Digitalisation in Service and Additive Manufacturing of Spare Parts

Aleš Prešern - Varna, 07.06.2018
What is digitalisation, anyway?

From data ...  
- Visualization and recommendations
- Increasing the availability of components
- Data analysis and simulation
- Optimizing energy consumption
- Secure data storage and transmission
- Improving cyber security
- Data collection
- Maximizing process

... to added value
MindSphere –
The cloud-based, open IoT operating system from Siemens

MindApps
Powerful Industry Applications and Digital Services

MindSphere
Open IoT Operating System (PaaS)

MindConnect
Connecting Products, Plants, Systems and Machines with MindConnect
Digital Solutions for your business today

**Digital Suite**

**Availability Services & Solutions**
- Remote Services
  - Remote Outage Service
  - Virtual Guidance
  - Remote Diagnostic Services & myConnect

**Performance Services & Solutions**
- Services
  - Flex LTP
  - Power Diagnostic Center
  - Performance Optimization Services

**Risk and Compliance Services & Solutions**
- Cyber Security Services
  - Cyber Security Consulting, Managed Services, Professional Services, Products

**Digital Services**

**On-premise Solutions**
- Instrumentation & Edge Solutions

**On-premise Emissions Optimization Solutions**
- Fleet Center Solutions
  - Combustion Optimization Solutions

**Advisors**
- myHealth (small turbines)
- My Health Advisor (large turbines)
- My StartUp Advisor
- My Performance Advisor
- My Auto Tuner
- Digital Lifecycle Services (Alarm Opt)

**Emissions Optimization Advisors**
- My Auto Tuner

**Transparency Applications**
- My Product Advisor
- My Spares Advisor
- My Asset Monitor

**Mindsphere**

**Units**
- Covering

**Plants**

**Fleets**

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Page 4 January 2018
Remote Diagnostic Services: Monitoring Rotating Equipment

Identify potential issues BEFORE they impact operations

Asset Monitoring.
Turn your data into value.
Monitor the complete range of your rotating equipment to help identify a potential problem before it impacts your operations.

Protect your plant operations
Real-time monitoring and analysis to increase operating life and cut maintenance costs

Instrumentation & Edge Services collect data from field devices such as sensors and rely on the processing speed of edge technology to run real-time analytics.

Continuous real-time monitoring of vibrations and processes, based on extremely sensitive measurement, combined with in-depth analysis of deviations can help reduce maintenance costs and avoid unnecessary tripping.

Instrumentation & Edge Services include:

- **MACHINERY PROTECTION**: Reliably detect undesirable machine states to avoid unnecessary tripping
- **MACHINERY MONITORING & ANALYSIS**: Detect abnormal machine performance and its root-cause at an early stage
- **PROCESS MONITORING & ANALYSIS**: Draw upon archived plant experience to recognize anomalies long before they reach a critical point
Example: GenAdvisor
The Generator Monitoring Platform by Siemens

Modular in design, the GenAdvisor™ Monitoring Platform provides a portfolio of specialized monitoring capabilities:

- Monitors are available for partial discharge, end winding vibration, interturn short circuit monitoring and rotor shaft voltage and shaft grounding current.
- Each monitor can be operated as a stand-alone application or integrated to a single common user interface via the platform server.
- The platform server also allows concurrent monitoring of multiple generators and connection to the Power Diagnostics Center.
Example: GenAdvisor

GenAdvisor™ – Monitoring of:

- Partial Discharges (PD)
- End Winding Vibrations (EWV)
- Rotor Interturn Short Circuits (ISC) – Flux Probe
- Rotor Shaft Voltage and Shaft Grounding Current (SVC)
- … in correlation with operational parameters
Virtual Guidance: the Siemens augmented reality solution

Keep your turbine up and running –
AUGMENTED REALITY
brings the experience of the expert to your site

Satisfy the need of expertise know-how at short notice, at
any time and in countries with travel restrictions.

Makes it possible to provide guidance in field-service,
industrial manufacturing, training and aftermarket service.

Augmented Reality lets you experience a simulated reality
in which you can talk and interact as if you were standing
next to each other.

Our expertise is at your disposal - no matter where
you are.
myHealth: Easy overview of your connected units

Have your important OPERATIONAL KPIs at your hand - any time

myHealth provides a transparent and easy way to manage performance logs and planned outages, and to browse notifications issued for your equipment.

The state-of the art interactive Trend Explorer tool shows sensor data from key instrumentation to help you understand your asset performance.

Provides the possibility to post comments with your feedback on the information provided.

Total transparency on assets
Asset Monitor: Asset monitoring at a point of need

Asset Monitor is able to:

- Visualize current versus historical comparative KPIs
- Compare unit and plant fleet data
- Turn data insights into actions for preventative maintenance, proactive planning, and plant improvements

1. Graphical visualization of plant asset data and Key Performance Indicators (KPIs) for early issue detection
2. Detailed visualization and trending of model based corrected results of asset data
3. Evaluation and benchmark of asset performance over time for different units in the fleet
Connect: A common data collector for a secure data collection

For secure Remote Diagnostic Service, we developed a standardized data collector solution.

As cyber security is a critical topic in our service delivery, the data collector covers the latest security requirements including applicable IEC 62443 and ISO27001 security requirements.

Collecting data safely and securely in order to deliver remote diagnostic service
In the age of Digitalization, Industrial Cyber Security is becoming the new attack frontier

Wanna Cry and NotPetya attacks disrupt IT and OT systems worldwide by encrypting harddisk data.

Iran has detected and removed malicious software from two of its petrochemical complexes.

BlackEnergy trojan infected SCADA systems of Ukrainian power grid with total outage for 225,000 customers.

Stuxnet attack ruins 20% of Iran’s nuclear centrifuges by taking control over Siemens Simatics in power plants.

German steel mill with massive physical damage after attack on steel furnace.

Havex virus hits industrial control systems and SCADA of ~1,000 energy firms (GER and CH amongst others).
Ukraine DSO Attack, December 2015

- A blackout affecting 7 Distribution Companies and 225,000 customers
- Attack initially started with emails targeted to utility staff, containing an infected attachment and carried over several months to one year
- Blackout on December 2015, further attack on a transmission substation on December 2016

The first publicly known cyber attack resulting directly in a blackout
Anatomy of an attack – How are the bad guys proceeding

**Typical attack steps**
- Reconnaissance
- Scanning
- Exploitation
- Pivoting
- Exfiltration | Damage
- Track covering

**Common weaknesses**
- Weak passwords
- Configuration mistakes
- Unpatched software
- Social engineering

**Typical initial attack vectors**
- Infected email
- Phishing
- USB
## Cyber Security Regulations

EU Member States are required to (i) establish national NIS authorities, (ii) establish CERTs and (iii) adopt national cyber security laws.

### Affected Enterprises

<table>
<thead>
<tr>
<th>Operators of Essential Services</th>
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<tbody>
<tr>
<td>in the sectors:</td>
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</table>

- to be identified by each Member State (different thresholds may apply);
- consultation between Member States only in case of cross-border services.

<table>
<thead>
<tr>
<th>Digital Service Provider</th>
</tr>
</thead>
<tbody>
<tr>
<td>limited to:</td>
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- conclusively defined in the directive.

### Obligations

- Member States have to define the obligations in further detail.
- Member States can impose stricter requirements.
- Implementation of technical & organisational measures to manage cyber security risks.
- Incident reporting.

Siemens Advanced Security Monitoring applies best-in-class technologies and OT expertise to manage cybersecurity risk

Industrial environments face a range of cyber threats... …Siemens provides advanced security monitoring to help manage risk... …allowing customers to focus on core operations

- 24 x 7 monitoring and detection
- Industrial cyber expert analysts
- 360° view of operational risk:
  - Global threat intelligence
  - Asset visibility
  - Anomaly detection
  - Operational process data
  - Vulnerability management

Serving Customers with a Global Footprint

Value:

- Cost Effective Security vs. Insourcing
- Benefits of Digitalization without Sacrificing Security
- Access to Industrial Cybersecurity Experts
- Custom Reporting, Notification & Alerts

Powered by:
Spare part 3D printing technology in nuclear power plants
Example Project „Perun“, Krško NPP

Aleš Prešern
Varna, 07.06.2018
What is Additive Manufacturing?

- AM (SLM) is a method that use laser beam to "weld" powder particles in a layer-by-layer way thus creating a component.
- AM takes place in a special atmospheric chamber with inert gases.
- To manufacture a component by AM technology:
  - 3D model of the component,
  - appropriate powder and
  - laser sintering equipment are needed.

Rapid Manufacturing is making functional end products “directly” from CAD using Additive Manufacturing technology.
Additive Manufacturing
Technology overview

Gartner Hyper Cycle and an industrial application example

The Gartner Hyper Cycle shows that 3D printing for industrial applications is moving towards productivity level

Industrial application example in airline industry

Steel buckle (155g) → Titanium buckle (70g)

Small cause, big effect:
- 75g weight reduction with titanium seat belt buckle
- ~70kg overall weight reduction for an Airbus 380
- Savings potential over airplane lifetime: 3.3 mio. ltr. of fuel or EUR 2 mio.

Source: CT BE, CT TIM, Gartner, Roland Berger, SAVING project/Crucible Industrial Design Ltd

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RaBuTir Process: Repair of the SGT-700 Burner

It starts on the computer – the gas turbine burner needs a new tip.

A layer of stainless steel powder is applied.

A laser beam fuses the powder.

The platform lowers by a few micrometers.

A new layer of metal powder is applied.

The process is repeated, layer by layer.

This process gradually produces a new burner tip that is melted onto the rest of the component.
Krsko 3D Print initiative
PERUN Project

The process:

- get an obsolete part. NO drawings, NO manufacturer known. 40 years old.
- reverse engineering $\rightarrow$ 3D CAD Model
- dummy printing
- manufacturing in stainless steel
- material testing (microstructure, chemical composition, mechanical destructive tests)
- part 3D scanning, dimensional comparison
- rotational balancing
- CT scanning
3D Scanning & Reverse Engineering of components

State of the art measuring

- Laser-tracker technology to enable measurements where conventional equipment is unable
- Quality assurance by high-end measurement systems

Reverse Engineering

- Scanning of components by photogrammetry or 3D scanner and reconstruction of 3D model
- Applicable for fact finding, work on non-OEM components, quality assurance and more
- From small parts to whole assembly
3D Scanning & Reverse Engineering of components

Hand held 3D Scan

Field of Application:
- HP casings
- IP casings
- LP casings
- Inner casings
- Shaft ends
- Horizontal Joint
- Bearing + Pedestal
- Glands
- Generators
- Auxiliaries
Perun: Reverse engineering

Mechanical sensor was used to determine the shape of a blade.

Digitalization of points

Points gained by mechanical sensor.

Cut-out of the first CAD model

3D model as obtained directly through the CT scan process; erosion marks from the scanned original are clearly visible.
Perun: CT Scanning & Dummy Printing
Perun: Selective Laser Melt Processing

TEST pieces, printed together with the product
REFERENCE CONFIRMATION

Project PERUN
3D printed spare parts

Nuclear Power Plant Krško

hereby certifies that

Siemens

has successfully engineered and delivered a functional spare part – water pump impeller – which was created using the technology of additive manufacturing (3D printing) in stainless steel.

We confirm that the delivered parts fulfilled all of the given quality requirements, specified by NPP Krško.
The impeller has been successfully tested and installed in January 2017, where it has been since performing normally and as per design specifications.

This represents the first time that Nuclear Power Plant Krško has installed and operated a part created by additive manufacturing.

Krško, February 2017

Stanislav Rozman
President of the Management Board

NUKLEARNA ELEKTRARNA
KRŠKO, d.o.o.

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June 07, 2018
Siemens sets industry milestone with first 3D printed part operating in nuclear power plant

Advantages of 3D printing with Additive Manufacturing*

- Lead time reduction for parts replacement
- Obsolete parts can be produced
- Saving of material
- Eliminated tools
- On demand

"The better than expected performance of this 3D printed part gave us confidence that we can reach the full life expectancy from our asset. Siemens has a long history of innovation in this area and their dedication to providing their customers with the latest, proven innovations made them an excellent partner for this project."

Vinko Planinc
Head of Maintenance at the Krško Power Plant

* Additive Manufacturing (AM) refers to a production process in which components are created layer by layer on the basis of digital 3D design data. Source: International Committee F42 for Additive Manufacturing Technologies (ASTM).
Včasih v filmih o Bondu, zdaj v nuklearnih elektrarnah

3D-tiskanje V Kršku so z natisnjenim rotorjem črpalke trasirali pot v prihodnost


Janko Tepavčič iz Siemensa: "Prva raziskava pokazuje, da je 3D tiskanje za nuklearno industrijo mogoče i občutljivo, vendar je bitno, da se 3D tiskanje uporabi kot dodatna tehnologija, ne kot samostojno rešitev."

V Neku je bila podpisana pogodba z Siemensom za izdelavo prvega 3D tiskalnega sistema za nuklearno industrijo. Siemens je v zvezi z Siemensom pridobil niz storitev, ki omogočajo izdelavo in uporabo 3D tiskalnikov za nuklearno industrijo. Siemens se priporoča, da se 3D tiskanje uporabi kot dodatna tehnologija, ne kot samostojno rešitev. Siemens in Nek se skupaj zavzemajo za razvoj in uporabo tehnologije 3D tiskanja v nuklearnem delu.

Slovenska Krško je prva v Evropi, ki je izdelala dijelove za jedrsko elektrarno z 3D tiskanja.

3D-printed part for Krško plant

99 March 2017

A 3D-printed impeller has been used in a pump at Slovenia's Krško plant since January. Siemens, which produced the component, said continuing safe operation of such a part in a nuclear power plant.

Energy & Environment New Nuclear Regulation & Safety Nuclear Policy

Kranjski Kranj

Siemens installed 3D-Druckteil in einem der sichersten Atomkraftwerke Europas

Die globale agierende Siemens AG ist auch im Bereich des 3D-Drucks aktiv. Nun hat sie mit diesem Verfahren einen bahnbrechenden Schritt in einem Atomkraftwerk installiert.

Dies stellt durchaus einen bedeutenden Durchbruch dieser Technologie dar; die Siemens-Kraftwerke sind überaus sicher, was die Verwendung von 3D-Druckteilen betrifft.

In Nuklearwerk Kranjski Kranj wurden Siemens produzierte 3D-Druckteile installiert.

Siemens produces 3D-Printed Part Operating in Nuclear Power Plant

Mar 9, 2017

WNN world news

Slovenska Krško je prva v Evropi, ki je izdelala dijelove za jedrsko elektrarno z 3D tiskanja.

Siemens sets milestone with first 3D-printed part operating in nuclear power plant

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Energy & Environment New Nuclear Regulation & Safety Nuclear Policy

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If you can dream it, you can PRINT it.

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