IEEE SA
STANDARDS ASSOCIATION

Overview of IEEE Smart Manufacturing Standards

Dr. Sha WEI, Chair of IEEE/C/Smart Manufacturing Standards Committee

July 20th, 2021

About the Speaker

Dr. Sha WEI is dedicated in standardization and strategy analysis of Smart Manufacturing, Digital Twin and Artificial Intelligence.

In ***IEEE SA***, she serves as the vice chair(M'21) and member (M'19-M'20) of NesCom and members of SASB (M'19-M'21) and CAG (M'18).

In ***Smart Manufacturing*****,** she is the Chair of IEEE/C/Smart Manufacturing Standard Committee, P2672 Mass Customization and P2806 Digital Representation, and members of IEC/SyC Smart Manufacturing and ISO/IEC JWG21 Smart manufacturing reference model, respectively.

In ***Digital Twin***, she is the convenors of ISO/IEC JTC1/SC41/WG6 Digital Twin and former ISO/IEC JTC1/AG11 Digital Twin.

In ***Artificial Intelligence***, she is the Chair of IEEE P2807 Knowledge Graph working group and committee member of ISO/IEC JTC1 SC42 Artificial Intelligence.

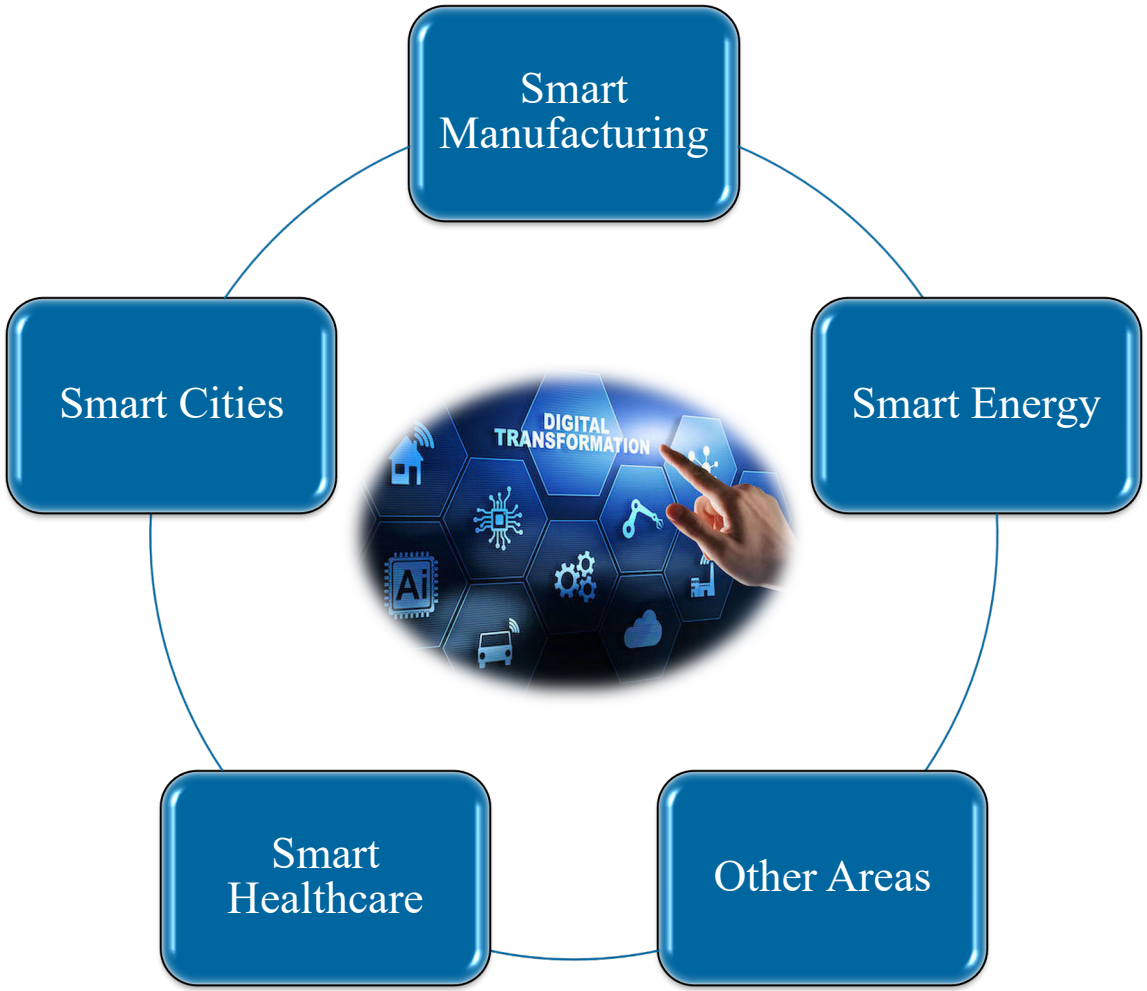
Outline

1. General Information: *Who we are?*
2. From Manufacturing to Service: *Mass Customization*
3. New Technology Applications: *Machine Vision, Digital Representation* and *Knowledge Graph*
4. Smart Factory: *Assessment* and *Logistics*
5. New Projects and Future Works

Part One

General Information: *Who we are?*

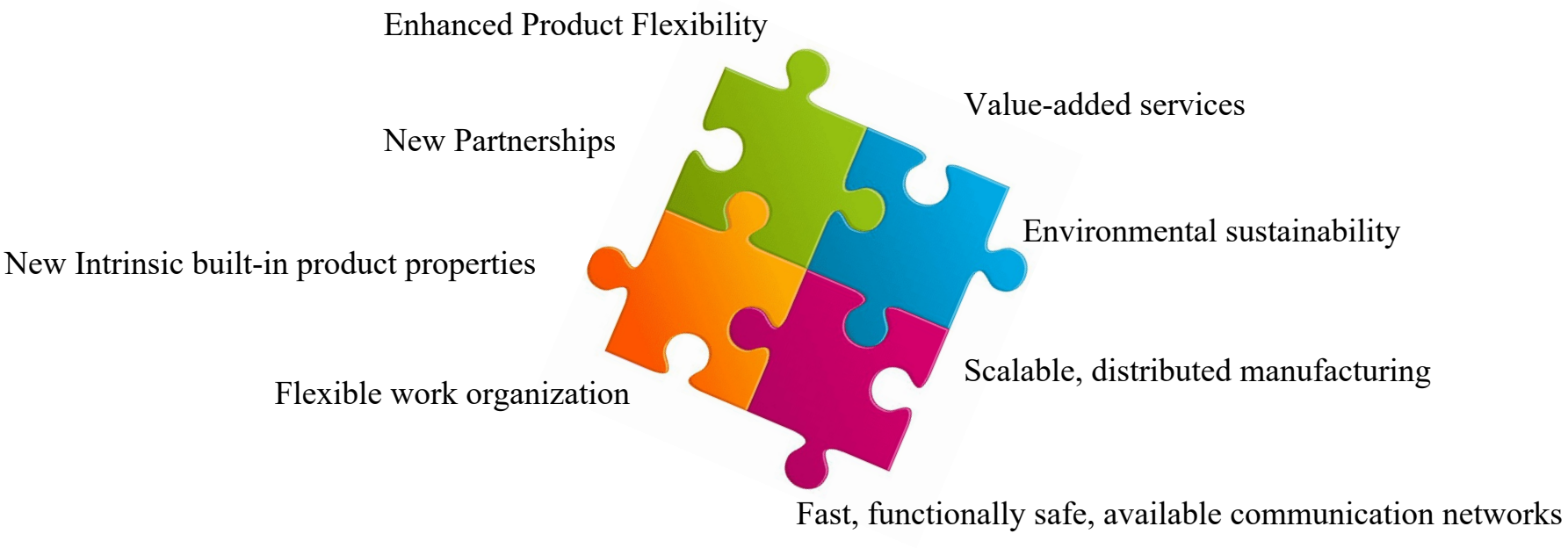
1.1 Digital Transformation



1.1 Characteristics of Smart Manufacturing

Smart Manufacturing

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 an enterprises' value chains.



Source: ISO/IEC JWG21 Smart manufacturing reference architecture

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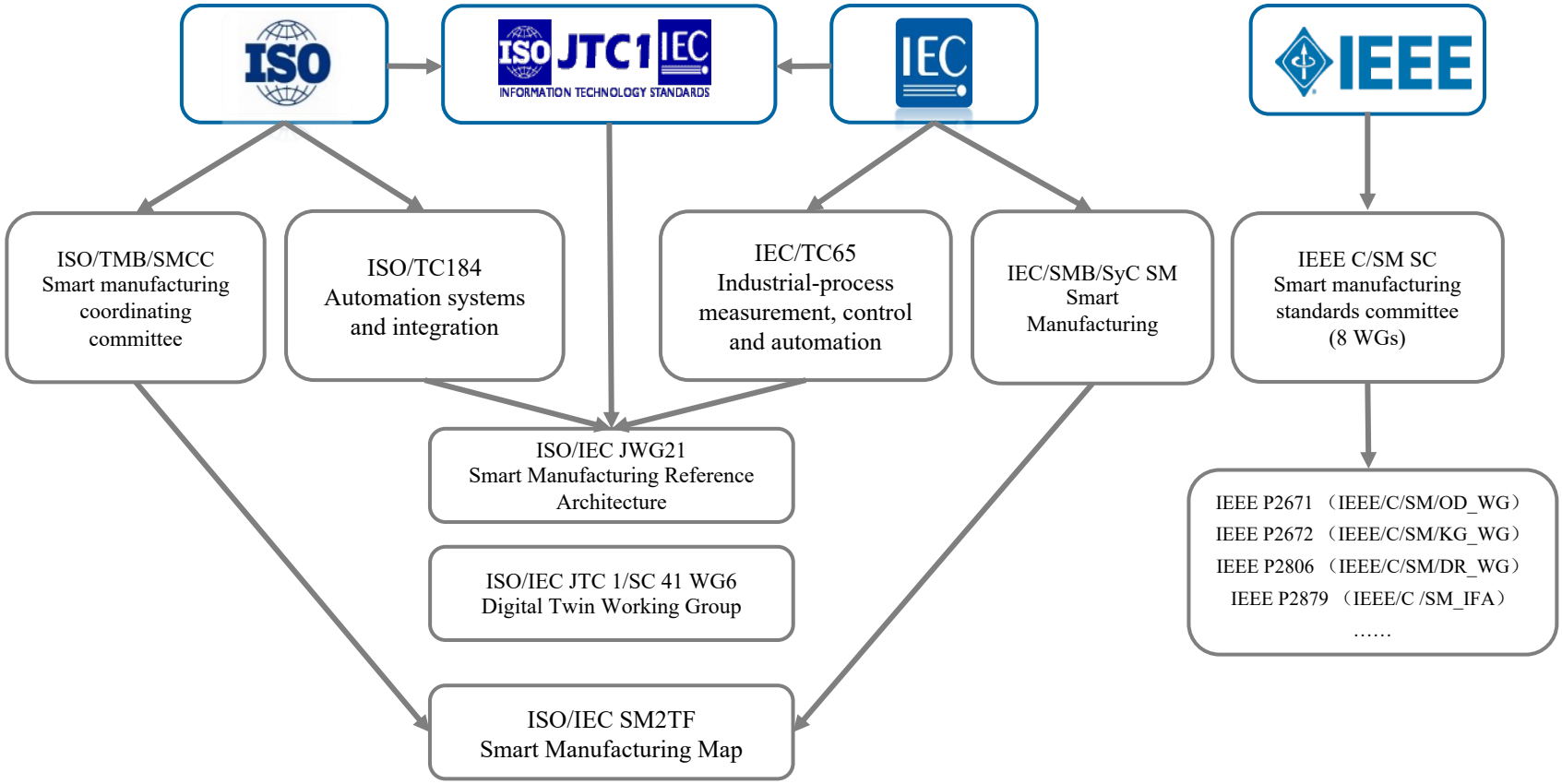
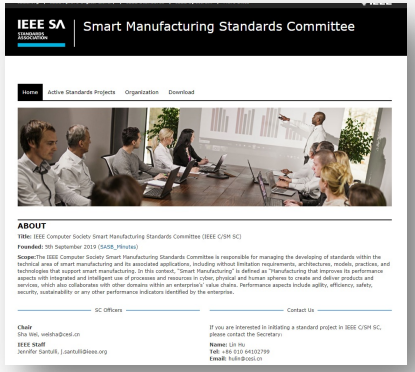
1.2 International standardization Organizations



1.3 Introduction of IEEE C/SMSC

IEEE Computer Society
Smart Manufacturing Standards Committee (IEEE C/SMSC)

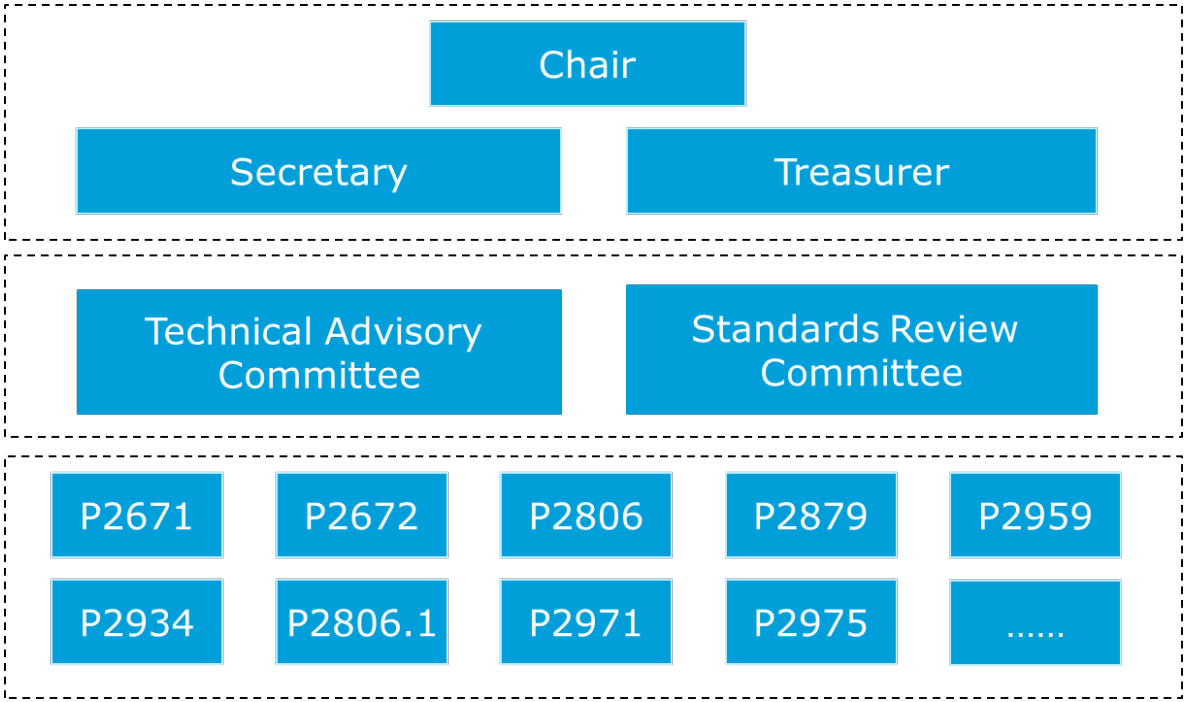


- The IEEE C/SMSC was established on September 5th, 2019.
- The IEEE/C/SMSC is responsible for managing the developing of standards within the technical area of smart manufacturing and its associated applications.
- The scope of IEEE/C/SMSC includes but is not limited to the requirements, architecture, models, practices and technologies that support smart manufacturing.

Public website: https://sagroups.ieee.org/smsc/

1.3 Introduction of IEEE C/SMSC

- Architecture



IEEE/C/SMSC is composed of a chair, a secretary, a treasurer, the technical advisory committee, the standards review committee and several working groups.

1.3 Introduction of IEEE/C/SMSC

9 Standard Projects under Research

P2672 Mass Customization

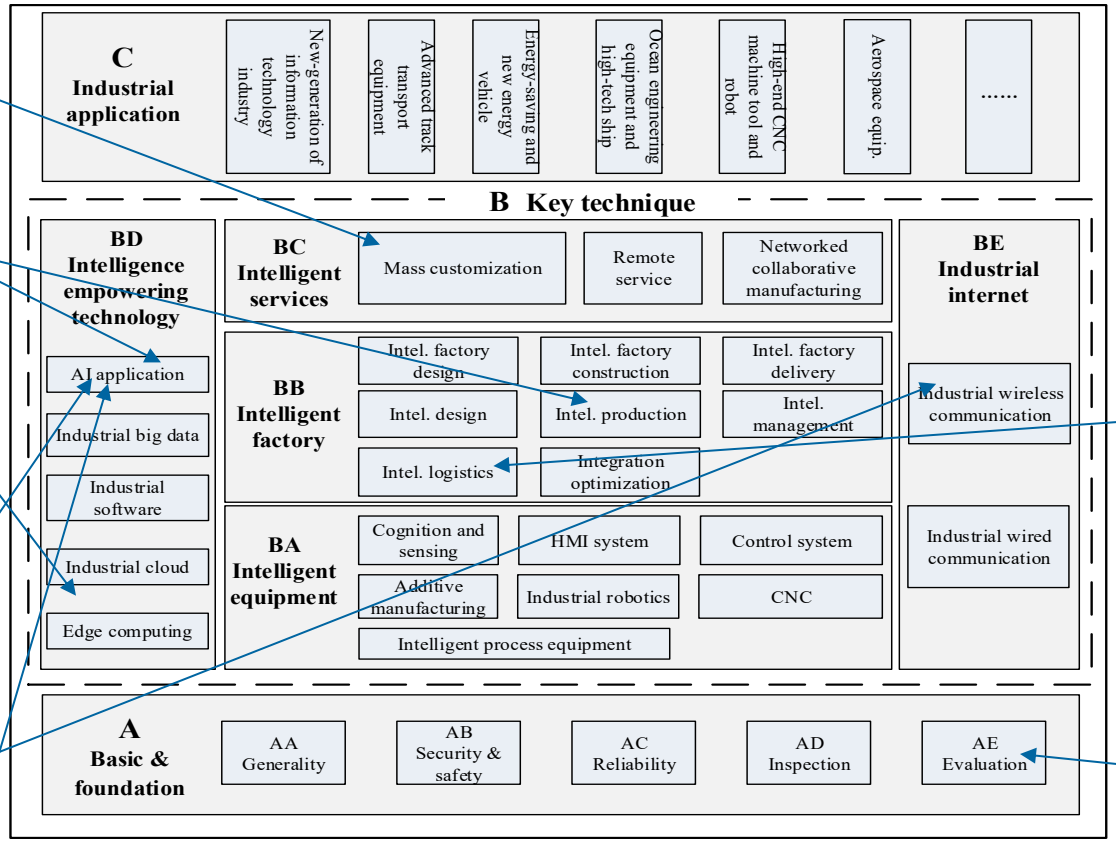
P2671 Machine Vision

P2806 & P2806.1 Digital Representation

P2959 Knowledge Graph

P2971 TSN Gateway

P2975 Industrial AI data



P2934 Logistics

P2879 Smart Factory Assessment

1.3 Introduction of IEEE/C/SMSC

From Manufacturing to Service	●P2672 Guide for General Requirements of Mass Customization
New Technology Applications	•P2671 Standard for General Requirements of Online Detection Based on Machine Vision in Intelligent Manufacturing •P2806 System Architecture of Digital Representation for Physical Objects in Factory Environments •P2806.1 Standard for Connectivity Requirements of Digital Representation for Physical Objects in Factory Environments •P2959 Standard for Technical Requirements of Standard-Oriented Knowledge Graphs
Smart Factory	●P2879 General principles for assessment of a smart factory ●P2934 Standard for Logistics Operation Process in a Smart Factory

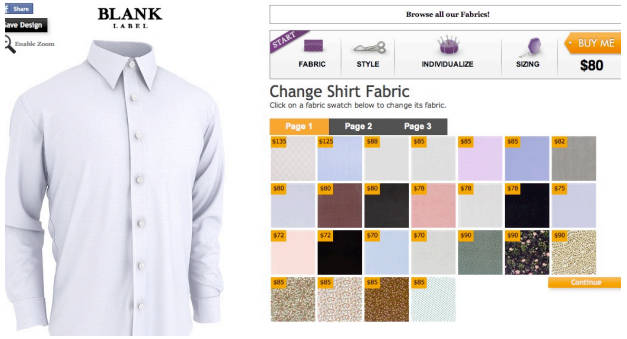
Part 2

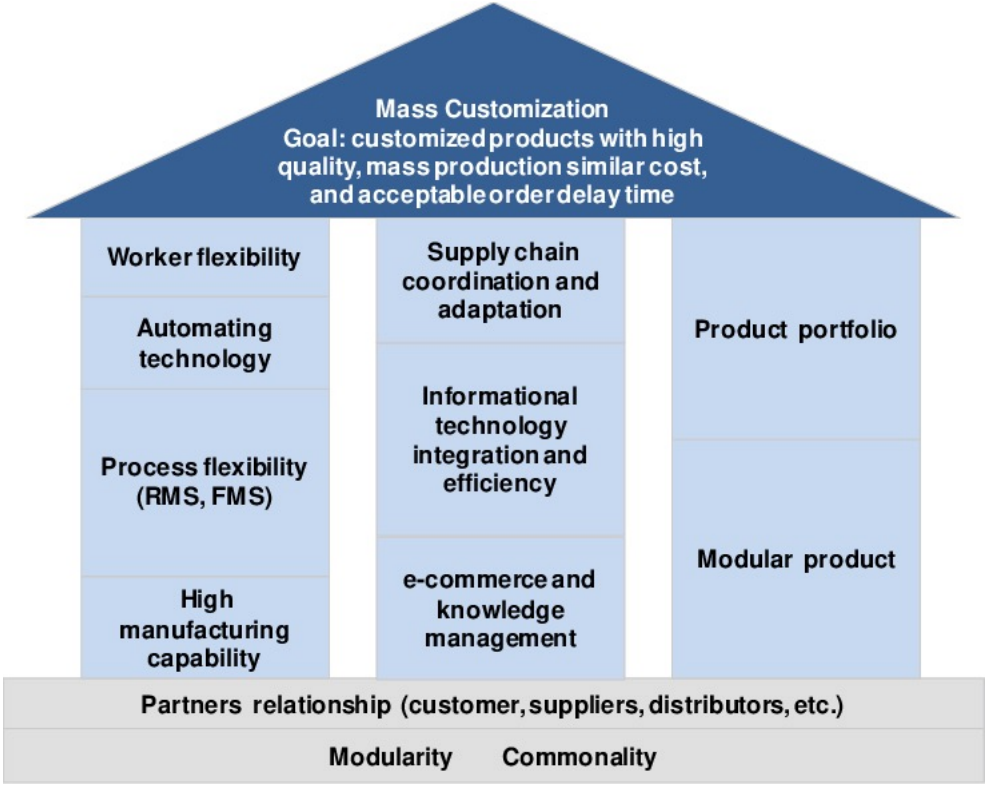
From Manufacturing to Service:

Mass Customization

2.1 About Mass Customization

Under the constraints of cost, quality, delivery time, laws, regulations and etc., mass customization refers to a manufacturing and service mode oriented on mass customer's personalized requirements.





2.2 Participants

Officers

Chair: Dr. Sha WEI, CESI
Vice Chair: Ms. Zhiman Chen, CRRC
Secretary: Mr. Xiaohu Wang, HAIER

Home Appliance

Haier Group

Cosmetics

Easy CARE Group

Computer

EVOC Intelligent Technology CO.,LTD.

High-Speed Railway

CRRC CO.,LTD. Zhuzhou

Clothes

Research Institutes and University

China Electronics Standardization Institute

Ocean University of China

WSN Technologies, Inc.

2.3 Scope

Provides the definitions, terminologies, operation procedures, system architectures

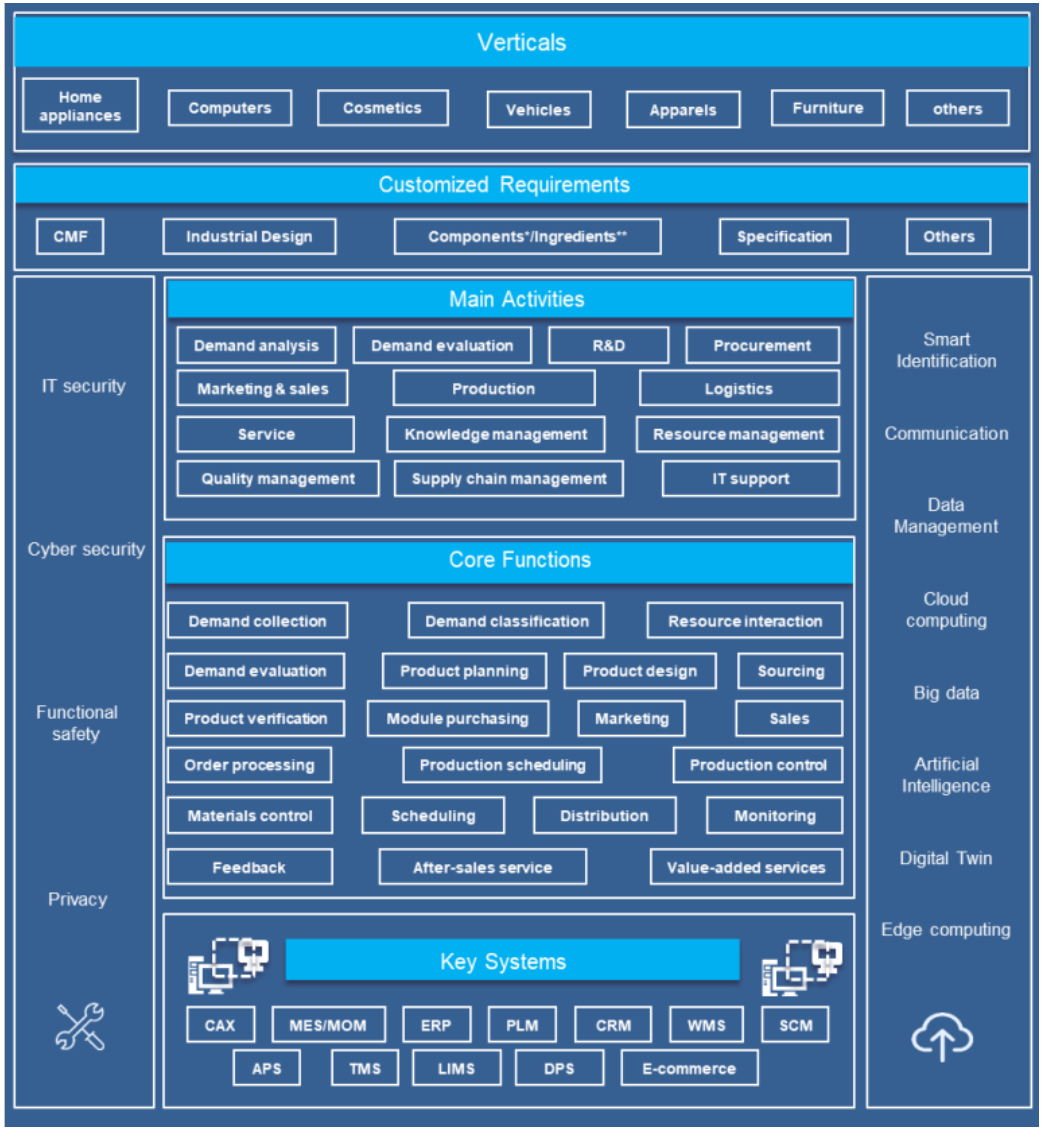
Provides key technological requirements, data requirements and applications related to user-oriented mass customization

Provide reference information to manufacturing enterprises for designing and implementing business models of mass customization

Since February 1st, 2018, the WG has held 12 F2F meetings and 6 Teleconferences.

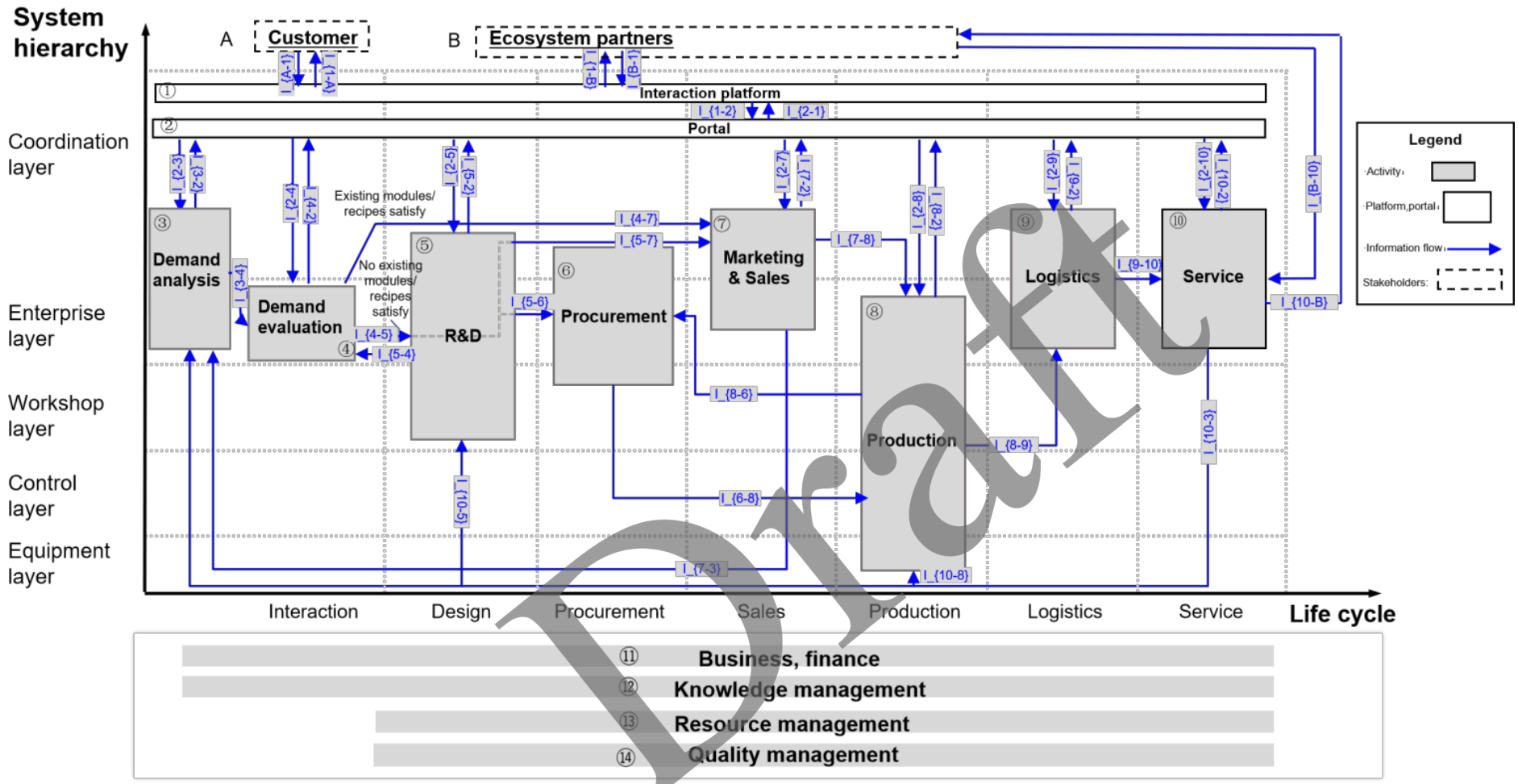
2.4 Main technical contents

Chapter 4: Architecture of Mass Customization



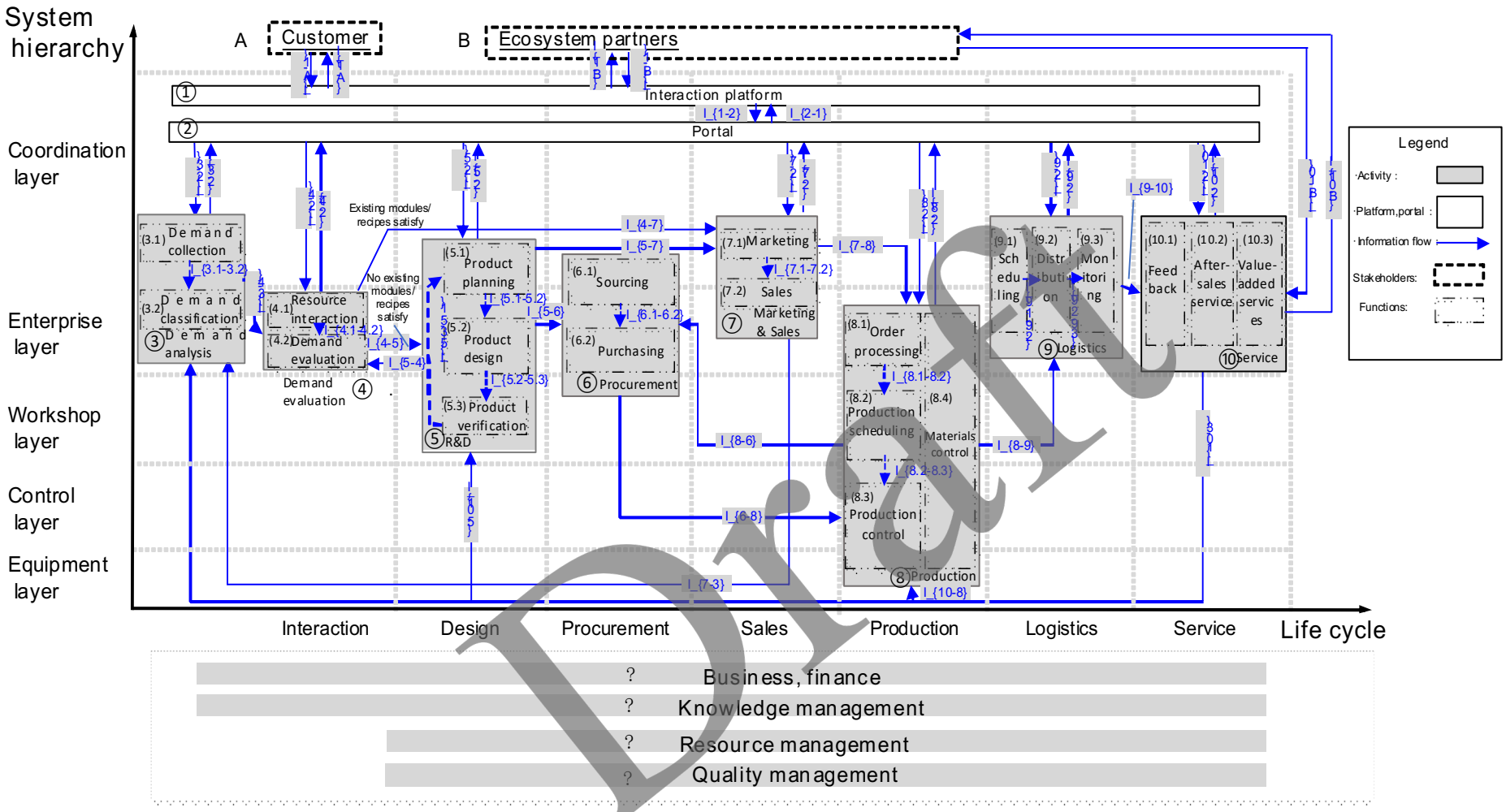
2.4 Main technical contents

Chapter 5: Activities



2.4 Main technical contents

Chapter 6: Core Functions



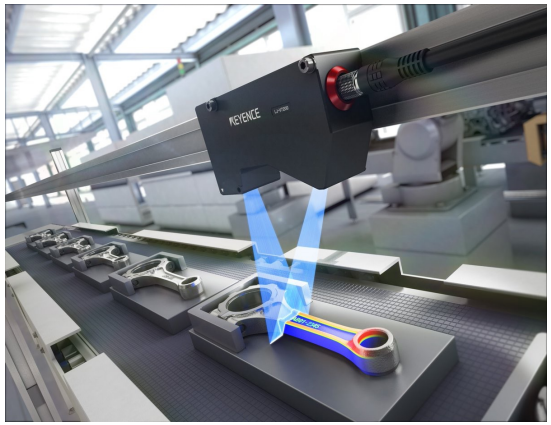
Part 3
New Technology Applications

- 3.1 Machine Vision
- 3.2 Digital Representation
- 3.3 Knowledge Graph

Part 3
New Technology Applications

- 3.1 Machine Vision
- 3.2 Digital Representation
- 3.3 Knowledge Graph

3.1.1 About Online Detection based on Machine Vision



Where human vision is best for qualitative interpretation of a complex, unstructured scene, machine vision excels at quantitative measurement of a structured scene because of its speed, accuracy, cost and repeatability.

Machine vision can replace manual labor for high-intensity continuous and precise operations in various production environments, greatly improving work efficiency and quality.


Automobile


Mechanics


Screen


Semiconductor


Plastics


Medicine


Steel


Others

3.1.2 Participants

Officers	Chair: Dr. Jonathan Chang Vice Chair: Dr. Feng WU, XJTU Secretary: Ms. Lin Hu, CESI

Home Appliance

Haier Group

Computer

EVOC Intelligent Technology CO.,LTD.

Semiconductor

Infineon

High-Speed Railway

CRRC CO.,LTD. Zhuzhou

Integrators

SIEMENS

中科飞测 SKYVERSE

Research Institutes and University

China Electronics Standardization Institute

Xi'an Jiaotong University

3.1.3 Scope

This standard specifies through the general requirements of online detection based on machine vision, including

- requirements for data format
- data transmission processes
- definition of application scenarios
- performance metrics for evaluating the effect of online detection deployment.

Since Jan. 30th, 2018, the WG has held 6 F2F meetings and 7 Teleconferences.

3.1.4 Main technical contents

1. Overview
2. Normative references
3. Definitions and abbreviations
4. Generic Flows and Architecture
5. Input
6. Process
7. Output
8. Function Requirements
9. Interoperability Requirements
10. Performance
11. Test methodology

Annex A IC Substrate Inspection

Annex B Thermal Grease Online Detection

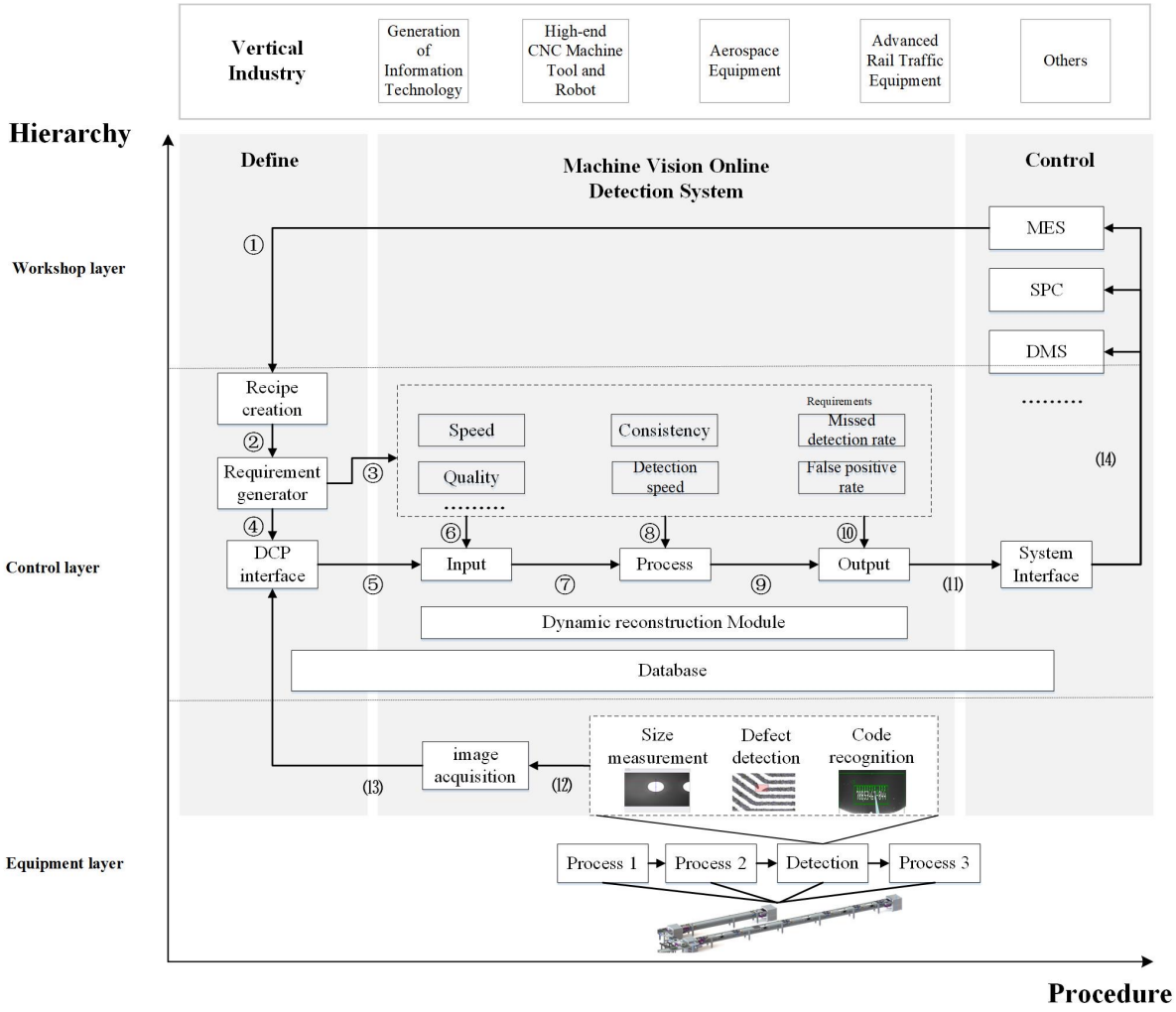
Annex C Machine Vision in Process Control of IC Manufacturing

Annex D Online Detection on Semiconductor Package

Annex E Defect Detection of Magnetic Tiles Based-on Machine Vision

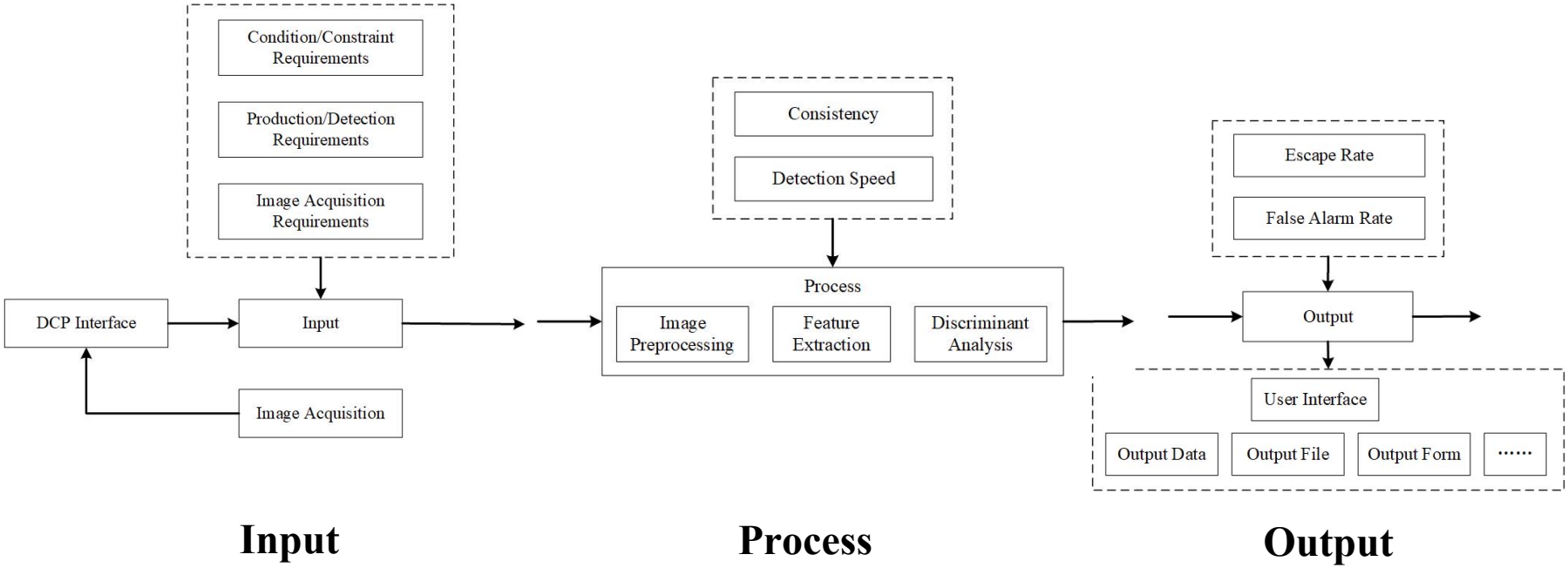
3.1.4 Main technical contents

Generic flow and architecture



3.1.4 Main technical contents

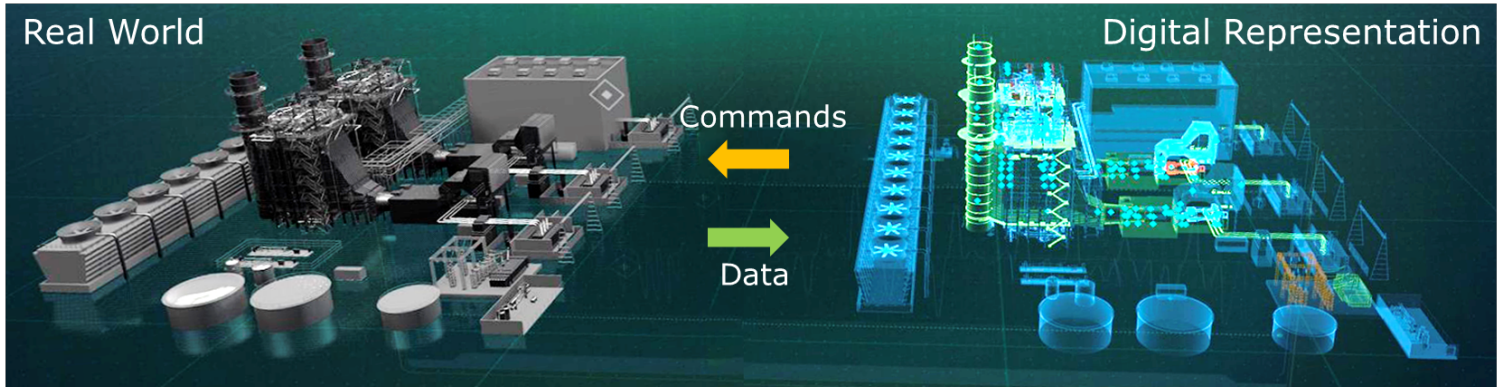
Requirements for input, process and Output

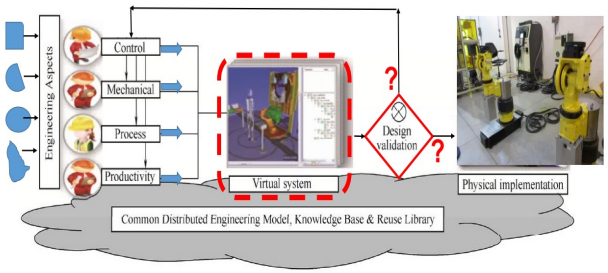


Part 3
New Technology Applications

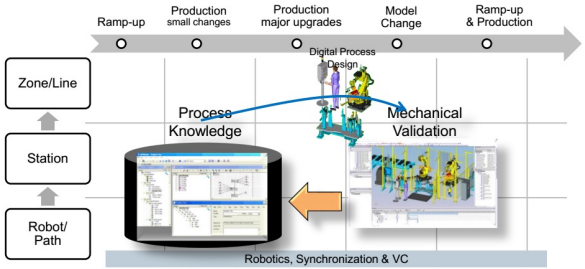
- 3.1 Machine Vision
- 3.2 Digital Representation
- 3.3 Knowledge Graph

3.2.1 About Digital Representation





Design Verification



Process Optimization

Predictive Maintenance

3.2.2 Participants

Officers	Chair: Dr. Sha WEI Vice Chair: Dr. Shiwan Lin, Yo-i Secretary: Mr. Jonathan Lin

Home Appliance

Haier

Computer

EVOC 研祥智能股份

Lenovo

High-Speed Railway

中国中车 CRRC

CRRC CO.,LTD. Zhuzhou

CiSTT

Integrators

优也 Yo-i

Alibaba Group

SensesGlobal

Research Institute

ESI

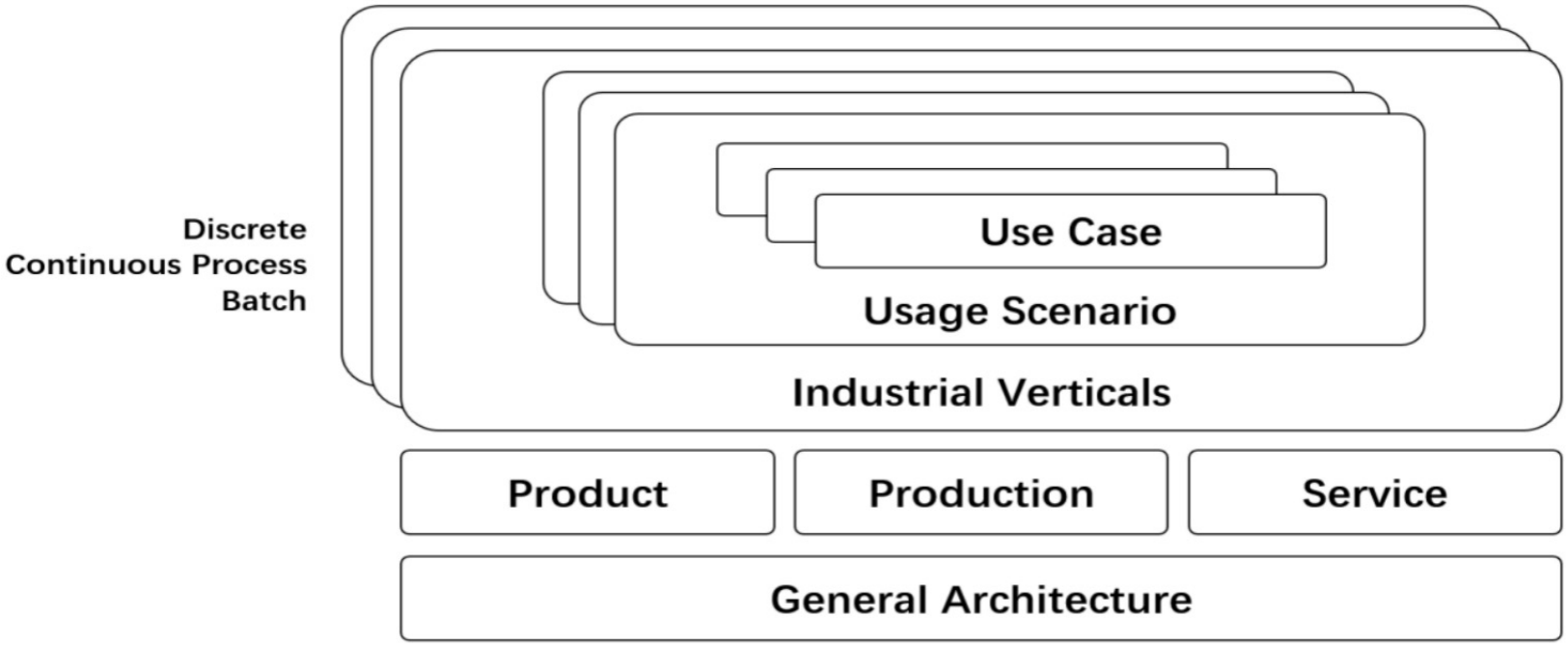
3.2.3 Scope

This standard defines the system architecture of digital representation for physical objects in factory environments,

- important components
- required data resources
- basic establishing procedure of digital representation in factory environments.

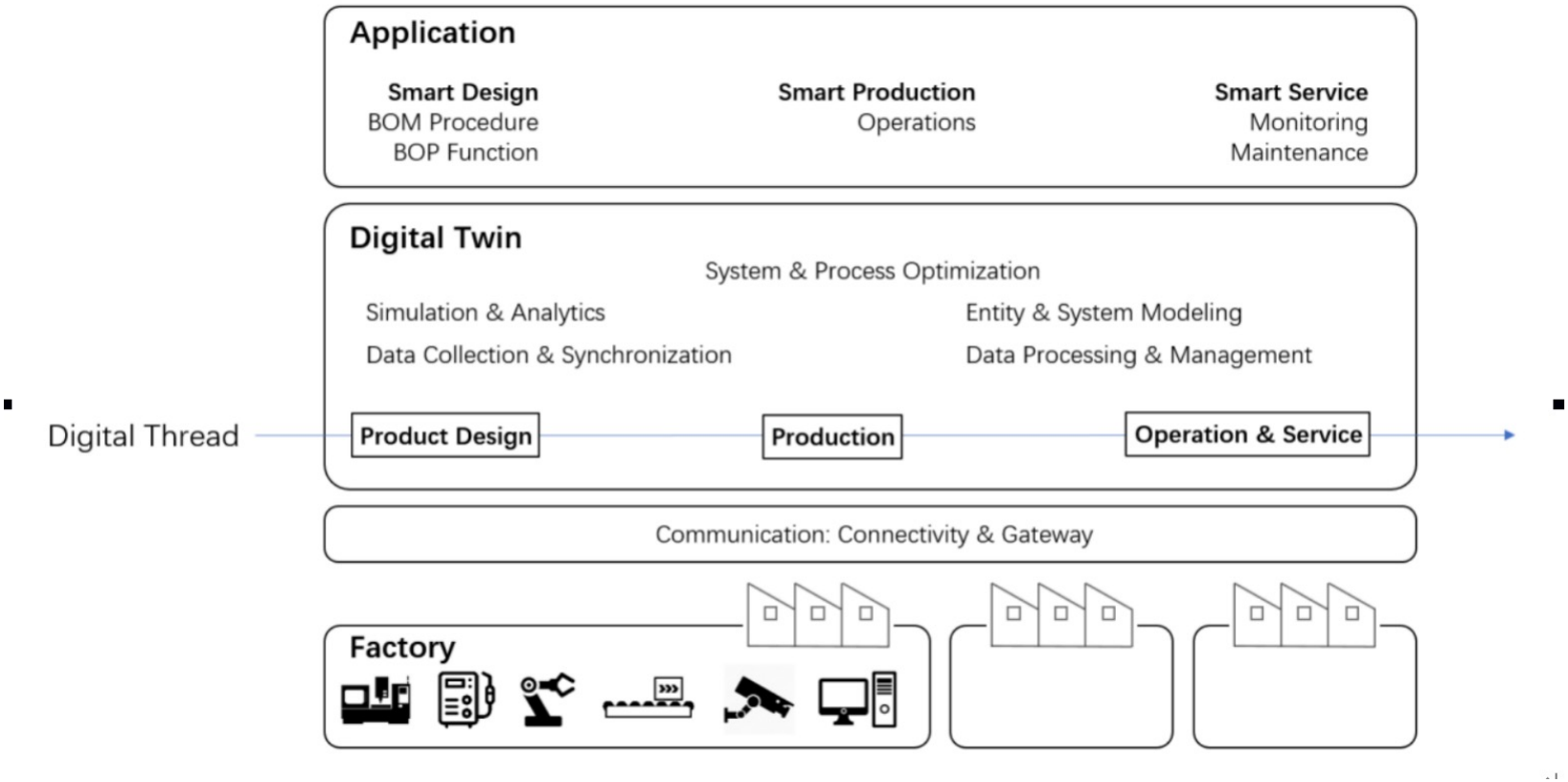
Since Aug. 22nd, 2019, the WG has held 2 F2F meetings and 6 Teleconferences.

3.2.4 Progress of P2806



Purpose and Scope

3.2.4 Progress of P2806



A manifestation of generic system architecture

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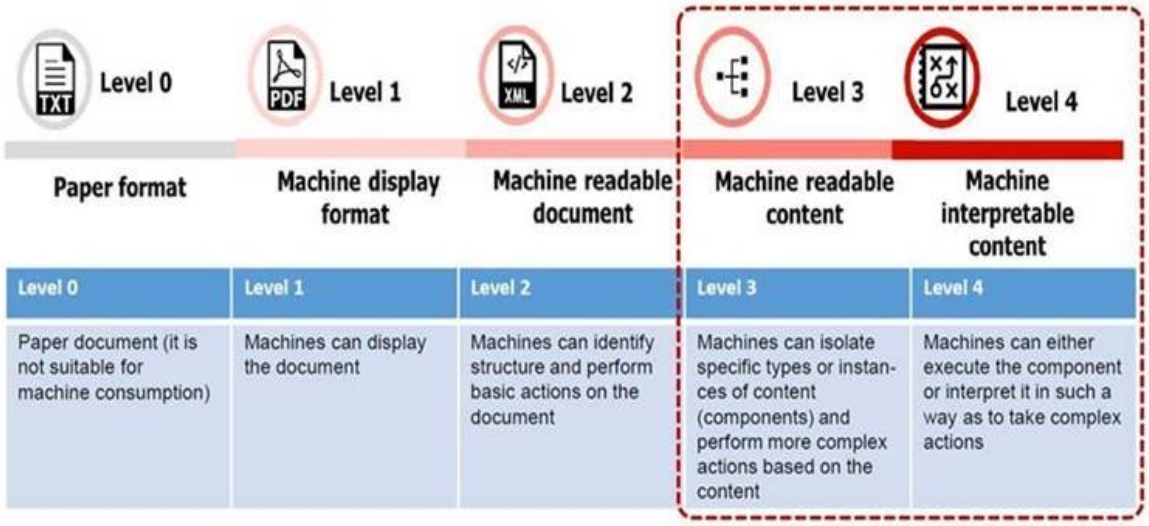
3.2.5 About P2806.1

- Project Title: Standard for Connectivity Requirements of Digital Representation for Physical Objects in Factory Environments
- Working Group: Digital Representation Working Group (C/SM/DR_WG)
- Scope: This standard defines the connectivity requirements of digital representations for physical objects in factory environments. Based on heterogeneous data, the connectivity requirements include high-speed protocol conversion, unified data modeling and data access interfaces to meet the interoperability and interaction requirements between physical objects and the corresponding digital representations.
- Officers: Dr. Yuanye MA (Chair) and Dr. Genzi Li (Secretary)
- The kick-off meeting was held on Nov. 28th, 2020.

Part 3
New Technology Applications

- 3.1 Machine Vision
- 3.2 Digital Representation
- 3.3 Knowledge Graph

3.3.1 About Knowledge Graph and Machine readable standards



Level 0	Level 1	Level 2	Level 3	Level 4
Paper document (it is not suitable for machine consumption)	Machines can display the document	Machines can identify structure and perform basic actions on the document	Machines can isolate specific types or instan-ces of content (components) and perform more complex actions based on the content	Machines can either execute the component or interpret it in such a way as to take complex actions

- Level 2: an xml-structured standard a “machine readable document”, the machine (software) can distinguish between content and layout.
- Level 3: we identify specific (granular) elements such as requirements and “tag” them the right way in order to retrieve and extract them later, and to transfer them into other systems (like requirement management software).
- Level 4: we structure the whole content in a database format so that it can be directly accessed by software (with little or without any) human intervention.

Source: IEC SG 12 “Digital Transformation”

3.3.2 About IEEE P2959

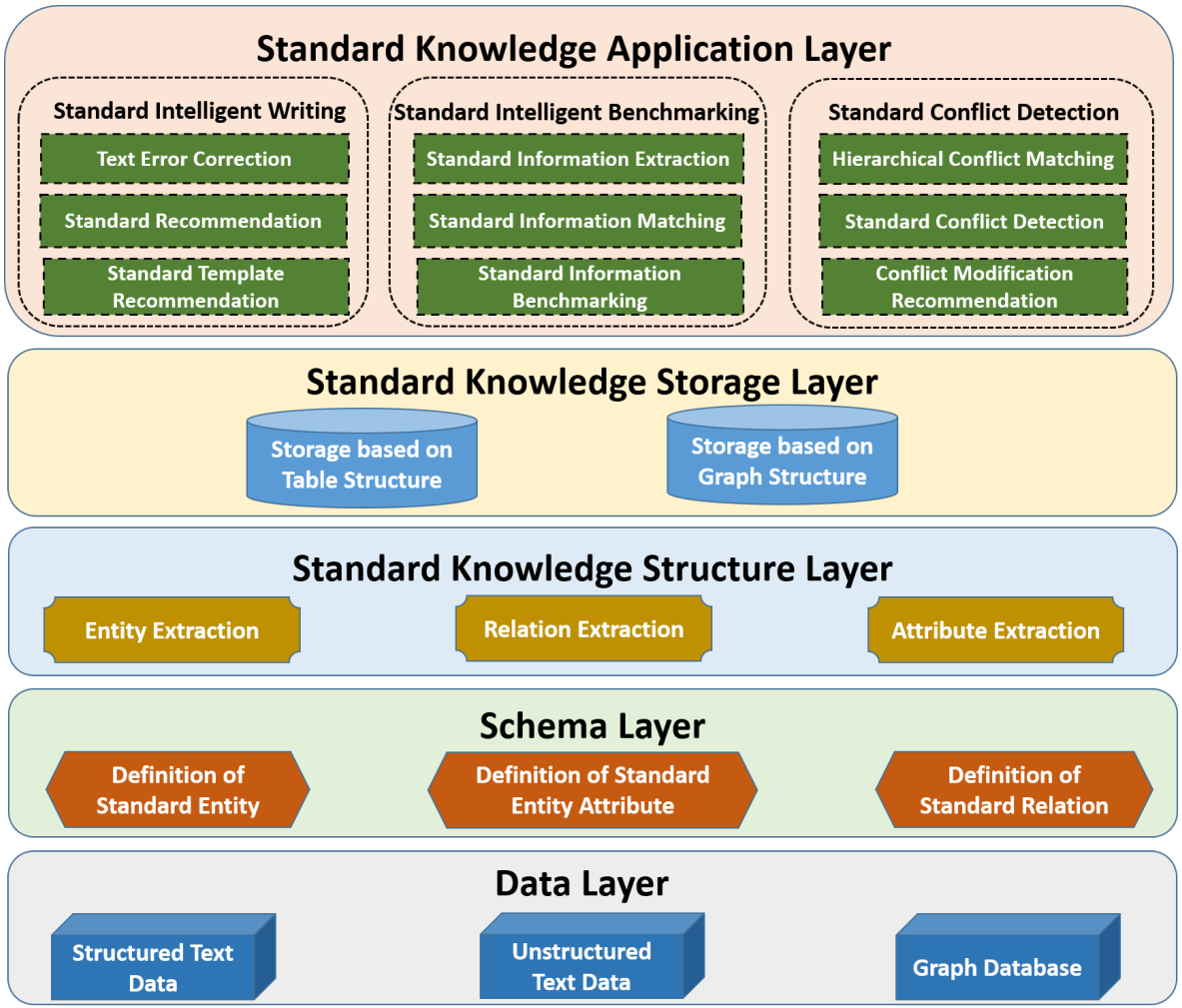
- Project Title: Standard for Technical Requirements of Standard-Oriented Knowledge Graphs
- Working Group: Standard- Oriented Knowledge Graphs Working Group (C/SM/SKG_WG)
- Scope: This document specifies data and schema requirements for knowledge graphs constructed from published standards which can be automatically machine readable. A knowledge graph construction process and performance metrics are specified. Application scenarios are also described.
- Officers: Wenjian HAO (Chair) and Yi MENG (Secretary)
- The kick-off meeting was held on Nov. 28th, 2020, and the second meeting was held on Mar. 30th, 2021. There are 22 IEEE corporate members in this WG.

3.3.3 Scope and Main technical contents

SCOPE

This document specifies data and schema requirements for knowledge graphs constructed from published standards which can be automatically machine readable. A knowledge graph construction process and performance metrics are specified. Application scenarios are also described.

Contents



Part 4
Smart Factory

- 4.1 Assessment
- 4.2 Logistics

Part 4
Smart Factory

- 4.1 Assessment
- 4.2 Logistics

4.1.1 About assessment of a smart factory

1. Assess a manufacturing factory's ability to initiate the digital transformation of its processes towards Smart Manufacturing

2. Provide a set of coherent guidelines for assessing a manufacturing system and its management practices, identify improvement opportunities and recommending technologies for adoption by manufacturers

3. Support the manufacturing stakeholders to define their Smart manufacturing vision, roadmap, and strategic projects, and ultimately lower the entry barrier and reduce the risk of the transition process towards smart manufacturing

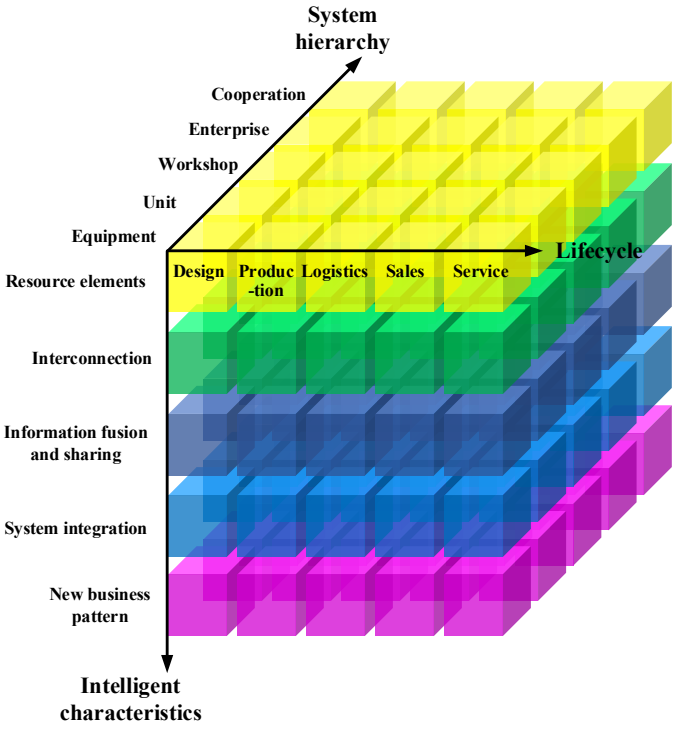
4. Allow companies to conduct self-assessments so that they can systematically and comprehensively align themselves with Smart manufacturing

5. Support manufacturing SMEs in their progress towards Smart manufacturing

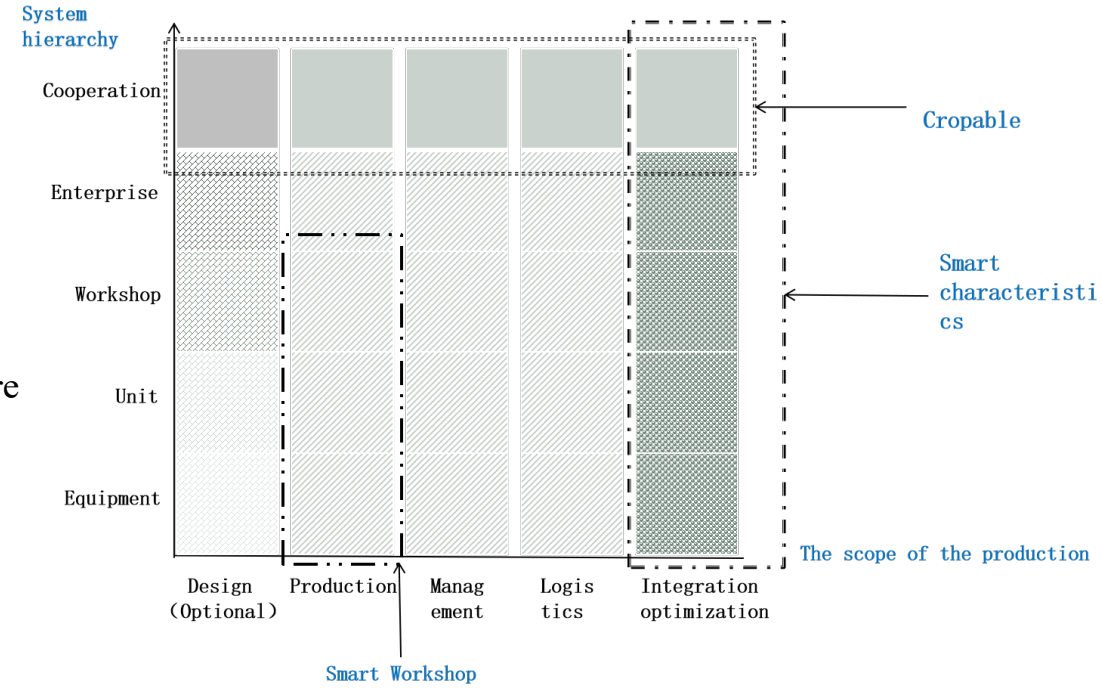
4.1.2 About IEEE P2879

- Project Title: General Principles for Assessment of a Smart Factory
- Working Group: Intelligent Factory Assessment(C/SM/IFA)
- Scope: This standard defines basic terminologies, assessment process requirements, indicator metrics, assessment methods and assessment criteria of smart factories
- Officers: Yuanye MA (Chair) and Genzi Li (Secretary)
- There are 9 IEEE corporate members and 13 observers in this WG.
- The kick-off meeting was held on Oct. 13th, 2020 and the first teleconference was held on Dec. 11th, 2020.

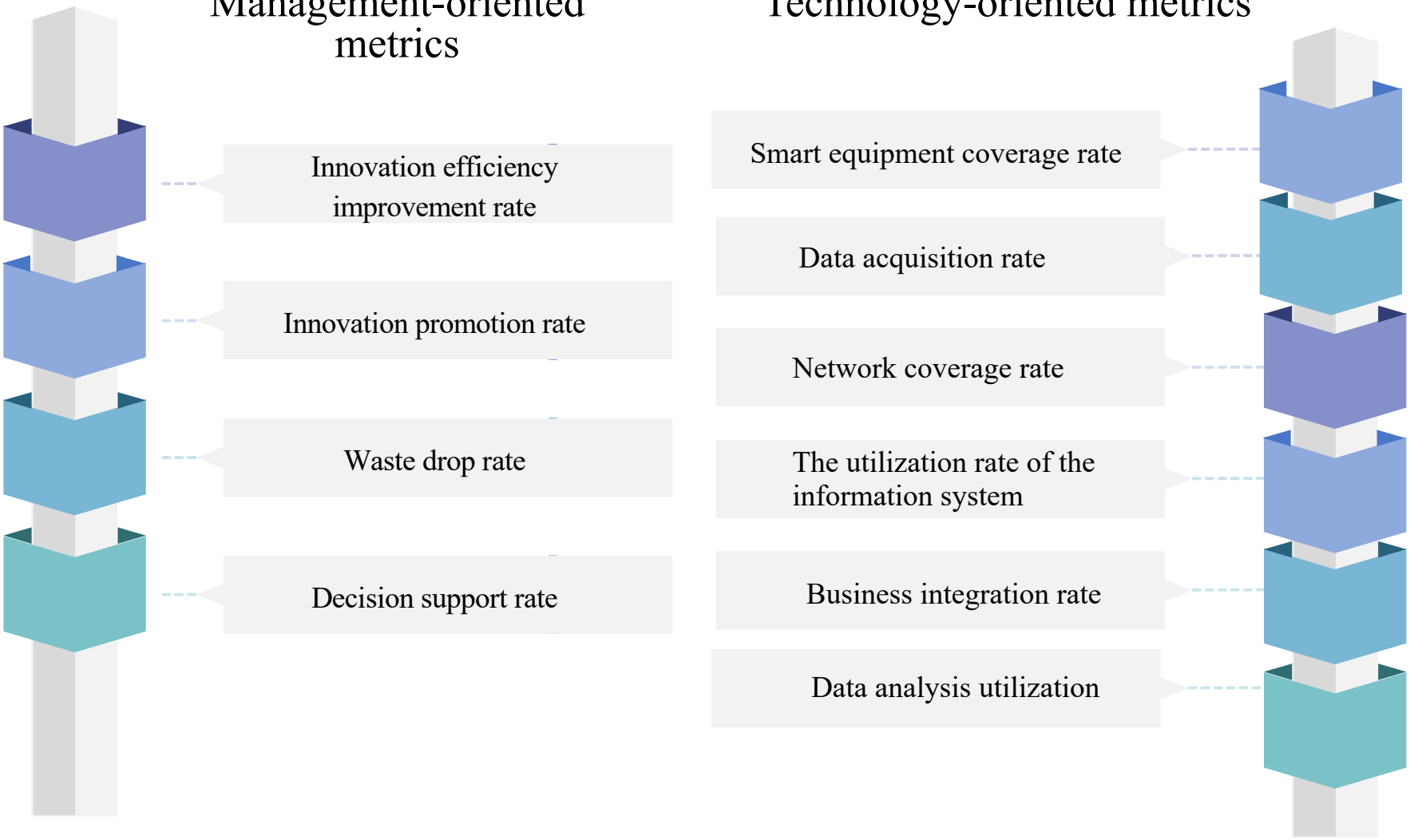
4.1.2 Initial Idea of Assessment



Intelligent Manufacturing System Architecture



4.1.3 Initial Idea of Metrics



Part 4
Smart Factory

- 4.1 Assessment
- 4.2 Logistics

4.2.1 About IEEE P2934

- Project Title: Standard for Logistics Operation Process in a Smart Factory
- Working Group: Intelligent Factory Assessment(C/SM/IFA)
- Officers: Zhenchao YU (Chair), Chunyang YANG (Vice Chair) and Weihua LIU (Secretary)
- There are 11 IEEE corporate members in this WG.
- Since June 20th, 2020, the WG held 3 F2F meetings, 4 Teleconferences and 3 times of enterprise researches.

4.2.2 Scope

Defines logistics operation processes in a smart factory, including the process composition such as warehousing, packaging, shipment or transportation, implementation conditions, process quality evaluation and process improvement.

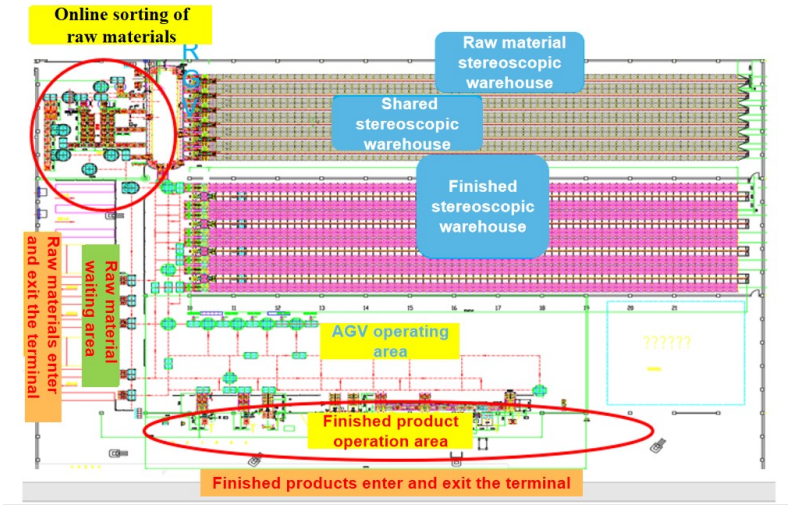
Defines methods for management organization, facility layout, equipment requirements, information systems, employee requirements, and emergency management and evaluation in a smart factory.

4.2.3 Main technical contents

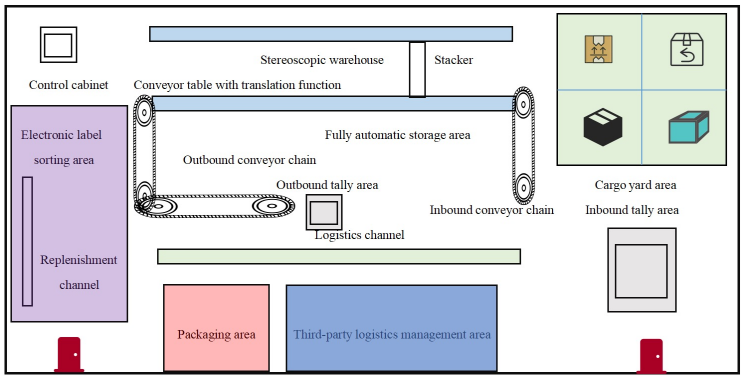
Chapter 4 Logistics process of smart factory	Chapter 5 Implementation guarantee of logistics operation process	Chapter 6 Evaluation and improvement of logistics operation process
• 4.1 Overall process of logistics operations • 4.2 In-plant logistics operations • 4.3 Out-of-plant logistics auxiliary operation links	• 5.1 Organization and responsibilities • 5.2 Layout of logistics facilities • 5.3 Logistics equipment • 5.4 Information system • 5.5 Personnel skill requirements • 5.6 Safety management • 5.7 Emergency management	• 6.1 Quality evaluation of logistics operation process • 6.2 Improvement of logistics operation process

4.2.4 Case Study

7. Case 1: The logistics operation process specification of the smart factory of a home appliance manufacturing enterprise
    - 7.1 Logistics operation process
        - 7.1.1 In-plant logistics operations
        - 7.1.2 Auxiliary operations of off-site logistics
    - 7.2 Guarantee of implementation of logistics operation process specifications
        - 7.2.1 Organization and responsibilities
        - 7.2.2 Division and layout of functional areas
        - 7.2.3 Device configuration
        - 7.2.4 Information system technical requirements
        - 7.2.5 Personnel skill requirements
        - 7.2.6 Safety management
        - 7.2.7 Emergency management
    - 7.3 Evaluation and improvement of logistics operation process
        - 7.3.1 Quality assessment of logistics operation process
        - 7.3.2 Improvement of logistics operation process



Household electrical appliances



3C

Part Five
New Projects and Future Works

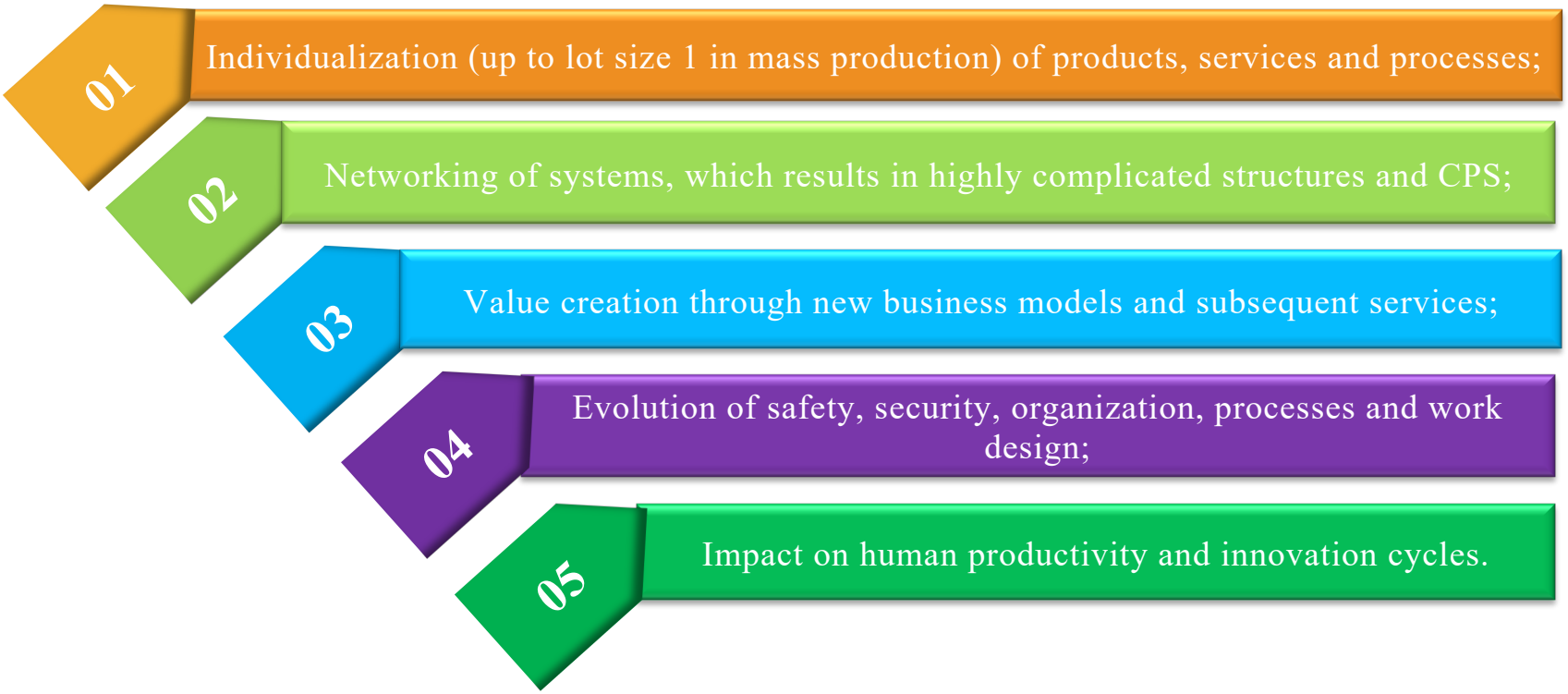
5.1 New Project

- Project Title: IEEE P2971 Standard for the Test Requirements of a Gateway Supporting a Time Sensitive Networking in the Field of Industrial Internet
- Working Group: Digital Representation Working Group (C/SM/DR_WG)
- Scope: The standard specifies general testing requirements for gateway devices which support TSN (Time Sensitive Networking) in the field of industrial internet. Requirements for protocol function testing, performance testing, security testing, and reliability testing are defined.
- Working Group Chair: Dr. Cailian Chen, SJTU
- There are 9 IEEE corporate members in this WG.

5.2 New Project

- Project Title: IEEE P2975 Standard for Industrial Artificial Intelligence (AI) Data Attributes
- Working Group: Digital Representation Working Group (C/SM/DR_WG)
- Scope: This standard defines attributes related to industrial Artificial Intelligence(AI) data that facilitates the classification, association, and mapping towards value creation using data. The attributes include but are not limited to data source, type, ownership, sampling frequency, traceability, privacy attributes for modeling, sampling, shareability and its use in AI algorithms.
- Working Group Chair: PADMASRI KRISHNAMURTHY, padmasri.sudhindra@gmail.com

5.3 Future Works



New value creation

Automation innovation

Computation intensive

Higher interoperability

Human centric

Security and Trustworthiness

Comprehensive digitalization

Information and knowledge intensive

5.4 Contact Information of the WGs

WG No.	Name of the WG	Contact Person	Mobile Phone	Email
P2671	Online Detection	Prof. Feng WU	+86-130-3859-6905	fengwu@mail.xjtu.edu.cn
P2672	Mass Customization	Dr. Sha WEI	+86-138-1078-5724	venessa724@vip.qq.com
P2806	Digital Representation	Dr. Ruiqi LI	+86 -185-1868-8242	lirqcesi@126.com
P2806.1	Digital Representation	Dr. Ruiqi LI	+86 -185-1868-8242	lirqcesi@126.com
P2879	Smart Factory Assessment	Dr. Genzi LI	+86 -136-1137-1 701	ligenzi@163.com
P2934	Logistics Operation Process in Smart Factory	Prof. Weihua LIU	+86 -135-1283-3463	lwhliu@tju.edu.cn
P2959	Standar-oriented Knowledge Graph	Ms. Guan HUANG	+86 -134-2607-4996	huangguan@cesi.cn
P2971	TSN Gateway	Dr. Qimin Xu	+86 -150-2661-1879	qiminxu@sjtu.edu.cn
P2975	Digital Representation	Mr. PADMASRI KRISHNAMURTHY	-	padmasri.sudhindra@gmail.com

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