THE REFERENCE ARCHITECTURAL MODEL RAMI 4.0 AND THE STANDARDIZATION COUNCIL AS AN ELEMENT OF SUCCESS FOR INDUSTRY 4.0

WASHINGTON D.C., 2018-04-10

A joint project by

bitkom  VDMA  DKE  DIN
ZVEI: Die Elektroindustrie
PLATTFORM INDUSTRIE 4.0
Overview

• What is Industrie 4.0
• Why Standardization Council Industrie 4.0
• How to realize Industrie 4.0
• Summary
WHAT IS INDUSTRIE 4.0?
Industrial Revolution
Transforming industries and innovation

1st industrial revolution
Triggered by mechanical production facilities. Driven by water- and stream-power.

2nd industrial revolution
Implementation of large-scale production. Based on the division of labor driven by electric energy.

3rd industrial revolution
Automation of the production with electronics and IT.

4th industrial revolution
Based on Cyber-Physical Systems.

1784
1st mechanical loom

1870
1st band-conveyor, slaughterhouse of Cincinnati

1969
1st programmable logic controller (PLC), Modicom 084

Today

26.04.2018
The potential of digital transformation
The main tracks of Industrie 4.0 (I4.0)

Horizontal Integration
- Life Cycle Costs
- Value Chains
- Tailored Products
- Continuously Engineering
- Systems Engineering
- Through Supply Chain
- Digital Factory

Vertical Integration
- Reconfigurability
- Batch Size 1
- Apps
- Steady Change
- Human as conductor of added value creation
- Orchestration
- Skill-sets
- Knowledge Based Work
- Training

Quelle: Festo & Siemens
WHY

STANDARDIZATION COUNCIL I4.0
The world of harmonized Standardization Today
From German Point of View

ISO: International Organization for Standardization
IEC: International Electrotechnical Commission
ITU: International Telecommunication Union
CEN: European Committee for Standardization
CENELEC: European Committee for Electrotechnical Standardization
ETSI: European Telecommunications Standards Institute
DIN: German Institute for Standardization
DKE: German Commission for Electrical, Electronic & Information Technologies of DIN and VDE

DIN and DKE represent German interests in European and international standardization.
Collaboration
Industrie 4.0 requires cross-connected standards over domains. The SCI4.0 connects all relevant organizations within the Industrie 4.0 Network.

Agile Standardization
Close relationship between the SCI4.0 and LNI4.0, to enable Standardization through trial and write.

Internationalization
The concepts from Germany are being discussed in an early stage with our international partners for consolidation.

Orchestration
How to realize Industrie 4.0?
Standardizing Industrie 4.0

Core Tasks

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**Orchestration**
How to realize Industrie 4.0?
Collaboration

Several standards development organizations need to be considered

Challenges:
- Increased complexity
- High amount on consortia standards
- Parallel solutions are increasing

Resulting:
- Coordination of partners needed
Standardizing Industrie 4.0
How SCI 4.0 is embedded
Collaboration
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Orchestration
How to realize Industrie 4.0?
Standardizing Industrie 4.0
Triangle of Digital Transformation

- Strategic planning / Recommendations
- International Cooperation
- SME integration

- Initiation of cross sectoral Standards
- Coordination of national and international Standards
- Cooperation with international fora & consortia

- Network of Testbeds / Labs
- Practical testing and validation of concepts
- Validated return of results into standardization
Standardizing Industrie 4.0
LNI 4.0 – Landscape of test centres

- ~30 test labs
- High availability through increasing numbers
- Regional distribution in Germany
- Local contacts
- Brought technology mix

SMEs 4.0 – Competence Centers (Mittelstand-digital.de)
Process to orchestrate „Industrie 4.0“ standardization

1. Initiate
2. Evaluate and Decide
3. Standardize (International)
4. Validate

„Industrie 4.0“ Standards

Consensual or Consensus based
Collaboration
Industrie 4.0 requires cross-connected standards over domains.
The SCI4.0 connects all relevant organizations within the Industrie 4.0 Network

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Orchestration
How to realize Industrie 4.0?
THE CHALLENGE:

HOW TO REALIZE I4.0?
Concepts of the I4.0-Component

Sub Models

Language of Industrie 4.0

Implementation Guidelines

Architecture of Industrie 4.0
Semantic – Identification – Functions – Communication – Standards – Internationalization & Partnering
The Reference Architectural Model

RAMI 4.0 is a three-dimensional structured layer model providing a uniform structure and uniform wording, presenting the entire scope of I4.0.

- RAMI allows the relevant aspect of a particular asset to be shown at every point in time along its life cycle
- Complex inter-relationships can be broken down into smaller, clearer sections
- Service-Orientated-Architecture
Standardizing Industrie 4.0
Reference Architectural Model Industrie 4.0 (RAMI 4.0)

Axis I Architecture

- Business: Organisation and Business Processes
- Functional: Functions of the Asset
- Information: Necessary Data
- Communication: Access to Information
- Integration: Transition from Real to Digital World
- Asset: Physical Things in the Real World

Layers

- Life Cycle & Value Stream
  - Business
  - Functional
  - Information
  - Communication
  - Integration
  - Asset

Hierarchy Levels

Source: ZVEI
Standardizing Industrie 4.0
Reference Architectural Model Industrie 4.0 (RAMI 4.0)

Axis II: Hierarchy – the Factory

new world

Layers

1. Business
2. Functional
3. Information
4. Communication
5. Integration
6. Asset

Life Cycle & Value Stream

Hierarchy Levels

IEC 62890

IEC 62264/IEC 61512

Connected World

Enterprise

Work Centers

Station

Control Device

Field Device

Product

Source: ZVEI
Standardizing Industrie 4.0
Reference Architectural Model Industrie 4.0 (RAMI 4.0)

Axis III  Product Life Cycle

Construction Plan
- Development
- Construction
- Computer simulation
- Prototype

Construction Plan
- Software Updates
- Instruction Manual
- Maintenance Cycles

Production
- Product
- Data
- Serial Number

Facility Management
- Usage
- Service
- Maintenance
- Recycling
- Scrapping

Layers
Life Cycle & Value Stream
IEC 62890

Hierarchy Levels
IEC 62264/IEC 61512

Source: ZVEI
Architecture of Industrie 4.0
Semantic – Identification – Functions – Communication – Standards – Internationalization & Partnering

Concepts of the I4.0-Component

Sub Models

Language of Industrie 4.0

Implementation Guidelines

Verwaltungsschale
- Identification
- Communication
- Engineering
- Konfiguration
- Safety (SIL)
- Security (SL)
- Lifecycle Status
- Energie-Effizienz
- Condition Monitoring
- Weitere...

Verwaltungs-Schale
- Bohren
- Fräsen
- Tiefziehen
- Klemmen
- Schweissen
- Lackieren
- Montieren
- Inszenieren
- Validieren
- Weitere...

Verwaltungs-Schale
- Gegenstand, z.B. Maschine
- Gegenstand, z.B. Klemmenblock
- Gegenstand, z.B. Elekt.-Achse
- Gegenstand, z.B. Standard SW

I4.0-konforme Kommunikation
Standardizing Industrie 4.0
The I4.0 Component

RAMI4.0

I4.0 Component

Administration Shell
Representation of Information
Technical Functionality

Asset

Unique description of the asset containing /linked to all relevant data
By defining an "Administration shell" that reflects the virtual image of an object, we build...

• ...a place to determine its **Function** in the whole business process
• ...the **Information** database of the product...
• ...the standardized **communications** interface in the network
• ...the **Integration** between the digital world and the physical asset
**Concepts of the I4.0-Component**

- Verwaltungsschale
- Identifikation
- Communication
- Engineering
- Konfiguration
- Safety (SIL)
- Security (SL)
- Lifecycle Status
- Energie-Effizienz
- Condition Monitoring
- Weitere...

**Sub Models**

- Bohren
- Fräsen
- Tiefziehen
- Klemmen
- Schweissen
- Lackieren
- Montieren
- Inspeizieren
- Validieren
- Weitere...

**Language of Industrie 4.0**

- Verwaltungs-Schale
- Gegenstand, z.B. Maschine
- Gegenstand, z.B. Klemmenblock
- Gegenstand, z.B. Elektr. Achat
- Gegenstand, z.B. Standard SW
- I4.0-konforme Kommunikation

**Architecture of Industrie 4.0**

- Semantic – Identification – Functions – Communication – Standards – Internationalization & Partnering
Standardizing Industrie 4.0
Sub Models enable to handle the complexity

The 5 main requirements for properties of sub-models:

• Properties must be **suitable for types and instances**
• There must be a **capability of hierarchical and countable structuring** of the properties
• Properties must be **able to reference other properties**, also in other Administration Shells
• Properties must be **able to reference information and functions** of the Administration Shell
• Properties must take into account **aspects of information security** by means of graduated guarantees of availability, integrity, confidentiality, visibility and authenticity
Standardizing Industrie 4.0
General structure of the Administration Shell with Sub Models

Administration shell

Submodel 1 e.g. energy efficiency
- Property 1.1
  - Property 1.1.1
    - Property 1.1.1.1
    - Property 1.1.1.2
- Data
- Function

Submodel 2 e.g. positioning mode
- Property 2.1
  - Property 2.1.1
    - Property 2.1.1.1
    - Property 2.1.2
- Function
- Function

Submodel 3 e.g. CAD model
- Property 3.1
  - Property 3.1.1
- Data (CAD)
- Data (CAD)

Source: ZVEI SG Modelle & Standards
Standardizing Industrie 4.0
Progress of Standardization

Architecture of Industrie 4.0
Semantic – Identification – Functions – Communication – Standards – Internationalization & Partnering

Concepts of the I4.0-Component
Sub Models
Language of Industrie 4.0
Implementation Guidelines
The communication (language) of I4.0 supports several modes

- Activation of assets in a station/plant
- Dynamic cooperation and reconfiguration
- Asset oriented hierarchies
- Decentralized Functionalities

The Knowledge is encoded in a common exchangeable **semantic** for e.g.

- Knowledge about the I4.0 component
- Knowledge about relations
- Properties
- Relations of Data and Informations
We need a "universal language" for all players and devices that is...

I. ... STANDARDIZED
- secure interoperability
- across branches
- across companies
- across devices
- globally accepted, no proprietary solution
- open standard instead of closed system

II. ... SAFE & SECURE
- right data
- right receiver
- no delay (real-time transmission)
- no external intervention
- security standards / security by design

III. ... TESTED & TRAINED
- established testing processes
- test environments
- test centres
- exchange of best practices
- training & qualification programs for developers and users

Summary
We need a "universal language" for all players and devices that is...
**Concepts of the I4.0-Component**

- **Sub Models**
  - Verwaltungsschale
    - Identifikation
    - Communication
    - Engineering
    - Konfiguration
    - Safety (SIL)
    - Security (SL)
    - Lifecycle
    - Energie-Effizienz
    - Condition Monitoring
    - Weitere ...
  - Bohren
  - Fräsen
  - Tiefziehen
  - Klemmen
  - Schweissen
  - Lackieren
  - Montieren
  - Inspizieren
  - Validieren
  - Weitere ...

**Language of Industrie 4.0**

- **Implementation Guidelines**

**Architecture of Industrie 4.0**

Semantic – Identification – Functions – Communication – Standards – Internationalization & Partnering
Roadmap Industrie 4.0
Version 3: 2018-04-24 Hannover Fair

- Additions in the standardization environment
- Recommendations for action in the environment of Industrie 4.0
  - Reference architecture model
  - Industrie 4.0 component
  - Semantics
  - Administration shell
  - Use cases
  - I 4.0 relevant standards and specifications
New Standards for Industrie 4.0 (Examples)

under preparation:
- DIN SPEC 27070 | RA eines Security Gateways zum Austausch von Industriedaten und Diensten
- DIN SPEC 16593 | Referenzmodell für Industrie 4.0-Servicearchitekturen [SOA]
- IEC 62832 Part2 | Model elements
- IEC 62832 Part3 | Application of Digital Factory for Life cycle management of production systems
- IEC 62657 Part1 | Industrial communication networks - Wireless communication networks
  - Wireless communication requirements and spectrum considerations
- IEC 62657 Part2 | Industrial communication networks - Wireless communication networks
  - Coexistence management
- IEC 62657 Part3 | Definition of system elements, properties, interfaces and relationships
- IEC 62657 Part4 | Coexistence management with central coordination of wireless applications
- 3GPP TR 22.xxx | Communication for Automation in Vertical Domains (5G)
- VDI/VDE GMA | Universal standards for automation (OPC-UA and AutomationML)
- DIN SPEC 91345 | Referenzarchitekturmodell Industrie 4.0 (RAMI4.0)
- DIN SPEC 16592 | Universele Schnittstellen für die Automatisierung (OPC-UA und AutomationML)
- DIN SPEC 91349 | Taxonomie zu Regelwerken bei Smart Data
- IEC 62832 Part 1 | Industrial-process measurement, control and automation Digital Factory framework
- IEC-PAS-63088 | Smart Manufacturing – Reference Architecture Model Industry 4.0 (RAMI4.0)

Identified Standards for Industrie 4.0 (in progress)

Standardlist for Smart Manufacturing/Industrie 4.0:
around 550 Stds are identified by international experts (IEC/ISO) as main standards for Industrie 4.0.
Classified (Facets for Smart Manufacturing) and needs to be proofed for update s

Core Standards for Industrie 4.0:
around 130 Standards were identified from experts (ZVEI SG Modelle & Standards) as core standards for Industrie 4. and has to be checked and e.g. modified case by case
Save the Dates

23rd – 27th April: Hannover Fair 2018

10th – 14th September: Hannover Fair USA 2018, Chicago

- Industrie 4.0 meets the Industrial Internet of Things – Solutions Theater
- US-German Standards Panel on Smart Manufacturing
Standardizing Industrie 4.0
How SCI 4.0 is embedded
Standardizing Industrie 4.0
Web-based process for Standardization

Just fill out -> send -> Standardization starts
www.lni40.de

automatic generated email
as pdf@ SCI4.0 office

Next steps
- Consolidation with the Platform I4.0/AG1 and the working groups
- Clarification of ressources and start of standardization

26.04.2018
Joint Use Cases Development – Value Based Services

Next steps until 2018

#1 Completion of the description of the Usage Viewpoint for a concrete business setup within the group “modelling examples”

#2 Completion of the description of the Functional Viewpoint aspects

#3 Detailing the “Use Cases” within TC65 Smart Manufacturing, Germany-Japan cooperation

#4 Achieve overall goal and create descriptions that match each other at the interface between Usage Viewpoint and Functional Viewpoint
Standardizing Industrie 4.0
Internationalization - China

Alignment Report
RAMI 4.0 / IMSA
Ab März
www.sci40.com

Standardization Roadmap of Predictive Maintenance
ab März
www.sci40.de

The Standardization Roadmap of Predictive Maintenance for Sino-German Intelligent Manufacturing/Industrie 4.0

A joint project of:
National Intelligent Manufacturing Standardization Administration Group (NISG) - Standardization Council Industrie 4.0 (SCI40)
Standardizing Industrie 4.0
Reference Architectural Model Industrie 4.0 (RAMI 4.0)

Axis II: Hierarchy – the Factory

old world

new world

Connected World
Smart Factory
Smart Products

Source: ZVEI
Standardizing Industrie 4.0
I4.0 Component: translate real product objects into virtual images

RAMI4.0

I4.0 Component

Administration Shell
Representation of Information
Technical Functionality

Manifest
Component
Manager

Unique description of the asset containing /linked to all relevant data
We have to translate real product objects into virtual images
We have to translate real product objects into virtual images
Standardizing Industrie 4.0
The I4.0 Component

IT-Systems of the Factory

Administration Shell contains of:

- **Data** (→ manuals, runtime data)
- **Decentralized Functionalities**
- **Knowledge**, described in a common exchangeable *semantic* for e.g.
  - Knowledge about the I4.0 component
  - Knowledge about relations
  - Properties
  - Relations of Data and Informations
  - Etc.
General structure of the Administration Shell

- Smart manufacturing compliant communication
  - Administration shell
    - Asset, e.g. machine
    - Asset, e.g. terminal block
    - Asset, e.g. electrical axis
    - Asset, e.g. standard SW
  - Administration shell
    - Asset gives access to Administration Shell
    - Higher-level system gives access to Administration Shell