Was uns Sensordaten verraten können

Verbindung von physischer und digitaler Welt

Oliver Mutz – INNEO Solutions

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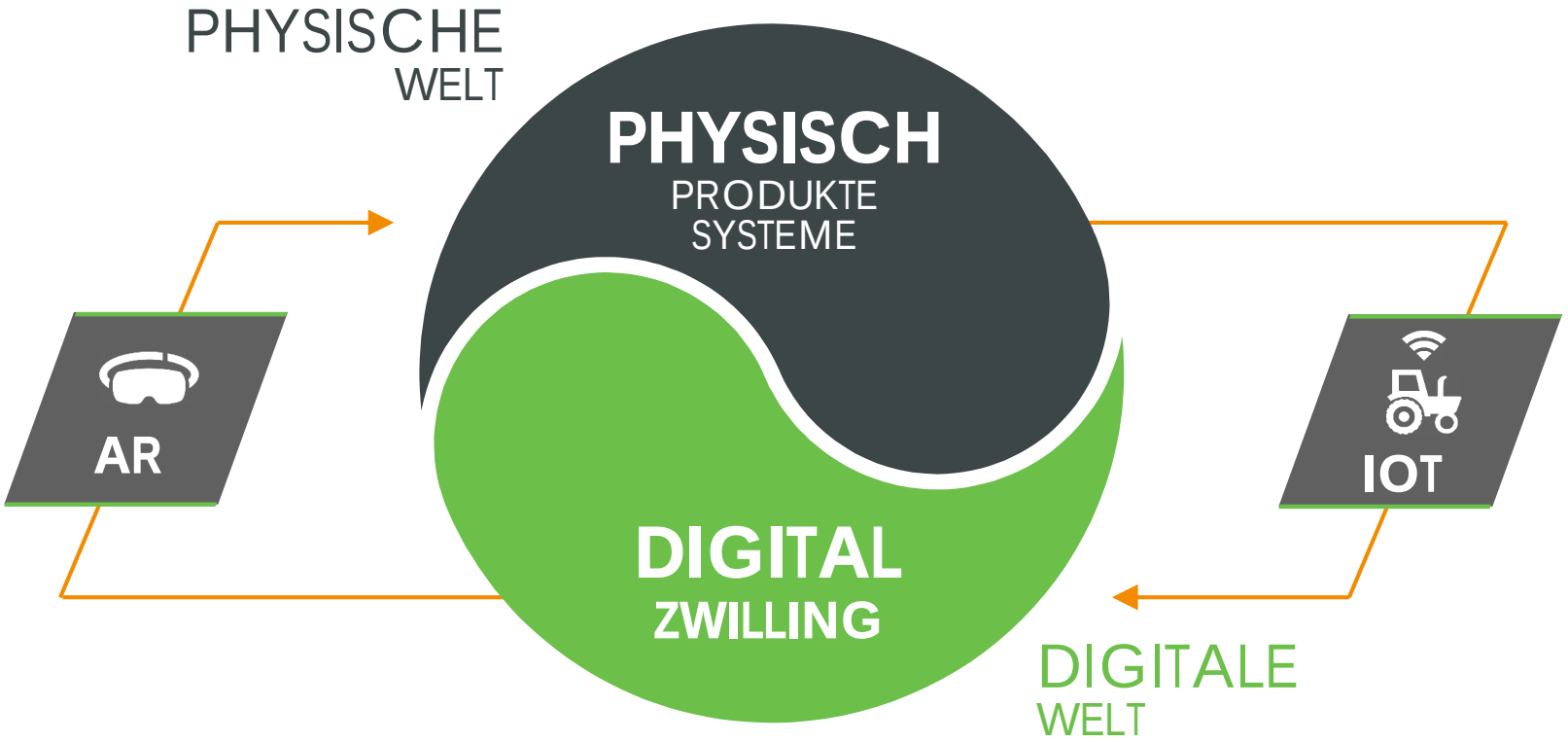
INNEO® That's IT.

Verbindung von physischer und digitaler Welt

- Aufnahme und Analyse von Sensordaten
- Monitoring von Fertigungsmaschinen
- Datenanalyse mit Hilfe von Machine Learning
- Rückführung von realen Sensordaten in das CAD Modell

Zusammenführung von physischer und digitaler Welt



Smart, Connected
Products

Smart Manufacturing
& Industrie 4.0

ptc
Digital System
Orchestration

Retail
Innovation

SERVICE & MAINTENANCE AUGMENTED REALITY
Augmented
Reality

Smart
Cities

INNEO®
That's IT.

thingworx®

Der schnellste Weg für Industrieunternehmen, sich den Wert der physischen digitalen Konvergenz zu erschließen.

thingworx®

PLATFORM + APPS + ECOSYSTEM

ThingWorx Platform

- INDUSTRIAL CONNECTIVITY
- FOUNDATION
- ANALYTICS
- UTILITIES

ThingWorx Studio

ThingWorx Apps

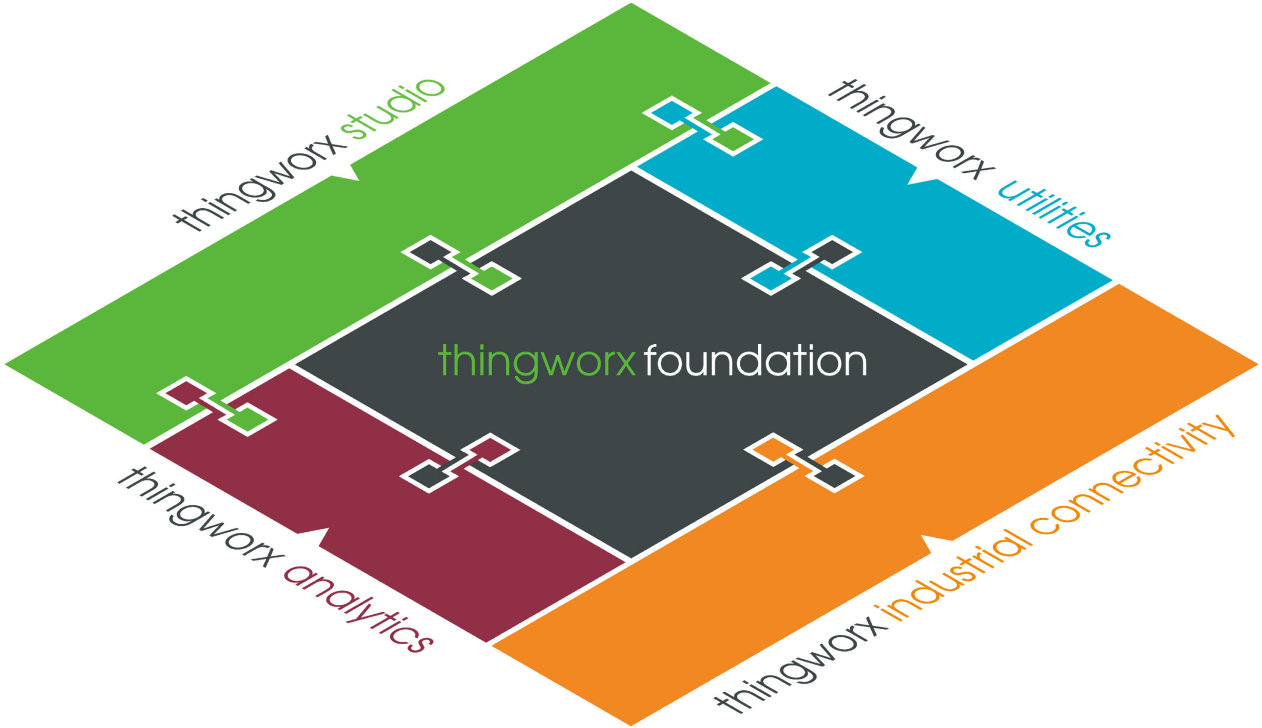
- THINGWORX NAVIGATE
- THINGWORX CONTROLS ADVISOR
- THINGWORX PRODUCTION ADVISOR
- THINGWORX ASSET ADVISOR

ThingWorx Developer Portal

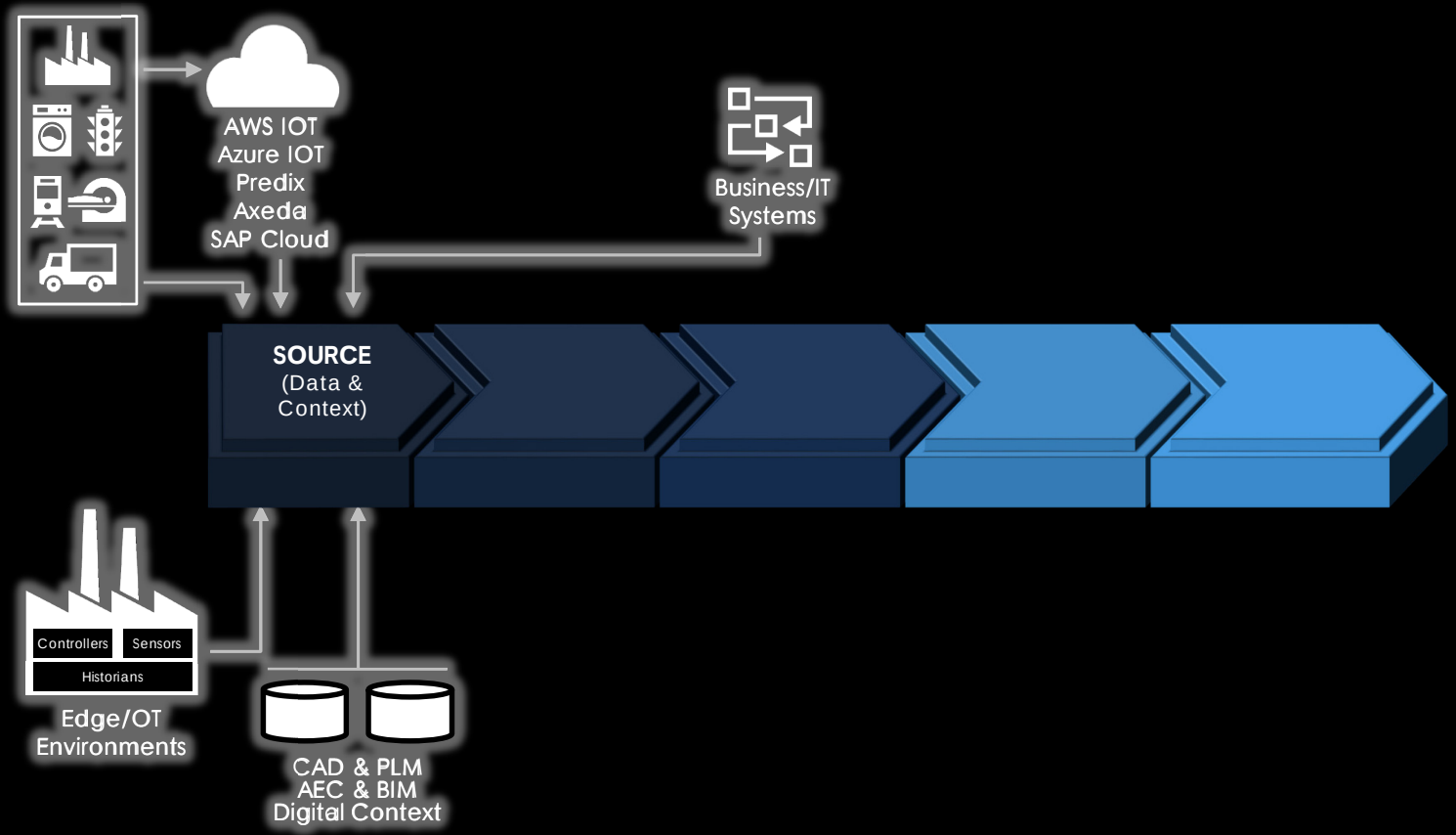
Partner Network

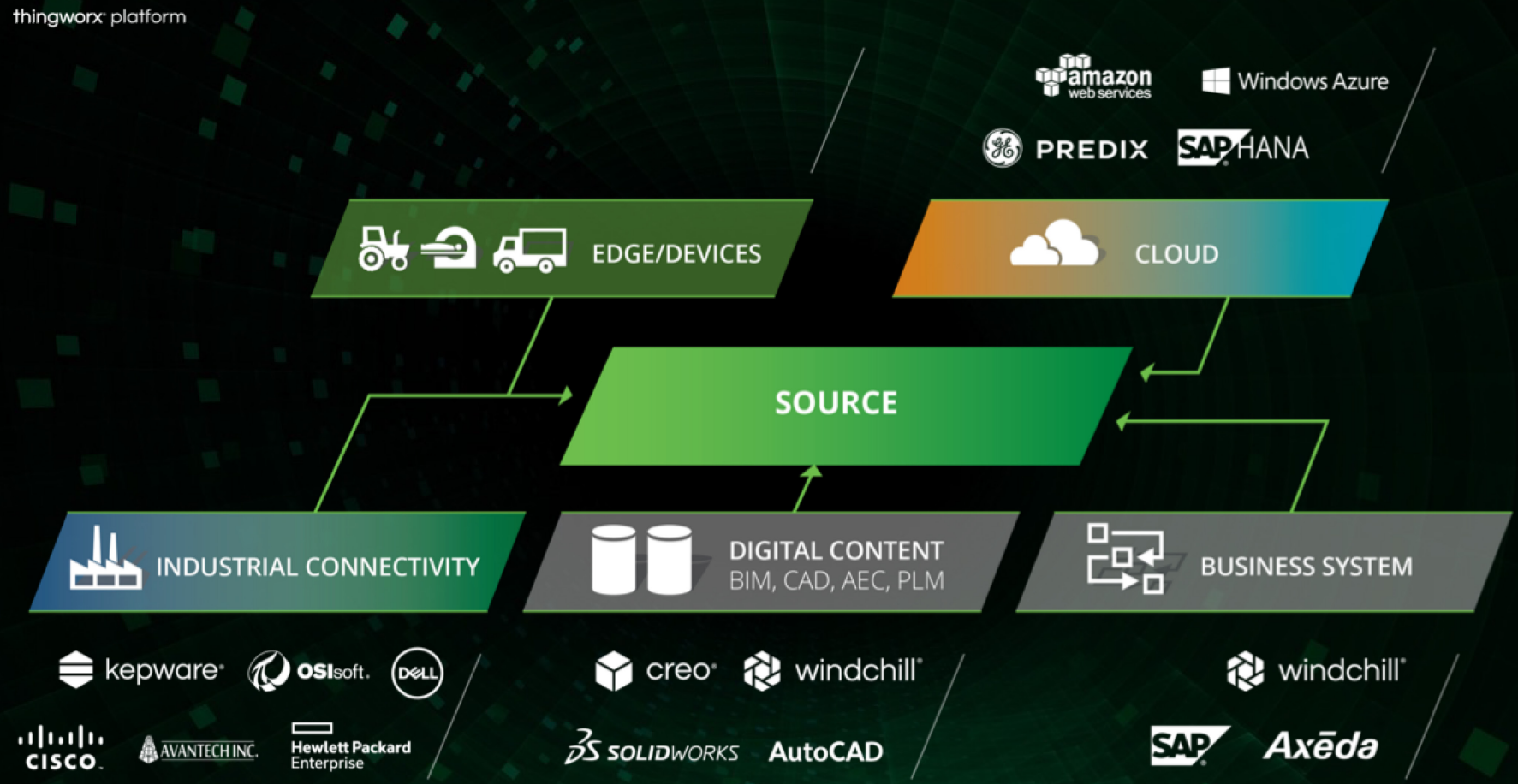
ThingWorx Marketplace

Thingworx IoT Plattform von PTC

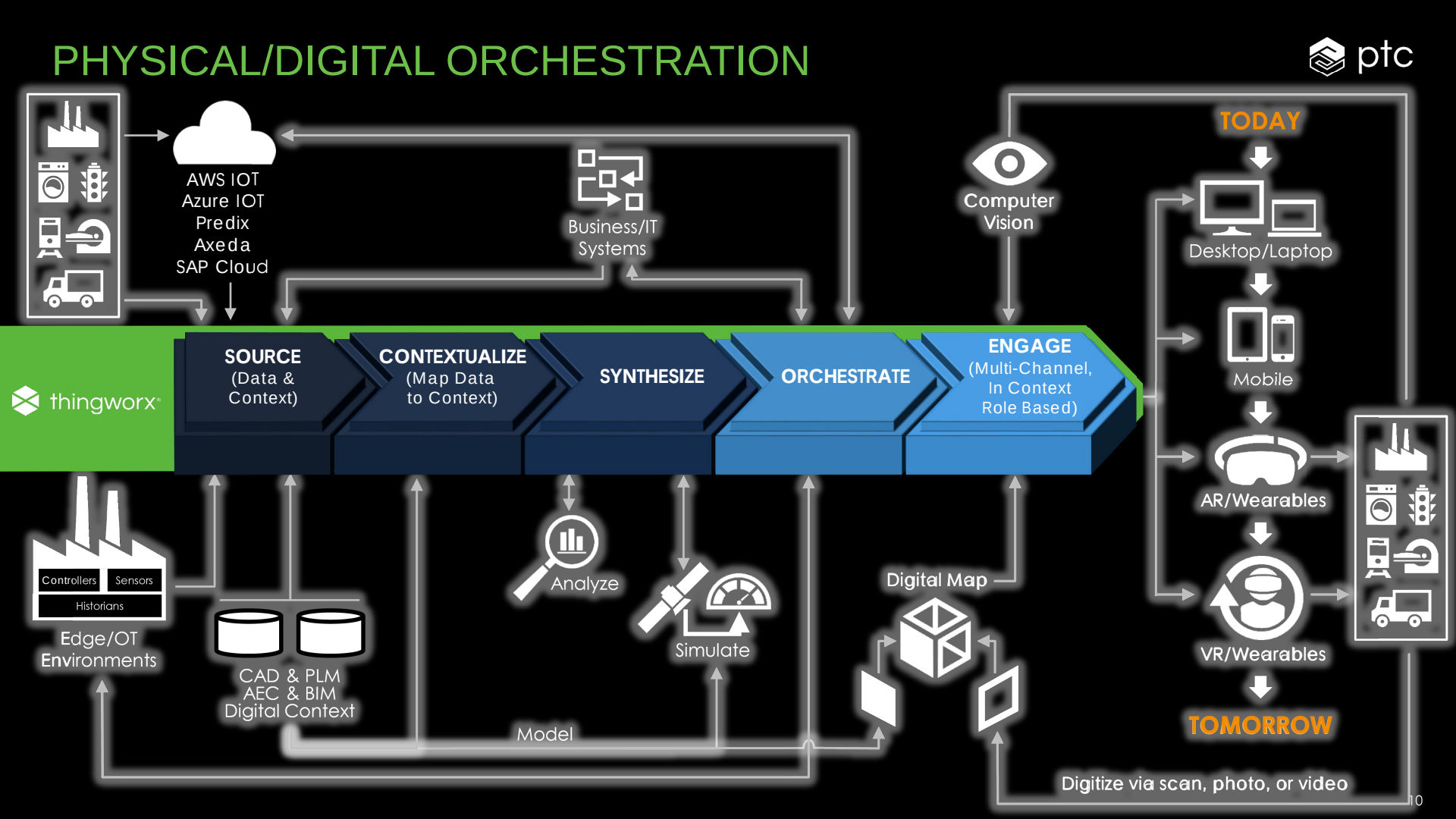


PHYSICAL/DIGITAL ORCHESTRATION

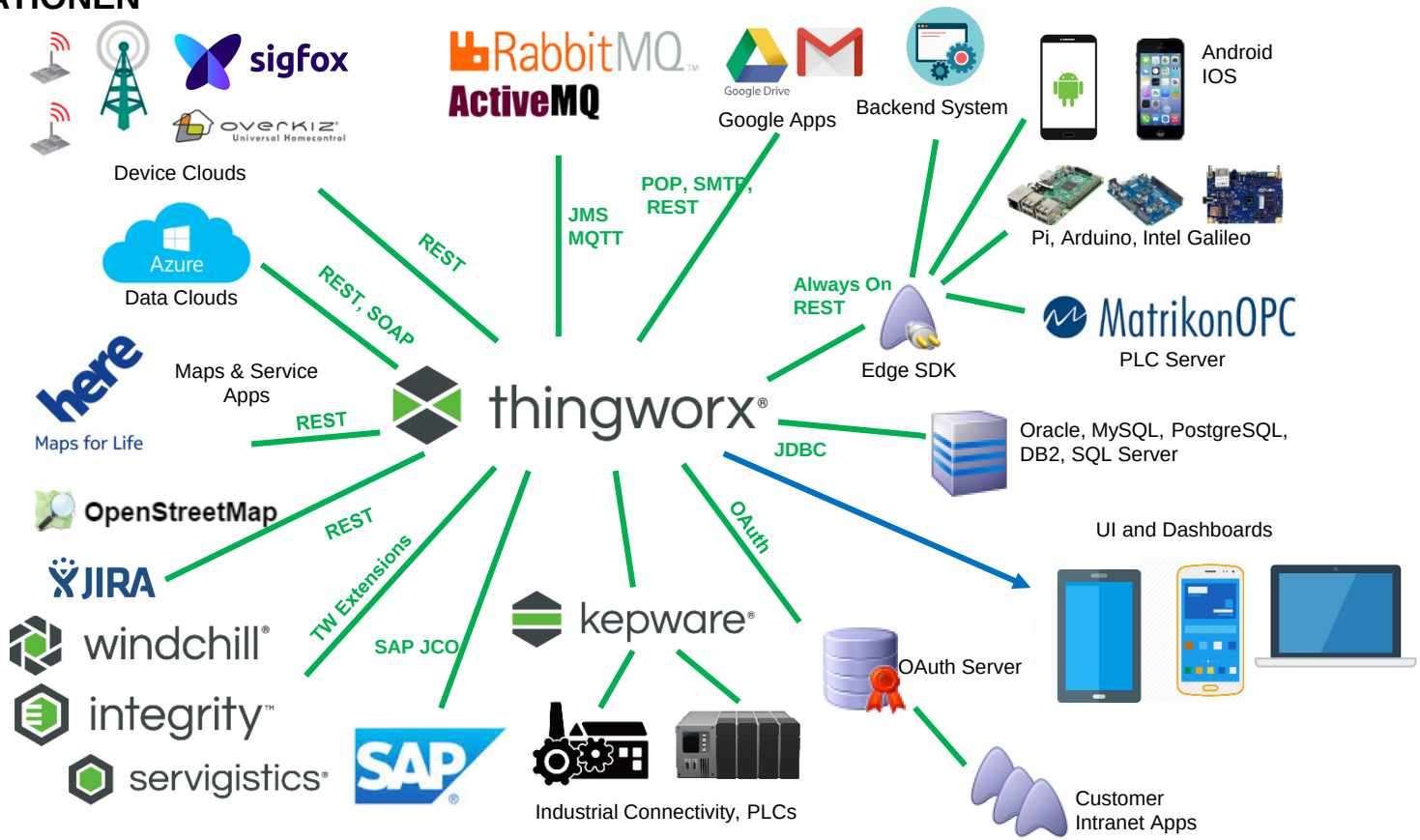



thingworx platform
amazon web services
Windows Azure
PREDIX
SAP HANA
EDGE/DEVICES
CLOUD
SOURCE
INDUSTRIAL CONNECTIVITY
DIGITAL CONTENT
BIM, CAD, AEC, PLM
BUSINESS SYSTEM
kepware
OSIsoft.
DELL
creo
windchill
windchill
CISCO
AVANTECH INC.
Hewlett Packard Enterprise
SOLIDWORKS
AutoCAD
SAP
Axēda

PHYSICAL/DIGITAL ORCHESTRATION

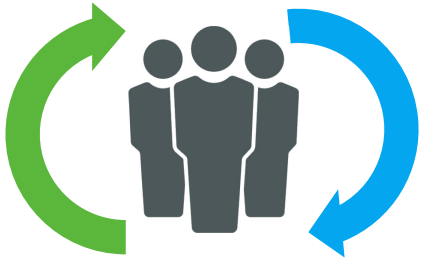


INTEGRATIONEN



Kooperation Microsoft und PTC

Microsoft und PTC haben sich ergänzende Strategien, die die digitale Transformation des Unternehmens ermöglichen



PTC befähigt Microsoft

Kunden ihre Geschäftsprozesse mit industriellen Anwendungen zu verbinden

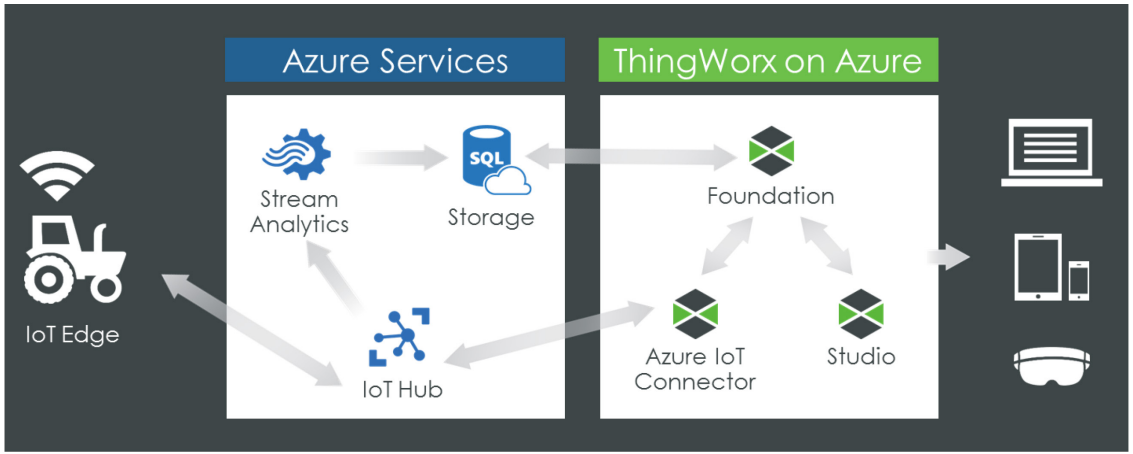
Microsoft befähigt PTC

Kunden industrielle Anwendungen mit Firmenprozessen zu verbinden

ThingWorx for Azure: Better together Value

Microsoft Strengths
- Azure IoT provides data ingestion and secure **connection**
- Azure provides **scalable**, compute, storage

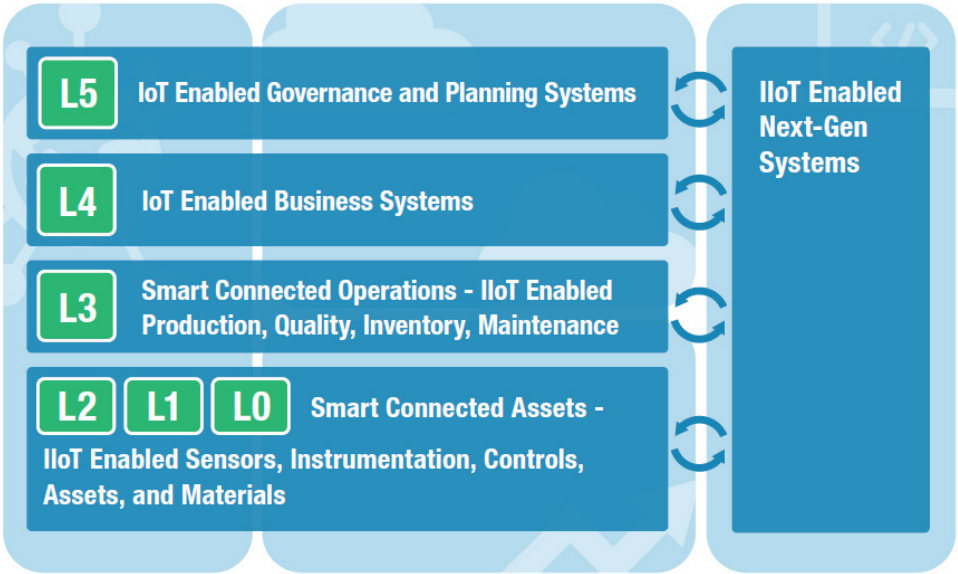
ThingWorx Strengths
- AEP for **fast** modeling, app building, visual design, user management
- Manufacturing expertise and **Industrial Connectivity**



This solution can be deployed two ways: **(1) ThingWorx deployed into existing customer Azure subscription or (2) ThingWorx for Azure turnkey solution with PTC Cloud Services**

Monitoring von Fertigungsmaschinen und -anlagen

IIoT is transforming the technology landscape



Source: LNS Research, 2015

"Rip and replace" gives way to "wrap and extend"

ThingWorx Manufacturing Apps

ThingWorx Production Advisor

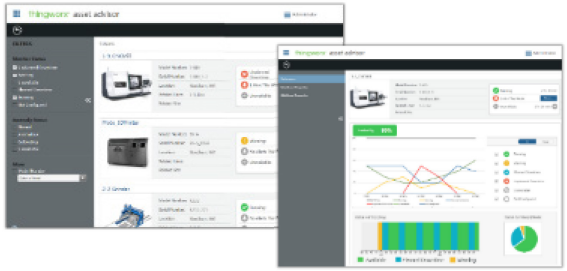
Produktionsleiter

Optimize Production Performance

- Echtzeit Überwachung des Produktionsstatus und kritischer KPI’s.
- Erkennen und direktes Reagieren auf Fertigungsplanungs- und qualitätsprobleme.

ThingWorx Asset Advisor

Wartung

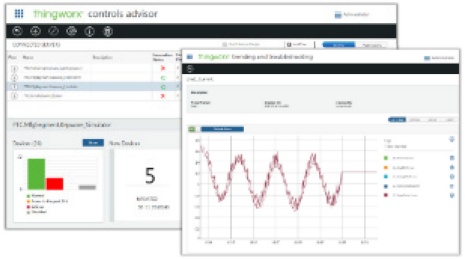


Verringerung ungeplanter Stillstandszeiten

- Echtzeit Überwachung von Status und Zustand von kritischen Fertigungskomponenten
- Erkennen von Anomalien, um potentielle Probleme zu erkennen, die zu ungeplantem Stillstand führen können.

ThingWorx Controls Advisor

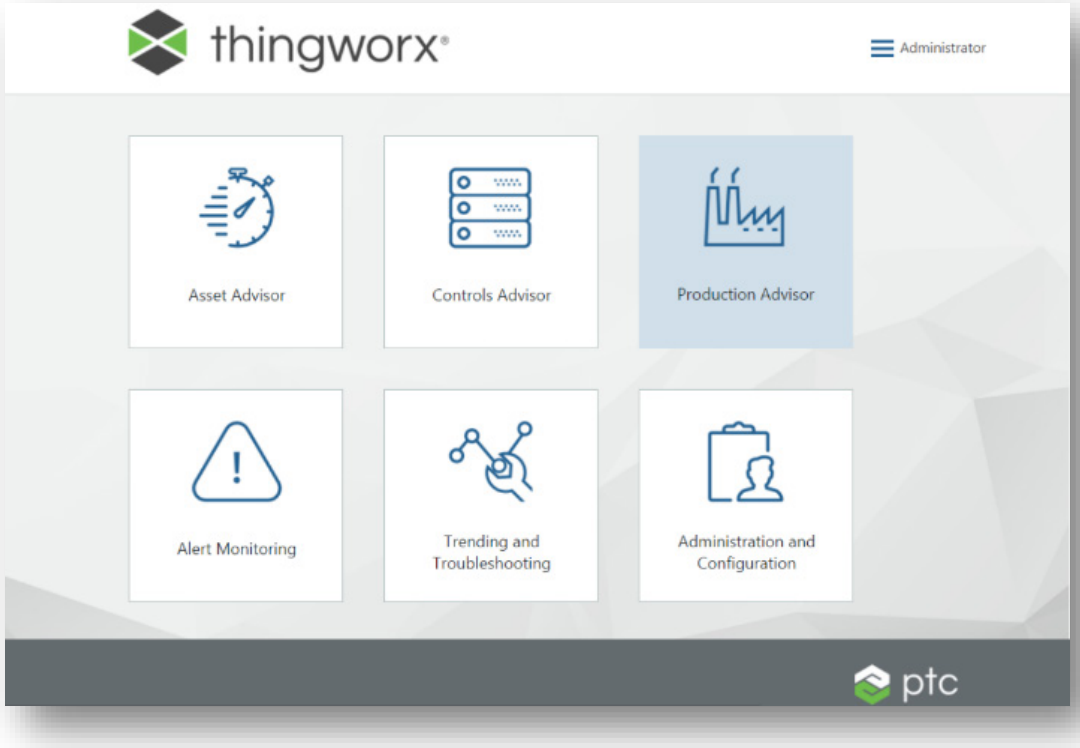
Regelungstechniker



OT Netzwerk Datenqualität sicherstellen

- Vereinheitlichte Echtzeit Überwachung aller verbundenen Endpunkte und zugehöriger Datenelemente im OT Netzwerk
- Schnelle und flexible Trendanalyse

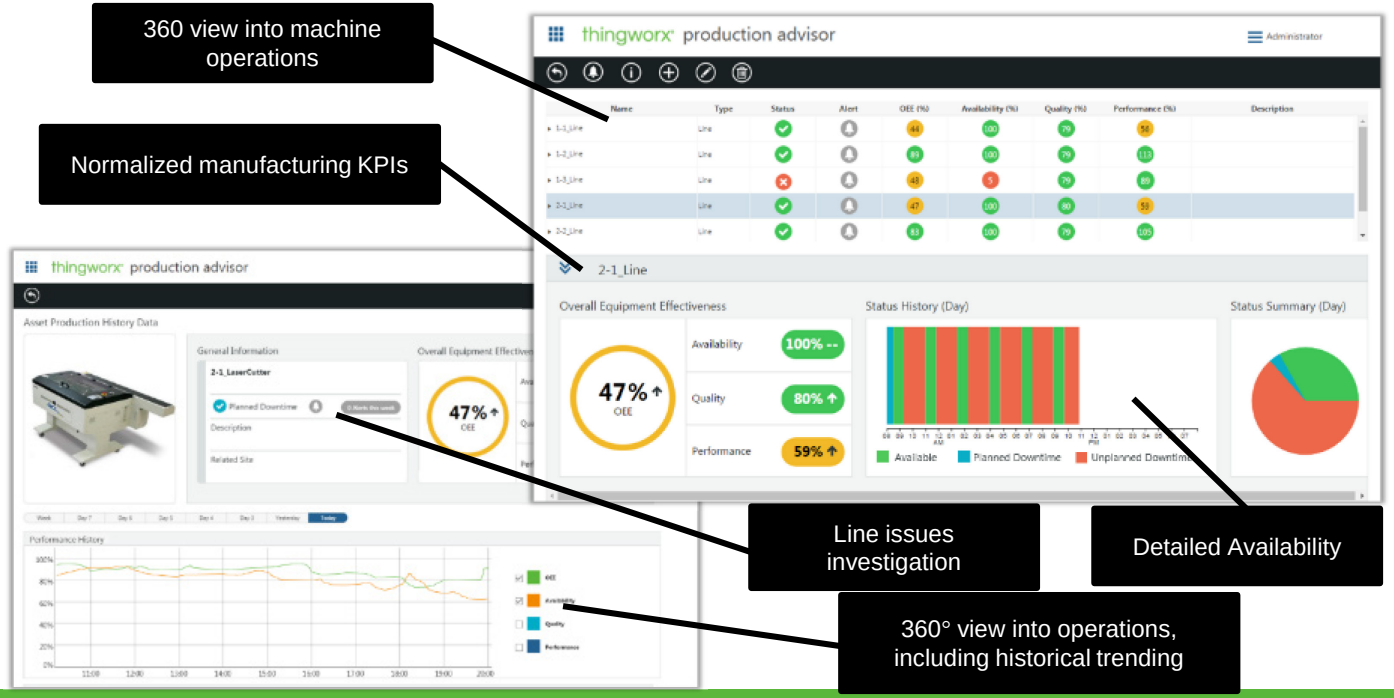
ThingWorx Production Advisor



ThingWorx Production Advisor – für den Produktionsleiter

CAPABILITIES

- Real-time visibility into performance and issues, for rapid problem resolution
- Drill down into underlying data for root cause analysis
- Role-based delivery for better and faster decision making
- Configurable KPI's to match your business needs

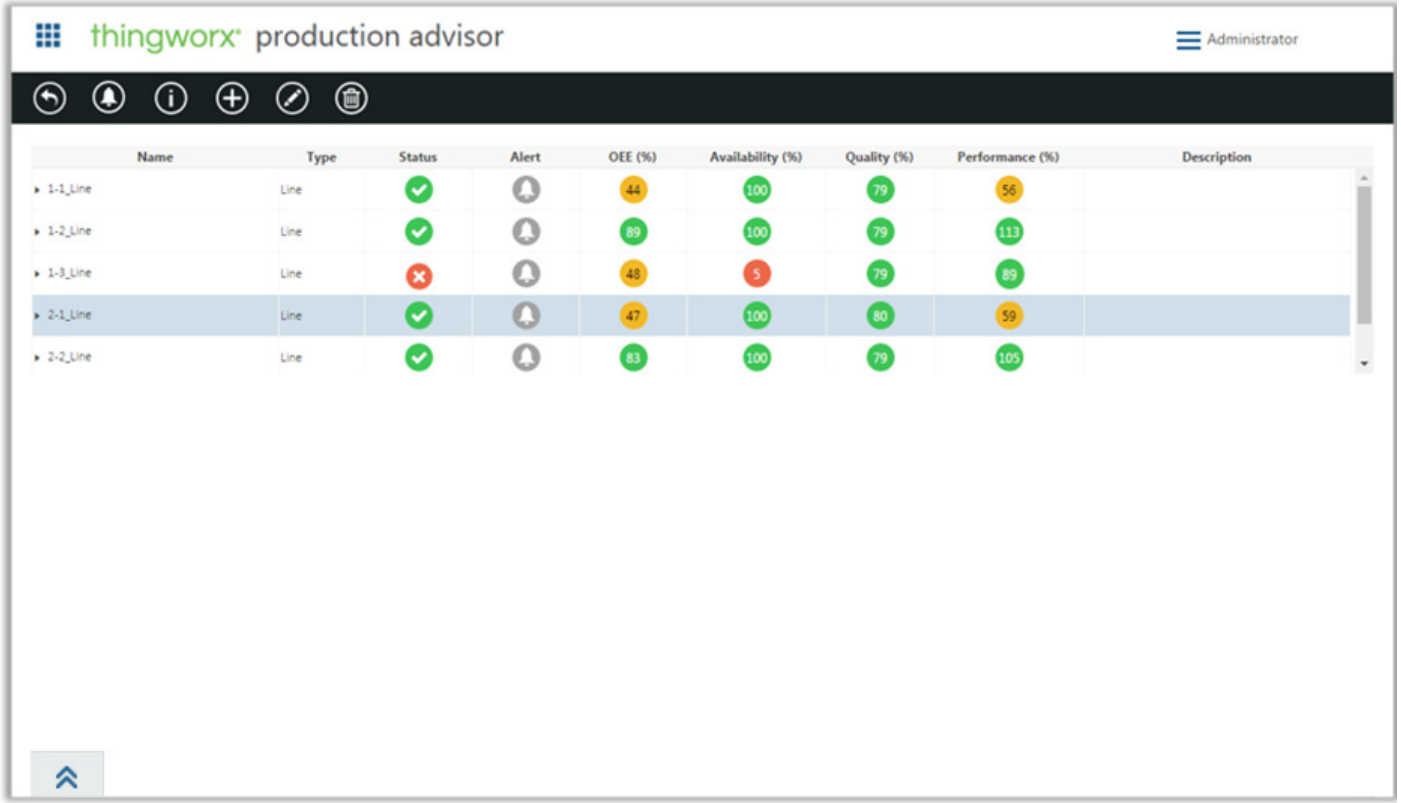


BENEFITS

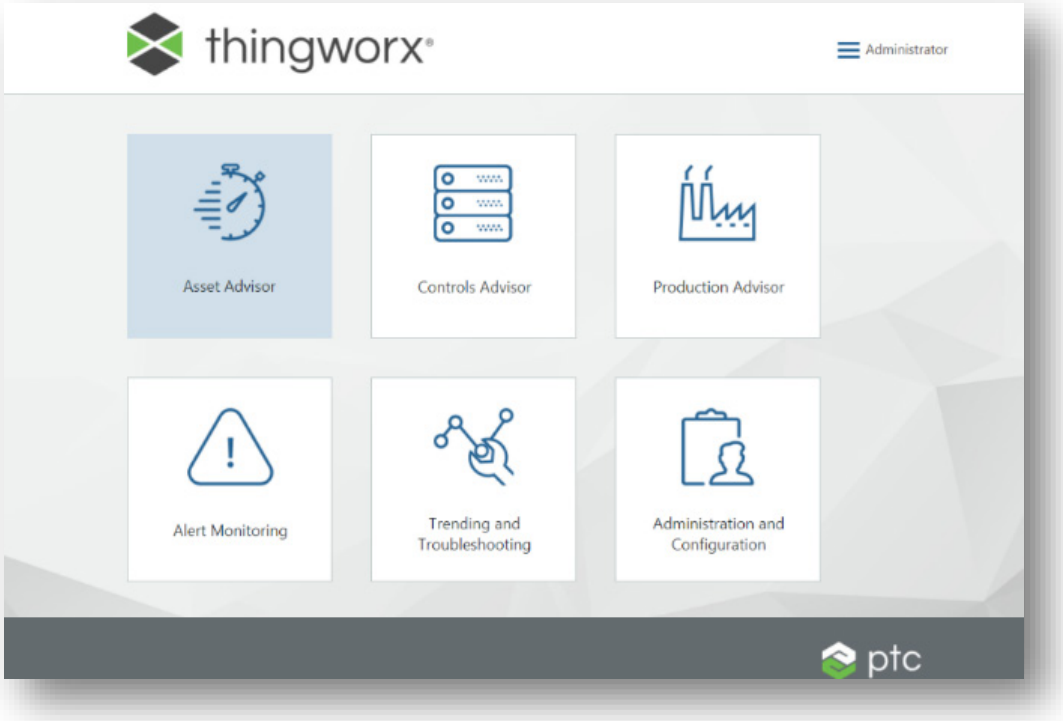
- Increased efficiency
- Maximized Uptime
- Improved quality
- Increased responsiveness

REAL-TIME VISIBILITY INTO PERFORMANCE ISSUES

- Immediate visibility to production line issues
- Facilitates supervision of production execution across the plant
- Increased management efficiency
- Facilitates benchmarking of plant lines and assets



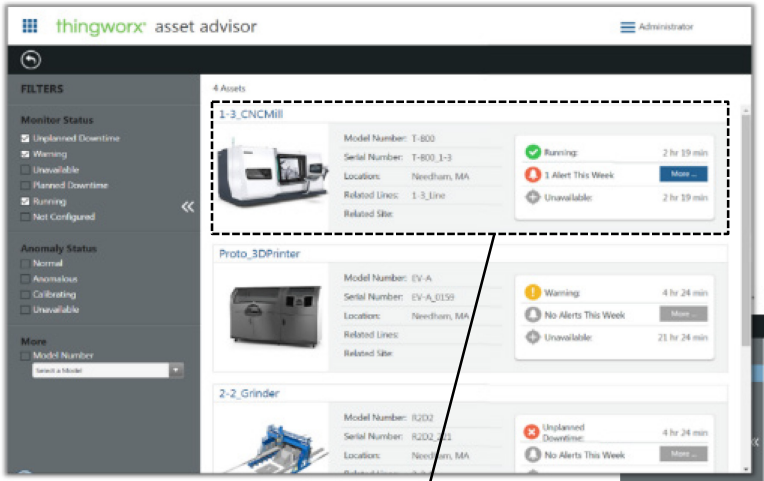
ThingWorx Asset Advisor

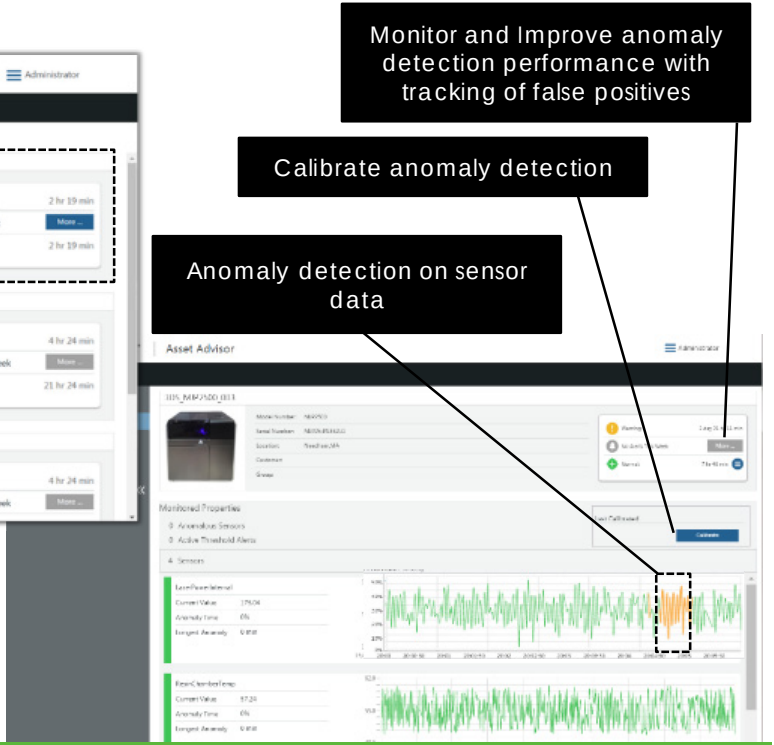


ThingWorx Asset Advisor

CAPABILITIES

- Monitor disparate assets performance in real-time
- Live view of assets status and health
- Visibility of sensors details
- Real-time anomaly detection
- Real-time alerts based on threshold or anomalous conditions
- Detailed view of multiple sensors data for troubleshooting



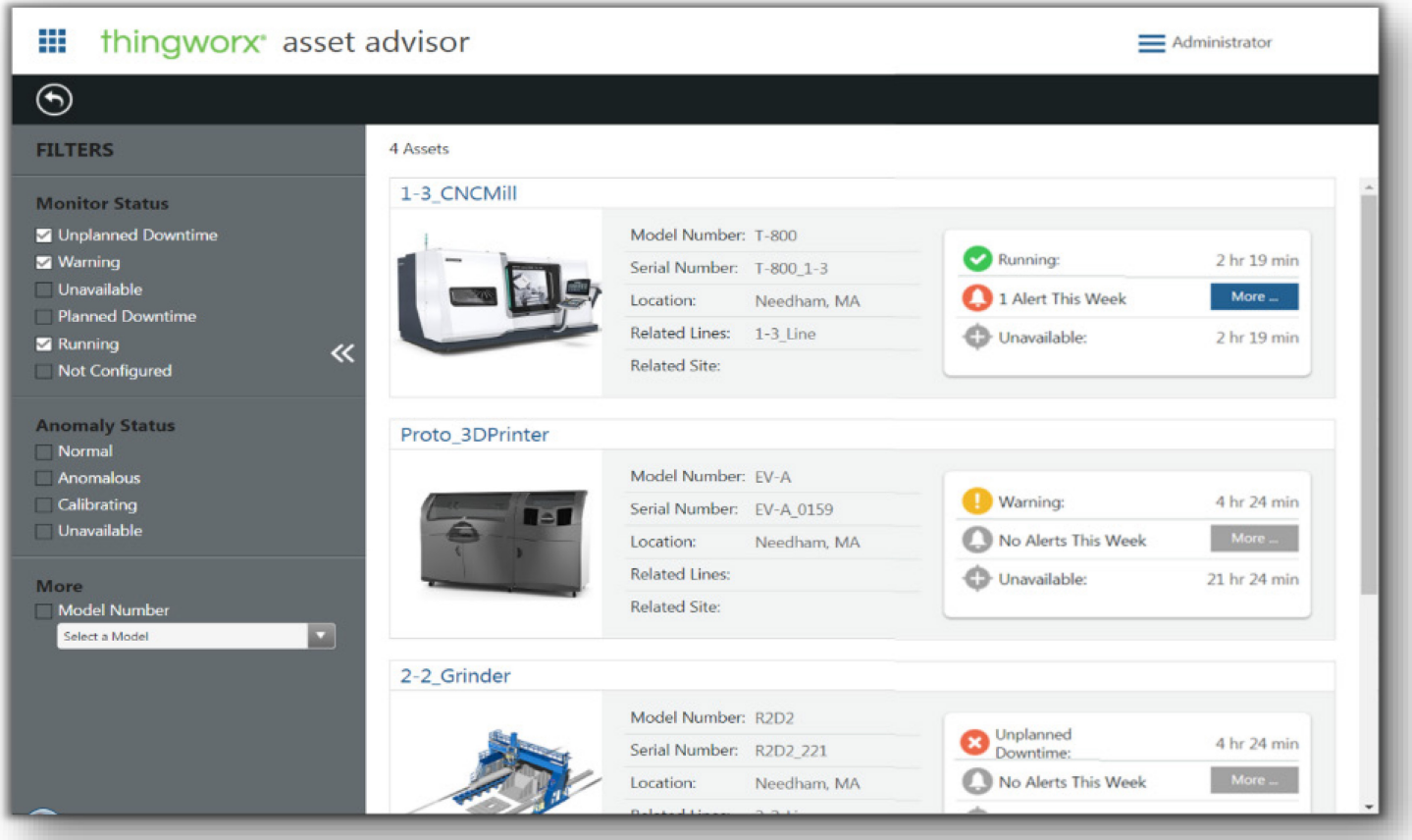


BENEFITS

- Unified Visibility to Disparate Assets
- Reduction of unplanned Down Time
- Faster Remediation

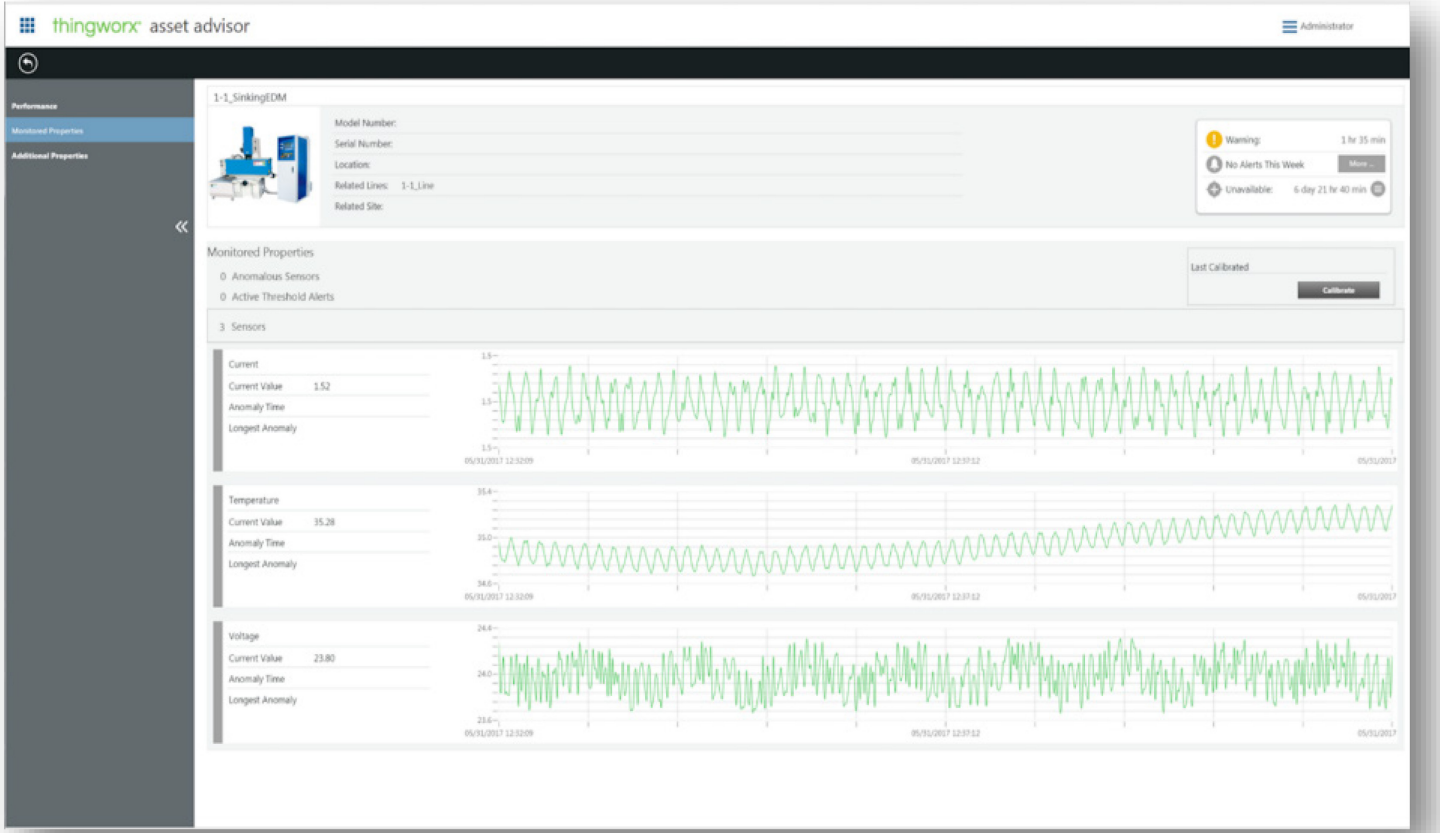
Unified connectivity for real-time visibility of all Assets and machines

- View of all assets in the factory
- Filtering for quick identification of asset of concern
- Summary of asset status and health
- Brief history of asset alerts and anomalous states within a click

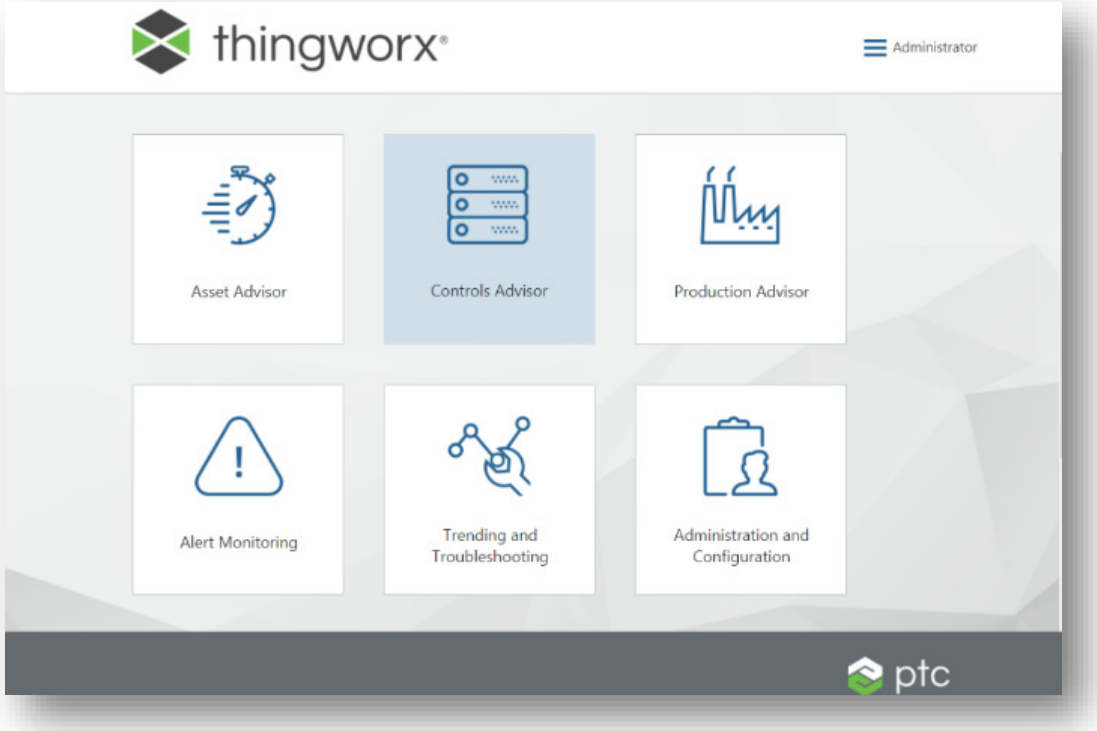


Real time sensors data visualization

- Real-time view of sensors data charts
- Visibility into patterns and trends
- Count and list of anomalous sensors and threshold alerts
- Sensors recalibration as needed



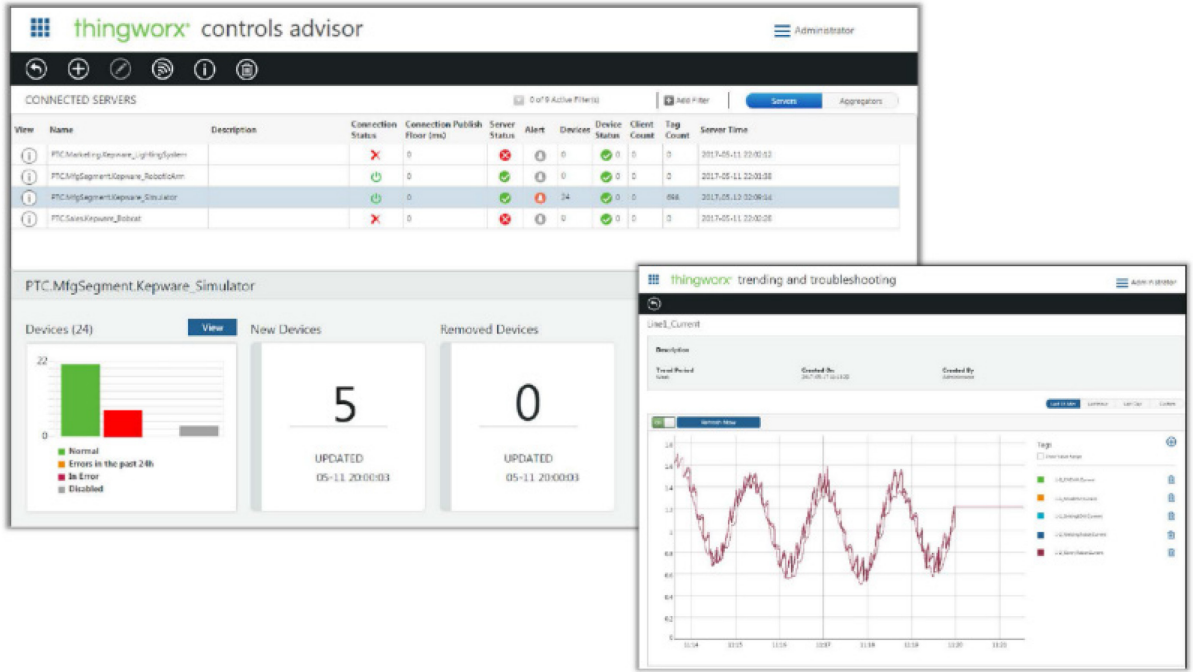
ThingWorx Controls Advisor



ThingWorx Controls Advisor

CAPABILITIES

- Real-time visibility of asset and device status
- Create alarms and issue text and email notifications for any tag
- Instant notification and alerts of device connectivity errors
- Trend tags in minutes to speed up root cause analysis
- Remotely troubleshoot PLC issues

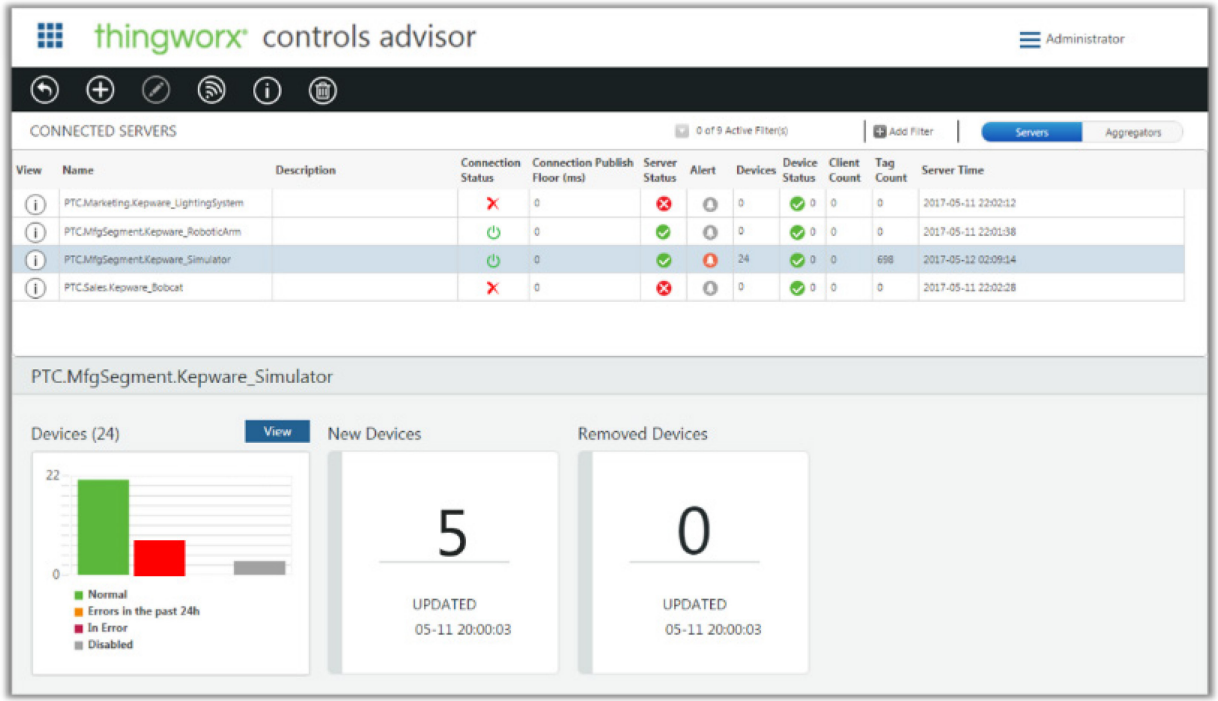


BENEFITS

- Proactive issue identification
- More reliable data collection
- Increased efficiency and flexibility
- Reduced unplanned downtime

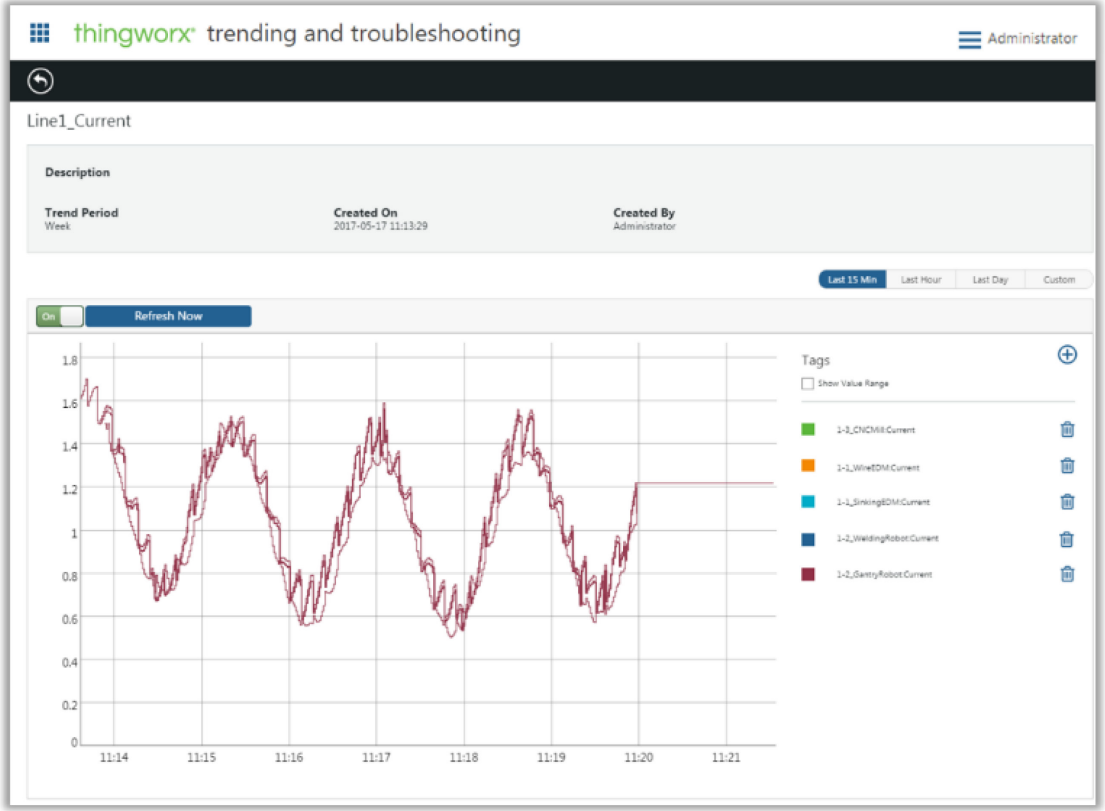
Real time visibility of OPC server status

- See that state of all OPC Server installs in a single web page
  - Server Status
  - Number of tags
  - Number of clients
  - Devices in error
- Be instantly notified via text and email alerts if a server or device goes down
- Remotely troubleshoot when a device goes down
  - Ex. read a tag value
  - Ex. view Kepware event log



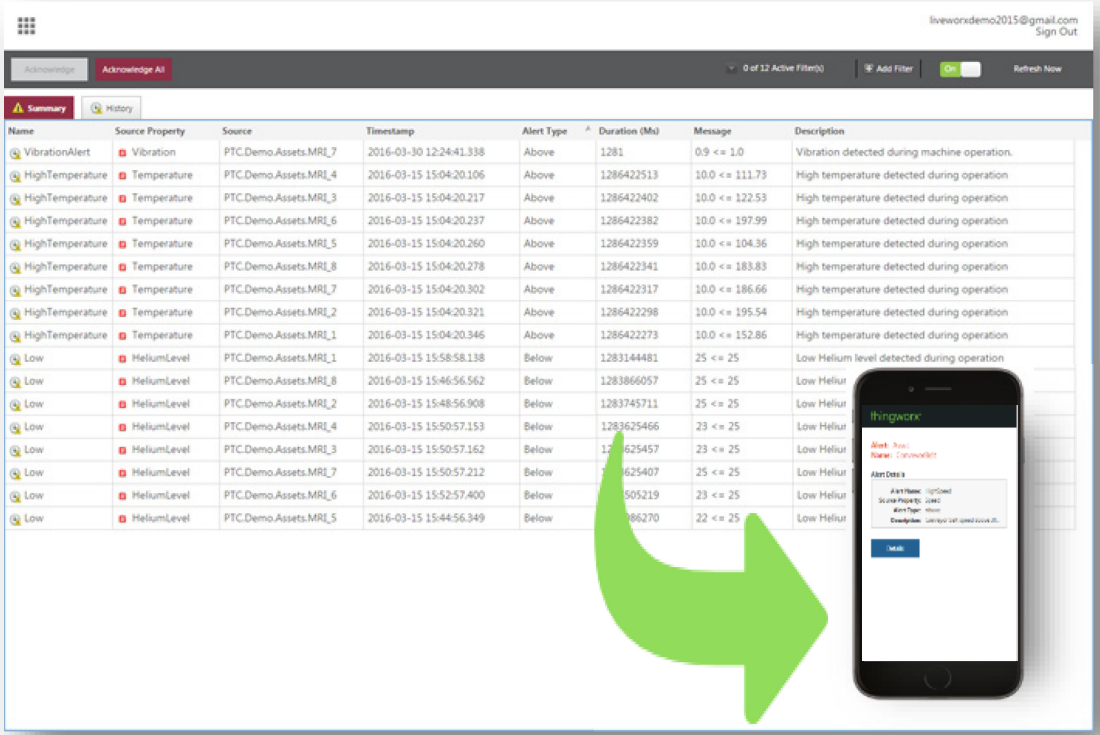
Easily trend tags in minutes

- Trend any tag in minutes without the cost and constraints of a historian
- Access trends via any browser, on a phone, tablet, monitor, or desktop
- Zoom in, out, add markers and more in seconds
- High resolution data



Set alarms and issue text and email notifications

- Define an alarm for any tag in minutes without the costs or constraints of your HMI
- Instantly receive alarms anywhere via the app, text, or email alerts
- Quickly create short term alerts on any machine sensor
- Define custom alarms to get notified of troublesome machine issues before others come asking



Datenanalyse mit Hilfe von Machine Learning

What is ThingWorx Analytics?

ThingWorx Analytics is an integrated capability of the ThingWorx IoT technology platform that enables developers to quickly and easily add real-time pattern & anomaly detection, predictive analytics and simulation to the solutions they build.

ThingWorx Analytics is designed to be used by those without expertise in complex mathematics, statistics or machine learning.

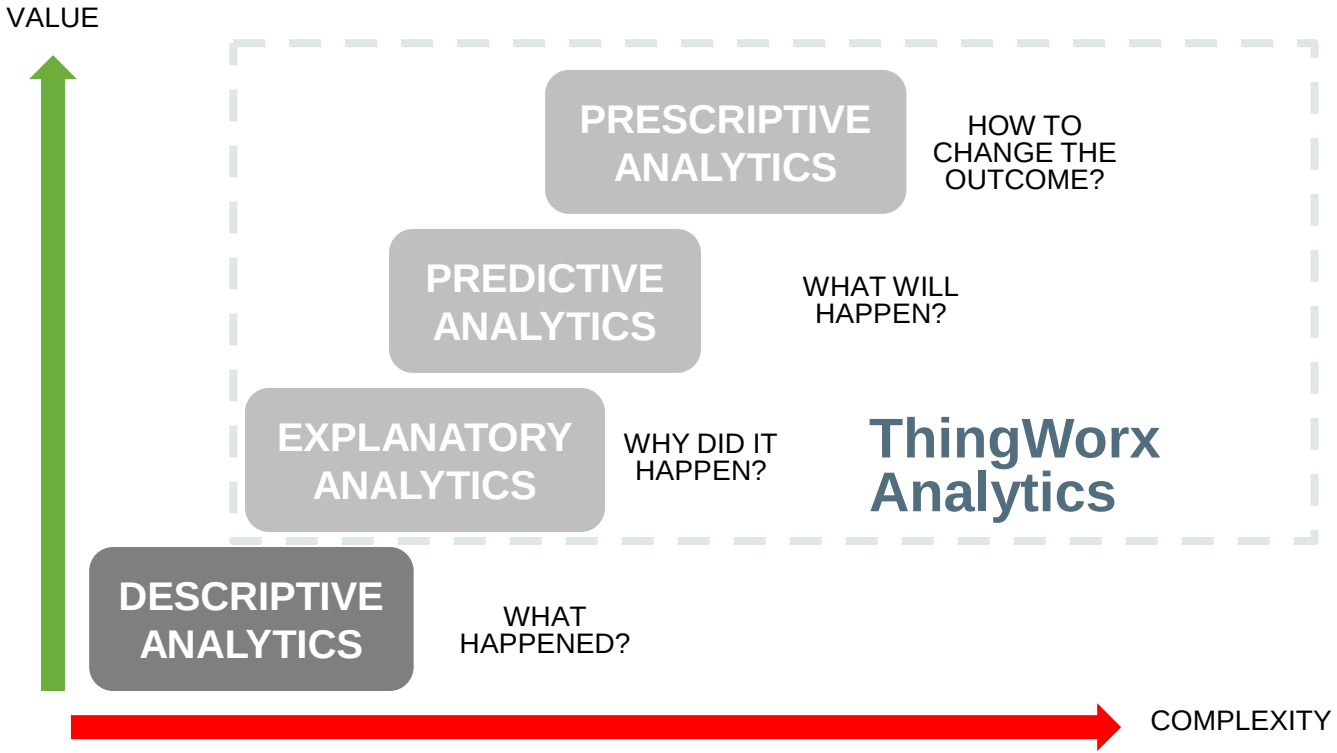
Easy to Use

Automated

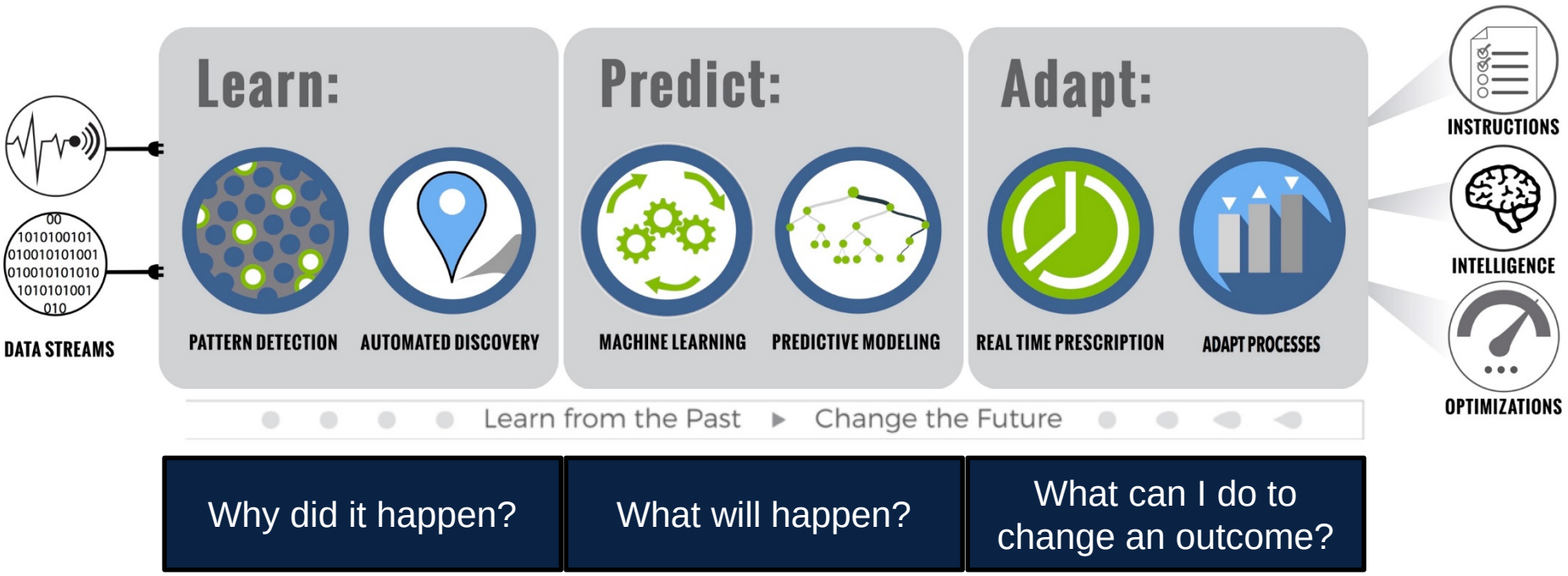
Scalable

Integrated

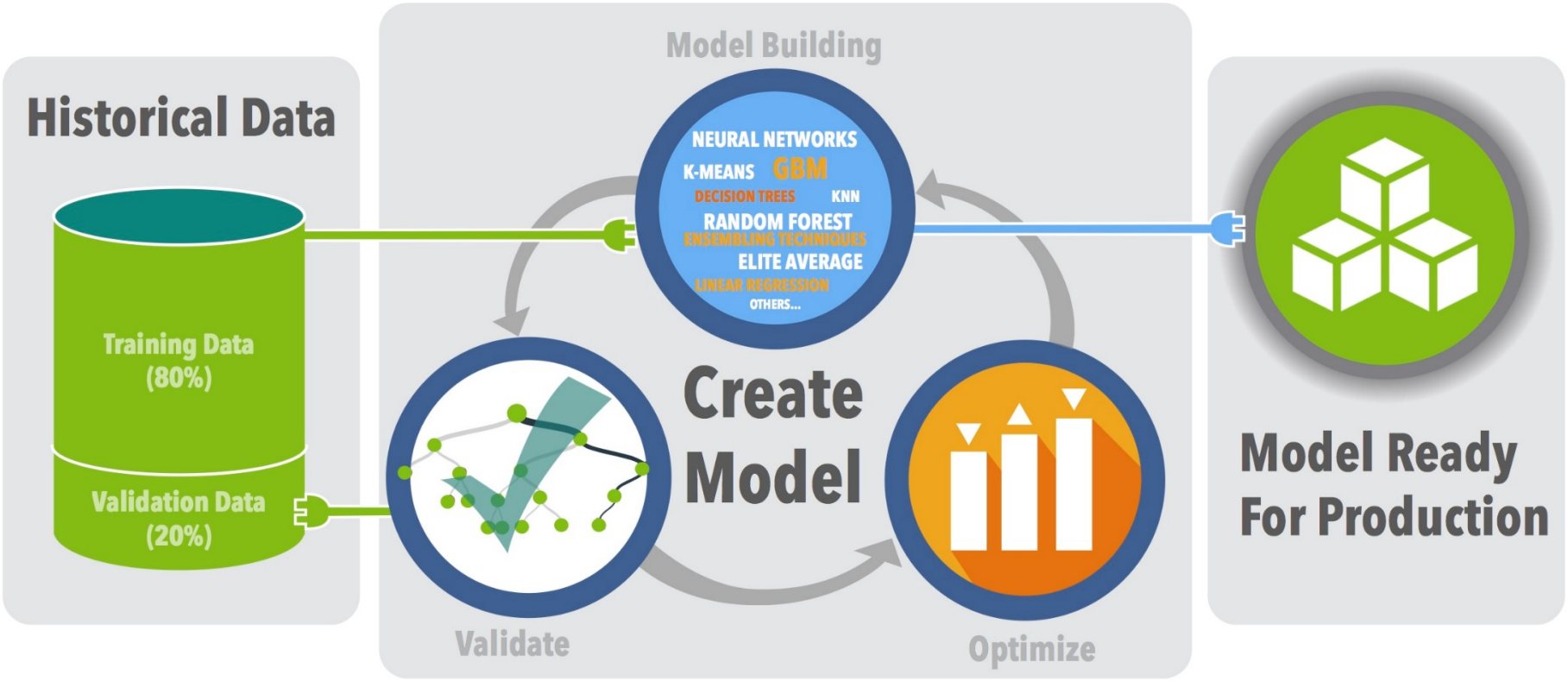
Maturity model of data analytics



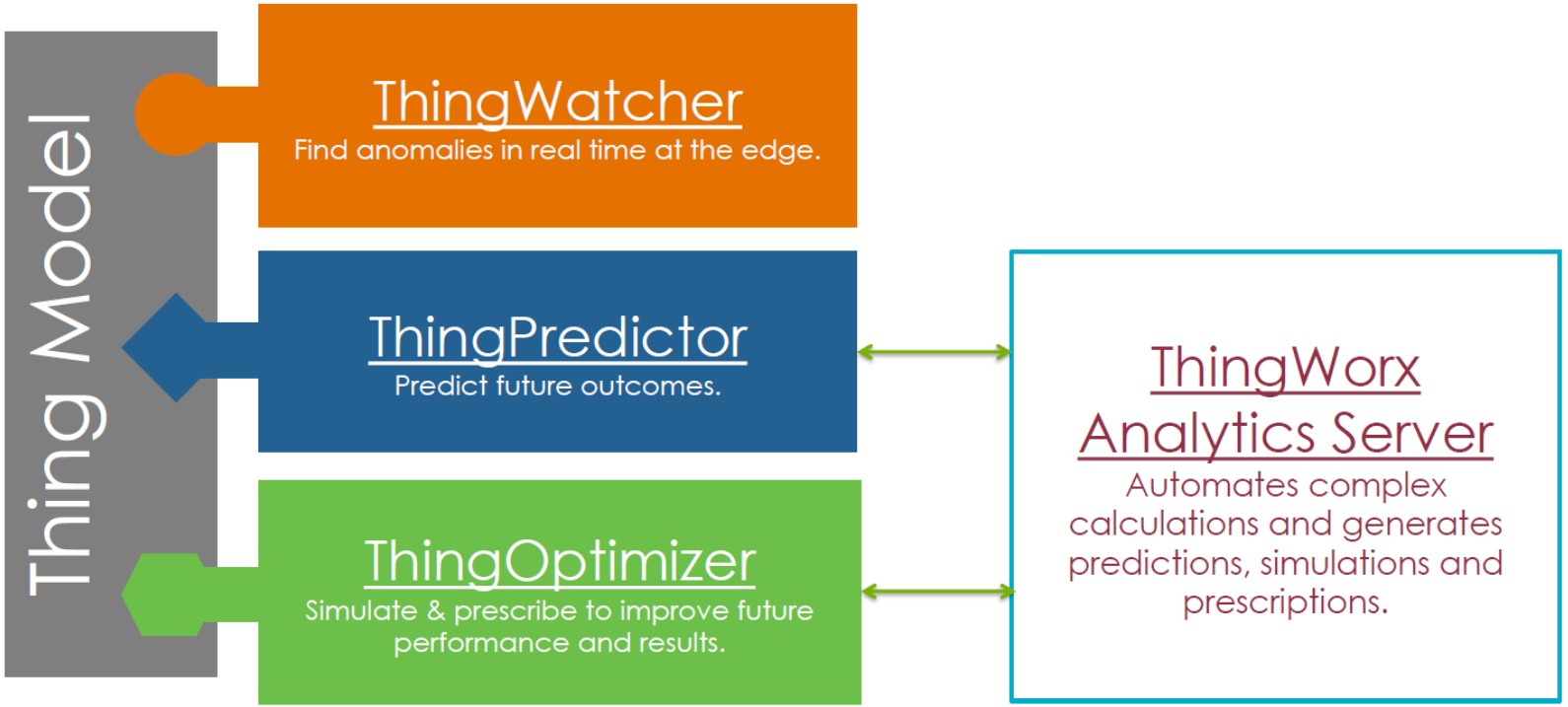
The Machine Learning Process



Automated Learning technology



Thingworx Analytics Components

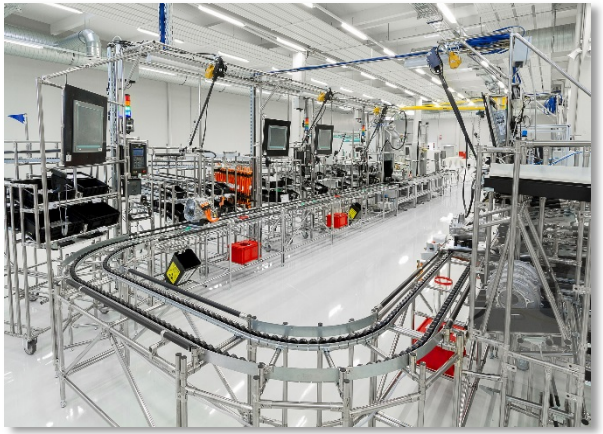


PoC Beispiel Fertigungsstrasse für Elektromotoren

Abhängigkeitsanalyse von Prozessparametern

Fertigungsanlage für kleinere Elektromotoren

- Gemischte automatische und manuelle Montage
- Gut Quote im ersten Durchgang von 90%
- ➔ 10% der Motoren gehen in die Überarbeitung
- Prozessdaten von ca. 1.1 Mio Motoren



- Zeitraum war ca. 1 Jahr (ca. 1.1 Mio Zeilen)
- 165 Fertigungs- und Prüfparameter
- Insgesamt ~ 181 Mio Datenpunkte für die Analyse
- Datenhaltung erfolgt derzeit über einen SQL Server
- Tabellen wurden konsolidiert und als CSV sowie SQL Server Datenbankbackup zur Verfügung gestellt

Ergebnisse PoC

- Es wurden **14 verschiedene Datensets** / Subsets der gesamten Datenmenge in den ThingWorx Analytics geladen.
- Es wurden **22 verschiedene Vorhersagemodelle** generiert. ThingWorx nutzt hierfür Machine Learning Algorithmen um die am besten geeignetsten Data Science Algorithmen zu nutzen
- Für **jedes Vorhersagemodell** wurde **jeweils eine Signal- und Profilanalyse** durchgeführt. Die Ergebnisse decken Korrelationen auf und erlauben es Kausalitäten zu finden.
- Zugriff und Prozessieren der Daten in der Cloud

- **In der Folge des PoC konnte die Gut Quote im ersten Durchgang auf 92% verbessert werden (22.000 Motoren mehr i.O.)**

Vergleich zu typischen Data Science Projekten

Durchführung eines klassischen Data Science Piloten ~ **3 Monate**
Benötigte Ressourcen: Data Engineer, Data Scientist, Domänenexperten

- 2 Wochen Ramp-Up
- 4 Wochen Datenakquise
- 4 Wochen Aufbau Vorhersagemodelle (~5 Tage pro Modell)
- 2 Wochen Evaluierung Ergebnisse und Identifikation Findings

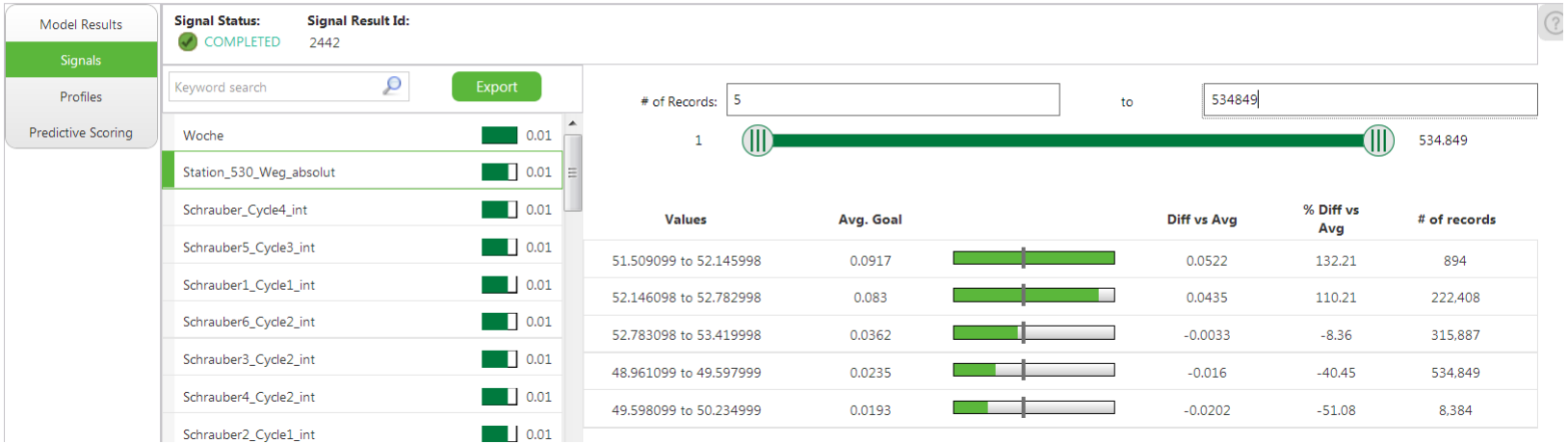
Durchführung eines Data Science Piloten mit Thingworx ~ **4 Wochen**
Benötigte Ressourcen: Data Engineer, Domänenexperten

- 1 Woche Ramp-Up
- 1 Woche Datenakquise (dank bereits guter Datenlage!)
- 1 Woche Aufbau Vorhersagemodelle (~3-5 Minuten pro Modell)
- 1 Woche Evaluierung Ergebnisse und Identifikation Findings

Beispiel Finding: Station 530 – Weg absolut

Model	Goal	Dataset	Filter	Exclusions
10032017_ab_7…	Station_720_Status_Fehler	FertigungsParams_GTEQ_Station_720	All_Data	23 Exclusions Applied

Avg. Value for Goal	Percent of Records Used	Number of Records
0.04	100%	1,082,429



Wenn der Weg absolut an Station 530 zwischen 52.15 und 52.78 liegt, ist die Wahrscheinlichkeit, dass an Station 720 ein Fehler auftritt erhöht auf 110% verglichen mit dem Durchschnitt.

Risiko Profile

- Wenn die folgenden Schrauberwerte vorkommen, dann steigt das Risiko des Aussortierens um 77%. Dies gilt für 370.505 Datensätze und entspricht 32.84%

Profile #3	Features	Values	Avg Goal	% Diff Vs Avg	# Of Records	% Of Total Records
	Schrauber6_Execution_Time	1.9419 to 2.6774	0.18	77.67%	370,512	32.84%
	AND Schrauber6_Analog_Depth_Step3	57.4250 to 60.500	0.18	77.67%	370,510	32.84%
	AND Schrauber6_Torque_Step3	1.1565 to 1.2700	0.18	77.67%	370,510	32.84%
	AND Schrauber_Analog_Depth_Step3	56.9500 to 60.0000	0.18	77.67%	370,505	32.84%

Rückführung von realen Sensordaten in das CAD Modell

Herausforderungen in der Produktentwicklung

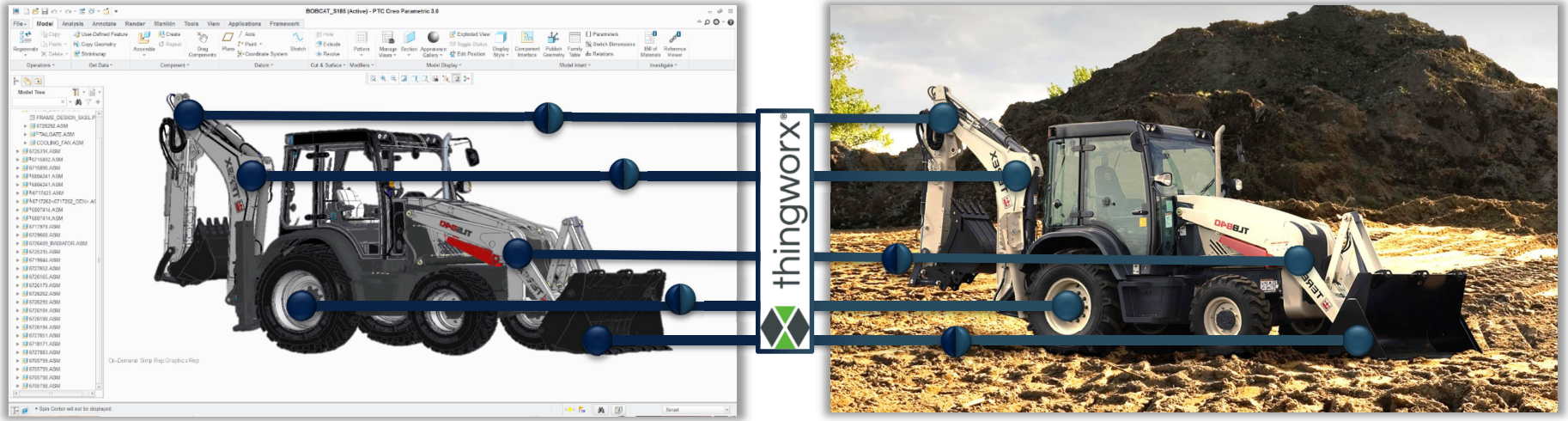
Woher kommen die Bauteilbeanspruchungen?

Annahmen, Schätzungen, Messungen

Wie ist die Beanspruchung des Produkts über die gesamte Lebensdauer?

Physische und digitale Welten

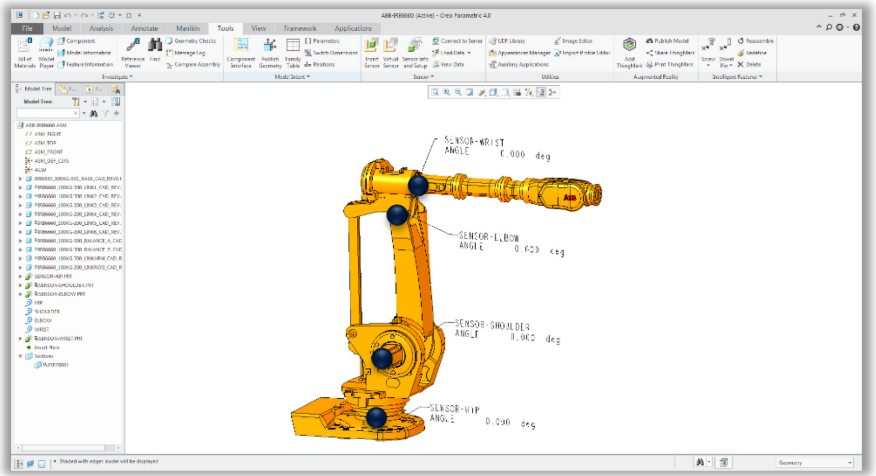
Digitaler Prototyp | Digitaler Zwilling | Physisches Produkt



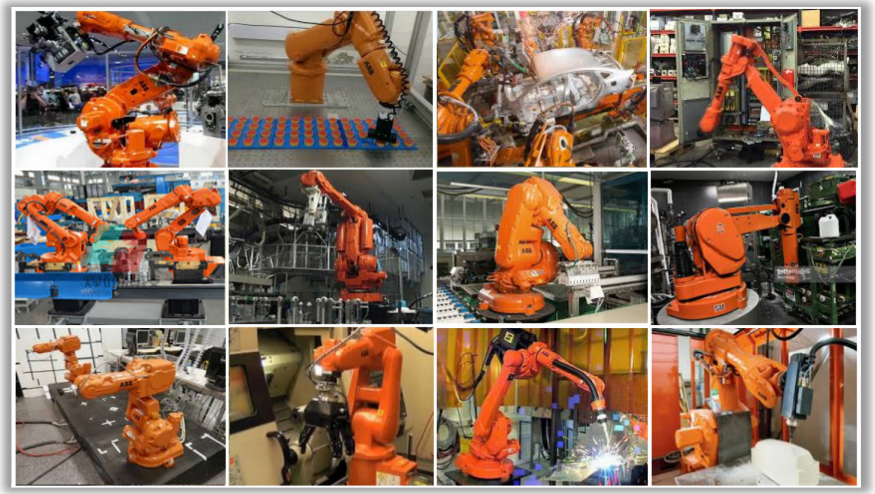
Digitaler Zwilling: Eine anforderungsorientierte digitale Representation eines bestimmten physischen Produkts, kombiniert mit der physischen Rückmeldung diese Produkts.

Design: Getrieben von Daten aus der realen Anwendung

Digitaler Prototyp



Produkte im Feld

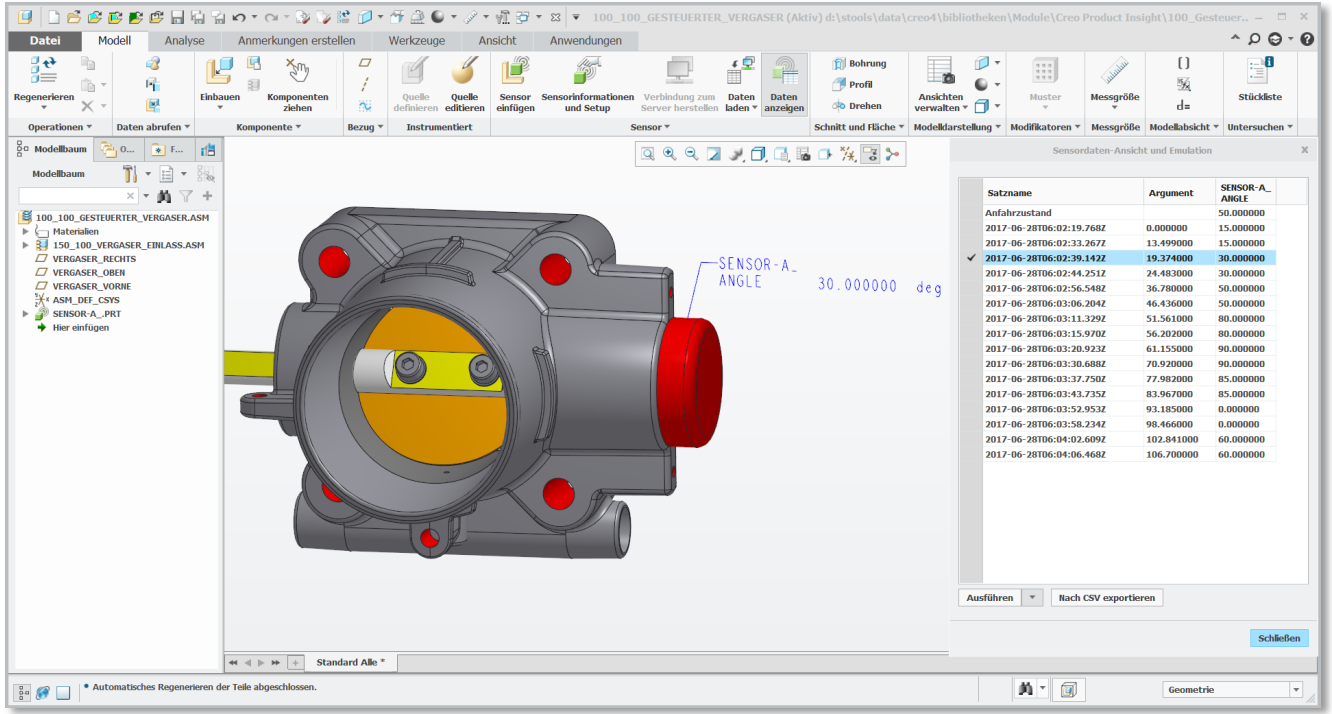


~~ANALYSE~~

REALITÄT

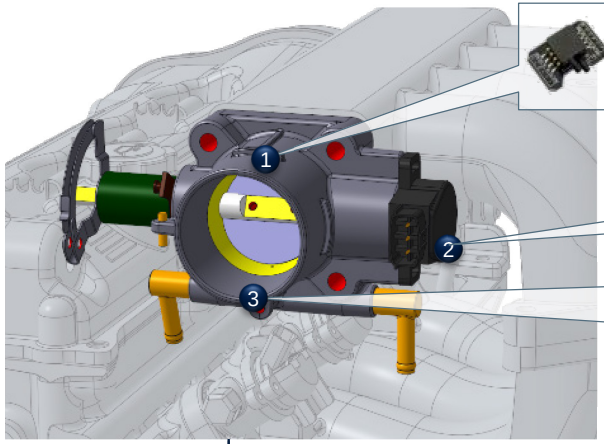
Creo Product Insight

Creo Product Insight ist eine Erweiterung für Creo (ab Version 4.0), welche durch die Integration mit ThingWorx® die IoT-Daten aus der realen Welt mit der Konstruktion vernetzt



Creo Product Insight

- ✓ Aktuelle, reale Werte in der Produktentwicklung nutzen
- ✓ Besseres Verständnis für die Verwendung und das Verhalten
- ✓ Sensoren direkt in die Konstruktion integrieren und deren Rückmeldung nutzen



V-Sensor 1:

Output: Pressure [PSI]

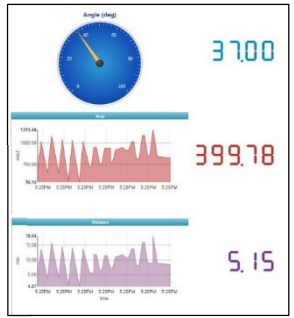
Sensor 2:

Valve Angle [DEG]

Sensor 3:

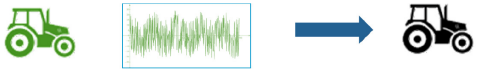
Output: Air flow Speed [mm^3/sec]

Input: Flow valve opening [mm]

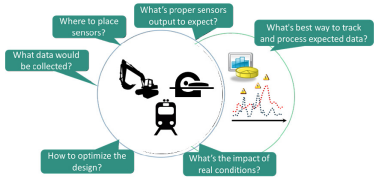


Product Insight Use cases

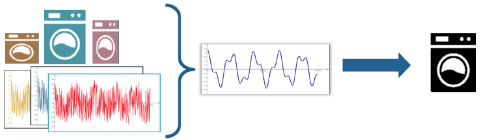
Improve new product design
- Validating design requirements
- Replacing assumptions with usage data



Improve new smart product design
- Optimizing sensor usage
- Prototyping value streams



Improve iterative product design
- Performing trend analysis
- Improving product quality



Enable the extended organization
- Creo as a Service
- Autonomous continuous testing

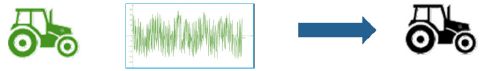
Improve new product design

Validate design assumptions & critical values with real-world data

Add digital sensors to the CAD model

Load prototype sensor data into Creo

- Data file or ThingWorx integration



Drive CAD model by sensor data

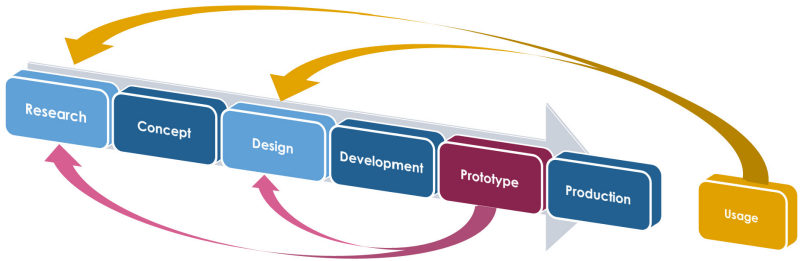
- Reproduce critical circumstances
- Obtain a better insight into product usage & performance

Validate design requirements

- Replacing assumptions with facts

Optimize design to meet requirements

- Creo analyses/measures
- Simulate – Structural & Thermal
- Mechanism – Kinematic & Dynamic



Creo Product Insight Workflow

Assembly

Sensors

Link

Load Data

Run & Report

Design Assembly / Instrumented

- **Embed sensors into design structure**
- **Use released design data**
- **Add design intent to be driven by sensors**

Sensors

- **Parts or assemblies as sensors**
- **Measured, Calculated &Virtual types**

Measured data

Calculated data

- **Measured type - read usage data**
  - Link sensor to dimension
- **Calculated type - report analysis results**
  - Link sensor to analysis

ThingWorx or Local file

- **Retrieve product usage data**
- **Through Thingworx integration**
- **From local CSV file**

Apply sensor data

Secure calculated data

- **Run data slices to set assembly into context**
- **Secure results into data table**
- **Send data back to ThingWorx server**

Improve new product design

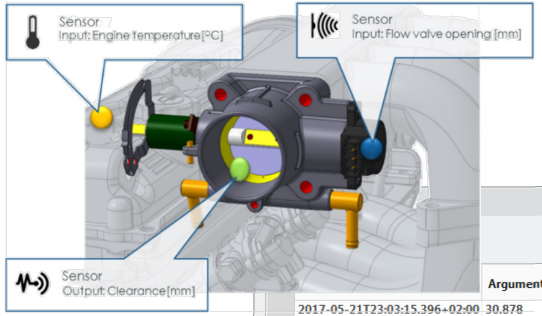
Responding to a field problem

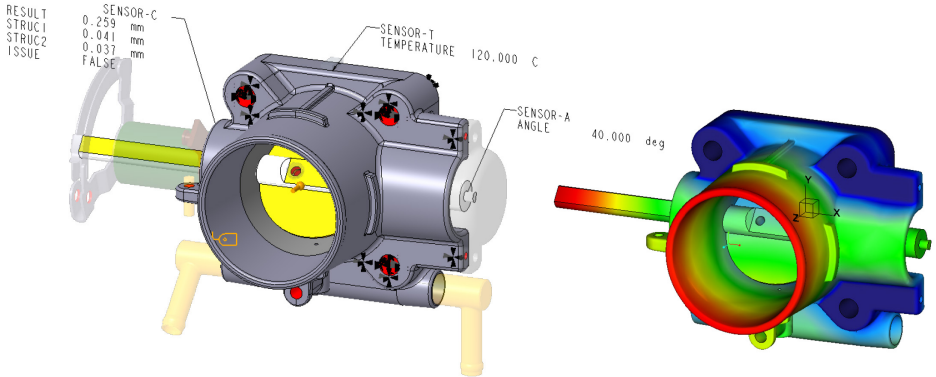
Measured sensors:

- Housing temperature
- Valve angle

Calculated/Virtual sensor:

- Thermal expansion



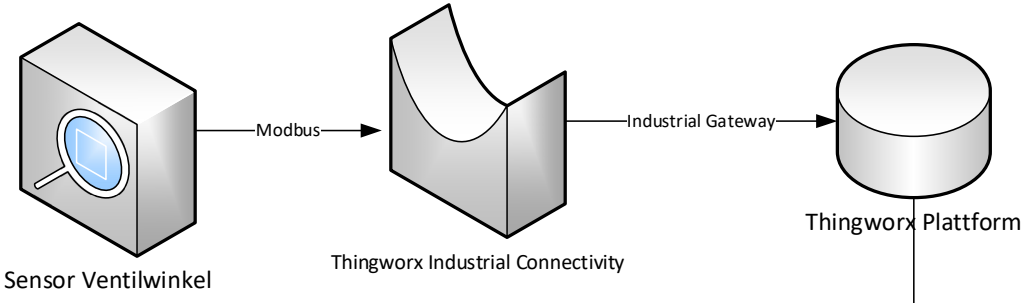


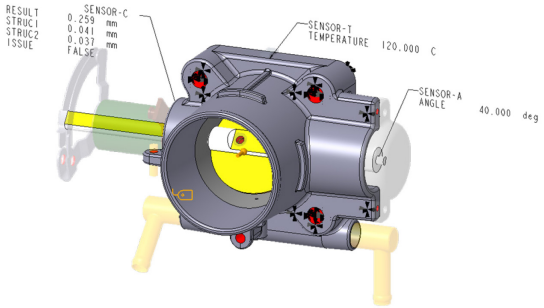
Sensor Data View and Emulation

Argument	SENSOR-T TEMPERATURE	SENSOR-A ANGLE	SENSOR-C RESULT	SENSOR-C STRUC1	SENSOR-C STRUC2	SENSOR-C ISSUE
2017-05-21T23:03:15.396+02:00 30.878	60.000	50.000	0.380	0.021	0.020	NO
2017-05-21T23:03:21.249+02:00 36.731	65.000	50.000	0.380	0.023	0.022	NO
2017-05-21T23:03:27.564+02:00 43.046	65.000	60.000	0.500	0.023	0.022	NO
2017-05-21T23:03:32.790+02:00 48.272	75.000	60.000	0.500	0.027	0.026	NO
2017-05-21T23:03:39.017+02:00 54.499	75.000	70.000	0.606	0.029	0.024	NO
2017-05-21T23:03:45.048+02:00 60.530	80.000	70.000	0.606	0.031	0.026	NO
2017-05-21T23:03:48.910+02:00 64.392	80.000	80.000	0.685	0.031	0.028	NO
2017-05-21T23:03:53.036+02:00 68.518	85.000	80.000	0.685	0.033	0.030	NO
2017-05-21T23:04:01.165+02:00 76.647	85.000	85.000	0.712	0.033	0.032	NO
2017-05-21T23:04:06.930+02:00 82.412	100.000	85.000	0.712	0.039	0.037	NO
2017-05-21T23:04:14.568+02:00 90.050	100.000	60.000	0.500	0.038	0.037	NO
2017-05-21T23:04:22.125+02:00 97.607	100.000	40.000	0.259	0.036	0.034	NO
2017-05-21T23:04:27.281+02:00 102.763	105.000	40.000	0.259	0.038	0.036	NO
2017-05-21T23:04:31.753+02:00 107.235	105.000	30.000	0.152	0.038	0.036	NO
2017-05-21T23:04:36.134+02:00 111.616	103.000	30.000	0.152	0.038	0.035	NO
2017-05-21T23:04:42.760+02:00 118.242	103.000	15.000	0.046	0.030	0.035	NO
2017-05-21T23:04:51.041+02:00 126.523	105.000	15.000	0.046	0.031	0.036	NO
2017-05-21T23:04:56.474+02:00 131.956	105.000	10.000				
2017-05-21T23:05:00.800+02:00 136.282	100.000	10.000				
2017-05-21T23:05:06.388+02:00 141.870	100.000	9.000				
2017-05-21T23:05:12.381+02:00 147.863	110.000	9.000				
2017-05-21T23:05:19.593+02:00 155.075	115.000	9.100	0.027	0.034	0.039	YES
2017-05-21T23:05:23.458+02:00 158.940	120.000	9.100	0.027	0.035	0.041	YES

Run | Export to csv | Close

Aufbau Demo Beispiel





Creo Modell

Zusammenfassung

- Aufnahme und Analyse von Sensordaten
  - Die **IoT Plattform Thingworx** ermöglicht es, Daten von realen Dingen zu sammeln, mit Daten aus Unternehmensapplikationen zu verknüpfen und dem Endanwender darzustellen

- Monitoring von Fertigungsmaschinen
  - **ThingWorx Manufacturing Apps** ermöglichen Überwachung und Analyse von Fertigungsmaschinen in Echtzeit

- Datenanalyse mit Hilfe von Machine Learning
  - **Thingworx Analytics** ermöglicht Datenanalyse und Vorhersage auf Basis von Machine Learning Algorithmen ohne Data Scientists

- Rückführung von realen Sensordaten in das CAD Modell
  - **Creo Insight** ermöglicht die Verbindung von realen Sensoren und Daten mit dem digitalen Modell

Vielen Dank für Ihre Aufmerksamkeit!

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