Smart Manufacturing in International Standards

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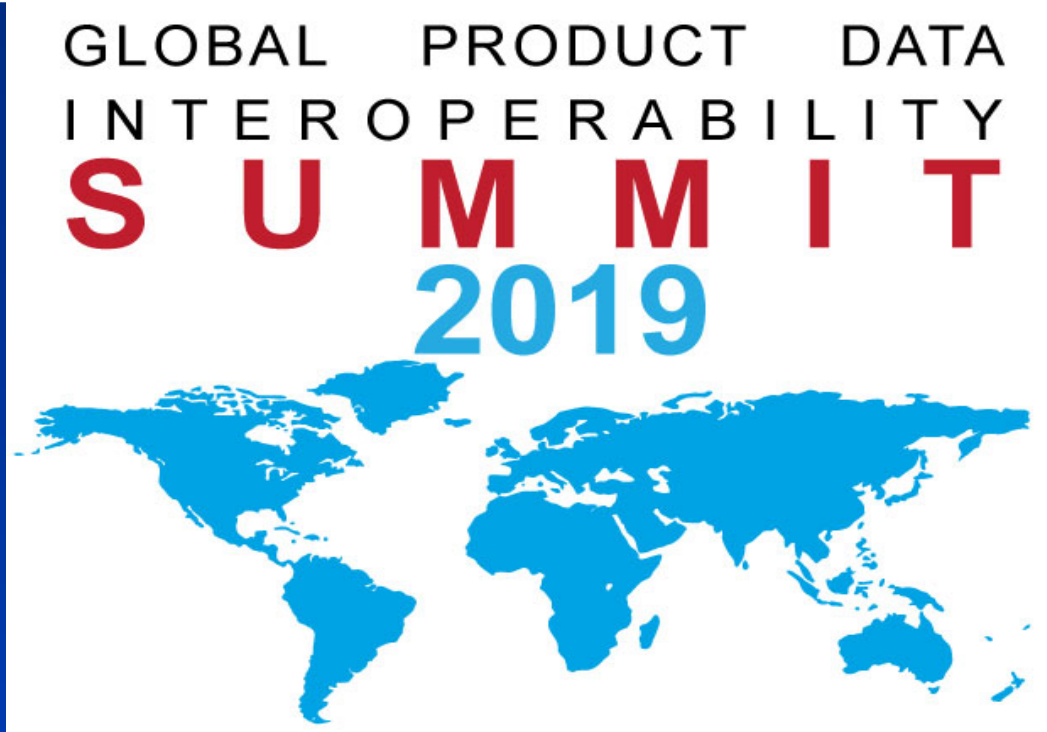


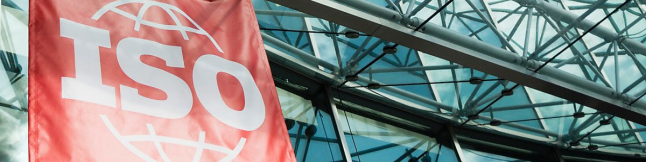
RROI: 19-160434-BCA

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/



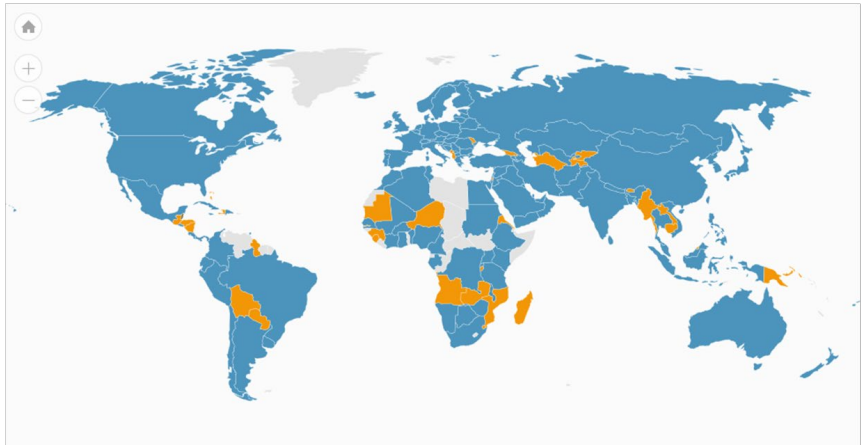
International Organization for Standardization

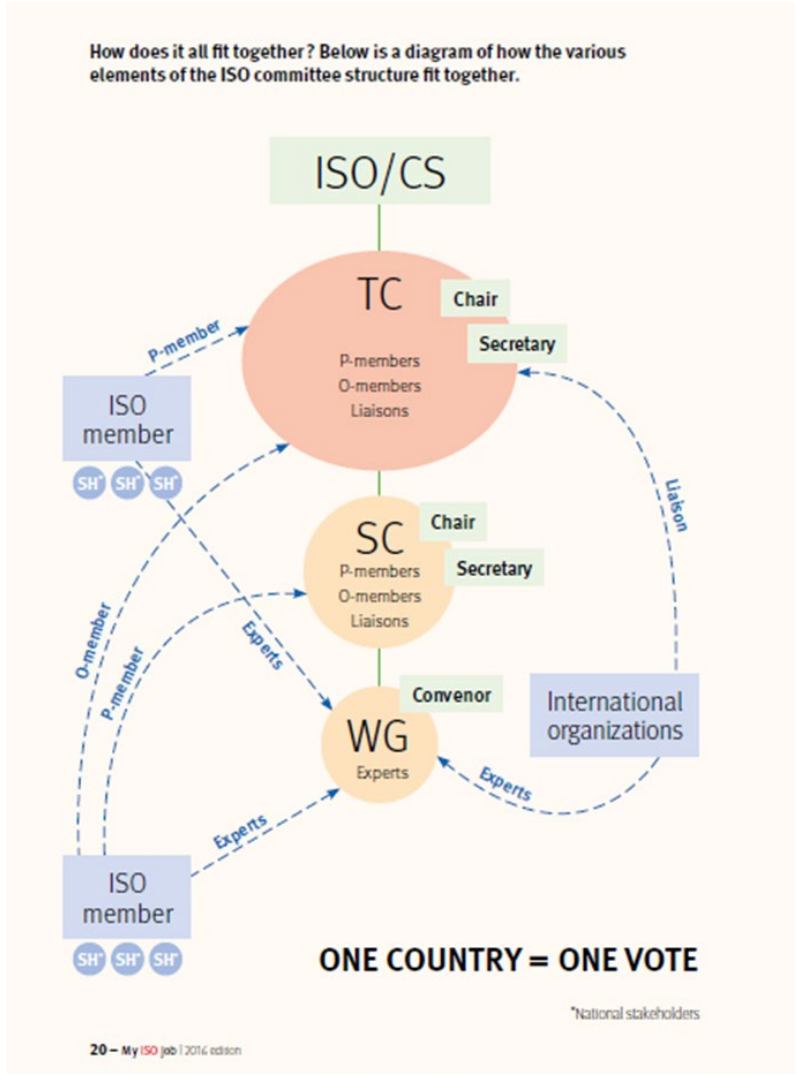
What ISO Does
Develops International Standards and other deliverables for products, services, processes, materials and systems, and for conformity assessment, managerial and organizational practice.

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



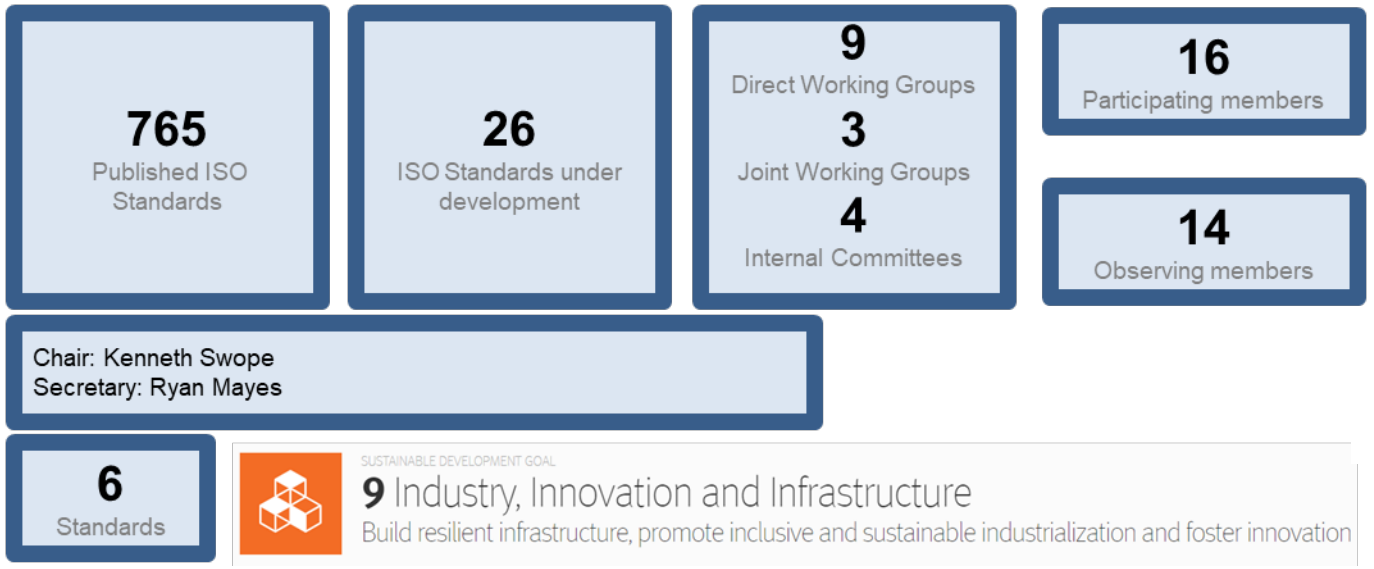


ISO/TC 184/SC 4: Industrial Data

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.



The 2007 Lawrence D. Eicher Leadership Award

ISO/TC 184/SC 4 Organization

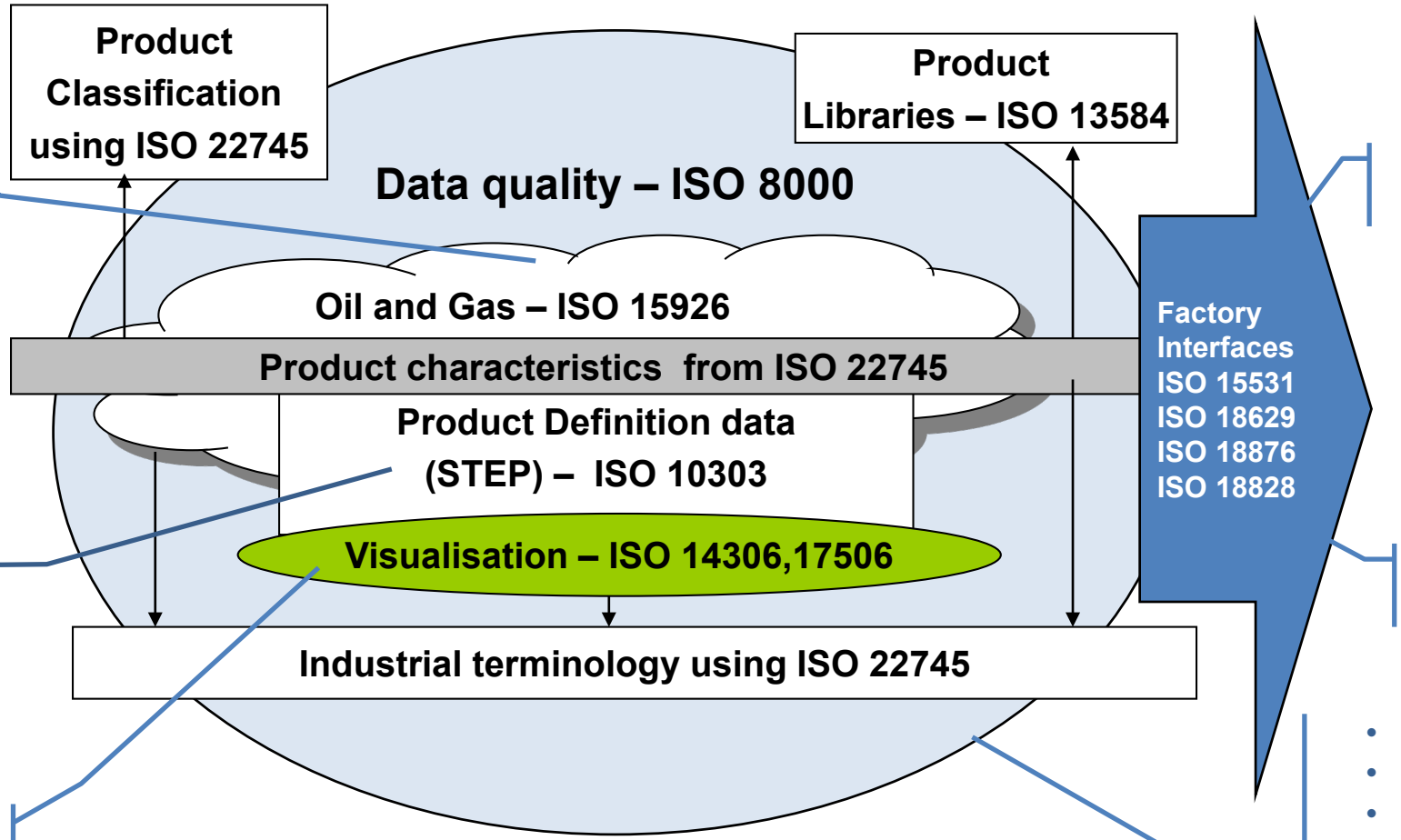
Work Group	Title	Convenor
AG 0	Change management advisory group	Kenneth Swope
AG 2	Implementation Forum	Paul van Exel
PPC	Policy & planning committee	Kenneth Swope
QC	Quality committee	Hikmet Hussain
WG 3	Oil, gas, process, and power	Paul van Exel
WG 8	Manufacturing process and management information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

Active Work in ISO/TC 184/SC 4

126 Active Projects!

- 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 23952 (30.99)
Quality Information Framework

ISO 23247 (20.00)
Digital Twin manufacturing framework

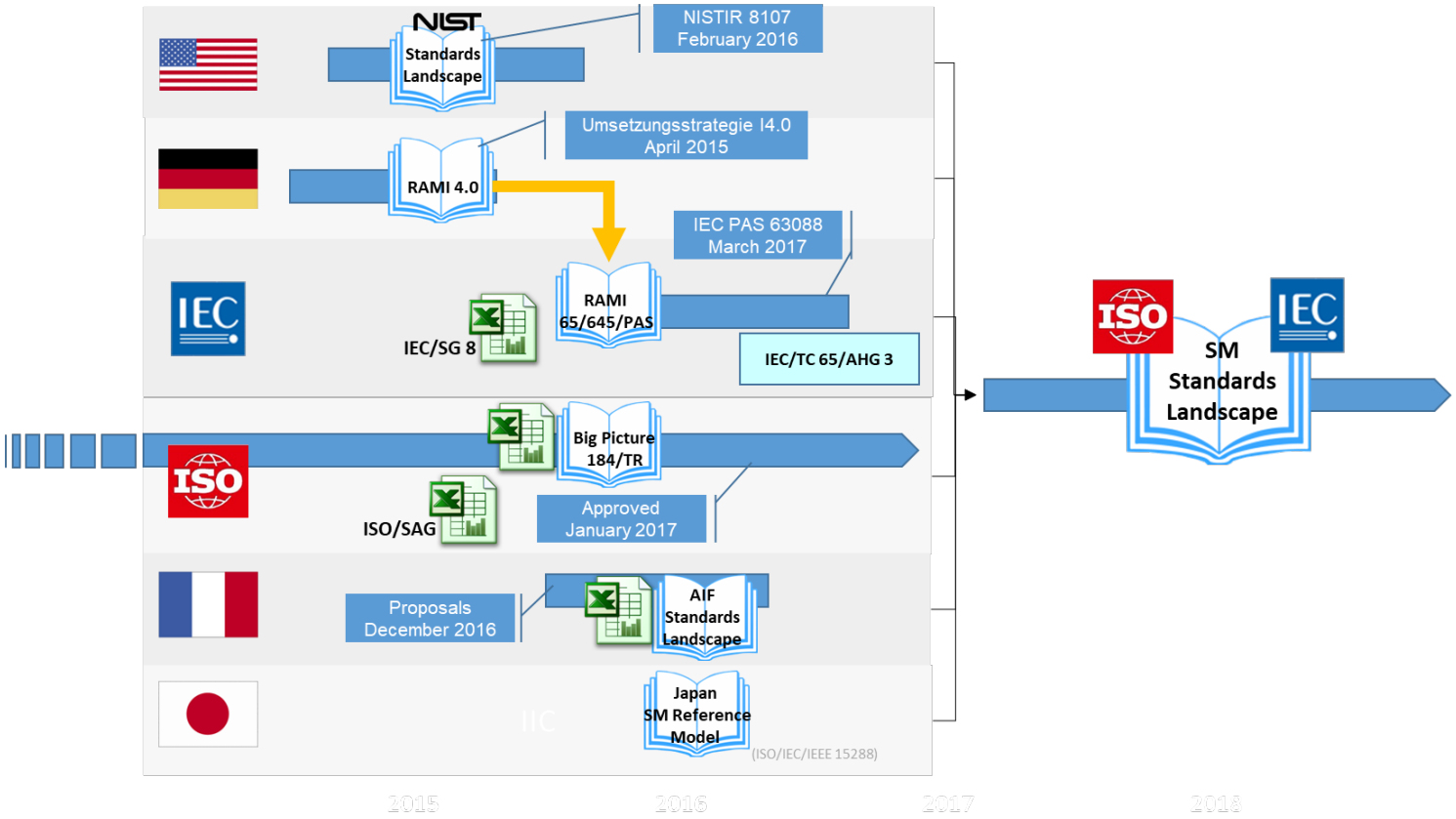
- ISO 14306 ed3 proposed
- ***ISO 23301 (20.00)***
  STEP Geometry services

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

- 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)

Smart Manufacturing @ ISO: Motivation

Global Product Data Interoperability Summit | **2019**



ISO TMB Strategic Advisory Group

Industry 4.0/Smart manufacturing

Final Report to ISO Technical Management Board

September, 2016

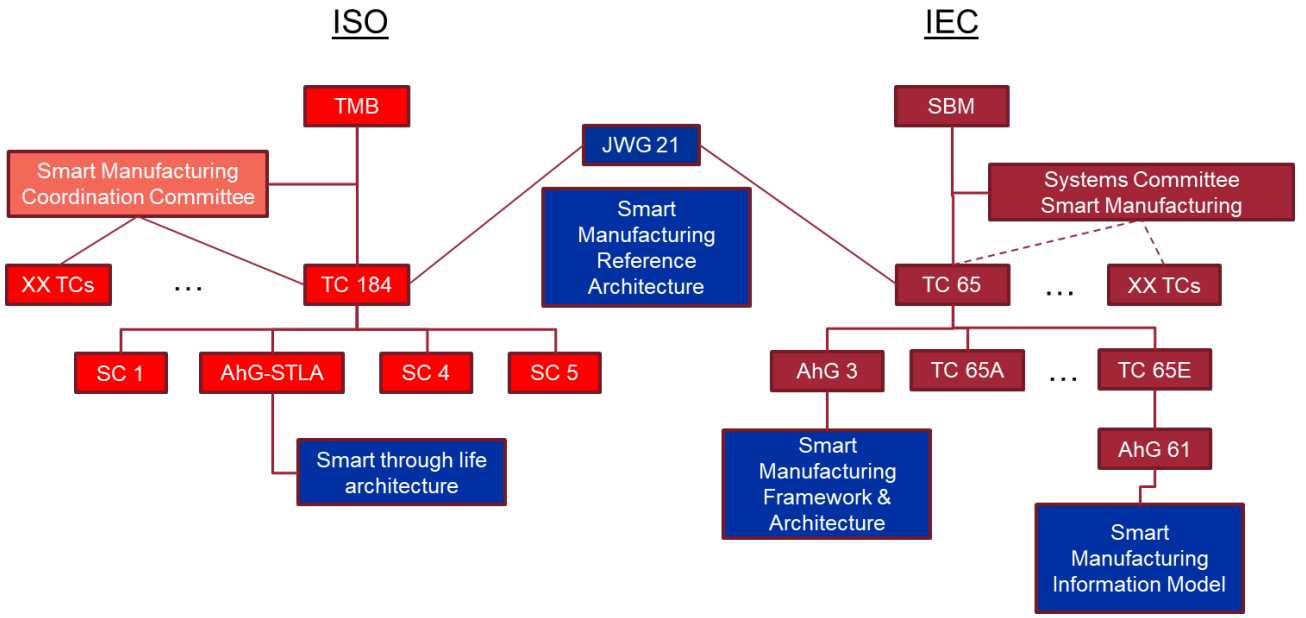
10 Recommendations

- **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-ISO Definition of Smart Manufacturing

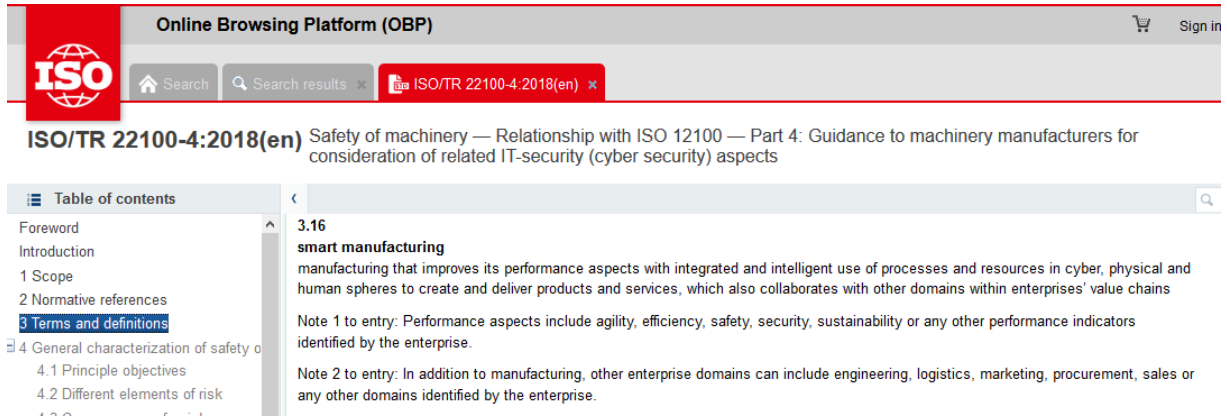
IEC SEG7 – ISO SMCC Definition

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.

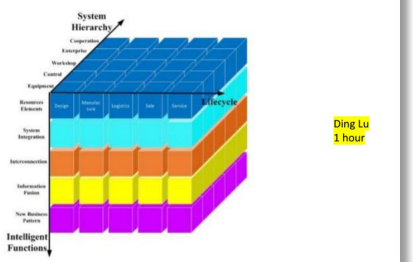
Action to all standards within ISO & IEC to incorporate definition when developing standards



“Smart Manufacturing” models by Country

Global Product Data Interoperability Summit | **2019**

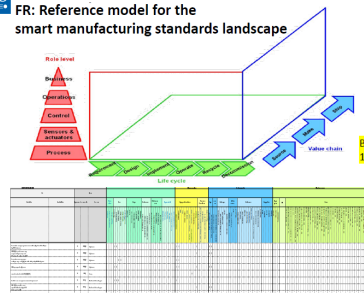
IEC TC65 & ISO TC184 JWG21
CN: Intelligent Manufacturing System Architecture



Ding Lu
1 hour

China

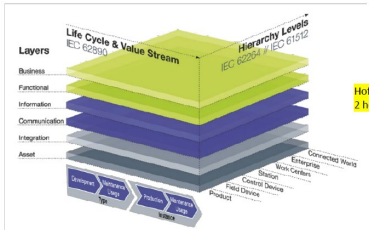
IEC TC65 & ISO TC184 JWG21
FR: Reference model for the smart manufacturing standards landscape



Briant
1 hour

France

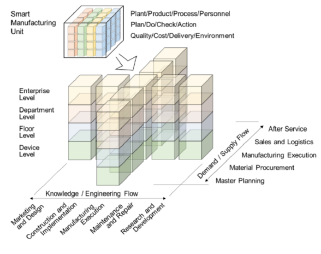
IEC TC65 & ISO TC184 JWG21
GE: IEC/PAS
Reference Architecture Model Industry 4.0 (RAMI4.0)



Hoffmeister
2 hours

Germany

IEC TC65 & ISO TC184 JWG21
JP: Industrial value chain reference architecture (IVRA)



Ogura
1 hour

Japan

IEC TC65 & ISO TC184 JWG21
JP: A proposal of Smart Manufacturing reference model

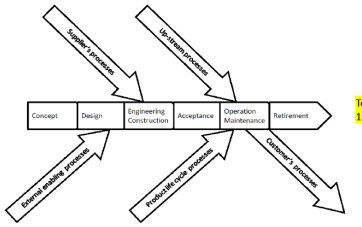


Figure 4 — Interaction with external systems

Toru (Koji)
1 hour

Japan

IEC TC65 & ISO TC184 JWG21
US: NIST: Smart Manufacturing Systems: Standards Landscape & Reference Models

Figure 1. Smart Manufacturing Ecosystem

Yan Lu
1 hour

USA

IEC TC65 & ISO TC184 JWG21
SE: Thomas Lundholm 2017-07-05

I could briefly present some **smart manufacturing results from and initiatives in Sweden** regarding:

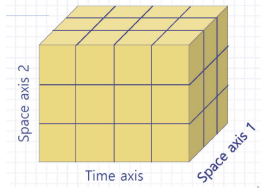
- LISA (line information system architecture)
- tweeting machine
- the Engineering innovation factory
- model-driven process and quality planning
- digital twins for efficient tool usage in manufacturing
- digital manufacturing infrastructure
- Swedish/German testbed for smart manufacturing.

Lindholm, Johnsson
1 hour

Sweden

IEC TC65 & ISO TC184 JWG21
KR: Soonhung Han

- RAMI 4.0 + simplification proposal



Soohung Han
1 hour

Korea

IEC TC65 & ISO TC184 JWG21
US: Dan Carnahan

- *Enterprise Reference Architectures (ISO 15704 - Requirements for Enterprise reference architectures and methodologies)*
- *Enterprise-Control Models (IEC [ISO] 62264 – Enterprise—Control System Integration)*
- *Key Performance Indicators (ISO 22400 Manufacturing Operations Management - Key Performance indicators)*
- *Open Technical Dictionaries (ISO 29002 - Exchange of Characteristic Data)*
- *Data Quality (ISO 8000)*
- *Open technical dictionaries (ISO 22745 – Application to Exchange of Master data)*
- *Oil & Gas Industry Interoperability (ISO/TC 184/WG 6, Project ISO 18101 – Automation systems and integration - Oil and Gas interoperability)*
- *Other relevant ISO/TC 184/SC 5 standards*

Dan Carnahan
1 hour

ISO Standards

IEC TC65 & ISO TC184 JWG21
US: Richard Martin

- Attached are:
- 1) a list of **eight (8) questions regarding the JWG21 Terms of Reference** (Several are naively stated to make sure I understand the intent of the JWG21 effort while others seek to clarify the guidance the Terms of Reference are to provide),
- 2) a spreadsheet based upon ISO 15704 – Requirements for enterprise-reference architecture and methodologies, with an assessment of several documents against conformance with ISO 15704, and
- 3) several articles highlighting aspects of the “smart manufacturing” concept.

- And some documents regarding smart manufacturing

No presentation planned

ISO 15704

IEC TC65 & ISO TC184 JWG21
CA: Wally Leonard

- currently I have no issues, other than a few concerns that I am hopeful will be addressed by the forthcoming information package… these concerns stem from my initial take on the direction set by the ISO strategic business plan which defines a basis for manufacturing, smart automation and smart manufacturing as a means to extend the enterprise capabilities of a manufacturing organization… at the enterprise level, there are well defined principles and requirements to guide the development of enterprise reference architecture and use of methodologies… its been my experience, that reference models do not become technical rather they break down the concepts of the enterprise into functional components enough to highlight the functional and cross-functional integration points where information flows must be managed to protect the integrity of critical data thru its life-cycle…
- finally and most importantly, enterprise reference models provide direction to refine critical integration points to develop information transformations need/requirements that will maintain the asset, operations and maintenance interoperability…
- below, I highlight a complete list of the ISO standards that represent what I just summarized for your consideration.

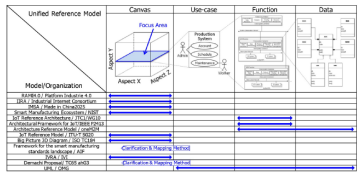
Wally Leonard 1 hour

- **ISO N1749 -- business plan establishes the strategic needs and requirements of the ISO/TC 184 business environment**
- **ISO 15740 -- industrial automation systems, requirements for enterprise reference architecture and methodologies defines the key principles, design considerations and approaches to developing reference architectures(models).**
- **ISO 15926 -- Industrial automation systems and integration -- Integration of life-cycle data for process plants including oil and gas production facilities**
- **ISO 18101 -- Oil and Gas asset management and operations and maintenance interoperability (OGI)**

Canada

- Canvas from JP

Nonaka
1 hour



Japan

…. Others

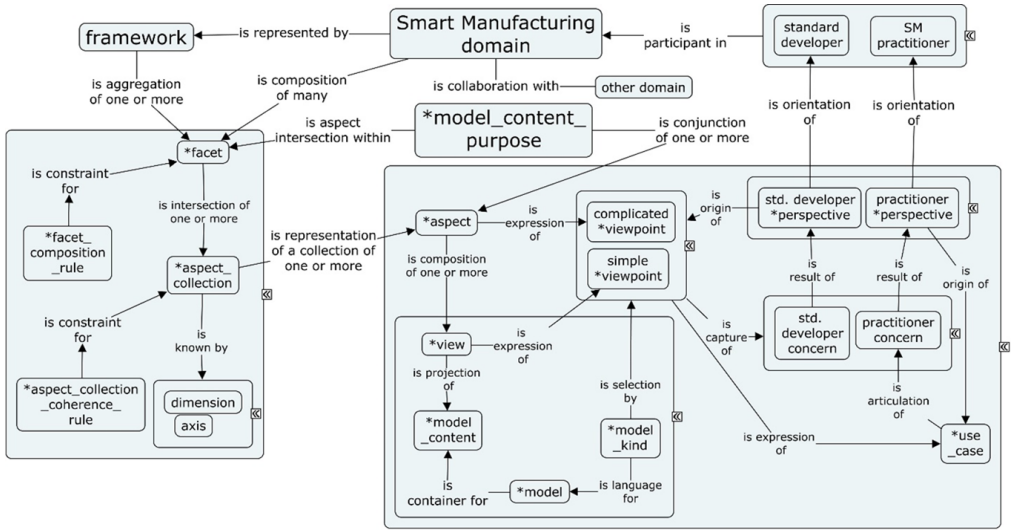
+ Spain

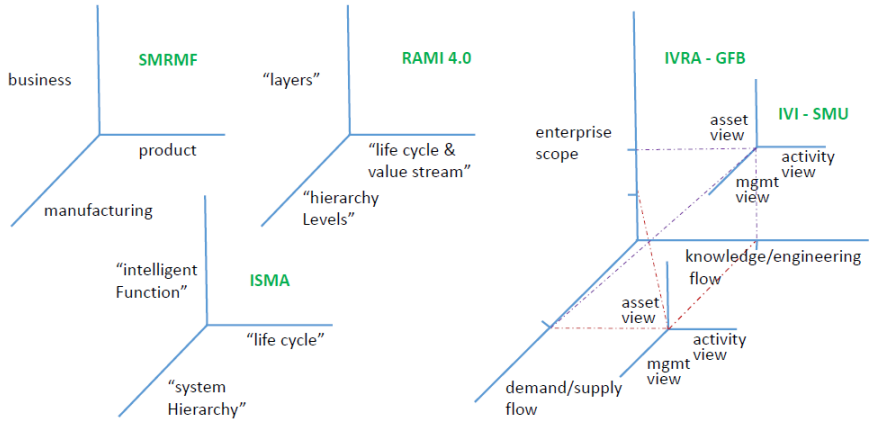
+ UK

+ Italy

Smart Manufacturing @ ISO: Approach

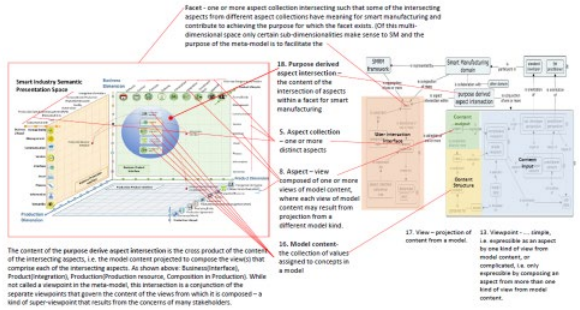
- Utilize ISO 42010 to develop a model of models (Meta-Model)
- Validate Country contributions to Meta-Model
- Release a Technical Report of the method
- Develop an International Standard for the reference model
- Release in parallel in ISO and IEC



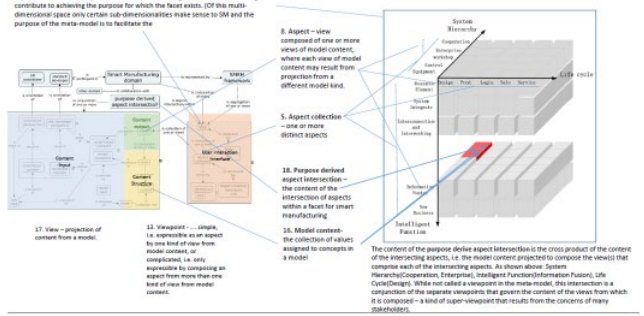


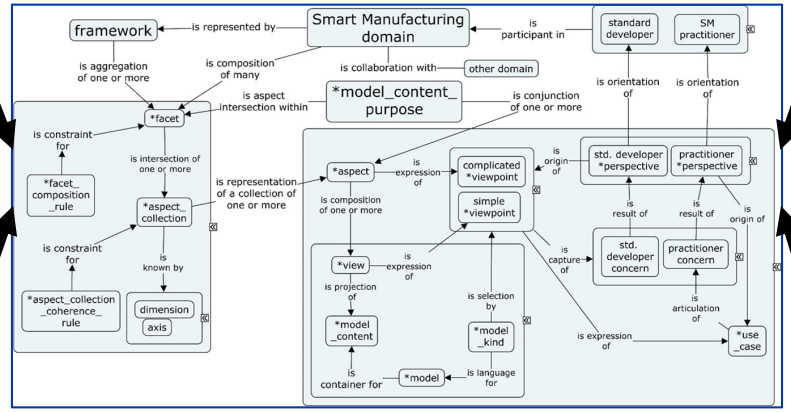
Validation Examples to demonstrate model quality

Scandinavian Smart Industry Framework mapping to SMRM Meta-model v1



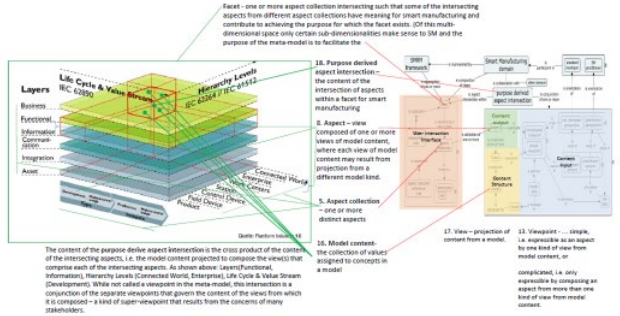
ISMA model mapping to SMRM Meta-model



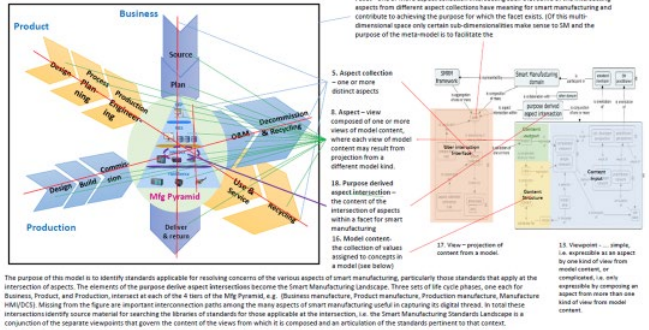


Interoperability of Meta-Models Facilitates collaboration with diversity.

RAMI 4.0 model mapping to SMRM Meta-model v1

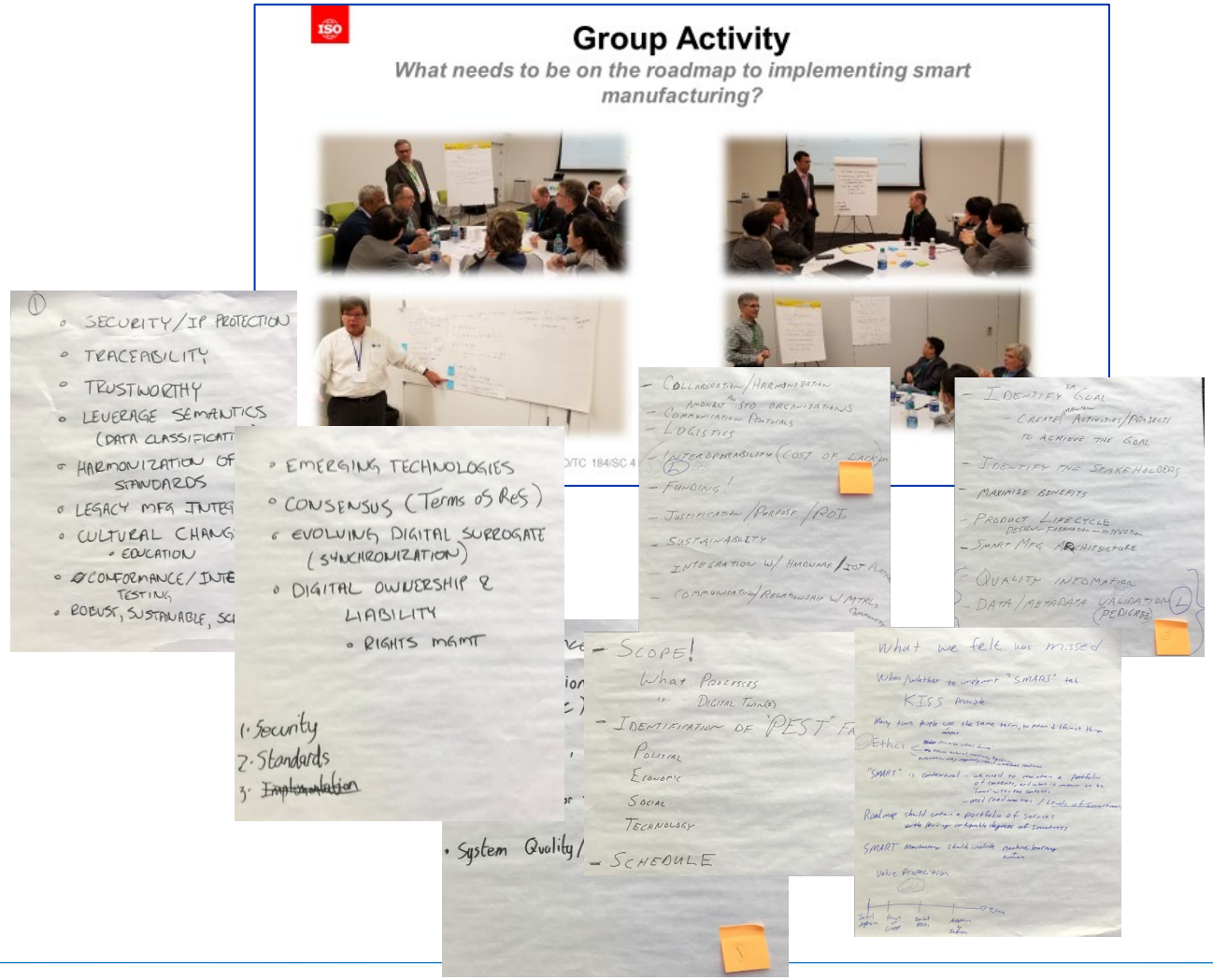


NIST model mapping to SMRM Meta-model v1

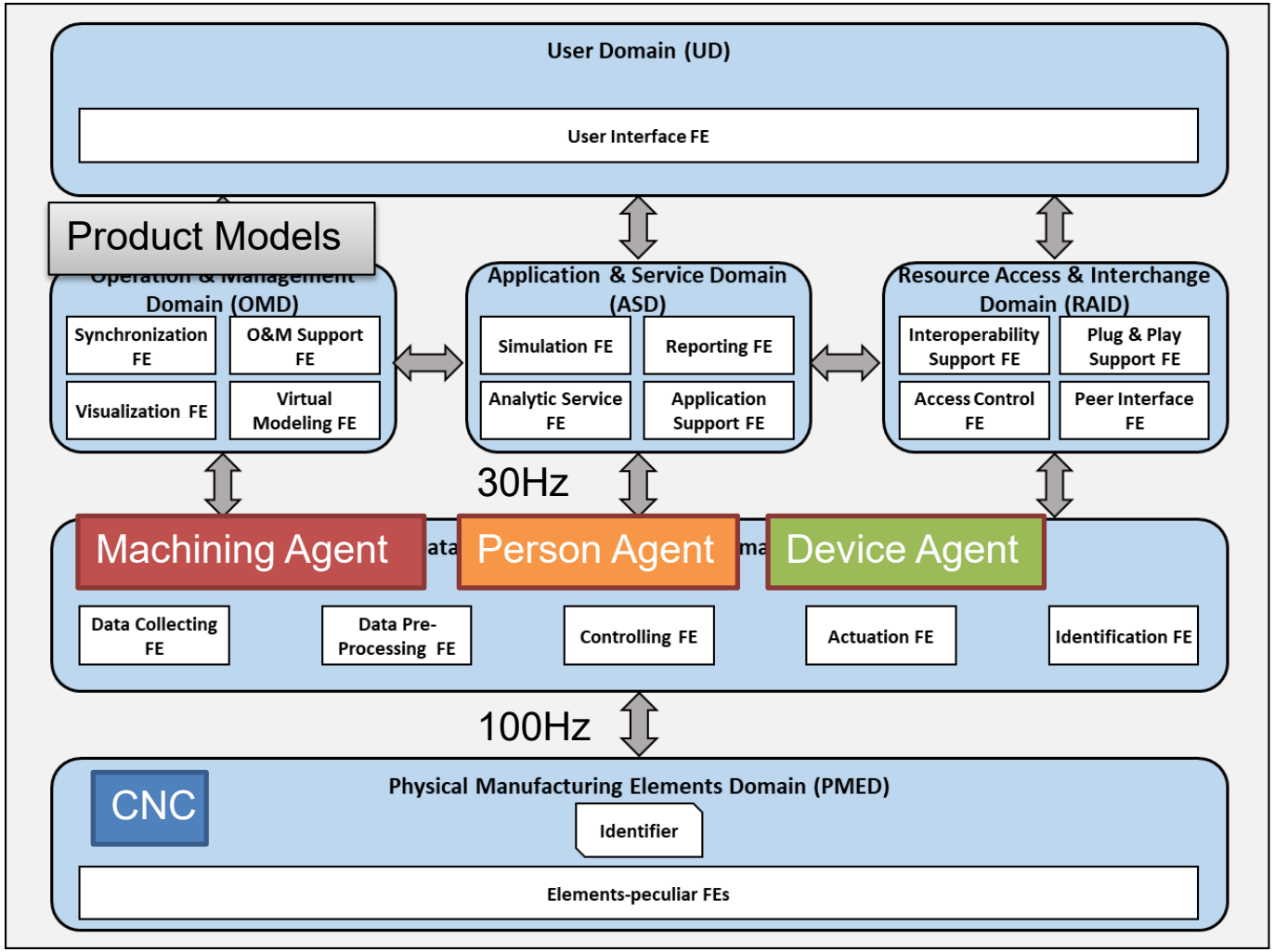


Roadmap to Smart Manufacturing: ISO/TC 184/SC 4 Industry Day, Nov. 2018

- 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

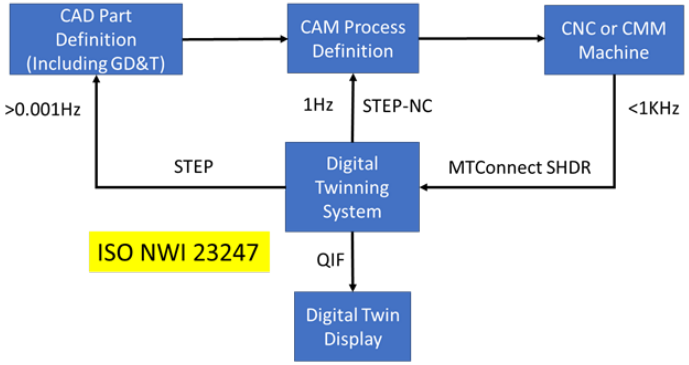


ISO 23247: Digital Twin Manufacturing Framework



IoT Architecture (ISO 30141)

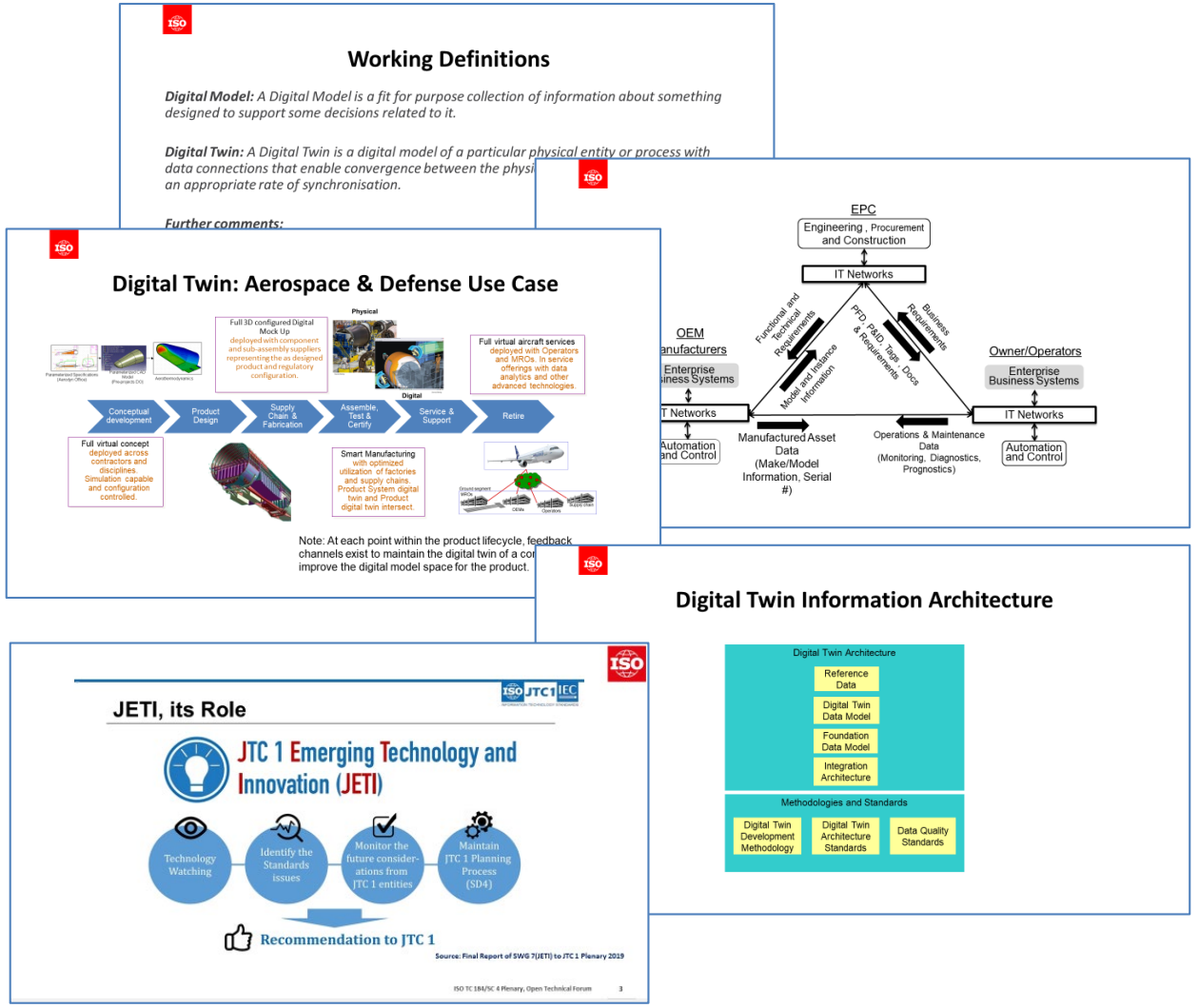
ISO 23247
Part 1 Overview
Part 2 Architecture
Part 3 Digital Representation
Part 4 Information Exchange



Committee Draft in Ballot

Digital Twin @ ISO

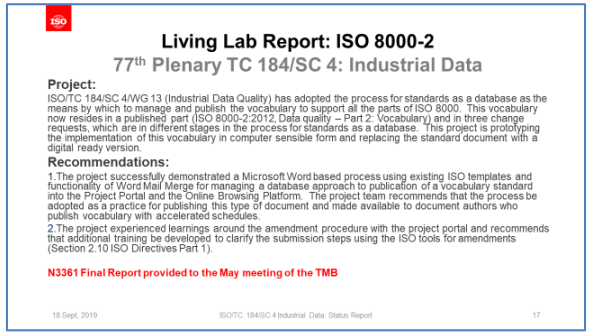
- Multiple Committees in ISO focused on Digital Twin
- TC 184 formed an AdHoc Group to propose a definition for the Digital Twin and provide a recommendation on a program of working including possible collaboration with IEC/TC 65
- The AdHoc is developing a proposed definition, architecture landscape, 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



Living Lab Report: ISO 8000-2

77th Plenary TC 184/SC 4: Industrial Data

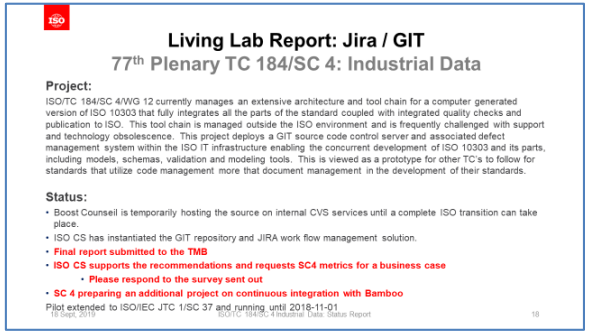
Project:

ISO/TC 184/SC 4/WG 13 (Industrial Data Quality) has adopted the process for standards as a database as the means by which to manage and publish the vocabulary to support all the parts of ISO 8000. This vocabulary now resides in a published part (ISO 8000-2:2012, Data quality – Part 2: Vocabulary) and in three change requests, which are in different stages in the process for standards as a database. This project is prototyping the implementation of this vocabulary in computer sensible form and replacing the standard document with a digital ready version.

Recommendations:

1. The project successfully demonstrated a Microsoft Word based process using existing ISO templates and functionality of Word Mail Merge for managing a database approach to publication of a vocabulary standard into the Project Portal and the Online Browsing Platform. The project team recommends that the process be adopted as a practice for publishing this type of document and made available to document authors who publish vocabulary with accelerated schedules.
2. The project experienced learnings around the amendment procedure with the project portal and recommends that additional training be developed to clarify the submission steps using the ISO tools for amendments (Section 2.10 ISO Directives Part 1).

N3361 Final Report provided to the May meeting of the TMB



Living Lab Report: Jira / GIT

77th Plenary TC 184/SC 4: Industrial Data

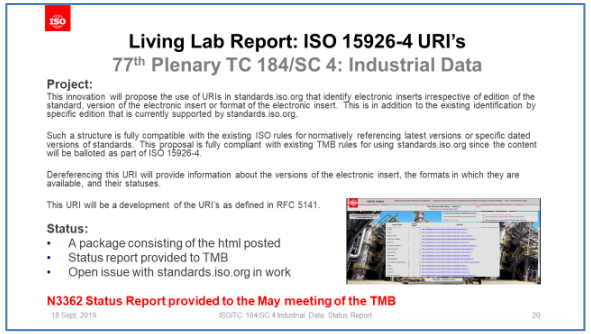
Project:

ISO/TC 184/SC 4/WG 12 currently manages an extensive architecture and tool chain for a computer generated version of ISO 10303 that fully integrates all the parts of the standard coupled with integrated quality checks and publication to ISO. This tool chain is managed outside the ISO environment and is frequently challenged with support and technology obsolescence. This project deploys a GIT source code control server and associated defect management system within the ISO IT infrastructure enabling the concurrent development of ISO 10303 and its parts, including models, schemas, validation and modeling tools. This is viewed as a prototype for other TC's to follow for standards that utilize code management more that document management in the development of their standards.

Status:

- Boost Counseil is temporarily hosting the source on internal CVS services until a complete ISO transition can take place.
- ISO CS has instantiated the GIT repository and JIRA work flow management solution.
- **Final report submitted to the TMB**
- **ISO CS supports the recommendations and requests SC4 metrics for a business case**
  - **Please respond to the survey sent out**
- **SC 4 preparing an additional project on continuous integration with Bamboo**

Pilot extended to ISO/IEC JTC 1/SC 37 and running until 2018-11-01



Living Lab Report: ISO 15926-4 URI's

77th Plenary TC 184/SC 4: Industrial Data

Project:

This innovation will propose the use of URIs in standards.iso.org that identify electronic inserts irrespective of edition of the standard, version of the electronic insert or format of the electronic insert. This is in addition to the existing identification by specific edition that is currently supported by standards.iso.org.

Such a structure is fully compatible with the existing ISO rules for normatively referencing latest versions or specific dated versions of standards. This proposal is fully compliant with existing TMB rules for using standards.iso.org since the content will be balloted as part of ISO 15926-4.

Dereferencing this URI will provide information about the versions of the electronic insert, the formats in which they are available, and their statuses.

This URI will be a development of the URI's as defined in RFC 5141.

Status:

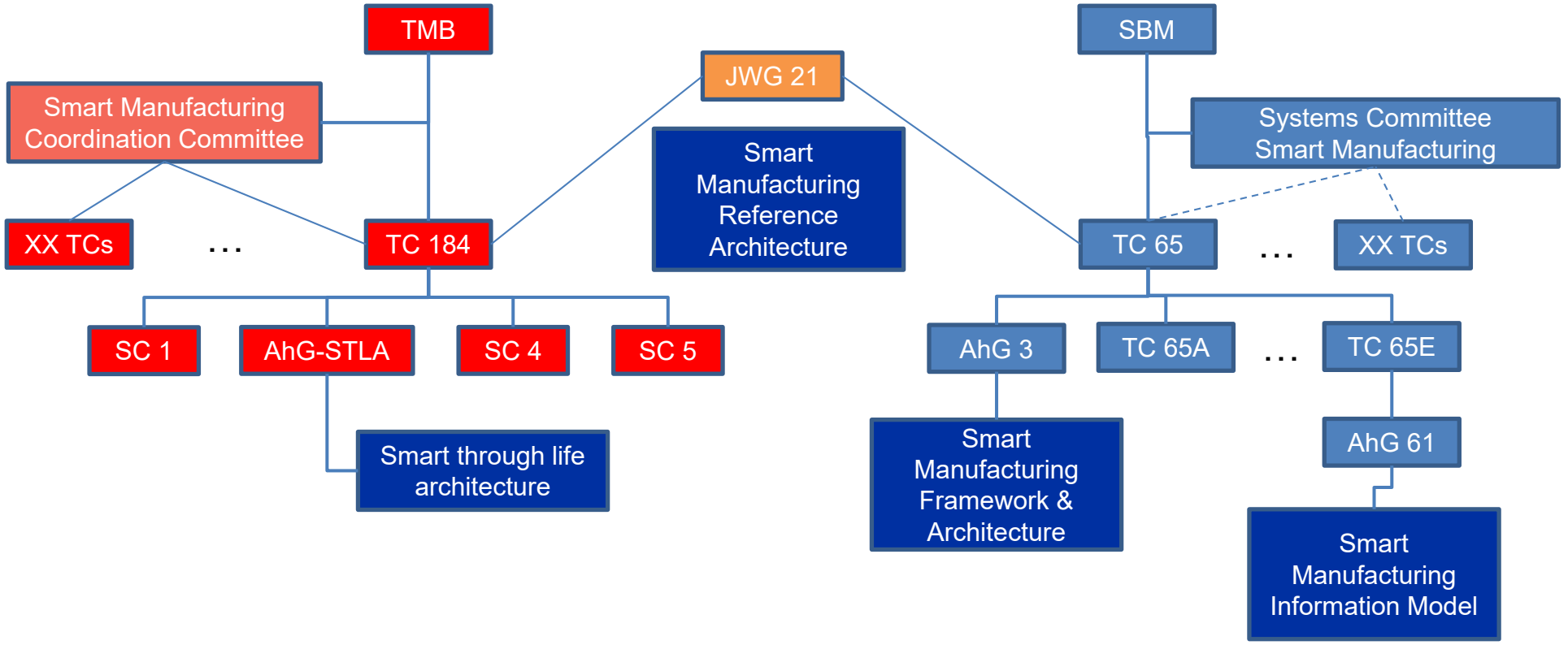
- A package consisting of the html posted
- Status report provided to TMB
- Open issue with standards.iso.org in work

N3362 Status Report provided to the May meeting of the TMB

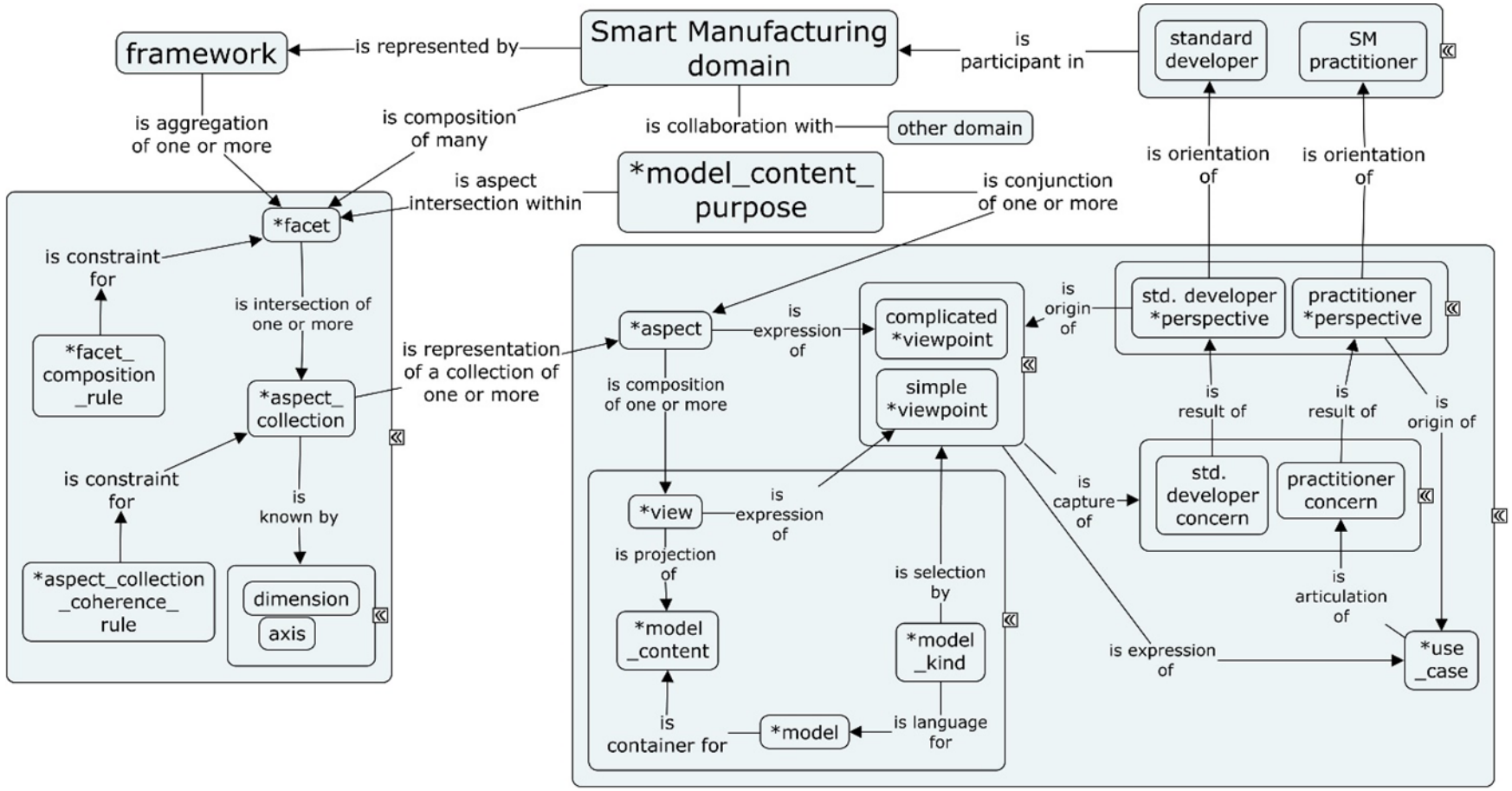
Questions?

Joint Working Group 21

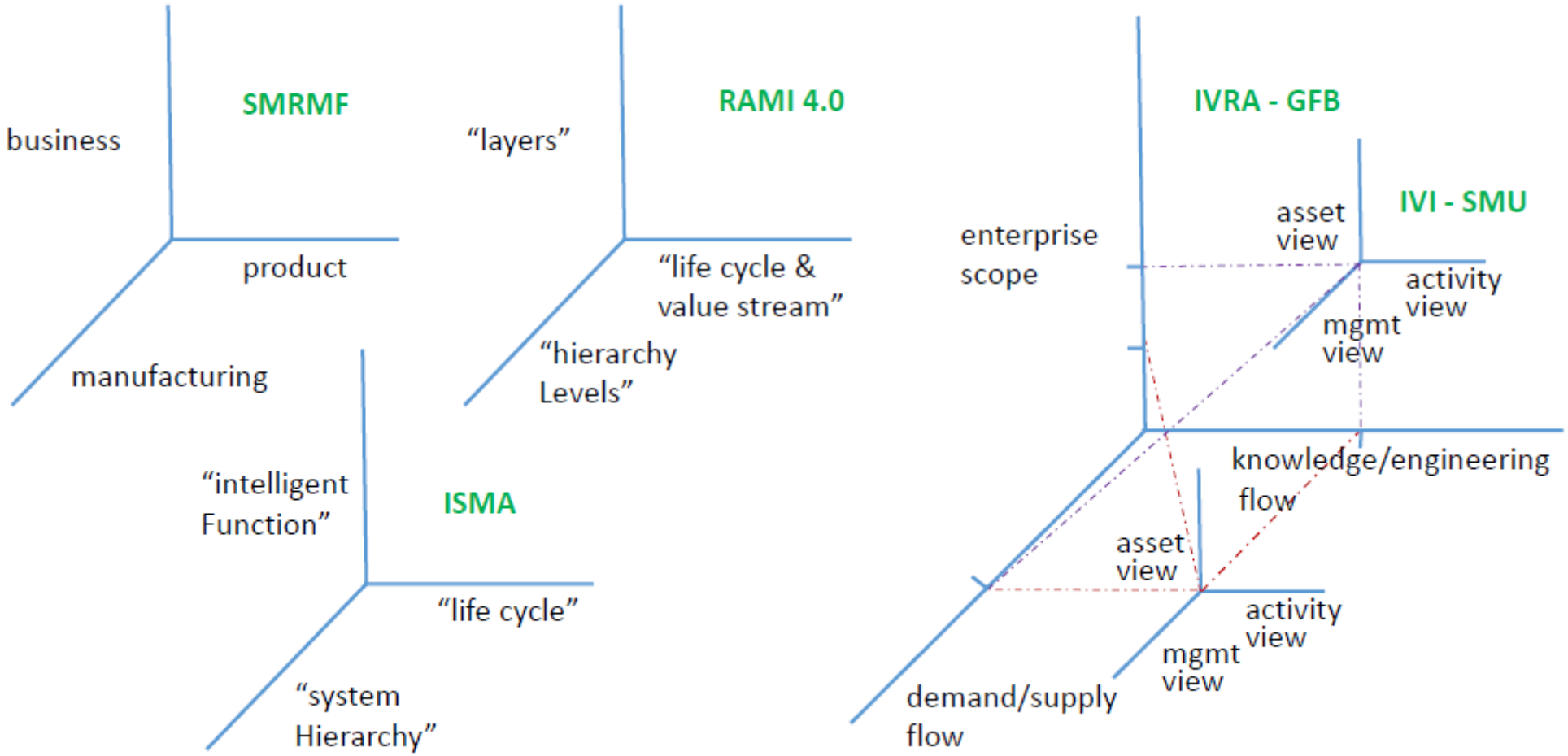
Smart Manufacturing Reference Model



Smart Manufacturing Reference Architecture

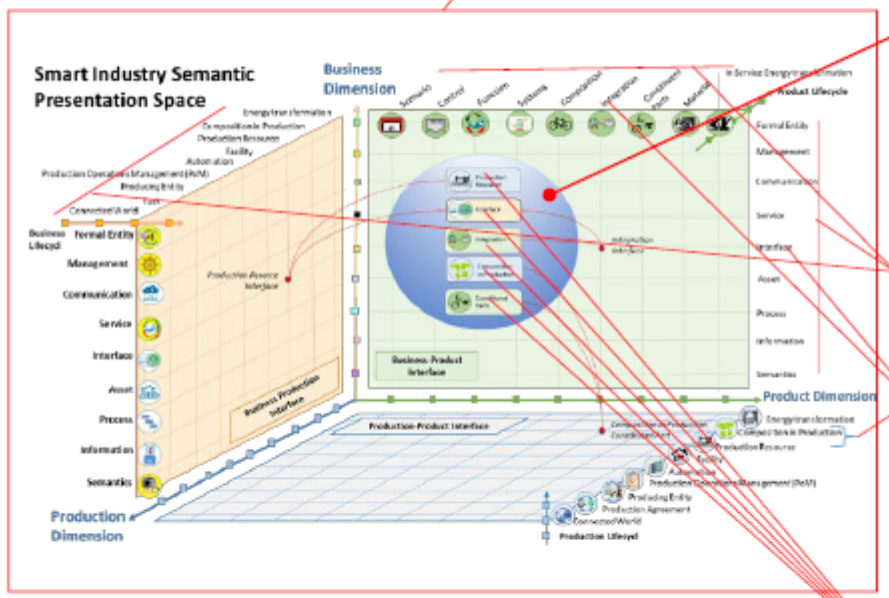


Even more opportunity for modelling using the SMRM Framework



Scandinavian Smart Industry Framework 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 the

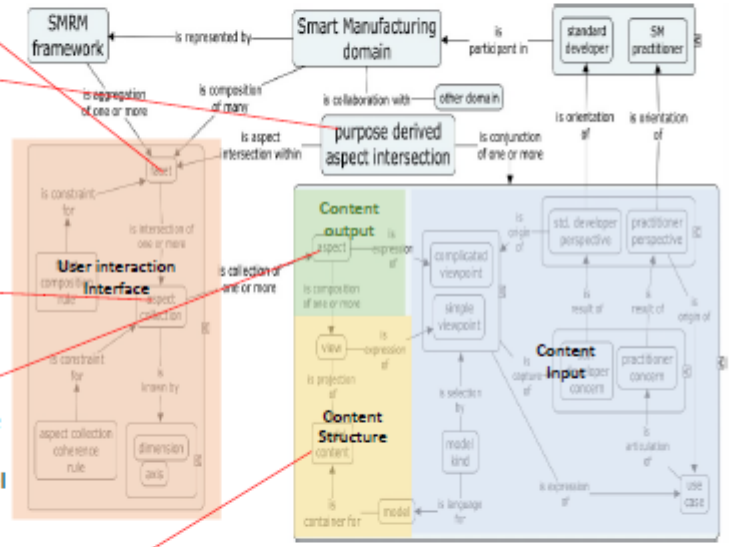


18. Purpose derived aspect intersection – the content of the intersection of aspects within a facet for smart manufacturing

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



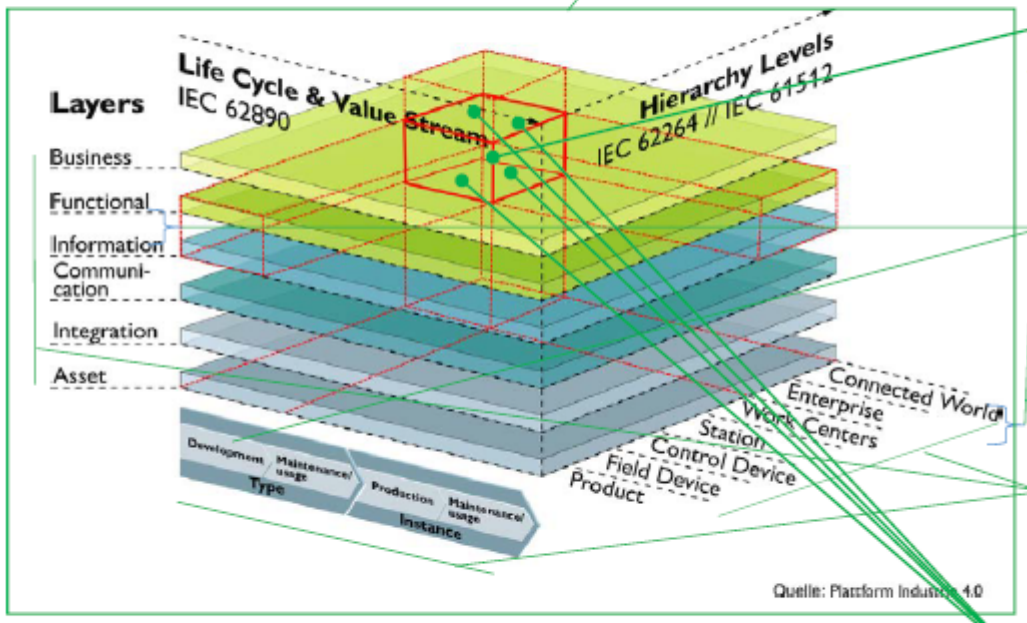
17. View – projection of content from a model.

13. Viewpoint - .... simple, i.e. expressible as an aspect by one kind of view 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: Business(Interface), Product(Integration), 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

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 the

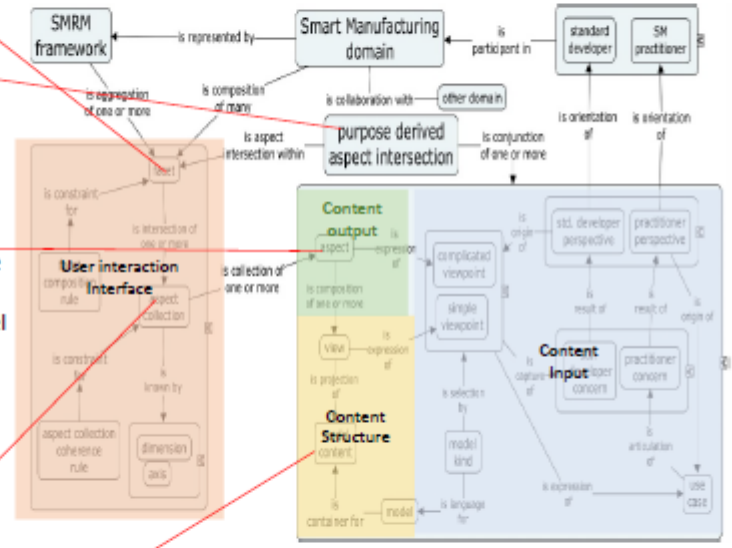


18. Purpose derived aspect intersection – the content of the intersection of aspects within a facet for smart manufacturing

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

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



17. View – projection of content from a model.

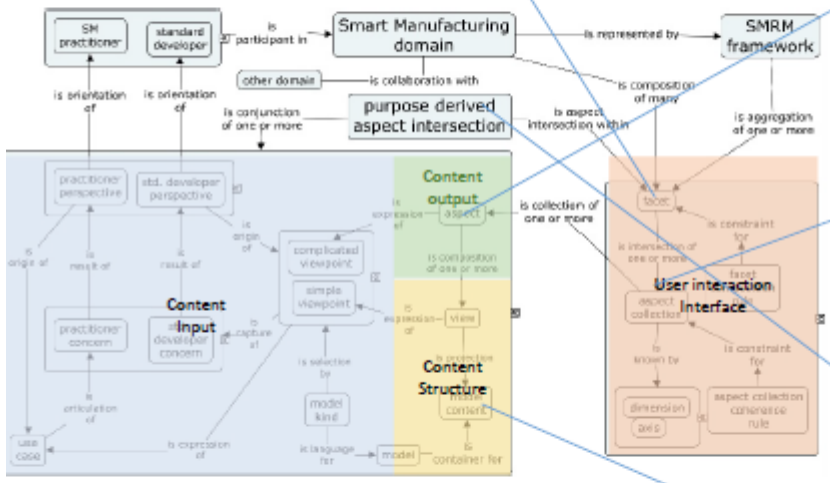
13. Viewpoint - .... simple, i.e. expressible as an aspect by one kind of view from model content, or

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: 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.

ISMA model mapping to SMRM Meta-model

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 the



17. View – projection of content from a model.

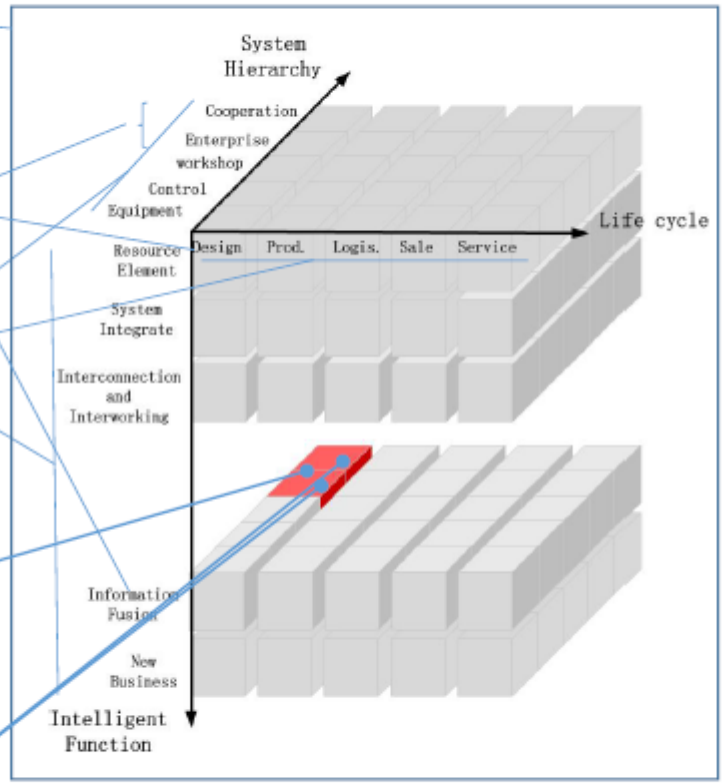
13. Viewpoint - .... simple, i.e. expressible as an aspect by one kind of view from model content, or complicated, i.e. only expressible by composing an aspect from more than one kind of view from model content.

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

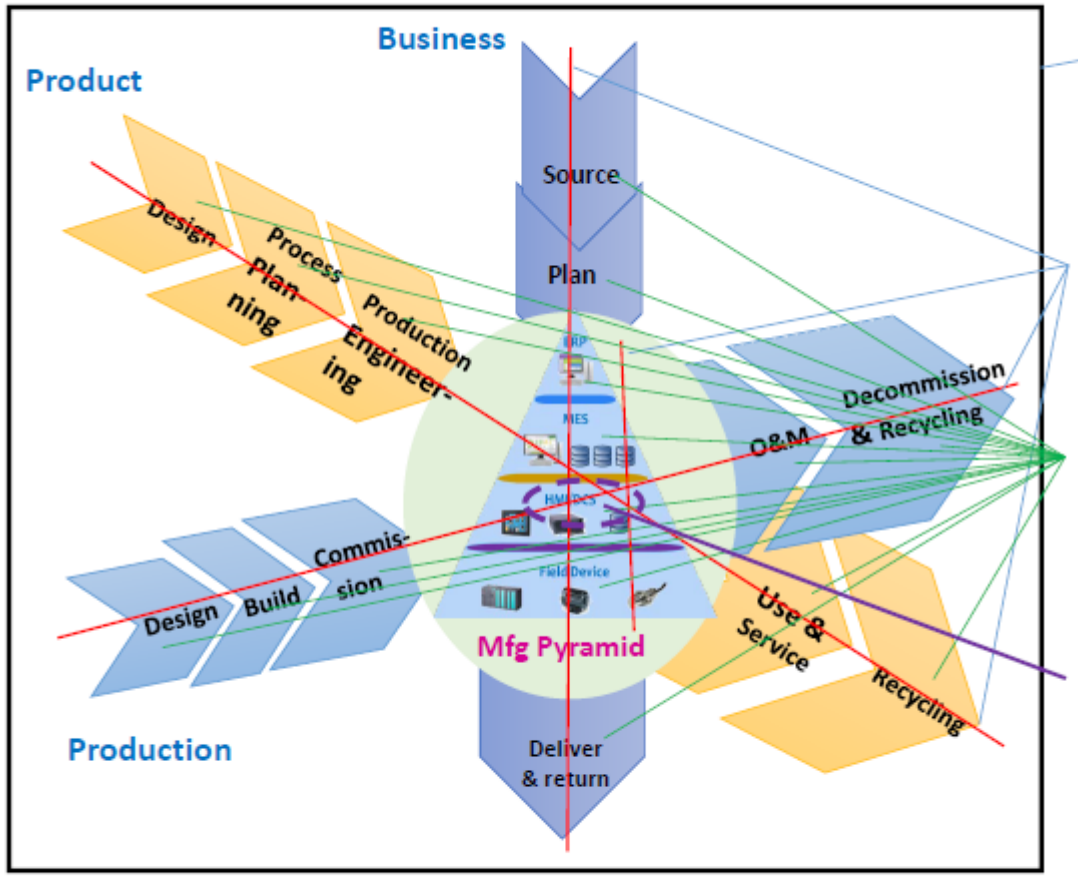
18. Purpose derived aspect intersection – the content of the intersection of aspects within a facet for smart manufacturing

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



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.

NIST model mapping to SMRM Meta-model v1



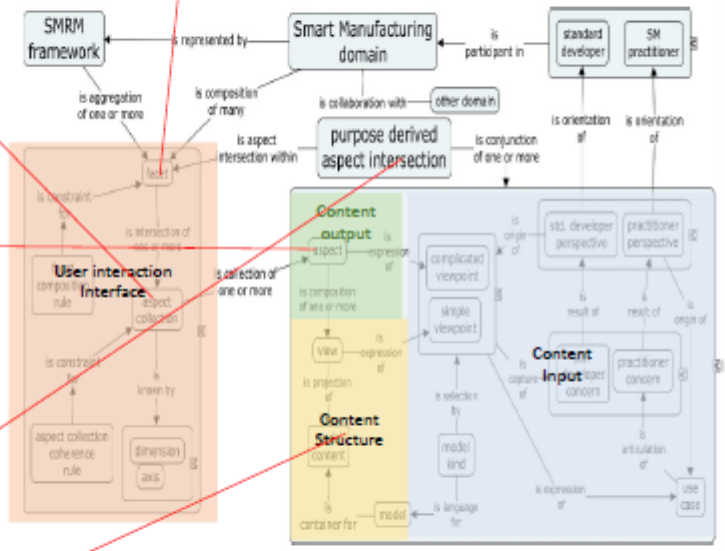
Facet - one or more aspect collection intersecting such that some of the intersecting aspects from different aspect collections have meaning for smart manufacturing and contribute to achieving the purpose for which the facet exists. (Of this multi-dimensional space only certain sub-dimensionalities make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

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.

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

16. Model content- the collection of values assigned to concepts in a model (see below)



17. View – projection of content from a model.

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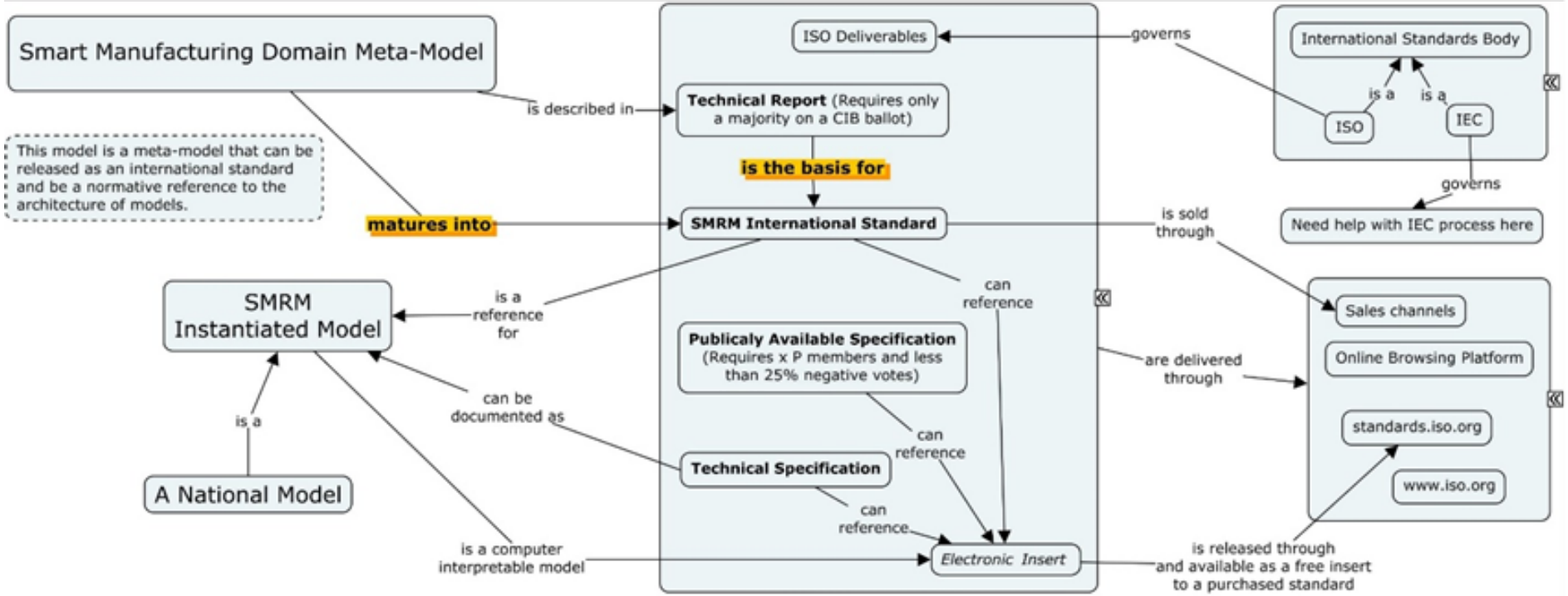
The purpose of this model is to identify standards applicable for resolving concerns of the various aspects of smart manufacturing, particularly those standards that apply at the intersection of aspects. The elements of the purpose derive aspect intersections become the Smart Manufacturing Landscape. 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



An implementation of the meta model can be a national model or any other model from contributing organizations that comply with the reference model noted in the standard. 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.

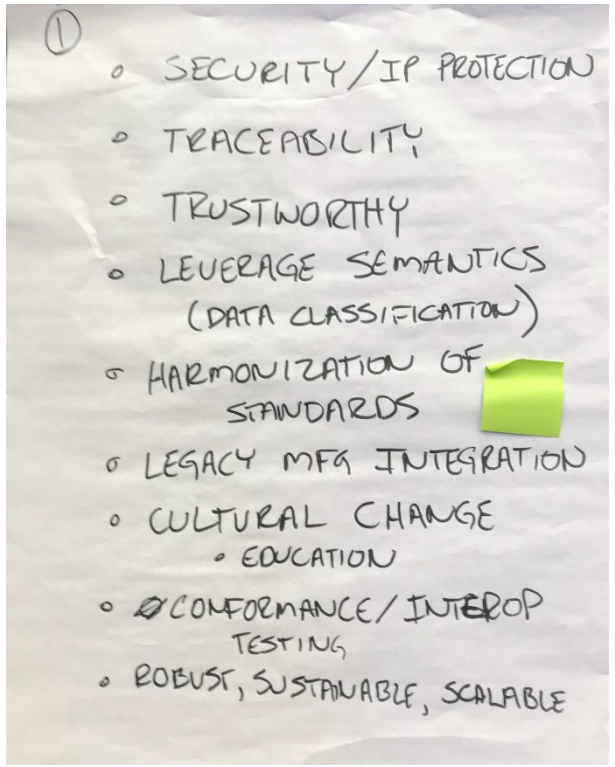
Group Activity

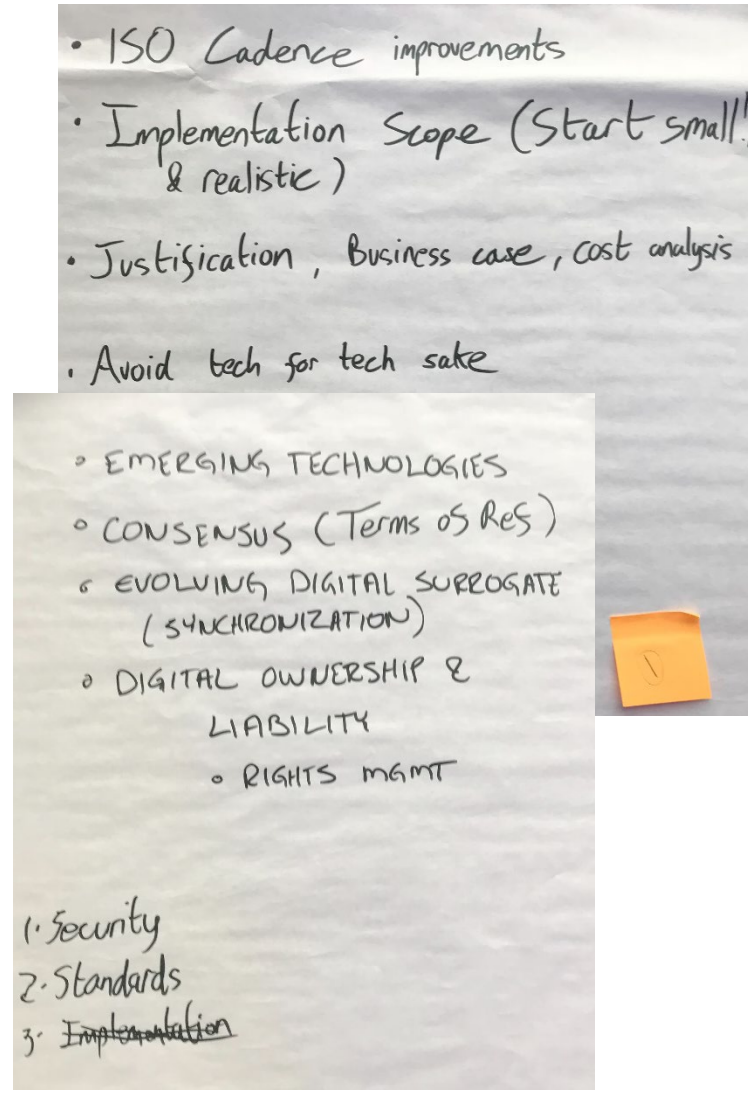
What needs to be on the roadmap to implementing smart manufacturing?

Team 1: Summary

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

- Simple scope, small pilots, early wins
- ISO cadence improvements
- Data security & provenance

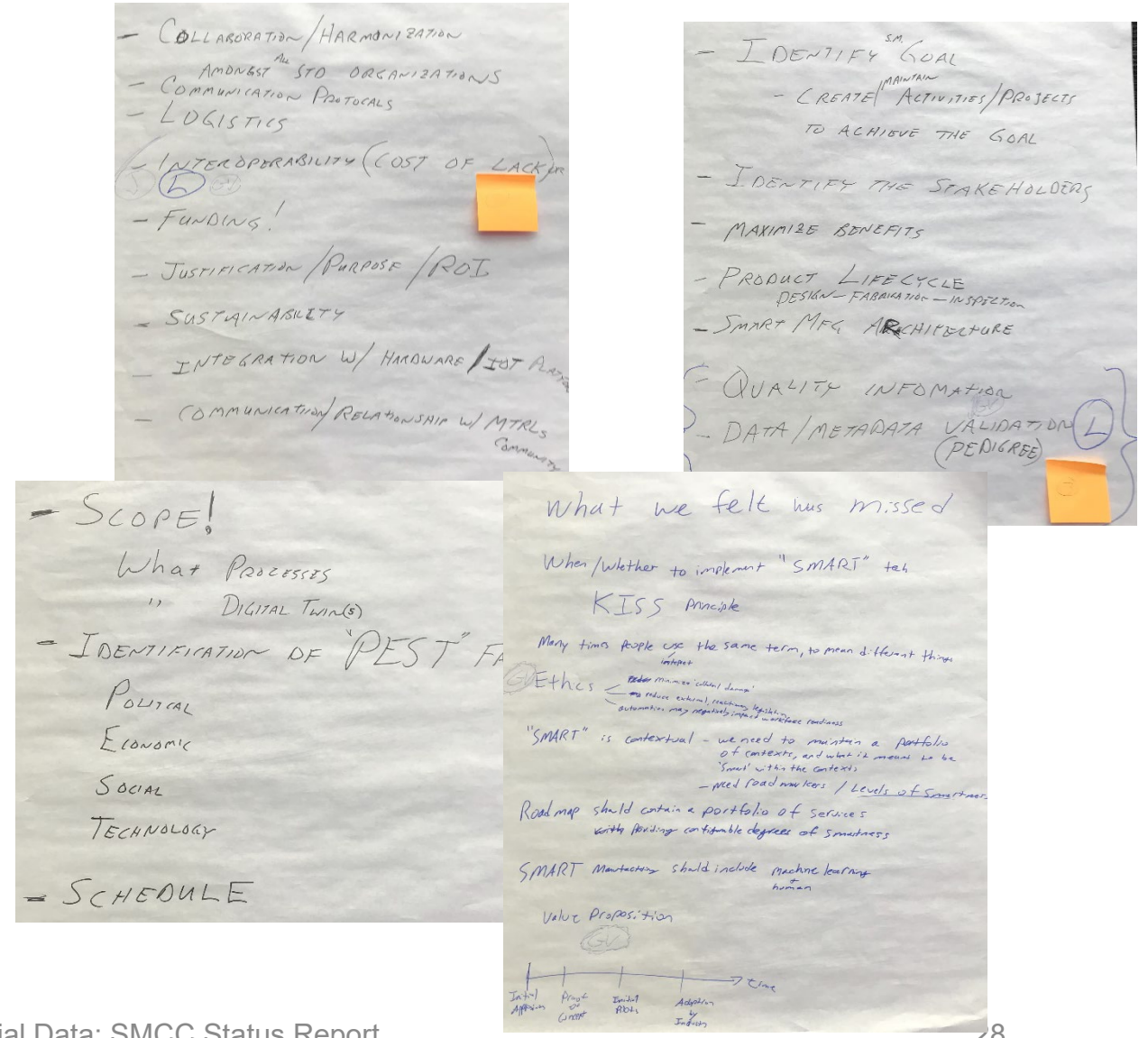




Team 2: Summary

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

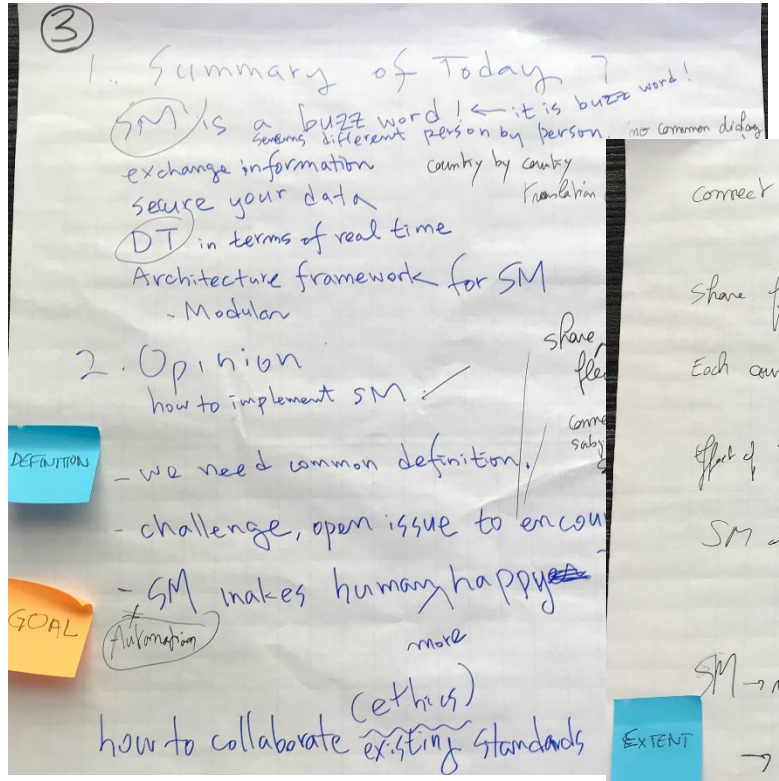
- Common ontology & terms across standards
- Interoperability targets
- Quality of information, pedigree of data
- Ethics needs to be on the roadmap

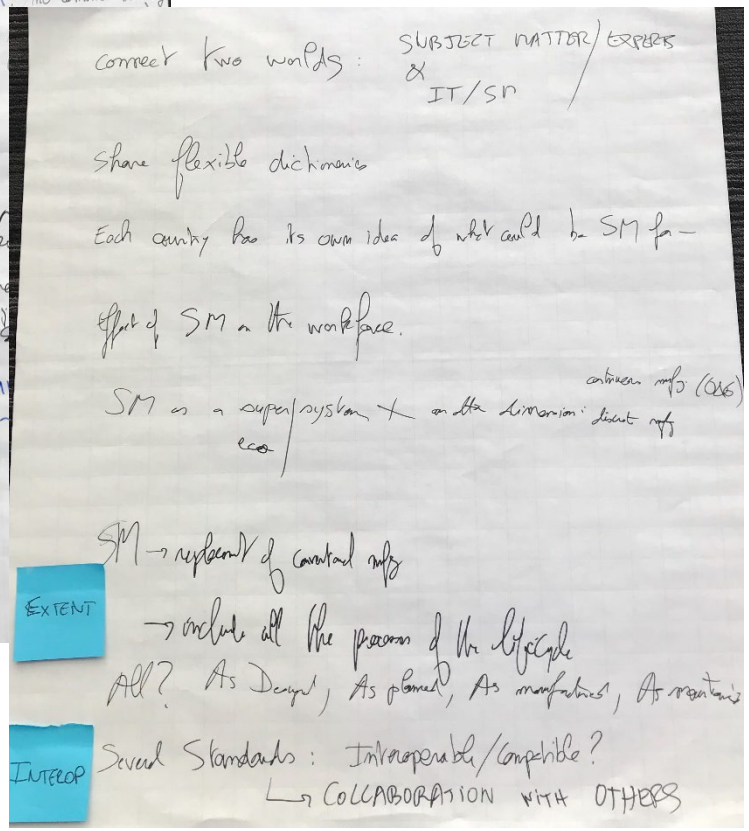


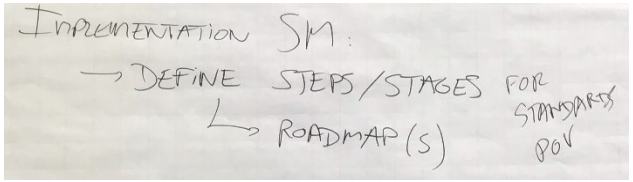
Team 3: Summary

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

- Ensure clear goals
  - "Happy Humans"
- Common definition
- Establish clear boundaries
- Interoperability capabilities



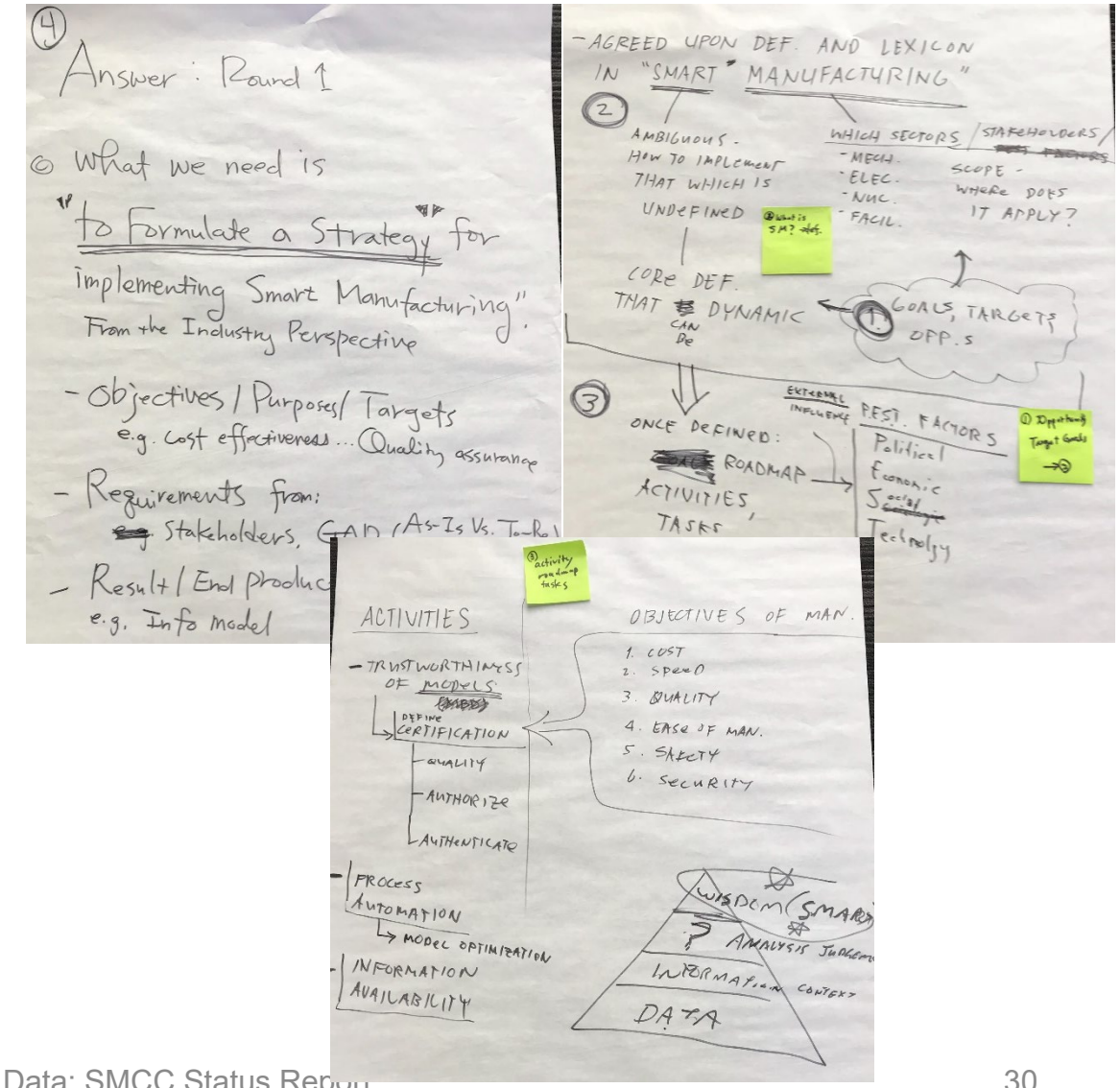




Team 4: Summary

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