Abstract—Logistics costs have a significant share of total product costs. Consequently, a company may be able to reduce costs, and thereby gain an edge on its competitors, by improving the fit between product design and logistics. However, current engineering design organizations and tools are not suited for structuring proper interface between engineering and logistics. This paper presents – at first- a literature review pertaining to the issue of logistics integration in product design. In this context, we propose an approach based on systems engineering. This approach integrates the logistics requirements in product design through the identification and characterization of these requirements according to the concepts of requirements engineering and design tools such as QFD and FMEA.

Index Terms—logistics, product design, systems engineering

I. INTRODUCTION

Product design is the creation of a synthesized solution that satisfies the needs. This usually involves the consideration of various parameters and alternative configurations of various components. As a prevalent methodology, Concurrent Engineering (CE) simultaneously designs products and related processes by integrating resources into a collaborative course to develop, manufacture, and deliver economically quality products [1].

Logistics is defined as the art and science of managing and controlling the flow of goods, energy, information and other resources, e.g. products, services, and people, from the source to the marketplace [2].

Because of the substantial costs involved in logistics activities, the lack of integration logistics in product design is an important and challenging issue to be addressed.

To carry out the integration of logistics in product design, the consideration of this problem’s characteristics is required, both in terms of actors to promote the methods and tools to support it. Moreover, systems engineering is a general approach that encompasses all the appropriate activities to design, develop and verify a system by providing an optimized solution to a client’s needs while satisfying all the stakeholders [3].

In this work, we define the methodologies of logistics integration in collaborative product design using the concept of systems engineering.

II. LOGISTICS AS INTEGRATION IN THE PRODUCT DESIGN PROCESS ELEMENT.

A. Tools and Approaches for Integrating Logistics in Product Design.

To support the development of the actors skills involved in both product design engineering and logistics process, the literature provides some methods that can facilitate integration. Design For Logistics (DFL) [4] and Design For Supply Chain Management (DFSCM) [5] have been described in literature as effective ways to take into account Supply Chain concerns in the Product Design early phases.

Dowlatshahi [4] has developed a Design For Logistics model to integrate Logistics-related issues (plant location, material management, storage, traffic, packaging, etc.) in the early phases of Product Design process. In this approach, Supply Chain concerns are embedded in interfaces, modelled according to four disciplines: Logistics engineering, Manufacturing Logistics, Design for Packaging, and Design for Transportability.

Lee and Billington [6] assert that one of the common pitfalls in managing Supply Chain is to overlook inventory, distribution and planning costs during the product-process design. The authors also claim that the product-process design should be evaluated not only in terms of functionality and performance, but also in terms of Design For Supply Chain Management (DFSCM), i.e., costs and serviceability issues.

B. Literature Review on Logistics Integration in Product Design.

To locate the research question of the logistics integration in product design, a lot of researches interested in this issue have been identified, among which the following can be mentioned:

The Design for Logistics (DFL) and the Design for Supply Chain Management (DFSCM) [4] propose a set of rules and methods to take into account the logistical constraints in product design. These studies put forward the benefits of qualitative concepts such as the modular design, the delayed differentiation and some other rules. These rules suggest the reduction of component number.
or used references, as well as suppliers’ integration in the upstream phase of design projects. This helps lower the costs related to storage and product transportation. Dowlatshahi [5] proposes a mathematical method to take into consideration these logistic constraints.

In his research, Koike [7] shows that the interactions between the logistics and engineering have not a good integration yet. In fact, his thesis presents the problematic of the integration of logistics in the manufactured projects of product design (case of a worldwide manufacturer of construction equipment). He proposed an interface model to support integration and a tool to integrating the Logistics Profile. Moreover, he emphasized the crucial role played by the interfaces as a catalyst for the creation of new knowledge and competencies at the frontiers between logistics and product engineering.

C. Limitations and Analysis of Previous Researches...

Dowlatshahi [5] did not explain, from this model and its factors, how requirements or rules can be developed to design activities and how they can be formalized and used in the early phases of the project. Logistics Profile tool by Tetsu Koike [7] has some limitations to its use, among which we can mention:

- Logistics Profile is dependent on the context in which it is used.
- Logistics Profile needs an entire structure for its use.
- Deployment Logistics Profile depends on the existence of a preliminary alternative design solution.

Logistics Profile does make sense in a logical change, i.e., in the context supported by a suitable application structure. Its use requires a depth from the learning step to the interface.

In our research, we consider an environment in which the integration of logistics is a goal during the projects of product design. Compared to literature, we use the systems engineering as well as a method that helps integration.

III. SYSTEMS-ENGINEERING-BASED APPROACH

In this paper, the integration methodology of logistics in the cooperative product design is described by integrating the concept of systems engineering. Our research can be considered as a continuity of Dowlatshahi [5] and Tetsu Koike works [7].

To control product design and its realization, while taking into account the whole product life cycle from the needs identification until the completion of the withdraw service, it is necessary to think of the systems engineering discipline.

Systems Engineering (SE) is an interdisciplinary approach to a structured, disciplined, and documented technical effort. It allows the simultaneous design and development of systems, products and processes while satisfying customers’ needs and requirements [8].

The V-cycle has become the main development cycle SE, is divided into two branches. In the descending branch, specification and system design are carried out. Besides, the specified requirements are validated against the previous level. Furthermore, the verification activities and system validation are anticipated and planned in terms of the expected. Once the realization phase of the elementary components is realized, the right branch of the cycle is integration, verification and validation of the system under the initial need [9].

The notion of V Cycle is a concept pertaining only to one part of the product life cycle which begins with a concept, then passes through a requirements engineering phase, and after that through a design phase in which the famous V-cycle is included. Subsequently, it passes through a phase transfer to the user, production, maintenance and withdrawal service and disintegration. ISO / IEC 15288: "System life cycle processes" perfectly describe the system life cycle.

These cycles consist of processes considered as sets of activities to be undertaken to transform inputs into output elements.

Our approach consists in the proposition of requirements for the integration of logistics processes in the upstream product design through requirements engineering phases, taking into account the strategic needs and operational logistical constraints in the early stages of product design.

In our model (Fig. 1), systems engineering is adopted as an integration method of logistics in product design. We think that systems engineering is more comprehensive than the other methods discussed in the literature approach.

The systems engineering is to identify a solution to a specific need. A set of processes (activities) has been defined to perform the gradual transformation of the need into stakeholders requirements then into a technical requirements system, then into functions, and finally into concrete components.
Requirements engineering covers any needs or functions without limitation whatsoever (business, technology etc.). Requirement / function is a general concept that can be found in all the industrial fields.

Logistics and its components are necessarily modeled with requirements or functions. The “logistics” requirements pertaining to the product must be taken into account in the design. Our approach essentially comprises the functional requirements of the designer and the logistics requirements, namely the requirements of the logistics process for the product design.

These logistical requirements fit in requirements engineering in the first two technical processes of the ISO 15288 standard:

- Definition of stakeholders requirements
- Requirement Analysis.

Both processes are in fact the starting point of the classic V-model.

The integration of logistics issues into the mainstream system design process is no longer an option. A highly competitive environment and a shrinking resource base mandate this involvement.

Logistics issues must be addressed early during the requirement definition process and progressively through evolved subsequent system design phases. The QFD method offers the necessary framework for the accomplishment of this objective.

QFD has been defined by the American Supplier Institute as “A system for translating consumer requirements into appropriate company requirements at each stage from research and product development to engineering and manufacturing to marketing/sales and distribution”.

We will develop a web application (Fig. 2) in which we will store all the necessary logistics requirements as well as the product requirements. All the application actors will be bound to this base. At an early stage of product design, the logistics actor can intervene.

To determine the logistical requirements we use the four disciplines defined by Dowlatshahi [5]: Logistics engineering, Manufacturing Logistics, Design for Packaging, and Design for Transportability.

This sample (Fig. 3) illustrates the use and implementation of our approach. Every phase of the product life-cycle should be considered when collecting requirements: manufacturing, transport, storage, retail, use, servicing, disposal, and any other appropriate phase.

There are some great examples of how the product design is affected by non-operational stages. Airbus manufactures the major components of its aircraft in different areas of Europe, then transports to Toulouse, where they are mounted together. Transport is carried out by road, sea, river and air, and the design of components has to take into account the constraints that each of these imposes.

During A380 Airbus building project, and despite the use of a systems engineering approach in the design phases, the transport and logistics have not been taken into consideration as requirements engineering. The negligence of this requirement causes problems for the aircraft assembling.

The dimensions of the components of A380 transport exceeded the capacity of “Beluga” and other already existing air transport means [10]. For example A380 wings that are built in Broughton (UK) and need to be transported to Hamburg then to Toulouse where the aircraft will be assembled. This has lead designers to integrate new constraints of transport and logistics in the design of components and thereafter to design and adapt new equipment and logistical resources to transport the components.

This example shows that the integration of logistics requirements at an early design stage, using requirements engineering, can consolidate the platform design and consider that logistics is an important element to be integrated in the product design process.
IV. CONCLUSION

This research focuses on the study of the logistics function integration in product design phases. We have treated these problems in order to establish the bases of an enriched approach using a process of systems engineering in particular requirements engineering. This integration will be able to improve the quality of the product and reduce the time and cost of its development as well as its manufacturing costs.

Our approach proposes a logistics integration methodology in the upstream product design through requirements engineering phases, taking into account the strategic needs and operational logistical constraints in the early stages of product design.

We have integrated the constraints of logistics in product design through the identification and characterization of the requirements according to the concepts of requirements engineering and design tools.

REFERENCES


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