms a vital part of ensuring UAE's defense sovereignity. HALCON relies on strong in-house research and development, supported by one of the region's most advanced testing facilities delivering high-tolerance, high-precision components and sub-systems, finished through the company's full assembly line services.

Business Requirement

The company needed a solution to ramp up its production capacity to meet the dynamic strategic demand in its Desert Sting missile's assembly line. The goal was to automate the majority of assembly activities to bring down the cycle time by 50%, reducing the worker content and enhancing the product's quality.

Observed Challenges

- Manual assembly activities often resulted in inconsistent production output
- Meeting tighter tolerance in the manual assembly line was difficult with traditional methods
- Lack of real-time quality inspections allowed defective materials added to the product assembly.
- High dependency on operator intervention led to inefficiencies and also posed challenges during critical times like pandemics.

Solution Overview

EDGE Industry 4.0 team worked in close collaboration with the HALCON team to automate the entire assembly line with 11industrial robots - both articulated robots and SCARA robots -, 300+ sensors, 6 machine vision stations, 16 bowl feeders, 6 automated screwing modules and automated material handling systems. automated 600+ tasks in this line, bringing together 30+ components, performing 70+ precise screwing operations, multiple camera-based inline inspections, and product identification and tracking through 13 QR scans. This include automated pick&place, part identification, PCB build, barcode scanning, soldering, quality checking, material handling, gluing and screwing. Also, the automated line has been integrated with the existing MES systems and ERP systems to build on the synergies in the production line.

Key Technologies Implemented

- Industrial robots
- Automated material handling systems
- Machine vision systems
- Bowl feeders
- Automated scanners

Realized Business Benefits

- **Enhanced Production Capacity:** Achieved 130% increase in the production volume
- **Reduced worker content:** Reduced worker content by 23%, while managing 2.3x volume
- **Quality Assurance:** Achieved higher quality output with tighter tolerances, ensuring customer satisfaction and compliance

Case Study #7: AGVs for Intra-plant Material Transfer

COMPANY NAME	LOCATION	RAK CERAMICS
RAK	UAE	

Company Overview

One of the largest ceramic brands globally, the company specializes in ceramic and gres porcelain wall and floor tiles, sanitaryware, faucets, and tableware. With 23 state-of-the-art plants across the UAE, India, Bangladesh, and Europe, it has an annual production capacity of 118 million square meters of tiles, 5.7 million sanitaryware pieces, 36 million porcelain tableware pieces, and 2.6 million faucets, catering to a global market with innovative and high-quality products.

Business Requirement

The company required a solution to optimize material handling processes, reduce manual intervention, and improve operational efficiency. The goal was to ensure seamless, accurate, and automated transport of materials across operations. Additionally, the company aimed to leverage advanced technology to streamline operations, enhance output precision, and support sustainability goals across its plants located in multiple regions.

Observed Challenges

- Manual material handling processes were time-consuming and labor-intensive
- Errors in manual transport caused workflow disruptions
- Scalability of traditional material handling methods was limited for growing operations
- A need for a reliable, automated system to reduce dependency on human operators

Solution Overview

Material handling is conducted using Automated Guided Vehicles (AGVs), which automate the movement of materials across processes. These vehicles operate based on pre-defined routes and real-time guidance, ensuring efficiency and precision in material transportation.

Key Technologies Implemented

- Automated Guided Vehicles (AGVs) with Real-Time Guidance Systems
- Pathfinding Algorithms & Fleet Management Software
- MES Integration

Realized Business Benefits

- **Increased Efficiency:** Automated material handling reduced operational delays and improved workflow.
- **Error Reduction:** Minimized manual errors, ensuring consistent and precise transport of materials.
- **Labor Optimization:** Reduced dependency on human labor, allowing reallocation of resources to higher-value tasks.
- **Scalability:** Enabled the handling of larger volumes with greater ease as operations grow.
- **Operational Cost Savings:** Lowered long-term costs through automation and reduced labor-intensive processes.

Case Study #8: Automated Storage & Retrieval

COMPANY NAME	LOCATION	
CARACAL	UAE	CARACAL

Company Overview

CARACAL is a world-renowned small-arms manufacturer. Based out of Tawazun Industrial Park, Abu Dhabi, CARACAL specializes in design, test, and assemble high-performance products. With over 15 years of experience, CARACAL has established itself as pioneers in building high- precision weapons. CARACAL builds high-quality next-generation firearms in state-of-the-art facilities, using some of the world's best CNC machines, QC equipment, and moulding technologies.

Business Requirement

With its increasing production output, the CARACAL team was exploring the means of addressing the need for additional Finished Goods warehouse and make its warehouse operations more agile. Storing high-value production outputs, it is imperative for CARACAL team to manage a highly agile Finished Goods warehouse, while managing its cost better.

Observed Challenges

- The existing warehouse (with 672 pallet capacity) was running out of space. The lack of space demanded the CARACAL team to invest on additional warehouse.
- Owing to location constraints, the additional warehouse was estimated to increase the operational expenses as well with additional staff and logistics infrastructure to run new facility.
- The speed of storage and retrieval operations in the existing warehouse was observed to be slow, with each operations taking 10-15mins on average, sometimes more.
- The non-uniform storage conditions reduced the efficient use of available space.
- Moreover, the manual handling of heavy materials posed risks of safety incidents.

Solution Overview

To address these challenges, the team identified 'Automated Storage & Retrieval System' with stacker, crane and conveyor system as the way forward. The focus was to utilize more of the horizontal storage space by converting the aisles into storage space and managing the operations through shuttle and crane systems. Also, the vertical storage space was planned to be utilized fully with enhanced vertical storage spaces.

Key Technologies Implemented

- Crane systems
- Robotics (Shuttles & Lifts)
- Identification and Tracking Tools (barcodes)
- Integration with Warehouse Management System

Realized Business Benefits

- **Enhanced Storage Capacity:** Improved the storage density by ~80%, thereby avoid investing on a new warehouse
- **Faster Operations:** Provided 3x faster storage & retrieval operations
- **Real-time Transparency:** Enabled real-time transparency and eliminated need for manual validation of inventory data
- **Improved Safety:** Implemented mechanism to avoid safety incidents related to handling of heavy materials

Case Study #9: Supply Chain Control Tower

COMPANY NAME	LOCATION	
PFSCM	Global	PFSCM

Company Overview

PFSCM specializes in ensuring lifesaving commodities reach hard-to-reach communities by supporting donors, governments, and humanitarian agencies in achieving public health goals. Through cost-effective procurement, efficient logistics, pharmaceutical-grade storage, and real- time shipment tracking, PFSCM delivers excellence backed by its ISO 9001:2015 certified Quality Management System, ensuring high standards across all operations.

Business Requirement

PFSCM needed to undergo a digital transformation to modernize its Supply Chain IT infrastructure, aiming to improve supply chain visibility, streamline collaboration among stakeholders, and automate key processes for faster, smarter customer service. The goal was to implement a flexible, scalable technology solution that supports supply chain innovations like the Internet of Things (IoT) and GS1 standards

Observed Challenges

- Outdated Legacy Systems
- Evolving Market and Client Requirements
- Change Management and Team Engagement
- Streamlining Processes and Collaboration

Solution Overview

PFSCM implemented the One Network Control Tower as their Supply Chain Control Tower to manage critical operational functions, from client requisitions to order placement and logistics execution. The platform enabled digital execution of processes, facilitating direct collaboration with suppliers and freight forwarders. Its native and custom-built functionalities allowed users to proactively manage transactions, track execution, and streamline exception handling, ensuring a centralized and efficient approach to supply chain management.

Key Technologies Implemented

- Supply Chain Control Tower Platform (One Network Control Tower)
- Integrated IoT Devices
- Workflow Automation Tool
- Data Analytics and Reporting
- Cloud-Based Infrastructure
- Integration Frameworks across Enterprise Applications (internal & External)

Realized Business Benefits

- **Faster Order Turnaround:** Reduced order turnaround times by approximately 85%, even with increased volumes and smaller teams.
- **Significant Efficiency Gains:** Achieved 5-10x improvements in operational efficiency through the integrated Control Tower solution.
- **Exception Management:** Enhanced ability to mitigate the impact of exceptions, ensuring smoother and more predictable supply chain processes.
- **Optimized Resource Utilization:** Enabled smaller teams to handle higher workloads efficiently, reducing resource strain.

Case Study #10: AI-Powered Waste Water Treatment

COMPANY NAME	LOCATION	
Wilmington Wastewater Treatment Plant	USA	Wilmington DE WATER

Company Overview

The Wilmington Wastewater Treatment Plant (WWTP), located in Wilmington, DE, processes an average of 60 MGD, with the capacity to handle up to 168 MGD during storm events. The facility plays a critical role in regional water management by ensuring effective wastewater treatment and compliance with stringent permit requirements.

Business Requirement

The Wilmington Wastewater Treatment Plant (WWTP) needed to optimize its disinfection process using sodium hypochlorite while ensuring compliance with permit requirements. The existing flow-pacing control scheme was overly conservative, leading to higher chemical usage and increased operational costs, particularly during storm events.

Observed Challenges

- Reactive dosing adjustments during storm events, leading to inefficiencies
- Overly conservative chemical dosing due to delayed bacteria elimination lab results (1–3 days)
- High chemical usage, driven by the need to ensure compliance with permit limits
- Increased operational costs due to rising chemical prices
- Limited real-time guidance for operators during daily rounds

Solution Overview

A digital transformation model was implemented in partnership with a predictive analytics platform. This model analyzed historical plant data and incorporated real-time weather information to forecast chemical needs. It provided operators with eight daily push notifications, offering targeted dosage recommendations to reduce chemical usage without compromising compliance or efficiency.

Key Technologies Implemented

- Predictive Analytics Platform (Custom Optimization Algorithms)
- Data Integration Models & Real-Time Weather Data
- Push Notification System Real-Time Weather Data

Realized Business Benefits

- **Chemical Cost Savings:** Achieved a 20% reduction in chemical usage, saving $250,000 annually
- **Improved Compliance:** Maintained 100% compliance with permit requirements despite variable conditions
- **Operational Efficiency:** Enabled operators to move away from conservative dosing practices, optimizing resource utilization.
- **High Operator Acceptance:** 86% acceptance rate for predictive recommendations, improving operational adoption
- **Sustainability:** Reduced chemical consumption without compromising treatment efficacy, contributing to environmental goals

07

WAY FORWARD

Industry 4.0 reshapes economic and trade dynamics of a country by driving high-value manufacturing, enabling smarter supply chains, and fostering global competitiveness. Being an innovation and manufacturing hub, UAE patronizes the faster adoption of modern technologies across its manufacturing ecosystem. To drive this transformation, MoIAT strives to provide support and guidance to the manufacturing community through structured initiatives.

The ITTI Framework acts as a digital maturity assessment tool for manufacturers to refine their digital strategies. The collective insights derived from the assessments, has been converted into 'ITTI Use Case Guide' in 2024 and that helps the organizations identify what use cases are best for their manufacturing maturity level. This 'ITTI Use Case Guide 2.0' takes it forward and provides directions to the manufacturers for efficient, faster and successful implementation of Industry 4.0 transformation. The detailed guidance provided in this 'ITTI Use Case Guide 2.0' aim to ease the implementation efforts for the manufacturers, thereby help them save time and cost during implementation. By spreading the experiences from other manufacturers' past implementations, this guide lays foundation for faster adoption of Industry 4.0 transformation.

The detailed implementation guide from this 'ITTI Use Case Guide 2.0' aims to inspire the manufacturers to opt for right use cases that would help them address their business challenges. The use case-specific insights on business scenarios and budgetary estimates help the business leaders with better decision making. The information on foundational tools and techniques required during preparation and the step-by-step guidance for implementation aids the organizations with faster project implementation. In addition, Learnings from other manufacturers' past implementations and reference to influential case studies helps the companies avoid potential costlier mistakes.

The detailed guidance provided in this 'ITTI Use Case Guide 2.0' aim to ease the implementation efforts for the manufacturers, thereby help them save time and money during implementation.

By spreading the experiences from other manufacturers' past implementations, this guide lays foundation for faster adoption of Industry 4.0 transformation.

To fully leverage the support from MoIAT, we urge manufacturers to get an ITTI assessment done to kickoff and accelerate their digital transformation journey. The findings from the ITTI assessment and the 'ITTI Use Case Guide' will aid the manufacturers to decide on the list of solutions that suit their business needs. Once the organization selects the use cases, we encourage the manufacturers to make use of this 'ITTI Use Case Guide 2.0' to prepare their resources better and plan for accelerated adoption of the selected use cases.

08

APPENDIX

- List of Abbreviations
- List of Key Industry4.0 Technologies
- Illustrative List of Industry4.0 Vendors

Appendix #1:

List of Abbreviations

SI.No.	Abbreviations used
1	5G – Fifth Generation Cellular Network
2	AGV – Automated Guided Vehicle
3	AI – Artificial Intelligence
4	AM – Additive Manufacturing
5	AMC – Annual Maintenance Contract
6	AMR – Autonomous Mobile Robots
7	API – Application Programming Interface
8	AR – Augmented Reality
9	AS/RS – Automated Storage and Retrieval System
10	BI – Business Intelligence
11	BMS – Building Management System
12	BPM – Business Process Management
13	CAD – Computer-Aided Design
14	CAM – Computer-Aided Manufacturing
15	CMMS – Computerized Maintenance Management System
16	CNC – Computer Numerical Control
17	CPS – Cyber-Physical Systems
18	DCS – Distributed Control System
19	DLP – Data Loss Prevention
20	DT – Digital Twin
21	EDI – Electronic Data Interchange
22	ELD – Electronic Logging Device
23	ERP – Enterprise Resource Planning
24	FMS – Fleet Management System
25	GDPR – General Data Protection Regulation
26	HIPAA – Health Insurance Portability and Accountability Act
27	HMI – Human-Machine Interface
28	ICT – Information and Communication Technology
29	IDPS – Intrusion Detection and Prevention System
30	IIoT – Industrial Internet of Things
31	IoT – Internet of Things
31	IT – Information Technology
32	IT/OT – Information Technology / Operational Technology
33	KPI – Key Performance Indicator
34	LMS – Learning Management System
35	LPWAN – Low-Power Wide Area Network
36	MES – Manufacturing Execution System
37	ML – Machine Learning
38	MQTT – Message Queuing Telemetry Transport
39	MR – Mixed Reality
40	OCR – Optical Character Recognition
41	OEM – Original Equipment Manufacturer
42	OPC UA – Open Platform Communications Unified Architecture
43	OT – Operational Technology
44	PLM – Product Lifecycle Management
45	PROFIBUS – Process Field Bus
46	QR – Quick Response
46	RFI – Request for Information
47	RFP – Request for Proposal
48	RFQ – Request for Quotation
49	RFID – Radio Frequency Identification
50	ROS – Robot Operating System
51	RPA – Robotic Process Automation
52	SCADA – Supervisory Control and Data Acquisition
53	SIEM – Security Information and Event Management
54	SIM – Simulation and Modeling
55	TMS – Transportation Management System
56	TQM – Total Quality Management
57	VPN – Virtual Private Network
58	VR – Virtual Reality

Appendix #2:

List of Key Technologies enabling Industry 4.0

1	**5G Connectivity**	High-speed, low-latency communication that supports realtime data transfer and connected devices in smart factories.
2	**Additive Manufacturing (3D Printing)**	Enables rapid prototyping and small-batch production, reducing lead times and material waste.
3	**Advanced Robotics**	Uses intelligent, collaborative robots (cobots) to automate complex tasks and enhance human-machine collaboration.
4	**Artificial Intelligence (AI)**	Powers machine learning, predictive maintenance, and autonomous decision-making in industrial processes.
5	**Augmented Reality (AR) and Virtual Reality (VR)**	Enhance worker training, remote assistance, and maintenance procedures by overlaying digital information on the physical environment or creating immersive simulations.
6	**Automated Guided Vehicles (AGVs)**	Mobile robots that autonomously transport materials throughout a facility, navigating fixed pathways or using sensors to avoid obstacles. AGVs increase operational efficiency by automating material movement and reducing manual labor.
7	**Automated Storage and Retrieval Systems (AS/RS)**	Automated systems that use robotics and shuttles to automatically place and retrieve items in storage racks, optimizing space and reducing retrieval time. AS/RS systems are key for high-density storage solutions and streamline order.
8	**Automated Warehouse Management Systems (WMS)**	Software solutions that leverage data analytics, AI, and IoT integration to monitor and control inventory, tracking materials from storage to transportation in real-time. An Industry 4.0- enabled WMS improves accuracy, reduces downtime, and optimizes the flow of goods.
9	**Autonomous Mobile Robots (AMRs)**	More advanced than AGVs, AMRs navigate dynamically, using sensors and maps to determine the most efficient paths. They are particularly effective in complex environments, making them ideal for flexible, real-time material handling.
10	**Big Data Analytics**	Enables real-time analysis of large datasets to optimize processes, predict maintenance needs, and improve decisionmaking.
11	**Blockchain Technology**	Provides secure, transparent data sharing across the supply chain, enabling traceability, improving trust, and reducing fraud in production and distribution processes.

Appendix #2:

List of Key Technologies enabling Industry 4.0

12	**Cloud Computing**	Provides scalable storage and computing power, enabling remote access, collaboration, and integration of digital systems.
13	**Collaborative Robots (Cobots)**	Automate complex tasks and work alongside humans, enhancing production flexibility, efficiency, and safety on the factory floor.
14	**Cyber-Physical Systems (CPS)**	Integrates physical processes with software, creating a seamless connection between the virtual and physical worlds.
15	**Cybersecurity Solutions**	Protects interconnected systems from cyber threats, ensuring data integrity, confidentiality, and availability.
16	**Digital Twins**	An advanced digital solution that create virtual replicas of physical systems, allowing real-time data collection and predictive analysis, helping to optimize processes and reduce
17	**Edge Computing Devices**	Processes data near the source, reducing latency and enabling real-time analytics and response on the factory floor, essential for time-sensitive automation.
18	**Energy Management Systems**	Uses data analytics and IoT to monitor and optimize energy consumption, supporting sustainable manufacturing.
19	**Human-Machine Interfaces (HMIs)**	Facilitates intuitive interaction between operators and machines, improving usability and efficiency.
20	**Internet of Things (IoT)**	Facilitates connectivity and data exchange between machines, sensors, and devices.
21	**Machine Learning (ML)**	A subset of AI that enables systems to learn and improve from data without explicit programming.
22	**Machine Vision Systems**	Use cameras and AI algorithms to inspect products, identify defects, and verify quality, providing data for quality assuranceand process optimization.

Appendix #2:

List of Key Technologies enabling Industry 4.0

23	**Manufacturing Execution**	Track and collect real-time data on production, equipment status, and work-in-progress, facilitating decision-making and improving production efficiency.
24	**Predictive Maintenance**	Uses IoT, AI, and machine learning to monitor equipment health, reducing downtime and maintenance costs.
25	**Programmable Logic Controllers**	Industrial computers that automate repetitive tasks and collect data on machine performance, production counts, and other metrics for efficient process control.
26	**Robotic Process Automation (RPA)**	Automates data entry, reporting, and other administrative tasks by interacting with software systems, freeing up human resources for more complex analysis and management.
27	**Smart Conveyors**	Equipped with IoT sensors and AI, smart conveyor systems can dynamically adapt speed, direction, and sorting processes to manage varying loads and prioritize specific items. They are essential for automated sorting, material handling, and production lines.
28	**Smart Sensors**	Capture real-time data on temperature, pressure, motion, and other factors critical to process optimization.
29	**Supervisory Control and Data Acquisition (SCADA) Systems**	Centralize data collection and monitoring by connecting equipment, sensors, and controllers, enabling real-time visualization, control, and analysis.
30	**Virtual Reality (VR)**	Immersive technology for training, simulations, and design reviews in a controlled digital environment.

Appendix #3a:

Illustrative List of Industry 4.0 Solution Vendors

OEM's providing hardware / software

1	ABB	38	Kardex
2	Aeroqual	39	Kawasaki Robots
3	Aiwaen Innovative Engineering LLC	40	Konica Minolta
4	Altair	41	Kuka
5	AnyLogic	42	Laser Isse
6	Argus AR	43	Lincoln Electric
7	ARuVR	44	Mark3D
8	AssurX	45	Microsoft
9	Atlas Copco	46	Mobile Industrial Robots
10	Atmata	47	Multivac
11	Autodesk	48	Nebula
12	AWL	49	NEO AR Worker
13	Beckhoff	50	Nvidia
14	Bosch	51	Omron
15	Cisco	52	OnRobot
16	Dassault Systèmes	53	Path Robotics
17	Daifuku	54	PTC
18	Denso	55	Qualitas technologies
19	DMG MORI	56	SAP
20	Du	57	SEW Eurodrive
21	Ericsson	58	Siemens
22	Emerson	59	SimPlan
23	Endress+Hauser UAE	60	Sphere Lens
24	Enviro & Industrial Solutions ME	61	STRIVR
25	Envirozone	62	Swisslog
26	eos	63	TeamViewer Tensor
27	Etisalat	64	Trackim
28	E-Plus-3D	65	TRUMPF
29	Fanuc	66	TSI Incorporated
30	GE Asset Performance Management	67	Ubisense
31	Hach Middle East & Africa	68	Universal Robots
32	Hitachi	69	Visco Technologies
33	Honeywell	70	Visual Components
34	Huawei	71	XR Labs
35	IBM	72	Xylem Water Solutions Middle East
36	Inspekto	73	Yaskawa Motoman
37	Invent UAE	74	Zebra Technologies

Appendix #3b:

Illustrative List of Industry 4.0 Service Providers

System Integrators & Service Providers

1	Ace Vega Technologies
2	Acme
3	AiRob
4	Applivity
5	ATCO World
6	Atlas Copco
7	Atlas Copco UAE
8	Atmata Trading LLC
9	ATS
10	Autel Robotics
11	AWM
12	Barcosoft LLC
13	Base Control Tech FZC
14	Business Experts Gulf LLC
15	C3 Automation
16	CAD Gulf LLC
17	Canatek
18	Cloud Seven Information Technology
19	Comi ME
20	CRO Gulf
21	DataRobot
22	DGWorld
23	DiFacto
24	Du
25	e2open
26	Emergency Safety Solutions LTD
27	EPSON Middle East
28	Etisalat
29	Eurogulf
30	FABPlus Consultants
31	German Gulf Enterprises
32	Hauberk Gulf Trading & Services
33	Honeywell International
34	Industrial Control Care
35	Infor
36	Kawasaki Robotics Middle East
37	Kinaxis
38	Labels & Labeling Co LLC
39	Lincoln Electric
40	LitumIOT
41	Logicom Group
42	LuminousXR
43	Maptec
44	Mechatronics Industrial Equipment
45	FZ-LLC
46	Multivac UAE
47	Newlevel XR
48	o9 Solution
49	Panatech
50	Passtech
51	Precast FZCO
52	Procal Measuring & Control Equipment
53	R&D Technology
54	Reliability & Machinery Trading LLC
55	Newlevel XR
56	o9 Solution
57	Panatech
58	Passtech
59	Precast FZCO
60	Procal Measuring & Control Equipment
61	R&D Technology
62	Reliability & Machinery Trading LLC
63	Startech GCC
64	Sterling International Consulting
65	SwissLog Middle East
66	Syscom
67	Vacker Global
68	Veetech
69	VentureOne
70	Waylog Automation