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Разработка эффективной системы информационной поддержки принятия управленческих решений на предприятиях ракетно-космической отрасли

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В статье рассматривается роль информационных технологий на промышленных предприятиях ракетно-космической отрасли, приводятся результаты анализа научных источников по организации систем информационной поддержки для принятия управленческих решений, анализ существующих методик построения управленческого учета на предприятиях и способов его автоматизации. Делаются выводы о недостаточной проработанности изученных решений, как с точки зрения логики организации учета, так и с технической точки зрения. Определяются основные задачи системы информационной поддержки, методы формирования эффективного управленческого учета и цели его внедрения. Предлагается подход к созданию системы информационной поддержки в виде надстроенной управляющей базы данных в виде OLAP-решения, посредством которой интегрируются функциональные информационные системы и строится детализированный управленческий учет, связанный с бухгалтерским и налоговым учетами в единую систему в едином информационном пространстве. Описываются преимущества внедрения предлагаемой системы, позволяющей проводить всесторонний ретроспективный и оперативный анализ текущего состояния протекающих на предприятии процессов с денежной оценкой средствами SQL с высокой степенью доверия к данным. Оговариваются принципы создания элементов информационной системы для последующего эффективного план-факт анализа и выработки управленческих решений. Приводится схема организации единого информационного пространства и системы, обеспечивающей информационную поддержку процессов управления предприятием, рассматриваются основные информационные потоки. Описывается логика поддержания процесса формирования структурированного хранилища данных при автоматизации финансово-экономической части АСУП на базе представляемого способа организации данных, позволяющая увязать управленческий, бухгалтерский и налоговый учеты с одним источником актуальных данных, создавая при это эффективное OLAP-решение. Приводится наглядный пример организации данных в виде увязки средствами БД отражений первичных документов предлагаемым способом, обеспечивающим возможность оперативного анализа дебиторской и кредиторской задолженности и осуществления предварительного финансового контроллинга. Приводятся

примеры интерфейсов пользователя из разработанной системы информационной поддержки, построенной на описываемых способах организации данных. Делаются выводы об эффективности предлагаемого решения.

Ключевые слова: система информационной поддержки принятия управленческих решений, интеграция, единое информационное пространство, финансовый контроллинг, OLAP-решение.

Development of an effective system of information support for management decision-making at the enterprises of the rocket and space industry

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The article examines the role of information technology at industrial enterprises of the rocket and space industry, provides the results of the analysis of scientific sources to organize information support systems for making management decisions, an analysis of existing methods for constructing management accounting at enterprises and methods of its automation. Conclusions are made about the insufficient elaboration of the studied solutions, both from the point of view of the logic of the organization of accounting, and from a technical point of view. The main tasks of the information support system, methods of forming effective management accounting and the goals of its implementation are determined. An approach to create an information support system in the form of a built-in control database in the form of an OLAP solution is proposed, through which functional information systems are integrated, and detailed management accounting related to accounting and tax accounting is built into a single system in a single information space. The article describes the advantages of implementing the proposed system, which allows for a comprehensive retrospective and operational analysis of the current state of the processes occurring at the enterprise with a monetary value using SQL tools with a high degree of confidence in the data. The principles of creating elements of the information system for the subsequent effective plan-fact analysis and development of management decisions are discussed. A diagram of the organization of a single information space and a system that provides information support for enterprise management processes is given, the main information flows are considered. The logic of maintaining the process of forming a structured data warehouse is described, while automating the financial and economic part of the automated control system based on the presented method of organizing data, which allows to link management, accounting and tax accounting with one source of relevant data, while creating an effective OLAP solution. An illustrative example of the organization of data in the form of linking the reflections of primary documents by means of a database using the proposed method, which provides the possibility of operational analysis of receivables and payables and the implementation of preliminary financial controlling, is given. The research provides examples of user interfaces from the developed information support system based on the described methods of data organization. Conclusions are made about the effectiveness of the proposed solution.

Keywords: information support system for making management decisions, integration, unified information space, financial controlling, OLAP solution.

Introduction

The prerequisite to implement economic activities (EA) is the application of information technology (IT) at the industrial enterprises to automate design processes, production management, logistic activities, financial economic and accounting processes. Successful automation of enterprise management system increases the efficiency of the management, stimulates labour productivity due to accelerating the information exchange in agreeing various issues, transiting to digital document workflow, reducing the influence of the human factor and the possibility of automated standard decision making. Information systems (IS) and processes at enterprises should be interdependent, since currently, it is impossible to provide workflow and management accounting without information support. IS ensures the fulfillment of the set goal satisfying numerous requirements for the production and accounting process, and not only records the results of business processes (BP) [1].

The relevance of the study in this article is determined due to the search for solutions to improve the efficiency of enterprise management in the rocket and space industry (RSI) within the state defense orders and high uncertainty.

An effective information support to the management process is required to make informed, relevant economic decisions based on reliable information from various sources, formed by means of accounting and analytical support for management processes, structured and supported according to certain rules.

Research analysis

The targeted research has demonstrated that the purpose of IP management is to provide consumers with appropriate relevant information in a certain subject area in the form of up-to-date information products [2].

Considering that the subject data of various processes are distributed over their functional IS, and management decisions are determined due to analyzing the financial and economic state of the enterprise and the ongoing processes, developing systems of information support management based on current economic data, connected in a database with the production process; the current economic data are available at any time. The process requires a data management tool for EA, integrated with functional IS containing the results of this activity, thereby forming management accounting (MA) at the enterprise [3].

In the sources [4–14], the methodology to construct MA mainly consists in determining the sequence of actions from the accounting audit to recommendations to automate the processes described and regulated before, which ultimately allow obtaining various mid-assessment of information necessary for making management decisions. However, there is a lack of clearly described solutions to organizing MA information support at large enterprises. One of the most important conclusions made as a result of the analysis is the need for MA obtaining data both on the planned performance of the enterprise and on the actual ones in the form of accumulated costs in case the required results are achieved. The purpose to develop information support to MA is to manage costs to control the cost of production. MA organization should be based on the management policy principles and consider enterprise features.

MA automation means a method of technical systematization of information into a single database with collecting, processing and transmitting the required information, which could be used to compile both accounting and management reporting, its measurement and evaluation of the results obtained. The analysis of sources [4–14] in the field of management accounting automation showed the following.

1. The proposed solutions based on accounting data are ineffective due to a significant information time lag concerning the fact of business transactions (BT), insufficient for managerial conclusions of analysis reflected in accounting entries, however, these data on work in progress (WIP) are not connected with the sales objects, affecting the cost of production. Fig.1 introduces a conventional approach to MA organization.

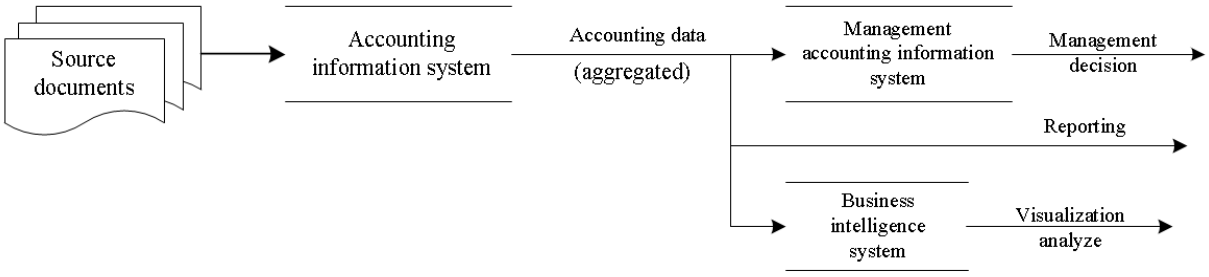

Рис. 1. Общий подход к организации УУ

Fig. 1. General approach to the organization of management accounting

2. MA automation problem is mainly solved by developing a parallel A autonomous MA system in an economic entity, which will certainly results in data discrepancies and distrust to information. Such solutions require very high qualifications of employees who process primary documents, since they are responsible for the correct distribution of the primary data across the MA registers. Large enterprises obtain employees working with primary documents being ordinary registrars and, as a rule, not having such skills when entering documents into the accounting system.

3. There are no ready-made solutions meeting the needs of companies in the rocket and space industry in the literature studied; on the contrary, there is a statement that such software has not yet been developed to be adapted for accounting, tax and management accounting simultaneously, this forces enterprises to use a whole set of tools, which is often inconvenient due to database incompatibility [14]. Among the many different programs and local solutions, the visibility (traceability) of the MA goals, the stages of their achievement with reference to the objects of control are lost.

Most of the scientists researching the problem of MA organization [4–14] conclude that it is necessary to build IS and their inherent information flows to store data to be considered as an OLAP system and be able to continuously compare the current data with the planned values of economic indicators tied to the objects of control and accounting. However, even such an approach to MA automation can contain hidden problems: processed and consolidated data, rather than primary data, can be overloaded, which can lead to distortion of information obtained on the basis of created data marts. In addition, accounting data is generated according to the rules and, for the accounting needs, they are unacceptable for operational decisions due to a delay. And, finally, the most important drawback of all approaches to the MA automation based on accounting data is the accounting records the performed BT and beautiful pictures in the BI system will show what a manager has not done, and they will use these data only to prepare a solution for the future, if the same conditions are created.

The most important accounting principles for MA is the availability of operational information about the real state of affairs rather than the document registration in the accounting system [8]. Accounting and MA automation does not only significantly increase the efficiency of the accounting department, but also reduces the likelihood of errors, improves the quality and efficiency of reporting by embedding mechanisms for BT visual reflection into the software [9].

In the rocket and space industry the main tasks to automate information support systems of enterprise management are:

– time-efficient analysis of receivables and payables;

– preliminary financial controlling (both at the stage of agreeing the payment requirement and creating a payment document);

– time-efficient tax accounting;

– organization of related management, accounting and tax accounting;

– management of the production cost in the form of accounting, controlling and managing production costs, decomposed by the price structure;

– connection of management accounting with PDM and PLM systems for accounting of technical results of activities to help detail work in progress to accounting objects.

In order to comply with the law, to ensure the ability to manage the life cycle (LC) of the manufactured products and their impact on the economy, developing information support systems become necessary for the processes occurring at the enterprise according to the regulatory authority requirements to accounting. The regulations to maintain separate management, accounting and tax accounting at an enterprise determine the conditions for the functionality of management information and control system (MICS), for the processes of structuring, transforming and storing information in a form meeting the requirements of regulatory documents and regulatory agencies for enterprise reporting, as well as suitable for analyzing statistical data. The tool for recording and analyzing data on EA should be able to integrate with functional IS, where the activity results are planned and considered. Up-to-date information about any individual item of the product should be available automatically in various views. Such an integrated IS should make compatible the processes of development and production of technology with the economics of these processes and can be used at enterprises as a PLM system. Fig.2 introduces MA main aspects.

The entire chain of processes from letting a contract to delivering finished products is accompanied by primary documents, the data of which are subject to mandatory accounting and tax accounting. The quality of information support to MA depends on the created opportunity to analyze the data of these documents in various aspects and with the least time serving the information consumer's interests. At large enterprises, with a large number of primary documents without an effective MA system, quickly finding results on constantly emerging issues is very difficult.

Analyzing standards, methods and experience in developing information support tools inevitably leads to an understanding the need for a transition to process management [15–19]. The most suitable and practical technology, combined with the principles of CALS/IPS, is the methodology to describe information flows in the IDEF0 notation and the Workflow technology of workflow management, supporting the BPMN notation [19]. A resolved issue can be considered the availability of BP description tools developed in the Russian Federation with the support of notations allowing to create detailed business models and generate regulations to implement processes in the covered areas of activity and of performers' job descriptions .

The management methodology, based on using the principles and developing information support for this, forms understanding of MA continuity and the quality management system (QMS) of an enterprise [17]. For managers to unambiguously understand a set of control objects and economic aspects of financial and economic activities (FEA), it is necessary to develop a corporate enterprise management system in a single information space (SIS) using one control database, with an unambiguous identification of accounting objects and primary documents associated with their life cycle.

Fig.3 demonstrates the principle of organizing information flows among the main functional systems and information consumers, the principle to which one should strive for MA purposes [18].

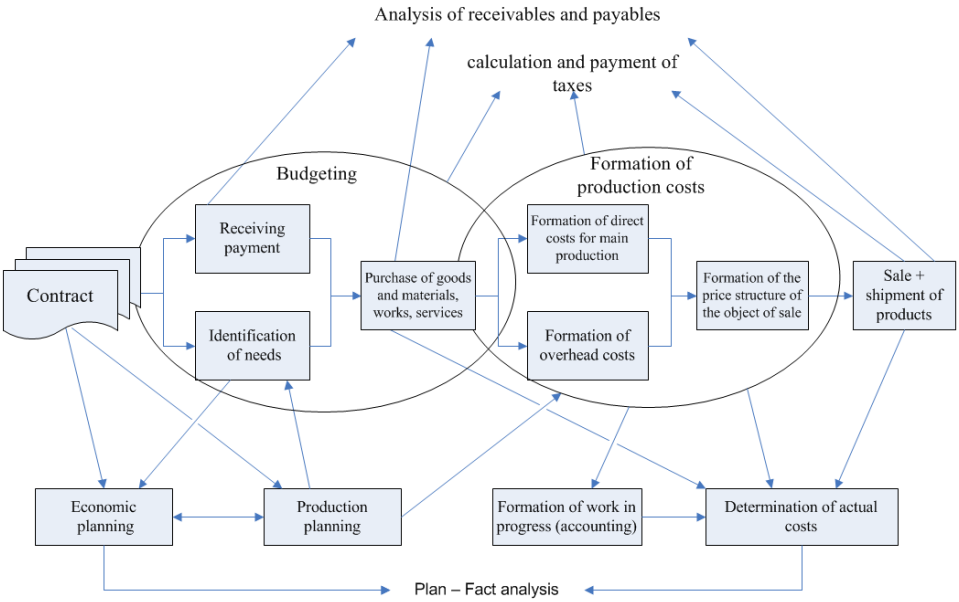

Рис. 2. Аспекты управленческого учета

Fig. 2. Aspects of management accounting

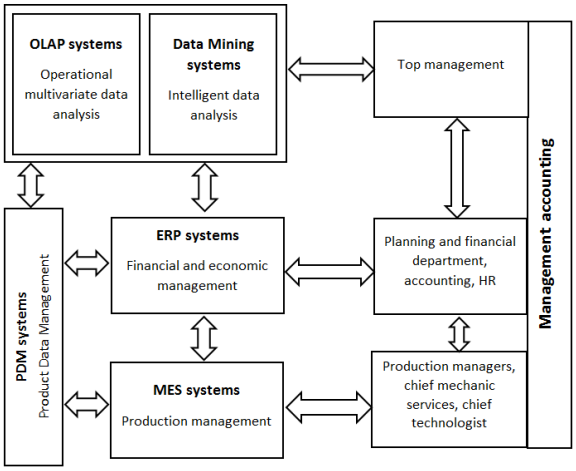

Рис. 3. Организация информационных потоков УУ как элемент СМК

Fig. 3. Organization of information flows of management accounting as an element of a quality management system

Developing MA information support

The most realistic and effective, and simultaneously, the most difficult way to develop MA information support is to develop MA database in the form of a SIS, in which the storage and accounting of the data of the main primary documents will be organized immediately in the form of an OLAP-solution that excludes the consolidation and overloading of primary data, and using the same structured array for the accounting and tax accounting. Realizing the solution will be effective through a built-in database and interfaces corresponding to MA goals, providing the processes developed for MA formation and their information flows. The data arrays formed by the solution are easily integrat-

ed with the necessary functional IS at the database level, as a result of which the linkage of subject IS with the economic system is organized, on the basis of which most management decisions are made.

Enterprise management, in addition to technical aspects, should be considered as a system of interrelated processes, where economic indicators (direct costs, payroll, overhead costs, budget, financing, etc.) act as controlled parameters. The result (feedback) to the deviation of the actual indicators from the planned ones will be a balanced management decision. For an effective MA, it is necessary to develop a methodology to store data for time-efficient analytical activities and making informed management decisions, as well as an applied functional model of the accounting process for the costs to develop products with the ability to provide preliminary, in most cases, automated financial control. Fig.4 demonstrates the developed approach to MA organization at the rocket and space industry enterprises.

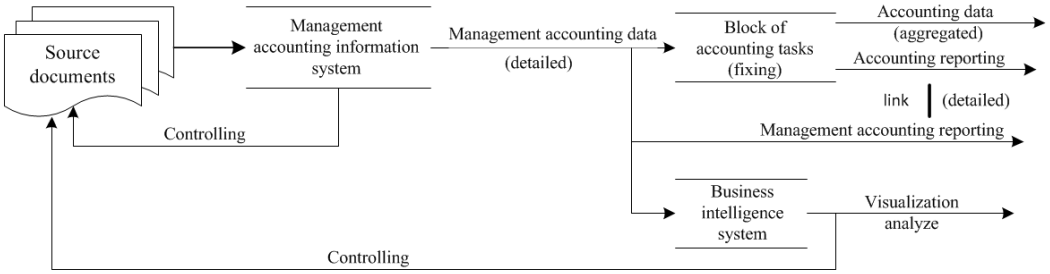

Рис. 4. Предлагаемый подход к организации УУ

Fig. 4. Proposed approach to organizing management accounting

The developed logic of building information systems distributes the entire burden of MA organization among the employees responsible for the primary documents, and the add-on in the form of the proposed software ensures the structuring and storing the data in the database according to the rules allowing to form MA and the related accounting and tax accounting, and not only hampering the work of the system users, but also facilitating it due to preliminary automated controlling.Many potential errors are eliminated at the stages of inputting primary information and linking data in the form of logically completed BTs. The result of the MA information support implementation system at the enterprise, based on the proposed approach, will be a unified database of the structured data concerning the progressing BT, suitable for a comprehensive operational analysis by SQL means.

Realizing this approach is possible when forming an OLAP solution based on a specially designed data warehouse meeting the MA goals. The most effective way of realization seems to be the development of a ROLAP system with storing actual data in the database tables [20]. The database logical structure must be developed to integrate functional systems on the same solution, which is also the most effective way of integrating IS. To form an up-to-date set of data available at any time, it is more expedient to use an incremental update of data changed in the OLTP system [21]. This approach contributes to developing a structured data repository prepared for the management analysis before it enters the accounting system.

To ensure the possibility of measuring MA controlled parameters, it is necessary to introduce analytical markers to the primary documents, selected from the reference books developed for MA purposes, corresponding to the logic of BP primary documents. As a basis for the formation of an OLAP cube for the main external primary financial documents, the most effective is to use the storage architecture with dimensions according to the "snowflake" scheme, in which it is necessary to create

fact tables providing the physical organization of data and organize links of primary documents corresponding to the logic of the fixed BP. It is also rational to use normalized data warehouses in one relational data storage systems (RDSS) for linking with OLTP systems of our own design. Metadata deserves paramount attention in the development of a data warehouse: information about the structure, placement and transformation of data, due to which the effective interaction of various components of the warehouse is ensured.

Management solution is, as a rule, a respond to a comparison of indicators that characterize the process. For MA, the forecast manufacture process values are compared to the actual accumulated data of the EA results. For convenience, efficiency, traceability and the possibility of automated analysis of ongoing processes, it is advisable to build planning systems according to the same principles in the SIS with a fact collection system, based on the same reference information (NRI). The systems should conduct efficient and automated plan/actual analysis. Adhering to the opinion that the cost of products is formed by the processes, it becomes obvious to develop and improve BP to eliminate information gaps, forming a root model (without information gaps and loss) and the basis for BP regulation, this results in increasing labour efficiency, management efficiency, and reducing manufacture costs.

For planning, amenable to operational analysis by means of SQL, it is advisable to build a project management system in the SIS as a central node integrated with all accounting systems, that contribute to linking all work performed at the enterprise with the concept of a project, which should go through all software and form the EA management basis. It is the work from the project work plan that should be the connecting element in all BPs, and its cost attributes should become the basis for the MA system. By linking work with sales objects (accounting objects), it is possible to obtain the opportunity to quickly manage the timing of production, estimate resources, predict the prospects for the activities of departments, as well as evaluate profitability both for individual projects and across the enterprise, which increases efficiency and transparency in the field of management.

The data in MICS in all of its accounting systems should be linked to forming the main information flow; Fig.5 demonstrates its diagram.

Applying certain methods of data structuring, based on the coding of analytical information about the object of control, the SIS prepares data suitable for automated control, increases their connectivity and traceability, which contributes to reducing the time of their analysis, improving the quality and relevance of the solutions generated and the management effectiveness in general.

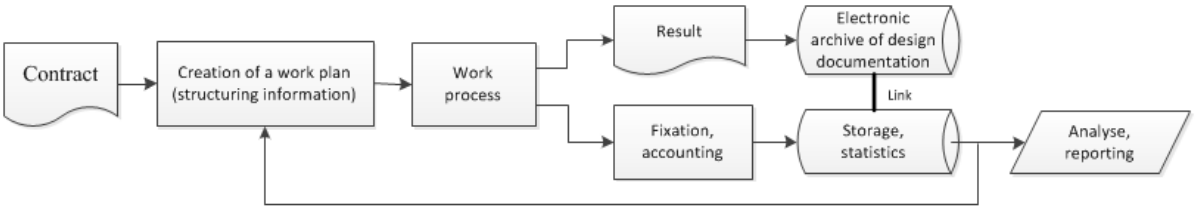

Рис. 5. Схема основного информационного потока в АСУП

Fig. 5. Diagram of the main information flow in the automated control system

Fig. 6 shows a simplified diagram to arrange SIS for the information support system, where each process is organized using the developed software, its implementation leads to automating the main information flows controlled in MA, and thereby, ensures the efficiency of the enterprise management process. Introducing such processes and software organizing the presented information flows in the

SIS makes it possible to conduct an operational plan/actual analysis at any time and generate any detailed reporting that corresponds to official accounting and tax accounting.

To support the process of forming a structured data warehouse when automating the MICS financial and economic part based on the presented method of data arrangement, the main software modules "Purchases" and "Sales" have been developed, in which all primary financial documents accompanying commodity-money relations are entered, registered and taken into account with counterparties, as well as proactive control over the legality of spending money. The main purpose of these modules is to create and maintain SIS by linking the reflections of primary documents to each other in the database tables and marking the resulting lines with analytical features. Documents are linked according to the principle of belonging to each other, where one document is the basis for generating another, or documents are two parties to one financial and economic transaction (FET). Documents are linked both fully and partially in the amount of money that identifies the weight in monetary terms of a particular FET [22].

The actual links of documents are stored in database tables and are supported by a set of rules and restrictions that correspond to the developed logic through user interfaces. The software logic provides the information structuring, the organization and maintenance of data connections in the described way for the entities "Purchase" and "Sale"; it is shown in Fig. 7 and 8 respectively.

Connecting within the framework of the developed method of reflecting the primary documents to purchases and sales, we obtain a lined up detailed MA within the framework of the cash flow before financial transactions on the accounting. The link between purchases and sales is carried out by connecting a contract and a customer with contracts for supplying goods, work, services through an open order in an integrated project management system [22].

Accounting records the same FET with the same analytics with a link to the primary documents. When using the developed method of linking primary financial documents, there is no need to build MA while analyzing receivable and payable on accounting entries, as it is arranged in most economic systems. Actual data are available to analyze them immediately after linking the documents and it can be changed before the documents are posted on accounting.

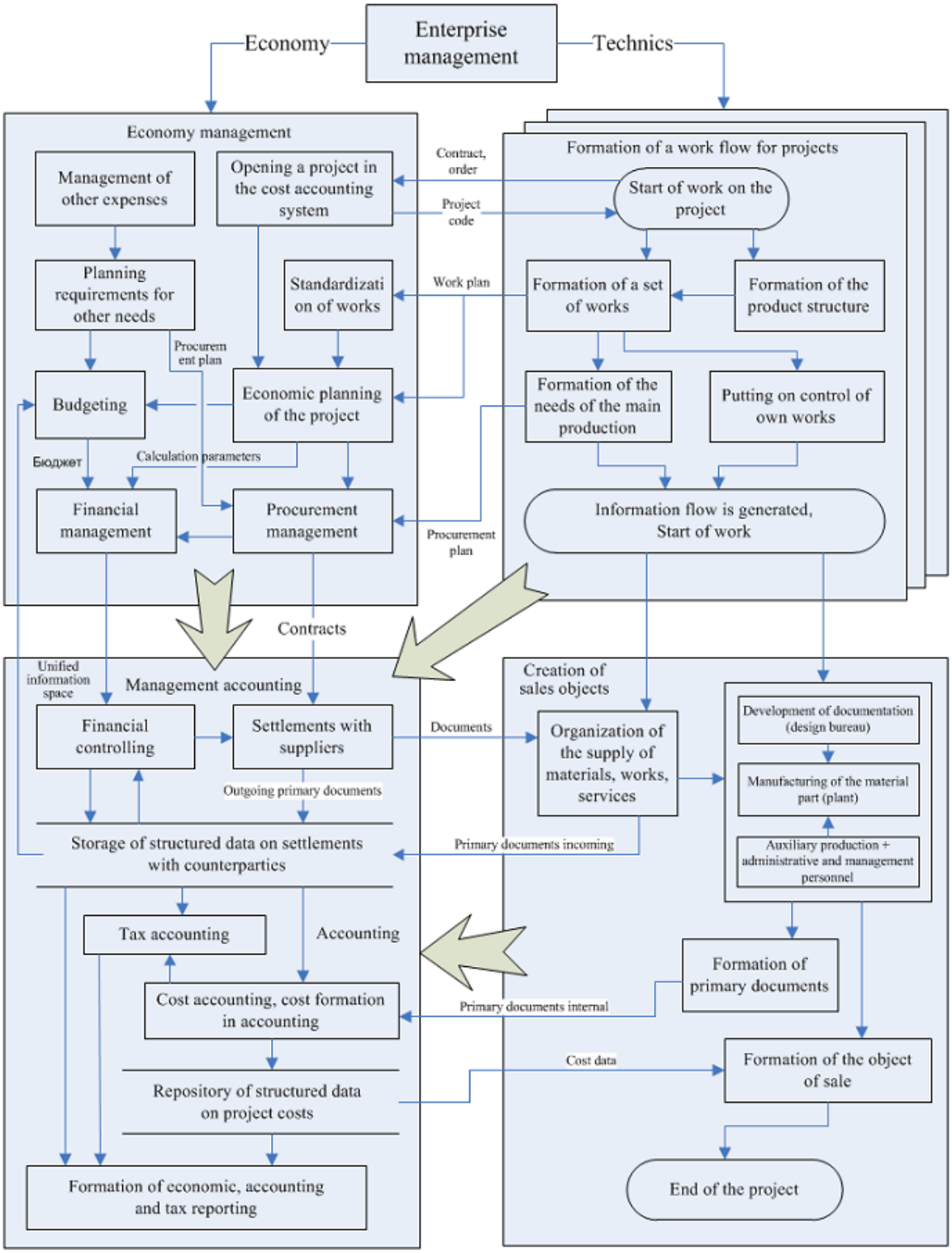

Рис. 6. Схема организации системы ИП процессов управления предприятием

Fig. 6. Organization diagram of the information support system for enterprise management processes

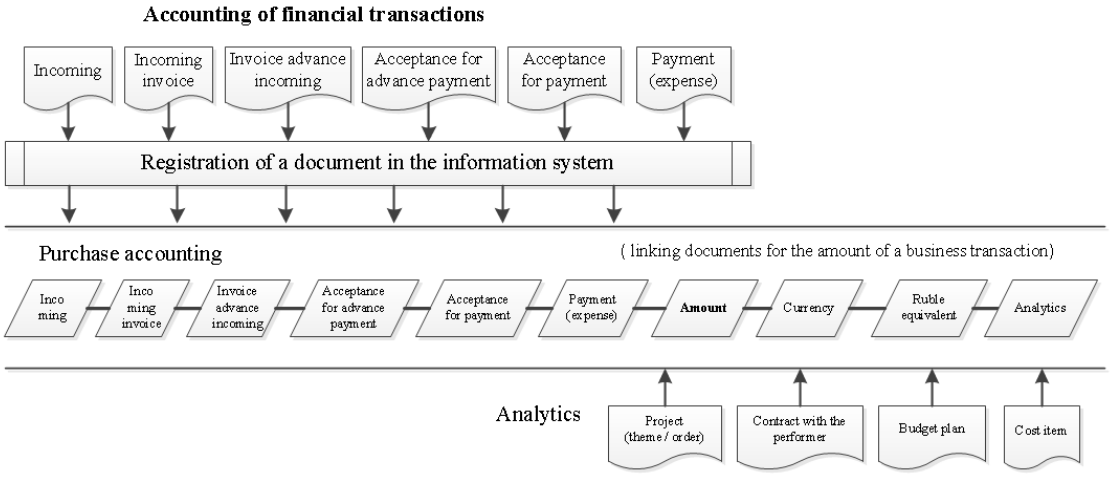

Рис. 7. Связь первичных документов для сущности «Покупка»

Fig. 7. Linking primary documents for the Purchase entity

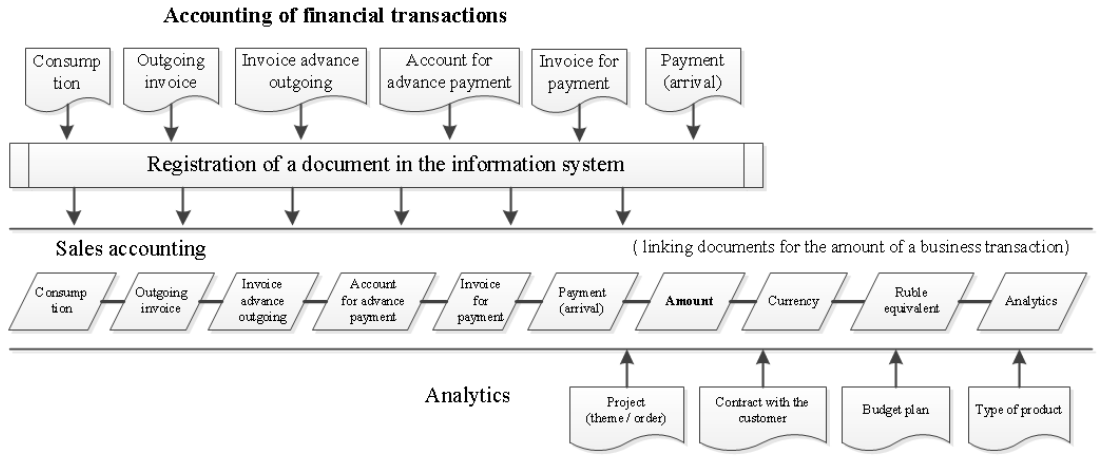

Рис. 8. Связь первичных документов для сущности «Продажа»

Fig. 8. Linking primary documents for the Sale entity

Since the primary documents being the grounds for accounting entries, are interconnected at the database level, then in accounting there is no need to keep a complete set of analytics tools characterizing FET in every entry. These data are easy to find and analyze in a multidimensional array supported in the described way, which is the basis of the OLAP system. Due to this approach, the relevance of data is maintained in one place, where the primary document is born and the information flow is generated, the logic of which is supported by the developed system and user applications.

The developed system links management, accounting and tax accounting, which are based on detailed data on FET with the necessary analytics and fixed links between them, forming a multidimensional array of structured data or OLAP solution. As a result, SIS is formed, containing up-to-date and consistent information about the state of all FETs based at least on one of the listed primary documents.

SIS, formed by the “Sales” and “Purchases” software modules, is a repository of structured data corresponding to primary documents, detailed to logically completed operations and having rigid links to each other in the form of external keys in the database table. Fig. 9 presents an example of organiz-

ing data within a separate process of supplying manufactured products (Sale) in the form of a structured array.

consignment note		invoice		invoice for advance payment		invoice for payment		account for advance payment		payment		analytics	amount in the currency of registration	currency	ruble equivalent	
№	Date	№	Date	№	Date	№	Date	№	Date	№	Date					
								1	15.12.2017			a	1	E	75	registration of an account for advance payment
										2	15.01.2018	a	1	E	75	registration of payment
				3	15.01.2018							a	1	E	75	registration of an invoice for advance payment
				3	15.01.2018			1	15.12.2017	2	15.01.2018	a	1	E	75	link of invoice for advance + payment + invoice
4	10.04.2018											a	3	E	225	registration of a consignment note
		5	15.04.2018									a	3	E	225	registration of an invoice
4	10.04.2018	5	15.04.2018									a	3	E	225	link of a consignment note + invoice
						6	20.04.2018					a	2	E	150	registration of an invoice for payment
										7	25.04.2018	a	2	E	150	registration of payment
						6	20.04.2018			7	25.04.2018	a	2	E	150	link of account + payment
4	10.04.2018	5	15.04.2018	3	15.01.2018			1	15.12.2017	2	15.01.2018	a	1	E	75	link of primary documents
4	10.04.2018	5	15.04.2018			6	20.04.2018			7	25.04.2018	a	2	E	150	link of primary documents

Рис. 9. Пример связи первичных документов для сущности «Продажа»
в рамках сквозного процесса поставки произведенной продукции

Fig. 9. An example of the relationship of primary documents for the entity Sale in the framework of the end-to-end delivery process of manufactured products

Proactive control of cash flow is performed in documents of the "Acceptance" type in the "Purchases" module, where all the characteristics of the future payment are automatically checked for the legality: budget plan item, payment purpose, contract balance, state contract identifier (SCI), bank details, accounting policy restrictions and various customizable conditions. Acceptance is an internal document of an enterprise, it acts as an integrator of the process of cash flow and it can be “loaded” with any checks. In its turn, preparing a payment document for budget planning items requires obligatory presence of an agreed registered acceptance, this budget rule is monitored. Software does not allow registering a payment document in the system if it does not meet the budget rules.

The forms for entering financial documents contain all the necessary reference books for MA for marking the data of primary documents with MA attributes for subsequent analytical tasks in the formed multidimensional array of structured data. Fig.10 presents the user interface for working with the financial document data structured and linked in the form of an OLAP solution. This application analyzes the relationship with counterparties, estimates receivables and payables.

Due to this data organization, the budget of the enterprise for a specific date is automatically collected; the budget can be compared with its planned values (Fig. 11).

Software, providing the rules to structure and store the data, consists of two classes. This is a class to maintain the logic of recording and process data about the primary documents and the links between them, and a class to maintain the logic of recording and process data on (VAT) in the documents taken into account, thereby forming tax accounting. The technically developed software maintains up-to-date a multidimensional data array distributed over several tables in the database, each being responsible for the necessary display of the same data on the operations that have taken place for various purposes of accounting and analysis. The set of attributes in various database tables is determined by the stored entity, technical fields to implement the method of data connection and additional fields to organize and maintain the rules laid down in the accounting policy of the enterprise. Additional details in database tables about VAT may vary depending on the selected accounting policy, while the part of the software responsible for calculating the purchase ledger and sales ledger can be modified to comply with the accepted accounting rules at the enterprise. As a result, the database tables can collect and store the current data about the primary financial document data on the document linkage, reflecting BT, thereby forming MA, and related data on VAT, calculated according to the accounting policy rules, forming the tax accounting.

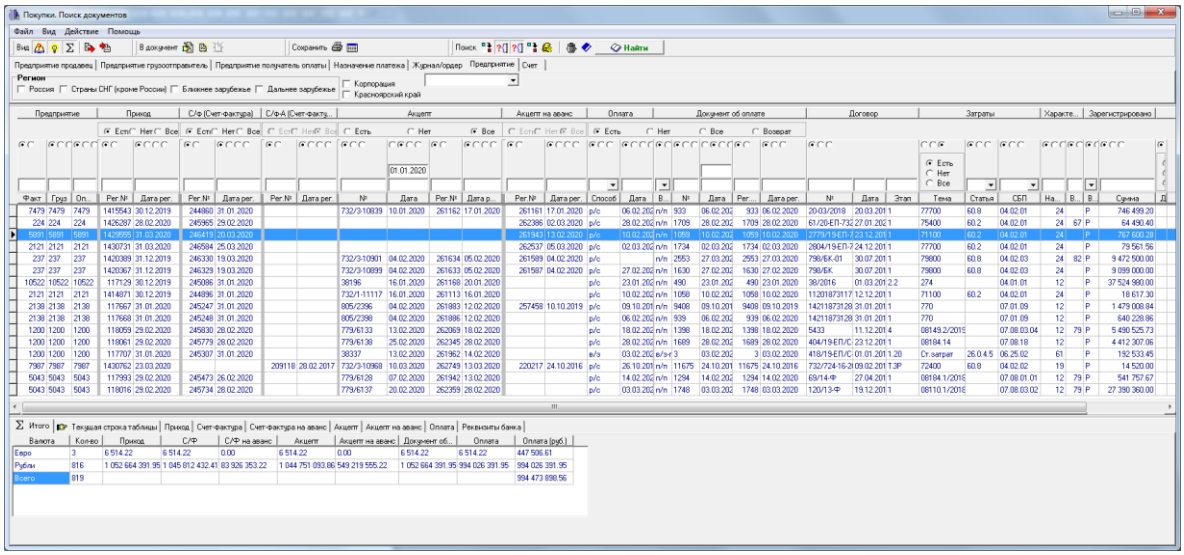

Рис. 10. Форма для работы в финансовой OLAP-системе АСУП

Fig. 10. Form for working in the financial OLAP-system

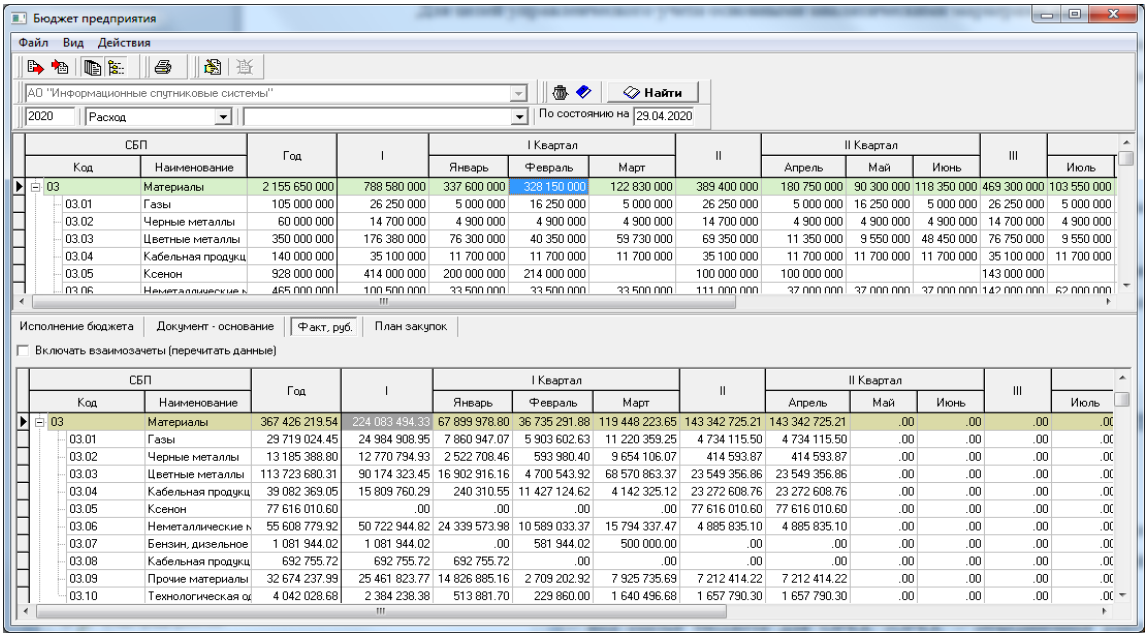

Рис. 11. Форма анализа бюджета предприятия в АСУП

Fig. 11. Form of analysis of the enterprise budget in the automated control system

In their turn, accounting entries in dependent accounting areas are developed on the basis of data from the prepared tables of links of primary documents and related tables that consider the VAT distribution. This allows analyzing the activities of the enterprise reflecting the BP financial and economic reflection of in real time, which increases transparency and accuracy in management. An analytical base is created for making timely and well-grounded management decisions, as well as preliminary financial control is carried out for the legality of financial transactions and their characteristics. The possibility of an automated solution of many typical financial and economic operations is formed, this results in saving time resources and increasing mobility and management efficiency. SIS, formed and maintained in this way, is a single data source of contemporary and consistent information for var-

ious types of reporting to various controlling organizations.

Conclusion

The studies demonstrate that the existing approaches to the automation of the control system are mainly in developing autonomous control systems operating in parallel with the control unit, which will certainly lead to data discrepancies and distrust of information. We consider the most effective way to develop MA information support to create a MA database in the form of SIS, where the storage and accounting of the data of the main primary documents is organized in the form of OLAP solution excluding the consolidation and overloading of primary data, while the same structured array is used for purposes of accounting and tax accounting. The proposed approach is realize through a specially designed data warehouse that meets the MA goals. ROLAP system is developed with the contemporary data stored in the database tables. To support the process of forming a structured data warehouse on the basis of the presented method of organizing data, software modules are developed; the software stores registers and considers all primary financial documents accompanying commodity-money relations with counterparties, as well as it performs proactive control of the legality of spending funds. The developed system links management, accounting and tax accounting, which are based on detailed data on the FET with the necessary analytics and fixed links between them, forming a multidimensional array of structured data. This results in developing SIS, that contains contemporary and consistent information about the state of all FETs, an analytical base is created for making timely and well-grounded management decisions and automated financial controlling.

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