GLOBAL PROJECT
Quality Infrastructure

Guidance
"Use Cases and Applications"

STANDARDIZATION COUNCIL INDUSTRIE 4.0

PLATTFORM INDUSTRIE4.0

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National Intelligent Manufacturing Standardisation Administration Group

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Contents

Context and Objectives

This joint report arose within the cooperation line "Use Cases and Applications" in the Sub-Working Group Industrie 4.0/Intelligent Manufacturing of the SGSCC (Sino-German Standardization Cooperation Committee). The overall objectives of this Sub-Working Group is the deepening and intensification of the Sino-German cooperation in the realm of standardization.

The cooperation line "Use Cases and Applications" analyses business strategies and customer needs in the manufacturing industries, especially by looking at concrete customerprojects. The findings are compiled into descriptions – so called use cases – based on well-known best practices, e.g. the Industrial Internet Reference Architecture (IIRA), see [1]. These use cases facilitate a common understanding of markets, trends, drivers, concepts, and solutions. Furthermore, they can serve as a fundament to articulate requirements for standardization aspects.

Within this document, the overall focus and general approach of the cooperation line "Use Cases and Applications" is presented. Updated versions will be published as well. This paper should be easily understandable. Nevertheless, there are two essential target group of readers:

- Technical experts familiar with digitalization in manufacturing industries: This target group shall gather orientation for processes regarding "Use Cases".
- People from industry, standardization, associations and politics: for these, this document entails an overview of the topic "Use Cases" without necessarily having to understand the detailed content of this document.

Overall Drivers and Restrictions

We acknowledge that significant changes in the realm of standardization occur. In the past, standardization often addressed only established technologies. In today's context of digitization, topics are discussed that often have not yet been realized. Additionally, information technology standardization is often supported by industry groups organized in forums and consortia. Whereas traditional engineering disciplines often use established ways of consensus-based standardization.

It follows, that we must change our more technology-centred perspective to a more customer-oriented one. For this, we follow a holistic system engineering approach separating the levels of strategy, processes, and technology. We separate abetween requirements and solutions and consider the needs and interests of the different stakeholders of the various industries. These are obviously constrained by external boundaries. The cooperation line "Use cases and Applications" is only a part of a larger overall system. Within a process perspective, this document only defines a framework including some few selected – and hopefully practical – examples. Since collaboration is a key element, we must identify suitable partners to apply the already existing theoretical foundation.

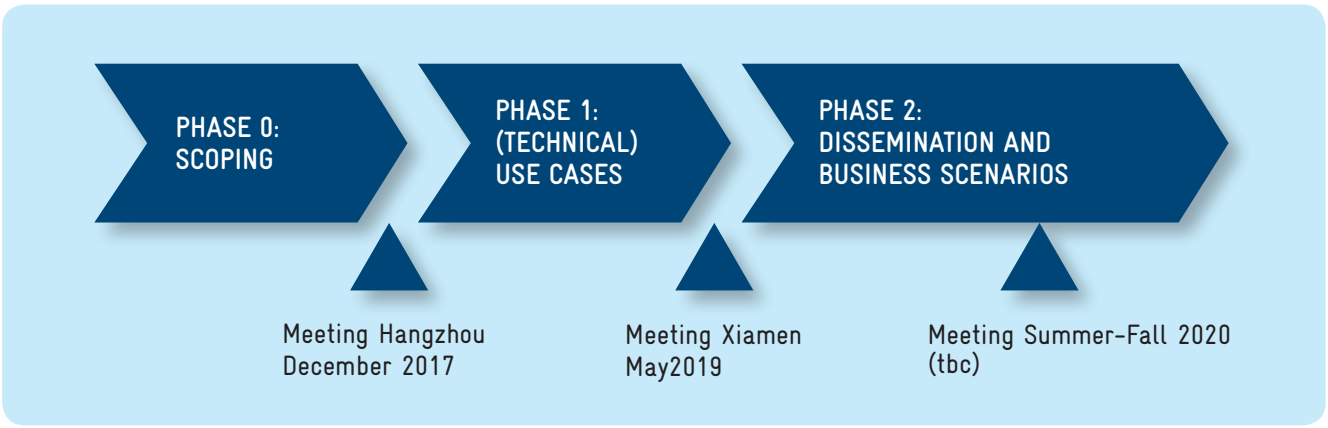
Overall Approach and Procedure

The cooperation line "Use Cases and Applications" follows an agile process with several phases; with each one following a different angle. Each phase builds on the previous ones, especially considering the lessons learned, see Figure 1.

Following the initial scoping phase, in which a common understanding of overarching goals and procedures was created, two more phases can be distinguished:

- A general framework for the topic "Use Cases" was created (Phase 1 in Figure 1) and best practice examples were elaborated with a focus on (technical) use cases. The work on these examples including the associated guidance regarding implementation have been completed and are available as corresponding documents, see [4], [5], [7] and [8].
- Phase 2 deals with the dissemination of the methodology, expansion of the development of best practice examples towards business scenarios (see [11]) and linking the activities with international standardization. This phase has not yet been completed and the cooperation line remains open for feedback from other bodies.

Figure 1: Overall approach of cooperation line "Use Cases and Applications"



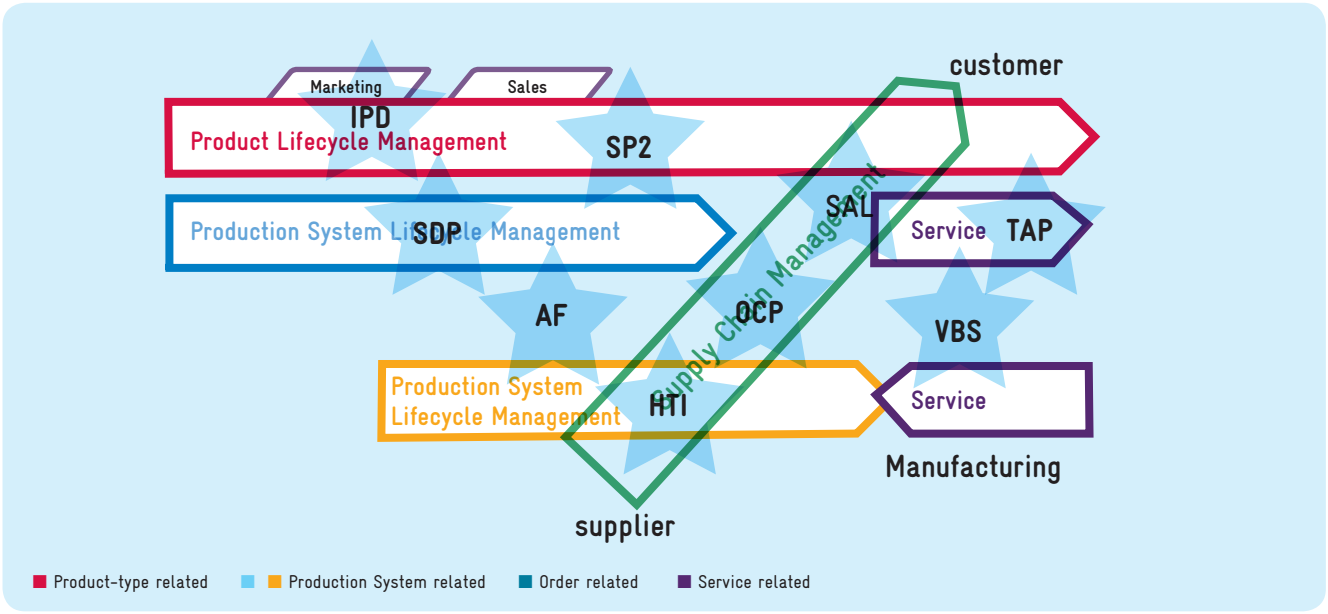
Phase 0: Scoping

Since there were many concrete projects in the context of Industrie 4.0/Intelligent Manufacturing, the clustering was challenging. Plattform Industrie 4.0 had developed so-called application scenarios and the China Intelligent Manufacturing had identified five kinds of intelligent manufacturing models with corresponding pilot applications to help structuring the overview regarding digitalization of manufacturing.

Application Scenarios of Plattform Industrie 4.0

The application scenarios (see Figure 2 and for details [2]) describe how German industry perceive its digital future. These scenarios shall demonstrate how value-added processes in the manufacturing industry could be managed and organized in a more efficient way with the help of digitization technologies. Additionally, they show which innovations in technology, work organization, law and society the German industry wants to utilize on its way to the digital future. However, the application scenarios also indicated areas posing major challenges and questions, for example standards, research, security, legal framework and labour, and thereby provided a common framework for the Plattform Industrie 4.0 Working Groups.

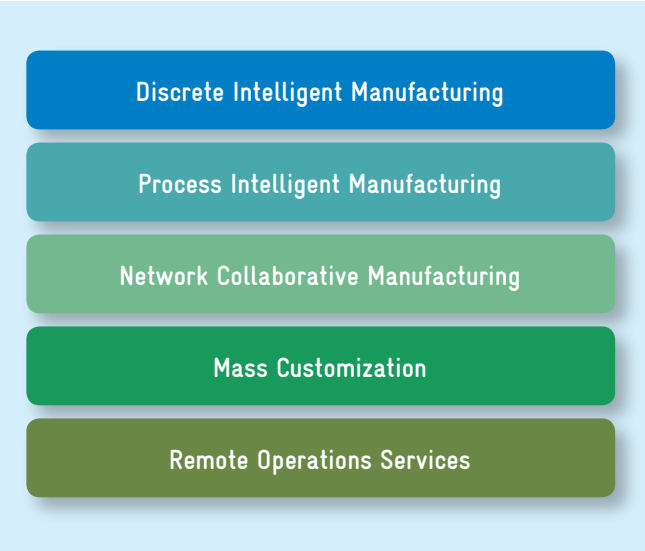
Figure 2: Application scenarios of Plattform Industrie 4.0



Intelligent Manufacturing Modes Identified by China Intelligent Manufacturing

According to China Intelligent Manufacturing Development Program (2016–2020) and China Intelligent Manufacturing Engineering Implementation Guide (2016–2020), five intelligent manufacturing modes, see Figure 3, were identified and focused on to encourage new mode innovation and carry out intelligent manufacturing pilot demonstration[1].

Figure 3: Five identified intelligent manufacturing modes



1 In the future also new modes could be considered, for example Cloud Manufacturing, Remanufacturing, or Sharing Manufacturing.

The five intelligent manufacturing modes can be characterized as follows:

Discrete Intelligent Manufacturing

- Digital product/ process/ production models and simulation based on key parameters
- Integrated lifecycle management of the product data
- Intelligent sensing and control, intelligent detection and assembly
- Collected production site data such as production schedule, on-site operation and quality
- Efficient collaboration and integration between systems, such as PLM (Product Lifecycle Management), ERP (Enterprise Resource Planning), MES (Manufacturing Execution System), field data acquisition and analysis system

Process Intelligent Manufacturing

- Digital process and production models
- Full-process monitoring/ control and high integration
- Remote monitoring and status evaluation of equipment
- Dynamic optimization of the production process

Network Collaborative Manufacturing

- Collaborative cloud platform under collaborative mechanism
- Integration of innovative resources and design capabilities
- Interenterprise management system and service support system
- Establishment of product traceability system across the whole operation chain
- Dynamic analysis and arrangement of manufacturing resources

Mass Customization

- Dynamic demand interaction platform with
- existing and potential customers
- Modular based design and product database
- Reconfigurable manufacturing equipment and/or production system
- Collaboration among production planning, flexible manufacturing, and resource supply oriented on mass customer's personalized requirements
- Single-piece or small-batch flexible, agile production and distributed logistics with lower or zero inventory

Remote operations services

- Standardized and open data interfaces
- Remote operation and maintenance service platform incorporated data analysis tools.
- Remote monitoring and fault diagnosis for equipment and product/ service
- Knowledge database based on expert library and expert consulting system
- Security mechanism for remote access

Conclusion

Industrie 4.0/ Intelligent Manufacturing is a multifaceted, complex topic that must consider the perspectives of many different stakeholders. Furthermore, the heterogeneity of manufacturing industries does not allow a "one-size-fits-all" approach. From the author's point of view, the application scenarios of Plattform Industrie 4.0 and the concept of intelligent manufacturing modes are similar. Nevertheless, it was a challenge to develop a common understanding on the scope of the coordination line "Use Cases and Applications".

Phase 1: Focus on (Technical) Use Cases

We concluded that we need a rigid description of use cases. We did not want to develop a new approach but to apply an established methodology. Therefore, we decided to use the usage viewpoint of the Industrial Internet Reference Architecture (IIRA), see [1].

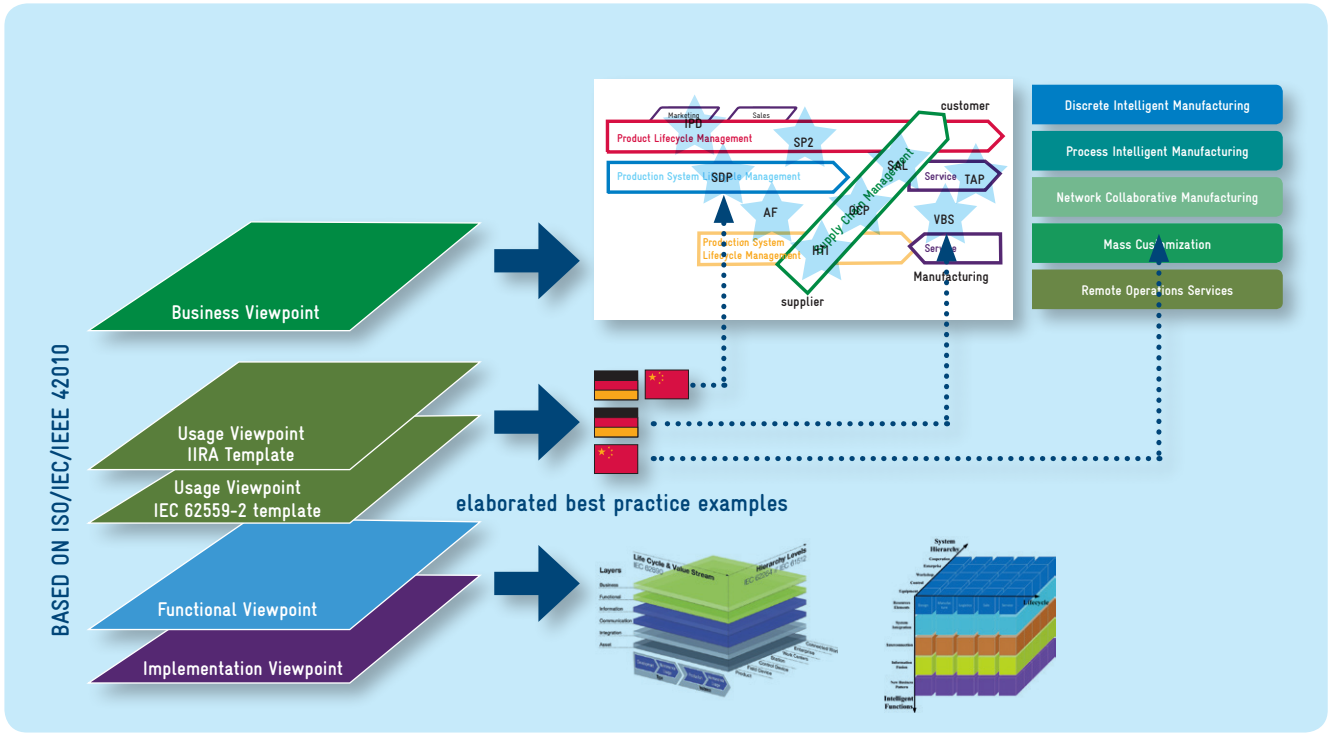
Common Understanding on Use Cases

A common overall understanding has been developed, shown in Figure 4, and was already integrated into the German Standardization Roadmap Industrie 4.0, see [3]. This framework is generic and not limited to the cooperation between Germany and China.

The basic idea is based on the proven practice to describe a system from different perspectives in the form of views. The left side shows the structure of the Industrial Internet Reference Architecture (IIRA) based on the international standard ISO/IEC/IEEE 42010. IIRA proposes four concrete views with corresponding description methodology.

- Both the application scenarios of the Platform Industrie 4.0 and the intelligent manufacturing modes address primarily aspects that are elaborated in a business view according to IIRA. Within here, a so-called business scenario is described. Following a business model logic (i.e. business canvas), the business stakeholders are identified, and their relationships are described in a value-added network.
- A use case is a list of actions or event steps that define the interaction between a role (or actor) and a system to achieve a goal. The actor can be a human or another external system. We agree with this widely accepted definition of use case. The IIRA usage viewpoint also aims to describe use cases in this sense. Therefore, we have agreed to prepare concrete use case descriptions according to the usage viewpoint of IIRA.

Figure 4: Common understanding on use cases



- In addition to the descriptors suggested in IIRA's usage viewpoint, there are other suggestions for describing use cases, such as the template of IEC 62559-2. This template requires a more detailed description than the IIRA's usage viewpoint. We estimate that an description according to IIRA has to be about 20 pages long, while a description according to IEC 62559-2 requires at least 50 pages. Regarding the resources available to us, we decided not to use the IEC 62559-2 template.
- Figure 4 indicates that discussions with respect to the alignment of RAMI4.0 and IMSA address the functional and implementation viewpoints, to illustrate the relation of the cooperation line "Use Cases and Applications" to other cooperation lines,

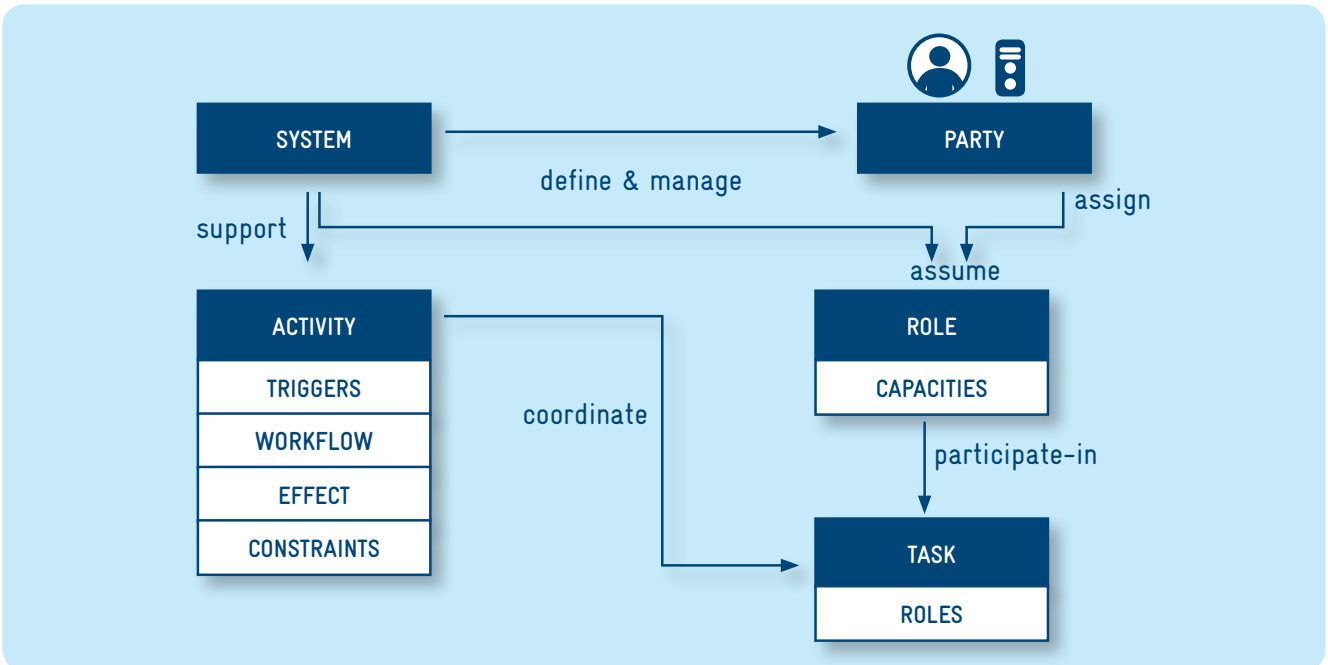
We aim to validate our approach by creating such descriptions for concrete use cases. We elaborated the individual use case description independently but reviewed the elaboration results of each other in detail to work efficiently. The focus of elaboration is on the underlying general requirements and principles, not the considered concrete implementation projects.

Use Case Template

The usage viewpoint proposed by the Industrial Internet Consortium comprises the following concepts, for details see [1]:

- A task[2] is the basic unit of work. A task is **carried**[3] out by a party assuming a role.
- A role is a set of capacities assumed by an entity to initiate and participate in the **execution** of, or consume the outcome of, some tasks or functions in a system as required by an activity. Roles are assumed by parties.
- A party is an agent, human or automated, that has autonomy, interest and responsibility in the **execution** of tasks. A party **executes** a task by assuming a role that has the right capacities for the execution of the task. A party may assume more than one role, and a role may be fulfilled by more than one party.[4]
- An activity is a specified coordination of tasks required to realize a well-defined usage or process of a system. An activity has the following elements:
  - A trigger is one or more condition(s) under which the activity is initiated.

Figure 5: Overview of Usage Viewpoint (according to [1])



2 The tasks according to [1] include a Functional Map referring to the Functional Viewpoint and an Implementation Map to the implementation Viewpoint. Since we are focusing on the Usage Viewpoint only, we do not consider Functional resp. Implementation Maps.

3 The bold marked terms refine and illustrate the single term "participate-in" in Figure 5.

4 Parties strongly depend on the business setup and the internal organization of the companies involved. We did not address the association of parties in this phase, because we did not discuss a business viewpoint at that time.

- A workflow consists of a sequential, parallel, conditional, iterative organization of tasks.
- An effect is the difference in the state of the system after successful completion of an activity.
- Constraints are system characteristics that must be preserved during execution and after the new state is achieved.

For this reason, our use case descriptions follow the following chapter structure:

- System under consideration: This chapter explains the system under consideration and its super-ordinate structure.
- Roles: This chapter describes the different roles that interact with the system under consideration.
- Activities: This chapter describes the individual activities while explaining the respective trigger conditions, a workflow of individual tasks, the effects achieved, the constraints to be considered, and any other background information. In addition, some of these activities are also graphically illustrated.

Best Practice Examples

- We described three concrete use cases following the described guiding principles, prepared them in the form of best practice examples and made them available to the general community in both Eng-lish and Chinese:

- The so-called GER use case is a description of the usage view of the application scenario "Value-Based Service". This work has been published at Hannover Fair 2018, see [4].
- The so-called CN use case is a description of "Mass Customization" of Intelligent Manufacturing Modes. This work has been published in April 2019, see [5].
- The so-called GER-CN use case describes the use case "Equipment Lifecycle Management" in the context of the Baowu and Siemens Go to Industrie 4.0 (BSG2I4.0) project. This is an exemplification of the application scenario "Seamless and Dynamic Engineering of Plants", see [6]. This work has been published in May 2019, see [7].

Conclusion

By working on these three examples, we demonstrate the viability of our approach. We think that the descriptions are clear, balanced and generally understandable and therefore promote our common understanding. Through our basic work, we have established a common understanding of the topic of (technical) use cases and have finalized our basic work with a first version of a guidance report, see [8]. Our expectation is that this framework is now promoted and applied, especially by the German and Chinese sides.

Therefore, we decided to enter the next phase, where we adjust the target within the scope of the cooperation line "Use Cases and Applications":

- We decided to continue to exchange experiences on (technical) use cases and have initiated discussions with various working groups.
- We decided to analyse business scenarios in more detail and to prepare concrete examples in the form of business views.
- We decided to establish a link to the ongoing use case activities in international standardization, especially within IEC TC65.

Phase 2: Dissemination and Extension to Business Scenarios

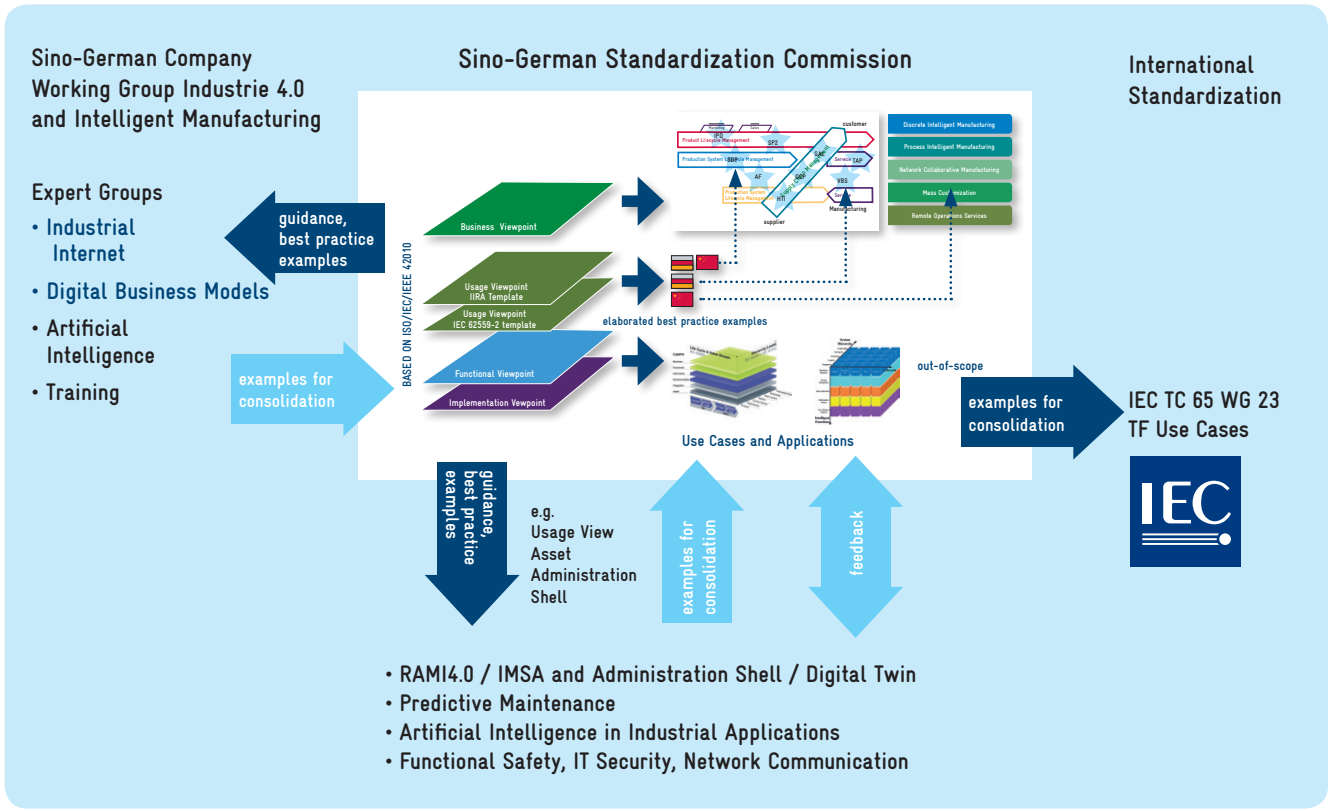
After completing the first phase according to Figure 1, we discussed the role of the cooperation line "Use Cases and Applications" of the Sino-German Standardization Commission in the overall context of various Sino-German activities. Based on our common understanding of use cases according to Figure 4 we elaborated Figure 6 to illustrate the role and relationships of the cooperation line "Use Cases and Applications" with the other working groups and activities including the other cooperation lines of the Sino-German Standardization Commission.

Based on this overall picture, we agreed on the following goals and topics for phase 2 of the cooperation line "Use Cases and Applications":

- Dissemination: the objective is to disseminate the guidance for (technical) use cases developed by the cooperation line "Use Cases and Applications" regarding the application of the proposed methodology. Other cooperation lines of the Chinese-German standardization commission and the expert groups of the Sino-German Company Working Group Industrie 4.0 and Intelligent Manufacturing are addressed.

- Extension to business scenarios: the objective is to take a closer look at the business impact of Industrie 4.0/ Intelligent Manufacturing and to elaborate guidance regarding the preparation of business scenarios.
- Link to international standardization: the objective is to transfer the results of the cooperation line "Use Cases and Applications" into selected activities of international standardization.

Figure 6: Context and role of cooperation line "Use Cases and Applications"



Dissemination

There are currently numerous activities on "Use Cases" in the context of Industrie 4.0/ Intelligent Manufacturing. But the cooperation line "Use Cases and Applications" operates in the context of standardization and therefore the discussions should be sufficiently formal or precise. Otherwise no compliance regarding standards can be expected. Discussions on "Use Cases" in other contexts do not necessarily have to meet such precision. In this respect, there will always be a field of tension regarding how formal or precise "Use Cases" should be described. Furthermore, this includes a decision by those who formulate a "Use Case".

In this context the cooperation line "Use Cases and Applications" assumes two roles:

- It provides a methodology for the description of (technical) use cases, see section "Phase 1: Focus on (Technical) Use Cases" and offers to explain this guidance and best practice examples to other working groups and activities. To a certain extent the cooperation line "Use Cases and Applications" also provides training and support to develop a "Use Case".

- It will analyze the results in the form of described "Use Cases" and will decide to what extent – possibly after some sharpening with respect to the own requirements regarding formality and precision – the described "Use Cases" will be disseminated as further best practice examples.

With regard to the individual cooperation lines within the Chinese-German Standardization Commission, a regular exchange of experience was carried out with the cooperation lines in **bold** in Figure 6. On the one hand to explain the methodology developed by the cooperation line "Use Cases and Applications" and on the other hand to receive feedback on the practicability and applicability of the methodology. These exchanges of experience are ongoing and have not yet been completed.

Coordination and consultation of the working groups of the Sino-German Company Working Group Industrie 4.0 and Intelligent Manufacturing (shown in Figure 6 in **bold**), formed a vital part of this phase:

- The working group "Industrial Internet" took the best practice example "Value-Based Service", see [4], as a starting point and prepared various examples, partly in the form of business scenarios (in the terms of the cooperation line "Use Cases and Applications"), partly in the form of a detailing of the usage view towards a functional view.
- The working group "Digital Business Models" has prepared business scenarios (in the terms of the cooperation line "Use Cases and Applications"). The preparation is aligned with the methodology described in section "Extension to Business Scenarios".

A consolidation of the results of the Sino-German Company Working Group Industrie 4.0 and Intelligent Manufacturing in order to transfer the examples according to the quality requirements of the cooperation line "Use Cases and Applications" is currently not planned.

In addition, further dissemination activities were initiated outside the Sino-German cooperation. For example, there were developed usage views of the "Asset Administration Shell" and the application scenario "Seamless and Dynamic Engineering of Plants". Both examples meet the quality requirements of the cooperation line "Use Cases and Applications".

Extension to Business Scenarios

The description of the (technical) use cases is based on a methodology proposed by the Industrial Internet Consortium (IIC) in the form of the so-called usage viewpoint, see [1]. The so-called business viewpoint proposed by the Industrial Internet Consortium serves as the basis for describing business scenarios.
This business viewpoint comprises the following concepts, for details see [1]:

- Vision: describes a future state of an organization or an industry and provides the business direction toward which an organization executes.
- Values: reflects how the vision may be perceived by the stakeholders who will be involved in fund-ing the implementation of the new system as well as by the users of the resulting system. The values provide the rationale as to why the vision has merit.
- Key Objectives: quantifiable high-level technical and ultimately business outcomes expected of the resultant system in the context of delivering the values. Key objectives should be measurable, and time bound.
- Fundamental Capabilities: refers to high-level specifications of the essential ability of the system to complete specific major business tasks and should be specified independently of how they are to be implemented.

In contrast to the usage viewpoint, we did not use the business viewpoint of the Industrial Internet Consortium as a fixed template but transferred the idea of the business viewpoint to value networks. The essence of this methodology is that a value network, in which value creation relationships between business partners are represented, is mapped to the enterprises involved (as legal entities). For each enterprise, the business model is described following the St. Gallen Business Model Navigator, see [9]. This mapping is illustrated in Figure 8. Note that this approach is aligned with the methodology proposed by the working group "Digital Business Models" of Plattform Industrie 4.0 to analyse practical examples, see [10].

Figure 7: Overview of Business Viewpoint (according to [1])

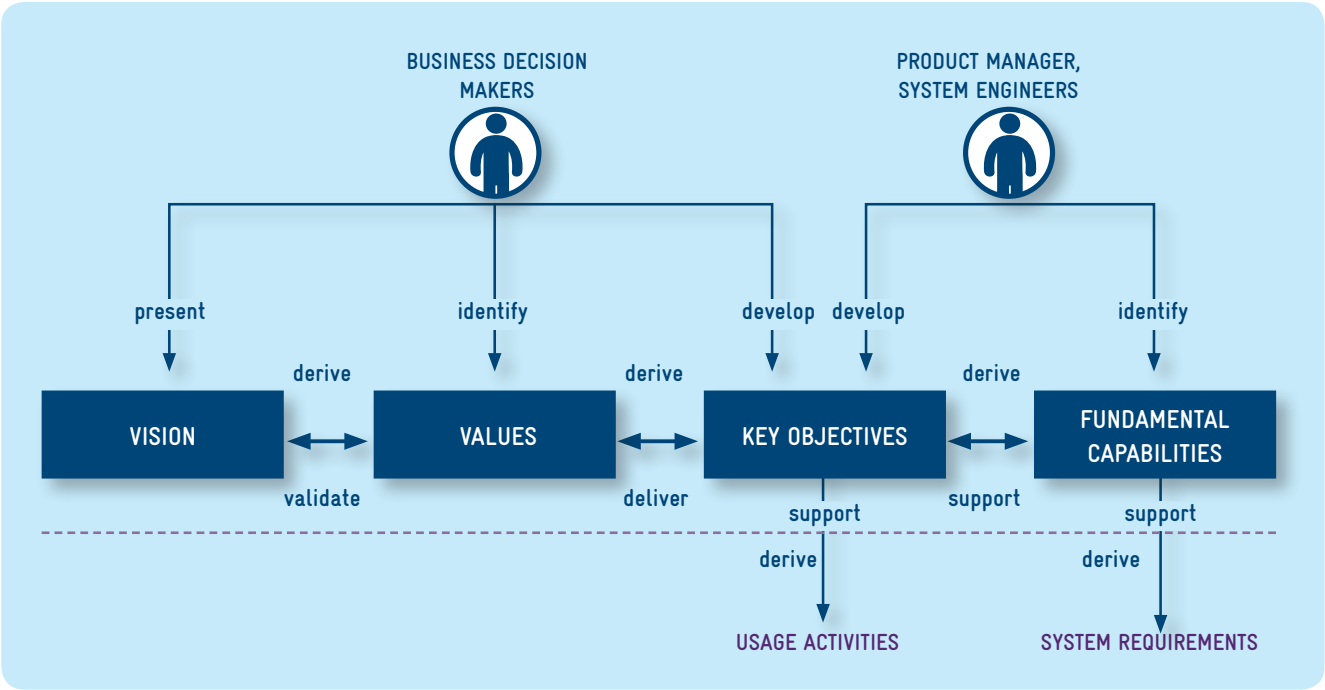
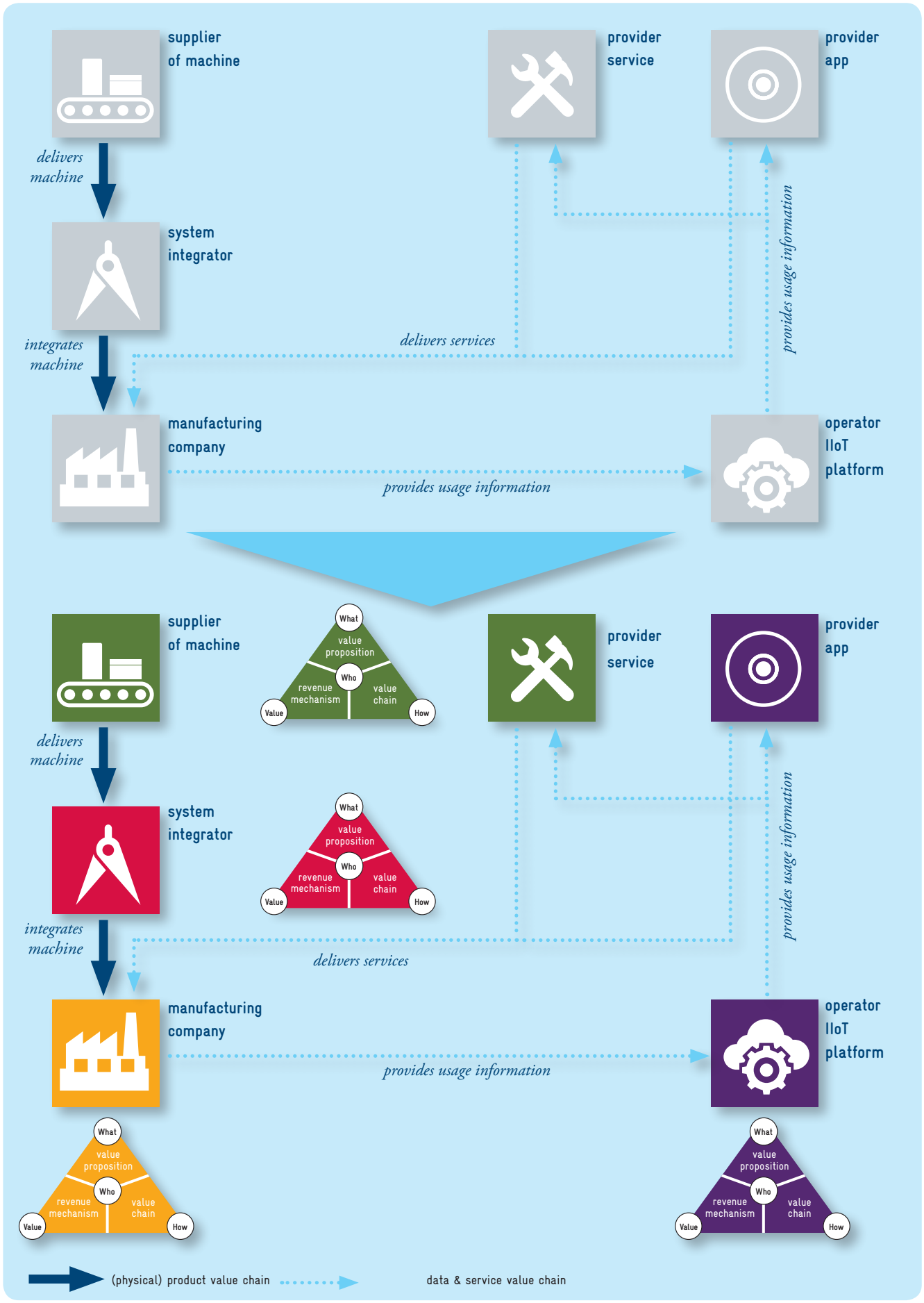


Figure 8: Value networks with business roles and possible implementation by enterprises



The (intended) future value network is compared with the current value network to illustrate the vision according to the business viewpoint. Values, key objectives und fundamental capabilities according to the business viewpoint are described based on the St. Gallen Business Model Navigator.

A more detailed description of the applied methodology including an elaboration of various examples can be found in [11].

Link to International Standardization

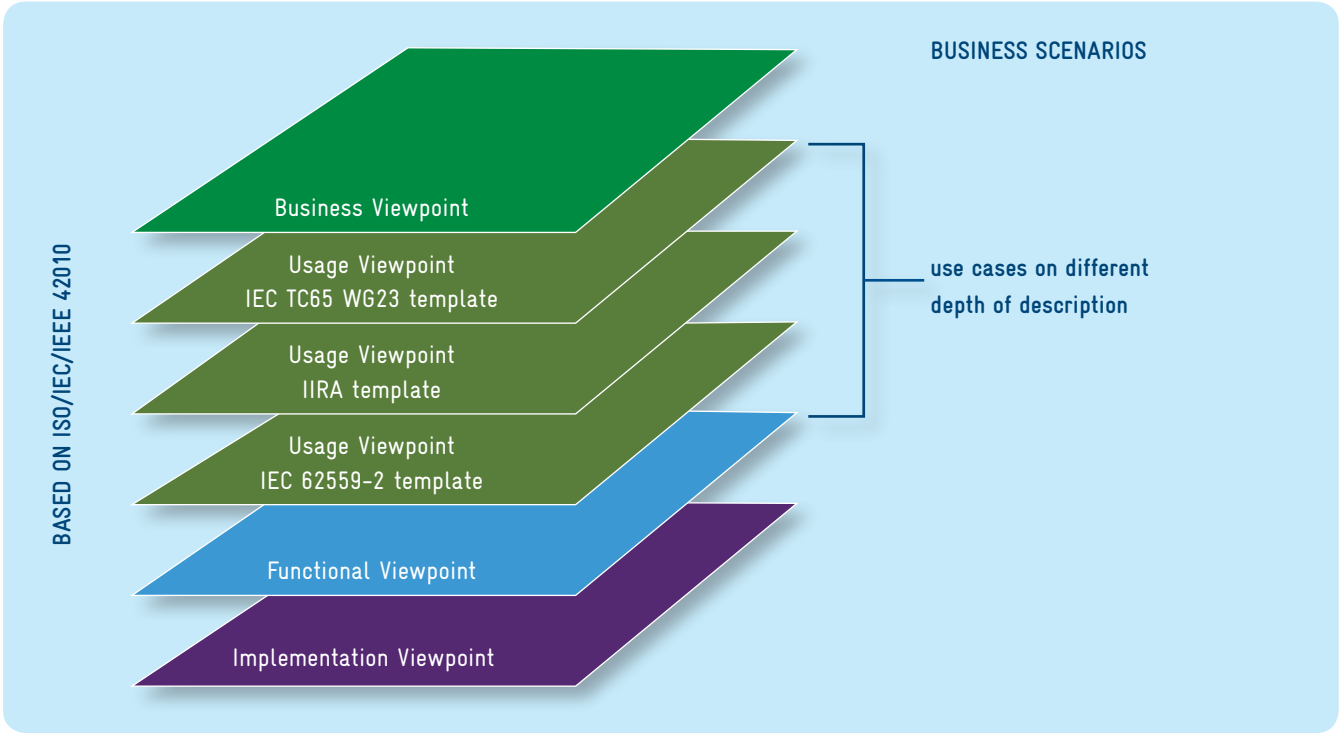
The working group IEC TC65 WG23 "Smart Manufacturing" and especially the task force "Smart Manufacturing Use Cases" aim to analyze the impact of "Smart Manufacturing" on standardization. The area of impact is restricted to IEC TC65, i.e. automation of control. Furtermore, the context of automation and control is taken into consideration. The impact of "Smart Manufacturing" on standardization will be identified from the application perspective of the manufacturing industry.

The approach chosen by the task force "Smart Manufacturing Use Cases" is the collection and evaluation of Use Cases. Use Cases are collected to obtain a sufficiently representative description of "Smart Manufacturing". These Use Cases are described from the point of view of the manufacturing value chains in order to show which value chains within the scope of "Smart Manufacturing" could be conceivable in the future.

After estimating the number of Use Cases to be described and knowing the effort required to develop a Use Case based on the IIRA template, see section "Use Case Template".The task force "Smart Manufacturing Use Cases" developed its own template. Based on the IEC TC65 WG23 template the description of a Use Case is possible with significantly less effort, but in return the description is much less detailed. Figure 9 illustrates how the various templates fit together in an overall context.

The different templates shown in Figure 9 describe particular specific usage views, but nevertheless are well aligned in terms of content refinement.

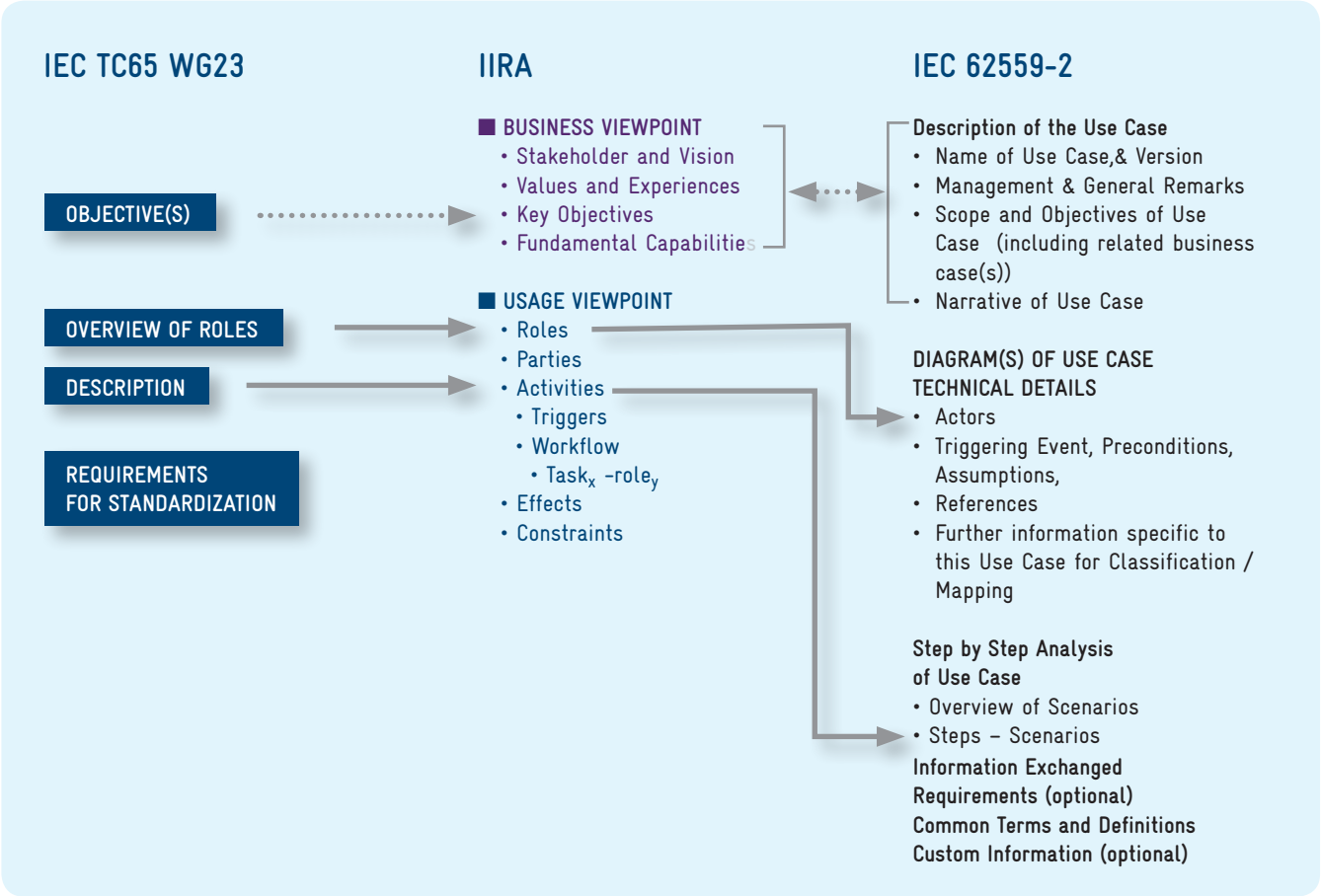
Figure 9: Classification of use cases on different level of detail in terms of IIRA



This means that a Use Case, which is based on the IEC TC65 WG23 template, can be refined retrospectively based on the IIRA template or IEC 62599-2 template as well. The relationships between the different templates for describing a specific usage view are illustrated in Figure 10.

The role of the cooperation line "Use Cases and Applications" is to provide the consolidated best practice examples of the task force "Smart Manufacturing Use Cases" in order to contribute to the representativeness of the IEC TC65 WG23 Use Case collection.

Figure 10: Relation between selected templates for use cases

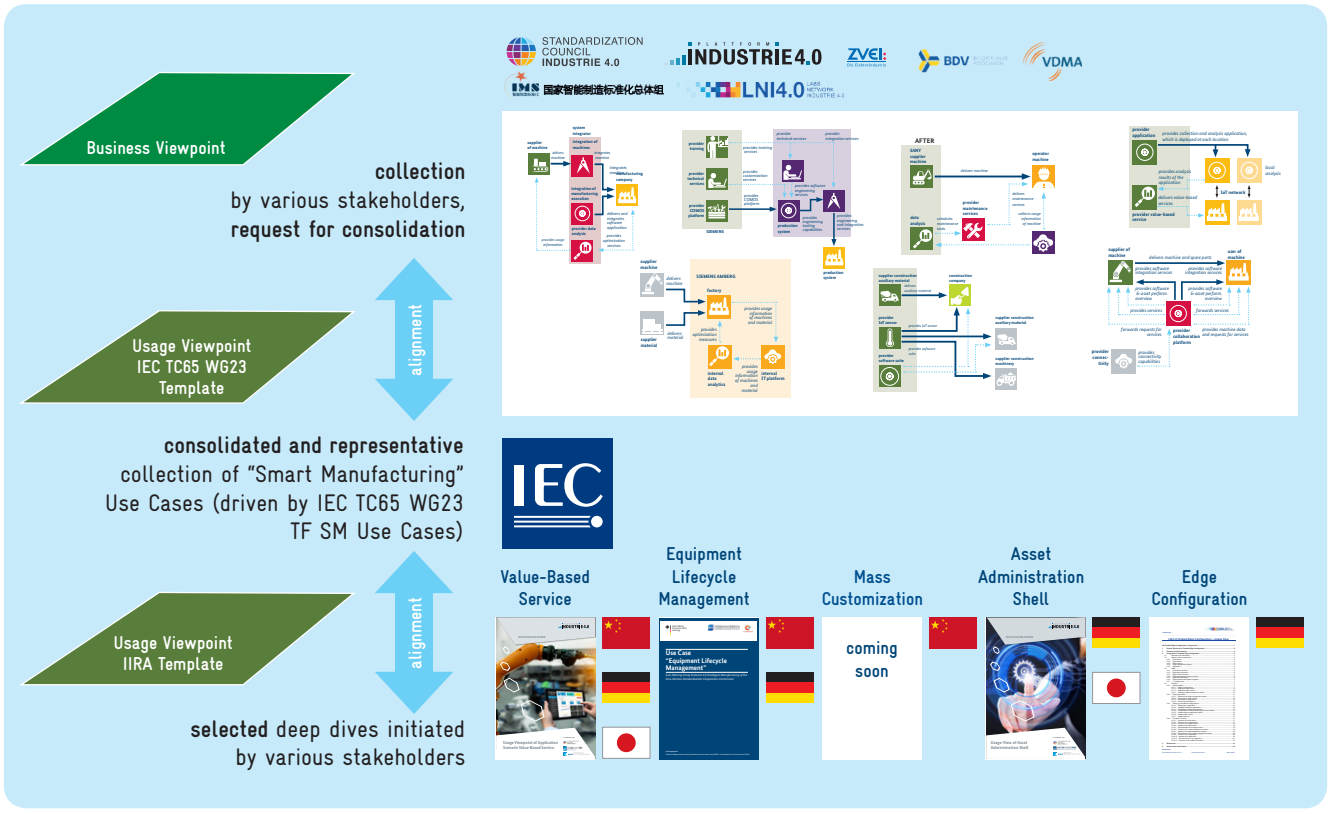


Conclusion

Figure 11 summarizes the various activities for the cooperation line "Use Cases and Applications" from a content perspective:

- We observe many activities regarding business scenarios. In general, these activities are compatible with the methodology described in section "Extension to Business Scenarios". However, we see a certain need for action to consolidate the variety of different business scenarios, for example by identification of certain patterns for business scenarios.
- With regard to the creation of a consolidated and representative collection of Use Cases by the task force "Smart Manufacturing Use Cases", one has to keep in mind that firstly, the alignment with the more detailed Use Cases based on the IIRA template is ensured and secondly – at a later date –an alignment to the business sciences should be established.
- We see the development of more detailed Use Cases according to the IIRA or IEC 62599-2 template as activities initiated and driven by specific interested groups.

Figure 11: Illustration of major alignment challenges



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List of Abbreviations

ERP	Enterprise Resource Planning
IIC	Industrial Internet Consortium
IIRA	Industrial Internet Reference Architecture
ISO	International Organization for Standardization
MES	Manufacturing Execution System
PLM	Product Lifecycle Management
SGSCC	Sino-German Standardization Cooperation Committee

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