Smart Manufacturing in International Standards

Kenneth Swope
Senior Manager, Business Architecture
The Boeing Company
Kenneth.a.swope@Boeing.com
Kenny Swope - Biography

Global Product Data Interoperability Summit | 2019

• 25 years at Boeing
• Senior Manager, Commercial Airplanes, Everett, WA
• Systems Engineering Integration Leader 2nd Century Enterprise Systems
• Business Architecture Leader Boeing Commercial Airplanes
• Chair: ISO/TC 184/SC 4: Industrial Data
• Masters: Engineering Management
• Bachelors: Mechanical Engineering & Physics
• Program Leader: Snohomish County 4-H Technology and FIRST Robotics Coach

https://www.linkedin.com/in/kennyswope/
International Organization for Standardization

What ISO Does
Develops International Standards and other deliverables for products, services, processes, materials and systems, and for conformity assessment, managerial and organizational practice.

ISO – the organization
Consists of a network of the most representative national standards bodies from all regions of the world, working in partnership with international organizations such as the United Nations, its specialized agencies and the World Trade Organization (WTO).

ISO’s origins
Founded in 1946 by delegates from 25 countries, ISO began operating on 23 February 1947.

162 Member Countries
ISO/TC 184/SC 4: Industrial Data

SCOPE:
Standardization of the content, meaning, structure, representation and quality management of the information required to define an engineered product and its characteristics at any required level of detail at any part of its lifecycle from conception through disposal, together with the interfaces required to deliver and collect the information necessary to support any business or technical process or service related to that engineered product during its lifecycle.

Note: Lifecycle includes recursive recycling to a terminal state.

Chair: Kenneth Swope
Secretary: Ryan Mayes

765
Published ISO Standards

26
ISO Standards under development

9
Direct Working Groups
3
Joint Working Groups
4
Internal Committees

16
Participating members

14
Observing members

6
Standards

9 Industry, Innovation and Infrastructure
Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation
## ISO/TC 184/SC 4 Organization

<table>
<thead>
<tr>
<th>Work Group</th>
<th>Title</th>
<th>Convenor</th>
</tr>
</thead>
<tbody>
<tr>
<td>AG 0</td>
<td>Change management advisory group</td>
<td>Kenneth Swope</td>
</tr>
<tr>
<td>AG 2</td>
<td>Implementation Forum</td>
<td>Paul van Exel</td>
</tr>
<tr>
<td>PPC</td>
<td>Policy &amp; planning committee</td>
<td>Kenneth Swope</td>
</tr>
<tr>
<td>QC</td>
<td>Quality committee</td>
<td>Hikmet Hussain</td>
</tr>
<tr>
<td>WG 3</td>
<td>Oil, gas, process, and power</td>
<td>Paul van Exel</td>
</tr>
<tr>
<td>WG 8</td>
<td>Manufacturing process and management information TC 184/SC4 – TC 184/SC5</td>
<td>Anne-Françoise Cutting-Decelle</td>
</tr>
<tr>
<td>WG 11</td>
<td>Implementation methods and conformance</td>
<td>David Loffredo</td>
</tr>
<tr>
<td>WG 12</td>
<td>STEP product modeling and resources</td>
<td>Keith Hunten</td>
</tr>
<tr>
<td>WG 13</td>
<td>Industrial data quality</td>
<td>Tim King</td>
</tr>
<tr>
<td>WG 15</td>
<td>Digital manufacturing</td>
<td>Martin Hardwick</td>
</tr>
<tr>
<td>JWG 16</td>
<td>Formats for visualization and other derived forms of product data TC 184/SC 4 – TC 171/SC 2 – JTC 1/SC 24</td>
<td>Soonhung Han</td>
</tr>
<tr>
<td>WG 21</td>
<td>SMRL validation team</td>
<td>Keith Hunten</td>
</tr>
<tr>
<td>WG 22</td>
<td>Reference data validation team</td>
<td>Nils Sandsmark</td>
</tr>
<tr>
<td>WG 23</td>
<td>Vocabulary validation team</td>
<td>Tim King</td>
</tr>
<tr>
<td>JWG 24</td>
<td>Product Properties and classes and their identification</td>
<td>Hiroshi Murayama</td>
</tr>
</tbody>
</table>
Active Work in ISO/TC 184/SC 4

- ISO 15926-4 (40.99)
- ISO 15926-6 (20.20)
- ISO 15926-10 (40.99)
- ISO 15926-14 (20.20)

- ISO 10303-1 (30.99)
- ISO 10303-15 (20.00)
- ISO 10303-16 (20.00)
- ISO 10303-17 (20.00)
- ISO 10303-59 (20.00)
- ISO 10303-113 (40.00)
- ISO 10303-209 (10.99)
- ISO 10303-210 (20.00)
- ISO 10303-235 (50.20)
- ISO 10303-238 (20.00)
- ISO 10303-239 (20.00)
- ISO 10303-242 (40.93)
- ISO 10303-243 (30.99)
- SMRL V8.0

- ISO 14306 ed3 proposed
- ISO 23301 (20.00)

- STEP Geometry services
- Living Lab: Jira & Git hosted by ISO
- Living Lab: URL mapping on iso.standards.org
- STEP Extended Architecture

126 Active Projects!

- ISO 23952 (30.99)
- ISO 23247 (20.00)

- Factory Interfaces
  ISO 15531
  ISO 18629
  ISO 18876
  ISO 18828

- ISO 8000-63 (40.99)
- ISO 8000-64 (20.00)
- ISO 8000-65 (20.00)
- ISO 8000-66 (20.00)
- ISO 8000-81 (20.00)
- ISO 8000-116 (40.60)

- Oil and Gas – ISO 15926
- Product characteristics from ISO 22745
- Product Definition data (STEP) – ISO 10303
- Visualisation – ISO 14306,17506
- Industrial terminology using ISO 22745
- Data quality – ISO 8000
- Product Classification using ISO 22745
- Product Libraries – ISO 13584

- ISO/TC 184/SC 4 Industrial Data
- 13 May, 2019
Smart Manufacturing @ ISO: Motivation

10 Recommendations
• Formalize the definition
• Formalize a joint future with IEC and ITU
• Establish collaboration internally across ISO
• Act on exposed gaps in ISO/IEC Standards

TMB RESOLUTIONS: 103, 104, & 105
from 67th TMB MEETING
(10 September 2016, Beijing)
Smart Manufacturing Strategy

- Form a Coordination Committee of ISO Technical Committees
- Establish joint ISO/IEC coordination
- Agree on definition of Smart Manufacturing
- Create Joint Working Group for a Reference Model
- Create a Task Force to map standards to definition
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.

Action to all standards within ISO & IEC to incorporate definition when developing standards
"Smart Manufacturing" models by Country

Global Product Data Interoperability Summit | 2019

- China
- France
- USA
- Sweden
- Korea
- ISO Standards
- ISO 15704
- Japan
- Korea
- Spain
- Italy
- UK
- Japan
- Germany
- France
- China
- Canada
- Others
• Utilize ISO 42010 to develop a model of models (Meta-Model)
• Validate Country contributions to Meta-Model
• Release a Technical Report of the method
• Develop an International Standard for the reference model
• Release in parallel in ISO and IEC
Validation Examples to demonstrate model quality

Interoperability of Meta-Models
Facilitates collaboration with diversity.
• Strategy: Industrial Perspective
• Agreement on definition and lexicon for smart manufacturing
• Simple scope, small pilots, early wins
• Data security & provenance
• Common ontology & terms across standards
• Interoperability targets & capabilities
• Quality of information, pedigree of data
• Data Ethics
• “Happy Humans”
• Clear boundaries
• Establish paths to wisdom from data
• ISO cadence improvements
ISO 23247: Digital Twin Manufacturing Framework

ISO 23247
Part 1 Overview
Part 2 Architecture
Part 3 Digital Representation
Part 4 Information Exchange

CNC 100Hz
30Hz
100Hz
Machining Agent
Person Agent
Device Agent

Product Models
Operation & Management Domain (OMD)
Synchronization FE
OPM Support FE
Visualization FE
Virtual Modeling FE

Application & Service Domain (ASD)
Simulation FE
Reporting FE
Analytic Service FE
Application Support FE

Resource Access & Interchange Domain (RAID)
Interoperability Support FE
Plug & Play Support FE
Access Control FE
Peer Interface FE

User Domain (UD)
User Interface FE

Cross-Domain Functional Element (FE)
Data Assurance FE
Information Exchange FE
Security Support FE

Physical Manufacturing Elements Domain (PMED)
Identifier
Elements-peculiar FEs

IoT Architecture (ISO 30141)

Committee Draft in Ballot

ISO NWI 23247
Multiple Committees in ISO focused on Digital Twin
- TC 184 formed an AdHoc Group to propose a definition for the Digital Twin and provide a recommendation on a program of working including possible collaboration with IEC/TC 65
- The AdHoc is developing a proposed definition, architecture landscape, and use cases
- JTC 1/SWG 7 launched Advisory Group on Digital Twin;
- JWG 21 formed a Task Force to mature
Committee Innovations: Improvement @ ISO
TC 184/SC 4: Industrial Data

• ISO 8000-2
  – Twice a year release of vocabulary using amendment procedure
  – Renewed to demonstrate process

• ISO 10303-242
  – Utilize Jira/Git to implement “Agile @ ISO” for computer interpretable content
  – ISO evaluating implementation, approval anticipated

• ISO 15926-4
  – Update standards.iso.org to provide version references “One-click” from the standard
  – Concept demonstrated, gaps identified in infrastructure
Questions?
Even more opportunity for modelling using the SMRM Framework
The content of the purpose derive aspect intersection is the cross product of the contents of the intersecting aspects, i.e. the model content projected to compose the view(s) that comprise each of the intersecting aspects. As shown above: Business(Interface), Product(Composition), Production(Production resource, Composition in Production). While not called a viewpoint in the meta-model, this intersection is a conjunction of the separate viewpoints that govern the content of the views from which it is composed – a kind of super-viewpoint that results from the concerns of many stakeholders.
RAMI 4.0 model mapping to SMRM Meta-model v1

The content of the purpose derived aspect intersection is the cross product of the content of the intersecting aspects, i.e., the model content projected to compose the view(s) that comprise each of the intersecting aspects. As shown above: Layers(Functional, Information), Hierarchy Levels(Connected World, Enterprise), Life Cycle & Value Stream (Development). While not called a viewpoint in the meta-model, this intersection is a conjunction of the separate viewpoints that govern the content of the views from which it is composed—a kind of super-viewpoint that results from the concerns of many stakeholders.

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-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

6. 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.

5. Aspect collection – one or more distinct aspects

17. View – projection of content from a model.

13. Viewpoint – ... simple, i.e. expressible as an aspect by one kind of view from model content, or complicated, i.e. only expressible by composing an aspect from more than one kind of view from model content.
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-dimensions make sense to SM and the purpose of the meta-model is to facilitate the)

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.

5. Aspect collection — one or more distinct aspects

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

15. 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 from model content, or complicated, i.e. only expressible by composing an aspect from more than one kind of view from model content.

The content of the purpose derive aspect intersection is the cross product of the content of the intersecting aspects, i.e. the model content projected to compose the view(s) that comprise each of the intersecting aspects. As shown above: System Hierarchy (Cooperation, Enterprise, Intelligent Function, Information Fusion), Life Cycle (Design). While not called a viewpoint in the meta-model, this intersection is a conjunction of the separate viewpoints that govern the content of the views from which it is composed — a kind of super-viewpoint that results from the concerns of many stakeholders.
The purpose of this model is to identify standards applicable for resolving concerns of the various aspects of smart manufacturing, particularly those standards that apply at the intersection of aspects. The elements of the purpose derive aspect intersections become the Smart Manufacturing Landscape. Three sets of life cycle phases, one each for Business, Product, and Production, intersect at each of the 4 tiers of the Mfg Pyramid, e.g. (Business manufacture, Product manufacture, Production manufacture, Manufacture HMI/DCS). Missing from the figure are important interconnection paths among the many aspects of smart manufacturing useful in capturing its digital thread. In total these intersections identify source material for searching the libraries of standards for those applicable at the intersection, i.e. the Smart Manufacturing Standards Landscape is a conjunction of the separate viewpoints that govern the content of the views from which it is composed and an articulation of the standards pertinent to that context.
Implementation Model for Smart Manufacturing

Smart Manufacturing Domain Meta-Model

ISO Deliverables
Technical Report (Requires only a majority on a C18 ballot)

is the basis for

SMRM International Standard

Publicly Available Specification
(Requires x P members and less than 25% negative votes)

Technical Specification

Electronic Insert

International Standards Body
ISO
IEC

Sales channels
Online Browsing Platform
standards.iso.org
www.iso.org

Matures into:

SMRM Instantiated Model

A National Model

An implementation of the meta model can be a national model or any other model from contributing organizations that comply with the reference model. These models can be released as technical specifications and don’t require the same level as an international standard. Further, the models can be documented and released through the governance system and the electronic version of the model itself can be released as an electronic insert. This can happen much faster than releasing an joint IS through IEC/ISO.
Group Activity

What needs to be on the roadmap to implementing smart manufacturing?
What needs to be on the roadmap to implementing smart manufacturing?

- Simple scope, small pilots, early wins
- ISO cadence improvements
- Data security & provenance
Team 2: Summary

What needs to be on the roadmap to implementing smart manufacturing?

- Common ontology & terms across standards
- Interoperability targets
- Quality of information, pedigree of data
- Ethics needs to be on the roadmap
Team 3: Summary

What needs to be on the roadmap to implementing smart manufacturing?

- Ensure clear goals
- “Happy Humans”
- Common definition
- Establish clear boundaries
- Interoperability capabilities
Team 4: Summary

What needs to be on the roadmap to implementing smart manufacturing?

- Strategy: Industrial Perspective
- Agreement on definition and lexicon for smart manufacturing
- Establish paths to wisdom from data
Team 5: Summary
What needs to be on the roadmap to implementing smart manufacturing?

• Visualization extensions to all data types
  • “It’s more than CAD”
• Recommended practices for standards
• Common vocabulary to keep digital twins aligned