Countries around the world are working on initiatives to apply IT into manufacturing and make their country’s manufacturing “smart”

There are multiple simultaneous standardization efforts underway

There are a lot of questions
  • Who is doing it?
  • What is the value?
  • How do you make sense of these efforts and determine what is best for your problems?
  • ... ?
What is Smart Manufacturing?

• Have we been doing Dumb Manufacturing before?
  • **NO!**

• Everything is getting smarter, faster, and cheaper
  • Artificial Intelligence
  • Robotics
  • Autonomous Vehicles
  • Digital Twins
  • Machine Learning
  • Analytics
  • Additive Manufacturing
  • Networks (5G wireless, 1-100G wired)
  • ...
Worldwide Smart Manufacturing

• Countries around the world are working on initiatives to apply IT into manufacturing and make their country’s manufacturing “smart”

• The efforts to define Smart Manufacturing are being led by industry consortiums and the related country’s national standards committees.

• This has led to a menagerie of different standards, based on industry needs, cultural differences, county pain points, and national pride.

• Most of these models are “Reference Models”
Smart Manufacturing Reference Models

• Use a Reference Model to define the architecture for an implementation
• It provides a pattern of elements and their relationships
• The Reference Model must focus on the problem area to be useful
• The IEC/ISO focus is manufacturing organizations & the entire supply chain
Country Specific - RAMI

• RAMI 4.0 is a reference architecture model for Industrie 4.0, which provides a structured view on main elements of Smart Manufacturing

• It describes fundamental ideas for Industrie 4.0 and is used to identify, structure, and illustrate the different areas where standards exist, or standards are required

• It allows setting standards in relation to different perspectives such as layers, hierarchies and life cycles

• RAMI 4.0 has three dimensions, which include layer, hierarchy and life cycle
Country Specific - Intelligent Manufacturing Development Plan

• According to the Intelligent Manufacturing Development Plan (2016-2020) in China, intelligent manufacturing refers to a new production mode based on the deep integration of new generation information and communication technology and advanced manufacturing technology, which runs through design, manufacturing, management, service and other processes of manufacturing activities, featuring self-sensing, self-learning, self-decision, self-executing and self-adaption.
How should you make sense of all these models?

• Create an ISO and IEC Joint Working Group to create a standard Reference Model that makes sense of all the different country, industry, and consortium models.

**Diagram:**
- ISO: TMB, JTC1, SM
- IEC: SMB, JWG21, SC3D
- IEEE: C/SM, TC184, JWG24

**Abbreviations:**
- **JTC1**: Information technology
- **SC32**: Data management and interchange
- **SC42**: Artificial intelligence
- **AG8**: Meta reference architecture and reference architecture for systems integration
- **SC41**: Internet of things and digital twin
- **WG6**: Digital twin
- **AHG1**: Support for smart manufacturing reference model
- **AG2**: Digital twin
- **SMCC**: Smart manufacturing coordinating committee
- **SyC SM**: Systems committee smart manufacturing
- **OF1 (SM2TF)**: Smart manufacturing standard map
- **JWG21**: Smart manufacturing reference model(s)
- **TF8**: Digital twin and asset administration shell
- **TC184**: Automation systems and integration
- **JWG24**: Use of IEC CDD for ISO data dictionaries and ontologies
- **WG15**: Digital manufacturing
- **TC65**: Industrial-process measurement, control and automation
- **WG16**: Digital factory
- **WG23**: Smart manufacturing framework and system architecture
- **WG24**: Asset administration shell for industrial applications
- **TC3**: Information structures and elements, identification and marking principles, documentation and graphical symbols
- **SC3D**: Classes, properties and identification of products - common data dictionary (CDD)
- **IEEE C/SM**: IEEE computer society smart manufacturing standards committee
IEC & ISO Definition of Smart Manufacturing

• IEC SEG7 – ISO SMCC Definition
  • Manufacturing that improves its performance aspects with integrated and intelligent use of processes and resources in cyber, physical and human spheres to create and deliver products and services, which also collaborates with other domains within enterprises’ value chains.
    • Note 1: Performance aspects include agility, efficiency, safety, security, sustainability or any other performance indicators identified by the enterprise.
    • Note 2: In addition to manufacturing, other enterprise domains can include engineering, logistics, marketing, procurement, sales or any other domains identified by the enterprise.
ISO TC184 / IEC TC65 - JWG 21
Smart Manufacturing Reference Model(s)

• JWG21 Terms of Reference
  • Prepare a standardized unified Reference Model to support ISO TC184 and IEC TC65 activities in Smart Manufacturing.
  • The Reference Model shall comprise a single model, possibly with a set of consistent and coherent sub-models, and align with the requirements of stakeholder groups, including manufacturing system users, suppliers, integrators, standardisers, and consumers of manufactured products.

• JWG21 Deliverables:
  • IEC TR 63319 SMRM (A meta-modelling analysis approach to smart manufacturing reference models) – RELEASED
    • The objective of the TR is to review the current status about smart manufacturing reference models and propose a meta-model to describe smart manufacturing reference models.
  • IEC 63339 IS:URMSM (Unified reference model for smart manufacturing) – IN DEVELOPMENT
    • Requirement and specification of a smart manufacturing reference model.
Models compared in JWG 21’s IEC TR 63319
Unified Reference Model for Smart Manufacturing
Simplified Meta-Model Description

• A Smart Manufacturing Framework
  • A collection of one or more facets

• Facet
  • A collection of aspects which may be represented in a dimension
  • Think about a diamond facet, a particular view into an internal structure

• Aspect
  • A collection of concepts in a particular context

• Dimension
  • A coherent collection of concepts in a particular context
  • The collection may be unordered, partially ordered, fully ordered, randomly related or disordered
  • Think lifecycle dimension, hierarchy, networks, ...
Unified Reference Model for Smart Manufacturing
A Map for Smart Manufacturing Models

PS: All Names are Compromises
Scandinavian Smart Industry Framework mapping to SMRM Meta-model v1

Facet – one or more aspect collections intersecting such that some of the intersecting aspects from different aspect collections have meaning for smart manufacturing and contribute to achieving the purpose for which the facet exists. (Of this multi-dimensional space only certain sub-dimensions make sense to SM and the purpose of the meta-model is to facilitate the)

18. Purpose derived aspect intersection – the content of the intersection of aspects within a facet for smart manufacturing

5. Aspect collection – one or more distinct aspects

8. Aspect – view
composed of one or more views of model content, where each view of model content may result from projection from a different model kind.

16. Model content – the collection of values assigned to concepts in a model

17. View – projection of content from a model.

13. Viewpoint – simple, i.e. expressible as an aspect by one kind of view of model content, or complicated, i.e. only expressible by composing an aspect from more than one kind of view from model content.
RAMI 4.0 model mapping to SMRM Meta-model v1

Facet – one or more aspect collection intersecting such that some of the intersecting aspects from different aspect collections have meaning for smart manufacturing and contribute to achieving the purpose for which the facet exists. Of this multi-dimensional space only certain sub-dimensionalities make sense to SM and the purpose of the meta-model is to facilitate this.

1. Business
2. Functional
3. Information
4. Connectivity
5. Integration

Layers

Life Cycle & Value Stream

Quelle: Plattform Industrie 4.0

17. View – projection of content from a model.

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15. Content Structure

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No Single Model Fits All Problems

• No single model suits all problems
  • Just as no single software model addresses all software problems
  • or no single bridge model address all possible bridges

• There is a lot of overlap across the models

• There is a lot of conflicting terminology across the models

• URMSM provides a common terminology to compare and help select the best model to use

• It is just hard to represent multiple dimensions on a 2D picture
Lots of Possible Frameworks using Different Dimensions, Aspects, and Facets
Unified Reference Model for Smart Manufacturing
IEC 63339 IS:URMSM will provide

• Unified Reference Model for Smart Manufacturing (URMSM)
• A common library of aspects
  • As a compilation of aspects from multiple models
• A common library of dimensions
  • To allow individual models to reuse information from existing models
• It defines a way to describe the different representations in a way that can be shared
• Provides the possibility for common way to electronically represent the information of a specific Smart Manufacturing model
Summary
JWG21 Smart Manufacturing Reference Model

• Smart Manufacturing is here
• It includes many different concepts
  • Multiple standards in development
• It includes many different technologies
  • Multiple standards in development
• Use a Reference Model to define the architecture for an implementation
• It provides a pattern of elements and their relationships
• No single model suits all problems
• IEC 63339 IS:URMSM (Unified Reference Model for Smart Manufacturing) will the basis for industry and problem focused Smart Manufacturing models