Research Project | itsOWL-ScAut
Scientific Automation – Integration of Engineering Findings in Standard Automation
Flagship high-tech strategy of Federal Government

- Regional pooling of economy and science along the value chain
- 15 leading-edge cluster represent high-tech competence ensuring growth and employment

**Leading-Edge Cluster it’s OWL**

- Funding: 40 Mio. € over 5 years for each Cluster
- Funding by BMBF ends this year
- Continuity of the Leading-Edge Cluster assured through sponsoring from the federal state NRW

**Beckhoff runs two projects:**

- Scientific Automation (itsOWL-ScAut)
- Extreme Fast Automation (itsOWL-efa)
Research Project | itsOWL-ScAut

Project overview

Scientific Automation approaches
Consistent engineering
Smart Factory (ScAut-Demonstrator)
Summary
Manufacturers are facing the challenge
1. To produce customized products with existing production technologies
2. To realize a efficient and sustainable production, with the objective to stay competitive

Requirements for production systems
- Highly flexible, precise, fast in lot size 1
- Reduction of breakdowns, downtimes, quality issues of the production and of the product

Approaches to fit the requirements
- Intelligence realized by control technology (Scientific Automation)
- Control technology with high performance
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Objective, Results

**Objective:** Integration of Engineering Findings in Standard Automation

**Results:** Scientific Automation Plattform

- Architecture for intelligent networked production systems
- Scientific Automation approaches
  - Measurement technology, condition monitoring, power monitoring, intelligent feedback control system with PC-based control
  - Control- and cloud-based analytics
- Consistent, model based engineering

**Period:** 1 July 2012 to 30 June 2017

**Project volume:** 5.6 Million Euros
Research Project | itsOWL-ScAut – Scientific Automation

Project Partners

Science
Heinz Nixdorf Institut, University of Paderborn

Automation technology
Beckhoff Automation GmbH & Co. KG

Machine construction
Hüttenhölscher Maschinenbau GmbH & Co. KG
IMA Klessmann GmbH wood-working systems
Schirmer Maschinen GmbH

Consumer goods production
Nobilia-Werke J. Stickling GmbH & Co. KG

Spitzen-cluster it’s OWL
Cross-section projects
Sustainability measures
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PC-Control + Scientific Automation
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Development of control technology

- Complexity

- Motion
- Industrial PC: operation, visualization, data storage
- PLC

Standard Automation
PC Control

Integration of
- visualization
- PLC
- motion (PTP, NC, robotics)
- control technology
- communication
- special functions

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Development of control technology

- **Measurement technology + engineering science**
- **Motion**
- **Industrial PC**
  - operation, visualization, data storage
- **PLC**

**Scientific Automation PC-Control**
Integration of
- Measurement technology
- Condition Monitoring
- Power Management
- …

**Standard Automation PC Control**
Integration of
- visualization
- PLC
- motion (PTP, NC, robotics)
- control technology
- communication
- special functions

Timeline:
- 1970
- 1975
- 1980
- 1985
- 1990
- 1995
- 2000
- 2005
- 2010
- 2015
- 2020
Research Project | itsOWL-ScAut

Project overview

Scientific Automation approaches

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Summary
Variety of application results
- Online and offline condition monitoring,
- Predictive maintenance,
- Pattern recognition,
- Machine optimization,
- Long term storage of data.

The applications include Scientific Automation solutions elements, e.g.:
- Bus terminals and software for consistent, cycle-synchronous data acquisition
- Software for data analysis and evaluation
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Variety of realized Scientific Automation solution elements

**Measurement technology:** Force measurement, vibration measurement, temperature measurement, …

**Analysis:** TwinCAT Scope, Gantt-Chart

**Power management:** Energy monitoring, data evaluation

**Condition monitoring:** Power spectrum, bearing monitoring, tool breakage monitoring, balancing of rotary equipment

→ Data acquisition and analysis with TwinCAT Analytics
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Sample application – Condition Monitoring

**ScAut demonstration:** Ball bearing monitoring at the drilling spindle, balancing of rotary equipment, analysis of use cases for order analysis

**Schirmer:** Tool breakage control (drill breakage)

**Hüttenhölscher:** Ball bearing monitoring at drilling spindle, tool breakage control

**IMA:** Vibration analysis Kontur-Fräsaggregat
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Sample application – Power Monitoring

ScAut demonstration: Energy consumption of single modules, single systems and overall → cloud-based analysis

Hüttenhölscher: Energy consumption of single modules and of the whole system → portable measurement system, measurements at nobilia

Schirmer: Long term measurement of energy consumption at customer machinery → energy costs per produced part, strategies for energy optimization

IMA: Energy measurement Kontur-Fräsaggregat
ScAut demonstration: Energy consumption of single modules, single systems and overall → cloud-based analysis

Hüttenhölscher: Energy consumption of single modules and of the whole system → portable measurement system, measurements at nobilia

Schirmer: Long term measurement of energy consumption at customer machinery → energy costs per produced part, strategies for energy optimization

IMA: Energy measurement Kontur-Fräsaggregat
Sawing causes high energy consumption

Effective power $P$ (W)

Air flow (l/min)

Time (s)

Stab 8 – 07.03.2014 – 4 parts

Sawing process

Power +S3

Air flow VU-Saw

Sample application – Power Monitoring

Standard window

1200 mm

1400 mm

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Sample application – Power Monitoring

Procedure:
- Long term measurement of energy consumption
- Identification of energy intensive process steps
- Development of strategies for a reduction in energy consumption

Strategies:
- Shut off nonproductive components
- Use different operational modes

Result:
- Use different modes during operation
- 17% reduction in energy consumption
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Project overview
Scientific Automation approaches
Consistent engineering
Smart Factory (ScAut-Demonstrator)
Summary
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Scientific Automation enables consistent engineering

- Automation platform TwinCAT 3
- Programming in IEC 61131-3 and the C or C++ languages
- Object orientation, modularization
- Integration of MATLAB®/Simulink®
- TC Condition Monitoring library
- Data evaluation and visualization with TwinCAT 3 Scope
- TwinCAT XCAD – data exchange between engineering tools
- Engineering in the Cloud
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Scientific Automation enables consistent engineering

Common data format

- Preliminary Design
- Detailed Design
- Implementation
- Simulation/Virtual Commissioning
- Real World

Order/Requirements

- Feasibility/Initial Models
  - Electrical Engineering
    - CAD, MATLAB
  - Mechanical Engineering
    - CAD, UML, MATLAB

Simulation/Commissioning

- Control-Software
  - TwinCAT Simulation
  - Gantt-Chart / Realtime Monitor
  - Configuration diagnosis (Scope, Gantt)

BigData

ScAut – solution elements

Scope

- Electrical Engineering
  - CAD, E-CAD
  - MATLAB
  - UML

- Mechanical Engineering
  - CAD, MATLAB
  - UML

- Modeling of the control
  - UML

- Implementation of the control
  - PLC/HMI/MES/ERP
  - TwinCAT
  - EtherCAT

- TC3 XCAD Interface

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Project overview
Scientific Automation approaches
Consistent engineering
Smart Factory (ScAut-Demonstrator)
Summary
Research Project | itsOWL-ScAut – Scientific Automation
ScAut-Demonstrator | Monitored, flexible production

- **Objective:** Monitored production of customized products in lot size 1

- **Product:** Parts with different milling contours

**General requirements:**
- Individual choice of milling contour
- Individual number of parts per order
- Quality assurance by weight measurement
- Energy efficient production
- Reliable production process
Objective: Monitored production of customized products in lot size 1

Product: Parts with different milling contours

Production process:
- Placing an order
- Removal of the necessary part (1)
- Identification of the part via a RFID-Reader (2)
- Machining (3)
- Quality assurance by weighting (4)
- Storage of the finished product (5)
Realization of different control and monitoring functions on one single control – Many-Core-Control with the automation software TwinCAT

- **Flexible transport:** linear transport system XTS
  - Servo control, Motion Control
  - Collision avoidance, centrifugal force limitation
  - Condition Monitoring

- **Handling:** TC Robotic
  - Control of a Delta-Robot
  - Calculation of complex kinematic transformations
Realization of different control and monitoring functions on one single control – Many-Core-Control with the automation software TwinCAT

- **Increase of energy efficiency**: Power monitoring
  - Acquisition of energy consumption data
  - Data transmission to superior systems

- **Increase of availability**: Condition monitoring
  - Vibration monitoring
  - Data analysis on the control
  - Data transmission to superior systems
Realization of different control and monitoring functions on one single control – Many-Core-Control with the automation software TwinCAT

- **Process reliability:** Monitoring
  - Measurement of differential pressure
  - Monitoring of vacuum for part handling

- **Manipulation and visualization:** HMI
  - Multi-touch Panel with TC HMI
  - Integration of third party hardware
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Beckhoff Industrie 4.0 Demonstration

Cloud Services

Headquarters
Verl, Germany

Outdoor, R139
Pub/Sub

Hall 16, A04
Pub/Sub

Hall 9, F06
Pub/Sub

Hall 7, C40
Pub/Sub

Hall 9, F06
Pub/Sub
Research Project | itsOWL-ScAut

Project overview
Scientific Automation approaches
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Summary
Research Project | itsOWL-ScAut – Scientific Automation
Benefits for participants in the project

Partner
- Increased reliability, sustainability and quality of the production systems
- 8 % increase in productivity
- 10 % reduction in energy consumption
- 8 % reduction in lead times
- 50 % reduction in scrap rate
- 20 % reduction in emissions and immissions
- 30-40 % increase in tool service life

Regional benefits
- Stabilization of lectures at universities, of further education, of research lead to qualified people
- Transfer of special knowledge about different technologies will increase the competitiveness of local companies