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Supportability Analysis in LCI Environment

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***Abstract*—**Starting from the basic pillars of the supportability analysis this paper queries its characteristics in LCI (Life Cycle Integration) environment. The research methodology contents a review of modern logistics engineering literature with the objective to collect and synthesize the knowledge relating to standards of supportability design in e-logistics environment. The results show that LCI framework has properties which are in fully compatibility with the requirement of simultaneous logistics support and product-service bundle design. The proposed approach is a contribution to the more comprehensive and efficient supportability design process. Also, contributions are reflected through a greater consistency of collected data, automated creation of reports suitable for different analysis, as well as the possibility of their customization according with customer needs. In addition to this, convenience of this approach is its practical use in real time. In a broader sense, LCI allows integration of enterprises on a worldwide basis facilitating electronic business.

***Keywords*—**E-logistics, integrated product development, standards, supportability analysis.

I. Introduction

THE competitive business environment requires the design and development of high-quality products. Business goal is developing a product that will not only meet customer requirements but will also fulfill requirements of other interested parties. To achieve this, organizations must use modern systems for integration to merge data related to product throughout their entire lifecycle. One such system is LCI environment which will be discussed in this paper.

This research study gives an review of the e-logistics framework whose implementation will reduce product to market time and lifecycle cost. To define this framework we use the basic elements of supportability analysis to examine its functioning in e-environment. Also, we made an overview of the existing literature related to standards in e-logistics environment. In addition to this, aim of this research is to propose the LCI framework that will contribute to better and more efficient supportability design process. This framework should allow greater consistency of collected data, as well as automatic report generation for different types of analysis and their adjustment in accordance to customer needs. Advantage of proposed approach is that it allows integration of organizations on a worldwide basis facilitating e-business.

This paper is organized as follows. Section II describes theoretical background about LCI environment. LCI structure is given in section III. Section IV, deals with supportability analysis in e-logistics environment and finally, section V presents the main conclusions and directions for future research.

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II. Theoretical Background

LCI system is integrated information system that follow the lifecycle of a product and combine the designing and production of objects (CAD (*Computer-aided design)*/CAM (*Computer-aided manufacturing)*/CAE (*Computer-aided engineering)* systems) with the systems of controlling the manufacture, resources, marketing, sale, maintenance, and repair of products [8]. Complex of uniform information models, standardization of access ways to the information and its interpretation under the international standards lays in a basis of LCI concept. LCI is conversion of product lifecycle to the highly automated process by reengineering of business processes included into it. It has been shown that during the development of perspective chemical productions the LCI technologies and main LCI (continuous acquisition and life cycle support) standard ISO 10303 STEP offer a handy solution of a problem of computer supported representation of all lifecycle stages: marketing, design, production, maintenance and sales [2]. Implementation of LCI technologies in chemical industry enables use of modern quality control technologies for production support which contributes significantly to sustainable development of company [2]. It is interesting that in Japan, the Ministry of Land, Infrastructure, Transport and Tourism has established the Continuous Acquisition and Lifecycle Support / Electronic Commerce (CALS/EC) Action Program 2008 [9], which advocates the development of a utilization environment for three-dimensional information. At present, the use of electronic data in public works projects has not been optimized, and efforts have not been undertaken from the viewpoint of total optimization in the lifecycle of projects [7].

The LCI concept is based on the complex of uniform information models, standardization of ways of access to the information and its correct interpretation in accordance with international standards. A key idea of LCI concept is increasing of product lifecycle due to increase of efficiency of control of the information on a product. In accordance to this, we can say that LCI transforms product life cycle into highly automated process through restructuring of its component business-processes [3]. In terms of LCI structure it is composed of several elements. In this section we will mention integrated product development (IPD), which is defined as process in which technical and non technical disciplines such as engineering, marketing and accounting are reunited to work interactively to conceive, approve, develop and implement product programs that meet predetermined objectives, focusing on satisfying the customer [5]. Prescriptive development models, such as IPD, suggest systematic approaches for companies to structure their development task by creating overlap and interaction between activities in order to improve the overall product development performance [13]. Also, IPD is characterized by a concurrent design approach in which multidisciplinary teams cooperate their activities both vertically and horizontally in the organization. In order to achieve the benefits of integration, IPD approaches require that the objectives of the development project are complete and well defined [13]. IPD have as major goals minimizing the product lifecycle, decreasing production cost, maximizing product quality and team work [11]. As a result of the use of IPD Toyota claims to have significantly accelerated the introduction of new car models, by up to two to three years. Also, American Society of Concurrent Engineering [12] indicated that there are many benefits of IPD, including 65% to 90% fewer engineering changes, 30% to 70% less development time, 200% to 600% higher quality, 20% to 110% higher white-collar productivity and 20% to 90% less time to market. According to this, Technical Center managers explain that taking manufacturing capabilities into consideration in new product development (NPD) projects helps solve problems that would otherwise arise during the manufacturing stage; and thus, it reduces the time needed to transfer a new car model to the manufacturing unit [10].

What matters and what we do in this paper is how to provide supportability in the LCI environment. We can define supportability as inherent characteristics of design and installation that enable the effective and efficient maintenance and support of the system throughout its planned lifecycle [4]. Supportability drive the operational effectiveness of a system and play a crucial role in procurement decision making [6]. Also, supportability issues includes maintainability, training, human factors, reliability etc. [1]. Hence, supportability should be one of the key requirements for developing a product. Therefore, we will define a model to describe the supportability analysis in LCI environment.

III. Structure of LCI Concept

Structure of LCI concept is composed of several elements, of which are basic: integrated product development (IPD), contractor integrated technical information service (CITIS), electronic data interchange (EDI) and interactive electronic technical manual (IETM).

IPD is an integral team approach to product process design and support elements in product lifecycle. The guiding idea is that the IPD in the process of creating a new product take into account all influential factors related not only to satisfy customer requirements ie. market, but also the requirements for the design process, quality, distribution, security, maintenance. In the product development process we must go hand in hand with product design and design of support system. This reduces development time and time to market and increase competitiveness. IPD has been around in one form or another for a very long time but its modern form may be attributed to the 1980s when the Renault Company applied it in the design and development of its Twingo model.

Another cornerstone of the LCI concept is CITIS. CITIS function is using automated procedures that enable the integration of information flow between different business partners. It is a service through which the connection is accomplished within suppliers, shippers, insurance companies, logistics providers, manufacturing and service companies, and other business partners. The original version of CITIS, developed in the USA, is focused primarily on transmission of technical data, while the British version of concept (UK CITIS) refers to a broader set of data comprising: commercial information, financial information, data loading and delivery, design-construction data, information on logistics support, data from technical manuals, data quality requirements, calls for proposals, information on the organization and project management, resource data, etc..

The third key element of the LCI structure is EDI. EDI is often defined as the exchange of data from computer to computer, or more specifically, as an exchange of spatial data between remote computing applications in a standardized format and transfer their processing without retyping. In the literature EDI is sometimes referred to as "paperless trading". The most common forms of application of EDI are: placement offer, confirming customer orders invoicing, cash transfers, data on inventories and demand, etc. There are three levels from which you can observe the development of EDI. The first level is related to the specific transaction sets that are designed for use in a particular economic activity. Sets of transactions that are known in the trade are WINS (Warehouse Information Network Standards), in the food industry are USC (Universal Common Standards), etc. The second level is the level of national standards such as the ANSI ASC X12 (American National Standards Institute Accredited Standards Committee X12). Initiative for the third and higher level of integration, was launched by the United Nations in 1988 and has resulted in the harmonization of standards ANSI ASC X12 and EDIFACT (EDI For Administration, Commerce and Transport). EDI has included in the concept of LCI at the end of the 1988., by which has enhanced traditional procedures for the exchange of technical and business information. In practice we have several types of EDI systems. The most common is VAN system (Value Aided Network), or “more customers-more suppliers”, where all transactions traveling through intermediaries who provided EDI services. Less common type of system is “one customer- more supplier” through which the company which is owner and user of EDI services directly supplied from a number of suppliers, which is much more expensive solution in terms of implementation and maintenance of systems and implies suppliers consent to be part of such a network. Although EDI can be used via Internet, it's a solution for which in recent years, due to low costs, many companies determines. It can be concluded that the EDI by providing fast access to information and improving the performance of the supply system contributed to the creation of new businesses. However, the greatest benefit from the application of EDI is fast response to customer needs and shorten ordering cycle.

Fourth important element of mentioned concept is Interactive Electronic Technical Manual (IETM). IETM is a digital version of the technical manual, based on the principles of interoperability, which combines a set of information necessary to process diagnostics and vehicle maintenance. It is a superior tool based on expert systems and artificial intelligence used to support and execute automated diagnostic activities. Through the interface, which includes graphics, text, video and sound recordings, IETM guides users through the diagnostic process and provides his expert advice in the form of instructions on how to perform the necessary maintenance activities. Equipped with an infrared adapter or adapters with radio frequency IETM transferred requirements of maintenance technicians for the parts you need in the real time. Compared to conventional technical manuals available on paper, the IETM as the digital version of manual, in terms of access, updating and accuracy of information, have proved to be much more effective in defect detection process. Depending on performance and functionality, data formats and types of display are five different classes of basic electronic technical manuals that are designated as: electronic indexed image, electronically scroll documents, linear structured IETM, hierarchically structured IETM, and integrated databases. The benefits of using IETM services include: increased accuracy and speed of repair of defects, reduced time searching for the information they need, reduced need accommodation facilities, fewer errors, more efficient training of technical personnel, and so on.

IV. Supportability Analysis in LCI Environment

Supportability analysis is the iterative process of design, implementing, monitoring, estimating, and adjustment of support system for the purpose to achieve just in-time availability of support elements in integrated mode. Supportability analysis includes whole lifecycle of system and support elements integration has been accomplished with help of modern information and telecommunication technology. When comes to product designing it is important to simultaneously develop the product and logistic support system. LCI framework has features that enable this simultaneously developing.

The first effects of standardization in the field of logistics activities are related to the beginning of the eighties when with standard MIL-STD 1388-1A have regulated relations in the field of logistics support analysis, and with standard MIL-STD 1388-2A have defined norms of registration data and generating reports in the logistic analysis support. With further development, the standard MIL-STD 1388-2A was in 1991. replaced with standard MIL-STD 1388-2B (DoD Requirements for a Logistic Support Analysis Record), which was kept in use until 1996 year when it was replaced with standard MIL-PRF 49506 (Logistics Management Information). Standard MIL-PRF 49506 was geared towards contractors and resulted in significant changes in respect of their obligations in terms of ways of placing information. Standard MIL-STD 1388-1A was withdrawn 1997. and was replaced with MIL-HDBK 502 (Acquisition Logistics). This standard has led to replacement of some old logistics terms with the new ones.

TABLE I
Logistics Terms according to Standard MIL-HDBK 502

OLD TERM	**NEW TERM**
Logistic Support Analysis (LSA)	Supportability Analysis
Logistic Support Analysis Record (LSAR)	Logistics Management Information (LMI)
Integrated Logistics Support Plan	Integrated Logistics Support Strategy

According to standard MIL-HDBK-502 supportability is the capability of a total system design to support operations and readiness needs throughout the system's service life at an affordable cost. It provides a means of assessing the suitability of a total system design for a set of operational needs within the intended operations and support environment (including cost constraints). Supportability is a design characteristic. The early focus of supportability analyses should result in the establishment of support related parameters or specification requirements. These parameters should be expressed both quantitatively and qualitatively in operational terms and specifically relate to systems readiness objectives and the support costs of the system. Achieving and sustaining affordable system supportability is a lifecycle management activity and is the result of sound systems engineering.

The goals of supportability analyses are to ensure that supportability is included as a system performance requirement and to ensure that the system is concurrently developed or acquired with the optimal support system and infrastructure (MIL-HDBK-502). The integrated analyses can include any number of tools, practices, or techniques to realize the goals. For example, repair level analysis, reliability predictions, reliability centered maintenance (RCM) analysis, failure modes, effects and criticality analysis (FMECA), lifecycle cost analysis, etc., can all be categorized as supportability analyses. Supportability factors are those operational needs which, by their nature, impose requirements on the support system and thus affect system supportability. Supportability factors may include deployment, mobility, mission frequency and duration, human capability and limitations, and anticipated service life. Supportability analyses require time and resources. It is pointless to impose supportability requirements that depend upon an analysis whose results may not be available in time to contribute to the design decisions which they are intended to affect. In order to be effective, supportability analyses should be conducted within the framework of the systems engineering process. Supportability analyses should identify operations and sustainment support requirements based upon system characteristics and the planned operations and support environment.

Also, supportability analysis should be identifying the maintenance activities to be realized and ensure the just-in-time support is procured. In the context of supportability analysis, it is necessary to perform two complementary procedures: Supportability Analysis Records and Supportability Analysis Reports. Supportability Analysis Records is a system in form of common relational database used to recognizing, store and sort supportability analysis data in a logical and accessible manner. The second notion refers to supportability analysis report system and statements that content and transfer data. In short, supportability analysis should be identifying the maintenance activities to be realized and ensure the just-in-time support is procured. Logistics data are stored in a maintenance data base. Maintenance data which may be shared under computer integrated logistics system are heterogeneous: engineering drawings, product data for design and manufacturing, technical specifications and standards, resource data, technical publications and handbooks, training materials for maintainers, spare parts descriptions, maintenance plans, etc.

The key principle is creating maintenance data once and uses it many times no matter where it resides. The whole approach is based on sharing digital information. The collection and analysis some of maintenance data (e. g. materiel, spare parts, etc.) support the purchasing process. Throughout the spectrum of supportability analysis, a basic kinds of maintenance data are associated with items such as the following: exploitation and maintenance requirements, reliability and maintainability characteristics, failure mode, effects and criticality analysis, human resource requirements, support equipment data, infrastructure description, etc. The just-in-time availability of maintenance data via LCI make the comprehensive and customizable logistics management possible.

As Fig. 1 shows, supportability analysis is embedded in LCI which presents the world benchmark for excellence in logistics and maintenance management. Advanced logistics systems are providing logistical support regardless of location and distance of users has become feasible with the development of the modern computer and telecommunications technology. There are no quick fixes or shortcuts to world-class product performance, cost structures, quality levels and competitive time-to-market [13]. The elements of logistics support in digital environment must be considered within a single framework such as LCI. LCI environment should ensure a smooth creation, modification, and exchange of product information throughout the product's lifecycle. For achieving this we could use mentioned standards such as MIL-HDBK-502 and MIL PRF 49506, which standardize logistics activities.

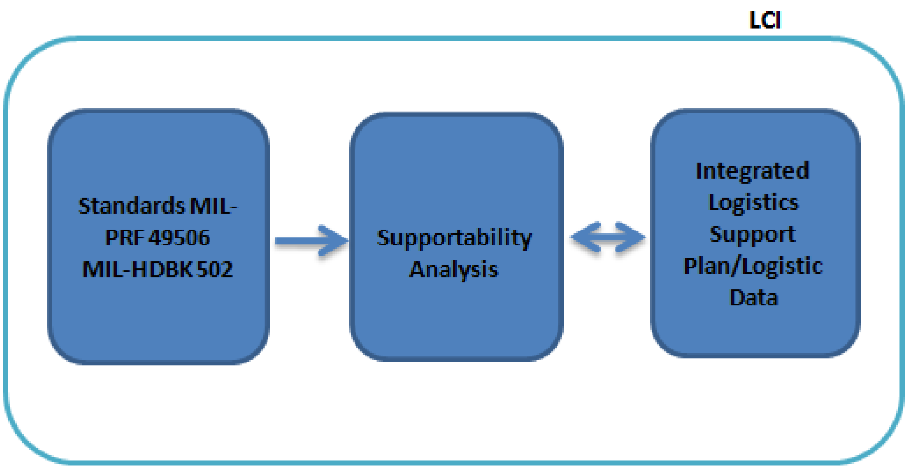

Fig. 1 Supportability in LCI environment

IV. Conclusion

The results of this paper indicate that including supportability analysis into product design is crucial in LCI environment. In addition to this, we proposed e-environment model which helps to generate savings, in terms of lifecycle cost and the time it takes to get a product to market. Given approach contributes to better consistency of data collected through the development of automated reports that are suitable for a variety of analyzes and adaptable to different customer needs. Preemption of errors and early problem detection, creation of flexibility to accommodate changes and provision of the best overall input are other advantages that come from using this approach. The concept of LCI environment has included supportability analysis, which allows the identification of needs related to support functioning of a technical system during its lifecycle. Also, we mentioned in paper standards which provide requirements and task descriptions of supportability analysis during the lifecycle of product. Standards play an important role in regulating logistics processes within the e-logistics environment. Therefore, standards should be used in this purpose because they enabling integration of organizations on a worldwide basis.

Research could be useful for researchers in the field of virtual logistics. This paper prepares engineers to effectively use information technology in a dynamic e-world. Software innovation leads to the creation of a fully automated support. So, directions for future research could include defining of standardized software components related to supportability.

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