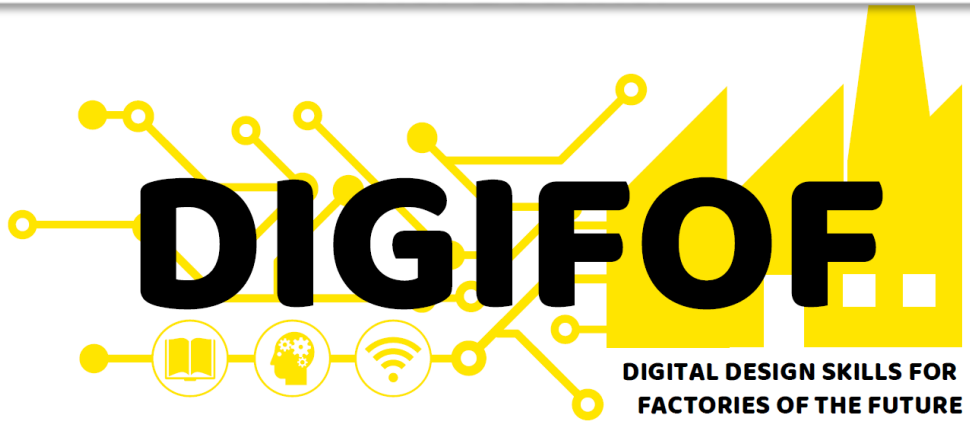
MINES Saint-Étienne

Une école de l'IMT

EMSE_O4
Introduction to the concept of PSS and to the dedicated PS3M modelling method

Xavier Boucher



The industrial transition towards Product-Service-Systems

- Mines Saint-Etienne (FR)
- Pr. Xavier Boucher

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Introduction
on
Product-Service- Systems (PSS)

Product-Service System… what is it about?

Product

A technical device, designed, and produced to ensure predefined functions, and delivered to be purchased by a client

Service

Realisation of activities by some actor(s) with the intention to create and deliver value for some other actor(s), resulting in a change of state for this (these) actor (s).

System

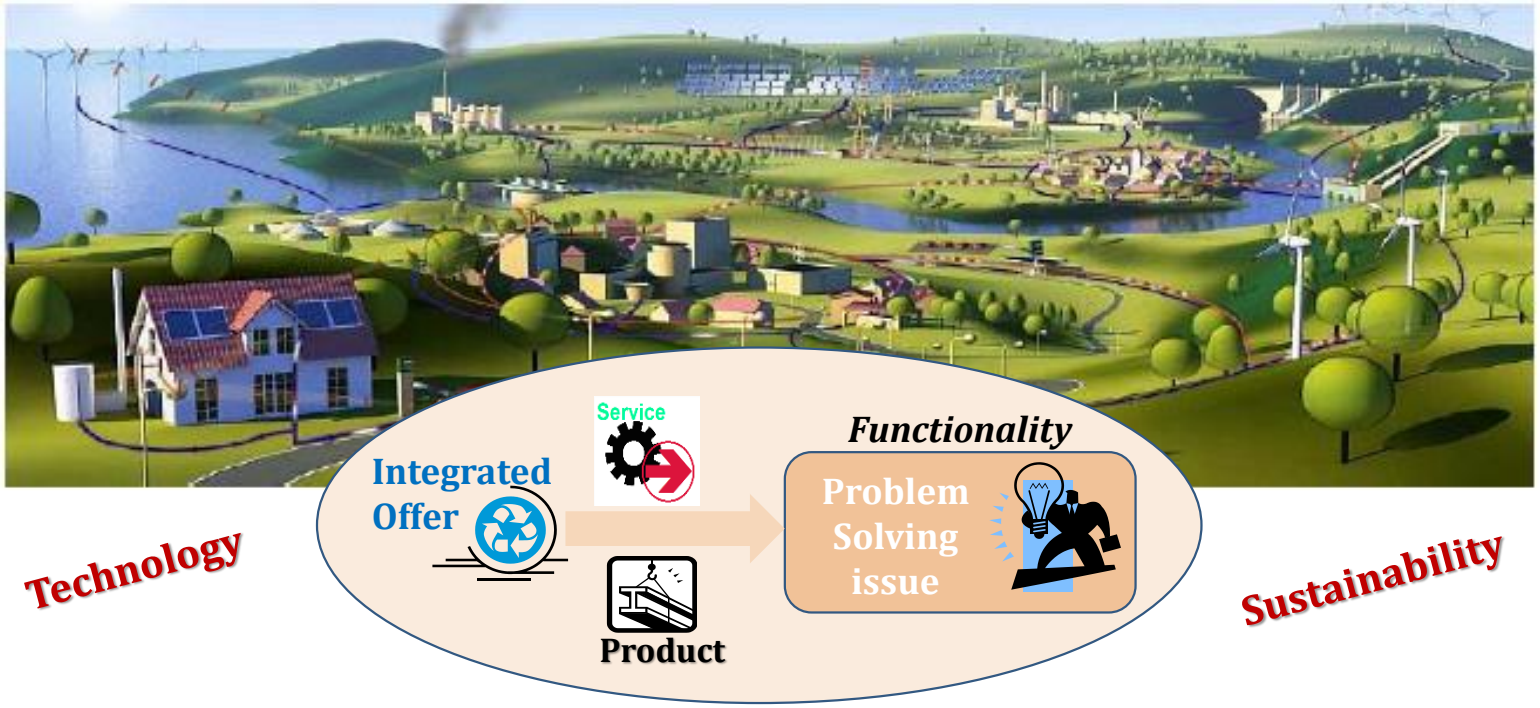
An interconnection of products and services, designed to fullfill complex functionnalities, in a specific context.

Product-Service Systems

'*A consciously designed value proposition, focusing on fulfilling the needs of a defined receiver, combining product and service elements and delivering the value through novel channels*'

[Tim Mc Aloone, IPSS 2015]

PSS are part of a transition towards a more cyberphysical world



PSS in a cyber-physical world ?

☞ *Product-Service-Systems embed the relationship between industry (FoF) and the citizen*

☞ *The client is no more reduced to a 'buyer/consumer' : he becomes a user, a functionality consumer, a stakeholder of the value creation process.*

☞ *PSS enlarge the vision of value creation. Sustainability can emerge from a transformation of consumer behaviors and provider-consumer relationships*

Product-Service System…in every-day life

PSS in B to C

Car Sharing Solution

PaaS- Printing as a Service

Medical support Solution

Common Points ?

- ❑ Offer a solution
- ❑ Purchase the usage
- ❑ Share the product functionnalities among multiple users

PSS in B to B

Tyre supply

AFFORDABLE FLEET TIRE LEASE PROGRAMS

› Mobility Provider

Automobile Industry Machinery

› Provider of Manufacturing Capacity

Air Compression Systems

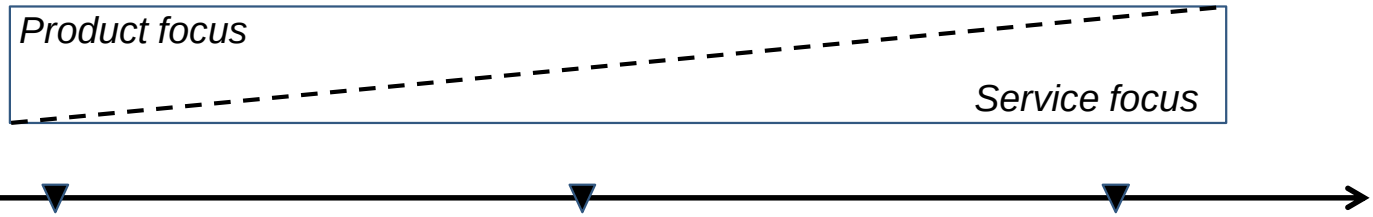
› Provider of Sustainable Energy

Change of Business model ?

- ❑ Understand the processes of your customers
- ❑ Take in charge a full & optimized function
- ❑ Transform the economic model….but also all the process of value creation

PSS typologies

- **PSS Typology: Hokkerts (1999), Tukker (2004)…Baines et al. (2007)**



Product-oriented PSS

Addition of services to ensure functionality and durability along the lifecycle of a product, sold with a usual transactional model

Use-oriented PSS

Only the availability or the use of the product is sold to the customer. Relational value creation model.

Result-oriented PSS

No more product sale, but sale of a well specified result or capability specified by the customer (contract on the ability to guarantee a performance)

FUNCTIONAL ECONOMY

Notion of 'Functional Economy'

C. du Tertre (2008) : Functional Economy

« … Dynamics of co-production by producers together with consumers, of overall solutions integrating products and services in order to answer needs of people (B2B) or enterprises (B2B), taking into account new environmental and societal requirements »

Characteristic of the economic model…

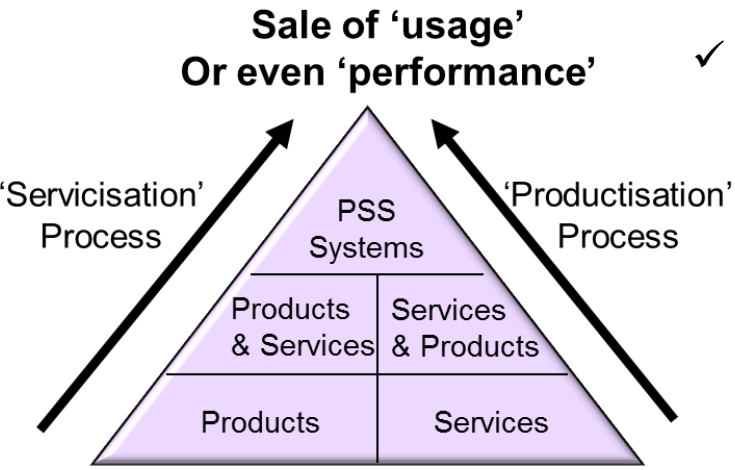
- Economic model with 'no possession transaction', but with a sale of service making possible the use of goods ; thus, economic on use-value and no more on transaction-value of the goods.
- Mutualisation of the use of goods, by putting forth service offers which tend to answer 'collective functional needs' : territorialisation of needs.
- Transformation de 'focus' of the production processes : New 'object of production' based on the integration of product and services over the whole life cycle (Design, Production, End of Life, Evolution of the offer,…).
- Dynamics of co-production (customer/user contribution, collaborative production networks, multiple stakeholders), generating new forms of value creation process & value creation factors.
- An intentionality which should be oriented on environnemental and societal requirements

The Transition towards PSS :

Needs for engineering and modelling methods ?

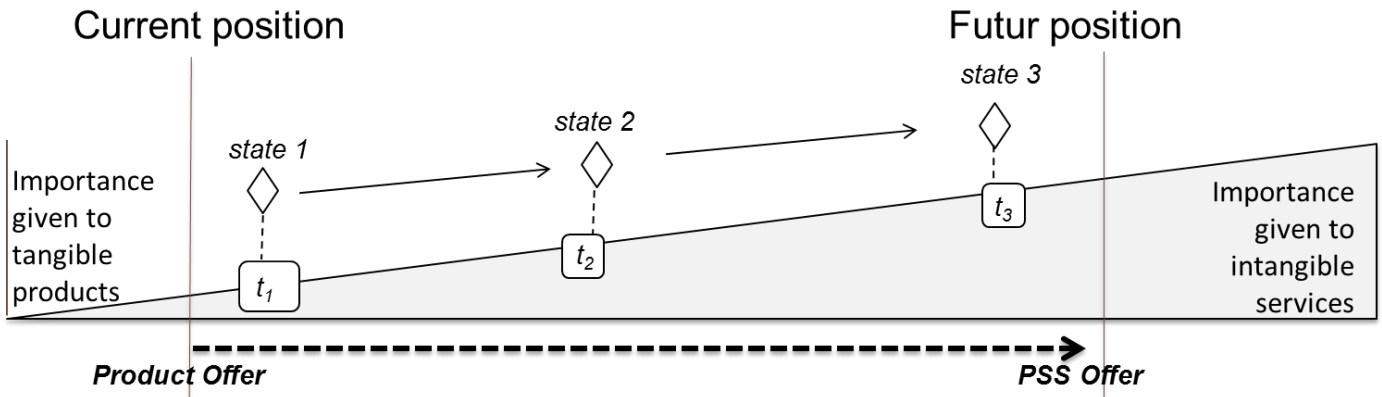
Servitization requires in-depth change of Business model for the industry …

(Baines et al., 2007)



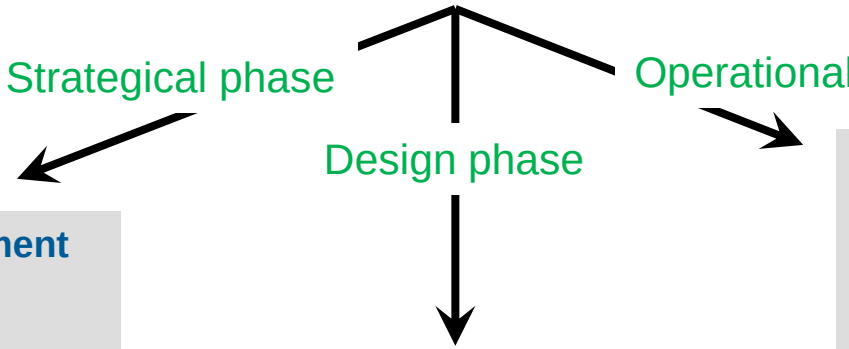
What BM dimensions can be affected ?

- ✓ *Change of innovation and managerial paradigm*
- ✓ *Transition of client-relationship model*
- ✓ *Transformation of economic model & impacting factors*
- ✓ *Transition through Digital Technologies*
- ✓ *Change of sustainability management*
- ✓ *Organisational and process changes*
- ✓ *Cultural transformation*



(Oliva & Kallenberg, 2003)

Requirements for Enterprise Modelling and Engineering Methodologies
To support the transition towards PSS Design, Delivery and Management



PSS Transition Management =>'Servitization'

Entreprise Modelling to provide support for Strategic Analysis, then Entreprise Transformation Project Management

Example : Servitization Decision Processes Diagnosis and Improvement

Definition and design of PSS offers, value creation networks, new economic model

Entreprise Modelling to support the configuration of value creation networks

Example : Value Creation Scenarios Modelling and Simulation – Economic model balancing

Operational PSS LifeCycle Management

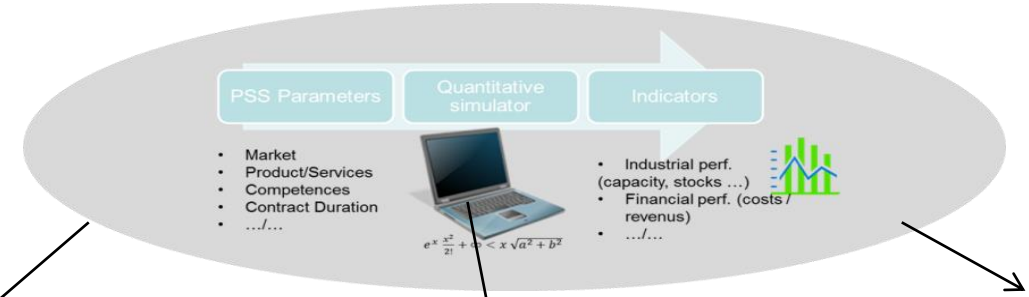
Entreprise Modelling, articulated with PLM, to manage high volume of life cycle data sets

Perspectives notably ontology and Big Data

Strong impact of servitization on the economic models

Necessity to organize progressively the economic model transition and to provide risk anticipation solutions

Engineering of the transition of economic model



Market Dynamics
Simulation of the sensibility to customer behaviors, analysis of market penetration scenarios and strategies

Risk Management
Short term and long term impacts of change of economic model on cash flow, turnover, internal accounting results, Multi-actor economic model balancing

Value creation network
Configuration of value creation network, determination of value sharing contracts, specification of collaborative regulation mechanisms

Towards an integrative PSS Design Platform (BtoB)

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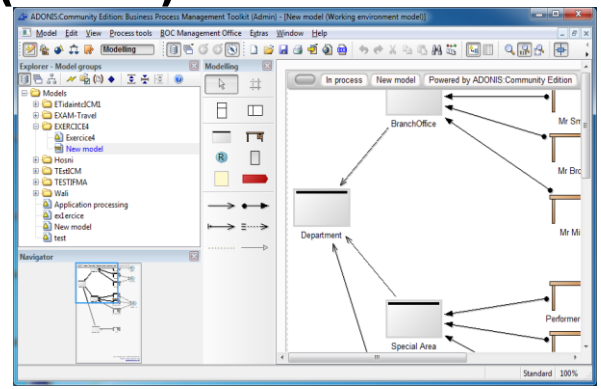
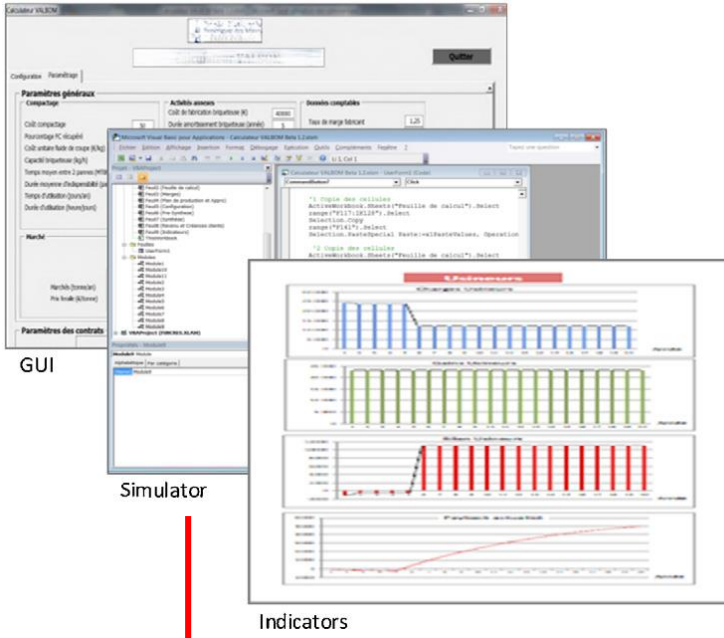


PS3M **PSS Scenario Modeller**

Strong needs of contextualisation thus customisation for the simulation environment

PSS Value- Network Analyser



Rapid customisation based on:

- Transfer of industrial quantitative data
- Semi-automatic configuration of PSS scenarios

Design Environment
Design PSS business and organisation scenarios

Decision-Making support
Risk management : evaluate and compare alternative economic models deduced from the scenarios.

PS3M
Development of a PSS dedicated modelling method :

- Meta-modelling procedure
- Meta-model
- Implemented modelling environment

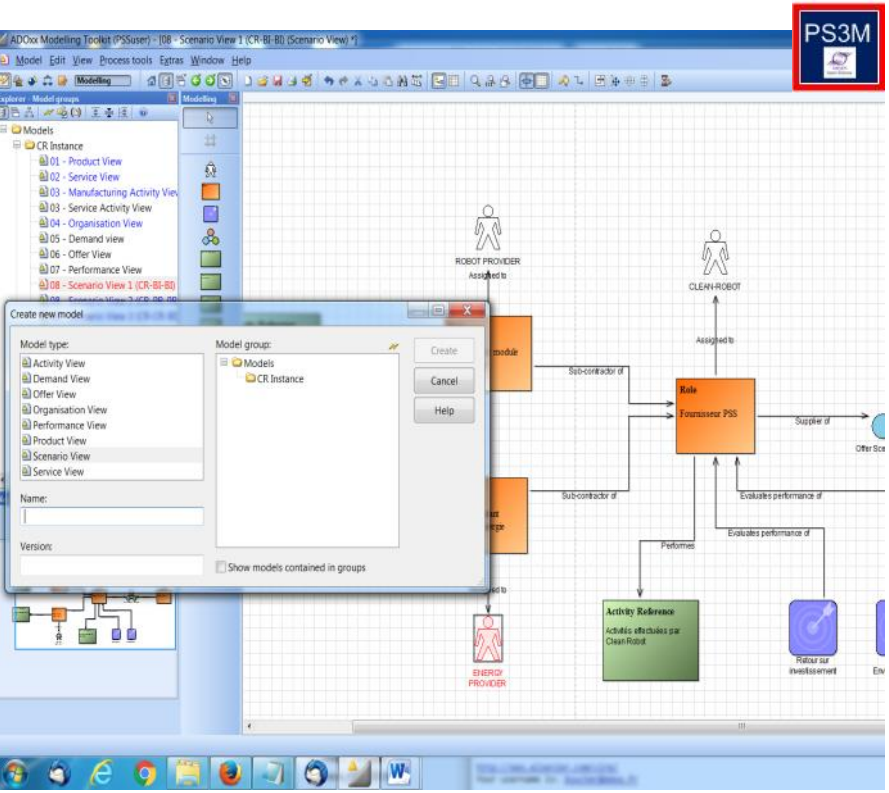
A modelling tool & method : for which purpose ?

- ✓ *Qualitative models, to capture and structure key pieces of information*
- ✓ *Cognitive support to make explicit all pieces of information required for offer enginering and help interactions among all design actors*

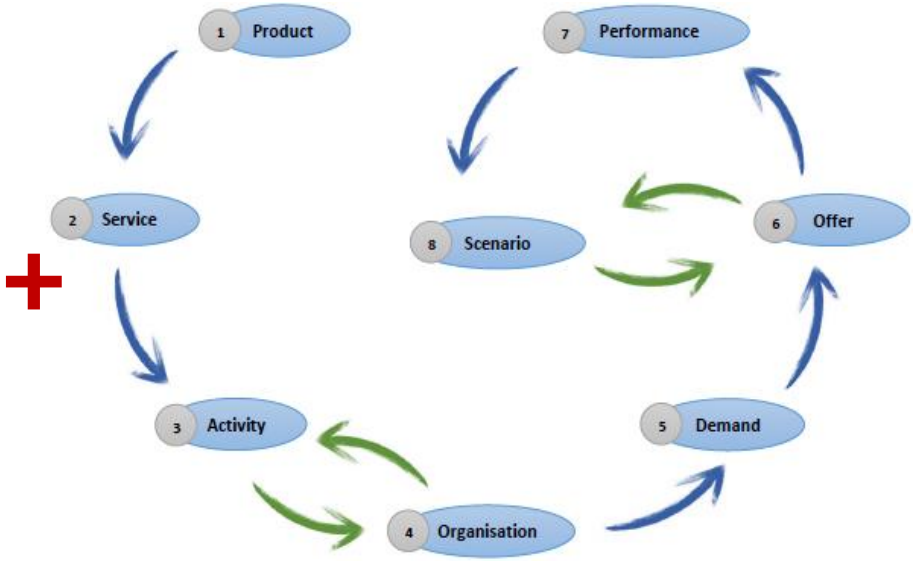
- ➢To make explicit the components of the PSS offer and its life-cycle.
- ➢To analyze the potential value creation networks
- ➢To provide a visual representation of the PSS organizational scenarios
- ➢To structure sufficient knowledge making possible a rigorous assessment of the various alternatives

Technical environment

ADOxx meta-modelling platform & specific meta-model



Structured modelling procedure



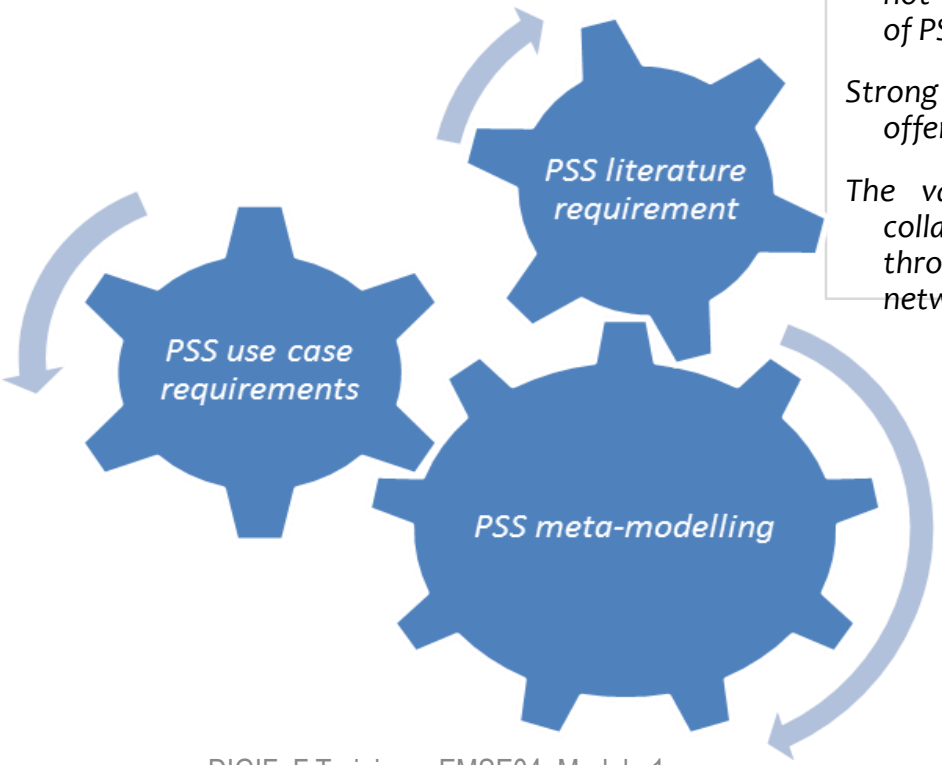
Issue : which approach to develop a specific meta-model ?
Insights on an iterative meta-modelling procedure

Iterative meta-modelling approach

Rationale…

An explorative research methodology combining requirements from the Product-Service-Systems literature and requirements from practical use cases

- *Available knowledge about a given use case is translated into a meta-model describing the way a PSS scenario could (not should be!) be modelled*
- *This process results in an initial use case based meta-model that was refined, in a second step, based on the PSS modelling and meta-modelling requirements*



Traditional modelling methods do not allow a clear representation of PSS.

Strong linkages between the PSS offer and its value network.

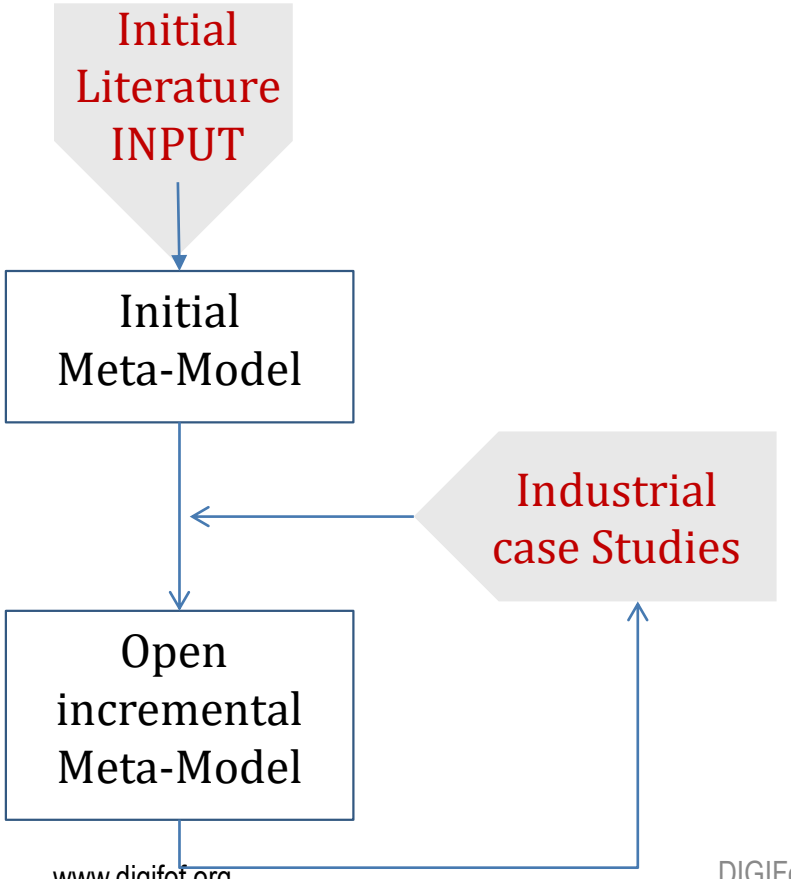
The value is generated out of collaborative processes throughout the PSS value network.

- *An iterative meta-modelling procedure utilising PSS modelling use cases*

First Step : creation of an initial MM based on industrial needs

Added-value of the iterative approach:

- Consistent integration of several complementary contextualized contributions
- Keep the meta-model proposal open to improvement by other points of view



Indus. Case Study	Added-value for the Metamodel
Use case 1 – ECOBEL **A SME supplying hospitals and local communities with water-efficient products.**	Basic PSS 'components' namely product and service; manufacturing activities; organisational actors; customer demand;
Use case 2 - AUTOMELEC **A SME in the domain of electrics and automation (Application to extraction of minerals).**	Specialisation of service; Introduction of service packages, contracts, performance evaluation, and operators;
Use case 3 – VALBOM **A group of SMEs comprised of an equipment provider for steel sludge treatment, steel makers, and steel smelters.**	Specialisation of activity; introduction of activity group; generalisation of operator and organisation actor into performer; introduction of the 'role' in scenarios modelling (to decouple activities from actors);

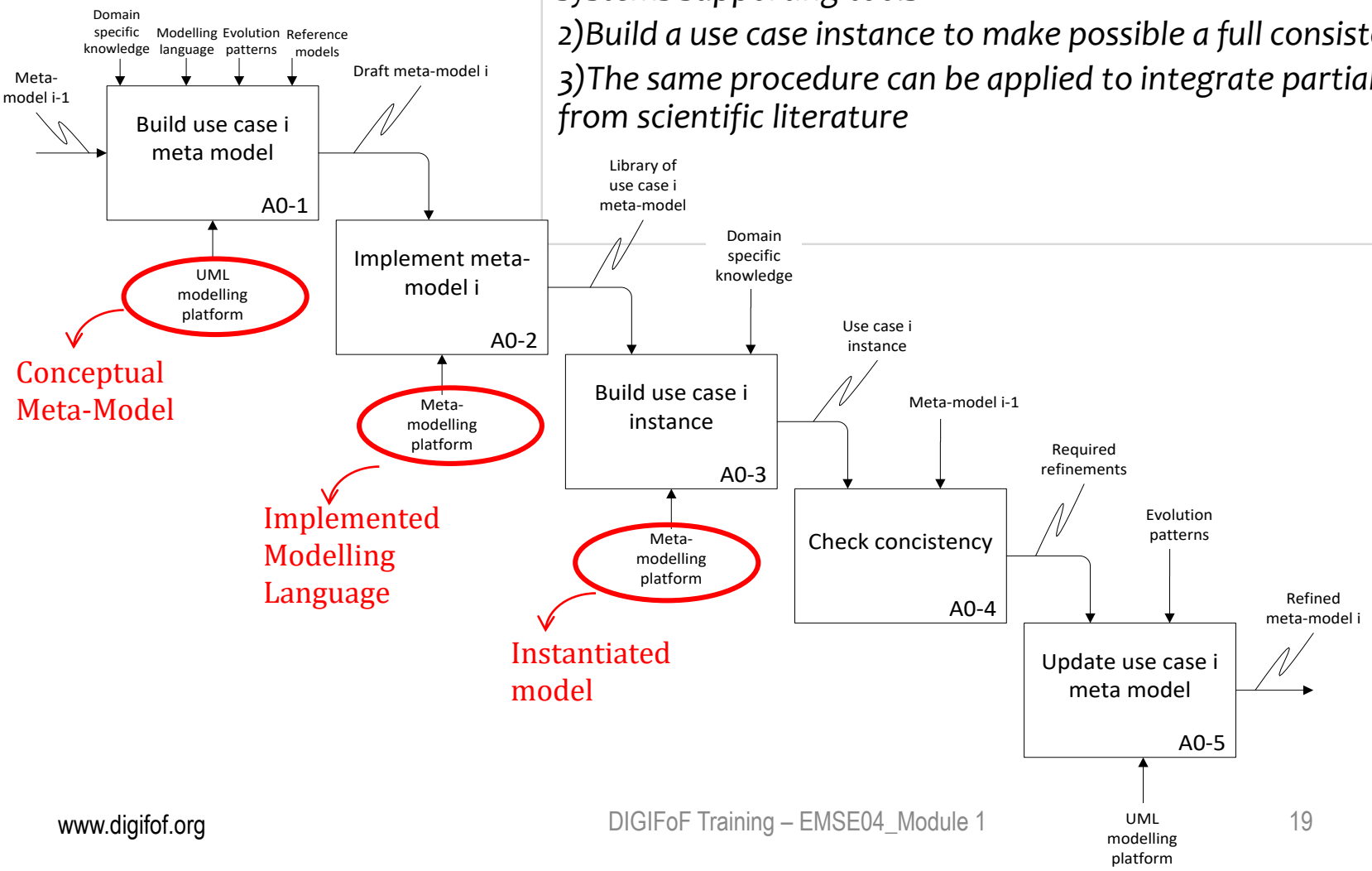
Iterative Meta-model building and refinement

Consider **each** of the use cases:

1)Build the use case meta-model in UML using data from use case reports, interviews with the use case personnel, and information systems supporting tools

2)Build a use case instance to make possible a full consistency checking

3)The same procedure can be applied to integrate partial meta-models from scientific literature



Integrated meta-model building

With ***n* use cases**…

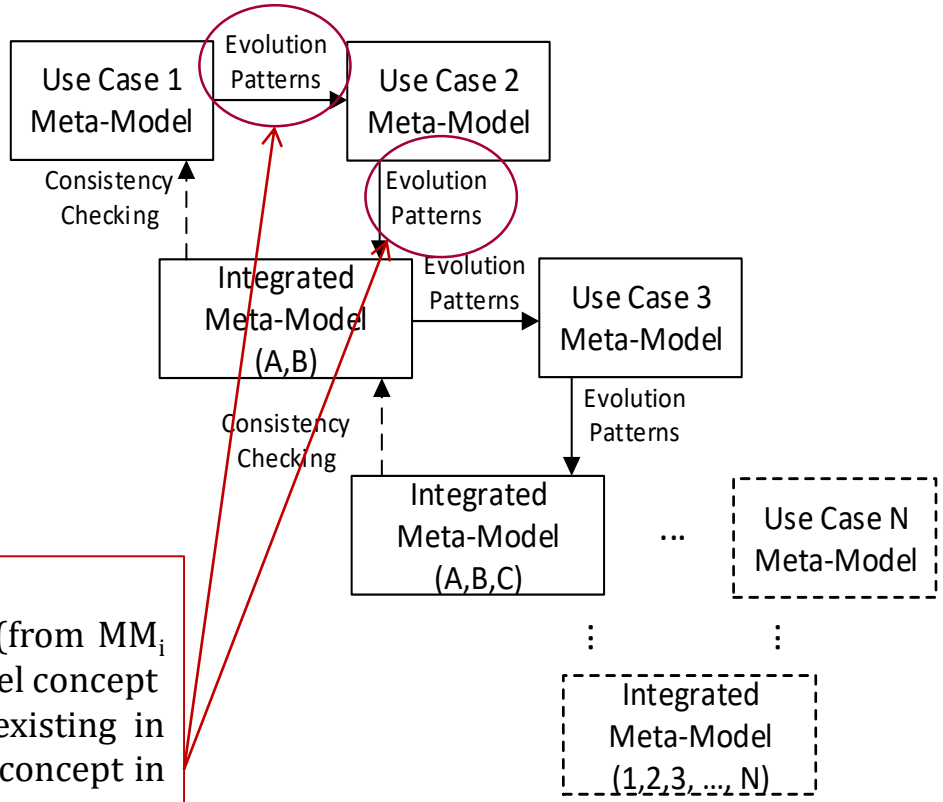
1)Build use case 1 meta-model

2)For i from 1 to n-1

1)Apply the evolution patterns to use case i meta-model to extend it to use case i+1

2)Apply the evolution patterns to build an integrated meta-model (i,i+1)

3)Check consistency of the integrated meta-model (i,i+1) with use case i



Key mechanisms for conceptual integration

- Concept generalisation: 2 distinct concepts (from MM_i and MM_{i+1}) can be generalized in a higher level concept
- Concept specialisation: A concept already existing in MM_i can be specialized in to a more refined concept in MM_{i+1}.
- Concept refinement: Keep the same concept in MM_i and MM_{i+1} but with a transformation of the properties of the concept, to better fit MM_{i+1} requirements.

Added Value of ADOXX meta-modelling platform : To check conceptual consistency via concrete applications

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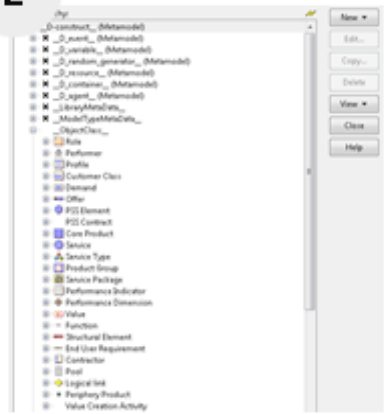
Result of the conceptual integration
Final Meta-Model

Industrial case study application

1

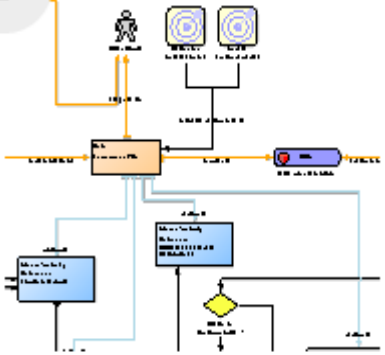
Modèle conceptuel

2



Implémentation
(development toolkit)

3



Instanciation
(modelling toolkit)

PSS Modelling Language
(ADOxx meta-modelling platform)

Outputs of the iterative meta-modelling procedure

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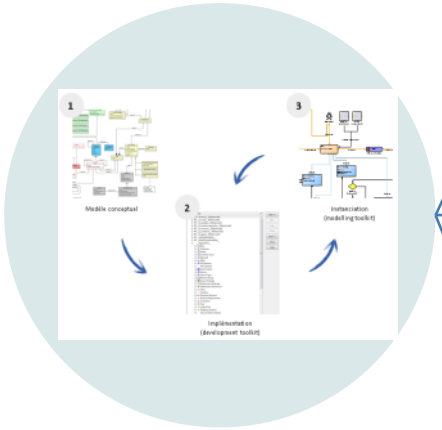
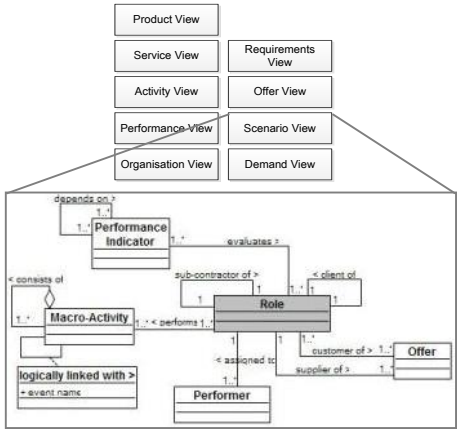
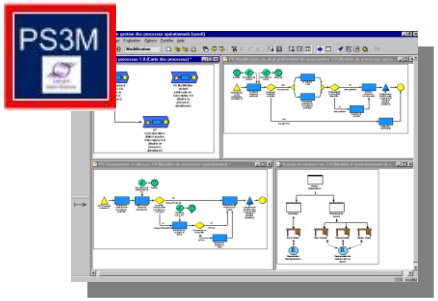


Meta-Modelling procedure

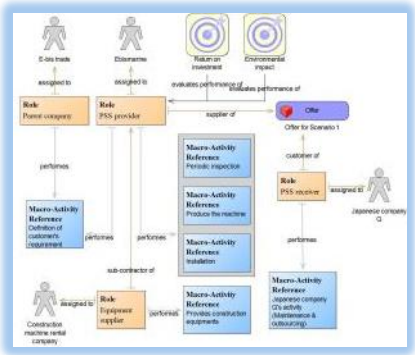
Conceptual meta-model



PSS dedicated Modelling Environment



Several Applied case studies



Open for further enrichment : case studies, new methods

Overall structure of the metamodel

Conceptual model built with 9 inter-related views

PSS STRUCTURE

- Structural dimension of the PSS required to formalise the PSS offer architecture and its value creation network.

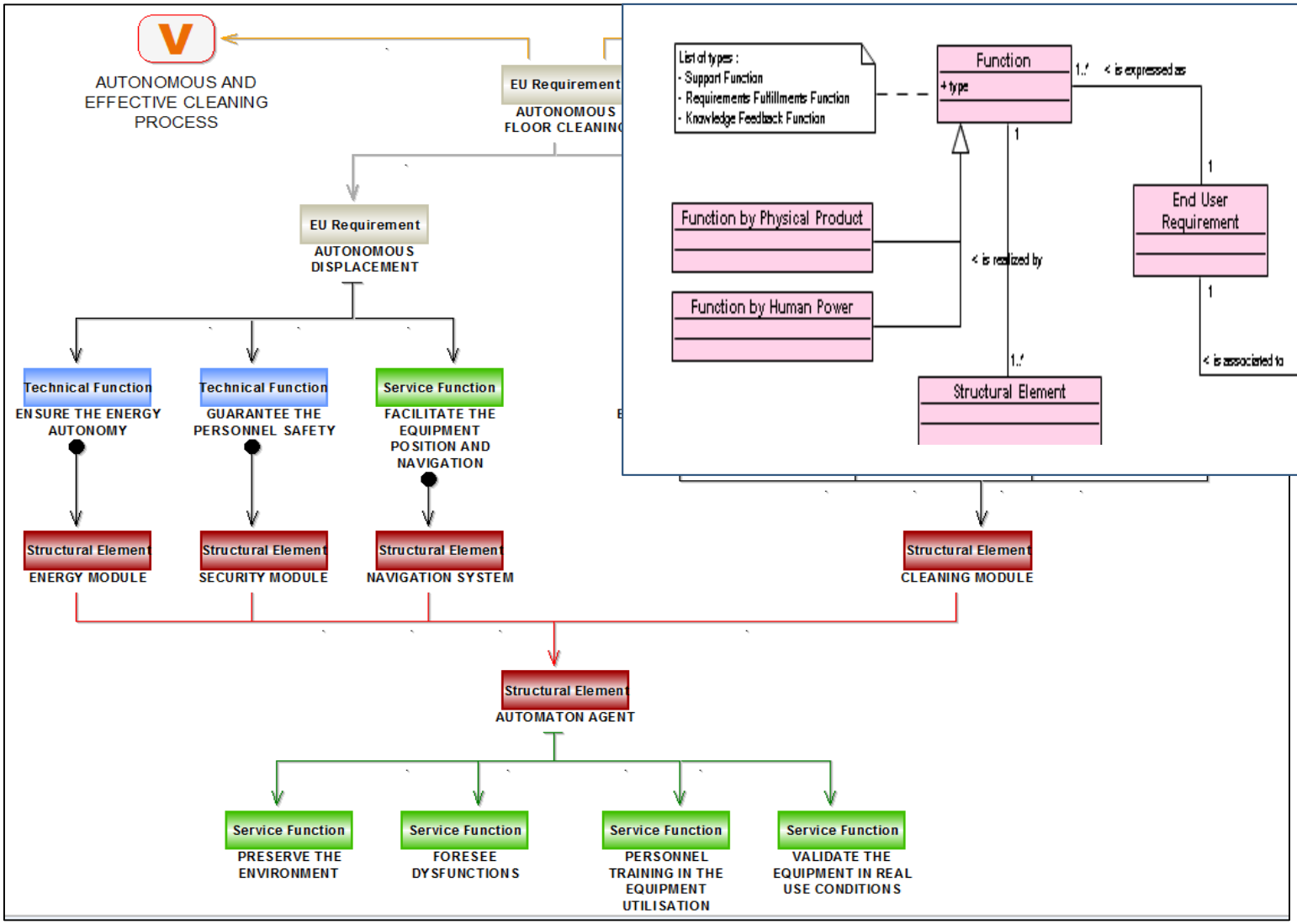
PSS DYNAMICS

- Behavioural dimension of the PSS. Market behaviours linked to the offer and performances factors associated to organisational capabilities.

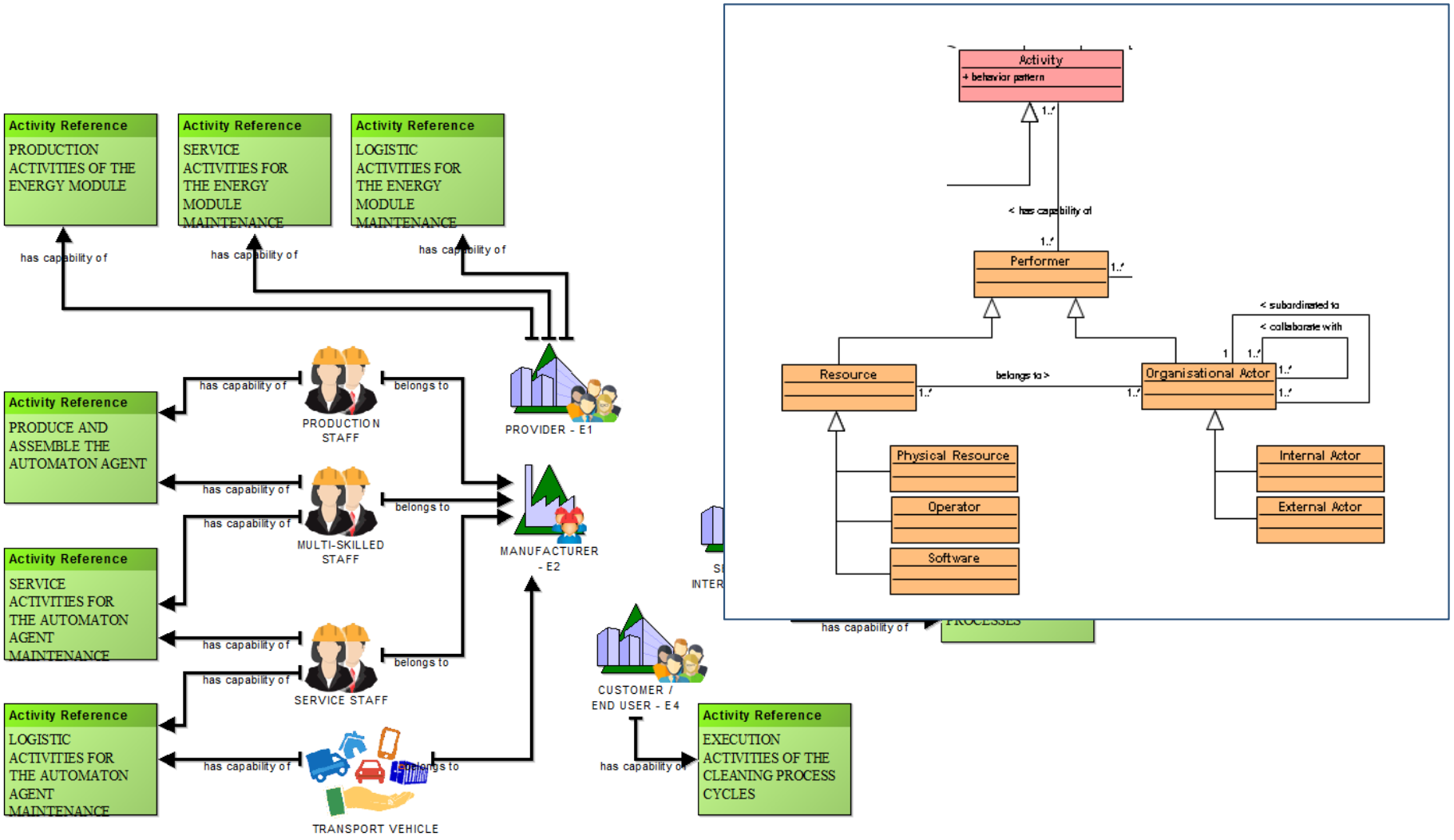
Views

- Requirement
- Product
- Service
- Activity
- Organization
- Demand
- Offer
- Performance
- Scenario

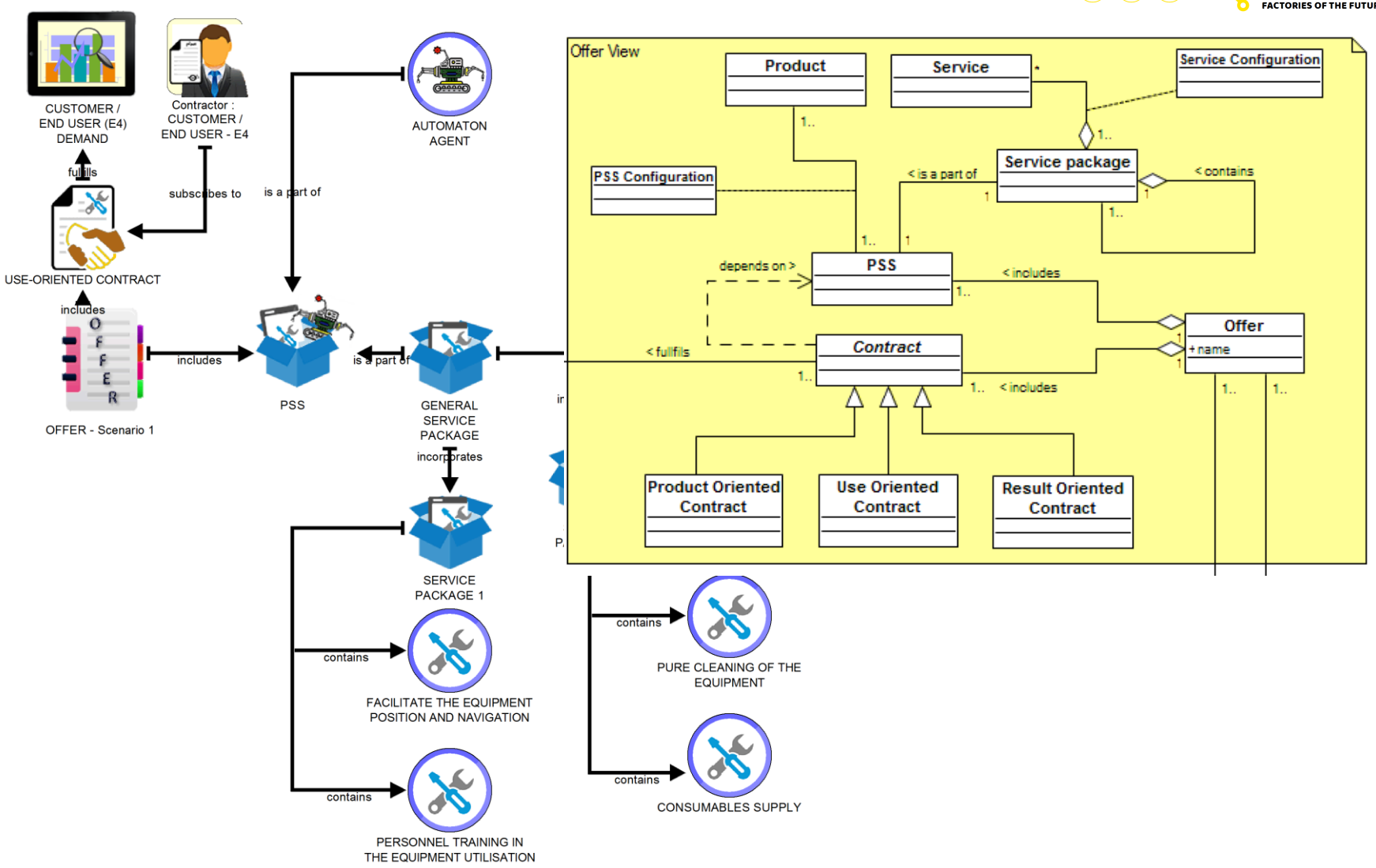
Example: STRUCTURE- « Requirement view »



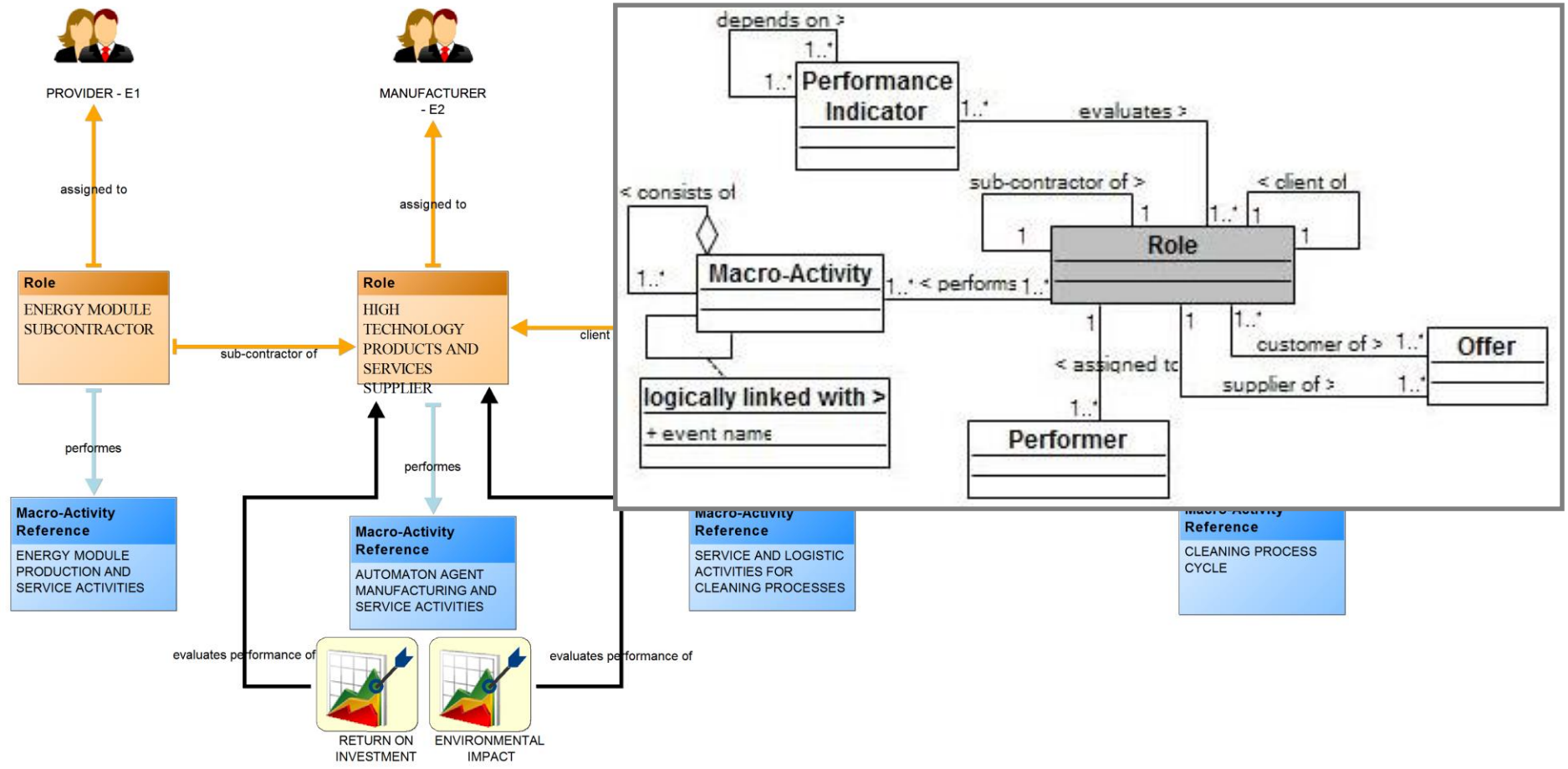
Example: STRUCTURE- « organisation view »



Example: DYNAMICS- « offer view »

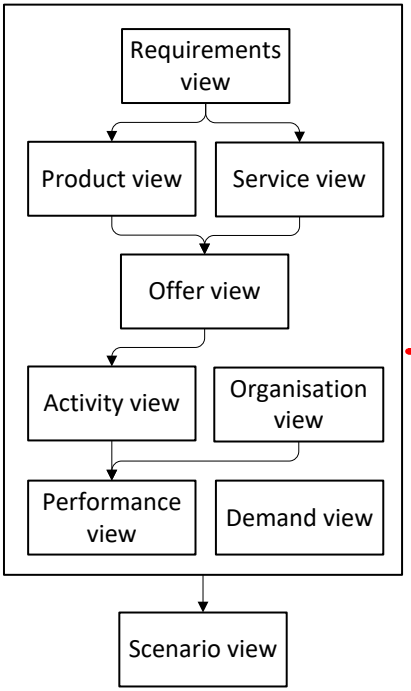


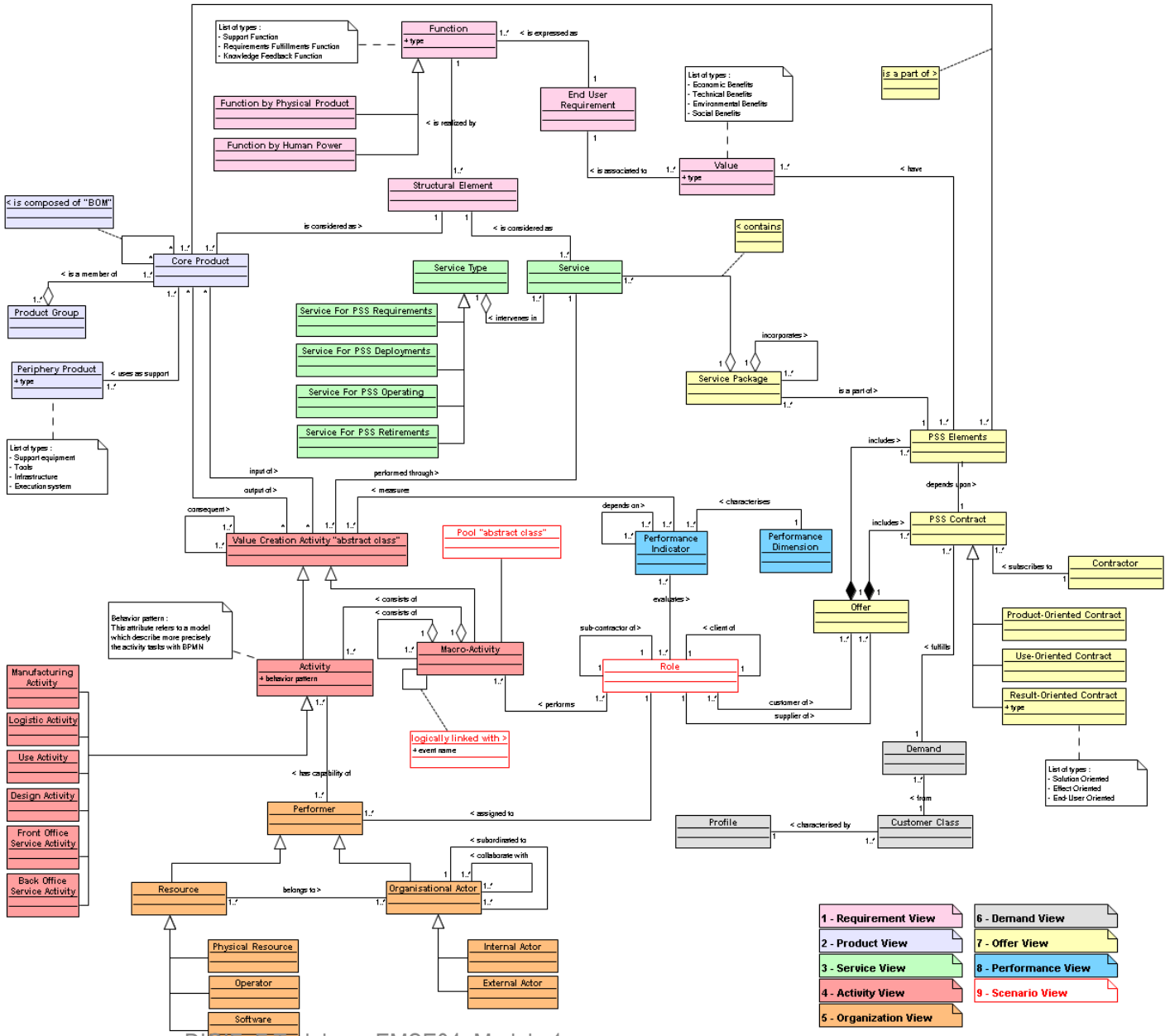
Example: DYNAMICS- « Scenario view »



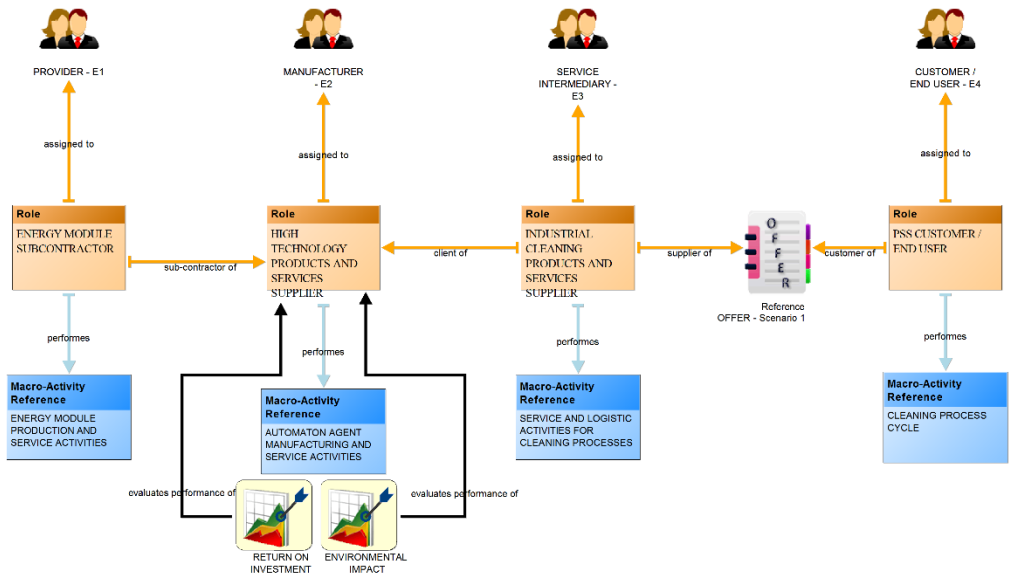
PSS Meta-Model

9 integrated views





PS3A
Decision-making solution for PSS value chain scenario assessment



Let's imagine:

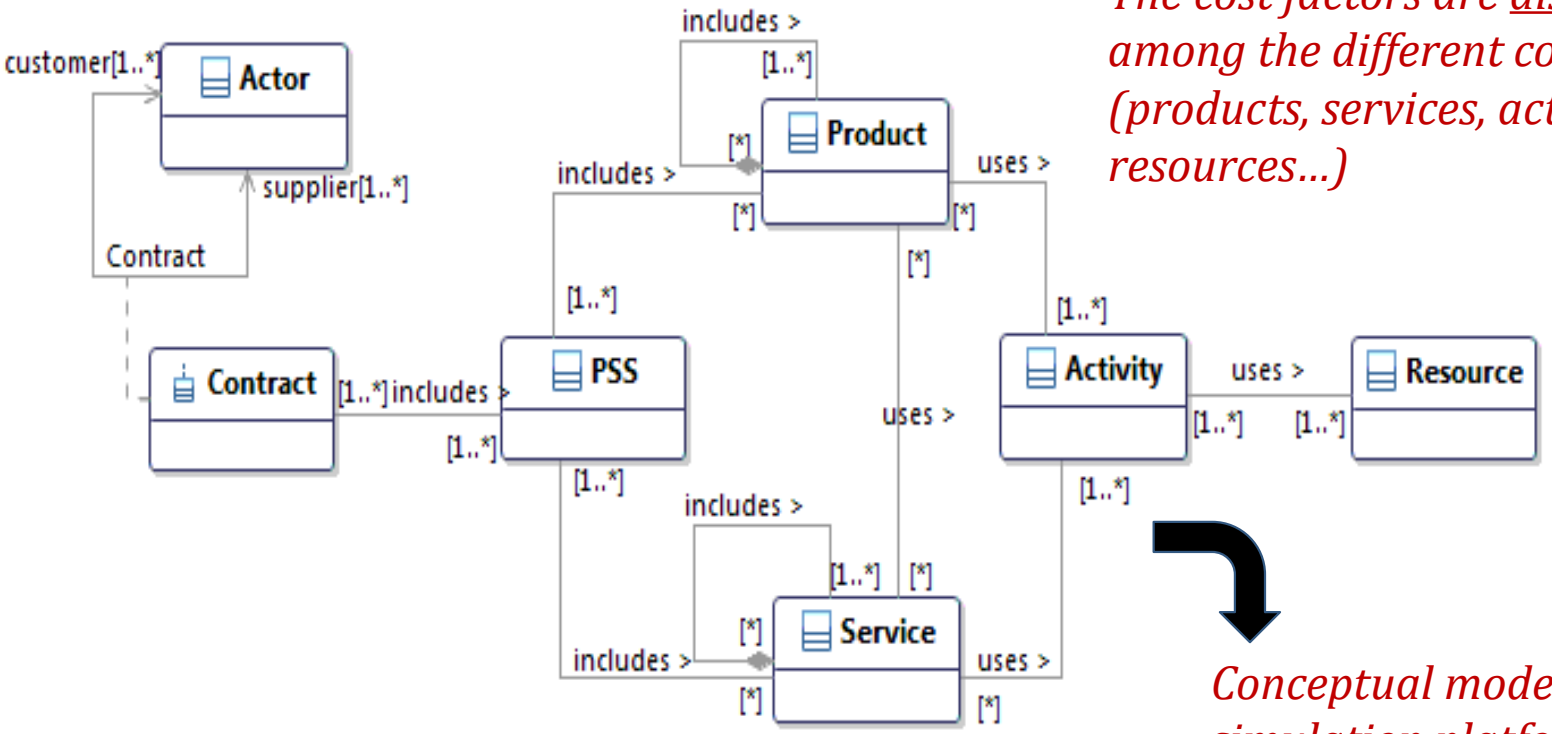
We have several alternative value network scenarios, each with a distinct economic model…

…and we want to compare them.

Principles of Cost Calculation :

- Activity- based costing (Manufacturing and service activities are the basis)
- Dynamic simulation of the costs, triggered by the PSS stochastic demand

Structure of the cost analysis



The cost factors are distributed among the different concepts (products, services, actors, activities, resources…)

Conceptual model of a dynamic simulation platform

Added-value of Cost SIMULATION:

- Representation of the market dynamics and their uncertainty
- Capacity to simulate a set of scenarios
  - Each scenario = a distinct value network
  - Each scenario = a distinct cost structure, a distinct economic model, distinct economic balances among actors
- Multi-actor analysis : key issue in supporting risk management and trade-offs among actors of the value-chain

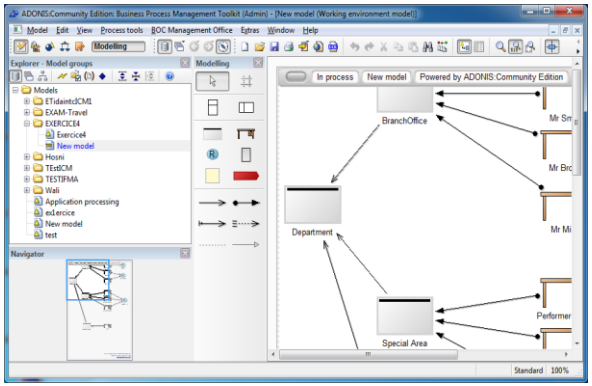
Algorithmic simulation : 4 complementary algorithms

- Algorithm 1 – Contract management
- Algorithm 2 – Contract service execution
- Algorithm 3 – Contract material requirements calculation
- Algorithm 4 – Components replacement

Generation of Cost & Revenues for the various actors, … with specificities of each case study and each scenario

Key difficulty !
Case study specificities and strong effort of simulation platform development

Rapid development of customized PSS simulator



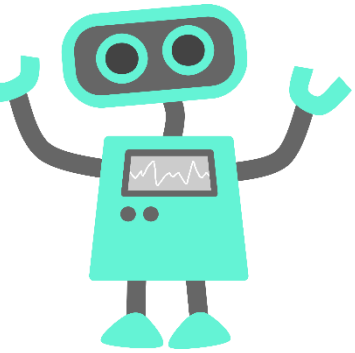
PSS Scenario Modeller

Rapid customisation :

- Transfer of industrial quantitative data
- Semi-automatic configuration of PSS scenarios

PS3A - PSS Scenario Analyzer

- Generic meta-model shared between PS3M and PS3A : same concepts and semantics to model PSS Case Studies
- PS3A separation between :
  - ✓ Generic objects vs instances
  - ✓ Declarative case study knowledge & generic cost calculation algorithms
- Data transfered from PS3M:
  - ✓ PSS structure : Product models (cost …), Service catalogue (cost…), Organizational actors, Offer definition
  - ✓ PSS dynamics : Quantitative demand, Roles and scenarios
- Case Study customisation
  - ✓ Specific structural objects
  - ✓ Specific performance indicators
  - ✓ Adaptation of algorithms
  - ✓ Specific user interfaces

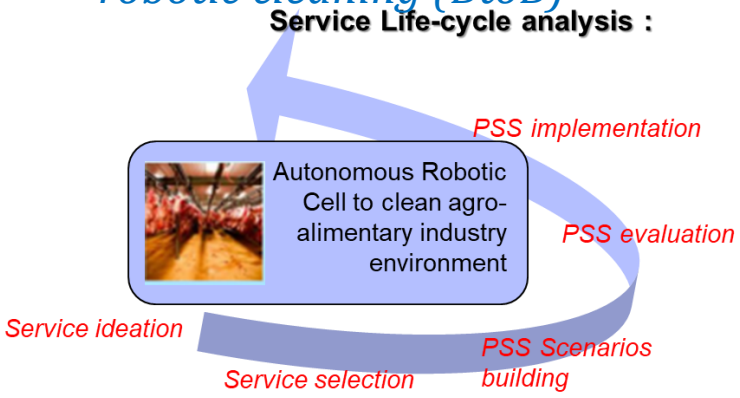


Industrial consortium 1

CLEAN Robot (Automaton)

PSS Solution for industrial robotic cleaning (BtoB)

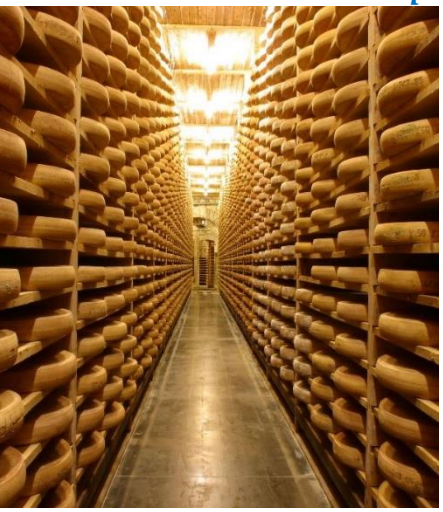
Service Life-cycle analysis :



Industrial consortium 2

AFFINID

PSS Solution cheese production control



RFID

+

Robotic solution

Development of PS3M modelling method and tool

+

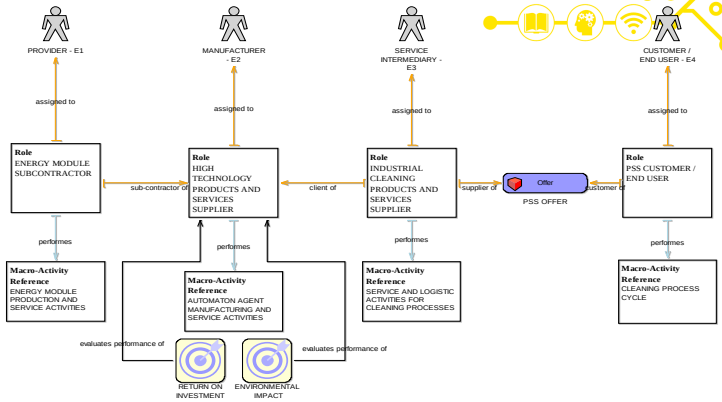
Development of a generic re-usable simulation platform

+

Specification of the customisation procedure and agile simulator development

Example 'Automaton'

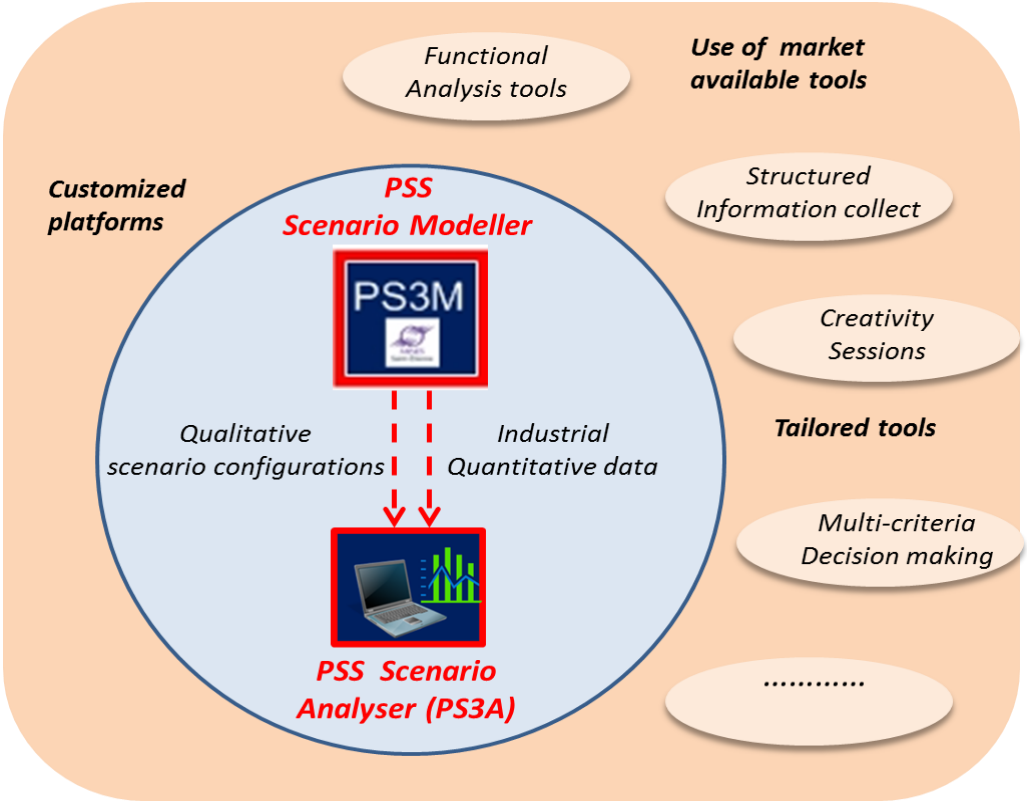
5 value network scenarios depending on (i) Robot owner, (ii) Cleaning activity execution, (iii) PSS type



Example of Key outputs

- Several value-chains studied: **key advantage for the partners to create a dedicated structure** (new company) for the commercialisation of the offer;
- Several PSS offers studied : **key advantage of a commercial offer based on renting contracts** with added-value services (with regards to traditional selling contracts)
- In this case study **the key influencing economic factors** are rather simple:
  - Contract duration and demand level ;
  - Product design : life span, cleaning capacities and speed, cleaning adaptability;
  - Customer behaviours : customer loyalty, customer resistance to PSS
- The quantitative **conclusions should be adapted to market resistances** : offers of distinct types could remain on the market, notably for specific client sectors – Commercial regulations to catalyze PSS deployment should be implemented.

Conclusion….towards a PSS integrated design platform



- Integration of PS3M tool within a larger PSS-oriented design platform
- Concrete industrial application under development: active field of industrial 'transfer'

- Any question ?

- Please consider more free material available:
  - Modelling Tool for any experimentation ;
  - Educational material to support users ;
  - Available on : www.digifof.org

Thank you for your attention !