Virtual Commissioning in the Digital Enterprise
Presented by: Thomas Hoffman
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Before we start… A Penny for Your Thoughts

At the end of the session, share your feedback via MiA App - and get a chance to win tickets to the Detroit Tigers baseball game!
What is a twin?
Comprehensive and precise Digital Twin
Comprehensive and precise Digital Twin

Product Digital Twin

Performance Digital Twin
Comprehensive and precise Digital Twin
Closing the Production Loop
Comprehensive and precise Digital Twin
Closing the Production Loop

Plant Simulation

Manufacturing Operations Management
Comprehensive and precise Digital Twin
Closing the Loop to Gain **Foresight** and **Insight**

Gain **foresight** by simulating products, people, processes and resources interacting in the virtual world.

Gain **insight** by matching real-world performance to our predictions so we can drive continuous improvement.
The Digital Twin in Action
Robotic Operations

CAD-CAM

Motion Control
The Digital Twin in Action
Automated Operations | Virtual Commissioning

Digital Twin of S7-1500

Real S7-1500
The Digital Twin in Action
Manual Operations

- Process Simulation
- Electronic Work Instructions
The Digital Twin in Action
Closed Loop Manufacturing

Plant Simulation
Manufacturing Operations Management
Closing the Loop with the Digital Twin
Across the entire Value Chain

1. Product design
2. Production planning
3. Production engineering
4. Production execution
5. Services

IDEATION
REALIZATION
UTILIZATION

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Different phases of the machine or plant lifecycle...

Development
1. Preliminary Design
2. Detailed Design

Realization
3. Commissioning
4. Operator Training

Utilization
5. Retrofit
…use a common simulation model…
...to shorten development time and increase quality
System Engineering Approach

Production Plants
- Plant Simulation

Production Cells
- Process Simulate

Machines
- Mechatronic Concept Designer

Machines Components
- Simcenter Amesim
Integrated Production Systems Engineering

Cell / Line Building
- Teamcenter Manufacturing
- Line Designer integrated in NX
- Automation Designer integrated in NX
- Totally Integrated Automation Portal
- Process Simulate / Plant Simulation / PLCSIM Advanced

Teamcenter
- Process planning
- Line design
- Mechanical design
- Automation design
- Automation engineering
- Virtual commissioning

Reusable components within mechatronics library

Integrated engineering of mechanics and automation with change management

Generators and round-trip capabilities

Integrated simulation and integrated validation

Machine Building
- NX / MCD integrated in NX
- Automation Designer integrated in NX
- Totally Integrated Automation Portal
- MCD / PLCSIM Advanced

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From simulation to Virtual Commissioning

1. Preliminary Design
   - Mechatronic concept
   - Tool Selection & Reachability
   - Material Flow Concept

2. Detailed Design
   - Mechanic, Electric, Automation Design
   - Toolpath and offline Programming
   - Line Design & Validation

3. Commissioning
   - Detailed design validation
   - Performance analysis

4. Operator Training
   - Training of shop floor-personnel
   - Upfront validation using virtual equipment
   - Shorter breakdown-times

5. Retrofit
   - Validation of the changes of the plant

Simulation

Software in the Loop

- Test of single plant parts and components
- Preliminary tests and validation
- Detailed design validation
- Performance analysis
Virtual commissioning
Software in the loop

TIA Portal
PLCSIM Advanced
WinCC

Virtual Commissioning

Automation process
Process & Mechanical simulation

Electrical & automation behavior simulation
From simulation to Virtual Commissioning

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   - Mechatronic concept
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5. Retrofit
   - Validation of the changes of the plant

Simulation
- Software in the Loop
  - Test of single plant parts and components
  - Preliminary tests and validation
- Hardware in the Loop
  - Cycle time validation
  - Mixed validation with hardware
  - Mixed validation with other plant parts
Virtual commissioning

Hardware in the loop

Siemens Automation device

SIMIT Unit

TIA Portal

Electrical & automation behavior simulation

Automation Process

Process & Mechanical simulation

Virtual Commissioning

Hardware in the loop

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Virtual commissioning

Switching HiL ↔ SiL

- S7-1500
- SIMIT Unit
- Siemens Automation device
- TIA Portal
- PLCSIM Advanced
- WinCC

Virtual Commissioning

Automation Process

Software in the loop

Electrical & automation behavior simulation

Process & Mechanical simulation

Hardware in the loop
System Engineering Approach

Production Plants

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Machines

Machines components

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Process Simulate

Mechatronic Concept Designer

Simcenter Amesim

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Optimizing performance of the machine
What is a system?

- Systems have **structure**, defined by parts and their composition
- Systems have **behavior**, which involves inputs, processing, outputs of material, energy or information
- Systems have **interconnectivity**: the various parts have functional and structural relationships
- Systems have by themselves **functions** or **groups of functions**

A group of **multi-domain | multi-physics**

Components **interacting** together
What is mechatronic system simulation?

Classical design issues:
- Is the electric motor powerful enough?
- What is the time response of the system?
- What maximum pressure can be reached?
- Is there any risk of vibration?
- How to optimize the control design?
What is mechatronic system simulation?

1D system simulation
Is (usually)

- Equations dependent of time (ODE, DAE)
- Linked to the power flow within a system
  - Where does the power go?
  - Where is power lost?
  - Where is power created?
  - Where is power exchanged?
- Linked to the control of this power
  - Linked to automation & control
  - Linked to electronics → mechatronics
- Based on direct input of a reduced number of parameters

1D system simulation
Is not (usually)

- Not equation dependent of space (X,Y,Z) (partial derivative equations)
- Not designed to simulate fixed structures
- Not designed to simulate a single physics
Machine optimization

Virtual commissioning with Simcenter Amesim

Capabilities
• Size actuators according to performance and consumption targets
• Connect directly with PLC Hardware or PLC Simulation (PLCSIM Adv.)
• In operation simulation for additional information on the current state of the machine and additional safety loops
• In operation optimization using the simulation of future machine states

Key Points
• Optimization before machine building and during operation
• Validate performances during retrofit phases
• Generate information through virtual sensors
Typical setup

Hardware in the Loop (HiL) & Software in the Loop (SiL)

Hardware in the Loop

Siemens PLC

Profinet

SiMII Unit

Simulation Unit API

LMS Amesim 16
(Dec 2017)

Software in the Loop

TIA Portal V.14SP1
PLCSIM Adv V.1.0 SP1

OPC UA

PLCSIM Adv. API

LMS Amesim 16
(Dec 2017)
Design and simulate the machine concept

NX Mechatronics Concept Designer
How will the machine work?

- Machine sequence
- 3D basic geometry
- Cam plates
- Sensor-actuator lists
- Kinematic description
- Reference designation
- Control signals
- Force/load profiles

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Integrated engineering reduces the time from the first idea to the machine realization

Today

- Planning
  - Requirements
- Concept Design
  - Mechanical concept
- Detailed Engineering
  - Mechanical design
  - Electrical / Fluid
  - Software
- Commissioning
  - Real Machine
  - Real commissioning

Future

- Systems Engineering
- Concept Design
  - Mechanical concept
- Interdisciplinary Engineering
  - Mechanical design
  - Electrical / Fluid
  - Software
  - Digital Twin
  - Virtual commissioning
- Commissioning
  - Real Machine
  - Real commissioning

Time saved
Granularity of the simulation during the concept phase

Simple process

Detailed process

Refined process

Complex process

- Mechatronic Simulation in the concept phase
- Validation of the concept idea
- Present and communicate a concept between the teams and to customers
- Data source for all the future multidisciplinary developments
Kinematic validation
Virtual commissioning with Mechatronic Concept Designer

Capabilities
- Define mechatronic model including kinematic, sensors, actuators, logic and signals
- Connect directly with PLC Hardware or PLC Simulation (PLCSIM Adv.)
- Share data between mechanical, electrical and automation departments
- Reuse standardized mechatronic components for a faster machine design

Key Points
- Define and validate the mechatronic concept of the machine directly with the CAD model in the early phases of development
- Optimize machine design before the first prototype (sequence, traveling path, speed of motors, position of sensors...)
MCD typical setup

**Hardware in the Loop (HiL) & Software in the Loop (SiL)**

**Hardware in the Loop**
- Siemens PLC
- SIMIT Unit
- SIMIT 9.1
- NX MCD 12
- Profinet
- Simulation Unit API
- OPC UA

**Software in the Loop**
- TIA Portal V.14SP1 PLCSIM Adv V.1.0 SP1
- SIMIT 9.1
- NX MCD 12
- OPC UA
- PLCSIM Adv. API
- PLCSIM Adv. API
System Engineering Approach

Production Plants

Production Cells

Machines

Machines components

Plant Simulation

Process Simulate

Mechatronic Concept Designer

Simcenter Amesim
Production engineering

Validate Automation Cells

Tecnomatix Process Simulate

Digital Twin of SIMATIC S7-1500
Cell validation

Simulation – typical objectives

- **Safety**
  - Comply with geographic facility requirements
- **Build Quality**
  - Achieve interlock and operator safety requirements
- **Cycle Time/Throughput**
  - Meet volume production and quality targets
Cell validation
Virtual commissioning with Process Simulate

Capabilities
- Validate Mechanical Sequences
- Verify PLC code, Robot Programs and HMI
- Test Safety Interlocks
- Perform System Diagnostic testing

Key Points
- Develop complete robot programs
- Perform “what-if” scenarios (Failure Modes)
- Validation prior to cell construction
Process Simulate typical setup

**Hardware in the Loop (HiL) & Software in the Loop (SiL)**

**Hardware in the Loop**
- Siemens PLC
- SIMIT Unit
- Tecnomatix Process Simulate v. 13.1.1

**Profinet**

**Software in the Loop**
- TIA Portal V.14SP1
- PLCSIM Adv V.1.0 SP1
- Tecnomatix Process Simulate v. 13.1.1

**OPC**

**Simulation Unit API**

**PLCSIM Adv. API**
System Engineering Approach

Production Plants

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Machines

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Plant Simulation

Process Simulate

Mechatronic Concept Designer

Amesim
Production engineering

Optimize material flow

Tecnomatix
Plant Simulation
Material flow optimization

Simulation – typical objectives

- Reduced throughput time
- Optimized lot size
- Reduced stock size
- Less work in progress
- Reduced over dimensioning
- Increased flexibility on customer demands
- “What if scenarios”
- Reduced number of “gut decisions”
- Investment savings
- Detection of interdependencies
- Optimized control strategies
- Reduced number of "gut decisions"
- Reduced throughput time
- Increased flexibility on customer demands
- “What if scenarios”
- Reduced number of “gut decisions”
- Investment savings
- Detection of interdependencies
- Optimized control strategies
Cell validation
Virtual commissioning with Plant Simulation

Capabilities
• Validate material flow and control logic
• Verify PLC code and HMI
• Verify conveying unit and head unit level
• Perform system diagnostic testing

Key Points
• Perform “what-if” scenarios (Failure Modes)
• Validation prior to conveying system construction
• Operator training
Plant Simulation typical setup

*Hardware in the Loop (HiL) & Software in the Loop (SiL)*

Hardware in the Loop
- Siemens PLC
- Tecnomatix Plant Simulation v. 11
- OPC

Software in the Loop
- TIA Portal V.14SP1
- PLCSIM Adv V.1.0 SP1
- Tecnomatix Plant Simulation v. 13.2
- PLCSIM Adv. API
Benefits of Virtual Commissioning

Speed

Flexibility

Quality

Efficiency

Security
Questions?

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