MINES
Saint-Étienne

The manufacturing transition towards Product-Service-Systems: needs and advances in enterprise modelling and engineering

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INSPIRING INNOVATION INNOVANTE PAR TRADITION

Key objective of the communication :

To highlight, then illustrate concretely, the link between Advance Enterprise Modelling approaches and the current transition towards Factory of the Future

AGENDA

- ✓ Key ambitions for FoF
- ✓ The place of Product-Service-Systems (PSS) in the transition
- ✓ Enterprise Modelling Method : a pertinent support to manage the transition ?
- ✓ Modelling and engineering needs for PSS: the lack of reference model
- ✓ Advances : Iterative Meta-modeliing approach to generate a generic re-usable model to support PSS design & engineering

Any future for our factories ?

- New consumption modes, customer relationship, user involvement to take in charge an increasing **individualism of costumer requirements**
- A full-integrated **life-cycle engineering and management vision**, covering the whole value creation chain of products and services from the idea to the end-of life
- Strong **real-time information exchanges and interconnectivity** among processes, objects, persons mediated by new big-data capabilities for real-time data treatment
- A **collective and adaptative intelligence** emerging from the dynamic interconnection among Systems, Objects but also Human-Beings, requiring new organisational abilities

Intelligence & Technology

Science & human-organisation

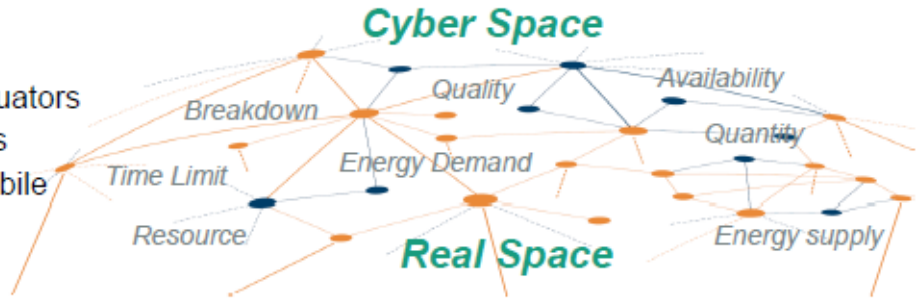
Connexion, Interoperability & Cooperation

Cyber-physical as a central issue for FoF

As a Cyber-Physical Production System, connecting the material and virtual world

Technologies:

- Sensors & Actuators
- Cloud Services
- Wireless & Mobile Com.
- Self X
- (Standards)



Functions:

- Communicating & Negotiating
- Interpreting & Deciding
- Configuration & Adjusting
- Analyzing & Optimizing

[Source : W. Sihn, Fraunhofer Austria Research GmbH]

Mines Telecom Institute develop his national strategy with the French Alliance for Factory of the Future, on 7 key enabling technologies for FoF

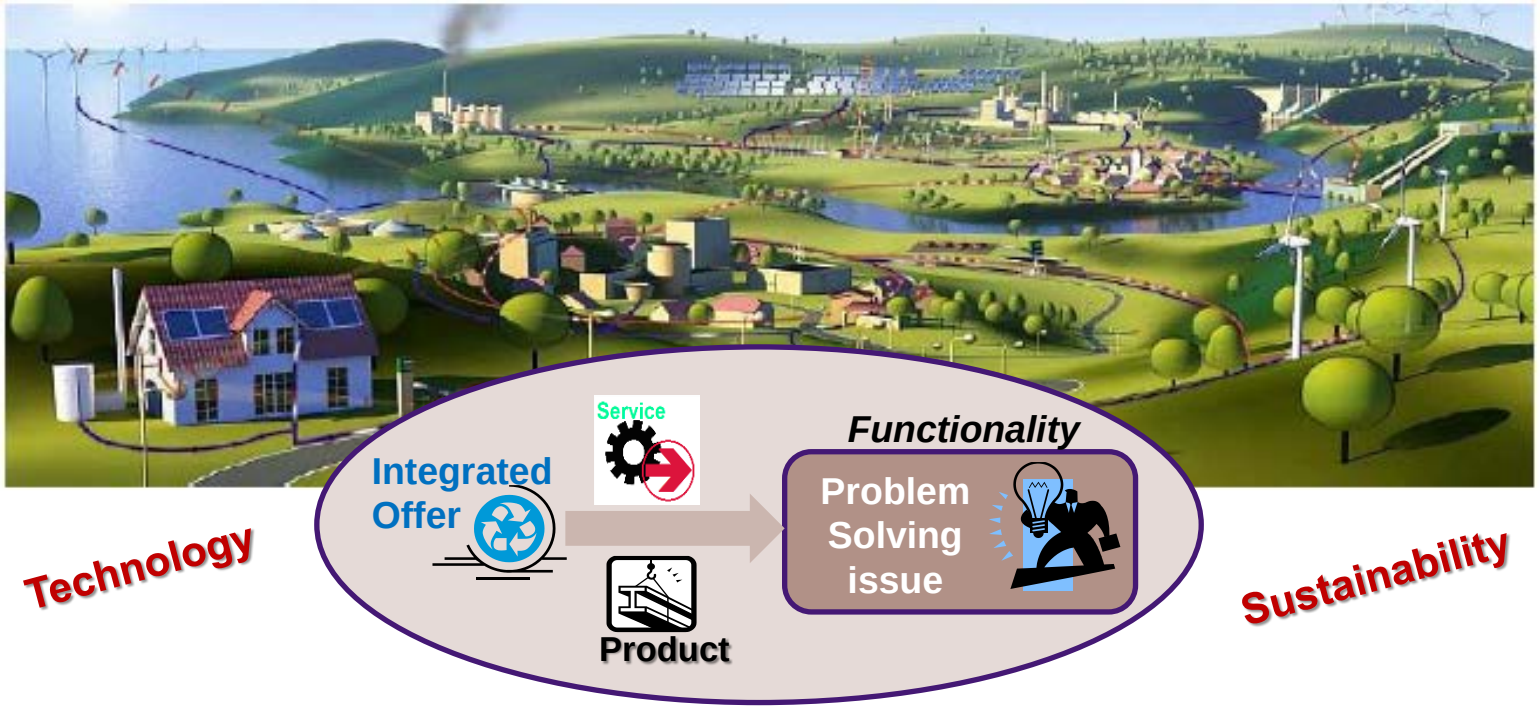
Technology

- ❑ Digitalisation of the value creation chain (Collaborations: 3DS)
- ❑ Automatisation and Cobotic (Collaborations: Gimélec & Symop)
- ❑ Additive Manufacturing (Collaborations: 3DS & CETIM)
- ❑ Advanced Control & Monitoring Technologies (Collaborations: CETIM & CEA)

Sustainability

- ❑ Human and organisational factors of the FoF (Collaborations: CEA & ENSAM)
- ❑ Energy-efficiency for production systems (Collaborations: FIVES)
- ❑ Advanced Composite Materials (Collaborations: CETIM & ENSAM)

Product-Service-System : a central role



PSS in a cyber-physical world ?

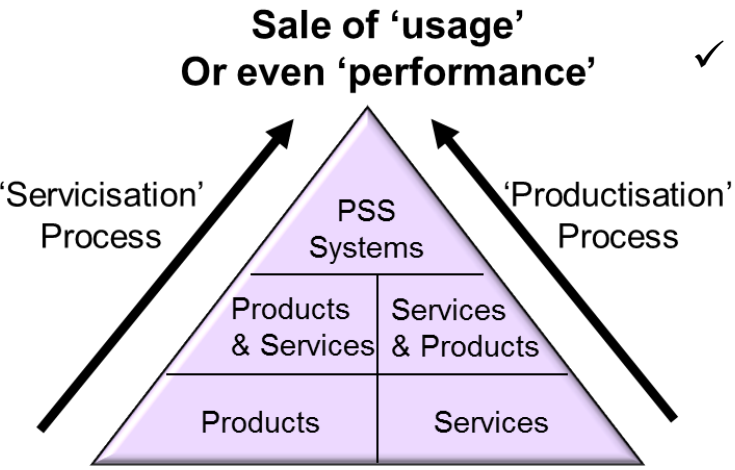
☞ *Product-Service-Systems embed the relationship between FoF and the citizen*

☞ *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*

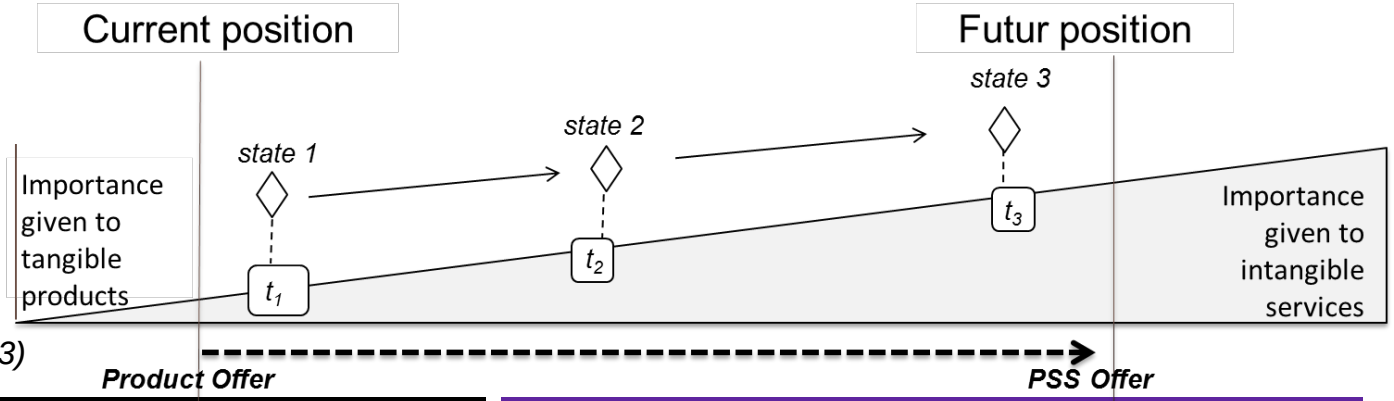
Servitization requires in-depth change of Business model for the industry …

(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*

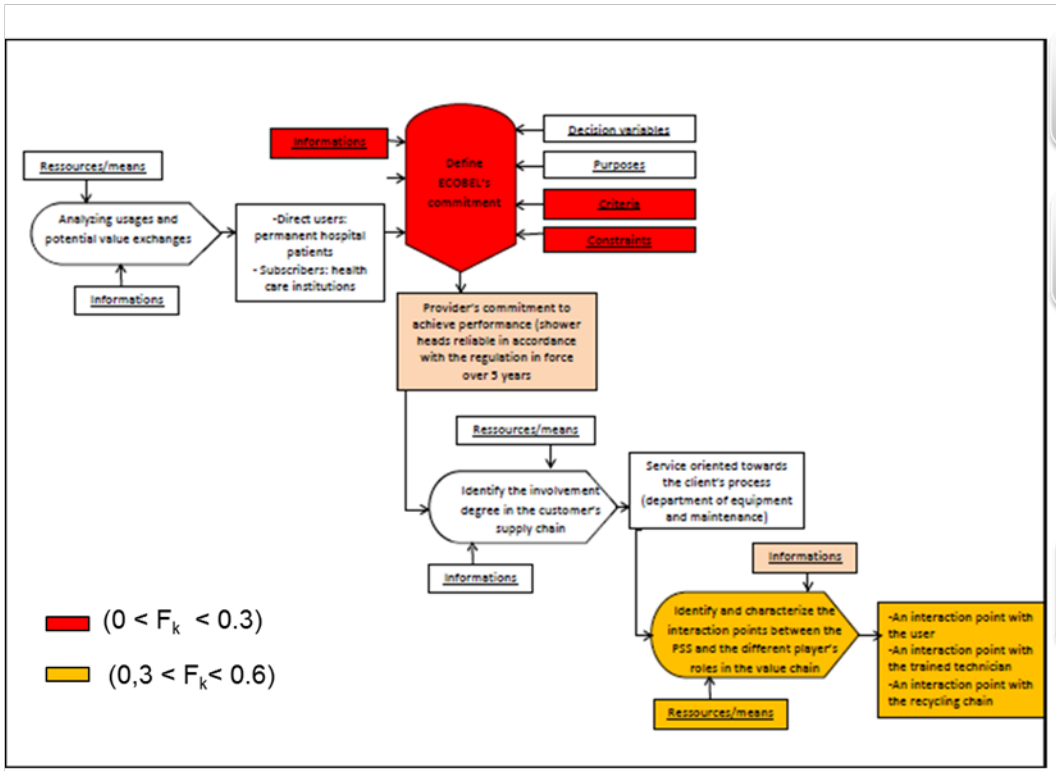


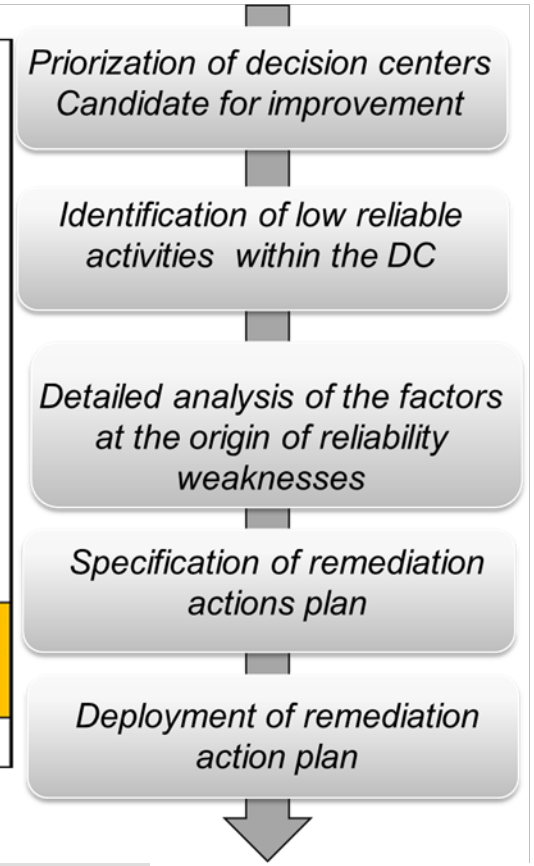
(Oliva & Kallenberg, 2003)

How to support the servitization path?

Key issues developped at Mines St Etienne

- ***Modelling of servitization decision-making system and processes***
- ***Evaluation of reliability and risks of failure***
- ***Management of the projects with remediation plans***





Transition towards PSS => large variety of Enterprise Modelling needs
+ 1 shared and general need:

Need of a generic Meta-Model for PSS modelling…

…used as shared basis for mutiple decision-making and design methods

A generic meta-model : Why ?

(Classification by : Qu et al., 2016)

Visualisation methods ***Modularity***

Modeling techniques ***Creativity - TRIZ***

Customer Perspective ***System dynamics***

Large number of PSS-oriented Design Methods

Which shared concepts and models ?

Lack of high level and general ontological point of view on PSS.

Needs of in-depth analysis of the relationships among all PSS modelling concepts

Lack of genericity and re-usability : integration of PSS modelling concepts in a reference framework ?

Requirements for a higher level of standardisation

Meta-modelling approach

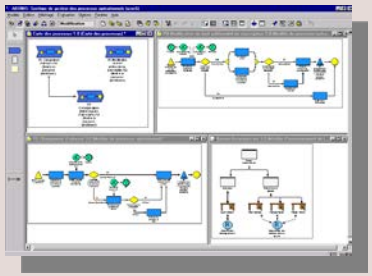
Models

Real Organisation

Specific

Model

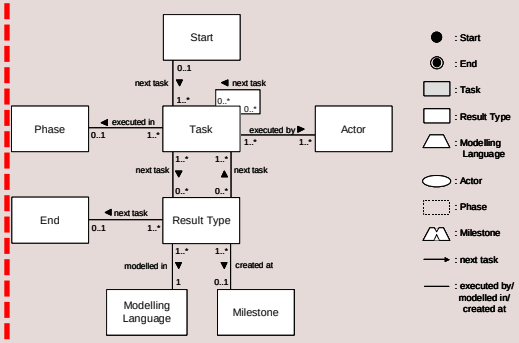
<u>used for:</u>
Decision-aid support



generic

Meta-Model

<u>used for:</u>
Creation of models



general

Meta^2-Model
(Formalism to create Meta-Model)

<u>used for:</u>
Creation of meta-models

Metaclass „Class“,
Metarelation „Relation type“

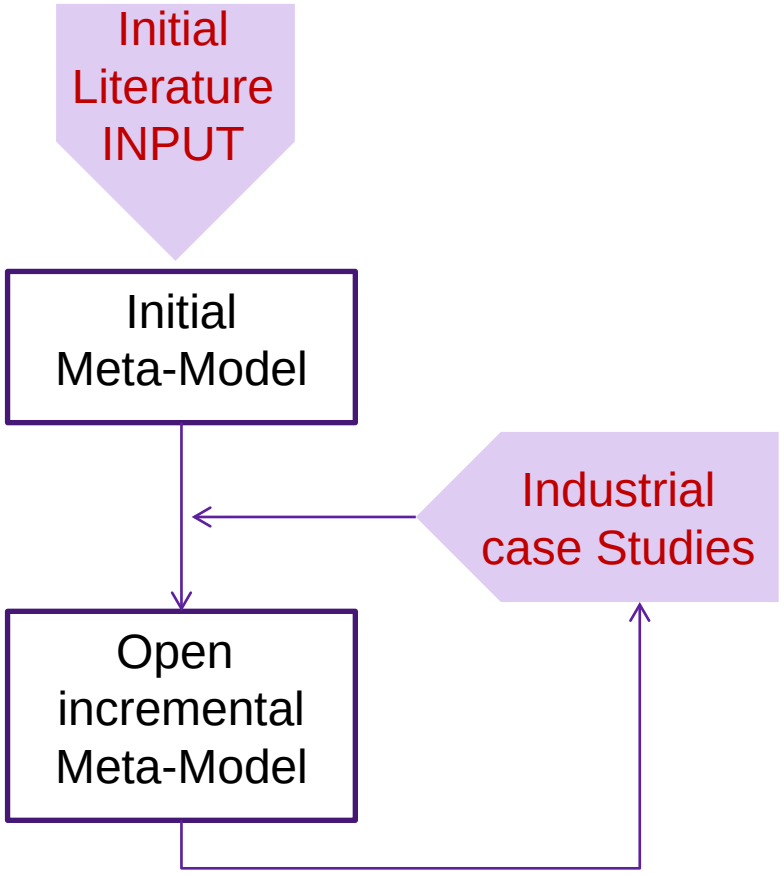
indirect model of

Class „Organisational Unit“,
Relation type „is subordinated“

Iterative meta-modelling approach

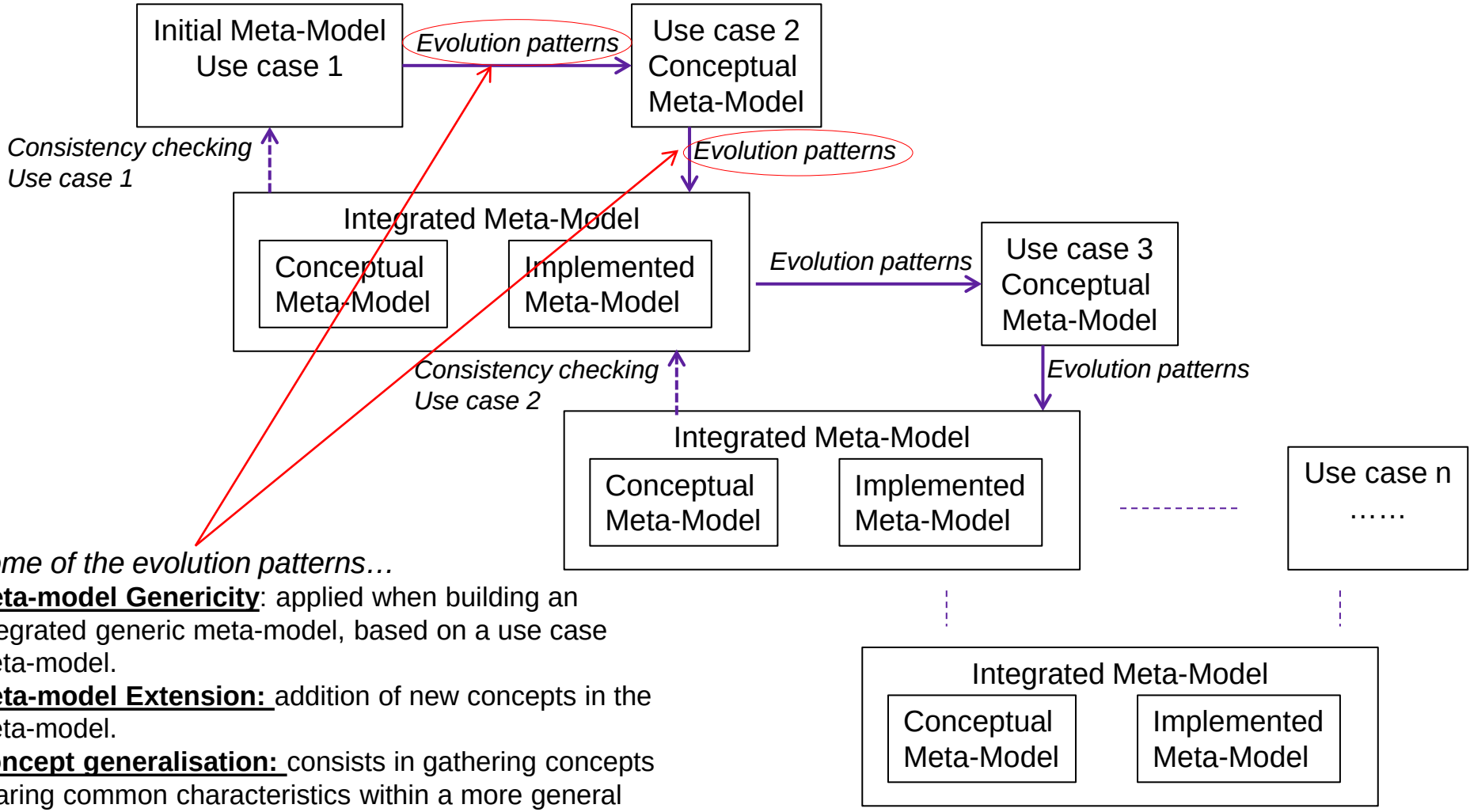
Added-value of the iterative approach:

- 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 An 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 An SME in the domain of electrics and automation.	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-modelling procedure



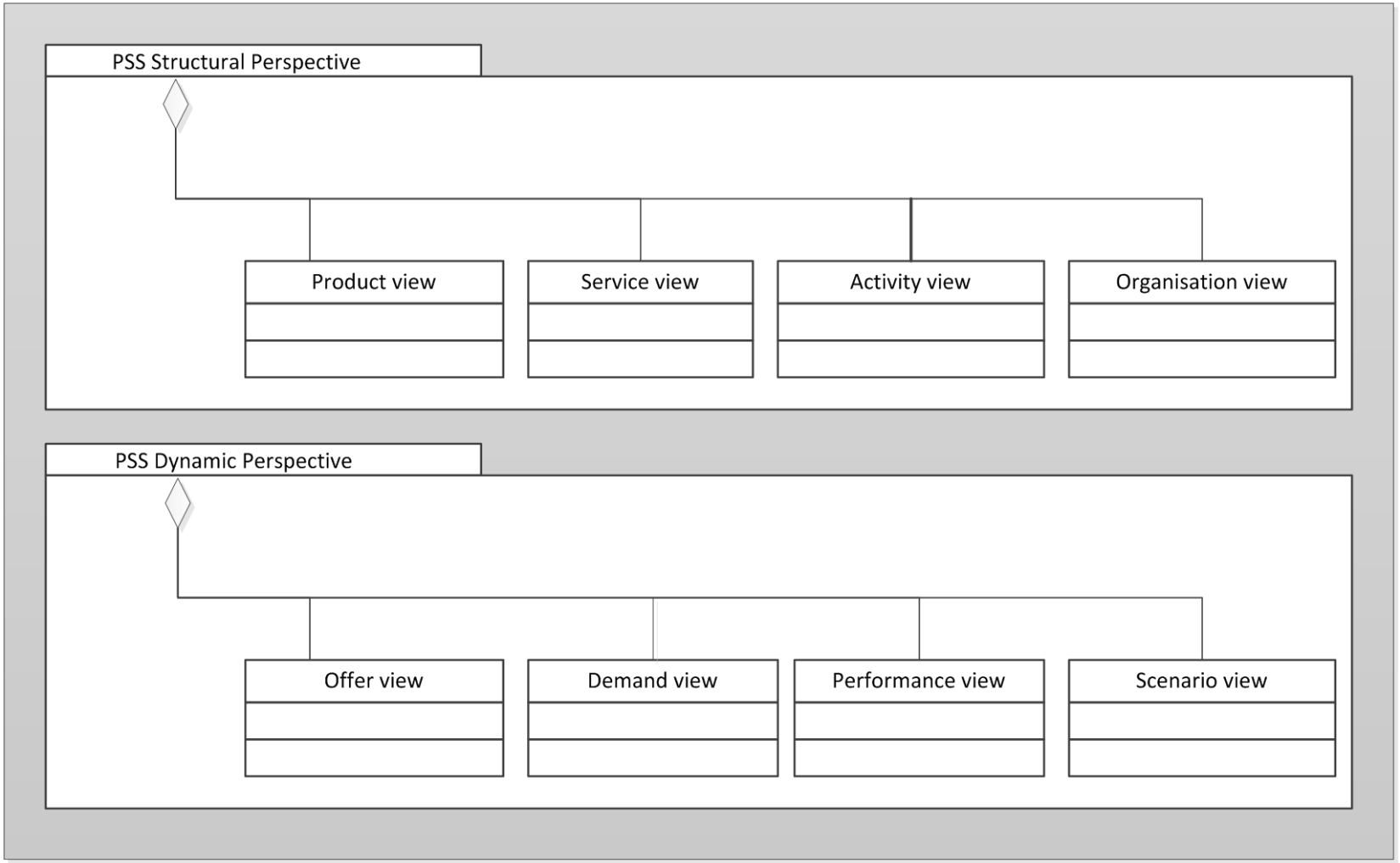
Some of the evolution patterns…

Meta-model Genericity: applied when building an integrated generic meta-model, based on a use case meta-model.

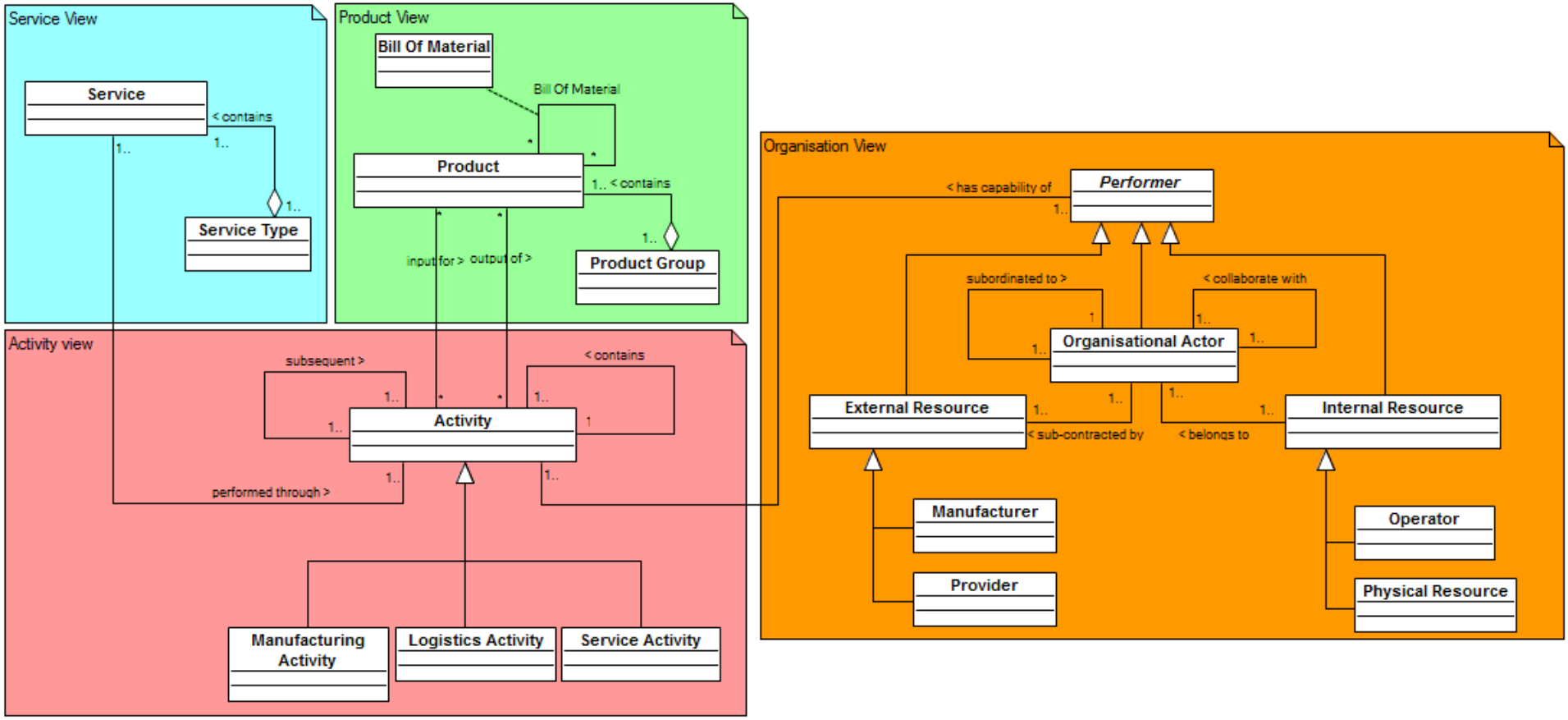
Meta-model Extension: addition of new concepts in the meta-model.

Concept generalisation: consists in gathering concepts sharing common characteristics within a more general concept.

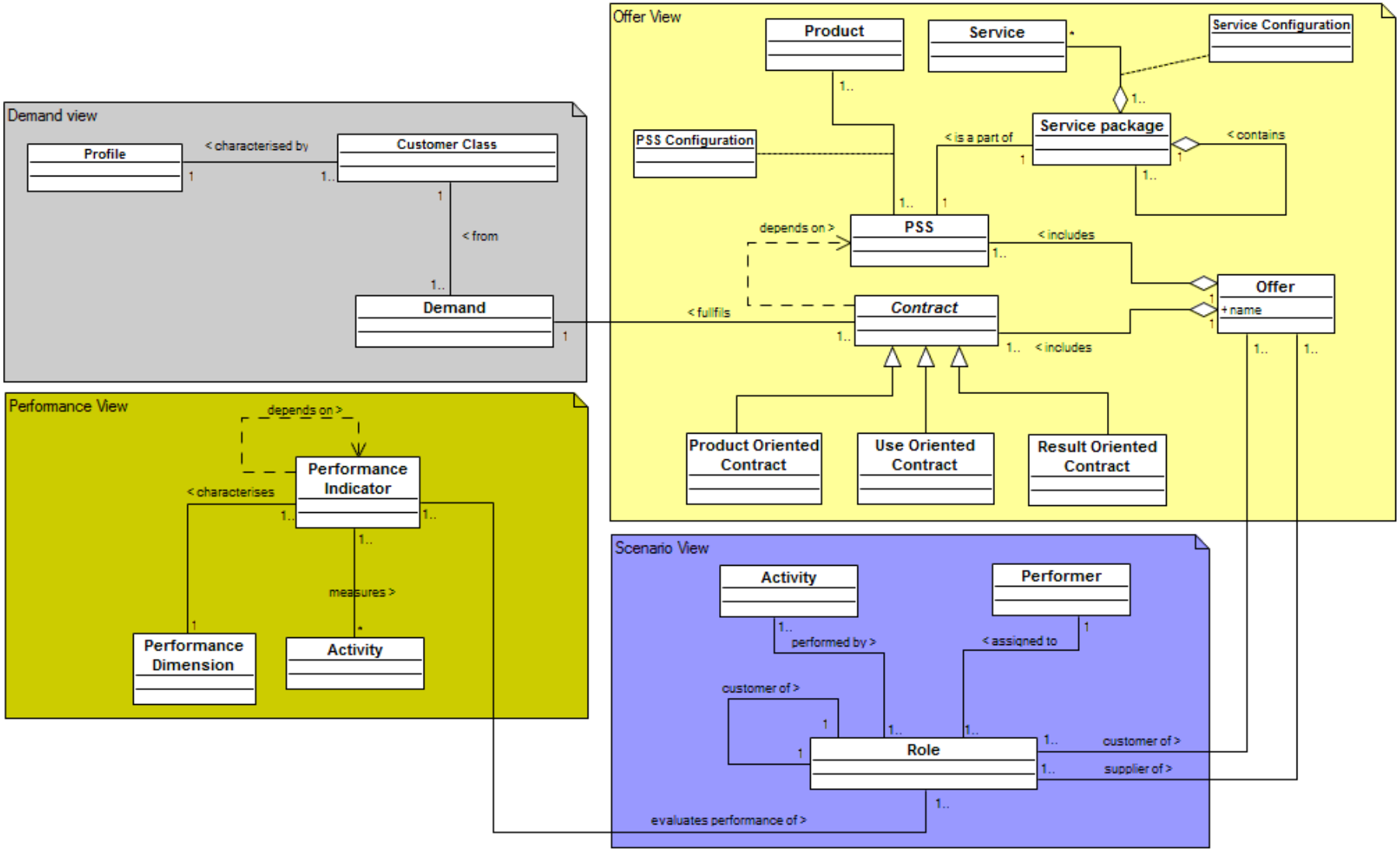
Overall structure of the resulting Meta-model



Structural perspective (4 views)

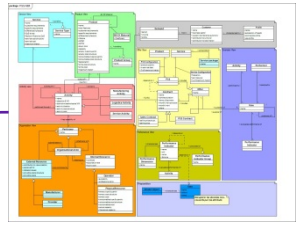


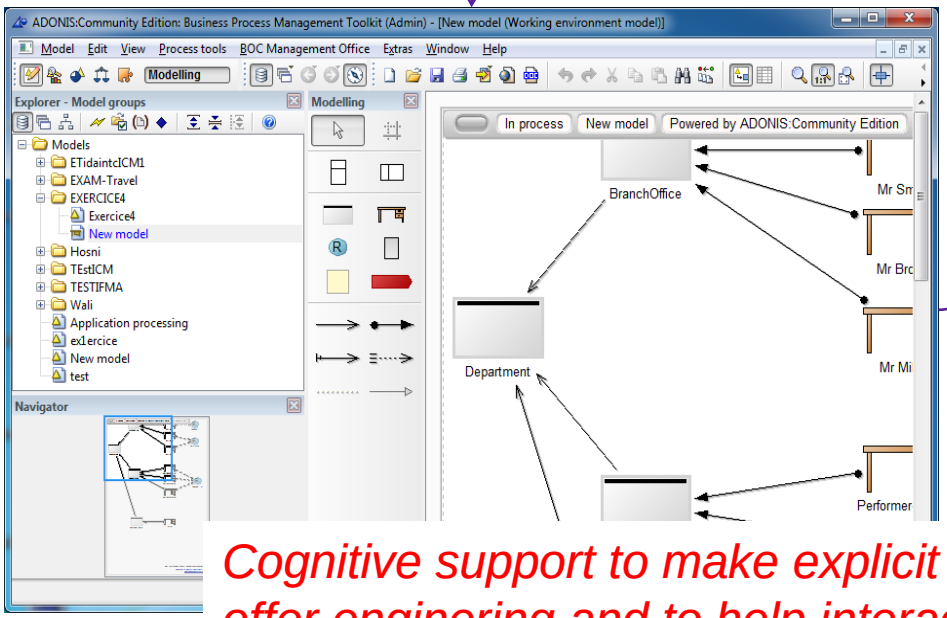
Dynamic perspective (4 views)



Utilization of the meta-model

PSS Scenario Modeller : an ADOxx Tool
Qualitative PSS Scenario Modelling is used to support offer engineering process





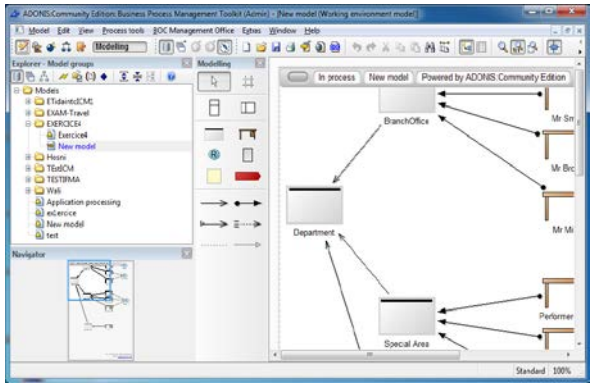
PSS Scenario Modeller added-value:

- Systematic reusable structure for all information required for offer engineering
- Structured process of industrial information collect
- Support to share and visualise PSS scenario information for all stakeholders

Cognitive support to make explicit all pieces of information required for offer enginering and to help interactions among all design actors.

Further utilization…expected

PSS Scenario Modeller

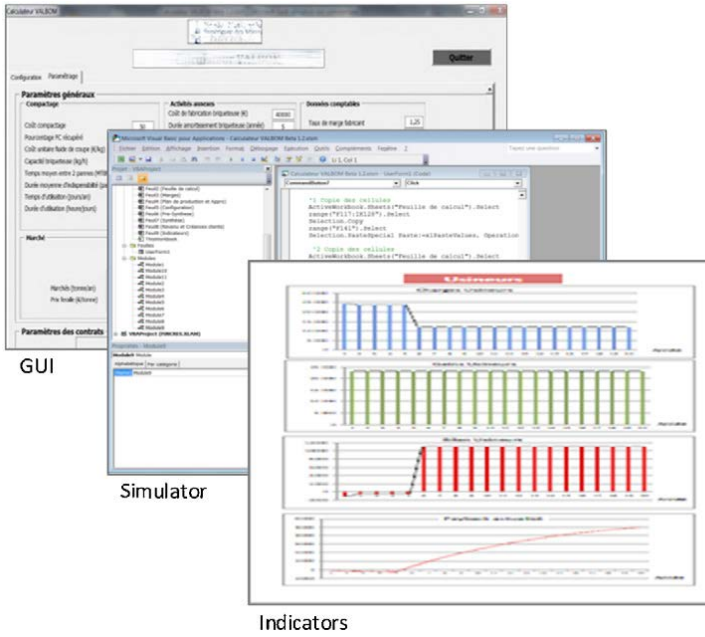


Strong needs of contextualisation thus customisation for the simulation environment

Rapid customisation based on:

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

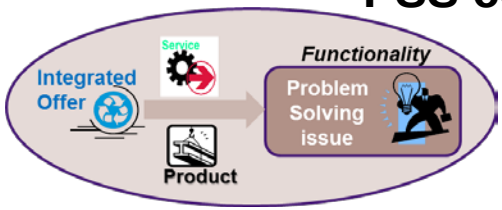
PSS Value-Network Analyser



A progressive journey towards industry transformation

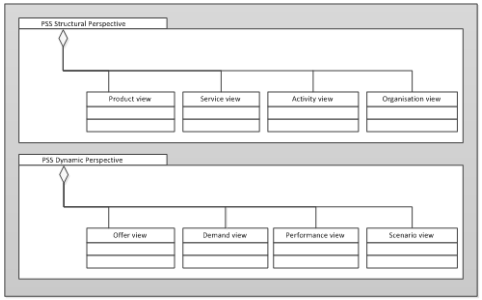
Enterprise Modelling and Engineering Methodologies

PSS concept



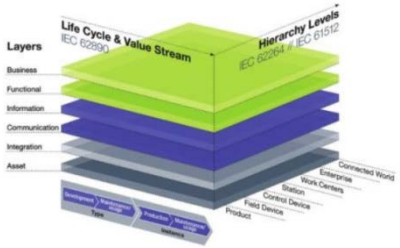
CPS principles and ontologies

PSS Design and engineering process



PLM and meta-models

Manage Business Model Transformations via servitization



Enterprise Architectures

Thank you for your attention !

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