The document management system as an integration basis for forming a unified data source of information support of a product life-cycle

Yu V Vilkov, B A Chernysh, A S Kartamyshev, E N Golovenkin and I V Poturemsky
JSC “Academician M.F. Reshetnev” Information Satellite Systems”, 52, Lenin Street, Zheleznogorsk, Krasnoyarsk region, 662970, Russia

E-mail: Cherhyshba@iss-reshetnev.ru, Kartam@iss-reshetnev.ru

Abstract. The article considers the possibility of organizing a single information space on the basis of a modernized document management system within the technically complex products life cycle, which involves the processing of a large amount of various information. The attention is focused on the fact that in the existing automation systems of various processes for creating products at various stages of the life cycle, the availability, connectivity and consistent storage of data in the corresponding accounting systems are not ensured. A method for organizing data on a product is proposed, and on its basis a tool for implementing a single source in the form of a document management system describes the advantages of its application when integrated into a single information space.

1. Introduction
Life cycle (LC) information support of the technically complex product development is presented by a wide variety of software consists of automation means for some activity and also accounting and analysis systems for this activity results. The software part of information systems includes different applications from general office programmes to specialized engineer equipment such as CAE/CAD/CAM, PDM, MES, ERP, SCM, CRM, PLM, which are systems and tools for management decision making support, project and risk management [1]. Economic features of business activity are planned and recorded by using economical, financial and accountant information systems, which are demanded by strict requirements for cost separate record-keeping. To organize effective information support of LC management process in aerospace manufacturers (ASM) it is necessary to integrate internally different software for forming up-to-date consistent information in a single information space.

2. Factors influencing the information support system
According to GOST R 50-605-80-93 Development and production system for production. Terms and definitions, products life cycle is a combination of interconnected processes of product status sequentially change from the formation of the original requirements for it to the end of its operation or application. In general case for LC products the following levels are assumed: investigation, designing, preproduction, production, operation and maintenance, disposal. It is advisable to consider as a separate stage of the LC work on the disposal or destruction of products, which is related to issues of environmental protection, safety, reuse, etc. The results of the design and development work carried out
are provided by various software and are taken into account in different information systems, which tend to operate autonomously, with their own individual set of regulatory and reference information (RRI), and created using a variety of technologies and methods of data storage [2]. Depending on the company’s model of operating processes, organizational structure, product assignment, complexity, production features, and other factors, life cycles can vary both in the list of stages and in their composition. In addition, some stages can be performed in parallel. A feature of real business processes is the lack of a strict sequence of all stages execution in relation to the whole product: the purchase can begin with the design, production can also be launched in the early stages of construction documentation working out, shipment begins as the components of the head product appear in the warehouse of the finished product. In addition to these features of the product creation real process, the governing bodies (government, state corporations, the Ministry of Defense, the tax inspectorate, etc.) require enterprises to keep separate records of the costs of creation technically complex equipment, within the framework of contracts and LC products. It is necessary to be able to calculate the object costs, accounting units, which are accompanied by a set of technical and economic documentation. Tighter requirements for enterprises, external control, point financing by the customer and regulatory bodies contribute to the confrontation increase between thematic departments (TD) that create the product sales, and economic departments (ED) forced to keep records of product development in economic characteristics. TD is increasingly necessary to engage in uncharacteristic tasks, to immerse in the process economy, which can negatively affect productivity. ED, in turn, has the task of accurately long-term economic planning and budgeting of the contract development process, as well as the analysis of unfinished production to the accounting facility. To pair these tasks, it is necessary to modernize information systems, integrate as much as possible specialized software to implement the end-to-end process and take into account activities in the single information space at all stages of the LC products. The challenge is to develop new approaches to the logic of data storage and work, as well as to modernize user interfaces so that information from the single information space is presented for different purposes in different ways, in a manner that is appropriate to specifics user work.

3. The way of information support organization for LC products

The content of LC product levels is showed in table 1.

| Stage name | Scope of work |
|------------|---------------|
| Investigation: research, advance project (AP), sketch project (SP) | Promising market researches; fundamental, predictive researches and investigations; applied market researches and rationing of product quality requirements; applied research realization; development of TT and evaluation of the product design and technical level. |
| Designing: operating documentation (OD) | At the design stage, design procedures are performed - forming a principled solution, geometric models and drawings developing, calculations, process modeling, optimization, etc. The design phase includes all the necessary stages, from external design, concept design (appearance) of the product to testing of a trial sample or batch of products. External design usually involves development of technical and commercial proposals and forming a technical task (TT) based on the results of market researches and/or customer requirements [3]. |
| Preproduction: OD | At the preproduction stage, route and operational technologies for the parts manufacturing are developed, implemented in the programs for CNC machines; The technology of product assembly and erection; Control and testing technology. |
| Production | At the production stage, calendar and operational planning is carried out; Purchase of materials and components with their input control; Mechanical... |
processing and other required treatments; Control of processing results; Build tests and final control.  

**Operation and maintenance**  
Maintenance; repair (simple, medium, capital); Monitoring of tactical and technical characteristics (TTch) and failures; Inventory and logistics management.

**Disposal**  
Recycling preparation for products to be disposed or destruction for products to be destroyed; Recycling or destruction; author's supervision, assistance in recycling or destruction and feedback.

Considering the contents of the main stages of the LC product, it is not difficult to notice that, starting from the investigation phase, a large amount of documentation and the raw data on the future product are generated. A significant portion of this information is used in later stages. For example, general preliminary schemes of dividing the product into components can be created, information for volumecalendar planning tasks can be summarized. Based on this data, drawings and models are created during the design phase, information is entered in CAE/CAD/CAM, PDM systems. In the future, during the preproduction and production stages, data is used by MES and ERP systems within the single information space (SIS).

The inefficiency of the described scheme is that during the investigation phase and the early stages of the designing phase, different information (calculation results, electronic documents, fission schemes, etc.) is stored in disparate sources, in different source units, in an uncoordinated state outside the SIS. Technical documents are created by different performers, in different notations and are differently accounted for in the accounting systems. This, in turn, requires additional costs in development "real" documents in CAE/CAD/CAM, PDM, MES, ERP systems, bringing them to an agreed view, identifying document links, building a documentation tree for the project.

The second drawback of the considered scheme is the need to plan the working out of future technological documents on the early stages of the product development process, calculating the material resources, process labour and economy required for this purpose. The process of developing scientific and technical documentation is the subject of constant monitoring with the fixation of intermediate results.

An acceptable solution of these problems is the provision of a specific tool for users, which would allow forming a coherent structure of the project (product) on the earliest stages of the LC and keeping it within the SIS. This solution may be the information system presented in figure 1 (document management system - DMS), which allows forming an entity tree (prototypes of future documents in the PDM system) with a set of predetermined attributes (internal identifier, designation, name, information about the executor, labor-intensive standards, etc.) Some of these attributes (e.g. designation) can be defined initially and invariably used throughout the LC, while the other part can be filled and adjusted as the product progresses through subsequent stages.

On the basis of these prototypes, "real" documents will be created in the PDM system. At the same time, a specific document should exist in a single copy, which eliminates the need to reenter data in heterogeneous systems. Such scheme will allow at all stages of the LC to guarantee the identity of documents, provided the use of a unique document ID in all SIS accounting systems. An important feature of the proposed system is that it stores only descriptions of documents, first future, in the early stages of the LC, and then real, caught in the PDM system. The technical documents themselves are not stored in the system, information about the real document location is maintained. It allows having descriptions of documents related to, among other things, restricted access information in an impersonal form, or an inventory number in DMS, to find it in the archive of a closed network.
Figure 1. Organization of documentation electronic records and storage.

The described functionality is complemented by the built-in fission scheme editor of the system (figure 2), developed on the basis of GOST, which allows creating of dividing schemes of any level and nesting.

Figure 2. Editor of the scheme dividing the product into constituent parts.

In addition to the fact that the scheme of dividing the product into components is an independent document, the editor's capabilities allow generating individual documents from the product components, or, on the contrary, forming the schemes of division on the basis of documents available in the system. Interactive transition scans and documents tied to the diagram are supported. Information objects created
in the DMS editor are stored in a database (DB) in the tree form with a large number of characteristics, supplemented at any given time.

Storage of document data (product component parts) in this way allows developing the document tree based on the project at the stage of the sketch project design of the future product with the possibility of an analytics variety filling. Conversely, having the prepared document tree, it is possible to get unified dividing schemes, the format of which can be adjusted to the necessary functionality. The document tree supported in this way becomes an integration bus for different accounting systems, primarily for the project management system and the actual performance collection system. Using the document tree, different information systems data is structured by adding the document tree ID attribute to their accounted entities. By adding the attribute of the DMS identifier to the accounting systems of interest for analysis, it is possible to keep records in these systems in the context of these information objects. In turn, the DMS can collect data from different accounting systems, both on individual elements of the tree, and on conditional groups such as device, node, system, contract statement stage, project, etc.

The DMS elements are classified on many grounds (project, LC stages, product composition, manufacturer, department, borrowing, resources, regulations, etc.), that gives possibility for multilateral analysis, as for the purposes of thematic departments (choosing the best solution according to economic characteristics, document package preparation for the customer, etc.), and for calculating, planning and controlling the economics of the component development process.

The sequence of data passing through the product LC stages is shown in table 2.

Table 2. Data passing through the product LC stages in DMS.

| Stage name       | Scope of work                                                                                                                                 |
|------------------|---------------------------------------------------------------------------------------------------------------------------------------------|
| Investigation    | General preliminary scheme development for dividing the product into components, information generalizing for the bulk-calendar task planning. Planning of "real" document development process in accordance with the documentation realization schedule. |
| Designing        | The document tree formation, assigning documents (if necessary, coordination with units that carry out normal control and labour protection) basic attributes. Development of real documents, models and drawings, their input into the PDM system with a single link to the record in the DMS. |
| Preproduction     | Technological documents (route, operating maps, etc.) are added to the DMS document tree.                                                                 |
| Production       | Using the DMS data in MES and ERP systems within the SIS. Calendar and operational planning with adjustments to attribute planning in documents. Formation on the basis of the DMS tree documents for the customer and controlling units, an electronic documentation archive at the enterprise. |
| Operation and maintenance | Entering documentation for repairs and results of TTch monitoring and failures in the DMS.                                                                 |
| Disposal         | Entering recycling documentation (acts, protocols, etc.) in the DMS. The formation of documents on its basis for supervisory bodies. |

The most important advantage of the DMS implementation is the ability to plan the real document development at the earliest stages in accordance with the documentation realization schedule, which is regulated by the contract with the customer, to plan procurement procedures, revenue and expenditure budgets, cash flows tied to future accounting facilities, to assess the production resource loading during planning and agreeing projects. There is an opportunity for effectively leading the economy of the product development process within the framework of contracts with customers.

While transferring the product documents to the documentation electronic archive, the original DMS tree can also be a single data source that unequivocally determines the position of the document in the hierarchy and contains all the necessary attributes, that allows automating routine data-entry operations and eliminating human errors.
4. Conclusion
The product lifecycle consists of the following main stages: investigation, designing, preproduction, production, operation and maintenance, disposal. The inefficiency of information flow organizing through these steps is the lack of a centralized information repository at the early stage, as well as the need for early planning of the technological document development. The introduction of the document management system and its integration into a single information space allows, starting from the earliest stages, having a single data source on the product throughout the LC, developing supporting tools, planning and reporting tools, structuring data in the documentation electronic archive of. It is possible to keep records of unfinished production in the context of objects included in the document tree with reference to economic and accounting information. The DMS in this form allows forming the SIS on different data entry and accounting sites and using it in all accounting systems, that directly affects the quality of management process information support and increase productivity on the enterprise.

References
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