Industry 4.0 Awareness Seminars Reports Template

1.	Date of the Seminar	21 June 2019
2.	Organizers	CII and CMTI
3.	Title of the seminar	Awareness Programme on Smart Manufacturing and Industry 4.0 The Indian Perspective
4.	Programme	Annexure 1
5.	Report: suggested contents (1) Main takeaway / good suggestions (2) Clusters covered - **Coimbatore** (3) Nos attended - **75** (4) Success stories that need to be compiled / shared – **PPT on Smart Sensors & Controllers**	**Main takeaway / good suggestions** • Information on Smart Sensors and controllers, smart machines & intelligent machining • Learning importance of machine accuracy • Understanding of big data and cloud computing • Industry & Research institutes are way to behind in technology • Detailed study is required before implementing smart
6.	List of Speakers with contact details	Annexure 2
7.	Presentations	Annexure 4
8.	Resource persons for providing consultancy, skilling, guidance etc.	• **Prof Dr P Radhakrishnan, Director** Nanotech Research Facility PSG Institute of Advanced Studies • **Mr V S Shanmugaraj** Scientist - F & Head SVT
9.	Photographs	Annexure 3
10.	Learnings from the seminar	Audience wanted more case studies rather than theoretical presentations

Annexure 1

Confederation of Indian Industry

Department of Heavy Industry
Government of India

CENTRAL MANUFACTURING TECHNOLOGY INSTITUTE

Awareness Programme on Smart Manufacturing and Industry 4.0
The Indian Perspective

Date: 21 June 2019
Time: 1500 – 1905 hrs
Venue: Hotel The Residency Towers, Coimbatore, Tamil Nadu

PROGRAMME		
1500 – 1515 hrs	Registration	
1515 – 1530 hrs	Welcome Remarks and context setting	**Dr N Balashanmugam** Joint Director Central Manufacturing Technology Institute
1530 – 1540 hrs	Address by	**Prof Mohan** Emeritus Professor IISc
1540 – 1550 hrs	Address by	**Prof Dr P Radhakrishnan, Director** Nanotech Research Facility PSG Institute of Advanced Studies
1550 – 1600 hrs	Special Address by Chief Guest	**Mr M Ramesh** Past Chairman, CII Coimbatore Zone & Managing Director Alphacraft Pvt Ltd
1600 – 1610 hrs	Tea Break	
1610 – 1640 hrs	Connecting Man and Machine for Smart Factory	**Dr. Kaustubh Nande** Director Marketing MSC Software Corporation, Hexagon Group
1640 – 1710 hrs	Smart Machines & Intelligent Machining	**Mr Prakash Vinod** Scientist - F& Head NMTC

1710 - 1740 hrs	Smart Sensors & Controllers	**Mr V S Shanmugaraj** Scientist - F & Head SVT
1740 – 1810 hrs	Smart precision metrology	**Mr K Niranjan Reddy** Scientist - E & Head UPE
1810 – 1840 hrs	CMTI Technologies & Technology Transfer Modalities	**Dr N Balashanmugam** Joint Director Central Manufacturing Technology Institute
1840 – 1900 hrs	Q & A	
1900 – 1905 hrs	Summing Up	
1905 hrs	Dinner	

Annexure 2

Speaker Details

S. No.	Name	Designation	Company Name	Phone	Email
1.	Mr M Ramesh	Past Chairman, CII Coimbatore Zone & Managing Director	Alphacraft Pvt Ltd	9843018651	ramesh@alphcraft.in
2.	Dr N Balashanmugam	Joint Director	CMTI	9449842676	balashanmugam.cmti@nic.in
3.	Mr V S Shanmugaraj	Scientist - F & Head	CMTI	9449842688	shanmugaraj.cmti@nic.in
4.	Prof Mohan	Emeritus Professor	IISC	91-80-22933291	smohan46@yahoo.co.in
5.	Dr. Kaustubh Nande	Director Marketing	MSC Software Corporation, Hexagon Group	9742236532	kaustubh.nande@mscsoftware.com
6.	Mr Prakash Vinod	Scientist - F& Head	NMTC		
7.	Prof Dr P Radhakrishnan	Director	PSG Institute of Advanced Studies	91-4224344000	director@psgias.ac.in
8.	Mr K Niranjan Reddy	Scientist - E & Head	UPE	9449842672	niranjan.cmti@nic.in

Annexure 3

Photo gallery


AND INDUSTRY 4
The Indian Perspective
21 June 2019, Hotel The Resid
CII


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SMART MANUFACTURING
AND INDUSTRY 4.0
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AND INDUSTRY 4.0
The Indian Perspective
21 June 2019, Hotel The Residency Towers, Coimbatore
V S SHANMUGARAJ
RADHAKRISHNAN


A Government of India Initiative
AND INDUSTR
The Indian Perspec
21 June 2019, Hotel The
CII


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Confederation of Indian Industry
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21 June 2019, Hotel The Residency Towers, Coimbatore
www.samarthudyog-i40.com
V S SHANMUGARAJ
KAUSTUBH NANDE
V RAMESH
PRABHAKARAN

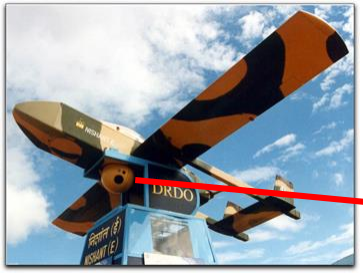
Annexure 4

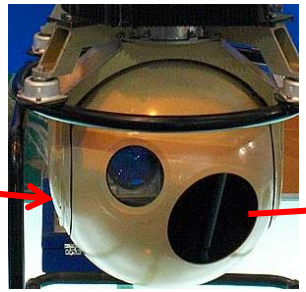
Presentations

CMTI
Technologies
&
Modalities for Tecchnology Transfer

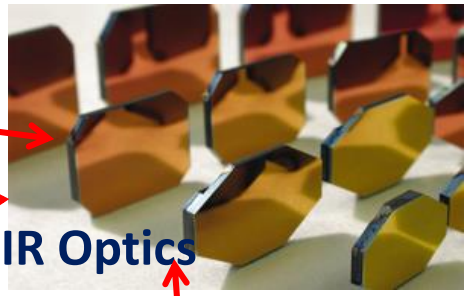
By
Dr. N.Balashanmugam
Joint Director, CMTI, Bangalore

Lenses for Night Vision & Thermography for Defense & Civil Industry





IR & Thermography system

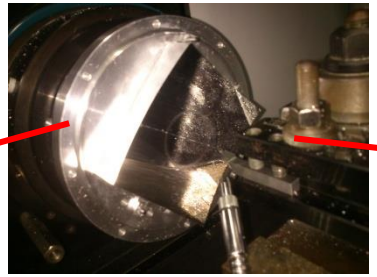


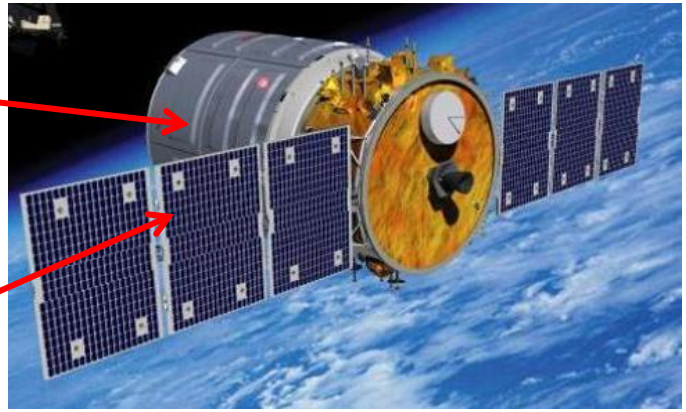
IR Optics

Night Vision

Germanium and silicon for IR optics, Night Vision, Thermography System

Metal Mirrors for Space & Astronomical Systems

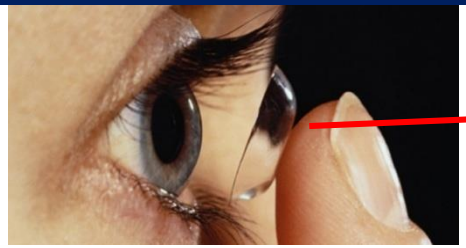


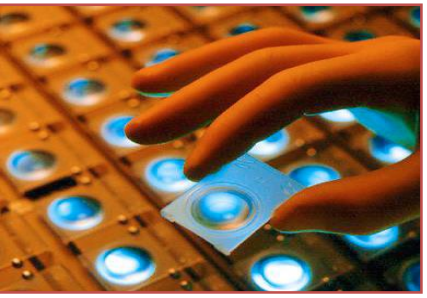


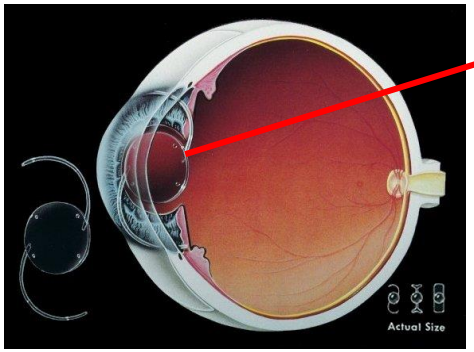
Space Satellite

Ophthalmic, Intro-ocular & Contact lenses for Medical Sectors

Contact Lenses







IOL Lens

Polymer optics for Ophthalmic

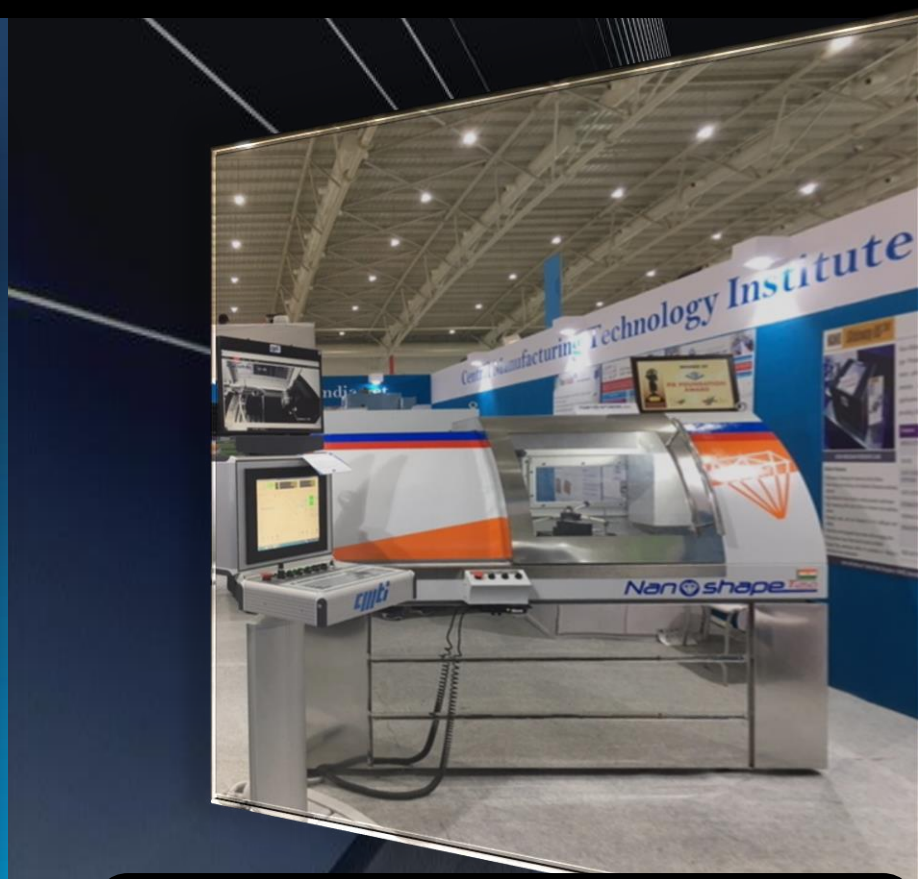
Ultra Precision Mechanical Components

Air Bearing elements.
Hydrostatic & Hydrodynamic Bearing Elements.
High Precision Mechanical Elements.

Ultra Stiff Ultra Precision Diamond Turning Machine

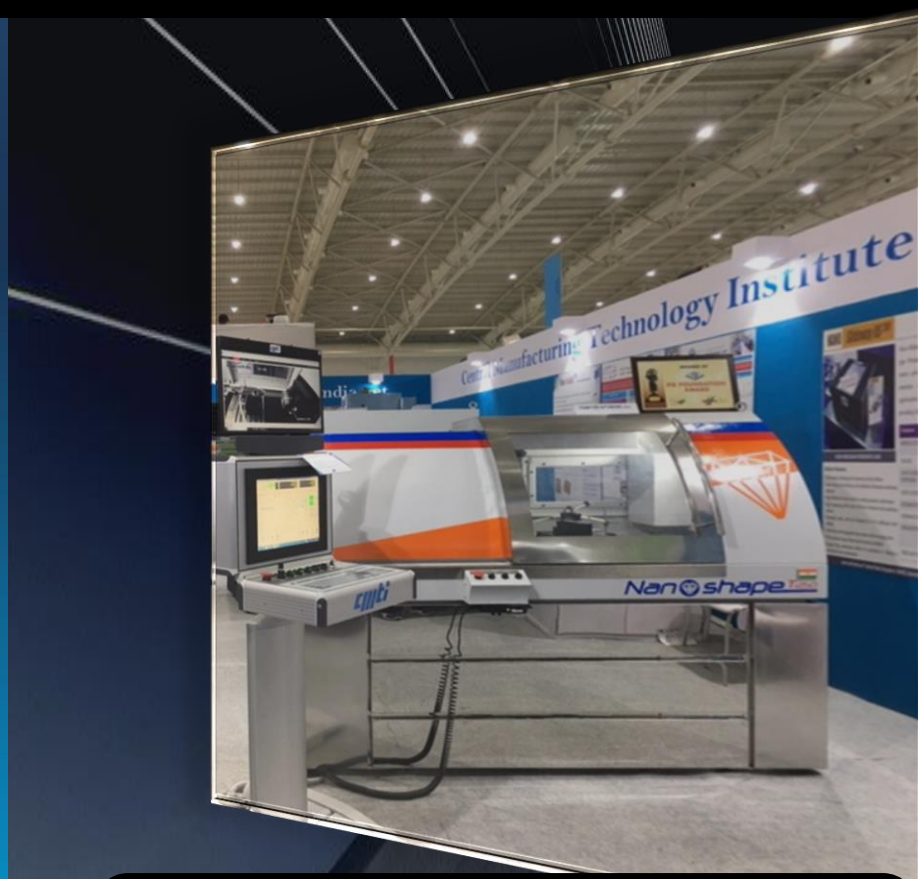
Salient Features:

- High Stiff Hydrostatic Oil Bearing Slides
- Ultra Precise Aerostatic Spindle
- Natural Granite Bed with Vibration Isolation System and active leveling
- Max Workpiece: Dia 250 mm, Lg: 150mm



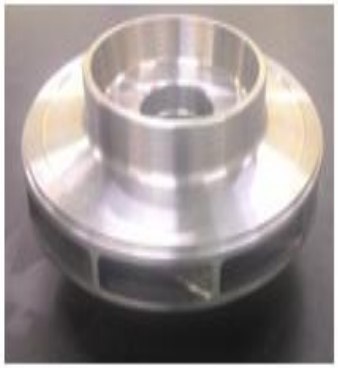
Ra: 2nm
Form Accuracy: <0.2 µm

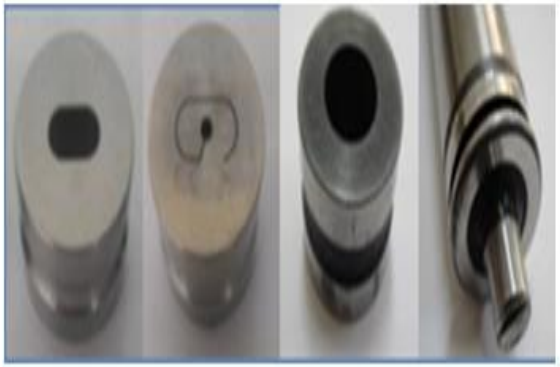
Ultra Stiff Ultra Precision Diamond Turning Machine



Ra: 2nm

Form Accuracy: <0.2 µm



How to Finish Intricate Components?

Abrasive Flow Finishing Machine

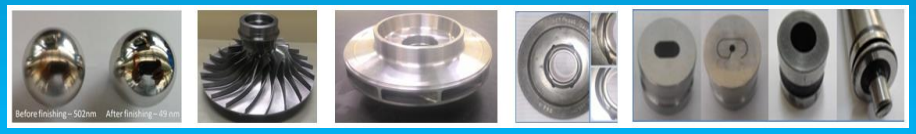
Salient Features:

- Super finish / deburr ID and OD of components
- Radiusing of sharp edges
- Finishes inaccessible areas & complex internal passages
- Temperature control of abrasive laden polymer media
- Simultaneous processing of multiple passages

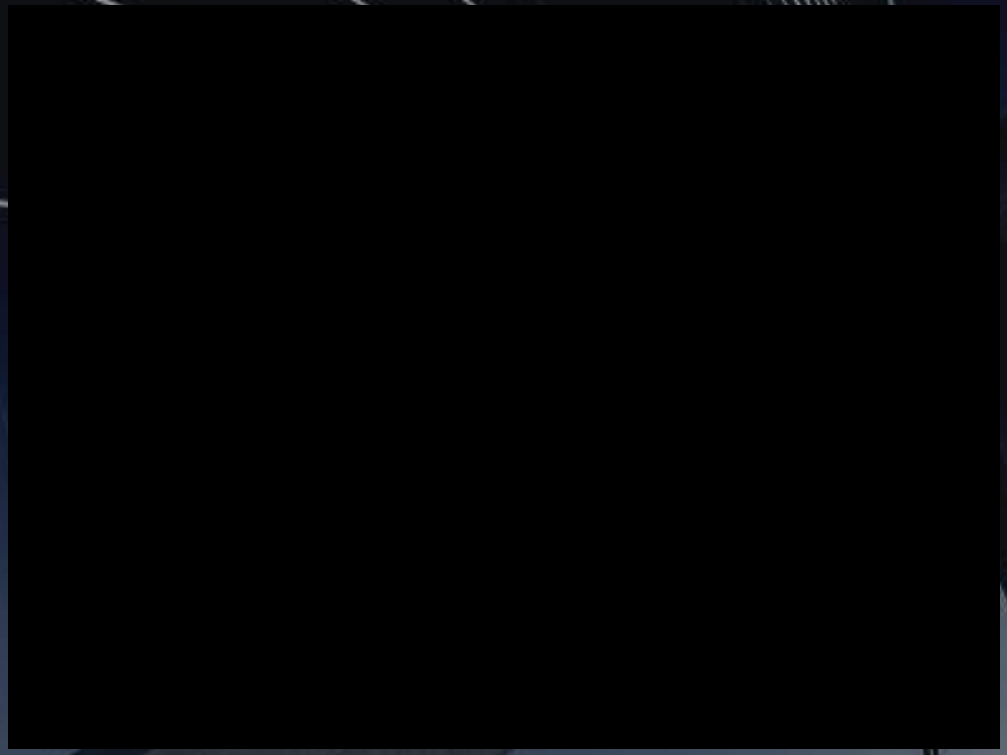
Applications:

- Micro/Nano finishing,
- Radiusing
- Deburring

Max. Hieght of the Component : 250mm

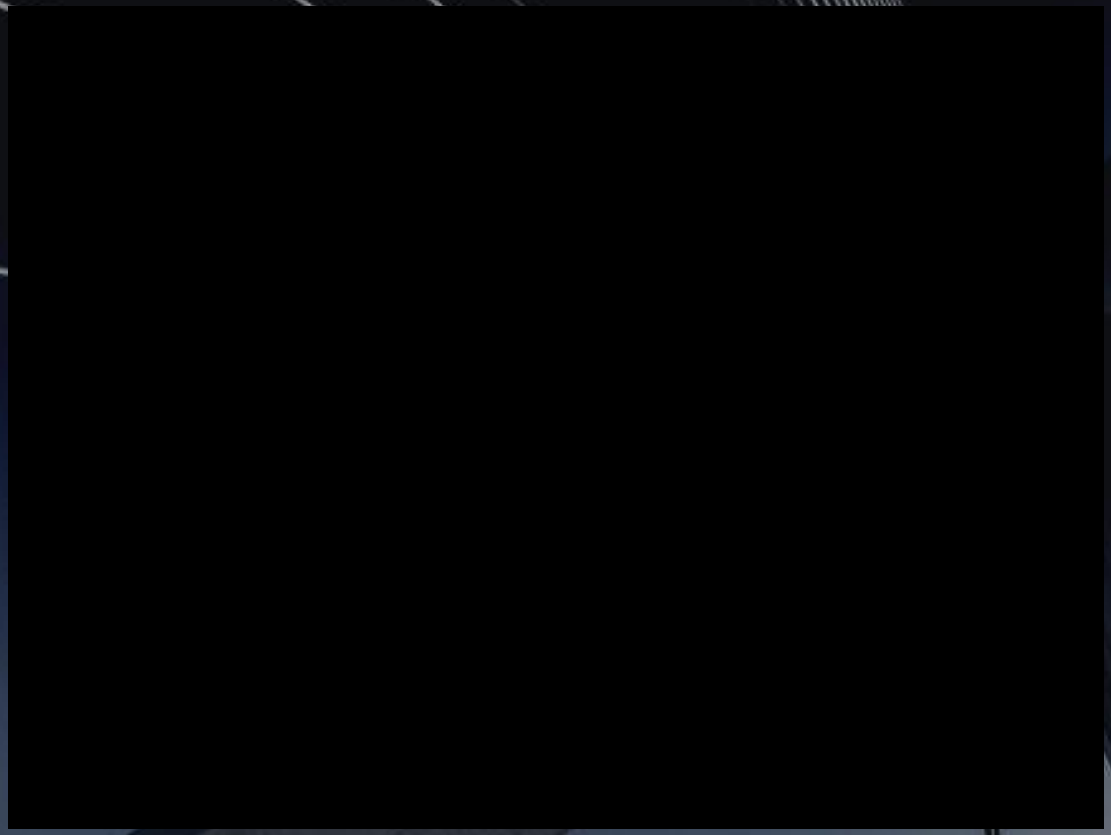


Abrasive Flow Finishing Machine



Centre tube for filter element

Abrasive Flow Finishing Machine



Shuttle valve for Aircraft landing gear actuator

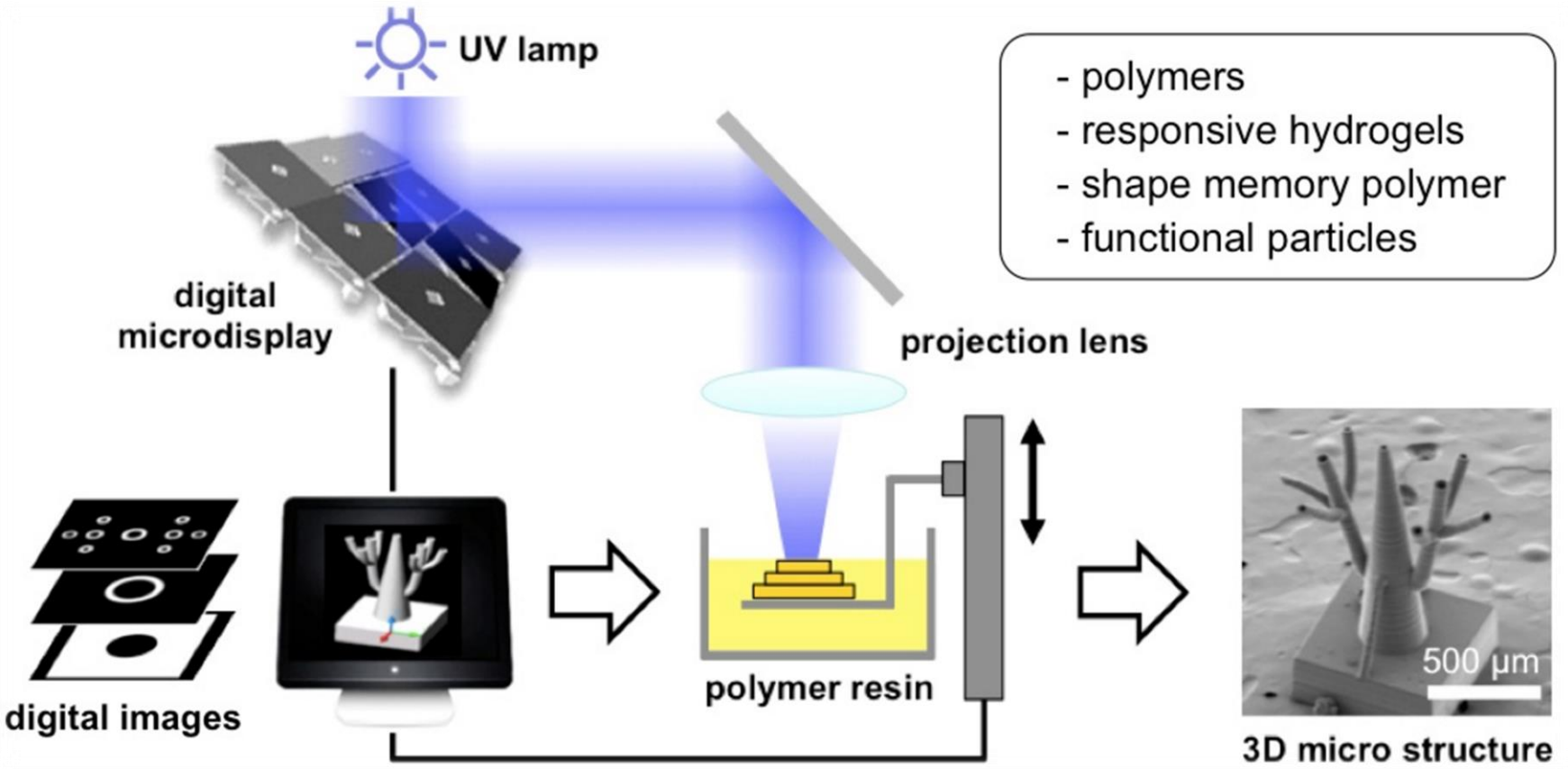
Mass - IH: Projection Microstereolithography (PμSL)System

Sūkshm3D.
सूक्ष्म Micro rapid prototyping

A product of cmti | Central Manufacturing Technology Institute

PMSL SYSTEM DEVELOPED BY CMTI

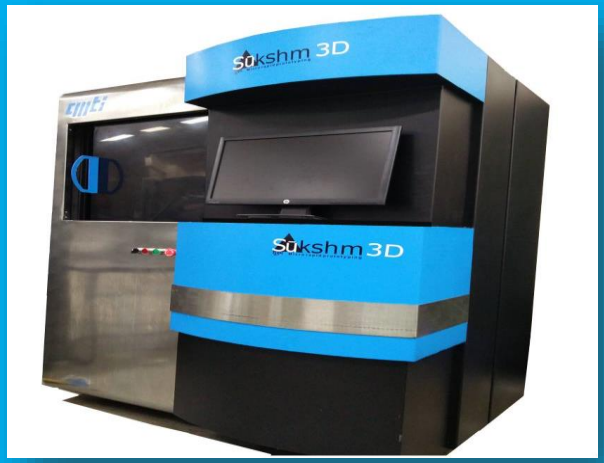
Mass IH Process- Projection Micro Stereo Lithography



Sukshm 3D Micro fabrication system

Salient Features:

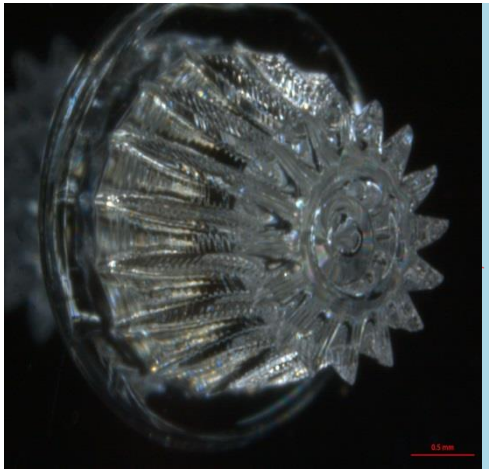
- *It enables complex 3D ultra fine solids to be made in a short time by means of spatial light modulation technique.*
- *A UV-curable resin on is cured at a super-precision resolution by a high-precision digital light exposure mechanism.*
- *3-D structures are created by the layer-by-layer forming method, under which 3-D ultra-fine solids are formed automatically by repeated light exposure and resin coating.*
- *Ultra-fine Features down to 10um level cab be fabricated*
- *Layer thickness can be optimized to 5um level so that staircase effect can be eliminated with continuous exposer of UV projection*

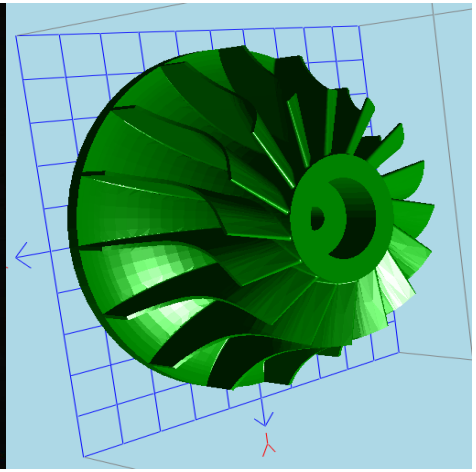


Applications:

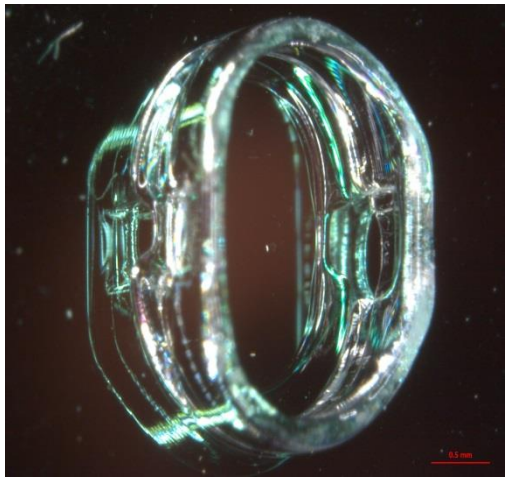
- Polymer based 3D Microfabrication for vari applications in MEMS, Jewellery, Biomed industries.
- Fabrication of complex 3D Micro components
- MEMS sensors, actuators, and micro bellows
- Micro fluidic channels and micro fluidic devices
- Bio medical Implants like coronary stents & scaffold
- Micro moulds and lenses for optics industry
- Micro mixers and micro pumps

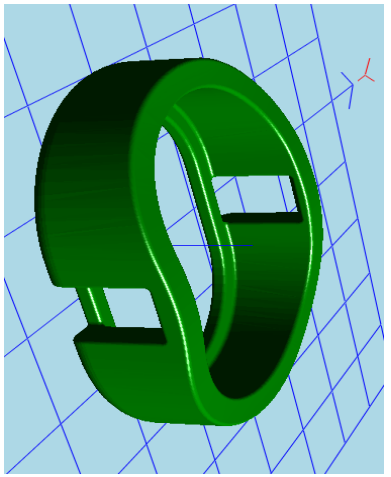
Fabrication of Complex 3D Micro Components



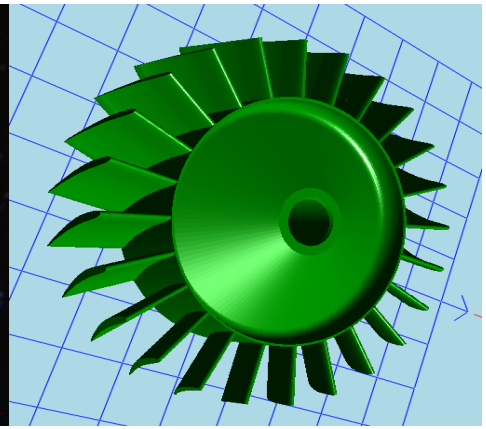


Micro Rotor- Compressor

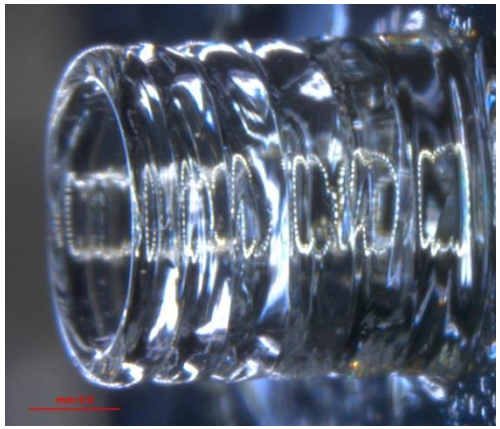


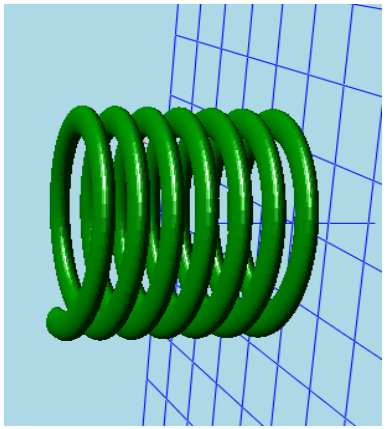


Micro Sensor Component



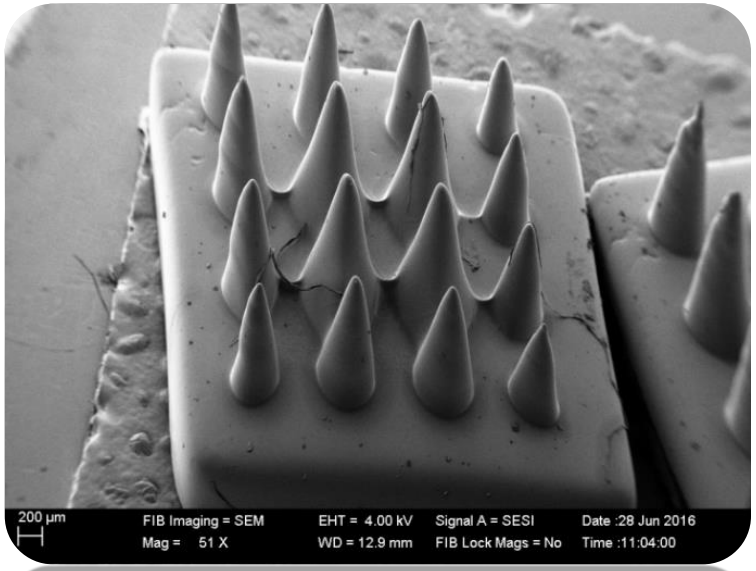
Micro Turbine

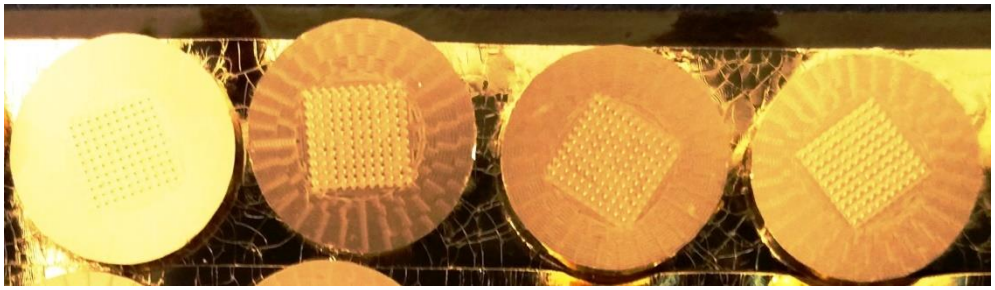




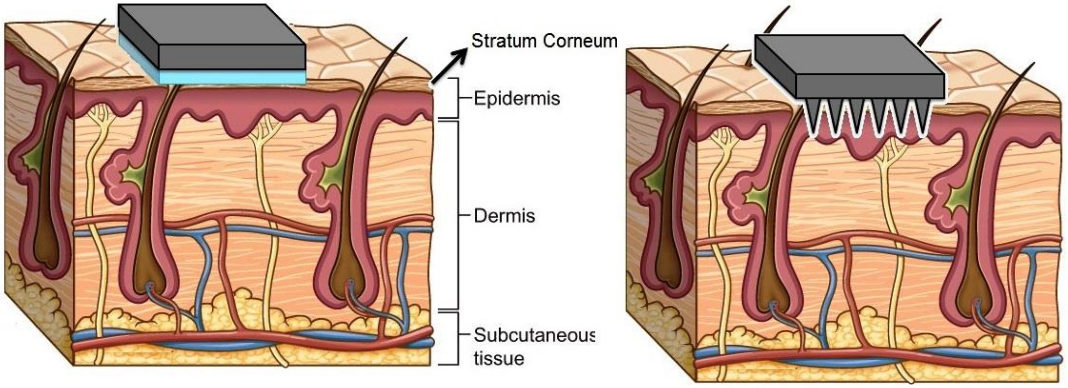
Micro Spring

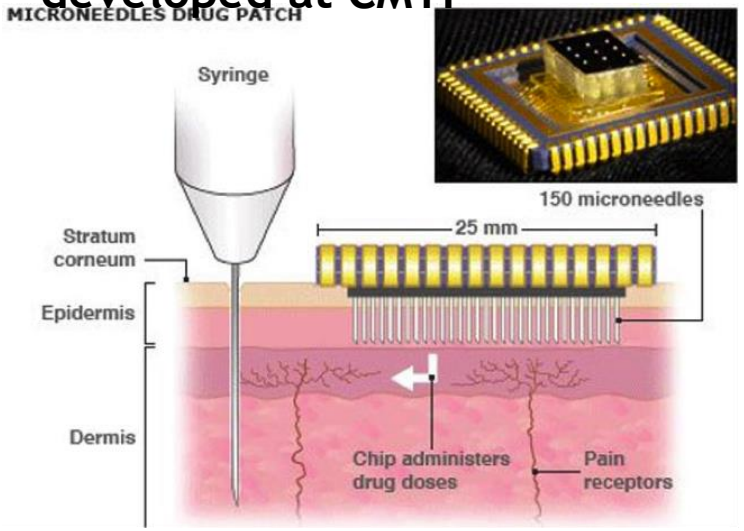
Fabrication of Microneedle Electrodes





Microneedle Array Based Biopotential Electrodes developed at CMTI

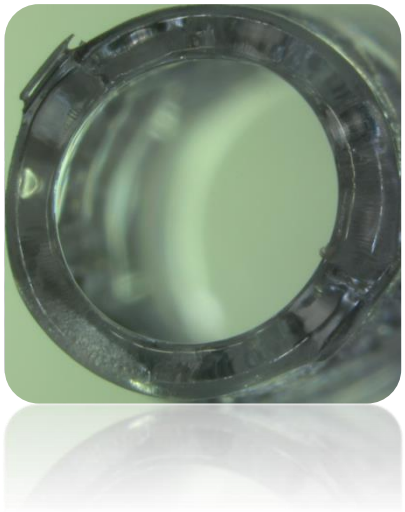




Micro Needle Electrodes for Biopotential Acquisition

Micro Needle Electrodes for Painless Drug Delivery

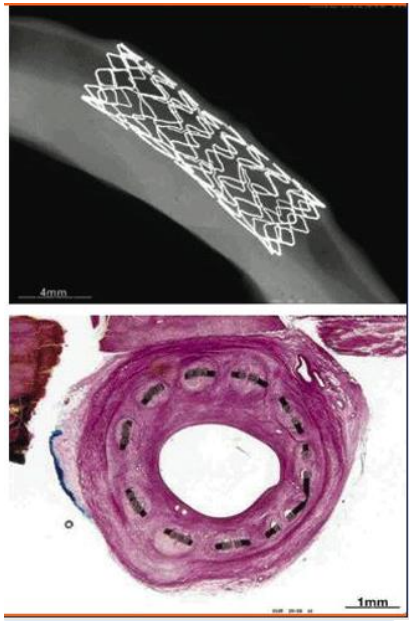
Fabrication of Polymeric Coronary Stents



"The dream has always been to find a temporary solution for a temporary problem, giving blood vessels a chance to bounce back to their natural state".

They do their job and disappea r...

Despite the development and progression of metallic stents, many concerns still remain because of their permanent nature. Thus, the concept of bio absorbable stents has emerged as an alternative to permanent metal stents.

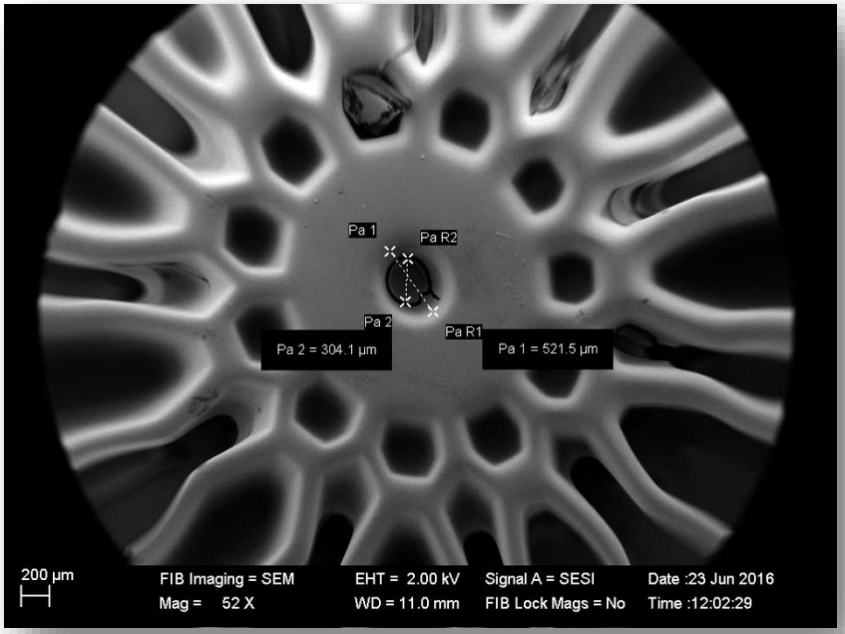


Metallic Stent

Polymeric Stent

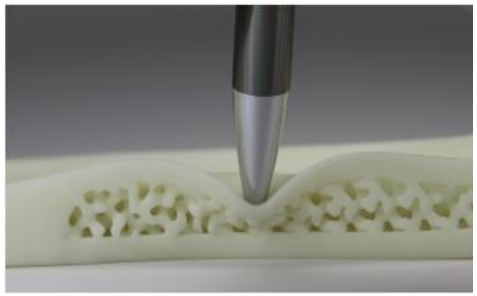
Ref: http://emag.medicalexpo.com/article-long/8671/
https://www.dicardiology.com/article/elixir-receives-european-approval-fully-bioresorbable-novolimus-eluting-coronary-stent

Fabrication of Scaffolds, Tissue & dental Implants



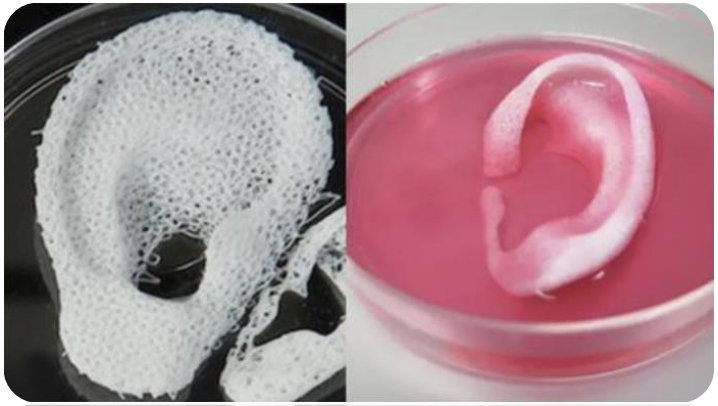
Projection Microstereolithography (PµSL) technology can fabricate three-dimensional (3D) tissue engineered scaffolds with controlled biochemical and mechanical micro-architectures.

Hearing aid caps



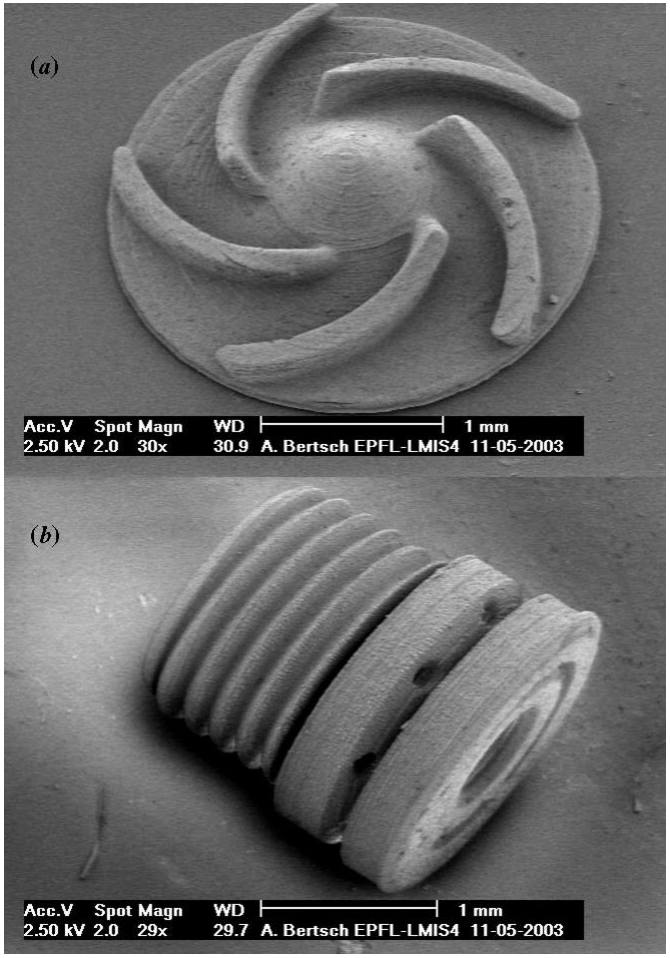
Soft biocompatible implants

Dental implants



Tissue Engineering

Ceramic MSL



Ceramic Micro Parts

- Alumina 75% by weight mixed with Polymer (HDDA)
- 3D parts made by MSL
- Polymer melted away by heating
- Green ceramic part is sintered at 1600 deg C
- Shrinkage is about 20%
- Scattering of radiation by ceramics is also an issue
- Curing depth and width gets reduced due to scattering

Issues: Scattering, Shrinkage, high viscosity

Source: Arnaud Bertsch, Microfabrication of ceramic components by microstereolithography, J. Micromech. Microeng. **14** (2004) 197–203

Thread Measurement System

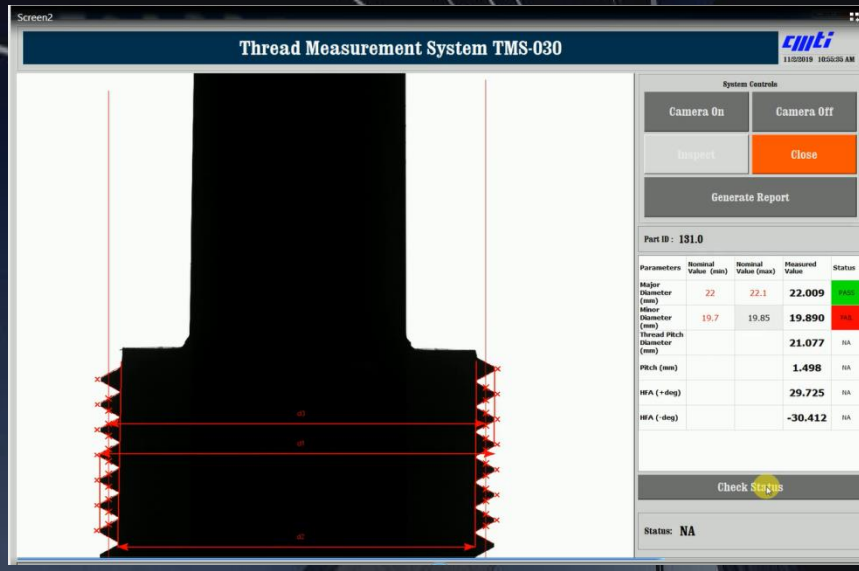
Salient Features:

- Non-contact method of external thread measurement to check for dimensional tolerances.
- High speed thread
- Can be used for automating in manufacturing lines.
- User friendly thread measurement system requiring minimum human intervention.
- Records measurement results for statistical analysis.

- Measurement Range: Upto 30mm
- Measurement Accuracy: +/- 10 µm

Thread Measurement System

GUI of the System displaying the measurement of a thread gauge



3D Scanner

Salient Features:

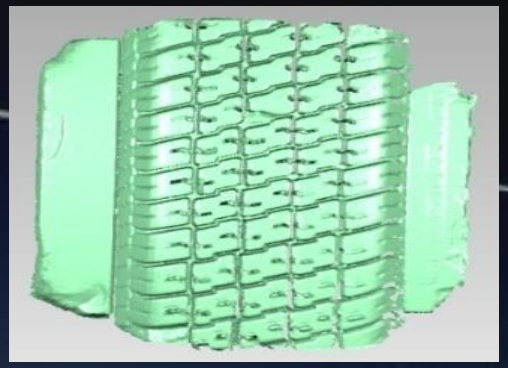
- *Short measuring times.*
- *Actual and nominal comparison with CAD data.*
- *Portable as it can be mounted on a tripod/robot.*
- *Automated registration using rotary table and markers.*

Applications

- *Dimensional measurements*
- *Reverse Engineering*
- *Automated Inspection Tasks*

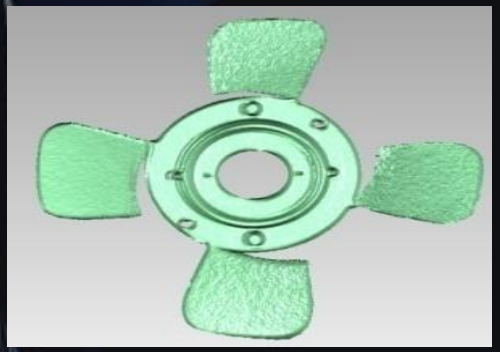
- *Measurement Area: 267*205*150 mm3*
- *Accuracy: 150 µm*
- *Fastest Measurement Time: 4 secs*

3D Scanner- Point cloud captured

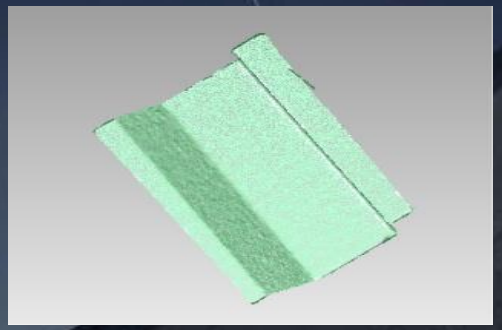


(a) Tyre Mold

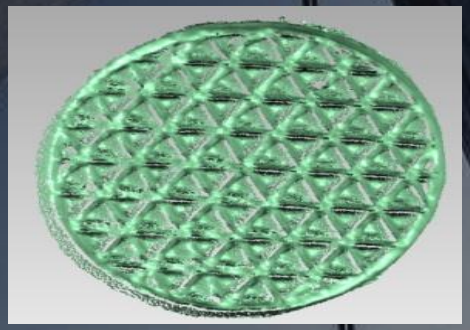
(b) Lower human jaw bone model



(c) Turbine



(d) A small locating component



(e) Lattice Mirror Housing

ULTRA STIFF ULTRA PRECISION HYDROSTATIC SLIDE

Salient Features:

- Hydrostatic oil Bearing gives infinite life
- True motion, zero stick-slip, zero backlash & Maximum positioning accuracy
- High stiffness for Heavy loads & excellent geometric performance
- High Dampening effect from oil film for vibration from machining process
- Direct drive with Integrated Linear motor with low cogging force
- Ultra precision Linear Glass Scale for position feedback

Applications:

- Ideally suited for development of Ultra Precision Machines

Nano Slide way HS 200

Model & Type	HS 200; Fully constrained o hydrostatic, box way slide
Travel	200 mm (8 Inch)
Load Capacity & Stiffness	1000Kg (10,000 N) 1000N/µm
Drive System	Brushless DC Linear Motor
Feedback Resolution	32 picometer
Straightness	Horizontal :0.2 µm over full travel Vertical : 0.4 µm over full tr

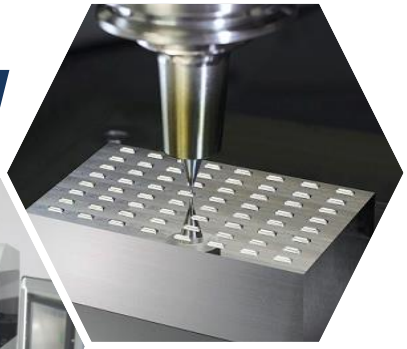
HYDROSTATIC SLIDE APPLICATIONS

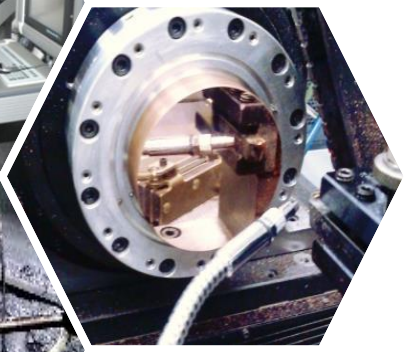
HIGH PRECISION MILLING/
BORING MACHINES

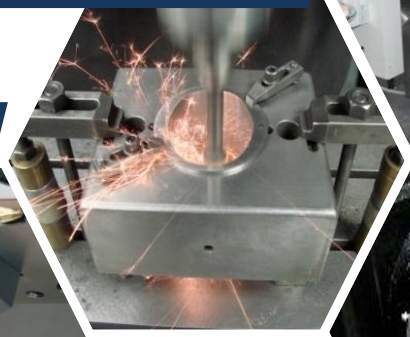
DIAMOND TURNING
MACHINES

HIGH PRECISION GRINDING MACHINES

HARD TURNING MACHINES





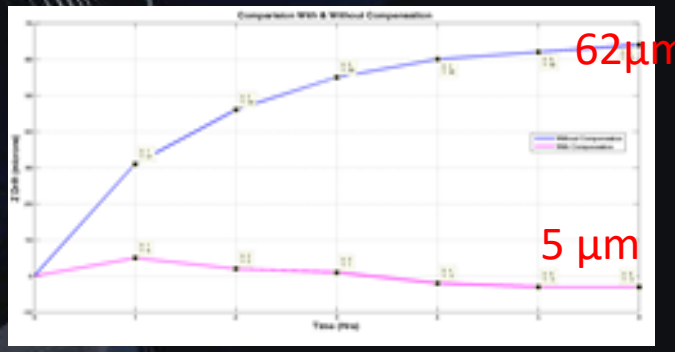


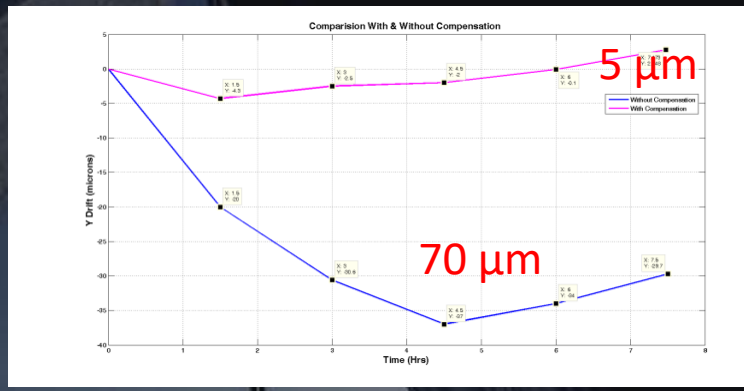
Thermal Error Compensation for Machine Tool Applications

Machine tool thermal distortion can account for 75 % of the total machining error.

Salient Features:

- *RTD based Temperature Sensors*
- *Recursive Neural Network based Algorithm*
- *CNC Interface module*
- *Real Time Compensation*
- *Upto 80% error compensation contributed by thermal distortion*
- *Low Cost solution*
- *Can work with all general purpose CNC controllers*



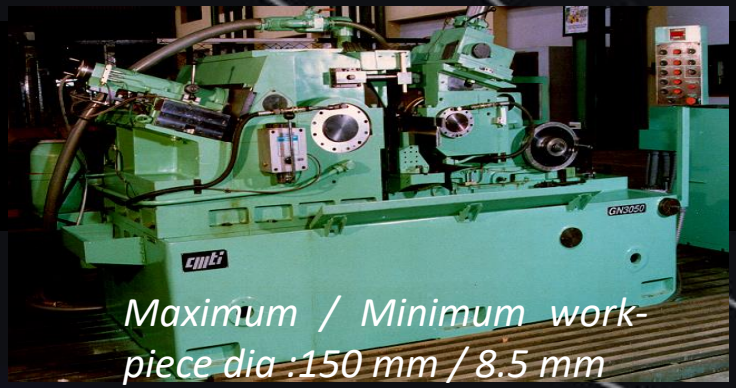


Blue: Without Compensation
Pink: With Compensation

Machine Health Management System (MHMS)- Machine Fault Diagnostic Module

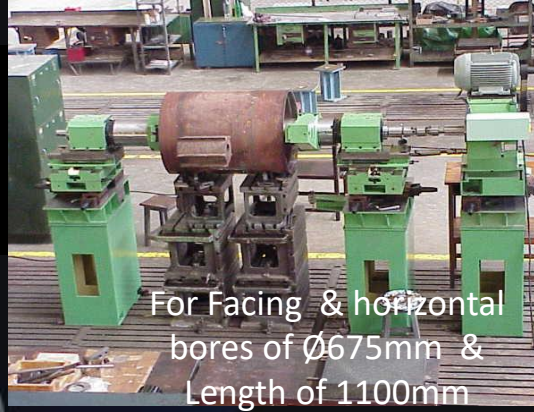
Salient Features:

- *Machine tool vibration measurement*
- *Data acquisition through MEMS Accelerometer*
- *Signal Conditioning and Analysis*
- *Fault diagnosis for Unbalance, Misalignment, Mechanical looseness and Bearing faults*
- *Fault display on LCD Display Screen*

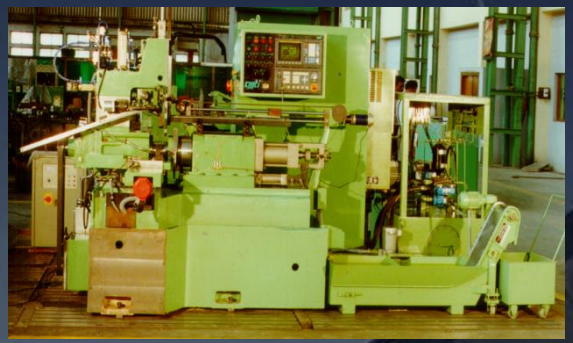


Centreless Grinding Machine GN 3050

Facing and Taper Boring Machine (FTB -320)

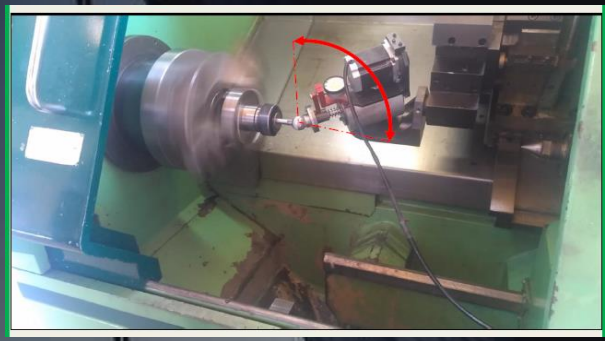


Line Boring Machine (LBM



Finish Turning Machine

Key Stone Piston Ring Grinding Machine (GKPR)



Sphere Lapping Attachment for CNC Lathe

Modalities for Technology Transfer

- Calling for Expression of interest
- Conducting Pre application conference
- Inviting Request for Qualification {Direct or through e-tendering (forward auction)}
- Evaluating Requests and selection of firms

Modalities for Technology Transfer

- Technlogy transfer is done on non - exclusive basis
- In certain cases, Technology Transfer is done on exculsive basis with lock in period
- License fee is different for both

Modalities for Technology Transfer

Technlogy transfer involves

- Licence fee
- Royalty

Modalities for Technology Transfer

What do we offer?

- Blue print of drawings
- Bill of Materials
- Technological process for critical parts
- Bought out items ;
- Vendor's list
- Testing Protocols
- Machineries and Infrastructure required
- Data base of process receipe
- Hand holding


Looking forward to have our
Technologies in your factories

Thank You

HEXAGON
empowering an autonomous future

Connecting Man an Machine for Smart Factory

Dr. Kaustubh Nande
Director – Marketing
MSC Software Indo-Pacific

June 2019

Global leader in **sensor**, **software**,
and **autonomous** technologies committed to

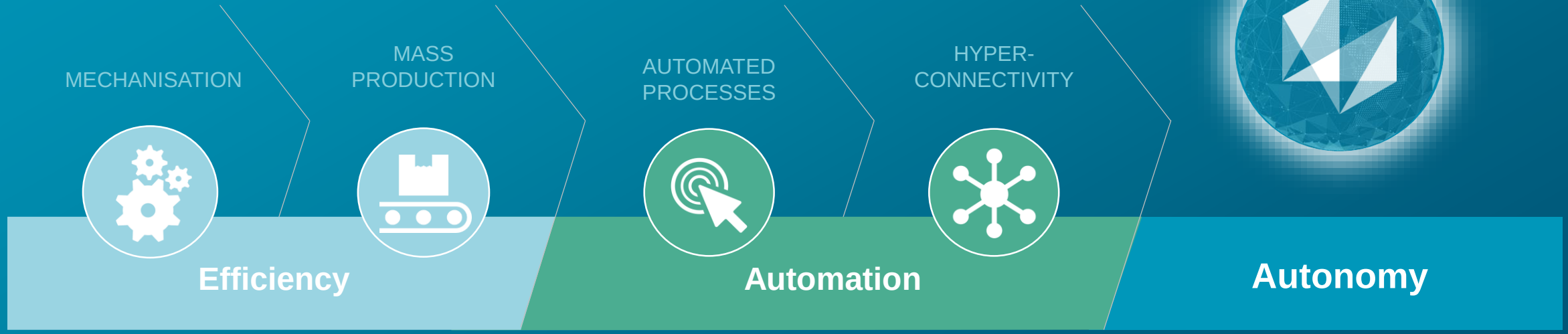
empowering an autonomous future

HEXAGON

Leading a revolution

From automation to autonomy

Autonomy is the ultimate form of putting data to work



Industry 1.0----------Industry 4.0

HEXAGON

The road to autonomy

Our core capabilities

CORE CAPABILITY
Reality Capture

CORE CAPABILITY
Positioning

SENSOR SOLUTIONS

data capture

AUTONOMOUS SOLUTIONS

data leverage

CORE CAPABILITY
Autonomous Technologies

SOFTWARE SOLUTIONS

data intelligence

CORE CAPABILITY
Design and Simulation

CORE CAPABILITY
Location Intelligence Mapping

HEXAGON

Smart Factories

that learn and adapt quickly to changing conditions in real time, pursuing perfect quality with optimised design, requiring fewer inputs and producing zero waste

SUSTAINABLE VALUE CREATION
- Fewer inputs
- Zero waste
- Perfect quality

PRIMARY APPLICATIONS
- Automotive
- Aerospace
- Electronics
- Medical
- Heavy industry
- Power & energy

Did you know?

Each year, Hexagon technology touches:

- **75%** of cars produced
- **90%** of aircraft produced
- **85%** of smart phones produced

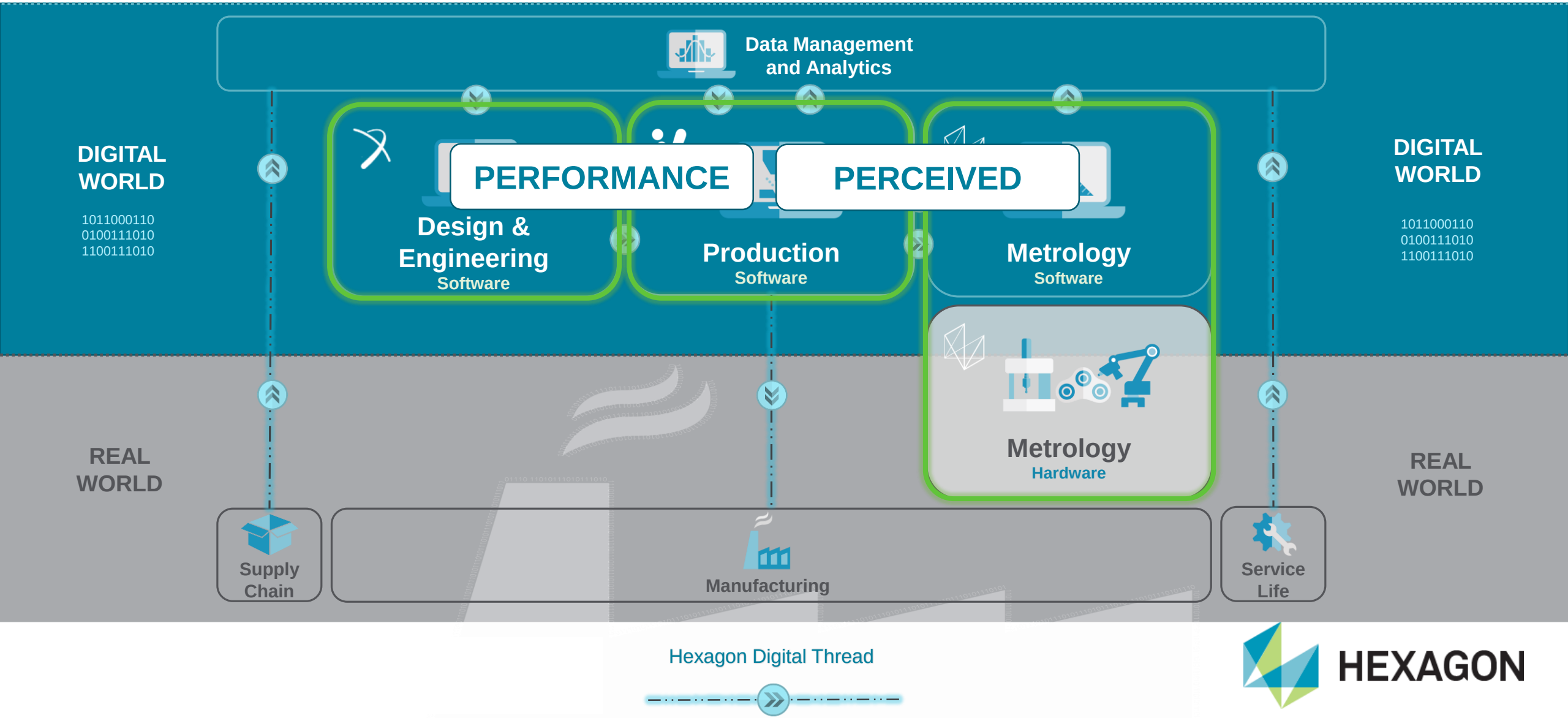
We have expertise in and connect all stages of the manufacturing lifecycle:

DESIGN AND ENGINEERING (CAE)
Optimise designs and ensure manufacturability

PRODUCTION (CAD/CAM)
Deliver on design intent and product quality with minimal waste

METROLOGY HARDWARE/SOFTWARE
Capture real-world data for positioning and inspection

The Hexagon Digital Thread: Design to Manufacturing to Quality



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Ecosystem for Smarter Manufacturing

SUPPLIERS

PRODUCTION

QUALITY & PRODUCTIVITY

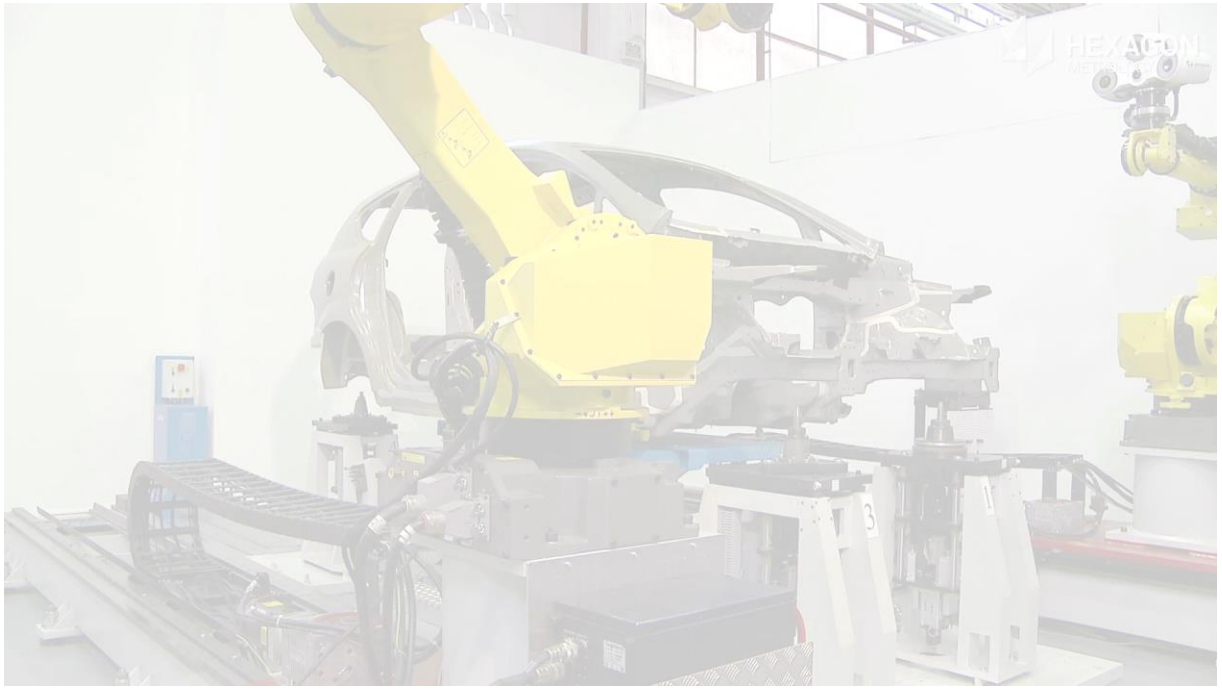
DESIGN & ENGINEERING

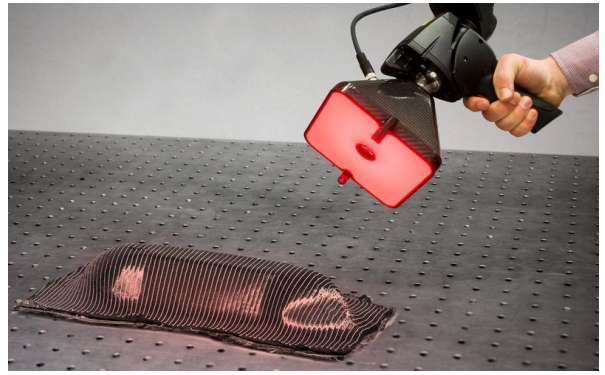
METROLOGY

CUSTOMERS

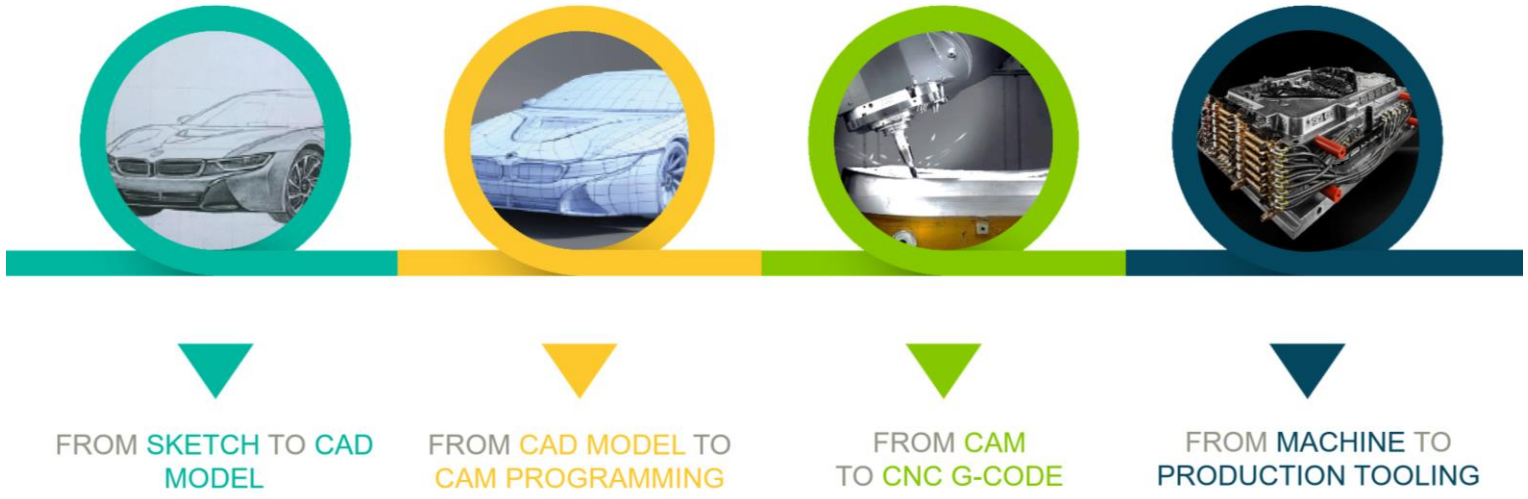
HEXAGON

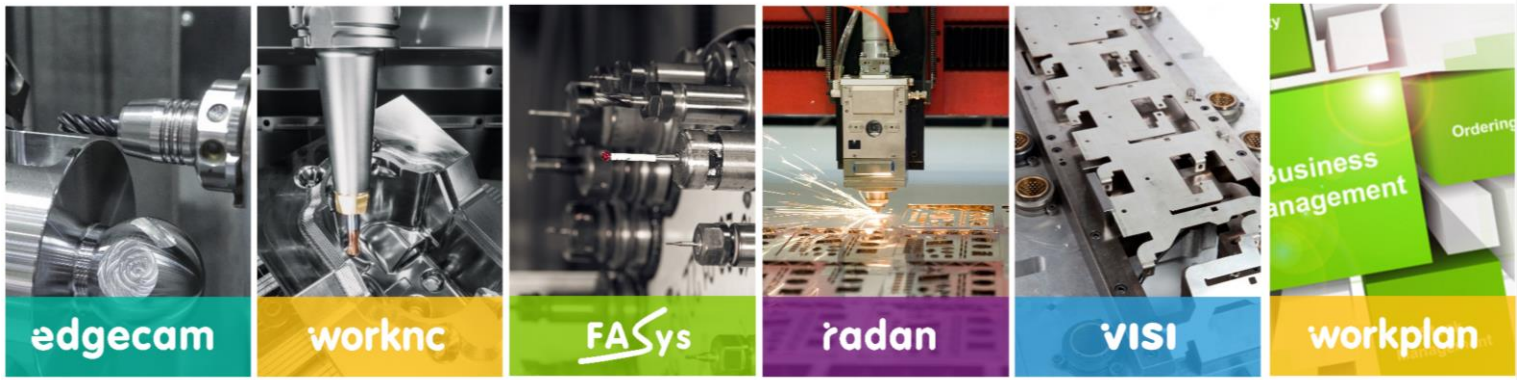
Industrial Metrology Applications: World Leader in Quality Measurement





Production Software: World's #1 CAM provider



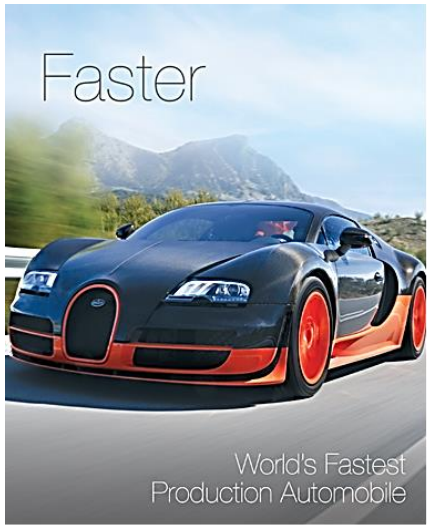


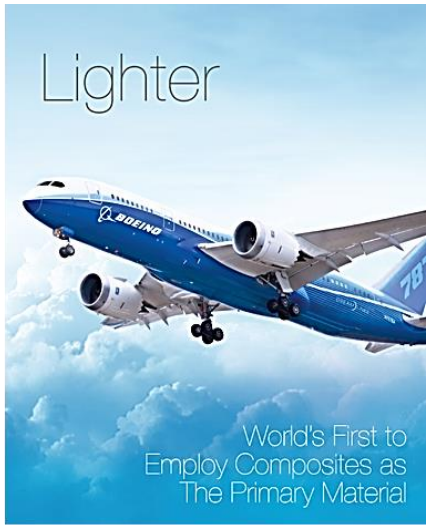
- CADCAM to address ***metal, sheet metal and woodworking industries***
- MES for die/mold processes, small scale ERP tools, machine simulation technologies
- Direct offices in 13 countries, development teams in 7 countries, ***700+ employees***, 140 resellers in 45 countries
- Strong relationships with all the largest machine tools OEMs

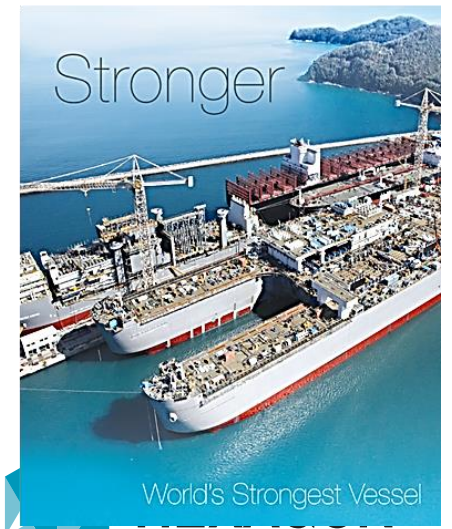
HEXAGON

MSC Software®
Simulating Reality, Delivering Certainty™

- **Presence in 23** Countries
- R&D in **10** Countries
- **90% of top 1000** manufacturing co.s use MSC Solutions
- Part of the US$ 4.5B Hexagon AB



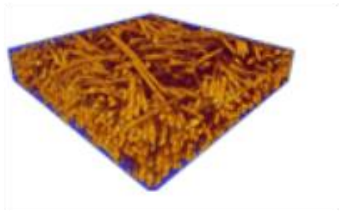
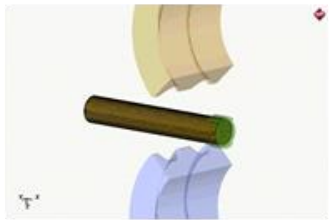
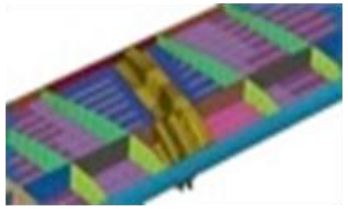
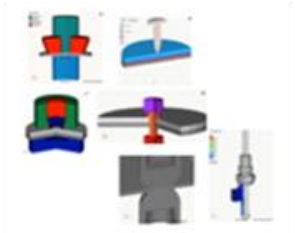




MSC Software®
Simulating Reality, Delivering Certainty™

Associated with India since 1983

Materials | Fabrication | Parts | Assembly | Systems | Quality







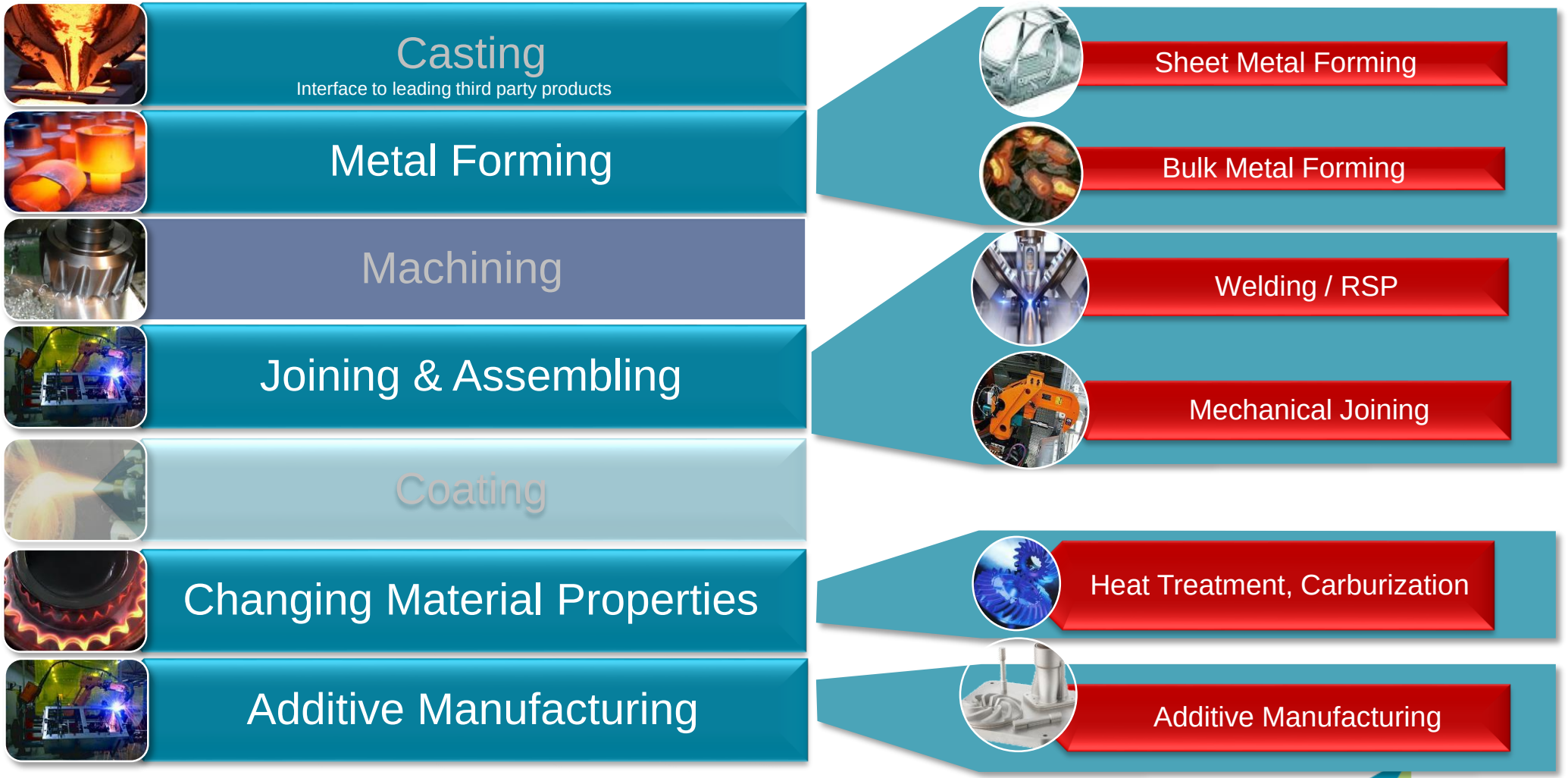








MSC's Virtual Factory Ecosystem



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Challenges faced by Manufacturing Industry

Connected Plant Floor to Improve Operational Efficiency

Manufacturers are missing out on a critical opportunity: Leveraging real-time data on cycle times, quality yields by machines, production run, utilization and other metrics to improve Operational Efficiency of the plant.

Preventive maintenance without affecting throughput

Keeping equipment functioning is an essential part of running a manufacturing facility. By collecting real-time data, and comparing with failure scenarios, it is possible to predict the appropriate time frames that the machines in the factory should be maintained.

Connected Quality for Final Inspection

Process of quality assurance, quality control, and QC inspections need to be optimized to increase productivity and lower costs

Better supply chain visibility

It is essential to integrate all the business applications including ERP, CRM, PLM with MES systems for a better visibility of supply chain

Customer-facing self-service applications

An organization’s customers typically consist of end-customers, partners (or service providers), and sub-contractors, or any combination of these. These customers have different needs, concerns and requirements for working with and interacting with manufacturers.

References

[10 greatest Manufacturing Challenges for CIOs]

[Top five challenges facing Manufacturing Industry]

[Six challenges facing Modern Manufacturing Companies]

HEXAGON

DATA CREATION

INTERNET OF THINGS

Introducing Xalt

One of our major R&D initiatives is a technology framework called Xalt, which will eventually underpin all of our solutions – making them faster, easier to use, more connected, and autonomously intelligent.

Xalt framework:

- Artificial intelligence
- Edge computing
- Mobility
- Advanced visualisation
- Enterprise integration

HEXAGON

Autonomous Connected Ecosystems with XALT

Meshing nets

AI

5G

MOBILITY

analytics

DATA MODELS

PROCESS MODELS / INPUT

EDGE

Cyber-security / Blockchain

STREAMING

UI / UX AI powered

CLOUD

Adaptive models

DIGITAL SIMULATION

VIZ

ENTERPRISE

VISUALIZATIO

PROCESS FEEDBACK

Digital Transformation with Xalt

Infinite Connectivity for Disconnected Data

CLOUD ENABLEMENT

Connecting B2B with an orchestrated microservice framework and cloud analytics for big, fast data.

EDGE CONNECTIVITY

Processes, combines, and analyses IoT and sensor data at the edge of the network and puts it to work with AI.

ENTERPRISE INTEGRATION

Plug-in enterprise integration for legacy connections, databases, and IT systems. equipped with middleware for messaging, file, system, and database connectivity and transformation.

MOBILITY

Secure and nimble framework that is native iOS- and Android-ready with zero client footprint and network-optimized for visualization of multiple georeferenced 3D & 2D data sets

UBIQUITOUS A.I.

Multiple AI data sources including imagery, video, and big data for applications such as predictive maintenance, change, and anomaly detection.

VISUALIZATION

Visualizes 2D/3D data, including point clouds, and is optimized for all mainstream OS, mobile, and web platforms. Augmented reality applications are validated on HoloLens, Daqri, and Oculus, and can process enormous datasets at high speeds.

Security without Rigidity: Xalt is HIPAA and PCI-compliant, is SOC2 certified, and has passed the United States Department of Defense regulatory process.

HEXAGON

Addressing the Complex Real-life Challenges in Manufacturing – not just Connectivity

THE BIG DATA DISCONNECT

Organizations have limited visibility to at-source data

QUALITY / COST INVERSION

Produce more at higher quality; deliver it faster at lower costs

4.0 MODELS & MARKETS

Lost revenue due to untapped, data-driven models and channels

PROCESS OPTIMIZATION

Real-time logistics, line uptimes, edge analytics of machinery

SMART QUALITY ASSURANCE

Real-time updates and alerts for on-premises, cloud, and sensor assets

CONNECTED WORKERS

Real-time mobile access to consolidated data (sensors, alerts, and workflows)

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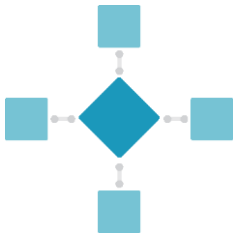
Why it's Different

Leverage Your Existing OS

=

OPEN CONNECTORS

INTEGRATION



SMART WORKFLOWS

LOW/NO-CODE IMPLEMENTATION

+

FLEXIBLE DEPLOYMENT

+

DATA ACCESSIBILITY

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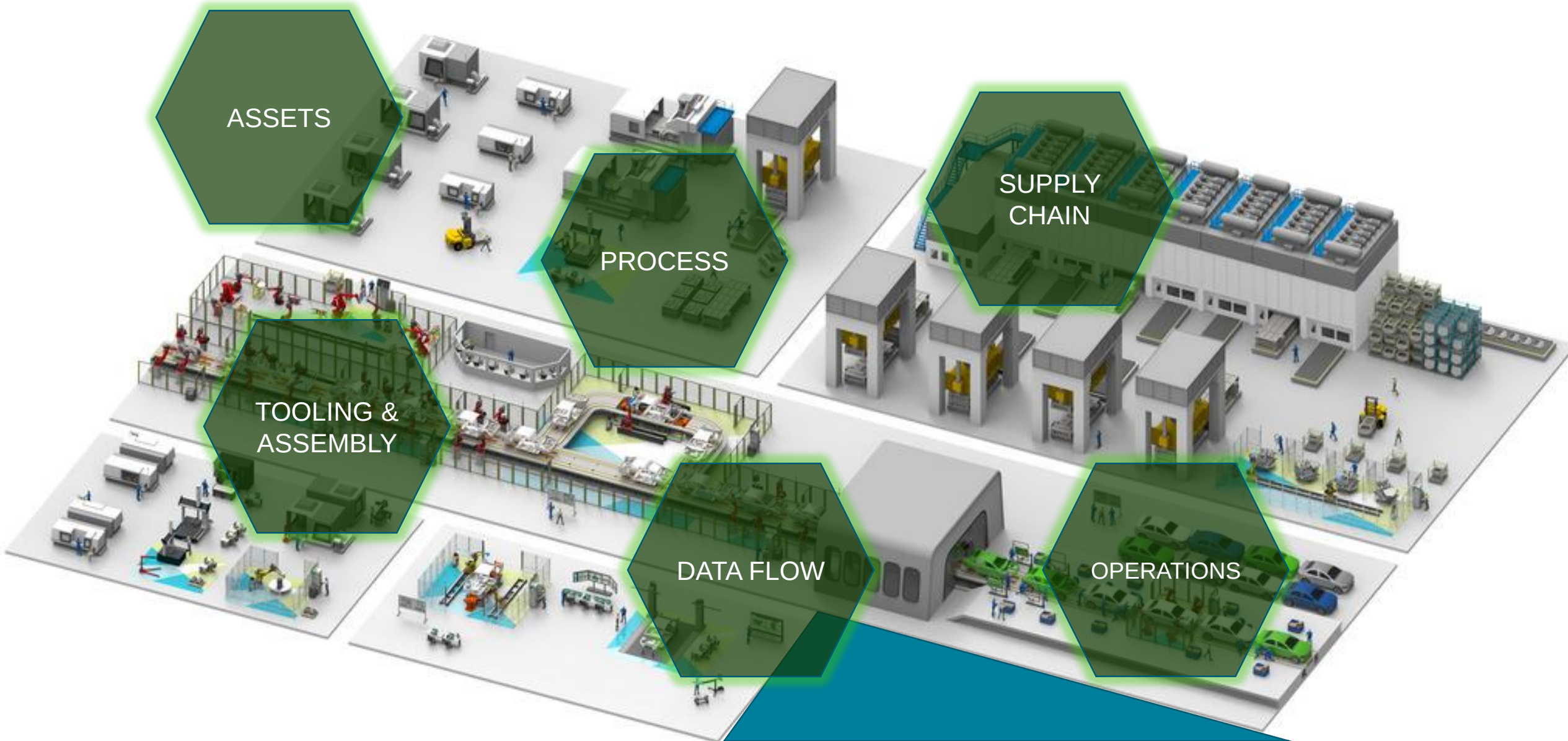
Smart Factory: Areas of Focus



Connected Worker

Innovating Work in the Field

HEXAGON

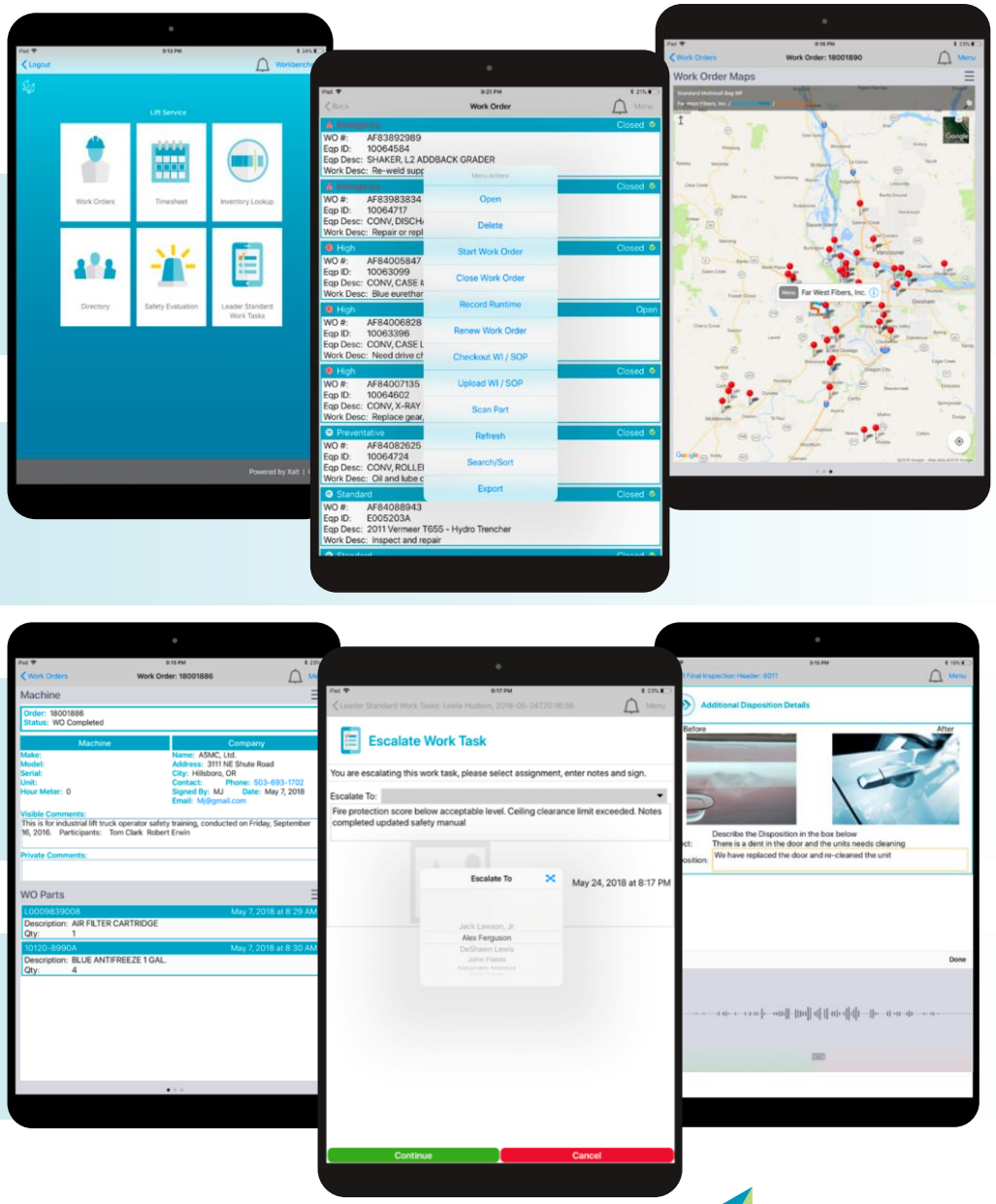
Connected Worker Solutions

AUTOMATED MAINTENANCE + SERVICE WORK-ORDERS

ACCURATE TIME PLANNING + PRIORITY ESCALATIONS

TOOL + EQUIPMENT TRACKING

SUPPLY + INVENTORY LOOK-UP AND REQUISITIONS



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PPM

Smart Factory

Sensor Fusion with User Enablement

HEXAGON

Smart Factory

MANUFACTURING

TRANSPORTATION

Body + Finished Good MFG
- Motor Vehicle + Truck
- Heavy Duty Vehicle
- Specialty Vehicle
- Aerospace

METAL + MACHINERY

- Packaging Machinery
- Door + Window
- Elevator + Convery
- Material Handling
- HVAC +Industrial Refrigeration

Quality Inspections

- Inspection Plans
- Times Tests
- Shared File Specs
- Rework WOs
- Production to Delivery Tracking

Field Service Suite

- Workorder Mgmt
- Time Allocation
- Supply Reqs
- Inventory
- Mileage Tracking

Maintenance

- Workorder Mgmt
- Time Allocation
- Supply Reqs
- Inventory
- Emergent Alerting

PLANT OPERATIONS

ELECTRICAL

Sub Contracting Of:
- Electrical Site Prep
- Commercial Bldgs
- Electrical Finishing
- 100 Employees+

MECHANICAL

Installation Of:
- HVAC System
- Plumbing + Piping
- Drywall + Structural
- Elevator+Equipment

UTILITY SYSTEMS

Construction Of:
- Oil + Gas Pipelines
- Power + Comm. Lines
- Water + Sewage Systems

Time Planning

- Jobsite HR
- Timesheets
- Payrate plan
- Project time Budgeting

Material Requisitions

- Inventory
- Prefab Reqs
- Equipment Rentals
- Supplier Orders

Tool Tracking

Asset Mgmt:
- Tools
- Equipment
- Rentals
- Maintenance Schedules

Project Reporting + Analysis

- Job Status
- Daily Site Reporting
- Project Budget
- Deadline Tracking

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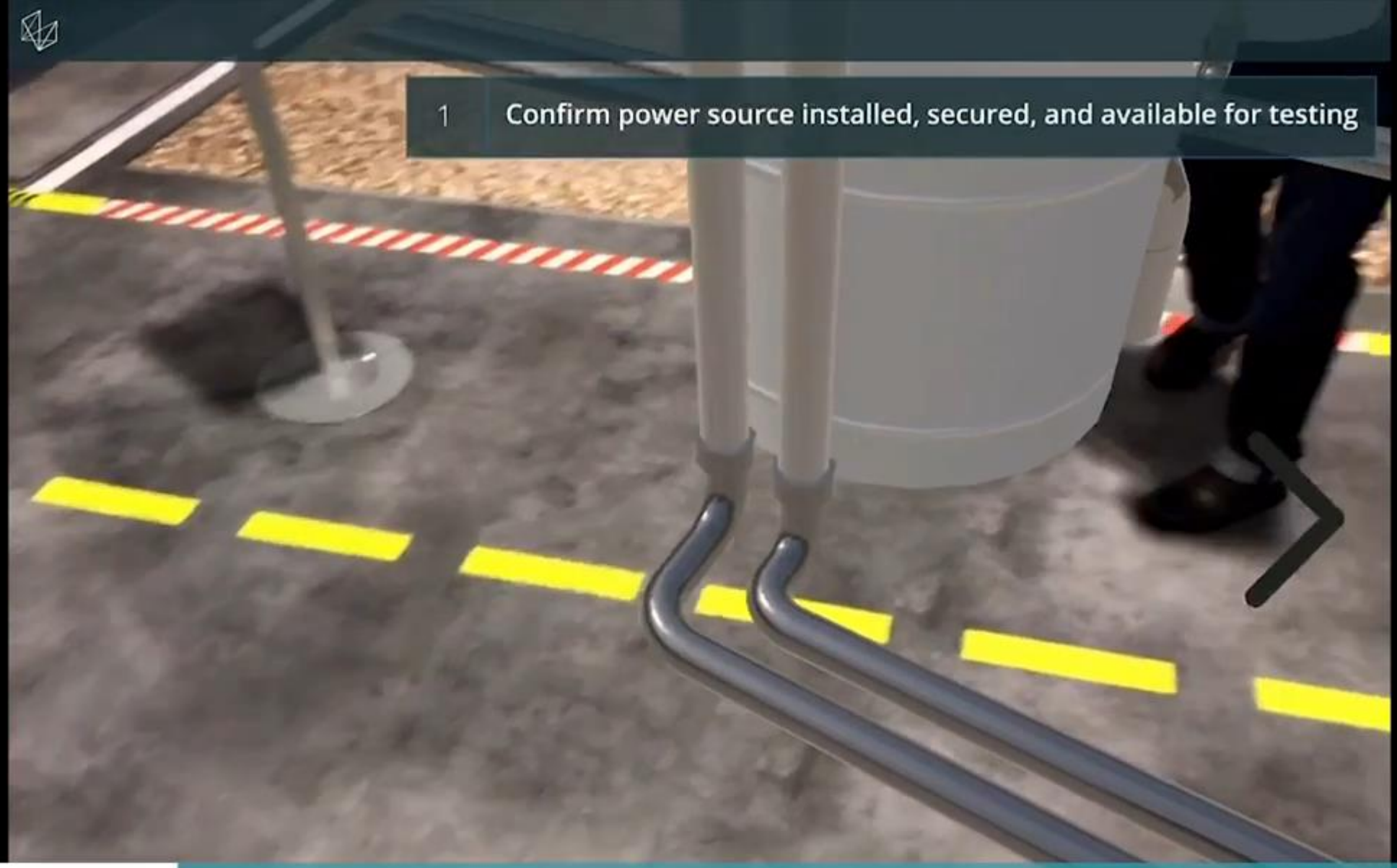
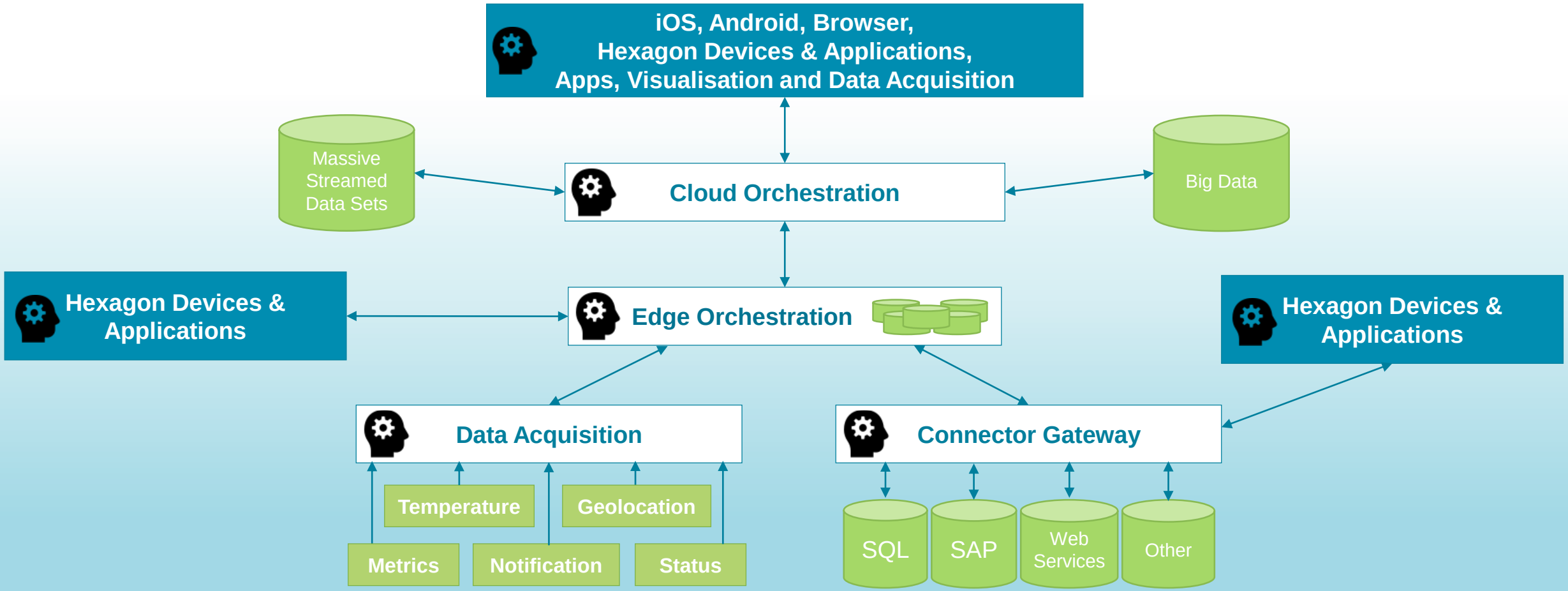
Xalt



Xalt

3D visualisation allows workers to lay piping and instrumentation diagram data over built structures

Xalt Framework



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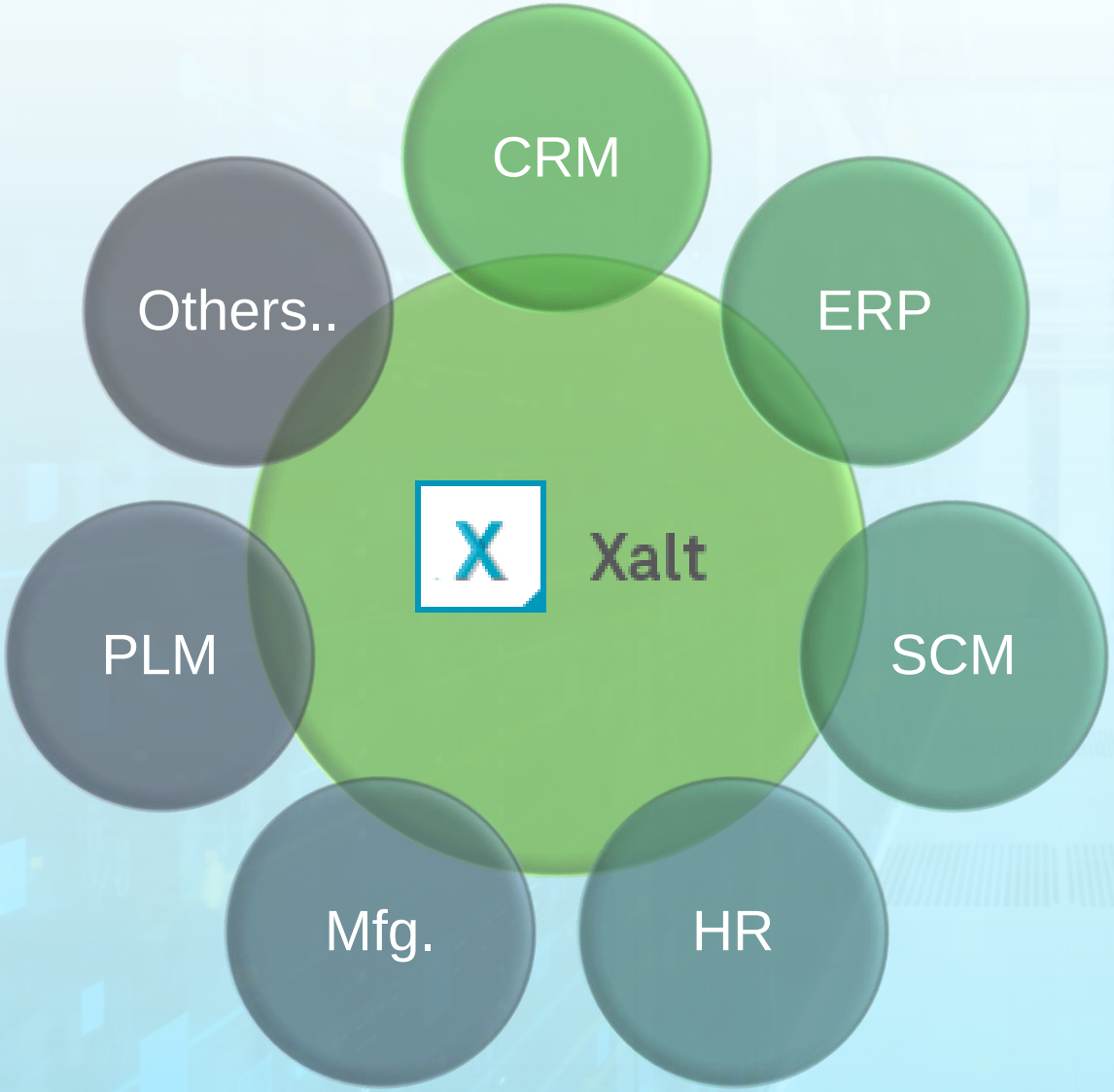
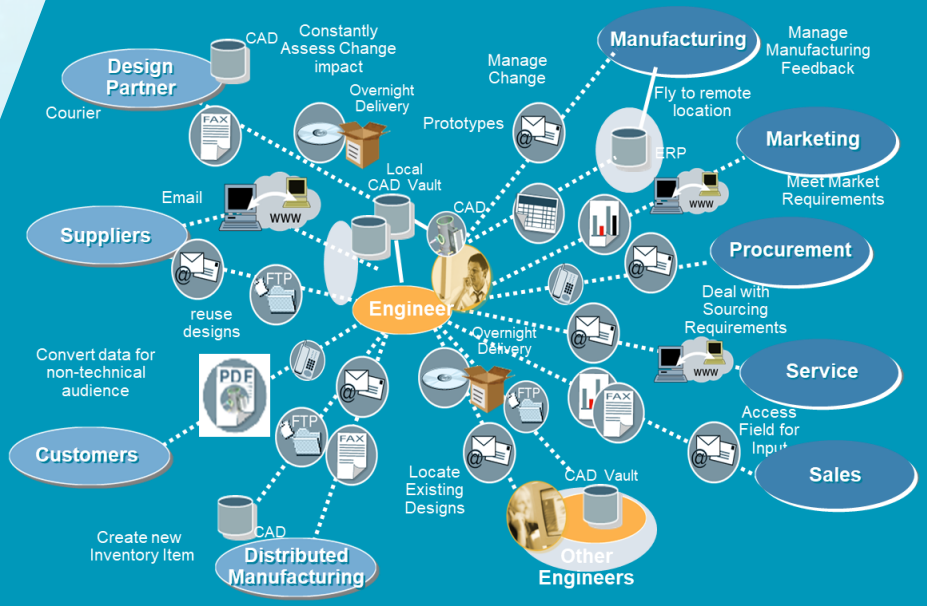
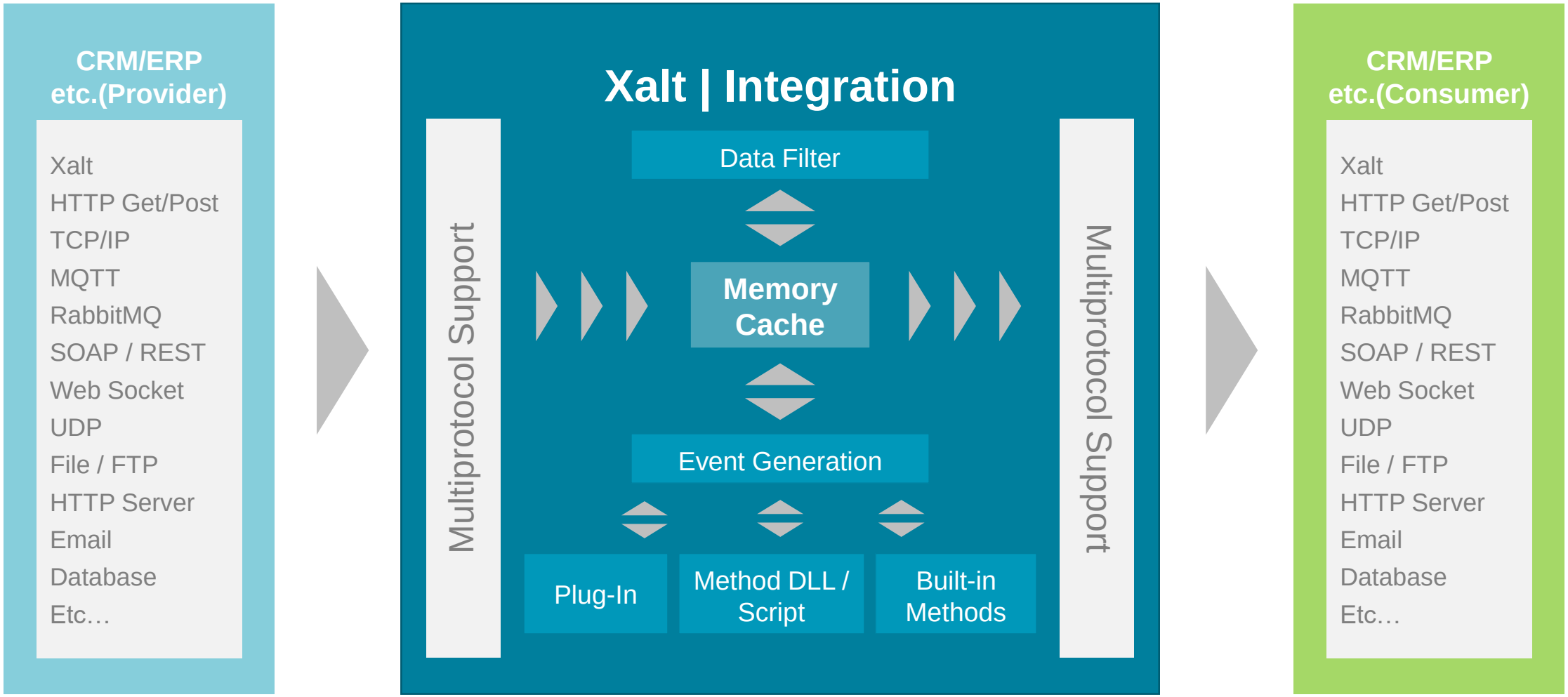
Connections to Business Applications





Xalt | Integration

Xalt | Integration provides interfaces to connect multiple software applications and a highly configurable *no-code* business rules engine to solve enterprise-level integration challenges.



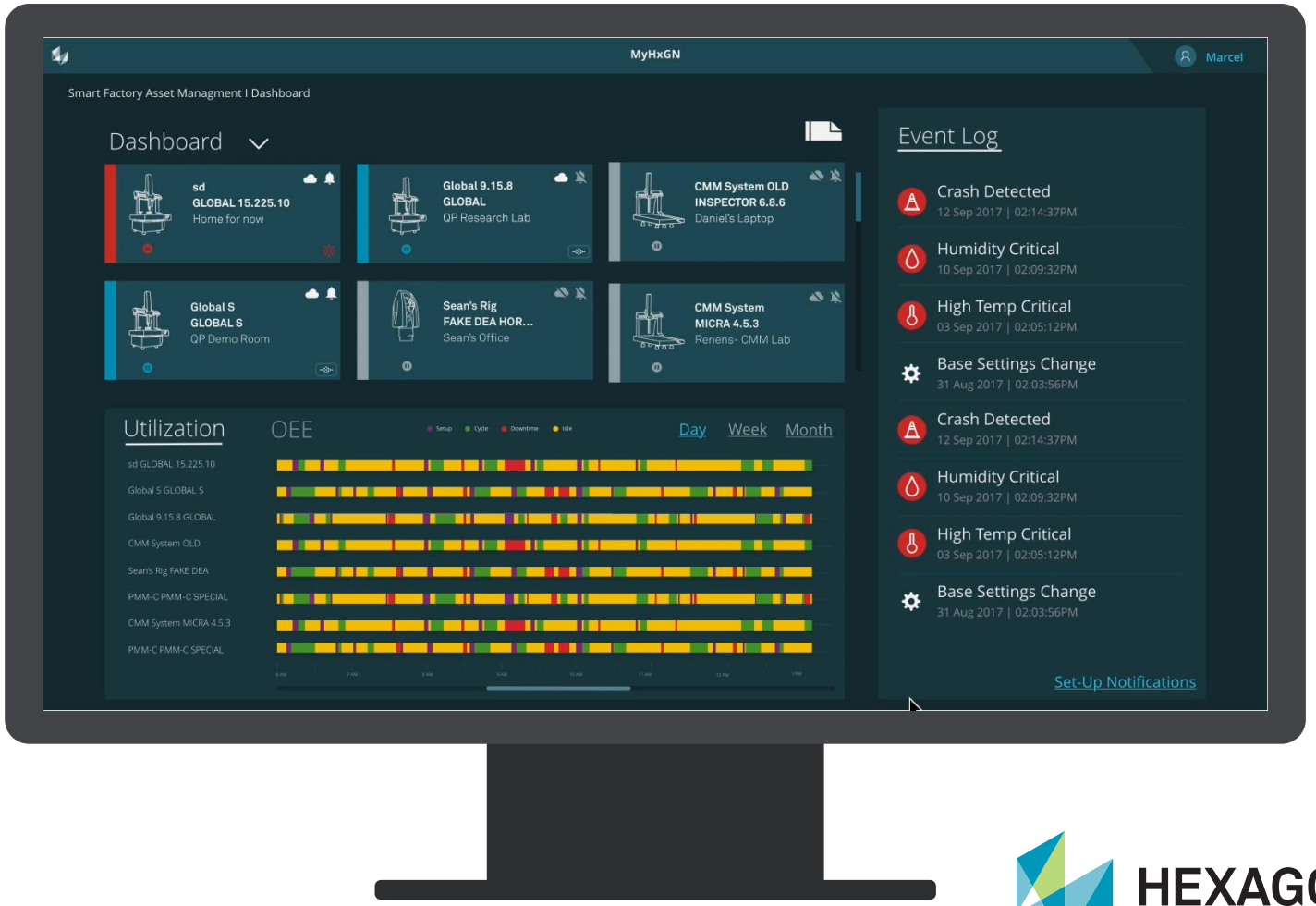
It's the glue that holds solutions together

HEXAGON

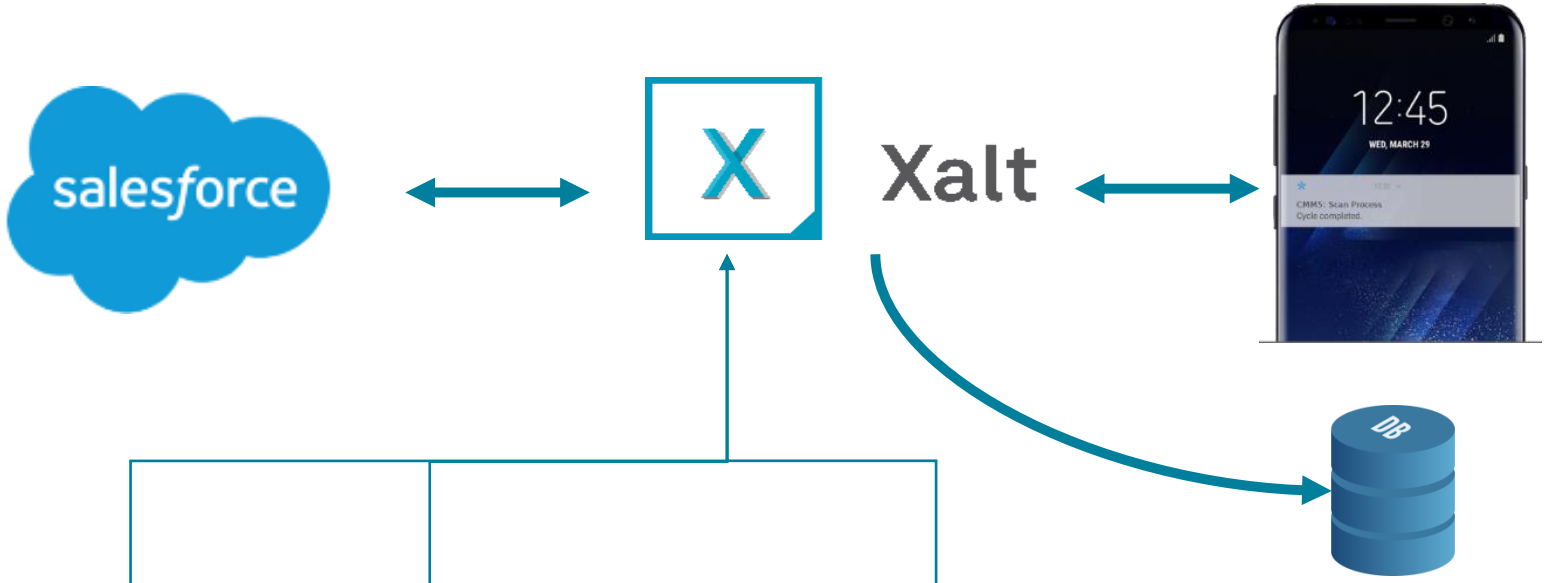
Asset Management

Minimize Downtime. Maximize Efficiency.

- System Health
- Asset Utilization Charting
- Facility Environment Tracking
- “OEE”
- System Notifications
- HMI Service Connection



Factory Monitoring and Load Balancing

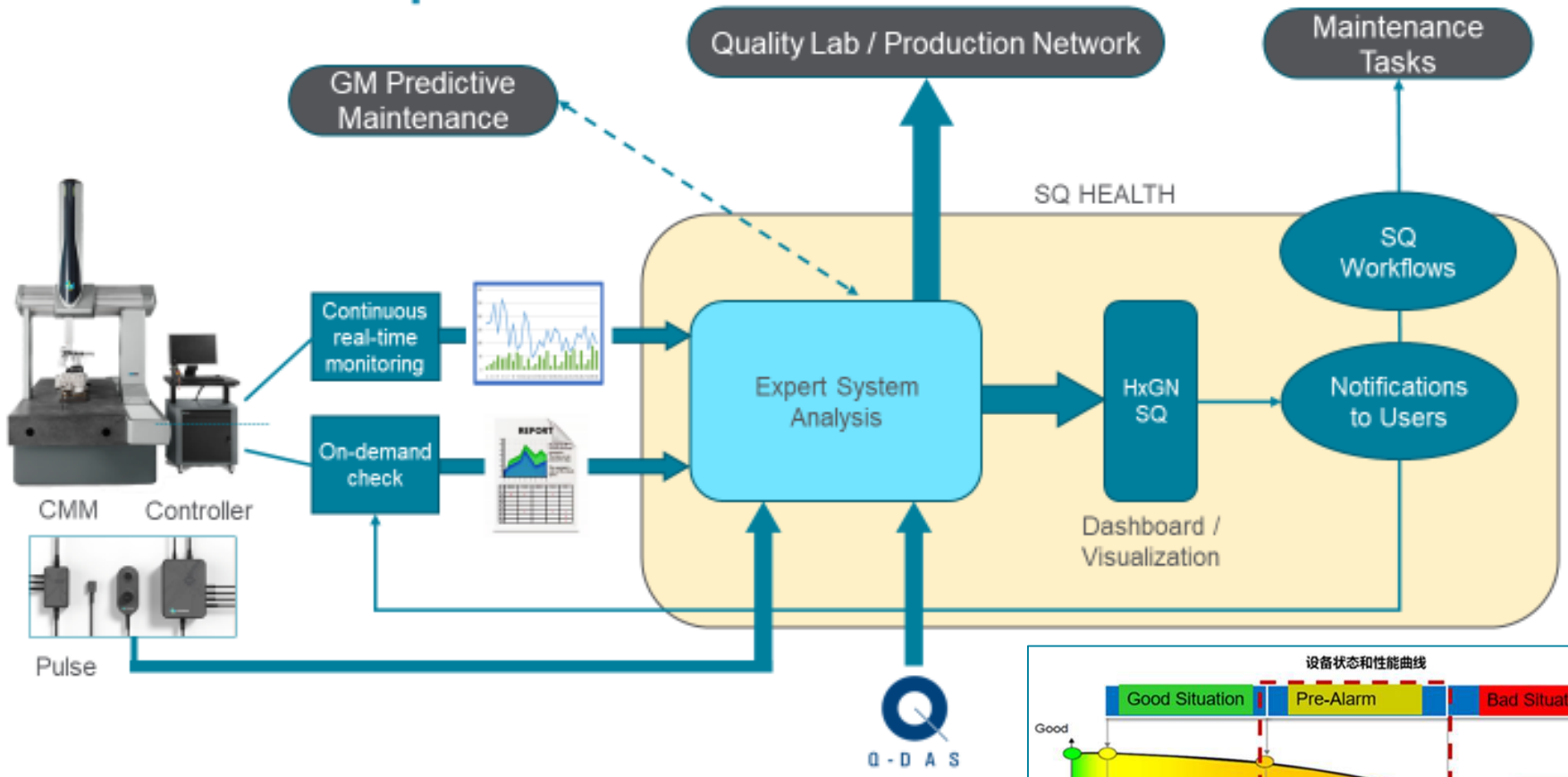


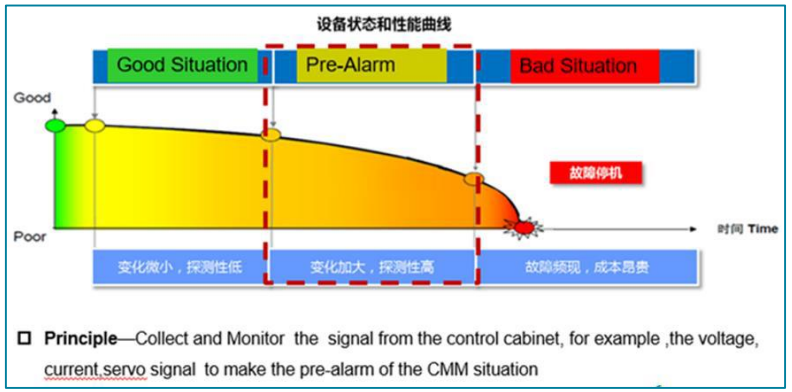
Scope

- Manage and see Assets in Smartphones
- Receive Notifcations on CMM Started, Busy, Idle, Crash, Error
- Master complextiy of setups in OEM environment
- Autodiscover assets
- Manage loads based on availability

Towards Predictive Maintenance

SQ Health Concept





Stepwise approach:

- **Step 1:** Rules-based notifications on pre-defined thresholds
- **Step 2:** Condition monitoring on parameters based on statistical methods
- **Step 3:** Predictive maintenance with ML algorithms trained on historical telemetry (machine, environment), failure/service events and process data

HEXAGON

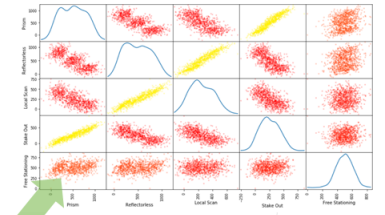
Data-Driven Customer Intelligence

- Observer logs usage data of different devices
- Mine this data for Business Insights
- Leverage AC's Advanced Analytics Platform *SIMPALA*
  - *Usage Analytics* module available
  - State-of-the-art data mining and machine learning tools

1) Detect Clusters
2) Map to Personas
3) Understanding and Decision Making

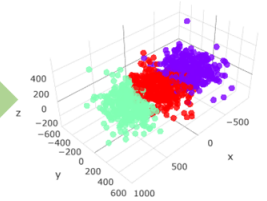
	Prism	Reflectorless	Local Scan	Stake Out	Free Stationing
0	984	393	240	520	617
1	504	478	225	264	493
2	644	487	200	405	526
3	770	311	226	433	422
4	679	708	374	174	839
...	...	...	...	...	...
995	546	374	122	272	526
996	659	234	190	306	397
997	397	284	40	193	448
998	672	552	321	413	490
999	740	512	240	257	755

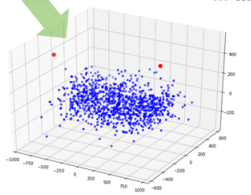
Customers #Sessions

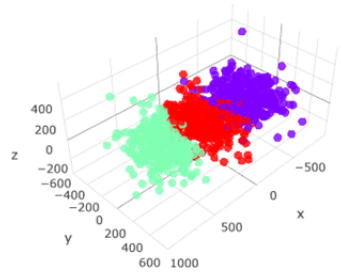


SIMPALA ADVANCED ANALYTICS

Feed data into *SIMPALA* and derive actionable insights







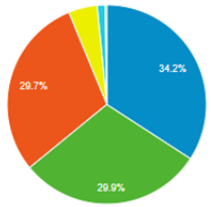
	Prism	Reflectorless	Local Scan	Stake Out	Free Stationing
Persona 0	185	806	418	76	497
Persona 1	809	200	84	423	501
Persona 2	508	490	244	256	498

Engineering

Infrastructure

Maintenance

SIMPALA ADVANCED ANALYTICS



In-Plant Logistics, Monitoring and Detection

Robot System

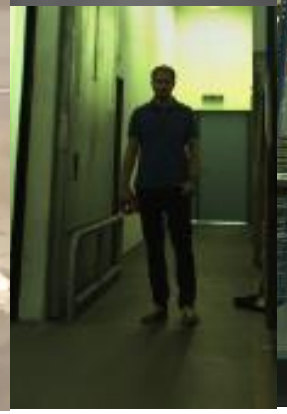
BLK 360
(incl. IR-Camera)

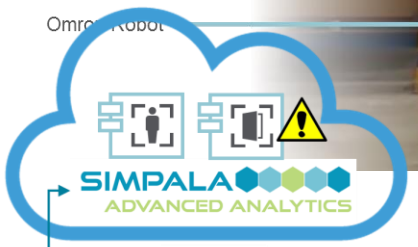
Axis Camera

Orbbec Sensor

Notebook
(Application Processor)

Omron Robot





MS Azure

Catavolt

Robot performs patrol
and tasks

Downloads WPs as
Instruction set to Robot

Enter Patrol
as Waypoints

Warehouse

On-Premise Servers

Anywhere

HEXAGON

Logistics Management

Physical Raw Material Flow

Tractors & Implements

Harvester Machines

Trucks & Tranships

Industry

Real Time Management

- Managerial Dashboards
- Monitoring Control
- Routing & Tracking
- Warning & Notifications
- Process Optimization

Ti7/5 Board Computer

3G/4G WiFi

- Operation monitoring
- Telemetry record
- Workflow automation
- onBoard Navigation
- Auto steering
- Precision agriculture
- Remote support/update

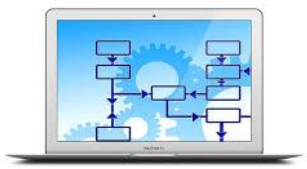
Cloud Servers

amazon web services™

- AgrOn Platform
- IoT Services
- Optimization Server
- Edge Frontier Server

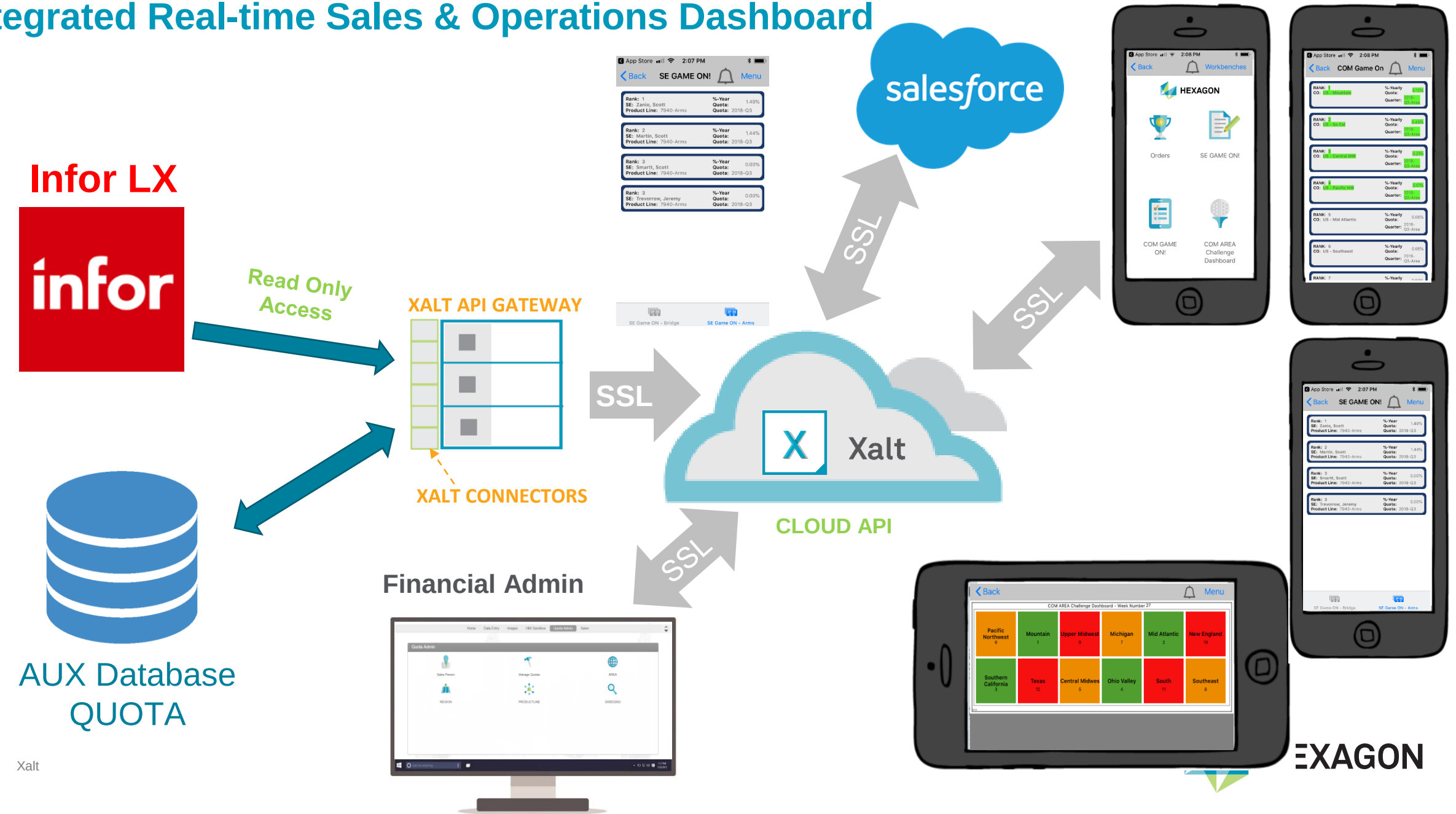
Control Room

Legacy Systems



HEXAGON

Integrated Real-time Sales & Operations Dashboard

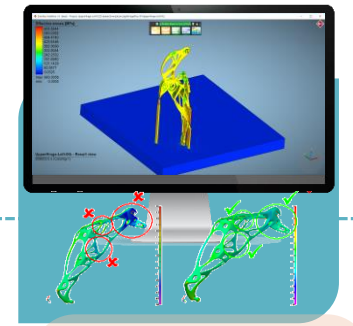


Hexagon Digital Thread from Design to Production to Quality

Hexagon Digital Thread

Function and manufacturing driven design

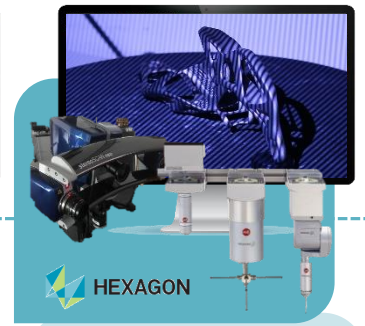
MSC Software



Virtual manufacturing (engineering)

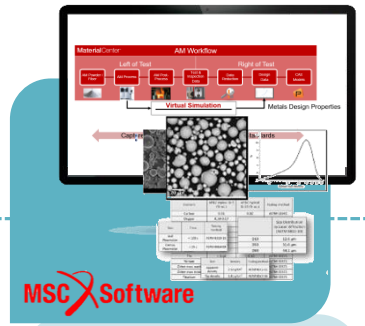
simufact

Preparation for printing/process planning (CAM)



Tactile and optical measurement, inline inspection, Ct scan

Fixed and mobile 3D measurement for reverse engineering



Material data management Test data, Virtual data, Production data

Process data management and analytics

HEXAGON

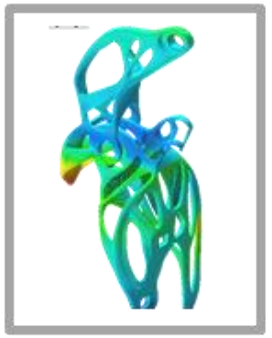
Capturing the End to End Additive Manufacturing Process Chain

Design space-Model

Topology-optimization

Active bonnet-function

Supporting structure optimization

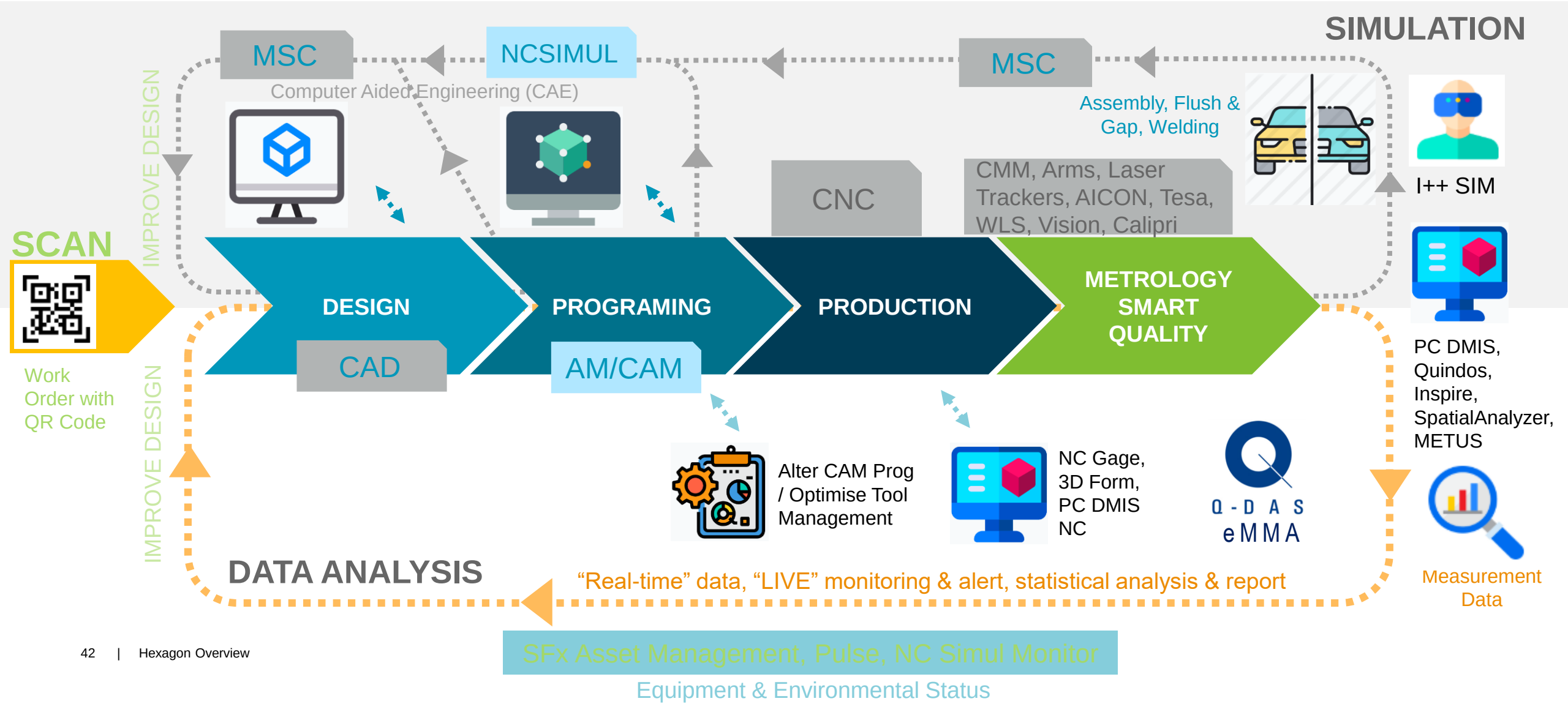


Distortion and residual stress optimization

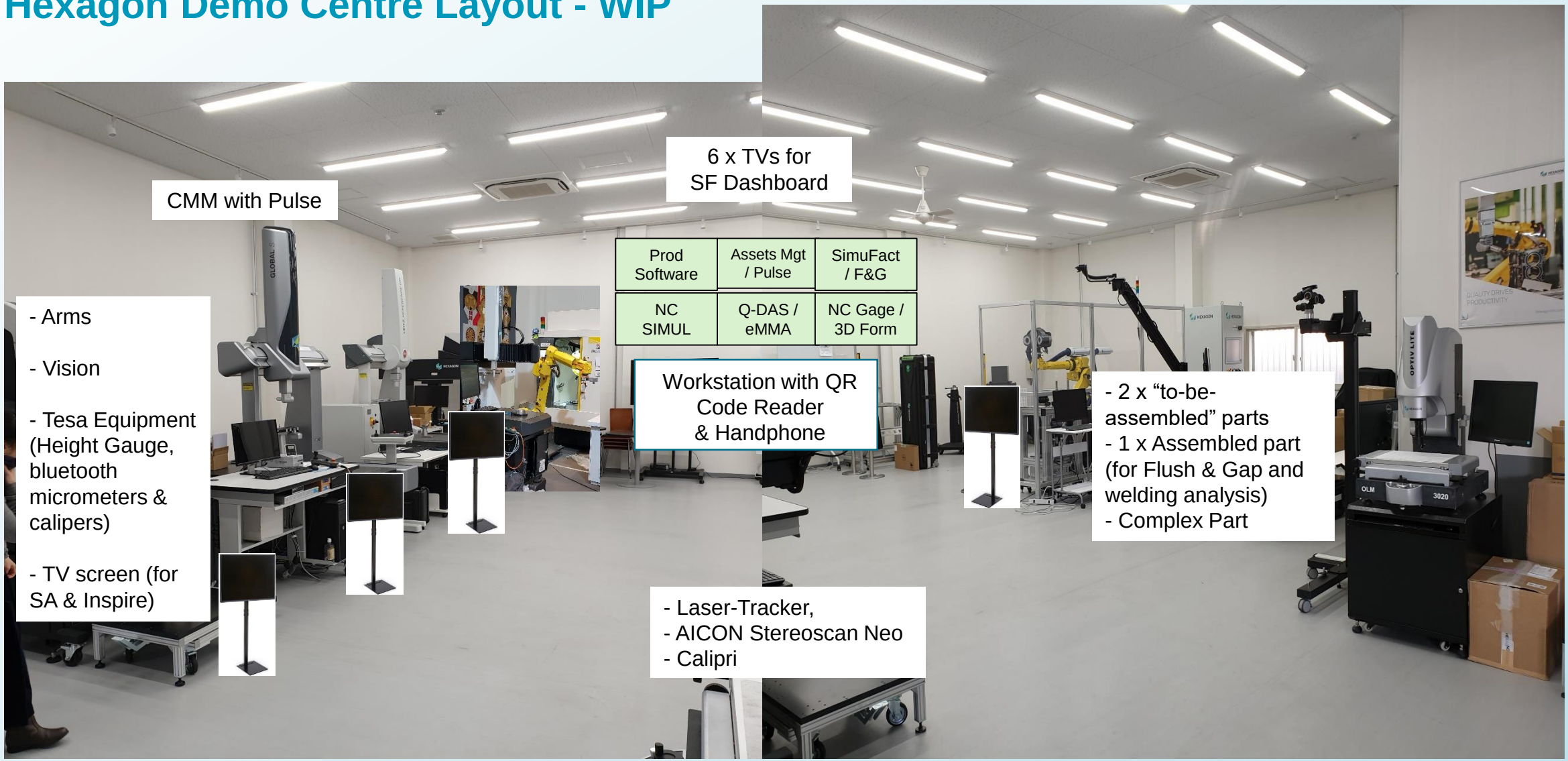
Manufacture LAM

Testing

Smart Factory Solutions APAC Concept

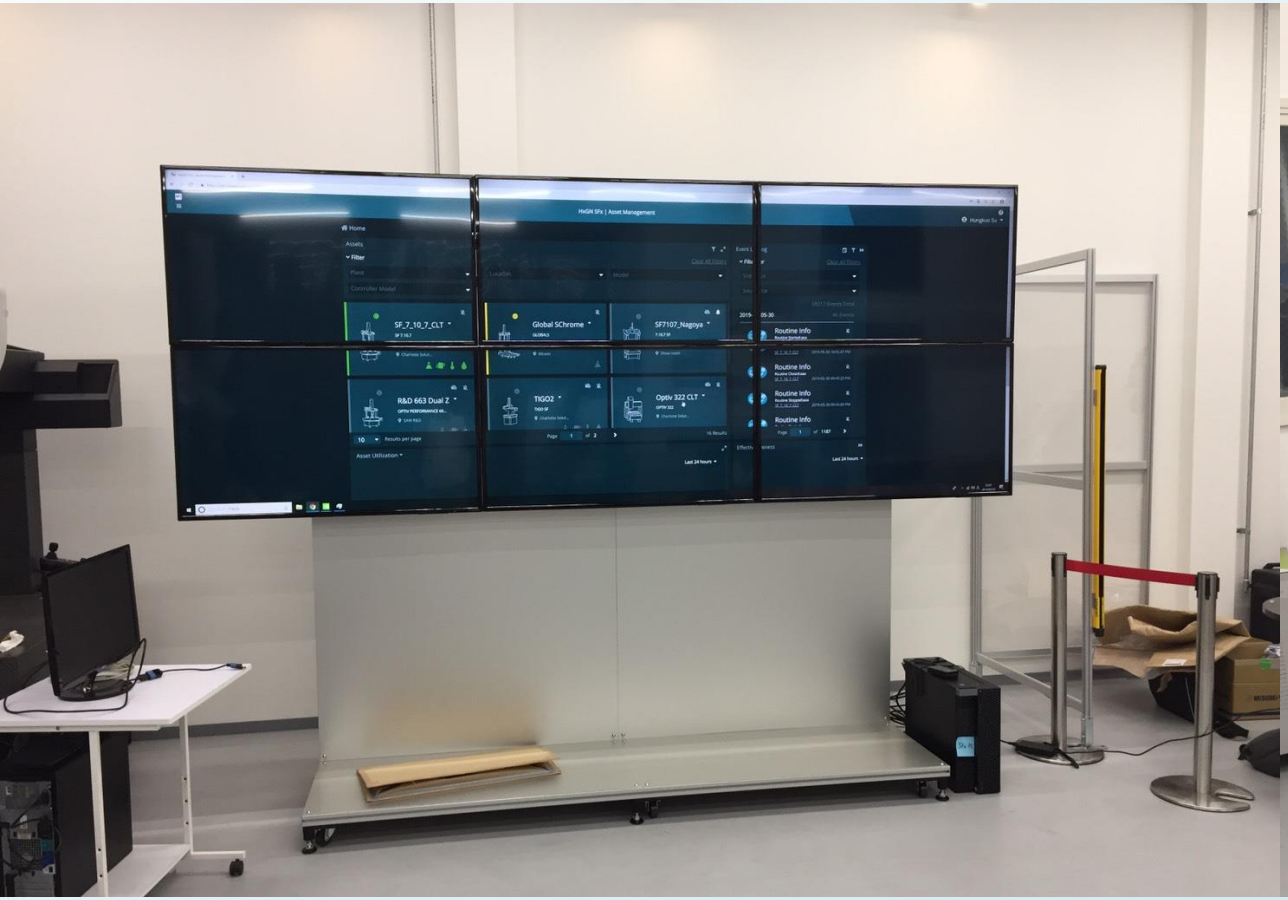


Hexagon Demo Centre Layout - WIP



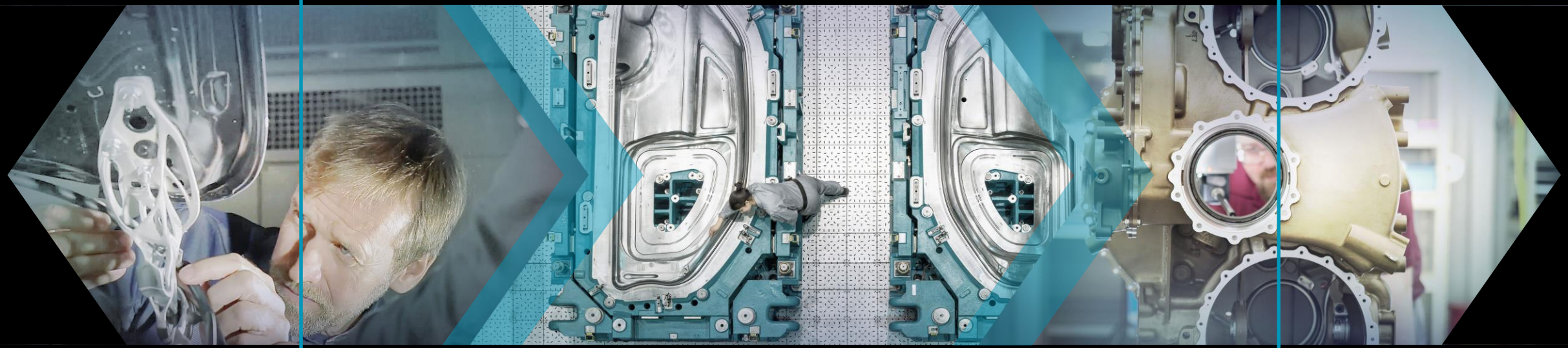
HEXAGON

Demo Centre - Work in progress



HEXAGON

Conclusion: Completing the Digital Thread with Optimized Design and Processes



DESIGN MANUFACTURING QUALITY

Feedback and Learning

Thank you.

HEXAGON
empowering an autonomous future

Precision and Smart Metrology

K. Niranjan Reddy

Scientist - E & Head – UPE
CMTI, Bangalore.

“If you measure

“Do it with Utmost Care”

and

“Remember the Measuring Errors”

- Anonymous

Etymology

The Science of Precision Measurement

“METRO” & “LOGY” are Greek Words

Meaning

“Measurement” and “Science”

Respectively

Etymology

Metrology Started in Ancient Egypt in

2750 BC

First Unit of Length Was **Cubit**

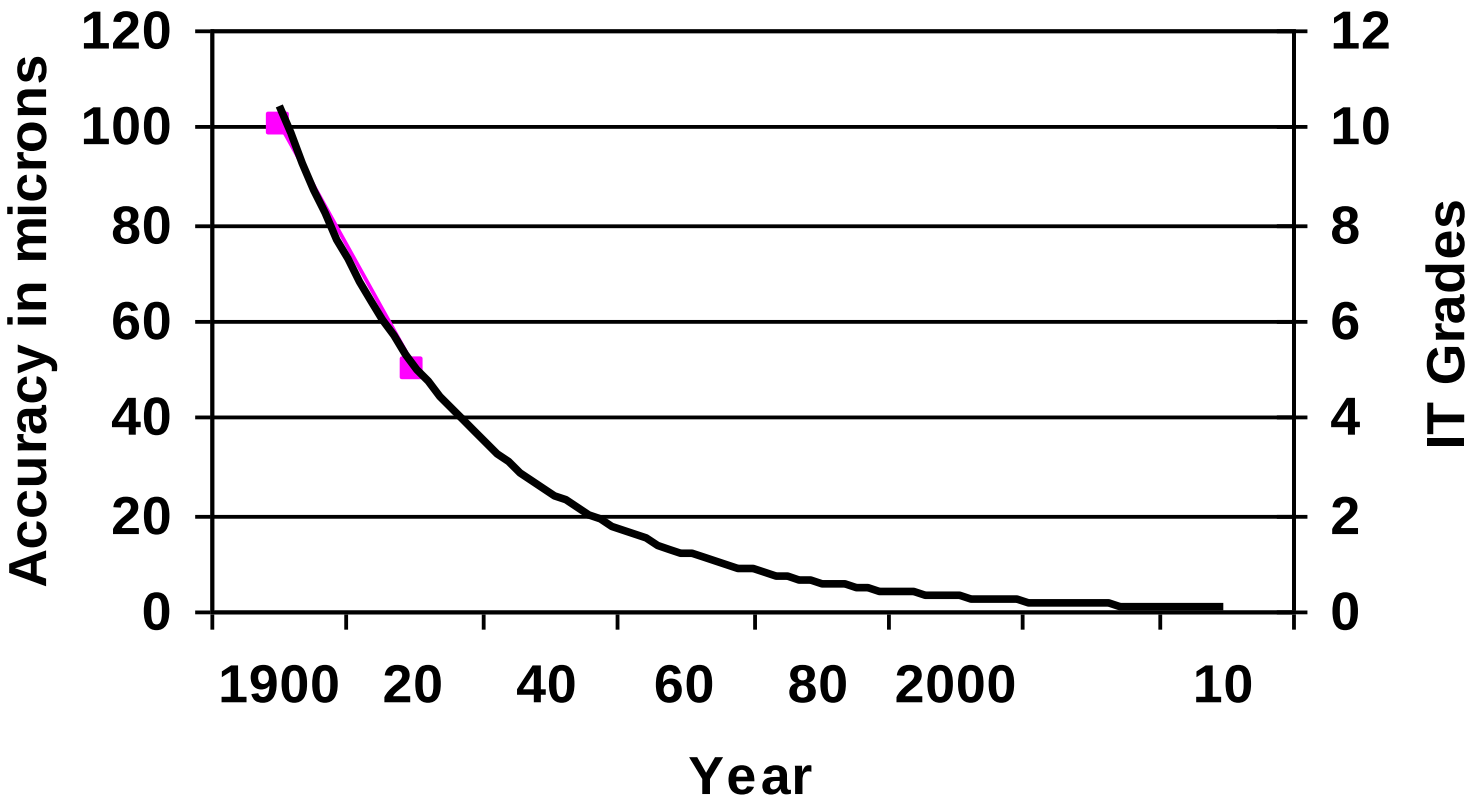
Cubit - Length of the Reigning

Pharaoh's Forearm

Journey towards Precision

- Started in 1775 with Wilkinson machining a ϕ1800 mm bore to 1 mm accuracy
- Today conventional precision machining is being carried out to dimensional accuracies of 1 μm on 100 mm length

Dimensional Accuracies since 1900

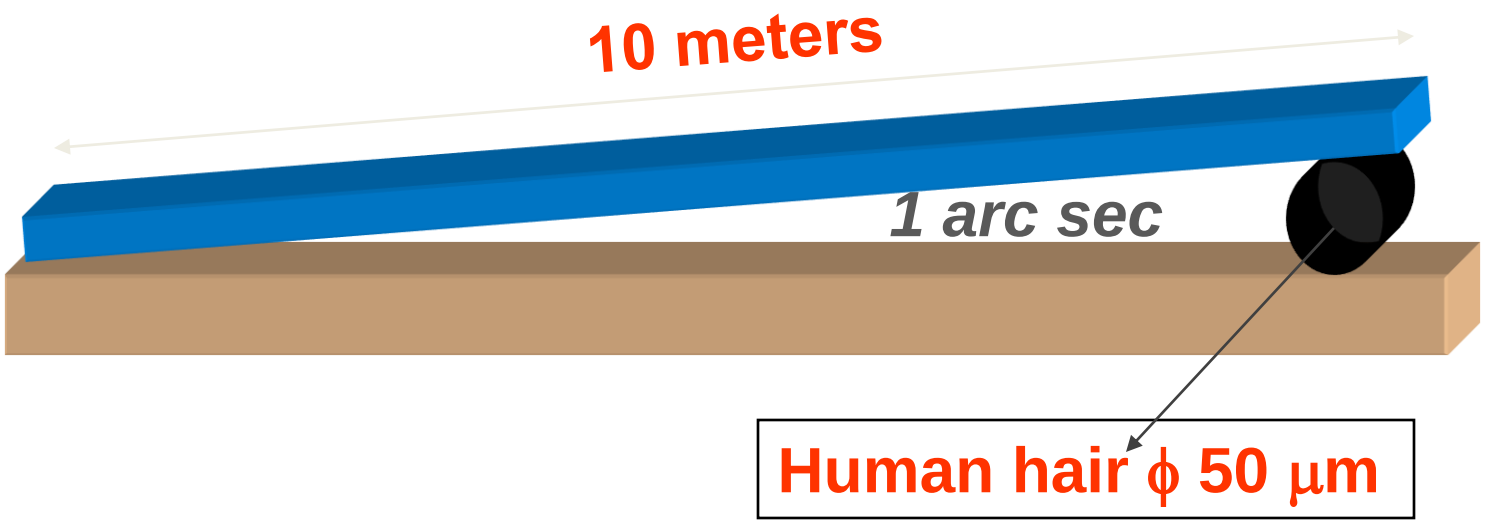


What is 1µm

1 µm

1nm=1/1000 µm

What is **1 arc sec**



The Goal of Metrology

- **Accept good products**
- **Reject bad products**
- **Better to reject few good ones than to accept a few bad ones**

Classification of Metrology

- **Dimensional Metrology**
- **Surface Metrology**
- **Co-Ordinate Metrology**
- **Mass Metrology**
- **Force Metrology**

and So on .....

BASIC TERMINOLOGIES

Basic Terminologies

- **RESOLUTION (of a displaying device)**

Smallest value that can be indicated by the displaying device.

or

Smallest difference between indications of a displaying device that can be meaningfully distinguished

Basic Terminologies

ACCURACY

Closeness of agreement between the result of measurement and the true value of the measurand.

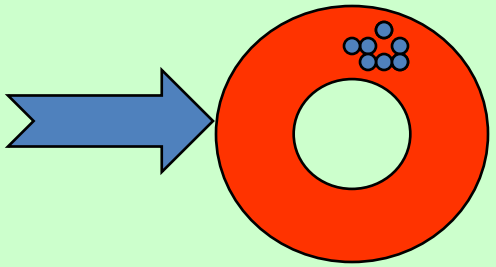
PRECISION

Closeness of agreement between the results of successive measurements of the same value of a quantity carried out under identical conditions at short intervals of time.

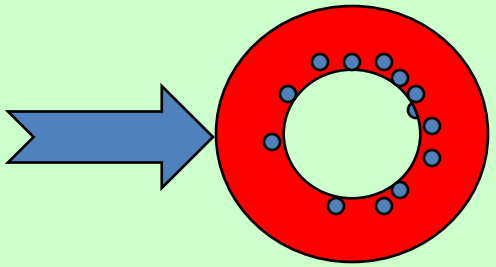
(Precision is also called Repeatability)

Graphic Distinction Between Accuracy and Precision

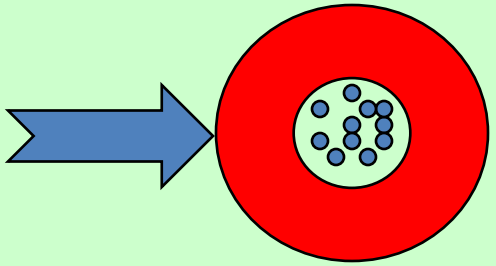
Precise but not Accurate



Accurate but not Precise



Precise and Accurate



Basic Terminologies

REPRODUCIBILITY

Closeness of agreement between corrected results of measurements of the same value of a quantity when the measurements are made under different conditions.

RELIABILITY

The ability of an item to perform a required function under stated conditions for a stated period of time.

Basic Terminologies

TRACEABILITY

The concept of establishing valid calibration of a measuring standard or instrument by step-by-step comparison with better standards upto an accepted national or international standard.

Measurement Standard

Material measure or physical property which defines or reproduces the unit of measurement of a base or derived quantity.

Types of Measurement Standard

- FUNDAMENTAL OR ABSOLUTE STANDARD
- INTERNATIONAL STANDARD
- NATIONAL OR PRIMARY STANDARD
- REFERENCE STANDARD
- SECONDARY STANDARD
- WORKING OR STANDARD

Hierarchy of Traceability

Primary Standard of Length (Metre)
Established by Interferometry

↓

Secondary Standard of Length
Verified by Interferometry

↓

Grade “00” Slip gauges Calibration Grade
Verified by Interferometry

↓

Grade “0” & “1” Slip gauges
Verified by high magnification comparator

↓

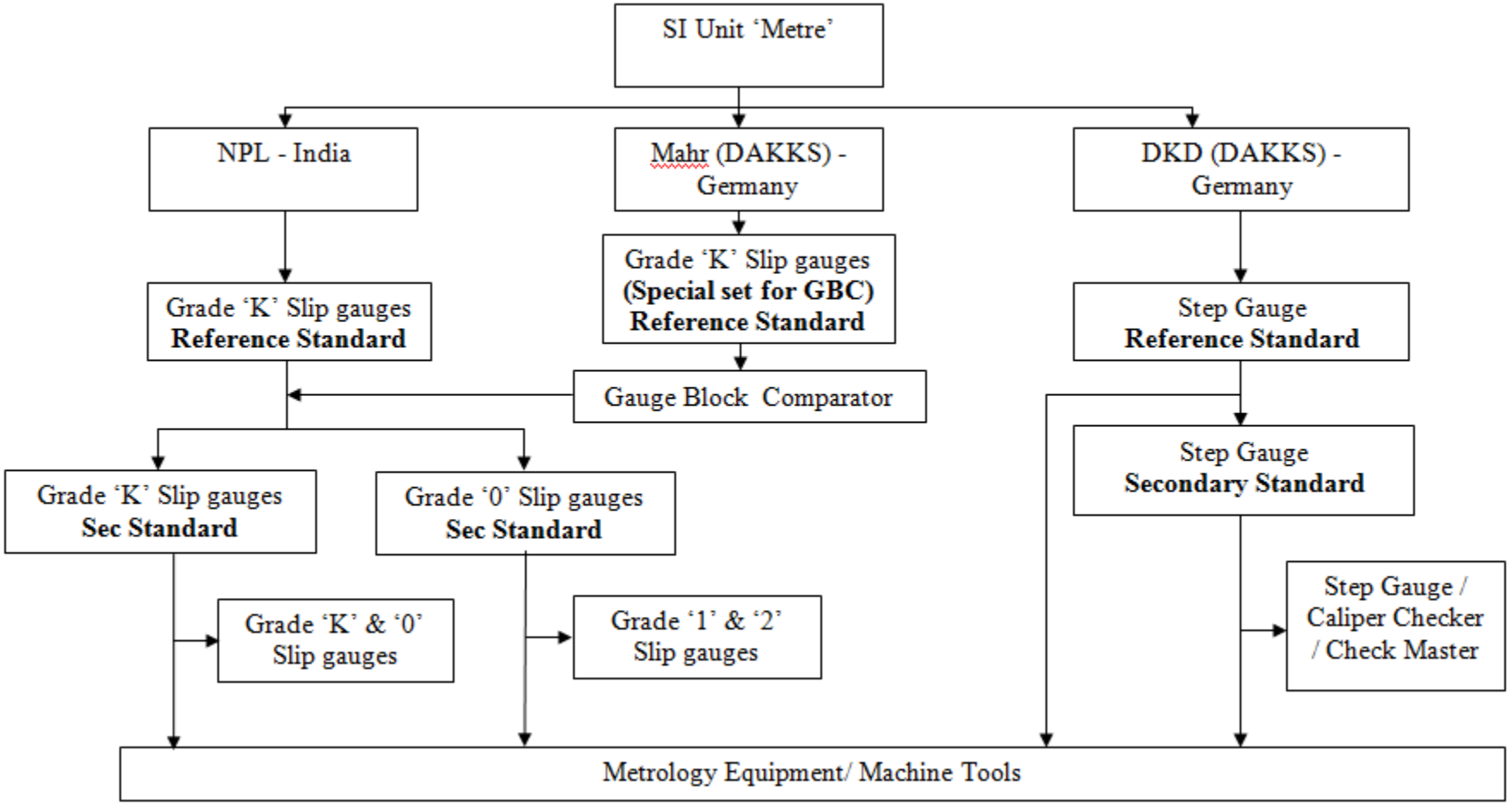
Grade “2” Slip gauges
Verified by high magnification comparator

↓

Work piece
Verified by suitable gauging practice

The metre is defined as the length of the path travelled by light in a vacuum in 1/299 792 458 second

Length Traceability at CMTI



Factors effecting the Accuracy of Measurements

S	**Factors affecting the Standard**
W	**Factors affecting the Work-piece**
I	**Factors affecting the Measuring Instruments**
P	**Factors affecting the Person**
E	**Factors affecting the Environment**

Factors affecting the Accuracy of Measurements

Environmental Effects:

- Room Temperature
- Part Temperature Stabilization
- Temperature Variation
- Humidity
- Vibration Level
- Dust Level
- Air Flow
- Lighting

Precision Metrology Laboratory at CMTI

NABL Accredited Dimensional Metrology Lab

Lab conforms to ISO/ IEC 17025:2005

Measurement of Dimension, Form, Surface Texture and Gear Parameters

Temp: 20 ± 0.5°C

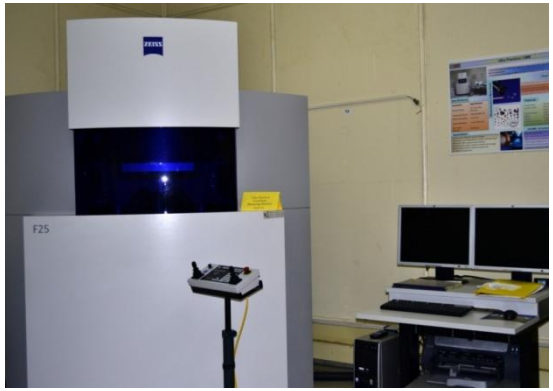
Vibration : < 0.2 μm

Noise: <60 dB

Clean Room Class: 10,000

"India's one of the kind metrology lab that is housed 6m below ground"

Dimensional Metrology at CMTI



Ultra Precision Co-ordinate Measuring Machine

Co-ordinate Measuring Machine

Gauge Block Interferometer

Surface Metrology at CMTI

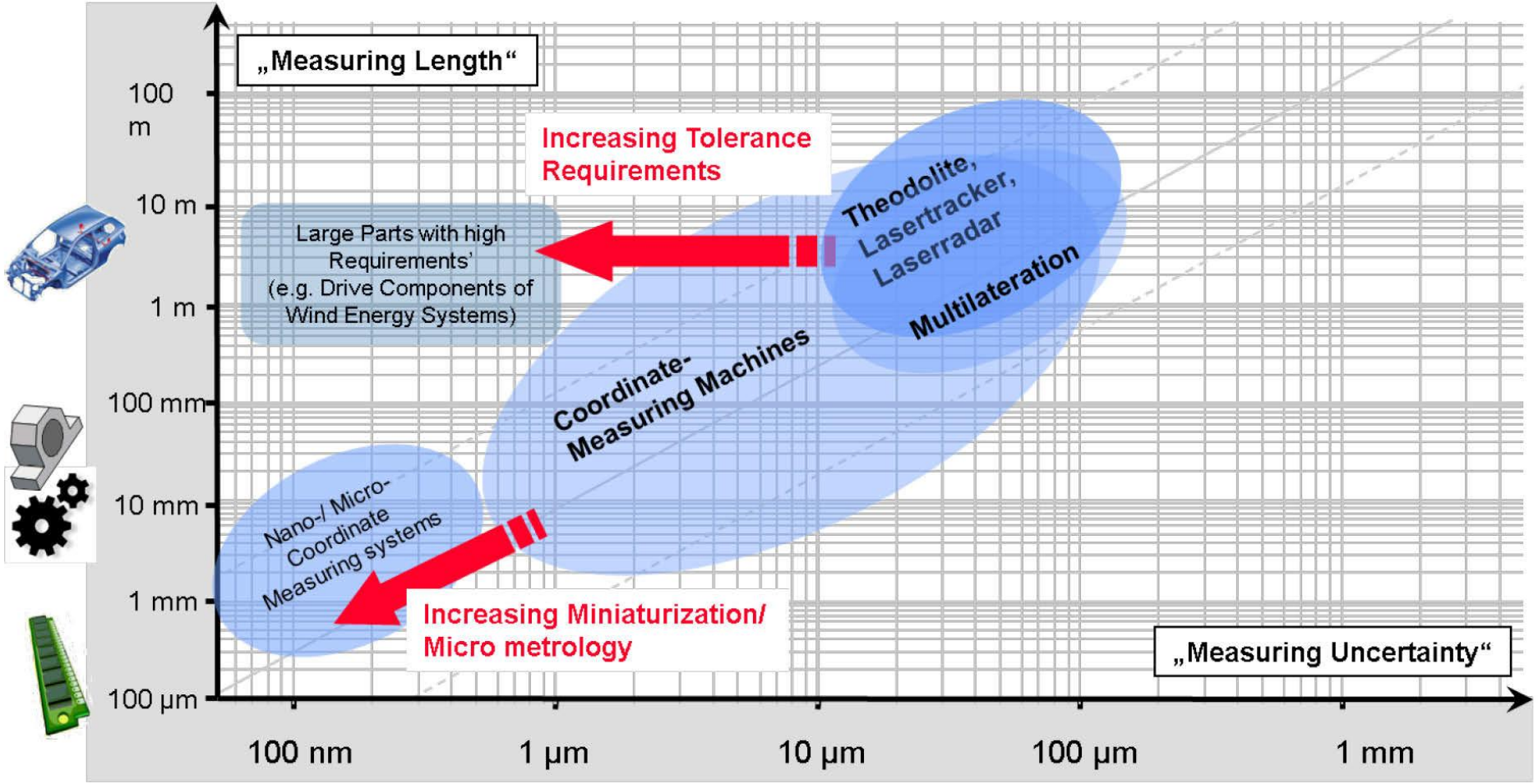
Form profiler

Roughness Tester

Flatness interferometer

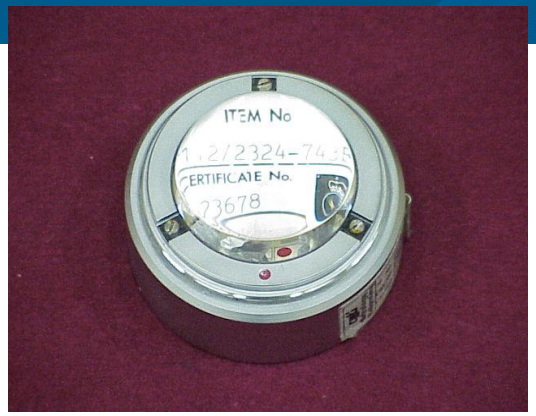
Optical Profiler

Trends of Accuracy/ Uncertainty in Length Measurement



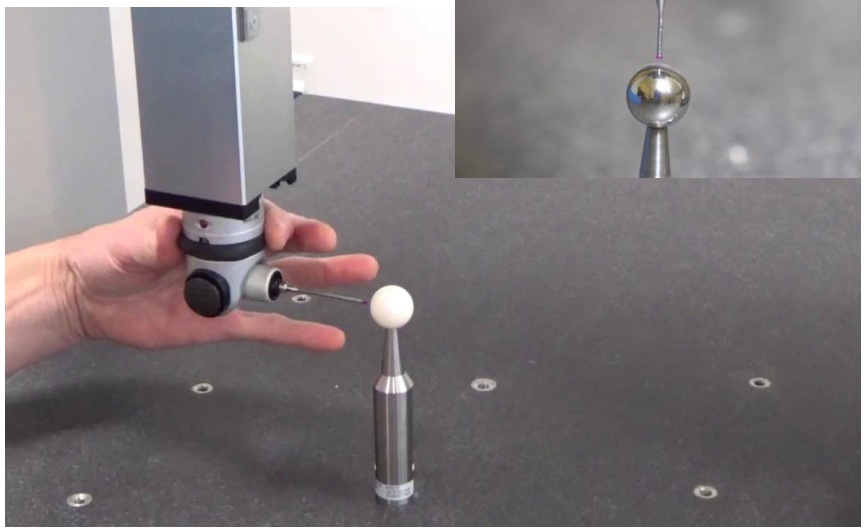
Metrology Artefacts

OPTICAL FLAT



GLASS HEMISPHERE

MASTER CYLINDER

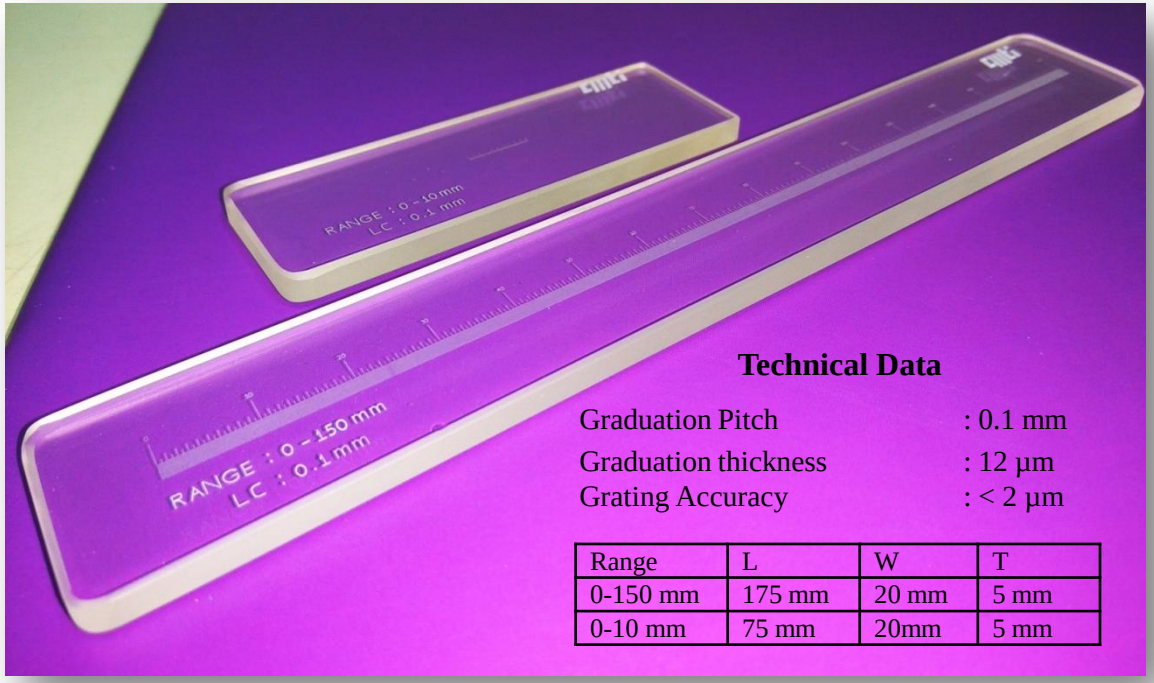


COORDINATE MEASURING MACHINE (CMM) AND MASTER SPHERE

Current Status: In the country most of these artefacts (>90 %) are being imported

Efforts of CMTI in development of Indigenous Metrology Artefacts

High Precision Optical Standard Glass Scales



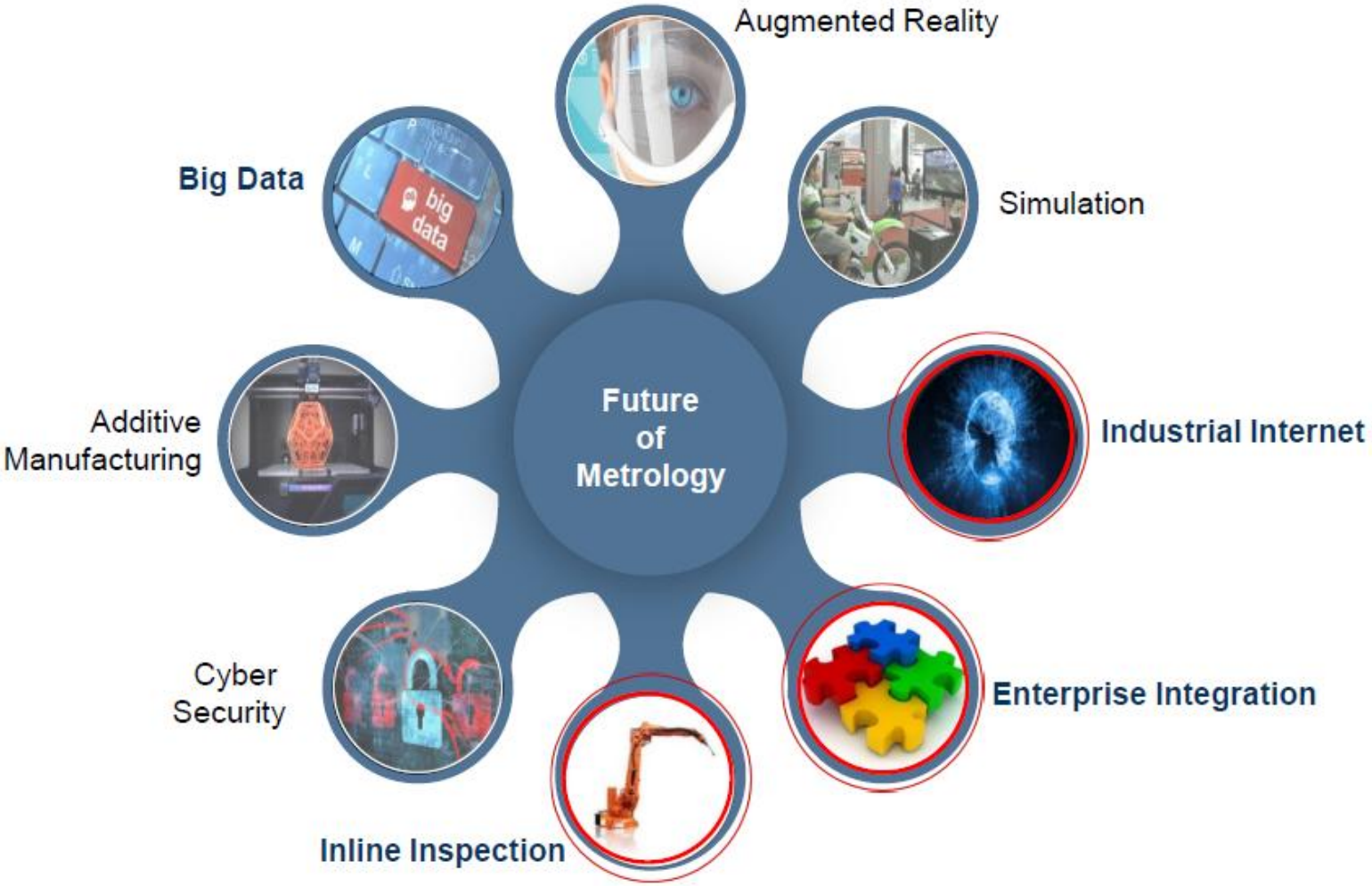
Linear Standard Glass Scales

Angular Standard Glass Scale

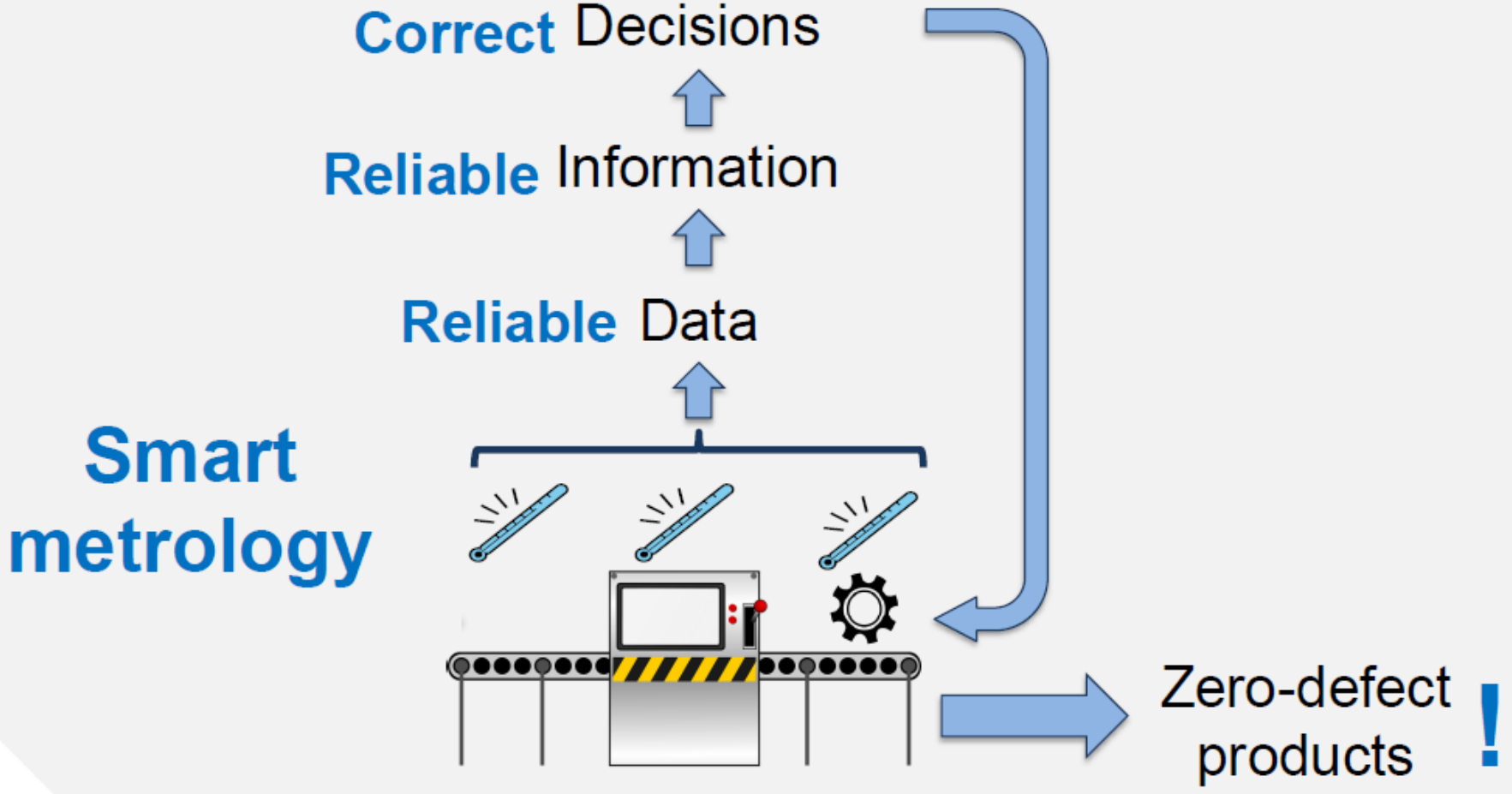
In-house facility used:

1. Femtosecond laser micromachining system
2. Confocal Microscope
3. Ultra Precision CMM

Transformative Forces Reshaping the Future of Metrology



The need for Smart Metrology

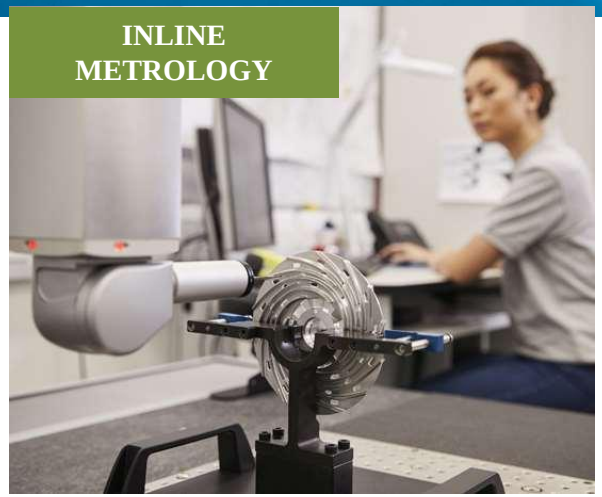


Smart Metrology Challenges

Product flow	• Measurement time • Accessibility of features • Motion and handling
Environment	• Temperature • Humidity • Vibrations, contamination
Diversity	• Multiple features per product • Variation between products
Data handling	• Task-specific uncertainty, • Numerical accuracy and Data integrity • Data fusion from multiple sensors

Factors to consider in adapting Smart Metrology

INLINE METROLOGY



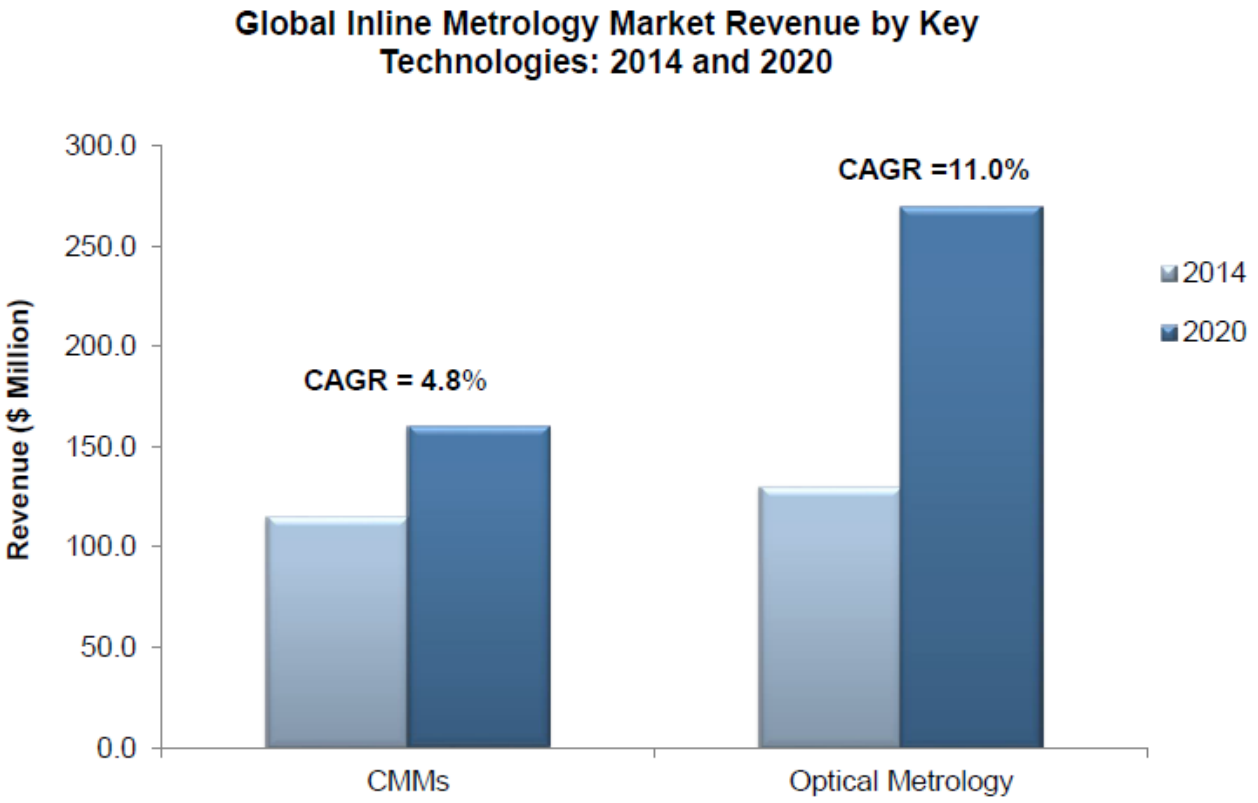
NON-CONTACT: OPTICAL AND LASER SYSTEMS

ROBOTS

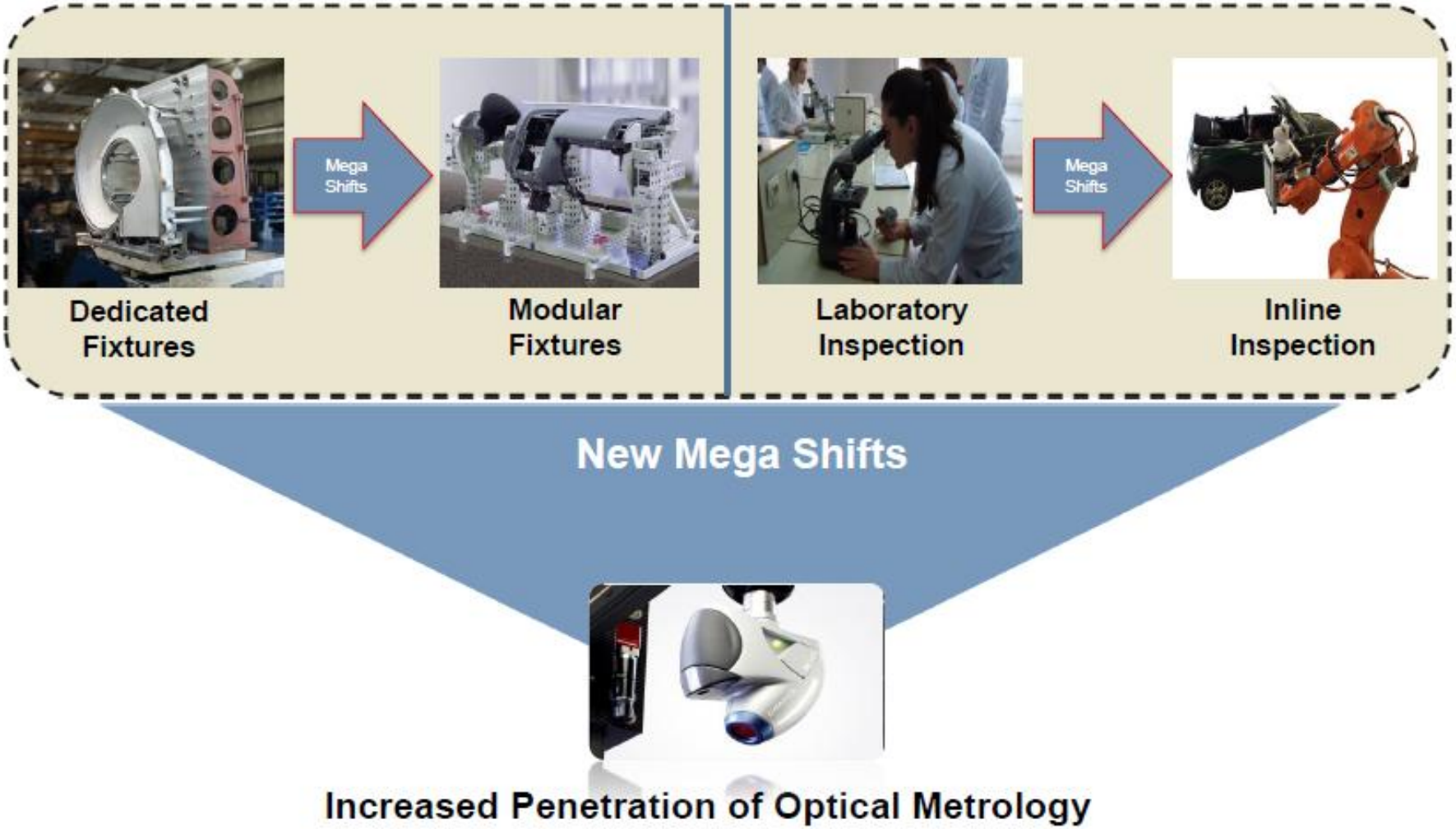
Inline Metrology

Inline Metrology—Market Size and Forecasts

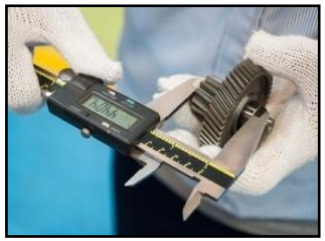
Speed, accuracy, and flexibility are key attributes that enable optical scanners to replace traditional CMMs.



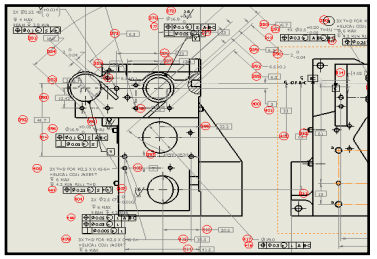
Mega Shifts


Mega Shifts
Mega Shifts
Dedicated Fixtures
Modular Fixtures
Laboratory Inspection
Inline Inspection
New Mega Shifts
Increased Penetration of Optical Metrology

Smart Metrology Lab



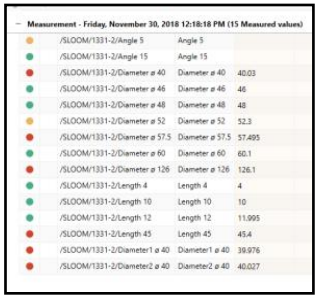
Manual Inspection Data



Auto Ballooning

CMM Data

Cloud / Server



Inspection Reports

Wireless Measuring Instruments Data

Quality Control

Smart Metrology Lab

Smart Inspection

- Automatic generation of Inspection Data sheet
- Wireless exchange of inspection data

Smart Data Management

- Integration across
  - Inline
  - Manual
  - CMM Inspection
- Real Time Data Visualisation

Smart Quality Management

- Improved Traceability
- Statistical Process control data (Cp,Cpk)
- Customized Inspection reports

Smart Inspection

Smart Inspection Facility encompassing

- Smart Measuring Instruments
- Smart Quality Monitoring
- Smart Process Monitoring

Smart Inspection Lab

A smart inspection and data management application for digital metrology is setup.
The application would collect, store, present digital data from Smart Bluetooth enabled instruments and data from other instruments/ equipments / gauges and CMM.
Data analytics such as Cp, Cpk are also performed to provide process capability information.

SMART Automated Inspection System Developed by CMTI
Auto-Correction Feedback

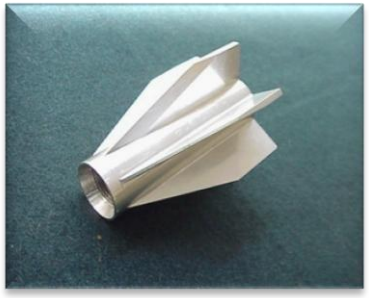
Multi Gauging System for Sabot

Multi Gauging System for Penetrator

Multi Gauging System for Tail Piece

SABOT

PENETRATOR



TAIL PIECE

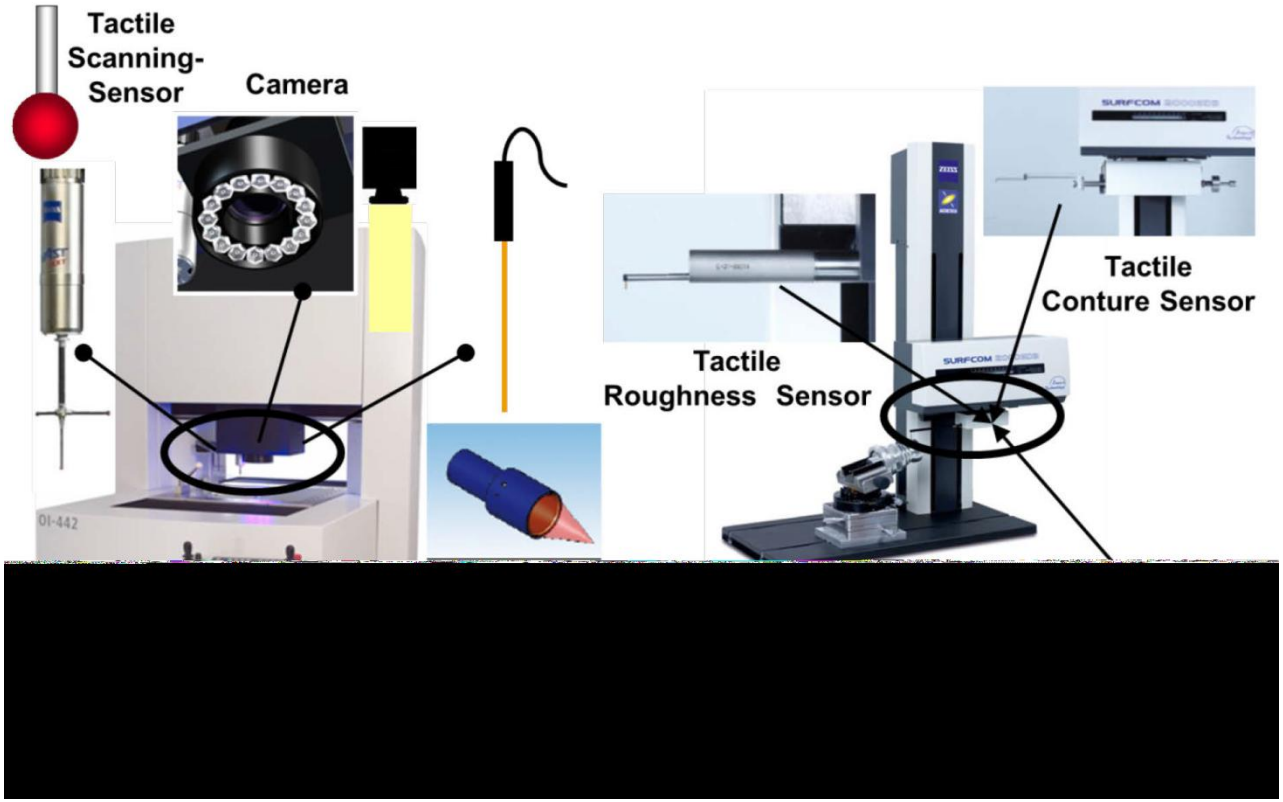
Highlights:

- **Automated Measurement of Internal Thread Parameters, Form Errors and Dimensions**
- **18 Parameters measured and documented in just over 3 minutes …..**

The system was developed for comparing manufactured dimensions of the components with that of the designed dimensions, record the deviations and indicate whether the component can be accepted, rejected or needs rework.

- **Automatic gauging significantly cuts down the inspection time**
- **Eliminates human measurement error**
- **Measured data is stored and accessed from the PC for statistical analysis.**
- **Online correction for the dimensional variation by automatically feeding the result of inspection to CNC system**

Multi Sensor Implementations



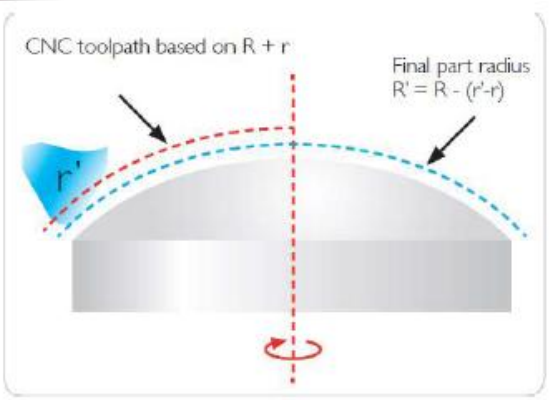
Parallel Sensor Implementation on a Co-ordinate Measuring Machine

Changeable Sensor Implementation on Surface Texture Measuring Device

Automated Integrations

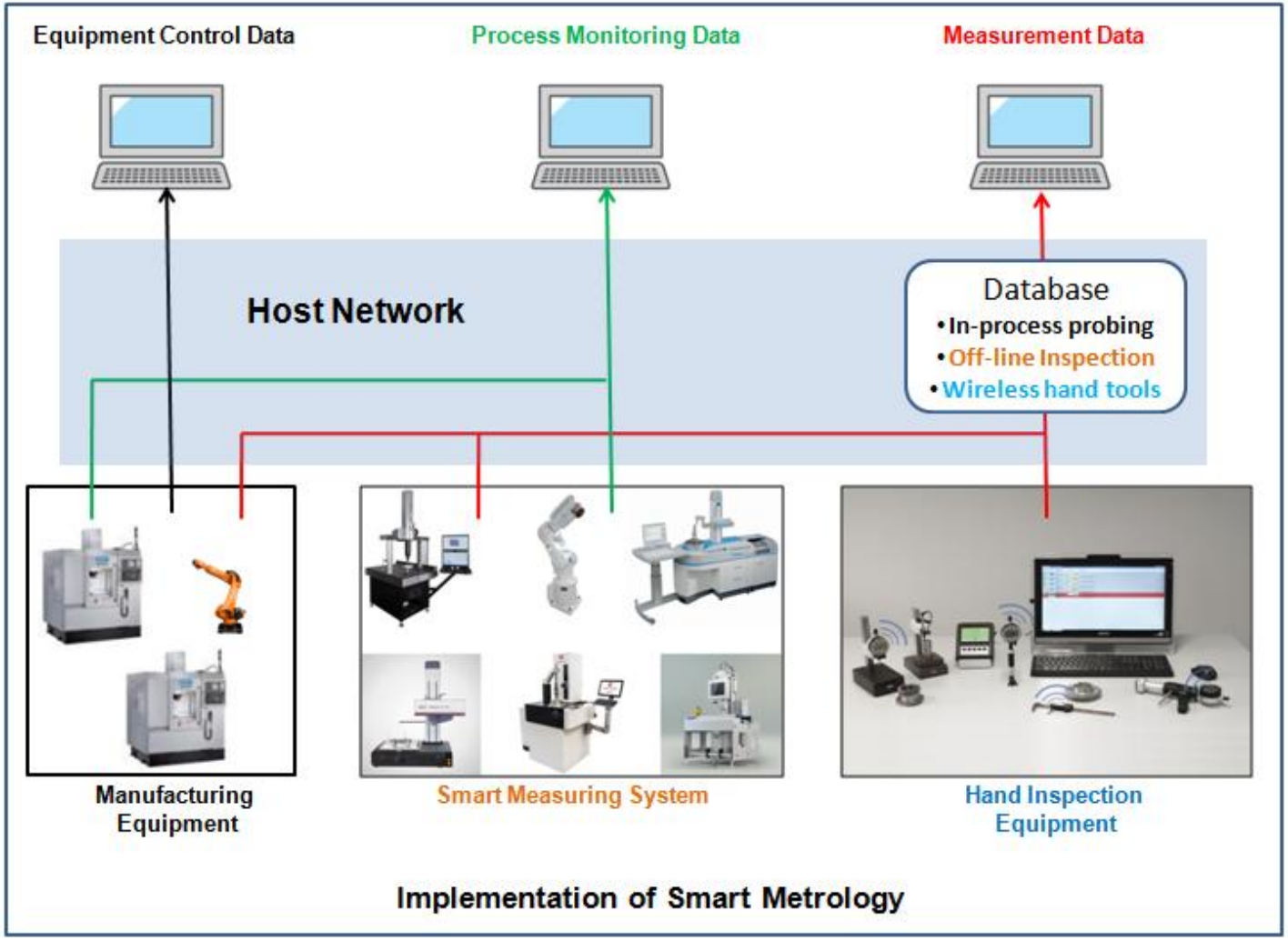
Faster metrology due to the automated integration of a CMM into material flow by Robot loading.

Process Correction Solutions



Measurement of X-offset / Tool Radius as well as automatic quick correction for it from direct measurement of a production asphere.

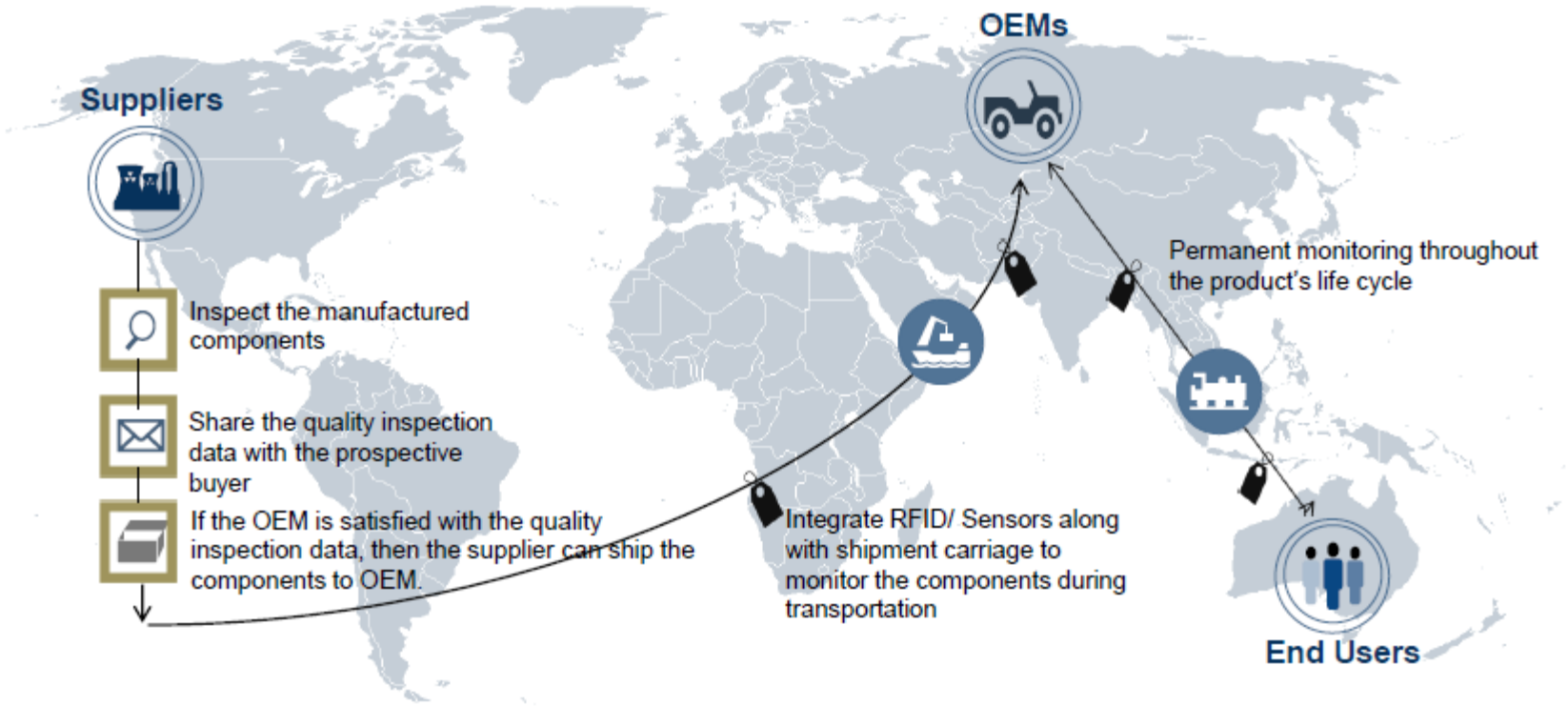
Smart Metrology Cell



Digitization

Digitization of Industrial Measurement Throughout the Supply Chain

Revenues from ERP software will surpass the hardware revenues over the next 5-8 years.



Establish process and quality inspection throughout the supply chain

Centralized global data for future references

Permanent monitoring will help manufacturers design effective root cause analysis, corrective and preventive strategies, and help manufacturers achieve the utopian vision of 'Zero errors in Manufacturing'.

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Success is a new dimension.

One stop solution for a complete range of dimensional, form, gear and surface roughness measurement & calibration accredited by NABL.

From Ultra precision CMMs to Gauge block interferometer, Flatness interferometer to Nano surface optical profiler, our calibration services guarantee *your* success.

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Smart Machine tool and Intelligent Machining

Gopi Krishna S, Scientist C

Smart Manufacturing, Precision Machine tools & Aggregates

Central Manufacturing Technology Institute, Bengaluru

Outline

1. Introduction
2. Features of a smart machine tool
3. Introduction to Intelligent machining
4. Development of an Intelligent Ultraprecision Machine Tool
5. Intelligent Machining – CMTI initiatives

Introduction

- Machining processes evolved around Sensing, process model, knowledge base and process control is **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 **Smart 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
- Development of technology for smart machine tools and intelligent machining is one of focus area of CMTI activities
- Improvement in accuracy of products , along with productivity and ease of operation is our targets for technology development in this domain

Main Features of a smart machine tool

1. Adaptation to Changing conditions
2. Open Architecture CNC and sensor interface
3. Extensive Information processing capability
4. Real time compensation of Geometrical & Thermo-elastic displacement errors
5. Sensor based machine condition monitoring, Self Diagnostics
6. Tool condition monitoring

Main Features of a smart machine tool

7
- Vibration and chatter control

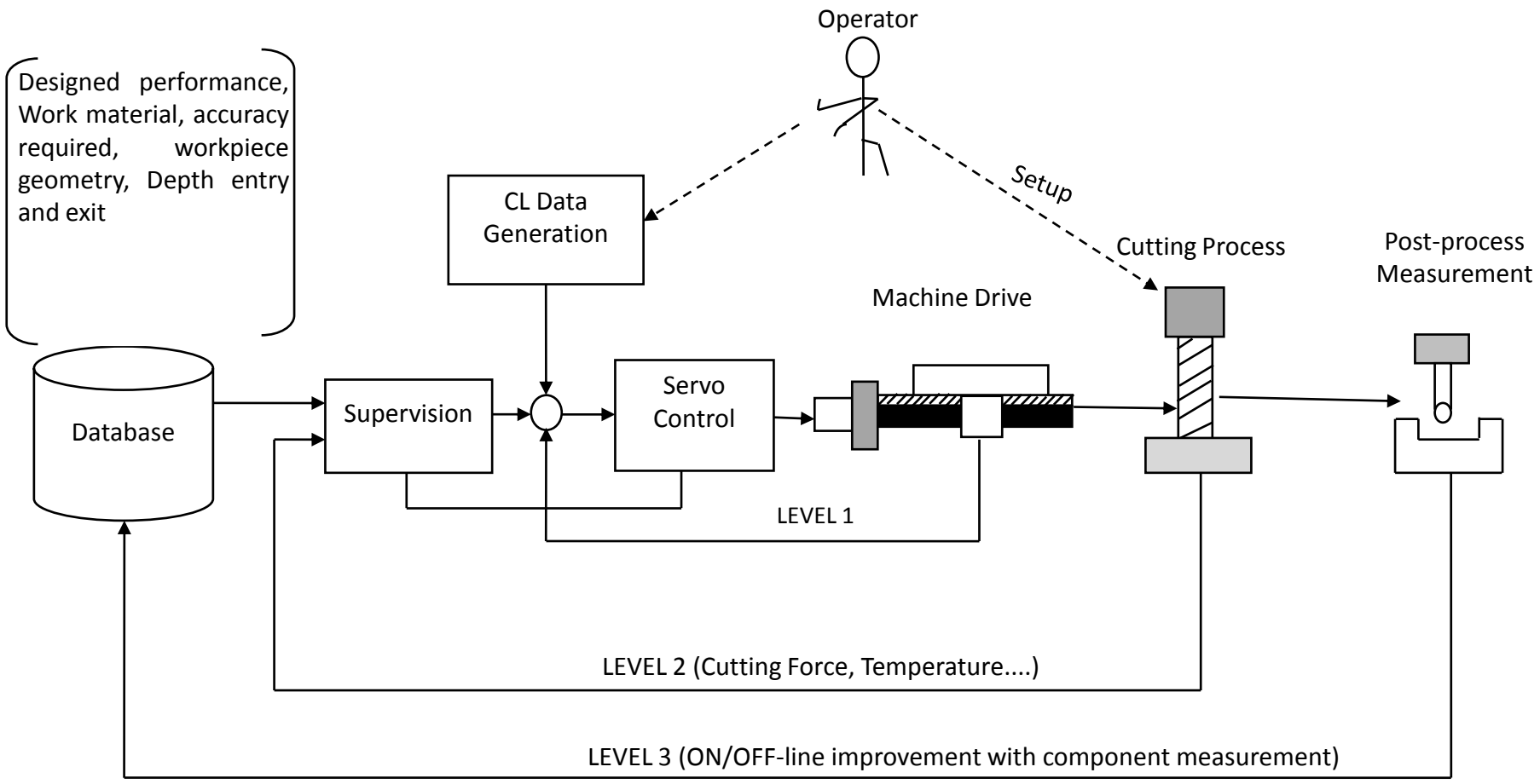
8
- Sensor based Process monitoring

9
- Models for machining processes, Integration of sensory input with stored models and process optimization/Control

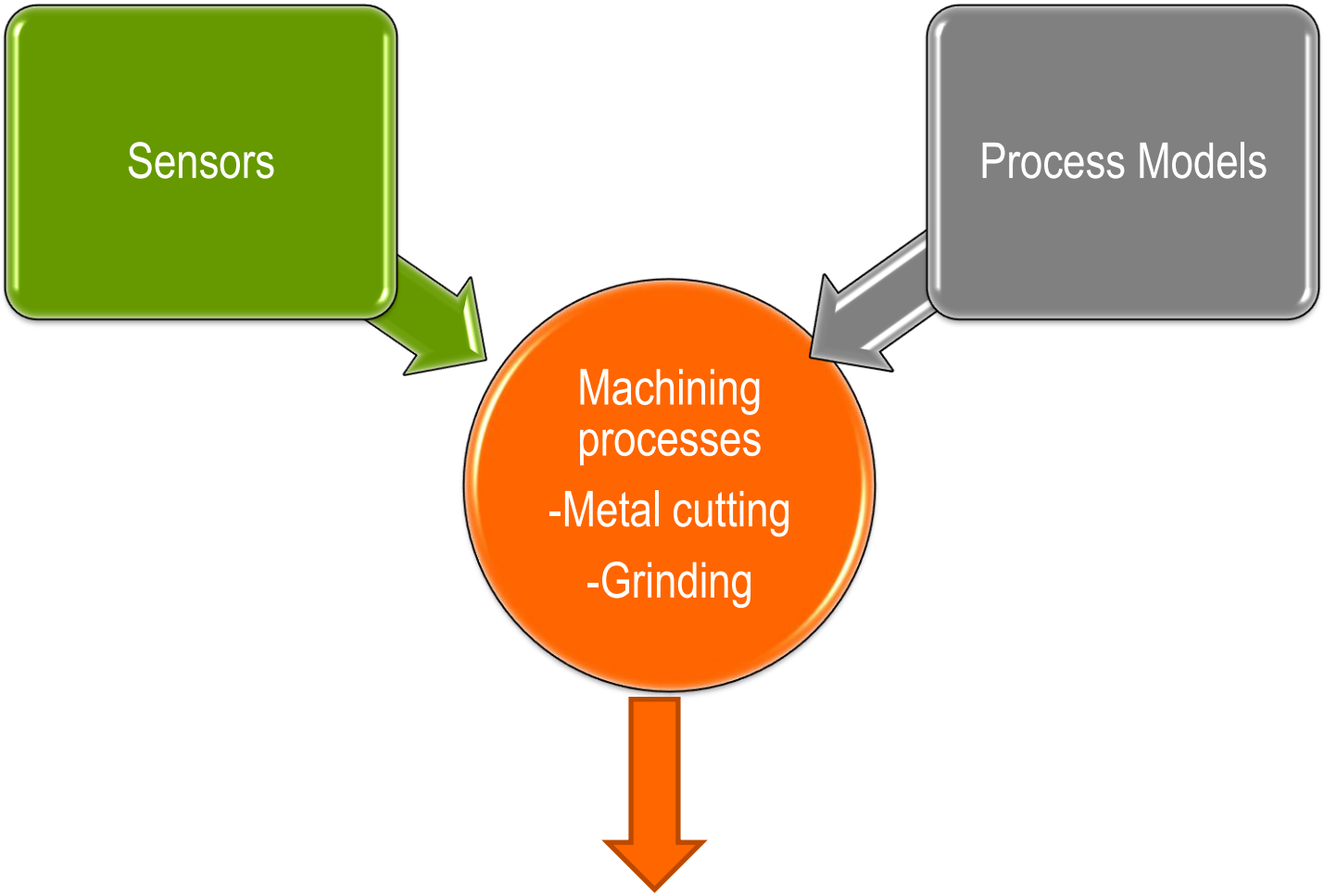
10
- On Machine Metrology and automatic handling of work piece accuracy

11
- Provision for sharing & storing knowledge, IOT enabled

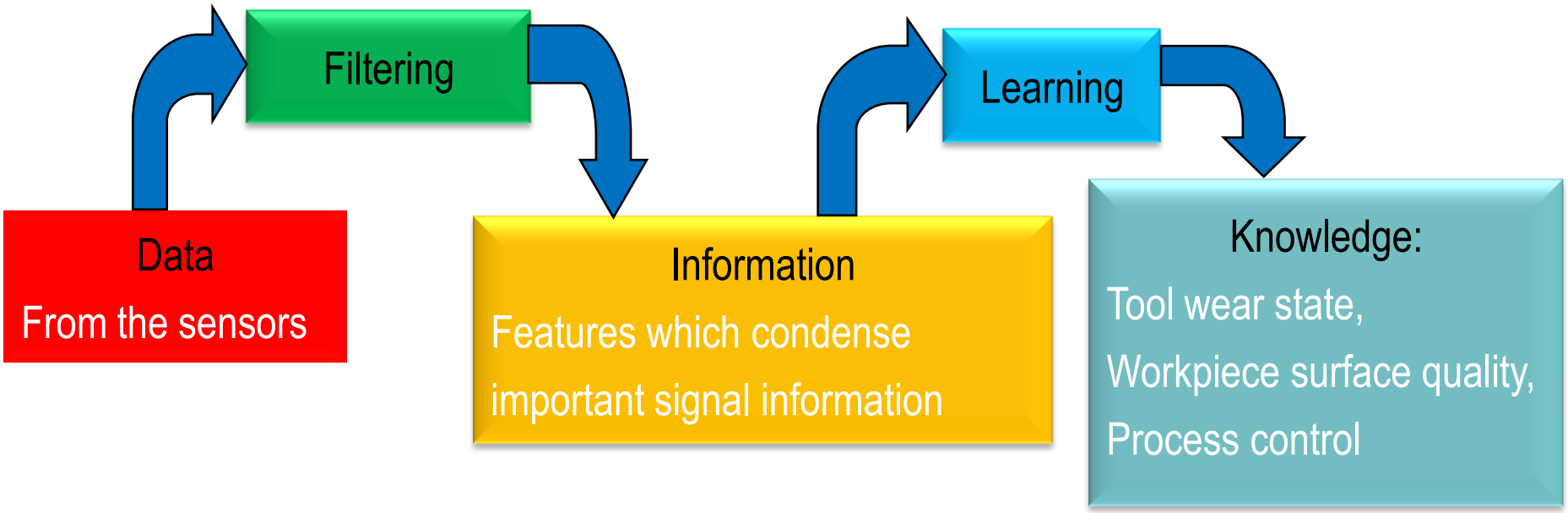
Concept of a Intelligent machine tool



What is Intelligent Machining



Software Structure of Intelligent Machining



Benefit from Smart machine tools & Intelligent Machining

1. Enhanced efficiency and productivity
2. Improvement in Machine Accuracy
3. Improvement in Machining (Part) Accuracy
4. Improved Reliability, Safety and ease in operation

Development of an Intelligent Ultra Precision Turning Machine

Intelligent Ultra precision Turning Machine (iUPTM)

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

Applications: Electro-optics, Space, Defense, Ophthalmic Industries, Photonics

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

Remote monitoring, diagnostics & control through internet

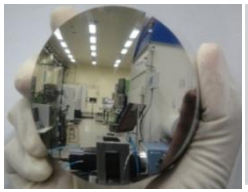
Open architecture Motion Control

Can integrate user developed control algorithms

Intelligent Machining & Prognostics

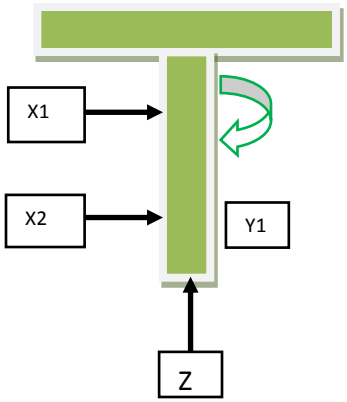
Surface error predictions for intelligent machining

Diamond Turned Mirrors on CMTI's iUPTM for industrial applications

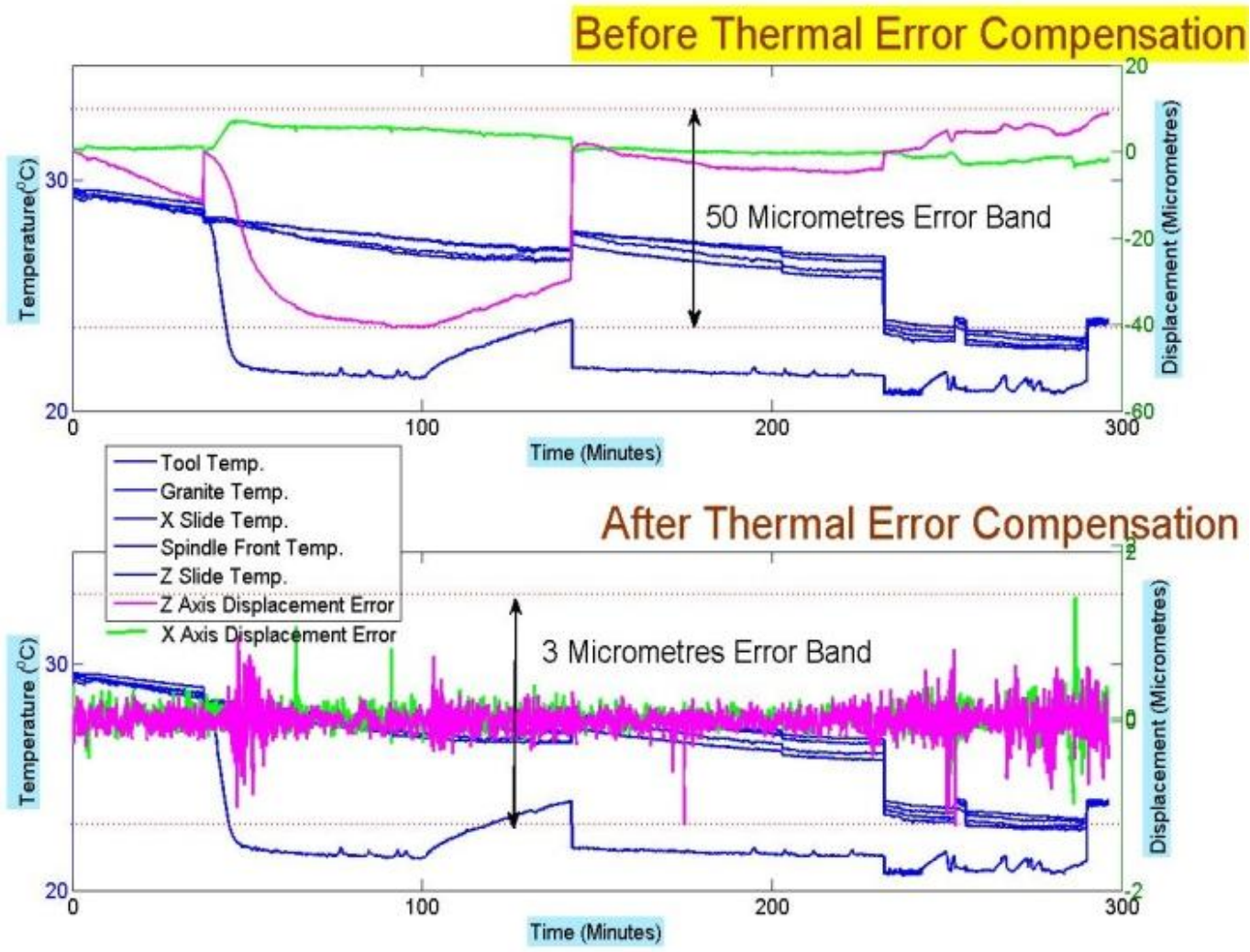


WINNER OF FIE FOUNDATION AWARD

Real-time Thermal Error Compensation for Machine Tools



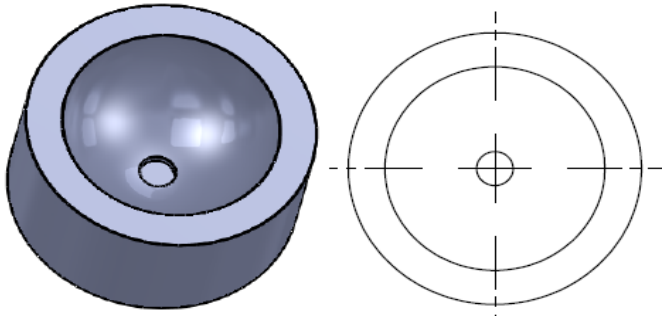
Flow Chart for Thermal Error Compensation



The Thermal induced displacement Errors can be reduced from 50 micrometres to 3 micrometres with the compensation system.

Improvement in Machining accuracy with Real Time thermal error compensation

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

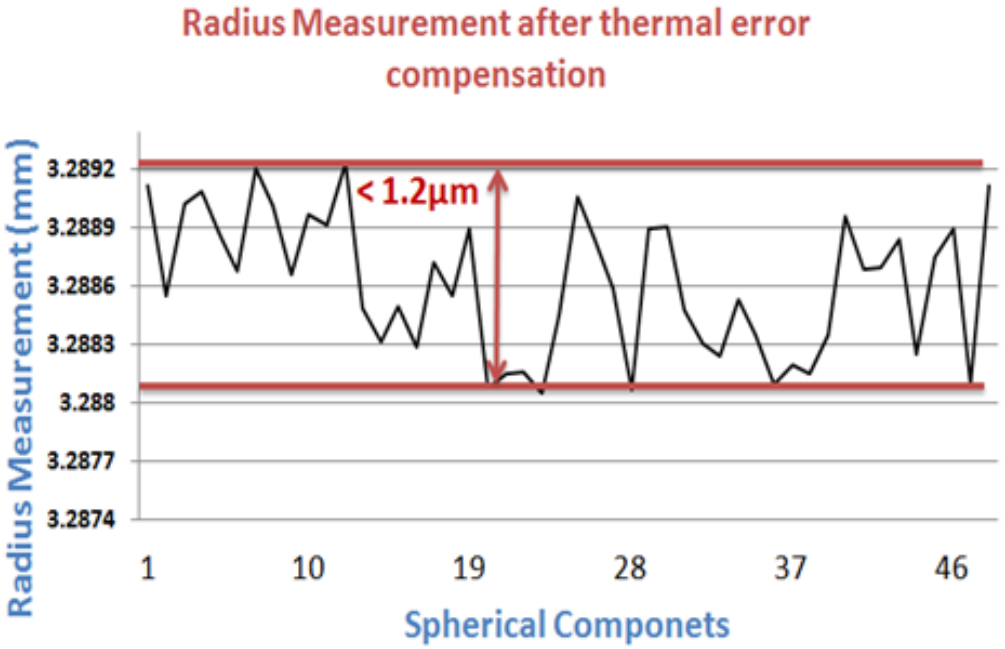


Spherical profile component machined in DTM

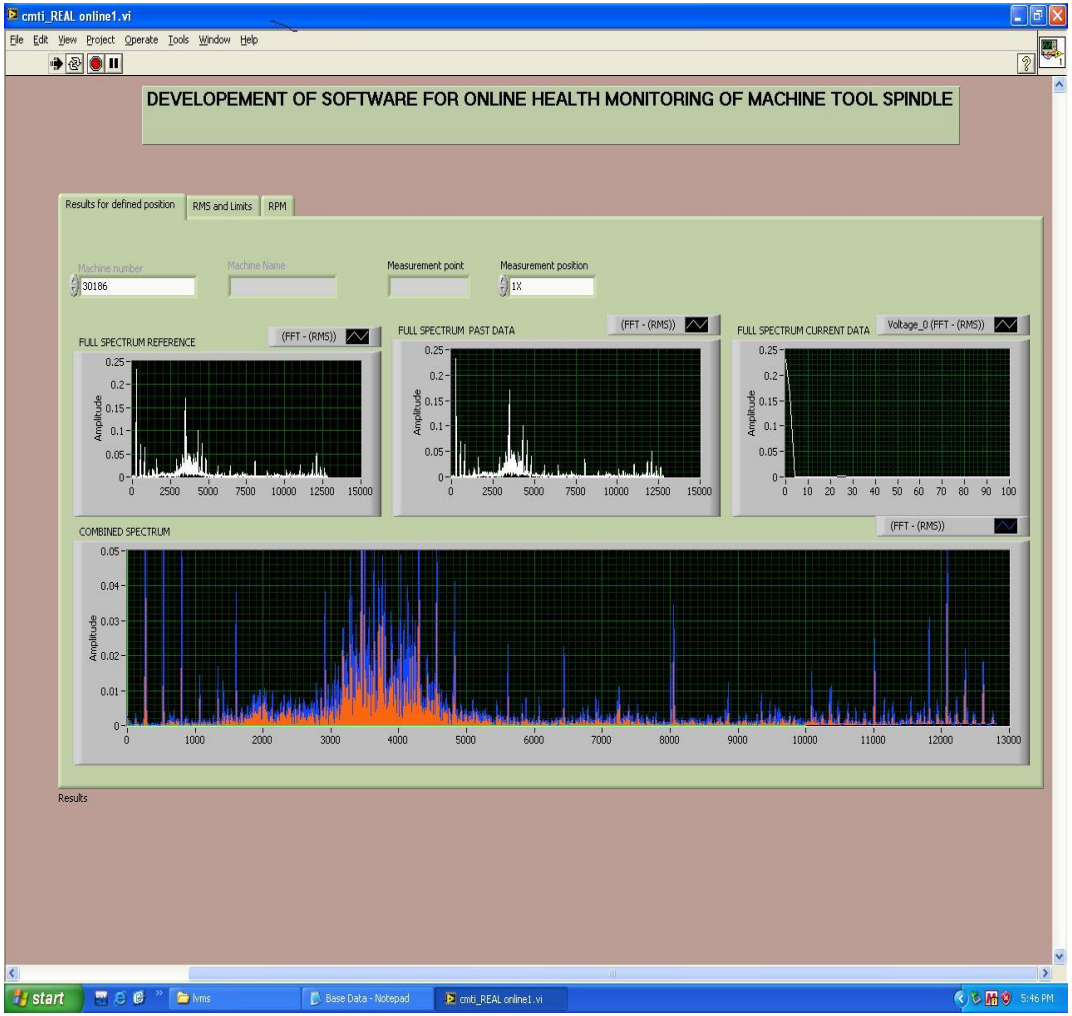
Parameter	Specification
Radius (mm)	3.288 ± 0.001
Form (µm)	1.2

Nanoshape

UPCMM



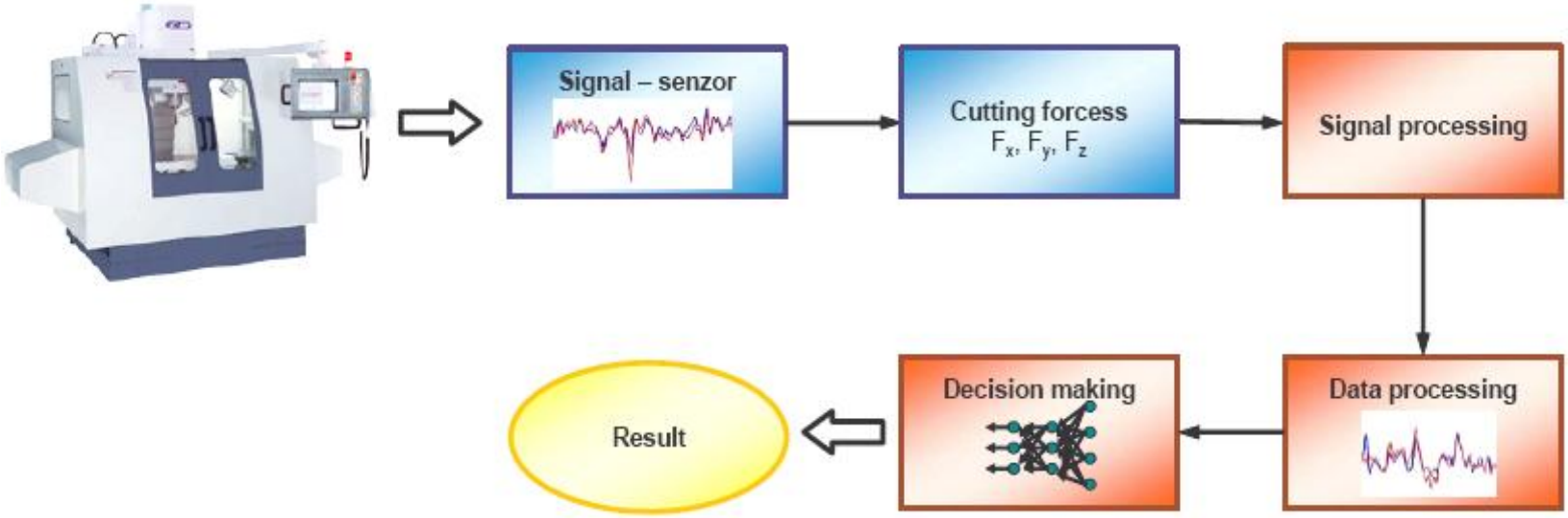
Online Health Monitoring Of Machine Tool Spindle

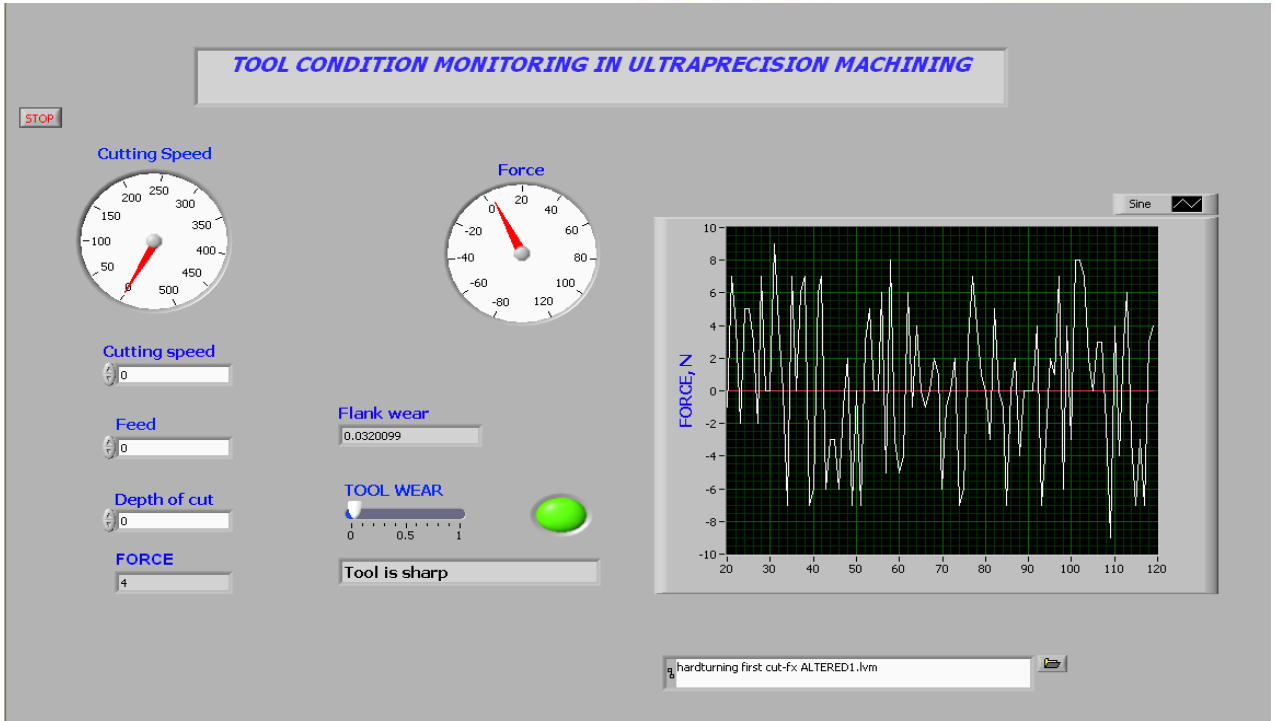


Features:

- Autonomous, in-situ spindle health monitoring system based on sensor feedback
- Online spindle problem identification using frequency analysis.
- HMI provides “a basic window for machine operators” and another window for “advanced diagnostics ” with alarms.

Tool Condition Monitoring in Ultra precision Machining





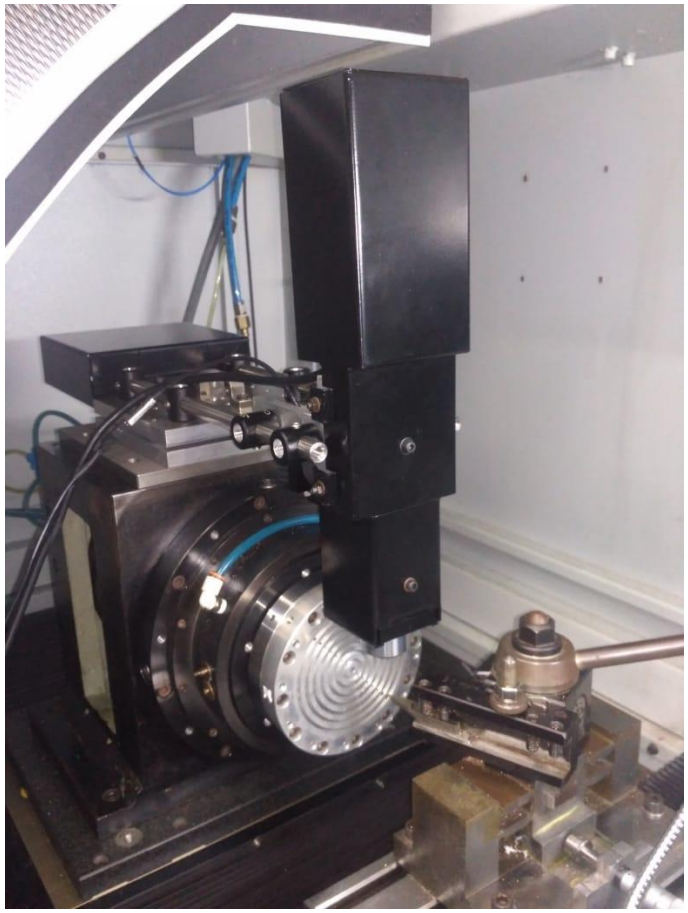
On-Machine Dynamic Balancing

On Machine Tool Setting And Monitoring By CMTI-Optical Tool Set Station (OpToSS)

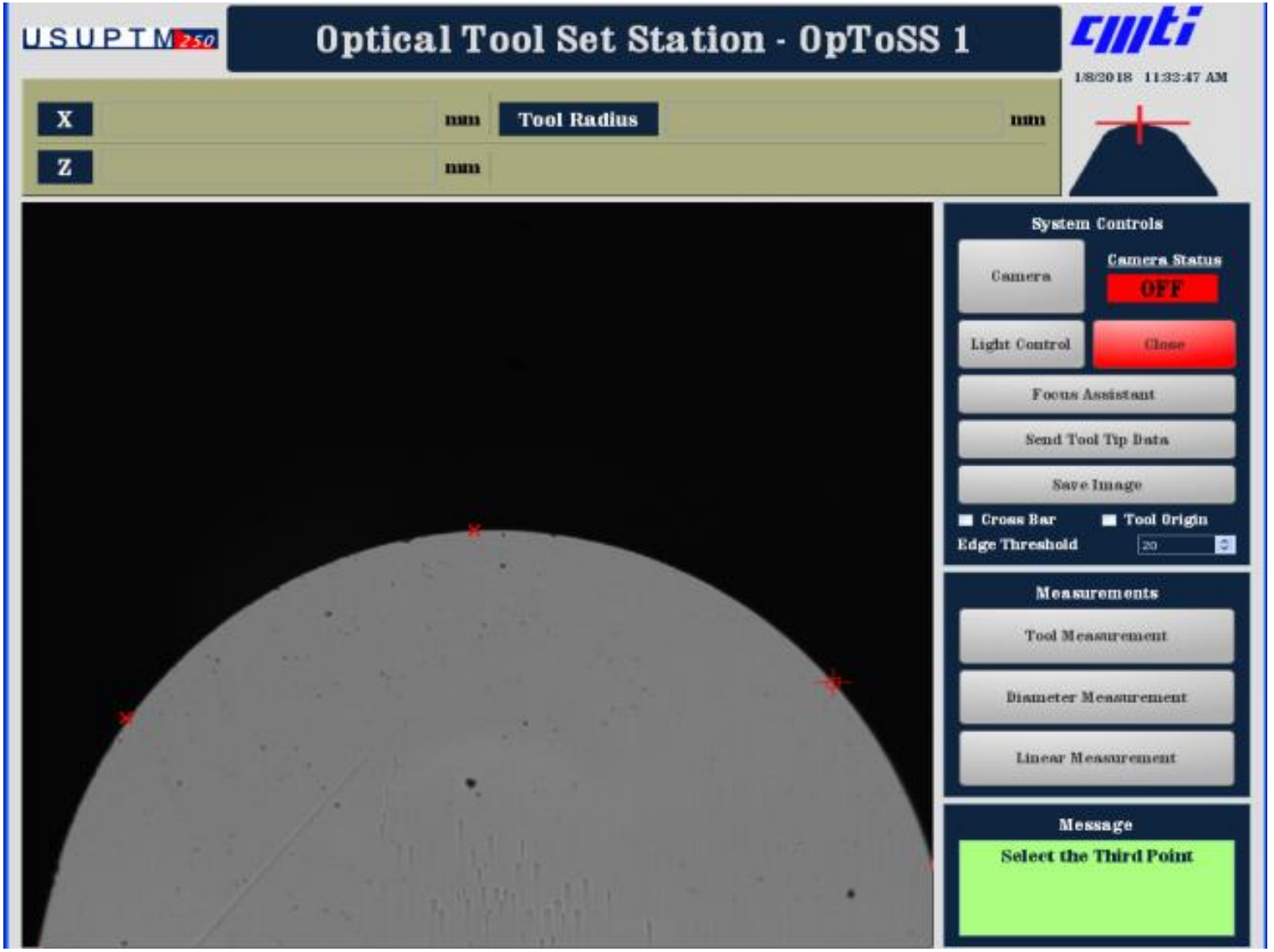
Optical Tool Set Station (OpToSS):

- Tool Radius Measurement
- Tool Position offset (X & Z)
- Tool Height Setting (within 6µm)
- Tool Inspection (Damage & Wear)
- Light Intensity Control for Diamond & CBN Tools

Accuracy	***≤ 5 µm***
Kinematic mount Repeatability	***≤ 1.6 µm***
Resolution	***0.8 µm***
Approx. Weight	***2.5 Kg (Ergonomically designed for ease of handling and mounting)***



Optical Tool Set Station (OpToSS)



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

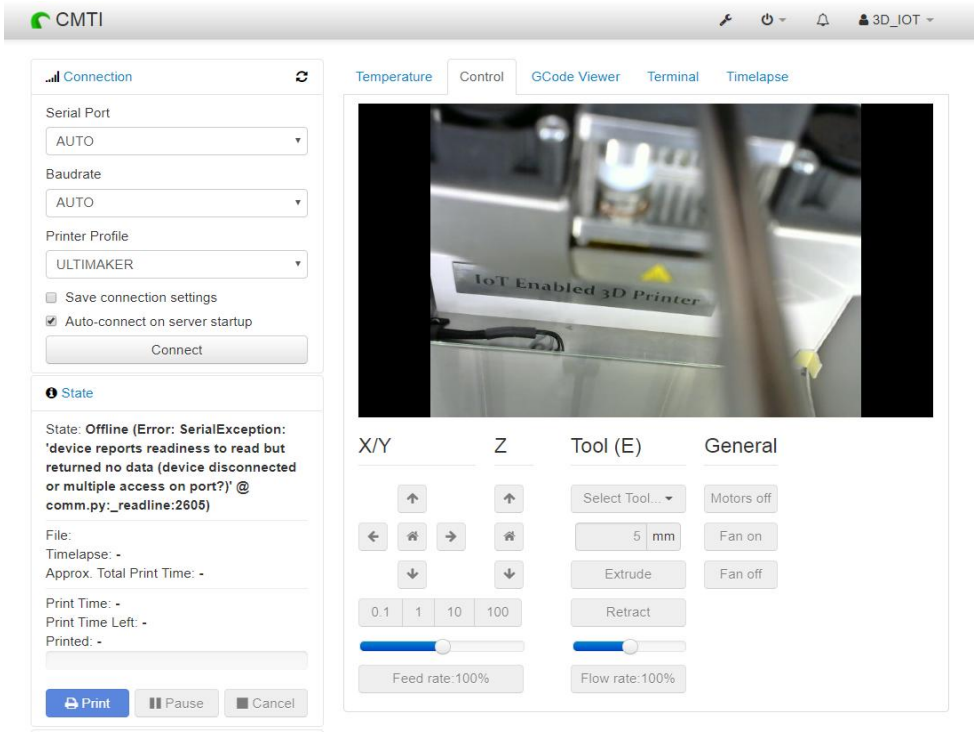
Outcome

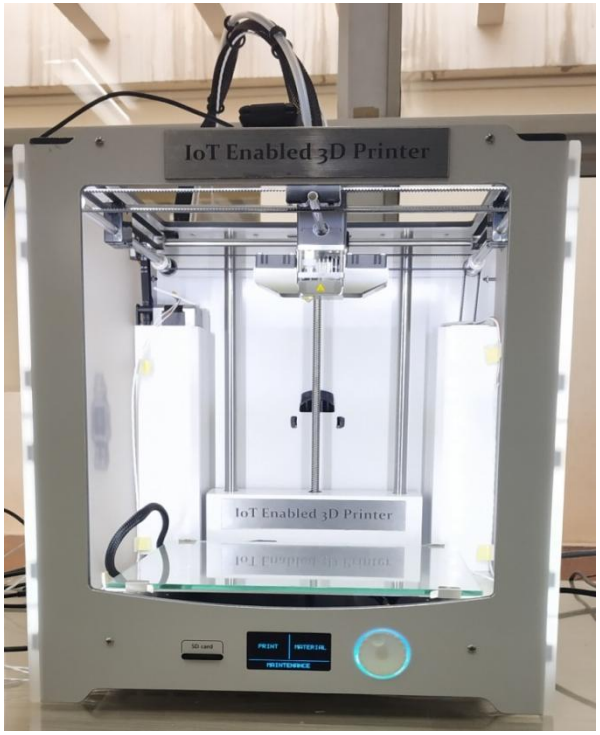
- Generate diagnosis reports / action plan
- Classify reports based on severity
- Enable deep dive information for better process understanding
- Establish data base for further analytics

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

Converting a Legacy 3D printer to IOT enabled printer





A IOT enabled Control GUI has been developed to control the 3D printer in a closed loop. The following features have been implemented.

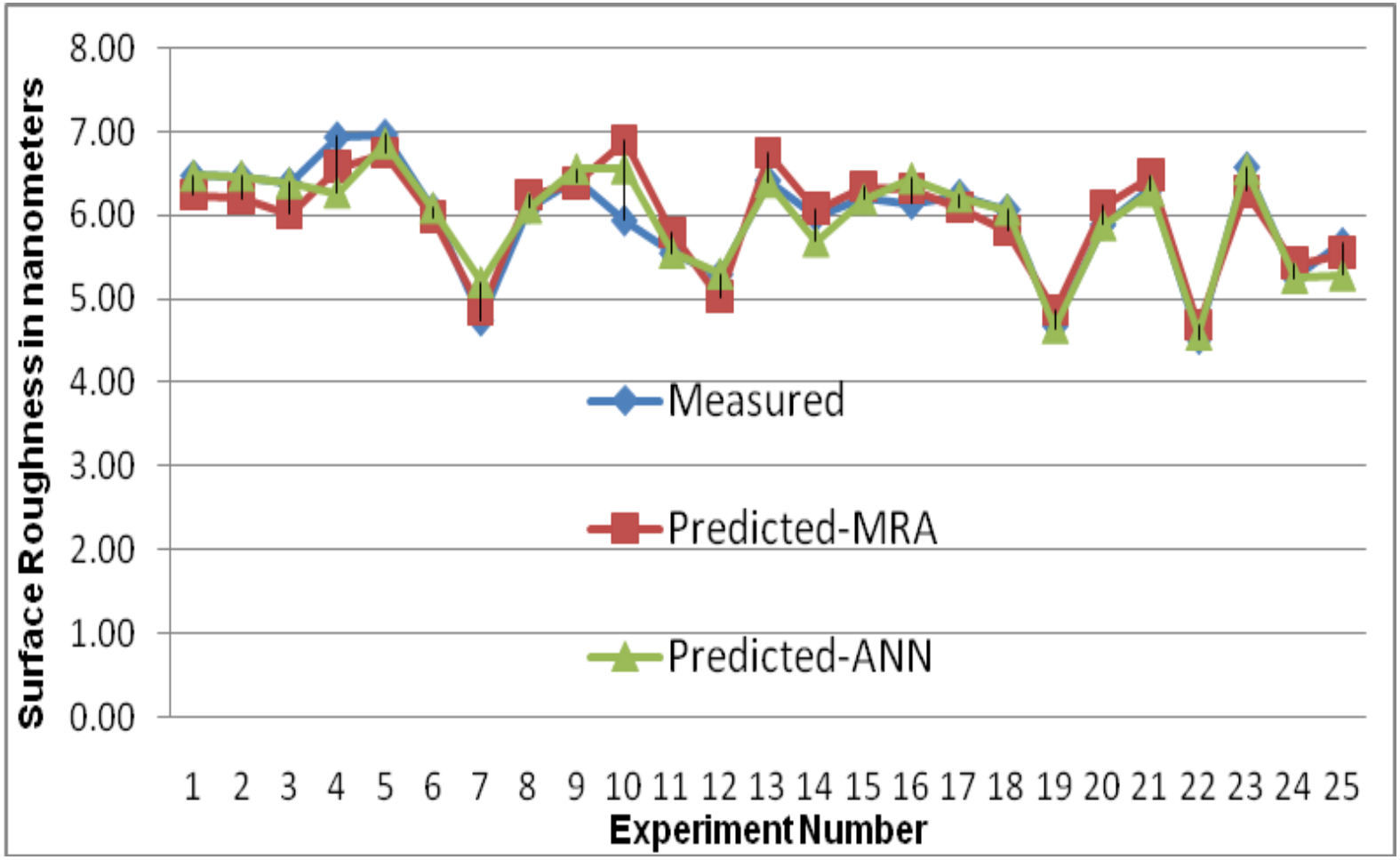
- Cloud based 3D printing by uploading G-code via Any internet connected device, i.e Mobile Phones & Tablets.
- Cloud based closed loop monitoring of process parameters & Temperature signatures of subsystems of 3D printer
- A complete live fabrication process can be viewed online via IOT process monitoring camera

PREDICTION OF SURFACE FINISH IN DIAMOND TURNING PROCESS

Prediction of Surface roughness-MRA

- Independent variables:
  - Cutting conditions:
    - Speed (S)
    - Feed(f)
    - Depth of Cut (doc)
  - Vibration from Process:
    - Vibration in tangential cutting force direction, Vx
    - Vibration in feed direction, Vy
    - Vibration in thrust cutting force direction, Vz
- Dependent variable: Surface finish

Comparison of measured and estimated values of surface roughness



Thank you

सेन्ट्रल मैन्युफैक्चरिंग टेक्नोलॉजि इंस्टिट्यूट

CENTRAL MANUFACTURING TECHNOLOGY INSTITUTE

Smart Sensors & Controls

V. Shanmugaraj

Central Manufacturing Technology Institute (CMTI)

Bangalore

Smart Sensors & Controls

Internet of Things(IoT)

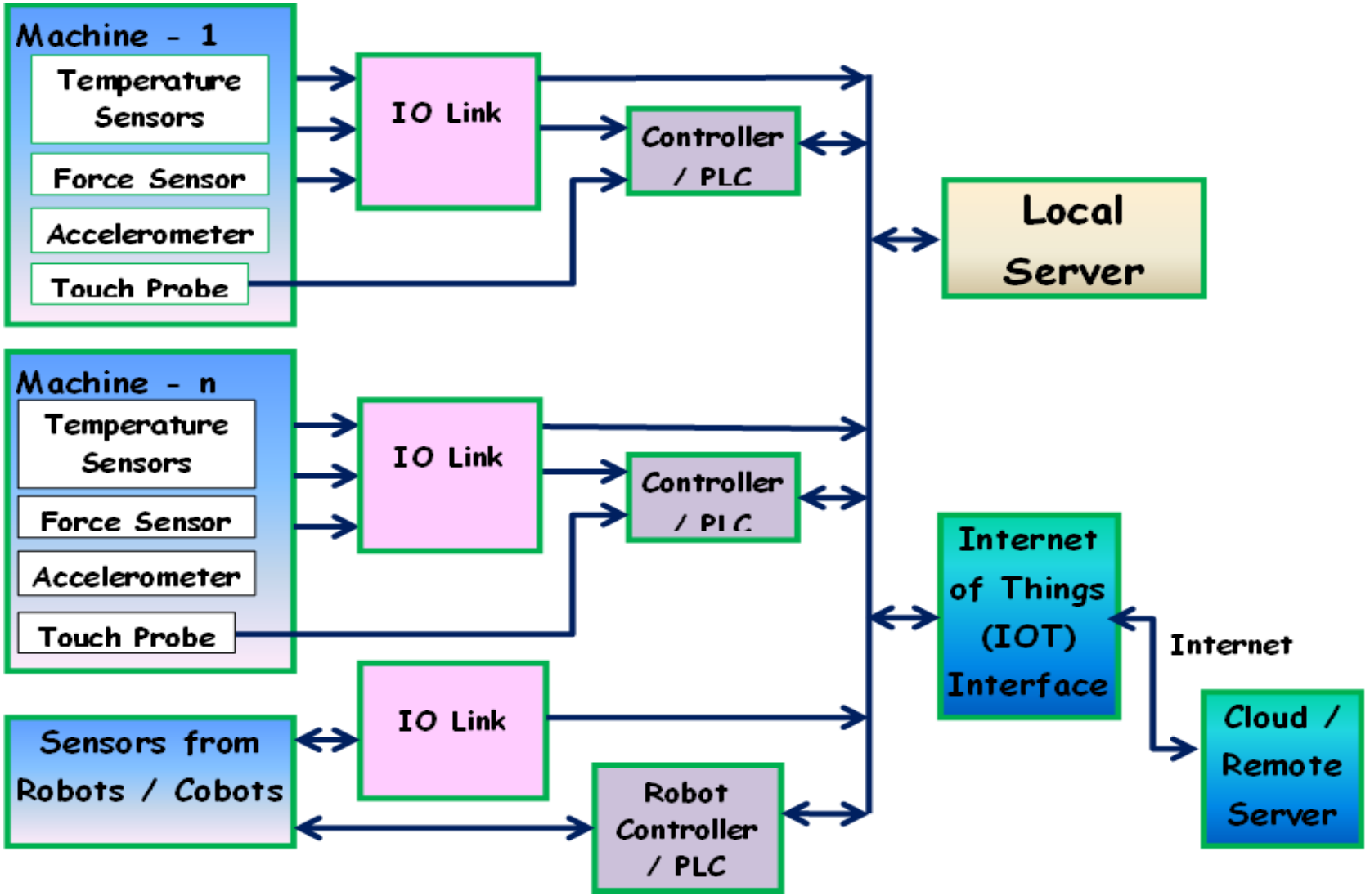
Sensors

Controller

(Data Acquisition and Analytics)

Cloud

Smart Sensors & Controls



Smart Sensors & Controls

- A Transducer is a device that can convert energy from one form to another
- A Sensor is a device that can detect a physical quantity and convert the data into an electrical signal.
- Sensors are also a type of Transducer

Smart Sensors & Controls

Sensors

- Macro (Conventional)
- Micro (MEMS – Micro Electro Mechanical Systems)

Smart Sensors & Controls

Sensors

- Temperature (upto 10Hz)
- Pressure
- Flow
- Force
- Torque
- Accelerometers (upto 20 KHz)
- Load Cells
- Acoustic (upto 1 MHz)
- Displacement
- Velocity
- RFID
- Gyroscopes

Smart Sensors & Controls

Transduction Principle

- Change in Voltage
- Change in Current
- Change in Resistance
- Change in Capacitance
- Change in Impedance

Smart Sensors & Controls

Output

- Machine status monitoring
- Higher Productivity
- Lower down time of the machine
- Preventive maintenance
- Better utilization of Resources

Smart Sensors & Controls

Temperature Sensors

- RTDs (Resistive Temperature Detecting)
- Thermistors
- Thermo-couples

- Factors
  - Temperature Range
  - Sensitivity

Smart Sensors & Controls

Pressure Sensors

- Absolute – A Sensor that Measures Input Pressure in Relation to a Zero Pressure – Altitude Measurement
- Differential – A Sensor that Is Designed to Accept Simultaneously Two Independent Pressure Sources. The Output Is Proportional to the Difference Between the Two Sources – Airspeed Measurement

Smart Sensors & Controls

Flow Sensors

- Variable Area (rotameters)
- Rotating Vane (paddle & turbine)
- Positive Displacement
- Differential Pressure
- Vortex Shedding
- Coriolis Mass
- Ultrasonic

Smart Sensors & Controls

Force Sensors

- Piezo electric
- Strain Gauge

Torque Sensors

- Strain Gauge

Smart Sensors & Controls

Accelerometers

- Piezo Resistive
- Piezo Electric
- Strain Gauge
- Inductive

Smart Sensors & Controls

Load Cells

- Tensile
- Compression
- Bending Beam

- Strain Gauge

Displacement Sensors

- Capacitive
- Eddy Current

THANK YOU