Product-Service-System (PSS) Design:
(II). *Design Mehtods*

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12-2023 Shanghai

Agenda

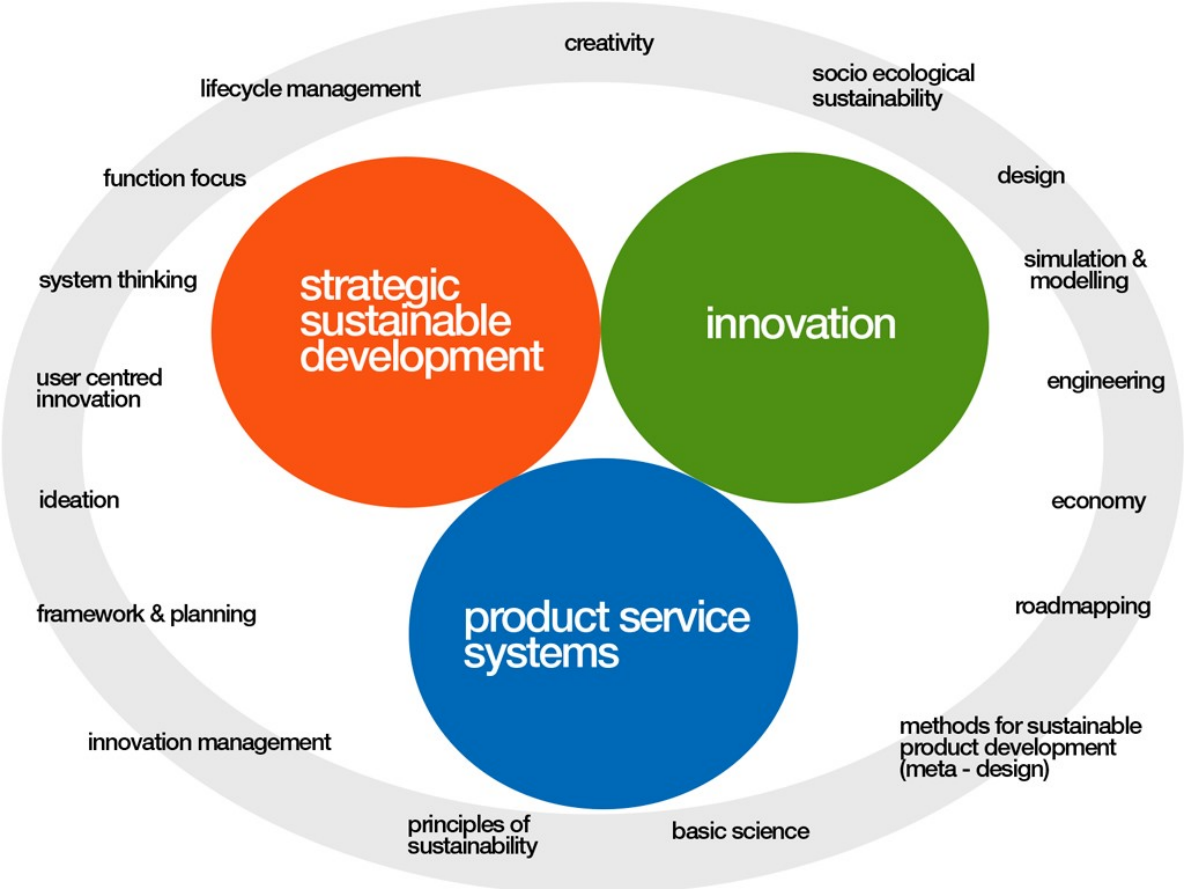
- PSS Features & Design Challenges
- Life-cycle Management and Modular Design Method
- Conclusion

Product-Service-System:
Features & design challenges

Product-Service-System (PSS)

- **What is a PSS?**

An Industrial Product-Service System is characterized by the *integrated and mutually determined planning, development, provision and use of product and service shares including its immanent software components in Business-to-Business applications and represents a knowledge-intensive socio-technical system*.



Product-Service-System (PSS)

- **PSS Features**

PSS is an integrated product and service offering that delivers values in industrial/civil applications.

PSS is a new product/service understanding consisting of integrated product and service shares.

PSS comprises the integrated and mutually determined planning, development, provision and use.

PSS includes the dynamic adoption of changing customer demands and provider abilities.

The partial substitution of product and service shares over the lifecycle is possible.

This integrated understanding leads to new, customer-adjusted solutions.

PSS enable innovative function-, availability- or result-oriented business models.

Product-Service-System (PSS) Concept in Different Perspectives

- **Traditional marketing perspective**

  PSS originates from the shift of marketing focus from products (whose characteristics are related to its material components) to a more complex combination of products and services supporting production and consumption.

  Feature: Integrated

- **Service marketing perspective**

  PSS represents the evolution of traditional generic and standardized services towards targeted and personalized ones.

  Feature: Customization

- **Product management perspective**

  PSS refers to the extension of the service component around the product for business activities that are traditionally product-oriented or the introduction of a new service component marketed as a product for business activities that are usually service-oriented.

  Feature: Business model

Implications for PSS Designer

The involvement of designers in the development of PSS implies an extension of the traditional disciplinary domain of design, towards new domains that provide designers with the necessary expertise to manage the particular characteristics of PSS. The design activity is projected on new dimensions; such a redefinition of the design activity has relevant methodological implications.

- **Techno-productive dimension**
  - ***What is the realm of the possible?***

- **Social and cultural dimension**
  - ***What are the explicit areas of demand and what the latent ones?***
  - ***What behavioral structures should one seek to influence?***
  - ***What values and qualitative criteria should we base our judgments on?***

Implications for PSS Designer

➢ Methodological Implications

- **What are the methodological tools available to designers for the purpose of analyzing PSS as social constructions?**

  Designers need tools to explore, understand, and address the needs of different actors. Moreover, they have to take into account the existence of possible friction between the socio-technical frames of different authors participating in the development of a service.

- **How can designers manage the different phases of design and planning activities?**

  Although a service only comes into existence during the use phase, the various events characterizing the use of the service must be planned in advance in order to anticipate and organize the interaction between clients, providers, and the technological infrastructure. The designer needs to organize the flow of events in a product/service system, and to ensure that any variables are catered for as far as possible

- **How can designers represent material and immaterial components of PSS?**

  While products are easily represented through technical drawings, there are not many metaphors and graphical tools available to represent the immaterial component in services and the relationship between material and immaterial elements of a product/service system

Implications for PSS Designer

➢ Analysis of PSS as a Social Construction

- **A product/service system is the result of the interaction between different actors and technological elements during the use phase. This means that the design activity should emphasize elements of convergence between several social and technological factors, including:**

(a) ***The social, technological, and cultural frames of the actors participating in the development of the system;***

(b) ***The technological knowledge embedded in the artifacts used for the service.***

Implications for PSS Designer

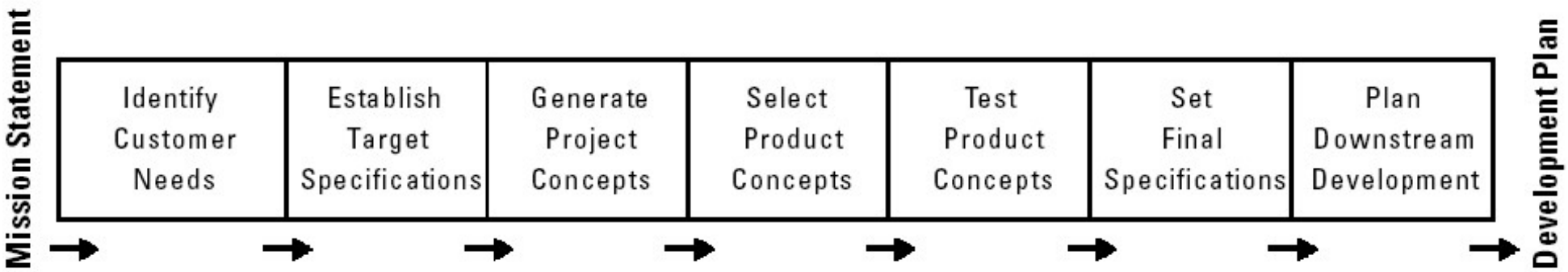
➢ Analysis of PSS as a Social Construction

Criteria	Explanation
Goals	The main needs each group wants to satisfy in relation to specific aspects of their work activities.
Key problems	The main problems to be solved or overcome for each group in order to achieve their goals.
Problem solving strategies	The strategies each group believes to be admissible and effective in solving the main problems.
Requirements to be met by problem-solving strategies	The criteria for admissibility and effectiveness of problem solving strategies.
Current theories	The theoretical knowledge supporting the activity of each group in setting goals, identifying and selecting problems, and proposing admissible problem solving strategies.
Tacit knowledge	The practice based-knowledge, upon which each group relies to set goals, identify and select problems, and propose admissible problem-solving strategies.
Testing procedures	The procedures each group uses to evaluate the effectiveness of each problem-solving strategy.
Design methods and criteria	The methods and parameters used for proposing technological solutions to emerging needs.
Users' practice	The users attitudes towards the existing solutions to the present needs.
Perceived substitution function	The products, services, or sets of functionalities each group believes is to be replaced when proposing or using innovative solutions.
Exemplary artifacts	The products and services that are used as models in developing new solutions. These often are derived from the perceived substitution function.

Implications for PSS Designer

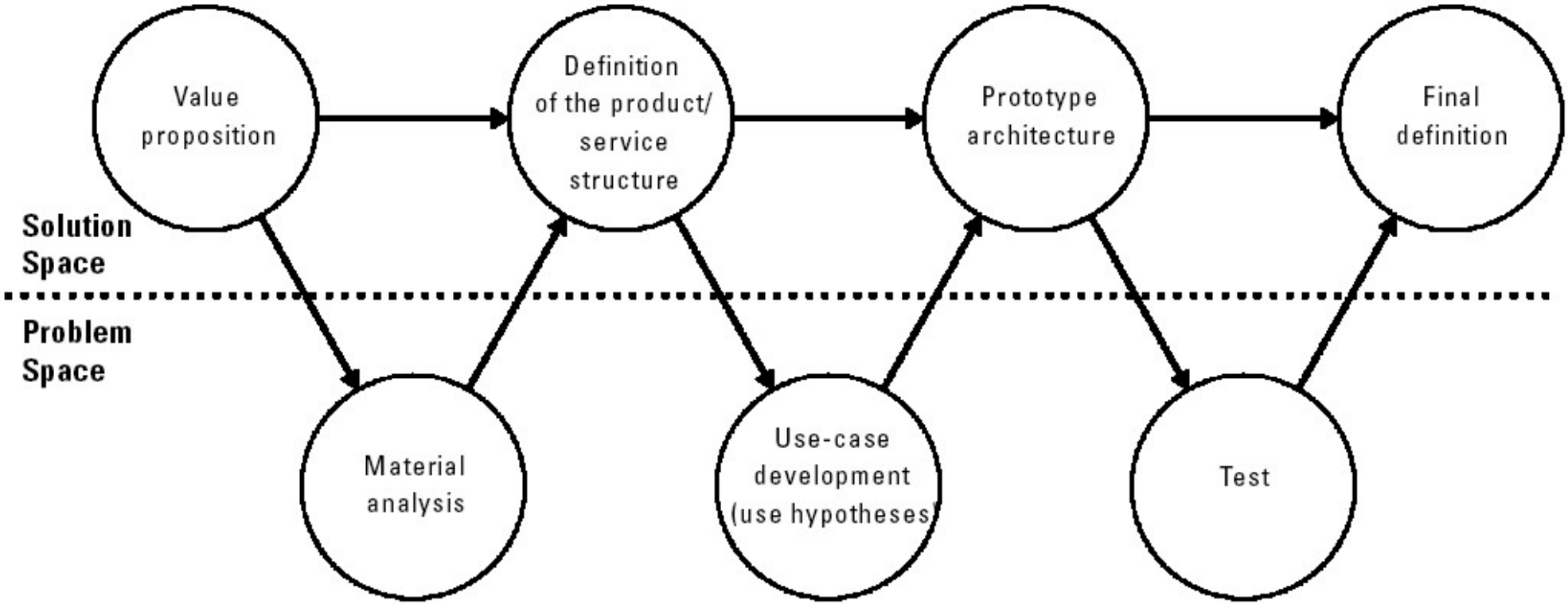
- **Management of the Design Process of a PSS**

- **The actualization of a PSS consists in managing the various concurrent elements including technological infrastructure, personnel, marketing, customer relations, and communication.**



Implications for PSS Designer

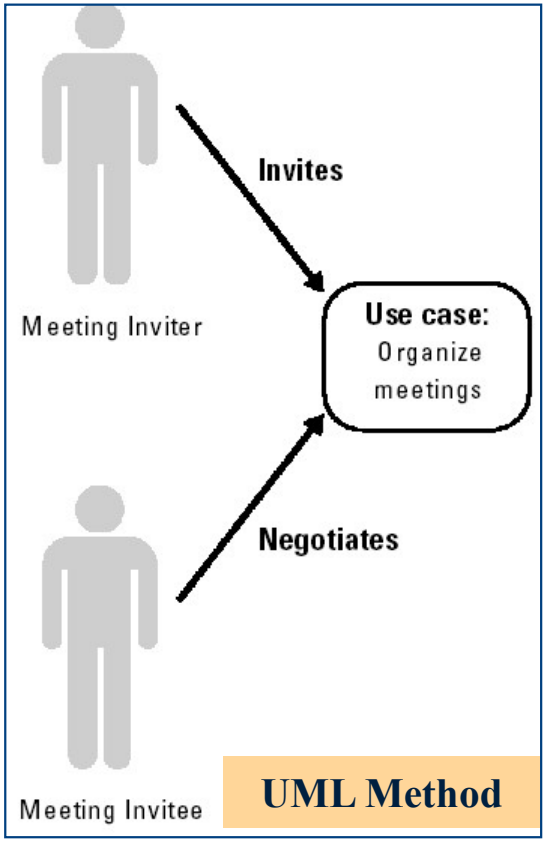
- **Management of the Design Process of a PSS**



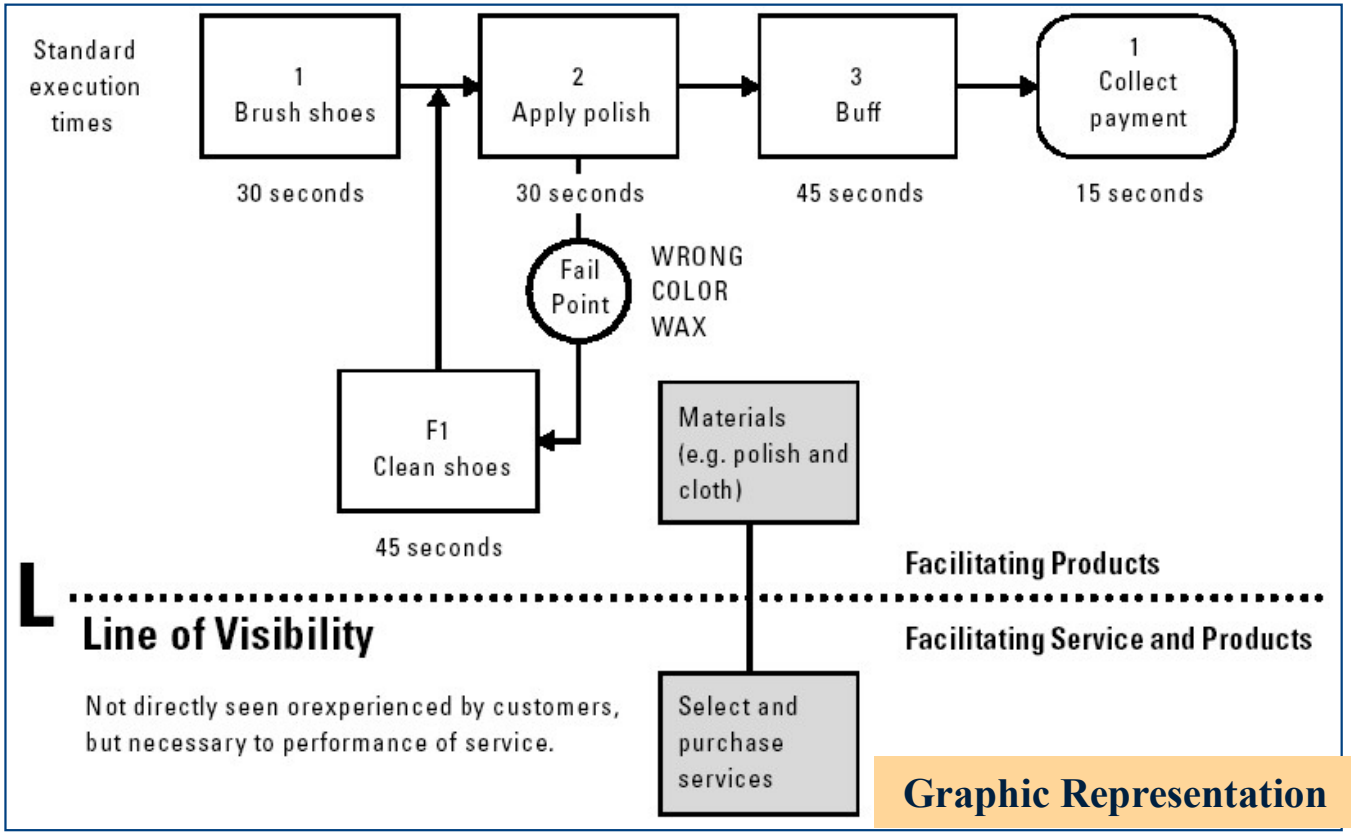
Implications for PSS Designer

➢ Technical Representation of Product-service Systems

- Specific representation techniques have been developed for product design which highlight specific aspects of the product. Product designers are able to produce a **blueprint** of a **product/prototype** that will be unequivocally interpreted by those who will manufacture and/or buy the product, or will provide some of its components.
- **In PSS, currently there is no matured representation method.**



UML Method



Graphic Representation

Product-Service-System:

A modular design method & Life cycle management

H2020 ICP4Life Project

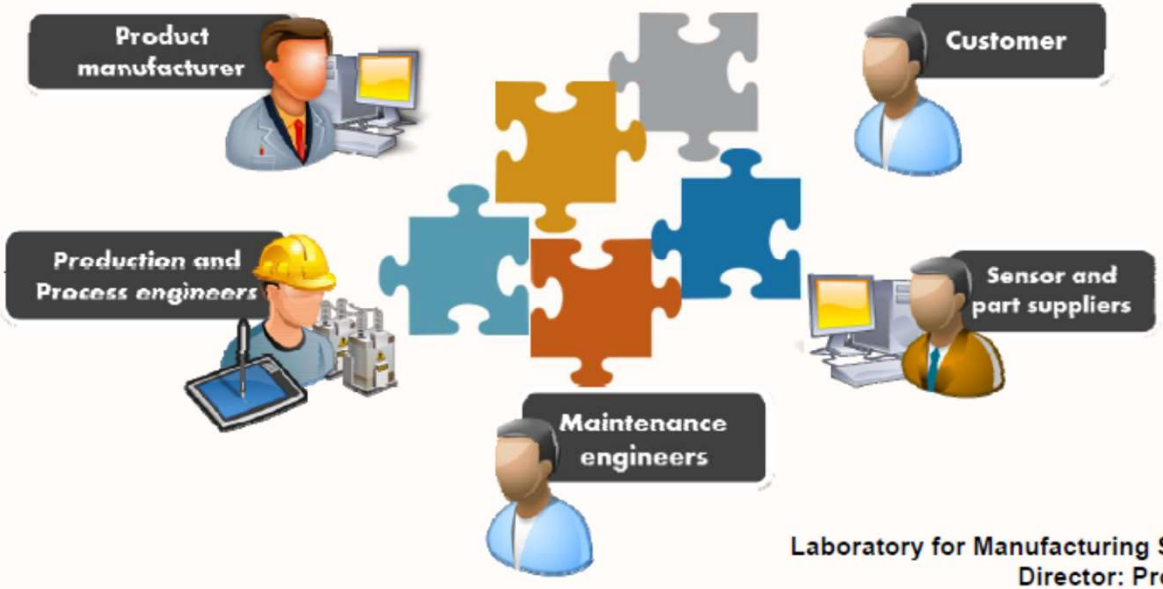
ICP4Life Project Overview

Problem Statement

ICP4Life

In today's product-services design and implementation systems:

- No support for dynamic **customer integration** into the **design-customization** phases of a product
- No support for collaboration between service **engineers**, product **designers** and the extended **supply network**
- Lack of an integrated method for holistic **acquisition** and **processing** of information emanating from product-services



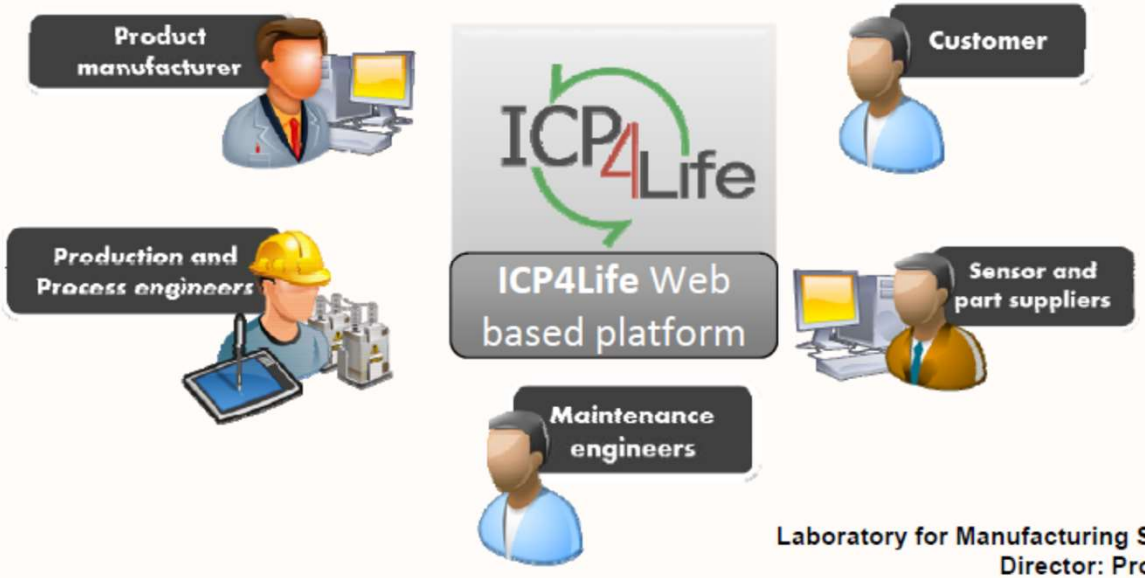
ICP4Life Project Overview

ICP4Life Approach

ICP4Life

An integrated collaborative platform for the design, development and support of product-service systems:

- Bringing together equipment manufacturers, energy suppliers and SMEs
- Providing easy and intuitive formation of Products and Services
- Covering the whole lifecycle of products measuring and analysing several information
- Controlling the energy consumption and environmental impact of products



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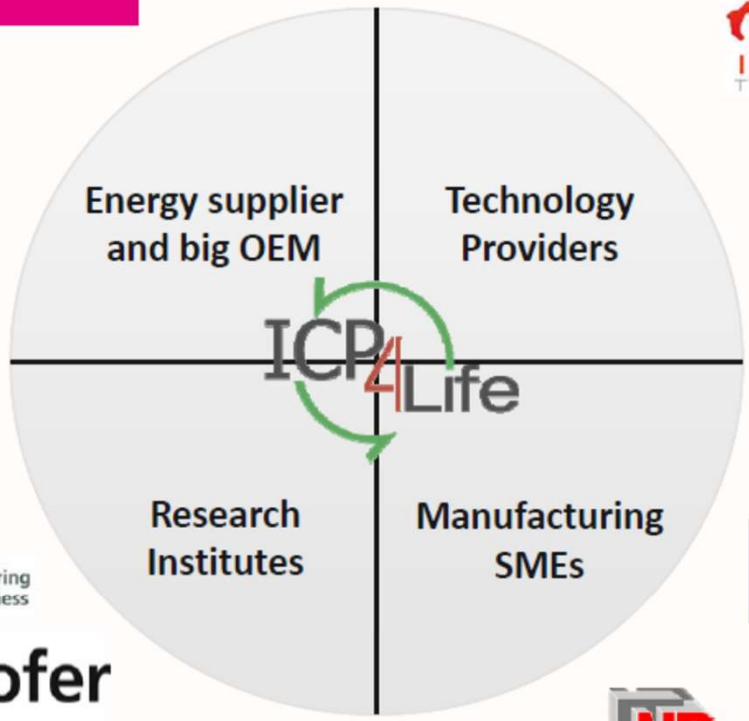
ICP4Life Project Overview

ICP4Life Consortium

ICP4Life



TAURON

sertech. Scientific Academy for Service Technology

INERTIA TECHNOLOGY

PRIMA INDUSTRIE

INTRASOFT INTERNATIONAL

ABGAM GRUPO SEGULA TECHNOLOGIES

LMS Laboratory for Manufacturing Systems & Automation University of Patras

tecnalia Inspiring Business

Fraunhofer IAO

LASERLAM

NB

ECN Centrale Nantes

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ICP4Life Project Overview

ICP4Life Use Cases

ICP4Life

PRIMA Use Case

- Sensor-based:
  - Process monitoring and process planning optimization
  - Equipment health monitoring
- Remote assistance for process planning and equipment configurations for special production requests
- AR-based remote maintenance assistance

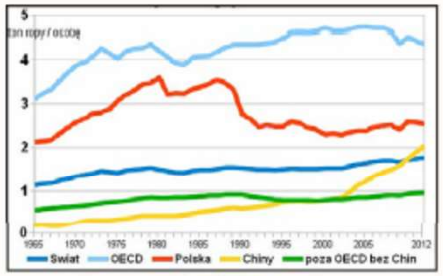
ICP4Life Project Overview

ICP4Life Use Cases

ICP4Life

TAURON Use Case

- Energy demand service for optimization of energy consumption in industrial environments
- Energy supply interruption planning improving maintenance planning for industries
- Advanced environmental impact calculation and provision of relevant recommendations



ICP4Life Project Overview

ICP4Life Use Cases

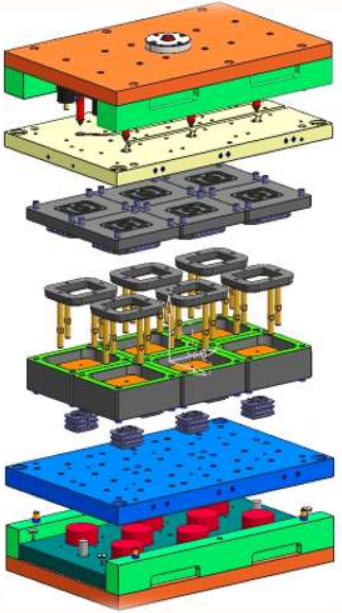
ICP4Life

BAZIGOS Use Case

Mold Maintenance History

- Identified problems / breakdowns.
- What were the required actions
- Replaced or repaired components
- Lead Time and costs of past cases

3D View Support



Condition Based Maintenance

- Identified patterns of failure
- Transition from Corrective Maintenance to Scheduled or Condition Based
- Access and exploitation of data never considered before

ICP4Life Project Overview

ICP4Life Components

ICP4Life

DESIGNER

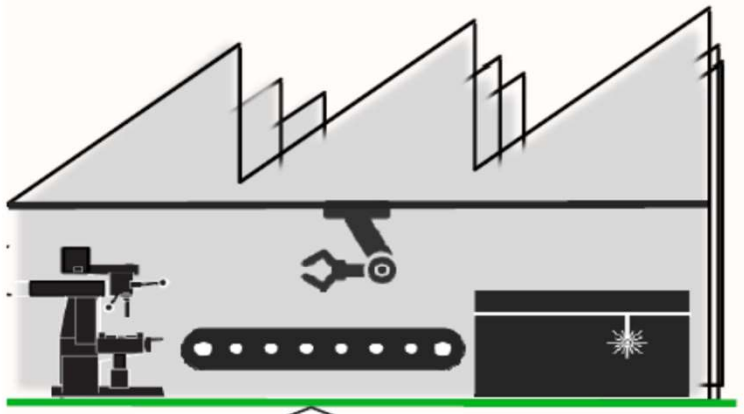
Collaborative web-based application for the creation and management of products and services by engineers and designers.

CUSTOMIZER

Product-Service configuration tool for customers, enabling the easy and intuitive formation of Products and Services.

PLANNER

Collaborative web-based tool for efficient, adaptive and responsive planning and decision making phases, for managing the dynamic operation of the plants .



Energy Supplier

Equipment Manufacturer

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Director: Professor G. Chryssolouris

ICP4Life Project Overview

ICP4Life Approach

ICP4Life

ICP4Life Customizer

- Assistance to customers in product-service configuration and provision of new services through the same or additional components (Meta Products)
- Development of web-based applications for checking and handling product-service data

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ICP4Life Project Overview

ICP4Life Approach

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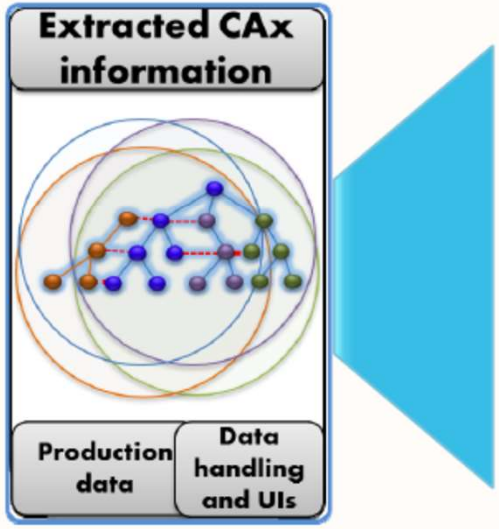
ICP4Life Designer

- Handling and linking of product design information to processes through a semantic model
- Product Modules Concept (PMC) for defining and selecting the appropriate product-service configuration considering a number of defined constraints and customer needs



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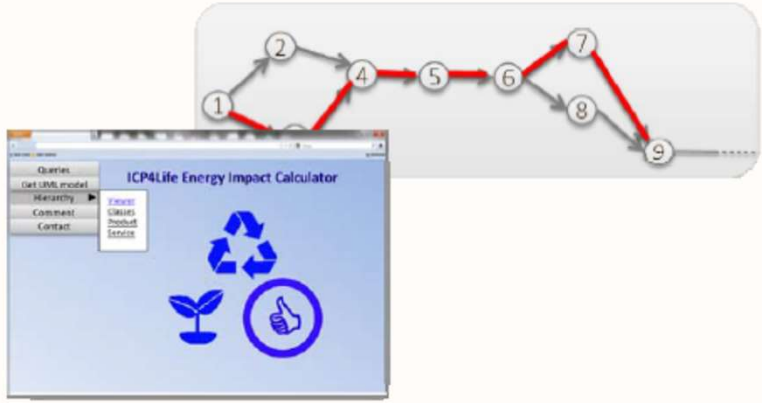
ICP4Life Project Overview

ICP4Life Approach

ICP4Life

ICP4Life Planner

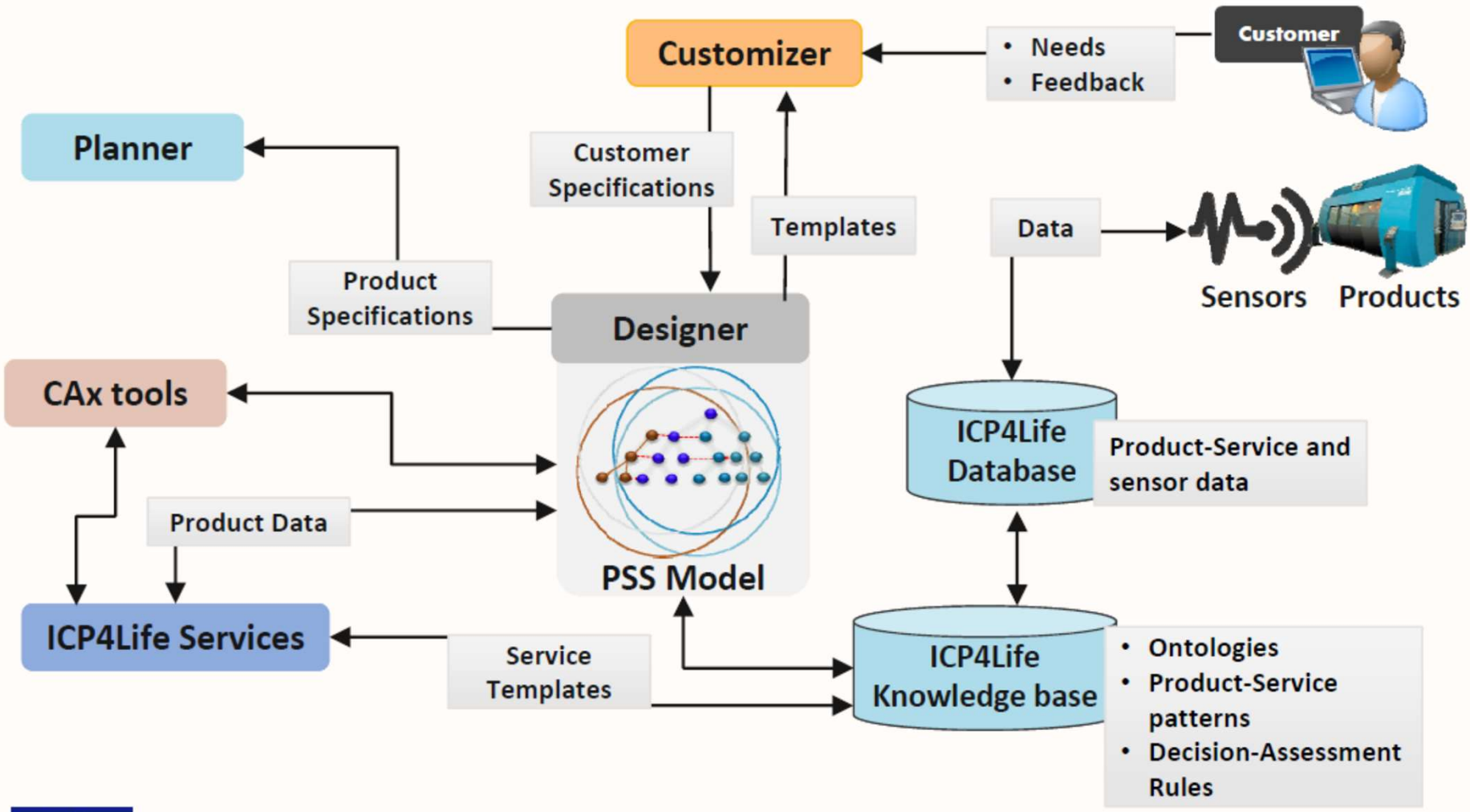
- Semi-automatic design and reconfiguration of production systems taking advantage of novel simulation models for the whole supply chain
- Identification of the most efficient production solutions in terms of time, cost and environmental impact



ICP4Life Project Overview

ICP4Life Conceptual Architecture

ICP4Life



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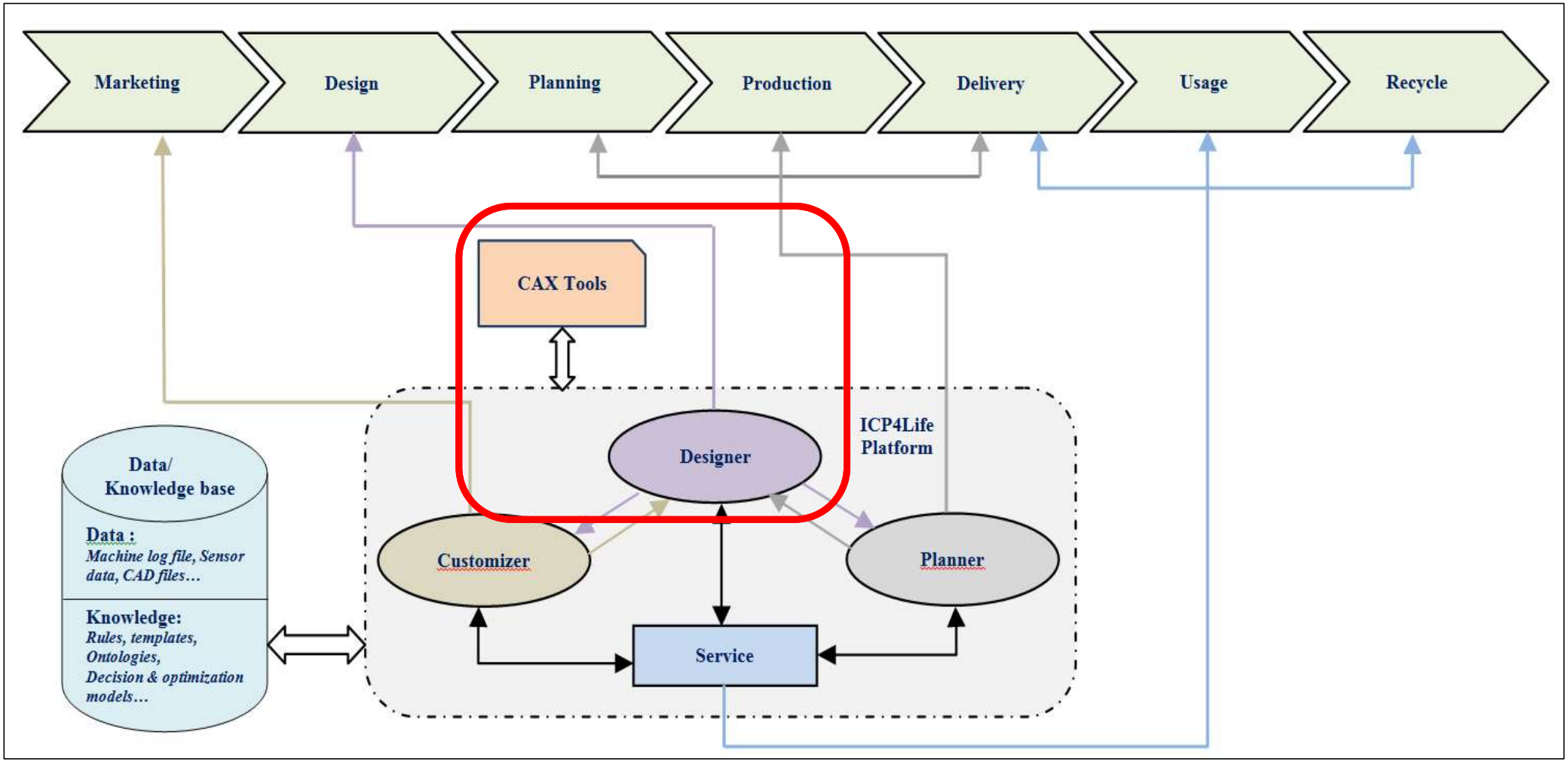
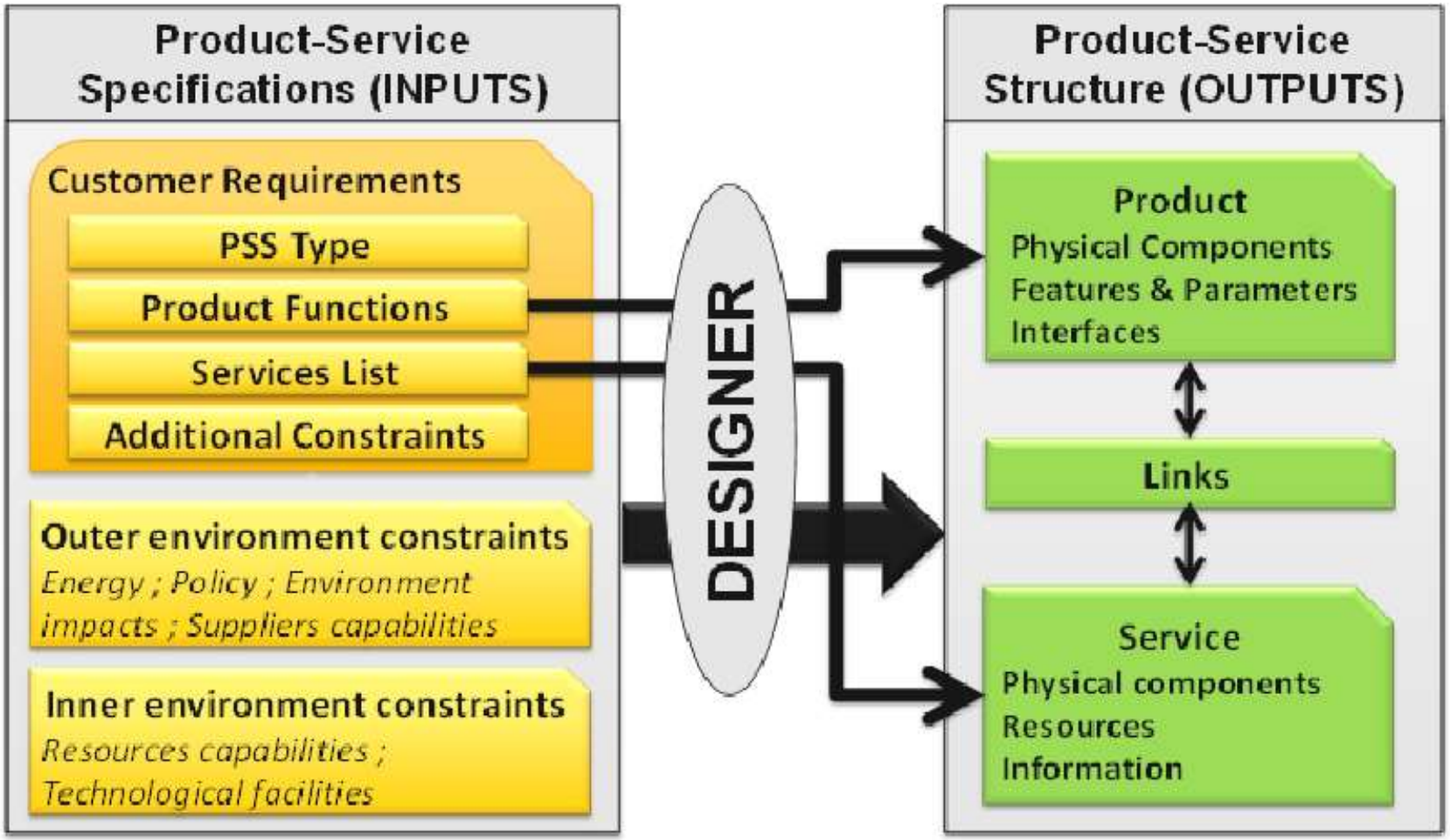
ICP4Life Project Overview

- **Life-cycle Management for PSS**



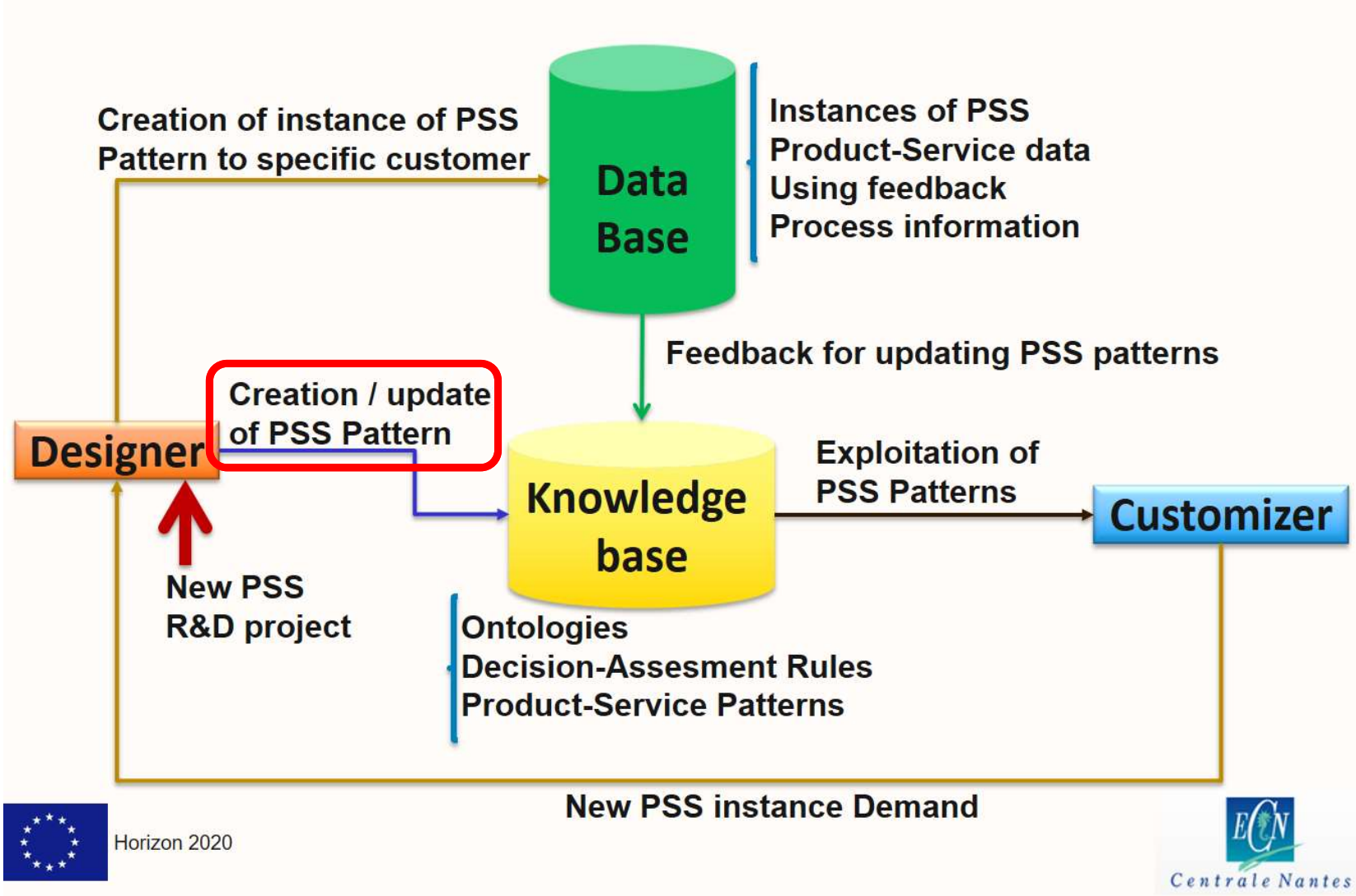
ICP4Life Project Overview

- **Designer Component Functions**



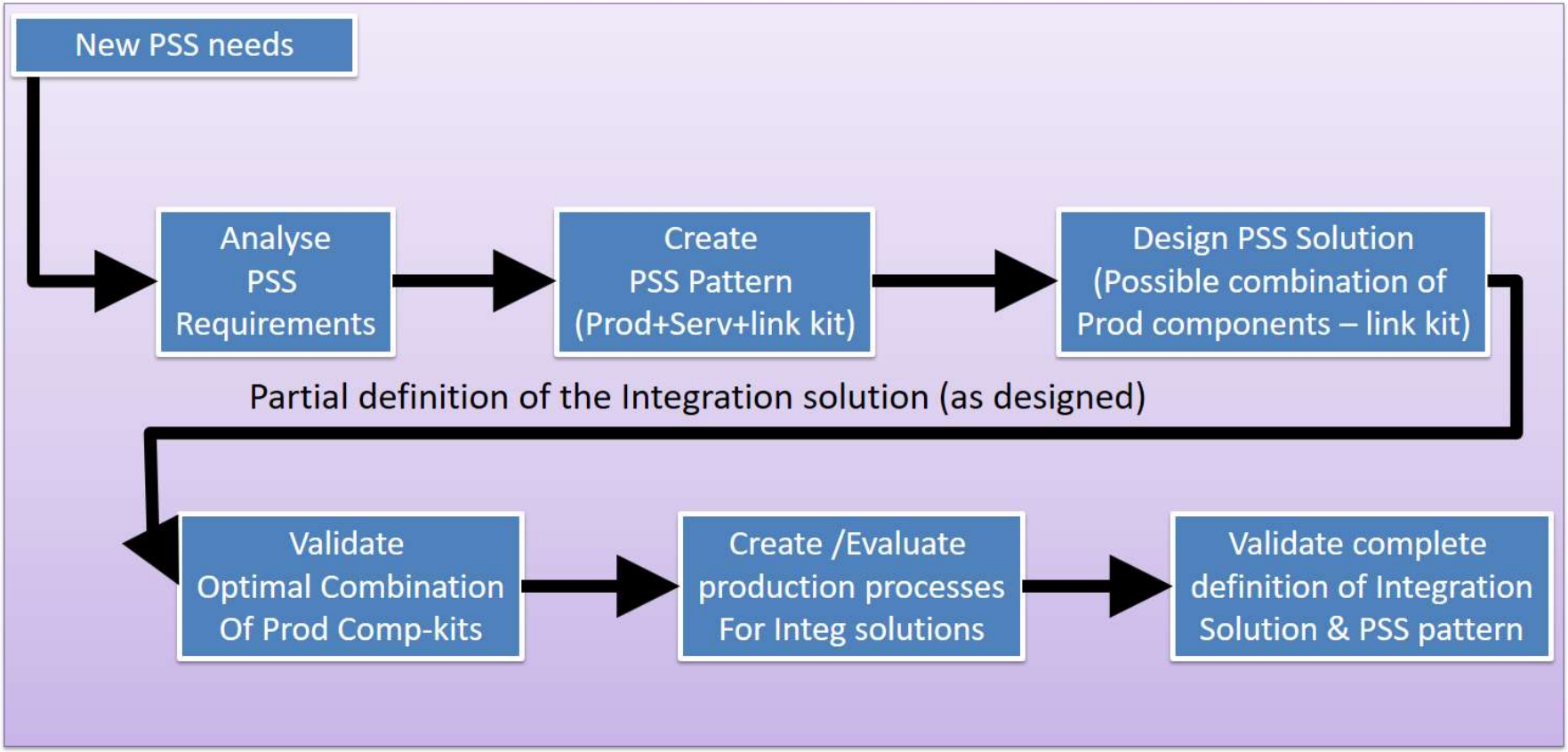
ICP4Life Project Overview

➢ Designer Component Architecture



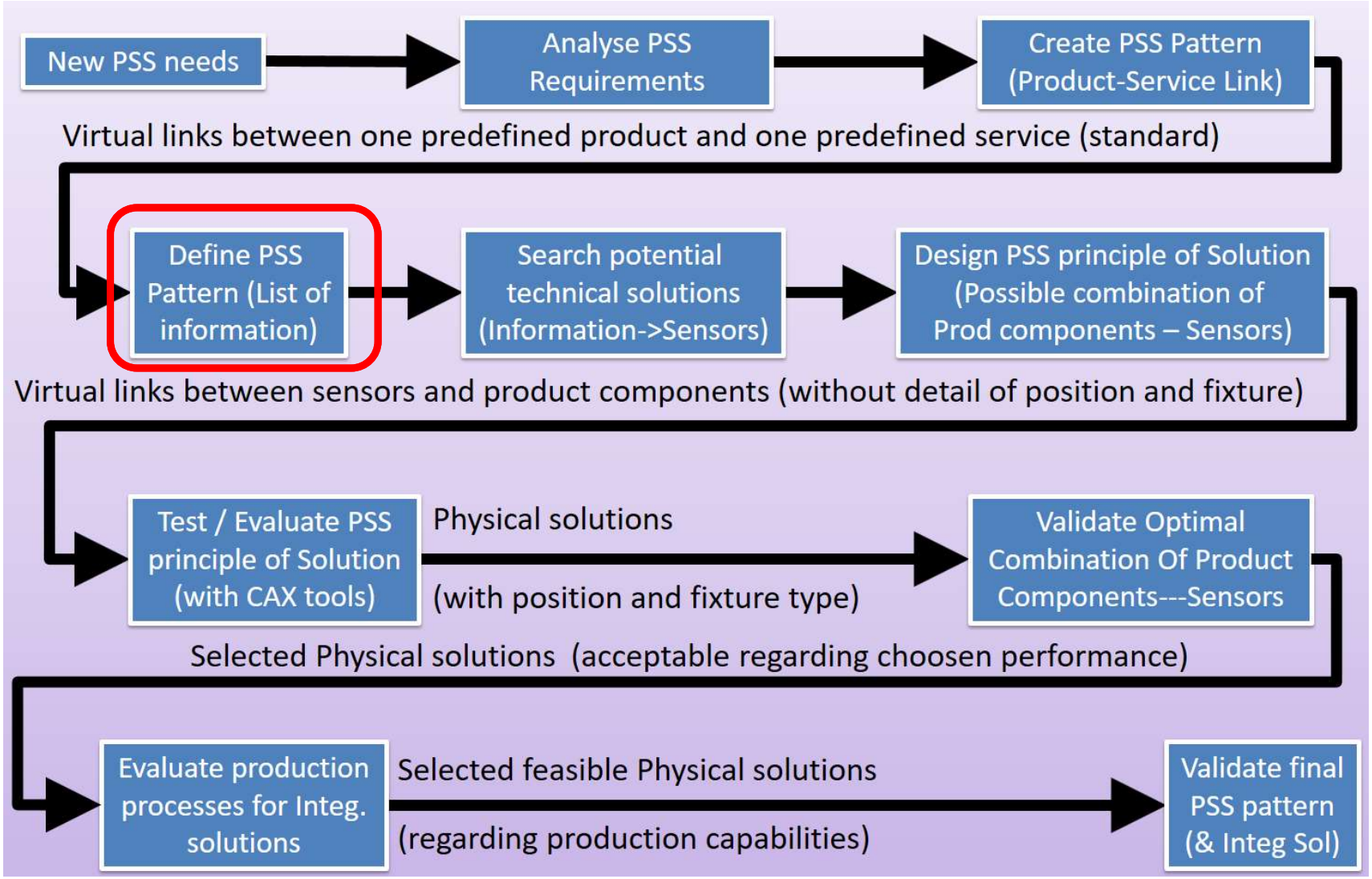
ICP4Life Project Overview

➢ General PSS Design Process



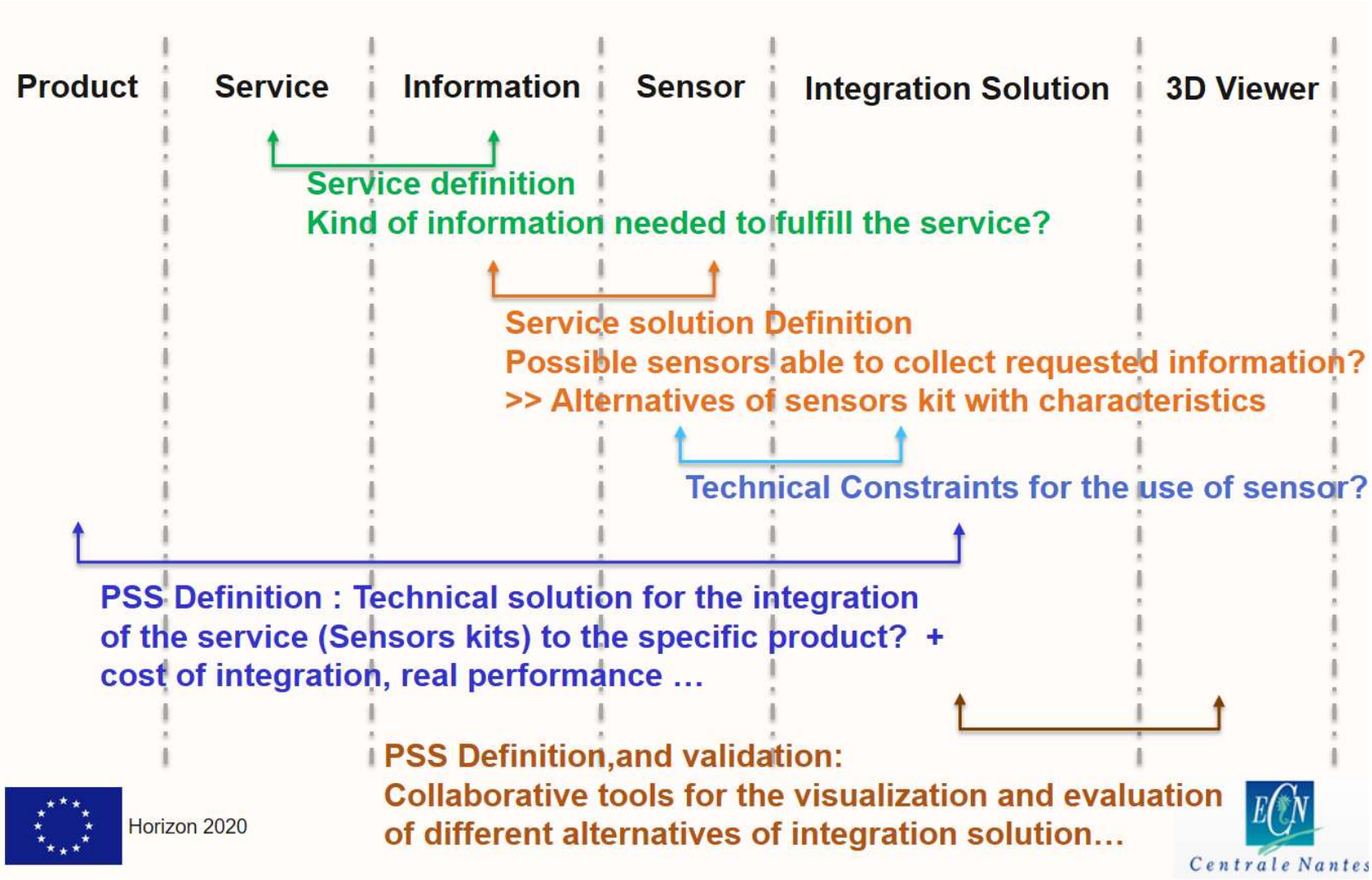
ICP4Life Project Overview

➢ Detailed PSS Design Process



ICP4Life Project Overview

- **Information-driven PSS Definition/Design Method**



Creation of new PSS Pattern: Project-Driven

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Marketing/Service Department

New Machine:
Laser Genius A110

New service need:
Dust detection
Performance requirements:
Granulity: [0.01-0.5mm]
Sensitivity error: <2%

Search

Customizer
Similar service for old machines not found!

Send request for develop new service for new machine (start from the scratch)

Information managed by the service

Information of sensor, User environment; Work conditions User requirements…

Mechatronic Engineer

Machine adaptations; Phyical interface solutions; Cable routing solutions…

Designer

New PSS Pattern

New Machine:
Laser Genius A110
New service name:
Dust detection
Alternative solutions:
Solution 1
Sensor kit: SSTK01;
Performance: [0,005-0,6], <1,5%.
Integration solution: physical interface..
Solution 2
Sensor kit: SSTK02;
Performance: [0,01-0,6], <2,5%.
Integration solution: drilling hole..
Solution 3
Sensor kit: SSTK03;
Performance: [0,01-0,2], <3,5%.
Integration solution: bonding..

Information on: User environment; Work conditions; Machine& interface; Performance requirements…

Sensor list ; Performances; Integration requirements; …

Solution proposals; Further request of information …

Use information; Environment information & work condition; Feedback & evaluation…

Sensor Engineer

Machine Provider/User

Knowledge Base

Searching for relevant sensors for each service information

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Adaptation of existing of PSS pattern

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Customer/Client

Machine:
Laser Genius A110

New service need:
Dust detection
Performance requirements:
Granulity: [0.01-1,5mm]
Sensitivity error: <1%

Send request

Customizer

Machine:
Laser Genius A110
Service name:
Dust detection
Alternative solutions:
Solution 1 (*Sensor kit: SSTK01; Performance: [0,005-0,6], <1,5%.*
Integration solution: physical interface..)
Solution 2 (*Sensor kit: SSTK02; Performance: [0,01-0,6], <2,5%.*
Integration solution: drilling hole..)
Solution 3 (*Sensor kit: SSTK03; Performance: [0,01-0,2], <3,5%.*
Integration solution: bonding..)

NO solution for the requested performance of the existing PSS pattern!

Send request of new solution

Information of sensor, User environment; Work conditions User requirements…

Mechatronic Engineer

Machine adaptations; Phyical interface solutions; Cable routing solutions…

Designer

New solution:
Solution 4 (*Sensor kit: SSTK04;*
Performance: [0,01-1,8], <0,5%.
Integration solution: physical interface..)

New PSS Instance

Data Base

Update PSS pattern

Knowledge Base

Information on: User environment; Work conditions; Machine& interface; Performance requirements…

Sensor list ; Performances; Integration requirements; …

Solution proposals; Further request of information …

Use information; Environment information & work condition; Feedback & evaluation…

Sensor Engineer

Machine Provider/User

Creation of new PSS instance (Using pre-defined PSS patterns)

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Client

Machine:
Laser Genius A110

Service need:
Temperature monitoring

Requirements:
Range: [10 ° 190°]
Accuracy: <5%

Customizer

Machine:
Laser Genius A110

Service list:
1, Temperature monitoring;
2, Vibration monitoring;
3, Quality monitoring…

Performance:
1, *[20 ° 180°], <3%;*
2, [5 ° 200°], <3%;
3, *[5° 150°], <8%…*

Designer

Machine:
Laser Genius A110

Performance:
1, [5 ° 200°], <3%;

Available sensor kits:
1, SSTK01;
2, SSTK02…
3, SSTK03…

Integration solutions:
1, SL001;
2, SL002 (optimal position of sensor, 12 holes and interface to fix sensor, add space for sheath of electric cable; cost =…

Data Base

Output optimal PSS solution

New PSS instance

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PSS Conception for TAURON Use Case

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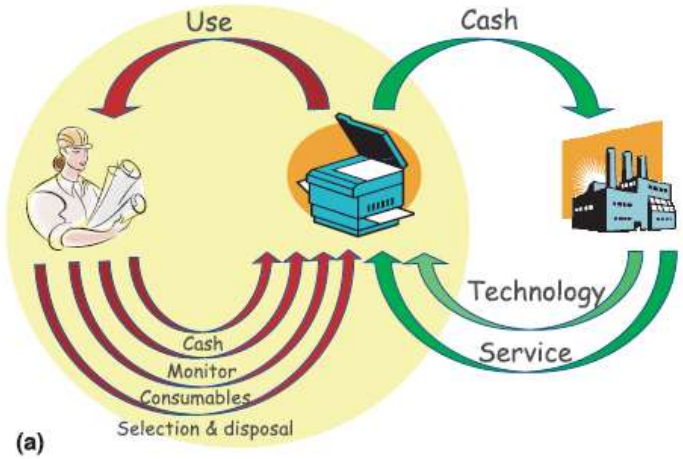
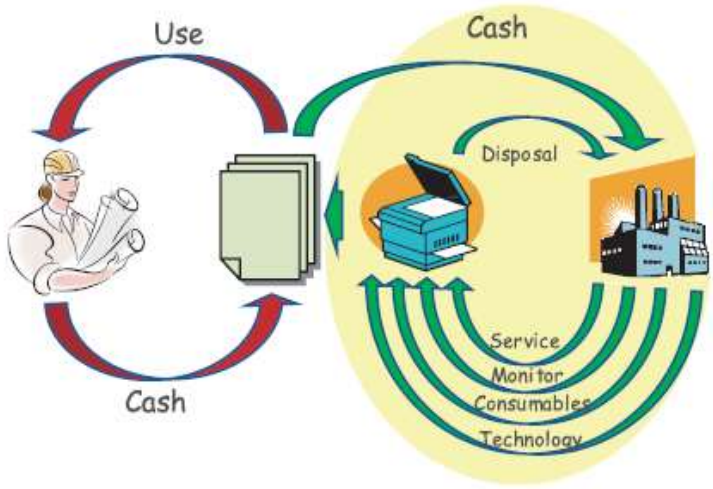
1. TAURON PSS Type:

Service-oriented (use-oriented), user pays for the energy providing service or energy use.

2. Main differences between PO and SO





Product-oriented (PO)
Ownership:
user owns the machine
Responsibility related with machine:
user share more responsibilities
Cost of user:
pay for machine, service and other costs, etc.

Service-oriented (SO)
Ownership:
manufacturer owns the machine
Responsibility related with machine:
user has no responsibility
Cost of user:
pay for use/use service.

3. PSS Comparison (TAURON & PRIMA)

TAURON (SO)		PRIMA (PO)
PSS Provider: *TAURON*		PSS Provider: *PRIMA*
PSS Receiver: *various clients using electricity*		PSS Receiver: *LASERLAM*
Equipment (machine): *plant, grid, meters and other electrical tools…*	**V S**	Equipment (machine): *laser cutting machine*
Ownership: *TAURON owns the equipment*		Ownership: *LASERLAM owns the equipment*
Responsibility: *clients takes no responsibility for equipment*		Responsibility: *LASERLAM takes responsibility for equipment*
Business manner: *clients pay for electricity use*		Business manner: LASERLAM *pays for equipment and also service*

PSS Transformation for TAURON Use Case

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4. Transferring TAURON SO PSS into Implicit PO PSS

TAURON (SO)

PSS Provider: *TAURON*

PSS Receiver: *various clients using electricity*

Equipment (machine): *plant, grid, meters and other electrical tools…*

Ownership: *TAURON owns the equipment*

Responsibility: *clients takes no responsibility for equipment*

Business manner: *clients pay for use*

Transfer

TAURON ('PO')

PSS Provider: TAURON

PSS Receiver: *clients*

'Equipment (machine)': energy buying *contract*

Ownership: *clients owns the 'equipment' (contract)*

Responsibility: *clients take responsibility for 'equipment' (contract)*

Business manner: clients *pay for 'equipment' (contract) and also service*

By analogy:

'Machine catalog' in TAURON use case: various contracts

'Service list for contracts': energy consumption optimization, energy demand prediction, calculation of environment impact, temporary additional energy support…

'Integration solution' (resources for realizing service): construction temporary grid, installing meters, sensors, developing prediction algorithms, etc.

PSS Pattern: contract + service + 'integration' solution

PSS Design Scenario:
Adaptation of existing of PSS pattern

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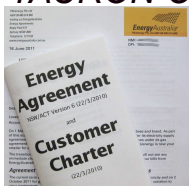
Client (production plant)

Contract:

TAURON Contract A110



Electricity type;
Service time;
Price…

Service need:

Temporary additional energy providing

Requirements:

Voltage: 240v-380v
Grid stability: turbulence < 0.5%
Service time: 15pm-23pm…

Send request

Customizer

Machine:
TAURON Contract A110
Service name:
Temporary additional energy providing
Alternative solutions:
Solution 1 (grid kit: SSTK01; Performance: <1,5%. construction solution: CS001)
Solution 2 (grid kit: SSTK02; Performance: <2,5%. construction solution: CS002)
Solution 3 (grid kit: SSTK03; Performance: <1,0%. construction solution: CS003)

NO solution for the requested performance of the existing PSS pattern!

User profile;
Environment information;
Work conditions,
Energy consumption
Weather condition…

Send request of new solution

Grid / Electrical Engineer

Grid adaptations;
Temporary sub-grid;
Electrical equipments;
Cable routing solutions…

Designer

New solution:
Solution 4 (grid kit: SSTK04; Performance: <0,3%. construction solution: CS004)

New PSS Instance

Data Base

Update PSS pattern

Knowledge Base

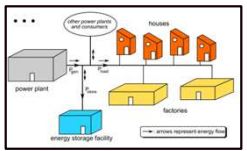
Information on: User environment; Work conditions; plant space/layout; Performance requirements…

Infrastructure solution; Performances; Demolition solution

Solution proposals; Further request of information …

Use information; Environment information & work condition; Feedback & evaluation…

Infrastructure construction Engineer



Production plant

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PSS Design Scenario: Creation of new PSS Pattern

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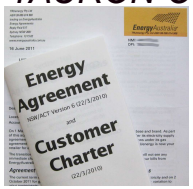
Client (production plant)

Contract:

TAURON Contract A110



Electricity type;
Service time;
Price…

Service need:

Temporary additional energy providing

Requirements:

Voltage: 240v-380v
Grid stability: turbulence < 0.5%
Service time: 15pm-23pm…

Search

Customizer

Similar service for this contract not found!

Send request for develop new service for this type of contract (start from the scratch)

User profile;
Environment information;
Work conditions,
Energy consumption
Weather condition…

Grid / Electrical Engineer

Grid adaptations;
Temporary sub-grid;
Electrical equipments;
Cable routing solutions…

Designer

Customizer

Machine:
TAURON Contract A110
Service name:
Temporary additional energy providing
Alternative solutions:
Solution 1 (grid kit: SSTK01;
Performance: <1,5%.
construction solution: CS001)
Solution 2 (grid kit: SSTK02;
Performance: <2,5%.
construction solution: CS002)
Solution 3 (grid kit: SSTK03;
Performance: <1,0%.
construction solution: CS003)
Solution 4 (grid kit: SSTK04;
Performance: <0,3%.
construction solution: CS004)

New PSS Instance

New PSS Pattern

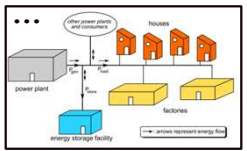
Information on: User environment;
Work conditions; plant space/layout;
Performance requirements…

Infrastructure solution;
Performances;
Demolition solution

Solution proposals;
Further request of information
…

Use information;
Environment information & work condition;
Feedback & evaluation…

Infrastructure construction Engineer



Production plant

Data Base

Knowledge Base

Horizon 2020

Conclusion

- **PSS Design Domain Is Interdisciplinary**

  PSS design involves both physical and non-physical issues, including technical, social and cultural factors.

- **PSS Design Tool and Method Are Still Not Matured**

  Currently, there is no widely-accepted/used PSS design support tool or method. New tools and methods are under development within EU funded projects.

- **Traditional Product and Service Design Methods and Tools Can Be Adapted**

  PSS can be decomposed into its elements, which can be designed and realized traditional design tools and methods in their specific techno-and non-techno domains. Innovative tools may be derived from those combined.

- **Modular Based Method for PSS Design Would Be Promising**

  PSS is highly-customized. Hence, modular methods have the potential to reduce PSS development cost, risk and time. Knowledge reuse is key to the knowledge-intensive creation process (PSS Design).

Thanks for your attention !