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Product Lifecycle Management Approach for Sustainability

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Abstract

Starting from the framework of Product Lifecycle Management (PLM), sustainability should be provided by continuous sharing of information among the different product lifecycle phases. A PLM system provides lifecycle knowledge generated by PLM systems through product lifecycle activities. The paper aims at presenting how PLM systems represent a very important foundation for achieving a more sustainable paradigm for life, a more sustainable development, engineering, manufacturing, use and disposal of products.

Keywords:

Sustainability, Sustainable Engineering and Manufacturing, Product Lifecycle Management

1 INTRODUCTION

From the semantics of the word, sustainability is a quality that permits to preserve, to keep, to maintain something. When something is sustainable, it is able to be kept. In the past, the term was mainly environmentally-oriented, i.e. as the quality to sustain the environment. However, in current literature, sustainability is defined with three dimensions: environmental, social, and economical; often adding a forth one, technology [1]. Therefore, what is meant with sustainability is to be able to keep human development in all these dimensions, which is often referred as sustainable development. Sustainable development is not a new concept, one of the most used definitions is the one given in 1987 by the Brundtland Commission as “the development that meets the needs of the present without compromising the ability of future generations to meet their own needs” [2].

From the basics, engineering is a key driver of human development. Looking at the role of technology in human development, engineering is the key driver of technology-based human development which is leveraging on a large collaboration from many individual disciplines (i.e. industrial, mechanical, electrical, etc). Henceforth, Sustainable Engineering can be defined as the way of applying engineering for sustainability purposes. This concept is depicted in figure 1, where Sustainable Engineering is seen as a layer of engineering oriented approaches, methods and tools crossing the four pillars of Society, Economy, Environment and Technology for achieving sustainability oriented results.

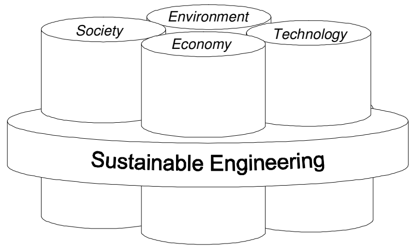

Figure 1: Sustainable Engineering dimensions.

Within this view, Sustainable Manufacturing is defined as, an instance of Sustainable Engineering, meaning to apply scientific knowledge to design and implement of products, materials, systems, processes, etc. that take into account constrains coming from the 4 pillars of sustainability to develop solutions for the design, operational and organizational activities related to products, processes and services in the manufacturing sector.

As known, sustainability will be a major issue for the next decades. The awareness of limited resources availability, of problems related to pollution, of increasing demand of goods, energy and materials from the already developed and the new developing countries and, as a consequence of these factors, the increase in costs of scarce resources, all are calling for a new paradigm of life, overcoming the obsolete consumerist model of modern societies. Assuming to maintain the current level of well being of developed countries as a reference target, the shift to the new life’s paradigm will be something like a Copernican revolution. Really, this shift will be extremely difficulty, requiring revolutionizing a well established model. Social, cultural and also psychological implications will be involved from one side; while from the other tremendous improvement of current technologies will be required to enable this kind of change. To reach such revolution, the product concept itself should be totally re-shaped, especially taking into account a lifecycle view: product design for a low-priced and clean production, for a long and safe use and for an integral recycling should be provided. Not only the product design is required to be substantially and continuously improved and innovated, but the development of new materials and an overall redesign of production processes will be needed; entailing for example, the development and subsequent processes of totally new production processes made of a sequence of small intelligent, clean and energy saving steps. In such a vision, Sustainable Manufacturing will surely become one of the most relevant topics in the next engineers’ interests.

The present paper aims at investigating the climbing role of Sustainable Manufacturing for engineers and designers, taking care of the general framework of Product Lifecycle Management (PLM). For this purpose, the paper is organized as follows:

- Section 2 defines the main elements of the general framework of PLM.
- Section 3 summarizes the relevance of Sustainable Manufacturing, also conducting a state-of-the-art of the tools and methods for its deployment.
- Section 4 investigates the role of PLM in Sustainable Manufacturing, also defining a research agenda for such a topic.
- Section 5 concludes the paper.

2 PRODUCT LIFECYCLE MANAGEMENT

In recent years, the competitive pressure coming from the opening of markets has strongly affected the companies approach to product development: shorter lifecycles and explosion of product variety have been the main consequences, together with an ever standing requirement for low production costs. Reduction of time to market, collaboration and delocalization have been the companies' answers to these issues, which were achieved by restructuring the organizational models of product design and production, while leveraging on the new ICT (Information and Communication Technology) tools for collaborative product design, development and production, made available by recent technology progress. The PLM paradigm emerged as "a product centric business model, ICT supported, in which product data, are shared among processes and organization in the different phases of the product lifecycle for achieving top range performances for the product and related services" [3].

PLM is already well known in the ICT market, even if unlike other technology solutions PLM is not a point solution or an off-the-shelf tool. Instead, it is grounded in the philosophy of connectedness of knowledge and seeks to provide "the right information, at the right time, in the right context". PLM is physically enabled by the integration of a variety of enterprise software applications, like Computer Aided Design (CAD) tools, Product Data Management (PDM) platforms, and Enterprise Resource Planning (ERP) and Supply Chain Management (SCM) solutions. These applications are offered by many market vendors with different backgrounds and expertises, for supporting enterprise information management, along diverse phases of an ideal product lifecycle. Such a term – lifecycle – generally indicates the whole set of phases which could be recognized as independent stages to be passed/followed/performed by a product, from "its cradle to its grave". According to [4], product lifecycle consists of three main phases (Figure 2):

- Beginning of Life (BOL), including design and manufacturing. Design is a multilevel phase, since it comprises product, process and plant design. Generally, a design action is performed in a recursive way, identifying requirements, defining reference concepts, doing a more and more detailed design and performing tests and prototypes. Today's knowledge-intensive product development requires a computational framework that enables the capture, representation, retrieval and reuse of product and process knowledge. Manufacturing means production of the artefacts and related plant internal logistic. At this stage, product information has to be shared along the production chain, to be synchronized with future updates.
- Middle-of-Life (MOL), including distribution (external logistic), use and support (in terms of repair and maintenance). In its life, a product passes from the company's hands to service suppliers (e.g. transportation suppliers, but also after-sales assistance suppliers), to arrive in the customer's hands. These passages could happen many and many times, in reiterative ways. Product usage data are to be collected, transformed and used for various purposes in the service chain. For example, data on product behaviour during the usage phase can be fed back in BOL and used for design improvement.
- End-of-Life (EOL), where products are retired – actually recollected in the company's hands (reverse logistic) – in order to be recycled (disassembled, remanufactured, reused, etc.) or disposed. Recycling and dismissal activities require and provide useful information on product components, materials and resources from/to the design and manufacturing stages. Many different actors are involved in this phase (company's service suppliers; customers, institutions, etc.). For many products (e.g. commodities, electronic goods), customer's environment sensibility has a relevant role to the management of such phase.

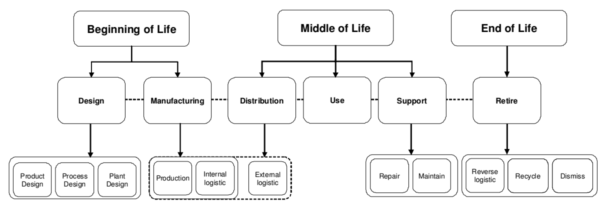

Figure 2: Reference model for product lifecycle phases (adapted from [4] and [5]).

The PLM concept is certainly a question of data visualisation and transformations, where ICT plays a fundamental role. However, PLM comprises other two important levels: processes (where data flow among actors/resources with relative competences, inside and outside an organization), and methodologies (practice and techniques adopted along the processes, using and generating product data). These three elements (ICT, Processes, and Methodologies) are the fundamentals of the PLM concept, evolving along the lifecycle phases of the product (Figure 3).

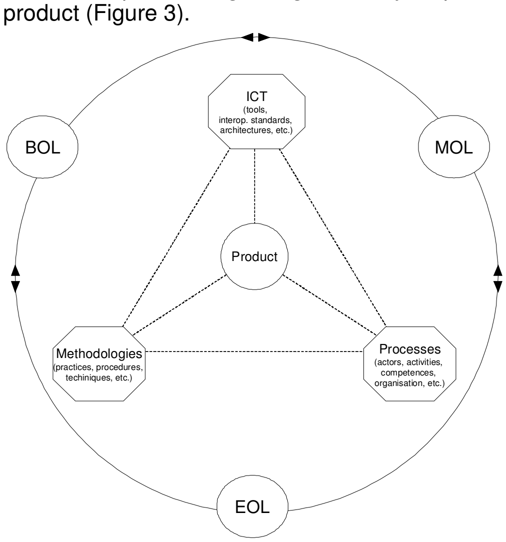

Figure 3: Reference model for product lifecycle management [3].

2.1 PLM as a “system of systems”

BOL phase deals with product design and manufacturing. These two main activities have an intrinsic difference: product design is a recursive and reiterative intellectual activity, where – generally – designers and engineers might find solutions for given problems. On the contrary, manufacturing is a repetitive transactional-based activity, which might concretize the decision taken by others. For this main reason, design and manufacturing are supported by a plethora of different ICT PLM tools: authoring tools (CAD, etc.) and collaborative product development platforms (PDM, etc.) in the design activity, and a set of enterprise applications (ERP, SCM, CRM, etc.) in the manufacturing and distribution activities. Then, during BOL phase, PLM is basically a design support system (Figure 4): product design data might be created and managed efficiently in order to be distributed to the right actors at the right time for efficient manufacturing. MOL and EOL phase could provide useful information, analyzing data gathering from the field. It might be honestly affirmed that in the market an entire PLM system supporting all the processes of BOL phases is not currently provided by a single vendor (and probably it will not exist in the next future), but PLM might considered like a “system of systems”, where diverse vendors just provide a piece of a larger PLM picture.

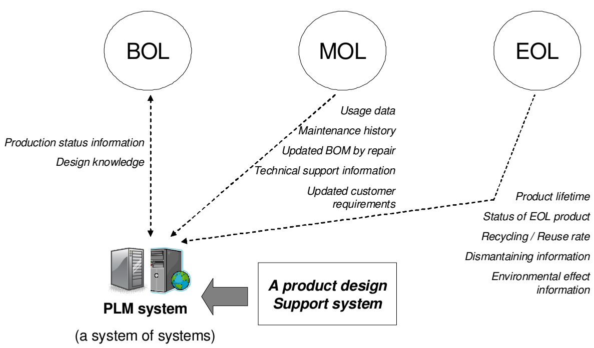

Figure 4: PLM in the BOL phase.

MOL phase deals with the real life of the product when it is in the customer’s hands, while EOL deals with its “death”. During these phases, many actors are in touch with the product: logistic service suppliers, customers, after sales service suppliers, recycling service providers, etc. All these actors perform their repetitive activities, generally without exchange much detailed information with other actors, being measured in term of process efficiency. Similarly to the BOL phase, during MOL and EOL phases, PLM is basically a service support system (Figure 5 as example of the MOL phase), composed by a plethora of subsystems: product data are collected from the field using various tools, in order to monitor and control the life status of the product, while information from BOL phase are needed to analyze and understand behaviors and structures of the product.

More and more product data management during these two phases is becoming an unavoidable aspect, since regulations and legislations are taking care of diverse product data in order to improve customer safety and security. In particular, this is already a relevant aspect in process industries (i.e. pharmaceutical, food and beverage, etc.). However, in spite of such increasing interests of normative offices, during MOL and EOL phases, the information flow becomes less and less complete. For the majority of today's products (e.g. consumer electronics, household machines, vehicles), it is fair to say that the information flow breaks down after the delivery of a product to a customer. As a consequence, actors involved in each lifecycle phase have made decisions based on incomplete and inaccurate product lifecycle information of other phases, which has led to operational inefficiencies.

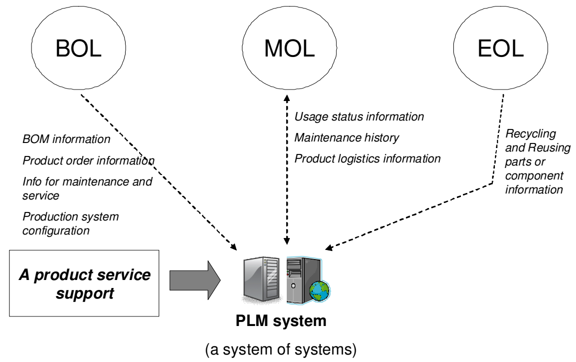

Figure 5: PLM in the MOL phase.

In spite of its vision, PLM has not yet received much attention so far from industry for the MOL phase because there are no efficient tools to gather product lifecycle data over the whole product lifecycle. Single applications exist for supporting specific activities within these phases (e.g. maintenance and after sales supporting tools), but a comprehensive system is not existing.

Recently [4], thanks to the advent of product identification technologies such as Radio Frequency Identification (RFID), PLM has now powerful tools to implement its vision. The product identification technologies enable products to have embedded information devices (e.g. RFID tags and on-board computers), which makes it possible to gather the whole lifecycle data of products at any time and at any place. Thus, in the near future, the whole product lifecycle could be visible and controllable, allowing all actors of the whole product lifecycle to access, manage, and control product related information. Especially, the information after product delivery to customers and up to its final destiny could be gathered, without temporal and spatial constraints. This way, BOL information related to product design and production could be used to streamline operations of MOL and EOL. Furthermore, MOL and EOL information could go back easily to designers and engineers for the improvement of BOL decisions.

3 SUSTAINABLE MANUFACTURING

From a general perspective, sustainability can be seen as a critical business issue driven by factors outside of the industry’s control, unlike many other business issues. Multiple constituencies such as shareholders, regulators, consumers, customers, NGOs (Non Governmental Organisations) are demanding that companies address it. Sustainability intercepts with every aspect of the business. Consumer businesses rely on a wide range of natural resource inputs, such as agricultural products, water, forestry and marine fish stocks. Consumer products and packaging are also one of the largest contributors to solid waste, compared to other industries. Sooner or later in each industrial sector, it will not be enough for product manufacturers simply to design their products for disposal and recycling: manufacturers will be responsible for the actual disposal and recycling, until the end of the life of their artefacts (as many regulations currently in place at an European level and in the road of legislation in most of the other industrialized countries, i.e. Table 1), facing the needs of Sustainable Manufacturing.

Regulation	Environmental Requirements
ELV End of Life Vehicle	Regulation for automobiles and electronic devices make the product producer responsible for recycling and disposal (e.g. 85% recycling/recovery rates in terms of weight by 2006 and 95% by 2015).
WEEE Waste Electrical and Electronic Equipment	Requires manufacturer to have a program to take back and recycle products such as TVs, computers and cell phones; register the product and finance the collection, treatment, recovery, and disposal.
RoHS Restriction of use of certain Hazardous Substances	Mandates companies to not manufacture products with more than a maximum concentration of a number of certain substances such as lead, mercury, cadmium among others.
REACH Registration, Evaluation, and Authorization of Chemicals	Designed to ensure that 30,000 banned chemicals do not make their way into a product at any point in the supply chain.
EuP Energy using Product	EuP is a product which requires or produces energy The Directive does not introduce directly binding requirements for specific products, but does define criteria for setting product environmental requirements (i.e. energy consumption).

Table 1: Summary of some of current environmental legislations.

It is clear that sustainability is not a new topic, even if it has reached a relevant attention in the last two-three years. The diverse dimensions of sustainability and the diverse declinations have been already investigated and developed. Also, Sustainable Manufacturing has been obtained many attention from the industrial and research communities, as the plethora of strategies, methods, procedures and tools existing in literature demonstrate. The following classification (adopted from [6]) outlines some of the many contributions that have been developed in the ambit of sustainable manufacturing practices, in terms of Principles, Tools and Strategies:

- Principles (Table 2): are fundamental concepts that serve as a basis for actions, and as an essential framework for the establishment of a more complex system.
- Tools (Table 3): contain a group or cluster of principles related to the same topic, building a more complex system, showing how to apply specific practices in order to contribute to improved industrial performance.
- Strategies (Table 4): Each consists of approaches and systems connected together that are to be met in order to incorporate the principle of sustainability into everyday business activities.

Principle	Description
Reuse	Reuse means using waste as a raw material in a different process without any structural changes
Recycle	Recycling is a resource recovery method involving the collection and treatment of waste products for use as raw material in the manufacture of the same or a similar product.
Recover	Recovery is an activity applicable to materials, energy and waste. It is a process of restoring materials found in the waste stream to a beneficial use, which may be for purposes other than the original use.
Repair	Repair means an improvement or complement of a product, in order to increase quality and usefulness before reuse; it decreases consumption, because the product’s life is extended.
Regeneration	Regeneration is an activity of material renewal to return it in its primary form for usage in the same or a different process.
Re manufacturing	Remanufacturing is defined as substantial rebuilding or refurbishment of machines, mechanical devices, or other objects to bring them to a reusable or almost new state
Factor X, Factor 4, Factor 10	A direct way of utilizing metrics in various activities that can reduce the throughput of resources and energy in a given process. The overall aim of Factor X is to enable society to achieve the same or even better quality of life improving human welfare, while using significantly less resource inputs and causing less ecosystem destruction. The Factor X concept proposes X times more efficient use of energy, water and materials in the future as compared to the usage today.
Waste Management	Activities involving the handling of Solid, liquid and gaseous wastes originating from the industrial manufacture of products (i.e. 4Rs: Reduction, Reuse, Recycling and Recovery)
Reduction	Practices that reduce the amount of waste generated by a specific source through the redesigning of products or patterns of production or consumption.

Table 2: Principles of Sustainable Manufacturing. (Adopted from Glavič, 2007 and Robert, 2002)

Tool	Description
Design for Environment	Also known as Eco-design is the integration of environmental aspects into product design with the aim of improving the environmental performance of the product throughout its lifecycle (e.g. design for recycling). [6]
Green Manufacturing	Identifies manufacturing methods that minimize waste and pollution during product design and production. [7]

Green Chemistry	The design of chemical products and processes that eliminate or reduce the use and generation of hazardous substances. [8]
Waste Minimization	Measures or techniques that reduce the amount of wastes generated during industrial production processes. [6]
Zero Emissions	Identification and development of new value-added products from existing waste streams or under-exploited by-products, creative search for completely new educts and products, and implementation of breakthrough technologies. [9]
Life Cycle Assessment	Methodological framework for estimating and assessing the environmental impacts attributable to the lifecycle of a product, such as climate change, stratospheric ozone depletion, ozone (smog), etc. [10]
Cleaner Production	The continuous application of an integrated preventive strategy to process products and services to make efficient use of raw materials, including energy and water, to reduce emissions and wastes, and to reduce risks for humans and the environment. [11]
Life Cycle Management	A comparative decision making tool that evaluates the difference between products or processes to arrive at the most economically and environmental possible option in a systematic business decision framework. [12]
Zero Waste	A design principle that includes ‘recycling’ but goes beyond recycling by taking a holistic approach to the vast flow of resources and waste through human society. [6]
Green Procurement	Environmentally responsible or 'green' procurement is the selection of products and services that minimize environmental impacts. It requires a company or organization to carry out an assessment of the environmental consequences of a product. [13]

Table 3: Tools for Sustainable Manufacturing.

Strategy	Description
Pollution Prevention (P2)	A strategic goal for effective environmental protection. P2 techniques are designed for the reduction of the quantity and toxicity of end-of-plant waste. P2 technologies have been developed for technology change, material substitution, in-plant recovery/reuse and treatment. [6]
Industrial Ecology	Systems-oriented study of the physical, chemical, and biological interactions and interrelationships both within industrial systems and between industrial and natural ecological systems. [15]
Environmentally Conscious Manufacturing	Emerging discipline concerned with developing methods for manufacturing products from conceptual design to final delivery, and ultimately to end-of-life, that satisfies standards and requirements [16]
Total Quality Environmental Management	a method of applying total quality management approaches to corporate environmental strategies. TQEM supports continuous improvement of corporate environmental performance. Developed by a coalition of 21 companies that operate in a variety of industry sectors and share best practices. The four basic elements of TQEM: Customer identification (i.e. environmental quality is determined by customer preferences), Continuous improvement, Doing the job right first time (i.e. elimination of environmental risks and a Systems approach. [17]
The Natural Step programme	a method of reaching consensus about sustainable futures. The theory has given its name to a global network which describes itself as 'an international organization that uses a science-based, systems framework to help organizations and communities understand and move towards sustainability. [18]
ISO and the environment	ISO14000 series is a family of environmental management standards. [19]
EMS Environmental Management Strategy	Set of management tools and principles designed to guide the allocation of resources, assignment of responsibilities and ongoing evaluation of practices, procedures and processes, and environmental concerns. [20]
Eco-Management and Audit Scheme (EMAS)	The European Union's voluntary programme which enables organizations within the EU and the European Economic Area to seek certification for their environmental management systems. Effective from 1995. [21]
Environment, health and Safety (EHS) Programmes	Programs driven by occupational health and safety regulations including environmental issues needed to be incorporated into operational practice. [22]
SA 8000	Standards in social responsibility accounting for: Child labour; Forced labour; Health and safety; Freedom of association and collective bargaining; Discrimination; Disciplinary practices; Working hours; Compensation; Management systems. [23]
Responsible Care	Chemical industry’s global voluntary performance guidance system. [24]

Table 4: Strategies for Sustainable Manufacturing.

Sustainable Manufacturing has been already investigated in deep, as literature and in industrial practices demonstrate, even if a comprehensive approach doesn’t exist. Moreover, as the global conditions are revealing every day, sustainability is still not one of the first key factors in industrial decisions. In their day-by-day decisions, companies cannot easily take into account Sustainable Manufacturing, which is more and more affected by lifecycle considerations. Additionally, this happens at global level and so requires the consideration of related technical, operational, societal and cultural issues. Many efforts have been made in the past twenty years for improving product development and lifecycle management. However, many of these efforts have been disconnected. Approaches like PLM for integrating and sharing product data can be of great help in controlling and supporting sustainability issues. As the next section aims at illustrating, in deep, PLM, [25] being the accepted setting for product design and management has the potential to incorporate all the lifecycle considerations needed for a sustainable development.

4 PLM FOR SUSTAINABILITY

Sustainability has an important global dimension and most of the major challenges cannot be solved in one isolated region of the world. The so-called "civilized" world is made of many products, consuming a large amount of global resources. This "way of life" is based on products (for living, for transportation, for dressing, for eating, etc.), which might be designed, manufactured, used, maintained, recycled, dismissed. As Global Sustainability Indicators show clearly [26], current patterns of mass production of cheap goods and over consumption of products with a short use cannot be evidently sustained. Evidently, sustainability has a social responsibility impact, but its attainment is matter of practical implementations: sustainability can be achieved through optimization of the use of resources along the product lifecycle, while retaining quality of products and services, but optimization and quality of product related processes are strongly based on the use of information. For this reason, PLM represents a very important approach for achieving a more sustainable way of work and life, a more sustainable development, manufacturing, use. Being PLM an ICT infrastructure able to support product data, information and knowledge sharing, it can be the foundation of the business model needed to comply with sustainability requirements (Figure 5). In particular, PLM could enhance design in the BOL phase, as well as provide new services for the MOL and EOL phases.

Sustainability in the context of the product lifecycle can be seen as an optimization of all the activities belonging to the product lifecycle: a more sustainable development could be reached managing efficiently processes and information. For example, during BOL PLM can support a sustainable product development providing a common system in which the relevant product information is stored, managed and actually retrieved by the applicable lifecycle phases. The PLM system can be used to store and manage relevant information regarding resources (such as energy and renewables, ground and soil, water, etc.) and materials (such as hazardous substances, waste and recycling, etc). In fact, a lifecycle approach means to evaluate a product/service beginning with material extraction, continuing with manufacturing and use, and ending with recycling and disposal. This information generation and sharing can be housed by PLM in terms of providing the place to be created, to be stored, to be processed and to be properly allocated.

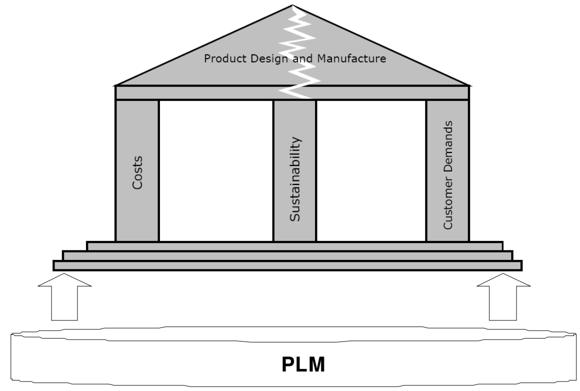

Figure 5: PLM can provide support to sustainability (adapted from [26]).

In terms of evolution of PLM for Sustainable Manufacturing, there is an urgent need to identify and retrieve decades-old product information for delivering service and sustainability along the product lifecycle. As mentioned, sooner or later in each industrial sector, it will not be enough for product manufacturers simply to design their products for disposal and recycling: manufacturers will be responsible for the actual disposal and recycling, till the end of the life of their artefacts.

In spite of this vision, for making PLM an efficient approach for Sustainable Manufacturing, many issues are still open, as well as some challenges might find a stable solution. Some of the most relevant open issues are the followings:

- It is a matter of fact that sustainability (and its dimensions) is more and more assuming a relevant role in our Societies. Even if a positive trend in sustainability dissemination is on going, many efforts might be spent to communicate such a concept to many stakeholders: not only users/customers might be involved, but more and more companies (in terms of manufactures and suppliers) have to understand sustainability in its wider dimensions. This question still remains a relevant open issue about sustainable development and manufacturing.
- Within such social increasing interest on sustainability, different business models might be declined within diverse industrial sectors, taking care of the diverse lifecycle stages. In particular, one-of-a-kind productions (e.g. ships building, tailored products) have relevant differences with many-of-a-kind ones (e.g. commodities). Such differences constitute a number of relevant open issues for sustainability and PLM.
- Sustainability entails an integration perspective. Sustainability is the final result of the interaction among many economic actors; interoperation of all product related domains is a pre-requisite to the evaluation and support of sustainability issues.
- As a matter of fact, a huge amount of data is generated during product usage. These data must be archived, filtered, extracted and transformed. These operations require an efficient data management system to be developed for each PLM system/tool in operation. Such product data management still remains an open issue, which might be solved to support a real product sustainable development.
- In terms of ICT, PLM is no more than a database problem, which physically enables a product-centred

business model. Information about products and processes are dispersed along a variety of information systems, which have been executed as isolated islands till now. Issues still open deal with the integration of these islands into more integrated distributed meta-repositories, in order to provide a wider and sustainable use of product data. This way, ICT interoperability is a relevant open issue afflicting sustainability deployment.

According to these open issues, two main challenges for doing PLM an effective tool for Sustainable Manufacturing can be highlighted:

- Closing product lifecycle information loops requires involvement of product users and contributes to the overall objective of sustainability of product systems. A strong element within this context is represented by information and knowledge sharing between producers and consumers. Such need of sharing constitutes a challenge to be solved adopting new available product embedded technologies. Embedded systems are complex electronic modules integrating computing devices, persistent storage, sensors and communications tools; embedded systems are already part of today products (e.g. airbag sensors, HD and DVD controllers, etc.) and in the next years the use of such technologies will be extended from the actual use in identification applications to a wide variety of applications by the generalization of tagging of products at the item level. Embedding intelligence in products is a practical way to create "intelligent products", which can be put together to create a network of intelligent objects interacting among themselves using wired or wireless communication technologies. These technologies will play a relevant role in PLM for Sustainable Manufacturing. Then, dedicated studies on this challenge are mandatory.
- A relevant challenge deals with the definition of a reference model for the PLM approach to sustainability and Sustainable Manufacturing in particular. Sustainability is a complex matter entailing business processes, technologies, organization and culture: a model integrating all aspects is needed to afford the epochal transition we have to face for the incoming future. There is a need of socio-technical models addressing topics such as ICT interoperability, knowledge sharing in the product chain and social implications of sustainability. A number of answers to these challenges are already under development, while a comprehensive PLM reference approach to sustainability is still lacking and it should be provided soon.

5 SUMMARY

Approaches for sustainability claim to have a holistic view. They need to manage the product lifecycle and keep track of the information flow within all of the lifecycle phases of the product. Evidently sustainability has a social responsibility impact, but its attainment is matter of practical implementations: sustainability can be achieved through optimization of the use of resources along the product lifecycle, while retaining quality of products and services. As the paper revealed; however, optimization and quality of product related processes are strongly based on the use of information. For this reason, Product Lifecycle Management (PLM) represents a very important approach for achieving a more sustainable paradigm of work and life, a more sustainable product development, manufacturing, use and dismissal.

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