

# Predictive Maintenance Workshop

Predictive maintenance is a technique that uses condition-monitoring tools to track the performance of equipment during normal operation to detect possible defects and fix them before they result in failure. Join Siemens & DMC in this workshop to learn how predictive maintenance can be used for your machines and increase the productivity on your shop floor.



# Agenda



**“Hold it Harry, there is a software update for the tooth brush!”**


- What is Predictive Maintenance?
- Predictive Maintenance use cases
- Connectivity solutions
- Getting started with Predictive Maintenance – Siemens portfolio
- When/Where can I learn more?

**Predictive maintenance is a technique that uses condition-monitoring tools to track the performance of equipment during normal operation to detect possible defects and fix them before they result in failure.**

# Predictive Maintenance Use Case #1

## (Machine operator): Runtime-based (preventive) maintenance






 **Purpose**

- Transparency over machine running times enables planning of preventive maintenance

HMI2019


EMO2017




 **Benefits**

- Greater transparency and information quality
- Higher machine reliability and avoidance of unplanned downtimes through optimized maintenance intervals
- Avoidance of downtimes and (reactive) service calls
- Cost reduction through optimal maintenance cycles


Transparency




Availability





Cost




 **Situation today**

- Components require regular maintenance
- No transparency about the actual running time of the machine, maintenance not properly prepared/planned
- Unplanned downtimes require ad-hoc service calls (e.g. replacement of components), spare parts not always available
- Rescheduling due to machine failure

With MMM 

 **Improvement**

- Individual configuration of variables enables monitoring of actual machine running times and states
- E-mail notification for maintenance at specific intervals (e.g. quantity-based) or based on defined thresholds
- Timely scheduling of preventive maintenance prevents unplanned downtime and ad-hoc service calls

 **Monetary Value**

Example for 10 machines:  
Savings minus recurring costs: **4600 €/year**  
Amortization of one-time costs:  $(5.320/4600) = 1,16$  **years**



# Predictive Maintenance Use Case #2

## Machine Health



Enhanced machine availability based on mechanical fingerprints of machine tools



**Relevance**


Time-to-market is crucial competitive factor. Predictive maintenance measures can reduce unexpected downtimes by 70%. The optimized repair planning can save about 12% of maintenance work and up to 30% of costs ([World Economic Forum, 2015](#)).

**Video**


**Benefits**

- Enhanced machine availability due to avoidance of downtime
- Trochoidal milling enables faster manufacturing
- Understanding of machines enables faster adaption of production
- Foreseeing instead of reacting
- Understand machine parameters that are critical for quality
- Intervene before producing low quality batches


**Cost & Speed**



**Flexibility**




**Quality**



**Monetary Value**

Saving  
**8100 EUR** per year  
ROI:  
**1.88** years

**Efficiency**



**Process Today**

Problems with machines seldomly occur, but sudden and unexpected and lead to downtime.

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Maintenance is done inefficiently based on fixed schedules or based on experience with buffer

Similar machines show different performances and change it over time. However, it is difficult to make a comparison and understand the root causes



**Future Process**

Regularly making a mechanical fingerprint of the machine tool. Certain parameters are captured and can be analyzed by experts

- Comparison of parameters over the time
- Comparison among different machines
- Parameters: Stiffness, Friction, Backlash, Quadrant error, Signature
- Automatic generation of test programs

# Predictive Maintenance Use Case #3

## Digital Twin



### Relevance

Focused on customers using a CAM system to create new part programs  
→ It is getting more and more common to provide a digital twin before the real machine

VNCK Hemrle



VNCK Skoda



### Benefits

- Up to 70% time reduction of ramp-up time of a real machine after all tests are executed on a virtual one

Cost & Speed



### Process Today

#### Machine delivery

After you have purchased the machine you have to wait the physical machine delivery to ramp-up the production w/ new machine

#### Machine ramp-up

After machine delivery you have to run-in existing part programs, optimize the programs at the machine, train the machine operators, etc. directly at the machine

With VNCK

### Future Process

Before the machine is delivered you can

- run in part programs (check whether the program can be executed, optimize machining)
- determine the machining time and optimize entire production
- train the machine operators
- create and check new part programs

### Monetary Value

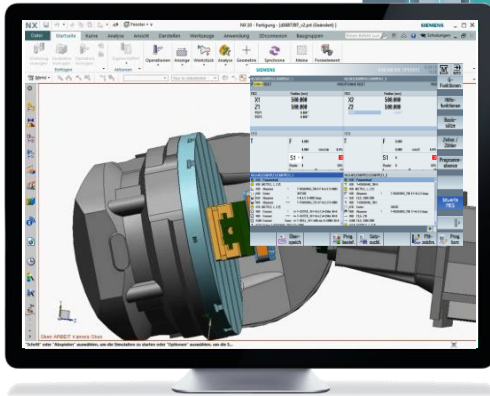
Saving depends on use case:  
**xxx EUR** per year  
depending on operating mode

Efficiency



# Predictive Maintenance Use Case #4 Tool Collision and Simulation

## Virtual NC kernel inside



### Relevance

Focused on customers using a CAM system to create new part programs  
→ It is getting more and more common to provide a digital twin before the real machine

CHECKitB4



VNCK Skoda



### Benefits

- Essential risk minimization at the real machine due to the virtual simulation

Risk free



- Switch to another machine in a virtual environment and check the feasibility

Flexibility



- Faster “green light” by entirely tested part programs – “...just press cycle start”

Speed



### Process Today

#### New part programs

In order to create part program (G-code) the CAM code has to be interpreted by post-processor. After postprocessing the part program (G-code) will be executed at the real machine for the first time -> risky and time consuming w/o pretesting

#### Machine change

If the targeted machine is not available for machining you cannot be sure that this part program can be executed on another machine w/o collisions

With VNCK

### Future Process

Before machining following activities can be applied:

- Test the part program (G-code) regarding collisions
- Check the precise machining time (align the entire process)
- Change to another in virtual environment and check the part program

### Monetary Value

Saving depends on use case:  
**xxx EUR** per year  
depending on operating mode

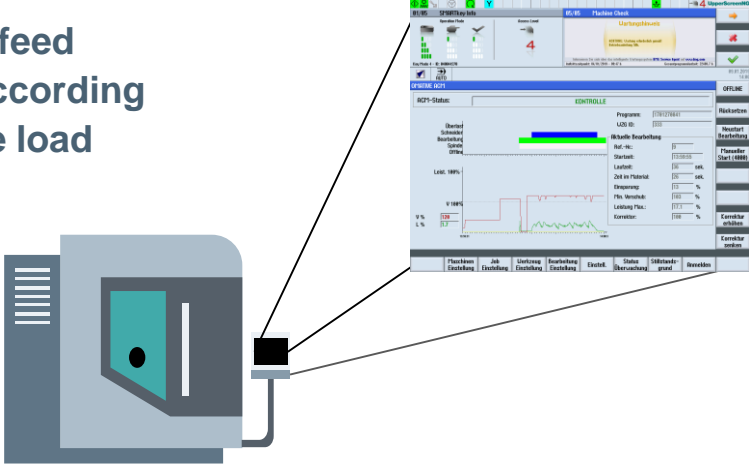
Efficiency



# Predictive Maintenance Use Case #5

## Dynamic Part and Tool protection

Adaptive feed control according to spindle load



Relevance

Adaptive control is widely used in roughing and semi-finishing operations  
→ Can bring strong competitive advantage

ACM principle

ACM in action

Benefits

Cost & Speed

- Cycle time reduction of 5-30% to shorten time-to-market
- Enhance tool stand time by 50-150% and incr. machine availability

Flexibility

- Optimization even for small lot sizes
- Automatic mode/ multi machine operation is facilitated

Quality


- Increased Workpiece quality due to constant loads
- Indication of tool wear

Monetary Value

Saving:

24000-36000 EUR per year depending on operating mode

Efficiency



Process Today

Rigid and inflexible cutting parameters

Constant feed rate, despite varying cutting conditions (such as cutting depth, material inhomogeneity, uneven workpiece surfaces)

Enhanced wearing of tools/ tool breakage

Due to load peaks

Opportunity cost due to decreased speed

Machine tools could run faster if conditions allow

With ACM

Future Process

ACM monitors the current **cutting conditions** in **real-time** and automatically adjusts the feed rate to the optimum speed.

If **overload** is **detected**, ACM reduces the feed rate and can trigger an **alert** to stop the machine

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# OPERATE & OPTIMIZE:

## Target platform architecture to address different needs

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*Ingenuity for life*

### In Cloud

- Fleet management
- Service management
- Condition monitoring
- Data exploration

Applications  
(Mind Apps)

MindSphere



Connectivity

### In Line

- Resource management and optimization
- Virtualization
- Condition monitoring

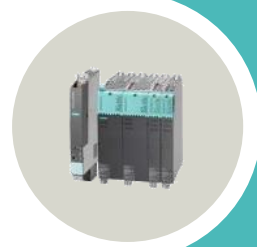
Applications

SINUMERIK Integrate/  
WinCC



### In Machine

- Process monitoring
- Machining process optimization
- Extended machine functionality

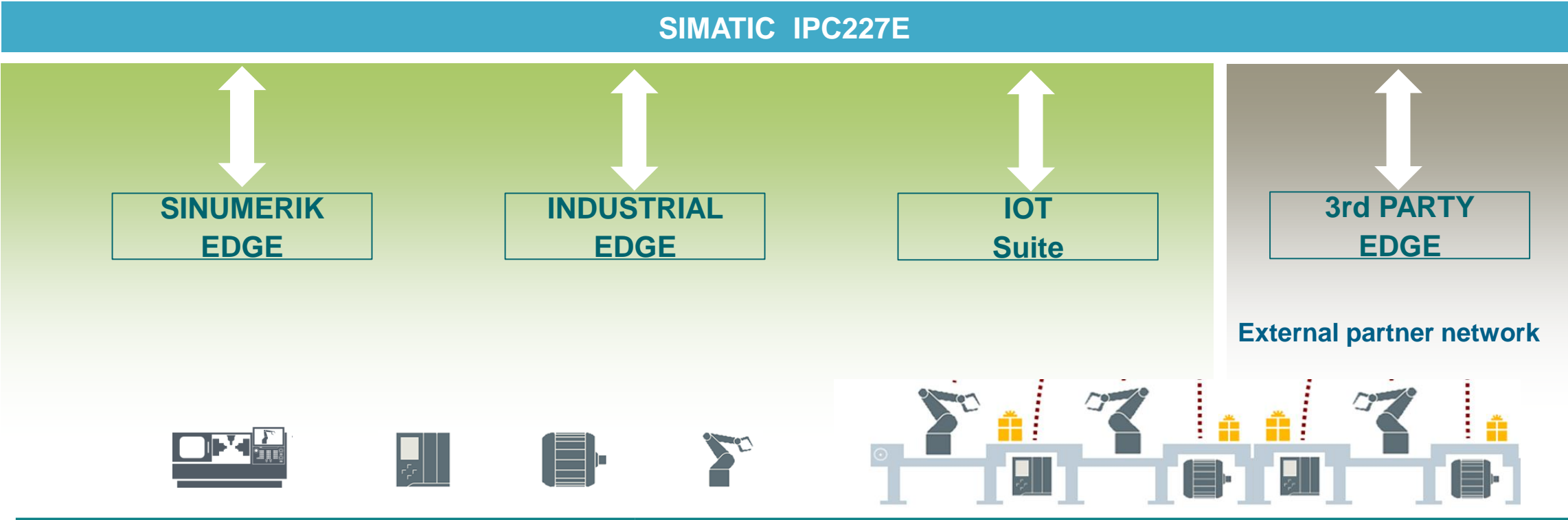


Applications  
(Edge Apps)

Industrial  
Edge



# One common Siemens Hardware platform for all edge and brownfield connectivity solutions based on SIMATIC IPC



Connect the complete shopfloor and legacy systems based on one hardware

# Edge Computing – Closing the gap between automation and Cloud

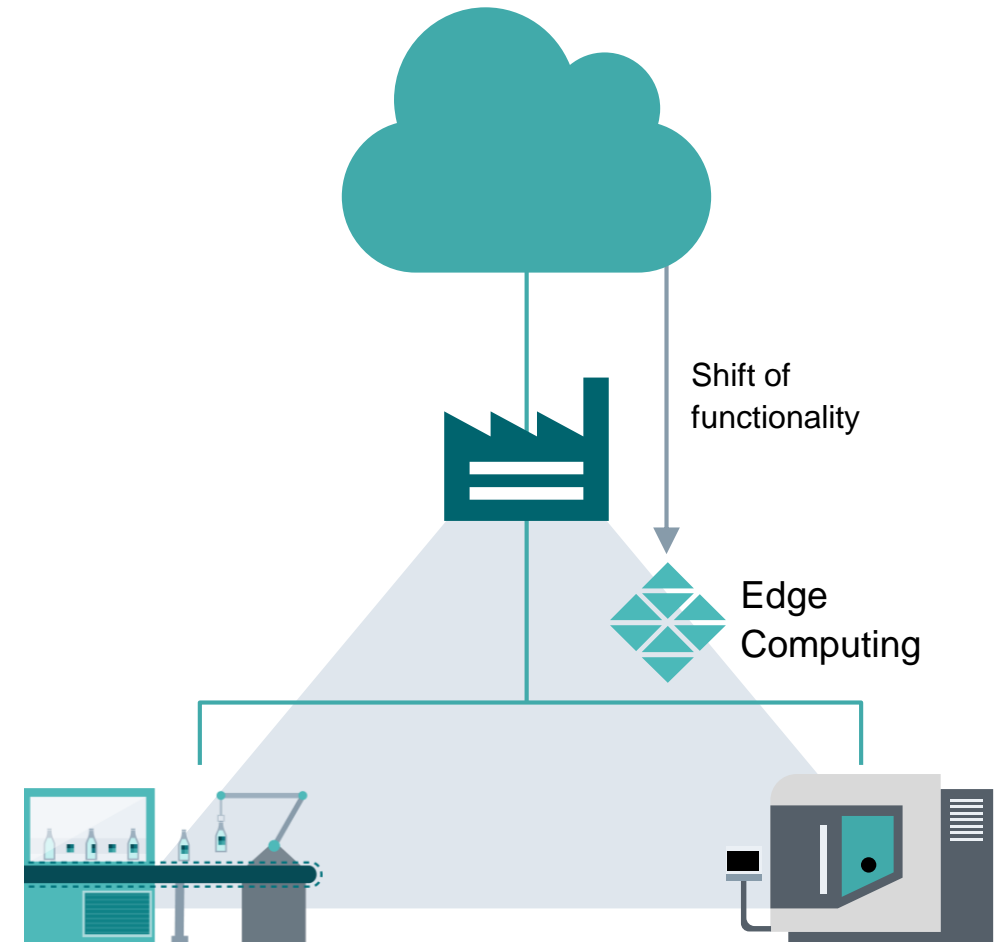
## Trend Edge Computing

### Limitations of pure cloud technology ...

- Physical (round trip times, bandwidth)
- Legal (data ownership, liability)
- Economic (transfer, storage, computing cost)

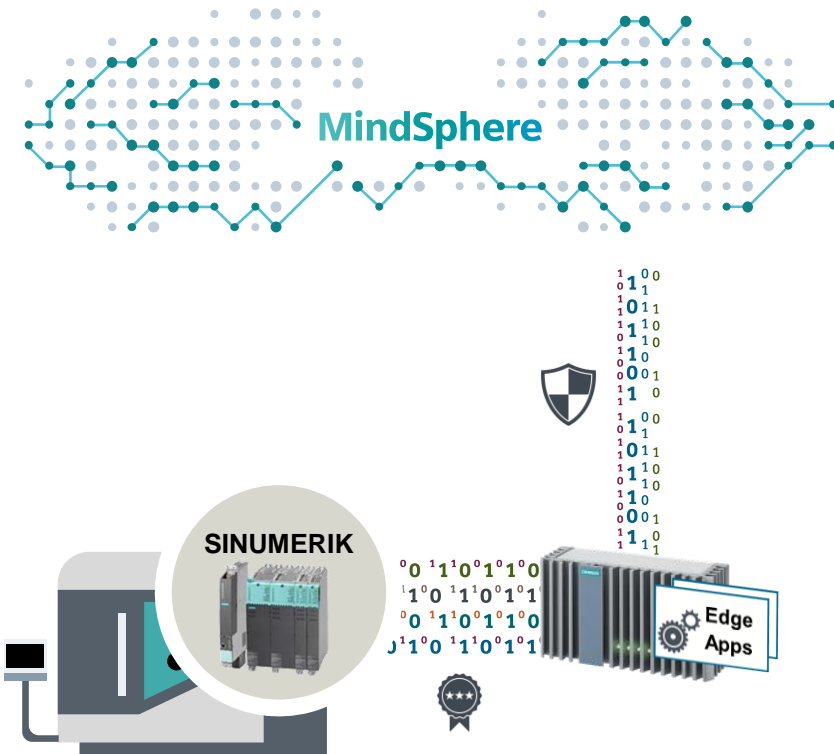
### Whereas Edge Computing leads to...

- ... additional **functional enhancements of shop floor devices** with new functionality e. g. analytics, preprocessing and decentral intelligence
- ... and enables **short innovation cycles of IT** in automation



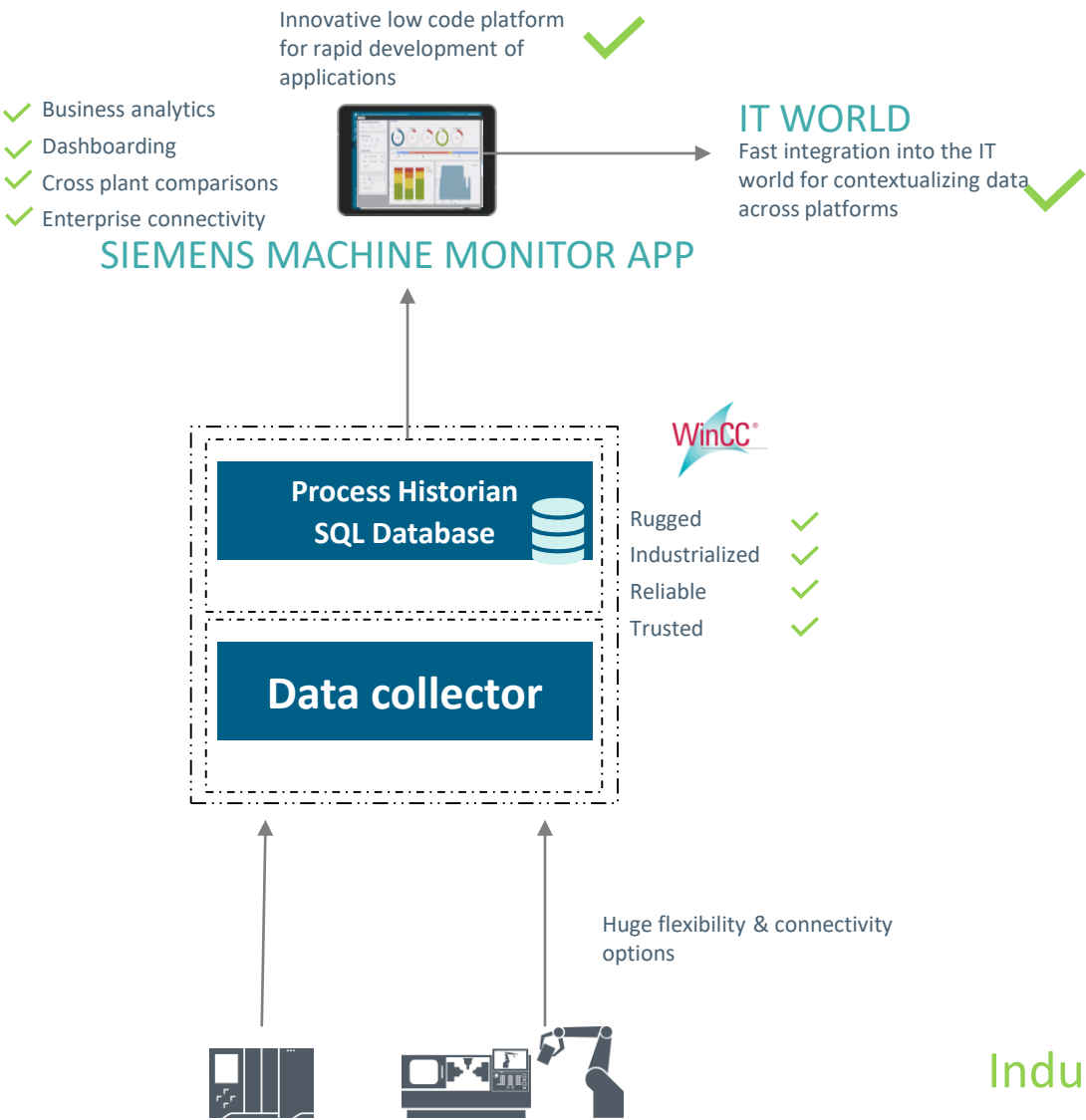


# Industrial Edge – open and secure Digitalization platform processing high quality data to improve your production



Feature / Function	Benefit
<b>Open Secure Platform</b> <ul style="list-style-type: none"> <li>Seamless data consistency from machine tools to in-factory IT and MindSphere</li> <li>Separated from Automation</li> </ul>	<b>IT-Security on several layers</b> <ul style="list-style-type: none"> <li>Device and firmware protected, isolated apps, encrypted communication to the cloud, user roles for interface interactions</li> <li>Machining process secured and unaffected</li> </ul>
<b>Efficient access to high quality data</b> <ul style="list-style-type: none"> <li>Up to 100 high frequency variables in interpolation/ controller cycle</li> <li>Variables from NC and PLC synchronized</li> <li>Data access via unique interface to NCU</li> </ul>	<ul style="list-style-type: none"> <li>Nearly no additional load for NCU (~1%)</li> <li>Efficient data model: data is available for Edge apps to derive value</li> </ul>
<b>Open platform for Apps</b> <ul style="list-style-type: none"> <li>App SDK to develop own applications</li> <li>Raw data processing in Apps (delayed real time)</li> <li>Data to MindSphere: status information, smart data, log files</li> </ul>	<ul style="list-style-type: none"> <li>Enable data driven services and new business models for 3rd parties and OEMs</li> <li>Data enables process understanding for maximum business intelligence</li> <li>Customized data analytics for end customers</li> </ul>
<b>Connected ecosystem</b> <ul style="list-style-type: none"> <li>Central management and updates via MindSphere App</li> <li>Seamless communication between machine, SINUMERIK Edge and cloud/ IT systems</li> </ul>	<ul style="list-style-type: none"> <li>Leverage data in integrated system landscapes</li> <li>Keep security, device and app features always up-to-date</li> <li>Minimum time-to-market for new Digitization solutions (accelerated PLM cycle)</li> </ul>

# A Simplified Look

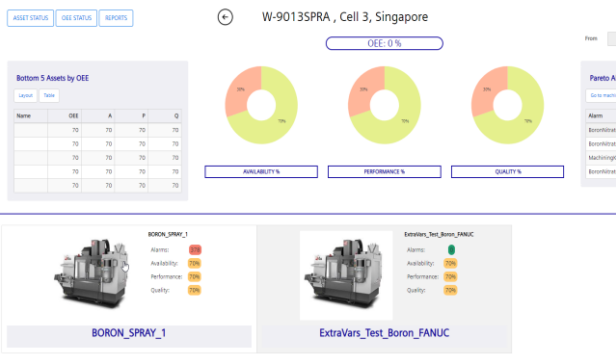
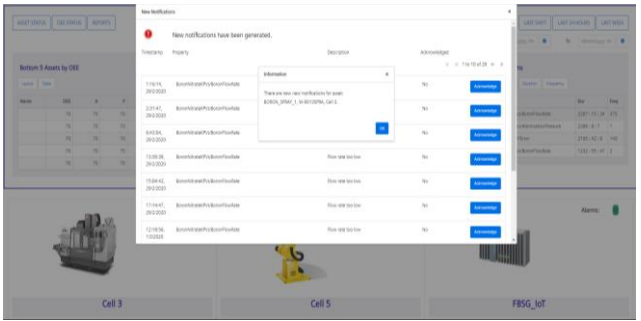
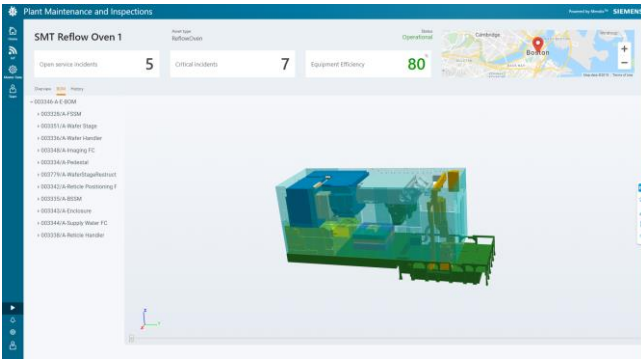
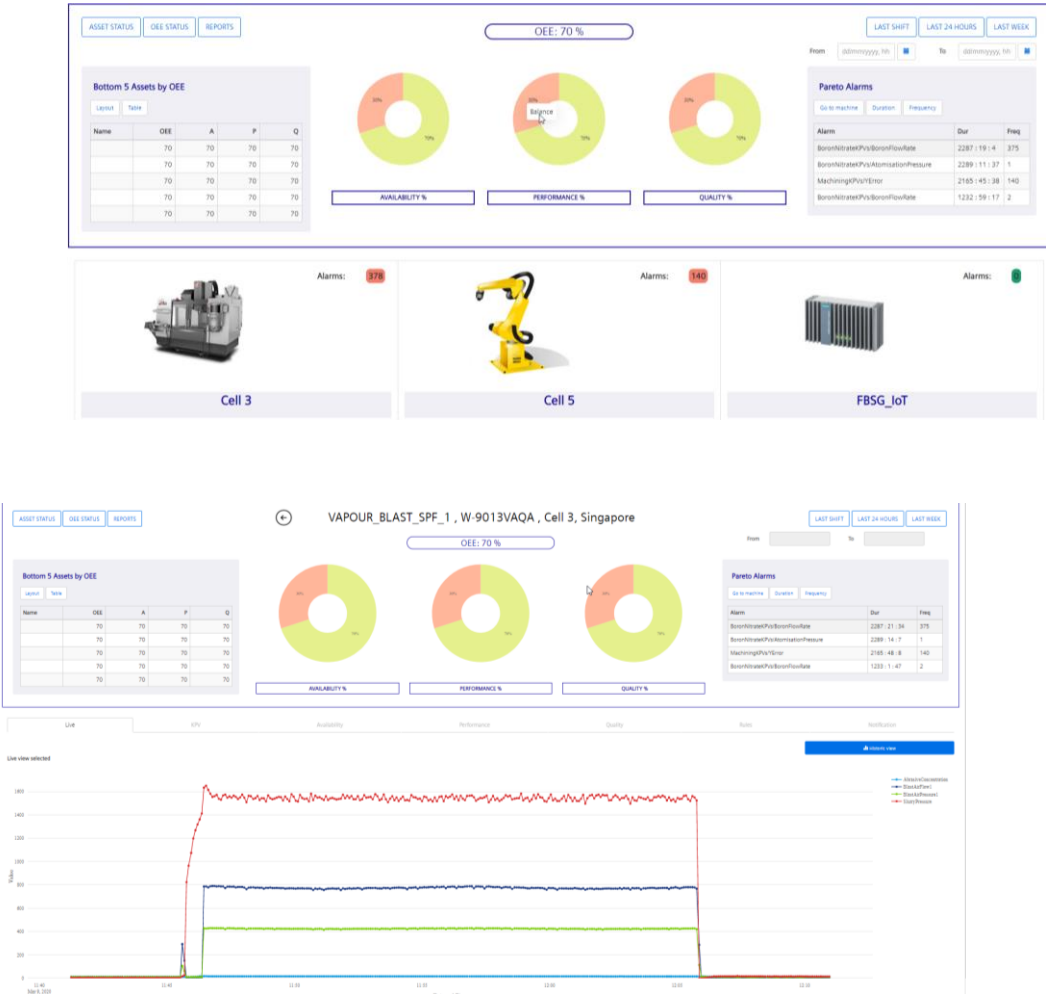


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Industry 4.0 Ready ✓

# Tailored OEE & Machine Health Application

## We take standard templates and enhance them for customers



WinCC Connectivity

Teamcenter Integration

Mindsphere Integration

On Premise/ Cloud



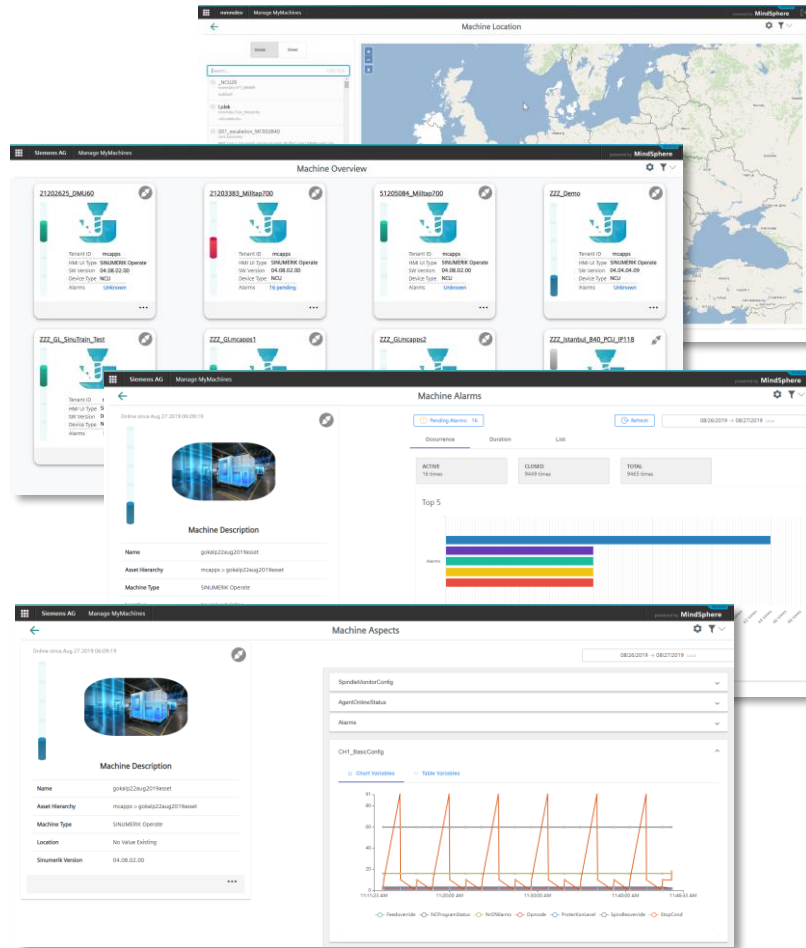
### WinCC® SIMATIC Process Historian

- ➔ Real-time database
- ➔ Central long-term archive
- ➔ High-performance SQL database
- ➔ Facilitates fast decision making

### WinCC® Main Benefits

- ➔ Central Interface
- ➔ 100s of brownfield drivers
- ➔ Sinumerik Power line connectivity
- ➔ Security through redundancy

# Manage MyMachines



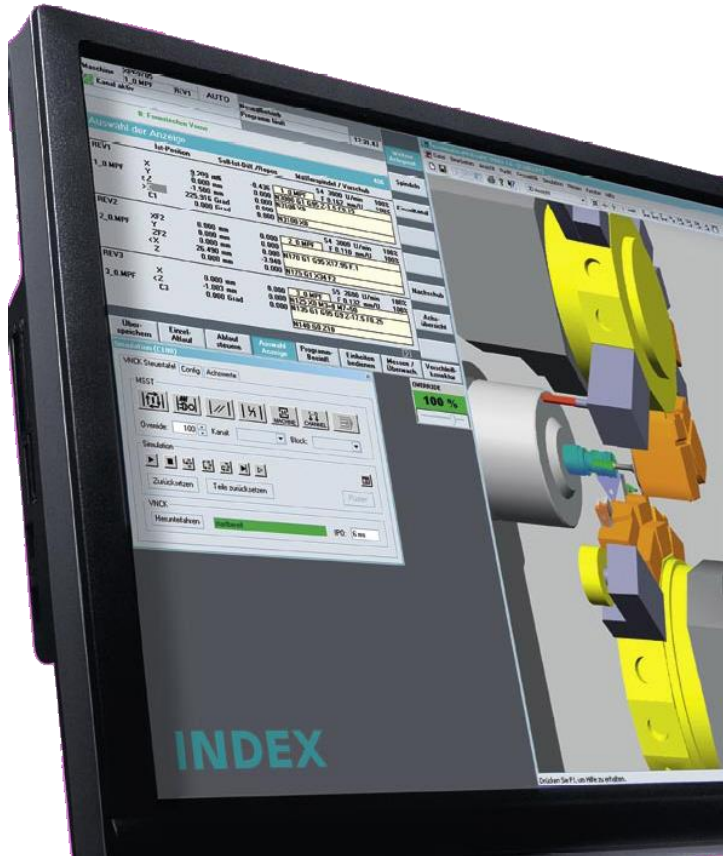
## Feature/Function

- Dashboard displaying the production status at a glance, based on automated recording of machine data
- Alarm dashboard and insights into alarm history
- Individual variable monitoring
- Easy creation of thresholds and rules for email notifications
- Automated file uploads from the controller (log files, traces)
- Plug- and-play connectivity for SINUMERIK 840D sl and 828D
- Further connectivity options, including SINUMERIK 840D pl, Fanuc (FOCAS2) and MTConnect
- Overview of machines spread across different locations – based on the MindSphere ecosystem

## Benefit

- Increased transparency enabling early detection of problems
- Higher availability and productivity of machine tools
- More efficient troubleshooting and failure analysis
- Reduction of unexpected downtimes
- Improved service and maintenance
- Connecting heterogenous machine parks to MindSphere
- Managing and monitoring globally distributed machine parks
- New service methods and business models

# Advantages of a virtual machine with VNCK for the machine tool operator



## Feature / Function

- Offline programming and optimization
- Original CNC kernel
- Programs are quickly run in on the virtual machine without any risk
- Machine-oriented employee training

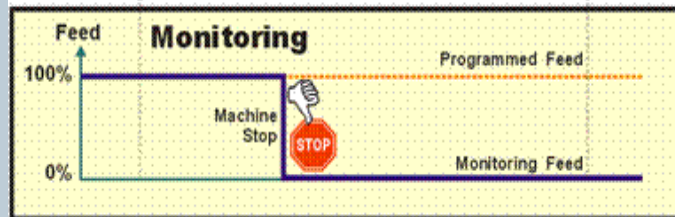
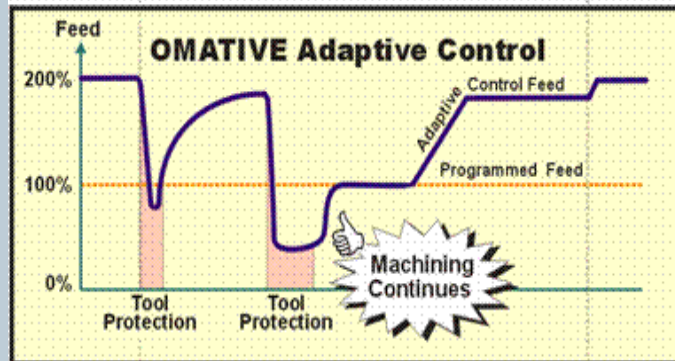
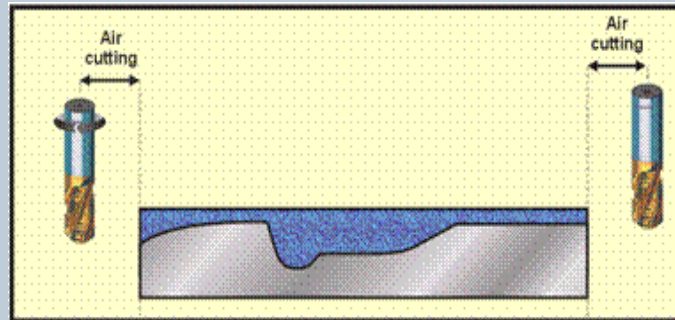
## Benefit

- ▶ **Machine availability for value-add production**
- ▶ **Safety for machine and human**
- ▶ **Productivity by more output in the same time**
- ▶ **Efficient & risk-free training**



# ACM (Adaptive Control and Monitoring)

## Main features and added value



### Feature/ function

Adaptive adjustment of the feed rate based on cutting conditions

Reduced feed when entering the material

Monitoring to detect divergence of reference value (e.g. overload)

Enabling flexibility, as ACM is organized by processing steps and tool type, not by NC program/ individual tool

### Benefits

▶ **Cycle time reduction and thus increased machine capacity**

▶ **Increased tool lifetime as well as increased work piece quality**

▶ **Increased lifetime of machine tool, spindle and tools**

▶ **Increased machine availability due to avoidance and foreseeing of downtime**

▶ **Even small lot size productions benefit from all advantages**

▶ **ACM allows workers with lower skills to use machine**

# Analyze MyWorkpiece /Toolpath

## Increase workpiece quality and production efficiency



### CAD / CAM verification



### Virtual / real verification



#### Feature/function

3D visualization of the NC program  
(programmed or based on post-processor)

3D visualization of the SINUMERIK Operate  
trace data

Color coding of the 3D objects

#### Benefits

##### Productivity in job preparation

- Localization of errors/tool paths not optimally programmed in the NC program before machining

##### Productivity in job execution

- Quick error localization (e.g. deviation in machine mechanics)

##### Usability

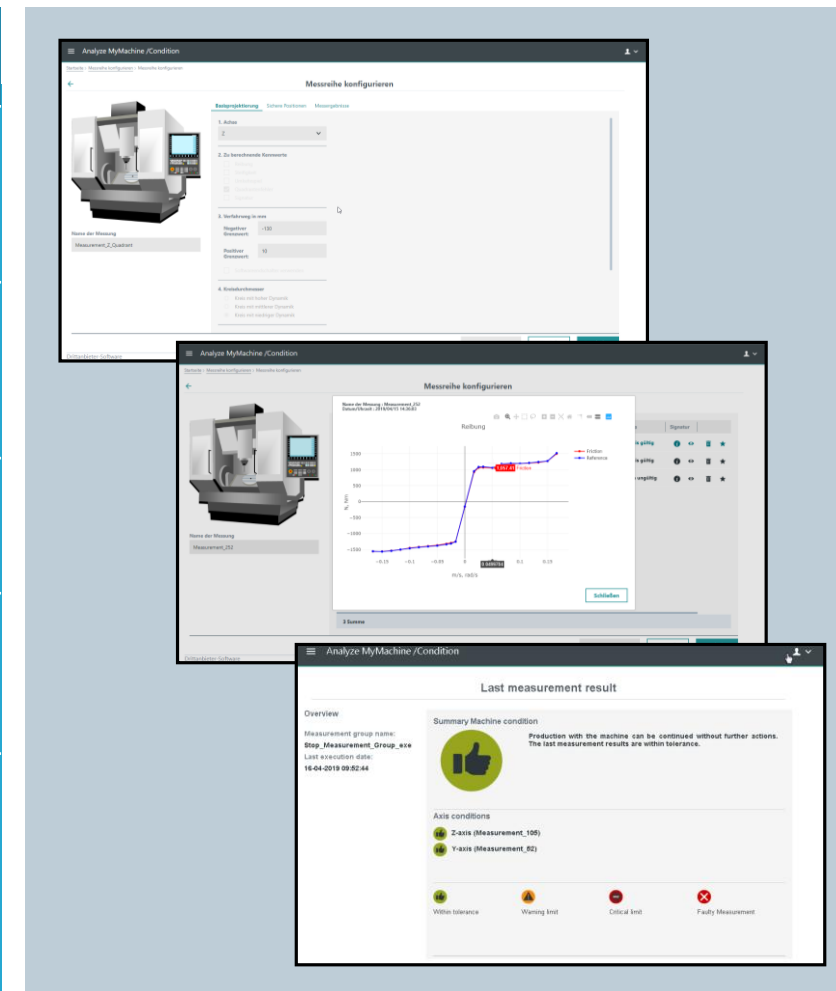
- Intuitive and transparent representation of various parameters for the 3D geometry
- Read-in data can be displayed in just one and/or multiple different views

# Analyze MyMachine /Condition

## Condition-based maintenance of machine tools



Feature/function		Benefits
Determination of the machine tool's <b>mechanical fingerprint</b>	▶	<ul style="list-style-type: none"> <li>• <b>Higher machine availability</b> due to enhanced maintenance intervals</li> <li>• Machine operation can be improved/corrected with the right settings</li> </ul>
Comparison of different measurements and machines <b>on MindSphere</b>		<ul style="list-style-type: none"> <li>• Long-term tracking of multiple machine's condition</li> <li>• Determine <b>deviations over time</b></li> <li>• Detect anomalies between different machines</li> </ul>
Active <b>involvement of the machine operator</b>	▶	<ul style="list-style-type: none"> <li>• <b>Machine operator is informed</b> of the result of the measurement and can follow recommended actions</li> </ul>
<b>Intuitive operation</b> and flexible definition of measurements	▶	<ul style="list-style-type: none"> <li>• <b>Save time by</b> performing one measurement program for all machine axis</li> </ul>
<b>SINUMERIK Edge</b> application	▶	<ul style="list-style-type: none"> <li>• <b>High quality measurement results</b> due to use of high-frequency data stream</li> <li>• Benefits thanks to options provided by the <b>SINUMERIK Edge eco-system</b></li> </ul>





# PCB cutting machine

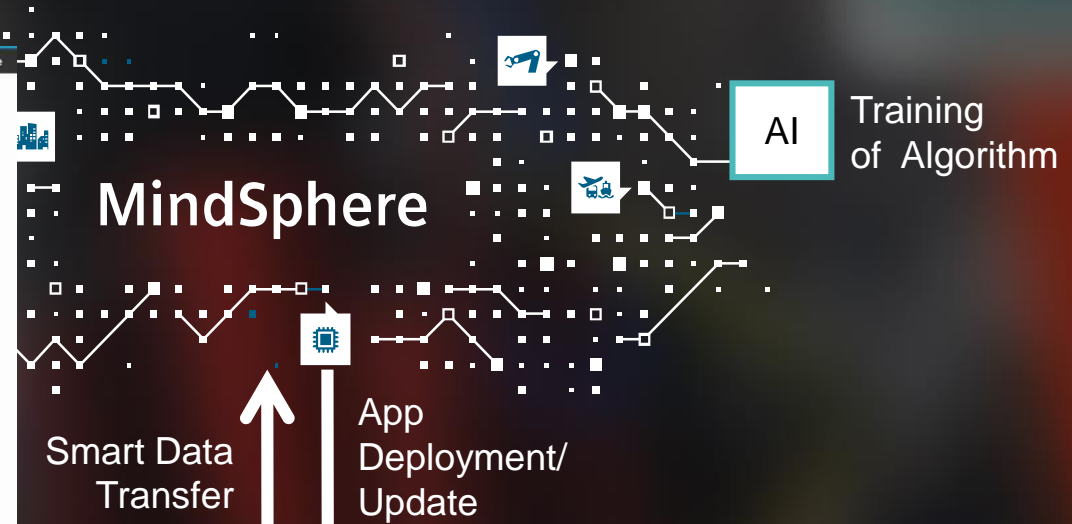
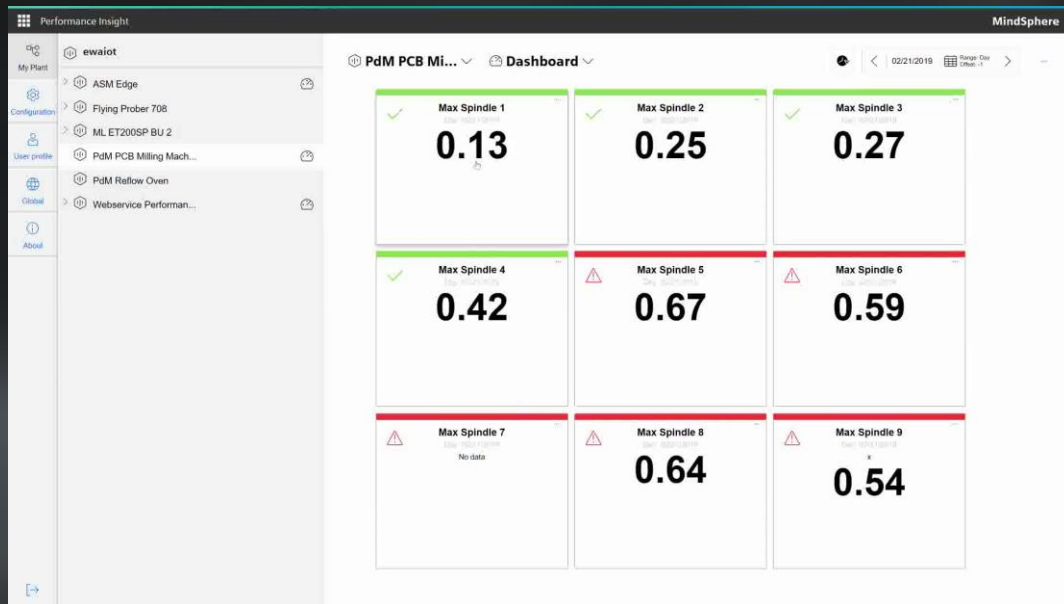
Siemens Electronics Factory  
Amberg, Germany

## The challenge



Aggressive milling dust causes  
drive bearing to get stuck

## Non production critical level



## Production critical level

Anomaly detection  
for Predictive maintenance



Machine data



PCB cutting machine

**AI predicts** spindle  
maintenance  
for PCB cutting  
machine up to

**2 days**  
in advance

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Reducing preliminary  
spindle failures of  
this type by

**100%**

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Total calculated  
savings for 18  
machines

**120k€**  
p.a.

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## When/Where can I learn more?



### IoT & Predictive Maintenance in-person workshops @ CCAT

A follow up session will be held @ CCAT to demonstrate these solutions and provide more detailed information regarding POCs and how you can get started!

Dates & Times TBA





# Thank you! Questions!?



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