Use of Information Technologies in Design and Production Activities of Instrument-Making Plants

Anatoly Grigorevich Korobeynikov¹ ²*, Michael Evgenievich Fedosovsky¹, Nadezhda Konstantinovna Maltseva¹, Olga Vadimovna Baranova¹, Igor Olegovich Zharinov¹, Andrey Vladimirovich Gurjanov³ and Oleg Olegovich Zharinov⁴

¹ITMO University, Saint Petersburg, Russia; korobeynikov_a_g@mail.ru, stts@diakont.com, maltseva@grv.ifmo.ru, baranova@diakont.com, igor_rabota@pisem.net
²SPbF IZMIRAN, Saint Petersburg, Russia
³JSC Elektrovatomatika, Design Bureau n.a. P.A. Efimov, Saint Petersburg, Russia; postmaster@elavt.spb.ru;
⁴Saint-Petersburg State University of Aerospace Instrumentation (SUAI), Saint-Petersburg, Russia; zharinov73hotboxru

Abstract

Background: In the market economy conditions the system of the economic indices reflecting the activity of the instrument-making plant may change quite often. The production activity of the instrument-making plant is always aimed at manufacturing the products to satisfy the demands with consideration of the customers’ requirements. Methods: All this dictates the necessity to use state-of-art methods and approaches at managing the economic processes of the instrument-making plant. Primarily, it means the implementation of high information technologies in management of various processes at the instrument-making plant in order to increase a labor productivity of the employees by decreasing the cost-production ratio and skills upgrading and developing professional competence of experts involved in management activity. Findings: This work presents the analysis of the existing means for practical implementation of the information technologies at the instrument-making plants which increase a competitive capacity of the plants, decrease production time and improve the quality of the products under design. It also gives a description of the information technologies and determines those with the relevant implementation in the instrument-making sector is at the current stage. A process chart for instrumentation equipment production at the plant is given and the stages (process operations) are distinguished at which the implementation of the information technologies is impossible without development of the new support tools. The authors have offered the new automated support tools for design and production processes which increase a competitive ability of the enterprise and which are the forms of a practical implementation of the information technologies. The aforementioned new automated support tools are dedicated for the instrument-making sector and are integrated into the plant information system. Improvements: The materials of the present article are of a practical value for the experts involved in solving the tasks associated with support of design, production and economic activities of instrument-making plants.

Keywords: Design, Instrument-Making Sector, Information Technologies, Production, Process Cycle

1. Introduction

Development of the new and implementation of the existing information technologies in the management activity of the instrument-making plants is a relevant direction of the organization growth. Information Technologies (IT) increase a competitive capacity and enable to automate the process of generation of design,
software and process documentation as well as to automate the process of preparation of the report documents which provide a financial and economic stability of the enterprises. Information technologies also enable to automate the process of manufacturing and setting up the onboard instrumentation equipment, etc.

By law, the issues associated with using the information technologies are governed by different statutory instruments. The main terms, used at applying the information technologies, are fixed by law:

- Information technologies are processes and methods for retrieving, collecting, storing, manipulating, presenting and distributing the information and means of implementing such processes and methods;
- Information system is a collection of information contained in databases and collection of information technologies and technical facilities which provide processing of such information.

In this regard the implementation of “design-production” process cycle can be considered as the main area of the activity of the instrument-making plants which affects the competitive advantages of these plants, and the activity in this direction may lead to a significant effect in terms of a decrease of production time and improvement of the quality of the products being designed.

The key role in solving the problems related to human resources management at the enterprises is given to implementation of the information technologies. Sophisticated, hierarchic and multilayer structure of the enterprise lays the groundwork for decreasing the “manageability” of the organization, for which reason at making management decisions at the disposal of the enterprise Chief Executive there should be provided various mechanisms of both centralized and decentralized management, which are used on different management levels and which enable to increase a performance of the employees of the enterprise from the level of an ordinary project executor to the level of a Deputy Director General.

2. Information Technology Classification Principle

Information technologies used in management activity at the enterprises can be conditionally divided into the following class types:

- Traditional and new technologies conditionally united by the mean of their practical implementation in a certain information system;
- Technologies designed for data processing, for automation of certain management processes and for support of making the design decisions at the enterprises, for implementation of the practice-oriented problem of “electronic office” or “virtual enterprise” management and for implementation of the function of analyzing the design solutions offered;
- Technologies aimed at providing the end user with a possibility to work with text editors (for example, MS Word), to work with tabular data (for example, MS Excel), to work with databases (particularly, SQL package) or with drawing objects (for example, Adobe Photoshop package) as well as to work with multimedia systems (video image, Flash Technology) and also to work with hypertext structures (for example, viewing xml files in the Internet Explorer);
- Technologies providing the user with an access to work with information system in a dialog mode, in data packet transfer mode or based on network information technologies;
- Technologies implemented within local area networks of the enterprises which do not have an access to a global network – Internet or implemented within multilevel area networks as well as those implemented using the computing structures of the distributed information systems;
- Technologies implementing the accounting functions, banking operation functions and the function of report documents preparation for tax authorities as well as those implementing the insurance, design and other activities of the enterprise.

3. Results

3.1 Single Information Space of Instrument-Making Plant

Standard hierarchic structure of the instrument-making plant management is shown in Figure 1. Plant management structure is based on three hierarchic levels which provide the information interaction of the departments, namely:

- Level of the enterprise Chief Executive (General Director) and his Deputies (Enterprise Development Line Directors) which together form the Board
of Directors of the enterprise (Public or Private Company);  
- Level of Design Managers of subject lines of development which form a “creative element” of high technology products developed at the enterprise;  
- Level of Heads of Scientific and Research Departments and Laboratories, Purchase and Production Departments which manage a low and mid-level engineering staff at the enterprise.

At the level of the enterprise Chief Executive a
marketing research is conducted and a strategic planning of the enterprise activity areas is done with a view to a practical implementation forecast for up to the next 10 years. The result of a strategic planning of the enterprise activity is a range of the products which are manufactured or are about be designed and manufactured (mastered) at the enterprise.

The integral parts of the enterprise activity strategic plan are primarily affected by as follows:

- Target government programs;
- Analysis of a scientific and technical potential of the enterprise encompassing the qualification assessment of the employees and best practices available at the enterprise (including the items of intellectual property);
- Analysis of production facilities of the enterprise including the assessment of the capacities of the enterprise machine-tool fleet.

At the level of the enterprise Design Managers, the advanced engineering practices relevant for a certain enterprise activity field are determined, as well as a tactical plan of the enterprise operation is made. Tactical planning of the enterprise activity is normally done for not more than the next 5 years. Both subject and calendar schedules of the enterprise activity are a final result of a tactical planning.

Tactical planning of the enterprise activity is mainly affected by the life cycle analysis of the product developed. The requirements of the technical (tactical and technical) assignment for the development of a product, i.e. device, system and complex, are basic data for the product development. As the past practice shows, the life cycle of the products, omitting the stage of marketing research includes as follows:

- Scientific and research works (engineering design and front-end engineering design, etc.);
- Detailed engineering (generation of detailed engineering design documentation at different stages or documentation updating including assigning a revision letter to the documentation);
- Manufacture of product models (mock-ups, prototypes, pilot models and production models, etc.);
- Testing (predelivery, acceptance, preliminary, interdepartmental, check and type tests) the number and “content” of which are determined by the stage of research and development works;
- Storage and transportation of a product to worksite specified by a user (customer);
- Use of a product within production facility with subsequent utilization of a product and conducting a marketing research with regard to the new type product.

Subject and calendar work schedules are implemented at the enterprise by placing the orders which determine the timings and persons being in charge of the development and manufacture (testing, etc.) of a product.

At the level of the Heads of Scientific and Research Departments and Laboratories the assessment of the enterprise units resources is done and the operational plan of the enterprise activity is made with the forecast of a practical implementation within not more than the next 2 years. The timings and “content” of the stages of the operational plan are determined by the staff employees of the enterprise as well as by the number and supportability of Automated Work Places (AWP) and by software installed in them, i.e. Computer-Aided Design systems (CAD-system).

Production cooperation developed and labor inputs in the fulfillment of certain types of work at the enterprise are of a paramount importance for the development of the “checkpoints” of the operational plan. In many cases the fulfillment of some specific process operations of product making turns out to be impossible for example, due to carrying out a preventive maintenance in the galvanizing room or due to a low workload of machine tool equipment, for which reason such process operations are fulfilled by co-operation enterprises. Consequently, a key role in optimization of the operational plan of the enterprise activity belongs to the Department of Economic Development and Planning and to the Production Office of the enterprise.

### 3.2 Use of Information Technologies in Product Life Cycle

Software, mathware, information, linguistic, organizational and technical support is the basis for implementation of the information technologies at the enterprise.

For the time being the development engineers are being offered the tools for solving the real-life problems associated with design support, and major of them have been implemented in the relevant software application packages.

Common interaction pattern of software packages which automate various production processes at the
enterprise in the product life cycle is given in Figure 2. It is evident that integral parts of the enterprise information system are CAD-systems, which automate the process of generation of technical documentation, as well as ERP-systems which support an electronic internal documentation flow at the enterprise, and some other automation systems (PDM-, CAM-, CASE-systems, etc.) which in common enhance an operational efficiency of the enterprise.

The most important tasks which are relevant for implementation of the information technologies in the management activity of the enterprise are:

- **Project management tasks** (research projects, development projects, etc.) associated with a practical implementation of record keeping and control of the development of project different integral parts at the enterprise;
- **Data generation and editing tasks** associated with using the information technologies at the enterprise and related to the development of technical documentation sets and report documents regarding the enterprise activity;
- **New technology development tasks** associated with creating the new automated processes for the production activity;
- **Tasks associated with record keeping and control of the versions of the projects under development and related to the creation of the automated file-archiving system as well as to the establishment of compliance check and process control of documentation at the enterprise;**
- **Tasks associated with creating the design alternatives as the variant solutions of one and the same production objectives using different methods and quality indices of design solutions obtained;**
- **Project visualization tasks** associated with creating the tools of automated representation in a visual graphical form of the design process information system and design results (production logistics support and three-dimension representation of the part under design, etc.) for a user;
- **Access restriction tasks** associated with the development of the organizational and technical measures which secure an access differentiation of the enterprise employees to professional, commercial and other information, an access to which is statute-restricted or restricted by the internal regulations of the enterprise;

![Figure 2. Use of information technologies in the product life cycle.](image-url)
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Tasks associated with the development of data storage and transfer formats and aimed at securing the coherence of protocols of data communication of various automated systems involved in the implementation of a single production process;

Workflow management tasks which provide as the fulfillment of the contractual obligation of the enterprise as well as the financial and economic stability of the enterprise activity.

Such design technologies, supported by different information systems implemented in the informational space of the enterprise, enable to fulfill the operations of all the stages of the life cycle of a product under design from the marketing stage to utilization one.

4. Discussion

4.1 Information Technologies and Competitive Ability of Instrument-Making Plant

Such position of the company which allows it to have the leading positions in the market of the development and production of onboard equipment, should be understood as a competitive ability of the instrument-making plant.

Such factors could be the economic and social ones which affect the main indices of the enterprise activity on the following levels: micro-level (products developed or manufactured by the enterprise), meso-level (interaction of the enterprise within a single corporate group, cluster, etc.) and macro-level (within the government enterprise system).

Competitive ability of the enterprise can be assessed quantitatively for example, based on the position in the relevant enterprise field rating or in some other way. However, the availability of the information resource at the enterprise as well as the ownership and command over this resource should be considered as integral parts of a competitive ability of the instrument-making plant.

Improvement of a competitive ability of the instrument-making plant is normally achieved by making the adequate management decisions including the use of the information technologies, as well as due to the government-funded programs associated with the development of a relevant economic sector and implementation of the targeted government programs aimed at increase in demand with respect to the new high-technology onboard instrumentation equipment, technical re-equipment and software upgrading of the enterprise production facilities, etc. And if the government targeted support of the enterprise is implemented in the form of the targeted programs, an increase in demand for the instrumentation equipment under current conditions is maintained in the frames of the government order.

In a certain sense, the government order is an indicator of a need of the government institutions for the results of the industrial activity. All hereinbefore expressed equally relates to aerospace, marine and automotive economy sectors.

It goes without saying that the quality of instrumentation equipment produced affects the improvement of a competitive ability of the enterprise, i.e. the quality of the product is an integral feature of all onboard instruments and systems which secures the existence of the enterprise in the market. It is evident that poor quality products will not be in demand and the activity of the enterprise will be acknowledged as ineffective. It appears that the products produced by the enterprise have some other features as well as the enterprise itself has, which in common would enable to improve a competitive ability of this enterprise sector-wise.

Consequently, the task of the improvement of a competitive ability of the enterprise is a multi-factor one which depends on the objective and subjective integral parts, and not all of these integral parts could be managed by the enterprise Chief Executive on his hierarchy level.

At assessment of the effect the information technologies may have on a competitive ability of instrument-making plant is it expedient to distinguish those competitive advantages which the enterprise gains in the market by implementation of the information technologies in management, design and production fields.

Such unique technology (in the broad sense of the word) the implementation of which at the instrument-making plant gives a certain advantage to the enterprise over the competitors should be understood as a competitive advantage. Such technology can allow the enterprise to decrease the costs and increase a labor productivity of the employees by using the automation facilities. These are so-called internal competitive advantages to which the qualification of the enterprise employees refers to as well as the availability at the enterprise of know-how protected by the patents and certificates of authorship for computer software program and availability of the management system at the enterprise which controls purchasing, sales
External competitive advantages of the instrument-making plant are primarily oriented to meet the expectations of the organization which operates onboard equipment. Image impressions of the users of the products made by the enterprise, availability of maintenance and repair services, which support the instrumentation equipment of the enterprise in operation, are the external competitive advantages of the enterprise. And finally, conjuncture conditions of the enterprise activity in the market in a certain economic period of the government activity also refer to the external competitive advantages of the enterprise which improve its competitive ability.

The main conclusion which has to be done from the analysis of the effect which information technologies may have on a competitive ability of the instrument-making plant is that it is not the information technologies which create the competitive advantages of the enterprise. Such competitive advantages are created by people (employees of the enterprise) who provide a solution of business-tasks using the information technologies at the enterprise.

As an example of the information technology implementation there should be used IS shown in Figure 3, the results of the estimation of time required for engineering design execution (development of piloted aircraft navigational complex) at the instrument-making plant using the information technologies at different stages of the development: Technical Proposal (TP), Front-End Engineering Design (FEED) and Detailed Engineering (DE), etc.

Information technologies the implementation of which at the enterprise improves a competitive ability of the organization can also include the availability of the Internet site of such organization, accounting information system of electronic tax payments, system of wages accounting, electronic transfer and calculation system, etc., as well as a corporate e-mail system, electronic document management at the enterprise, through CAD-system, etc.

It is clear that major of such information technologies which improve a competitive ability of the enterprise are based on the Internet-technologies in general and on the network distributive computer technologies in particular.

Summing up the results of the information technology effect on a competitive ability of the instrument-making plant, one can make a conclusion that the measures of a paramount importance at implementation of the information technologies at the enterprise should be the measures providing the organizational and technical support, namely:

- Measures of the information interaction of business units at the enterprise;
- Information interaction of the enterprise with domestic and foreign enterprises in the frames of the
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corporate interaction patterns as well as in the frames of the inter-sectoral interaction;
• Information interaction of the enterprise with the government institutions.

5. Conclusion

Specificity of the implementation of the information technologies at the instrument-making plants is primarily conditioned by the type of the product designed and manufactured at the enterprise as well by the need to use diversified CAD-system tools in a single process cycle “design-production”.

Specific components of the information systems, including the unique math-and software as well as technical support facilities, are designed for supporting the development of onboard instruments. Practical implementation of such type of support facilities is done within automated work places and computerized control benches used for developing, checking, setting up and adjusting the equipment.

Implementation of the new and updating of the existing information technologies are the priority development area of the instrument-making plant which enables the enterprise to occupy a dominant position in the competition.

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