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Functional and Information Modeling of Production Using IDEF Methods

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For process of modeling are developed suitable CASE tools. In the course of building this process a standard is used for functional modeling of IDEF0 realized through BPWin tool. Family of integrated IDEF methods presents basic tool of some modern strategies and methodologies of business process improvement. In paper is given functional and informational model of "Investment building of production facility" using graphical language IDEF0 that is, CASE BPWin tool. We also suggest context diagram, information model and decomposition diagram of production - investment building.

Keywords: business process, process modeling, IDEF

0 INTRODUCTION

IDEF (*Integration Definition)* is reprsented as set of standardized methods and family of graphical language for informational modeling in field of Software Engineering (SE), business processes and objects, and improvent of business process. In frame of project ICAM (*Integrated Computer Aided Manufacturing*), was developed at the end of 1970 as IDEF (*ICAM Definition*) standard, by USAF (*United States Air Force*), whose goal was to improve manufacturing production productivity using Information Technology (IT) and modeling [1] to [7].

The goal of newly developed IDEF techniques is to enable experts to comprehend problems from different views and levels of abstraction. In this regard, integrated IDEF methods present basic tools of some modern strategies and methodologies of business process improvement, for example: BPR (*Business Process Reengineering*), CPI (*Continuous Process Improvement*), IPD (*Integrated Product Development*), JIT (*Just-in-Time*), PPC (*Production Planning and Control*), QFD (*Quality Function Deployment*), TQM (*Total Quality Management*), TPM (*Total Productive Maintenance*), etc. [6] to [14]. The application of integrated IDEF methods can solve narrow class problems, as well as can eliminate deficiencies of these problems proposing general methods.

Ang. C.L. Luo et al. [7] conducted a research on development of a Knowledge-based Manufacturing Modeling System based on IDEF0 for the metal-cutting industry. A model for integrating process planning and production planning and control in machining processes was reviewed by Ciurana, J. et al. [8]. Hernandez-Matias, J.C. et al. [9] reported on an integrated modeling framework to support manufacturing system diagnosis for continuous improvement. Kang, H.W. et al. [10] commented on unified representation of the physical process and information system. Development of a novel simulation modeling system for distributed manufacturing was presented by Qin, S.F. et al. [11]. Eldabi, T et al [12] made an evaluation of tools for modeling manufacturing systems design with multiple levels of detail.

Strong software support there exists, which integrates IDEF methods, and enables connection of IDEF methods with other tools, such as software for simulation of business processes, software for activity based management of costs etc. Some integrated IDEF methods are: IDEF0 for function modeling, IDEF1 for information modeling, IDEF1X for data modeling, IDEF2 for modeling simulations, IDEF3 for modeling processes, IDEF4 for object-oriented projecting, IDEF14 for modeling networks etc (Table 1) [15]. Some types of IDEF methods are described in the works: IDEF0 [16 to 25], IDEF1 [26], IDEF1X

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[27 to 31], IDEF2 [32], IDEF 3 [33 to 36], IDEF4 [37], IDEF5 [38], IDEF6 [39] etc.

All of the aforementioned IDEF versions are used for different purposes, as techniques for informational (semantic) modeling of data and as formal graphical language; also for needs of relation modeling of data and forming relation database (RDB). Initially the IDEF0 language for functional modeling was created in the frame of SADT (*Structured Analysis and Design Technique*) technique, and one subset of these methods (the IDEF1X method, which was the first published in 1993) with NIAM (*Natural Language Information Analysis Method* or previously *Nijssen's* or *An Information Analysis Method*) method presents the precursor of EXPRESS software tools for development of STEP (*Standard for the Exchange of Product Model Data*) applications. Complementary use of IDEF and UML is given in refs [4, 40].

Table 1. *List of IDEF methods*

Type	Description of IDEF methods
IDEF0	Function Modeling
IDEF1	Information Modeling
IDEF1X	Data Modeling
IDEF2	Simulation Model Design
IDEF3	Process Description Capture
IDEF4	Object-Oriented Design
IDEF5	Ontology Description Capture
IDEF6	Design Rational Capture
IDEF7	Information System Auditing
IDEF8	User Interface Modeling
IDEF9	Scenario-Driven IS Design
IDEF10	Implementation Architecture Modeling
IDEF11	Information Artifact Modeling
IDEF12	Organization Modeling
IDEF13	Three Schema Mapping Design
IDEF14	Network Design

Aimed at procedures of modeling are developed suitable CASE (*Computer Aided Software Engineering*) tools. In Fig. 1 a general model of system development is shown [5] and [13].

IDEF standard is available at Web sites: http://www.idef.com/ and http://hissa.nist.gov/!ftp/idef/.

In early 1990's, the IDEF Users Group, in cooperation with NIST (*National Institutes for Standards and Technology*), has formed standards for IDEF0, published in 1992 (U.S. Government standards documents), known as FIPS (*Federal Information Processing Standards*) [42]. These standards are under coverage of IEEE and accepted by ISO [43]. IDEF0 and IDEF1X are techniques of modeling based on combination of text graphics which are presented in organized and systematic manner to increase reasonability and to supply logics for potential exchange, specified requests, or in another manner, to support system analysis at various levels.

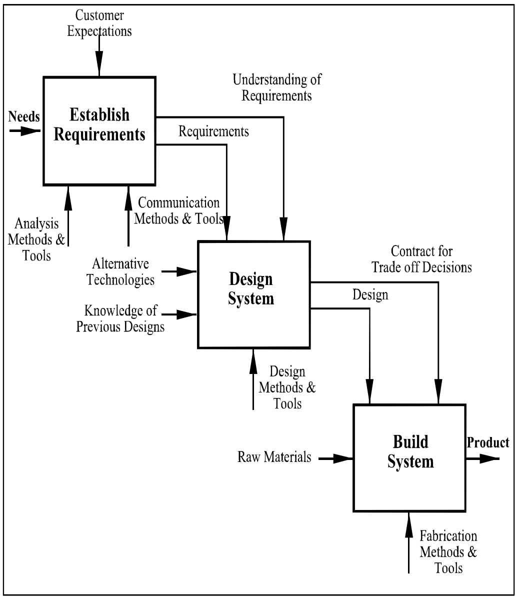

Fig.1. *System development (IDEF0 Model)*

The integrated concept of modeling has been accepted by the USA government, Pentagon and NATO and neither document can be defined until it is described using this methodology. A task which achieves this methodology must involve problems characterized by client/server architecture, that is, to connect multiple computers. This approach enables connection of future IS and demands systems of quality defined by the ISO 9000 standard.

1 IDEF0 - FUNCTIONAL MODELING

Demands which have motivated the creation of activity modeling are [13] and [16] to [25]:

- To serve as documentation and manual for description of complex activity and procedures and manuals demanded by the standard ISO 9000. One of the basic rules is: the larger the documentation – the less the reading. Document of one or two pages with diagram, is going to be cursory previewed and only when there is appropriate time. Documentation consisting of many pages has a great chance not to be read for months.
- To enable fast organizational changes and to give insight into critical activities which need to be performed with suitable resources.

The most important benefit in the application of activity modeling is the prototype access where alternative ideas are simply and quickly checked. It is much cheaper to draw process and data models than to develop a new information system.

IDEF0 and IE *(**I**nformation **E**ngineering)* standards enable [13] and [16] to [25]:

- Execution of system analysis and design at all levels, for manned systems, machines, materials, computers and informations;
- Making documentation as a base for integration of the ISO 9000 standard;
- Better communication between analysts, designers, users and managers;
- Discussion within a teamwork to accomplish mutual understanding,
- Management of large and complex projects.

IDEF0 formalism is based on the SADT methodology. Developed in 1985, by Douglas T. Ross from company SoftTech Inc. seated at Boston (Massachusetts – USA) [19].

The semantics of the graphical language IDEF0 implicates the meaning of syntax language components and lightens interpretations of corrections. The stage of interpretation describes parts like notations for activity and arrows and interlines of functional relationships.

Through functional analysis of IS, are presented:

- Diagram of context, indicating system boundaries,
- Activity stem to establish vertical connection between activities,
- Decomposition diagram to establish horizontal links between activities.

Rectangle (activity) and arrows (information carrier) determine the relationship between activities and informations. This relationship is shown in Fig. 2.

Arrows from the left side of the rectangle are defined as Input. Arrows which enter rectangle from above are defined as Output. Exits are data or objects produced by activity.

Elements shown in Fig. 2 can be described by the sentence: ″Under Control, ACTIVITY, Input makes Outputs, using Mechanisms″. Arrows on the bottom side of rectangle present mechanisms. Arrows pointed up identify meanings that support executed activity.

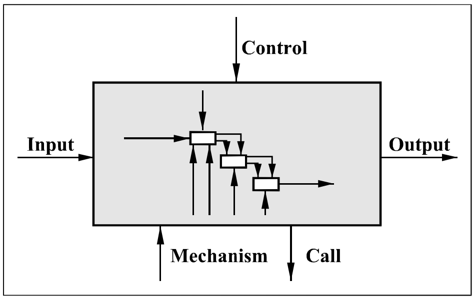

Fig.2 *Basic concepts of IDEF0 methodology*

Arrows of mechanisms pointed down are defined as Call arrows. Arrows on diagrams are called ICOM (abbreviation of):

- I - Input, something used in activity,
- C - Control, controls or conditions on activities,
- O - Output, activity result and
- M – Mechanism, for example, employees who perform a given activity.

A question is frequently asked: which resources carry certain arrow types?

An Input arrow presents material or information which is used or transformed aiming at defining Output. A possibility is allowed that certain activities need not to have Input arrows; certain activities don’t need to have input arrows.

Control arrows regulate, when and whether the activity will be performed. Every activity must have at least one control arrow.

Controls are commonly in the form of rule, regulation, politics or standards. They affect activity without possibility to be transformed or performed. There will be cases when a goal of activity is to change a rule, regulation, politics, procedure or standard. In that case, it is expected that arrows containing this information are actually inputs.

Output arrows are materials or informations created by activity. Every activity must have at least one output arrow. An activity which does not create output is not to be modeled.

Mechanism arrows are these sources which perform activity and do not wear themselves. Mechanisms can be humans, machines and/or equipment i.e. objects which supply energy needed for performing activity. By free will of the project performer, mechanism arrows can be let out of activity.

Call arrow is a specific case of mechanism arrow and it denotes that the calling rectangle does not have its own detail diagram but a more detailed preview is performed on another rectangle of the same or other model.

In IDEF0 standard knowledge capturing and reuse approach is based on an ontology and relevant database. The ontology provides formal specification in modular product development and the design relations and graphical modeling tool, a clustering method is used to capture potential relations in the abundant data, and the ontology is used to record and reuse these relations.

M-IDEF0 method is developed as an improved graphical modeling tool to achieve the visualization of modular product conceptualization. Basic syntax for an IDEF0 representation, in M-IDEF0, is intended for modular representation of a product M-IDEF0 (Fig. 3) [14].

2 FUNCTIONAL AND INFORMATION MODEL

Based on the above defined assumptions, the first discuss is functional modeling where with functional decomposition would be identified *Information model of production-investment building* in the frame of functional model process *Production-investment building*. For performing these activity, it is used graphical language IDEF0 that is Case tool Bpwin. IDEF0 technique is typical graphical language which enables process description according ISO 9000:2000 standards request.

Functional decomposition needs to be performed through next subordinate activity:

- To define model limit,
- To define activity tree,
- To define user's requesting,
- To define decomposition activity diagram.

Resulted activity by decomposition, on the last level, needs to be described.

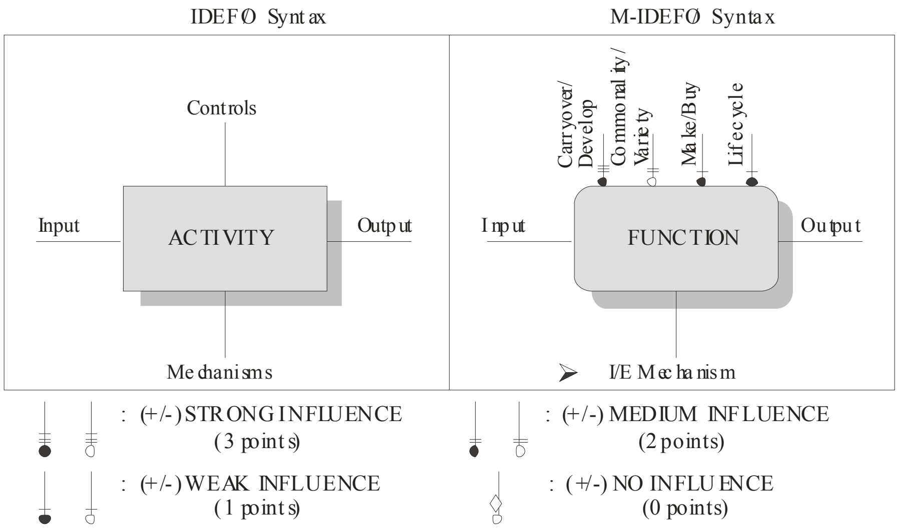

Fig.3 *Modified IDEF0 (M-IDEF0) syntax* [14]

2.1 To Define Model Limit

To define model limit is connect for supposition given for developing process *"Information model of production-investment building"*.

In the frame of determining model limit it needs clearly define the targets which must to next elements content:

- reason of model modeling,
- results of activity presentation,
- what model user would made with it,
- model purpose.

Answers on these questions must give to help in focusing on problem supposition.

Next questions which requests answers, are:

- which are assignments on given task or activity,
- which is sequence of events,
- how is control performs and
- which resources are used.

Context diagram defines with rectangle which represents study of model limit. The arrows show how, in that model and out of them, information flow.

Context diagram is the highest level of abstraction which, by decomposition diagrams would be lead in lower level of abstraction.

To define model limits is necessary because, where its must be stopped with modeling, before all.

This problem must be considers from aspect:

- width (to define watching elements) and
- depth (to define detailed level).

Model width is connected for context diagram defined (which is in IDEF0 notation marked with A0) and the first level of decomposition is signed as A1. In the frame context diagram it must to take care of defined input sets, controls and mechanisms, which produce output sets that is in this level to generalize observed problematic with less details.

Model depth is defined with decomposed levels, where are defined detailed levels. Decomposition went according defined possibility of primitive process. It recommends that is needed to start with defined output arrows, and move on to input, resources and controls. It starts from the act that every activity has appropriate outputs which can be identified. During defining the outputs, it must take care of negative outputs, which causes feedback arrows.

Next elements which must be defined are input arrows, which are transformed because appropriate output with help of appropriate mechanisms and control.

With aspect IDEF0 standard like and ISO 9000:2000 standards requests, it would be defined like the first step appropriate context diagram, it sets and observing model limit.

2.2 Context Diagram of Functional Production-Investment Building

Fig. 4 shows functional model context diagram of Information model production-investment building developing in regard model limit define.

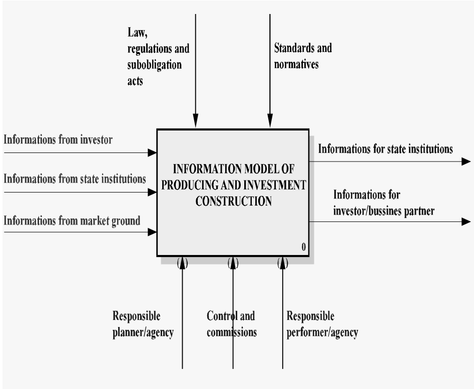

Fig.4. *Context diagram which defined model limits*

Context diagram consist next elements:

1) Input information are: Investor's information
   - Information from State institutions
   - Ground's information
2) Output information are Information to State institutions,
   - Information for investors.
3) Mechanisms are:
   - Responsible planner/agency
   - Commissions and controls,
   - Responsible performer/agency.
4) Controls are:
   - Laws, regulations and sub obligation acts,
   - Standards and normative.

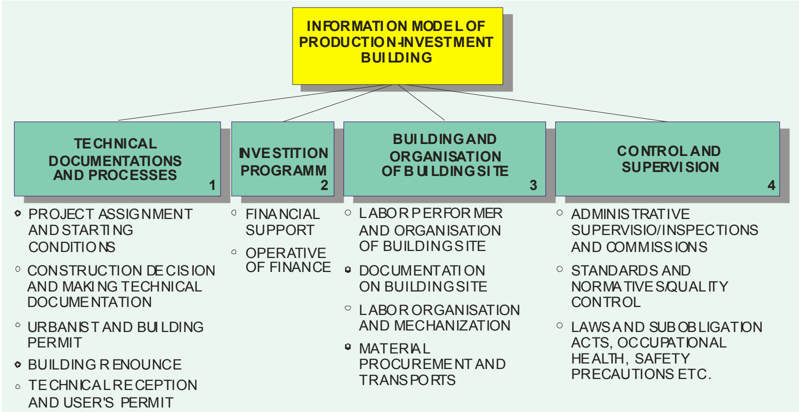

Fig.5. *Information model production-investment building- activity tree process*

Fig. 5 shows information model production-investment building model. The first step is established decomposition diagram that is horizontal link definition between jobs/activity defined in the first level.

2.3 Decomposition Diagram of Information Model Production-Investment Building

The model of decomposition process diagram production-investment building would decompose on four global activities (Fig. 6):

- Technical documentation and process,
- Investment program,
- Building and building state of organization,
- Control and supervision.

With respect to IDEF0 standard, appropriate arrows present sets of documents, which are defined as information. Each information would be divided until to the activity level where concrete documents are defined as arrows.

Internal communication stands for a number of activities which is a basic information assignment of all partners in all segments of production-investment building, assigned on following trends of modern building aspects and new methods in planning and realization for increasing productivity and efficiency.

Production-investment building process is a very complex project, which needs to be systematically planned, with convinced justification, successful realization and to reach useful value and efficiency i.e. profitability. With analysis of individual problematical segments, which are very large and long-term, and time of real action is very short, we'll show all justifications of IDEF0 standard modeling.

Investment choice problematic in one common admission that possesses two sides and two different supervising levels. The first one is the choice of global investment structure which means investment allocation between production sector, branches of production and different production activities, as their whole suitable arrangement. The second one is the investment choice in the frame of one homogeneous kind of production, that is to say, the choice between a different investment variant, with reference on homogeneous production, on production of the same useful value. With the first kind of choice production structure of economy is determined, and the second one searches the most satisfactory decision for realization of certain production assignment.

The way of performing optimally investment arrangement between production sectors and branches of production constitutes, without doubt, the most complex area of economy developing policy. It holds a central place, because with that choice strategy questions of each economy are decided.

In any investment project, the greatest care is, or would be, *how would be profit from that investment*? The answer depends on two components: *the profit of investment project output sales (output quantity which would be multiplied by with sales price) and costs of output production*. If a planned profit is higher than the planned costs, it's good to invest and vice versa.

The next segment of process is planning. Planning is a very complicated activity aimed at converting the uncertain (future), based on certain (known past and present) with acceptable risk. That means that the risk and future uncertain are not to be moved, but with planning may be reduced on probability which may be successfully controlled and realized.

That extraordinary human activity may not be left on strongly consolidate methods like: approximately, commander, with right date, politically and similar, than with modern methods operation research techniques, according to science-technological progress and with support modern computer systems corresponding software support.

The planning may not be based only on intuition, what in real life is a very usual case. With respect on the fact that intuition is based on experience and knowledge gotten by education, it must consider and definition that intuition is subconscious memory and that it expressive subjectivity events, which would not be majority in plans creating because it brings with itself, more or less expressive subjectivity mistake of unexpected disposition. Except that, such way plans creating is narrow limited on small number of experts who had reliable data for plans making, even more so that data are officially edited nowhere, that they would haven't common disposition. In that way, planning would be, like scientific discipline, degrading in individual skill, and dynamic plans shows graphically, the most frequently serve only for wall decoration or evidence something great, but no useful work.

In real life, the fact that planning of building project realization is connecting traditionally for talent, skill and long range individuality experience, which they got expert reputation for building realization are not encourage, because only memories on something similarly, soon or long time ago realized projects, at least that be and from experts side, and still is not good future visa. In the focus of contemporary project-management, is not important how much is built, than building "Just in time" which characterize unrealized construction at the expiration of agreed time limit, than right in time, and means building, with minimum expenses and building without quality defect.

Next important chain link is, certainly, Investment program.

Investment program is review and working out of enterprises idea and targets which are plan accomplish with determine investigate.

The reason of investment project making is to enable and enterprise management and other partners, who needs to engage in investment realization (business partners, bankers and local governments) to get fully and systematized clear picture about enterprise status, project obviously and condition for project realization.

Investment project may not to be established on unrealistic suppositions, wishes and dreams of any member in their realization. Realization has a sense if it is establishing on realistic enterprise status (investor), market and management, and like that, it can gives foundation for bringing realistic decision about investment in realization idea and project. It is necessary technical-technological analysis to support investment project with especially regards on both segment.

Technological analysis starts from detailed description of producing and working process flow which execute or will be executed in the enterprises after investment. It is necessary equipment description like expended normative of inputs in production of single product, immediate use of capacity and produce volume accomplish, like and projection and plan for these categories after investment, with expenses analyze.

Technical analyze means accessibility and developed infrastructure necessary for technological process free develop (building object, internal transport, energetic approaching and other elements). It is necessary to work out the management of labor, plans for training and qualifying.

In this segment of investment project it's obligated paying attention on ecological aspect of firm business by influence and protection of life surroundings and influence and protection of engaged labor.

Namely, described documentation has more than hundred or thousand pages which are very difficult to be presented to investor or to

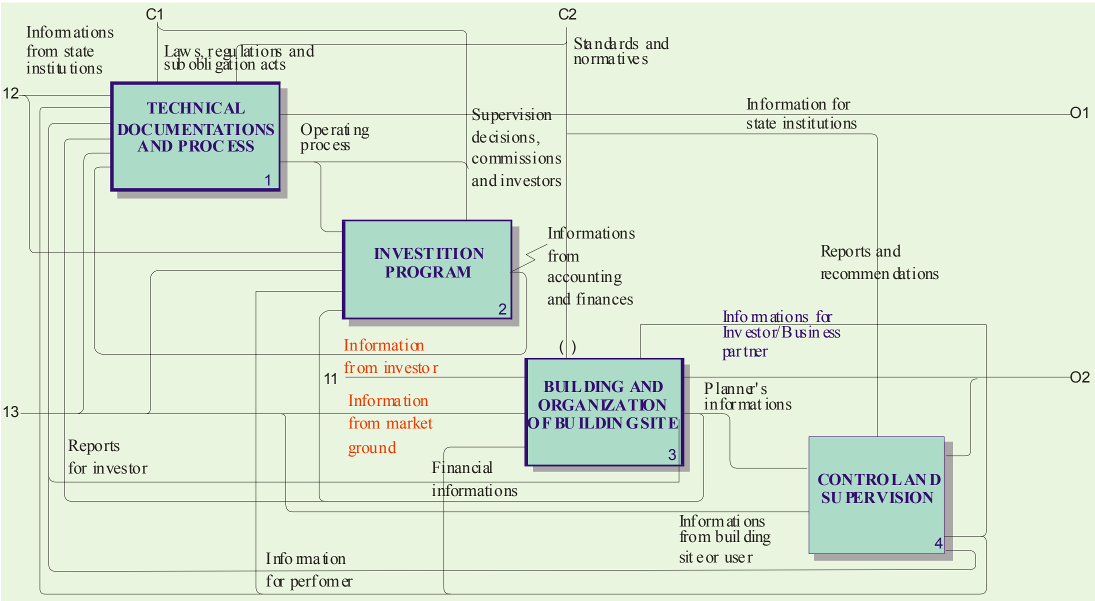

Fig.6. *Decomposition diagram of information model (production-investment building_*

donators, in the first order necessary time period for informing and conviction, volume and complex of project, expected results and guarantee...

IDEF0 standard, this very complex process describes picture, with diagrams on several pages, on which you can see the whole process with all needed elements. It's easy for presentation and not necessary high education of investor or donator, so that they follow marked flows. Everything is very clear, every connection, controls, call, all kind of information, it can be expecting results and to reach optimism which is necessary for successful project start and realization.

To be in competition today is not a question of success, than a question of survival. We must apply what we know, notice what we don't know and we occupied by thinking observation on expanding our area of understanding.

3 CONCLUSION

IDEF standard was developed at the end of 1970 by USAF with the assumption of improving manufacturing productivity using IT and modeling, and represents a set of standardized methods and languages for information modeling in the field of software engineering towards improvement of business process.

We have defined a context diagram, information model and a decomposition diagram to develop process *"Information model of production-investment building"*. Information model contains the basic three activities of IDEF standard: Input information, Output information, Mechanisms, and Controls.

User's requests for a model decomposition process diagram of production-investment building are defined through four main activities: Technical documentation and process, Investment program, Building and building state of organization, and Control and supervision (figure 6).

Process of production-investment building is a very complex project, which requires systematic planning with successful realization in order to accomplish usefully value and efficiency.

4 REFERENCES

[1] Ang, C.L., Luo, M., Gay, R.K.L. (1994) Automatic generation of IDEF model. *Journal of Intelligent Manufacturing*, vol. 5, no. 2, p. 79-92.

[2] Cheng-Leong, A., Pheng, K.L., Leng, G.R.K. (1999): IDEF: a comprehensive modeling methodology for development of manufacturing enterprise system, *International Journal of Production Research*, vol. 37, no. 17, p. 3839– 3858.

[3] Cho, H., Lee, I. (1999) Integrated framework of IDEF modeling methods for structured design of shop floor control systems. *International Journal of Computer Integrated Manufacturing*, vol. 12, no. 2, p. 113-128.

[4] Dorador, J.M., & Young, R.I.M. (200) Application of IDEF0, IDEF3 and UML methodologies in the creation of information models. *International Journal of Computer Integrated Manufacturing*, vol. 13, no. 5, p. 430-445.

[5] Mayer, R.L., Painter, M. *IDEF Family of Methods*. Technical Report, KBS Inc., College Station, Texas (USA), 1991.

[6] Marca, D.A., McGowan, C.L. *IDEFO - SADT Business Process and Enterprise Modelling*. Eclectic Solutions Corporation, 1993. p. 392.

[7] Ang, C.L., Luo, M., Gay, R.K.L. (1994). Development of a Knowledge-based manufacturing modeling system based on IDEF0 for the metal-cutting industry. *International Journal of Production Economics*, vol. 34, i. 3, p. 267 – 281.

[8] Ciurana, J., Garcia-Romeua, M.L., Ferrer, I., Casadesus, S.M. (2008) A model for integrating process planning and production planning and control in machining processes. *Robotics and Computer-Integrated Manufacturing*, vol. 24, i. 4, p. 532–544.

[9] Hernandez-Matias, J.C., Vizan, A., Perez-Garcia, J., Rios, J. (2008) An integrated modeling framework to support manufacturing system diagnosis for continuous improvement. *Robotics and Computer-Integrated Manufacturing*, vol. 24, i. 2, p. 187–199.

[10] Kang, H.W., Kim, J.W., Park, S.J. (1998) Integrated Modeling Framework for Manufacturing Systems: A Unified Representation of the Physical Process and Information System. *International Journal of Flexible Manufacturing Systems*, vol. 10, no. 3, p. 231–265.

[11] Qin, S.F., Harrison, R., West, A.A., Wright, D.K. (2004) Development of a novel simulation modeling system for distributed manufacturing, *Computers in Industry*, vol. 54, i. 1, p. 69–81.

[12] Eldabi, T., Paul, R.J. (2001) Evaluation of tools for modeling manufacturing systems design with multiple levels of detail. *International Journal of Flexible Manufacturing Systems*, vol. 13, no. 2, p. 163–176.

[13] Šerifi, V., Dašić, P.,Dašić, J. (2008) Functional and information model of expert specialization using IDEF standard. *Journal of Modelling and Optimization in the Machines Building Fields (MOCM)*, vol. 14, i. 2, p. 268-279.

[14] Chang, X., Sahin, A., Terpenny, J. (2008) An ontology-based support for product conceptual design. *Robotics and Computer-Integrated Manufacturing*, vol. 24, i. 6, p. 755– 762.

[15] Dašić, P. *100.000 technical and ICT abbreviations*. SaTCIP, Vrnjačka Banja, 2009.

[16] Ang, C.L., Luo, M., Gay, R.K.L. (1997) A knowledge-based approach to the generation of IDEF0 models. *International Journal of Production Researches.,* vol. 35, no. 5, p. 1384-1412.

[17] Chin, K.S., Zu, X., Mok, C.K., Tam, H.Y. (2006) Integrated Integration Definition Language (IDEF0) and colored Petri nets (CPN) modeling and simulation tool: a study on mould-making process. *International Journal of Production Research*, vol. 44, i. 16, p. 3179–3205.

[18] Colquhoun, G.J., Baines, R.W., Crossley, R. (1993) A state of the art review of IDEF0, *International Journal of Computer Integrated Manufacturing*, vol. 6, no. 4, p. 252– 264.

[19] Khoo, L.P., Ang, C.L., Zhang, J. (1998) Adapting IDEF0 modeling to perform manufacturing diagnosis. *The International Journal of Advanced Manufacturing Technology*, vol. 14, no. 12, p. 928–934.

[20] Kim, S.-H., Jang, K.-J. (2002) Designing performance analysis and IDEF0 for enterprise modeling in BPR. *International Journal of Production Economics*, vol. 76, i. 2, p. 121-133.

[21] Lu, L, Ang, C.L., Robert, K.L.G. (1996) Integration of information model (IDEF1) with function model (IDEF0) for CIM information system design. *Expert Systems with Applications*, vol. 10, i. 3-4, p. 373–380.

[22] Mayer, R.J.: *IDEF0 Function Modeling: A Reconstruction of the Original Air Force Report*. KBS Inc. College Station, TX,1990.

[23] Osullivan, D. (1991) Project management in manufacturing using IDEF0. *International Journal of Project Management*, vol. 9, no. 3, p. 162-169.

[24] Ross, D.T. (1985) Applications and Extensions of SADT. *IEEE Computer*, vol. 18, i. 4, p. 25-34.

[25] U.S. Air Force. In *Integrated computer-aided manufacturing (ICAM) architecture Part II, Vol. IV-Function modeling manual (IDEFO) Air Force Materials Laboratory*, Wright-Patterson AFB, OH 45433, U.S.A. (1981) AFWAL-TR-81-4023.

[26] U.S. Air Force. In: *Integrated computer-aided manufacturing (ICAM) architecture Part II, Vol. V-Information modeling manual (IDEFI)*, Air Force Materials Laboratory, Wright-Patterson AFB, U.S.A. (1981) AFWAL-TR-81-4023.

[27] Kusiak, A., Letsche, T. & Zakarian, A. (1997) Data modelling with IDEF1x**.** *International Journal of Computer Integrated Manufacturing*, vol. 10, no 6, p. 470-486.

[28] Lu L., Ang C.L., Robert K. L. Gay (1996) Integration of information model (IDEF1) with function model (IDEFO) for CIM information systems design. *Expert Systems with Applications*, vol. 10, i. 3-4, p. 373-380.

[29] Mayer, R.J. *IDEF1 Function Modeling: A Reconstruction of the Original Air Force Report*. KBS Inc. College Station, Texas (USA),1990.

[30] Mayer, R.J. *IDEF1X Function Modeling: A Reconstruction of the Original Air Force Report*. KBS Inc. College Station, TX, 1990.

[31] Ma, Z.M., Zhang, W.J., Ma, W.Y. (2002) Extending IDEF1X to model fuzzy data. *Journal of Intelligent Manufacturing*, vol. 13, no. 4, p. 295-307.

[32] U.S. Air Force. In: *Integrated computer-aided manufacturing (ICM) architecture Part II, Vol. VI-Dynamics modeling manual (IDEF2)*, Air Force Materials Laboratory, Wright-Patterson, U.S.A. (1981) AFWAL-TR-81-4023.

[33] Kim, C.-H., Yim, D.-S., Weston, R.H. (2001) An integrated use of IDEF0, IDEF3 and Petri net methods in support of business process modeling. *Proceedings of the I MECH E Part E Journal of Process Mechanical Engineering*, vol. 215, no. 4, p. 317-329.

[34] Mayer, R.J., Menzel, C.P., Mayer, P.S.D. *IDEF3: A Methodology for Process Description*. Final Technical Report, Integrated Information Systems Evolution Environment Project, USAF - AL/HRGA. Wright-Patterson Air Force Base, OH, 1991.

[35] Menzel, C.P. *Knowledge Based Systems Laboratory. IDEF3 Formalization Report. Integrated Information Systems Evolution Environment*. USAF - AL/HRGA. Wright-Patterson Air Force Base, OH, 1990.

[36] Jeong, K.-Y., Cho, H., Phillips, D.T. (2008) Integration of queuing network and IDEF3 for business process analysis**.** *Business Process Management Journal*, vol. 14, no. 4, p. 471-482.

[37] Mayer, R.J., Edwards, D.A., Decker, L.P., and Ackley, K.A.: *IDEF4 Technical Report*. Integrated Information Systems Evolution Environment. USAF - AL/HRGA. Wright-Patterson Air Force Base, OH, 1991.

[38] Menzel, C.P., Mayer, R.J. *IDEF5 Concept Report*. Final Technical Report, Integrated Information Systems Evolution Environment. USAF - AL/HRGA. Wright-Patterson Air Force Base, OH, 1991.

[39] Mayer, R.J., deWitte, P., Griffith, P., Menzel, C.P. *IDEF6 Concept Report*. Integrated Information Systems Evolution Environment. USAF - AL/HRGA. Wright-Patterson Air Force Base, OH, July, 1991.

[40] Kim, C.-H., Weston, R.H., Hodgson, A., Lee, K.-H. (2003) The complementary use of IDEF and UML modeling approaches. *Computers in Industry*, vol. 50, i. 1, p. 35–56.

[41] BPWin Methods Guide. Logic Works Inc., Princeton, New Jersey, 1997. p.128.

[42] FIPS Publication 183:1993 Integration definition for function modeling (IDEF0). Available on the Web site: http://www.itl.nist.gov/fipspubs/idef02.doc.

[43] ISO TR 9007: 1987 Information Processing Systems – Concept and Terminology for the Conceptual Schema and the Information Base