Predictive Quality in Electronics Manufacturing
# Siemens corporate structure

## Managing Board

<table>
<thead>
<tr>
<th>Corporate Services</th>
<th>Regions</th>
<th>Corporate Core</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power and Gas</td>
<td>Energy Management</td>
<td>Siemens Gamesa Renewable Energy</td>
</tr>
<tr>
<td>Energy Management</td>
<td>Building Technologies</td>
<td>Siemens Healthineers</td>
</tr>
<tr>
<td>Mobility</td>
<td>Digital Factory</td>
<td>Siemens Corporate Services</td>
</tr>
<tr>
<td>Process Industries and Drives</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Siemens Energy Management</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Siemens Gamesa Renewable Energy</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Financial Services</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Divisions

- **Factory Automation**
- **Control Products**
- **Product Lifecycle Management**
- **Motion Control**
- **Customer Services**
Excellence in manufacturing – For our customers

Our Mission

"Be the Role Model for Excellence in Manufacturing to provide proven Value Add for our Customers and Business Unit, based on the methods of Digital Enterprise and Lean Industrial Engineering"

Shape the Digital Future. Together.

Dr. Gunter Beitinger, Vice President Manufacturing

Our Locations

Evaluate new Business models

- Shorten time to market
- Increase Flexibility
- Improve Quality
- Boost Efficiency
- Increase Security

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Advanced data analytics as a key enabler to optimize our processes

“Predictive Analytics uses Big Data to analyze past patterns and predict the future”

Gartner

“Predictive Analytics uses Big Data to analyze past patterns and predict the future”

Gartner
CRISP-DM¹ as the preferred approach for our advanced data analytics projects

To get the best results make sure to include process domain know-how!

¹ CRISP-DM: Cross Industry Standard Process for Data Mining
“Predictive Analytics requires both domain and scientific know how!”
A digital factory needs an analytics eco system

- Training data
- Streaming data
- Data lake
- Real time model execution
- Algorithm results
- Algorithm performance
- Deploy
- Enrich
- Continuous Model Development
- Process refeed

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„One of the biggest challenges is to build up an analytics ecosystem!“
Actual EWA IT-architecture already covers a large portion of desired Lean Digital Factory blueprint

<table>
<thead>
<tr>
<th>Management</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>BI-Software, Analytics &amp; AI</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Product Lifecycle Management and ERP</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>NX/ Tecnomatix</td>
<td>Teamcenter</td>
</tr>
<tr>
<td>~460 Clients</td>
<td>~70 Clients</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Operations</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>SIMATIC IT</td>
<td>SIMATIC WinCC</td>
</tr>
<tr>
<td>~1,300 Clients</td>
<td>~100 Clients</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Control</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>SIMATIC Controller</td>
<td>SIMATIC HMI</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Field</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>SIMATIC Distributed I/O</td>
<td>SINAMICS</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>~2,800 Clients</td>
<td></td>
</tr>
</tbody>
</table>

- ~1,300 Clients
- ~1,000 Clients
- ~650 Clients
- ~250 Clients
- ~460 Clients
- ~70 Clients
- ~20 Clients
- ~650 Clients
- ~250 Clients
- ~70 Clients
- ~100 Clients
- ~1,000 Clients
- ~460 Clients
- ~70 Clients
An edge-based system combines the benefits of a pure local and pure cloud solution.
Hot topics for advanced data analytics in manufacturing environment

“How to stabilize processes while lowering control effort?”

“How to improve quality level while reducing test effort?”

“How to increase uptime while minimizing maintenance costs?”

“How to achieve one-piece-flow while maximizing utilization?”

“How to stabilize processes while lowering control effort?”

“How to improve collaboration while reducing communication?”

Quality Improvement

Predictive Maintenance

Process stabilization

Supplier collaboration
Three use cases for advanced data analytics in manufacturing

“How to increase machine uptime while reducing maintenance costs?”

“How to achieve one-piece-flow while increasing machine utilization?”

“How to improve our quality level while reducing our test effort?”
Advanced data analytics reduces test effort significantly

Objective: Connector PCB\(^1\) of a distributed I/O

Problem: X-Ray test is a time and cost intensive work step

Target: Evaluate quality prediction model to reduce X-Ray test effort

 aujourd'hui: [\(\text{SMT}: 100\% \rightarrow \text{X-Ray}\)]

demain: [\(\text{SMT}: < 50\% \rightarrow \text{X-Ray}\)]

\(^{1}\) PCB: Printed Circuit Board
Inspection data and X-Ray test data are used to create a prediction model for product quality.

Model inputs: 52Mio datasets with very high Process Quality of 7dpm

Model requirements: Optimize test slip (Bad products are labeled as good)
X-Ray testing effort can be reduced from 100% to at least 70%

Next steps

- Further data model validation
- Adapt algorithm to new product
- Implement automatic data collection and prediction model

<table>
<thead>
<tr>
<th>Slips-optimized model</th>
<th>True result</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n.i.O.</td>
</tr>
<tr>
<td>Prediction</td>
<td></td>
</tr>
<tr>
<td></td>
<td>n.i.O.</td>
</tr>
<tr>
<td></td>
<td>i.O.</td>
</tr>
<tr>
<td>Class Recall</td>
<td>1.0</td>
</tr>
</tbody>
</table>

Target: Minimize slip
Current best data analytic process:
Gradient Boosted Trees + MetaCost (0 / 10 / 100 / 0)
+ Undersampling mit 1.000 i.O. w/o shielding pins

Model pseudo-error

less x-Ray tests needed!
Most common error types in base unit production detected by X-Ray testing

<table>
<thead>
<tr>
<th>Error Type</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Part orientation X1</td>
<td>18%</td>
</tr>
<tr>
<td>Shield pin not soldered X1</td>
<td>17%</td>
</tr>
<tr>
<td>Shield pin not soldered X2</td>
<td>14%</td>
</tr>
<tr>
<td>Defective part manufacturer X2</td>
<td>13%</td>
</tr>
<tr>
<td>Signal pin not soldered X1</td>
<td>10%</td>
</tr>
<tr>
<td>Part orientation manufacturer X2</td>
<td>5%</td>
</tr>
<tr>
<td>Signal pin not soldered X2</td>
<td>5%</td>
</tr>
<tr>
<td>Part orientation X2</td>
<td>4%</td>
</tr>
<tr>
<td>Defective solder joint signal pin X1</td>
<td>3%</td>
</tr>
<tr>
<td>Solder brige X1</td>
<td>3%</td>
</tr>
</tbody>
</table>

X-Ray of X1 Connector
The X-Ray system setup according to our analytics eco-system

- Model development
- Deploy
- Enrich

- Solder paste inspection data
- Real time model execution
- Defect?
  - Yes: X-Ray Testing
  - No defect: No testing!

- SMT process

Quality Improvement

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The panel for SMT production consists of 48 boards and is double-sided assembled.

**Bottom – connector X2**
- 48 Boards per panel
- 52 Pins per board_X2
- 2496 Pins per panel_X2
- 8 Field of views

**Top – connector X1**
- 48 Boards per panel
- 79 Pins per board_X1
- 3792 Pins per panel_X1
- 8 Field of views
Alternative routing of the printed circuit board depending on the label of the algorithm

Scenario 1) All boards of the panel are predicted as good quality
Scenario 2) All boards of the panel are predicted as poor quality
Scenario 3) Some boards of the panel are predicted as good / poor quality
Dynamic X-Ray testing enables additional productivity

<table>
<thead>
<tr>
<th></th>
<th>Handling</th>
<th>Testing time</th>
<th>FOV skip</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Unit forecast</strong></td>
<td>20%</td>
<td>80%</td>
<td></td>
</tr>
<tr>
<td><strong>Process time</strong></td>
<td>20%</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Time/FOV</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Costs/FOV</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

![Graph showing process time and handling with 20% and 80% distribution.]

![Graph showing unit forecast and process time with 20% and 80% distribution.]

![Graph showing time/FOV and costs/FOV with 20% and 80% distribution.]

![Graph showing process time and handling with 20% and 80% distribution.]

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AI minimizes necessary X-RAY tests by currently 30%. While maintaining the high Quality rate of 100%, resulting in reduced capital invest for further X-RAY machines of 500k€.
Thank you for your attention