

COMPUTER SIMULATION OF SHIPBUILDING  
PRODUCTION PROCESS MANAGEMENT

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ABSTRACT: The business-production managements of shipbuilding-PPBP, namely with one shipyard, in today's too complex business conditions, is one of the most complex management organization systems. For this organization system, the intuitive-collective management is not efficient enough especially today. For the management of such complex systems it is necessary today to apply the most contemporary method of management with obligatory computer support. In this paper, the authors are going to present the results achieved in researching the efficiency of System Dynamics Computer Modelling of the Business-Production Shipbuilding Process-PPBP, which they did in 1988 and are continuing in the "BRODOGRAĐEVNA INDUSTRIJA SPLIT, YUGOSLAVIA, one of the biggest shipyards in Yugoslavia.

P R E F A C E

System Dynamics computer simulation model of the Business-Production Shipbuilding Process-PPBP aims at enabling the managers, i.e. the business-production structure of a shipyard, to check the behavior dynamics of the organization system of the shipyard depending on the chosen business policy, without jeopardizing the observed subject since the managers will check all possible scenarios by means of their personal computers before they adopt any of them. The PPBP is a continuous model, so the entire structure of the shipbuilding process will be presented by means of a verbal, structural, mathematical and finally computer simulation model, which will be expressed in advanced DYNAMO language, while the simulation on a personal computer will be done in SYSDYNS, which is also an advanced language whose author is Dr. Ante Munitić.

The model is suitable for everyday use among managerial personnel so they may:

1. check the behavior dynamics of the system in relation to historical data,
2. predict the future behavior of the observed system,
3. select the most suitable scenario for the future development of the PPBP-system.

1. A CHARACTERISTIC OF THE BUSINESS-PRODUCTION SHIPBUILDING PROCESS-PPBP

By applying two basic principles: abstraction, and aggregation; it is possible to present the shipbuilding business-production process by means of these phases;

1. SUPPLY OF SHIPBUILDING CAPACITIES in the world shipping-shipbuilding market. In this phase, it is necessary to have the information concerning supply and demand, technical documentation, and the information on the strength of competitors and solvency of the ordering party. Also, one researches the market of raw and production materials as well as contractors and sub-contractors.
2. A SUCCESSFUL CONCLUSION OF BIDDING, that is the signing of the contract with the consignee, which means continuing the making of the technical documentation. Furthermore, one specifies materials and production materials, signs the contract with contractors and sub-contractors, sets delivery dates, stipulates the amount of material and the dynamics of hiring sub-contractors. One also works out a detailed plan of the building and fitting out of the ship depending on the shipyard.
3. THE COMPLETION OF THE TECHNICAL DOCUMENTATION, comprises the entire technical and executive documentation. Then the production of the sections and the parts of the equipment starts, with regard to this it is necessary to provide the reception-warehouse with the necessary documentation.
4. THE START OF THE BUILDING OF THE SHIP ON A SHIPWAY, that is a laying of the keel of the ship-PK, when the building of the hull and its' gradual fitting out begins. In this phase it is essential to make sure that the shipyard-warehouse has the suitable documentation; transport and equipment documentation.
5. THE LAUNCHING OF THE SHIP, when the final fitting out of the ship begins and when it is necessary to have the equipment, the control and the final documentation.
6. THE TRANSFER OF THE SHIP. For this, one needs the final documentation in case of some last minute changes due to possible shipowner's complaints.
7. THE GUARANTEE PERIOD OF THE EXPLOITATION OF THE SHIP which ends when the stipulated guarantee period runs out.

On this basis of the verbal model of PPBP it is possible to reach these conclusions:

1. The PPBP is very complex, dynamics, time-consuming (the construction of a ship can take up to 4 or 5 years), continuous, non-linear, of high order, stohastical, and open, which means that it is subject to the legislature of the country to which it belongs and the recession in the world market.
2. The PPBP starts with the bidding and ends when the guarantee period runs out.
3. The PPBP in Yugoslavia business conditions is subject to a critical lack of high-grade financial resources, in other words, it is affected by financial insolvency!

## 2. SYSTEM DYNAMICS APPROACH TO THE RESEARCH OF THE BUSINESS-PRODUCTION SHIPBUILDING PROCESS-PPBP

The Sistem Dynamics methodology is extremely suitable for the computer simulation of the behaviour dynamics of the most complex organization systems to which the PPBP without doubt belongs.

In accordance with the System Dynamics methodology we will approach the PPBP as a whole, that is as a system consisting of nine sub-systems:

1. Planned process of ship construction.
2. Cooperation, i.e. the flexibility of working capacities.
3. Basic Organizations of Associated Labour-BOAL that carries out the scheduled plan.
4. Acquisition of the materials, production materials, machines and equipment that will be built into the ship.
5. Level of financial claim and financial debit,
6. The transfer of the account balance, i.e. the inflow and outflow of cash.
7. Gross income, nominal income, profit, costs of productions, penalty, and stimulation.
8. Capital expenditure and investment in capital assets and current assets.
9. Short-term and long-term loans, i.e. subsystems of the financing of the building of the ship.

Among the above-mentioned sub-systems which represents the highly aggregated structure of the PPBP-system, there exists a circulatory flow of materials, energy and information. In fact, there is the circulatory flow of: steel plates, production materials, auxiliary materials, machines and equipments that are built into a ship, labour potentials of the shipyard, and flexible labour potentials of subcontractors, money, documentation, information about the state of and any change in the elements of sub-systems and of the system as a whole.

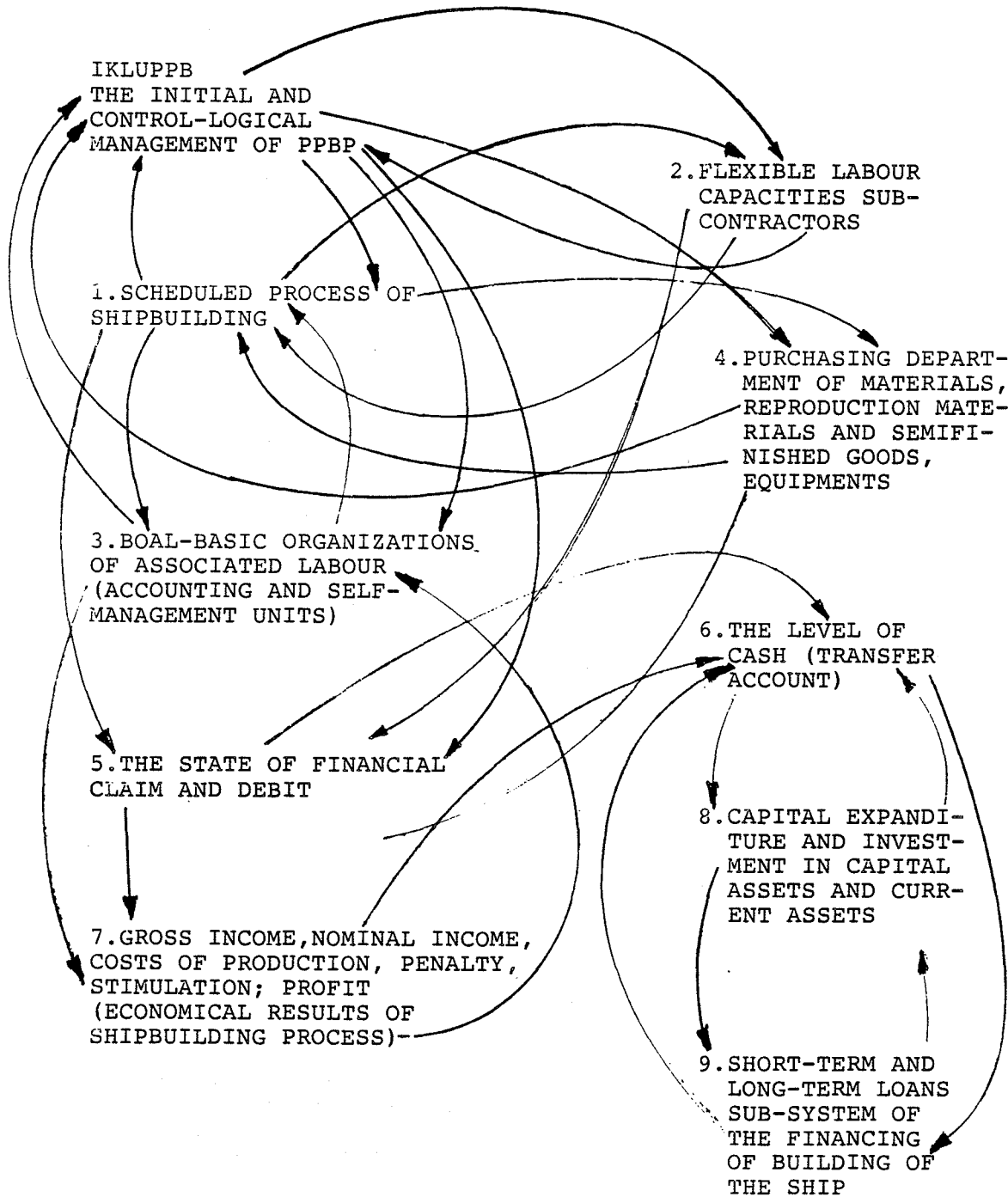


Figure 1 - Rudimentary structural model of PPBP

The rudimentary account of the PPBP could be presented by the following model of the communication flow of materials, energy and information among the relevant sub-systems (Figure 1).

The initial and control logical element of the shipbuilding process actually represents the computer simulation of the shipbuilding process management. That means that the offered model has the characteristics of an "intelligent" model because during that eight key periods (i.e. the completion of the seven phases of ship construction) the IKLUPPB-element controls everything and decides on the further construction of the ship (i.e. on starting the next phase of production). While making decisions, that same element checks all the participants involved in the board of directors. The checking and decision making process is identical to the way in which a directorial committee operates. In case that IKLUPPB-element concludes that a participant has fallen behind schedule, it then decides to slow down the execution of other tasks. If all participants have completed their tasks, then the IKLUPPB-element makes a decision about commencing the next phase of ship construction.

It is possible to build in the regulative elements which speed up the activity of certain work units, which reduces the possibility of falling behind schedule and paying a penalty to a shipowner.

The IKLUPPB-element initiative and control logical management of the shipbuilding process consists of eight stages (Figure 2):

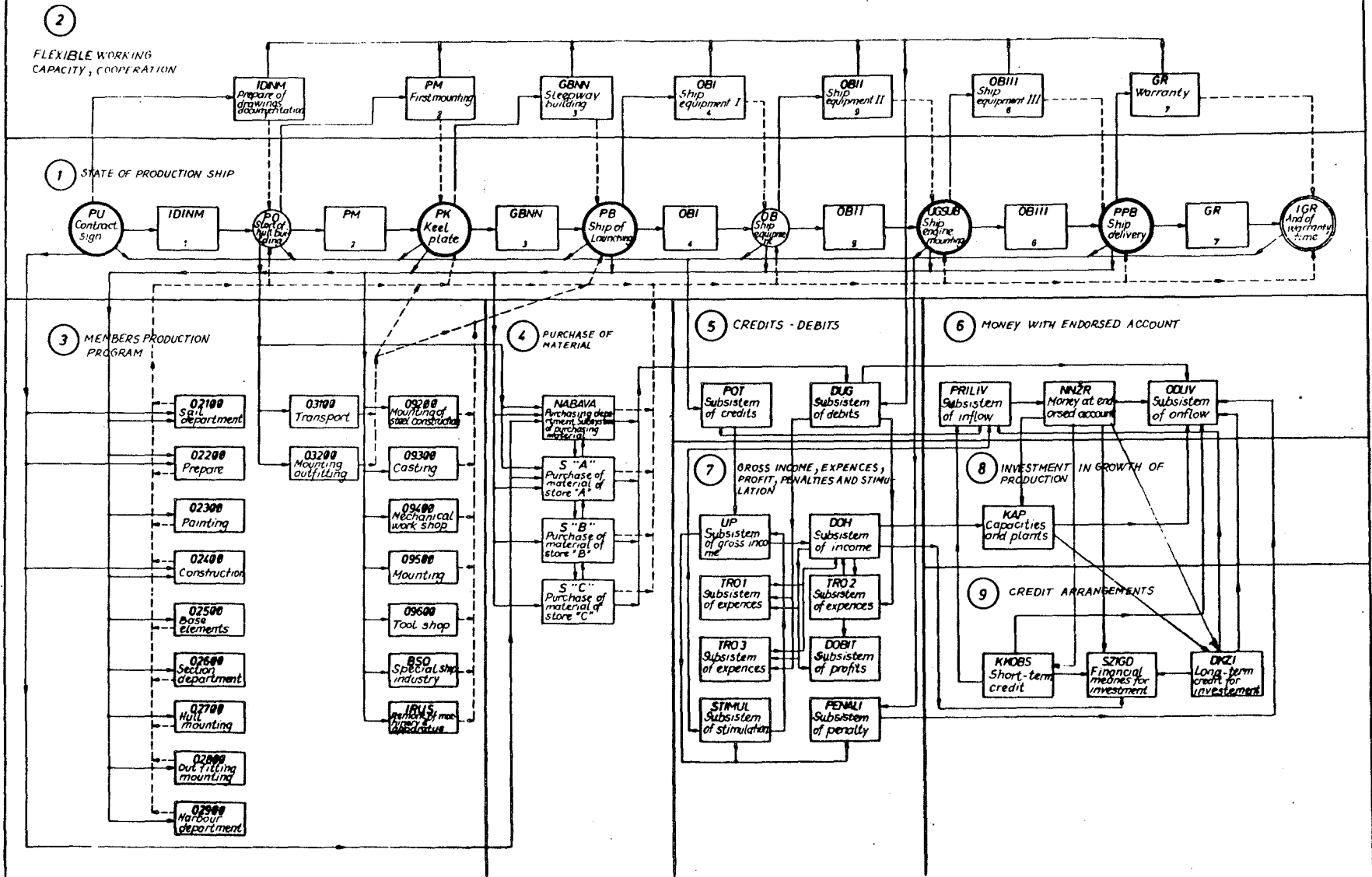
1. Signing of the contract-PU,
2. Commencement of the process-PO,
3. Laying of the keel of the ship-PK,
4. Launching of the ship-PB,
5. Fitting out of the ship-OB,
6. Building in of the main machine of the ship-IGSUB,
7. Acceptance of the ship to the owner-PPB,
8. Expiry of the guarantee period-IGR.

The ship construction is actually divided into seven phase, so that the shipbuilding process commences with the initiative element PU=1, which means that the contract is signed, and that a series of work units can begin the execution of their tasks in the first phase of work (i.e. the making of documentation-ID).

The first phase of work ID ends with the PO-element commencement of the process, which has a double role; it controls the execution of tasks and is, at the same time, a logical manager, which will get the value of "1" (PO=1) if all requirements are fulfilled.

The second phase of ship construction-PM-preliminary assembly starts only if PO=1 and it ends with the control element PK-laying of the keel of the ship if all tasks which are the requirements for the continuation of the production process are executed.

Fig. 2. - STRUCTURAL INFORMATIV INTERSECTIONAL MODEL OF CONSTRUCTION OF SHIP No. 356 (AMURELLA)



A third phase-GBNN-the construction of a ship on the shipway begins with the element PK=1 (which means the keel is laid down on the shipway), and ends with the control and logical element PB-launching of the ship. The PB-element-the launching of the ship will become a logical unit on condition that all participants complete their tasks in the GBNN phase.

The fourth phase OBI-the fitting out of a ship I-begins with the logical element PB=1, and ends with the control and logical management element OB-fitting out of the ship. The fifth phase OBII-the fitting out of the ship II-begins with the condition of the element OB=1, and ends with the control and logical management element UGSUB-building of the main machine of the ship.

The sixth phase OBIII-fitting out of the ship III-begins with the logical management element UGSUB=1, and ends with control and the logical management element PPB-the transfer of the ship.

The seventh phase GR-the guarantee period begins with the control and the logical management element IGR-the expiry of guarantee period.

### 3. PRESENTATION OF THE PPBP

DYNAMO was developed at MIT for the purpose of rendering possible the continuous computer simulation of the most complex management systems. However, DYNAMO is much more than just computer language. It possesses special symbols by means of which models can be presented by a graph of circulatory flows, which is very convenient for determining subsystems, elements, even the complete model.

The PPBP is very complex, so it is necessary to present each subsystem (i.e. each part of the model structure separately) in a gradual and unified way!

#### 3.1. Sub-systems of shipbuilding process

The sub-system of the shipbuilding process is divided into seven different parts which are all presented by unified structural model (Figure 3).

Equations in DYNAMO are:

|       |                         |  |
|-------|-------------------------|--|
| 1,A   | PU,K=1                  | PU-signing of the contract (without dimension)   |
| 2,R   | BID,KL=NBID*SKL1,K*PU.K |  |
| 2.1,C | NBID=913                | BID-speed of the documentation production (\$/day)<br>NBID-normal speed of the documentation production (\$/day) |

SKL1-logical switch element which stops  
the first phase of the documenta-  
tion production (without dimension)  
PU-signing of the contract (w.d.)

3,L      DUI.K=DUI.J+(DT)\*(BID.JK-ZD.JK)  
3.1,N    DUI=0

DUI-the production of the documentation  
(\$)  
BID-speed of the documentation producti-  
on (\$/day)  
ZD-speed of the realization of the do-  
cumentation (\$/day)

4,R      ZD.KL=DELAY3(BID.JK,VZKD)\*(SKL1.K)  
4.1,C    VZKD=30

ZD-speed of the realization of the do-  
cumentation (\$/day)  
BID-speed of the documentation produ-  
ction (\$/day)  
VZKD-time of the realization of the  
documentation (day)  
SKL1-the logical switch element which  
stops the first phase of the docu-  
mentation production (w.d.)

5,L      SZD.K=SZD.J+(DT)\*(ZD.JK)  
5.1,N    SZD=0

SZD-state of the completed documenta-  
tion (\$)  
ZD-speed of the realization of the do-  
cumentation (\$/day)

6,A      PO,K=CLIP(1,0,S102200.K+S102400.K +S102100. K,SZD.K)\*  
\*CLIP(1,0,S1SA.K,PS1SA)\*CLIP(1,0,SZDK.K,NSZDK)  
6,1,C    PS1SA=2159000

PO-commencement of the process(w.d.)  
S102100-state of the completed works of  
the BOAL-02100 in the ID-phase (\$)  
S102200-state of the completed works of  
the BOAL 02200 in the ID-phase (\$)  
S102400-state of the completed works of  
the BOAL 02400 in the ID-phase (\$)  
SZD-state of the completed documentation  
in ID-phase (\$)  
S1SA-state of stacks in the "A"-warehouse  
in the ID-phase (\$)  
PS1SA--planning the state of the stocks  
in the "A"-warehouse in the ID-phase (\$)  
SZDK-state of completed documentation  
of the sub-contractors in the ID-phase  
(\$)  
NSZDK-planning the level of the completed  
documentation of the sub-contractor in  
the ID-phase (\$).



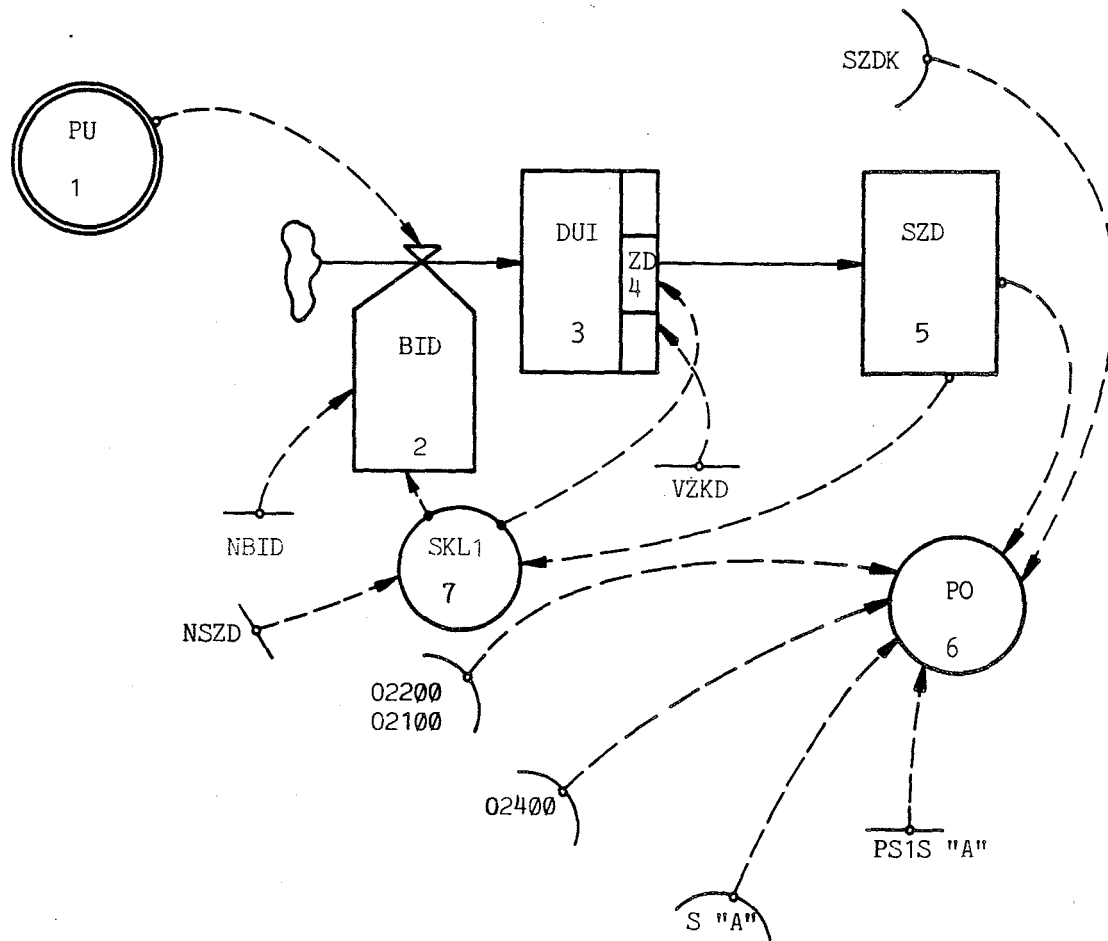


Figure 3-Flow diagram of the ID-phase

7,A SKL1.K=CLIP(0,1,SZD.K,NSZI)  
 7.1,C NSZD=17537

SZD-state of the completed documentation in the ID-phase (\$)  
 NSZD-planned state of the completed documentation in the ID-phase (\$)  
 SKL1-logical switch element which stops the ID-phase (w.d.)

### 3.2. Other sub-systems of the PPBP

All remaining phases of the PPBP are presented by analogous structural models, and so are all other sub-systems in all other phases. The overall number of elements of the PPBP model is 1500, and the system has just as many equations, 250 of which are differential!

Considering that the complete System Dynamics model of PPBP is very complex, the authors are not able to present it in its entirety in this paper, but it will be presented in detail to all interested parties at their request during the demonstration of the model.







#### 4. DEMONSTRATION OF THE BEHAVIOUR DYNAMICS OF THE PPBP MODEL

The validity of the computer simulation model of PPBP has been checked on computer of the MARITIME FACULTY DUBROVNIK, CAMPUS OF SPLIT, YUGOSLAVIA, on the basis of the data available from the SHIPBUILDING INDUSTRY in Split, Yugoslavia.

In fact, the data used pertained to a particular ship in the SHIPBUILDING INDUSTRY-SPLIT, Yugoslavia, and so the obtained results have confirmed the validity of the proposed model.

In this paper the authors will present the behaviour of the NNZR (level of cash)-variable which depends mainly on the changes in the financial capacity of the bank. PVPL-constant is the average time of the financial adaptation of the NNZR(level of cash)-variable.

The first scenario is: PVPL=10 days, the second scenario is PVPL=1 day, and the third scenario is PVPL=15 days. The result of the simulation of those three scenarios shows that the best cash liquidity of the PPBP is in case when PVPL=1 day! This result is logical and valid. (Figure 4, 5 and 6)

Names of variables:

|                 |                                   |
|-----------------|-----------------------------------|
| NNZR--N.....    | LEVEL OF CASH (\$)                |
| UP--U.....      | GROSS INCOME (\$)                 |
| DOHODAK--D..... | NOMINAL INCOME (\$)               |
| TRO1--T.....    | COSTS OF PRODUCTION (\$)          |
| FAZA--P.....    | PHASE OF PRODUCTION (\$)          |
| SKK--K.....     | LEVEL OF THE SHORT-TERM DEBT (\$) |

#### 5. CONCLUSION

The application of System Dynamics Computer Simulation Modelling of the PPBP can:

1. reduce the uncertainty of the ship-builders future,
2. increase the stability of the business,
3. reduce the sensitivity of the business-production shipbuilding process,
4. increase the flexibility and adaptability of the shipbuilding system,
5. reduce the fluctuation of labor,
6. increase the utility of production capacities,
7. improve ship-builders solvency, and
8. improve the management of the business-production process.

The authors are available to all interested parties; they will present the entire computer model "live" (i.e. on a personal computer) and will simulate different scenarios on the same computer simulation model.

## 6. LITERATURES

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