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Integrated Intelligent Information and Analytical System of Management of a Life Cycle of Products of Transport Companies

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Abstract

Developed an integrated intellectual computerized system of ecological-economic monitoring, modeling, and managing the life cycle of the products of technogenic enterprises of transport engineering, which is presented in the form of a 3-equation structure, functioning in conditions of instability. The proposed paradigm system life cycle management applicable to any other control system of large and complex systems, such as techno-genic type. This new paradigm of complex systems and process management, including technical systems. The system is based on the following findings: concepts, principles, a set of non-linear models, decision-making methods, and the environmental and economic governance, integral criteria. As an example, in this paper offer solution to the problem of estimating the cost of the product life cycle of railway transport.

Keywords: Industry 4.0; Application Systems; Product Life Cycle Process; Technical Operation System; Continuous Acquisition System; Lifecycle Support System.

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Introduction

Important technological advancements for the development of INDUSTRY 4.0 are computer-integrated systems (CIS), computer-integrated manufacturing, application systems: CAD, CAE, CAM, CAPP, and others. Other important issues include industry digitalization, strategists, criterion, and principles of creating intellectualized and integrated systems. The necessity of using intelligent information technologies (IT) in organizing modern knowledge-intensive manufacturing is unquestioned nowadays.

An analysis of the use of modern information technologies in the industry shows that one of their development areas is an increasing application of these technologies at all stages of the life cycle (LC) of complex, knowledge-intensive products, in particular, transport engineering products, within the framework of an integrated information environment (Berg D.B, 2014; Zabegalin E.V, 2006; Lipatov S.V, 2013).

Materials and Methods

Problem Statement

The necessity to increase labor productivity and product quality while at the same time reducing the time for launching new products prompted high-tech companies to develop and implement information technologies (IT) on a large-scale. There emerged a concept of computer-integrated manufacturing, which consisted in not only the use of IT to automate technological processes and operations but also in the construction of a hierarchically integrated information system (IS) based on the use of common databases in the processes of technical preparation of production and production management.

The combination of technologies focused mainly on reducing a LC cost (LCC) while ensuring the re-quired availability factor has been called an integrated logistics support (ILS) in the modern scientific and technical literature and regulatory documentation (Ships E.V, 2003).

Literature Review

Obtaining maximum competitive advantages by enterprises in the transport machine-building market directly depends on the effective use of modern CALS technologies (Continuous Acquisition and Lifecycle Support) or a system of information support of product life cycle processes (ISP) (Ships E.V, 2003). In the 1980s of the XX century, an understanding of this fact and the level of IT development created the conditions for the development of ISP systems in the industry as a whole. The use of these technologies ensures the creation, maintenance, and development of technical operation systems (TOS), the properties of which must be rationally aligned with product design. Since the term CALS always had a military connotation, the terms Product Life Cycle Support (PLCS) or Product Life Manage-ment (PLM) have become widely used in the civil sphere.

A great number of works by mainly foreign researchers are dedicated to the PLM problem. Domestic works mostly provide an overview of the problem. Upon reviewing some of these works, a conclusion sug-gests that their authors have reached no consensus on what the PLM is. There are two assessments: broad and narrow. The proponents of broad assessment practices include almost all automation tools and systems in the PLM: design and technological CAD (CAD/CAM/CAE, CAPP), ERP (MRP) systems, customer relationship management tools (CRM), supply chain management (SCM) tools, technical service management tools, etc. This also includes PDM systems, which play a key role in organizing the information interaction of all participants in the product life cycle through the integrated information environment (IIE). The proponents of the narrow assessment practices actually tend to identify PLM with PDM, while considering other tools and systems as “external” to PLM.

A broad interpretation of the concept of PLM to the greatest extent meets the modern needs of the industry, and the main hopes for the progress of industrial production are associated with it. “Modern business solves a threefold task: firstly, it is necessary to establish closer and more trusting relationships with suppliers and customers and, secondly, increase the level of the enterprise’s operating efficiency and, thirdly, in-crease the competitiveness of its products. The first component is ensured by relationship support systems, which are increasingly widespread – SCM and CRM systems; the second one – by even more popular ERP systems, but the third one does not yet have sufficient comprehensive information support. An approach called “new PLM” lays claim to this place.” (Gontareva, I et al., 2019). This is what determines the growing industry interest in PLM technologies. A PLM system is an integrated structure that combines all information about the processes of creating and manufacturing products from the technical specifications and description of the functional composition of products to the development of design documentation and process specifications of manufacturing equipment. The PLM system contains a digital description of the product that is expanded during the life cycle or a digital layout of the product. Building an effective PLM system requires streamlining and structuring all work processes of managing a product life cycle by building their models that integrate systems of various departments, enterprises, partners, vendors, and consumers.

It should be noted that the main components of PLM solutions at enterprises are as follows: a PDM system (Product Data Management, PDM) - for organizing and managing all engineering data about products; a CAD system (Computer-Aided Design, CAD)- a computer-aided product design system; a CAE system (Computer-Aided Engineering, CAE) - a system to aid in engineering analysis tasks; a CAM system (Computer-Aided

Manufacturing, CAM) - a system used to design software to control machine tools and production lines.

In addition to the main systems, a full PLM solution may also include a CAPP system (Computer Aided Production Planning, CAPP) - for planning production processes; an MPM system (Manufacturing Process Management, MPM) - for modeling and management of production processes; a digital manufacturing system (Digital Manufacturing – DM); a system supporting product operation, maintenance and repair (Maintenance, Repair, and Operations or Overhaul – MRO), and others (Lipatov S.V, 2013; Hrabovskyi, Y et al., 2020).

Since the main objective of the CALS concept (ISP) is to organize the interaction between the industry and the state customers, CAD and ERP systems are considered to be enterprises' internal tasks and are not considered in detail (of interest are only various inter-faces), however much more attention is paid to the after-sales product support - integrated logistics support (ILS) (Vetrov S.I, 2010; Lipatov S.V, 2013).

The objective of the research

The objective of this work is to develop an intelligent integrated information logistics system for environmental and economic monitoring, modeling and management (SEEMM) of the life cycle of products of transport enterprises that are technogenic industrial enterprises – TIEs (i.e. it is a manufacturing system, which is presented in the form of a 3-tier management structure in conditions of instability).

Results and Discussion

The problem of increasing the competitiveness of individual products remains among the priorities as it is directly associated with ensuring a proper level of development and the capacity of the State and with the prospects for economic and technical cooperation with foreign partners.

In all the above technologies and systems, mainly information integration is considered, however, both environmental and technogenic factors are not taken into account. Therefore, an important and urgent problem is to develop an integrated intelligent computerized system (an "X" type system), which is an information system built based on the principles of a systematic approach and the concept of four "I", i.e. with maximum integration, intellectualization, individualization and a single information base, the principle of maximum consideration of "NOT - and MANY - factorial" synthesis, as well as the maximum possible environmentalization of production processes (i.e. based on the concept of four "I" + 2"). "X" type systems are classified as large and complex logistics transport systems (Ramazanov S.K, 2008; Gontareva, I et al., 2019; Babenko, V et al., 2019).

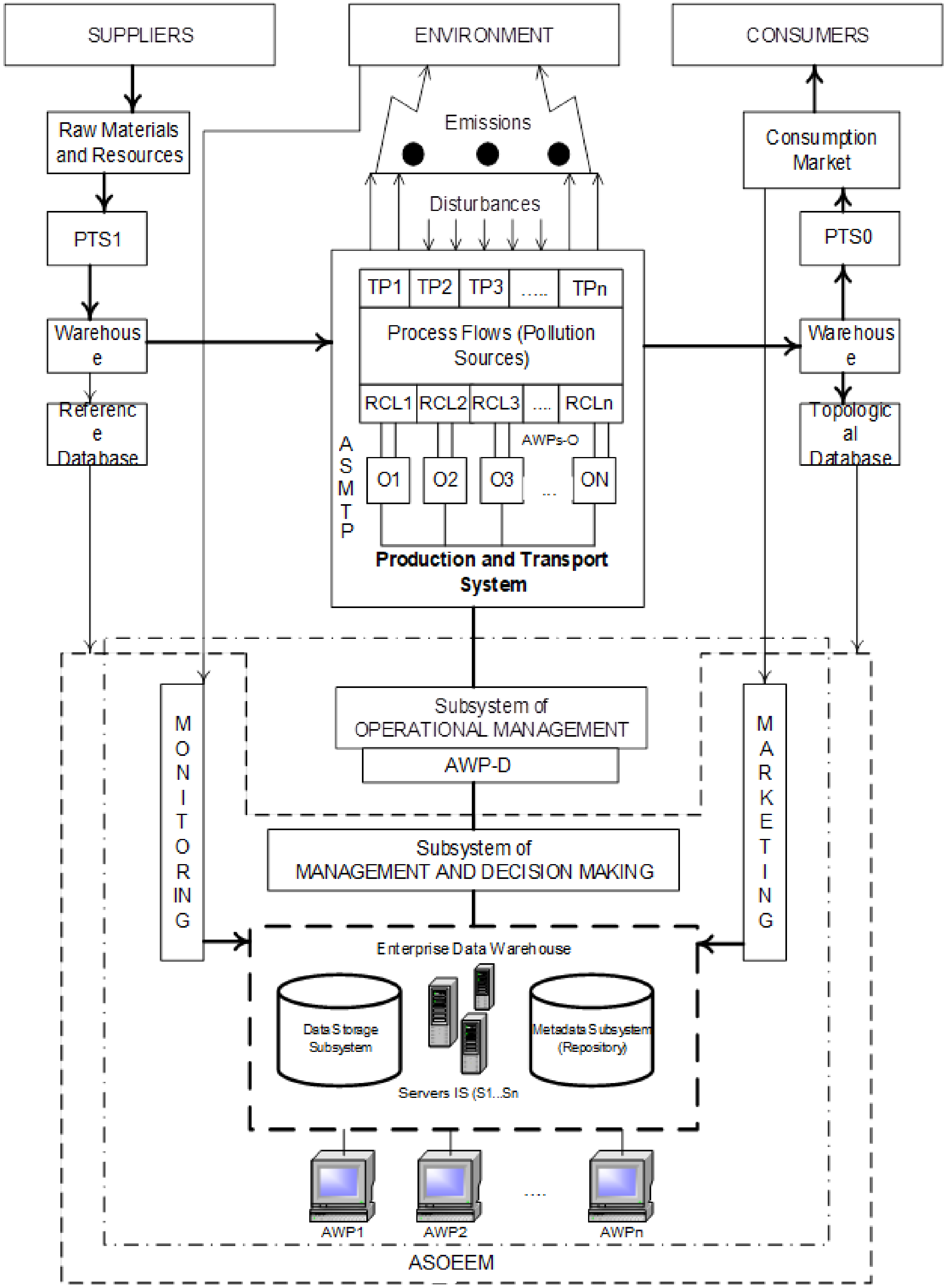

Figure 1. Logistic Integrated System for EEMM of Enterprises

Unlike well-known works, the author offers the following integration and intellectualization directions:

1. Directions of Subsystems Integration in “X” System: the integration of information and knowledge databases and the creation of a single data bank with distributed processing (i.e. information integration); the technical integration and the creation of a heterogeneous local information and computer network of auto-mated worksites and workstations; mathematical, algorithmic and software integration across hierarchy levels.

2. Directions and Levels of Intellectualization in “X” System: intellectualization of automated WS at all levels; intellectualization of regulators based on active expert systems with a mixed knowledge base, including fuzzy one; intellectualization of system software package interfaces; intellectualization of the tasks of designing, monitoring, and diagnostics of coal processing technology facilities. To implement all of the above system properties as a whole, it is necessary to synthesize IAMS as an enterprise's logistics system in the form of the following structure (figure 1.).

The developed integrated system takes into account all the underlying subsystems of a company’s logistics system, namely: an automated system of organizational, economic and environmental management with elements of artificial intelligence and based on a single information base, which includes a management subsystem, an environmental monitoring subsystem, and a marketing subsystem; an operational dispatch control subsystem; a production and transport subsystem, which sub-systems are controlled by the automated operational dis-patch control system (AODCS) and by the automated process control system (APCS) based on hybrid (flexible) expert systems with a fuzzy knowledge base and models, as well as IMS and DSS (Pavlov N.V, 2011; Rama Zanov S.K. et. al., 2009; Babenko V. et. al., 2019).

Conclusion

There has been developed an integrated computerized system of environmental and economic monitoring, modeling and management (SEEMM) of a technogenic industrial enterprise – TIE (a manufacturing system, which is presented in the form of a 3-tier structure, i.e. management is carried out at all levels of the hierarchy) in conditions of instability. This is a new paradigm for managing complex systems and processes, including technical systems. The system is based on the concepts, principles, a complex of nonlinear models (about 30 both integral and local models that form a mathematical base of the system), decision-making techniques and environmental and economic management (EEM); integral criteria (economic, environmental, technological, transport, etc.). The use of the idea of a “5-pole”, instead of the traditional 4-pole, i.e. TIE output is presented as two sets of outputs: “useful” and “harmful”;

the use and presentation of a mixed information base: deterministic, stochastic, multiple and fuzzy for EEMM of TIEs; intellectualization of SEEMM. It should be noted that the proposed paradigm of the SEEMM applies to any other system for the management of large and complex systems of a technogenic type. As an example, this paper proposes a solution to the problem of estimating the cost of the life cycle of railway products, in particular, proposes a parametric model of the cost of the life cycle of technical railway systems.

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