Lausanne, 16 November 2021

A Digital factory twin for continuous improvement in Milling Spindle manufacturing processes

CIS Digital Twin Days

Roberto Perez, Jerome Clavel
Innovation Network – Technology Office – Digital Business Unit

Outline

- Introduction – GFMS and its Digital Business Unit
- GFMS Digital Twin Framework
- Boost 4.0: Spindle Factory and Milling machine application case
- Factory Twin
- Predictive maintenance
- Real Time Process Monitoring
- Summary and Conclusions

Introduction

The three divisions of GF
Key figures 2020

GF Corporation	137 companies	14’118 employees	CHF 3’184 million sales

GF Piping Systems

CHF 1’708 million sales

GF Casting Solutions

CHF 752 million sales

GF Machining Solutions

CHF 725 million sales

About GF Machining Solutions

Site information

8 Production plants

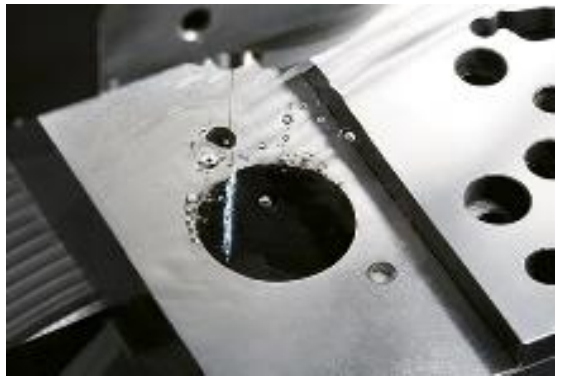
20 Centers of Competence

33 Sales Companies

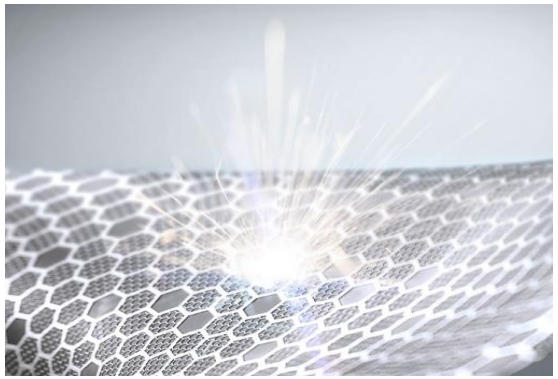
Unique Portfolio

Milling

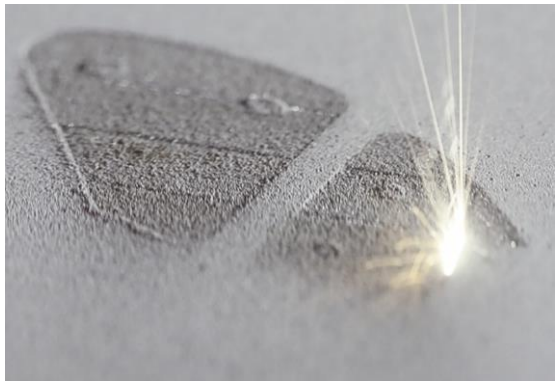
EDM



Laser and Micromachining



Additive Manufacturing



Spindles

Tooling and Automation

Digital Business

Services and Training

Digital Business

Our products enable a full digital workflow

Digital Transformation and Digital Twin @ GF Machining Solutions

Digitalisation is an enabler for our Customers

- Machine digitalisation
  Connectivity, Edge, big data, IoT, Cloud
- Digital Factory
  Automation, Process, Life cycle management
- Digital Customer Services
  Remote Assistance, Equipment Efficiency monitoring
- Digital Technology Services
  Manufacturing Process Insights & Optimization

Customer Value Proposition and Portfolio

Digital Customer Services
Amplify customer experience by integrated digital services to ensure stable manufacturing performance

- Live Remote Assistance
- Customer Cockpit & Messenger
- Proactive maintenance
- Dashboard / KPI / OEE

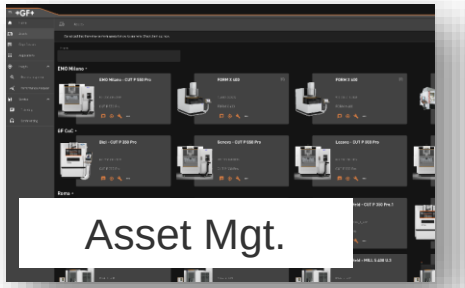
Augmented machine capabilities
Enhanced machine performance by delivering customer-centric, cutting-edge digital products & services

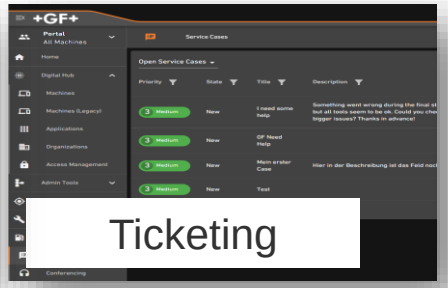
- Connectivity (OPC-UA)
- Part and Process Validation
- E-Tracking
- Technology Management
- Digital Twin

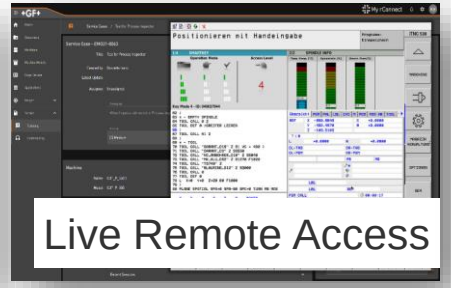
Process integration & optimization
Powering true machining solutions by enabling our customers to implement cross-technology processes

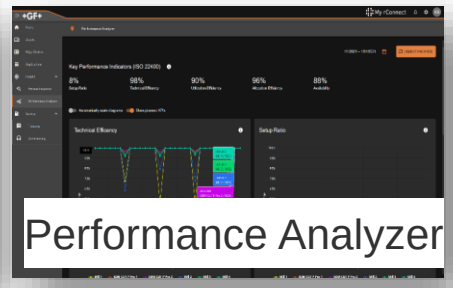
- Automated Workflow generation
- Optimized technology for Milling, EDM and Additive Manufacturing
- Higher overall speed, accuracy and precision

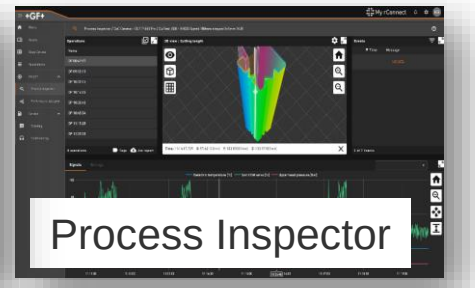
My rConnect

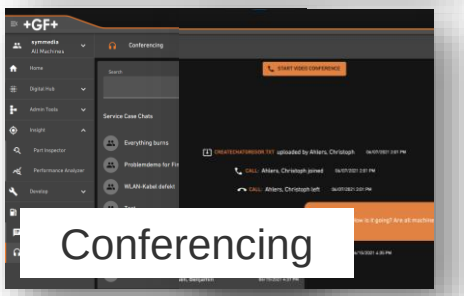


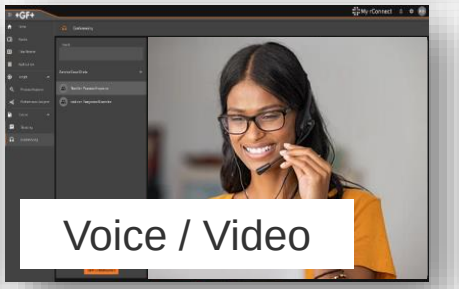


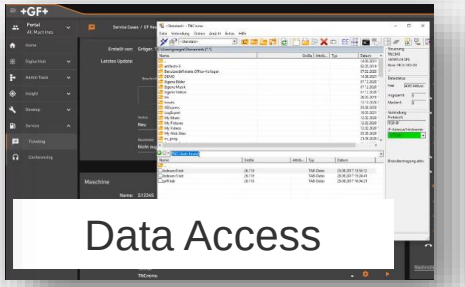


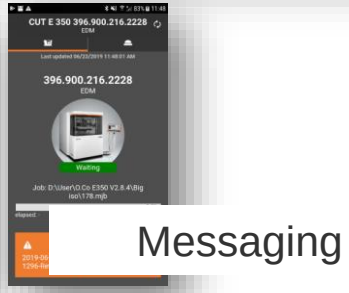




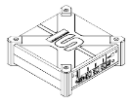








Cloud only



OPC UA 01011 01011

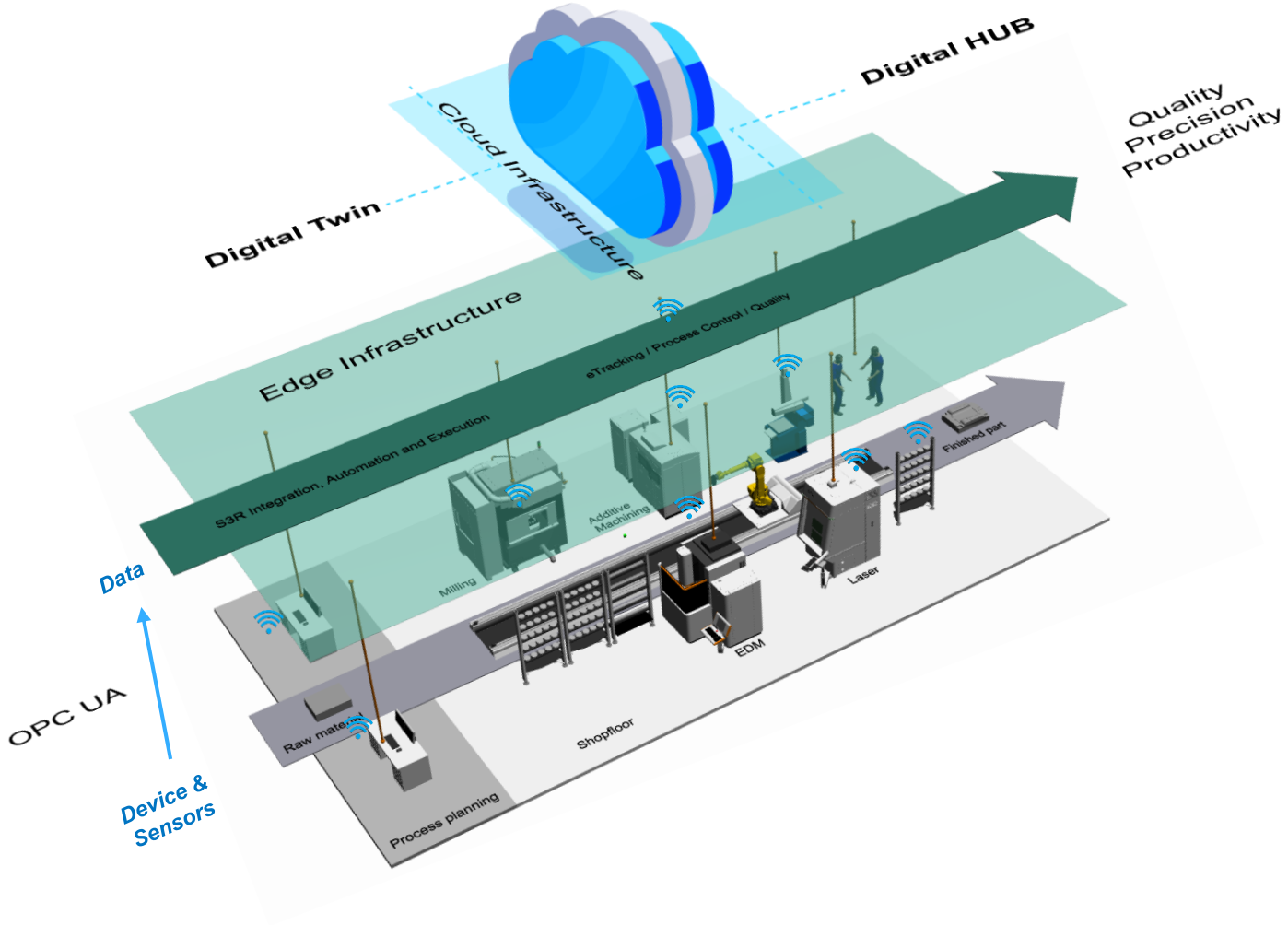
OPC UA HF 01011 01011

** New Applications and Products defined*

Digital Machine & Part Twin Developments

GFMS IIOT STACK

- Business Applications
- Analytics platform
- Cloud Infrastructure
- Connectivity
- Onsite Software
- Automation / Integration
- GFMS Smart Machines
- PLCs, HMI
- Devices/Sensors

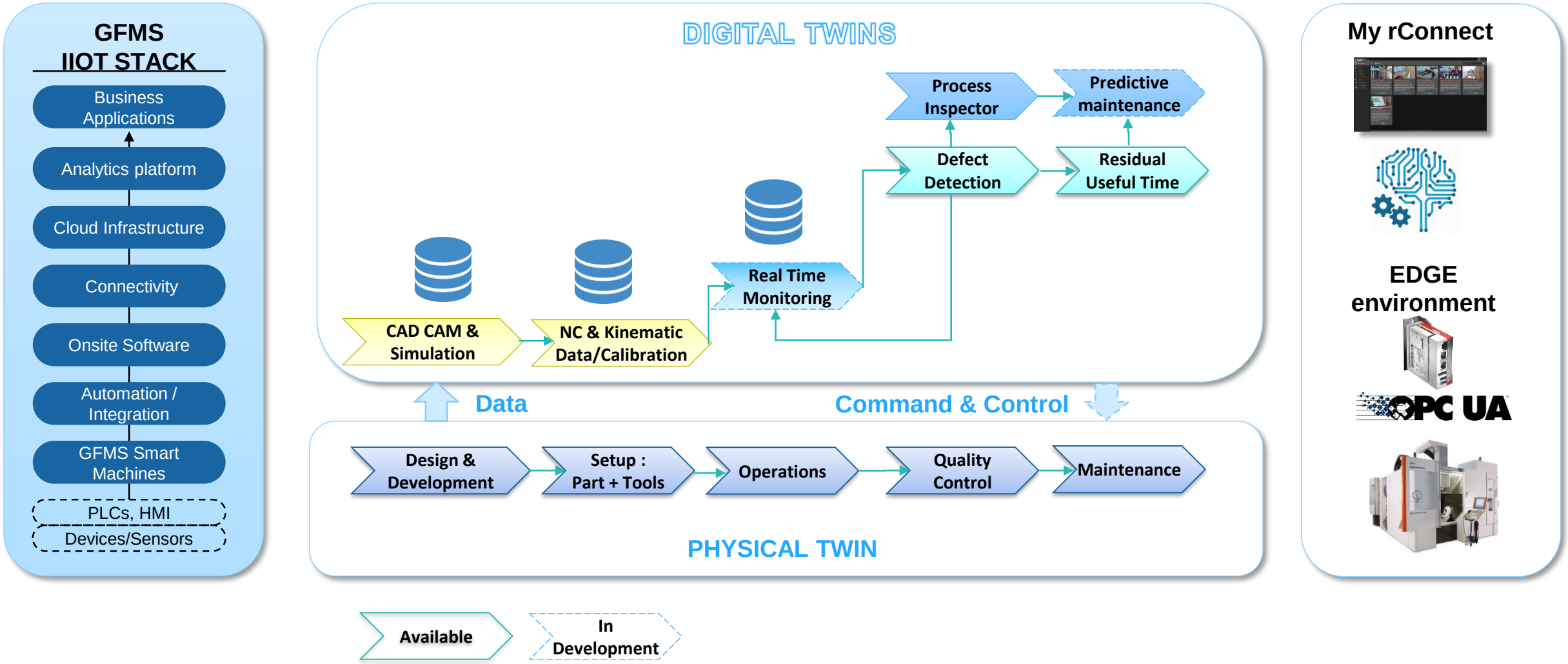


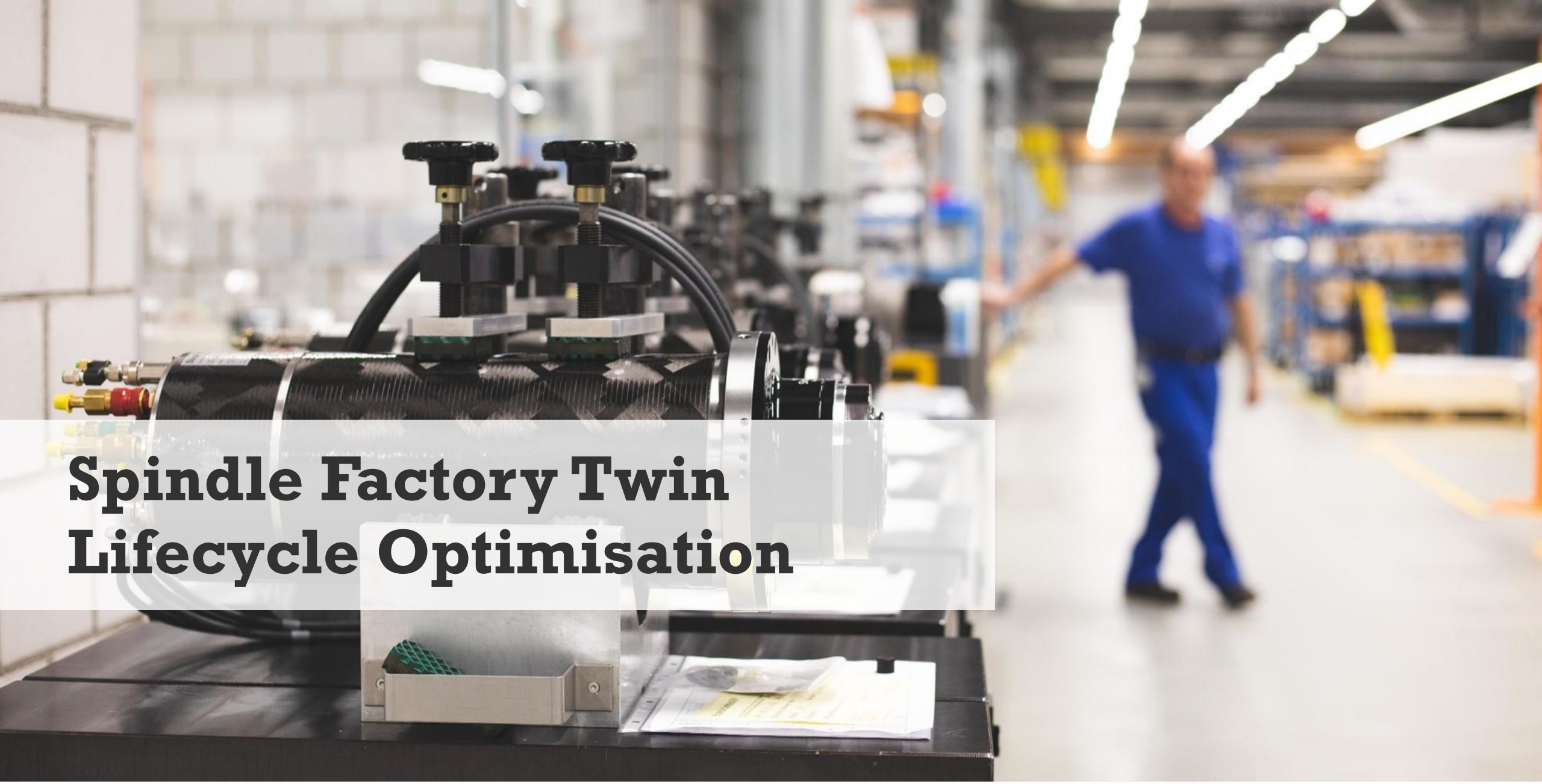
My rConnect

EDGE environment

OPC UA

Digital Machine & Part Twin Developments





Spindle Factory Twin Lifecycle Optimisation

Smart Digital Factories 4.0

Boost 4.0
BIG DATA FOR FACTORIES

THE FRAMEWORK PROGRAMME FOR RESEARCH AND INNOVATION
HORIZON 2020

EU Project 2017-2021

Big Data Production Spaces for Factory 4.0 Processes

Smart Casting & Machine Tool Digital Engineering

Nemak, FILL, INNOVATION RADAR

Smart intralogistics planning & zero defect factory

+GF+, VW, INNOVATION RADAR

Smart Operations & Digital Workplace Optimisation

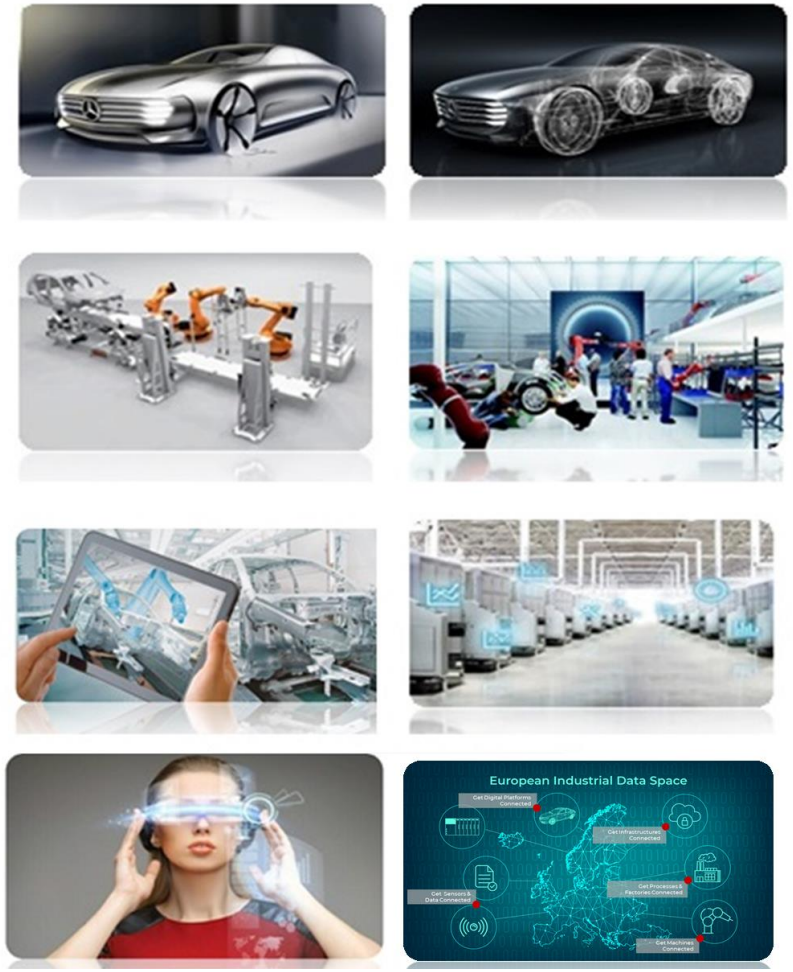
CRF, PHILIPS

Smart Connected Quality Control & Business Network Tracing

innovalia METROLOGY, Gestamp, PIACENZA, INNOVATION RADAR, INNOVATION RADAR

Smart Customer Service & Maintenance

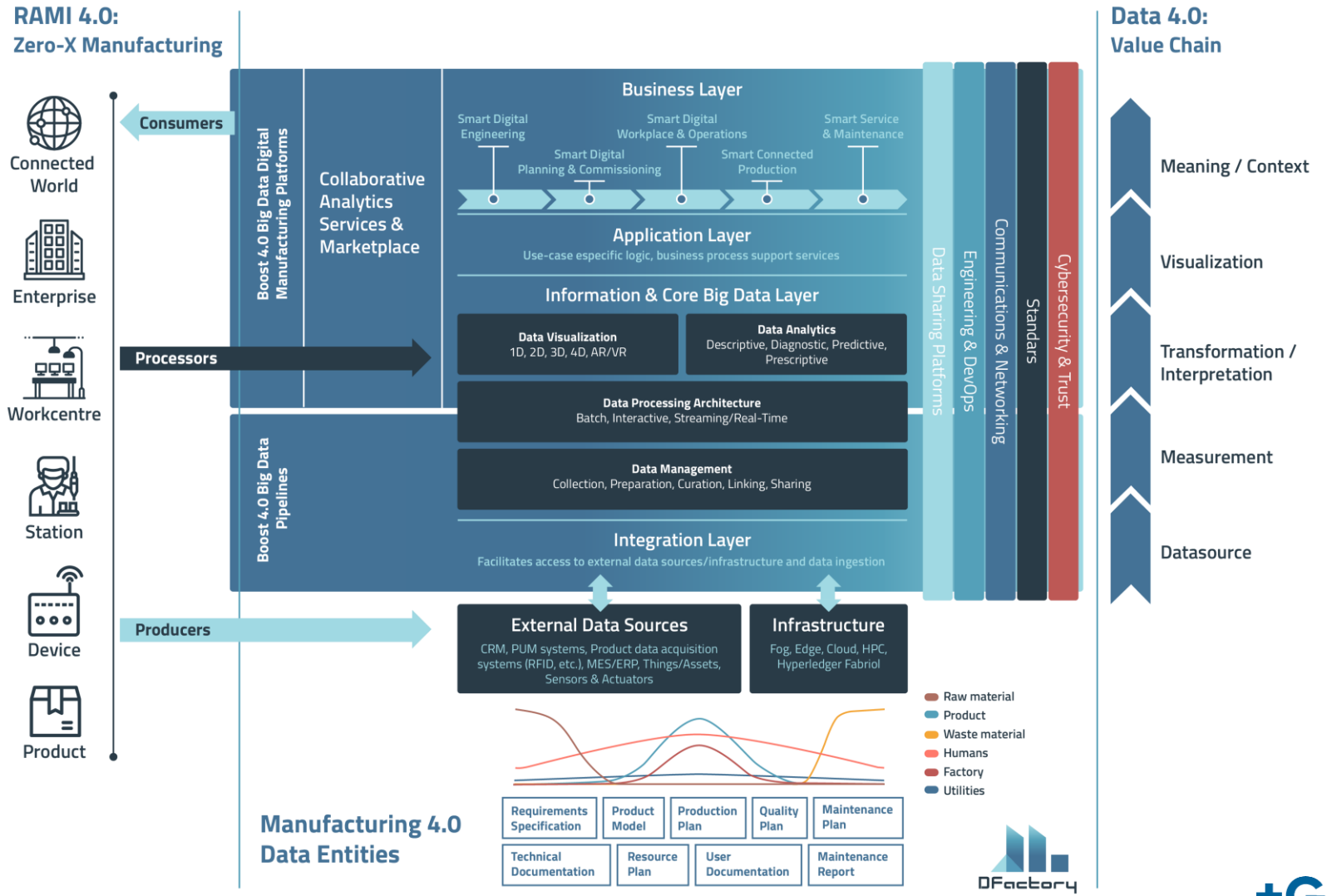
BENTELER, Whirlpool, INNOVATION RADAR



+GF+

Industry 4.0 Big Data Reference Model

BREAKING THE DATA SILOS | ISO 20547



+ Boost 4.0: Project description

Pilot project deployment definition

Goal and Objectives:

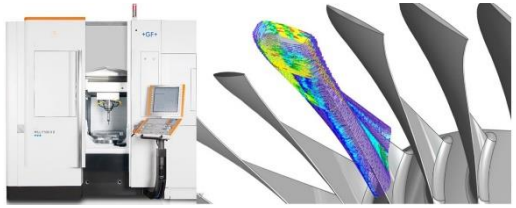
Enable a +GF+ machine tool optimum, zero-defect production factory through a data-driven adaptive production integrating a full product Digital Twin for:

- **Providing transparency** to the full production chain of **milling spindles**
- Improving spindle **assembly lead time and quality** towards zero-defect operations
- Further optimise **product quality and lifecycle costs** by implementing **Predictive maintenance** for Milling machines critical components

GF Spindle Factory Twin

Boost 4.0: Spindle Lifecycle Twin

Ultra reliable
Low latency



Real Time Process Monitoring
& Control Infrastructure

Spindle Factory
Twin

High
Broadband
Capacity

Massive IoT
component
communication

Condition Monitoring &
Predictive Maintenance

Spindle Factory Twin

Boost 4.0: From spindle to machine

Process explanation

Machines

Measurements

Spindle Assembly Line

SpindleTest

Machine Test

Supplier

Customer Service

+GF+

Boost 4.0: Factory KPI Monitoring & Business Case

Main KPIs and first expected results

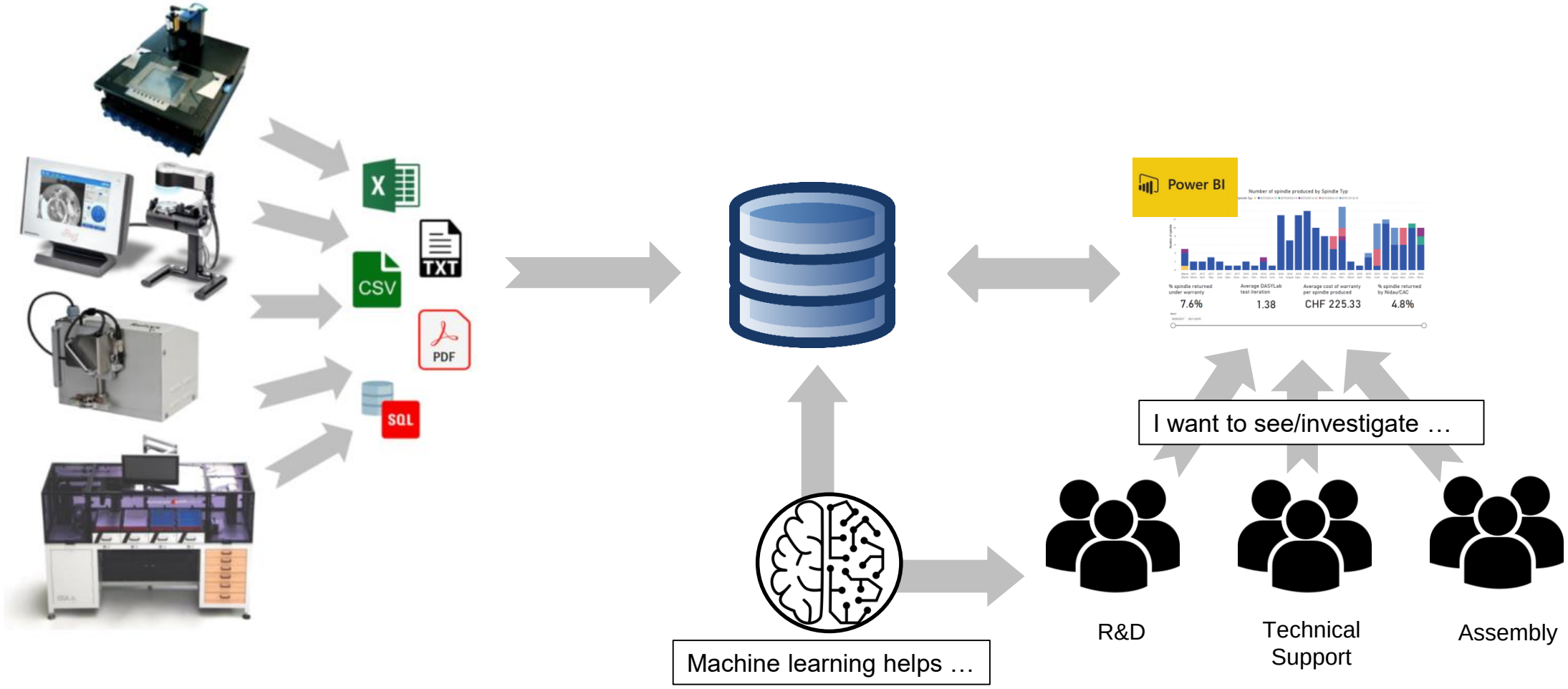
Measurements	Assembly	Test	Machine Assembly	After Sales
Shaft	Assembly Card	Functional test	Machine assembly data	Repaired spindle
Rear bearing flange				Quality release
Sleeve				
5-10% parts reworked (**500-600CHF/part**)	**10%** of spindle returned to production after operational test	Mean of **2 iterations** after spindle assembly	**3-5%** spindle returned to Step Tec after machine assembly	**200-250 CHF** warranty cost per spindle (5-10% of margin) **5-7%** of spindle returned under warranty

100+ hours spent annually maintaining/integrating data in the process

Potential Cost Reduction: 3-5% sales revenue -> Overall 10-20 % benefits improvement

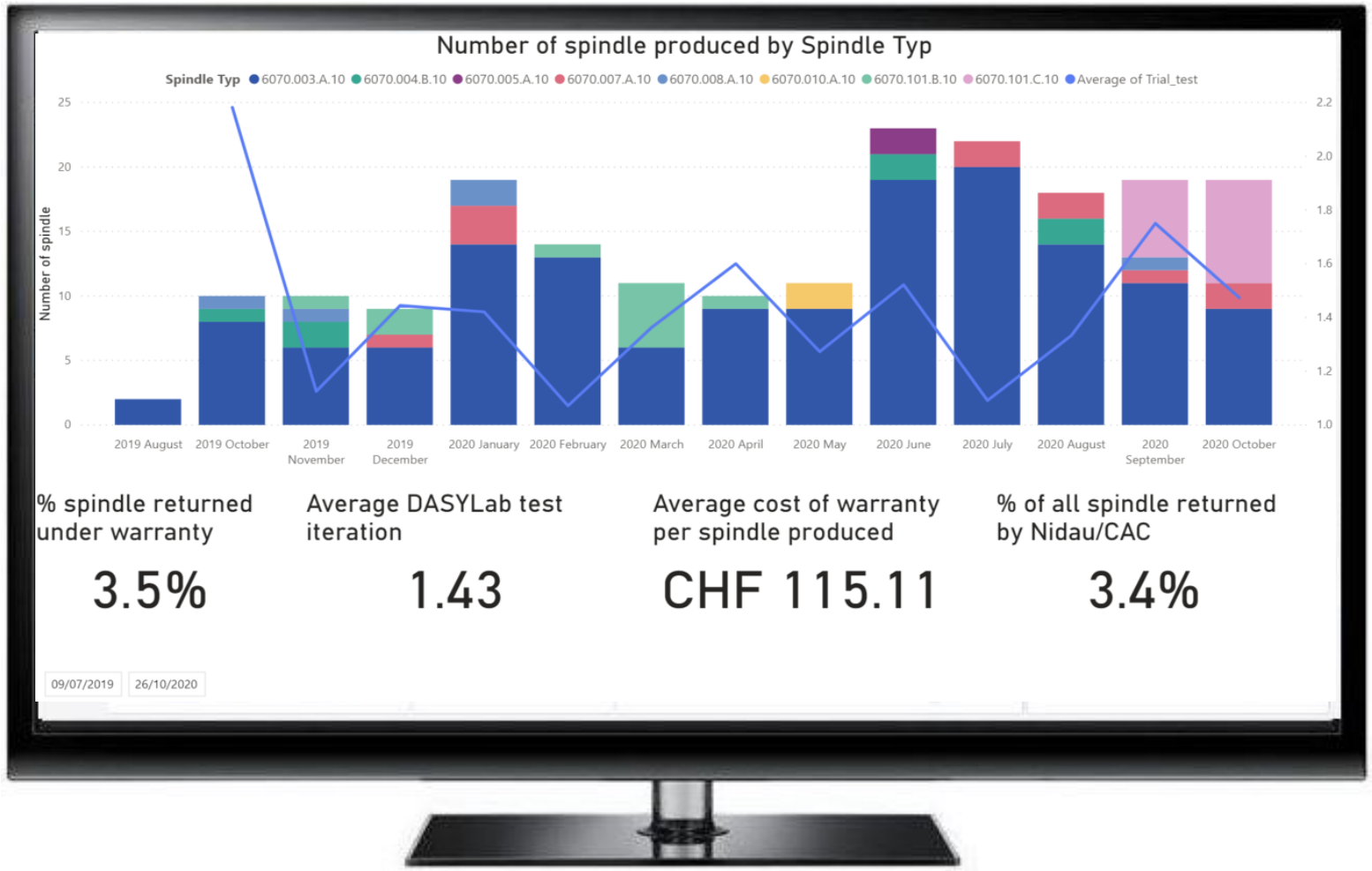
Boost 4.0: Integrating data sources

Stakeholders can access to data from production to final test or tech. support in one click



Boost 4.0: Monitoring & Analytics benefits

Dashboard for monitoring KPIs for continuous improvement



% spindles returned by Biel (SAP)

3%

% spindles returned by China (SAP)

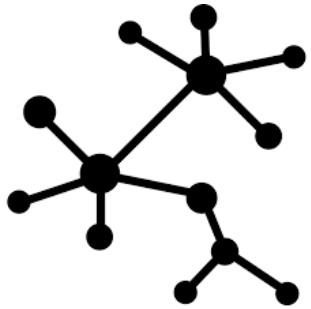
7.50%

% of spindle 003/004/101 returned by Nidau/CAC

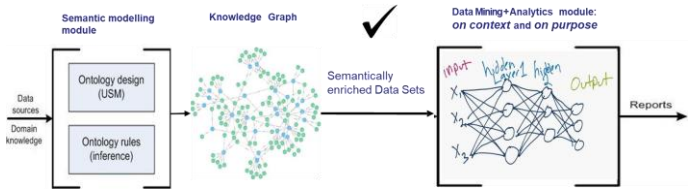
2.2%

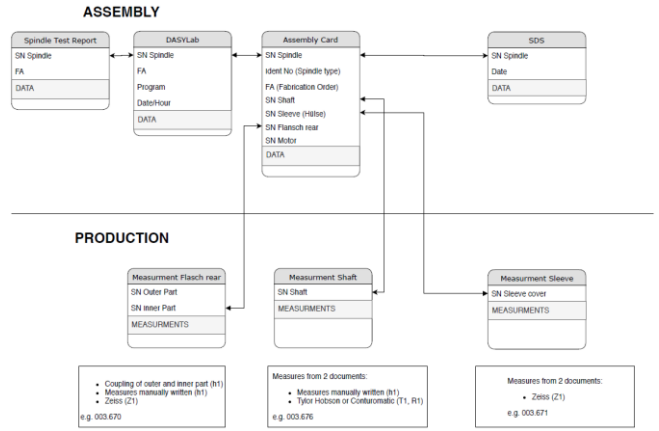
+ Boost 4.0: Integrating knowledge and data sources

Objective and achievements: beyond datalakes



Organized data



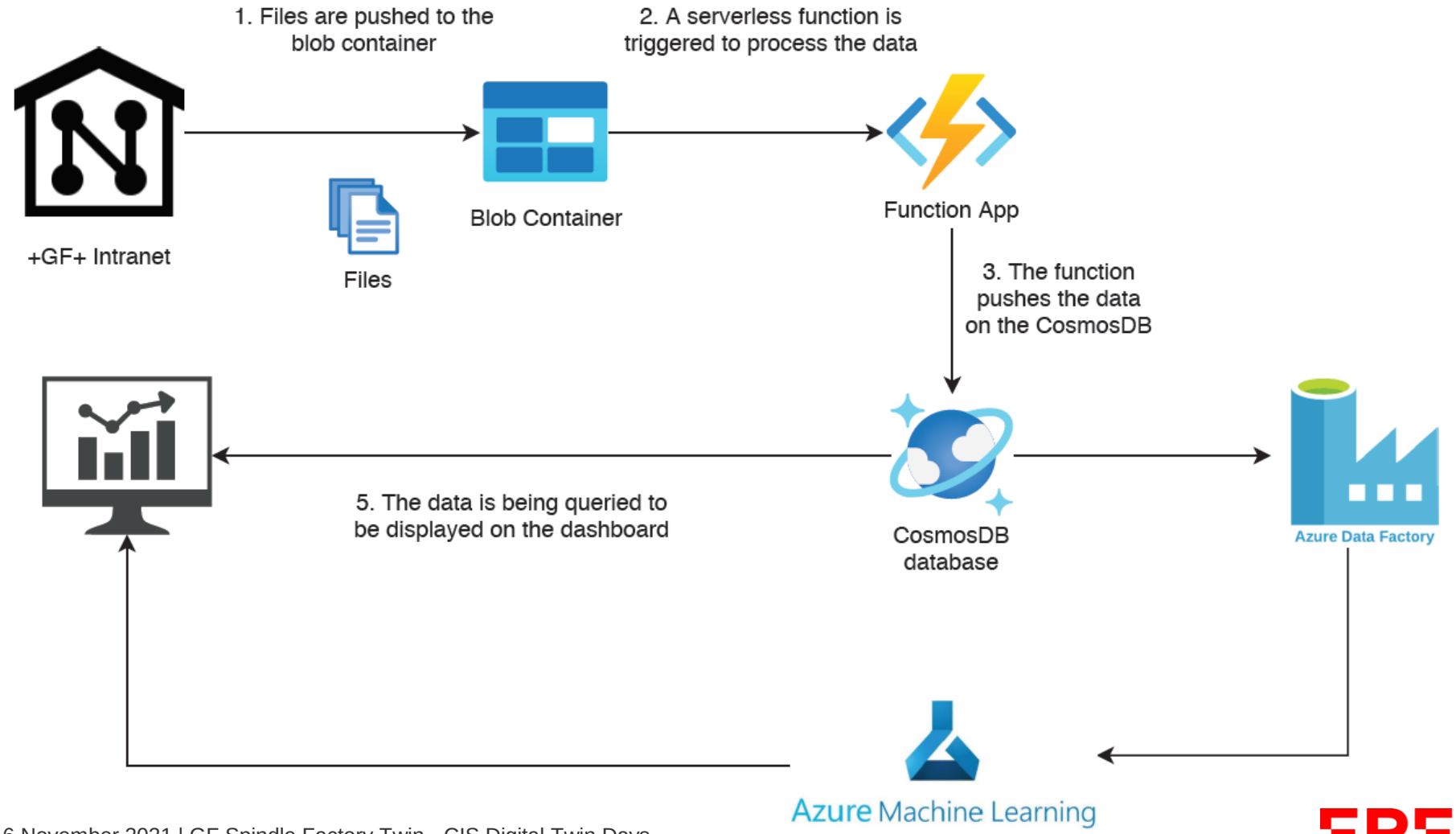


GF Boost 4.0 Ontology

EPFL +GF+

+ Boost 4.0: Integrating knowledge and data sources

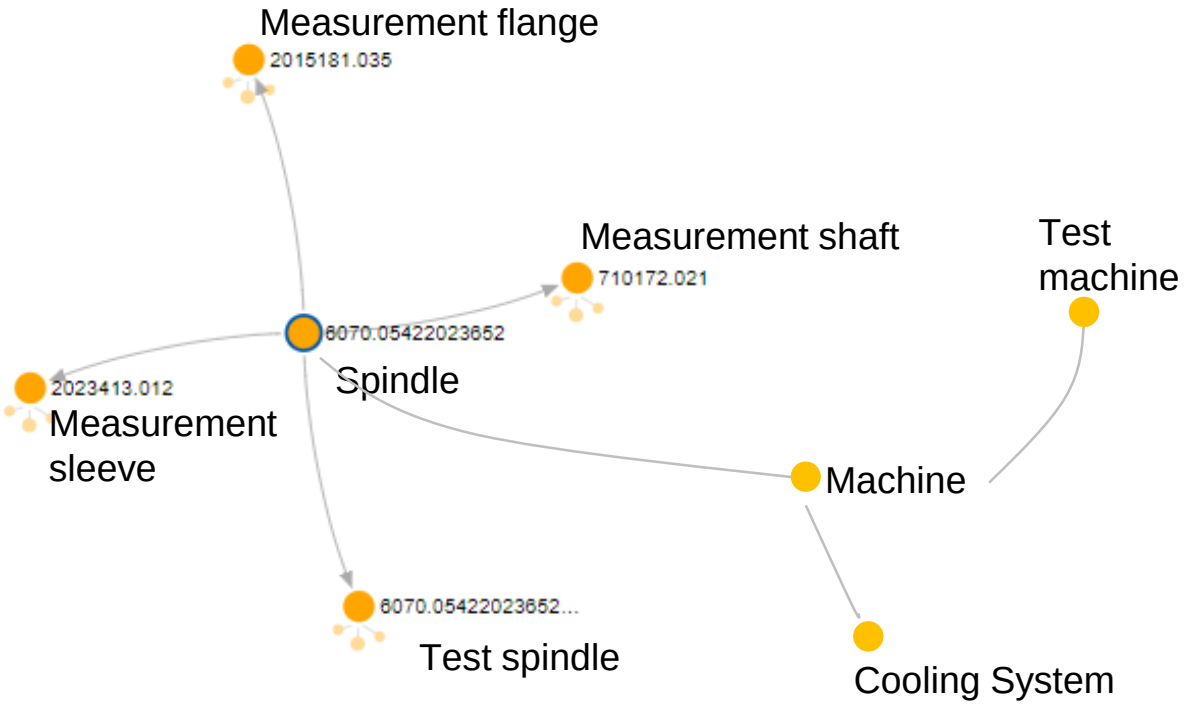
Architecture and achievements: data and ontology framework integrated into GF infrastructure

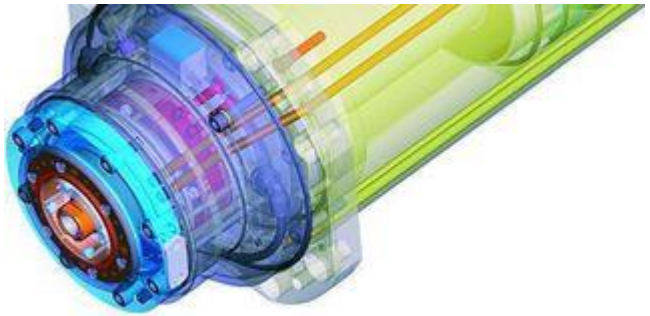


EPFL +GF+

+ Boost 4.0: Integrating knowledge and data sources

Benefit of semantic model: traceability



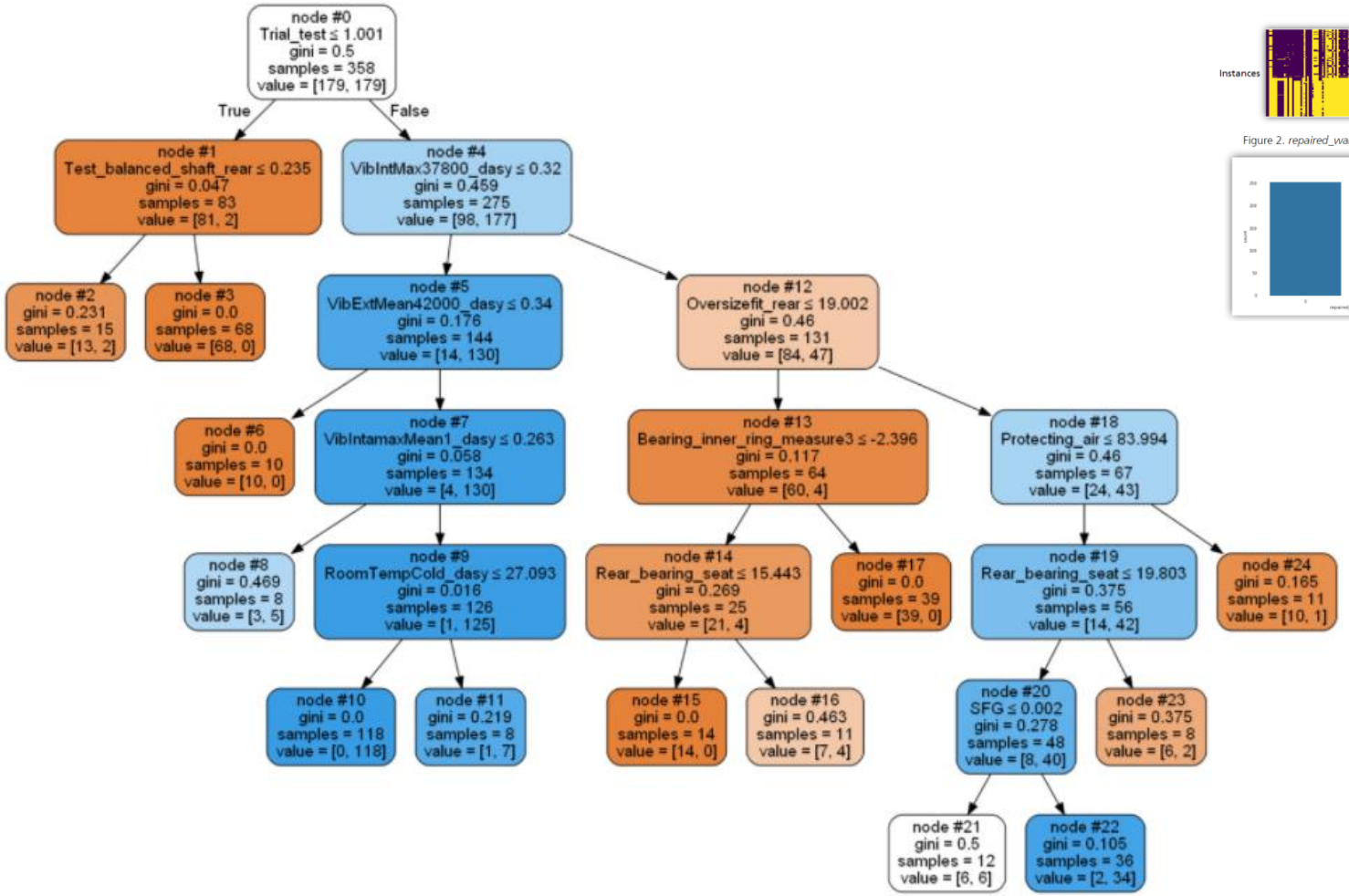


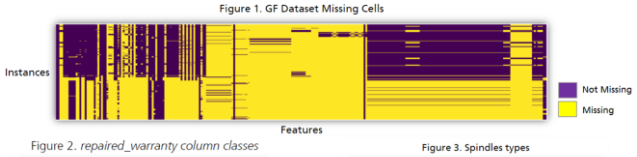
6070.05422023652

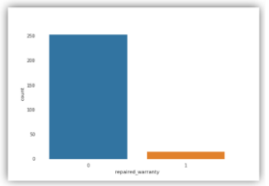
innerRingMeasure3	-1
innerRingMeasure4	-2
oKTrialTest	Yes
unbalancedShaftF...	1.7
unbalancedShaft...	1.1
unbalancedShaftF...	1.7
balancedShaftFront	0.3
balancedShaftRear	0.2
testRun1State	Fehlgeschlagen
testRun1Descripti...	AMS-Versatz (geschüttelt)
testRun2State	Erfolgreich
testRun2Descripti...	

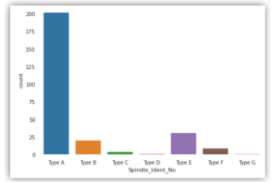
+ Boost 4.0: Roll out Digital Twin for quality assurance

Achievements: AI model refinement and quality prediction with root-cause information









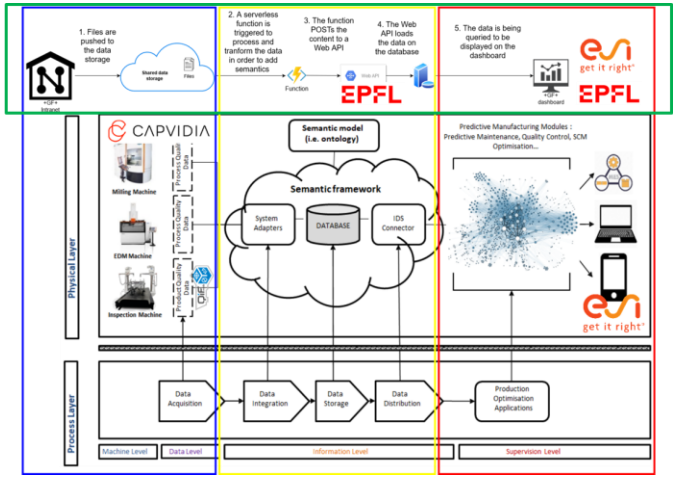

```
Confusion Matrix:
 [[78  0]
 [ 2  3]]

True Positives:  3
False Positives:  0
False Negatives:  2
True Negatives:  78
```

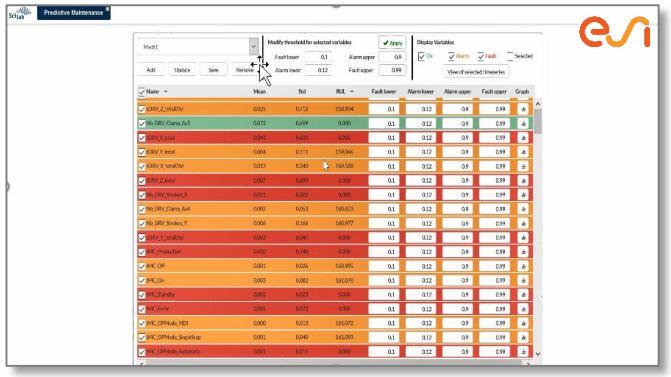
Model adapted for detecting
exclusive suspect sets
(6% of spindles)
3 out of 5 expected to be defective:
Quality control benefits

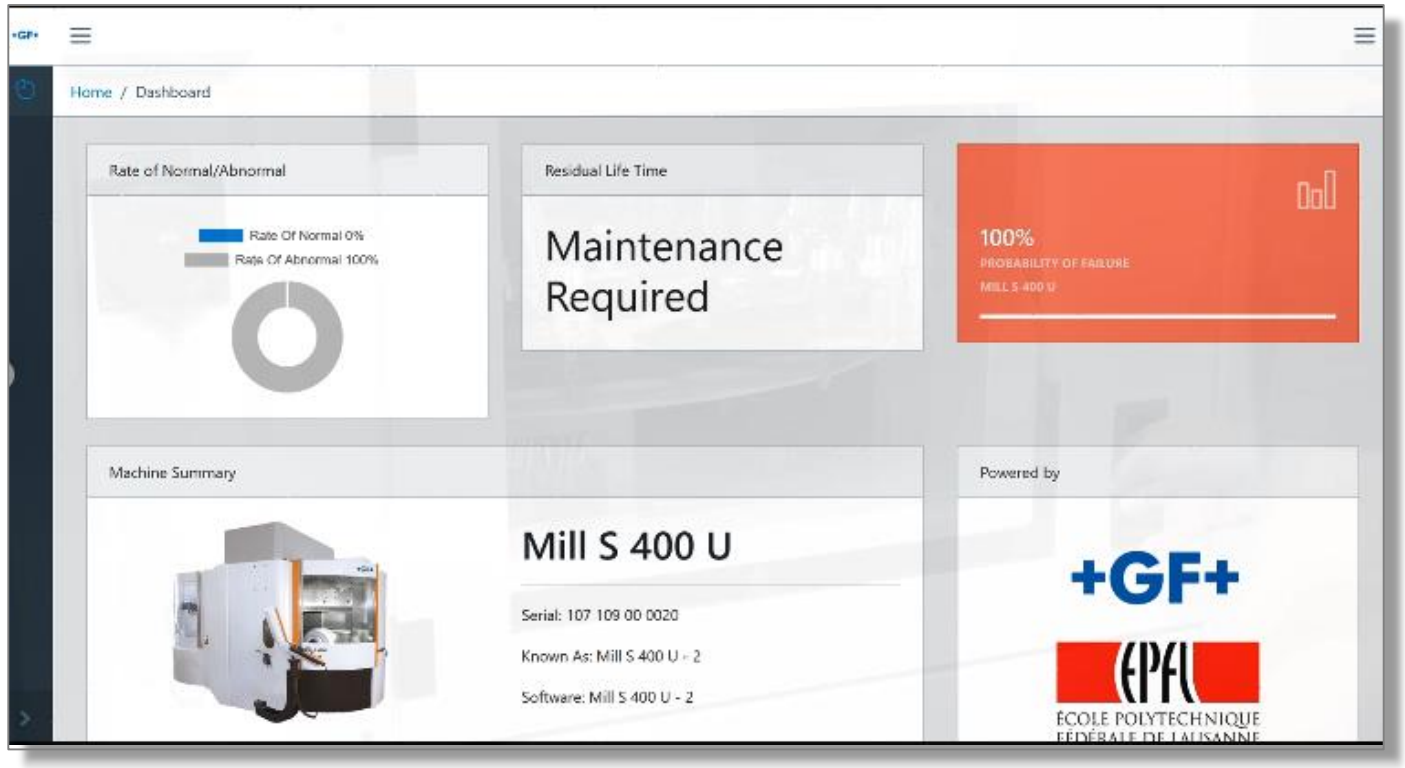
Predictive Maintenance

+ Predictive Maintenance Pilot

AI Model based on Data from 30 machines over 2 years, increasing to >1000 in 2022



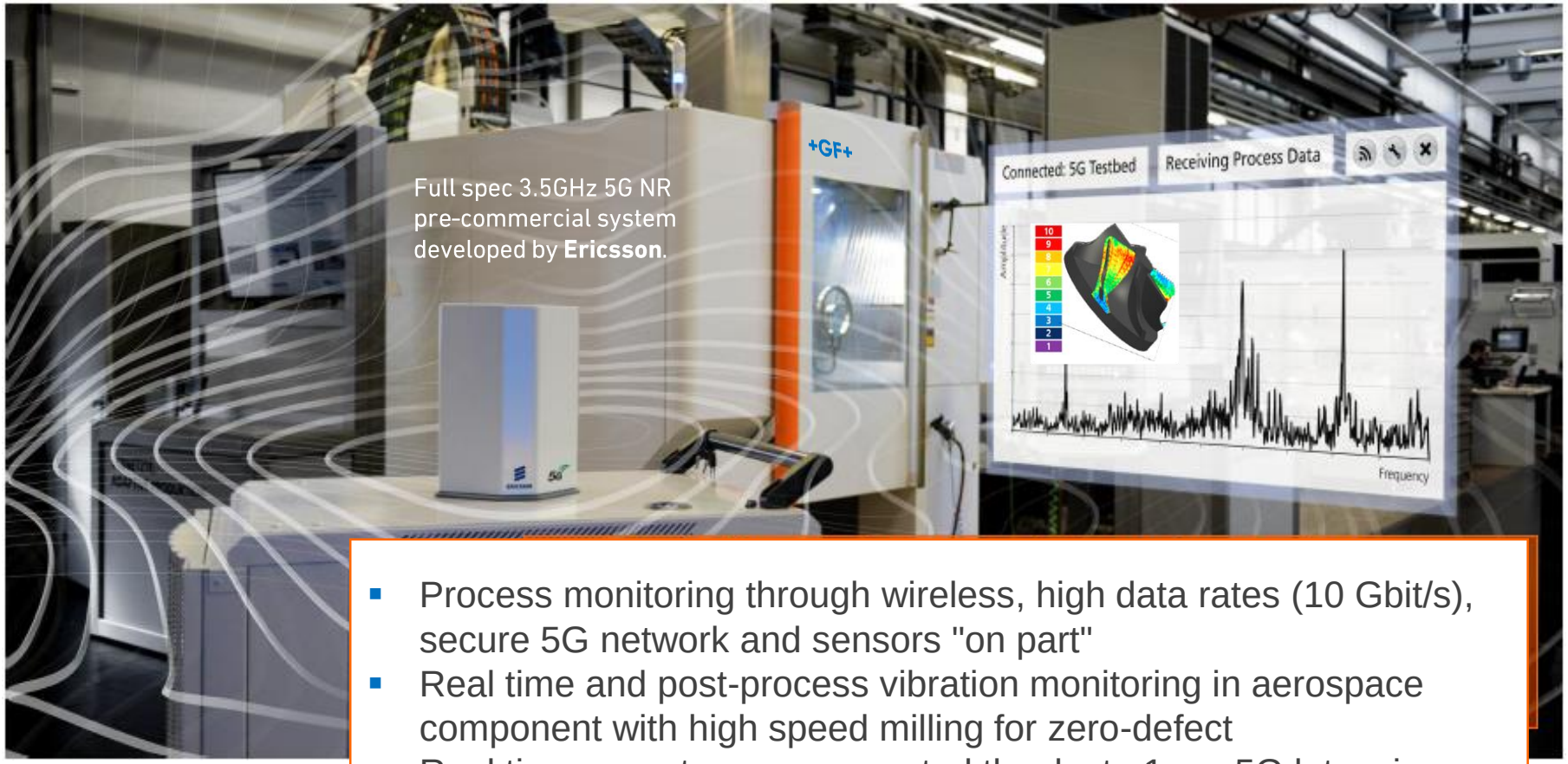




KPI: Increase from 20 to 50 KHrs lifetime - avoiding unexpected failures

Real Time Process Monitoring

5G Real Time Process Monitoring Solution

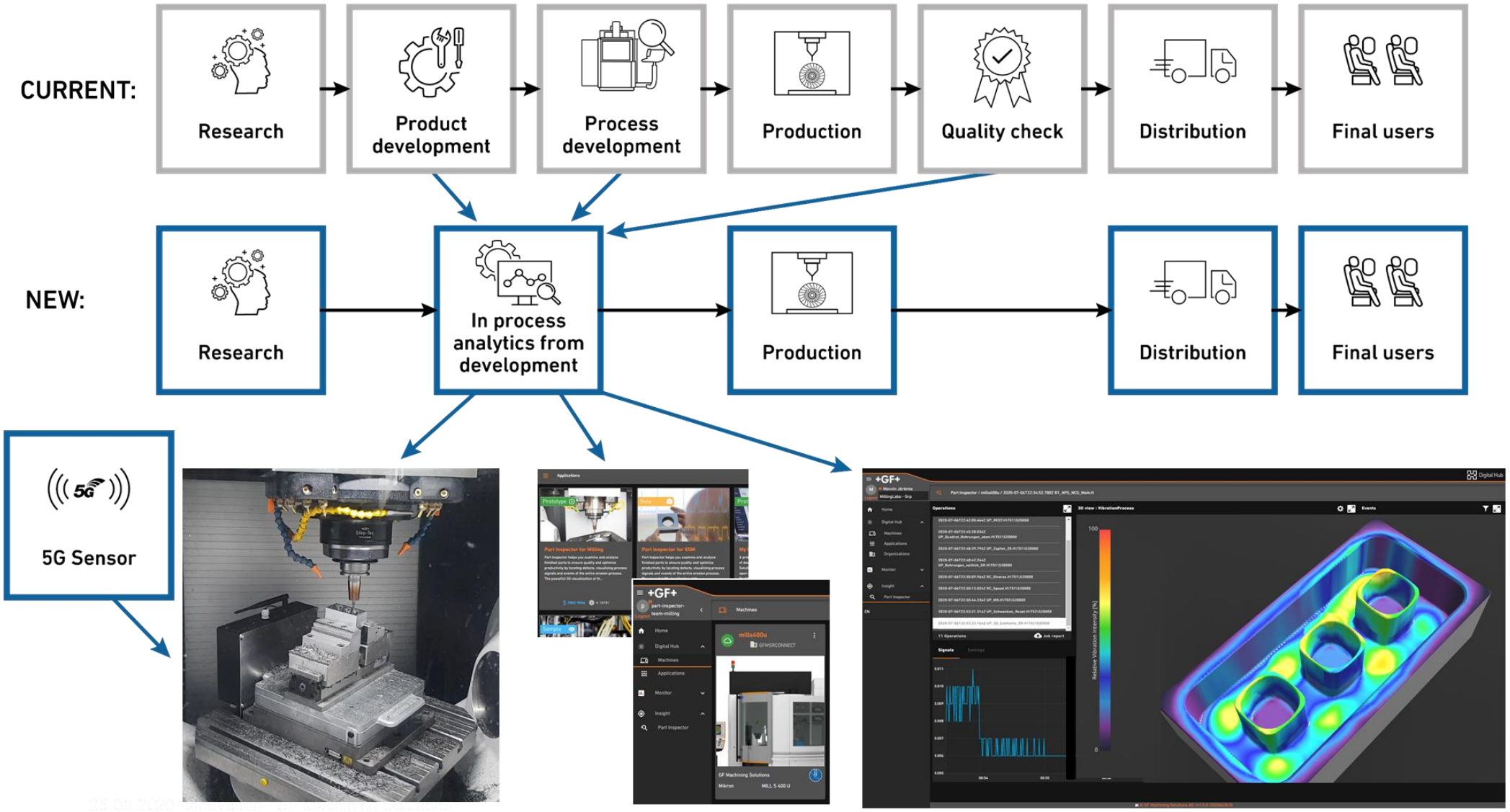


- Process monitoring through wireless, high data rates (10 Gbit/s), secure 5G network and sensors "on part"
- Real time and post-process vibration monitoring in aerospace component with high speed milling for zero-defect
- Real time, remote process control thanks to 1 ms 5G latencies

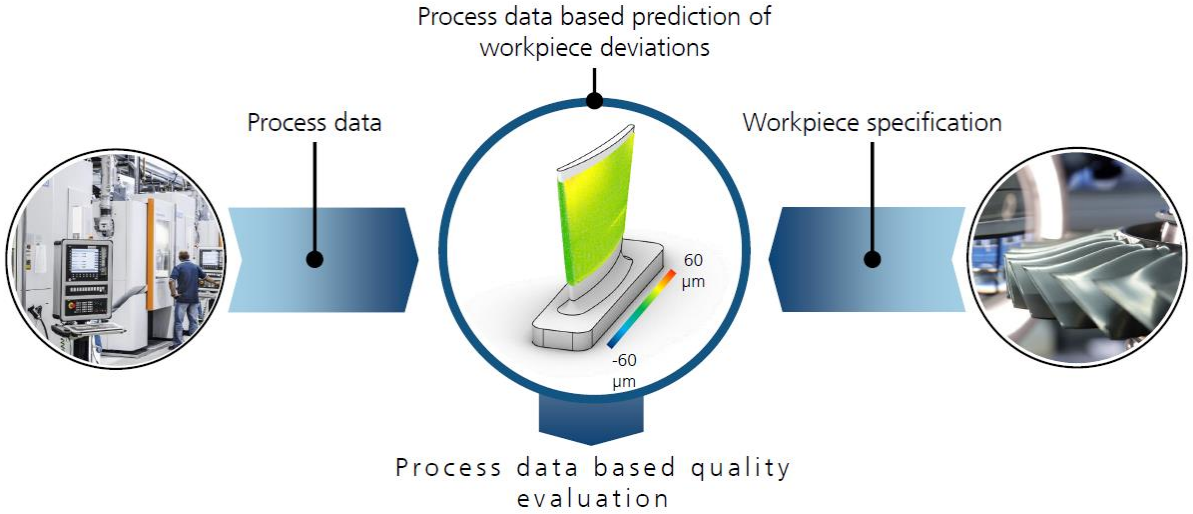
+GF+

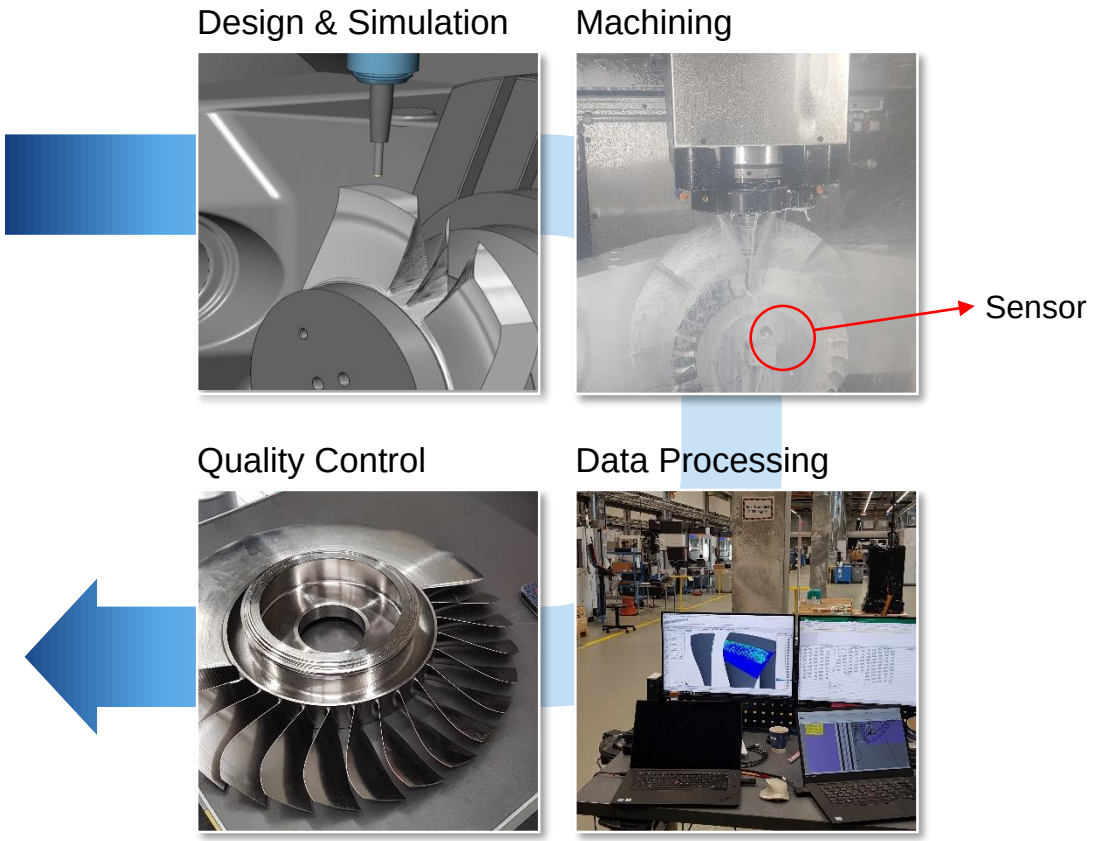
Fraunhofer +GF+

Advanced Business Process Benefits

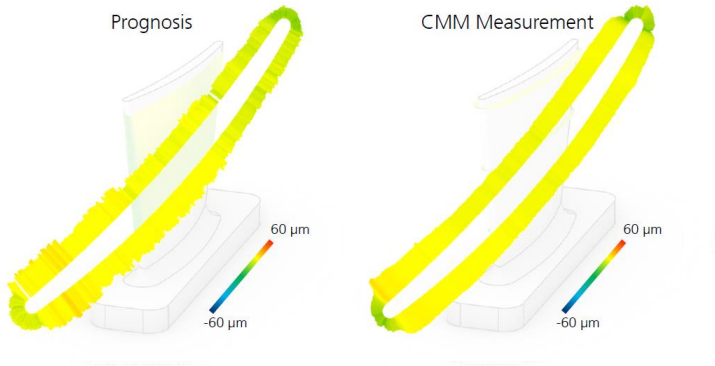


Virtual Metrology





- Real time data processing for accurate-online dimensional control in blade manufacturing: +/- 10 um achieved offline



gemineers Fraunhofer +GF+

Summary

- New Hardware and Digital Infrastructures delivering augmented machine capabilities across unique GFMS portfolio
- Implementation of Spindle Factory and Milling Machine Twins for business processes optimisation across lifecycle
- Successful pilot applications for Factory quality KPI improvements, predictive maintenance and machining process optimisation
- Demonstration of potential of Digital thread, shadow and twin for sustainable improvement in manufacturing industries

GF Machining Solutions

Passion for Precision

Disclaimer

This document is for presentation purposes only and should not be construed as an offer, invitation or solicitation to subscribe for, purchase or sell any investment. Neither it nor anything it contains shall form the basis of any contract whatsoever.

Opinions expressed herein reflect the current judgement of the management of GF. The presentation contains forward-looking statements that involve risks and uncertainties. The actual results of GF may differ materially from those anticipated in these forward-looking statements and forecasts as a result of a number of factors.

The management of GF does not accept any liability whatsoever with respect to the use of this presentation.