Industry 4.0 Awareness Seminars Reports Template

1.	Date of the Seminar	28th November 2019
2.	Organizers	EEPC India
3.	Title of the seminar	Awareness Programme on Industry 4.0
4.	Programme	Annexure 1
5.	Report: suggested contents (1) Main takeway / good suggestions,	-Emphasis on change in skill set and mind set for adoption of Industry 4.0 -Filling up of gap between industry and academia in implementation of Industry 4.0 through consulting -Adequate investment by private sector to build Industry academia linkages -Proposal to set up centre of excellence in Jalandhar -Language support can be provided as per the audience -Setting up of Help desk at EEPC India - Organize more seminars in Jalandhar
	(2) Clusters covered,	Foundry, steel re rolling, electrical appliances, mechanical engineering, handtools, surgical equipment.
	(3) Nos attended,	75+
	(4) Success stories that need to be	

	compiled / shared	— Remote Access to Machine HMI — Converting Legacy Machines into Smart Machines — Intelligent Ultra Precision Turning Machine. — Industry 4.0 Assesement Model — Development of Human IoT
6.	List of Speakers with contact details	As per Annexure 2
7.	Presentations	Annexure 3
8.	Resource persons for providing consultancy, skilling, guidance etc.	NA
9.	Photographs	Annexure 4
10.	Learnings from the seminar	• MSME be sensitized upon the need for adopting Industry 4.0 • Dedicated Infrastructure or CFC desired in Jalandhar region • Making MSMEs aware about the assessment tools to help identify their current technological position and possible solutions • Skilling may be identified as an important parameter to be addressed for Industry 4. Sessions

Annexure 1: Program copy

<div align="center">

Seminar on Industry 4.0
28th November 2019, 1030 hrs, Jalandhar
EEEPC India, Plot Comm. 1, Focal Point, Jalandhar 144012

</div>

	Registration
Inaugural Session	
10.30-10.35 hrs	Welcome by Mr. Rakesh Suraj, Regional Director (NR), EEPC India

10.35-10.45 hrs	Address by Mr. Sanjay Chavre, Sr. Development Officer, Department of Heavy Industry, Government of India
10.45-10.50 hrs	Remarks by Ms Kamna Raj Aggarwalla, Regional Chairman, EEPC India-NR
Session II – Current status of Jalandhar Engineering Cluster & their readiness for adoption of I 4.0	
10.50-11.00 hrs	Address by Mr. Tushar Jain, Panel Convenor Agriculture Machines & Implements Panel. EEPC India
11.00-12.50 hrs	**Session III – Technical Presentations by Industry 4.0 technology providers**
11.00-11.20 hrs	Interactive session on Identifying Operational Benchmarks, challenges and Readiness for Industry 4.0 by **Mr. Anup Wadhwa, Director, IIT D – AIA, Foundation for Smart Manufacturing, Delhi**
11.20-11.35 hrs	Address on "CMTI activities and technology development works for Smart Manufacturing" by **Mr. Prakash Vinod, Centre Head-Smart Manufacturing, Precision Machine Tools and Aggregates, (CMTI), Bangalore**
11.35-11.55 hrs	Presentation on Industry 4.0 Maturity Model - A C4i4 diagnostic tool for Indian manufacturers to identify Where & How to start Industry 4.0 journey?" and "SMART 50 - Digitalization Ideas by C4i4 for Indian manufacturing fraternity" by **Mr. Satish Ivaturi, C4i4 Labs , Pune**
11.55-12.10 hrs	Address on Internet of things and its applications in Industry 4.0 by **Dr Sujata Pal, Assistant Professor in Computer Science and Engineering, IIT Ropar**
12.10-12.30 hrs	Address and case study on "Creating a pilot towards Smart, Affordable and Customer Centric production" by **Mr. Anup Wadhwa, Director, IIT D – AIA, Foundation for Smart Manufacturing, Delhi**
12.30-12.50 hrs	Talk by Mr. **H S Saggu, Managing Director, Sam Automation Technologies Pvt. Ltd.** On Success Stories
12.50-13.10 hrs	Interactive Q/A
13.10 hrs	Vote of Thanks and Concluding Remarks by EEPC India
	Lunch Follows

Annexure 2: Speaker details

Mr Sanjay Chavre
Senior Development Officer,
Department of Heavy Industry, Government of India,
475A, Udyog Bhawan, New Delhi
Telefax: 01123063692, M 09958985634, Skype: sanjay.chavre
Email: sanjay.chavre@nic.in

Ms. Kamna Raj Aggarwalla
Regional Chairman (NR)
Flat No.10
P, Q, N, 10th Floor
DCM Building, 16 Barakhamba Road
New Delhi - 110 001
Phone : (+91 11) 23314171/74
Fax : (+91 11) 23317795

E-mail : kamna.aggarwalla@gmail.com

Mr Tushar Jain
Panel Convenor - Agricultural Machinery

General Manager
Basant International
Plot No. B-38, Industrial Development Colony
Jalandhar-144 008
Phone : (91 181) 2611-881
Mobile : 09478478881; 08569069085
E-mail: tushar@basantinternational.com

Mr. Anup Wadhwa
Director
IIT D – AIA, Foundation for Smart Manufacturing, Delhi
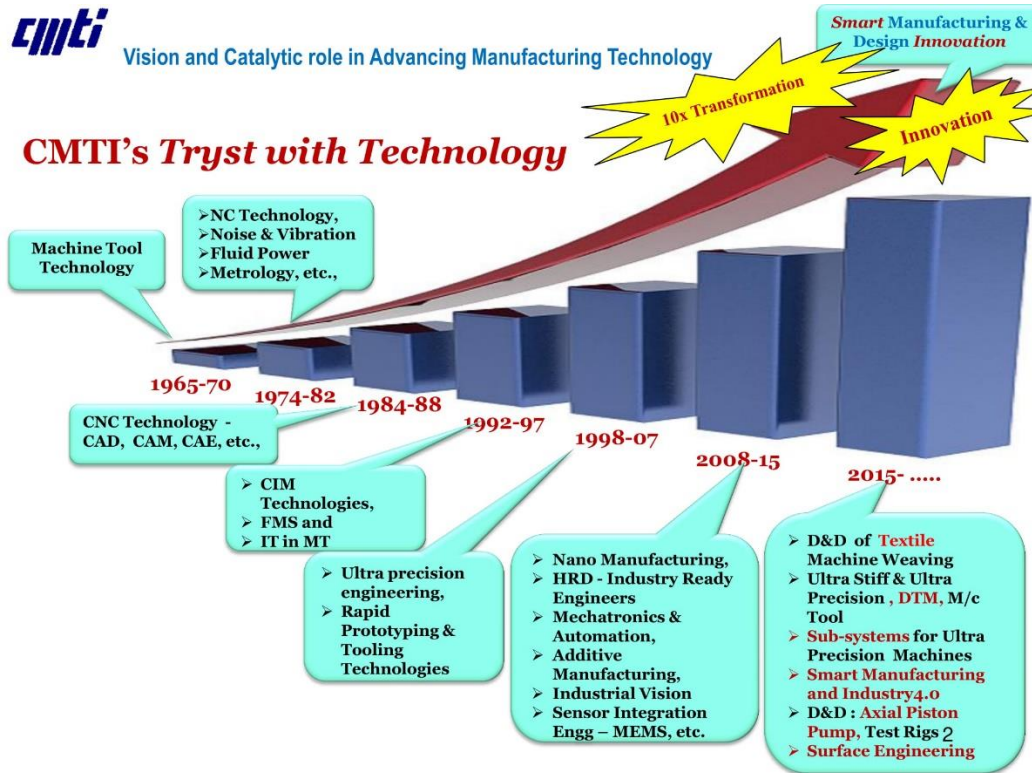Mobile: 9810026674
Email: director@aia-india.org

Mr Prakash Vinod
Centre Head-Smart Manufacturing, Precision Machine Tools and Aggregates
Central Manufacturing Technology Institute (CMTI),
An autonomous R&D Institute under the Ministry of
Heavy Industries & Public Enterprises, Government of India
Tumkur Road
Bangalore-560022
M:+ 91 (0) 9449842680
T:+ 91 80 23371516, 22188243
Email   : prakashv.cmti@nic.in

Dr Sujata Pal, PhD
Assistant Professor
Department of Computer Science and Engineering
IIT Ropar
Mobile: 8054407385
Email: sujata@iitrpr.ac.in

Mr. H S Saggu

Managing Director

Sam Automation Technologies Pvt. Ltd

D-123, INDUSTRIAL AREA,

PH – 7, MOHALI – 160062.

Phone no.: +91-172-2236911

Fax: +91-172-4644911

Email: sales@samautomation.org

Email: samautotech@yahoo.co.in

Website: www.samautomation.org

Mobile: 9814108903

Annexure 3: Presentations

PPT 1: Activities & technology development works for Smart Manufacturing at CMTI

By Mr. Prakash Vinod, Centre Head-Smart Manufacturing, Precision Machine Tools and Aggregates, (CMTI), Bangalore

Vision and Catalytic role in Advancing Manufacturing Technology

CMTI's *Tryst with Technology*

Smart Manufacturing & Design *Innovation*

10x Transformation

Innovation

Machine Tool Technology

- NC Technology,
- Noise & Vibration
- Fluid Power
- Metrology, etc.,

1965-70

1974-82

1984-88

1992-97

1998-07

2008-15

2015- .....

CNC Technology - CAD, CAM, CAE, etc.,

- CIM Technologies,
- FMS and
- IT in MT

- Ultra precision engineering,
- Rapid Prototyping & Tooling Technologies

- Nano Manufacturing,
- HRD - Industry Ready Engineers
- Mechatronics & Automation,
- Additive Manufacturing,
- Industrial Vision
- Sensor Integration Engg – MEMS, etc.

- D&D of **Textile** Machine Weaving
- Ultra Stiff & Ultra Precision , **DTM, M/c Tool**
- **Sub-systems for Ultra Precision Machines**
- **Smart Manufacturing and Industry4.0**
- **D&D : Axial Piston Pump**, Test Rigs 2
- **Surface Engineering**

Core Activities of CMTI

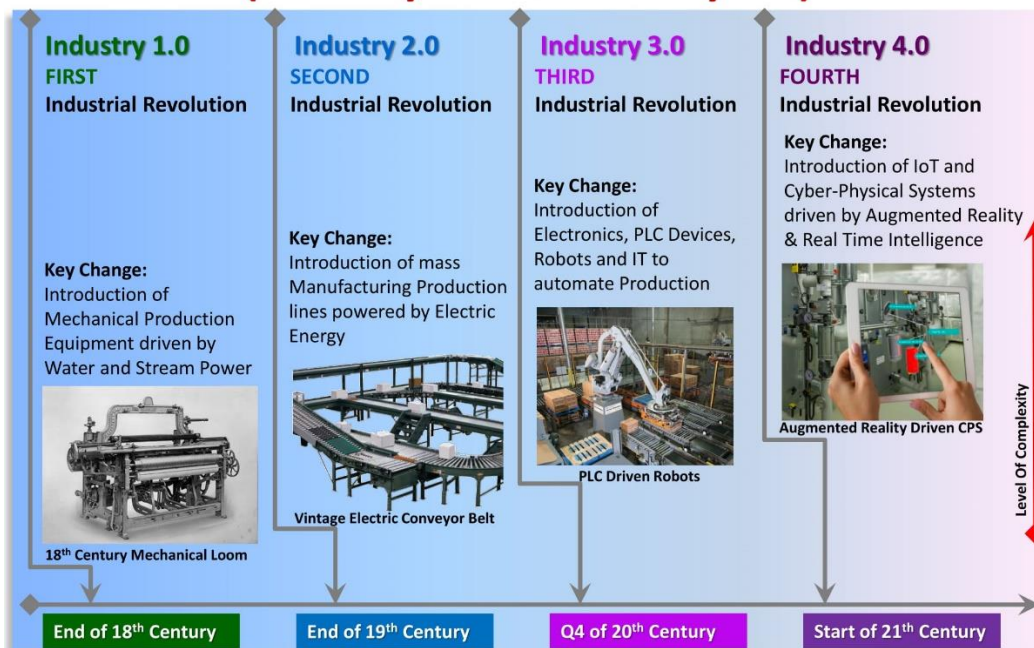| New Product Development	Research, Design & Development	Laboratory Services	Human Resource Development
Special Purpose Machines	Co-Creation with Academia	Metrology & Calibration	Post Graduate Programs
Machine Sub-Systems	Productization of 'Proof of Concept'	Fluid Power & Testing	Corporate training programs
Special Products	Technology Development	Noise & Vibration	Seminars, Workshops & Conferences
Inspection / Test Systems	Patents & Publications	Chemical & Metallurgy	Student Projects
		Nano Characterisation	

What CMTI Would Offer

We Undertake Research, Develop Technologies and Machines, Train Manpower and Deploy into Industrial Applications

CMTI
www.cmti-india.net

Ultra Precision Machine Tools
Special Purpose Machines
Sensors and Controllers
Textile Machinery
Aircraft LRUs and Test Rigs
Precision Metrology
Smart Manufacturing and Industry 4.0
Additive Manufacturing
Industry Employable Manpower (Skilling & Reskilling)
Technology Transfer and Incubation

MADE – IN – INDIA

Manufacturing Revolution
(Industry 1.0 to Industry 4.0)

CMTI
www.cmti-india.net

Industry 1.0
FIRST
Industrial Revolution

Key Change:
Introduction of Mechanical Production Equipment driven by Water and Stream Power

18th Century Mechanical Loom

Industry 2.0
SECOND
Industrial Revolution

Key Change:
Introduction of mass Manufacturing Production lines powered by Electric Energy

Vintage Electric Conveyor Belt

Industry 3.0
THIRD
Industrial Revolution

Key Change:
Introduction of Electronics, PLC Devices, Robots and IT to automate Production

PLC Driven Robots

Industry 4.0
FOURTH
Industrial Revolution

Key Change:
Introduction of IoT and Cyber-Physical Systems driven by Augmented Reality & Real Time Intelligence

Augmented Reality Driven CPS

Level Of Complexity

| End of 18th Century | End of 19th Century | Q4 of 20th Century | Start of 21th Century |

What is Smart Manufacturing?
Value Chain Network Based Manufacturing

Business Systems, ERP

Mapping SAP information Into operation

Customer

Supply Chain

Distribution Center

Smart Factory

Tracking & traceability

Smart Grid

Dynamic plant configuration and readiness
Dynamic product component/material configuration
Dynamic inventory minimization & management
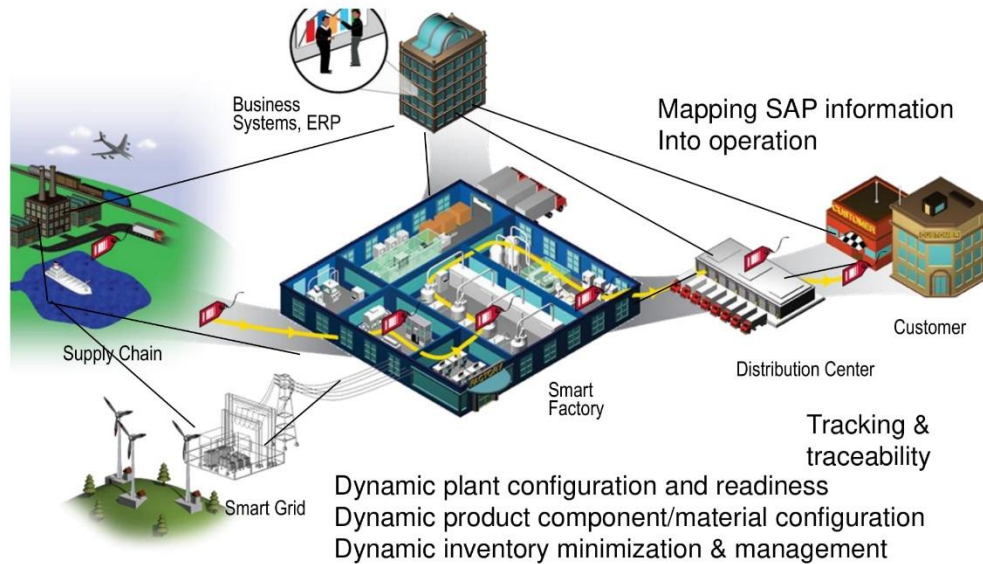
Graphics courtesy of Rockwell Automation

SAMARTH Udyog Bharat 4.0 Platform
(DHI Industry 4.0 Initiative)

cmti
www.cmti-india.net

Smart Manufacturing Demo and Development Cell
(SMDDC @ CMTI)
Focus Area

- ❑ Pilot implementation of '**Smart manufacturing Demo cum Development Cell -Machine Tool centric**' at CMTI, **Experience Centre** (Awareness & Propagation) & **Platform for development** (Technology driver)

- ❑ Technology development, demonstration, trials, training, experience of learning, testing & validation of I4.0 products (**R&D, Product development & Best practices**)

- ❑ Customization & rollout of smart manufacturing solutions for MSMEs (**Enabling localization & customised Implementation, Handholding**)

- ❑ Industry Employable Manpower (**Skilling & Reskilling**)

Smart Factory Layout-SMDDC
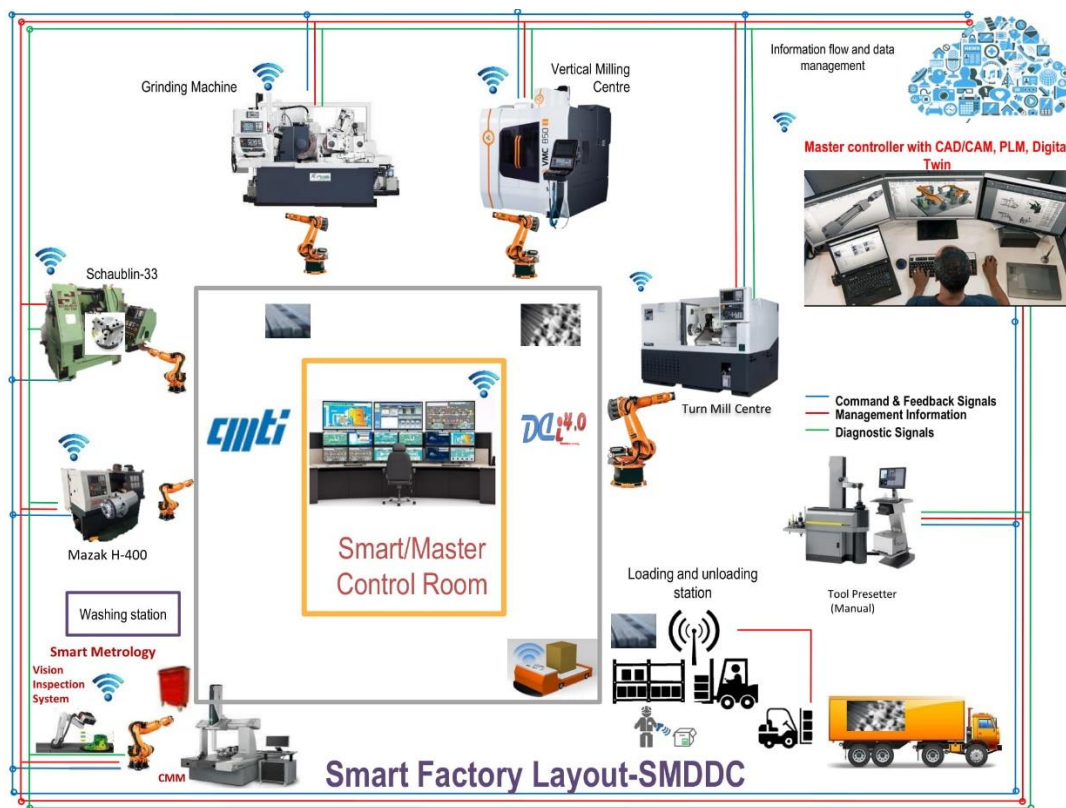
Smart machine tools and intelligent machining

- ❖ Smart machine is an intelligent device that uses machine-to-machine (M2M) communication and are able to make decisions and solve problems without human intervention.

- ❖ An **Intelligent machine tool** takes the CAD data, the materials and the set-up plans as inputs and can take autonomous decisions and produce accurate machined parts with quality, machine condition and productivity data as outputs

- ❖ Machining processes evolved around Sensing, process model, knowledge base and process control is **intelligent machining**.

- ❖ Development of technology for smart machine tools and intelligent machining is one of focus area of CMTI activities

- ❖ Improvement in accuracy of machines , along with productivity and ease of operation is our targets for technology development in this domain

Designed performance, Work material, accuracy required, workpiece geometry, Depth entry and exit

Operator

CL Data Generation

Setup

Cutting Process

Post-process Measurement

Machine Drive

Database

Supervision

Servo Control

LEVEL 1

LEVEL 2 (Cutting Force, Temperature....)

LEVEL 3 (ON/OFF-line improvement with component measurement)

Intelligent Ultra precision Turning Machine (iUPTM)

A state of the art smart machine with intelligent features, developed by CMTI, for producing ferrous, non-ferrous, IR and polymer components with optical quality. IUPTM a world-class, next generation machine tool with in-built intelligence.

Applications: Electro-optics, Defense, Ophthalmic, High precision mechanical comp, Medical

Intelligent Machine error compensation
Real-time Positioning, Geometrical & Thermo elastic error compensation taking feedback from sensors mounted on machine

Intelligent Ultra Precision Turning Machine (iUPTM) developed at CMTI

Intelligent Machine Diagnostics
➢ Spindle & Slide Health Monitoring
➢ On Machine Spindle balancing
➢ Sensor fault detection
➢ Tool condition monitoring

Open architecture Motion Control
Can integrate user developed control algorithms
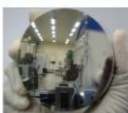
Remote monitoring, diagnostics & control through internet

Intelligent Machining & Prognostics
Surface error predictions for intelligent machining

Diamond Turned Mirrors on CMTI's iUPTM for industrial applications

WINNER OF FIE
FIE FOUNDATION AWARD

Geometrical error correction of X-axis in real time through NN based program

Linear Error VS Position

Pitch Error VS Position

Yaw Error VS Position

Roll Error vs Position

Vertical Straightness Error Vs Position

Horizontal Straightness Error VS Position
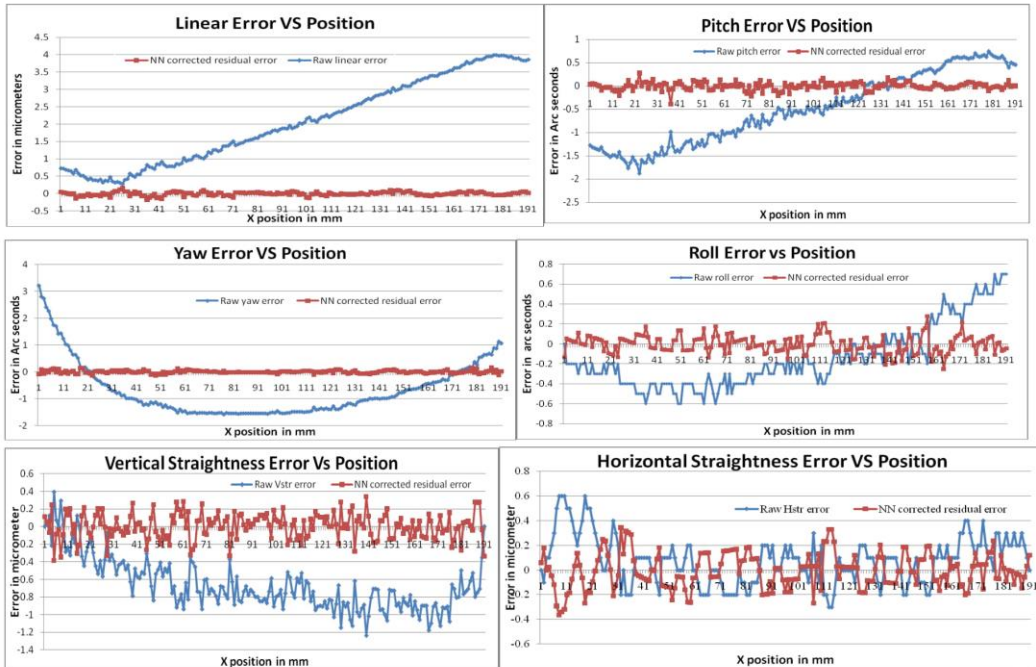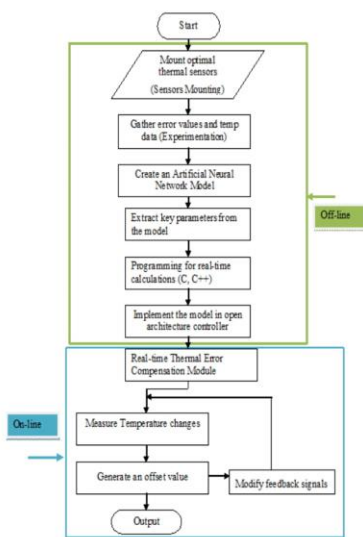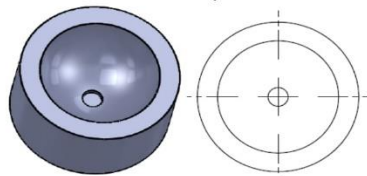
Flow Chart for Thermal Error Compensation
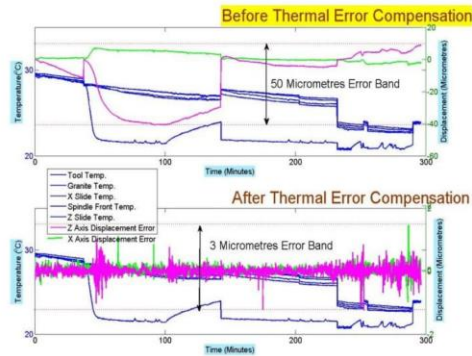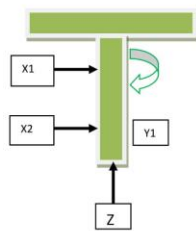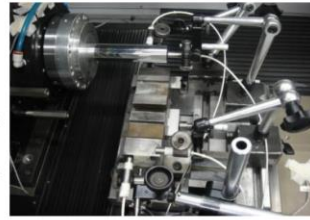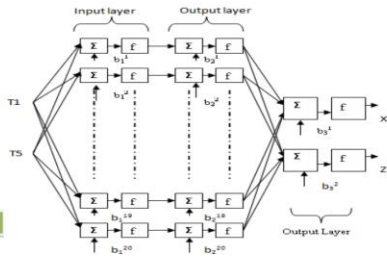
The Thermal induced displacement Errors can be reduced from 50 micrometres to 3 micrometres with the compensation system.

13

Problem Statement : The radius use to go out of specification after machining of 5 to 6 components.
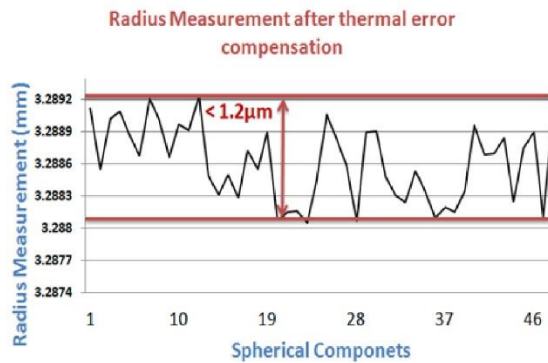

Spherical profile component machined in DTM

Parameter	Specification
Radius (mm)	3.288 ± 0.001
Form (μm)	1.2

Nanoshape

UPCMM

Radius Measurement after thermal error compensation

< 1.2μm

14

Sensors

Process Models

Machining processes
-Metal cutting
-Grinding

Intelligent Machining

15

Filtering

Learning

Data
From the sensors

Information
Features which condense
important signal information

Knowledge:
Tool wear state,
Workpiece surface quality,
Process control

16
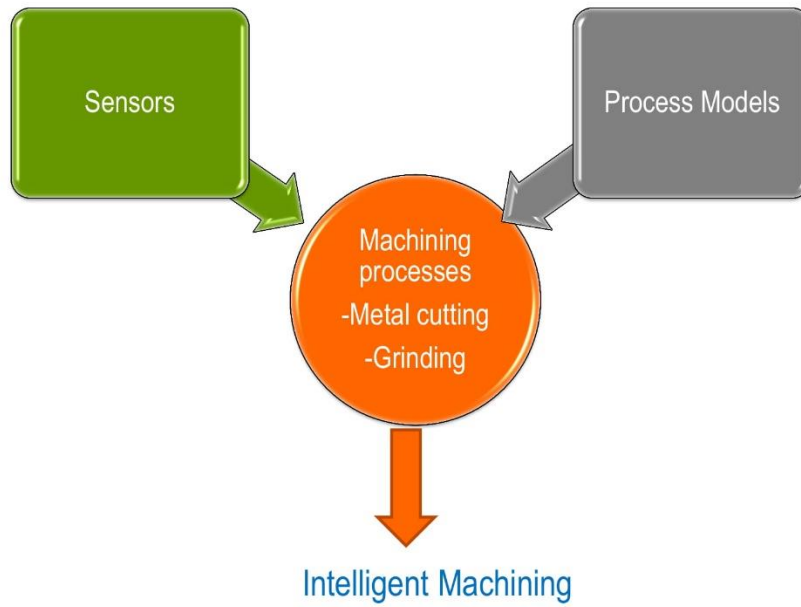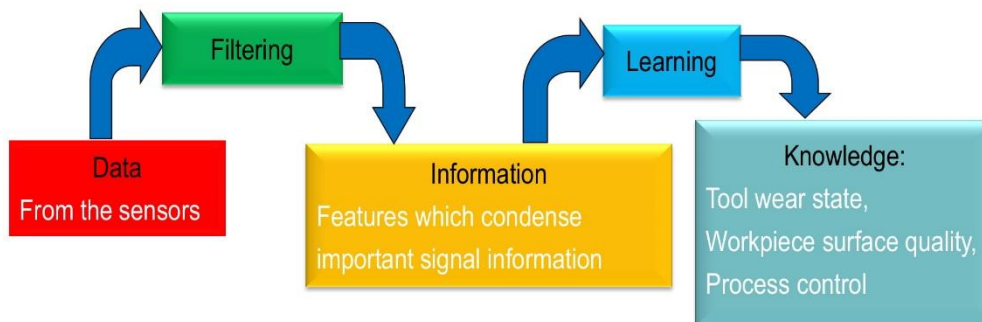
Comparison of measured and estimated values of surface roughness in ultra precision turning using predictive analytics
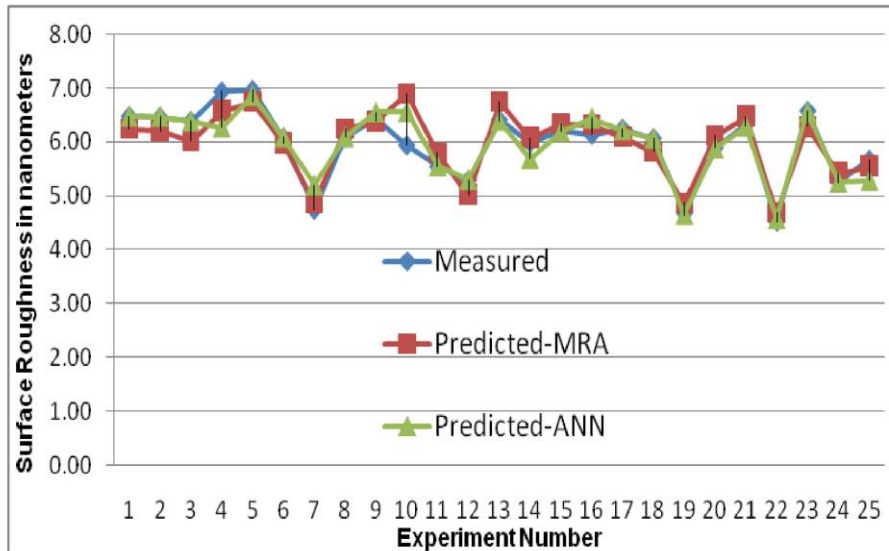
Other Completed/On going Internal R&D works

- ❖ Technology Development for **Converting legacy machine tools to IIOT Smart Enabled Machine tools** (Completed)
- ❖ Conversion of selected **CNC legacy machines @ CMTI into smart machines** (Completed)
- ❖ Development of **Low cost Energy Monitoring module for productivity enhancement** (completed)
- ❖ Development of a affordable **IIOT module** for making legacy machines smart (On-going)
- ❖ Development of a **compressive machine tool health condition monitoring and predictive maintenance module** (On-going)
- ❖ Development of **comprehensive dashboard for remote monitoring** of CNC machine tools

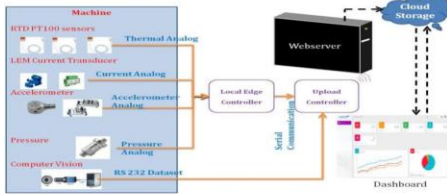# IOT Enabled "SMART" Metal Cutting Machine - empowering a Legacy Machine @CMTI

Smart features

Sensor modules

- ❖ **Temperature :** Machine thermal plot
- ❖ **Vibration :** Machine health
- ❖ **Evaluate TcP** (tool center point) drift
- ❖ **Pressure :** Spindle coolant pressure
- ❖ **Energy :** Downtime of the machine
- ❖ **Vision :** In-situ inspection / Quality

Machine Tool: Milling Machine(5 axis VMC)

Dashboard
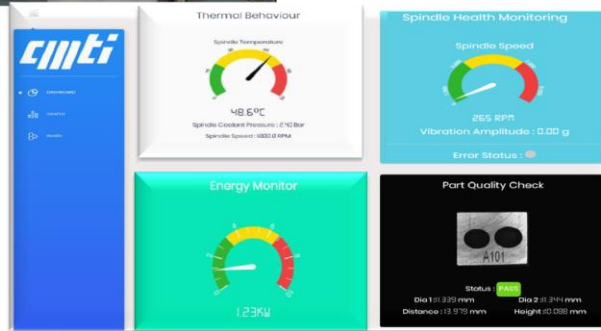
Outcome

- ❖ Generate diagnosis reports / action plan
- ❖ Classify reports based on severity
- ❖ Enable deep dive information for better process understanding
- ❖ Establish data base for further analytics

Outputs

- ❖ IOT enabled connected machine
- ❖ Remote access of machine health and process data
- ❖ Real time Machine health monitoring
- ❖ Energy monitoring
- ❖ Better process monitoring
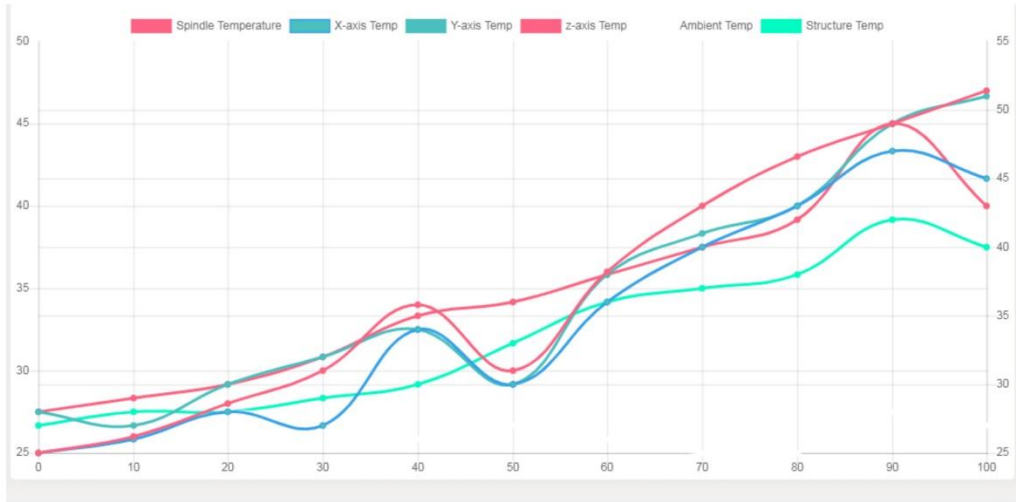- ❖ Reduced machine down time
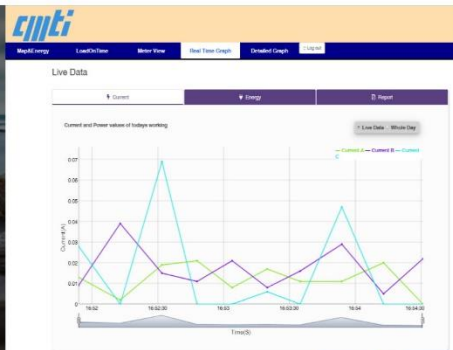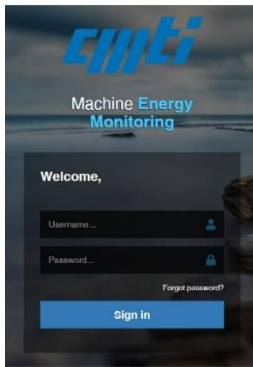
19

Machine Thermal Behaviour

Machine Thermal Behaviour

Spindle Motor Temperature	Ambient Temperature	Structure Cast Temperature
29.3 °C	29.3 °C	26.1 °C

X-axis motor Temperature	Y-axis motor Temperature	Z-axis motor Temperature
26.4 °C	38.7 °C	27.9 °C
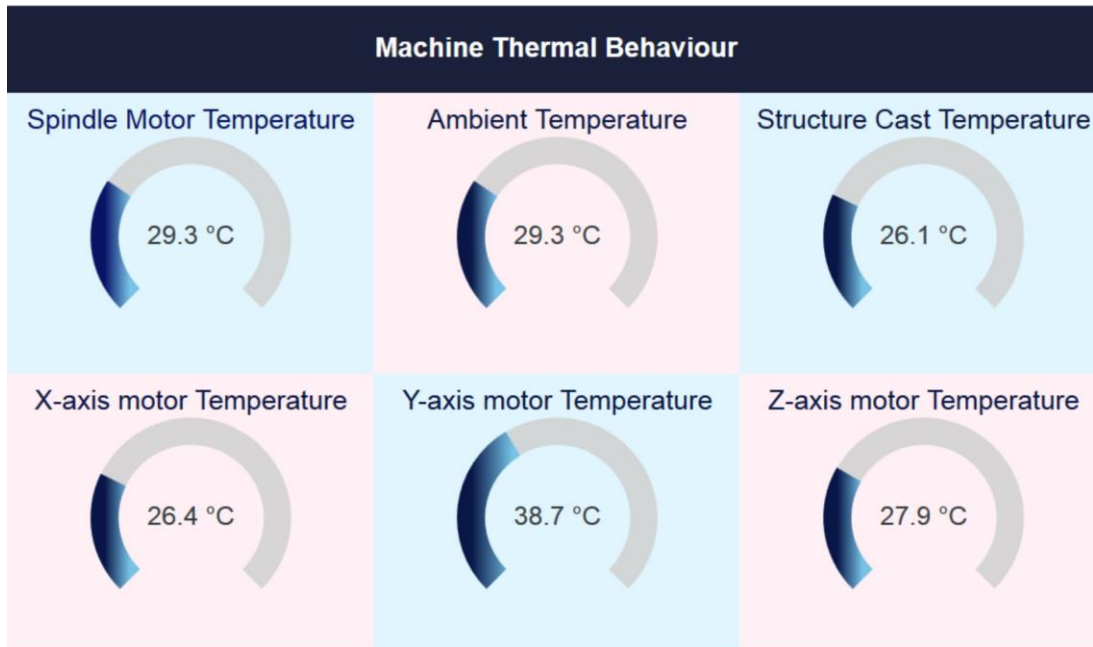
Weblink: www.cmti.online/mtb

20

Snapshots of Web portal
Thermal Behavior of Machine*(graphical)*

Energy Monitoring Module

The low cost energy monitoring module has been developed for MSME industries

Weblink:
http://cmti.online/emm1ed

TOOL CONDITION MONITORING IN ULTRAPRECISION MACHINING
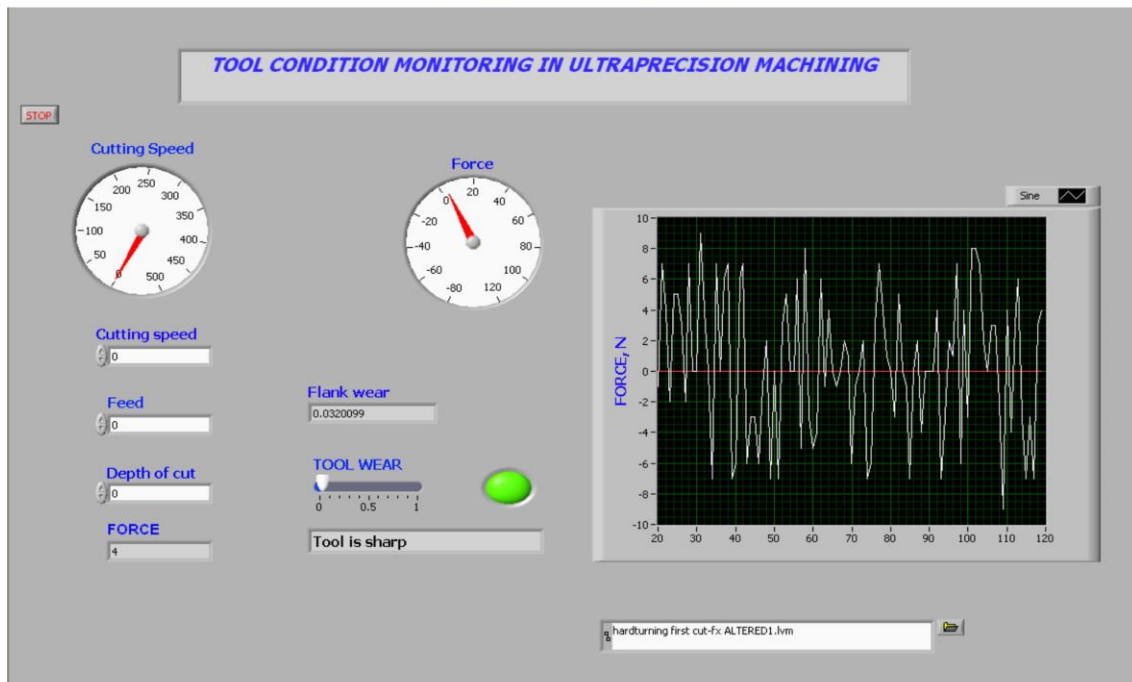
23
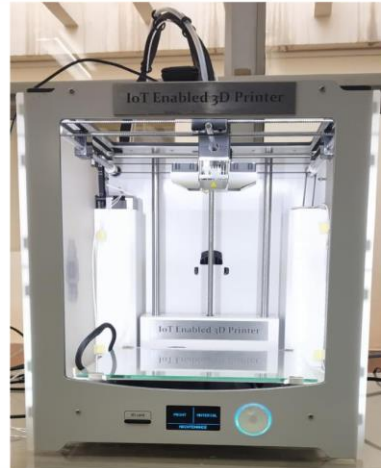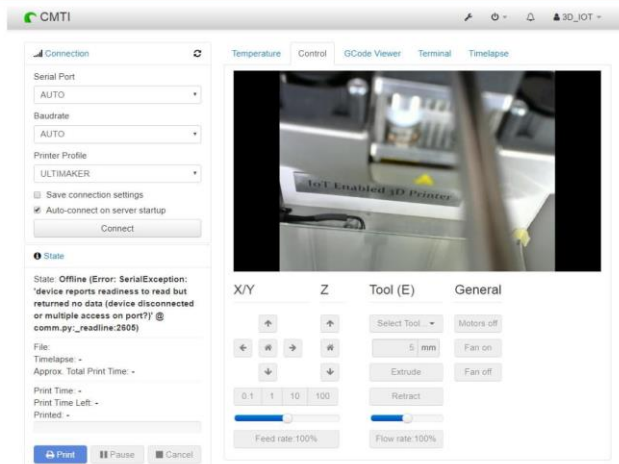
A IOT enabled Control GUI has been developed to control the 3D printer in a closed loop. The following features have been implemented.

➢ Cloud based 3D printing by uploading G-code via Any internet connected device, i.e Mobile Phones & Tablets.

➢ Cloud based closed loop monitoring of process parameters & Temperature signatures of subsystems of 3D printer

➢ A complete live fabrication process can be viewed online via IOT process monitoring camera

Awareness Programmes/ Workshops on Smart Manufacturing and I4.0

1. On 13, April 2019 at Rajkot
2. On 26, April 2019 at Hubli
3. On 21, June 2019 at Coimbatore

National Seminar/Conferences

1. Smart Manufacturing in India Taking Stock to Look Ahead on 08th, May-2019 at CMTI
2. National Conference on Smart Manufacturing and I4.0 on 30-31, May 2019.

User Meets, Exhibitions

1. IMTEX 2019, Factory of the Future Pavilion
2. Industry Meet-I(30-10-2018)
   Theme: I4.0 Industry Perspective
3. Industry Meet-II (21-12-2018)
   Theme: Theme: Steps towards Implementation of I4.0

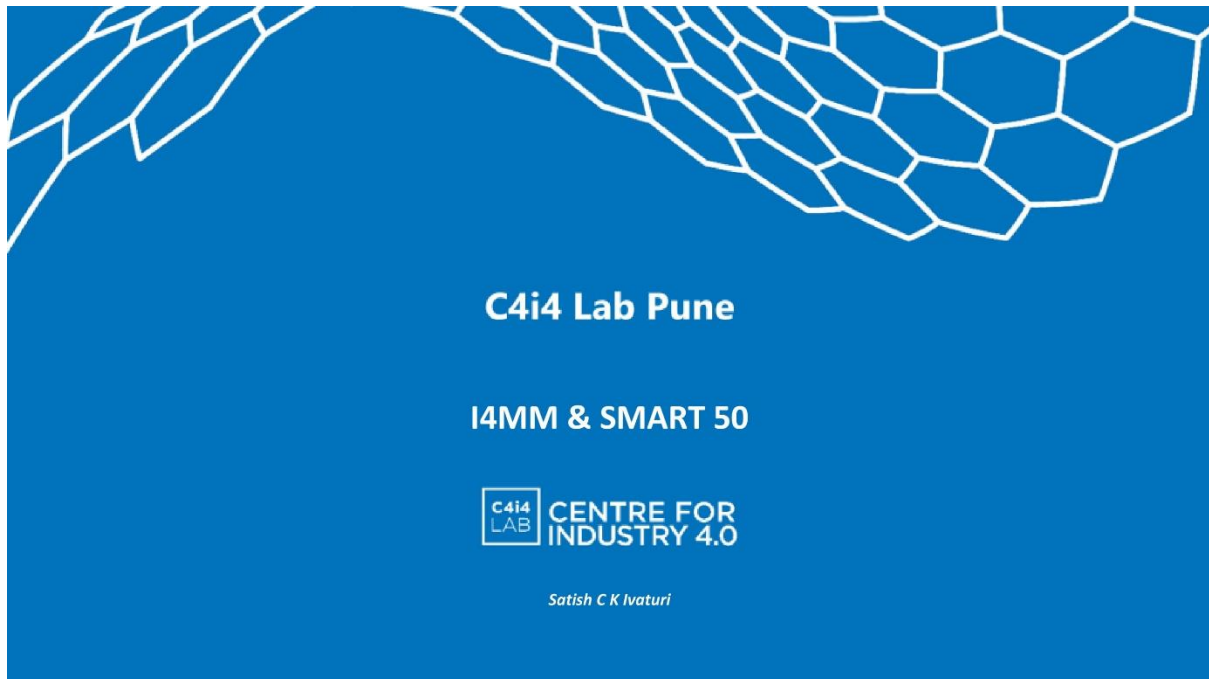## Training Programmes/Innovation Clinic on Smart Manufacturing and I4.0

1. Training programme to the Executives from Ordnance factories from 1st to 3rd July, 2019
2. Introduced regular training program to Industries and start-up companies. The first program was conducted from 29th to 31st July, 2019
3. Design Innovation Clinic for Engineering students at CMTI on 16-18, March 2019

Thank you

सेन्ट्रल मैन्युफैक्चरिंग टेक्नोलॉजि इंस्टिट्यूट **CMTi**
CENTRAL MANUFACTURING TECHNOLOGY INSTITUTE

PPT 2: I4MM & SMART 50
By: Mr Satish C Ivaturi, C4i4 Labs Pune

C4i4 Lab Pune

I4MM & SMART 50

C4i4 LAB | CENTRE FOR INDUSTRY 4.0

Satish C K Ivaturi

AGENDA

- SMART 50 - Idea

- Industry 4.0 – Latency Model view

- Industry 4.0 Maturity Model (I4MM)

- Industry 4.0 Grand Objective

- SMART 50 – DEMO

- About C4i4 Lab Pune

INDUSTRY 4.0 – OUR VIEW

Myth 1
Industry 4.0 is about extracting data from the machines so as to do analysis and derive meaningful insights out of the data.
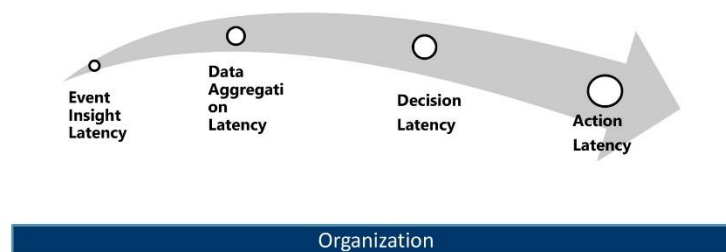
Myth 2
Industry 4.0 may result in substantial man power reductions.

C4i4's view
Industry 4.0 is more about using tools and technologies so as to reduce latencies and make a worker SMART.

TYPICAL LATENCIES IN ORGANIZATIONS

Event Insight Latency

Data Aggregation Latency

Decision Latency

Action Latency

Organization

DATA
INFORMATION
INTELLIGENCE

The Industry 4.0 Maturity Model (I4MM) is designed as a simple & effective tool to understand current state of Industry 4.0 maturity & readiness for manufacturing organizations across all industries and helps them to plan a comprehensive and sustainable digital transformation roadmap.
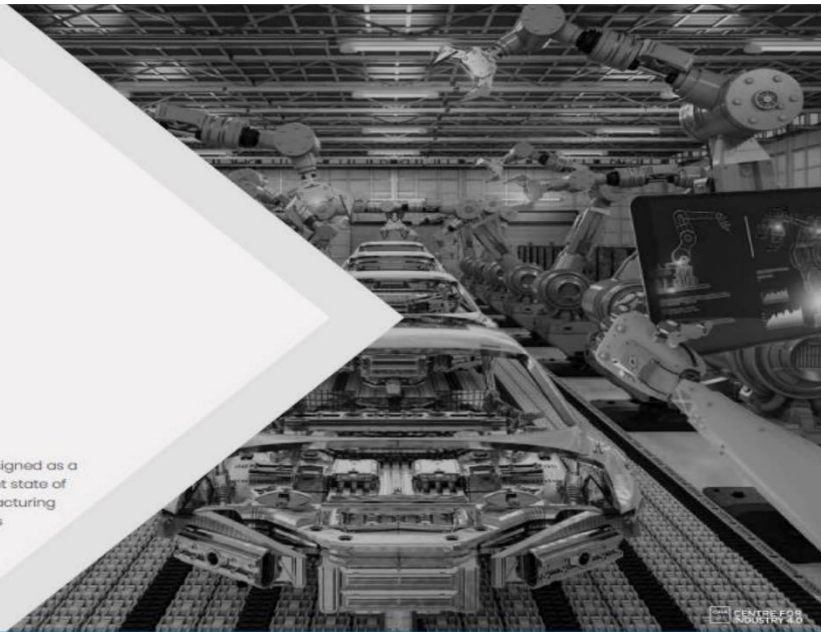
THE CHALLENGE

Industry 4.0 is no longer a buzz word. Many Indian companies are eager to transform themselves, but are uncertain about way forward. Experience of C4i4 with 1000+ companies expands the topic into three easy questions :

- **WHERE** to start Industry 4.0 journey?

- **HOW** to prepare a systematic **digital transformation** roadmap?

- **ARE** my suppliers/customers ready **for horizontal integration** of Industry 4.0 solutions?

5 LvL
I4.0 VISIONARY

4 LvL
I4.0 ACCELERATOR

3 LvL
I4.0 INVESTOR
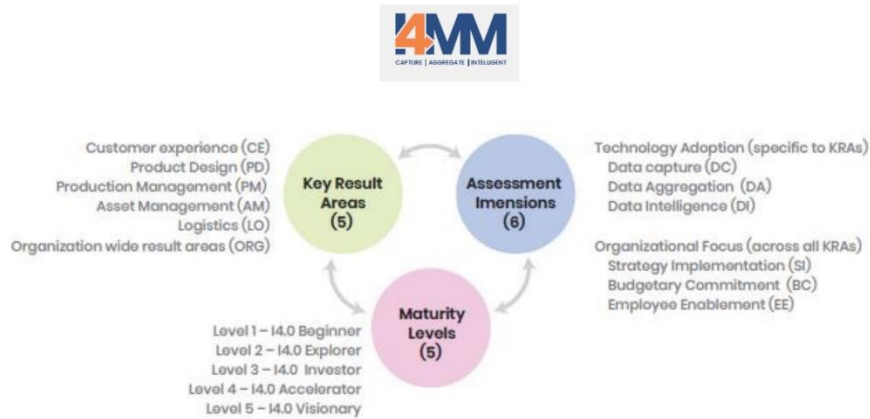
2 LvL
I4.0 EXPLORER

1 LvL
I4.0 BEGINNER

THE SOLUTION

Centre for Industry 4.0 (C4i4) Lab Pune developed an Industry 4.0 Maturity & Readiness assessment tool called Industry 4.0 Maturity Model (I4MM) specific for Indian manufacturing companies. The primary objective of this tool is to help companies:

- Understand **where they are in the** journey towards Digitalization.

- Identify & **prioritize immediate** areas for Digitalization.

- Create a successful **digital transformation roadmap.**

INDUSTRY 4.0 ASSESSMENT MODEL (I4MM)

Key Result Areas (5)
Customer experience (CE)
Product Design (PD)
Production Management (PM)
Asset Management (AM)
Logistics (LO)
Organization wide result areas (ORG)

Assessment Dimensions (6)
Technology Adoption (specific to KRAs)
Data capture (DC)
Data Aggregation (DA)
Data Intelligence (DI)

Organizational Focus (across all KRAs)
Strategy Implementation (SI)
Budgetary Commitment (BC)
Employee Enablement (EE)

Maturity Levels (5)
Level 1 – I4.0 Beginner
Level 2 – I4.0 Explorer
Level 3 – I4.0 Investor
Level 4 – I4.0 Accelerator
Level 5 – I4.0 Visionary
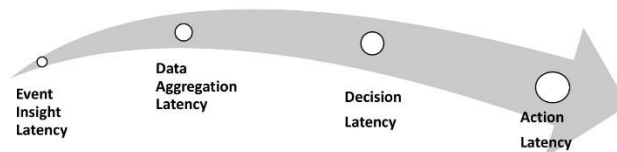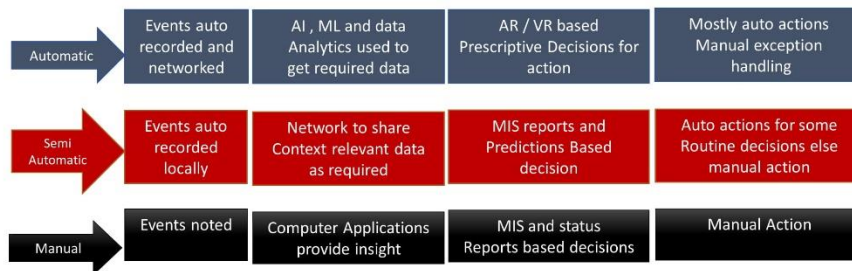
INDUSTRY 4.0 ASSESSMENT MODEL (I4MM)

HOW IT WORKS

1 Registration
Register online or send an enquiry mail to C4i4 Lab.

2 Online Assessment
Answer web based interactive Questionnaire (60) from anywhere.

3 Workshop by C4i4
Get detailed implementation roadmap with action areas prioritized based on assessment outcome, plant visit & company KPIs.

4 Assessment Report
View basic online report at the end of test. Detailed report will be mailed by C4i4.

BENEFITS

Current Digital level
Assess As-Is level of digitalization or industry 4.0 readiness of your organization.

Future Digital level
Insights on future Industry 4.0 capability requirements.

Benchmark
Benchmark digital maturity against your peers.

Showcase
Showcase Industry 4.0 maturity level to customers & stakeholder.

Showcase
Showcase Industry 4.0 maturity level to customers & stakeholder.

I4MM OVERVIEW

DATA CAPTURE (DC)
DATA AGGREGATION (DA)
EMPLOYEE ENABLEMENT (EE)
CUSTOMER EXPERIENCE (CE)
PRODUCT DESIGN (PD)
LOGISTICS (LO)
ORGANISATION (ORG)
BUDGETARY COMMITMENT (BC)
ASSET MANAGEMENT (AM)
PRODUCTION MANAGEMENT (PM)
DATA INTELLIGENCE (DI)
STRATEGY IMPLEMENTATION (SI)

Self – Assessment
Customer nominate senior/mid-level managers across departments and divisions to take **C4i4 I4MM**

Interpretation of Results
C4i4 will issue a report based on the interpretation of the outcome of Self assessment

Outcome Discussion
Discussion between Client and C4i4 Lab experts for recommendations/digitalization opportunities

OPTIONAL

Transformation Roadmap
Development of a digital roadmap, target operating model, etc. based on the results generated together in the workshop

Digitalization Workshops
Workshops for Prioritization of I4.0 activities as agreed by customer and C4i4 experts based on Assessment outcome, Shop floor understanding and Organization KPIs.

Plant Visits
Visit to Customer plant by C4i4 experts to correlate Assessment outcome with actual shop floor

TYPICAL LATENCIES IN ORGANIZATIONS

Automatic	Events auto recorded and networked	AI , ML and data Analytics used to get required data	AR / VR based Prescriptive Decisions for action	Mostly auto actions Manual exception handling
Semi Automatic	Events auto recorded locally	Network to share Context relevant data as required	MIS reports and Predictions Based decision	Auto actions for some Routine decisions else manual action
Manual	Events noted	Computer Applications provide insight	MIS and status Reports based decisions	Manual Action

Event Insight Latency

Data Aggregation Latency

Decision Latency

Action Latency

Organization

SAMPLE ASSESSMENT OUTCOME

NOTES

1. Low Scores do not indicate any poor performance

2. Low scores in CE, PD, PM, AM, LO only point out to Opportunities for Improvement in terms of Data Capture or Data Aggregation or Data Intelligence

3. Low scores at Organization level only point out to Opportunities for Improvement in terms of Strategic Implementation, Budgetary commitment or Employee Enablement

4. Results do not indicate exact state of operations of the organization. Instead, they reflect how the respondents(employees) are perceiving the state of operations of their organization.

5. There is no Right or Wrong answer to a specific question.

6. Each option points out to certain level of Technology Adoption / Organizational Focus of the organization. It is up to the stakeholders inside the organization to decide the target level of maturity and develop a roadmap for improvement.

ASSESSMENT – OVERVIEW

- Participant Company : American MNC in India

- No of respondents for the Questionnaire : 3 (Groups)

- Overall I4.0 Maturity Level : I4.0 Explorer

- Opportunities for Improvement : Asset Management

CENTRE FOR INDUSTRY 4.0

CONSOLIDATED - SCORING SUMMARY

KRA / AD	Data Capture	Data Aggregation	Data Intelligence	Strategic Implementation	Budgetary Commitment	Employee Enablement	Grand Total
ORG		2.00	3.17	3.58	2.50	2.93	**2.87**
Customer Experience	1.72	2.00	2.22	2.17	2.00		**2.04**
Product Design	3.33	2.11	2.39	2.44			**2.42**
Production Management	2.28	2.78	3.00				**2.69**
Asset Management	1.17	2.50	1.33				**1.57**
Logistics	2.33	1.67	2.17				**2.10**
Grand Total	1.93	2.23	2.49	2.57	2.40	2.93	**2.34**

Note: Areas of Improvement are highlighted in Red

CENTRE FOR INDUSTRY 4.0

SAMPLE RESULT – IMMEDIATE AREAS OF IMPROVEMENT

S.No	Q.Code	Score	Question Details
1	AM-DC001	1.00	What is the level of sophistication of material handling equipment? (KRA- AM, AD-DC)
2	AM-DC006	1.00	How are services requests created and managed? (KRA- AM, AD – DC, DA)
3	AM-DC003	1.33	How does machine or process condition monitoring lead to machine maintenance? (KRA- AM, AD-DC,DA)

SAMPLE RESULT – IMPLEMENTATION ROADMAP

How does machine or process condition monitoring lead to machine maintenance? (KRA- AM, AD-DC,DA)

a. A set of parameters are manually monitored periodically to trigger manual action for maintenance

b. Historical data is collected and parameter values analyzed periodically to decide if maintenance is required, and when it can be taken up

c. Data driven early warning systems exist that warn operator for any existing or impeding problems with machines that require to take action

d. A set of parameters are continuously generated and collected automatically and later sent to central system that generates warning messages or decides on maintenance actions to be taken, in offline mode

e. Machine data is transmitted to a central system continually to intelligent systems that take preemptive action or trigger specific actions like conditional maintenance in real time

OUR ROOTS

Nation building initiative, devised to transform India into a global design and manufacturing hub

SAMARTH Udyog

Smart & Advanced Manufacturing & Rapid Transformation Hubs

ABOUT C4I4 LAB

C4i4 Lab Pune is the one of its kind centre setup by Government with a Public Private partnership model catering to all sizes of companies Pan-India

C4i4 Lab Pune closely works with

- Domain Experts
- Technology Experts
- Business Ambassadors
- Industry Associations

C4i4 Vision & Strategic Objectives are evolved with active participation of each of the stakeholders.

OUR VISION & ASPIRATIONS
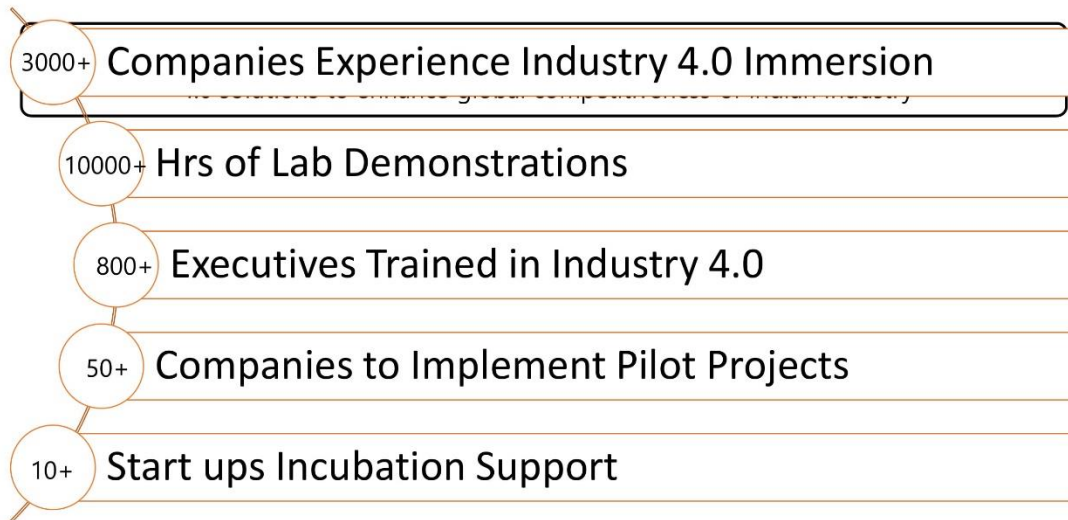
3000+ Companies Experience Industry 4.0 Immersion

10000+ Hrs of Lab Demonstrations

800+ Executives Trained in Industry 4.0

50+ Companies to Implement Pilot Projects

10+ Start ups Incubation Support

C4I4 LAB PUNE OFFERINGS

FOR ORGANIZATIONS

I4.0 Enablement Learning → I4.0 Model Factory Demonstration → I4.0 Assessment & Roadmap Workshops → I4.0 Implementation Advisory

OUR OFFERINGS PROVIDE COMPLETE END-TO-END INDUSTRY 4.0 JOURNEY SUPPORT FOR MANUFACTURING COMPANIES

FOR ACADEMIA/ORGANIZATIONS

I4.0 for Academia

I4.0 Certification Program

PPT 3: The Awareness Programme on Industry 4.0, The Industry Perspective

By: Mr Anup Wadhwa, Director, IITD-IAFSM

AWARENESS PROGRAMME ON INDUSTRY 4.0
The Indian Perspective

November 6, 2019 (Wed.)

CICU Complex, Phase-V, Focal Point, Ludhiana

Dr. Sunil Jha, Professor
Department of Mechanical Engineering,
IIT Delhi, Hauz Khas, New Delhi - 110016
suniljha@mech.iitd.ac.in

IITD-AIA Foundation
for
Smart Manufacturing
www.iafsm.in

Sunil Jha, Department of Mechanical Engineering, I.I.T. Delhi   1

Challenges 4.0

4 Major Challenges of your Organization

1. More Customers Globally — 5 New
2. Customer Satisfaction/Delight
3. Capacity to Produce More (Uptime) 100%
4. Lean Manufacturing (more adaptive)
5. Monitoring Process (insight)
6. Zero Rejections (Defects) (BAD) – Break, Accident, Defects.
7. People.

Manufacturing Challenges

Higher % Rejections   **Low OEE**   **Process variations**

Lack of operations insight

Extensive Rework

Sub-optimal Process control

Un/Semi-skilled manpower

Long setup and production time

Scattered & unstructured information

Unprecedented downtime

Delayed Decision Making

Machine Maintenance

FSM

Challenges vs Technologies

Real Time Information

Data Visualisation

Data Analysis

Remote Maintenance

Smart Machine Interface

Augmented Reality

AI & Machine Learning

Additive Manufacturing

Collaborative Robots

Machine Vision

FSM

Smart Manufacturing

Economic Potential

Ability to **accelerate** corporate **decision-making** and **adaptation** processes

Agility

Ability to implement **changes**
in the company in **real-time**

Corporate Adaptation Processes
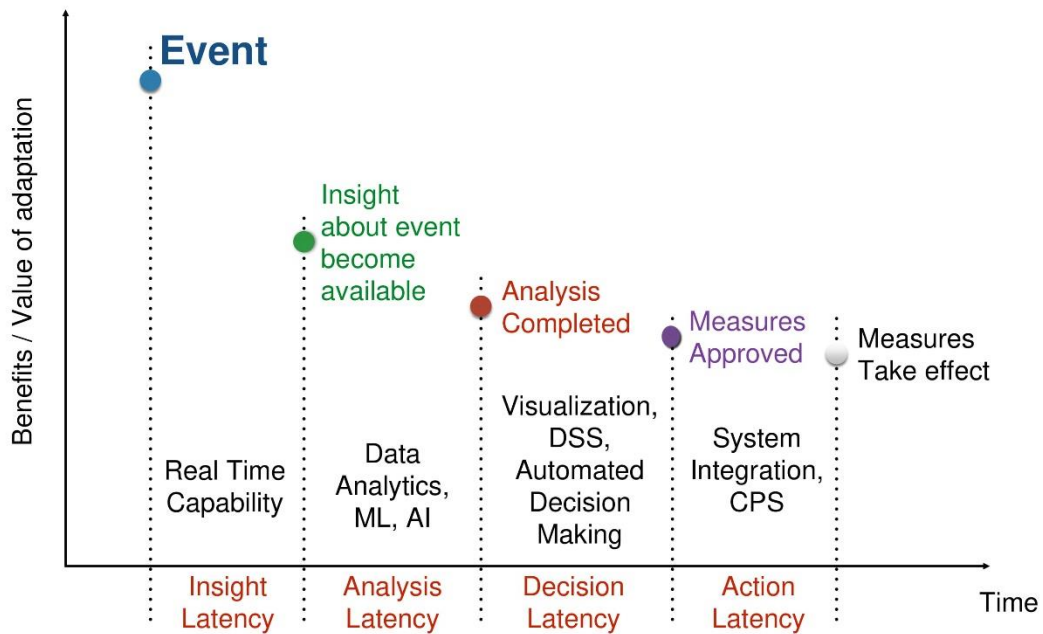
Source: based on Hackathon 2002; Muehlen/Shapiro 2010

Stages in Smart Manufacturing

6	**Adaptability**	**Self-optimize**: How system adapt to change?
5	**Predictive Capacity**	**Being Prepared**: What will happen?
4	**Transparency**	**Understanding**: Why is it happening?
3	**Visibility**	**Seeing**: What is happening?
2	**Connectivity**	Foundation / Prerequisite
1	**Computerisation**	

Industry 4.0

Digitalisation
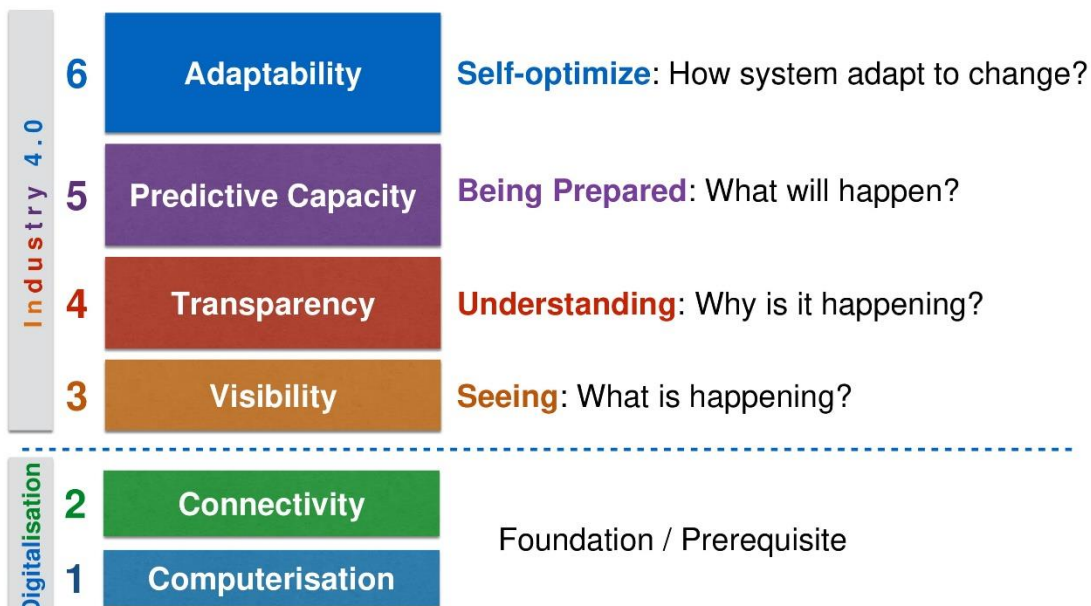
(source: RWTH Aachen University)

Machine
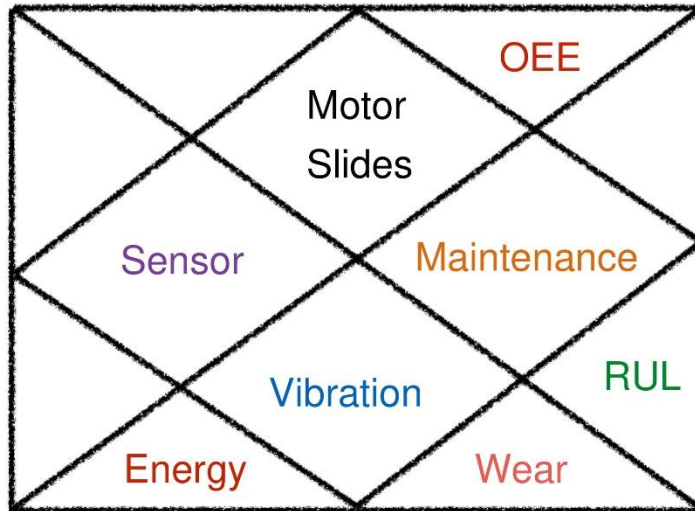
Smart Manufacturing Technologies

Remote Visibility & Insight
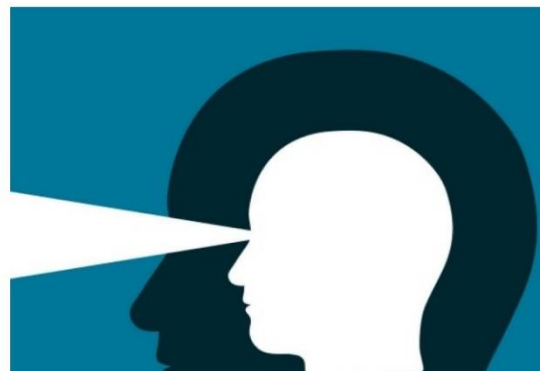
Insightful real-time information for effective decision making

Realtime Dashboards

FSM
Web Ordering
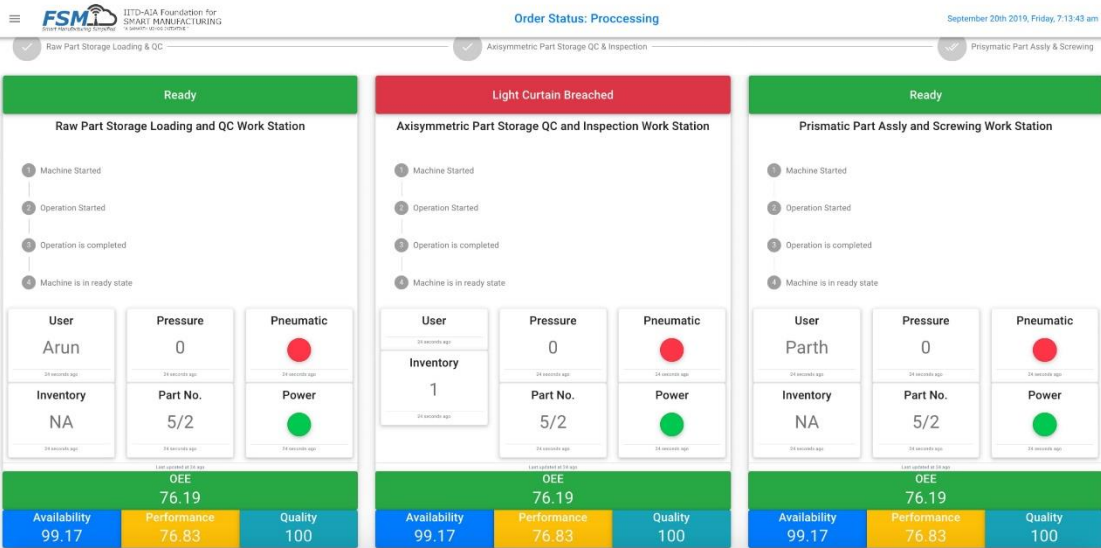
Live Dashboard
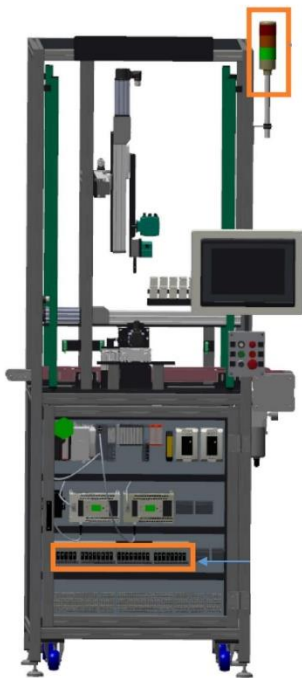
Remote Access

Remote Access to Machine HMI
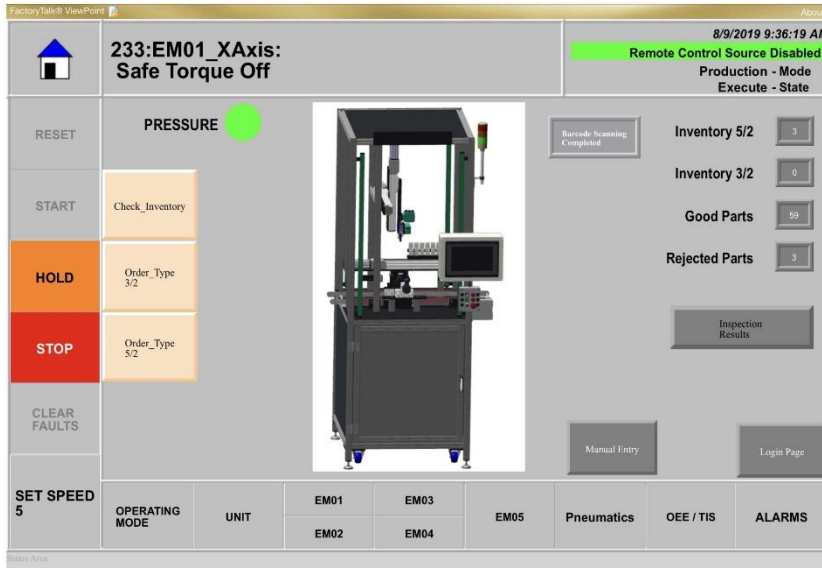
Live

Remote Access to Development System
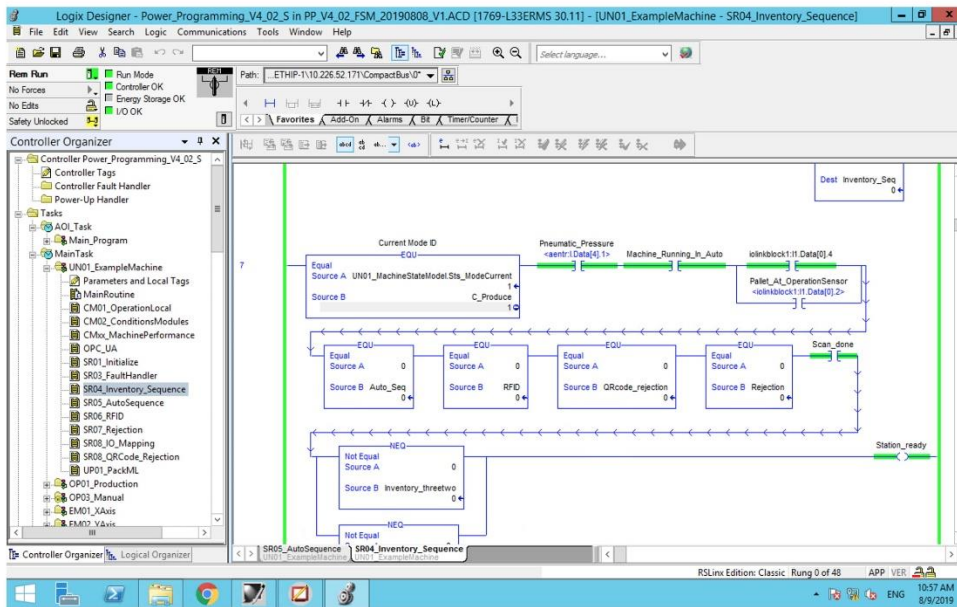
Remote Expert Support on Shop Floor
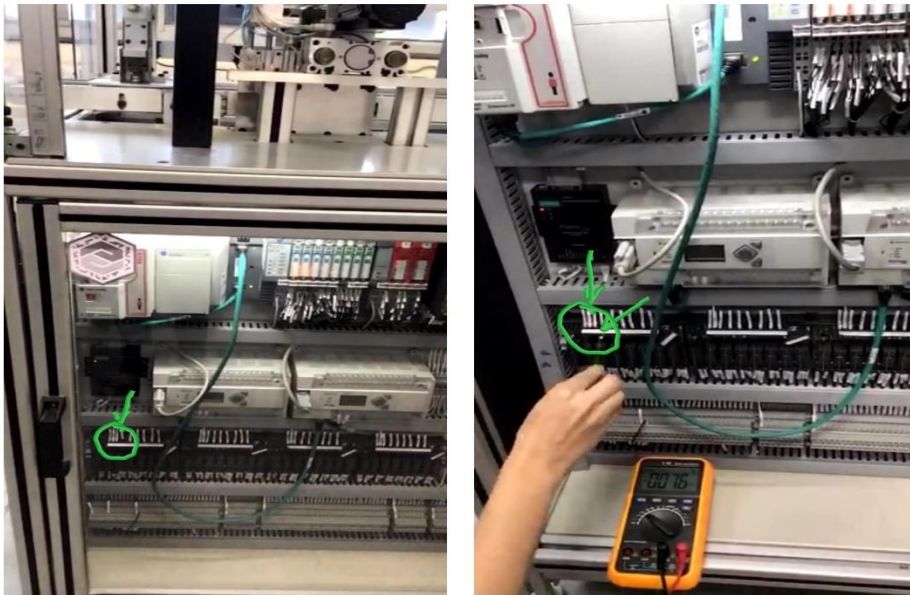
Understanding Critical Systems of a Machine

Mechanical System

Electrical System

Control System

Communication System

Pneumatic System

Hydraulic System

Digital Representation of System & Data
CAD, PLM, IIoT

System Behaviour Analysis & Fault Diagnosis
CPS, Digital Twin, ML

Remote Access & Maintenance
Augmented Reality
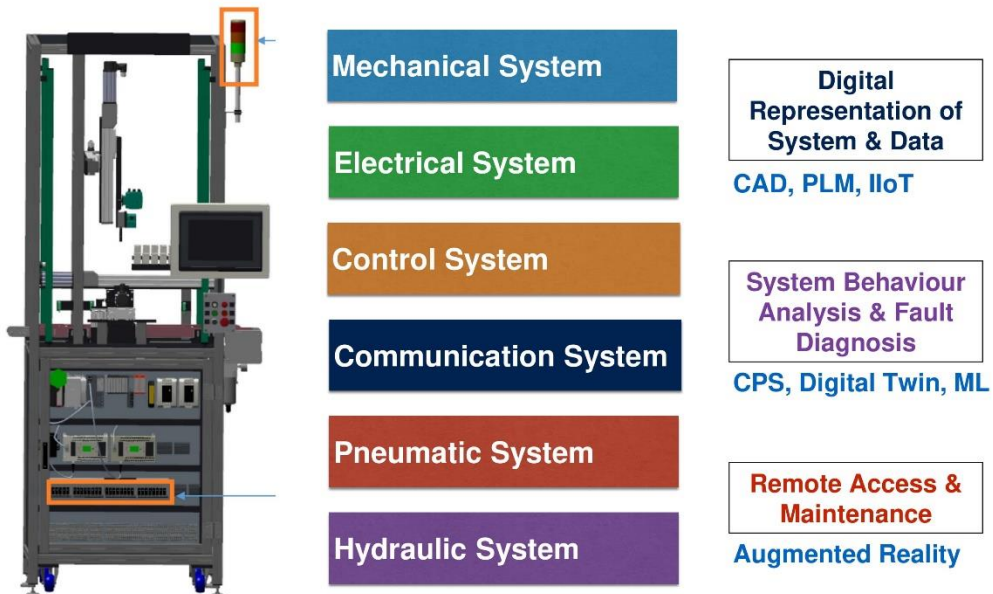
Augmented Reality in Maintenance

Electrical Fault Finding Approach

CAD Model	Electrical Schematic	IIoT	Augmented Reality
Digital replica of Physical System	When Synced with CAD model Add Electromech layer of information	Provides data, when analysed gives the detailed information about machine's running state	Provides GUI to the digital data in user understandable format
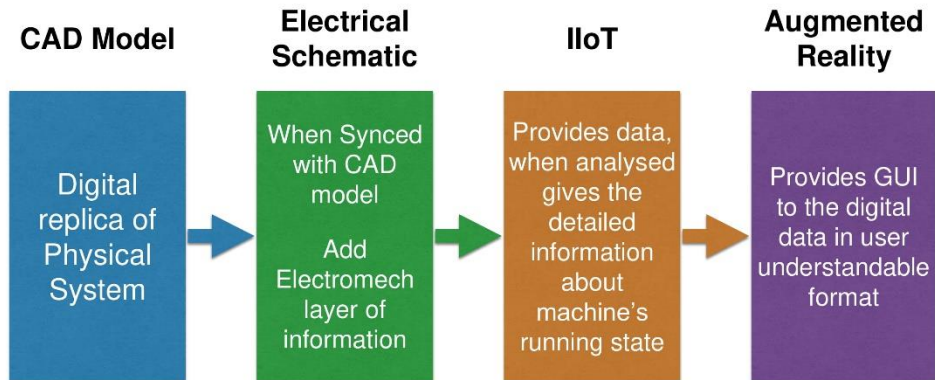
AR Guided Electrical Maintenance

Cyber Physical Assembly Line

FSM

Electromechanical Component Assembly

1 Raw part Storage, Loading & QC	2 Axisymmetric part Storage, QC & Insertion	3 Prismatic Part Assembly & Screwing

☐ ←→ Conveyor **Pallet with RFID**	←→ Conveyor	Conveyor ←→

Robot Multiprocess Cell

4d Raw part Storage, Loading & QC	4e Axisymmetric part Storage QC & Insertion	4f Prismatic Part Assembly & Screwing
	←→ Conveyor	←→ Conveyor
4c Finished Product Storage	4b Product Packaging	4a Product Functional Testing

---

Cyberphysical Assembly Line

FSM
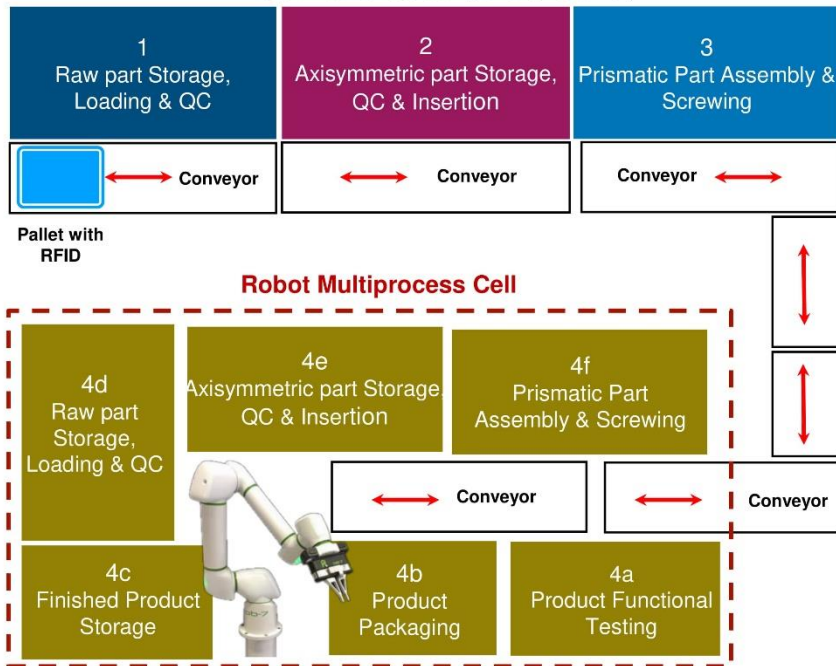
Raw part Storage, Loading & QC	Axisymmetric part Storage, QC & Insertion	Prismatic Part Assembly & Screwing

Smart Machine Interfaces

FSM

Voice Interaction

Whatsapp messaging

Voice Call

Augmented Experience

Using AI, NLP, ML, Analytics

Smart Machine Interfaces

FSM

Using AI, NLP, ML, Analytics

Smart Factory Connectivity for IIoT

Cyber Physical System (CPS)

- Making **machine tools intelligent** for Smart Factory which can implement **self-aware**, **self-prediction**, **self-compare**, and **self-configure** to be more **resilient** to dynamic changing environments
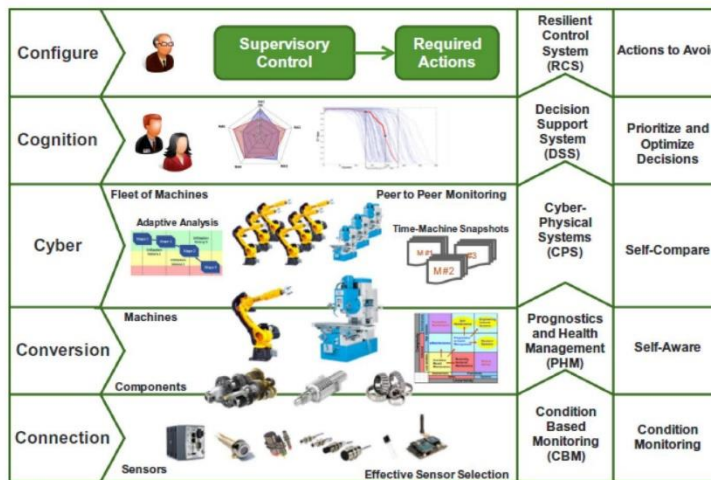
Going on with Machine Learning
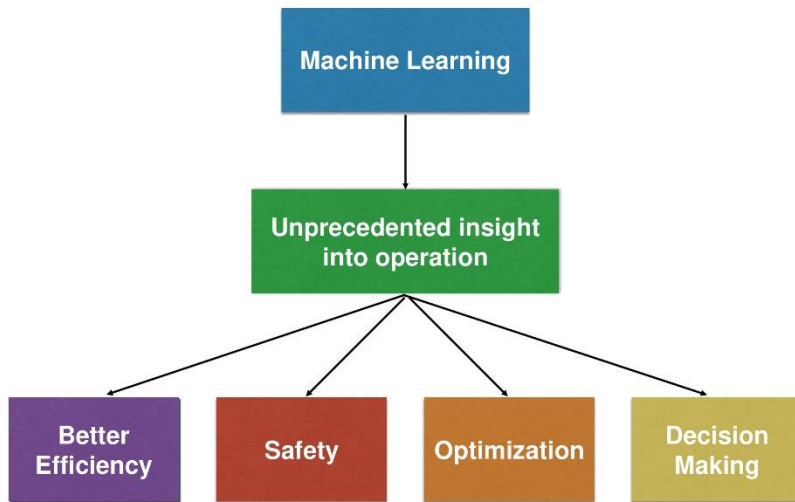
Technology Development

IIoT Gateway for Legacy Machines

Key features
- Indigenously developed low cost hardware
- Easy to program open source interface
- Communication with standard PLCs - Profinet, S7, Modbus TCP
- OPC-UA connectivity
- Web Visualization
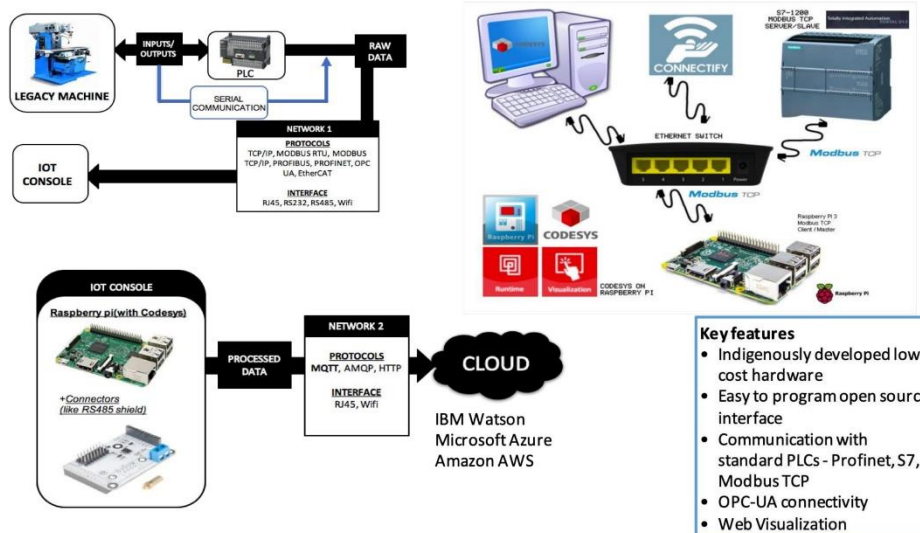
Technology Development

Machine Vision

Camera: Basler acA4024-29um Ace
Lens: Ricoh FL-BC3518-9M

Pallet with Valve Body

Spool

Workpiece
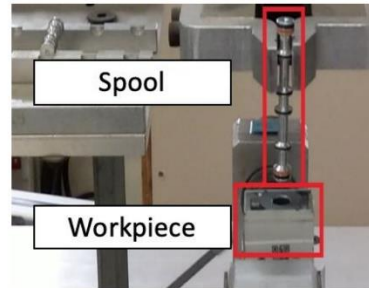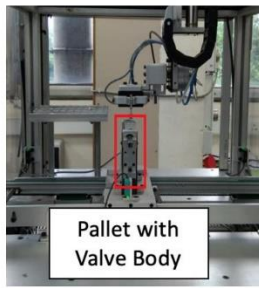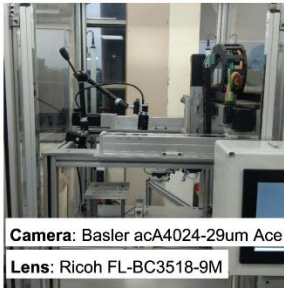
```
a1 = imread('vb52_dbg_scale.png');
imshow(a1);
im = imbinarize(a1);
[B,L,N,A] = bwboundaries(im);
imshow(im);
hold on;
for k = 1:N
    if (nnz(A(:,k)) > 0)
        boundary = B{k};
        plot(boundary(:,2),...
             boundary(:,1),'r','LineWi
        for l = find(A(:,k))'
            boundary = B{l};
            plot(boundary(:,2),...
                 boundary(:,1),'g','Li
        end
    end
end
```

In collaboration with **MathWorks®**
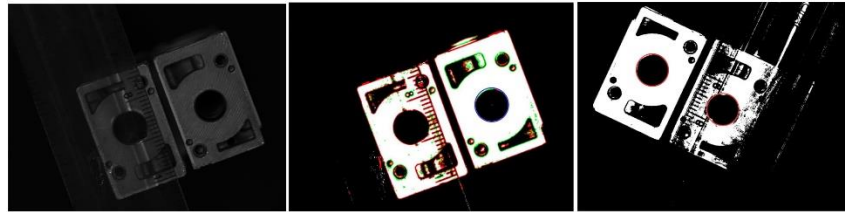
Actual Dia: 8.00 mm
Measured Dia: 7.95 mm

Error in Dia: 0.05 mm

Digital Twin

IIoT
CPS
ML

Model

Can you assemble
Flow Control Valve?

What will be vibration
level if i run conveyor
at 2 m/min?

Which component is
responsible for major
downtime?

When is next
maintenance required?

Digital Twin

Digital twins - **Dynamic Digital Representations** that enable companies to **understand**, **predict**, and **optimize** the performance of their **machines** and their **business**.

By applying **Advanced analytics** and **Machine learning** to continuously improving asset models, **Digital Twins** gain enough resolution to drive important business outcomes - **Asset optimization**, **Manufacturing efficiency**, and **Machine operator intelligence**.

Physical Science	Data Science	Learning System

IITD-AIA Foundation For SMART MANUFACTURING

Ministry of Heavy Industries and Public Enterprises

Department of Heavy Industry (DHI)
Scheme for enhancement of competitiveness in the Indian Capital Goods Industry

(GoI Notification No. 7/6/2011- HE&MT dated 5.11.2014)

IITD-AIA FSM is one of the four pivotal agencies engaged with creating "**Samarth Udyog**", India's very own platform for **Industry 4.0** (under the aegis of DHI)

Academic Partner + **Industry Partner** → IITD-AIA Foundation For SMART MANUFACTURING

Industry-Academia Partnership

Industry Partners

B&R | MITSUBISHI ELECTRIC *Changes for the Better*

Rockwell Automation | PEPPERL+FUCHS

KUKA | ptc | HEXAGON

MSC Software | FESTO

SIEMENS

More Partners to Join …

Govt. Support
Department of Heavy Industry (DHI)
Govt. of India

Faculty @ IITD

S.No.	Name	Department
1	Prof. Sunil Jha	Mechanical Engineering
2	Prof. P. M. Pandey	Mechanical Engineering
3	Prof. Sitikantha Roy	Applied Mechanics
4	Prof. Kolin Paul	Computer Sc. &Engg
5	Prof. S. Bhasin	Electrical Engineering
6	Prof. S. K. Saha	Mechanical Engineering
7	Prof. Tapan Gandhi	Electrical Engineering
8	Prof. Jayant Jain	Applied Mechanics
9	Prof. Jyoti Kumar	IDDC
10	Prof. Bhaskar Mitra	Electrical Engineering
11	Prof. A. K. Darpe	Mechanical Engineering

www

Common Engineering Facility

Partners

- Technology Partners
- Digital Manufacturing Intergrators
- Digital Business Architects
- Skill Partners
- Process Innovatrion Partners
- Machine Builders
- End Users
- Education Partners
- CSR Partners

FSM
Smart Manufacturing Simplified

www.iafsm.in

Industry Engagement

- **Awareness on Smart Manufacturing Technologies**
  (Access to FSM programs / Specialised cluster specific)

- **Readiness Assessment** (Onsite Survey)

- **Proof of Concept** (Handholding for First Pilot project)

- **Skilling people** (Hands on Training)

- **Road map** (for scaling & process improvement)

Thank You

Creating Together, for India!

PPT 4: Internet of Things and its applications in Industry, Dr Sujata Pal, Associate Professor, IIT Ropar

Internet of Things and its Applications in Industry 4.0

Prepared & Presented by

Dr. Sujata Pal
PhD: IIT Kharagpur
Post-Doc: University of Waterloo, Canada
Assistant Professor
Computer Science & Engg.
IIT Ropar

Note: All images are copied either from the existing research papers or from the original sources.

Nov 2019   Prepared by Dr. S Pal

WANet (Wireless Ad hoc Networks) group

- PhD
  - → Avani Vyas (Wireless Body Area Networks)
  - → Vivek Sethi (Vehicular Ad hoc Networks)
  - → Priyanka Kamboj (Software Defined Networks)
  - → Vidushi Agarwal (IoT)

- Graduated
  - → Neeraj Sharma, MS (With Dr. Junghyun Jun), MS, 2019
  - → Amit Behal (Delay Tolerant Networks), MS, 2019

Why IoT?

- We are lazy?

- We want to control everything remotely.
- We want to automate everything.
- We want to see data in real-time.

Internet of People/Things

Internet of People, 2010
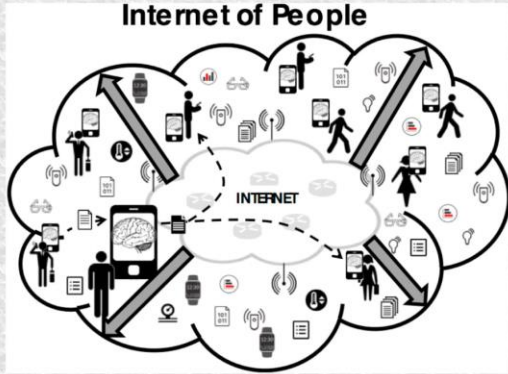
Source: The Internet of People (IoP): A new wave in pervasive mobile computing, Marco Contia Andrea Passarellaa, Sajal K.Das, Pervasive and Mobile Computing, 2017

People connected to Internet

Internet of Things, 2020

https://towardsdatascience.com/iot-in-action-a8b7fac83619
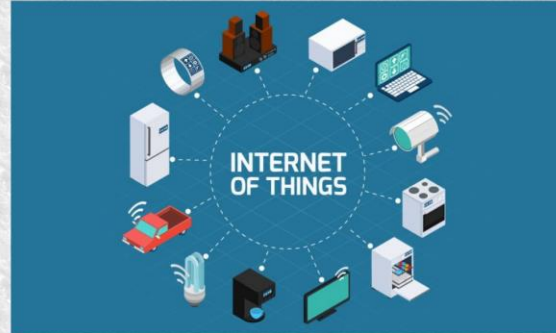
People connected to Internet + Things connected to Internet + Things connected to things

---

IoT

- The goal of IoT is to "connect the unconnected"
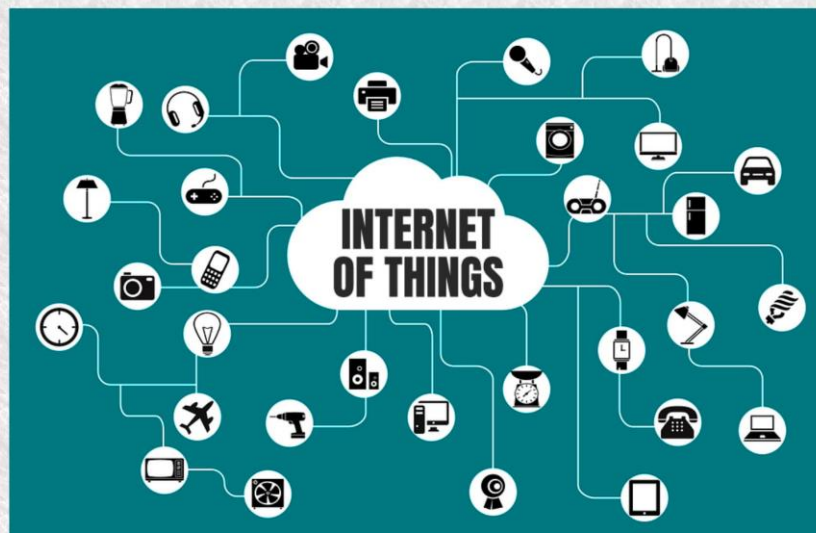
Internet of Things (IoT)

- The Internet of Things (IoT) [1,2] is the network of physical devices, vehicles, home appliances, and other items embedded with electronics, software, sensors, actuators, and *connectivity, which enables these things to connect and exchange data.*

Copied from https://en.wikipedia.org/wiki/Internet_of_things#/media/File:Internet_of_Things.jpg

1."Internet of Things A to Z: Technologies and Applications". Wiley.com. 2018-06-13. Retrieved 2018-06-05.
2."Internet of Things Global Standards Initiative". ITU. Retrieved 26 June 2015.

Evolutionary Phases of the Internet

Evolution of the Internet in five phases.

- Connecting two computers together

- Creating World Wide Web by connecting large number of computers together

- Connecting mobile devices to the Internet

- Then, peoples' identities joined the Internet via social networks.

- Finally, connecting every day objects to the Internet.
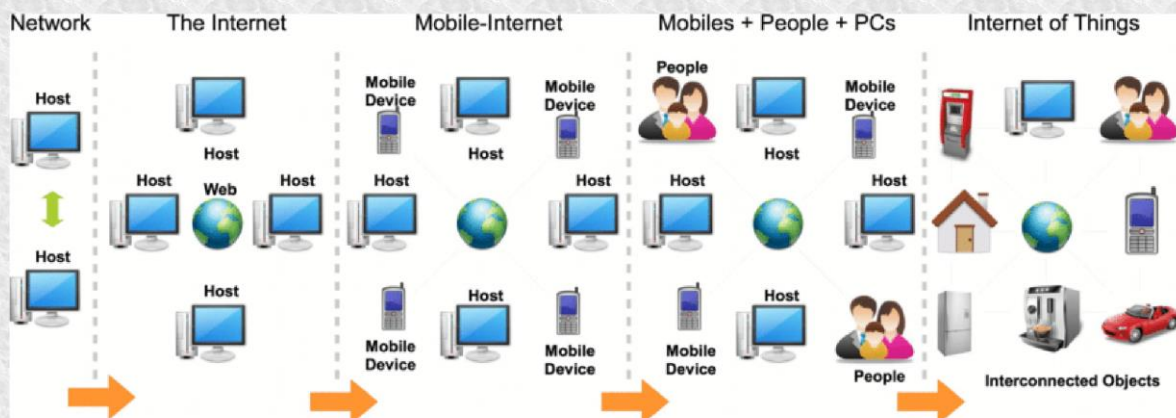
Where is IoT?

- It's everywhere!

Healthcare
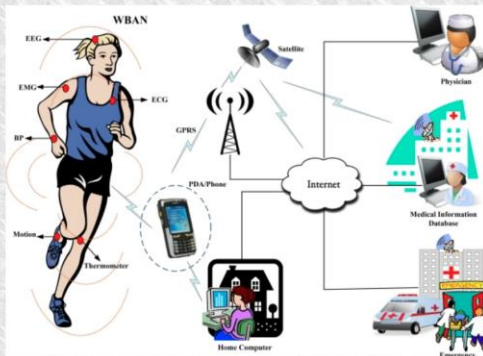
A Study of IEEE 802.15.4 Security Framework for Wireless Body Area Networks, Shahnaz Saleem, Sana Ullah, Kyung Sup Kwak

Industry Automation

Source: https://www.gadgeon.com/iot-products/iiot-platform-delpheon/

Agriculture

Smart Agriculture and Irrigation Monitoring System using IOT, Sourav Sarkar

Smart Home

Thinking about an IoT device for your home? Check security first.https://www.fierceelectronics.com/electronics/thinking-about-iot-device-for-your-home-check-security-first

---

How IoT works?

- Tons of data are generated from the devices in the world.

- Where could we store this data?

- Answer is "Cloud"

- Next part is "Data Analytic"

- Data collected from the devices is qiute large and complex that becomes difficult to analyse using traditional data collecting techniques, we call those data as Big Data.

- Analytics deals with the extraction of meaningful data from big data.
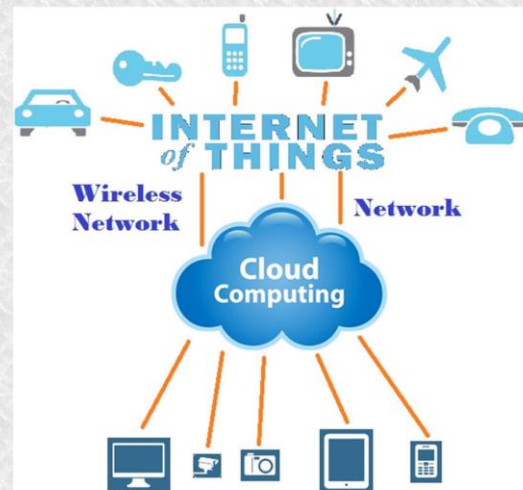
Sensors in the Internet of Things

- Two important things of IoTs ecosystem are
  - *The Internet and*
  - *Physical devices like sensors and actuators.*

FIVE SENSES LINE ICONS

Sight

Smell   Hearing

Touch   Taste

Human

Things + Sense & communicate

Things

Source: https://www.centricabusinesssolutions.com/blogpost/5-uses-smart-sensors-manufacturing

---
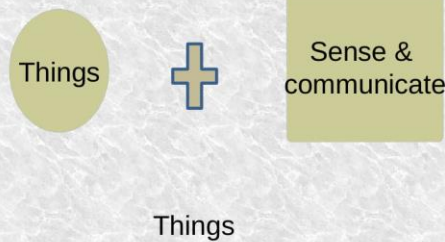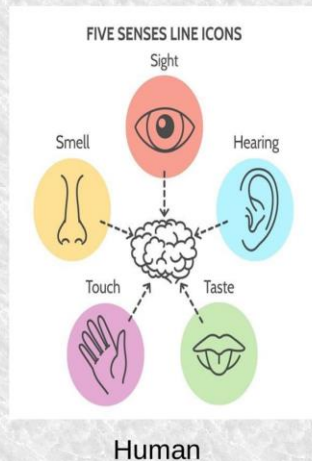
Industrial Internet of Things (IIoT)

- The industrial internet of things (IIoT) is the use of smart sensors and actuators to **enhance** manufacturing and industrial processes.

- Also known as the industrial internet or Industry 4.0.

- The IIoT is an evolution that allows a higher degree of automation by using cloud computing to refine and optimize the process controls.

IIoT and IoT

- The IoT can be thought of as two types of network, coined by Human IoT and the Industrial IoT

- The "Human IoT" is characterized as having human interaction and include a person using a device (phone, tablet, computer, etc.). For example, it includes most consumer and wellness devices.
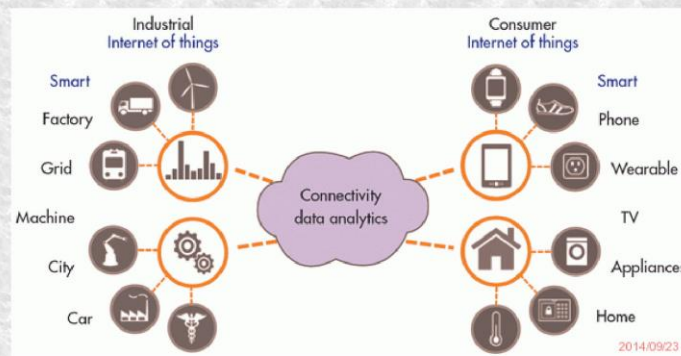
M2M vs IoT

- In IIoT, primarily devices work with one another without human interaction or intervention (M2M).
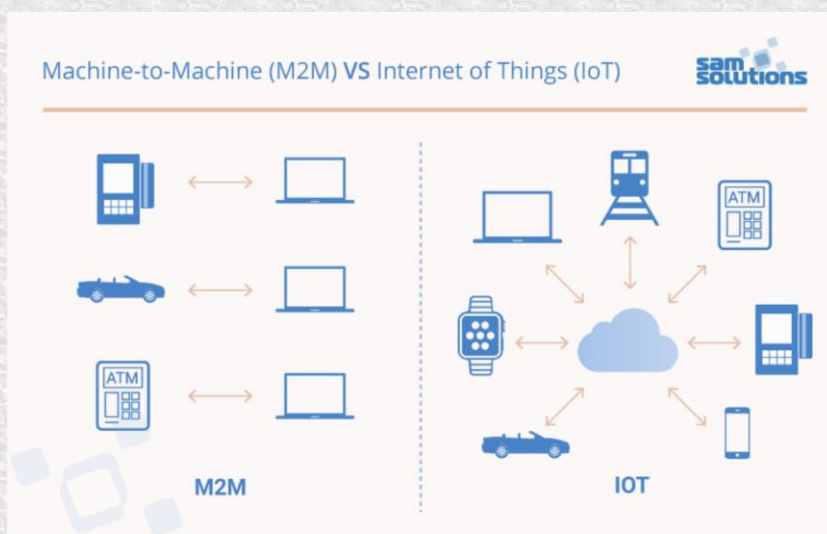
Industry 4.0

- Industry 4.0 is the subset of the fourth industrial revolution that concerns industry.

- Industry 4.0 factories have machines which are augmented with wireless connectivity and sensors, connected to a system that can visualise the entire production line and make decisions on its own.

Industry 1.0
The Industrial Revolution begins. Mechanization of manufacturing with the introduction of steam and water power

Industry 2.0
Mass production assembly lines using electrical power

Industry 3.0
Automated production using electronics, programmable logic controllers (PLC), IT systems and robotics

Industry 4.0
The 'Smart Factory'. Autonomous decision making of cyber physical systems using machine learning and Big Data analysis. Interoperability through IoT and cloud technology.

Components of Industry 4.0

- Cyber-physical systems
- Cloud computing
- Cognitive computing
- IoT
- etc.
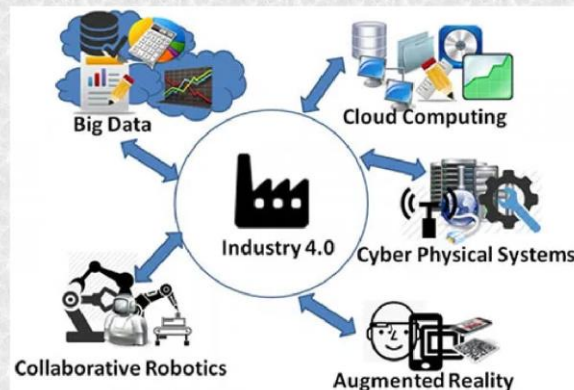
IoT

- IoT is a technology transition in computer network
  - allow us to sense and control the physical world by making objects smarter and connecting them through an intelligent network

- Connections of object with machine improve
  - Efficiency,
  - Accuracy
  - Automation
  - Enables advance applications

The overall picture of IoT

Copied from "Internet of Things: A Survey on Enabling Technologies, Protocols, and Applications", Ala Al-Fuqaha, Mohsen Guizani, Mehdi Mohammadi, Mohammed Aledhari, and Moussa Ayyash, IEEE COMMUNICATION SURVEYS & TUTORIALS, VOL. 17, NO. 4, FOURTH QUARTER 2015

The IoT elements

- Identification- Ex: Electronic product codes (EPC)

- Sensing- Ex: Smart sensors, actuators or wearable sensing devices, RFID tag

- Communication- Ex: WiFi, Bluetooth, etc.

- Computation- Hardware: Arduino, Raspberry PI, Mulle, and T-Mote Sky

- Software: Contiki, TinyOS

- Services: Smart home, Intelligent transportation systems, Smart healthcare etc.

- Semantics: Semantic in the IoT refers to the ability to extract knowledge smartly by different machines to provide the required services.

Challenges in IoT

- Scalability: Million of devices connected to form IoT

- Security: Things become connected, So security becomes complex

- Privacy: which data to share with whom?

- Technological standardisations:
  - various protocol and architecture
  - different technology leads to interoperability issue
  - Recent IoT standards are helping minimizing this problem

- Big data and Data analytics:
  - massive amount of sensor data
  - from different sources and various forms
  - extract intelligence form the heaps of data

Pollution Check using IoTs

S. Pal, *A. Ghosh, V. Sethi, "Vehicle Air Pollution Monitoring Using IoTs", in Proc. of 16 th ACM International Conference on Embedded Networked Sensor Systems (SenSys), Shenzhen, China, 2018.*
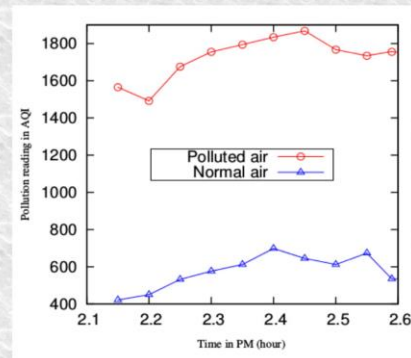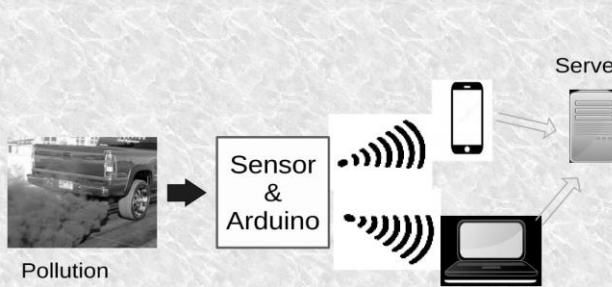
Posture Correcting Chair

Guided by Me (Btech 2nd year Students)

- Aman Pandey
- Anmol Kumar
- Aman kumar
- Gyan Prakash Singh

https://www.youtube.com/watch?v=_krcZkFwCtI&feature=youtu.be

Mechanical Prosthetic Arm

Guided by Me (Btech 2nd year Students)

- Bhawna, Abhineet, Harshit, Akansha, Hersh

https://www.youtube.com/watch?v=oBxRbCkRGzo&feature=youtu.be

3D-Mapping Using Li-DAR

Guided by Me (Btech 2nd year Students)

- Adarsh Kumar
- Dilip Sharma
- Rama Krishna
- Manoj Gudi

https://www.youtube.com/watch?v=6kJ5JbySaB0&feature=youtu.be

- SMART_TALKING_MIRROR

- SHUBHENDRA GAUTAM
- 17 subscribers
- Right now in this 'SMART_TALKING_MIRROR', I have used "RASPBERRY PI 3B+". Later on, I will be using ROCK64 or "ASUS TINKER BOARD S" for better processing.
- This TALKING MIRROR can be controlled by voice with this TALKING MIRROR you can ask for any information which is present on google. With this TALKING MIRROR you can do "HOME AUTOMATION" easily, and with this mirror, you can read your emails and notification.
- #SMART_TALKING_MIRROR

https://www.youtube.com/watch?v=eZ4KuTRJPe0&feature=youtu.be

Annexure 4: Photos of Industry 4.0