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First Version
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<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
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<tbody>
<tr>
<td>API</td>
<td>Application Program Interface</td>
</tr>
<tr>
<td>BC</td>
<td>Business Case</td>
</tr>
<tr>
<td>BPEL4WS</td>
<td>Business Process Execution Language for Web Services</td>
</tr>
<tr>
<td>BPMN</td>
<td>Business Process Model and Notation</td>
</tr>
<tr>
<td>CA</td>
<td>Consortium Agreement</td>
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<tr>
<td>CMM</td>
<td>Capability Maturity Model</td>
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<td>ICT</td>
<td>Information and Communication Technologies</td>
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<td>IDM</td>
<td>Information Delivery Manual</td>
</tr>
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<td>i.e.</td>
<td>id est (Engl. = that is to say)</td>
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<tr>
<td>IPR</td>
<td>Intellectual Property Rights</td>
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<td>KM</td>
<td>Knowledge Management</td>
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<td>Key Performance Indicators</td>
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<td>KGI</td>
<td>Key Goal Indicators</td>
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<td>LCA</td>
<td>Life Cycle Assessment</td>
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<tr>
<td>PDCA</td>
<td>Plan-Do-Check-Act</td>
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<td>PES</td>
<td>Product Extended Services</td>
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<td>PESDLC</td>
<td>PES development life cycle</td>
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<tr>
<td>RTD</td>
<td>Research and Technological Development</td>
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<td>SDLC</td>
<td>Software Development Life Cycle</td>
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<tr>
<td>SEI</td>
<td>Software Engineering Institute</td>
</tr>
<tr>
<td>SPICE</td>
<td>Software Process Improvement and Capability Determination</td>
</tr>
<tr>
<td>S &amp; T</td>
<td>Scientific and Technological</td>
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<tr>
<td>SME</td>
<td>Small and Medium-sized Enterprise</td>
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<td>WP</td>
<td>Work package</td>
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<td>w.r.t.</td>
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1 Executive Summary

This report (D200.11, Methodology for Collaborative Product Services & Process Design-First Version) presents a range of collaboration models, team management and team collaboration support, collaboration profiling models, collaboration services and a proposed collaboration platform as a part of the methodology of collaboration product services and process design. The collaboration models, presented in this report, help in analysing and managing the team composition with regard to the PES design and development.

Collaboration barriers that a company might experience during the design and development process were addressed in this report with possible remedies through promoting a collaborative culture and proper management of such culture where effective tools are required to provide team management, enhance collaboration, on-going performance monitoring and problem resolution.

Collaboration required for designing and developing a PES could also be supported by collaboration profiling models, such as Maturity models and Model Driven Configurations. The Maturity models discussed in this deliverable helped in describing the capabilities and nature of the collaboration amongst PES design teams while Model Driven Configuration methodology provided a profile of attributes to indicate the maturity of each element of the processes involved in collaborative PES design.

The collaboration profile discussed in this report identified a number of configurable elements resulted in an appropriate initial configuration of the collaboration services provided in the ProSEco platform. These services are comprised of Communication services, Coordination services and Cooperation services. Furthermore, three-layered system architecture was proposed comprising user interface layer, service layer and data and knowledge layer.

Since the development of the PES is customized with reference to the sequence of a traditional Software Development Life Cycle (SDLC) with multi-functional, domain-specific expertise, collaboration among team members will also be organised at each phase of the life cycle. To facilitate this collaboration at each phase of the life cycle, the Information Delivery Manual (IDM) approach has been used to specify the type of information to be created and consumed, who (actors) are going to consume that information, and the possible ways of exchanging the information among actors or between organizations.
2 Introduction

This document presents deliverable D200.11, “Methodology for Collaborative Product Services & Process Design - First Version”, of the ProSEco project. The deliverable (D200.11) summarises the work realised under task T210 in work package WP200, titled “Methodology for Collaborative Product Services and Process Design”.

2.1 Document Purpose

The objective of this document is to provide a collaboration methodology for eco products/services and the production processes that harmonize the task/activities, actors, and flow of information within each phase of the PES development life cycle. According to the scope of T210, this report addresses the following issues:

- Possible collaboration barriers and how to overcome them
- Collaboration tasks necessary for optimising designs and production processes
- Potential collaboration methods and components that will comprise the collaboration platform

2.2 Approach Applied

To support the collaboration activities in each phase of the PES development life cycle, a collaboration platform is required that supports the workflow process and enhances cooperation among team members by providing appropriate communication channels. For this, collaboration modelling techniques are presented to develop a collaboration platform by integrating the Software Development Life Cycle (SDLC) together with the Information Delivery Manual (IDM) approach.

A detailed description of these techniques and how they will support collaboration during the PES development process is presented in Section 7 - Modelling the PES Collaboration.

2.3 Document structure

The document consists of:

- Section 1: An Executive Summary with a short and concise overview of the overall content of the whole document.
- Section 2: gives the Introduction which describes the purpose of this document, the position of this document with respect to the whole project, and provides a brief overview of the contents of the document.
- Section 3: describes the purpose of collaboration and how the team composition and team collaboration of the PES development is different to traditional products/services.
- Section 4: presents the collaboration management techniques to overcome the possible collaboration barriers. It also proposes “Oobeya” as an effective collaboration management tool to support collaboration.
- Section 5: describes the Collaboration Profiling Models and Maturity Models to define the capabilities and nature of the collaboration amongst team members.
- Section 6: elaborates the collaboration services into three sub-levels that explain the collaboration activities required for workflow process, to manage the team members according to the task/activities and to facilitate communication among actors.
- Section 7: envisages the PES collaboration platform designed by integrating the software development life cycle methodology and the IDM approach that maps the collaboration services to a single platform.
- Section 8: Summarizes the report with a conclusion
- Annexe 1: References
3 Collaboration

Collaboration is the basis for bringing together the knowledge, experience and skills of multi-functional team members to contribute to the development of a new product more effectively than in the case of individual team members performing their narrow tasks in support of product development [1]. The software development process requires collaborative problem-solving activities where knowledge acquisition, information sharing and integration, together with the minimization of communication breakdown bring success to the project.

The production of large and complex systems usually requires coordination and collaboration among many individuals including developers, marketing staff, standards’ experts, and customer representatives. Often, these individuals are spread among numerous divisions of a corporation or among different sectors [2]. Collaboration among these actors is extremely crucial in order to synchronize the various system development activities. Software development projects are inherently cooperative, requiring multiple software engineers to coordinate their efforts to produce large software systems [3]. Integral to this effort is developing a shared understanding of the emerging artefacts, where each artefact embodies its own model over the entire development process - also called “Model Oriented collaboration”. Collaboration helps actors from different domains (system architects, system designers, system developers etc.) to negotiate, create alliances, and to engage domain experts to ensure convergence on a single system architecture and design [2]. Collaboration increases productivity by raising team interaction and awareness of the project’s responsibilities [4].

Keeping the nature of the ProSEco project in consideration, where a number of participants are involved from different domains and functional capabilities and different actors are responsible for the completion of a particular phase of the PES development process, thus it is crucial to design an effective collaboration methodology to eliminate communication barriers among geographically distributed team members. As already discussed in D100.3 (ProSEco Concept), the purpose of this methodology is to design a collaboration framework for eco-product services and production processes, by analysing the life cycle phases, the nature of multi-functional teams, the collaboration tasks necessary for optimising designs and production processes, and also by looking into potential collaboration methods and components that will comprise the collaboration platform.

3.1 Team Composition

Designing and deploying PES brings a new set of challenges for manufacturing organisations and, in particular, product design teams. New PES can comprise both physical and intangible properties such that the nature of the tasks involved and the composition of PES design teams are dramatically different to traditional product design teams that have been mainly concerned with the physical characteristics and the production engineering aspects of a new product. Many new PES will also have substantial lifespans associated with a physical product making it important for the PES design teams to carefully determine and balance skills and capabilities needed in carrying out the design and validation of new the PES, as well as understanding their impact across the entire product life cycle [5]. A typical production system from partner ONA, for instance, comprises hundreds of parts and has an expected lifespan of 15 to 20 years which must be taken into account when designing a new PES. Products from partner Volkswagen have an even greater number of parts and similar lifespan challenges, but must address the challenges of introducing new PES on a scale that is potentially of a larger magnitude due to the nature of automobile production volumes.

The innovation processes that have led to the success and competitiveness of ONA and Volkswagen products in the market when applied to PES may involve new actors and roles both within these manufacturing organisations, as well as outside the organisations such as existing and new supply chain actors and third-party service providers. New competencies and capabilities may need to be introduced that are not exclusively part of the traditional engineering design team as the PES design and development teams must often manage product knowledge and data in a “shared context” [6] across functional and even organisational boundaries to create new PES that deliver value for customers throughout the lifespan of the manufactured products. Knowledge sharing across the supply chain and third-party actors can be a key enabler for successful PES innovation [7].

In many cases, PES innovations require the integration of a wider span of expertise into product design teams in comparison to pure product innovation activities [8] as shown in Figure 1.
This places requirements on the ProSEco tools to facilitate a shift in the way product design teams collaborate in two dimensions:

1. moving from product or project-focused teams to a more network style of collaboration, and
2. shifting from transaction based relationships with supply chain actors to creating more long-term relationships within a dynamic network of supply chain and third party actors

The effectiveness of knowledge acquisition and sharing across the network, however, depends on the degree of closeness and the intensity of the relationships among partners [9]. In particular, PES innovation relies on developing ties across partner networks in order to analyse and exploit knowledge already collected, as well as exploring new opportunities for capturing product and use knowledge and applying these towards the design of new and innovative PES. The PES designers will often seek to incorporate a “system thinking” approach in the development process considering how the manufactured product and new product-service fits together with other system elements from within the manufacturing organisation, and possibly those provided by third-party partners. The effectiveness of this knowledge-sharing network for designing and deploying PES is dependent on the ability to find and access relevant knowledge, but also on strong collaboration capabilities in order to involve people more easily who possess the specific knowledge and skills needed in the PES design and deployment processes.

Table 1 summarises the main challenges and needs for collaborative knowledge sharing in the context of PES design, development and deployment.

<table>
<thead>
<tr>
<th>PES Challenge</th>
<th>Requirements for PES Design Teams</th>
<th>Knowledge Challenge</th>
<th>Knowledge Sharing Needs for PES Design</th>
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<tr>
<td>Understanding complex product life cycle properties</td>
<td>New competencies to analyse product data, user behaviour and product relationships with the operating environment</td>
<td>Gathering wide spectrum of knowledge from many actors in the company and potentially from external partners</td>
<td>Need to utilise both &quot;strong&quot; and &quot;weak&quot; ties within the network of actors</td>
</tr>
<tr>
<td>Need to develop valued service offerings</td>
<td>Analyse and understand customer needs and new service opportunities and communicate these within the team</td>
<td>Capture, analyse and share the intent of the new service design</td>
<td>Ensure the transfer of new service intent and rationale from one actor to another</td>
</tr>
<tr>
<td>Operational performance responsibility</td>
<td>Need access to more information about downstream performance and to anticipate impacts of new services</td>
<td>Feedback product use knowledge and experience to PES design team</td>
<td>Capture and sharing of downstream use knowledge across functional and organisational boundaries</td>
</tr>
</tbody>
</table>
Knowledge sharing in the PES design presents many new challenges and may require potentially many new competencies and the inclusion of new actors in design teams.

The ProSEco collaborative product-services and process design tools provide a knowledge-management system that supports the gathering, dissemination, analysis and application of knowledge for the collaborative design and deployment of new PES. Fundamentally, these tools must ensure that the right actors have the right knowledge at the right time to make the right PES design and deployment decisions.

### 3.2 Team Collaboration

PES design and deployment requires the coordination of networks of internal and often external actors. The characteristics of supply networks require the careful synchronization of actors to deliver complete product-service solutions to the customer [8]. It has also been shown [10] that shared knowledge, defined into three categories - shared knowledge of customers, suppliers, and internal capabilities - during the initial product design tasks enhances product development performance and it is reasonable to assume that similar enhancements to the PES development performance would accrue when these knowledge types are shared within PES design teams. Further improvements are likely to be achieved if the shared knowledge is extended to include collected product data and use data. Learning network approaches to encourage experience sharing and collaboration between actors enables organisations to transition from traditional product selling to combinations of products and services’ solutions [11]. Collaborative knowledge sharing amongst actors participating within company and inter-company networks is an essential element of successful and innovative PES design.

Research on the knowledge-based view of companies has suggested that collaboration facilitates the creation of new knowledge within organisations [12] and that companies can acquire and utilise new knowledge through their collaborative ties [13] and inter-company networks [14]. Figure 2 depicts a traditional product manufacturing knowledge sharing network.

![Figure 2: Traditional product manufacturing knowledge sharing network](image)

Research also shows that effective knowledge acquisition and sharing depends on the degree of closeness and intensity of a relationship between partners [9] where closeness and intensity can be represented using a simplistic scale from weak ties at one extreme to strong ties at the other. While the modelling and analysis of ties has been heavily studied within the context of social networking among individuals [15], tie strength concepts have only more recently been applied to understanding the knowledge flows, frequency, and intensity of interactions within cross-company settings. For example, it was found that weak ties help companies to build initial relationships and strong ties help companies to acquire higher quality and fine-grained knowledge [14].
The product manufacturer remains at the centre of the collaborative network during PES design and initial deployment and is responsible for bringing the knowledge and competencies into a shared context through knowledge exploitation and exploration in the network. PES design and deployment tasks often leads to the development of several strong and weak ties across partners in the network (see Figure 3) in order to gain competitive advantages by both exploring new knowledge and opportunities with weak ties and exploiting existing knowledge and building stronger partnerships with strong ties. Collaboration and knowledge sharing is a key function in a PES design and deployment cluster in as much as one actor’s learning and experience can influence other actors in the network in developing new PES ideas and innovations.

From the knowledge sharing perspective, the evolution of ties within collaborative PES design teams with respect to the degree of closeness and intensity are likely to evolve over time. A typical relationship between the strength of ties within a PES design team to knowledge sharing and collaboration is shown in Figure 4.

At the initial stage, a weak tie may be established when the manufacturer communicates and exchanges information on a first-time basis amongst the PES design team actors. The second stage represents cooperation whereby the PES design team starts working together for a goal or attempt to fulfill the desired service or address a new market opportunity. At the third stage, the PES design team works in harmony by sharing resources, expertise and content. From a tie perspective, the third stage represents an intermediate position where the actors set goals and share mutual interests to work together. The fourth stage represents a partnership whereby the PES design team establishes a common identity and begins to consider deployment topics and common benefits through bilateral ties. At this stage, the collective actions aiming to achieve a new PES are defined. In the final stage, the PES design team establishes effective knowledge-sharing through strong multi-lateral ties which create a high level of trust, openness, and reciprocity within the team to achieve team level learning amongst the actors. In this way,
one actor’s learning and experiences can influence other actors in the team to create incremental innovations, and potentially radical innovations in PES design and new market targets.

Research [9] indicates that strong ties are helpful for the diffusion (exploitation) of existing knowledge in the network because of higher levels of trust and embedded relationships, while weak ties are useful to explore new knowledge (exploration). Table 2 summarises the key characteristics of weak and strong ties with respect to knowledge sharing within PES design teams.

**Table 2: Key characteristics of weak and strong ties with respect to knowledge sharing**

<table>
<thead>
<tr>
<th>Nature of Shared Knowledge</th>
<th>Explicit</th>
<th>Explicit and tacit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flow of Knowledge</td>
<td>Mostly unidirectional (as-needed basis)</td>
<td>Mostly multidirectional (routine-based network learning)</td>
</tr>
<tr>
<td>Frequency of Interaction</td>
<td>Low</td>
<td>High and longer-term interactions</td>
</tr>
<tr>
<td>Nature of Interaction</td>
<td>Informal</td>
<td>Both formal and informal</td>
</tr>
<tr>
<td>Resources</td>
<td>No sharing of sensitive information or commitment of significant resources</td>
<td>Sharing of sensitive information, resources and strategies</td>
</tr>
<tr>
<td>Acquisition Strategy</td>
<td>Exploration</td>
<td>Exploitation</td>
</tr>
<tr>
<td>Identity / Common Ground</td>
<td>Initial development of identity in the network</td>
<td>Strong common identity and reciprocal trust with shared goals and defined interests</td>
</tr>
</tbody>
</table>

The move towards PES shifts the development focus from product-based properties to the lifecycle behaviour of a product which requires that the PES design teams have a shared understanding and shared context beyond established knowledge domains and organisational boundaries. Synergies are needed over a wide spectrum of competencies from multiple actors in order to address sophisticated customer needs and create innovative PES. PES design typically requires more experiential working knowledge and contextualized information (e.g. product, ambient, etc.) from different stages of the product lifecycle compared to traditional product-focused design.

The ProSEco collaboration tools will need to support and adapt to a continuum of tie strengths amongst actors within the PES design teams. Some examples of key functionalities within the ProSEco platform and toolset that potentially could be affected by the weakness or strength of ties and their impact on knowledge sharing amongst the PES design and deployment team are shown in Table 3.

**Table 3: ProSEco Collaborative platform features affected by tie strength**

<table>
<thead>
<tr>
<th>Nature of Shared Knowledge</th>
<th>Explicit</th>
<th>Explicit and tacit</th>
<th>Effect on ProSEco Platform Configurations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flow of Knowledge</td>
<td>Mostly unidirectional (as-needed basis)</td>
<td>Mostly multidirectional (routine-based network learning)</td>
<td>Features for defining design team roles and customising workflows</td>
</tr>
<tr>
<td>Frequency of Interaction</td>
<td>Low</td>
<td>High and longer-term interactions</td>
<td>Visibility and accessibility of product and customer usage data or knowledge</td>
</tr>
<tr>
<td>Nature of Interaction</td>
<td>Informal</td>
<td>Both formal and informal</td>
<td>Use of synchronous or asynchronous collaboration tools</td>
</tr>
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<td>Resources</td>
<td>No sharing of sensitive information or commitment of significant resources</td>
<td>Sharing of sensitive information, resources and strategies</td>
<td>Capturing of collaborative PES design exploration, design decisions and logging of transactions</td>
</tr>
<tr>
<td>Acquisition Strategy</td>
<td>Exploration</td>
<td>Exploitation</td>
<td>Security policies and enforcement points for product and customer data</td>
</tr>
<tr>
<td>Identity / Common Ground</td>
<td>Initial development of identity in the network</td>
<td>Strong common identity and reciprocal trust with shared goals and defined interests</td>
<td>Prominence of exploratory tools such as the Meta-Product Simulation and Eco-tool</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Effect on ProSEco Platform Configurations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Features for defining design team roles and customising workflows</td>
</tr>
<tr>
<td>Visibility and accessibility of product and customer usage data or knowledge</td>
</tr>
<tr>
<td>Use of synchronous or asynchronous collaboration tools</td>
</tr>
<tr>
<td>Capturing of collaborative PES design exploration, design decisions and logging of transactions</td>
</tr>
<tr>
<td>Security policies and enforcement points for product and customer data</td>
</tr>
<tr>
<td>Prominence of exploratory tools such as the Meta-Product Simulation and Eco-tool</td>
</tr>
<tr>
<td>Functionalities for defining and customising workflows, roles, and formalisation of design processes</td>
</tr>
</tbody>
</table>
Table 3 demonstrates the importance of understanding the nature of the collaboration amongst actors that seek to use the ProSEco platform to design new PES in order that the platform is tailored to the way knowledge is made available, exchanged and managed. This can be achieved through the use of assessment techniques of the PES design and deployment team processes, the actors involved and the maturity of the relationships in terms of strength of ties amongst the actors.
4 Collaboration Management

The complexity of product services and processes are continuously increasing and therefore an individual is not able to design and develop them on their own. The design or development process requires a group of specialists from complementary backgrounds and domains to work together. Since collaboration is required in almost every design and development project, managing collaboration becomes crucial in these projects. Nevertheless it could be difficult to achieve for a number of reasons. Each of the specialists working on a design or development project has their own domain-specific language and or culture and could well be working in distributed geographical locations. In the case of small or medium companies this is due to the fact that design and development occurs in collaboration with other subcontractors. However, in order to lower engineering costs, large firms tend to move not only manufacturing overseas but also design and development.

Collaboration management has a strong impact on development costs, time and the developed product quality. As the ability to collaborate is not natural and has to be developed, it is seen by many as a competitive advantage, especially for international corporations [16].

4.1 Collaboration Barriers

However in order to support collaboration, companies need to recognise and overcome the difficulties and barriers that hinder collaboration. Patel et al. [17] identified a general list of barriers to collaboration taking human factors’ contributions into consideration (Table 1).

<table>
<thead>
<tr>
<th>Type of barrier</th>
<th>Exemplary way of occurring</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-supportive organisation</td>
<td>No culture of collaboration; systems geared to individual work</td>
</tr>
<tr>
<td></td>
<td>Weak senior management</td>
</tr>
<tr>
<td></td>
<td>No commitment of resources to collaborative working</td>
</tr>
<tr>
<td></td>
<td>Poor communication and low levels of trust</td>
</tr>
<tr>
<td></td>
<td>Non-participatory structures and processes</td>
</tr>
<tr>
<td></td>
<td>Lack of support through training, supervision etc.</td>
</tr>
<tr>
<td>Inadequate supply chain and partnering arrangements</td>
<td>Mismatch or conflicts in leadership styles, culture, performance measures and goals</td>
</tr>
<tr>
<td></td>
<td>Inability to see constraints faced by partners, or others’ perspectives</td>
</tr>
<tr>
<td></td>
<td>Differences in technical support, networks, systems availability</td>
</tr>
<tr>
<td></td>
<td>Reduced or no face-to-face time</td>
</tr>
<tr>
<td></td>
<td>Poorer coordination, communication and trust</td>
</tr>
<tr>
<td></td>
<td>National or cultural differences</td>
</tr>
<tr>
<td>Weak management</td>
<td>Weak team identity and weak identification with company/project goals</td>
</tr>
<tr>
<td></td>
<td>Sub-optimality - prioritisation of function or department performance at expense of total company performance</td>
</tr>
<tr>
<td></td>
<td>Concentration on technical skills rather than collaboration skills</td>
</tr>
<tr>
<td></td>
<td>Allowing divisions to grow and conflicts to remain unresolved; avoidance of issues</td>
</tr>
<tr>
<td></td>
<td>Allowing knowledge not to be shared, or people to opt out of collaboration</td>
</tr>
<tr>
<td>Poorly conceived, planned or managed projects</td>
<td>Lack of project goals’ definition</td>
</tr>
<tr>
<td></td>
<td>Rigid organisational hierarchies</td>
</tr>
<tr>
<td></td>
<td>Poor transfer of collaboration experiences from other projects</td>
</tr>
<tr>
<td></td>
<td>Poor choices in personnel mix in project team selection</td>
</tr>
</tbody>
</table>
Lack of care over face-to-face and especially virtual team meetings
Little organisational support for project

Reliance on technology fix
Collaboration which is technology availability push-led rather than user needs’ pull-led
Overly optimistic views on technology capabilities
Overly pessimistic views on technology capabilities
Poor technology interfaces
Poor technology implementation

Different knowledge held by different partners without clarity
Inadequate project central knowledge store
Lack of clarity on confidentiality of knowledge for different partner companies
Reluctance of individuals to release, or even share, their own (tacit) knowledge

High start up costs, including technology cost
Unknown or out of control running costs
Cut backs on technical/communications’ support
Attempts to collaborate across too many business units
No examination of cost-benefit and opportunity cost of collaboration

Although the above list is an extensive one, it does not indicate which barriers are the most common ones. Hansen and Nohria [16] conducted a survey on a group of managers from more than hundred companies. Their aim was to identify dominant barriers to collaboration within multinational corporations. As a result the following four barriers have been distinguished:

- **Unwillingness To Seek Input and Learn From Others.** This may be very troublesome for development projects because they rely on the exchange of knowledge and good problem solving. This barrier occurs when employees from one company or department close themselves in and do not want any help from employees from other companies or departments. This may happen:
  - in a work culture where people are expected to solve problems by themselves without asking for help,
  - when reward systems give more credit for heroic individual problem-solving than for collaborative work,
  - employees believe that others have nothing to teach them.

- **Inability To Seek and Find Expertise.** This barrier influences development projects heavily. The lack of expertise in development projects may lead to ‘reinventing the wheel’. This barrier occurs when employees cannot find the appropriate expertise which could be due to the size of the organisation or its culture. Ward and Sobek [18] pointed out that engineers may spend more than half of their time looking for information or expertise when they could have spent the time on developing a product service or a process.

- **Unwillingness To Help.** This barrier influences the development project in a similar way as the first one – it prevents the knowledge from flowing between stakeholders and problems not being solved. It occurs when employees are reluctant to share what they know which might be due to:
  - a company’s culture that does not foster knowledge sharing,
  - performance management that is focused on individual performance. In such a situation people will be more focused on their individual performance instead of team work,
  - contradicting goals that make people focus on optimizing their own area/department and leads to sub-optimization.

- **Inability to Work Together and Transfer Knowledge.** In development projects this barrier may significantly slow down knowledge transfer or problem solving, especially in the case of tacit or specific knowledge. This barrier appears when employees are willing to collaborate but cannot easily exchange knowledge due to a lack of context, culture or domain understanding. It also appears when a majority of the knowledge related to a project that should be the subject of communication is tacit and not explicit.
A common factor amongst the above barriers is a lack of social skills and poor company culture that does not support collaboration. But when one focuses directly on design and development projects, the emphasis on social aspects becomes apparent. Experts say that the success of software design and development projects depends more on the social skills of stakeholders involved rather than solely on their technical and engineering skills [7]. Therefore companies willing to improve their collaboration should primarily focus on improving their business culture which will ultimately develop employees’ social skills.

4.2 Business Culture

In their work on exploring the underlying concepts necessary to create a collaborative culture, Gautier et al. [19] introduced a theoretical model identifying four main requirements: learning, communication, trust and respect, as illustrated in [20].

In design and development projects a business culture that better supports collaboration results in shorter development lead times, better scheduling, etc. An example here may be Toyota. In the nineteen-eighties, the Japanese automaker collaborated with their suppliers on an outstanding scale. The supplier share of engineering was 51% in comparison to only 14% in America.

![Figure 5: Requirements of a collaborative culture](image)

The large engagement of suppliers in the development process has not influenced the development process negatively. More than that – Toyota has collaborated with suppliers so well that during recent research only 5% of Toyota suppliers reported having significant problems working with Toyota compared to 50% of U.S. automakers’ suppliers [21]. The fact that there were only a small number of suppliers raising significant problems with Toyota was a result of collaboration-supportive business culture. Such success is due to meeting the requirements necessary for creating a collaborative culture (Figure 5). Examples of good practice can refer to their building long-term relationships with suppliers based on trust, using a semi-standard one-page format tool for communication to ensure common understanding, clear objectives and project ownership. Furthermore, the use of appropriate medium like drawings, charts, equations, words, and numbers assisted in creating a common understanding and open communication. The preparation for meetings and their efficient conducting enable continuous engagement and open communication. Finally, a “welcome problems” attitude focuses on solving problems and not searching for a guilty party which results in a no blame culture [18].
4.3 Oobeya – a tool for project team management, collaboration, performance monitoring and problems’ resolution

Oobeya is one of the tools used by Toyota product development to enhance collaboration. In many ways it reflects the company’s business culture. Oobeya was developed in the mid-nineties by Takeshi Uchimayada and his team. Mr Uchimayada was appointed as the chief engineer of Global 21 - a project that resulted in the development of both the Prius model and the Oobeya tool. Oobeya in Japanese means “big room”. In Toyota, the tool has been developed as a place where domain specialists met regularly (in the Prius case once every two days or so) together with the chief engineer responsible for the product development. The reason that Mr Uchimayada brought all the domain specialists into one room was very simple - he himself lacked the authority and knowledge required to make optimal decisions. As a solution he developed a space where other domain specialists were available to support him in the discussion and decision-making [22]. The most important information relating to the project is gathered inside Oobeya and visualised on the walls as graphs, charts etc. Oobeya’s focus is on collaboration and communication, so the project’s objectives, issues, schedule, milestones, progress versus plan, counter measures to existing problems and other useful information are depicted on the walls [23] [24]. Thanks to the easily accessible information to the whole team, the Oobeya enforces and speeds up learning in the Plan-Do-Check-Act cycle (PDCA) (also known as the Deming cycle). Therefore, problems can be discovered and solved as early as possible. However, quick problem-solving is just a means to the real purpose of the Oobeya - to ensure project success.

The content of a typical Oobeya includes (1) Objectives’ Board, (2) a long-term schedule, (3) a short-term schedule (usually two weeks) and (4) an Issues Board hanging on the walls. Additionally, a projector with a screen to be used for meetings and high tables may be present (without any chairs to make the meetings last shorter). What makes this tool so powerful is not its layout, but the culture behind it: the open stating of project objectives, goals, KPIs, regular meetings of project team, regular KPIs and KGIs tracking, visualized updated project-related data available at a glance, concise reporting based on PDCA, openness to detect and raise issues, methodical problem-solving and task status tracking by visual colour coding. During these meetings, the boards are reviewed starting from Objectives’ Board and proceeding according to the order presented in Figure 6. This flow (Figure 6) follows on logically: it starts with more general information (objectives), follows-up with schedules and finishes with more specific information (issues).

The Oobeya board review should be as follows:

4.3.1 OBJECTIVES’ BOARD REVIEW

The objectives’ board is the most static element of Oobeya. It should not change every week, however some changes may occur during the project’s life cycle. The objectives’ board includes: Theme, Background, Objective, Policy, Target, Actions, Team Structure, Brief Schedule/Milestones, Key Process Indicators and Key Goal Indicators as presented in:

4.3.2 SCHEDULES’ REVIEW

During the Schedules’ review, a form based on PDCA is used. In order to keep the meeting focused, each referring person should be able to report in 3 minutes [25]. The report consists of 4 parts:

- Plan: “My target is…. I am on plan / ahead / behind. If behind I encountered such issues and plan to utilize these countermeasures”
- Do: “Towards my target, since last meeting I accomplished …”
- Check: “I learned the following… and because of that learning I will …”
- Act: “Next week I will…”

4.3.3 ISSUES’ BOARD

Between the meetings, difficult-to-solve issues may arise. These issues should be depicted on the Issues’ Board. An issue description should be clear, concise, and constructive. It should contain an analysis of the problem and a recommendation (however, it is better to raise an issue without recommendations than keep it hidden because of no recommendations). An issue description should also include the person’s name who raised the issue and the date it was raised. These issues should be examined at each review and advanced to senior management if necessary.

When properly used, Oobeya enhances the development of the company’s business culture and changes people’s behaviour [26]. The implementation of the Oobeya supports a company’s transformation towards a collaboration culture and is explained with some examples in Table 5.
Theme: **Supporting eco-driving via a mobile application**

**Background**
- 65% customers are sensitive to fuel costs
- Companies buying a car fleet are sensitive to fuel consumption and costs
- Eco-driving is trendy

**Objectives**
- Define final goal to achieve
  - Sell 2 million apps in 2 years
  - Generate profit of 0.5 million EUR for car manufacturer and 2 million for IT company in 2 years
  - Development project budget: 1 million EUR
  - App launch date: 10.03.2016 (12 months from start of development)

**Policy**
- Principal, shared value, ground rule
  - If problems occur we don't hide them (we have the "welcome problems" attitude)
  - If cross-sectoral problems occur top management will provide support with solving them

**Team Structure**
- Manager, leader, members
  - Project Leader (IT)
  - Hardware support (CM - car manufacturer)
  - Organizational chart

**Reason why reach the theme**
- Define final goal to achieve

**Key Goal Indicators**
- What to achieve (quantified target with due date)
  - Fuel consumption reduction
    - Project tasks burn down
    - 20% fuel consumption reduction thanks to app

**Key Process Indicators**
- What to do to achieve target
  - Including main project stages, milestones & responsibilities
  - Regular meeting time, responsibilities, follow-up routines

**Schedule/Milestone**
- Milestone 1: First users test 5 different versions of app prototypes - 15th May
- Milestone 2: 3 versions of app help to reach 7.4 l per 100 km in fuel consumption - 31st July
- Milestone 3: 3 different versions of User Interface in tests - 15th August
- Milestone 4: Integration of available solutions (3 app versions and 3 User Interfaces) tested with a positive result - 10th January
- Milestone 5: The final version of app and its User Interface chosen and ready to install - 28th February

**Management rules**
- Meet daily at 9:00 AM
- John facilitates the meeting, Ron updates KGI’s and KPI’s
- 2 issues weekly can be elevated to top management due to time constraints and effective problem solving

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**Figure 7 - Example of the Objectives’ Board**

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D200.11 Methodology for Collaborative Product Services & Process Design
Table 5 - Mapping Oobeya’s influence on requirements of a collaboration culture

<table>
<thead>
<tr>
<th>Requirements’ categories</th>
<th>Requirement of a collaboration culture</th>
<th>Oobeya’s influence on collaboration culture</th>
<th>How Oobeya influences collaboration culture</th>
</tr>
</thead>
<tbody>
<tr>
<td>Learning</td>
<td>Clear objectives</td>
<td>Positive</td>
<td>Oobeya requires clear project objectives to be established and agreed by all involved</td>
</tr>
<tr>
<td></td>
<td>Fate sharing</td>
<td>Neutral</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Experimentation</td>
<td>Neutral</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Project ownership</td>
<td>Positive</td>
<td>Part of Oobeya is to assign ownerships for the whole project and tasks</td>
</tr>
<tr>
<td>Communication</td>
<td>Jargon</td>
<td>Positive</td>
<td>Regular meetings and review of tasks allows jargon-related issues to come up and be clarified quickly</td>
</tr>
<tr>
<td></td>
<td>Common understanding</td>
<td>Positive</td>
<td>Developing the objectives’ board and reviewing it allows people to obtain a common understanding of the project</td>
</tr>
<tr>
<td></td>
<td>Complementarities</td>
<td>Neutral/Positive</td>
<td>Oobeya does not influence this requirement directly; however it requires depicting the team structure so if a lack of competences arises it can be visible</td>
</tr>
<tr>
<td>Trust</td>
<td>Common values</td>
<td>Neutral</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Shared risk</td>
<td>Neutral</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Understanding of each other</td>
<td>Positive</td>
<td>It focuses on the visualization of items important to the successful management of a project (objectives, schedule, issues) therefore enabling better understanding</td>
</tr>
<tr>
<td></td>
<td>Positive feedbacks</td>
<td>Neutral</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Continuous engagement</td>
<td>Positive</td>
<td>Regular meetings at Oobeya require continuous engagement</td>
</tr>
<tr>
<td>Respect</td>
<td>Open communications</td>
<td>Positive</td>
<td>The way reporting is undertaken during the Oobeya review supports open communication.</td>
</tr>
<tr>
<td></td>
<td>Understanding of each other</td>
<td>Positive</td>
<td>It focuses on visualization of items important to the successful management of a project (objectives, schedule, issues) therefore enabling a better understanding</td>
</tr>
<tr>
<td></td>
<td>No blame</td>
<td>Positive</td>
<td>Problem identification is a key part of Oobeya – therefore it requires a blame free culture so that people will not be afraid of raising issues</td>
</tr>
<tr>
<td></td>
<td>Continuous engagement</td>
<td>Positive</td>
<td>Regular meetings at Oobeya require continuous engagement</td>
</tr>
</tbody>
</table>

Developed at Toyota (and used as a development project standard), the Oobeya tool has gained popularity and is utilized in other companies including Scania (Sweden), Irwin Seating (U.S.), Lean Enterprise Institute (U.S.), Lean Enterprise Institute (Poland) etc. [27].

Since large companies have their own tools for managing product development projects, Oobeya is recommended for SMEs. It is also recommended to those large companies which utilize simultaneously several different project management tools and which do not have a common organization-wide standard project management tool.

A company should benefit from implementing the Oobeya when the organisation is experiencing difficulties with:

- a lack of project management standards,
- poor change management and poor communication
- too formalized project management standards
- an unrealistic project schedule and budget
- quick problem identification and solving.
5 Collaboration Profiling Models

This section presents the Maturity models to describe the capabilities and nature of the collaboration amongst the PES design team actors and also the Model Driven Configuration methodology that provides a manufacturer with a profile of attributes that indicate the maturity or sophistication of each element of the processes involved in collaborative PES design.

5.1 Maturity Models

Some of the earliest known examples of maturity models include a hierarchy of human needs [20], which remains widely taught in social sciences, and others relating to economic growth [28] and the stages of growth for information technology in organisations [29]. In particular, Nolan's model has been widely used by both academics and professionals and was the forerunner of many maturity models based on the sequence of levels' concept [30] which is still prevalent in maturity models widely used today.

Maturity models are used in many areas and they are generally deployed for three purposes:

- Descriptive: a maturity model is applied to assess the current situation where an organisation's abilities are evaluated against certain criteria [31] and the maturity model is used as a diagnostic tool [32].
- Prescriptive: a maturity model allows the identification of desirable target levels of maturity and provides guidance on measures to achieve increased maturity which provides benefits or improvements for an organisation [31].
- Comparative: a maturity model allows a comparative view to analyse or benchmark current capabilities and compare these with other assessments from internal or external organisations [32].

Within the ProSEco project a maturity model will be used to describe the capabilities and nature of the collaboration amongst PES design team actors which will enable the ProSEco platform configuration to be tailored to the composition of PES design team actors and the expected collaboration activities and innovation processes.

Maturity models are based on the assessment of competency objects with a goal to objectively verify statements about these objects with regard to their status, degree of usage and quality of their execution. Frequently used objects are organisations and related processes [33]. The different levels of maturity within the models are used to describe the different achievable levels of capabilities which may take the form of specific skills, use of processes, actions to ensure quality or reliability and many other factors. Different definitions of maturity models can be found in the literature including:

- "Maturity models describe the evolution of a specific entity over time. Commonly, this entity is an organizational area or function" [34].
- "Maturity models are used to describe, explain and evaluate life cycles. The basic concept of all models is based on the fact that things change over time and that most of these changes can be predicted and regulated" [35].

In actual practice maturity models have been well-established and are widely used in support of monitoring and improving business performance including:

- Quality management of software and software development
- Project and process management
- Knowledge management and e-learning
- Analysis of the state of business processes
- Use of best practices for product and business innovation

The most prevalent model for measuring maturity levels and the basis for many variant maturity models is the Capability Maturity Model (CMM) from the Software Engineering Institute (SEI) of Carnegie Mellon.
University [36]. The five step evaluation scheme was originally established for use in evaluating the quality of the software development processes of suppliers to the U.S. Department of Defence [37] where the maturity levels of CMM were designed to provide an indicator for the capability of an organisation to develop and deliver software with the required quality levels and within specified financial and time constraints. Over the years many maturity models have been created that use model-based assessment techniques for understanding current practices and providing guidance towards increased performance [38]. One such model closely related to PES design and development is the Business Process Maturity Model (BPMM) published by the Object Management Group [39]. The BPMM adapts the five step maturity model of CMM to address a wide variety of business operations (see Figure 8).

The BPMM provides a framework for evaluating the nature of PES design and deployment activities and, in particular, the maturity of the collaboration amongst the actors within the PES design teams. Of particular interest is the guidance provided by BPMM on the types of work outputs that characterise each maturity level which are strongly correlated with the tools and functionalities of the ProSEco platform.

The SPICE (Software Process Improvement and Capability Determination) model also evolved from the original CMM model and is an international ISO standard for process evaluation [40]. Specification development was initiated under ISO in 1993 to support the development and validation of a practical standard for process improvement. The initial versions focused exclusively on software development processes while, in later versions, it was expanded to address all processes relating to software life cycle, project management, configuration management, procurement, e-learning and quality assurance [36]. The underlying approach of the SPICE Model can be used for process improvement as well as for capability determination [41], the latter being of particular interest as a methodology for the evaluation of the capabilities of new and existing PES design teams. The SPICE model enables organisations to use the standard in three modes: process capability determination, process improvement and self-assessment. SPICE includes the evaluation of the capability, effectiveness and quality of processes and organisations.

The particular use of a maturity model within ProSEco is not focused on encouraging a fulfilment of a sequence of levels toward a final state, but instead toward factors that determine the status and capabilities of the PES design team and associated processes. In particular, the intent is not to encourage or prescribe that PES design teams should seek to achieve or even progress through different levels of maturity. Rather, the maturity model in ProSEco is a useful and relatively precise tool to assess the design team situation and determine the initial configuration of the ProSEco collaboration framework and associated tool parameters. The expected benefit for the PES design teams in using the maturity model is to increase immediate usability, to enable certain features that are important given the nature of the relationships and ties between actors and the organisations they represent, and to not overwhelm a PES design team with advanced features they are not yet capable of exploiting.
The ProSEco approach is based on the assumption that predictable patterns exist in the design and deployment of new and innovative PES. These patterns will be conceptualised as processes that perform at defined maturity levels. The maturity implies progress in demonstrating specific capabilities or achieving targets, from an initial state where few capabilities regarding collaborative PES design are considered, to more sophisticated and longer term states, where capabilities are more complete. Each level will describe different degrees of collaboration maturity of the PES design team with each maturity level to be defined by specific characteristics.

The determination of the collaboration maturity level will be carried out by using assessment methods. The predefined requirements and characteristics will be analysed and validated (i.e. by means of questionnaires, checklists, and procedures for their use) and the status of the collaboration maturity for a specific PES design team situation determined. Based on the actual maturity status, a specific platform configuration, tool usage and tool parameters can be derived to maximise the efficiency, productivity and business impact of the ProSEco platform and tools for a specific set of PES design team actors.

5.2 Model Driven Configurations

The ProSEco collaboration assessment methodology will be used to assess the maturity and other aspects of the collaboration processes of industrial organisations involved in the design and deployment of PES. The methodology will provide a manufacturer with a profile of attributes that indicate the maturity or sophistication of each element of the processes involved in the collaborative PES design.

The assessment profile will be based on an underlying generic collaboration process model consistent with international standards and representative of best practice for project team collaborations that is broad enough to reflect the differing collaboration styles found in industrial organisations irrespective of whether design teams are intra- or inter-company in their composition. The use of a profile for reporting the outcomes of the assessment accommodates the fact that:

- not all collaboration processes need be present in every PES design team, and
- Manufacturers and third-party PES partners may have very different collaboration profiles due to the type of products they produce, how they use ICT, the services they seek to deliver, and their specific business goals and objectives.

The methodology will provide an assessment vehicle that allows for the PES design teams to determine their current capabilities and for the ProSEco platforms to utilise specific collaborative attributes that influence which ProSEco tools and features are of the highest priority to be utilised and their respective initial or default configuration parameters at system instantiation or at launch of a new PES design project. Once the ProSEco platform has been configured for a specific PES design team or project, the team can selectively expand their use of ProSEco tools and features that support their evolving capabilities to share, evaluate and exploit available product and production knowledge to create new PES innovations.

5.2.1 Collaboration Assessment Methodology Components

The ProSEco collaboration assessment methodology will provide an instrument for analysing PES design teams interested in collaboration through the introduction of ProSEco technologies and collaborative PES design processes. It will provide an indication of readiness for adopting the ProSEco technologies and specific characteristics of the PES design team and associated processes that should be considered when configuring the ProSEco platform. The objective of the methodology is to minimise the start-up time and maximise the benefits of the technology innovations being developed in the ProSEco project for the manufacturers.

The three essential components of the ProSEco collaboration assessment methodology will be as follows:

- Collaboration Profiling Model
- Collaboration Profiling Method
- Collaboration Profiling Tool

The collaboration Profiling Model utilises the same methods defined in the Reference Model specified in the SPICE standard for process assessment [40] and extends this standard to support additional
processes relating to collaborative PES development. The extensions to SPICE will be based on a subset of the generalised collaboration model for product design teams developed in the European Commission funded CoSpaces project [42] with adaptations and extensions to address specific attributes for PES design and deployment. The Profiling Method defines how an assessment shall be performed and a collaboration capability profile created. The Profiling Tool collects assessment data and is used to carry out the analysis to determine a recommended initial configuration of a ProSEco platform and toolset for a specific PES design team. Figure 9 shows the relationship of the various components in the ProSEco collaboration assessment methodology.

Figure 9: Components of the ProSEco Collaboration Assessment Methodology

5.2.2 PROFILING MODEL

The profiling method describes the usage of the profiling model, profiling methods and profiling tool in the overall collaboration assessment process. Attribute indicators, which are used to support profiling, are embodied within the profiling tool. The indicators are used as guides in collecting the evidence that enables the assignment of ratings to collaborative process attributes.

The profiling model architecture will be constructed in two dimensions:

- Process dimension - characterised by process purpose statements which are the essential measurable objectives of a process
- Process capability dimension - characterised by a series of process attributes, applicable to each process, which represent measurable characteristics necessary to manage a process

In order to support an assessment of the performance and capability of an implemented process, the profiling model provides for the definition and use of profiling indicators.

In the process dimension, each process will have a defined set of associated input and output work products which may be evidenced when judging the performance of the process. In the capability dimension, each process attribute has associated with it a number of practices. Associated with each process attribute for each and every process are a number of defined practices and practice indicators. The practices and their indicator set will be contained within the profiling tool.

The practices and practice indicators, together with the input/output work products and their characteristics, all represent types of evidence that would substantiate the extent to which a process attribute is being achieved.

5.2.3 PROCESS DIMENSION

The processes in the process dimension are grouped into five process groupings, each of which contains several process categories according to the type of activity they address:

- **Teamworking** processes are associated with collaborative teams being productive and efficient in working together to complete design tasks.
- **Delivery** processes consist of the process categories that are undertaken specifically to complete collaborative design project objectives.
- **Lean** processes are those associated with implementing well-established Lean Management best practices when carrying out design tasks.
- **Support** processes are those associated with the organisational and technological environments in which collaborative teams operate.
- **Organisational** processes are essential for establishing and managing collaborative teams in completing a wide range of project objectives.

Process categories and processes provide a grouping by type of activity. Each process will be described in terms of a purpose statement. These statements comprise the unique functional objectives of the process when instantiated in a particular environment.

### 5.2.3.1 Teamworking processes

Specific areas to be assessed relating to how the actors within a team work together to carry out the tasks associated with PES design are shown in Table 6.

**Table 6: Teamworking processes and assessment areas**

<table>
<thead>
<tr>
<th>Processes</th>
<th>Assessment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Roles</td>
<td>Identification of specific responsibilities and positions (roles) as well as associated tasks and activities within the team.</td>
</tr>
<tr>
<td>Composition</td>
<td>Variability in team member roles, organisations represented, expertise and skills, and size.</td>
</tr>
<tr>
<td>Strength of Ties</td>
<td>Nature of the links between team members in terms of informal (personal), organisational, inter-company and contractual relationships.</td>
</tr>
<tr>
<td>Workflow</td>
<td>The extent to which team members have a shared culture, vocabulary, established working practices and group norms.</td>
</tr>
<tr>
<td>Structure</td>
<td>The structure of team member roles and the nature of the role relationships (e.g. hierarchy, star, sequential) and the degree of enforcement.</td>
</tr>
</tbody>
</table>

### 5.2.3.2 Delivery processes

Specific areas to be assessed relating to how the team carries out the tasks associated with PES design are shown in Table 7.

**Table 7: Delivery processes and assessment areas**

<table>
<thead>
<tr>
<th>Processes</th>
<th>Assessment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Information Production</td>
<td>Individuals’ and the team’s capabilities to produce the required information of the right quality, at the right time, and make it available for access by the right people.</td>
</tr>
<tr>
<td>Decision Making</td>
<td>The way decisions are made, the level of involvement of actors, and how decisions are communicated to the team.</td>
</tr>
<tr>
<td>Communication</td>
<td>Degree of information exchanged as required by the task, and conveyed to the right people at the right time and in the appropriate way.</td>
</tr>
<tr>
<td>Coordination</td>
<td>Setting of goals, managing and monitoring time and schedules, integrating people and information, and providing feedback on the status and performance.</td>
</tr>
<tr>
<td>Cooperation</td>
<td>Time allocated to working together, level of dependency between team members, and degree of commitment to common goals and target outcomes.</td>
</tr>
</tbody>
</table>
5.2.3.3 Lean processes

Specific areas to be assessed relating to how the team utilises related Lean Management practices to carry out the tasks associated with PES design are shown in Table 8.

Table 8: Lean processes and assessment areas

<table>
<thead>
<tr>
<th>Processes</th>
<th>Assessment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Work Standardisation</td>
<td>Degree to which team members and their organisations attempt to standardise tasks and work practices.</td>
</tr>
<tr>
<td>Part Standardisation</td>
<td>Extent to which team members and their organisations seek to standardise components used in products and product-service designs.</td>
</tr>
<tr>
<td>Supplier Involvement</td>
<td>Degree to which suppliers are maintained long-term and their involvement in new product designs.</td>
</tr>
<tr>
<td>Performance Evaluation</td>
<td>Extent of which team members and their organisations establish performance indicators and targets and monitor their achievement.</td>
</tr>
</tbody>
</table>

5.2.3.4 Support processes

Specific areas to be assessed relating to the support processes for a team to carry out the tasks associated with PES design are shown in Table 9.

Table 9: Support processes and assessment areas

<table>
<thead>
<tr>
<th>Processes</th>
<th>Assessment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Knowledge Management</td>
<td>The degree to which the organisations supporting the team ensure that knowledge is captured, structured, stored, and made available as necessary.</td>
</tr>
<tr>
<td>Collaboration Tools</td>
<td>The nature and extent of use of existing tools available to teams for collaborating when co-located and at distance.</td>
</tr>
<tr>
<td>ICT Infrastructures</td>
<td>The nature and extent to which teams have available and are required to utilise specific infrastructures relating to data management, security, conferencing, documentation, and other ICT.</td>
</tr>
<tr>
<td>External Resources</td>
<td>Degree of accessibility to actors outside the team with specific skills that might be required.</td>
</tr>
</tbody>
</table>

5.2.3.5 Organisational processes

Specific areas to be assessed relating to the organisational processes that affect the ability to carry out the tasks associated with PES design are shown in Table 10.

Table 10: Organisational processes and assessment areas

<table>
<thead>
<tr>
<th>Processes</th>
<th>Assessment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trust</td>
<td>Degree of trust amongst team members considering personal / informal and impersonal / institutionalised dimensions.</td>
</tr>
<tr>
<td>Conflict</td>
<td>The degree to which conflicts have occurred, or are likely to occur, due to a range of factors including personal, organisational, process, risk taking and others.</td>
</tr>
<tr>
<td>Goals</td>
<td>Degree to which individuals and the teams have a clear understanding of tasks and project goals and objectives.</td>
</tr>
<tr>
<td>Integration</td>
<td>Degree to which common practices and procedures are applied across teams where appropriate.</td>
</tr>
</tbody>
</table>
5.2.4 PROCESS CAPABILITY DIMENSION

Process capability is expressed in the profiling model in terms of process attributes grouped into capability levels. Process attributes are features of a process that can be evaluated on a scale of achievement, providing a measure of the capability of the process. They are applicable to all processes. Each process attribute describes a facet of the overall capability of managing and improving the effectiveness of a collaboration process in achieving its purpose.

A capability level is a set of process attribute(s) that work together to provide a major enhancement in the capability to perform a process. Each level provides a major enhancement of capability in the performance of a process.

There will be six capability levels in the profiling model aligned with the well-established CMM and BPMM definitions with respect to process capabilities:

- **Level 0: Incomplete**
  
  There is general absence of the process. There are little or no easily identifiable work products or outputs of the process.

- **Level 1: Initial**
  
  The purpose of the process is generally achieved. The achievement may not be rigorously planned and tracked.

- **Level 2: Managed**
  
  The process delivers work products that are managed and controlled and the process is planned and tracked. Work products conform to specified standards and requirements.

- **Level 3: Standardised**
  
  The process is performed and managed according to well-defined process definitions with evidence of the achievement of quality in the process outcomes.

- **Level 4: Predictable**
  
  The process is performed, managed and standardised using an established process. The standardised process and its tailorability are stable.

- **Level 5: Innovating**
  
  The process is carried out efficiently and effectively to achieve its established goals. Metrics are defined and adopted in the process, and detailed measures of performance are collected and analysed.

In addition, a set of attributes will be associated with each process which will be evaluated on a four point ordinal scale of achievement. The process attributes provide insight into the specific aspects of the process capability required to support process capability determination and the overall maturity of each process.

5.2.5 CONFIGURATION OF COLLABORATION SERVICES

The Profiling Method will define how an assessment shall be performed to determine the collaboration capabilities of a PES design team that will utilise the ProSEcO platform. The Profiling Tool collects the assessment data needed to create a Collaboration Profile for a specific PES design team by identifying key characteristics and capabilities of the PES design project, the actors, the infrastructures and the organisations involved. An analysis of the Collaboration Profile determines an appropriate initial configuration of the collaboration services provided by the ProSEcO platform. Figure 10 shows the relationship between a Collaboration Profile and the typical configurable elements of the collaboration services that could be adapted for a specific PES design team.
Depending on the maturity of the collaboration within the PES design team, specific parameters, templates and workflows would initially be set, and certain features and options made more or less visible when instantiating the ProSEco collaboration services for a new PES design project. The objective is to reduce the start-up time for the team and provide a configuration for collaboration services already adapted for the specific team and project requirements that will increase productivity, while not overwhelming the team with features that are beyond their current collaboration capabilities or not aligned with established team and organisational procedures and policies.
6 Collaboration Services

The CoSpaces project [43] identified three distinctive but interlinked services required within a collaboration service platform. These services are; communication services, coordination services and co-operation services. A detailed description for these services is provided below.

6.1 Communication Services

Communication is important for collaboration to attain good quality team work. A software project’s success is highly dependent upon knowledge acquisition, information sharing and integration. Better communication services among participants is directly proportional to the quality of work and to the degree of satisfaction [44]. A communication system used to support geographically dispersed team members can have a significant impact on team productivity, perceived interaction quality, and group process satisfaction [45].

Due to the geographically dispersed locations of the ProSEc project’s team members, it is not easy for the participants to have face-to-face interactions very often. Therefore, proper communication channels are required for the participants to collaborate with each other during the progress of the production process.

Since communication is the central activity of any project, whether it is verbal or visual, the majority of time is spent in some form of team interaction where the use of artefacts and visual representations of the design becomes crucial. This is because complex designs and engineering concepts are constructed through continuous interaction between multi-disciplinary actors [46] and, therefore, a tremendous amount of collaborative work is required to achieve shared thinking, shared planning and shared understanding [47].

Since communication is a core element in creating a collaborative culture [19], it has become one of the on-going challenges that team members face, that is essential to the success of any project [48][49]. To facilitate communication, regular meetings are usually organised throughout the entire project life cycle to identify any potential issues among the various competencies [50]. Previous research [51] shows that collaborative workspaces with direct and indirect communication channels can significantly enhance communication and collaboration. This is because team members could explore more design alternatives, were supported in their design discussions, were able to solve design problems and identify mistakes earlier.

6.1.1 Communication for Detailed Product Design

During the design and development phases of the PES development life cycle (PESDLC), the communication services will be provided by (1) audio and video sharing and (2) document sharing to support different collaboration modes. However, a different set of tools is required to manage collaboration among actors during the flow of the whole PES development cycle. An example of such tools is ‘the e-Barashi boards’ discussed in section 4.

In order to understand how people can communicate and interact with each other during these meetings, it is important to study the conceptual model of the multi-user interface illustrated in Figure 11 as presented by Miles et al. [52]. In this diagram, one can see that, in order to enable a shared understanding or shared goal (channel e), participants need to interact with each other either directly (by channels a and d) or indirectly (by channels b and c). Examples of direct communication are face-to-face speaking, hand gesturing and eye contact (channel a) or making a reference to the artefact (channel d). Indirect communications are those occurring interactively to or through the artefacts such as physical and virtual objects (channels b and c). A communication channel (channel c) implies that communication could take place when a participant is performing an operation such as direct manipulation or undertaking changes to the artefact which is directly visible to the others. A communication channel (channel b) implies that the participant can perform an interaction task independently and then communicate it to others by making the artefact available to them.
The implementation of these communication channels in project meetings is a challenging task since it involves multi-disciplinary teams and complex artefacts. Typically, multi-disciplinary teams collaborate in four different modes as identified by Huifen et al. [53] as illustrated in Figure 12: face-to-face (same place, same time), synchronous distributed (different places, same time), asynchronous (same place, different time) and asynchronous distributed (different places, different time). The approach for establishing these communication links in each mode can vary, each providing a different degree of "bandwidth" in conveying the intended message to others. For example, face-to-face meetings provide a high bandwidth for channel (a) since gestures, eye contact and body language could easily be communicated to others, whereas the synchronous distributed mode has a lower bandwidth in transmitting such human behaviour due to the limitations in current tele-immersive technologies.

The purpose of channels (c) and (d) implies that these channels should be formed within a shared workspace since any interaction with the design artefact by a participant should be directly visible to others. The purpose of channel (b) is to provide independent interaction with the design artefact and then to allow the possibility of transmitting changes made to the artefact by a participant to other participants.

As explained earlier, the above channels will support communication for the design of the PES, while the Oobeya tool will be used to manage collaboration among actors to manage task/events smoothly and effectively.

As a part of the communication services, the PES Collaboration Platform also presents “Eco-Observation Wall” which provides an opportunity to the users to analyse the facts and findings around a product, to explore new ideas and to apply them in a new business model. Detail description of this tool is provided in the next section.
6.1.2 Eco-Observation Wall

The innovation processes when applied to PES may involve new actors and roles both within these manufacturing organisations, as well as from outside the organisation such as existing and new supply chain actors and third-party service providers.

As already described in Section 3.1, new competencies and capabilities may need to be introduced that are not exclusively part of the traditional engineering design team as PES design and development teams must often manage product-around knowledge and data in a “shared context” across functional and even organisational boundaries to create new PES that deliver value for customers throughout the lifespan of the manufactured products. Therefore, PES innovation process will rely on the eco-Observation Wall, where all the data, knowledge and thoughts around the product is captured. This tool is more than just a container of data; it is a thinking tool that allows the PES designer team to explore different approaches of the product taking into account the life-cycle perspective, the sustainable principles and the eco-innovation strategies to finally identify concrete problems and the needs of the current reality that should be solved as well as exploring new opportunities for capturing product and use knowledge and applying these towards the design of new and innovative PES.

The rationale behind the tool is to build a common understanding of the needs and problems of the user in context through a deep, empathetic and multidisciplinary journey following the steps showed in the Figure 13.

![Figure 13: Eco Observation Journey](image)

Further elaboration of the Eco-Observation Wall is provided in D300.11 where it explains the eco-observation journey process step-by-step in more detail.

6.1.3 OobeYA Tool

Since communication services will be provided through audio/video conferences, document sharing, eco-observation wall etc., there is still a need of some management techniques/services that ensure the use of communication services effectively. In this regard, OobeYA is presented in this report as a management tool to address this issue.

OobeYA will be presented as a dynamic web-bases tool that can be accessed through the ProSECo portal. The data for the OobeYA will be mainly in an Excel-type spread sheet and will be easily editable. This data will be accessible after logging into a user account.

Detailed description of OobeYA tool that how it will manage the communication services among participants is already presented in Section 4.3.

6.2 Coordination Services

Himmelman [54] defined coordination as exchanging information and altering activities for mutual benefit and for a common purpose. Coordination builds on networking (exchange of data/information) by adding behaviour, modifying activities and foci, mutual benefits and a common purpose. Coordination increases efficient use of resources and the ability to meet community needs.

Managing a step-by-step workflow of the whole process, elaborating the number of activities taking place at each subsequent level, from the start of the PES development process to the deployment of the final
product defines the coordination services. Defining the workflow for each particular phase eliminates the collaboration barriers among heterogeneous groups as well as inter-organization team members and facilitates participants understanding the project in more detail. Event management/role management in intra-organizational as well as cross-organizational scenarios also help to coordinate the services effectively.

With regard to the PES development process, the whole workflow (that will be defined in terms of actions/activities corresponding to each engineering tool and also who (actor) is responsible for all those activities in each phase of the cycle) facilitates the coordination services.

The coordination services to create a PES are leveraged by the following attributes:

1. Workflow of the collaboration process
2. Event/Role management
3. Access Control

### 6.2.1 PES COLLABORATION WORKFLOW

The collaboration will start at the “idea creation” stage where the actors get together to analyse the product performance in terms of eco-analysis and sensor data analysis and also to discuss the business activities, as shown in Figure 14.

The outcome of this collaboration will be shared to the rest of the partners as “new product features and business model agreement”. Once the existing product/system/business environment is analysed to finalize the new PES product/service requirements, the new business offer will be simulated under “market simulation” where the actors collaborate to agree the social acceptance through agent-based and system dynamic simulation. The output of these simulation activities will be collected and agreed as “business outcome forecasts”.

After the partners’ agreement on the expected business forecasts, the actors will collaborate together at the “knowledge management/data mining” stage to identify the product performance patterns and user behaviour patterns for the new product. This will help in identifying the data requirements that will be agreed by the partners as AmI data specifications. After recognizing the kind of data that will be needed to design and develop new PES products and services, the actors will collaborate to agree on the selection of sensors as well as on the configuration of acquisition and storage conditions.

Once the kinds of sensors that will be used for the data collection are agreed upon, the next phase of the PES development life cycle where collaboration is required is “functional specifications”. At this stage, all the participants will agree on the functional specifications of the PES solution that will be provided by the ProSEco solution to a particular business case. This step leads to the “context modelling” stage of the PES solution providers to a particular business case. Whereas, in the collaborative session of the context modelling phase of the cycle, mutually agreed PES models will be defined and shared among the participants.

At the final stage of the design process of the PES development life cycle, the security policies and the enforcement points will be discussed in a collaborative session to get agreed for a specific security architecture that will be implemented for a PES solution within a particular business environment.

Similarly, collaboration will also be required at the development phase of the life cycle, where PES will be orchestrated by the mutual agreement of the partners. Here, the participants will decide what modules will be created to provide a customized PES and what others can be reused from the ontologies’ shared repository. After the PES configuration, no significant collaboration is required to finish the process, so the collaboration workflow will be ended at deployment phase of the PESDLC.
Figure 14: Collaboration Workflow
Similarly, Coordination services will provide support for event/role management and access control. Access control will be managed by ensuring security constraints at each phase of the PES development life cycle.

6.3 Cooperation Services

Interaction among all the participants, who may belong to different sectors or different functional groups, to achieve a common task defines cooperation services.

In the PES development environment, all the actors who are responsible for the accomplishment of tasks/activities in their particular domain will share the information/data among themselves to manage collaboration. All this information/data will come as an output of a particular workflow (actions/activities corresponding to each engineering tool) and will be shared to other partners using the communication services integrated in the ProSEco platform, for instance such as ‘audio/video’ and ‘document sharing’. In this case, managing actors to provide timely output for each particular phase of the PES development process as well as managing tasks/activities corresponding to each engineering tool is collectively named as cooperation services. Here, all the actors who will be responsible for the development of a complete PES as well as all those actors who are responsible to successfully complete a particular stage of the PES development life cycle will be articulated and their roles/responsibilities will be assigned to them accordingly. Specifically speaking for PESDLC, the cooperation services will be provided in terms of:

1. Managing Actors according to their roles
2. Managing Activities corresponding to each engineering tool

The following sections highlight a generic list of possible actors who will participate in the creation of the PES product/services as well as the engineering tools that will help to accomplish the workflow for PESDLC.

6.3.1 ACTORS

This section identifies the platform actors’ profile within a collaborative process providing information on the role of each actor, their responsibility within the project and the nature of each role (Table 11).

It should be noted that the actors have been identified here in a generic way with reference to their roles/responsibilities according to the PES development life cycle phases, irrespective of the ProSEco four business cases. However, one (Final Users/Customer) can reconfigure this list according to the requirements of the PES and can synchronize it with a customized workflow process.

As identified in Table 11, the "OEM manager/CEO/ PES Manager” provides the supervisory services and most of the time will hold the authority to approve a particular phase of the PES development process and thus to proceed to the next. Such services include accessing the collected data to offer new services to the customer. This involves analysis of the product performance and business activities at the Idea Creation stage as well as the Market Simulation stage focusing on the user behaviour.

“Meta Product Designer Teams” may consist of product manager, industrial designers, marketing managers and/or environmental experts who will take part in simulating the market against a particular PES to foresee its market value and to provide expected business outcomes.

“Observers” are the ones who may go to the place where the product is installed to analyse its working and to identify the hotspots that needs to be considered to provide improved extended services.

Later on in the process and during the Functional Specification stage, the OEM collaborates with the System Designer to define these specifications. Throughout the whole process, the OEM acts as a supervisor authorising the following stage.

The role of the “System/PES Designers” can have different descriptions in various organisations although their generic role is to design new Meta product/process/services. The “System/PES Designers” collaborate with different actors throughout the software design stages (3-7). At the Knowledge Specification and Data Mining stage, the System Designer collaborates with the “R&D team” to identify product performance and user behaviour patterns. Then during the Ami Selection stage, the System Designers team collaborate to agree on the selection of sensors. Following this, the System
Designers collaborate with the OEM to define the functional specifications. System Designers then share context models before specifying the security policies with the “Security Manager/Architect”.

“System/PES Developers” (usually referred to as System Engineers/Firmare Engineers) are responsible for the PES development and PES configuration during the Software Development phase, while the “System Installers”, “System Administrators”, “Security Administrators” and “Infrastructure Operators” are responsible for executing PES during the Deployment phase.

The “Customer/Final Users” who will be the product users have an essential role in this process. The users can identify new requirements and can provide feedback about the product design at the Idea Creation stage. The role of the “Eco-friendly group” which is an optional one exists in the BC of VW is to explore individual data streams to understand trends, discuss possible business opportunities for PES development and influence policies as well.

Table 11- Specific actors in the ProSEco business cases including their profiles, roles and project responsibility

<table>
<thead>
<tr>
<th>Actor</th>
<th>Role/project responsibility</th>
</tr>
</thead>
<tbody>
<tr>
<td>OEM Manager/CEO/PES Manager</td>
<td>Process supervisor and authorises the next phase.</td>
</tr>
<tr>
<td>Meta Product Designers</td>
<td>Provides marketing advice.</td>
</tr>
<tr>
<td>(Product managers/Industrial designers/Marketing managers/Environmental experts)</td>
<td></td>
</tr>
<tr>
<td>Observer (Company Employee/Market Designer/Industrial Designer)</td>
<td>Observes the use of the product and provides user behaviour data accordingly.</td>
</tr>
<tr>
<td>R&amp;D Team</td>
<td>Provide user behaviour data analysis and patterns</td>
</tr>
<tr>
<td>System/PES Designers</td>
<td>Designs new PES for the customer.</td>
</tr>
</tbody>
</table>
| Security Manager/Architect | Provides security configurations 
Specifies security policies |
| System/PES Developer (System Engineer/Firmware Engineer) | Provides PES specific development 
Provides PES configurations/orchestrations |
| System Installers | |
| System Administrators | |
| Security Administrators | |
| Infrastructure Operators | PES deployment |
| Customer/Final User | Provides requirements and feedback regarding product design |
| Eco-friendly group | Explores data and discusses eco-business opportunity |
### 6.3.2 Engineering Tools

Table 12 provides a list of all those engineering tools, with their corresponding inputs and outputs, responsible for providing the ProSEco services that will facilitate cooperation services.

#### Table 12 - PES engineering tools - Input and Output

<table>
<thead>
<tr>
<th>Tool</th>
<th>Input</th>
<th>Output</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eco-Tool</td>
<td>Processes: production, energy generation, transport and disposal scenarios&lt;br&gt;Products: A product can be an assembly of several materials, processes or even services&lt;br&gt;Services: A commodity service&lt;br&gt;Materials: Brass, Copper, Wood, etc.&lt;br&gt;Inventory quantities: mass, energy, time, etc.&lt;br&gt;User selected variations&lt;br&gt;User selected parameters&lt;br&gt;User selected processes&lt;br&gt;User Selected Impact method</td>
<td>Impact calculation: Accessed by user interface or API from the Configuration tool&lt;br&gt;Eco-innovation strategies: Accessed by a user interface</td>
</tr>
<tr>
<td>Eco-Observation Wall</td>
<td>Product or Process for which one wants to create a new PES&lt;br&gt;Eco-innovation strategies&lt;br&gt;Final User and Customer observation&lt;br&gt;Company vision and Product Evolution</td>
<td>Conceptualization of new PES</td>
</tr>
<tr>
<td>Simulation of Meta Products</td>
<td>Product or Process for which one wants to make the PES&lt;br&gt;Inputting of discrete numeric data rating scores for the attribute criteria of own potential PES offerings under design / development, and for competitors’ PES offerings: e.g., customer functional expectations such as ease of use, AmI, lean, eco, purchase price, etc.</td>
<td>Simulation results in the form of, for example, line graphs, bar charts, sensitivity diagrams, which provide visual comparisons of answers to “what if” questions about alternative PES designs</td>
</tr>
<tr>
<td>Engineering tool for definition/design of AmI solutions</td>
<td>Product or Process for which one wants to make the PES&lt;br&gt;AmI systems/sensors that are available at the Product or Process</td>
<td>Concept phase: List of AmI systems/sensors at the Product or Process which will be used in the PES&lt;br&gt;Deployment phase: List of AmI systems/sensors that the Product</td>
</tr>
<tr>
<td>Configuration Tool</td>
<td></td>
<td></td>
</tr>
<tr>
<td>--------------------</td>
<td></td>
<td></td>
</tr>
<tr>
<td>The ontology in a formal definition.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rules to guide the Configuration process</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Instances of ontology classes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Configured instances of the classes in the ontology</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Documentation reflecting the configured instances</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Text files describing the instances (can be used as inputs for other systems)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Engineering tool for Context Modelling</th>
</tr>
</thead>
<tbody>
<tr>
<td>Product or Process for which one wants to make the PES</td>
</tr>
<tr>
<td>AmI systems/sensors that are available for the Product or Process and selected for the PES</td>
</tr>
<tr>
<td>Sector specific (or Business Case Specific) Context model (template for the PES specific context model)</td>
</tr>
<tr>
<td>Concept phase: PES specific context model (ontological context model)</td>
</tr>
<tr>
<td>Deployment phase: PES specific context model (ontological context model) which can be applied at the specific Product/Process variant</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Engineering tool for Security Architecture Design &amp; Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Application architecture</td>
</tr>
<tr>
<td>Preliminary security architecture</td>
</tr>
<tr>
<td>Security policy specification</td>
</tr>
<tr>
<td>Security adequacy analysis results</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Engineering tool for Security Policy Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Text or tabular representation of entities</td>
</tr>
<tr>
<td>Text or graphical representation of policy</td>
</tr>
<tr>
<td>Checked policy or error indications</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Engineering tool for Security Policy Database Builder</th>
</tr>
</thead>
<tbody>
<tr>
<td>A complete and consistent security policy specification</td>
</tr>
<tr>
<td>Policy database</td>
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<table>
<thead>
<tr>
<th>Collaboration Tools</th>
</tr>
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<tbody>
<tr>
<td>Define meeting objectives</td>
</tr>
<tr>
<td>Notify the actors who will participate</td>
</tr>
<tr>
<td>Files to share and view during Tele-conference</td>
</tr>
<tr>
<td>Agreement on new ideas and issues</td>
</tr>
<tr>
<td>Generate minutes of the meeting</td>
</tr>
<tr>
<td>Schedule another meeting (if required)</td>
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<table>
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<tr>
<th>Engineering tool for Customer and supplier behaviour (data mining)</th>
</tr>
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<tbody>
<tr>
<td>Desired series to be predicted</td>
</tr>
<tr>
<td>(Eventually) Storing of the Results</td>
</tr>
<tr>
<td>The behavioural pattern in the past</td>
</tr>
<tr>
<td>The expected behaviour for future</td>
</tr>
<tr>
<td>The Data Mining process is</td>
</tr>
<tr>
<td>Aml systems/sensors are identified and selected</td>
</tr>
<tr>
<td>And/or</td>
</tr>
<tr>
<td>Context model for the PES under development specified/defined</td>
</tr>
</tbody>
</table>
6.3.3 KNOWLEDGE MANAGEMENT

Knowledge Management (KM) is not a technology or a set of methodologies; it is truly a practice or discipline that involves people, processes and technology. KM is an evolving discipline that can be affected by new technologies and best practices.

KM is about the right knowledge available to the right people. Therefore, it is about making sure that all the knowledge generated inside an organization can be retrieved and used in other applications in order to start a learning process for creating benefit and competitive advantage.

![Multi Layered ProSEco ontological base](image)

In the context of the ProSEco project the entire software platform will rely on a rich KM solution as the foundation for any optimization, analysis, adaptation, and learning process.

In order to implement a useful KM approach, it is necessary to establish a common terminology to address every concept involved, a terminology that can be used by people, processes, and software. Such terminology is the basis for an ontology.
ProSEco KM will be based on a multi-layered ontological base. These ontologies’ construction and maintenance are part of the ProSEco Platform construction and development, and they can be achieved using already available tools, such as Protégé, or Semantic Configurator Builder.

During the ProSEco generic PES Design and Development workflow, these ontological concepts will be instantiated in different phases. In other words, at different stages of the PES development workflow, different knowledge artefacts will be created by the actors involved in the PES design process, such as:

- Specific instances of AMI Sensors parameterized to be used in a specific PES
- Specific instances of configured products which are involved in a PES design (for instance, a modelled ONA machine to be monitored)
- PES definitions of the specific PES under construction.
- Final PES solutions ready to be deployed
- Associated files (documents, drawings, etc.) attached to any of the previously mentioned items.
- LCA analysis for a specific solution.

In every step of this workflow, the reuse of previously existing elements similar to the one being created is clearly advisable and, therefore, the ProSEco Knowledge Base will allow for the search and reuse of any of the knowledge artefacts stored: the user will fill in a form, specifying the characteristics of the element he/she needs and the system will suggest a list of the pre-existing items that are compliant with such characteristics. This approach will be advised as a better alternative to creating everything from scratch.

This interaction with the ProSEco Knowledge Base can be achieved in many different technological ways, for instance, a web-services based API can guarantee its invocation from any other ProSEco tool.

6.4 Characteristics of a collaborative platform

This section briefly presents the overall system architecture approach in providing the three key services, Communication, Collaboration and Coordination services as illustrated in Figure 16.
In this architecture, the data layer will provide access to a range of data sources including user behaviour data extracted from AmI data, context models under discussions, emerging PES ideas, meta product designs and so on.

The service layer will provide access to a range of services for supporting collaboration. This layer will provide tools for supporting communication such as video, audio, chat, in addition to forums and blogs and Oobeya boards for managing collaboration. The communication services will also provide information about users such as their roles, profiles and will also keep the user aware of other team members’ status. The set of tools for supporting coordination in the service layer can include workflow, event management and access rights, while the tools used for supporting cooperation can include engineering tools, data sharing and annotation and brain storming. These services can be accessed via a service orchestrator which will support the execution of one or more services according to a workflow to provide the desired result.

The interface/application layer will provide an interface with a set of tools that will offer both tool sharing facilities as well as a collaboration portal.
7 Modelling PES Collaboration

The collaboration methodology proposed for the PES development process is designed by integrating the Information Delivery Manual (IDM Methodology) together with the Software Development Life Cycle (SDLC) as shown in Figure 17. Both these methodologies allow the two different domains, i.e. Business partners and the PES solution providers, to communicate each other to support collaboration at each stage of the development process until its completion.

![Collaboration Modelling Technique Diagram]

**Figure 17 - PES Collaboration Modelling Technique**

To support the collaboration activities at various stages of the PES development life cycle (PESDLC), corresponding to each particular engineering tool, a traditional software development life cycle (SDLC) is tailored to present the sequence of the PES workflow activities. A traditional software development life cycle (Waterfall [55], Spiral [56], Agile software development [57], rapid prototyping [58], incremental [59], and synchronize and stabilize) is composed of a number of clearly defined and distinct work phases which are applied by the system developers to plan for, design, develop and deploy the software systems.

However, due to the complex service-oriented nature of the project and also to incorporate a variety of services in terms of knowledge management, context modelling, intelligent data analysis, security enhancement etc., it is not possible to follow the exact sequence of a traditional software development life cycle (SDLC) in a classical flow of the model. Also, to keep the software applicability traits aligned with the business orientation whereby a number of actors/participants will be involved from different organizations/backgrounds, it was decided to follow an interdisciplinary approach by combining the IDM (Information Delivery Manual) methodology in connection with a traditional software life cycle approach which will provide a mutual understanding of the model in both sectors (software solution providers as well as business entities).

7.1 Information Delivery Manual (IDM) Methodology

The IDM methodology specifies the process and who the actors are involved in creating, consuming and benefitting from the information as well as what information is created, exchanged and consumed [6]. It intends to help software vendors to cope better with the specified individual process-related information requirements of the clients. The workflow description of the project can be sufficiently described in the “Process Map” section of the IDM. The connection between the process map and the functional map is established by the “exchange requirements” [60].
In our specified case, providing a PES solution for a specific business domain, the exchange of requirements defines exactly which artefacts are created during which activities, who is responsible for the roles, and what are the consuming activities. It is so-as-to-speak the glue between activities that define their relationships and enable each responsible actor to identify what kind of input and output are required for each engineering tool’s activities and who has to deliver the input for the preceding activities. So, IDM methodology, in case of the PES development modelling, will help in making a bridge between the PES solution providers and the business partners to exchange information smoothly and flawlessly.

Furthermore, the IDM methodology aims at providing the integrated reference for process and data and helps in [61]:

- making the information exchange between project participants more reliable
- improving information quality
- improving decision making

7.1.1 BUSINESS PROCESS MODEL AND NOTATION (BPMN)

The Business Process Model and Notation (BPMN) is a standard for expressing process maps which are flow-oriented representations of business operations. This provides a common tool and method for process modelling and mapping. BPMN aims to bridge the communication gap that frequently occurs between the business process design and implementation. The language is similar to other informal notations such as UML activity diagrams and is extended to event-driven process chains [62]. BPMN models are mainly used to facilitate information exchange and communication between project participants, to support decision-making based on various analysis techniques and to provide input to software development projects. Furthermore, the BPMN models are also used to specify the information nuggets being shared or exchanged in the process map; subsequently it would be possible to identify the required software features in the system’s development effort [63].

There are two main components of process models developed with BPMN. These are flow objects and connecting objects. While the flow objects represent activities, decision-making gateways, or business events with different triggers or results, the connecting objects capture either the message flow between activities or the logical sequence of activities [64]. A common set of BPMN notations is provided in Figure 18. BPMN uses “swimlanes” to categorize activities with different functional objectives or capabilities (White, 2004). Thus, BPMN creates a standardized bridge for the gap between the business process design and process implementation [65].

![BPMN Elements](image)

Figure 18: BPMN elements covering the fundamental control flow in BPMN [63]

The reasons for adopting these notations are [61]:

- It is supported as an emerging standard by the Object Management Group (OMG)
- It is increasingly being used in the specification of business processes within major projects
- There are several available software tools that range from fairly simple free applications that work with common industry solutions, such as Visio, to extensive industrial strength solutions
The notation has a conversion method to the Business Process Execution Language for Web Services (BPEL4WS) which is emerging as a standard XML based approach for workflow control.

However, in January 2011, OMG released a new version of BPMN named BPMN 2.0 with the following modifications/extensions [66].

- Aligning BPMN with the business process definition Meta model BPDM (Business Process Definition Meta model) to form a single consistent language.
- Enabling the exchange of business process models and their diagram layouts among process modelling tools to preserve semantic integrity.
- Expanding BPMN to allow model orchestrations and choreographies as stand-alone or integrated models.
- Supporting the display and interchange of different perspectives on a model that allow a user to focus on specific concerns.
- Serializing BPMN and providing XML schemes for model transformation and to extend BPMN towards business modelling and executive decision support.

7.2 Software Development Life Cycle

A traditional software development life cycle (SDLC) comprises the following main stages:

1. Requirements’ Gathering and Analysis
2. Software Design
3. Software Development
4. Software Deployment/Implementation
5. Software Testing and Maintenance

Following the same hierarchy, a traditional software development life cycle (SDLC) is mapped to the PES development life cycle/PES process. A more detailed description is available in D200.21 (Specification of development platform & collaborative KM services).

The collaboration methodology for the PES product/process development is provided in Figure 19. Depending on the functional capabilities/responsibilities of each particular participant, the overall workflow process shows the dependencies of business partners and technical expertise on each other, making the whole process a “Cross Organizational Business Process Model”. The PES development process does not initiate until receiving an input from the business partners, wherein they analyse the product requirements with technical team members who provide the software solution. Each horizontal pool of the “swimlane” helps to understand the whole model in detail, for instance;

- **Software Development Life Cycle (SDLC):** It presents the general phases of a traditional software development life cycle
- **PES Development Life Cycle (PESDLC):** It encapsulates the workflow stages of the PES development process that maps to the phases of the traditional software development life cycle
- **Actors:** All the possible number of actors that will support the collaborative activities at each phase of the PESDLC are included in this section
- **Communication Services:** this section highlights the possible communication channels that will be adopted to share information among actors along the flow of collaborative activities from one phase to another during the development of the PES
- **Coordination and Cooperation Services:** this presents the flow of information from one stage to another, managing interaction among actors, and organizing the knowledge repository accordingly to share information
• **Input/output (Knowledge Management):** This section provides the output of collaborative activities that happen at each stage of PESDLC and shares this information as an input with the consecutive phase of the cycle.

Mostly, collaboration will take place at the “requirements’ gathering”, “software design” and “software development” stages of a traditional software development life cycle (SDLC) which are mapped to the “idea creation”, “social simulation”, “knowledge specification/data mining”, “data capture methods/Aml selection”, “functional specifications”, “context modelling”, “security configuration” and PES configuration stages of the PES development life cycle (PESDLC), as shown in Figure 19.
Figure 19: Collaboration Platform
8 Conclusions

This document is the first version of the “Methodology for Collaborative Product Services & Production Process Design” that gives an insight on the collaboration activities that are essential for the completion of a project. It investigates the new attributes in “team composition” and “team collaboration” that should be included in offering the extended services which makes this project different from the traditional products and services. This document also reports on the possible collaboration barriers that users can come across during the development of a product and their potential solutions. For instance, the “Oobeya tool” is presented as an effective collaboration management tool to support team management, collaboration, performance monitoring and problem resolution. Maturity models and Profiling models are included in this report to describe the capabilities and nature of the collaboration amongst team members and for providing the profiling attributes that help to assess the maturity of the processes involved in collaborative PES design.

This report also presents the collaboration services that are required at each stage of the PES development process. These services are divided into three sub-categories; Communication services, Coordination services and Cooperation services that help to understand the kind of collaboration required to manage the workflow, to organize the tasks/activities at each phase of the PES development life cycle, and to encourage teamwork among actors. Lastly, it envisages a comprehensive dynamic collaboration platform that is designed by using software development life cycle methodology together with an Information delivery manual (IDM) approach that maps the collaboration services into a single platform.

In the final version of this deliverable (D200.12-“Methodology for Collaborative Product Services & Process Design-Final Version”) collaboration methodology will be refined further to address the nature of collaboration required at each phase of the development process and to assess how it will be incorporated using provided collaboration tools.
Annex I – References


42. Patel, H., et al., A descriptive model of collaboration to underpin a collaboration profiling methodology, in International Reports on Socio-Informatics p. 15-23.


64. OMG, Business Process Modeling Notation (BPMN) Version 1.0. OMG Final Adopted Specification. 2006, OMG.
