



**IoT Week Bilbao 2018**

4-7 JUNE 2018, BILBAO (SPAIN)  
EUSKALDUNA CONFERENCE CENTRE

## How IoT can affect Machine Tool industry?

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Senior Researcher

BILBAO, JUNE THE 7<sup>TH</sup> 2018

IK4  TEKNIKER  
Research Alliance



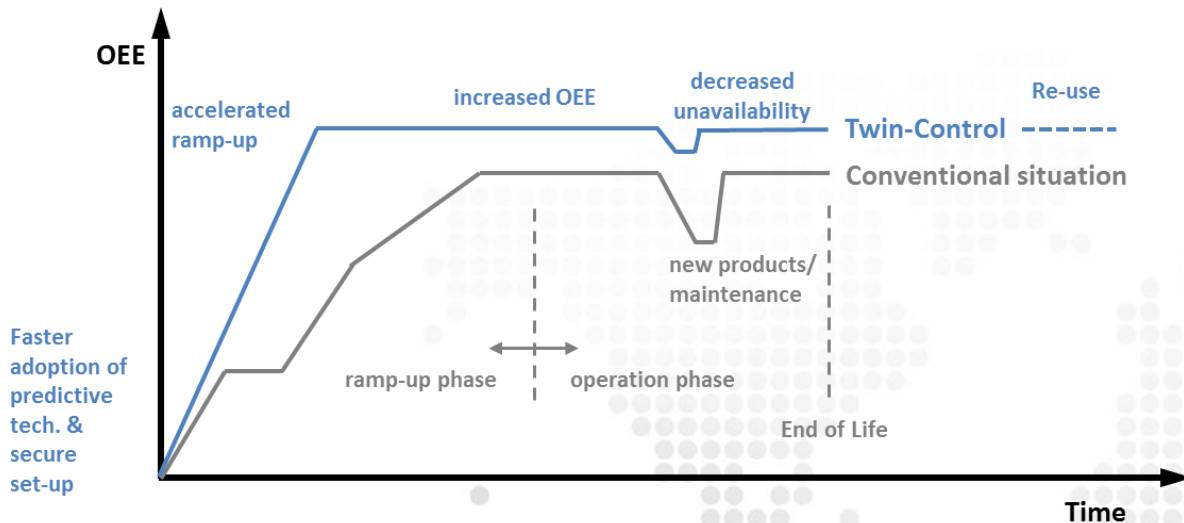
**twin**control

**IoT**•Forum



# Introduction

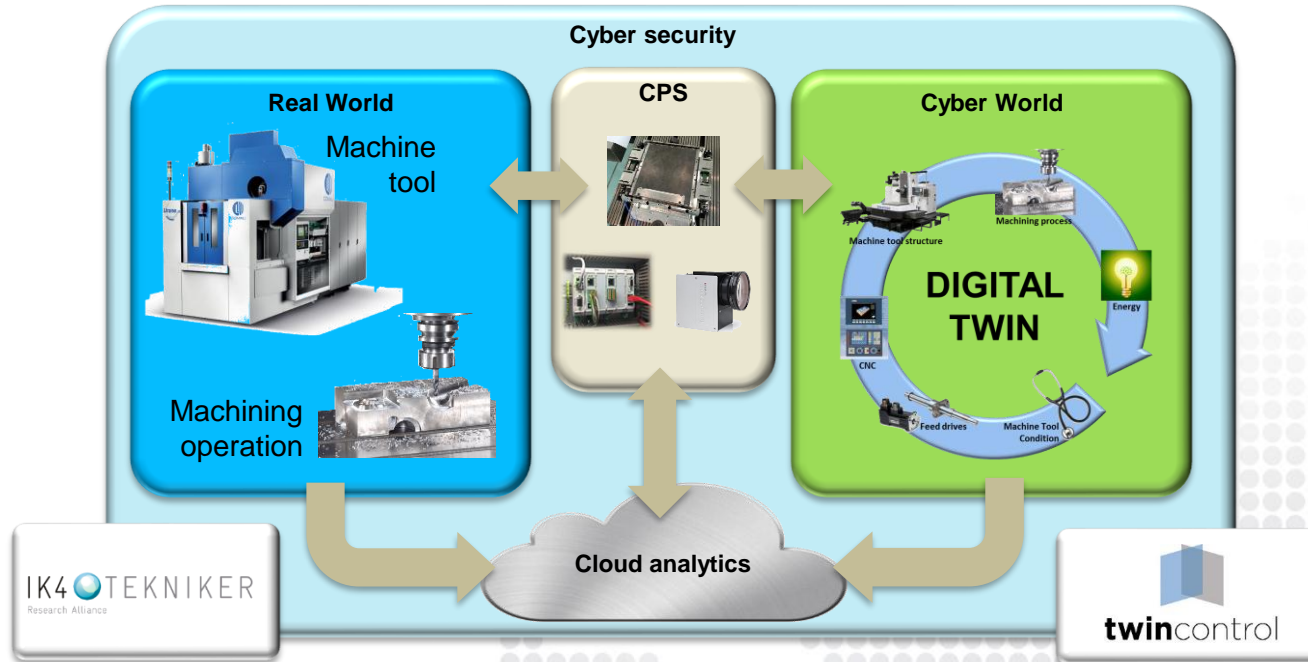
- Main goal in Manufacturing → Increase the Overall Equipment Efficiency



- Reduce machinery and process set-up time.
- Increase the reliability of the process
- Increase the machine up-time
- Reduce life cycle costs
- ...

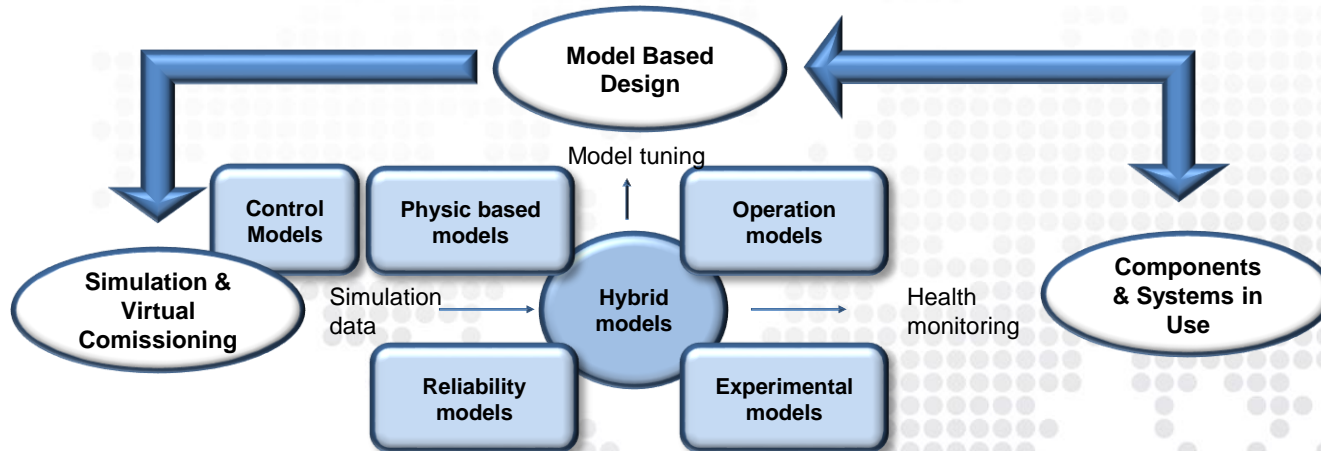
# Introduction

- Machine Tool as a CPS



# Digital Twin

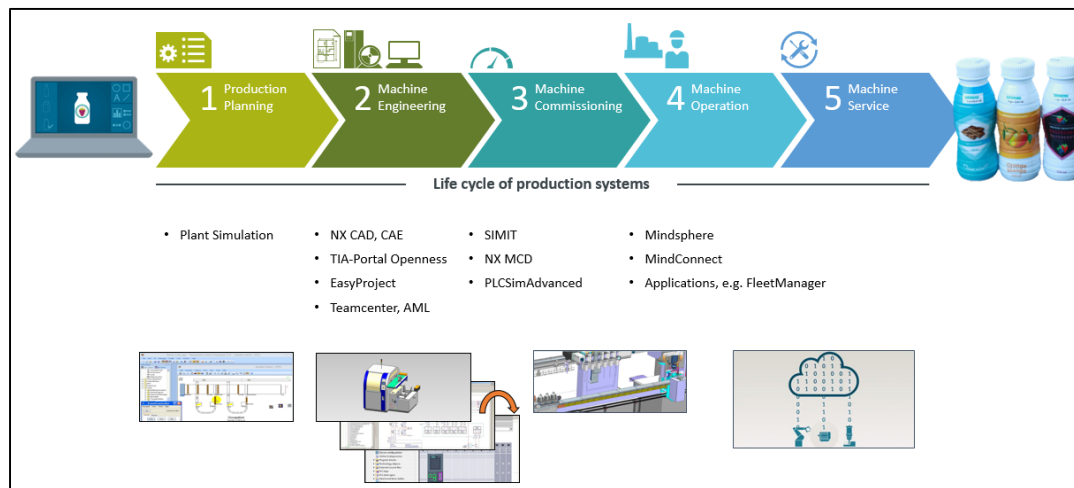
- Virtual representation of machinery/processes with interaction with the real world:
  - Model optimization → tuning
  - Virtual Commissioning → reduction of the overall production stage of a product
  - Process control
  - References for health monitoring → improve the detection of anomalous performance
  - ...



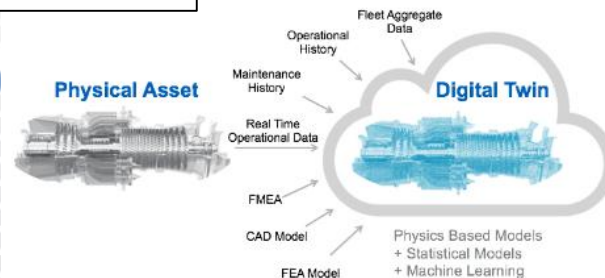
# Digital Twin

## • Digital Twin in the market

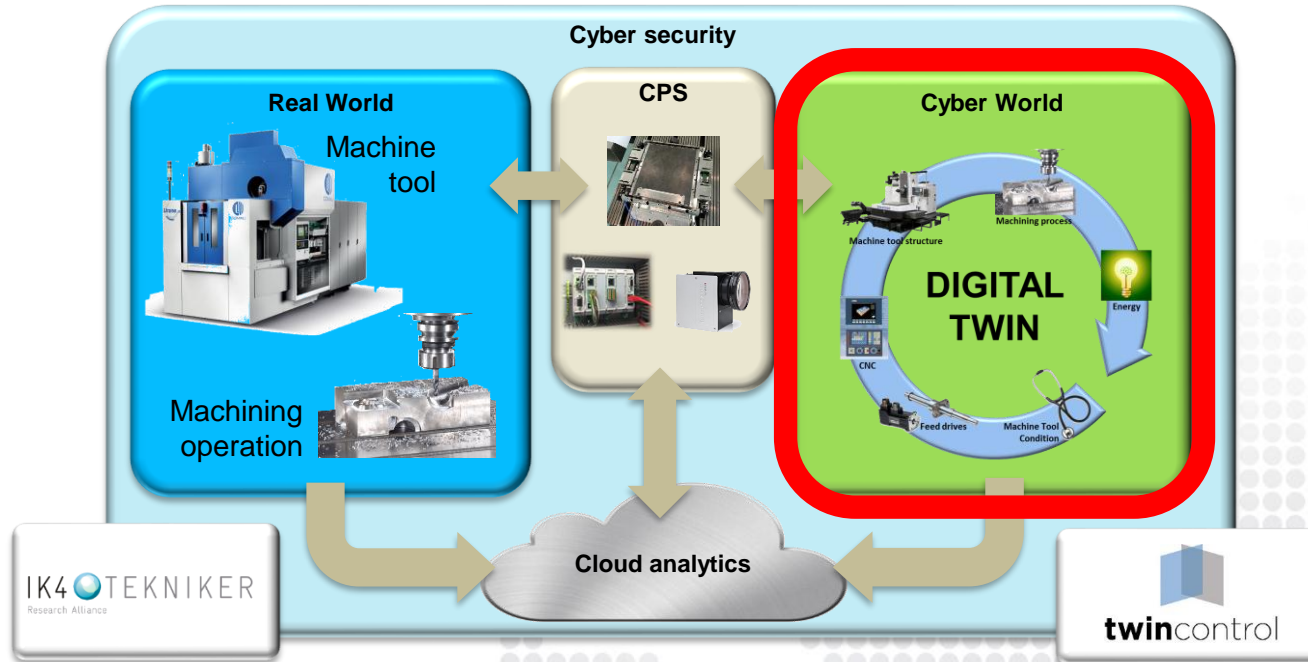
SIEMENS



IBM

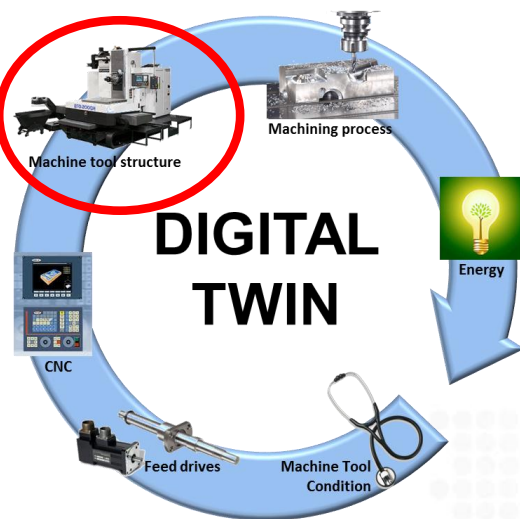


- Machine Tool as a CPS

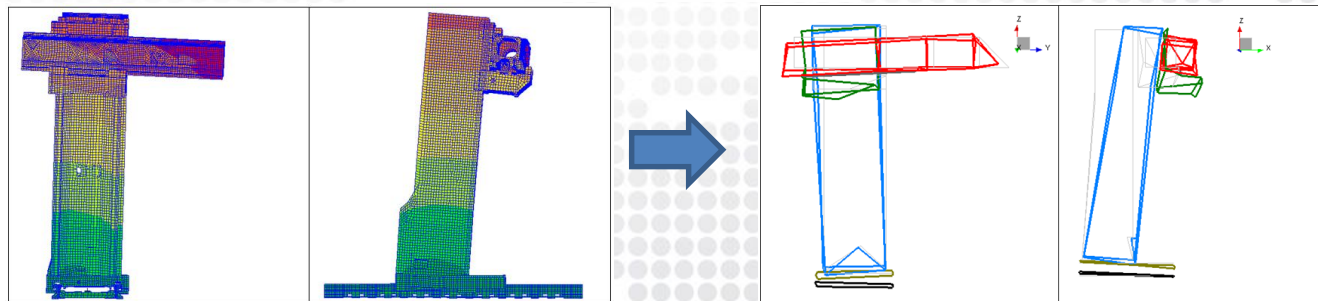




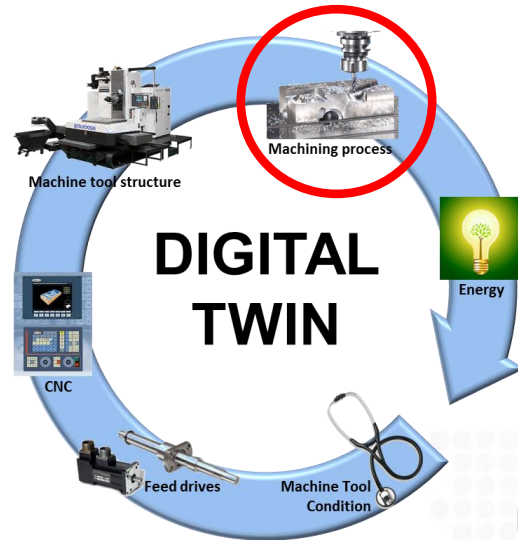
# Digital Twin



- Machine Tool modelling
  - 3D design tools (CAD)
  - Rigid body models → Kinematics and component sizing
  - FEM analysis for structural optimization



# Digital Twin

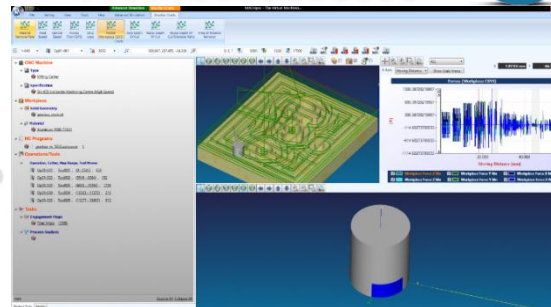


## • Machining Process modelling

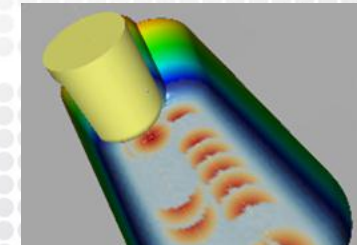
- Software available in the market: VERICUT, MACHPRO, etc.
- Tool path Simulation, Cutting force prediction, Stability analysis...

## • Optimization

MACHPro → Feedrate scheduling

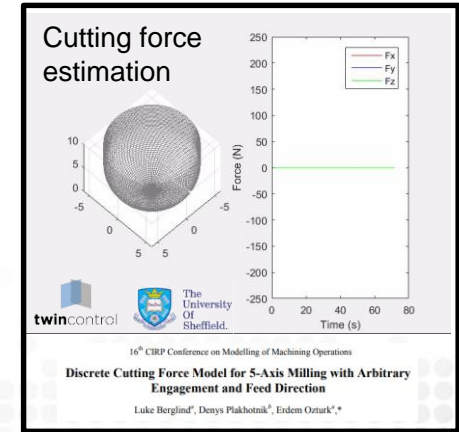


Visualization of process data over workpiece



**ModuleWorks**  
Innovating for You

Simulated and real data

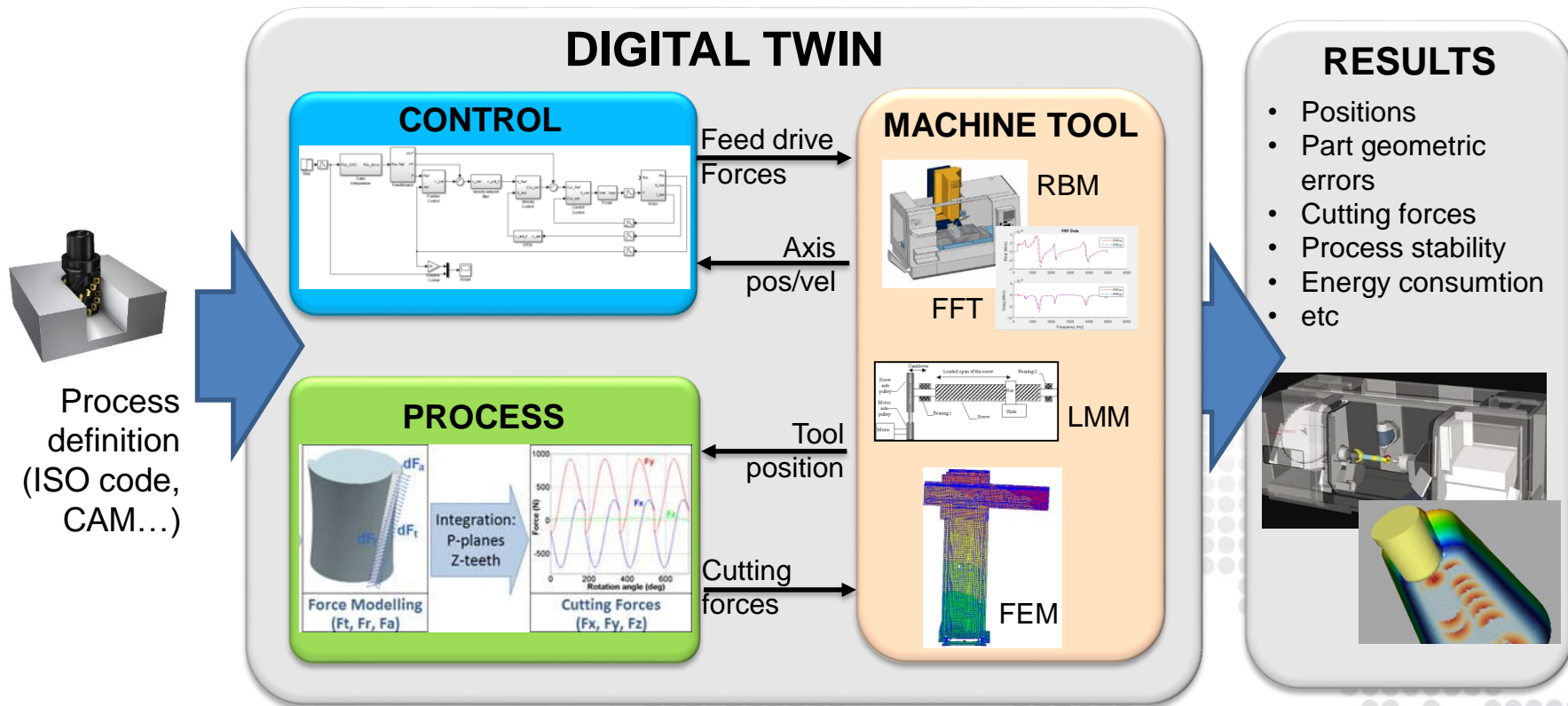




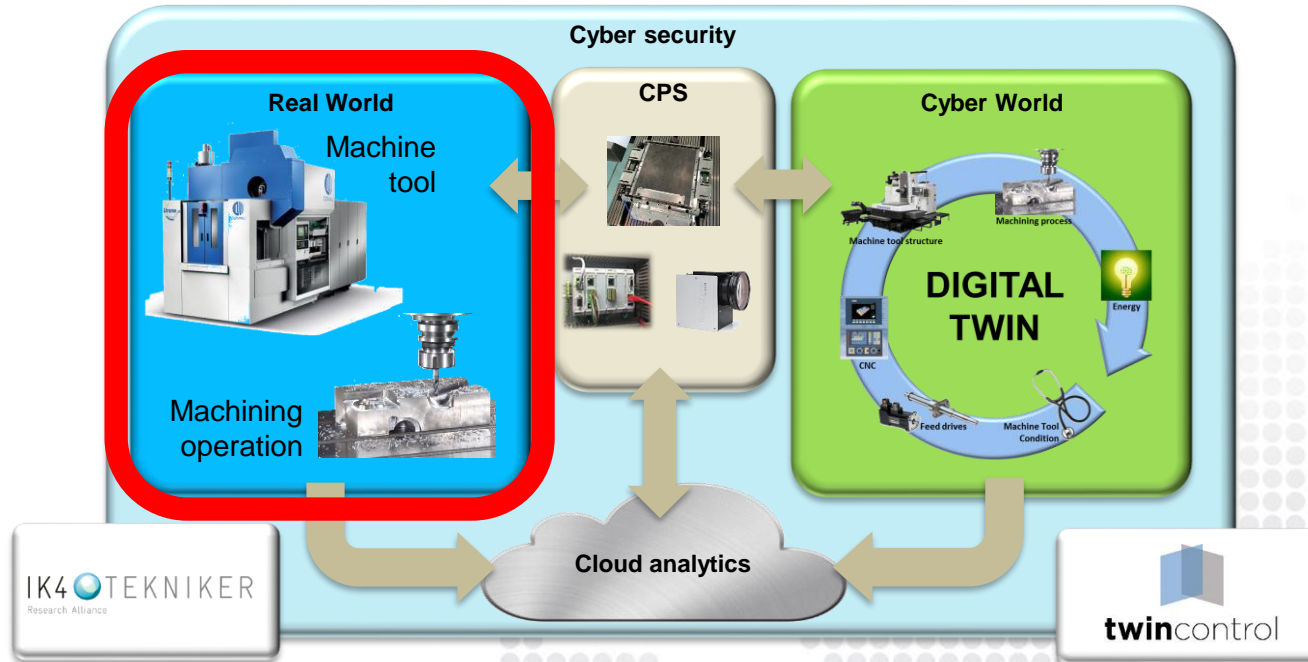
## Virtual Machine Tool

- Integration of machine dynamics, process, control and toolpath generation

## Digital Twin

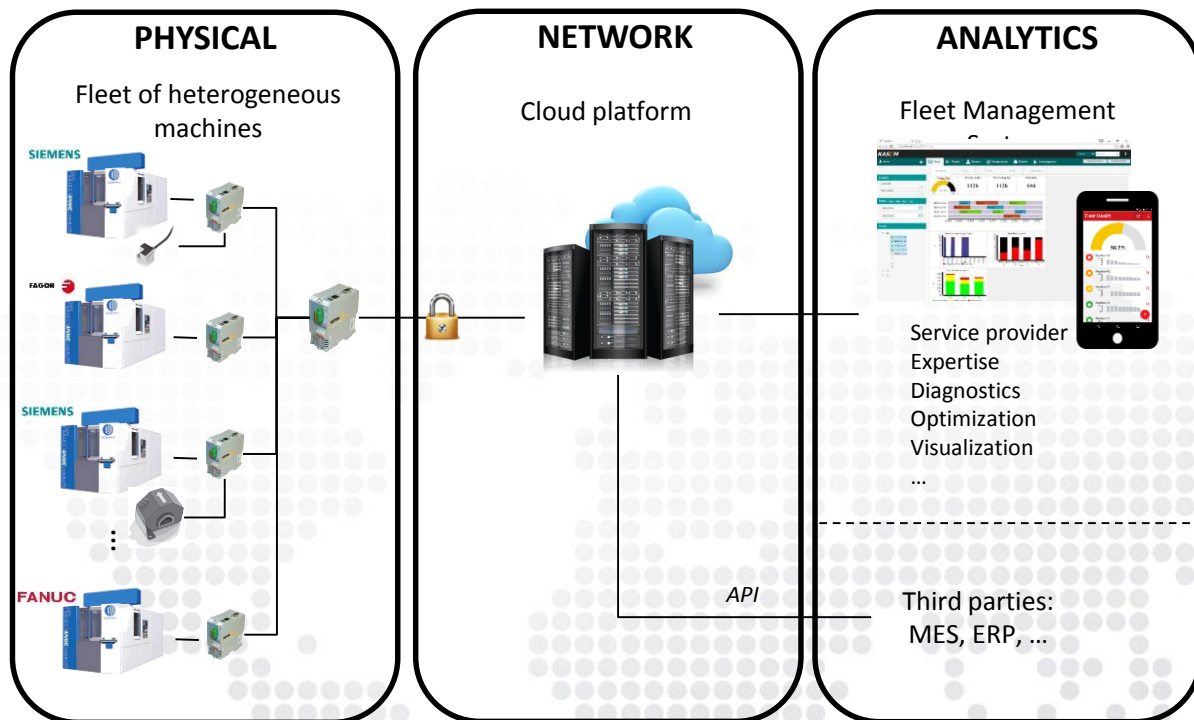
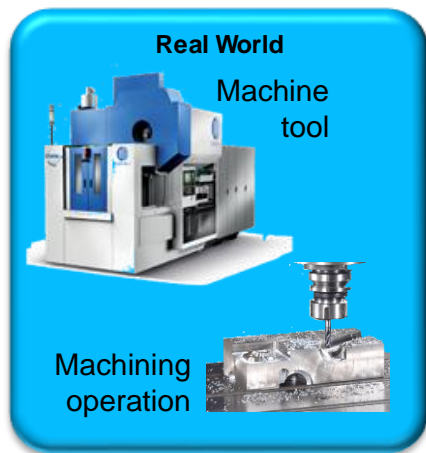


- Machine Tool as a CPS



# Monitoring and data management

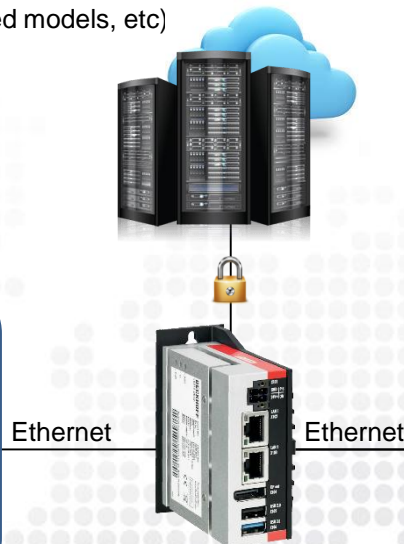
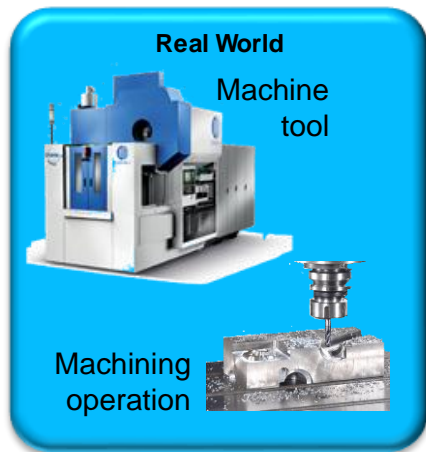
- Data monitoring and management architecture



# Monitoring and data management

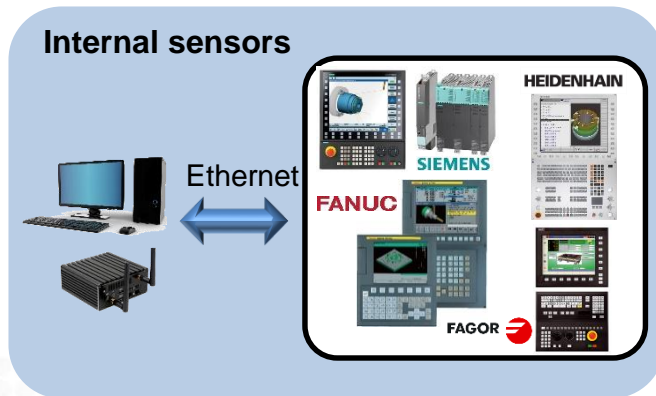
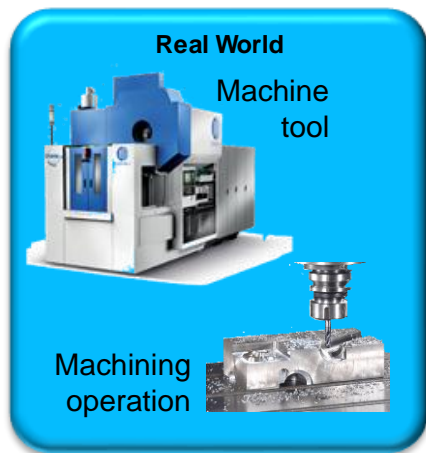
- Monitoring infrastructure - TEKNIKER

- Industrial micro-PC
  - Internal machine sensor monitoring (50-100 Hz)
  - Operating conditions (OPC - 1 Hz)
  - Local processing (Fingerprint, embedded models, etc)
  - Data upload to the cloud
- External sensors
  - Vibration analyses and others
  - Third party or ad-hoc hardware



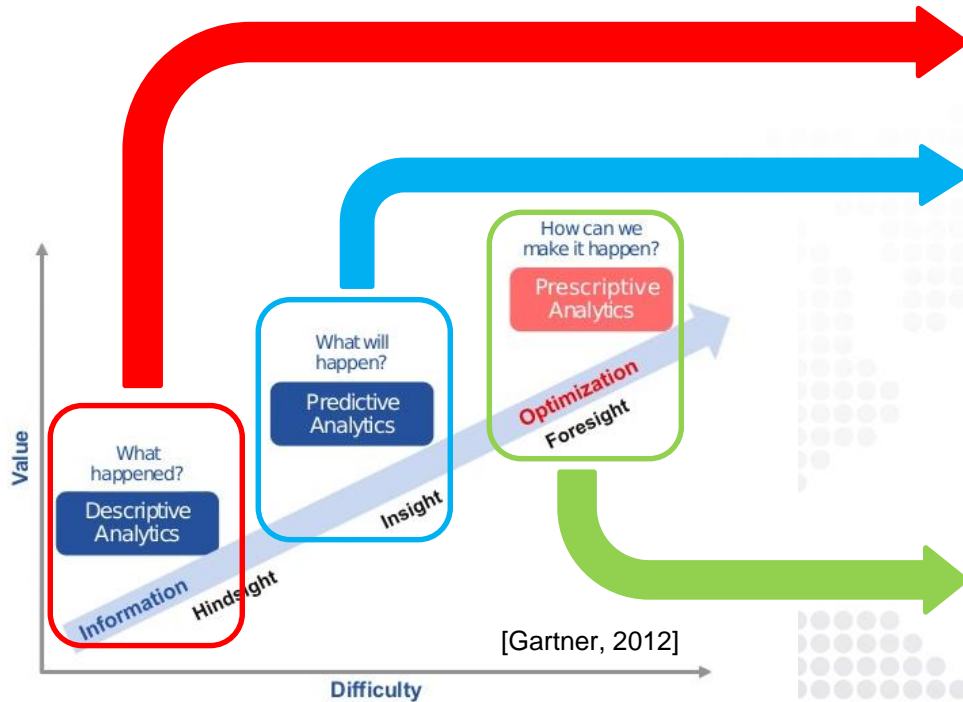
# Monitoring and data management

- Data sources

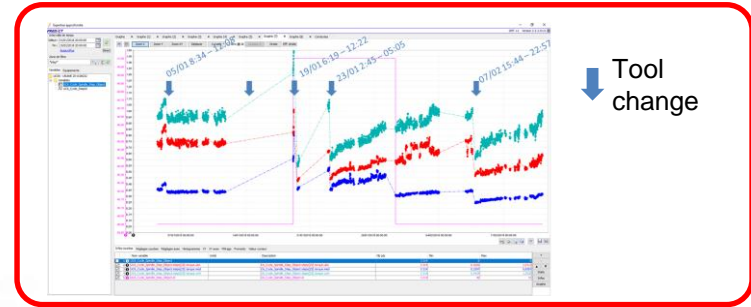




- Data analytics



## Monitoring and data management



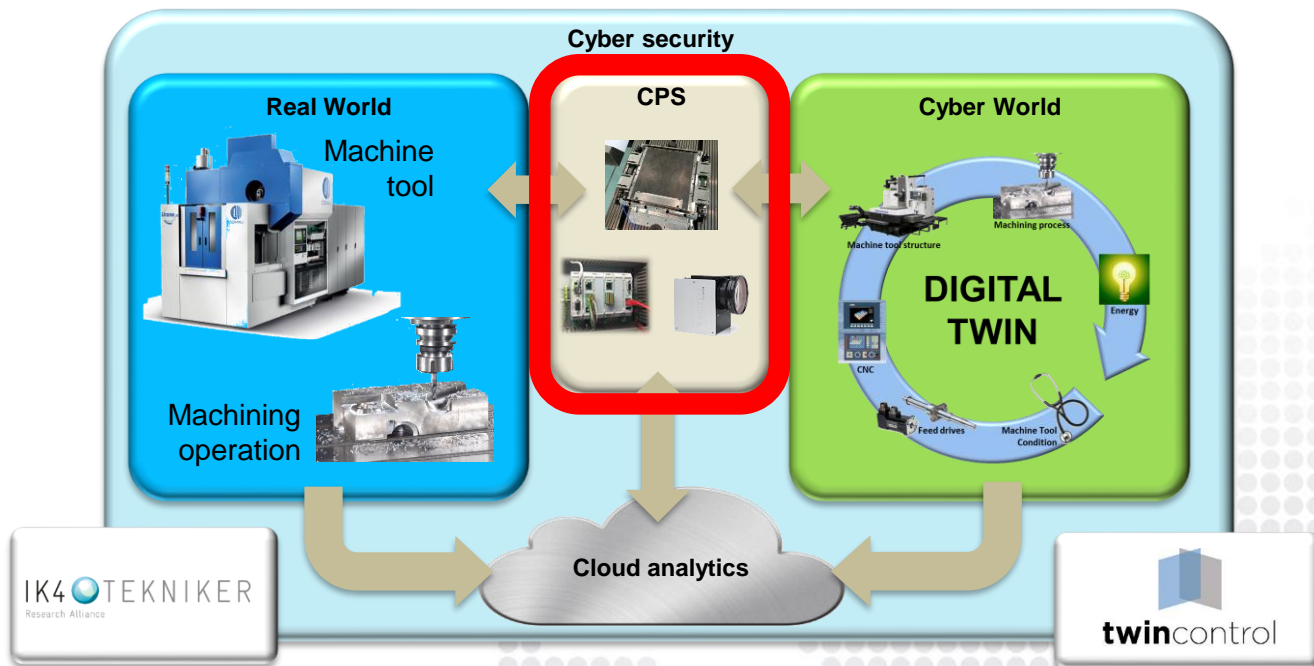
Learning of the wear curves and predict tool wear

Optimized tool usage  
Minimization of tool breakage risk

Machining conditions adaptation according to tool wear and tool change events

Automated tool management

- Machine Tool as a CPS



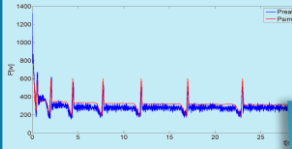
# Cyber Physical System

- iCNC: Process optimization

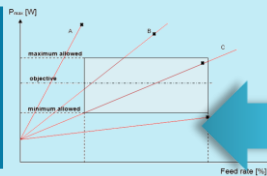
**PHYSICAL**

**VIRTUAL**

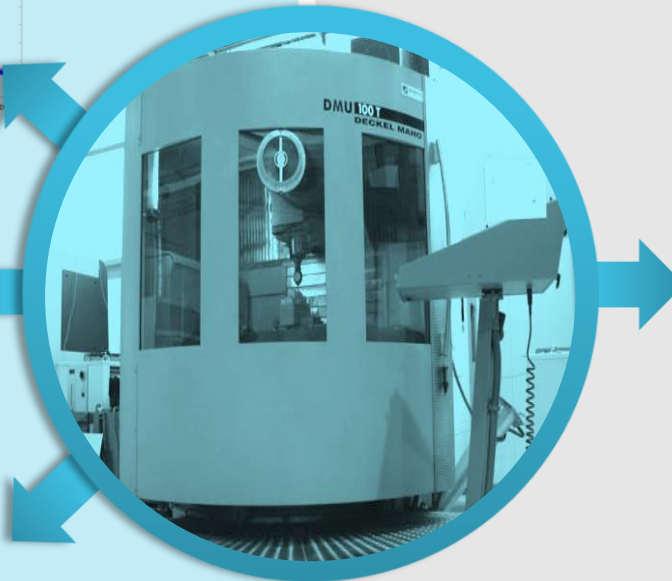
**Power monitoring**



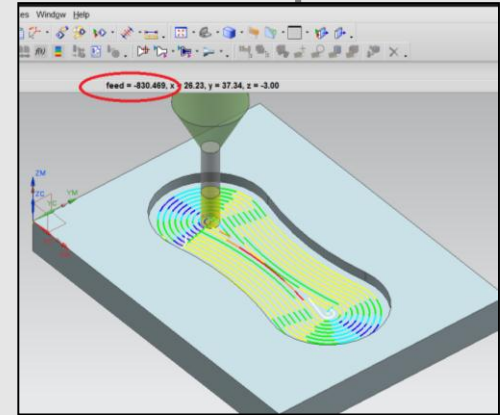
**Signal processing**



**Feedrate scheduling / Stop**



**Model-based power estimations**



**Modified NC code generation**

# Cyber Physical System

- CPSs for chatter suppression

CPS



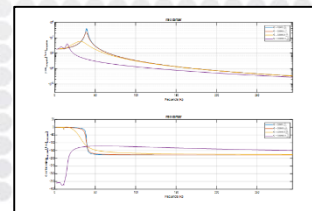
Accelerometer



Real time controller



Active Mass damper

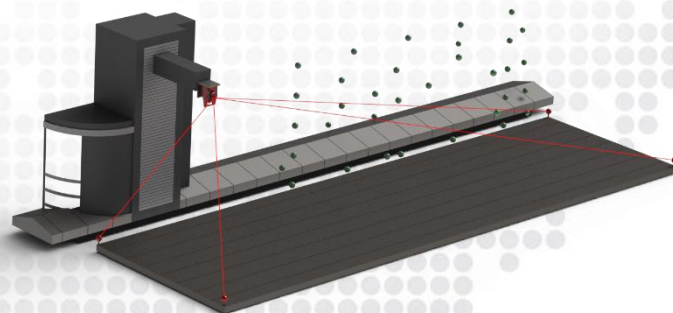
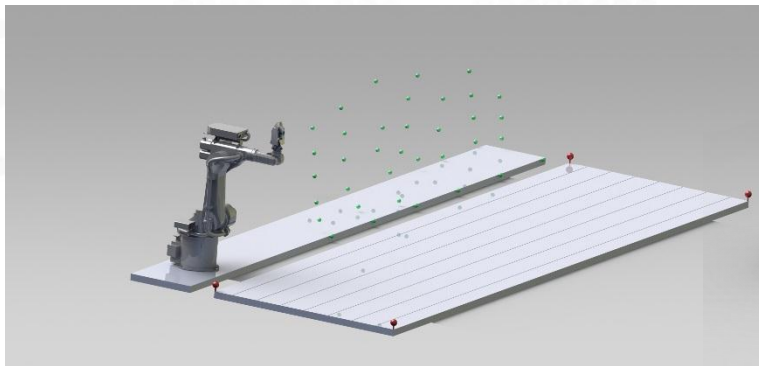


# Cyber Physical System

## CPS



- Automatic MT geometric verification procedure
  - Installation of a laser tracker in the end-effector/tool
  - Reduction of verification time of big machines  $\rightarrow$  75 %
  - Minimization of uncertainty due to thermal effects

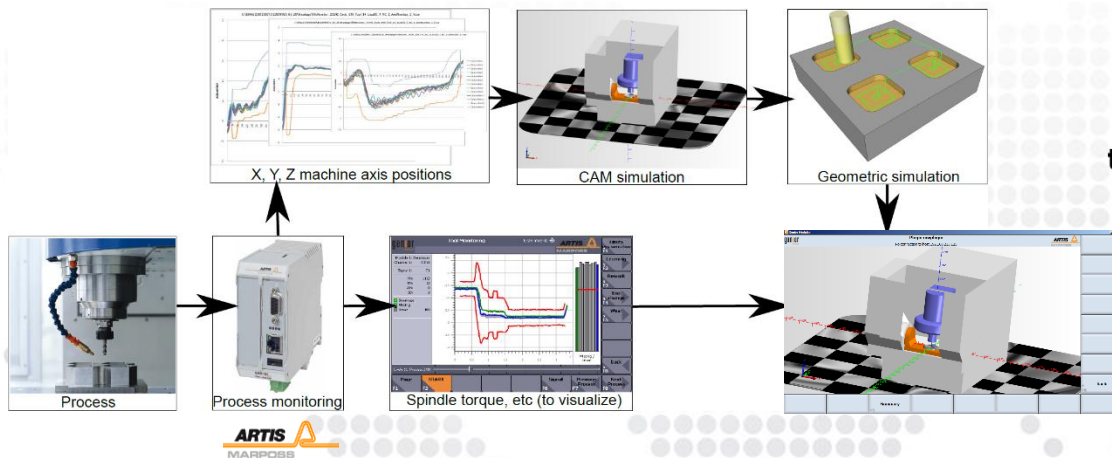




# Cyber Physical Systems

- Process supervision and adaptative control system
  - Integration of process and CNC Simulation models in the monitoring equipment
  - Usage of real data to:
    - Feed the models
    - Compare with simulated references

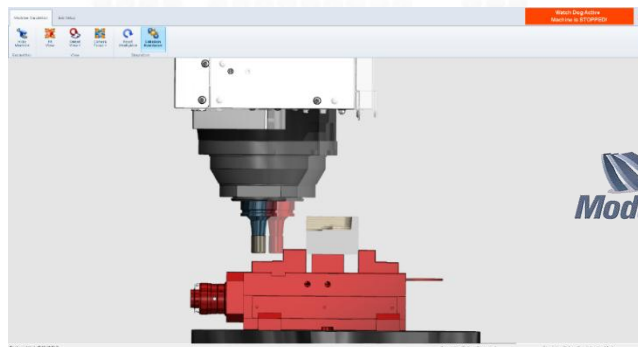
## CPS



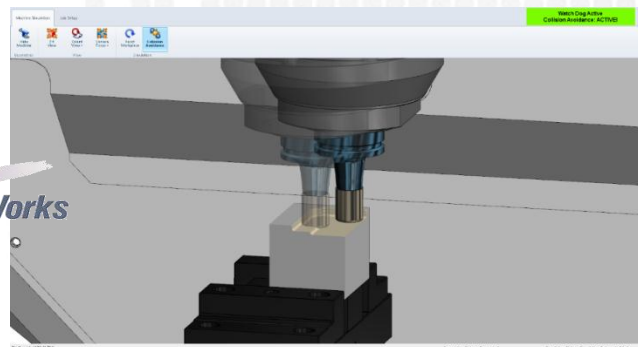
# Cyber Physical Systems

- Process supervision and adaptative control system
  - Collision Avoidance System
    - Avoid machine crashes by look ahead simulation of NC code including:
      - Dynamic workpiece & fixture
      - Tool shape (including holder / adapters)
      - Realistic 3D machine model
    - Support of all operating modes: AUTO / MDI / JOG modes
    - Integration in CNCs or external hardware

## CPS



*ModuleWorks*



## Conclusions

- ICT advances enable the possibility to improve MT performance through all its lifecycle
- Simulation models getting closer to reality and with enhanced possibilities: Virtual Commissioning, health monitoring...
- Monitoring and data management: several products available but companies still reluctant to “share” data
- There are commercial partners ready to sell projects results: SAMTECH-SIEMENS, ARTIS, PREDICT, MODULE WORKS

SIEMENS

  
ModuleWorks

  
ARTIS  
MARPOSS

  
PREDICT

  
COMAU

  
gepro  
systems

  
HSA

  
RENAULT

# Thank you for your attention



**twin**control  
(<http://twincontrol.eu/>)



Grant agreement  
680725

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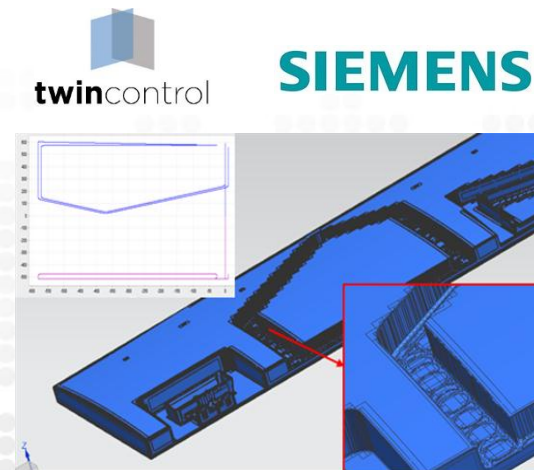
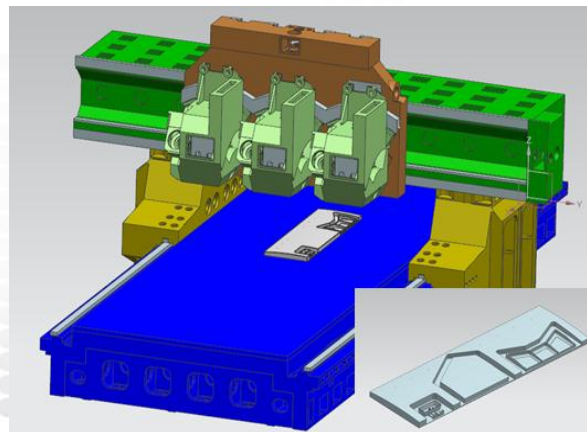
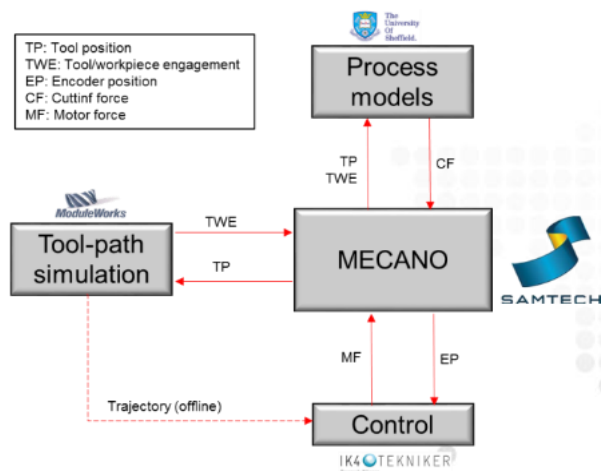


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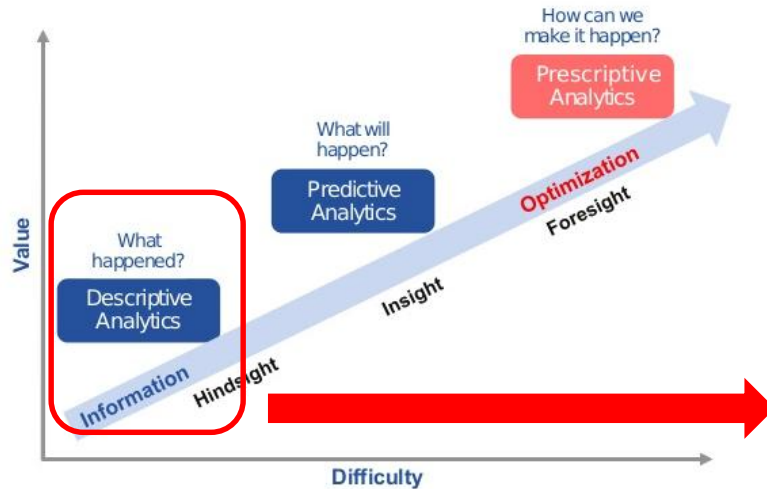
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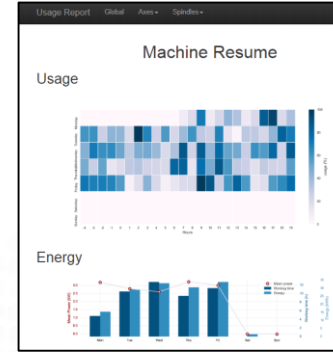


# Monitoring and data management

## • Data analytics



Derived from: Gartner (December 2012)



## Usage and MT characterisation test reports

