D23.1 – Open Manufacturing Modelling Suite Design – M6

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Version History

No.	Date	Notes and Comments
0.1	27.02.2012	Initial version of Deliverable
0.2	13.03.2012	Polimi Input
0.7	28.03.2012	Submission (internal Review)
0.8	18.04.2012	Submission MSEE review
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0.94	09.07.2012	Update according Review
0.95	30.07.2012	Final Iteration
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Internal Review

ID	Comments	Addressed (✓) Answered (A)
1	What does virtualization of an asset exactly mean?	A: ‘Virtualization’ means to represent tangible assets, which are physical objects of economic value, as virtual objects. Particular focus is put to tangible assets for manufacturing.
2	You use terms ”tangible”, ”´virtual´ tangible”, ”(extended) tangible”, ”(extended) tangible asset”, ”(tangible) manufacturing asset”, ”virtualized tangible (manufacturing) asset”, ”tangible manufacturing asset”, ”manufacturing ecosystem asset”. I assume most of these terms are synonyms.	✓ Harmonized
3	Typos	✓ ok
4	Please provide definitions for ”virtual enterprise”, ”manufacturing ecosystem”, ”smart organization”. Especially, what is the difference between an ecosystem and supply chain? Which will you use?	A: Has not to be addressed in D23.1, Reference to WP21, SP1 provided. Input from WP25 needed.
5	Do Virtual Enterprises comprise steep and flat hierachies?	A: They follow the idea of a ‘matrix organization’: flat & knowledge driven. We say: knowledge is the glue between organization (incl. processes) and ICT.
6	What are tangibles?!	A: Due to the fact that it provokes too much irritation, this term has been abandoned. We talk about tangible assets.
7	A general question: Why do you use the round brackets all the time?	✓ Abandoned
8	Figure 11 missing	✓ Added
9	Semantics on tangible assets not yet clear.	A: More details based on industry partners and literature reviews provided in D23.2.

Table of Contents

Executive Summary

This deliverable describes the first design of the Open Manufacturing Modelling Suite (OMMS), resulting from work of the first six project months in T2.3.1 of MSEE's WP23. The final OMMS will comprise a method for virtualizing tangible assets, a taxonomy and templates to represent 'virtual' tangible assets. 'Virtualization' means to represent tangible assets, which are physical objects of economic value, as virtual objects. Particular focus is put to tangible assets for manufacturing.

According to the original description of task T23.1 in the MSEE DoW[1], a *meta-model will provide means for semantic enrichment of input-output dependencies as well as logical and (formal) physical relations between (extended) tangibles in OMMS models. It will support the management concepts developed in Task 2.3.2 for flexible and IT-driven orchestration and/or self-organization of (extended) tangibles (see Open Manufacturing Services specification). Accordingly, special attention will be put on the virtualisation of interaction mechanisms of (extended) tangible assets e. g. in different life cycle phases, affiliated management functionalities as well as related constraints.*

The outcome of this task will be the OM Modelling Suite, including semantically enriched meta-models, adequate guidelines on how to apply the newly developed modelling tool, and basic concepts for the management of (extended) tangibles.

This first version of the OMMS focuses on drafting of a virtualization process, initial real-life templates, and taxonomy for contextualising tangible assets in manufacturing industries. Furthermore, in strong cooperation with Polimi as well as industrial MSEE partners, a roadmap has been drafted to specify how WP23 and WP22 can be integrated to derive a holistic approach for in-/tangible assets management in MSEE.

Accordingly this deliverable contains the following chapter:

Chapter 1: Introduction to the topic and objectives, and to the MSEE WPs relation
Chapter 2: Framework for management of tangible assets
Chapter 3: Initial OMMS (requirements and method)
Chapter 4: Relationship with intangible assets management (WP22)
Chapter 5: Conclusion

The drafted process for virtualization as well as templates and a taxonomy will be evaluated and further elaborated with respect to the outcomes of other MSEE work packages (e.g. requirements analysis & progress in industrial use cases).

Work during the next period will in particular focus to the completion of the virtualisation method of tangible assets in manufacturing. This includes a. o. the integration of existing taxonomies and ontologies for classification and description of tangible manufacturing assets, a processable and interoperable language for virtualised tangible assets in manufacturing, and the extension of the virtualisation method to further categories of assets in Manufacturing Ecosystems.

[1] The following text in italics is copied from the DoW

The final version of the OMMS will be described in version 2 of this deliverable, due in M15 of MSEE. The OMMS will be tested stand-alone for scenarios of the industrial partners, and prepared for integration with the Innovation Ecosystem Platform (resulting from WP26).

1 Introduction

According to T23.1 outlined in the MSEE DoW, this deliverable sums up research results of WP23 regarding management principles for tangible assets in Ecosystems – especially in Manufacturing Ecosystems[2].

The term "Tangibles" comprises tangible manufacturing assets and tangible business assets (including product assets). For the first development work the focus was put to (general) tangible assets. In the course of the further work in WP23 this approach will be detailed for (domain specific) tangible manufacturing assets. A taxonomy for these terms is provided later in this document.

The objective is to develop a framework and to enable a service-driven management of tangible assets (e.g. intelligent materials or resources like machinery or humans), taking into considerations preliminary results from SP1 (namely modelling principles) and other WPs in SP2 (e.g. WP 21: Definition of MSEE Innovation Framework). The following figure sums up essential cross links between MSEE work packages that are dealing with tangible assets.

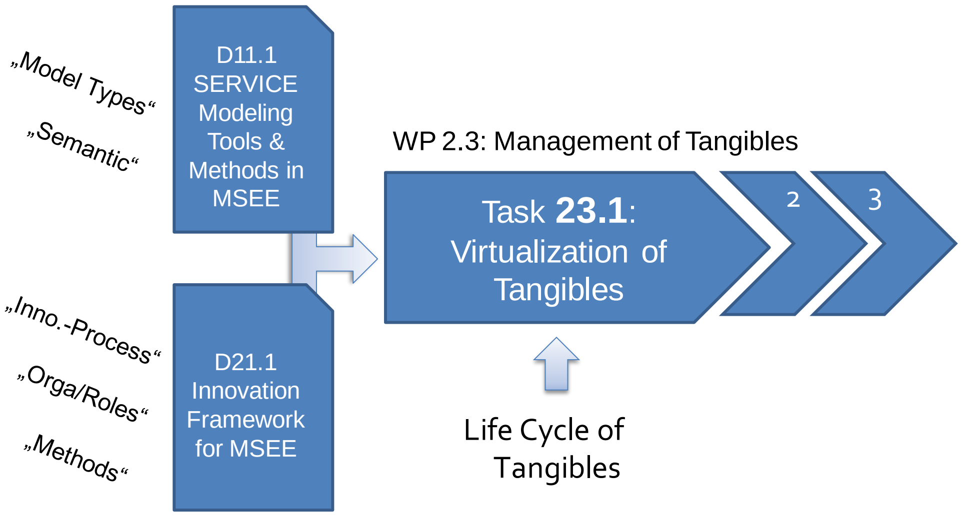

Figure 1: Cross-links between MSEE WPs regarding "management of tangible assets"

The main outcome of this deliverable in T23.1 is the first specification of an Open Manufacturing Modelling Suite (OMMS) for virtualization of tangible assets. This OMMS shall be used to virtualise tangible assets in (Manufacturing) Ecosystems in order to <u>prepare</u> their promotion as a service e.g. in a marketplace, where offer and demand of manufacturing services could meet in a win-win situation. In contrast to the work performed in SP1, virtualisation of tangible assets does not mean to provide tangible assets as a service but to represent real-world tangible assets as virtual tangible assets (e. g. as digital objects of a

[2] The full term of the title of the related sub project SP2 according to the DoW is "Manufacturing Virtual Enterprises Innovation Ecosystem", and also the short versions "Manufacturing Ecosystem" and "Innovation Ecosystems" are used there. In this document the term "Manufacturing Ecosystem" is used.

business model) that can then be used to describe a service (e. g. as a combination of virtualised tangible assets and virtualized intangible assets).

Both functional (e.g. drilling, milling, weaving, finishing, ironing) and non-functional aspects (e.g. time, price, set-up, quality, and location) need to be virtualised for a later availability in services at the marketplace of WP 26. Therefore, OMMS will be able to provide Manufacturing Ecosystems with methods, (transitional, makeshift) tools, and guidelines for virtualisation (sector, domain dependent). In synthesis, OMMS provides:

- Adequate means for virtually **describing tangible assets** in Manufacturing Ecosystems (esp. notation, digital objects of models, and exemplarily filled in templates)
- A structured process (including process step description) for the **virtualization of tangible assets**
- **Rules and constraints** for expressing/sharing tangible assets specifications in Manufacturing Ecosystems

As MSEE will have to handle both, tangible assets and intangible assets, there is a strong connection between WP23 about tangible assets and WP22, which is dealing with intangible assets. Consequently, the respective WP leaders DITF and PoliMi have set up an initiative to integrate the results of the respective work packages. The intermediate outcome of this initiative is demonstrated in chapter 4 as a drafted roadmap about in-/tangible assets management in MSEE. In fact, the same considerations expressed above could be applied to human competencies projects and knowledge assets collections, including virtualization, functional, and non-functional properties.

This deliverable document represents the first version of the OMMS to be developed within this task. The developed initial method for virtualization as well as templates and meta-models will be evaluated and further elaborated with respect to the outcomes of other work packages (e.g. requirements analysis & progress in industrial use cases).

Work during the next period will in particular focus to the virtualisation of (tangible) manufacturing assets. This includes e.g. the integration of existing taxonomies and ontologies for classification and description of tangible manufacturing assets, the processable and interoperable language for virtualised tangible assets, and the extension to further categories of virtual assets.

The final version of the OMMS will be described in version 2 of this deliverable, due in M15 of MSEE. The prototypical tools will be tested stand-alone, and prepared for integration with the Innovation Ecosystem Platform (resulting from WP26).

These initial concepts and drafted tools will be further elaborated, complemented, tested and finalized in version 2 of this deliverable (due in month M15). Particular attention will also be put to the integration with WP25 and WP26, as well as to the interaction with the industrial pilot cases.

2 Framework for Tangible Assets Management

As a starting point for setting up a holistic Open Manufacturing Modelling Suite for virtualizing tangible assets in MSEE (according to the task T2.3.1 description in the DoW), a top down perspective on Ecosystems (including Manufacturing Ecosystems) has been taken into consideration.

In general, Ecosystems should integrate approaches that equally focus tangible and intangible assets. Thus the following chapters on tangible assets in Manufacturing Ecosystems always consider both, tangible assets as well as their semantic enrichment and potential linkages with other intangible assets. The complete framework for intangible assets management is subject to WP22.

2.1 Innovation Framework and Open Manufacturing Principles

High value-adding processes for knowledge-intensive products and services are facing growing complexity of scientific, technological, environmental, legal as well as business requirements and ask therefore for close partnerships between enterprises and various institutions. Considering that agility and interoperability are esteemed to outpace traditional business characteristics like efficiency and robustness, appropriate concepts, methods and tools for immediate pragmatic support of especially Manufacturing Ecosystems are needed. One pragmatic approach to support Manufacturing Ecosystems in terms of innovation management and collaboration is to apply Open Manufacturing principles (and in case later, to provide even Open Manufacturing Services).

The OM idea is a variant of the Smart Networking concept (Lau u. a. 2009), which is based on the Smart Organisation idea: In principal virtual enterprises that usually evolve in Manufacturing Ecosystems as well as Smart Organizations '…are knowledge-driven, internetworked, dynamically adaptive to organizational forms and practices, learning as well as agile in their ability to create and exploit opportunities' (Filos 2006) in order to increase the competitiveness, the flexibility and the possibilities of the legal entities. Networking in the three dimensions ICT networking, Organisational networking and Knowledge networking (see Figure 2) and the importance of easy manageable representations of e. g. tangible assets and collaborations are the core elements of both concepts.

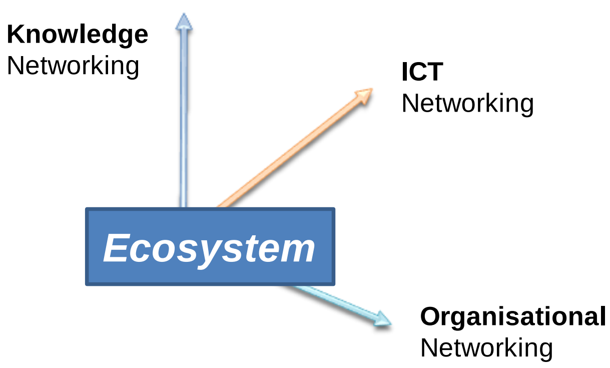

Figure 2: Top down perspective on Ecosystems (according to Filos 2006)

Camarinha-Matos (Camarinha-Matos 2009) identified a large variety of collaborative network concepts from the Virtual Enterprise to the Agile Shop Floor. Of particular importance for virtual enterprises in Manufacturing Ecosystems are the Extended Enterprise, Virtual Organisation, Dynamic Virtual Organisation and Virtual Organisation Breeding Environment. All these concepts are capable to support the strategic goals of resource optimisation, synergy creation, achievement of a critical mass and to increase benefits of the partners (Filos und Banahan 2001). They are mainly focused on ICT or organisational structures.

Networking in the organisational dimension describes the shift from steep hierarchies to flat hierarchies paired with networked cross-functional teams. Bureaucracy, represented by the organisational hierarchy, is able to maximise efficiency and provide stability. Networks, represented by cross-organisational teams, enable flexibility and effectiveness. Knowledge-driven organisations and virtual enterprises are combinations of both. The success of teams is strongly depending on the information and knowledge exchange, primarily the quality of communication not the quantity, which is hooked on the networking in the ICT and knowledge dimension. All three aspects have to be aligned in context of service/product development and production in Ecosystems. As a consequence, in the context of tangible assets management in Ecosystems an appropriate innovation process for products and services (that consists of tangible and intangible parts) has to be applied (Figure 3).

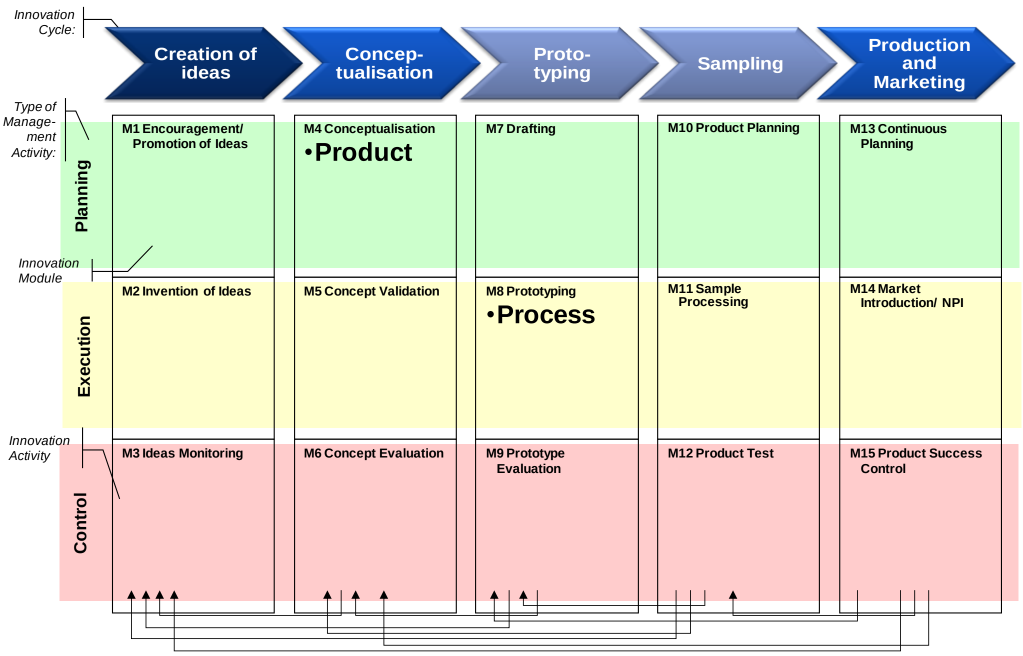

Figure 3: Exemplary Innovation Process for service/product innovations in Ecosystems – applicable for both, tangible and intangible product/service components (adapted from IPRM of the AVALON project (www.avalon-eu.org))

Networking in the knowledge dimension empowers individuals and teams to dynamically link up with each other to share information and knowledge e. g. about tangible assets. Entities in Ecosystems require the organizational capability to promote the creation of knowledge, to conserve the acquired knowledge and most important to exploit the knowledge, thus requiring knowledge management as core competence of the entity. In order to generate e. g. competitive Manufacturing Services, (Manufacturing) Ecosystems need to be open systems with continuous and dynamic interactions between the network entities themselves and also to external partners. To realize this exchange, a certain level of trust and loyalty between all participants is required, which is also required for networking in the ICT dimension.

Networking in the ICT dimension enables organizations to enter into virtual collaborations. Moving to extended or virtual organizational forms are an essential characteristic of such Ecosystems. ICT instruments supply distributed teams with information and knowledge required for value creation across geographical and organizational boundaries. This openness comprises hazards. Integrity and security is a challenge open communication networks and associated information systems have to cope with. Trust in used technology, e.g. through security technologies, as well as trust in partners, e.g. through contracts or inter-organizational teams, has to be established and maintained.

This networking capability allows for Manufacturing Ecosystems to cope with complexity and with rapidly changing economic environments. MSEE draws on this idea and applies parts of the smart organization principles in context of collaborative innovation in an Manufacturing Ecosystem.

In general, MSEE aims at providing a holistic framework for different types of services (for the MSE: Manufacturing Service Ecosystem), and, this deliverable does not focus on Manufacturing Services, but on virtualised manufacturing assets that can be used to create services or products alike.

2.2 Tangible Assets – Definition and Examples

Contributors: DITF, PoliMi[3]

Tangible assets should be properly defined and managed to achieve the best results in terms of products life cycle management and overall performances of an organization.

As described in the DOW, **tangible assets are whatever kind of physical objects with economic value; manufacturing assets and product assets, are considered [mostly] tangibles, where manufacturing assets are used in processes that an organization performs in order to create product assets** (Allee 2008). This definition is in general still valid, as there is no reason to change this MSEE perspective on tangibles, which is derived from well known scientific resources like (Quartel u. a. 2007) and (Joshi u. a. 2010). The following paragraphs will use the term tangible and intangible as adjectives and not as nouns, taking into account that in-/tangible assets are often confused with e. g. tangible products and/or intangible services.

Speaking about manufacturing services composed of in-/tangibles assets, it has to be highlighted that in-/tangible assets are also used to provide IT- and/or organizational services (see other MSEE deliverables, e. g. D11.1 or D21.1)

Manufacturing assets include machines, tools, material, work place equipment, material flow components, control systems, storage systems, and the manufacturing environment (building, air conditioning, cleaning). However, these are tangible assets that can be complemented by intangible components – also in context of manufacturing. Accordingly, from our point of view, the term Manufacturing Asset should cover both, tangible assets as well as intangible assets for manufacturing products (and service) assets.

[3] Further partners with significant contributions are listed here

However, this distinction between tangible assets and intangible assets has no direct consequence on the nature of a business asset being a product or a service:

> “The distinction between goods and services has been traditionally interpreted by economists as if it were equivalent to a distinction between physical commodities, or tangible material products, on the one hand and immaterial, or intangible, products on the other. The economics literature is full of statements to the effect that goods are material, or tangible, whereas services are immaterial, or intangible. Such statements are casual and conventional rather than scientific, as the nature of an immaterial product is not explained. In practice, intangible products deserve more serious attention because they play a major role in the 'information economy.' They are quite different from services. […] The habit of describing services as intangible products is an *invention* of economists “ (Fulcher und Hills 1996)

According to Fulcher and Hill, **there is no scientific reason for identifying tangible assets as products or services as intangible assets** – on the contrary, the authors state that there are tangible and intangible goods (called ‘tangibles’ and ‘intangibles’, = nouns) on the one hand, and services on the other! In contrast to (intangible) goods, a service is not an entity that can persist in time independently of its producer or consumer and therefore should not be treated as if it were some special kind of good, namely an 'immaterial' one – even though **services in general are intangible** (= adjective). For MSEE this means that the semantics used in the project have to be harmonized and seriously chosen (see Figure 4) to be able to classify MSEE outcomes properly:

- **Manufacturing assets**
  - There are **tangible** and **intangible** (manufacturing) assets
  - Both types can either persist in time (object-like, materialized) and be **owned** by a single system (e.g. producer or customer) OR happen in time (process-like, **serviced**) and instantiated as a result of two interacting systems (e.g. provider and consumer).
- **Business assets** (that are exposed to system-external markets/partners are composed system-internally by tangible – and according to the new D22.1 also intangible – assets.)
  - Products are tangible, materialized, physical objects e.g. for manufacturing; classical products (e.g. cars, machineries as a product, medical stents, motorcycle helmets, …) but also raw materials and intermediate products, which can be seen as products of somebody else. Products are outcome of a single (production) system.
  - Extended-hybrid Products are tangible, serviced, physical objects with service components that support the respective core-product (e.g. drilling machinery with maintenance contract)
  - Virtualised-functionalised knowledge assets and competences (& Services), which are servitized intangible assets (see D22.1).
  - Knowledge assets and competences, which are owned intangible assets (or services) (see D22.1).

The life cycle of tangible assets comprises all value adding stages from idea generation, concept specification, multiple evaluation stages, prototyping and sampling, production/ implementation, distribution, usage and maintenance as well as dismantling and recycling (Anderson und Zeithaml 1984). These phases are considered to be strongly dependent on each other but finally distinct development stages of e.g. products.

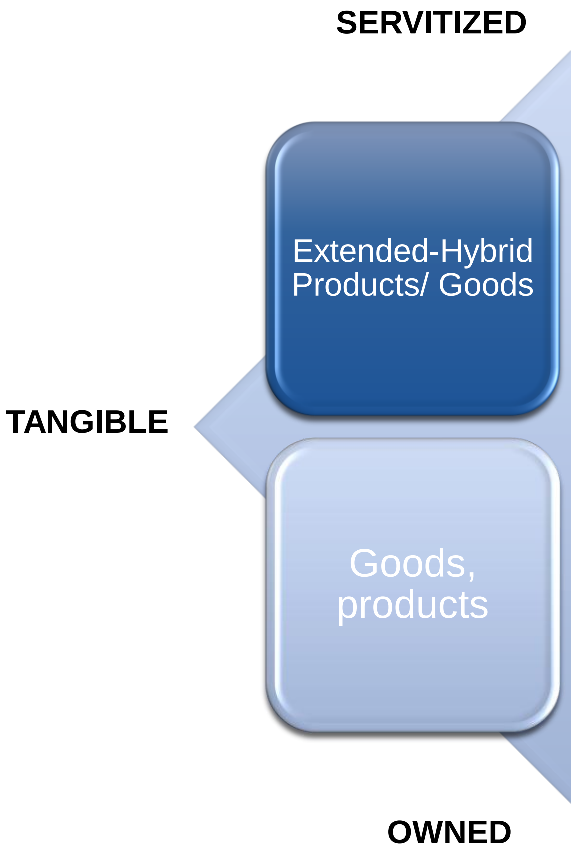

Figure 4: (Extended) Products definition in Manufacturing Ecosystems

The aim of this deliverable is to provide top level, generic, as well as exemplary domain specific templates and categories for tangible assets in Ecosystems. These templates can be adapted and easily be transferred to any collaborative innovation and manufacturing initiative in industries.

2.3 Management of Tangible Manufacturing Assets

Management of tangible assets means to identify, plan, decide, initiate, execute, monitor, assess, check, and update business-related action plans – in a hierarchical closed loop control structure (Schubert 2008).

Some functionality is essential to the management and usage of manufacturing assets in the development and production of (extended) product assets in Manufacturing Ecosystems:

- Identification, tracking and tracing: RFID and Barcode (Palmer 2004)
- Planning and scheduling: ERP systems allow for sophisticated planning of the production program and scheduling of the production (assignment of machines, sequencing of orders) (Gronau 2003).
- Monitoring, control and supervision: MES enable the control of the material flows and order status, the allocation and consumption of resources, the quality of product and processes, i.e. all what is necessary to control and monitor the production and manufacturing assets respectively.
- Maintenance and repair: based on continuous monitoring and control mechanisms, efficient maintenance and repair strategies can be developed in order to manage (extended) tangible assets during their use phase.

- Re-purposing, recycling, or dismantling: Typically, the end-of-life treatment of product assets can be managed in the same way as their production, as it can be seen as a transformation process that leads to new “products”.

As far as production management is concerned, different organizational methods (Adamides und Pomonis 2009) for production have recently been applied, such as lean manufacturing, Kaizen or SixSigma (Schonberger 2008), essentially derived from Toyota Production System, thus resulting in a significant improvement of efficiency and flexibility in manufacturing.
Furthermore, efficiency and flexibility of production systems is still and more than ever a major challenge, in particular in a globalised economy. MSEE will take into account that planning and monitoring features focus mainly on intra-organizational management of tangible assets, whereas Supply Chain Management (SCM) enables inter-organizational management, basically on a highly aggregated information level of manufacturing assets and on a high level of transparency about product assets. This is why tangible assets have to be made accessible by means of a manageable representation of them.

2.4 Representation of Tangible Assets

Contributors: DITF, UB1; Sources: MSEE D11.1

To enable Ecosystem actors to manage tangible assets from a holistic business perspective, real-life objects have to be transferred into their virtual representation, e.g. models, templates, or references. Depending on the use case, each tangible has to be represented differently. In context of financial decisions, different details of tangible assets have to be modelled in context of design, production, or marketing activities. In MSEE we focus on development and manufacturing tasks and to provide virtualization means for tangible assets with respect to the Open Manufacturing idea outlined above. Accordingly, tangible assets are represented as part of Open Manufacturing modelling dimensions as well as the business aspects elaborated by (Wojda und Barth 2006). Based on this framework, tangible models and templates, semantics as well as a dedicated method for virtualization of tangible assets is provided in the following.

2.4.1 Modelling Dimensions

As mentioned in D11.1 representations for tangible assets should be based on a modelling framework that also reflects the business and ecosystem perspective as well as architectural concepts. Figure 5 shows the model types available for describing these Ecosystems and their relationships. Following a top-down approach the first model type used is the ecosystem model. This model type describes the ecosystem/network and its environment including stakeholders as well as the goods and processes. The second model type is the process model. It provides more details like sequence of activities or used resources about the identified processes in the ecosystem model. The last model type (resource model) describes the infrastructure of the network, the capabilities and dependencies of resources – and especially **tangible assets**. Beside this top-down sequence of model two other model types exist to describe intangible assets – the information landscape of the network and the knowledge landscape.

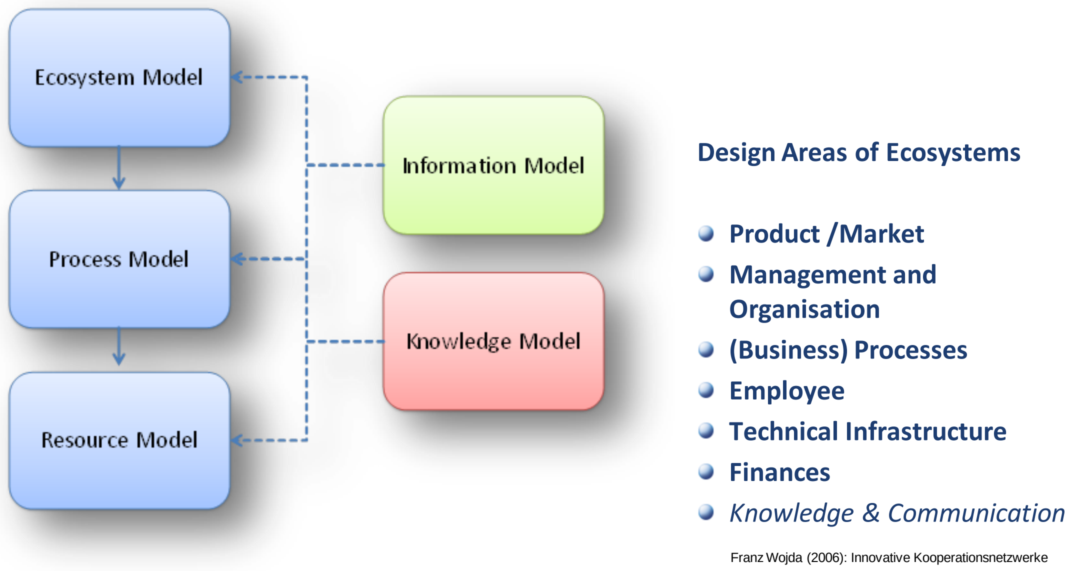

Figure 5: Ecosystem modelling dimensions

For the ecosystem model, the process model, and the resource model (all representing the organizational networking perspective, Figure 6) various views have been defined. These views reflect the six areas of networking identified by Wojda (see Figure above).

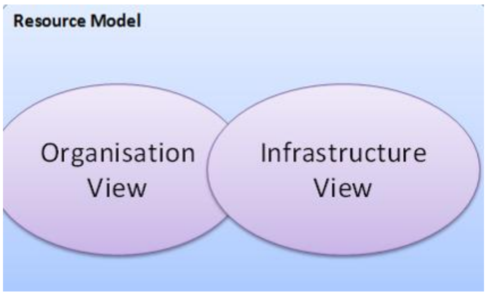

Figure 6: Views of the organizational perspective

The **resource model** describes the organization and their machinery, materials & intermediate products, and other physical objects (tangible assets) used for realizing products and services (Figure 7). Two views allow a focused image of the networking resources. The organization views concentrates on the classical organizational relationships to represent an organizations but also enables additional aspects like cultural background or qualifications to be considered in modelling. The infrastructure view is concentrating on the tangible assets of an organization like production **sites, machinery or software systems**. These tangible resources are linked with the organizational structure to describe the control over the specific resource.

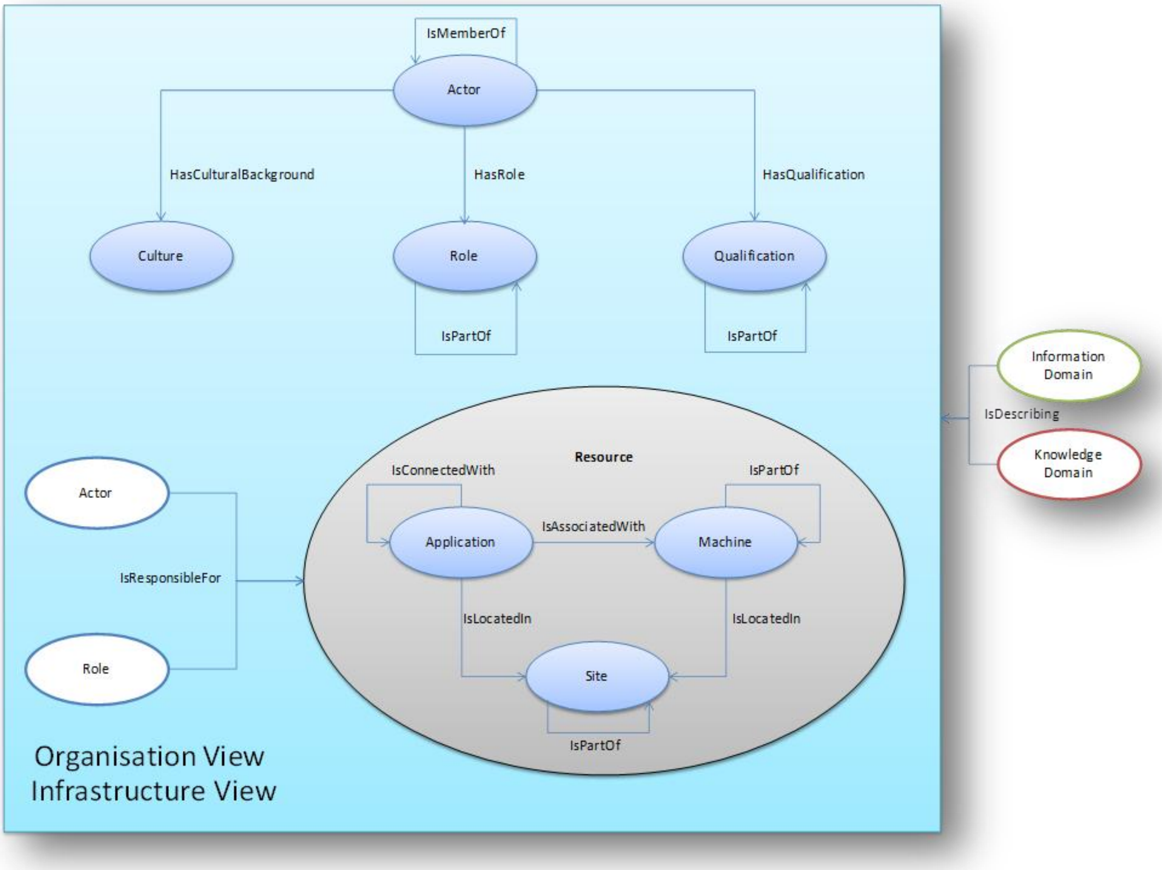

Figure 7: Structure of the resource model

In compliance with the top-level perspective on Ecosystem modelling outlined in D11.1, the abovementioned **meta-models** can be mapped on the Service Oriented Modelling schema cited in Figure 8.

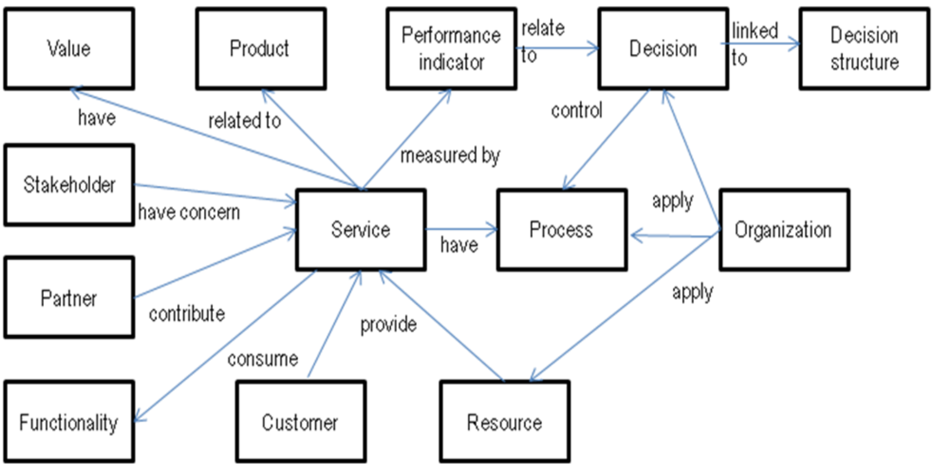

Figure 8: Service Oriented Modelling schema (source: MSEE Deliverable D11.1)

As the abovementioned meta-model for the Open Manufacturing Modelling Suite will be facilitated by means of dedicated MSEE SP1 tools in the near future, initial as-is models for the industrial pilot case had/have been realized by means of the already existing tool "Smart Network Modelling" (see Annex 3) for modelling tangible assets. The corresponding concepts can be mapped as follows:

Service Oriented Modelling	**Open Manufacturing Modelling Suite**
Product	Product
Organization, Partner, Customer, Stakeholder	Organizational Unit
Service	Service
Process	Process, Activity
Resource	Resource
Functionality, Value	Product, Service, Human feature
Decision, Decision structure	(specific) Process
Performance Indicator	(specific) Information Object
	Knowledge Object, Competences
	Role
	…

Table 1: Mapping concepts of Service-Oriented Modelling with OMMS

How real-life tangible assets can be transferred into digital representatives is outlined in chapter 3.

2.4.2 Semantics

Based on the findings outlined above, MSEE semantics regarding tangible assets will be further detailed in context of products and services (especially the transformation from one to another later in MSEE).
Attention must be drawn on the following **labels**, which are used in this document: Extended and Hybrid Product, Knowledge/Competences and Service (i.e. intangible transformation), in contrast to physical products (i.e. tangible assets like machinery, material, intermediate products and so on). It is important to have a common agreement on the following topics (Figure 9):

The term “materialized” (“ownable”) means products which persist over time, while “serviced” is related to an occurrence (not only services, but also hybrid products).

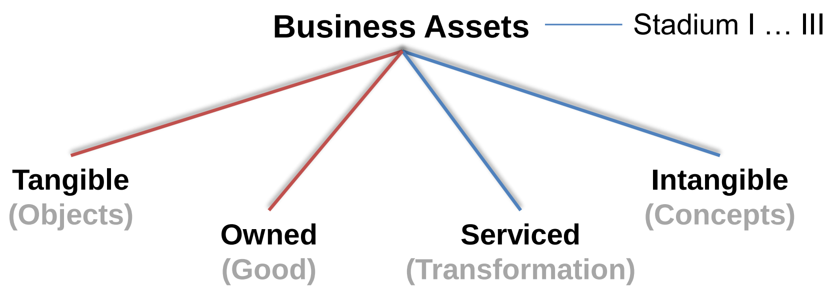

Figure 9: Products as well as Extended and Hybrid Products vs. Services

From a more theoretical point of view, tangible assets are common business objects that have to be related to business activities and business actors within a certain business environment. Therefore, the **Collaborative Innovation Ontology** (CIO) (Manuel Hirsch 2012) captures the dependencies between these objects in relation to Ecosystem actors and activities, and provides ontological rules to automatically evaluate and manage real-life business cases. As in MSEE different levels of IPR (see section 3.1) apply, CIO has been extended towards a comprehensive tool for managing business object stadiums, which can be used to represent IPR levels, access rights as well as visibility aspects (Figure 10).

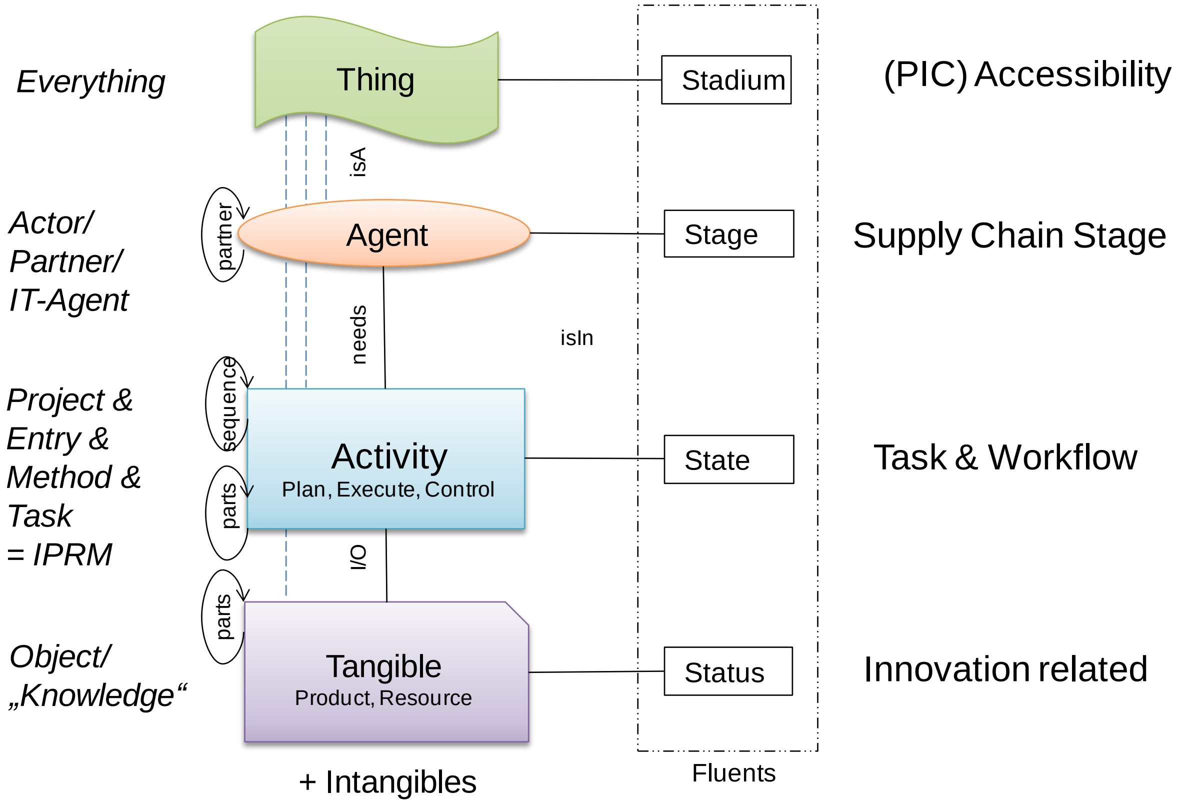

Figure 10: Extended Collaborative Innovation Ontology (CIO)

3 Open Manufacturing Modelling Suite for the Virtualization of Tangible Assets

In order to create high value products and services in the MSEE ecosystem context, all actors need to learn how to combine their complementary core competencies across sectors, and how to share highly specialized knowledge about new materials, features, and processing procedures (Senge, Carstedt und Porter 2001). In this respect, the ideas of knowledge and competence [but also products] as a services are currently gaining growing (Xu und Zhang 2005).Scalability, flexibility and adaptability are essential factors to meet the needs of interdisciplinary, dynamic, and dispersed actors in Manufacturing Ecosystems.

3.1 Requirements and Concept

Contributors: DITF, PoliMi, UB1

Additional aspects that have to be considered when talking about tangible management in Manufacturing Ecosystems are Intellectual Property Rights (IPR) and access restrictions. Actors in innovation-related networks are facing a twofold challenge in order to enhance their competitiveness and ensure future success. On the one hand they need knowledge input and competences from one another in order to derive real product and/or innovations; on the other hand they have to avoid the drain of unique knowledge (e. g. about tangible assets).

MSEE proposes a three level IPR architecture in development and manufacturing networks, where knowledge about tangible assets as well as respective knowledge structures are treated differently on each layer. There is an internal perspective on knowledge and knowledge structures, which is very detailed and represents all aspects that are needed to actually produce or deploy a product or service by the respective company. These assets have to be kept secret; un-supervised access from any community, network, or third-party actor has to be prohibited. To enable efficient and successful collaboration on community or network level and to allow for collaborative optimization of knowledge representations as well as knowledge assets, parts of the knowledge and knowledge structures that are used internally have to be adapted and prepared for sharing with partner institutions. On community level, where access restrictions apply, adaptations should extensively be discussed, and deletions should be documented. The third security level is dealing with knowledge and information about products and services that is available to the public. Here, no IPR measures apply. Network actors should focus on publishing only data that is relevant for end-users or other companies in order to order and buy respective products. The following paragraphs will show how information technology means can be used to manage IPRs on internal (individual enterprise), community (Manufacturing Innovation Ecosystem), and public (FI Cloud) level (see Figure 11).

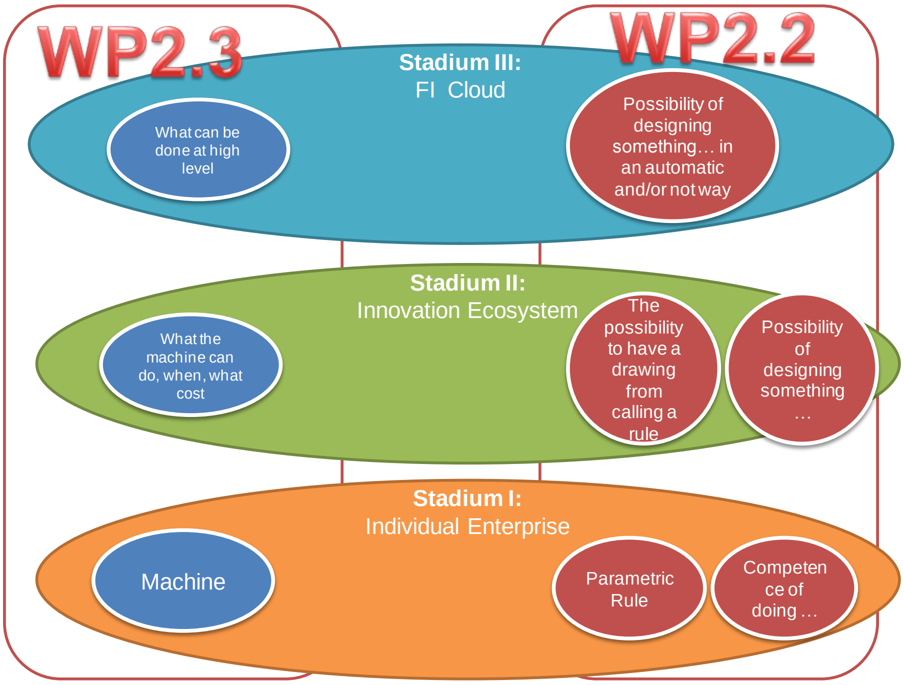

Figure 11: IPR and access right levels (stadiums) in context of MSEE

The design of the meta-models and templates complies with basic modelling principles (Becker, Rosemann und Schütte 1995). The respective framework consists of a set of principles important for modelling and a process model for the design process. The six principles identified by Becker and adapted to meta-modelling are (copied from D11.1):

Principle of Correctness: This principle requires that the representation of the real world in a model correlates to the real world. For meta-modelling the modelling objects and relationships with their attributes should represent real world elements. This principle is very difficult to prove. The representation and its correctness is directly related to the modelling context. In one context the representation could be correct in another similar context it could be incomplete.

Principle of Relevance: The problem covered by the modelling method defines the relevant modelling objects and relationships. The modelling language has to cover all aspects required for solving the problem. This principle is very close to the next principle described below.

Principle of Cost Effectiveness: The level of detail is essential for this principle. The more details available in a meta-model the more effort has to be used to realize it. Details in a meta-model not required in the modelling context should be avoided.

Principle of Clarity: Readability, comprehensibility and the clearness is essential for modelling and meta-modelling. It demands that a meta-model is as easy as possible and only as complex as required. For meta-modelling this results in an approach to use as less modelling blocks and relationship types as possible without neglecting the business perspectives and architectural concept.

Principle of Comparability: This principle states that various models developed with different modelling methods should be comparable. For meta-modelling this principle is not relevant.

Principle of Systematic Design: The target is to take care of consistency in the meta-model. This comprises modelling objects and their references as well as relationships between these modelling objects. Therefore all views and models have to be integrated into an overall architecture concept to guarantee the referential integrity.

According to Becker, a process of **virtualization and meta-modelling** should follow AT LEAST these steps:

1. **Purpose and Scope:** The first step is to fix the problems that should be answered by the modelling language. Also a system border for the modelling has to be defined. Without these limitations it would be impossible to develop a modelling language following the principles stated above.
2. **Construction of the modelling framework:** To cover the demands of the principle clarity a modelling framework has to be designed. The framework splits the model into various parts (sub models and views) with reduced complexity. This complexity reduction increases the readability of models and allows to split the modelling problem in smaller parts that can be handled more easily.
3. **Modelling of the meta-structure:** This phase describes the design of the meta-models including the interfaces between model types. For meta-modelling a clear structure is necessary to allow an easy update. Naming conventions but also common approaches for the realization of certain modelling aspects are essential.
4. **Consolidation and completion:** In this phase the meta model will be evaluated and extended/changed according to the feedback of the users. This phase is not part of this deliverable because the testing phase will be performed throughout the whole project. After each large modelling session the experiences will be collected and used to consolidate the modelling language with its meta-model.

Implementation: As a temporary solution, for MSEE we use the Generic Modelling Environment (GME) of the Vanderbilt University until MSEE specific tools will be provided in SP1. For a short introduction to GME and the Smart Network Modelling – as basis for the Open Manufacturing Modelling Suite HowTo – please refer to Annex 3 and D11.1. This tool allows directly interpreting a meta-model and using the same application to model based on the rules states in this meta-model. Therefore phases 3 and 5 are performed at the same time. As soon as the final modelling language is available it is possible to implement the meta-model in another tool with better usability features. The tool will be described later.

3.2 Virtualization Method

In order to facilitate the handling of tangible assets in context of development and manufacturing in MSE, an appropriate virtualization method for tangible assets is drafted in the following. This method will comprise a dedicated Virtualisation process, rules & constraints, as well as representative templates for virtualised tangibles assets, which are typical for MSEE.

3.2.1 Process and Rules

Virtualization is a term known from IT, where e. g. hardware components (like servers) are virtualized in order to get rid of their physical aspects and to be able to manage and use only virtual representations of respective components (virtual server). Unfortunately, this radical perspective on physical components in IT cannot be transferred to manufacturing and the management of tangible assets, as

manufacturing services strongly depend on the physical representation of underlying tangible assets. Accordingly, a new virtualization process is needed to represent real-life tangible assets (e. g. as part of manufacturing services).
To define manufacturing services, MSEE fosters a two-step approach:

1. Virtualization of tangible assets (and intangible assets) in SP2 in order to provide tangible assets as a Service.
2. Specification of manufacturing services in SP1 by means of models, comprising tangible assets (and Intangible assets) as a Service.

The following virtualization process (see Figure 12) is the starting point for a dedicated procedure for preparing tangible assets to be virtually managed as services (e. g. in Manufacturing Ecosystems).

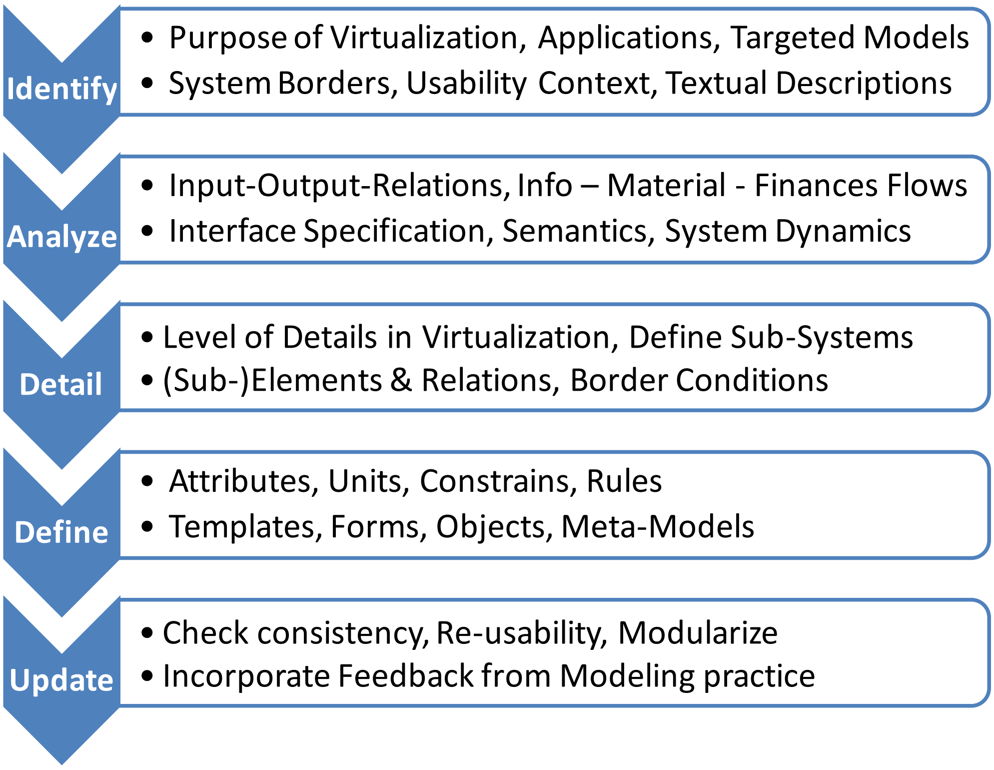

Figure 12: Basic Virtualization process for tangible assets

The virtualization process outlined above, answers questions like "What to model when?", "Which parts of the model to communicate when?", "Which degree of details to realize?", "Where are the system borders?" and so on. The virtualization steps in detail are as follows:

1. **Identify**
   In this step the purpose of the virtualization of the respective tangible asset is defined and documented in plain text. Depending on the usability context, different aspects of the respective tangible asset will be analysed and modelled in the following steps. Accordingly, semantic models will be provided complying with the foreseen application scenarios of the virtualized tangible assets. In general, tangible assets are the object of the virtualization process, namely the system to be virtualized. The foreseen virtual representation of tangible assets comprise a well-defined system border as an interface to the environment, descriptions of the expected information,

material, and financial flows across this border, the identification of sub-systems and elements of the system as well as structural details of these elements.

2. **Analyse**
   In the second step of the virtualization process, input-output-relations and more details about information, material, and financial flows are identified. Respective findings are used to determine interface specifications, semantics, and overall system dynamic in context of the to-be virtualized tangible. In this step a comprehensive taxonomy about tangible assets (see T23.2) will be utilised to identify the most appropriate type to represent the to-be virtualized tangible assets by means of a dedicated set of attributes and I/O-relations. Appropriate methods for text and data mining or similar might be applied in this step.
3. **Detail**
   Step three is about further detailing the virtual representation of a tangible. Depending on the IPR levels defined in D23.1, multiple views and perspectives can be taken into account: structures and templates used for describing the respective tangible asset internally might ask for very detailed information, while documents and sheets to specify the respective tangible on community level might be less informative or leaflets for marketing and publishing purposes might cover only top level information about the respective tangible. This is where border conditions may apply and where rules and constraints are defined for each attribute of the virtualized tangible.
4. **Define**
   In step four, the ramp up procedure for the virtualized tangible assets starts. The attribute sets are filled with adequate values, documented, and prepared for distribution. Therefore all attributes to specify a real-life tangible are described, units defined, constraints and rules outlined. The outcome of this procedure is a ready to be used virtual representation of the respective tangible.
5. **Update**
   Feedback given by partners and practitioners that gained experiences in applying the TaaS will be used in step five of the virtualization process to continuously update and re-define the virtual representations of tangible assets. The aim is to provide consistent, easy to used, re-usable, transferable, thus modular and extendable sets of a Tangible assets as a Service.

The outcome of this virtualization process will lead to virtual artefacts (representing tangible **assets e. g. in USDL-like notation) that can be combined with intangible assets in order to build up service (or products) in manufacturing industries, which – themselves – can be modelled and represented virtually by means of e.g. the USDL service description language.**

3.2.2 Initial Taxonomy for Tangible Assets in MSEE

Based on the feedback provided by MSEE industrial partners, an initial taxonomy for essential tangible assets in MSEE have been deduced that brings together top-level concepts and domain-specific classes. Details will be provided in D23.1b – as discussions are on-going in the project.

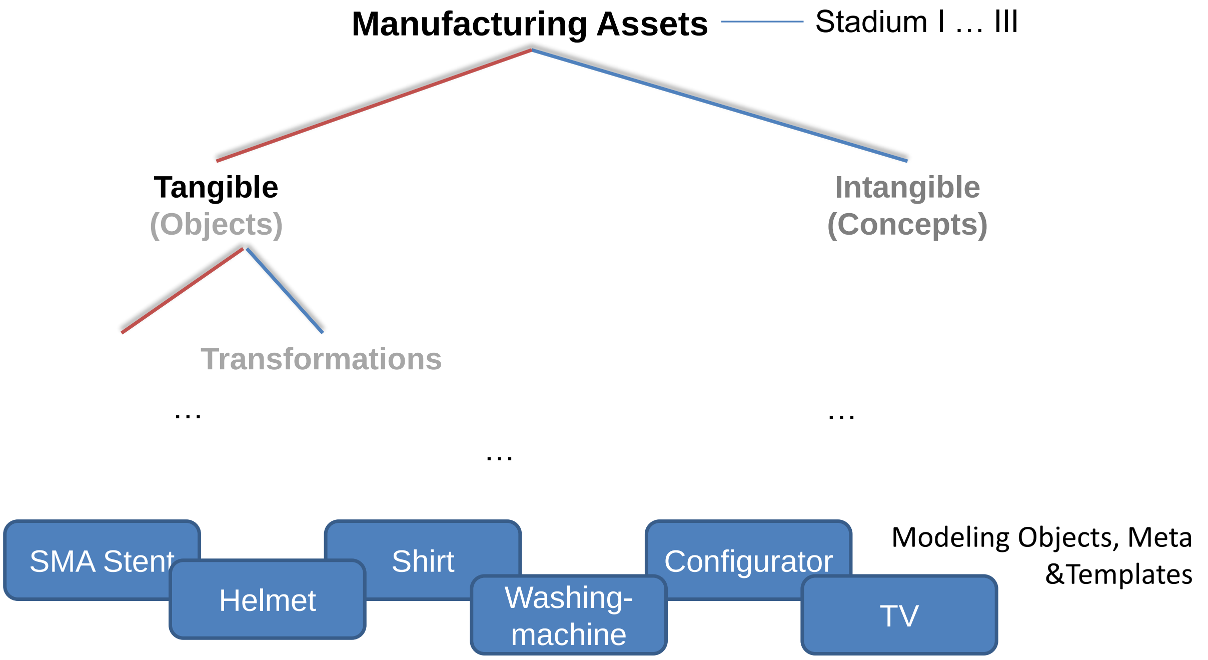

Figure 13: Top- down and bottom-up perspective on tangible assets

The figure above (Figure 13) shows, how these *bottom-up* categories of MSEE tangible assets will be integrated into a holistic semantic model about assets in Manufacturing Ecosystems that has been derived *top-down*. As outlined in the introductory part of this deliverable, MSEE tangible assets are categorized as serviced and materialized. Hence, products are distinguished from extended products and hybrid products (as well as services). Suggestions for a domain-specific linkage "[…]" between top-level and detailed templates has to be further investigated and will be outlined in part b) of this deliverable. Examples for templates for tangible assets are provided in chapter 4.
Generalized details and templates about MSEE-specific instances of product/service descriptions will be provided on basis of real-life product specification sheets (as e.g. in Annex 2) in the version 2 of this deliverable. A first draft of the taxonomy is depicted below in Figure 14.

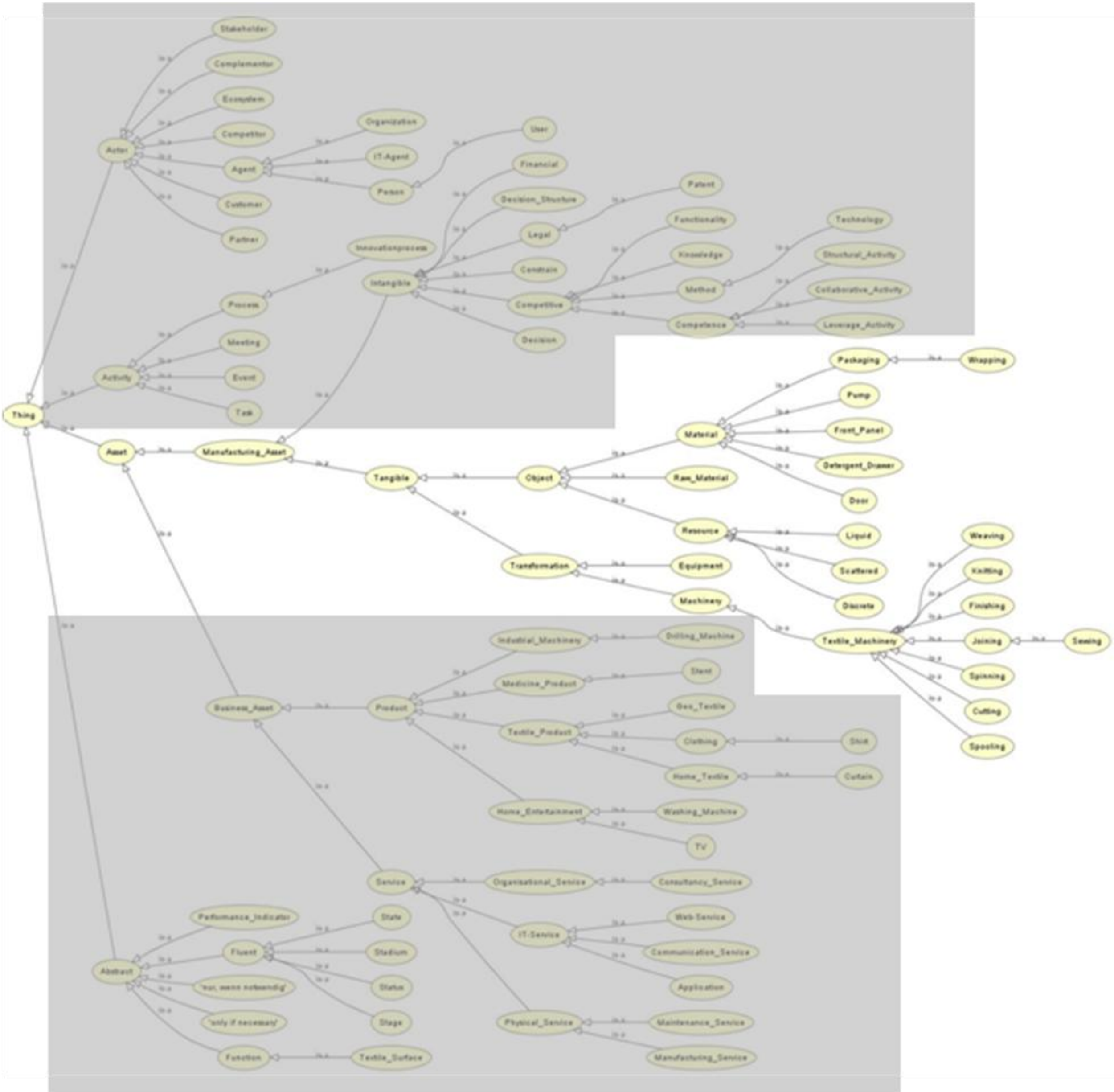

Figure 14: Initial taxonomy on assets (activities, and actors) in MSEE

3.2.3 Rules and Constraints

Rules and constraints are necessary as a support for the decision process on which real-life features of objects shall be virtualized – and especially on how this virtualization process can be successfully finalized. IPR specific attributes and values are prominent examples for context-specific rules to be applied to virtualized tangible assets: Some attributes/values of virtualized tangible assets shall only be accessible for community members; others are for internal use only or to be shared with the public. Rules help to decide on which attributes/values to share with whom.

However, adequate rules and constraints cannot be developed before a commonly accepted vision of virtualized tangible assets in Manufacturing Ecosystem has been derived. Therefore, details about virtualization rules and constraints will be outlined in version 2 of this deliverable.

3.2.4 Example for an Enterprise-Specific Virtualization of Tangible Assets and the related Service-Oriented Model

This section introduces an example about how the industrial partner Bivolino describes (as shown in Annex 1) the individually electronically configured shirts, and an initial service-oriented model.

The MSEE partner Bivolino is responsible (as so called a Manufacturing Service Provider - MSP) for its Ecosystem on producing made-to-measure, individually configured shirts (as a service). Besides keeping track of the order progress, the MSP also provides the necessary data to the (micro-)factories for the production of the garments, and to providers of supporting services. These include generally:

- Consumer related data: Address, bank account …
- Bill of labour: Listing of all the tasks to be fulfilled for each order (financial, garment or fabric making, transportation, …)
- Bill of material: List of materials needed to do the order
- Technical data files:
    - Cut files
    - CAD files
    - Pattern plot
    - 3D technical sketch

At the moment the Bivolino business model is across level 3 and 4 of K.D. Thoben approach to servitization[4], but its expertise could be exploited within a Manufacturing Ecosystem, to gain further opportunities on the market. As a starting point for further investigation of the product-service relation, exemplary data for describing tangible assets at the Bivolino ecosystem has been gathered. Shirts are described as pictures, configuration file incl. user data, xml-specification, and cut-file data (see Annex 1).

The following table and figure shows the initial top-level service-oriented model of the Bivolino pilot case.

Service modelling element	BIVOLINO Case
Service	Automatic shirt configuration service
Product	Shirt (sold by Bivolino)
Functionality	(1) propose shirt model (color, style, tissue), (2) help to determine size, (3) propose personalized shirt
Resource	Mobile development and delivery platform, 3D configurator, e-shop tools, Bivolino website, CAD-CAM-M”M-Link
Partners	Shirt manufacturer, carriers, Provision of textile QR-code infrastructure, e-retailer

[4] “Servitization” is the process of looking at customers needs as a whole. It is moving from the old and outdated focus on product OR service to integrated “bundles” or systems, as they are referred to, with services in the lead role. (Vandermerwe und Rada 1988)

Service modelling element	**BIVOLINO Case**
Supplier/providers: (service providers)	Laundry providers, Social Media, Mobile providers
Other stakeholders	Bivolino designers,
Customer	Shirt buyers
KPIs	Increase of shirt sale, number of new customer, number of customer who come back for second and third times,
Value	Improve the image of Bivolino, fidelisation of Bivolino customer, reduced waste using digital model
Organization	Collaborative decentralized and networked organization
Decisions	Supply decision, Delivery decisions, marketing and sale policy decision
Process	Customer registration and subscription process, Shirt customization process, online payment process, shipping process

Table 2: Bivolino service description on community level

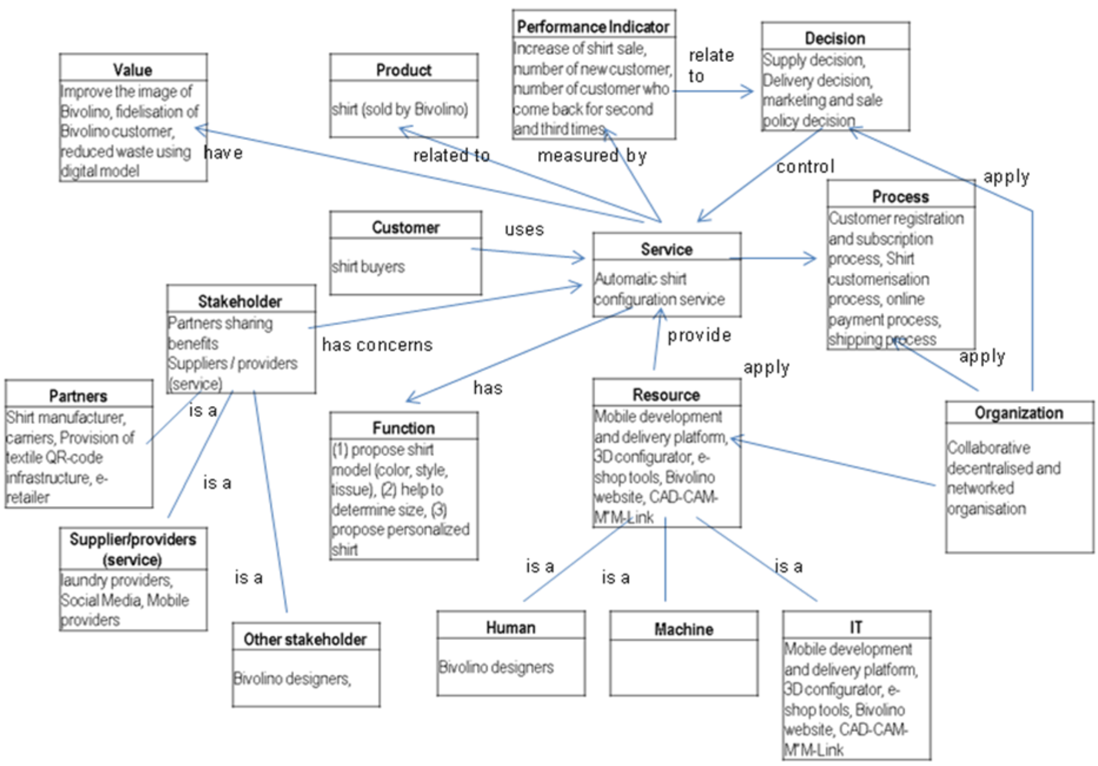

Figure 15: Bivolino Service Oriented Model

4 Relationship with Intangible Assets Management (WP22)

This chapter outlines the relationship with T22.1 Intangible Assets Management, and the first steps towards a common interface to access tangible assets as well as intangibles assets as a service. Both tangible and intangible asset management are herewith discussed, with reference to their mutual interaction within MSEE.

As mentioned above, tangible assets are whatever kind of physical objects with economic value (Allee 2008). Taking into account MSEE's Ecosystem perspectives, they are no longer distinguished into manufacturing assets and product assets, because manufacturing assets, which are used in processes that an organization performs in order to create product assets, can be seen as products of others. Tangible assets include machines, tools, material, work place equipment, material flow components, control systems, storage systems, and the manufacturing environment (building, air conditioning, cleaning).

On the other hand, intangible assets are defined as those key drivers whose essence is an idea or knowledge, and whose nature can be defined and recorded in some way (Hall 1992). The author has split them into intellectual property (those assets for which the organization has property rights) and knowledge assets (those assets for which the organization does not have property rights). As such, accounting, strategy, human resource management, information systems, knowledge management, among others should be considered intangible assets (Marr und Adams 2004).

In order to create high value products and services in this ecosystem context, all actors need to learn how to combine their complementary core competencies across sectors, and how to share highly specialized knowledge about new materials, features, and processing procedures (Senge, Carstedt und Porter 2001). In this respect, the ideas of knowledge and competence as services are currently gaining growing attendance (Xu und Zhang 2005). Scalability, flexibility and adaptivity are essential factors to meet the needs of interdisciplinary, dynamic, and dispersed actors in Manufacturing Ecosystems.

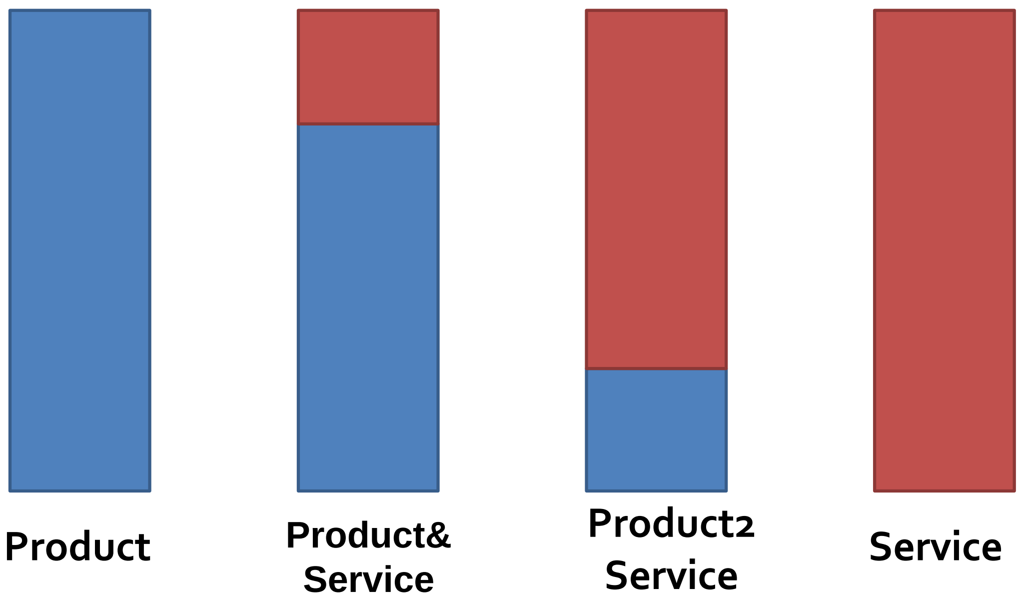

Figure 16: In-/tangible vs. services and products

MSEE distinguishes different portions of in- and tangible assets per product/extended product/hybrid product/service (see Figure 16). The figure below demonstrated how in-timepersistent products are different from in-time-happening services in terms of their respective portion of "in- and tangiblility". While products are very much tangible, service are intangible. Intermediate states of business goods – as described by Thoben (Product&Service, Product2Service) – combine both in- and tangible features.

With reference to MSEE, both tangible and intangible assets will be involved on the different levels of the architecture, i.e. individual enterprises, manufacturing ecosystem and FI cloud (Figure 11).

As far as WP23 is concerned, i.e. tangible asset management, product/machines are physically present at the single enterprise level. Further utilization, in terms of innovation within a Manufacturing Ecosystem, is analysed at the second stage, while the third stage is represented by a wider use of machines and products by the internet of service (FI clouds). The rules that will have to be applied in this context will be outlined in V2 of this deliverable.

A similar approach may be adopted by WP22, i.e. intangible asset management, where the three stages are applied to a different and innovative use of knowledge and human resources at the enterprise level, within the Manufacturing (Innovation) Ecosystem or within FI cloud.

While bearing in mind that all three levels must be properly aligned and that they all interact with each other, appropriate management models and tools should be defined.

Moreover, it is unlikely to consider a standalone approach to product innovation within MSEE, rather than a combination of product and service innovation evolving to the next stage. This concept is visually presented in Figure 11.

5 Conclusion

To sum up the findings of T23.1 documented in this deliverable one can conclude that tangible assets in manufacturing industries can be virtualized by applying a dedicated virtualization process designed for domain-specific modelling and context-sensitive capturing of real-life manufacturing assets. The outcomes of this virtualization process can thus be combined with intangible assets in order to build up innovative services (or products), which – themselves – will then be described by means of e.g. USDL service description language.

The semantics provided in this deliverable are focusing on tangible assets. However, they can easily be extended towards intangible assets as well as organizational, procedural, and even abstract business assets in manufacturing industries. A holistic semantic model should draw on the abovementioned findings and merge them with D22.1.

The drafted method for virtualization as well as templates and the taxonomy will be evaluated and further elaborated with respect to the outcomes of other MSEE work packages (e.g. requirements analysis & progress in industrial use cases).

Work during the next period will in particular focus to the virtualisation of (tangible) manufacturing assets. This includes a.o. the integration of existing taxonomies and ontologies for classification and description of tangible manufacturing assets, the application of methods for self-description of tangible manufacturing assets, the processable and interoperable language for virtualised tangible assets based on USDL, and the extension to further categories of virtual assets. In addition, MSEE industrial partners will be asked to demonstrate how they describe already existing manufacturing services – e.g. by application of USDL.

The final version of the OMMS will be described in version 2 of this deliverable, due in M15 of MSEE. The OMMS will be tested stand-alone for scenarios of the industrial partners, and prepared for integration with the Innovation Ecosystems Platform (resulting from WP26).

Annex 1: Bivolino-Specific Virtualised Tangible Assets (

On the public level, a Bivolino customer deals with shirt-data that refers to the visual effects and fit of the shirt Figure 17.

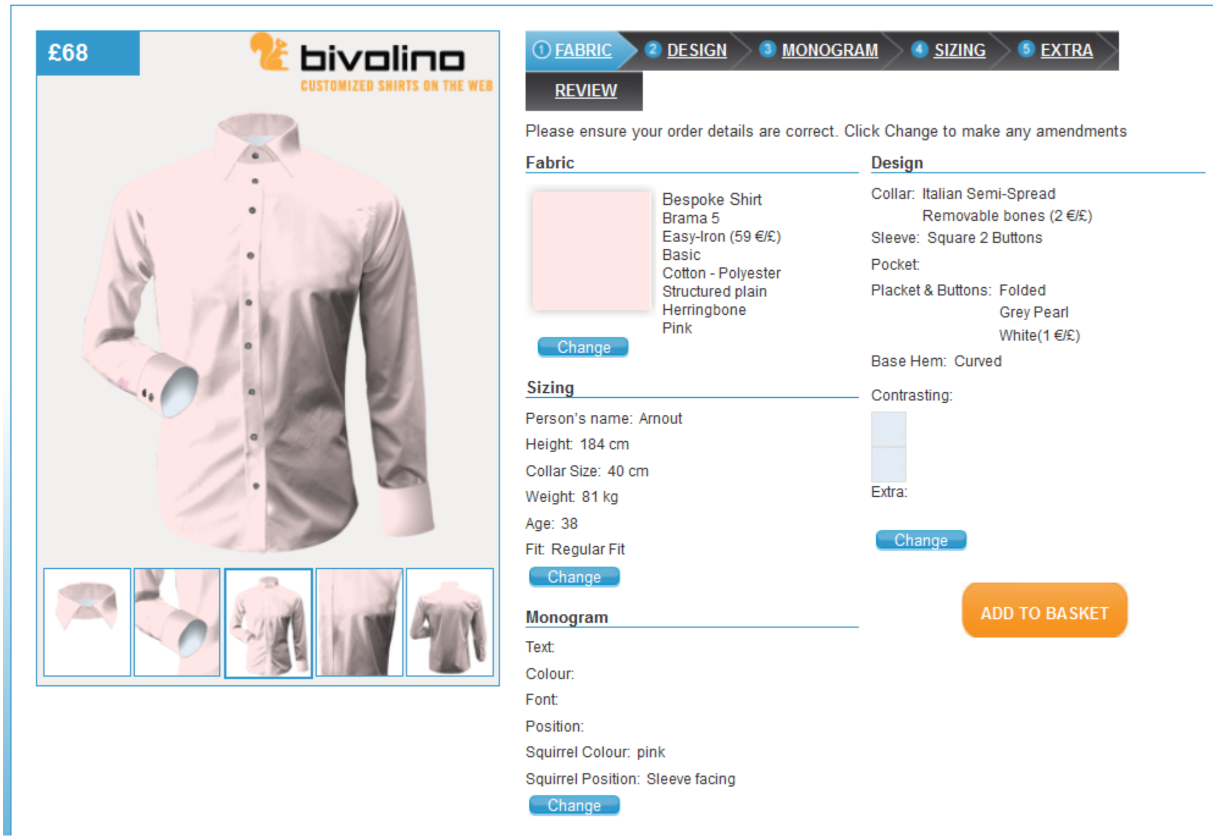

Figure 17: Bivolino shirt ordered by a customer

The data provided by the customer is automatically transformed into an order (Table 3).

Bivolino ordre 1888123456789 Bivolino ordre 1888123456789
Ref client col 40 Bivolino
surname last name
weg 000 0000 town EU

Quantité = 1 col = 40 emballer (2) + catalog ARTY Theme = 51 Chemise sur Mesure Repassage facile Bivolino (coupe 10) coudre à 7 points/cm
Couture émmanchure anglais, couture côté français, monogram 5 mm, petit emballage

12115 Les tissus brama 5 (nr=2115) Coton - Polyester
20005 Le col italien 1
240001 Baleine amovible baleines amovibles
621104 Empiècement contraste interne (nr=1104)
622272 Empiècement contraste interne (nr=2272) entre les deux
30034 La manchette & La manche carré 2 boutons
601104 Manchette contrastée tissu intérieur (nr=1104)
602272 Manchette contrastée tissu intérieur (nr=2272) entre les deux
810001 Bouton patte capucine bouton patte capucine
50004 La gorge pliée
640003 Couleur boutons nacré gris
770008 Couleur fil boutonnières et bouton blanc
90002 Le pan arrondi
100001 Le dos fixe
8018015 Cintrage dos coupe cintrée
1300038 Lieu écureuil manchet de droite patte capucine
1400024 Couleur écureuil rose

Fichier coupe 1: B164667A
Fichier coupe 26: B164667Z triplure

Fichier contrast 1: B164667B tissu : 1104 (fabcode LP) Fichier contrast 1: B164667C tissu : 2272 (fabcode LP)

Details triplure : voir fiches techniques

FICHE TECHNIQUE DES BRODERIES/PRINTS/MONOGRAMMES : respectez petite et grande écriture

Contrôlez longueur manche 67.1 cm
Contrôlez longueur dos 81.30 cm

Controle Administration : Controle Qualité :
o Contrôlé par : ___________ o Alignement (col, manchette, gorge, poche.): ___
o Emballé par : ___________ o Bouton (emplacement, alignement, f...): ___
o Longeur manch gauche ___ droite ___o Broderie (couleur, aligner, présence...): ___
o Largeur manch gauche ___ droite ___o Symétrie (col, manchette,...) : ___
o Pince : ___________ o Mesure (dos, cou, manche,...) : ___
o Longueur dos : ___________ o Contre fiche chemise (tissue, couleur,...): ___

Table 3: Respective shirt configuration of the Bivolino shirt, ordered by a customer

This data is then enriched with details in xml (Table 4)


```
.<order>
  <affiliate>1</affiliate>
  <age>44</age>
  <armpictogram>1</armpictogram>
  <back>100001</back>
  <bodypictogram>1</bodypictogram>
  <boxermen_price>0</boxermen_price>
  <brand>1</brand>
  <button_colour>640001</button_colour>
  <button_yarncolour>770010</button_yarncolour>
  <button_yarncolour_price>0</button_yarncolour_price>
  <buttononsleevefacing>810001</buttononsleevefacing>
  <centimeter>1</centimeter>
  <collarsize>45</collarsize>
  <collection>129</collection>
  <configurator>42</configurator>
  <cufflinks>4031821</cufflinks>
  <date>2012-4-2</date>
  <fit>8018020</fit>
  <handkerchief_price>0</handkerchief_price>
  <height>189</height>
  <linosoft>1</linosoft>
  <pid>47679</pid>

 <profile>0</profile>

 <profilename>Jan</profilename>
  <selectorid>cfda632b-4a9e-4b67-bc0a-d9c24ef15b79</selectorid>
  <squirrelcolor>1400024</squirrelcolor>
  <squirrelcolor_prod>0|61408|1821</squirrelcolor_prod>
  <squirrelplace>1300038</squirrelplace>
  <theme>51</theme>
  <tiefixer_price>0</tiefixer_price>
  <time>13:36:47</time>
  <url>http://www.bivolino.com/confpage.aspx?CID=42&affid=10010</url>
  <weight>121</weight>
  <fabric>10174</fabric>
  <fabric_price>79,00</fabric_price>
  <collar>20015</collar>
  <collar_price>0,00</collar_price>
  <cuff>30027</cuff>
  <cuff_price>2,00</cuff_price>
  <placket>50004</placket>
  <placket_price>0,00</placket_price>
  <pocket>70001</pocket>
  <pocket_price>0,00</pocket_price>
  <basehem>90002</basehem>
  <basehem_price>0,00</basehem_price>
</order>
```


Table 4: xml-Document to describe the order of a shirt

Parts of this data is finally sent to an automatic fabric cutter (Table 5).


```
H1*M70*D2*M15*M20*B163482K/L=82.80cm/W=147.00cm*N1*M26*M15*D2*M15*X33Y1638*
M14*X34Y1863*X1220Y1863*X2406Y1862*X2448Y1866*X2483Y1877*M19*X2486Y1865*M1
5*X2483Y1877*M14*X2485Y1877*X2519Y1888*X2564Y1906*X2650Y1956*X2729Y2002*X27
59Y1954*X2784Y1908*X2816Y1858*X2837Y1823*X2872Y1777*X3248Y1335*X2972Y1092*
X2783Y1317*X2749Y1229*X2657Y1310*X2564Y1388*X2517Y1426*X2468Y1462*X2418Y1
496*X2365Y1525*X2304Y1549*X2240Y1568*X2175Y1583*X2109Y1596*X1977Y1620*X18
44Y1640*X33Y1638*M15*N2*M15*D2*M15*X34Y2165*M14*X33Y2389*X1844Y2387*X197
7Y2407*X2109Y2431*X2175Y2444*X2240Y2460*X2304Y2478*X2365Y2502*X2418Y2531*
X2468Y2565*X2517Y2601*X2564Y2639*X2657Y2717*X2749Y2798*X2783Y2711*X2972Y
2935*X3248Y2693*X2872Y2250*X2837Y2204*X2816Y2170*X2784Y2120*X2759Y2073*X2
729Y2025*X2650Y2071*X2564Y2121*X2519Y2140*X2485Y2150*X2483Y2151*M19*X248
6Y2162*M15*X2483Y2151*M14*X2448Y2161
*X2406Y2165*X1220Y2165*X34Y2165*M15*N3*D2*M15*QX70Y1204*M01*M15*M15*D2*X
1103Y752M43*M15*D2*X1103Y719M43*M15*D2*X520Y735M43*M15*D2*X1427Y736M43*
M15*D2*X1659Y590M43*D2*M15*X2024Y172*M14*X1786Y131*X1743Y120*X1676Y96*M
19*X1677Y108*M15*X1676Y96*M14*X1526Y86*M19*X1529Y98*M15*X1526Y86*M14*X13
93Y163*X1347Y175*X1308Y183*X1268Y190*X1220Y197*X1171Y201*X1103Y205*M19*X
1103Y217*M15*X1103Y205*M14*X965Y188*X845Y168*X712Y147*X623Y130*X519Y111*
M19*X518Y122*M15*X519Y111*M14*X483Y111*X325Y114*X268Y114*X264Y191*X260Y2
30*X257Y249*X253Y268*X235Y312*X215Y354*X170Y437*X126Y520*X106Y563*X90Y60
7*X75Y686*X68Y766*X64Y847*X63Y928*X63Y1009*X65Y1090*X70Y1253*M19*X82Y125
3*M15*X70Y1253*M14*X70Y1291*X1307Y1291*X2543Y1291*X2531Y1253*M19*X2519Y1
255*M15*X2531Y1253*M14*X2531Y1231*X2532Y1210*M19*X2520Y1208*M15*X2532Y12
10*M14*X2537Y1192*X2557Y1148*M19*X2546Y1144*M15*X2557Y1148*M14*X2562Y113
1*X2576Y1097*X2584Y1081*X2592Y1066*X2612Y1040*X2636Y1013*X2648Y1001*X266
2Y990*X2681Y978*X2701Y967*X2721Y957*X2741Y949*X2770Y941*X2799Y935*X2887Y
922*X2706Y420*X2625Y440*X2543Y460*X2482Y472*X2421Y481*X2334Y488*M19*X233
4Y500*M15*X2334Y488*M14*X2255Y481*X2216Y475*X2197Y471*X2178Y465*X2151Y4
54*X2126Y439*X2101Y423*X2078Y404*X2064Y389*X2051Y374*M19*X2041Y380*M15*
X2051Y374*M14*X2037Y341*X2026Y308*X2023Y288*X2022Y268*X2021Y227*X2024Y1
72*M15*N4*D2*M15*QX70Y2834*M01*M15*M15*D2*X1103Y3286M43*M15*D2*X1103Y3
319M43*M15*D2*X520Y3303M43*M15*D2*X1427Y3302M43*M15*D2*X1659Y3448M43*D
2*M15*X2024Y3866*M14*X2021Y3811*X2022Y3770*X2023Y3750*X2026Y3730*X2037Y3
697*X2051Y3664*M19*X2041Y3658*M15*X2051
Y3664*M14*X2064Y3649*X2078Y3634*X2101Y3615*X2126Y3599*X2151Y3584*X2178Y
3573*X2197Y3567*X2216Y3563*X2255Y3557*X2334Y3550*M19*X2334Y3538*M15*X23
34Y3550*M14*X2421Y3557*X2482Y3566*X2543Y3578*X2625Y3598*X2706Y3618*X288
7Y3116*X2799Y3103*X2770Y3097*X2741Y3089*X2721Y3081*X2701Y3071*X2681Y306
0*X2662Y3048*X2648Y3037*X2636Y3025*X2612Y2998*X2592Y2972*X2584Y2957*X25
76Y2941*X2562Y2907*X2557Y2890*M19*X2546Y2894*M15*X2557Y2890*M14*X2537Y28
46*X2532Y2828*M19*X2520Y2830*M15*X2532Y2828*M14*X2531Y2807*X2531Y2785*M
19*X2519Y2783*M15*X2531Y2785*M14*X2543Y2747*X1307Y2748*X70Y2747*X70Y278
5*M19*X82Y2785*M15*X70Y2785*M14*X65Y2948*X63Y3029*X63Y3110*X64Y3191*X68
Y3272*X75Y3352*X90Y3431*X106Y3475*X126Y3518*X170Y3601*X215Y3684*X235Y37
26*X253Y3770*X257Y3789*X260Y3808*X264Y3847*X268Y3924*X325Y3924*X483Y392
7*X519Y3927*M19*X518Y3916*M15*X519Y3927*M14*X623Y3908*X712Y3891*X845Y38
70*X965Y3850*X1103Y3833*M19*X1103Y3821*M15*X1103Y3833*M14*X1171Y3837*X
1220Y3842*X1268Y3848*X1308Y3855*X1347Y3863*X1393Y3875*X1526Y3952*M19*X1
529Y3940*M15*X1526Y3952*M14*X1676Y3942*M19*X1677Y3930*M15*X1676Y3942*M
14*X1743Y3918*X1786Y3907*X2024Y3866*M15*QX3259Y0*M0*N,0001L0*
```


Table 5: Exemplary data for automatic cutting of fabrics into parts for the shirt

Annex 2: Product Specification Sheets provided by MSEE Partners

	8-9kg Prime Washing Machines				7kg Washing Machines	
Model	**PWE9168S**	**PWE8168S**	**PWE8148S PWE8148W**	**PWC8128W**	**IWE7168S IWE7168B**	**IWE7145K IWE7145S IWE7145B**
Page Number	11	11	11	11	13	13
Specifications						
Appliance Height x Width x Depth (cm)	85x59.5x60	85x59.5x60	85x59.5x60	85x59.5x60	85x59.5x53.5	85x59.5x53.5
Net Weight (kg)	72	72	72	72	66	66
Packaged Height x Width x Depth (cm)	89x65x65.5	89x65x65.5	89x65x65.5	89x65x65.5	89x65x59	89x65x59
Total Weight (kg)	74	74	74	74	69.3	69.3
Spin Speed (rpm)	1600	1600	1400	1200	1600	1400
Max Load Wash Capacity (kg)	9	8	8	8	7	7
Number of Wash Programmes	16	16	16	16	16	16
Features						
180° Opening Door	•	•	•	•		
Automatic Water Level Control	•	•	•	•	•	•
Detergent Recycling System	•	•	•	•	•	•
Instant Door Release	•	•	•	•	•	•
Load Balancing System	•	•	•	•	•	•
Safety Delay to Door Lock	•	•	•	•	•	•
Soak & Rain Wash Action	•	•	•	•	•	•
Stand by Function	•	•	•	•	•	•
Type of Display	Digital	Digital	Digital	LED	Digital	Digital
Wash Options						
0°C - 90°C Adjustable Thermostat	•	•	•	•	•	•
Cool Wash	•	•	•	•		
Daily Wash						
Delay Timer	Up to 24hrs	Up to 24hrs	Up to 24hrs	Up to 9hrs	Up to 24hrs	Up to 24hrs
Delicates	•	•	•	•	•	•
Duvet	•	•	•	•		
Easy Iron	•	•	•	•	•	•
Eco Time					•	•
Express Wash	•	•	•	•	•	•
Extra Rinse	•	•	•	•	•	•
Intensive					•	•
Jeans	•	•	•	•	•	•
MixCool 30'	•	•	•	•		
Outdoor Wear	•	•	•	•	•	•
Rinse Hold	•	•	•	•	•	•
Shirts	•	•	•	•		
Smart Technology Mode	•	•	•	•		
Sports Clothes						
Sports Intensive					•	•
Sports Light					•	•
Sports Shoes	•	•	•	•	•	•
Time4You Wash/Flash Cotton					•	•
Variable Temperature & Spin	•	•	•	•	•	•
Wool	•	•	•	•	•	•
Performance						
Washing Performance Rating	**A**	**A**	**A**	**A**	**A**	**A**
Energy Efficiency Rating	**A+**	**A+**	**A+**	**A+**	**A+**	**A**
Spin Efficiency Rating	**A**	**A**	B	B	**A**	B
Energy Consumption (kWh)	1.36	1.36	1.36	1.36	1.19	1.33
Water Consumption (litres)	69	69	69	69	60	60
Water Remaining After Spin (%) (as a percentage of dry weight of wash)	48	38	38	52	38	48
Colour	White/Silver	White/Silver	White/Silver White	White	Silver White	Black Silver White

Table 6: Indesit washing machine public specifications (1/2)

	5-6kg Washing Machines					Integrated
Model	**IWC6165S IWC6165**	**IWC6145S IWC6145**	**IWC6125S IWC6125**	**IWB5113**	**IWSC6125**	**IWME126**
Page Number	14	14	14	14	15	15
Specifications						
Appliance Height x Width x Depth (cm)	85x59.5x53.5	85x59.5x53.5	85x59.5x53.5	85x59.5x53.5	85x59.5x45	85x59.5x53.5
Net Weight (kg)	66	66	66	61	66	68
Packaged Height x Width x Depth (cm)	89x65x59	89x65x59	89x65x59	89x65x59	89x65x51	89x65x59.5
Total Weight (kg)	69.3	69.3	69.3	62.6	69.3	70
Spin Speed (rpm)	1600	1400	1200	1100	1200	1200
Max Load Wash Capacity (kg)	6	6	6	5.5	5	6
Number of Wash Programmes	16	16	16	16	16	20
Features						
180° Opening Door						•
Automatic Water Level Control	•	•	•	•	•	
Detergent Recycling System	•	•	•	•	•	•
Instant Door Release						
Load Balancing System	•	•	•	•	•	•
Safety Delay to Door Lock	•	•	•	•	•	•
Soak & Rain Wash Action	•	•	•	•	•	•
Standby Function	•	•	•	•	•	
Type of Display	LED	LED	LED	LED	LED	LED
Wash Options						
0°C - 90°C Adjustable Thermostat	•	•	•	•	•	•
Cool Wash						
Daily Wash						•
Delay Timer	Up to 12hrs	Up to 12hrs	Up to 12hrs	Up to 12hrs	Up to 12hrs	Up to 9hrs
Delicates	•	•	•	•	•	•
Duvet						
Easy Iron	•	•	•	•	•	•
Eco Time	•	•	•	•	•	
Express Wash	•	•	•	•	•	
Extra Rinse	•	•	•	•	•	•
Intensive	•	•	•	•	•	•
Jeans	•	•	•	•	•	
MixCool 30°						
Outdoor Wear						
Rinse Hold	•	•	•		•	
Shirts						
Smart Technology Mode						
Sports Clothes						•
Sports Intensive	•	•	•	•	•	
Sports Light	•	•	•	•	•	
Sports Shoes	•	•	•	•	•	•
Time4You Wash/Flash Cotton	•	•	•	•	•	•
Variable Temperature & Spin	•	•	•	Temp only	•	•
Wool	•	•	•	•	•	•
Performance						
Washing Performance Rating	A	A	A	A	A	A
Energy Efficiency Rating	A+	A	A	A	A	A+
Spin Efficiency Rating	A	B	B	B	B	B
Energy Consumption (kWh)	1.02	1.14	1.14	1.14	0.95	0.93
Water Consumption (litres)	52	52	52	52	43	64
Water Remaining After Spin (%) (as a percentage of dry weight of wash)	38	48	59	59	54	52
Colour	Silver White	Silver White	Silver White	White	White	White

Table 7: Indesit washing machine public specifications (2/2)

Unterstützte Audio-/Videodateien

Multimedia-Dateinamen dürfen nicht länger als 128 Zeichen sein.

AV CLASS													
File Extensions	Container	Video codec	Maximum Resolution	Max. Frame Rate (fps)	Max. Bit Rate (Mbps)	Audio codec	USB	DLNA	CE-HTML	HTML5	HbbTV/MHEG/ MHP	Video Store	YTLB
.mpg .mpeg .vob	PS	MPEG1	1920x1080	25p,30p,50i,60i	20 Mbps	MPEG-1(L1&L2), MPEG-2 L3, AAC/ HE-AAC(v1&v2), DVD-PCM, AC3	YES	YES	YES	YES	NO	NO	NO
		MPEG-2	1920x1080	25p,30p,50i,60i	20 Mbps		YES	YES	YES	YES	NO	NO	NO
		H.264	1920x1080	25p,30p,50p,60p,60i	20 Mbps		YES	YES	YES	YES	NO	NO	NO
.ts	TS	MPEG-2	1920x1080	25p,30p,50i,60i	20 Mbps	MPEG-1(L1&L2), MPEG-2 L3, AAC/ HE-AAC(v1&v2), AC3, E-AC3, Dolby Pulse	YES	YES	YES	YES	YES	NO	NO
		MPEG-4 ASP	1920x1080	25p,30p,50i,60i	20 Mbps		YES	YES	YES	YES	YES	NO	NO
		H.264	1920x1080	25p,30p,50p,60p,60i	20 Mbps		YES	YES	YES	YES	YES	NO	NO
.mp4	MP4	MPEG-4 ASP	1920x1080	25p,30p,50i,60i	20 Mbps	AAC/HE-AAC (v1&v2), AC3, E-AC3	YES	YES	YES	YES	YES	YES	NO
		H.264 HP	1920x1080	25p,30p,50p,60p,60i	20 Mbps		YES	YES	YES	YES	YES	YES	NO
		H.264 HP	1920x1080	25p,30p,50p,60p,60i	20 Mbps		YES	YES	YES	YES	YES	YES	NO
.mkv	MKV	MPEG-4 ASP	1920x1080	25p,30p,50i,60i	20 Mbps	MPEG-1(L1&L2), MPEG-2 L3, AAC/ HE-AAC(v1&v2), AC3, E-AC3	YES	YES	NO	NO	NO	NO	NO
		H.264 HP	1920x1080	25p,30p,50p,60p,60i	20 Mbps		YES	YES	NO	NO	NO	NO	NO
		H.264 HP	1920x1080	25p,30p,50p,60p,60i	20 Mbps		YES	YES	NO	NO	NO	NO	NO

Unterstützte Audio-/Videodateien

Multimedia-Dateinamen dürfen nicht länger als 128 Zeichen sein.

AV CLASS													
File Extensions	Container	Video codec	Maximum Resolution	Max. Frame Rate (fps)	Max. Bit Rate (Mbps)	Audio codec	USB	DLNA	CE-HTML	HTML5	HbbTV/MHEG/ MHP	Video Store	YTLB
.asf .wmv	ASF	MPEG-2	1920x1080	25p,30p,50i,60i	20 Mbps	MPEG-1(L1&L2), MPEG-2 L3, AAC/ HE-AAC(v1&v2), LPCM, AC3, WMA	YES	YES	YES	YES	NO	YES	NO
		MPEG-4 ASP	1920x1080	25p,30p,50i,60i	20 Mbps		YES	YES	YES	YES	NO	YES	NO
		WMV9/VC1 SP	1920x1080	30p,60i	20 Mbps		YES	YES	YES	YES	NO	YES	NO
		WMV9/VC1 MP	1920x1080	30p,60i	20 Mbps		YES	YES	YES	YES	NO	YES	NO
		WMV9/VC1 AP	1920x1080	30p,60i	20 Mbps		YES	YES	YES	YES	NO	YES	NO
.avi .mkv	AVI	MPEG-4 ASP	1920x1080	25p,30p,50i,60i	20 Mbps	MPEG-1(L1&L2), MPEG-2 L3, AC3, LPCM, WMA	YES	YES	NO	NO	NO	NO	NO
		DivX 3.11	1920x1080	30p,60i	20 Mbps		YES	YES	NO	NO	NO	NO	NO
.flv	FLV	On2 VP6	-	-	-	MPEG-2 L3, AAC	NO	NO	YES	YES	NO	NO	YES
		Sorenson H.263	-	-	-		NO	NO	YES	YES	NO	NO	YES
.swf	SWF	Contains FLV	-	-	-	-	NO	NO	NO	NO	NO	NO	YES
.divx	DMF (DivX)	MPEG-4 ASP	1920x1080	25p,30p,50i,60i	20 Mbps	MPEG-1(L1&L2), MPEG-2 L3, AC3, LPCM, WMA	YES	YES	NO	NO	NO	NO	NO
		DivX 3.11	1920x1080	30p,60i	20 Mbps		YES	YES	NO	NO	NO	NO	NO

Unterstützte Audio-/Videodateien

Multimedia-Dateinamen dürfen nicht länger als 128 Zeichen sein.

AUDIO ONLY CLASS													
File Extensions	Container	Video codec	Maximum Resolution	Max. Frame Rate (fps)	Max. Bit Rate (Mbps)	Audio codec	USB	DLNA	CE-HTML	HTML5	HbbTV/MHEG/ MHP	Video Store	YTLB
.mp3	MP3	-	-	-	384 kbps	MPEG-2 L3	YES	YES	YES	YES	YES	NO	NO
.wma .asf	WMA (V2 upto V9.2)	-	-	-	192-768 kbps	WMA	YES	YES	YES	YES	NO	NO	NO
.lpcm (PC) .pcm (pc)	LPCM	-	-	-	768 kbps	LPCM	NO	YES	NO	NO	NO	NO	NO
.wav (PC)	LPCM	-	-	-	768 kbps	LPCM	YES	YES	NO	NO	NO	NO	NO
.aac .mp4 .m4a	AAC	-	-	-	384 kbps 512 kbps 640 kbps 1024 kbps 3200 kbps	AAC, HE-AAC (v1&v2), AC3, E-AC3	YES	YES	YES	YES	YES	NO	NO

Table 8: Philips public TV specifications

Annex 3: GME Modelling Tool

Modelling needs support of suitable applications. The last step is the implementation and evaluation of the application support for the Smart Network Modelling Method. The applications have to enforce all modelling rules (built-time as well as run-time). For the implementation of the modelling method the 'Generic Modelling Environment' (GME)5 of the Vanderbilt University has been used.

GME is a configurable application for creating domain-specific modelling environments. The configuration of the application is performed with a meta-modelling language (MetaGME) similar to Meta Object Facility (MOF)6 that means it is based on UML class diagram notation and uses the Object Constraint Language (OCL)7 to describe constraints. MetaGME can be used to describe domain-specific modelling languages with a set of models. These models are translated to a configuration for the GME application. The application is now able to support the domain-specific modelling language by enforcing the modelling rules stated in the MetaGME models.

GME supports two types of rule sets. The first rule set (built-time rules) describes rules that can be evaluated without context information of instances of modelling objects (e. g. the object 'person' can be connected to the object 'department' or the model object 'activity diagram' can contain the object 'activity'). Built-time rules are described with the UML class diagram notation (see Figure 18). The second supported rule set (runtime rules) describes rules requiring context information of object instances (e. g. the naming of object has to follow certain conventions or an instance of object 'person' can only be connected ones to the same instance of object 'department'). A third type of rule set, called modelling style guide, describes rules, which are specific to certain fields of application and provides additional restrictions to the freedom of modelling. This type of rule set is not supported by GME but it is necessary for automatic processing (e. g. transformation to the Business Process Execution Language) but also often use to improve the readability of models.

[5] See (Ledeczi u. a. 2001)
[6] See (OMG 2011)
[7] See (O A)

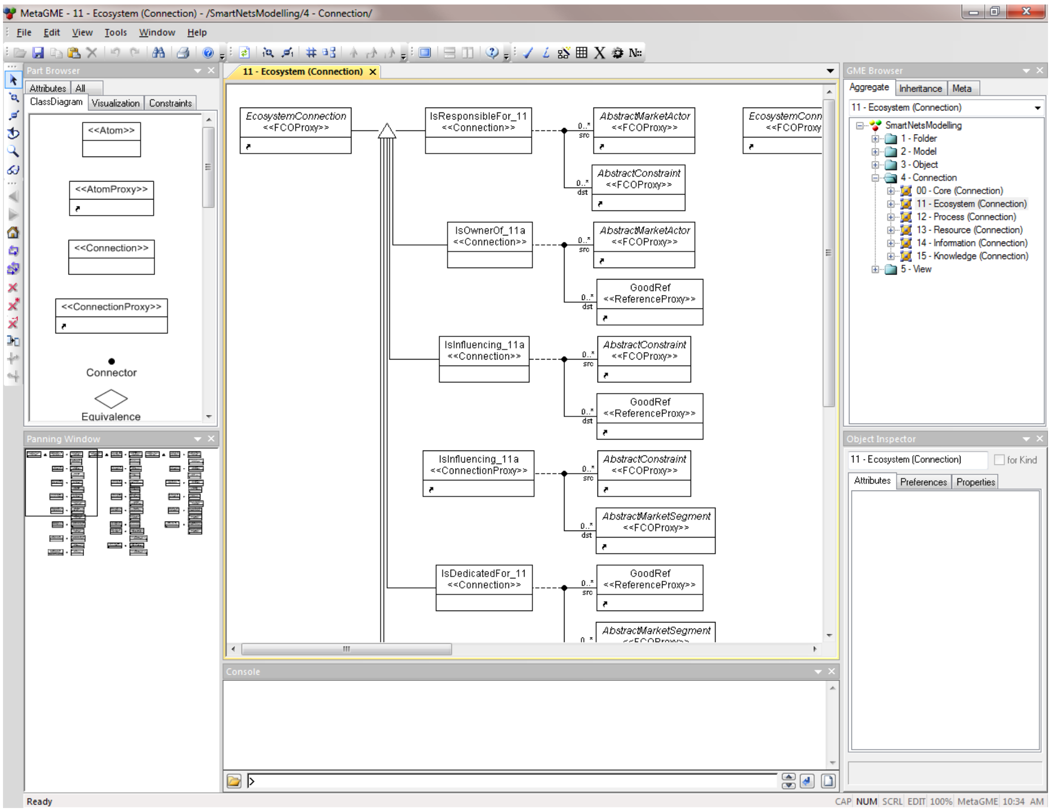

Figure 18: GME with an excerpt of the meta-model for the Smart Network Modelling Method

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