Feedback mechanisms Across the Lifecycle for Customer-driven Optimization of iNnovative product-service design
Acronym: FALCON Project No: 636868
FoF-05-2014 Duration: 2015/01/01-2017/12/31

PROJECT DELIVERABLE 3.1:

FALCON semantic concept definition document

Content: This deliverable aims at defining the main "concepts" of the FALCON domain, creating a sort of reference glossary for the project. For this reason, at first the deliverable starts with a specific state of the art of knowledge management and semantic modelling of the product lifecycle. Subsequently, functional requirements of TO-BE of business scenarios are explored through a custom-designed questionnaire followed by user story mapping method. From these analyses a first map of the FALCON concepts has been formulated and a reference glossary has been realised.

Versioning and contribution history

Version	Description	Contributors
0.1	Preparation of the deliverable outline	Ana Milicic (EPFL)
0.2	Preparation of the first draft	Ana Milicic (EPFL)
0.3	Comments after the first review addressed	Ana Milicic (EPFL)
1.0	Final version compiled	Ana Milicic (EPFL)

Reviewer

Name	Affiliation
Christian Melchiorre	Softeco
Wilfred van der Vegte	TU Delft

Table of contents

TABLE OF CONTENTS 3
LIST OF TABLES 3
1 INTRODUCTION 4
2 SEMANTIC MODELING 6
2.1 DOMAIN KNOWLEDGE DEFINITION 6
2.2 ONTOLOGY IN PRODUCT SERVICE SYSTEMS 7
2.3 SEMANTIC MODELLING OF KNOWLEDGE DOMAINS 7
3 BUSINESS SCENARIO DOMAIN DEFINITION 11
3.1 BUSINESS SCENARIO 1: HOUSEHOLD APPLIANCES 11
3.1.1 White goods business scenario 11
3.1.2 Brown Goods Business Scenario 14
3.2 BUSINESS SCENARIO 2: HEALTHCARE PRODUCTS 16
3.3 BUSINESS SCENARIO 3: CLOTHING TEXTILES 18
3.4 BUSINESS SCENARIO 4: HIGH-TECH PRODUCTS 21
3.5 GENERALIZATION OF BUSINESS SCENARIOS 23
4 CONCLUSION 26
5 REFERENCES 27

List of tables

Table 1 Use case requirements form 9
Table 2 White goods domain definition 13
Table 3 Brown goods domain definition 16
Table 4 Health-care domain definition 17
Table 5 Clothing textile domain definition 20
Table 6 High-tech product domain definition 23
Table 7 Generic upper level concepts 25

1 INTRODUCTION

The purpose of domain knowledge definition is to build a bridge between end users of a software platform that is being designed and the software platform implementation. It is a common gap in software design process that end-users do not perceive well, what are the possibilities of a new product, while the engineers who are designing the software lack the depth in understanding the specific domains of application. In order to address this issue, the FALCON project uses a systematic approach to the analysis of user requirements and strives to create a common understanding and detail description of AS-IS state of use cases, as well as TO-BE which will be accomplished through the FALCON VOP. Both WP1 and WP3 tackle the task of defining the user requirements, but while WP1 addresses open platform functionalities with a focus on implementation and architecture design, WP3 focuses on gathering everything that is relevant in business scenario domains and creation of map of knowledge that will serve as common ground for end-users and designers. WP3 (specifically D3.1) deals with the analysis of the domain and consequently identification of the USER REQUIREMENTs, i.e. the needs, expectations or wishes FALCON USERs might have concerning the improvement of their workflow. On the other hand, WP1 (specifically D1.1) aims at identifying what are specific FUNCTIONAL and NON-FUNCTIONAL REQUIREMENTs that the VOP platform have to meet in order to satisfy the former. Through capturing of knowledge, a base layer for supporting the system architecture is created while preserving the role of communication bridge between all involved actors. Through the first tasks of work packages WP5 through WP8, domains are analysed by formatting end-users expectations in a "user stories" format that is further on transformed to a lists of concepts as a first step to ontology design. "The generic format for the user stories is in the form of:

As <ACTOR> I want to <DO/BE ABLE TO DO> in order to <OBTAIN SOME RESULT>";

which allows end user to express his expectation in non-formal, non-technical manner. Considering the diversity of involved actors and diversity of their professional background, it is extremely relevant to establish easily understandable and still formatted means of communication.

The process of capturing knowledge generated in the implicit form, over a period of an organization's operations, requires methodical communication and an exchange of information between a number of different actors. Deep understanding and common vocabulary have to be established between knowledge management (KM) experts and domain experts, since domain experts can often fail to recognize some of their personal experiences as valuable knowledge components. Moreover, KM experts have to gain a deep understanding of the domain, to be able to recognize and formalize all the relevant relations and dependencies within an organization's operations. The domain can be highly complex, containing a number of operations and functionalities, from many different departments of an organization, and KM experts have to be able to grasp the overall structure in one model or schema. This may lead to problems such as non-harmonized terminology, information loss or an unclear hierarchy model within an organization. Addressing every relevant actor within an organization individually allows KM experts to detect inconsistencies in terminology or cause-effect relations between different departments and generate a model that spans the entire domain and imposes mutual understanding. Several methodologies have been elaborated on to guide knowledge acquisition activities and thus avoid omitting essential knowledge (Skarka, 2007), however they have resulted in flat structures, in the sense that they don't lead to the study and analyses of the domain primarily in terms of interactions and cause-effect relations. The User Story Mapping (USM) (Patton, 2008) method, from agile software development, appears to be a promising approach to addressing the previously stated challenges. It is a user centric method, which allows the designers of software to learn about what future users expect, besides helping the users express their overall demands in a functional view which is common to them.

If we consider the USM to be the first step of gathering information regarding the domain of interest, a following step can be defined as translating user's functional needs into list of concepts. As will be explained in Chapter 2, if we select ontology as a knowledge representation tool, modelling requires that all relevant objects and factors are defined as concepts. After the application of the USM we have a detailed and structured information about knowledge present in the domain, how it is exploited and exchanged between actors. Creating concepts requires recognizing leading objects and factors that will be translated directly into concepts. For example, in a manufacturing company, the term "machine" will be present in a number of user stories, so it is clear that the ontology will contain the concept "Machine". This concept will model all the knowledge about one machine, as well as its usage and functionalities.

In addition to user activities and experiences, valuable sources of knowledge are industrial standards and experiences from previous projects and organizations. The same procedure of recognizing key aspects for purpose of concepts definition can be applied here.

In this deliverable we will apply the USM methodology to clearly define the scope of each business scenario. Every domain will be presented in a form of a list of relevant concepts that will be a ground layer for all FALCON open platform functionalities that rely on exploitation of any data sources or handling of relevant information. Although the business scenarios come from four very different industry branches, it will be shown that the same USM template can be recognized for any domain knowledge structuring.

2 SEMANTIC MODELING

In this chapter, there is a brief overview of theoretical background required for business scenarios domain definition. First, state of the art of domain knowledge definition is covered, explaining what are the challenges in this task. Further, a short introduction about ontology in Product Service Systems (PSS) is given, as the one of the focuses of the FALCON project. Finally the semantic modelling of knowledge domain is described as more abstract notion of ontology design.

2.1 Domain knowledge definition

Innovation is the application of knowledge to produce new knowledge (Drucker & Drucker, 1994). It requires systematic efforts and a high degree of organization. As we enter the knowledge society, ownership of knowledge and information as a source of competitive advantage is becoming increasingly important. In other words, organizations depend more on the development, use and distribution of knowledge-based competencies. This is particularly relevant in a knowledge intensive processes such as product innovation. Consequently, research and development (R&D) organizations are paying more attention to the concept of managing their knowledge base and tools in order to increase competitive advantage, through effective decision making and increased innovation (Nonaka & Takeuchi, 1995)(Davenport, De Long, & Beers, 1998)(Sveiby, 1997). Knowledge is a key resource that must be managed if improvement efforts are to succeed and businesses are to remain competitive in a networked environment (Gunasekaran, 1999). In particular, the two major challenges that face organizations are: (a) ensuring that they have the knowledge to support their operations and (b) ensuring that they optimize the knowledge resources available to them. Managing knowledge is about creating an environment that fosters the continuous creation, aggregation, use and reuse of both organizational and personal knowledge in the pursuit of new business value. In short, the overriding purpose of enterprise knowledge management is to make knowledge accessible and reusable cross disciplinary and independent of time and location.

Application of knowledge engineering in product/service information management context requires that the format used for representing the knowledge is understandable by both humans and machines. For this reason, a number of methods was developed, including relational diagrams and linked tables but lately, ontologies have shown to be preferable choice (Spivak & Kent, 2012) . In theory, an ontology is a "formal, explicit specification of a shared conceptualization" (Gruber, 1993) . An ontology renders shared vocabulary and taxonomy which models a domain with the definition of objects and/or concepts and their properties and relations. In other words, in computer science and information science, an ontology formally represents knowledge as a set of concepts within a domain, and the relationships between those concepts. It can be used to reason about the entities within that domain and may be used to describe the domain. It is a common language between different actors and bridge for knowledge exchange. This schematic representation of knowledge makes it more understandable for humans, compared to other semantic representations of objects and relations such as Ologs which although structural models, lack the expressivity of the ontological schema (Spivak & Kent, 2012). Ontological tools require every concept and relation to be semantically defined and structured, which makes ontology machine-understandable. If populated, ontologies have shown to be very convenient for organizing and storing the data (Orme, Yao, & Etzkorn, 2007). This enables automatic reasoning and inference which means that beside the knowledge gathered in the time of modelling the ontology, additional relations will be automatically built up in time. In the perspective of selecting an ontology as a knowledge representation method, capturing domain knowledge needs to lead to definition of the domain concepts.

2.2 ONTOLOGY IN PRODUCT SERVICE SYSTEMS

Product Service Systems (PSS) are characterized by an integrated and mutually determined planning, development, provision, and by usage of knowledge-intensive socio-technical systems (Meier & Kortmann, 2007). By integrating products and services the lines between both are increasingly blurring (Meier, Roy, & Seliger, 2010). The business relation between customer and provider shifts from a transaction-based relation towards a relation-oriented model that covers a long period of time (Steven & Richter, 2010) (Kowalkowski, 2010). There is an increasing interest towards PSS in order to develop theories, methodologies, tools and techniques to understand the concept as well as to support industries and designers in developing these offerings (Meier et al., 2010).

An ontology is commonly defined as an explicit formal specification of the terms in the domain and the relations amongst them (Gruber, 1993) . Although ontologies may be used for various purposes and applications, they are most commonly used for sharing, navigating, searching, indexing and retrieving domain knowledge. Furthermore, these purposes are used widely to validate the proposed ontology. The importance and applications of ontologies have been widely discussed in literature and are emphasized in many domains. As discussed in (Annamalai, Hussain, & Cakkol, 2011), the immediate advantages of developing a PSS ontology are:

- To provide a platform for stakeholders to communicate and share their concepts with each other effectively and without ambiguity
- It helps to understand the uniqueness of research outcomes
- And it aids to validate the research outcomes.

Schlenoff (Schlenoff, Ivester, Libes, Denno, & Szykman, 1999) also stress that a domain ontology is helpful for unambiguous communication, standards-making and semantic alignment efforts as well as future industrial information infrastructures.

2.3 Semantic modelling of knowledge domains

Specification and conceptualization of ontologies lean on the identification of the relevant concepts of a particular domain, their type, and the constraints on their use. Existing methodologies such as Diligent (Casanovas, Casellas, Tempich, Vrandečić, & Benjamins, 2007), Methontology (Fernández-López, Gómez-Pérez, & Juristo, 1997), or On-To-Knowledge (Staab & Studer, 2004) lack detailed and clear guidelines for building the concepts. It is important to emphasize that, the process of concepts definition represents a key issue for knowledge gathering as it has to cover in an optimal way the whole domain. On the other hand, several knowledge resources may exist and their concepts reuse can be of a key importance.

For ontology design improvements, the main idea is the usage of an approach from the agile software development called the User Story Mapping (USM) for knowledge domain definition (Milicic, Perdikakis, & Kadiri, 2012). This is in line with the software engineering approach adopted in FALCON (see WP1). When a new software product is being developed, one of the first steps of the process is to document the idea. The USM is a user centric approach that organizes the backlog (the knowledge) along scenarios and users. It gives an overview, which helps to think about the product as a whole. Furthermore, it shows a synthesized view of how the different involved parties (users) interact with the product and what their expectations are on how to use this product (their knowledge about the product). The process involves the definition of users (or user groups) and their expectations on the functionalities that the product will have. To facilitate the described communication, in the FALCON project we decided to use a questionnaire that was defined to provide a ground layer for common terminology and "TO-BE" goals. The form is given in Table 1.

Background Information (AS-IS)	• Story • Processes Description • Flow Chart
Actors involved	• Actors • Role / Internal department • Responsibilities
Description of perceived problems or limitations	• Main issues • Technology, Processes, information/Knowledge limitations
TO BE: Description of the task sequence as it should be with FALCON	• Story • Processes Description • Flow Chart
Expectations	• Provide some KPIs • Try to quantify the main expected benefits • Describe some means of verifications
Expected outputs	Describe what you expect from Falcon (Software, methodology, etc…)
User Requirements	For each actor
Type of information needed	What are the data sources available
Legacy systems	• What kind of systems are currently used and for what (specify only systems related to Falcon) • Technical constrains / Boundaries

Table 1 Use case requirements form

The process of defining a backlog for software development can be also transferred to processes in the domain of knowledge definition. Interviewing actors of the organization will give pieces of domain knowledge, without knowing what the whole picture is. USM is a method for creating a good backlog, where actors are directed on how to formulate the description of their activities and functions, reducing the risk of misunderstanding due to different terminologies. It is a method for structuring the backlog so that every requirement is precisely positioned in the structured system functionality. Last but not least, it is a visual aid for KM experts, using which they can have an overview of an entire domain. As such, it is a communication bridge not only between KM experts and actors, but between actors among each other.

Based on this, the process of building a complete and structured knowledge base is illustrated in Figure 1:

Step 1: apply the USM method

Step 2: gather other sources of information (standards, past experience, etc.)

Step 3: create a unique list of concepts that covers entire domain

Step 4: define relations and dependencies among these concepts (Task 3.2)

Step 5: create a dynamic knowledge base covering the domain, expressed in some of the standard formats like relational data base, ontology, semantic model, etc.

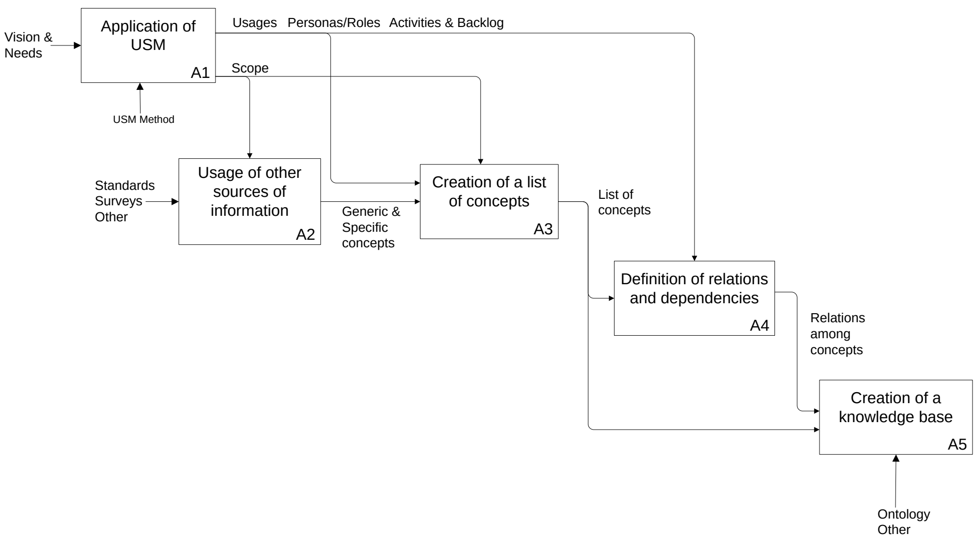


Figure 1. The proposed process for creation of knowledge base (Milicic et al., 2012)

In this scenario, USM is vital part as it will create a base view of the domain in question. Switching from USM to a list of concepts is a relatively straightforward step made through communication of semantic experts and domain experts. Although there are more formalized approaches to concepts naming choices (Bachimont, Isaac, & Troncy, 2002), in this project we rely on non-experts in semantic technologies to be the key sources of domain knowledge. Functionalities required by user stories are described in form of sets of functional modules and each module is translated into concepts of the domain. Next, the list is extended with additional concepts coming from other sources of information like industrial standards or similar projects. Finally, concepts are described using relations and expressed in some of the usual knowledge base formats.

3 BUSINESS SCENARIO DOMAIN DEFINITION

Within the FALCON project, four very diverse use cases are addressed to provide proofs of concept, in order to make sure that project contributions are generic and re-usable. Following the same trend, a domain definition is performed for four cases independently but using the same methodology. The key focus was put on how the “AS-IS” state of business scenarios can be transformed into “TO-BE” state using available sources of information such as sensors, PEIDs (Product Embedded Information Devices) or customer feedback from social media. The “TO-BE” is defined in form of users’ stories, where the improvements are expressed through innovative users’ activities.

3.1 Business scenario 1: Household appliances

As one of the goals of FALCON project is to provide improved Product Service Systems to the customer the White and Brown Goods Business Scenario is defined in the form of two independent scenarios to exploit diversity of potential improvements. The White Goods Business Scenario focuses on the exploitation of sensor data in order to improve the physical product and further to provide customized additional services to customers. The Brown Goods Business Scenario on the other hand focuses on the improvement and re-design of the dedicated service (such as Smart Applications) based on exploitation of social media data.

3.1.1 White goods business scenario

With the Arçelik White Goods, namely washing machines, the current state is that very little service is provided along with the purchase of product. Customers who own and use washing machines are responsible for their maintenance, initiating communication with technical support service (TSS) and reporting on current state and potential failures of goods. The issue is thus that only the customers with a certain level of expertise are able to optimally exploit and service their washing machines. In the FALCON project, added value for the scenario will be created through providing improved service and assistance to the customers.

A new generation of washing machines will be equipped with a number of sensors measuring and recording the usage of the machine. Physical features, such as number of cycles, temperature of the chosen program, foam overload and many more are recognized and will be communicated to the FALCON platform automatically. Based on this information, combined with customer profiles and a set of predefined rules, assistance will be provided either though Call Centre Service (CCS) or Technical Support Team. The targeted services in this initial functional requirements definition are :

1. Based on usage over a period of time, the customer will get recommendations regarding required servicing of machine parts, such as filter cleaning or heater change.
2. Detergent usage will be guided based on program selection and history of overdosing for specific customer.
3. Warranties of the goods will be customized according to usage habits, creating added value for the customer.

In order to enable such functionalities, a unified knowledge base needs to be created, mapping the sensor readings, data processing routines, customer profiles and recommended automatic responses to each other. The information needs to be available to a number of actors at all times and support a number of different activities. To define the boundaries of the domain which will be spanned by the knowledge base, the first step is to create a list of relevant concepts present in the domain. Following the above described methodology, user story mapping resulted in the below listed user stories and finally list of concepts in Table 2.

- As <Customer> I want to <be notified about required maintenance tasks> in order to < prevent malfunctioning according to customized maintenance schedule>
- As <Customer> I want to <be informed about proper usage of detergent and programs> in order to <prevent issues with machine overload>
- As <Technical Support Service> I want to <get recommendations about adjusting the warranty period based on user profiles> in order to <increase customer satisfaction>
- As <Call Centre Service> I want to <get recommendation about which customers should be contacted for the maintenance service> in order to <improve Technical Support Service efficiency>
- As <Technical Support Service> I want to <have access to user profiles when performing maintenance or service> in order to <make better informed decisions>

Concept	Description
Washing machine	The washing machine
Part	All the parts of the washing machine that might require maintenance or service, such as filters or heaters. Extensive list will be created in the next phase through collaboration with WP2 and data wrappers design
Program	Choices of time, temperature etc. that are left to the user are modelled as a program for washing
Customer/Consumer	Customer is the buyer of a washing machine, and the person who will use it. He doesn’t have the direct access to the FALCON platform as an active user but his actions and behaviour are a relevant source of data.
Technical Support service	Technical Support Service is the team responsible for scheduled maintenance of washing machines as well as responding to malfunctioning calls. As such, their service will be improved by providing them with customers’ washing machine history as well as customers’ profile of behaviour
Call Centre	Call Centre operator is responsible for answering the calls from the customers and documenting each report. They are also responsible for notifying customers about scheduled

	maintenance according to their specific washing machine usage.
Factor	Set of rules that will define when the event needs to be triggered based on the resources' state. More specifically, all the rules for recommending warranty duration adjusting, rules for recommending customized maintenance frequency etc. are grouped under the concept Factor.
Usage logs (sensor data)	Sensor data will define the adjustments in the maintenance schedule as an alternative to predefined maintenance activity frequencies. Depending on the type of activity, the customer or the Technical Support Team will be informed. Additionally, based on sensor data, adjustments of warranty durations will be suggested
Customer profile	Based on the history of following maintenance suggestions and the history of calls to the Call Centre, users will be profiled to one of the established types, using clustering. This information will contribute to more efficient responses from the Technical Support Team and the Call Centre.
Event	Concept describing the alert that customer has to be contacted with an important recommendation. Each type of action will be modelled as a sub-concept, currently that is : • Maintenance required • Usage of detergent problem • Warranty adjustment
Previous events logs	This data resource can be understood as similar to usage logs but on a more general level. Events logs will not include sensor reading and details of each washing but rather, history of malfunctioning and services that were performed.

Table 2 White goods domain definition

3.1.2 Brown Goods Business Scenario

While in the White Goods Business Scenario, the data source of customer feedback is not really available, the Brown Goods Business Scenario is defined with the main focus on precisely this data source. The Brown Good Business Scenario addresses Smart TVs as a product and Smart Applications as Service, with online content and applications developed by Arçelik as product components. Currently, the process of creating new applications and updating the existing ones for improved user experience is done through a number of sequential steps transferring information from one department to another. The process is initiated based on market trends, customer feedback and customer satisfaction criteria, that are all collected and processed manually, creating sometimes significant delays. Also, a number of data streams such as TV usage data are without integration into a unified data structure.

In the FALCON project, the goal is to provide mapping and extraction of information from all available semi-structured and non-structured data sources. This will create a common knowledge base that will be available to all involved Arcelik workers and that will provide updated and consistent information at all times. The overall added value lays in improved communication between departments, leading to better planning, reduced execution time and cost of launching new release and thus increased customer satisfaction. The first step towards providing such knowledge bases is on definition of the knowledge domain that will be modelled, in a form of list of concepts defining data sources and involved actors in Table 3.

- As <Product & Project Management> I want to <have insight into statistics of application usage based on my custom queries> in order to <make strategic planning more efficient>
- As <Product & Project Management> I want to <be alerted when response to some application is critically low> in order to <make fast and informed decisions>
- As <Test & Verification Department> I want to <have an overview of known problems and details of each one> in order to <focus on critical points when testing>
- As <Software development Department> I want to <have continuous insight into Test & Verification Department activities > in order to <prevent potential problems learned on previous versions of application>
- As <Software development Department> I want to <have continuous insight into Project & Product Department activities > in order to <be prepared for future releases as soon as possible>
- As <Call Centre> I want to <use convenient tools to tag calls with details such as caller and type of problem> in order to <enable semantic enrichment of customer calls>

Concept	Description
The Smart TV	The Smart TV
Application	All the applications that are available through the application store.
Customer/Consumer	Is the owner and/or user of Arçelik smart TV. Although he is not the user of the FALCON VOP,

	his behaviour is an important source of information.
Product & Project Management Office	FALCON users receive information through the VOP in two different modes, the first being responses to initiated queries about specific application usage and second being automatic alerts when statistics in certain application usage exceeds predefined thresholds.
Test & Verification Department	FALCON users from this group will be able to access Customer usage data analysis results in order to get better insight into critical and weak points of previous application releases in order to make the testing procedure more efficient.
Software Development Department	FALCON users from this group will have insight into activities and conclusions of Product & Project Management Department in order to prevent issues reappearing in new releases.
Call Centre	Call Centre operators are responsible for collecting the data about smart TV malfunctioning or assistance that customers required. Through key-words labelling of each call centre interaction with customer statistics of smart TV usage will be produced as a valuable data source.
Social Media	Social media data are gathered through a 3rd party company and are semi-structured.
E-mail	Emails are sent to customer service and will be processed with a keyword search engine to create statistics of topics priorities. Each email will be tagged with the occurrence of key words.
Call Centre Data	Calls directed to the call centre will be combined with multiple-choice questionnaires that will create meta-data for this unstructured data source. Meta-data are modelled through this concept.
TV Usage Data	Usage of applications is followed through a number of downloads and interaction. It is defined in a form of log files for each customer.
Feedback	Feedback is an abstract concept that will contain conclusions of data processing modules, which

	are fed by Resource data. Each instance of Part will be related to one instance of Feedback.

Table 3 Brown goods domain definition

3.2 Business Scenario 2: Healthcare Products

With the complex and sensitive equipment such as high-tech health-care products, installation and integration with other parts of the system is a challenging task. A similar problem lays in maintenance and updates of such systems with the additional constraint that the downtime of the system has to be minimal. As a matter of fact, optimized service and maintenance is absolutely imperative since in a hospital patients lives depend on availability of the equipment. To address this issue, Philips has a team of experts available for consultation and assistance at any place and any time.

The current state, which the FALCON project is aiming to improve is that all interventions are initiated only after the problem is reported by the customer. This creates a high costs for both parties since often quick trips have to be organized while the equipment is unavailable. The opportunity for the improvement that will be addressed in FALCON is in exploiting available data sources to create better prevention of problems and more efficient equipment software updates. The fist data source that will be included as input to the FALCON Virtual Open Platform are log files of the machines. These files contain information about machine usage, which operations it performed and how much time it took to adjust settings and perform the desired operations. The second data source is found in help desk data, where all issues reported by customers are recorded with additional meta-data such as the topic, the details of the problem, the client, the time to address the problem etc.

In the initial stage of FALCON Virtual Open Platform functionality definition for this business case, several directions are noted. First, the activities of support team will be optimized through analysis of the help desk activity data (field call logs) for every client. Based on previous behaviour, the future interventions can be predicted and planned. In addition, using the same data, critical issues can be detected and frequent problems can be assigned as high priority for improvement in future updates. Finally, through analysis of common problems with interoperability of different devices, rules can be defined and automatically communicated to clients owning the same system configuration, leading to error prevention.

The following list of user stories is defined:

- As <Development team> I want to <be notified about the most critical issues> in order to <better plan future innovations>
- As <Support team> I want to <get information about system configuration and previous issues of the client> in order to <solve issue more efficiently>
- As <Support team> I want to <get notified when certain problem is frequently occurring> in order to <prevent the same issue for other clients>
- As <Client> I want to <be notified if I can prevent typical problems> in order to <make Phillips devices integration more efficient>

The domain spanned in order to support these functionalities is described using concepts in Table 4.

Concept	Description
Healthcare equipment	Phillips healthcare equipment: ‘medical image acquisition modality, also known as ‘scanner.
Integrated Part	Group of parts that are considered as relevant when analyzing interoperability or interaction-related issues.
Client hospital / Customer	Clients are owners of Phillips health care products. Although they are not direct users of FALCON platform, their behaviour is one relevant data source and FALCONs’ functionalities’ outputs are targeted to modifying clients behaviour
Service engineers	Service engineers are team who travel to clients facility to perform scheduled maintenance and service activities.
Development team	The development team will gain insight into statistically the most frequent issues with product functionalities or installation problems, based on which they will adjust the future generations of products or software updates for the existing ones.
Support team	Based on log files and information coming from help desk, the support team will have all the relevant information about previous and potential issues before getting back to the client and thus leading to increased product-service value
Log files	Log files contain the history of usage modes and operations
Help Desk	The help desk uses a labelling system to add semantic structure to phone call data and email free text data
Client profile	Clients are clustered into several standardized profiles that determine typical behaviour and appropriate services which are required.
Integration	This concept models the pairs of product-part sequences that can cause integration problems and the problem description

Table 4 Health-care domain definition

3.3 Business Scenario 3: Clothing textiles

The Fashion industry, although it is a form of artistic expression, is still a fast growing industry where fast decisions, information availability and quick market-ready production are vital for business competitiveness. Currently, most of the information present in the domain is highly subjective, unstructured in a form of conversations, sketches, verbal or gesturing descriptions, comparison description etc. Preparation of a new collection requires a long process of research through media, material suppliers and designers' work. Once the ideas are ready, the entire process of design, sample production and finally production is conducted via person-to-person communication without records for future reuse.

In order to provide strategic structuring of the information, a certain terminology has to be established for the efficient communication between actors. In FALCON project, a categorization of styles and colours will be defined and followed, resulting in a glossary of terms. Following, data sources will be defined, together with exploitation strategy to reduce time required for trends research and collection preparation. Finally, customer feedback will be established through e-commerce, a Comments & Review section and social media analysis, giving the designers statistically processed opinions on each specific article.

The following list of user stories is defined:

- As <Collection Manager> I want to <have access to a set of KPIs related to previous sales> in order to <better understand the market and prepare accordingly production and purchase orders>
- As <Collection Manager> I want to <have access to information about suppliers offer> in order to <prepare accordingly production and orders>
- As <Designer> I want to <get information about fashion trends in terms of materials, colors and shapes> in order to < design the new collection>
- As <Manufacturer> I want to <get notified when certain production techniques are required > in order to <set up the machines accordingly and improve the quality of products >
- As <Customer> I want to < get recommendation of looks and customize certain products> in order to <follow fashion trends>

The concepts designed to structure such complex domain are given in Table 5.

Concept	Description
Clothes	The categories of clothing definition which have been defined on the basis of end user requirements are: • Gender: male/female/unisex • Type of product: general categories used by international custom and trade agreements[1]

[1] http://www.dutycalculator.com/popular-import-items/import-duty-and-taxes-for-clothing/

	• Fitting description: on the basis of tightness parameters on the body (see paragraph after the table). • Material description: general categories used by international custom and trade agreements • Brand producer: as described on the product label or description • Color description: LAB or Pantone, calibrated when possible on the basis of light and device • Type of color: on the basis of 3 basic categories of textile, which are plain/solid color, mélange (mixed raw materials of different colors) and fantasy (different color in warp and weft) • Material composition: with reference to international material definition rules • Season: the 2 main ones of clothing production (F/W or S/S) • Price: when available accompanied by currency definition (Euro, Usd, etc…)
Part	All parts that are treated as design questions. List of sub-concepts defined here is not definitive and can be extended as required. • Sleeve • Collar • Pockets • Stockings • Zipper • Stitch
Actor	Generic concept created to group all involved parties. The list of sub-concepts is : • Consumer/Customer • Collection Manager • Designer • Manufacturers/Machine programmer • Vendor • Suppliers
E-commerce	On the Dena web site, users are able to purchase and then leave a review about their clothes. The reviews are in a form of free text but also accompanied by set of categories that can be graded on 1-5 scale. The categories are : • Size • Material • Quality • Durability • Over-all satisfaction

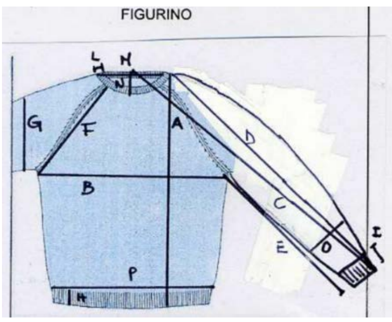
Social media	Giving all the labels and keywords that can be assigned to a product or a part, specific social media are monitored for these words' occurrences and statistical processing will result in recommendation of currently interesting topics to the Collection Manager.
Communication logs	All communication between company employees is recorded and labelled with topics as keywords in order to enable easy and fast retrieval for future reuse.

Table 5 Clothing textile domain definition

Fitting can be described as the physical relationship between the body of the consumer and the piece of clothing. Example of fitting categories are "slim fit", very tight to the body on the one side, and "over fit", very slight to the body on the other. The definition of the fitting is based on the comparison between the measures of the piece of clothing and the ones of the target consumer who will wear that piece of clothing. Because of this reason the name of the necessary measures and the indication about how to collect them must be precisely defined and is object of a semantic definition.

In order to define the fitting i-Deal needs to be provided with a certain number of information regarding the piece of clothing:

A. Body length
B. Chest width
   Shoulder width
C. Sleeve length from centre collar
D. Sleeve length
E. Underarm length
F. Front raglan length
G. Muscle width
H. Bottom hem height rib 1x1 double
I. Cuff height rib 1x1 double
L. Neck hem height rib 1x1 double
M. Neck opening width
N. Neck opening height
O. Sleeve width at 10cm from the bottom
P. Bottom width



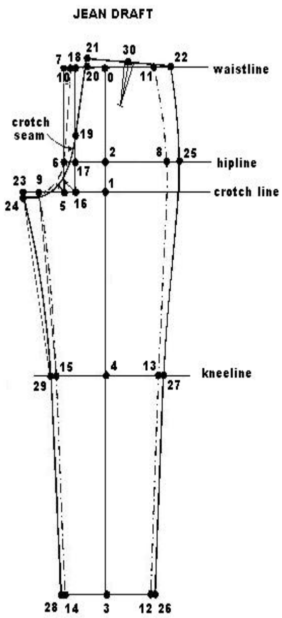


Figure 2. Measurement guide for clothing industry

All these parameters are available as production technical specifications per style and size. As regards the web it will be necessary to verify how to collect them, at least the essential ones, in order to collect the necessary indications from this source.

As regards consumers i-Deal will need to be provided by Dena with the following measures of the target customers per each size (*= essential):

- Height *
- Waist *
- Belly *
- Hips *
- Shoulder width
- Arm length
- Collar width
- Arm muscle
- Belt
- Inside leg length
- Crotch
- Upper muscle

3.4 Business Scenario 4: High-tech products

The High-tech products business scenario is focusing on advanced 3D scanning solutions that are used for dimensional quality control during manufacturing of, in this specific business case, HHP (High Horse Power) camshafts. The specific metrology solution (M3 Portable) considered in FALCON, is composed of three main components. The first element is hardware composed of an optical sensor and the machines and robots in charge of moving it following a specific measurement plan previously defined. The second part of the product-service is the M3 software that collects, processes and transforms the raw data measured by the optical sensor into 3D model based on a point-cloud. This model is then compared to an ideal digital part in order to detect any dimensional defects/deviations through the application of alignment and colour-mapping techniques between the ideal CAD model and the point-cloud captured. The third part finally is the digitalization programme which is designed and customized according to the dimensional requirements of the part (respect to size, geometry, etc.) as well as the accuracy degree of the measurement (sensor quality setting, scanning setting, speed required, etc.). One of the most important steps in metrology solution usage, is making sure that it is verified, maintained and calibrated properly. To determine the optimal frequency for developing key steps within the metrology process, such as maintenance & verification and calibration, are not trivial tasks. They depend on the analysis of key information such as the variation of environment conditions (temperature, mainly) or the state of the metrology solution under working conditions (detection of dimensional deviations, operation patterns, etc.). This is a clear technological advantage that could be reached through the integration of FALCON VOP within the metrology process. In summary, the goal of the

FALCON project in this business scenario is to gather and exploit available data sources in two main directions. The first required functionality is that the system will provide recommendations for calibration and maintenance, as well as verification of metrology equipment using the data gathered in “raw log files” based on thermal variation (collected by a sensor) and the information related to usage of the machine (registered by M3 software). This data source is named “PEIDs”. Using this data source, the usage and working conditions will be analyzed to classify whether the calibration schedule needs to be adjusted or the maintenance & verification is advised. The second functionality of the open platform will be to provide a unified knowledge platform, combining the information included in the mentioned “raw log files”, together with user feedback coming from technical support team files. This second data source is categorized as an “Enterprise and Legacy System”. This platform will be used to enhance machine programming options as well as the content of final reports.

- As <Production worker> I want to <get custom recommendation for calibration scheduling> in order to <exploit scanners more efficiently>
- As <Calibration and Maintenance team> I want to <be notified of potential failures of a machine> in order to <take preventive measures>
- As <Help desk worker> I want to <have easy-to-use tools for labelling customer calls> in order to <create meta data for unstructured sources>
- As <Quality Product Deportment Worker> I want to <be notified about of quality of systems' performance> in order to <make better informed decisions about system upgrades>
- As <Metrology team> I want to <get results of statistical data processing> in order to <learn about critical issues>
- As <Metrology team> I want to <have data visualization > in order to <make better informed decisions about future projects>
- As <Metrology team> I want to <have easy-to-use project management tools> in order to <prioritize project scheduling>

The domain that needs to be considered in order to provide such functionalities is listed in Table 6.

Concept	Description
Metrology system	Metrology solution
Part	A product is composed out of three main parts and sub-concepts : • Hardware • M3 software • Digitization Program
Metrology team	The metrology team at DATPIXEL is responsible for managing projects, updates and upgrades offers based on user experience

Help Desk workers	The help Desk workers in DATAPIXEL are responsible for collecting information from clients about their issues and inquiries
Calibration and Maintenance team	The team is responsible for defining calibration and maintenance schedule according to specific scanning program and installation conditions
Production workers	Production workers at the clients facility are the ones actually handling the devices
Quality Product Department	The quality Product Department at the clients facility is monitoring and reporting issues with product/service system
M3 reports	M3 reports contain the history of usage of every metrology system as well as conditions in which it operated. Based on these data streams the module for recommending calibration or maintenance & verification is designed.
Help desk questionnaires	Each call to the help desk will be tagged with caller, topic, equipment in question, source of problem etc. Based on these, Datapixel can make decisions about future improvements of the metrology system. In the same time, user profiles will be created to contribute to better informed responses of technical support team to new issues.

Table 6 High-tech product domain definition

3.5 Generalization of business scenarios

When designing a software product such as the FALCON Virtual Open Platform (VOP) it is important to design solutions which are generally applicable. In the FALCON project we have an opportunity to ensure this generality as the business cases that will be addressed are very diverse in their nature and functionalities. A step toward generalization of the business scenarios is in defining the ontology that will serve as “upper”, template ontology to which all FALCON business cases as well as future business cases will relay on. . These abstract concepts support system architecture planning and optimization by composing a top-level overview of factors to be taken into account. Each business scenario domain is thus composed of generic upper level concepts and the concepts that are specific for a given scenario. As a consequence, the implementation of system modules which relay on upper level concepts will be done once for all of the business scenarios while only the business scenario-specific functionalities have to be addressed for each scenario individually.

Within WP2 of the FALCON project, data sources, from both sensor data and social media data will be collected and mechanism for structuring them and loading into the VOP will be developed. This particular challenge will be greatly simplified by mapping concepts of data sources to upper-level concepts in order to avoid redundancy or conflicts. At this stage of WP3 progress, some of the upper level concepts that can be identified are given in Table 7. A more detailed schema can be found in Figure 3.

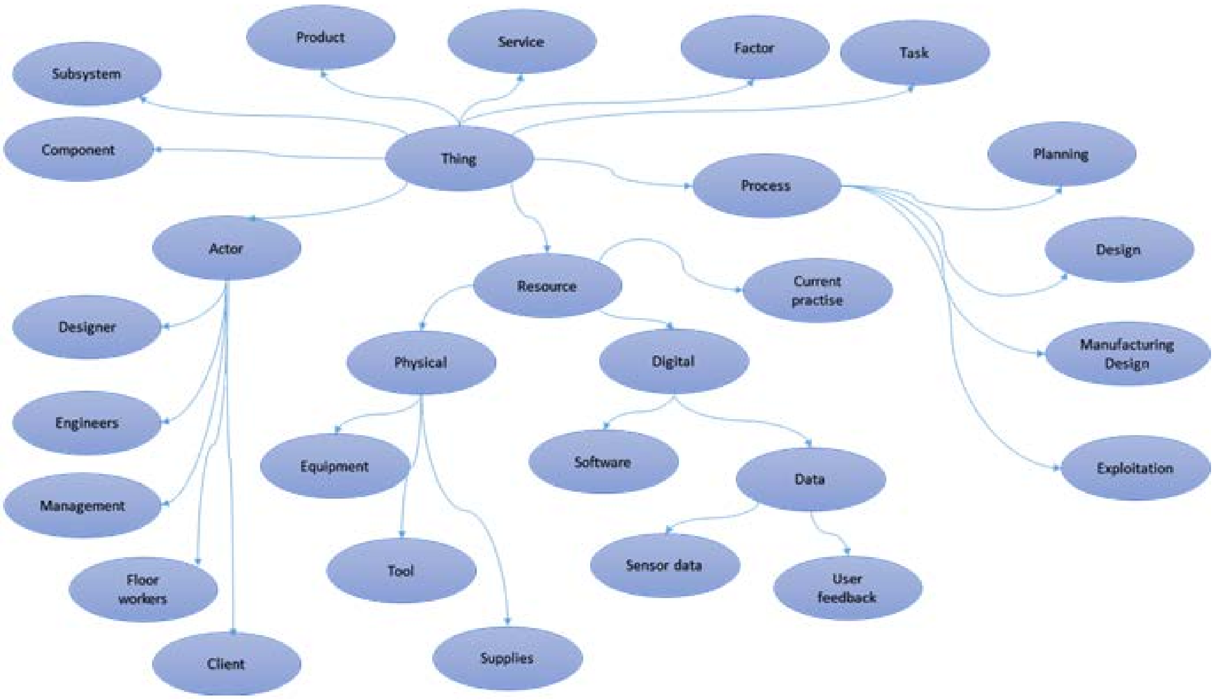


Figure 3. Upper ontology concepts

Concept	Description
Product, Service	Abstract representation of all product/service
Part	Composing element of a Product
Actor : • Data analyst • Project manager • Developer • Consumer/Client • Customer service • Support service	All roles that a human can take in a sense of requirements or responsibility. It is a list of types of interactions that an individual can have with the VOP. Subconcepts are created through merger and generalization of roles that appear in different business scenario
Resource	Resources are generalized models of data sources. Two main groups are : • Product middle-of-life sensor data • End User feedback

Factor	Factors incorporate all implicit pieces of knowledge such as rules for concluding when an action is required

Table 7 Generic upper level concepts

4 CONCLUSION

The main objective of Work Package (WP) 3 is to build up the knowledge base for all FALCON business scenarios, to ensure seamless access to knowledge and information throughout the product and process lifecycle, thus facilitating knowledge sharing and reusing in engineering and design. For doing this, WP3 must at first provide robust definitions of the business scenario domains, defining the relevant concepts, in that way creating the FALCON-wide reference semantic vocabulary.

This Deliverable 3.1 – the first of the whole WP – aims to create the basis for the rest of WP3. For this reason, it has an introductory content, which is supposed to be general enough to launch the next activities. In fact, the main concepts here described will serve as input to the second Deliverable (3.2), in which the detailed ontology will be defined and then implemented.

Deliverable 3.1 has deepened the state of the art of the design context, giving to the consortium the needed knowledge on how a design process generally works and how it is shaped in the involved Industrial Partners. From the questionnaires, it is evident that the four industrial cases together (Arcelik, Phillips, Dena and Datapixel) adequately representative for the status and the needs of the European industries. They work in different industrial sectors, they have different design processes, and they use different tools. At the same time, they share the same competitive factors and the same problems. All of them are facing challenges in managing their knowledge along their product-service lifecycle.

From this analysis (literature and industrial practices), a first list of concepts was elaborated. This activity will continue in the next months and it will be regularly updated, in order to arrive to a consolidated domain by the end of WP3.

5 References

Annamalai, G., Hussain, R., & Cakkol, M. (2011). An ontology for product-service systems. *Functional Thinking for …*. Retrieved from http://link.springer.com/chapter/10.1007/978-3-642-19689-8_41

Bachimont, B., Isaac, A., & Troncy, R. (2002). Semantic commitment for designing ontologies: a proposal. *... : Ontologies and the Semantic Web*. Retrieved from http://link.springer.com/chapter/10.1007/3-540-45810-7_14

Casanovas, P., Casellas, N., Tempich, C., Vrandečić, D., & Benjamins, R. (2007). OPJK and DILIGENT: ontology modeling in a distributed environment. *Artificial Intelligence and Law*, *15*(2), 171–186. doi:10.1007/s10506-007-9036-2

Davenport, T., De Long, D., & Beers, M. (1998). Successful knowledge management projects. *SLOAN MANAGEMENT REVIEW*, *39*(2), 43–+. Retrieved from http://apps.webofknowledge.com/full_record.do?product=WOS&search_mode=Refine&qid=16&SID=S2c4rW27R1FHKohyLmA&page=1&doc=2

Drucker, P. F., & Drucker, P. F. (1994). *Post-capitalist Society*. Routledge. Retrieved from http://books.google.com/books?hl=en&lr=&id=IYVBmM5z69cC&pgis=1

Fernández-López, M., Gómez-Pérez, A., & Juristo, N. (1997, March 1). METHONTOLOGY: From Ontological Art Towards Ontological Engineering. Facultad de Informática (UPM). Retrieved from http://oa.upm.es/5484/1/METHONTOLOGY_.pdf

Gruber, T. R. (1993). A translation approach to portable ontology specifications. *Knowledge Acquisition*, *5*(2), 199–220. doi:10.1006/knac.1993.1008

Gunasekaran, A. (1999). Agile manufacturing: A framework for research and development. *International Journal of Production Economics*, *62*(1-2), 87–105. doi:10.1016/S0925-5273(98)00222-9

Kowalkowski, C. (2010). What does a service-dominant logic really mean for manufacturing firms? *CIRP Journal of Manufacturing Science and …*. Retrieved from http://www.sciencedirect.com/science/article/pii/S1755581711000058

Meier, H., & Kortmann, D. (2007). Leadership-From Technology to Use Operation Fields and Solution Approaches for the Automation of Service Processes of Industrial Product-Service-Systems. *Advances in Life Cycle Engineering for Sustainable …*. Retrieved from http://link.springer.com/chapter/10.1007/978-1-84628-935-4_28

Meier, H., Roy, R., & Seliger, G. (2010). Industrial product-service systems—IPS 2. *CIRP Annals-Manufacturing Technology*. Retrieved from http://www.sciencedirect.com/science/article/pii/S0007850610001915

Milicic, A., Perdikakis, A., & Kadiri, S. El. (2012). Towards the definition of domain concepts and knowledge through the application of the user story mapping method. *Product Lifecycle …*. Retrieved from http://link.springer.com/chapter/10.1007/978-3-642-35758-9_6

Nonaka, I., & Takeuchi, H. (1995). *The Knowledge-creating Company: How Japanese Companies*

Create the Dynamics of Innovation. Oxford University Press. Retrieved from http://books.google.com/books?hl=en&lr=&id=B-qxrPaU1-MC&pgis=1

Orme, A., Yao, H., & Etzkorn, L. (2007). Indicating ontology data quality, stability, and completeness throughout ontology evolution. *Journal of Software* …. Retrieved from http://onlinelibrary.wiley.com/doi/10.1002/smr.341/full

Patton, J. (2008). User Story Mapping. Retrieved from http://www.cs.northwestern.edu/academics/courses/394/slides/spr12/Patton Building Better Products Using.pdf

Schlenoff, C., Ivester, R., Libes, D., Denno, P., & Szykman, S. (1999). *An analysis of existing ontological systems for applications in manufacturing and healthcare*. Retrieved from http://www.mel.nist.gov/msidlibrary/summary/9911.html

Skarka, W. (2007). Application of MOKA methodology in generative model creation using CATIA. *Engineering Applications of Artificial Intelligence*, *20*(5), 677–690. doi:10.1016/j.engappai.2006.11.019

Spivak, D., & Kent, R. (2012). Ologs: a categorical framework for knowledge representation. *PLoS One*. Retrieved from http://dx.plos.org/10.1371/journal.pone.0024274

Staab, S., & Studer, R. (Eds.). (2004). *Handbook on Ontologies*. Berlin, Heidelberg: Springer Berlin Heidelberg. doi:10.1007/978-3-540-24750-0

Steven, M., & Richter, A. (2010). Hierarchical planning for industrial product service systems. *Proceeding of the 2nd CIRP IPS^2 Conference*. Retrieved from http://www.ep.liu.se/ecp/077/019/ecp10077019.pdf

Sveiby, K. E. (1997). *The New Organizational Wealth: Managing & Measuring Knowledge-based Assets*. Berrett-Koehler Publishers. Retrieved from http://books.google.com/books?hl=en&lr=&id=xKNXlgaeCjAC&pgis=1

