Chapter 7
Use Cases

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Abstract This chapter describes in details all the different use cases involved in the project. It is focused on how each of them has applied Manutelligence methods and tools in order to improve Product-Service system design and management. A particular focus is dedicated to the usage of the Manutelligence platform.

7.1 Ferrari Use Case

7.1.1 The Ferrari Company

Ferrari S.p.A. is an Italian luxury sports car designer and manufacturer based in Maranello. Founded by Enzo Ferrari in 1929, as Scuderia Ferrari, the company sponsored drivers and manufactured race cars before moving into production of

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street-legal vehicles in 1947. Since then, Ferrari has caught on race tracks and roads all over the world more than 5000 victories, creating the basis of the Ferrari legend. Ferrari road cars are generally seen as a symbol of speed, luxury and wealth. The famous symbol of the Ferrari race team is the Cavallino Rampante ("prancing horse") black prancing stallion on a yellow shield, usually with the letters S F (for Scuderia Ferrari), with three stripes of green, white and red (the Italian national colors) at the top.

7.1.2 The Ferrari Business Challenges

The main challenges in developing Ferrari cars derive from the Ferrari corporate business drivers, which are:

- Deliver outstanding cars (innovative, high performance and reliability, cost controlled, enhances Product-Service).
- Deliver best product portfolio (manage product differentiation, exploit special series and supercars, high configuration offering, address traditional and new markets).
- Shorten time to market (high frequency of new car introduction, decrease risk of failing behind the market, control product development and manufacturing).

Obviously, these business drivers affect the whole vehicle life cycle from the concept to the after-sale; furthermore these drivers dictate extremely high rules that the enterprise has to fulfil towards their customers (product excellence, customer attitude and service). For these reasons the usual development and the manufacturing functions in Ferrari are very special. In detail, the process from concept to delivery is very long and sometime could take more than one year and a half. Thus, due to such a long period and complexity of processes, several challenges should be taken into account:

1. During the time horizon the technical characteristics as well as the specifics could change therefore they have to be integrated into the vehicle, which could be already entered from the engineering into the manufacturing process. Although this ensure to the customer the best of last technologies and some more features not yet available at the moment of the order, on the other hand it leads a complex process of requirements traceability and change.
2. The creation of a vehicle addresses disparate lifecycle phases, especially among design, engineering and manufacturing. One of the most important phases is the validation of the vehicle in term of design, this means that the virtual and physical prototype have to be benchmarked as easily and reliably as possible using dashboards and KPI. In addition, the resulting data from testing have to be used as feedback in the design and engineering phase in order to optimize the product. This triggers the need for fast, ubiquitous and secure sharing of product and service information across the entire Product-Service lifecycle involving all the relevant decision makers from the different functions.

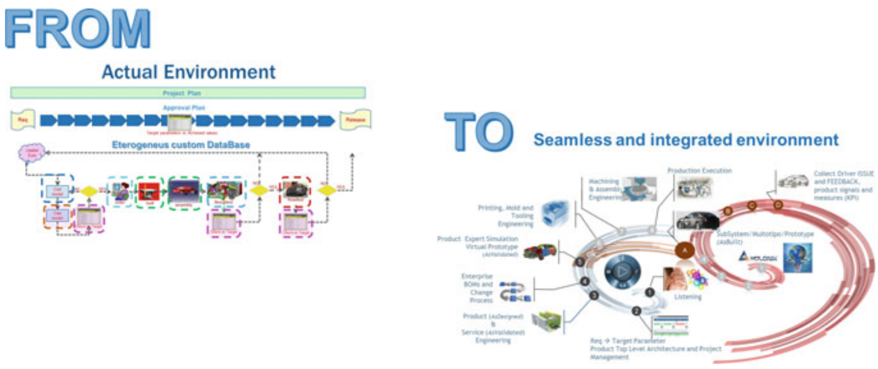

Fig. 7.1 The Ferrari objectives

3. The enterprise Ferrari would like to offer to its customers not only a car but also a strong experience that should start from the delivery of the vehicle or even more challenging without buying the vehicle. Thus, services related to the product should be designed in parallel and managed along the usage of the car as well as the related requirements.

7.1.3 The Ferrari Objectives in Manutelligence Project

The Manutelligence project offered the opportunity to evaluate how to address some of the previous challenges, especially the ones related with the Product-Service business. Effectively, if is it possible to retrieve data from physical prototypes during the tests and afterwards to provide services and feedbacks to the designers in the same way, changing the data model, it could be possible to collect data from the drivers experience and then to provide specific services to customers. This requires to adopt a platform able to support in a seamlessly way the access to all the needed information, from the usage of the car by the end users to the design and manufacturing project data (Fig. 7.1).

Business Objectives

- Improve the design of existing or new car, based on data coming from the real usage of the car.
- Captured data simulating a car customer testing on a circuit, to improve the design to obtain an enhanced “drive line” accuracy/driving comfort.
- The integration of the IoT information, to grab end user driving styles, technical data acquisition and elaboration, with the designer system tools in a single platform constitutes the innovative character providing a new way to design the Product/Service (Fig. 7.2).

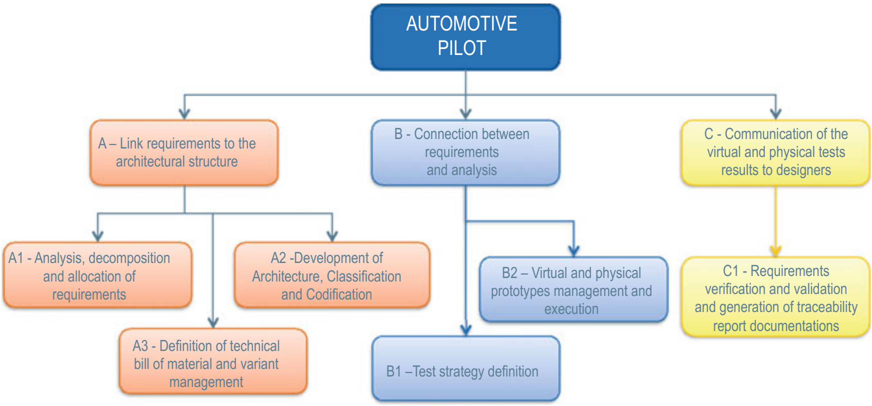

Fig. 7.2 Automotive pilot

Going more in detail, the following items have to be supported by the Manutelligence Platform:

- Management of product and service requirements and configuration features for variants connected.
- Define product template (archetype) and KBE.
- Link target parameters to the top level architecture.
- Definition of a complete, hybrid or partial product configuration, depending on the activity of test to perform, to be defined from beginning.
- Full traceability of produce and service requirements and accurate management of change impacts during design activities on design parameters to consider.
- Configure DMU to support physical and virtual test.
- Design validation process and optimization of product performance.
- Organize feedback to designers and data acquisition from field.
- To extend and improve the use of Simulation and optimize it through use of data collected from the field.

Business Scenario

In order to develop the Manutelligence platform a specific Ferrari Product-Service scenario has been identified. The FXX Programmes emerged out of the ingenious and rather fascinating idea of involving a group of special customers in the development of the Ferrari of the future, asking them to help provide information to the "Corse Clienti" technicians. Indeed, the enthusiasts who own these cars take part in a number of technical test sessions over the year closely monitored by Ferrari experts and have the chance to meet Maranello's engineers and professional testers in an environment in keeping with the tradition of the world's most famous race team (Fig. 7.3).

Fig. 7.3 FXX programme servitization-driven R&D

7.1.4 Use Case—Drive Style Comfort and Accuracy

In order to validate the Manutelligence platform a specific use case was selected, the Drive Style Comfort and Accuracy. The Drive Style is strongly depending on the accuracy, i.e. the capability to be precise while using the steering wheel to execute the best path, either on the circuit either on the road, and on the comfort, i.e. the easiness to control the steering wheel that requires to minimize any vibration deriving from the powertrain transmission system.

The objective is to improve the performance of the driving sensitivity and precision at low and high speeds by reducing the amplitude of the vibration of the steering line, caused either by the road irregularities (holes or kerb) either by the vibrations induced by the system itself. The vibrations cause a loss of sensitivity (sensitivity/driving accuracy) so that the driver is reducing speed when on circuit or is subject, when driving on the road, to a more or less evident fatigue driving.

Then the use case was analyzed executing one session of test on Fiorano circuit using FXX car and one specialist test driver, capturing the data related to the steering line, composed by the suspension corner, the steering box, the steering column and the steering wheel. In parallel the virtual model of the car was developed to execute frequency and modal analysis. Using the test data, the virtual model was calibrated (Figs. 7.4, 7.5, 7.6 and 7.7).

Another fundamental analysis was setup in order to enable the traceability of the tests. The management of the requirements, the target parameters, the test execution data, the BOM of the specific car used in the test, the test execution measurements were implemented. This means to manage

- Serialized BOM.
- Test case versus test results.
- Traceability matrix (components/tests data).

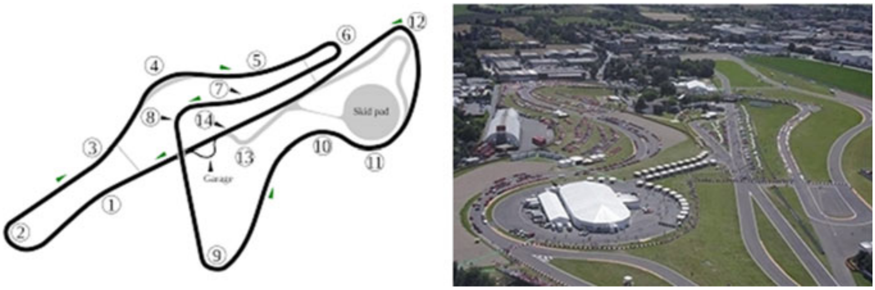

Fig. 7.4 Ferrari XX programme Fiorano circuit

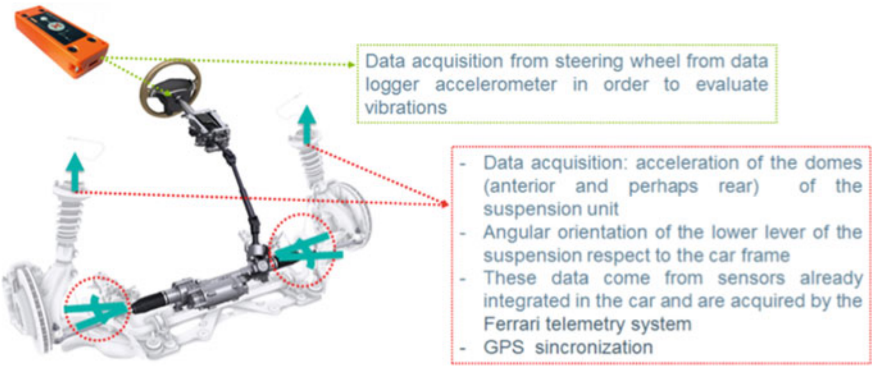

Fig. 7.5 Data acquisition from the steering line

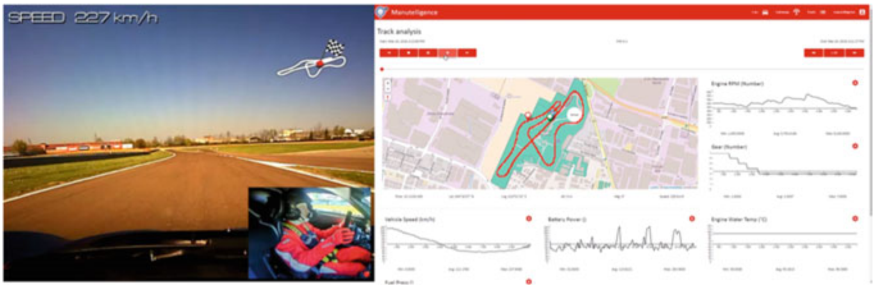

Fig. 7.6 Data acquisition on the 3DEXPERIENCE platform

The final target is to improve the development of new car with a process that is able to capture and organize data coming from the real usage of the product by the end users, leveraging the IoT technology, to develop a virtual model to simulate the real usage in a quick and at less cost way, leveraging on the Design and Manufacturing platform solution. This iterative process will support the improvement of the Product-Service design in a more efficient and time-to-market oriented approach (Fig. 7.8).

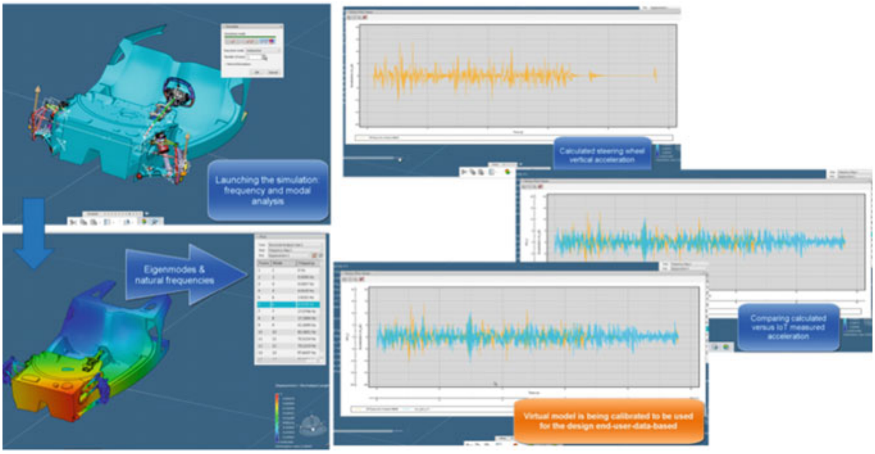

Fig. 7.7 Virtual model and data elaboration on the 3DEXPERIENCE platform

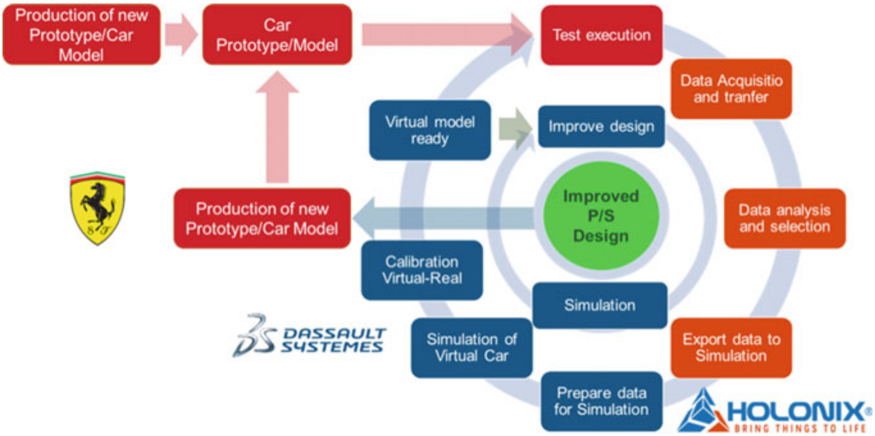

Fig. 7.8 Improved product and service design methodology

7.2 FabLab—Ateneus of Digital Fabrication (ADF)

7.2.1 The FabLab—Introduction

The city of Barcelona has created a FabLab facility with the MIT badge, promoted by the founder of the Institute of Advanced Architecture of Catalonia (IAAC). A Fabcity vision is being pushed through the gradual opening of public funded Ateneus

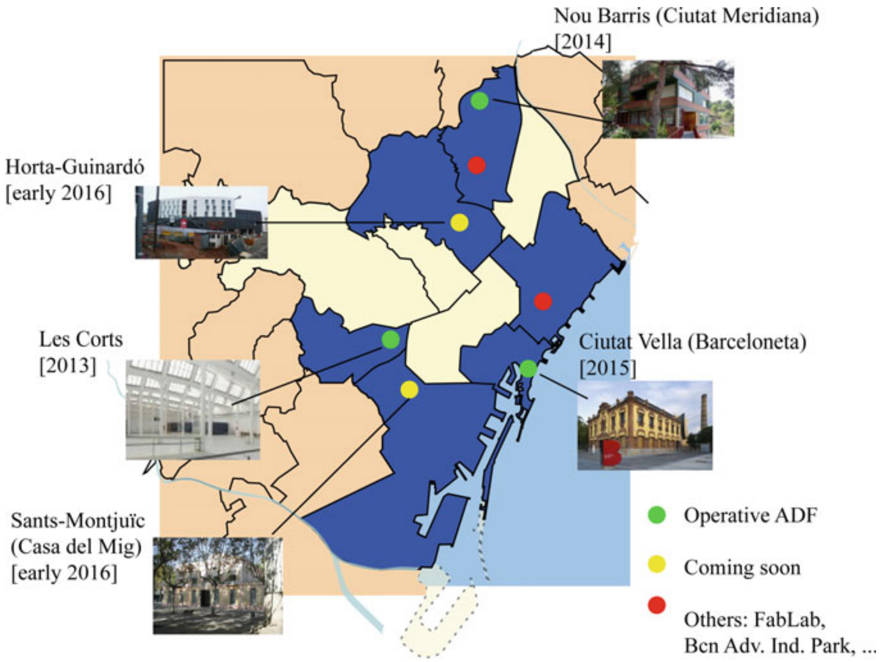

Fig. 7.9 Ateneus of Digital Fabrication (ADF) in Barcelona city

of Digital Fabrication (ADF) for each Barcelona district, as can be seen in Fig. 7.9. Besides, there are other FabLab type facilities like the Barcelona Advanced Industry Park. The network of FabLab/ADF is envisaged as becoming part of the public infrastructure of a sustainable city.

7.2.2 Context and Motivations

The use case FabLab/ADF aims at extending the Manutelligence concepts and tools to an emerging production paradigm for digital fabrication and rapid prototyping. The level of customization in a FabLab/ADF is usually very high, leading to a less structured design and production environment that have to meet the needs of customers with different level of expertise.

The implementation of five scenarios has been carried out for the FabLab/ADF pilot within ManuTelligence scope (Fig. 7.10).

Each scenario is divided in different use cases in order to cover all the process performed in a FAB-LAB.

In the next sections the different scenarios and use cases are explained and also the practical approach used during the project.

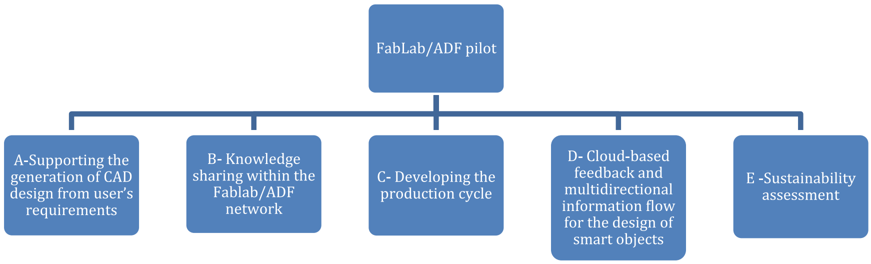

Fig. 7.10 FabLab five scenarios

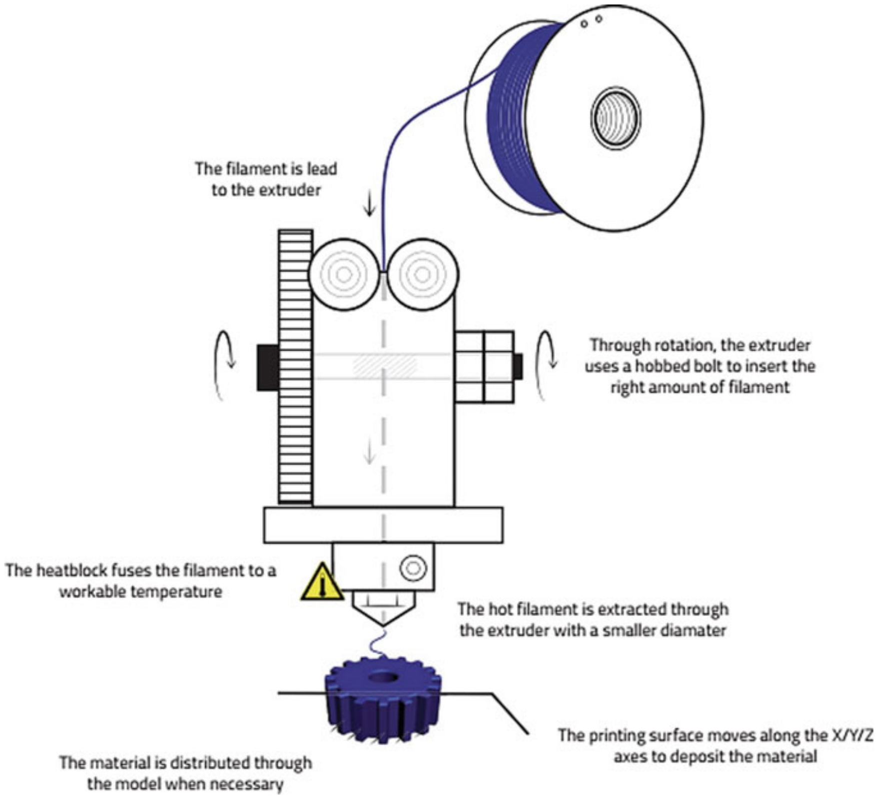

Fig. 7.11 Schematic representation of fused deposition modeling process. (Copyright BCN3D Technologies, image extracted from the User manual BCN3D+ page 4)

Fused Deposition Modelling (FDM) is the technology used for this practical implementation. FDM is a method of rapid prototyping that, starting with a digital 3D model divided on thin layers, consists on melting a filament—usually made of plastic—and deposition of those layers on a build platform (Fig. 7.11).

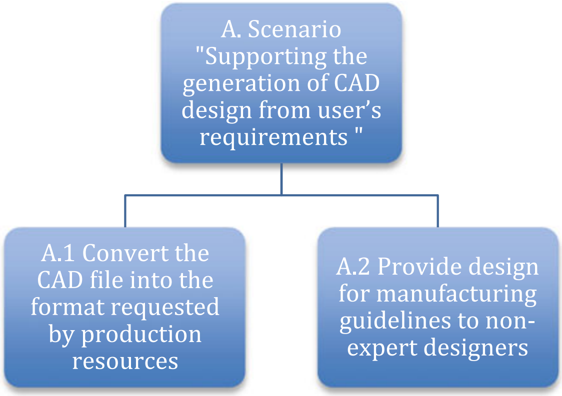

Fig. 7.12 Description of scenario A

7.2.3 *Scenario A: "Supporting the Generation of CAD Design from User's Requirements"*

This scenario aims at improving the generation and management of CAD files (both 2D and 3D models), the first step towards the production of a prototype. In fact, several customers approaching the FabLab/ADF network are likely to be not so familiar with the use of a CAD and could need support in translating their idea into a CAD file, first, and in a format usable by the production resources after. For this reason, the Manutelligence platform is expected to make easier the generation and conversion of CAD file also by showing the users some design for manufacturing guidelines that can reduce the time it takes to FabLab/ADF operators to review and adjust a design developed by a customer.

Challenges in Scenario
The main challenge in the scenario was the identification of a set of suggestions that could be in some way automated within the platform and that are suitable for the additive manufacturing resources but also for other manufacturing technologies like laser cutting/engraving (Fig. 7.12).

Use Cases and Practical Approach

1. Convert the CAD file into the format requested by production resources.
2. Provide Design For Manufacturing guidelines to non-expert designers. In order to support the customer/user in the development of the CAD design, some guidelines in the form of Design For Manufacturing suggestions are provided by the platform, thus reducing the time it takes to FabLab/ADF operators to review CAD design and to make them producible (Fig. 7.13).

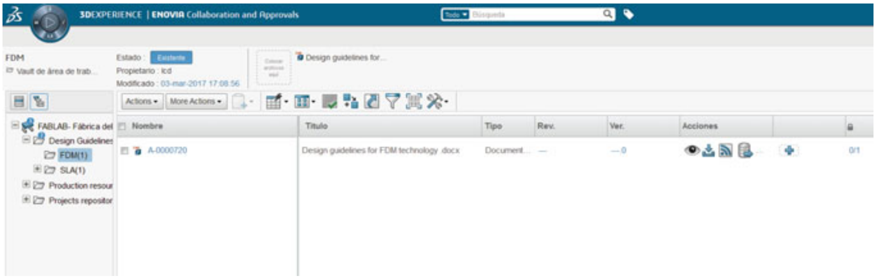

Fig. 7.13 Guidelines available on the platform

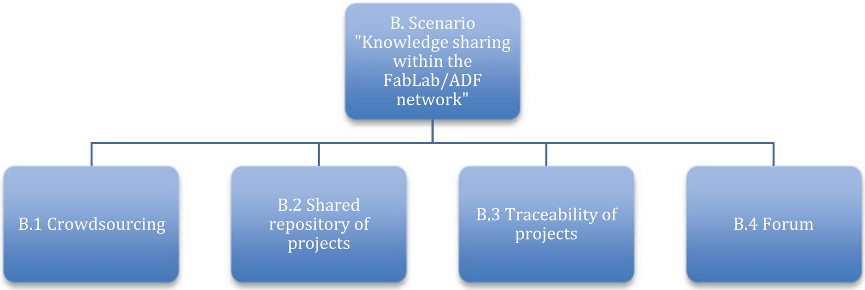

Fig. 7.14 Description of scenario B

7.2.4 *Scenario B: "Knowledge Sharing Within the FabLab/ADF Network"*

The objective of this scenario is to make easier the collaboration, communication and sharing of information between customers/designers who attend FabLab/ADF facilities to turn their ideas into real products.

The result of this scenario is also a process design that is more structured than the current one, thanks to the inclusion of the Bill of Material (BOM) of the products, representing a real innovation. Defining BOM of a product is an extended strategy for more complex industries such as car, ship or aerospace.

Challenges in Scenario

Integrate different technological platform in the scope of FabLabs/ADF networks (Fig. 7.14).

Use Cases and Practical Approach

1. Crowdsourcing. To involve more people in the realization of a project. The inclusion of a simplified BOM of a product will facilitate LCA and LCC analysis (see scenarios E). The possibility to add information in the platform by expert users and the possibility of using forums for the knowledge exchange facilitates collaboration between different disciplines.

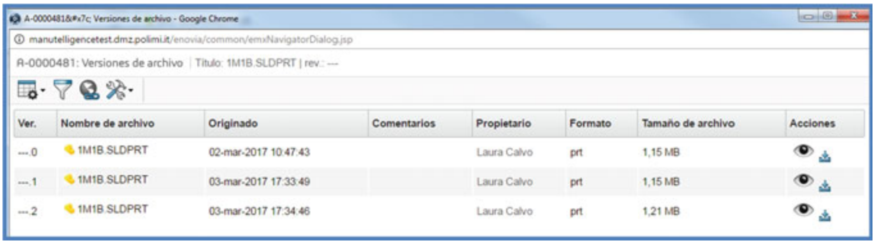

Fig. 7.15 File versions generated in 3DExperience allows design traceability

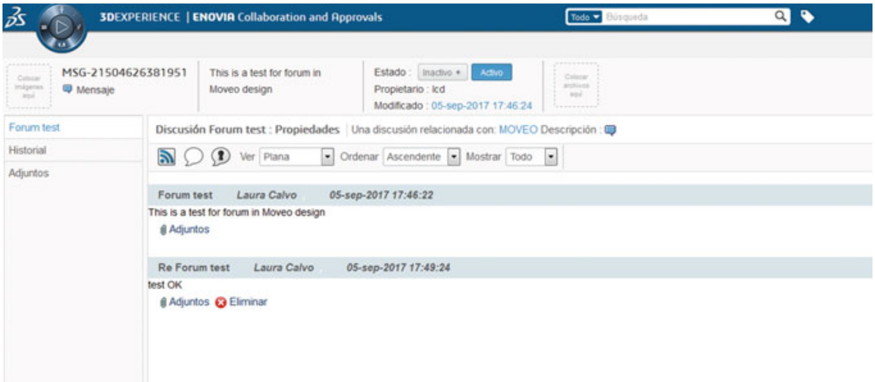

Fig. 7.16 Chat room test

2. Shared repository of projects. This use case seeks to implement an accessible portfolio of projects within 3DExperience software, adapting tools and strategies already implemented in more complex products and services (as the ones associated to cars, ships or aerospace).

This use case is planned for being a step-forward in the manner of sharing Fablab/ADF projects, typically represented by 3D printing products and services, currently supported by unconnected tools.

3. Traceability of projects. Closely connected to the previous point, this deployment will create a structure for the data repository of a single project so that it will possible to build a history of each product keeping trace of contributors, different versions, dates, production cycle information and so on (Fig. 7.15).
4. Forum. To make easier the communication of participants to the network, a tool that will enhance the possibility of sharing ideas, asking for support, providing expertise and creating joint projects, to name the main uses (Fig. 7.16).

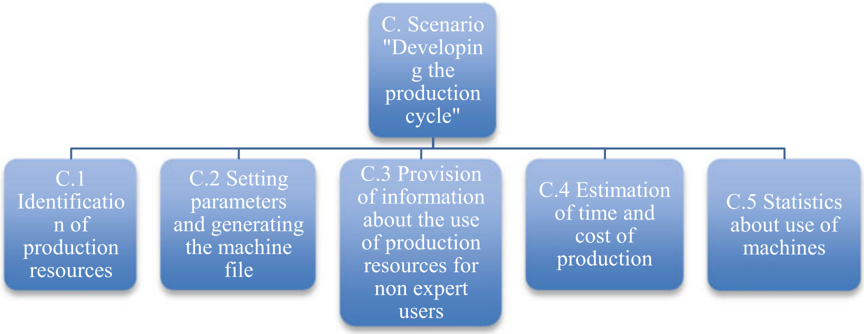

Fig. 7.17 Description of scenario C

7.2.5 Scenario C: "Developing the Production Cycle"

The Manutelligence platform is also expected to act as a link between the design phase and the production phase by making smoother the overall process to get the final product. This scenario focuses on the use of the platform as a support for the definition of the production cycle and for the analysis of some production parameters including time and cost.

Challenges in Scenario

The main challenge for implementing this scenario was related to data needed to make the system working. A lot of data about the use of machines and their performance had to be analyzed in order to populate the platform.

Use Cases and Practical Approach

1. Identification of production resources. From the analysis of the CAD design, the production resources that can be used for the production are identified (Fig. 7.17).
2. Setting parameters and generating the machine file (Fig. 7.18).
3. Provision of information about the use of production resources for non-expert users. Non-expert users can rely on some online information about the use of the selected machines, thus reducing the time it takes to FabLab/ADF operators to provide information about them (Fig. 7.19).
4. Estimation of time and cost of production. When the production cycle is defined, the customer/user is provided with the estimation of the production time and of the production cost (in terms of materials and energy).
   In order to achieve a better estimation of production time, Manutelligence project proposes to gather real data of the production machinery (Fig. 7.20). Then the cost estimated for the product will include the cost of all the energy really used, including for example the cost of producing scrap parts.

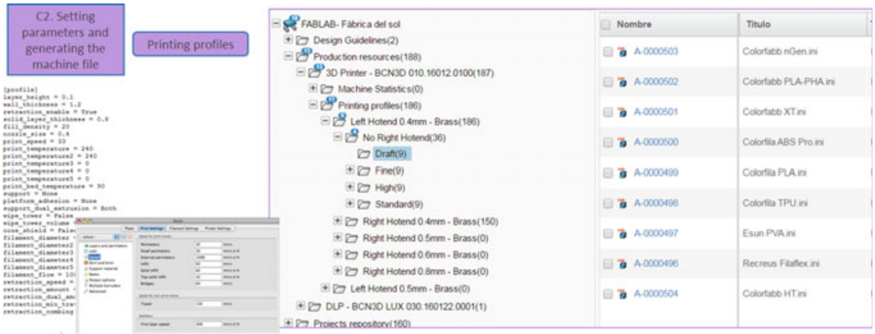

Fig. 7.18 Printing profiles added in the 3DEXPERIENCE

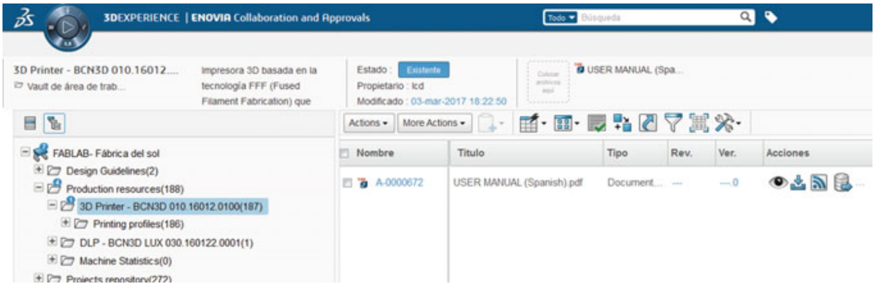

Fig. 7.19 Screenshot from the Platform

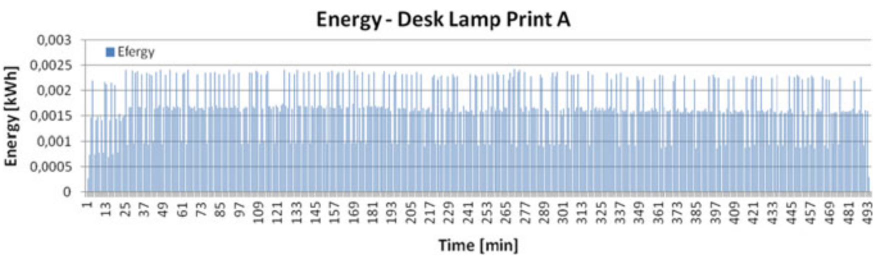

Fig. 7.20 Energy monitoring report

5. Statistics about use of machines. This pilot aims the monitoring of several digital production machinery included in a standard Fablab/ADF facility (3D printers, laser engravers, vinyl cutters…) with cost-affordable monitoring energy systems, capable of sending data to I-Like software from the Manutelligence platform and keeping it in a big database (Fig. 7.21).

Fig. 7.21 i-Like software from Holonix adapted to Fablab/ADF digital machinery

7.2.6 *Scenario D: "Cloud-Based Feedback and Multidirectional Information Flow for the Design of Smart Objects"*

The objective of this scenario is to set up an area of the ManuTelligence platform to be dedicated to collection and storing of data coming from sensors embedded in smart objects for carrying out multiple analysis. Users can have access to these data to analyse the product performance and behaviour during the use phase. On the other hand, FabLab/ADF operators could access the whole database to carry out statistical analysis on the smart objects with the aim of improving their expertise on them and being able to provide a better support for the design of this kind of product.

Challenges in Scenario

The main challenge was due to the innovativeness of this scenario compared to what happens at the moment: usually, products are not smart and during the use phase no information are collected. It means that training of FabLab/ADF operators who will

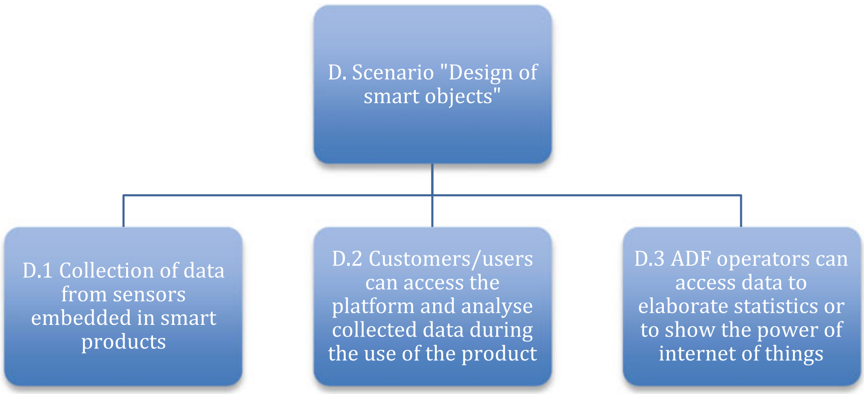

Fig. 7.22 Description of scenario D

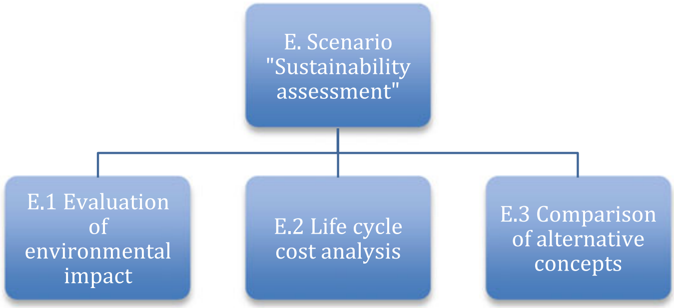

Fig. 7.23 Description of scenario E

be requested to become familiar with new tools and technologies is requested. On the other hand, also users need to be trained in order to correctly use sensors and perform analysis.

Use Cases and Practical Approach

1. Collection of data from sensors embedded in smart products. The ManuTelligence platform will have an area dedicated to the real-time collection and storing of data coming from sensors embedded in FabLab production resources and even smart products developed in the facilities (Fig. 7.22).
2. Customers/users can access the platform and analyse collected data during the production of the product.
3. FabLab/ADF. Operators can access data to elaborate statistics or to show the power of Internet of Things (IoT).

Fig. 7.24 3D printed lamp

7.2.7 Scenario E: "Sustainability Assessment"

The objective of this scenario is the integration of LCC and LCA tools into the design process of the FabLabs/ADF. Methods suitable for little structured design process like the one in FabLabs/ADF have to be developed starting from the Manutelligence tools. During the design process, it is possible to provide information about the environmental and the economic sustainability of the product being developed. On one hand, this allows the choice of the more sustainable solution among the available options thus improving the level of sustainability of the FabLab/ADF production. On the other hand, also users not directly interested in sustainability are made aware of the sustainability impact of their decisions thus increasing the level of knowledge and attention about this topic that, per se, is a social aim.

Challenges in Scenario

The main challenge in this case was related to the introduction of one more step into the design process that implies also the training of FabLab/ADF operators who had been be requested to become familiar with new tools and new concepts. The knowledge of these tools should be enough to support users/customers in their understanding.

Use Cases and Practical Approach

1. The evaluation of environmental impacts. It was done with the Manutelligence adapted LCA tool, MaGA. The LCA of the lamp was done in MaGa using the data collected when building the 3D printed lamp (Fig. 7.24) (more information in Chap. 6) (Figs. 7.23 and 7.25).

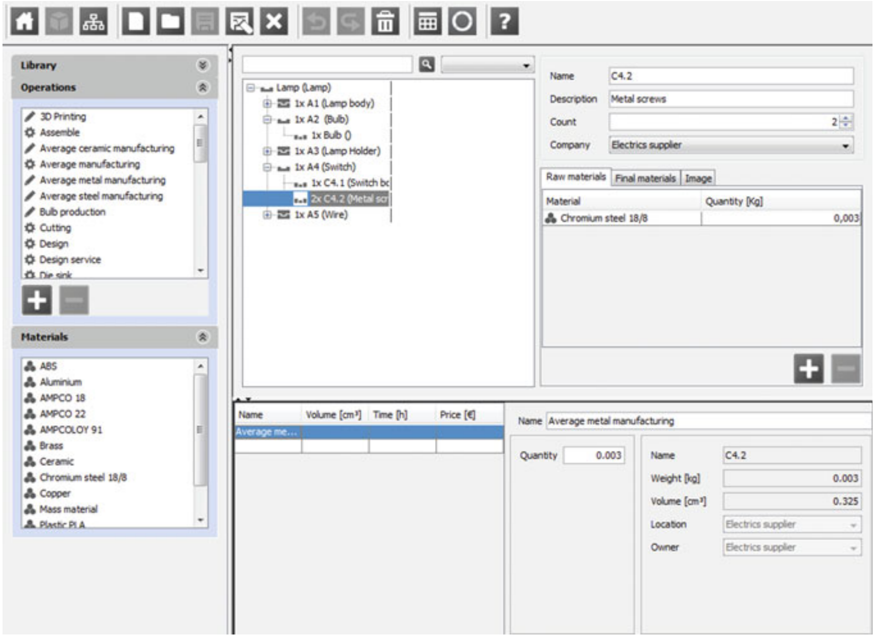

Fig. 7.25 Screen shot showing the creation of the 3D printed process in the MaGA software

2. Currently very simple models or methodologies are used to evaluate the cost of products and services developed within a Fablab/ADF, like using a table based on an excel sheet.

The aim of this pilot is to advance in evaluating the cost of developing a product and service within a Fablab/ADF. For this reason, the pilot is developing demo products such as the lamp for being implemented in LCPA software module by Balance. This use case is linked with the developments done in the Scenario C.

This way of evaluating the project developed within the Fablab/ADF helps to improve the evaluation of counterpart services that a customer of an Ateneu of Digital Fabrication (ADF) must do for using for free the digital production machinery installed for the city council.

3. Comparison of alternative concepts. The sustainability assessment provides data in (almost) real time so that it is possible to compare different concepts of the same product on the basis of its sustainability impacts. The designer is thus supported in the selection of the final design making him/her aware of the generated impact (more information in Chap. 6). An example is shown at Figs. 7.38 and 7.39.

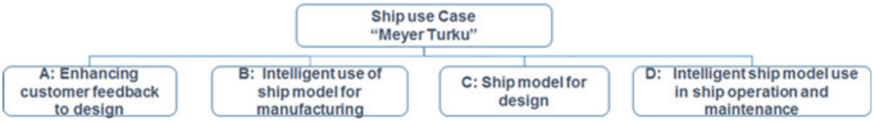

Fig. 7.26 Meyer Turku main scenarios in Manutelligence

7.3 Ship Use Case: Supporting Customer Feedback for Product-Service Design

7.3.1 Objectives and Results

The main goal is to move from product information management towards manufacturing intelligence, through more efficient management and integration of ship data and information. Focus is given on sharing the ship model to different stakeholders and supporting the communication between the different lifecycle phases, both forward and backward. This is needed to improve the engineering and service development, both cost- and time-efficiency and quality but also to create preparedness for offering the ship model as a service to the customer.

In Manutelligence, Meyer Turku currently defined four potential scenarios as described in Fig. 7.26 and several use cases belonging to them. From the beginning it was clear that not all of them could be implemented in Manutelligence. During the project the main focus was given to Scenario A: Enhancing customer feedback to design. The implementation of the scenario is described more in detail below.

The main objective in Meyer Turku use case is to receive feedback from the yard customer (ship owner) with new and more efficient communication methods. The idea is to add knowledge as a service to the product, to allow customer to view the ship with virtual reality and to be able to have more visual communication about current product prototype. In shipbuilding, product prototype means first ship in ship series. Normally one ship series contains 1–5 sister ships. With improved customer communication, it is possible to increase value of product by fulfilling customer needs in better way. Virtual reality tools are used as a communication method, because, from physically very large objects like a ship, it is difficult to create real 1:1 prototype or mock-ups. This idea can be also used in other product lifecycle phases, like between design and production. With new methods of communication it is possible to have more streamlined processes and finally to have better and more competitive product (Fig. 7.27).

Traditionally, material value is added in production to convert material into a product. In service sector, knowledge is sold as a service product. Combining product and service in the same entity as Product-Service makes better and more intelligent business.

In Meyer Turku use case, new service layer was added to standard shipbuilding process (shipbuilding process is basically a material management process).

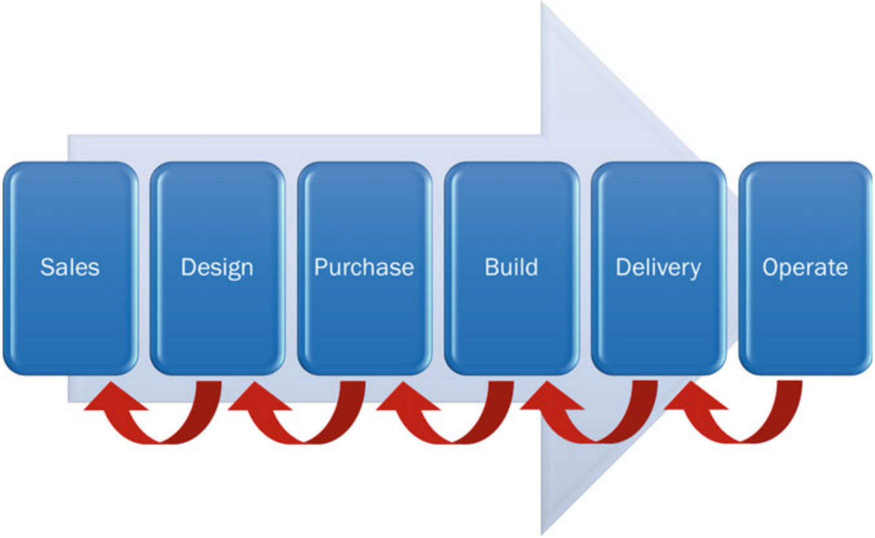

Fig. 7.27 Processes and feedback

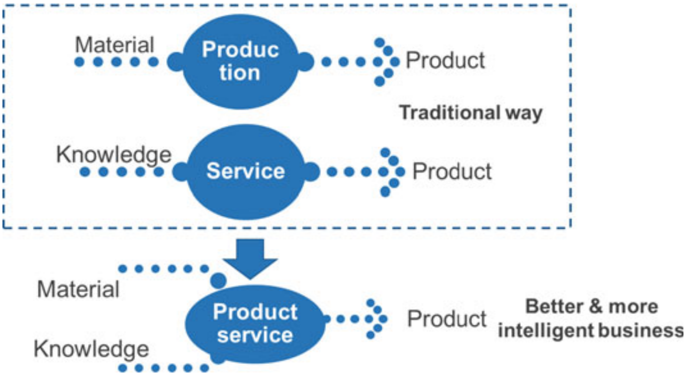

Fig. 7.28 The product-service combination

New process was developed for creating a virtual reality experience from Yard's standard 3D-models. See example below about example output in HTC-Vive virtual reality device (Fig. 7.28).

New process includes automatic clean-up of CADMATIC 3D model and own customized tools, which are created in Unity3D game engine (Figs. 7.29 and 7.30).

One example about customized tools is measurement and commenting tools inside virtual reality (Fig. 7.31).

Another example is the usage of MMO (Massive Multiplayer Online)-concept, where several engineers can connect to same virtual reality session by using Avatars.

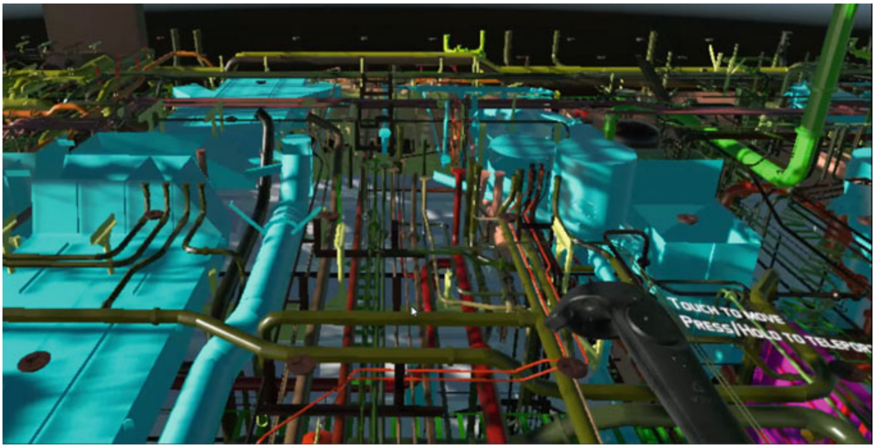

Fig. 7.29 Example output in HTC-Vive virtual reality device

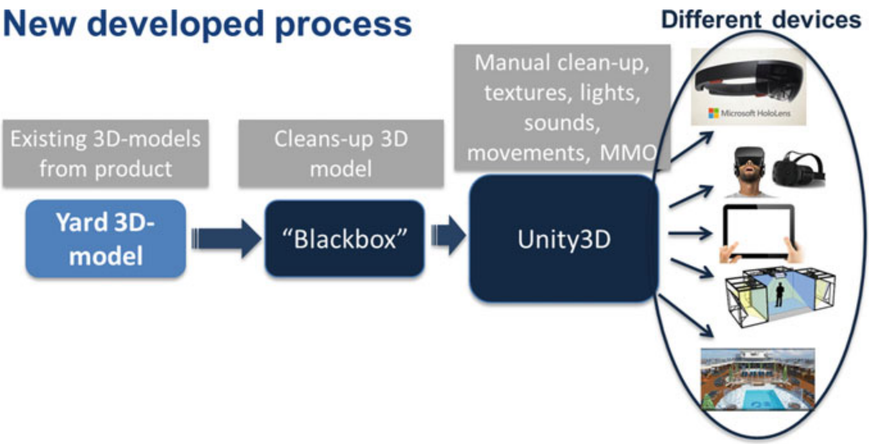

Fig. 7.30 Scheme of new developed process

Avatar characters can use different hand movements and also VoIP communication is possible. (Voice over Internet) (Fig. 7.32).

Meyer Turku has created in Manutelligence project demonstrator, which can be used as a collaborator-tool in real time usage. See picture Fig. 7.33 about idea and layout of demonstrator.

The parts of the demonstration include:

- Presenter has got Laptop computer or mobile phone, which is connected to MMO-cloud (Massive Multiplayer Online). Presenter can show own desktop with standard data projector.

Fig. 7.31 Example of comments into the virtual reality

Fig. 7.32 Meyer demonstrator: networked VR-platform mock-up

- Mobile VR-platform (virtual reality) where it is possible to see 3D-model with HMD-device (Head Mounted Device) via MMO-cloud. It is also possible to see "Presenter" and "Satellite-site in Finland" as avatar in virtual reality environment. Same information without HMD can be seen also in normal display in the table.
- Satellite-site in Finland is connected to same MMO-could and audience in the final project review can see and hear also what's happening in satellite-site in Finland.

With practical approach and by creating a real existing demonstrator it makes possible to really present new and more efficient communication layer to existing shipbuilding process.

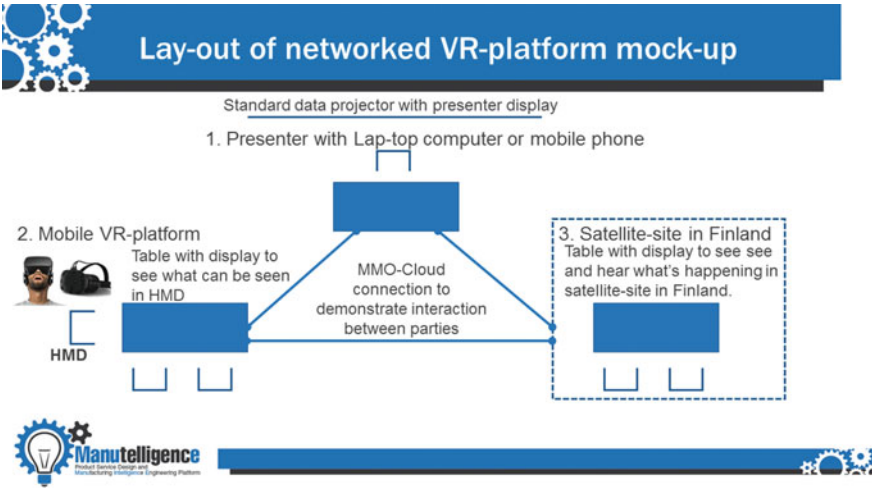

Fig. 7.33 Layout of networked VR-platform mock-up

7.4 Smart House Case—Introduction to Lindbäcks and Their Business Challenges

Lindbäcks is a family business from Piteå in northern Sweden. In close cooperation with our customers and with a huge motivator for innovation, Lindbäcks develops environmentally friendly and economical construction of apartment buildings in wood—all to create effective and sustainable places for tomorrow's needs. Lindbäcks place great emphasis on high quality accommodation where good materials and good design are the core ingredients. By always cooperate with some of the country's premier architectural offices, we create beautiful, healthy and practical homes where people enjoy and want to live.

Lindbäcks is Sweden's leading company in industrial construction of apartment buildings with a good knowledge of construction, production processes and project development. With the goal of becoming Europe's most modern producer of apartment buildings we are currently building a brand new production plant in Haraholmen, Piteå. It will be inaugurated by the end of 2017 and be fully powered by solar energy and district heating. Together with our production plant in Öjebyn, Piteå we will be able to produce 2400 apartments/year in 2020.

Lindbäcks houses are designed to last for more than a century. Based on the relatively long life cycle, the knowledge about the behaviour of the product throughout its lifecycle is crucial to remain competitive. Besides complaints during the warranty time, failure management and adjustments of new house orders from established customers, LINDBÄCKS receives limited feedback from the use-phase of their houses. In fact, it is a missed opportunity for iterative product improvements. Part of the required use-phase information is the monitoring of the energy consumption. While the theoretical energy consumption is calculated in the house design process, there is no real life validation of the actual energy consumption. Since the energy costs are becoming a cost driver in terms of life cycle costs, the real life proof of energy efficient houses could become a competitive advantage on the market.

Furthermore, Lindbäcks is looking for ways to enhance their business. Adding additional services to the houses to offer a product-service system is one way of thinking to approach new business areas. There are several ideas to establish additional services for living and how to integrate them into the product service system. However, the service for living ideas have to serve a market. Therefore, the service for living needs an appropriate business model, that relies on a precise cost structure. Internet of things technology could help to analyse the cost structure of the envisaged service for living offering and thereby support the development of new business areas. The chapter describes, how the usage of the Manutelligence platform enables Lindbäcks to cope with the addressed business challenges.

7.4.1 Collecting Information of the Use-Phase to Improve Lindbäcks Houses

To tackle the business challenges described in Chap. 1, Lindbäcks pursues the approach to implement internet of things technology within the Manutelligence project. The installation of the sensors is supposed to provide data to track the quality of Lindbäcks houses throughout the lifecycle and to gather the actual energy consumption. The gathered data of the sensors is transferred to the I-like platform of Holonix to serve as input parameters to the house designer at Lindbäcks and to the tenants, who can track his own energy consumption. Moreover, life cycle analysis based on the measurement data could serve as marketing instrument for Lindbäcks to position their houses as sustainable in the market (Fig. 7.34).

In a first step, Lindbäcks selected several key parameters to measure throughout the lifecycle.

Key parameters in the LINDBÄCKS use-case
Cold water
Water warm
Heating system
Humidity in wood
Humidity air
Temperature air
Water leakage kitchen sink
Energy consumption of floor heating systems

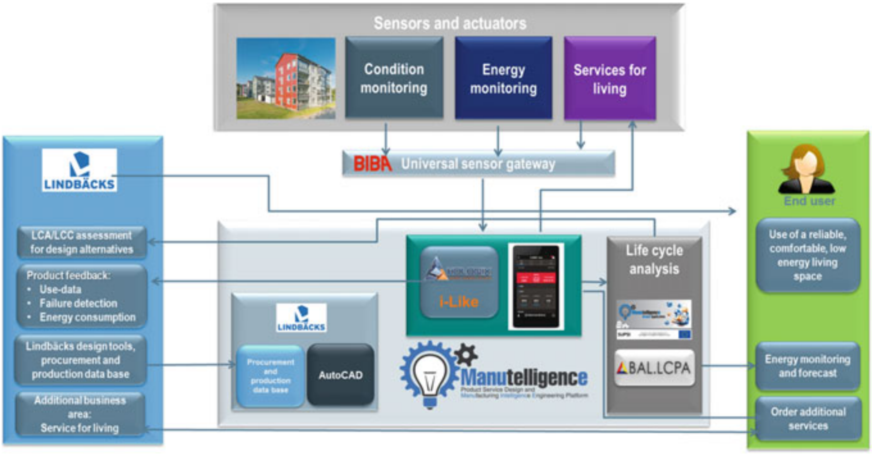

Fig. 7.34 LINDBÄCKS use-case approach in the Manutelligence project

Humidity in wooden houses is a key issue. Therefore, humidity sensors in the wood as well as in the room should be installed. Moreover, the room temperature shall be measured to identify causes for potential moisture issues and to crosslink the temperature information with the heating energy consumption. Sensors to detect water in the sink is conceived to be a prototype instalment to monitor water leakages in pipes, which can lead to major damages of the houses. In addition, the water consumption is measured to identify unusual water consumption combined with an alarm system to mitigate the risk of major water damages.

The measurement and sensor selection process followed a first prototype installation in a flat of a Lindbäcks employee. Thereby the prototype consist of one air temperature sensor, one air humidity sensor and a sensor to detect water leakage in the kitchen sink. The gathered data has been collected by the universal sensor gateway unit and transferred to the I-LIKE module of the Manutelligence platform. The overall prototype testing underlined the potential benefit of developing and utilising the Manutelligence platform.

After the first prototype, a second, more comprehensive instalment has been planned. The second instalment comprises room temperature measurements in five different rooms. In addition, the outdoor temperature is measured as well. The measurement data is transferred to the I-Like-module of the Manutelligence platform, where that data values and data visualisation is handled (see Fig. 7.35). House designer and house operator can access the I-like module on a computer or a mobile device to analyse the data or to check the alarm.

In addition, the gathered data of the use-phase of a house enables to perform life cycle assessment and life cycle costing. To ease this process, a webservice has been established to import the required life cycle data into life cycle analysis tools, like BAL.LCPA. Based on the real measurements, the calculation of the operating

Fig. 7.35 Measurement value representation on the I-LIKE module of the Manutelligence platform

costs of the use-phase, especially costs for heating, is more precise and lead to more meaningful results (see Fig. 7.36).

The gathered data of the use-phase serves also as feedback -loop to Lindbäcks house designer. Based on the knowledge about the long use-phase of Lindbäcks houses, house designers can improve future house iterations and thereby improve the overall product quality in the long-term perspective.

7.4.2 Use-Phase Information to Create Additional Services

The collected information of the use-phase may also enable Lindbäcks to create new business areas. Developing additional services for living to be offered in combination with LINDBÄCKS houses could be realised based on the gathered knowledge. In the Lindbäcks use-case, the development of bathroom floor heating as a pay per use-service for the tenants has been developed. On the one hand, the technical realisation is based on state of the art technology. As part of the prototype testing described in Chap. 2, a bathroom floor has been equipped with a floor heating system as well as measurements of the energy consumption, system status information (on/off) and an

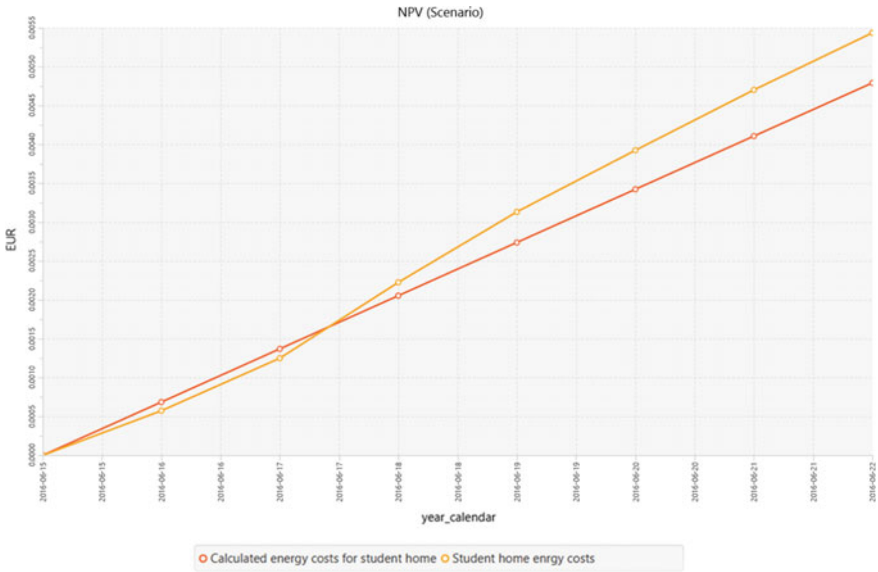

Fig. 7.36 Energy costs comparison theoretical values versus measured values

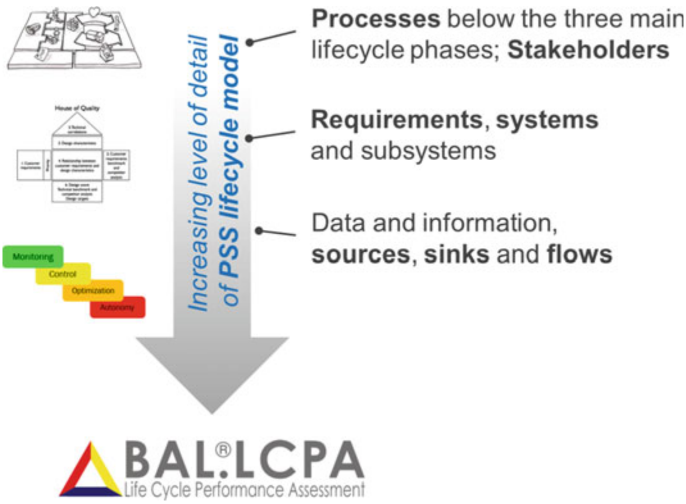

Fig. 7.37 Manutelligence PSS system development methodology

actuator to change the system status remotely. On the other hand, the development of the service including business model, pricing and payment options is more complex. Therefore, the Lindbäcks use-case applies the PSS system development of the Manutelligence project to create a new product service system (see Fig. 7.37).

The PSS development methodology starts with the development of a business model for the PSS in a business model canvas. In the second step, a quality function deployment is carried out. A third step includes an evaluation of the IoT functionality of the PSS. Concurrent to the first three steps, a life cycle model is developed containing relevant processes, stakeholders, and flows along the life cycle of the PSS. In a last step, the life cycle model is imported to life cycle analysis tools like BAL.LCPA, to evaluate the long-term profitability potential of the developed PSS. Part of the profitability analysis is the price definition of the pay-per-use service. Thereby, two different approaches for price finding are supported: On the one hand, a detailed life cycle cost analysis with profit margin can determine the price, or focus group testing among potential customers identifies the accepted price for the offered service.

7.4.3 Conclusion

The Manutelligence platform enables Lindbäcks to tackle their business challenge in terms of gathering product feedback throughout the lifecycle, optimising the actual energy consumption of their houses and developing new business areas. In particular, the internet of things implementation combined with the I-Like platform for data analysis and -visualisation creates valuable product feedback to improve Lindbäcks houses in the long-term perspective. Based on the gathered information of the use-phase, Lindbäcks expects to reduce material and construction failures, lower repair costs due to earlier recognition and optimise the energy efficiency of their houses. In addition, the life cycle analysis tools supports the product optimisation process and their results are supporting Lindbäcks in positioning their wooden houses as sustainable products in the market. The Manutelligence platform also encourages Lindbäcks to explore new business areas with its own methodology to develop product-service systems.

In fact, after the end of the Manutelligence project, Lindbäcks envisages to install IoT sensors in multiple commercial houses to gain the described benefits.